JUNE 5, 1980

SPEED IS THE KEY TO ENCRYPTION-CHIP MARKET/96

Distributed processing supervises wafer fabrication/151

Chip set gets radio-control designs off the ground/145

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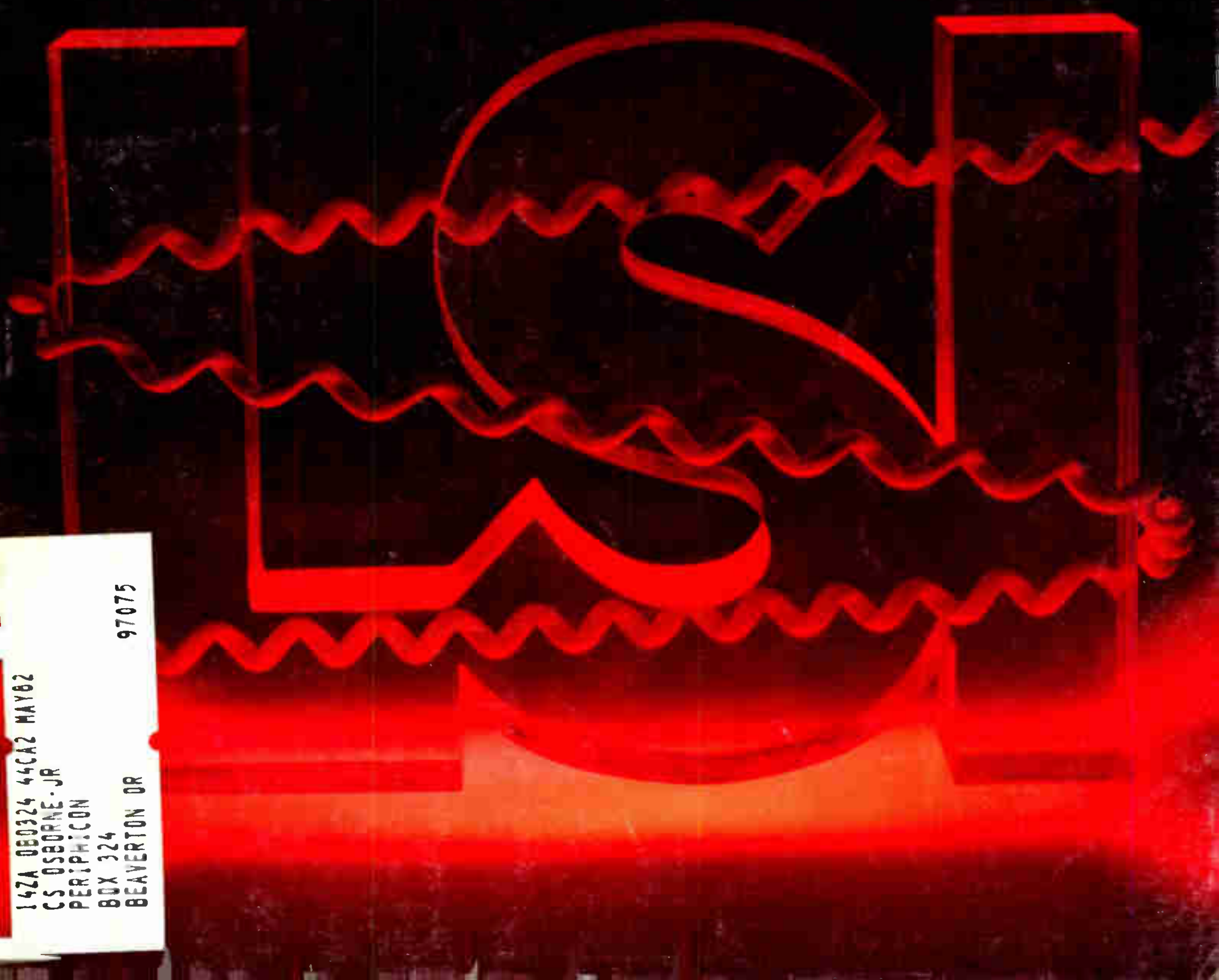
Electronics

THE TELEPHONE CONNECTION



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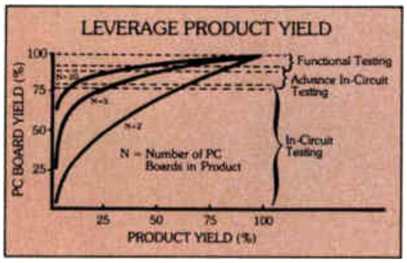

circuit testing provides a relatively small increase in board yield. But as you can see from the accompanying diagram, this small increase can mean a large improvement in product yield. For example, in a 5 PC board product, an increase in board yield of only 8% (from 90% to 98%) will leverage product turn-on rate from about 59% to 90%.

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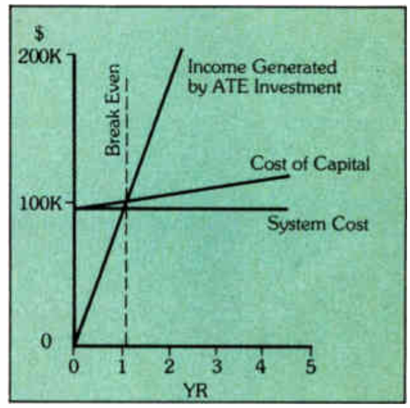
To help you determine this for yourself, HP now offers a very helpful brochure titled "Financial Justification — Circuit Test Systems." It includes a production test model worksheet, and has guidelines for calculating the 3060A Automatic Board Test System's payback period, average return on investment and/or discounted cash flow. You can use this information to determine the rate of return offered by the HP 3060A in your facility, even in light of today's high-interest economy. For your free copy of "Financial Justification — Circuit Test Systems," or for more information on the HP 3060A, (Priced at $85,000* for standard operational system) write to Hewlett-Packard, 1507 Page Mill Road, Palo Alto, CA 94304. Or call the HP regional office nearest you: East (201) 265-5000, West (213) 970-7500, Midwest (312) 255-9800, South (404) 955-1500, Canada (416) 678-9430.



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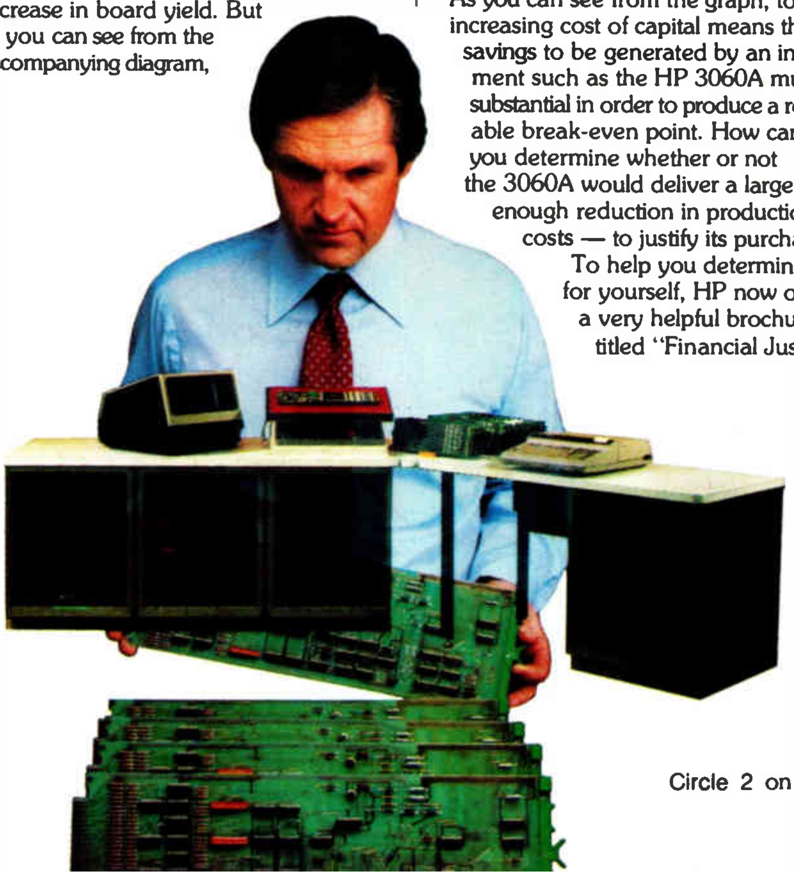

HP Circuit Testers — The Right Decision

HEWLETT PACKARD

Circle 2 on reader service card

Electronics
The International Magazine of Electronic Technology
Vol. 53, No. 13 • June 5, 1980

113 Technical Articles

Electronics

Highlights

Cover: LSI makers are connecting with the phone system, 116

It is likely that large-scale integrated circuits will invade telephone networks in force during the next few years, as chip makers and phone companies get the details ironed out. Complementary-MOS is becoming the technology of choice for the power-conscious telephone establishment, which is ready for the benefits of digital switching and transmission as soon as conservative equipment-lifetime requirements can be assured.

Cover photograph is by Kenneth Karp; sculpture is by Robert Strimban.

18-bit d-a converter decodes MSBs to get 16-bit linearity, 128

The linearity of a conventional digital-to-analog converter leans heavily upon the precise resistance of the switch handling the analog contribution of the input's most significant bit. By reducing the binary weight carried by any one switch, high linearity can be achieved with a more relaxed set of production tolerances, as a two-chip hybrid converter with a 0.001% linearity error specification proves.

Future VLSI components: success through flexibility, 138

Rising levels of integration threaten to place unmanageable demands on chip designers—and manufacturer-customer relations will be severely tested as well. Standard VLSI products will be nearly impossible to specify, and the cost of custom designs stratospheric. The answer lies in a semicustom approach represented by such devices as read-only memories, programmable gate arrays, and programmable signal processors.

Distributed processing network manages IC plant, 151

The production of LSI parts has become an extremely involved task. Hewlett-Packard's automated production facility for MOS LSI uses a number of linked computers to go beyond process control and testing. It collects and analyzes data and handles tedious chores such as mask inventory control—pointing the way towards fully automated IC foundries.

A net is cast for ATE users, 169

When an operator changes disks on a piece of automatic test equipment to load a new test program, valuable run time is lost. A data-communications network dedicated to ATE applications centralizes program files and transfers them at 655 kilobits per second to speed the process.

. . . and in the next issue

A special report on developing VLSI production techniques . . . an IEEE-488 controller made for designers custom-building their own automated test equipment . . . a microprocessor-based unit that simplifies attaching peripherals to computers . . . a C-MOS d-a converter.

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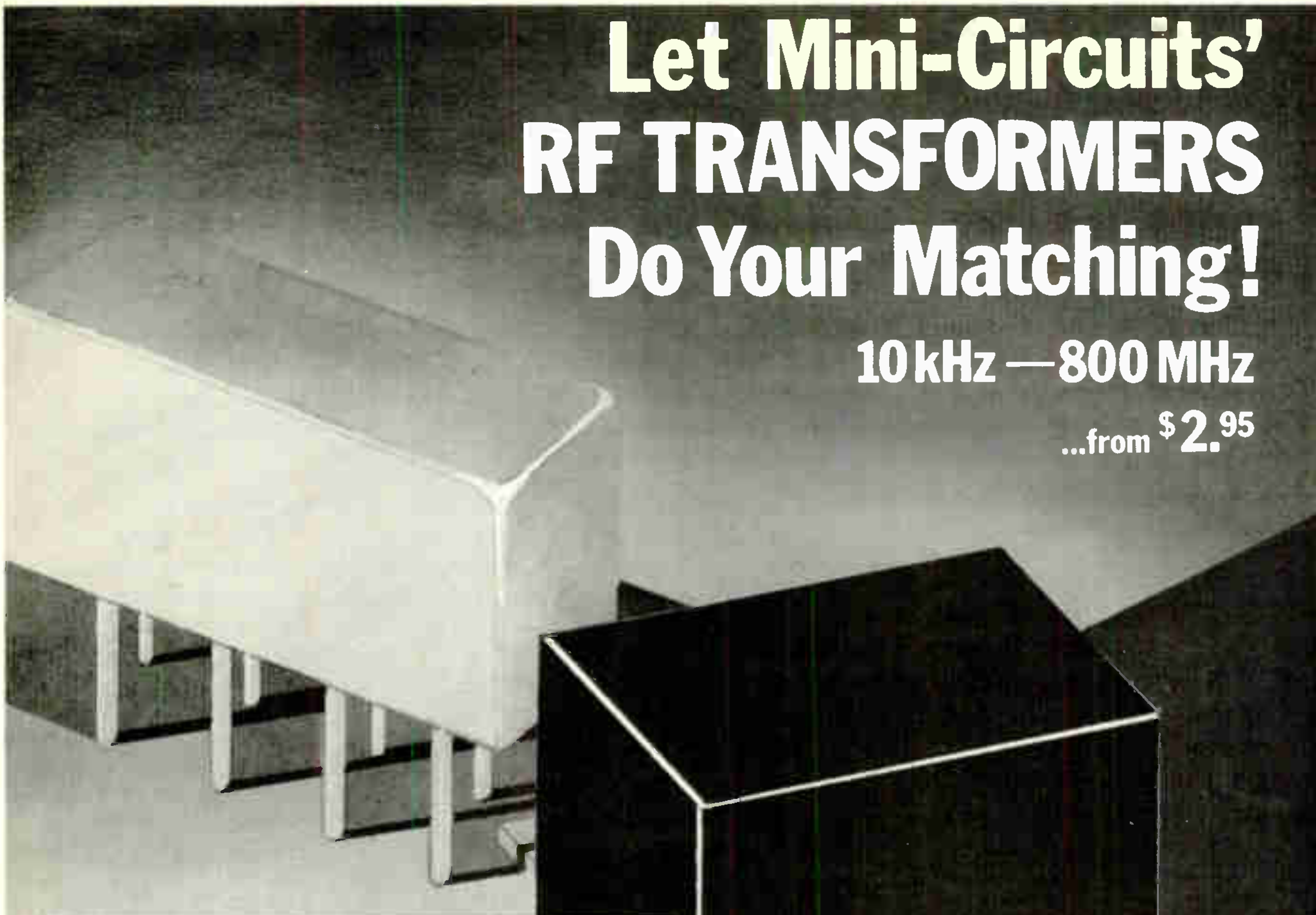

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T2 5-6	2.5	.01-100	$3 95
TM02.5-6	2.5	.01 100	$6 45
T4-6	4	.02-200	$3 95
TM04-6	4	.02 200	$6 45
T9-1	9	.15 200	$3 45
TM09-1	9	.15 200	$6 45
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42/Rev/B

Publisher's letter

Telecommunications is one of the oldest electronics technologies, yet it continues to change. Particularly important has been the development of large-scale integrated circuits designed to replace electromechanical and hybrid parts in telephone instruments and switching gear.

Not only do these LSI devices perform standard functions, but also they are adding capabilities to telecommunications hardware, reports communications editor Harvey Hindin. His special report (p. 113) concentrates on the chips designed specifically for telephone use, although there are also many applications for general-purpose microprocessors and memory chips.

Harvey notes that LSI in communications has quickly become a big business. "For some semiconductor companies, shipments of telecommunications products will represent about 20% of their business in a few years," he observes.

The reasons for this growth are familiar. LSI now represents a reliable cost-effective design route toward the conversion to digital technology. The trend is worldwide.

"In the developing nations, the situation is explosive," Harvey says. "Oil-rich countries have been able to install the most advanced telecommunications systems virtually overnight," he notes.

Coming soon will be smarter and smarter telephones able to store messages and route calls to other numbers. At the switching end, pulse-code–modulation amplifiers will make transmission lines more efficient. And subscriber-loop interface circuits (SLICs) are coming on strong. In short, there is a tremendous diversity in telecommunications chips, Harvey points out.

There is still some debate, but it appears that complementary-MOS is the favored technology. Chip architectures, however, are still up in the air. For example, there is no clearly defined, standardized set of components that make up a coder-decoder, or codec, especially when it involves a proprietary design.

Part of the problem is rooted in the ongoing conflict between the equipment makers, who want customized components, and the semiconductor houses, who want to produce standard chips in high volume. Nevertheless, comments Harvey, the LSI producers and the telephone equipment makers are working closely together.

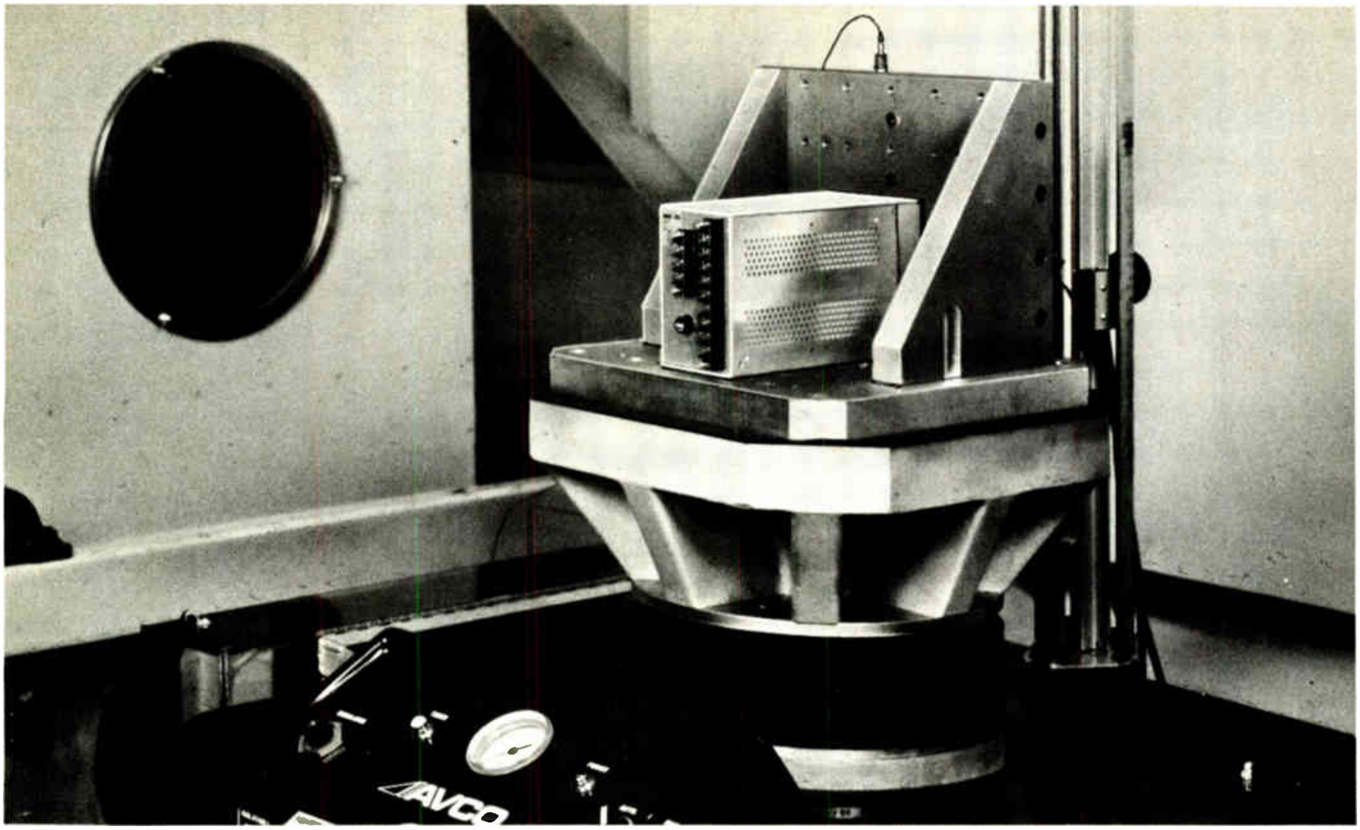
Entering the era of very large-scale integration, many may have wondered whether high-density devices packing such tremendous computing capability will introduce insurmountable applications problems.

Will the semiconductor industry be able to handle the customer interface problems that will result from the increased complexity of VLSI circuits? And can the industry handle the potentially enormous design costs of future custom products? These questions are posed by James L. Fischer, group vice president of Texas Instruments Inc.'s Semiconductor group, in an article starting on page 138. Both of these questions can be addressed with what TI calls solid-state programmation.

"With the industry fast approaching VLSI applications, we believe that programmable systems components hold great promise for providing the customization of standard products essential to widespread use of logic VLSI circuits at affordable cost," the TI executive comments.

"Today we are seeing a time and cost escalation of circuit design that parallels increasing complexity in both custom and standard products. We think our view toward programmable VLSI offers a viable road map for the future," Fischer states.

The TI vice president gained insight into technical aspects of programmation early from William C. Holton, manager of research, development, and engineering for the Semiconductor group, and from Harvey G. Cragon, TI senior fellow, who spearheaded the development of programmable systems components.



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Readers' comments

Needed: teachers

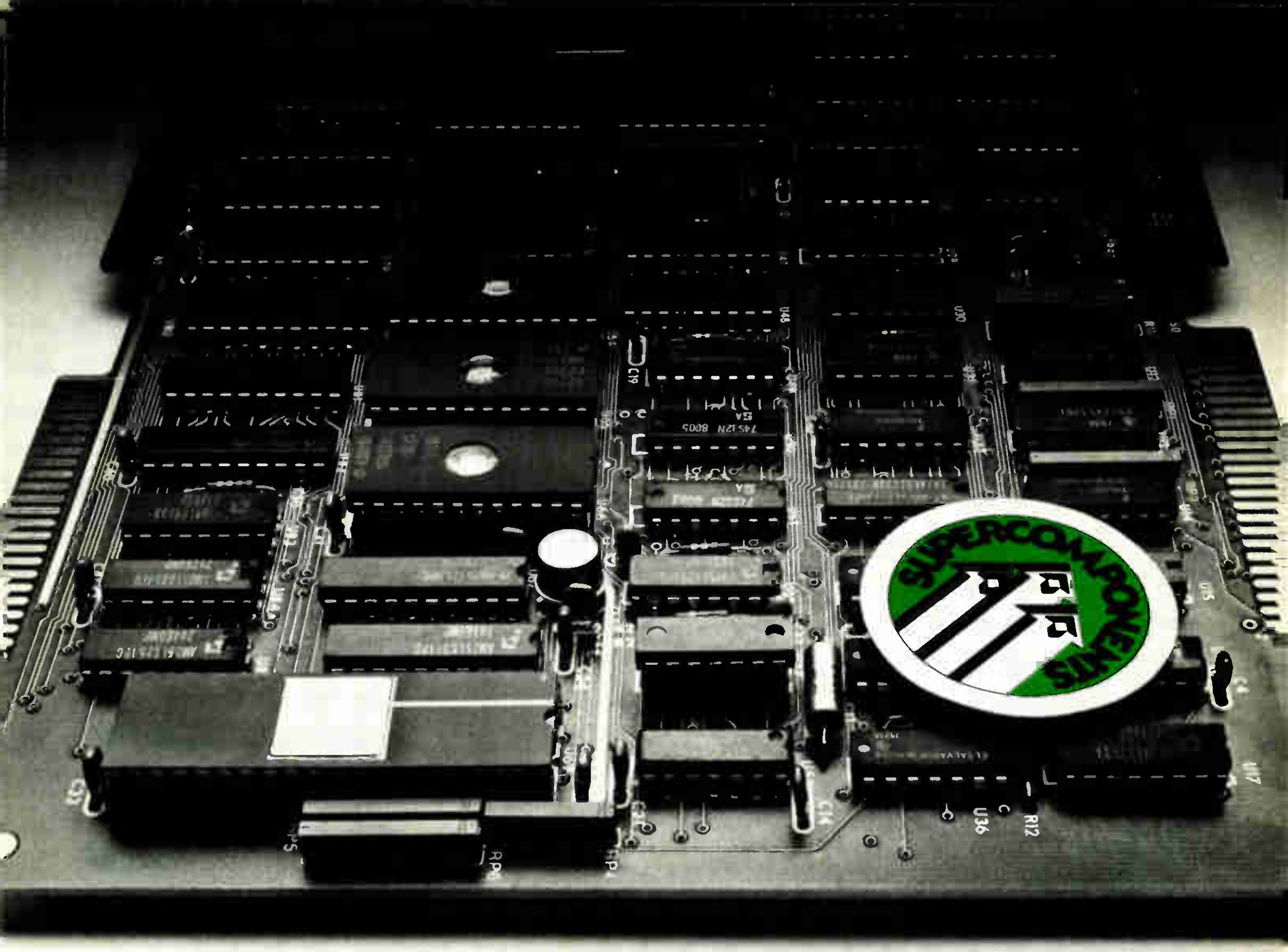
To the Editor: "Needed: a plan for educating engineers" [April 24, p. 26] discusses a serious problem, but I believe that it misses an essential point. To understand why universities cannot keep up with the demand for engineers, one need not resort to philosophical considerations of resistance to the "upheavals that a redirected emphasis on technological education will create." One need only consider some hard economic facts. A recent conversation with a friend at an area university revealed that five electrical engineering courses scheduled for the fall semester were to be taught by "staff," which means that there is no one currently available to teach the courses. The reason? Starting faculty salary is in the range of $18,000, while roughly equivalent industrial positions offer salaries up into the $25,000-to-30,000 range. Add to this the mediocre benefits and small salary advances provided by the faculty positions, and the bottleneck begins to become obvious. At least for the institution to which I am referring, there is no lack of prospective engineering students, but rather a lack of engineers willing to tolerate the small economic rewards of employment in the field of education.

Mark H. Polczynski
Watertown, Wis.

Corrections

Typographical errors in the Electro/80 preview (April 21, pp. 174 and 176) gave incorrect throughput and conversion rates for Data Translation Inc.'s 12-bit data-acquisition system. The throughput is 25 microseconds per channel; conversion time is 10 µs.

The noise figure, gain, conversion gain, and dynamic range of a receiver are related, but not directly, as indicated in the "Advantages" column of the table comparing the inherent trade-offs of mixers in "Two hams capture manufacturers' ears" (May 8, p. 93). The noise figure should have been set apart from the aforementioned parameters by means of semicolons or bullets for the bipolar transistor, JFET, and diode mixer, respectively.



You're only as smart as your next floppy disk controller.

News update

■ American Telephone & Telegraph Co.'s Advanced Communications Service (ACS) plods along on its embarrassing way, still plagued by software and regulatory issues, for all its claims to hold the answers to the problems facing the office of the future.

But Bell is not sitting around. With a recent tariff filing, the Bell Telephone Co. of Pennsylvania is continuing AT&T's move into information processing by offering customers store-and-forward switching services.

Now, some Pennsylvania customers can have what Bell terms call answering and advanced calling. Call answering uses microprocessor technology for central office answering of calls, much like a subscriber-site answering machine.

Novelty. Advanced calling is the real novelty. Here voice messages sent by the subscriber are delivered, later or immediately, as desired, to other subscribers anywhere in the network. This is really a form of electronic mail, with the sender specifying phone numbers, the message, and the delivery time.

Industry observers expect AT&T to offer some form of these services as part of the ACS system when it comes about [*Electronics*, Nov. 22, 1979, p. 34]. For now, the limited service is for Philadelphia only, but Charles Coughlan, the company's consumer interpremise development manager, says plans are being formulated to introduce the new services around the country.

The system control for advance calling is the 1A voice storage system designed by Bell Laboratories, a device the company says uses "complex software, advanced memory and processing electronics, and stored program control." But still-sensitive Bell says it is an electronic switching system—not a computer.

Telephone-based ACS should offer digital transmission of the outputs of virtually every type of office equipment, but is late because it is having trouble developing the necessary software. Cynics, however, say ACS is delayed because it was introduced too hurriedly. **-Harvey J. Hindin**

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Circle 13 on reader service card

People

Davies gets his wish and moves into computers

Impressario. Davies hopes to orchestrate annual 50% growth rate for his companies.

The electronics entrepreneur is primarily a North American species, but there are a few European mavericks. One such is C. A. (Tony) Davies, who in 1970 at age 26 founded Membrain Ltd., the fast-growing British automatic test equipment company. By December 1977, when Davies sold his company to the French multinational Schlumberger Ltd., he had built it into a thriving $6 million operation.

Now he is rolling the dice again, and part of his next venture is Computer Technology Ltd., the high-performance minicomputer company founded by Iann Barron. (Barron is now a director of Inmos Ltd., the microcircuit company backed by the British government.)

"I always wanted to get into computers," say Davies. The opportunity presented itself when four engineers from IBM Corp.'s research center in Hursley Park, Winchester, asked the British venture-capital company, ICFC Ltd., to fund an advanced work station for the office of the future.

At the time, Davies, an ICFC consultant, advised that such an IBM spinoff could fit well with Computer Technology, in which ICFC had a major stake. So a new company, Office Technology Ltd., was formed alongside Computer Technology. Davies is taking over as chief executive of Information Technology Ltd., the holding company for the other two operations and for startup ventures yet to come.

Davies says that Computer Technology's hardware, based on a modular, highly interactive computer architecture, will fit well with the work stations being developed by Office Technology. So far the team has spent a sum total of 55 man-years in the general areas of man-machine interfacing and office automation. However, their first product, to be introduced in 1981, will be a simple no-frills word processor. But there probably will be hooks on which to hang future voice-, data-, text-, and image-handling capabilities.

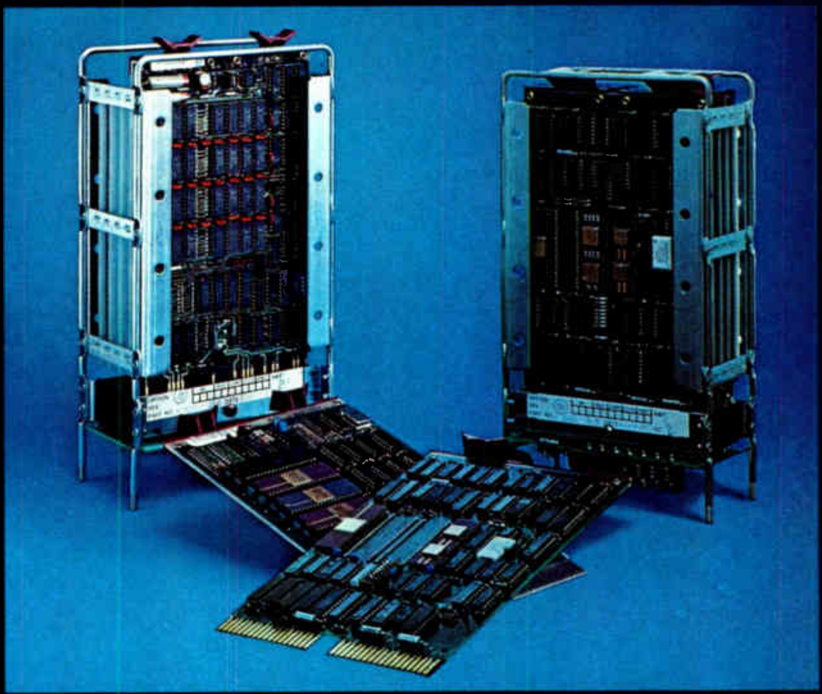
Davies hopes to push the combine from a volume of $13 million today to $100 million by 1985 and from profits of $1.3 million to $13 million. That is an ambitious 50% annual growth rate, which he hopes to succeed in achieving by aggressive marketing focusing on specific market opportunities.

Rittenhouse has a plan to make RCA a top bidder

Now that he has been in the job for a year, John D. Rittenhouse has taken an aggressive stance in the military marketplace. As the division vice president and general manager of RCA Corp.'s Government Systems division, Moorestown, N. J., Rittenhouse, 44, has put together an active technological strategy that is calculated to push RCA into the forefront of contract bidding.

"We have to bid and win jobs in an extremely competitive business," he observes. "The other part of this business is running jobs well once you've won them." Keeping these two maxims in mind, Rittenhouse has identified seven areas of technological thrust for his division. "All of our planning wraps around them," he says.

■ Microelectronics, or solid-state processing. "The time is ripe for the lead in distributed microprocessing to be taken in the military marketplace. Program implementations can grow in a modular fashion through



People

Target. One of John Rittenhouse's aims is military distributed microprocessing.

the use of microprocessors."

■ Digital processing. "It can be used for a number of things. For instance, signal processing is important, especially array processing in radars."

■ Thermal-mechanical systems. "This is unusual work for an electronics company. It mainly involves software programs to identify structural failure modes in satellites."

■ Microwave technology. "We're at the forefront of designing power amplifier devices, but, alas, the Japanese have a slight edge."

■ Systems analysis. "You can't be in the defense business and be responsive to the customer's needs without a systems analysis capability."

■ Electro-optics. "The area needs more exploration."

■ Software. "Software modularity and transportability won't be merely a fond wish."

In fact, it's this last area to which Rittenhouse has devoted much of his time and energy. He is establishing a software-development facility scheduled to come on line in 1981, as well as implementing a company program dedicated to software training.

Rittenhouse, who joined RCA in 1958, holds an MSEE and has attended a Harvard Business School management program. This combination of business and technical expertise is strongly evident in his approach to the military marketplace. "I want my sights set on the right technology and I want the capabilities of the company to match the needs of the marketplace," he emphasizes. □

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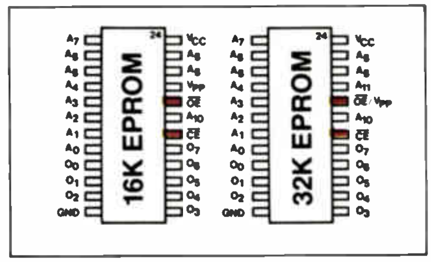
Intel's EPROM reliability procedures are some of the most stringent in the semiconductor industry. We burn-in 100% of the 2716s at an accelerated temperature of 150°C. Reliable bit storage (data retention) is assured by baking at 150°C for 72 hours. We also test program margins and full electrical parameters.



Finally, before you receive your 2716s, we program and erase each of the 16,384 bits in every device. For military applications, our mil-spec M2716 goes through even more—to meet the full Level B requirements of MIL-STD-883B.

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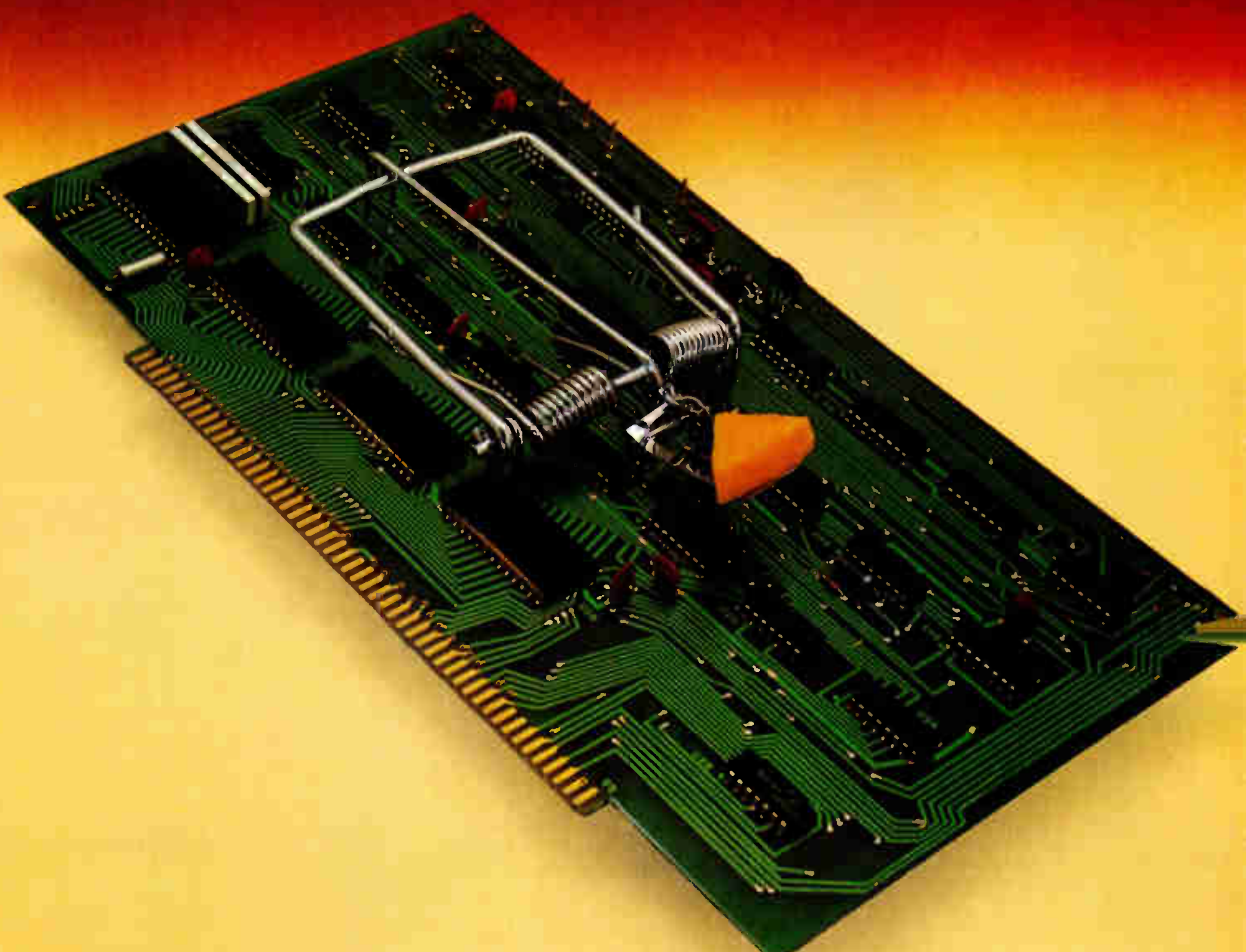
Circle 19 on reader service card

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Editorial

What is a person to do?

The American communications equipment market is mature and well supplied by vendors from the U. S., Canada, Europe, and Japan. So the obvious next step for American manufacturers seeking new business is to look abroad, where the Canadians, Europeans, and Japanese are already zealously and skillfully going about their business. But some executives of equipment houses complain bitterly that the Federal government permits its concern with foreign policy directives, national security, and moral stances to override any interest it might have in forging strong trade relationships.

Also, U. S. laws prohibit bribery to win contracts, while other nations simply look the other way. Matters that also make the Americans go home muttering are loan terms, prohibition of trade with certain countries, and the high cost of maintaining highly visible representatives abroad, which is attributable to the U. S. tax structure. In fact, the Yankee Group of Cambridge, Mass., says in a study that of three factors vital to clinching a foreign contract—technology, diplomacy, and financing—the American company usually has only technology.

Bribes and trade boycotts for political ends are sensitive and emotional subjects. No one wants to campaign loudly for payoffs and against support of human rights, though one marketing manager says: "The fact is we lose contracts. I'd like to know just what is accomplished besides making a point." The answer might be that there are some things more important in the long run than contracts.

Is help on its way for small business?

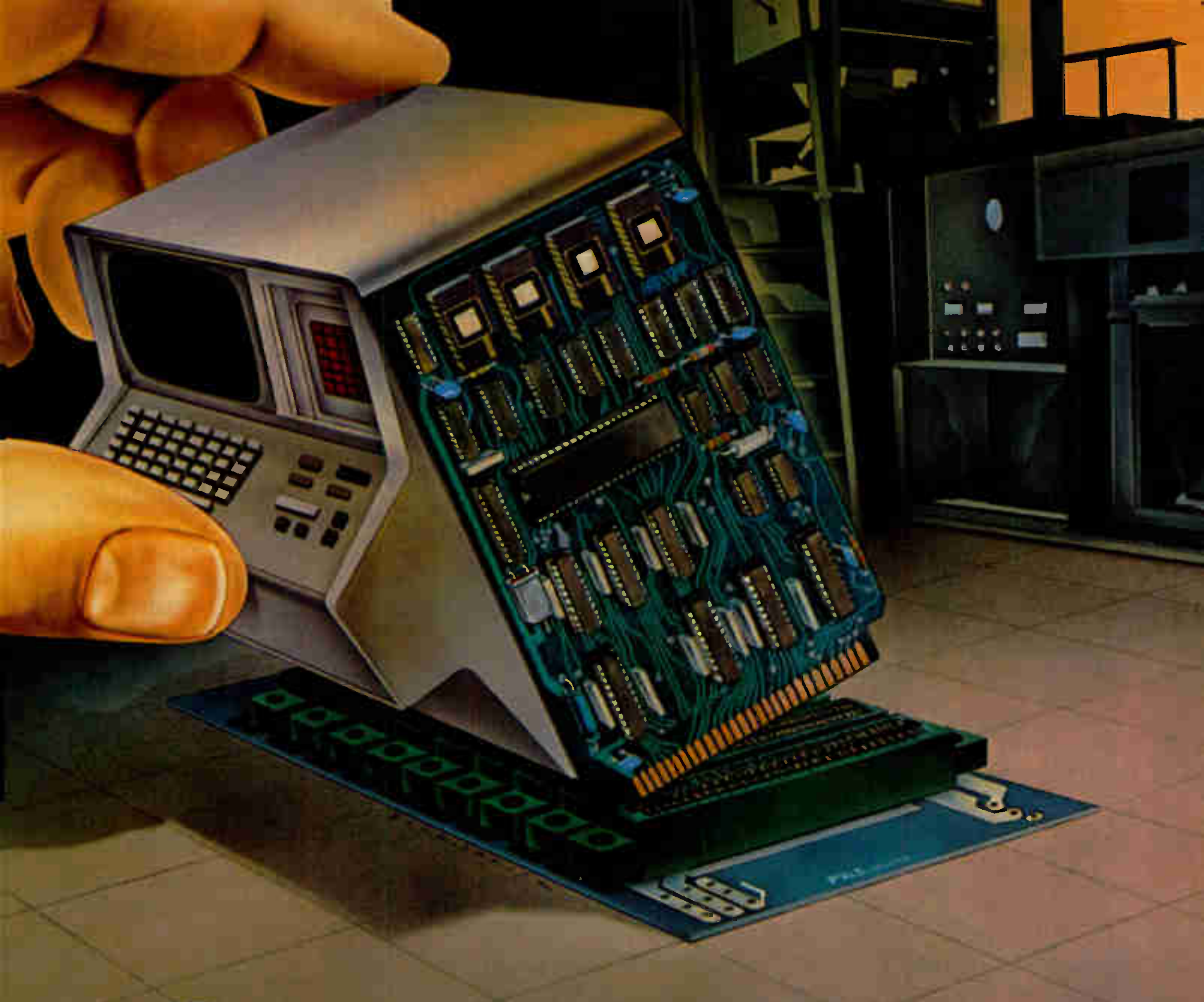
The entrepreneurial spirit is alive, well, and growing in the high-technology world. A session entitled Starting and Operating a Small High-Technology Business at Electro/80 in Boston drew a standing-room-only audience of would-be businessmen as a number of panelists detailed the whys and wherefores of launching a venture.

It's time again for the growth of small business. After the raft of new business startups in the 1960s, the 1970s provided little venture capital for entrepreneurs. Government overregulation and overtaxing had taken the fight out of many who might have dared. That regulatory stance is finally beginning to ease somewhat under the present Carter Administration, although much remains to be done.

The White House Commission on Small Business concluded a two-year study last month, calling for government to end a policy of neglect toward small companies, so that they in turn may take part in helping with the problems that confront the nation.

Several bills pending in Congress could address some of the problems facing small enterprises doing business in the large corporate world. The most important of these—the Small Business Innovation Act of 1980—would have agencies that are dispensing R&D funding seek them out more actively, as well as provide them with certain patent rights and tax provisions. The house version, H. R. 5607, would set aside up to 15% of the total R&D funds of an agency for that purpose, whereas the Senate bill, S. 1860, would provide up to 10% of such funds. Of equal import to nascent high-technology businesses are Senate bill S. 2911 and House bill H.R. 4660. These would clear away much of the regulatory morass encountered by the small business.

All of the pending legislation attempts to answer important questions that must be resolved if the entrepreneurial spirit is again to germinate and grow in the U. S. Any measure that can strengthen this growth should be supported by the high-technology community.



Meetings

29th Power Sources Conference, U. S. Army Electronics Research and Development Command (Fort Monmouth, N. J. 07703) *et al.*, Deauville Hotel, Atlantic City, N. J., June 9–12.

Automated Testing for Electronics Manufacturing Seminar/Exhibit, Benwill Publishing Corp. (1050 Commonwealth Ave., Boston, Mass. 02215), John B. Hynes Veterans Auditorium, Boston, June 16–18.

Automation for Safety International Symposium, International Federation for Information Processing *et al.* (ASSOPO '80, Studieadministrasjonen, The Norwegian Institute of Technology, N-7034 Trondheim-NTH, Norway), Norwegian Institute of Technology, Trondheim, Norway, June 16–18.

First Annual Conference of the National Computer Graphics Association Inc. (1129 20th St. N. W., Suite 512, Washington, D. C. 20036), Sheraton National Hotel, Arlington, Va., June 16–19.

1980 Power Electronics Specialists Conference, IEEE Aerospace and Electronic Systems Society, Dunfey Atlanta Hotel, Atlanta, June 16–20.

International Microcomputers Minicomputers Microprocessors/DATACOMM '80 Conference, Industrial and Scientific Conference Management Inc. (222 W. Adams St., Chicago, Ill. 60606), Palais des Expositions, Geneva, June 17–19.

Chicago Spring Conference on Consumer Electronics, IEEE, Arlington Park Hilton, Arlington Heights, Ill., June 18–19.

19th Annual Technical Symposium, Association for Computing Machinery (1133 Avenue of the Americas, New York, N. Y. 10036) and National Bureau of Standards, NBS, Gaithersburg, Md., June 19.

17th Design Automation Conference, IEEE Computer Society *et al.*, Radisson Hotel Downtown, Minneapolis, Minn., June 23–25

38th Annual Device Research Conference, IEEE *et al.*, Cornell University, Ithaca, N. Y., June 23–25.

11th International Quantum Electronics Conference 1980, IEEE *et al.*, Sheraton-Boston Hotel, Boston, June 23–26.

Conference on Precision Electromagnetic Measurements—CPEM 1980, IEEE and Physikalisch-Technische Bundesanstalt, Stadthalle, Braunschweig, West Germany, June 23–27.

IBI World Conference on Transborder Data Flow Policies, Intergovernmental Bureau for Informatics (P. O. Box 10253, 00144 Rome, Italy), Auditorium della Tecnica, EUR, Rome, June 23–27.

34th Annual Convention, Armed Forces Communications and Electronics Association (5205 Leesburg Pike, Suite 300, Falls Church, Va. 22041), Sheraton Washington Hotel, Washington, D. C., June 24–26.

Electronic Materials Conference '80, Metallurgical Society of TMS-AIME (Box 430, 420 Commonwealth Dr., Warrendale, Pa. 15086), Cornell University, Ithaca, N. Y., June 24–27.

Third International Conference on Hot Carriers in Semiconductors, Université des Sciences et Techniques du Languedoc (Centre d'Etudes d'Electronique des Solides, 34060 Montpellier, France), Montpellier, July 7–10.

Siggraph '80—Seventh Annual Conference on Computer Graphics and Interactive Techniques, Association for Computing Machinery (Siggraph '80, P. O. Box 88203, Seattle, Wash. 98188), Olympic and Park Hilton hotels, Seattle, July 14–18

Annual Conference on Nuclear and Space Radiation Effects, IEEE *et al.*, Cornell University, Ithaca, N. Y., July 15–18

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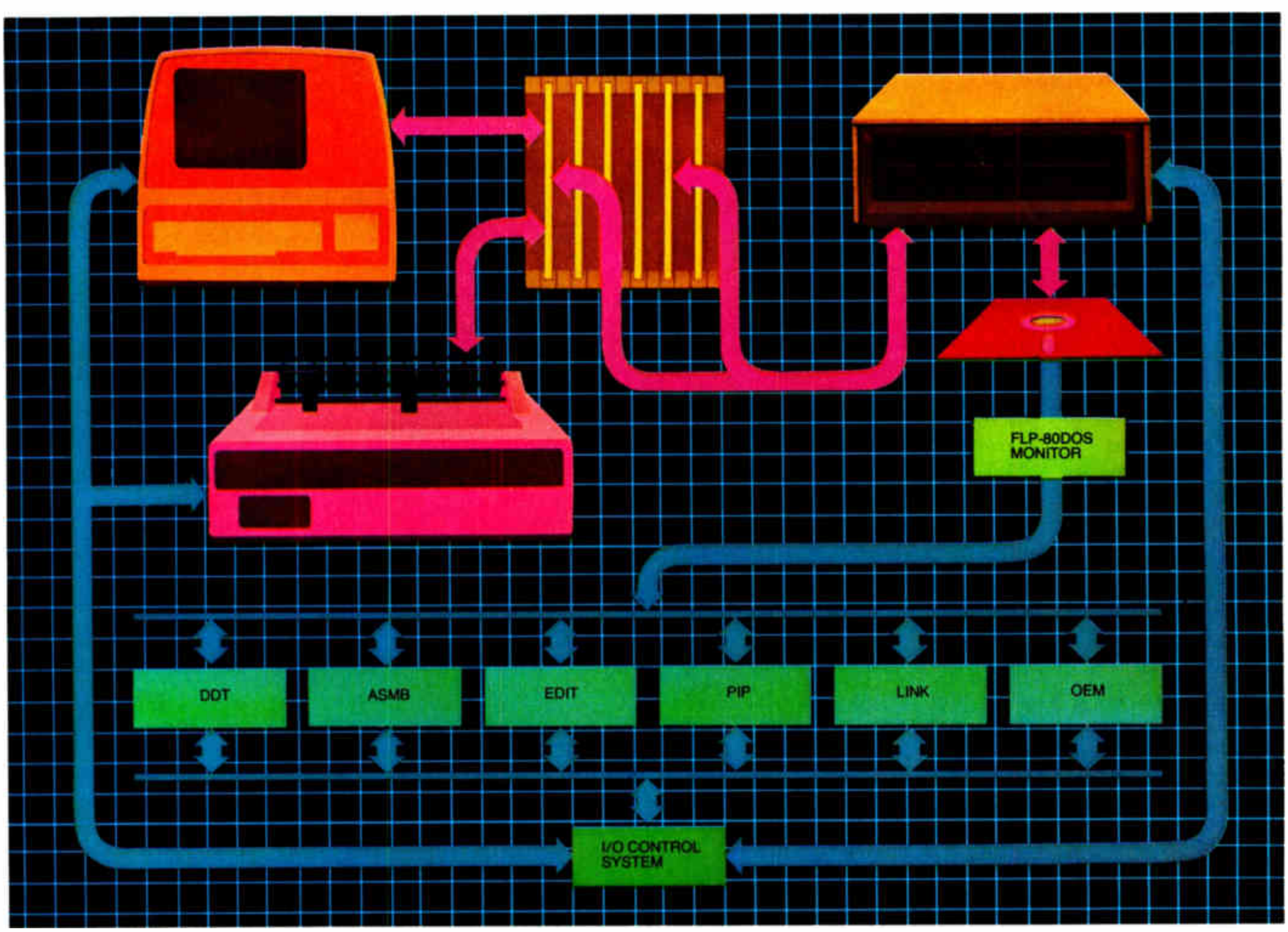

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Electronics newsletter

12-bit converter from Harris offers absolute accuracy

Harris Semiconductor Products division of Melbourne, Fla., has developed a hybrid (actually only three monolithic chips on one substrate) 12-bit analog-to-digital converter with absolute accuracy to the 12-bit level over the entire military operating temperature range of $-55°$ to $+125°C$. The unit is housed in a 40-pin ceramic dual in-line package and is slated for introduction this year. The converter achieves an accuracy of $\pm\frac{1}{2}$ least significant bit over the military range **thanks to a quantizing a-d conversion scheme.** It reportedly converts in 30 μs and includes an advanced microprocessor interface and a sample-and-hold amplifier. At the same time, Harris has developed a leadless chip-carrier technology that puts an entire 12-bit data-acquisition system in two DIPs (see p. 40).

LCD construction technique yields 50-μs response

American Liquid Xtal Chemical Corp., Kent, Ohio, has come up with a liquid-crystal-display construction method that allows the material to respond to modulating signals extremely fast—in under 50 μs. A nematic liquid-crystal cell is made 2 to 3 mils thick (conventional thicknesses are 0.25 to 0.5 mil). A fixed-voltage bias is applied to the display, and a modulating signal, superimposed on the bias potential, **causes what the company calls a surface-mode effect**—only liquid crystal at the display's surface is switched, with the bulk of the material held motionless.

According to its inventor, James Ferguson, president of the company and holder of patents on dynamic-scattering LCDs, this type of behavior has applications in high-speed displays, as in TV sets, where images must be produced at a rate that does not distort moving objects or graphics. Other applications include pulse modulation for control circuitry and simple voice-transmission circuits.

Matsushita readies $800 home computer

Look for Matsushita Electric Industrial Co. to introduce a low-cost portable home computer, possibly in time for the upcoming Summer Consumer Electronics show in Chicago. The Japanese parent of Quasar and Panasonic is mum about the product, but industry observers expect the price to be around $800. The memory size of the standard machine could be 64 kilobytes and, if so, **would place the home computer way ahead of anything in that price range.** An alphabetically ordered keyboard, more convenient for nontypers, will be used instead of the conventional typewriter layout.

Survey sees emerging market for medical minis

According to a survey by Creative Strategies International, the San Jose, Calif., market analyst, a new market is emerging for turnkey medical information systems built around low-cost minicomputers. **The company projects compound annual increases in revenue of 37.2% from the sale of minicomputers to medical groups and 33% to nursing homes.** Revenues from sales to those respective markets in 1979 were $35 million and $9 million. Cost-performance improvements in minicomputers over the last few years make it possible to provide a full range of information services to independent physicians, dentists, clinics, medical groups, nursing homes, and other health care facilities. These new clients cannot afford traditional mainframe systems and were limited to the simple services offered by timesharing services, says the survey, which also spots a potential market in veterinary medicine.

Electronics newsletter

New hearings bid for Van Deerlin bill picks up backers

A roster of blue-chip computer and communications companies is known to be considering joining Harold E. O'Kelley's crusade to form an *ad hoc* lobbying committee to force Congress to open new hearings on the proposed rewrite of the Communications Act of 1934. **The list includes Basic-Four, Harris, Hazeltine, Hewlett-Packard, IBM, Pertec, Sperry Univac, and Texas Instruments.** They were among some 30 companies whose representatives attended a planning meeting held at the National Computer Conference in Anaheim, Calif. O'Kelley, president and chief executive officer of Datapoint Corp. of San Antonio, Texas, is concerned that since the 1978 hearings, the proposed rewrite by Rep. Charles Van Deerlin (D., Calif.) has been changed substantially in both House and Senate versions [*Electronics*, May 22, p. 64]

The view in Washington is that the committee will not obtain hearings in the current congressional session, but that its activities could serve to slow or halt the bill's passage. Congressional observers also point out that by delaying action on the bill until the next session the lobbyists on both sides will have a chance to regroup and face a new cast of Congressmen.

NOAA forecasts magnetic superstorms causing blackouts

A new class of "super magnetic storms" will probably strike earth in the next few years, **causing unprecedented disruptions in power transmissions and operations of computers and telecommunications,** predicts a National Oceanic and Atmospheric Administration scientist. Howard Sargent of NOAA's Space Environment Services Center, Boulder, Colo., says superstorms, which set up currents in power lines causing overloads and cutoffs of power, tend to occur after the peak in the sun's 11-year sunspot cycle. They are especially likely in odd-numbered, active cycles, he says. The sun is now just past the peak of a particularly spotty cycle, Cycle 21. Evidence shows that a series of August 1972 storms, which ranked 220 on an index where a major storm rates 100, could be "weaklings" in comparison.

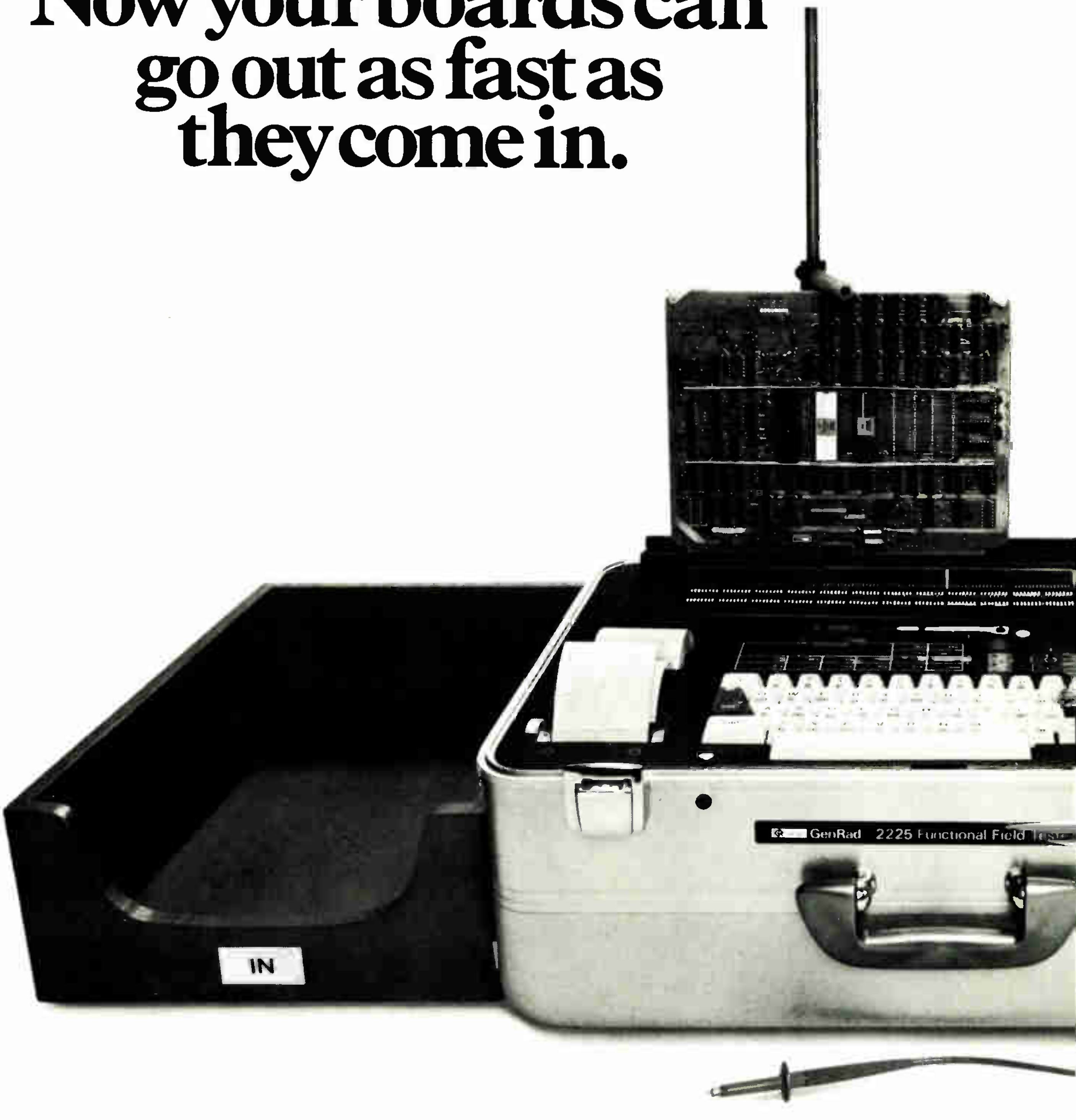
New company ready to show office products

Syntrex Inc. of Piscataway, N. J., the word-processing company recently formed by the founders of Interdata, will introduce three new products this month. Aimed at the office of the present, **the two system-level products offer redundant microprocessors and bus structures** for added reliability and maintainability. The lower-end, stand-alone work station will interface with a standard IBM electronic typewriter, to provide a fully configured word processor for under $10,000.

Addenda

Revealing plans for Control Data Corp.'s new top-of-the-line Cyber 205 mainframe, computer company president Robert Price says the Minneapolis firm is **also working on optical or video disk products for data storage.** The Cyber 205 will offer two to eight times the power of CDC's current flagship systems. . . . Apple Computer Inc. plans to begin manufacturing personal computers soon in a new Carrollton, Texas, plant. **It will be Apple's first manufacturing activity outside its Cupertino, Calif., headquarters.** . . . Microwave oven makers do not expect the torrid pace of sales to continue for the rest of the year. Tight credit has produced a somewhat contradictory trend: sales were up in 1980's first quarter compared with a year earlier, but **many customers bought the less expensive mechanically operated models** ($300 or less) rather than lay out $450 or more for those with digital controls.

GenRad's Automatic Functional Field Tester. Now your boards can go out as fast as they come in.



At last, sophisticated board testing has come to the field. With GenRad's 2225 Automatic Functional Field Tester.

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With the 2225, your technicians can diagnose and repair boards far faster than with conventional field equipment. Which means you can utilize your highly skilled people more efficiently.

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In fact, by using the 2225 in all field depots, your company can save literally millions of dollars. Because the 2225 can practically eliminate the three-month board repair pipeline that ties up as much as 10% of your company's gross sales.

Just send the coupon, attached to your business card or letterhead, and get the full story on GenRad's 2225 Automatic Functional Field Tester.

And find how fast you can make a bad board good.

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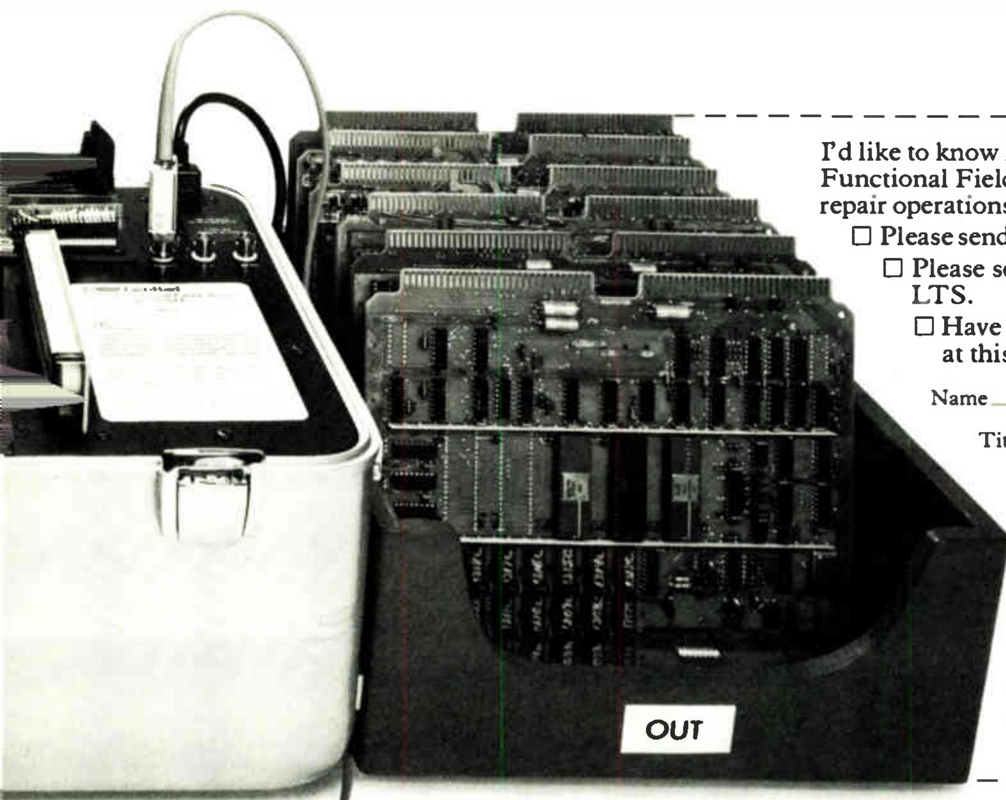
For high-volume service depots, GenRad offers the 2225 compatible Omnicomp Logic Test System.



I'd like to know how GenRad's 2225 Automatic Functional Field Tester can simplify my board repair operations.

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Gould's digital OS4000 stores event data for the life of the scope. Solid state memory lets the Gould OS4000 give you instant replay of stored event data for as long as you need it (while the unit is getting power). In addition to the event itself, the OS4000 uniquely stores and displays what happened before the event and after it. The OS4000 can then expand the event display so you can study it in slow motion detail. Plus, it also allows you to compare delayed and original sweeps. And, when needed, the OS4000 can perform as a real-time scope with a bright, stable, flicker-free display.

The Gould OS4000 is easy to operate whether it's being used as a digital storage or conventional oscilloscope, waveform recorder, transient recorder, comparator or signal generator. Interfaced with a recorder, the OS4000 can generate hard copy data from both ongoing events or 'replayed' displays.

For more information on the scope that out-remembers any tube storage scope on the market, contact Gould Inc., Instruments Division, 3631 Perkins Ave., Cleveland, Ohio 44114.

For brochure call toll-free: 800-331-1000 (in Oklahoma, call collect 918-664-8300).

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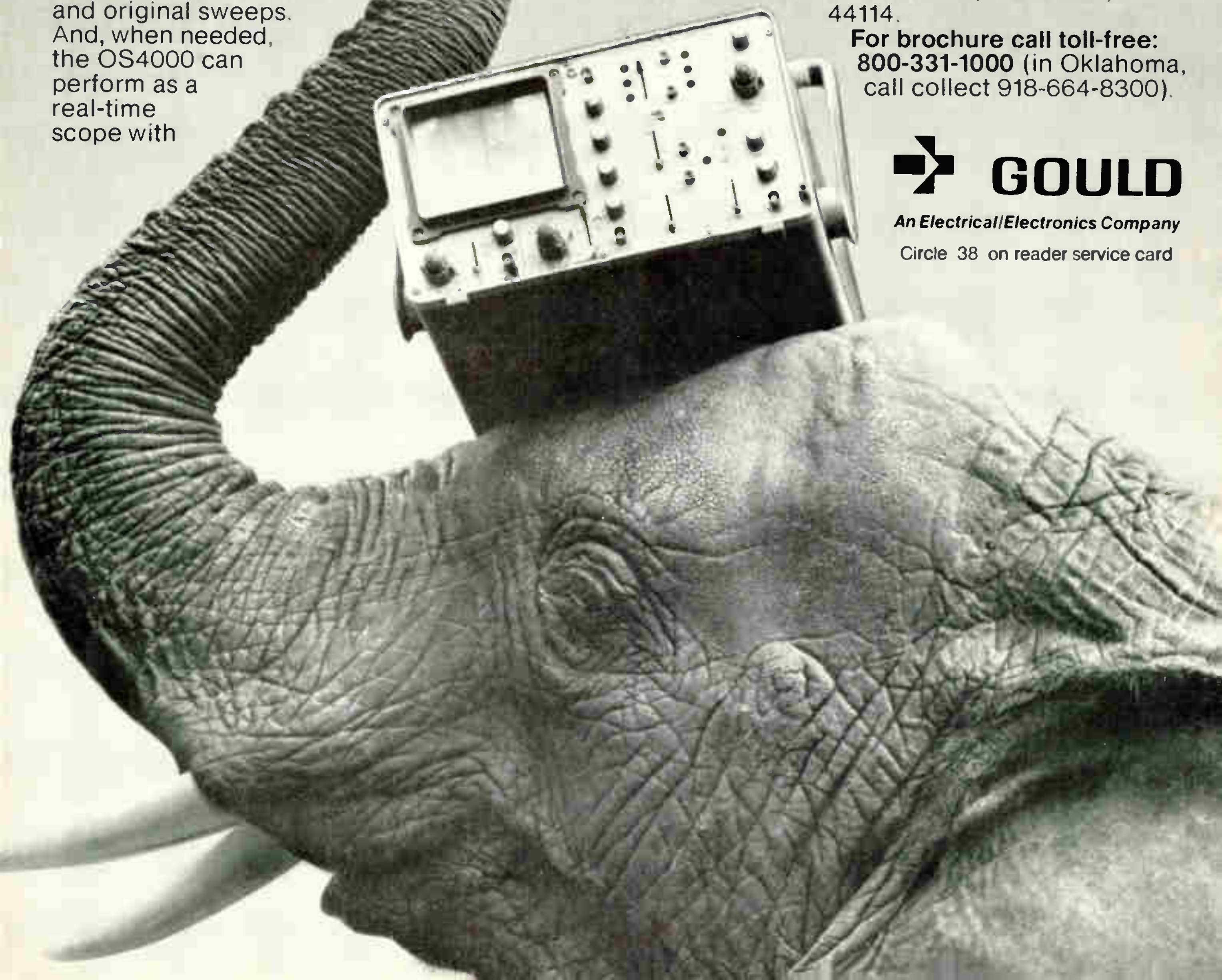
Circle 38 on reader service card



System for terminals creates 'keyboards' anyone can use

by Linda Lowe, Boston regional bureau

Hardware-software package is able to interface with almost any computer for ease of programming

Named for the Greek god who could change his form to match any occasion, Proteus is a hardware-software package that may make computer terminals every bit as flexible as its namesake. It eliminates the need for hard-keyboard inputs by users, generating instead specialized keyboards and displaying them on a cathode-ray-tube screen, where users can activate them using a touch-sensitive overlay panel.

Because the system's on-screen keyboards display only the inputs possible for any given step of an applications routine and can incorporate easily understood instructions and graphics, Proteus can prompt unskilled operators through even very complex routines.

Programmers, regardless of expertise, can use development versions of Proteus to create applications programs. Using an interactive editor, they can design specialized keyboards from symbols offered to them on screen by the character library.

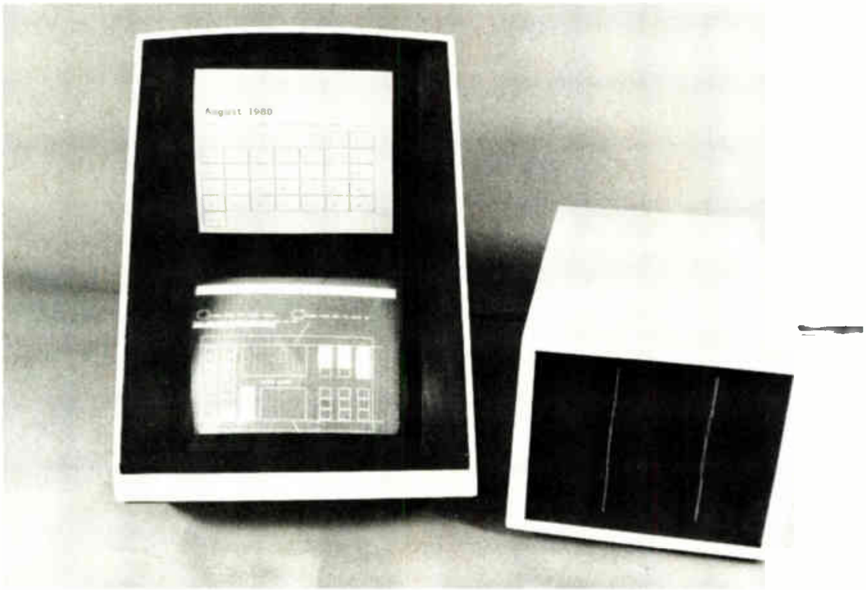
Unlike hard-keyboard symbols, usually encoded in 8-bit segments, Proteus characters have 16-bit codes, allowing programmers to choose from up to 64,000 characters for any individual application. Since each character may also vary in size, shape, color, and assigned meaning as required, the package's overall character-generating capability is enormous.

Programmers can arbitrarily assign any meaning to any symbol, making a character stand for a whole instruction set, subroutine, or program. Designing their own keyboards using such symbols, they can easily manipulate programs.

Many talents. Solid State Technology Inc. (SSTI), which developed Proteus under a patent-licensing agreement with the Massachusetts Institute of Technology, Cambridge, Mass., expects to have 11 prototype terminals operating within a month and plans to be in full production by late 1980, according to Leonard I. Hafetz, vice president of applications engineering at the Woburn, Mass., company. Proteus, he says, will be going after nearly every segment of the terminal market, at prices "competitive with those of conventional terminals."

Hafetz believes Proteus will be at home in most existing terminal applications, as well as opening up some new ones with its ease of use and adaptability. Several run-time prototype terminals will be installed shortly in a public library, where people can use them to access computer-based information on community services and educational activities. "When people can start coming in off the street and using a terminal, you're going to see computers used where they never have been before," Hafetz contends.

Popular language. SSTI provides a simple, Pascal-like programming language with the development version. The language, using no more than 15 or 20 statements, lets authors design an initial keyboard in about five minutes, according to Edward S. Harriman, senior systems



Seeing double. With the Proteus system it is possible to assign functions to an on-screen "keyboard" by choosing from up to 64,000 characters for any individual application.

engineer. Other source-program development tools from SSTI include a debugging package and the interactive editor, which the programmer can use to mix fonts, character sizes, and symbols on a line. Customers readying Proteus for specific applications create appropriate keyboards on the development version, Harriman explains; then run-time versions can access and run these either from diskette storage or directly from a host computer.

Proteus' software, written in the versatile and increasingly popular C language [*Electronics*, May 8, p. 129], "systematizes" in their most basic forms all inputs and outputs needed for any applications program. Through compilers or interpreters available in the industry today, it transmits input information to a host processor in machine code; a "software driver" residing in 16 kilobytes of either programmable read-only memory or floppy-disk memory transforms coded responses from the central processing unit into software steps that can be expressed by Proteus keyboard displays.

The ability to communicate in machine code means Proteus can support most systems' programs, whether they are in assembly language, Basic, Cobol, Fortran, or Pascal, says Hafetz. Further, he notes, Proteus' CP/M-compatible operating system makes it able to run any of the many CP/M-based applications programs.

Versatile. Proteus' developers demanded that all complementary hardware incorporate off-the-shelf components. The design is modular, using separate circuit boards for each function, so that the system can be upgraded by adding or exchanging boards and by plugging in peripheral devices. It can stand alone or operate without software modification in host-CPU, master-slave, or network configurations.

Proteus will offer up to 256 K of random-access memory and up to 32 K of programmable ROM; options include up to 4 megabytes of diskette storage or up to 20 megabytes on hard disks. Based on a Z80A microprocessor, the terminal can contain one or more CRT displays.

The system contains a high-resolution overlay switch capable of supporting an optional word-processing keyboard. Other options will include high-speed graphics, color graphics, character or graphics printers, and for systems employing only black and white video, up to eight levels of gray scale.

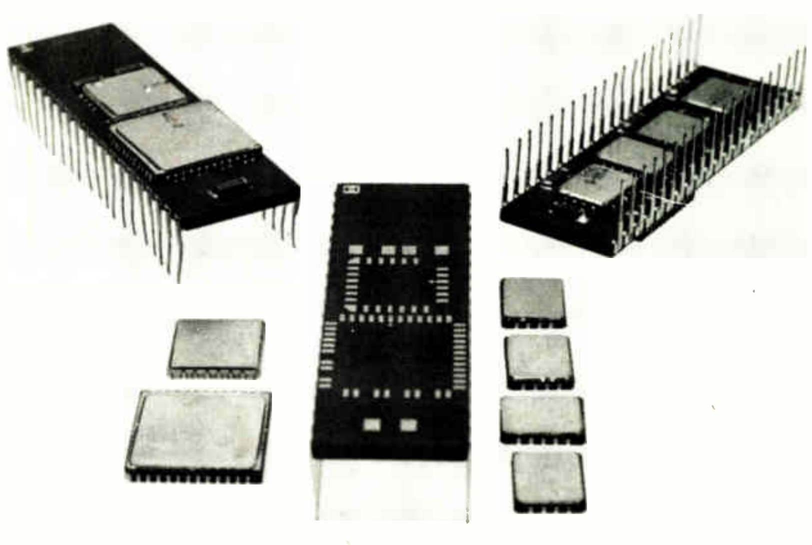
Packaging & production

Packages-within-a-package technique embraces data-acquisition system

Harris Semiconductor Products division has perfected a layout and interconnection scheme that promises to expand the availability of complex integrated circuits in packaged ceramic chip-carriers. The Melbourne, Fla., group has unveiled a complete 12-bit, eight-channel differential data-acquisition system in two dual in-line packages. The DIPs hold several leadless-chip-carrier (LCC) subsystem components, on both sides of the ceramic mother substrates.

