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Electronics®

The case for component burn-in

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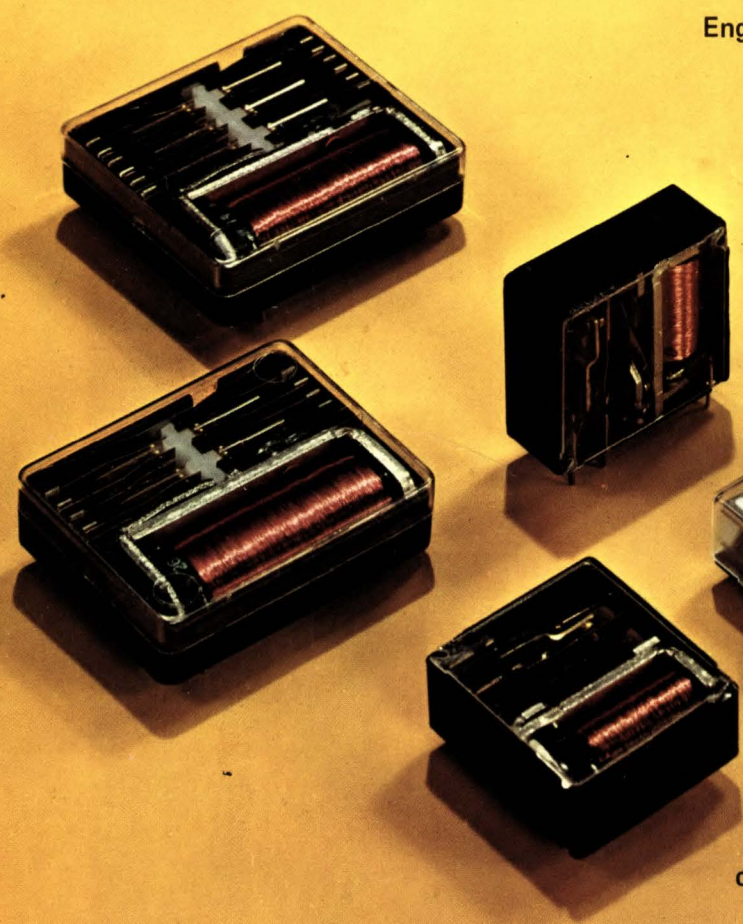

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These compact relays are particularly suited for communication systems, data processing equipment, automatic control systems, process control, automotive and consumer electronics.

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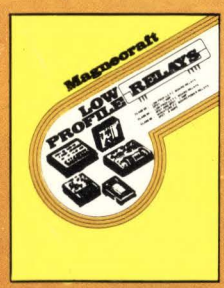

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Circle 900 on reader service card

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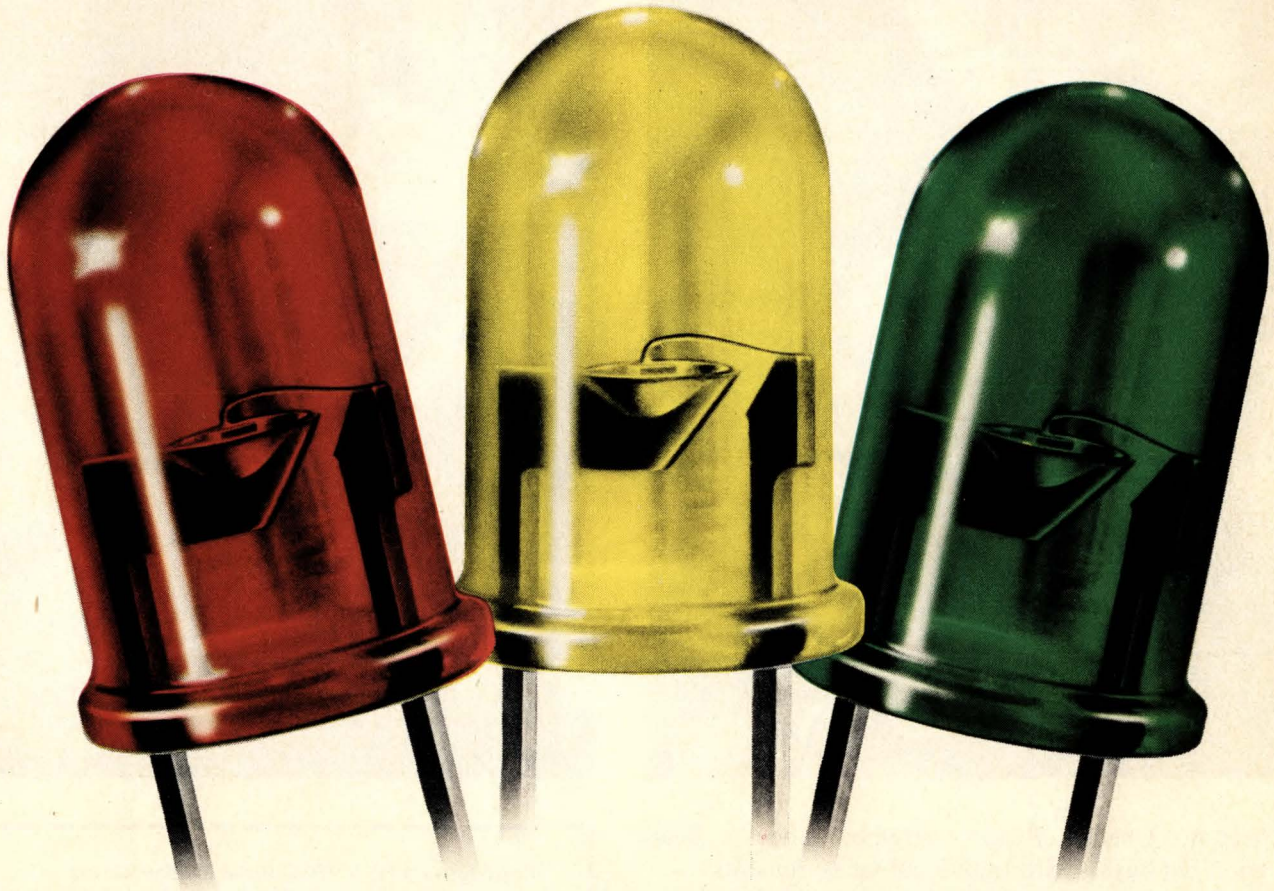

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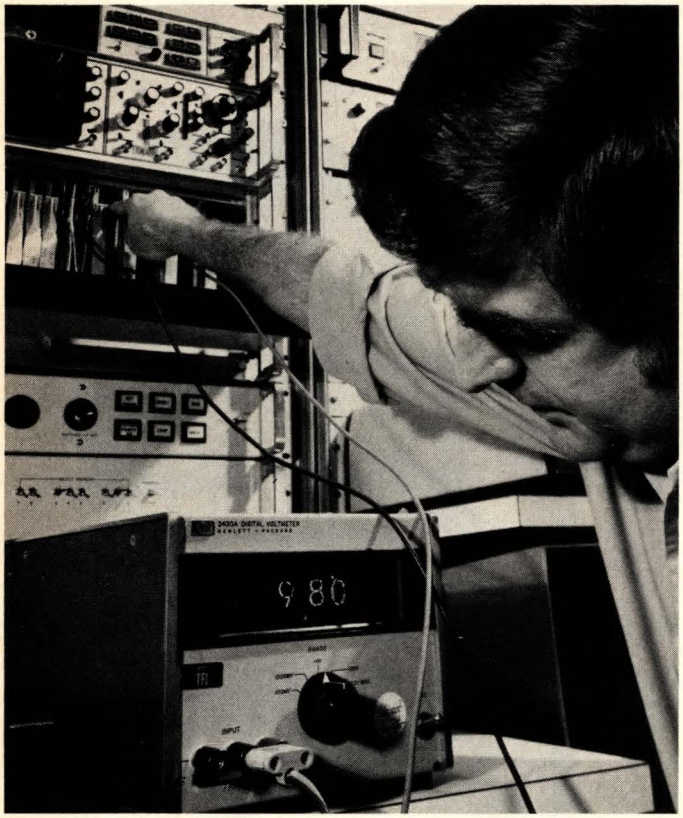

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095/46

Electronics

The International Magazine of Electronics Technology

Vol. 48, No. 2 • January 23, 1975

Highlights

The cover: Component burn-in pays off, 73
Using failure models, the systems builder can calculate for himself what component burn-in can save him in over-all costs. Several manufacturers also testify that in-house burn-in these days is both economical and informative. Cover is by Art Director Fred Sklenar.

POS price-tag standard slow to win support, 62
Though an optical-character reader font (OCR-A) has been adopted as standard for point-of-sale equipment, retailers are in no hurry to accept it, and equipment manufacturers will probably begin conforming to it only gradually.

Standard logic yields custom microprocessors, 90
A microprocessor built with high-speed standard logic is faster and more flexible than MOS chips and has a smaller device count than random-logic designs. Part 1 of this two-part article describes the three basic elements of such a processor.

Sine-wave clock maximizes network bit rate, 96
A high-speed synchronous digital network will transmit data faster if it uses a sinusoidal clock signal for timing instead of the usual, distortion-prone square-wave signal.

And in the next issue . . .
Integrated injection logic breaks into microprocessors . . . a calculator on a substrate . . . designing circuits that minimize explosion hazards.

Electronics

Publisher's letter

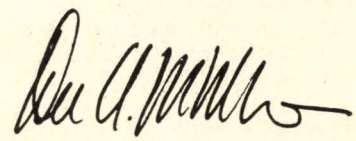
Our cover article this issue presents the case for component burn-in. That technique, which was essential for space and military programs, now is showing its economic usefulness in less demanding applications (see p. 73).

The whole approach is based on the established concept that an electronic device will most likely fail early in its life if it is going to fail at all. The devices that survive the infant-mortality stage when subjected to accelerated aging show heartening low and steady failure rates. The result: a final system that exhibits a high degree of reliability and a more predictable lifespan.

The economic fall-out of a high reliability product is legion. The reduced cost for field repairs is an obvious economic benefit. It's harder, of course, to put a value on other benefits, including such important intangibles as buyer confidence in a brand name and the resultant willingness to go out and repurchase that brand.

Every systems designer has to come to grips with a host of design tradeoffs as a product works its way to market, and component burn-in more and more is making economic sense in the juggling of those tradeoffs. So turn to page 73 for a detailed discussion of the benefits, methods, and dollars-and-cents payoffs that are the story of component burn-in.

The start of another year finds us at one of our traditional annual chores—the preparation of the index of articles published last year. As in the past, a copy of the index will be mailed to any reader who requests it. All you have to do is circle number 475 on the reader service card, which you'll find inside the back cover.



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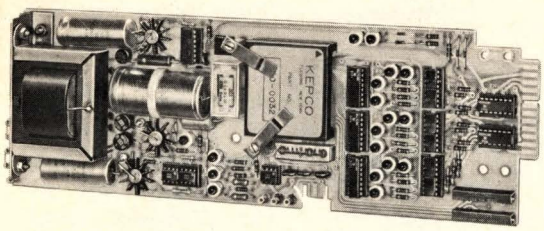
KEPCO | your source for digitally programmed d-c power supplies

This, for example, is a typical digitally-controlled voltage stabilizer, comprising a standard Kepco plug-in power supply with the new Kepco SN Digital Interface.

The combination produces 0–100 volts, 0–200 mA with 12-bits resolution. The power supply is a Model PCX 100–0.2MAT programmed by an SN–12 Digital Interface Card mounted on a slide adapter and fitted to a dual-slot bench style enclosure.

There are hundreds of similar Kepco Power Supplies, ranging from 0–6V @ 90 A to a model that can produce -5000V @ 5 mA. Because they're rated as *operationally programmable,* these models can be combined with one of the five Kepco SN Digital Interfaces to produce a custom digital voltage or current source, tailored to your needs.



The SN Digital Interface Card accepts your data input on parallel lines, strobed for noise immunity, and stores the data in a buffer register. For isolation, the program is transferred across optical couplers so that your digital signal and the power supply it controls can be up to 1000V apart.The five SN Cards offer a choice of BCD or complementary binary programming.

The analog output from the SN Card is in the form of a 0–1V/0–10V range selected signal* that is linearly amplified by the companion power supply to produce the desired output. In the illustrated combination of SN–12 and a Kepco Model PCX 100–0.2MAT, the power supply functions as a fixed gain-of-ten power amplifier to produce a digitally-controlled output, 0–100V with 12-bits (0.024%) resolution. The range selector on the SN allows the full resolution to be spread over the lowest 10% of the output: 0–10V d-c.

*The SN Card also produces ±10V & ±5V outputs to control bipolar power supplies and 0.5V, 1.0V outputs to control current stabilizers.

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MODEL	RESOLUTION	LINEARITY
SN–2	2 BCD	±0.2%
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SN–8	8-bit	±0.2%
SN–10	10-bit	±0.05%
SN–12	12-bit	±0.01%

These SN Cards are fully self-contained digital programmers, featuring an on-card line operated power supply. Kepco offers a variety of housings and accessories to accommodate them to various programmable power supplies. As many as eight cards can be accommodated in a standard 5¼" x 19" panel.

For complete specifications, write Dept. EW–14

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Readers comment

Stirring a hornets' nest?

To the Editor: I am writing, as I hope others will, to let you know that I found the cover of the Dec. 12, 1974, issue of *Electronics* offensive. I believe it is your responsibility to encourage women to be part of your readership, not to use them as sex objects.

Alison Stone Ament
Falmouth, Mass.

To the Editor: *Electronics* passes through my hands, as it does with other secretaries, on its way to our respective bosses. Please note that I object vehemently to your Dec. 12 cover, on professional and personal grounds. That type of cover, and your type of publication, are certainly incongruous. The watches could have been just as effectively displayed, or even more so, in a handsome case or on plain black velvet. In this time of female activism, why do you deliberately stir up a hornets' nest?

Incidentally, my employer, Seymour Hochman, president of this company, concurs with these sentiments.

Irene T. Remer
S & S Associates, Inc.
King of Prussia, Pa.

To the Editor: Unless she is intended to be one of the "wares," I see no reason for the woman to be present at all. If you were doing a feature article on medical electronics, would you show a naked man with five defibrillators draped down his chest? Her presence is sexist at worst, or inane at best. You've done many excellent covers. I hope this one is an aberration that will not be repeated.

N. D. Wittels
Cambridge, Mass.

To the Editor: Nudes on the cover of *Electronics*—that's the last straw!

Robert H. Light
Palo Alto, Calif.

■ **Editor's note:** *Ann Dalton, who posed for the cover, is an experienced free-lance artist. She has done a number of our covers, most recently the inflated-balloon cover for our Western European markets issue (Dec. 26, 1974). Readers may be in-*

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Readers comment

terested in seeing an uncropped version of the cover set-up and in hearing her view.

"When asked to pose for the cover, I was pleased and flattered, and in no way felt exploited. I'm sorry some readers were disturbed by the cover, but our intent, as artists, was to produce something different, something eyecatching in symbolizing the article's subject matter."

Playing with dimensions

To the Editor: I especially enjoyed The Engineer's notebook article by Kai Lanz [*Electronics*, Sept. 19, 1974, p. 126] because it brought to mind my own experience in the early 1960s. At the time, I was doing research at the University of Toronto, conducting a study of the circuits exhibiting a negative resistance.

The two-dimensional N- or S-shaped plots of the circuits turned out to be very complex Lissajous figures when periodically excited to oscillate. In trying to overcome this, I introduced a simulated third axis, which did create a 3-D perspective. Later I added a fourth dimension, time, by a grid modulation of the CRT with a clock frequency.

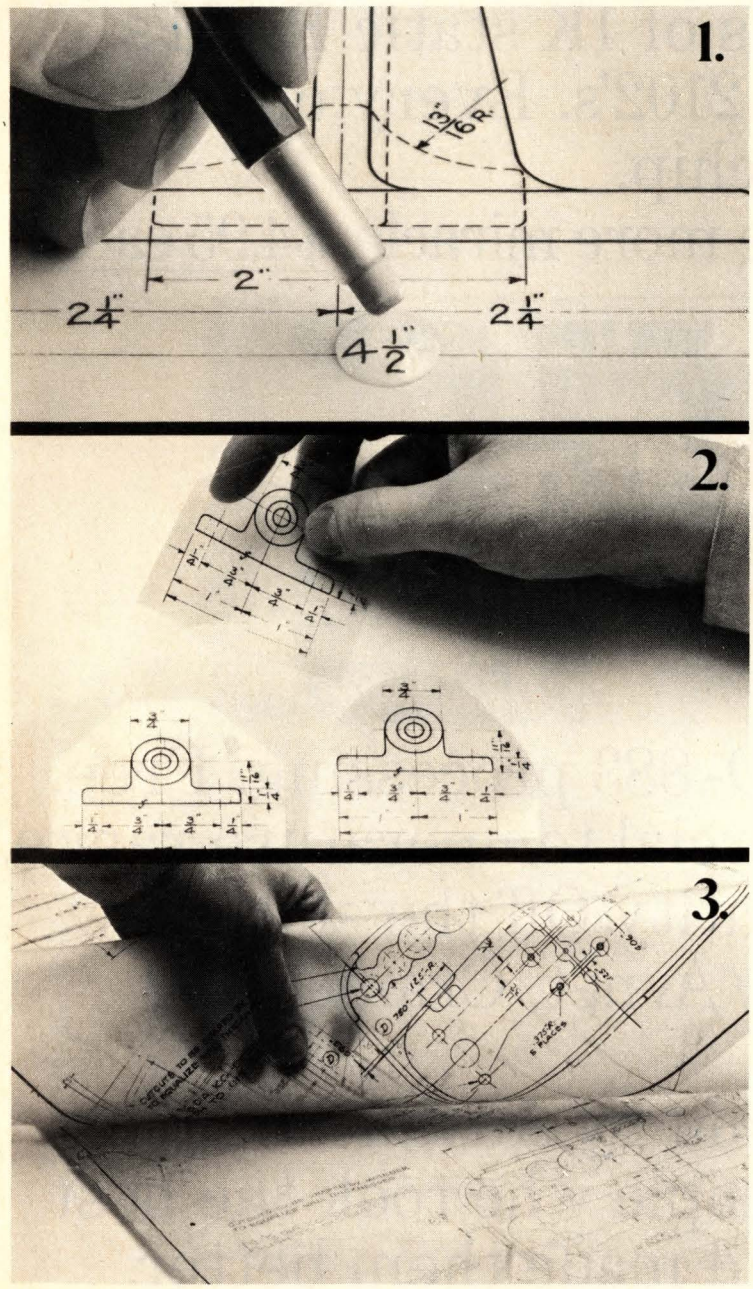
With these changes, I had much less trouble with the design of many useful devices. But the 3-D effect was not taken seriously by associates. Apparently it was too psychedelic then.

J. Opalinski
Toronto, Ont.

1974 index is coming

The index of articles published in *Electronics* in 1974 will be available shortly. For a copy, circle 340 on the reader service card.

Avoid that drawn-out feeling.



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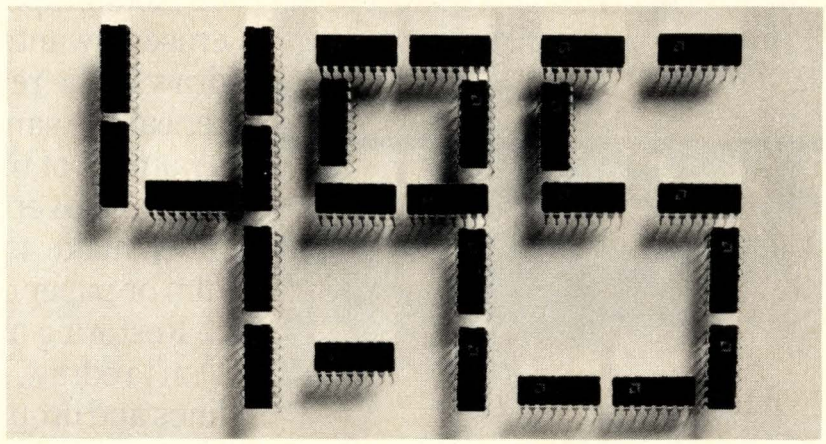

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Sixteen 1K Static RAM's Under $5.

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2102-2	300mW	650ns	$4.95
8102	300mW	1300ns	$4.95
8102-2	300mW	850ns	$4.95
4102	300mW	1000ns	$4.95
7552	300mW	1000ns	$4.95
7552-1	300mW	500ns	$4.95
7552-2	300mW	650ns	$4.95
2602	225mW	1000ns	$4.95
2602-1	225mW	500ns	$4.95
2602-2	225mW	650ns	$4.95
9102	225mW	650ns	$4.95
9102A	225mW	500ns	$4.95
91L02	140mW	650ns	$4.95
91L02A	140mW	500ns	$4.95

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- Maximum reading rate approximately 100/second.

This completely automatic 18 GHz microwave counter costs $3,995

New EIP Model 331

- The Model 331's Autohet™ technology allows measurement of signals with FM rates to 10 MHz and FM deviation to 200 MHz, something which phase-lock loop limitations of an automatic transfer oscillator preclude. Using the Model 331, you can easily test high-density communications links and vital EW/ECM circuits without removing them from service.
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- Sectionalized display eliminates need for decimal positioning.
- 7 digit display resolution.
- Remote programming, BCD output, and rear inputs optional for systems capability.
- Maximum reading rate approximately 900/second.

It'll only take us 5 minutes to prove you can get as much microwave measurement capability out of our $3,995 EIP Model 331 counter as you can get out of a $6,200 Hewlett-Packard counter. Call Rick Bush collect at (408) 244-7975 for a demonstration. And if higher resolution, wider frequency range, and more sensitivity are worth an extra $2,000 to you, we make a $6,200 Automatic Frequency Counter, too. Except ours only costs $5,675.

DANA EIP

EIP, Inc.
3230 Scott Boulevard
Santa Clara, CA 95050
Telephone (408) 244-7975

Circle 13 on reader service card

People

Hoppe hopes to expand to commercial markets

A time-honored approach to growth in a sluggish economy is to ferret out more markets to serve, and that's what Paul P. Hoppe Jr. is doing. One of his first tasks as marketing vice president for Amphenol Industrial division will be to launch a low-cost commercial connector, aimed at the appliance, consumer, and automotive markets.

While he doesn't intend to sacrifice his company's hold on the telephone and computer markets—"and we've just scratched the surface in these two fast-growing areas"—the new rectangular connector will be Amphenol's first significant product for the commercial market. "We've been serving this market with some old standbys—tube and relay sockets, and printed-circuit connectors—but there's been no concerted effort to get into the commercial market until now," he says.

Actually, Hoppe is quite familiar with the new connector. In his earlier job as vice president for engineering at the Chicago-based division of Bunker-Ramo Corp., Hoppe shepherded the connector through its development phases. It's a version of the widely used Molex commercial connector, able to mate with, and interchangeable with, many competitive styles. But it sports improvements, he claims. It's molded of a flame-retardant plastic, for example, and features both front- and rear-release capability.

Hoppe came to his present post entirely through the engineering ranks at Amphenol. He figures his technical background will stand him in good stead with customers. "As I talk to a customer, I have a pretty good idea what he's looking for," he says. "More importantly, I know Amphenol's capabilities and know what we can do to help."

After a stint as project engineer for Underwriters Laboratories in Chicago, Hoppe joined Amphenol in 1953 as a technical writer. He held various engineering posts before being named engineering vice president in 1967. Underlining his strong technical bent is a recent appointment to the executive committee of the U.S. national committee of the International Electrotechnical Commission.

Expansion. Amphenol's Hoppe is looking to new connector markets.

Marketing departments are traditionally responsible for profit and loss, but Hoppe points out that, even in his engineering roles, he's had his eye on the bottom line. "When I had engineering responsibility, I never felt in charge of a scientific organization, but of a function that was part of a business," he says. "And the overriding influence, as far as I'm concerned, is the overall business, and not the specific organizations that make it up."

Floppy disks are on Massaro's mind

Floppy disks haven't lived up to their early market expectations, but recent data-processing product introductions suggest the momentum is building (see related story, p. 59). One company betting heavily on the future of floppy disks is two-year-old Shugart Associates of Sunnyvale, Calif. And one man betting on Shugart's future is Donald J. Massaro, its young new president.

"We started out with the idea of building a number of OEM data-processing products," he says. "But when the [business] slowdown started coming, we realized we were stretching ourselves too thin. So we consolidated operations, put everything else on the shelf, and are concentrating on floppy disk systems."

"Floppies" will prosper, he says,

"Virtual storage helped us handle increasing production while maintaining high standards of customer service."

Few developments so greatly enhance the usefulness of the computer as does virtual storage. By increasing the effective or "virtual" capability of the IBM System/370 to manage information, virtual storage opens the way to a wide range of user benefits.

Here one company reports on its experience with a virtual storage system.

Motorola's Thomas Koch demonstrates communications equipment at Schaumburg, Ill. division headquarters.

At Motorola, "it's the key to our worldwide data system."

"We strive to maintain a tight delivery schedule for our customized communications systems—worldwide. Our two Model 158s with virtual storage are the key to a worldwide data system that helps make such quick deliveries possible."

So says Thomas Koch, manager of international manufacturing operations of the Communications Division of Motorola at Schaumburg, Illinois. Plants in the United States and abroad now share a common data base for order entry, purchasing and material control, with the application running under virtual storage at Motorola's Chicago computing center. As a result, manufacturing operations are closely adjusted to product demand, production can be scheduled with closer tolerances and shipment dates made with assurance.

"Growth is a fact of life at Motorola," says Koch. "We wanted to be able to handle constantly increasing production while maintaining our high standards of customer service. Virtual storage has been of immense help in enabling us to achieve this."

For further information, call your local IBM Data Processing Division office. Or write IBM Corp., Dept. 83F-E, 1133 Westchester Avenue, White Plains, N.Y. 10604.

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because they're better than the competition: cassette, cartridge-tape systems, and key punches. They are, he says, more than 40 times faster than cassettes or cartridges and with error rates 10,000 times lower, will find their greatest use as low-cost, direct-access storage devices with terminals that use the disk mainly for stand-alone applications.

"Our projections for this market show that floppy disk sales will grow from about $20 million in 1975 to more than $90 million in 1980," he says. "In terms of units, the market will grow from 51,000 next year to about 276,000 in 1980."

Dropout. Massaro describes himself as a "graduate school dropout,, (he was working on a Ph.D. in mechanical engineering seven years ago) who "sort of fell into the computer business" and found that he liked it. In the interim, the hard driving and technically knowledgeable Massaro has come far and fast.

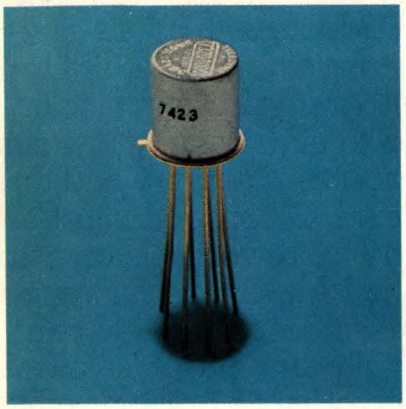
After a year and a half at IBM he moved to Memorex to work on disk drives. Within six months he was engineering manager of his technology group and in another six months, director of engineering for Memorex's 3670 disk drive program. He remained for three years until 1973 when he started up Shugart Associates with nine other ex-Memorex employees. Beginning as manager of manufacturing, he soon became vice president and, two months ago, president.

The 31-year-old executive concedes much of the business will be dominated by IBM and its floppy disk system, but he predicts IBM's market share will drop from 43% next year to about 23% in 1980. And as IBM's market umbrella shrinks, he anticipates Shugart will be there ready to spread its own.

"We were one of the first on the market with an IBM-compatible floppy system—the SR 900," he says. "That's given us an edge we don't want to lose, and we're going to do our best to see that we don't."

From anticipated sales of $4 to $5 million in 1975, Massaro expects Shugart to grow sixfold to $25 to $30 million in sales by 1980.

RF switching to 500 MHz in a TO-5 package



RF circuit and packaging engineers are discovering that Teledyne TO-5 relays make excellent subminiature rf switches for frequency ranges up through UHF. Their reasons are: inherently low inter-contact capacitance and low loss contact circuit geometry. Typical rf performance: Isolation — 45db at 100 MHZ, 35db at 500 MHZ; Insertion Loss — 0.2db at 100 MHZ, 0.4db at 500 MHZ.

And Teledyne Relays offer the widest possible selection: MIL relays in SPDT & DPDT standard, sensitive, and maglatch types, all available with internal diodes; commercial models in DPDT standard and sensitive types, also available with internal diodes. All Teledyne TO-5 relays feature hermetic sealing, gold plated contacts, and all welded construction for high reliability.

For Transmit/receive switching in hand-held transceivers or any low power remote band switching application, Teledyne TO-5 relays are an excellent choice. No other relay offers this combination of rf performance, low coil power dissipation, and small package size.

And they're **in stock** at your local Teledyne Relays distributor. Call your nearest Teledyne Relays office for location of your local representative or distributor.

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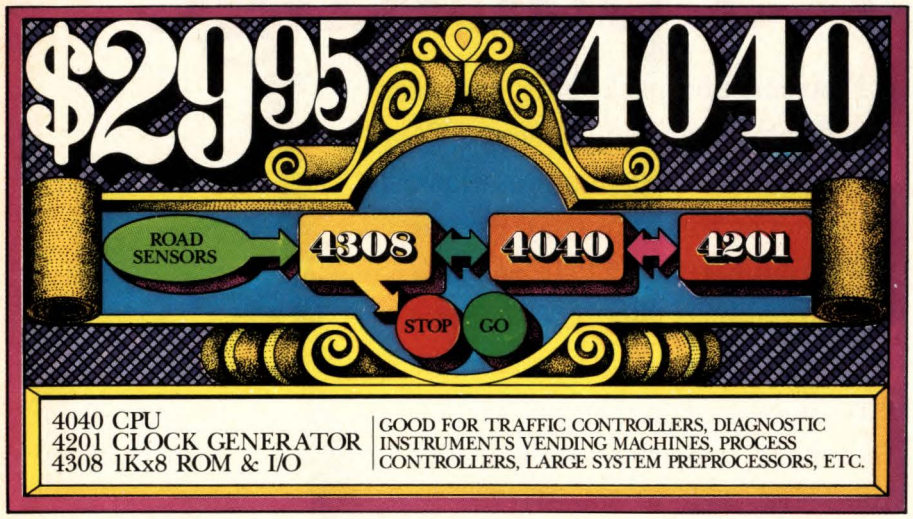
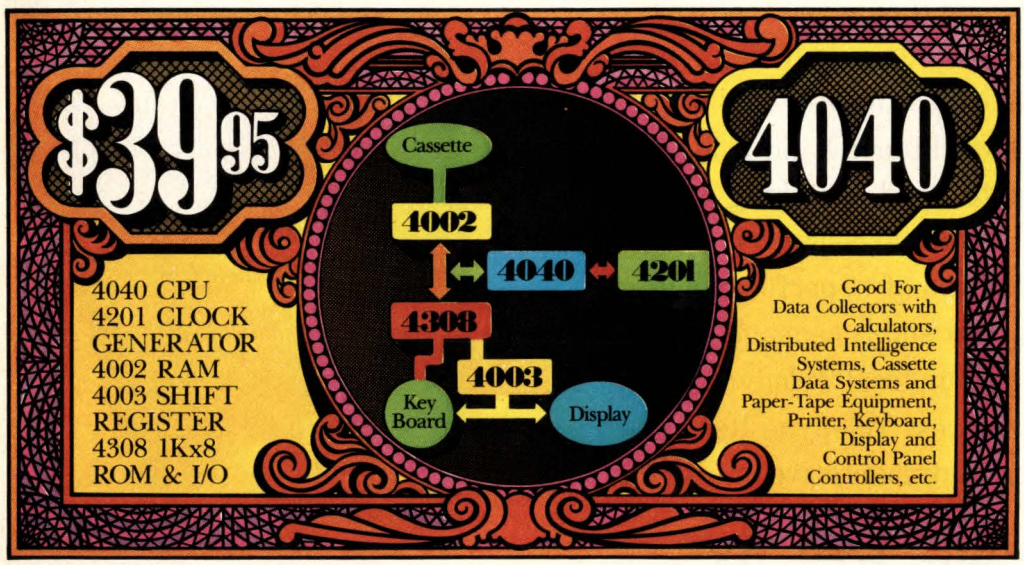


Cash in on the demand for economical intelligent products with Intel's inexpensive new 4040 CPU, 4201 integrated system clock, 4308 high density, low cost program memory and three new I/O components. Faster and more versatile than any other MOS 4-bit microprocessor unit, the 4040 can totally automate a smaller system or large portions of a big system. Yet an MCS-40 microcomputer system with CPU, clock, memory and I/O costs as little as $29.95.

Many equipment manufacturers are replacing hardwired logic and bulky electromechanical assemblies with MCS-40 systems. Most moderate speed control logic built with TTL can be replaced. The savings certificates show only a few 4040 applications. MCS-40 devices can be used with our 4004 central processor unit, too. The 4004, in production since June 1971, can lower system costs even more.



With either CPU, you'll save development time, lower component count and reduce assembly costs. You'll save even more as microcomputer costs decline while other system costs rise. And you'll gain valuable insurance against product obsolescence. Any design is easy to program and update with Intel's total development support, assemblers and Intellec 4/MOD 40 development systems. Our training centers will even teach you how to use Intel microcomputers.

microcomputer in than $30.

In high volume for just $29.95, you can buy an MCS-40 system with the 4040 CPU, 4308 1Kx8 ROM with four independent I/O ports, and 4201 system clock generator. The 4040 itself has 60 instructions, 7-level subroutine nesting, 24 index registers, interrupt processing, memory and index register bank switching, single-step operation and a low power standby mode.

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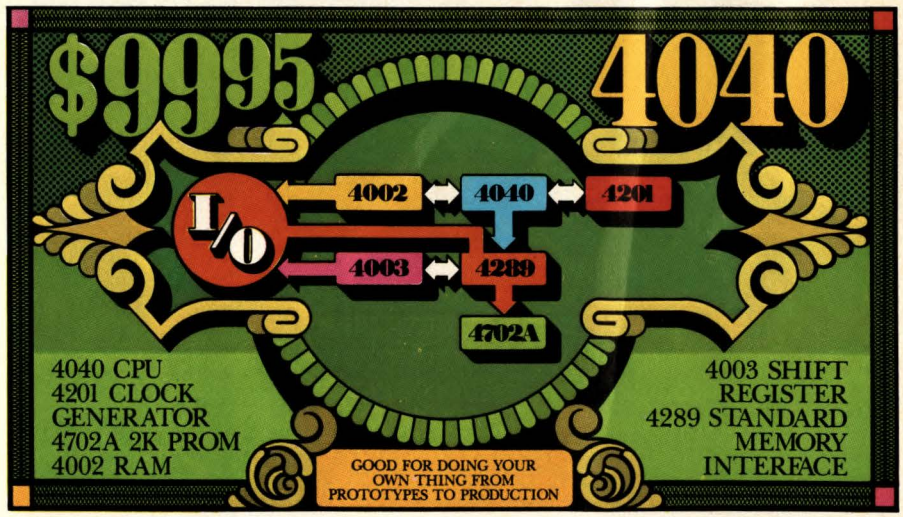

At these prices, you can even use several microcomputers in large systems. Knowledgeable designers are putting 4040 intelligence into new products at less cost than simple-minded electromechanical parts and single-minded logic cards. Write for details on the MCS-40 family and the industry's most extensive software support. Or call any Intel office for an appointment with our applications engineers.

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Computer Architecture, IEEE, University of Houston, Houston, Texas, Jan. 20–22.

Reliability and Maintainability Symposium, IEEE et al., Sheraton Park Hotel, Washington, D.C., Jan. 28–30.

Physics of Compound Semiconductor Interfaces, University of California, Los Angeles, Feb. 4–6.

Wincon—Aerospace & Electronic Systems Winter Convention, IEEE, Aerospace & Electronics Systems Society, Americana Hotel, Los Angeles, Calif., Feb. 5–7.

Nepcon '75 West and International Microelectronics Exhibition, Industrial Scientific Conference Management Inc. (Chicago, Ill.), Anaheim Convention Center, Anaheim, Calif., Feb. 11–13.

CAD/CAM III. Computer-Aided Design and Computer-Aided Manufacturing, Society of Manufacturing Engineers, Hyatt Regency O'Hare Hotel, Chicago, Ill., Feb. 11–13.

International Solid State Circuits Conference, IEEE, Marriott Hotel, Philadelphia, Pa., Feb. 12–14.

Compcon Spring—Computer Conference, IEEE, Jack Tar Hotel, San Francisco, Calif., Feb. 25–27.

Industrial Applications of Microprocessors, IEEE, Sheraton Hotel, Philadelphia, Pa., March 11–12.

Reliability Physics Symposium, IEEE, MGM Grand Hotel, Las Vegas, Nev., April 1–3.

Southeastcon '75, IEEE, Sheraton Center, Charlotte, N.C., April 6–9.

Intercon—IEEE International Convention, Coliseum and Americana Hotel, New York, N.Y., April 8–10.

Electronics Production and Test Equipment Exposition, U.S. Department of Commerce, Stockholm, April 7–11; London, April 15–18.

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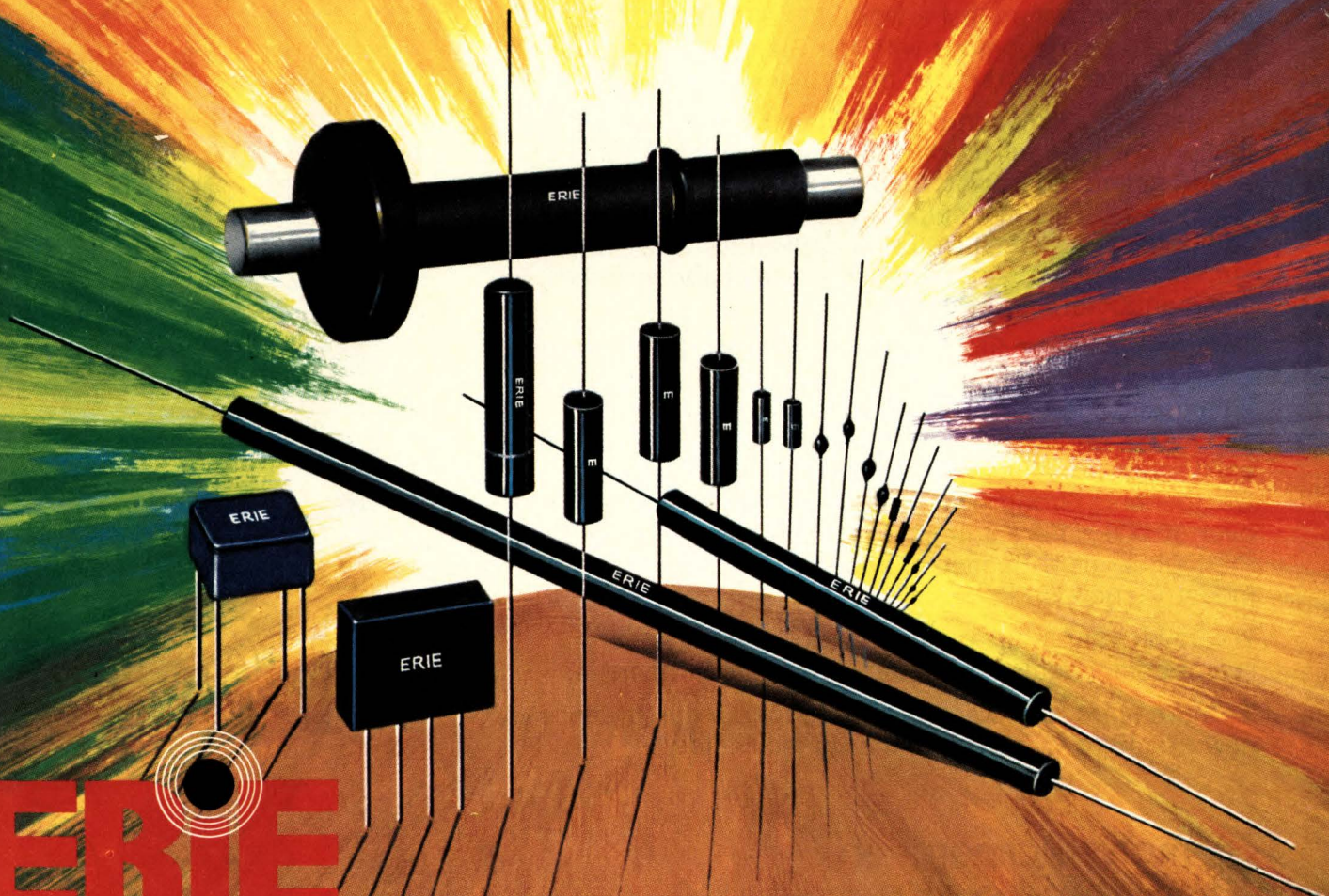

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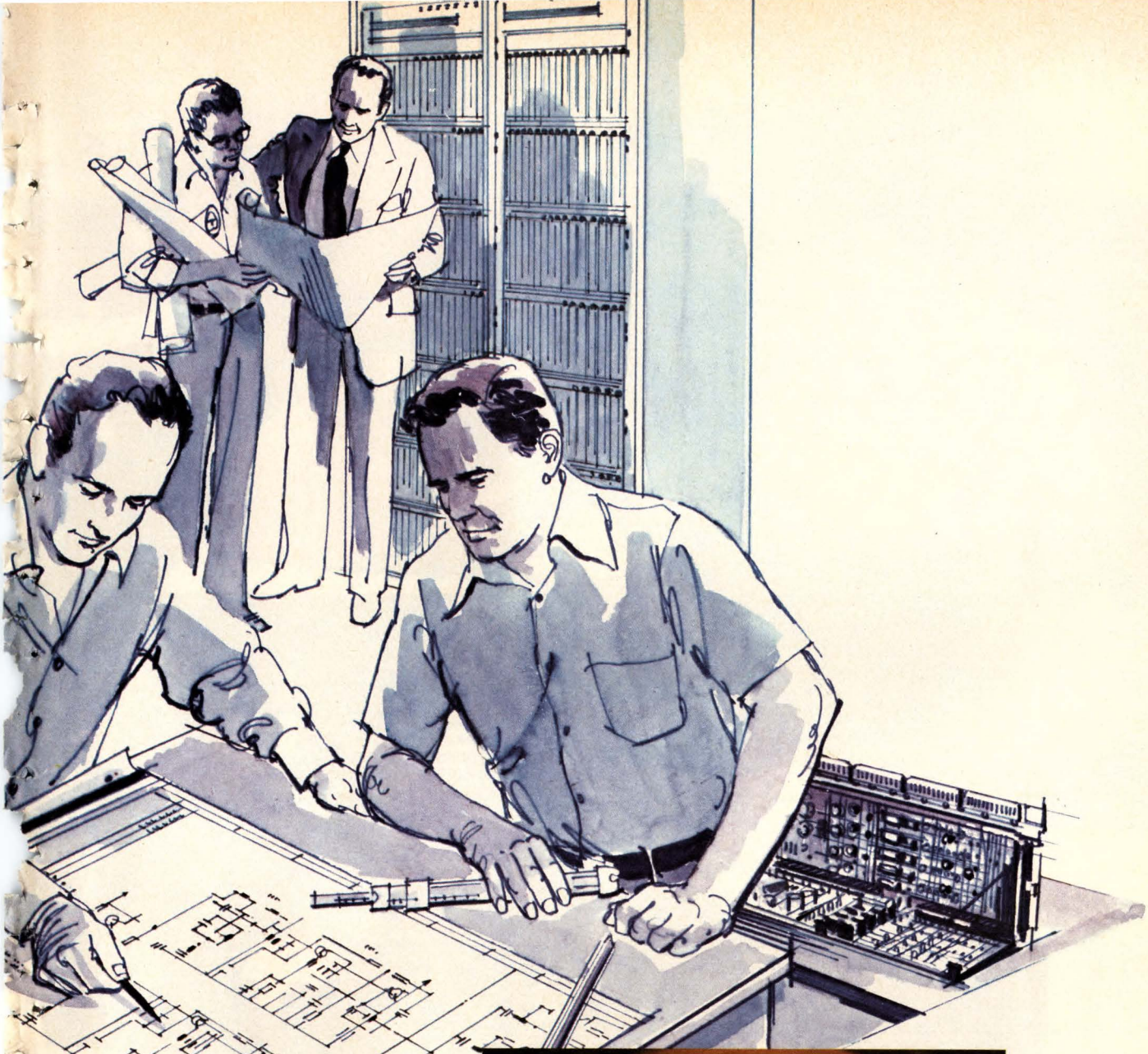

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Electronics newsletter

Gas shortage may force RCA to close plant

The RCA Electronic Components group's color-TV picture-tube plant in Scranton, Pa., hit by a 58% reduction in natural gas by Pennsylvania Gas & Water Co., **may have to close and furlough its 1,300 employees.** RCA has installed fuel-oil facilities to heat the plant, but needs natural gas to operate the special furnaces that seal components into the tubes.

Intel builds 16-k CCD memory . . .

Look for mid-February introduction of a 16,384-bit charge-coupled-device memory from Intel Corp. of Santa Clara, Calif. Designated the 2416, the 64-by-256 serial memory device has been placed in a standard 18-pin dual in-line package and **is scheduled to be on distributor shelves in sample quantities by the second week of February.** The 2416's primary function will be as a low-cost semiconductor replacement for drum and disk memories.

. . . and 4-k RAM with 80-ns access time

Intel Corp. has built a 4,096-bit random-access memory with an access time of 80 nanoseconds—**three times faster than the fastest 4-k parts now on the market and matching the speed of the 7001-type 1,024-bit RAMs.** Aimed at buffer, cache, and scratchpad memories, the device is fully compatible with emitter-coupled logic.

4-k Famos PROM due from National

Using a silicon-gate p-channel process with the floating-gate avalanche MOS, or Famos, technology, **National Semiconductor is now supplying a 4,096-bit programable read-only memory.** Previously offered only in a 2,048-bit format by Intel Corp., which developed Famos, the denser part has a 512-word-by-8-bit organization.

According to Bruce Moore, product marketing manager for the device, typical access time is 750 nanoseconds, and programing can be done in only about 30 seconds. Operating from +5 and -12-volt power supplies, the 4-k PROM, which has tri-state outputs for easy expansion and is TTL-compatible, typically draws 28 milliamperes while operating. **And it has a power-down mode specified at only 4 milliwatts.**

Rockwell starts unit to develop SOS for military

Rockwell International has established a new organization **to develop silicon-on-sapphire and other advanced devices for military uses.** The new group reflects earlier announcements of increased emphasis on military applications by SOS pioneer Rockwell, which has stopped most commercial work, including that on an SOS microprocessor for General Automation (see p. 66). **Rockwell does claim substantial progress in SOS processing, principally through innovations in masking operations.**

Though reporting to the commercially oriented Microelectronic Device division, the Special Device division under Robert L. Doty will concentrate on military applications where the radiation hardiness, low standby power, and high noise immunity of SOS can offset costs.

Japanese splice optic cable in the field

Japanese researchers have demonstrated a technique for splicing fiber-optic cables outside the lab. **The inability to make such splices in the field with low loss is one of the obstacles, along with development of light sources and connectors,** to wide implementation of optical com-

munications systems. The researchers, from the Furukawa Electric Co. of Tokyo, say they can splice and couple cables with an average loss of 0.29 decibel and minimum crosstalk. Bell Labs has developed a splice-and-couple technique, still in the lab, that loses 0.1 dB, about equal to the best results of the Furukawa method.

System writes mask pattern on photoresist

Electromask Inc. of Woodland Hills, Calif., is developing a pattern generator suitable for exposing master hard-surface photomasks for IC production. The system, to be delivered in early summer to TRW Systems for advanced LSI work, **can write directly on the photoresist used to make chrome or iron-oxide photomasks.** Current pattern generators write on photosensitive emulsion with xenon flash tubes, but photoresist requires a much longer exposure time and selected light wavelengths. Electromask uses a mercury-vapor lamp with shutter.

The master hard-surface mask is better, particularly for complex devices occupying large areas, since it provides fewer defects. **And any defects can be removed with a laser zapper** made by Electromask; emulsion masks cannot be corrected. The TRW system also includes two image repeaters, one of five times for conventional contact printing, and one of two times for projection printing. Similar systems for less complex ICs will be for sale to other systems houses for about $300,000.

Report says planes can do work of ERTS

Suppliers of satellites and related electronics for the Earth Resources Technology Satellite will suffer another heavy blow when a new Federal study receives congressional attention. **Specially instrumented high-altitude aircraft could provide more benefits than ERTS,** according to a recently completed $1.5 million Government-funded study.

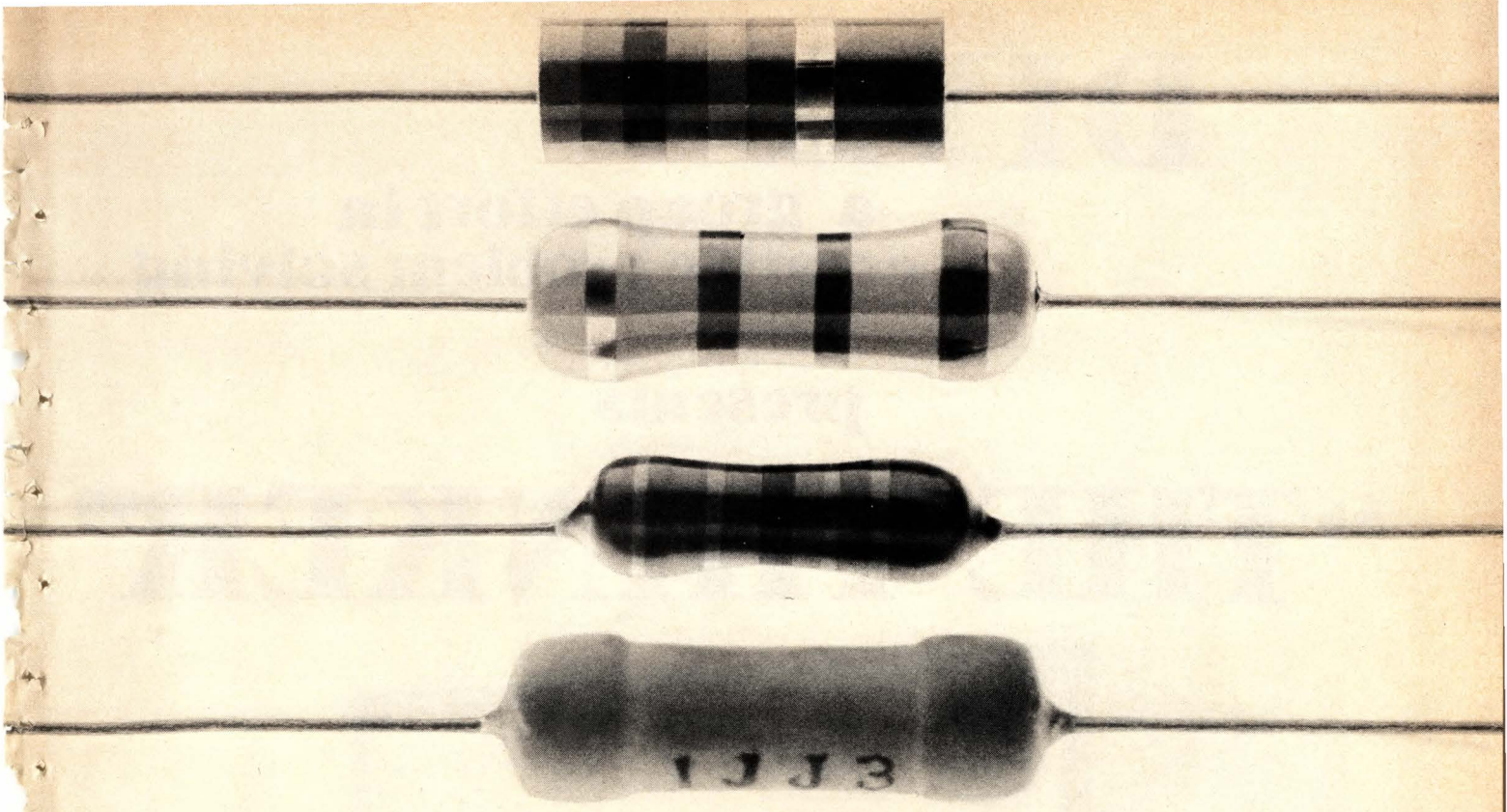
An airplane-based system could save $514 million in land-use and mineral-resource planning, compared to an estimated high of $475 million in resources located by a series of satellites in continuous operation. The study, by Earth Satellite Corp., Washington, D.C., is expected to provide **additional ammunition in the White House campaign to dissuade congressional advocates** from funding future ERTS projects.

