JUNE 22, 1978

THE BUSINESS BOOM: HOW LONG CAN IT KEEP GOING?/81

The new look in bulk storage: charge-coupled memories/133

Single hybrid houses 12-bit data-acquisition system/113

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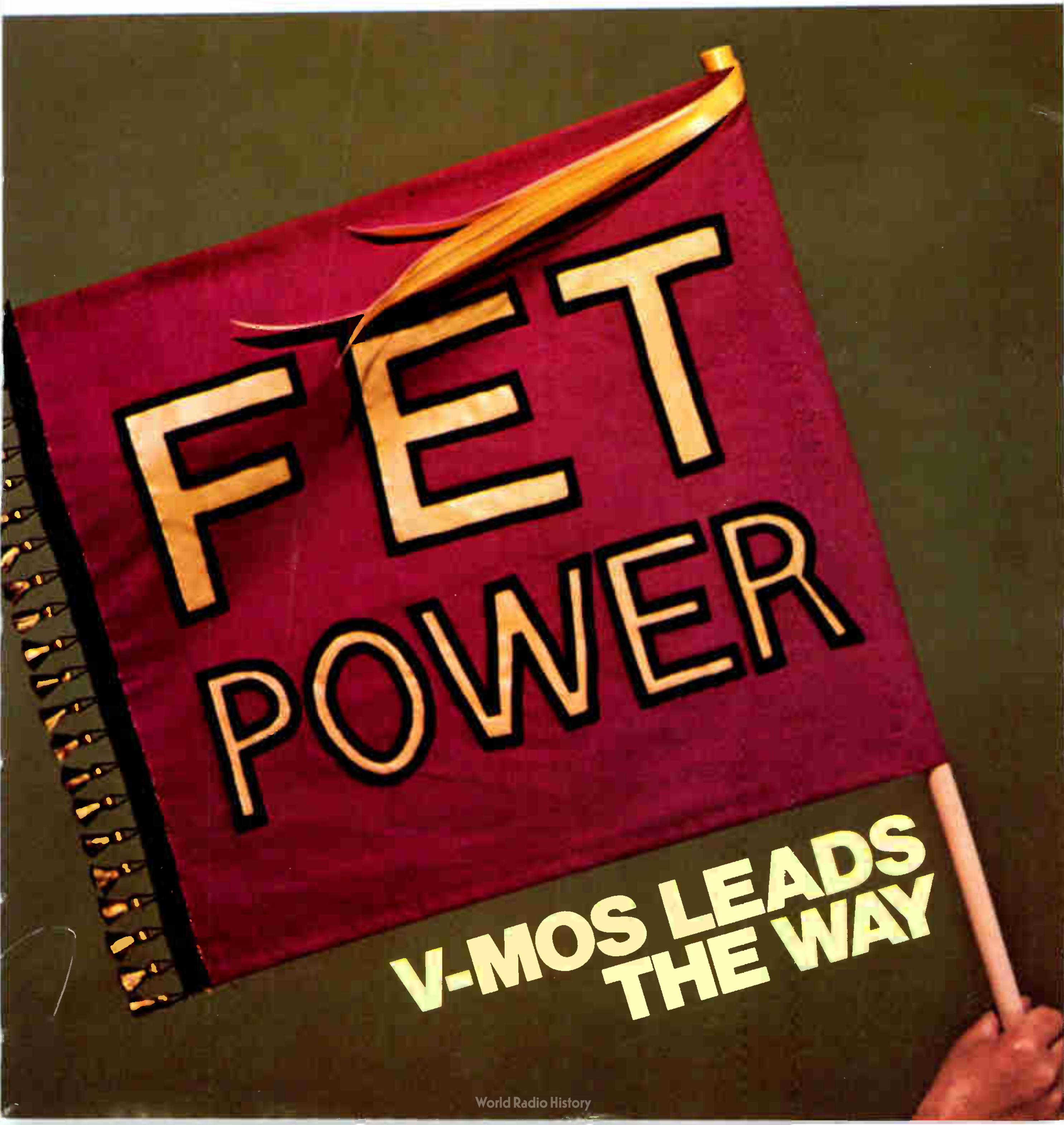

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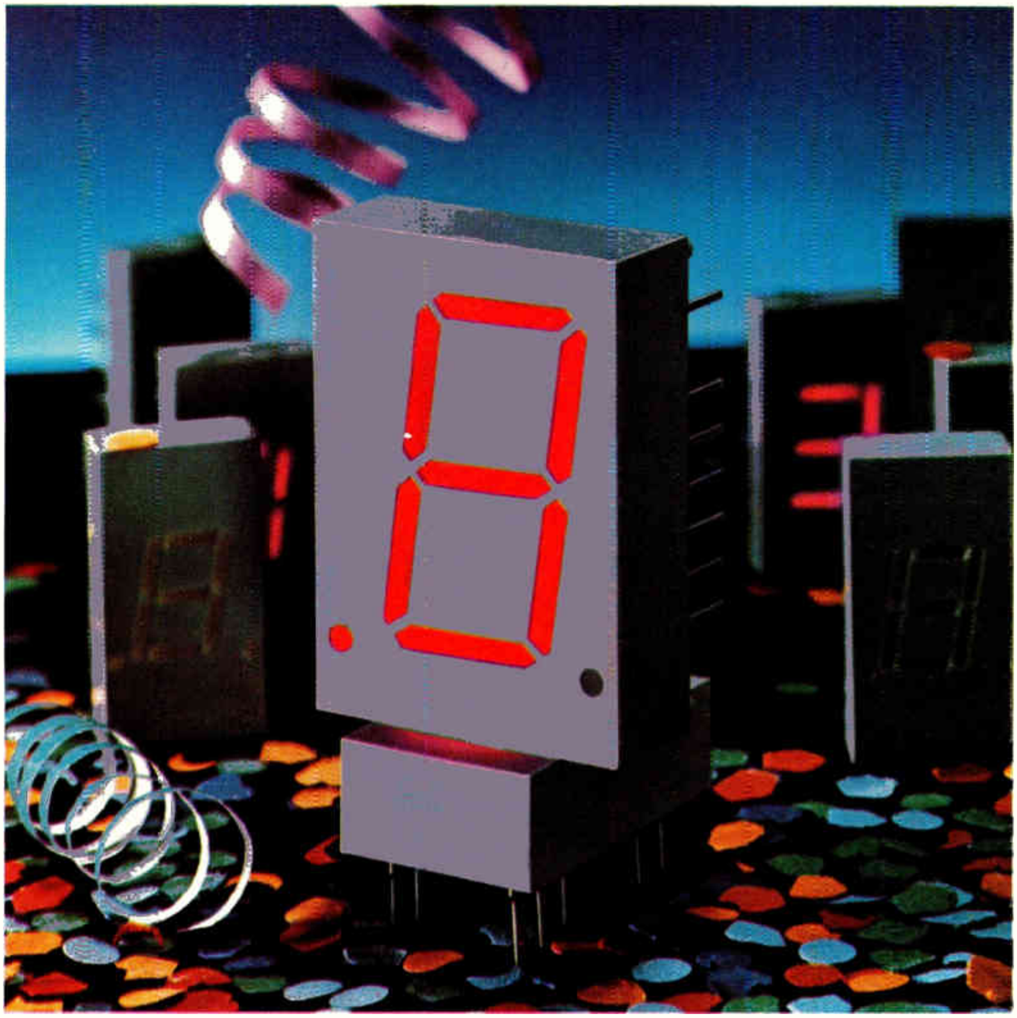

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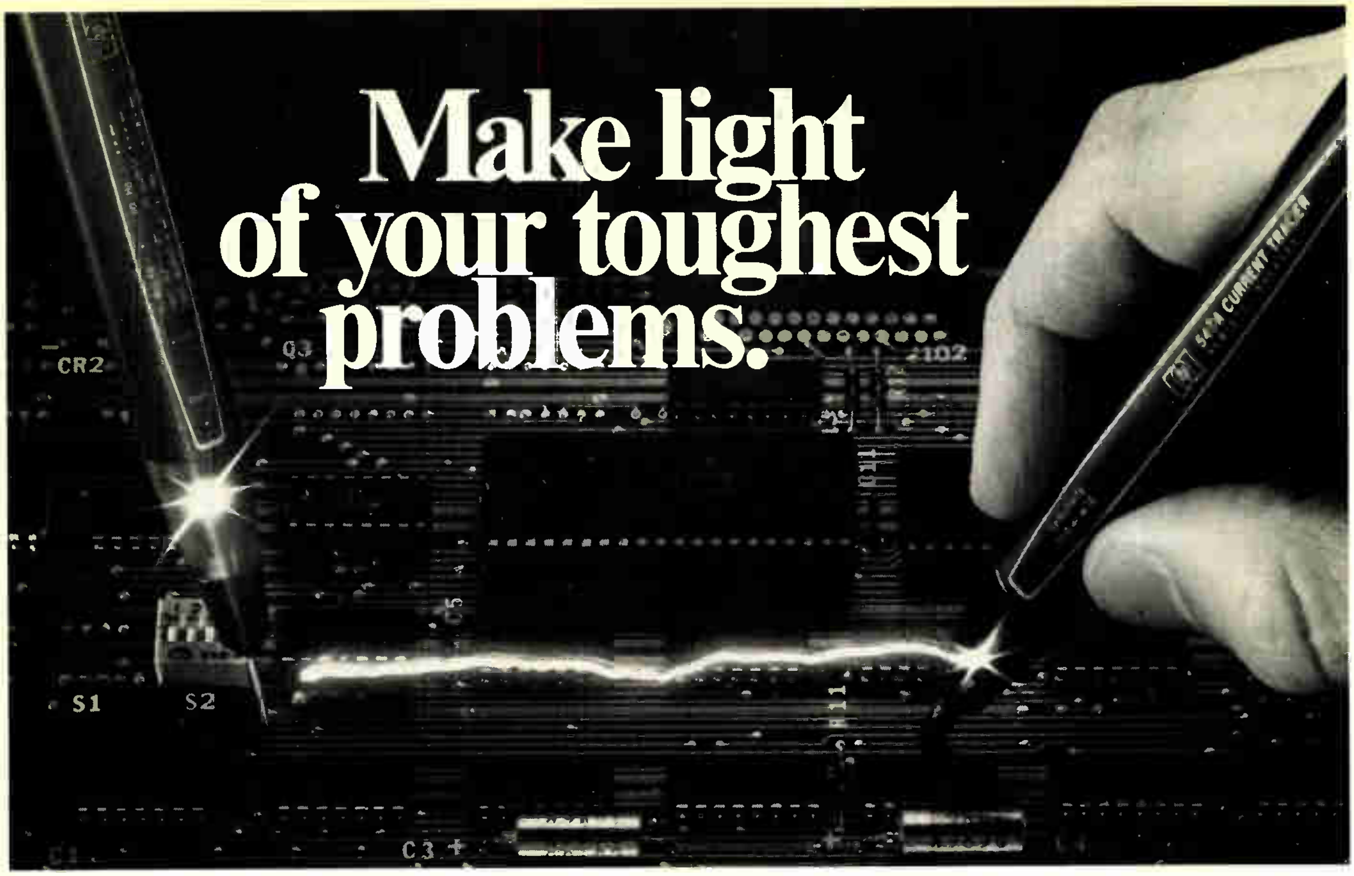

Those aggravating stuck node digital troubleshooting problems won't leave you in the dark anymore. Light has arrived in the form of Hewlett-Packard's 547A Current Tracer.

The vast majority of digital troubleshooting faults can be tracked right down to the component level by HP's 5004A Signature Analyzer or an HP Logic Probe. However, zero voltage situations like the microcomputer example at right in which line D2 is stuck low always present special difficulties. No voltage based tool will take you further unless you're prepared to start cutting board traces and unsoldering components in an attempt to isolate the faulty circuit element.

Enter the HP 547A Current Tracer.

It responds inductively to current pulses in the circuit from 1mA to 1A by lighting up. Just follow the light down the circuit path and it will lead to the exact component or wiring fault that is sinking the current (in this case, RAM 1).

The 547A does it without risky circuit trace cutting or hit or miss component replacement. It's just a very straightforward and simple procedure.

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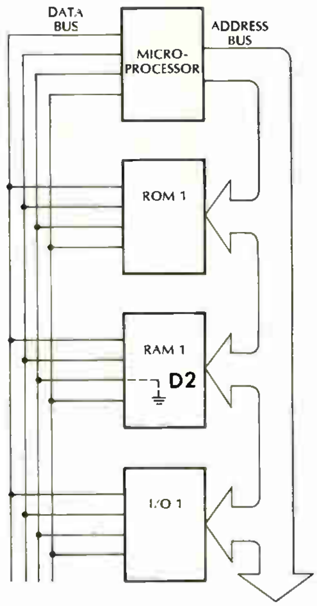

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Electronics

The International Magazine of Electronics Technology

Vol. 51, No. 13 • June 22, 1978

Highlights

Cover: V-MOS expanding in power uses, 105
Field-effect transistors made with vertical-groove metal-oxide-semiconductor technology have climbed to new performance highs at both audio and radio frequencies. Thus a new range of applications is opening up for power V-MOS.

Cover is by Ann Dalton

Few plaudits for communications bill, 84
The proposed revision of the Federal Communications Act is reaping decidedly downbeat reactions from industry and Government telecommunications executives. One oft-raised criticism: the bill is not sweeping enough, ignoring or slighting some vital areas.

Single hybrid acquires 12-bit data, 113
A 12-bit data-acquisition system offers the convenience and cost savings of a single integrated-circuit-compatible package, together with the high performance and reliability of a hybrid circuit. It acquires data at 50 kilohertz or faster from many sources.

Scopes sharpening accuracy, 138
Digital readouts and crystal references enable delayed-sweep oscilloscopes to take the uncertainty out of measuring nanosecond intervals. This is part 2 in a continuing series on time and frequency measurement.

And in the next issue . . .
32-bit minicomputer architecture . . . a C-MOS erasable read-only memory . . . semiconductors and thermal design.

Electronics

Publisher's letter

For a show that is growing in size and attendance, there comes a time when success itself is a problem. That seems to be the case for the National Computer Conference, which earlier this month had a record number of exhibitors and registrants. What with the delays in getting into the parking lot, the long lines registering, and the difficulty in having a bite to eat, the show had all too evidently strained the facilities available to serve it.

Probably the toughest test came for the exhibitors assigned to the "West Hall" at the Anaheim, Calif., convention center. This extra show space was actually a parking garage converted to hold the overflow.

As computer editor Tony Durniak put it, "The garage was a severe enivronmental test chamber for the computers, but though the hardware seemed to survive, the sales engineers manning the booths wilted in the heat and humidity."

To make the garage usable, it was necessary to put up temporary walls, lay down carpeting, hang light fixtures, and install air-conditioning units—the latter as much to keep the equipment happy as soothe the attendees. But even with air conditioning, the booths got rather warm.

As a result of this year's problems, the show's chief sponsor, the American Federation of Information Processing Societies, is planning to ease the strain for next year's show, which will be in New York City. According to Larry Curran, Boston bureau manager, who put together a wrap-up story in Anaheim on the exhibitors (p. 88), the federation is welcoming suggestions in its struggle to keep everyone happy.

"One of the complaints is the show-business hoopla in the exhibit floor," he points out. "For example, booths limited in space to a maximum of 2,400 square feet have been growing vertically to see which name sign can outreach the other. One exhibitor tried oneupmanship by hiring airplanes trailing commercial messages to circle the convention center."

Another exhibitor came prepared to put up a two-story booth but had to shrink. Assigned to the garage area, the company had to chop off the top half of its display in order to fit under the 8-foot ceiling.

How's business? Booming along, according to the roundup of key companies contacted in our midyear sampling. All across the land there are signs of better-than-expected sales, despite the problems of inflation and economic uncertainty (p. 81).

Perhaps the most encouraging word from the veterans of past roller-coaster sales rides is that the electronics industries are generally better able to handle the eventual downturn expected next year than in previous market cycles. Overcapacity prompted by double ordering and inventory imbalances may be a thing of the past—or at least much reduced. Apparently neither buyers nor sellers want to go through the costly trauma of empty orders.

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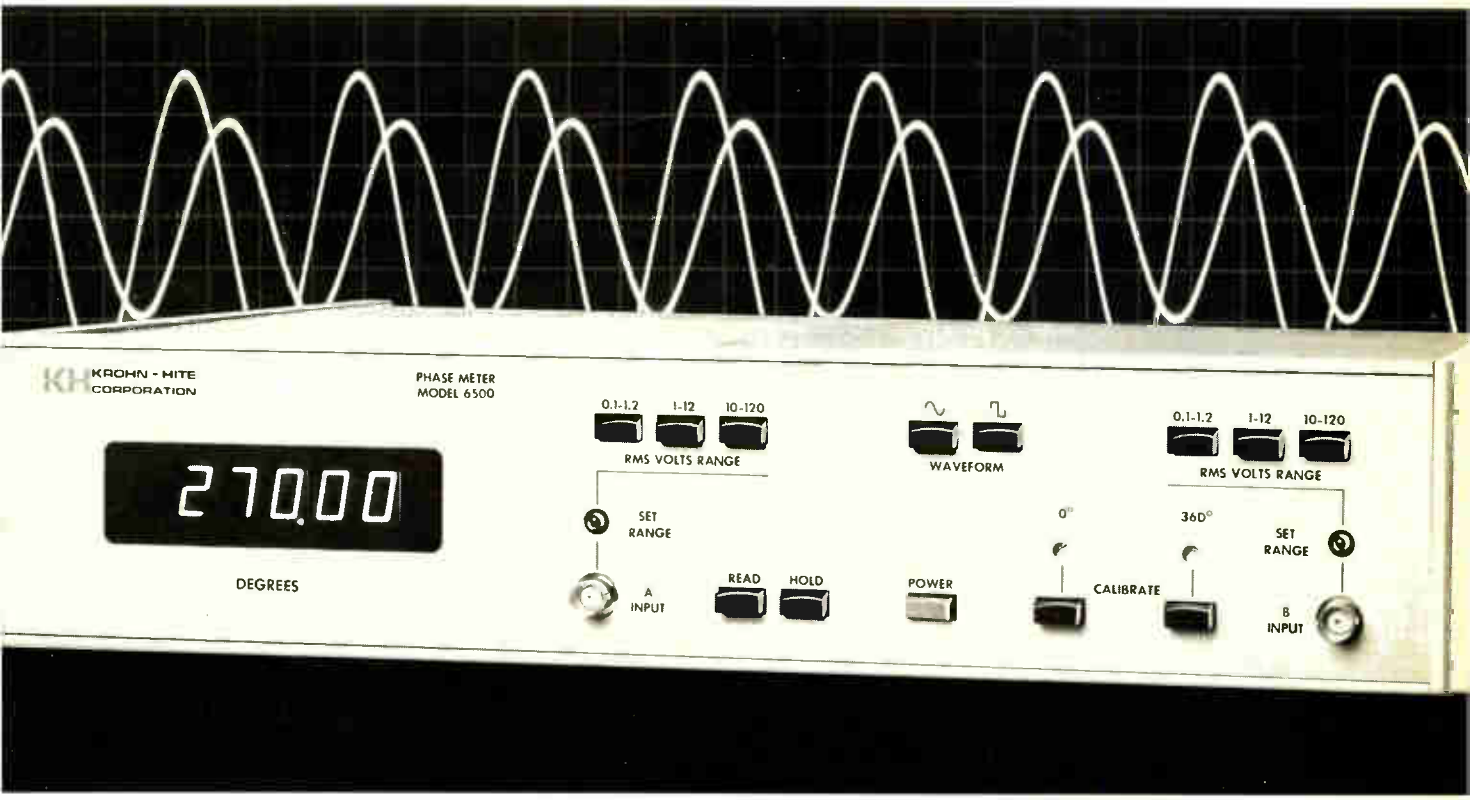

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Circle 4 on reader service card

Readers' comments

Language difficulties

To the Editor: The basic contention of Langer and Dugan ["Say it in a high-level language with 64-K read-only memories," April 13, p. 119] that "the availability to microcomputers of high-level programming languages. . . . which now require expensive disk-based systems for their effective use" will be mitigated by the availability of larger ROMs is simply not true. Their implication that with LLL Basic and Nibl now available in ROM, APL, Fortran, Pascal, or Cobol will be next is equally spurious.

From the beginning, Basic has been available with inexpensive non-disk-based microcomputers because of its single-pass, entirely self-contained nature. Fortran requires not only a compiler, but also a linker or link-editor, as well as execution-time support. Though some of these can be put in ROM, how do the authors propose saving and documenting the large amount of high-level source code written by the user? The answer is that users will require an expensive disk-based system for program development. Simply having a compiler in ROM will only save having to load it into random-access memory from disk.

Consider how much greater the problem is in moving from Fortran to APL, Pascal, or Cobol. These languages have dynamically definable data structures, recursive subroutine calls, and other bizarre features. To put the compilers, libraries, and run-time monitors all into ROM should take several full processor address spaces. That certainly will not leave much room for the user source and object codes, or for the remainder of the development system.

I can only assume that the authors, working as they do for a major semiconductor manufacturer, have attempted to make a case for the new ROMs their employer will shortly release. There will be uses for the 64-K and the future 256-K ROMs, but they will not "affect the ways in which computer software is implemented [and] stored." High-level languages will be used because of the availability, not of large ROMs, but of high-level language compilers or interpreters.

L. Edward Reich
Arlington, Va.

The authors reply: *Some of the exceptions Mr. Reich takes to our article seem to be due to a miscommunication of our point about the widened availability of high-level languages encouraged by the advent of cheap, large ROMs. The user we have in mind does not have a "large amount of high-level source code" to process. Indeed, the equipment for handling such a load has been considered a prerequisite for the use of high-level language tools. Now, by means of ROM, and of course other technology, these tools can be made available to people using desktop computers with very limited or no external peripheral capabilities.*

Further, Mr. Reich is right that APL will not be next after Nibl, because it preceeded Nibl by several years, though not, alas, under the auspices of National Semiconductor. The IBM 5100 desktop computer uses a proprietary ROM to store its APL. The system could, and probably will, serve as a model for a whole class of systems.

As for the relevance of the ROM in Cobol systems, since publication of the article we have received letters from two different manufacturers of such terminal-based systems saying that the crucial parts of their systems are ideal for large ROMs.

In the case of Pascal, Mr. Reich might consult "ROM-based Implementation of UCSD Pascal and Its Applications in Math Education" by the University of California at San Diego's Institute for Information Systems (May 15, 1978). The author of this note has stated privately that "64-K ROMs seem to offer a neat way to make a big sophisticated software system available to . . . users with S-100–based hardware."

Mr. Reich feels that we have attempted to make a case" for some new parts our employer is about to release, and that is true; but we have attempted it by suggesting that concepts embodied in such parts are common, not just for National, but for anybody who has the imagination to grasp their potential.

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Circle 7 on reader service card

News update

■ An automated wire-routing and -soldering technique, using conventional printed-circuit boards and dating from the early 1970s, is finally available for use in production runs. Up to now, no wiring service has existed for the technique, which was developed as Infobond by the Inforex Inc. division of that name in Burlington, Mass., and as Tiers (through insulation electronic reflow system) by the Weltek division of Wells Electronics Inc. in South Bend, Ind.—though Weltek was supplying automatic machines.

However, a year-old company in Waltham, Mass., called Bondex Inc., has designed and built six multiheaded, fully automatic machines to perform the job, which consists basically of heat-strippable reflow soldering [*Electronics*, May 25, p. 134]. Bondex also has developed special boards and the manual tools needed to make prototype boards with the technique. Although the company now does wiring of production quantities, it is considering leasing its machines, says James Steranko, founder of Bondex. Steranko helped develop Infobond while with Inforex.

Jerry Lyman

■ The U. S. Navy continues to go all ahead, full, in its effort to equip all of its vessels and aircraft with standard, militarized computers and peripherals. And the Qantex division of North Atlantic Industries Inc., for one, could not be happier. The Plainview, N. Y., firm has just received an order in excess of $1.4 million for 93 of its AN/USH-26 Cartridge Magnetic Tape Units [*Electronics*, Dec. 23, 1976, p. 54].

The new order is, according to Qantex president Joel Kramer, the service's "largest single release" and brings the division's USH-26 backlog, under its requirements contract with the Navy, to $3.8 million. The tape unit has received interim approval by the Navy; full approval is expected by late summer, and with that Kramer expects a lot more orders. "Right now," he adds, "there are lots of uses, as in tactical situations, that can't be ordered for until full approval."

Bruce LeBoss

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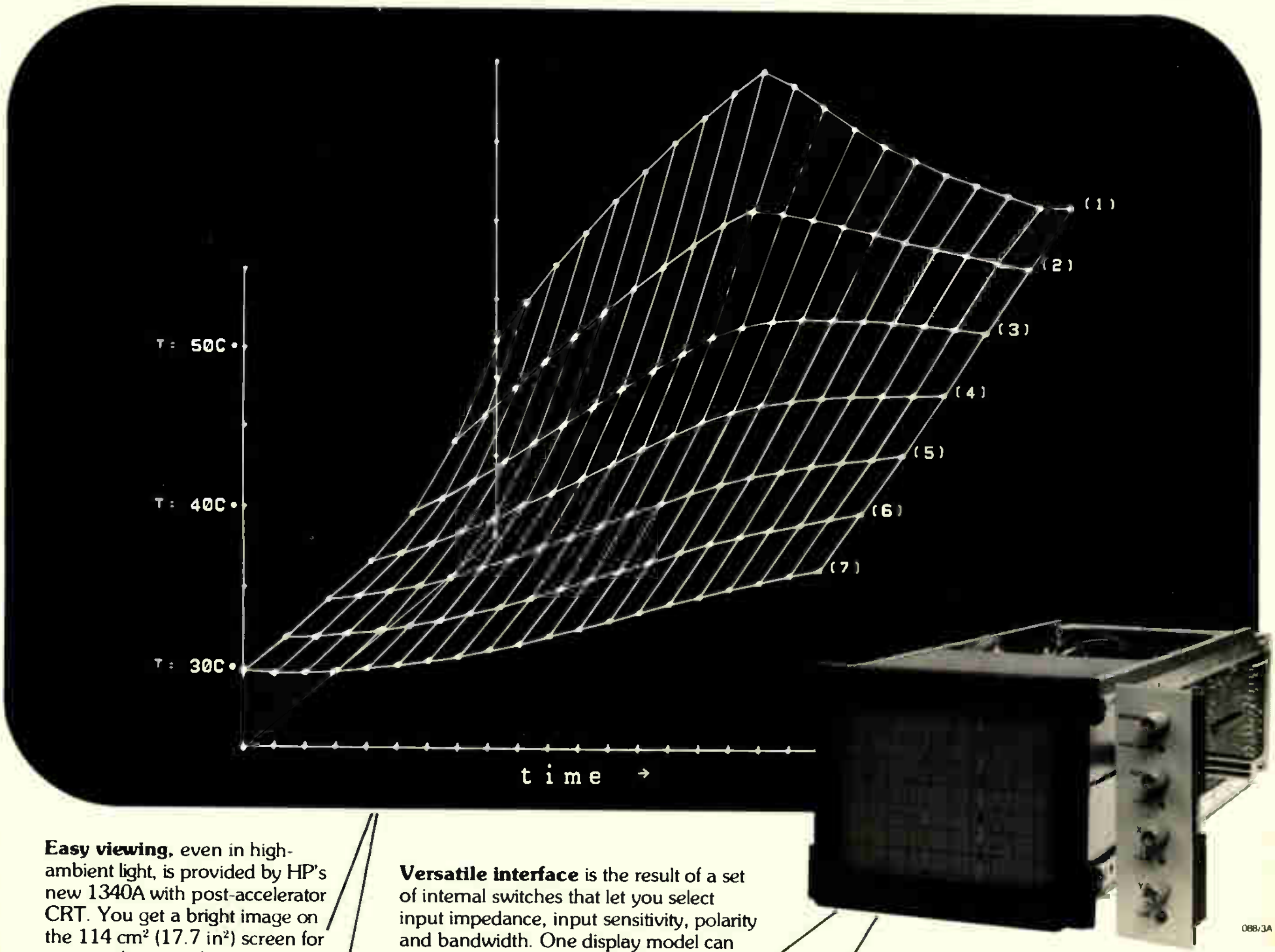

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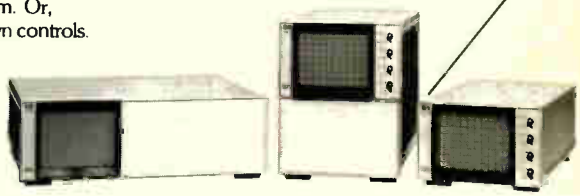

HP's new 1340A is a true OEM display component. And to accommodate most OEM requirements, options such as different phosphors and TTL blanking as well as a choice of packaging schemes are available. For only $1,000*, you get a cost-effective display that easily adapts to almost any instrumentation system.

So for a better image of your system's performance, look into HP's new OEM display. For further details, ask your local HP field engineer.

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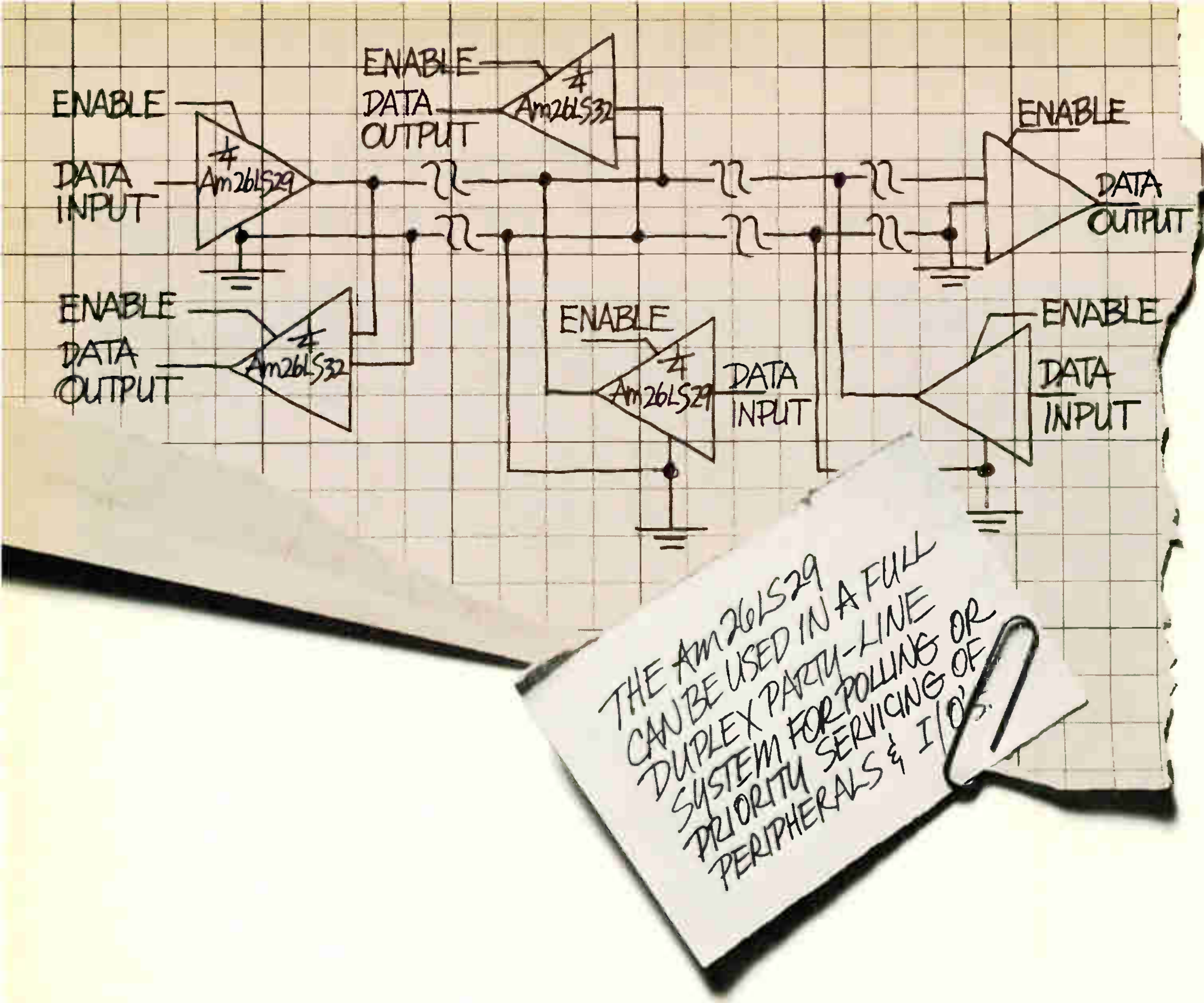

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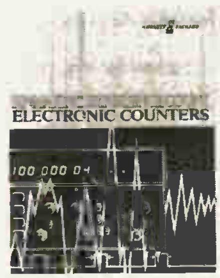

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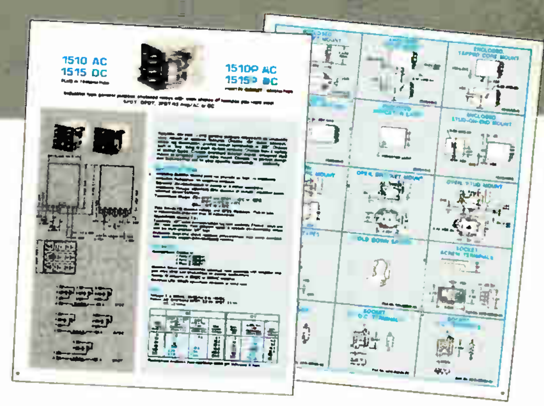

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4011UB	Gate	✓	✓
4012UB	Gate	✓	✓
4023UB	Gate	✓	✓
4025UB	Gate	✓	✓
4049UB	Buffer	✓	
4069UB	Buffer	✓	
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- ☐ CMOS Pocket/Wall Selector Guide, Spring, 1978
- ☐ CMOS IC Reliability, 1978
- ☐ UB Data Sheets

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Editorial

Growing up in good times and bum times

Here we go again. Business, we are told by the people who are doing it, is great (see p. 18). Bookings, backlogs—all the indicators point upward. But wait. Isn't it time for those who have lived the recent history of the electronics industries to glance over their shoulders, start to think about economic cycles, and remind themselves that everything that goes up inevitably comes down again—especially growth curves? One semiconductor executive even admits that he would welcome the rain that follows the sunshine. "We're in a masochistic state of mind, looking for a sign of it," he says. "In fact, we're getting nervous and we'd love to get it over with." His anxiety is that of one who has ridden his share of downturns that were economic killers.

That anxiety is being fed by Government economists talking about reduced growth in the second half and uncertainty about what lurks in 1979—while some private forecasters say there might be a recession next year. Then there is inflation to worry about, not to mention foreign competition, the devaluation of the dollar, and its resulting weakness in the world money markets. All this adds up to a repeat of the old boom and bust cycle—or does it?

Consider some of the indications amid the signs of prosperity that this time around the makers of semiconductors, computers, television sets, instruments, components, and the like are waltzing to a different tune. Remember 1974 and the glutted inventories of those who purchased electronic equipment? In 1978, there is no inventory buildup discernible to electronics managers. And what about double and triple ordering? So much of the last upsurge turned to paper because of that quaint custom. Then there were lead times that stretched so far one could fairly hear them twanging as though about to snap. Not this time—delivery schedules and backlogs appear to be sane, reasonable, and manageable. Finally, there were lists of companies hell-bent on expansion, only to find themselves with square footage and no business to fill it with. Now, semiconductor makers are just beginning to talk cautiously about adding capacity.

What all this seems to add up to is maturity—that blessed state defined as full development. In other words, electronics people have pulled up their socks and prepared themselves for prosperity. No more the gleeful flight to the heights only to be followed by the sickening plunge to the depths; it appears that careful planning and mature consideration have replaced the bandwagon instinct that made young entrepreneurs rich even as it aged them overnight.

Which is not to say that next month or next quarter might not bring with it a change in the climate and an end to the good times. But it does mean that the change won't be so abrupt as it has been in the past. Thanks to the spread of electronics across a broad applications base, the electronics industries appear finally to be able to handle some sales falloff gracefully and with maturity. In short, the electronics industries have grown up. If that is truly the case, it has been a long time coming.

Fill in the Blank.

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- ☐ Counters
- ☐ Generators
- ☐ Amplifiers
- ☐ Power Supplies
- ☐ Oscilloscopes
- ☐ Logic Analyzers
- ☐ Word Recognizers
- ☐ Digital Delay
- ☐ All of the above, plus

______________________.

If you checked "All of the above, plus__________," nice going. You're close. But what did you put in The blank? An analog multiplier? Relay circuit? Switches for signal routing? Test oscillators at pre-set frequencies? Digital logic circuits? Converters? Special processors?

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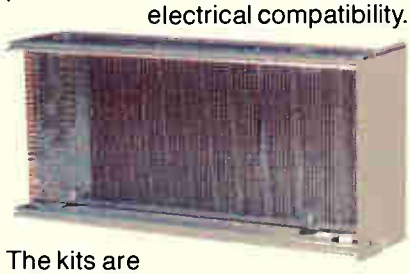
A TM 500 custom Plug-in Kit includes a perforated main circuit board, all mechanical components to assemble a complete plug-in, plus instructions on mainframe electrical compatibility.



The kits are available in both single and double compartment sizes. One single compartment version includes all the components for 3 voltage regulators at the rear of the board. With your TM 500 you can receive on request TM 500 Construction Notes to build special-purpose instruments including parts lists and schematics.

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Meetings

Fiber Optic Con West, Fiber Optic Communication and Information Society (Boston), San Jose Convention Center, San Jose, Calif., July 19–20.

Intersociety Energy Conversion Engineering Conference, IEEE, Town and Country Hotel, San Diego, Calif., Aug. 20–25.

International Optical Computing Conference, IEEE, Imperial College, London, Sept. 5–7.

CompCon 78—17th IEEE Computer Society International Conference, Capital Hilton Hotel, Washington, D. C., Sept. 5–8.

International Machine Tool Show 1978, National Machine Tool Builders' Association (McLean, Va.), McCormick Place, Chicago, Sept. 6–15.

Wescon/78 Show and Convention, Electronic Conventions Inc. (El Segundo, Calif.), Los Angeles Convention Center, Los Angeles, Sept. 12–14.

Sixth Computer-Aided Design and Computer-Aided Manufacturing Conference and Exhibition (CAD/CAM VI), Society of Manufacturing Engineers (Detroit), Hyatt House, Los Angeles, Sept. 19–21.

Eascon—Electronic and Aerospace Systems Convention, IEEE, Sheraton International Hotel, Arlington, Va., Sept. 24–27.

Convergence 78—International Conference on Automotive Electronics, Society of Automotive Engineers, Hyatt Regency Hotel, Dearborn, Mich., Sept. 25–27.

ISHM '78, International Society for Hybrid Microelectronics (Montgomery, Ala.), Radisson Hotel, Minneapolis, Sept. 25–27.

International Electrical Electronics Conference and Exposition, IEEE, Automotive Building, Toronto, Sept. 26–28.

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Both the HP 2635A Printing Terminal and the 2631A Printer zip along at 180 cps in both directions. The microprocessor determines the optimum print path. A high-speed slew speeds up printing columnar data, and the long-life, self-aligning print head makes for a quick change. Both have self-test features for quick verification of operational status.

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Circle 31 on reader service card

TI plans 39 new linears this year . . .

Look for significant new linear products to emerge from Texas Instruments in the third and fourth quarters as the semiconductor giant cashes in on its diverse process technologies. Of the 39 devices planned, **TI will mix technologies in plasma-display-driver ICs** with noise-immune diffused MOS inputs, low-power C-MOS inside, and bipolar outputs with high breakdown voltage characteristics. This BIDFET (bipolar diffused complementary-MOS field-effect transistor) process will make plasma displays competitive with cathode-ray-tube displays as soon as the price for the 32-bit ICs drops to 14¢ per bit, according to TI.

Among other technology explorations, the firm is heavily engaged in an ambitious program to replace the majority, if not all, of the mechanical sensing devices on autos with silicon elements. Under contract with one of the Big Three automobile manufacturers, the Electronic Devices division initially will offer temperature sensors replacing nickel-wire devices and offering response times on the order of 1 to 5 seconds. **The company has also developed surface-acoustic-wave devices for UHF TV tuners,** enabling the Federal Communications Commission to broaden its frequency assignments for adjacent channels. The filter and resonator are available together with complete schematics and complementary discrete metalized semiconductor field-effect transistors as part of a tuner kit.

. . . as well as a 256-K bubble memory

At the same time, all of TI's digital technologies are hot. For example, due in the fall is a 256-K bubble-memory device. In a 22-pin package, the new device has a block-replicate structure and uses an asymmetrical-chevron cell arrangement rather than the older T-bar. Not to neglect semiconductor memories, samples will appear before year's end of a 64-K erasable programmable read-only memory, a 64-K random-access memory with a single 5-V supply, and a 256-K charge-coupled memory. **The future, TI envisions, will bring 2-μm line widths to very-large-scale technologies that promise both higher speed and lower power.** First up is a Schottky version of integrated injection logic expected next year with gate delays in tens of nanoseconds. For the 1980s, TI is bullish on metalized semiconductor field-effect transistors, which will have better yields since they will eliminate the defect-sensitive oxide. The technology will feature propagation delays of a few nanoseconds while drawing but 10 μW per gate.

GI develops programmable sound maker

Attempting to humanize microcomputers, General Instrument Corp.'s Microelectronics group in Hicksville, N. Y., has developed a programmable sound generator that emits various familiar or exotic sounds for such uses as video and nonvideo games, music synthesis, and alarms for industrial and security controls. **Called the AY-3-8910, the n-MOS device interfaces with most 8- and 16-bit microprocessors and has three independently programmed sound channels,** an analog envelope generator, and two general-purpose 8-bit input/output ports. Housed in a 40-pin dual in-line package, the chip is available off-the-shelf at $3 in lots of 50,000. The firm also is developing a lower-cost version, which it calls the Gimini Cricket. Designated the AY-3-8912, it will come with but one 8-bit I/O port and be available in a 28-pin DIP at $2.50 for 50,000. A similar device from TI uses linear/integrated-injection-logic technology and comes in 16- and 28-pin packages.

Electronics newsletter

Panel to send software copyright ideas to Congress

In a report to be sent to the President and the Congress on July 31, the blue-ribbon presidential Committee on New Technical Uses will recommend that the language of copyright laws protecting computer programs and data bases be strengthened. **The committee will also suggest that the coding, testing, and debugging required to develop a computer be protected by copyright,** since those processes are part of a written work by an author. But, the committee adds, the concept behind the software—in this case, the algorithm—is a general concept and should remain in the public domain. The report will also attempt to define the act of copying software—long a thorny problem—as loading a program to run.

System permits hook-up of phone to ac outlet

A new company, Astech Inc. of Bedford, Mass., has developed a way to connect a phone extension to any ac outlet for $229. **The patented technique, which the company describes only as reactive coupling, involves connecting the phone line to the power line.** The system, called Phone Link, consists of two units. One connects the phone line to the power line; the other connects it to a wall outlet. Each has a receiver, transmitter, and decoder. The company says that its system adheres to Federal Communications Commission regulations that allow connection of customer equipment to the telephone network.

Fairchild quitting small-instrument business

Fairchild Camera and Instrument Corp. is getting out of the business of making and selling small instruments **in order to devote all its resources to large test systems.** James Moreton, general manager of the Instrument and Control division, says the company is talking to other firms about the sale of product lines. Most of one line of digital panel meters has been sold to Dynamic Sciences Inc. of Van Nuys, Calif., and the IEEE-488 family of bus couplers and bus testers has been sold to ICS Electronics Corp. of San Jose, Calif.

SIA prepares to take position on Japanese trade

The Semiconductor Industry Association is culling Government data preparatory to issuing a policy statement this fall on Japanese trade. Although Fairchild Semiconductor, Mostek, and National Semiconductor have held rather hawkish views on Japanese electronic imports to the U. S., **the 35-member SIA is expected to take a milder stance by looking at such things** as equalization of duties between the two countries and improved tax measures. The latter might include lower capital-gains taxes and credits for research, development, and investment. Some believe that these measures would help the competitiveness of U. S. companies better than quotas or present antidumping and countervailing-duty laws, which take too long to be enforced to do any good.

Precision reference provides 3 outputs

Single-voltage references are not uncommon, and neither are bipolar ones. But this month Analog Devices Inc. of Norwood, Mass., will introduce a multiple-voltage reference that is unusual. **It provides three outputs simultaneously with a maximum deviation of 5 ppm** over the full commercial range of 0° to 70°C. The pin programmable device, designated AD 584, has a total of seven possible outputs— +2.5 v, +5v, +7.5 v, +10 v, −5 v, −7.5 v, and −10 v.

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National Semiconductor

Single silicon chip synthesizes speech in $50 learning aid

Texas Instruments relies on linear predictive coding and p-channel MOS chip for digital signal processing

The master's voice. Up to eight letters are displayed as child presses alphabet keys to spell word spoken by TI's Speak & Spell.

There's now a chip that can talk to a child. It duplicates human speech electronically in a teaching aid called Speak & Spell, which was shown for the first time at the Consumer Electronics Show in Chicago earlier this month. Developer Texas Instruments Inc. plans to sell the aid for only $50. (The chip itself is not for sale.)

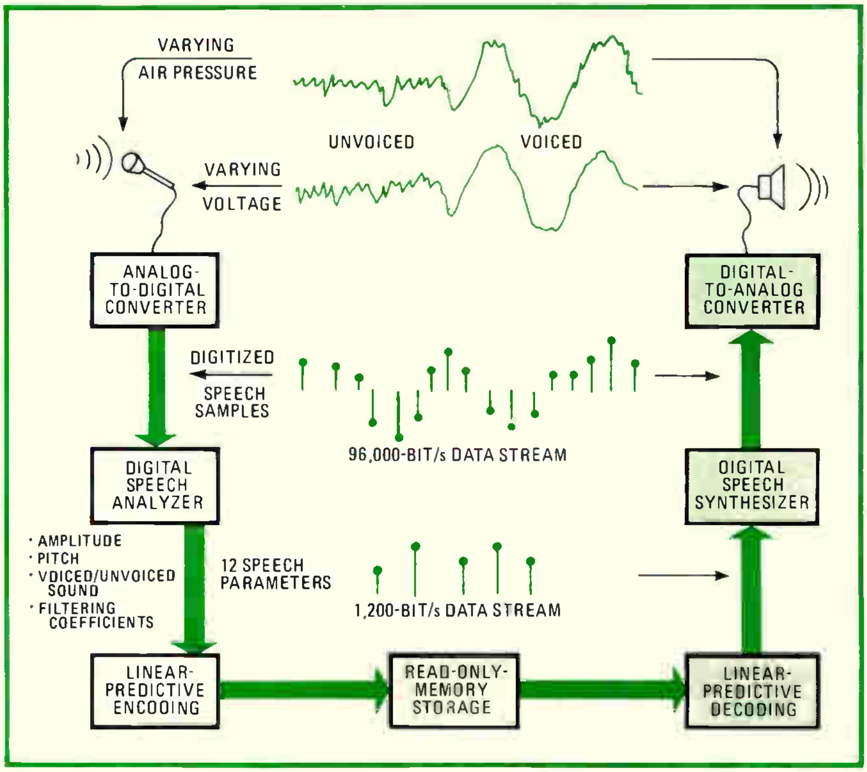
Working with a pair of 128-kilobit read-only memories and a special version of TI's TMS1000 8-bit microcomputer, the silicon chip can produce a total of 200 seconds of sounds for a vocabulary of over 200 words. However, it is capable of accessing a lot more memory—as much as 2.1 megabytes. Since the speech generator uses memory at a maximum rate of only 1,200 bits per second, it could be designed to speak for as long as 30 minutes.

Chip. The firm calls its metal-oxide-semiconductor chip the TMC0280. It is built with the metal-gate, depletion-load, p-channel technology used in TI's earliest calculators. The chip contains an entire digital signal processor, with timing and decoding circuits, a 10-stage digital filter, and a digital-to-analog converter. Everything fits on a 44,000-square-mil piece of silicon. Only with p-channel MOS did TI have the confidence that it could build such a large chip reliably.

Basically, the chip takes data randomly every 20 milliseconds from a ROM coded with representations of the sound waveform. Data is addressed in blocks: small ones for, say, a single spoken letter, larger ones for a phrase of several words. From the data, the chip synthesizes an analog waveform with adequate fidelity for intelligible speech.

The data taken from the ROM—anywhere from 4 to 49 bits in each 20-millisecond frame, depending on the complexity of the sound—will average less than 1,200 b/s. Still, this rate is sufficient to carry the 4-kilohertz bandwidth needed for speech. The secret is a data-compression technique called linear predictive coding.

The technique makes it possible to encode a complex speech waveform



Talk is chip. Elements in TI's synthesizer chip (tinted blocks) recreate speech from data placed in ROM by equipment that analyzes components of a human voice.

with very little data. "A speech signal has a lot of redundancy," explains Richard Wiggins, a staff scientist at TI's Central Research Laboratory in Dallas. "The data base that's needed to define it is actually very small."

Linear predictive coding defines speech by determining the characteristics of a time-varying digital filter that is directly related to the characteristics of the vocal tract determined by the lips, tongue, teeth, and so on. "LPC is widely used in narrow-bandwidth communications, but when we said we were going to put in on a chip, everyone thought we were crazy," Wiggins remarks.

The reasons for incredulity are well founded. Linear predictive coding gets its name from the way the coefficients characterizing the digital filter are predicted from a linear combination of previous coefficients. In the TMC0280 there are 10 such coefficients. Combining them means lots of multiplications and additions—number crunching that would be a chore even for a minicomputer.

Many tricks. Wiggins and Larry Brantingham, a senior staff member in component design at TI's Lubbock, Texas, Consumer Products division, had to use several tricks to do the fast math. Even the narrow 4-kHz bandwidth for speech requires 160,000 additions and an equal number of multiplications every second—about 6 microseconds for each operation. Minicomputers would have trouble executing the 10-by-14-bit multiplication in that time.

To get around the speed problem, Wiggins transformed the LPC algorithm into a lattice formulation to keep all coefficients less than unity so that fixed-point math could be used. Brantingham designed the number-crunching circuits with a pipelined approach so that several operations are carried out at once.

Modeling. Speech is first broken down into voiced and unvoiced sounds. Voiced sounds, like *l*, *o*, and *m*, have a definite pitch and include vowels and fricatives that can be represented by low-frequency, high-amplitude signals. Unvoiced sounds, like *s*, *f*, and *sh*, are mostly rushing air and are represented by low-amplitude, random high-frequency signals similar to white noise.

The characteristics of the vocal tract are imparted to the sounds by the LPC filter. In all, 12 parameters determine the sound created in any 20-ms period: the first is the energy or amplitude; the second is the unvoiced or voiced signal, which includes pitch information; and the other 10 are the filter coefficients. ☐

Teaching aid launches TI's voice synthesizer

"Say it—COLOR: C—O—L—O—R," commands the voice in the box as the letters appear on a blue fluorescent display. Beneath the toylike orange-plastic exterior of a word-teaching device called Speak & Spell, Texas Instruments Inc. has hidden its speech-synthesizing chip that reproduces words uttered by a male voice.

The educational product, which will be available next month, joins others in TI's Learning Center Product group that include a silent spelling aid, a "first watch" time-telling aid, and beginners' calculators. Speak & Spell has a vocabulary of more than 200 words that it says randomly for the various exercises. The unit's push buttons select exercises, which include pronunciation, as above, spelling quizzes, and Hangman, a spelling game. Users also punch in letters for the spelling game using the keyboard.

The company records all the words in two 128-kilobyte read-only memories, which are low-performance p-channel MOS chips designed expressly for Speak & Spell. Although TI refused to comment on future products involving synthesized speech, a spokesman said the technique could be used "anywhere an alphanumeric display would go." Since the firm is researching all three areas of speech processing—speaker verification, word recognition, and of course, speech synthesis—it is probably closer than any other manufacturer to the home computer that will listen and speak.

Communications

Line is busy for electronic telephones as competitors flock to show wares

Semiconductor makers, traditional telephone-equipment suppliers, new equipment makers: all are crowding into the electronic telephone market. Last week's Consumer Electronics Show in Chicago saw the introduction of new electronics-laden telephones from a number of firms, while others showed prototypes or discussed plans to enter the business.

The decade-old retail telephone market was pretty much on hold until Government action last fall struck down telephone company regulations that prevented most consumers from installing their own equipment. The resulting spate of new products is making many observers predict another consumer free-for-all, much as happened with digital watches and calculators.

Among the traditional phone suppliers, GTE Automatic Electric Inc.'s Consumer Products division in Northlake, Ill., took the wraps off a miniaturized phone that uses two custom integrated circuits, one to convert the push-button entry to regular dial pulsing and one to perform tone ringing.

The one-piece Flip-Phone is about 2 by 2 by 7 inches and weighs less than the handset alone of a conventional model. It will be available in some areas in October, with full distribution in 1979, at a suggested retail price of $49.95, says Tom Massey, division general manager.

GTE also showed a prototype based on the model 1650 n-channel metal-oxide-semiconductor single-chip microcomputer from General Instrument Corp., Hicksville, N.Y. The unit "will probably be available in

AFIPS for controlling costs."

Smith is not sure what those suggestions will be, but he feels that the NCC management should try to avoid high-labor-rate locales, if possible—"although that's difficult to do because so few cities can accommodate a show this size." He thinks costs might also be cut by eliminating the circus atmosphere at the NCC. The show-business influence was evident in Anaheim at a number of booths, ranging from puppet shows and animated figures to flashy models making product pitches.

Gimmicks needed. Other exhibitors, though, believe there must be some showmanship, especially if their booth is in a remote location. For example, Morris D. Dettman, director of advertising for Honeywell Information Systems, Waltham, Mass., says "you need a gimmick to attract the crowds, especially if you're on the fourth floor of the Coliseum, as we'll be next year."

Also a possibility for the fourth floor next year—in the attic, as Dettman calls it—will be Digital Equipment Corp., if the Maynard, Mass., minicomputer giant exhibits. Because it had not been in the show for the three previous years, DEC wound up in the almost unbearably hot "West Hall"—a euphemism for a converted parking garage—at Anaheim. Booth locations are assigned according to a formula that allocates more points to an exhibitor for consecutive years in the show than for booth size.

"We were way down on the list, and so we got the fourth floor," says Andrew C. Knowles III, DEC's corporate vice president for marketing. "That's a bad position, and if we end up there, we may not be in the show next year." □

Photovoltaics

Thin-film cadmium-sulfide solar cells have efficiencies boosted to 9.15%

Photovoltaic solar cells using cadmium-sulfide–copper-sulfide thin-film technology have demonstrated efficiencies of 9.15% in full sunlight, according to researchers at the University of Delaware's Institute of Energy Conversion at Newark. Moreover, IEC director Allan M. Barnett believes that 10% efficiency—the Department of Energy's 1980 goal—will be demonstrated by the end of this year.

He also contends that the institute's researchers should be able to beat the DOE 1986 price goal of 30 cents a watt for a manufactured cell. He predicts the demonstration as early as 1982 of cells that could sell for 25 cents per watt.

Significant. The 9.15% efficiency was hailed by the DOE's Donald Feucht, chief of advanced materials research and development in the Solar Technology division, as a significant contribution toward making solar electric power competitive with other energy forms. Barnett spoke at the four-day 13th Photovoltaic Specialists Conference sponsored by the Institute of Electrical and Electronic Engineers in Washington, D. C., early this month.

Materials for single-crystal silicon cells now on the market cost about $150 per square meter, compared with the Delaware institute's current $3 per square meter for thin-film cadmium-sulfide cells, Barnett says.

Barnett certainly caught the attention of some silicon-oriented solar-cell specialists at the conference. They had been discussing the potential of polycrystalline silicon and thin-film ribbon production techniques for increasing efficiencies and lowering photovoltaics costs before hearing his paper.

In an interview at the conference, Barnett moved to counter skepticism by some of the participants about his claims for reproducibility and price. He says he is in the midst of lining up five independent companies to participate in a $6 million continuous-process pilot plant using Federal research and development funds to demonstrate the feasibility of the 25¢/W goal by 1982. However, he declines to identify the companies involved until all are committed.

One is ready. Only one company is ready to sign, he says. Industry sources believe that company is Shell Oil Co.'s SES Inc., also of Newark and a specialist in CdS cells. Barnett says he expects to disclose all participants by the summer's end, begin operations a year later, and scale up cell production to an annual capacity of 100 kilowatts at the end of 1981 or early 1982.

The IEC achieved its 9.15% efficiency peak through engineering

CdS-Cu_2S cells: how it's done

The 9.15% efficiency thin-film CdS-Cu_2S cells reported by the Institute of Energy Conversion are fabricated using a substrate of electroformed copper, approximately 25 micrometers thick, which is plated with $1/2$ μm of zinc. CdS powder is then vapor-deposited at a temperature of approximately 1,100°C. Cells have been made with CdS thicknesses ranging from 8 to 50 μm, with typical values of 20 μm. The resistivity of the CdS layer is in the range of 1 ohm-centimeter. Crystallite diameters are approximately 5 μm.

The Cu_2S layer is formed by reacting the CdS film in a cuprous ion solution at 90°C for about 10 seconds. Before applying the Cu_2S, a light trapping (antireflecting surface) is formed using a hydrochloric acid etch. The Cu_2S is about 1,000 angstroms thick. The formation of the Cu_2S down grain boundaries to a depth of a few micrometers can be seen in cross-sectioned samples. Historically, the top contact was made by laminating a gold-plated copper grid with a protective cover onto the Cu_2S surface.

For the present work, technology was developed to vapor-deposit the transparent contact (grid) directly onto the Cu_2S. An antireflection layer is then applied.

design improvements in the 7.8% efficient cell reported by the institute 21 months earlier, he explains. Process technology was not involved.

"We found [energy] losses in some screwy places," he says. One example occurred with the relocation of a cell grid that had been blocking sunlight entry. "That sent the current up, but then the fill factor went down into a shunt loss that was unpredictable." □

Arkansas getting largest solar unit

The sun shines bright on Blytheville, Ark., and when the doors of its Mississippi County Community College open for the fall 1979 semester, it will own the world's largest photovoltaic installation. The 360,000-watt setup heats and supplies hot water, as well as electric power.

Funded by the U. S. Department of Energy and the county itself, the photovoltaic system alone will cost about $15 million. It is all part of a Federal program intended to demonstrate the feasibility of photovoltaic power as an alternative to conventional ways of heating and providing electricity.

Daniel P. Ahearne, president of Team Inc., which is putting the system together, says the school "should be able to generate 93% of its total power requirements, with luck." Ahearne's Springfield, Va.–based systems consultant group is responsible for design and installation. He detailed the system's promises and problems during a panel discussion at the IEEE's 13th Photovoltaic Specialists Conference in Washington, D. C.

Receivers. To reach its 360-kilowatt peak output in full sun, the system will employ 600 solar photovoltaic receivers mounted in optical concentrators with a 20× concentration, Ahearne says. The receiver assembly also tracks the sun across the skies.

Prototype collectors have been developed by Honeywell Inc., with each receiver containing 100 rectangular, glass-faced silicon cells, each measuring 1.75 by 2 inches. Solarex Corp., Rockville, Md., which developed the cells, says they can achieve a 14% efficiency. The resultant $6-to-$7-per-watt cost of the concentrator-receiver units will be lower than any photovoltaic system installed to date, Solarex says.

The sun's heat, focused at each receiver, is carried off by a water-based cooling system to the school's heating and hot-water systems. The photovoltaic cells themselves are kept at 55°C.

Charges. The array will also charge a 2,400-kw battery bank for use at night and during overcast weather. Excess power will be fed to the Arkansas-Missouri Power Co. for credit, Ahearne says. Should the battery bank run low, power can be drawn from the utility at off-peak hours when lower rates prevail.

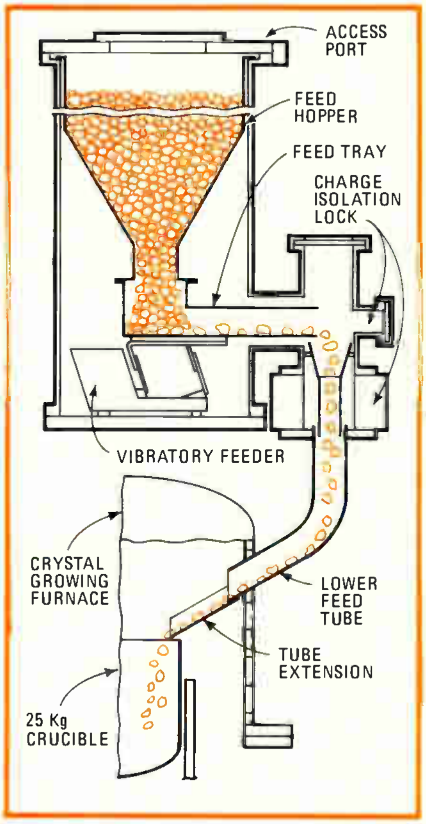
"Innovation is the name of the game," he says, in describing how the system was designed. "If rigid hardware standards existed today, the Department of Energy could not have afforded to fund the program. The equipment prices would have been out of sight." □

Packaging & production

Silicon furnace gets multiple charges

Unintentionally, the quartz crucible in which single-crystal silicon is grown by the common Czochralski method turns out to be a throwaway item. This is because the crucible cracks as it cools from its 1,400°C-plus operating temperature each time a crystal has been pulled. At anywhere from $190 to $240 each, it is an expensive object to throw away, accounting as it does for more than half the total material costs of crystal growing, according to Robert G. Wolfson, manager of advanced materials at the Lexington (Mass.) Vacuum division of Varian Associates.

The firm, a manufacturer of crystal-pulling furnaces and other production gear for the semiconductor industry, thinks it has a way to prevent cracking. Its idea is simple: don't let the crucible cool down.



Stoker. Basic idea behind the new Varian furnace is to feed silicon into the melt after an ingot is withdrawn and while the crucible remains at its high operating temperature.

Auto charging. To eliminate cooling, Varian is developing a furnace with an automatic charging mechanism that drops raw silicon pellets into a small amount of melted silicon that is allowed to remain in the crucible after a completed ingot is removed. There is nothing really fancy about the charger—it consists basically of a hopper for storing the pellets and a vibratory feeder that moves the silicon to the crucible. Wolfson calls it "an extrapolation of well-established techniques."

Varian's new furnace will be able to be repeatedly recharged, producing up to 100 kilograms of ingots before the crucible must be replaced. In contrast, conventional Czochralski furnaces produce an ingot weighing 20 to 25 kg. The company is under contract to the Department of

Energy under the low-cost silicon solar array project administered by the Jet Propulsion Laboratory in Pasadena, Calif.

The furnace will be ready next March. To demonstrate feasibility in the interim, Wolfson's engineers have modified a Varian model 2850 crystal-growing furnace to accept an external recharging mechanism.

Wolfson says the assembly has so far been used in three runs, recharging the furnace up to three times during each run without any problems. Soon, the furnace will produce "high-quality, dislocation-free, single-crystal silicon suitable for semiconductors or solar cells," he says.

Longer ingots. The largest ingots in the modified furnace will be 4 inches in diameter and about 36 in. long, but the new furnace will deliver ingots up to 72 in. long. Wolfson emphasizes that although the division can grow larger-diameter ingots, the DOE contract calls for 4 in. "because that's about the largest the solar-cell firms can handle in diffusion furnaces and other equipment."

The recharging mechanism is loaded with polycrystalline silicon pellets through the access port to the storage hopper. The access port is then closed, a vacuum is drawn in the recharging enclosure, which is isolated from the growing chamber, and the enclosure is back-filled with argon to the same pressure (10 to 15 torr) as the furnace's growing chamber (see drawing). It is this isolation that allows the crucible to remain at its high operating temperatures.