The LCC concept, pioneered by the 3M Co., St. Paul, Minn., about a decade ago, has not until now been extensively applied to commercially available ICs except for some single-function devices like memories. In the LCC approach, a chip is die-bonded to interconnections on the chip-carrier. The carrier, which has connecting solder pads wrapped around its outer sides, is reflow-soldered to the mother substrate. Besides space-saving advantages, the Harris scheme of complex LCC packages offers the ease of IC reworking (just reheat the solder and replace the chip and the carrier it is on) and allows individual testing before the chip carriers are mounted onto a substrate, thus increasing yields.

Grounds. In developing the multilayer substrate, Harris paid careful attention to the interconnection scheme's layout to minimize ground-loop problems, according to Dick Ti Tung, Harris's supervisor of design engineering for hybrid and board products. Now that it has solved this problem, Harris is working on integrating the two-part data-acquisition system into one DIP, which could one day include a sensor and a microprocessor, according to L. E. Enriquez,



Complex. Multilayer interconnection makes possible a complete 12-bit a-d converter on a DIP ceramic substrate. The converter has a companion signal processor in another DIP.

product line manager for hybrid and board products.

The two new DIPs are the five-layer 32-pin HI-5900 analog signal processor and the seven-layer 40-pin HI-5712 12-bit a-d converter. The 5900 is the front end of the data-acquisition system and includes the multiplexer, a software-programmable gain amplifier (gains of 1, 2, 4, and 8), and a sample-and-hold amplifier. The 5712 includes an 8-microsecond successive-approximation analog-to-digital converter, a 10-volt reference, an internal clock, three-state outputs, and necessary signal lines to interface with 8, 12, or 16-bit microprocessors. Both parts are rated for operation over the military temperature range of −55°C to +125°C and will also be offered in commercial 0°-to-70°C grades.

"The mix-and-match approach of the LCC concept lets us economically select the best subsystem parts for a circuit," Enriquez says.

While declining to be specific, Enriquez said that the HI-5900 signal processor will first be priced at about $100 for the commercial-grade part (100-piece quantities) and at about $175 to $200 for the commercial-grade HI-5712 a-d converter, though he expects prices to be halved within 18 months.

Military and aerospace markets will be the first to be tackled, with process control, instrumentation, and computer peripherals to follow later on. -Roger Allan

A line on the printers

Keeping up with the new computers and terminals, several companies unveiled new printer technologies at the NCC. A prominent entry was General Electric Co.'s prototype of its Terminet 8000 nonimpact printer. Developed at the firm's Data Communications Products Business Department, Waynesboro, Va., the printer uses a magnetic-tape imaging mechanism to produce up to 8,000 lines per minute.

This mechanism is an electromagnetic write head that creates a pattern on a magnetic belt—essentially a wide piece of Mylar magnetic recording tape. The pattern on the tape then attracts magnetized toner (much the way a magnet attracts iron filings), which is then transferred to the paper to print the image. This technology is similar to that being developed by CII-Honeywell Bull in France, among others. GE will not say what the pricing is since the production version of this unit will not be available until late next year, according to a GE spokesman.

Also testing the waters with a prototype was Okidata Corp., Mount Laurel, N. J. It hopes its dot-matrix printer has high enough quality for the output of word-processing systems, yet could be priced, in quantity, at less than $1,000. Dot-matrix technology is generally not good enough for such systems, but Okidata's parent company in Japan, Oki Electric Ltd., has developed a 24-pin print head that produces much denser arrays of dots than conventional printers having 7 or 9 pins. Although a final product could be available after January, specifications for features like fonts, interfaces, and control of forms are still being determined.

To broaden its line of products compatible with the IBM 3270, Memorex Corp. of Santa Clara, Calif., has created the model 1300 matrix screen printer. It is a 100-character-per-second machine and is usable only with the Memorex 1377 display terminal. The printer can record directly from the display terminal without the necessity of intervention by the central processing unit or the terminal controller, thus reducing host-computer overhead. At $1,400, it is a low-cost plain-paper printer that can adapt to cut sheets, fan-folded stock, or rolled paper. Its print mechanism uses a seven-by-seven-dot matrix that will reproduce a 96-character set at 10 characters per inch for a line up to 80 characters long. **-A. D., M. M.**

NCC

Computer networks, terminals abound

With a cavalcade of computers and color terminals, a compendium of technical papers, and lots of commotion, the National Computer Conference met in California this past month in an overwhelmingly upbeat atmosphere. The record number of exhibits were jammed with over 80,800 attendees, topping last year's 79,400 mark and once again straining Anaheim Convention Center's facilities to the limit.

As always, the conference provided a backdrop for a number of product and technology announcements. Among the popular topics were the rapidly growing number of high-speed local data-communications networks (see p. 89), the proliferating color and graphics terminals [*Electronics*, May 22, 1980, p. 171], and some interesting new printer technologies (see "A line on the printers," above).

One of the few mainframe announcements at the show, however, was Sperry Univac's introduction of an array processor subsystem for use with its large-scale 1100/80 computers. The Blue Bell, Pa., division says the array processor can perform a maximum burst rate of 120 million floating-point operations per second. Selling for $950,000, the array processor is scheduled for first customer shipments in the first quarter of 1981.

Colorful show. Color terminals were prevalent throughout the show, reflecting the current industry trend towards those more eye-appealing displays. [*Electronics*, April 10, 1980, p. 135]. Adding to the lineup was Panasonic's CRT Display group, Secaucus, N. J., which introduced two 13-inch color monitors, as well as 15- and 19-inch models. All four feature a delta red-green-blue high-resolution tube made by parent company Matsushita Electric Industrial Corp., Osaka, Japan.

As part of a continuing trend toward making software easier to generate, Point 4 Data Corp. of Irvine, Calif. [formerly Educational Data Systems Inc.], has come up with the Force automatic programming system. Force is an interpreter-based program that requires the presence of Point 4's business Basic and runs on the ISIS operating system, used by Data General's Nova-compatible computers. The program, which comes in four levels at prices from $400 a month to $1,500 a month, establishes a data dictionary of screen formats and files that can be reused in the creation of new programs. Force is among the first of the automatic code-generation systems, which also include the "no code" program developed by General Automation Inc. of Anaheim, Calif., the software synthesizer developed by Scientific Enterprises Inc. of Portland, Ore., and a Cobol-based system under development by Data General.

More software. Another aid to software development is also capable of hardware emulation. Zilog's ZSCAN 8000 is a self-contained analyzer/emulator for the Z8000 family that can be used either as a stand-alone module or as a front-end peripheral to a development system. Priced at $4,500, it contains two RS-232-C ports that allow the module to be placed in a serial data path between the developer's host computer and a cathode-ray-tube console. As such, it can allow the user to bypass a development system altogether by using the host computer for software development and the 8000 unit for hardware emulation. The 8000 is capable of emulating either the Z8001 or Z8002 microprocessors, and its development probably represents the first announcement by a semiconductor manufacturer of a stand-alone emulator. Other stand-alone emulators previously announced for this market include the E-H International model 800, and Millennium Systems' microsystem analyzer.

In the small-business computer area, Dynabyte Inc. of Menlo Park, Calif., announced a multiple independent processor that plugs into its 5000 series of microcomputer systems. The processor, for which a price has yet to be determined and for which deliveries will begin this fall, includes both a Z80 and an 8086 microprocessor. The latter is augmented by an 8087 floating-point math-processing integrated circuit.

In the peripherals area, a new company, Data Master Inc. of Camarillo, Calif., has come up with a way to make floppy disks less floppy and to double their capacity in the process. The company's first products, Megamasters 2 and 4, rely upon a unique disk-centering retractable-pin mechanism that levers the diskette onto the drive's hub as an auto mechanic levers a tire onto a wheel. The result, claims company president Ko Ko Gyi, is "a metal-to-metal disk clamp and self-centering spindle that provides unprecedented accuracy in securing the diskette within the drive."

Using this concept, Data Master has developed a two-diskette drive that fits into a packaging space normally reserved for one 5¼-in. floppy-disk drive. In the Megamaster 4, four read/write heads, one per surface, are powered by the same drive to achieve a 2-megabyte total capacity. The Megamaster 2 has two read/write heads to handle a halved, 1-megabyte capacity.

Although delivery of both units is scheduled for the first quarter of 1981, only the Megamaster 2 has been priced. It sells for under $700 in sample quantities and $550 each in lots of 1,000 or more, according to the company.

Also among the peripheral products of note were the 8-in. Winchester disk drives that created so much interest a year ago. A new entry into this arena was Hitachi America Ltd., San Francisco, which unveiled its DK801 drive. Available in both 6.9- and 13.9-megabyte versions, the unit has an average access time of 70 milliseconds and uses a recording density of 7,300 bits/in, the Japanese supplier reports.

The momentum apparent among the industry's vendors this year is already spilling over into the coming year. Exhibitors have reserved all of the 1,900 booths—some 250 more than were occupied this year—that will be available at next year's NCC to be held May 4–7 at McCormick Place in Chicago.

-Anthony Durniak, Martin Marshall

Speech synthesis

Unlimited vocabulary fits on OEM boards and integrates into computer systems . . .

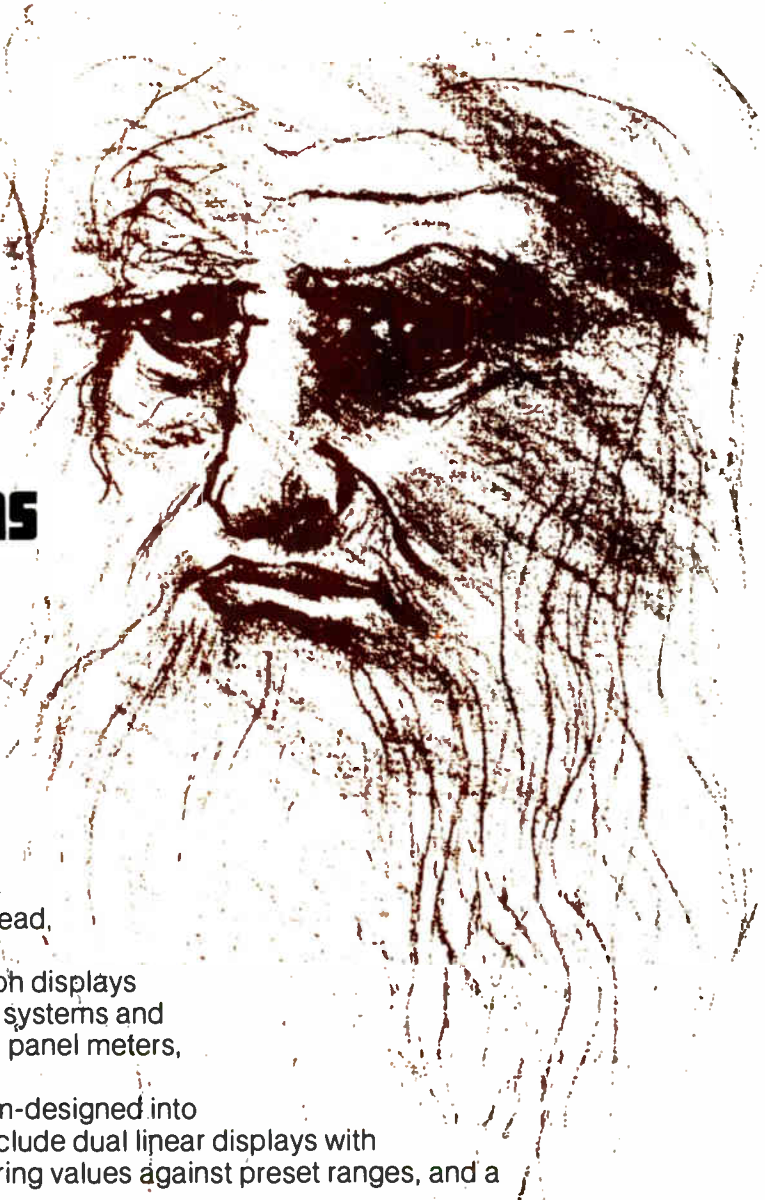
A leader in developing speech-synthesis products designed for the blind, Kurzweil Computer Products Co. plans to market its new Kurzweil Talking Terminal (KTT) to original-equipment manufacturers. The unlimited-vocabulary KTT, which converts ASCII- or EBCDIC-encoded text into full-word speech, acts as a speech-output device for either computers or terminals.

The Cambridge, Mass., company plans to deliver prototypes this month and to begin regular deliveries by early 1981, according to Stephen D. Pelletier, director of speech research and development. The firm will offer the KTT in two forms. To OEMs, it will sell a pair of circuit boards that can be integrated into systems for process control, telephone access to data bases, and similar applications. For blind programmers and computer operators, it will sell a suitcase-sized, 15-pound module with keypad and other controls. If there is enough demand, the OEM version could be integrated into a single board. Pricing is still uncertain, but Pelletier estimates that the board set will sell for $1,500 to $2,000 and the module for $4,000 to $5,000.

Phoneme-able. Pelletier expects no competition between the KTT and other speech-synthesis chips entering commercial markets [*Electronics*, March 27, p. 39; April 24, p. 42] "We're going into areas where the large number and variety of spoken messages require unlimited-vocabulary operation," he reveals.

One of the OEM boards is Kurzweil's proprietary speech synthesiz-

If Leonardo da Vinci designed a visual indicator today... he'd use a Burroughs SELF-SCAN® bar graph display



Leonardo da Vinci would have considered Burroughs SELF-SCAN bar graph displays a designer's dream. These compact, flat panel, gas plasma indicators present instant analog displays with digital accuracy. They're bright and easy-to-read, even in high ambient light.

Hundreds of thousands of SELF-SCAN bar graph displays are currently in use worldwide for process control systems and instrumentation, automotive and aircraft displays, panel meters, and many other diverse applications.

Versatile SELF-SCAN bar graphs can be custom-designed into practically any configuration. Standard models include dual linear displays with 1/2% or 1% scales, a dual reset display for measuring values against preset ranges, and a 120 element circular display.

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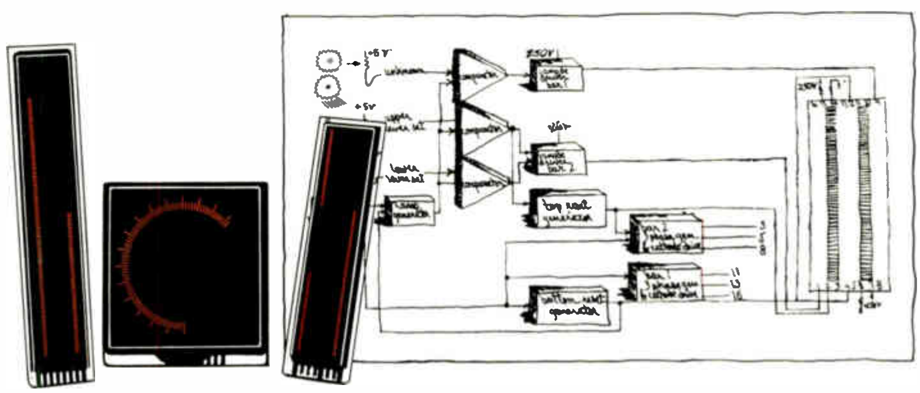


Burroughs

Circle #42 for General Information

Circle #43 for Detailed Specifications

er, the same unit found in its Reading Machine [*Electronics*, May 22, p. 99]. Using computerized analog synthesis and very complex software stored in programmable read-only memory, it identifies the thousands of possible interphoneme relationships that make up speech and directs the speech-synthesizing circuitry to generate appropriate audio frequencies, timings, inflections, and stresses as it strings phonemes together to form continuous speech.

The second board contains the KTT's 8-bit, Z80 microprocessor controller, 64 kilobytes of memory, digital interfaces, and code-conversion circuitry. An 8,000-character buffer memory retains the equivalent of three standard cathode-ray-tube displays.

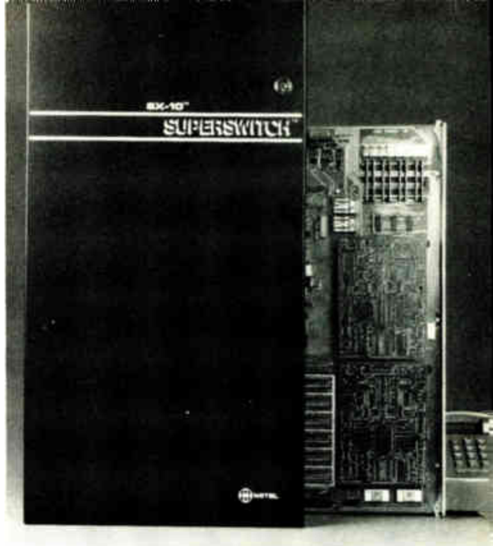
Interfaces. Customized PROM firmware interfaces make possible specialized "dictionaries," suiting the KTT to applications that require unusual character sequences, technical terms, and the like. These interfaces also allow the KTT to be queried via a 12-key keypad. The user can get "speak-outs" of screen contents line by line, word by word, or character by character and can direct the terminal to back up, repeat lines, or even spell out words that might otherwise be unclear.

The KTT package connects to data-processing equipment through either RS-232 lines or 20-milliampere current-loop bidirectional serial interfaces. Users can select 11 transmitting and receiving rates ranging from 110 to 9,600 bauds, Kurzweil says. **-Linda Lowe**

. . . while PBX enters talking

Mitel Corp., Ottawa, Canada, has jumped on the speech-synthesis bandwagon with a new private branch exchange, SX-10, that talks.

Built around speech-synthesis integrated circuits produced in house, the SX-10 is the latest in the firm's series of Superswitches designed to penetrate the existing key system market of 4 million systems in the U. S. and Canada. According to Mitel president Michael Cowpland, the system will also be marketed in Europe, Australia, and New Zealand, with the principal targets small and medium-sized businesses.



Phone talker. Mitel's SX-10 private branch exchange features a 50-word-vocabulary voice-synthesis board built around components produced by the company.

At present the voice synthesizer in the "Talking 10," as it is also called, uses the waveform digitization technique. In Mitel's approach the necessary bits of digital information are stored in two erasable programmable read-only memories mounted on a single control board and then are converted into analog voice signals when necessary.

Messages. The E-PROMs in use are prototypes. Production versions may well use another synthesis technique and may be produced by Mitel or purchased from chip suppliers. The advantage of the synthesis board is that it replaces with voice messages the more expensive key-set buttons used to find free lines. As it is at present, the board has less than a 50-word vocabulary.

The basic $3,000 SX-10 can interface with eight internal handsets, as well as provide four external functions on trunk lines such as alarm, intercom, and paging systems. With an additional printed-circuit board, the basic unit's capacity is doubled at a cost increase of 50% to 70%. Customers requiring more than 16 internal numbers would need additional units.

Ease of programming is a key feature in this system. Comments Patrick Beirne, Mitel's senior research and development engineer, "We're trying to do to the telephone what was done to calculators three years

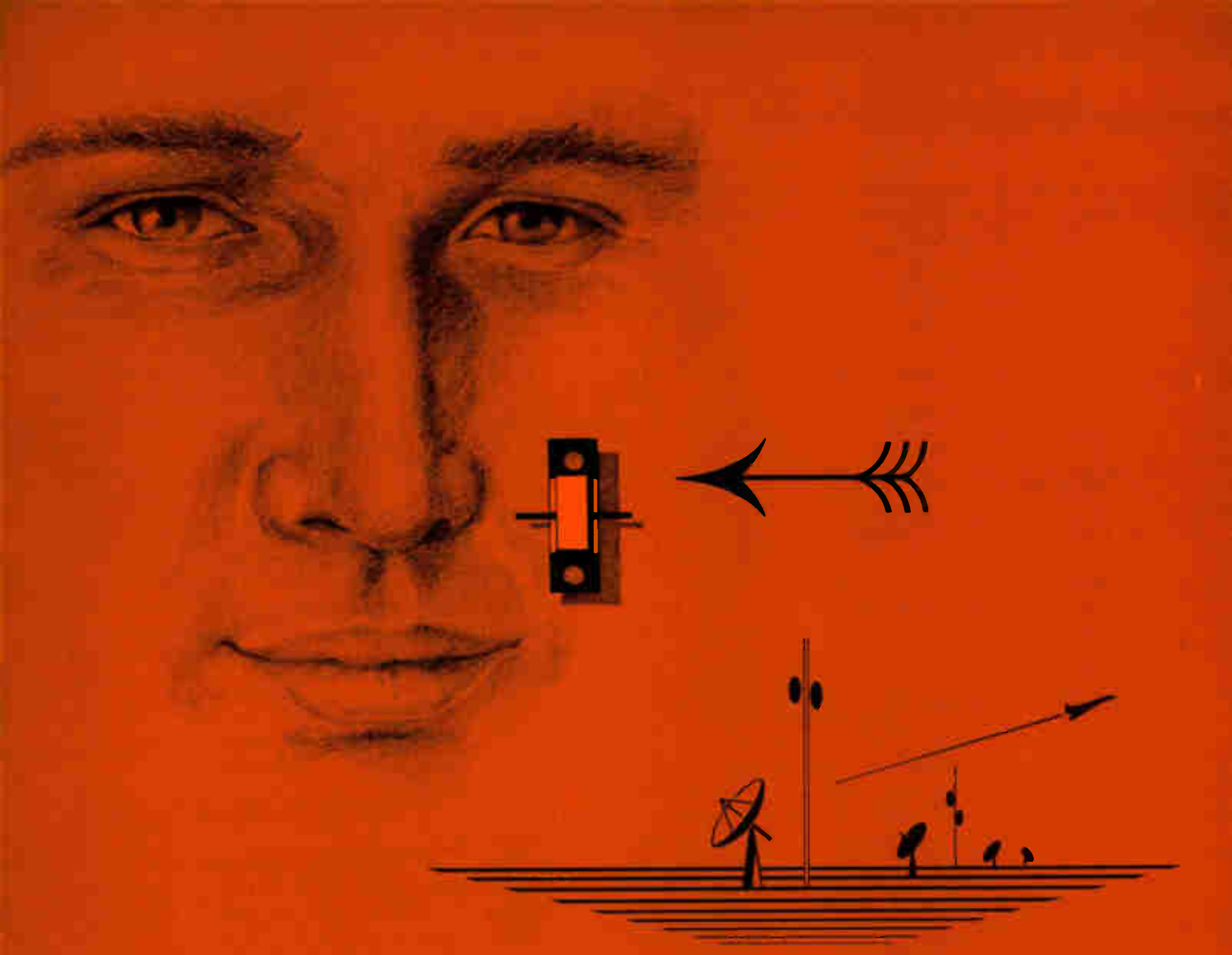
Meanwhile, on the recognition front . . .

A pioneer in voice recognition equipment, Threshold Technology Inc., is gearing up to put its isolated-word data-entry system on a chip set.

Earlier this year, the Delran, N. J., firm acquired Auricle Inc., an IC design house in Santa Clara County, Calif. Working with Auricle, Threshold has been putting some of its systems features into IC form and will be announcing an agreement later this month with a semiconductor manufacturer to make these devices. Full production should start within the next 12 to 18 months.

A Threshold 600 voice data-entry system, using the company's Quik Talk algorithm, recognizes isolated words at a rate of 180 to 200 words per minute with an accuracy of 99%. The typical price for such a system ranges from $7,500 to $75,000, notes Marvin B. Hercher, executive vice president. In comparison, the chip set with either three or four ICs will have a 20-word vocabulary and sell for about $20. A board-level product will also be available with a 50-word vocabulary and price tag of under $1,000. A printed-circuit board or stripped-down terminal unit with a larger vocabulary will sell for under $2,000.

Central to Threshold's design is a feature extractor that is used to develop spectral derivative features showing the overall spectrum shape of the incoming word. Threshold has developed and patented a device it calls an analog threshold logic element (ATLE). Herscher compares these devices to artificial neurons operating under excitory and inhibitory pulses. "The ATLEs are similar to operational amplifiers except for a discontinuity step that gives the user noise immunity. The output from the ATLEs makes it possible for the user to do Boolean logic operations," he explains. (For a related story see page 93.) **-Pamela Hamilton**



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Circle 45 on reader service card

ago. For example, the SX-10 offers more than 100 features and requires less than an hour to program."

The company expects to get Federal Communications Commission approval of the PBX by July 31. Up to 1,000 production models will be made by the end of the current fiscal year next Feb. 28. **-Ken Pole, McGraw-Hill World News**

Communications

Digital filter sets off Bell codec design

Bell Laboratories' n-channel MOS single-chip codec with filters, to be announced at the International Communications Conference in Seattle next week, contains a unique architecture that is a radical departure from convention. The 296-by-342-mil device is highly digital, has few analog components, and is designed for "high yield, economy, and ease of testing" while meeting the governing specification with "a comfortable margin," Bell says.

In the usual pulse-code-modulation encoding schemes for telephony, analog filtering is performed before analog-to-digital conversion to remove frequency components above the Nyquist frequency. For the standard 8-kilohertz sampling rate this means a rather sophisticated analog anti-aliasing filter. The decoder filter that removes images around integral multiples of 8 kHz is likewise a problem.

Faster converter. The Bell approach, according to researchers Toshio Misawa, J. Eric Iwersen, and Jacques Ruch of the Murray Hill, N. J., facility, reverses the signal processing order (see illustration). Key to this change is the replacement of the analog filter by a digital one. The higher data-sampling rate that is required to make this change is implemented in the analog-to-digital converter.

The necessary band limiting to ensure an 8-kHz sampling rate is performed digitally after the wideband analog-to-digital conversion. It is still necessary to provide an anti-aliasing filter but now this is a simple, noncritical device, easily designed and produced, the Bell researchers contend.

Because it can be readily adapted to the silicon-gate n-MOS technology that Bell chose for its codec and because its concept is ideal for making a codec that is mostly digital in nature, a delta-sigma modulator was Bell's choice for the a-d conversion function. According to Misawa, similar modulators have been designed before, as part of multichip bipolar codecs, but they lacked the performance that the new approach provides. In particular, he says the quantization noise of Bell's μ-255 law device is superior and all the necessary codec parts such as the anti-aliasing filter are on the chip.

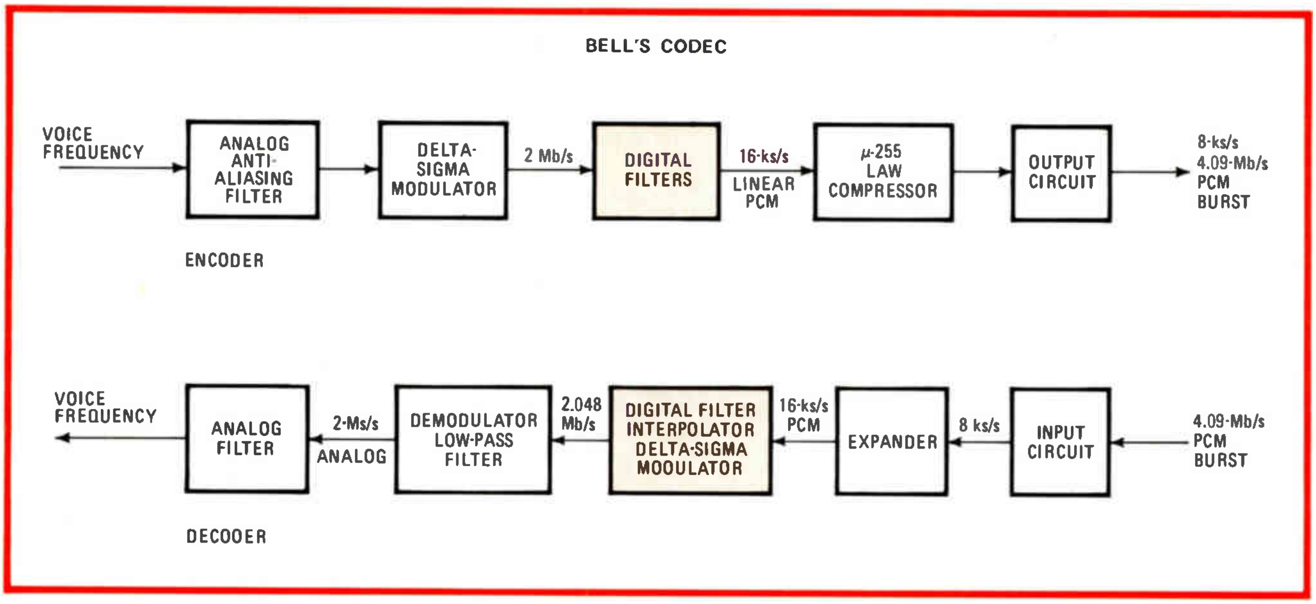
Do it once. The codec's design philosophy was based on the simple idea of designing a chip without precision components that would have a high yield as soon as possible, according to the Bell team.

The strategy was very successful. Idle-channel noise of 13 dBrnC and gain tracking to within ± 0.05 dB from +3 to −37 dBm and ± 0.1 dB between −37 and −50 dBm were achieved with the first design on all chips that worked. **-Harvey J. Hindin**

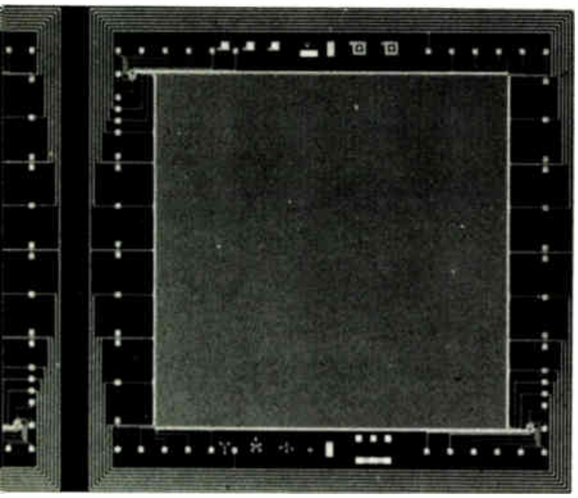
Solid state

Giant CCD imager boasts 640,000 pixels

Spacecraft astronomy is lifting the state of the art in charge-coupled devices to new heights. To meet the needs of the National Aeronautics and Space Administration's space telescope satellite, Texas Instru-



A digital delight. In the encoder a delta-sigma modulator performs linear analog-to-digital conversion at 2.048 megasamples per second. This high sampling rate allows a simple analog anti-aliasing filter. The modulator output goes through successive digital signal processing.



Big chip. These 640,000-pixel CCD imaging chips, 700 mils on a side, have been developed by Texas Instruments for cameras in NASA's forthcoming space telescope.

ments Inc. has devised a CCD chip 700 mils on a side with a spectral range 150% that of the typical CCD imager. Moreover, it fits into a specially designed package that enables it to withstand temperatures as low as -100°C.

The CCD array in the big chip gives 640,000 picture elements—800 by 800 pixels. For next-generation portable color TV cameras, Japanese manufacturers are working on chips with formats that are less than a third that size [*Electronics*, Feb. 14, p. 143]. TI has begun delivery of 120 of the chips under contract to NASA and the Jet Propulsion Laboratory.

For each of two cameras in the space telescope, JPL will employ four of the new imagers, for a format of 1,600 by 1,600 pixels. For one camera, the goal is wide area coverage; for the other, it is high resolution, indicates Fred J. Vescelus, manager of JPL's Imaging Systems division at the California Institute of Technology in Pasadena.

Spectral range. An equally important goal was a spectral range that extends much further than the typical CCD imager to capture spectral emissions of faraway stars. TI's engineers used an organic phosphor coating applied to the rear surface of the chips to extend the spectral range down from 4,000 angstroms—where most MOS devices cut off—to 500 Å in the ultraviolet region.

The phosphor, known as coronene, absorbs photons in the UV frequencies and reemits them in the spectral region in which the CCD is sensitive. The upper spectral limit of the device is in the near-infrared band, at 11,000 Å, the same as for standard CCD chips.

TI fabricates its imagers with a three-level polysilicon-gate technology. To meet the low-noise, high-sensitivity requirements of space operation, the Dallas company employs a buried-channel design, which places the CCD wells as far as possible from surface noise, and on-chip signal amplifiers, Vescelus notes.

Package. Some of the exposure times for the space telescope's cameras will be about an hour. Such long imaging periods can be thwarted by the thermal currents generated naturally in silicon, because these dark currents could fill up the CCD wells with spurious electrons.

To overcome this, the CCD imagers will operate at −100°C, which requires a hermetically sealed 40-pin package largely fabricated from an iron-nickel alloy with a thermal expansion coefficient closely matching that of silicon. The matching coefficients prevent shattering of the imaging membrane—which is only 8 micrometers thick—as the temperature changes, explains Morley B. Blouke, manager of the JPL project at TI's central research laboratories.

The work for JPL began in 1973 with 100-by-160-pixel imagers—then the state of the art—and went through successively larger generations. A 1,000-by-1,000-pixel part using a virtual-phase CCD technology that TI recently developed may be next. -Wesley R. Iversen

Industrial

Radar saves sand on new locomotives

Nestled in the undercarriage of General Motors Corp.'s new Super Series 50 freight locomotive is a short-range, low-power digital radar for measuring speed. It is a key component in a new automatic control system that improves the locomotive's wheel-to-rail adhesion by 33%.

The standard way of controlling adhesion is to inject sand under the locomotive's wheels. Earlier models had to carry 58 cubic feet of the stuff. However, engineers at GM's Electro-Motive division, La Grange, Ill., found that operators tended to waste sand by using it at the first sign of slippage.

Operation. The new automatic system uses the radar to measure ground speed and adjusts the speed of the locomotive's four wheel-

It's consumer showtime

RCA Corp.'s final production version of its Selectavision video disk player (below) is one of the many new products that will be on display at the Electronic Industries Association's Consumer Electronics Show in Chicago starting June 15. Despite the recession, the EIA has booked almost 900 exhibitors and expects 60,000 attendees. -Gil Bassak

mounted traction motors to minimize slippage accordingly. When slippage becomes too great, sand is automatically injected. Thus EMD boosts minimum adhesion from 18% to 24%, uses a sixth the former load of sand, and reduces the maintenance necessary to counteract the effects of sand on the operating gear.

EMD built 23 prototypes of the new locomotive and put them through six months of field testing. The improvement in adhesion and reduction in deadweight improves performance, so that the diesel locomotives can pull additional weight, notes Henry H. Koci, assistant chief of engineering at EMD. The doppler radar was designed by the division, RCA Corp.'s David Sarnoff Laboratories, Princeton, N. J., and C. M. I. Inc., a small Minturn, Colo., designer and manufacturer of traffic-control radars and other electronic gear for police departments.

The radar is a digital doppler unit because only the doppler effect measures ground speed reliably, says Harry F. Quinn, chief of electrical control engineering at EMD. Wheel speed does not measure it reliably because of wheel slip.

The GM division went to two suppliers for the new system in order to avoid the single-source problem. Both C. M. I. and RCA capitalized on previous rather different development work.

In the C. M. I. version, a Gunn diode emits signals that are returned to a horn antenna with a 4-inch aperture. Because of the varied ground topography, the inputs vary from 0 to 31 hertz. A combination of automatic gain control and bandpass filters reduces this spectrum to three ranges, and a phase-locked loop converts them into a single signal rate of about 22 Hz per mile per hour. The signal-processing circuits generally employ complementary-MOS technology, says Jack D. Fritzlen, president and principal designer.

The RCA version, also with C-MOS signal processing, uses a printed-circuit antenna and a transferred-electron oscillator and corporate feed rather than a Gunn diode, according to Fred Sterzer, director

News briefs

TI reorganizes corporate ladder

Texas Instruments Inc. has made several changes among upper echelon management ranks, including the creation of a corporate-level marketing activity. Among those changes: Stewart Carrell, group vice president previously in charge of European semiconductor operations in Nice, France, has been assigned to the firm's Dallas headquarters, where he will take over corporate control activities from John M. Walker, senior vice president and treasurer; Walker will retire later this year. Replacing Carrell in Europe is Charles M. Clough, vice president previously in charge of U. S. bipolar operations in Dallas. The new corporate marketing operation, to be headed by group vice president Grant A. Dove, encompasses TI's Supply Co., which is the company's worldwide industrial distribution arm, as well as the marketing organ for TI's Europe and Asia Pacific divisions.

Philips gains ally for video disk

Score yet another one for the optical video disk player. Sanyo Electric Co. of Osaka signed a license agreement with NV Philips Gloeilampfabrieken of the Netherlands last month. Under the agreement, Sanyo will manufacture, use, and sell video disk players that meet the standard specifications of the Magnavision optical video disk system developed jointly by Philips and MCA Inc. [*Electronics*, Dec. 21, 1978, p. 33]. Magnavision players were first introduced in the U. S. in late 1978; nationwide marketing is expected by the end of 1980. Sanyo will be joining Sharp Corp., Trio-Kenwood, and Sony Corp. of Japan, as well as Grundig, in support of the Magnavision system.

TRS-80 computer will have phone access to data bases

Tandy Corp., Fort Worth, Texas, is taking orders from commercial accounts for fourth-quarter delivery of a device known as the TRS-80 Videotex that will allow phone-line access to computer data bases for TV screen display. Retailing initially at about $400, the Videotex employs a Motorola microprocessor, a video display chip, 4 kilobytes of memory, and a modem in a keyboard-equipped unit designed to attach to a user's phone jack and television antenna. Beginning this summer, Tandy also plans to sell the Videotex software separately through Radio Shack stores for under $30 for use in a variety of personal computers and dumb terminals.

GenRad acquires tester manufacturer

GenRad Inc., Concord, Mass, acquired Omnicomp Inc. in an exchange of stock, effective May 21. The Phoenix, Ariz., manufacturer of field service equipment now supplies the larger firm with the model 2225 field-service tester. The acquisition marks the return to GenRad of Omnicomp founder and president, Robert G. Fulkes, who was project leader on the industry's first commercial automated board tester at General Radio in the late 1960s.

Ampex will make memories for Control Data

Control Data Corp., Minneapolis, and Ampex Corp., Redwood City, Calif., have entered into a manufacturing license agreement under which Ampex will produce ferrite-core memories and memory products for CDC. Ampex will supply Control Data's internal requirements, support existing large-volume core-memory contracts and repair installed core-memory products.

Perkin Elmer adds power to transaction processing

Perkin Elmer's Computer Systems division, Oceanport, N. J., has beefed up its transaction-processing software offering. Reliance II can now handle up to 128 transaction-processing terminals and 64 software-development terminals for each 3220 or 3240 32-bit minicomputer. It will also support an interactive query system, IQ/32, allowing *ad hoc* queries of the data base. An enhanced Cobol compiler—offering 30% to 50% better performance than the previous one—and an RPG II compiler are part of the $12,500 software package. IQ/32 is offered as an option at $3,000.

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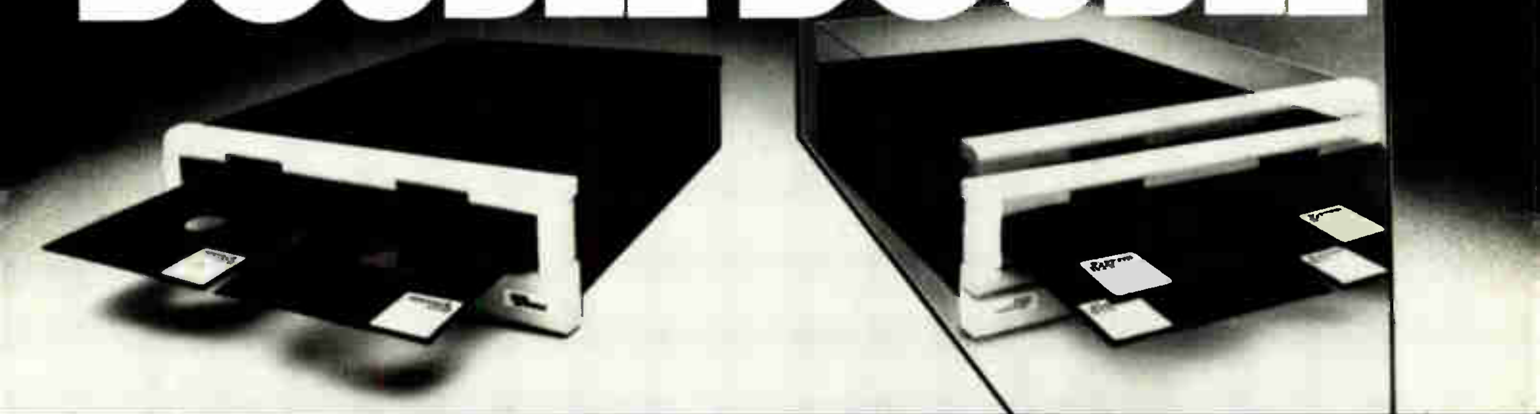

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Circle 51 on reader service card

Radar speedometer. This control module on a GM locomotive processes information from a radar to measure ground speed and adjusts motors to minimize slippage.

of the microwave technology center at RCA. This design derives from an earlier package RCA proposed as part of an automotive anti-skid system, whereas the C. M. I. unit is based its traffic-control radar.

For both systems, the power output is about 10 milliwatts, and power consumption is about 3 watts at 15 volts.

Part of the design challenge was the varied terrain traveled by locomotive. For example, to compensate for the lack of ground under a trestle, the PLL in the C. M. I. system can freeze the last signal for several seconds. If the system malfunctions, the locomotive operator can control the sand injection mechanism.

C. M. I. also will package the radar with control circuitry for retrofitting older locomotives to meet new Federal regulations requiring speedometers. For the next few years, Fritzlen expects to sell several thousand annually at $2,200 each in single-quantity orders, a far larger business than the annual sales of 200 to 300 he expects to be able to make to EMD. **-Larry Marion**

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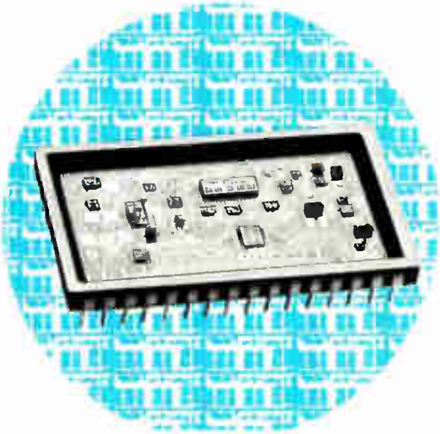

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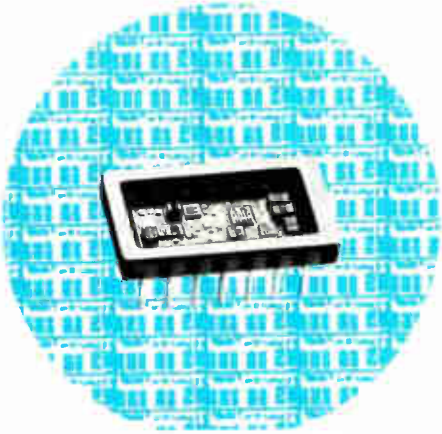

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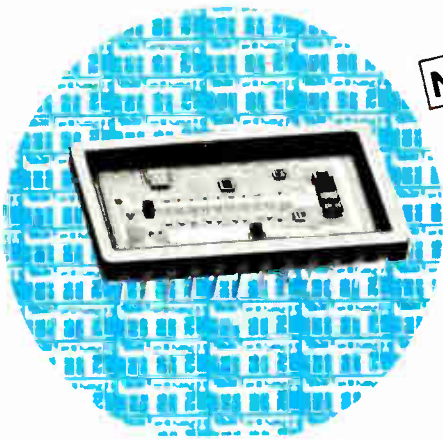

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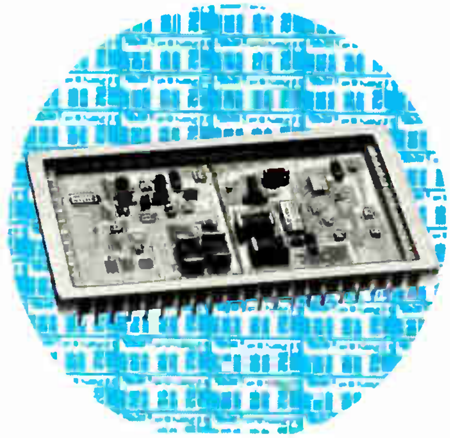

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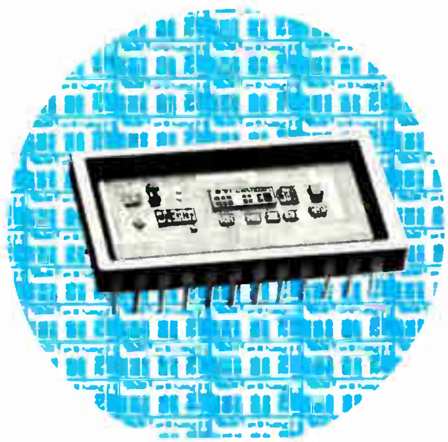

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Washington newsletter

Military avionics to go to China for its MIG fleet . . .

Shipments of American avionics bearing military nomenclatures to the Peoples' Republic of China are expected to begin late this summer as Peking moves anxiously to upgrade its inventory of close to 5,000 early-model MIG fighters, most of them MIG-6s. Competition to sell the new ultrahigh-frequency tactical air navigation, communications, and perhaps radar systems is keen among U. S. producers as negotiations continue among Defense Secretary Harold Brown, the State Department, and a Chinese delegation to the U. S. led by Vice Premier Geng Biao. **"The sales will be limited to avionics that have no application as weapons per se,"** says one U. S. official. However, he declines to specify if the AN/ARC-186(V) very-high-frequency a-m/fm multiband communications transceiver now being delivered to the Air Force by Rockwell International Corp.'s Collins Government Avionics division is on the list.

. . . as House report raises challenge to nonweapons sales

But Carter Administration initiatives to bolster military ties with China through sales of nonweapons like air and ground telecommunications and tracking systems face "serious reservations" in Congress, according to a new House Foreign Affairs Committee report. Written by Rep. Lester Wolff (D., N. Y.), who headed a congressional delegation to eight Asian nations in January, the report disagrees with the White House assertion that Washington and Peking have "many parallel strategic and bilateral interests" beyond containing Soviet expansionism. Recalling China's invasion of Vietnam, **the Wolff report questions whether "the strategic and bilateral interests which we posit are in fact shared by the Chinese."** It calls for "mature deliberation" by the White House—and consultation with Congress—before any high-technology sales to China are made.

Air Force runs first flight tests of fiber-optic controls

The first Air Force flight tests of digital flight controls using fiber optics—popularly called "fly-by-light"—**are expected to produce "better aircraft and reliability at a lower cost,"** according to Forrest Stidham, program manager at the Aeronautical Systems division's Flight Dynamics Laboratory, Wright-Patterson Air Force Base, Ohio. In the program, known as Digitac—for digital tactical aircraft control—Honeywell Inc. fiber optics are used in a multiplexed data bus on the A-7D research aircraft. Two lightweight wires replace heavier wire bundles with a computer controlling the data-transfer functions.

The tests at Edwards Air Force Base, Calif., are the first of digital flight-control computers that check themselves and their data sources for faulty signals. "We particularly want to know if flight-control data could be lost for a few seconds in the presence of electromagnetic interference and what effects this would have on system performance," Stidham says. Laboratory ground tests of the fiber optics and the data bus have shown the system's vulnerability or susceptibility to emi is very low, he says.

U. S. finally adopts standard to link computer nets

A new standard designed to cut networking costs of Federal agency computers becomes effective June 13 following approval by the Department of Commerce and publication as a Federal information processing standard by the National Bureau of Standards. Known as FIPS PUB 71, the standard **defines the data-link control procedures to be employed by the Federal computers and services** that use bit-oriented synchronous data-link control.

Washington commentary

Getting a U. S. policy on technology and trade

The U. S. trade balance in electronic components looks good when products like semiconductors are highlighted. But there is bad news, too, notably in categories like integrated circuits, and it is getting worse.

The Department of Commerce, for example, in its latest 1979 figures on component trade likes to stress that both exports and imports increased by about one third last year from the 1978 level, so that the U. S. trade balance rose nearly 20% to $384 million. Semiconductors alone produced $179 million, or nearly half of that balance, a 15% rise in a year. That is the good news.

In integrated circuits, however, last year's trade deficit grew nearly 40% from 1978 to exceed the $1 billion mark for the first time and more than wipe out the gains in other components trade. The Government's figures give the deficit as $1.27 billion.

Japan's dominant role

The bad guys in the worsening storm over semiconductor trade are the Japanese, of course. They shipped to the U. S. nearly three times as many products as they bought and thereby accounted for $445 million of the American 1979 deficit. Malaysia, Singapore, South Korea, the Philippines, and Taiwan were next in line with more semiconductor exports than imports, although some of this is due to American offshore operations. Four nations bought more U. S. semiconductor products than they sold back. They were Mexico, Hong Kong, Canada, and West Germany. The remainder of the positive trade balance, some $751 million, came from all other countries, which bought some $1.2 billion, or nearly 30%, of American semiconductor exports while shipping only $451 million worth to the U. S.

Japan's dominant role as the lead supplier of components to the U. S. did not yield to American pressures to increase U. S. shipments to the island nation. While U. S. exports to Japan rose in the year by 47% to $253 million, the Japanese more than offset the gain by increasing their shipments by nearly $700 million in the same period. "It is very difficult to stop the Japanese once they target a market," says one U. S. trade official. "And it becomes impossible given the size of the American market and the fact that the U. S. doesn't begin to have the degree of cooperation between Government and industry that Japan has."

That is an old complaint, and it has a familiar ring to veterans of the home entertainment electronics war with Japan over more than a decade. But there is more involved than the degree of Government-industry cooperation. There is the issue of product quality, with an increasing number of U. S. computer and instrument makers saying they now use Japanese ICs not because they are cheaper but because they are better. Hewlett-Packard Co. first made that point in Washington this spring [*Electronics*, April 10, p. 81], and chairman David Packard reiterated it during the National Computer Conference in May.

To many American manufacturers it is heresy to suggest that they might learn from the design innovations of their Japanese competitors. Nevertheless, that is what a delegation from the Electronic Industries Association of Japan has proposed. As for greater cooperation between American Government and industry, it is unlikely to come in the rigidly structured form that flourishes in Japan. "In this country, manufacturers are just going to say, 'Give us a tax cut and let us take it from there,' " says one Commerce Department official. "Some manufacturers want to have as little to do with Government as possible, particularly in semiconductors."

The need for an industry voice

Still, the traditional independence of the U. S. semiconductor industry may have to be subordinated to greater cooperation with Government if the U. S. is going to retain its role as leader in the global IC marketplace, in which the U. S. is still the largest consumer by far. But much must change before that can happen.

Now, for example, the semiconductor industry has no effective voice in the capital, despite the abundance of trade associations in Washington. The departure of Texas Instruments Inc. from the Electronic Industries Association in the 1960s left a gap that no one group has been able to fill, despite some valiant efforts. It has been every company for itself—a situation reflected all too clearly in the lack of any coherent national policy on advancing technology.

That lack is one that U. S. engineers, facing a recession as well as an increasingly competitive world marketplace, might do well to raise with their congressional and senatorial candidates this summer as issues evolve. The candidate who wants your vote must do more than bemoan America's lack of strategies for trade, exports, and industrial development. The winners will be those who can come up with viable alternatives at your insistence. Have you written your Congressman lately?

-Ray Connolly

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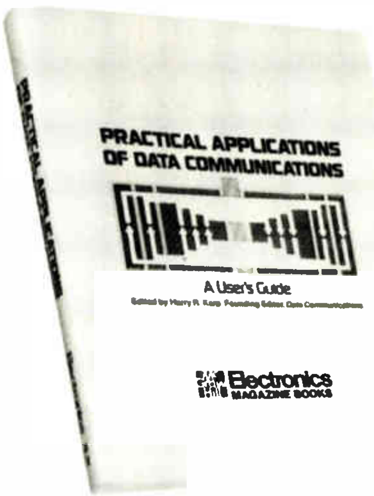

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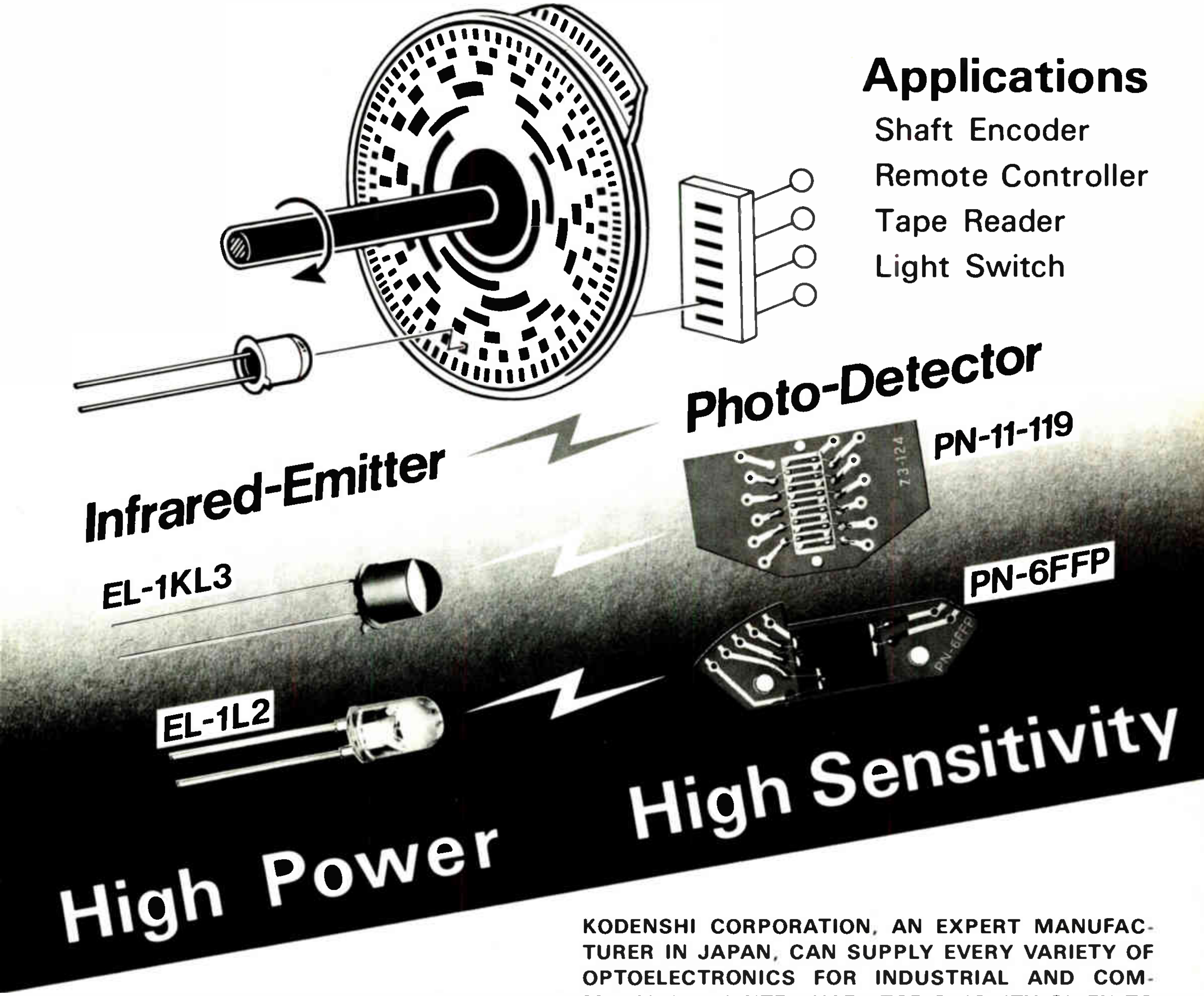

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This optional light-pipe feature makes the C30950 series ideal for optical communications, as well as for military and industrial range-finding.

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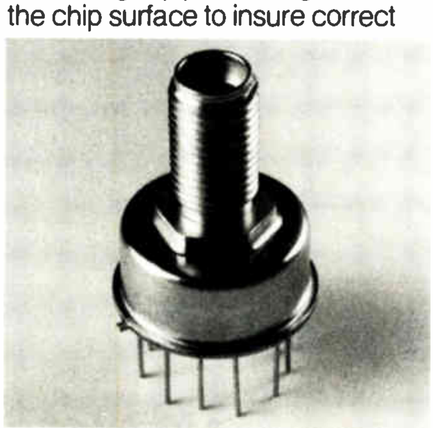
Responsivity (at 830nm)	5.2×10^5 V/W	1.9×10^5 V/W	5.8×10^4 V/W
Noise equivalent power (at 830nm)	0.029 pW/Hz½	0.079 pW/Hz½	0.260 pW/Hz½
System bandwidth	50MHz	100 MHz	200MHz



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International newsletter

Racal-Redac launches desktop pc-board design system

The microprocessor looks set to transform the economics of computer-aided design systems, leading to an explosive growth phase. Setting a trend is the British company Racal-Redac Ltd. in Tewkesbury, Glos., which will be launching (at a private conference in Amsterdam, June 9–13) a benchtop printed-circuit–board design system called Cadet. Built round an Intel 8086 16-bit microprocessor, **the unit sells for $44,000, roughly one quarter the cost of the firm's minicomputer-based system.** It triples throughput over manual layout methods and is economical for companies processing as few as five pc boards a year. The system, which includes a graphics display, a keyboard, and a layout tablet, can be used interactively to lay out single- or double-sided boards having a complexity of up to 100 or more integrated circuits. Design tapes generated on the Cadet terminal are processed at Racal-Redac bureaus in England, West Germany, and the U. S. to produce finished artwork.

Hitachi enters IC lithography market with 10:1 optical unit

Japan's newest manufacturer of wafer lithography equipment should have no trouble persuading its customers that it believes in its equipment: Hitachi Ltd. has already installed several units of its RA-101 10:1 projection machine for step-and-repeat wafer exposure in its Central Research Laboratory and one of its semiconductor plants. The system is **nominally specified for minimum line widths of 1.5 μm with a 3-μm pitch,** but it can produce line widths down to 1 μm with a 3-μm pitch when the wafer surface is truly planar. Absolute positioning (accuracy) and repeatability (precision) are within ±0.2 μm. The maximum chip size that can be exposed in one shot is 10 mm square (394 mils square). The standard system comes with a loader-unloader for 76-mm (3-in.) wafers, but those for larger wafers can be supplied at a surcharge. The price in Japan will be about $680,000.

Two firms join Thomson in French digital fax awards

The French telecommunications authority will be supplied with preproduction models of low-cost digital facsimile machines from Matra SA and SAGEM (Société d'Applications Générales d'Electricité et de Mécanique), as well as from Thomson-CSF [*Electronics*, Aug. 30, 1979, p. 72]. CIT-Alcatel, the fourth principal company bidding for **the contracts, worth about $3 million each for 50 machines,** had its proposal rejected by the Direction Générale des Télécommunications. Engineers at the French government's telecommunications laboratory apparently feel that the reproduction quality on the CIT-Alcatel machines does not come up to par. But CIT-Alcatel officials insist that they will continue development of their innovative electrochemical reproduction system [*Electronics*, Jan. 17, 1980, p. 64] despite the setback. Specifications call for a CCITT group 3 facsimile machine with a production cost of less than $500 in runs of more than 100,000 machines per year.

EE shortage grows in West Germany

Concern over the growing shortage of engineers is mounting in West Germany's electronics industries. Although the number of engineering graduates is on the rise again, the demand far outstrips the supply. **Siemens AG of Munich, for example, says that 2,500 engineering positions in its worldwide operations are currently unfilled.** Also, there is a need for some 500 engineers solely for printed-circuit–board and thick-film technologies. As for semiconductors and related fields, some authorities see the shortage of specialists seriously impeding the rate of growth and innovation. Comments Alfred Prommer, head of the components section in West Germany's Central Association for the Electrotechnical Industry, "Only if we succeed in getting enough qualified people will we be able to maintain our competitive edge in the 1980s."

International standards for microprocessors likely to move forward

A significant stride toward worldwide standards for microprocessors could well come out of the general meeting of the International Electrotechnical Commission in Stockholm, June 4–13. **Rough guidelines for the standards already have been blocked out informally:** the effort will stress bus interfaces, languages, input/output signals, generated rf radiation, and immunity to interference. The 43 member countries of the IEC, the Geneva-based body that sets international standards for electrical and electronic equipment, very likely will set up a technical committee for microprocessor standards at the meeting, along with the main job of agreeing on some 100 new standards for 34 product groups.

West German firm at work on RAM-based phone-answering unit

As part of a design contest sponsored by West Germany's post office, Zettler GmbH, a communications equipment and components producer in Munich, is developing a digital telephone-answering unit small enough to be integrated right into the telephone handset. Built around eight 64-K random-access memories, the unit **holds any message up to 22 seconds long.** Zettler is also developing an answering unit using a 50-second minicassette store that likewise can be integrated into the phone handset. The latter solution not only provides a more natural voice than does the digitally stored speech, but it also is less expensive to implement. At current prices, Zettler says, the electronic, RAM-based unit is roughly six times more costly than the electromechanical, minicassette-based version.

Fujitsu outdid IBM in Japan in 1979

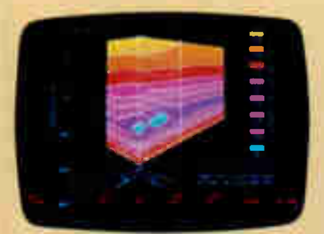
Fujitsu Ltd. claims to have passed IBM Japan last year in total sales of computers (including exports) to become the leading manufacturer of computers in Japan. **Among native firms, Hitachi Ltd. retained second place,** but sales of third-place Nippon Electric Co. grew at a faster pace to narrow the gap. Much of NEC's business is in the fast-growing office computer and terminals market, whereas Hitachi was hurt by a cutoff of sales to Itel. Second-tier companies Oki Electric Industry Co. and Mitsubishi Electric Corp. also grew apace in the office computer and terminals market.

ESA expects Ariane to stay close to schedule

Although they will not know for several weeks exactly why their second experimental Ariane launch vehicle broke apart and plopped into the Atlantic Ocean less than 2 minutes after liftoff from French Guiana on May 23, **European space officials suspect the failure was provoked by a one-shot anomaly** in one of four first-stage engines. Therefore they still hope they can stick reasonably close to their original schedule for building up to operational launches—two more experimental launches by early 1981, with full-fledged launches to start later the same year. So far, the European Space Agency has a dozen firm orders for Ariane launches, plus nine options.

Meet HP's new System 45C color graphics computing center. It plugs into the wall--not into another computer.

Engineering Design



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400 2

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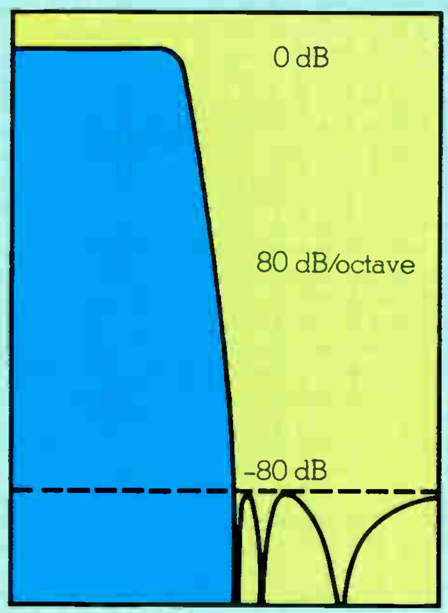

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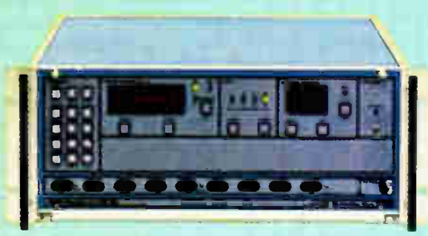

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Multiple-drain MOS packs in very fast logic gates

by Kenneth Dreyfack, Paris bureau

Comparable to integrated injection logic, MD-MOS technology lends itself to computer-aided design

When they started developing multi-drain-MOS (MD-MOS) technology some five years ago, engineers at the French government's telecommunications laboratory were seeking first and foremost a quick and easy way to use computer-aided design for large-scale integrated circuits. But they managed more than that: their CAD-oriented technology also offers very fast logic gates even when tightly packed. In fact, the design team used CAD MD-MOS for the speech synthesizer due out by the end of this year [*Electronics*, May 22, p. 104].

MD-MOS technology is the MOS counterpart of integrated injection logic. A standard n-channel logic gate is combined with multiple drains, with a depletion-mode n-channel transistor controlling the input (which means that it consumes more power than I^2L). The common gate serves as the input, and the drains serve as the outputs (see cross section). Thanks to the common gate, drains can be tightly packed. More important, gate width is constant, making MD-MOS highly amenable to computer-aided design.

One part. "What it really means is that an MD-MOS CAD library has only one element—the basic MD-MOS logic gate with a variable number of drains," says Jacques Majos, head of the custom circuit design group within the Microelectronics department of the Centre National d'Etudes des Télécommunications in Lannion, Brittany. This greatly facilitates LSI logic circuit design because it permits the use of a simple symbolic design format.

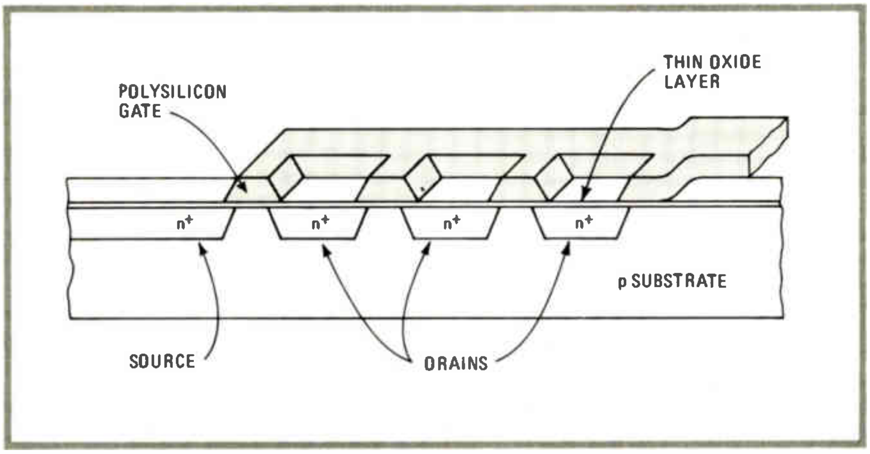
The circuit designer need concern himself only with the functional elements in his design—inputs, drains, and power supply. The symbolic representation he comes up with for the functions he wants can be readily translated into an actual circuit layout; there are no significant differences in proportion between the symbolic design and the actual (see comparative diagram).

Grid. Because of the constant gate width and the linear arrangement of the elements in any MD-MOS logic circuit, the overall width of the gate circuit is also constant. For computer-aided design, CNET engineers draw up an X-Y grid based on this constant width. The center-to-center measurement for two adjacent gate circuits is equal to two squares of that grid. The minimum length for the logic circuit is never less than five squares (for a two-drain gate) and can be longer, depending on fan-out or additional space needed for interconnections. The actual distances involved depend on the width of the polysilicon gate. What is important is that the proportions remain unchanged.

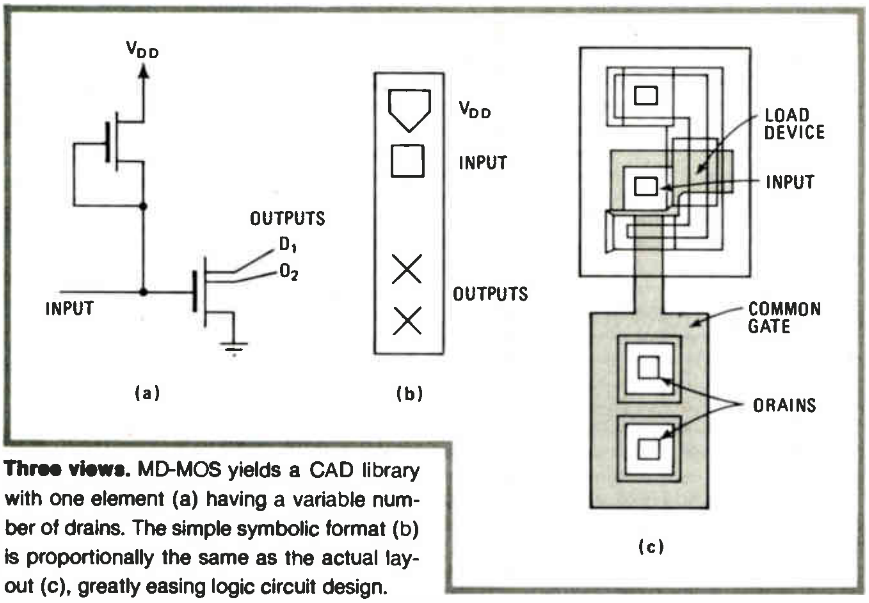
The CNET has been working with a CAD system based on a grid of 20-micrometer squares, with gate widths of 8 μm. In this case, the theoretical minimum space occupied by the simplest logic gate (two drains) is 4,000 μm^2; that is, the gate width is two 20-μm squares and the length is five squares.

In practice. Thus, theoretically, using 8-μm polysilicon gates, a maximum of 250 MD-MOS logic circuits can be packed onto 1 square millimeter of silicon real estate. In fact, Majos explains, fan-outs and interconnections cut the actual maximum integration for computer-designed MD-MOS random logic circuits by about half, to 125 logic gates/mm^2.

In contrast, with 8-μm gates,



Down the drain. Multiple drains serving as outputs make this logic gate from France's CNET the MOS equivalent of I^2L. The common gate functions as the input.



Three views. MD-MOS yields a CAD library with one element (a) having a variable number of drains. The simple symbolic format (b) is proportionally the same as the actual layout (c), greatly easing logic circuit design.

Majos says that only 80 n-channel NAND gates or 40 NOR gates can be packed into 1 mm². These figures apply to gates with a propagation delay of more than 45 nanoseconds. For delays of less than 20 ns, he contends, CAD is out of the question for n-channel NAND gates.

The highest integration achieved so far by the CNET has been in a counter fabricated with 6-μm polysilicon gates. Largely because of the regular and relatively simple layout, it gets 310 gates, with a gate delay of 4 ns, on each square millimeter of silicon.

A main drawback of MD-MOS, as noted, is that, since it is static, it requires much more power than I^2L. What's more, the use of a thin polysilicon gate means the capacitance between it and the source is about three times greater than for I^2L. At 5 volts, the power-delay product for MD-MOS is 1 picojoule, considerably greater than for a comparable I^2L gate. Even at 3 V, the optimum voltage for MD-MOS gates, the power-delay product—0.5 pJ—is still above the I^2L level.

France

Gallium arsenide IC makes decisions for fast PCM transmission system

Practical GaAs integrated circuits have started to appear, nearly a decade after researchers first realized that gallium arsenide's high carrier mobility could supply the fast switching needed for future digital communications systems. One pioneering IC is a regenerator that Thomson-CSF has fabricated for an experimental 840-megabit-per-second pulse-code-modulation coaxial-cable transmission system of the French telephone network.

Gérard Nuzillat, head of the fast devices laboratory at Thomson's central research facility in Corbeville, suburban Paris, thinks that this is the first GaAs IC produced in "industrial" fashion. "We have processed tens of wafers," he explains, "with yields exceeding 60% for most of them."

Intended for signal regeneration at rates of between 1 and 2 gigabits per second, the IC has 60 devices, mostly depletion-mode metal-semiconductor field-effect transistors, integrated on a 0.5-by-0.5-millimeter (roughly 20-by-20-mil) chip. The gate length of the MES FETs is 0.75 micrometer, and thus the cutoff frequency is a very high 20 GHz. That works out to rise and fall times of 100 picoseconds and a maximum clock frequency of up to 3 GHz for the circuit. Just as important, the power consumption is moderate—typically 350 milliwatts.

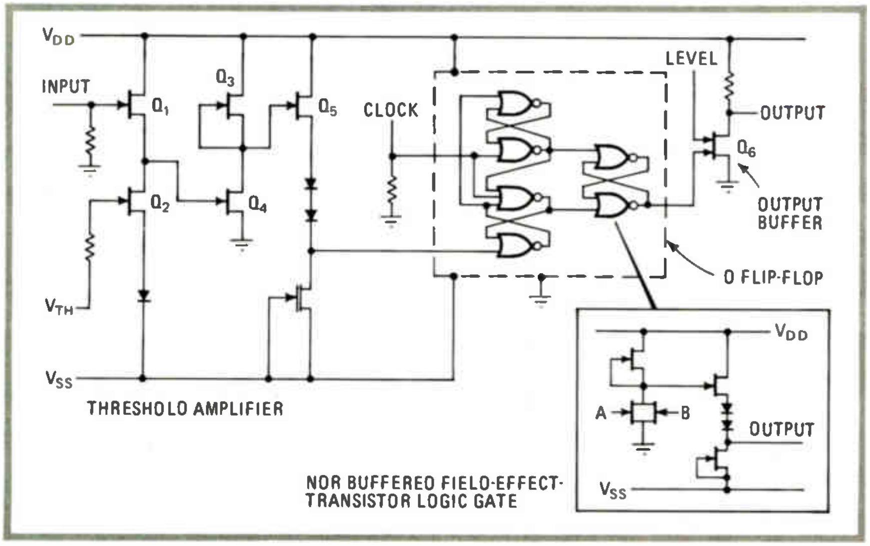
Three tasks. Essentially, the regenerator, crucial to the repeater in long-haul PCM systems, does three things. First, it judges, at precise, clocked intervals, the logic state of the degenerated input signal to the repeater (which is why it is also called a decision circuit). Next, it retimes the incoming pulse train. Finally, it reshapes the output signal to the transmission format.

For the experimental 840-Mb/s PCM system, the format is ternary, so that the decision circuits must work in pairs. One decides between the +1 and 0 levels, and the other between the −1 and 0 levels. The two binary half-signals are summed to get the ternary output train.

Deciding. To make the decision, the input signal is compared with a preset threshold level. The result is amplified and then fed to an edge-triggered D flip-flop, built around a half-dozen NOR buffered logic gates (see figure). The flip-flop samples the threshold amplifier output at each negative transition of the clock and signals changes of state. The output of the flip-flop is interfaced by a dual-gate FET, which makes it possible to operate decision circuits in parallel with no problems. All told, the dynamic sensitivity of the circuit is 65 millivolts peak to peak at clock frequencies of up to 1 GHz.

To make the circuits, Thomson starts with a chromium-doped semi-insulating GaAs substrate topped by an n-type active layer deposited by vapor-phase epitaxy. It processes them in six steps, including electron-beam lithography, lift-off engraving, and local etching, to obtain a recessed-gate structure. The integrated resistors are nickel-chromium, and there are two layers of metal interconnections.

With electron-beam technology, submicrometer gate lengths can be obtained; typical values run between



Decisive. Thomson-CSF's GaAs regeneration circuit for an experimental 840-Mb/s PCM system boasts a maximum clock frequency of 3 GHz and rise and fall times of 100 ps.

