FEBRUARY 19, 1976

SPECIAL REPORT ON ISSCC/105

The 16-k RAM: triumph of n-channel technology/116

Squelching line reflections with diode terminators/123

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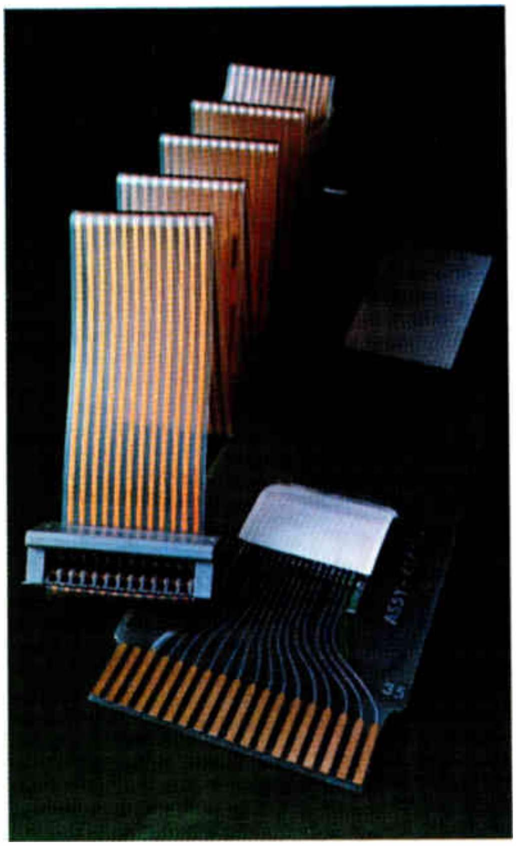
Electronics®

BREADBOARDS

New look in designers' fare

BRAND-REX TAPE CABLE® - SOMETHING FLAT TO ROUND OUT THE BROADEST LINE IN THE INDUSTRY.



TAPE CABLE is a flat, flexible cable — the newest addition to the long line of Brand-Rex cables which already include bonded and woven ribbon cable, insulated copper and aluminum strip for power distribution, and a wide range of standard round configurations.

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- Many insulation types, including PVC, polyester, Kapton*, Teflon*.
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- Controlled spacings to meet any electrical or mechanical requirement.
- Signal cables for digital data transmission in computers.

*Dupont Trademark

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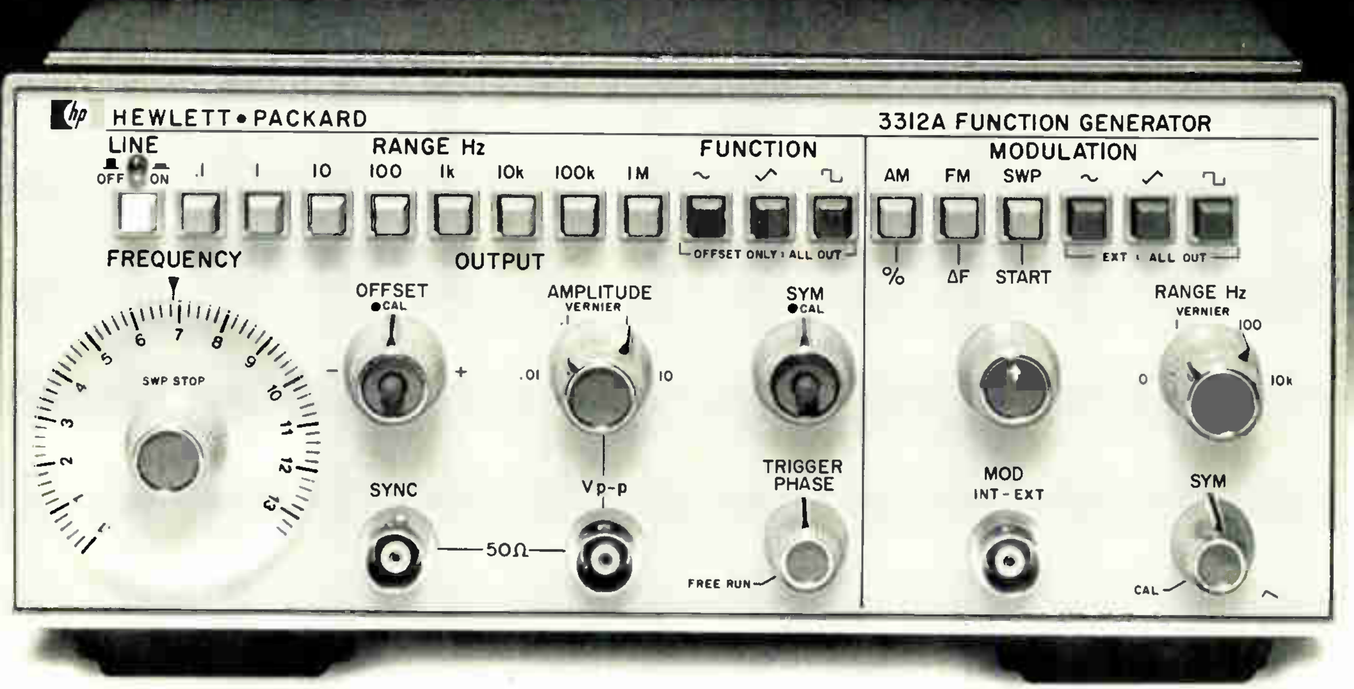
Circle [illegible] on reader service card