When the ingot being pulled is completed and raised into the cooling chamber above the crucible, the isolation lock between the growing chamber and the recharging mechanism is opened. A feed tube directs pellets singly or in clusters from the vibrating feed tray into the lower feed tube. A tantalum lip on the lower tube extends over the lip of the crucible, directing the pellets into the melt. □

Trade

Commerce giving U. S. electronics firms a new kind of assist with dealings in Japan

U. S. electronic firms who feel official barriers have unfairly blocked them from selling in Japan may now be able to get some real help from the Department of Commerce.

"If you can identify the [Japanese] government's hand in a case, we can go after it," Paul T. O'Day told a Computer and Communications Industry Association meeting earlier this month in Anaheim, Calif. The CCIA gathering was held in conjunction with the National Computer Conference.

O'Day, a deputy director for industry and trade at the Department of Commerce, is eager for cases involving electronics companies. "We are interested in developing solid cases in your area of whatever [the Japanese] do domestically to keep out your products," he told the CCIA members, most of whom were unaware that the Commerce program was in existence.

The program is run by a group called the Facilitation Trade Committee. Formed late last year, it grew out of the negotiations between Administration trade representative Robert Strauss and high-level Japanese trade officials, and its job is to review specific grievances brought by American companies. If it judges them warranted, it takes them up with Japan's all-powerful Ministry of International Trade and Industry. It already has been successful in nearly 25 nontechnological cases.

The makeup of the committee varies, reflecting the kinds of cases brought to its attention. For example, when cases involving the electronics industries are filed, a dozen or so specialists from the Science and Electronics Directorate of the Commerce Department will be called in, according to O'Day. The permanent head of the committee is Frank Weil, assistant secretary for industry and trade.

Examples of unfair restrictions abound, and CCIA members gave a number of them to O'Day. A common one: a Japanese customer cancels an order or refuses to honor a contract for equipment, citing some vague policy change as the reason. Also named are troubles in upgrading or changing an established product. One member said his company tried to add an internal peripheral board, but MITI arbitrarily reclassified the equipment, calling for higher tariffs and causing insurmountable delay in selling.

In another kind of problem mentioned at the CCIA meeting, a Japanese firm agrees to buy a quantity of electronic products but actually takes delivery of only a few before refusing the rest, even breaking a signed contract. Then, months later, a copy of the product, often improved, starts turning up, perhaps in the Common Market, manufactured by the Japanese firm. "It happens too often to be coincidence," says a computer firm president; "MITI has to be involved in it."

Facts wanted. Terming himself "the window onto the program," O'Day asks electronics companies to come forward with complaints, not just "word-of-mouth horror stories that often are myths, but hard facts that can be documented." His experience so far has shown that often MITI "is not aware of them but corrects them when informed," he

Reacting to O'Day's remarks, CCIA members reflected skepticism and frustration from years of problems in trying to do business in Japan. One member scoffs at "being reduced to being detectives to put together a case." Another calls it "nitpicking a case-by-case defensive posture." Still others fear retribution by MITI against firms that complain.

But all such objections can be overcome, O'Day holds. CCIA president A. G. W. (Jack) Biddle sees it as "an opportunity that should not be missed." Discussions among CCIA members might also uncover common experiences that could be

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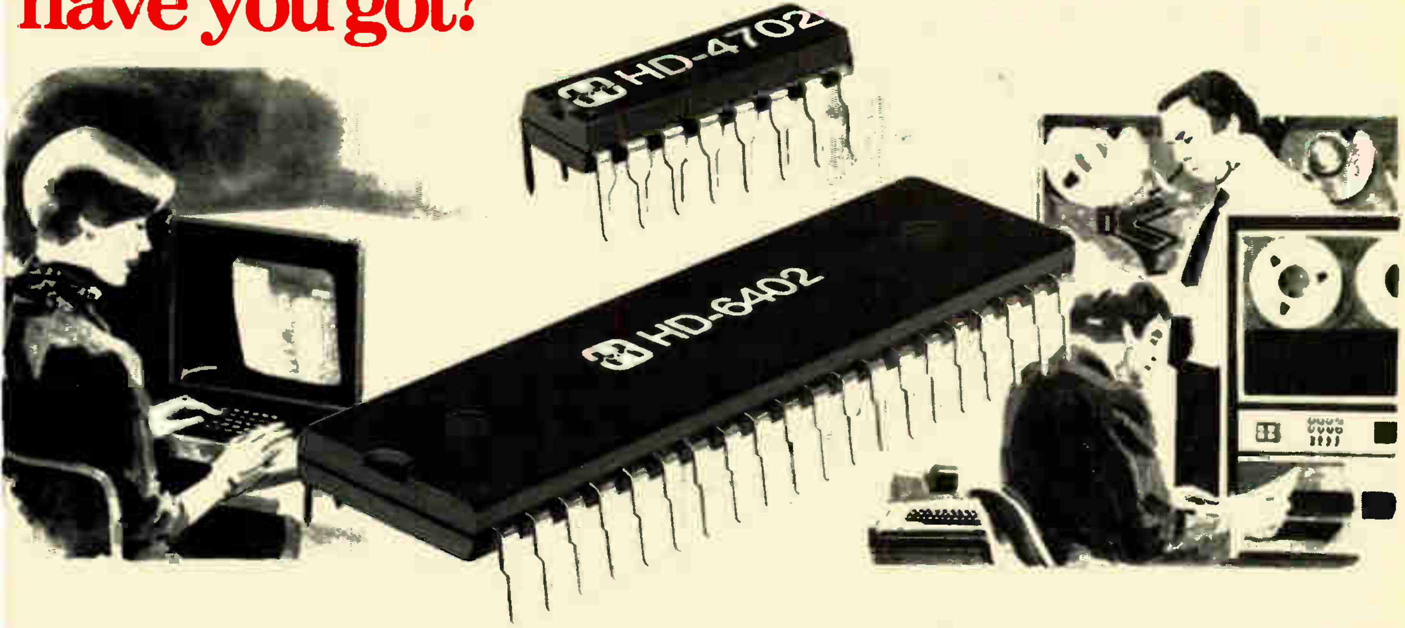

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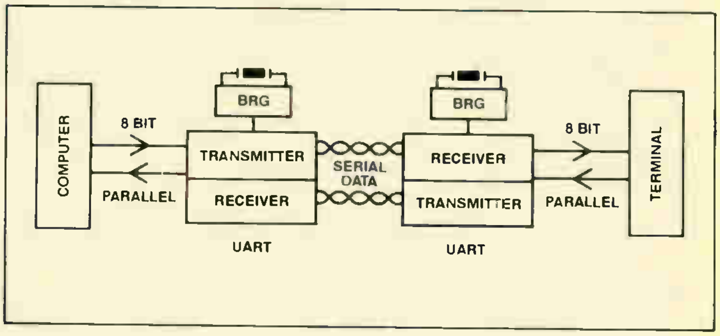

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pooled into a group grievance likely to be more effective than a single company's charge, he says. □

Memories

Add-on makers face loss of a choice

The $500 million market for IBM-mainframe add-on memories is extremely price-sensitive, forcing independent competitors to balance profit margins against the cost of being compatible. As they take aim at the newest IBM processors, the System/370 models 3031, 3032, and 3033, they may no longer be able to choose between static and dynamic random-access memories: the 3033 is so fast that the more expensive static chips may be necessary. The use of such chips could force them to lose some of their price advantage compared with IBM's $110,000-per-megabyte memories.

The required refresh cycle makes the dynamic-RAM add-on slower than a unit using static chips. But even though IBM has used static RAMs in all of its semiconductor memories, some add-on makers have chosen cheaper dynamic parts and compensated for the difference in speed by the design of their interface with the central processing unit.

New dynamics. As the last of the add-on makers introduced their IBM-303X–compatible wares at the National Computer Conference, the score became two favoring dynamic RAMs and three choosing static parts. But those using dynamic chips admit that they may have to go static in order to attach to the speedy top-of-the-line 3033 processor.

Intersil Inc., Cupertino, Calif., does no direct marketing, but its add-on unit surfaced at the NCC under the label of Memorex Inc., Santa Clara, Calif. Both firms say the add-on box uses 8-K dynamic RAMs and can hold 10 megabytes of memory at $74,000 per megabyte.

They note, however, that the unit currently attaches only to the 3031 and 3032 processors. Intersil marketing vice president Richard Andrieni says the firm is starting tests with the faster 3033 computer and hopes the dynamic RAM will also work with it.

National Semiconductor Corp.'s Computer Products Group, also in Santa Clara, hopes to use the company's own 5290 16-K dynamic RAM in its newly introduced 833X family of add-ons [*Electronics*, June 8, p. 36], according to group general manager Dave Martin. Although National is sure it will work with the 3031 and 3032 computers, Martin concedes that the firm has still not decided if the dynamic part will be used in the 3033-compatible memories, or if National will secure static chips from an outside vendor.

4-K statics. Previously announcing units were Intel Corp.'s Memory Systems division, Sunnyvale, Calif.; Cambridge Memories Inc., Bedford, Mass.; and Electronic Memories & Magnetics Corp. of Hawthorne, Calif., each of which say they are using in-house 4-K static RAMs for products that attach to the entire IBM 303X family.

Intersil's Andrieni thinks it is not yet clear whether the fastest dynamic RAMs now available can be used to achieve the required 3033 memory speeds. "The breakoff appears to be somewhere at about a 100-to-120-nanosecond dynamic RAM," he says.

But National's Martin says there is no risk involved for his company. They already have a 4-K static design "to fall back on," he reports. □

Navigation

GAO's Navstar plans are not very popular

A plan proposed to Congress to make a military satellite navigation system still being developed the core of the nation's radio-navigation network by 1985 is drawing sharp criticism from Federal agencies. The proposal for joint military and civilian use was submitted late last month by Congress's investigative

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News briefs

New top-of-the-line unit from Harris Computer Systems
Harris Corp.'s Computer Systems division, Fort Lauderdale, Fla., has introduced its top-of-the-line series 500 computer system, expanding its capability to directly address memory from a previous limit of 726 kilobytes to 3 megabytes. Instead of Harris' usual 24-bit architecture, the new unit uses a 48-bit bus structure. It also uses the Vulcan virtual-memory operating system. The model S550, which can support up to 48 interactive terminal users is priced at $255,000, and the S570, for as many as 64 interactive terminals, is $376,000. Shipments will start early in 1979.

Honeywell, GE to combine international computer operations
General Electric Co. of Fairfield, Conn., and Honeywell Information Systems of Waltham, Mass., have agreed in principle to merge the worldwide operations of GE's Information Services Business division with Honeywell's time-sharing marketing operations in the United Kingdom, Europe, and Australia. GE would own 84% of the proposed new company, Honeywell 16%.

Fluke to expand custom-IC manufacturing facility
The John Fluke Manufacturing Co. of Mountlake Terrace, Wash., is expanding its custom integrated-circuit laboratory from an 8,000-square-foot research-and-development department to a 25,000-ft² in-house manufacturing facility. The lab has been producing custom ICs for Fluke's precision and standard instrumentation line for the past six months. The laboratory's capabilities include thin- and thick-film hybrid manufacturing, with programmable automatic laser trimming to be added shortly. The expansion is expected to increase the present 20,000-device/year output tenfold.

Fairchild looking to expand automatic test line
Negotiations are nearing completion for the purchase of Testline Instruments Inc., Titusville, Fla., by Fairchild Camera and Instrument Co. The acquisition by the Mountain View, Calif., company would broaden its coverage of automatic test equipment, now limited to semiconductor and memory testing. Testline's AFIT 4000 and 3000A are large- and medium-sized production board testers; the AFIT 1500 and 1000, portable board testers.

TI to supply gear for 1980 Winter Olympics
Texas Instruments Inc.'s Data Systems division announced at the National Computer Conference that it had been selected as a supplier for the 1980 Winter Olympics to be held in Lake Placid, N. Y. It will supply model 990 minicomputer systems, plus several 700 series silent terminals and peripherals, for hotel reservations. Also announced were an 8-bit data-bus version of the TMS9900 microprocessor; a 16-bit microcomputer-on-a-chip with a resident erasable programmable read-only memory, the TMS9940; and a development system for the 9940, the $2,750 990/40DS. It also added Pascal, a high-level language, to its 9900 family.

arm, the General Accounting Office.

It calculates that $277 million could be saved over eight years by relying on the new $3.13 billion triservice Navstar/Global Positioning System and by phasing out seven systems regarded as overlapping. But agencies now using the systems proposed for phase-out object.

The Department of Transportation, responsible for navigation policy planning, leads the opposition, with vigorous support from its Federal Aviation Administration and the Coast Guard. Other criticism comes from the White House Office of Management and Budget and the Defense Department.

All concur in effect that GAO has oversimplified complex issues and advanced an overly optimistic timetable for reliance on a not-yet-proven satellite system that would lead to scrapping billions of dollars in existing user hardware and training. They point out that Navstar, to have

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24 satellites in three planar orbits of eight satellites each [*Electronics*, Oct. 16, 1975, p. 39], will not be fully operational before 1985 and has not yet been proven feasible.

Tests beginning. The Air Force is only now beginning tests at its Yuma, Ariz., range using the first two Rockwell International Corp. satellites in orbit. The Pentagon says a decision to deploy Navstar/GPS will not be made before February.

DOT charges it "would come very close to dereliction of duty" to make plans around a system several years away from operation and to forego "necessary and cost-beneficial improvements to currently proven and needed systems." Another irritating aspect of GAO's plan is its recommendation that the President name a single navigation systems czar.

According to the plan, the government would phase out the FAA- and military-funded very-high-frequency omnidirectional ranging (VOR) systems, tactical air navigation (Tacan) systems, and Vortac (a combination of the two), as well as the Coast Guard's Loran-C and its more accurate Air Force counterpart, Loran-D, plus the navigation component of the Army and Marine Corps developmental position-location reporting system. The Navy's long-established Transit satellite system could also be dropped, as could the military's nondirectional beacons.

"The total investment in VOR-DME [distance-measuring equipment] is of the order of $2 billion," retorts the Transportation Department "This cannot be scrapped overnight." Supporting the DOT is the Pentagon, which notes that "more recognition should be given to the need for backup systems."

Helping out. Along with Navstar, the GAO proposes use of three systems already available: self-contained inertial and doppler radar systems and civilian nondirectional beacons, plus the Coast Guard's eight proposed Omega low-frequency transmitters.

The military believes it will need up to 25,000 air, ground, and seaborne receivers of varying complexity for Navstar. These would determine position on the ground and in the air by picking up accurately timed ultrahigh-frequency signals from two or more satellites. Location could be determined with accuracies between 30 and 300 feet.

As for civilian use, the Federal Aviation Administration doubts that a cheap enough receiver could be developed in time—GAO talks about a $2,500 receiver based on a 100,000-unit market. It calls this assumption "a fundamental weakness of the report." The Coast Guard also calls the receiver development unrealistic, adding that it would be unable to locate positions accurately enough in coastal waters.□

Canada

Business group seeks aid for technology

Trying to help high-technology companies in Canada do business, an association of Canadian companies is out to swing more weight in government councils. Late last month, the Canadian Advanced Technology Association, or CATA, presented a multifaceted plan to major departments of Canada's executive branch, including the ministries of Industry, Trade and Commerce, Communications, and Defense. The group, founded in late 1977, seeks adoption of:

- Research and development tax credits.
- A federal and provincial government "Buy Canada" program.
- An end to discrimination by governmental agencies against small companies.
- Assistance in solving the capitalization problems of small companies.
- Modification of the federal sales-tax structure so that goods are not taxed at the manufacturing but at the purchasing level.

Doing well. CATA members—companies with more than 51% of their common stock held by Canadian citizens—are doing well, and sales overall have increased tenfold in the last five years. But the group

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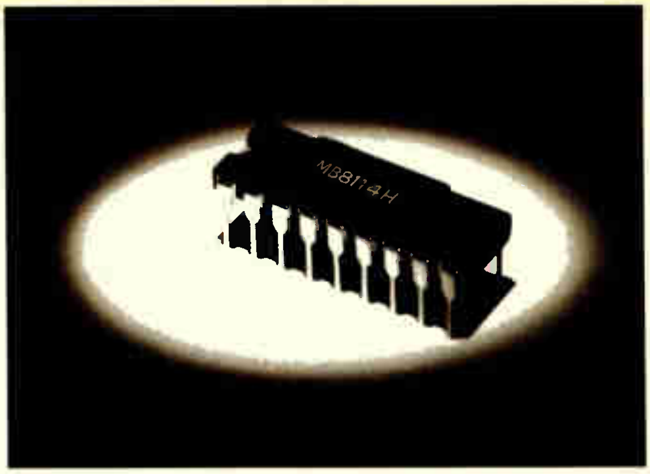

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Softened labor bill could pass late in Congress

Watch for some form of S. 2467, the Labor Law Reform Act, to emerge from the Senate later in this session despite the filibuster efforts led by Sen. Orrin Hatch (R., Utah). That's the judgment of senior Senate staff members who note that the bill—**one that has electronics companies, large and small, fearful that passage would wipe out safeguards against union entry to organize their plants**—will be softened by amendments to protect industry interests. One key amendment would eliminate union access to plants during working hours to woo workers and limit access to areas like cafeterias during lunch and parking lots between shifts. What troubles senators like Hatch, however, is that a strong prolabor version is already through the more liberal House, and any weakening on the Senate side could tip the scales toward labor in a House-Senate conference seeking to reach a compromise on the two versions.

Motorola gets $370,000 from DOE for photovoltaics

June busted out with a $460,000 Department of Energy system design award for a 500-kw photovoltaic concentrator system. It will be split 80–20 by Motorola's Government Electronics division in Scottsdale, Ariz., and the Arizona Public Service Co., an electric utility. Following completion and acceptance of the nine-month design study, **the companies stand to get an estimated $6 million to $8 million contract** about June 1979 to build the demonstration system at the Phoenix Sky Harbor International Airport. First, however, the department would have to approve the second phase as one of the 9 projects to be selected from among 17 first-phase competitors. The department's project manager is Edward Burgess of Sandia Laboratories at Albuquerque, N. M.

TI seen ready for entry into photovoltaics

Energy insiders say Texas Instruments Inc. is preparing for the plunge into photovoltaics before the year is out, getting into the systems end of the solar-cell business as well as photovoltaic cell manufacturing. Longstanding signs of the Dallas company's interest **include its quiet acceptance of Department of Energy research-and-development money totaling about $3 million** over the last two years and an in-house proprietary systems project. They were supported by two TI papers at the IEEE's 13th Photovoltaic Specialists Conference in Washington, D. C., earlier this month. Their titles: "Optimized Solar Module Design," in a session on low-cost production, reflecting the company's interests in tandem-junction silicon cells; and "A 1982 Low-Cost Photovoltaic Module Factory Study" during session dealing with low-cost R&D for large-scale production.

New EFT rules permit terminal sharing by S&Ls

Final regulations governing electronic funds transfer transactions by Federally chartered savings and loan associations have been approved. **They permit associations to share automated teller machines** on their premises with other financial institutions, says the Federal Home Loan Bank Board. But American Bankers Association president A. A. Milligan is not altogether happy with an electronic-banking consumer-protection bill (H. R. 12775) proposed by the House Banking Committee. "Generally, the measure represents a substantial improvement over previous proposals," Milligan says, but he notes that the bill's proposed minimum pricing of EFT services is still unrealistically high.

Van Deerlin's impractical principle

Despite 20 months of hearings, studies, and analyses, the long-awaited rewrite of the 1934 Communications Act just introduced on Capitol Hill is widely regarded as a shallow piece of work. That, at least, is the opinion of most industry and Government specialists after a first reading. Numbered H. R. 13015 and called The Communications Act of 1978, it is the product of the House subcommittee on communications chaired by California Democrat Lionel Van Deerlin. First hearings are expected next month.

The Van Deerlin bill is strong on good intentions but weak on their implementation. It would substitute marketplace competition wherever possible for Federal regulation of telecommunications and broadcasting. The role of the Federal Communications Commission would be sharply reduced, confined largely to technology and its impact on spectrum usage. Sound good? Wait a minute.

Oligopoly for monopoly

Competition in telecommunications would be achieved by opening the market completely, except that no one with a monopoly service like American Telephone & Telegraph Co. would be allowed to manufacture equipment. But if AT&T spun off Western Electric Co. and its $8 billion in annual sales, it could enter any markets it chose—from data-processing services to cable-television distribution, with the latter completely deregulated. One widely respected early advocate of competition sums it up this way: "The bill pays lip service to competition but does not come to grips with the issues. The end-user equipment market would become competitive, it's true, but it would be controlled quickly by an oligopoly of Western Electric, IBM, and a few others, possibly foreign companies. Meanwhile, AT&T could wreak havoc in markets like cable television and computer services. They already have the lines in place."

Similar criticisms are heard on the broadcasting side, where H. R. 13015 would phase out periodic license renewals in favor of market competition. Licenses would be issued for an indefinite period subject to revocation for violations of law. The bill would reduce the number of licenses for radio and TV stations that could be held by any single organization but—in its haste to get the Government out of the regulatory business—it seeks to avert opposition from existing licensees by exempting them from any cutbacks unless they voluntarily disposed of a holding. Broadcasters were surprised to hear that former FCC Commissioner Nicholas Johnson, who once reveled in the role of the wild-eyed radical, rejects the approach. A free market, Johnson says, "would be preferable to the present system of regulated monopolies. But I'm afraid Van Deerlin has proposed instead to put us at the mercy of unregulated monopolies."

Several critics concur with the communications-equipment-makers' lobbyist who says, "The legislation reads like a college paper in sophomore economics on 'If I could change the world, here's how I would do it.'" Another attributes Machiavellian motives to the authors: "If I thought they were smart enough, I'd say they deliberately left it so full of holes that all of us [in industry] can respond, get our part amended, and come away saying we won something. But that is not the way to write good legislation."

Goodness is in the eye of the beholder, of course, and the Van Deerlin subcomitttee staff headed by chief counsel Harry Shooshan seems satisfied with the product of its labor. Staff members reject the notion that they have dodged the whole international area by noting that making treaties is a prerogative of the President subject only to later congressional consent. The fact that the needs of the developing land-mobile communications market with its enormous potential are nowhere addressed is countered by the observation that it is not yet a big enough issue for inclusion in a bill that is already more than 200 pages long.

Amendments to come

The faint praise that can be heard for H. R. 13015 is damning. More often than not, it labels Van Deerlin's bill "a good beginning" and not much more. The bill's advocacy of a free marketplace is good; so is its corollary that the Federal government should cease overregulating the market. What is bad about the bill is that, after years of close regulation, the withdrawal would come so swiftly that the resultant vacuum would likely stifle as many innovators as the existing structure has repressed.

The giants of the telecommunications industry view deregulation as a challenge; most growing companies see it as a threat. Each group will move in its own way to fill that vacuum by getting H. R. 13015 amended in ways that will advance its own interests. Legislation that passes into law is certainly the product of compromise. But the Van Deerlin bill is so vulnerable to amendment that, if it passes, the resultant law may be unrecognizable by its authors.

Ray Connolly

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For complete technical data, write for Engineering Bulletin 6250B to: Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Mass. 01247.

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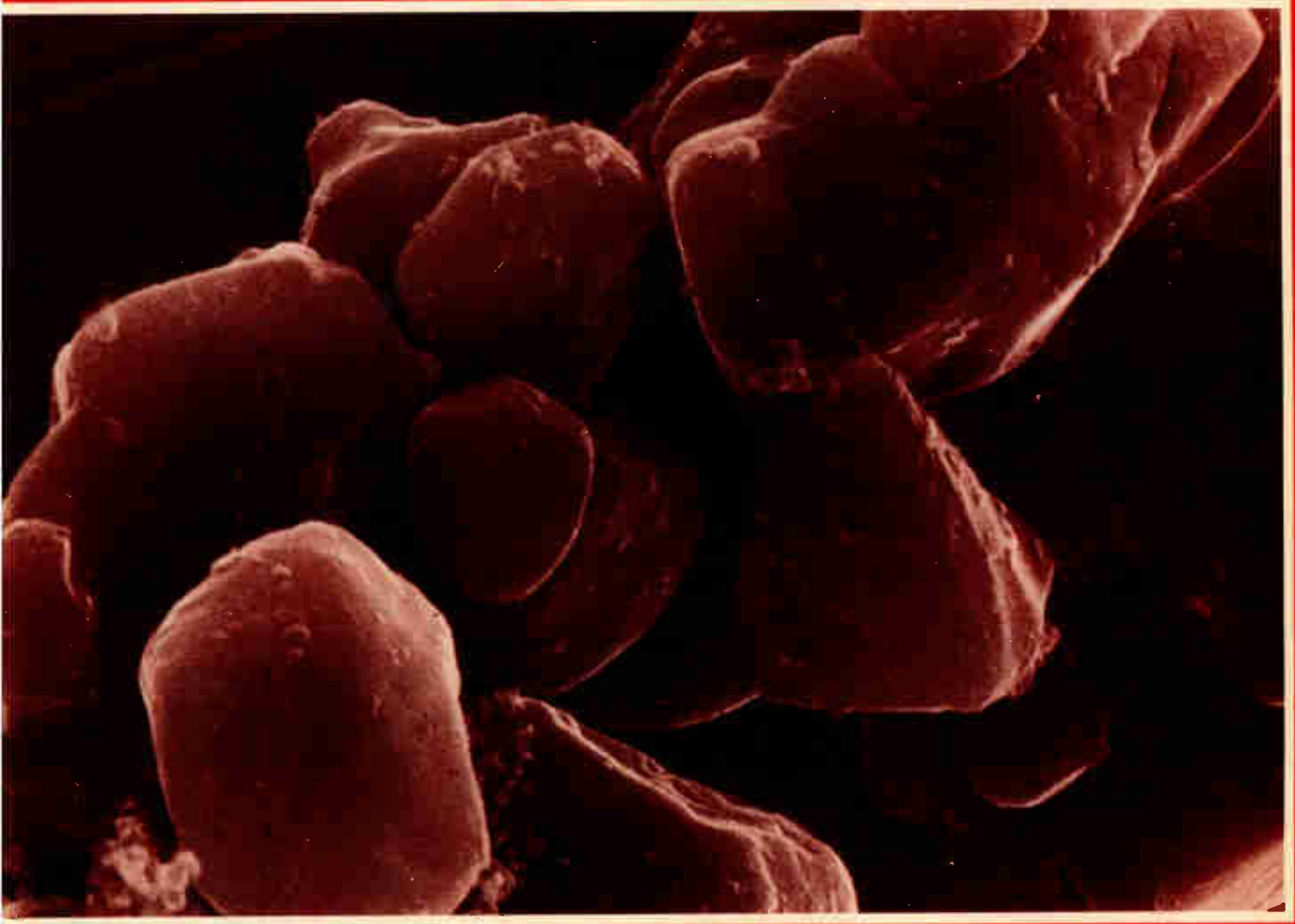
Circle 58 on reader service card

June 22, 1978

Electronics International

Chips bring self-tuning controller to the hardware stage: page 67

A new thick-film resistive material (magnified 10,300 times) promises to combine high performance with lower costs: page 70



International newsletter

GEC Ltd. talking to U. S. firms about expansion

Expansion plans in the solid-state field for the British giant General Electric Co. Ltd. appear to center around joint European ventures with U. S. semiconductor makers. An impeccable source says its discussions are with companies like Intel and Fairchild Semiconductor that have no English or Continental production base. **On another tack, GEC, an Intel distributor, is working with the U. S. firm** to obtain Ministry of Defense type approval for shipping certain Intel products in wafers. When required by the ministry, GEC could perform diffusion in the UK. The firm also is talking to other U. S. semiconductor makers facing difficulties with tighter ministry procurement procedures for ICs.

NHK pushing its work in plasma displays

Plasma color displays are reaching toward the size of cathode-ray-tube TV receivers, with a 16-inch diagonal unit up and running in the Technical Research Laboratories of NHK, Japan's public-service broadcast system. Peak white brightness is still a fairly dim 7 ft-L, but it is the same as in a display of only a quarter the area that was shown last year. **NHK engineers maintain the brightness by driving the top and bottom halves of the display independently, which permits twice as long an application of the drive to each line.** Another NHK group had developed a flat display that uses ultraviolet generated in positive columns to excite phosphors. Almost 10 inches diagonally, it has a brightness of about 11 ft-L, but it may not be amenable to sizing upwards because it is difficult to make.

New CCD camera shrugging off blooming problems

The Hirst Research Laboratories of General Electric Co. Ltd. is readying a new charge-coupled-device TV camera incorporating charge overflow circuitry that handles overloads of 1,000 times saturation without picture blooming. Chips with 300-line resolution and others with antiblooming circuitry have been demonstrated separately, **and the lab is putting the two techniques together in a 9-by-11-mm chip yielding a 72,000 element array**—300 lines each with 240 image points. GEC says that its three-phase, three-level buried-channel, polysilicon, frame-transfer CCD technology can be stretched to match the 448- and 512-line systems from U. S. companies by going to high-resolution electron-beam mask making.

East Germany may grab phone deal from Western firms

Barring a last-minute change of mind, postal authorities in Greece are planning to award a contract worth as much as $100 million to East Germany to expand the country's telephone network. If the order is placed, it will be over the heads of at least three native communications producers managed by or affiliated with Siemens AG, Philips, and Standard Elektrik Lorenz AG, an ITT subsidiary, **The contract for installation of about 250,000 new subscriber lines is likely to be followed up** with orders for exchange equipment. The East Germans' offer is up to 50% lower in price, and includes some kind of a barter deal.

Flat EL display for characters available in samples

Coming up: an electroluminescent display less than 2 in. thick with a diagonal equivalent to that of a 7-in. cathode-ray tube. Sharp Corp. is offering samples of the display for about $1,360 and plans to begin quantity sales next year. The unit has 12 rows of 40 characters, displayed as a seven-by-nine-dot matrix. Brightness is in excess of 15 ft-L, and power consumption is less than 7 W. **At the recent Chicago Consumer Electron-**

ics Show, Sharp displayed a black-and-white TV set with an EL display. Area of the picture is 120 by 90 mm, compared with 144 by 74 mm for the character display. The firm says the TV display has a peak white brightness of 25 ft-L and a 30-step gray scale with a contrast ratio exceeding 50 to 1. It expects to start selling a portable TV with a similar display within two years.

Sales curves flatten for French telephone makers

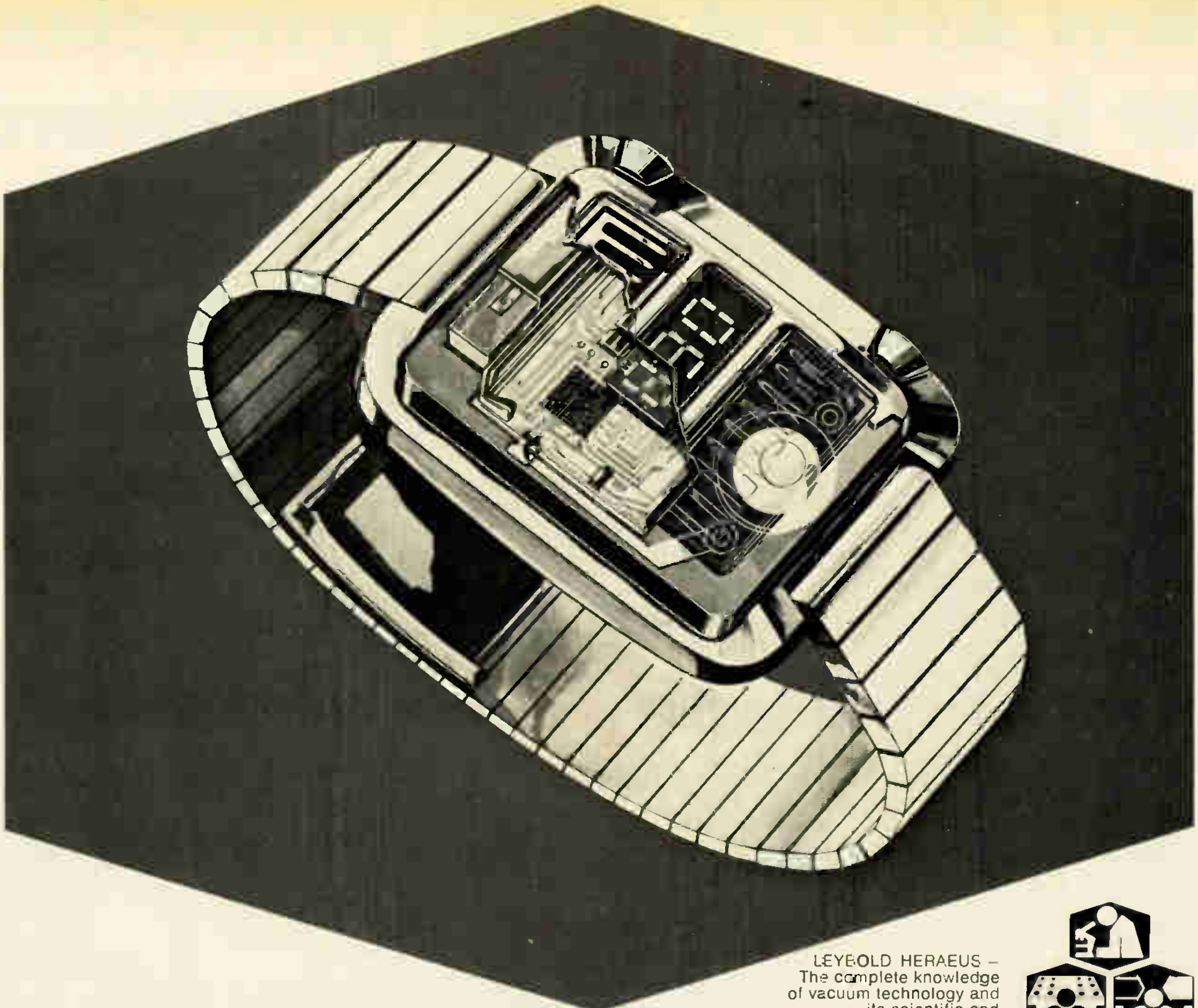
French producers of telephone and telegraph equipment saw their sales curves flatten last year and don't expect any improvement this year. Reporting its 1977 results in early June, the industry trade association SITT (Syndicat des Industries Téléphoniques et Télégraphiques) noted that the $2.139 billion revenues were up just over 16%, well under the nearly 25% annual gains registered in the mid 1970s. **The growth should slow even more this year:** export orders are down; and the government-owned telephone network has earmarked only a slight increase for hardware investments. However, these investments are at a high level, since the plan is to expand the network to 20 million primary lines by 1982.

VCR camera to cost $760 in Japan

Technical improvements plus production economies are responsible for the sharply reduced price tag that Victor Co. of Japan is putting on its new color TV camera for video cassette recorders, now on its way to Japanese and American consumers. Victor says its roughly $760 camera **features a new form of color-stripe filter integrated into the faceplate and new circuits to separate the chrome and luminance signal components in its output.** Helping to lower manufacturing costs is the firm's move of the production line to its TV plant to take advantage of economies of scale. The $760 version is the cheapest of three models and features a fixed lens with a 25-mm focal length. In the U. S., Magnavox showed the Victor camera at the Chicago consumer show under its own label. It plans to price them starting at $895.

Addenda

Cooperation across the English Channel may spread to computers. The French and British governments are commissioning a study **on collaboration in computer development and manufacture.** . . . Engineers at Japan's NHK public broadcasting system have devised a 60-in.-diagonal color TV. **The picture is as bright as on the basic 30-in. tube,** because a parabolic mirror reflects it within a fairly narrow viewing angle. . . . Motorola has hit a slot-machine jackpot **for the 6800 microprocessor with two British makers of the equipment:** Barcrest Ltd. specializes in electronic slot machines, while Bell Fruit Ltd., the largest British maker of the machines, expects to go solid-state within a year. . . . CII-Honeywell Bull will take a majority holding in R2E (Réalizations Etudes Electroniques), **the company that pioneered distributed data processing in France.** The $6 million firm is likely to be a good customer for CII-HB peripherals, while the big computer maker is likely to become a volume customer for R2E's microprocessor-based Micral computers, as they are smaller than anything CII-HB now offers. . . . The VHS camp of video cassette recorder has won a significant new follower: **Britain's Thorn Consumer Electronics Ltd.** is starting to sell three-hour VCRs made by Victor Co. of Japan, originator of the Video-Home-System technology.



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- LEDs and LCDs for the digital displays have vapour-deposited contact coatings, conductor paths, reflection-reducing optical coatings and cathode-sputtered mask coatings.

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Oxford laboratory develops hardware for self-tuning controller

Prototype uses SBC 80/10 to monitor response of system to a control input; from this, it adjusts the transfer function

Self-optimizing computerized process control is taking the step from theory into hardware in a microprocessor-based developmental system from the department of engineering science at Oxford University. The system features a program that continually adjusts its transfer function so that it exactly models the process. For example, it compensates for runaway thermal instabilities.

By contrast, conventional analog controllers assume an unchanging transfer function. An operator must compensate for instabilities.

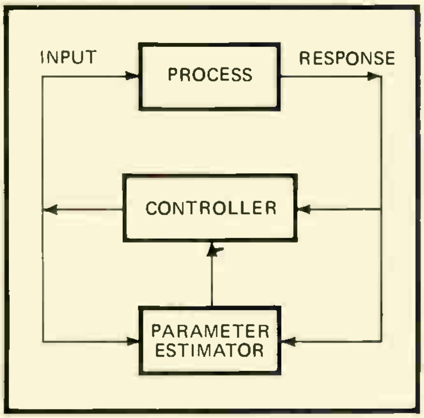
Demonstration. To introduce the self-tuning controller to potential users, David Clarke and his development team have put together a demonstration unit called Sesame, for self-tuning evaluation system and microcomputer equipment. It is based on the Intel SBC 80/10 single-board computer.

As a developmental system, it comes well equipped: 16 kilobytes of fast static random-access memory from Intel; a twin-drive floppy disk from Icom Inc.; an analog interface board from Analog Devices Inc. onto which is packed a 16-channel multiplexed 12-bit analog-to-digital converter, two 12-bit d-a converters, and a real-time clock system; a keyboard; and a display.

Clarke says a complete self-tuning controller could be constructed from an 8080 processor with associated clock, 2.5 kilobits of read-only memory, 500 bits of RAM, and a-d and d-a converters, together with an operator console. For consumer applications, he believes that a dedicated microprocessor eventually could be designed to optimize itself automatically for every installation.

Sesame can be taken to any plant, connected to existing process-control channels, and put on line rapidly. For equally fast on-line program modification, the Oxford group developed an interpreter based on the 2-K Tiny Basic. When tailored to the group's applications, by the addition of floating-point routines, interrupt handler, and disk interface, the interpreter fits into 5 kilobits of read-only memory.

Two roles. Clarke predicts that his self-tuning controller will be used in industrial and commercial roles. In industry, it is a natural for controlling processes that are nonlinear and time-varying and processes in which the control parameters are unknown.



Easy adjusting. An Oxford University demonstration self-tuning controller, based on a microprocessor, checks on the process under control in order to update the control.

It is also ideal for process systems with long time constants, The Lund Institute of Technology in Sweden has already applied conventional digital computers with self-tuning programs to thickness control in paper mills and load control in ore-crunching plants.

In office and consumer applications further downstream, Clarke sees one-chip microcomputers with self-tuning programs controlling such functions as central heating systems. Present-day on-off controllers hunt around the set point and are grossly inefficient, he says.

These controllers could be replaced by present-day industrial analog controllers, which can give far better tracking. But they require that the coefficient of the proportional, integral, and differential terms must be set by skilled technicians. Moreover, they take no account of changes in such parameters as the external temperature.

However, a self-tuning controller will adjust to such parameters as long-term changes in the outside temperature, and it also can adjust to differences between installations. It works by applying a control input to the system being controlled, then comparing the actual system response to that predicted (see diagram). From this, the parameter estimator works out the coefficients of an algorithm describing the new behavior. These coefficients feed into the controller, which computes the required input to achieve a target output. Thus the control parameters are constantly updated to adjust for any external disturbances.

Following successful analog and digital simulations, Sesame is provisionally slated to go to work controlling a tricky chemical production process at one of the plants of ICI, the British chemical giant. Also, British Steel is running self-tuning software developed at Oxford on a General Electric Co. Ltd. 4070 mainframe to control a slab-reheat furnace.

Clarke expects that self-tuned microprocessor-based controllers eventually could take on the analog controller in general-purpose industrial applications, if the unit is time-shared between loops. At present, the program execution is 10 times slower than real time.

His group is also working on software safeguards to inhibit excessive control inputs during startup and to monitor system performance to prevent excessive compensation for such incorrect inputs as those from a sticking valve. □

Japan

Compact dielectric ceramic resonator simplifies microwave-frequency control

When is a solid cylinder lighter than air? When it is a ceramic dielectric resonator used in place of the cavities that stabilize the frequency in microwave oscillators.

Such resonators, developed by engineers at the Nippon Electric Co., have reached the takeoff point for incorporation into systems. Now they are hard at work on a series of experimental transistor microwave oscillators. Their ceramic material permits a more compact configuration than their cavity counterparts, so they are lighter. Also, they can be coupled easily to striplines.

Features. An important bonus for circuits using the new dielectric resonator is that it is the only frequency-determining element in the oscillator. Thus the same microwave integrated circuit can be used with a series of resonators to cover a frequency band. Furthermore, the load power is coupled through the resonator, eliminating the possibility that energy at any other frequency can be coupled to the load.

An added advantage is the ability to combine outputs of several microwave ICs for higher power output without any adjustments. NEC engineers have combined the power output from four stepped-electrode-transistor oscillators through a single dielectric resonator for an output of 263 milliwatts at 6 gigahertz.

The low-loss ceramic NED-39, developed in NEC's central research laboratory in Kawasaki for resonator use, is predominantly a mixture of barium and titanium oxides with a few tenths of a percent of other oxides. It has a dielectric constant of 39 ±0.5. Since the linear dimensions of the resonator are inversely proportional to the square root of the dielectric constant, the ceramic component is much smaller than a comparable cavity, where the dielectric constant for the air within it is essentially unity.

Thus a resonator for a 7-GHz bandwidth measures only 7.5 millimeters in diameter and 3 mm high. The metal cylinder surrounding a typical 7-GHz cavity is 70 mm in both diameter and height.

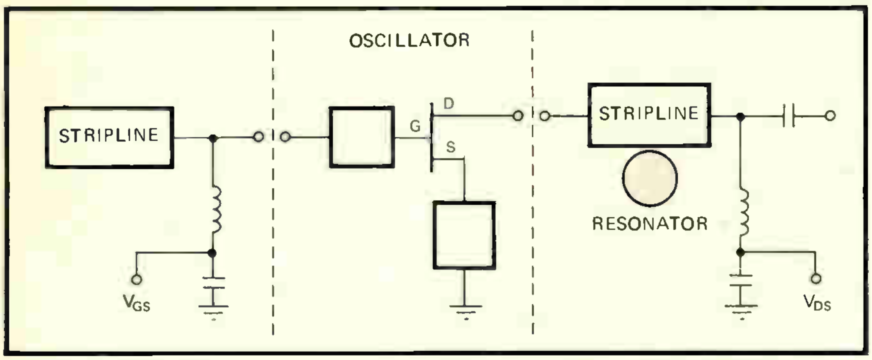
The high dielectric constant of NED-39 provides a discontinuity at the cylinder surfaces that in effect confines the electrical field within the resonator. NEC engineers say performance is excellent, with an unloaded Q at 7 GHz on the order of 7,000.

However, the magnetic field extends outside the resonator, permitting coupling to a nearby 50-ohm stripline. A movable metal disk at one end of the cylinder can vary frequency by about 1% without degrading performance. Also, a varactor connected to the stripline can control or modulate the frequency.

Another feature of NED-39 is the way in which the temperature coefficients of the dielectric constant and thermal expansion offset each other's effects on resonant frequency. The resulting temperature coefficient of frequency can be controlled between 0 and 50 parts per million per degree centigrade. But an unstabilized oscillator has a small negative temperature coefficient, so adding the resonator can result in a design with a coefficient on the order of 1 or 2 ppm/°C.

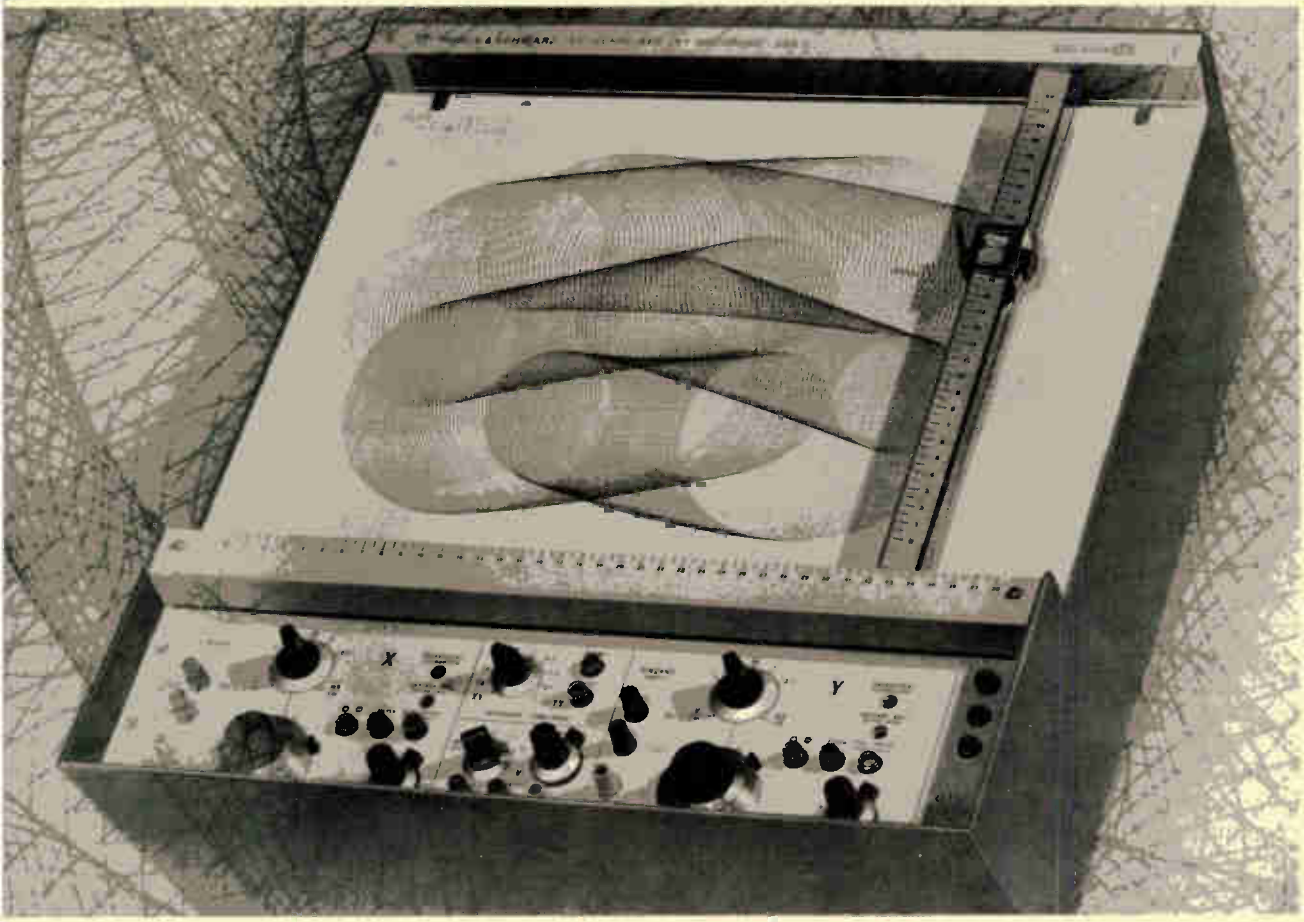
For extra frequency stability, the NEC lab has fabricated a temperature-stabilized resonator that gives an oscillator a stability of ±10 ppm over a 70°C range. For the highest possible stability, phase lock to a quartz crystal improves it to ±3 ppm over the same temperature range.

Two types. With the basic resonators, NEC has developed many types of oscillators. The central research lab has developed one type, shown in the figure, that uses metalized semiconductor field-effect transistors. Operating in the 6-to-12-GHz bands, these oscillators have higher efficiencies than those made with Gunn



Good vibrations. With a compact ceramic dielectric resonator, a 7-GHz MESFET oscillator has higher efficiencies than with Gunn diodes and lower noise levels than with Impatt diodes.

New recorder family: precision priced right



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diodes and lower noise levels than those made with Impatt diodes.

The microwave and satellite communications division has developed a type using bipolar SETS [*Electronics*, Jan. 22, 1976, p. 63 or 6E]. They operate in the 6- and 7-GHz bands at extremely low noise levels. However, 7 GHz is about the limit for efficient operation of these transistors, so the division uses MESFETS for higher frequencies.

An oscillator developed by the lab for operation in the 7-GHz band uses NEC's NE464R GaAs MESFET, which has a gate width of 1.5 micrometers. Output is 100 milliwatts, with an efficiency of 15%, and frequency stability over a range of $-10°$ to 50°C is only 1.8 ppm/°C. Fm noise is reduced more than 30 decibels over nonstabilized oscillators. □

West Germany

Thick-film resistor material reconciles good performance with lower cost

Thick-film resistor technology, long a standoff between the high-priced cermet and low-performance organic techniques, is effecting a major reconciliation between economy and performance. Behind this move is a West German components producer, Preh-Werke, with a radically different technique dubbed polypyron.

"Our new method is a low-cost alternative to the expensive cermet technique, yet it matches most of the latter's technical parameters," says its inventor, Wolf-Erhard Steigerwald, senior vice president. Compared with organic resistors, polypyron devices have better dielectric strength and better noise, temperature, and moisture behavior. As potentiometers, they exhibit superior contact resistance characteristics.

Just how much better the performance is cannot yet be pinned down because the technique is still being refined by the Bad Neustadt firm and measurements are not yet complete. "But preliminary results show that the improvement is substantial," Steigerwald says. Temperature coefficients can range from ±200 ppm/°C to ±600 ppm/°C, almost as good as for cermet resistors, he says.

Process. The polypyron resistors use a resistive paste in which nonconducting, refractory, inorganic particles from 1 to 5 micrometers in diameter are dispersed in an organic binder. To form a conducting layer, these particles are coated with complex liquid or plastic pyropolymers formed by subjecting gaseous hydrocarbons first to dehydrogenation in a pyrolitic environment and then to condensation.

A major advantage is the ease with which the conductivity of the pyropolymers may be altered during manufacture so that specific resistor values can be obtained. Changing the layer's thickness, crystal structure, expansion coefficient, or doping, or varying the particles' material combination, crystal structure, or surface area are all possibilities. Combinations of these schemes can produce a conductivity range of 10 ohms per square to 1 megohm/sq.

Steigerwald and his development team also have come up with new materials for the binder and the substrate onto which the paste is screen-printed. Essentially they are noninflammable organic substances.

Moreover, the hardening process is new to thick-film engineering. It involves heating resistive particles in the binder by microwave radiation, a technique that insures uniform and simultaneous hardening throughout the resistor's volume. Also, microwave hardening can be selectively applied so that even small areas can be heat-treated without affecting the surrounding substrate.

Savings. What makes polypyron a low-cost technique compared with the cermet approach "is the use of less expensive materials," Steigerwald points out. "Moreover, the microwave hardening process takes a very short time and can be highly automated."

Also, the Preh technique lends itself to a high degree of reproducibility in making resistors with uniform, close-tolerance resistivity values. The technique uses resistor materials with conducting particles having a maximum possible concentration in the binder, and the resistivity values are determined primarily by the properties of the conducting particles.

The technique lends itself to producing discrete resistors, resistor networks, resistors for hybrid cir-

Stubborn stuff. Polypyron material (magnified 23,500 times) makes high-performing, low-cost resistors with an inorganic resistive material and pyropolymers for the conducting layer.

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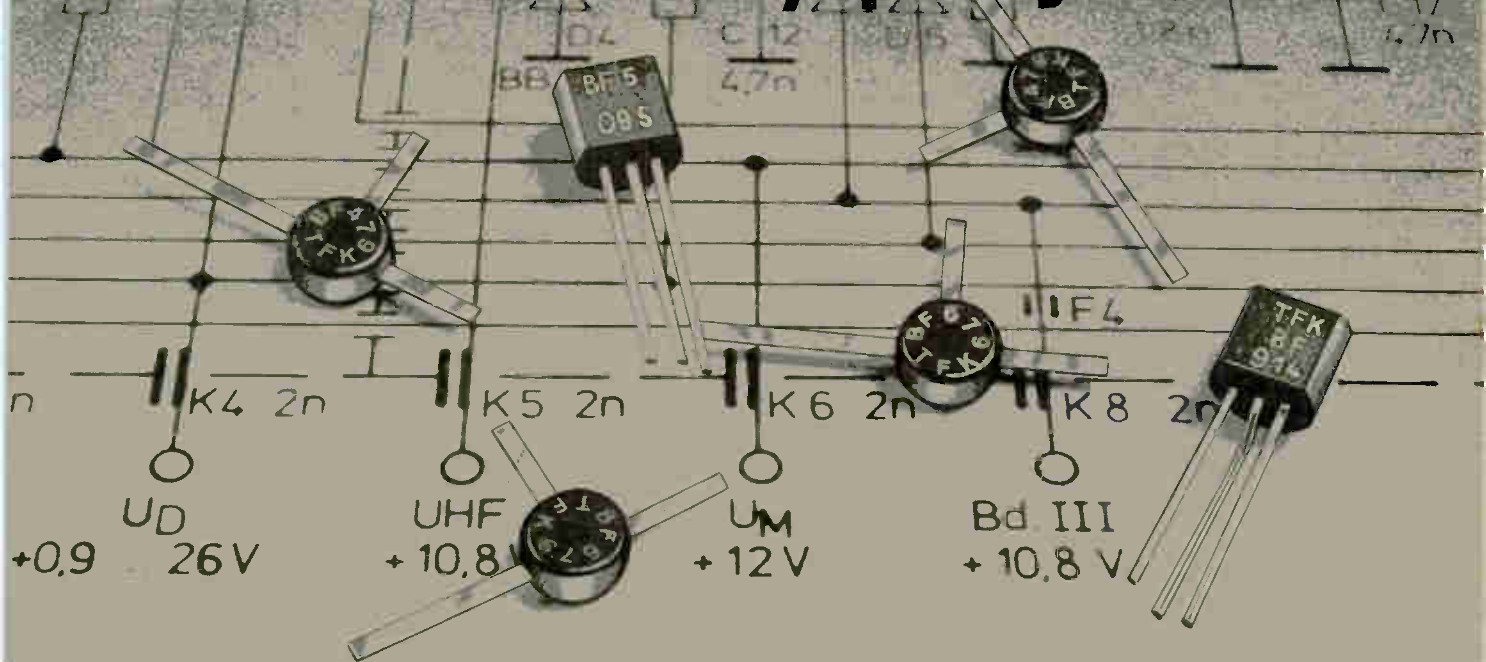

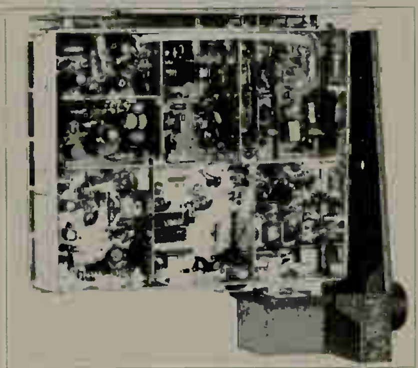

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cuits, and resistive elements for potentiometers. Moreover, "polypyron unlocks areas of application that have thus far been closed to thin-film technology for reasons of costs," Steigerwald declares. The first products, he confides, will have their debut at Munich's big Electronics show in November. □

France

6800s ease task of sonar operator

Time was when a subchaser's success depended largely on the skills of its sonar operators. But now it is as much a matter of how cleverly a sonar maker can process the echoes digitally with microprocessors, although a well-trained ear still is essential for some situations.

"An operator simply can't exploit all the information this sonar develops," says Stéphane Zyromski, speaking of the Beluga sonar under development by his group at Thomson-CSF's submarine-equipment division at Cagnes-sur-Mer on the French Riviera. So to sift out what is significant among the echoes, Beluga analyzes them with three microcomputers built around Motorola M6800 microprocessors.

Beluga continues the Thomson tradition of naming sonars after fish and was designed for warships of 1,500 tons or more. It sends out sound waves at a fairly low frequency, either 6.75 or 7.80 kilohertz, and high sound levels, up to 135 decibels (the reference level is 1 microbar/meter). The combination makes for a maximum range of 40,000 yards.

In effect, the sonar divides the sea around the ship into thousands of cells, each about 1.5 m thick, along the range of each 7.5° pencil beam. To cover the range out to the 20,000 yards realistic for naval operations, the sonar has to process some 500,000 cells. No human operator could analyze that much information, hence Beluga's signal extractor and its three microcomputers.

The cylindrical transducer head is made of 48 identical arrays of piezoelectric transducers. For active surveillance, the arrays may be powered simultaneously or selectively. The 6800's memories can store up to 50 tracks, and as many as 12 of the most interesting can be passed on to the plan-position display for operator evaluation.

Essentially, the extractor performs three analyses to pull out the necessary cells for the operator. It checks the signal-to-noise ratio, which is high for cells where there is a submarine or other substantial underwater object. It also examines the echoes for spatial coherence: underwater objects have distinctive sonar signatures, formed by the echoes that come back from adjacent beams, and they can be compared with stored signatures to sort them and distinguish them from background noise like bottom return. Finally, it checks echoes for coherence in time; that is, positions are compared from sweep to sweep.

For all its features, Beluga has an excellent price/performance ratio, Zyromski maintains. The basic version of the transducer head in its dome, a rack carrying the transmitter-receiver hardware, a rack for the digital signal-processing equipment, and an operator's console sells for about $2 million. Zyromski presented the gear to the world's navies during the early-June naval technology exposition in Rotterdam. □

Is an automatic conductor next?

True to form, West Germany's Federal Railways continues to go all out for electronic gear, not only to enhance safety of train operations, but also to offset rising labor costs. One of the latest labor-saving systems in the Bundesbahn's lineup is this microprocessor-controlled automatic ticket-vendor now undergoing a test at the Kassel railroad station.

The heart of the AEG-Telefunken vendor is a registering and control unit using an Intel 8080 microprocessor with a directly addressable memory capacity of 64 kilobytes. Among the many jobs the unit handles are: controlling the operation of subsystems like the coin checker, printer, and the change-return apparatus; advancing the date and time-of-day with due regard to leap years and daylight-saving/normal-time switchovers stored in the memory; and processing the data on train fares prevailing at different times during the week.

Further, the control unit triggers an alarm when someone tampers with the vendor. It also helps perform fault diagnoses and sends messages on the operational status to a central station, such as reporting that the paper supply needs to be replenished. It even ensures that a ticket purchase in progress is completed should the system's power supply suddenly fail.

The vendor's needle printer produces tickets with the appropriate date, time of day, and fare, as well as the destination that the user has picked by pushing buttons on a 28-key panel. The print speed is about 140 characters per second. The panel is expandable to 64 keys if the vendor is to be used to sell tickets to destinations in a larger geographical area.


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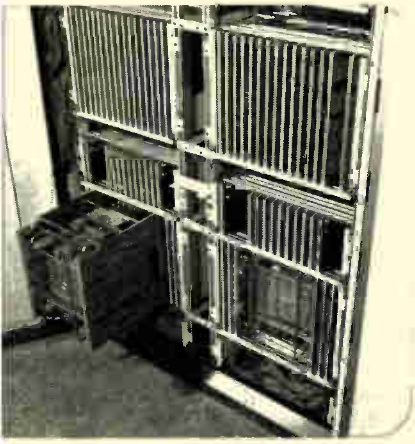
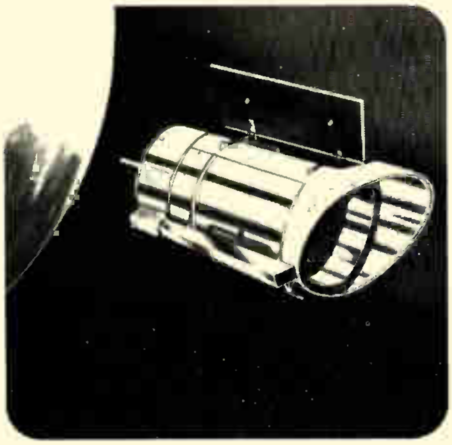
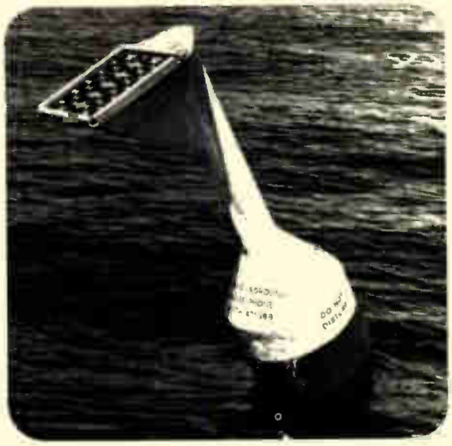


Stored Program Control, or SPC, resents the logical integration of vanced computer techniques with histicated communication electronics. eads to drastic improvements in ephony, telegraphy and data com- inications.



IRAS - Infra-Red Astronomical Satellite - due to be launched into a 900 kilometre polar orbit in 1981, is the first scientific satellite designed to make a detailed inventory of infra-red sources in space. The on-board computer, which will process about 500 million bits of measured data per day, will be supplied by us along with other electronic systems.



Solar energy is used to re-charge the storage battery aboard each of the forty survey buoys currently performing a marine study in the Indian Ocean. Continuously monitored data is automatically transmitted from each buoy every hundred minutes via the Nimbus-Six satellite. The study is being carried out by the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Philips supplied the solar collector panels.

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Stability*	≦ 0,5% or 4 mV	≦ 0,01% or 1 mV	≦ 0,01% or 2 mV	≦ 0,01% or 4 mV	≦ 0,01% or 1 mV	≦ 0,01% or 2 mV	≦ 0,01% or 4 mV	≦ 0,05% or 1 mV	≦ 0,05% or 2 mV
Ripple* Voltage (RMS)	≦ 1,5 mV	≦ 1 mV	≦ 1 mV	≦ 1 mV	≦ 1 mV	≦ 1 mV	≦ 1 mV	≦ 0,5 mV	≦ 1 mV

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Circle 265 on reader service card

Data-acquisition system lets users build to suit their needs and wallets

by Kevin Smith, London bureau manager

Built around a DEC LSI-11 card computer, system can handle up to 4,096 channels

The freedom to mix and match transducers and peripherals in an integrated system is what every user of data-acquisition systems would like. Usually, though, it costs too much. But now Solartron-Schlumberger has put a Digital Equipment Corp. LSI-11 card computer instead of a full-blown minicomputer in its new 3550 plug-in module data-acquisition system. To tie the modules together into an operational system, they have come up with a new software language called Basac IV.

Like many of its competitors, the Farnborough, Hants., company till now has built its big acquisition systems around general-purpose computers like the DEC-11/04 and 11/34. But to cut costs and allow the user to tailor a hardware system to his needs from plug-in modules, it has turned to microprocessor technology. The LSI-11 was a natural choice because of the transferability and quantity of its existing software, says J.W. Williams, Solartron-Schlumberger's marketing manager. The card processor is central to its operation, processing digitized measurements and status signals, storing and formatting data, and outputting it either to floppy-disk or to disk cartridges.

The 3550 mainframe incorporates up to 14 module cards, each a self-contained printed-circuit board that plugs into a 65-track mother board. The unit can control up to 4,096 channels via the company's 3502B slave scanner unit and 3501B master measuring unit. It is designed to work with a wide range of the company's already existing peripherals and transducers for measuring voltage, current, resistance, temperature, and strain. "We are aiming to produce a complete data-acquisition system in which all the components have been thoroughly tried, tested, and proved" says Williams.

The 3550 processor has a priority-structured interrupt input/output system organized to give highest priority to the modules electrically nearest to the processor. The watchdog printed-circuit board that monitors alarm sensors thus gets maximum priority while the 28-K memory module has the lowest. The system operates asynchronously so that I/O devices run as fast as possible. Optional plug-in boards include an IEEE-488 interface bus and a storage bus for floppy-disk and disk cartridge.