0.7 and 0.8 μm, with source-to-drain distances of 3.6 μm. The circuits are housed in 10-pin flat packages designed for the high frequencies associated with gigabit data rates.

Nuzillat and two of his fellow scientists, Michel Peltier and Maurice Gloanec, reported on the regeneration circuit at the International Microwave Symposium held May 28–30 in Washington, D. C., by the Institute of Electrical and Electronics Engineers. -**Arthur Erikson**

Japan

Microphone 'zooms in'

Video cameras with zoom lenses are old hat, but until now "zooming in" simultaneously with a "shotgun" microphone has proved unwieldy at best. The Victor Co. of Japan has made the process much simpler by developing a stationary on-board microphone that "zooms in" on a sound source electronically.

The microphone, which sticks out of the camera above and parallel to the lens, contains three back-to-back mike units. The front two point forward, and the third points toward the camera, picking up sound mainly from behind the operator.

Running with the lens at its widest angle, the camera records ambient nondirectional sound through the second and third units. As the lens starts to zoom in on its subject, gears connected to four volume controls gradually reduce the output of mike unit three. When its output reaches zero and only mike unit two is operating, unidirectional sensitivity is achieved.

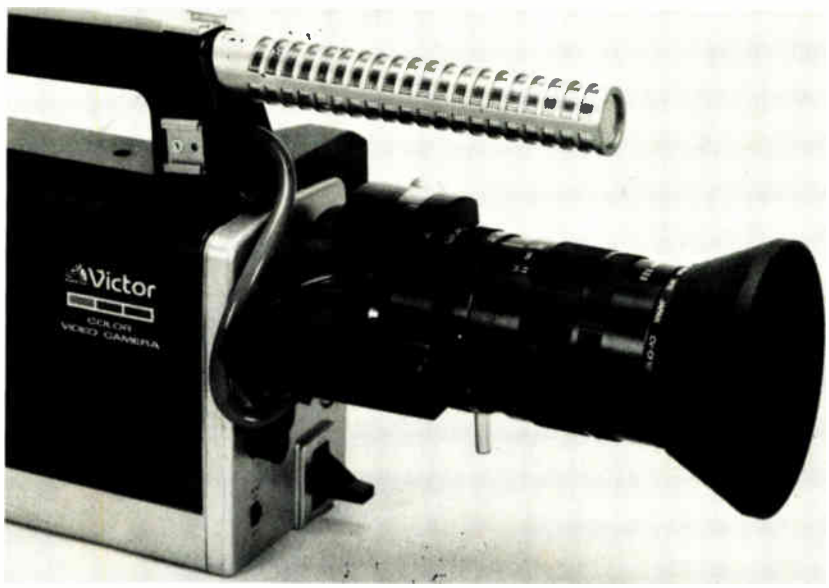
In a park, for example, a wide shot of three people sitting on a bench would record all ambient sounds indiscriminately. Zooming in on the three, the microphone would amplify their conversation while reducing ambient noise.

If the lens zooms in closer, say, on just one person, the gears activate mike unit one. What JVC terms "super-directivity" is achieved by subtracting unit one's output from unit two's via reduction circuits. The subject's voice is recorded at up to 2.7 times higher volume than that of the other speakers.

Smaller, better. Such a mike unit configuration is not new, nor of course are highly directional shotgun microphones. But JVC's is much smaller and reportedly overcomes previous problems involving uneven directivity, signal-to-noise ratio, and wind noise.

As directivity narrows, low frequencies tend to fall off. Directional mikes use an equalizer to correct this problem, but the correction factor is often so great that it exacerbates wind noise and reduces the S/N ratio. JVC, which is seeking more than a dozen patents on the microphone, will not reveal how it has solved these problems.

Processing. Signals from all three mike units feed into a central adder. Unit one's signal first goes through a phase process circuit and a volume control, unit two's feeds into the adder directly, and unit three's first passes through a volume control;



Zooming in aurally. JVC claims to have overcome problems of uneven directivity, S/N ratio, and wind noise with its "zoom" microphone, which is also smaller than similar mikes.

from the adder, the synthesized signal moves through an equalizer with a built-in volume control and then through an amplifier before passing through the fourth and final volume control.

The microphone's sensitivity ranges from −66 decibels/microbar/kilohertz in its nondirectional mode to −54 dB/μbar/kHz in its super-directional mode. The S/N ratio is above 45 dB for nondirectional operation and above 43 dB when super-directional. The sound-pressure level is 120 dB, with distortion in the super-directional mode 3%.

JVC plans to start marketing a home video camera this fall incorporating the microphone. It will likely sell for about $90 more than a regular video camera. **-Robert Neff**
McGraw-Hill World News

East Germany

Digital telephone switching system compares with those in the West

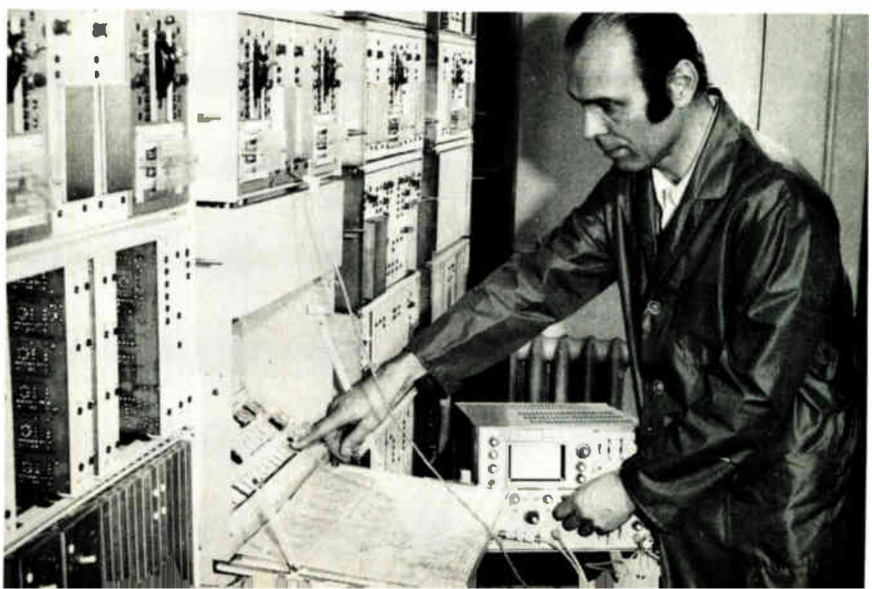
The latest show of economic cooperation on a bi- or multi-lateral basis among Comecon bloc countries in electronics is a joint East German–Soviet development in telecommunications. Called Ensad, the acronym for the German words for "unified communications system for analog and digital switching" [*Electronics*, March 13, p. 63], the project represents what East German industry officials consider an approach to third-generation switching systems.

Judging by its performance characteristics, the computer-controlled Ensad system seems to be matching similar equipment developed in the West. It, or its all-digital follow-up version, may well become the standard for East European countries. A prototype has already been installed and is now undergoing trials in an actual operating environment.

The East German partner in the development effort is VEB Kombinat Nachrichtenelektronik, an organization combining the capabilities of 25 facilities, including a research center and an engineering bureau. Employing some 38,000 workers, engineers, and scientists, the combine handles virtually all of East Germany's activities in communications, from initial research and development to production and marketing. During the past two decades, the country's communications sector increased its exports ninefold, selling to more than 30 countries.

The Ensad system, whose development started in the mid-1970s, is a product of VEB Fernmeldewerk Arnstadt, one of the combine's members. Like similar Western products, it

Eastern switch. The East German–Soviet Ensad analog and digital switching system offers performance characteristics and services comparable to those of similar Western products.



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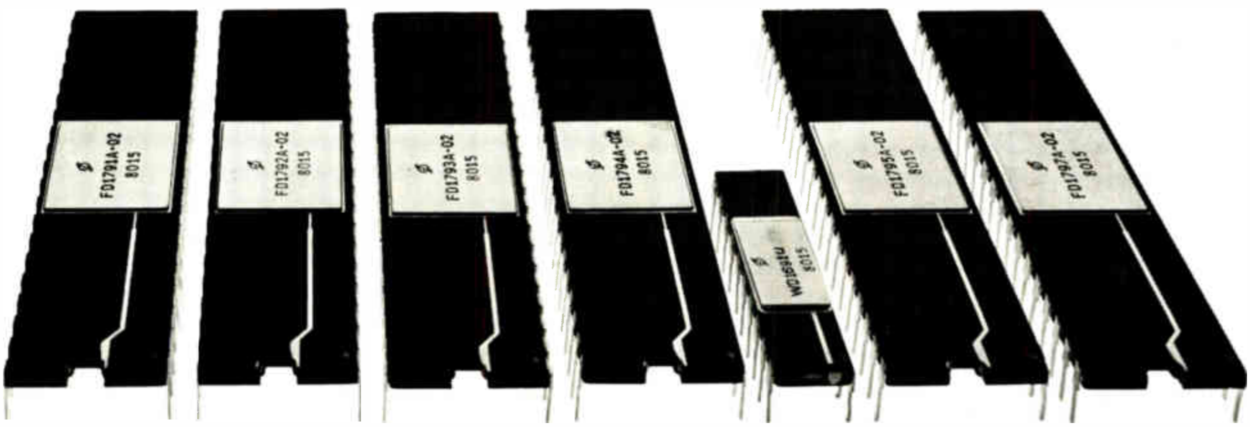

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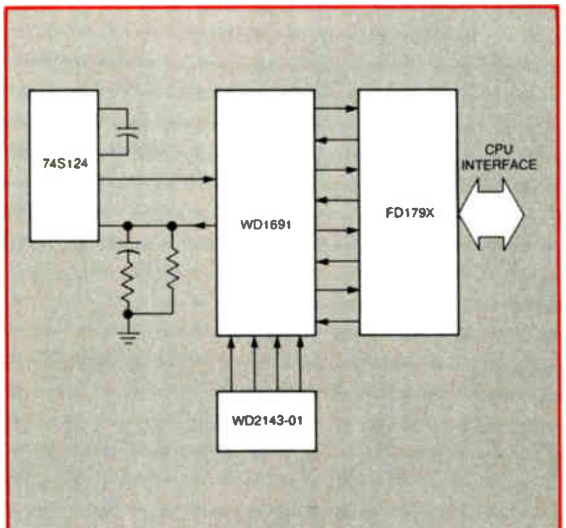

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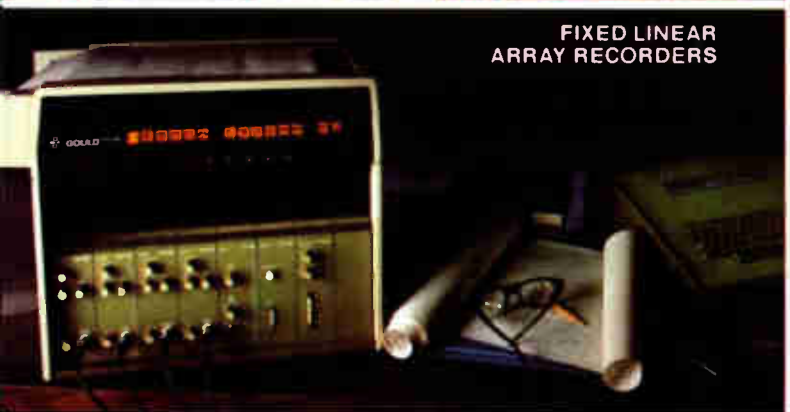
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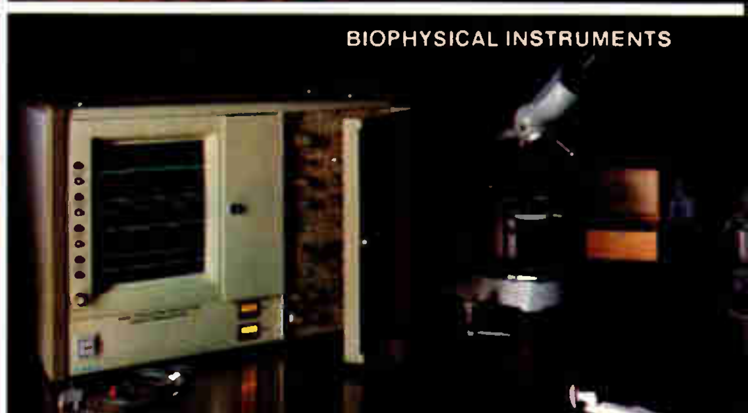
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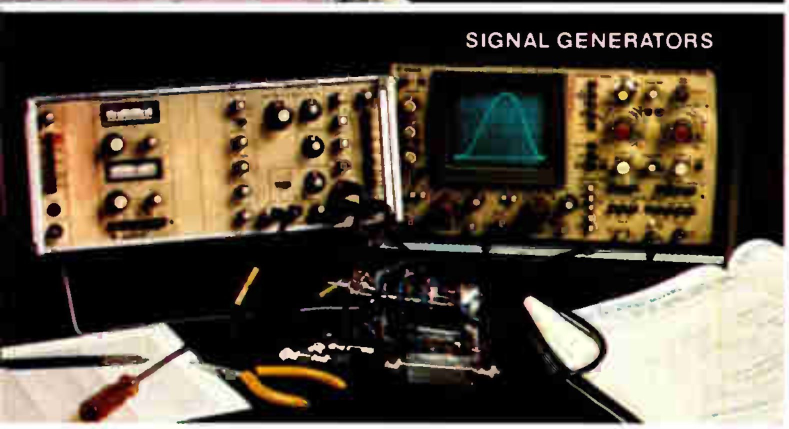
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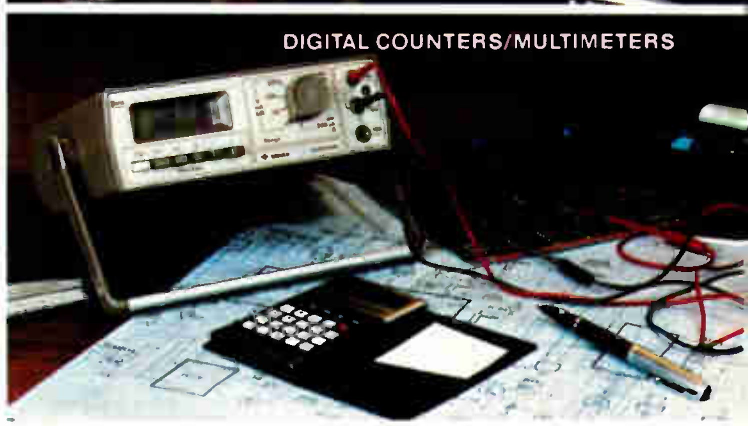
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Local networking grabs NCC spotlight

Ethernet proposal, combining skills of Xerox, DEC, and Intel to link noncompatible systems, is the talk of the computer show

by Anthony Durniak, Computers & Peripherals Editor

Perhaps the hottest topic of conversation at last month's National Computer Conference in Anaheim, Calif., was not so much the computer and peripheral equipment but rather ways to connect them.

Stimulating the attention was the announcement the week before the show that Xerox Corp. had recruited Digital Equipment Corp. and Intel Corp. to assist it in establishing the specifications for its Ethernet local data-communications network [*Electronics*, May 22, p. 70]. Xerox, which first introduced the technique last December [*Electronics*, Dec. 20, 1979, p. 33], will supply its communications protocol, while DEC will supply systems expertise, and Intel will add its semiconductor knowledge. All three will enjoy cross licensing of the ideas that come out of the cooperative development effort.

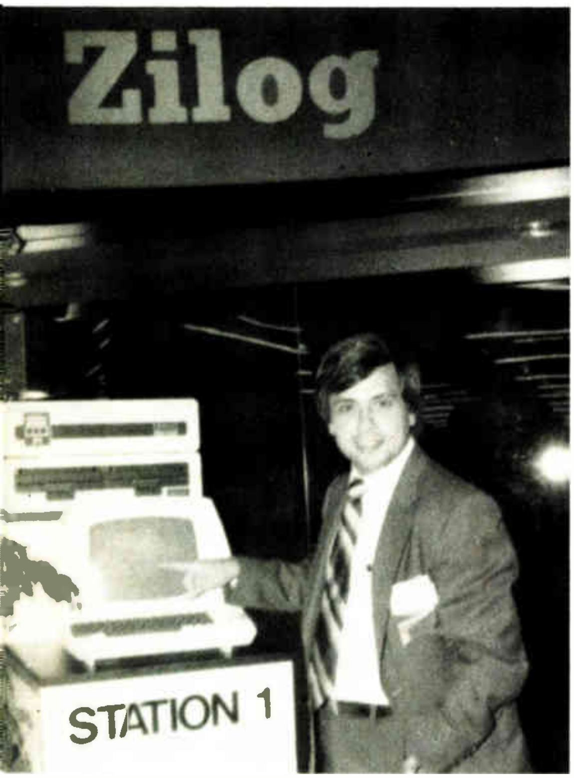
Such local networks are gaining popularity because of their ability to link the various computers, terminals, and word-processing gear to support increasingly widespread distributed-processing and office-automation applications. These applications typically require devices to be linked over relatively short distances throughout an office building or industrial complex.

Xerox's Ethernet proposal is especially ambitious, calling for industry support to establish it as a standard. Xerox hopes Ethernet will be widely used, encouraging the design and manufacture of interface chips that would be as inexpensive as a current universal asynchronous receiver-transmitter (UART) chip, which costs $4 to $6, according to David Liddle, vice president of systems development at the Xerox Office Products division, Dallas, Texas. To encourage wide use, Xerox will make patent licenses readily available.

General view. Although the final specifications will not be ready until the third quarter of this year, the three companies are discussing the general outline of the network's operation. All information will be transmitted in packets of 1,024 bytes preceded by 144 bits of header information. The key part of the header is a 48-bit address that indicates the device to which the information is to go. Such an address theoretically permits an almost unimaginable 281 trillion devices to be connected to the network. A 32-bit cyclic redundancy code will be added at the end of each packet for error detection and correction.

The network itself operates like a party line—the transmitting device listens for a quiet period on the line and then broadcasts the packet to all devices on the net. Only the addressed device picks the information off the network. Since this approach essentially lets the devices handle their own message routing, no central network controller is needed. This increases reliability—because there is no single point of failure that could knock out the entire network—while reducing cost.

A key element in Xerox's Ethernet design is its patented collision-detection and -avoidance algorithm, says Liddle. When a device tries to transmit and finds the network busy—called a collision in communications jargon—the algorithm directs the device



Great day a-comin'. Zilog's Manny Fernandez sees Ethernet-like systems opening a whole new market and becoming the local communications of the future.

to wait a randomly specified amount of time before trying again. If the network is still busy, the device waits still longer and longer before retrying, thus preventing network bottlenecks during peak loads—the so-called deadly embrace that occurs when two devices keep trying to transmit coincidentally and then continually find the line busy (much like two stubborn drivers trying to move in opposite directions on a single-lane bridge).

Standard cable. The network itself is built from standard coaxial cable in lengths up to 500 meters long. Taps—the same used for cable-television nets—make attaching terminals easy and inexpensive. The preliminary specifications call for Ethernet to operate at 10 million bits per second, a rate fast enough to handle large volumes of data yet slow enough to be handled by MOS large-scale integrated circuits.

The cooperative work initiated on Ethernet comes on the heels of two other recent local networking announcements. Last month Ungermann-Bass Inc. of Santa Clara, Calif., unveiled its Net/One, also a packet-switched coaxial-cable-based network operating at 4 megabits/second [*Electronics*, May 8, p. 40]. But Net/One is unique in that it will also convert between incompatible computer and terminal protocols. Ethernet requires all terminals attached to it to observe the same communications rules.

At the same time, Zilog Inc. of Cupertino, Calif., introduced its coaxial-cable-based Z-Net to tie its MCZ-2 microcomputers together. Z-Net transmits information packets at speeds up to 800 kilobits/second. Each packet is 8 bits wide and up to 512 bytes deep; header information is additional. It also can communicate with other networks; for example, its work stations can emulate an IBM 2780 or 3780 intelligent terminal. That, in turn, permits it to talk to Zilog's earlier MCZ-1 series.

When Z-Net comes on the market this summer, the MCZ-2 will make available 10 to 40 megabytes of cartridge disks that will serve as network nodes. Consequently, the Z-Net scheme will wind up with the ability to connect as many as 255 stations having one processor apiece. Then, in the fourth quarter, Zilog will begin marketing a four-processor package that also may be linked by Z-Net.

Other companies offering local networks include Datapoint Inc. of San Antonio, Texas, which calls its system Attached Resource Computing, and Wang Laboratories Inc. of Lowell, Mass., but these include sophisticated network control software to handle the sharing of files and peripheral devices that was not included in the Xerox proposal.

Also offering general-purpose local networks based on coaxial cable is Amdax Corp., of Bohemia, N. Y., but this company's networks operate at a broader bandwidth to carry video signals, too, and are based on centralized controllers.

Work together. Xerox's Liddle does not feel these networks have to compete with Ethernet, but rather can build on the basic transmission medium that Ethernet proposes. Similarly, distributed-processing architectures that have appeared already like DEC's DECnet and IBM Corp.'s Systems Network Architecture could conceivably work with Ethernet, since they involve a higher level of control function.

And rather than compete with systems such as Xerox's own proposed Xten satellite-based communications system [*Electronics*, Dec. 7, 1978, p. 84], Satellite Business Systems, or AT&T's now delayed Advanced Communications Service (see p. 12), Ethernet will complement these long-haul services and connect to them through "gateway boxes."

David House, general manager of Intel's Microprocessor and Peripheral Operation, which is working with Xerox, says that "this type of high-speed local network has become a common requirement of our customers." And since Intel, Xerox, and DEC are such good customers of each other it made sense for them to work together, he continues.

According to Dale Kutnick, a communications industry analyst with the Yankee Group in Boston, such networks "eliminate the communications problems now cropping up" in distributed-processing and office-automation applications. As a result, he says, their market potential is huge, although he was unable to supply a specific dollar amount.

Called endorsement. Manny Fernandez, group vice president of Zilog, views Xerox's moves as an endorsement of the concept of Zilog's Z-Net. "We're on the verge of throwing open a whole new market for communications, and it will be big enough for everybody," he says. "Ethernet-like communications network systems will be the local communications of the future." And making Z-Net compatible with Ethernet is a distinct possibility in the future, he notes.

Edward J. Zander, director of general systems marketing for Data General Corp., Westboro, Mass., perhaps sums up the reactions of others. Though saying it is too early to pass judgment on the Ethernet system, he agrees that "there's a tremendous need for an inexpensive high-speed local communications technique. It makes no sense to spend $2,000 to $3,000 on a box to connect a $2,000 or $3,000 terminal to a network." □

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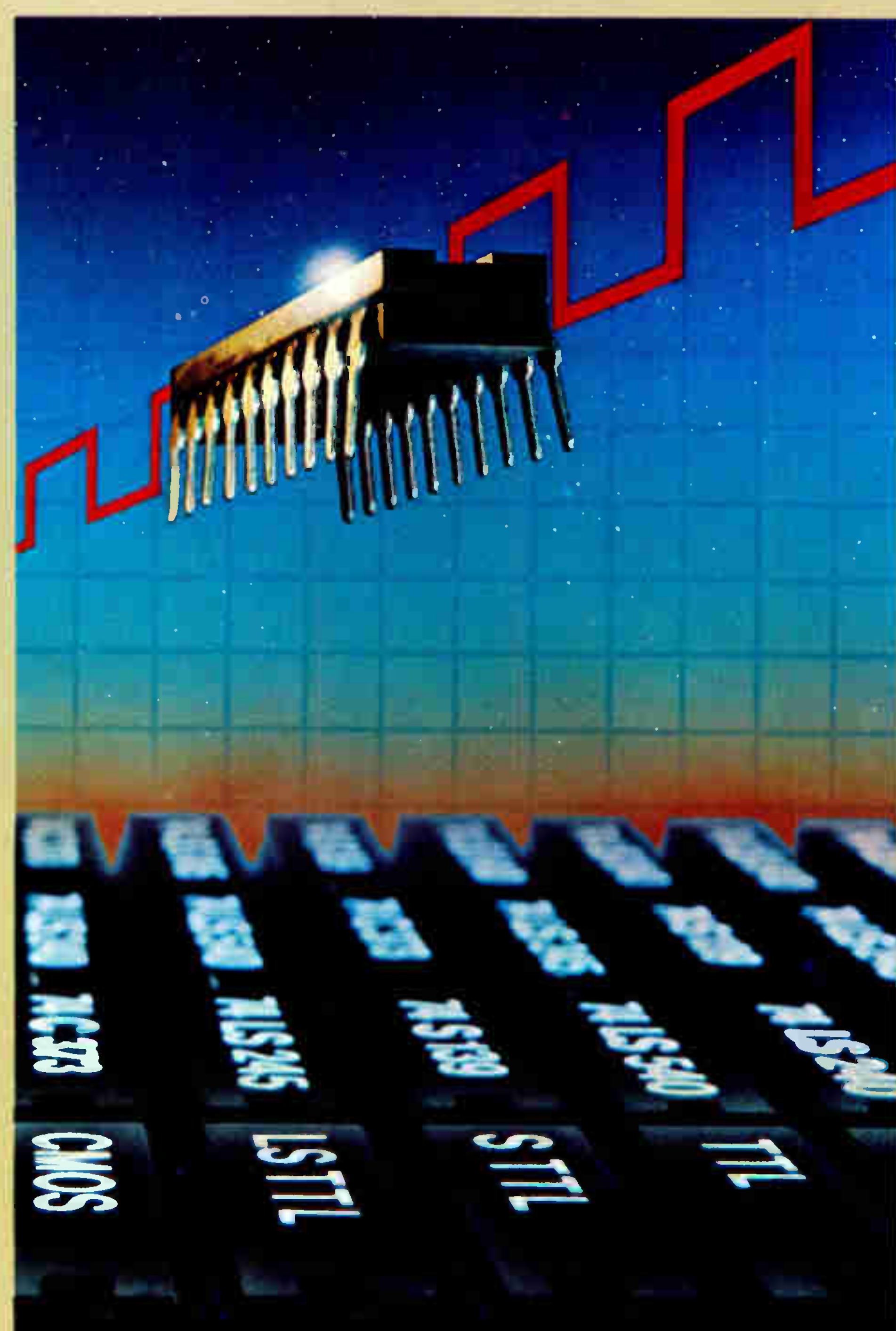

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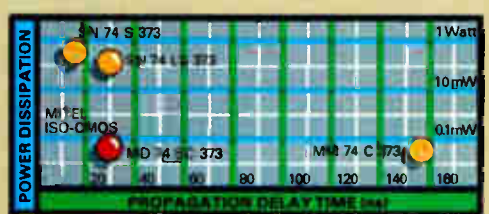

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Electronic speech

Military has its eye on speech

Voice synthesis and recognition are sought for applications in training, in automated terrain mapping, and in the cockpit

by Wesley R. Iversen, Dallas bureau manager

Speech synthesis and voice recognition are receiving increasing attention these days as a growing number of vendors scramble to cash in on an expected high-growth market for low-cost consumer, commercial, and industrial applications of these emerging technologies [*Electronics*, May 22, p. 95]. However, another less heralded but also potentially lucrative market—albeit longer term—involves Government, military, and aerospace applications for voice input/output systems.

That fact was evident last month in Dallas, where a three-day symposium on voice interactive systems, sponsored by a subgroup of the U. S. Department of Defense, provided industry and Government officials with an overview of the technology, emphasizing potential military uses. Also evident was the need for additional research and for improved voice systems—designed to take a variety of linguistic, psychological, environmental, and other human factors into account in an interdisciplinary approach to solving problems.

Among the papers presented by more than 30 speakers at the symposium were many describing prototype systems and ongoing research aimed a military applications, such as recruit training, automated terrain mapping, and reduction of pilot workload in today's increasingly complex aircraft.

Hearing voices. Applications of voice technology in the cockpit hold a particular military appeal. A synthetic voice warning system, which would replace the bells, tones, and buzzers currently used in many aircraft, could provide pilots with specific information on a problem and reduce the visual workload associated with instrument scanning to determine the severity of the problem and appropriate response. Voice-recognition systems that would enable pilots to fire weapons or perform control functions verbally could be particularly valuable in many of what the military labels hands-busy cockpit situations.

Before such systems find widespread military use, however, additional work involving a variety of human and environmental factors must be completed. In the case of cockpit voice-recognition systems, for example, the effects of high cockpit ambient noise levels, vibration, and pilot psychological stress on speech characteristics and hence on systems recognition accuracy are not yet well known.

Research on these types of questions is under way at various laboratories—including the National Aeronautics and Space Administration's Ames Research Center at Moffett Field, Calif., and at McDonnell Douglas Corp. in St. Louis—using cockpit simulators and commercially available speaker-dependent recognition systems. Such systems require "training" in which each human subject repeatedly verbalizes each word in the system vocabulary to provide the templates, or voice reference patterns, to which comparisons are later made for word recognition. Perhaps not surprisingly, prelimi-

Fledgling. Pilot trainee in a Manned Air Combat Simulator from McDonnell Douglas practices formation flying without leaving ground. Image is on a 40-ft-diameter projection screen.

nary data seems to indicate that recognition accuracy under high noise or vibration conditions improves if the training is done under similar conditions, but that accuracy then declines when conditions become less harsh, researchers report.

Down the road. Since cockpit voice-recognition research is just now moving out of the simulators and into actual airframes, its application in production military aircraft is still years away.

The use of solid-state speech synthesis in military cockpits is a nearer-term prospect, officials indicate, with several efforts aimed at installing prototype systems already under way. Voice warning systems employing magnetic-tape players have been used in Air Force B-58s for years and have been popular with pilots despite a limited, 20-word vocabulary and problems with tape brittleness at high altitudes, says Eric Werkowitz, an official at Wright-Patterson Air Force Base in Dayton, Ohio. Current questions involve the functionality of voice messages other than warnings and the necessity for providing visual information to support the voiced messages, as well as the need for a distinctive voice or technique that allows the pilot to pick out and identify the message within normal radio traffic.

The use of voice for less critical noncockpit functions is further advanced, with various demonstration and prototype systems already being tried. For example, a system that employs both speech-synthesis and voice-recognition technologies to teach aircraft ground-control approach skills to Navy recruits has recently been tested at the Navy's air traffic control school in Memphis, Tenn.

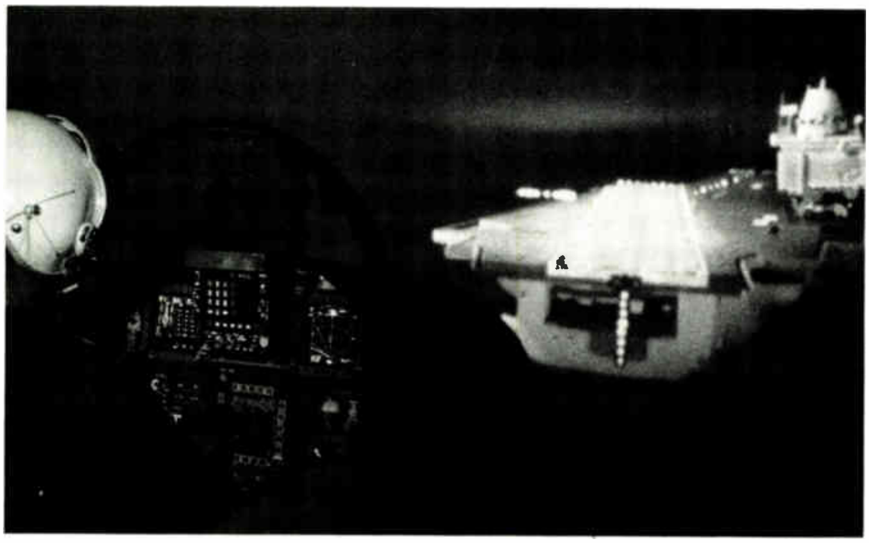
Developed by Logicon Inc., San Diego, Calif., under contract to the Naval Training Equipment Center, Orlando, Fla., the system make use of isolated word-recognition equipment provided by Threshold Technology Inc., Delran, N. J. It enables the student to direct the movement of a simulated aircraft that appears on a simulated radar screen. A voice synthesizer supplied by Federal Screw Works' Votrax division, Troy, Mich., allows the system to talk to the trainee and is used for prompting and to take the role of the pilot and tower controller. In tests ended in April, voice recognition accuracy recorded for 20 students using the ground-control training system ranged from 59.5% to 97.9%, with an average accuracy of around 84%.

Rules coming. Guidelines for routine consideration of voice technology for use in Navy training systems are due for adoption within a year, says Robert Breaux, research psychologist at the NTEC's human factors laboratory. But improvements will be required before the voice-recognition technology goes into widespread use in Navy training situations, he indicates.

Another experimental military use of recognition technology is under way at the Defense Mapping Agency Aerospace Center in St. Louis. There, a system in place since last November that uses voice-recognition equipment from Threshold Technology has improved the productivity of workers who are involved in mapping significant features based on an examination of aerial photographs. Each individual terrain is assigned a number descriptor code for input to a computer, and these codes can be recited by workers who view the photographs through stereo viewers. The system makes use of a 16-character light-emitting-diode display seen through the viewer for visual verification that digits have been properly recognized, thus enabling workers to proceed without looking away from the viewer. Developed under the supervision of the Rome Air Development Center, Rome, N. Y., the system replaces previous techniques involving manual recording of codes with subsequent keypunch or optical scanning computer data entry.

Basics needed. Several at the Dallas conference voiced concern over the lack of significant Government-funded basic research in voice-recognition technology since termination of the speech-understanding research program—a five-year, $15 million project sponsored by the Defense Advanced Research Projects Agency that ended in 1976.

Wayne A. Lea, a research linguist and engineer at the Speech Communications Research Laboratory in Los Angeles, warned participants that recent and expected new commercial voice-recognition products are doing little to advance the state of the art. Rather, such systems typically offer "somewhat perverted methods of using old, existing algorithms" and seem more oriented toward grabbing a piece of the anticipated large commercial market, Lea complained. Since recognition systems on the market today are "all promised with over 99% accuracy," there is a growing concern about how to evaluate them, said the 40-year-old researcher, who is currently under an NTEC contract to come up with just such an method. □



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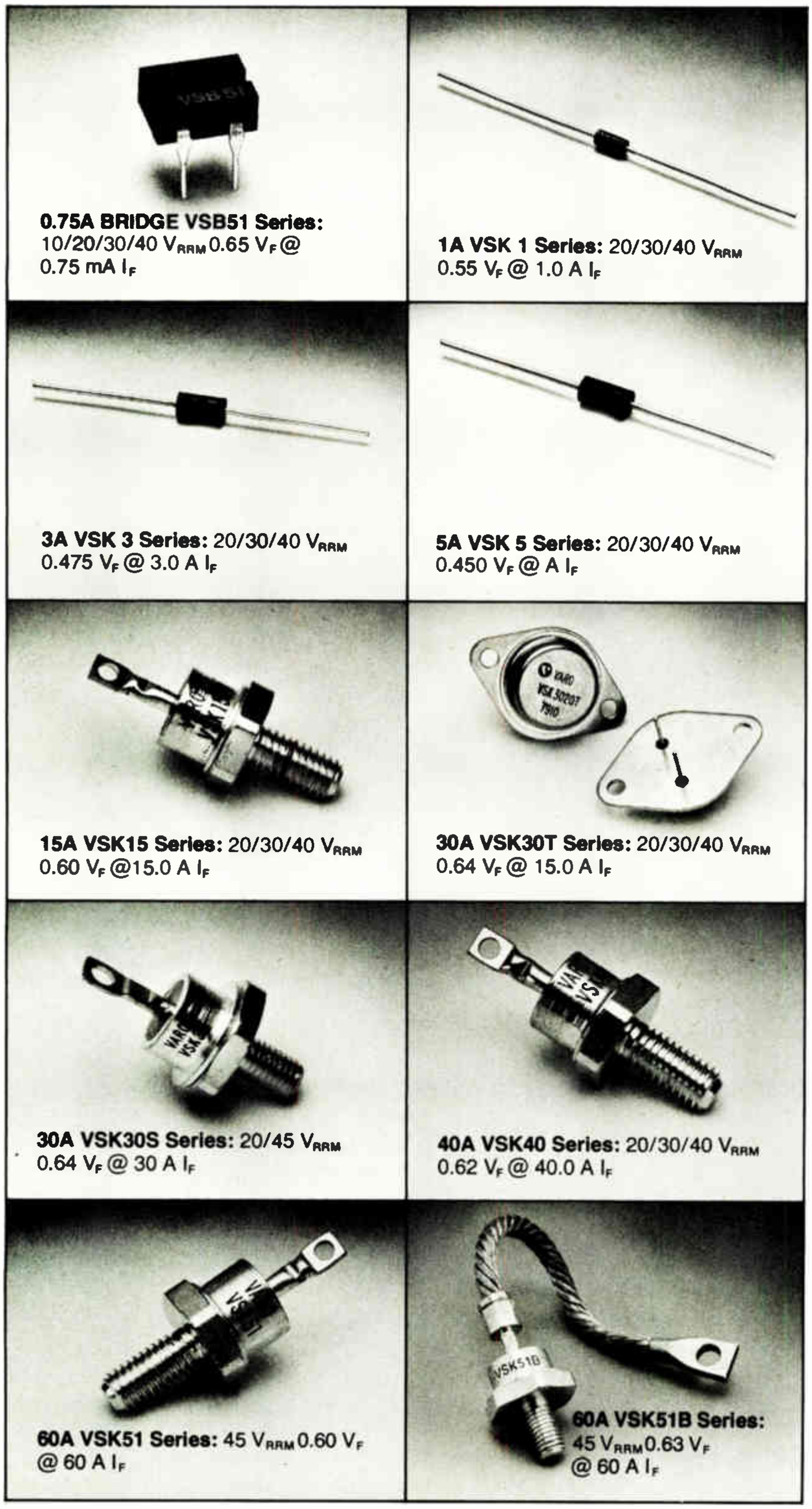

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Encryption chips sort themselves out

Now that dust has settled, user choices are clear but they aren't queueing up with shopping lists

by Harvey J. Hindin, Communications & Microwave Editor

Now that the technological improvements and product introductions have halted for the moment, it is possible to get a clear look at the chips available to implement the data encryption standard, or DES. Two classes have evolved, each defined by data rates.

Either the devices are so fast that they can handle input data in real or almost real time for high-speed communications or computer data applications or they just plod along taking care of facsimile and telex services, credit-card verification, and the like. But chips for these applications cannot be chosen by speed alone.

There is a variety of other considerations such as the number of encryption keys that can be handled, whether the device has been certified to comply with the DES, and which microcomputer it is compatible with. In the now classic manner of the large-scale integration industry, a bewildering array of approaches to encryption has been made available, ranging from simple programming of the on-chip read-only memory of a microprocessor, as in the device from Texas Instruments Inc., Dallas, to the ultrafast bit-slice four-chip set made available by Fairchild Camera and Instrument Corp., Mountain View, Calif.

Module option. To complicate matters, it must be remembered that chips are not the only way to go for a given DES application. Says Heather Bryce, strategic product marketing engineer with Motorola Semiconductor Group's Austin, Texas, facility: "The purchase of a chip is the least out-of-pocket expense but requires the most software development." Bryce notes that potential users of the DES algorithm can also buy a chip on a board with associated hardware—which requires a microprocessor to make it work—or they can buy a stand-alone unit to do the whole job. This approach is the most expensive but involves little or no design effort.

Many encryption devices, including modules and stand-alone versions as well as chips, have been certified by the National Bureau of Standards as complying with the requirements of the DES algorithm. These include, according to test program director Dennis Branstead, one device each from Burroughs Corp., Nixdorf Computer Corp., Racal-Milgo, Sperry Univac, General Telephone and Electronics Corp., Collins, Intel Corp., Fairchild, and Western Digital Corp. and two from Motorola.

Chips from TI and American Microsystems Inc. have not been certified by the NBS, although they have been advertised as complying with the standard. The implications of this are not clear for the potential purchaser of those devices. If the device is intended to be used to implement DES in non-Government applications, that is one thing. But if it is intended to be used in some manner connected with the Government, the user should investigate what effect, if any, the lack of an NBS blessing will have.

At AMI in Santa Clara, Calif., manager of microprocessor marketing Mitchell Goozé says his company has decided to leave certification to the customer. As for TI, it says that it did not seek certification because its chip is not on the market.

According to Branstead, all of the chips or devices that have been submitted have passed through his laboratory. So for the foreseeable future at least, the chips listed in the table are the ones that will be available.

Quick pick. It is possible to make a choice of chips easier than the table would indicate by asking a few basic questions. Of course, if a chip must have NBS certification, then the AMI and TI offerings are out of the question. And, as the table shows, a simple calculation of the data-handling rate needed may well eliminate all but the three chips in the fast category. For example, for almost real-time encryption of computer output data with a minimum of storage and buffering, the Fairchild chip set may be the only way to go. It is a stand-alone device, one that has no need of a microprocessor to control it and is unique among the DES chips in this respect. But there is a tradeoff—it needs a pair of data registers, four 8-bit shift registers, control logic, and two read-only memories laid out as 64 by 4 bits to make it go. The other encryption chips also need auxiliary devices to varying but lesser degrees.

Once the data rate is settled, the next criterion is whether the user needs multiple-key encryption. For this need there are only the offerings of AMI and Motorola.

Multiples. The use of secondary keys adds to the security of a system. In this approach a primary key encrypts a secondary key, and the secondary key—perhaps at a remote site—decrypts the message. Depending on the number of reception sites and the degree of security required, it may be necessary to have many secondary keys.

COMPARISON OF DATA-ENCRYPTION CHIPS

Manufacturer and part number	Data throughput	Number of keys	Compatible with microprocessors	National Bureau of Standards certification
Motorola MC6859	400 kb/s	2	6800, 8080	yes
Intel 8294	0.64 kb/s	1	8080	yes
Texas Instruments 9940	4.8 kb/s	1	9900	no
American Microsystems S6894	4.7 kb/s	multiple possible	6800	no
Fairchild 9914	13.3 Mb/s	1	not required	yes
Western Digital 2001	1.34 Mb/s	1	8080A	yes

AMI's two-chip set—based on the Motorola microprocessor—offers two or more secondary keys, but at 4.7 kilobits per second it is slow. The Motorola version can handle only one secondary key, but it is the third fastest.

Once the number of required keys, the need for certification, and the data-encryption speed have been determined, the number of chip possibilities is drastically reduced. Then, the user may bring in other considerations. Among them are what kind of microprocessor is available, what kind of power supplies are needed, and a perception of the relative ease of implementing the software and hardware needed to make the chips work in real systems, no matter how self-contained they are claimed to be. These devices are complicated, since, with appropriate modifications, some chips can be made to work with other microprocessors, different chip clocks can establish higher data rates, chips can be paralleled for greater throughput, and so on.

However, not many designers are now occupying themselves in making these determinations. While few marketing managers will admit that their company's chip is not selling, Branstead says, "there is no question that people are not flocking to buy these chips. The market just isn't there for any kind of security."

Scare stories. The major thing that the security issue seems to have spawned, says one former DES enthusiast, is "lots of consultants going about telling people about spectacular computer crimes and engaging in exotic debates concerning the relative merits of DES and public-key encryption systems." The latter system does not exist in hardware yet, although the Massachusetts Institute of Technology has worked on one chip.

Supporting the view that all is not well commercially is a report issued by Carnegie-Mellon University in Pittsburgh. It says that encryption is not following a normal market development but is going to be "event-driven," and the events have not started yet. Spectacular computer crimes are still seen as isolated incidents by the people who make encryption purchasing decisions. "The DES industry is waiting for a shoe to drop" is the way Branstead describes it.

While DES is developing slowly, one form of the chief competitor, the so-called public key technique [*Electronics*, Aug. 16, 1979, p. 81], is being used in combination with the DES by Mitre Corp. of Bedford, Mass., and Digital Communications Corp. of Gaithersburg, Md. What the two companies want to do is avoid dangerous and time-consuming transmittal of DES keys by mail or courier, so they are investigating the means of encoding DES keys with one of the public-key system codes for electronic transmission. As is customary for public-key systems, the user would simply make his encryption key public, so that everyone could communicate with him while keeping his decryption key secret. ☐

Computers

IBM foes look to joint ventures

Flurry of mergers and acquisitions lends financial muscle and broader market reach to plug-compatible makers

by the editors of Electronics

In the seemingly eternal race to catch up with IBM Corp., the latest ploy is the joint venture, acquisition, or merger. Lately there has been an uncommonly large number of them, all involving competitors in the IBM-compatible market.

The latest list includes a joint venture between Fujitsu Ltd. and TRW Inc.; the acquisition of The Computer Software Co. by Nixdorf Computer Co. while its parent, Nixdorf Computer AG, goes into the mainframe business; an investment by C. Ing. Olivetti & Cie. in IPL Systems Inc.; and a merger of Amdahl Corp. and Storage Technology Corp. And there is no assurance that the list is complete.

Perhaps the most significant move is the Fujitsu-TRW alliance to form the TRW-Fujitsu Co., with headquarters planned in the Los Angeles area. Indeed, the joint venture is only part of a plan by the Japanese company to compete extensively in the U. S.—a plan that has it calling itself "a new element in the American electronics industry."

Fujitsu has good reason for the self-awarded appellation. It plans to invest \$30 million in American operations beyond the \$10 million it has sunk into TRW-Fujitsu (TRW has put in \$9 million). This includes \$10 million for a Fujitsu Microelectronics Inc. semiconductor memory plant in San Diego, Calif., and \$5 million earmarked for its recent acquisition of The Word Machine, an IBM mainframe-based word-processing system developed by DPF Inc. of Hartsdale, N. Y. Also, Fujitsu is setting up a factory in a leased building in Melbourne, Fla., to make the word processors.

What does Fujitsu bring to the TRW wedding? Quite a bit: it is the largest Japanese computer maker—ranking second overall to IBM Japan—and a leading producer of telecommunications systems and equipment, as well as semiconductors and other components. Some of its computer peripheral products are already being offered to original-equipment manufacturers through Fujitsu America Inc. of Santa Clara, Calif.

Cash and customers. Aside from TRW-Fujitsu, the question is "why all the activity now?". At least part of the answer comes from Stephen J.

Fujitsu's chief faults U. S. managers

As Fujitsu America Inc. prepares to open new factories in the United States, its president, Norihiko Nakayama, has little doubt about what to expect from American employees. "I can trust the American worker under good management to produce high-quality products," says the 52-year-old executive. "It is possible for them to have the same work habits as Japanese workers if the management is correct." The holder of a Ph.D. degree in electronic engineering, Nakayama has been president of Fujitsu America in Santa Clara, Calif., for two years; before that he headed the Fujitsu liaison office in New York for three years.

When Nakayama discusses "correct" management, he has some barbed remarks to make about his American counterparts. American managers do not want to hear bad news, he says, and they do not make the same effort that Japanese managers make to mingle with their workers and discuss problems. "Top U. S. management people sit in beautiful offices with beautiful secretaries and look at documents," he says. "But [our] managers go around to the factories on foot to see if the factories are clean and if the workers are happy to work for Fujitsu. I have not seen this" being done by managers in the U. S.

Such interaction between workers and management makes for good communication, which Nakayama considers crucial for quality production. It is a lack of good communication that "is the biggest difference between management in the U. S. and Japan," he says. "Japanese management is very sensitive to problems. We want to be told bad news, not just good."

Nakayama also has some points to make about the Japanese decision-making process, which he concedes is slow by some U. S. standards. "We may make decisions slowly, but we believe the total time from idea to finish is almost equal. This is because we take time before the decision is made to discuss the situation so people will know what it is about and what must be done. Then, when the decision is made, everyone works for it. People will even volunteer their help. This would not be the situation in an American company. People just wouldn't know what to do to help when a decision is made only at the top. And management may not be able to give clear direction.

"The decision time [in the U. S.] may be short, but actual performance is slow."

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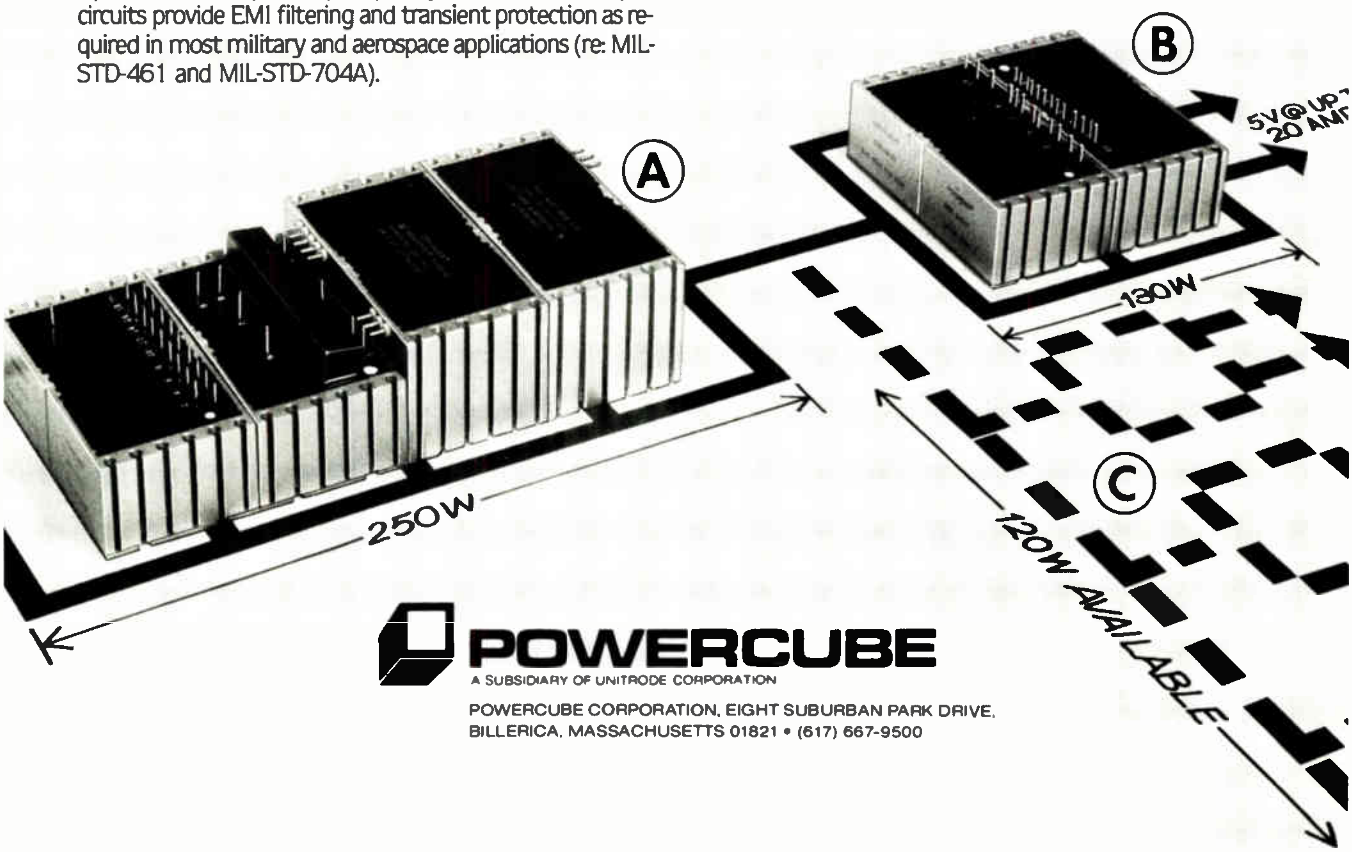

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Probing the news

Ippolito, president of IPL Systems of Waltham, Mass., who sees several advantages. First is money. In the case of his firm, Olivetti's established size and financial base will add to IPL's financial strength. Second is markets. "Getting a foothold in Europe will help cushion us against any recessionary downturn in markets here at home," he says.

The threat of recession is also cited by Ryal Poppa, president of Pertec Computer Corp. of Los Angeles. His firm was acquired earlier this year by Triumph Adler Inc., a wholly owned subsidiary of Triumph Werke Nurnberg AG, a unit of West Germany's Volkswagen organization. Says Poppa, "OEM suppliers limited in product scope, manufacturing capacity, or the capital to invest in new plant and equipment or in research and development, are at a disadvantage going into this recession and will be less competitive during the following business upswing."

To achieve a position in the forefront of technology, Memorex Corp. not only had to triple R&D outlay during the 1974–79 period, but had to use "affiliations with Teigin, Toda, and Fujitsu in Japan," says Clarence W. Spangle, chairman of the Santa Clara, Calif., firm. Donald Fuller, chairman of Microdata Corp., the Irvine, Calif., minicomputer maker acquired last year by McDonnell Douglas Corp. of St. Louis, believes "the industry is going through a phase where the big companies get bigger by gobbling up the smaller ones" because "very few companies have the resources to get bigger" simply by growing.

Development cost. For Paul Ely Jr., who is a vice president of Hewlett-Packard Co., Palo Alto, Calif., and also general manager of its computer groups, the reason for tie-ins is obvious. "For general-purpose markets, where a need exists to develop worldwide sales and service support, as well as in-house semiconductor and peripherals capability, the cost of development, even for medium-size companies, is overwhelming."

What of the independents? Will they be able to continue alone? Joe Hitt, chief executive officer of Magnuson Systems Inc. of San Jose, Calif., is unafraid. "We are not looking for mergers or acquisitions," he says. Integrated-circuit developments won't obsolete his product line, he believes, because "the bus-structured architecture means redesign of a single board, not an entire system. That we can do typically in four to six weeks."

In Japan, Mitsuhiro Saitoh, manager of the planning department of Hitachi Ltd.'s computer group, points out that his company is already competing successfully with IBM in Japan without benefit of mergers or acquisitions. The group wants to increase its export ratio, and its executives are still examining methods, though Saitoh says a joint venture isn't the answer. For Nippon Electric Co., the way to expand its U. S. operations is by hiring superior local talent, not through joint ventures, says Yasukuni Kodaka, assistant general manager of the electronic data-processing planning office. Also, says Kodaka, Nippon has no major problems selling IBM-compatible mainframes in Japan.

Natural moves. Whatever has happened up to now, a lot more is coming, agree the experts. E. Floyd Kvamme, president of National Advanced Systems of National Semiconductor Corp., sees the alliances as natural since "it is very expensive to develop a computer product" and "the electronics industry, for its size, is probably one the most splintered industries in the world." And HP's Ely says, "What we have seen is only the beginning. We'll see a lot more, especially internationally."

A highly respected computer-industry analyst, William Becklean of Bache Halsey Stuart Inc. in Boston, says, "It's definitely a continuing trend, and will be very effective as long as IBM leaves its system architecture and software alone." But he suggests that IBM could counter by changing its systems "to offer significant benefits that are hard to duplicate." In fact, he points out, "IBM is looking at a substantial change in its product offering, and the 4300 may be part of it. IBM is due for a major new generation—it's four years late, but it will be introduced. I wouldn't bet any money against IBM." □

Letter from Ireland

Prosperity is tied to electronics

50 companies in the past five years have used Ireland as the gateway to the Common Market, and the recruiters are casting about for more

by Kevin Smith, London bureau manager

Ireland is a land of green and fertile valleys, thatched roofs, and friendly pubs. That's what the tourist people want the world to believe. But to the hard-nosed corps of specialists at the Industrial Development Authority, their nation is one with a plentiful and willing labor supply, an irresistible menu of tax incentives, and consequently what may be the fastest growing electronics industries in the world.

The romantic image of the Republic of Ireland is one that the IDA men, who have been remarkably successful in attracting electronics firms, more than 60% of them American, realize they have to live with. But the image they would rather broadcast is of an electronics community worth $892 million and employing 11,400 persons. And from what amounts to a standing start five years ago with 20 firms, it now numbers 70 companies scattered across Eire and boasts the highest return on investment in Europe—29.9%. The target for 1985 is a $2 billion industry employing 25,000 to 30,000.

The attractions are fat investment grants, a tax holiday on exports, a plentiful supply of labor, and a foothold inside the European Economic Community's tariff barrier. But there are obstacles, among them a shortage of skilled technical personnel and a communications system that has not kept pace.

The key is subsidies. "For each job we create, we spend around $10,000," says David Hanna, manager of the IDA's electronics division, who adds that the investment is returned to the economy within two years. In the past four years, the IDA has spent $165 million, but to get its money's worth it tries to pick companies in the professional sectors. The list of firms with plants in Ireland includes such names as Amdahl, Digital Equipment Corp., Analog Devices, Centronics, Computer Automation, Data 100, Memorex, Prime Computer, and Wang.

Fight. Though the IDA is far and away the most successful development agency in Europe today, the competition is getting tougher. There was a spectacular no-holds-barred battle last year between the Irish and Scottish development people over Mostek Corp. of Carrollton, Texas. The semiconductor maker finally settled on Dublin as the site for a $92 million assembly and diffusion facility.

Even then the IDA had to subsidize at well above its going rate to win Mostek over—an estimated $40,000 per job—and also agreed to establish a microcircuit research and undergraduate capability at nearby Dublin University.

Now that Mostek is in hand, the IDA is chasing additional semiconductor companies. Japan's Fujitsu Ltd. and America's Rockwell International Corp. are looking for European plants, and Nippon Electric Co. is adding to its assembly facility in Ireland.

Still, some companies make the point that almost everything has to be flown in. A shortage of support companies such as cabinet manufacturers and mechanical engineering

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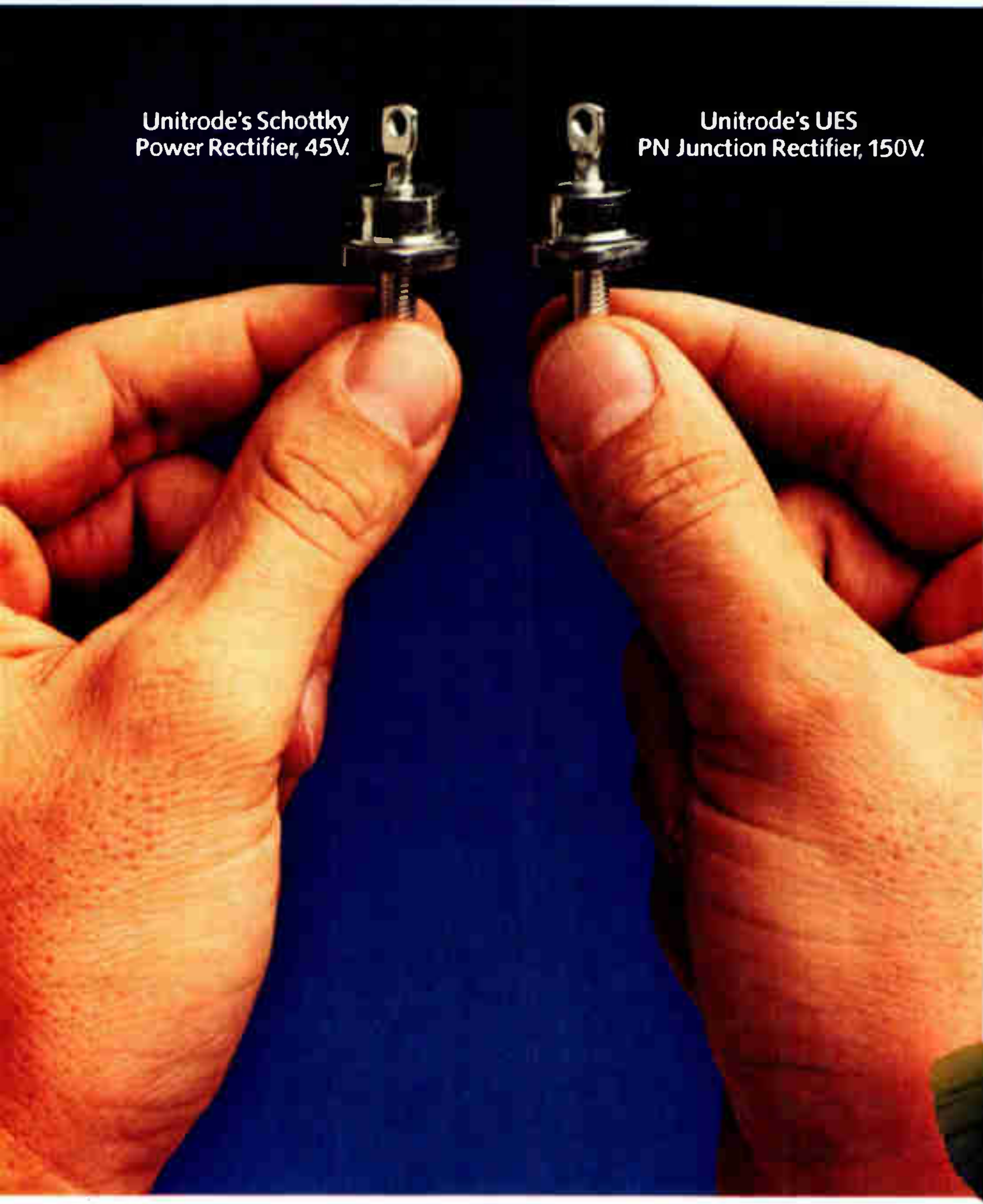

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Circle 103 on reader service card

See page 176

design outfits has presented problems in the past. But the IDA works to plug these problems as they arise, in one case persuading an English rack maker to come to Ireland.

Not so easily moved is the biggest roadblock in the IDA's plans for creating a fully integrated electronics industry: the shortage of skilled personnel. In the competition to attract high-technology firms, neighboring Scotland already has a highly developed university and technical education system boasting a top microcircuit research center at the University of Edinburgh. The industry there is highly integrated.

School days. To counter this challenge, gearing Ireland's educational system to the requirements of local industry is a top priority. New microcircuit research and training centers have been created at Dublin and Cork and an applications center at Limerick. And to meet the shortage of skilled technical personnel, one-year electronics conversion courses are now being offered to science graduates. Even so, the IDA is throttling back a little on its investment targets and is carefully monitoring projected demands for skilled personnel.

Companies already in Ireland have found other problems. Communications are bad, as even the IDA admits. But equally, because Ireland is such a small country, investment planned to improve matters can achieve rapid returns. Over the next five years, for example, some $1.3 billion is to be spent on modernizing the telephone network. This will effectively double its size and give it a high digital content, as modern solid-state exchanges are to be bought from the French company CIT-Alcatel and from the Swedish manufacturer LM Ericsson.

High inflation. A more worrisome problem for companies locating in Ireland is a rate of inflation now running at 17%, in part because of the high levels of indirect taxation. Wage rates for skilled personnel are now actually higher than in England. But for all that, both Ireland and England are among the cheaper European labor markets. □

How STC speeds production testing by a factor of five to one . . .

Storage Technology Corporation's revolutionary 8650 Winchester disc subsystem for big, mainframe computers utilizes double-density recording to pack twice the normal amount of data in the same space as a conventional, single-density disc.

Critical to the success of this technology are complex, high-speed, analog read/write and servo boards. In fact, STC's read/write board contains more than 350 separate active and passive components.

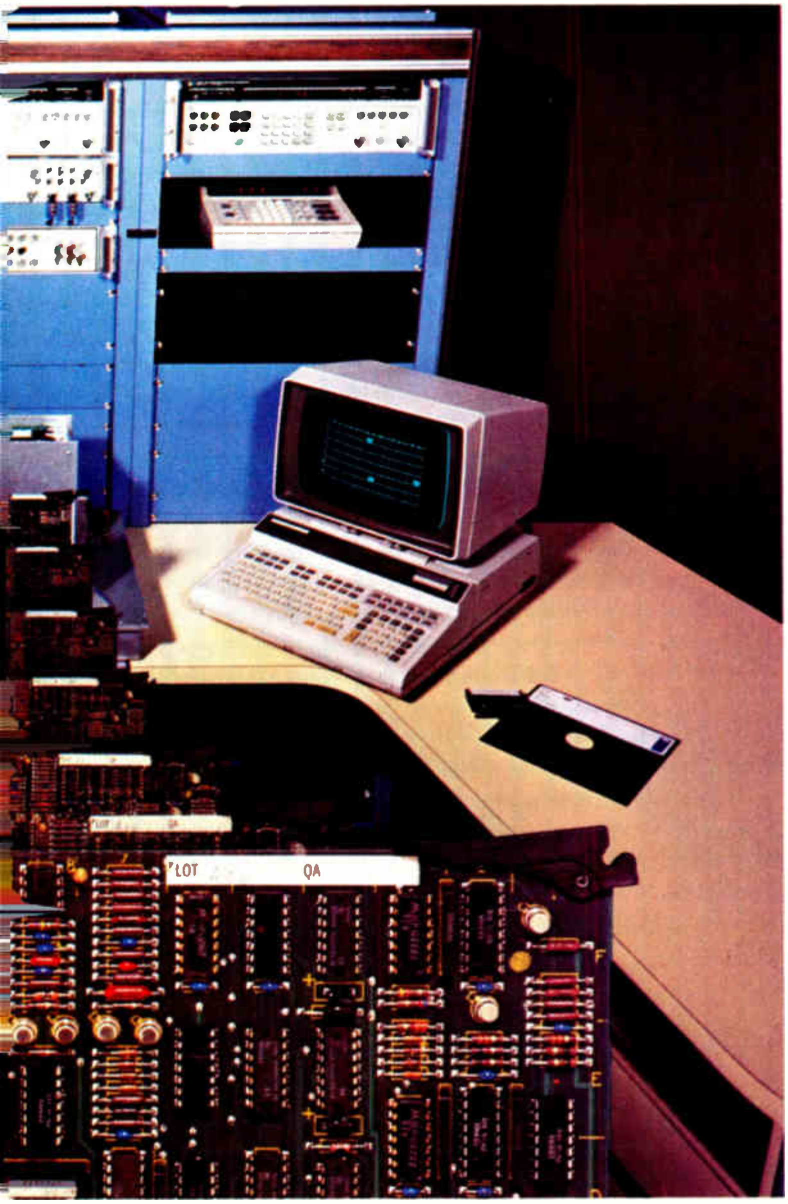
When conventional methods were used, it took approximately 15 minutes to test each board. As this testing time became more and more unacceptable, the decision was made by STC to switch to automatic testing.

Paul Zieschang, Manager of Hardware Development, recommended that the company assemble its own system using 12 HP-IB compatible insruments, an HP 9835A Desktop Computer as system controller and a 9885 Disc. Zieschang reports that the 9835A was chosen because its large CRT display made it easy for an operator to interface with the system, and because of its programming ease. What's more, STC incorporated diagnostics into the system which help STC technicians better understand the testing procedure. This software even helps technicians locate — via a flashing cursor and a graphic display of the board's topology — the position of any component on the board. Finally, the 9835A also delivers a print-out of the component's value and STC part number.

Documentation simplifies system configuration.
According to Zieschang, some of the many application notes supplied by Hewlett-Packard were helpful both in deciding the first configuration and speeding assembly of STC's first HP-IB system.

Flexibility that reduces the chance for obsolescence and speeds assembly.
Twelve HP-IB compatible instruments were chosen for this system, according to Zieschang, because HP's bus architecture and programming ease permit the flexiblity necessary to make changes within the system as STC's requirements change and, thus substantially reduce the possibility of system obsolescence.

HP instruments also provide STC with speed of assembly. The company assembled and programmed its first automatic



using HP-IB "designed for systems" instruments and computers.

test system faster than other comparable ways of solving its system test needs. Zieschang believes they will be able to assemble and program future systems even faster.

The bottom line.

Just as important, Zieschang says the STC HP-IB compatible system will reduce testing time from 15 minutes per board to approximately three minutes. A factor of five to one. The system is also expected to reduce the time required to debug faulty boards from 45 to 20 minutes. In short, STC's HP-IB system will help the company turn out more boards per day.

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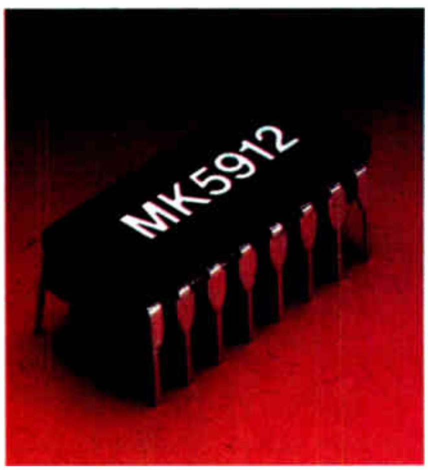
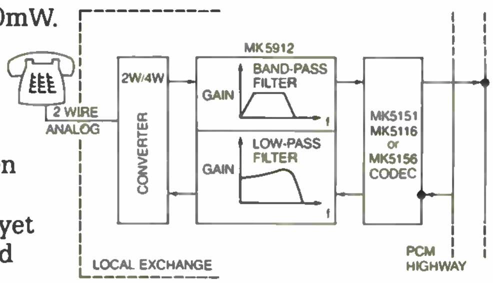


The receive filter in the MK5912 is a low-pass filter which smooths the voltage steps present in the Codec output waveform. Then provides the correction necessary to give unity gain in the passband for the Codec decoder and receive filter pair.



The MK5912 complements Mostek's present generation Codec products. Power supply and clocking requirements are identical for the two devices. This insures compatible system architecture. Reduces external circuitry. And simplifies interfacing.

For more information on the MK5912 as well as Mostek's complete line of lower power telecommunications ICs, call or write the low power source: Mostek, 1215 West Crosby Road, Carrollton, Texas 75006. Phone: (214) 323-6000. In Europe, contact Mostek Brussels at 660.69.24.

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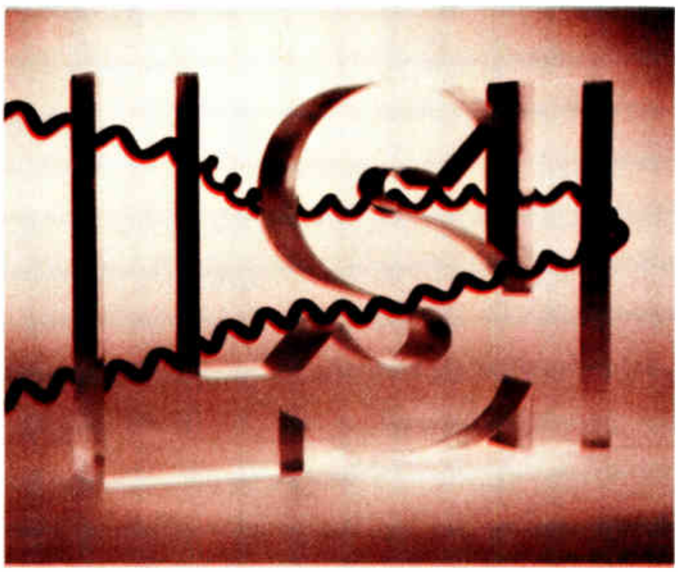
Circle 112 on reader service card

SPECIAL REPORT

Large-scale integration latches onto the phone system

A $2 billion chip market will shortly open up as manufacturers of telecommunications gear and semiconductors resolve their differences

by Harvey J. Hindin, *Communications & Microwave Editor*



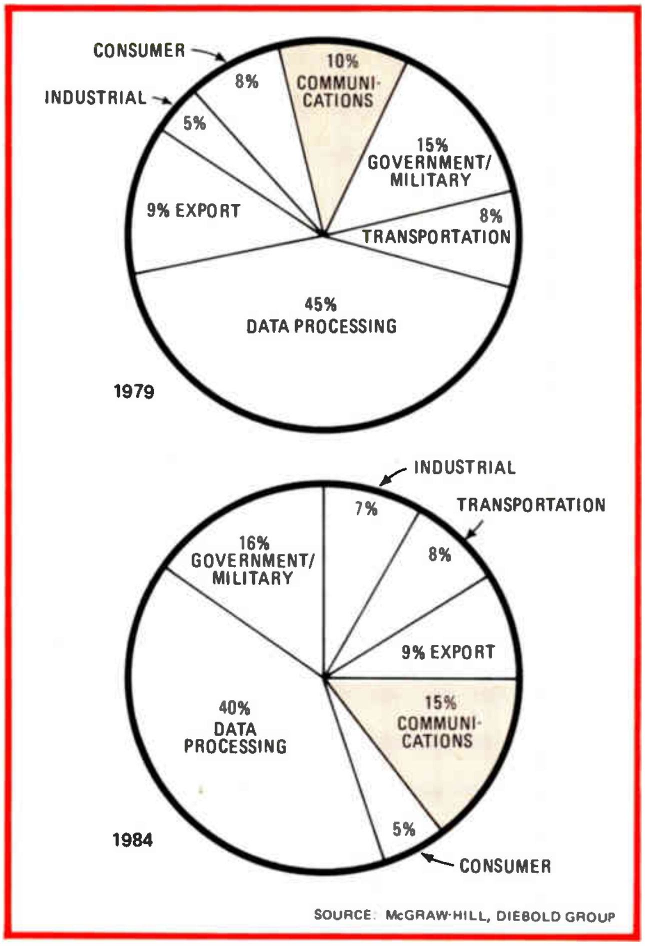
☐ Though in terms of circuit design all-electronic telephones and telephone networks have been feasible for many years, in terms of performance and cost they became practical only with the large-scale integrated-circuit developments of the late 1970s. For the 1980s, these developments portend a new LSI market that semiconductor companies estimate at between 10% and 20% of chip shipments within two or three years (Fig. 1).

Texas Instruments Inc. of Dallas is typical. According to telecommunications circuits branch manager Glen Haas Jr., it estimates that "the opportunities are there for what may be 16% of our sales by 1985."

The telephone manufacturer will shortly be offering the user higher performance, better reliability, and altogether new features at little or no extra cost (Table 1). The user will gain a previously unobtainable convenience that also makes his phone more cost-effective. The benefits of LSI will also accrue to the switching equipment manufacturer and the telephone operating companies.

The European view of these benefits typifies the worldwide industry opinion. "For the subscriber, LSI is making the subset more attractive in that it easily implements already existing or soon-to-come features such as repeat and abbreviated dialing, indication of time, rate and length of call on a handset-mounted display, and storage of often used numbers," says Rüdiger Karnatzki, director of European marketing at Intermetall GmbH of Freiburg, West Germany, leader of the ITT Semiconductor Group.

Werner Flagge, product marketing manager for telecommunications integrated circuits at Siemens AG of Munich, sees LSI as also a means of "optimizing the production cost for manufacturers." LSI, he says, "can make all these services possible with high reliability, at reasonable additional cost, and without consuming much space in the subset." Amplifying, Karnatzki adds that LSI can make switching technology faster and more flexible and allows better use of space. This is particularly true for digital devices. For example, Flagge says that "the savings in space is enormous when a digital is compared with an analog central office switch." LSI also



1. Half again as good. A comparison of actual 1979 figures with these 1984 predictions shows that the communications chip share of the semiconductor market will grow 50% in that period. In dollar terms, there will be 300% growth, from $0.69 billion to over $2 billion.

makes for better interfacing of this switch gear with transmission lines, he adds.

With all these advantages an electronic phone that is cost-competitive with older electromechanical devices is still no mean feat. Having been manufactured for a century now by the gigantic worldwide telephone industry (see "Where the top telephone markets are heading," p. 115), electromechanical phones have undergone many engineering economies and are well advanced on the learning curve. The LSI chips basic to their replacements must therefore be manufactured in large volume to keep overall costs down to comparable levels.