1+1=10



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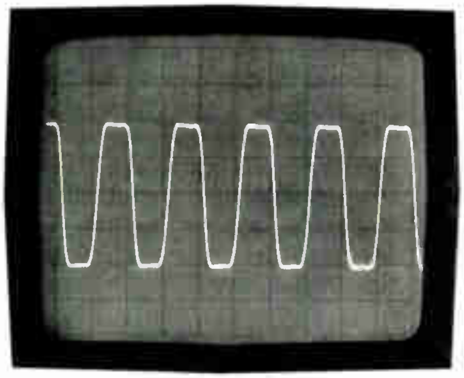

Unretouched scope display of the 3312A's 10 MHz square-wave output, showing 18 nsec rise time.

*Domestic USA price only.

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Now, another 300 IC test programs free. That's 1,000 in all!

Some manufacturers charge $175 for each IC test program.

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The bench-top tester people

Electronics
The International Magazine of Electronics Technology

Vol. 49, No. 4 • February 19, 1976

Highlights

Cover: Breadboards serve old role in new style, 97
Breadboards are becoming almost as sophisticated as the circuitry they help design. This survey pinpoints five types: the most popular, the cheapest, the fastest growing, the most easily wired, and the quickest to use and reuse. Cover design is by Art Director Fred Sklenar.

Venture capital shying away from startups, 73
The reluctance to back new companies could damage the growth of the electronics industries. Financiers blame their caution partly on a slower rate of return on investment and partly on new laws penalizing capital gains.

Memories make this year's ISSCC memorable, 105
Star performers at the International Solid State Circuits Conference being held in Philadelphia this week include the 16-kilobit random-access memory and the first 65-kilobit charge-coupled memory. Excellent supporting performances come from two new logic circuits and several new analog devices.

Hail to the 16,384-bit RAM, 116
A two-level cell structure is what gives this 16-kilobit random-access-memory chip its record-breaking bit density. Otherwise, it uses the same n-MOS technology—and the same 16-pin package—as its 4-kilobit predecessor.

And in the next issue . . .
Special report on the citizens' band boom . . . the push to safer instruments . . . designing reliability into solid-state power equipment for industry: part 1 of a two-part series.

Electronics

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Publisher's letter

Our editors have long been concerned about the career problems that face EEs. From the mid-career crisis to continuing education, the pages of *Electronics* have chronicled a number of significant steps in the growth of a sense of professionalism among EEs.