IEEE brief accepted by court in BART firing

The Superior Court of the State of California has accepted a nine-page brief filed by the IEEE as a friend of the court that is **highly favorable to three engineers dismissed by the San Francisco Bay Area Rapid Transit District,** ostensibly for taking complaints about safety hazards outside the normal chain of command. The statement advises Judge George W. Phillips Jr., who is hearing the case starting Feb. 3, that in the IEEE code of ethics, as well as codes for other engineering societies, it's the engineer's **obligation to call safety hazards to the attention of the client.**

Addenda

Texas Instruments, emphasizing its commitment to microprocessors, will present a microprocessor design course **on early morning commercial TV in 17 cities.** The one- week course, to start in March, will run a half hour daily. . . . John W. Barnum is trying for the top job at the Federal Aviation Administration **after the current administrator, Alexander Butterfield, resigns under pressure this spring.** Barnum is now deputy secretary of the Department of Transportation, the FAA's parent.



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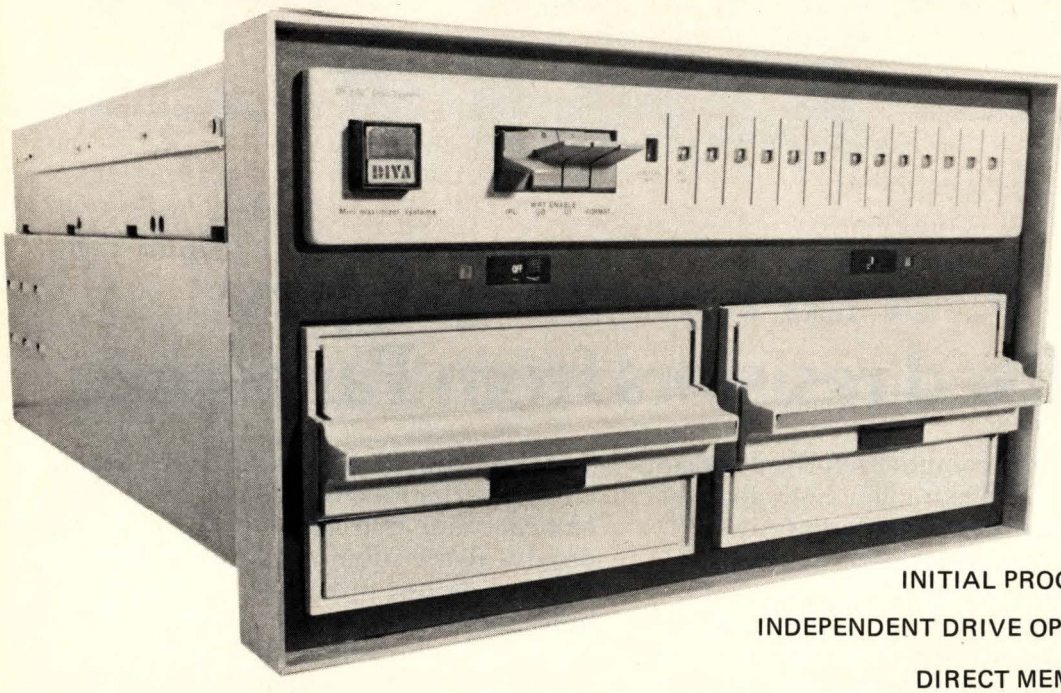

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First I²L processor in four-bit design surpasses n-MOS

Texas Instruments sampling parallel device aimed at low-end minis; performance bridges n-channel—TTL gap

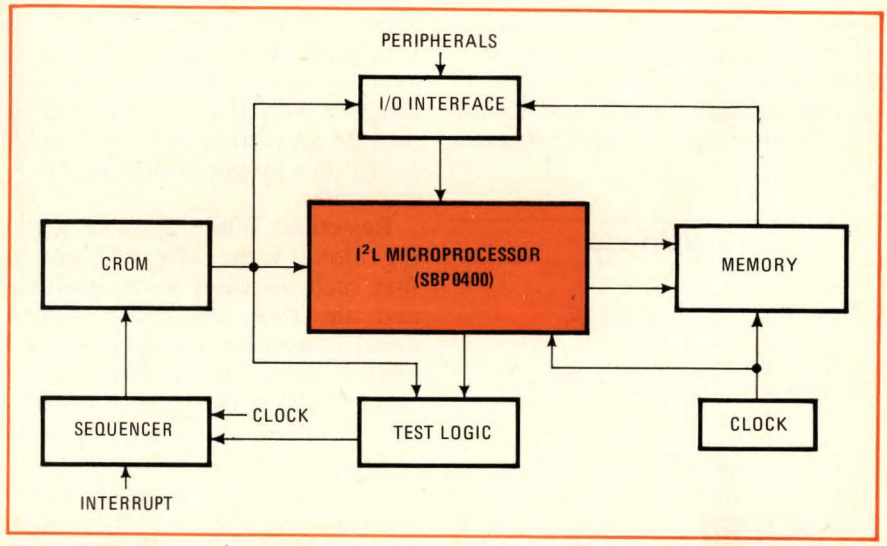
A bipolar microprocessor built with integrated injection logic is being made available by Texas Instruments in sample quantities. Aiming at the low-end minicomputer market [*Electronics*, Nov. 14, 1973, p. 29], TI has put all the circuitry for a full 4-bit-slice microprogramable parallel processor into a single-chip, 40-pin package that surpasses the performance of existing metal-oxide semiconductor products.

The new device, the model SBP 0400, is directly expandable into any 4-bit multiple system. Its performance falls between 8-bit n-channel MOS microprocessors and 2-bit-slice Schottky transistor-transistor-logic processors. Thus, applications for the 0400 range between relatively small controllers and the high performance and high speed of minicomputer-based multicontroller and process-control systems.

It's suited for such middle-range jobs by virtue of an execution time that's up to five times faster than can be attained with n-channel devices. And although it is slower than Schottky systems, the I²L processor with its equivalent of more than 1,450 gates is twice as complex as the Schottky device. What is more, it operates at one-tenth the power and at significantly lower cost.

Design. TI designers used a nonisolated form of injection logic in this first microprocessor design, as opposed to the isolated I²L structures used in linear and watch circuits. The nonisolated design eliminates the need for active pn-isolation regions that consume valuable chip area, which in turn permits high functional density. Perhaps most important, TI's nonisolated I²L process offers a low-power bipolar process suitable for LSI designs. Typical propagation times of 110 and 530 nanoseconds at power dissipations of only 128 milliwatts are possible with the 0400.

With this bipolar processor, TI is aiming not only at the low-end minicomputer market, but at standalone controller applications as well. The fully-microprogramable and expandable design of the 0400 makes it ideal for emulating many of today's 16-bit minicomputers with a system requiring fewer than 20 packages, excluding memory. Besides four 0400 chips, all that's needed for the processing section is four control read-only-memory packages, a sequencer, two interrupt packages, seven input/output circuits, and three clock drivers. By comparison, standard hard-wired designs require well over 100 standard transistor-transistor-logic packages. And most important, the new LSI design will require no new software investment.



Expandable. Texas Instruments' SBPO400 can be built into a fully microprogramable n-bit microcomputer using a control ROM, sequencer, I/O interface circuits and memory.

Flexible. Primary among the 0400's architectural features are:

- Full parallel access available to control, data, and address I/O.
- Symmetrical arithmetic/logic unit with 16 operations, implemented with full-carry look-ahead.
- General register file of 8-words, including program counter with incrementer.
- Two 4-bit working registers for both single- and double-length operations.
- Scale-shifting multiplexers with

end conditions handled on the chip itself.

- On-chip control transformation, generated by a factory-programable logic array.

The programable logic array (PLA) for program control replaces the usual ROM program. The PLA, with its large I/O capability makes available a standard repertoire of no fewer than 512 one-clock operations. Unlike processor elements containing fixed-instruction sets, a user has available virtually any instruction set he needs. This means a single device type can be applied to a wide range of applications, from microcontrollers to multiprocessor systems. □

Business

Air freight rates hit IC producers

Already faced with severe threats to their profitability, semiconductor makers were dealt another blow last week when the Civil Aeronautics Board approved increases in air-freight rates ranging as high as 60% between U. S. and north/central Pacific production sites. The rates, proposed by the International Air Transport Association (IATA), which represents most major airlines, will become effective Feb. 13.

Several semiconductor firms had tried for months—either through Wema, an electronics industries trade association, or independently—to get the CAB to disapprove IATA's proposed rate boost, arguing at length that any increases at this time would increase some manufacturers' trans-Pacific shipping costs by $1 million or more annually.

But in its order, the CAB says that it has "carefully considered the shippers' contention that the rate increases on electronic parts would be unduly sharp, could not be absorbed by the shippers or passed on to the ultimate customer, and will result in potential losses of traffic to IATA carriers. We cannot find, however, that these assertions warrant disapproval of the agreement." In response, a spokesman for Simat, Helliesen & Eichner Inc., a New York City transportation consultant hired by Wema last year to help fight the rate hike, stated: "All this means to me is that the board didn't believe anything the (semiconductor) industry told them."

The CAB says that presently effective electronic parts shipping rates are "clearly insufficient even to enable the carrier to break even" on its U.S. to north/central Pacific traffic. Semiconductor shippers, however, disagree with this position, stating that the air carriers have yet to fully justify the proposed increases over the routes.

Rejection. While apparently going along with IATA's contention that such increases were cost-justified, the CAB nevertheless turned down a separate proposed general increase of 8% in cargo rates to the same Pacific area for all commodities—including everything from electronics to fruits and vegetables.

Not surprisingly, industry sources reacted sharply to the board's order. Charles B. Kovac, vice president and general manager of Rockwell International Corp.'s Microelectronic Device division, Anaheim, Calif., says he is "disappointed" by the board's decision. "In today's competitive world environment, the last thing American semiconductor manufacturers need is a freight-rate increase."

Cooperation proposed. Eben S. Tisdale, Wema's vice-president for government affairs, in Washington to discuss responses to the CAB decision with the association's attorneys, says several semiconductor houses are already discussing the establishment of cooperative charter flights to such production points as Malaysia to avoid the new higher rates.

National Semiconductor Corp., in fact, through Wema, had told the CAB that it is exploring greater use of non-IATA carriers and of air charters, as well as leasing or buying a company aircraft to ship its products. National also said it already ships some 35% of its parts by sea, adding that as air-freight rates increase, the balance edges in favor of sea cargo.

Alternatives for semiconductor firms, says Tisdale, include petitioning the CAB for reconsideration and filing a complaint with the U. S. Court of Appeals. "But since the board voted unanimously against us, it probably wouldn't be terribly productive to go back to them," he says. □

Military

F-16 avionics seen topping $1.6 billion

When the Air Force picked the General Dynamics Corp. F-16 as the winner in its lightweight tactical fighter competition, it launched an avionics market estimated at $1.67 billion over the next decade. The General Dynamics single-engine entry won last week following a competitive fly-off and technical evaluation against Northrop Corp.'s twin-engined YF-17.

The Air Force order for an initial 650 F-16s could go to 1,000 during the next 10 years. And the Navy is in the market for 800 lightweight fighters. Its decision will come in several weeks. Also included in the market are projected orders for 350 lightweight fighters from a consortium of four European NATO nations, and hundreds of others from "third-world" countries of the Middle East and Asia. In sum, as many as 3,000 lightweight fighters may be ordered over the next 10 years, according to Air Force Secretary John L. McLucas.

While the Air Force decision has handed General Dynamics an enormous piece of the pie, competition for overseas orders remains. Also being considered are the YF-17, the F-1 M-53 Mirage, made by France's Dassault, and, a much less likely candidate, the Viggen, produced by Saab of Sweden. The NATO group, comprised of Bel-

Flying high. The 750-pound avionics package aboard each General Dynamics F-16 lightweight tactical fighter for the Air Force may cost roughly $750,000

gium, Denmark, Norway, and the Netherlands, should make a choice within three months.

McLucas has Pentagon support to persuade the Navy to pick the F-16. In that case, few European nations are expected to choose the YF-17.

In winning the Air Force award, General Dynamics' Convair division, Fort Worth, Texas, will receive a $417.9 million fixed-price contract for 15 engineering development models of its single-seat fighter. United Aircraft's Pratt & Whitney division, East Hartford, Conn., will get $55.5 million to produce the planes' F-100 engines. This powerplant is the same as that used in the Air Force F-15, being built by McDonnell Douglas, and was a key factor in the lightweight fighter choice, says McLucas.

So was the F-16's performance, and the Air Force's projection that it would cost less to develop a production model than the YF-17. McLucas says the price per plane will be $6.7 million for the 650 planes, including some $548 million for research and development. Not counting R&D, cost per plane will be $4.6 million. For the Northrop YF-17, total cost would be $7.7 million per plane, with production costs accounting for "about $5 million per aircraft," he says.

Avionics. By making General Dynamics its choice, the Air Force expressed confidence in digital "fly-by-wire" technology and will make the F-16 the first U.S. production fighter to have electronic flight controls instead of electromechanical cable systems.

Excluding weapons systems, the F-16's nine-part avionics package will run to "about 750 pounds and costs roughly $1,000-per-pound," according to an Air Force official. Included will be a UHF/VHF radar, to be chosen late this summer following tests of competitive models being developed by Westinghouse Electric Corp., Baltimore, Md., and Hughes Aircraft Co., Culver City, Calif.

Nearly 150 of the other subsystems for the Air Force version will also be subcontracted. The key electronics packages and their potential suppliers include:

- Central air-data computer: Sperry Rand Flight Systems division
- Fire-control computer: Litton Systems Inc., General Motors' Delco Electronics division, or IBM.
- Inertial navigation set: Litton Industries, Delco, or Singer-Kearfott
- Tacan system: Collins Radio or General Dynamics
- Countermeasures pod and controls: Westinghouse Electric Corp.
- Head-up and radar electro-optic displays: Kaiser Aerospace & Electronics or Marconi Elliott of Britain
- Radar threat warning system: Applied Technology or Dalmo Victor
- IFF control: Hazeltine Corp. □

Packaging & Production

Thin-clad board gets extra protection

A Swedish company has found a new way for preventing the undesirable undercutting that occurs when lines are chemically etched on printed-circuit boards. Lines as narrow as 10 micrometers are possible, says the manufacturer, Perstorp AB.

Perstorp offers printed-circuit-board laminates to which an ultra-thin—5-micrometer—layer of copper is attached. This fragile layer is first fastened to an aluminum foil for extra strength, and the combination is attached to the circuit-board laminate. Then, once the aluminum foil is stripped off, the circuit pattern is created and the user plates up the conductor pattern to the height desired.

Marketed under the trade name of Utece, the laminate should find military and commercial applications where fine line widths are needed for high packing density.

Easy handling. The normal thickness of copper on printed-circuit boards is 35 μm, although thicknesses of down to 18 μm are available. But the thinner copper creates handling problems that affect both the laminator and the user. Perstorp solved this by first electrolytically plating the 5-μm thick copper onto aluminum foil. The foil serves first as a temporary carrier and later as a protector. The copper-aluminum layers are then bonded to a high-grade epoxy glass laminate, with the aluminum layer on the outside of the board.

The coated board is shipped to the user who drills and processes it conventionally. Perstorp says that a major processing advantage for the user is that the normal drilling burrs that occur are confined to the aluminum layer. This means that users can eliminate the standard mechanical deburring. The aluminum is removed by dipping the board into a caustic soda solution. Perstorp also offers a peel-off type.

Goeran Friberg, Perstorp technical sales manager, points out that the circuit pattern on a standard 5-by-10-inch circuit board with normal line width and spacing of 0.015 inch covers 25% of the board. However, the ultra-thin copper-clad laminate will easily yield line widths and spacings down to 0.01 in., and the circuit pattern will cover 40% of

the board, Friberg says. He also claims that his board reduces the manufacturing rejection rate for 10-mil line widths to about 5%, compared to the usual 10% to 15%.

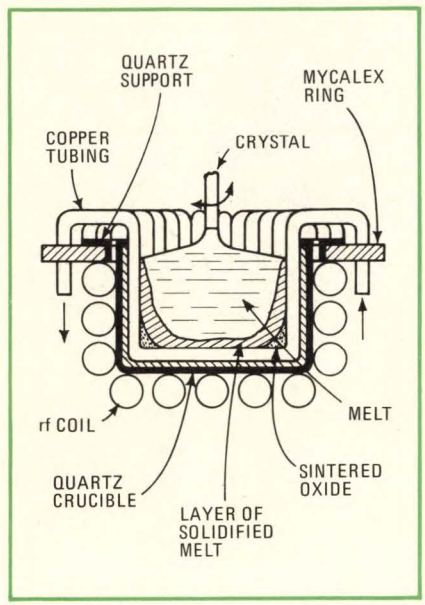
Moreover, with higher density on the boards, designers may be able to avoid using multi-layer designs, he continues. Another advantage he cites is that with thinner copper, the uniformity of copper in the holes and on conductors is improved. Etching time is also reduced, and so are the risks for breakdown of the chemical photoresists.

The ultra-thin clad material is not cheaper than normal boards. The price in Sweden is about 30% above conventional boards with plating on both sides. However, Friberg says that reduced rejections, elimination of deburring, cutting down on etchant and reclaiming costs—plus improved packaging possibilities—will more than make up for this cost. □

Cooling shell superheats materials

"It's like a volcano in the laboratory," says Joseph F. Wenckus, president of Arthur D. Little Inc.'s new division, Intermat Corp. He's referring to an induction furnace developed in the Soviet Union but being introduced in this country early this year by Intermat, which achieves exceptionally high temperatures by, paradoxically, cooling the exterior of the molten material. The cooled material forms a shell or "skull" that supports the rest of the melt and keeps it out of contact with the surrounding container.

For the semiconductor industry, the furnace will produce purer materials than have been possible in the past. For example, contamination that occurs in conventional Czochralski-type crystal-pulling furnaces because the melt contacts the supporting crucible walls is eliminated. Moreover, the melt temperature is no longer limited by the characteristics of the crucible. Temperatures as high as 2,800° C have been obtained, considerably above the 2,000° C limit of conventional induction-heating furnaces, Wenckus points out.



Furnace. Water jacket on melt forms container in which molten material can reach exceptionally high temperatures.

The periodic table of the chemical elements is big, "and this new tool allows a big chunk of it to be explored," says Wenckus. "It allows us to melt materials that have never been melted before." And the high temperature can be achieved in cheaper crucibles—a skull crucible costs $15,000 compared to $90,000 for an iridium crucible.

Potential. Wenckus says it is almost impossible to tell what new materials and applications might result from skull melting, but he has some ideas. It might be possible, he conjectures, to produce new types of single-crystal ferrites, grown in oxygen under pressure of 10 to 100 atmospheres. And the furnace could be used to work with oxides of thorium and beryllium that melt above 2,000° C. This gives the potential, Wenckus points out, to make substrates with improved thermal conductivity and dielectric properties. Also, refractory glasses and ceramics might take different forms, once exposed to the high temperatures of the new furnace, Wenckus says.

Intermat's skull crucible is a cage of vertical copper tubes and a copper baseplate 4 inches high and 2 ⅞ in. in diameter, through which cold water circulates. A quartz tube around the crucible holds in the material to be melted. Induction heating is supplied by a radio-frequency coil wrapped around the quartz. An rf power supply with a 50-kilowatt output at frequencies of 3 to 8 megahertz is used. A feedback system monitors the rf current to control precisely the balance of heat loss and heat generation.

Development. Originally developed at the P.N. Lebedev Physical Institute in Moscow, the skull-melting technique is being used by the Soviets to grow new crystals for laser applications and crystals for gem and jewelry applications. It has also been used to grow crystals of zirconium up to 6 inches long; in the U.S. using conventional techniques zirconium is produced in chips only a few millimeters on a side, according to Wenckus.

Intermat was recently formed to increase the effort to sell the high-pressure induction furnaces that Arthur D. Little had been selling since 1962. Sales are about $1 million yearly and the skull furnace is the company's first new product. Also coming early in the year will be a system to automatically control crystal diameters and a high-pressure reactor for polycrystalline gallium phosphide. □

Consumer electronics

Calculators abound at Chicago show

"I'm walking around hoping I won't be surprised," said Charles E. Sporck, president of National Semiconductor Corp., Santa Clara, Calif., as he surveyed exhibits of calculators at the Consumer Electronics Show in Chicago. "So far, I haven't been."

Indeed, there were few surprises at the early-January show. Faced with what appears to be a seasonal business, most major calculator sup-

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pliers seemed content to flesh out their lines with new low-end and advanced models. Novus, National Semiconductor's consumer-products division, in fact, brought 14 new calculators to Chicago. They ranged in price from $14.95 to $169.95 for a slide-rule model. And Rockwell International Corp. nearly doubled its line with five new entries. Texas Instruments and Litronix Inc. filled one of the few vacant spots in the so-called "dedicated" calculator market, formally introducing new statistical models.

The new models, wide-ranging in both price and features and backed by national-advertising programs, prompted considerable discussion concerning the survivability of the lesser-endowed suppliers, the non-vertically-integrated companies that don't make their own components.

"Inevitably," says H. Donald Nelson, marketing vice president of Rockwell's Microelectronic Product division, "the companies that have the right combination of marketing expertise, manufacturing, and R&D capability, as well as cash on hand, will cause the marginal companies to seek a more profitable use of their talents." Nelson was recently named chairman of the Electronic Industries Association's Consumer Electronics group's Calculator division.

Gene Landrum, Novus general manager, put it more succinctly: "If we don't make at least 70% of the content, we don't play. I want an unfair advantage."

Nelson foresees a "profound shakeup and settling out in the calculator business" in 1975. "For those who survive," he says, "there will be two choices. They can be light on their feet and feed off the present market, or stay in the forefront with new technologies to improve the product and also develop new markets for those technologies."

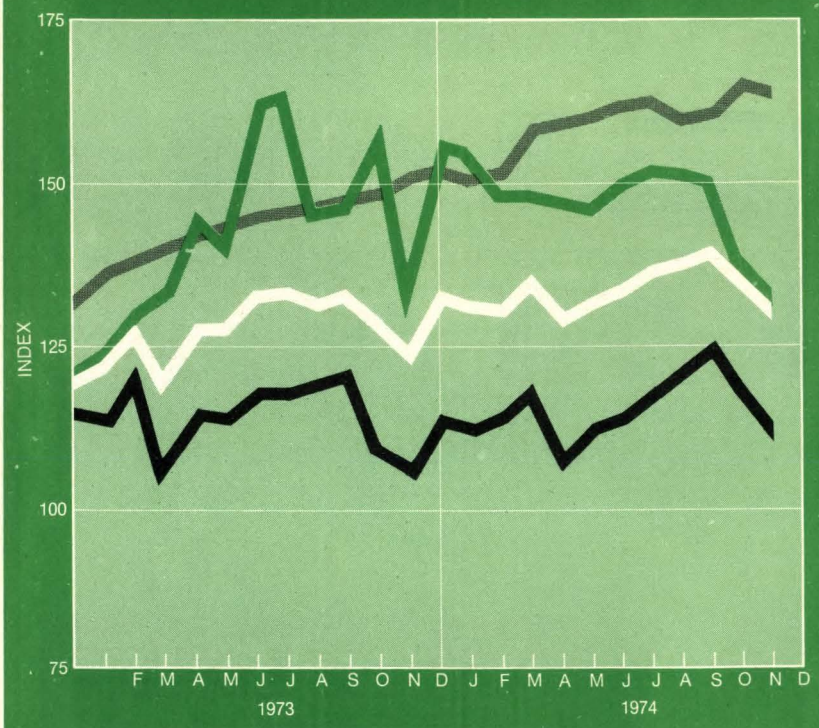
But suppliers like General Instrument Corp. and Casio Inc. indicated they could generate interest among assemblers and dealers alike with a little innovation in products.

Modules. GI's Microelectronics division in Hicksville, N.Y., which already supplies 37 calculator chips to major calculator assemblers, offered four modules, each containing the electronics required to produce a calculator. The new modules include an MOS LSI chip, light-emitting-diode display, driver chip, and, when necessary, passive components. Presumably, the assembler needs to worry about only the 9-volt battery, keyboard, and case.

Peter A. Lesser, the GI division's marketing vice president and general manager for calculator products, says that, initially, GI will market modules with four functions and percent, four functions with memory, five functions plus memory, and a slide-rule calculator. Lesser adds that it is too early to disclose prices, but claims the cost-effectiveness of the finished modules will strengthen the nonvertical supplier's competitive position against the semiconductor firms in the calculator market.

Casio, meanwhile, introduced a new hand-held calculator with an impact printer and 8-digit display. The heart of this unit, which has a

Electronics Index of Activity



Segment of Industry	Nov. '74	Oct. '74*	Nov. '73
Industrial-commercial electronics	164.5	166.2	152.9
Consumer electronics	133.6	138.4	153.6
Defense electronics	113.0	118.7	95.4
Total industry	131.8	136.2	122.4

In November, the total industry index nosedived, dropping 3.2% to its lowest point since November 1973. Largest decline was in the defense sector which fell 4.8%, but this index remained 18.4% above last year's level. The consumer sector fell for the third straight month. Its 3.5% decline left it 13% below last year's level. The industrial-commercial sector declined 1% below October's level, still up 7.6% from a year ago.

Indexes chart pace of production volume for total industry and each segment. The base period, equal to 100, is the average of 1965 monthly output for each of the three parts of the industry. Index numbers are expressed as a percentage of the base period. Data is seasonally adjusted.
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Module	f_{MHz}	P_{out}	G_P dB Min	V_{DC} Supply
MHW601	146-174	13.0	21.0	12.5
MHW602	146-174	20.0	20.6	12.5
MHW401-1	400-440	1.5	15.0	7.5
MHW401-2	440-470	1.5	15.0	7.5
MHW709-1	400-440	7.5	18.8	12.5
MHW709-2	440-470	7.5	18.8	12.5
MHW709-3	470-512	7.5	18.8	12.5
MHW710-1	400-440	13.0	19.4	12.5
MHW710-2	440-470	13.0	19.4	12.5
MHW710-3	470-512	13.0	19.4	12.5

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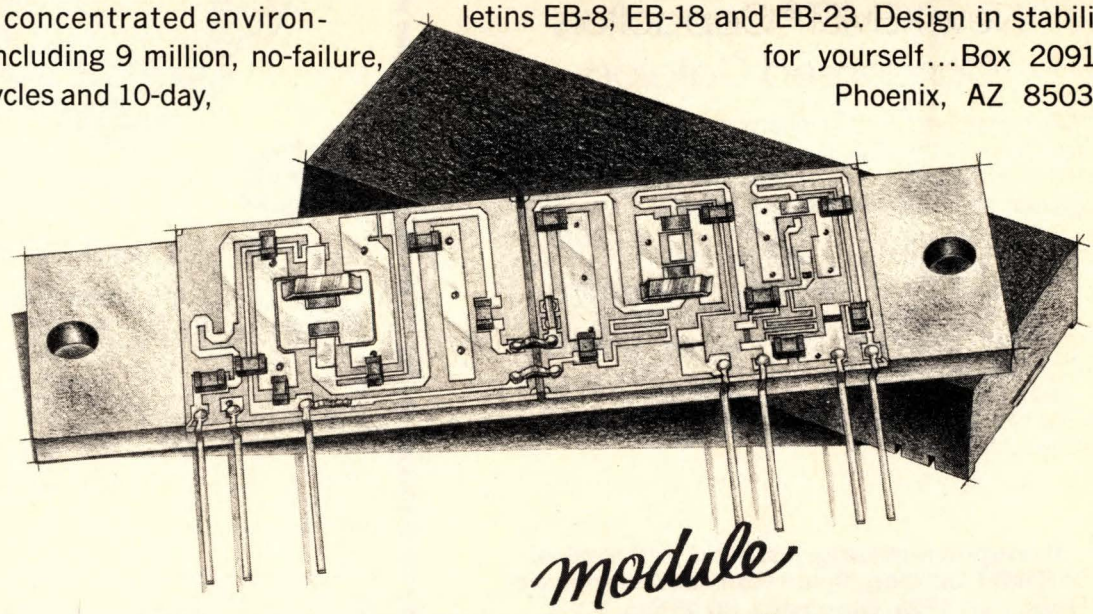

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TV-set makers expect slight sales drop

As expected, few television-receiver manufacturers exhibited at the semiannual Chicago Show. But with what passes for optimism in that industry these days, TV-set manufacturers who did attend predicted 1975 sales to dealers will be level with or only slightly below the 1974 figures. Forecasts for 1975 ranged from 7.5 million to 8 million color sets and from 5.6 million to 6 million black-and-white units.

"All manufacturers are afflicted by a lack of profitability on the manufacturing level," says J. Dan Dougherty, executive vice president of Zenith Sales Co. "The net result will be an all-out effort to improve technology, but only that which will yield lower costs and higher reliability."

That spells gloom for such big-ticket electronics as digital tuning. "Major innovations and major product moves are not in sight this year," adds Robert McCarthy, vice president for video products at GTE Sylvania, which now also sells the Philco label. "We just can't afford radical changes and new technologies in a year where the goal has got to be sales volume."

suggested retail price of $129.95, is a pulse-generator circuit that controls a spoked print wheel. The wheel is inked continuously by a cartridge as a reel of ¼-inch paper tape with a capacity of 14,000 characters passes between the print wheel and impact hammer. The flip of a switch makes the choice of printing in algebraic logic all entries or only intermediate and final answers. □

Components

C-MOS chip is 10-bit a-d converter

Analog-to-digital converters delivering 10-bit accuracy have heretofore been multi-chip devices, but Analog Devices Inc., of Norwood, Mass., has unveiled the industry's first 10-bit monolithic a-d converter. And it's a complementary metal-oxide-semiconductor device, meaning low power consumption.

The model AD7570L is available in evaluation quantities and is priced at $69, at least $20 less than competitive 10-bit hybrid units. Production quantities should be available in about 20 weeks. By that time, the unit will also be fully specified for worst-case ratings and typical dynamic performance.

The AD7570L is a successive-approximation converter. It offers a typical total conversion time of 20 microseconds when run at a clock rate of 0.6 megahertz. However, this initial specification is conservative, notes George Krautner, assistant marketing manager at the Santa Clara, Calif. facility where the converter is being produced. Krautner says it is likely that conversion time can be cut to 13 μs for a 1-MHz clock.

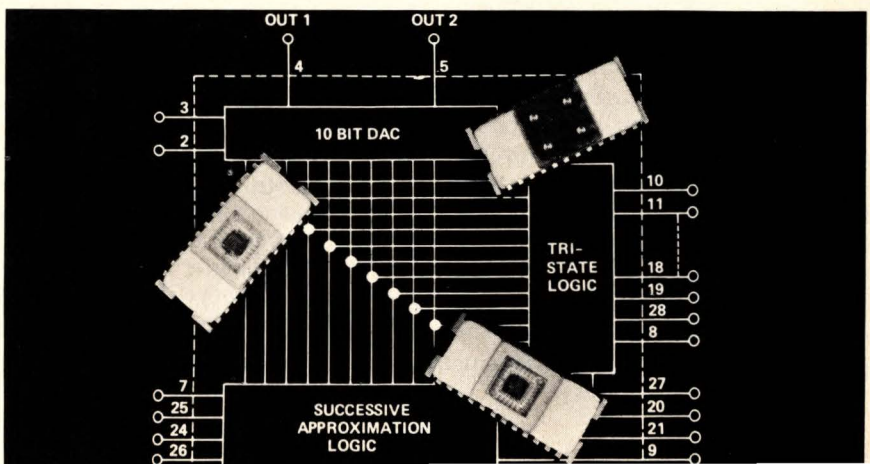
Blocks. Essentially, the chip can be thought of as three major functional blocks: one is a 10-bit multiplying digital-to-analog converter, which includes its own on-chip thin-film resistor network; the second block is the successive-approximation logic; and the third is a three-state logic output designed for easy interfacing with a microprocessor.

The AD7570L also includes its own internal clock. To operate, the converter requires only an external comparator, a ±10-volt dc reference source, and a 15-v dc supply. If transistor-transistor-logic compatibility is desired for input and output, a 5-v logic supply is needed, too.

Quiescent power consumption is 20 milliwatts, and the maximum gain temperature coefficient is 10 parts per million of full scale per degree celsius, over the range of 0°C to 75°C. Both parallel and serial data output lines are provided.

The silicon-nitride-passivated chip is housed in a 28-pin ceramic dual in-line package. An eight-bit version, the model AD7570J, is also available, and except for resolution it offers the same features and performance as the 10-bit unit. The cost of the eight-bit device is $52 in quantities of 1 to 49. □

Monolith. Ten-bit a-d converter from Analog Devices puts three separate functions on a single C-MOS chip. Evaluation quantities of the part cost $69.



Commercial electronics

Funds transfer gets new cash control

In these days of tight money and high interest rates to borrowers, companies are not only trying to speed deposit of invoice payments, but can now obtain daily information of the amount of cash sitting in their bank accounts.

This computer service is being offered nationwide by National Data Corp., Atlanta, which has previously set up credit authorization, credit card billing, and deposit reporting systems. The new Cash

Control System, as it is called, gathers information at the end of each day on cash balances and account activity at multiple bank locations in the U.S. and Canada. It also provides subscribers with immediate access to that information—eventually by way of a cathode-ray tube terminal at each subscriber's desk.

Set to go into trial operation in March, the service will be available nationally in April, and the CRT terminals will be offered in May. In effect, users get a daily bank statement, but with all accounts on one document. Other reports provided by the Cash Control program include one that identifies current balances by location and recommends the sums that should be transferred to achieve optimum use of cash; a transfer report that summarizes the funds transferred to and from each bank account; and a service costs comparison report that pinpoints services performed by the banks. □

Solid state

Nonvolatile memory relies on bismuth

With bismuth titanate substituted for the more common nitride gate insulator, a nonvolatile MOS memory being developed in Japan promises operation at lower voltages and currents than other nonvolatile devices. The basic feasibility of using such a ferroelectric insulator has been established in prototype transistors at the Central Research Laboratory of Nippon Electric Co., and the effort is now turning to fabricating integrated circuits.

Tests indicate that the number of on-off cycles is unlimited. No change in characteristics was noted after more than 10^5 power cycles, and the polarized state of the gate film proved to be quite stable. There is a slight decay of the on conductance initially, but no change of the off current. The write and erase currents are essentially equal to the gate-capacitance charging current;

News briefs

Solarex develops 1-ampere solar cell
Solarex Corp. of Rockville, Md., says it has produced a 3-inch-diameter solar cell disk capable of producing more than one ampere of current per cell. The cell, according to Solarex, is about 10 times as powerful as the individual solar cells used on most satellites.

System/32 from IBM combines new components
IBM's recently announced System/32, a small computer aimed at industrial and commercial applications below the level of the company's System/3 computers, combines several relatively new components, although each of them has previously appeared in an IBM product. The components include:

- A semiconductor random-access memory, using 2-kilobit n-type metal-oxide-semiconductor chips to provide 16,000 bytes of storage.
- A magnetic disk storing 5 million bytes that uses a newly designed pivoting-type data-access head, rather than the common radial-motion head. This results in less head movement and higher mechanical reliability.
- A small cathode-ray-tube display for operator instructions and inquiries that can show six lines of 40 characters each from a 64-character set.
- IBM's floppy disk for data entry.

All circuits, including the semiconductor memory, fit on 24 circuit boards. The system rents for $770 to $1,000 per month on a three-year lease or sells for $33,000 to $40,000, depending on the program.

Sanders Associates files antitrust suit against IBM
Sanders Associates Inc. of Nashua, N. H., has filed its delayed antitrust complaint against IBM Corp., seeking relief and damages in excess of $255 million, for losses that include the $19.1 million in red ink recorded by Sanders in fiscal 1974 [*Electronics*, Sept. 19, 1974, p. 38]. Sanders, which said in September that it was planning to file its suit within 30 days, delayed its filing to study the Justice Department's suit against IBM. Sanders states that IBM "exploits its control over compatability to exclude competition from independent display-terminal manufacturers."

Litton predicts 25% boost in microwave-oven market in 1975
Industry sales of home microwave ovens this year will increase 25% over 1974, exceeding 900,000 units, predicts William W. George, president of Litton Industries' Microwave Cooking Products subsidiary. This represents a retail market of $360 million, says George. "Last year's sales were up 65% over 1973, in sharp contrast to other major cooking appliance sales, which were down about 15% from 1973 levels."

U.S. Army to procure Roland missile
In what amounts to one of the largest procurement programs involving a non-American weapons system, the U.S. Department of Defense has picked the German/French-developed Roland anti-aircraft missile system for the U.S. Army. An initial $108 million has been appropriated to get production under way at Boeing Aerospace Co., which will supply the vehicle and some electronics, and Hughes Aircraft Co., which will build the missile and radar.

Roland, a development by West Germany's Messerschmitt-Boelkow-Blohm GmbH and France's Aérospatiale, is a mobile weapons system designed for defense against low-flying planes. First tests and deliveries are scheduled for 1977.

Texas Instruments and Honeywell cut more workers
After ending 1974 with 66,000 employees, down from a mid-year 78,000, Texas Instruments said early this month it would lay off an additional 9,000 in the first quarter of 1975. Lower incoming order rates was the reason cited. And Honeywell Information Systems plans to cut back about 4%, or 800 people, in the next six months.

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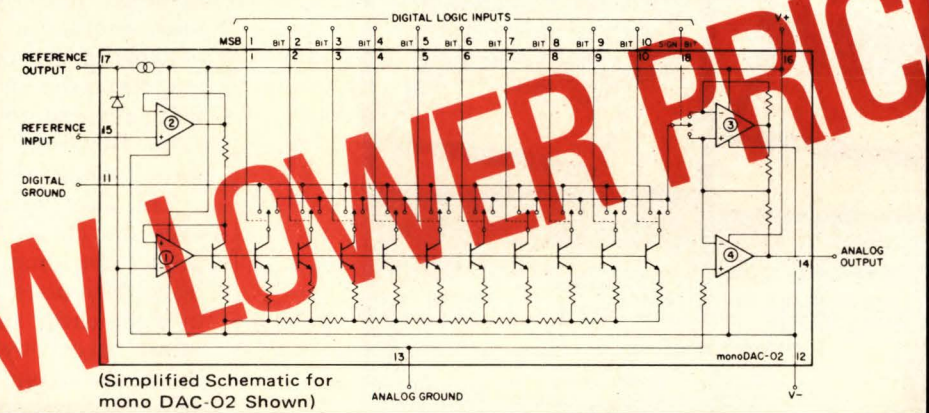

(Simplified Schematic for mono DAC-02 Shown)

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extrapolation of decay at room temperature shows almost unlimited retention of memory.

Fabrication. Even though they operate differently, the configuration of the new transistors resembles that of nonvolatile metal-nitride-oxide semiconductor transistors.

The substrate is 1/0/0-type silicon with a resistivity of 10 ohm-centimeters. The silicon-dioxide layer directly over the channel is a thermally grown oxide layer about 150 nanometers thick. Between this oxide layer and the gate is the layer of bismuth titanate, 1 micrometer thick. Source and drain metalization of experimental devices is platinum, but successive layers of titanium, platinum, and gold are used for the gate. However, aluminum metalization should also be satisfactory.

The thin silicon-dioxide layer over the channel is necessary for proper operation of the device. The bismuth-titanate layer is deposited over the entire substrate from a ceramic target by radio-frequency diode sputtering in a soft-vacuum argon atmosphere at about 6 nanometers per minute. It is masked and etched to the desired pattern. After heat treatment in an oxygen atmosphere for 30 minutes at a temperature typically about 700°C, the bismuth titanate shows its typical monoclinic polycrystal structure. This temperature is low enough not to damage the semiconductor.

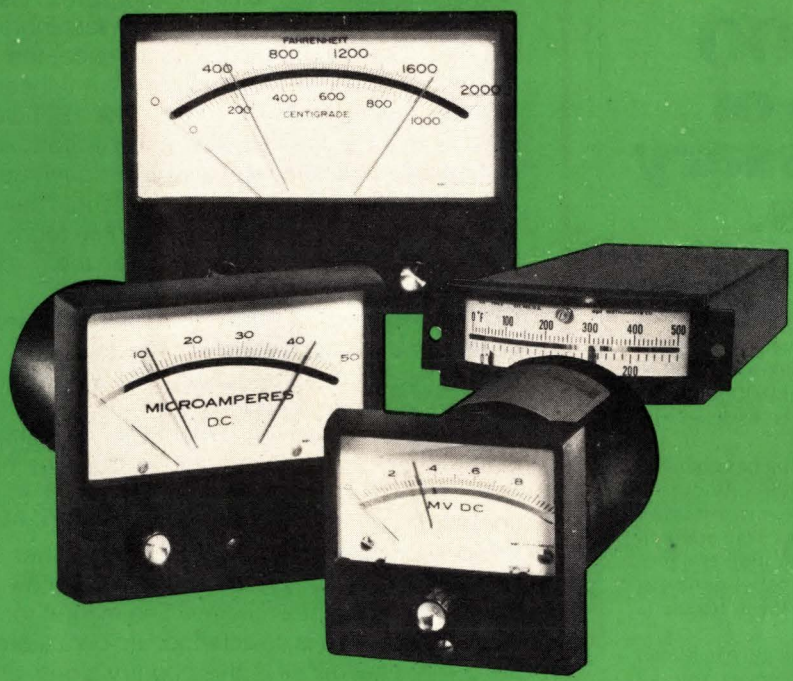
Specifications. The small-signal dielectric constant of the bismuth titanate is about 90 when measured at 1 megahertz and room temperature. Resistivity is 7×10^{12} ohms.

The switching time, which depends on applied voltage, varies from 300 milliseconds with an applied voltage of −15 V to 500 nanoseconds at −35 V.

Because off current can be kept to extremely small values, the on-to-off ratio is adequate, even at low current levels. Thus, drain current needs only be sufficient to give desired access speed, which is the same as other p-channel MOS transistors of similar geometry. Operating speeds of n-channel devices should be even higher. □

~~THE BIG BUY~~

THE BEST BUY



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Circle 41 on reader service card

News update

Design engineers' show to be repeated by EIA A good many design engineers and component makers apparently liked the first Design Engineers' Electronic Components Show, because the Electronic Industries Association plans to put on a second one this year. Held in Washington in conjunction with the Electronic Components Conference, the show was conceived by the EIA as a means of getting the engineers and manufacturers together [Jan. 10, 1974, p. 40]. The 1975 version will take place May 12 to 14 at the capital's Statler-Hilton, and 25 of the 30 companies that exhibited last year have signed up again. Tyler Nourse, EIA Parts division staff vice president, says of the new show, "We've got to consider it successful in terms of exhibitors' expectations, at least, since so many of them expressed a desire to come back."

Collins developing mine communications system The U.S. Bureau of Mines appears finally to be closing in on a decision concerning the frequency that would be best for wireless underground-communications systems. After years of debate, the bureau last year decided there was "something wrong with every major means, from vhf to uhf" and asked industry for new ideas [Jan. 10, 1974, p. 53]. The result was a $150,000 development contract to the Collins Radio division of Rockwell International for a two-way wireless voice system and other smaller contracts for cable systems. They're all being tested now in a Kentucky mine, say Bureau of Mines officials. The market for such equipment, regardless of which is selected, could be a lucrative one, since there are 5,000 coal mines in this country alone, and 2,000 of them are underground.

Bus-fleet operators to get tabulating system Operators of bus lines are going to find out how pervasive electronics can be as the result of $300,000 in contracts awarded by the Urban Mass Transportation Administration. The contracts went to the Mitre Corp. and five subcontractors for a breadboard automatic tabulator of passengers, revenue and maintenance. The onboard system is supposed to help operators plan their fleet schedules [Jan. 10, 1974, p. 53]. Delivery of the design model is expected in June, with a decision on prototype production due by the end of the year.

Data goof causes ship to go aground A Swedish supertanker ran aground off Denmark last year, and therein lies a story. The incident—unreported until recently—only resulted in damage to the bottom plates of the tanker Sea Swift. But Swedish authorities believe it may be the first merchant marine accident resulting from computer error—though the error was the result of faulty data fed into the vessel's navigation computer. The mishap, of course, has not deterred Swedish shipbuilders from turning their tankers into veritable floating electronics installations. A new class of 15 supertankers building at the Kockums shipyard is an example: the Sea Saint, first of the class, has around $1 million worth of electronic gear aboard. This ranges from two separate computers to a radio and television entertainment system for the crew of 35. On the Sea Saint, one Norwegian-made Kongsberg SM-4 computer system controls loading and load control, and another handles the machine room plus navigation and piloting [*Electronics* International, Dec. 12, 1974]. **—Howard Wolff**

Intended to bring *Electronics* readers up to date on news stories of the past months.

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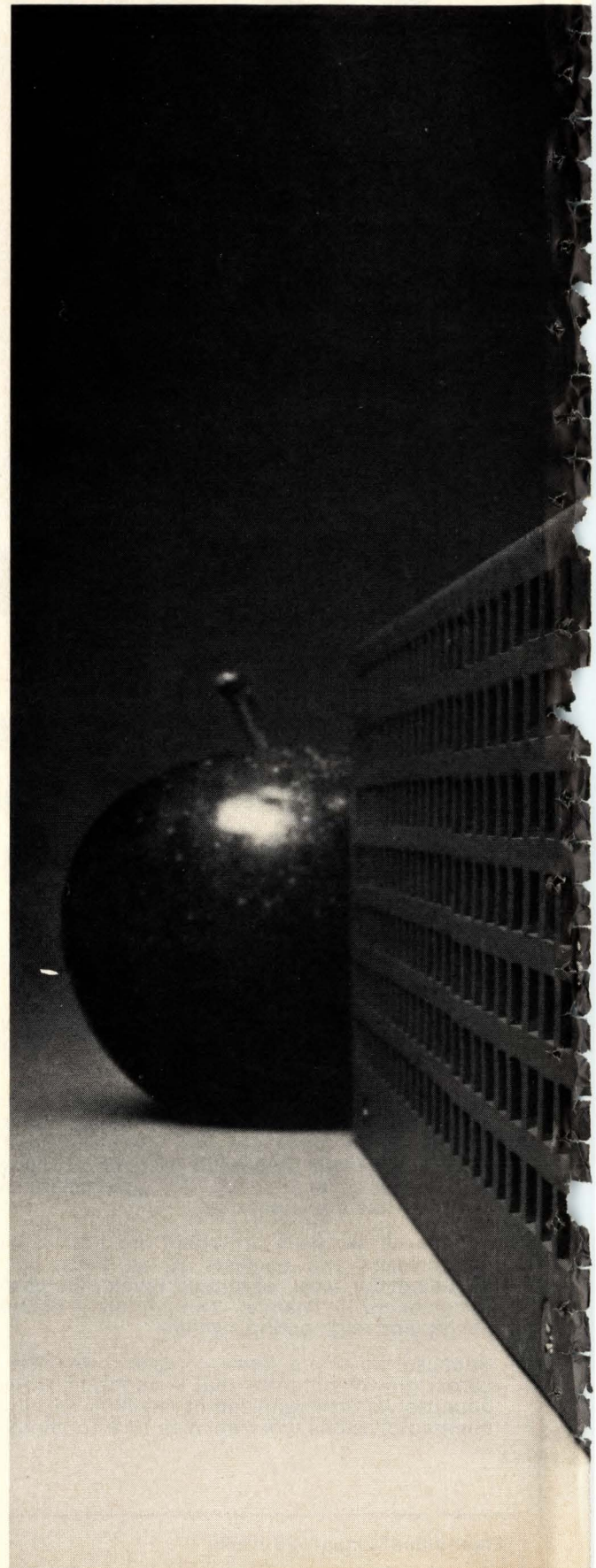

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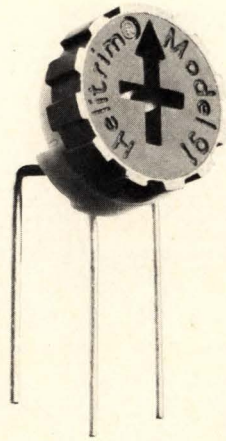

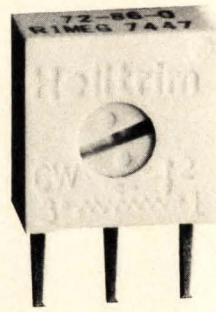

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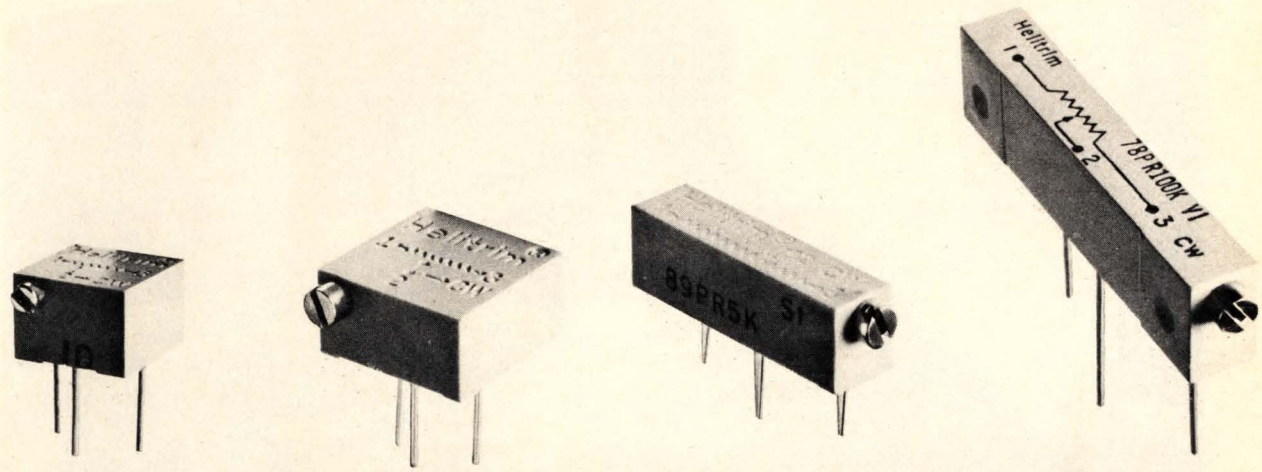

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- 100% inspected
- 22 turns of adjustment
- Resistance range: 10Ω to 2 megΩ
- 100 ppm/°C tempco

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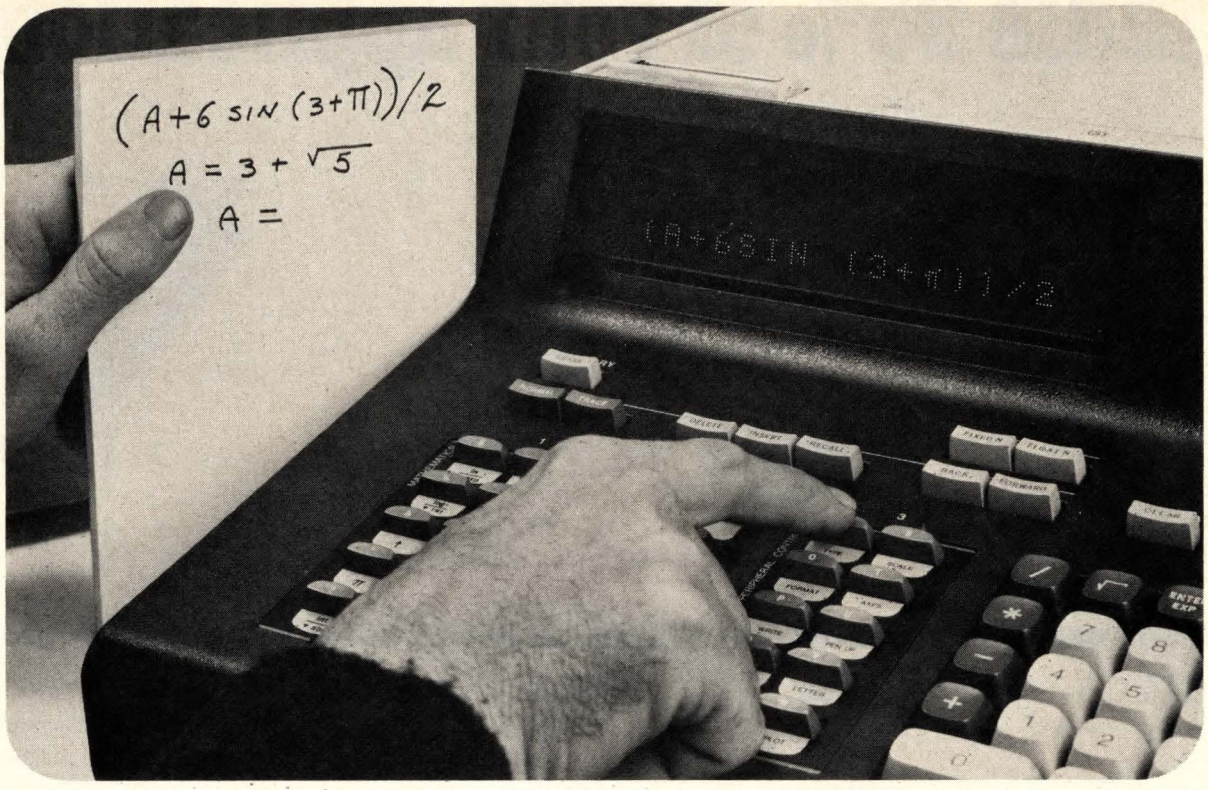

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Washington newsletter

Slowdown seen in U.S.-Soviet electronics trade

The Soviet Union's mid-January cancellation of its 1972 trade agreement with the U.S. is likely to bring the slowly expanding electronics export market to the USSR and its East European satellite nations to a standstill, say Government trade experts. Particularly affected, according to Commerce Department sources, will be large technology exchange agreements like "the proposal to build a turnkey semiconductor production plant in Poland, for example." While Poland and the Soviets are still anxious to obtain this technology, officials note that **the U.S. bureaucracy is unlikely to look favorably on such export-license applications,** even though denial of these applications for purely political reasons is unlawful. **Companies with Soviet trade agreements completed but awaiting implementation—like IBM, ITT, Control Data, Singer and others—were uncertain about the future of those agreements immediately after the Russian cancellation** since the preambles of their agreements all cite the 1972 agreement between governments.