A 500-W power supply is rated for the full plug-in board capacity and incorporates a power-down mode so that when the power line is low, the system switches over to standby operation but does not cause a system crash; the memory module is kept alive by a dc ground. A complete external power loss switches the memory to on-board battery power for up to 30 minutes. Restart is automatic.

Working from the Basic high-level language, Solartron has developed the Basac IV conversational high-level software system for use in a real-time measurement and data-

acquisition environment. Typically, it is organized with a foreground-background capability so that the system can scan measurement channels while the processor is busy carrying out other computational tasks. The real-time executive routine is already proved on logging applications and handles all peripheral operations, program management, and time control.

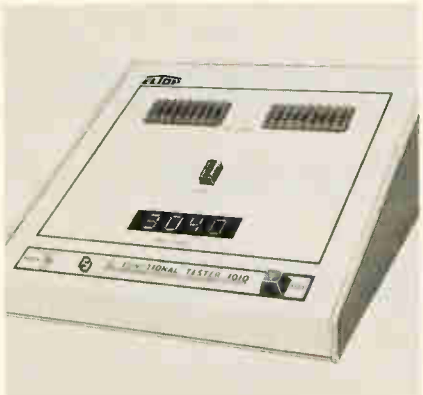
The new 3550 is designed for use with the 3510 measurement system introduced just over a year ago. This unit incorporates a fast reed-relay scanner teamed with a variable-integration-time analog-to-digital converter, thus allowing the user to trade resolution for speed as re-

quired. The 3510 is based on the company's patented pulse-width conversion technique originally developed for the Maestro series of digital voltmeters. A feature of the technique is its improved noise rejection, needed to maximize benefit from the 3510's sensitivity at the longer integration times.

The 3510's highest resolution of five digits at an integration time of 100 ms offers 100-nv sensitivity at the 10-mv level. Since strain and temperature measurements entail detecting input changes of no more than a few microvolts, the ability to recognize a change of 100 nv is an advantage. At all other scanning speeds except the fastest, the 3510 has a 1-μv sensitivity.

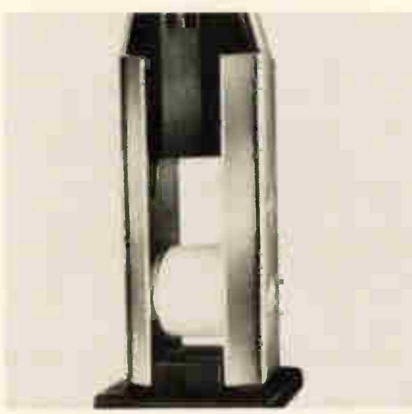
Also novel is the reed-relay scanner, constructed on a double-sided printed-circuit board having the reed switches on one face and their energizing coils on the other. The reeds are thus electrostatically and thermally screened from the coils, minimizing the possibility of errors due to spurious emfs. Also to improve switching performance, the reed is pulled in by a current pulse dropping to a far lower holding level, thus increasing switching speed and reducing power consumption. The net result is a 200-channel-per-second system.

Solartron-Schlumberger Ltd., Farnborough, Hampshire England GU14 7PW [441]

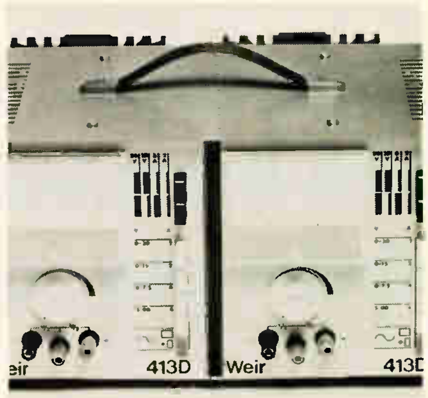


An integrated-circuit tester, designated model 1010, will dynamically inspect a 14- or 16-pin TTL device in 1 second. A four-digit LED display gives the results. Punjab Digital Industrial Systems Ltd., C-30, Industrial Focal Point, Phase II, S.A.S. Nagar (Mohali) -160051, Punjab, India [443]

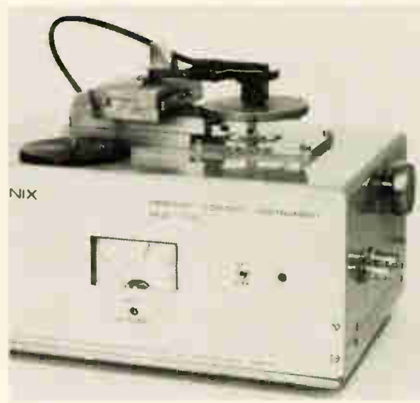
Available with a four- or six-digit readout, the Orbit 74T electronic interval timers have 1-MHz crystal-derived time bases. Timing increments can be selected from 10 μs to 10^6 s. Orbit Controls Ltd., Lansdown Industrial Estate, Gloucester Road, Cheltenham, Gloucs. GL51 8PL, England [444]



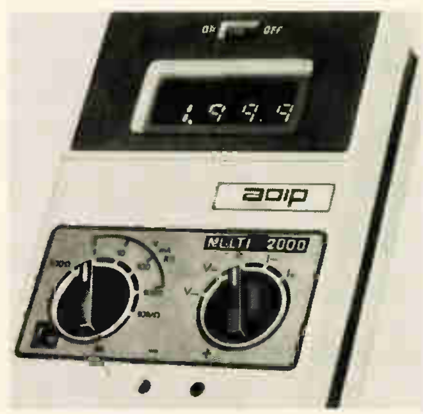
Suitable for mounting in installations and equipment, a 220-V ac surge protector has current ratings of up to 10 A. Depending on the steepness of the wavefront of the voltage surge, sparkover voltage is between 800 and 1,500 V. Cerberus AG, CH-8708, Männedorf, West Germany [445]



Twinpack power supplies with a four-ground output capability can simultaneously provide +5 V at 2 A and +12 V at 1 A, making them useful for laboratory or test applications with microprocessor-based systems. Weir Instrumentation Ltd., Durban Road, Bognor Regis, Sussex, England [446]



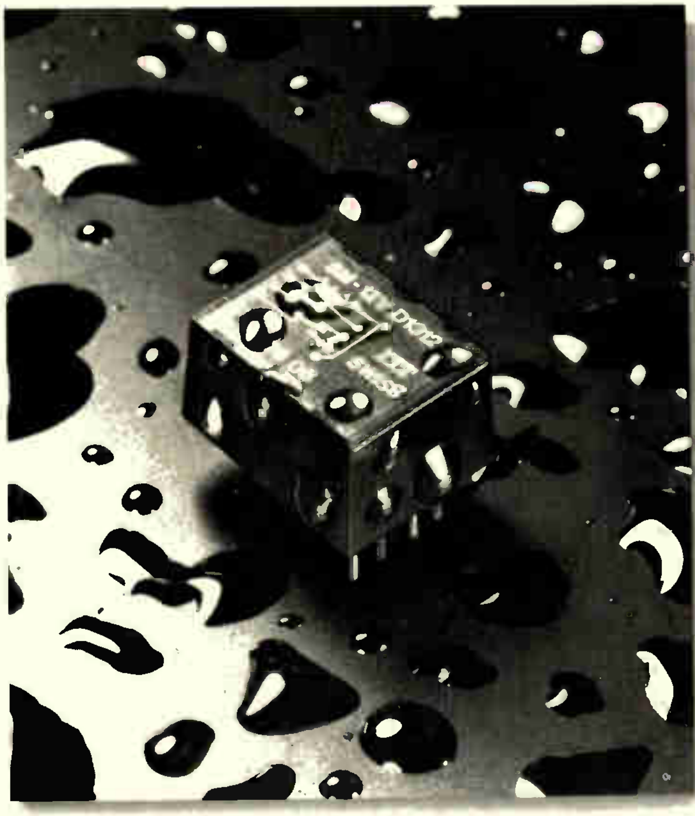
A mercury probe, type 703, can profile epitaxial wafers for subsequent return undamaged to the production line, an improvement over the Schottky method, says the company. The unit measures 12 by 8 by 9 in. Silitronix SA 6, chemin du Progrès, CH-1214, Vernier-Geneva, Switzerland [447]



A battery-operated digital multimeter, Multi 2000, resolves 2,000 counts and will measure dc and ac voltage, dc and ac current, and resistance. It measures 160 by 110 by 50 mm. A.O.I.P. Dépt. Mesures, 83-85, Bd Vincent-Auriol, 75013 Paris, France [448]

The new SM-Relay:
Reliable in any environment.

The new SM-Relay is cast completely in sealing epoxy resin which does not become brittle.
A more effective protection from moisture, dust, corrosive atmosphere, fluxes and cleaning-agents is hard to achieve.



Key characteristics of the SM-Relay:

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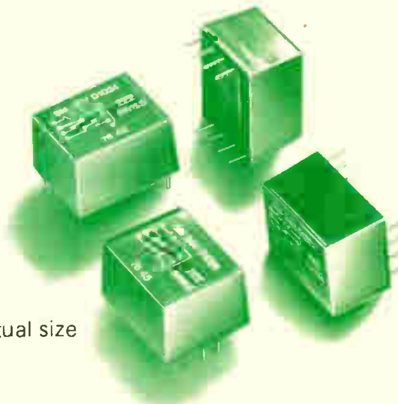

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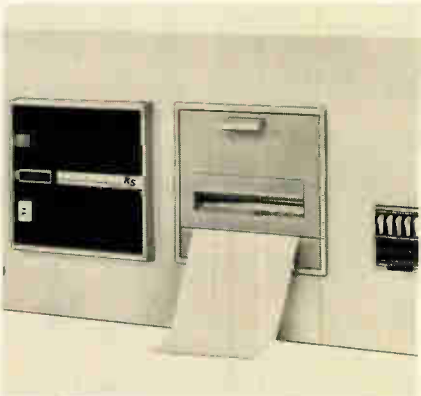
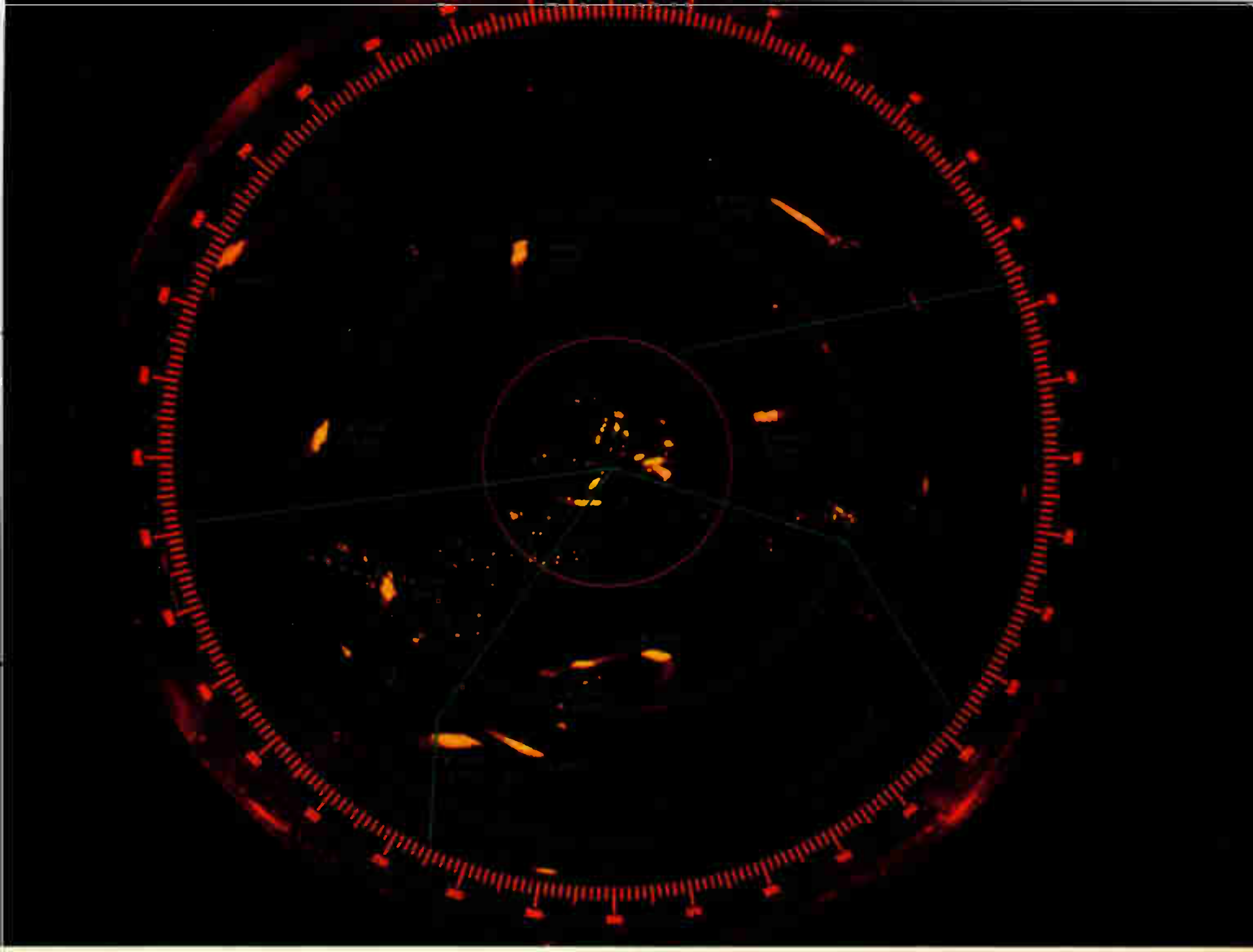


An assembly of devices based on the PG 350 printing counter will periodically record pulses representing objects or units of various kinds. The period between two printings may be from 1 minute to over 60 days. Sodeco-Saia SA, Grand-Pré 70, 1211 Geneva 16, Switzerland [450]

Schottky power diodes with near-zero transient recovery times are designed for dc-dc converters, switching-type power supplies, and power couplers. They will accept from 5- to 80-A forward currents. L.T.T., 89 rue de la Faisanderie, 75782 Cedex 16, Paris, France [451]



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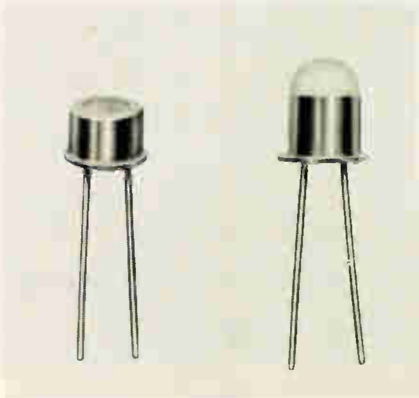
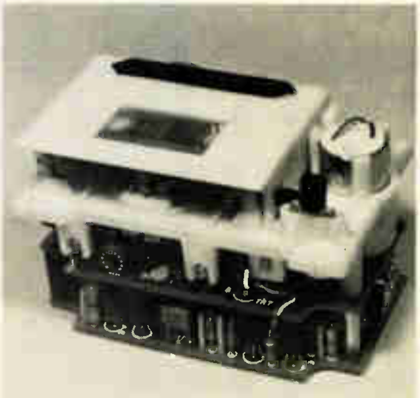
Circle 272 on reader service card

New products international

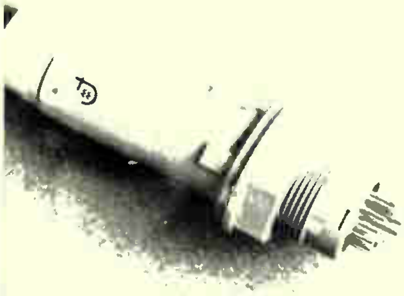
A head-up-display cathode-ray tube survives severe environmental avionic conditions. The 3-in. tube has a luminance of 45,000 cd/m^2 with a writing speed of 8,000 in./s and a resolution of better than 0.15 mm. Rank Electronic Tubes, Sidcup By-Pass, Sidcup, Kent, DA14 6LZ, England [458]



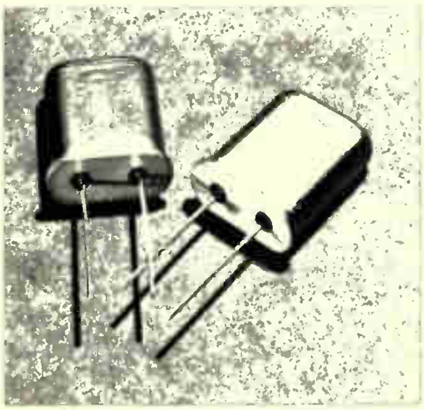
Meeting the need for high-speed laser applications, S1188 and S1188-01 silicon photodiodes feature a rise time of less than 1 ns. They have a dynamic range of 1 A at 50 Ω at a reverse voltage of 40 V. Hamamatsu TV Co. Ltd., 1126-1 Ichino-cho, Hamamatsu, 435, Japan [459]



A digital minicassette tape transport measures 3.2 by 2 by 2 in. and weighs approximately 160 g. It can be used as a portable input/output and memory device. Creative Machineries International Inc., Shizugin Bldg., 2-19-12, Shinjuku, Shinjuku-ku, Tokyo 160, Japan [460]



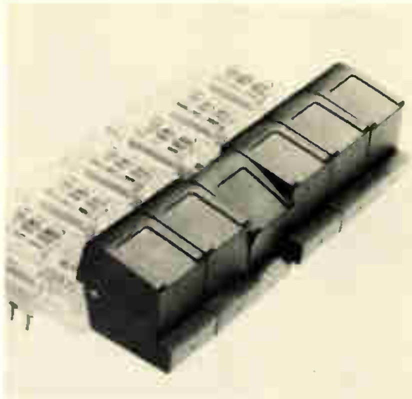
Electrical connectors, designated the 400 series, are available with 3, 4, 5, 9, 12, or 15 contacts. They are self-locking and provide 12 keying positions. The contact resistance remains low over a long service life. W. W. Fischer Ing., CH-1143 Apples, Switzerland [461]



A range of crystals is designed specially for use with microprocessors. Those with a frequency of 3.2 MHz and above are supplied in style J holders; those below 3.2 MHz, in style D holders. ITT Components Group, Standard Telephones and Cables Ltd., Harlow, Essex, England [462]

The TR-4132 spectrum analyzer covers a range from 100 kHz to 1 GHz. Its Quasi-Peak capability is standard, allowing it to measure electrical noise in accordance with CISPR and JRT specifications. Takeda Riken Industry Co. Ltd., 1-32-1 Asahi-cho, Nerima-ku, Tokyo 176, Japan [463]

New products international



This modular selector-switch assembly contains from 2 to 10 individual switches, each having a 10-W rating and a contact resistance of less than 20 mΩ even after 20,000 operations. Egen Electric Ltd., Canvey Rd., Canvey Island, Essex SS8 OPG, England [464]

A personal computer, the Pasona-1, designed for use by researchers, engineers, and students, has 16 kilobytes of RAM and 2 kilobytes of ROM. It can be programmed in Basic or assembly languages. Kokusai Data Machinesystems Inc. 3-33-21 Takaido Higashi, Suginami-ku Tokyo 168, Japan [465]

Digital capacitance meter NS 535 is designed to test capacitors in quantity and to gather inspection data. It has a range of 1 pF to 999.9 nF. Digital limit comparators can be added. Anglo-Japan Electronics Corp., Maruzen Bldg., 2-3-10 Nihonbashi, Chuo-ku, Tokyo 103, Japan [466]

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Motorola MC6800 earns listing on QPL

It's the QPL-listed microprocessor with a fully-compatible hi-rel component family. The MC6800 recently earned JAN approval for listing in the QPL, Part II. Concurrently, DESC completed certification of Motorola's Austin, Texas factory for all its MOS integrated circuits. QPL listing for additional M6800 Family components is being pursued at this time.

Now the MC6800 can be used for defense systems with greater confidence than ever, and with less delay and red tape.

M6800 Family hi-rel series expanding to 38.

M6800 Family hi-rel series components numbered 28 at the end of the first quarter, '78, with additions through the third quarter raising the projected total to 38. A hi-rel version of the MC3870 single-chip microcomputer also is due for availability in the third quarter. All M6800 hi-rel series parts are processed to MIL-Standard-883.

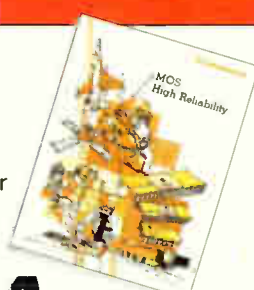
MIL-processed M6800 Family parts include the MC6802-6846 two-chip system, a variety of I/O functions, programmable timer, data link controller, MODEM, IEEE 488 bus interface, and plenty of memories: 1K and 4K Static RAMs, 4K and 16K Dynamic RAMs, EPROM, and 1K, 8K, 16K, and 32K ROMs.

Motorola Hi-Rel Microcomputer Components

Part Number	Function	Status
MC6800BQCS*	Microprocessor	Available
MC6800CQCS*	Microprocessor	Available
MC6802BQCS	Microprocessor with RAM and Clock	Available
MC6846BQCS	MC6802 Combo with ROM, I/O, Timer	Available
MC6802CQCS	Microprocessor with RAM and Clock	Available
MC6846CQCS	MC6802 Combo with ROM, I/O, Timer	Available
MCM6810BJCS	Byte-organized RAM	Available
MCM6810CJCS	Byte-organized RAM	Available
MC6821BQCS	Peripheral Interface Adapter	Available
MC6821CQCS	Peripheral Interface Adapter	Available
MCM6830BJCS	1K ROM	3rd Qtr '78
MCM6830CJCS	1K ROM	3rd Qtr '78
MC6840BTCS	Programmable Timer	Available
MC6840CTCS	Programmable Timer	Available
MC6850BJCS	Asynch Comm Interface Adapter	Available
MC6850CJCS	Asynch Comm Interface Adapter	Available
MC6852BJCS	Synchronous Serial Data Adapter	Available
MC6852CJCS	Synchronous Serial Data Adapter	Available
MC6854BTCS	Advanced Data Link Controller	Available
MC6854CTCS	Advanced Data Link Controller	Available
MC6860BJCS	0—600 bps MODEM	Available
MC6860CJCS	0—600 bps MODEM	Available
MCM2114BVCS	4K Static RAM	Available
MCM2114CVCS	4K Static RAM	Available
MCM4027BECS	4K Dynamic RAM	Available
MCM4027CECS	4K Dynamic RAM	Available
MCM4027BEBS	4K Dynamic RAM	2nd Qtr '78
MCM4027CEBS	4K Dynamic RAM	2nd Qtr '78
MCM4116BECS	16K RAM	3rd Qtr '78
MCM4116CECS	16K RAM	3rd Qtr '78
MCM68316EBJCS	16K ROM	Available
MCM68316ECJCS	16K ROM	Available
MCM68332BJCS	32K ROM	3rd Qtr '78
MCM68332CJCS	32K ROM	3rd Qtr '78
MC68488BQCS	General-Purpose Interface Adapter	3rd Qtr '78
MC68488CQCS	General-Purpose Interface Adapter	3rd Qtr '78
MCM68708BJCS	8K EPROM	Available
MCM68708CJCS	8K EPROM	Available
MC3870BQCS	Single-chip Microcomputer	3rd Qtr '78
MC3870CQCS	Single-chip Microcomputer	3rd Qtr '78

*The military equivalent part numbers for the MC6800 are JM38510/40001BQC and JM38510/40001CQC.

Our MOS high-reliability story is explained in a brochure covering wafer fabrication, assembly, testing, reliability, and how to order our hi-rel MOS products. For your copy, please circle the reader service number or write to Motorola Semiconductor Group, P.O. Box 20912, Phoenix, AZ 85036.



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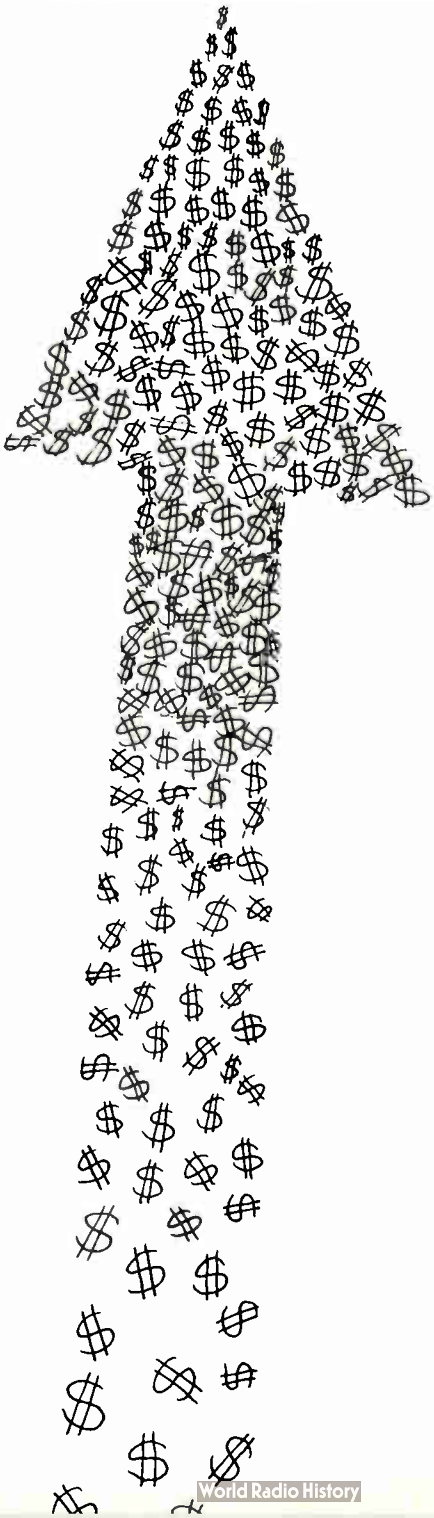
Semiconductor Group

Electronics executives are smiling

Agreement that business exceeds forecasts for most sectors goes with the big question: when the next slump will come



The three little words they're singing these days in the electronics industries are "business is booming." With 1978 conditions described as good to great, caveats voiced by some of the more cautious executives are muffled by the refrain from those who see nothing but market strength ahead.

Of course, nowhere is it written that conditions cannot turn down and take those optimistic forecasters with them. Inflation, assaults on the dollar, lack of a coherent national energy policy—all or any of these and other factors could have a stultifying effect on growth, sales, and profits. Still, as the hard-eyed analysts on Wall Street point out (see "Analysts see health," p. 82), never before have the electronics industries been so well prepared to ride out a recession.

Better. In the semiconductor industry, where friendly differences of opinion are the rule, there is agreement that business so far this year has been better than most had expected. The Semiconductor Industry Association, for example, had predicted a 10½% growth rate; manufacturers now expect a figure closer to 15%.

One company that forecast a 15% growth rate right from the start was Texas Instruments Inc. Breaking that down further, James L. Fischer, senior vice president for U.S. and Asian semiconductor operations, sees a growth of 7% for discrete-device sales and 22% for integrated circuits. "The strongest sector is computers," he says, "but we see strength across the board—in the distribution, consumer, and industrial sectors as well." Business in the military segment is steady, he adds.

In Silicon Valley, after toting up the increased bookings and looking in vain for signs of a downturn, most semiconductor makers have increased their expansion appropriations. "We had already planned to increase our facilities, but now we're working the high side of our projections," says James C. Harwood, president of Signetics Corp.

Fairchild Semiconductor is increasing its capital equipment expenditure by 35%. National Semiconductor is just making expansion plans now, not because of cautiousness but because its fiscal year does not end until May 31. And Intel's president, Gordon E. Moore, says the biggest obstacle to expansion is not necessarily any of the economic imponderables, but finding enough qualified personnel.

Some hard lessons about inventory and double ordering were learned in the 1974 recession, and the industry seems to be profiting from them. "We're trying to keep a balanced capacity so that there is no need for someone to order 40 weeks in advance," says National's E. Floyd Kvamme, senior vice president and general manager of the Semiconductor Products division. George D. Wells, senior vice president at Fairchild, notes, "Like us, the customer learns. Most say, 'The last thing we will ever do is double-order again.' "

Back east, the view is as bright as it is in the Golden State. Bernard V. Vonderschmitt, vice president and general manager of RCA Corp.'s Solid State division, sees a healthy inventory situation and no great rush to double-order. However, he expects the economy to weaken going into 1979, possibly making 1978 a replica of 1977, with slower growth in the second half.

For General Instrument Corp.'s Microelectronics division, the second half is eagerly anticipated by Andy R. Sass, director of product planning, for its expected July–August influx of orders from the consumer marketplace. For GI, the year to date has been particularly good for industrial products, with shipments of semiconductors exceeding last year's first half by 30%.

Amid all the bullishness, Motorola Inc.'s Semiconductor Group is taking a cautious stance. "We've had a great start in 1978," says Pasquale Pistorio, director of world marketing, "but it wouldn't be wise if we were to relax our cautious attitude and control of expansion. There is need to be vigilant." John Welty, vice president and general manager, adds, "Over the past few years, the industry has experienced a bookings pause at the beginning of the third quarter. In 1976, the 'pause' extended through the second half of the year; in 1977, it ran from August through October." So he, too, expects markets to soften in the second half.

Prosperity. For computer makers, the vista is perhaps described best by Donald M. Fuller, chairman and president of Microdata Corp. His growth projection for what he describes as the low-end, transaction-oriented marketplace is in the range of 30% to 35% compounded annually. The only problems he sees are those of prosperity: applications engineers and software and service people are hard to find.

"There are fewer doubts and negatives now than in other years," says Lawrence A. Goshorn, president and chairman of General Automation Inc. He credits the business surge to efforts to reduce labor-intensive operations.

In Wellesley, Mass., president Kenneth Fisher of Prime Computer Inc. calls predictions of 80% to 90% growth for Prime "in the ball park." His company doubled sales each of its last three years, though, with the 1977 figure totaling $50 million, that probably will not happen this year. Still, Fisher remains bullish, saying, "I think our industry may be underestimating the demand. Some companies are basing their predictions on forecasts of a business pullback by the end of this year or in 1979, but we don't see it."

Minicomputer giant Digital Equipment Corp. looks for reasonably good growth in the fiscal year starting July 2. It will probably wind up doing sales of $1.4 billion to $1.5 billion, up from $1.05 billion last year, which was a 44% increase over the previous year. Andrew C. Knowles III, vice president for marketing, is a bit cautious. "I don't see a downturn," he says, "but we can't maintain the kind of momentum we have historically."

He expects DEC's growth to be in the 20% to 30% range. "The end-user business is holding up fairly well, with the OEM [original-equipment manufacturer] business slowing more than others, and microcomputers coming on strong," he says.

Instruments. The test and measurement instrument sector appears to be in a healthy state (see table on p. 83), says John W. Zevenbergen, president of John Fluke Manufacturing Co. Through May, the order

ESTIMATED U.S. SEMICONDUCTOR SALES
(MILLIONS OF DOLLARS)

	1975	1976	1977	1978	Est. annual growth rate 1977 – 1981
Total semiconductor	1,790	2,291	2,572	2,855	12 %
Discretes	800	921	888	830	–3 %
Integrated circuits total	990	1,370	1,604	2,025	16 %
Digital bipolar	360	504	558	545	–1 %
MOS	430	590	777	1,105	29 %
Linear	200	276	349	375	15 %

SOURCE: SEMICONDUCTOR INDUSTRY ASSOCIATION, GOLDMAN SACHS

Analysts see health

The electronics marketplace appears healthier than ever, according to Wall Street analysts. Not only are incoming orders robust, backlogs at record levels, and inventories quite clean, with a minimum of double ordering, but the industry's ability to weather a downturn or a recession is perhaps at an all-time high.

"Business has been pleasantly strong in all aspects of the industry, from components on up through systems," says Hans C. Severiens, vice president at Merrill Lynch, Pierce, Fenner and Smith Inc. "It is hard to find an industry segment that is weak. All of them are going into the second half of 1978 with record backlogs." Thus, it looks to him as though the industry will be in a healthy situation for the third and fourth quarters.

Despite this bright picture, Severiens sees slower growth rates in incoming orders as the summer starts. But "with the head of steam the industry has built, it would surprise me if the summer correction will be as severe as it was last year," he adds. Similarly, he sees the national economy going into a slowdown in 1979, but the electronics industries "won't be hurt very much by it. In that next recession, instrument and computer companies will continue to grow and semiconductor firms, although they may not be up, won't suffer as they did in 1974 because their inventory situation is under control." Hence, while 1979 will not be up as much as this year, Severiens forecasts, "it will be an up year, nonetheless."

Less bullish for this year's second half and for 1979 is Sal F. Accardo, vice president at Kidder, Peabody and Co., who sees the increase in semiconductor demand approaching 20% for 1978's first half but leveling off at 15% for the full year. "I see a possible slowdown in the second half led by consumers who may stop buying because of inflation fears and aggravated by capacity build-up at both the user and manufacturer levels," he says. Similar views are held by Kent A. Logan, vice president at Goldman Sachs and Co., who envisions the rate of acceleration in semiconductor orders turning down and, eventually, flattening. This is due to what he predicts will be "a slowing down of final equipment sales and involuntary accumulation of inventory" in the third and fourth quarters of 1978.

Unlike last year, he says, when the second half slowdown was more seasonal than cyclical, the reverse will be true this year. Logan expects that the slowdown will carry into the first half of 1979 but, he notes, "will be nowhere near as bad as in 1974." Accardo concurs. "Were a recession to develop, the industry may hold up better than in past recessions."

Accardo sees several key semiconductor markets, such as the telecommunications and defense industries, holding up well. "There may be a nice incremental demand next year from Detroit," he says, because of mandated fuel-economy and -emission standards. These and other factors "indicate that the semiconductor industry may not perform as badly as has been its pattern in past recessions."

The test and measurement instruments industry may fare even better. As was the case in 1977, the instruments market is growing faster than that for semiconductors. "Orders are up 15% to 20% thus far and for the full year may rival last year's growth of 20% to 25%," says Accardo. What's more, if there should be a recession, "demand for instruments should hold up better than that for semiconductors."

Logan of Goldman Sachs sees it differently. While capital spending is picking up across the board, he believes the instruments industry "may have a rougher time in late 1979" than the semiconductor sector. Capital spending will be fairly strong through early 1979, he says, suggesting that the slowdown in instrument orders will lag behind that in semiconductor orders, probably not occurring until the second quarter of 1979.

Managers of many electronics firms were quite cautious as recently as mid-1977 with respect to what they anticipated the demand to be for their products and "kept the lid on capital and discretionary spending," he notes. "Now backlogs are at record levels and incoming orders are quite strong. Thus, they are starting to step up capital spending and raising discretionary spending, perhaps, just at the wrong moment," Logan concludes. **Bruce LeBoss**

ESTIMATED WORLDWIDE INSTRUMENT SALES
(MILLIONS OF DOLLARS)

	1974	1975	1976	1977	1978	Projected growth rate
Voltage, current, and resistance measurement	145	155	165	180	220	12 %
Frequency and time measurement	110	120	130	145	175	11 %
Oscilloscopes	325	350	360	425	485	9 %
Other waveform analyzers	115	130	140	155	200	15 %
Signal sources	235	250	265	305	350	12 %
Automatic test equipment	215	210	225	280	330	12 %
Other	455	485	515	560	640	8 %

SOURCE: GOLDMAN SACHS

rate has been a little stronger than forecast, up nearly 53%, he says. Fluke plans to start construction in the Seattle area on a 73,000-square-foot facility. At GenRad Inc., which also makes automatic test equipment, president William Thurston does not see a downturn, saying predictions of one are based purely on speculation.

B. J. Moore, president of Biomation Corp., agrees that business is good, particularly overseas. He expects the rest of the year to continue in that vein for the industry as a whole. However, for his Cupertino, Calif., firm the growth of the logic analyzer market has slowed and will not reach the 15% predicted for 1978. The test and measurement instrument picture is a different story for Biomation: there, Moore expects to see good growth through the first half of 1979.

Upswing. The consumer industry, notorious for its ups and downs, is now on one of its more spectacular climbs. Makers of calculators, video games, television sets, and audio systems talk about record sales. With production at capacity for the upcoming Christmas season, most observers predict double-digit sales growth at least through the first half of 1979. Games are hot, and foreign competition for TV makers has eased, though it is still a problem.

In games, microprocessor-based models have led the way. Atari Inc. has doubled its volume over last year's similar period, and Bally Manufacturing Co., which markets higher-priced games, is preparing for the advent of the home computer as it expands its distribution network.

Sums up Mike Shey, Atari's marketing director, "Only 15% of the homes in America currently have video games, so the potential market is largely untapped."

Atari is sitting pretty because it believes its own forecasts. Last year, anticipating a doubling in volume for 1978, the company went ahead and doubled its plant space and capital equipment expenditures. And business so far this year has doubled.

Sharing Atari's bullishness is General Instrument, one of the major suppliers of LSI for video games. GI will sell about a third of its consumer chips this year to makers of programmable games, though it still sees a healthy growth curve ahead for dedicated chips.

Among the TV makers, RCA, General Electric Co., and Zenith Corp., beset for years by Japanese competitors, now find the balance shifting in their favor after the Japanese government agreed to limit exports. All three report record May sales—for Zenith the increase was 46.9% over May 1977—though Walter Fisher, Zenith's executive vice president for sales, says that the offshore quota system "just prevents it from being a runaway and is not leading to fair, direct competition."

RCA, which says it doesn't count on import quotas to improve sales, has shaped its sales strategy around high-end color TVs and the promising replacement market. Now, says Jack Sauter, division marketing vice president, both are starting to peak. □

Reporting for this survey was provided by Robert Brownstein in Palo Alto, Larry Waller in Los Angeles, Larry Armstrong in Chicago, Lawrence Curran in Boston, and Bruce LeBoss and Francis Duffy in New York.

Communications

Communications bill finds few friends

Proposed reorganization of phone and broadcasting markets criticized by Government and industry telecommunications chiefs

by Ray Connolly, Washington bureau manager

Superficial, sophomoric, and confusing.

These and similar derogations are being used by most industry and Government telecommunications executives in private conversations to describe new congressional legislation designed to deregulate and open America's telephone and broadcasting markets to competition and a free flow of technology. The two ranking members of the House subcommittee on communications, Rep. Lionel Van Deerlin (D., Calif.), chairman, and Rep. Lou Frey Jr., the panel's minority leader, introduced early this month the legislation containing 217 pages of sweeping changes (see "The big shakeup of 1978," p. 85).

Comments for attribution were guarded for the most part as interested parties sought to study the bill's implications before hearings begin next month. The Electronic Industries Association's John Sodolski, Communications and Industrial division vice president, believes the bill's sponsors are optimistic in their 1980 enactment goal because of the comprehensive nature of the legislation and its vulnerability to amendment.

"There are a number of developing areas like land-mobile communications as well as citizens' band radio that are not referenced directly at all," he points out, "and these need clarification to eliminate confusion." There is "a potential defect, too," Sodolski says, "in that it doesn't address the complex issues of internationalization" as global communications rapidly expand. In the international area, the Van Deerlin bill calls only for a task force to coordinate international facilities planning.

American Telephone & Telegraph Co.'s vice chairman William Ellinghaus proved most outspoken in an initial survey of 12 affected organizations, favoring some segments of the bill and opposing others.

Predictably, its proposal to free AT&T from the restraints of the 1956 antitrust consent decree limiting it to telephone services is welcomed by Ellinghaus. It would permit AT&T to form subsidiaries to enter the computer services market by linking its advanced Electronic Switching Systems to push-button telephones, and would also allow telephone companies to offer television programs to subscribers in competition with cable TV companies and broadcasters.

Hits hardware ban. On the other hand, AT&T opposes the provision that would bar monopoly carriers from making telecommunications hardware. That would require AT&T to divest Western Electric Co. three years from enactment of the law. The abolition of such vertical integration, Ellinghaus contends, "would slow technological innovation, increase the cost of facilities, and lead eventually to higher rates for service."

While General Telephone & Electronics Corp., the largest domestic competitor of AT&T, took much the same stance, other prospective large competitors were more cautious. For example, ITT Corp. and Communications Satellite Corp. say they are still studying the bill and probably will not comment publicly before hearings start. Satellite Business Systems Inc., the potential communications giant owned by IBM, Aetna Life & Casualty, and Comsat General Corp., says only that it "supports the legislation's suggestion of expanding the availability of competitive telecommunications services and a less stringently regulated environment." Even the pro-competition Ad Hoc Committee for Competitive Telecommunications, made up of small communications companies, speaks cautiously of the bill as an "excellent beginning" with "a very positive intent."

Independent equipment makers of the North American Telephone Association modify their high praise of the legislation's pro-competition "spirit" by calling for checks to protect smaller competitors from being overwhelmed by AT&T's entry

Backer. Rep. Van Deerlin of California heads House communications subcommittee and is sponsoring reorganization measure.

The big shakeup of 1978

Key provisions of H. R. 13015, the Communications Act of 1978, include:

- **Regulation:** replace the seven-member Federal Communications Commission with a five-member Communications Regulatory Commission whose presidential appointments would be limited to single terms of 10 years instead of the FCC's renewable seven years. CRC's 25% smaller staff would result from a new policy to substitute "full and fair" telecommunications marketplace competition for regulation. Common carriers would be free to compete for any service through subsidiaries but could not make equipment if they maintained a monopoly service. The CRC would retain powers over equipment quality control. More important, it would exercise Federal control over intrastate telecommunications, like telephones, that use radio frequencies in direct distribution of service to consumers.
- **Policy:** create a National Telecommunications Agency as a separate, executive policy-making body, with spectrum-allocation powers, to replace the National Telecommunications and Information Administration just beginning operations in the Commerce Department.
- **Broadcasting:** retain only technical rules for radio and TV broadcasters, eliminating the three-year license-renewal requirement immediately for radio and over 10 years for television. Both would be replaced with open-ended licenses subject only to legal challenges. New or revoked licenses would be awarded by random selection—much like a lottery—rather than by commission determination of the best-qualified candidate after hearings. License ownership would be limited to five radio and five TV stations, including at most three TV in the top 50 markets. This would affect only new licensees.
- **Fees:** administrative costs of the new CRC and NTA would be paid by fees—estimated at $400 million after 10 years—paid by licensees based on the "scarcity value" of the spectrum used and license processing costs, with fees—estimated at $400 million after 10 years—from licensees based on license would pay a high fee, less for a uhf or small vhf market station, with only nominal fees charged for multiuser channels like citizens' band. The money would also finance public TV through a new nine-member Public Telecommunications Programming Endowment replacing the Corporation for Public Broadcasting; it would also support rural telecommunications facilities loans, plus minority-group broadcast interests through a 30-year, low-interest loan account.

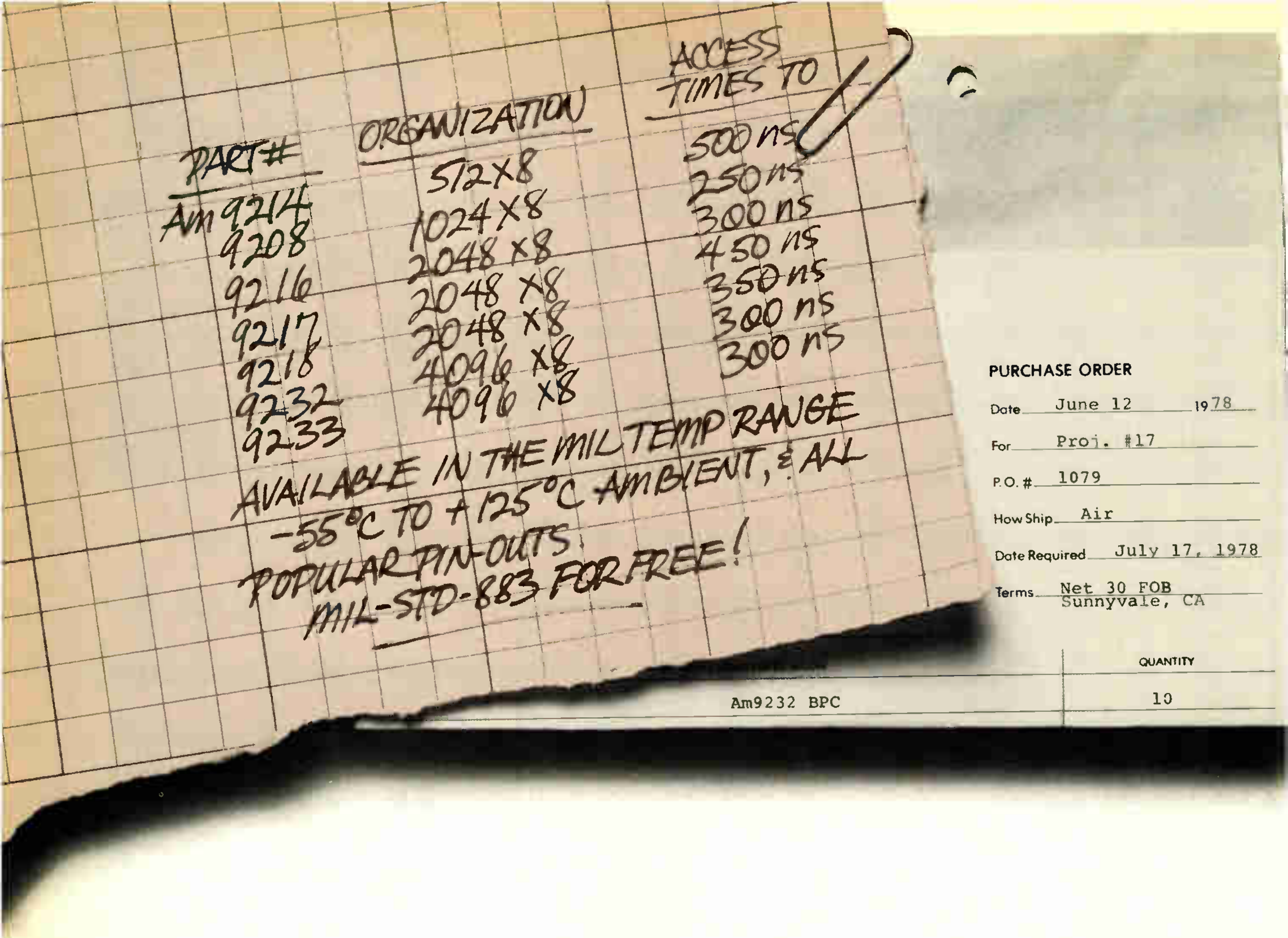
into any market if the 1956 antitrust constraints were removed.

Similar fears were expressed by individual independent equipment makers, who believe AT&T, using its affiliates, will undertake a massive lobbying effort to amend vague sections of the bill in its favor. That is how they read the observation by AT&T's Ellinghaus that "the Congress is a more appropriate forum for resolution of this issue than are the courts."

FCC stance. At the Federal Communications Commission, sources say chairman Charles Ferris is unhappy with many aspects of the bill. For starters, there is the provision that would permit totally uncontrolled equipment competition by independent Western Electric Co. and other giants, like IBM, certain to enter the market. Ferris says only that the agency has "started to take a 'zero-based' look at our own regulations and will develop our view on the rewrite bill based on that."

Politically, there are signs that the Van Deerlin bill is in trouble already. Apart from Rep. Frey, who admits he has reservations about some aspects of the legislation, none of other 12 subcommittee members was asked to cosponsor the bill. Moreover, House Speaker "Tip" O'Neill is reportedly unenthusiastic about the sweeping scope of the legislation.

Other signs being read as significant are the silence of the White House and of Sen. Ernest Hollings (D., S. C.), chairman of the Senate's Communications subcommittee and Van Deerlin's counterpart in the upper chamber. Hollings, staffers report, is "taking a let's-wait-and-see approach" to the legislation until the air clears, and has no plans to introduce a matching proposal in the Senate. □



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Computers

Emulators move in on Nova

National Computer Conference sees introduction of models by Ampex, Lear Siegler, and SCI

by Anthony Durniak, Computers Editor

The emulation fever that has hit the IBM computer market in the last month appears to be spreading. This time the target is Data General Corp.'s Nova minicomputers.

Although they are not the first to do so, Ampex Corp. of El Segundo, Calif., Lear Siegler Inc. of Anaheim, Calif., and SCI Systems Inc. of Huntsville, Ala., unveiled their emulators earlier this month at the National Computer Conference in Anaheim. Their predecessors have been beset by legal challenges from Data General, but the new competition is confident it can avoid those obstacles.

The Nova emulators' introduction follows last month's introduction of several IBM-compatible mainframes to compete with the compuer stand on its own ground [*Electronics*, May 11, p. 81; May 25, p. 93] and Amdahl Corp.'s earlier success with its IBM-compatible machines.

Among minicomputers, the Nova is the most attractive to emulate, the new contenders say, because of its popularity, primarily with original-equipment manufacturers and systems houses: the estimated demand is close to 15,000 Nova minis a year. This popularity has also fostered development by independent companies of Nova-compatible software and peripherals.

"There is a lot of software available that is compatible with the Data General Nova that we can buy," says Cathy Raftery, product marketing manager for Lear Siegler's VDP series. "The Digital Equipment market may be bigger, but there aren't as many independents with DEC software and peripherals available."

Models. Lear Siegler's VDP 410 computer, which emulates the Nova 1200, can support 64 kilobytes of memory, has a 200-nanosecond instruction cycle time and uses Fairchild's 9400 series of 4-bit-slice microprocessors. Without software, it sells for $3,500. The VDP 1000 system, which includes the computer with a 10-megabyte disk, plus the ADM-3 cathode-ray-tube terminal, a 300-series 180-character-per-second bidirectional matrix printer, and a virtual-memory operating system, is priced at $18,000.

Ampex's Model 12 minicomputer also emulates the Nova 1200, using bit-slice technology from Advanced Micro Devices. It can handle as much as 128 kilobytes of directly addressed memory, has a 300-ns central-processing-unit instruction cycle, and is priced at $3,975 in OEM quantities with a five-slot chassis and 64 kilobytes of memory.

OEM marketing manager Al Sroka argues that such firms prefer the Nova because "interfacing to the Digital Equipment Unibus is mo[re] complicated." Since Ampex alread[y] supplies OEMs with Data Genera[l]-compatible add-in memory, dis[k] drives, and tape drives, it was natu[ral] to offer the computer, he adds.

"Our Data General-compatibl[e] memory was well received and w[e] were already known as a prove[n] supplier," Sroka says. "We no[w] offer our OEM customers one-sto[p] shopping. Looking at the way th[e] add-in business was expanding, w[e] saw that we must supply it all."

Like his competitors, Olin King[,] president of SCI Systems, intends t[o] concentrate on OEM customers. "[I] won't compete head to head wit[h] Data General for end users, but t[o] the OEM I'm offering speed and flexi[-]bility," he says.

The Mercury 3 minicompute[r] from SCI uses standard Schottk[y] transistor-transistor logic and has th[e] speed and instruction set of the Nov[a] 3, he says. The Mercury has a three[-]processor architecture that provide[s] for concurrent handling of memory[,] input/output devices, and arithmet[-]ic/logic functions and can suppor[t] 128 kilobytes of directly addresse[d]

Emulator. Lear Siegler's Cathy Raftery says there is a lot of software available that is compatible with the Nova minicomputer.

memory. A computer with 64 kilobytes of memory will cost about $5,000.

Danger. But hanging over the business is a threat: lawsuits. Digital Computer Controls, Keronix, and Fairchild Camera and Instrument Corp. have all introduced units compatible with the Nova instruction set and were promptly sued by Data General for patent infringement and theft of trade secrets. A Data General spokesman says it won its case against Digital Computer Controls, which it later acquired. The others still market their Nova-compatible units, but the lawsuits are pending.

The new entrants claim they can avoid lawsuits because their machines' internal designs are different from Data General's, even though their computers are compatible with the Nova instruction set, memory organization, and I/O architecture. By offering operating systems and programming-language compilers developed by independent software houses, they will help customers avoid violating their Data General software licenses.

Not pleased. However, Data General's senior marketing vice president, Herbert Richman, is not flattered by all the imitation. The firm's lawyers are studying the situation, he says.

"We've been so successful with that particular product that people are trying to get on the bandwagon. It demonstrates we have the most elegant computer architecture. But we'll maintain our rights and file suit where we feel we've been violated."

A former Data General competitor, Phil Goodman, previously marketing vice president at Digital Computer Controls and now marketing vice president at Digi-Log Systems, agrees that the Nova emulator market is a good one. As he points out, "When DCC was acquired by Data General they had revenues of about $20 million."

He feels that Data General's acquisition of the firm left a market need that the new competitors hope to fill. But he warns that the market may become oversaturated. "They're all thrashing after the DCC customer base. It's a large pool of sharks snapping at a small school of fish." □

Probing the news

the development of prototype systems; its development budget has leaped from $25,000 two years ago to today's $250,000. The team will install another six systems and plans to solicit proposals for 25 more by the end of the year.

"The techniques have been here for years," says John P. Corrunker Jr., chassis quality assurance supervisor at Ford and the manager behind the firm's push to contactless inspection. "But industrialization—making the equipment live in our manufacturing environments—is very recent." He cites a pair of television cameras that Ford installed four years ago in an Indianapolis plant. "The program was successful for several months," he says, "and the equipment is still there, but it hasn't worked for years."

Now, however, buoyed by the reliability of recent installations, Ford is steering more of its plants to optical inspection. "For all new gauging programs, we are quoting both contact and contactless systems, and we're recommending that our divisions go with an automated, noncontact system," Corrunker says. And though the firm is studying contactless inspection approaches that use such instruments as an audio spectrum analyzer to listen for unusual gear noises, optical systems account for the lion's share of the noncontact inspection techniques that it is funding.

Simple change. The optical systems also allow the company an inspection flexibility to which it is unaccustomed. Last month, for example, it equipped an axle-manufacturing line in Sterling Heights, Mich., with a microprocessor-based system that looks at the axle's ring gear to determine the axle gear ratio [*Electronics*, May 25, p. 44]. "As we start building different axles on the line, the only component in the system that we have to change is the programmable read-only memory that stores the look-up table," points out Dennis G. German, advanced gauging engineer at Ford.

Besides the axle inspection system, other Transmission and Chassis division installations include:

- A microfinish sensor in Ford's San Juan, Puerto Rico, plant that uses reflected laser light to look through grinding oil to check for a smooth finish on the input shaft of a power steering pump.
- A second laser that searches for a series of threads tapped into a ⅛-inch hole in the end of the same input shaft. From 2 feet away, the system's photodiode detector array counts the first eight threads, determines their direction and spacing, and checks for burrs, nicks, and broken taps.
- Another optical inspection system in the Sterling Heights plant that scans down the side of a bearing cup that is 3½ inches deep. It is looking for an undercut that is necessary to dissipate heat from the drive-shaft's U-joint bearings.
- A split-beam, scanning laser system in the Sharonville, Ohio, transmission plant that looks at each end of assemblies built there, ensuring that three 0.022-in.-thick washers are in place.

Too much. Although Ford has harnessed helium-neon lasers for most of its jobs, it is already beginning to turn to simpler, more reliable light sources. "In some applications, a gas laser is overkill," German says. "It offers a level of sophistication that we don't need." Even though the lasers the company opted for were in the milliwatt range, stringent Government regulations controlling them resulted in more red tape than the firm bargained for. Further, "we've had reliability and shelf-life problems with gas lasers," German adds. "Their manufacturing quality has simply deteriorated over the past few years."

For those reasons, most new optical systems at Ford probably will rely on more conventional light sources. The axle-inspection system, for example, was conceived using a laser source, but implemented with a pair of quartz halogen lamps normally found in film projectors. The firm is also toying with 10-cent tail-light bulbs to project profiles of parts on detector arrays or to light parts sufficiently for imaging with photodiode detectors. It has even found that light-emitting diodes will supply enough reflected light to spot some surface imperfections. □

Instrumentation

New standard has long way to go

Lack of enthusiasm among makers of data terminals for interface specs designed to replace RS-232-C reflects feelings of customers

by Robert Brownstein, San Francisco bureau

It's one thing to ordain a standard, but it's quite another to sell it. The fact is, as makers of data terminals are finding out, that it is the marketplace that governs acceptance, here as in so many other cases.

The standard in point is actually a set of specifications that governs data-communications terminal interfaces. Written by the Electronic Industries Association's subcommittees TR30.1 and TR30.2 as RS-422, -423, and -449, it is designed to replace the decade-old RS-232-C (see "Presenting a new interface," below). But although interest in the new requirements is high, a survey of terminal makers shows that most do not yet offer it as an option. What's more, they do not intend to do so until they feel some customer pressure for it. That pressure, they say, has yet to be exerted.

In contrast with how quickly the 8-bit, parallel-interface standard (IEEE-488) was adopted, the terminal-interface standard is off to a slow start. However, the new standard's predecessor has been and still is the most widely used interface for serial data communications, whereas 488 had no entrenched standard to compete against.

Calling RS-232-C entrenched is putting it mildly: it is so pervasive that it is hard to make a good case for adopting the new standard unless the application specifications exceed the capabilities of the older one. "The new standard will become more accepted as designers realize they need greater distance and data-speed capabilities than are possible with RS-232-C," states Walter B. McClelland, chairman of subcommittee TR30.1, which was responsible for the standard's electrical specifications portions, RS-422 and -423. Functional and mechanical requirements are described in RS-449, written by subcommittee TR30.2, which is headed by Hal Folts of National Communications Service, Washington, D. C.

A. Philip Arneth, advisory engineer at IBM Corp. in Raleigh, N. C., who is chairman of EIA committee TR30, parent of the two subcommittees, says he expects the first real push for the new interface to come from Federal government requests for quotations on new equipment. IBM is one of the firms that does not offer the new interface in its data-terminal line, joining such manufacturers as Conrac Corp. and Ann Arbor Terminals Inc. On the other hand, some of the makers of cathode-ray-tube display terminals plan to offer it. One of them, Lear Siegler Inc. of Anaheim, Calif., intends to include it in its new ADM-42 and possibly the ADM-31 models, says Paul Michelson, design engineer.

Required. The new standard is already mandatory in all new designs for Federal equipment, McClelland points out. Furthermore, committee meetings have been attended by representatives of such notables as Belden Corp., Bell Laboratories, Honeywell Information Systems, IBM, Sperry Univac, and Teletype Corp. Other recent attendees have included Advanced Micro Devices, Fairchild Semiconductor, Motorola Semiconductor, National Semiconductor, and Texas Instruments, with AMD, National, and TI already making some integrated-circuit line drivers and receivers that operate within the specifications set

Presenting a new interface

The new standard put together by the two subcommittees actually consists of three sets of requirements that, as a group, establish the full electrical, functional, and mechanical characteristics for the new interface. All three must be incorporated in designing either a single-ended or a differential interface for data-communications terminals.

The standard that is to be replaced, the RS-232-C interface, issued by the Electronic Industries Association in 1969, is a single-ended bipolar voltage circuit that can handle data rates up to 20,000 bits per second up to a distance of 50 feet. The RS-423 is also single-ended, but it extends the data rate to 300,000 b/s at 40 ft while offering 3,000 b/s rates at 4,000 ft.

RS-422, a differential balanced voltage standard, ups the data-rate capability to 100,000 b/s at 4,000 ft and all the way up to 10 million b/s over shorter distances. What's more, the differential input gives the interface better noise-immunity characteristics, since noise appears as common-mode signals to the input and is rejected.

RS-449 is the third of the new group—it was issued last November—and is the functional and mechanical standard. It describes 30 interchange circuits and defines a 37- and 97-pin interface-connector pair, along with pin assignments, for connecting to data-terminal equipment and data-circuit terminating equipment.

by standards RS-422 and -423.

One snag delaying acceptance of the new standard is the problem of adapting it to digital party-line, or multipoint, data-communications systems, says Roy J. Levy, senior applications engineer for bipolar products at AMD. Levy says the committee's standard did not address such use, but the higher data rates did create interest in the standard for this application.

Moreover, there has been some pressure from Europe, where the CCITT recommended V.10 and V.11, based on RS-422 and -423. The French pushed for a digital party-line capability, creating a need for three-state drivers, says Arneth, but 422 and 423 call for two-state types. The next meeting of subcommittee TR30.1 is scheduled for July in Boston, and the subject of party-line applications is on the agenda, McClelland says, and a November CCITT meeting in Geneva is likely to consider the same topic.

The problem surrounding the new standard's use in multipoint systems is related to common-mode voltage differences between drivers along the line. McClelland says that conferees will try to tighten allowable offset limits in the RS-422 specification (it is now 3 volts) at the Boston meeting and to iron out some of the other impediments to multipoint applica tions. "We will have some fairly sticky problems to overcome," he admits.

In minis. At any event, Levy does not see the new interface being designed first into standard (up to 9,600-baud) data-communications systems. "I think you'll see it in the next go-around of minicomputers because of the increased line length allowable," he says. For 9,600-baud looping communication networks, RS-232-C is adequate, but a 4,000-foot line tied to a RS-422 interface would let the system poll an entire building, making it an attractive interface for the new mini systems, Levy believes. "I expect the new interface to back into the mass market slowly," he adds.

Until there is a large demand for the new interface, it is unlikely that major terminal manufacturers will offer it. Even the smaller manufacturers, who might gain a market edge, have been vague about plans to offer the new interface. Zentec Corp. of Santa Clara, Calif., manufacturer of intelligent terminals, which offers it as an option with its ZMS 50 and ZMS 70 terminals, is not sure whether it works in a real-life system.