In this issue, for example, you'll find, on page 31, the story of the footwork now going on among candidates for this year's IEEE elections. Last year was the first time that anyone mounted an election challenge by rounding up enough petition signatures to gain a spot on the ballot. This year, the ball is really rolling and it looks like there will be more challengers by petition. Also, on page 86, there is a Probing the News story on the ferment in the ranks of the professional activities committees of IEEE chapters. The IEEE is, after all, the EEs' professional organization, and changes in it both cause and reflect changes in the profession itself.

Breadboarding, that fine old electronic art, is still very much a part of the design process. Even with computer-aided design and the wealth of simple-looking packages full of complex circuitry, the equipment designer can't just plug everything together and call it a day.

Like many another fine old art, breadboarding has evolved and has reached a new level of sophistication. Starting on page 97, you'll find a profile of breadboarding today. Our eight-page report details the five major forms of commercial breadboarding systems—and compares the advantages of each.

Jerry Lyman, our packaging and production editor, who calls himself "the world's worst solderer," was impressed by the amount of "hybridization" among the breadboards he saw. "It was really quite surprising to see parts from one breadboarding system being used with other systems. But, I guess that is one mark of the designer's talent—to be able to juggle what the marketplace has to offer, even if no one ever thought to do it that way before. And if he is thinking along those lines for the final product, it's only natural to do it with the breadboards, too."

One of the boards on our cover, by the way, shows how far the humble breadboard has come. "Part of a custom circuit, the wire-wrap board is itself the finished product," says Jerry, "although it was assembled using typical breadboard techniques."

It's hard to believe that another year has passed since the last International Solid State Circuits Conference, but it has. And this year's meeting looks like it's even more interesting than the last. One of the handful of annual meetings that can be called trend-setters, the ISSCC has always been a rich mine of technological progress. We have prepared a preview of some of the more noteworthy advances in a six-page article that starts on page 105. And in issues to come, you'll be seeing more fall-out from the conference in our pages.

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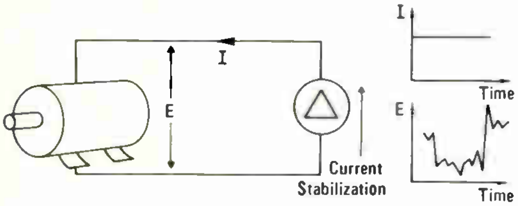
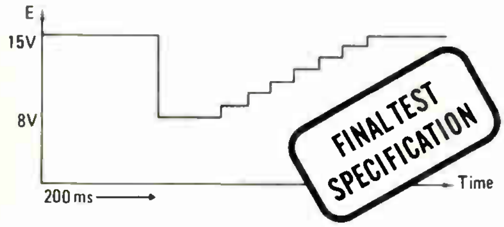
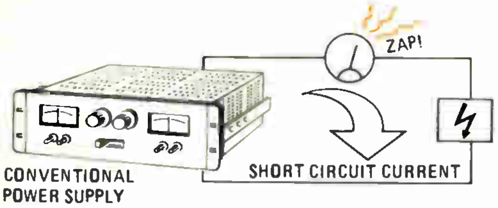
four important reasons to specify the KEPCO OPS power supply



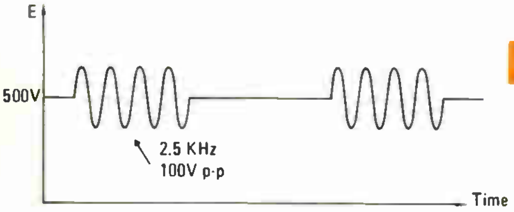
1 **YOU'VE GOT THIS MOTOR** that wants to be driven by constant current. Trouble is, its impedance varies wildly, and your conventionally-filtered current regulator can't hardly keep up. **YOU NEED A KEPCO OPS**—whose lack of output capacitance allows a stabilized current to be stable—even though the compliance voltage is doing nip-ups.