DOD has $30 million for fiber optic systems; Bell Labs interested

Up to $30 million could be approved this year for the development by the Defense Department of fiber optic data-bus and voice communication systems, say DOD officials who have formed a tri-service committee to coordinate and oversee fiber optic R&D programs in the Army, Navy, and Air Force. And Bell Telephone Laboratories Inc., Holmdel, N.J., has informed DOD researchers that it wants in on the DOD action. **Approximately $4-5 million will be spent on optic research, DOD officials say, but "five to six times as much" is available for systems applications** if the services can justify it on economic and technical grounds.

The Navy plans to use fiber optics for fire control, communications and navigation systems wiring on its advanced surface-effect ship, an air-cushion vehicle, while **the Air Force last July awarded a $1.6 million contract to IBM's Federal Systems division, Gaithersburg, Md., for a fiber-optic-wired navigation and weapons-control system aboard an A-7 jet fighter.** Army projects include a field cable for communications between command posts and front lines [*Electronics*, Jan. 9, p. 29].

Fleetsatcom antenna to cost and weigh more

Problems with the uhf receiver antenna being developed for the Fleetsatcom model communications satellite by TRW Systems group, Redondo Beach, Calif., **have not only boosted contract cost 86% to an estimated $65 million, but have also increased antenna weight and delayed delivery about a year,** Pentagon officials confirm. TRW reports that an additional $7 million will be sought later this year to cover increased costs of redesigning the receiver antenna to reduce interference with the system's transmission antenna, a reflector 16 feet in diameter.

The receiver antenna, a 1.6-ft-long helical design, will be enlarged to a 14-ft-long helix with a 15-in. diameter. In addition, the transmitters will be rewired and redundant components added to guarantee system reliability. The changes will raise the satellite's weight by about 350 pounds to 4,000 lb. The slippage of the development model's delivery to the USAF Space and Missile Systems Organization is also expected **to delay the proposed launch of the four production satellites** that have still to be ordered.

Washington commentary

Avionics: after the F-16, what?

Years have come and gone since John Foster, then Director of Defense Research and Engineering, warned an audience of aerospace and military electronics contractors that the Pentagon no longer could support seven military airframe manufacturers. There was just not enough business, he said. Foster's warning now seems likely to become reality within the next year. Following the Air Force selection of General Dynamics Corp.'s YF-16 entry for the role of lightweight fighter (see p. 30), virtually no major military aircraft buys have been scheduled, though there are some advanced technology ideas on the drawing boards exploring new aerodynamic shapes.

Thus it is expected that among the seven major U.S. airframe builders cited by Foster—Grumman Aerospace, Fairchild Industries, Lockheed, LTV Aerospace, McDonnell Douglas, Northrop, and Rockwell—a shakeout will develop within the next year or two that will see at least a couple of these companies fold or be absorbed by their stronger competitors, just as McDonnell picked up the sputtering Douglas Aircraft Co. several years back.

Avionics' brighter side

The future is not so grim for the much larger community of military avionics suppliers, however, even though the F-16's avionics potential at the program's start seems small—no more than 750 pounds per plane at $1,000 a pound, says one Air Force program officer. Excluding weapons system electronics, that figure is not much more than 16% of the F-16's unit production target price of $4.6 million. This is small potatoes compared to the halcyon days of the '60s when black box avionics accounted in some cases for as much as 40% of the pricetag.

Nevertheless, the Air Force's estimate of a 3,000-plane market for lightweight fighters within the U.S., NATO, and "third world" countries such as Iran over the course of a decade means this could become the biggest avionics market in aviation history. Already it is considered one of the most viable.

But what do designers of avionics equipment have to look forward to after the F-16? A great deal, even though much of the new business will represent retrofits for existing aircraft. Then there is the smaller potential of the market for the military remotely piloted vehicle—where interest is strong from both the Army and the Air Force but which are not urgently needed in peacetime.

For avionics makers unwilling to wait for the age of the RPV, therefore, the best market lies in uprating radars, electronic countermeasures, and communications and navigations packages for retrofitting both Air Force and Navy planes. Those services guesstimate that their combined budgets for such projects this year will be in excess of a billion dollars. Add to this the electronics subsystems peculiar to airborne and ground-air weapons systems, and the dollar total "probably could be doubled," estimates one Pentagon budget specialist.

The radar example

Consider, for example, the strong military interest in multimode airborne radars—an area in which much work has been done already by such developers as Emerson Electric Co., and where work is continuing to go forward at such places as Westinghouse Electric and Hughes Aircraft. The contention of the Air Force Avionics Laboratory's advanced avionics flight test program is that the electronically scanned multimode phased array has come of age.

Flight tests of Emerson's RARF system—for radome, antenna and rf circuitry—aboard an RB-47 over the past four and a half years have been carried out without a single malfunction. That record of 5,000 hours of operation has sufficiently impressed the Air Force that it is pushing hard on the Westinghouse follow-on program—the Electronically Agile Radar System called EARS—for use aboard the Rockwell B-1 bomber [*Electronics*, Oct. 17, 1974, p. 171]. The RARF phased array is being considered for retrofit in the F-111, replacing the functions of three separate radars for attack, Doppler navigation, and terrain following and avoidance, with a single multimode system.

Generating substantial improvements in equipment originally designed by someone else is not as exciting to many engineers as designing their own packages from the start. Nevertheless, the Defense Department finds the resulting increases in cost-effectiveness one of the few ways they have to cope with soaring system costs. Redesign and equipment improvement programs are therefore assuming steadily increasing importance in the minds of the Pentagon's planners. And in an era when new aircraft programs are becoming rare, programs to retrofit existing aircraft with better avionics may prove the economic salvation of an important segment of the electronics industries.

—Ray Connolly

"The principal quality of any synthesizer is spectral purity." (**Microwaves**, Nov. 72, p. 54)

Purity is just one good reason for choosing S-D synthesizers.

Another is economy. Systron-Donner programmable synthesizers not only provide the purest signals attainable today but cost substantially less than comparable systems.

That's because Systron-Donner's approach eliminates the need for costly frequency multipliers. S-D uses octave band signal sources—1-2, 2-4, 4-8 and 8-12.4 GHz. See the difference this makes:

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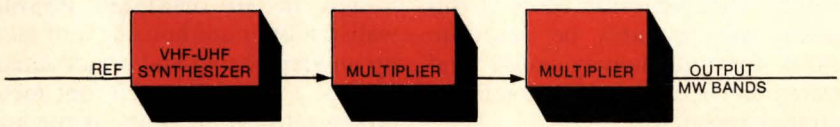
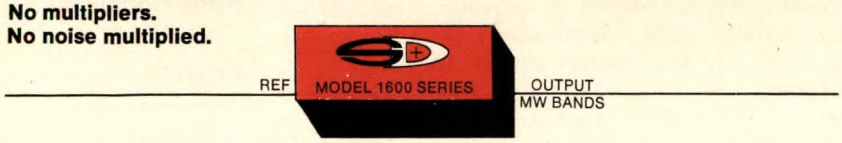


The S-D way

No multipliers. No noise multiplied.



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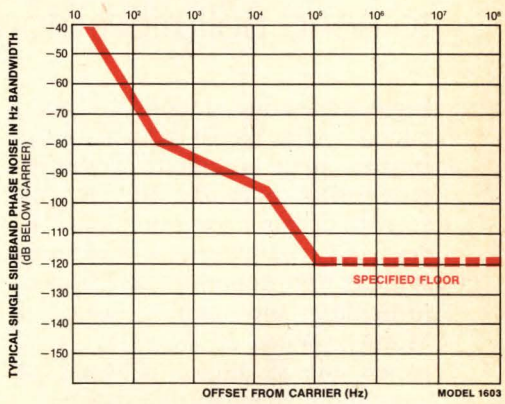

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Leveled output +13 dBm ±0.5 dB

Frequency accuracy as good as reference oscillator

Frequency resolution 10 KHz standard, 1 Hz optional

Frequency stability (internal oscillator) 3×10^{-9} per 24 hours

Phase noise −85 dB at 1 KHz from carrier in a 1 Hz bandwidth

Spurs −70 dBm minimum

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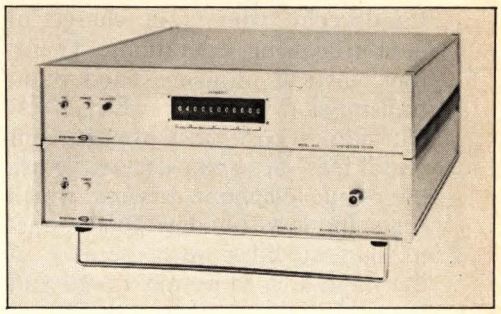

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Bavarian system uses phone network to send pollution-monitoring data

Eight measuring stations are being added by the West German state of Bavaria to its automatic pollution-monitoring network. In the first stage of construction, completed last year, 14 computerized measuring stations were connected to the data-processing and control center in Munich. When all stages are completed, the $5 million network will have about 80 measuring stations.

Digital data, transmitted through the public switched telephone network, uses hardware and interfaces of the international Camac (computer-aided measurement and control) system. Camac modules convert analog signals from the instruments to digital form and help transfer the data to the central computer. Camac hardware and software interfaces, available from several suppliers, control the modems and provide computer interfacing.

In selecting the network configuration, the paramount objective was low operating costs, says Josef Landbrecht, who is in charge of data-processing operations. Therefore, instead of using fixed data-transmission lines—for which West Germany's post office charges stiff rental fees—designers decided to use the public telephone network, which rents for less, but has good transmission qualities. Also, because of the large area to be monitored and the multitude of measurements, an automatic on-line measurement system was selected.

Heading the Bavarian state-government project is Dornier System GmbH. The data-processing equipment comes from Digital Equipment Corp., West Germany's Rohde und Schwarz is integrating the system, and the instrumentation is supplied by a number of firms.

Measurements. Measurements cover such pollutants as sulphur dioxide, carbon monoxide, hydrocarbons, hydrogen sulphide, and dust, as well as meteorological factors, such as wind direction and velocity, air temperature, humidity, atmospheric pressure, precipitation, and solar radiation. Suitable measuring instruments are still being sought for nitrogen oxide, ozone, and hydrogen fluoride. More instruments will probably be added to check for radioactivity, noise, and water purity, and help in biometeorology research.

Instead of transmitting continuously, the measured data and other information are stored at the satellite stations until automatically requested by the control center in Munich. At each station, a DEC PDP-11/10 minicomputer with 8,192 16-bit words of memory handles data-acquisition, preprocessing, and storage during the intervals between data requests. It also performs such tasks as control, calibration, and check-out of the instruments, as well as housekeeping chores.

A PDP-11/45 controls the system from the central station in Munich through an RSX-11D operating system. Polling is controlled from there by automatic switching equipment. Modems, designed for transmission at 1,200 bits per second and fitted with automatic answering sets, allow the measuring stations to send data in digital form to the center and to receive control commands from it.

Cycles. Data is requested from the stations every eight hours if air quality is good. If conditions deteriorate, the cycle is automatically shortened by software control, or manually by the operator.

All of the 14 stations now in operation are self-sufficient, but later, additional stations located within the same local exchange network will be interconnected to economize on minicomputers and modems. Then, one minicomputer-equipped measuring station in each area will act as a central substation and accept measurement data from stations connected to it.

Locations of the measuring stations are based on a grid system drawn across Bavaria. Each station, of modular construction, is contained in an insulated double-walled aluminum housing and takes up an area of two and a half square meters. Topped by a 23-foot meteorological mast, it contains the sensor system, two 19-inch racks for the instruments, and another rack for the data-processing equipment. □

France

Navy to build digital ship loop

Boatswain's mates still whistle commands in the world's navies, but telephones and intercoms carry the bulk of communications aboard ship. That means a mass of cables to communicate from stem to stern and from hull to conning tower.

A trunk line looping around the ship obviously would have many advantages—the saving in cable alone would be enormous. And digital systems avoid the bulky and complicated filters needed for frequency-multiplexed analog systems.

Now the French navy plans to move up a notch in sophistication. Together with the Philips-group company, Télécommunications Radioélectriques & Téléphoniques, it is developing a digital time-multiplexed system designed to handle 800 "subscribers."

TRT already has built two models of the system and is helping the French navy draw up the specifications for a sea-going prototype. "It should be ready for trials by 1976 or so," surmises Guy David, head of

special digital systems for TRT. As a rough guess, David puts the cost of a full-fledged system for a corvette at $450,000 to $650,000.

Loop. The system, known as SLI—the acronym for système de liaisons intérieures par transmissions digitales—hooks shipboard subscribers indirectly into a coaxial-cable loop that transmits delta-modulated signals at 11 megabits per second. Initial SLI systems will distribute only audio signals, "slow" signals like teletypewriter code, displays, and remote fire-surveillance information. Eventually, David foresees faster SLI systems that would carry data among weapons, navigation, and ship-control systems.

The system is related to others now under development. Last year, the U. S. Navy awarded a contract to the Autonetics group of Rockwell International for an advanced development model of a shipboard system that uses digital multiplexing techniques. And, in the United Kingdom, Ferranti Ltd. has readied a digital multiplex system to link radar and navigation-system elements [*Electronics*, Electronics International, July 25, 1974].

Indirect. In SLI, the loop works under control of a master station that injects a frame code with 320 data channels into the loop. Terminals aren't hooked in directly, but rather through a maximum of 50 interface/junction units. Each junction unit handles a maximum of 16 terminals, demultiplexing signals addressed to them and multiplexing signals originated by them onto the loop. (The data-transmission rate is 32 kilobits per second). In addition, the junction units act like repeaters in a long-distance digital network and regenerate each frame. All this adds up to a slight delay when the frame returns to the master station after circling the loop; a digital delay line in the master station takes care of synchronization.

Doubling. TRT has built redundancy into the system as a safeguard against outages. There are two loops, one serving as a backup, and two master stations. Each frame includes check codes, and when a junction unit doesn't repeat its code for two frames in a row, the system logic reroutes traffic through the standby loop. For extra security, important stations like the bridge and the combat-operations center are tied into the system through two junction units.

TRT designed the system around standard TTL packages for high-speed circuits and complementary-MOS packages for low-speed circuits. And the hardware has been kept as modular as possible. "Rewiring" is mainly a matter of plugging printed-circuit boards in and out. Although the system is designed principally to handle voice communications with telephone quality, services that require higher digital-data rates can be accommodated—within reason. □

Around the World

Nixdorf's small computer has disk store

The 8870 data-processing system, which West Germany's Nixdorf Computer AG plans to market in April, is aimed at the small-computer market now dominated by IBM Corp.'s System/3. The 8870, first of the new Nixdorf 88 family—larger and smaller units will be forthcoming—has a 12-megabyte disk file, which can accept or display data in parallel with processing operations.

Cycle time of the microprogramed central-processing unit is 1.1 microseconds. Capacity of the central core store is 40 kilobytes. Each byte contains 8 data bits and a parity bit. In its maximum configuration, the 8870 can handle four data-entry stations, each with a keyboard and cathode-ray-tube display that reads out 12 80-character lines. A variety of peripherals is available for the system, which has communications capability.

On a five-year contract, rental for the minimum configuration with one data-entry station will be about $1,600 a month, and for the maximum configuration, it will be $3,700 a month. Selling prices range from $63,000 to $139,000. Klaus Luft, in charge of sales, predicts that the 8870, which cost nearly $5 million to develop, will win nearly half of the small-computer market in Germany, with sales of 500 systems during 1975 and about 1,000 a year after that. Most future series 88 machines will contain the Nixdorf-designed NCF1 microprocessor.

British display terminal fits in briefcase

A new terminal, packaged in a briefcase with a plasma display, has editing capabilities and can be operated through any telephone. The 20-pound terminal, called Synapse, was developed by Modular Technology in Oxhey, near Watford, England. The all-weather terminal is priced from $1,400 to $4,800, depending on options, which include a battery-powered model. The terminal can be operated either as a portable teletypewriter or computer terminal, but it won't operate as a line printer. The standard unit contains Fairchild complementary-MOS logic circuitry, General Instrument Corp. n-channel MOS random-access page and scratchpad memories, a C.P. Clare teletypewriter keyboard, and a Burroughs 256-character fold-up plasma display, which provides eight lines of 32 characters each.

German equipment boosts standards accuracy

An inexpensive frequency controller, developed by the Munich firm Efratom Elektronik GmbH, compares the output of atomic or quartz frequency standards with the signals radiated by so-called standard-frequency transmitters and automatically adjusts the standards to the transmitted frequencies. After phase-comparison, the Efratom EFR generates counting pulses, which are converted to analog dc voltages that electronically adjust atomic and quartz frequency standards. For about a quarter the price of a cesium frequency standard, Efratom claims, the EFR and a quartz standard can provide long-term stability at least as good as that of the cesium standard. A typical rubidium frequency standard sells for around $3,700, Efratom says, and the EFR for about $2,700.

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International newsletter

Europeans weigh sales offers for fighter aircraft

The choice between an American or European lightweight fighter to replace the aging F-104 Starfighter of four NATO countries—Belgium, Holland, Denmark, and Norway—could well come during March. The four-country buying consortium in Brussels has heard the United States, France, and Sweden present their final offers of replacement fighters. **The steering committee is now expected to prepare a final report for ministers of the four countries by the end of January.**

Offers of the selling countries are good until March 31, although they could be extended beyond that date. **So far, it appears the French F-1 Mirage and the General Dynamics YF-16 are the main contenders.** The YF-16 has been adopted by the U.S. Air Force after a fly-off with the Northrop YF-17 (see p. 30). Brussels sources rule out the Swedish Viggen because of high costs and low salability to third countries. **Consortium members are reported to be divided—the Belgians favor the French Mirage, and the others, the U.S. contender.** Although the Mirage has been priced at more than $6 million, it is probably lower than the YF-16, a new-generation aircraft.

Univac enters Spanish computer partnership race

Sperry Rand's Univac division has entered the competition against Japanese and German manufacturers to set up a computer-development venture for the Spanish government. The U.S. company submitted the proposal directly to the president of Spain's Institute National de Industria, Jose Maria Guerra Zunzunegui. Univac's offer will be weighed against a previous Fujitsu Ltd. proposal and an improved Nixdorf Computer AG entry. **As a result, official sources say that a decision is not expected soon, even though it means further slippage of the project.** Last month, Fujitsu signed an agreement in principle with the former INI administration, but a political shuffle has upset that, sources say, and the agreement has been held up pending a review.

INI is seeking outside help in developing the capability to build medium-size computers—and it wants the partnership as a springboard for exports. However, the agency is leaving the other segments of the growing Spanish market to the companies that already dominate them—IBM Corp. in large computers and Spain's Telesincro in small computers.

Crunch compels Japanese layoffs and salary cuts

Japan's electronics and electrical industries will lose about a million working days during January "vacations." However, many, if not most, employees will receive high percentages of their pay. Hitachi, the largest employer, with 81,000 in these two industries, is planning about 100,000 days of mostly paid vacations at about 20 of its 31 plants. However, there are order backlogs for computers and heavy electrical equipment. **Hitachi has also cut the pay and bonuses of about 4,000 management personnel 5% to 15% through September.** Salaries of 3,000 section heads will be cut by 5%, 1,000 department heads by 7%, and 54 top executives by 15%. **Sony and its subsidiaries will give about half of its 16,000 employees in Japan five extra days of vacation during the first three months of 1975 at 90% of their salaries.** Although Sony is giving its employees time off to cut one to two months' worth of supplies from inventories that have stretched to six months worldwide, layoffs are not planned in the magnetic-tape manufacturing plant.

Oscillator fails in Franco-German Symphonie comsat

The Franco-German communications satellite Symphonie, spaceborne since Dec. 19 and undergoing tests since Jan. 13, is having its first troubles. One of two oscillators, built mainly by France's Thomson-CSF, has broken down despite thousands of hours of ground-testing on nine similar units. Thomson-CSF technicians are running new laboratory tests in a bid to get the unit back in operation. **Meantime, a back-up onboard oscillator is handling the sound and video signals, said to be of first quality.**

After several months of exhaustive tests and experiments, the Symphonie link is to transmit demonstration programs on German and French television channels. **Later in the five-year program, the satellite will start linking up with far-flung ground stations in Canada, Africa, and the West Indies.**

Symphonie was launched into its position just under the belly of Africa by a U.S. Thor-Delta rocket, **but launch of another French satellite, a smaller vehicle named Starlette, has been set back by more trouble with France's own Diamant BP-4 launcher.**

Japan suffers first decline in VTR sales

Sales of video-tape recorders in Japan are expected to decline for the first time in 1974. The Electronic Industries Association of Japan says that production during the first 10 months was 106,145, or 90.8% of the output for the same period a year ago. **The primary reason appears to be the large fall in exports, especially to the U.S., which accounts for 90% or more of the export market.** U.S. imports during the first nine months of 1974 were 23,680 units, a 63% decrease from the 1973 level, Japanese sources say. **One cause is poor business conditions in the U.S.**

British scholars urged to shift research thrust

Too much telecommunications research is being performed by British universities on propagation and transmission at the expense of detailed systems studies, concludes a special panel of the Science Research Council. In recommending that the SRC begin a progressive re-emphasis of funding policies toward more interdisciplinary research, the panel suggests such systems studies as new methods of multiplexing, speech behavior, communications in developing countries, the merits of cable television, topographical analysis, synthesis of communications networks, and computer control of switched networks. **Research grants from SRC telecommunications total about $735,000 of its 1974 budget of $3.1 million for electrical and systems engineering.**

Solartron launches digital voltmeters in European market

The European competition for the digital voltmeter market is going to heat up if Solarton Ltd. of Schlumberger International has its way. Aiming at John Fluke Manufacturing Co. and Hewlett-Packard Co. of the U.S., the company is introducing on Feb. 1 two new bench-type DVMs built with p-channel MOS LSI circuitry. **Price of the 5½-digit 7050 will be about $1,100 and the 4½-digit 7140, about $800, less than comparable models by Fluke, the company claims.** Both models measure dc and ac voltages, resistance, and current. They also provide floating input and excellent interference rejection. **The company now claims 70% of the UK market and hopes to increase its 25% slice on the continent.**

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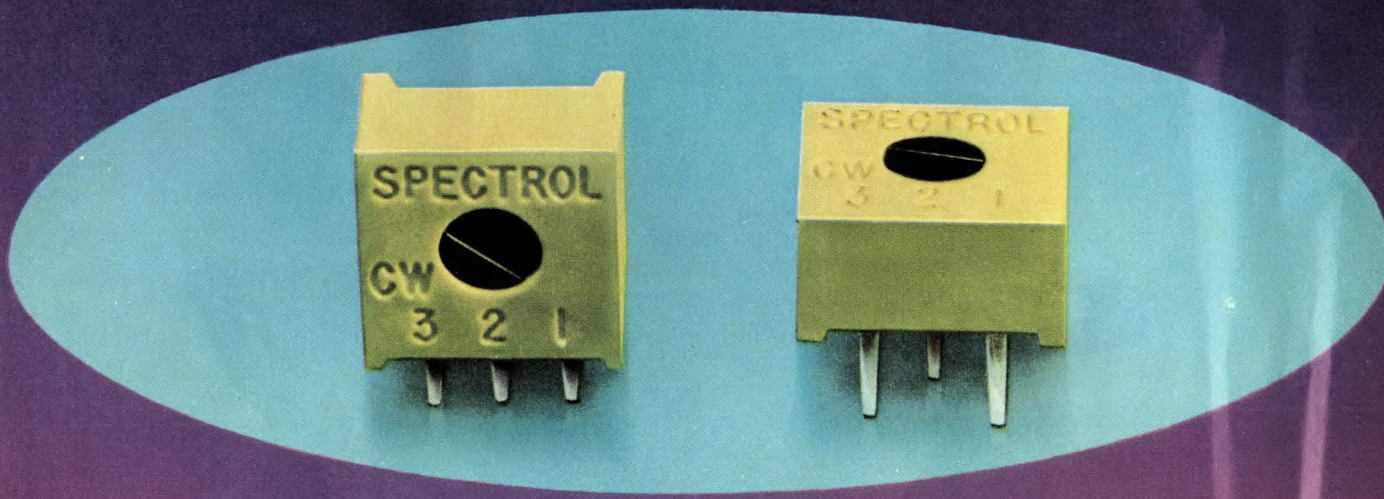

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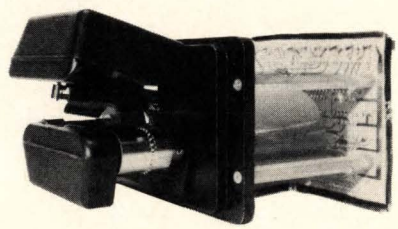

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Memories

Floppy disks spin into systems

Two years after their first use by IBM as data-entry devices, they're in new System/32 and three DEC mini-based units

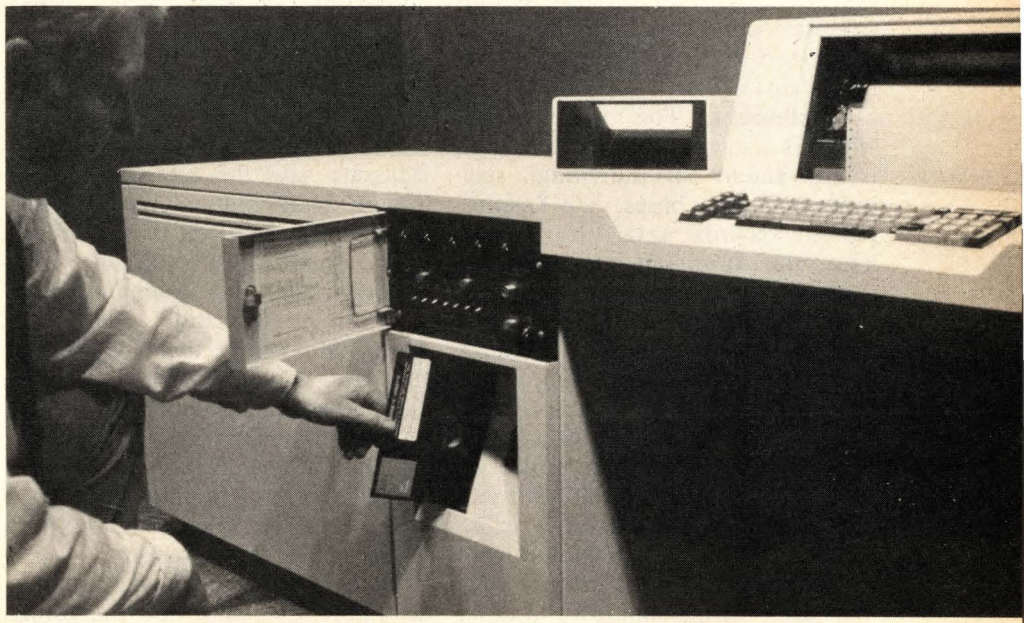
by Paul Franson, Los Angeles bureau manager

After drifting for four years, the floppy-disk memory finally seems to be making its mark. International Business Machines Corp. developed the medium, and its use in IBM's new small System/32 computer (see p. 38) blesses the floppy disk for mass storage. Other major firms are also jumping on the bandwagon; floppy disks are used in the Burroughs Corp. recently announced S1000 document encoder/sorter, and Digital Equipment Corp. has announced three minicomputer-based systems that use floppy disks.

All this activity should make the disk-drive makers healthy and happy. Unfortunately, most are still waiting for substantial orders for their systems.

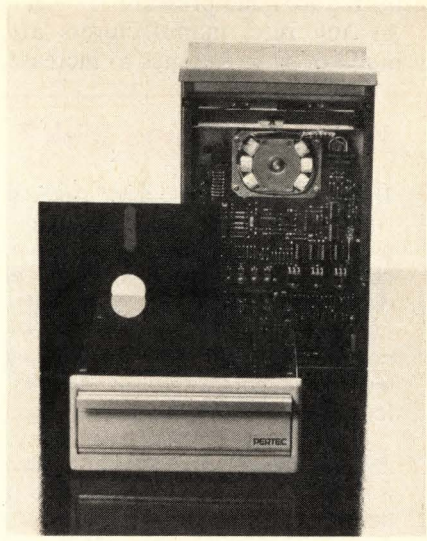
John Ring, president of Orbis Systems Inc., Costa Mesa, Calif. laments, "The contracts are just dragging out. The product is being evaluated to death—it will be better proven than any product in history." Charles A. Dickinson, general manager of Control Data Corp.'s Hawthorne, Calif., Memory Products division, agrees. He comments that general use of the floppy disk is spreading much more slowly than most manufacturers had anticipated. His firm, like most, is running behind initial forecasts, and he doesn't foresee big sales in 1975.

Donald E. Taylor, disk-product manager at Pertec Corp., Chatsworth, Calif., says volume orders are still six to nine months in the future. Dickinson says that the industry shipped about 17,000 units in 1974 for about $6.5 million, and "we think we're competing for about 40,000 units—$15.5 million to $16 million—in 1975."



When IBM developed floppy disks in 1970, they were intended for loading programs into the big 3330 disk drive. Then IBM two years ago set the standard for floppy disks in data-entry systems with its model 3740. Of the floppy-disk systems shipped in 1974 by other makers, only 6,000 or 7,000 were compatible with that 3740 standard, "but we feel the non-IBM-compatible market is destined to dry up," says Dickinson.

Innovex Inc. in Bedford, Mass., which brought out its first system at about the same time IBM did in 1970, feels the mix will be half IBM-compatible, but rising. For example, only 5,000 noncompatible systems are expected to be shipped this year—most of them by Memorex Corp. of Sunnyvale, Calif. By 1980, however, Dickinson predicts that the world market will take 50,000 to



In and out. Top picture shows floppy disk or diskette, being inserted in IBM's new small computer, System/32. System above is from Pertec, which feels that volume orders for floppy disk memories are still six to nine months away.

300,000 units per year, worth a total of about $75 million.

The drives now sell for $600 to $750 in single quantity, but large quantity prices drop to $400 or less. These figures should be halved when producers begin true volume production. The floppy-disk controllers, however, can cost as much or more. This situation should change in mid-1975 when such manufacturers as Motorola Semiconductor and Rockwell Microelectronics introduce single-chip semiconductor formatters designed for use with the floppy disks.

Capabilities. The floppy disk, which is also easy to store and mail, is convenient for individual, self-contained data bases, like hospital patient records, says Victor Poor, R&D vice president at Datapoint Corp., San Antonio, Texas.

The main disadvantage of floppy disks is that they are more limited in capacity than other recording media, but in most of the prospective small-scale applications, this isn't a serious problem. However, the life expectancy of the head and disk is a greater objection, because the head is actually in contact with the disk as it spins. Pertec disengages it during standby and other firms reduce head pressure.

At any rate, manufacturers are using various techniques to increase life. Likewise, a number of manufacturers such as Control Data Corp., Hawthorne, Calif., and Pertec Corp., Los Angeles, are going to longer-life ceramic-ferrite heads. Even with a conventional head, they are claiming life at 10,000 hours and more. Joel H. Levine, marketing manager at California Computer Products Inc., Anaheim, Calif., says, "We promise 10,000, but we're getting 30,000."

Marketers. Memorex has probably delivered the most drives, and its spinoff, Shugart Associates, appears to be the leader in the faster-growing IBM-compatible market. Shugart claims to have delivered 5,000 units, more than half of them IBM-compatible, and shipments are now 700 a month. President Donald Massaro says the company is supplying Datapoint, Sperry Univac, Four-Phase Systems of Cupertino, Calif., three divisions of Litton Industries; Modular Computer Corp. of Fort Lauderdale, Fla., RCA Corp.; Storage Technology Corp. of Boulder, Colo., Prime Computer Corp. of Framingham, Mass., Compugraphics of Boston, Docutel Corp. of Dallas, and National Semiconductor Corp. of Santa Clara, Calif. for use in the microcomputer-programing aids it sells to users.

In second place behind Shugart is probably Calcomp, and marketing manager Levine claims to be shipping 300 to 400 drives per month. Calcomp, which is supplying Computer Automation Inc. of Irvine, Calif., and Diva Inc., Eatontown, N.J., is believed to be one of DEC's suppliers. Other suppliers are Orbis Systems Inc., a spinoff from Calcomp when its disk group was called Century Data Systems. Orbis, in Costa Mesa, Calif., has ties with Britain's Data Recording Instruments Co., and Japan's Yaskawa Electric. Orbis also sells to Remex of Santa Ana, Calif., on an OEM basis, and has a contract for 4,000 units.

Control Data supplies NCR Corp., and Pertec is aggressively marketing its minimum-cost, minimum-size unit and has received a contract from Advanced Electronics Design Inc., Sunnyvale, and a few smaller orders.

Applications. The major use of floppy disks—thanks to IBM—is in data-entry systems, but intelligent terminals and remote-batch applications are not far behind. However, by 1980, predicts Venture Development Corp., a Wellesley, Mass., research firm, terminals will account for 23% of the total; data-entry and point-of-sale systems, 15% each; and peripherals for small computer systems 13%. Fewer will be used with programable calculators and in word-processing, control, and test systems, in addition to the original use as a program loader.

Manufacturers agree that both the sluggish economy and lack of acceptance by users have held back the flexible disks. For example, DEC, the largest minicomputer manufacturer, waited for a product that lives up to its expectations. Now, Robert W. Puffer, vice president of hardware development, says that during the past year, DEC has changed its attitude and is convinced that the floppy disk will be important as a data-entry device.

Another peripherals firm, Datapoint Corp., emphasizes a major advantage—the compatibility forced on the industry by IBM's *de facto* standard. Datapoint's Poor says: "It's intrinsically an interchange medium, and we'd adopt alternate technologies only if IBM accepted them first. Any other alternative would be like coming out with punched cards with triangular holes—you'd never be able to sell them." □

What's a floppy disk?

The floppy disk—variously called diskette, flexible disk, or minidisk by those who think "floppy" sounds frivolous or worse—is in effect, a large, round piece of magnetic tape. It is an oxide-coated Mylar disk, looking much like a flexible 45-revolution-per-minute phonograph record. It's 7.8 inches in diameter, and 0.005 in. thick, with a 1.5-in. hole in the center. The disk is contained in a flexible plastic envelope 8 in. square and 1/16 in. thick. It's coated on the inside with a soft material that permits easy rotation of the disk inside the envelope at 360-rpm. A slot in the envelope provides access for the read-write head to the disk surface.

A single floppy disk holds about 3.1 million unformatted bits—roughly 250,000 bytes in the standard format. The data is recorded on 77 tracks at a maximum density of 3,200 bits per inch on the inside track, and track density is 48 per inch. Transfer rate is 250 kilohertz. Any point of the disk can be randomly accessed in less than a second, a compelling advantage over any tape format, including cassettes, reels, or cartridges. Although early disks were not uniform in format, virtually all manufacturers are now concentrating on the standard IBM adopted for its 3740 data-entry system. Dual-density, hard-sectoring, and other upgrading techniques are waiting in the wings for noncompatible systems.

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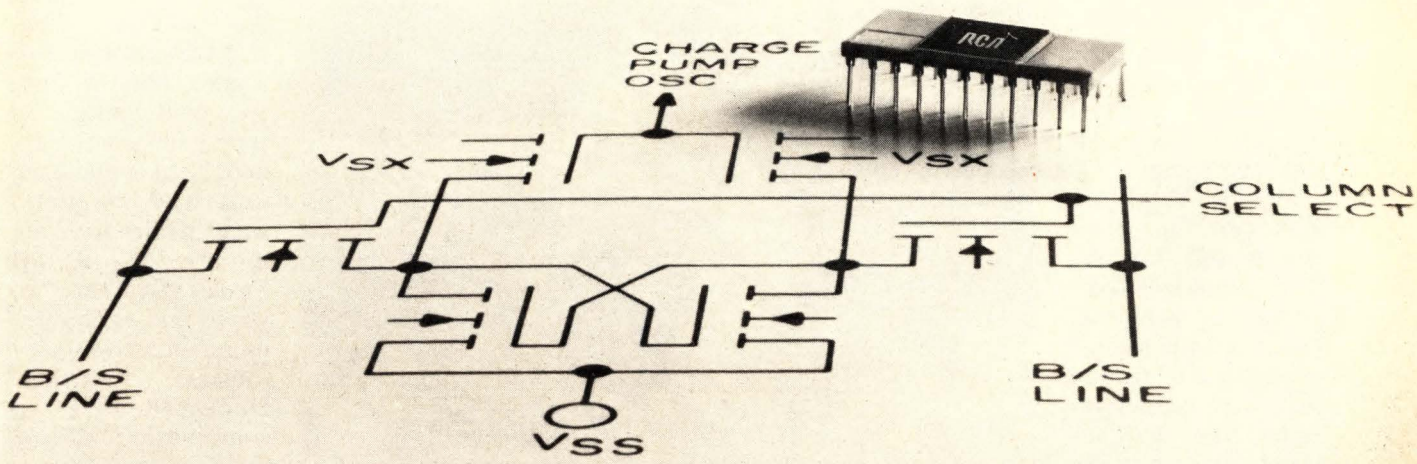

RCA. The first house in CMOS moves into memories.

Commercial electronics

POS marking stirs indecision

Since picking OCR-A as merchandise-tag format, retailers have caught point-of-sale equipment makers on horns of dilemma

by Gerald M. Walker, Associate Editor

There's a new standard marking system for merchandise tags in retail stores, but point-of-sale hardware manufacturers are finding that their customers have mixed reactions about using it. The result is a continuation—for now at least—of the splintered market: POS systems that can operate with the new standard OCR-A system, magnetic-stripe encoding, optical color bars, or no ticket-reading wand at all.

The National Retail Merchants Association adopted the standard for machine-readable systems last fall and is now strongly urging members to comply, but acceptance has been slow. Part of the reason is that it took something like four years to decide on the standard, and some retailers chose other marking types in the meantime.

Another problem is that full acceptance of the standard also depends on suppliers marking goods at the source. To date, only about 200 of the thousands of suppliers to department stores, specialty shops, clothing stores, and the like have begun putting OCR-A (for optical-character-reader font A) tickets on their merchandise before shipping.

Finally, there are still some important details left for the NRMA standards committees to wrap up. The most important is to establish a function code and format to interface with the Universal Product Code for symbols adopted by the supermarkets. This would permit a common marking program for the many products now sold in both grocery chains and retail stores. It could mean machine-readable tags in optical format for virtually all goods sold to consumers. And that, in turn, could force credit cards, currently using magnetic stripe, to be converted to OCR as well.

Struggle ahead. These possibilities are still a long way off, and they will not take place without a struggle that will involve the many links in the merchandising and credit-purchasing chain. In fact, some of the strain in promulgating the OCR-A standard showed at the recent NRMA convention in New York. There, leaders of the standards task forces brought their inspirational show into town and made telling points about the benefits of the format that they helped design (See "Why OCR for retailers?" p. 65).

Retailers express a range of responses, well summarized by one vice president of operations who remarks, "As you know, department-store managers like to do things their own way, so don't expect 100% cooperation."

Caught in the middle, the POS-hardware producers have taken various positions. NCR Corp., which has its own two-color bar-code marking system, also has an OCR-A hand-held wand scanner available. Should the tide turn toward the new standard, NCR can retrofit the wand to its 280 POS terminals with a simple field change of one read-only-memory circuit.

Singer Business Machines division has also displayed an OCR-A wand, but has stated for some time that it can supply any scanner required. A buffer board installed in the terminals makes it possible to hook up either OCR or magnetic wands without a retrofit alteration.

Independence. IBM Corp., on the other hand, is sticking to a statement released last October concerning OCR. At that time, IBM said, in effect, that the new standard is nice, but the company will continue to supply its own magnetic ticket-encoding unit and magnetic wand reader with the model 3650 Retail Stores System "to serve the varied requirements of our customers." Further, Unitote/Regitel, a combination owned by General Instrument Corp., has a

Light touch. Wand from Recognition Equipment Inc. includes features from company's systems manufactured for banks and the postal service.

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RCA Solid State

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wand of its own that has a light-emitting-diode array to read round holes in the tags. The firm is not yet showing an OCR wand. Sweda International, originally a backer of magnetic wands, is now set to provide either type, though it's not demonstrating a wand.

TRW Data Systems, which has taken over the future development and marketing of a POS system originally developed by and for the May Co. department store chain, is studying the situation. W. Bruce Walker, director of new-product development for TRW's Transaction Data Systems, who is credited with the original design, says the May stores approach to the Mark 2000 terminals excluded a wand reader. The preference from the beginning was for key-entry of tag data. Now, says Walker, TRW may want to design and build its own OCR wand or else buy one from an OEM supplier.

The two OEM suppliers that stand to benefit immediately from a switch to OCR-wand readers are Recognition Equipment Inc., Dallas, and Data Source Corp., El Segundo, Calif. Data Source, a subsidiary of Hercules Inc., has entered the data-capture market with a credit-authorization terminal capable of reading embossed numbers, magnetic stripe, and OCR-A through a hand-held wand. The wand uses a fiber-optic reader with speed quoted at 0.5 to 15 inches per second at a tilt up to 10° in any direction from the surface. This wand is available for POS terminals.

Microprocessor used. Recognition Equipment has been marketing OCR reading equipment since 1963. Much of the same technology used in making machines for banks and the postal service has gone into the company's wand, such as an amplitude correlator that uses MOS and the analysis-recognition and context-editing functions by means of an MOS microprocessor.

The read head contains two low-voltage lamps to illuminate the characters and a lens to transmit the image to an MOS LSI self-scanned 12-by-38-element imaging array. A hybrid amplifier then transmits the sensor's analog output to a processing module.

Recognition Equipment has signed agreements to supply both NCR and Singer. But, Gary F. Hall, OCR Wand division manager, surmises that other competitors will probably begin moving into the OCR-wand field as demand increases. "POS-systems companies may want to design their own wands," he remarks, "but it's not as easy as it seems. We're depending on our experience and previous investments in product development to stay in the lead." □

Why OCR for retailers?

Since announcing the OCR-A merchandise identification standard, members of the NRMA's Systems Specification Working Committee have toured the country to promote the idea among influential retailers. As for the advantages of OCR, Hans Rubner, chairman of the merchandise identification task force and program manager, corporate systems, for Montgomery Ward & Co., lists reasonable ticket size, no need for dual encoding (alphanumeric and another code on the same ticket), low-cost ticket-marking at any location, readily available marking equipment, easy alterability of tickets at the store, and compatibility with the grocery industry's Universal Product Code.

In listing the advantages of having suppliers mark OCR tags, Norman Weiser, chairman of source mark task force and vice president of John Shillito Co., reveals results of an experiment at his stores. With 100% source-marking of some 7,000 units the store realized a 51% savings in labor—equal to about $213,000. In addition, many vendors are already source-marking products, but not in machine-readable format; therefore, a changeover means a lot lower investment for manufacturers to provide the OCR tickets.

Both the Toy Manufacturers Association and the American Textile Manufacturers Institute have made initial inquiries about cooperating with OCR source marking, Weiser reports.

Solid state

How much will SOS help?

High-volume producers of semiconductors are beginning to close gap in performance between sapphire and bulk-silicon devices

by Howard Wolff, Associate Editor

Time is running out on the chances of silicon on sapphire to become the next high-volume technology for digital circuits. Once considered the thin-film technique that would supplant bulk silicon, SOS may have to be content in a niche reserved for special applications such as military systems and in-house process control.

In recent months, a number of volume metal-oxide-semiconductor manufacturers—all of them using n-channel processes—have downgraded SOS as a way to turn out digital circuits in volume. The reason: they have found ways to improve the performance of bulk-silicon devices.

These houses, among them Texas Instruments, Motorola Semiconductor, Fairchild Semiconductor, and Intel, have narrowed the performance gap between devices of bulk silicon and those of SOS enough to make the extra cost of SOS devices less worthwhile. And they have done the job with standard materials and processes like ion-implantation (to build depletion modes) and silicon-gate (to build small circuits). SOS devices now cost three to five times more than bulk-silicon devices, a figure that could be pushed down by volume production, but no volume producer is planning a general line of SOS devices at this time.

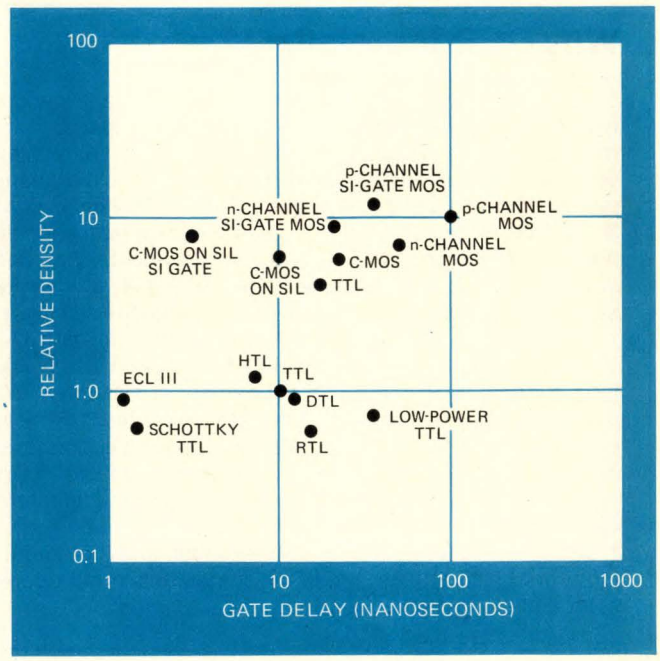
Still, there is a good deal of interest in SOS among complementary-MOS houses such as RCA, Inselek Corp., and Solid State Scientific Inc. That's because the biggest advantage of SOS is that it enhances the performance of C-MOS. Although the biggest factor in favor of C-MOS is that it consumes little power, it is also slow and requires relatively large real estate. But C-MOS on sapphire is faster and smaller than plain C-MOS, meaning that sapphire turns C-MOS into an LSI technology. However, the recent decision by Rockwell International Corp.'s Microelectronic Device division to drop most of its commercial SOS work [*Electronics*, Dec. 26, 1974, p. 23] tends to bolster the opinion in some quarters that n-channel MOS on sapphire isn't the way to go.

Advocate. But Joseph R. Burns, president of Inselek Corp. in Princeton, N.J., says he feels that the customer for Rockwell's SOS—General Automation Inc. in Anaheim, Calif.—promoted SOS devices too heavily and too soon. General Automation, which now has no supplier for the n-channel microprocessor that was to serve as the single-chip central processor in its LSI-12 microcomputer, "had a tremendous PR campaign going," says Burns, "it was completely out of proportion. The real story is that Rockwell was turning out one circuit a week."

Inselek, which had agreed with Rockwell to jointly develop SOS products and second-source each other, will pick up where Rockwell left off, says Burns. The company now has 35 standard products for sale in both memory and high-speed devices—all pin-to-pin compatible with RCA's 4000 series.

And RCA is forging ahead. Henry Miiller, director of MOS and memory products at the Solid State division in Somerville, N.J., says, "SOS pays off when you have high gate-to-pin ratios." Miiller foresees applications in arithmetic units, parity networks, multipliers, counters, programable logic arrays, and memories. He says RCA plans to introduce a series of self-aligning MOS-on-sapphire circuits in produc-

In place. On paper, C-MOS on sapphire scores high. But makers think they can close gap with standards in next LSI generation.



tion quantities during the second half of the year. Beyond 1975, RCA is looking at SOS versions of presettable binary-coded decimal up-down counters, a presettable binary up-down counter, and a crosspoint switch.

Another East Coast firm, Solid State Scientific of Montgomeryville, Pa., "is not going across the board with the 4000 series as Inselek seems to be doing," says Walter Kalin, C-MOS marketing manager. "We're selecting those SOS products that primarily offer speed as an advantage over conventional MOS."

Also, says Kalin, "We think SOS has an appeal in the very large circuits, but you don't start out big and work down in this business. We're trying to develop a process that doesn't have a cost penalty built into it." Kalin says he believes that a 10% to 20% add-on cost margin for SOS is commercially acceptable for the advantages it brings to the product. "We feel that for a $9 RAM to go to $10 in an SOS version would be acceptable."

Moving west, the optimism drops away. Texas Instruments does not believe that SOS is a strong candidate now to replace bipolar or MOS. However, TI concedes that the technology may find some special niches—military uses, for example, in hardened circuits. Though conceding that SOS has a favorable speed-power product, high performance, and bipolar-compatiblity, TI believes that's only true when the equipment isn't run all the time at maximum speed, a unique requirement most often found in military circuits.

Intel waits. Intel, in Santa Clara, Calif., doesn't have any SOS-product plans now, which indicates "in a way that we don't believe it is a viable production technology at this point in time," says Leslie Vadasz, director of engineering. One factor governing whether or not it ever will be, says Vadasz, is "how fast n-channel MOS improves in performance by the time SOS has reached the point on the learning curve where it is producibly cost-effective and competitive. It also depends on how much improvement can be made in the SOS performance specs."