"We tested it and it appears to do the job," says Lionel Martin, director of engineering, "but there are no computers out there with the interface to test it with." Nevertheless, while updating the RS-232-C and current-loop boards, Zentec's design engineer felt that he could accommodate RS-422 and -423 with little extra effort. As a result, the larger ZMS 70 system has the interface as a strap option, and the smaller ZMS 50 offers it as a board choice. □

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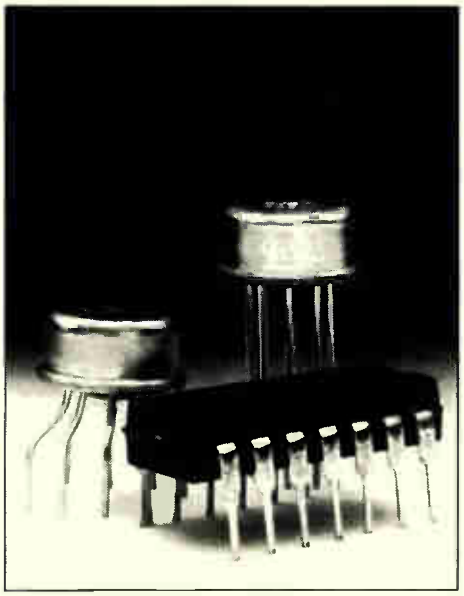

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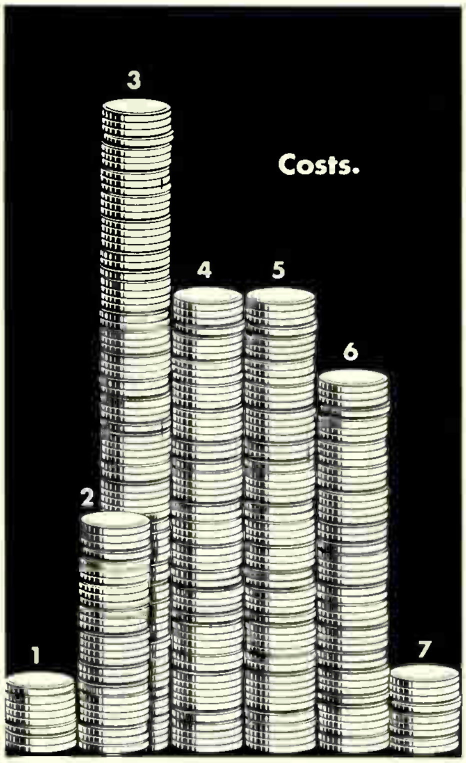

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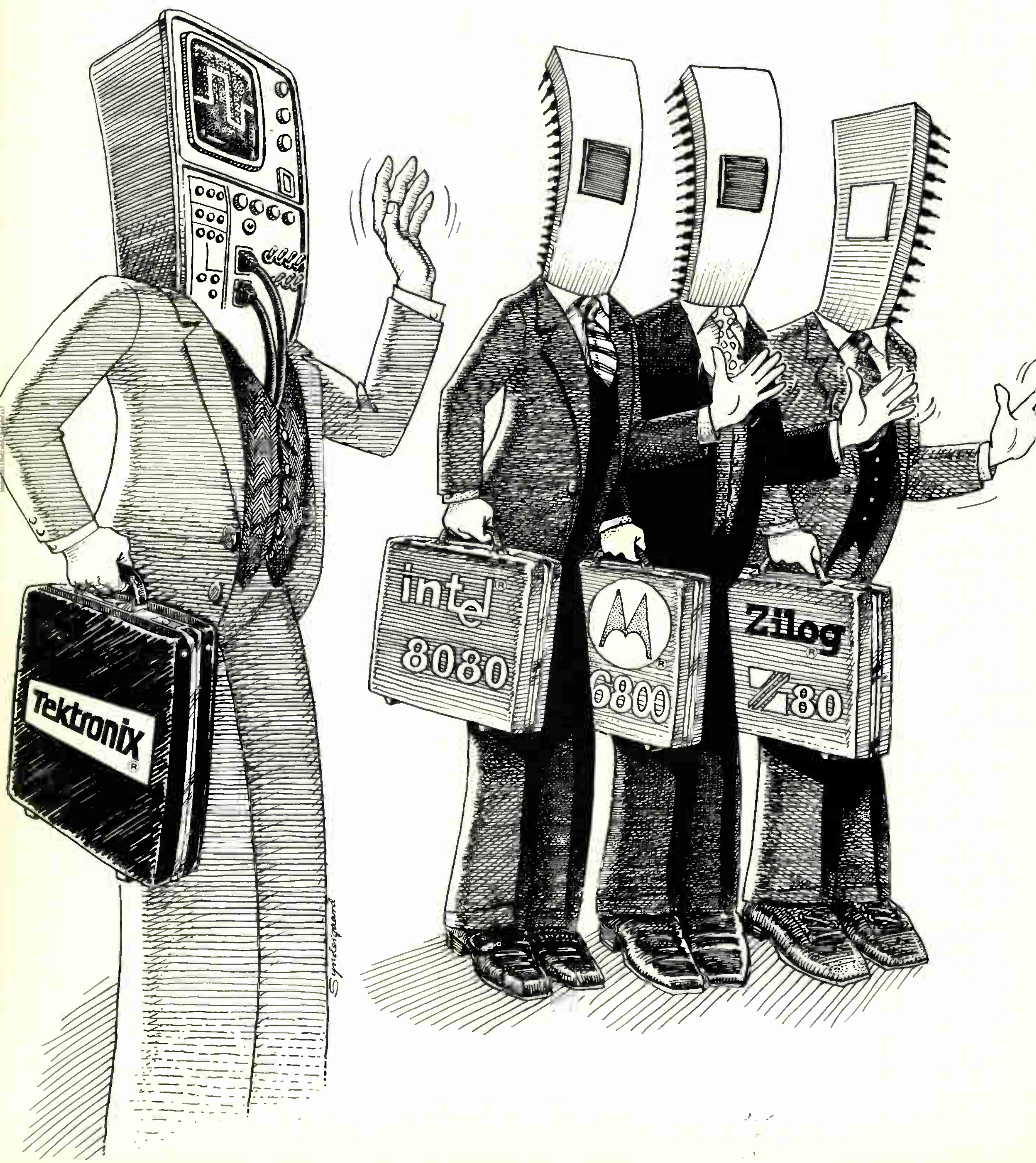

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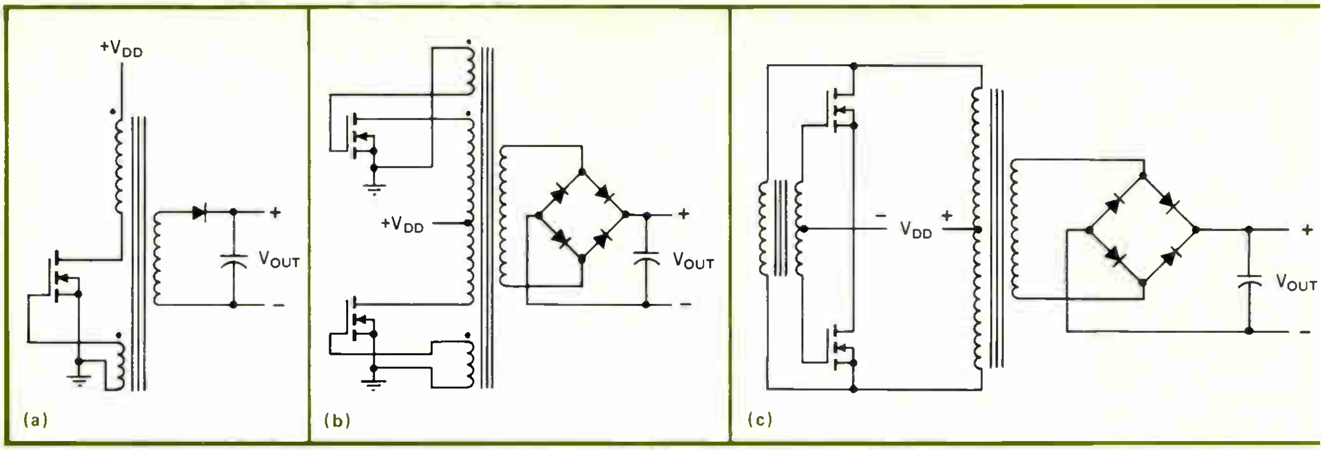
Higher power ratings extend V-MOS FETs' dominion

Handling new highs in current and voltage, they are moving into rf amplifiers, switching power supplies, motor controllers, and audio amplifiers; high-efficiency switching amplifiers are likely

by Arthur D. Evans, David Hoffman, Edwin S. Oxner, Walter Heinzer, and Lee Shaeffer
Siliconix Inc., Santa Clara, Calif.

☐ The banner of power V-MOS is being raised over more and more applications these days. Since the appearance of the first moderate-wattage power MOSFETs about two years ago, performance ratings for these field-effect transistors made with vertical-groove metal-oxide-semiconductor technology have climbed to a new high at both audio and radio frequencies. Low-frequency devices able to handle 400 volts at 4 amperes and 80 V at 12.5 A are now becoming commercially available, as are units capable of delivering up to 125 watts in the rf region.

These developments are opening up a whole new range of applications for power V-MOS, not only in rf amplifiers but also in switching power supplies, motor-speed controllers, and audio amplifiers, and for switching analog signals. What's more, at rf, V-MOS transistors are promising the realization of switching amplifiers that



can operate at efficiencies in excess of 90%.

With good reason, V-MOS FETs are competing for the same sockets as bipolar transistors in the power domain, where the latter have long held sway. In general, power FETs offer a number of performance advantages over equivalent bipolars (see "The inside story on power V-MOS," p. 110). All in all, these various strengths mean a V-MOS circuit that outperforms its bipolar counterpart in key respects.

Traditionally, switching power supplies operate at frequencies of 20 to 25 kilohertz; but within limits, the higher the frequency, the better the performance. As frequency increases, inductors or transformers become smaller, circuitry becomes less complex, weight decreases, and filter capacitors also get smaller, so transient response time goes down. Because of these advantages, power-supply manufacturers have recently been pushing operating frequencies up to the region of 50 to 60 kHz. Even higher-frequency operation would be desirable, but the relatively slow rise and fall times of bipolar power transistors have limited the ultimate switching speed.

Higher efficiency for switching supplies

V-MOS power FETS, however, can switch from 10 to 100 times faster than equivalent bipolars, and devices are now becoming commercially available that are able to switch 10 A of current in as little as 50 nanoseconds. For switching power supplies, that means smaller components, as well as improved overall efficiency. In the majority of switching applications, most of the transistor power loss occurs during the transition times. Because V-MOS transistors switch extremely fast, the power dissipated during transitions is reduced. Also, the high input impedance of these devices results in very low drive-power requirements, so switching supplies can operate more efficiently. In fact, typical steady-state input current is less than 10 nanoamperes, permitting power V-MOS transistors to be driven directly even from a complementary-MOS gate.

What is more, the safe operating area of these devices is not restricted by secondary-breakdown limitations and the temperature coefficient of their drain current is negative. As a result, V-MOS switching circuits offer better reliability than those using bipolars, and because of the absence of secondary breakdown, no voltage derating is needed as operating current increases. The simplicity of the drive circuitry required also helps to enhance reliability, and the improved efficiency means less heat sinking. Taken together, these factors add up to significant size and cost reductions for switching supplies built with V-MOS power FETS.

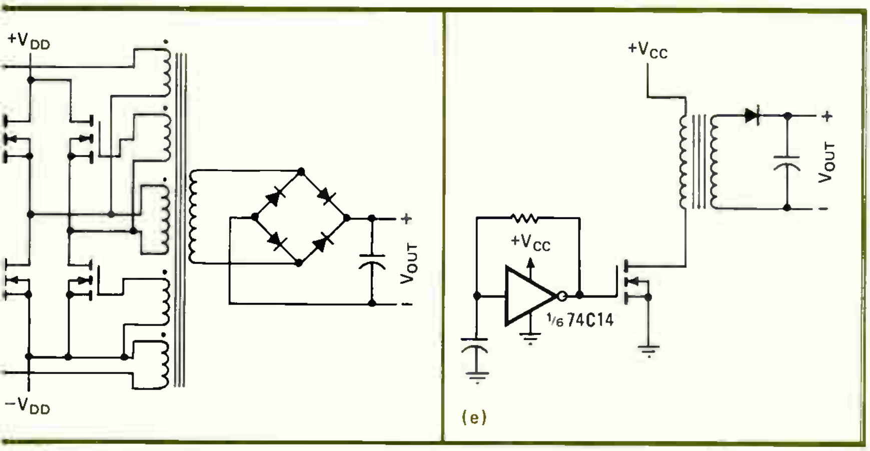
Furthermore, standard circuit configurations may be used for designing V-MOS inverters, several of which are illustrated in Fig. 1. For example, in the ringing-choke single-transistor dc-dc converter (Fig. 1a), a transformer couples a V-MOS blocking oscillator to a half-wave rectifier. Because of its low operating efficiency, such an inverter is used primarily in low-power applications. Also, the load receives power for only a small fraction of the oscillator cycle; ripple factor is therefore high, and a good deal of output filtering is required.

Standard circuits for V-MOS inverters

The two-transistor push-pull inverter (Fig. 1b), on the other hand, delivers a square wave to the load, lowering the ripple factor and reducing output filtering requirements. Adding a transformer for the gate drive (Fig. 1c) prevents the output transformer from going into saturation, thus increasing overall supply efficiency. The operation of the single-transformer bridge inverter (Fig. 1d) is similar to that of the push-pull inverter, but it halves the voltage requirements of the transistors. To improve efficiency, the bridge inverter may also be implemented with two transformers.

When standard bipolar transistors are being used, self-oscillating inverters such as these are the best way to go if parts count must be minimized and efficiency is a secondary consideration. V-MOS transistors allow the designer to use the more efficient driven inverter type, like the one shown in Fig. 1e, without the large drive circuitry required by bipolars. With this type of circuit, the transformer does not operate in its saturation region nor does operating frequency vary with the load, so the design of the output transformer and filter may be optimized for efficiency. (Any of the self-oscillating configurations may be converted to a driven inverter by eliminating the gate drive windings on the transformer and substituting a suitable driver.)

Many of the characteristics that make power V-MOS attractive for switched-mode power supplies also apply to motor-control circuits. With the recent increases in



1. For power supplies. Power V-MOS FETs bring such key advantages to switching power supplies as high-frequency operation, high efficiency, and improved reliability. Furthermore, they may be used in standard inverter configurations—for example, the single-transistor dc-to-dc converter (a), the push-pull inverter (b), the two-transformer inverter (c), the brigade inverter (d), and the driven inverter (e).

voltage and current ratings, V-MOS power FETs are now excellent candidates for use in motor controllers, where they offer the advantages of low drive power and high-speed switching, as well as eliminating the need for derating due to secondary breakdown.

Motor controllers can be simpler

In traditional motor controllers employing bipolar transistors, silicon controlled rectifiers, or triacs as the switching elements, the drive circuitry becomes very complex and consumes a lot of power. Because their beta drops at high output currents, bipolar transistors need high-current driver circuits, often involving the use of floating supplies for each phase of the controller. Similarly, triacs and SCRs require complex turn-on and turn-off circuitry, and they often perform unpredictably.

V-MOS power FETs, on the other hand, need only microwatts of drive power, thus simplifying drive circuitry. Additionally, their fast switching and freedom from secondary breakdown improve efficiency, performance, reliability, and cost-effectiveness, just as in switching power supplies.

Figure 2 illustrates how simply a motor controller may be built with V-MOS transistors. It employs pulse-width modulation, via a quad micropower comparator, to maintain the set speed of a small fractional-horsepower motor, regardless of the load applied.

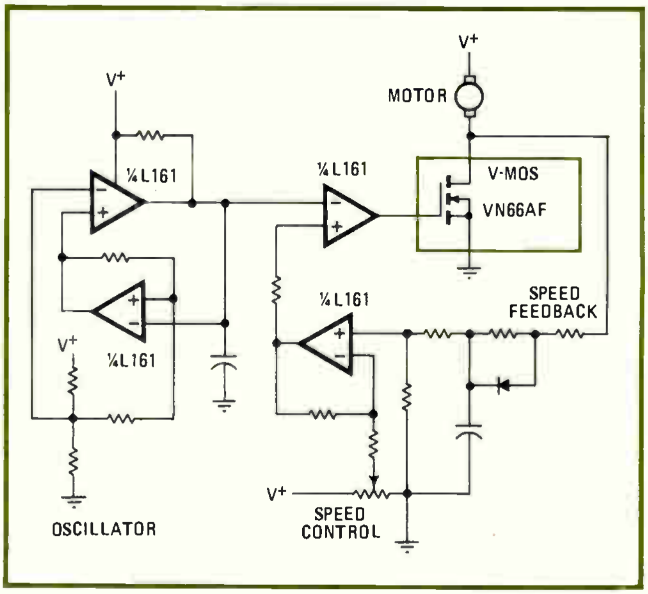
In operation, the reverse electromotive force of the motor serves as a speed indicator. This reverse emf, along with the dc set voltage, is fed into a difference amplifier. The output of the amplifier controls the pulse-width modulator, which supplies the gate drive for the V-MOS power FET. The efficiency of the circuit is very high, because the transistor operates in the switched mode rather than in the linear mode. In fact, for a 5-A, 120-V motor, efficiency is greater than 95%. Even multiphase motor controllers may be designed with equal ease using V-MOS power FETS.

Switching analog signals

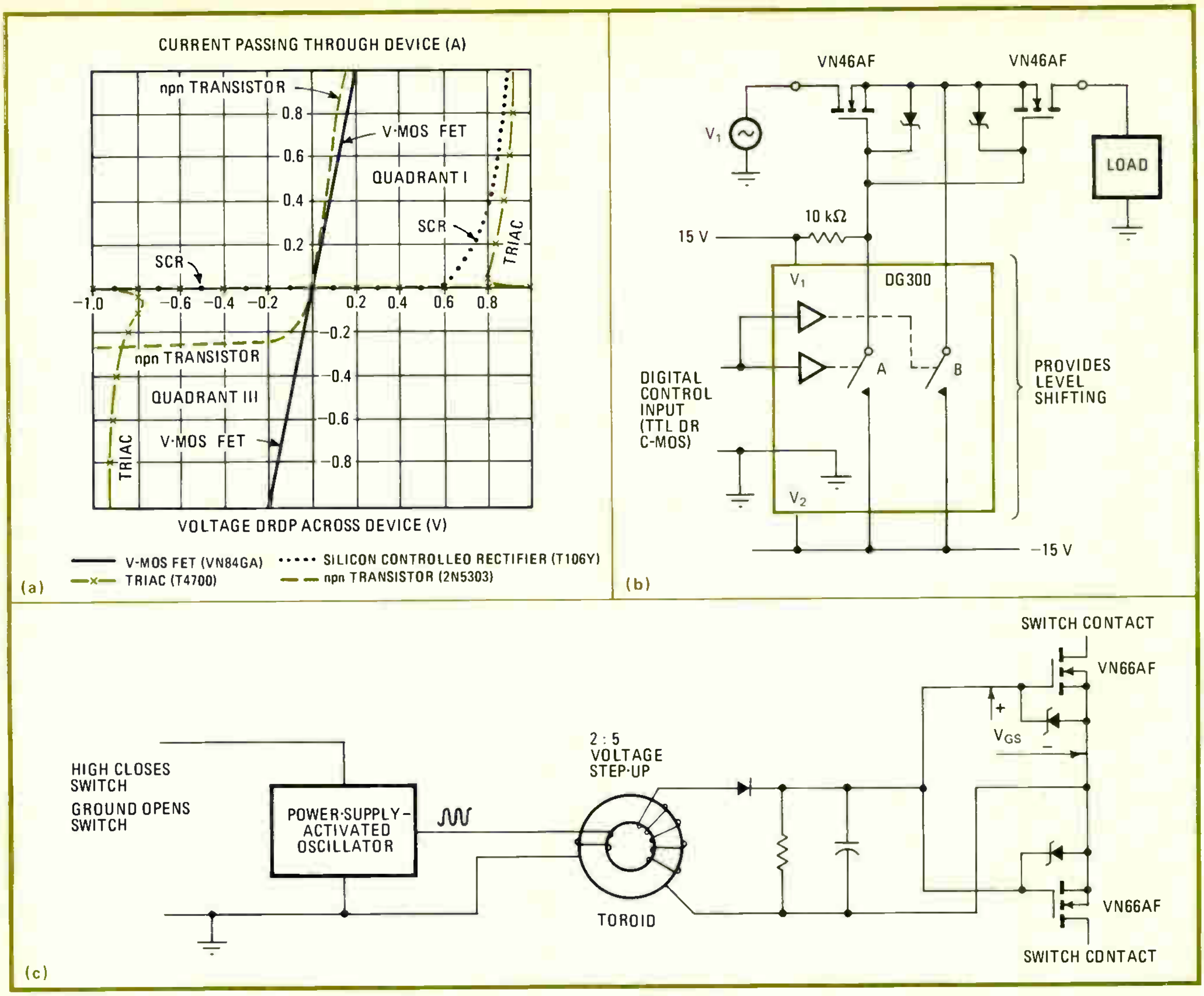
Next to amplification, the switching of analog signals is the most important function performed by discrete semiconductors today. And in the realm of analog switching, the V-MOS transistor comes very close to being ideal. Besides low linear on resistance, it offers high off resistance, high speed, isolation between the control input and the signal path, and clean switching (no contact bounce).

The low on resistance minimizes power dissipation. In switching raw power, it is very important to system efficiency, and both SCRs and triacs generally do a good job in this kind of application. However, in switching analog signals, although power loss is still important, the more fundamental problem is nonlinearities in the switching element that can alter and distort the signal. All current-injection devices, whether bipolar transistors, SCRs, or triacs, suffer from nonlinear currents that introduce error voltages in series with the analog signal, as illustrated in Fig. 3a. In contrast, the V-MOS transistor is free of offset voltage. Being a majority-carrier device, its on-condition properties are determined by bulk silicon, which is inherently linear.

Although it is generally true that electromechanical relays and switches provide the lowest on resistance (merely milliohms) of any electronic device, they are prone to a tremendous increase in contact resistance with the number of operations. But V-MOS transistors main-



2. For motor control. When used in motor-speed controllers, V-MOS power FETs mean low drive power, fast switching, and freedom from secondary breakdown. The motor control shown here employs pulse-width modulation via a quad micropower comparator.



3. To switch analog signals. Bipolar transistors and thyristors introduce error voltages in series with the analog signal being switched (a). V-MOS transistors are free of offset voltage. They may be used to build a bidirectional analog switch (b) or even a solid-state relay (c).

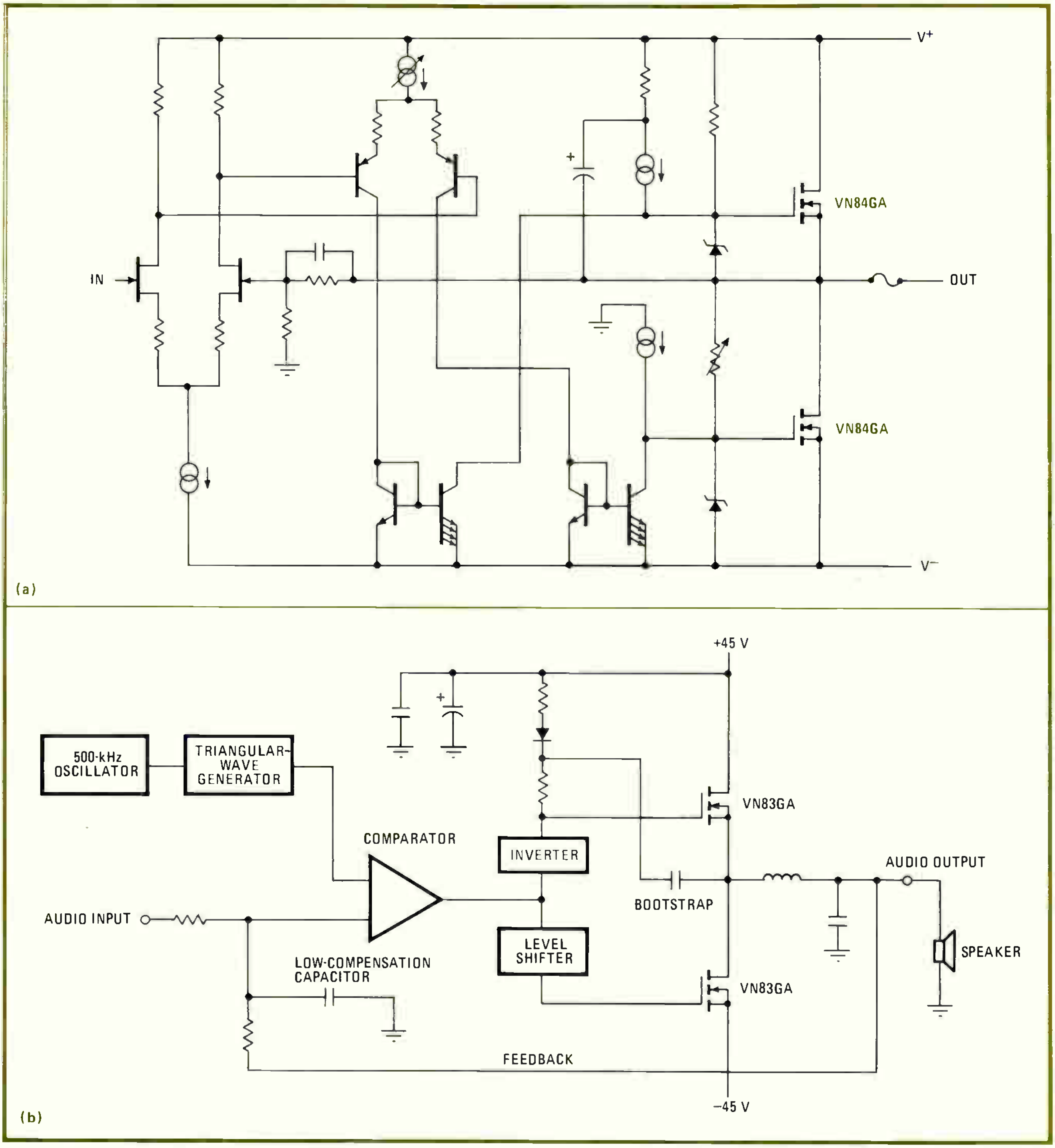
tain the same on resistance throughout their lifetime. Moreover, even though relays and mechanical switches provide the highest overall off isolation, V-MOS devices, because they are metal oxide semiconductors, offer the same kind of isolation between control input and signal path. Typically, dc off leakage from drain to source is in the nanoampere range, and ac leakage is just as low, with off isolation about 60 decibels at 10 megahertz.

Furthermore, V-MOS power FETs can carry the high peak currents needed for charging and discharging reactive loads—a capability that is especially important in analog-to-digital converters, sample-and-hold circuits, and integrators. A more subtle advantage of power V-MOS is its wide dynamic range: it can switch easily over seven decades of current, without the buildup of contact oxide or the erosion of electrodes typical of mechanical switches. This wide range is particularly useful in audio switching applications, where good linear performance must be maintained for signals ranging from 1 microvolt to 50 V. In contrast, current-injection devices have trouble at low signal levels because of the inherent offset voltages generated by the pn junctions.

Employing the V-MOS transistor as an analog switch is easy. The motor-speed control of Fig. 2, for instance, is a suitable circuit for a unidirectional analog switch. For a bidirectional switch, level-shifting circuitry is needed, as shown in Fig. 3b. Making the equivalent of a solid-state relay, though, requires high common-mode noise isolation from the analog signal path. This could be achieved simply by using a toroidal transformer for the isolation scheme, as in Fig. 3c. Or instead, voltage-output optocouplers could provide the isolation, thanks to the microwatt drive requirements needed to turn the V-MOS switch on and off.

Linear amplifiers that perform better

The characteristics of V-MOS power FETs also make them well suited for use in the output stages of linear amplifiers that must deliver considerable power to a load, such as a loudspeaker or a motor. Moreover, V-MOS amplifiers tend to be easier to design and more rugged, and in many respects they perform better than their bipolar counterparts. Also, now that high-current, moderately high-voltage V-MOS transistors are here,



4. In audio amplifiers. Power FETs serve as the output devices for an 80-W audio amplifier (a) that holds transient intermodulation distortion to virtually unmeasurable levels. V-MOS's fast switching speed also makes it practical to build a 100-W class D amplifier (b).

audio and servo amplifiers built with these devices are economically competitive with the more standard designs using bipolar transistors.

One of the most important advantages power V-MOS transistors brings to linear amplifiers is lack of thermal runaway. In a bipolar amplifier, an increase in the temperature of an output device will cause it to conduct more current, and the increase in current raises the power dissipation, which in turn further raises the temperature. Indeed, if nothing is done, the current will continue to increase until the transistor is destroyed—the victim of thermal runaway.

Although some thermal-feedback mechanism is usually employed to reduce the drive to the power device when it heats up, the feedback is not totally effective because of the difficulty of measuring chip temperature exactly, as well as the time it takes for the change in chip temperature to reach the sensing element. To allow for these deficiencies, bipolar transistors are usually operated at less than their optimum quiescent current, with

The inside story on power V-MOS

From the designer's viewpoint, V-MOS power field-effect transistors combine the high-power, high-voltage, and high-current capabilities of bipolar transistors with the high-frequency, high-gain, high-input-impedance, and linear-transfer characteristics of short-channel metal-oxide-semiconductor FETs.

Essentially, V-MOS transistors avoid the problems of turnoff delay (caused by minority-carrier storage in the base region) and secondary breakdown and current hogging (due to the positive temperature coefficient of emitter current) that are inherent in bipolar transistors. Similarly, power V-MOS devices bypass the current limitations of the conventional lateral MOSFET, because their channels are arranged so that the current flow is vertical instead of horizontal. Vertical arrangement permits the back of the V-MOS chip to serve as the drain terminal, thus yielding more conducting channels per unit of top surface area.

Vertical

In fact, current flows vertically in both the V-MOS power FET (b) and the bipolar transistor (a)—from the source to the drain in the former and from the emitter to the collector in the latter. Indeed, in some respects, the vertical structures of the V-MOS power FET and the double-diffused epitaxial planar bipolar transistor are similar. They both have n^+, p, n^-, and n^+ layers, and current flows from the surface n^+ layer to the substrate n^+ region. Moreover, they both generate an n^- epitaxial space-charge region that results in high collector or drain breakdown voltage.

The operation of these two devices, however, is quite dissimilar. The bipolar transistor turns on when its emitter-base junction is forward-biased and minority carriers are injected into the base. These carriers diffuse through the base region to the high field at the collector junction. Reducing the emitter-base voltage to zero stops the injection of carriers into the base, but collector current continues to flow until the minority carriers stored in the base region diffuse to the collector-base junction and are swept out. This delay in turnoff, which is usually referred to as the minority-carrier storage delay, limits the operating speed of the bipolar transistor.

In contrast, the n-channel V-MOS transistor turns on when its gate-source voltage becomes positive, creating a channel that provides a conducting path from the source to the drain. Since the only current needed to charge the gate capacitance is that required to create the channel, the input resistance of the V-MOS power FET is high. Furthermore, there is no minority-carrier storage, so turnoff is fast. In comparison, the turnoff time of a bipolar power transistor is typically on the order of 1 microsecond, whereas that of a V-MOS power FET is generally less than 10 nanoseconds for about 1 ampere of current.

Moreover, with a bipolar transistor, a localized hot spot on the chip causes an increase in current through that area that, in turn, produces a localized increase in power dissipation and a further increase in temperature. In the presence of a moderately high collector voltage, this situation can result in a destructive secondary breakdown, which is probably the major failure mode of switching bipolar power transistors.

No thermal runaway

On the other hand, a localized hot spot in the V-MOS power FET causes the current through that area to decrease, thus lowering the dissipation. As a result, V-MOS transistors may be paralleled for increased current handling and higher power rating without the need for negative-feedback resistors to prevent current hogging and thermal runaway. When driven into saturation, the V-MOS power FET exhibits an on resistance that has a positive temperature coefficient. If one device tends to take more than its share of the load current, that device's on resistance will increase as temperature rises, thus forcing part of its current to be shunted to the other devices in the circuit. Therefore, if several devices are connected in parallel, current sharing tends to be self-equalizing.

In the conventional MOSFET (c), current flow in the conducting channel is parallel to the surface of the chip. Typically, spacing between source and drain is on the

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the result that performance is compromised somewhat.

In contrast, V-MOS transistors behave in just the opposite way when they heat up—a temperature increase reduces device current, thereby decreasing power dissipation and pushing the temperature back down. No thermal feedback is required, and V-MOS transistors easily operate at quiescent currents 5 to 10 times higher than those of bipolars. The higher operating current lowers signal distortion, especially at high frequencies.

The same behavior that protects V-MOS power FETs from rising temperature also guards against unusual operating conditions, like a short-circuited load. An instantaneous overload causes current through the V-MOS device to decrease as its temperature increases, protecting it long enough for a fuse to blow. Conversely, the positive temperature coefficient of a bipolar transistor aggravates the overload condition, causing the device to destroy itself long before the protection fuse has a chance to respond. A fast-acting electronic fuse—of the output-current–limiting form—may be built into the bipolar amplifier, but it requires extra circuitry and often results in a compromise between good performance and adequate protection. The compromise is especially noticeable when highly capacitive loads, such as electrostatic speakers, are being driven, since they require high peak currents at high frequencies. V-MOS FETs can deliver these peaks without the threat of destruction.

What is more, V-MOS linear amplifiers provide superior high-frequency performance for both open- and closed-loop operation. Unfortunately, bipolar transistors trade off high frequency for ruggedness—high-frequency devices are prone to secondary breakdown, whereas devices having a large safe-operating area sacrifice frequency response. With power V-MOS, no such compromise need be made—slew rate may be more than 100 V/microseconds, which is two to five times faster than that of bipolar amplifiers, yet open-loop frequency response can be greater than 400 kHz, an improvement by a factor of about four to eight. Far from being superfluous, this superior high-end performance means better sound quality when reproducing transients in audio amplifiers.

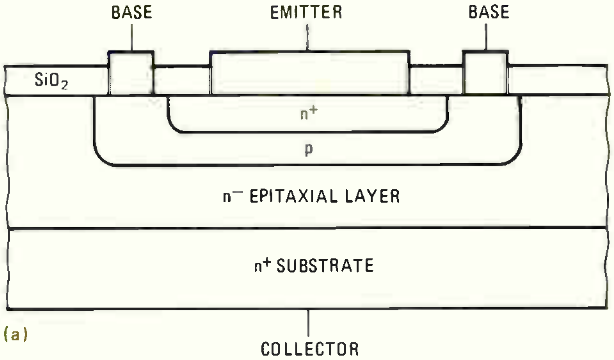
order of 5 to 10 micrometers. Decreasing this channel length so as to boost transconductance reduces drain-source punchthrough (breakdown) voltage. Smaller spacing also makes processing more difficult, because a combination of diffusion and photoresist masking controls the source-to-drain geometry.

However, in the V-MOS power FET, current flow is vertical, or perpendicular to the chip surface, so that channel length is controlled by diffusion, as opposed to masking. Consequently, high transconductance may be achieved by making the channel short—say, less than 2 μm. Furthermore, the addition of an n^- epitaxial layer, which provides a space-charge region at the drain end of the channel, permits a high drain-voltage rating. This low-carrier-concentration region also reduces output capacitance and drain-gate feedback capacitance—both important advantages for high-frequency operation.

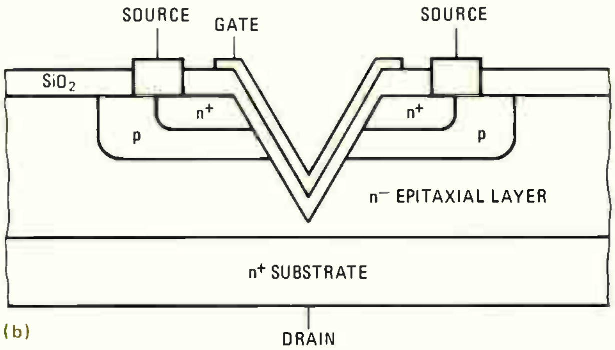
V-shaped channels

The channels of the V-MOS power FET are parallel to the wall of the V groove through the p-type body. Since the slope of the V is precisely determined by the crystalline structure of the silicon, the channel length is determined by the difference between the diffusion depths of the p-type body and the n-type source. Both walls of the V serve as channels, so that a single gate metal stripe controls two channels. The resulting short channel provides high current per unit of channel width, as well as a linear relationship between drain current and gate-source voltage.

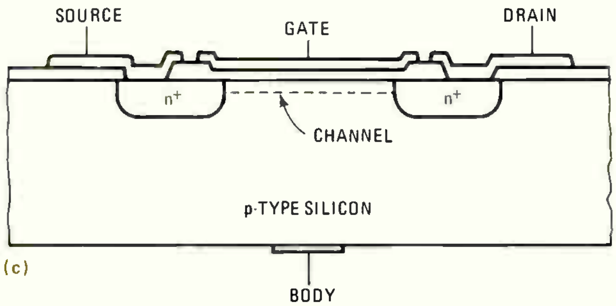
Although the n^- epitaxial layer adds a component to the on resistance of the V-MOS transistor, it does result in a number of performance advantages. Besides high drain-source breakdown voltage and reduced output feedback capacitances, this layer keeps output conductance low and threshold voltage independent of drain voltage. In part, the thickness and resistivity of the n-type epitaxial layer does determine the drain breakdown voltage. Higher voltage ratings may be achieved at some increase in the on resistance of the device.



(a)



(b)



(c)

Another advantage of V-MOS transistors is their nearly constant transconductance, since distortion is caused by variations in this parameter. While the transconductance of V-MOS FETs hardly changes above a certain drain current, the transconductance of bipolar transistors is directly proportional to their collector current. The reduced distortion permits a V-MOS amplifier to be designed with less feedback circuitry.

Other advantages

Added benefits of power V-MOS include its high input impedance at audio frequencies, which eliminates the need for high current gain in the driver stages. Also, since the V-MOS transistor has a voltage-controlled input, a zener diode between its gate and source is all that is required to effect output current limiting.

How do these various benefits translate into practice? Figure 4a shows a simplified schematic of an 80-W audio amplifier using V-MOS FETs as output devices. Because of their low distortion, the amplifier requires very little negative feedback to provide a good overall distortion figure. The reduced negative feedback results in improved amplifier stability at high frequencies, as well as a transient intermodulation distortion that is virtually unmeasurable. (The latter occurs when negative feedback is temporarily nonexistent during high-frequency transients, so that the high-gain driver stages operate open loop and consequently overload.)

Several components are unique to the V-MOS design. For example, the variable resistor in the output stage provides local feedback from the drain to the gate of the lower of the two power FETs, making the common-source configuration behave as a source-follower, similar to the operation of the upper power FET. Adjusting this resistor reduces the even harmonic distortion by balancing the gain of the two output FETs. The zener diodes limit the amount of possible gate-source enhancement drive on the output devices. In the event of a short-circuited load, these diodes hold drain current to a value below the absolute maximum rating of the transistors—until the fuse blows.

Power V-MOS also makes it possible to build class D audio amplifiers, which has been difficult in the past. Because of their minority-carrier storage time, bipolar transistors require a delay in the drive circuitry to ensure that the upper and lower devices in a totem-pole output are never on at the same time. This delay not only complicates the driver but also adds to the distortion of the amplifier.

The introduction of suitable V-MOS transistors means class D audio amplifiers of higher quality and lower cost. The fast switching speeds and the absence of storage time of V-MOS devices improve the frequency response, eliminate the need for delay circuits in the driver, and reduce the total distortion. Furthermore, the low drive power needed by V-MOS transistors simplifies amplifier design. For example, Fig. 4b shows a 100-W class D audio amplifier built with V-MOS devices. Its high switching frequency of 500 kHz results in low distortion, a small output filter, and improved transient response.

A real winner at rf

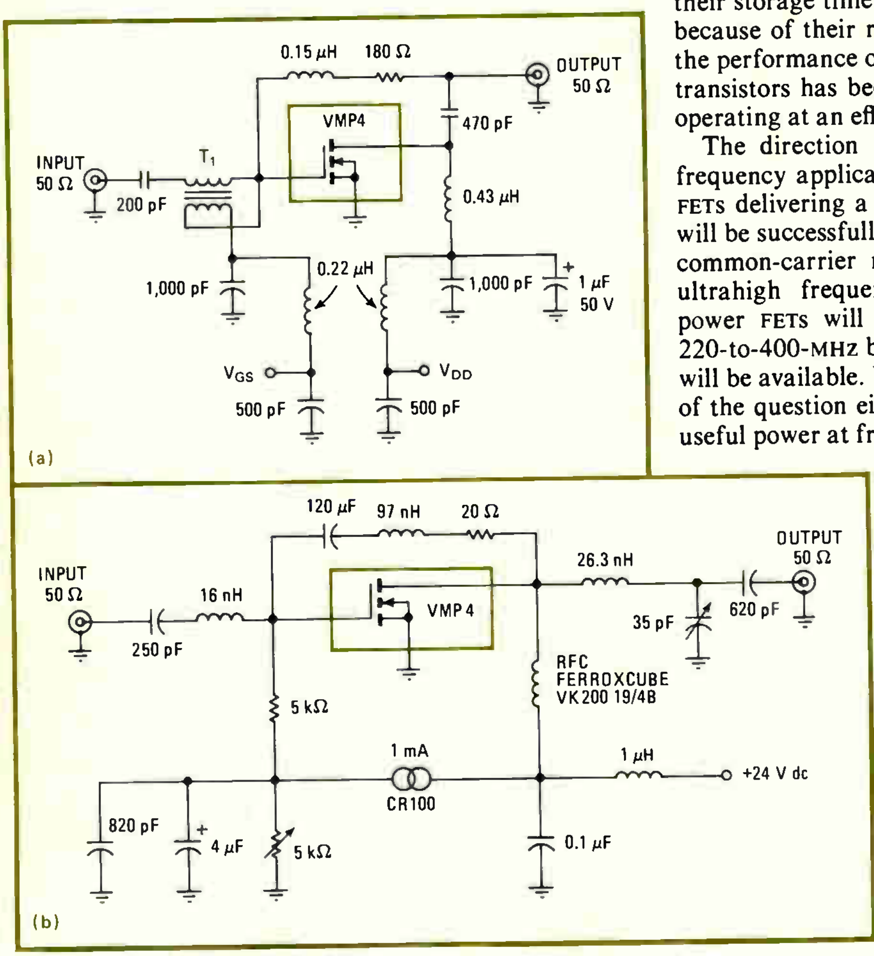
But where power V-MOS promises really to outshine bipolar technology is up in the rf region. Aside from its outstanding switching advantages, this process offers inherently low sideband noise, as well as the singularly outstanding benefit of unconditional stability when subjected to severely mismatched load conditions. In other words, V-MOS transistors can successfully withstand any mismatched condition, unlike most bipolar transistors, which are considered fail-safe only when menaced by well-defined mismatched conditions. Additionally, because V-MOS has low Q feedback capacitance, out-of-band parasitic responses are exceptionally low.

With V-MOS, it is possible to build broad-band high-gain amplifiers simply. For instance, the circuit shown in Fig. 5a offers a bandwidth extending from 40 to 200 MHz and a flat gain of nearly 12 dB. Of special note is the simple transformer input coupling for broad-band performance. Another unusual characteristic common with V-MOS as noted earlier, is wide dynamic range. Saturated output occurs at approximately 3 W, with a two-tone, third-order intermodulation interception point of +47 dBm.

V-MOS transistors give rf amplifiers another advantage, as well: unlike high-frequency bipolar transistors, they are not generally hampered by high reverse feedthrough. The neutralized, small-signal, 200-MHz amplifier of Fig. 5b, for example, not only delivers high forward gain of 18 dB at a 1-W output but also holds reverse feedthrough to −50 dB.

Because they are not subject to minority-carrier storage, V-MOS FETs make high-efficiency switching-type rf amplifiers practical. These switching amplifiers are class D, E, and F types. Theoretically, efficiency cannot extend beyond 50% for class A amplifiers and beyond 78.5% for class B, and typically it is 85% for class C. In contrast, a theoretical efficiency of 100% is the hallmark of switching amplifiers, although of course it is unattainable in practice—with bipolar transistors, because of their storage time and saturation voltage, and with FETs, because of their relatively high on resistance. However, the performance of switching amplifiers built with V-MOS transistors has been impressive, with a 5-W class E unit operating at an efficiency of 90%.

The direction that power V-MOS will take in high-frequency applications is clear. Within the year, V-MOS FETs delivering a usable output power of 40 W or more will be successfully competing for inclusion in the radio-common-carrier markets at low-band, high-band, and ultrahigh frequencies. For military communications, power FETs will find wide application in the popular 220-to-400-MHz band, where output power of 10 to 40 W will be available. Use at microwave frequencies is not out of the question either, for V-MOS power FETs can deliver useful power at frequencies of over 1 gigahertz. □

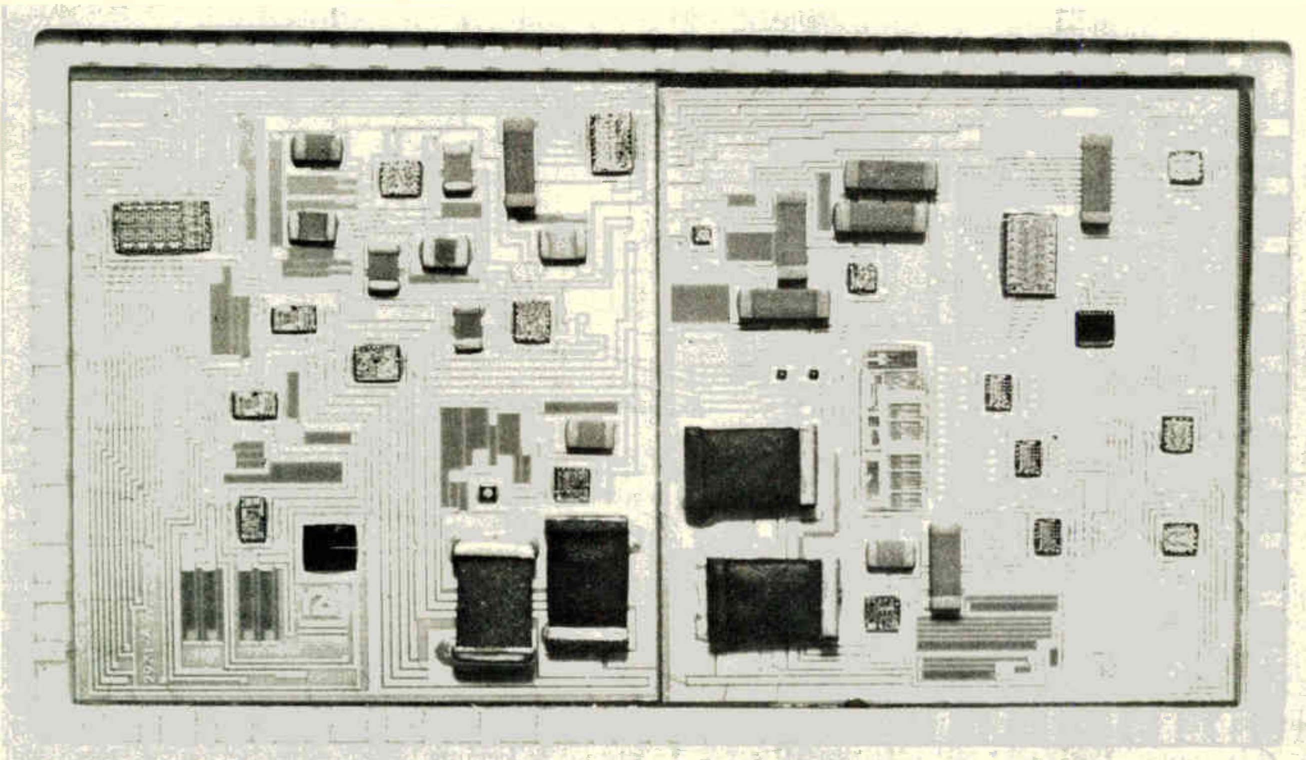


5. Up at rf. Unconditional stability is what V-MOS delivers at rf, even for severely mismatched load conditions. Power FETs are making it easy to get broad-band performance from 40 to 200 MHz with 12 dB of gain (a), as well as to attenuate reverse feedthrough by 50 dB in a 200-MHz amplifier (b).

Single hybrid package houses 12-bit data-acquisition system

Handling either 8 differential or 16 single-ended inputs, device acquires data at 50 kHz or faster from many sources

by Wayne E. Marshall, *Datel Systems Inc., Canton, Mass.*



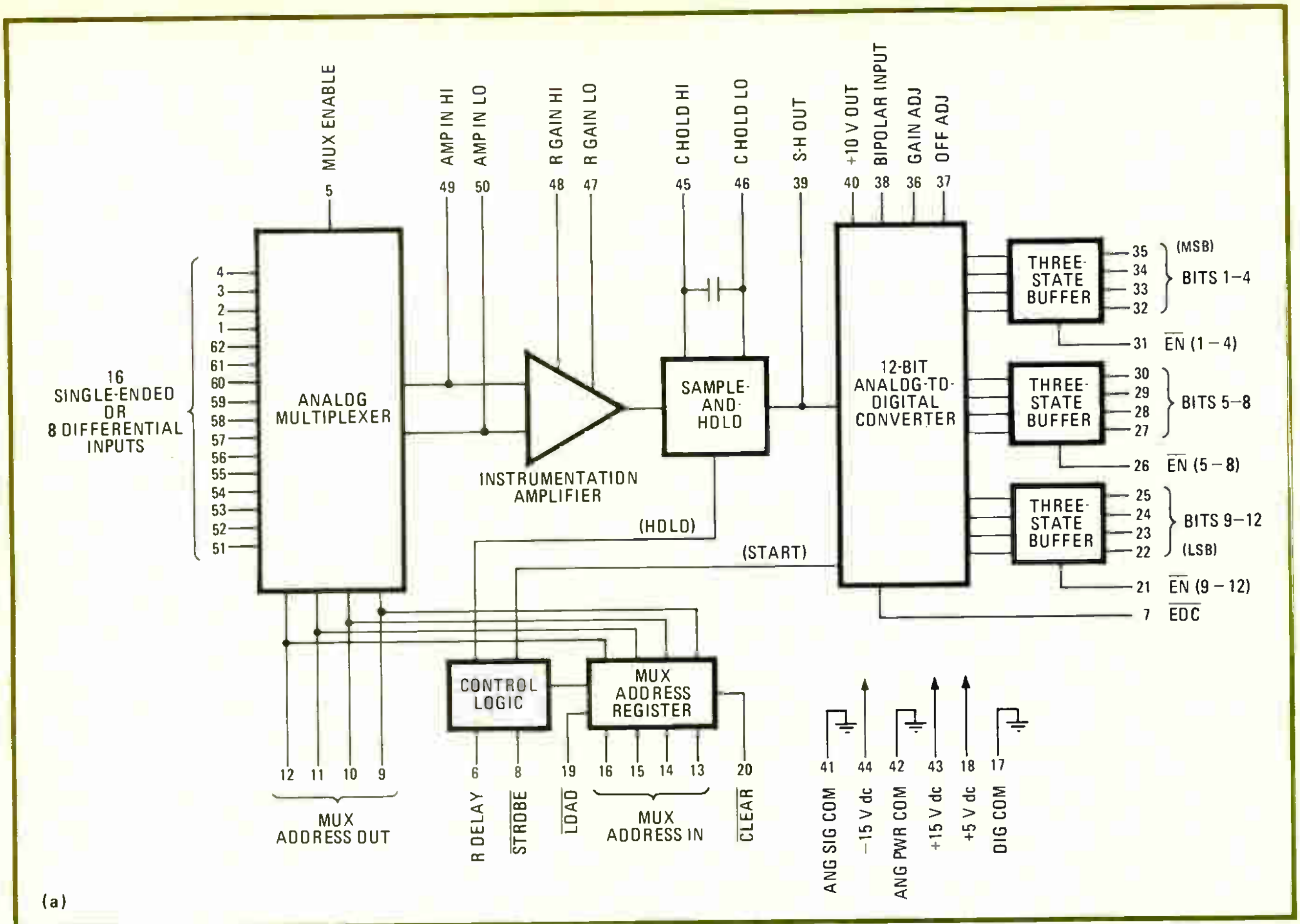
☐ The shift from minicomputers to microcomputers in data processing has been paralleled by the shift from boards and modules to microcircuits in data conversion. By now, complete microprocessor-compatible data-acquisition systems are available as single plug-in hybrid or monolithic components. Eight-bit performance has been the limit, though, with the hybrid devices being much faster though less economical than the monolithic converters. For 12-bit performance, users have had to turn back to bulky modules or else interconnect two or more hybrid circuits.

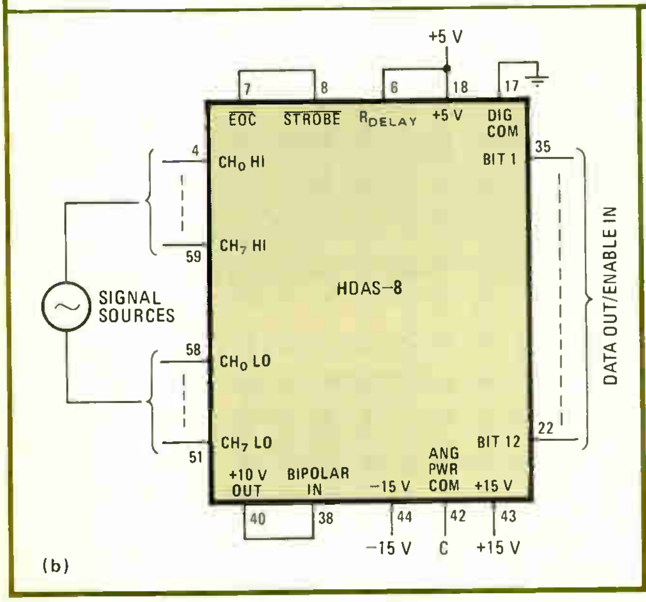
Getting down to one package

But a new 12-bit hybrid data-acquisition system is offering users the convenience and cost savings of a single integrated-circuit-compatible package, together with the high performance and reliability of a hybrid circuit. Besides multichannel capability, the device includes address decoding logic, an adjustable-gain instrumentation amplifier, a sample-and-hold circuit, a 12-bit successive-approximation analog-to-digital converter, control logic, and three-state output buffers for interfacing with a microprocessor data bus. It is manufactured in two versions, the HDAS-8 handling eight differential inputs and the HDAS-16 handling 16 single-ended inputs.

Housed in a hermetic 62-pin ceramic package, the device meets all the requirements of MIL-STD-883A, class B. To shrink its overall size, as well as optimize the internal layout and make external access easy, the pins are arranged around all four sides of the package, instead of in two parallel rows. The use of ceramic instead of metal keeps cost and especially weight down.

With such a complex hybrid, internal power consumption, of course, must be minimized. An equivalent modular unit uses about 4.5 watts, which in the hybrid's 62-pin ceramic package would push the temperature at the chip-mounting surface 50°C above ambient. Since





1. The device. Hybrid data-acquisition system (a) delivers 12-bit data for 8 differential or 16 single-ended input channels. A few simple connections (b), and the hybrid will automatically address the input channels sequentially for a system throughput rate of 50 kHz.

the unit must be able to operate at 125°C ambient, and silicon semiconductors deteriorate at junction temperatures above 150°C, the internal temperature rise must be limited to 25°C. Considerations of power therefore override those of space so that, wherever possible, the device employs bulky tantalum chip capacitors and low-power transconductance-mode amplifiers, while the digital control circuitry uses low-power Schottky transistor-transistor logic only.

Finally, in a move that reduces device complexity as well as temperature rise, as many of the internal thin-film resistors as possible are placed directly on the ceramic substrate, and not on separate chips of glass, silicon, or ceramic. With either technique, there will always be a resistor-to-conductor interface. But making a resistor part of the substrate eliminates the two wire-bond interfaces at its terminations, making wire-bond weakness a less likely cause of failure.

How the device operates

The circuit configuration (Fig. 1a) for the device is a fairly common one for a data-acquisition system. At the front end is an analog multiplexer having either 8 differential or 16 single-ended channels, which may be addressed randomly or scanned sequentially. Following the multiplexer is an instrumentation amplifier that extracts the input signal from common-mode noise. The gain of this amplifier is adjustable (through an external resistor) from 1 to 1,000, so that the maximum expected range of the input signal becomes ±10 volts at the amplifier output for optimum dynamic range.

A precision sample-and-hold circuit then buffers the selected signal, holding its level constant during the actual conversion. The output of the sample-and-hold serves as the input to a 12-bit a-d converter, which produces a binary number that is the digital representation of the selected analog input. For flexibility in data-bus organization, three-state logic elements, which are configured in 4-bit bytes, buffer the digital data output from the a-d converter.

The hybrid is very easy to use, as is evident from the simplicity of the circuit (Fig. 1b) needed to acquire eight differential inputs. A few straightforward connections, and the HDAS-8 delivers 12-bit binary data at a rate of 50 kilohertz from eight sequentially addressed channels, each having a ±10-v signal range. Since no gain resistor is used, the amplifier's gain is unity. A single strap selects bipolar operation (+10 v), and another strap from R delay to the +5-v supply selects the internally allotted delay time for the multiplexer and the amplifier to settle.

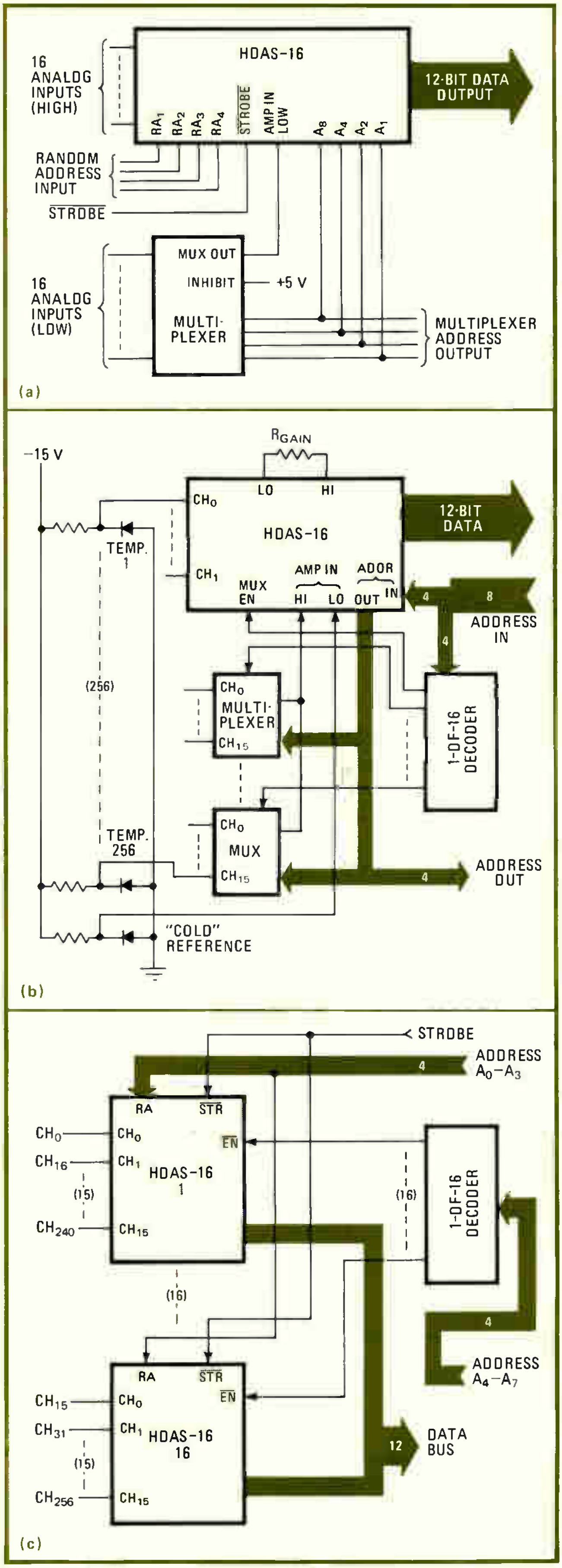
To obtain continuous scanning of the input channels, the user need do nothing at all to the address control inputs. With its end-of-conversion flag tied to the strobe input, the device will acquire data continuously at the maximum rate. For self-strobe operation, though, the rise time (from 10% to 90%) of the +5-v supply (when power is first applied or interrupted and then reapplied) must be less than 10 microseconds, or else a latchup may occur. For reliable operation, the user should examine the $\overline{\text{EOC}}$ flag and apply a $\overline{\text{STROBE}}$ signal when it is required. Even supply-bypass components are included in the package.

Protection

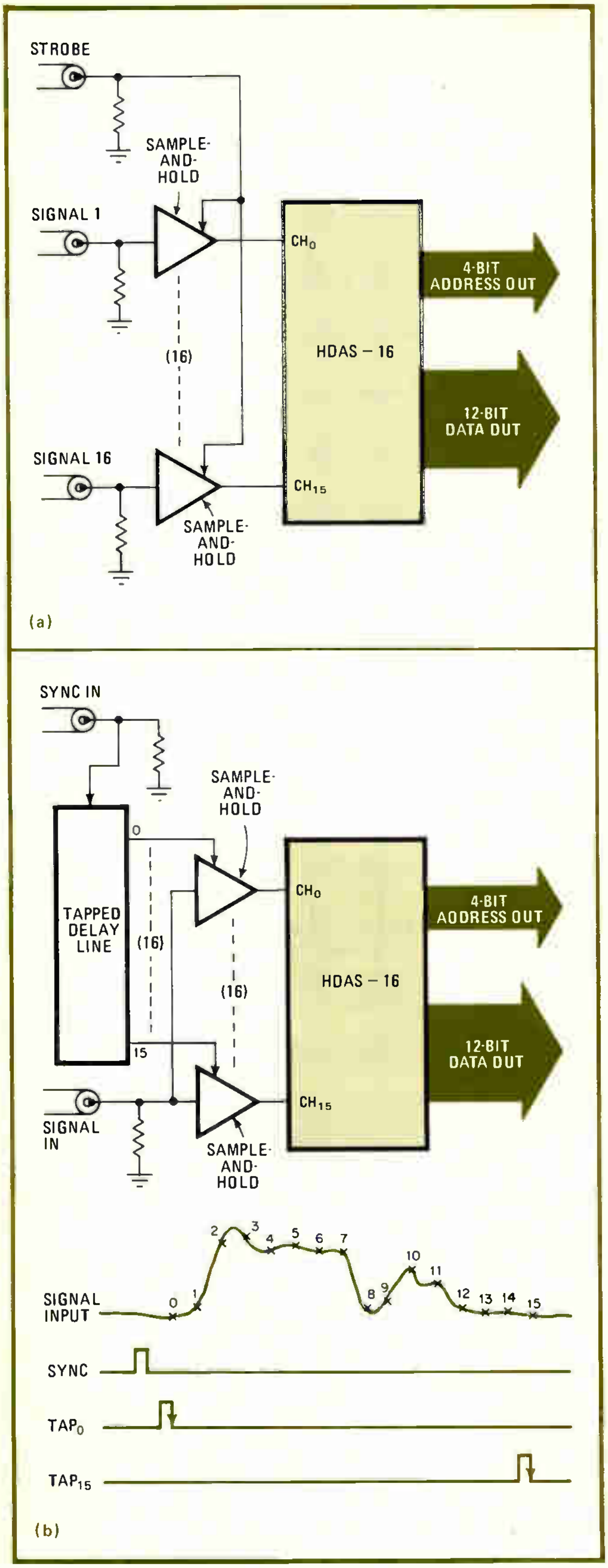
A good part of the device's ruggedness is due to overvoltage protection circuitry for the multiplexer. A 1-kilohm resistor on each channel input limits the current flowing through protection diodes and, in combination with stray nodal capacitance, limits the rise time of large spikes so that the diode can clip them before they do any damage. Even without using any external components, protection is assured to 20 v beyond the ±15-v supply voltages.

Adding a series resistance to each input can increase protection up to a diode current limit of ±10 milliamperes. But large values of input resistance are not altogether desirable. Besides raising the input noise, they increase the settling time of the instrumentation amplifier for changing input signals, as well as the multiplexer's recovery time from switching transients.

Expanding the channel capacity of the hybrid requires just one external component, connected as shown in Fig. 2a. This hookup converts the HDAS-16 from a 16-channel single-ended unit into a 16-channel differential part. In fact, channels may be added almost without limit at very little cost, as Fig. 2b illustrates. Here, with the addition of just 15 multiplexers and one logic device (a one-of-16 decoder), the HDAS-16 acquires 256 channels of low-level analog signals. In this application, the unit compares the outputs from 256 temperature-sensing



2. Easy channel expansion. One external component converts the HDAS-16 into a 16-channel differential part (a). Adding 15 multiplexers and a single logic decoder accommodates 256 input channels (b). For throughput faster than 50 kHz, more hybrids are needed (c).



3. Handling high-frequency inputs. To acquire signals beyond the mid-audio range requires a sample-and-hold circuit for each channel (a). For a nonrepetitive high-frequency signal, a delay line and a string of sample-and-holds slice the input into 16 pieces (b).

diodes with the output of a single reference diode.

Indeed, the hybrid is built to be expanded—it can handle up to 65,536 channels with the addition of only 17 logic circuits. The unit's multiplexer-enable line is what makes this possible. Left alone, it is high, and the internal multiplexer is enabled. But when pulled low, it disables the internal multiplexer and frees the amplifier input lines for external multiplexer control.

Although the circuit of Fig. 2b is an economical way to handle 256 channels at a 50-kHz rate, that throughput may not be fast enough for some applications. A faster throughput of 800 kHz is easily achieved by interleaving 16 hybrids into 256 channels (Fig. 2c). This circuit is actually just as simple as the slower one, for it still requires only one external decoder device. Because the hybrid uses three-state data outputs, all 16 units can be tied to one data bus and enabled one at a time during the delay period preceding the next conversion while the data from the last conversion is still valid.