Keep it working

The need for mass production has driven the LSI industry to address the problems of chip reliability and testing, correct process technology, and chip architecture that have hindered its forays into telecommunications applications until now. And, while these problems are far from being solved, solutions are now at least on their way. Thus the impact of LSI on telephony will develop to its fullest in the next few years.

"They ask for 20 years of life data on a two-year-old chip," remarks an LSI test engineer, in frustration. Another chip engineer deplores New York Telephone Co.'s recent hoopla over the retirement of a 1923 electromechanical switch at the Wadsworth Exchange Office in Manhattan. "What can you do with people like that?" he exclaims. "They're proud of it—I'd hide it."

These outbursts reveal a mutual lack of understanding—of chip manufacture, on the one hand, and of the economics of the telephone industry and its regulatory environment, on the other. And a quick change in such attitudes is not helped by the fact that telephone people tend to be older and more conservative than the go-go inhabitants of Silicon Valley in California and Silicon Gulch in Texas.

Yet it is important to remember that long-term equipment service has been the rule worldwide. For example, according to W. T. Jones of Standard Telecommunications Laboratories Ltd. in Harlow, England, "telecom-

TABLE 1: SERVICES FOR THE TELEPHONE CUSTOMER OF THE 1980s

Service	Description
Short code dialing	Allows the customer to associate a long telephone number with a short code, by saving him (or her) the necessity of entering the full phone number each time he wishes to call that number.
Repeat last call	Sets up a repeat attempt to the last telephone number dialed – particularly helpful when a number is engaged upon the first attempt.
Repeat last stored call	Enables the number last dialed to be stored for later use, enabling the user to dial other numbers before making a repeat attempt at the stored call.
Alarm call	Enables the customer to book a call to his own phone at a specified time. The maturing call can then be used as a reminder or an alarm call.
Incoming calls barred	Enables the customer to bar incoming calls to his phone.
Outgoing calls barred	Enables the customer to bar outgoing calls from his phone.
Basic diversion service	Diverts all incoming calls to another phone.
No-reply diversion	Diverts incoming calls to another phone if the call remains unanswered for a specified period of time.
Engaged diversion	Diverts incoming calls to another phone if the called phone is engaged.
Call waiting	Provides a means of answering an incoming call when the customer is already engaged upon the phone.
Three-party service	Enables the customer to set up a three-way conversation on his phone.
Remote control service	Enables a customer to set up services on his phone from any other phone.

SOURCE: BRITISH POST OFFICE RESEARCH CENTER

Where the top telephone markets are heading

The U. S. will trail not only Europe but also Asia in the number of telephones installed by the end of the decade, predicts the consulting firm of Arthur D. Little Inc. in Cambridge, Mass. But have no fear, says the firm's senior telecommunications expert, Edgar A. Grabhorn. With the 1990 world population projected at 5.3 billion and a total of "only" 520 million telephone main stations installed by then, the market "will be far from saturated."

In terms of revenue per telephone, the major share of this $380 billion market (in constant 1979 dollars) will still belong to the U. S. because of its tremendous business usage. Nevertheless, Grabhorn believes that, in terms of numbers of phones alone, the U. S. will lose the lead to Europe by the end of 1981.

Such mind-boggling statistics have long been characteristic of the telephone industry, and it clearly is going to remain a giant among the giant industries of the world. According to Little's Clifford A. Bean, also a senior member of the telecommunications staff, the worldwide market for business communications alone will quadruple over the next decade. This translates from a $6 billion level at the beginning of 1980 to $24 billion (in 1979 dollars) by 1990. Here the U. S. accounts for more than half the total, despite the fact that European nations have more business telephones. Reflecting the nature of its economy, the honor of having the highest percentage of business phones (57% of total phones) goes to Africa, says Bean.

Suppliers of devices to go along with telephones for business purposes and of telephone systems, like private branch exchanges, geared to business applications, should note that business communications networks in Europe and Asia lag those in the U. S. by about five years, Bean says. The rest of the world is up to a decade behind.

The best of the telecommunications markets? Bean names the transmission equipment sector. Including local cable, carrier, microwave, satellites, fiber optics, and all associated equipment, its sales will increase fivefold. So the $1.7 billion laid on the table in 1979 will grow to $10.3 billion (in 1979 dollars) by 1989.

It is hard to find out just what percentage of this transmission equipment market is open to, for example, the kind of pulse-code-modulation amplifier chips made by Exar, Precision Monolithics, and others. But for the makers of these and the dozens of other LSI products, it is a several hundred million dollar business to tap. This is true of not only the transmission path but also the telephone itself and the telephone switching offices.

Moreover, because the telephone industry is adopting digital technology in place of the older analog technology, which is less able to make cost-effective use of LSI, the digital telecommunications market alone is expected to grow nearly eightfold from 1978 to be in the $1.5 billion range by 1985, concludes the Cambridge, Mass.-based Yankee Group market research firm.

According to the Yankee Group president, Howard Anderson, digital telephone switching will "almost completely dominate the high end of the network hierarchy by the mid-1980s." That is good news for purveyors of codecs, filters, and subscriber-loop interface circuits, which are used in vast quantities in these large switches. The news is also good for those who want to put their digital chips in local telephone offices. By 1990, according to the Yankee Group, the digital telephone switch will be "in a dominant position" in the switch market.

munication systems and equipment are expected to have a lifetime of 20 years or more according to CCITT recommendation G.1029."

Most spokesmen for the semiconductor industry feel that the reliability problem has been overplayed: the chips have adequate safety margins, and it is simply a matter of proper communication to determine what real systems require.

Siemens' Flagge, for instance, to whom reliability is always "in the foreground," says that "the knowledge in chip development is so extensive that the industry has got the reliability problem under control." For example, he notes that many transmission-line chips achieve a failure rate of 50×10^{-9} error per hour—that is, only 50 errors in 1 billion hours. His view has weight because Siemens, like Bell Laboratories in the U. S., Canada's Mitel Inc., and others, has access to the views of in-house chip and in-house equipment people. Still other companies without the benefit of a direct connection work very closely with their customers (see "Improving connections between users and makers," p. 117).

For Bell the reliability problem is defined by infant mortality rates, which it has devoted a lot of effort to beating. Says Klaus Bowers, Bell's vice president of electronic technology at the Murray Hill, N. J., facility: "Wear-out just does not occur," meaning that the long lifetimes traditionally required for telecommunications equipment need not be compromised if the chips are selected so as to avoid infant mortality.

He feels that Bell's handle on reliability is real—that it is not technology-limited but "will-limited." By this he means that once the management decision has been made to go after a certain level of achievable reliability, it can be done. This approach has been taken by the Japanese [*Electronics*, March 13, 1980, p. 140]. In Bowers' opinion, the much-publicized Japanese reliability is excellent but no better than Bell's. "The reliability on the outside is much more variable than ours," he says, although "the best on the outside is equal to ours."

Other industry people who were willing to comment agree with Bowers that the LSI industry and the equipment manufacturers will work out their reliability problems, once they decide what needs to be done. And, of course, a great deal of the reliability problem will go away once chip architectures and processes are standardized. For now, there are just too many of these for reliability engineers to be comfortable.

How to test it

"The investment in test equipment needed to be in the telecommunications business can be taken care of without any more effort than in the consumer or automotive business. The market is not more demanding than other fields we are in." These remarks by TI's Haas sum up the semiconductor industry viewpoint.

Until quite recently, that was not the case. Chip

TABLE 2: COMMON DIALING STANDARDS				
Name of service	Where used	Total number of tones	Code	Number of characters
Dial-tone multifrequency (DTMF); Touch-tone; Tone-dialing	subscriber to central office	8 (4 high-band, 4 low-band)	dual 1-out-of-4 (two bands, with each code composed of one tone from each band)	16 total, 12 commonly used (digits 1–0, * and #)
Dial pulse; rotary dial	subscriber to central office (10 pps)	none	1 to 10 breaks in loop current for digits 1 through 0 respectively	10
20-pps (pulses per second) dialing	private branch exchange to central office, or office to office (20 pps)	none	1 to 10 breaks in loop current for digits 1 through 0 respectively	10
Multifrequency; MF; toll MF	office to office, or PBX to office	6	2-out-of-6	15 total; 10 commonly used
Compelled multifrequency; MFC; R2	international standard for gateway to gateway	12 (6 high-band, 6 low-band)	2-out-of-6 forward channels; 2-out-of-6 reverse channels; compelled handshaking	30 total: 15 forward and 15 reverse

companies scrambled to jury-rig test gear or else bought bits and pieces of whatever test equipment was available and hired people with telephone experience specially to modify it. But now they buy ready-to-operate systems.

To test coder-decoder chips, or codecs, for example, a system made by W&G Instruments Inc. of Livingston, N. J., is popular (see "Testing telecommunications chips," p. 118) and in fact is commonly described as the industry pacesetter. In one use, TI controls its W&G system with a TM990 minicomputer working through an IEEE-488 bus.

Overall, the test engineer has a much easier life than a few years ago, even though some problems of data interpretation remain.

What's in a process?

Even as the industry gets a handle on reliability and testing, a scorecard is needed to keep track of the various process technologies used to implement the chips. Yet, even here, one process—complementary-MOS—will ultimately take over except for special applications.

The reason is that the telephone system is very power-conscious. The telephone itself is powered by central-office batteries. Typically, hundreds of thousands of chips sit in a central office and, in the aggregate, burn up amperes of current. C-MOS, in general, uses the least of this precious power.

In commenting on the best technology for LSI phone circuits, Intermetall's Karnatzki says "the low-voltage C-MOS processes are most favored" for devices used in telephone handsets. This preference holds also for chips for amplifiers used in the transmission path between switching offices.

According to Alan Grebene, vice president of Exar Integrated Systems Inc. in Sunnyvale, Calif., his company is starting to move into C-MOS for its pulse-code-modulation (PCM) amplifier chips. Lower power consumption is the reason Grebene gives for moving away from bipolar technology.

The C-MOS consensus seems international. Says Emile Julier, chief of the external research and development service for the industrial and international affairs division of the French telecommunications authority: "The pulse dial circuits required for the push-button phones going into service in France are our first LSI circuits in handsets, and C-MOS is the prime choice for them because of its low power requirement."

Another telecommunications executive confessed to being "amazed that Intel and others have not made major moves into C-MOS." He was commenting on what some have called "process inertia". It is no easy thing to expend the funds to bring a new technology into an LSI house that has been using fully developed older processes. Markets, technology, and personnel, as well as funding, must all be available.

Decisions, decisions

To make matters worse, even deciding what process to go to in a particular product may be a problem. The situation in codec filters has been particularly chaotic, with companies actually having changed processes in the middle of the product development cycle (p. 124).

Improving connections between users and makers

Semiconductor companies, which work directly with their telecommunications customers on the development of new large-scale integrated circuits, are very hesitant about revealing details. "The equipment people are very concerned with the proprietary nature of their architecture," explains one LSI marketing manager. "It's that architecture they feel makes their product unique. We understand that and cooperate."

But there are dissenting voices. "Unique my foot" is one of the more printable comments. "The large equipment manufacturers and telephone companies have well-established in-house LSI groups or tight private relationships with certain LSI manufacturers. Neither the companies nor the designers want to do anything that might put some of their buddies out of work, so they talk about custom chips and unique architectures. For the most part, if they were open about it and defined what they needed in advance, we could furnish them with a lot more in the way of standard products."

This critic, who wished to remain anonymous, went on to claim that "the whole industry would benefit from the price reductions such an approach would bring." But he does not expect it to happen.

Besides not wanting to surrender the proprietary appeal of their gear, the equipment manufacturers worry about dealing with LSI houses whose reputation for on-time delivery of new products is less than the best. Moreover, to these conservative buyers, the ideal is second and even third sourcing of chips.

The view of most telecommunications chip manufacturers and equipment makers is fortunately more positive. They feel that the relationship is an evolving one: "We are learning what the requirements are—this is a new endeavor for all of us."

In this evolving relationship, the LSI companies are trying to adopt a modular approach. They want to sell as many standard chips as possible, with auxiliary chips and read-only memory used to specialize devices and functions. But their customers' acceptance of this approach is still unsure. Companies such as AT&T, Bell Canada, and Mitel Inc. have both equipment and LSI groups in house and lack the obstacles to communication that can hinder the modular approach. Instead, the two camps in these operations usually have the same goals and cooperate closely in realizing them.

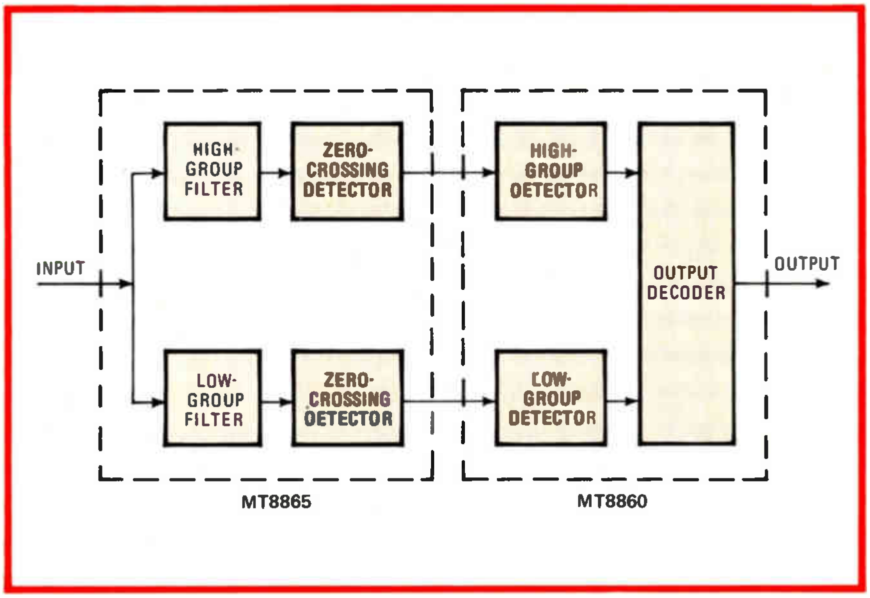
Even without this identity of aim, both the LSI houses and the equipment manufacturers need and work with one another. The semiconductor makers recognize a market when they see one and try to maintain good customer relationships. And the equipment makers know that, as the U. S. Department of Commerce put it in its 1980 survey of key industries, "the increased use of LSI promises more cost-effective communications in the 1980s. The wired household and office will begin in this decade."

England's Plessey Co., for one, is expending a lot of effort on deciding whether to make its codec filter with the charge-coupled-device or the switched-capacitor approach. In the main, though, other companies in the field have already decided on switched capacitors.

Still, the diversity of processes used by the LSI companies will become obvious as this report is read, even though, unlike a few years ago, one process—C-MOS—seems to be developing a substantial following.

Mass production is the aim of all LSI manufacturers to keep the price rock-bottom. To meet it, they prefer a modular approach in which a few chips, each with a well-defined function, are interconnected to yield the desired performance. But just how many chips are needed, what their functions should be, and how they are to be interconnected has been a matter of controversy with the equipment makers.

For its part, the LSI industry feels that if the equipment manufacturers are sufficiently open with their specifications, the chip people can supply general-purpose devices. That, it says, will suit everyone and the chips can be manufactured in a cost-effective way. Where variations are needed, programmable read-only memories or a few special devices will be adapted. On



2. Smart pair. The Mitel two-chip set performs all the functions necessary for a dual-tone multifrequency telephone receiver. Digital counting algorithms are implemented in the output decoder to ensure the correctness of the number that has been received.

Testing telecommunications chips

Testing of the new large-scale integrated telecommunications chips, though not an insurmountable problem, has been difficult for the manufacturers who have to guarantee specifications. Several test equipment makers offer combinations of test gear, but one of the most popular setups seems to be made by W&G Instruments Inc. of Livingston, N. J. An affiliate of the firm of Wandel and Goltermann of West Germany, W&D's AMS-95was originally intended for telephone company operations centers, according to director of marketing Bob Handrahan.

"Products like codecs are made by people whose expertise lies in digital rather than analog areas of the technology," Handrahan says. But a codec, being in part a digital-to-analog and analog-to-digital converter, needs direct d-a and a-d measurements.

"No one had an easy way of getting into the middle of the bit stream to do this kind of measurement," says Handrahan. The codec people, he says, were relying on what is known as parametric measurements. Here the transmission tests are made and dc measurements obtained by means of purely digital techniques, and the numbers require interpretation and translation before transmission performance can be predicted.

But, says Handrahan, "the AMS-95 can make a-d or d-a measurements directly" on such parameters as quantizing noise, idle channel noise, tracking, signal-to-distortion ratio, insertion loss, frequency response, intermodulation distortion, and crosstalk—in short, the key tests of codec capability. Many of these tests either cannot be carried out at all by competitive equipment or are much harder, he maintains. Three of the LSI manufacturers said much the same thing, although they would not be quoted.

To achieve this capability, W&G uses its knowledge of telephone transmission measurements, which have a long history in both the U. S. and Europe. In contrast, the techniques of digital measurements are not only newer but also not geared specifically to codecs.

The AMS-95 can also be used for testing channel banks and switches as well as line cards. It is only necessary to make appropriate software and hardware modifications. All the hardware is housed in a 72-inch rack controlled by a Hewlett-Packard 9825S desktop calculator.

According to the chip makers who have bought the gear, it is not for the uncommitted, since depending on options it costs in the neighborhood of $100,000. But, they add, "you have to have something like it."

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the other hand, the equipment manufacturers want to maintain the proprietary nature of their system designs, so they have often striven for custom chips suitable for specific purposes in specific systems. Only now, with the increase in communication between the chip and equipment manufacturer, does the debate look as if it is being resolved.

These days, semiconductor manufacturers determine their component architecture in close collaboration with telecommunications customers. Unfortunately, the fact that there are no industrywide standards and that architectural design is done on a one-for-one basis has caused many problems. Worse still, to quote one LSI marketing manager, there have been "a lot of bucks wasted" on producing what one equipment manufacturer called "parts which do not even remotely function the way their name implies—at least as far as we are concerned."

The words "as far as we are concerned" are significant. The specific product in contention here was a codec that had been designed by the LSI company to the specifications of one customer. But, as far as this other customer was concerned, the codec had too few functions on chip and needed too many auxiliary chips.

The problem is a continuing one for the industry and is particularly acute for codecs, codec filters, and subscriber-loop interface circuits. Only time and the long overdue but inevitable shakeout will tell which functions should or should not be included on the chip.

A horrible example

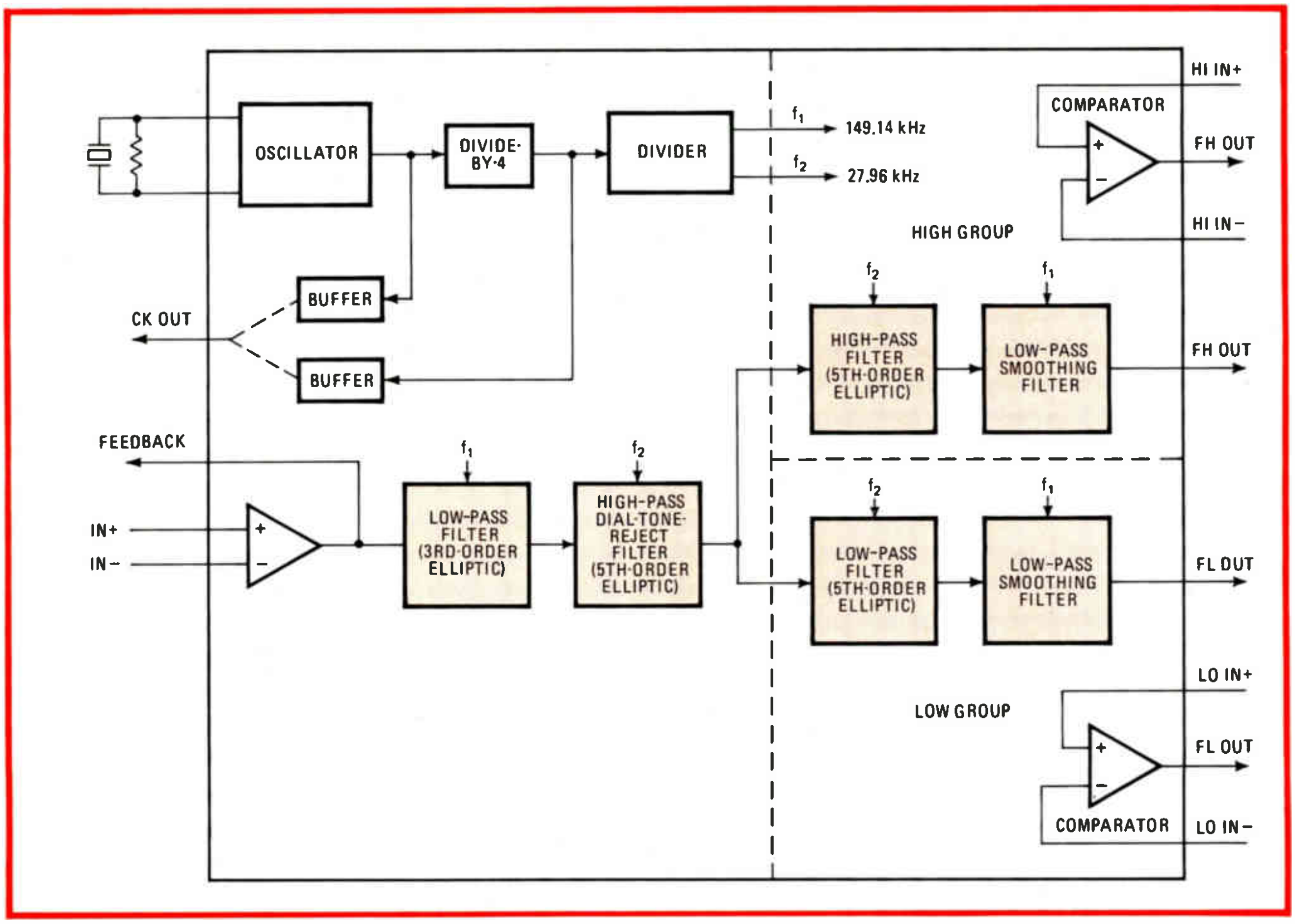
Codec design is an example of a game with no architectural rules. There is American Microsystems Inc. of Sunnyvale, Calif., with its single-channel separate coder and decoder chips. There is Precision Monolithics Inc. of Santa Clara, Calif., which is shipping lots of its shared-channel multiple-chip codecs. And available from several manufacturers are single-channel single-chip codecs.

PMI pushes the space and power-saving abilities of its shared-channel codec. But its competition, while agreeing that sharing is valid in many cases, adds hastily that over the long term, shared-channel codecs will be replaced by per-channel devices.

For the director of Bell's Pennsylvania Laboratories, in Allentown, Pa., the shared- versus per-channel codec issue is readily settled. Says Michael Thompson: "When you have lots of multiplexing, shared devices are the way to go. But individual encoding gives more flexibility." He observes that Bell engineers feel that there is no such thing as a universal codec—whether shared- or per-channel—and the LSI industry would be wrong if it tried to design one. "For example," he says, "codecs need varying dynamic ranges for different applications, maybe from an 8- to 12-bit swing, so it is not practical to design one device to do it all—you would pay too high a price in performance."

The codec will not appear in actual phones for many years yet. That seems clear to all segments of the industry, at least for volume applications. For the phone itself, for the next two or three years, the major concern will be the LSI chips that work with the keypad. This use of LSI technology has been developing since the late 1970s and is now almost mature—or as mature as an LSI industry can be. In contrast, for the switching office, brand-new codecs, filters, and subscriber-loop interface circuits have just begun to make their mark. Already heavily used in Canada, they will enter common use throughout the world within the next few years. For the transmission path, new PCM amplifier chips will be used even more than now.

That is not to imply that there are no telecommunications opportunities for less specific LSI devices—far from it. Microprocessors and memories, both read-only and



3. Extra amplifiers. The American Microsystems bandsplit filter is designed to work with other manufacturers' DTMF receiver chips. It provides all necessary filtering functions, as well as an uncommitted amplifier for users' convenience in adjusting signal levels.

random-access, are finding extensive use in the telephone switching network and private branch exchanges as well as in certain new telephones. But these applications, governed by stored program control, have their own special problems and are not addressed in this report.

Still other components that can fit into an electronic phone, such as chips that replace the carbon microphone and the mechanical bell, are not yet ready to make their impact in volume-production devices. Similarly, in order to keep this discussion within bounds, speech-analysis and -synthesis chips, although important for the telephone of the 1990s, are not discussed. Their impact will only start to be felt in the mid-1980s.

Behind the dial

LSI technology has been utilized in the design of telephones since the mid-1970s in simple applications. But since the start of the 1980s, far more sophisticated uses have become possible.

The best example is the upgrading of the dialing procedure, with LSI circuits interfacing with the telephone keypad. This upgrading must be both downwardly compatible with old devices and upwardly compatible with forthcoming ones, for the industry is too large and has too much invested in physical plant to pursue any other course.

The push-button keypad is both the actual entry point into the telephone system and the first device to interface with LSI circuits. It can provide one of two forms of telephone signaling.

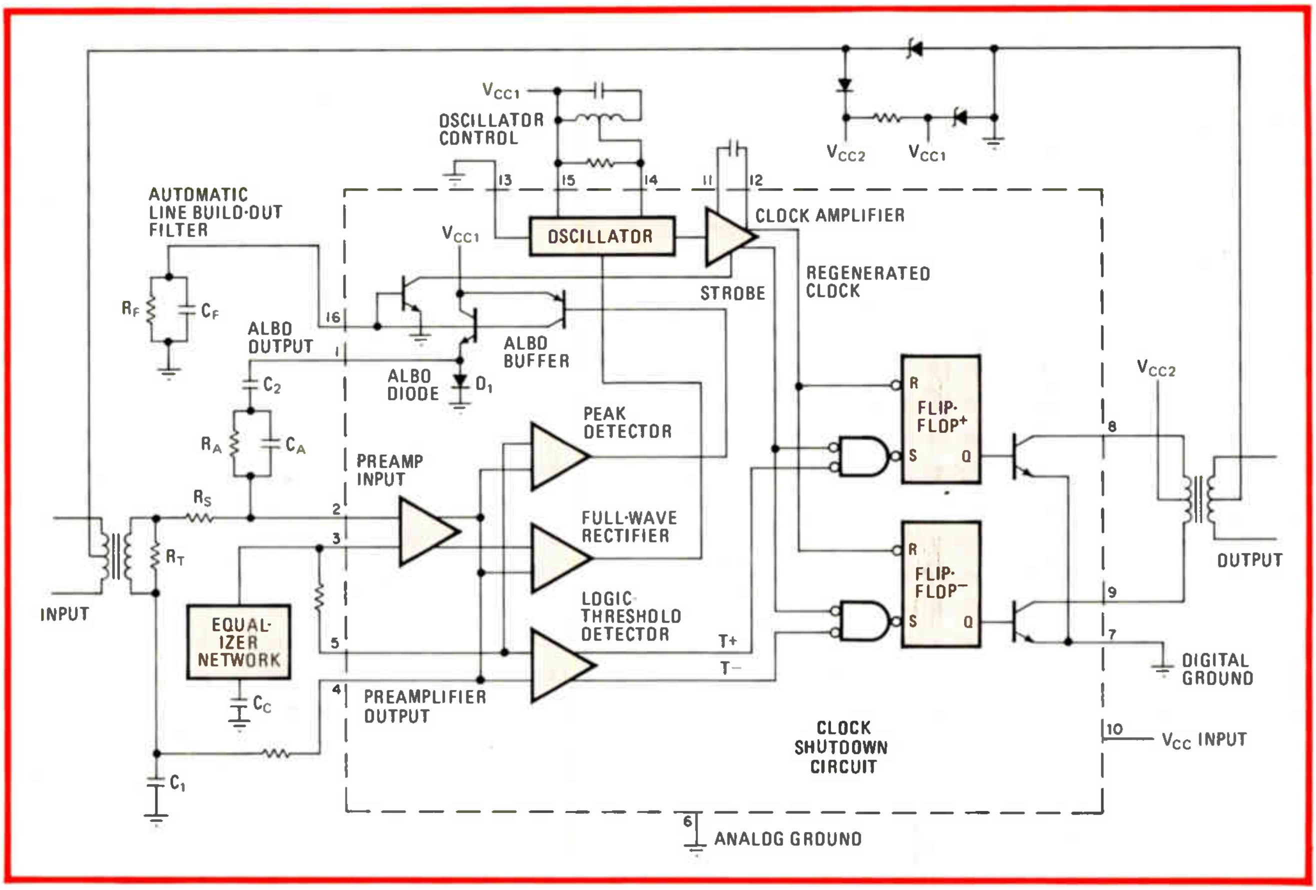
On the one hand, the keypad may originate the so-called loop-disconnect pulsing of the kind produced by the older rotary dial. In fact, many digits (18 or more) must be keyed in rapid succession. LSI chips then store and pulse the signals out to the transmission line at 10, 20, or more pulses per second (Table 2).

The number of digits, pulses, and other operating parameters of the system are determined by the standards of the country of origin and the nature of the equipment (telephone, private branch exchange, or switching office). All the necessary pauses to keep the pulses well synchronized and timed, such as pre-sending pause, interdigit pause, and post-sending pause, are taken care of by the chips.

The DTMF approach

In contrast to the well-established loop-disconnect pulse method is the newer approach of multifrequency tone signaling, or dual-tone multifrequency dialing. In the DTMF technique each digit is represented by a different pair of frequencies within the audio band. Depressing a button sends a tone, audible in the handset earpiece, to the line for as long as the button is held down.

In the race to make the phone all-electronic, these



4. Flexible. The Precision Monolithics RPT-82 is a monolithic chip that provides the amplifier and other circuit functions for pulse-code-modulation repeaters used in transmission lines. The chip can accommodate up to 36 decibels of loss variation in these lines.

keypad interface chips form the largest market in the short term, or so many companies feel. They look with envy at Mostek Corp., Carrollton, Texas, which ships 150,000 chips of this type per week.

Approaches to this market vary from Mitel Inc., Ontario, Canada and its Touch-Tone–decoding two-chip set, which deals with either rotary or push-button dials, to Siliconix Inc. of Santa Clara, Calif., and its offering of a new design specific to the loop-disconnect technique. Both companies claim that there is enough of a market for them each to gain a significant share in it in the next few years. Nor are they alone in this view. AMI, for example, even feels that it is important to address special chips just for parts of a DTMF system.

Buyers of the Mitel set will be able to use it not only for tone decoding but also to upgrade older rotary dial switches in central offices to receive Touch-Tone pulses. As a bonus, the chip set can be used to restrict certain digits and thus control the placing of long-distance calls.

In this design, says the company's Robert Broomfield, integrated-circuits applications manager, the front-end operations of band splitting, dial-tone rejection, and limiting are done by the MT8865. This is an analog chip containing two sixth-order bandpass filters and comparator circuitry. It is mated to the MT8860 digital decoder chip, which detects and decodes the DTMF signals using all-digital techniques (Fig. 2).

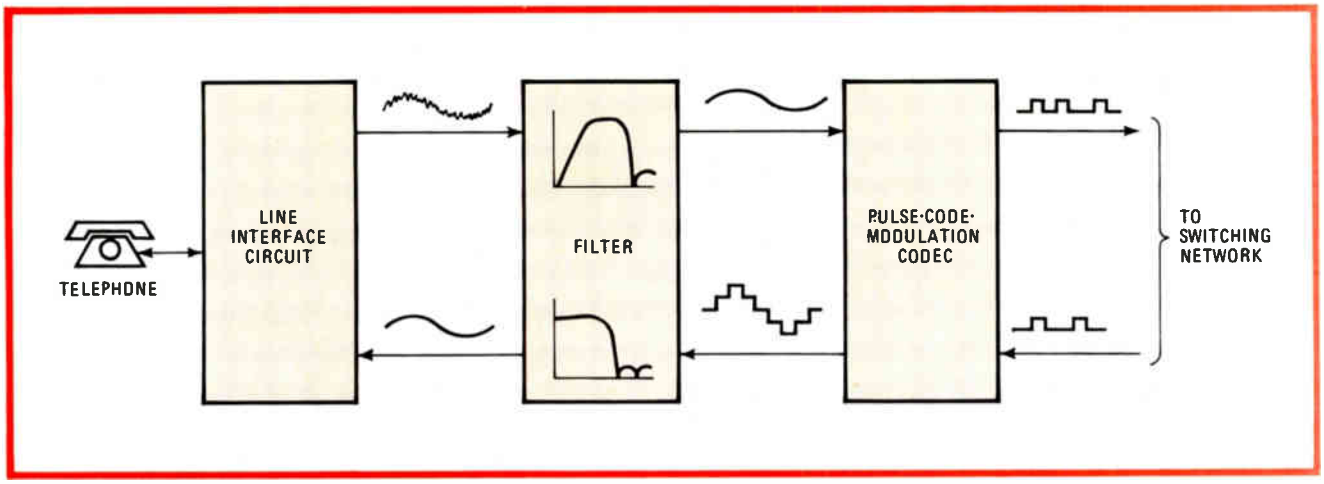
Early in the decoder chip design cycle Mitel decided to limit the number of detectable tone combinations to 16. "This number is adequate for most applications," Broomfield says. It also simplified the tone detection problem, so that a scheme to do it could be implemented with just two chips. The price paid? Multifrequency receivers, which must detect two out of a greater number of possible combinations and are therefore more complicated to implement, cannot use this chip set.

The loop-disconnect route

Even though DTMF receivers are taking over a substantial part of the keypad business, for Graydon Timm, Siliconix senior design engineer in Swansea, Britain, and Barry Boulton, telecommunications marketing manager based in Siliconix' headquarters in Santa Clara, Calif., there is still a lot of business in loop-disconnect dialers. They have what they believe is a most cost-effective offering and it is in the design stage. Samples will be ready in October of this year, according to Boulton.

Users of telephones employing one of the four DF820 chips will be able to redial the last number they called by just hitting one button. They will also be able to enter a number directly from information without the intermediate step of writing it down. Both will be unique for loop-disconnect dialer chips, especially at the price.

A low price (which is not yet established) will be possible because Siliconix solved the problem of pulse output timing, the requirements for which vary from country to country. Siliconix did not want to offer the variations by creating an expensive chip with multiple



5. All in one. The subscriber telephone is connected to three cascaded LSI chips before it is interfaced with the telephone switching network. Today, only the codec and filter are available on one substrate. Ultimately all the components shown will be on one chip.

programming pins, so it designed a separate ROM in which all the combinations could be preprogrammed.

The chips from Mitel and Siliconix are by no means the only choices available to the telephone keypad interface designer. Silicon Systems Inc. of Tustin, Calif., for example, has for months had production quantities available of what the company calls the first DTMF receiver on a single chip.

No front-end prefiltering is necessary in this system. Only a crystal for a reference oscillator and two bypass capacitors are needed to turn on the monolithic device. The analog input signal is subject to both a 60-hertz reject filter and a preemphasis shaping before it is fed to high- and low-bandsplit filters and the zero-crossing detectors. The decoded output digit is furnished to the subsequent telephone circuitry as a binary code, with four pins providing 16 different signals. The chip provides its own power regulation and all necessary timing and voltage references.

For low-cost keyboards

For Intersil Inc. of Cupertino, Calif., a Touch-Tone decoder chip should also work with inexpensive keyboards. So, says the company's director of telecommunications products, Fred Kashkooli, it is introducing a Touch-Tone decoder chip that not only contains an oscillator mute feature but is also designed for operation with single-contact calculator-type keyboards.

The latest in a family of Touch-Tone decoders, the ICM7206C, has an oscillator mute that enables output switching only when a special key is pressed, so that spurious side-tone generation is completely avoided. It interfaces with either a four-by-three or four-by-four single-contact keyboard, for it can generate either the single or dual tones required by such systems. The 16-pin dual in-line package is also available in die form for direct mounting and will operate with as little as 3 volts. To become a minimum-operation low-cost tone generator, it needs only nine additional parts, which Kashkooli says is a minimum of extra parts for such a system.

DTMF components are also being made available by manufacturers who have chosen not to make complete systems because of their complexity. One chip with several user-oriented features that will be ready for sampling by customers in the second half of this year is the S3525A/B from AMI (Fig. 3).

This bandsplit filter for DTMF receivers has an uncommitted input amplifier to let the user control programmable on-chip amplification. This feature is useful for equalization of the different signal levels that must be accommodated when the filter chip is used in different kinds of receivers. As an 18-pin monolithic device designed to work in conjunction with other manufacturers' receivers, the 3525 serves the complete filter function, including a dial-tone filter, high and low group separation filtering, and limiting for squaring off of the filtered signals. Another benefit of the design: for flexibility the limiter and filter outputs are externally available as is the chip's internal ground.

The only difference between the A and B versions of the chip is in the frequency of the output clock signal. In the B version, it is 894.89 kilohertz; in the A, it is 3.85 megahertz. The different clocks are suitable for different applications. For example, the A can be used with digital DTMF receiver chips that need the industry-standard 3.85-MHz time base. Then, only one crystal is needed for both the filter and receiver chips.

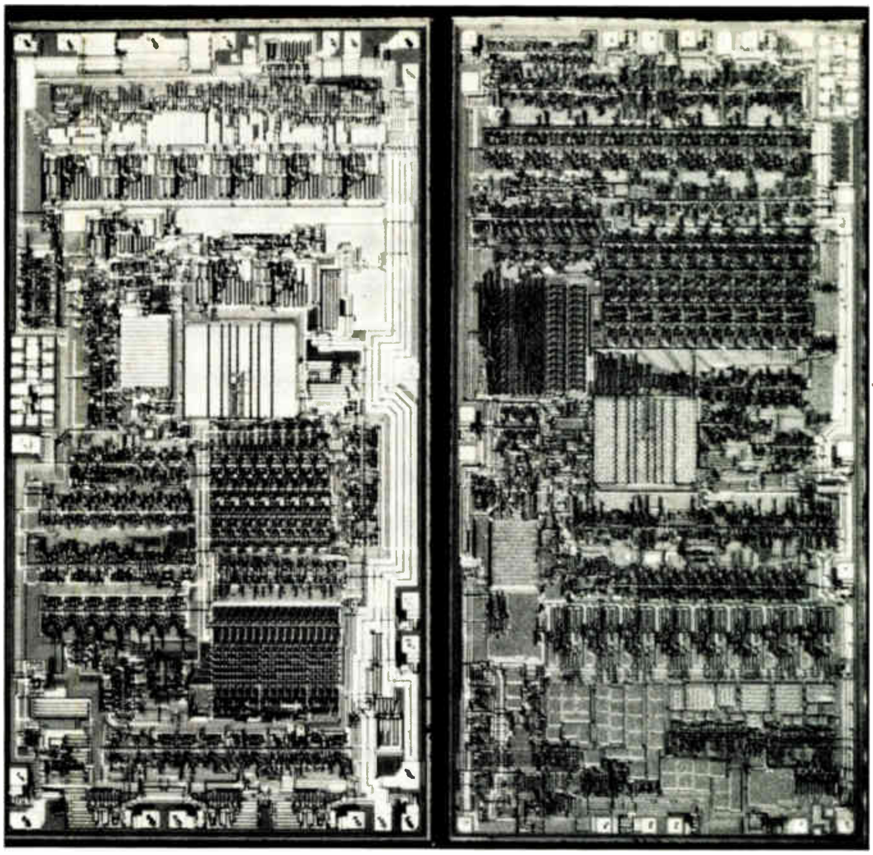
On the continent

The myriad of chip designs for interfacing with the keypad to be seen in the U. S. is to be found in Europe also. Many of the same features are available, as the chips are geared to the same kind of application.

Typical of these chips are those manufactured by Intermetall, including the SBA5089 and the SBA5091. The 5089 is a C-MOS DTMF dialer chip now obtainable in sample form. The 5091 is similar but is designed for European specifications only. Siemens has the S359 dialer, which is made with integrated injection logic.

NV Philips Gloeilampenfabrieken also uses I^2L in its TDA1077 tone-generator chip. But for loop-disconnect dialing Philips favors C-MOS and uses it in its MH320 and MH323 chips. Both chips can work with either a single-contact three-by-four or standard double-contact keyboard. Redialing is possible with up to 23 digits.

Earlier this year Texas Instruments of France intro-



6. No crosstalk. The American Microsystems two-chip codec performs encoding and filtering functions on one chip and decoding and filtering on the other. Thus, there is no possibility of crosstalk between the transmit and receive circuits in the switching network.

duced its new pulse-dialer chip. The TCM1101 features a low-voltage operation capability of 2.2 V. The process used is C-MOS with three mask-programmable features: interdigit pause, pre-impulse pause, and mark-space ratio. The ability to preprogram these pauses adapts the chip to many different kinds of telephones and telephone standards.

Leaving the telephone, the next place LSI makes its impact is in the digital transmission line connecting two or more switching offices. At periodic intervals along this line an amplifier is needed to build up the strength of the multiplexed 1.54-megabit-per-second signal.

Compared with chips interfacing with the keypad, supplying amplifier chips is a small business dominated by one company, Exar Integrated Systems. But competition is on the way. Precision Monolithics is trying to make inroads with a new chip.

Proof wanted

One reason the business may be small is that some industry people are not enthusiastic about such products. Siemens' Walter Flagge, for instance, says that "LSI has yet to prove itself in transmission equipment." But he admits that ultimately it will improve the cost and reliability of amplifiers.

For Alan Grebene, vice president of Exar, the proof that that has already happened is in his company's shipments. Exar has been in the amplifier chip game since 1975 and, Grebene says, has "80% to 90% of the non-Bell business." He adds that "a lot more ends up in the Bell system through intermediate manufacturers making amplifiers." Half of the company's $15 million in sales in 1979 was in the telecommunications business.

Grebene says that new amplifier chips do not come at a rapid rate in this part of the telecommunications business. He is not planning to introduce a new one until the later part of this year.

Hoping to make a big dent in Exar's sales, Precision Monolithics has just introduced the RPT 81/82. These chips, according to Guido Pastorino, telecommunications senior staff engineer, perform all the functions required for a PCM amplifier that operates at either of the standard 1.54- or 2.048-Mb/s rates.

Pastorino says the chips are unexcelled when it comes to regenerating all the pulses that meet voltage threshold requirements without inserting pulses incorrectly into empty time slots. This is important because in a PCM system the coded information is transmitted by the presence or absence of pulses in specified time slots.

Helping an amplifier maintain a low error rate is not all the 81 and 82 can do. The 82, for example, includes a line-bail-out circuit that automatically compensates for up to 36 decibels of line loss (Fig. 4). And for system people, its automatic clock-shutoff circuit inhibits the clock amplifier when no signal is coming in. This greatly reduces total system noise.

Lots of interfaces

Besides the handset and the transmission path, LSI is found in the subscriber-loop interface circuits, in the codecs and the filters found in switching offices, and in private branch exchanges of all kinds.

These are all interface chips of a sort. The SLIC interfaces the subscriber loop with the switch-gear circuits, and the codec converts the analog voice signal into a digital signal for interfacing with the telephone system's PCM devices. For its part, the codec filter provides all of the band limiting needed to keep the signal noise-free (Fig. 5).

The codec was one of the first of these chips to be developed with some versions available for production use in 1978. Yet the questions concerning codec process technology and architecture are by no means answered, and new products continue to appear as the LSI companies fight for a market share.

Two chips or one?

This effort at American Microsystems has resulted in a two-chip C-MOS codec set. There are almost a dozen codecs on the market already, so why this one?

Its developers, engineers Yusef Haque and Victor Godbole, answer, "Our chip is partitioned so that the transmit and receive portions of the line interface are independent," eliminating any co-channel crosstalk due to either sharing of the circuitry or leakage between on-chip components. It also means the two chips can be operated synchronously or asynchronously (Fig. 6).

There is another advantage to the separate encoder (the S3501) and decoder (the S3502) approach: AMI can sell to several markets with its chips. "In applications that require either a-d or d-a conversion but not both, such as some forms of digital signal processing, there is cost saving because unnecessary circuitry is eliminated—the user can just buy what he needs," says Haque.

Other advantages of the new chip set include its machine-insertable 16- or 18-pin DIP construction and its low, 100-milliwatt power consumption. This is a result of C-MOS technology.

Not everyone agrees with AMI that the leakage problem necessitates separating the encoder and decoder functions. Some of Haque and Godbole's peers believe—although they would not be quoted by name—that leakage is readily controlled and one chip would do the job. They feel that AMI was giving an engineering reason to justify a marketing ploy.

Meanwhile Bell Laboratories, accused by some of dragging its feet in codec development, has not really been idle. The much anticipated Bell codec and its associated filter will finally see the light of day at the upcoming International Communications Conference to be held in Seattle, Wash., beginning June 9. The Bell architecture is unknown to the industry, which is wondering if Bell has any surprises in store for it.

Codecs overseas

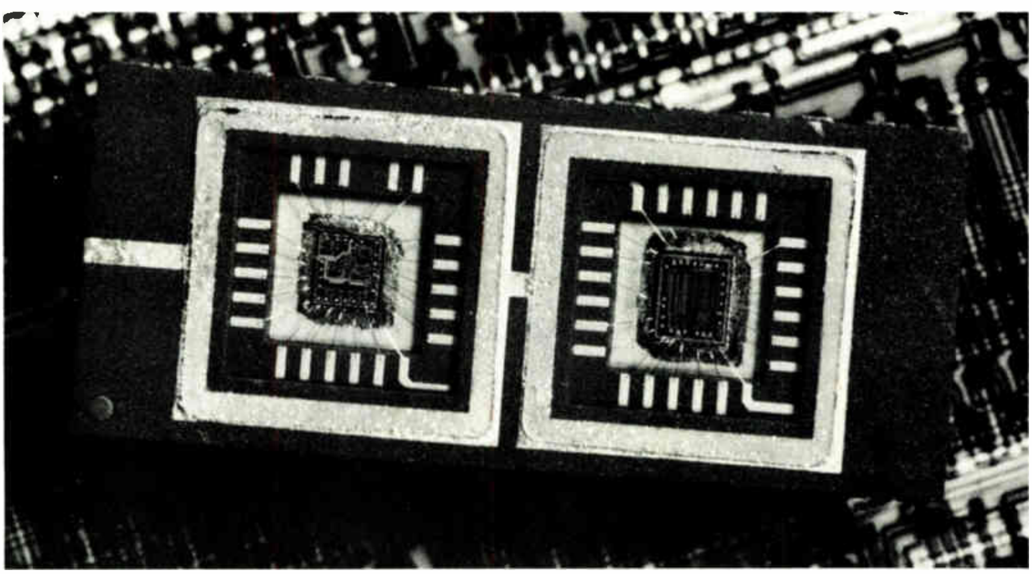
Still other codec developments are on the way from Europe and Japan. Siemens' two-channel codec—a combination bipolar and C-MOS device—is about to enter production. The SM610 (Fig. 7) occupies a place between the single-channel approach favored by nearly all U. S. manufacturers and the 4-, 8- or 16-shared-channel codec pushed by PMI. It offers users still another option (see "Channels to share," p. 124).

In Britain, several codecs have emerged in recent months. In one development, the British Post Office teamed with both the General Instrument Microelectronics division, London, and Ferranti Ltd., Chadderton, Oldham, to develop a single-chip codec. The Ferranti bipolar device needs but a single 5-V supply and is dubbed the ZNPCM1. GI's device is made with n-channel MOS technology.

For its part Plessey Telecommunications Ltd., Liverpool, England, decided that sharing is the way to go. It succeeds in outdoing everyone else in terms of numbers of channels with a 30-channel two-chip device [*Electronics*, Feb. 15, 1980, p.67].

On the other side of the world, the Japanese have finally entered the codec market. Until the 1980 International Solid State Circuits Conference (held in San Francisco in February), no one knew about the two-chip codec set from Fujitsu Ltd. of Kawasaki, which is similar in architecture to AMI's. One chip with an on-board filter takes care of encoding, and the other chip with an on-board filter takes care of decoding. As with AMI, transmit and receive crosstalk elimination is given as the reason for this method.

Hitachi Ltd. of Tokyo also has a product for the codec market that it says will be ready this year. At the



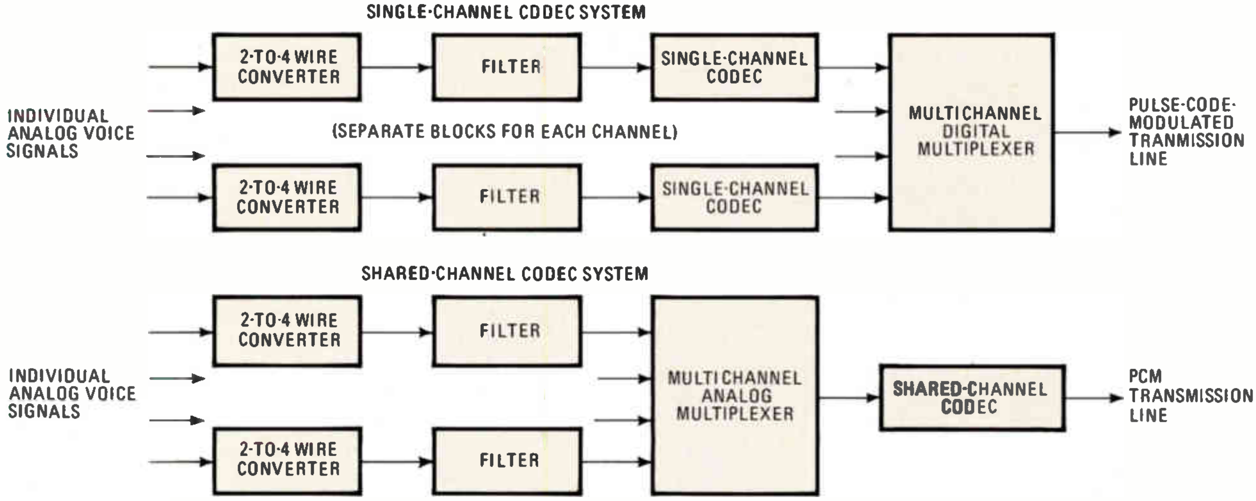
7. Share the burden. The Siemens SM610 codec is a two-channel device. Such shared-channel codecs have been the traditional approach to telephony and can to handle up to 30 channels. Codecs installed directly in a subscriber digital telephone need to handle only one channel each.

Channels to share

Why is Precision Monolithics Inc. virtually alone in the U. S. in pushing the multichannel, or shared-channel, codec? Says Glenn Satterthwaite, marketing vice president: "Many companies don't have the technology to produce a shared codec. The codec is really a linear, or analog, chip. Intel and Mostek, for example, are digital MOS houses. And to implement linear functions in MOS, you give up something in performance and speed." The PMI devices are bipolar chip sets.

Elaborating, Satterthwaite offers the following example. "If a D-3 channel bank runs at an 8-kilohertz clock rate, there is only a 125-microsecond slot in which to decode one channel. No known MOS technology can perform these linear functions with enough accuracy and speed to share that 125 μs among four or eight channels."

"Of course," Satterthwaite adds, "just because it's a unique device is no reason to buy it," and he quickly launches into a discussion of the price structure of using one codec per channel versus the shared-channel codec and the power consumption problem. Then he speaks of relative chip areas and package pin counts. Finally, "just watch our cost compared with per-channel codecs as we go sliding down the integrated-circuit learning curve," he says in conclusion.



conference it spoke of what it calls an "interpolative codec" with "multiplexed digital filters." But details are sparse and the device is still under development. The digital portion of the chip is said to use I²L.

Filters, those devices that ensure that the codec signals are properly band-limited and noise-free, are a perfect example of the confusion in the LSI industry as to the best process technology. To make matters worse, it is not at all clear which of the telephone switching network system's filtering functions should be included on the chip. So a wide variety of types is available.

A flurry of filters

The approach at National Semiconductor Corp. of Santa Clara, Calif., in its soon-to-be-released codec filter, is to incorporate transmit, receive, and line-frequency-reject filters on a single C-MOS die. The double-polysilicon-gate chip uses a proprietary switched-capacitor design (Fig. 8), according to Tom Reynolds, the firm's telecommunications industry business manager.

National feels that the power consumption and noise characteristics of this chip, developed in conjunction with the University of California, give it a better chance of capturing a good share of the codec filter market than previously available devices. These, National says, compromised overall system performance.

As a bonus to the user, the National filter includes balanced power drivers to directly energize the transformer-wound two-to-four-wire hybrids a codec filter connects to. This is the older, classic method of providing SLIC functioning. Clearly, then, an LSI SLIC will not be needed for a cost-effective system. National is taking care of some SLIC problems (p. 125) in advance.

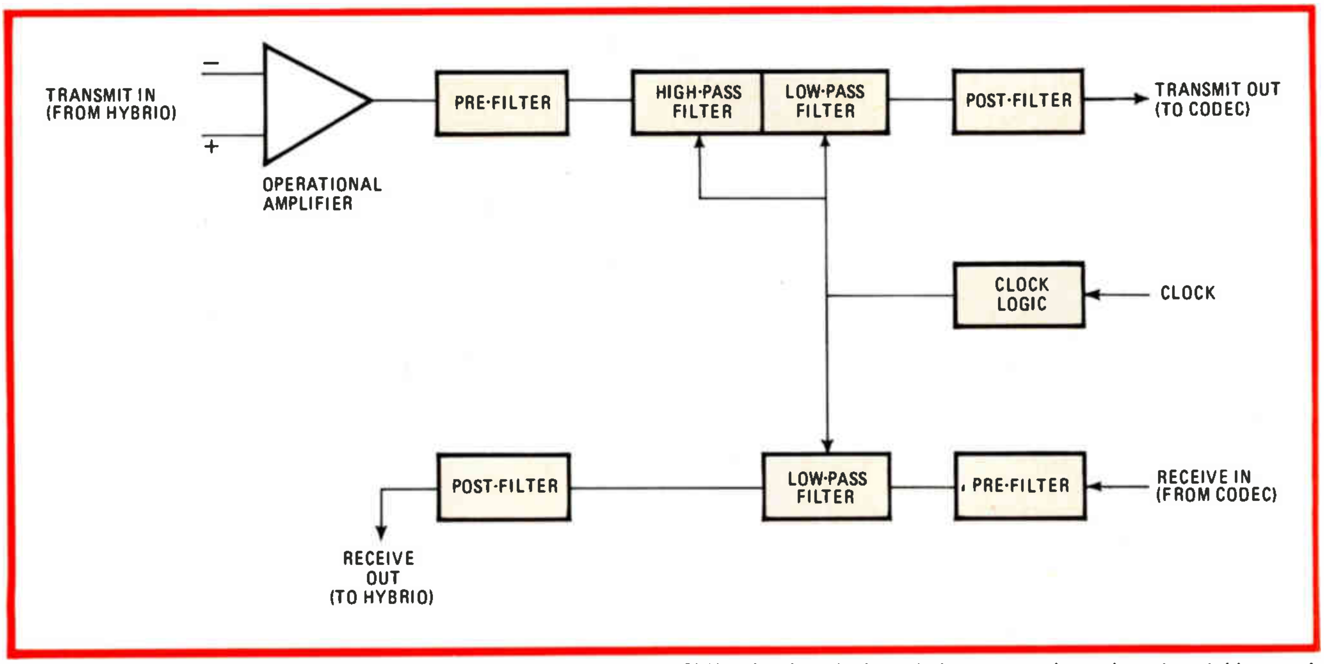
National's entry into what has been called "the filter fuss" is pin-compatible with the codec filter introduced two years ago by Intel Corp., Santa Clara, Calif. That filter's architecture seems to be the industry standard, as many manufacturers are copying its pinout.

So far as a process technology is concerned, however, Intel for the time being is sticking to its guns with n-MOS. And, according to Robert Holm, telecommunications product marketing manager, it expects that n-MOS is still capable of lots of power reduction.

In another contrast to the Intel approach Mitel, according to its integrated-circuits design director, Tom Foxall, is supplying samples of its new C-MOS switched-capacitor filter. Volume production will occur this year.

Confusing matters further, Mostek has taken a giant step and given up on its C-MOS and charge-coupled-device filter that it announced only last year. It has decided to go with n-MOS, although it will continue with a C-MOS codec. Truly the process technology pot is boiling in the LSI industry.

According to Ian A. Young, senior designer in Mostek's telecommunications department, the 5912 consumes a mere 20 mW—one of the lowest power figures



8. Still better. The National Semiconductor codec filter is yet another LSI filter for the telephone industry to evaluate. Introduced this year, it features a proprietary switched-capacitor construction technique said to result in superior electrical performance and noise characteristics.

available—and is pin-compatible with the Intel filter.

Meanwhile, quietly going about its business with a minimum of fuss and publicity (as is its style), TI is looking into codec filters of various kinds. It has even gotten so far as to assign model numbers, although these cannot yet be released.

While TI's codec is the same as Intel's (it's a second source), TI is on its own technically with a filter and hopes to market a superior device. The transmit and receive filters are complete and are in what is known in the trade as "bar layout." It is scheduled for 1981 production.

A novel codec filter

Meanwhile Steve Kelley, telecommunications product engineering manager of Motorola Inc. in Austin, Texas, has a patented design concept behind the newly introduced and innovative MC14413 codec filter. Comparing it with other devices, he says, "The MC14414, which has been available since 1979, has two on-board low-pass filters to do its filtering. But the 14413 is better since it has a high-pass filter for additional 50/60-Hz and 20-Hz noise rejection" (Fig. 9). This, Kelley says, is a better approach than the notch filter Intel uses to perform just the 50/60-Hz rejection, where the 20-Hz rejection must be taken care of by external devices.

Other unique features of the 14413 include the ability to amplify the signals applied to it and, most important, a circuit patented by Kelley to optimize the filter's time-delay characteristics.

Motorola is also supplying an LSI circuit called a time-slot assignment chip, or TSAC. Two of the controversial chips were introduced in early 1980, and a third is slated for later this year. To some observers, these chips appear unnecessary. Why is this so?

A TSAC is an addressable, programmable per-channel chip that allows programming of codec time-slot assignments through a serial microprocessor port. In this approach, one codec is assigned to each TSAC (Fig. 10). The TSAC's function is to assign the codec to receive and transmit the right time slots in the data stream.

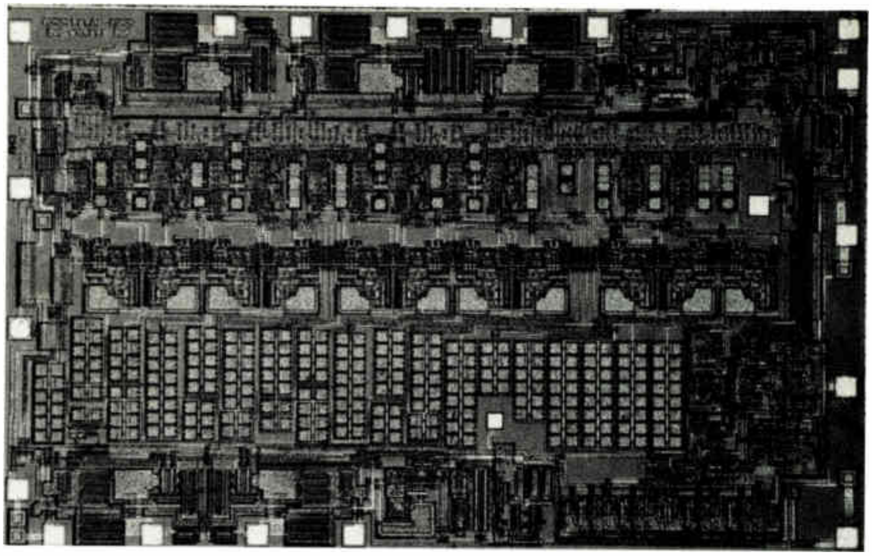
The 16-pin MC14416 TSAC—a C-MOS part—performs basic time assignment functions plus some off-hook multiplexing control. The full-blown version—the 22-pin 14418—takes even more functions under its wing, so as to reduce system parts count, says Motorola. The not-yet introduced 14417 is a medium-scale integrated version of the 14418; it performs time assignment functions but on a reduced scale.

To some industry observers and Motorola competitors, the only reason a designer would need a time-slot assigner would be that Motorola neglected to put one on board its codec. (Mostek's codec, for example, is said to have such functions on chip.) Others say that, rather than simplify digital switch architecture, the Motorola design would complicate it and that "what Motorola did adds parts that did not need to be developed separately and could have been incorporated into the codec function."

A job to be done

For the LSI companies, a true SLIC has yet to be developed. The most successful approach using hybrid technology has for years belonged to ITT MicroSystems of Deerfield Beach, Fla. And, it is about to upgrade with a still better SLIC. Other firms such as Motorola have had only problems so far, whereas Harris Semiconductor has a year or more to go before it has a product. Meanwhile taciturn TI will say little about its SLIC.

Why has Motorola been supplying samples of a product that is, in the words of one wag, "not too slick a SLIC"? Part of the difficulty is the nature of the device. *N* telecommunications engineers will have *n* opinions about what a SLIC has to do and how it can best do it. What's to be done depends on what degree of chip



9. Extra filter. The Motorola 14413 codec filter has a high-pass filter on board to take care of both 20 and 60 hertz noise. It also has a patented delay-distortion compensation network and several uncommitted amplifiers, so that it can drive subscriber-loop interface circuits directly.

integration is desired and what kind of equipment the SLIC goes into. For example, for Mostek's telecommunications department manager, David Sealer, there is no difficulty with external diodes to help the SLIC take care of lightning problems, whereas others feel that diodes are a no-no. "We are not treating the SLIC as a component *per se* but as a cost-effective solution to an equipment problem," Sealer says in explaining his viewpoint.

Borsht functions

SLICs are supposed, in theory, to satisfy what is known as the Borsht functions. These are B for battery feed, O for overvoltage protection, R for ringing, S for signaling, H for the two-to-four-wire hybrid functions, and T for test features. Just how these functions are defined and which are important depends on whether the chip is used in the U. S. or Europe, whether it is in a PBX or a central office, and how many auxiliary chips are acceptable.

Harris Semiconductor of Melbourne, Fla., is developing its SLIC in conjunction with Télécommunications Radioéléctriques et Téléphoniques in France. Production is slated for late 1981 in this deal, to which TRT brings a patented circuit design and Harris brings a worldwide manufacturing and marketing capability. The chip, Harris claims, will provide even more than the Borsht functions—for example, the polarity reversals necessary for certain digital switches.

The chip will be made with dielectric isolation technology. Industry observers and Harris competitors are quick to point out that this may be an expensive way to do the job. At the same time, they admit that if Harris can make a SLIC acceptable to many diverse customers and quickly move down on the semiconductor learning curve so the price is right, it will have a winning product.

Harris and TRT are exerting all this effort because of some very fundamental economics. As Philippe Klejiman, sales manager for Harris Semiconductor in France, explains it: "If the cost of a digital time-division switching exchange is expressed in terms of cost per subscriber line, then the BORSHT functions represent somewhere between 30% and 45% of the cost". He further estimates that the SLIC being developed by Harris and TRT should cut overall cost per subscriber line by about one third.

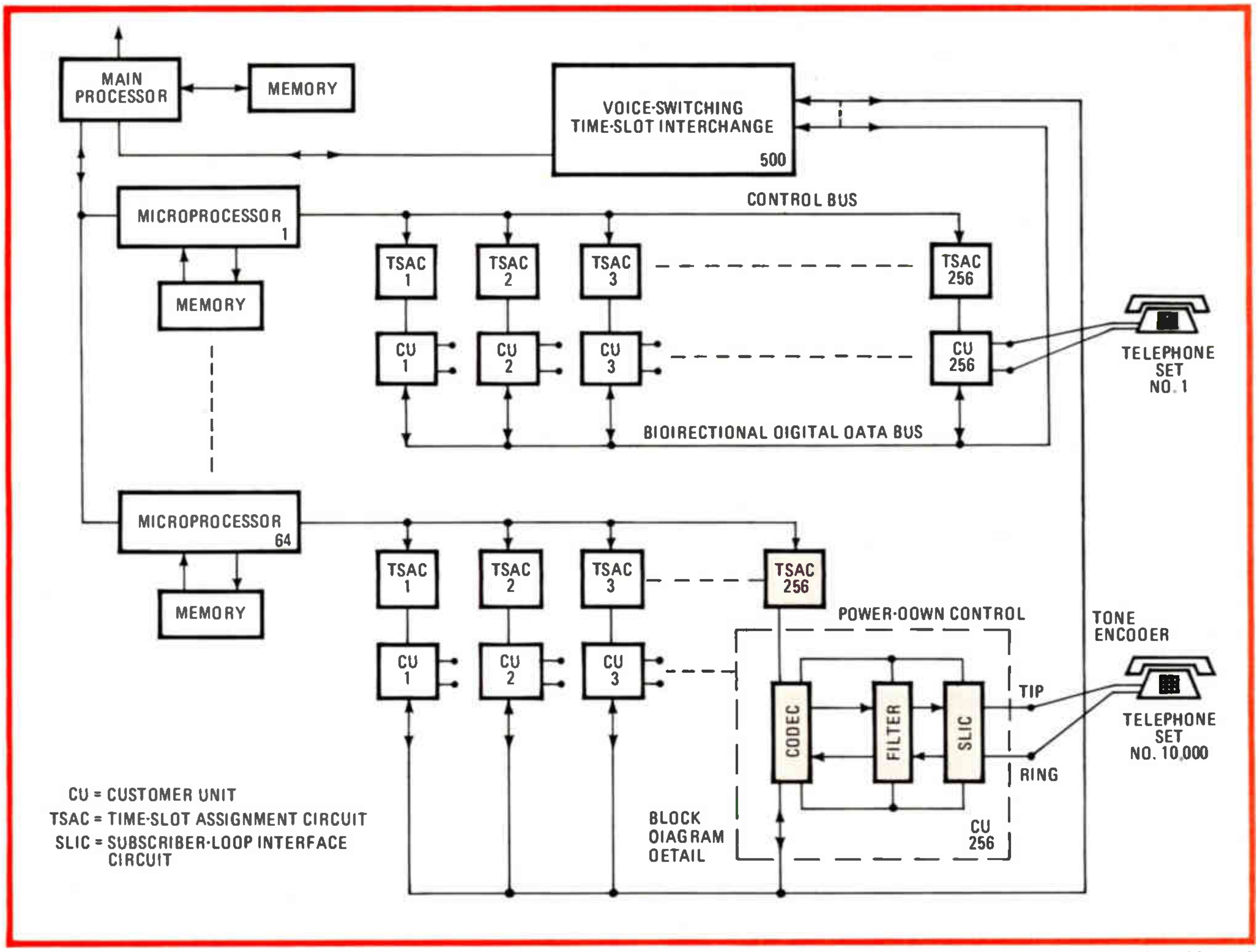
While Harris goes ahead with its isolation technology, ITT MicroSystems—which has delivered thousands of hybrid SLICs to the telephone industry—has opted to take the medium-scale rather than large-scale integration path for its SLIC development. For MicroSystems, a device which combines the benefits of MSI with hybrid technology is the way to go to quickly produce the next generation of SLICs for its customers. Its new SLIC (a number is not yet assigned) will be ready in sample quantities in the first quarter of 1981, with production in the middle of that year.

The company is anxious to avoid the "now you see it, now you don't" approach to SLIC production, which it says adds to the credibility problem that the semiconductor industry has with generally conservative telecommunications manufacturers. Says Frank Ashford, manager of applications engineering, "Our SLIC is a monolithic device which can best be described as using medium-scale integration." Most of the SLIC circuitry is incorporated on one chip, while critical components such as resistor and high-voltage–handling devices are on a hybrid substrate. In this way, Ashford says, the resistors can be precision–laser-trimmed and large amounts of power can be handled without affecting the reliability of the bipolar chip itself.

Laser trimming will also be used by Siemens for its SLIC [*Electronics*, March 27, 1980, p. 73], which is scheduled to reach the sample stage in 1981. The bipolar G 150 has on-chip laser-trimmable resistors. Like the MicroSystem design, it will be able to handle both PBXs and central offices.

The ITT MicroSystems SLIC collects points in the SLIC specifications sweepstakes because not only does it meet the Rural Electrification Administration requirements for lightning strikes—and the REA funds many rural telephone companies—but it meets the REA specification for power cross as well. Power cross occurs when power lines touching or coming near telephone lines induce currents in them that the SLICs must be capable of withstanding.

But the new SLIC is not perfect, according to Wilbur



10. Assign a slot. In one Motorola conception of a 10,000-line telephone exchange, a separate time-slot assignment chip works with each codec in the network. TSACs are in control of the timing and the placement of the voice signals in the multiplexed network.

Riner, MicroSystems' marketing director. It does not provide the T for test function—but then, "no one else does either," he says. He notes that there was not enough commonality of definition of the test procedures for MicroSystems to be able to satisfy their potential customers in the U. S. and Europe.

What will be done? The tests will be handled without recourse to the SLIC by the use of auxiliary, off-chip devices. So the chip will readily fit in either a 24-V PBX or a −50-V central office where the two test situations are quite different.

In contrast to the MSI SLIC from MicroSystems, TI is opting for an LSI Bidfet device that combines bipolar with prolonged-diffusion MOS and field-effect-transistor technology. But it is not saying much else. All the company will reveal is that there is a low-pass filter—needed for the SLIC functions—on the SLIC output line. It is not integrated into the SLIC proper. And, TI says, its SLIC will have on-board software to help it do its chores, which depend on what kind of equipment it is working with. Samples of the SLIC, which TI's Haas calls "a leadership product but a high-risk one," will be available at the earliest in the fourth quarter of this year.

One way to deal with the SLIC problem in the central office is to reduce the number needed. That may be possible if a recent development by Peter Schackle of Bell Laboratories in Murray Hill, N. J., bears fruit.

Schackle has made a monolithic—albeit expensive—bidirectional two-by-two crosspoint array, a switching matrix that routes calls from one set of wires to another as they come into the central office. But as he did it on a raised potential dielectric substrate that can handle 500 V, it may be possible to produce an integrated circuit capable of switching dozens of incoming subscriber loops onto one SLIC.

SLIC significance

Even more important than this reduction in the number of SLICs needed in a central office is the significance of the new technology for constructing the SLIC itself. Even now the new circuit satisfies the requirements of a loop switch—voltage blocking to 500 V and the ability to withstand the 1-ampere or so surge currents forced by the 50-V battery used to power the loops. If the process were workable at 1,000 V or more, some industry observers think that it might be used to make a SLIC that could readily handle lightning problems without add-on diodes or other devices. □

Decoding scheme smooths 18-bit converter's nonlinearity

Reducing the maximum binary weight carried by switches helps two-chip 18-bit digital-to-analog converter achieve 16-bit linearity

by Samuel Wilensky, *Hybrid Systems Corp., Bedford, Mass.*

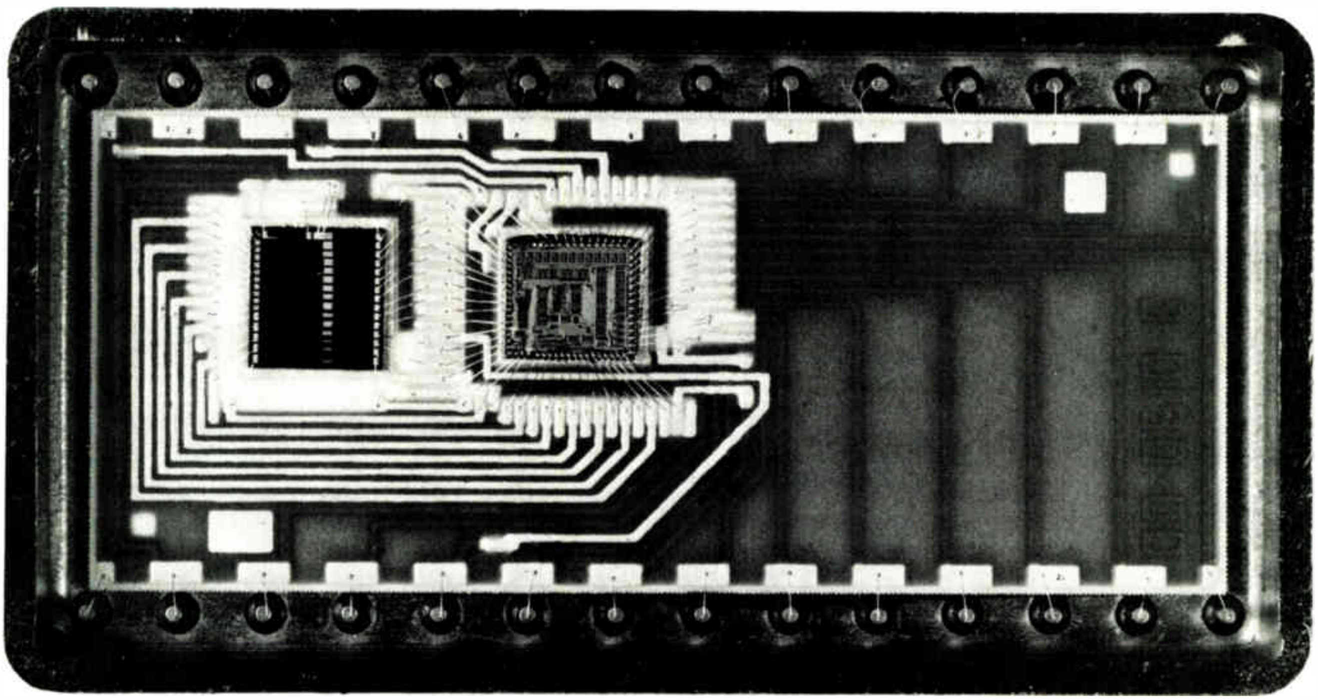
□ As the data converter industry pushes its digital-to-analog converters to the 16- and 18-bit level, it faces some tough design problems. It is very difficult to make parts with linearity to match this level of resolution with the techniques used for 12- and 14-bit d-a converters.

Despite this fact, 16-bit d-a converters have been built by adding four current switches and four discrete resistors to existing 12-bit converter designs; the method has been extended to 18-bit parts now available. However, as performance climbs to the 18-bit level, potential users are in the awkward position of being unable to verify a linearity specification of ±½ least significant bit for these converters, unless they have access to very expensive laboratory equipment.

A digital decoding technique originally used by Hybrid Systems at the 12-bit level to reduce glitch size [*Electronics*, Aug. 2, 1979, p. 131] has been applied at the 18-bit level to make a relatively small, low-cost d-a converter with 16-bit linearity (a linearity error of 0.001%). The decoding scheme reduces the maximum binary weight carried by the converter's current switches, reducing the accuracy required of the switches and resistor network. The only penalty is a slight increase in circuit complexity.

The DAC370-18 is a two-chip hybrid d-a converter: one chip is a custom switching-network integrated circuit and the other carries a thin-film resistor network. It is a two- and four-quadrant multiplying converter that accepts a reference input of −10 to +10 volts, produces an output current that settles to within 0.01% of full scale in 2 microseconds and requires only 1 milliampere at 15 V to operate. It is housed in a 28-pin hermetically sealed metal package with 0.600-inch spacing between pin rows (twice that of a dual in-line package).

Comparative measurements can improve confidence in the use of high-resolution d-a converters, if equipment for making absolute measurements is not at hand. A 16-bit converter with a 10-V full-scale output would have



1. Hybrid pair. Only two chips make up this 18-bit hybrid digital-to-analog converter. The right chip is a custom switching-network integrated circuit. On the left is a thin-film resistor ladder network. The converter is a multiplying type with 16-bit linearity.

to be verified to ±0.00078% of full scale, or ±78 microvolts to make an absolute measurement to ±½ LSB. For a 10-V 18-bit d-a converter, this is ±0.00019% or 19 μV. Measuring to this accuracy absolutely requires measuring 10 V to an uncertainty of 10 μV, something on the order of 1 part per million. This is nearly impossible to do with conventional production test equipment.