But SOS has several desirable features for the designer, he says. Higher density circuits with higher performance and excellent isolation characteristics may be designed.

"All you have to do is etch away silicon where you don't want it, or use oxide isolation. In addition, it has very low parasitic capacitances," says Vadasz.

One possible application when SOS cost comes down, adds Vadasz, is in watch circuits. "The power-speed tradeoffs are better for SOS than for C-MOS, resulting in better high-frequency, low-power circuits. But, frankly, none of these advantages are enough to offset the prohibitive costs of SOS technology right now."

Jerry Larkin, National Semiconductor's memory-product marketing manager, points out: "The recession certainly hasn't helped SOS. The kinds of things which get cut back in times like these are those programs which address the farther-out 10% of the market, rather than the mainstream. And SOS certainly isn't in the mainstream."

Amid the talk of finding a special place for SOS, at least one company has found that place—Hewlett-Packard Co. of Palo Alto, Calif. H-P decided it had special needs that could be filled best by SOS devices, so it made what Larry Lopp, integrated-circuit lab manager at the Computer Systems group, terms some "rather large commitments." The result is that H-P now has facilities "in the development mode" dedicated to C-MOS on sapphire.

His company's needs are different from those of semiconductor makers, points out Lopp. "We see SOS as the technology to provide us with the kind of capacity we need in our equipment," particularly computers. Lopp lists three major advantages of SOS:

- It is fast; propagation delay is 1 to 4 nanoseconds.
- It requires so little power that in standby the drain is "essentially zero." This, as even those who are cool to the technology agree, is an important advantage in very large-scale integration.
- Processing, says Lopp, is "very similar" to that of silicon without many production problems. □

Companies

IBM beefs up staff in Europe

Personnel are shifted from New York to new Paris organization to eliminate layer of management, placate governments

by Michael Johnson, McGraw-Hill World News

As International Business Machines Corp. prepares to fend off the U.S. Justice Department's antitrust suit next month, the computer giant is already moving cautiously toward breaking up its foreign operations into more autonomous parts.

About 160 IBM professionals have been quietly moved from the New York area to Paris since the summer, and another 250 are being shifted from posts around the world to join them in the new regional headquarters, IBM World Trade Europe/Middle East/Africa, called EMA by the company. A smaller parallel company is responsible for Canada, Latin America, and the Far East, but IBM Corp. will continue to handle the U.S. market.

The new Paris-based EMA group, headed by chairman and chief executive officer Jacques Maisonrouge, was created on paper last April, but only now is it becoming fully operational. Not surprisingly, top executives, fresh from New York, enthusiastically back the move toward greater independence for international operations.

Frank Cummiskey, president of the EMA superstructure, says one of the biggest gains is the elimination of the "Tinker-to-Evers-to-Chance style of doing business with headquarters." In effect, the new system eliminates one layer of management, IBM World Trade Corp. in New York.

Timing. But outside observers are intrigued by the timing of the decentralization. IBM's domination of computer markets is under fire, not only in the United States, but in Europe, too—at the Common Market Commission in Brussels. In addition, European governments are growing more and more feisty about seeing locally implanted multinationals in all industries obey faceless masters in New York City, Los Angeles, or Armonk, N.Y.

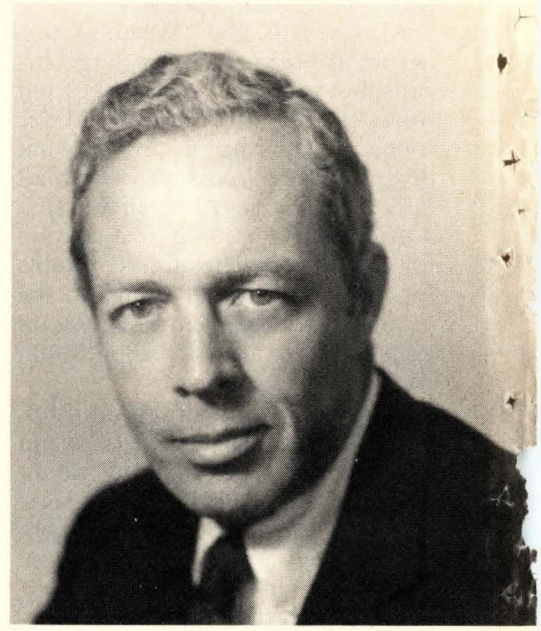
IBM's decision to shift major centers of gravity to Paris may help calm some of those fears. Certainly, the local governments are pleased to see an operation based in Europe also exert control over Middle East and African personnel, marketing strategy, and product-line management. Indeed, even one full-time IBM-watcher at a major European competitor grudgingly acknowledges, "They've greatly improved their local standing."

To be sure, IBM is not spinning off its international activities entirely. The European market alone is a major money-maker, accounting for 35% of consolidated sales. And to make sure the worldwide operations remain cohesive, product development will remain tightly centralized in the U.S. Moreover, all major decisions will still have to pass through the board of directors in Armonk.

The advantages come in expediting problems that traditionally have required four levels of approval, often accompanied by weeks of agonizing analysis at each level.

Streamlining. "We've managed to deal with size," says Cummiskey. "We have eliminated that [New York] headquarters step that in some cases was duplicative." But more important, Cummiskey considers the shift "further recognition that Europe makes a significant contribution to the profit of the corporation."

In organizational terms, the new system has reduced IBM World Trade Corp. to a holding company and merged its decision-making power with that of the old IBM-Europe organization, which now acts on behalf of EMA as the superstructure for the national subsidiaries and branches. Also, the resulting transfer of personnel to Paris is putting some international computer types in direct touch with their market for the first time.



New chief. Frank Cummiskey heads IBM World Trade Europe/Middle East/Africa.

The payoff comes quickly. "We get a lot closer look, in real time, at what the product problems and successes are," says Malcolm Robinson, head of product-line management in Paris.

"There are significant differences in the kinds of computation and information-processing between Europe and the United States. The

way we tailor our equipment is important, and we've been doing it remotely from New York until now," he says.

Labor. Perhaps the most rapidly changing factor for the new EMA system to cope with is European labor relations. Trends unknown in the United States—such as the strong worker voice in management, protection against inflation and unemployment, and the welfare-oriented history of European labor—had gone down hard with IBM's austere personnel experts.

"I'm constantly amazed at what I'm learning about the French," says newly arrived Norman Haddad, director of compensation and benefits at the Paris headquarters. "Being here, you get a much better feel for employees' thought processes. For one thing, their outlook on compensation is completely different." Haddad, who formerly did about the same job in New York, notes that Europeans feel they have a right to maintain their purchasing power and a "right to a piece of the action."

In the previous organization, IBM had been at pains to adapt quickly to local subsidiary demands that clashed with the corporation's tough-minded personnel philosophy. "Now I interface directly with the countries," Haddad says. "Sitting in New York, no matter how many reviews you read, you can't fully understand."

Specifically, the company has enhanced its ability to deal with sudden personnel requirements, which sometimes can be "completely foreign to the American environment," he says. Maisonrouge now has the power to grant final approval to any benefit plan that does not represent a precedent; the old chain of command would have required transatlantic negotiation between Paris and World Trade Corp.—after the proposal had cleared personnel analysts at IBM-Europe in Paris.

For Cummiskey and Maisonrouge, the transfer of power to Paris has an additional practical payoff. Last year, each made about 15 flights from Paris to New York for meetings at headquarters. This year, they hope to cut that travel bill in half. □

Education

Kit offers instant insights

Developed by Virginia Tech and breadboard maker, equipment allows students to work with LED display and ICs the first day.

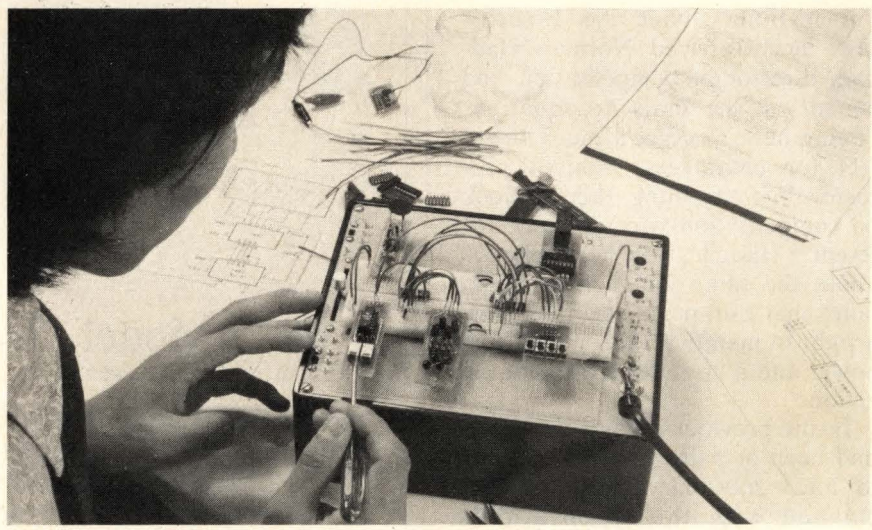
A relatively simple and inexpensive system that leapfrogs some of the traditional methods of teaching electronics has been developed by a university in Virginia with hardware built by a Connecticut breadboard maker.

The system, developed at Virginia Polytechnic Institute and State University, Blacksburg, is built by E&L Instruments Inc. of Derby, Conn. With it, students can gain first-hand experience with ICs and seven-segment displays at the very start of the course.

The one-year course was developed, oddly enough, by members of the chemical and chemical engineering faculties at Virginia Tech, Peter R. Rony and David G. Larsen. They explain their involvement by pointing out that electronics has become a vital component of both disciplines.

Their idea was to eliminate the protracted and often dull traditional approach and bring their students face-to-face with ICs and seven-segment displays on the first day. They say that digital electronics is much easier to understand than analog electronics, and that the seven-segment display is an effective teaching tool, which, much like the more traditional oscilloscope, enables the student to grasp key concepts.

Says Larsen, "We encourage a student to use manufacturers' specifications for the various IC devices, making him self-sufficient right at the start in creating digital circuits. Later on, he may return to the fundamentals of electronics—such as transistor and diode theory—and build a strong base."



Putting it all together. Student at Virginia Tech works with hardware designed to give him instant feeling for work with ICs, light-emitting-diode displays, other digital circuitry.

The heart of the $247.70-breadboard system is E&L's SK-10 socket. It mounts 840 spring contacts with an expected life of 10,000 wire inserts apiece. A student simply plugs ICs directly into the sockets and interconnects them point to point by pushing wires into contacts.

Novel parts of the system are the outboards. These are preassembled modules with prepackaged functions, such as logic switches, light-emitting-diode displays that include a 7447 decoder-driver, and a clock whose frequency range can be adjusted from 30 kilohertz to 1 megahertz. Plugged in along the periphery of the socket, these outboards give the student the feel for the subsystem concept.

Two textbooks accompany the course, which is aimed at the student with little or no knowledge of electronics. A third text, due in May with accompanying hardware, will cover microcomputers, while a fourth, probably coming in May also, covers interfacing and data transmission. These will expand the course to two years.

More sales. Since Virginia Tech and E&L got together, community colleges and some manufacturers like IBM have become customers.

E&L was preceded in the educational field by Hewlett-Packard Co.'s 5035T Logic Lab, a more complex arrangement that sells for $695 with a logic probe, logic pulser, and logic clip, plus a LED display, mainframe, and breadboard. The H-P mainframe and breadboard are for sale separately for $345. It also contains prestripped wires and solderless connectors, and handles everything from basic gates to random-access and read-only memories. H-P's Bruce Hanson, product manager, says most sales are to industry, but that Yale and Ohio State Universities are using the 5035T. □

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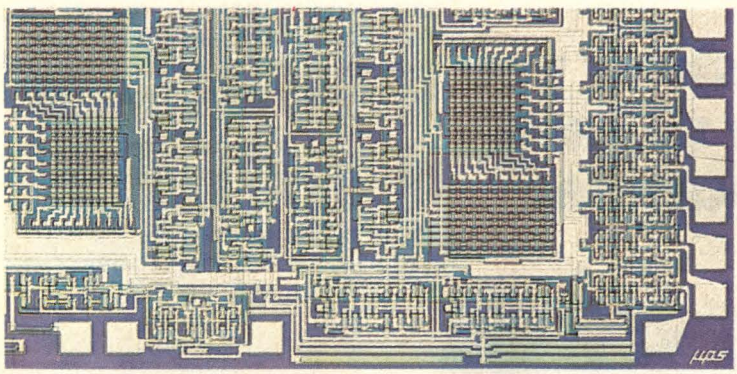

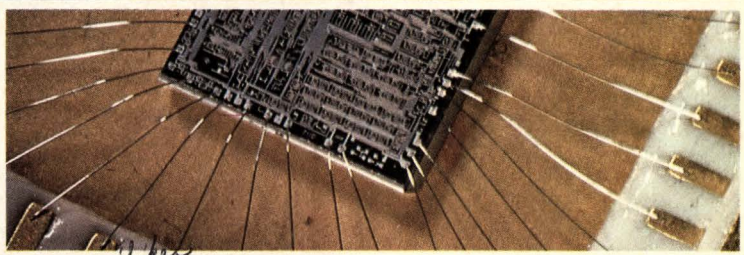

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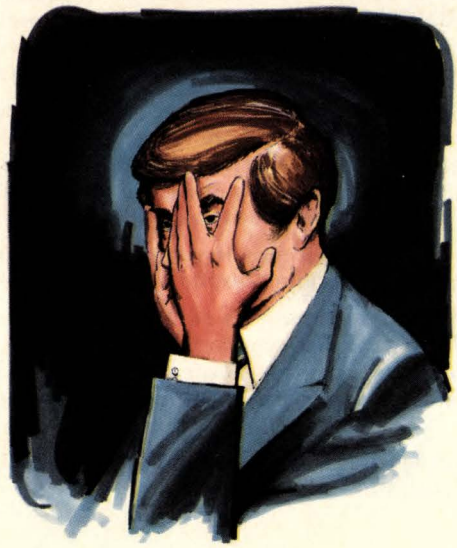

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The case for component burn-in: the gain is well worth the price

Besides significantly increasing systems reliability, component burn-in can give substantial cost savings to the systems builder, as it greatly reduces the need for reworking and field repair

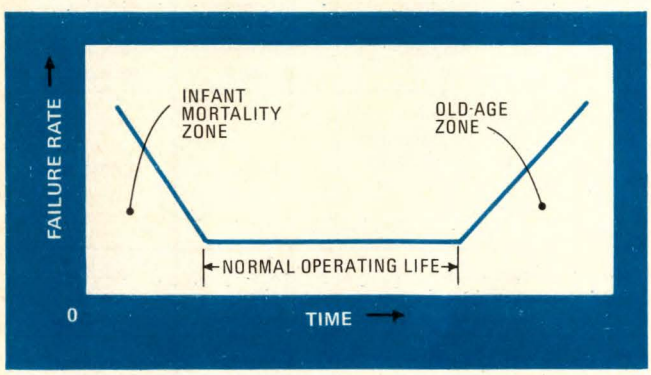
by J. Albert Loranger Jr., *Loranger Manufacturing Corp., Warren, Pa.*

☐ An electronic device will most likely fail in the early hours of its life, if it is going to fail at all. That's the basis for the concept of burn-in, which can be used to precondition all types of components, particularly semiconductors, whether commercial or military grade. Yet, even in today's sophisticated world of electronics, component burn-in is not universally practiced, nor is it necessarily done in any standard way.

Burn-in, in effect, accelerates the aging of a device. The component is baked at an elevated temperature for so many hours, generally with an appropriate dc power-supply voltage applied. Component failure rate is most severe during the infancy of a device, as shown in Fig. 1. The failure rate then levels off throughout the device's normal life and again increases when the device becomes old.

With burn-in, components are aged beyond their infant-mortality-life stage. The devices that survive burn-in, therefore, should have very low and steady failure rates, making the system using them highly reliable.

Needless to say, burn-in is only as good as the electrical testing done afterwards. Such testing must be thorough and meaningful if burn-in is to be effective. Also, the conditions under which burn-in is run must approximate the operating mode of the system that is being built.



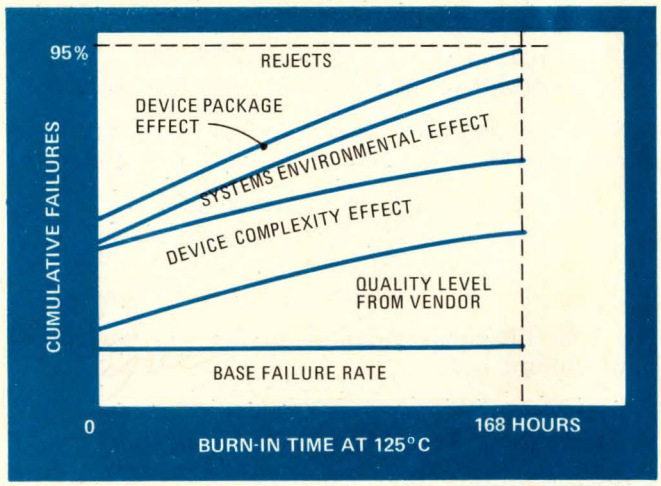
1. Component life. Failure rate is highest during the early life of a device. With burn-in, components are deliberately aged, or matured, so that most time-related "infant" mortalities can be weeded out. The failure rate levels off through a device's normal operating life and then increases again when the device grows old.

Although burn-in adds to the price of a component, it can pay off in the long run by saving the component's user quite a bit of money in other cost areas. Measurable cost savings come from a significant reduction in reworking and field repair. Then there are intangible factors, such as a good company reputation and satisfied customers, which cannot be measured in terms of dollars.

Component burn-in can be done in-house, with the systems builder buying and running his own burn-in equipment, or he can pay an outside testing facility to do it. A third alternative is to pay a premium to the component supplier for a burn-in test. It's up to the systems builder to decide which approach, if any, best suits his needs.

The measurable cost advantages of burn-in can be illustrated by developing a generalized systems model. Such a model will enable the systems builder to determine for himself whether or not component burn-in is worthwhile for him.

Figure 2 shows how an electronic device accumulates failures as a function of time. The total number of failures depends on a base failure rate, the quality control



2. Failures add up. Components are subject to a number of failure modes. For a given population, these failure modes cause cumulative device rejects. Burn-in can catch at least 95% of the weak devices before they become part of an assembly and are hard to find.

at the manufacturing level, the complexity of the device, the environment in which the device is used, and how the device is packaged. Other parameters, such as variations in processing and the temperature of the environment, also influence the aggregate failure rate.

Therefore, the following cost analysis will consider both an appreciable-failure model and a minimal-failure model to cover the full range of possible circumstances. Table 1 shows the general approximations that can be made for these two models. In each case, the hypothetical system being considered is regarded to be a single-purpose unit, such as a single circuit board, a single computer, or a single missile.

For M systems, the rework cost is:

rework cost = (probable number of systems requiring rework) × (M systems) × (cost per incident)

For 1,000 systems using the minimal-failure model:

rework cost = 39.3% × 1,000 × $7.50
rework cost = $2,947.50 for 1,000 systems built

For 1,000 systems using the appreciable-failure model:

rework cost = 63.2% × 1,000 × $30
rework cost = $18,960 for 1,000 systems built

The cost of field repair can be determined in a similar manner. Of course, this expense is paid by the systems builder if the systems are leased. Even if the customer owns the systems, the cost of field repair is passed back to the systems builder eventually in free service calls or in lost orders.

For M systems, field repair will cost:

field-repair cost = (probable number of systems requiring repair) × (M systems) × (cost per incident)

For 1,000 systems (minimal-failure model):

field-repair cost = 39.3% × 1,000 × $50
field-repair cost = $19,650 for 1,000 systems built

For 1,000 systems (appreciable-failure model):

field-repair cost = 63.2% × 1,000 × $84
field-repair cost = $53,088 for 1,000 systems built

Now, suppose these systems are built with burned-in devices. For M systems, the total testing cost becomes:

testing cost = [(burn-in cost per device) + (parameter testing cost per device)] × (M systems) × (number of devices per system)

For both the minimal-failure model and the appreciable-failure model:

testing cost = [($0.05) + ($0.01)] × 1,000 × 100
testing cost = $6,000 for 1,000 systems built

When burn-in is done, significant cost savings can be realized for both systems. In either case:

cost savings = (rework cost) + (field-repair cost) − (testing cost)

For the minimal-failure model:

cost savings = $2,947.50 + $19,650 − $6,000
cost savings = $16,597.50 for 1,000 systems built

For the appreciable-failure model:

cost savings = $18,960 + $53,088 − $6,000
cost savings = $66,048 for 1,000 systems built

Obviously, then, proper testing for time-related failures can result in significant savings.

Moreover, this analysis completely ignores the cost of defective devices themselves. Normally, defective units can be returned to the vendor. Or the effect of their cost can be canceled out in the calculation by first adding it to the rework and field-repair costs in the initial computations and then later deducting it from the testing costs.

The expense of incoming inspection has also been neglected. Acceptance testing is intended to discover as many weak devices as soon as possible, before the cost of parameter testing becomes prohibitively large. Burn-in offers a way to catch the most probable failures after incoming inspection, but before further work is added. Furthermore, after burn-in, inexpensive test equipment can still be economically utilized.

Designers will often compensate for time-related failures by including redundant or compensating networks

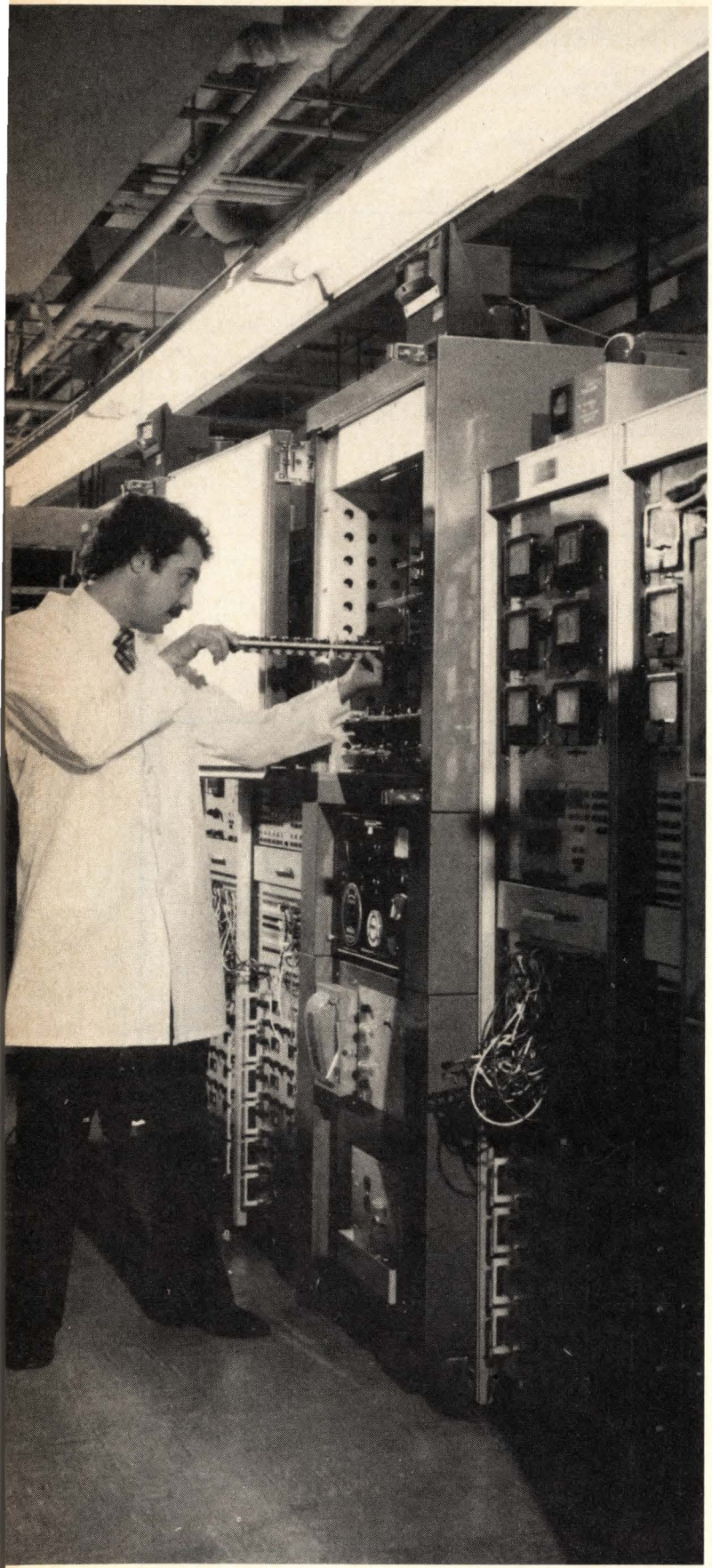
TABLE 1: GENERALIZED SYSTEMS MODELS

Model parameters	Minimal-failure model	Appreciable-failure model
Device type	axial-lead capacitors	dual-in-line ICs
Incoming acceptance quality level from vendor (time zero)	1% per lot	2% per lot
Time-related failures (discovery of weak devices through burn-in)	1% per lot	2% per lot
Number of device types included in each system	100	100
In-plant trouble-shooting and repaid cost per system	$7.50 per incident	$30.00 per incident
Field trouble-shooting and repaid cost per system	$50 per incident	$84.00 per incident
Statistical determination of in-plant rework probability per system based on time-zero acceptance quality levels with 100 devices per system (based on Poisson distribution)	39.3%	63.2%
Burn-in cost per device (see Table 2)	less than 5 cents per device	less than 5 cents per device
Parameter testing cost per device after burn-in	1 cent per device	1 cent per device
Statistically determined probabilities of field repair due to time-related failures (based on Poisson distribution)	39.3%	63.2%

TABLE 2: MODEL* FOR IN-HOUSE BURN-IN COSTS

FIXED EQUIPMENT COSTS	Power Supplies	Total watts = (voltage) X (amperage per device) X (number of devices) Total watts = (5 V) X (0.065 A) X (10,000 devices) Total watts = 3,250 W Needed: five 650-W supplies ($1,095 each) plus one backup supply Total cost = 6 X $1,095 = $6,570	Grand Total $6,570 4,000 5,000 17,895 $33,465
	Ovens	Oven size is determined by the number of devices to be accommodated, the volume of heat to be handled, and the desired burn-in temperature. Needed: one 24-cubic-foot oven with burn-in blower modifications Total cost = $4,000	
	Racks, Connectors, Wiring	Cost of custom-made aluminum pc-board rack = $1,500 Cost of 85 high-temperature connectors = $1,275 Cost of wiring from power supplies to connectors = $2,225 Total cost = $1,500 + $1,275 + $2,225 = $5,000	
	Pc boards, Sockets, Soldering	Cost of 85 double-sided boards (7 in. by 18 in. by 1/16 in.) having plated-through holes = $2,975 Cost of 10,000 burn-in sockets = $12,400 Cost of wave-soldering = $2,520 Total cost = $2,975 + $12,400 + $2,520 = $17,895	
VARIABLE OPERATING COSTS	Power Consumption	Device power = (total supply power) ÷ (supply efficiency) Device power = (6 X 650 W) ÷ 50% = 7.8 kW Oven power = (maximum oven power rating) X (estimated utility) Oven power = (9,800 W) X 50% = 4.9 kW Total maximum cost = [(device power) + (oven power)] X (cost per kilowatt-hour) X (hours per year) Total maximum cost = (7.8 kW + 4.9 kW) X $0.025 X 8,760 h Total maximum cost = $2,781 per year	Grand Total $2,781 4,940 9,880 $17,601 per year
	Direct Labor	Loading cost = [(number of positions to be loaded) ÷ (loading rate)] X (labor rate per hour) X (number of batches per year) Loading cost = (10,000 ÷ 1,500) X $3.00 X 52 batches Loading cost = $1,040 per year Unloading cost = [(number of positions to be unloaded) ÷ (unloading rate)] X (labor rate per hour) X (number of batches per year) Unloading cost = (10,000 ÷ 2,000) X $3.00 X 52 batches Unloading cost = $780 per year Cost of direct supervision by technician = $3,120 per year Total cost = $1,040 + $780 + $3,120 = $4,940 per year	
	Indirect Labor	Cost = (direct labor cost) X (overhead ratio) Total cost = $4,940 X 2.0 = $9,880 per year	
TOTAL BURN-IN COSTS PER DEVICE	Capital Equipment	Cost = [(total equipment cost) ÷ (number of years amortized)] ÷ (number of devices per year) Cost = ($33,465 ÷ 5 years) ÷ (520,000 devices per year) Total cost = $0.0129 per device	Grand Total $0.0129 0.0338 $0.0467 per device
	Variable Operating Costs	Cost = (total variable cost per year) ÷ (number of devices per year) Cost = $17,601 ÷ (520,000 devices per year) Total cost = $0.0338 per device per year	

*Single device is 14-lead dual-in-line package. Equipment burns in (per MIL-STD-883) 10,000 devices at a time. Equipment operates 52 weeks a year. Hand tools are used to load and unload devices.



Setting up. Technician loads component board into burn-in oven at facilities of RCA Solid State Division in Somerville, N.J.

to bypass the weaknesses of components. But this far-too-common practice really ignores the basic problem and tries to catch the horse after he is out of the barn.

Many companies will expend a great deal of effort to weed out time-zero defects—components that are dead on arrival—while they neglect time-related failures, assuming such failures to be the customer's problem. These companies should ask themselves how many times an individual will continue to buy a brand of appliance or automobile if he has experienced major problems with it. Field repair, therefore, is a major cost area that cannot be ignored—and that will reflect back into sales sooner or later.

Additionally, many companies will argue that burn-in should be done at the completed assembly level. Although this approach has value, it does complicate the final assembly checkout with electronic component failures. A final assembly-testing program should only do what the name implies—check out mechanical-assembly quality, which should be mainly a visual check for mechanical defects. Testing the electronics at this point is expensive and time-consuming because the assembly operation has already added significant cost to the components.

The generalized model calculations presented here assume that 100% of the faulty devices are removed from the population by the burn-in and by final component testing. In reality, about 5% of the rejects are not found because of human error and the necessarily practical time limit that must be imposed on burn-in. However, this 95% success figure represents an improvement of two orders of magnitude over no testing at all.

Additional dramatic increases in systems reliability can be achieved by raising the burn-in temperature, and/or driving the parts in a dynamic mode, and/or increasing the power to the devices. However, all of these approaches have some drawbacks, and the user should gain burn-in experience before he attempts to implement any one of them. First, he should aim at finding at least 95% of those dead-on-arrival and time-related weak devices by following the burn-in procedures contained in MIL-STD-883. He can then refine his process further, but at some later time.

How should burn-in be done?

As previously mentioned, there are three ways to implement a burn-in program, and each approach has certain advantages and disadvantages.

Components can be bought from the supplier already burned-in. This is the usual approach when a company is new to the burn-in concept. There is a lot to be said for the argument that the component supplier knows the most about his own products and therefore should be better prepared to screen them.

What is not generally considered, however, is that the components house regards orders requiring burn-in as special items, requiring special scheduling and handling. Also, components suppliers cannot be expected to know as much about systems applications as the systems builder does.

An independent testing house can do the component burn-in for the systems builder. But, this approach is

somewhat questionable because the testing house will be using universal equipment intended to suit a variety of customers, rather than a specific customer. The universality of the equipment makes it nearly impossible to give a true simulation of a particular system's operating environment. Schedules can falter, too, since equipment utilization and volume are the primary considerations for the testing house.

In-house component burn-in is often the best way. It can be much less expensive, for one thing, because the systems builder will not be paying part of the profit and overhead charges of the component supplier or the independent testing house.

Additionally, delivery of burned-in parts to the production floor is quicker because the burn-in schedule is under the control of the systems builder. Also, the component vendor can ship directly from his production lines, increasing the stock from which he can choose.

The burn-in equipment itself can be tailored to provide optimum product-life expectancy and volume. The dedication of equipment normally will improve final device reliability, since the burn-in test can be patterned after a specific system's operating mode. What's more, capital expenditures are applied to company growth. Burn-in will improve production yields and, therefore, a company's profitability. The purchase of burn-in equipment, then, can be regarded as capital expenditure for increased productivity.

There is also better control over the accelerated-aging data. The actual failure data is assurance that the test was performed, as required, to specification. In fact, this data can be reported back to the component vendors, helping them to pinpoint batch-to-batch variations and better serve their customers. In addition, failure data enables a company to evaluate alternative suppliers, so that several sources can be qualified, and a company's delivery position further enhanced.

With in-house burn-in, there is far less chance of information leaks to competitors. What's more, cost improvements resulting from multiple-source qualifications, device redesign, and improved manufacturing control would be less accessible.

The in-house route has another, often overlooked, advantage. Failure analysis can be an effective tool in training engineering talent and developing company expertise. If a vendor or testing house is doing the burn-in, chances are that a systems house will not learn of the problems that are encountered with the various components. Consequently, improvement of that company's product rarely follows. Expertise normally results from analyzing mistakes and searching for a better way. When a systems builder learns about the component problems within his own organization, he will be able to develop a higher level of skill.

The systems builder necessarily knows his own application best. The man who designs the system chooses semiconductors, resistors, capacitors, and the like, with one idea in mind: to perform a specific task.

On the other hand, the component designer is trying to develop a device that fits many applications and increases his company's profit through increased volume. As a result, there are always device parameters that may be superfluous to the systems engineer's requirements. Often, testing for these parameters may cause rejects that might be acceptable on a deviation basis since they do not really affect the system. Independent testing houses or component manufacturers simply may not be familiar enough with the application to evaluate fully the needs of the systems company. Furthermore, the systems builder may not get the feedback he needs to alter his future designs.

At one time, burn-in was regarded as a highly complex and mysterious procedure. The mystery has long since been stripped away, and the supposed complexity has proven to be false. If a company can design a complex system function, such as a missile or a computer, then that company can certainly lay out wiring from power supplies to connectors to sockets mounted on printed-circuit boards.

Moreover, company technicians are normally available to turn on power supplies and direct the production help in the loading and unloading of sockets. There is no real mystery to the art of burn-in. Engineering talent is required only to analyze the results of the burn-in.

How much does burn-in cost?

The cost of doing in-house burn-in will, of course, vary from application to application. To give a reasonable indication of the dollars involved, a hypothetical systems model is given in Table 2.

Here, each device is assumed to be a 14-lead dual-in-line package. The in-house burn-in equipment is operated for 52 weeks a year. The equipment can accommodate 10,000 devices at the same time. Each device is burned-in for 168 hours at 125°C with reverse bias applied, following the requirements of MIL-STD-883.

The analysis shows the cost of in-house burn-in to be less than a nickel per device for this example. Certainly, 5 cents a device is a small premium to pay compared to the substantial cost savings and other benefits that can be realized from component burn-in. □

Although manufacturers may disagree about how burn-in should be done—in-house or otherwise—and what is the optimum burn-in environment for effective screening, many believe that some kind of device preconditioning is absolutely necessary and that, on the final balance sheet, burn-in saves money. Here are several testimonials from experienced systems builders who make their case for component burn-in. —*Editor*

Needless to say, component reliability is essential in military applications. Component reliability is crucial for long-term space missions, communications satellites, and other applications where repair is impossible and there are obviously limits to the degree of redundancy that is practical. Moreover, catastrophic failures of electronic devices cannot be tolerated in a weapons environment.

Because of the nature of existing semiconductor manufacturing processes, a single manufacturing run will produce a wide variation in quality, performance, and operating-temperature capability. While over-all yield may be satisfactory, the yield to any single demanding

specification will be low. Therefore, reliable high-performance parts will be more expensive because they must be identified through additional testing. For the foreseeable future it will be necessary, through screening and some forms of process control, to distinguish between those parts that will last for millions of hours and those that will fail in a few hours.

In many of our systems, we have been able to attribute as many as 30% to 50% of the failures to overstress, especially when the parts have not been exposed to burn-in screening. These findings tend to make us believe the parts that failed, although stressed beyond their capacity, may not actually have been stressed beyond their specification limits and were merely victims of time. This is why, in the military specification system for microcircuits, we insist on 100% screening of all significant device parameters and strongly favor the part quality level for which burn-in adds full-rated stress, as well as stress beyond time-zero.

Joseph B. Brauer, Chief, Solid State Applications
Rome Air Development Center, Griffiss AFB, N. Y.

Since we manufacture signal equipment for rapid-transit and train systems, our end products must be absolutely safe, as well as having maximum reliability. Therefore, several years ago, we instituted a burn-in program that not only proved to be highly effective, but also saved us a great deal of money within a very short period of time.

The table shown here illustrates some of our findings

FAILURES FOUND THROUGH BURN-IN

Component	Device type	Population distribution	Percentage of failures
Diodes	signal	80%	4.0%
	zener	15%	1.5%
	reference	5%	2.6%
Transistors	small-signal	75%	1.5%
	power	25%	
ICs	digital	80%	2.6%
	linear	20%	
Resistors	metal-film, wirewound, and carbon	100%	0.65%
Capacitors	non-electrolytic	65%	2.7%
	electrolytic	35%	

Average failure rate for all above devices: 2.8%
Range of batch-to-batch and vendor-to-vendor variations: ½% to 20%

on defective components. With burn-in, we detect an average of 2.8% defective devices in a given batch. However, this average does not reflect the wide variation in the number of bad devices that can occur from batch to batch and vendor to vendor. Our experience indicates that anywhere from 0.5% to 20% of a component population can be rejects.

Herbert Schwartz, Manager of Reliability Engineering
General Railway Signal Co., Rochester, N. Y.

To us, the real advantage of burned-in integrated circuits is the outstanding reliability they give our logic boards in the field. Some of our boards contain as many as 262 ICs. Before we initiated our burn-in program, we were experiencing considerable production test times and unreasonable board fallout in the field because of IC failures.

Now, however, most of the ICs we use are preconditioned through burn-in, and the number of boards failing in the field has been reduced by at least 50%. Also, more boards are passing their initial electrical test. Because of this, we are realizing a cost saving in board testing that more than offsets the expense of our burn-in operation. We are now shipping higher-quality boards at lower overall production cost.

Jack H. Holland, Manager Test Engineering
Inforex Inc., Burlington, Mass.

We've found that component burn-in is essential in order to ship integrated circuits to such low-cost high-volume markets as the automotive industry. We use burn-in as a production screen, in addition to a long-term reliability burn-in on an audit basis, for our own p-MOS devices.

Although the purchase of equipment for 100% production burn-in represents a substantial capital investment, we feel that burn-in is still very cost-effective when the warranty expense of repairing or replacing our products is considered. In reality, not only can burn-in reduce manufacturing costs, but the favorable impact that a reliable product has on a customer can also result in more business and lead to higher profits in the future.

Robert Reichenbach, Quality Control Manager
Essex International Inc., Pittsburgh, Pa.

The primary objectives of any reliability program are to provide cost savings to the manufacturer and improve his customer relationships. Such a program must begin in the manufacturing process to produce more reliable devices that, in turn, generate significant cost savings in troubleshooting and field-repair costs.

Since we not only manufacture and test our systems, but also service them in the field mostly on fixed-price maintenance contracts, the economic trade-offs regarding component burn-in become obvious. Many of our printed-circuit assemblies contain upwards of 120 integrated devices. Statistics indicate that with only 1% to 2% of this population defective, an average of 70% to 90% of our pc assemblies would fail their initial test because of defective ICs alone.

As a result, we burn-in 100% of the ICs we use, regardless of their source. This burn-in involves temperature cycling, followed by baking with power applied, and finally complete dc testing. Furthermore, we do additional assembly burn-in to detect any parametric deficiency specifically related to the application in which the system will be used.

We are continually studying and re-evaluating the cost and effects of burn-in. To date, we have found that it would be unwise to eliminate burn-in with the present state of device technology.

Ronald A. Follett, Quality Assurance Director
Incoterm Corp., Northborough, Mass.

Monolithic converter augments ac-measurement capabilities

A low-cost thermoelement with inherent linearity, repeatibility, and sensitivity can act as an rms converter from dc to 100 MHz, regulate rms voltage, and measure rms power and amplifier gain

by William E. Ott, *Burr-Brown Research Corp., Tucson, Ariz.*

☐ Such devices as thermocouples and thermopiles have usually been used for high-accuracy wideband ac measurements, wideband rms-to-dc conversion, and rms-power measurements. However, these instruments are priced from $800 to $1,000, and their typical response time is 1 second or longer. Although recent computing rms-to-dc converters priced at $100 have true rms response and fast settling time, their bandwidth is typically only 20 to 40 kilohertz.

By circuit integration, researchers have developed a single-chip thermal converter priced at $25 that provides a large bandwidth, settles in less than a second, and outperforms conventional thermal devices. In addition to performing the normal functions, the BB 4131 can regulate wideband rms voltage and provide precision measurements of amplifier gain.

The BB 4131 combines a pair of bipolar npn transistors and a pair of diffused resistors on a monolithic chip. A view of one half of the converter is shown in Fig. 1. The transistor senses the change in the chip's temperature that results from the power dissipated by the resistor. The inherent linearity, repeatibility, sensitivity, and low thermal mass of the monolithic thermoelement provide accuracy within 0.05% over a 30-dB dynamic range and accuracy within 2% for the high-frequency limit of 100 megahertz.

Analyzing the circuit

An electrical equivalent circuit of the thermoelement (Fig. 2a) includes the resistor isolation and substrate junctions, D_{iso} and D_{sub}, respectively. To describe the static and dynamic behavior of the thermoelement, it is convenient to model it with thermoelectrical analogs. A lumped thermoelectrical model is shown in Fig. 2(b), where the heat flow has been replaced by a current source, E_i^2/R_h, temperature by voltage, heat capacity by capacitance γ, and thermal resistance by electrical resistance θ. The isolation diodes, D_{iso}, have been replaced by their capacitance, C_{iso}.

The Ebers-Moll relationship shows that the temperature coefficient of a transistor's base-emitter voltage for constant emitter current is:

$$\left.\frac{dV_{be}}{dT}\right|_{I_E=constant} = [(V_{BEo} - V_{go})/T_o] - (3k/q)[1 + ln(T/T_o)]$$

where $V_{BEo} = V_{be}$ at I_{Eo} and T_o, V_{go} = band-gap voltage at 0 kelvin = 1.11 v, q = charge on electron = 1 eV, k = Boltzmann's constant = $8.62(10)^{-5}$eV/K, and T = temperature in kelvin.

The junction temperature coefficient, found to be about –2.0 mV/°C, has a nonlinearity of less than 2% for temperatures between 0°C and 100°C. Temperature dependence of the junction has been modeled by an amplifier with gain M in Fig. 2(b).

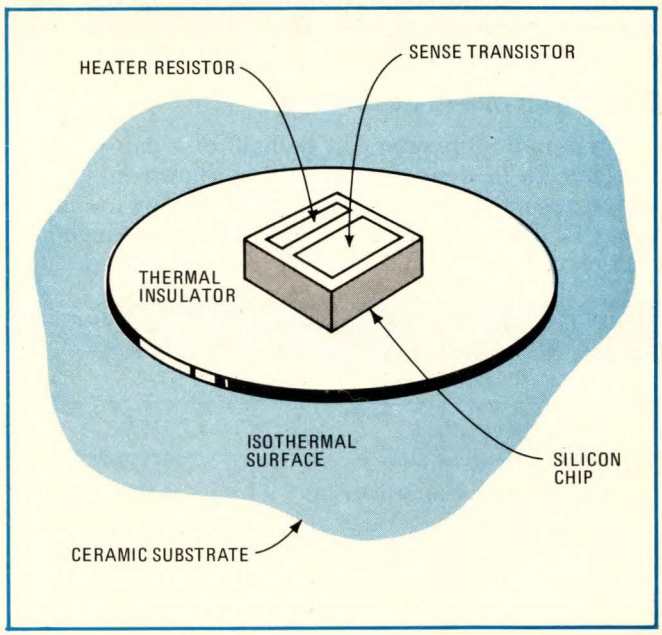
If the capacitances of resistor-isolation junctions, C_{iso}, are neglected, the equation for the thermoelement in the frequency domain can be written as

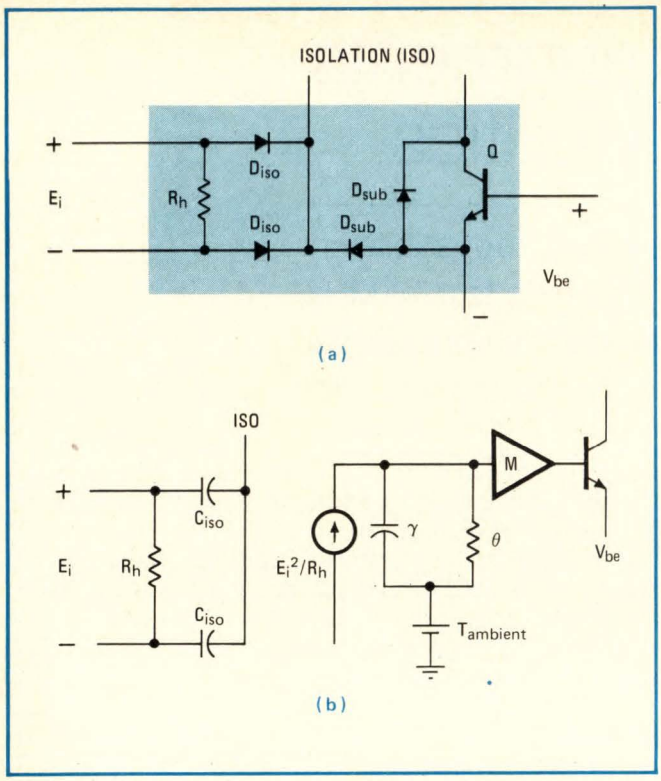
$$V_{be}(s) = V_{VE} + (M\theta/R_h)(1/1 + s\gamma\theta)E_i^2(s)$$

where V_{BE} is the ambient base-emitter voltage with zero input signal. To facilitate analysis, it is convenient to define a thermal gain, A_T, and a thermal time constant τ_T:

$$A_T(s) = A_{TO}/(1 + s\tau_T)$$
$$A_{TO} = M\theta/R_h$$
$$\tau_T = \gamma\theta$$

1. IC thermoelement. This fast-response monolithic thermal element is composed of a silicon chip containing an npn transistor and a diffused resistor. Changes in the transistor's base-emitter-junction voltage correspond to temperature changes in the chip resulting from heat generated by the power dissipation of the resistor.





2. Circuit equivalents. An exact electrical equivalent of the monolithic thermoelement is shown in (a). A more practical circuit is the lumped thermoelectric model (b).

The thermoelement transfer function now can be simplified to:

$$V_{be}(s) = V_{BE} + (A_{TO}/1 + s\tau_T)E_i^2(s)$$

The dc thermal gain A_{TO} is slightly nonlinear because of the small nonlinearity of the junction-temperature coefficient M, as discussed above, and also because of the temperature coefficient of the heater resistance and the thermal resistance. This nonlinearity has little effect on the dynamic behavior of the thermoelement; however it can produce some errors in the dc response. Typical characteristics of a monolithic thermoelement can be found in Table 1.

Building an rms-to-dc converter

A rms-to-dc converter can be built of a pair of thermoelements in a single package, as shown in Fig. 3. Power dissipated in the heater resistor R_{h1} by the input signal E_i heats the input thermoelement, producing a change in the base-emitter voltage of Q_1. This generates an error voltage, which is amplified by Q_1, Q_2, and operational amplifier A_1. The amplified error voltage, applied to R_{h2}, heats the output thermoelement and tends to bring the circuit into equilibrium. When the circuit is in equilibrium, $E_{orms} = E_{irms}$.

For high-frequency input signals, the thermal time constant of the input thermoelement acts to average the input power, so that E_o is a dc voltage. For slowly varying input signals, the temperature of Q_1 will track the instantaneous value of E_i^2, and E_o would tend to follow E_i. Negative ac feedback from the output provided by amplifier A_2, C_F, and R_F forces the output to be a dc voltage for very low frequency inputs.

Capacitors C_1 and C_2 are included to provide phase-compensation for the composite operational amplifier formed by Q_1, Q_2, R_{C1}, R_{C2}, and A_1. For the circuit values shown, there is sufficient phase margin to prevent 100% ac feedback ($R_F = 0$, $A_2 = 1$) from producing oscillations. So long as C_1 and C_2 do not become large enough to reduce the open-loop gain to unity before about 10 kHz, they do not effect the closed-loop response, other than to provide phase margin.

Since feedback is thermal, a negative output at the E_o terminal would produce the same feedback signal as positive output, and feedback would be positive for the circuit in Fig. 3, which would drive the circuit into saturation. Diode D_1 in the output limits the output to positive signals.

TYPICAL CHARACTERISTICS OF A MONOLITHIC THERMOELEMENT

PARAMETER	TYPICAL VALUE
Heater resistance, R_h	115 Ω
Effective thermal resistance, θ	575°C/W
Junction-temperature coefficient, M	2 mV/°C
dc thermal gain, A_{TO}	10 mV/V^2
Effective thermal capacitance, γ	113 μW-s/°C
Thermal time constant, τ_T	65 ms

Calculating the transfer function

From the thermoelement equation, it can be shown that the midband and dc-transfer function for the rms converter in Fig. 3 is

$$E_o = [(A_{TO1}E_{irms}^2 + V_{BE1} - V_{BE2})/A_{TO2}]^{1/2}$$

where E_{irms} is the rms value of the input, and A_{TO1}, V_{BE1}, A_{TO2}, and V_{BE2} are the dc thermal gain and ambient base-emitter voltage of the input thermoelement and output thermoelement, respectively.

This expression shows that two error sources exist at midband frequencies. Mismatch in the thermal gains produces a gain error that can be compensated by a scale-factor adjustment in the dc-measuring circuit that is applied to the output. Ambient mismatch in the base-emitter voltages of the sense transistors Q_1 and Q_2 produces a nonlinearity in the rms-to-dc conversion. The error caused by offset voltage between the sense transistors can be nulled by suitable adjustment of the potentiometer R_1.

Output stability as a function of drift in thermal gain, and offset voltage can be derived from the midband and dc equations. Over an input-signal range from 0.1 V rms to 3.0 V rms, the thermal converter typically provides an output stability in relation to temperature and time of $(50E_{irms} + 50/E_{irms})$ μV/°C and $(150E_{irms} + 100/E_{irms})$ μV/month, when E_{irms} is in volts. The nonlinearity over the same input range is typically reduced to ±0.025% of full scale by adjusting R_1 with $E_{irms} = 0.1$ V rms. The residual nonlinearity of ±0.025% is caused by mismatch between the nonlinearity of the dc thermal gains A_{TO1} and A_{TO2}.

As mentioned previously, negative ac feedback can

provide accurate rms-to-dc conversion for input signals with frequencies even much lower than the thermal time constant. Low-frequency performance of the rms converter shown in Fig. 3 may be nonlinear because the thermal feedback is governed by the square law. For this reason, if a reduced low-frequency cutoff is required and fast response time is desired, nonlinear ac feedback should be employed.

Determining ac feedback

Two modes of ac feedback are relevant—linear, for circuit simplicity, and square law, for optimum performance. The ac feedback voltage for these two modes is:

$$E_{F1} = A_2 E_o, \textit{ linear } A_2$$
$$E_{Fs} = \rho E_o^2, \textit{ square law } A_2$$

where ρ is the gain of the square-law amplifier.