2 **YOUR SYSTEM DESIGNER SPECIFIED THIS TEST SEQUENCE:** . . . *"15V for 200 milliseconds, shift to 8V (1 ms settling time) then stair step back to 15V @ 20 ms/step in 1V steps."* Your conventionally-filtered power supply has a shunt capacitor that takes a half-second just to make it down to 8V . . . . **YOU NEED A KEPCO OPS,** whose capacitorless output circuit can be programmed rapidly (up to 1V/μsec) and yet suppress ripple and noise some 60–80 dB below peak output.



3 **YOU'VE POWERED UP THIS SENSITIVE LOAD** that suddenly shorts — zapping the delicate series ammeter . . . . But the specs on your conventional power supply said "current limited." Problem is, the output capacitor isn't included! **YOU NEED A KEPCO OPS:** No output capacitor, no surge current, even when shorted!



4 **YOU NEED TO SUPERIMPOSE THIS 2.5 KHz MODULATION** on top of a d-c level. You can either buy a modulator/amplifier and put it in series with your conventionally-filtered power supply, or **USE A KEPCO OPS,** which is a "modulatable power supply" and which for 1V/μsec slewing, will allow you up to 100V p-p modulation at 2.5 KHz.

OPS III (Modular Style)

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Whenever your application requires a dynamically programmable voltage, a stable current into a dynamic load, or you just plain can't tolerate the energy stored in an output filter, you really do need a Kepco OPS. There are 61 models ranging from 20 W to 1000 W and offering outputs from 0–6 volts up to 0–5000 volts.

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Model S3D

400 ∿ to DC
(56,148 Hrs.)
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Abbott's New Hi-Performance Modules

are designed to operate in the stringent environment required by aerospace systems — MIL-STD-810B and MIL-STD-461A for electromagnetic interference.

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QUALITY CONTROL — High reliability can only be obtained through high quality control. Only the highest quality components are used in the construction of the Abbott power module. Each unit is tested no less than ***41 times*** as it passes through our factory during fabrication — tests which include the scrutinizing of the power module and all of its component parts by our experienced inspectors.

NEW CATALOG—Useful data is contained in the new Abbott Catalog. It includes a discussion of thermal considerations using heat sinks and air convection, a description of optional features, a discussion of environmental testing, electromagnetic interference and operating hints.

WIDE RANGE OF OUTPUTS — The Abbott line of power modules includes output voltages from 5.0 volts DC to 740 volts DC with output currents from 2 milliamperes to 20 amperes. Over 3000 models are listed ***with prices*** in the new Abbott Catalog with various inputs:

60∿ to DC
400∿ to DC
28 VDC to DC
28 VDC to 400∿
12-28 VDC to 60 ∿

Please see pages 1037-1056 Volume 1 of your 1975-76 EEM (ELECTRONIC ENGINEERS MASTER Catalog) or pages 612-620 Volume 2 of your 1975-76 GOLD BOOK for complete information on Abbott Modules.

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Readers' comments

Let technology flow

To the Editor: It is refreshing to hear that after 30 years, the Commerce Department realizes that it cannot control the "illegal" high-technology flow from the U.S. to the Soviet Bloc [Jan. 8, p. 68]. Now let's take some laws off the books so it won't have to try.

Have you ever known a design engineer who wouldn't talk your leg off about how much better the product would have been with a little more time and about all the great features he now knows he can get into the next model? Our market-price system only needs free trade to keep this knowhow at home.

No currently exporting firm can risk appearing on Commerce's black list just to tell the full story. But there are some of us that can tell the story. Then I'm sure that the active traders would welcome the chance to argue effectively the merits of free and open trade with all nations—especially with our adversaries.

We all understand too well whence cometh technology and what makes it grow. We also understand the inefficiencies of technological stealing. But our hell-bent policies of giving technology away not only stifle our economy, but are setting us up for the permanent runner-up position. How we go about educating the bureaucrats and politicians to these simple facts is the problem.