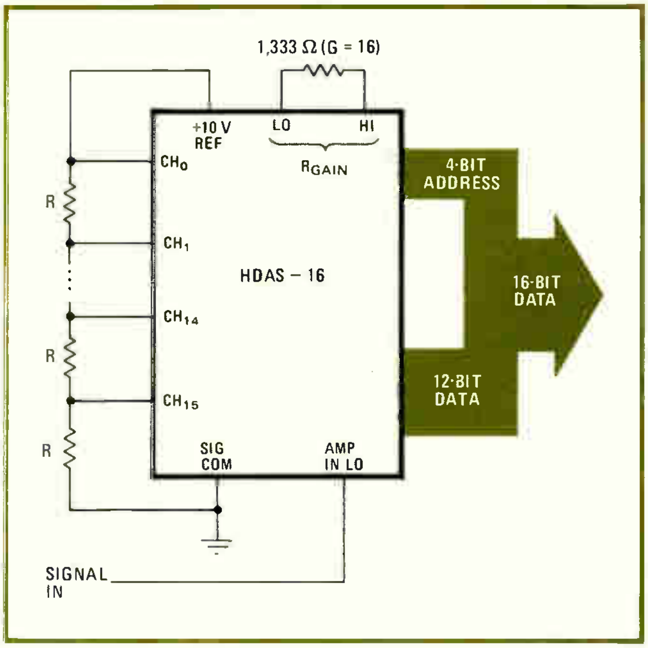
Both the HDAS-8 and the HDAS-16 are ideally suited to acquiring data quickly from many sources, with two provisos: the sources should all have similar maximum signal levels, and the highest frequency components of the signal sources must be in the low audio range. When the signal sources have dissimilar ranges, the dynamic range of some signals will be less than optimum because the gain of the differential amplifier will be set to accommodate the largest signal range. This limitation is normally overcome by using prescaling amplifiers, which also serve as convenient low-impedance signal line drivers and as filter points to reduce unwanted power-line signals and the like.

Acquiring high-frequency signals

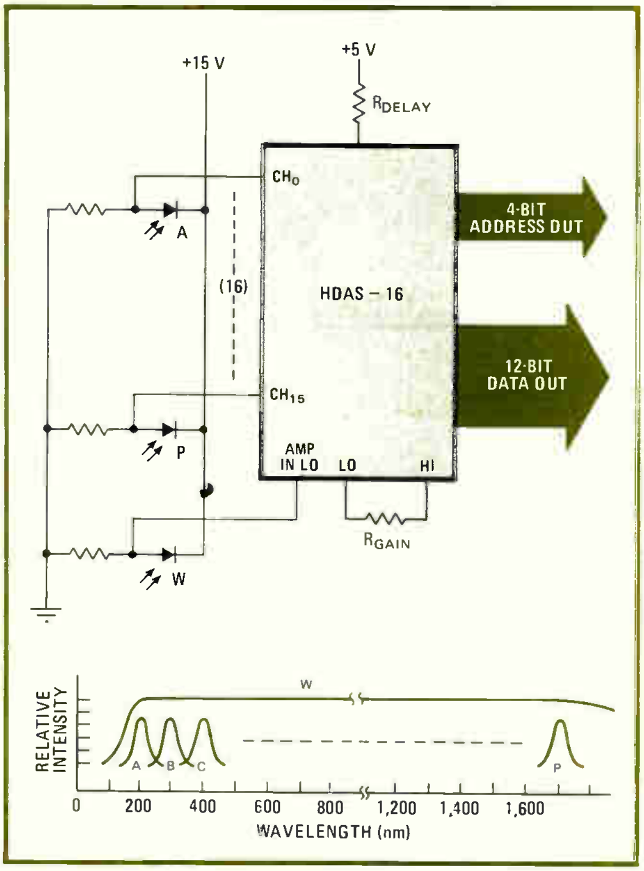
When the signal sources are to contain high-frequency components that the data-acquisition system must recognize and acquire accurately, a very fast track-and-hold circuit or, better yet, a true sample-and-hold should intercept the signal and hold it for a precisely controlled time. Once the signal has been processed by the multiplexer, the amplifier, and so on, its bandwidth and phase delay are no longer precisely known. Figure 3a shows one way to do real-time analysis of input signals having frequencies up to 25 kHz. With this circuit, to retain precise information as to the time of sample, 16 fast sample-and-holds simultaneously sample the input signals, and the data-acquisition system digitizes the held analog value on each input channel.

Beyond 25 kHz, the inability of the hybrid to generate two data points per cycle of the input signal violates the Nyquist criteria of signal sampling. When repetitive events need not be analyzed in real time—for example, when synchronized sampling heads provide sample snatches with varying delays—the frequency limit extends to the bandwidth of the sample-and-hold circuits. But for real-time analysis of nonrepetitive signals, another approach is needed.

Radar pulses are a common example of nonrecurring pulses that contain critical target data that must be analyzed in exceedingly fine detail in real time. To handle them, the HDAS-16 data-acquisition system requires just a tapped delay line and a string of fast



4. Putting amplifier gain to work. It is even possible to turn the HDAS-16 into a 16-bit a-d converter by applying the input signal to the internal amplifier's inverting input. Here, the amplifier-input-low line is being viewed as a high-impedance, transient-free signal input.



5. High gain. In this fast spectrophotometer application for monitoring industrial waste, the hybrid's high-gain capability and adjustable settling time are exploited. Careful tailoring of delay time versus gain provides best system resolution in terms of data rate needs.

sample-and-holds, as noted in Fig. 3b. In effect, the sample-and-holds slice the radar pulse into 16 easy-to-digest pieces, while the delay line causes each sample-and-hold to retain the analog information at incremental times following the synchronization pulse. Meanwhile, the hybrid can address and digitize each input slice at a comparatively leisurely pace, producing a 12-bit binary word for each of the 16 slices at a word rate of 50 kHz. Clearly, there is a limit to the number of sample-and-hold circuits that may be addressed and digitized before hold-capacitor droop problems destroy analog signal accuracy. This limit may be circumvented by adding more hybrids to the circuit, at any rate until system cost reaches that of a real-time video converter.

To increase resolution up to 16 bits

Besides being useful as a video a-d converter, the HDAS-16 may be operated as a 16-bit a-d converter. Unlike the HDAS-8, in which the two multiplexer outputs are both committed to the amplifier's inputs, the HDAS-16 has only one multiplexer output so committed. It is tied internally to the amplifier's noninverting (high) input, leaving the inverting (low) amplifier input for the user to connect, for example, to the signal source common. (In any event, the user must of necessity return eventually the signal source common to the hybrid's signal or power common.)

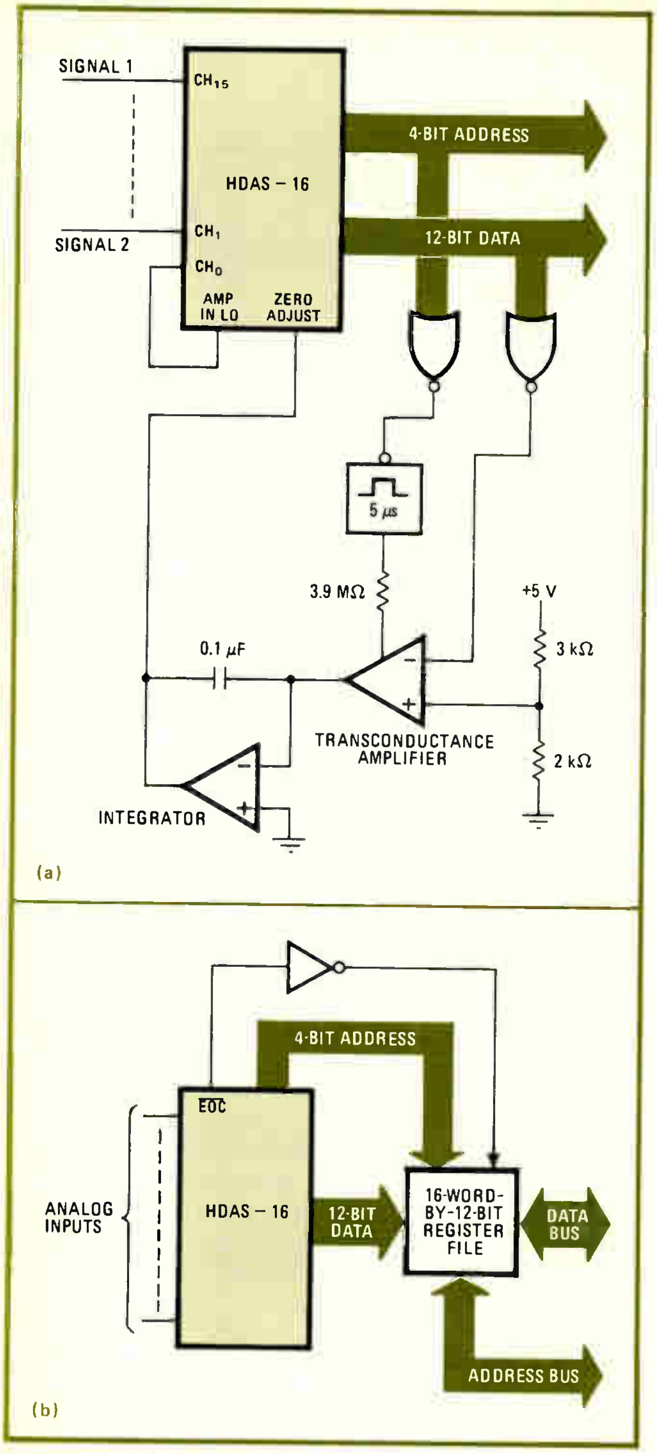
Another way of looking at the HDAS-16's amplifier-input-low line is as a high-impedance transient-free signal input, as illustrated in Fig. 4. Wired in this way, the HDAS-16 operates as a 16-bit a-d converter. Fifteen resistors, precisely matched and equal in value, divide the internal 10-v reference into 16 equally spaced voltages, so as to bias the input channels into 16 contiguous windows. The amplifier will only amplify the difference between the input signal and the selected channel voltage. (With R gain at 1,333 ohms, amplifier gain is 16.)

Only one channel address will be associated with an in-range 12-bit data word, and all other channels will yield all zeros or all ones. When the address of the selected channel is used as the top 4 bits and the resulting conversion data as the bottom 12 bits, the HDAS-16 generates a 16-bit complementary binary data word. For input signals in the audio-frequency range, the channel address will change by no more than one count from one conversion to the next, so that no more than two conversions are ever necessary to obtain valid data. This means that the HDAS-16 will typically deliver 16 bits in 20 microseconds, or 40 μs maximum.

When high gain is needed

Some applications require both high gain and multichannel capability. However, when the gain exceeds 20, the hybrid's amplifier needs more than the internally allotted 9 μs for settling to within 12-bit accuracy. Even though the signal inputs may change slowly, the amplifier sees the multiplexer output as a fast-changing step function, with changes occurring whenever the multiplexer address changes.

The amplifier, then, must have enough time to settle fully in response to these abrupt changes before a conversion takes place. Suppose, for example, the appli-



6. Odds and ends. Charge-pump loop (a) cancels troublesome offset errors for all time and temperature. A twin circuit could be used to cancel gain errors also. Register file (b) creates memory location for HDAS-16, so data access is independent of the hybrid's status.

cation calls for a fast spectrophotometer for monitoring industrial waste or a similar cost-sensitive task. Figure 5 shows one solution utilizing the hybrid's high-gain capability and its user-adjustable settling delay time. Here, the outputs of 16 photodiodes, each of which has a different narrow-band filter, are compared to the output of an unfiltered white-light reference diode. Since the photon-induced diode voltage is small, amplifier gain must be large for a reasonable dynamic range. Instead of strapping the hybrid's R delay pin directly to the +5-v supply, as is usually done, the user may add a series resistor to increase the delay time between an address change and the start of a conversion. By carefully tailoring the delay time to the gain, the user can optimize system resolution versus data-rate needs. Even at a gain of 1,000, throughput rate will be at least 3.3 kHz, with root-mean-square system noise held to less than ½ least significant bit.

Dealing with accuracy errors

Many users of data-conversion devices are puzzled by the seeming inconsistency of specifications for relative accuracy and absolute accuracy. But distinguishing between the two is not all that difficult. In brief, relative accuracy is a measure of a device's differential linearity and monotonicity, while absolute accuracy reflects the unit's gain and offset stability. Furthermore, relative accuracy requires that similar components do the same thing with time and temperature, whereas absolute accuracy requires that a component does not change with time and temperature—a requirement that flies in the face of reality.

As it advances, process technology will continue to reduce accuracy errors, but it will always come closer to optimizing relative than absolute accuracy. Certain circuit techniques, however, permit doing away with absolute-accuracy errors altogether. For example, the simple one shown in Fig. 6a cancels offset errors, and a twin circuit could be used to cancel gain errors as well. This technique uses a charge-pump loop to hold absolute errors below measurable levels for all time and all temperatures. When data (offset voltage) appears on channel zero, the transconductance amplifier receives a bias-set pulse for 5 μs. If the data is zero, this amplifier sinks (or sources in the case of non-zero data) a current pulse to the integrator that minutely adjusts the hybrid's zero. At null, there is an imperceptible ±1-pulse hunt traded off against capture time.

In a microprocessor-based system the time needed to digitize analog data can become very long with respect to the processor's cycle time, particularly if the data-conversion device is a reasonably priced unit. This time difference causes all sorts of software problems that require complex interrupt schemes to solve. But, in fact, the delay is totally unrelated to the need for fully updated signal data, and the data-conversion device is usually quite capable of generating digital data at a fast enough rate to satisfy most signal-analysis requirements.

One simple way to work around the delay is to insert a multiple-port register file between the data-conversion device and the digital processor, as shown in Fig. 6b. Essentially, the register file creates a memory location for a continuously scanning HDAS-16. Data access is fast, free, and independent of the hybrid's status. Thus, the hybrid generates new data words at 50 kHz and updates a 16-word file at a rate of over 3 kHz. Meanwhile, the digital processor can request and retrieve data at normal memory-access speeds without disturbing or waiting for the data-acquisition system. □

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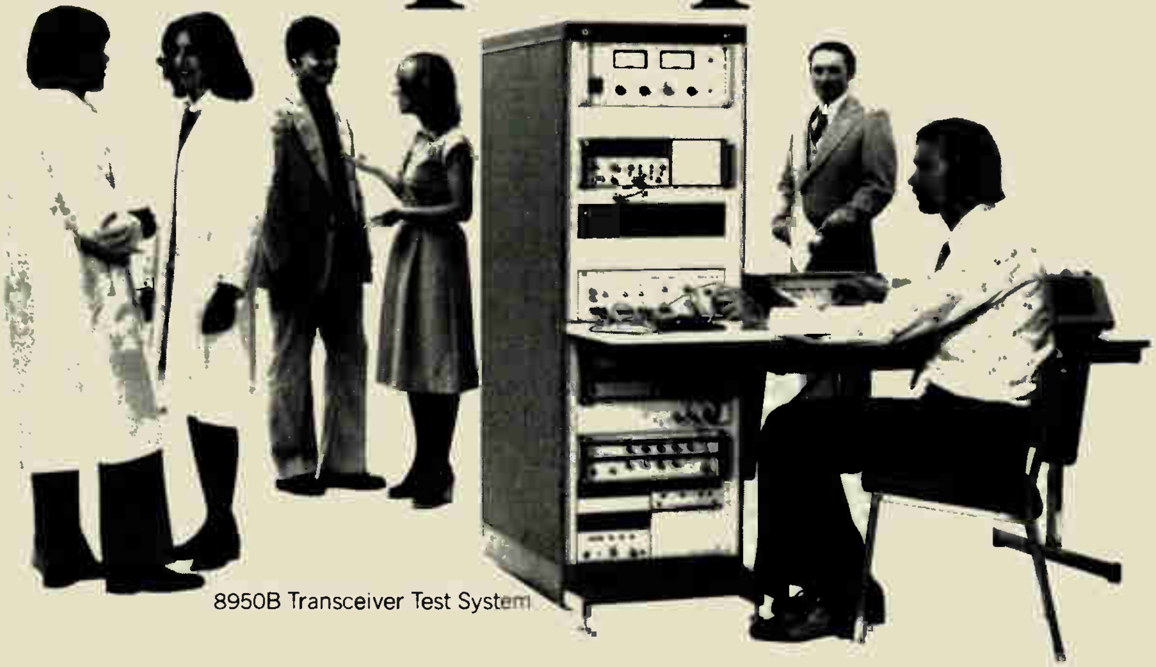

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Circle 119 on reader service card

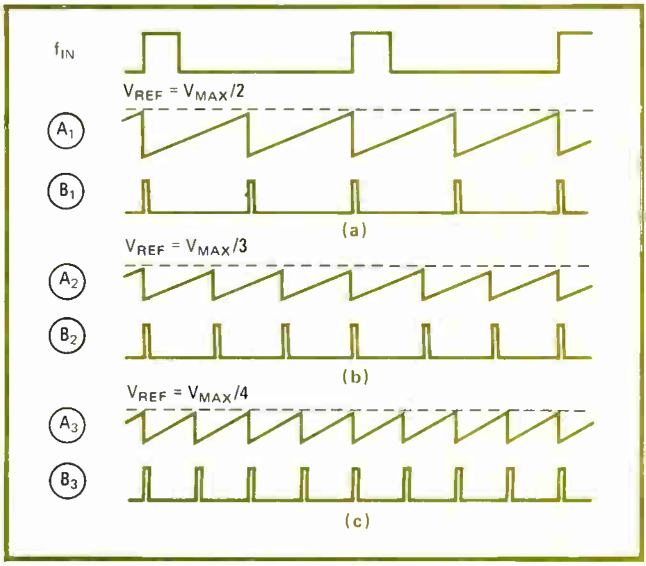
Programmable multiplier needs no combinational logic

by Noel Boutin
University of Sherbrooke, Electrical Engineering Department, Quebec, Canada

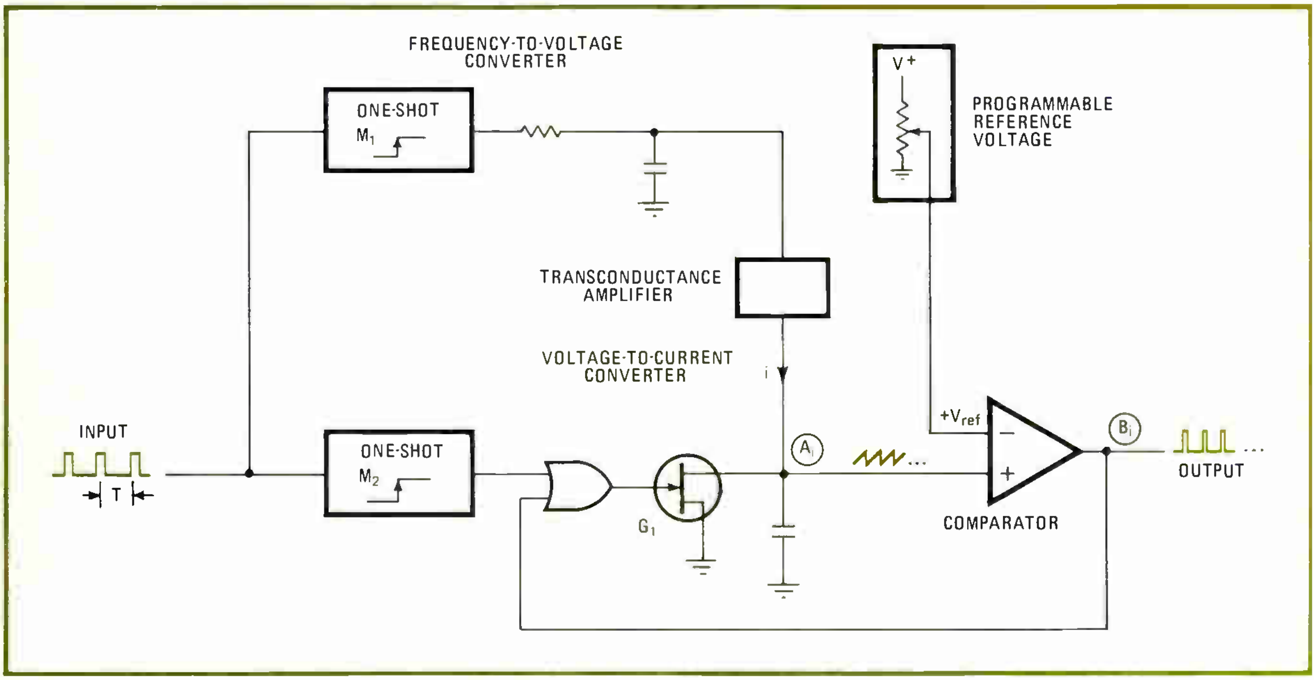
The frequency multiplier circuit proposed by R. J. Patel [*Designer's Casebook*, March 16, p. 119] can be vastly simplified for applications where the duty-cycle of the output waveshape must or may be kept low. Specifically, no combinational logic is needed for a frequency multiplication of N, and only one comparator is used in place of the N − 1 comparators required in Patel's circuit. A programmable voltage reference, which can be just a potentiometer, a digital-to-analog converter, or a keyboard [*Designer's Casebook*, Dec. 22, 1977, p. 80], can be used to set the multiplication ratio desired.

The modified circuit is shown in Fig. 1. Two one-shots are fired on the positive edge of each input pulse, f_{in}. The input signal may have almost any duty cycle.

Emanating from the transconductance amplifier is a sawtooth waveform, which has a period determined by M_2. The one-shot drives one input of an OR gate that switches gate G_1 on at regular intervals. Connected to the other input of the OR gate is the output of a comparator, which turns on G_1 and resets the ramp whenever the value of the sawtooth amplitude exceeds the value set by the programmable reference voltage at the comparator's inverting port. This operation is shown in the timing diagram of Fig. 2 for multiplication ratios of 2, 3, and 4, respectively. Thus frequency multiplication is achieved by the feedback signal from the comparator, not by the use of combinational logic, which derived the output wave from the input signal in Patel's circuit. The



2. Two, three, four . . . Frequency doubler (a), tripler (b), and quadrupler (c) are easily synthesized by adjusting the ratio V_{max}/V_{ref} with the programmable reference source. Output signals are pulses, but may be converted to square waves by adding a flip-flop operating as divide-by-2 counter to comparator output.



1. Simplified. Circuit can achieve frequency multiplication without using logic or more than one comparator (see text). Multiplying signal is derived from input wave and comparator, which periodically resets sawtooth each time the ramp itself exceeds a present reference voltage.

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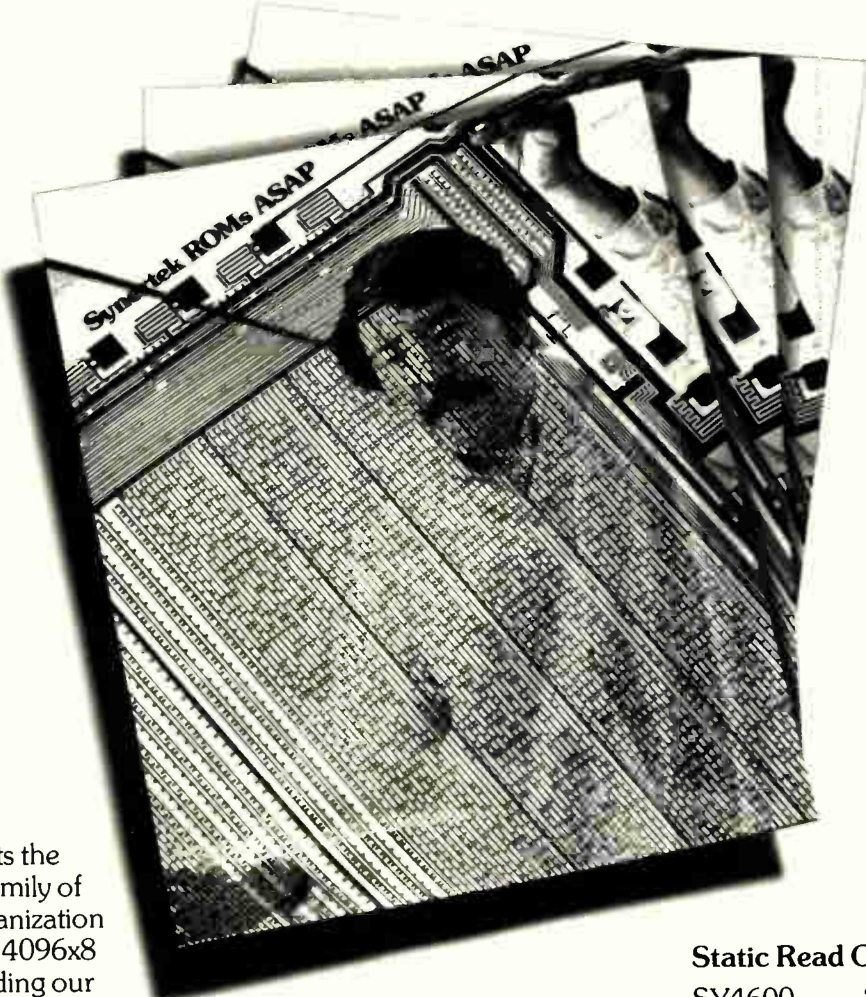

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SY2332	4096x8, 450nsec (2716 compatible)
SY2364	8192x8, 450nsec, 24 pin

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number, N, of equally spaced spikes that appears at the output of the comparator during each period of the input signal is given by $N = V_{max}/V_{ref}$, where V_{max} is the maximum voltage that would be reached if the feedback signal were not present.

If a symmetrical output (square wave) is required, a flip-flop operating a divide-by-2 counter can be added to the output of the comparator. It will also be necessary to adjust the multiplication ratio to twice the desired value (2N) in order to recover a square-wave output frequency of Nf_{in}. □

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.

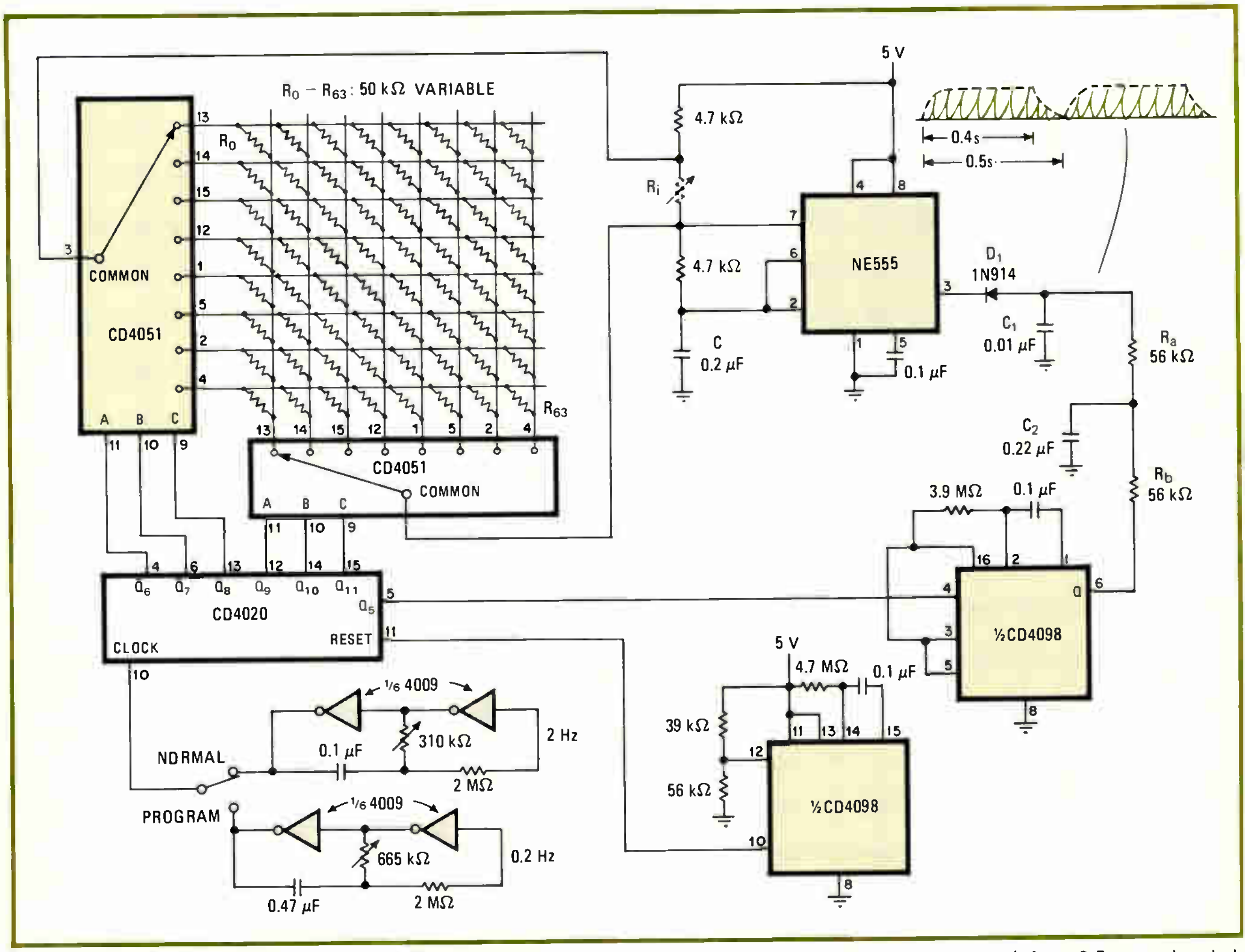
Resistor matrix orchestrates electronic piano/tone generator

by Hsi Jue Tsi
National Taiwan University, Taipei, Taiwan

Combining an eight-by-eight-resistor matrix that is programmed to generate 64 different frequencies with control circuits that send each tone in sequence for half-second intervals, this unit makes a tuneful electronic music box. It can also serve as a programmable tone generator for testing purposes, in which case the number of tones may be extended to 512.

In this circuit, the resistor timing element in an astable multivibrator is periodically switched to a new value every half second with the aid of a multiplexer circuit. Serving as the multivibrator (or tone generator) is the versatile 555 timer, which can generate frequencies over a range of 100 hertz to 5 kilohertz.

Timing resistors are switched into the R_iC network with the aid of two CD4051 multiplexers, as shown. Each device has three address ports that are updated by a 4020 counter, which is in turn stepped by an oscillator normally running at 2 Hz. If, for example, all outputs of the 4020 are low, the common ports of the 4051s will be



Tuning up. Music box/tone generator uses programmable resistor matrix to generate 64 tones in sequence, each for a 0.5-second period. Oscillator clocks 4051s, which in turn place each of 64 resistors in timing network of 555. Output of timer is shaped by a 4098 one-shot and suitable integrator network for click-free output during switching. Matrix can be programmed in 10 minutes if counter is available.

connected to row 1, column 1, of the matrix and R_0 will be in the 555's timing loop. As the counter steps through all locations, R_1–R_{63} in turn set the frequency of the 555.

The output of the 555 is a train of square waves. To avoid the key clicks that occur each time the frequency of a tone is changed, the square wave is rounded off, being converted to a sawtooth wave with D_1, R_aC_1, and R_bC_2. Note that the 4098 monostable multivibrator connected to R_b aids greatly in controlling the attack-delay characteristic of each waveform at the output; it applies a gradual turn-on bias to D_1 initially and then a turn-off bias after about 0.4 second. This 4098 is driven by the 4020. R_b and C_2 integrate the 4098's output pulse, then C_2 discharges, enabling the device to bias the diode as described. A second 4098 one-shot is used to reset the 4020 so that resistor R_0 will be immediately accessed on power-up.

Programming of the resistor values can be tedious, but with practice it can be done in 10 minutes. A frequency counter connected to the output of the 555 is helpful. Despite the harmonics in the 555's output, the counter will read the fundamental frequency of a given tone.

First, it is necessary to switch to the program clock. This clock will advance the 4020 counter once every 5 seconds and gives the user time to adjust each R_i for the particular output frequency desired during that span. Two passes over the 64 tones should be adequate.

If a counter is not available, a piano or tuning fork will be needed and tuning will have to be done by ear, requiring an extremely long programming time. Means will also have to be found to single-step the 4020.

For more demanding applications, the number of tones can be expanded to 512 by adding another CD4051 and the appropriate number of resistors. □

Double-balanced mixer has wide dynamic range

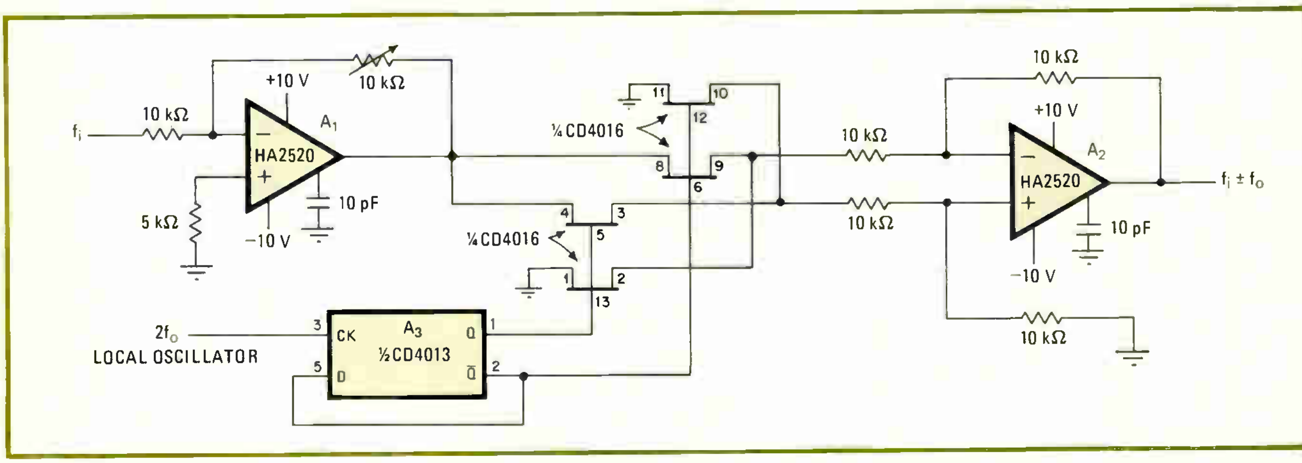
by Carl Andren, Eric Heinrich, and William Mosley
E-Systems Inc., St. Petersburg, Fla.

This double-balanced mixer is ideal for use in frequency-division-multiplexed systems and because of its extremely wide dynamic range will also find use as the baseband mixer in phase-shift-keyed demodulator circuits. Operating linearly on input signals extending from 5 microvolts to 5 volts at frequencies from dc to 1 megahertz. the circuit owes its wide range to a combination of factors, notably a balanced output-stage configuration, low offset voltages in its switching circuits, low local-oscillator feedthrough, and the low-noise output of the active devices used. The mixer has the additional advantages of a very low output impedance and extreme stability over a wide temperature range.

The mixer is shown in the figure. A_1, serving as a wideband buffer amplifier with selectable gain, routes input signal f_i toward A_2 through the CD4016 quad analog switches. The CD4016, which contains four transmission gates, is turned on through A_3 by a local oscillator signal (which equals, in this case, $2f_o$), alternately switching A_2 between its inverting and noninverting modes. This action varies the gain of the amplifier from +1 to −1, so that the amplifier performs a chopping (mixing) operation on the input signal.

The input signal, f_i, is thus translated into a frequency of $f_i \pm f_o$ at the output of A_2. Mixer balance is achieved by using the combination of a symmetrical driving source for the switches (Q and $\overline{Q}$ output of the 4013) and a symmetrical input circuit for amplifier A_2. Thus the local oscillator (carrier) will be effectively suppressed at the output—feedthrough will be 60 decibels below the amplitude of the f_i signal. Double balancing ensures that the input-signal feedthrough will also approach the −60-dB value.

An added benefit of A_2's balanced input circuit is that the switch-transient feedthrough is reduced. This is because the pulses introduced to both ports of the op amp are about equal, and because the differential input voltage is therefore near zero, the output of A_2 is approximately zero for these transient components. □



Dynamic. Mixer operates linearly over input-signal range extending from 5 μV to 5 V. Double-balanced circuit reduces local-oscillator and input-signal feedthrough to −60 dB below f_i. Switch-transient feedthrough is reduced by A_2's balanced input circuit.

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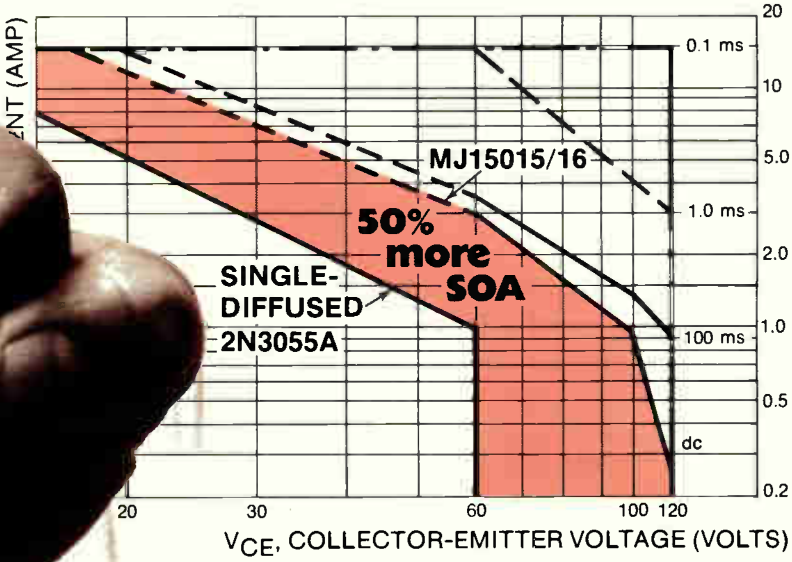

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2N3773	2N6609	140	1.5 A @ 100 V	15– 60 @ 8 A	1.84	2.07
2N4347	—	120	1.5 A @ 60 V	10– 60 @ 2 A	0.78	—
MJ15003	MJ15004	140	5 A @ 50 V	25-150 @ 5 A	2.56	2.56
MJ15011	MJ15012	250	1.2 A @ 100 V	20-100 @ 2 A	1.80	1.80
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Factoring in software costs avoids red ink in microprocessor projects

In selecting a microprocessor for a system, attention must focus on the costs of programming, development systems, and memory types

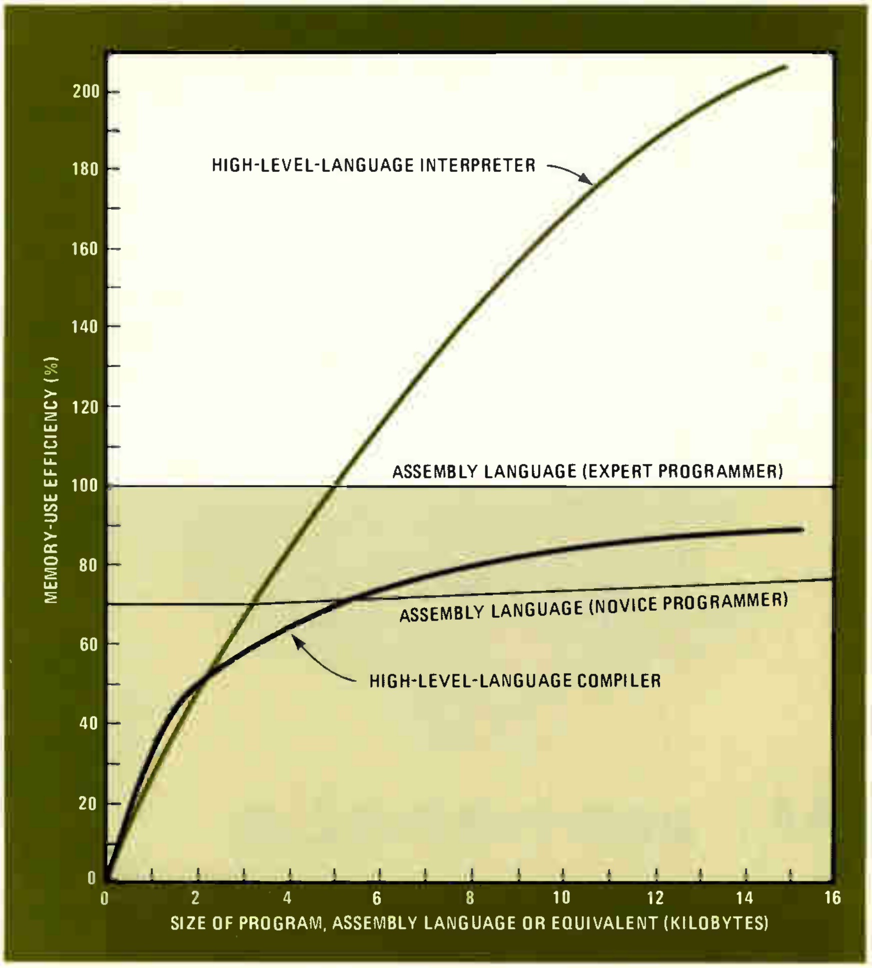
by Phillip Hughes, *National Semiconductor Corp., Santa Clara, Calif.*

☐ Selecting a microprocessor for a system design is a serious business, for the choice can mean the difference between success and failure, profit and loss. However, many of the criteria involved are not readily apparent. Of course, such engineering considerations as selection of speed and word length are relatively simple to handle. But there are factors that do not show up on data sheets yet strongly influence costs for better or worse.

Consider, for example, startup costs. Such decisions as selection of the level of the language in which programming will be done and choice of a development system will affect the cost of programming.

Other important options include choosing between a read-only memory and a programmable ROM and deciding whether to go for a single-chip microprocessor as against the multichip solution. Finally, two important questions that must be settled are: is a true second source available? And what would be the impact on spares, maintenance, and training should the microprocessor selection be changed sometime during the system's life?

Essentially, all of these factors hinge on the costs involved. Thus the designer must have a clear picture of these outlays as he settles upon a microprocessor for his system. The discussion that follows will give an idea of



1. Programming efficiencies. Microprocessor memory-use efficiencies vary with the type of software language and program size. Assembly-language efficiency depends on programmer experience. But a compiled high-level language, on the other hand, has a curve that varies with program size.

where the dollars go in making these six decisions.

As well as affecting startup costs, the choice of a programming language influences the speed of evaluation and the amount of memory needed. The question here is which level of language to look at. There are essentially three choices: assembly language, macro-assembly language, and high-level language.

Selecting a language

Assembly language, the simplest available, is a one-for-one symbolic equivalent for machine code. A major advantage is that it simplifies address calculations. With an assembler, an experienced programmer will produce a 30% more efficient code than can a novice, as Fig. 1 suggests. Memory-use efficiency in the figure is defined as the number of bytes of memory required for a program in software language, with 100% efficiency assigned to a program in assembly language created by an experienced programmer.

There is one important difference between assembly language and macro-assembly language: the latter can define strings of instructions that can be called by just one symbol. This convenience shortens coding and eliminate errors. The savings in programming costs over assembly language will run between 5% and 20%, depending on the experience of the programmer. However, selecting a macro-assembler has no effect on evaluation speed or efficient memory use.

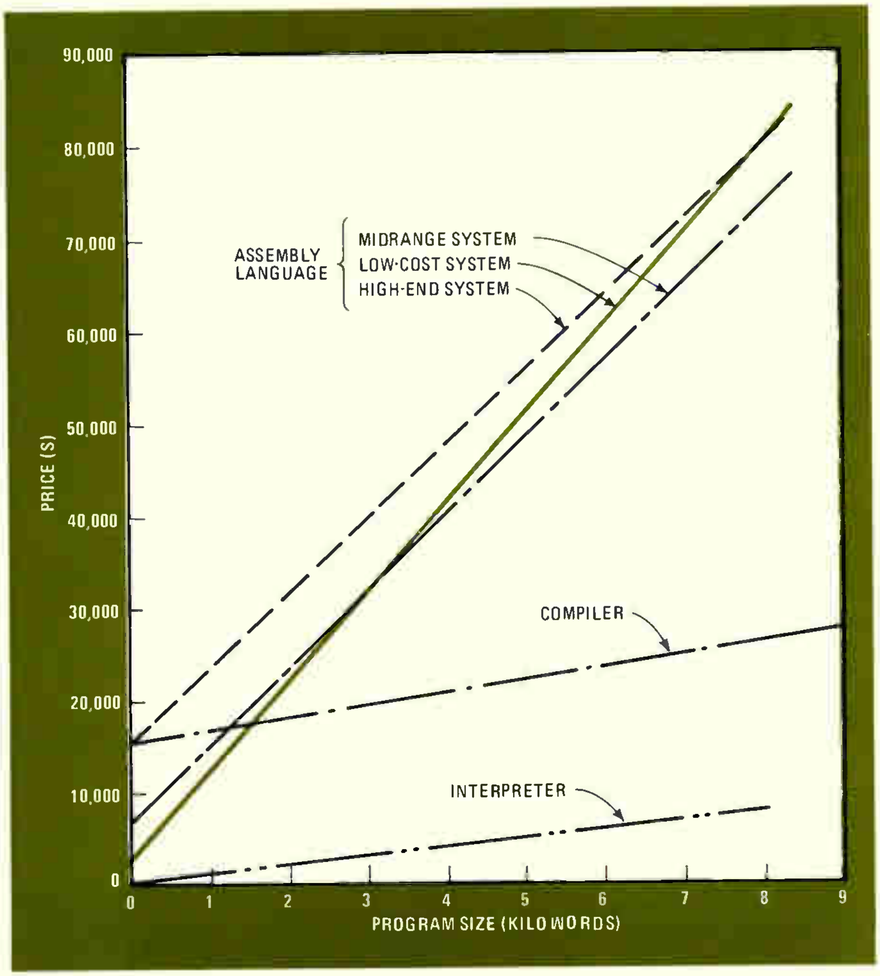
A high-level language will permit the programmer to code in terms related to everyday English and mathematical expressions. The source statements that the programmer writes can be translated into machine code and specialized subroutines added. The outcome is a package compiled from several routines and machine-language statements.

The compiler and the size of the program determine the relative efficiency of this programming method. For small programs, efficiency is relatively low, because the specialized subroutines are used only once or twice. Figures 2 shows that, as a program grows, memory-use efficiency can climb to 90%.

Efficiency above 100% can be achieved with an interpreted high-level language. Such programming is actually accomplished at two levels: the programmer writes in high-level language, and the interpreter, which is written in assembly language, reads the program and executes it directly. This two-level technique slows execution by a factor of five, but in systems such as data logger and position controllers, this slowdown is unimportant.

However, an interpreted language is highly efficient for very short programs. The cutoff point for 8-bit microprocessors is about 5 kilobytes. This will permit a high-level source program of something under 1 kilobyte, and an interpreter program of around 4 kilobytes.

The investment in a development system is the largest sum to be paid out at the beginning of a project. The



2. Getting started. Startup costs for any microcomputer chiefly consist of the cost of a development system plus programming costs. As this family of curves show, startup costs are a function of both the program size and the level of language to be used.

largest variable item is programming cost, which depends on the language level selected and the development system used.

Starting from scratch, the minimum cost for a development system will be between $2,500 and $3,500, for an assembler, a random-access memory, and a teletypewriter interface. A midrange system of a central processing unit and a teletypewriter interface will cost between $5,000 and $7,000. The high-end system cost will be between $13,000 and $18,000, depending on what peripherals and options are included.

Programming costs

For a low-cost development system, programming costs will run about $10 per instruction of fully debugged assembly code. Efficiency will rise 10% to 20% with a midrange or high-end development system because of the extra features that help create the program, such as an editor, and that translate it into machine code, such as an assembler.

Even at the low end, it pays to look for a system with a good macro-assembler, since experienced programmers will put it to good use. When settling on an expensive system, it is sensible to ensure that it will work with more than one kind of processor. Such versatility will help write off the large initial investment over more projects.

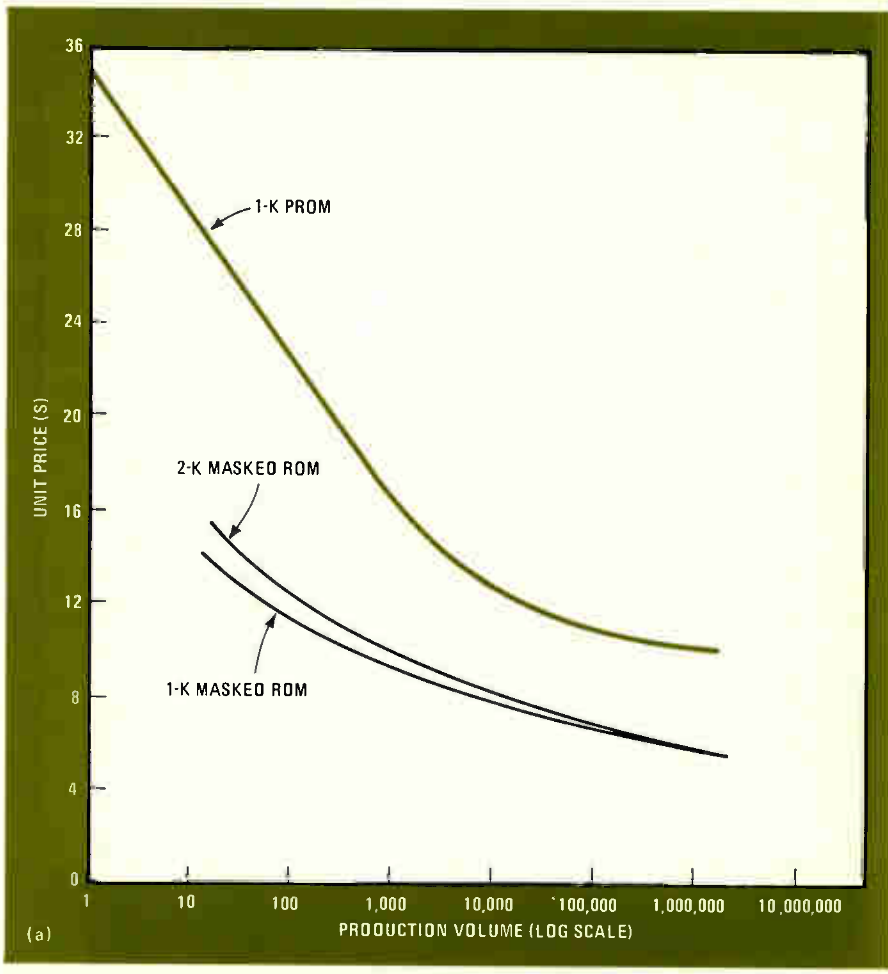
The cost of programming in assembly language follows the curves of Fig. 2. Clearly, for a one-time project that involves less than 4,000 words, a low-cost development system is appropriate. If programs grow larger or more numerous, the more expensive systems should be acquired. Keep in mind that these costs are usually underestimated, especially when the programming is being started from scratch.

If the initial choice is for a high-level language, the development costs take on another aspect. With an interpretive language, an expensive development system is unnecessary, because programming may be done interactively on the system under development. A line of source code contains the equivalent of about 40 assembly statements and will cost about $20 a line to write, debug, and document. The only interface that is needed is one for a teletypewriter.

Choosing a compiled language means that a high-end development system must be used. The estimated cost of an average line of compiled code consisting of 40 assembly instructions will be around $50 for writing, debugging, and documenting. Moreover, the development system's cost will be at the top of the scale, because of the extra RAM required for a compiler. In fact, a system using 64 kilobytes of RAM can cost over $20,000.

Once the size of a program and the number of systems to be produced have been determined, it is relatively easy to choose between a ROM and a PROM in terms of basic costs. Figure 3a compares the cost structure of typical 1-K-by-8-word ROMs and PROMs and a 2-K-by-8 ROM.

3. PROM vs ROM. Unit price of PROMs is always higher than that of comparable ROMs as shown in (a). With a customer's masking charges added to the device cost of a ROM (b), a PROM is cost-effective in quantities below the 75-unit level.



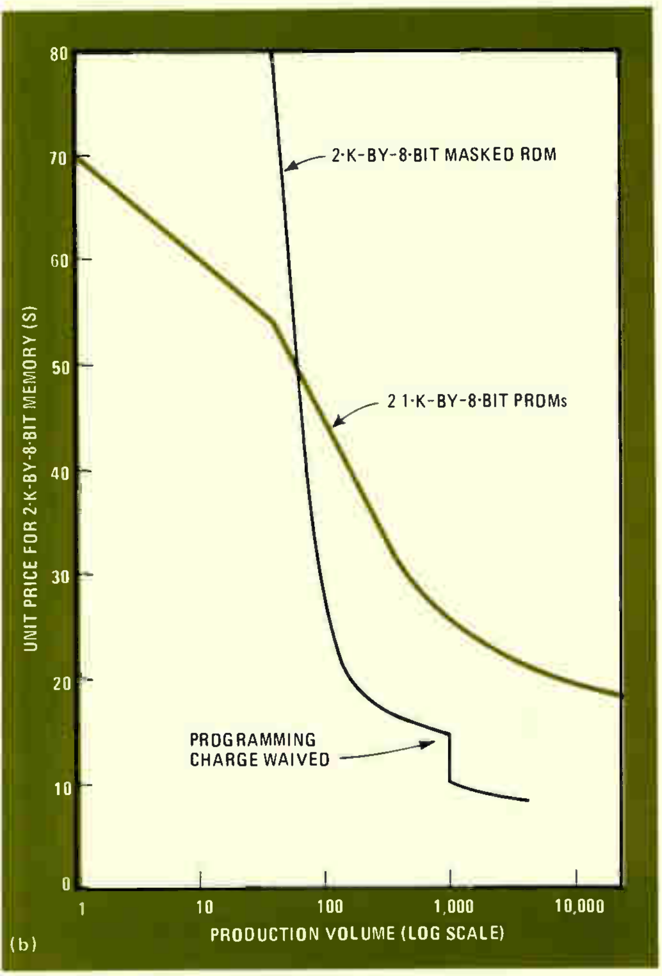
Since the price difference between the two ROM types is about $1.50, the cost per kilobyte for the larger type is almost 50% lower. Projecting this trend, the cost per kilobyte for an 8-K-by-8 ROM is less than $1 in quantity. Of course, there usually is a mask-manufacturing charge, which is another $500 to $1,000 for a minimum quantity ranging between 250 and 1,000 units.

Weighing ROM vs PROM

An example will bring the ROM/PROM option into focus. For 250 systems with a 2-K program size, the larger ROMs plus a $1,000 masking charge will total about $4,000, with a small savings if the smaller 1-K memories are used. Now, comparing the unit costs of the 2-K ROM including mask charges and of the 1-K PROMS shows that the masked memories will be cheaper than the programmable chips if more than 75 systems are to be built (Fig. 3b).

However, there are some drawbacks to the choice of a ROM over a PROM. For instance, turnaround time can be from 8 to 10 weeks. In addition, there is always the chance that the specified ROM pattern might contain errors, and the complete program debugging necessary for safety's sake takes about $1,000 in extra testing.

For certain systems with relatively large volumes, the single-chip microcomputer is an excellent choice. In quantities of 50,000 to 100,000, a 4-bit single-chipper will cost between $3 and $6, and an 8-bit device between



(b)

$6 and $10. The costs for similar systems realized with discrete integrated circuits will be between $12 and $18.

If the 4-bit chip offers adequate performance, there is no way the 8-bit device or any multichip processor can compete. The price differential is just too great.

The choice most designers are likely to be facing, however, is between one-chip and multichip 8-bit solutions. Factors that come into play include production volume, memory size, number of interface pins, interface signal levels, and expandability.

Looking at one-chip vs multichip computers

When fewer than 10,000 systems are involved, the single-chip computers are simply too costly. However, this situation could change in the future.

As for memory size, the single-chipper requires an added component for each memory increment. In the multichip family, on the other hand, it is easy to move from a memory chip with a capacity of 5 kilobytes up to one with a capacity of 8 kilobytes. Moreover, the central processing unit can control as much as 64 kilobytes of memory itself.

Interfacing the single-chip microcomputer to a relay or display has its disadvantages, too. In most cases, the output is not enough to drive external devices, so drivers must be added. Then the price and parts-count advantages of the single-chipper quickly erode. In addition, I/O port pins must be committed to the interface, limiting the amount of input/output available.

Still another disadvantage of the single-chip system is the difficulty in expanding computer power without adding another processor and more ROM, RAM, and I/O. With a multichip processor in a bus-oriented systems, it is easy to double the computing power by adding a second processor and modifying the program. Interfacing remains the same, and communication between processors is simple.

Taking these factors into account, multichip processors look cost-effective with a production volume of less than 10,000 systems a year (Fig. 4). Until the crossover point with single-chip unit costs drops to the 1,000 level, multichip solutions will pay for medium-volume systems.

Considering second sources

No matter what microprocessor is chosen, it must have an alternate source of supply. There really are three kinds of alternate suppliers, often lumped together: the second source, the alternate source and the "designed-it-ourselves" source.

A second source will have received masks, process information, and engineering help from the chip's developer. An alternate source gets masks and process details but no engineering assistance. He may have difficulty coming up to production speeds.

The third type of source is one who builds his own version of another's design. Such parts must perform at least as well as and preferably better than the original to overcome the disadvantage of lack of official recognition. However, it pays to be wary of this source, since a user is in effect getting a single-source product. Such a buy can be risky if the product uses new technology.

Along with second sourcing, another factor often ignored is the impact of a choice of a new processor on spares, maintenance, and training. A new microprocessor type may require expensive modifications in these areas, so the apparent gain in employing a better device may disappear.

The contributions to unit cost of many of the factors discussed and shown in the figures can be expressed in one simple equation:

CALCULATING UNIT PACKAGE PRICE			
Item	Interpreter	Compiler	Assembler
Su	\$2,000	\$20,000	\$20,000
Fe	42%	50%	100%
ROM	2 kilobytes	2 kilobytes	2 kilobytes
Rc	\$10 for 2 K	\$10 for 2 K	\$10 for 2 K
ROM/Fe	5 K	4 K	2 K
ROM R_c/Fe	\$28	\$20	\$10
Su/V	\$2	\$20	\$20
SYS	\$15	\$15	\$15
C_T (unit price)	\$45	\$55	\$45

$$C_T = \left(\frac{S_u}{V} + \frac{\text{ROM}}{F_e}\right) \times (R_c + \text{SYS})$$

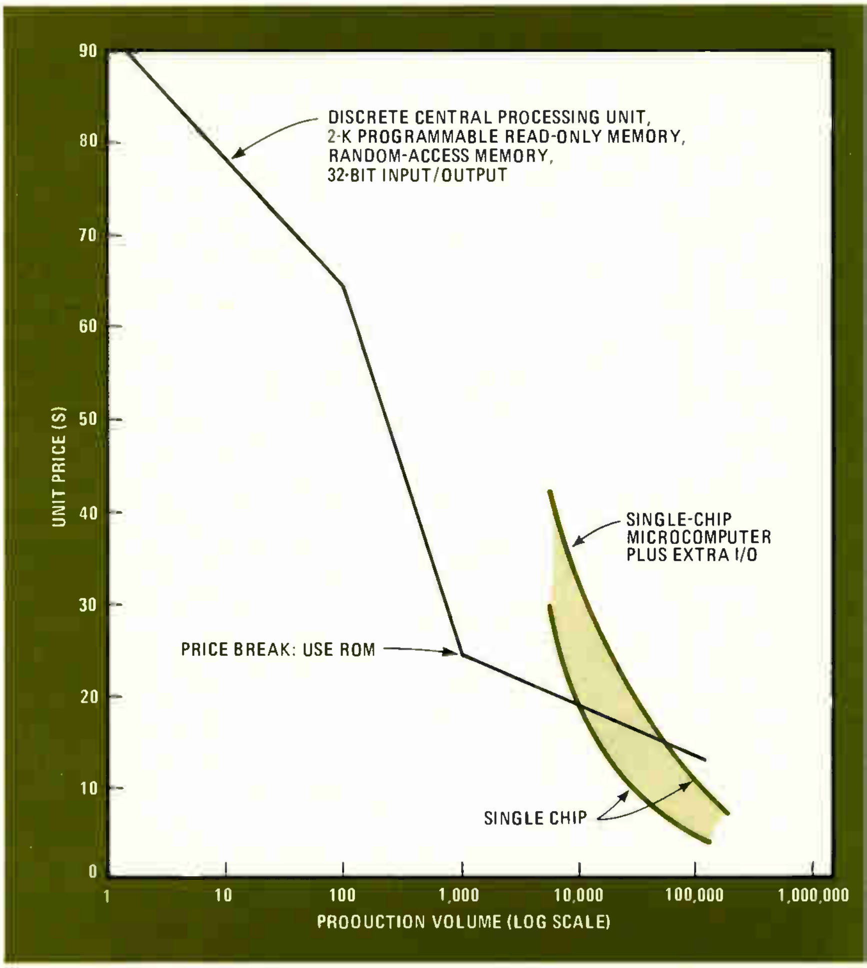
where

C_T = total package price
S_u = startup costs
V = production volume
ROM = kilobyte capacity of the ROM
F_e = memory-use efficiency
R_c = ROM cost per kilobyte
SYS = cost of the rest of the system.

Figuring costs

For example, a product is conceived that will be produced in 1,000 units. The manufacturer has no prototyping system, but he can get an expert programmer. System specifications call for a ROM capacity of 2 kilobytes. With the help of the curves in Figs. 1, 2, and 3, a table can be generated to estimate C_T for each of three alternative language approaches: interpreting, compiling, or simple assembly. The table shows that for such a system, the assembler and compiler are competitive with the interpreter, despite their higher startup costs.

Clearly, the software aspects of system design with microprocessors bear heavily on device selection. Careful attention to the areas of concern outlined in this article can spare the system designer a nasty surprise when it comes time to tote up final costs. □



4. Multichip systems dominate. Until the 10,000-unit level, the one-chip microcomputer is not price-competitive with multichip microcomputers. In the future, however, the crossover point of these curves may move back to the 1,000-unit level.