These feedback voltages produce effective filter time constants of:

$$\tau_{FI} = R_B C_F A_2 / 2A_{TO2} E_o, \textit{ linear } A_2$$
$$J_{Fs} = R_B C_F \rho / A_{TO2}, \textit{ square law } A_2$$

For optimum settling time, feedback resistor R_F should have a value that produces a zero in the response of the ac-feedback network at the thermal time constant of the thermoelement:

$$R_F = (\tau_{T2}/C_F) - R_B$$

If the input is a dc level that steps from an initial value E_{i1} to a final value E_{i2}, settling time T_S for small settling error η is approximately:

$$[R_B C_F A_2 ln1/(2\eta)]/2A_{TO2}E_{o2}, \textit{ linear } A_2$$
$$T_S = [R_B C_F \rho ln1/(2\eta)]/A_{TO2}, \textit{ square law } A_2$$

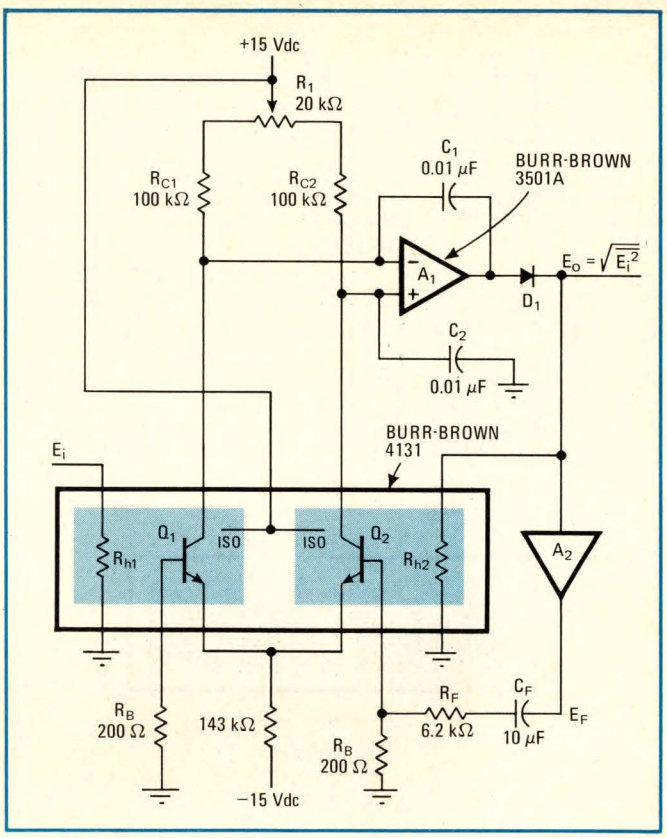
η is settling error expressed as a fraction of its ideal value. For instance, when T_S is measured to 1%, η is equal to 0.01.

These expressions for settling time not only assume small settling error η, but also that the filter time constant is larger than the mismatch between thermal time constants τ_{T1} and τ_{T2}

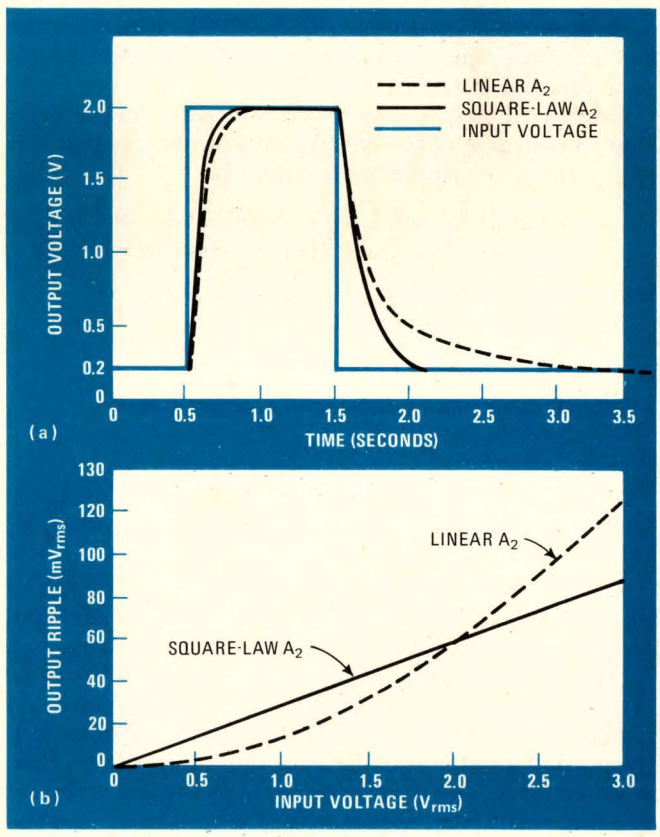
In Fig. 4(a), responses for both a +20-dB and a -20-dB input step are shown for both linear and square-law ac feedback. For linear ac feedback, A_2 was made a short ($A_2 = 1$), and for square-law ac feedback $\rho = 0.25$. These ac feedback gains provide similar settling times for 2.0-V final values, and, as will be shown, they also provide the same output ripple for 2.0-V rms inputs.

As stated earlier, the step response for linear-ac feedback is asymmetrical, and the settling time is roughly inversely proportional to the output's final value. The square-law ac feedback provides roughly a symmetrical step response, and settling time is independent at the output's final value.

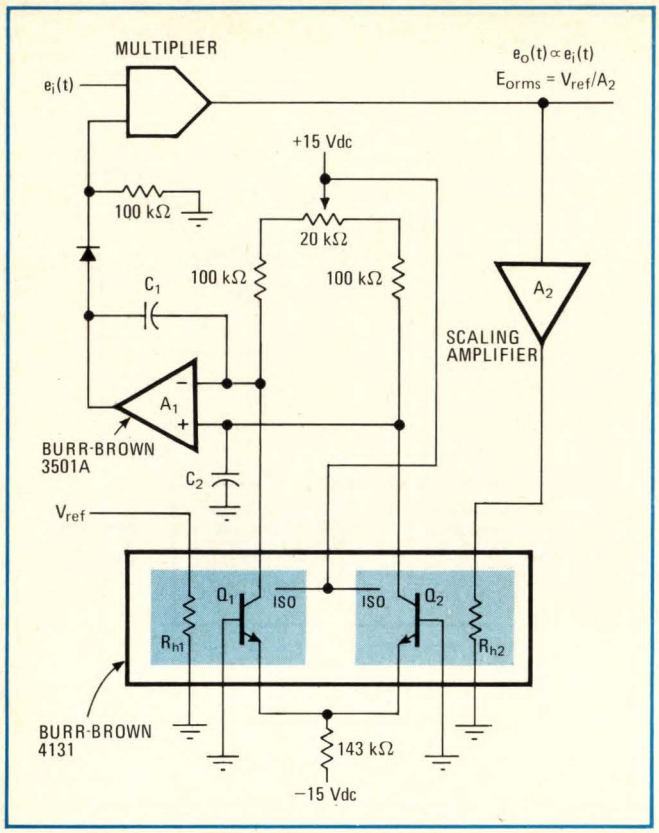
The thermal time constant of the thermoelements may impose a lower limit on the settling time. Because of the low thermal mass and repeatability of the monolithic thermal element, the thermal time constants typically limit the output to requiring only about 500 milliseconds to settle within 0.1% of step for a 20-dB



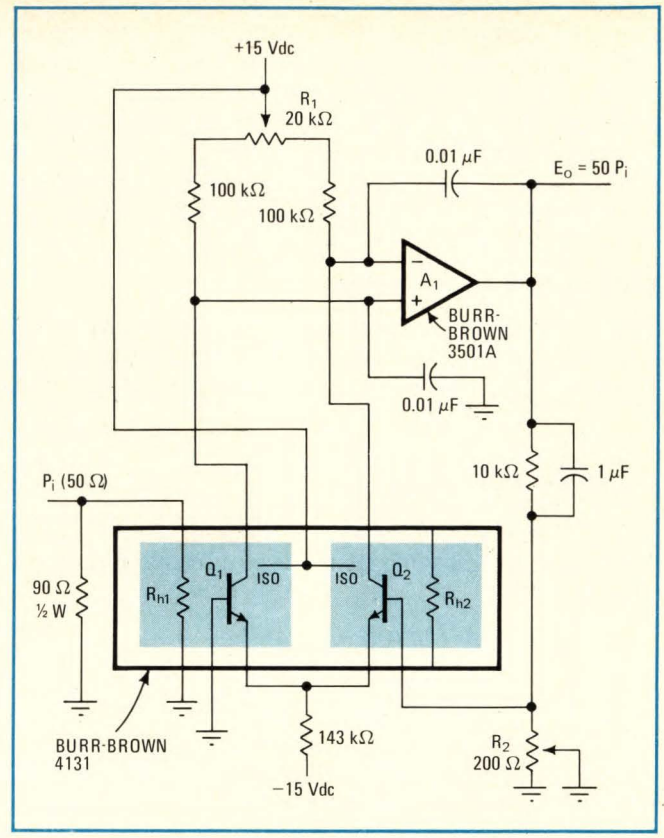
3. Conversion. An rms-to-dc converter is formed by two monolithic thermoelements and an op amp in this closed-loop configuration. A feedback loop (A_2, C_f, and R_f) maintains a dc output at vlf.



4. Step response. Type of feedback used in the rms-to-dc converter (3) affects output-step response (a) and ripple (b).



5. Rms regulation. Two identical thermal converters compare rms values of the output voltage to a dc reference. Resulting error voltage controls gain of a multiplier for adjusting output voltage.



6. Power measurement. With this circuit, rms power can be measured within 2% accuracy at frequencies to 100 MHz. Power delivered to a 50-ohm load is converted to a dc voltage.

step input and square-law ac feedback. For optimum settling time, the value of R_F should be adjusted for each thermal converter.

With a sinusoidal input having a frequency greater than the inverse of the effective filter time constant, the rms value of the ripple at the output is

$$E_{ripple} = 2^{1/2} A_{TO2} E_{odc} E_{irms} / 8\pi f R_B C_F A_2, \textit{ linear } A_2$$
$$E_{ripple} = 2^{1/2} A_{TO2} E_{irms} / 16\pi f R_B C_F \rho, \textit{ square law } A_2$$

where f is the frequency of the input in hertz.

Since $E_{orms} = E_{irms}$ and:

$$E_{orms} = (E_{odc}^2 + E_{ripple}^2)^{1/2}$$

for small error, the low-frequency cutoff f_L is:

$$f_L = A_{TO2} E_{odc} (K_r)^{-1/2} / 8\pi R_B C_F A_2, \textit{ linear } A_2$$
$$f_L = A_{TO2} (K_r)^{-1/2} / 16\pi R_B C_F \rho, \textit{ square law } A_2$$

where K_r is the error. For example, 1% ripple error: $K_r = .01$.

In Fig. 4(b), the rms value of the output ripple is plotted against the rms value of the input for an input frequency of 20 Hz and the circuit values shown in Fig. 3. The feedback-amplifier gain was unity for linear ac feedback and $0.25E_o^2$ for square-law ac feedback. As expected, the output ripple with linear ac feedback is proportional to the square of the rms value of the input, whereas, it is linearly proportional to the rms value of the input with square-law ac feedback. The square-law ac feedback, therefore, provides a low-frequency cutoff that is independent of the signal level.

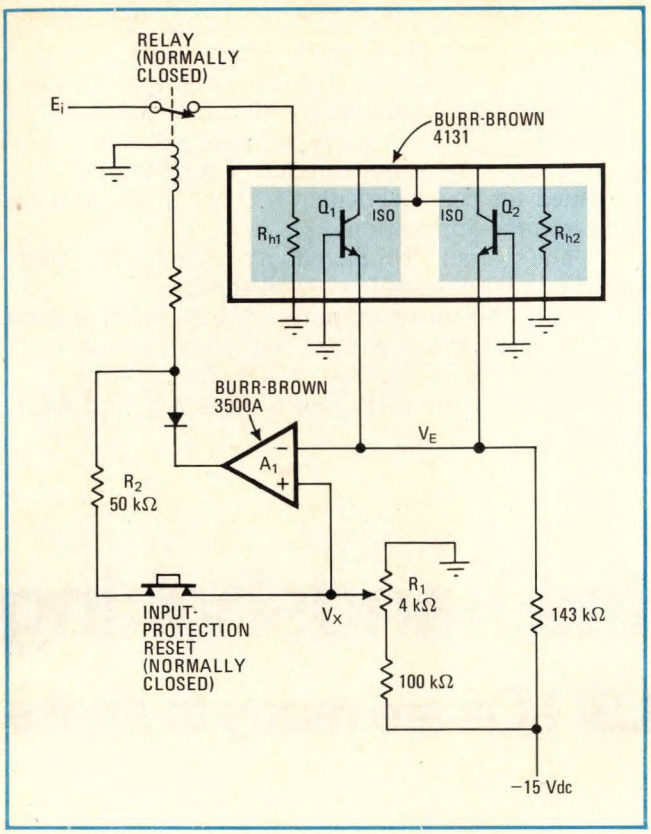
Primary high frequency limitations of the rms-to-dc converter in Fig. 3 are the distributed capacitance on the input-heater resistor and capacitive coupling of high-frequency signals into the dc circuitry. Since the total distributed capacitance on the heater resistor is only 6 pF (C_{iso} = 3 pF in the model shown in Fig. 2b), the -3-dB input frequency would be about 1 GHz for a 50-ohm source impedance.

A more significant problem is isolating the sensitive dc circuit from the high-frequency input, since even a very small high-frequency swing in the dc circuit can saturate the input stage of A_1. For this reason, the ground sides of the base resistors R_B should be connected together and then grounded on a single bus to prevent ground loops.

Also, high-frequency bypass capacitors of about 1 nanofarad should be grounded to the resistor-isolation terminal, and the collectors, bases, and emitters of the sense transistors should be used to prevent high-frequency swings in the dc circuit. With these bypass capacitors and careful base-circuit wiring in the sense transistors, the thermal converter provides a ±0.02% bandwidth deviation at 5 MHz and a ±2% deviation bandwidth at 100 MHz in this particular circuit configuration.

Applications

In addition to rms-to-dc conversion, the monolithic thermal converter can be used in several other ac-measurement and control applications, including wideband



7. Thermal protection. This thermal-responding input-protection circuit passes high-crest-factor inputs, while limiting the rms value of the inputs by opening a protective relay driven by A_1.

rms-voltage regulation. A circuit for rms voltage regulation and precision measuring of amplifier gain is shown in Fig. 5.

In this application, a thermal converter compares the signal output to a dc reference and generates a feedback signal that controls the gain of a wideband multiplier. Capacitors C_1 and C_2 provide loop-phase compensation and set the low-frequency cutoff for regulation. The value of these capacitors is a function of the scaling amplifier's gain, frequency response, and the low-frequency cutoff required.

Outputs of an amplifier or signal generator's rms power can be easily measured to very high frequencies with a thermal converter. The circuit in Fig. 6 converts power delivered to a specified load to a dc-output voltage. This circuit is scaled for 50-ohm input impedance. By adjusting R_1 for zero output with zero input, and R_2 for an output of 9 V dc with 3 V dc input, accuracies within ±2% at 100 MHz are possible.

Measuring amplifier gain

Accurate measurement of amplifier gain requires true-rms measurement, particularly if the input voltage is not a pure sine wave. A true-rms response is necessary, since phase shift of the input harmonics by the finite bandwidth of the amplifier under test can cause significant errors in average responding measurements. For instance, only 1% third harmonic in a signal can produce as much as 0.33% error, depending on the phase shift, in an average responding measurement. The thermal converter, on the other hand, responds to the total signal, independently of the relative phase of its components.

A precise wideband gain-measuring circuit can be built around a thermal converter and suitable circuitry. In this circuit, the input to the amplifier under test is also applied to one half of a thermal converter, and the output of the amplifier is applied to the other half of the thermal converter through an appropriate attenuator. The differential output of the two converters are then amplified by in a differential amplifier, and produce an output E_o related to the difference between the input and the attenuated amplifier output.

Two sources of error exist in this measurement, a mismatch in ambient base-emitter voltages and a mismatch of the thermal gains of the converters. The difference in base-emitter voltages can be nulled out at zero input and the thermal mismatch can be compensated for in the attenuator.

If the gain error δ in the amplifier under test is small, the calibrated output simplifies to

$$E_o = (2A_{TO1})(R_1 + R_2)(\delta V_{irms})/R_1$$

where $\delta = (\alpha\ V_o - V_i)$ and it has a value that is less than 1.

The upper frequency limit on the gain measuring circuit is primarily that of the attenuator at the output of the amplifier. Again capacitive coupling of high-frequency swing into the dc portion of the circuit can produce errors similar to those discussed for the rms to dc converter.

All thermal converters require some form of input protection. Application of an excessive rms voltage can easily damage the converter's input heater resistor. The monolithic thermal converter requires input voltage to be limited according to the expression

$$Maximum\ V_{input} = (125°C - T_a)/6)^{1/2}(V_{rms})$$

If only sine waves and other low-crest-factor signals are to be measured, a simple diode clamp in parallel with the input may be sufficient input protection. However, if signals with high crest factors are to be measured, the input protection should be capable of limiting the rms value of the input signal while allowing low-duty-cycle signals with peak values much greater than their rms value to be measured.

The thermal-responding input-protection circuit of Fig. 7 prevents input signals with excessive rms value from being applied to a thermal converter. With an ambient temperature of 25°C and zero input voltage, R_1 should be adjusted for a voltage V_x, which is 200 mV more positive than V_E. This allows input signals to be applied to the thermal converter if the thermoelements are at a temperature below 125°C. For any combination of ambient temperature and input signal that causes the thermoelement temperature to exceed about 125°C, the protection amplifier's output will go to its negative saturation level, opening the contact of the input-protection relay. Resistor R_2 provides positive feedback for latching the protection amplifier so that the relay contacts remain open until the input-protection-reset switch is opened. □

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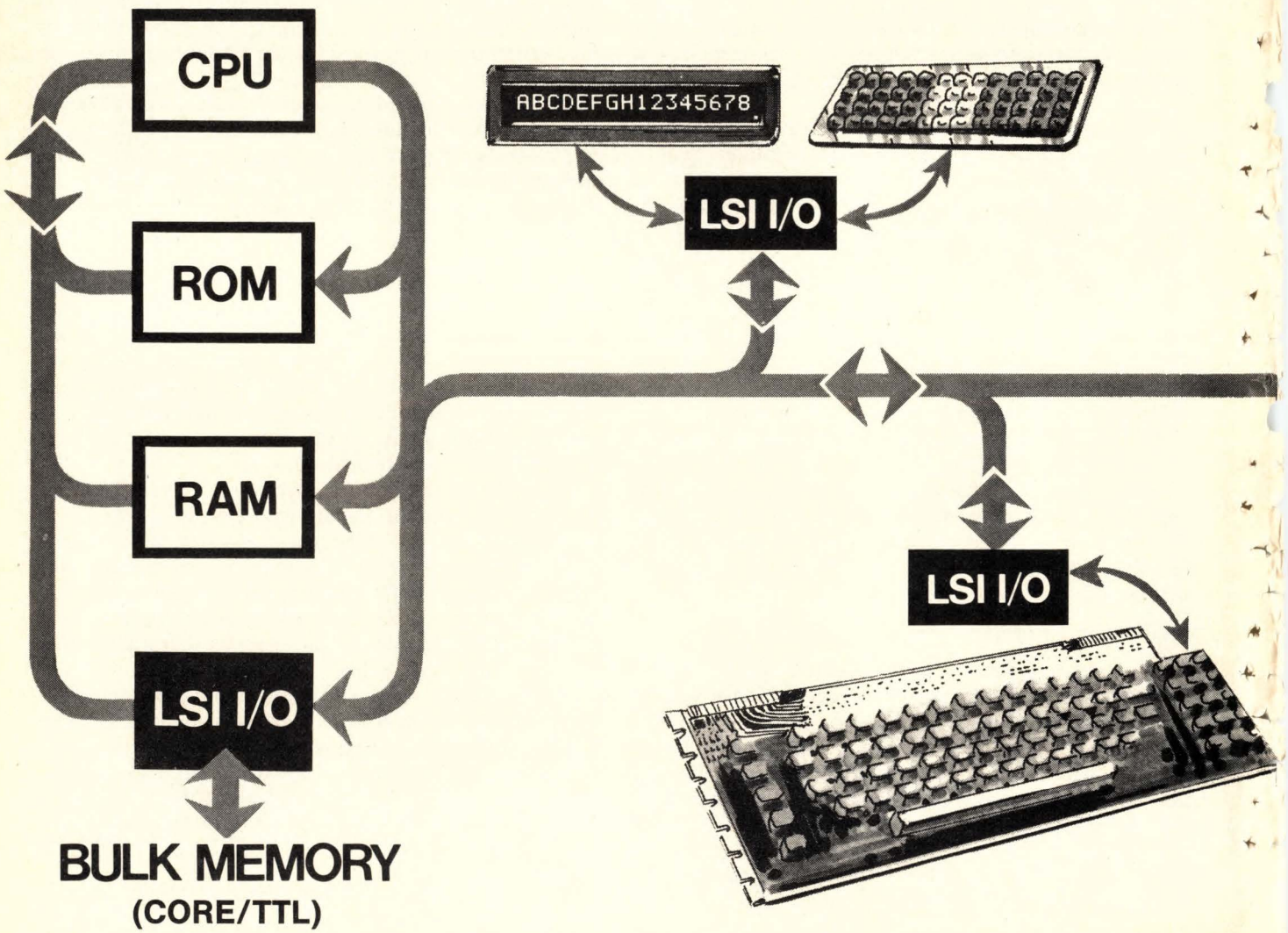

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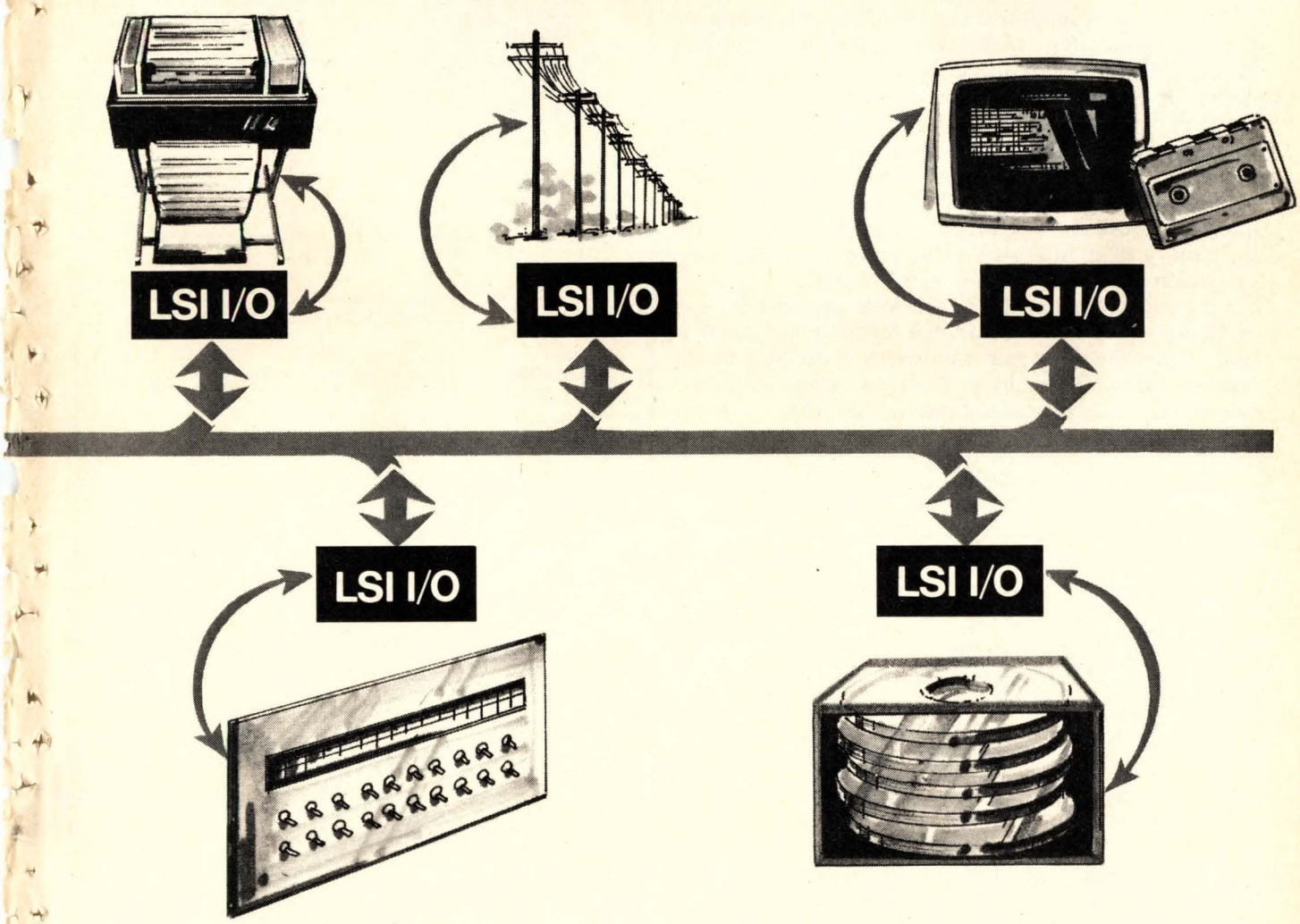


Digital-to-analog converter controls active filter

by Jerry Whitmore,
Analog Devices, Santa Clara, Calif.

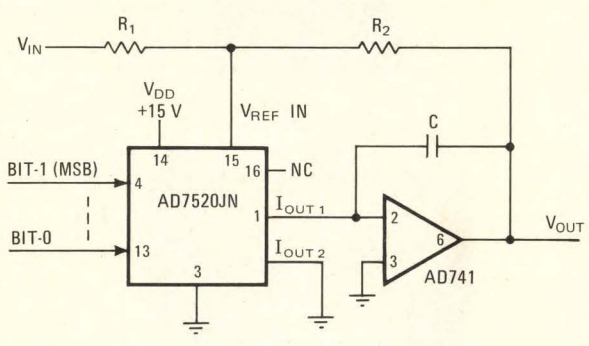
A monolithic digital-to-analog converter can be the control element of an active filter. Shown in Fig. 1 is a circuit that generates a low-pass, single pole that can be moved over a dynamic frequency range of 2^n:1, where n is the resolution in bits of the d-a converter. If, for example, a converter with 10-bit resolution is used in this circuit, dynamic range is 1,024:1.

An equivalent simplified version of Fig. 1 is shown in Fig. 2(a), where R_4 and R_3 take on the values shown. R_{ladder} is the characteristic resistance of the R-2R ladder of the d-a converter and the coefficients A assume a value of 1 for an on bit, and zero for an off bit. Note that R_4 in parallel with R_3 equals R_{ladder}.

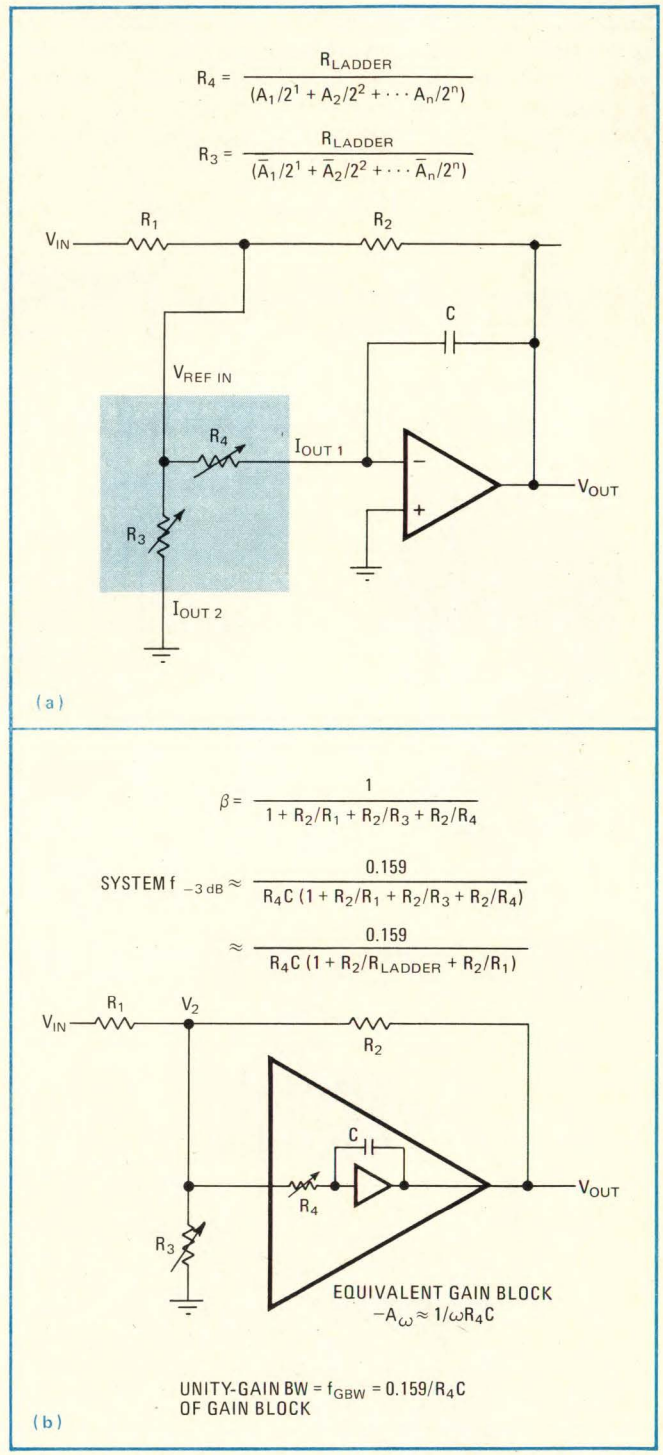
The circuit, consisting of R_4, C, and the amplifier, can be treated as a gain block as shown in Fig. 2(b). At frequencies above the open-loop corner, the response of the gain block is $A(\omega) = V_{out}/V_2$ or about $1/\omega R_4 C$. Its unity gain bandwidth is $F_{GBW} = 0.159/R_4C$.

Frequency response of a closed-loop amplifier is $F_{3dB} = BF_{GBW}$ where B is the amplifier feedback attenuation ratio. Using the unity gain bandwidth of the gain block and the system B results in the filter closed loop frequency response equations shown in Fig. 2(b). □

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.



1. 1,024:1. An active low-pass filter such as this, built around an operational amplifier, passive components, and a 10-bit digital-to-analog converter, has a dynamic-frequency range of 1,024:1.



2. Equivalent circuits. The d-a of (1) can be replaced by the circuit within the dashed lines (a). A further simplification (b) lumps R4, C and the op amp into a gain block.

Twin oscillators form intruder detector

by Joshua Premack
Honeywell Inc., North Hopkins, Minn.

A system that can detect an intruder approaching an ungrounded metal object, such as a steel desk or a parked vehicle, is one job for a highly sensitive capacitive sensor. When scaled to operating frequencies high enough to give adequate bandwidth, the circuit is also suitable for many other applications, such as a capacitive microphone, capacitive seismic sensor, or an indicator of the eccentricity of the path of a rotating object.

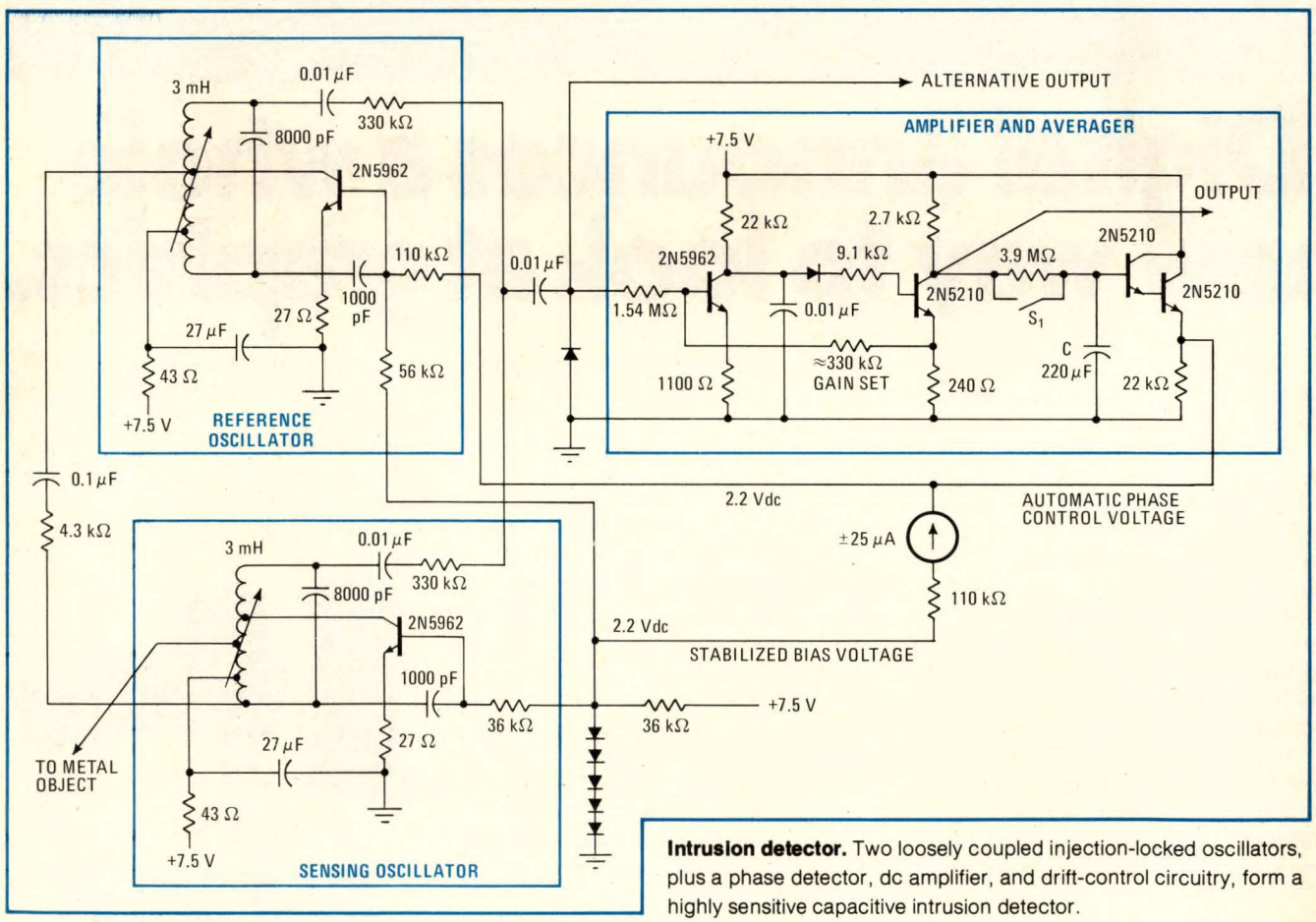
The circuit is based on the behavior of a pair of mutually synchronized oscillators. One oscillator is used as a reference, and the other is connected by a tap on its tank-circuit inductor to the object being protected. By this auto-transformer action, the loading effect on the oscillator, caused by the resistive component of the object, is reduced to an acceptable value. The protected object's capacitance is connected to an effective circuit capacitance of 2×10^6pF. A sensitivity of a few picofarads is available with a good signal-to-noise ratio. Bandwidth for a 33-kilohertz carrier is ± 25 hertz at 3 decibels down. If one of the oscillators, both of which have a small fixed coupling between their tuned circuits, is tuned to approach the frequency of the other, their combined output produces beats that indicate their frequency separation.

As tuning is continued in the same direction, the beat frequency decreases until the coupling pulls the oscillators into synchronism, whereupon the beats stop abruptly instead of decreasing smoothly to zero. At this adjustment, the oscillators are at the same frequency but are 90° apart in phase. As tuning is continued, the phase angle varies through 0° to 90° in the opposite direction. Then, with further tuning, the beats reappear.

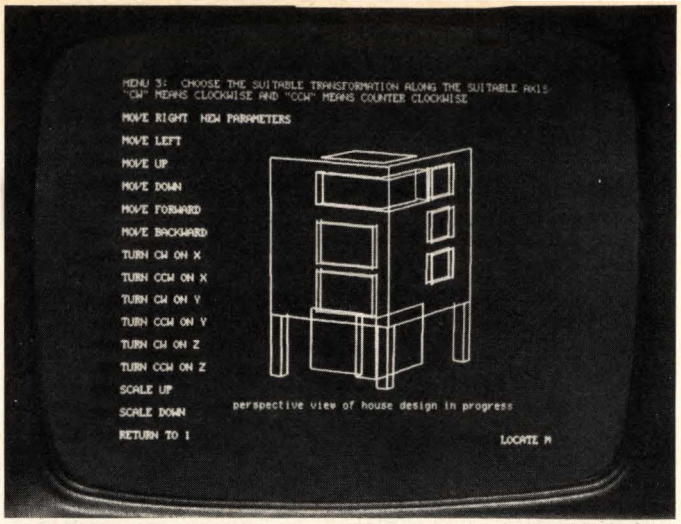
If the coupling between the oscillators is reduced, the beat-free tuning interval narrows, but the ±90° phase shift always occurs between the onset and cessation of beats. This interval may be made very narrow by using very little coupling—provided that the oscillators are kept from drifting in frequency. Drift compensation is achieved with feedback by converting phase difference to an error voltage in a slow-feedback system, so that an interval of 5 to 6 pF on a base value of 8,000 is quite satisfactory.

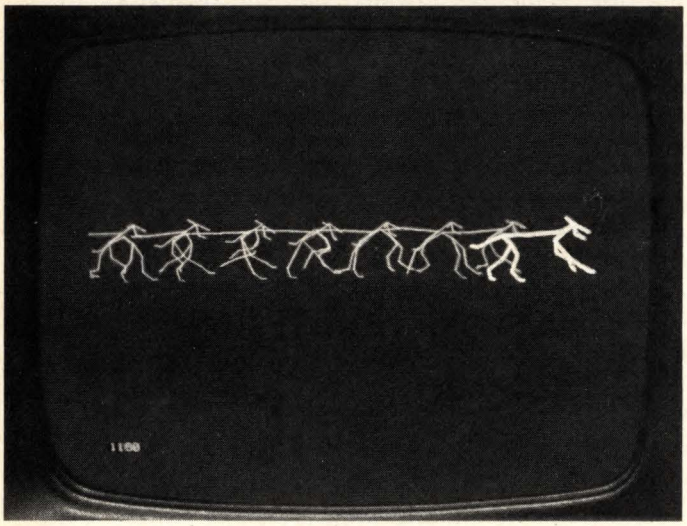
In the intrusion-detection system, the two essentially identical oscillators have resistive coupling between the collector and base, which theoretically should keep the oscillators 180° out of phase when synchronized. The oscillators are actually designed to operate only 150° to 160° out of phase. Their outputs are summed at the junction of the two 330-kilohm resistors.

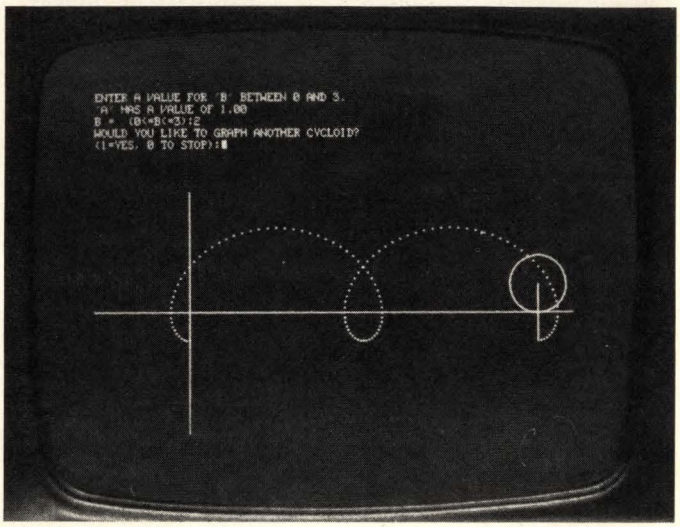
If the oscillators were exactly 180° out of phase, the voltage at the junction would be zero. The non-zero



Intrusion detector. Two loosely coupled injection-locked oscillators, plus a phase detector, dc amplifier, and drift-control circuitry, form a highly sensitive capacitive intrusion detector.







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voltage at this point is the quiescent value, which increases as the capacitance in the sensing oscillator changes. This voltage is usable as an output of the circuit, especially when a wide dynamic range is wanted.

A two-stage dc amplifier provides an output and also charges a large capacitor—220 microfarads—through a 3.9-megohm resistor. This voltage changes very slowly in response to sudden changes in the capacitance of the sensing oscillator. This output also supplies part of the base bias for the reference oscillator, which compensates for any tendency of the oscillator to drift.

Before tuning the oscillators to synchronism and to the desired phase position, the time constant of the averaging circuit is shortened from 858 seconds to 0.594 second by closing the switch across the 3.9-megohm resistor. The tuning of the sensing oscillator is varied until the tuning meter dips suddenly, indicating that the oscillators are synchronized. When the meter reads zero, and after allowing several seconds to charge averaging capacitor C fully, the switch S is opened and the sensor is operational. This operation is easily automated.

When used as an intrusion detector, the circuit may be attached to ungrounded metal objects that have lossy (30% to 125% dissipation factors) capacitance, ranging from 500 to 15,000 picofarads. Overload-recovery time of the system from transients is in milliseconds, and that of desired signals is in the seconds range. The use of two injection-locked oscillators as a sensor is covered by patents 3,222,664 and 3,293,631.

No exotic measures were taken in the manufacture of these sensors, but care should be exercised to ensure good oscillator stability and tracking. Rapid temperature fluctuations should not be imposed on oscillator components, nor should large temperature differentials exist between the two oscillator assemblies. Careful attention should be given to confining the coupling between the oscillators to the desired path. Stray inductive coupling, common power-supply impedance, and possible paths where oscillator outputs are fed to the detector should be controlled. □

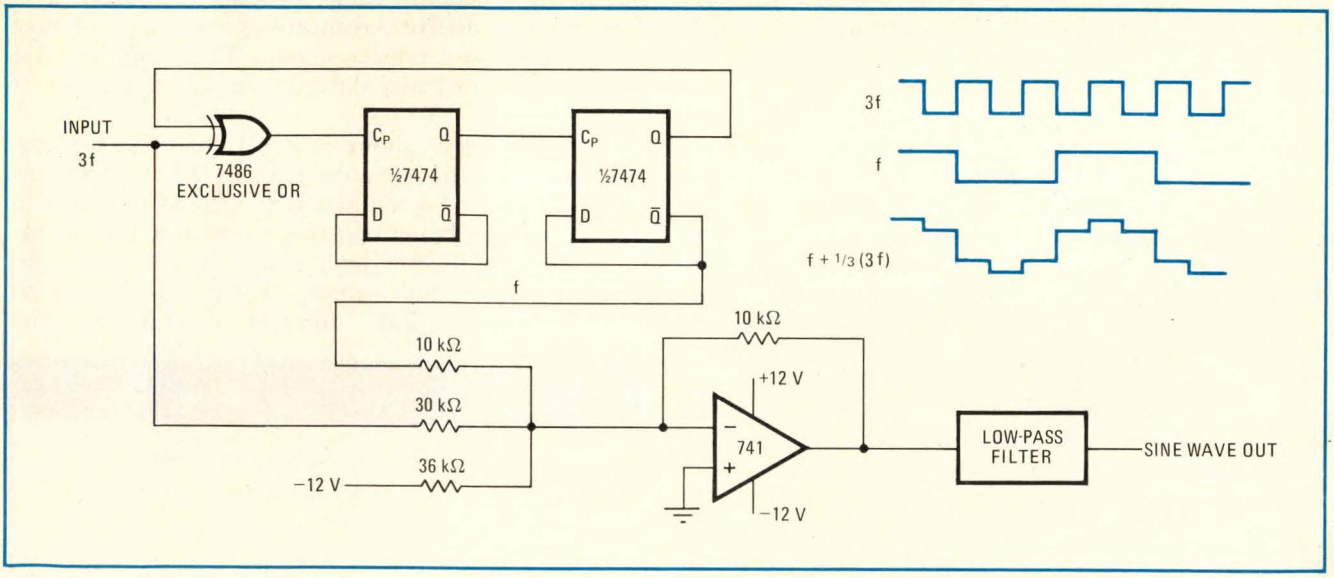
Frequency divider plus op amp approximates sine wave

by John Taylor,
NOAA, Boulder, Colo.

A group of digital and analog integrated circuits can be combined to create an audio tone from a digital pulse train. Ordinarily a single flip-flop can convert pulses into a symmetrical square wave. But for many applications, it is desirable to produce a closer approximation to a sine wave.

This can be done with the circuit shown here. The frequency divider accepts a square wave at a frequency of 3f, and produces a square wave at the required output frequency f. Use of an exclusive-OR gate at the clock input of the first flip-flop results in two advantages over a more conventional divide-by-3 circuit: (1) the output is symmetric, and (2) the input (3f) is 180° out of phase with the third harmonic of the output (f).

This phase relation is such that if f and 3f are summed together in the 741 op amp (with weighting factors of ⅓ and 1 respectively), the third harmonic of square wave f is canceled. This produces a stepped waveform which is a much better approximation to a sine wave at frequency f than a square wave. If a zero average sine value is desired, a dc offset can also be included in the summation. If an approximate sine wave is not good enough, the output of the op amp can be filtered by a simple low-pass filter, since the lowest harmonic to be rejected is five times the fundamental. □



Pulse to audio. An exclusive OR, two-stage frequency divider and op amp are used to sum the third harmonic and fundamental of a square wave, producing a stepped approximation to a sine wave that is easily filtered.

Designing microprocessors with standard-logic devices, Part 1

Application-oriented processors that utilize standard-logic families like ECL or Schottky TTL are an economical alternative to random-logic designs and perform better than MOS microprocessors

by Robert Jaeger, *Signetics Corp., Sunnyvale, Calif.**

☐ MOS microprocessors are growing in popularity mainly because digital systems designed around them require relatively few integrated circuits. They do have drawbacks, however. They are slower and less flexible than random-logic TTL systems, and they are not widely second-sourced.

But there is a third design route available to meet certain system requirements: the small, applications-oriented processor built with standard high-speed logic devices, either ECL 10K or Schottky. These "standard-logic processors" perform about as well as random-logic TTL designs and use logic families available from four or five major sources. Although they require more ICs than metal-oxide-semiconductor microprocessors, they can replace random-logic TTL designs that need five to 10 times as many devices. By designing his own processor, an engineer can minimize system costs by including only as much capability as he needs, and can provide special features that would be unavailable in an off-the-shelf MOS device.

Part 1 of this two-part article will outline the requirements for the three basic processor elements—the register/arithmetic/logic unit, the control memory, and the input/output circuitry. Part 2 will discuss how proper selection of the microinstruction format can minimize control-memory size; it will also cover memory branching and outline some designs for standard-logic processors.

Processors

A processor, whether in a large computer or in a hand-held programable calculator, differs from random-logic designs in two important respects. First, the processor performs a sequence of logic or arithmetic operations. By contrast, in a typical random-logic design, several operations, such as data manipulation or system input and output control, can take place concurrently. One of the requirements in a random-logic design, in fact, is to ensure that these concurrent operations do not interfere with each other. Second, a processor can modify its sequence of operations on the basis of the results of previous operations.

It is worth repeating that a processor is not a computer—although it can be designed to function as the central processing unit (CPU) in a computer system. In this application, the processor interfaces with the main memory and controls data transfer into and out of the system. A CPU, then, is a processor with special features and capabilities.

Functions of ICs

Each IC function in a system can be classified as either arithmetic/logic, control, or interfacing. In an average system containing 100 to 300 devices, about 35% are used in arithmetic/logic functions, 40% for control, and 25% for interfacing. Depending on the particular product and design approach, this breakdown will vary somewhat—but seldom more than 10% in a system with more than 100 ICs. A processor design can incorporate all the arithmetic/logic and control functions in one small subsystem. In addition, the use of bussing techniques can reduce the number of internal interfacing functions needed. Because of this, whether a processor requires one, two or 20 devices matters far less than the question of whether a processor can be used instead of random logic while still maintaining the necessary system performance level.

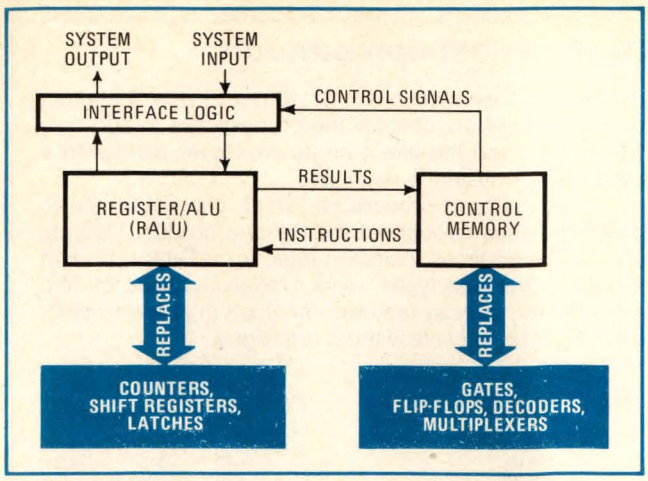
A system with 100 to 300 ICs will use various types of devices to implement the arithmetic/logic, control and interfacing functions. Table I shows a breakdown of these devices into five classifications and the percentage of each used in a typical system. These numbers are representative of many different designs and types of products.

A basic processor, shown in Fig. 1, has three sections. The register/arithmetic/logic unit, or RALU, performs all the logical and arithmetic functions on system data and replaces the buffer registers, counters and shift registers used in a random-logic design. The RALU is controlled by the control memory, which provides it with instructions specifying different operations. The

TABLE 1:
DEVICE USAGE IN TYPICAL RANDOM-LOGIC DESIGNS

30%	Counters, shift registers, latches
10%	Decoders and multiplexers
35%	Gates and flip-flops
15%	Interface
10%	Miscellaneous

*Now with MSI Data Corp., Santa Ana, Calif.

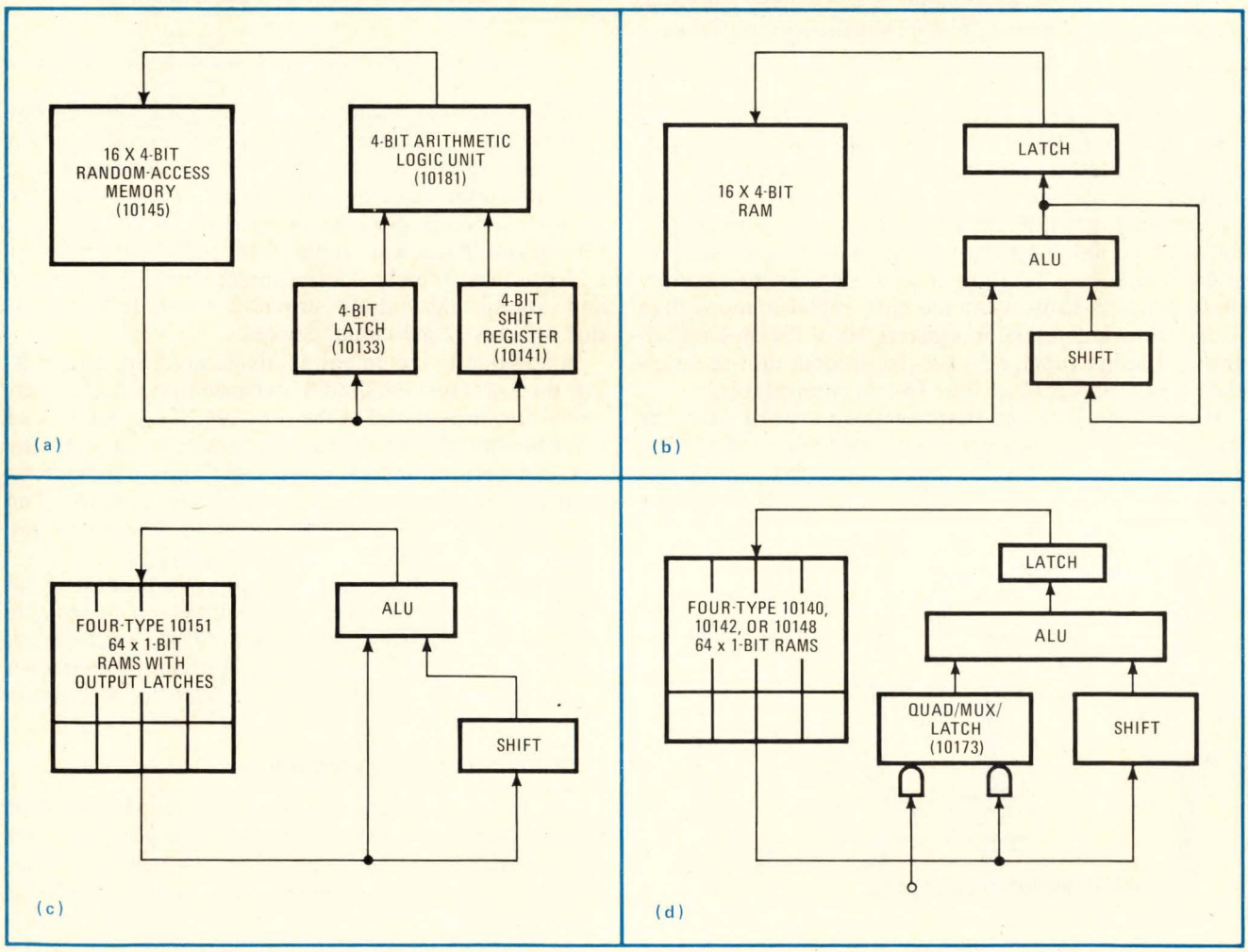


1. Basic processor. Replacing large numbers of registers, counters gates, flip-flops, decoders and multiplexers, are three basic components comprising a processor: the register/arithmetic/logic unit (RALU), the control memory, and the associated interface logic.

memory also receives "feedback" signals from the RALU, indicating the results of a current or previous RALU operation, and is capable of modifying its sequence of instructions on the basis of these signals. The control memory replaces gates, flip-flops, decoders, and multiplexers used in random-logic designs. The control memory also steers data into or out of the RALU through the interfacing logic.