Herman P. Miller III
hpm Associates
Stockton, Calif.

The 1 . . . 1 exception

To the Editor: In one exceptional case, the unwanted zero can still occur in my one's complement adder design [Feb. 5, p. 103]. The addition of 1 . . . 1 to itself still produces 1 . . . 1. However, in a system using my adder design, 1 . . . 1 does not normally occur as an adder output, and so it would not normally occur as an input.

John F. Wakerly
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News update

■ It looks, at long last, as though Underwriters' Laboratories may finally win industry approval of a safety standard for test and measurement instruments and publish it, possibly before summer. Strong objections from manufacturers about the original draft of the proposed standard—UL 1244—sent UL back to the drawing board and resulted in a much improved second version [May 29, 1975, p. 75]. Now UL is circulating a third and, it hopes, final proposed standard.

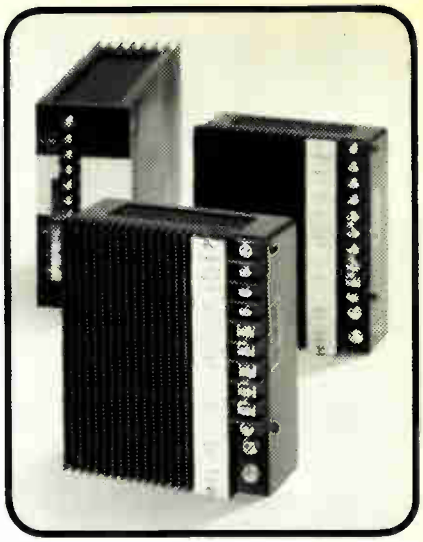
For their part, instrument makers have formed an *ad hoc* committee whose job it is to present a unified response. Under the aegis of Wema, the trade association of electronics firms, the committee is headed by Richard Nute, manager of product safety engineering at Tektronix Inc., Beaverton, Ore.

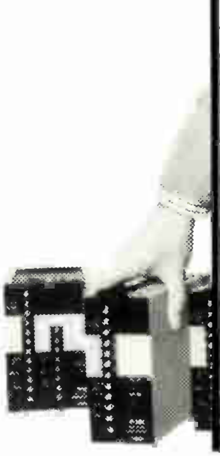
■ Researchers at Stanford University Electronics Laboratories had hoped to implant their artificial ear in humans by this time [Feb. 20, 1975, p. 38]. However, there have been some setbacks, primarily in getting physicians to accept the device before animal tests have been performed. Currently, says Tushar Gheewala, research associate, 20 units are installed in dogs and cats at Stanford Medical School and the University of California Medical School in San Francisco.

The National Institutes of Health, which is sponsoring the research, wants to be sure that the devices are reliable and offer definite advantages before they are implanted in humans. Gheewala believes that five or six people will receive the ears in the next nine months, but adds that it will then take the experimenters two years to evaluate their effectiveness.

To be examined closely by researchers will be the devices' resistance to body moisture. Another vital parameter will be durability: they want the implantable ear to operate for two to five years before it has to be replaced.

—Howard Wolff





The first true universal LED lamp.

You get constant brightness from 4.5v to 12.5v—or even 16v. And that's not all.

Good-by resistors.
Good-by brightness fluctuation.
Good-by higher loading costs.
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The Constant Brightness Lamp (CBL) is a bright new packaging idea from Litronix. The CBL has an IC voltage regulator built into the lamp so the voltage across the lamp doesn't matter so long as it is within a wide range. You can even take the lamp out of one circuit and put it into another.

The brightness never varies.

Our CBL's operate over three wide voltage ranges between 4.5 and 16 volts. And they plug into any PC board that accepts a T1 or T1 ¾ package. Even existing boards. What could be more convenient!

Price-wise, they make incredible sense. When you consider you don't have the extra costs for resistors, loading, inventory, and overhead, you can get the convenience of CBL's for about the same installed cost as ordinary lamps.