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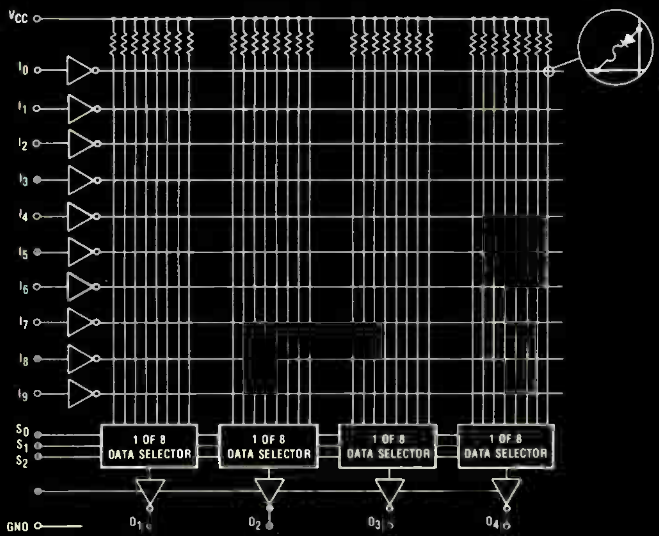

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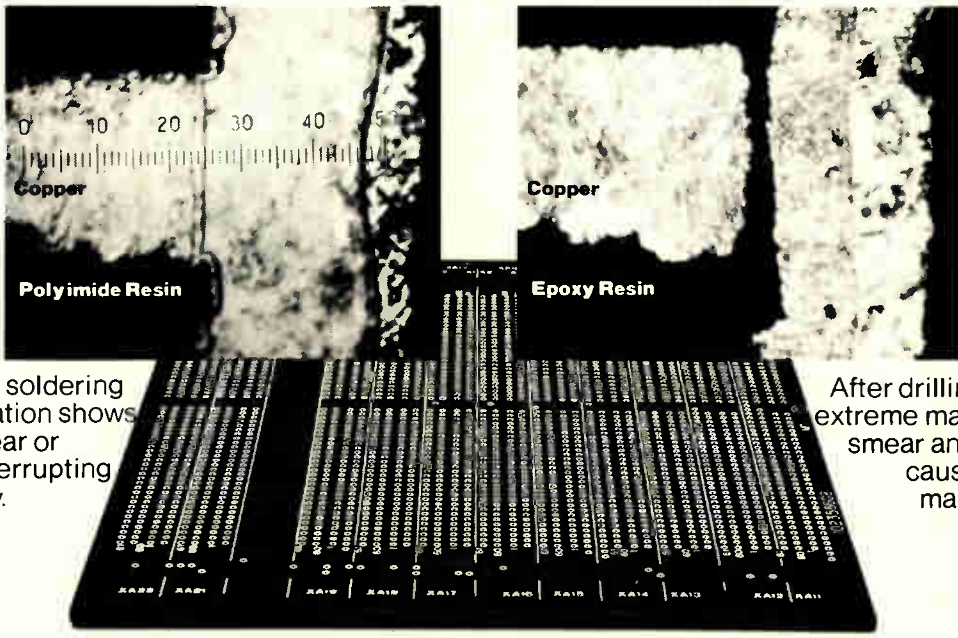

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CCDs bring solid-state benefits to bulk storage for computers

Series-parallel-series structure gives extremely dense charge-coupled-device memory, now commercially available

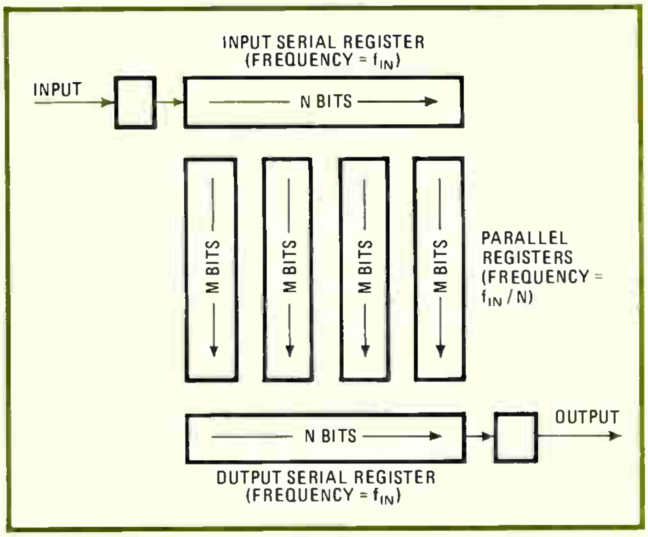
by Bruce Threewitt, *Fairchild Camera and Instrument Corp., Mountain View, Calif.*

☐ In less than three years, the capacity of charged-coupled-device memory chips has zoomed from 9,216 to 64-K bits. This rapid growth—greater than that of the MOS dynamic random-access memory—can be attributed to several factors:

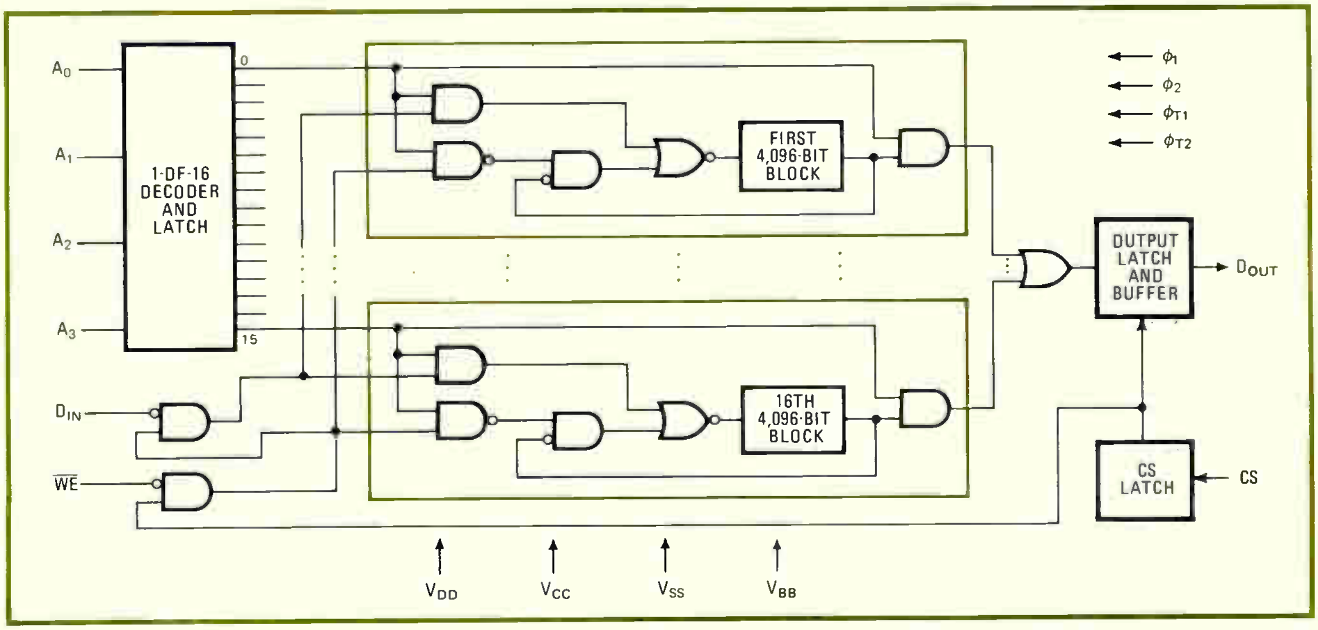
- Compatibility with established metal-oxide-semiconductor technology.
- High packing density, resulting in low cost.
- Low power dissipation, giving higher reliability.
- Fewer contacts per bit, resulting in better yield.
- Faster access time (latency) than magnetic storage memories and faster data rate than large MOS RAMS.

Of this list, perhaps the single most important factor for CCD success is that the fabrication technique is the same as that used to manufacture high-volume n-channel MOS devices. Consequently, designers can put their years of experience with a familiar process into play, thus shortening the learning time usually required for a new technology.

Of course, CCD memory is a low-cost alternative for bulk memory, not a replacement for high-speed RAM. General computer architectures can use caches for stor-



1. Tight organization. Series-parallel-series architecture provides a high-density and cost-effective organization for CCD memories. Basically, memory consists of a group of shift registers that move data in serial form at input and output, and in parallel in between.



2. Big memory. The Fairchild F464 CCD memory is organized as a 65,536-by-1 bit format in 16 blocks of 4,096 bits. To select one of the blocks to read, write or read-only, four transistor-transistor-logic-compatible address bits are provided.

ing data in block form, which need not be accessed randomly. Since a computer usually performs operations sequentially, it can tolerate the serial organization of a CCD device. In this case, data rate (the reciprocal of memory cycle time) is more crucial than random-access time, thus making the simpler, cost-effective serial-access memory more practical for bulk storage than RAM. Charge-coupled devices now fill the gap between magnetic and random-access memories at a cost 3.5 to 5 times less per bit than RAMS.

CCD-memory architecture

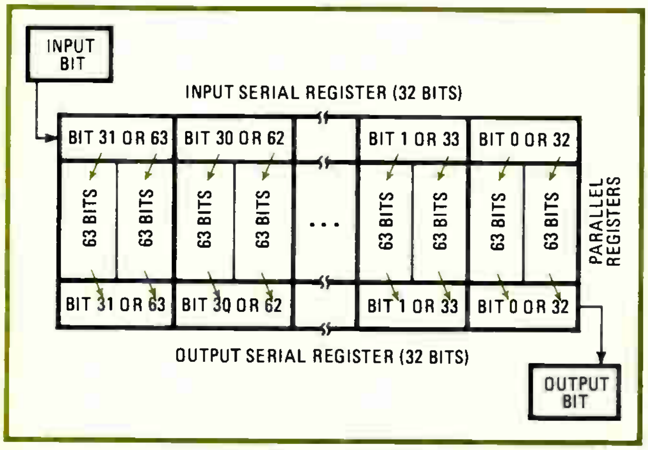
With such a young technology, there are a number of architectures and clocking schemes under investigation. Fairchild believes that serial-parallel-serial is the best organization for high-density, cost-effective CCD memories. SPS combines the performance and density benefits found in other charge-coupled-device architectures with even more significant density improvements and suitable latency when compared to magnetic media.

Development of SPS architecture (Fig. 1) is in keeping with the goal of replacing magnetic bulk-storage memories with semiconductor memories. Briefly, SPS works like this. Data is entered into a serial input register at frequency f_{in}. When the register is full, a series-to-parallel conversion occurs, and data is shifted in parallel at frequency f_{in}/n where n is the number of bits that the serial register will hold. At the other end of the parallel register, a parallel-to-series conversion takes place, and data is shifted out at frequency f_{in}.

The structure is extremely dense, since the series-to-parallel and parallel-to-series conversions require no overhead logic within the SPS block. These conversions are accomplished by four external clocks: two phases for the serial registers, which also are buffered and used in the parallel sector, and two for the conversion. The two conversion clocks are connected only to the interfaces between the serial and parallel registers.

Since this conversion is a low-capacitance function, the external input capacitance of these two phases is very low. And since the serial register clocks only drive 2n bits per block, this clock capacitance is also relatively small. These four low capacitances make interfacing to transistor-transistor logic simple, with standard low-cost drivers being used.

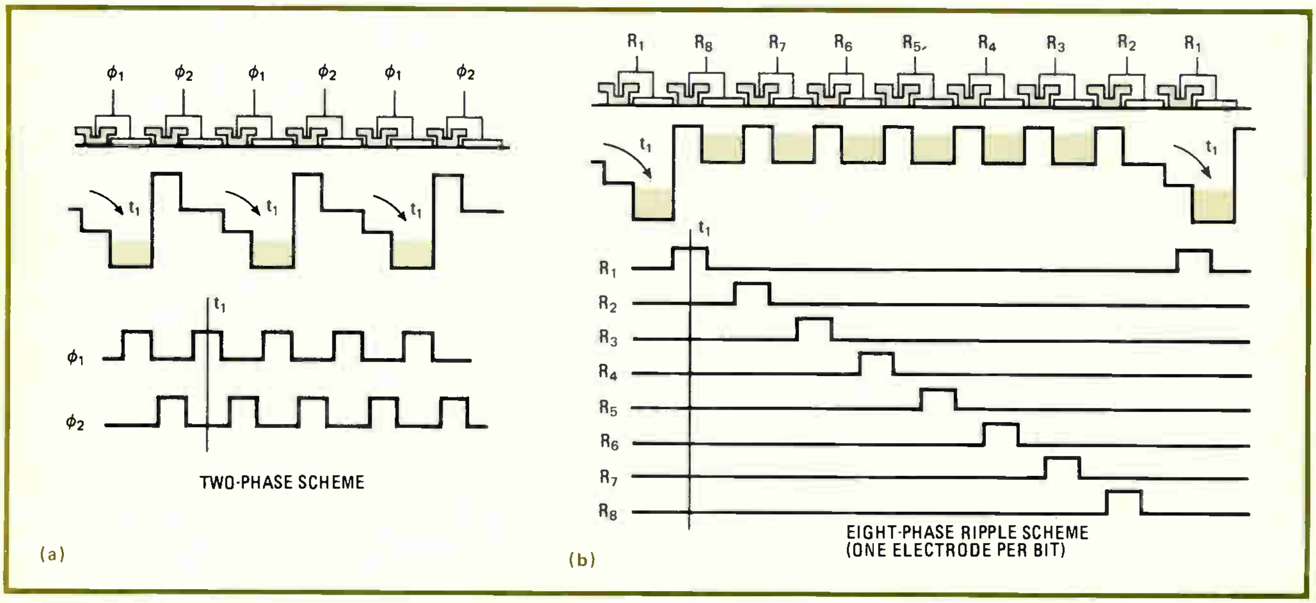
Another advantage, in power dissipation, accrues from the much lower frequency of the internal parallel phases (f_{in}/n; typically $n = 64$) relative to the serial register clocks. Thus they can be buffered on the CCD memory chip without dissipating significant power.



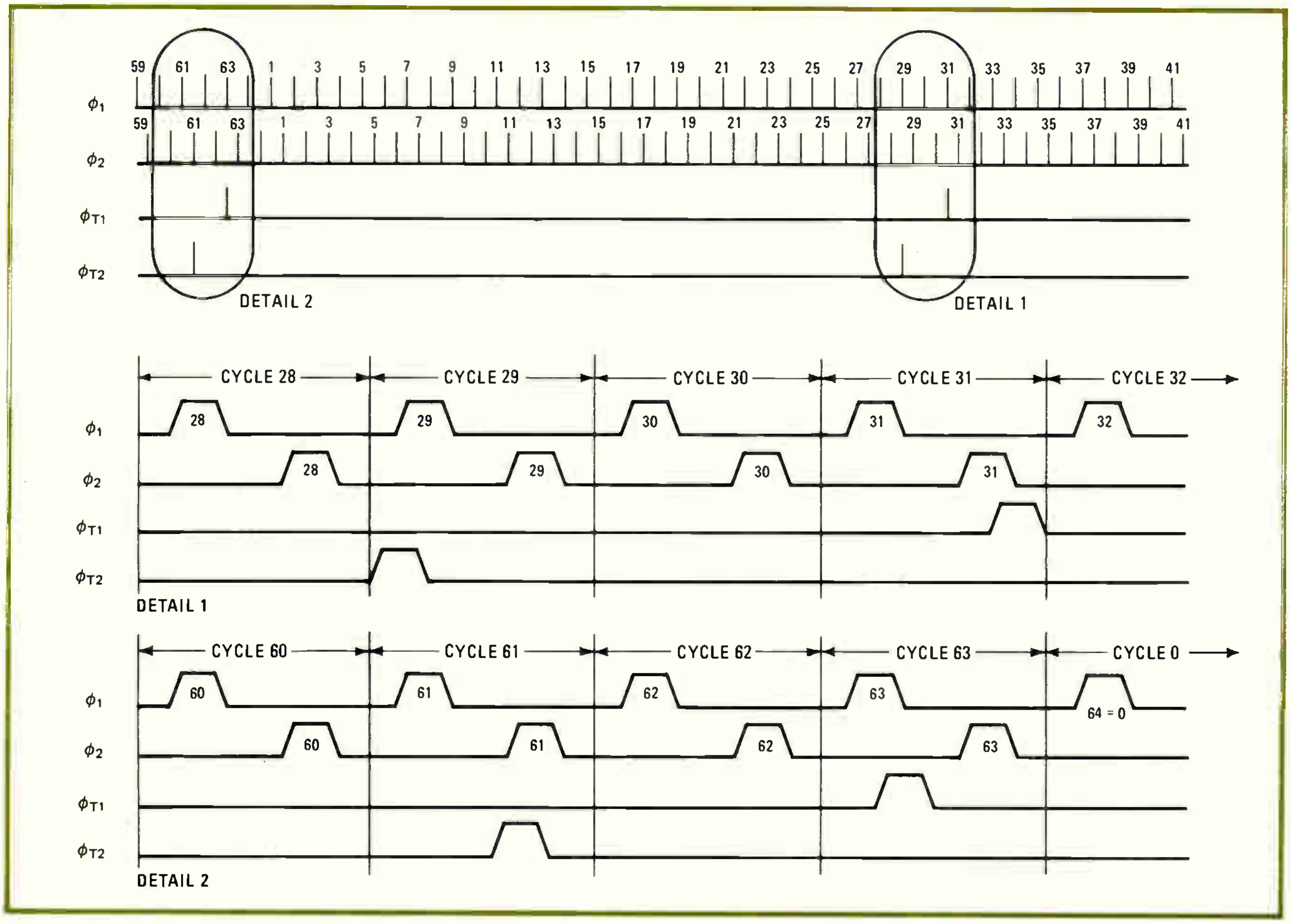
3. Interfacing. Modified SPS structure uses two electrodes of the serial input register to also serve two parallel registers for each block on the chip. Data is transferred on an odd-even interlaced basis from serial to parallel registers. Packing density is in effect doubled.

The F464 64-K CCD memory

The F464 CCD memory (Fig. 2) is the first commercially available semiconductor bulk-storage device. Bits are organized as 65,536 by 1 in 16 randomly accessible blocks of 4,096 bits. Four TTL-compatible address bits are provided to select one of the 16 blocks for read and write-only operations.



4. Ripple. In conventional two-phase clocking system (a), two CCD electrodes store a single data bit. To enhance packing density in the F464, an eight-phase clocking scheme (b) is used that cuts electrode count almost in half and reduces number of internal data transfers.



5. High time. CCD memory requires four clocks. Two high-frequency clocks ϕ_1 and ϕ_2 control input and output registers, while lower-frequency transfer clocks ϕ_{T1} and ϕ_{T2} control charge transfer from series to parallel registers and vice versa.

Each shift-register block is implemented using an interlaced SPS structure in which two electrodes of the serial input register serve two parallel shift registers (Fig. 3). The input register transfers data to the odd-numbered parallel registers and then, on a second scan, transfers the next 32 bits of data to the even-numbered parallel registers. As a result, each serial input register stores 32 bits using 64 electrodes that service 64 parallel shift registers. In a conventional SPS structure, each bit of the serial shift register serves only one parallel shift register. Using the interlaced scheme, this width may be equal to that of only one electrode; hence the packing intensity is doubled.

To further enhance the packing density, an eight-phase ripple technique is used in the F464's parallel register to shift the data. In a synchronous two-phase clocking system (Fig. 4a), two CCD electrodes are required to store one bit of information. In a ripple system (Fig. 4b), the density averages a little more than one electrode. In general, the number of electrodes, n_b, required to store one bit is given by:

$$n_b = \frac{N}{N-1}$$

where N is the number of ripple clocks.

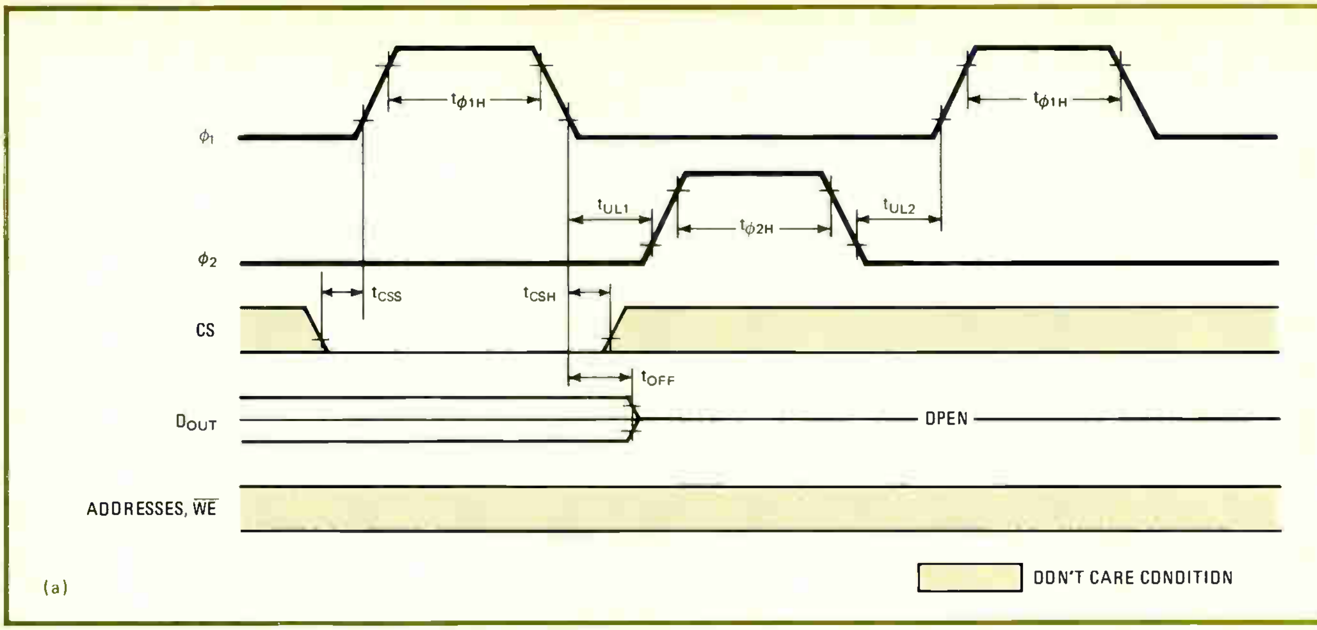
As the number of ripple phases increases from two to eight, the number of electrodes required to store 1 bit is reduced from 2 to 1.14. Thus, when the eight-phase ripple system is used, packing density is almost twice that of a two-phase system.

In addition, the ripple technique reduces the number of transfers required to move a packet of data from the input of a parallel shift register to the output. In an M-bit shift register, the number of required transfers is $M \times n_b$. Thus, a 63-bit shift register needs only 72 transfers in an eight-phase ripple system, compared to 126 transfers in a standard two-phase system. This obviously minimizes signal degradation that is due to charge-transfer inefficiency.

Another advantage of the ripple technique is the reduction of average leakage current per bit. The charge collected is reduced in proportion to the number of electrodes required to store a bit.

F464 operation

The 16 blocks, each consisting of a 4,096-bit SPS shift register for data storage, are randomly accessible using four address inputs (A_0–A_3). The data in every block advances at the same rate of 1 bit per cycle. Each block has its own reference-charge generator, sense amplifier, input/output logic and CCD input circuit. The data-in (D_{in}), data-out (D_{out}), and write-enable ($\overline{WE}$) circuits are common to all blocks and are activated by the chip-select (CS) signal to minimize standby power. The memory



requires four MOS-level clocks (Fig. 5). The two high-frequency clocks, ϕ_1 and ϕ_2, run at a frequency equal to the data rate and control the movement of data within the input and output series registers of each 4,096-bit block. These clocks also control all the peripheral MOS circuits. The two low-frequency transfer clocks, ϕ_{T1} and ϕ_{T2}, transfer charge from the serial-to-parallel and parallel-to-serial registers of each block.

Interlacing of the data is achieved by first transferring data from the input serial register into the parallel registers when the charge packets are under the ϕ_1 gates, then reloading the input register with the next 32 bits and transferring this data when the charge packets are under the ϕ_2 gates. Parallel-to-serial transfer is accomplished in a similar manner. Thus, to achieve proper transfer phasing, the two transfer clocks must be asymmetrical around a 32-cycle interval but symmetrical around a 64-cycle interval.

The ϕ_{T1} and ϕ_{T2} clocks are skewed to achieve correct bit storage in each block. When ϕ_{T1} occurs during ϕ_1 time, ϕ_{T2} occurs during ϕ_2 time, 1.5 cycles prior to ϕ_{T1}. When ϕ_{T1} occurs during ϕ_2 time, ϕ_{T2} occurs during ϕ_1 time, 2.5 cycles before ϕ_{T1}.

Four operating modes

In the standby, recirculate-only, mode (CS low) shown in Fig. 6(a), the contents of all 16 blocks are recirculated automatically, and the device disregards the $\overline{WE}$, address, and D_{in} inputs. The output latch goes into the high-impedance state after the trailing edge of the ϕ_1 clock. Minimum power dissipation occurs when the device is operated in the recirculate mode with minimum ϕ_1 and ϕ_2 pulse widths at the lowest allowed frequency.

In the read-recirculate mode of Fig. 6b ($\overline{WE}$ and CS high), the data from the selected block is presented to the output buffer immediately following the leading edge of ϕ_2. It appears at the output (D_{out}) after a delay equal to the access time t_{acc}. Thus, the access time is referenced from the leading edge to the ϕ_2 pulse and is independent of the duration of ϕ_2.

The output buffer is latched by the trailing edge of ϕ_2, and output data remains valid at the D_{out} pin until the end of the ϕ_1 clock pulse in the next cycle. D_{out} then goes into the high-impedance state until the access to the next bit occurs. The data in all 16 blocks recirculates automatically.

Read-write mode

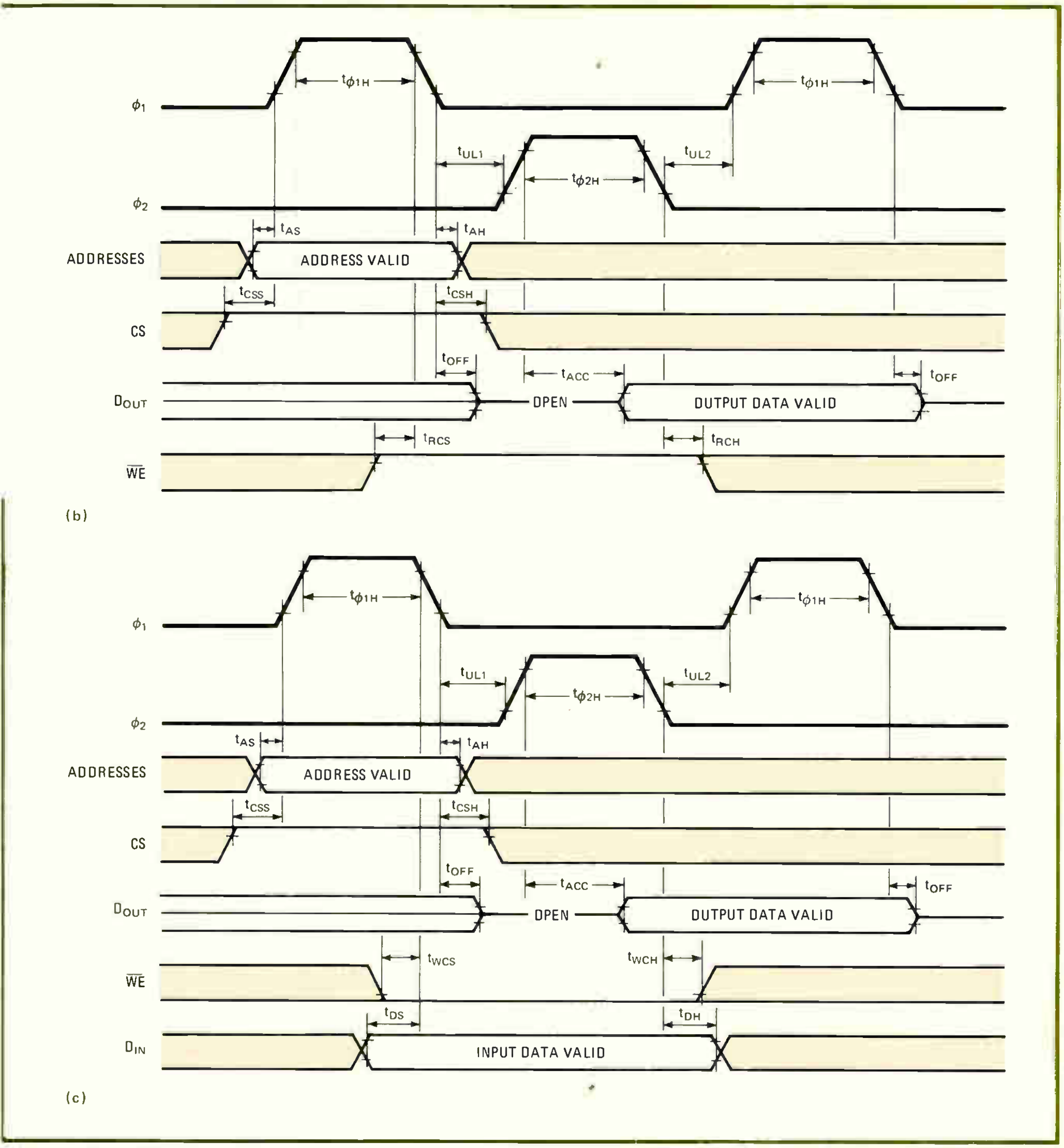
In the read-write mode ($\overline{WE}$ low and CS high), the output data from the selected block is available at the output pin, as in the read-recirculate mode; however, the recirculate path of that particular block is disabled. Input data present at the D_{in} pin during ϕ_2 is written into the selected block by the falling edge of ϕ_2, while the other 15 blocks automatically recirculate their contents.

The functional timing diagram for the read-write mode is shown in Fig. 6c. The four addresses (A_0–A_3) and CS are buffered when ϕ_1 is high. The trailing edge of ϕ_1 latches the information and disables the addresses and chip-select buffers to prevent changes that occur on these pins from entering the internal circuitry when the ϕ_1 clock is low.

The $\overline{WE}$ dynamic buffer is unconditionally preset during ϕ_1 time. In the read-only mode, $\overline{WE}$ remains high, disabling the buffer. In the write model $\overline{WE}$ may go low before or after the trailing edge of ϕ_1, and the $\overline{WE}$ buffer is activated by ϕ_1 or $\overline{WE}$ going low, whichever occurs later. The D_{in} buffer, which is disabled during ϕ_1 high time, is enabled when $\overline{WE}$ buffer is activated. Therefore in the write mode, the data must be valid before ϕ_1 or $\overline{WE}$ goes low, whichever occurs later.

Simple mode

The read-modify-write mode (CS high, $\overline{WE}$ high and goes low) is simple because the memory is always in the read mode whenever CS is high. Since the access time is referenced to the leading edge of ϕ_2 and the setup times of $\overline{WE}$ and D_{in} are referenced to the trailing edge of ϕ_2, this mode of operation requires only an extended ϕ_2 high time to provide the required modify time.



6. Operating modes. In a standby mode (a), data in all 16 blocks of the F464 CCD memory recirculates, and device ignores write commands and address or data inputs. In read-recirculate mode (b), data appears at output after delay equal to access time, and write-enable and chip-select go high, following leading edge of ϕ_2. Comparable timing diagram for the read-write mode is shown in (c).

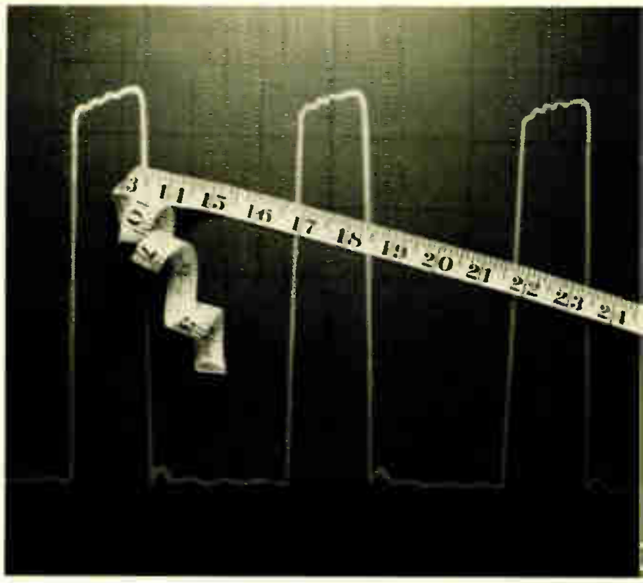
The F464 CCD memory operates over a 1-to-5-megahertz range with power dissipation of less than 3.5 microwatt per bit in the active mode at 5 MHz and less than 1 μW per bit in the standby mode at 1 MHz. Typical capacitance on the TTL-compatible inputs—addresses, CS, $\overline{WE}$, and D_{in}—is only 5 picofarads. On the 12-volt clocks, capacitance is 100 pF (ϕ_1 and ϕ_2) and 30 pF (ϕ_{T1} and ϕ_{T2}). Use of CCD techniques, interlaced SPS architecture, and an eight-phase ripple scheme results in a chip of less than 40,000 mil^2 that fits neatly in a standard 16-pin, 300-mil-wide, dual in-line package.

The buried-channel CCD process, using SPS architecture coupled with proven Isoplanar n-channel silicon-gate technology, is a strong contender for bulk memory because of its high density and its low cost per bit. The 64-K CCD memory is an excellent vehicle for demonstrating workable techniques that can be used in larger memories, such as 256-K and 1-megabit sizes. All indications point to 256-K CCD memories by late 1979 or early 1980 at costs under 10 millicents per bit. □

Eliminating time-base errors from oscilloscope measurements

Delta-time models take the uncertainty out of measuring nanosecond intervals, says Part 2 of *Electronics'* series on time and frequency measurement

by Jerald B. Murphy
Hewlett-Packard Co., Colorado Springs (Colo.) Division



☐ For most of their existence, oscilloscopes have been used to study those waveform parameters that can be determined from the shape of the traces displayed, like noise on analog control lines, ramp linearity, and amplifier response. But with the tremendous growth of digital systems and techniques, the emphasis has shifted to time-related parameters.

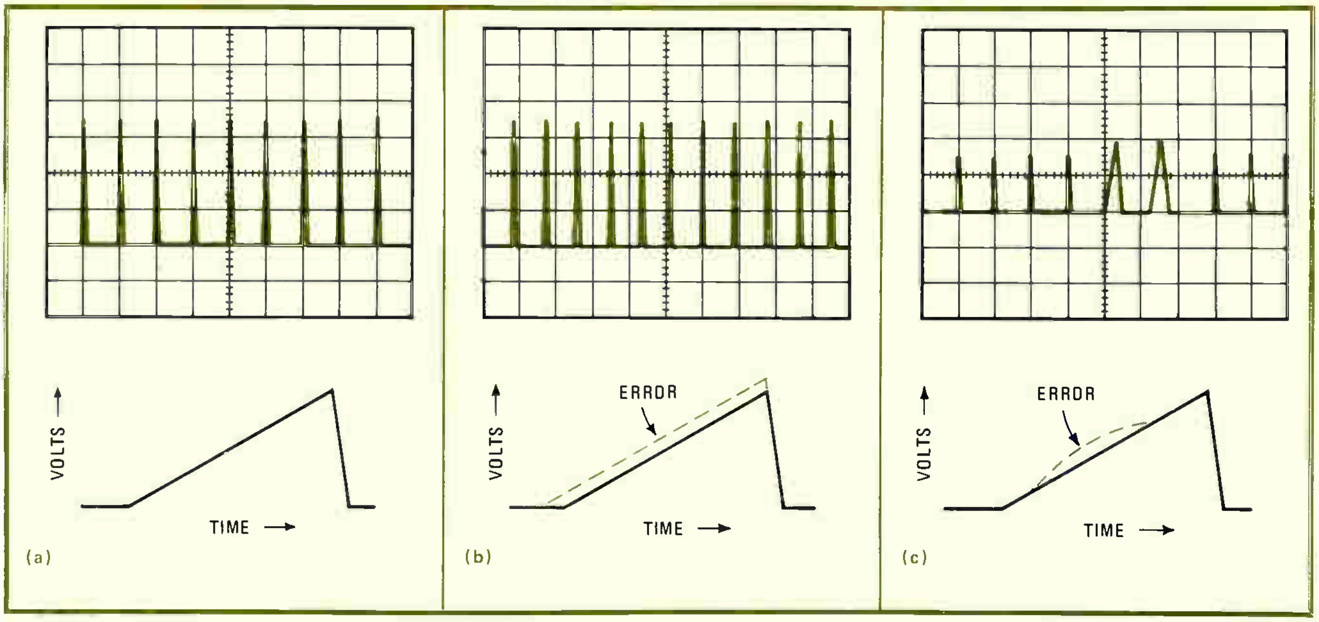
No longer can a few nanoseconds be ignored. The synchronization and timing of control signals, data, and propagation delays have become of paramount importance, making transition times, the width and period of pulses, and clock phasing the typical measurements of interest. And as digital systems' operating speeds have increased, so has the need for more accurate timing measurement—and so has the emphasis on the performance of an oscilloscope's horizontal axis.

In general, a basic oscilloscope can measure time intervals with an accuracy of $\pm 3\%$ of full scale. That is to say, with the oscillosope's main sweep set to a rate of 10 nanoseconds per division, the uncertainty of a measurement read on the face of the cathode-ray tube is ± 3 nanoseconds.

Contributing to this not inconsiderable figure are all three elements of the instrument's horizontal deflection system: the single-ended sweep generator, the wideband power amplifier, and the CRT. However, efforts to improve matters have focused on the last two, since if their effects could be ignored, the scope's accuracy would equal that of the sweep generator and fall well within just 1% of full scale.

Why this should be so is made immediately obvious by an inspection of the two types of time-base errors that

This is part 2 of the continuing "Microseconds and megahertz" series, which is designed to bring engineers up to date on the latest techniques of time and frequency measurement. Part 1, which appeared in the March 30 issue, pp. 81–88, covered the use of digital counters and timers. Followup articles will describe other modern instruments like microprocessor-controlled spectrum analyzers, triggering oscilloscopes, and time-base oscillators.



1. Error sources. Slope-angle and slope-linearity errors of ramp cause a deviation from ideal response shown in (a). Slope-angle errors (b) are due to a deviation from the specified ramp angle. Slope-linearity errors (c) are due to nonlinear changes in the sweep-ramp path.

are the source of the inaccuracy. Both slope angle and slope linearity are involved (Fig. 1).

Slope-angle errors are the result of a deviation from the specified sweep ramp angle of the kind shown in Fig. 1b. This causes the beam to travel across the screen at speeds directly proportional to the erroneous ramp angle, so that there is a linear change in the sweep time between the graticule markers.

Slope-linearity errors are due to nonlinear changes in the sweep ramp path, such that the accuracy of a time-interval measurement changes at various places on the sweep ramp as shown in Fig. 1c.

Both these errors can usually be traced to the horizontal power amplifier and CRT. The power amplifier interfaces the single-ended sweep generator to the CRT plates, but because of the high sweep speeds required in modern scope applications, it must have a large bandwidth and therefore cannot escape the distortion typical of wide-band power amplifiers.

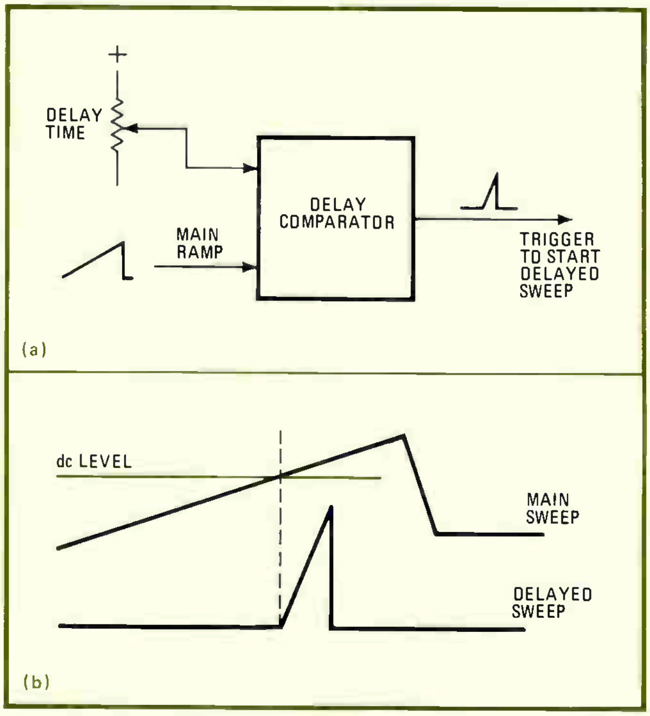
The CRT's contribution to the total error stems partly from the near-field interference of the beam's magnetic field with the electrostatic field of the plates at the ends of the sweep and partly from nonlinearities in the tube's expansion lens system.

One answer

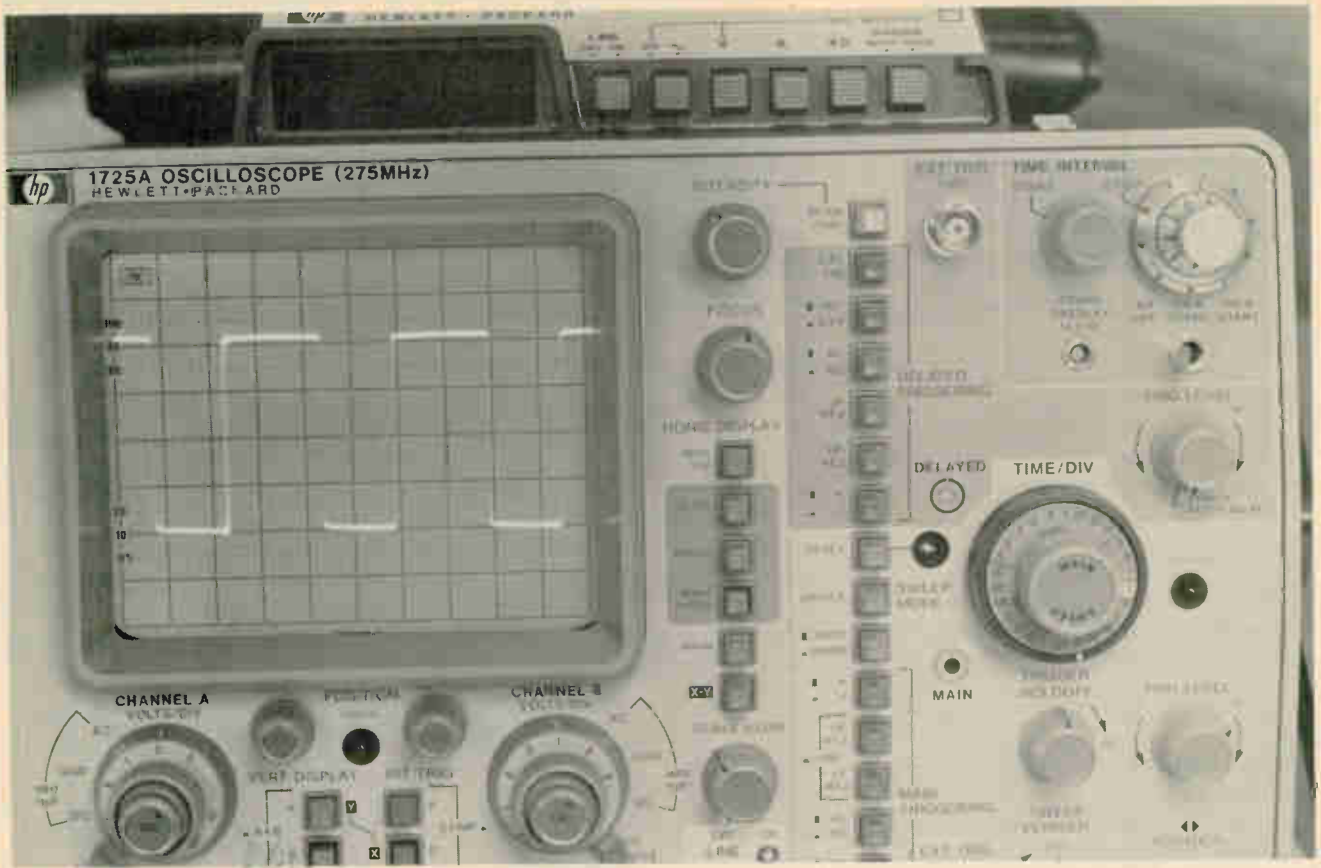
The delayed-sweep oscilloscope, originally introduced in the late 1950s by Tektronix as its type 535, minimizes the effects of the errors associated with the horizontal power amplifier and the CRT. This is done by causing the oscilloscope to act as a null detector. The center of the screen serves as an offset reference position for the start and stop points of the delayed time interval, and readings of the two points are made by adjusting a 10-turn delay-time control. The first reading is subtracted from the second to obtain the time-interval measurement, and at the same time the errors consistent with both readings virtually cancel.

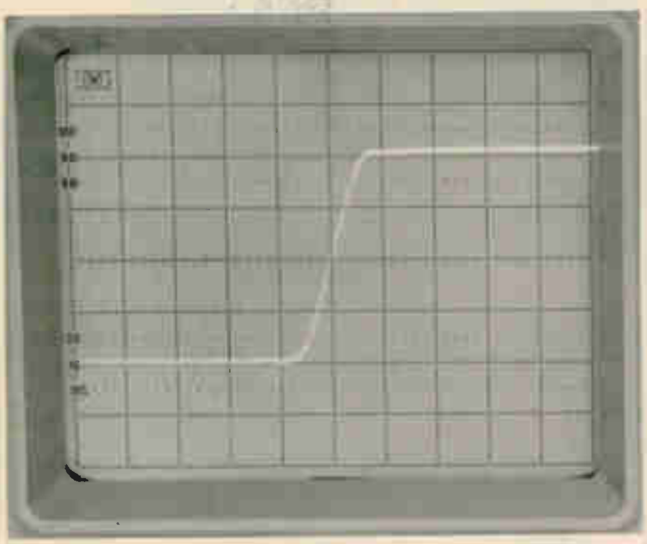
This kind of oscilloscope uses two relatively independent sweep generators to produce the main and delayed sweeps. The faster delayed sweep may be started at almost any point along the slower main sweep ramp (Fig. 2). A precision dc voltage is compared to the rising voltage of the main sweep ramp, and when the two are equal, a trigger pulse starts the delayed sweep.

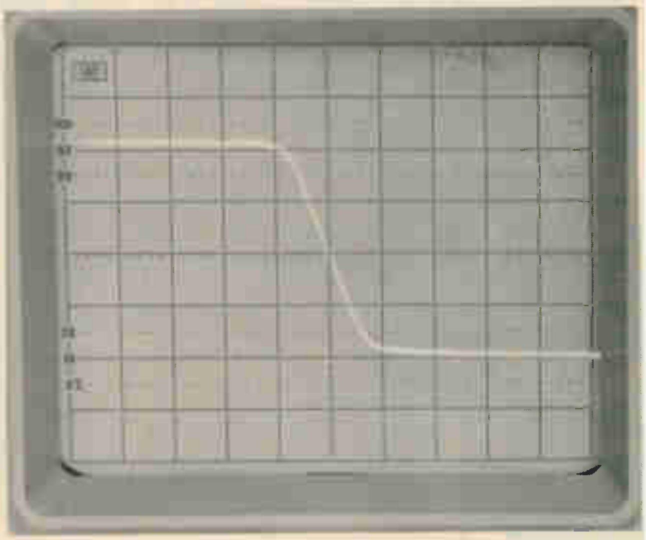
Figure 3 indicates the clumsiness of this technique. After bringing the starting point of the time interval

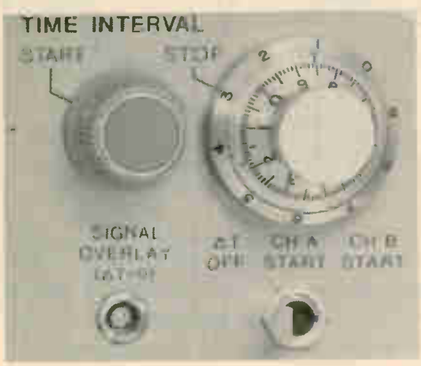


2. Error null. With delayed-sweep measurement, center of screen becomes the offset reference for the start and stop points of delayed-time interval, and time difference is determined with pot, so that errors consistent with readings of both points are canceled.









3. Clumsy. Delayed-time measurements are arduous and prone to user errors. After bringing the designated start and end points to the center of the screen (see top and center photographs), the difference between points must be measured with the delay-time control and then multiplied by the main-sweep time-base speed to yield the actual time interval (bottom left and right photographs). The accuracy of the measurement, however, will normally be within 1% of full scale if no user errors are made.

being measured to the center of the screen, the delay-time control is read (T_1 = 1.86 divisions). Next, after being adjusted so that the interval's end point aligns with the screen center, the delay-time control is read again (T_2 = 3.98 div). Then the difference between the two is multiplied by the main sweep speed to yield the time interval in the proper units (microseconds, in this case):

$$(2.12 \text{ div} \times 0.5\ \mu s/\text{div}) = 1.06\ \mu s$$

The uncertainty of this measurement is the uncertainty of the reading due to the sweep generator plus the uncertainty of the full-scale measurement due to the 10-turn delay time control, or:

$$\pm(0.5\% \text{ of reading} + 0.1\% \text{ of full scale})$$
$$= \pm[0.005(1.06\ \mu s) + 0.001(5\ \mu s)] = 10.30 \text{ ns}$$

This is an accuracy of within ±0.972% of reading.

Evidently, the delayed-sweep oscilloscope is more accurate than a single-sweep oscilloscope. But it requires very skillful handling, and even then the mechanical gear slop of the 10-turn delay potentiometer limits the accuracy of the readings made with it.

The two-marker delta-time system

Hewlett-Packard Co. therefore introduced a two-marker delta-time system in 1975 that greatly improved both the accuracy and ease of making delayed-sweep time-interval measurements. The system was first incorporated in the HP model 1722A, later in the HP 1712A, 1715A, 1725A, 1742A, and 1743A oscilloscopes and the DM44 option on the 400 series, as well as in the 7B85A option in the 7000 series by Tektronix. Besides giving less leeway to operator error, the two-marker delta-time system can simultaneously display two events separated in time and eliminates the effects of signal drift from the measurement.

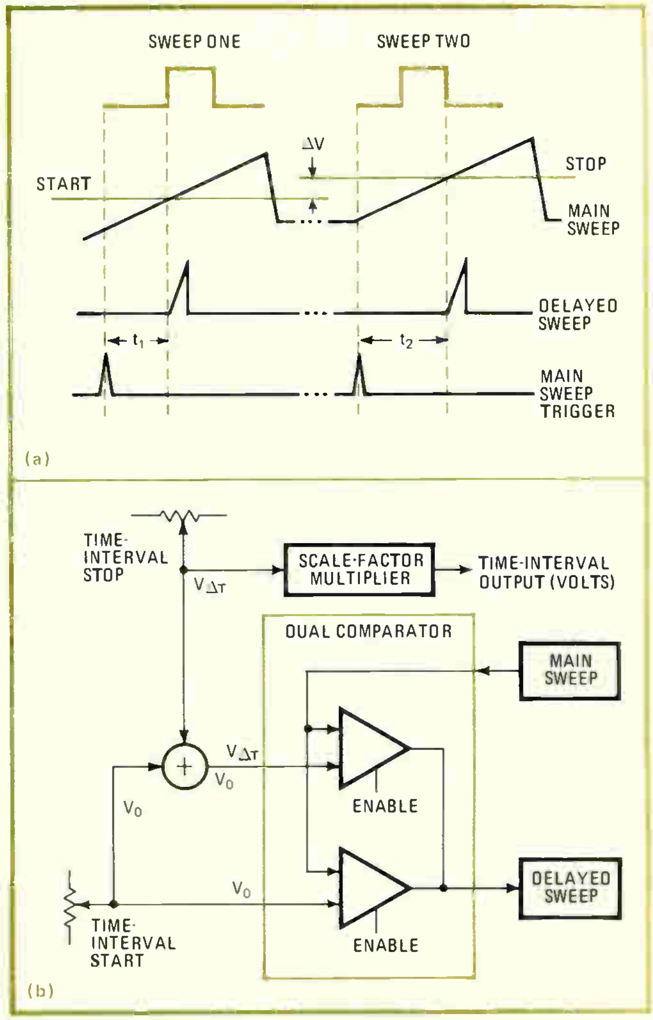
The two-marker delta-time system also uses the horizontal power amplifier and CRT as a null detector, but it adds a digital voltmeter to display the time-interval measurement instead of requiring the operator to gauge the position of the delay-control knob.

The two-marker delta-time system displays two delayed-sweep markers on alternate sweeps (Fig. 4). The first time the main sweep ramp occurs, the voltage level of the start time delay is compared to it till they meet and trigger a delayed sweep that starts at the beginning of the time interval being measured. The next time around, the voltage level of the stop time delay eventually meets the ramp and produces a second delayed sweep starting at the end of the time interval. The start and stop delayed sweeps are displayed alternately, but so rapidly that the start and stop markers appear to be being presented simultaneously. The difference between the start and stop voltages is an analog of the time interval being measured.

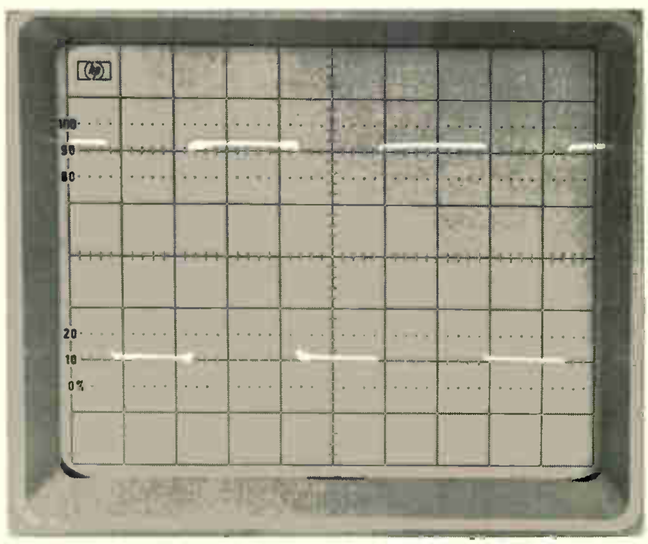
Three-step operation

The two-marker delta-time system requires only three basic steps of its operator:

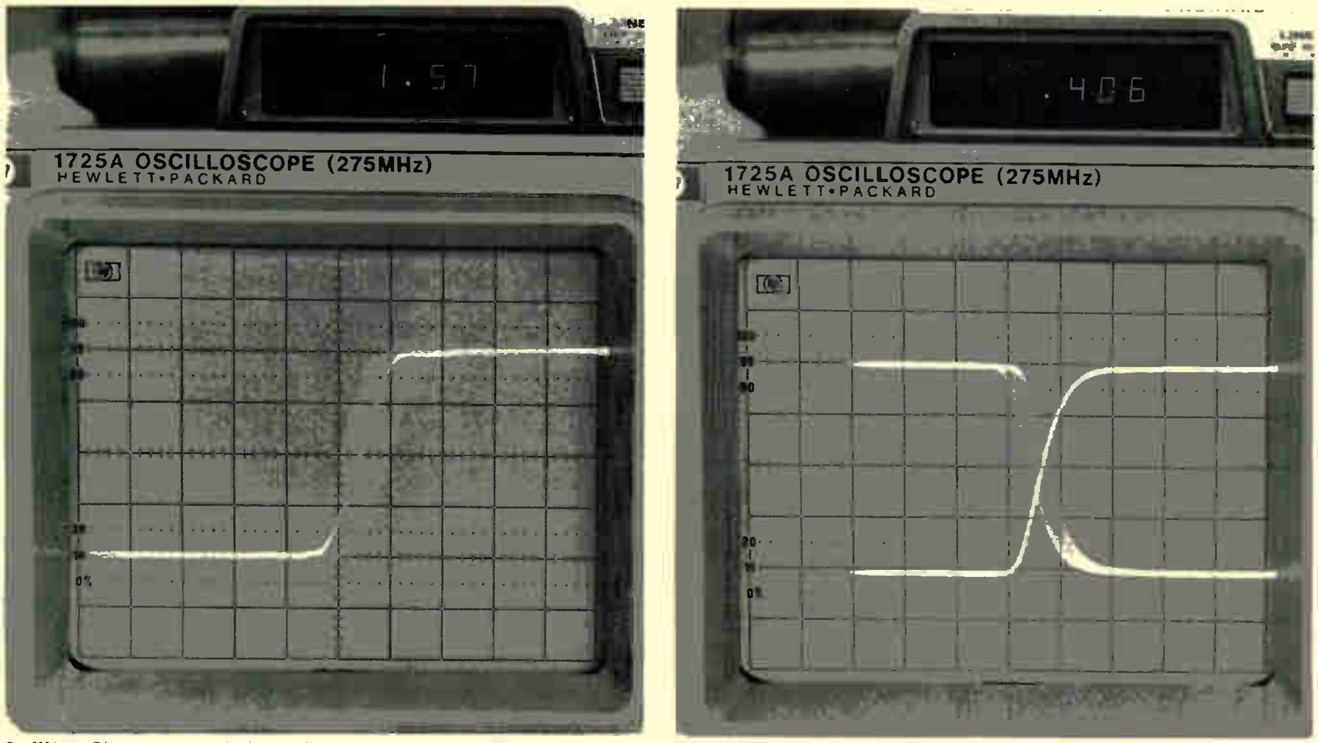
- Set the start and stop markers to the beginning and end of the waveform (Fig. 5).
- Select the delayed sweep and adjust the stop marker to



4. Ease and accuracy. Two-marker delta-time system displays two delayed-sweep markers on alternate sweeps, enables time-delay measurements to be performed with greater ease. Measuring technique also minimizes the effect of signal drift.



5. Three-step operation. Two-marker delta-time technique requires that operator set the start and stop markers, select the delayed-sweep time and adjust the stop marker to overlap the start and stop traces at their halfway points (Fig. 6), and read pulse width.



8. Jitter. Short-term variations of a time parameter with respect to a reference (jitter) are measured much like any other periodic phenomenon when an oscilloscope is used. Period jitter (left) and width jitter (right) are easily measured by technique discussed in the text.

and the stop marker is adjusted for overlap.

Width jitter may be present in the modulator of a radar transmitter or a computer handshake flag signal. It is measured in the same way as period jitter, starting with the basic width-measurement technique. The delayed-sweep traces are overlapped and the horizontal jitter is measured on the CRT and multiplied by the delayed-sweep time-base setting (Fig. 8, right).

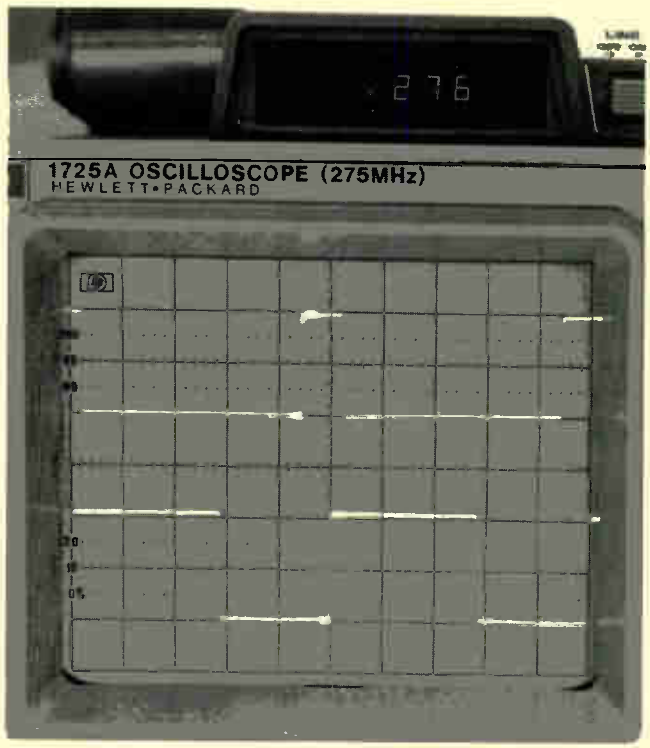
Interchannel measurements

Interchannel measurements of time intervals are also made in a straightforward manner on a delta-time system. Such a dual-channel capacity makes it easier to measure repeatable propagation delay, setup time, hold time, and response time. In the alternate-display mode, the start marker will be displayed on one trace and the stop marker on the other.

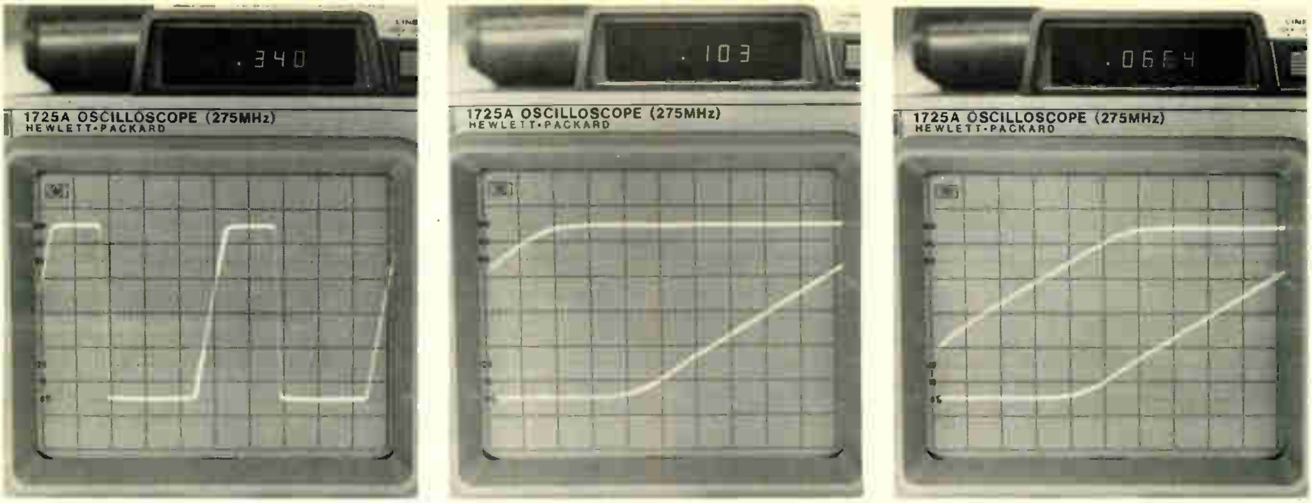
The A Start/B Start switch selects the vertical channel upon which the start marker will appear. For example, to measure the lead time between the clock pulse on the upper trace of Fig. 9 and the data pulse on the lower trace requires the start marker to be on the A trace (A Start mode). But to measure the time the clock pulse remains high after the leading edge of the data pulse has occurred requires the start marker to be on the B trace (B Start mode). Once the start and stop markers are in place, though, the procedure is the same as for a single-channel measurement.

With dual-channel measurements there might be a small fixed offset delay due to difference in probe length. This error can be easily measured by connecting both probes to a common node and measuring the offset.

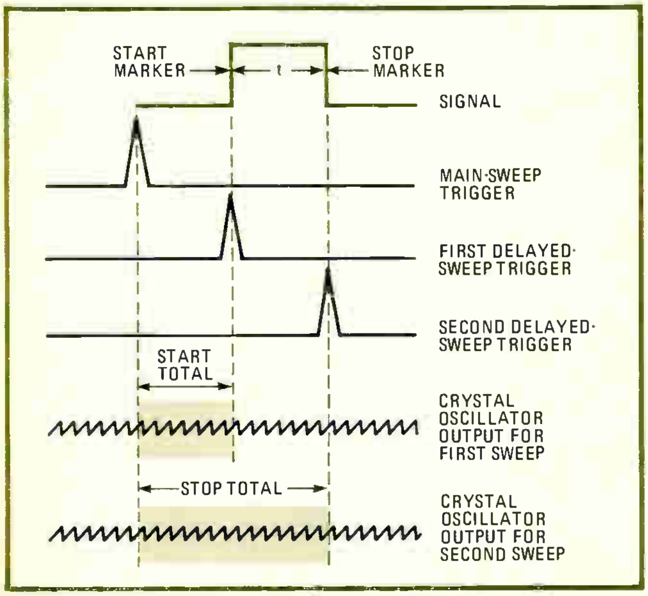
Transition times can also be measured much more easily and with greater confidence with delta-time oscilloscopes. Here, the vertical controls are adjusted to obtain a five-division display, and the delayed-sweep mode is selected. Then the start control is adjusted till the 10% level of the trace crosses the vertical graticule



9. Cross channels. Interchannel measurements of time intervals are made in a straightforward manner by a delta-time system. Such a dual-channel system makes it easy to measure propagation delay, setup and hold times, and response times.



10. Changing times. Transition time is measured by delta-time system by using five-division display (left) and displayed-sweep mode. Start control is adjusted until trace's 10% level crosses vertical graticule (center), stop control till 90% level crosses it (right).



11. Second-generation delta-time system. Crystal oscillator is timing reference. Pulses are counted from the start of main sweep, triggering first delayed sweep. Then they are counted again till the second delayed sweep. The difference is the time interval.

line, and the stop control is adjusted until the 90% level intersects the same graticule line. The resulting transition time is displayed on the DVM (Fig. 10).

Two additional sources of error affect the accuracy measurements of transition time. The first is nonlinearities in the vertical axis of the CRT, which unlike those in the horizontal axis have not been nulled and from which very small errors, in the 20-to-50-picosecond range, can be expected. The second source of error also derives from the vertical system and is due to the fact the observed transition time is approximated by the square root of the sum of squares of the transition times of the oscilloscope, signal, and probe. This error can generally be ignored if the oscilloscope's rise time is at least five times faster than the transition time to be measured.

In the first delta-time systems, however, no attempt was made to improve on the accuracy of the third major element in a scope's horizontal deflection system—the main-sweep generator, which produces the ramp voltage output that supplies the instrument's time-base reference. The optimum accuracy this generator can yield is within 0.5% of reading.

Changing the timing reference

A second-generation delta-time system introduced by Hewlett-Packard about a year ago uses a 100-megahertz crystal oscillator instead of the main-sweep generator for its timing reference and then further enhances this 10-ns resolution by means of time-interval averaging. As a result, the 1743A attains an accuracy of within 0.002% ±1 count of the reading displayed on its five-digit panel meter, offering timing resolutions of 1 ns and 100 ps for measurement ranges of 5 ns and 0.5 ns per division, respectively.

Such a crystal-reference delta-time system operates somewhat differently from its analog counterpart. The main-sweep trigger enables a counter that sums the crystal oscillator's pulses until disabled by one of the delayed-sweep triggers (Fig. 11). The first time this happens, the pulses are counted from the start of the main sweep to the beginning of the start marker, which triggers the first delayed sweep. The next time, they are counted till the stop marker triggers the second delayed sweep. Subtracting the first count from the second yields the time interval.