Comparative measurements, however, can be made with relatively unsophisticated equipment to yield differential nonlinearity information about a high-resolution d-a converter. And production-line measurement and testing of converters has also been simplified with the introduction of desktop computers. Together with instruments compatible with the IEEE-488 interface bus, these computers have made possible high-speed comparative testing of high-resolution converters. Although such testing does not guarantee that an 18-bit d-a converter has 18-bit accuracy, it does provide information about the converter's differential nonlinearity (see "Unscrambling converter specifications," p. 130).

Trading switch sensitivity for complexity

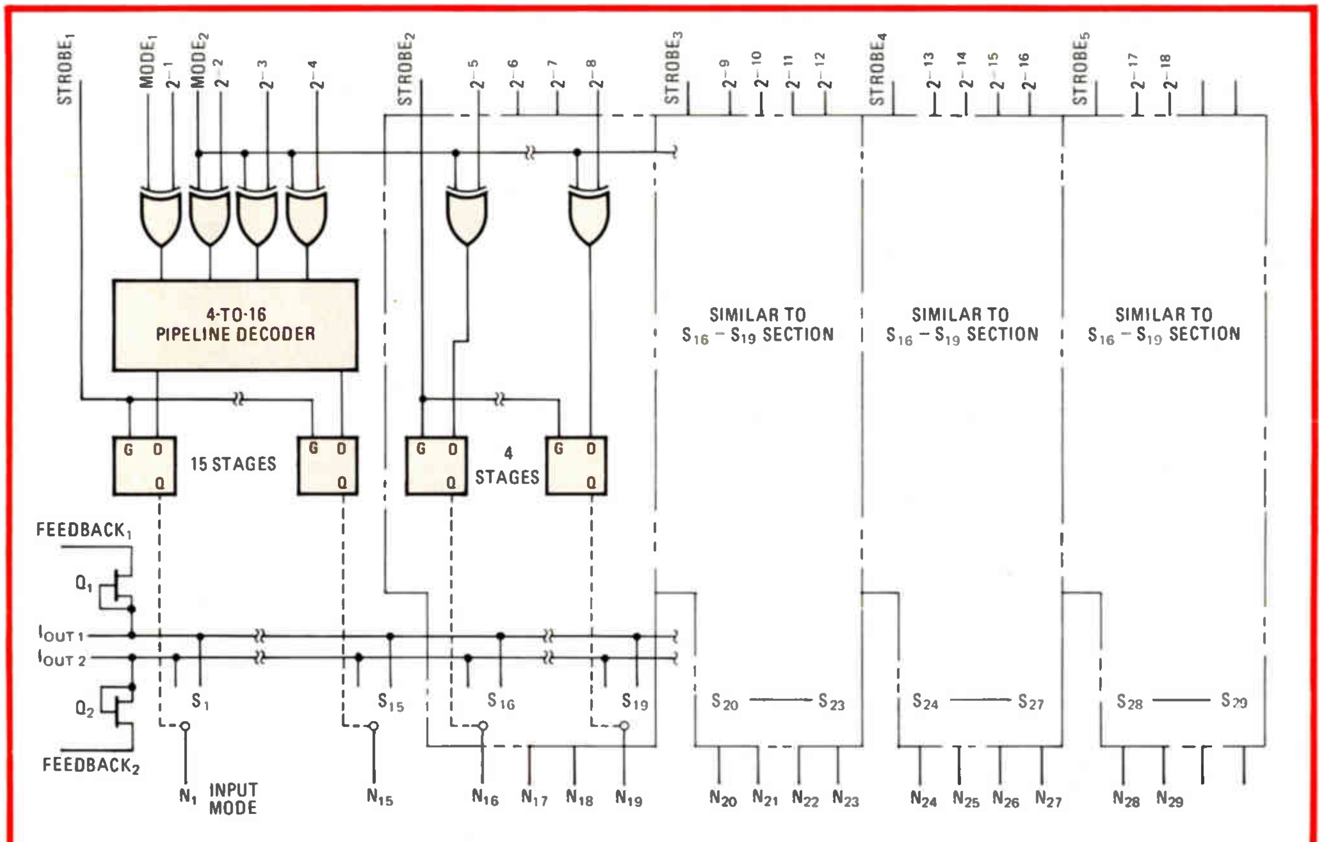
The most common technique for building a d-a converter of n bits is to use n switches to turn n current or voltage sources on or off. The n switches and n sources are so designed that each switch or bit contributes twice as much to the d-a converter's output as the preceding bit. This technique is commonly known as binary weighting and allows an n-bit converter to generate 2^n output levels by turning on the proper combination of bits.

In such a binary-weighted network, the switch with the smallest contribution (the LSB) accounts for only 2^{-n} of the d-a converter's full-scale value. Similarly, the switch with the largest contribution (the most significant bit) accounts for 2^{-1} or half the d-a converter's full-scale output. Thus it is easy to see that a given percent change in the MSB will have a greater effect on the d-a converter's output than would a similar percent change in the LSB. For example, a 1% change in the MSB of a 10-bit d-a converter will change the converter's output by 0.5%. On the other hand, a 1% change in the LSB of the converter affects the output by only 0.001%.

Looking at the MSB (2^{-1}) and the preceding bit (2^{-2}) of a conventional d-a converter, as shown in Table 1, note that all combinations of the on and off states for the two bits result in four output levels, assuming that all other converter bits are in the off state. By replacing the 2 MSBs in Table 1 with 3 bits, all weighted the same as the 2^{-2} bit, the same performance from the converter can result. But there is also an additional factor. Turning on none, one, two, or all three of such bits correspondingly produces 0, ¼, ½, or ¾ of the converter's full-scale

TABLE 1: CONTRIBUTION OF 2 MOST SIGNIFICANT BITS

2^{-1} (MSB)	2^{-2}	Output
0	0	0
0	1	¼ of full scale
1	0	½ of full scale
1	1	¾ of full scale



2. Switching network. The 18-bit d-a converter's switching network consists of current-steering field-effect-transistor pairs. Depending on which FET in each switch pair is in the on state, current entering the switch's input node is steered to either $I_{out\,1}$ or $I_{out\,2}$.

Unscrambling converter specifications

As if it were not difficult enough to keep track of the meaning of the multitude of digital-to-analog converter specifications, some users and manufacturers often refer to totally different parameters interchangeably. For example, accuracy is often confused with resolution, and the term linearity is often used to mean integral and/or differential linearity.

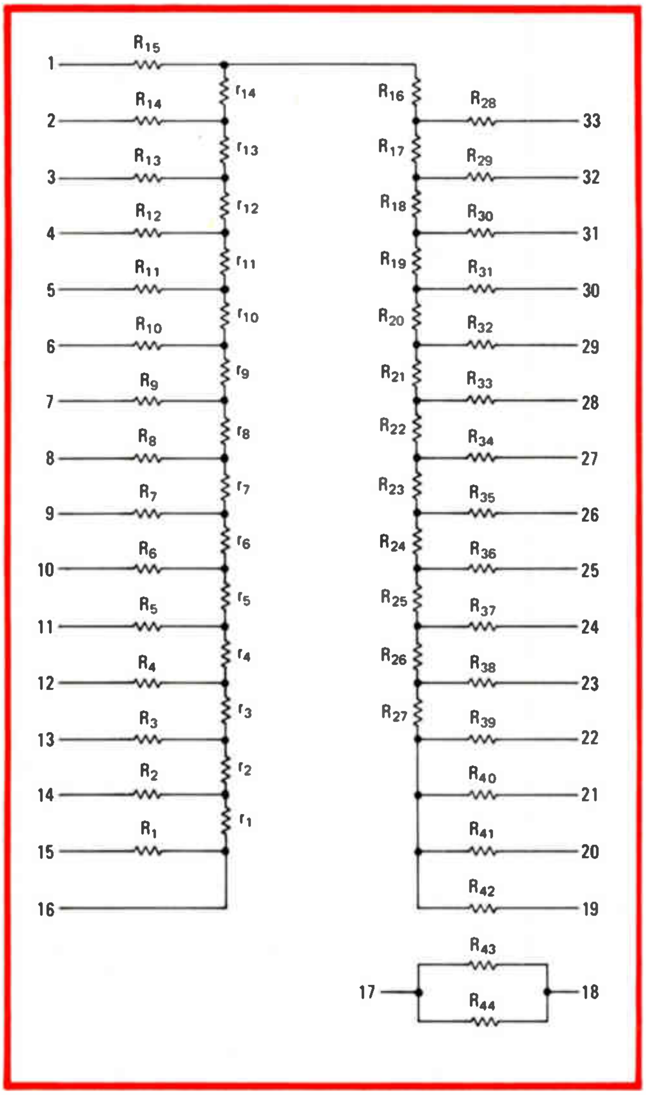
The important parameters to specify for a d-a converter are resolution, absolute accuracy, relative accuracy, and differential linearity. A little understanding of each parameter's role can go a long way toward easing converter selection.

☐ Resolution. This defines the number of digital inputs for a d-a converter. The term resolution does not in any way define the converter's accuracy. It only indicates how many input pins a converter manufacturer has provided for his product.

☐ Absolute accuracy. This is the maximum deviation of a converter's actual output compared with its theoretical output were the converter an ideal device. This parameter is usually specified as a percentage of the converter's full-scale range.

☐ Relative accuracy. This figure is the maximum deviation of the d-a converter's output from a straight line drawn through all the device's output points. Relative accuracy is usually expressed as a percentage of the converter's full-scale range, or as some fraction of the least significant bit.

☐ Differential linearity. This is the maximum deviation between any adjacent output steps of the converter compared with its theoretical deviation. This parameter is usually expressed in the negative sense: differential nonlinearity specified as a fraction of the LSB. A d-a converter is monotonic—that is, its output will always increase with increasing inputs—if its differential nonlinearity is never more than ± 1 LSB.



3. Resistor network. This thin-film network includes a 29-resistor ladder for the 4 decoded most significant bits (r_1–r_{14} and R_1–R_{15}), a conventional R/2R network (R_{16}–R_{39}) for the other 14 bits, and a paralleled pair (R_{43} and R_{44}) used as feedback resistors.

output. Thus by replacing the two switches with three, the maximum contribution of each switch to the converter's output was reduced from ½ to ¼.

With the above method, a 1% change in any one of the converter's switches affects the output by no more than 0.25% of full scale, compared with 0.5% in a conventional d-a converter with two switches. In other words, the conventional d-a converter's output can be made less sensitive to the accuracy of its switches by decoding the two MSBs into three lines.

As with anything in design engineering, a sacrifice must be made when something is gained. The reduced sensitivity of a d-a converter's switches was obtained at the expense of an increase in circuit complexity—more switches were added. In fact, if more can be sacrificed in terms of circuit complexity, the first 3 MSBs of a d-a converter can be decoded onto seven lines of switches controlling equal binary weights to reduce switch sensitivity by a factor of 4, or the first 4 MSBs can be decoded into 15 lines to bring down switch sensitivity by a factor of 8.

Decoding—within reason

Like any technique, decoding can be carried too far. A 10-bit converter can be built with 1,023 individual switches, all with equal weighting, and no switch would contribute more than 1/1,024 of the converter's full-scale output. The reasonable approach lies somewhere between decoding all of a converter's bits, which in the case of an 18-bit d-a converter would mean 262,143 switches, and decoding none of the bits. In the latter case, it would be necessary to make a switch and source combination that is stable to within 0.0002%, an equally unacceptable penalty. For the DAC370-18, the 4 MSBs were decoded, and the lower-order 14 bits were designed in a conventional manner. Since the design goal was an 18-bit d-a converter with 16-bit linearity, it was easy then to build a 12-bit d-a converter in the conventional manner, decoding the next 4 bits. This approach allowed converter linearity to within 0.001%.

An 18-bit d-a converter whose 4 MSBs are decoded requires 29 analog switches that are matched to within 5% of each other and that track closely over changing temperature. Fourteen of the switches are used for the lower-order bits and 15 for the 4 decoded higher-order bits.

Assembling such a network with discrete components is very difficult, if not impossible. An integrated circuit, however, can be easily made on a custom basis with such a topology. Such an IC, together with a thin-film IC made by Hybrid Systems, constitutes the two-chip DAC370-18 (Fig. 1). Partitioning the converter into separate switching and resistor network chips makes possible individual-chip laser trimming on the wafer for achieving 14-bit linearity (0.003%) without the need to trim the finished converter actively.

The use of a custom IC switching-network chip in the DAC370-18 d-a converter allowed the incorporation of latches and gates for a universal building block component. Each switching element consists of a pair of current-steering field-effect transistors. Depending on which FET is on, the current coming into the input node is steered to either $I_{out\,1}$ or $I_{out\,2}$ in Fig. 2. The on-resistance of each of the transistors that make up the 15 switches for the decoded top 4 bits (S_1 through S_{15}) is nominally 250 ohms.

FETs matched to within ±5%

The FETs are matched to better than ±5% of each other. The first five lower-order switches (S_{16} through S_{20}) have binary-weighted on-resistances ranging from 500 to 8,000 Ω. Since each successive switch handles half the current of the switch preceding it, the voltage drop across each switch is the same, and the relative weights of the bits track with temperature. Lower-order switches S_{21} through S_{29} have on-resistances of 8,000 Ω.

FETs Q_1 and Q_2 compensate for the change in gain caused by the temperature coefficient of the on-resistance of the switching FETs, which is about 0.7%/°C. Latches for driving the switches are transparent. When the control line is high, data at the latch's input is transferred to the latch's output. When the control line is low, the latch holds the data that was present at its output when the control made the transition to low. Exclusive-OR circuits are also provided so that complementary or straight binary coding can be selected.

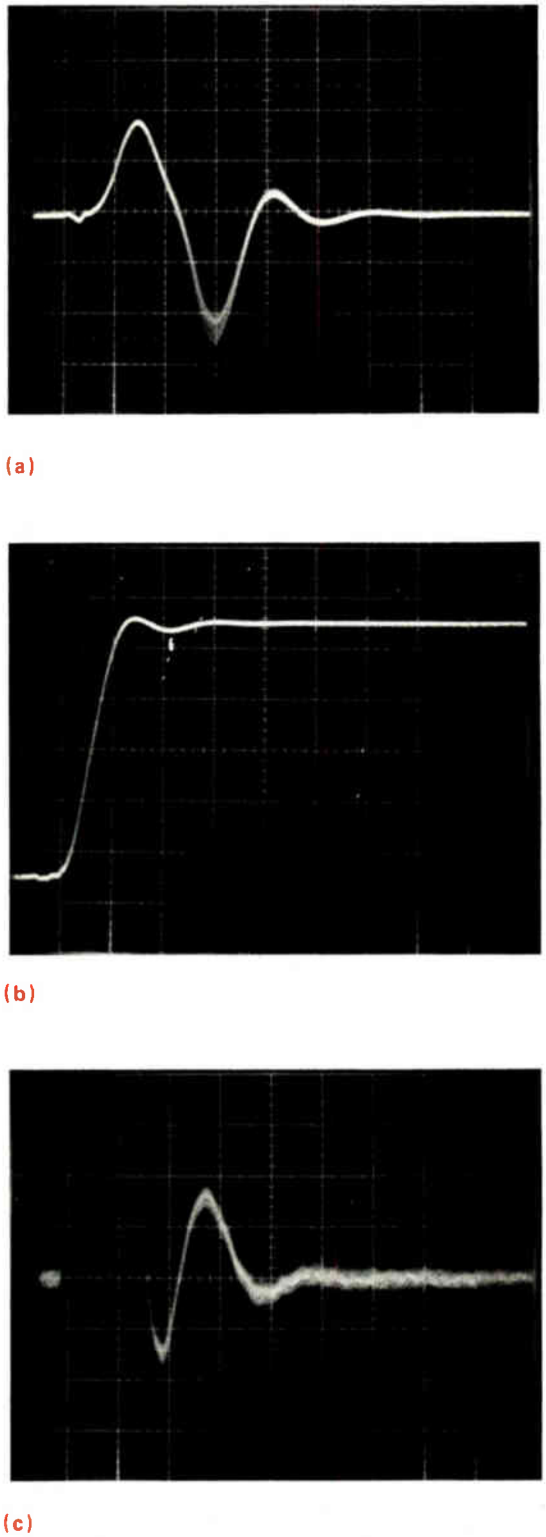
The IC was designed to operate using a 15-V supply and to switch TTL input levels. Its dimensions are 148 by 134 mils. The IC's switches are designed so that the outputs $I_{out\,1}$ and $I_{out\,2}$ must be operated into a ground potential. Current sources for the switches are generated by connecting a reference voltage through the converter's resistor network to the input nodes of each switch.

A thin-film ladder network

The resistor-network chip that generates the current sources for the switches is shown in Fig. 3. The thin-film network includes a 29-resistor ladder (r_1–r_{14} and R_1–R_{15}), where:

$$r_i = R_0[0.005/(15-i)]\big|_{i=1}^{14}$$
$$R_I = R_0(1.005-0.005I)\big|_{I=1}^{15}$$

The resistor-network chip also includes a conventional



4. Settle. DAC370-18 settles to 0.01% of full scale in 2 microseconds (0.2 μs/division). An LSB major transition (a) and a full-scale change (b) are shown with vertical scales of 0.5 and 2 V/division, respectively; (c), at 5 mV/division, shows how latches improve on (a).

TABLE 2: LINEARITY MEASUREMENTS FOR DAC370-18

Transition (Octal code)	Differential linearity error (LSB)
1 → 0	+0.5
2 → 1	+0.5
4 → 3	0
10 → 7	0
20 → 17	0
40 → 37	0
100 → 77	0
200 → 177	0
400 → 377	+0.25
1000 → 777	+0.25
2000 → 1777	+0.25
4000 → 3777	+0.50
10000 → 7777	−0.25
20000 → 17777	0
40000 → 37777	+0.25
100000 → 77777	+0.25
140000 → 137777	+0.50
200000 → 177777	+0.50
240000 → 237777	0
300000 → 277777	+0.50
340000 → 337777	+0.50
400000 → 377777	+0.50
440000 → 437777	0
500000 → 477777	+0.25
540000 → 537777	+0.50
600000 → 577777	0
640000 → 637777	+0.50
700000 → 677777	+0.25
740000 → 737777	+0.75

R/2R network ($R_{16\text{-}39}$), where:

$R_{16\text{-}27} = R_0/2$
$R_{28\text{-}39} = R_0$

The other two resistors on the chip (R_{43} and R_{44}) are wired in parallel and used as the feedback resistor with an external operational amplifier; the value of the parallel combination is $R_0/16$.

In choosing the value of R_0, which determines the absolute values of all of the network's resistors, one must compromise between maximizing R_0's value and maintaining a practical chip size. A large value of R_0 minimizes the on-resistance effects of the switches but also produces a very large chip size and thus lower chip yields.

For the DAC370-18, R_0 was chosen to be approximately 80,000 Ω. This gives a total resistance on the chip of just under 5 megohms and leads to a chip size of 142 by 133 mils. Since the binary weighting of the switches is carried only down to 2^{-9}, the resistor network is trimmed by a laser to compensate for the effect of the switches' on-resistances for the lower-order bits.

The resistor network is fabricated on a silicon substrate. Resistors are nickel-chromium and the metal interconnections are aluminum.

The current-output converter features respectable settling time, even when an output amplifier is used for voltage output. The settling time for an LSB major transition (400000 to 377777 octal) is shown in Fig. 4a, while a full-scale change of 0 to 10 V is shown in Fig. 4b. Both photographs were taken with the converter's latches in the transparent state, so all timing errors due to signal propagation through the decoder are included. Figure 4c shows the converter's LSB major transition with the latches in use. Note the reduction in switching glitches with the latches in operation.

Verified linearity

The technique used to verify the DAC370-18's linearity performance involved the use of a Hewlett-Packard model HP 9825A desktop computer, a Hewlett-Packard model HP 3455 digital voltmeter (used as the ultimate reference), and the appropriate interface between the d-a converter, computer and digital voltmeter. The d-a converter's output is fed to the input of the digital voltmeter through an interface developed by Hybrid Systems. The computer interacts with the digital voltmeter and sends its own data back to the d-a converter, through the interface, to complete the test loop. Such an arrangement allows the measurement and verification of the converter's differential as well as integral linearity parameters at a selected number of input codes.

Differential linearity is measured at both the 14 lower-order bit transitions and at each of the 15 higher-order transitions. Integral linearity is measured at all 128 points determined by the 7 MSBs. The results of both measurements are shown in Table 2.

This measurement technique is not the ultimate for high-resolution measurements, but provides a practical indication of the converter's actual performance. □

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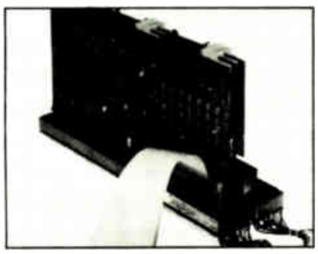

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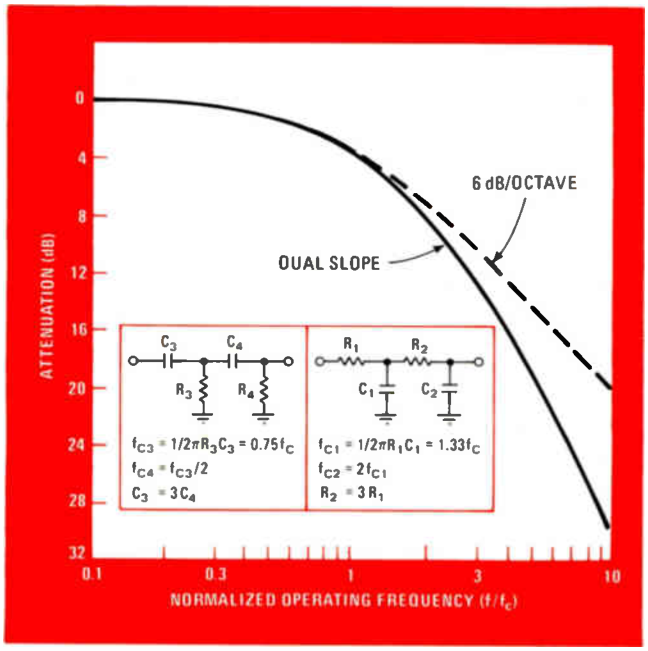
Circle 133 on reader service card

Dual-slope filters optimize speaker's crossover response

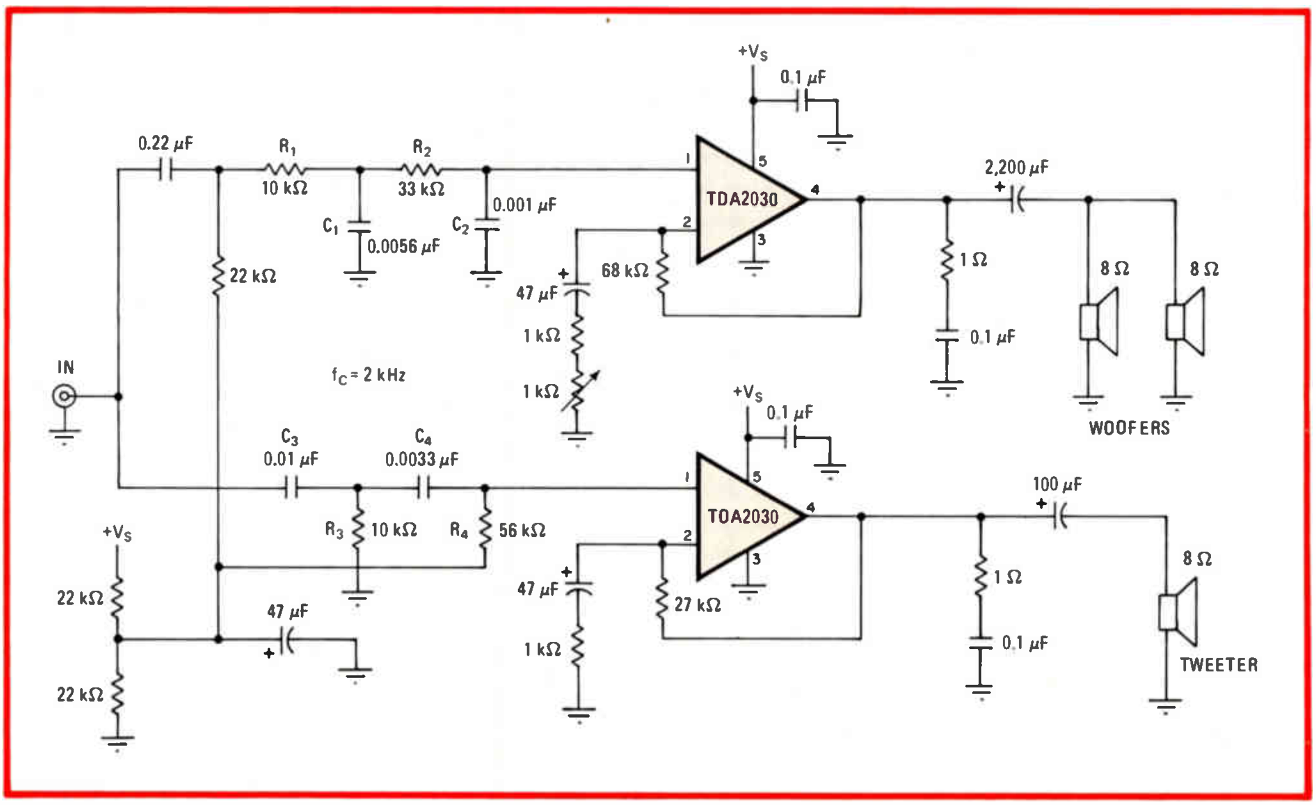
by P. Antoniazzi and A. Hennigan
SGS-ATES Electronic Components, Milan, Italy

The crossover response, and thus the overall performance, of a two-way high-fidelity loudspeaker system can be significantly improved with these high- and low-pass networks. Staggering two cascaded RC filters in the woofer channel yields a slope of 6 dB/octave near the cutoff frequency, f_c, and a notably steeper 12 dB/octave beyond f_c. When combined with the complementary (inverted response) output of the tweeter section, optimum crossover characteristics are achieved at low cost and without audio-frequency discontinuities at f_c.

In general, many simple low-pass networks can provide a 6-dB/octave response at frequencies approaching f_c from the low side. When a single-pole filter is used, however, as is still done on occasion, the maximum roll-off beyond f_c can never be greater than 6 dB/octave. Unfortunately, the typical loudspeaker does not have a linear enough response to handle high-level signals (de-



2. Response. Dual-slope filter, using staggered RC networks, virtually eliminates drop-off in audio output at the cutoff frequency of hi-fi speakers, while providing a roll-off of greater than the usual 6 dB/octave. Equations for woofer and tweeter sections summarize design.



1. Distortionless. Staggered low-cost, low-pass filters in woofer channel achieve slope of 6 dB/octave approaching cutoff frequency f_c and 12 dB/octave above f_c without introducing quadrature phase shift and accompanying distortion produced by loudspeakers. When combined with complementary output of high-pass section, system achieves crossover characteristic devoid of audio discontinuities at f_c.

graded by only 6 dB/octave) at its high-frequency limits, and so distortion results.

With second-order filters (12 dB/octave), a loss of audio usually occurs at the crossover point. This phenomenon is caused by the +90° phase shift of the low-pass network, which when combined with the −90° output of the system's high-pass filter tends to cancel the audio output.

Using a third-order Butterworth filter solves both of the aforementioned problems, yielding a flat response from dc to near f_c, steep cutoff (18 dB/octave) above f_c, and a gradual phase change across the band of interest. But this method is expensive, requiring two or three op amps and a large number of external components.

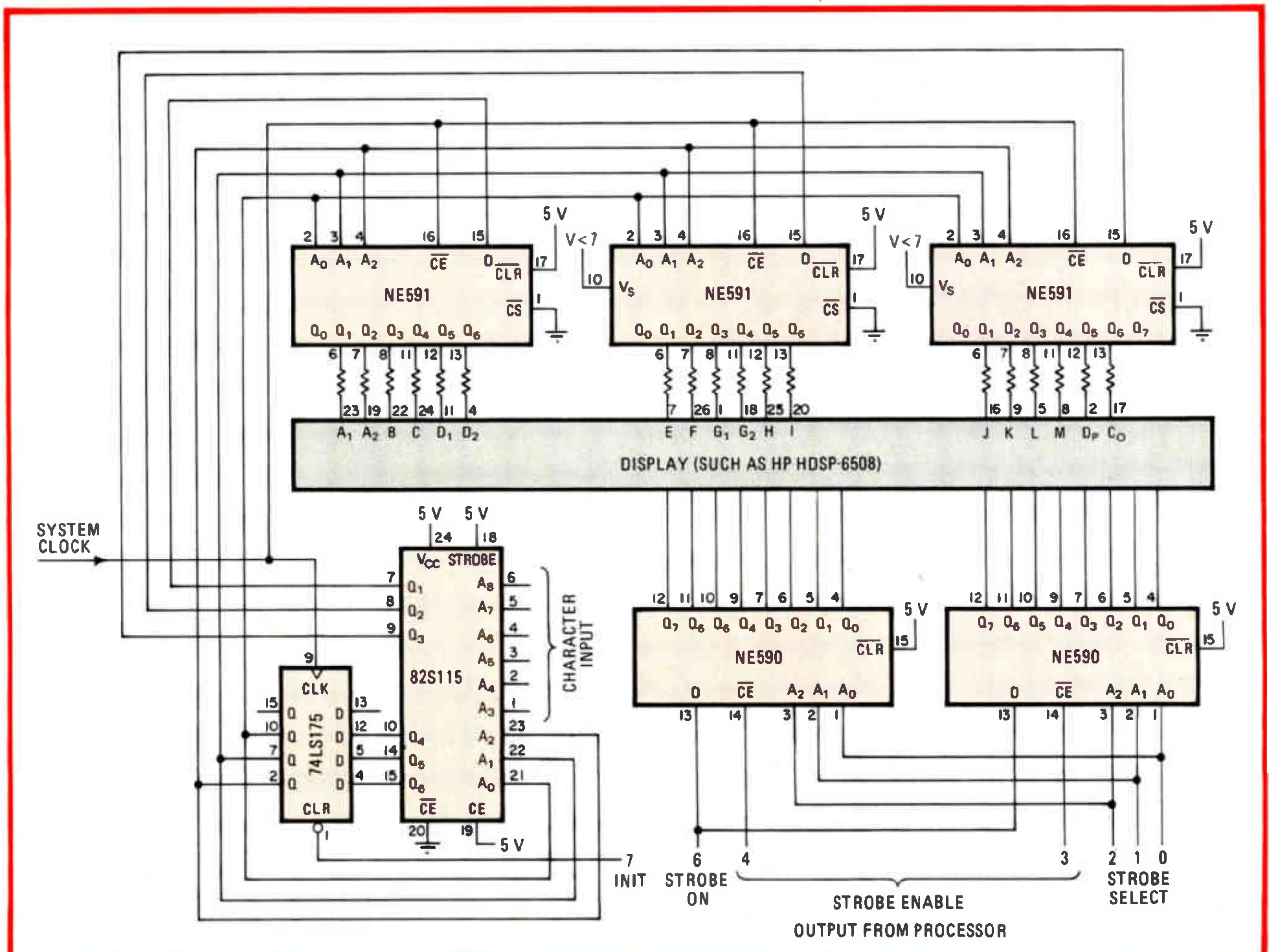
The dual-slope crossover network (Fig. 1) provides a viable answer to the problem. Staggering the responses such that the cutoff frequency of the first RC network is one half that of the second, attenuation at the crossover frequency will be 3 dB as in other systems, but the phase shift at f_c will be 60°; thus the cancelation problem typical of second-order filters is avoided. This circuit is ideally suited to active loudspeaker systems.

The plotted response of the woofer section is shown in the curve, which is complete with the required design equations. Corresponding equations for the tweeter are also included. □

Low-cost alphanumeric decoder drives British-flag display

by S. Cash Olsen
Signetics Corp., Sunnyvale, Calif.

Converting 64-character ASCII into an 18-segment ("British-flag") display font, this microprocessor-controlled alphanumeric decoder is a low-priced ($12) alternative to circuits costing up to five times as much. Most 18-segment displays (from Hewlett-Packard, Monsanto, and others) may be driven directly. And with the addition of high-breakdown output transistors to the driving circuitry, vacuum fluorescent panels and similar displays

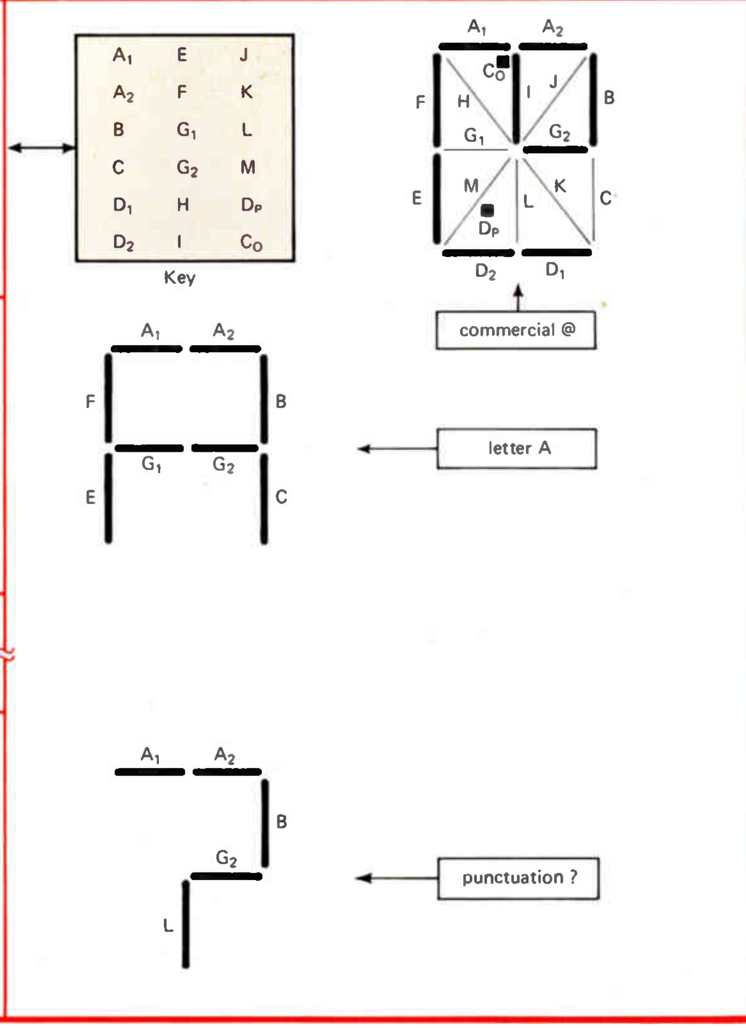


Charting characters. Low-cost alphanumeric decoder converts ASCII symbols into 18-segment display representation. Segment information, stored as table in 82S115 PROM, is clocked out in 3-bit segments over six states for each character, placed in display via NE591 drivers at any location by NE590 strobe latches. PROM character-generation table outlines method utilized to create symbols.

READ ONLY MEMORY CHARACTER GENERATION

Address	Q_6	Q_5	Q_4	Q_3	Q_2	Q_1
000_8	0	0	1	X	X	X
001	0	1	0	1	1	0
002	0	1	1	1	1	0
003	1	0	0	1	1	0
004	1	0	1	0	0	0
005	1	1	0	1	0	0
006	1	1	1	1	0	0
007	1	1	1	X	X	X
010	0	0	1	X	X	X
011	0	1	0	1	1	0
012	0	1	1	1	1	0
013	1	0	0	1	1	0
014	1	0	1	1	1	0
015	1	1	0	0	0	0
016	1	1	1	0	0	0
017	1	1	1	X	X	X
⋮			⋮			
770	0	0	1	X	X	X
771	0	1	0	1	0	0
772	0	1	1	1	0	0
773	1	0	0	1	0	1
774	1	0	1	0	0	0
775	1	1	0	0	0	0
776	1	1	1	0	0	0
777	1	1	1	X	X	X

Symbol



requiring high voltage may be accommodated, also.

In general operation (see figure), the microprocessor coordinates character selection, strobe-timing, and overall control duties with the aid of the NE590 strobe drivers, the NE591 peripheral display drivers, and the 74LS175 quad latch. When suitably addressed, the 82S115 512-word-by-8-bit PROM, which stores all the ASCII characters, delivers a logic-state table corresponding to the character selected via the clocked 74LS175 and the NE591s.

The PROM functions both as a character-request look-up table and as a state machine, with the quad flip-flop holding the current machine state. Bit 7 of the processor initializes the state to zero at the beginning of a character-decode cycle.

Logic signals corresponding to the character desired are then applied to pins A_3–A_8 of the PROM, and the device is clocked through seven states (see table) so that the desired segments are excited. The display is then strobed and the character thus placed in any desired location via command from pins 0 to 6 of the processor via the strobe latches, each latch of which is enabled separately. This process is repeated for up to 64 characters, the maximum that may be placed on the display at any given instant. Thereafter, as in all multiplexed displays, only one character is enabled at any time. All characters will appear to be displayed continuously, however, because of the high scanning rate.

As seen in the table, during each clocked state the PROM generates 3 bits of segment information. Six such states define the character produced. Thus only three display segments switch during each NE591 latching period, substantially reducing load transients and large load-current variations, which tend to cause difficulty in circuits of this kind. Only six of each NE591's eight outputs are used, to reduce power dissipation. Note that each device handles 6 of the total of 18 display segments for each character.

As the circuit is digital, neither layout nor component values are critical. The clock frequency, typically less than 5 MHz, should have a minimum pulse width (t_w) of 100 ns, however, in order to ensure proper display and strobe latching. □

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

Programmable components: the shape of VLSI to come

For economical solutions, very large-scale integration will rely on ROMs, gate arrays, and in the analog realm, programmable signal processors

by James L. Fischer, *Texas Instruments Inc., Dallas, Texas*

□ Entering the 1980s, the semiconductor industry is focusing its attention on developing and applying the next generation of technology—very large-scale integration. VLSI promises a far greater level of capability for devising electronic solutions to problems. Indeed, it is now apparent that the semiconductor industry is on the brink of perhaps one of the most profound technological developments of the century, the extension of human intellectual capability through microelectronics.

The revolution will be made possible by several trends that have characterized the industry from the beginning. Among these is ever-diminishing feature size. Currently, advanced semiconductor products are manufactured with approximately 3-micrometer line widths. Those will decrease to less than 1 μm by the end of the decade as the industry converts to advanced lithographic techniques and increases its use of computerized process control in manufacturing.

Decreasing geometries have allowed an increasing number of what Texas Instruments calls active-element groups (AEGs)—defined as one logic gate or 1 bit of memory—to be incorporated on a single chip. Today's technology permits manufacture of advanced products like the 64-K dynamic random-access memory with a density, including control functions, approaching 100,000 such groups per chip. The path of memory product development in the 1980s is well charted and predictable, leading to complexities of 1 million or more active element groups per chip by the end of the decade.

Increasing complexity at a decreasing cost per AEG has produced an explosive demand for semiconductor products in industries far afield from the traditional electronic equipment market. The single-chip microcomputer, for example, offers a cost improvement of more than 1,000 times over a comparable system implemented with discrete components and more than 15 times over the same system implemented in custom LSI circuitry (Table 1). As a result, the semiconductor content as a percentage of electronic equipment market value has doubled in the past decade to about 7% currently and is expected to increase to more than 10% by 1990.

Design stretchout

As the complexity of integrated circuits increases, the time and cost of circuit design multiplies. That trend has prompted questions regarding the nature of future customer-supplier relationships, which now range from the

TABLE 1: THE COST IMPACT OF MAJOR MICROELECTRONIC DEVELOPMENTS

Evolutionary step	Components to assemble	Component and assembly costs*	Cost ratio
1. Discrete-component systems (transistors, resistors, capacitors, etc.)	20,000 – 30,000	\$6,000 – \$9,000	—
2. Integrated circuits (small-scale integration—less than 10 gates or bits of memory per device)	350 – 500	\$600 – \$900	10:1
3. Medium-scale integration (adders, counters, etc.—100 gates or bits of memory per device)	125 – 150	\$250 – \$450	20:1
4. Large-scale integration (microprocessors and custom LSI circuits-more than 100 gates or bits of memory per device)	7 – 10	\$100 – \$200	50:1
5. Single-chip microcomputer	1	\$5 – \$10	1,000:1

*excluding backplanes, cables, cabinetry, etc.

usual dealings for standard products (where there is some design interaction between the supplier and customer) to those for custom products (which require a much higher degree of design interaction). First, will the semiconductor industry be able to handle the much greater and more complicated relationships with customer's that will result from the increased complexity of VLSI circuitry? Second, can the industry handle the potentially enormous design costs of future custom products? In essence, will the customer be able to afford VLSI so as to get a fair return on his investment?

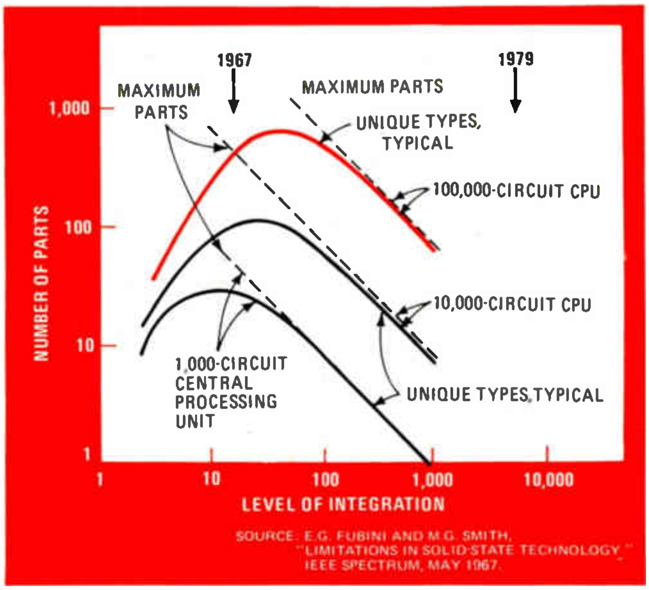
Those problems will be resolved, of course, just as others have been resolved in earlier stages of semiconductor development. Indeed, the first steps toward that resolution have already been taken.

New interface

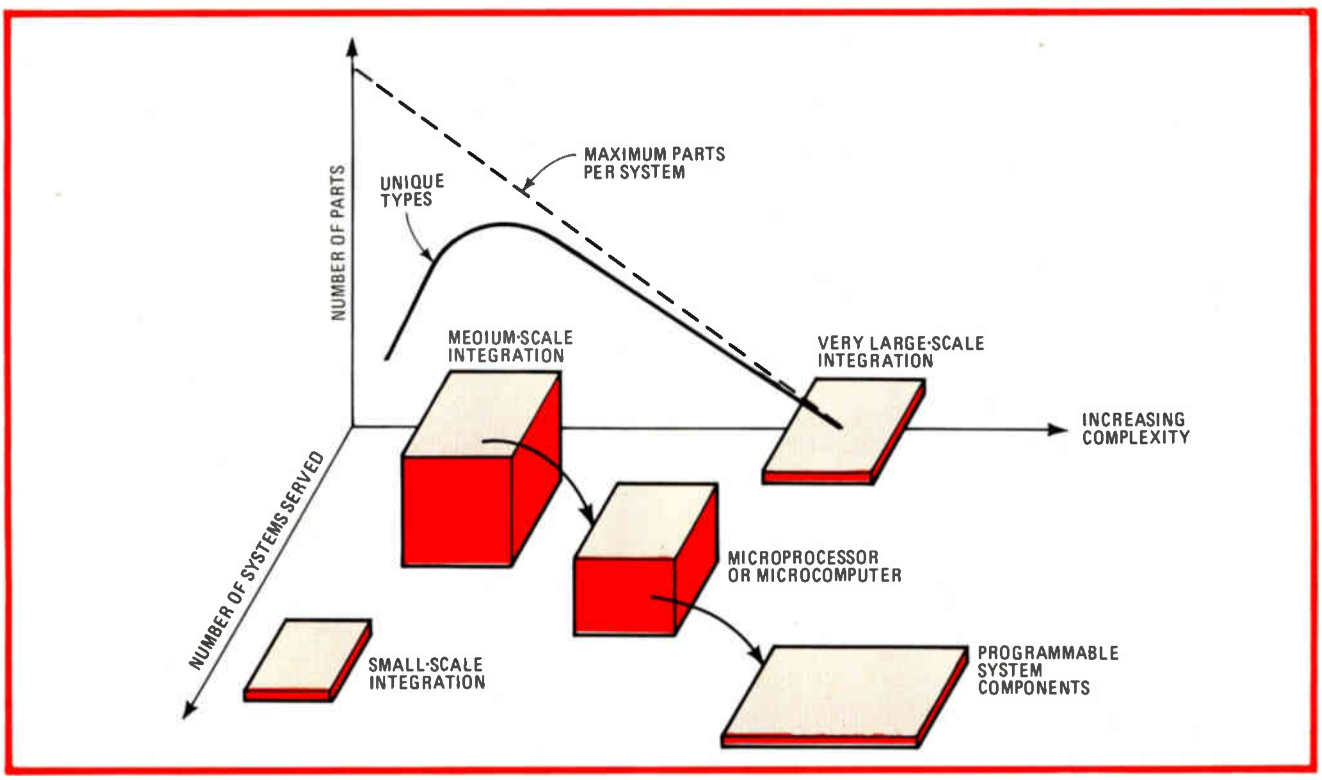
For most current interactions between component suppliers and system manufacturers, the design interface process for both standard and custom parts works very well, especially at the lower levels of product complexity, where the amount of information exchanged is small. For applications of standard products, the component manufacturer supplies the product specifications and data, and the system designer does the design and prototyping. In some situations, however, it may be necessary or more practical to specify a custom circuit. In that case, the customer must pay the extra development costs; however, he receives the advantage of unique circuit characteristics.

As complexity increases, the time and cost of circuit design multiplies exponentially. This fact constrains the affordability of VLSI designs, since they will involve a larger portion of the overall system design and will become more specialized in nature.

As early as 1967, Fubini and Smith expressed concern about two problems.[1] The first was the growing part-number problem (Fig. 1). They pointed out that as the level of integration, or chip complexity, increases, the number of unique parts required to construct a computer of a given size must also increase, resulting in difficult



1. Parts problem. The explosion in number of unique circuit types with increasing integration was predicted by Fubini and Smith in 1967, when chips comprised but 20 gates. They also predicted that the situation would reverse itself when one-chip computers arrived.



2. Added dimension. Coupled to the part-number problem is the consideration of how many systems can be served by parts of increased integration. With greater integration, the parts become so increasingly distinctive that, at the VLSI limit, each fits only one particular system.

TABLE 2: COMPARING TMS 1000 PROGRAMMING AND CUSTOM LOGIC DESIGN			
	Programming	Custom design	Savings
Number of applications	400	400	–
Design cost ($ millions)	10	80	70
Technical effort (man-years)	30	700	670
Cycle time per application, from specification to prototype (days)	50 – 75	200 – 400	150 – 325

problems for the manufacture of large machines. But at some level of complexity, they correctly predicted, that trend would reverse as technology eventually attained a level of integration that would make possible a single-chip computer.

Fubini and Smith also recognized the key problem associated with very high levels of integration: the difficulty in specifying a single-chip solution, because of the specialized nature of the application. The two suggested that designs would need to become increasingly general-purpose to serve more end-equipment applications.

Interestingly, those problems were foreseen when the level of integration ranged from 10 to 20 gates per chip. Though the specialized specification problem appeared then to be far in the future, it is very real to designers facing the 1980s.

Growing problems

Associated with the specialized specification problem are problems of design cost and design cycle time. As the level of integration increases and the parts become more complex, both the design cost and the cycle time required for each part increase dramatically. Whereas the number of unique parts required for a particular system increased with the evolution of small-scale to medium-scale integration, at a certain level of integration the trend reversed itself (as predicted by Fubini and Smith) and suddenly another dimension had to be considered—the number of systems served (Fig. 2). The reason: as the level of complexity increases beyond MSI toward VLSI, the maximum number of parts required for a given system decreases. Moreover, the number of systems served by individual parts also decreases. Taking that to the VLSI limit, where a single part fulfills the total system requirement, a new custom device is needed for each system application. Obviously, the very high design costs and long lead times required would limit the number of systems served by VLSI to only those where large numbers of systems would be built.

As has been the case in the application of LSI, programming offers a viable alternative to the high cost of customizing individual dedicated systems. The single-chip microcomputer best exemplifies this approach. However, the level of complexity achieved to date has limited that concept to relatively simple applications, most of which have been digital in nature. Because of the tenfold increase in complexity possible with VLSI, however, the concept of programmability—with its associated lower costs—will serve much larger numbers of system applications using a new class of components that may be called programmable system components. The customizing of these components is referred to at TI as solid-state programmation.

Three product families within this new classification are already apparent. They are microcomputers, gate arrays, and digital signal-processing circuits. Among the microcomputers, the TMS 1000 family of single-chip 4-bit microcomputers is the most pervasive example.

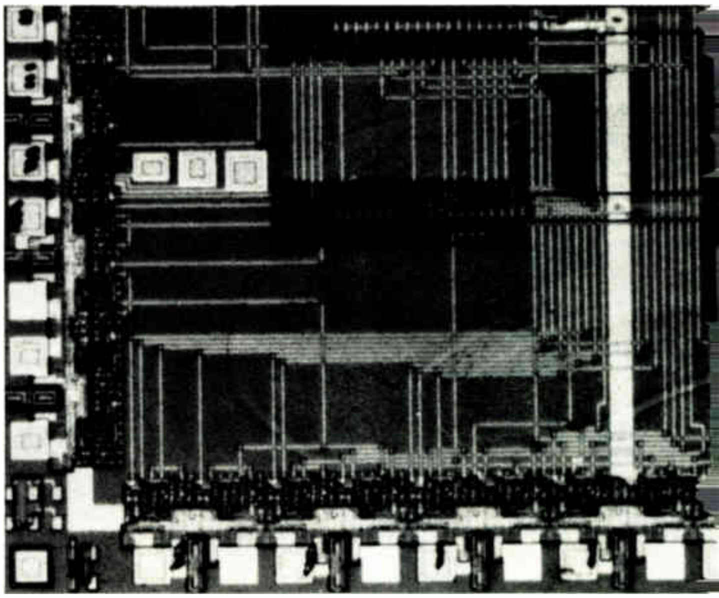
Programmable components

The architecture of all members of the TMS 1000 family is essentially the same. Only during the final processing of the silicon slice is the program developed by the customer to define the system's functional specifications converted into a single-level mask and then embedded within the microcomputer's memory. That final mask programs three parts of the microcomputer: the read-only memory, the instruction decoder, and the output encoder. These three, respectively, control the input of data to the central processing unit, the processing of the data, and the encoding of the output information to meet the needs of the system.

This class of device, currently in high-volume production, provides a preview of the programmable system component of the future. The TMS 1000 architecture encompasses more than 20 base sets comprising memory expansions from 500 bytes to 4 K of ROM, various input/output configurations, and output variants that meet the needs of high- or low-voltage and differing display technologies. From these base sets, over 400 different applications, or customizations, have been produced to date. That represents a total volume of more than 40 million units.

Chips for toys

Among the first applications for single-chip microcomputers were microwave oven controls, followed by many other appliance-industry and personal-electronics



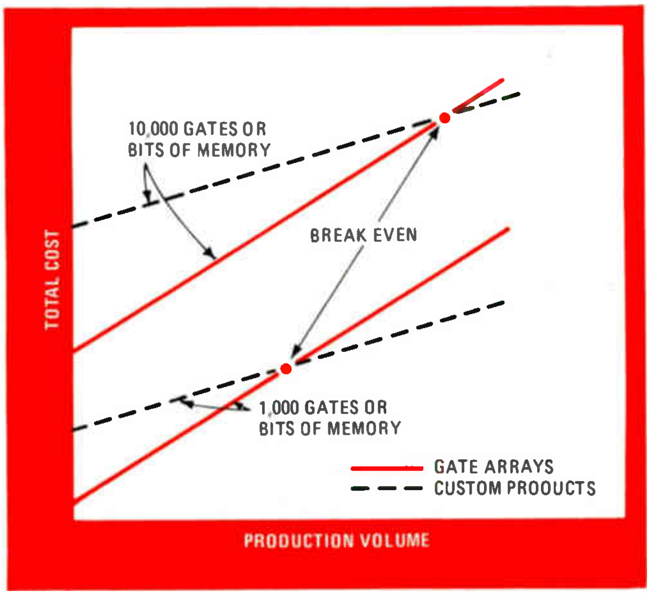
3. Array alternatives. The gate array will be especially effective for customizing circuits in low-volume applications. The key is to interconnect logic elements (the dense clusters in this portion of an array) using advanced computer-aided design techniques.

applications. In 1977, the toy industry became a major user of the one-chip microcomputer. Such cost-effective applications have expanded the electronic toy market from $21 million in 1977 to $480 million in 1979. The most significant aspect of the single-chip microcomputer is that it made these applications possible at a much lower cost than would have been possible through custom circuit design. Indeed, most would not have been produced were custom designs the only option.

Another illustration of cost-effective customization can be found in the Solid-State Software modules that determine the function of TI's programmable calculators. The modules—actually programmed ROMs—can change the calculator, for example, from a tool for investment analysis to one for a golf handicapper, to an instrument for marine or aircraft navigation, to a surveying aid for civil engineer. In each case, the change is primarily one of software. The only hardware cost involved in serving each new application is the incremental design cost of programming the ROM.

Speak & Spell is a learning aid that takes advantage of both forms of programmation—the microcomputer that acts as the synthetic-speech system's controller, and preprogrammed Solid-State-Speech ROM modules that can be plugged in to expand the basic vocabulary stored within the two 128-K ROMs incorporated in the basic chip set.

The use of programmed TMS 1000 microcomputers, rather than equivalent custom circuit designs, has resulted in substantial savings for system manufacturers (Table 2). The 400-plus designs now in production cost $7 million less because of programmation. But of even more significance is the savings of 670 man-years of highly skilled MOS circuit design effort. No firm had the design resources to develop 400 unique custom IC designs during that period. What's more, even if the resources had been available, custom designs would not have been cost-effective for most of these low-cost, consumer-oriented applications.



4. Breaking even. Because the initial design costs of custom ICs increase with circuit complexity, greater and greater volumes will be needed to break even on VLSI parts. Gate arrays have a far lower design cycle time and cost than custom circuits.

TABLE 3: COMPARING GATE-ARRAY PROGRAMMING AND CUSTOM LOGIC DESIGN

	Gate arrays	Custom logic	Savings
Cycle time per application, from specifications to prototype (days)	50 – 75	200 – 400	150 – 325
Design cost (normalized dollars)	1	3 – 10	2 – 9

A custom design might seem favorable because of its smaller die size, which initially suggests a lower manufacturing cost. The learning curve for custom circuitry, however, must be continuously recycled for each specific system application. The programmable system component, on the other hand, rides steadily down the learning curve, since the same basic part is produced for all programmations. Not only does that allow the initial component cost to be amortized over all customizations, but also it substantially adds to component reliability. For example, the TMS 1000 family now carries a failure rate of less than 0.05% per 1,000 hours of operation. That is equivalent to less than one failure in 210 years of continuous operation.

Gate arrays

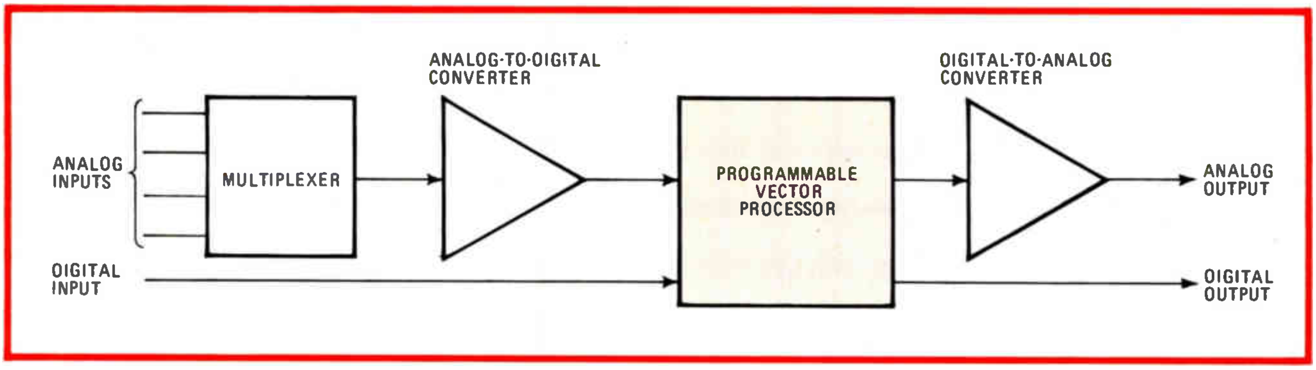
The second programmable system component that serves as a system solution for a growing number of logic circuit requirements is the gate array, whose initially unconnected logic elements are interconnected to perform a predefined logic function. Gate-level structures are defined by the systems manufacturer in terms of the function desired. These functions can be routed at low cost by computer, which links logic elements into the desired function (Fig. 3).

The gate-array approach is particularly effective in low-volume applications. Since the initial design cost of a custom part increases more rapidly with circuit complexity than does the cost of a comparable gate array, the break-even point for a custom circuit involves larger and larger production volumes with increases in complexity (Fig. 4).

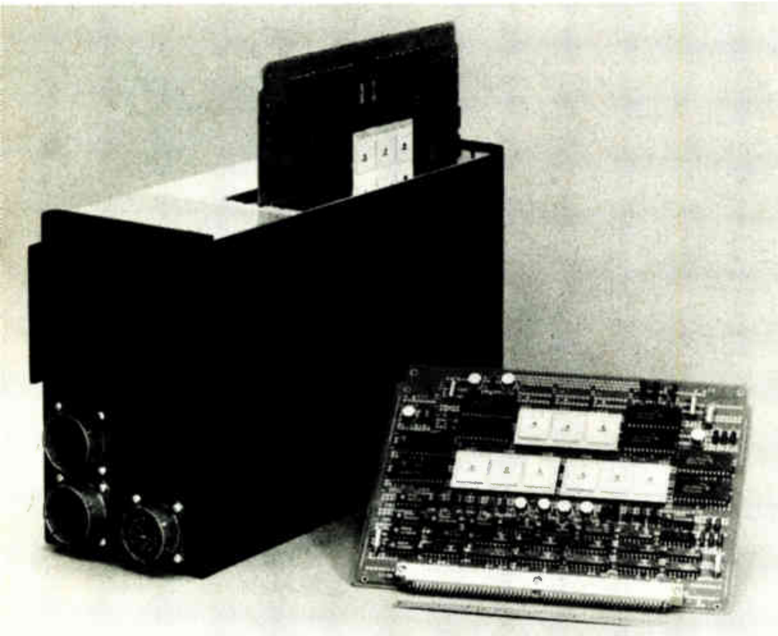
The advantages of programmed logic arrays over custom logic can best be seen by comparing the design cycle times and costs. The cycle time of gate arrays is one sixth to one fourth that of custom logic. Moreover, the design cost is one third to one tenth, a most significant savings in favor of gate arrays (Table 3). Since the programmation of gate arrays requires a metalization manufacturing step, electron-beam direct writing will play a vital role in minimizing prototype cycle time.

Analog-signal VLSI

The third programmable system component is the digital signal-processing circuit, an emerging technology that will replace single-function linear and analog circuits with programmable circuits. For example, the combination of a multiplexer, an analog-to-digital converter, a high-speed programmable vector processor, and a digi-



5. Analog processing. Digital signal-processing circuits will replace analog systems with programmable components that rely on analog-to-digital conversion at the input, programmable array processing at the heart, and d-a conversion at the output.



6. Precursor. A digital signal processor suitable for VLSI, this Micro-Vector Processor, built with integrated-injection-logic circuits, uses a pipelined design. It combines real-time signal-processing techniques of seismology, telecommunications, and acoustics.

tal-to-analog converter constitutes a flexible and efficient signal-processing system. Such a system can perform many functions, as indicated in Fig. 5. And since it is programmable, the subfunction as well as the sequence can be programmed.

A digital signal processor representative of the current state of the art is the Micro-Vector Processor (Fig. 6). This fast pipelined processor, implemented in integrated injection logic for military applications, combines more than two decades of real-time processing experience in seismology, telecommunications, and acoustics, along with VLSI technology.

New customer relations

As technology changes occur, corresponding changes in manufacturers' relations with customers will result. The relationships for standard products can be expected to remain much as they are today: the component manufacturer will continue to supply custom designs—mostly logic—but the relationship will be strained significantly with the advent of higher design costs per product.

The growing capability of programmable system components will relieve much of the need for unique custom parts. Thus, the part of the customer interface that can be expected to grow significantly will be the one falling between standard and custom products. But to use programmable system components effectively, the component maker must be capable of a fast turnaround for product prototyping and—equally important—he must provide a computer-based design-support system to the systems manufacturers.

In looking ahead to the application of VLSI, it is essential not to lose sight of the fact that the initial design of VLSI circuits, both programmable and single-function, will continue to require significant design-automation programs and large computers. The industry must continue to develop design-support systems to minimize the growth in design cost for very complex circuits. On the other hand, small distributed computing systems provide all the computer support needed for individual programmations. The tremendous difference in required computer support—and skilled manpower support—is a key driving force for employing programmable system components.

The future

Based on the future opportunities and semiconductor industry trends, there is every reason to believe that the world semiconductor market will grow from $10.4 billion in 1979 to over $45 billion by the late 1980s. Of that, programmable system components will account for $20 billion—or almost half.

It is safe to say that the growth of the semiconductor industry will not be limited by market opportunities. Instead it will continue to be driven by technology, bound at the upper limit by the effectiveness of the interactions with customers.

The world electronics market is expected to grow to $400 billion by the late 1980s, with the semiconductor content representing more than 10% of that. Considering the potential of VLSI, the total figure should well be even higher. But that potential may only be achieved through programmation, which charts a path toward the next microelectronics revolution. □

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1. E. G. Fubini and M. G. Smith, "Limitations in Solid-State Technology," IEEE Spectrum, May 1967, pp. 55-59.

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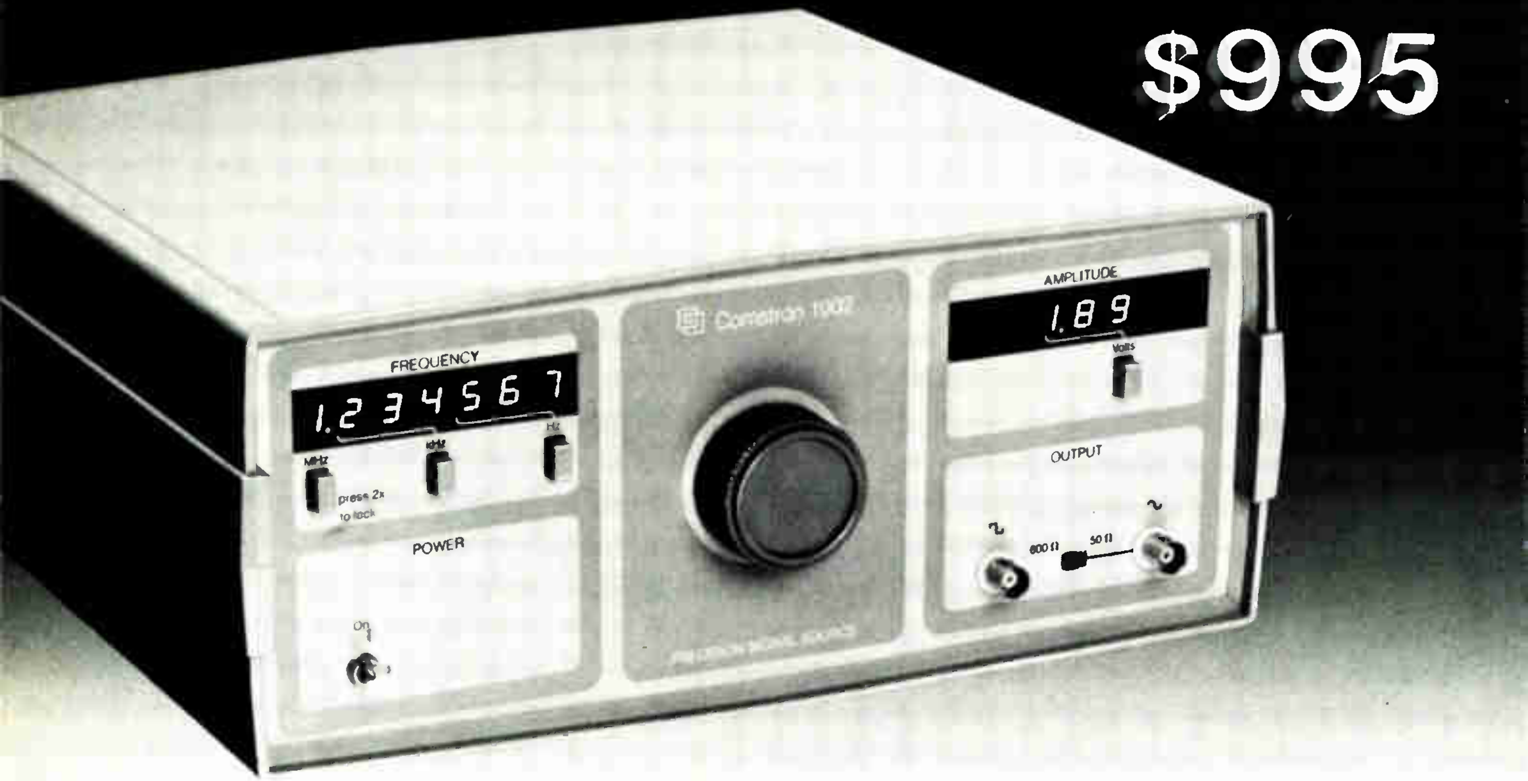

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Two-chip radio link pilots toys and models

Transmitter and receiver ICs for multichannel remote control give low-cost digital and proportional system a 100-meter range

by Martin Giles, Kerry Lacanette, Dennis Monticelli, and Ron Page, *National Semiconductor Corp., Santa Clara, Calif.*

☐ Toys and model vehicles with radio-frequency remote control have long been limited to committed hobbyists and radio amateurs working with expensive control terminals. But the price of radio control will drop enough to spur a consumer boom now that inexpensive but sophisticated integrated circuits are moving into the field.

Penetration of this high-volume, low-cost market is helped considerably by ICs designed for easy, reliable assembly and operation. Two of the first such chips, introduced at the end of 1978 and now in volume production, are the LM1871 encoder-transmitter and the LM1872 receiver-decoder. They make it possible to build a complete radio control system for only $10.

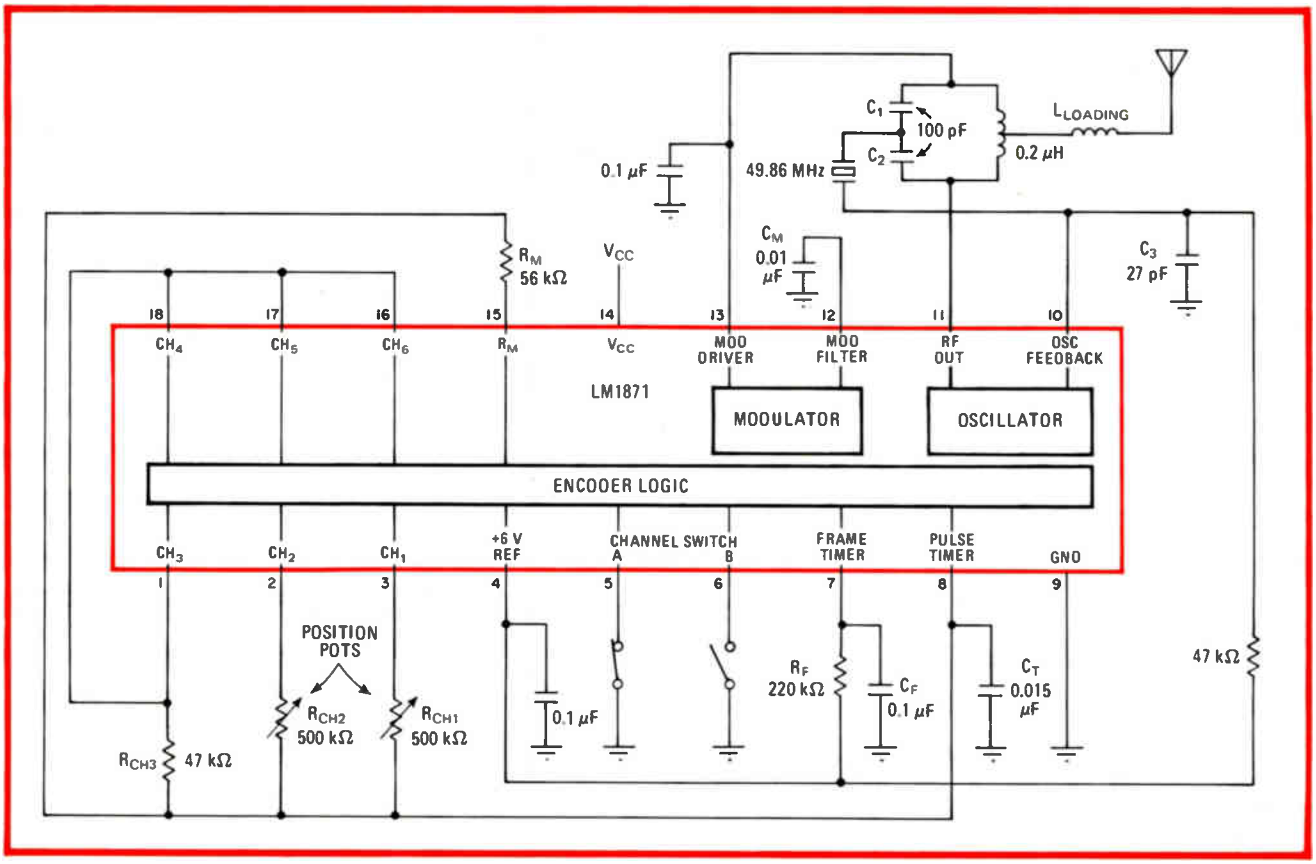
The LM1871 encoder-transmitter contains all the circuitry required to modulate an rf carrier as high in frequency as 80 megahertz with up to six analog channels of control information. The LM1872 receiver-decoder uses a combination of pulse-width and pulse-count techniques to recover two analog signals and to accommodate two others for digital (latched) service. Alternatively, simple external circuitry provides for handling a total of four independent channels in any combination of analog or digital formats. The versatile chip pair thus may be adapted to many other tasks such as activating burglar alarms or the remote switching of lights, TV channels, or data links, to name just a few.

With or without a license

While sharing many of the features of the typical 0.75-watt, $200-to-$400 radio control set used by the serious hobbyist in the licensed portion of the spectrum at 72 MHz, the LM1871/LM1872 combination is also designed to provide superior performance over the frequencies where no operator license is required (see Table 1). The modulation technique used is compatible with the requirements of the Federal Communications Commission for all allocated frequencies. The decoding technique, suitable for use in the licensed bands at the

REMOTE-CONTROL FREQUENCY ALLOCATIONS AND GENERAL REQUIREMENTS

Frequency (MHz)	Carrier tolerance	Maximum power or field strength	Bandwidth	Modulation	Notes
26.995 27.045 27.095 27.145 27.195 27.255	0.01%	10,000 μV/m measured at 3 meters.	± 10 kHz	On/off keying or amplitude tone modulation only	• Low power. Licensed operators permitted transmitting powers to 2.5 W • Frequency, phase and amplitude modulation prohibited • Maximum out-of-band emission: 500 μV/m at 3 m • Channel spacing: 50 kHz
49.830 49.845 49.860 49.875 49.890	0.01%	10,000 μV/m at 3 m	± 10 kHz	Any type	• No license required • Maximum out-of-band emission: 500 μV/m at 3 m • Channel spacing: 15 kHz
72.160 72.320 72.960	0.005%	0.75 W	± 4 kHz	On/off and tone	• License required
72.080 75.640 72.240 72.400	0.005%	0.75 W	± 4 kHz	On/off and tone	• Remote control of model aircraft only • License required



1. Guidance. LM1871 encoder-transmitter guides toys and models at 27, 49, and 72 MHz. Digital and proportional unit, shown configured for two channels each of digital and analog data, can be set up to deliver up to six channels of pulse-width–modulated information.

allowed higher power levels, works equally well in the low-power unlicensed segments at 27 and 49 MHz.

The LM1871 is a six-channel combination digital and proportional type encoder and rf transmitter (Fig. 1). A bipolar linear device, it is designed to generate a field with a strength of 10,000 microvolts per meter at a distance of 3 meters from its antenna at frequencies up to 50 MHz. This is the maximum field strength permitted for unlicensed transmitters. Encoding involves a pulse-width modulation scheme: analog information is converted into a train of pulses whose widths are proportional to the corresponding channel inputs.

In practice, the analog information at each channel input, and thus the output pulse width, can be set by a potentiometer that corresponds to a given control variable. Each of up to six pots may be sequentially switched to discharge the timing capacitor at pin 8, which is periodically charged by the 1871. The setting of switches A and B (pins 5 and 6) determines the number of channels sent in the transmitted pulse train. This number may vary from three to six. Each frame of six pulses lasts about 20 milliseconds, which includes a terminating sync pulse 5 ms long to allow the receiver to discriminate between one set of pulses and the next.

In operation, capacitor C_T at pin 8 is charged to two thirds of the supply voltage (V_{cc}) through the pulse timer in a time determined by both R_M and C_T. This time corresponds to the carrier-off period. The capacitor is then discharged back down to one third of V_{cc} through external potentiometer R_{CH1}, which sets the carrier-on period for the corresponding channel, with the sum of the on and off periods constituting the pulse width for the channel. This width is usually between 1 and 2 ms, with a nominal 1.5-ms value. At the receiver, a corresponding potentiometer connected into a pulse recovery circuit is mechanically set in position by a servo, the servo rotating until the pulse widths at receiver and transmitter match.

Closed loop or open

This pulse-width matching is a form of closed-loop analog control: the rotation of the receiver's servo is proportional to the control position of the transmitter's potentiometer—that is, a steering, or positional function. Alternatively, open-loop control can be obtained for any channel by omitting the corresponding receiver potentiometer and comparing the transmitted pulse with a fixed pulse width at the receiver (usually a 1.5-ms monostable vibrator triggered by the leading edge of the transmit pulse). A shorter transmitted pulse will cause the servo to rotate in one direction. Matching pulses will result in a stationary motor, and a wider transmitted pulse causes rotation in the other direction. The motor speed can either be fixed for positional control or variable, depending on the actual difference in the pulse widths for speed control. Because this open-loop method initially requires matched pulses for a stationary motor, the LM-1871/1872 can also use another method, described later, that avoids the need for a time reference to control latched channel controls (digital channels).