RLC-200	20 ma @ 4.5-12.5v	T1 ¾ package	37¢ in 1000 pc. quantities
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litronix

Rookie of the year.

Advanced Micro Devices' new four-bit, high speed ALU: The Am25LS181. A major league version of the TI model. Playing its first full season and already destined for greatness.

How? By increasing speed 20%, improving noise margin by 50mv and doubling fan-out over the military temperature range.

The Am25LS181 does an eight-bit add or subtract in 52ns at only one quarter of the power of standard TTL. Wow! It'll also handle 14 other arithmetic operations and has full look-ahead. And, of course, MIL-STD-883 is yours for free.

A perfect addition to the best low-power Schottky team around.

Check the list for the other Am25LS players. Better still, send for the souvenir book.

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The First Team. High Performance Low-Power Schottky Am25LS SERIES	The Bench. (If you'd like to go with the veterans, we understand. Here's our standard Am54/74LS roster.)	Function
Am25LS07		Six-Bit Register With Clock Enable
Am25LS08		Four-Bit Register With Clock Enable
Am25LS09		Four-Bit Register With Two-Input Multiplexer on Inputs
Am25LS14		Serial/Parallel Two's Complement Multiplier
Am25LS15		Four-Bit Serial/Parallel Adder Subtracter
Am25LS22		Eight-Bit Serial/Parallel Register
Am25LS23		Eight-Bit Universal Shift Register, Synchronous Clear
*Am25LS123	*Am54LS/74LS123	Dual One-Shot
Am25LS138	Am54LS/74LS138	One-of-Eight Decoder/Demultiplexer
Am25LS139	Am54LS/74LS139	Dual One-of-Four Decoder/Demultiplexer
*Am25LS148	Am54LS/74LS148	Priority Encoder
Am25LS151	Am54LS/74LS151	Eight-Input Multiplexer
Am25LS153	Am54LS/74LS153	Dual Four-Input Multiplexer
Am25LS157	Am54LS/74LS157	Quad Two-Input Multiplexer; Non-Inverting
Am25LS158	Am54LS/74LS158	Quad Two-Input Multiplexer; Inverting
Am25LS160	Am54LS/74LS160	Synchronous BCD Decade Counter, Asynchronous Clear
Am25LS161	Am54LS/74LS161	Synchronous Four-Bit Binary Counter, Asynchronous Clear
Am25LS162	Am54LS/74LS162	Synchronous BCD Decade Counter, Synchronous Clear
Am25LS163	Am54LS/74LS163	Synchronous Four-Bit Binary Counter, Synchronous Clear
*Am25LS164	Am54LS/74LS164	Eight-Bit Serial Shift Register
*Am25LS170	*Am54LS/74LS170	4 x 4 Register File (O.C.)
Am25LS174	Am54LS/74LS174	Six-Bit Register With Clear
Am25LS175	Am54LS/74LS175	Quad Register With Clear
Am25LS181	Am54LS/74LS181	Four-Bit ALU/Function Generator
Am25LS190	Am54LS/74LS190	BCD Decade Up-Down Counter
Am25LS191	Am54LS/74LS191	Four-Bit Binary Up-Down Counter
Am25LS192	Am54LS/74LS192	Synchronous BCD Decade Up-Down Counter
Am25LS193	Am54LS/74LS193	Synchronous Four-Bit Binary Up-Down Counter
Am25LS194A	Am54LS/74LS194A	Four-Bit Register; Shift Right, Left or Parallel Load
Am25LS195A	Am54LS/74LS195A	Four-Bit Register; Shift Right or Parallel Load
*Am25LS240	*Am54LS/74LS240	Octal Bus Driver, Inverting
*Am25LS241	*Am54LS/74LS241	Octal Bus Driver, Non-Inverting
Am25LS251	Am54LS/74LS251	Three-State Eight-Input Multiplexer
Am25LS253	Am54LS/74LS253	Three-State Dual Four-Input Multiplexer
Am25LS257	Am54LS/74LS257	Three-State Quad Two-Input Multiplexer; Non-Inverting
Am25LS258	Am54LS/74LS258	Three-State Quad Two-Input Multiplexer; Inverting
*Am25LS273	*Am54LS/74LS273	Octal D-Type Flip-Flop
*Am25LS281	*Am54LS/74LS281	Four-Bit Parallel Accumulator
Am25LS299	Am54LS/74LS299	Eight-Bit Universal Shift Register, Asynchronous Clear
*Am25LS374	*Am54LS/74LS374	Octal D-Type Flip-Flop (3-state)
*Am25LS377	*Am54LS/74LS377	Octal D-Type Flip-Flop, Common Enable
	Am54LS/74LS378	See Am25LS07
	*Am54LS/74LS379	See Am25LS08
*Am25LS381	*Am54LS/74LS381	Four-Bit ALU/Function Generator
	*Am54LS/74LS398	See Am25LS09
*Am25LS670	*Am54LS/74LS670	4 x 4 Register File (3-state)
*Am25LS2517		Four-Bit ALU/Function Generator
*Am25LS2518		Four-Bit Register With Standard and Three-State Outputs