Other advantages of this crystal-referenced delta-time system include:

- Self-triggered measurements, where the instrument automatically tracks changes in the signal without operator intervention.
- First-pulse measurements, allowing asynchronous signals like software-generated pulses to be measured by a delayed sweep starting at the same time as main sweep. (The fact that the main sweep no longer supplies the timing reference is what makes this possible.)
- Recalibrated sweep measurements, the vernier being used to calibrate the horizontal CRT axis to, say, the clock periods or whatever other units apply to the system under test. □

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Mismatched waveguide calibrates VSWR scope display

by James B. McDonald
Commercial Engineering Associates, Princeton, N. J.

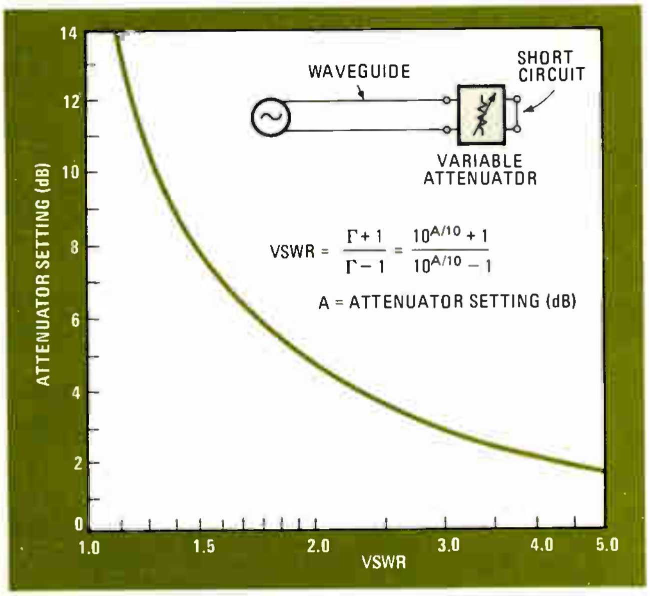
By using a variable attenuator to provide a selectable mismatch on a microwave transmission line, an automated check of the waveguide's voltage standing-wave ratio can be made over a wide range of frequencies with just an oscilloscope and a sweep-frequency generator. The mismatched waveguide serves to calibrate the scope face for various values of the VSWR so that when the attenuator is removed and an actual antenna load is connected, the system VSWR may be directly and immediately observed for the desired band of frequencies scanned by the sweep-frequency generator.

The adjustable waveguide mismatch is made by placing a short circuit across the output port of the variable attenuator, as shown in Fig. 1. It will be observed that the VSWR at the attenuator's input port will depend only on the setting of the attenuator, as is seen from the standard equation for the VSWR and the plot of its curve.

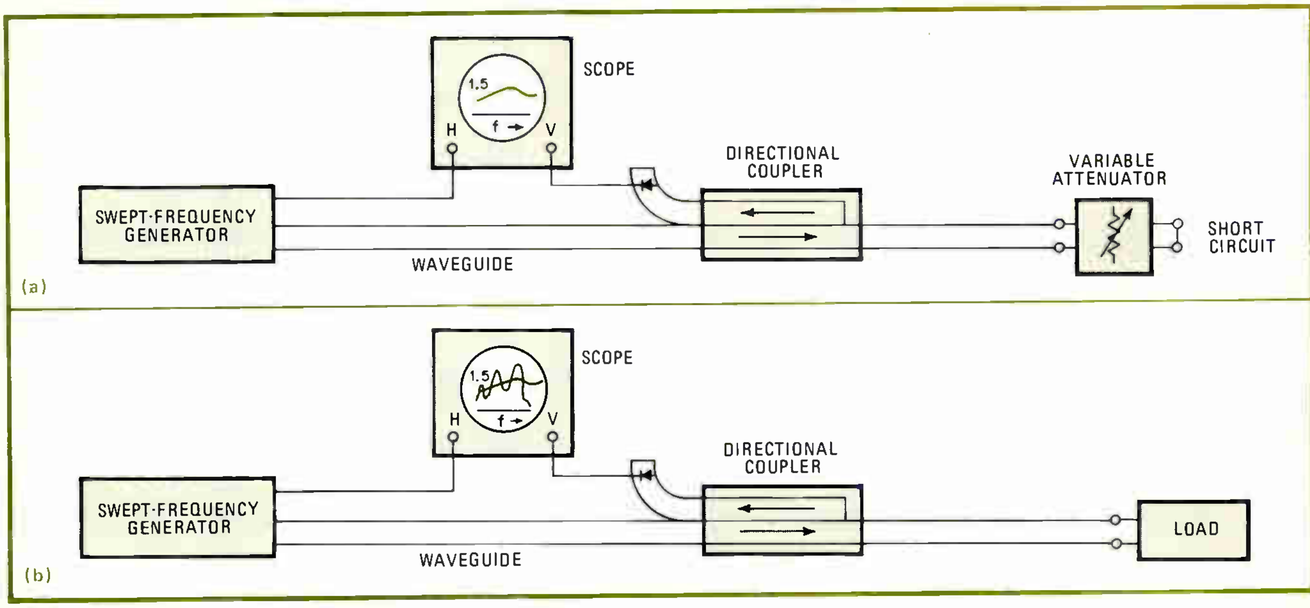
The scope face is calibrated for one or more VSWR values by overlaying it with a sheet of transparent material like acetate and tracing on the overlay the lines of the VSWR that are produced by the various attenuator settings as the sweep-frequency generator scans over the required frequency range (Fig. 2a). The range of frequencies swept can be 1 to 4 gigahertz at 5 to 10 GHz, otherwise known as the X band.

When the VSWR for an actual load (antenna, filter, cavity, etc.) is plotted versus frequency, it may then be compared with the reference VSWR (Fig. 2b). Note that the sweep-frequency rate will not affect the accuracy of the VSWR measurement.

The variable attenuator can also be used to create a mismatch in coaxial lines that are used in microwave systems. All that's necessary is to place a coax-to-



1. Attenuation versus VSWR. Voltage standing-wave ratio at input of short-circuited waveguide attenuator is a function of attenuator setting only. Thus attenuator can serve to calibrate scope for displaying VSWR value as a function of frequency for antenna systems.



2. Reflections. Waveguide reflectometer displays line of constant VSWR (1.5-to-1) versus frequency (a), and line is used as reference for measuring VSWR with actual loads (b). Sweep-frequency rate does not affect accuracy of VSWR measurements.

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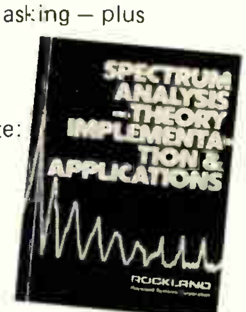

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waveguide adapter at the attenuator's input port. The adapter should be of high quality, however, because any reflections due to the inherent discontinuity at the point where the coax meets the waveguide will generate a ripple voltage in the VSWR reading as the frequency is swept over the desired range. □

Industrial counter handles widely varying intervals

by Rudolf E. Six

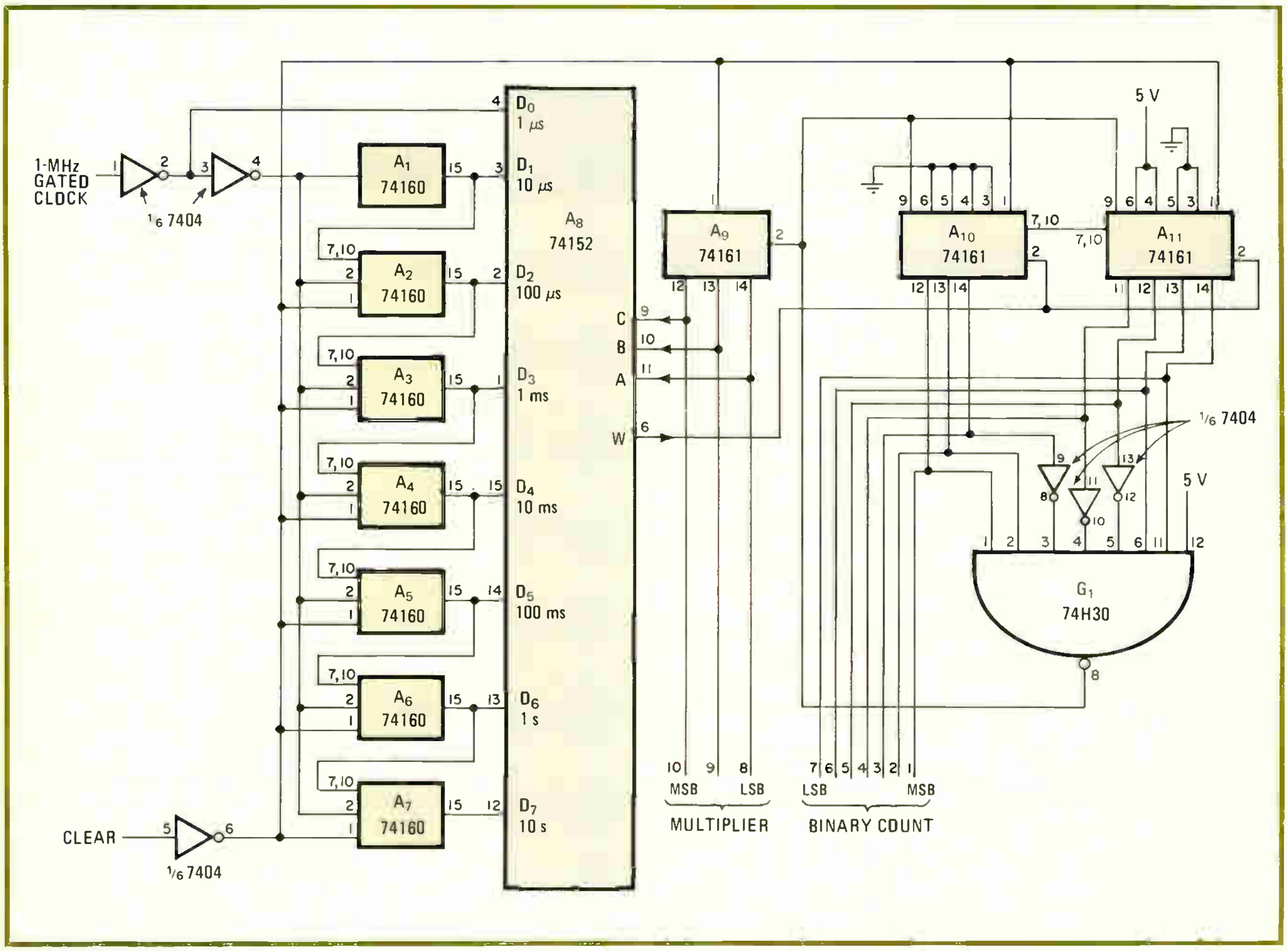
The Detroit News, Electronics Department, Detroit, Mich.

The time intervals between consecutive events in industrial processes can often vary over several decades, creating a problem if their values are to be stored in a microprocessor-based system. Normally, a great many input/output ports would be needed to handle, say, the 24 significant bits needed to represent a 10-second interval measured with a 1-megahertz clock. But this counter requires only 10 output lines to represent intervals ranging from 1 microsecond to 10 seconds, making it easy for a 16-bit data system to process a 24-bit binary number.

Wiring a set of 4-bit counters, A_1–A_7, as a one-decade divider is what makes it possible for fewer lines to be used. At the start of a measurement, a string of 74160 counters immediately begin to divide down a gated 1-MHz clock signal into seven decades of time ranging from 1 microsecond to 10 seconds in duration, as shown. The outputs of A_1–A_7 are then presented to A_8, the 74152 eight-to-one multiplexer.

A_{10} and A_{11}, two 74161 binary counters, are incremented once each microsecond until their combined count reaches 99. G_1 moves low at this time. On count 100, G_1 moves high and presets A_{10}–A_{11} to a count of 10, and steps the multiplier counter A_9. A_9 enables A_8 to advance to the next decade position (D_i to D_{i+1}). A_{10}–A_{11} now counts at one tenth of the rate it did before A_8 was stepped to D_{i+1}.

The process continues until such time that the measurement interval is terminated. On the seven binary-count lines will be a binary-equivalent number that is



Line reduction. Counter that measures time interval between two events over a range of 1 microsecond to 10 seconds needs only 10 output lines to display the results and store them in a microprocessor-based system. System resolution is adequate for most applications but may be increased if an extra 74161 is cascaded with the A_{10}–A_{11} counter, at a cost of three more output lines.

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related to the number of pulses in the gated clock signal. The actual (decimal-point) magnitude in microseconds, milliseconds, etc., is determined by the remaining three multiplier output lines, which indicate the decade value (D_0–D_7) as a three-bit binary number.

For example, an output of 01010001 on the binary lines combined with an output of 001 on the multiplier lines indicates a time interval of 810 μs between two events. After the computer has stored the information, a clear signal resets all the counters.

The resolution of the system (1 μs at the low edge, 10 s at the high end) is adequate for most applications, but it may be improved if an additional 74161 counter is cascaded to the A_{10}–A_{11} circuit. This extension will increase system accuracy by 1 bit, but then three additional output lines will be required. □

Three LEDs display response of null-detector circuit

by William A. Palm
Magnetic Peripherals Inc., Minneapolis, Minn.

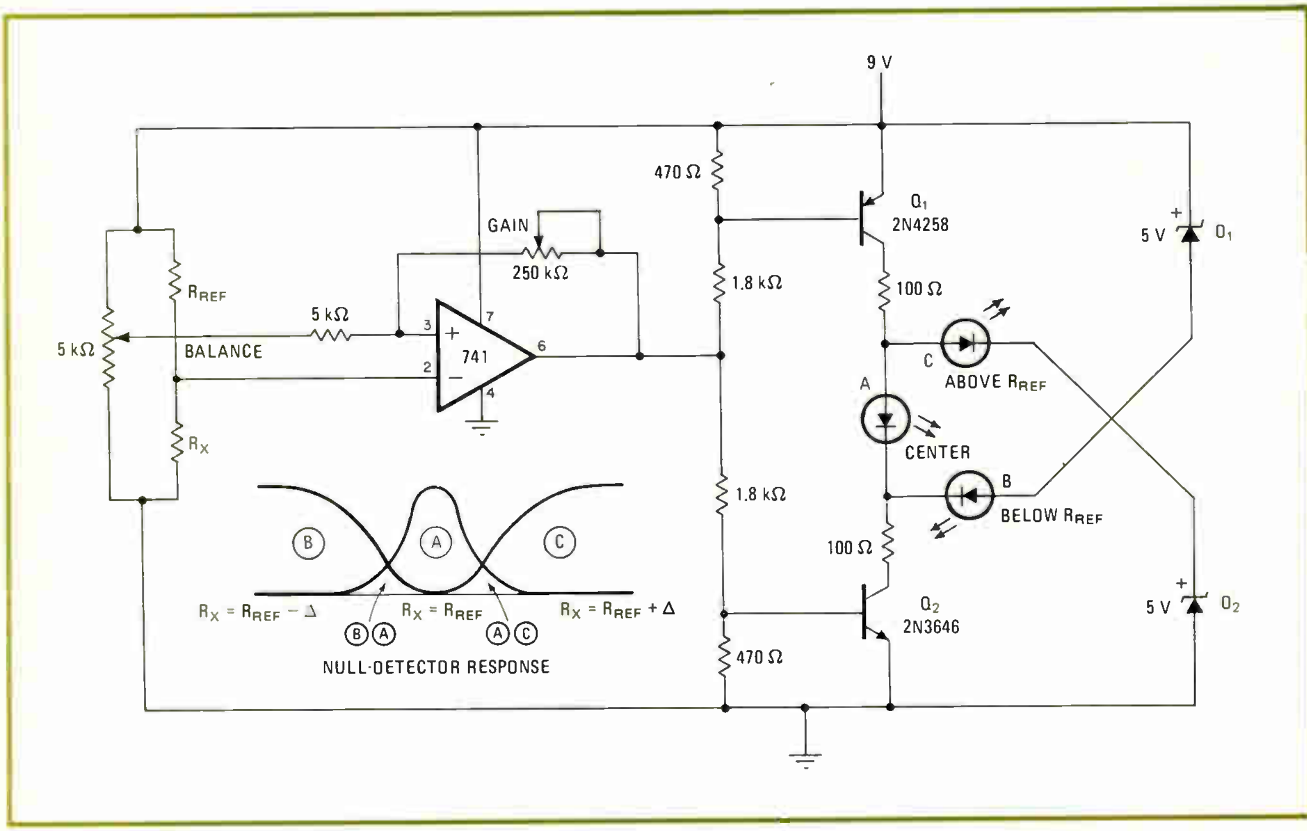
Three light-emitting diodes provide a visual readout for this null-detector/bridge circuit that can be used to match resistors to within 0.5%. The LED display is better suited for production-line measurement purposes than an output meter, is lower in cost, and takes up less space.

Circuit operation is straightforward. Transistors Q_1 and Q_2 will both be on when bridge resistor R_x, the resistor to be tested, is approximately equal to R_{ref}, the reference resistance, because the differential voltage at the input ports of the 741 operation amplifier is near zero. Thus the output of the 741 assumes its midrange value of 4.5 volts, and LED A turns on. At this time, the voltage dropped across A and the 100-ohm collector resistors connected to Q_1 and Q_2 ensure that D_1 and D_2 cannot conduct, and so B and C cannot light.

When the differential voltage at the inputs of the op amp increases or decreases because of a change in R_x, one transistor will turn off, and this action will divert all current through LED B or C instead, depending on the polarity of the input voltage.

The null-detector response is illustrated within the circuit diagram. Note that there is no single step-transition from one region to another, but rather two small regions where two LEDs may be on simultaneously. These regions correspond to a value of R_x that is about 0.5% to either side of R_{ref}. □

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.



Light reaction. Null detector uses simple LED readout to indicate if test resistor R_x is below, equal to, or greater than test resistance R_{ref}. If $R_x = R_{ref}$, 741 output sits at midpoint value of 4.5 volts and LED A lights. Otherwise, output of 741 turns off one transistor, diverts current from other transistor through B or C, depending on polarity of input voltage difference. Null-detector response is illustrated.

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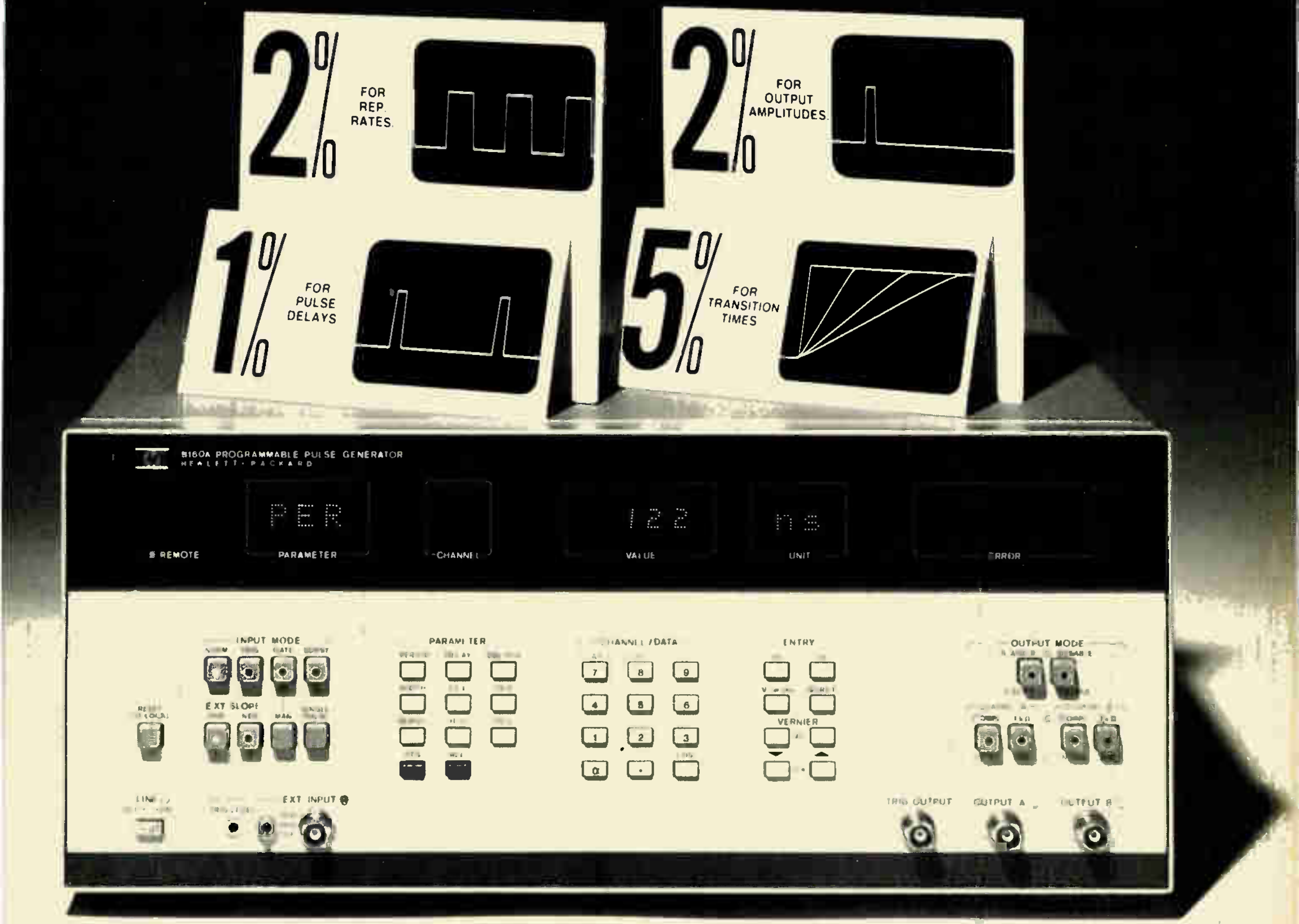

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Engineer's newsletter

Why not cushion electronic packages with foam?

Getting high-density electronic products ready for shipping can be both expensive and troublesome. But a process that has been around since 1970, International Packaging Systems' foam-in-place system, is already cutting the cost and assembly time of protective packaging at firms like IBM, GE, and Superior Electric Co. of Bristol, Conn.

Two liquids, a polymeric foundation and a polyol resin, are mixed in and dispensed by a hand-held gun that an operator aims into a cardboard shipping box. The combined liquids **create a foam that expands to roughly 100 times its original volume while forming a semirigid polyurethane foam.** While the foam is still curing, the operator lays a 1.5-mil-thick polyethylene film over it, places the product on top, covers the product with another sheet of film, and then repeats the process to form a top cushion cap. The result is a two-piece polyurethane cocoon that forms a close-fitting, protective cube around the product.

By using this scheme for protective packaging of custom voltage regulators and stepping motors, Superior Electric has halved its packaging material costs and cut package assembly time by 80%. For further information on the process, write International Packaging Systems Inc., Brook St., Norwalk, Conn. 06851.

Use lossy chokes to cut vhf noise on TTL boards

Here's a solution to the noise problem on TTL power supply lines. Iklil Kayihan of the Technical University of Istanbul notes that if you are not using an extremely wide-band (200–500-MHz) oscilloscope to monitor the noise on TTL or Schottky TTL supply lines, you may be in trouble. Good decoupling capacitors, even if placed at every IC package, cause a buildup of oscillations in the upper vhf range on those lines. In fact, the power supply traces on the printed-circuit boards form shorted pieces of transmission lines—actually resonators at vhf frequencies, which are shock-excited at every transition of the TTL output stage. Contrary to the general assumption, these lines are not lossy enough to damp such oscillations. Adding more decoupling merely shifts the frequency of oscillation.

The only cure is **adding more loss in series with the line in the form of series resistance or, better yet, lossy chokes.** Such chokes can be constructed by winding several turns of enameled wire through a lossy ferrite bead. Special six-hole cylindrical ferrite cores made from lossy material like the Siemens N22 material are particularly effective. These chokes should be placed in series with the supply lines of each TTL package and the package decoupled very close to its supply pins. Two packages can be fed over a choke. Lower-frequency decoupling is necessary at the voltage input to the circuit board.

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Jerry Lyman

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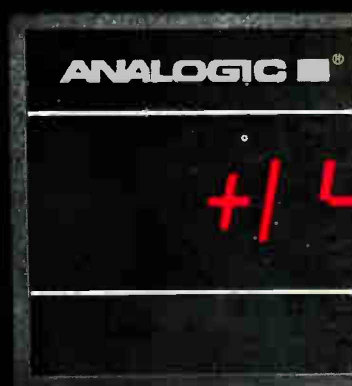

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See Products newsletter, p. 213

Chip controls CRT displays' attributes

The n-MOS device also generates characters; with companion timing chip, it handles all display functions

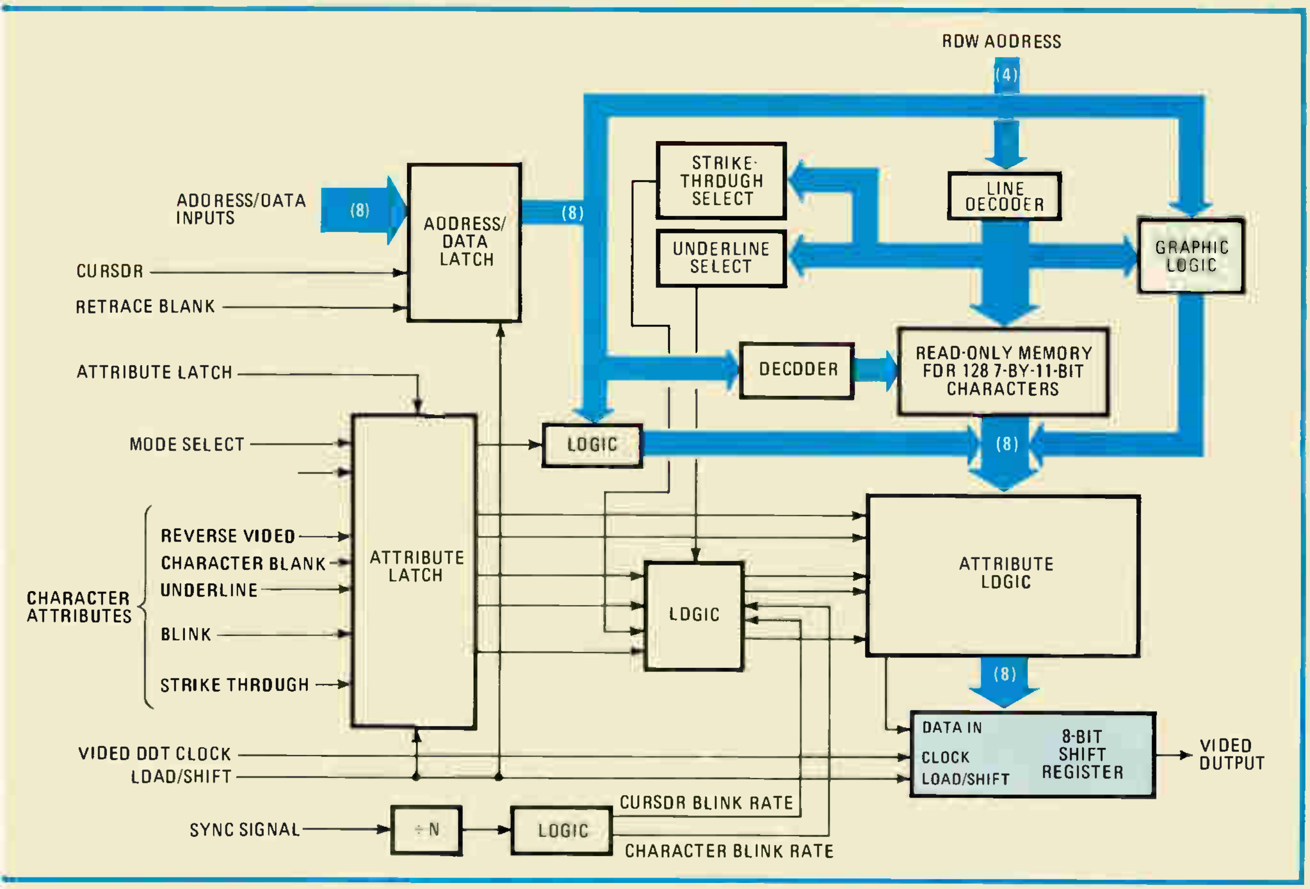
by Bruce LeBoss, New York bureau manager

Several semiconductor makers have leveloped single-chip devices con-aining the logic functions required o generate all timing and control ignals for presenting and formatting video data on cathode-ray-tube ter-minals. Now one such firm, Stan-lard Microsystems Corp., has also leveloped a companion chip that ntegrates the logic needed to gener-ite characters and to alter the attri-butes of the character field.

Designated the CRT 8002 video-lisplay-attributes controller, the n-channel metal-oxide-semiconductor device will work with the firm's CRT 5027 video timing and control chip [*Electronics*, Feb. 17, 1977, p. 119] or with CRT timing/control chips from other manufacturers, says senior vice president Gerald E. Gollub. "Together, these two types of chips comprise all of the circuitry required for the display portion of a video terminal," he claims.

The 8002 is a 20-MHz-plus device made using Standard Microsystems' new Clasp process that fixes the data in the character-generating read-only memory at the end of the wafer-fabrication process [*Electronics*, May 25, 1978, p. 39]. In addition to generating 128 7-by-11-dot characters, the 8002 has modes for producing both wide and thin graphics, an external-input mode, four cursor modes, a high-speed video shift register, and logic for controlling field and character attributes.

Housed in a 28-pin ceramic dual in-line package, the 228-by-197-mil chip contains nearly 12,000 devices. Operating at 5 V and compatible with transistor-transistor-logic levels, it consumes 500 mW and has a



maximum access time of 400 ns.

Among the popular video-display attributes provided by the 8002 are reverse video, character blanking, blinking, and underlining. The character blinking rate is mask-programmable from 15 Hz to 1 Hz. For improved readability, the blinking has a duty cycle of 75% on and 25% off, compared with the common arrangement of 50% on and 50% off. Unlike many terminals, in which the underline bumps the character and is presented in lieu of it, "the 8002 displays both the character and the underline," Gollub says. What's more, the 8002 can provide a continuous underline as opposed to the common breaking-dash underline.

A novel attribute arose out of a need by such users of word-processing systems as law offices to retain documents in both original and edited forms. Called "Strike-thru," this function strikes through the character with two parallel horizontal lines at full brightness, but, Gollub adds, "it doesn't completely block out the characters or make them illegible." The strike-through and underlining are similar but independently controlled functions that can be mask-programmed to any number of raster lines at any position in the character block.

The four cursor modes available with the CRT 8002 are underlining, blinking underline, reverse video blocking, and blinking reverse video blocking. Any one of these may be mask-programmed as the cursor function. The cursor blinking rate can be set similarly from 30 to 2 Hz, or twice that of the character blinking rate, Gollub notes. The standard 8002 will blink at 3.75 Hz for the cursor.

The 8002 has two mode-select lines that allow the chip to run in four modes that can be intermixed. The alphanumeric mode makes use of the internal 9,856-bit ROM to generate the standard ASCII set of 128 characters, which then pass through the attributes logic on the way to the 8-bit shift register.

However, an external-input mode is available for users with requirements for special characters, such as the degree or ohms symbol. In this mode, the eight address lines become data lines and the data bypasses the ROM and goes directly into the attributes logic and, subsequently, into parallel inputs to the shift register. "This gives you control of the shift registers on a dot-by-dot basis, and allows you to bring in special characters from an external ROM, programmable ROM or random-access memory," Gollub says. External control also allows signatures to be put in, from a large RAM, he adds, and "is an attempt to provide flexibility into the circuit and not be preempted by special requirements that may develop downstream."

The third mode, called thin graphics, enables the user to create single-line drawings and forms. The fourth mode, wide graphics, divides the character block into eight graphic entities, each of which is associated with 1 bit of a graphic byte. This provides 256 unique symbols to construct bar graphs and histograms, for example.

The 8002 will be available in three speeds. The standard 8002B will have a maximum shift register frequency of 15 MHz and will be priced at $30 for 1, $15 in 1,000-piece lots, and $10 in 10,000-unit quantities. A 20-MHz 8002A and 10-MHz 8002C will be priced 15% to 20% higher and 15% to 20% lower, respectively. Standard Microsystems is now providing samples, and production quantities are expected to be available by the end of September.

According to Gollub, the 8002 replaces from 10 to 15 transistor-transistor-logic packages used to perform address and attributes latching, as well as a ROM package. The chip is designed for use in dumb, smart, and intelligent terminals, a market estimated at 400,000 to 500,000 units this year and growing to 1 million by 1980, as well as high-end personal computers. The standard B version, he adds, is targeted for the 85% of the video terminals market operating below about 15 MHz.

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New products

Instruments

Rf voltmeter works to 2 GHz

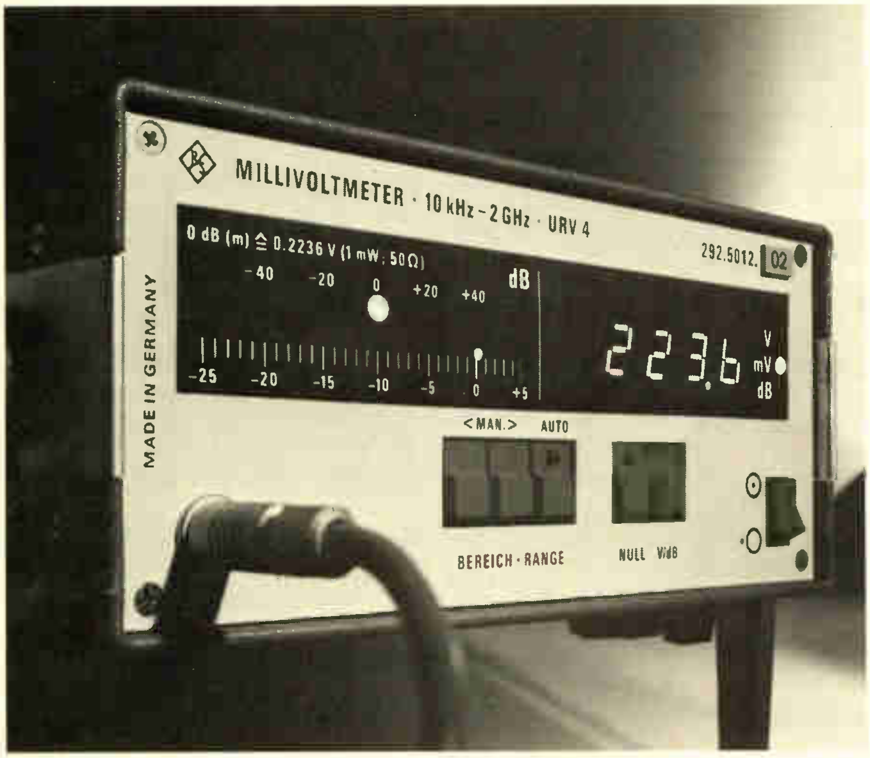
Detector-type instrument reads down to 300 μV; sells for less than $2,000

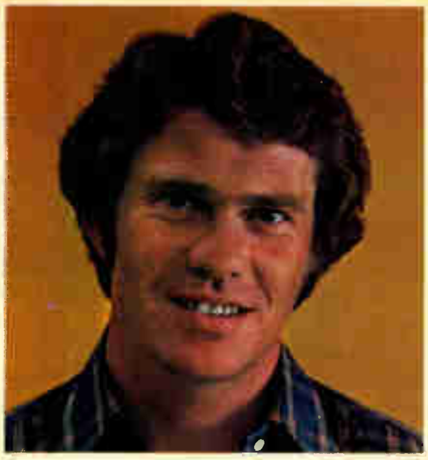
When it comes to instruments, high performance usually means high price. An exception to the rule is the model URV4 radio-frequency millivoltmeter from Rohde & Schwarz. Designed to sell for just under $2,000, the German company's detector-type instrument can measure voltages from 300 μV to 1 kV over the frequency range from 10 kHz to 2 GHz. Readings are presented in both volts and in dBm across a 50-Ω load. The dBm measurements cover the range from -57 to $+73$ dBm.

A particularly attractive feature of the URV4, says Tilman Betz, head of the group that developed the meter, is its dual-display technique that presents measured values in digital and analog form simultaneously. The digital readout uses four 11-mm light-emitting-diode characters to read either decibels or voltage values. The analog display reads in decibels only; it is implemented by a row of light-emitting diodes and is logarithmically divided into 1-dB increments. The analog display spans 30 dB and uses a five-position switch to cover the instrument's full measuring range.

The URV4's relatively low price, which Betz claims is "lower than that of other detector-based rf millivoltmeters on the market," results, for one thing, from the use of modular construction concepts. "Many of its mechanical and electrical parts and subsystems can be employed in other instruments in our production program, and that helps keep its manufacturing cost low," Betz explains. For another thing, since the meter is so new, it uses the latest components, such as large-scale integrated circuits and integrated analog-to-digital converters. "That, too, is a cost-reducing factor," Betz points out.

Other features of the URV4 are automatic nulling, ranging, decimal-





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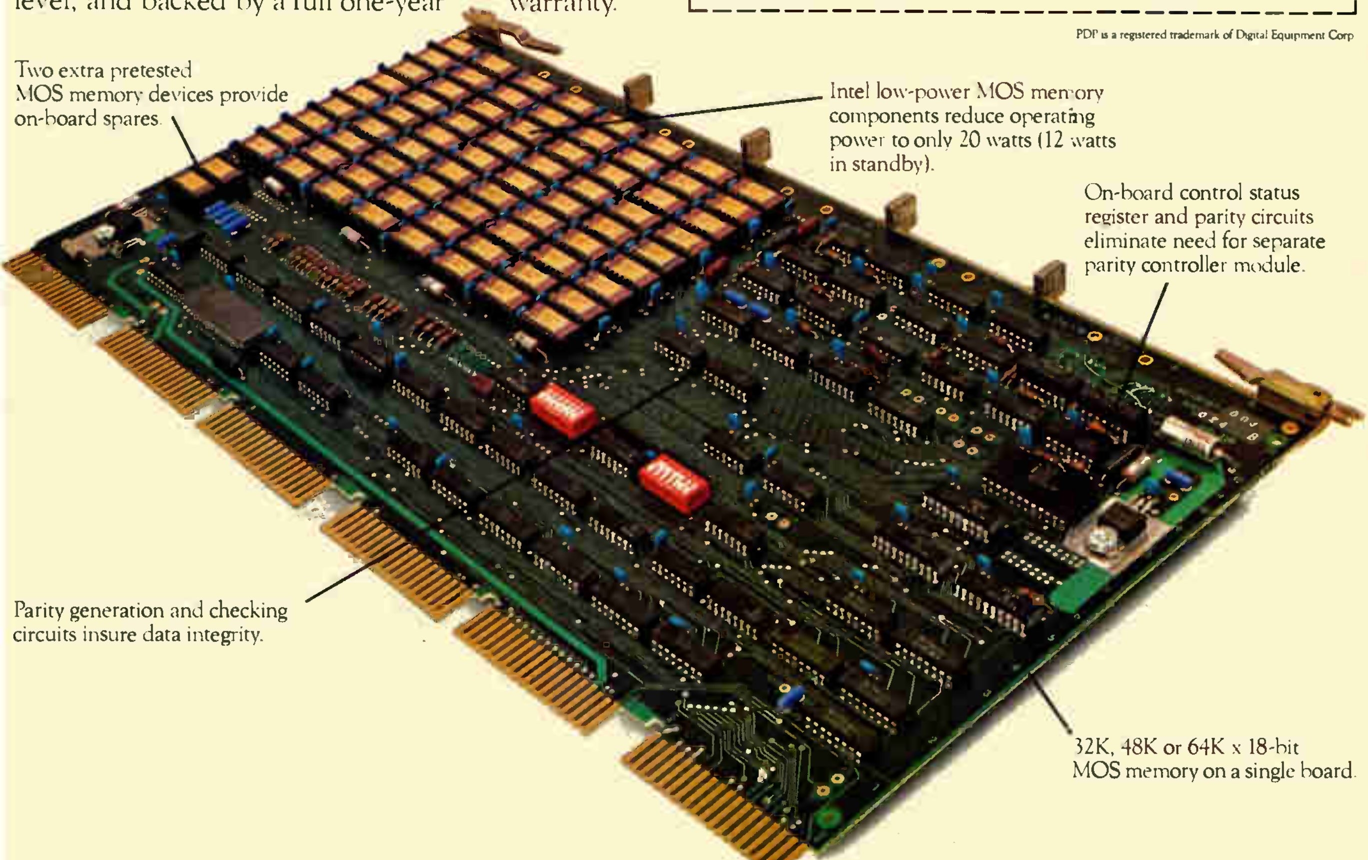

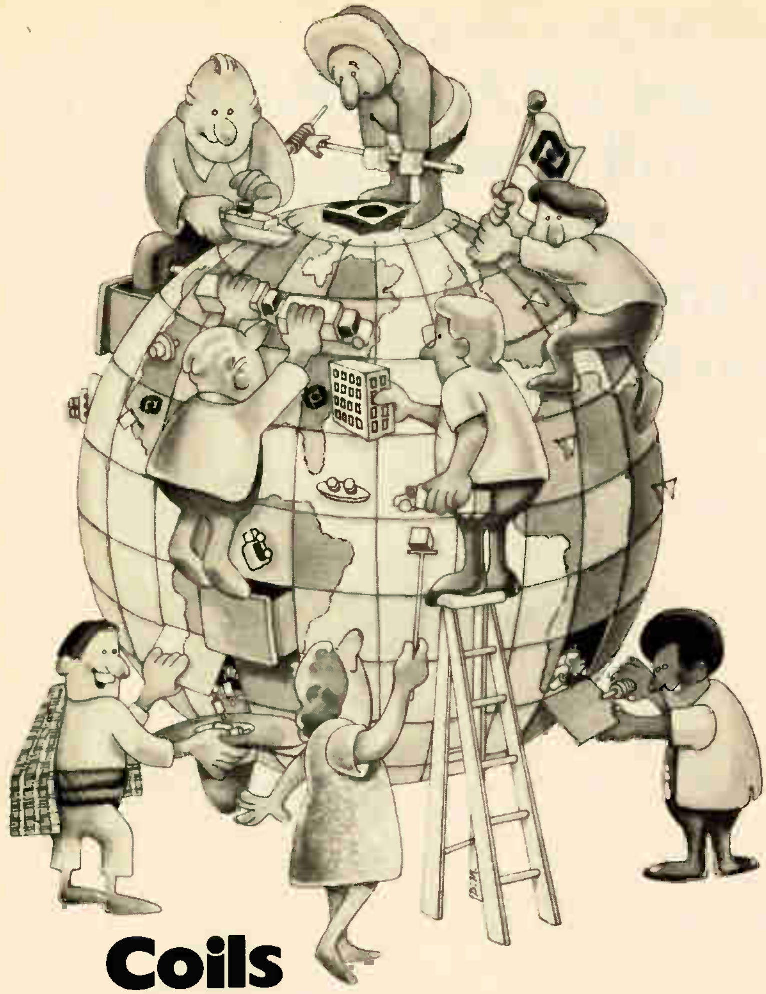

point positioning, and measuring-unit readout. With these features, using the instrument is simply a matter of turning it on, hooking up its measuring probe, and reading the results.

The automatic nulling feature will be especially attractive to many users. As Betz points out, with conventional detector-type rf meters, the null point must be manually adjusted with a potentiometer when measurements are being made in the highly sensitive lower ranges. With the URV4, however, nulling is an automatic operation, initiated by simply pushing a button. The null point is maintained until the instrument is turned off.

Powered by line voltage or by a 12-v battery, the URV4 consumes only about 3.6 w. Its low weight of 2.6 kg makes it a handy unit for mobile applications. The instrument's market debut in the U. S. and elsewhere is set for this summer.

Rohde & Schwarz Sales Co., 14 Gloria Lane, Fairfield, N. J. 07006

In Europe: Rohde & Schwarz, 8000 Munich 80, P. O. Box 801469, West Germany [351]

Tester evaluates saturable magnetic cores

The model 305B magnetic core test set is a versatile instrument designed to determine the magnetic properties of saturable magnetic cores. It has five magnetic-drive ranges, from 0.3 to 30 gilberts full scale, and five core-response ranges, from 1,000 to 100,000 maxwells full scale.

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The 305B has coaxial jacks for connection to an oscilloscope so that the hysteresis loops of cores under test can be displayed. Its overall measurement error is no more than 5% for ambient temperatures from 55°F to 90°F and line voltages from 105 to 125 V. Under the same conditions, differential error is no more than 1%, so the instrument can be used in critical core-matching applications.

The 305B sells for $2,275 including the test fixture, cables, and a maintenance manual.

Mayberry Electronics Co., 1250 Industrial Ave., Escondido, Calif. 92025. Phone (714) 747-4940 [352]

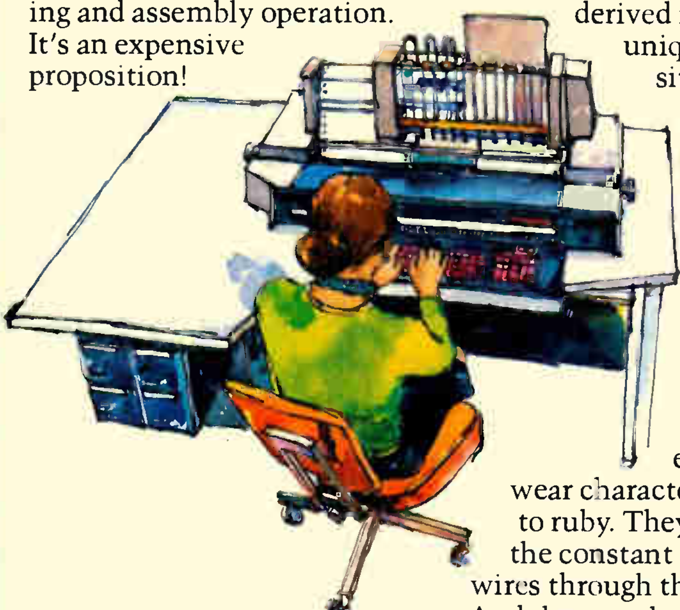
Analyzer captures and generates digital waveforms

Built around a 32-location by 30-bit random-access memory, the model DSA600 digital synthesizer analyzer is a state-linear instrument that can capture and display up to eight input signals. It uses a row of light-emitting diodes to indicate the logic levels of the input signals at a given point in time. When any of the inputs changes its state, the display is updated and the precise time of

FOTOCERAM® What the Swiss are seeing red about.

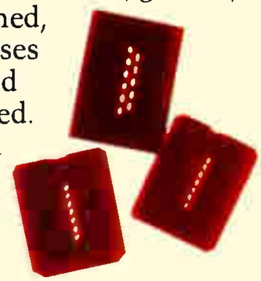
FOTOCERAM materials are replacing ruby wire-guides in high-speed, computer-controlled impact matrix printers. The printers operate by moving a single, vertical column of print wires across a horizontal line. Individual wires are activated in sequence to impact an inked ribbon against the paper, forming characters from patterns of dots. Those characters are generated at speeds up to 300 per second.

Precise vertical alignment of the print wires is extremely important. Up to now, many print-head manufacturers have used synthetic ruby wire guides because of their durability. Holes in the guide must be laboriously machined to less than 0.015 inch diameters, with a total tolerance within 0.001 inch. And the finished ruby guide must go through a polishing and assembly operation. It's an expensive proposition!



FOTOCERAM materials by Corning compete on price and durability. Using a FOTOCERAM brand glass-ceramic, derived from Corning's unique photosensitive glass, extremely small holes can be chemically machined with precision. Manufacturers' tests show that FOTOCERAM wire guides exhibit excellent wear characteristics equal to ruby. They can withstand the constant motion of the wires through the guide holes. And they can be mass produced at significantly lower cost than ruby.

The FOTOCERAM material is only one of a family of unique FOTOFORM materials that can be precision etched with holes of almost any shape and size. In excess of 50,000 holes per square inch, in pieces as thin as 0.010 inch. Holes, slots and channels, as small as 0.002 inch. And with tolerances within 0.001 inch. These photosensitive materials can be precision-etched, machined, cut, milled, chamfered, ground, lapped, polished, sealed to glasses or ferrites, and even metalized. FOTOFORM materials offer you engineering flexibility—the flexibility to do it your way.



We've given the Swiss something to think about. Maybe we've given you an idea. FOTOFORM and FOTOCERAM materials are being used to solve design problems for a wide variety of applications. Chances are they can solve a problem for you.

FOTOFORM and FOTOCERAM materials by Fotoform Products Group, Corning Glass Works, Corning, New York 14830, (607) 974-4304.

In Europe contact: SOVIREL, S.A., Materials Division, 90 Rue Baudin, 92306 Levallois, France (1) 739 96 40

CORNING

the transition is recorded. In this manner, 32 parallel states and their associated timing data can be acquired for subsequent study.

Automatic triggering allows the instrument to self-start on the first logic-state change on any input channel. Or it can be triggered externally by a predetermined word and two additional qualifier inputs. The trigger can be used either to start or stop signal-state storage and, hence, to capture pre- or post-trigger information.

The DSA600 also has a synthesis mode in which it can generate any desired digital signals. These may be programmed by the user or reproduced from signals that were previously captured.

The digital synthesizer analyzer sells for $6,250 and has a delivery time of 90 days.

Marketing Services, Gould Inc., Instruments Division, 3631 Perkins Ave., Cleveland, Ohio 44114. Phone (216) 361-3315 [353]

Active current shunt includes output amplifier

Like most precision current shunts, the model 2575 contains an array of precision wideband resistors with full-scale voltage drops of 100 mv. Unlike the others, however, it also includes a high-accuracy output amplifier with a gain of 10 to provide a higher output level for driving thermal transfer standards.

Called an ac-dc active current shunt, the model 2575 has six precision resistors ranging in value from 1 milliohm to 100 ohms. It can thus measure current in decade ranges from 1 mA to 100 A. The four-terminal noninductive resistors have 99.9% accuracy and have flat frequency responses that go beyond a kilohertz.

The shunt is designed for the 10°-to-40°C operating range and has a temperature coefficient of ±5 ppm/°C. It sells for $895 and is available from stock.

Valhalla Scientific Inc., 7707 Convoy Ct., San Diego, Calif. 92111. Phone (714) 277-2732 [354]

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we also offer our know-how as reagent manufacturers, gained over decades of work in this field.
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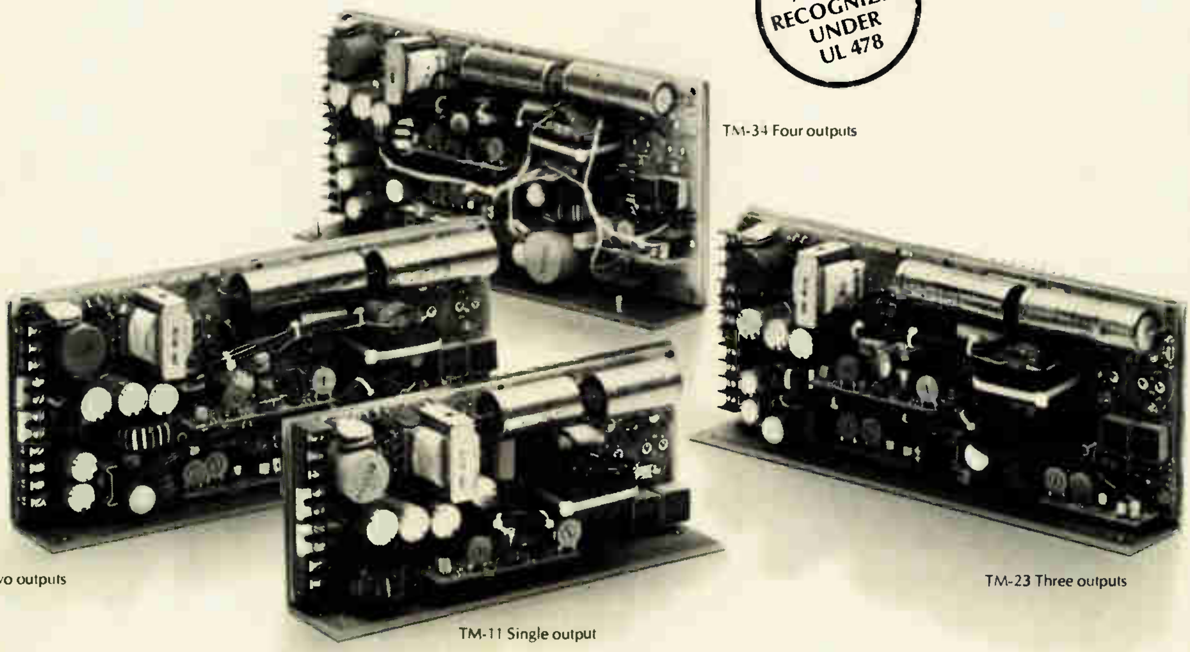
Circle 249 on reader service card

LH's Tiny-MITE Series Open-Frame Switchers Now UL Recognized!

ALL MODELS RECOGNIZED UNDER UL 478



TM-34 Four outputs

TM-22 Two outputs

TM-23 Three outputs

TM-11 Single output

Designed specifically for high-volume OEM computer and terminal applications.

Now recognized under UL 478, LH's low-cost, single and multiple-output *open-frame* Tiny-MITE (TM) Series switchers are great choices wherever OEM computers and terminals are manufactured in high volume.

Single-output TM-11 units pack 100 watts in 9.5" L x 4" W x 2.5" H packages . . . Two-output TM-22 and three-output TM-23 units pack 150 watts in 12.0" L x 5.15" W x 2.80" H packages . . . Four-output TM-34 units pack 175 watts in 13.0" L x 6" W x 2.75" H packages.

Four models, all open-frame, all UL recognized with the industry's most technically advanced specifications:

- Output voltages — TM-11: 5 V adjustable ± 5% @ 100 W. Other voltages from 2-28 V DC also available. TM-22 main output: 5 V ± 5% @ 20 amps; choice of various voltages on 2nd output. TM-23 main output: 5 V ± 5% @ 20 amps; choice of various voltages on 2nd and 3rd outputs. TM-34 main output: 5 V ± 5% @ 20 amps; choice of various voltages on 2nd, 3rd, and 4th outputs.
- Wide input range — 92-130 or 180-260 V AC, 47-450 hz.
- 1% or 50 mv p-p ripple and noise.
- 75% efficiency (TM-11), 70% efficiency nominal (TM-22, 23, and 34).
- 0.4% line regulation over entire input range.
- 0.4% load regulation from no load to full load.
- 20-msec holdup time if AC power fails.
- All outputs fully regulated and adjustable ± 5%.
- Power fail signal — standard on all models. 1-cycle ride-through (16 msec).
- 200 μsec to 1% response time after 25% load change @ 5 amps/μsec (primary output). Secondary outputs 50 μsec to 1% response time (typical).
- 0°C to 50°C operating temperature.

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World's largest, most comprehensive standard line of switchers.

LH's open-frame TM Series of switchers are just one of six standard series based on LH-developed technology and proven in almost 50,000 field-tested units. Nobody packs more power in smaller packages or offers more desirable features including 1 through 7 outputs, up to 2.26w/in., up to 80% efficiency, and a 2-year warranty on all models . . . For price and delivery information on LH switchers, call or write today!

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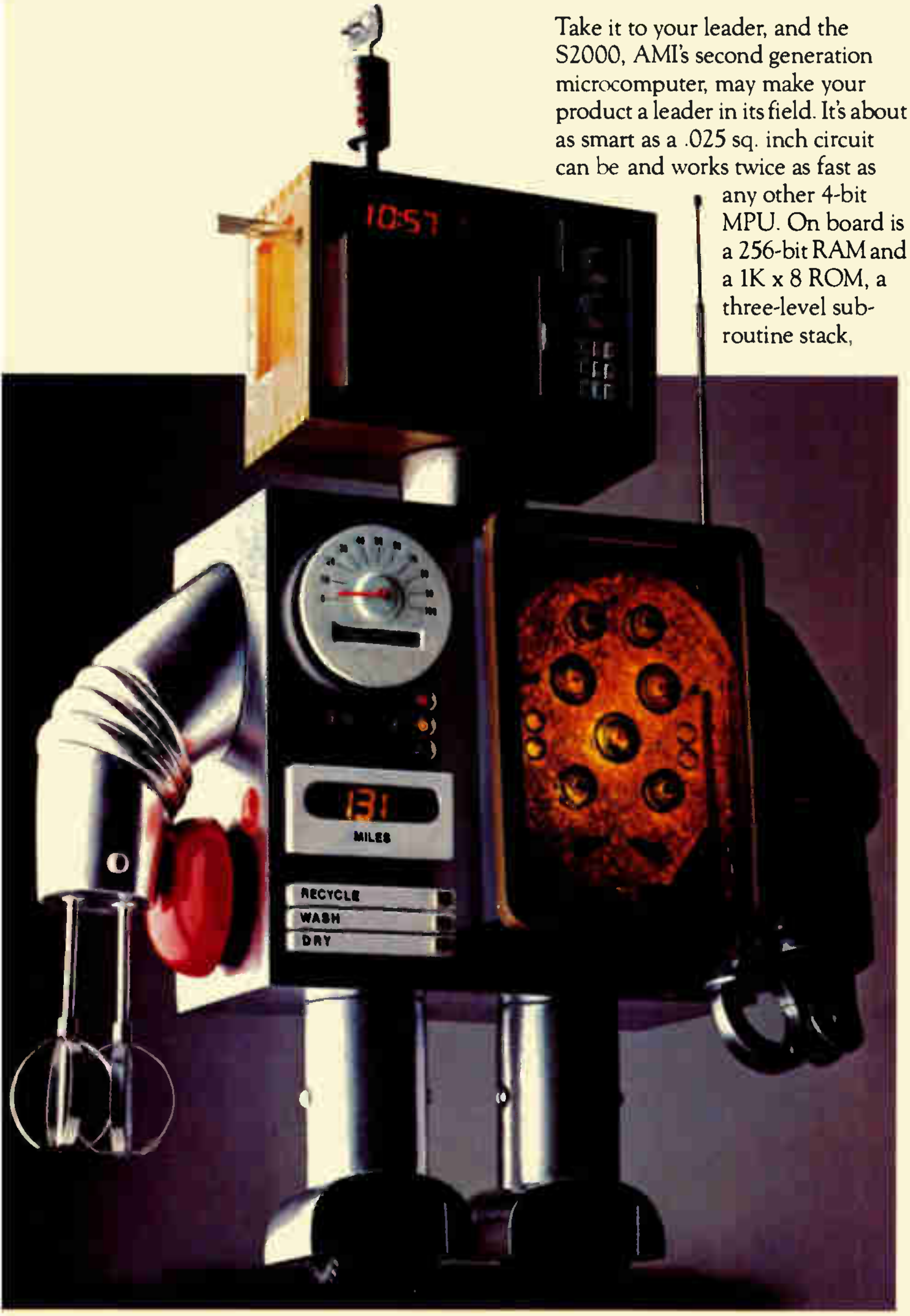
Our single microcircuit puts all kinds of electrical devices at your command. Appliances, car instruments, security systems, air conditioners, electronic games, industrial heating and refrigeration systems—all these and more can be controlled by our S2000 microcomputer. And, because we've packed so much onto ne tiny chip, you can save a bundle over multi-circuit alternatives. AMI has been inding ways to cut our customer's costs longer than any other company in the busiess. Now we've created another economical way to get everything under control.



Take it to your leader, and the S2000, AMI's second generation microcomputer, may make your product a leader in its field. It's about as smart as a .025 sq. inch circuit can be and works twice as fast as any other 4-bit MPU. On board is a 256-bit RAM and a 1K x 8 ROM, a three-level subroutine stack, 7-segment decode, and both Touch Control™ and regular switch interfacing. Its high current output can drive LEDs, Triacs and SCRs directly. (We have a second version, the S2000A, for fluorescent displays.)

We make it simple to get control of your product by offering complete hardware and software support. Our Microcomputer Development Center, built around an intelligent CRT terminal, has a flexible text editor, simulator and macroassembler. And there's timesharing software for cross assembling and hardware emulators.

To get things rolling, we'll hold seminars at your company. And, if you run into trouble, our application engineers are always on call. So call us now for complete information at (0793) 3135 or 25445. Or write to AMI Microsystems, Ltd., 108A Commercial Road, Swindon, Wiltshire, England. You'll be amazed how much control one tiny chip can give you.

AMI®
MICROSYSTEMS LTD.

age-regulating accuracy.

The common problem of input current spiking due to transformer saturation or crossover switching has been dealt with by including a 900-kHz oscillator to drive the switching transistors.

Potential applications for the device include use in clinical, analytical, nuclear, and test instrumentation, as well as process-control applications. Use of the 722 with optically coupled isolation amplifiers can provide the complete system power and signal isolation often required in medical applications.

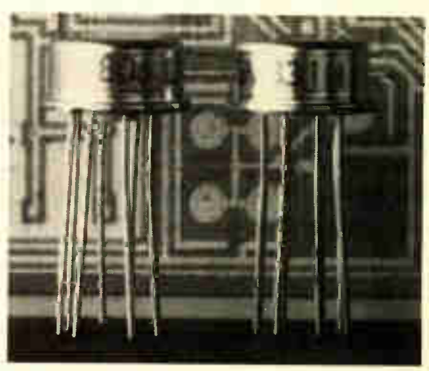
Not the least of the converter's attributes is its size; the entire package less pins measures only 1 in. by 1 in. by 0.3 in. In a ceramic 20-pin dual in-line package, the device sells for $30 each in quantities of 1 to 24.

Burr-Brown Research Corp., International Industrial Park, Tucson, Ariz. 85734. Phone Dennis Haynes at (602) 746-1111 [381]

V-f converters guarantee high temperature stability

The LM131A is the first voltage-to-frequency converter guaranteed to have a maximum gain temperature coefficient of 50 ppm/°C over the entire military temperature range of −55° to +125°C, according to its manufacturer. Like the five other members of the 10-kHz v-f converter series to which it belongs, the unit offers a guaranteed maximum nonlinearity of 0.01% whether it is used as a straight v-f converter or turned around for frequency-to-voltage conversion.

Designed as pin-for-pin replace-



New products

ments for 4151 v-f converters, the LM131 series is specified to operate over its 4-to-40-v supply range with improved accuracy. Increased linearity and temperature stability have been realized through the design of the converter's band-gap reference circuit. Typically, LM131 units have a gain nonlinearity of 0.004%.

The series, formally designated LM131/231/331, is divided into standard units, which have maximum gain temperature coefficients of 150 ppm/°C, and A units, which offer the 50-ppm specification. The 131s are the military units; models labeled 231 are intended for the −25°-to-+85°C range, while the 331s work from 0° to 70°C.

For lots of 100, prices range from $12 for the LM131A to $5.25 for the standard LM331; each device comes in an eight-lead TO-99 package. LM331s, in plastic mini-DIPs, are available for $3 each in hundreds.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051. Phone Dave Whetstone at (408) 737-5287 [383]

Upgraded d-a converters boast ±0.1 nonlinearity

Directly interchangeable with other 1408/1508 digital-to-analog converters, AD1408/1508 8-bit, bipolar, multiplying d-a converters have guaranteed nonlinearity of ±0.1%—or accuracy to within ±¼ least significant bit. The units also have an improved settling time of 250 ns.

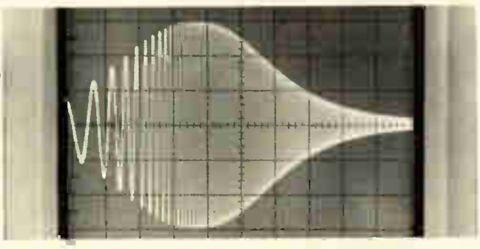
The converters additionally feature a voltage compliance range of 0.5 to −5 v, a 4.0-mA/μs slew rate, and power consumption of less than 160 mw. The operating temperature range for the AD1408 is 0° to 70°C; for the AD1508, −55° to +125°C.