The typical transmitting antenna used in the field will be a telescoping or fixed wire antenna about 0.6 m in length. At 27 and 49 MHz, this length is less than one tenth of a carrier wavelength, so the antenna is capacitive. At 49 MHz, a 0.6-m, 5.6-mm-diameter antenna can be represented by a 6.2-picofarad capacitor. The ability of such an antenna to radiate power can be represented by an equivalent radiation resistance (R_A) that would dissipate the same power. R_A is given by:

$$R_A = 40\ (\pi L/\lambda)^2 \text{ ohms}$$

where L is the length of the antenna and λ is the wavelength, both in meters. For an antenna 0.6 m long, R_A equals 3.78 Ω.

The current through R_A needed to generate a given field strength, E (in μV/m), is given by:

$$I_A = Ed\lambda/(120\pi L)$$

where d is the distance in meters from the antenna. Plugging in the FCC limit for E of 10,000 μV/m at d = 3 m, it is seen that the antenna current is 0.8 mA. If the capacitive reactance of the antenna is tuned out with a loading coil (resonating with 6 pF at 49 MHz) less than 3 mV is required from the oscillator tank circuit, in theory. The loss resistance, R_L, is considerable, however, and must be taken into account. This resistance will be a function of the terrain, transmitter height, load mismatch, and other factors. For a typical hand-held transmitter with a consequently poor ground return, R_L will vary from several hundred ohms to kilohms. Practical experience indicates that the tank coil should be suitably tapped to deliver 20 mV peak to peak at 49 MHz and about 200 mV p-p at 27 MHz to the antenna loading coil in order for the 1871 to deliver the maximum field strength. The transmitter is regulated so that the maximum power output is maintained for a supply voltage variation extending from 16 down to 5 volts.

The extremely low radiated power permitted in the unlicensed bands does indicate one difficulty in utilizing these frequencies, apart from the limited range. Specifically, FCC regulations mandate that out-of-band emissions must be at least 26 dB below the peak permitted carrier level: that is, less than 500 μV/m. Because of the substantial losses encountered in the antenna circuit, the oscillator power level must usually be made high to achieve the maximum permitted field strength. This means that the level of harmonics being radiated directly by the oscillator can easily be above the FCC limit if care in circuit layout is not exercised. Oscillator and output leads, including ground returns, should be kept as short as possible. Design and evaluation kits for both the 1871 and 1872 are now available for those who wish to eliminate construction-phase headaches.

Range versus terrain

The range to be expected with this low-power transmitter is dependent on the transmitting and receiving antenna heights and the local geography. Outdoors, the transmitted field strength can be expected to be similar to that of the color curves of Fig. 3, taken across an asphalt parking lot with a transmitter 3 feet above the ground. Wet grass or water and higher antenna locations will yield an increase in field strength for a given distance from the transmitter. In contrast, operation within buildings can drastically reduce range if they contain much metal. Metal furniture, refrigerators, filing cabinets or steel beams will cause dramatic local variations in field strength making any range predictions subject to large errors. However, in domestic environments, a range of at least 10 to 20 m can usually be attained.

But while the permissible output power is an important factor in determining the control range, of equal importance is the sensitivity of the LM1872 receiver.

Sensitive superhet

To obtain sensitivity along with good selectivity, the LM1872 (Fig. 2a) is configured as a single-conversion superheterodyne receiver. The local-oscillator and mixer stages are capable of operation up to 80 MHz with good conversion gain and low intrinsic noise. The intermediate frequency is 455 kHz, and a wide-range (97-dB) automatic-gain-control circuit is employed in the i-f amplifier to handle the wide range of input voltages typically encountered. This circuit also provides good immunity to voltage transients on the supply line. The active digital detector that follows raises the system gain to 88 dB. The resulting baseband signal is then applied to the decoding logic, so that the original signal information sent on each channel can be retrieved.

A high-gain precision comparator, a 30-μs integrator, and a 25-mV reference make up the unique digital detector. When the signal voltage from the i-f amplifier exceeds 25 mV (the detector threshold level), the comparator will drive transistor Q_{11} to discharge the envelope-detection capacitor, C_{12}. A period of 30 μs is normally required for the 1-μA current source to linearly charge C_{12} to the 3 V ($V_{cc}/2$) level necessary to fire the Schmitt trigger. But the presence of the 455-kHz carrier waveform (2.2-μs period) prevents C_{12} from reaching this threshold until the carrier signal goes to zero during the interchannel time. The Schmitt will respond 30 μs later. This delay does not upset system sync since the LM1872 decoder responds only to the negative edges of the modulation envelope.

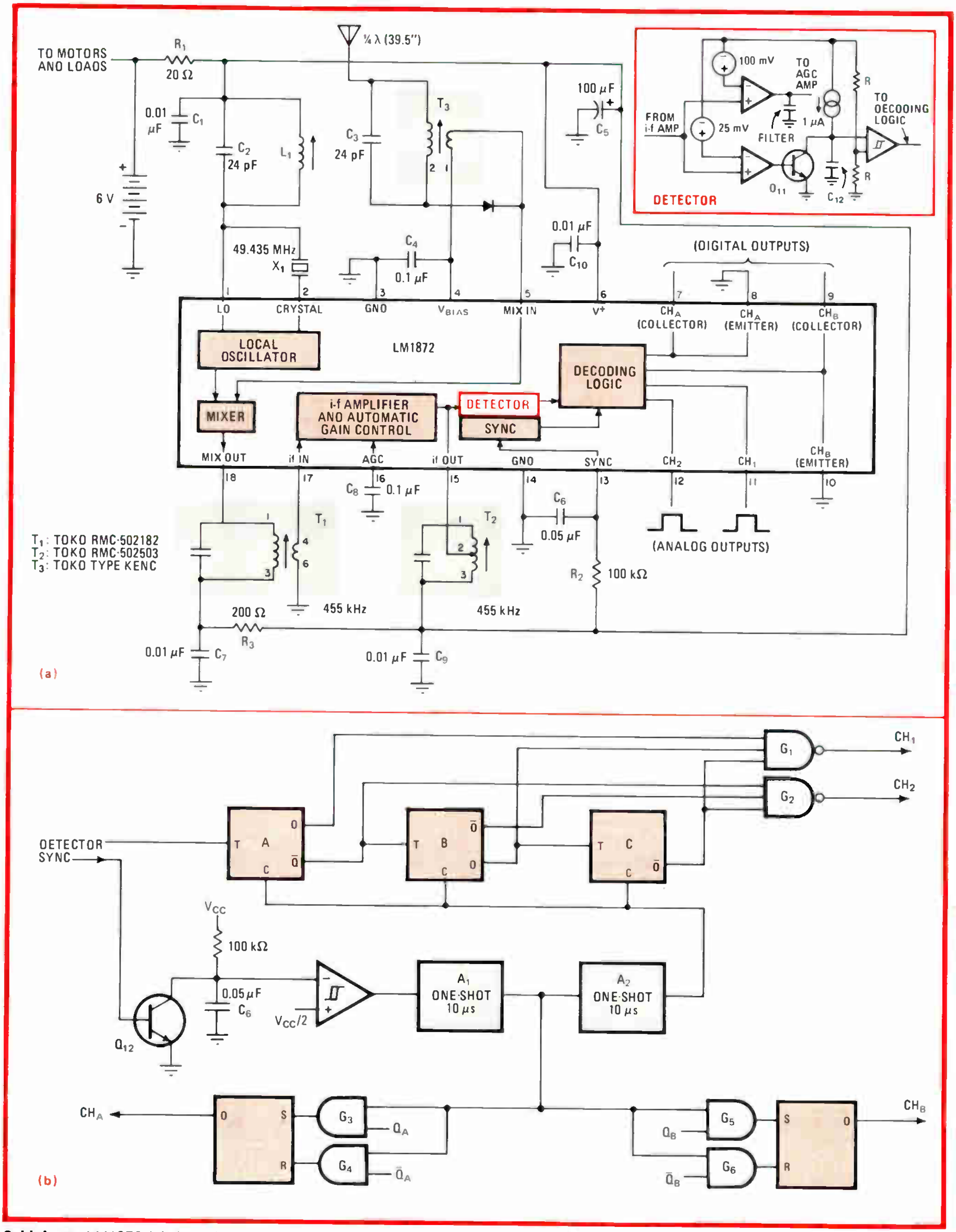
Recovering the data

The decoder (Fig. 2b) extracts the timing information from the carrier for the analog channels (of which there are normally two) and the pulse-count information for the digital channels (normally two). At the heart of the decoder is a three-stage binary (flip-flop) counter, A–C, that is advanced by one count on each negative transition of the modulated carrier envelope.

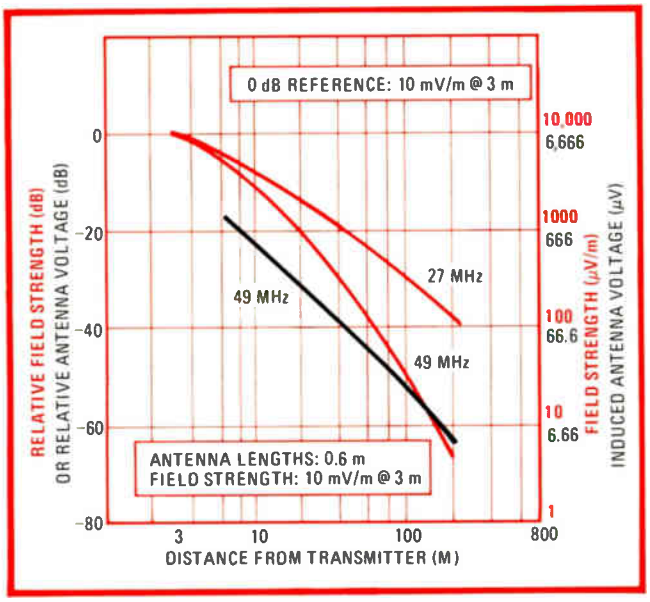
When the rf carrier drops out for the first modulation pulse, its falling edge advances the counter. During this time the sync capacitor C_6 is held low by transistor Q_{12}.

When the carrier comes high again for the variable channel interval, C_6 ramps toward $V_{cc}/2$ through the 100-kΩ resistor but is unable to reach it in the short time that is available. At the end of the pulse, the carrier drops out and the counters advance once again. The sequence is repeated for the second analog channel.

Gates G_1 and G_2 decode the analog channels by exam-



2. Linkage. LM1872 (a) demodulates up to four channels of incoming data, converting it into positional data for model vehicle's analog- and digital-channel servos. Single-conversion superhet is built on par with standard a-m receiver, except for digital decoder (b), which is needed for extracting the timing and pulse-count data from carrier in order to deliver the proper channel command to its corresponding servo.



3. Profile. The field transmitted by the 1871 (color curves) induces a voltage at the 1872 receiver's antenna (black curve) sufficient for operation at 100 m. The receiver's automatic-gain-control threshold is reached at an input voltage of 250–280 μV.

ining the counter's binary output to identify the time slots that represent those channels. Decoded in this manner, the output pulse width equals the sum of the standard interpulse time and the variable pulse width representing channel information. A Darlington output driver then delivers the channel pulses to their corresponding servos.

Following the transmission of the second analog channel, one to four (in this case, two) pulses representing the digital information are received in the manner outlined in the detector discussion. Up until the end of the pulse group frame period, the decoder responds as if these pulses were analog channels, but it delivers no output. At the conclusion of the frame, the sync pulse is sent. Because the sync time is always made longer than the period of the sync timer (pin 13), the timer can deliver a signal to monostable (one-shot) multivibrator A_1. The first A_1 enables gates G_3–G_6 to read the state of flip-flops A and B into a pair of RS latches.

The latches can source or sink up to 100 mA, thus serving as an ideal device for transferring the digital command to its servo. If A or B, and thus its corresponding latch, is at logic 1, then its respective servo will be activated. Upon conclusion of the read pulse, one-shot A_2 is triggered, the counter is reset, and the chain is ready for the next frame.

The motor noise factor

The voltage induced by this encoder into a receiving antenna 0.6 m in length at 49 MHz is plotted in the solid black curve of Fig. 3. As seen, the maximum typical outdoor range will be 100 meters. The minimum receiver sensitivity needed to effect a successful command has been set at 15 μV nominal. Higher sensitivities can be easily achieved and the range possibly increased significantly, but the high-noise environment created by inexpensive servo motors themselves makes this consideration impractical for low-cost applications.

The automatic-gain-control (AGC) threshold is reached for an input of 250 to 280 μV from the antenna. This signal level corresponds to a position roughly 25 m distant from the transmitter. At the detector threshold level (12 dB below the AGC threshold), the antenna signal is 60 to 70 μV, corresponding to a minimum range between 50 m and 60 m. To run a small vehicle on a received signal of only 60 μV does require good suppression of motor noise. Although the LM1972 is immune to noise transients on the common supply lines, rf noise generated by the motor brushes will always be picked up at the antenna or i-f transformer windings. Motors with wire or carbon brushes are usually better in this respect than motors with metal-stamping brushes, but even the latter can usually be effectively suppressed by inductors mounted close to the brush leads. In applications where the drive or servo motors are more remote from the antenna circuit, the LM1872 can be designed with higher sensitivity. At the licensed frequencies around 72 MHz, the circuit is able to operate with a signal below 2 μV at the antenna input.

Four-channel flight

The 72-MHz band is intended primarily for control of model aircraft, which often requires more than two analog channels. Expansion to four analog channels is easily accomplished by modifying the LM1871 encoding waveform such that channels 1, 2, 4, and 5 are pulse-width–controlled by potentiometers. Channel 2 is made to emit a fixed long pulse (5 ms) such that after decoding channels 1 and 2 at pins 11 and 12, the LM1872 will recognize channel 3 as a sync pulse and reset the counter chain. Simultaneously, both digital channel outputs will be latched low and then channels 4 and 5 will be decoded at pins 11 and 12. Because the digital channels are at a logic 1 (high) during encoding of channels 1 and 2 but are at a logic 0 during encoding of channels 4 and 5, they can be used to steer the analog channels—providing four independent analog controls.

This type of transmitter encoding may also be used to provide simultaneous control of four independent single-channel receivers, each receiver using the digital channel output to identify its control pulse.

Other transmission media

Although the LM1871 and LM1872 have been designed primarily as an rf link, other alternatives are possible, including common carrier transmission, ultrasonic, or infrared data links. To use the LM1872 as an infrared receiver, the local oscillator is defeated and the mixer stage runs as a conventional 455-kHz amplifier. For an ac line link, a 262-kHz i-f is more suitable but will have a similar configuration. The choice of carrier will depend largely on application—rf links being suited to relatively long-range outdoor mobile control, infrared and ultrasound to applications where room-limited transmission is needed for privacy. Common carrier will apply best to stationary locations where communications is desired without additional wiring around a building. Additional information is available in the application notes for the 1871 and 1872. □

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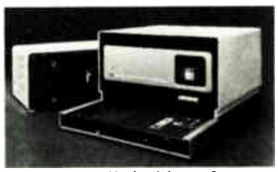

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Distributed computer network takes charge in IC facility

Computers at the helm of MOS chip production line manage fabrication and testing of wafers, data collection, and generation of test reports

by David P. Clemens and Gary L. Castleman, *Hewlett-Packard Co., Corvallis (Ore.) Division*

☐ Very large-scale integrated circuits have become so complex that computers are moving into virtually every stage of their fabrication, including factory management. Hewlett-Packard's automated production facility in Corvallis, Ore., was designed in response to this situation. The plant, which produces LSI MOS chips for calculators such as the HP 85A, has an integral distributed computer network that controls the chip-processing equipment with both flexibility and precision and collects and analyzes a very large amount of technical data. It also manages a data base of accounting, manufacturing, and test information.

At the distributed network, a variety of LSI MOS circuits are routinely and simultaneously made on the same production line to diverse process specifications. Each lot of wafers, under the direct control of the computer network, can receive individually tailored processing. As the analysis of production and engineering data is increasingly performed by the computer network, the result is less paperwork.

Many benefits have been realized with the computer network, which was originally started in HP's integrated circuits laboratory at Palo Alto in 1975–76 and then transferred to Corvallis, where it went on line in April 1977. Engineering efficiency has increased as data acquisition and reduction have been simplified. With the network, an engineer can solve problems more quickly because complex process interactions are much more easily correlated. Also any process alteration can be implemented as easily for one product as for another.

Distributed management

The distributed computer network is composed of a hierarchy of interlinked computers, each performing the task its size and power best suit it to. Shown in Fig. 1, the system spreads the factory's computational workload among three major networks: the LSI process network controls wafer fabrication; testing is managed by the LSI testing network; and data is collected and reduced in the factory management network. These areas are linked by the ringlike structure shown in Fig. 1.

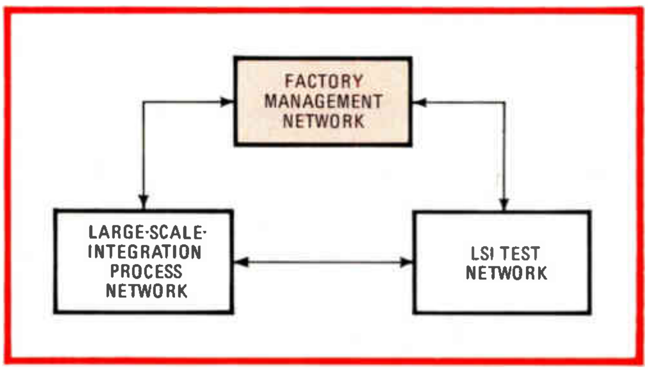
The factory management computer, which resides in the top block, requires software and hardware designed for batch processing. This processor must be able to manipulate a very large data base accessible by direct computer link to the rest of the distributed network and to generate reports in business ledger form. The programming languages must be suited to business and scientific functions. The HP 3000 was chosen for its mass data storage and flexible data formatting.

The computers used in the process network and test network blocks must be fast, efficient, and relatively inexpensive for the real-time management and control functions they are called on to do. The minicomputers chosen were HP 1000s, which have a real-time operating system with high-speed floating-point calculations and a flexible input/output architecture.

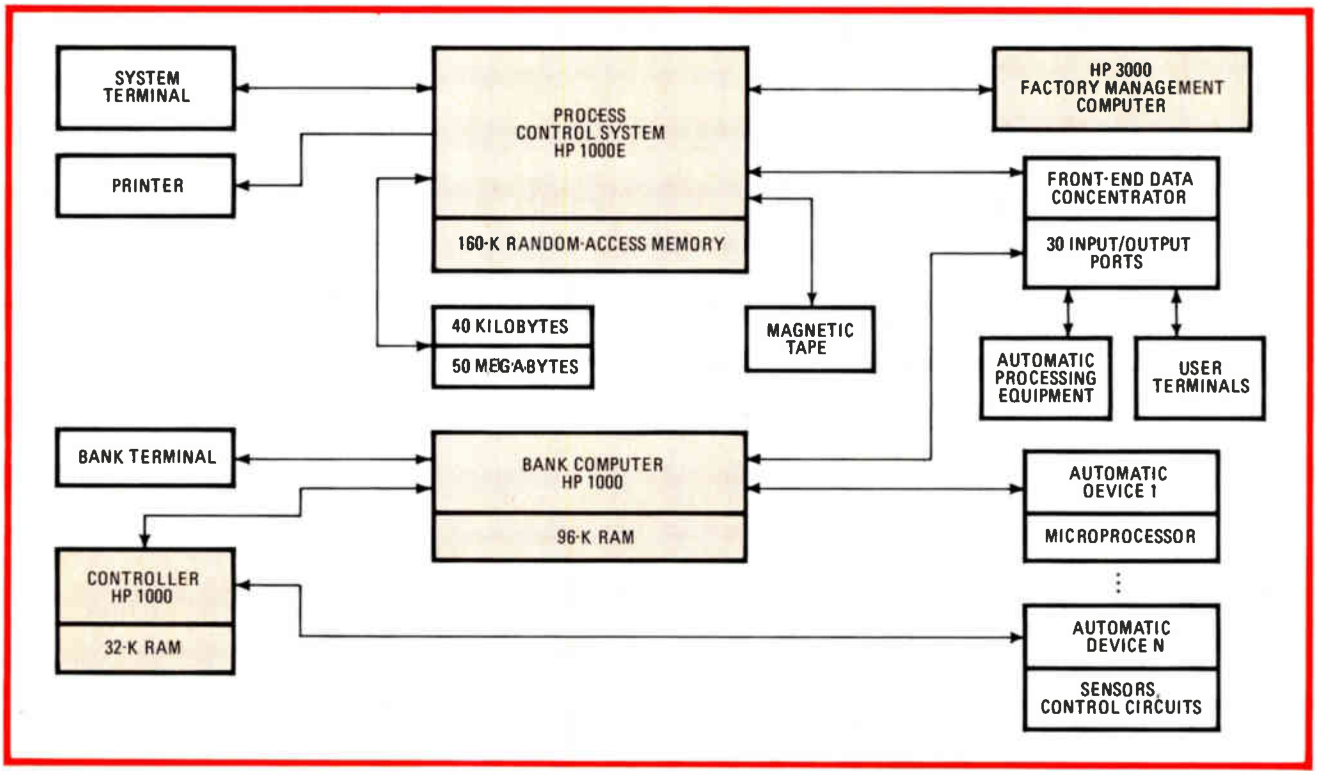
The network is tied together with HP distributed system hardware and software. In the network, information can be transferred to and from any node. At each node, information can be assembled and reduced to its most useful form. Each data base is updated as information is entered, with management and engineering reports containing the most recent data.

For report generation, if the central processing unit of one network node is busy, its stored information can be transferred to another that does have time available. For an even more efficient mode of operation, redundant communication links and a management hierarchy can be added to this distributed network.

The automatic LSI processing network shown in Fig. 2 manages wafer movements through each wafer-processing step while at the same time precisely controlling each process step's parameters and collecting information about each wafer lot—a group of wafers that is pro-



1. Load sharing. At Hewlett-Packard's Corvallis, Ore., facility, a distributed computer network, shown greatly simplified, shares the computational workload of an MOS fabrication line among linked factory management, LSI process, and LSI test networks.



2. Processing. Wafer fabrication is managed by the process control system (PCS)—an HP 1000E. It interfaces with equipment controllers via the front-end data concentrator (top right). Bank computers manage data transfer between PCS and automatic processing stations.

cessed from a common beginning to a common end. A process is defined as an ordered set of operations that, when executed sequentially, convert a lot from bare silicon wafers into ICs.

One goal of the automatic processing network is to lower costs by enhancing yield, improving product reliability, and simplifying the collection of production and engineering data. Another important goal is to minimize operator and environmental influence on the wafer processes. Detailed instructions are presented to the operator on cathode-ray-tube terminals at each operating station, and each piece of processing gear is controlled as automatically as possible.

The main components of the LSI processing net are the process control system (PCS), front-end data concentrator, bank computers that control a bank of equipment, and the equipment controllers. The PCS sends instructions to and gathers data from a series of automatic controllers—minicomputers or microprocessors—at the various wafer-processing stations. The front-end data concentrator is a customized communications interface that allows the PCS to communicate with the rest of its net without loading associated tasks on its CPU.

Bank computers manage the transfer of information between the PCS and one or more automatic processing stations. At present there are four bank computers on line. Automatic processing stations are basically automatic controllers for each IC processing step that also gather real-time data on the process.

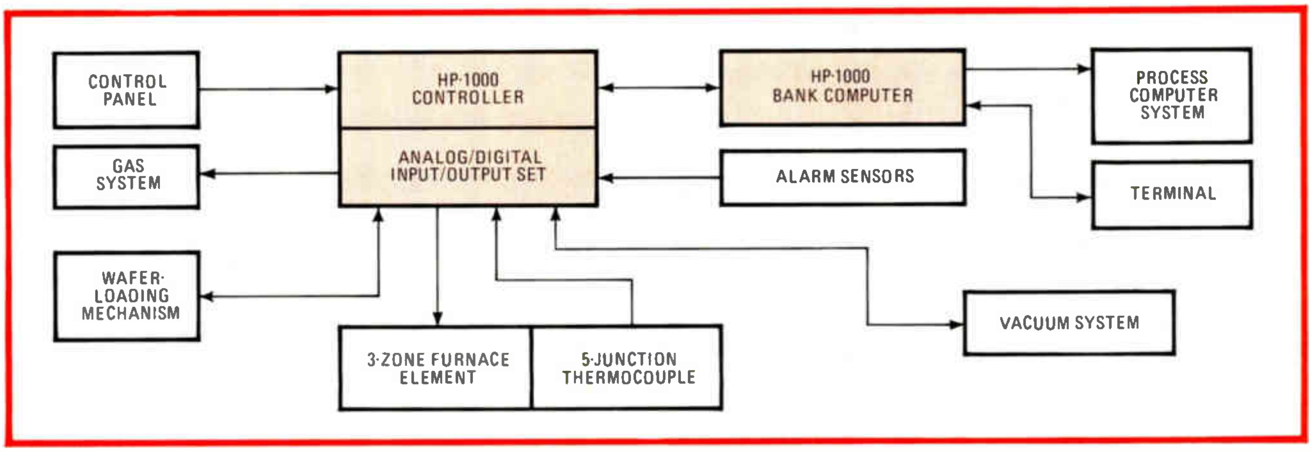
At the center of the process control system is an HP 1000 E-series processor with 160 kilobytes of random-access memory. The system manages the movement of wafer lots and makes sure that the processing steps occur in the correct sequence. Its operating system occupies 40 kilobytes.

The mass store in the process control system is an HP 7900 disk, which has 5 megabytes of storage meant for application and system software. A 50-megabyte 7920 disk is used for accumulating the data base. A magnetic-tape system is used for mass storage of the operating system and of each day's transactions. A second system, which is identical to the PCS, is also utilized at the plant for generation of off-line software and as a backup for the PCS.

The PCS interfaces through its front-end data concentrator with as many as 30 external devices, including bank computers and user input/output terminals. The data concentrator is flexible enough to adapt to the wide range of asynchronous communication protocol formats needed to interface with the different protocols of both purchased equipment and that designed in house.

Asynchronous protocols generally require many time-consuming routine tasks such as check-sum calculations, special character recognition, intramessage timeouts, and automatic retries on errors. The front-end data concentrator firmware saves valuable time by handling all of these tasks.

Messages pass between the PCS and each automatic processing station through a two-way link. The communication interpreter is the bank computer, which is an HP 1000 with 96 kilobytes of RAM. A terminal connected to each bank computer may communicate with the PCS or with any automatic equipment in the production network. In the rare case when the PCS is down, the bank computer and terminal can be used in a backup mode to operate all of the automatic equipment



3. Automated deposition. A digitally controlled low-pressure chemical vapor deposition system has been integrated into the LSI process network. An HP 1000 controller provides real-time closed-loop control of the gas, vacuum, temperature control, and wafer-handling systems.

with which it directly communicates. Equipment installed in the automatic production network is selected primarily for its processing suitability and secondarily for its adaptability to the computer network.

Purchased microprocessor-controlled equipment can normally be connected directly to a bank computer via an RS-232 link, and the division is planning to install two additional automatic processing stations for microprocessor-automated equipment for both deposition and inspection. One of the stations will link a microprocessor-controlled automated planar magnetron sputtering system from Materials Research Corp., Orangeburg, N. Y., into the LSI process network. A second station is intended for control of a group of microprocessor-automated wafer-measurement equipment, including an automatic spectrophotometer from Nanometrics Inc., Sunnyvale, Calif.

Possible modifications

Equipment not automated by its manufacturer can be modified by installing the appropriate transducers and control circuits. This equipment is then connected to another HP 1000 computer system configured as a universal equipment controller.

Each equipment controller contains a utility set of control software, a user-definable set of lookup tables for system definition, and an I/O set including expandable analog signal handling. The modular nature of the bank computer and controller designs adds significantly to the flexibility of the overall facility.

An example of automated processing equipment constructed at Corvallis is a direct-digital-controlled, low-pressure chemical-vapor deposition (LPCVD) system designed in house. The LPCVD system contains four tubes, each able to deposit silicon dioxide, silicon nitride, and polysilicon films on silicon wafers. Each tube, under computer control, adjusts critical process parameters according to instructions received by computer link from the PCS. During processing, the system monitors its performance and sends processing data to the PCS for real-time logging in the lot history file.

The LPCVD system was designed to maximize control over the process in order to achieve predictable film qualities. A block diagram of the LPCVD is shown in

4. Wafer logging. An operator is pictured logging wafer and material movement into a cathode-ray-tube terminal. This information is stored in the factory management computer and is used to monitor the flow of wafer lots through each station in an MOS process.

Fig. 3. The HP 1000 controller computer provides real-time closed-loop control over the gas, vacuum, and temperature-control systems and the wafer-insertion mechanism. All gas flows are set and monitored by the computer, using mass-flow controllers.

The computer also sets and controls the temperature profile by monitoring a five-junction thermocouple and then adjusting the power furnished to a three-zone furnace. Alarm conditions are automatically sensed, activating audible and visual signals. These alarms also automatically trigger a shut-down sequence appropriate to the situation.

Before the processing of a particular lot begins, two types of information must be stored or inserted into the PCS—a lot history file and an operation description. The lot history is composed of all wafer-identification, yield, and measurement data. The operation description is a detailed set of processing instructions.

A production supervisor creates the lot in the process control system's data base by interactively providing the following information to it through one of the data input terminals: lot number, process, number of wafers, work order number, required date out, responsible engineer, part name or priority.

The PCS reserves space in its data base for logging process information as each lot moves through. A lot history file is maintained as the lot moves from operation to operation. Information recorded includes the following taken at each operation:

- Date and time in and out.
- Operator responsible for processing.
- Measurements taken at each operation.
- Wafer fabrication yield.
- Process alarm messages.
- Automatic hold for engineering disposition of any out-of-spec lots.

The process begins

The starting point of the wafer flow occurs when the operator identifies the lot that is to be processed to the PCS. The process control system then checks the lot history file and the process description in order to determine which operation the lot is scheduled to receive. The automatic recipe is transferred from the PCS to the appropriate automatic equipment via a direct computer link. Then the operator is given wafer-handling instructions for the operation on a computer terminal at the processing position.

The operator then loads the wafers according to the instructions and presses the start button. The operation proceeds to completion with alarms logged automatically in the lot history file.

Then the PCS checks the data collected on the processed wafer for conformance to specified limits and places out-of-spec wafer lots on hold for examination by the engineering staff.

A lot is automatically scheduled for the next operation in its process immediately after it successfully completes the previous operation. Lots are scheduled at each equipment station on a first-in, first-out basis, with the higher-priority lots—according to the lot description—moving ahead of lower-priority lots in the lot QUE file in the PCS.

Lots are selected for processing at each station by an operator who consults the equipment QUE file on any bank or system terminal. A typical terminal position is illustrated in Fig. 4. The operator selects lots at the top of the QUE list and programs them for processing through the operation the PCS has scheduled. The operation description can also be listed on any PCS terminal.

Each PCS operation contains:

- An equipment designation.
- A recipe, or processing instructions, for the automatic equipment.
- A set of wafer parameter measurements, which is required for the lot history file after an operation has been completed.
- A set of processing instructions for the operator.

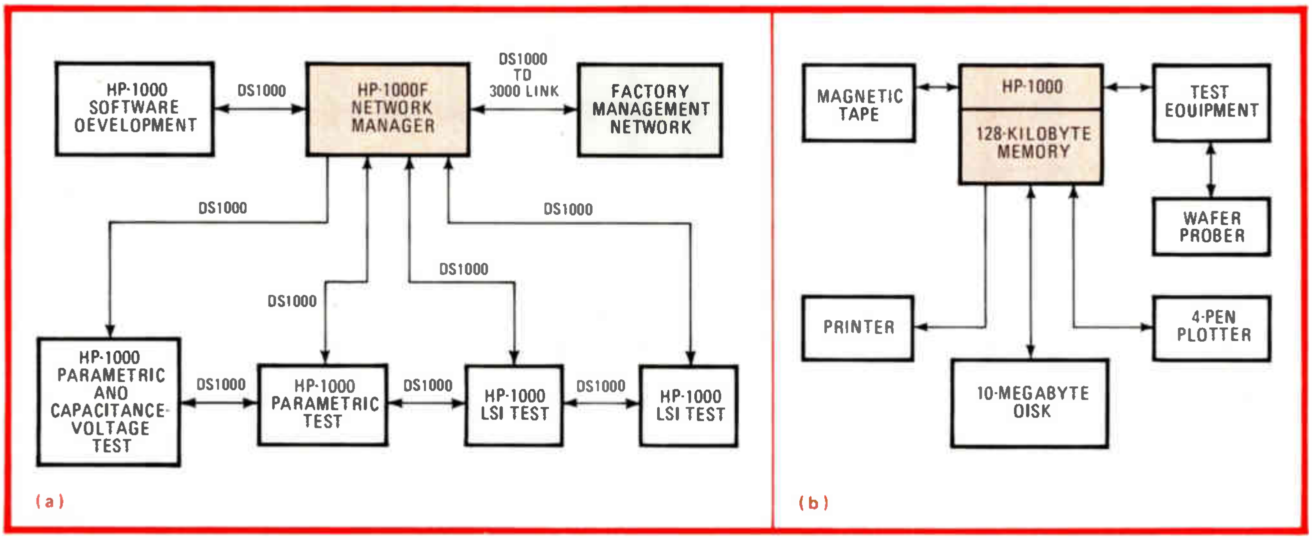
Operations are segments of processes, and different processes may contain many identical operations. Lots destined for different processes may be passed through the same operation simultaneously if the operation is contained in all the process descriptions.

Each piece of automatic equipment has a complete description of its features and specifications stored in the PCS. This information is known as an equipment definition, or bounds, table. The PCS checks the bounds table each time a new operation file is entered and verifies that each event in the automatic recipe is possible with the equipment called for in the operation file.

When the equipment bounds table is used in conjunction with the process and operation-definition files, a diverse product and process mix can be fabricated by using the same equipment, while the probability of incorrect procedures is minimized.

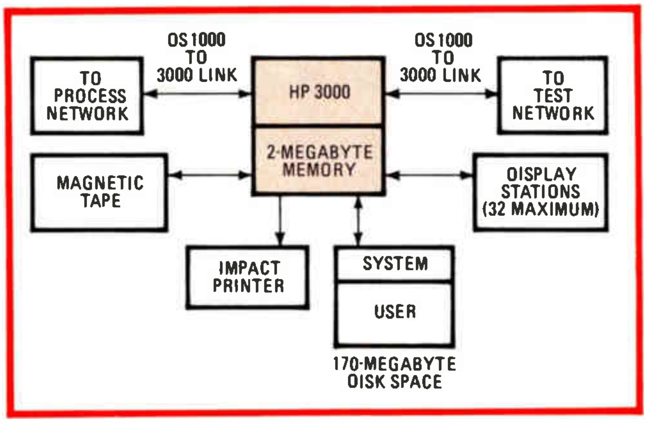
Another feature of the computerized process-control scheme is that any piece of equipment can be used for more than one operation. Any set of operational parameters can be varied by altering the automatic recipe. These features are used extensively in the facility for customized processing.

Data accumulated in the lot-history–file data base is accessible for generating special reports. An example is a



5. Test management. LSI test network (a) links six HP 1000 minicomputers and other wafer test equipment. Test network manager is an HP 1000F processor. A detailed diagram of fully automated parametric test station with an HP-1000 handling probe placement is shown in (b).

6. Computer management. The factory management network, based on the use of a HP 3000 computer with a massive storage capacity, keeps track of all wafer lots from processing to test. The same computer calculates yields and generates reports.



lot-movement prediction report, which is a graphical representation of the movement of a lot through each operation in its process, plotted on a time line in days. Movement through each operation is plotted using the symbol O. The symbol X is used to predict the time that is required for movement through each of the remaining operations.

Movement prediction is based upon the average time each wafer lot spends on a queue and is active at each operation for lots recently processed. A format similar to the lot prediction report has been used to predict the number of wafers in process and average cycle time at each operation. Other reports have been generated for production and engineering purposes by sorting lot history data in various ways.

The test network

The distributed test network, shown in Fig. 5, is responsible for collecting, reducing, and processing large quantities of chip parameter measurements. This network is composed of six HP 1000 minicomputers linked together with a variety of wafer test equipment. The test network manager is an HP 1000F capable of floating-point computation. A second CPU, to the left of the HP 1000F in Fig. 5a, is used for software development. Of the remaining four computers, two control parametric testing and the others collect data from LSI functional testers.

The test network's parametric testing shown in Fig. 5b is fully automated, with an HP 1000 system controlling probe placement and test circuitry. Each of the parametric test systems has a 10-megabyte disk-storage unit, 128 kilobytes of semiconductor memory, one magnetic-tape drive, two input/output display stations, and one line printer. One parametric test station is equipped with a four-color-pen graphics plotter.

For functionally testing the LSI circuits, two major categories of equipment are used—general-purpose and dedicated. Two Fairchild Sentry systems are available for testing production parts or for those engineering applications requiring extensive data collection. For routine production testing, various dedicated testers are available. The Sentry testers are tied into the test network by direct computer link.

Parametric information relating to IC performance, continuity tests, and thin-film process quality can be combined with functional test data to provide valuable diagnostic information about the process and the circuit design. Information collected at various stations in the test network is sent to the network manager for reduction and compilation into a report. Trend charts of parametric and functional data are generated as needed.

A project is under way to construct X-Y plots of functional yield against parametric test data. These graphs of yield versus functional parametric data can be used to judge the sensitivity of circuit and device performance to process variations. One goal of the test information network is to predict yields through the analysis of data trends. The main analytical techniques used for this are time series analysis and pattern recognition. Another goal is to provide direct information feedback to wafer fabrication to aid process control.

The last block of the overall distributed system is the factory management computer shown in Fig. 6. This computer collects reduced data from the production and test networks that can be used for report generation, facility projection, data analysis, long-term data storage, and cost accounting. The factory management computer can also control the mask and spare parts inventory and track parts through test and assembly.

An HP 3000 series III processor with 2 megabytes of semiconductor memory controls factory management. The mass data storage available to the factory management computer consists of a 10-megabyte system disk, three user disks of 20 megabytes each, and two HP 7970 magnetic tape systems. A maximum of 32 display stations can be connected to the factory management computer for data entry and extracting reports. The factory management computer is connected by direct computer link to the processing and test networks.

Mask inspection

The mask-inventory control system satisfies both production and engineering needs. Each of the new masks is given a unique control number to reflect the part number, mask level, and vendor. A history file that contains critical mask dimensions, defect count, usage, and inspections is entered from the terminals connected to the HP 3000. The mask inventory and inspection data base is used to provide inventory management reports based upon wafer production needs and useful mask life history. These reports can also be used to evaluate the mask vendor performance and to correlate mask defects to process parameters. Both of these factors can directly contribute to device yield.

Mask inventory control is only one example of the kind of management function done by the management computer system. The system will be used to provide management data for making decisions and for more complete resource control by mid-1980. At that time, the management computer will do things like plan wafer starts based upon production needs, correlate process and test data for process control and optimization, and perform many other facility management functions. ☐

Contact tester quantifies open-, short-circuit tendencies

by Steven Nirenburg and Wunnava V. Subbarao
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Many present-day electronic systems, being modular in nature, rely heavily on connector blocks to hook the various functional units together. As such, it is becoming increasingly important to detect any momentary open-circuit or short-circuit tendencies of the system at the connector—especially in high-vibration environments—both in production-line testing and during actual operation. This tester detects both, while indicating if either condition persists beyond a given time preset by the user.

Consider the detection of an open-circuit tendency of contact S_1, as shown in the figure. For the purposes of discussion, the open-circuit condition is arbitrarily chosen to be one in which the resistance across S_1 is greater than 10 ohms for a period equal to or greater than 100 microseconds.

On system reset, the 74192 counters and 7476 flip-flops are brought to logic 0. If S_1 is closed, voltage V_1 will be near zero and the outputs of comparators G_1 and G_2 will be high. Light-emitting diode D_0 then glows, indicating the contact is closed.

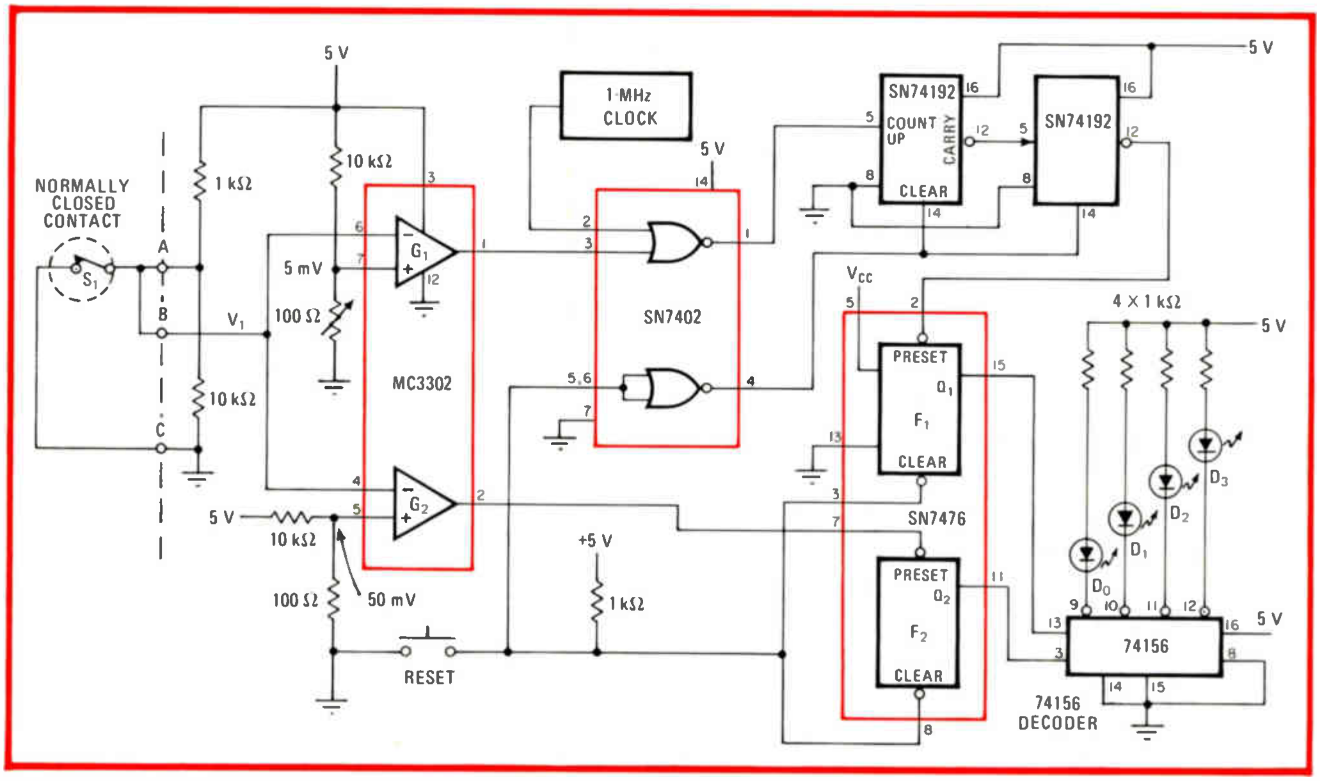
If S_1 is momentarily opened or shows any contact deterioration, V_1 rises slightly above ground potential, forcing G_1 low and gating the output of the 1-megahertz clock through to the counters. Thus should the contact deterioration last for 100 μs, 100 clock pulses will be counted and the resulting carry pulse generated from the second 74192 will set flip-flop F_1. And if the ohmic resistance across S_1 goes above 10 Ω, V_1 will rise above 50 millivolts, forcing G_2 low and flip-flop F_2 high.

Thus D_1 will glow if F_1 is set and F_2 is clear. D_2 will glow if F_1 is clear and F_2 is set. D_3 will light if both F_1 and F_2 are set, so that the predetermined open-circuit time and resistance of S_1 may be readily recorded.

Short circuits are readily detected by connecting points A and B across the normally opened contact under test. When the contact is open, V_1 is near zero and the system remains in the reset position, lighting up D_0. If shorted momentarily, S_1 will cause either D_1, D_2 or D_3 to light. For the values shown in the figure, D_1 will glow if the short circuit exceeds 100 μs or more; D_2 indicates if S_1's resistance is less than 1 MΩ; D_3 illuminates if both of the aforementioned conditions exist.

By changing the clock frequency or the counting limit, any time interval can be preset. Similarly, the impedance at which the circuit responds may be selected by adjusting the threshold voltage at G_2. □

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.



Connection. Tester for block connectors, pc boards, and cable assemblies indicates if duration of open or short circuit in circuit pin or lead exceeds preset time and checks relative magnitude of resistance across switch or broken wire. Four LEDs indicate state of affairs.

TI-59 derives receiver's dynamic range, noise figure

by August C. Neitzel Jr.
Manassas, Va.

Calculating the noise figure, gain, input-intercept point, and dynamic range of a multistage communications receiving system can take hours, even after the corresponding values for each individual section have been measured. This program for a TI-59 calculator derives the desired quantities in seconds, given the noise bandwidth of interest for the system.

The program finds the system's input intercept (IP_{in}^K) and noise figure (NF) from:

$$IP_{in}^K = -10\log[(G_1G_2\ldots G_n)/IP_n^K + (G_1G_2\ldots G_{n-1})/IP_{n-1}^K + \ldots G_1/IP_1^K]$$

$$NF = 10\log[NF_1 + (NF_2 - 1)/G_1 + (NF_3 - 1)/(G_1G_2) + \ldots (NF_n - 1)/(G_1G_2\ldots G_{n-1})]$$

where:

IP_n^K = output intercept point of stage n
G_n = gain of stage n
NF_n = noise figure of stage n
K = order of magnitude (either second or third) of the distortion product that determines a stage's intercept

The spurious-noise–free dynamic range (SFDR) of the system is then found thus:

$$SFDR = (1 - 1/K)[IP_{in}^K - (NF + kTB)]$$

for K = 2 or 3 (whichever yields the lowest SFDR), where:

k = Boltzmann's constant
T = temperature in kelvin (set at 290 K in program)
B = noise bandwidth in megahertz

To minimize program complexity, only the insertion loss (IL) of a passive stage is considered. The noise figure and gain of such a stage are derived from the IL value by means of the relations NF = IL and G = −IL.

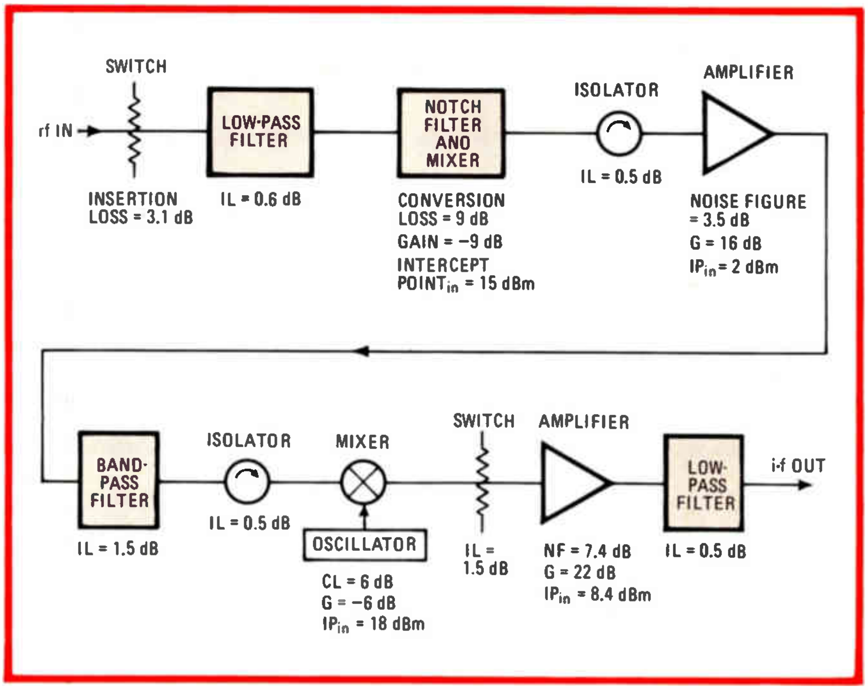
The passive stage's gain and noise figure are factored into the corresponding values of the first active stage that follows. Passive mixer stages are considered to have a conversion loss (CL). Generally, NF = CL and G = −CL. The total number of passive stages that the program can accommodate is unrestricted, and the maximum number of active stages is 10.

An example illustrates the program's usefulness. The double-conversion superheterodyne receiver shown in the figure below has a total of 11 stages. Entering each stage's parameters as instructed for K = 3 and B = 1 MHz yields:

NF = 18.57 dB
G = 14.8 dB
IP_{in}^3 = 10.29 dBm
SFDR = 70.46 dB

Note that the input intercept of a stage is specified via register C′, and the output intercept is entered via register C. If a data-entry error is made in this long list, the user can sometimes correct the affected registers. Otherwise, the program should be restarted at label ADV by pressing GTO ADV, R/S.

If no printer is attached to the calculator, the user should set flag 0. This flag will cause the program to halt after the calculations are performed and will prevent the clearing of the registers that contain the output data. To initialize the entry of the next set of parameters, it is only necessary to press the R/S key and wait for the program to halt. □



Overload. Given the noise figure (NF), gain (G), and input or output intercept (IP) of each section of an 11-stage dual-conversion superheterodyne receiver, this TI-59 program quickly finds system NF and IP_{in} for a stated noise bandwidth. System gain and dynamic range are then readily found.

TI-59 PROGRAM: COMMUNICATIONS RECEIVER ANALYSIS

000	LBL	055	0	110	π	165	00	220	X⇌T	275	PRD	330	STO	385	OP
001	A	056	+/−	111	RC•	166	STO	221	÷	276	STO	331	55	386	04
002	SBR	057	SUM	112	00	167	31	222	RCL	277	37	332	INV	387	RCL
003	IFF	058	00	113	SBR	168	2	223	38	278	1	333	IFF	388	34
004	R/S	059	INV	114	LOG	169	0	224	=	279	.	334	03	389	OP
005	LBL	060	STF	115	PRD	170	SUM	225	SUM	280	3	335	TAN	390	06
006	A′	061	04	116	38	171	31	226	37	281	8	336	RCL	391	RCL
007	SBR	062	R/S	117	RTN	172	9	227	SBR	282	EE	337	32	392	54
008	IFF	063	LBL	118	LBL	173	5	228	Σ+	283	2	338	−	393	OP
009	+/−	064	D	119	1/X	174	ST•	229	SBR	284	0	339	1	394	04
010	=	065	STO	120	RC•	175	31	230	1/X	285	+/−	340	+	395	RCL
011	SBR	066	33	121	00	176	INV	231	1	286	X	341	RCL	396	33
012	Σ+	067	R/S	122	SBR	177	STF	232	8	287	2	342	56	397	OP
013	SM•	068	LBL	123	LOG	178	04	233	+/−	288	9	343	=	398	06
014	00	069	CP	124	÷	179	RTN	234	SUM	289	0	344	STO	399	LBL
015	1	070	STF	125	RCL	180	LBL	235	00	290	X	345	55	400	ADV
016	0	071	01	126	38	181	E	236	RCL	291	RCL	346	LBL	401	ADV
017	+/−	072	INV	127	=	182	INV	237	36	292	33	347	TAN	402	ADV
018	SUM	073	STF	128	1/X	183	IFF	238	X⇌T	293	SBR	348	INV	403	ADV
019	00	074	02	129	SUM	184	04	239	RCL	294	EE	349	IFF	404	ADV
020	STF	075	X⇌T	130	39	185	EXC	240	00	295	SBR	350	00	405	INV
021	02	076	1	131	RTN	186	SBR	241	X⇌T	296	PRD	351	SIN	406	STF
022	R/S	077	STO	132	LBL	187	DEG	242	INV	297	STO	352	R/S	407	01
023	LBL	078	38	133	Σ+	188	LBL	243	GE	298	40	353	LBL	408	INV
024	B	079	0	134	X⇌T	189	EXC	244	COS	299	RCL	354	SIN	409	STF
025	SBR	080	STO	135	1	190	RCL	245	GTO	300	39	355	INV	410	02
026	Σ+	081	00	136	0	191	00	246	ENG	301	−	356	ENG	411	INV
027	SM•	082	X⇌T	137	SUM	192	STO	247	LBL	302	(	357	OP	412	STF
028	00	083	RTN	138	00	193	36	248	COS	303	RCL	358	00	413	03
029	STO	084	LBL	139	X⇌T	194	1	249	OP	304	37	359	RCL	414	RCL
030	31	085	EE	140	RTN	195	STO	250	30	305	+	360	59	415	36
031	INV	086	X	141	LBL	196	00	251	SBR	306	RCL	361	OP	416	+
032	STF	087	1	142	IFF	197	RC•	252	Σ+	307	40	362	04	417	2
033	02	088	EE	143	IFF	198	00	253	SBR	308	=	363	RCL	418	0
034	R/S	089	6	144	01	199	SBR	254	π	309	)	364	37	419	=
035	LBL	090	=	145	FIX	200	LOG	255	SBR	310	INV	365	OP	420	STO
036	B′	091	RTN	146	SBR	201	STO	256	Σ+	311	IFF	366	06	421	00
037	STO	092	LBL	147	CP	202	37	257	SBR	312	03	367	RCL	422	LBL
038	32	093	LOG	148	LBL	203	OP	258	1/X	313	RAD	368	58	423	SUM
039	STF	094	÷	149	FIX	204	20	259	RCL	314	X	369	OP	424	0
040	03	095	1	150	IFF	205	LBL	260	38	315	(	370	04	425	ST•
041	R/S	096	0	151	02	206	ENG	261	SBR	316	1	371	RCL	426	00
042	LBL	097	=	152	X̄	207	RC•	262	PRD	317	−	372	38	427	DSZ
043	C′	098	INV	153	OP	208	00	263	STO	318	1	373	OP	428	00
044	+	099	LOG	154	20	209	SBR	264	38	319	÷	374	06	429	SUM
045	RCL	100	RTN	155	LBL	210	LOG	265	RCL	320	RCL	375	RCL	430	0
046	31	101	LBL	156	X̄	211	−	266	39	321	32	376	57	431	STO
047	=	102	PRD	157	SM•	212	1	267	SBR	322	)	377	OP	432	39
048	LBL	103	LOG	158	00	213	=	268	PRD	323	=	378	04	433	R/S
049	C	104	X	159	STF	214	X⇌T	269	+/−	324	LBL	379	RCL		
050	SBR	105	1	160	04	215	9	270	STO	325	RAD	380	39		
051	Σ+	106	0	161	RTN	216	SUM	271	39	326	STO	381	OP		
052	SM•	107	=	162	LBL	217	00	272	RCL	327	34	382	06		
053	00	108	RTN	163	DEG	218	SBR	273	37	328	RCL	383	RCL		
054	2	109	LBL	164	RCL	219	π	274	SBR	329	56	384	55		

Instructions

- Key in program
- Enter parameters of each circuit element, mixer, or amplifier stage:
  (IL), A′ for elements, or
  (CL), A, (−CL), B, (IP_{in}), C′ for mixers, or
  (NF), A, (G), B, (IP_{in}), C′ for amplifiers
- Specify order of intercept-point response, system bandwidth in megahertz:
  (K), B′, (BW), D
- Press E to execute program
  System noise figure, gain, intercept point, dynamic range, and bandwidth are displayed in order

Registers	
32	K
33	BW
34	DR
37	NF
38	G
39	IP_{in}

Engineer's newsletter

Understanding dielectric embedding

"Reliable protection of high-performance electronic components is all-important in these days of rising component prices," notes Harry E. Pebly, chief of the plastics technical evaluation center (Plastec) of the U. S. Army Research and Development Command in Dover, N. J. For a full knowledge of the subject, he goes on, "it's essential to acquaint engineering personnel with **the plastic resins and the typical processes used in applying these polymers to circuit components."** Pebly and Plastec have published the latest word on "Dielectric Embedding of Electrical or Electronic Components." The design handbook with this title concentrates on epoxies, polyurethanes, and silicones—the most widely used resins. The newer polyxylenes, which are vacuum-deposited on substrates, are also discussed. Send $16.50 to the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22161, and ask for AD A074139.

Dial up an analysis program

Stardyne, HEC-2, and DOE-2 are not cohorts of R2-D2 and C3-PO—they are 4 of 13 new software tools available to engineers on Mainstream-EKS, a dial-up computing service of Boeing Computer Services Co. For $90 to $150 per hour, designers can enlist aid for everything from **planning a solar-energy installation** to analyzing a satellite antenna. Contact BCS headquarters at 177 Madison Ave., Morristown, N. J. 07960, or call (201) 540-7700.

Software: write it or find it?

Efficiently avoiding the wasteful repetition of software efforts calls for a centralized listing of available programs, the more comprehensive the better. The International Directory of Software is one such listing. The magnitude of the problem tackled is reflected in the price: $140. The volume has **more than 3,200 software products indexed in as many as five categories each; 107 categories are listed.**

The date of each program's origin, its installed base, function, terms of lease or purchase, and operational mode are supplied along with names and addresses. Contact CUYB Publications Inc., First Federal Building, Suite 401, Pottstown, Pa. 19404, or phone (215) 326-5188.

Keep tabs on Telidon

Suppliers of equipment for, potential users of, and **makers of systems competitive with Canada's Telidon interactive television-based information system** will want to receive Telidon Reports. This newsletter, published by the Department of Communications of the Government of Canada, is "designed to help keep those interested in Telidon informed about significant developments." The newsletter is published every two months. Those interested in videotext may get it by writing to Telidon Reports, DOC-DGSRP, Room 2000, Journal Tower South, 300 Slater Street, Ottawa, Ontario, KIA OC8. It is also available on Telidon subscribers' television sets via the telephone.

For its part, the Manitoba Telephone System in Canada's Manitoba Province is offering a bilingual (English and French) newsletter for keeping up with new developments in the home, office, and farm of the future in Manitoba. According to editor Jane Stewart, Dialogue, as it is named, will also keep readers informed about the latest in Canadian fiber optics projects. Write Manitoba Telephone System, B-101C, Box 6666, Winnipeg, Manitoba R3C 3V6.

-Harvey J. Hindin

308 DATA ANALYZER

Big power in a small package.

The 308 operates in four modes: parallel state, parallel timing, serial state and signature analysis.

The 308 Data Analyzer. From Tektronix.

The new 308 Data Analyzer packs an impressive array of logic analysis capabilities inside its trim, 8 pound (3.6 kg) frame. For instance, it operates in the serial and signature modes as well as parallel state and timing. And samples both synchronously and asynchronously up to 20 MHz. With a variable voltage threshold that covers all logic families in addition to TTL.

Two separate memories, acquisition and reference, allow automatic data comparisons. If there's no data difference, the sampling process is repeated until a discrepancy appears. And the acquisition memory can be automatically searched for any given word.

Word recognition can be up to 25 bits and includes an external output to trigger other instruments. And the trigger itself can be delayed up to 65,535 clock pulses past the trigger point. The 308 features a latch mode (5 ns), a memory "window" to let you closely examine portions of the memory and state tables which are displayed in binary, hex and octal.

The 308 Data Analyzer, from Tektronix. Performance? Uniquely versatile. Size? Conveniently compact. Price? Exceptionally reasonable.

If you're interested, contact your local Tektronix field office, or write us at:

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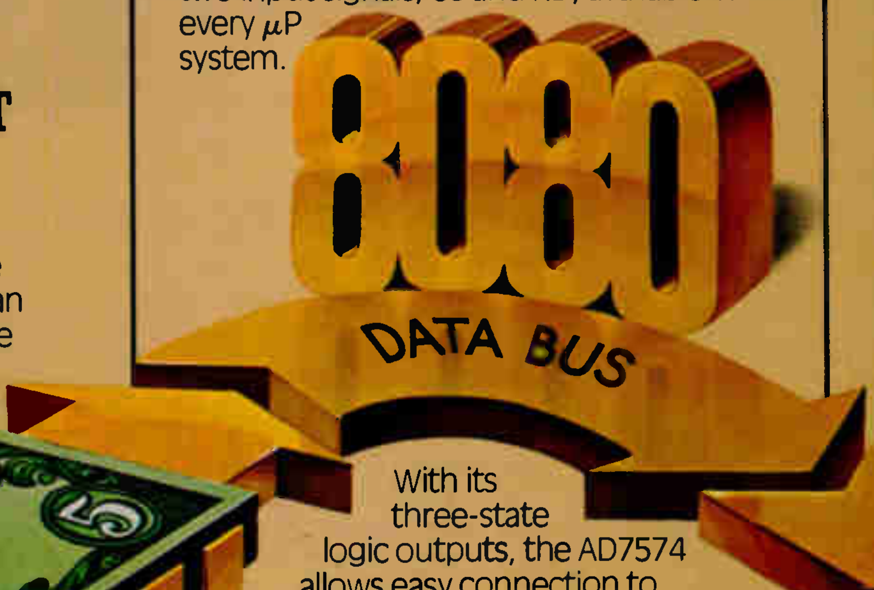
Our AD7574 comes as low as $5 in 1000's, and offers specs and features you expect only from more expensive hybrids. Our AD7524 is priced even lower – $3 in 1000's. Take them together and you've got a complete, reliable A-D/D-A μP interface for only $8.

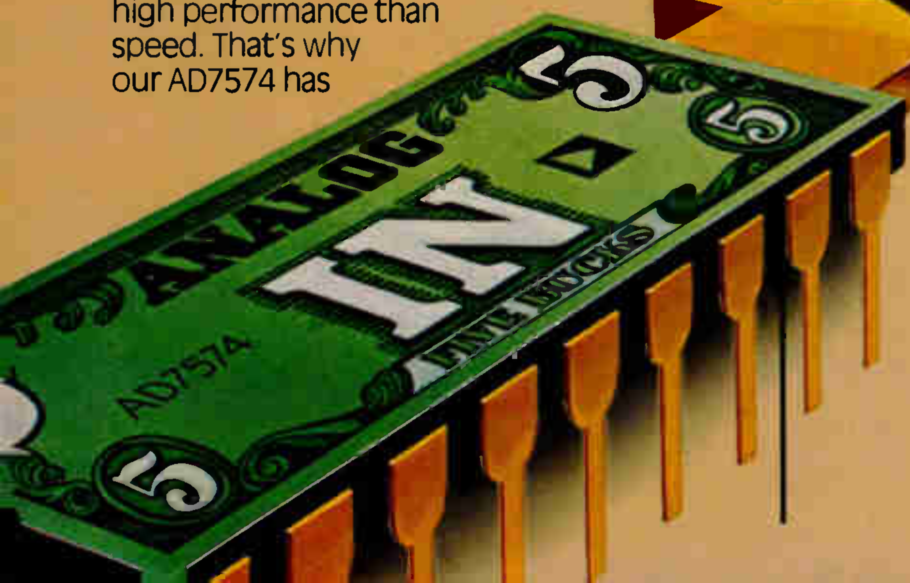
OUR AD7574 IS A HIGH PERFORMANCE 8-BIT ADC WITH SUPER SPEED, SUPER SPECS.

First, we're fast. We use the successive approximation technique to give you an accurate 8-bit A-D conversion in as little as 15 μs. But there's more to high performance than speed. That's why our AD7574 has its own internal comparator so you never have to fiddle with external components to get full 8-bit transfer accuracy. And our internal clock oscillator runs only during conversion for minimal power dissipation. In addition, the AD7574's small 18-pin DIP size, monolithic reliability, +5V supply, and the low power consumption inherent in CMOS make it perfect for applications in avionics, instrumentation and process automation.

DIRECT INTERFACE TO μP.

Our AD7574 has great handshaking ability for quick and easy μP interfacing. And all conversion operations are controlled by just two input signals, $\overline{CS}$ and $\overline{RD}$, available in every μP system.





With its three-state logic outputs, the AD7574 allows easy connection to any μP data bus or system I/O port. And to make interfacing even easier, you can treat our AD7574 just like memory.

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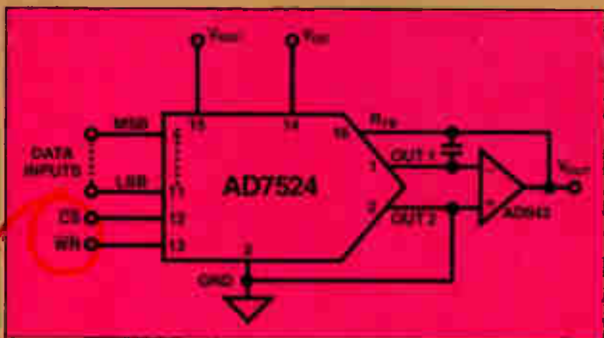
OUR AD7524 IS AN 8-BIT DAC WITH LATCHES, AND ACCURACY TO ± 1/8 LSB.



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We've taken one of our high performance 8-bit multiplying digital-to-analog converters and added level triggered latches – with on-chip control logic for extended interfacing capabilities. So our new AD7524 can be easily connected to nearly all 8-bit μP's, as well as I/O ports that provide latched data, without the need for supplementary circuitry.

Our AD7524 also features full four-quadrant multiplication so it can accept both negative and positive variable references – a big plus for applications in digitally controlled gain setting, signal control and attenuator circuitry. Other pluses with our AD7524 include advanced thin-film on CMOS fabrication for accuracy to ±1/8 LSB, single-chip construction for increased reliability, guaranteed monotonicity over the entire operating temperature range, +5V to +15V supply range, and a low 20 milliwatt power dissipation.

AND THE PRICE IS RIGHT!

Bus in with our AD7574. Bus out with our AD7524. Or go round-trip with both. No matter which way you go, you won't find better fares than Analog's. To get all the facts on these two exciting new full performance μP-compatible converters, call Doug Grant or Don Travers at (617) 935-5565. Or write Analog Devices, Inc., P.O. Box 280, Norwood, MA 02062.

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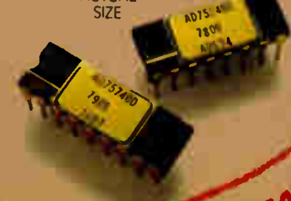

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Analog Devices, Inc., Box 280, Norwood, MA 02062. East Coast: (617) 329-4700, Midwest: (312) 894-3300, West Coast: (714) 842-1717, Texas: (214) 231-5094, and representatives around the world.

Circle 163 on reader service card

The sensible source for your

Now, it makes economic sense to automate your receiving test stations...your in-process or final test stations...your QA audit stations...even your design engineer's workbench. Look into Systron-Donner's IEEE-488 family.

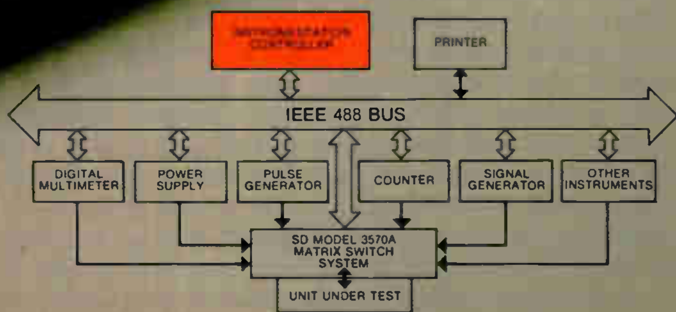
It starts with the new S-D Model 3520 BUSser. The 3520 is *specifically* designed to control IEEE-488 compatible test instruments.

The idea was to make this controller easy to use, easy to understand, easy to transport, easy to read, and easy to store programs. And that's what S-D has done by using a standard teletypewriter keyboard layout, IEEE-488 special function keys, BASIC as the programming language, and a large legible single line fluorescent display.

Program storage is simple with the PROM option. One or more programs can be stored in the PROM cartridge and erased later if desired.

Systron-Donner also made this compact controller easy to buy: $795* without PROM option, $995* with it. We put you on the bus without taking you for a ride!

Systron-Donner's IEEE-488 family



*U.S. prices

SYSTRON DONNER

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IEEE-488 system needs.

Wide-ranging systems capability

Systron-Donner's extensive line of standard, off-the-shelf IEEE-488 compatible instruments includes frequency counters, signal generators, multimeters, pulse generators, power supplies, and a precision DC voltage source. In addition, our Model 3570A Matrix Switch automates the interconnect, saving time-consuming operator interface.

Here is a representative but by no means complete sampling of bus compatible Systron-Donner instruments. Let us know what your exact requirements are. Contact Scientific Devices or Systron-Donner, 2727 Systron Drive, Concord, CA 94518, U.S.A.; phone: (415) 676-5000.

Frequency Counters. S-D's wide selection of IEEE-488 compatible counters ranges from 100 MHz all the way to 26 GHz. Model 6043A shown here is one of several thin-line designs with bus interface standard. This 1,350 MHz counter is ideal for communications work and other frequency measurement applications. Note front panel lights that tell the operator the status of the instrument while it's active in the system.

Signal Generators. One of S-D's most popular signal generators is the Model 1702 which provides a range of 100 Hz to 999.999 MHz in a single range with 100 Hz resolution. It's fully programmable on the IEEE-488 bus. For microwave frequency applications, Models 1618 and 1626 extend coverage to 18 and 26 GHz respectively.

Digital Multimeters. Systron-Donner's 4½ and 5½ digit multimeters for systems use include the Thin Line Model 7344A pictured here. This 4½ digit autoranging DVM includes the bus interface, DC volts, resistance, true RMS as standard. In the 5½ digit category, consider Model 7115 with microprocessor control, auto-calibration, and automatic fault detection and isolation.

Pulse Generators. Model 154-4 is an automatic pulse generator which is fully programmable with its IEEE-488 interface and the Model 3520 Controller. Model 154-4 provides a repetition rate of 10 Hz to 50 MHz, pulse delay and width from 10 ns to 10 ms, and outputs of 0.5 to 10 V within a –10 to +10 volt window. An exceptionally versatile instrument for the systems user.

Systems Power Supplies. Systron-Donner's P series of power supplies receives its bus commands via the S-D Programmer module shown here. Controls up to 8 supplies. One DAC board controls V, I, and V limit. Modular flexibility allows anywhere from 50 to 500 watts.

S-D: the IEEE-488 systems people.
And a lot more.

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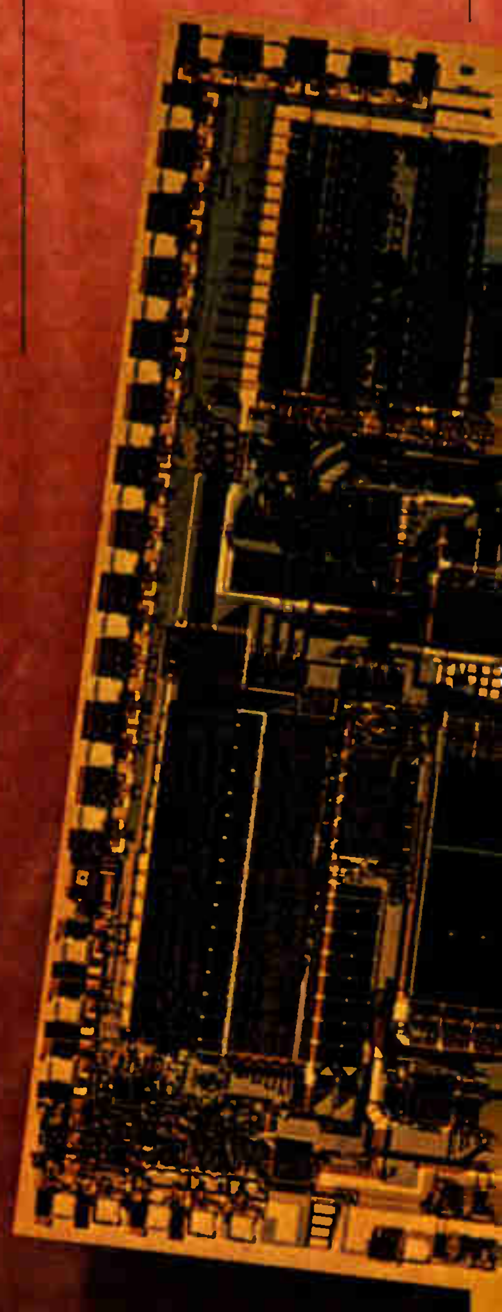
Circle #165 for demonstration



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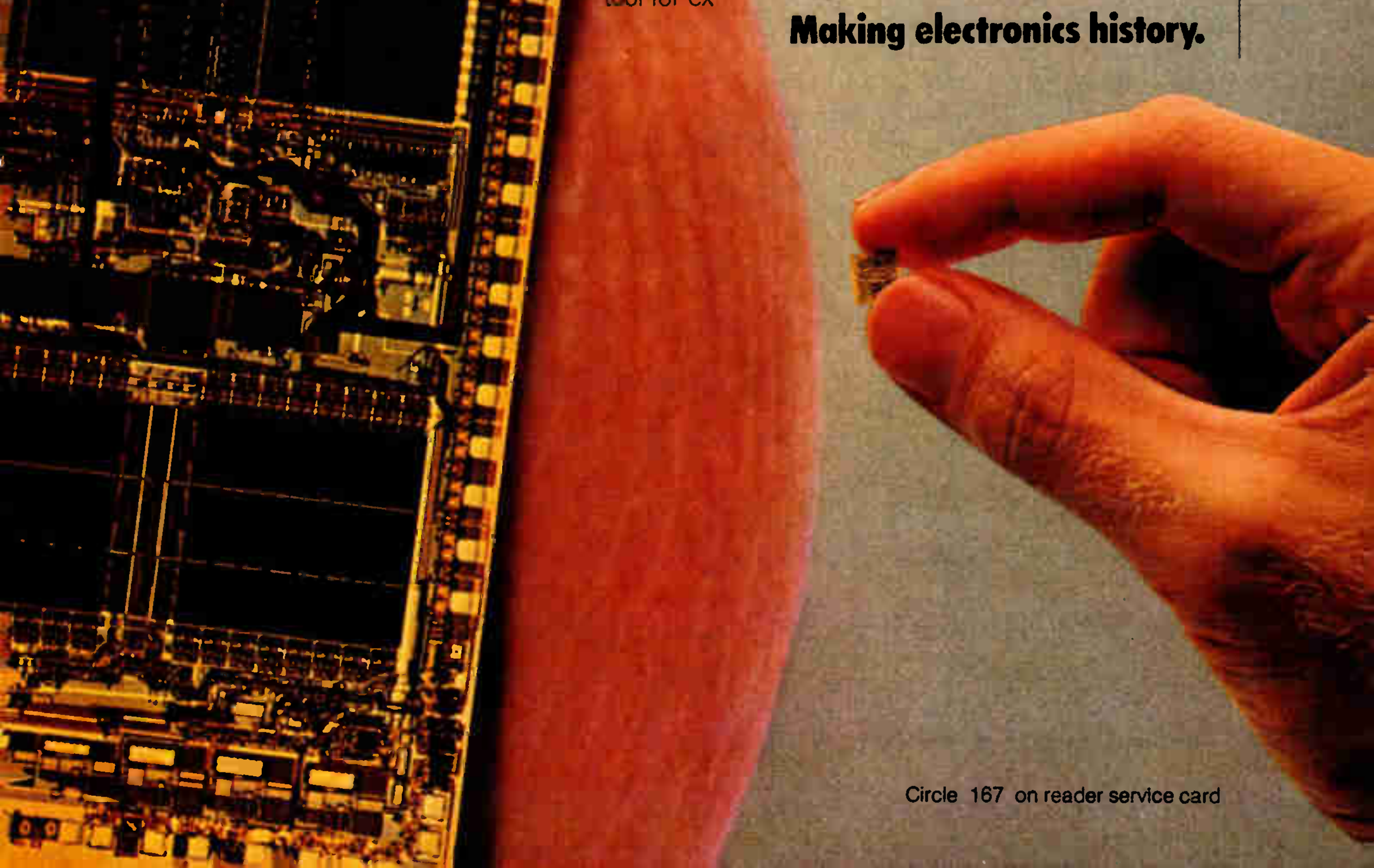

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ATE users get net system

Fast network allows centralized software capacity, operates 30 to 70 times faster than RS-232-based systems

by James B. Brinton, Boston bureau manager

Though other automatic test equipment firms already have interconnection systems available [*Electronics*, Dec. 20, 1979, p. 82], GenRad's may be the fastest yet, the company believes. GenRad calls its new GRnet, "a high-speed, intelligent, highly reliable data-communications network . . . dedicated to the needs of the ATE user." It is composed of a series of communications processors called network-interface modules, or NIMs, plus interconnecting hardware, cable, and software.