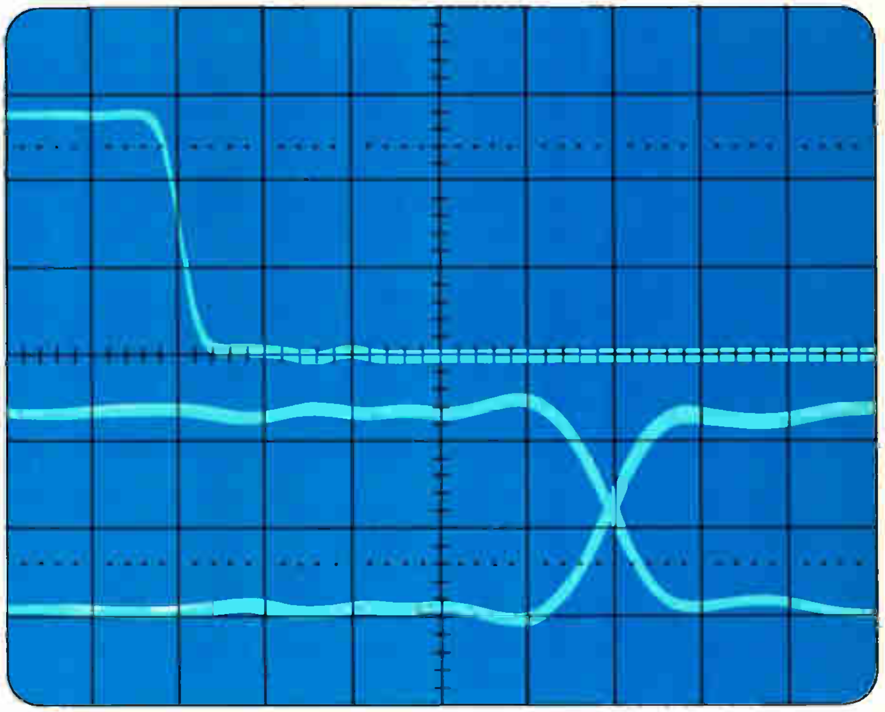
*in development

Announcing the replacement for

Intel's newest family of 16-pin 1024-bit static RAMs offer bipolar speed, MOS economy and delivery from distributor stock.

The new 2115 and 2125 low voltage, silicon gate, n-channel MOS RAMs are plug-in replacements for the popular 93415 and 93425 bipolar RAMs.

Like the high speed bipolar RAMs they replace, these new MOS RAMs are fully static, requiring no clocks or refresh, drive TTL directly, operate at TTL logic levels and use a single +5 volt power supply. And they are available with either open collector (2115) or three state (2125) outputs.