Figure 2a shows a RALU design that uses only four devices to perform the same function as 16 individual registers, counters or shift registers. Although this and the other examples shown here use ECL 10K devices, the concepts and techniques apply equally well to any standard-logic family. ECL 10K does, however, have several advantages in this type of application. It is the fastest standard-logic family and obtains a higher level of performance from a system of a given size. The open emitter outputs minimize the need for multiplexers by allowing wire "ORing" of outputs. The ability to terminate critical path signal lines with their characteristic impedances eliminates ringing and overshoot and permits system speed to approach that of the logic devices more closely. Finally, ECL 10K is designed to operate at high speeds without an increase in operating power, in contrast with Schottky TTL, where power dissipation increases rapidly above 20 megahertz.

The combination of a small random-access memory, arithmetic/logic unit (ALU), shift register, and latch shown in Fig. 2a provides an extremely versatile basic



2. Variations on a theme. Four versions of the basic RALU configuration, are implemented with 10K emitter-coupled-logic devices, although other standard logic families could be used. A four-device configuration like (a) can replace 16 individual registers and counters.

Processors vs random logic: a cost comparison

Are high-speed, standard-logic processors only a way of providing higher-performance microcomputers? Or are they also cost-competitive with random-logic TTL designs? In the table shown, the total costs for random-logic TTL designs using 100, 200, and 300 devices are compared with the total costs for three different sizes of processor using TTL read-only memories, programable ROMs, and ECL 10K logic devices. The IC costs were calculated from prices for comparable device quantities.

This shows that, as a substitute for random-logic TTL designs with more than 165 ICs, even a complex 8-bit ECL processor is less expensive. Processor designs using Schottky TTL will be about 30% cheaper than the ECL versions, bringing the crossover point still lower.

The table also shows that the total cost of a random-logic design is highly insensitive to reductions in the price of the ICs. A 10% drop in IC prices results in only a 2.5% drop in total system cost and can easily be wiped out by a small increase in overhead costs. The processor designs, by contrast, use expensive devices which make up almost all of the total system costs. Not only are these devices dropping in price at rates twice that of TTL, but any IC price reductions translate almost entirely into over-all cost reductions.

It is not strictly true that smaller systems have the same overhead cost per IC as larger systems since this figure tends to get larger as IC count decreases. However, even if the figure should double to $2.40 per device, the effect on the total system cost for the processor is to add only $20 to $40, and the effect on its crossover point with a random-logic system is negligible.

Other benefits of processors, which can contribute to cost reductions throughout the life of a product, include shorter design times, common logic for different product models, fewer part types, higher reliability, ease of field modification, special features for custom requirements, and longer product life without redesigns.

COST COMPARISON	IC cost*	Overhead cost**	Total cost
Random-logic TTL			
100 ICs	$ 40	$120	$160
200 ICs	80	240	320
300 ICs	120	360	480
Simple 4-bit ECL processor			
13 ICs, plus 8,192-bit memory	$125	$ 20	$145
Simple 8-bit ECL processor			
18 ICs, plus 8,192-bit memory	$160	$ 26	$186
Complex 8-bit ECL processor			
25 ICs, plus 16,384-bit memory	$225	$ 40	$265

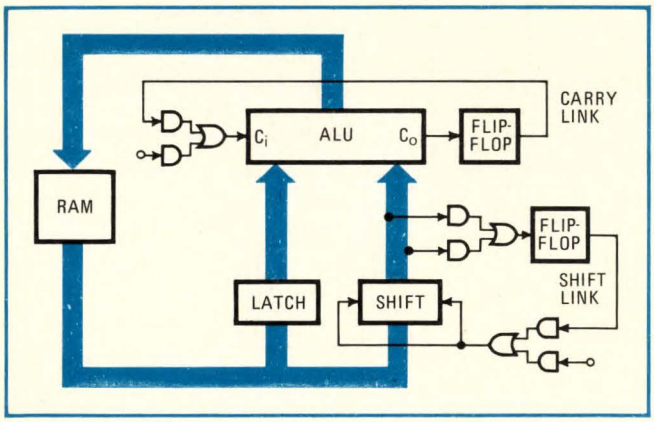
*Assumes average selling price of 7400 TTL logic at $0.40.
**Average is $1.20 per IC, and includes cost of connectors, wiring, pc boards and board checkout, cabinets, fans, IC test and assembly, and power supply.

building block for a system. Any of the memory locations may be treated as a 4-bit counter and incremented or decremented by passing the word from the memory through the ALU and back into the memory. Transferring a word through the shifter is enough to perform a shift-left or shift-right operation. A word may also be moved from one location in the memory to another. (Actually, the 16-by-4-bit memory replaces more than 16 individual counters or registers, since the on-chip address decoding replaces a 4-to-16 decoder and the multiplexed outputs replace four 16-to-1 multiplexers.)

It might be expected that accessing a word from the RAM, passing it through the latch and ALU, and writing it back into the RAM would take longer than simply incrementing a counter. However, the whole operation takes a maximum of only 45 nanoseconds, allowing the memory to be accessed and a word incremented or decremented at a 22-MHz rate. This is comparable to the maximum counting frequency of a 74163 TTL counter, which is specified at 25 MHz. While the basic four-device RALU can replace 16 individual registers and counters, merely adding another RAM in parallel and "ORing" the outputs provides a five-device RALU that replaces 32 individual devices.

In addition to incrementing, decrementing, and shifting, the RALU may be used to perform many other operations on words stored in the memory. If one RAM word is loaded into the latch and another into the shifter, the ALU can perform a total of 16 logic and 16 arithmetic functions on the words taken from the memory. The ALU's performance of these functions eliminates the need for specialized MSI devices in the design.

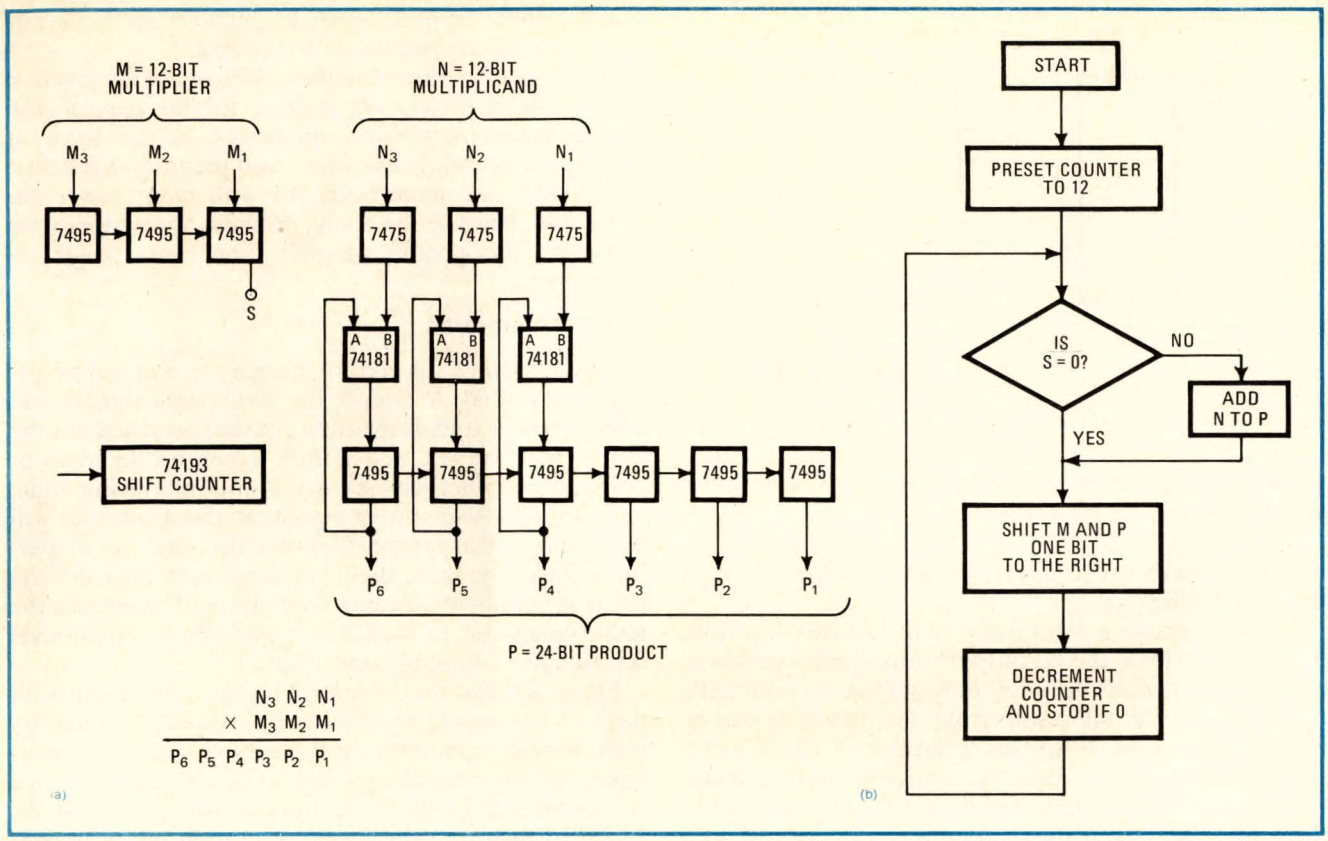
Figure 2 also shows some possible variations in the basic RALU, each of which has features which may be valuable in a particular application. Of particular interest is the design that uses RAMs containing their own output latches. This eliminates the need for a separate latch in the RALU.



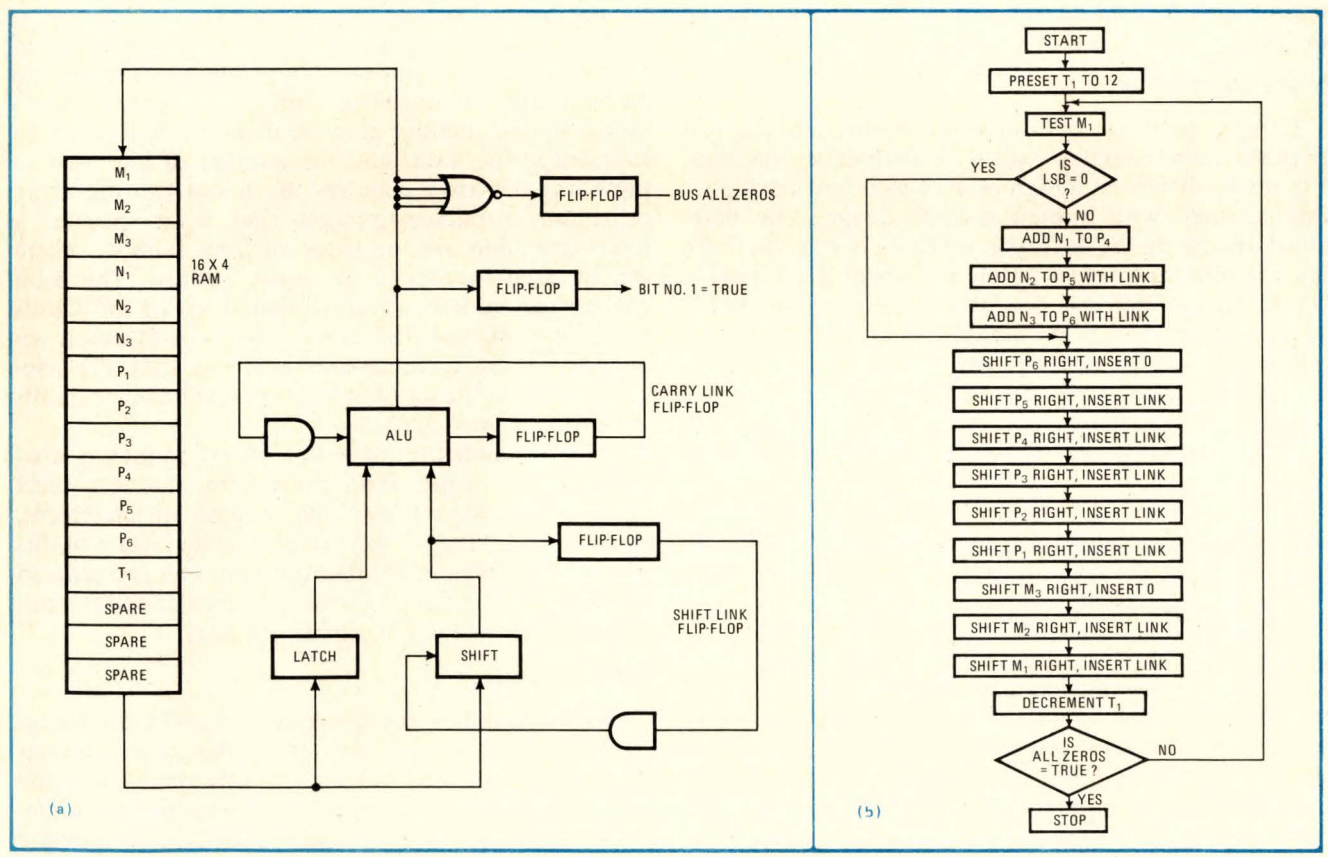
3. Togetherness. Adding "shift linking" and "carry linking" features to the basic RALU enables it to handle words of any width by operating on their segments in sequence, but at lower operating speed.

Shift linking and carry linking

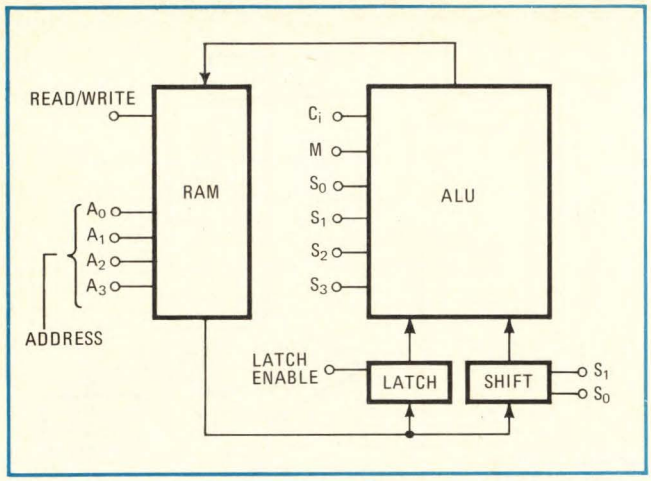
In those cases where data formats are wider than 4 bits, the basic RALU may be expanded to accommodate them in either of two ways. The simpler and more straightforward is to widen the data path by adding more of each device to form an 8-, 12-, or 16-bit design. Each additional 4 bits of data path requires four additional devices. The other alternative is to include a provision in the 4-bit RALU for multiple word operations;



4. Complex way. Building a multiplier using a random logic design with 7400 series TTL (a) can be costly in terms of number of device packages. Flowchart for the 12-by-12-bit multiplier, in which sequence is performed at each bit position, is shown in (b).



5. Simple way. Multiplier, equivalent to that of Fig. 4 and implemented with a 4-bit RALU design, operates at a reduced speed—but halves the part count. For larger numbers, the reduction is even greater. Sequence of operation is shown in (b).



6. Control. Any size of RALU requires a minimum number of 14 control inputs, as shown in this diagram.

that is, to enable it to operate 4 bits at a time on data more than 4 bits wide.

Figure 3 shows a 4-bit RALU with two link flip-flops added. One stores the bit output from a shift operation, and the other stores the carry output from an arithmetic operation, so that the results from one operation can be linked to the next. With this technique, a 12-bit word, stored in three 4-bit memory locations, can be incremented or decremented. Although the operation takes three times as long as the same function performed with a 12-bit RALU, it requires far less logic. Linking can be used in a sequence of operations to operate on a number of any size up to the entire bit capacity of the memory.

More complexity

Using a sequence of simple operations, a RALU can perform more complex logical or arithmetic functions. Figure 4a shows the design of a 12-by-12-bit multiplier implemented with a random-logic design. The flowchart describing the operation is shown in Fig. 4b. If the least significant bit (LSB) of the multiplier is a logical 1, the 12-bit multiplicand is added to the most significant 12 bits of the partial product, and the multiplier and partial product are shifted right one bit. If the LSB is 0, no addition takes place, but the multiplier and partial product are still shifted one position to the right. This operation is performed at each bit position in the multiplier.

Figure 5a shows a 4-bit RALU with carry linking and shift linking that can perform the same function. It also tests the least significant bit of the ALU output and tests for an all 0s condition.

Figure 5b lists the sequence of operations required to perform the multiply operation. In this example, a RALU using seven devices can perform the same function as a specialized random-logic design that requires 16 devices. The RALU, of course, operates much more slowly but, where high speed is not important, this permits halving of the parts count. For multiplying numbers longer than 12 bits, the reduction becomes even larger. In addition, because the RALU memory locations are not committed to specific system functions, the same location could be used for other purposes, such as converting the binary product to BCD digits.

It was stated earlier that about 40% of the devices in a typical digital system are needed for the control and timing functions. Control memories, in the form of high-speed read-only memories and programable ROMs, can provide the same functions with many fewer devices, and, because the RALU provides the system data functions, this greatly simplifies the control-logic requirements.

Control memories

The purpose of the control memory in a processor design is manifold: to supply the RALU with signals that select a source and destination for data, and control the functions of the ALU and shifter; to control the input or output of data between the RALU and interfacing logic; and to send a sequence of signals to the RALU that will determine which system function the RALU is to perform. Basically, then, the control memory provides the RALU with individual control signals, and sequences the RALU operations to enable it to perform a system-level function like a multiply operation.

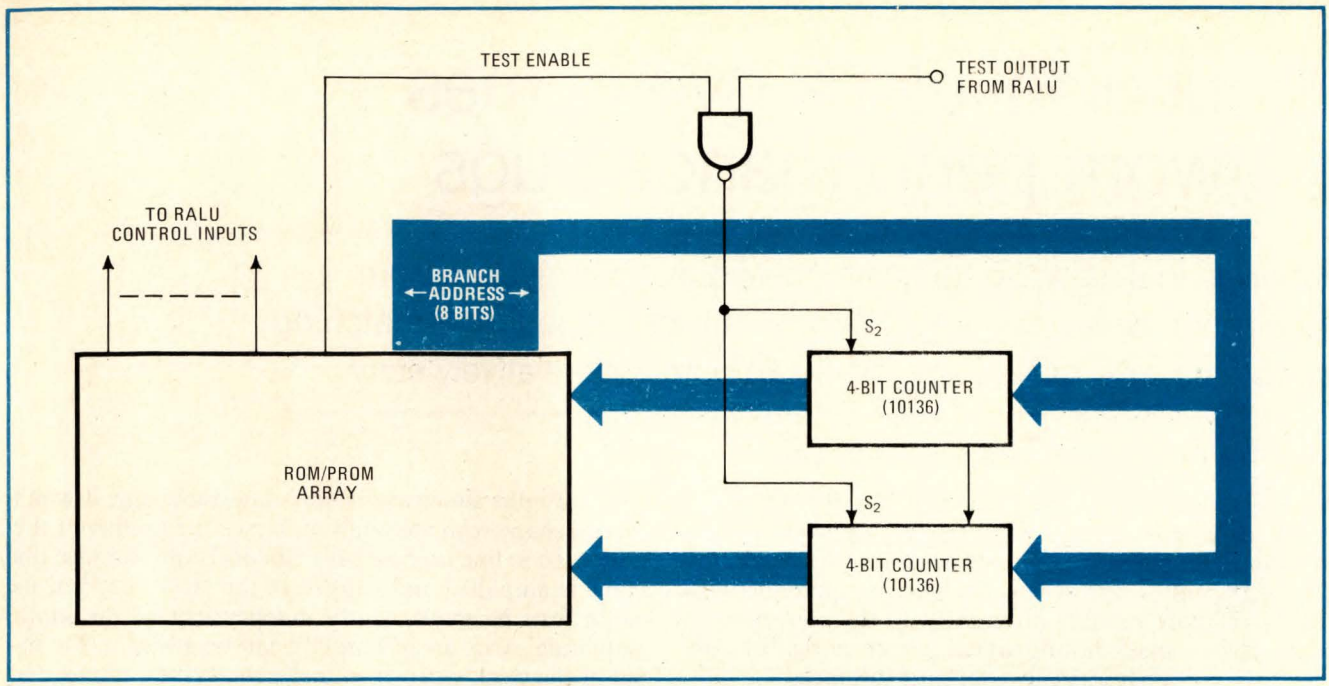
Figure 6 shows the 14 control inputs to the basic 4-bit RALU. These inputs specify a memory address, memory read or write operation, ALU function, and shift operation. Significantly, the number of RALU control inputs is independent of the RALU data width—that is, an 8-, 12-, or 16-bit RALU would each require the same 14 control inputs. However, as features are added, such as linking, bus testing and extra latches and shifter inputs, the number of control inputs increases.

Figure 7 shows a simple control memory consisting of a ROM/PROM array and two 4-bit counters that provide an 8-bit array address. The width of the array is determined by the number of control signals that must be supplied to the RALU and the number of bits used in presetting the array counters. Each word in the array constitutes a microinstruction—that is, it specifies a RALU operation and provides an 8-bit number which can be used to change the array address. The 8-bit counter can address an array that is up to 256 words deep. Incrementing the array counter provides a sequence of these microinstructions to the RALU. This sequence defines the series of RALU operations that results in a system-level function.

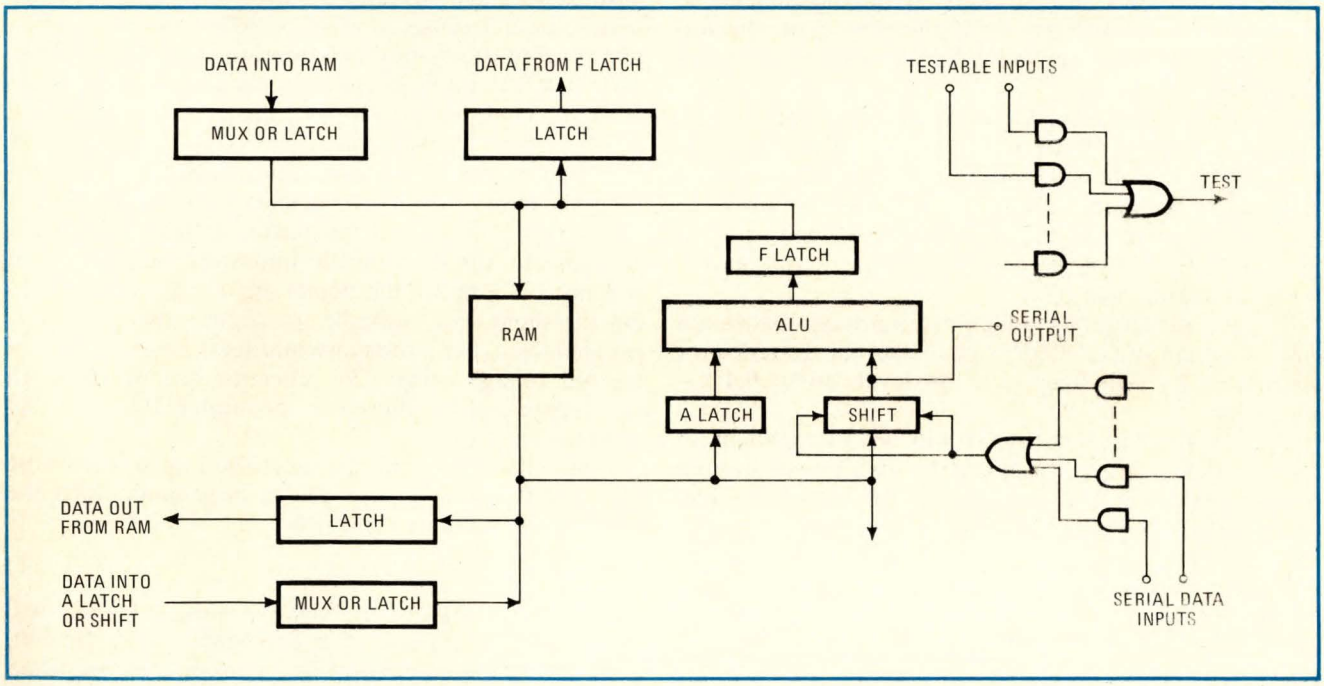
In this example the 10136 ECL binary counter is used to address the array. With the counter function select input, S_2, at a logic 1 level, the counter will increment, and at a logic 0 level it will preset. The logic state of this signal will determine whether the counter increments to select the next microinstruction or presets to select a microinstruction in another part of the array.

Input/output

Regardless of how fast the control memory can be accessed or the RALU can operate on data, the performance of the processor will be seriously impaired if the input/output facilities require cumbersome and time-consuming program steps. Consequently, interfacing a processor with other system elements easily and economically becomes a prime design consideration.



7. Control memory. Width of the ROM/PROM array in this control memory depends on the number of control inputs to the RALU and the number of bits used for presetting the two 4-bit counters which address the array to select appropriate microinstructions.



8. Flexibility. One great advantage to standard-logic processors is the ability to place interfaces at almost any point. Here such interfaces are provided at RAM and shifter inputs and outputs. Also, it's fairly simple to provide additional testing or control functions at other points.

One of the most useful features of a processor design utilizing standard-logic devices is its unique ability to provide an interface at any point in the processor logic. Figure 8 shows a processor with interfaces at the RAM input and output and at the shifter input and output. Inputs can be tested directly with "test and branch" instructions which sense the state of one or more input lines. Similarly, by decoding a set of bits in an instruction, a single pulse or set of pulses may be sent from the processor to set or clear flip-flops or to perform some other external control functions.

I/O instructions, then, can be simply extensions of other processor instructions. As an example, instead of transferring a word from the RAM to shifter or "A" latch, the word may be transferred directly to an external register or bus. The ability to interface different system elements to different points in the processor can reduce to an absolute minimum the external interfacing logic required in the system. □

(Part 2 of this article will appear in the next issue.)

Sinusoidal clock overcomes network performance bugs

Change to sine wave frees synchronous digital system from frequency-dependent distortion, eliminates impedance-matching problems, and makes time-delay adjustments relatively easy

by Otakar A. Horna, *Comsat Laboratories, Clarksburg, Md.*

☐ The maximum bit rate of a high-speed (150 megahertz or higher) synchronous digital network is ultimately determined by the preciseness of the clock timing. It should be of interest, therefore, to examine what can be a more reliable alternative to the conventional square-wave clock-timing signal, which is readily subject to distortion, especially over long distances.

A square wave has many high-frequency components, and the electrical characteristics of solid dielectric transmission lines are strongly frequency-dependent above several megahertz. So if rise time is in the nanosecond range, the transmitted pulse will invariably be distorted.

There are other considerations as well. Clock timing can be temperature-dependent to the extent that the gate-threshold voltage is affected by temperature shifts. The clock-distribution network must be immune to crosstalk from other signal lines. And clock timing must be adjustable at various network points to compensate for transmission delays.

These considerations, which are normally associated with a square-wave clock signal, can be lessened or eliminated by switching to a low-level—about 0.4 v—sine wave.

The sinusoidal clock signal will be independent of transmission-line quality. It can be distributed through multiple branches without difficulty. And its time delay can be adjusted easily. The only trick is to send the sine wave throughout the transmission system. Then, at the various driving points of the system, the signal is amplified in the clock receiver, phase-shifted to add the necessary delay, and finally clipped to provide the square shape necessary to drive the "clock inputs" of each particular subsystem.

Sine wave advantages

Because the sine wave's amplitude is relatively low, the output power of the central clock is low. It never gets above the milliwatt range even when a low-impedance transmission line (25 ohms, for example) is used for signal distribution. Low signal amplitude, low clock-line impedance, and the sinusoidal waveform all contribute to a reduction of crosstalk. A sine wave is clearly better than a square wave of the same frequency and amplitude because crosstalk voltage is proportional to the derivatives, dv/dt and di/dt.

Because the sine wave is only one frequency, it won't change shape with attenuation; hence the quality of the transmission line is of no consequence. And because the signal is amplified and clipped in the clock receiver, its output can be made nearly independent of the input amplitude. Also, an ac coupling can be added to the input of the clock receiver to make the system insensitive to dc-level shifts.

Reflections from line discontinuities or impedance mismatches have virtually no adverse effect on a sinusoidal signal because, in practice, reflections do not distort the sine wave; they only tend to create a standing-wave pattern. Again, in practice, the reflections in a network can completely distort a transmitted square-wave pulse if line propagation time is not substantially shorter than signal rise time. The amplitude of the reflections must, therefore, be kept well below the so-called "noise margin" of the particular gate. Noise margin indicates the resistance to undesired switching, and is defined in terms of the points surrounding the switching threshold. For example, in circuits using emitter-coupled logic (ECL), the noise margin is typically 15% of the full voltage swing. The reflection coefficient, K, in the network must, therefore, be under 10%, i.e., $|K|$ must be less than 0.1.

Generally, if Z_o is the characteristic impedance of the line, and Z is the load or source impedance, then the permissible impedance mismatch is:

$$Z/Z_o = (1 + K)/(1 - K) \quad (1)$$

If $|K|$ is less than 0.1, then the value of Z/Z_o will range between 0.81 and 1.22. This may be very difficult, even impossible, to achieve in a complicated branched network in which a square-wave signal is used.

Here is where a sine wave is markedly superior. Since its reflections only create standing-wave patterns, if a clock receiver can handle signals with a dynamic range of 1:4, then a standing wave ratio, S, of the same magnitude, in which:

$$S = (1 + |K|)/(1 - |K|) \quad (2)$$

does not affect the signal distribution in the network. Therefore an impedance mismatch can be tolerated where Z/Z_o ranges from 0.25 to 4.0. Complicated configurations thus can be used without impedance-matching networks.

The other advantage of the sine-wave clock signal is that the delay at any point can be adjusted by changing the phase of the sine wave in an all-pass phase-shift network. One of the easiest phase-shifting techniques is the well-known RC network. The phase shift (α) of the output signal relative to the input signal is

$$\alpha = 2tan^{-1}\omega RC = 2tan^{-1}2\pi fRC \quad (3)$$

The relationship between phase shift and signal delay is $t_d = \alpha/\omega$.
Therefore:

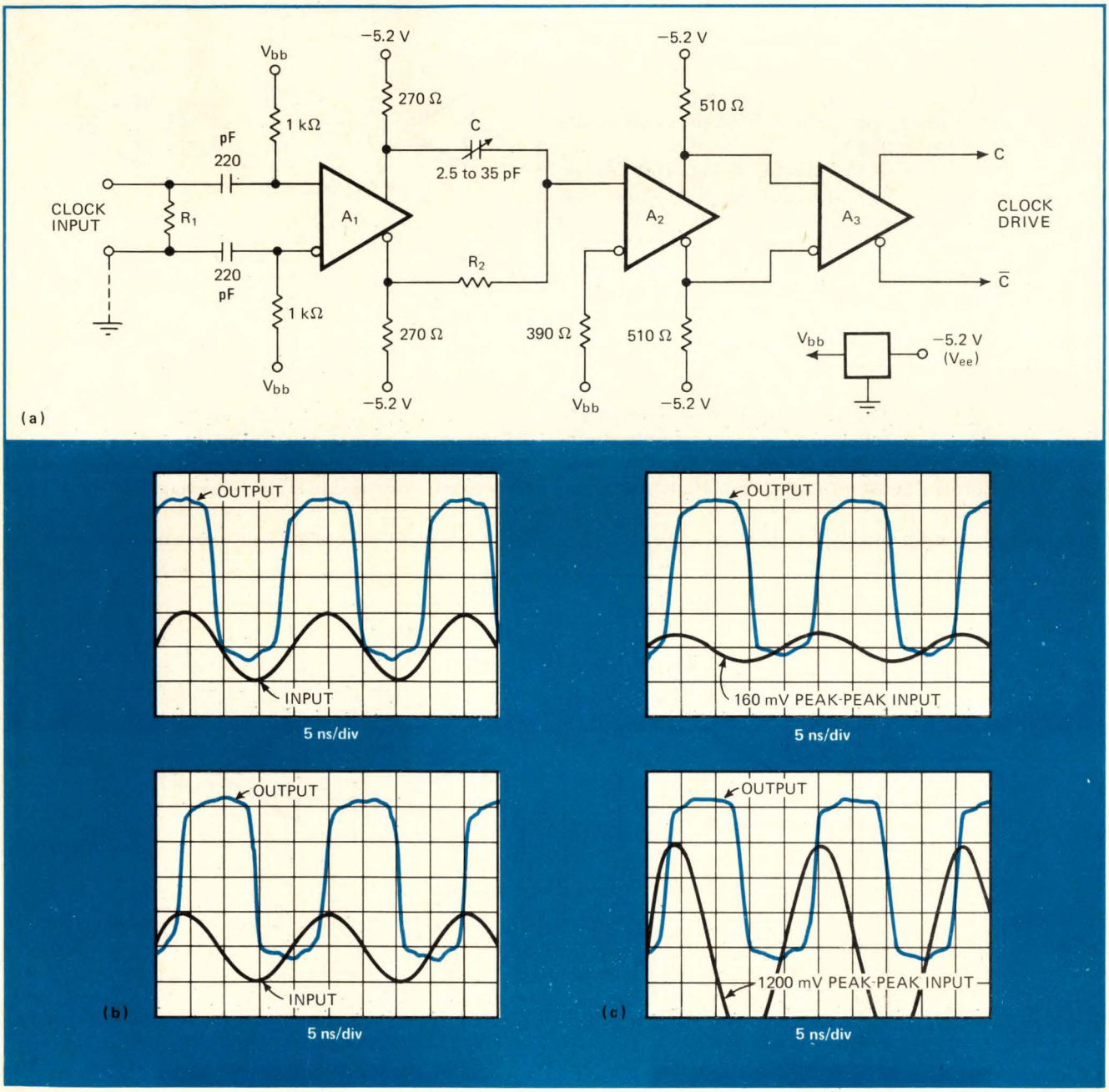
$$t_d = (2/\omega)tan^{-1}\omega RC \quad (4)$$

For small angles: $tan\alpha = \alpha$, and the delay is $t_d = 2RC$, which is essentially independent of the frequency. Therefore, if the clock frequency varies in a limited range, the RC network can make precise adjustments of the delay through a simple trimmer capacitor.

Clock driver

Comsat developed this system for use in high-speed digital computing networks. To verify that this approach would work, a clock driver with adjustable delay was designed and built for use with Motorola's MECL 10K logic. The circuit in Fig. 1(a) is built around a triple differential amplifier, in this case MC10116, with a

1. Sine-wave clock driver. In this circuit, designed for Motorola's MECL 10K logic (a), amplifiers A_1, A_2 and A_3 are contained in one IC, a triple differential amplifier, MC10116. By trimming C in R_2C network, the phase angle (b) can be shifted 130°. Notice that the output waveform (c) remains constant even though the input signal varies from 160 to 1,200 mV peak-to-peak.



threshold voltage source (V_{bb}). The first amplifier receiver (A_1) is ac coupled to the clock-distribution line. This amplifier receiver, which can accept voltages from 0.1 V to 1 V, drives the phase shifting network CR_2. The input can be connected to a balanced-pair line (which is preferable for a clock-distribution network) or to an asymmetric line (coaxial cable). In the latter case, one input can be ac grounded, as shown. The input impedance of the amplifier is 2 kilohms, which can be adjusted to a specific value Z_0 by the addition of a resistor, R_1.

The phase angle can be adjusted in the range of approximately 25° to 155° with a miniature trimmer, C. The selected trimmer's value (35 pF) represents a compromise between size and the loading effect of the input capacitance of the second amplifier, A_2. The value of resistor R_2 is dependent on the clock frequency, f_c, and if C is equal to 10pF, it can be determined from equation (3) as follows:

$$R_2 = 10^{11}/2\pi f_c \qquad (5)$$

Amplifiers A_2 and A_3 limit the sine wave to form a square wave of the proper level to drive the clock inputs of MECL 10K logic circuits.

The performance of the circuit in Fig. 1(a) can be evaluated from Figs. 1(b) and 1(c). Fig. 1(b) shows that the input phase angle can be varied 130°. In Fig. 1(c) the 50-MHz input signal with 160- and 1,200-mV peak-to-peak amplitude is compared with the output waveform. (Note the insensitivity of the output-to-output voltage variation.)

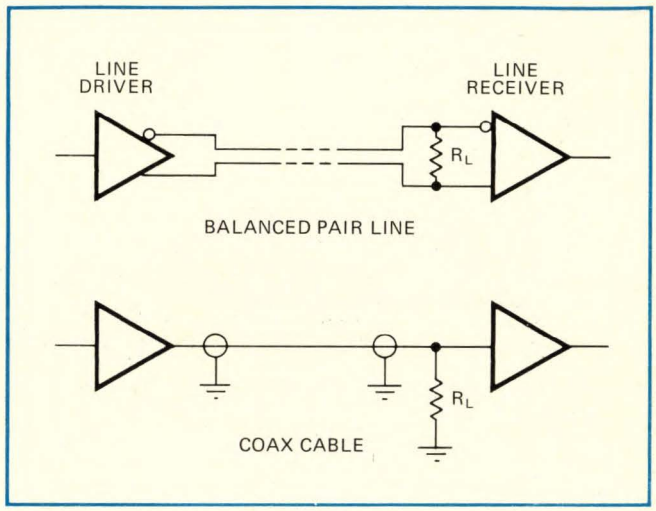
The whole circuit (including the output driver) can be easily integrated by using standard hybrid technology; the only external parts are resistors R_1 and R_2, and the trimmer, C. The delay in A_1, A_2, and A_3 is affected very little by temperature. Therefore, the temperature coefficient of the delay is determined only by R_2 and C, and these parts can be chosen to have the temperature stability that is required for the application.

For Motorola's MECL III logic, a quad line receiver (four differential amplifiers) can be used with a slight variation of the circuit (Fig. 2) and will have slightly different properties; e.g., the input level of the clock sine wave must be at least 250 mV peak-to-peak.

Output driver

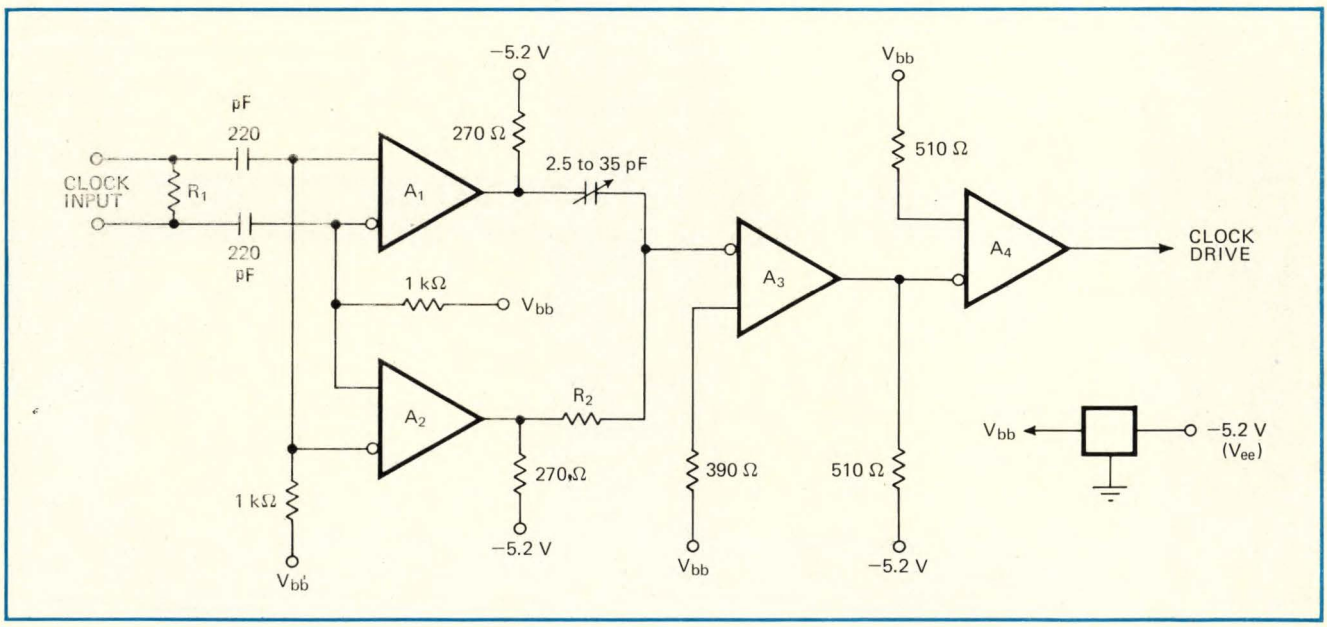
For MECL 10K and MECL III circuits, the allowable current of the output emitter follower limits the impedance (Z_0) of the interconnecting transmission lines to 50 ohms. If a single power-supply system is used where V_{ee} = -5.2 V, then the line load resistor $R_1 = Z_0$ must be connected to -2 V, or a voltage divider (see the output of A_2 in Fig. 4) is required.

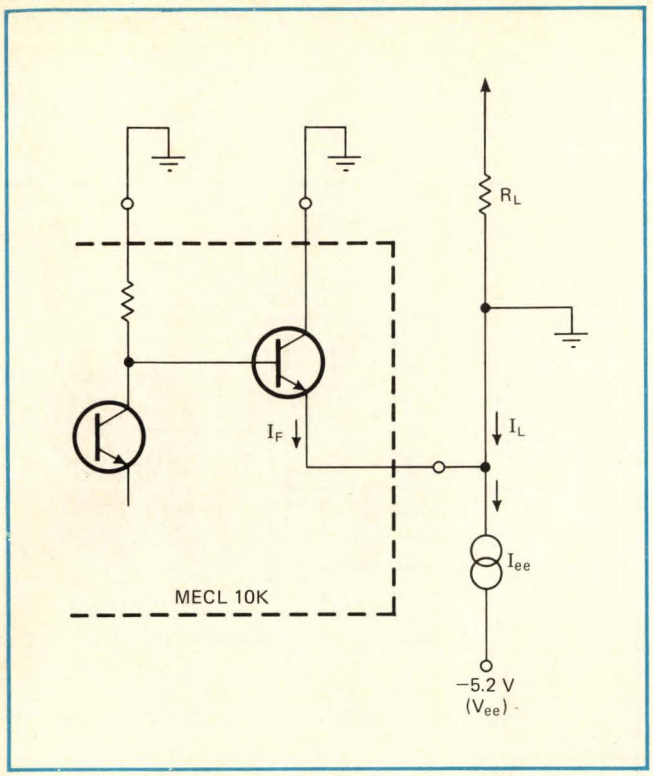
Special line drivers must therefore be built (Fig. 3) to drive lines in which the impedance is less than 50 ohms;



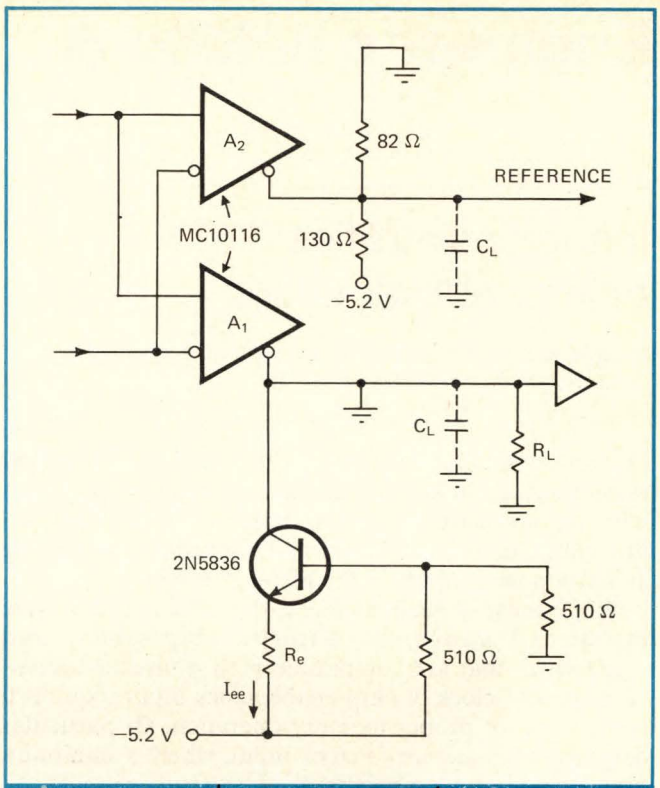
3. Situations. A special driver is needed when either line impedance is below 50Ω, or there is a floating balanced pair, or when a shielded transmission line with load R_L is common grounded.

2. For Motorola's MECL III logic. A slight variation of the clock driver in Fig. 1(a) is shown in this circuit, which uses a quad line receiver.





4. Eliminating special driver. If a single power supply is used for either Fig. 1(a) or Fig. 2, a special line driver normally is required. This line driver can be eliminated by replacing the emitter resistor of the output emitter-follower with a constant-current source.



EMITTER RESISTOR (R_e), OHMS	MINIMUM LOAD IMPEDANCE, OHMS	SOURCE CURRENT (I_{ee}), MILLIAMPS
39	50	40
33	40	50
27	30	60
20	25	75

5. Low-impedance loads. If the amplifier A_1 in Fig. 1(a) is connected to transistor 2N5836, which serves as a current source, then the circuit can drive loads as low as 25 ohms.

or for a floating balanced-pair line, which is preferable for pulsed signal transmission over longer distances; or for a shielded transmission line with load R_L connected to a common ground. The latter method is preferable for a longer coaxial cable or a longer stripline because it eliminates the problem of decoupling the auxiliary power supply (−2 V) distribution system or the voltage divider.

If the emitter resistor (R_e) of the output-emitter-follower of the ECL device is replaced by a constant-current source (I_{ee} in Fig. 4), then this simple configuration in most cases can take the place of a special line driver (see the output of A_1 in Fig. 5). If the common ground impedance can be accidentally disconnected while the circuit is operating, the constant current source is limited by the maximum permissible current of the emitter follower. (This maximum current of the emitter follower, I_F, is, for example, 50 mA with Motorola's MECL 10K, as in Fig. 4). But if the common ground impedance R_L is connected permanently, then the constant current source I_{ee} can be higher than that of the emitter follower as long as I_F is greater than $I_{ee} - I_L$. Then the circuit is able drive loads as low as 25 ohms, as shown in the table of Fig. 5.

Circuit performance can be evaluated by taking the output waveform of a line receiver—such as MC10116 loaded with a standard 82 + 130-ohm divider (labeled "reference" in Fig. 5)—and comparing it to a similar receiver for which a constant current source of 50 mA is loaded with 50 ohms to common ground, and the waveform at the load R_L is artificially delayed by 5 ns. For all practical purposes, the waveforms are identical. The rise and fall time of the circuit with R_L connected to ground is superior to that of the standard circuit if a capacitive load of 100 pF is connected in parallel with R_L (as in Fig. 5, with C_L the capacitive load).

With a current of 75 mA and impedance of 25 ohms, the rise and fall times are approximately 40% longer than those of the 82 + 130-ohm divider reference output. This is to be expected from the characteristics of the ECL-output emitter-follower transistor, but a 100-pF load in parallel with 25 ohms does not practically affect the response.

There are disadvantages to the sine-wave approach. A digital system that uses phase-shifting networks for delay equalization cannot be substantially "slowed down" by decreasing the clock rate, say, for troubleshooting, because the phase-to-delay relation (Equation 4), is frequency independent for only a limited frequency and phase range. In addition, the clock receiver/driver in Figs. 1(a) and 2 is relatively complicated, with one IC and more than 10 discrete components, and the units cannot be cascaded to increase the total delay. Of course, the former disadvantage can be substantially overcome by implementing the circuit in a hybrid IC. □

Inductor simplifies memory-driver circuit

by Robert Johnson, Paul Feldman, and Edwin Fisher
Honeywell Information Systems, Billerica, Mass.

Designing memory systems with 4,096-bit n-channel random-access memories poses a number of problems with the associated interface circuitry. But a small inductance can at least eliminate the headache of having an extra power supply in the memory driver.

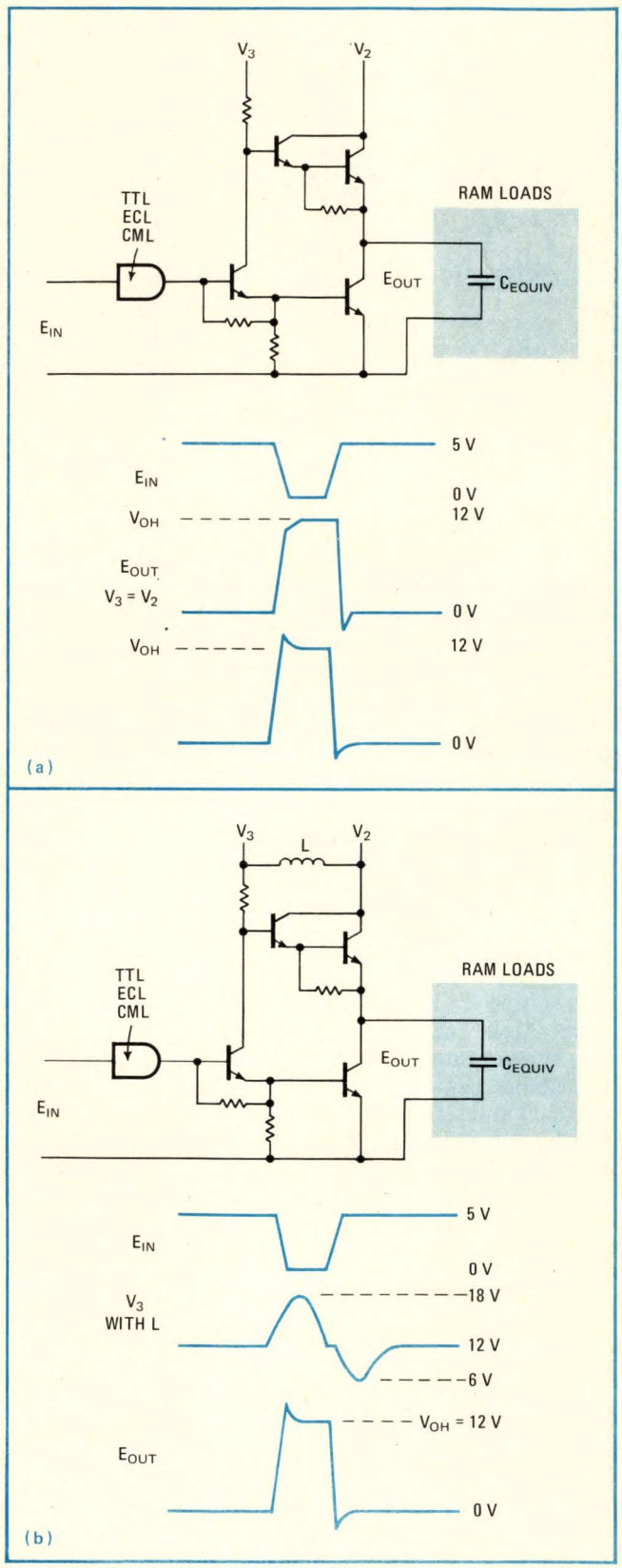
While most of such RAMs on the market today have inputs—all addresses, data-in, chip-select, and read/write—that are compatible with transistor-transistor logic, the clock or chip-enable clock input requires 0 to 12 volts for proper memory operation. Of particular concern is the memory's clock input, where a minimum high level of 11.4 V is required.