The system links GenRad's 2290 multi-user programming station with any GenRad 1790 or 2270 series test system or with another programming station. Drop-line networks of up to 64 nodes are possible in a basic system, but since each 2290 can support four such networks, and since a node in any one of the four can be another 2290—itself capable of supporting three networks—GRnet seems highly expandable.

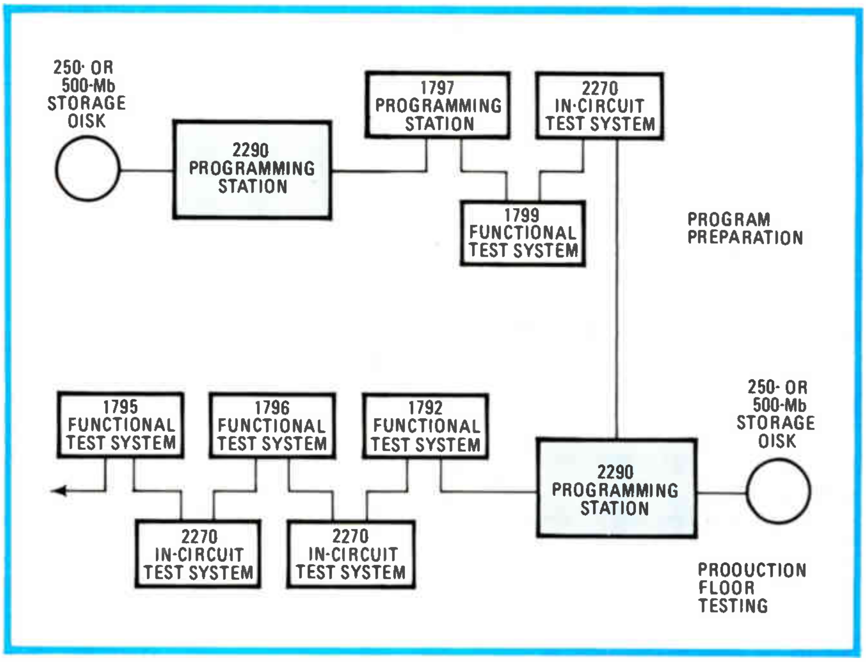
The idea behind GRnet's development is centralized control of test programs and files, which makes factory software management more efficient. Such centralized control would be impossible if not for a high data-transfer rate. GenRad claims that GRnet is 30 to 70 times faster than RS-232-based systems at its raw transfer rate of about 655,000 b/s. In practice, though, serving multiple users, the packet-based GRnet's throughput is about 40,000 b/s—well in excess of the 9,600 b/s characteristic of RS-232 or the 19,200 b/s of RS-232-C.

Saving time. Central control saves time, says Genrad. The test routines for many of today's circuit-board assemblies are stored on disk, and it is not unusual for these disks or disk packs to be changed several times daily as new board types must be tested. "A test-system operator can take from 10 to 20 minutes changing disks on the production floor," according to Gary D. Culbertson, product marketing engineer, "so we wanted a system that could also transfer software fast enough to keep test systems active a greater percentage of the time."

Though it may be an extreme case, Culbertson shows how disk-change time can add up: "Say an operator changes disks 10 to 20 times daily and takes 10 to 20 minutes each time. At best, the operator's machine will be off line for an hour and 40 minutes a day and, at worst, far more than that." Even if Culbertson's figures are halved, it is easy to see how such nonproductive time can accumulate.

Further, GRnet wastes no central-processing-unit time. The NIM, a plug-compatible board capable of fitting into any of the Digital Equipment Corp. minicomputers used in Gen Rad's testers, is an independent communications processor, allowing the test-system central processor full time for testing. In this respect, GRnet compares well even with DECnet III, recently announced by DEC [*Electronics*, Feb. 14, p. 183]. DECnet III offers greater potential speed, through a variety of modems, but does incur some CPU overhead and must set aside some system main memory for store-and-forward communications with other nodes.

Topologically, GRnet is a daisy chain. Starting at a 2290 master-station node, units are added to the net simply by running coaxial cable



from node to node. The NIM has an on-board coaxial interface. Therefore there is no need to do more than plug in the NIM, connect the cable, and load system software at the 2290.

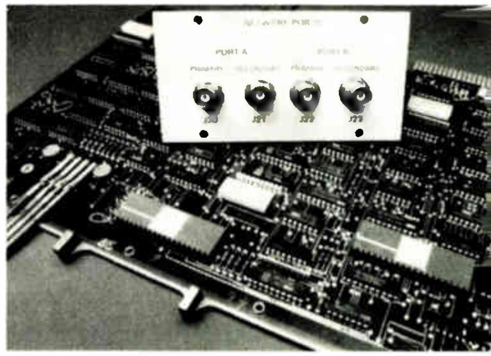
Inclusions. The NIM is a Z80-based system with 8 K by 8 bits of programmable read-only memory, 4 K by 8 bits of random-access memory, timing and internal direct-memory-access (DMA) control, host input/output, and DMA controllers to couple the NIM to a Unibus, Omnibus, or Q-bus. It also includes a Synchronous Data Link Control, or SDLC, implementation and the necessary cable interconnection electronics—but the modem commonly needed in most networking applications is not required.

The NIM is inactive unless it "sees" its own address at its SDLC port or unless a request for data is made by its host computer. If the host must send data to another storage site, the Z80 uses its local DMA control to take data from its host's bus and stores that data in its own RAM. The NIM then uses the protocol stored in its PROM and the SDLC interface to gain momentary control of the net and discharge the block onto the coaxial line. Such blocks or packets can be up to 4,000 bits long.

The receiving NIM performs a cyclic redundancy check (CRC) for errors while the incoming data is still stored in its RAM; if the CRC shows an error, the receiving NIM requests retransmission. This check and re-send operation can occur up to four times. If the data is clean, it is dumped onto the host computer bus through the NIM's calls for the rest of the file, and the process repeats until transmission is complete.

While the net is not busy with file transfers, it can be performing diagnostics. Each NIM runs through a series of diagnostic tests at startup; other checks are under user control through the host 2290 system. The diagnostics reach into all but certain parts of the NIM SDLC, host I/O control, and host DMA control.

GenRad's Ralph P. Anderson, product line manager for test systems, notes that GRnet is about twice



the price of RS-232 systems, but says that "it does a lot more." It allows the user to relocate disk stores from the factory floor and at the master 2290 programming system; it improves productivity through higher speed reprogramming of test systems than is possible manually or with other networking systems; it offers almost foolproof operation by test technicians; and it can save money by cutting the type or amount of bulk storage needed to hold test programs, as well as allowing disks to last longer than they would in the tough factory floor environment.

GenRad suggests that the user attach a 250- or 500-megabit disk to the master 2290 in any GRnet. Company engineers say that it makes simple sense in the name of centralized data storage and in many installations costs less than disk drives installed beside the tester.

From the user's point of view, operation is simple. A test technician punches in a code like "Boardz," thereby triggering a series of operations: new space can be made available in the working store; new test routines can be requested over the network; the tester can be automatically configured to suit the new routines; and the operator—after a one- or two-minute wait—can begin it.

GRnet users must own a 2290 in its multi-user configuration as a precondition to networking. Beyond this, the entry fee is $15,000 for the first, or 2290, node and $5,000 per node thereafter.

Delivery of GRnet in small quantities is immediate; production lots should be available in September.

GenRad Inc., 30 Baker Ave., Concord, Mass. 01742. Phone (617) 369-4400 [338]

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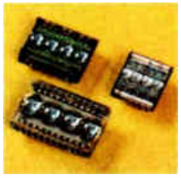

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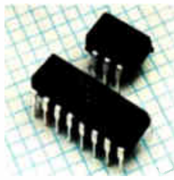

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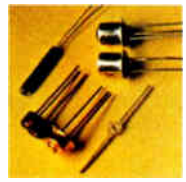

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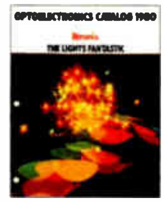

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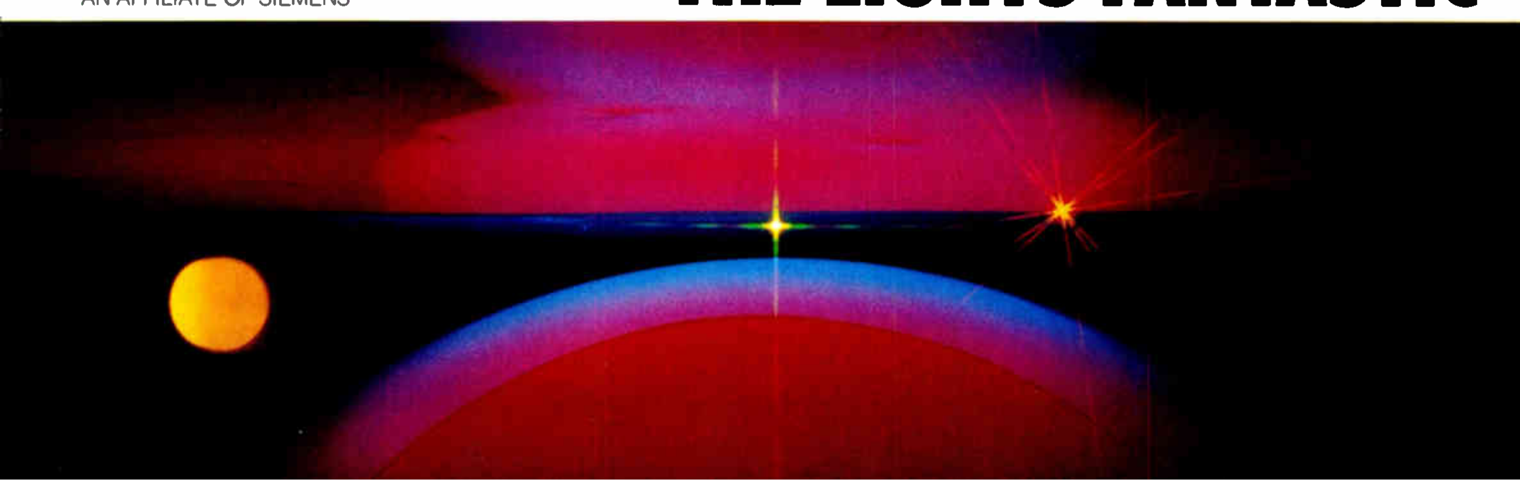

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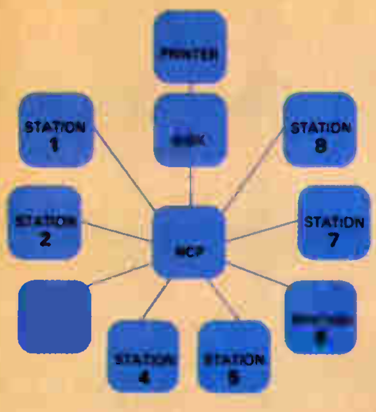

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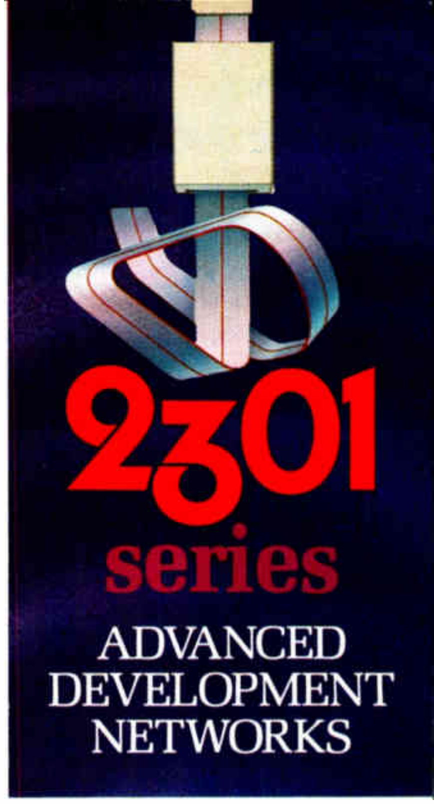

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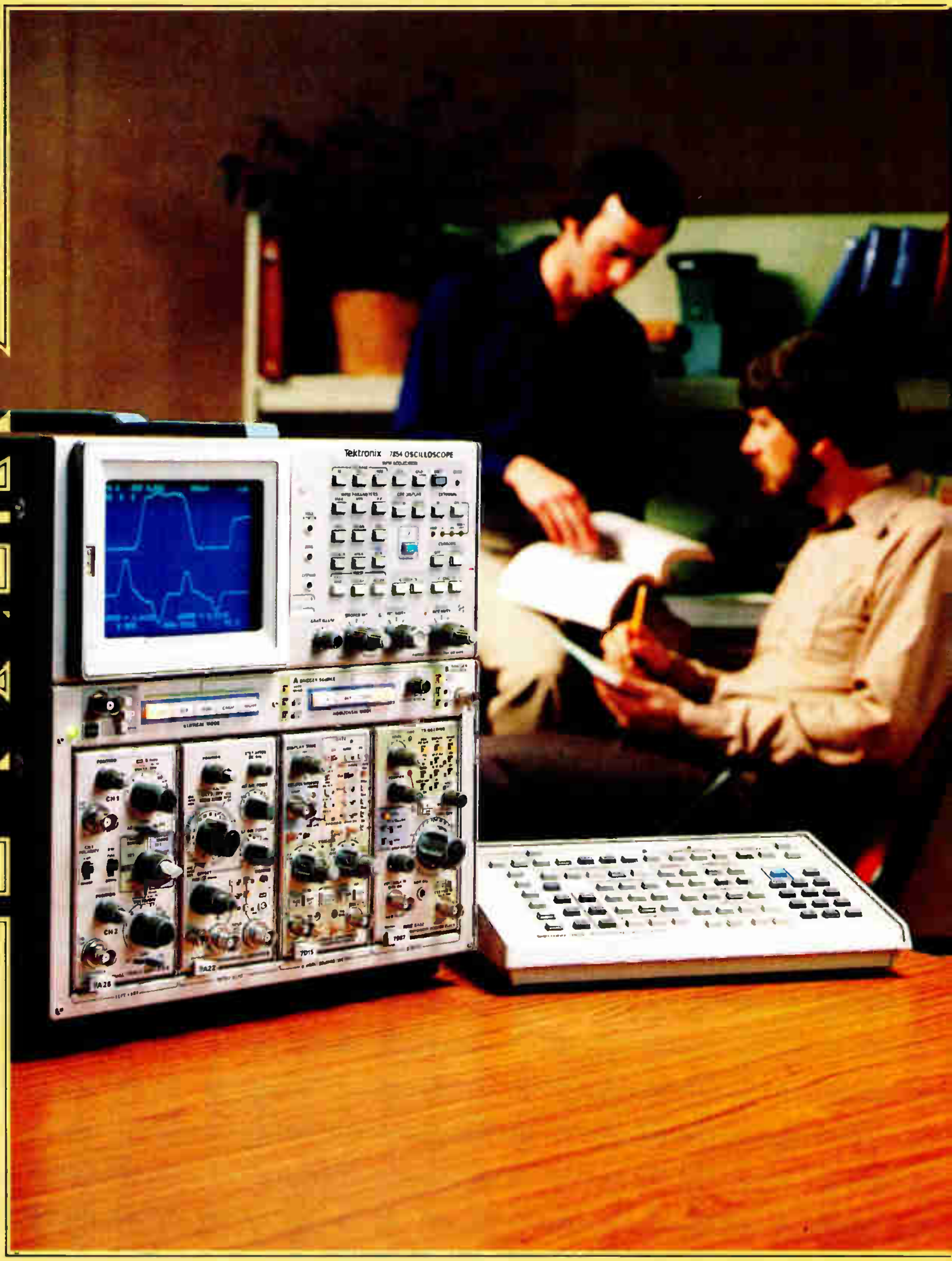
GenRad/Futuredata universal development systems – expanding your world of microprocessor-based design.

Circle 173 on reader service card

Tektronix announces the

PLUG-INS



next generation of scopes.
The 7854.

Now Tektronix offers a new measurement tool for those who depend on oscilloscope measurements — the 7854. It is designed to improve measurement quality yet simplify measurements. Look at these features to see how you can put its measuring power to work for you.

Digital storage.

Digital storage lets you view the same node twice or compare waveforms without bothering with waveform photography or having to move probes and repeat control adjustments. Digital storage improves measurement quality, since resolution is increased to .01 division. Averaging improves measurement accuracy on signals buried in noise. With digital storage, you've got an open door to fast waveform processing and more repeatable measurements.

Waveform processing.

At the touch of a button, waveform processing gives you solutions for common waveform measurements like rise time, period, frequency, RMS, energy, mean, max, and mid. Also, cursors aid in delta time and delta voltage measurements.

Within seconds, you can obtain repeatable answers like rise time without having to adjust position controls or determine the number of divisions between points.

Keystroke programming.

Like a handheld programmable calculator, the 7854 offers keystroke functions for storing, organizing, and reducing data. You can program the scope to acquire and monitor data without an operator's presence. You can even tailormake special functions to avoid manually repeating a series of keystrokes.

Solutions at the touch of a button.

GPIB.

The 7854's GPIB interface provides access to processing in external controllers like the Tek 4050 Series. GPIB also allows mass storage and coordination with other instruments.

Part of the Plug-In Family.

The 7854 is the newest member of Tektronix' well-respected 7000-Series family of high performance scopes. Featuring a real time bandwidth of 400 MHz, it's compatible with 7000-Series plug-in units including differential amplifiers, samplers, DVM's, counter/timers, logic and spectrum analyzers, TDR's, and others.

Put the 7854's processing power to work for you. For more information on this new generation of oscilloscope from Tektronix fill out the coupon below or call your Tek Sales Engineer.

For the address of your nearest Tektronix Field Office, contact:

U.S.A.
Tektronix, Inc.
P.O. Box 1700
Beaverton, OR 97075
Phone: 503/644-0161
Telex: 910-467-8708
Cable: TEKTRONIX

Africa, Europe Middle East
Tektronix Int'l, Inc.
European Marketing Center
Postbox 827
1180 AV Amstelveen
The Netherlands
Telex: 18312

Asia, Australia, Canada, Central & South America, Japan
Tektronix, Inc.
America's/Pacific
P.O. Box 500
Beaverton, OR 97077
Telex: 910-467-8708
Cable: TEKTRONIX

Tektronix®
COMMITTED TO EXCELLENCE

Yes, I'm interested in the new 7854.

Name ____________________

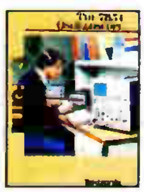
Company's name ____________________

Title ____________________

Address ____________________

____

Phone (_____) ____________________ ext ______



_____ I'd like information on GPIB systems applications

_____ Please send me additional information

_____ Please contact me for a demonstration

The 7854 Oscilloscope brochure and accompanying specifications folder provide full details on this new instrument.

"Take it from me, flat is beautiful."

"Speaking as an expert on flat, I would like to recommend another expert: Spectra-Strip.

They really know that flat is where it's at. They delivered their first flat cable in 1956, and now offer more kinds than anybody. Their flat cable line includes gray and color-coded bonded, laminated, and extruded flat and twisted pairs, twisted pairs that can be mass terminated (Twist 'N' Flat®), transmission line and ground plane, and extruded jacketed cable (Spectra-Guard™) that can take a real beating.

They can also provide IDC receptacles, headers, DIP plugs and sockets, PCB transitions and card-edge connectors.

And when things get tight, they won't leave you flat: their value-added distributors can whip together standard jumpers and assemblies (single-ended, double-ended or daisy-chained), or Spectra-Strip can provide custom assemblies using their own products and *anybody else's* wire, cable and connectors. That way you get pretested assemblies that are usually less expensive than if you did them yourself.

For the name and number of your nearest distributor or rep, write Spectra-Strip, 7100 Lampson Avenue, Garden Grove, CA 92642, telephone (714) 892-3361. In the East, call (203) 281-3200.

Say that you heard about them from me and my dog Splat."

Circle 176 on reader service card

SPECTRA-STRIP

An Eltra Company

When you're down to the wire

Data-net tester aimed at field

Simulation of data-communications equipment and terminals, combined with PROM-directed test menus, aids field service

by Bruce LeBoss, San Francisco regional bureau manager

The proliferation of complex data-communications networks has spawned many sophisticated network control systems for use by field-service technicians. Still very much in demand, however, are fast, simple, yet accurate instruments for identifying which system element is malfunctioning and why.

The model 834 programmable data-communications tester from Tektronix is a portable (less than 14 lb) go/no-go tester that eases problem isolation because it monitors "both sides of a communications network," to quote Garth W. Eimers, product marketing manager in the company's Service Instruments division. It does so by simulating the data terminal equipment as well as the data-communications equipment. Only the latter was simulated by the earlier 833 remote site tester and 832 terminal tester.

The model 834 uses two 8-bit microprocessors—Motorola's 6802 for keyboard and display control and Zilog's Z80 for system control and data processing. The instrument performs standard bit-error-rate and block-error-rate tests (BERT/BLERT) on the communications channel, makes cyclical and longitudinal redundancy checks (CRC/LRC), and checks error-detection codes.

With the eight-button control keypad, the user can select synchronous, asynchronous, or high-level data link controls (HLDC) and data rates to 19.2 kb/s (twice those of the 832 or 833), in addition to full- or half-duplex operation and hexadecimal, ASCII, or EBCDIC character sets. The 834's 16-character, five-by-seven-dot matrix display translates hexadecimal data into ASCII or EBCDIC—"window" data in a form the user most easily understands.

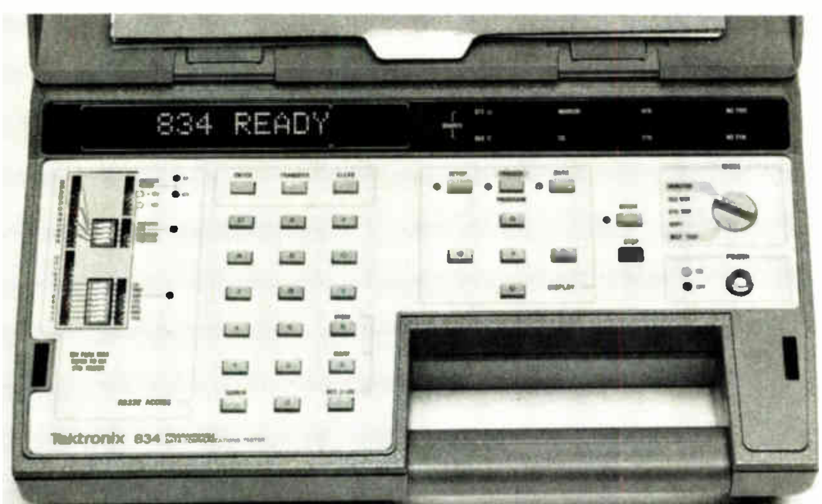
Further enhancing the programmability of the tester are four control keys. With these keys in the simulate mode, the operator can scroll through a menu of 99 program steps (including compare, wait, halt, send, receive, jump, and up to 50 timing commands) and, in conjunction with the 21-button hexadecimal keypad, set up a list of 19 parameters and 19 test messages. This interactive prompting, shown on the 834's fluorescent display, lets any nonprogrammer perform many data-communications tests.

To make field service faster and easier, the 834 uses a series of read-only memory packs containing preprogrammed, standard test routines for common protocols. Inserting these ROM packs (containing up to 8,192 bits) into the tester's back panel allows a service technician to call the program into the instrument, which then automatically executes the test and immediately displays go/no-go results.

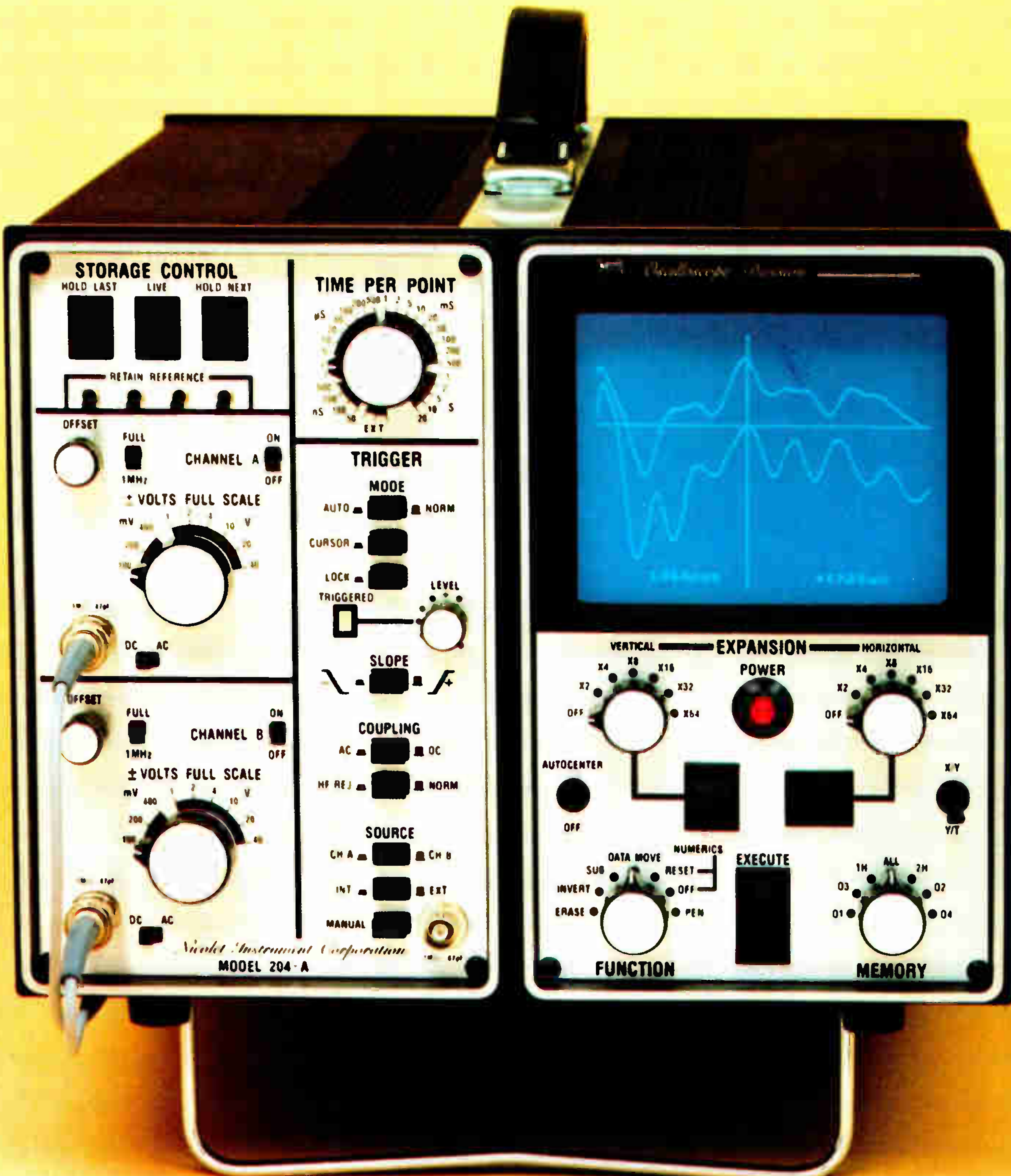
According to Eimers, the ROM packs "give the 834 added power in the field." At the factory, for example, data-communications specialists can program into the (actually programmable) ROMs a series of tests, including setup conditions for the 834 and the program sequence, he continues, "giving the technician [all the instructions] he needs to find the problem in specific equipment."

The 834 can be set up to match the data parameters of virtually any data-communications system that conforms to the RS-232-C/CCITT V.24 interface. An optional adapter also provides current-loop capabilities for the tester. Available in August, the 834 has a base price of $3,700 and, Eimers claims, "provides 80% to 90% of the functionality of data-communications analyzers costing three times as much."

Tektronix Inc., P. O. Box 500, Beaverton, Ore. 97077. Phone (503) 644-0161 [339]



Nicolet EXPLORERS



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PM3500 100MHz 16 Channel Logic Analyzer

PM3212 25MHz Dual Trace Scope

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PM3243 50MHz Multiplier/Storage Scope

PM3263 100MHz Microprocessor-Equipped Scope

PM3266 100MHz Storage Scope

PM3218 35MHz Delayed Time Base Scope

PM3540 10MHz Logic State Analyzer

PM3214 25MHz Delayed Time Base Scope

You can't buy a faster 100MHz logic analyzer than our PM3500. You can't buy a more tested and proven 25MHz delayed time base scope than ours. And between those two there's a full line of superlative scopes from Philips.

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For more information call 800-631-7172, except in Hawaii, Alaska, and New Jersey. In New Jersey call collect (201) 529-3800, or contact Philips Test & Measuring Instruments, Inc., 85 McKee Drive, Mahwah, New Jersey, 07430.

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PM3225 15MHz Single Trace Scope

PM3207 15MHz/5mV. Dual Trace Scope

PM3216 35MHz Single Time Base Scope

PM3262 100MHz Dual Trace Universal Scope

PM3244 50MHz 4-Trace Scope

PM3265 150MHz Scope with 100MHz Analog Multiplier

PM3234 10MHz Dual Beam Storage Scope

PM3233 10MHz Dual Beam Scope

PM3211 15MHz Dual Trace Scope

From Philips, of course.

PHILIPS Test & Measuring Instruments

PHILIPS

Circle 183 on reader service card

Instruments

Data system packs performance in

New DVM technique and FET switching overcomes speed, leakage problems

Where data acquisition is concerned, the bywords have always been more and smaller—collect more data from more sources, collect more accurate data with more repeatability, and do it faster with smaller systems using smaller modules and providing less unneeded capacity. Now, one of the latest data-acquisition and -control systems to enter the field—Hewlett-Packard's model 3497A—seems intent not only on continuing that tradition, but on doing it with new technology.

Usable in conjunction with an HP computer, the model 3497A provides a clock/timer, front-panel keyboard, and display in a user-oriented layout. For example, the operator can monitor a particular analog channel or digital slot without disturbing a continuously running measurement program. Also, keyboard control lets the operator evaluate likely 3497A configurations before writing a program. So that it can be used as part of larger systems, an HP-IB interface is included or, optionally, an RS-232-C interface to permit the system to operate with other computers, or to transmit data via telephone lines.

Voltage measurements may be provided by an optional internal digital voltmeter having unusual precision and sensitivity, due to a new measurement technique, and a burst mode of 300 readings/s. On its lowest range (0.1 volt) with 5½-digit resolution, sensitivity is 1 μV in the last digit; its best accuracy is 30 ppm, achieved on the upper three ranges (1, 10, and 100 V).

Further, this is a fully guarded DVM with selectable integration times from 1 to 0.01 line cycle. Speed and resolution vary with integration time from 5½ digits at 50 readings per second and 1 line cycle of integration, to 3½ digits at 300 readings and 0.01 integration cycles. In addition, a built-in programmable current source with ranges from 10 μA to 1 mA permits precise resistance measurements.

Behind the DVM's performance is an unusual integration technique that basically combines dual-slope integration and successive approximation in a new method called Multi-slope II. The company says the technique will be incorporated into other HP developments to be released soon.

Multi-slope II uses four run-down slopes. A steep slope derived from the precision reference power supply is applied first. At zero crossing, there is a finite amount of overshoot leaving a residual charge on the integrator's capacitor. For the next three steps, additional slopes, each exactly one tenth as steep as the previous one, are applied to the remaining voltage until the zero crossing. The final crossing is therefore done with a slope 10^{-3} as steep as the first.

Additional new technology will be

Here's an inexpensive way to give your existing products a face lift.

Our new snap-in pushbuttons fit standard rocker switch mounting holes. And they're available now, so you can use them to enhance your panel design *without costly restamping or re-cutting of the face panel*.

These new pushbuttons are available with all the circuits, terminations and ratings found in our standard rocker switch line. Actuators can be hot-stamped, illuminated or color-coded to meet every need.

For more information, contact your Cutler-Hammer salesman or switch distributor. Or write for our new catalog of commercial switches. Eaton Corporation, Commercial Controls Division, 4201 N. 27th St., Milwaukee, WI 53216.

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EATON
Electrical/Electronic Control

Circle 185 on reader service card

evident in an optional 20-channel multiplexer that uses field-effect transistors to provide high isolation. It is able to scan and digitize more than 5,000 channels a second. Unlike customary FET designs, the HP approach resists off-voltages to 85 V with leakage current limited to 1 μA, maximum. The company describes the process as a tree-switching technique that minimizes stray capacitance in order to minimize noise. The plug-in option is scheduled for a fall introduction along with a plug-in board that includes thermocouple compensation capability, says the company.

Other options to be available by the end of the year include counters, alternative multiplexers, d-a converters, and input arrangements. Price for the 3497A data-acquisition and control unit ranges from $2,150 to $25,000, depending on the options selected. Deliveries are slated for this month.

Hewlett-Packard Co., 1507 Page Mill Rd., Palo Alto, Calif. 94304 [351]

0.1–990-MHz signal generator is GPIB-programmable

A synthesized-signal generator from Hewlett-Packard Co. has full general-purpose interface bus (HP's own HP-IB) programmability over a 0.1-to-990-MHz frequency range with absolute level accuracy of ±1.5 dB. Frequency in the model 8656A switches in less than 2 seconds (within 100 Hz). The microprocessor-controlled unit handles frequency (a-m or fm) and output level, as well as decibels referenced to a microvolt.

The 8656A's store and recall function aids repetitive testing by remembering 10 complete front-panel signal setups. Resolution for the unit is 100 Hz or 250 Hz; stability comes from an internal 2-ppm/year crystal time base. Since the unit is intended primarily for in-channel receiver testing, the single-sideband phase noise is less than −122 dBc/Hz at a 20-kHz offset at 225 MHz. The output level is calibrated from +13 to −127 dBm with an accuracy of

Turn schematics into PC boards in one-third the time.

Nicolet introduces System 80.™

Nicolet's revolutionary new System 80 is the compact, complete electronic drafting table that fits into your design department and speeds work through faster than you can imagine. In only five days, you can become an expert on the System 80, because it is incredibly easy to operate.

System 80 instantly displays pads, lines, DIPs, component outlines, characters — and in up to 20 colors so you can work on all layers simultaneously. You have tremendous mobility in the design because you can pan around very large drawings, or zoom in on specific details.

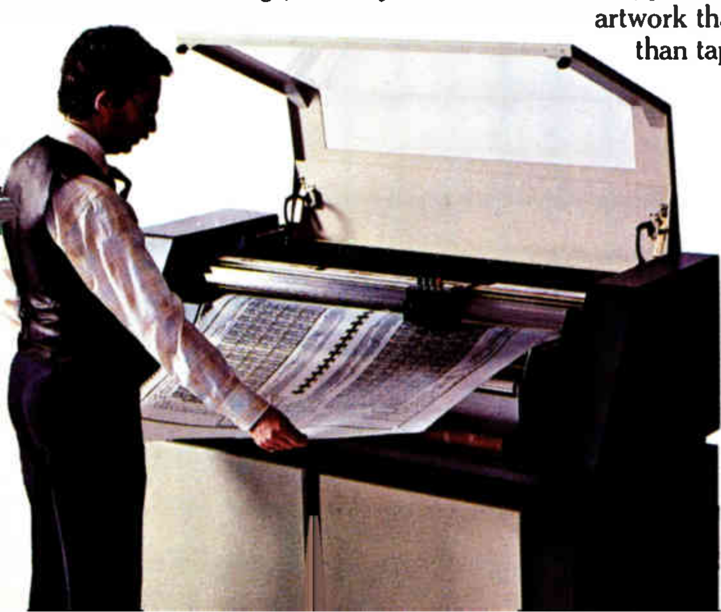
You can "key in" elements to be repeated, and the system duplicates them as many times as you want at the touch of a button. Time spent on tedious detail work can now be used for creative designing. As you work, an auxiliary screen gives you a high resolution overview, helps you make changes fast. All your designs are stored on diskettes — more compact, less expensive and safer than storing tape-ups.

Make changes and additions quickly

You can make revisions and see results right on the screen, as you work. System 80 lets you transfer parts of designs from stored drawings, which you can instantly rotate or reposition. You can move, erase or add whole groups of pads and traces for fast revisions.

Artwork is always accurate

Your prototypes will be ready faster, and because the system always positions the pads and lines exactly on the grid you specify, you can be sure that your final art will be exactly what you had in mind. System 80 includes a Nicolet Zeta 3653SX pen plotter which produces clean, precise, camera-ready artwork that is far more accurate than tape-up.



System 80 can pay for itself in a year

System 80, at $73,200, is priced lower than any comparable CAD unit, yet it provides the features and the capabilities of systems costing three or four times as much. It saves money and time by eliminating bottlenecks at the design stage. No other CAD system can increase your productivity so dramatically, or give you more accurate results while being so simple to operate. On a cost/performance basis, your average board cost over two years can drop by 50%. Check out System 80 today.

NICOLET CAD CORPORATION
2530 San Pablo Avenue
Berkeley, CA 94702
415/848-6600. Ask for Mike Smith.

Circle 188 on reader service card

±1.5 dB and a resolution of ±0.1 dB. The synthesized-signal generator sells for $6,250.

Hewlett-Packard Co., Inquiries Manager, 1507 Page Mill Rd., Palo Alto, Calif. 94304 [352]

Multibus-compatible frequency synthesizer sells for $1,300

The PR080 single-card, Multibus-compatible frequency synthesizer can make frequency or phase changes in less than 300 ns after receiving an execution command. It operates over a 10-Hz-to-2-MHz range and offers 0.0023-Hz resolution. It can achieve 1-μHz resolution under microprocessor control. The output waveform is sine or square.

The unit is designed for measurement and control, communications and tracking, system simulation, and automatic test. It is programmed using a binary number base. The frequency stability is 100 ppm on its internal reference—a crystal oscillator—but the oscillator can be locked to an external frequency standard.

The PR080 is priced at $1,300 each, with large quantity discounts available for original-equipment manufacturers.

Proteon Associates Inc., 24 Crescent St., Waltham, Mass. 02154. Phone Howard C. Salwen at (617) 894-1980 [355]

$50 digital panel meter has 3½-digit resolution

Even though the DM-3100N digital panel meter costs only $50, it has 3½-digit resolution, 0.1% accuracy, and 1,000-MΩ balanced differential inputs. The low-profile DPM displays voltages from −1.999 to +1.999 V dc on a 0.5-in.-high red light-emitting-diode readout.

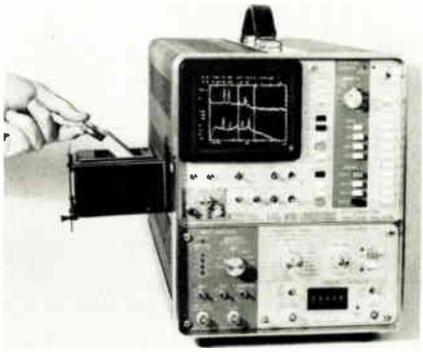
The DM-3100N's differential inputs require a 5-pA bias current typically and provide a common-mode rejection of 80 dB. Overvoltages to ±250 V dc are safely tolerated.

The unit, which sells for $34 in quantities of 100 or more, is available in two to four weeks from the receipt of an order.

Datel Intersil, 11 Cabot Blvd., Mansfield, Mass. 02048. Phone (617) 339-9341 [356]

Spectrum analyzer has built-in tape storage, IEEE-488 link

A portable fast-Fourier-transform spectrum analyzer has a built-in tape storage, an IEEE-488 interface, and a sinewave output at the cursor. The Mini-Ubiquitous model 446B-1311 measures, stores, compares, and evaluates vibration signatures, resonances, or noise on a remote location.



The analyzer has all the capabilities of the widely used model 446A real-time spectrum analyzer, plus three new features: it can store time or frequency digitally; it has stroboscope control through the sinewave output; and it can transfer and control by means of digital peripherals operating through the interface.

The analyzer will be ready for delivery in the third quarter of 1980 and will sell for $15,750.

Nicolet Scientific Corp., 245 Livingston St., Northvale, N. J. 07647. Phone (201) 767-7100 [359]

Period multiplier operates in TM-500 power modules

The model PI-110 dual-channel clock-period multiplier operates in Tektronix Inc.'s TM-500 series power modules. The unit can generate synchronous signals, variable time

marks, programmable clocks, counted bursts, or three-frequency pulses. It can also be used as a period multiplier.

The ratio of the multiplied clock period to the clock source, which can be set at any integer between 2 to 999, can be increased to 998,001 maximum in the cascaded mode by using the three-digit front-panel switch or by programming remotely. The clock source can be generated internally from a variable period oscillator, a crystal reference, or the ac line.

The price of the device is $675.

Pulse Instruments Co., 1536 West 25th St., San Pedro, Calif. 90732. Phone (213) 548-1327 [357]

Clamp-on ammeter allows 50-Hz calibration

The model 10-E ac ammeter clamp-on adapter from Tripplett Corp. allows the model 310, 630, 630 PLK, and 60 testers made by the same company to clamp onto 50-Hz lines for current readings. Line loads from 0 to 300 A may be measured without interrupting the circuit. A thumb-slide switch allows the user to select ammeter ranges of 0 to 6, 12, 30, 60, 120, or 300A at ±3% accuracy. The adapter may also be used with the company's own model 101 line separator to divide two-conductor cords or cables. The price is $33.

Tripplett Corp., One Tripplett Dr., Bluffton, Ohio 45817. Phone (419) 358-5015 [358]

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Why do people buy Digital's high-performance micros more than anyone else's?

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Digital Equipment Corporation has sold more 16-bit microcomputers than any other company in the business.

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So you can develop your products faster, and offer your customers the right balance of cost and performance every time.

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Just look at what we offer:

Digital's microcomputer family.

You can choose from eight different configurations of our LSI-11/2 and -11/23 micros, in both boards and boxes. With high-performance features like general-purpose registers. Double-precision floating point processor. Up to 256Kb memory addressing. And the full instruction set of the PDP-11 family.

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More options on the industry-standard bus.

Once you have the micro you want, your possibilities are wide open.

You can choose from dozens of micro products: 9 different memory boards, 11 I/O modules, 9 communications options, even kits for designing your own custom interfacing.

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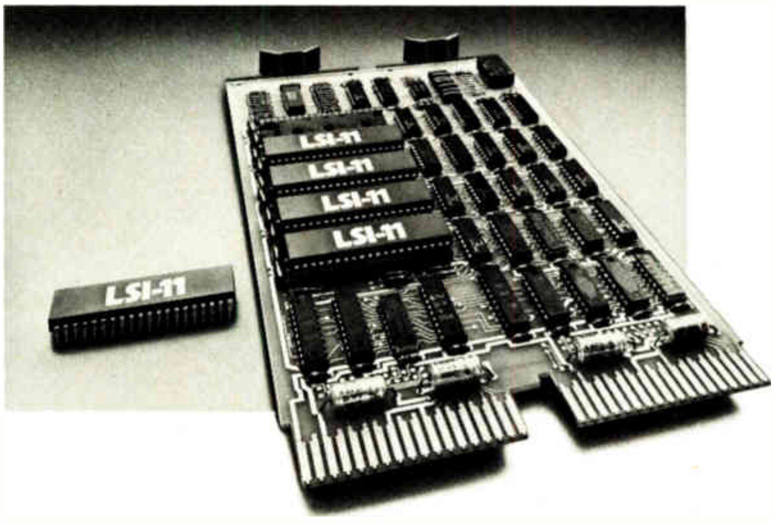
For more information, contact **Digital Equipment Corporation,** MR2-2/M65, One Iron Way, Marlboro, MA 01752. Or call toll-free 800-225-9220. (In MA, HI, AK, and Canada, call 617-481-7400, ext. 5144.) Or contact your local Hamilton/Avnet distributor. In Europe: 12 av. des Morgines, 1213 Petit-Lancy/Geneva. In Canada: Digital Equipment of Canada, Ltd.



It took the minicomputer company to make micros this easy.

digital

Circle 197 on reader service card

The first functional PCB tester good enough to be called Fairchild.

It's the company behind Series 70 that puts it a generation ahead.

In the world of ATE, no name has so consistently been synonymous with innovative technology, dependable quality, and total systems support as the name Fairchild.

With the introduction of Series 70, Fairchild brings that long tradition of excellence to the functional board tester.

Series 70 offers true state-of-the-art hardware and software, developed for efficient and accurate board test and program simulation. It is modular in design for off-the-shelf economy and cost-effective expansion. It has a computer specifically designed for functional testing. It has a high-speed memory bus and a separate high-speed I/O bus. It can diagnose faults down to the component level with logic clip and probe capability. And it can test all of today's most advanced LSI devices —high-speed digital, analog and hybrid.

Without a doubt, Series 70 is the most complete, comprehensive and capable functional tester available today. And with the increasing complexity of today's PC boards, you can't afford a system that offers less.

And Series 70 is faster, smarter and easier.

While other testers operate at a leisurely 1.8 MHz, Series 70 gives you data rates to 5 MHz across all digital pins in parallel and collects probe data at full test speed. It offers faster, more accurate fault isolation, and it lets you program timing increments with 20 ns resolution. You can even track bus-related faults at full speed with Series 70.

Thanks to MEDIATOR, Series 70 gives you a high-level conversational test program language instead of low-level code. And MEDIATOR is an English-like, multi-level language so you can write your own hybrid board programs easily and economically.

More accurate, more flexible, and more adaptable.

Compared to today's best known functional tester, Series 70 offers specifications that are truly impressive:

	Series 70	An older tester
SPEED	5 MHz	1.8 MHz
PROGRAMMABLE PULLUP RESISTORS	Yes	No
COMPUTER	Specially designed dual bus architecture 16 bits 64 K words memory (128 K bytes)	PDP-8 12 bits 32 K words memory (48 K bytes)
SIMULATOR	High accuracy Can be run on tester	Longer debug time Have to add memory
MASS STORAGE	12 or 24 MB disk	2.4 MB or 4.8 MB disk
SOFTWARE	Virtual memory	Overlay & linking
EDITOR	Continuous on-line operation	Call-up mode
SYSTEM INITIALIZATION	Totally automatic	Boot from TTY
DIAGNOSTIC CAPABILITY	Fault tracing to the component level with FLO-TRACER	No equivalent
ADVANCED LSI TECHNIQUES	Live data compression	No equivalent
HIGH-SPEED CLOCKS	8 phase with OR capability	No equivalent
HYBRID CAPABILITY	6 bus dual-pole throughout	Limited scanner

The world's first true hybrid tester.

Unlike other functional testers, Series 70 covers all types of boards—bus oriented microprocessors, dense dynamic memories, fast static memories, complex linear circuits and discrete devices. And it can handle boards from MOS and CMOS to TTL and advanced bipolar.

With Series 70, you also get a wide choice of fixturing systems—universal, edge connector, or optional Thinline® bed-of-nails interface.

And it's from the first family of ATE.

Like all Fairchild test systems, the Series 70 is backed by the largest support network in the industry. Training, applications software, special hardware configurations and maintenance are all part of the Fairchild support package. Together they provide a comprehensive, proven and state-of-the-art solution to your functional PCB testing needs today and tomorrow.

For more information on the new Series 70 Functional Board Tester from Fairchild, call or write for our new brochure:

Fairchild Test Systems Group
Fairchild Technical Center
Billerica, MA 01821
(617) 663-6562

"Come See the Series 70
ATE Boston, June 16-18"

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Circle 199 on reader service card


simulator
the component level
12 or 24 MB disk
Dual IEEE bus
Live data compression
Virtual memory

Industrial

Thermometer is accurate, and rugged

Instead of sacrificing accuracy for ruggedness, or vice versa, Analogic Corp. has produced a digital thermometer and calibrator that is both accurate and rugged and is also portable. The model AN6520 is a microprocessor-based thermometer made to calibrate thermocouple instruments or to measure temperatures directly and read them out in degrees Fahrenheit or Celsius on a light-emitting-diode display.

The instrument also doubles as a millivoltmeter with microvolt resolution. Furthermore, the manufacturer considers it "the only available, portable microprocessor-based thermometer and calibrator to have 0.1°C of conformity and resolution."

Its performance makes it especially useful for portable thermocouple instrument calibration for the process and service industries.

The AN6520 is available as a four-range unit for measuring millivolts and ANSI types J, K, and T thermocouples and as an eight-range unit to include types E, R, S, and C. The unit offers measurement resolutions of ±0.1°C for base-metal thermocouples (such as types J, K, T, and E); ±1.0°C for other thermocouple types (R, S, and C); ±1.0 μV for inputs up to ±20 mV; and ±10 μV for plus or minus measurements between 20 and 101.1 mV.

The instrument is packaged in a waterproof, epoxy-painted metal case and operates from a rechargeable battery pack. The connections for field calibrations consist of dual sets of input/output five-way binding posts. Optional thermocouple adaptor plugs are also available. The internal complementary-MOS microprocessor circuit also lets the user know via instant readouts whether there is an open thermocouple, whether input limits are going high or low, or whether the battery is running low.

A separate 220-V ac version featuring eight ranges is available for use in Europe. This version covers J-, K-, T-, and S-DIN thermocouples. It also measures millivolts and Degussa curve types E, R, and B.

The U.S. versions are available within 90 days and their prices start at $1,295 (in the U.S. only) for a four-range unit. Discount pricing is available when more than 10 units are ordered.

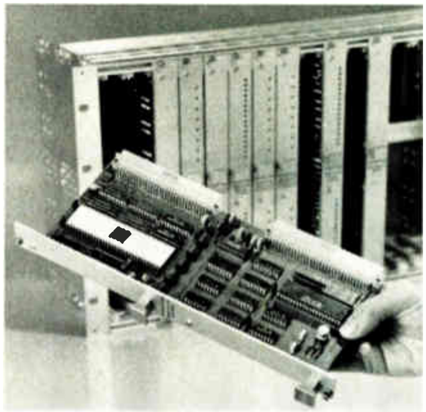
Analogic Corp., Audubon Rd., Wakefield, Mass. 01880. Phone (617) 246-0300 [350]

TI 990 gets software-compatible board

The model CPU-200 microcomputer board from Erni & Co. is based on Texas Instruments' 16-bit TMS 9900 microprocessor. It provides the central processing functions for Erni's recently announced 990E industrial microcomputer system while offering software compatibility with TI's 990 minicomputers and microcomputers.

The CPU-200 features a 56-line proprietary bus that allows memory addressing of up to 64 kilobytes and input/output capabilities by using the TMS 9900 bit-serial communications register unit. Up to 4,096 inputs and outputs may be addressed individually. An RS-232 or current-loop serial port is provided.

The unit also features 16 vectored



interrupts, an eight-line bit programmable port, and an internal timer. It operates at 3 MHz. The external control functions of the TMS 9900 are available to the user.

The board sells for $560.

Erni & Co., 3316 Commercial Ave., Northbrook, Ill. 60062. Phone (312) 480-9240 [341]

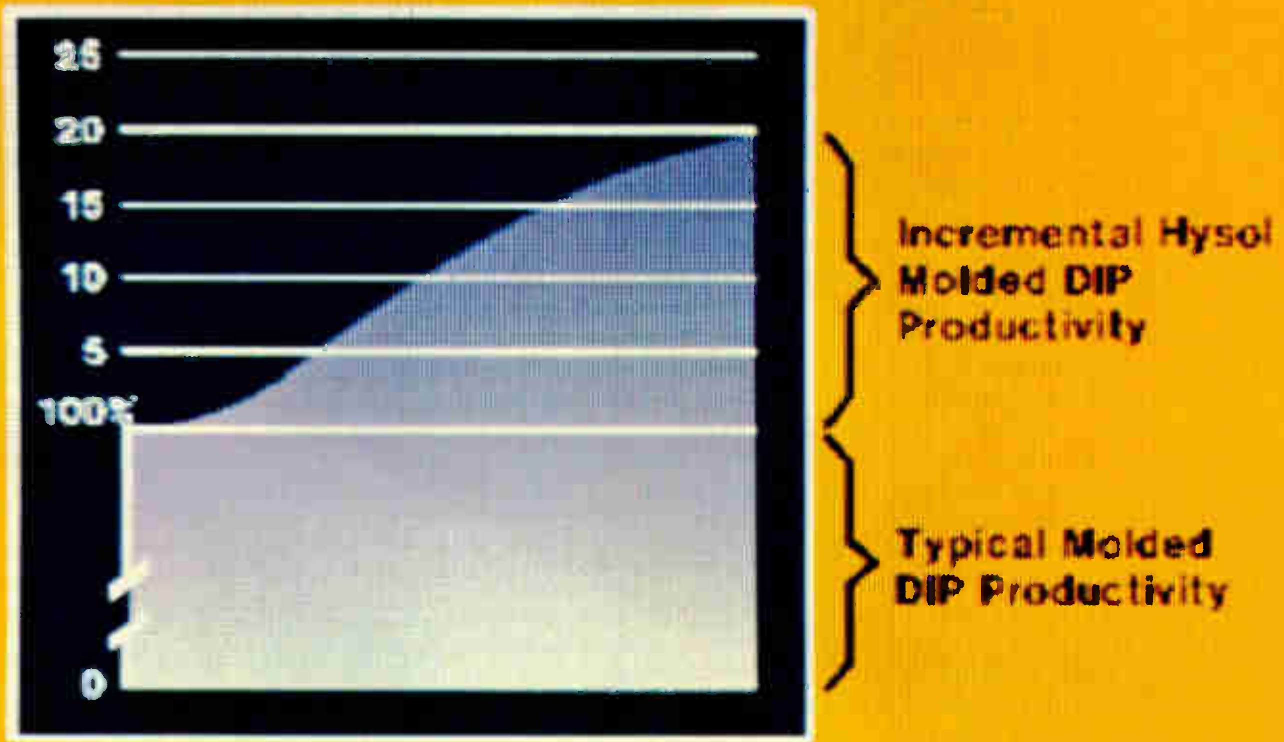
Line conditioners reject 40 dB per decade above 6 kHz

Designed for systems such as computers that are sensitive to critical changes in voltage, the LC-2 line conditioners use a switching regulator circuit that operates at 99% efficiency and generates no noise or distortion, says the manufacturer, Power-Matic Inc. The response time for complete correction of a worst case is a half cycle. The conditioners are insensitive to frequency, load, and power-factor changes. The basic regulator circuit, combined with heavy-duty capacitors, forms a filter network that achieves a normal-mode noise rejection of 40 dB per decade from 6 kHz up. This is a useful parameter, since most spikes and noise occur in the frequency spectrum above 30 kHz. The unit also includes a spike suppressor.

The line conditioners come in eight models for 110- and 220-V operation. All units are rated for continuous duty at a 2-kW load. The price is $760 for the 110-V model.

Power-Matic Inc., 7667 Vickers St., San Diego, Calif. 92111. Phone (714) 292-4422 [342]

AMAZINGLY SIMPLE R&D EFFORT YIELDS UP TO 20 PERCENT EXTRA MOLDED DIP PRODUCTION.



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These advanced epoxy compounds are formulated for optimum production characteristics as well as superior device performance.

For example, Hysol epoxies develop a higher hot hardness than conventional epoxy compounds. So instead of an average three minute mold cycle, the same mold press can produce a finished shot in *two*.

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You get five, ten—up to 20 percent extra molded DIP production per shift. With no extra investment.

Along with better productivity, of course, you get the extra assurance of Hysol quality.

Plus all the advantages of Hysol performance. Like improved moisture resistance, better thermal cycling characteristics and increased thermal stability—for better reliability.

Hysol is the leader in semiconductor epoxy technology. And to prove it, we'll supply the Hysol epoxy and qualified field support for a full productivity and performance comparison on your test line.

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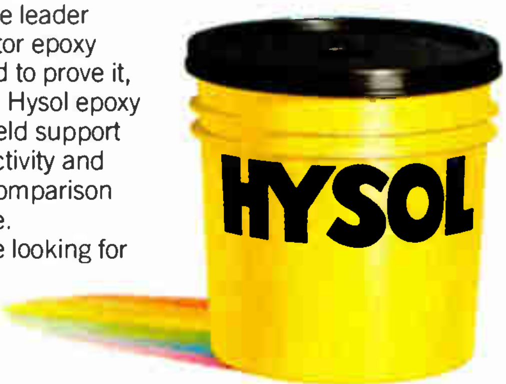
Telephone (213) 968-6511.



Circle 201 on reader service card

THE FUTURE IN LLSI BELONGS TO THE POWERFUL.

And to those who can successfully test the limits of their linear LSI and beyond.

Now a new generation of LTX LLSI Testers removes those limitations to concentrate tremendous computer power where it counts ...at the test socket. And does it without sacrificing compatibility with your existing job plans.

The new LTX features:

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What it all adds up to is this... better quality, greater yield, faster payback, and the ability to use all of this new computer power for testing. More importantly, the new, more powerful LTX lets your linear LSI testing capability keep pace with the leading edge of technology as new, more sophisticated devices are developed.

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Contact LTX Corporation.
Telephone: (617) 244-7800.

TEST LTX POWER AT SEMICON WEST, BOOTH 1418-1420, San Mateo (May 20-22) or **ATE, EXHIBIT/SEMINAR, BOOTH 120-124,** Boston (June 16-19).

Bob Baszner, LTX Corporation, 160 Charlemont Street, Newton Highlands, MA 02161.

RESPONDS

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- **Digital Input/Output Board**
- **Analog To Digital Converter**
- **High Speed Arithmetic Unit**
- **Power Supplies**

System packaging

All system modules are mounted on 9″ by 6″ shock and vibration resistant boards. A 7.62″ by 4.88″ 12.62″ chassis (½ ATR) holds up to 6 boards.

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We've got core and semiconductor memories for military and commercial use, a Digital Data Acquisition System for the 1553 bus, and a compact Digital Tape System with 23 megabit capacity.

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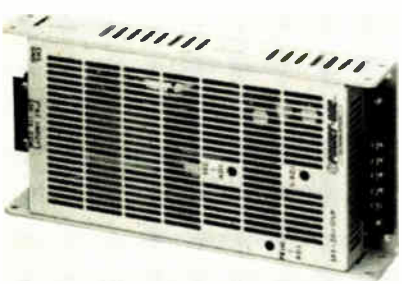
Circle 204 on reader service card

Power supplies

Five supplies each provide 100 W of power

The SF series of high-frequency switching power supplies each provide 100 W of regulated dc output power. Having a 75% efficiency, the five programmable units are rated for 5 V at 20 A, 12 V at 8.4 A, 15 V at 6.7 A, 24 V at 4.2 A, and 28 V at 3.6 A. The devices operate from 90 to 130 V ac or 180 to 260 V ac at 47 to 63 Hz. The voltage range is selected at the input barrier strip; no jumpers are required. Output ripple and noise is 50 mV peak to peak, while line regulation is ±0.05% for a full line change of 90 to 130 V ac or 180 to 260 V ac, and load regulation is ±0.05% for a 100% load change.

The units also offer brown-out protection, remote sensing capability, remote shutdown, output overload protection, overvoltage protection, reverse voltage protection, and input protection. During a brownout, regulation is maintained down to either 90 or 180 V ac at full load. If the ac input voltage is lost, the units provide a minimum hold-up time of 20 ms. The units offer good stability with less than 0.1% output voltage changes over a 24-hour period. Overload protection limits output to 105% to 125% of full rated current. Overvoltage protection is present at 120% to 130% of nominal output voltage set point. The power supplies have remote sensing capabilities to compensate for load lead losses of up to 0.5 V total. An external resistance may be used to program output voltage.



Other specifications for the units include a recovery response time of 150 µs typical and 300 µs maximum. The maximum voltage deviation is 5% from nominal voltage set point. The units have a temperature coefficient of ±0.01% maximum over the temperature range from 0° to +70°C. The units meet MIL STD 810C, method 514, procedure X for vibration and MIL STD 810C, method 516, procedure V for shock.

The units come in a 2-by-4.87-by-10-in. package and weigh 3 lb each. They sell for $170 each and delivery is from stock.

Power-One Inc., Power One Dr., Camarillo, Calif. 93010. Phone (805) 484-2806 [413]

Two power systems use one battery bank

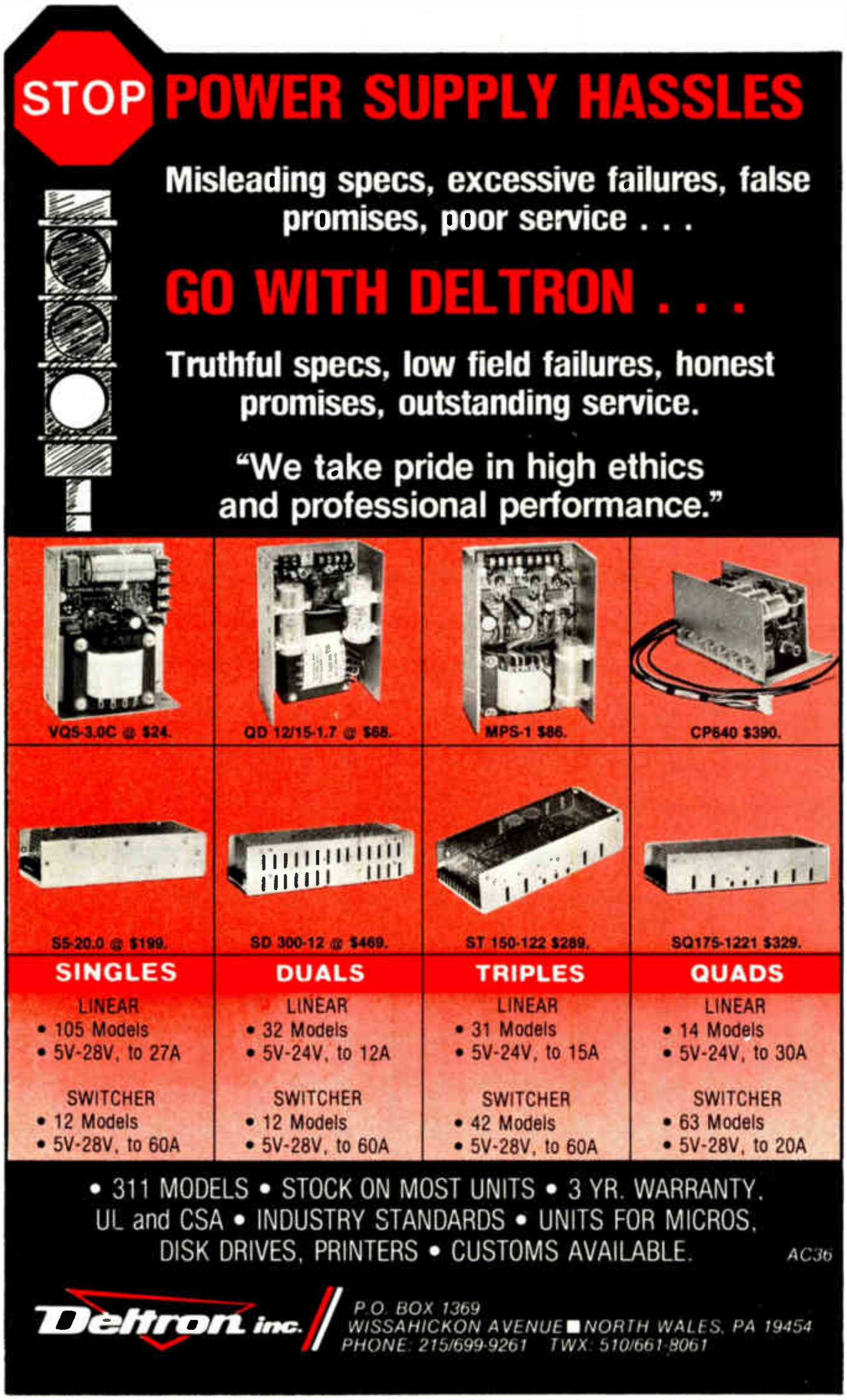
Two solid-state 415-Hz frequency converter/uninterruptible power systems use the same battery bank normally provided for one large 60-Hz system. Designated High-Links, the 475H and 4125H are rated at 75 and 125 kVA respectively and have a dc terminal voltage of 395 to 425 V. They convert a 50- or 60-Hz line frequency into the regulated 415-Hz power required by processors like the IBM 303X and /370 model 168, the Amdahl 470V5-6-7-8, and many other mainframes. The High-Links have a 91% efficiency at full load and a mean time between failures of 15,000 hours, or 10,000 hours in redundant operation. The price is about $40,000 for the 475H and $48,000 for the 4125H. Delivery takes 90 to 120 days.

Franklin Electric, Programmed Power Division, 995 Benicia Ave., Sunnyvale, Calif. 94086. Phone (408) 245-8900 [414]

Monitor indicates input/output levels

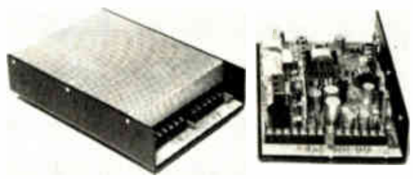
The PM-1 monitors power failure of the S series switching power supplies and in applications like a memory dump where precise signaling is desired. The power-fail monitor consists of two detectors, one of which senses the ac input voltage while the second senses the power supply output voltage. The monitor provides a TTL signal—a logic 0—if the supply output voltage drops below a threshold voltage that is adjustable from 90% to 110% of nominal output voltage. A logic 0 signal is also generated if the ac input voltage falls below the minimum ac input rated value. The logic signal provides a 5-ms warning of an output drop resulting from an input voltage drop under full load conditions. At turn-on, a TTL signal is generated after the input voltage comes to within rated limits and the main output is above its threshold value. In sample quantities, the PM-1 is $25.

Deltron Inc., Wissahickson Ave., North Wales, Pa. 19454. Phone (215) 699-9261 [418]



95-W switcher has four outputs

A line of 95-W switched-mode power supplies comes in either open- or enclosed-frame versions. The EPS95 has outputs of 5V at 12 A, ±12 V at 1.5 A, ±15 V at 1.2 A, and a floating 5 V at 0.5-A output. With an efficiency of better than 70%, the unit operates from a dual input range of



90 to 125 V or 180 to 250 V ac. It includes current limiting with automatic recovery. In lots of 250, the open-frame model sells for $164.57 and the enclosed for $178.02.

Elpac Power Systems, 3131 South Standard Ave., Santa Ana, Calif. 92705 [416]

Hermetic dc-dc converter is 1 by 2 by 0.3 in.

The M series of dc-dc converters is housed in a hermetically sealed package that measures only 1 by 2 by 0.3 in. They provide an output of up to 4 W over the temperature range from −55° to +85°C. Designed for airborne and military-type applications, the units accept inputs of ±12, 24, 28, or 48 V dc. They are housed in a 38-pin metal package. In lots of 100, the converters sell for $130. Delivery time is from stock to six weeks.

Integrated Circuits Inc., 13256 Northrup Way, Bellevue, Wash. 98005. Phone (206) 747-8556 [417]

MICROSOFT.

YOU'LL NOTICE SOMETHING DIFFERENT.

MIDAS Operating System

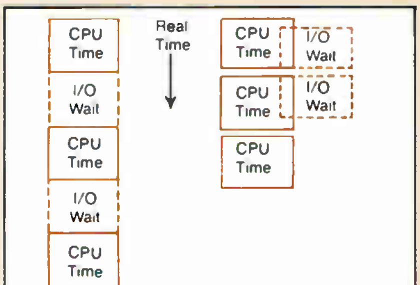
Usually, an operating system is most noticeable when it's not doing the job. If you've looked at a microcomputer OS lately, you've probably noticed a lot of things: slow response time, inefficient I/O, no security for disk files, interfacing headaches. And upgrading to a multi-user system often means even more problems.

With Microsoft, you'll notice something different.

Microsoft introduces MIDAS, an interrupt-driven asynchronous system that is designed specifically for the multi-user environment and has most of the capabilities of a minicomputer OS.

Asynchronous I/O

In a multi-user system, CPU time must be divided among all the users, but overlapping I/O can help compensate for this loss. With MIDAS, I/O wait time is used for program runtime, so that most tasks can run faster on a MIDAS multi-user system than on a synchronous single-user system.



Synchronous System. Program always waits for I/O.

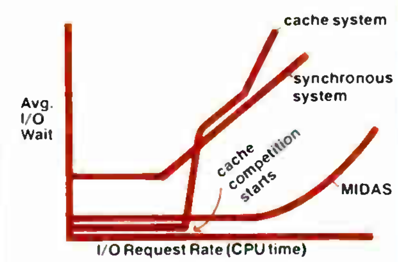
Asynchronous System. Program continues to run while I/O is being done.

And MIDAS' smart interrupt routines and I/O request queues for each device keep all peripherals running at the maximum rate. MIDAS is the only microcomputer system whose asynchronous I/O does not fall apart as the demand for I/O increases.

Device Independence

Programs run smoothly under MIDAS regardless of what's hooked up to the computer. Device interface routines are short and simple and MIDAS does the rest. Any combination of floppy disk drives, hard disks, printers, terminals or custom devices is possible. Disk I/O needn't be dependent on a particular drive: MIDAS can use disk names to find disks via content, or drive names to find disks via physical location.

Comparison of MIDAS and Cache-type Asynchronous System



MIDAS displays I/O efficiency even under heavy I/O loads. A synchronous system degrades as more I/O requests are added. A cache system reaches saturation when the number of cache buffers equals the number of I/O requests. Rapid degradation results because competition for the cache renders it ineffective. MIDAS degrades much more slowly because there is no competition between tasks for cache buffers. Instead, each task has its own cache, or buffer ring. The number of buffers in this ring is user-settable on a per-file basis.

MIDAS is available to OEMs in single-user and multi-user versions that run on 8080/Z80 hardware.

BASIC Compiler

The Microsoft BASIC Compiler is the ideal programming tool for developing BASIC applications or microprocessor system software. The machine code for any application program may be placed on diskette or ROM, but the BASIC source program need not be distributed. Thus the original application program is protected from unauthorized alteration.

Optimized Machine Code

Compiled BASIC programs are noticeably faster than interpreted BASIC programs. Their speed and compactness are due to extensive optimizations performed during compilation: **1.** Expressions are reordered to minimize temporary storage and eliminate common subexpressions **2.** Constants are folded wherever possible **3.** Peephole optimizations are performed **4.** The code generator is template-driven, allowing optimal sequences to be generated for the most commonly used operations **5.** String operations and garbage collection are extremely fast.

BASIC Language Features

The BASIC Compiler supports all the language features of the Microsoft BASIC-80 interpreter, including:

- WHILE/WEND conditional for structured programming
- CALL statement for assembly language subroutines
- PRINT USING for formatted output
- Long variable names, up to 40 characters

Plus the BASIC Compiler supports double precision transcendental functions (SIN, COS, TAN, ATN, LOG, EXP, SQR).

Off the shelf, the BASIC Compiler is $395 for CP/M, ISIS-II, or TRSDOS Model II. OEMs, contact Microsoft.

Make the most of your microcomputer hardware. Introduce it to Microsoft system software. You just can't help but notice how good it is.

For more information on all of Microsoft's system software including BASIC, COBOL, and FORTRAN, contact:

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THE SMART LASER TRIM SYSTEM.

It trims your operating costs, too.

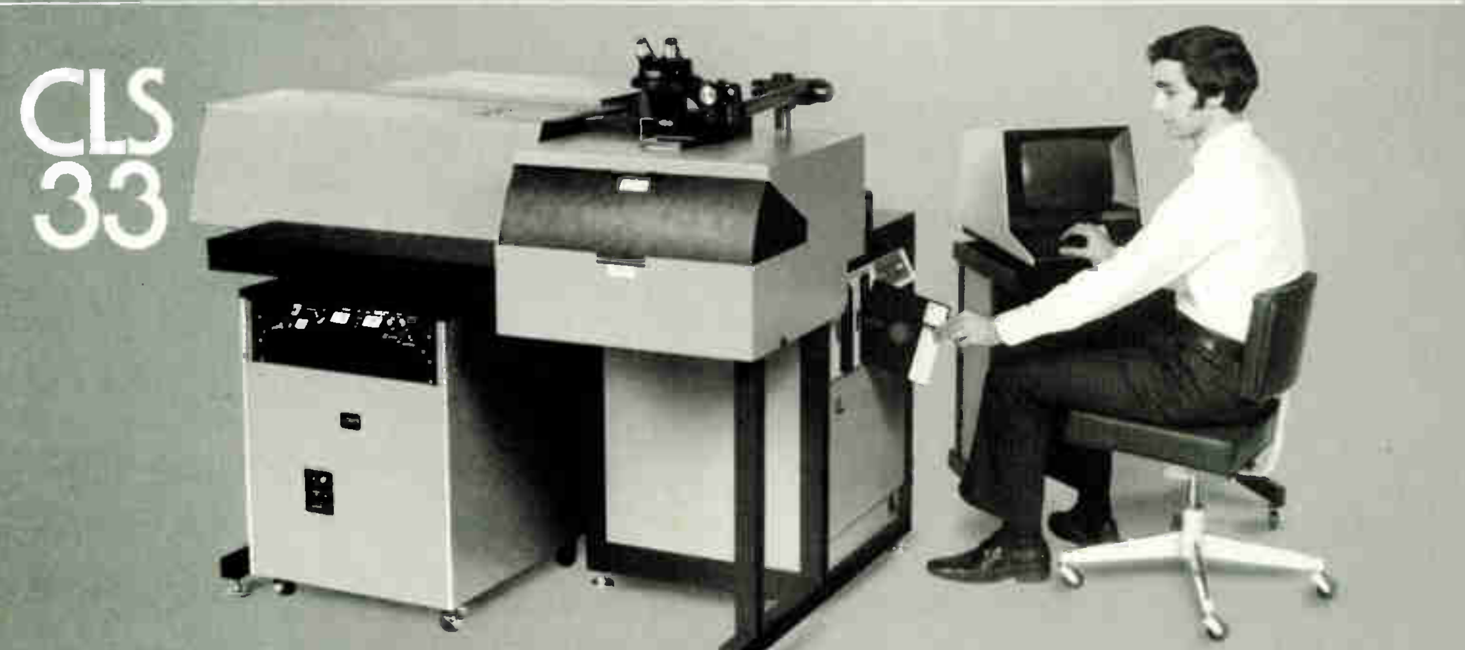
All laser trim systems can trim components, but the CLS-33 from Chicago Laser Systems does much more. In addition to being designed to be the smartest, highest throughput laser trim system available, it reduces both immediate *and* long term trimmed network and hybrid costs.

Chicago Laser engineers have brought together a blend of micro-computer, laser optic and electro-mechanical technologies to form a well balanced state-of-the-art system. Its most striking aspect is its overall simplicity. With fewer major components than competitive systems, the engineering sophistication of the CLS-33 has overcome traditional size and complexity barriers . . . an accomplishment recognized by the many major network manufacturers who have installed it.