Housed in a 16-pin ceramic dual in-line package, the AD1408 is priced at $3.45 in quantities of 100 or more. The AD1508 is available processed and screened in accordance with MIL-STD-883B, Level A.

Analog Devices Inc., 829 Woburn St., Wilmington, Mass. 01887. Phone Doug Grant at (617) 935-5565 [386]

SERIES 40's Frequency Marker ends frequency-chasing and control-twiddling.

1.

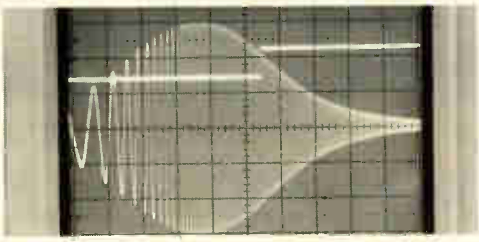


Sweep the Unit Under Test. Here, for example, is the output of a filter being swept from 600 Hz to 60 KHz on channel 1 of the scope.

2.

Select Sweep Marker. On Interstate's new F47 function generator, you select "Marker" and tune the marker to appear anywhere within the sweep limits. The marker is displayed as a TTL step on the scope's channel 2.

3.



Adjust the vernier. Then you fine-tune the marker vernier to pinpoint the TTL step at the exact position on the waveform for which you want to know the frequency. On the scope shown, the marker is positioned at the 70% roll-off point...the −3 db level.

4.

Select Calibrate Mode. Next, you switch from the Continuous Sweep Mode to the Calibrate Mode.

5.

Get the exact frequency. A counter at the F47's output will then display the precise frequency at which the filter's −3 db point occurs.

SERIES 40 FUNCTION GENERATOR...your best buy for the money.

This is the only function generator line with marker, 10-step frequency calibrator, state-of-the-art high output voltage to 40V p-p open circuit, and Interstate's exclusive direct-reading Sweep Width Control. Write or call Interstate Electronics Corporation, Department 7000, P.O. Box 3117, Anaheim, CA 92803. (714) 772-2811.

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New products

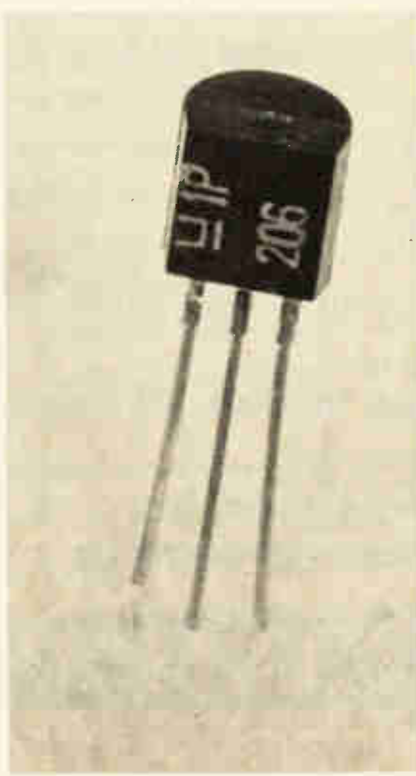
Semiconductors

Low-cost SCRs block up to 800 V

Aimed at ground-fault interrupters, units can handle high in-rush currents

Because of increasing consumer demand for protection against electric shocks, Joseph Pappalardo thinks he is onto a good thing with a new line of high-voltage silicon controlled rectifiers. Pappalardo, product manager for thyristors at Unitrode Corp., believes that the market for ground-fault interrupters—the devices that protect against shock—will be as big as that for smoke detectors.

The series, called the IP200, has voltage ratings of 100 V (IP200), 200 V (IP202), 400 V (IP204), 600 V (IP206), and 800 V (IP208). Pappalardo says each ground-fault interrupter uses at least one high-voltage SCR in its triggering circuit. But the IP200 series will find use elsewhere too. Among other possible applications are high-voltage relay and lamp drivers and high-voltage sensing, triggering, and detection circuits. In addition, the units are suitable for high in-rush current applications, such as ignition circuits, photo flashes, and small motor controls.



The SCRs, housed in plastic, injection-molded TO-92 packages, have two features that Pappalardo believes set them apart from the pack: the peak forward-surge current rating is about double that of available competitive components, and the maximum on-state current rating is higher. The latter is 1 A rms, which Pappalardo says compares with about 0.8 A for other devices, and the peak forward-surge current is 15 A for 8.3 ms, versus 6 to 8 A for competing parts.

Maximum gate-trigger current is 200 μA, with typical gate current ranging from 10 to 50 μA, which is comparable to available components "and ideal for low-level logic triggering while still offering good dv/dt capability," Pappalardo adds.

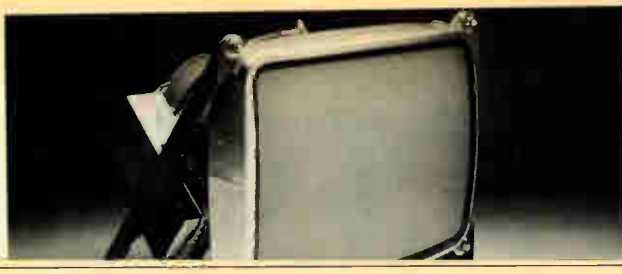
Sample quantities are available immediately, and volume deliveries take 4 to 6 weeks after receipt of order. Prices in quantities of 5,000 or more for the 200-V and 600-V units are 26 cents and 49 cents, respectively. But typical orders are expected to be much larger, and prices will be approximately 30 cents for the 600-V part, 21 cents for the 400-V unit, and 18 cents for the 200-V SCR.

Unitrode Corp., 580 Pleasant St., Watertown, Mass. 02172. Phone (617) 926-0404 [411]

Shunt regulator ignores changes in temperature

The TL431 is a three-terminal, shunt-regulator integrated circuit that is fully temperature-compensated over its entire operating temperature range. Its average temperature coefficient is 50 ppm/°C.

The device's programmable output voltage can be set at any value between approximately 2.5 V, the



New products

microprocessor interface. Microprocessor interfacing allows dynamic assignment of the time slots for either synchronous or asynchronous transmission and reception. Each codec can compute its own time slot and multiplex and demultiplex its own pulse-code-modulated data onto and off the PCM highways.

Signals received by the chip are decoded using an input register, a digital-to-analog converter, and a hold circuit. Transmitted signals first enter a sample-and-hold circuit; a successive-approximation circuit formats the signal using the receiving section's timeshared d-a converter to generate values that are compared with those in the sample-and-hold circuit.

The 2910 has a 78-dB dynamic range and resolution equivalent to 12-bit linear conversion about zero; the 2911's dynamic range is 66 dB, with 11-bit equivalent resolution. Idle channel noise for the 2910 is typically 12 dBrnc0. Samples, in quantities of 100 or more, are priced at $40.

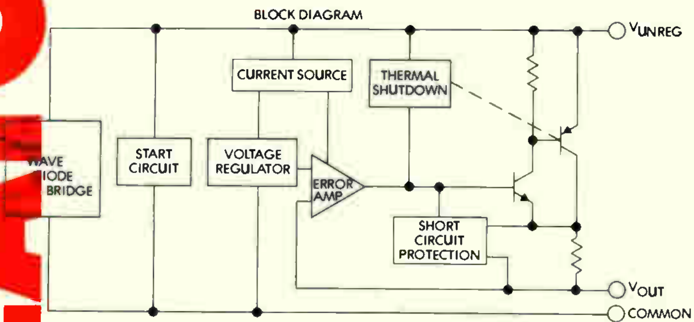
Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051. Phone Rob Walker at (408) 249-8027 [413]

Microwave transistor is linear and efficient

In the 2-to-5-GHz range, the half-watt HXTR-5102 bipolar transistor handles signals with minimal distortion and excellent efficiency. At a gain compression of 1 dB, the minimum power output is 26.5 dBm and associated gain is 6 dB. Class A power-added efficiency is 37% at 2

AC INPUT REGULATOR

Now there's one less bridge to cross to get to your power supply.



Fairchild's new SH1705 makes it a whole lot easier to arrive at power supply designs. It's a 5 V, 5 A positive voltage regulator with a twist. There's a full wave diode bridge built-in.

So now, you can design in about half the time, using fewer parts, less board space and at least one less assembly step.

The SH1705 is in a hermetically sealed TO-3 package so it can fit into even the tightest squeezes on your pc board. It features low dropout voltage across the regulator section. Internal current and thermal limiting. And 50 W power dissipation.

Bridging the gap between build or buy.

Until the SH1705, you had two choices. Build-up from discretes which is time-consuming and costly. Or buy a complete open frame power supply which is bulky. And costly, no matter what your quantities are.

Designing with the SH1705 gives you the best of both worlds without the disadvantages. And it's easy. All you need is the transformer, capacitors, heat sink and the SH1705.

Bridge over troubled power supplies.

If you're having trouble with power supply designs, or just interested in saving time, space and money, we'll send you one of our new positive voltage regulators with a bridge inside. Contact your Fairchild distributor or representative.

Or, for more immediate results call your nearest Fairchild sales office.

France: Fairchild Camera & Instrument S.A., 121 Ave. d'Italie, 750013 Paris. Tel: 00331 584 55 66. Telex: 0042 200614. **Italy:** Fairchild Semiconduttori S.P.A., Via Rosellini, 12, 20124 Milano. Tel: 02 6887451. Telex: 36522. **Germany:** Fairchild Camera & Instrument (Deutschland) GmbH, 8046 Garching Hockbruck, Daimlerstr. 15, Munchen. Tel: 089 320031. Telex: 52 4831 fair d. **England:** Fairchild Camera & Instrument (UK) Ltd., 230 High St., Potters Bar, Hertfordshire EN6 5BU. Tel: 0707 51111. Telex: 0051 262835. **Sweden:** Fairchild Semiconductor AB, Svartengsgatan 6, S-11620 Stockholm. Tel: 8-449255. Telex: 17759.

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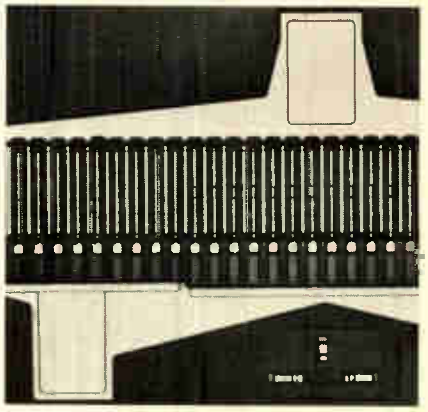

GHz and 23% at 4 GHz.

Typical power output figures for a 1-dB gain compression are 29 dBm at 2 GHz and 27.5 dBm at 4 GHz; associated gain is typically 11.5 and 7 dB, respectively, at those frequencies.

Partial internal matching makes the transistor useful for broad-bandwidth designs in commercial and military communications, and it should also find use in radar and electronic-countermeasure applications. Its minimum emitter-base breakdown voltage of 3.3 V suggests it for use in applications where input power surges can occur.

Priced at $75 each in quantities of one to nine, the HXTR-5102 is available from stock.

Hewlett-Packard Co., 1507 Page Mill Rd., Palo Alto, Calif. 94304 [416]

12.5-A V-MOS FET is available now

The VN84GA is the first member of an anticipated new family of high-power V-groove metal-oxide-semiconductor field-effect transistors [*Electronics*, June 8, p. 245]. With input power in the microwatt range, the device can put out 80 watts at low frequencies or 50 watts at 30 MHz.

The units come in TO-3 packages and are priced at $19.76 each for 1 to 99 units. The 80V, 2-A VN86HF, to come, will cost $1.13 each for 100 or more units.

Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, Calif. 95054 [418]

Data handling

TV monitor has high resolution

19-inch color unit owes 1,000-line performance to its 0.31-mm-pitch CRT

The use of color monitors outside the television industry for such diverse purposes as weather mapping, biological thermographing, and high-quality graphics displays has created a demand for greater than standard image resolution. Designers at Ramtek Corp. have responded to this need by creating a 1,000-line monitor that allows users to address over 1.3 million picture elements.

The 1,280-by-1,024-pixel addressability of the set is made possible by the close spacing of individual color dots in the black-matrix three-dot cathode-ray tube. Pitch—center spacing between the dots—is only 0.31 mm. This is the highest density pitch currently available for a 19-inch-diagonal CRT.

The monitor operates with a video bandwidth of 50 Hz to 40 MHz, which provides faithful reproduction of incoming signals and ensures that resolution will not be bandwidth-limited. The incoming signals specified for the device are red-green-blue with composite synchronization on green, RS-343A being used as a guide. By means of a switch, the nominal horizontal line frequencies of 28.3 kHz, 31.2 kHz or 34.75 kHz can be selected. Other frequencies within the 28-to-36 kHz range can also be accommodated. The monitor's refresh rate is nominally 44 to 68 Hz. Horizontal flyback time is 5 to 8 μs; vertical is 600 μs.

Misconvergence measured within a circle having a diameter equal to the screen's vertical height and its center in the middle of the screen is less than 0.62 mm. Measured on a horizontal axis outside the circle, it increases to under 0.7 mm and at the screen's corners is less than 1.0 mm. The monitor's low misconvergence results in an image that has sharply defined characters and good edge definition.

With a picture brightness of 20 foot-lamberts, the unit consumes 300 W operating from standard

Now, the first data logger with get-up-and-go.

Take EMR's suitcase-sized COMPACT 3430 Data Logger away to those "difficult" sites where bulky equipment or hardwiring would be too inconvenient or costly. Just take it and leave it — anywhere, any time, for as long as a month. COMPACT's built-in battery and power source make it easy.

You can even take your pick of three models: one with a built-in line printer; one with a built-in cassette tape recorder; and one with a universal peripheral interface usable with a line printer, paper punch tape, teleprinter or modem. All three are microprocessor-controlled, providing keyboard programmability for up to 30 analog inputs and 20 (optional) digital status inputs, with any mix of voltage or thermocouple inputs.

As simple to use as a pocket calculator, COMPACT's pushbutton control eliminates plug-in modules, and lets you set individual high and low limits, specify channel input type, skip channels and select scan intervals. A choice of three modes lets you record *all* input data, out-of-limit conditions only, or inputs as they pass through the set limits. You can even print out alarm conditions.

For more details or a demonstration, call or write today.

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P.O. Box 3041, Sarasota, FL 33578
813-371-0811

Circle 195 on reader service card

American or European ac power lines. It weighs approximately 100 lb and can fit into a rack space measuring 19 by 17.5 in. The set is also available in a tabletop cabinet or stylized case.

Prices for the 19-in.-diagonal CRT monitor begin at $9,900 with delivery 90 days after receipt of order. Quantity discounts are available, and a 13-in.-diagonal model can be provided on special order.

Ramtek Corp., 585 North Mary Ave., Sunnyvale, Calif. 94086. Phone Beverly Toms at (408) 735-8400 [361]

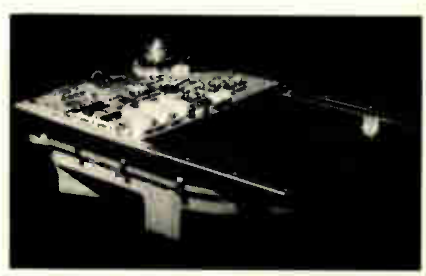
Dual-technology drive arrives with a price under $1,300

Among the latest moves by the hard-disk-drive manufacturers to attract floppy-drive users is the development of the combination Winchester and floppy drive [*Electronics*, April 13, p. 43]. The most recent arrival in the marketplace, the Marksman, claims to be the first 14-in. rigid-disk drive to be priced at less than $1,300 in quantity.

Average access time for the 17-megabyte, single-platter drive is 80 ms, and its track-to-track time is just 3 ms. Use of an integral microprocessor allows the stepper motor to slew at high speed with controlled acceleration.

The Marksman comes with a variable-frequency-oscillator data separator, has a power supply that is compatible with floppy drives, and accepts customer-designed formatters and controllers. Drive options include integrated controllers, off-line exerciser, and rack mounting.

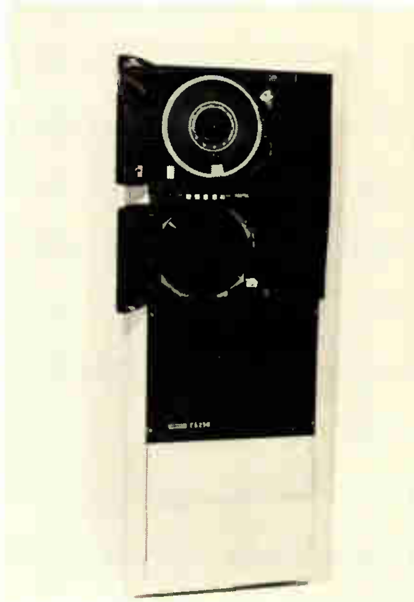
Initial delivery of the drive is scheduled for the third quarter of 1978, with production shipments



expected to begin in October.
California Computer Products Inc., 2411 W. La Palma Ave., Anaheim, Calif. 92801. Phone (714) 821-2541 [364]

Rack-mountable tape system records 6,250 bits per inch

Introduced at the National Computer Conference, a vacuum-column tape-drive subsystem consisting of the T1940 transport and the F6250 microprocessor-based formatter utilizes group code recording to obtain a data density of 6,250 bits per inch. Unlike other high-density units, the transport measures only 24½ by 19 by 26 in. and fits easily in a standard



rack, as does the 15¾-by-19-by-10-in. formatter.

The T1940 is available in configurations that transport tape at either 75 or 125 in. per second; the F6250 can handle up to four transports. As a team, they provide complete self-diagnostics, under either computer or manual control. Information is logged in the formatter for later computer interrogation to permit monitoring the system's integrity.

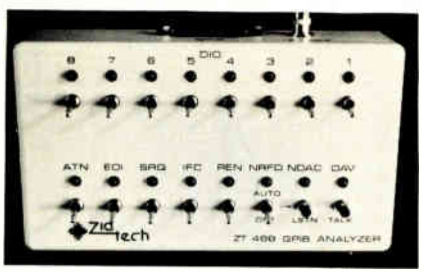
The system, which automatically threads 10½-inch open-reel tape and accepts Easy-Load cartridges 1 and 2, is priced at $13,500 each in production quantities.

Pertec Division, Pertec Computer Corp., 9600 Irondale Ave., Chatsworth, Calif. 91311 [365]

Handheld logic analyzer observes, controls for $349

The ZT 488 is about the size of a standard engineering calculus text. But it weighs less—only 1 lb—and is a lot easier to master.

On its front panel, the unit can display logic transmitted on an IEEE-488 bus, including eight data lines, five control lines, and three handshake lines. Front-panel switches allow the user to set the data and control lines, and the hand-



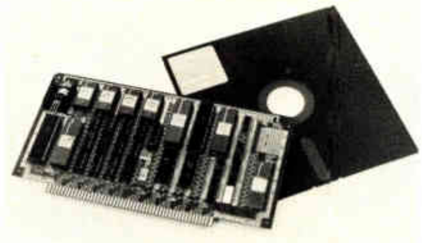
shake lines can be automatically controlled by internal logic or single-stepped by front-panel switches.

Requiring 5 V at 0.4 A, the ZT 488 comes with a 5-ft power cord and universal clips. It is available from stock.

Ziatech Corp. 10762 La Roda Dr., Cupertino, Calif. 95014. Phone Bert Forbes at (408) 996-7082 [373]

Controller prevents multiple-head aches

Having developed a four-head flexible-disk drive [*Electronics*, May 25, p. 180], PerSci is also offering a means to support up to eight of the units at one time: the model 1170 is a Z80-based controller that is compatible with IBM 2D, IBM 3740, and S-100 buses. In addition to managing up to 32 diskette sides to provide a formatted data capacity of



over 16 megabytes, the stand-alone device will perform most of the housekeeping functions usually done by the central processing unit. File management functions include initialization, allocation and de-allocation of diskette space, error correction and retrying, and creation, deletion, renaming, and copying of files. Diagnostic testing can be managed, too.

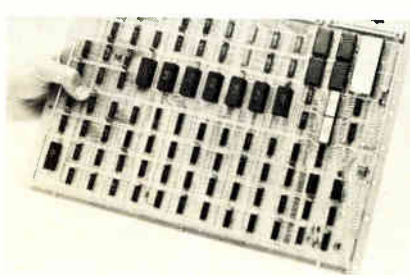
Priced at $800 in original-equipment-manufacture quantities, the model 1170 is available for delivery in 60 to 90 days.

PerSci Inc., 12210 Nebraska Ave., Los Angeles, Calif. 90025. Phone (213) 820-3764 [366]

Programmable formatter takes on all comers

The model 61F-600 is a floppy-disk-drive formatter that can be programmed to accommodate virtually any set of operating features and parameters. The unit allows selection of both single-density and double-density modes with both single-sided and double-sided operation. A single formatter can handle up to eight mixed-density disk drives with multiple formats. The 61F-600 sells for $850.

Applied Data Communications, 1509 E. McFadden Ave., Santa Clara, Calif. 92705. Phone (714) 547-6954 [367]



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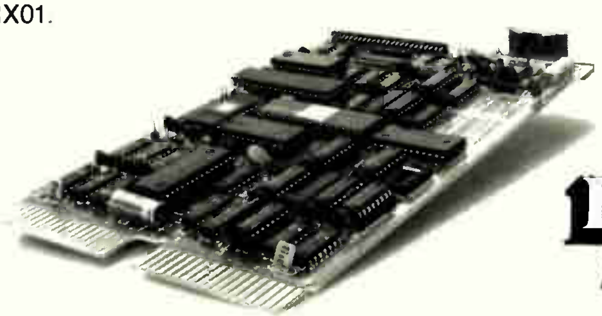
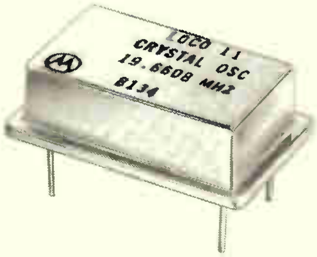


Data Systems has combined interface, formatter, controller, and hardware bootstrap on this single dual-wide card. Available separately in OEM quantities.

Data Systems

Circle 201 on reader service card

$3.75



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For price list, rep list and data sheet, call Barney Ill at (312) 451-1000. Or write Motorola, Component Products Department, 2553 N. Edgington, Franklin Park, IL 60131.

*1,000 price. Ⓜ Motorola and LOCO II are trademarks of Motorola Inc.

MOTOROLA INC.
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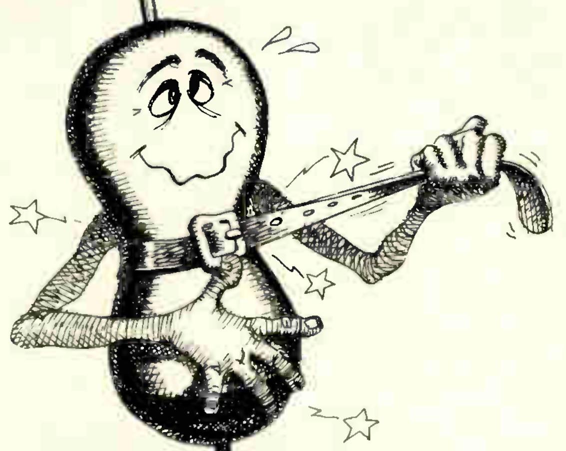
Circle 203 on reader service card

MINI STIC



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Reverse Recovery Time (Max.): 300ns
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D.C. Blocking Voltage @25°C: 7500 & 10,000V
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Circle 205 on reader service card

Communications

Automatic system monitors network performance

Although all high-speed modems are constantly gathering data on transmission-line parameters to aid in the recovery of received signals, this data is seldom available to the operators of data-communications networks.

An exception is the Paradyne MP-48 modem—a 4,800-bit/second unit with dual microprocessors. One of its microprocessors handles such functions as equalization, scrambling, encoding, and filtering. The other provides dynamic information on transmission impairments and controls the modem processor when diagnostic tests are being performed.

Because the MP-48 makes its line-quality information readily available, it can be used as the basis of a network monitoring and control system. Such a system, capable of collecting data from 144 multidrop lines, has been developed. Called Analysis, it consists of a minicomputer-based central-site control unit, one or more MP-48 master modems, and up to several hundred MP-48 slave modems. The system automatically gathers, displays, and stores data using a low-speed (110-baud) noninterfering diagnostic channel.

Information on loss, noise, phase jitter, amplitude distortion, phase distortion, and other parameters is gathered from every drop on the network, assembled and analyzed for exception and alarm states, and displayed in conversational English.

A key benefit of Analysis is that it documents line availability, which allows users to recover the costs of unavailable lines. In some cases this can amount to thousands of dollars a month, according to product manager William Siegrist.

Analysis is available in two versions. The model CCB has a central-site control unit that contains a 16-bit minicomputer with 24 kilobytes of memory, a 1920-character cathode-ray-tube display terminal with a separate keyboard, a disk controller and two floppy-disk drives, and a 150-character-per-second printer. Prices for the CCB begin at $36,000. The model CCA omits the hard-copy printer, substitutes a light-emitting-diode readout for the CRT display, replaces the keyboard with a Touch-Tone entry pad, and makes other similar econo-

mies. It is priced from $3,500.
Paradyne Corp., 8550 Ulmerton Rd., Largo, Fla. 33541. Phone (813) 536-4771 [401]

Fiber-optic connector makes 1-dB losses possible

Although fiber-to-fiber losses of 2 dB are typical, values as low as 1 dB are possible with the model FOS fiber-optic connector. The single-fiber connector, which is available both as connector components and in complete cable assemblies, is designed to meet military connector specifications while in a mated condition. It will withstand an outdoor environment, the maker says.

Key to the performance of the connector is a precision ferrule that provides the necessary axial, angular, and gap alignments. Ferrules are available for fiber diameters from 100 to 150 μm (4 to 6 mils). In quantities of 100 and up, the connectors sell for $125 per mated pair. Delivery time is 8 to 10 weeks.
ITT Cannon Electric, 666 E. Dyer Rd., Santa Ana, Calif. 92702. Phone Richard L. Harmon at (714) 557-4700 [404]

Medium-speed facsimile unit has low rental tag

The Qwip Two facsimile transceiver is an inexpensive unit that can transmit an 8.5-by-11-in. page in either 2 or 3 minutes, depending upon the resolution required. The 3-min. transmission yields a resolution of 96 lines/in. in both directions; the 2-min. time reduces the resolution in one direction to 78 lines/in.

A key feature of the Qwip Two is its interrupt capability, which allows either the sender or the receiver to terminate a transmission. This capability is expected to save transmission costs by eliminating wasted messages. A second cost-saving attribute is a handshaking feature that allows the operator to know when both units are ready to send and receive.

This feature allows the send-

ing of multiple-page documents without picking up the phone after each page.

Believed to be the lowest-priced facsimile transceiver of its type, the Qwip Two rents for $65 a month.
Qwip Systems Division of Exxon Enterprises Inc., 1270 Avenue of the Americas, New York, N. Y. 10020. Phone (212) 398-5151 [403]

Pigtailed IR emitter sells for $17.50

The FOE-7 pigtailed emitter assembly is an infrared unit with a bandwidth in excess of 20 MHz, a typical output power of 10 μW at a forward current of 50 mA, and a price of $17.50 (any size order). Useful for both analog and digital transmission, the FOE-7 has light rise and fall times of 25 and 15 ns, respectively. When pulsed with currents of 4 A, the assembly can put out as much as 200 μW of optical power.

Peak emission occurs at 900 nm with a spectral half-width of 50 nm. To transmit this wavelength, the pigtail consists of a fused silica core with silicone cladding and a black Tefzel outer jacket. The unit has an expected lifetime in excess of 50,000 hours. It is available from stock.
Radiation Devices Co., P. O. Box 8450, Baltimore, Md. 21234. Phone (301) 628-2240 [405]

Bell-compatible modem fits on single circuit board

Built on a printed-circuit board with an area of less than 100 in.^{2}, the model 208 data modem is a 4,800-bit/second unit offered in versions that are compatible with both Bell

How fast can you accurately measure period or frequency of this wave form?

The old way.

(About 5 minutes)

1. Find a scope and voltmeter.
2. Connect signal to scope.
3. Determine proper trigger points.
4. Connect signal to counter.
5. Select period or frequency function.
6. Select time base.
7. Set input voltage range.
8. Set input coupling to DC.
9. Connect voltmeter to trigger level output – if counter has output. (If not, good luck.)
10. Set desired trigger level.

The easy way.

(About 5 seconds)

1. Connect signal to Racal-Dana 9000 counter.
2. Push P or FA button.
3. Push TL button.
4. Push AU button.

The rest is automatic.

Now it's up to you.

You can continue to struggle along the old way. Or you can find out about the Racal-Dana 9000 Microprocessing Timer/Counter. The patented Auto-Trigger capability makes it the fastest and most accurate instrument in the world for the precision measurement of wave forms. Give us a call and we'll tell you how Racal-Dana systems technology can solve all your measurement problems the easy way.

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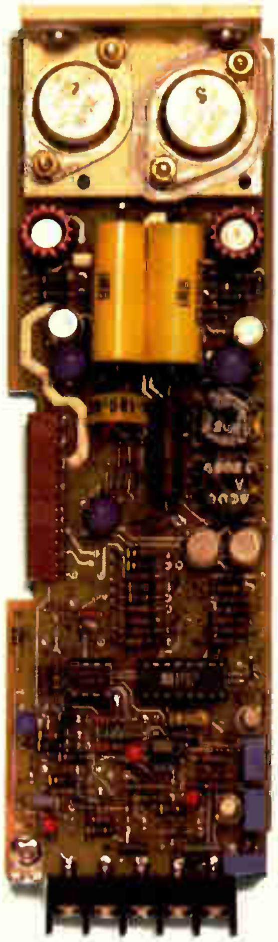

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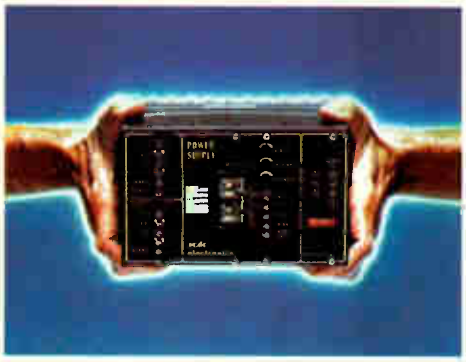
To make sure each Sub-Modular Switcher lives up to its specifications, we computer test all its operational parameters. And you get a complete EDP test report with every one you buy. The Sub-Modular Switcher's calculated MTBF exceeds its 5-year warranty. In fact, Life Test data indicate that actual MTBF should be considerably greater than the warranty period.



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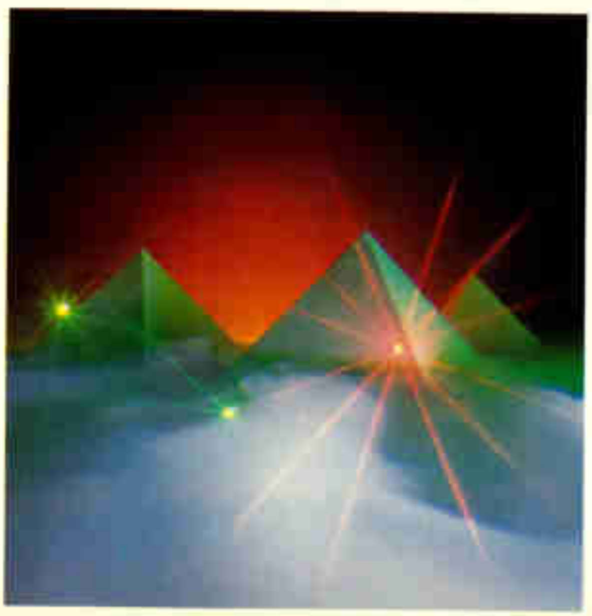


Circle 212 on reader service card

Products Newsletter

Instrument maker to sell its own trigger-pulse synchronizer board

Berkeley Nucleonics Corp., a Berkeley, Calif., instrument manufacturer for the last 13 years, is moving into the precision subassembly market. Stemming from the company's work in digital delay generators is **the C-1000 Zepher (for zero phase error) board, which synchronizes trigger pulses at rates up to 20 MHz to an onboard 100-MHz crystal oscillator.** The Zepher uses emitter-coupled logic to reduce synchronization error between the trigger and the clock to no more than 100 ps. Available now at single-quantity prices of $1,100, the subassembly is geared for such high-frequency applications as real-time signal processing.

Analog Devices second-sourcing 12-bit d-a converter

Add Analog Devices Inc., Norwood, Mass., to the list of alternate sources for the DAC80 12-bit hybrid digital-to-analog converter introduced a few years ago by Burr-Brown Research Corp. Though AD's DAC80 is a direct pin-for-pin replacement of the Burr-Brown part in a 24-pin epoxy-sealed dual in-line package, **it cuts the chip count inside from 11 for the older hybrid to 3 and tightens some of the specifications.** Differential linearity is improved from ⅞ to ¾ least significant bit, for example, and lower digital input currents allow the circuit to run off any complementary-MOS gate without a buffer, as the older part requires. The AD DAC80 will sell for $18.50 each in hundreds and will be available late this month.

Easy D-type flip-flop implementation promised by semicustom chips

Master Logic and Interdesign, Inc., both of Sunnyvale, Calif., will be offering a 350-gate, semicustom complementary-MOS logic chip that features 32 locations designed for easy D-type flip-flop implementation. **Master Logic's ML350 and Interdesign's MCD350 are identical parts,** and the special design feature increases gate complexity by 70% with only a 30% increase in chip area, according to Charles Allen, Master Logic president. Larger C-MOS circuits usually require more D flip-flops for counters and shift registers; therefore, the companies designed in the new cells so that the user can make a flip-flop with only one instead of the previous two interconnected cells. Design costs are about 30% higher than for the 200-gate chip. The price of Master Logic's part is $13.

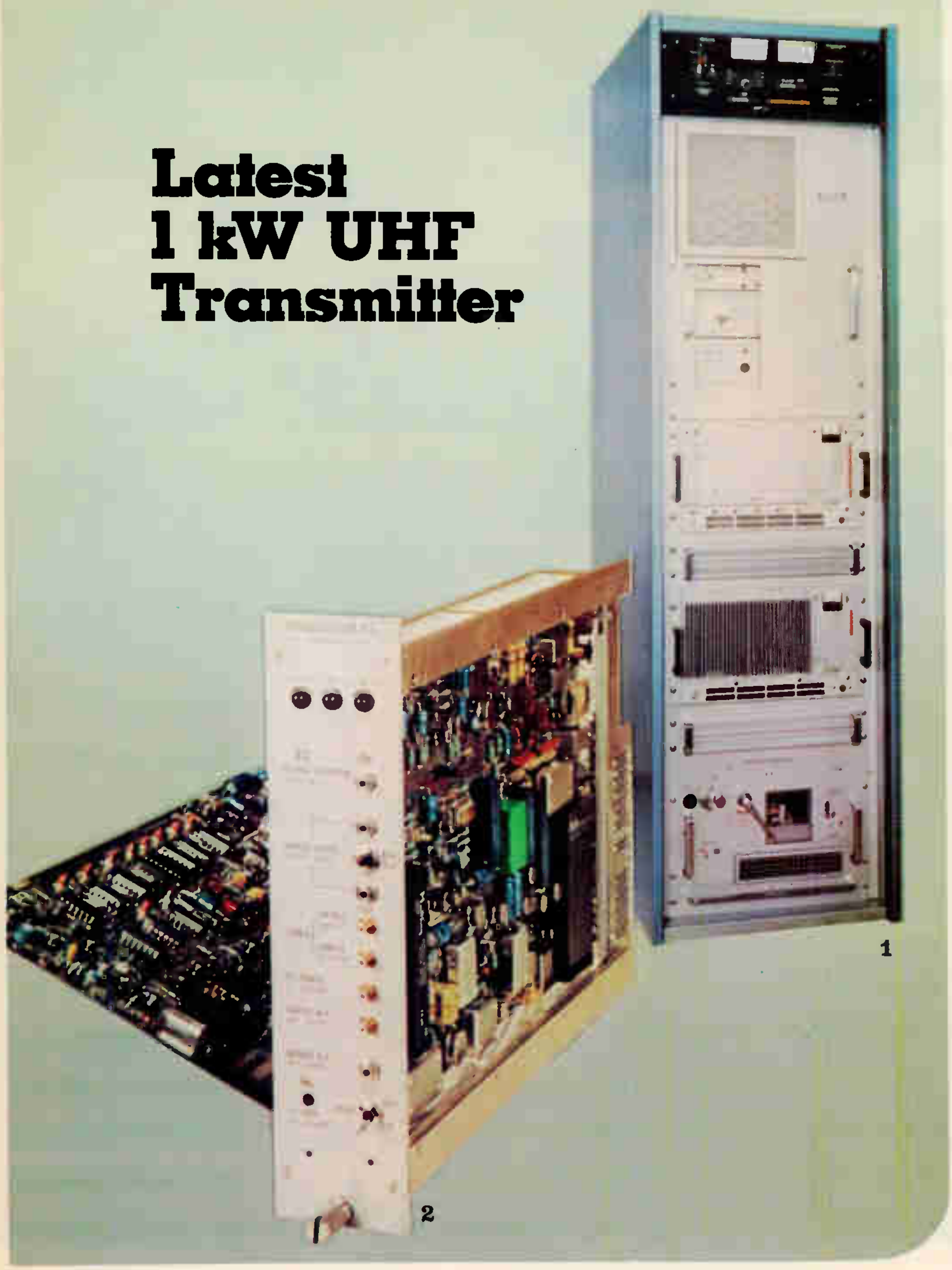
There's a new source for germanium power transistors

Germanium lives. Silicon Transistor Corp. of Chelmsford, Mass., is now manufacturing the pnp germanium diffused-alloy power transistors that General Motors Corp.'s Delco Division used to make for fast switching and power-amplifier applications. **The DTG110A and DTG110B are both available from stock, priced from $2.20 in 100-and-up-quantities.** Current ratings are 25 A pulsed and 15 A continuous, and BV_{CEO} voltages are greater than 70 V.

Price changes

Recent price changes have been announced:
- **National Semiconductor Corp.,** Santa Clara, Calif., is cutting bi-FET LF13741N op amp from 50¢ to 33¢ and LF1374H from 75¢ to 43¢ in quantities of 100 or more.
- **Kertron Inc.,** Riviera Beach, Fla., has reduced 2N6542 through 2N6547 high-voltage switching power transistors by 22%.
- **Computer Applications Corp.,** Ames, Iowa, is reducing two versions of 6500 microprocessor cross-assemblers from $1,200 and $900 to $600 each. The new price includes test programs and one-year free support.

Latest 1 kW UHF Transmitter



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Up to the tube stage all amplifiers have built-in redundancy
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Formulated Resins Inc., P. O. Box 508, Greenville, R. I. 02828 [475]

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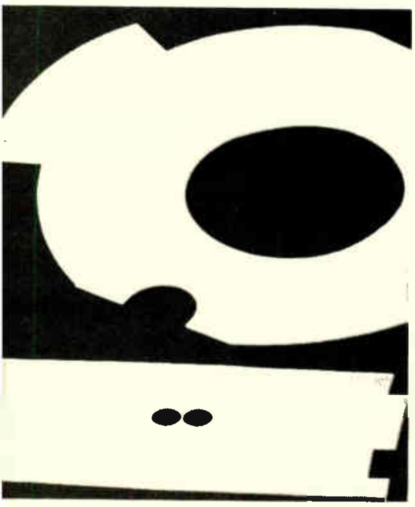

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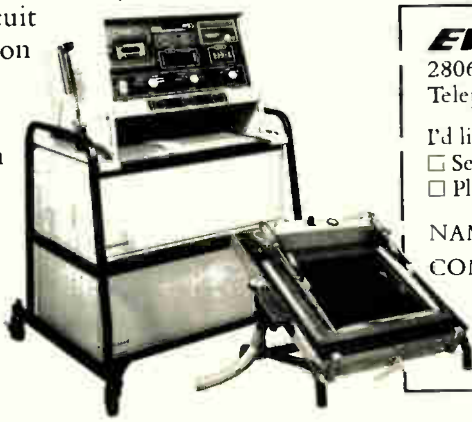

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New literature

Make-or-buy LSI. All the steps required to design and build large-scale integrated devices can now be subcontracted; LSI technology is therefore within reach of companies big and small, concludes Anderson/Bogert, a Santa Clara, Calif., high-technology consulting firm in a 185-page report. Entitled "Vertical Dis-Integration," it describes the key steps and details the factors that influence the make-versus-buy decision at each step. The prepublication price is $395 until July 5 and $475 afterward. Electronics Technology Publications, 10050 N. Wolfe Rd., SW #3, Suite 200, Cupertino, Calif. 95050

Voltage controls. Illustrations, engineering data, diagrams, and specifications for a line of standard voltage controls are offered in a 72-page booklet. Also included is a section on how to specify and order ac voltage

controls. Staco Inc., 301 Gaddis Blvd., Dayton, Ohio 45403. Circle reader service number 422.

Pc-board production equipment. "Automatic Pc Board Production

New literature

Equipment," a six-page catalog, points out the key characteristics of nine printed-circuit-board machines and two automatic roll-soldering systems. Photographs of each machine and system are given. Union Tool Co., Warsaw, Ind. 46580 [423]

Microwave communications systems. A 17-page catalog provides information on several types of microwave communications products, including control and data-acquisition systems and components, baseband conditioning and interface components, and frequency-shift-keying data-transmission equipment. Dantel Applications Department, 1922 N. Helm, Fresno, Calif. 93727 [424]

Photomultipliers. "Photomultipliers for Applied Spectroscopy," a six-page product guide, describes a line of side-on photomultiplier tubes and integrated photodetection assemblies that are intended specifically for photometric and ratiometric applications. A bar graph depicts the spectral response range of the photomultiplier tubes. RCA, Box 3200, Somerville, N. J. 08876 [425]

Components. Electrical and mechanical specifications for six electronic component lines for use by original-equipment manufacturers are detailed in a 40-page catalog. Products covered include potentiometers, cermet resistor networks, and trimmers. Photographs and diagrams are also given. CTS Corp., 905 North West Blvd., Elkhart, Ind. 46514 [432]

Vacuum gages. Detailed descriptions, specifications, and ordering information for a line of vacuum gages in the 300/400 modular series are provided in a 25-page brochure available from CVC Products Inc., 525 Lee Rd., P. O. Box 1886, Rochester, N. Y. 14603 [427]

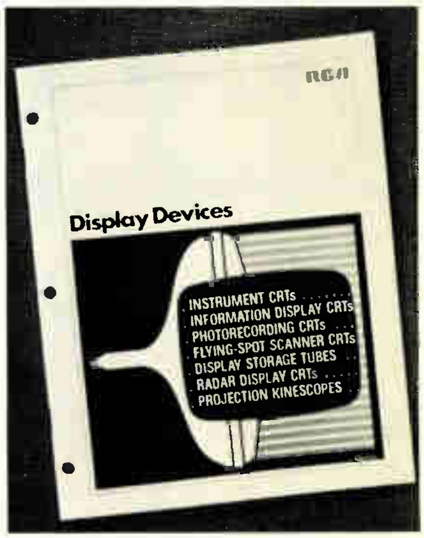
Relays. "The Relay Selection and Application Manual" gives a broad description of various types of relays—general-purpose, latching, sensitive, impulse, stepping, military, solid-state, and such time-delay types such as thermal and solid-

New literature

state, as well as hybrid, pneumatic, and motor-driven timers. Different sections cover the various aspects of selecting a relay type—contacts, coils, enclosures, terminals, and mountings. This 25-page manual can be obtained from Publications Department, Relay Specialties Inc., 13-00 Plaza Rd., Fair Lawn, N. J. 07410 [428]

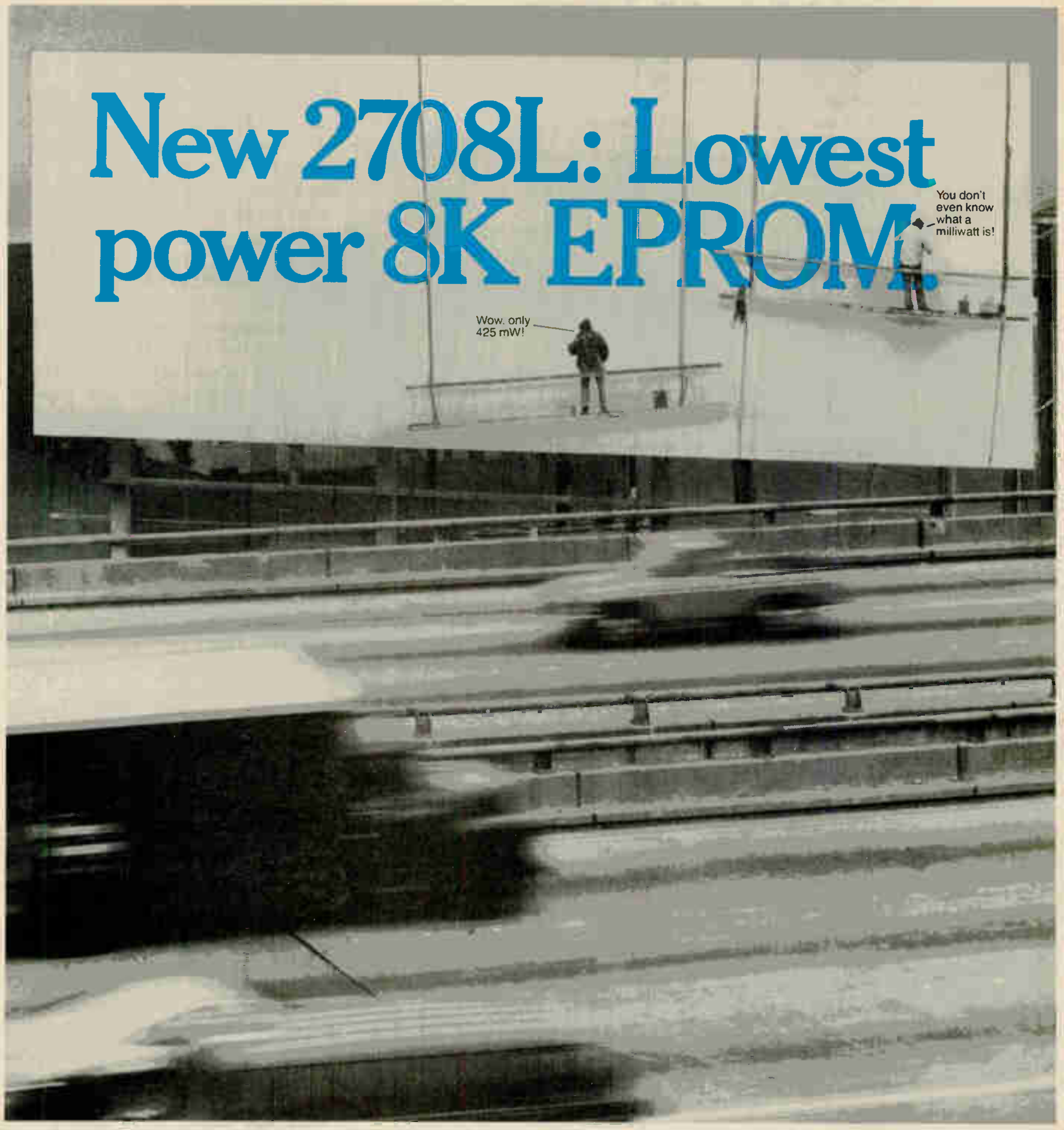
Power supplies. Over 1,300 models of solid-state, regulated and unregulated, rack-mounted, miniature, and modular high-voltage power supplies are covered in a 13-page brochure. It gives the features, specifications, and options for each type of power supply. The brochure is being offered by Spellman High Voltage Electronics Corp., 7 Fairchild Ave., Plainview, N. Y. 11803 [429]

Display devices. A 35-page catalog gives details of several types of specialized cathode-ray tubes. Entitled "Display Devices," it lists the



general characteristics of the display devices and the specific operating characteristics for each type. Some of the CRTs are: instrument, information display, photorecording, flying-spot scanner, display storage tubes, and radar display. A glossary of terms is also provided. RCA, Box 3200, Somerville, N. J. 08876 [430]

Plasma-etching aluminum. "DryAl Etching: Etching Aluminum in a



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European Headquarters: Intel International, Brussels, Belgium, Telex 24814. Japan: Intel Japan K.K., Telex 781-28426.

U.S. and Canadian Distributors: Almac/Stroum, Component Specialties, Cramer, Hamilton/Avnet, Harvey, Industrial Components, Pioneer, Sheridan, Wyle/Elmar, Wyle Liberty, L.A. Varah and Zentronics.

New literature

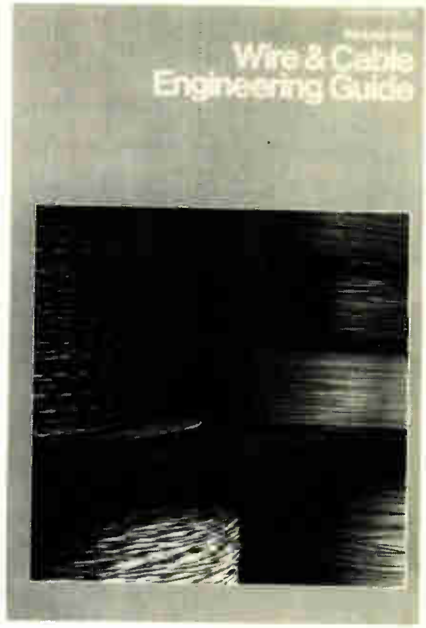
Planar Reactor," a four-page bulletin, explains the DryAl process for plasma-etching aluminum and gives typical operating parameters for each step. It also discusses the handling of wafers before and after processing. International Plasma Corp., 31159 San Benito St., Hayward, Calif. 94544 [431]

Electromagnetic interference. The "Quiet Line Filter Handbook" will help an engineer understand electromagnetic interference and how to eliminate or prevent it. This 16-page booklet specifies several methods of preventing radiated interference, including grounding, shielding, and the use of balanced lines, twisted pairs, and coaxial cables, as well as how to prevent conducted interference by using various types of filters. Proper filter testing, installation, and application are also covered. AMP Capitron Division, Elizabethtown, Pa. 17022 [426]

Surge suppressors. A technical application note discusses the various types and uses of voltage surge suppressors, including RC circuits, silicon voltage limiters, metal oxide varistors, and selenium suppressors. It also points out the limitations of these devices. A table summarizes the performance data, giving such information as maximum average power loss, internal thermal resistance, maximum avalanche peak current, and the maximum allowed energy for nonrepetitive pulses. FMC Corp., Semiconductor Products Division, 800 Hoyt St., Broomfield Colo. 80020 [433]

Wire and cable. A 72-page guide "Wire and Cable Engineering Guide," is designed for use by electrical and electronic circuit designers. The guide contains information on conductor material and coatings insulation, circuit identification braiding, shielding, cabling, and jacketing. Cable design formulas and a temperature conversion chart are also given. It sells for $10 per copy in the U.S. and Canada and $15 per copy elsewhere. Brand-Rex Co., Wire & Cable Engineering

New literature



Guide, WC-78, P. O. Box 498, Willimantic, Conn. 06226 [435]

Low-pass active filters. A 16-page guide, "Fixed Frequency Lowpass Active Filters," defines the applications and response characteristics of multipole Butterworth, Bessel, Chebyshev and Cauer-elliptic low-pass filter designs. Theoretical responses of 2-, 4-, 6-, 7-, and 8-pole functions in graphic and tabular form provide gain, phase, and step response data. Frequency Devices Inc., 25 Locust St., Haverhill, Mass. 01830 [434]

Rentals. Information on major microcomputer development systems and logic analyzers that can be rented is given in a comprehensive catalog. The products are: American Microsystems Inc.'s 6800 microcomputer development center, Hewlett-Packard's logic analyzers, Intel's Intellec series, Millennium's microsystem analyzer, Motorola's Exorterm and Exorciser, Pro-Log's programmable read-only memory programmers and systems analyzers; and Tektronix' microprocessor labs and logic analyzer. Weekly and monthly rates are provided. Longer-term, as well as daily and hourly, rates are available upon request. Microcomputer Rentals, 705A Lakefield, Westlake Village, Calif. 43161 [436]

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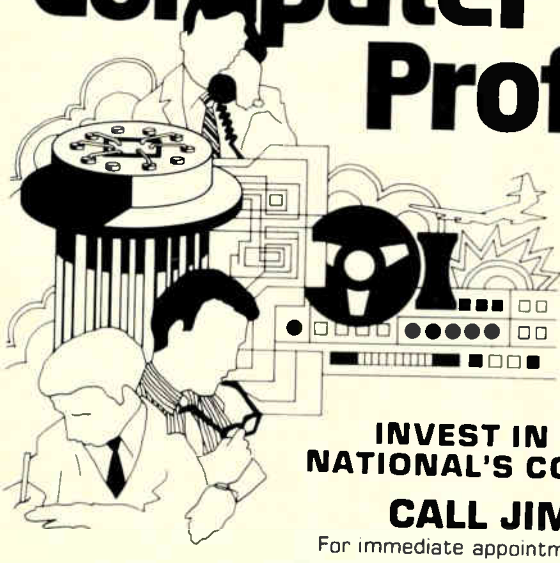

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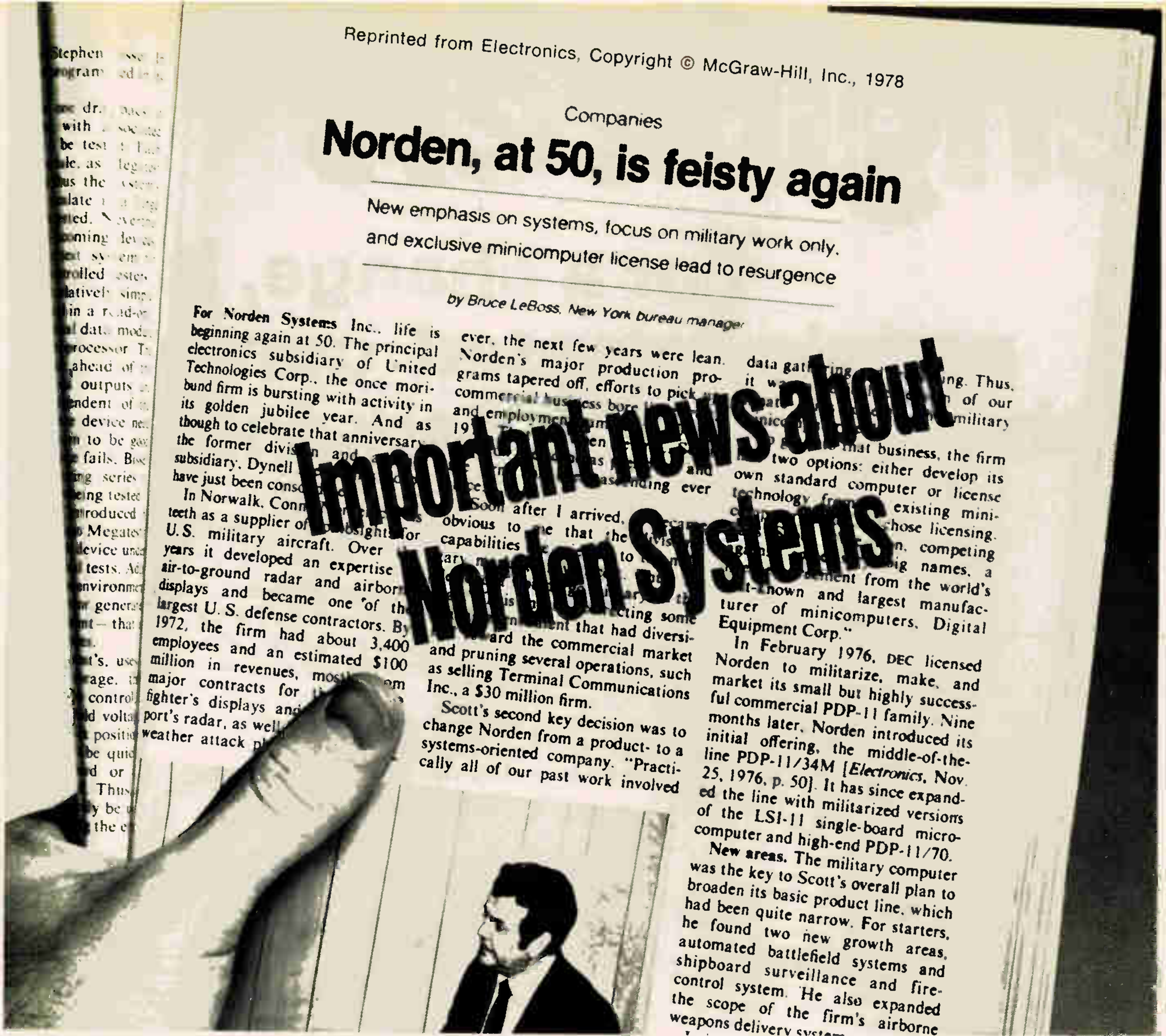

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■	ACDE Electronics	211
	ADAC	50
*	Adret Electronique	97
	Advanced Micro Devices	86-87, 10-11
*■	AEG-Telefunken	71
■	Alco Electronic Products (Sub. of Augat	224
■	Allen-Bradley	32
	American Microsystems Inc.	173
‡	Analog Devices	187, 98-99
	Analogic Corporation	153-156
	Biomation	189
‡■	B & K Precision, Div. Dynascan Corp	185
	Boschert	161
■	Bourns, Inc.	4th cov
■	Bowmar Commercial Products	198
■‡	Bud Industries Inc	171
*■	Burr Brown Research Corp	12E
	Canadian Thermostats & Control Devices	48
*	Carlo Erba SA	171
	Computer Automation, Inc., Industrial Prod. Div.	181
	Conrac Div/Conrac Corporation	215
‡■	Continental Resources Inc.	45
■	Corning Glass Works, Fotoform/Fotocerm Div.	169
■	Corning Glass Works Morse	229
‡	Cortron Div of Illinois Tool Works Inc	175
	Cromemco	197
	Cts Corporation	168
■	Data Systems Design Inc	200-201
■	Delevan Div., American Precision Ind.	166
	Digital Electronics Corporation	160
‡	Eastman Kodak Co., Graphic Markets Division	65
■	Electronic Measurements	16
	Electronics Trend Publications	188
	Elevam Electronic Tube Co Ltd	196
	EMM/CMP	227
■	Everett/Charles, Inc.	219
	EMR Telemetry	195
■	Erie Technological Products	206-207
■	Exact Electronics	182
	Fairchild (Semiconductor Operations Div)	35, 191
	Fairchild Systems Technology	199
‡	Ferroxcube Corp. Div of North Amer. Philips	66
	Figaro Engineering Inc.	85
‡	First Computer Corporation	132
■	John Fluke Mfg Co Inc	54, 123
‡	Fujitsu America Inc	69
	Fujitsu America Inc.	52-53
	Futuredata Computer Corporation	102-103
	Gainesville Area Chamber of Commerce	217
■‡	General Electric Instr Rental Div	158
■	General Instrument Microelectronics	74-75
*	Golden Gate Enterprises	175
■	Gould, Inc./Instrument Systems Div./T & M	210-212
‡	Gould Electronics Components Div	61
	Guardian Electric Mfg. Co.	15
	Galileo Electro Optics Corporation	3rd cov
	Herbert Numerical Controls	198
■	Guildline Instruments, Inc.	157
■	Harris Corporation PRD Electronics Div	160
	Harris Semiconductor	47
■	Hewlett-Packard	2nd cov., 1, 2, 7, 9, 12-13, 22-23, 26, 30-31, 119, 145, 151, 162-163, 167
■	Hipotronics, Inc.	194
■	IEE Industrial Electronic Engineers, Inc.	96
■	ILC Data Device Corporation	214
	Information Control Corporation	190
■	ITEK/Measurement Systems Division	220
	Intel Memory Systems	164-165
	Intel Telecommunications	179
	Intel Special Products Division	225
	Intelligent Systems Corporation	188
	International Electronic Research Corp.	174
	Intersil	28-29
	Interstate Electronics	180
*	ITT Bauelemente Gruppe Europa	7E
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	Jepico Co. Ltd.	10E
■	Johanson Manufacturing Corp.	8
■	Keithley Instruments	184
	Kertron	220
■	Krohn-Hite Corporation	5
*	Leybold Heraeus	66
	L.G.T.	216
	LH Research Inc.	172
	Litronix	193
	Matrox Electronic Systems	178
■	Microswitch, Div. of Honeywell	17
■	Microtechnical Industries	85
■	Microwave Power Devices	14E, 15E
■	Mini-Circuits Laboratory	38
	Mitel Semiconductor Inc	92-93
	Mostek Corp	27
■	Motorola Semiconductor Products	18-19, 49, 78-79, 125, 217
	Motorola Communications & Electronics	203
	M & T Chemicals Corporate	20-21
‡	McGraw-Hill Book/Co	218
*	Murata Mfg. Co. Ltd.	221
■	National Semiconductor Corp	36-37
■	Non-Linear Systems, Inc.	242
	Noritake Electronics Inc	223
■	North American Philips Controls	192
	Optron, Inc.	14
	Pinellas County	176
*	Philips Elcoma	45
*	Philips Industries	2E-3E
‡■	Philips TMI	97
*■	Philips TMI	4E
	Plastics Engineering Company	89
■	Power One Inc	208
	RAC—Reliability Analysis Center	224
	Racal-Dana Instruments	209
*	Racal Thermionic Ltd.	76-77
	Raytheon Company	131
	RCA	100-101
	RCA Solid State	62
‡	Rental Electronics Inc	73
	Reliability Inc.	55
*	Rhone Poulenc—Chimie Fine	132
‡	Robinson Nugent Inc	76-77
■	Rockland Systems Corporation	147
*	Rohde & Schwarz	65, 69
	Sangamo Data Recorder Div Schlumberger	205
	Scanoptik, Inc.	178
*	Schlumberger	1E
‡	Semiconductor Reliability Labs	91
	Semtech Corporation	204
*	Sescosem Thomson CSF	16E
*	Sfernice	16E
*	Siemens AG Munich	60
‡	Siliconix	221
	Slaugher Company	192
	Solartron	17E-20E, 158
	Solid State Scientific	43
*	Sonimag	9E
■	Spectrol Electronics	95
■	Sprague Electric	59
■	Superior Electric	202
	Synertek	121
	Systron-Donner, Concord	6
	Systron-Donner, Data Products Div.	239
	TEAC Corporation	56
■	Tektronix	25, 177
	Teradyne, Inc.	80
*	Thomson CSF Division D.T.E.	13E
	Trio Kenwood Corporation Test Inst. Division	91
	Ultra-Violet Products	196
■	United Systems Corp Sub Monsanto	170
	Utah Industrial Development Division	149
■	Vactec Inc.	183
	Wall Industries	186
	Wavetek San Diego	104
	Weckesser Company Inc	217
*	Weston Schlumberger	9E, 11E
*	Zeltron	187

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Boshert	237
Easta Translations	232
GTE Lenkurt	234, 235
Honig W. Dr.	232
IFR, Inc.	232
Illinois University of	236
Lowe M. David	232
National Semiconductor	231, 236
Norden Systems, Inc.	233
Northrop	237
Tektronix	230
U.S. International Rec.	232
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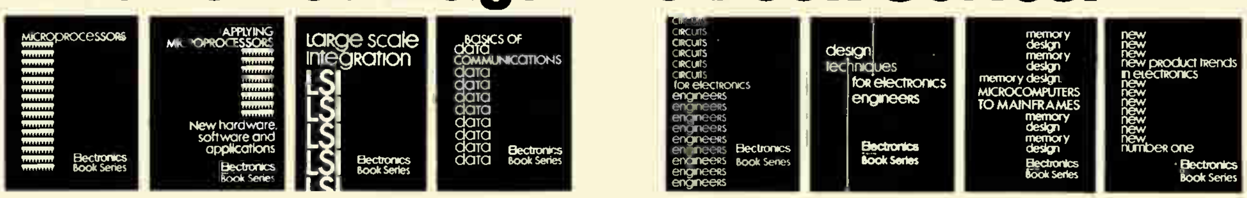

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