A common totem-pole output driver circuit—similar to the SN75365 or MC3960 initially used with p-channel RAMs—tied to a number of n-channel-RAM clock inputs, is shown in (a). Capacitive loading is typically 390 picofarads per clock driver. When $V_2 = V_3 = V_{DD}$, the outputs appear degraded, and $V_{OH} = V_{DD} - 1$ V at $I_{OH} = 50\ \mu A$. Increasing V_3 to $V_{DD} + 3$ V changes the output to a more acceptable level, normally $V_{DD} - 0.3$ V at $I_{OH} = 100\ \mu A$.

However, in n-channel systems, the values of V_{DD} and V_{CC} are usually 12 V and 5 V, respectively. If the method of increasing V_3 is used, V_{DD} must be raised to 15 V for V_3 and then dropped back down to 12 V for V_2 and other parts in the system to generate a separate supply voltage on each array card. The alternative is for a separate supply voltage to be bused in for V_3. These methods, while feasible, are not very practical because of increased power consumption and cost.

A way to provide the correct output levels for both chip and driver with only a +12 V supply is to place an inductor from V_3 to V_2. The inductor overcomes the drawbacks of operating with $V_3 = V_2$ without adding a supply greater than V_{DD} to the system, as shown in (b). The inductor provides an energy source in the form of a voltage "kick" whenever the output totem pole is in a transition state. The increased voltage on V_3 supplies the additional current needed as E_{out} changes from low to high, resulting in a smooth and uninterrupted transition to V_{OH}.

A small value of L will not provide an adequate voltage increase at V_3, while too large a value will not recover fast enough at high repetition rates. Values between 36 and 100 microhenries work well at a pulse width of 500 nanoseconds and repetition rates of 1 microsecond or less. □



Power supply transients kept under control

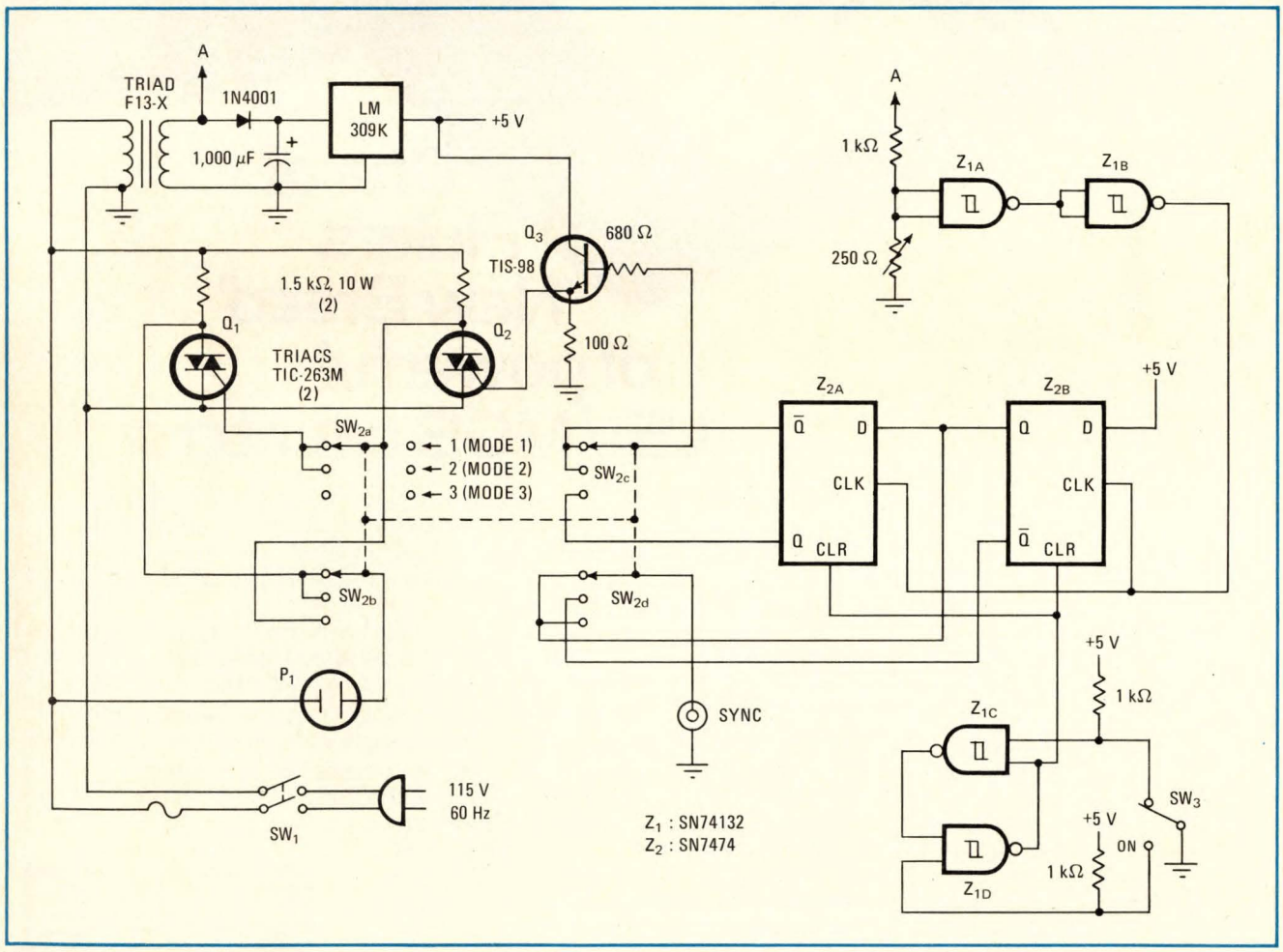
by Ralph Tenny,
Texas Instruments, Dallas, Texas

Two specifications of power supply performance can easily be overlooked, since most manufacturers never mention them. These are turn-on/turn-off spikes and voltage rate-of-rise at turn-on. Most integrated circuits can be damaged or destroyed by power supply spikes which momentarily exceed the device voltage rating. Fortunately, not many commercial supplies do this. However, it is important that in-house designs be checked for spiking during design debugging. In addition, some digital systems with multiple power-supply requirements may lock up if the power supplies come on in a particular order, so it is important to know the voltage rate-of-rise of each supply.

The circuit shown in Fig. 1 will energize ac-powered individual dc supplies or power-supply systems connected to a controlled outlet, P_1. And it will furnish a scope sync signal to allow detailed examination of the power supply output during turn-on. Turn-on can be at line zero crossing or at an adjustable point near line peak to reliably check for worst-case turn-on conditions.

The circuit is based on two triacs which control the ac power to the power supply under test; Q_1 is resistively triggered from the line and turns on and off at zero crossing. Q_1 is controlled by Q_2; when Q_2 is turned on, it diverts gate drive from Q_1. However, if Q_2 turns on in midcycle, Q_1 does not turn off until the next zero crossing. Q_2 is turned on by dc drive from Z_{2A} via Q_3. Z_2 is controlled by a line-derived trigger from Z_1. A line voltage sample (A) is used to generate a phase-variable trigger. This is accomplished by a resistive attenuator and a TTL Schmitt Trigger (Z_{1A}). Adjustment range is sufficient to generate a trigger 90° after zero crossing. After inversion in Z_{1B}, this trigger is applied continuously to a two-bit shift register (Z_2). Z_2 is cleared by a latch or allowed to run at 60 Hertz. At the first trigger after Z_2 is released, Z_{2B} switches and produces a sync signal. On the next trigger, Z_{2A} switches and applies gate drive to Q_2, which turns on. At the next zero crossing, Q_1, which was conducting, turns off (mode 1 operation).

Mode switch SW_2 has three positions to allow these checks: turn-on at zero crossing or at line peak, and turn-off to allow checking for turn-off spikes. In position 1, the power supply is switched by Q_1 at zero crossing.



Transient testing. This power-supply transient-response tester, in conjunction with an oscilloscope, can measure turn-on time at zero crossing (mode 1) or line peak (mode 2) and turn-off time (mode 3).

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With SW_3 off, Q_2 is conducting to hold Q_1 off until SW_3 is turned on. Sync is generated a minimum of 16 milliseconds before Q_1 turns on. In mode 2, everything is the same, except that sync is generated just before Q_1 turns off. In mode 3, Q_1 is not triggered and Q_2 switches the power supply on command, 16 milleseconds after sync.

A safety note: SW_1 opens both sides of the line; this is the minimum acceptable arrangement. At best, the entire circuit should be operated on an isolation transformer. When adjusting the trigger for proper phase angle turn-on of Q_2, be sure to use a filament transformer if an isolation transformer is available. □

Using a frequency counter to measure capacitance

by Thomas McGahee,
Don Bosco Technical High School, Boston, Mass.

Many frequency counters can be used to measure capacitances by exploiting their capability to measure time spans. Basically, the circuit described here charges the capacitor under test with a constant current. The constant current produces a linear voltage increase, and the time it takes for the current to cause a given change in voltage is directly proportional to the capacitance being determined.

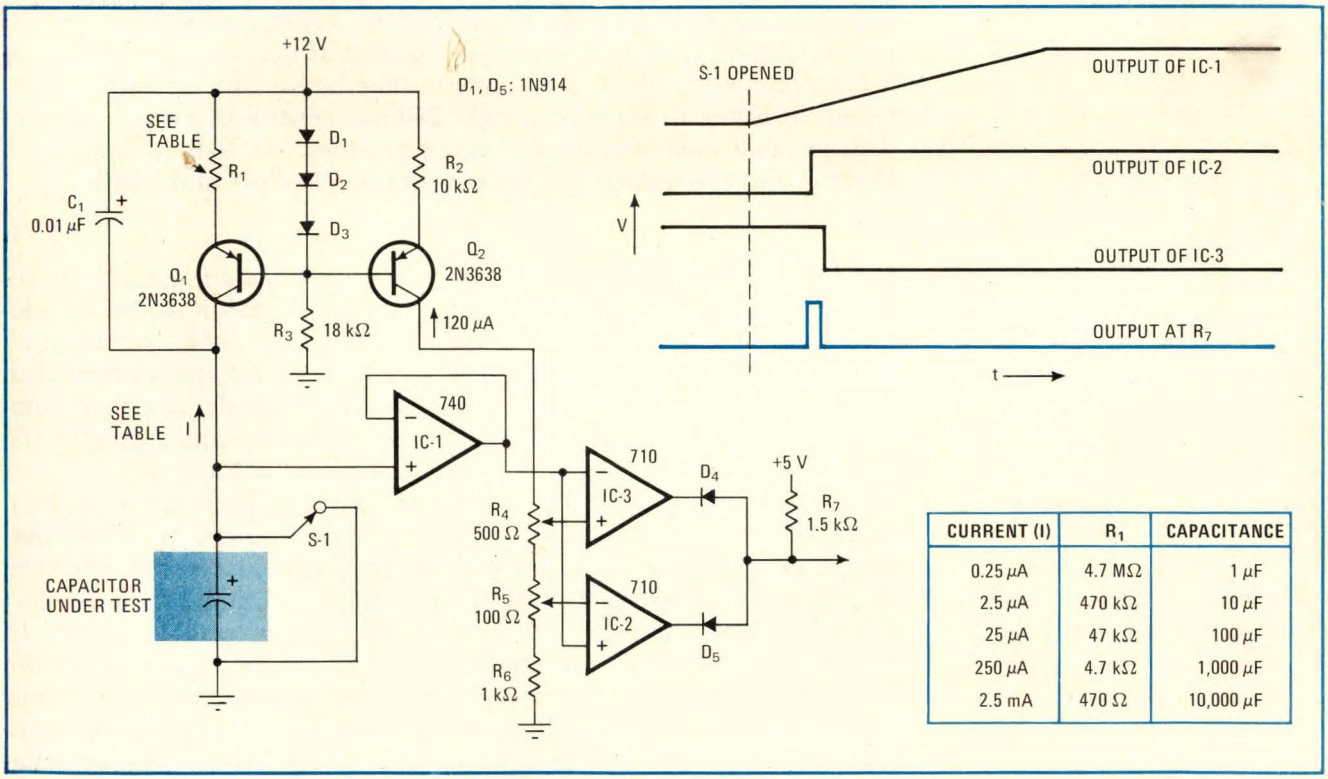
In the accompanying circuit design, components Q_1, R_1, D_1, D_2, D_3, and R_3 form a simple constant-current source for charging the capacitor under test, C_{ut}. Another constant-current source, consisting of R_2 and Q_2 (and using D_1, D_2, D_3 and R_3), provides current to R_4, R_5, and R_6 to make up a dual reference voltage. When S_1 is opened, capacitor C_{ut} charges linearly, and the 740 operational amplifier buffers the voltage from the relatively low input impedances of IC_2 and IC_3. IC_2, whose output is normally at ground, switches to a positive output when the voltage from the op amp becomes greater than IC_2's reference voltage (at its inverting input).

A short time later, when the voltage from the buffer reaches the reference voltage of IC_3, the output of IC_3 switches from a positive level to ground. There is a small overlap where both outputs are positive. D_4 and D_5 detect this condition, and, when it occurs, R_7 causes the junction of the diodes to go positive, producing a pulse having a width proportional to the capacitor under test.

R_4 serves as the "coarse" adjust and R_5 is the "fine" adjust. R_6 is included so that IC_2 will always switch at some voltage greater than 0.1 v. This eliminates accidental triggering at the instant S_1 is opened.

With the proper capacitance standard, accuracies to within 0.1% can be obtained. The circuit is relatively insensitive to power-supply variations, since the references are driven by a constant-current source. □

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.



CURRENT (I)	R_1	CAPACITANCE
0.25 μA	4.7 MΩ	1 μF
2.5 μA	470 kΩ	10 μF
25 μA	47 kΩ	100 μF
250 μA	4.7 kΩ	1,000 μF
2.5 mA	470 Ω	10,000 μF

Counting capacitance. Two adjacent points on a voltage ramp (a), created by charging a capacitor, C_{ut}, are detected by comparators IC_3 and IC_2. These two voltages are compared in an AND gate, producing a pulse having a width proportional to capacitance.

PROM can convert Ascii to hex code and vice versa

You can convert an Ascii, binary code to a hex code or vice versa through a single device—a programable read-only memory, notes Glen Coers of Garland, Texas. **To convert Ascii-to-hex code, you need a PROM with at least seven address lines and four data lines.** Then simply apply the Ascii inputs to the address lines with the eighth input line grounded, and program the output-data lines to provide the appropriate hex value.

To convert from hex to Ascii code, use a PROM with at least four address lines and seven data lines. The hex value is placed on the address lines with the fifth input line grounded, and the output-data lines are programed for the corresponding Ascii character.

Controls eliminate defects in pcb additive process

Engineers struggling with an additive process in the production of printed-circuit boards shouldn't get discouraged; others have succeeded against overwhelming odds. In a paper delivered at the Second National Plated Printed Circuit Conference, last month in Chicago, Fulvio Romano, who handles Motorola's additive process for its communications division, shares his early experiences with the process.

Romano's additive program reads like a litany of hardships: corners cracked, surfaces became gouged, cracks appeared between the holes, solder masks kept peeling off the copper, blisters grew between the laminate and the copper, the copper peeled at the edges and filled the holes, conductors lifted—you name it, they had it. But Romano persevered. **The key to success: a tight 24-hour control of copper, formaldahyde, and sodium-hydroxide concentrations, as well as keeping a sharp eye on the specific gravity, temperature, and pH of the bath.**

Kits simplify design of complex custom circuits

Circuit designers faced with building complex custom circuits on reduced budgets should check out the array of monolithic circuit elements being offered by Interdesign, a Sunnyvale Calif., IC supplier. Monochips, **composed of npns, pnps, current sources, and resistors, can be designed into a wide variety of digital bipolar and linear circuit combinations**—flip flops, gates, dividers, multipliers, op amps, amplifiers, converters, detectors, oscillators—not available as standard ICs.

Once you breadboard the circuit (kits of design parts are available), you make a circuit schematic and send it to Interdesign. **Its production people generate the tapes, perform the final mask step, and will even provide some free design consultation.** Turnaround time can be as short as three weeks. The price of 50 prototype circuits is less than $1,800. In production quantities, costs range from $1.50 to $20, depending on the quantity, circuit type, and complexity. **The company now offers four Monochip types—the latest in the family is an 80 × 80 mil chip that contains 209 circuit elements built with a high-voltage process that can handle a maximum supply voltage of 36 V.**

—Laurence Altman

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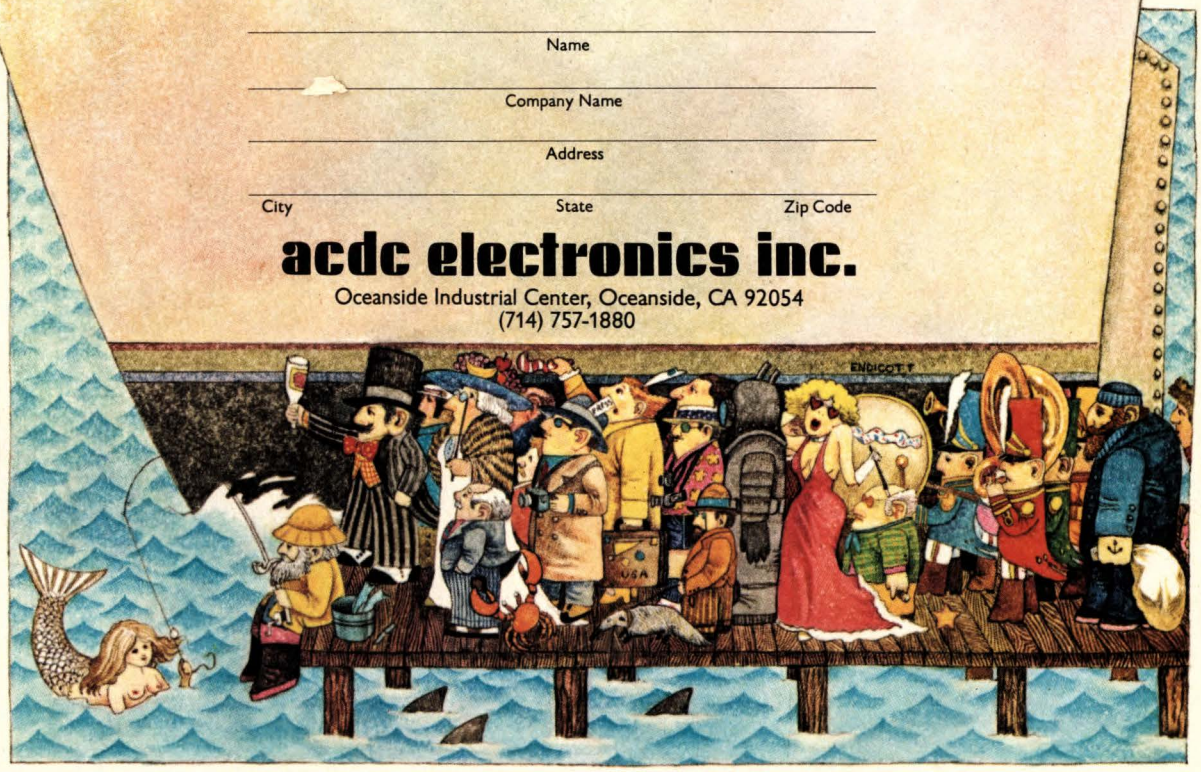

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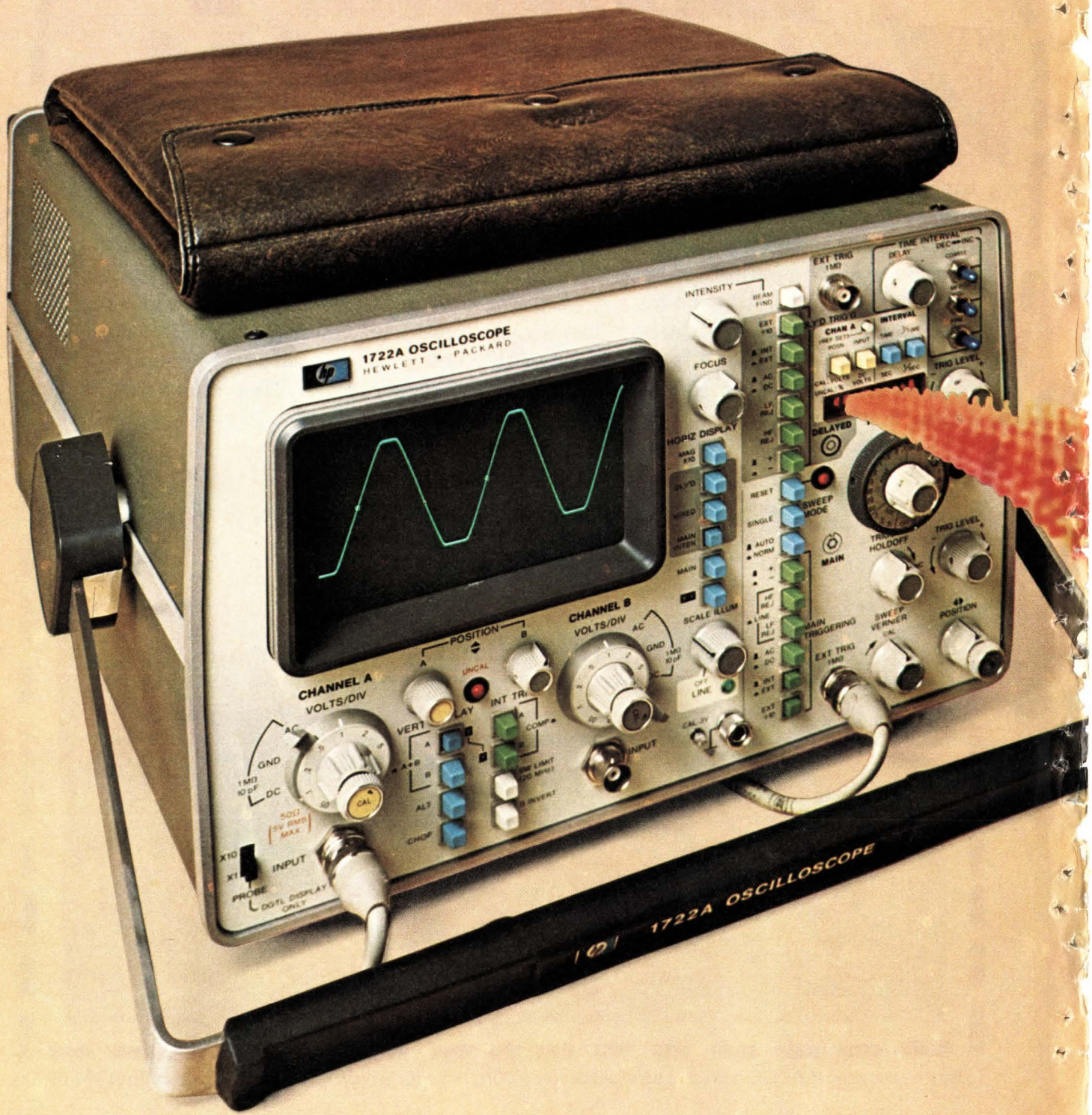

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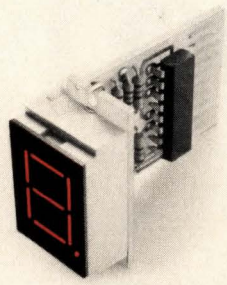

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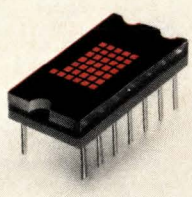
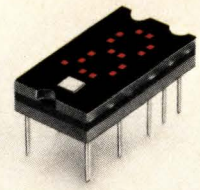


745-0005 Dot matrix LED readout display produces a bright 0.300" high character or symbol display. Has wide angle visibility and is compatible with USASCII and EBCDIC codes. Low power requirements. Mounts into standard 14-pin DIP socket. The display is also available in bezel assemblies with or without code generator.



745-0007 LED hexidecimal display with on-board logic operates from 5 to 6 volt supply, low power consumption. Integral TTL MSI chip provides latch, decoder and drive functions. 0.270" character display has wide angle visibility and mounts into standard 14-pin DIP socket.

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I/O card cuts cost of peripheral links

Single board drives eight cables, each with a microcoded processor; Computer Automation also develops Naked Milli and a new minicomputer

by Paul Franson, Los Angeles bureau manager

Best known for the Naked Mini computers it developed in 1970, Computer Automation is introducing two new computers that it claims gives it the widest line of plug- and program-compatible minicomputers in the industry. The firm is also introducing a universal distributed-interface system that may help reduce costs of interfacing peripherals, in line with the price reductions in processors and memories during the past few years.

The first of the new computers is dubbed the Naked Milli, a small-board computer that fits between microcomputers and minicomputers. This system, more formally called the LSI-3/05, is priced at $295 in single quantity for the processor alone, and $695 with 1,024 words of memory. It is the size of a microcomputer board (7 by 15 inches). But Sol Zasloff, marketing vice president, says it has most of the features—other than speed—of the company's minicomputers, including a full instruction set, minicomputer architecture, improved input/output capability, and full compatibility with the California company's larger machines.

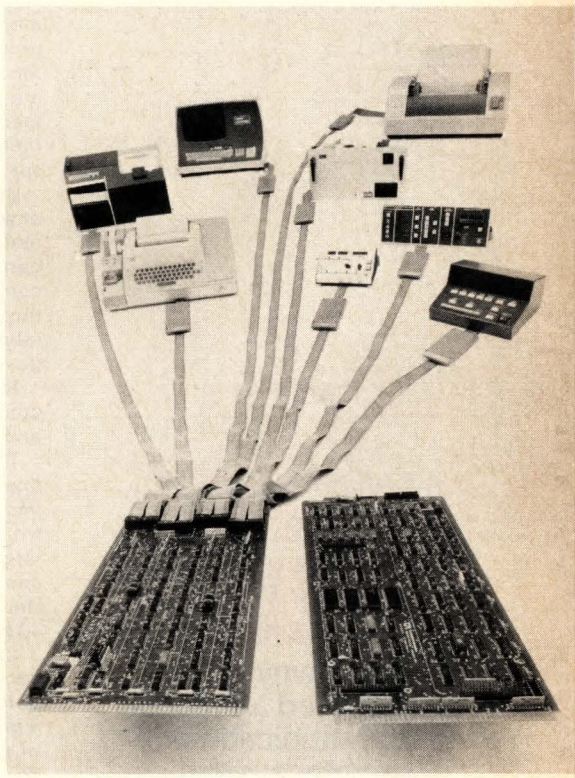
Another debut. Computer Automation will also soon introduce a large minicomputer, the Megabyter (LSI-2/60), which will handle one million bytes of memory. It will compete with machines like the Digital Equipment Corp. PDP-11/45, Data General Eclipse, and Interdata 7/32.

Perhaps the most interesting of the new products, however, is the distributed-input/output system, which depends on universal interfaces. A single I/O distributor board used with any Computer Automation LSI minicomputer drives as many as eight "intelligent cables," each containing a small speedy PicoProcessor that is microcoded for its specific peripheral. "This means savings to the OEM, who otherwise finds that he spends more money for custom or even standard interfacing hardware than he does for his computer," says Zasloff." "With the distributed I/O system, we have brought the cost of interfacing down to the same low level as the cost of the small processors." The I/O distributor card is priced as low as $380 in single quantities, and the cables are $145 each.

Plug-in. The I/O distributor plugs into the direct-memory channel of the computer, and the peripherals are addressed as if they were in the memory. The distributor is a half-card (7 by 15 inches) that has output connectors for eight ribbon cables, and more than one I/O distributor can be used for additional peripherals. The cables from the I/O card are identical, and they connect to a flat 3-by-8-inch box mounted in or on the peripheral. A short cable, equipped with the peripheral's connector, is included.

The PicoProcessor contains fast transistor-transistor logic with a 250-nanosecond cycle time—MOS isn't fast enough for the application. The units handle data rates up to 82 kilobits per second, depending on the computer used, and three types are available to handle the major classes of peripherals.

The parallel PicoProcessor is used with line printers, card readers, paper-tape readers and punches and other unit-record-type devices, as well as analog-to-digital converters and point-of-sale terminals. The PicoProcessor can control devices with 8-bit inputs, 8-bit outputs, or 16-bit inputs. Two serial PicoProcessors are also available. One has a standard EIA interface for cathode-ray-tube terminals, modems and other peripheral devices using 5- and 8-bit characters. The other serial-type PicoProcessor is for current-loop devices, especially teletypewriters, and such special devices as keyboards, badge readers, control panels, and relays. The universal interfaces are



Distributed power. Naked Milli computer (right) is shown with I/O distributor card that can control eight peripherals by cables containing microcoded processors.

not used for peripherals with very high data rates, such as magnetic-tape and disk drives. These are connected to the direct-memory channel.

Computer Automation hopes the model 3/05 Naked Milli computer will compete effectively with semiconductor-chip-set microcomputers. Product manager Phil Kaufman says one big advantage of the 16-bit unit is that it's compatible with other Computer Automation machines. "Every other machine in this range is the top of its line. If you start with a microprocessor, you can't move up easily, and that can be very important as you try to add capability to a system. The Naked Milli can be unplugged (if a full-size slot is allotted) and replaced by a larger computer with no changes in hardware or software." Kaufman says that the computer has much of the capability of the larger CA machines, but is slower. It has an add time of 7 microseconds in contrast to the 4 μs of the LSI 2/10 and 2 μs of the LSI-2/20. Although the Naked Milli also has a somewhat smaller instruction set, Kaufman claims that the set of 93 instructions is considerably more powerful than that of microcomputers, which typically have 40 to 70. "This means it requires less memory for a given job, and the total system cost can be lower," he adds. The bipolar Naked Milli computer uses separate core or semiconductor memory on full 14-by-15-inch boards and can address a total of 32,000 words, including random-address and read-only memory. "Memory-addressing is one of the places where microprocessors generally fall down," says Kaufman," and the new computer has all of the addressing modes of the more powerful LSI-2."

Compatible. Included are standard direct-memory access, direct-memory channels (vectored interrupts), and capability to use either words or bytes. Because the interfacing is also compatible with the higher-end CA machines, the new computer can be used with the new distributor I/O, as well as existing CA peripherals and controllers. "The user can concentrate on designing his product, not on producing peripheral interfaces," Kaufman adds. Options for the Naked Milli computer include real-time clock, power/fail restart, auto-load and teletypewriter/CRT serial interface. The computer can be supplied as a board or with a standard LSI-family chassis, or with a small motherboard for applications where there is limited space.

In volume orders, the Naked Milli LSI-3/05 is priced below $560 each with 1,024 words of memory. Delivery time is 30 days.

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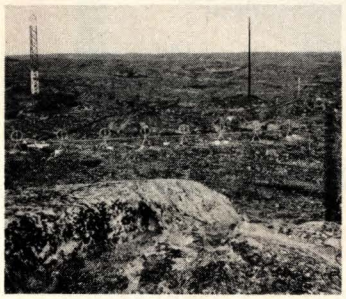

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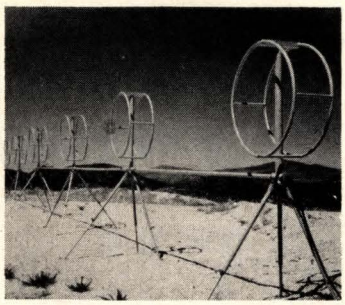

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Printer controlled by microprocessor

Machine for OEM market uses print wheel, operates at 30 characters a second; Interdata also unveils data-communications terminal utilizing the printer

By Ron Schneiderman, New York bureau manager

Acting on highly optimistic market forecasts, Interdata Inc. has entered the programable-printer field. Interdata, a subsidiary of Perkin-Elmer Corp., this week introduced the Carousel, a microprocessor-controlled printer that operates at 30 characters per second, and was designed specifically for the OEM market [*Electronics*, Dec. 26, 1974, p. 19]. At the same time, Interdata has unveiled a data-communications terminal, called the Carousel 300, that incorporates the new printer. Both products are scheduled for delivery in May.

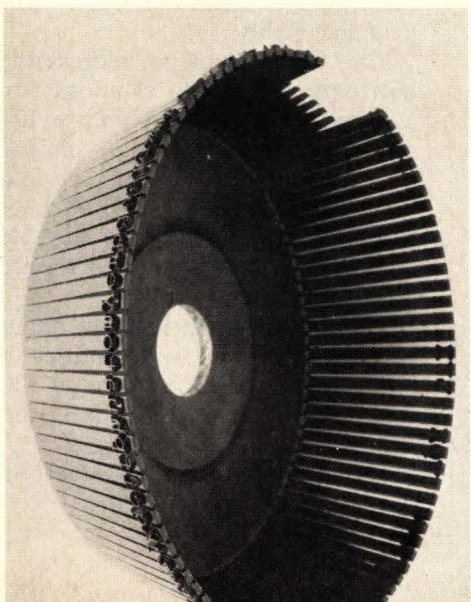
Interdata expects the Carousel printer to interest OEMs who produce their own data-communications terminals, business and accounting machines, as well as text revision and word-processing systems. It also operates as a plotter. In a word-processing environment, the printer can handle cassettes or other storage mediums associated with the system, provide proportional-spacing line justifications, as well as superscripts and subscripts. As a data-communications terminal, the Carousel is a compatible replacement for many terminals now in use, including the IBM 2741, GTE 15/5741, GE Terminet or the Teletype model 33.

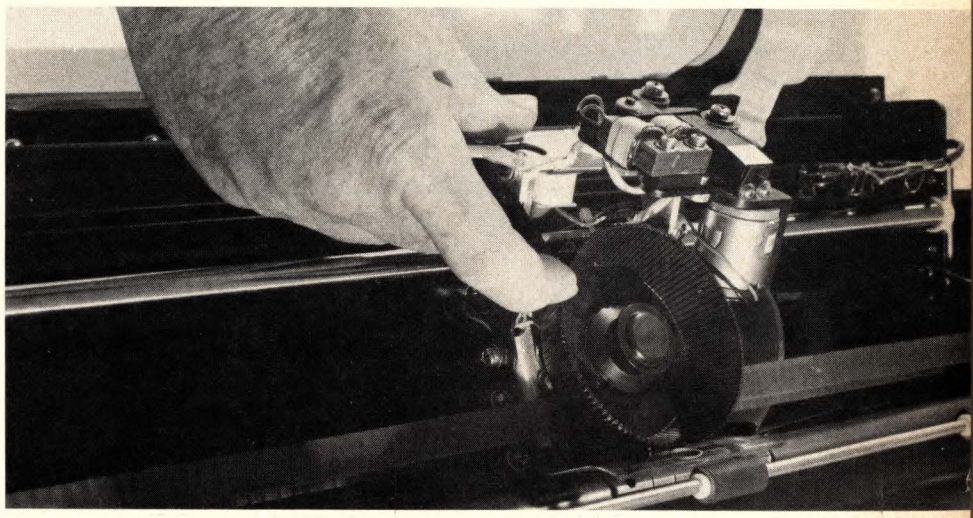
Designs acquired. The Carousel is an outgrowth of work done initially at I/O Devices Inc., Mountain Lakes, N. J. Interdata early last year acquired certain rights and designs from I/O, hired engineers from the company and set up what it now calls its Terminal Products Group in Randolph, N. J. Ludwig Kapp, formerly of I/O and now head of the Interdata group, says the Carousel is built around many of the concepts developed at I/O.

The Carousel's custom microprocessor was patterned after off-the-shelf medium scale integration circuits acquired from several sources. Kapp explains that commercially available microprocessors were too costly and not fast enough. "As faster microprocessors become available and they drop in price," says Kapp, "we'll probably go to a standard product. But I think we made the right move initially because it gave us speed and cost."

The custom product is an 8-bit microprocessor, with 4,000 words of addressable memory, and an access time of 1.5 microseconds. The printer uses 2,000 of these words, including 256 words of read/write memory. The 2,000 words of additional storage capacity, says Kapp, can be used by the OEM as a "systems builder." He says, "It gives the OEM considerable latitude to expand the buffer, to establish a line-justification format, to incorporate a look-up table of codes, or to control

The printing wheel. The cup-like arrangement at left has 100 spokes, 94 of them bearing characters. It requires 17 milliseconds to move from one character position to another. Photo at right shows wheel installed, but before control mechanism is placed inside.





New products

CRTs, floppy disks, credit card verifiers or other peripherals. The microprocessor controls character selection, motor control, monitors communications lines and controls transfers to and from the computer memory.

Possibly the Carousel's most unusual feature is its printing wheel, a cup-like arrangement of 100 spokes (or "fingers" as Interdata calls them) of which 94 have characters. The print wheel always returns to the home position and permits immediate viewing of the last three characters typed. The print head requires 17 milliseconds to move from one character position to another. An "escape" hold key allows the operator to underline or strike over a character. The print cup is positioned by stepping motors instead of a servo. Stepping motors, Kapp says, offer greater printing accuracy and cleaner copy. According to Kapp, the maximum error possible with the Carousel printing system is 3% of 1.8° in positioning.

James Brennan, Carousel's product manager, says the printer's additional 2,000 words capacity alone may be enough justification for many OEMs to adopt the unit. Meanwhile, the Carousel will become part of Interdata and Perkin-Elmer offerings as an add-on to existing products.

Versatile. An additional enhancement, says Brennan, is the Carousel's paper-handling options, from 8-by-10-inch sheets to bank and stock transfer forms and other business documents.

The Carousel offers addressable horizontal tabbing to 132 positions, addressable vertical tabbing to 127 positions, horizontal column spacing of up to 100 columns per inch and vertical line spacing up to 48 lines per inch. As a plotter, it is capable of covering 4,800 points per square inch.

The printer is priced at about $1,700 per unit in 1-9 quantities to the OEM market. The Carousel 300 terminal, without options, is priced at $2,450.

Interdata Inc., 2 Crescent Place, Oceanport, N. J. 07757 [339]

IR's new glass passivated, high voltage Power Transistors and Darlingtons...

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The three other largest selling high voltage power transistor lines of today offer you good characteristics. But while a specific device may excel in specs for one parameter, it may be marginal in other equally important characteristics. Not so with IR's new high voltage power transistors. They easily meet or exceed all established specifications. Now you can design a better, more efficient circuit without compromising.

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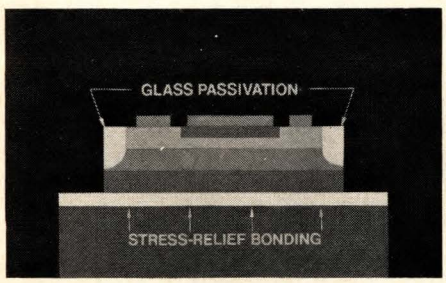

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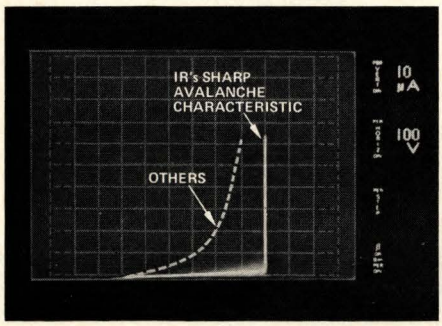

pictured shows our "sharp" curve and the "soft" curve of the others. Convincing evidence of better junctions that you can operate at full rated specs without a worry.

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*** "Stress-Relief" Bonding for better resistance to temperature cycling.**

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IR P/N	Delco P/N	RCA P/N	Motorola P/N
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IR403	DTS 403		
IR409	DTS 409		
IR410	DTS 410	RCA410	MJ410
IR411	DTS 411	RCA411 2N5838 2N5839	MJ411 MJ1800 MJ3029 MJ3430
IR413	DTS 413	RCA413 2N5840	MJ413
IR423	DTS 423	RCA423	MJ423
IR424	DTS 424		MJ424
IR425	DTS 425		MJ425
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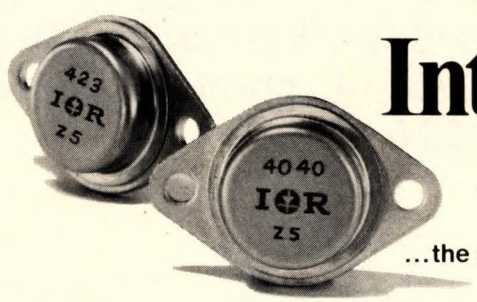

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Circle 115 on reader service card 115

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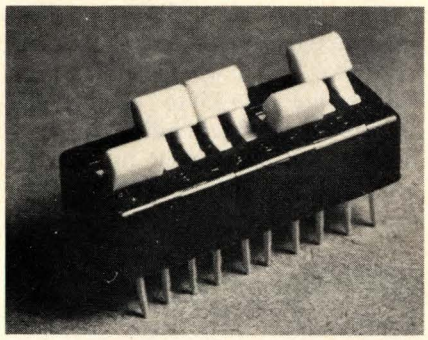
biomation

Components

DIP switch line expanded

Modules have two to five units, each providing spdt or dpst action



Small versatile switches in dual-in-line packages are being used extensively on printed-circuit cards for computers, computer peripherals, communications systems, and test equipment. But these DIP switches have been available in only single-pole, single-throw configurations. Now, Molex Inc. is introducing single-pole, double-throw and double-pole, single-throw versions.

A single DIP module may contain from two to five switches, and every switch provides either spdt or dpst action. Each switch can be accessed individually. The switches are operated manually without use of special tools. An optional transparent snap-on cover can protect them against accidental switching.

Like the earlier Molex BOSS (Binary Option Selection Switch) devices, the new units rely on double-cantilever contacts for low-stress, high-force closures. Cams on the actuators open the switches by forcing the contact pairs apart. These same cams provide a butting/wiping action to close the contact pairs, thereby maximizing contact integrity. The phosphor-bronze terminals have gold contact areas.

Designed for logic-function programing, these BOSS DIP switches, packaged in polyester, are rated for 50 milliamperes at 30 volts dc. Contact resistance, when measured at 10 mA, is a maximum of 100 milliohms. Insulation resistance between adjacent switches, whether open or closed, is at least 10^{13} ohms.

The new models will be available in mid-February from stock. In 1,000-lots, price will range from 20 to 25 cents per switch position.

Molex has also redesigned its spst DIP switches for compatibility with pc cards having a center-to-center spacing of 0.5 inch. Seated height for the new low-profile versions is 0.36 in., which is reduced from the 0.46-in. height of earlier models.

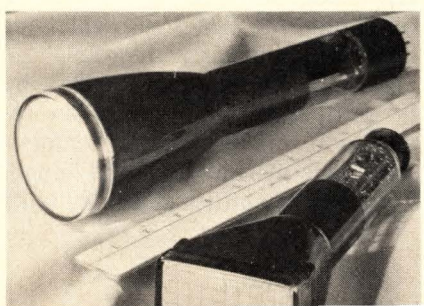
Molex Inc., 2222 Wellington Ct., Lisle, Ill. 60532 [341]

Rectangular CRT for portable scopes draws only 95 mA

Size and power consumption of cathode-ray tubes are two limitations that manufacturers of battery-powered oscilloscopes must build around. With that in mind, designers at Hitachi Ltd. have developed a CRT design that reduces both factors significantly.

The Hitachi model 95AB31 measures 3.68 inches diagonally across its rectangular screen (foreground, below). Minimum usable height is 2.13 in., and width is 2.62 in. The flat screen also offers an internal graticule to eliminate parallax. The tube's low-current heater draws only 95 milliamperes at 6.3 volts dc, compared with the 600 mA required by small tubes designed for line-power operation. Maximum frequency is 10 megahertz.

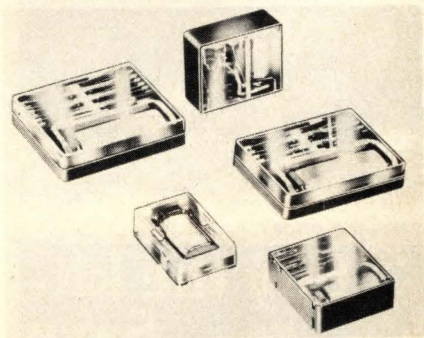
The CRT is 9.25 in. long, and is made to be used with inexpensive, readily available, 90° color-picture-tube sockets, instead of special 60° sockets needed by most round CRTs. In production quantities, the tube is priced at $50 each. Delivery time is 6 to 8 weeks.



International Importers Inc., 2242 S. Western Ave., Chicago, Ill. 60608 [342]

Low-profile pc-board relays can switch up to 8 amperes

Packaged in dust-proof housings with seated heights of only 0.4 in., a new family of printed-circuit relays offers hefty power-handling capabilities. For a 24-V dc resistive load, the Class 63 double pole, double throw (dpdt) units, as well as the Class 64 4pdt and 6pdt units, are rated at 1 A. And the Class 65 spdt units can handle a continuous current of 8 A maximum. Terminals are spaced on a standard 0.1-in. grid. In quantities of 1 to 24, price ranges from $3.40 to $8.11. Delivery is from stock.

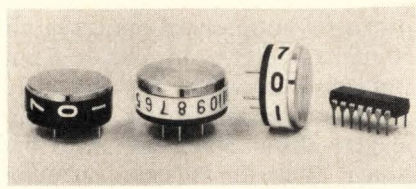


Magnecraft Electric Co., 5575 North Lynch Ave., Chicago, Ill. 60630 [343]

Rotary switch is 0.375 inch high, 0.9 in. in diameter

Intended for use on card racks spaced on 0.5-inch centers, the Janco Mini Code Switch is similar to a thumbwheel unit but measures only 0.375 inch high and less than 0.9 in. in diameter. The unit can be produced to provide decimal, octal, hexadecimal, and most other common digital codes and variations. Markings can be provided in any axis on the indicator wheel with cus-

New products

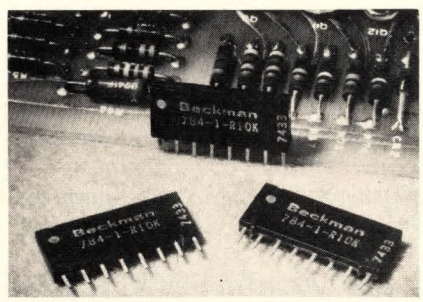


tom legends or characters, and in any of six colors. The switches can be supplied with or without rotational stops, seals, or internal lighting. The basic switch is designed to meet the environmental requirements of MIL-S-22710.

Janco Corp., 3111 Winona Ave., Burbank, Calif. 91504 [344]

SIP resistor networks range from 100Ω to 22 kΩ

Beckman/Helipot, which has long had a line of resistor networks housed in dual in-line packages (DIPs) is now producing two types of resistor networks in single in-line packages (SIPs). The series 784-1 contains seven equal resistors with a common termination at pin number 1; the series 784-3 contains four equal resistors which are isolated from each other. Both eight-pin SIP networks are available in 15 resistance values ranging from 100 ohms to 22 kilohms. Resistor accuracies are within 2%. For both networks

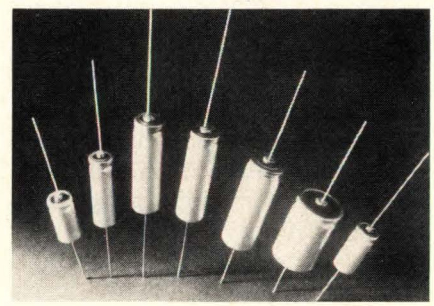


total package power dissipation is 2 watts at 25°C. Individual resistor ratings are 0.3 W for the 784-1, and 0.5 W for the 784-3. Designed for automatic machine insertion, the eight-pin SIPs measure 0.090 by 0.780 by 0.350 inch, and allow installation on 0.100-inch centers—both side-by-side and end-to-end. Prices for quantities of 1 to 99 units are 65¢ for the 784-1, and 60¢ for the 784-3.

Beckman Instruments Inc., Technical Information Section, Helipot Division, 2500 Harbor Blvd., Fullerton, Calif. 92634 [345]

Electrolytic capacitors are stable at low temperatures

Combining a novel anodizing system with a truly non-aqueous electrolyte, the series 139C computer-grade axial-lead tubular electrolytic capacitor has an operating temperature range of −55 to +85°C. Designed for high reliability, the 139C uses a special phenolic and rubber laminate for the positive-terminal seal. Applications for the capacitors



are expected to include computers, power supplies, industrial controls, and airborne equipment where stability at very low temperatures is vital. The 139C is also claimed to offer the highest capacitance available for each of the cases in which it is packaged. The largest size is rated at 22,500 microfarads at six volts or 600 μF at 150 V. Series 139C capacitors are available on a six-week delivery schedule.