The system microcomputer is backed up by the laser trimming industry's most intelligent software operating system. It was developed specifically for high-speed laser trimming. The software directs the measurement/laser interaction, using a Chicago Laser exclusive high-level programming language. As a result, no comparable laser trim system is easier or faster to program than the CLS-33. On-line compiling and editing are featured for user convenience and easy program debugging in user language.

Just as the powerful software reduces programming time and personnel costs, the maintenance ease of the CLS-33 ensures low long-term costs. This system can be easily maintained by your maintenance staff. Training is quick and free to CLS customer personnel.

A variety of complementary parts handling mechanisms are available for the CLS-33. Fed by the recently introduced air-bearing Step-and Repeat Handler, the CLS-33 trims an incredible 100,000 resistors per hour. At the same time, the simple sophistication that has established Chicago Laser as a leader in the laser trim industry has been maintained. The handler is also available with stack load and unload to minimize operator support.



Circle 208 on reader service card

The Chicago Laser Systems CLS-33 is the smart way to solve your network or hybrid trimming problems. For the complete story and a frank appraisal of how the CLS-33 can fill your needs, contact Chicago Laser Systems Inc.

Chicago Laser Systems Inc.

4034 North Nashville Ave. Chicago, IL 60634 • Phone 312-282-2710

VAX Distributed Processing. Ask any user.

"VAX was the only supermini to offer the address space and networking capability we needed."

Jim Hart
Chief of Systems Development, NASA Ames Research Center, Moffetfield, California

Scientists at the NASA Ames Research Center are working in the fields of aeronautics, space science, life science, and spacecraft technology. They use more than a dozen specialized facilities, located in the field and throughout Ames' headquarters. An extensive DECnet system allowed Ames' large central mainframes to interact easily with Digital's PDP-11s located in each lab.

But according to Jim Hart, Chief of NASA's Systems Development, "Our PDP-11 users were constantly generating new requirements for greater capacity."

That's why Ames needed more number-crunching capability at their mainframe site. But they didn't want another mainframe.

Says Hart, "A supermini like VAX was the natural choice. And because of its power and networking capacity, VAX was the only one we considered."

Now VAX works with both Ames' PDP-11s and mainframes with the help of DECnet. "For example," explains Hart, "scientists studying fluid dynamics send the huge amounts of data collected by their PDP-11s to a central Illiac IV super computer. After it's finished the heavy number-crunching, the Illiac leaves data post-processing to VAX. Final results are then transferred, via DECnet, back to the PDP-11s in the labs for either graphic plotting or interactive work."

Hart concludes, "VAX's computing and distributed data processing capabilities have helped us get the maximum use out of all our computers."

"With a distributed processing system built around VAX, we're getting information to our users in near real-time."

Roger Vossler, Section Manager and Systems Engineer,
TRW Defense and Space Systems Group, Redondo Beach, California

Data acquisition

Converters are stable to 10 MHz

Hybrid voltage-to-frequency units trimmed to 2.5 MHz have monotonic output

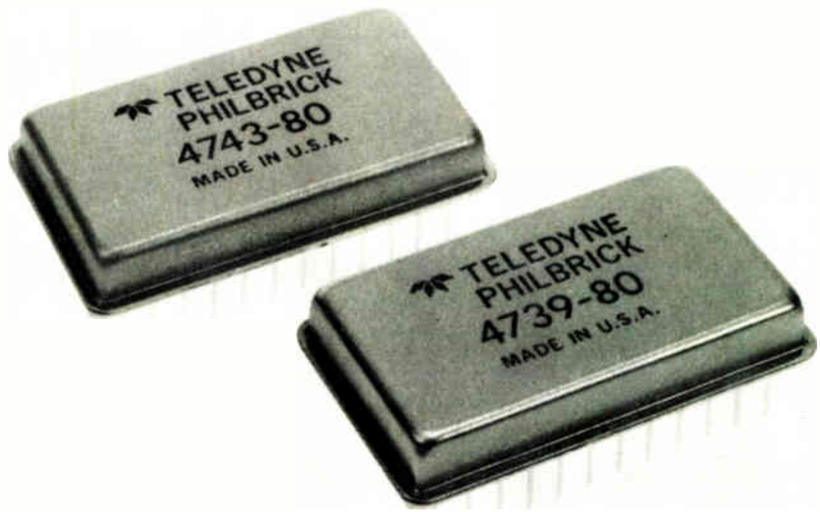
Two new hybrid voltage-to-frequency converters from Teledyne Philbrick, models 4743-80 and 4739-80 can maintain good linearity and stability within an operating temperature range of −55° to +125° C, when trimmed with a potentiometer.

With trimming, nonlinearity for the 4743-80 is 0.05% of full scale and 0.05% of input or output signals over a full dynamic range of 100 Hz to 10.5 MHz. By adjusting the potentiometer on the 4743-80, the user is able to trim the converter's full-scale output from 10 MHz down to 2.5 MHz.

The trimmed 4739-80 holds nonlinearity to 0.05% for full scale and 0.001% of signal over a dynamic range of 50 Hz to 5.25 MHz. Its output is limited to from 5 MHz to 2.5 MHz, permitting trimming to tighter linearity and stability. The user may also elect to offset value to zero on both models.

Over its full temperature range, the 4743-80 drifts ±100 to ±200 ppm/°C; the 4739-80 drifts only ±75 to ±125 ppm/°C. For each percent change in power supply voltage, the 4743-80 drifts ±125 ppm, and the 4739-80, ±75 ppm. Both units operate over a voltage input range of ±14 to ±18 V. Settling time to 0.01% of full scale is one to two cycles of the new frequency, plus 14 μs, for both converters; overload recovery takes 10 cycles of the new frequency.

Although response times of the voltage-to-frequency devices may be slower than those of some analog-to-digital converters, other advantages inherent in the units make them competitive in many applications, asserts Mitchell A. Bloom, product marketing manager. For one thing, V-f converters are always monotonic, whereas a-d devices may not be. Also, the pulsed output of the 4743-80 and 4739-80 gives digital expression to analog signals without the conversion circuitry usually required for a-d devices, he says, and their outputs make them easier to interface with microcomputers than some other converters. Then, unlike a-d and d-a arrangements, V-f systems need not synchronize signals at



either end of a data link.

A major market for the 4743-80 and 4739-80 converter, Bloom believes, will be among makers of process-control systems, who are looking more at the advantages of fiber-optic data links such as high electrical isolation, noise immunity, and the elimination of sparking [*Electronics*, Feb. 28, p. 171]. Teledyne Philbrick, he says, has several experimental in-house fiber-optic transmission systems using V-f converters.

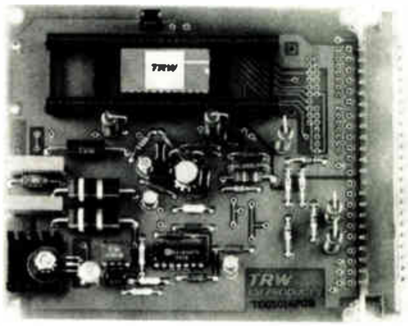
The 4743-80 and 4739-80 hybrids reside in 24-pin dual in-line packages measuring 1.4 by 0.8 by 0.2 in., giving them a size advantage over comparable nonhybrid converters, Bloom says. In lots of 100, the 4743-80 costs $155, and the 4739-80, $145. Delivery takes six weeks.

Teledyne Philbrick, Allied Drive at Route 128, Dedham, Mass. 02026. Phone (617) 329-1600 [382]

Evaluation unit does 6-bit conversion in 33 ns

Designed as an evaluation board but also suitable for small-volume production, the TDC1014PCB contains the components needed to perform 6-bit analog-to-digital conversion in 33 ns. It is a redesign of an earlier model intended for evaluation of the 8-bit TDC1007J converter chip.

The 4½-by-5½-in. board accepts and digitizes a 1-V peak-to-peak signal from a 75Ω source at sample rates from dc to 30 megasamples per second. It does not require an external sample-and-hold circuit. A 2-bit input code permits output coding in true or inverted binary or 2's com-



New products

plement formats. The TDC1014J a-d converter chip contains 63 parallel differential comparators that look at the analog inputs simultaneously and compare them with a reference voltage. The comparator outputs are then translated into a binary code by means of a 63:6 encoder.

The 6-bit board together with the converter chip, in quantities of 100, sells for $168; the chip alone sells for $93 in the same quantities.

TRW LSI Products, 2525 E. El Segundo Blvd., El Segundo, Calif. 90245. Phone (213) 535-1831 [383]

12-bit d-a converter is microprocessor-compatible

Housed in a 16-pin dual in-line package, the AD7542 digital-to-analog converter offers true 12-bit linearity over two specified temperature ranges. Consuming only 40 mW, the microprocessor-compatible device has an on-board four-quadrant multiplier that allows digital control of ac signal amplitudes or dc voltage levels in process control, instrumentation, and industrial control applications.

Two versions of the device are available: the KN operates from 0° to 70°C; the BD operates from −25° to +85°C. The device has a maximum nonlinearity of ½ least significant bit and a guaranteed monotonicity over either temperature range. Other specifications include a gain drift of ±5 ppm/°C, a maximum current output settling time of 2 µs, and operation from a single 5-V power supply. In quantities of 249, the KN device sells for $15.75 each and the BD sells for $18.75 each.

Analog Devices, Route 1, Industrial Park, P. O. Box 280, Norwood, Mass. Phone Eric Janson at (617) 329-4700 [384]

Module interfaces directly with microprocessors

A 12-bit hybrid analog input system, the MP32, connects directly with 8080A, 8048, Z80, and SC/MP microprocessors without the need for additional external components; it connects to other microprocessors and minicomputers with minimal external logic. Contained in an 80-pin quad in-line ceramic package, the system occupies only 3.75 in.^{2} of board space.

The MP32 consists of a 12-bit complementary-MOS analog-to-digital converter, an instrumentation amplifier, an input multiplexer that accepts up to 16 single-ended or 8 differential signals, an address decoder, and control logic. The low-drift instrumentation amplifier features high speeds at gains above unity. Gain can be selected from unity to 54 dB and is programmed by an external resistor, permitting input ranges as low as ± 5 mV. The a-d converter offers 35-μs conversion time and three-state outputs. By using 12 address lines, the MP32 can communicate with up to 4,096 memory locations, each with its own address. It has a nonlinearity of $\pm 0.0125\%$. The unit sells for $267 in lots of 100 and delivery is from stock.

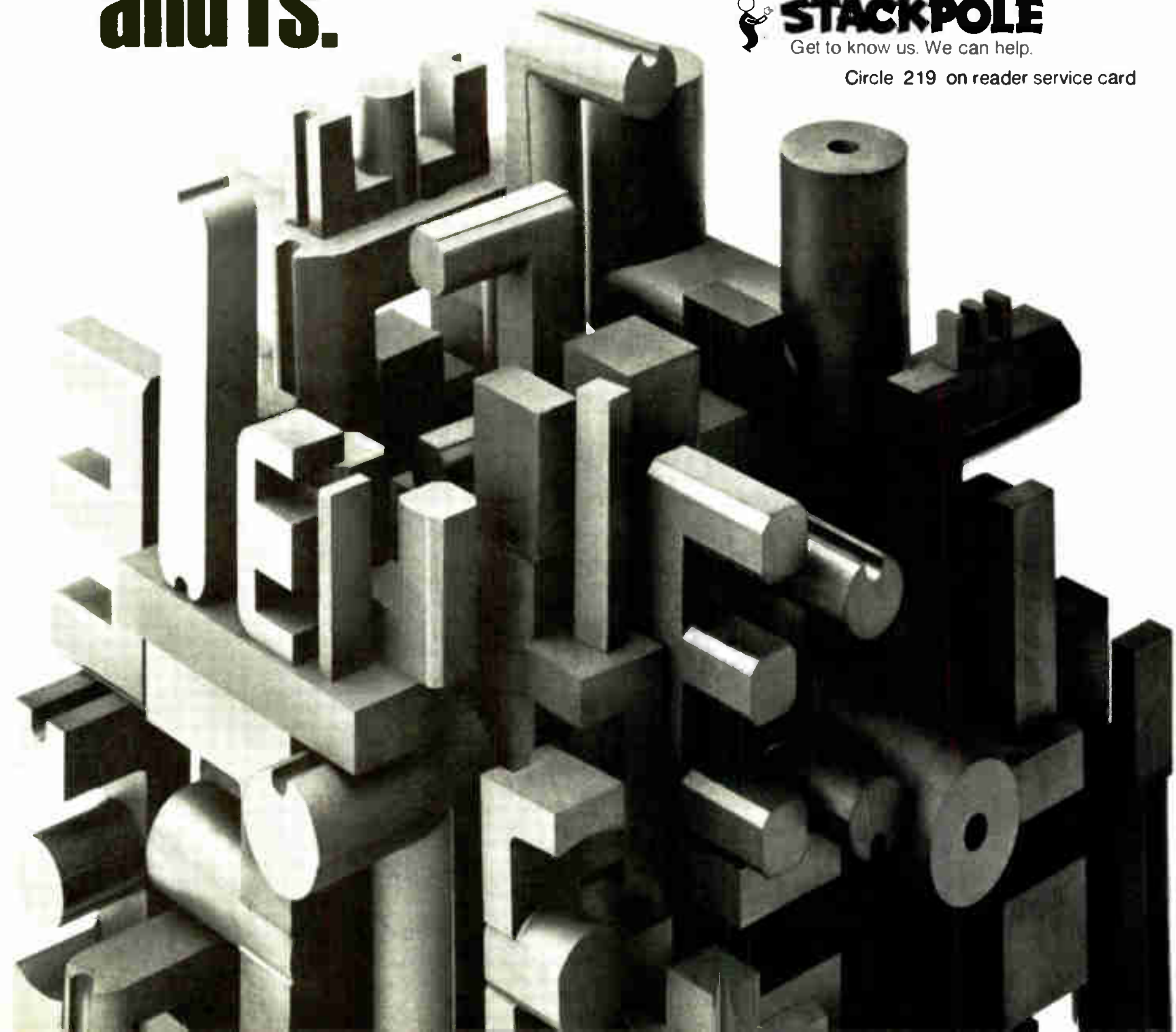
Burr-Brown, P. O. Box 11400, Tucson, Ariz 85734. Phone (602) 746-1111 [385]

Naked Minis work with industrial controllers

A pair of low-cost 64-bit TTL input/output interfacing modules connect Naked Mini 4 computers to industrial controllers. The interfaces are also compatible with Naked Mini LSI-2 series computers. Both modules feature 40-pin locking type connectors.

They allow a variety of I/O data formats to be monitored by the computer, including four 16-bit words or up to 64 discrete stimuli such as switch closures. Byte or word data formats are supported with each module. On-board terminating resistors are provided. Both input and output modules are priced at $400 each.

Computer Automation Inc., 2181 Dupont Dr., Irvine, Calif. 92713. Phone (714) 833-8830 [387]



Microcomputers & systems

Board accepts 8- or 16-bit CPU

Multibus-compatible single-board computer runs CP/M or ISIS II software

If either an 8- or a 16-bit microprocessor could function equally well on a single-board computer, original-equipment manufacturers would not have to stock two different cards. Also, designers would have the option of choosing either of two chips, based upon the demands of the applications. Such flexibility is designed into a Multibus-compatible microcomputer board made by Zendex Corp.

Through a staggered-pin socket, the model ZX-85/88 board accommodates either an 8-bit 8085A microprocessor or a 16-bit 8088 for execution of 8086 code on the 8-bit bus. Both versions of the board have a bipolar PROM that can map the memory or the input/output. The boards also support Digital Research's CP/M and Intel Corp.'s ISIS-II disk operating systems and allow the use of high-level languages such as Pascal or Cobol.

A single 32-K, 250-ns 2732A erasable programmable read-only memory provides system bootstrapping, diagnostic, and monitoring functions. Also, 64 kilobytes of dynamic random-access memory provide a 250-ns medium for the CP/M and ISIS-II software.

Two 8251A universal synchronous/asynchronous receiver/transmitters (Usarts) provide serial I/O ports for cathode-ray tubes, teletypewriters, and other terminals. Each serial port has RS-232 interfaces at the edge connectors. Interrupts are processed by two 8259A interrupt controllers. A Multibus arbiter and parallel-priority resolution circuit control the masters on the bus.

The ZX-85 provides the integrated-processor-board (IPB) environment of Intel's Intellec Series II MDS-220 and -230. In fact, it matches the pinouts so closely that a ZX-85 may be plugged in to take the place of the original IPB and the 32-K RAM board to achieve what Zendex calls "an overall speed improvement."

To emphasize the ease of use of the new boards, the company calls "any software that the MDS-230 will execute" compatible with the ZX-85. Since the 230 and the 85 boards are hardware-compatible, standard peripherals for microprocessor development systems—such as floppy-disk controllers, PROM programmers, and in-circuit emulators—can be used. Standard development software is available from Forth Inc. as polyForth and from Digital Research as CP/M V2.2, specified for MDS-220 or -230.

Support hardware from Zendex is listed on the table at left. The delivery time for the boards is four to six weeks, and each sells for $1,799.

Zendex Corp., 6398 Dougherty Rd. MS32, Dublin, Calif. 94566. Phone (415) 829-1284 [371]

HARDWARE SUPPORT FOR ZX-85/88 PROCESSOR BOARD

Model	Description	Price per single unit
ZX-4DD	Intelligent diskette controller	$ 950
204	Universal diskette controller	$ 525
905	Prototyping card	$ 85
906	Bus display	$ 300
907	Video bus trace	$ 950
908	Programmer for 2716, 2732 programmable read-only memory	$ 450
909	Programmer for 8755 PROM	$ 450
635	Quad power supply	$ 410
640	Heavy-duty quad power supply	$ 475
660	Chassis, eight-slot	$ 725
710/720	Diskette hardware system	$2,900
740	8-in. Winchester-disk system with floppy backup	$7,000
028	128-kilobyte random-access memory	$4,655

12-MHz microcomputer series has features of 8048 and more

All of the features that made Intel Corp.'s 8048 8-bit single-chip microcomputer an industry standard are included in the new 12-MHz 8051 series. Each of the three chips also has additional features that some users of the 8048 requested, such as extra memory address space, a serial communications port, advanced on-chip peripherals, and expanded hardware instructions.

The 8051 can directly address up to 64 kilobytes of program memory and 64 kilobytes of data memory. Although it is classified as an 8-bit machine, the microcomputer can operate on 16-bit words, 4-bit nibbles, and single-bit data via an on-chip Boolean processor.

On-chip features include nested interrupts, 32 input/output lines, and a serial communications port that can operate synchronously or asynchronously. The arithmetic instruction set has been expanded from that of the 8048 to allow 8-bit-by-8-bit multiplications or divisions within 4 μs.

In quantities of 250, the 8051 will sell for $29.50. This does not include a $3,000 one-time-only masking charge. The model 8751, which has 4 kilobytes of ultraviolet-light–erasable PROM, will sell for $255, and the 8031, which has no on-chip program memory, will go for $39. Deliveries will start in late 1980, and an in-circuit emulator will follow.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051. Phone Jim Jarrett at (408) 987-5090 [372]

Development system offers modular software

Designed initially to support the Motorola MC68000 16-bit microprocessor chip, the Software Synthesizer development system requires writing only those parts of a program that implement new functions. Using Scientific Enterprises' own

Software Synthesis Language (SSL), a user combines core software programs with his own additions to produce complete programs for specific applications.

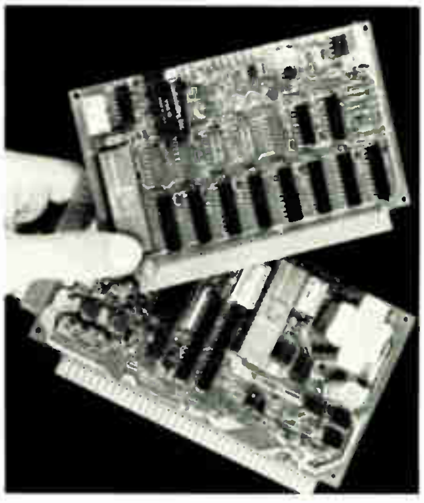
The system is capable of supporting any byte-addressable mini- or micro-computer with appropriate SSL compiler code generators now under development. It also offers transporting of programs between microcomputers such as the 68000, Z8000, Z80, and 6809 or such minicomputer or mainframes as the Perkin-Elmer series 16, DEC PDP-11, and IBM 360/370.

The essential features of the system are the SSL, a 16-bit minicomputer with a quarter megabyte of error-checking and -correcting memory, 38 usable megabytes of Winchester disk memory, four video terminals, and a 13-megabyte cartridge tape for disk backup and archiving. The total cost is $83,000.

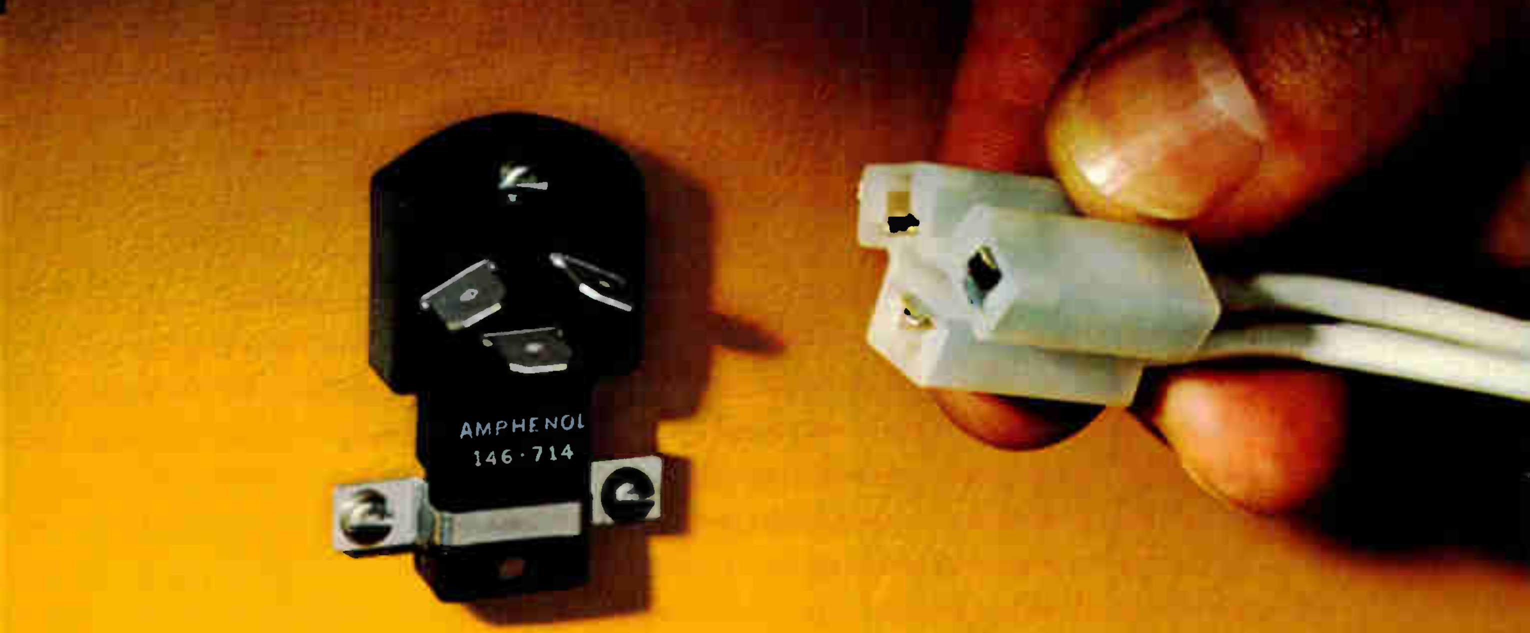
Scientific Enterprises Inc., 6900 S. W. Haines Rd., Tigard, Ore. 97223. Phone Steve Vollum at (503) 620-3500 [373]

Software guides probe through microcomputer

A software package called Fastprobe promises to ease the task of troubleshooting by guiding an operator, measurement probe in hand, through a microcomputer system. The high-level language package runs on a host computer linked to Millennium



Now, TO-220's can beat the heat.



No soldering with Amphenol® 146 Series Mounting Connectors. So, no overheating problems. Just crimp-connect for fast, easy mounting.

TO-220 crimped to 146 Series Connector.

Soldering TO-220 leads to PC boards can damage the package. And it takes valuable time.

But our 146 Series Mounting Connector solves that problem. It simply *crimps* to TO-220 leads. With its standard ¼" termination lugs, the 146-plus-TO-220 package can then be separately mounted away from the PC board.

The result is easier access plus economy. The TO-220 is easy to get to, because it can be mounted on the outside of a chassis. Or on a remote metal surface, thus eliminating a costly heat sink. Testing, trouble-shooting, and replacement are simpler—no de-soldering, just remove three screws.

Our termination tool cuts and forms the leads, then crimps all three at once.

The optional mating connector (shown above) accepts three terminals and is keyed to avoid mismating.

Turn a hot problem into no problem with no-solder Amphenol 146 Series Mounting Connectors. They're just one of our many problem-solving connectors.

For more information, technical data, dimensions and prices, contact the sales office nearest you.

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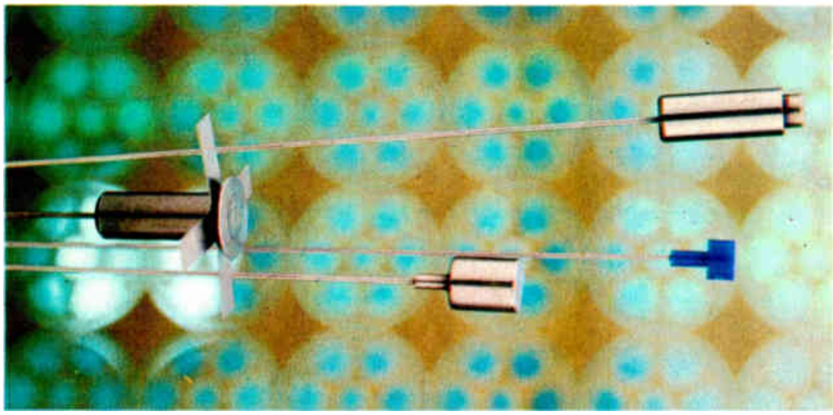
Canada: Montreal (514) 482-5520 • Toronto (416) 291-4401 • Vancouver (604) 278-7636 • **International:** Oak Brook, Illinois TELEX 206-054

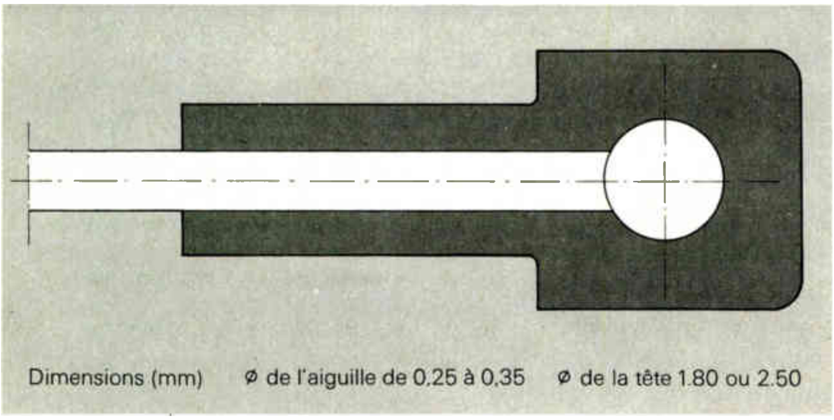
Circle 227 on reader service card

Wires for printers

Seitz

Seitz, c'est sûr !





Seitz technology

Seitz experience in the machining of hard materials has contributed to the realization of wires enabling to print characters of a perfect quality.

The materials used for these wires are extremely hard. They make it possible to obtain a highly polished surface and a great precision. They are resistant to wear (less than 0.1 mm per 30,000,000 characters), to chemical agents and heat.

Seitz research and developping departments co-operate closely with the manufacturers of printing heads.

The booklet «Wires for printers and their guides» will give you detailed information.

Design Borel

Seitz SA, CH-2416 Les Brenets, Tél. 039/32 11 12, Télex CH 35 505 SEITZ

Pierres Holding, Faubourg du Lac 6, CH-2501 Bienne
Téléphone 032 / 22 65 11, Télex 34 566

Systems Inc.'s MicroSystem Analyzer via an RS-232 connection. To troubleshoot, the combination uses in-circuit emulation, signature analysis, and time-domain analysis. Once the system's circuit topology is entered, Fastprobe takes over to verify the interconnections. It then directs the user to probe various points via a proprietary algorithm.

The guided probe can operate in seven modes, ranging from skipping points to save time to checking even the continuity of solder runs.

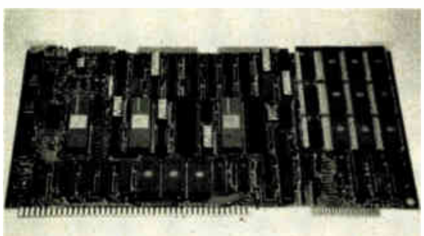
As a package, the analyzer and Fastprobe will support the 8080, 8085, Z80, 6800, and 6802 microprocessors and the 8048 family. It consists of Digital Equipment Corp.'s PDP-11 or LSI-11 central processing unit with a terminal and dual floppy-disk storage. One host computer can support several test stations located in the plant or in the field.

The MicroSystem Analyzer costs from $4,600 to $5,400.

Millennium Systems Inc., 190 Pruneridge Ave., Cupertino, Calif. 95014. Phone (408) 996-9109 [374]

Bubble memory board fits TI 990 minicomputers

The model 990-040 bubble memory board is compatible with the 990 series of mini- and micro-computers manufactured by Texas Instruments Inc. It provides 69 kilobytes of nonvolatile, nonmechanical mass storage on a half-slot communications-register-unit (CRU) board. Six TIB0203



bubble storage devices provide 92 kilobits of storage apiece for a total of 69,228 bytes of data storage.

No external hardware is required to plug the board directly into the computer chassis, and multiple boards can be used to increase storage in one computer. The memory has less than a 7.5-ms access time for the first byte.

Production quantities are available immediately, with the units priced at $1,950 each.

Digital Interface Systems Inc., P. O. Box 1446, Benton Harbor, Mich., 49022. Phone (616) 926-2148 [375]

All–C-MOS microcomputer fits the Multibus card cage

The PPS-1201 is an all–complementary-MOS single-board microcomputer that can plug directly into Intel's Multibus card cage. The system employs a C-MOS 6100 microprocessor and 4 kilowords of memory that can be configured as any combination of C-MOS random-access memory and C-MOS erasable programmable read-only memory. Also included are a programmable real-time clock, memory-expansion controller, three 12-bit-wide parallel ports, and a single serial port that is compatible with RS-232 or 20-mA current loop through board optocouplers. The 1201 sells for $995.

Pacific Cyber/Metrix Inc., 6800 Sierra Court, Dublin, Calif. 94566. Phone Ted Netoff at (415) 829-8700 [376]

Mass storage unit contains hard and floppy disks

A mass-storage unit that contains both hard and floppy disks has been designed by GenRad/Futuredata to be used with its 2300 and 2301 universal microprocessor development systems and network stations. The 2303 system incorporates a 35-megabyte Winchester-type hard disk and a 1-megabyte, single-sided, double-density floppy. The company's disk-operating software has been refined to take advantage of the new mass-storage system. The 2303 sells for $11,500.

GenRad/Futuredata, 5730 Buckingham Pkway., Culver City, Calif. 90230 [377]

There's no body like our new ZOOM BODY

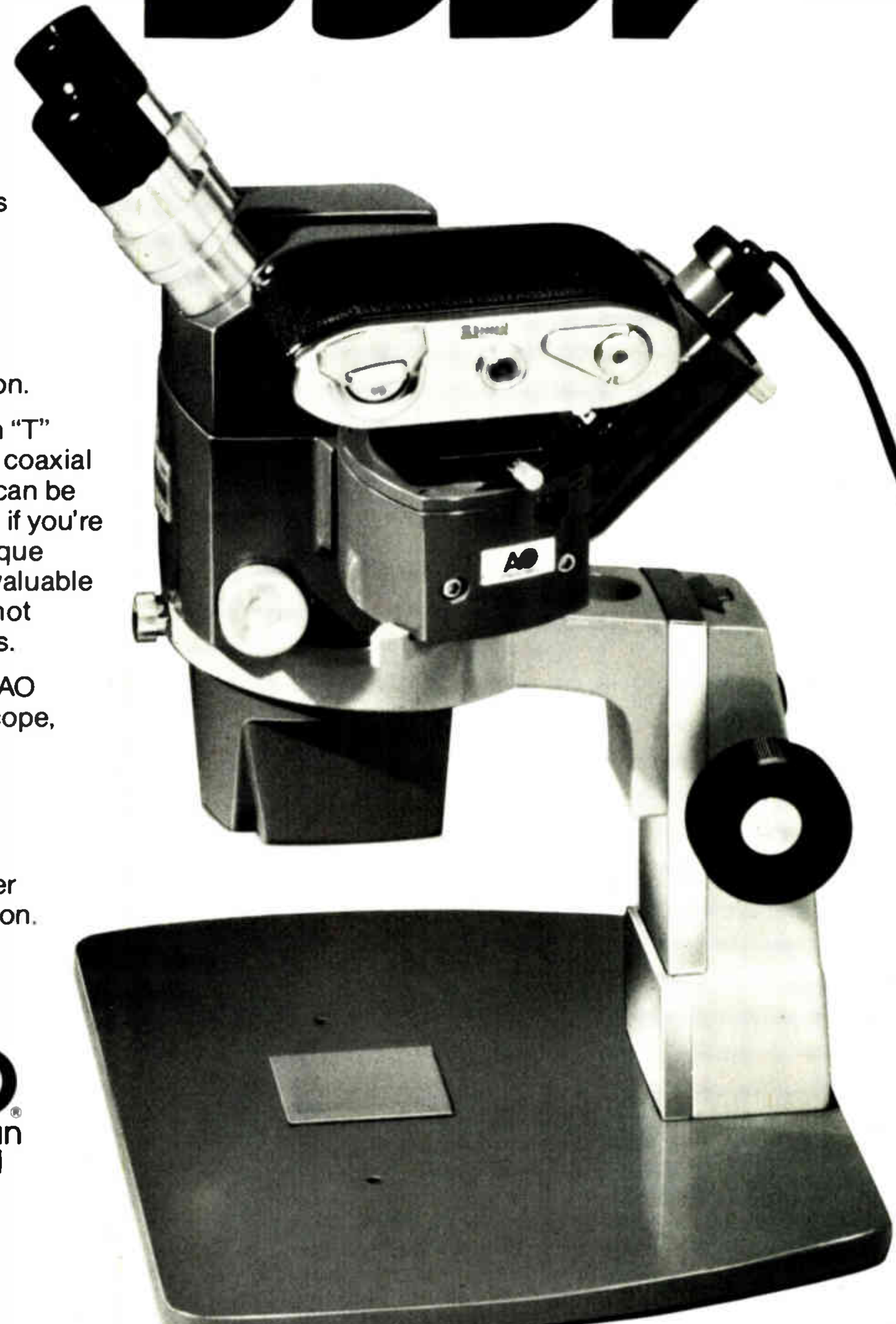
The new AO STEREOSTAR¾ Zoom "T" microscope features the "T" zoom body with coaxial illumination and photo capabilities. It may be just what you need to boost output in your production, assembly or inspection department.

The Zoom "T" gives you a constant 4" of working room. It has a 1x - 6x magnification range, and with auxiliary lenses and eyepieces it offers a total range of 5x - 300x. Magnification can be conveniently changed with controls on both sides of the body. No matter what magnification you're working with, you get crisp, sharp image definition.

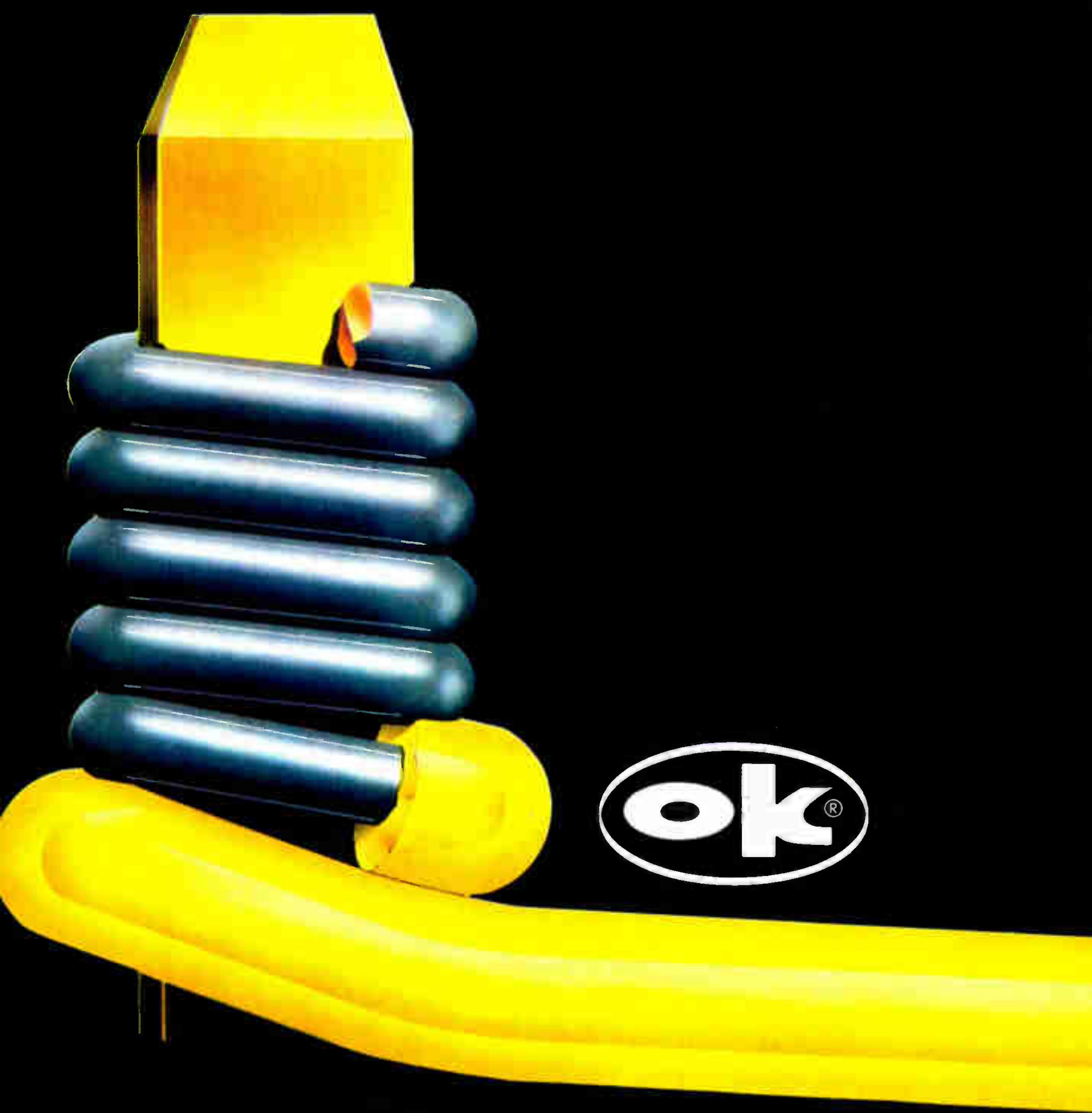
Modular in construction, the Zoom "T" can be ordered with or without the coaxial illuminator. In fact, any accessory can be simply added at any time. However, if you're working with highly reflective opaque surfaces, coaxial illumination is invaluable because it gives contrast without hot spots, glare, reflections or shadows.

We invite you to compare the new AO STEREOSTAR Zoom "T" microscope, feature by feature, with any other competitive microscope.

We're confident you'll immediately see that it offers the outstanding value in its field. See your AO dealer or representative for a demonstration. Or write for a detailed brochure. American Optical, Scientific Instrument Division, Buffalo, NY 14215.



AO® American Optical



Computers & peripherals

Business machine, a stand-alone unit, is fully integrated

Billed as the company's lowest-cost business computer in the Astra series, the model 205 is a fully integrated stand-alone unit and software-compatible with larger, multiterminal Astra systems.

It uses a 16-bit microprocessor with 114 business instructions oriented to data processing and offers multiple programming languages, communications protocols, text-processing capability, and an integrated set of business applications systems.

Offered with it is the Astra Write system for text processing. The combination includes 128 kilobytes of main memory (expandable to 256 kilobytes; two 1.2-megabyte dual-sided, dual-density diskette drives, themselves expandable to a total of four drives; and a 120-character-per-second matrix printer. Communications protocols allow the system to work as a stand-alone small-business system, as an element of an Astra network, or as part of IBM networks under the 3780 and 3740 batch or asynchronous modes.

The 205 supports Cobol, Basic, and a micro-assembler language. Entry-level price is under $14,000.

NEC Information Systems Inc., 5 Militia Dr., Lexington, Mass. 02173. Phone (617) 862-3120 [363]

Computer terminals are for modular and host systems

Designed for smaller modular computer systems, the Executive 80 series encompasses two models. Model 20 is a buffered video display terminal, and model 30 a high-performance editing terminal.

Standard features of the series include video highlighting, line drawing, status line, programmable function keys, and a horizontal split-screen display. Also available is an enhanced video option that selectively displays characters at normal font size, twice normal height and width, or in a 132-column format on a 15-in. monitor.

The list price for the model 20 is $1,295. The model 30—with ex-

panded function key capability, additional transmission modes, and paging and data validation—is priced at $1,695.

Hazeltine Corp., Commack, N.Y. 11725. Phone (516) 462-5100 [364]

Q-bus interface system runs with IBM mainframes

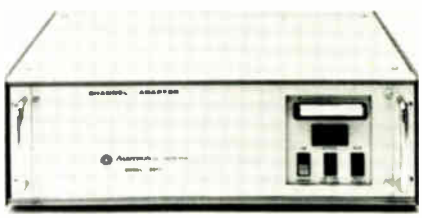
A hardware and software system that allows any nonstandard equipment to operate with the IBM 360/370, 3300, and 4300 mainframes via their input/output channels is intended for original equipment manufacturers.

The model 8900 IBM-QBUS interface is a set of three quad-sized printed-circuit boards that connect standard byte or block multiplexers or selector channels to an LSI-11 QBUS. It can appear as up to 256 subchannel addresses and has a data throughput of up to 1 megabyte/second.

The model 8911 Programmable Channel Interface, a complete LSI-11–based system that includes 8900 card sets, allows direct coupling of two or more IBM mainframes. Also part of the 8911 are two serial ports, an LSI-11/2 central processing unit, 32 kilobytes of random-access memory, channel driver-receiver modules, a TU-58 minicartridge tape drive, a QBUS card cage, and a power supply.

The 8911s cost $12,995 each; in OEM quantities the 8900 is priced at $2,995 each. Deliveries will start next month.

Austron Data Systems, 2007 Kramer Lane, Austin, Texas 78758. Phone Dave Huss at (512) 836-3523 [367]



"I went flat instead of fluffy."

"As an engineer, I used to get pretty frazzled whenever I had to use twisted pairs.

Heaven knows, I needed the performance, but the labor costs drove me wild!

Then one day Dave from Spectra-Strip stopped by and solved all my problems—he showed me their new Twist 'N' Flat.®

How fantastic—twisted pairs in a flat cable with flat, parallel sections that I can mass terminate wherever I need them on the cable. (Standard spacing is 18" of twist with 2" of flat, but if I order as little as a thousand feet at one time, they'll put in any spacing I want!)

Well, let me tell you—this has reduced termination time by 97% and cut our costs by 36%. I liked their thinking so much, I checked them out and found that they were a terrific source for all my flat cable needs—cable, connectors, and even complete terminated jumpers and custom assemblies, fully tested and ready to go.

If you're as concerned about your interconnect performance and costs as I am, you really ought to write Spectra-Strip, 7100 Lampson Avenue, Garden Grove, CA 92642, telephone (714) 892-3361. In the East, call (203) 281-3200.

But don't ask for Dave—he's at home taking care of the baby."

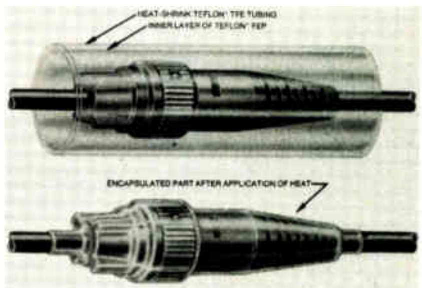
When you're down to the wire.

Circle 237 on reader service card

New products/materials

Dual-shrink tubing of Teflon TFE and FEP seals out moisture, dirt, and chemicals and exhibits good electrical properties. It is designed to provide a tight bond over such items as wires, cables, connectors, splices, and terminals that are subjected to heat, corrosion, shock, and other harsh conditions.

The TFE (exterior layer) shrinks tightly over the inserted parts when the covered section is heated, while the FEP (inner layer) melts and forms a solid or near-solid encapsulation. The tubing has a dielectric strength of approximately 1,200 V/mil and a tensile strength of approximately 4,000 psi. It has a continuous-use temperature of up to 450°F. The price of the tubing



ranges from 48 cents/ft to $11.82/ft. Delivery time is from stock to six weeks.

Zeus Industrial Products Inc., Foot of Thompson Street, Raritan, N. J. 08869 [476]

A chemical test kit, containing the 24 most commonly used soldering fluxes and chemicals, aids engineers in determining the proper flux for 23

MDB makes DEC, DG, HP, P-E and Series/1 Compatible Controllers for every major Line Printer in the world.

Imagine what else we can do!

MDB does it! Lets you pick and choose the exact line printer with the exact speed and performance you need for your system. Because MDB interfaces PDP*-11/03 through 11/70, LSI*-11 & 11/23, VAX* 11/780, PDP-8, Nova,** Eclipse,** P-E, IBM Series/1 and HP 2100, 21MX and 1000 to (ready?) Centronics, Dataproducts, Data 100, Data Printer, Documation, Printronix, GE TermiNet,™ Houston Instrument, Innovative Electronics, Okidata, LA180, Florida Data, CDC and many other line printers. That makes over 100 possible computer/printer combinations including the one you need. Long line options for all combinations are available which allow full speed parallel data transmission at distances up to 3,000 feet.

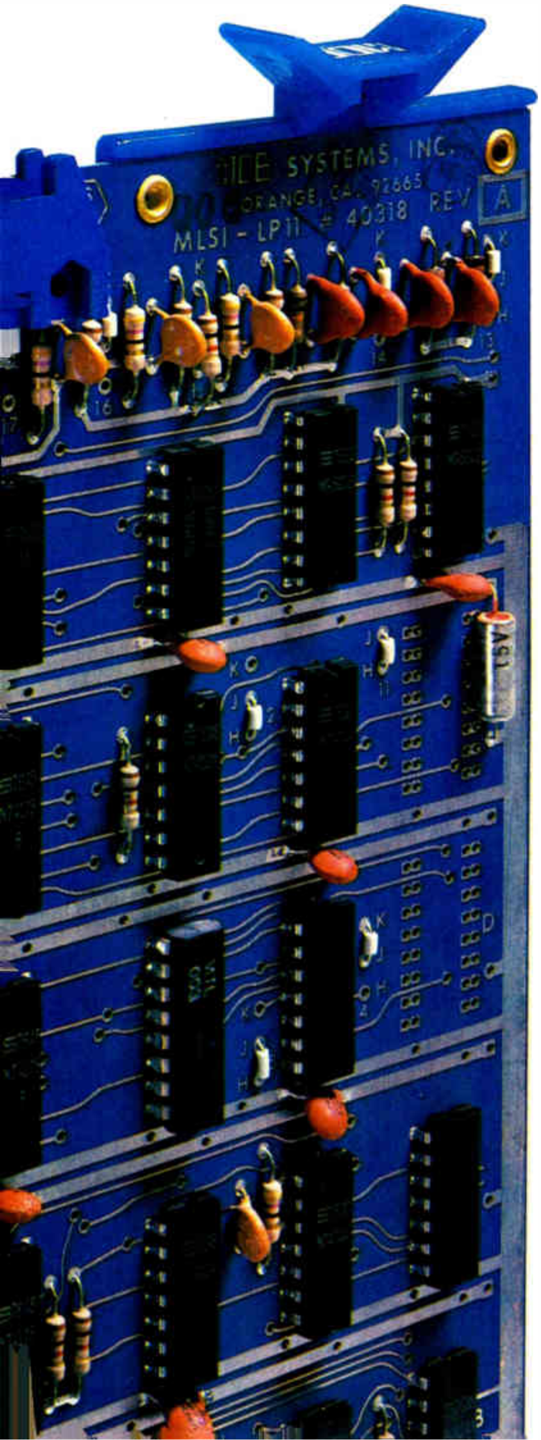
And with MDB you not only get what you want but you pay less for it because an MDB controller with your choice of line printer may cost up to 50% *less* than the host manufacturer's printer system(s).

MDB line printer/controllers are single printed circuit boards that require only one host chassis slot. And each controller is completely transparent to the host operating systems and diagnostics. Operation and programming are exactly as described by the computer manufacturer.

What else can MDB do for you? Look at our data communications interfaces, multiplexors, foundation modules and interprocessor links. Our products range from plain vanilla to plain incredible — like the new memory modules that let you program PROM right on the board. All MDB boards are made by hand, warranteed for one full year and delivered in 30 days or less. Imagine. And they're available under GSA contract #GS-00C-01960.

Now it's your turn. Call or write today.

*TM Digital Equipment Corp. **TM Data General Corporation, a computer manufacturer not related to MDB.



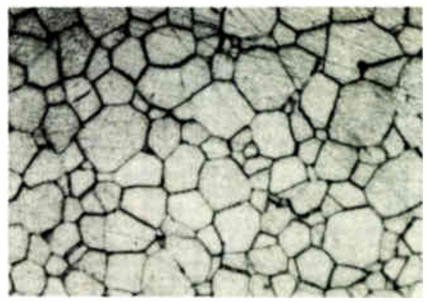
MDB SYSTEMS INC. 1995 N. Batavia Street
Orange, California 92665
714-998-6900
TWX: 910-593-1339

Circle 262 for LSI, 263 for PDP, 264 for DG, 265 for P-E, 267 for IBM 266 for H-P.

metals. The kit consists of 10 different rosin fluxes, as well as inorganic fluxes, water-soluble organic fluxes, residue removers, and metal surface activators. The kit costs $30.

Kester Solder Division, 4201 Wrightwood Ave., Chicago, Ill. 60630 [477]

A manganese-zinc ferrite material is designed for recording-head applications in computer tape, disk, video tape, and related systems. This relatively void-free MND5100 material has a density of 5.09 g/cm³, yielding 99.7% of X-ray density. The fine grain (the mean grain size is 10 μm) and low porosity of the material inhibit gap erosion and ensure good

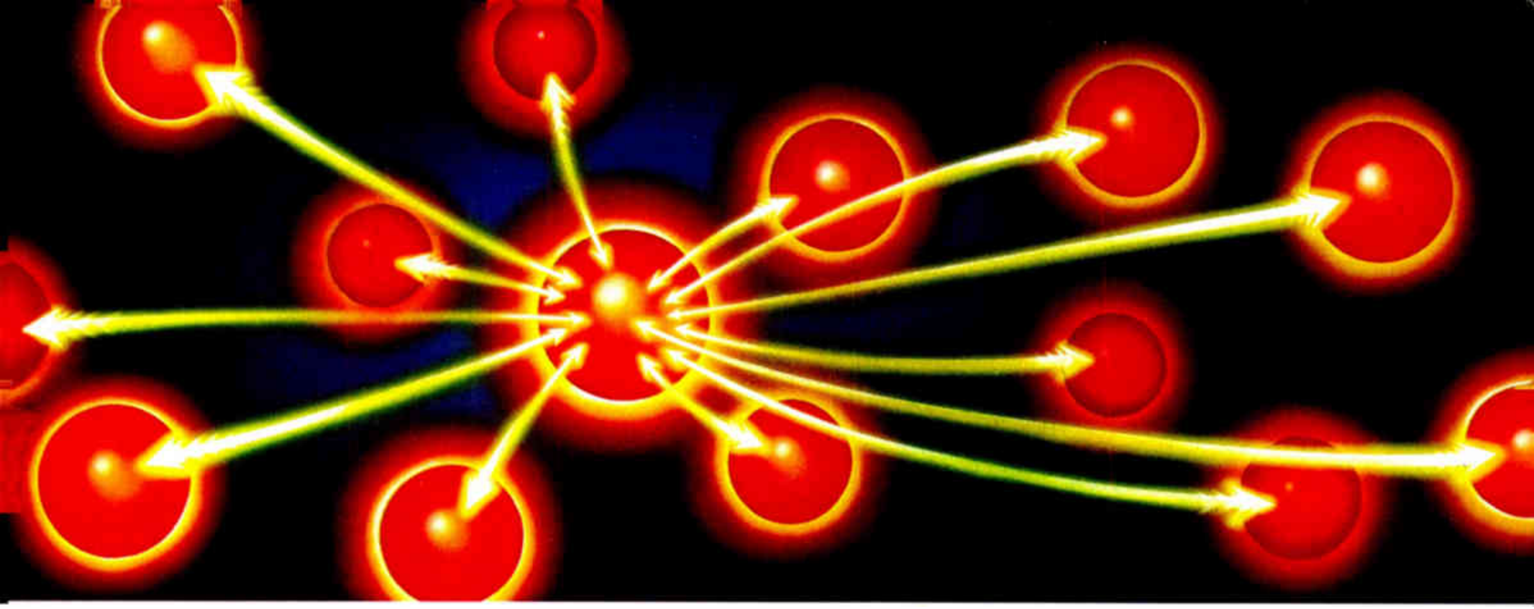


wearability. The initial permeability of the composition is 5,000; the maximum flux density is 5,000 gauss. It has an operating temperature of 180°C and a resistivity of 10 ohm/cm dc. The material in prototype quantities sells for $300/in.³ Production pricing is available.

Ceramic Magnetics Inc., 87 Fairfield Rd., Fairfield, N. J. 07006 [478]

A thermoset plastic compound that can be permanently magnetized and withstands temperatures as high as 500°F is specially designed to intensify the flux of components that must be magnetic. The compound also has potential applications for many other electronic parts. The K-49 material, made from diallyl phthalate resins, has a molding temperature from 290° to 350°F. It has a specific gravity of 4.0, a tensile strength of 3,000 psi, a bulk factor of 1.8 to 2, and a Barcol hardness of 55 to 60. The material sells for $6/lb and delivery is 10 days to two weeks.

Cosmic Plastics Inc., 12314 Gladstone Ave., San Fernando, Calif. 91342 [479]



Managing to cover all bases.

Expansion. Diversification. Acquisition. Growth. As a business becomes more complex, its information management needs expand exponentially. The more locations involved, for example, the greater the need for centralized control of intercity communications.

Many corporations seeking ways to increase productivity, while controlling communications costs at all locations, are converting to Bell's Dimension® PBX.

With Electronic Tandem Switching, it provides an integrated system with over 150 customized management and control capabilities. Its stored programs bring cost-saving features to the network, add time-saving functions to existing telephones. Long distance calls automatically take the least expensive routes. Calls that encounter busy signals are redialed electronically. Detailed calling records facilitate the allocation of charges. And each company as well as each of its locations can modify its own system without calling in Bell installers.

We have applied such advances for some of America's leading businesses, integrating many divisions, plants, warehouses and service centers into one total system.

That's our business—applying a knowledge of networks and advanced communications to the specialized information management needs of your business.

It's a process that starts with a call to your Bell System Account Executive.

The knowledge business

Circle 241 on reader service card

Products newsletter

Litronix introduces new display concept

The company that introduced the first intelligent displays some three years ago, Litronix Inc. of Cupertino, Calif., is unveiling another new concept—the building-block approach to interactive display assemblies [*Electronics*, March 13, p. 129]. The first such offering from the affiliate of West Germany's Siemens AG will be **a module containing four four-digit light-emitting-diode displays that are stacked together to create a 16-character intelligent display.** In fact, as many as four intelligent display assemblies, or IDAs, each with its own address, can be connected to a microprocessor for applications, like airline reservation systems, where many display terminals are linked to a single computer.

TM990 gets faster and more powerful

Texas Instruments Inc. is applying its bipolar bit-slice technology at the board level to provide enhanced speed and number-crunching capabilities for users of the TM990 microcomputer module series. The TM990/1481 is a two-board set that **uses the company's SN74S481 Schottky TTL 4-bit slices to provide a 16-bit central processing unit** that emulates the MOS TMS9900 CPU. It includes instructions that enhance integer and floating-point arithmetic. Although the 1481's bipolar circuitry uses up much more power than does the MOS circuitry of the TM990/100M and 101M, it is three to six times faster, the Dallas company says. The 1481 is priced at $5,000 per unit and will be delivered in 16 weeks.

Tek presents GPIB version of 492 spectrum analyzer . . .

Last week at the International Microwave Symposium in Washington, D. C., Tektronix Inc. showed the 492P, a fully programmable version of the 492 spectrum analyzer that was announced late last year [*Electronics*, Nov. 22, p. 160]. Like the 492, **the 492P covers 50 kHz to 21 GHz and, with external mixers, can go up to 220 GHz.** Besides adding an IEEE-488 general-purpose interface bus, the Beaverton, Ore., firm has given the 492P internal routines that allow it, for example, to locate maximum and minimum values of a displayed spectrum and to track drifting signals. It uses a high-level English-like command language that recognizes standard abbreviations for measurement units. A model with all the options sells for $31,850 and takes 36 weeks to receive.

. . . as well as GPIB-compatible digitizing scope

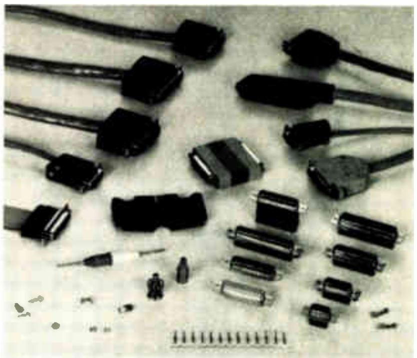
Tektronix will have available by August another GPIB-compatible instrument, a digitizing oscilloscope with **plug-in time-base and 10-bit vertical resolution.** Priced at $4,995, the 5223 combines features of the 7854 (GPIB) and the 468 (sampling rate of up to 1 megasample/second) scopes to digitize, store, and display 10-MHz to 100-kHz signals.

Amdahl hikes computer prices

Amdahl Corp. has hiked lease and maintenance prices on its 470 V/7 and V/8 series computer systems. **Lease prices on all V/7 and V/8 systems are increased 7%,** and those on upgrades to higher-performance systems are 21% to 26% higher. Maintenance price increases range from 5% on the V/7B model to 7% on the higher-performance V/7 and V/8 systems. The Sunnyvale, Calif.-based manufacturer also plans to boost by $100,000—approximately 5%—the purchase price of the V7/A, as of July 1.

New literature

Cables and connectors. A catalog contains information on cables and connectors for a wide range of computer applications. Described in its 36 pages are cables and connectors manufactured by Hewlett-Packard, Data General, IBM, Texas Instruments, and Digital Equipment Corp. The catalog also covers bulk cable, Underwriter Laboratories–listed



shielded and unshielded multiconductor cables, coaxial cable, AMP connectors, and connector components. It gives complete ordering information for single cables or bulk quantities in any configuration requested. Craig Data Cable Co., 154 Post Rd. E., Box 5192, Westport, Conn. 06880. Circle reader service number 421.

Adapters. A 20-page catalog provides schematics for adapters used for high-efficiency transitions between various types of radio-frequency coaxial connectors. Adapters

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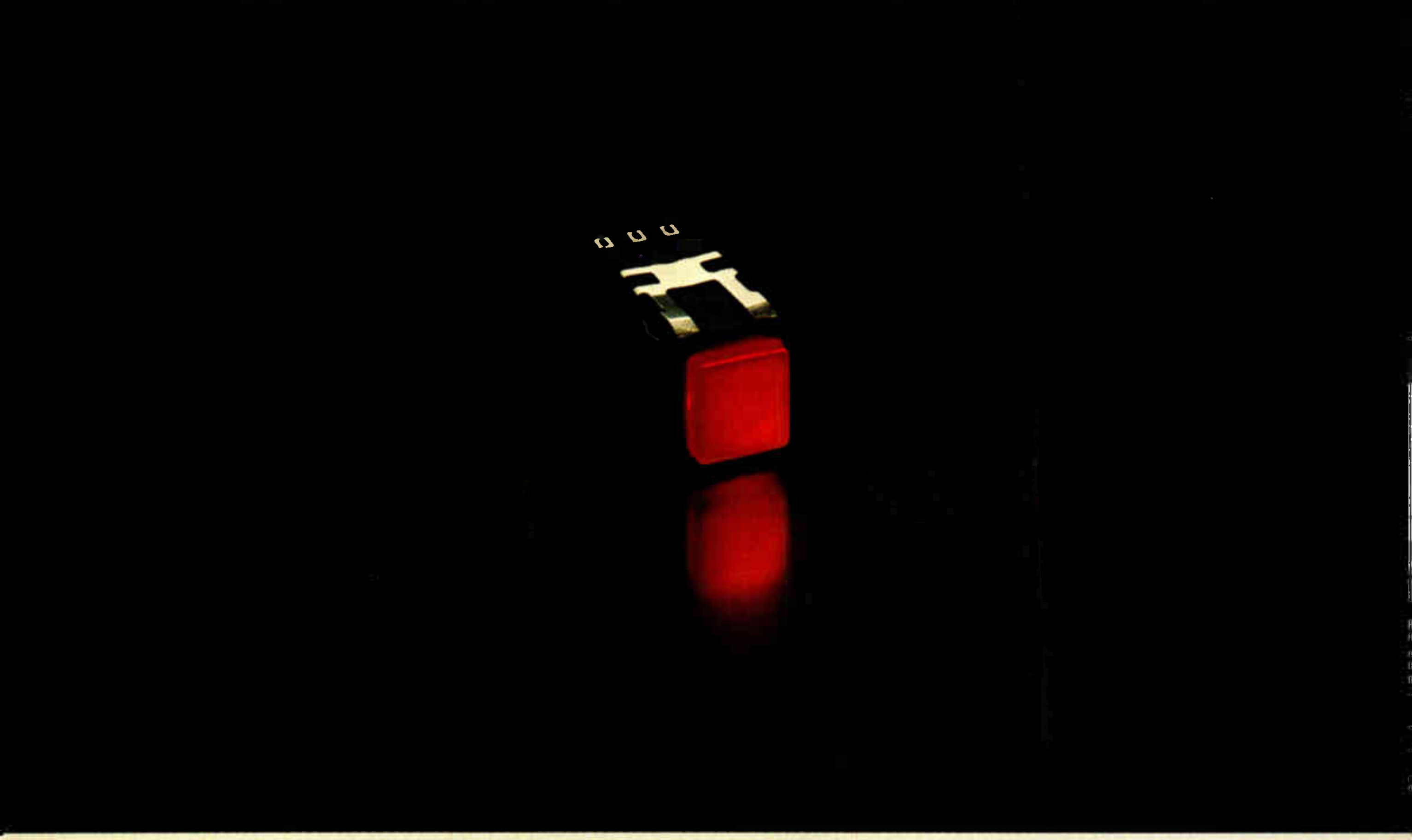

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New literature

are available for TNC, N, BNC, GR-900 (General Radio Co.) APC-7 (Amphenol RF), SMA, SMB, SMC, NanoheX, and Kwick-Konnect connectors. Sealectro Corp., Mamaroneck, N. Y. 10543 [422]

Lasers. Technical information on a variety of lasers, including continuous-wave, pulsed, frequency-doubled, mode-locked, cavity-dumped and Q-switched neodymium-yttrium-aluminum-garnet lasers, as well as laser transmitters and oscillator amplifier systems, is given in a 48-page catalog. It is offered by General Photonics Corp., 2255F Martin Ave., Santa Clara, Calif. 95050 [423]

Thyristor-diode modules. A 60-page catalog contains detailed information on thyristor-diode modules. It includes key electrical, mechanical, and thermal specifications and data. There are circuit diagrams, definitions of data, information on heat sinks, and 37 pages of performance curves. Semikron International Inc., 11 Executive Dr., Box 66, Hudson, N. H. 03051 [424]

Rfi-shielded cases. An eight-page catalog describes cases that shield against radio-frequency interference, as well as rf transfer switches and accessories. The accessories include printed-circuit boards, feedthroughs, rf connectors, test cables, adapters, coaxial terminations, and attenuators. Drawings and diagrams are provided for the products. The catalog can be obtained from Compac, Marketing Department, 279 Skidmore Rd., Deer Park, N. Y. 11729 [425]

Telemetering products. A 32-page catalog gives information on a line of telemetering products such as voltage-controlled and other oscillators, fm discriminators, analog signal isolators, pressure transducers, and power supplies. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343 [426]

Switches. Described in a 20-page catalog are miniature and standard-

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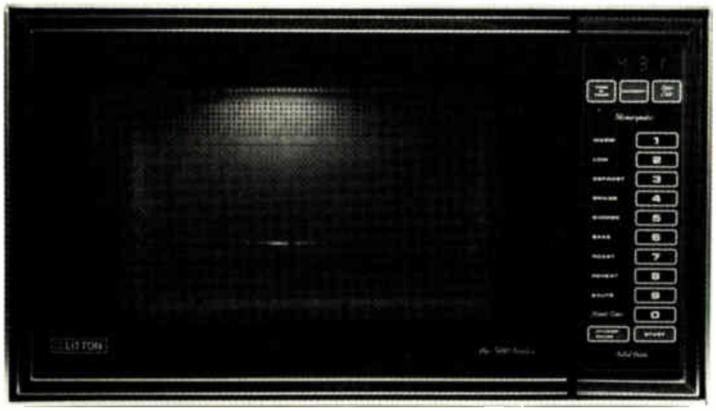

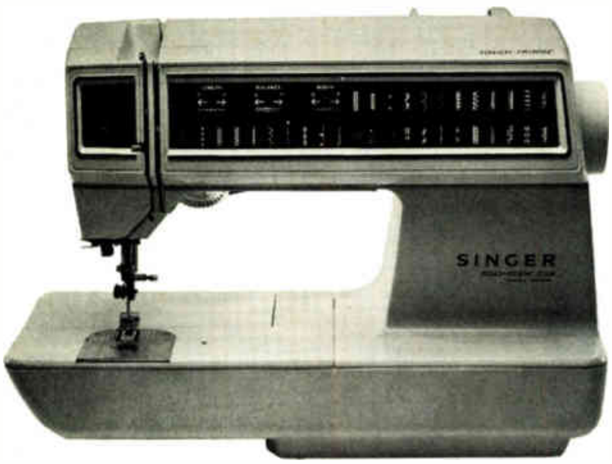

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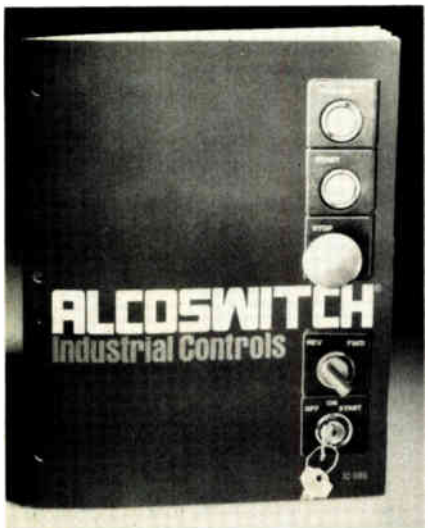
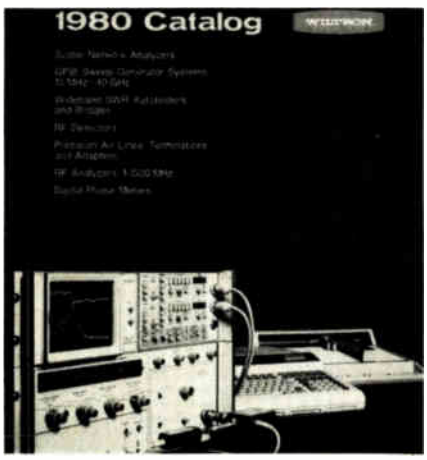


sized oil-tight push buttons, selectors, keylocks, and illuminated controls and pilot lights. Ask for catalog No. IC-380. Alco Electronic Products Inc., 1551 Osgood St., North Andover, Mass. 01845 [427]

Microwave devices. Microwave measurement systems, instruments, and components are covered in Wiltron's 1980 catalog. Products described are: sweep generators, scalar network analyzers, standing-wave–ratio autotesters and bridges, radio-frequency analyzers, precision termina-



tions, adapters, rf detectors, limiters, and digital phase meters. The catalog also serves as a microwave measurements handbook. The application notes cover recommended test procedures. Wiltron Co., 825 East Middlefield Rd., Mountain View, Calif. 94043 [428]

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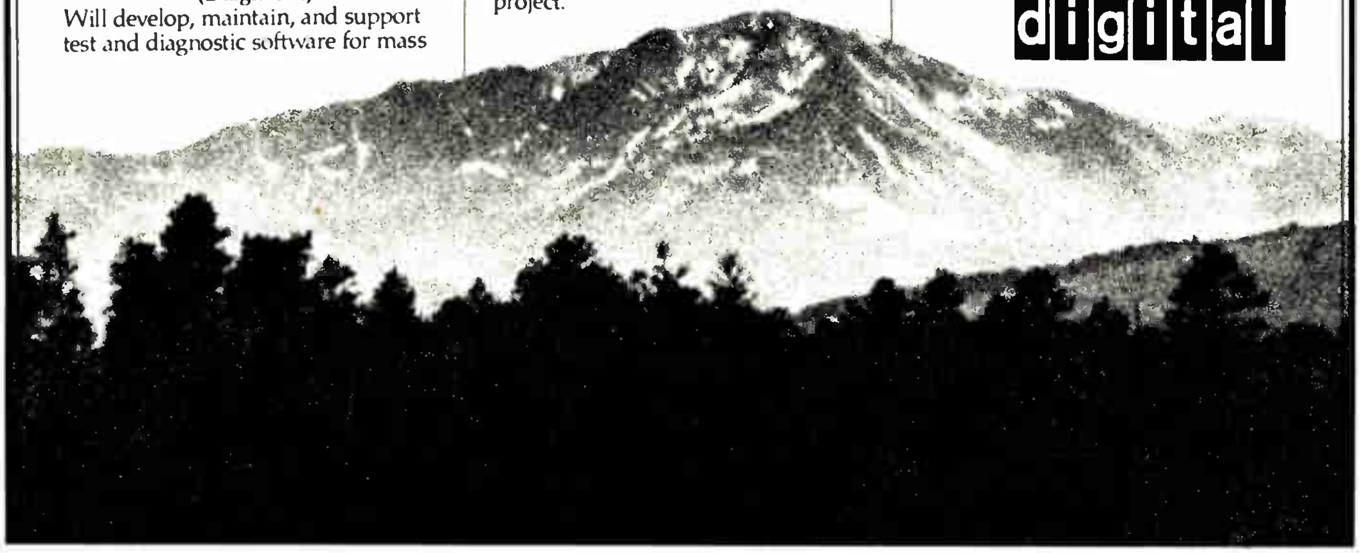

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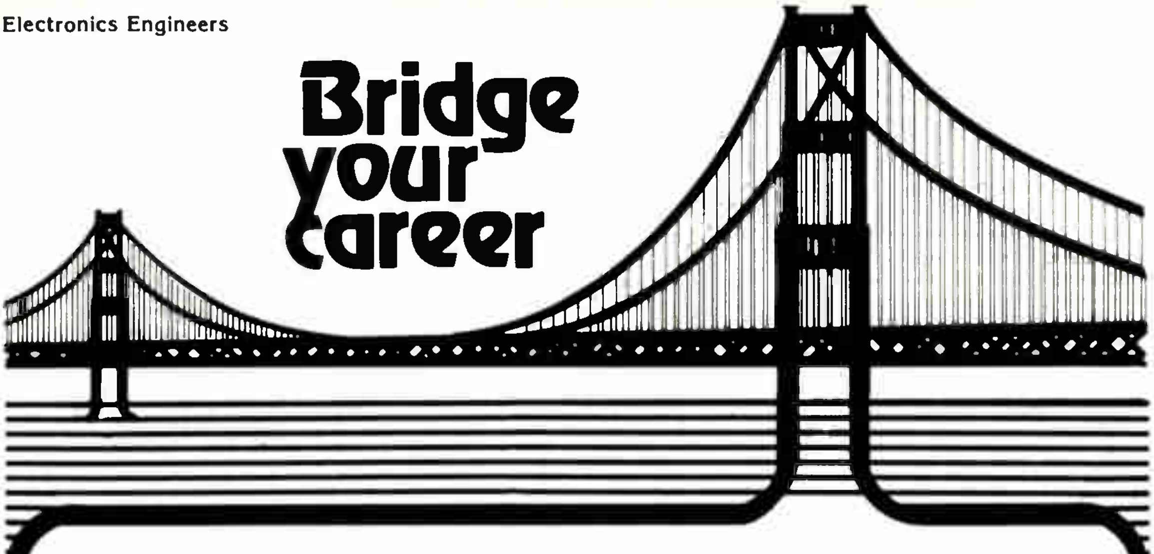

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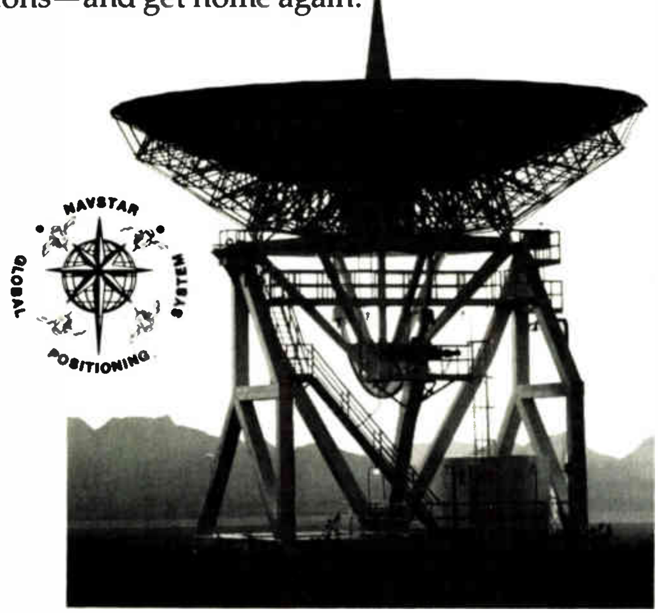

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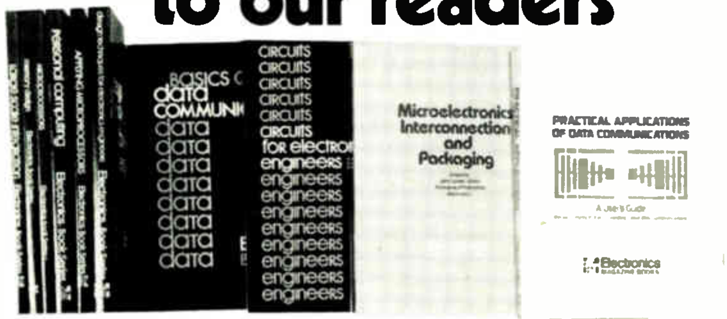

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