Mepco/Electra Inc., 2909 Chapman St., Oakland, Calif. 94601 [346]

Low-level transformer has 200 dB of isolation

Nanotran isolation transformer IT-3056 is an ultra-low-level signal-conditioning device with an equivalent noise voltage of 0.3 microvolt, an isolation voltage of 500 V, and a common-mode rejection ratio of 200

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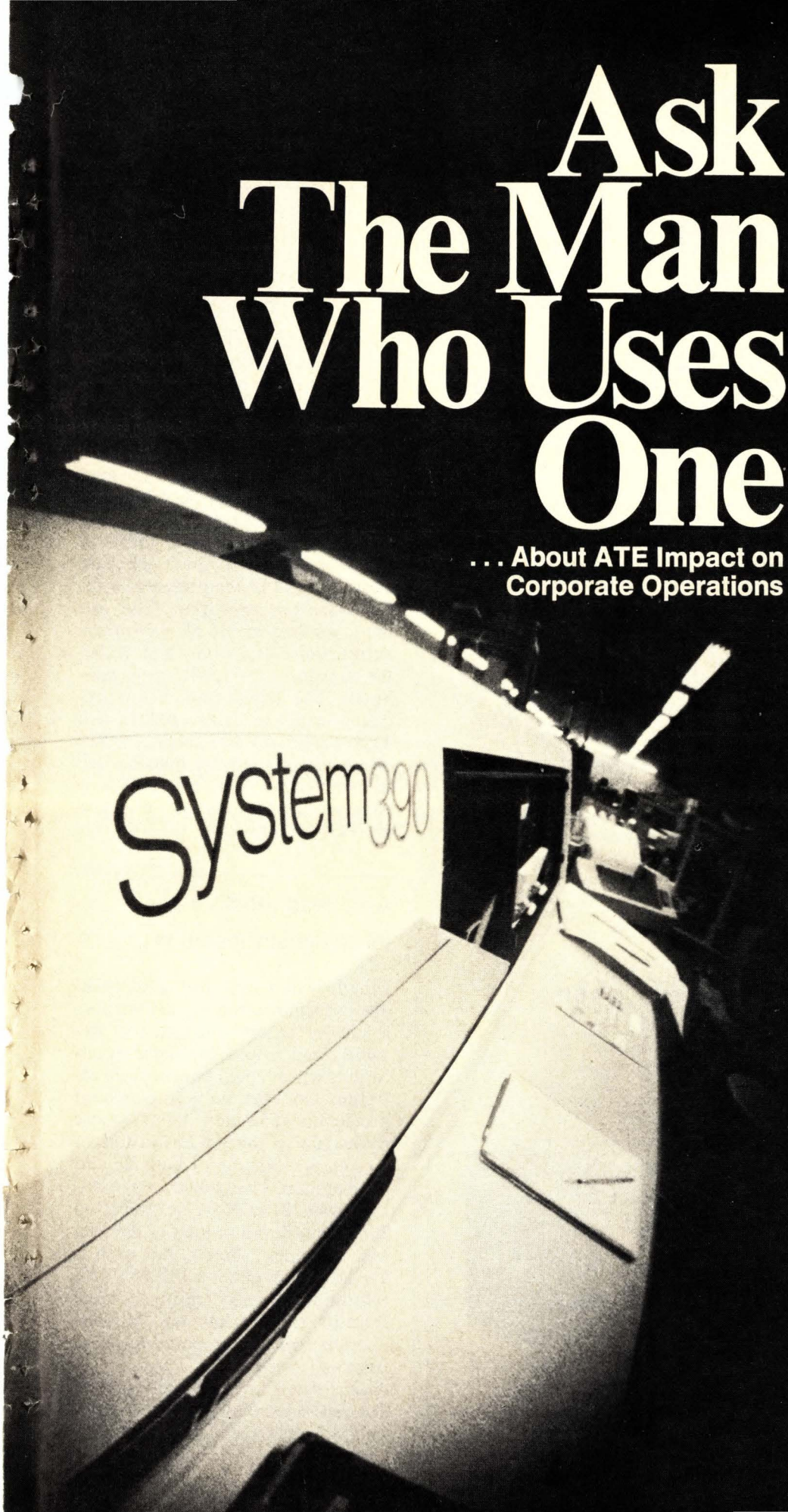

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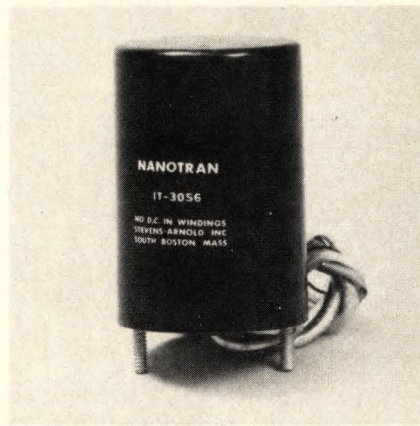
Circle 119 on reader service card

New products



decibels. Housed in a triple-shielded mu-metal case, the IT-3056 is meant for nanovolt-level instrumentation applications, particularly those in which equipment must operate above ground in the presence of input transients or surges. The primary winding of the IT-3056 has a dc resistance of 2 ohms and a 100-Hz impedance of 1,000 ohms minimum. The transformer has a frequency range of 1 Hz to 10 kHz, and a turns ratio of 1:100. Its price is $24 in lots of 100; delivery time is stock to four weeks.

Stevens-Arnold Inc., 7 Elkins St., South Boston, Mass. 02127 [347]

Axial-lead varistors are for automatic insertion

Mounted in a new axial-lead package to facilitate automatic insertion, a line of GE-MOV varistors is designed and priced for those applications which could benefit from reliable, low-cost voltage-transient protection. The new units, whose prices run as low as 25¢ in lots of 10,000, are capable of both dc and ac operation. They have voltage ratings from 121 to 365 V dc, and 88 to 264 V rms. Seven models of the new MA series are offered, and each is available with either a 10% or a 15% tolerance. Energy ratings range from 100 to 700 millijoules. All units operate over the temperature range from −40 to +125°C.

General Electric Co., Semiconductor Products Department, Bldg. 7, MD 49, Electronics Park, Syracuse, N. Y. 13201 [348]

Circle 121 on reader service card→

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Plan to own the 550 linear tester for a long, long time.

The Alma 550's modular design allows you to change programs and update your system. Any time. Just plug in a new module or limit card.

Foolproof. All program and limit cards are hard wired. That means operator programming errors are impossible.

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Twenty tests. 1 second. Alma's programmable bench-top performs 20 different tests on most linear IC's. Op amps, voltage regulators or comparators. And the 550 has the potential to test phaselocked loops, four-quadrant multi-

Denotes and evaluates. If an IC fails, the 550 tells you where it failed and displays test results as well as the programmed limits.

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Semiconductors

Chip design cuts parts count

One-IC financial calculator requires a minimum of external components

Underlining the trend toward more functions per calculator chip are National's latest entries into the scientific and financial markets. The MM5760 scientific-calculator chip, which was introduced last October, and the new MM5762 financial-calculator IC are both built with a standard metal-gate p-channel process, and need a minimum of external components to form a complete calculator. Specifically, only a keyboard, a 9-volt battery, a LED display, and a DM8864 digit driver need be added to the MM5762 to make a complete business machine.

Furthering the trend toward low parts counts, each of these chips is designed to interface with the general-purpose MM5765 calculator-programing chip to form a programmable calculator. As shown below in the diagram of a programable financial calculator, all that are needed to interface the programing chip with the rest of the machine are a single static switch, four dynamic keys, and a means for displaying an alarm condition.

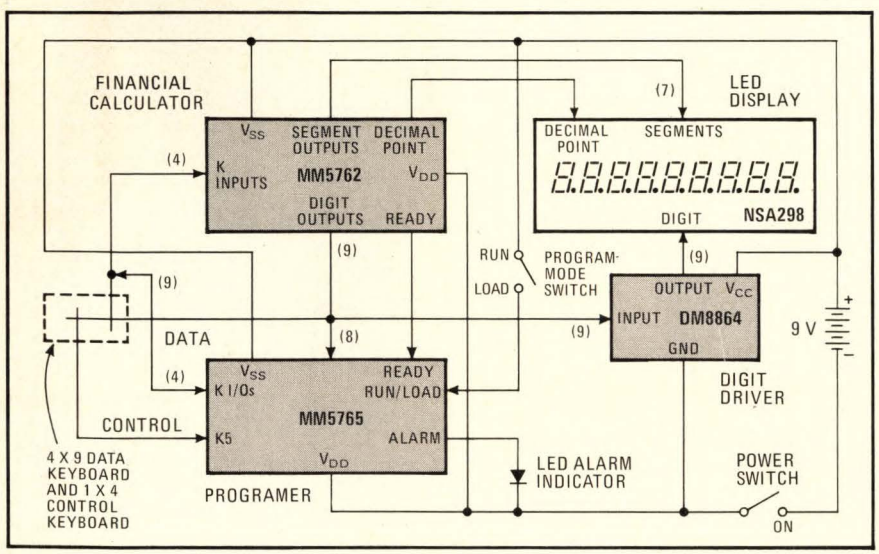
Included on the MM5762 chip are keyboard-decoding and key-debounce circuitry, all clock and timing circuitry, seven-segment output display encoding, and sufficient output power to drive the segments (but not the digit lines) of most light-emitting-diode displays. The chip can typically put out a peak segment-drive current of 8.5 milliamperes for an average of about 0.9 mA, assuming a 0.104 duty cycle for each digit.

An additional feature on the MM5762 is a power-on clear circuit, which clears all circuits, including memory, when the drain and source voltages are first applied.

The eight-digit MM5762, in addition to performing standard arithmetic and percentage calculations, has special function keys for performing sum-of-digits calculations (for computing depreciation or "rule of 78s" loan costs), present-value or future-value calculations, deposit or sinking-fund amounts, and loan payments or loan amounts. Other features include an automatic constant function, an automatic accumulation mode of operation, and a battery-saving automatic display cutoff that is activated when no key is depressed for a period that exceeds approximately 35 seconds.

Housed in a 24-pin plastic dual in-line package, the MM5762 requires a supply voltage between 6.5 and 9.5 volts. It draws a maximum current of 16.0 mA at 25°C. with 9.5 V applied. Its operating temperature range is 0°C to +70°C.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, Calif. 95051 [411]



1,024-bit C-MOS RAM uses low standby power

The rush to C-MOS random-access memories continues with introduction by Intel of a 1,024-bit unit, organized 256 words by 4 bits. [*Electronics*, Dec. 26, 1974, p. 111].

Designated the 5101, the new RAM operates from a single 5-volt power supply and has an access time of 450 nanoseconds (500 ns on standby). Its very low standby power of 15 nanoamperes per bit makes the device suitable in low-power applications where battery backup for nonvolatility is required, Mike Markkula, Intel's North American marketing manager, points out.

The low standby power requirement of the 5101 is expected to open up applications in point-of-sale terminals, optical character readers, airborne computers and avionics systems, battery-powered microprocessors, and as a replacement for plated-wire memories.

Simultaneously with introduction of the 5101, Intel brought out 21 new types of silicon-gate n-channel MOS devices in a significant broadening of its static 1-kilobit-RAM product line.

With the 2102 1-k static RAM that Intel introduced in 1972 and the 21 new circuits, the C-MOS device rounds out a family consisting of 25 types in four configurations and seven speed ranges.

The 21 new n-channel circuits—designated the 2101, 2111, 2112 and 2102A series—use a single TTL supply, operate at TTL-logic levels, have three-state outputs and are fully static (requiring no clock or refresh), like the 2102.

Intel Corp., 3065 Bowers Ave., Santa Clara, Calif. 95051 [412]

"Think Hz for a

"A different point of view . . . that's often the key to a problem solution. And that's just what HP analyzers give you. A look at your problems in the frequency domain instead of the time domain."

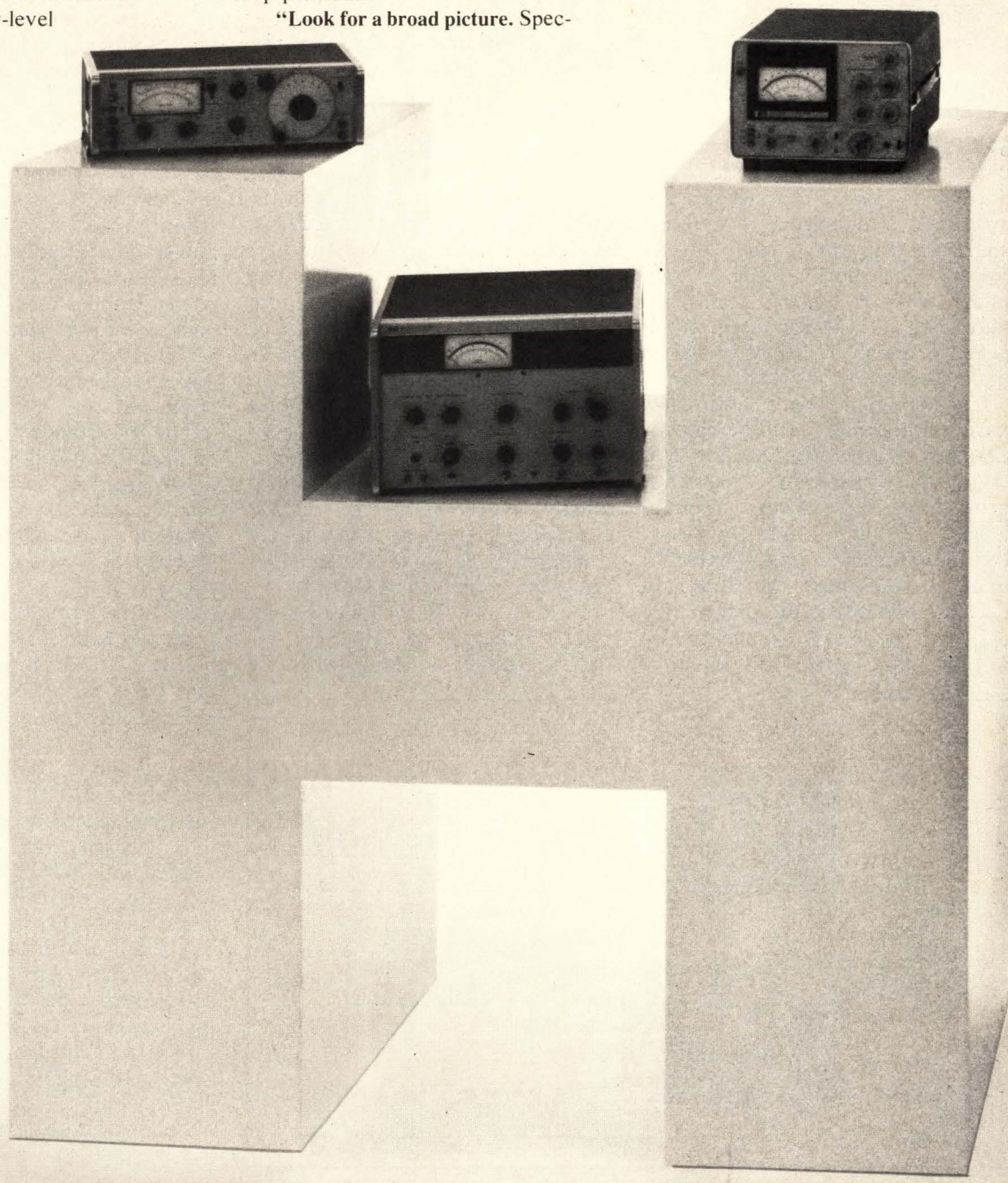
"HP high-frequency analyzers have a solid reputation for providing RF and microwave designers with accurate frequency-domain measurements. But what about analyzers to help engineers with low-frequency problems?"

"I'd like to tell you about HP's broad line of low-frequency analyzers that can solve some of your tough measurement problems. Problems such as making low-level measurements in the presence of noise, analyzing frequency components of a signal, determining the transfer function of a network, or making distortion measurements on analog circuits."

"Take the narrow view. HP's 3581A wave analyzer lets you home-in on a specific frequency for amplitude measurements. Look at a signal through a 3 Hz bandwidth. Monitor low-level signals to 30 nV over a 15 Hz to 50 kHz range. This ability to measure low-level signals in the presence of noise simplifies transducer signal monitoring. Helps you isolate ground-loop problems."

"Look for a broad picture. Spectrum analyzers display your waveform's Fourier components on a CRT. That's an easy way to see your signal and its component relationships. It's also an ideal way to characterize mechanical devices that have unique spectral 'signatures.'"

"HP's 3580A spectrum analyzer gives you a 5 Hz to 50 kHz range and the sensitivity to operate directly from the lowest level transducer outputs. Its digital memory lets you store traces for accurate comparison of two signals. And a narrow 1 Hz bandwidth allows you to resolve 60 Hz sidebands."



different view"

"There's also an in-depth view provided by HP's network analyzers. These dual-channel analyzers provide amplitude and phase measurements as a function of frequency. This simplifies transfer-function measurements, speeds the location of poles on a Bode plot, and accurately determines resonant frequencies and phase margins in circuit design."

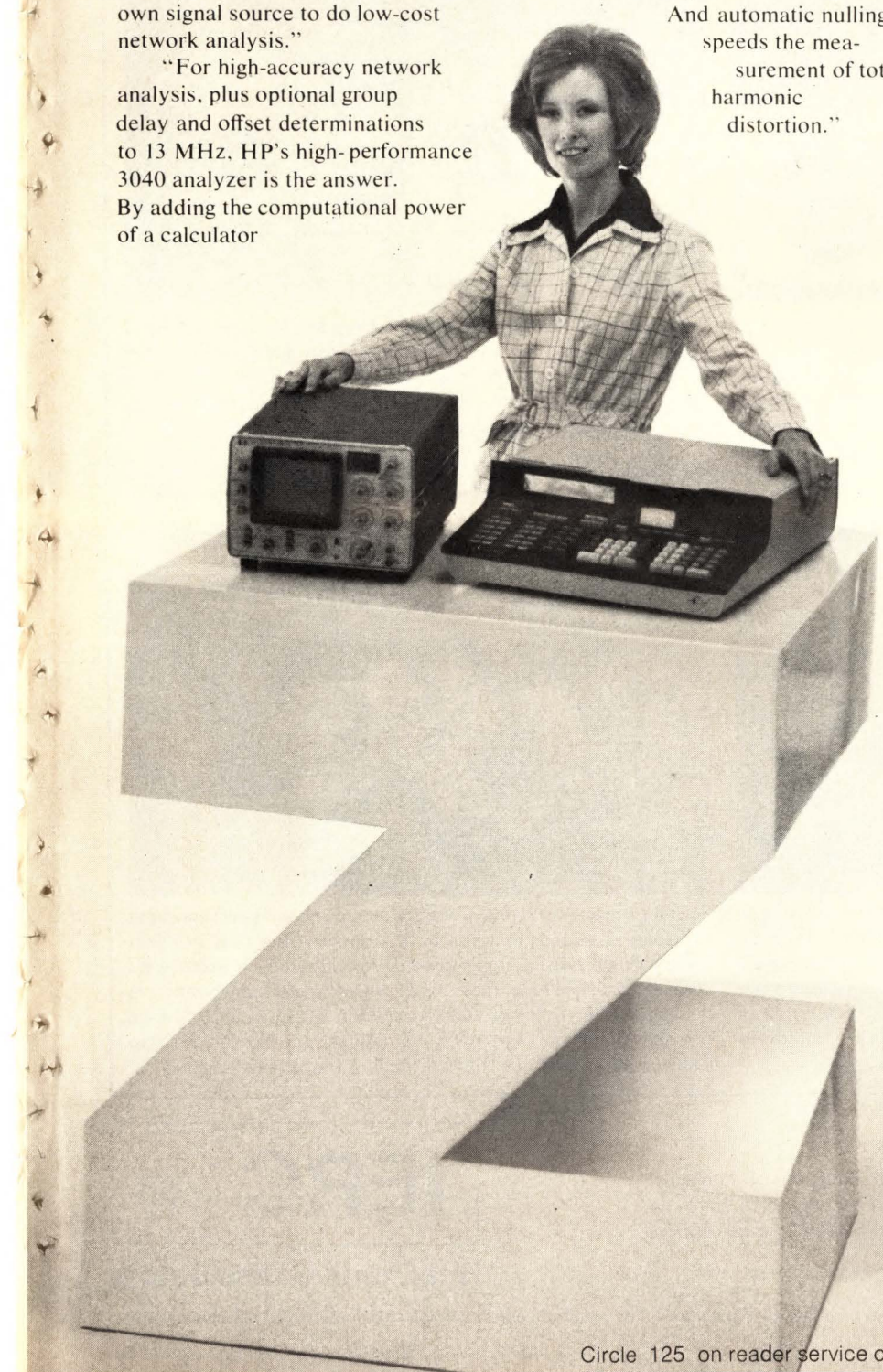
"Our broadband 3575A gain-phase meter gives you a range of 1 Hz to 13 MHz and lets you select your own signal source to do low-cost network analysis."

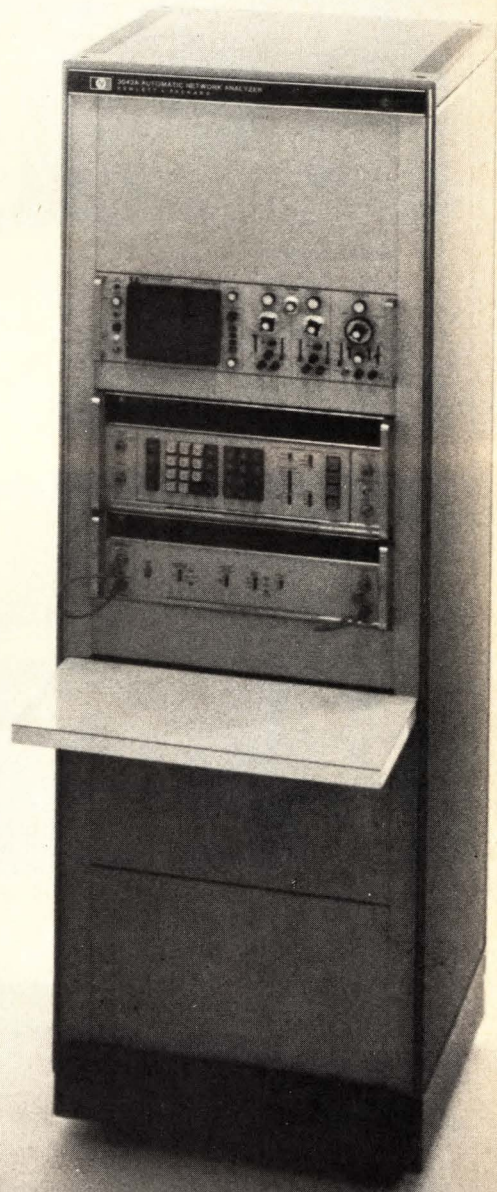
"For high-accuracy network analysis, plus optional group delay and offset determinations to 13 MHz, HP's high-performance 3040 analyzer is the answer. By adding the computational power of a calculator to either the 3575 or 3040 analyzers you can view the results of 108 tests in less than 20 seconds . . . and with greater precision."

"And there's a reciprocal view. HP's distortion analyzers give you the reciprocal function of a wave analyzer. By rejecting the fundamental and monitoring the remaining harmonic and spurious components, distortion is measured and displayed on a meter. Our 331A to 334A series provides a wide range of 5 Hz to 65 MHz. And automatic nulling speeds the measurement of total harmonic distortion."

"So think hertz and get a different view . . . in design, in manufacturing, and in servicing. Think hertz and get a different view of everything from electronic components and networks to mechancial devices and systems. Think hertz for a different view and look to HP for help in applying analyzers to your measurement problems."

"You're local HP field engineer will be happy to give you additional details on our broad line of analyzers that operate from 1 Hz into the GHz range. Give him a call today."





Measurement with a different view

094/54

HEWLETT hp PACKARD

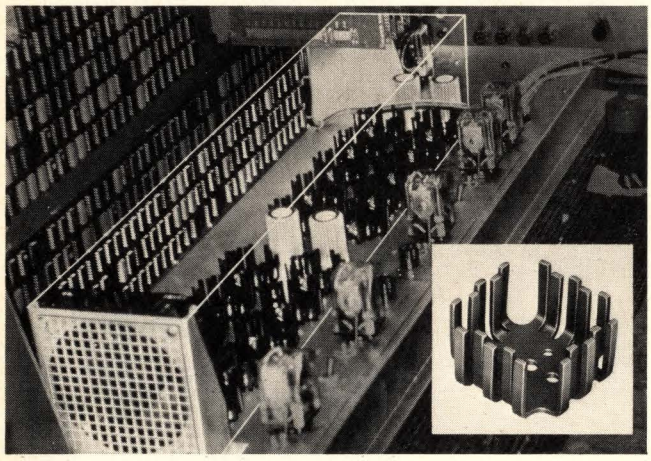
Sales and service from 172 offices in 65 countries.
1501 Page Mill Road, Palo Alto, California 94306

Circle 125 on reader service card

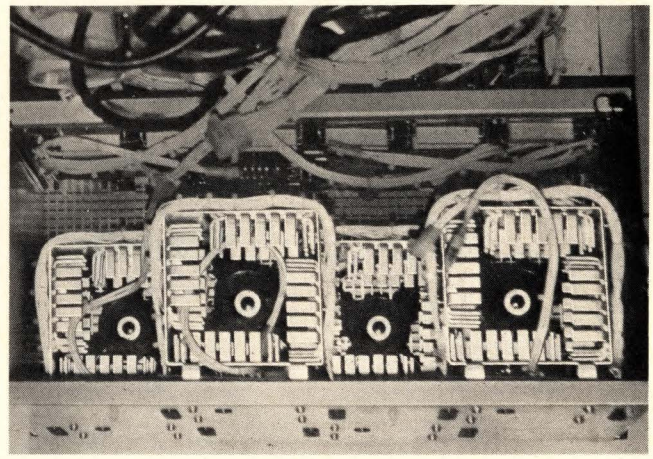
These power semiconductor cooling ideas could get you out of a hot spot.

No. 12 of a Series

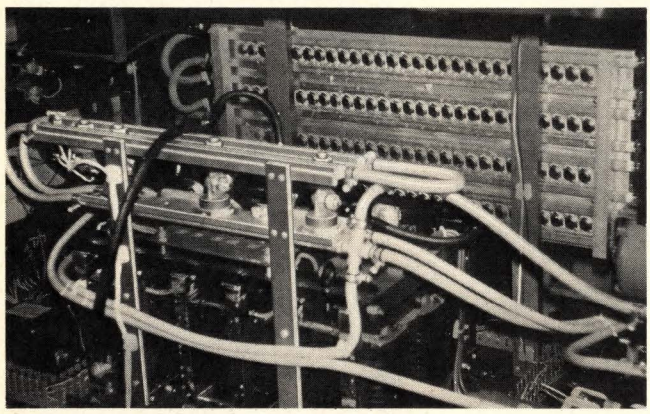
Semiconductor control of power means lots of heat generation in the semiconductor device. If the inherent power handling and switching capabilities of the device are to be taken advantage of, you've got to get rid of that heat. But in power applications, the capabilities of discrete dissipators relying on natural convection or unchanneled air movement are soon outstripped. Here are some innovative ways power circuit designers have used IERC liquid-cooled heat sinks, IERC heat dissipators in channeled air environments, and IERC heat dissipators in IERC forced air packages to get themselves out of big-power hot spots.



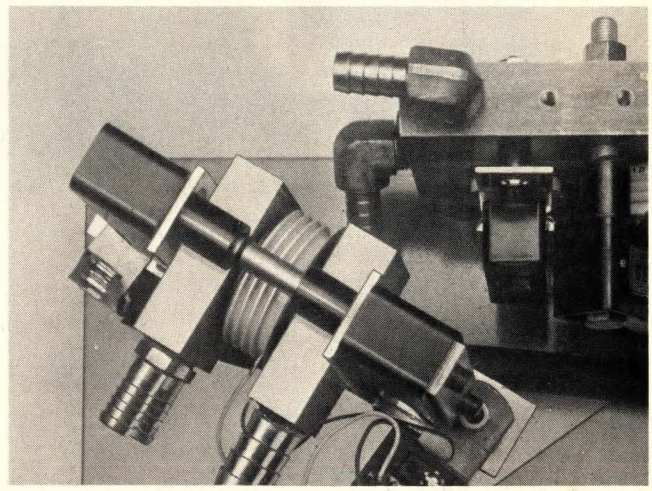
X-Y plotter designer put all his hot TO-3 power transistors in one basket to cope with heat problem. Utilizing existing chassis, he mounted devices in UP dissipators, wrapped a shroud around the assembly, and installed a blower. The UP's staggered fingers create turbulence in air stream for maximum efficiency of both the dissipator and air flow, and allowed the designer to meet his design goal of 80°C case rise maximum. He also had room within the shroud to cool his hot resistors.



Dissipate 1280 watts in 530 cubic inches was the word given to designer of this power supply so he turned to our FAHP4 forced air packages. It took 4 units to do the job at a cost of $26 ($6.50 each/1000 pc qty.) plus $40 for the fans. Average case rise of the 16 transistors was only 75°C.



6000 watts of heat produced by 125 TO-3 case transistors in an industrial welding machine power supply was raw-power problem solved by IERC E4 liquid cooled sinks. Designer brazed together four standard E4's cut to 36 inches in length and tier stacked two other E4's to cool high power SCR's. Total area of heat sinks used only a fraction of the space required for a blower-cooled system of similar capacity.



Fork-lift truck speed control used SCR's in hocky puck packages to handle thousands of watts in drive power. Big heat problem was solved with IERC liquid-cooled, double-side heat exchangers specially designed to let these big pressure-mount semiconductors dissipate on the order of 1000 watts each with just a 20°C case rise above ambient. Where did the designer get the coolant? He routed vehicle hydraulic fluid through the heat exchangers.

For more information
on heat sinks and dissipators for milliwatts to kilowatts, send for the IERC Short Form Catalog today. It covers the most complete line of thermal problem solving devices available anywhere.

IERC DCA

Heat Sinks/Dissipators

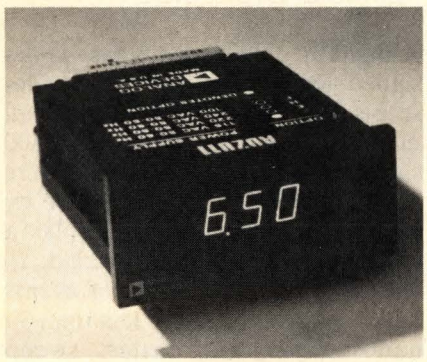
INTERNATIONAL ELECTRONIC RESEARCH CORPORATION/A SUBSIDIARY OF DYNAMICS CORPORATION OF AMERICA/135 WEST MAGNOLIA AVENUE, BURBANK, CALIFORNIA 91502

Instruments

True-rms meter has four ranges

Digital panel instrument uses computing converter to improve accuracy

When accurate measurements of nonsinusoidal ac voltages are required, an instrument that reads out true-rms values is a must. Rms-calibrated averaging meters cannot take accurate readings unless the input is



an undistorted sine wave within a narrow frequency range.

Analog Devices' line-operated digital panel meter, designated the model AD 2011, uses a computational rms-to-dc converter to permit measuring the true rms value of an ac waveform with accuracy to within ±0.1% of reading ±0.1% of full-scale range ±1 digit. By using a computing technique, the AD2011 achieves a 170-millisecond response time, and the instrument will measure inputs that range in frequency from 45 hertz to 300 kilohertz.

The AD2011 offers four calibrated input ranges—1, 10, 100, and 1,000 volts full scale—and displays the measured voltage on three 0.55-inch-high Beckman seven-segment gas-discharge displays. A fully floating opto-isolated input allows measurements to be made with common-mode voltages as high as 300 V rms.

The ac-line-powered DPM provides binary-coded-decimal outputs and control signals for interfacing to data-logging or digital-feedback control systems. Versions are available for 50 or 60 Hz, and 100, 115, 220, or 240 V.

Applications include measurements of chopped-waveform outputs of silicon controlled rectifiers used in lighting, motor, and furnace controllers, noise and vibration measurements, and measurements of transformer parameters.

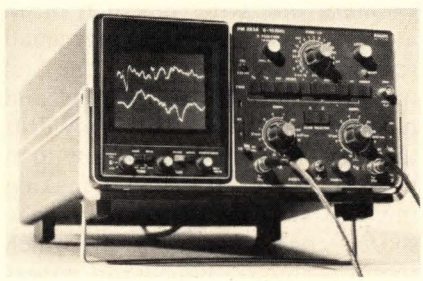
The AD2011 is priced at $295 each in quantities of fewer than 10, and $195 each in hundreds. Delivery is from stock.

Analog Devices Inc., P.O. Box 280, Rte. 1 Industrial Park, Norwood, Mass. 02062 [351]

Dual-beam 10-MHz scope offers half-tone storage

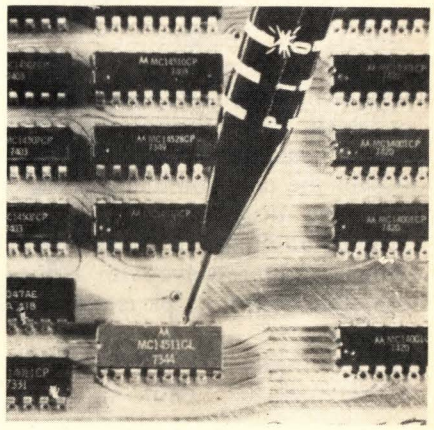
Because it has two electron beams with completely independent vertical deflection plates (but common horizontal plates) the PM3234 storage oscilloscope can capture and display pairs of single-shot waveforms in their true time relationship. The 10-megahertz variable-persistence instrument uses the same half-tone storage technique employed in Philips' wider-bandwidth storage scopes. The technique allows a continuously variable persistence from 0.3 second to 10 minutes. The scope also has a low-intensity mode in which the display lasts for two hours. Priced at $1,945, the PM3234 has a maximum sensitivity of 2 millivolts per division across its full bandwidth.

Philips Test & Measuring Instruments Inc., 400 Crossways Park Dr. Woodbury, N. Y. 11797 [354]



C-MOS logic probe is priced at $25

Capable of handling all complementary-symmetry MOS logic supply voltages from 3 to 18 volts, a C-MOS logic probe sells for only $25. The probe, which has an input resistance of 2 megohms, can detect



pulses as narrow as 500 nanoseconds. For ease in reading the light-emitting-diode indicator lamps, short input pulses are stretched to a duration of 200 milliseconds. The probe indicates a logic 0 when its input voltage is less than 45% of the supply voltage; a logic 1 is indicated when the input is greater than 55% of V_{DD}. Delivery is from stock.

Questronics Inc., P. O. Box 15803, Salt Lake City, Utah 84115 [353]

Three-in-one audio tester is priced at $78.95

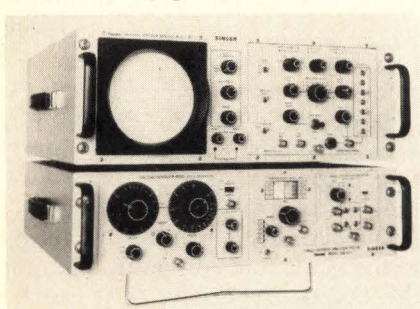
A combination audio oscillator, sweep generator, and frequency meter, the model 140B, is intended for testing equipment such as amplifiers, loudspeakers, and tape recorders. The $78.95 generator has two frequency ranges: 40 Hz to 1 kilohertz, and 1 kHz to 20 kHz. For each range, the oscillator can be either manually tuned or swept over the entire range. A built-in analog frequency meter can be connected to the generator's output to monitor the output frequency, or it can be

used as an independent measuring instrument. The instrument's output level is adjustable from 0 to 2.5 volts peak to peak, and is flat within 0.25 dB over the entire frequency range. Sine-wave distortion is less than 1.5%. In addition to the sine-wave output, a square-wave with a fixed amplitude of 8 V pk-pk is also produced.

Production Devices, 7857 Raytheon Rd., San Diego, Calif. 92111 [355]

SSB spectrum analyzer resolves 10 Hz in 40 MHz

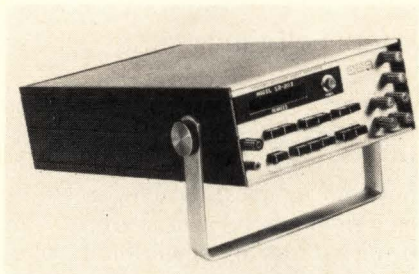
A spectrum analyzer, model SSB-50-1, has a resolution of 10 hertz over its tuning range of 10 Hz to 40 megahertz. This resolution, together with its 0.5-microvolt sensitivity (minimum measurable signal), steep-skirted i-f filters, and low residual fm, makes the analyzer suitable for the study of single-sideband signals. For example, the instrument can measure 60-Hz sidebands 60 decibels below a carrier. Usable for more than 200 MHz, the analyzer has preset scan widths of 150 Hz, 500 Hz, 3.5 kHz, 7 kHz, and 14 kHz. Selection of a preset scan width automatically provides an i-f bandwidth and a scanning rate that result in optimum resolution. The price of the SSB-50-1 is $7,000; delivery time is four weeks.



Singer Instrumentation, 3176 Porter Dr., Palo Alto, Calif. 94304 [357]

Digital indicators display synchro and resolver angles

Two all-solid-state instruments that convert the analog-output data from synchros and resolvers into digital form are available with two different accuracies: the model HSR-202 has a resolution and maximum error of 0.01°, and the SR-202 has the same resolution but a maximum error of 0.03°. Both five-digit units use LED displays and can track angular

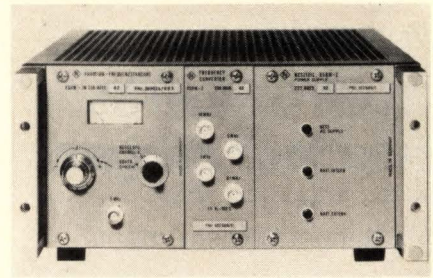


rates up to 1,080° per second without velocity error. Niether instrument requires adjustment or calibration to operate properly.

"Applications Engineering," Data Device Corp., a division of ILC Industries Inc., 105 Wilbur Pl., Bohemia, N. Y. 11716 [356]

Rubidium frequency standard weighs only eight pounds

Measuring only 5 inches high by 4 in. wide by 13.5 in. deep, the 8-pound XSRM rubidium frequency standard offers the precision of an atomic standard in a package small enough to be used in airborne and other mobile communications and navigation systems. Frequency drift that results from aging is less than five parts in 10^{11} per month, making the XSRM an ideal frequency source for applications in which recalibration is difficult or impossible. The operating voltage may vary between 22 and 32 volts, and magnetic shielding is provided.

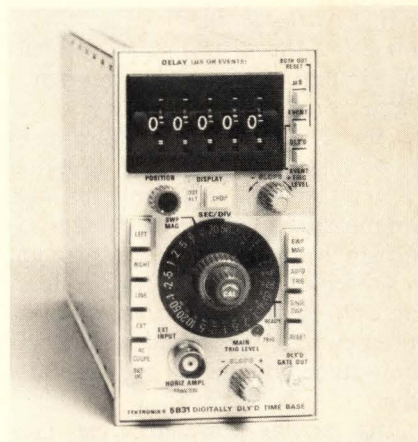


Rohde & Schwarz, 111 Lexington Ave., Passaic, N. J. [458]

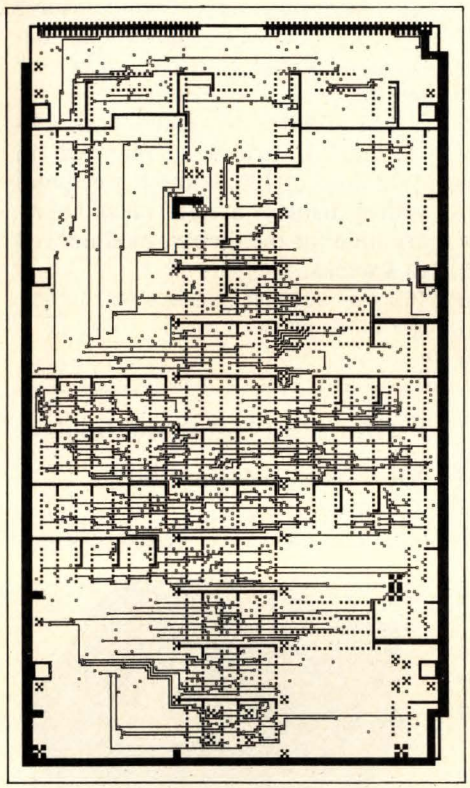
Delayed time base runs in time or event mode

A digitally delayed time base is designed for low-cost plug-in oscilloscopes and is compatible with all mainframes in the Tektronix 5400 series. Two push buttons set the 5B31's delay mode—by time or by events. Five thumbwheels display a delay time of 1 microsecond to 99,999 μs or any number of events to 99,999. Delay jitter is less than 10 nanoseconds, and fastest sweep speed is 20 ns/division. Besides being accurate and free of most jitter, the 5B31 is simple to operate because of the digital controls. Applications include production-line testing, educational systems, and other areas. The delay-by-events mode extends the usefulness of the instrument to computer servicing.

Tektronix Inc., P.O. Box 500, Beaverton, Ore. 97005 [359]



By the time your drum plotter turns this out, a Gould printer/plotter can turn it out 400 times.



If what you're looking for is higher plotting speed and lower plotting cost, we've got something that can give you both. And something else besides.

A Gould electrostatic printer/plotter. The one that makes your old drum plotter remarkably underproductive. The one that gives you a useful printing capability in the bargain. A Gould plotter is so fast, it can turn out this plot in only 2 seconds – versus an average 13½ minutes for your old drum plotter.

And what gives that Gould plotter its blinding speed is its direct on-line operation to your computer. Whether it's the PDP-8/E, PDP-9, PDP-11, PDP-15, HP2100, Nova/Supernova, H316/516, Raytheon 704, UNIVAC 1108, IBM 360/370, CDC 3000/6000, Interdata 70 and more.

In addition to output speeds up to 400 times faster, a Gould printer/plotter gives you a lower unit cost, as well as lower paper cost. Better-looking output, since there's no ink to smudge, clog or run out of. Few moving parts for quiet operation, high reliability. Software that's upward compatible with the leading drum plotter. Without any sacrifice in mainframe CPU time.

And, in addition to everything else, it gives you an alphanumeric printing capability that also lets you compile management reports at speeds up to 3000 lines per minute.

Users will tell you that a Gould electrostatic printer/plotter makes their computer-aided design system truly interactive since output of modified data for verification can be quickly obtained. And by producing hardcopy output in a matter of seconds – instead of the many minutes it can take with older methods – time savings are maximized.

This all adds up to the best printing/plotting hardware and software available anywhere. And it's backed by Gould's own factory-trained service technicians.

To learn more about Gould electrostatic printer/plotters – get in touch with Gould Inc., Instrument Systems Division, 20 Ossipee Road, Newton, Mass. 02164 U.S.A., or Kouterveldstraat 13, B 1920, Diegem, Belgium.

GOULD

Subassemblies

LEDs readable at 50 feet

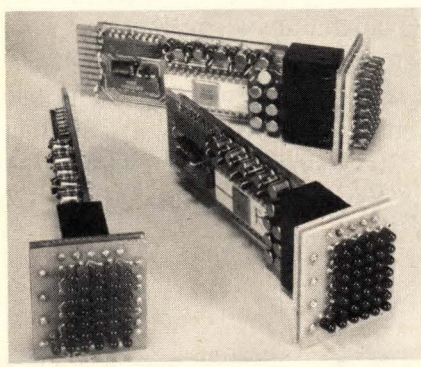
35-diode matrix generates alphanumerics 1 or 1¾ inches high

Most alphanumeric displays made from light-emitting diodes are small and intended for close-up reading. But with computer terminals, industrial control systems, and similar applications in mind, TEC Inc. has developed red, green, and yellow readouts that are among the largest on the market. The characters can be either 1 inch or 1¾ in. high and can be read from a distance of 50 feet.

Designated the MDA-6400 series, the displays come with read-only-memory decoders, drivers, and clocks. The readout is a matrix of five by seven LEDs that use an internal character generator to display 64 Ascii characters. Character-selection is achieved by a 6-bit binary word at the input. The inputs are compatible with diode-transistor and transistor-transistor logic, and the units operate from two low voltages. Power required is 250 milliamperes at 5 V, and 40 mA at −12 V.

Minimum input for logic 1 is 3.5 V, and the maximum for logic 0 is 0.6 V. The input-current level is under 10 microamperes.

The display consists of a vertical circuit board that contains the diodes, drive board, and edge-board



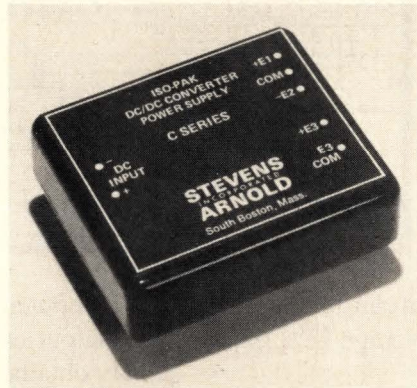
connection. The connector can be a TEC 781462-000 or Viking type 2H10/1JN-5.

The LEDs have a brightness of 2 millicandelas per diode at 10 mA, and the company says viewing angle to half-brightness is more than 150°. The diodes are said to be highly resistant to shock, vibration and extreme change in temperature. The displays, which operate from 0°C to 70°C, can be stored at temperatures of −55°C to 100°C. An optional bezel is available with red, amber, or neutral polarizing filter.

The red display, either 1- or 1¾-in. high, is priced at $48 each in quantities of 100, and the green and yellow displays are $55 each. Delivery time for the display modules is 3 to 4 weeks.

TEC Inc., 9800 North Oracle Rd., Tucson, Ariz. 85704 [381]

Power-supply module built for use with converters



Manufacturers of analog-to-digital and digital-to-analog converters sometimes specify separate digital power supplies to minimize digital-noise breakthrough to the analog section. Stevens-Arnold Inc. has introduced a 9-watt, triple-output, fully shielded dc/dc power-supply module that serves this purpose. It has transformer-isolated digital and analog grounds to minimize problems with digital-noise interference and system ground loops.

The Iso-Pak series C has inputs ranging from 5 to 48 volts; the 15-V input can also be used as a power isolator to power an analog circuit sensitive to noise. The supply has dual three-wire analog outputs of +15 V with ±165 mA current, and digital output of +5V with 750 mA. The analog output is accurate to within ±0.02%, and accuracy of the digital output is within ±0.1%.

The transformer has multiple shields to give a common-mode noise current of 500 microamperes peak to peak and output noise voltage of 20 mA peak to peak. All three outputs can be fully loaded simultaneously with a reflected input ripple current of 70 mA peak to peak. All three are constant-current-limited with no latchdown, and each has a thermal-shutdown feature for long-term fault-protection—the supply can survive for eight hours with any output shorted to its common.

The module, measuring 2.56 by 3 by 0.75 inches, is shielded on all six sides; the header is epoxied with the same material as a printed-circuit board, so that when it is put on a board, no metal will short out the wiring.

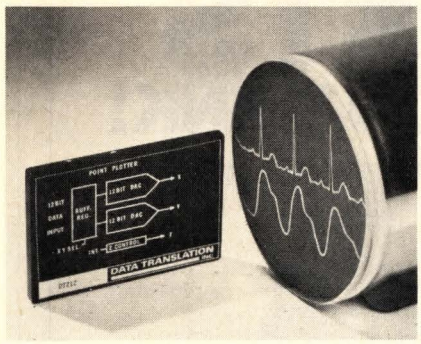
Price of the Iso-Pak C series is $99, and units are available off the shelf.

Stevens-Arnold Inc., 7 Elkins St., South Boston, Mass. 02127 [382]

Point plotter generates CRT displays and analog traces

Believed to be the first standardized module for generating CRT images from digital data, the DT212 point plotter is expected to find wide use in microprocessor- and minicomputer-based systems. Useful for driving both cathode-ray-tube displays and analog recorders, the module provides all of the converting, timing, and control functions needed to interconnect a display with a computer. At the heart of the DT212 is a pair of 12-bit digital-to-analog converters, one for each axis. Since most CRT displays are organized as 1,024-dot by 1,024-dot matrixes, the 12-bit converters ensure a worst-case position error of ⅛ of a dot interval. Power amplifiers

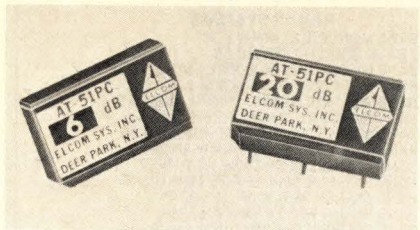
New products



on the d-a converter outputs guarantee settling to within 0.1% of final value within 1 microsecond, and to within 0.01% within 3 μs with up to 50 feet of terminated cable hanging on the output. Price of the DT212 is $245 each in quantities of 100 pieces; delivery time is two weeks.
Data Translation Inc., 109 Concord St., Framingham, Mass. 01701 [383]

500-MHz DIP attenuators occupy only 0.08 cubic inch

Mounted in a 14-pin dual in-line package, the AT-51PC series of rf attenuators measure 0.21 inch high and have a volume of 0.08 cubic inch. The fixed rf devices are available in values from 1 to 10 dB in 1-



dB steps, and from 10 to 20 dB in 2-dB steps. Attenuation accuracy is within 0.5 dB to 200 megahertz, and within 1 dB to 500 MHz. Price is $9.50; delivery is stock to 30 days.
Elcom Systems Inc., 127F Brook Ave., Deer Park, N. Y. 11729 [384]

Amplifier spans 5 to 1,500 MHz

A thin-film hybrid amplifier, the WJ-A25, covers the frequency range from 5 to 1,500 megahertz with a

New products

gain of 10 decibels, a noise figure of 6 dB, and a power output of +9 dBm (about 8 milliwatts). Its third-order intercept point is typically +20 dBm. The device is packaged in a hermetic four-pin TO-8 can, and can be used either alone or in cascade. A complete amplifier, the WJ-A25 contains its own internal power-supply decoupling, and a very stable biasing circuit. The unit is designed to work over the range of ambient temperatures from −54°C to +100°C and to be unconditionally stable for all source and load conditions. Small-quantity orders of the WJ-A25 are shipped from stock. Their price is $129 each in quantities of one to nine.

Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif. 94304 [385]

ICs cut costs of power-supply modules

Designed for the cost-conscious marketplace, three new series of OEM power supplies use integrated-circuit regulators to reduce component costs and the costs of wiring and other manufacturing processes. The lowest-power units, called the Red Baron series, put out voltages from 5.0 to 28 V dc at currents from 0.8 to 3.0 amperes. Next up the power ladder is the Green Hornet series, which puts out the same five voltages—5, 12, 15, 24, and 28 V—at currents of 6, 4, 3, 2.2, and 2 A, respectively. The high-power Black Beauty series provides the same voltages, but at currents as high as 10 A, for the 5-V version, and 4 A for the 28. Pricing, in quantities of one to four pieces, is $26.95 for the Red Baron, $48.45 for the Green Hornet, and $72.25 for the Black Beauty. Hermetic IC regulators, 100-watt output transistors, and hermetic dual rectifiers derated to 30% or less of their ratings give the new supplies full-load MTBFs of 38,000 hours, compared with 5,000 hours for some other IC-regulated power supplies.

Advanced Power Inc., 1621 So. Sinclair St., Anaheim, Calif. 92806 [386]

New literature

Keyboards. Features and specifications of three interactive visual-display keyboards are described in a product sheet available from the Micro Switch division of Honeywell, 11 W. Spring St., Freeport, Ill. 61032. The solid-state keyboards are Hall-effect, MOS-encoded devices. Circle 421 on reader service card.

Power supplies. Modular, rack-mounted, constant-voltage, constant-current, ac-input, and dc-input power supplies, along with battery chargers, shielded-line isolators, and unregulated supplies are covered in a 24-page catalog put out by CEA division of Berkleonics Inc., 1 Aerovista Park, San Luis Obispo, Calif. 93401 [422]

Rotary switches. A 40-page catalog giving details on the company's newly standardized line of industrial rotary switches can be obtained from Centralab Marketing Services Department, 5757 North Green Bay Ave., Milwaukee, Wis. 53201 [423]

Projection displays. A four-page data sheet, called a product profile, is a combination catalog and application note on the series 1100 projection displays and their driver/decoders. The product profile is available from IEE, 7740 Lemona Ave., Van Nuys Calif. 91405, Attention: Display Systems Division [424]

Characterizing logic circuits. A calculator application summary entitled "Digital Simulation on the HP 9830A" describes some new software that can reduce the time needed to verify logic behavior. The summary, No. 5952-8918, is obtainable, free of charge, from Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [425]

Cartridge lamps. A family of two-pin cartridge lamps that insert easily from the front of a panel into matching holder assemblies are described in a 16-page catalog published by Eldema Division, Genisco Technology Corp., 18435 Susana Rd., Compton, Calif. 90221 [426]

Electronics advertisers

January 23, 1975

■ For more information on complete product line see advertisement in the latest Electronics Buyer's Guide
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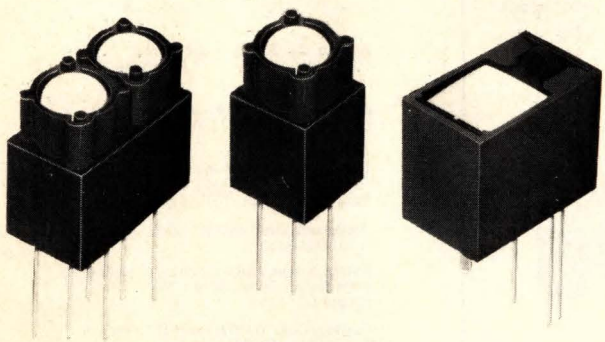

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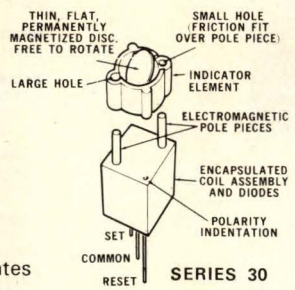

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For full information and specifications, contact the Display Components Department,

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The five applications cited here are from a long list of actual systems. Please tell us about your image processing activity. We may have some ideas for you.

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