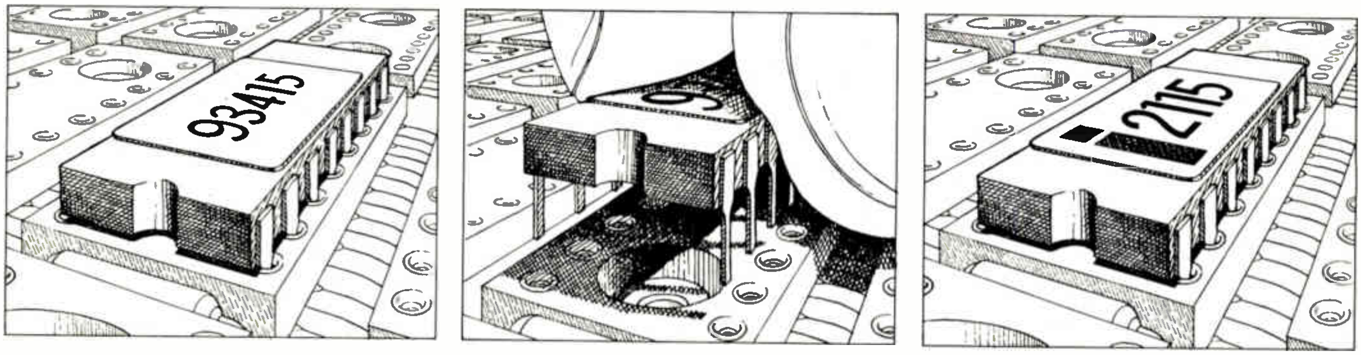
As bipolar RAM plug-in replacements, the Intel 2115 and 2125 MOS RAMs make it practical for system manufacturers to reduce all major systems costs simultaneously—power supply, cooling and packaging, as well as component costs. The high speed, 70 ns, 2115-2 and 2125-2 have a maximum power dissipation of 656 milliwatts per package compared to 815 milliwatts for standard 1024-bit bipolar RAMs.

INTEL'S HIGH SPEED MOS 1K STATIC RAM FAMILY

Part Number	Access times (ns) Typical	Access times (ns) Maximum 0-75°C	Maximum Current (mA)	Output Option
2115-2	60	70	125	OC
2125-2	60	70	125	TS
2115	70	95	100	OC
2125	70	95	100	TS
2115L	75	95	65	OC
2125L	75	95	65	TS

For applications that demand very low power consumption, the 2115-L and 2125-L can be used. These devices

first MOS plug-in 1K bipolar RAMs.



dissipate a maximum of only 341 milliwatts per package.

The 2115 and 2125 can also be used in new designs instead of dynamic or quasi-static MOS RAMs, thus eliminating clock, refresh and strobe circuits, multiple high voltage power supplies, special level converters, drivers and sense amplifiers.

With your choice of either 70 ns or 95 ns maximum access times you get all the advantages of MOS plus bipolar speed.

The 2115 and 2125 are mass produced using the same line as Intel's industry standard 2102A RAM. Using a process with a volume production history assures lowest possible cost.

Start saving now by replacing your bipolar 1024 x 1 RAMs with Intel MOS RAMs.

To order, contact our franchised distributors: Almac/Stroum, Component Specialties, Components Plus, Cramer, Elmar, Hamilton/Avnet, Industrial Components, Liberty, Pioneer, Sheridan or L.A. Varah. For your copy of the 2115/2125 data sheet use the bingo card or write:
Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051.

COMPARISON OF BIPOLAR AND INTEL MOS 1K STATIC RAMs

Part number	93415	2115-2
Pins	16	16
Circuitry	static	static
Technology	bipolar isoplanar	silicon gate n-channel MOS
Metallurgy	2-layer	1-layer
Max. access time	70 ns	70 ns
Max. cycle time	70 ns	70 ns
Max. power dissipation	815 mW	656 mW
Power supply	+5V	+5V
Output sink current	16 mA	16 mA

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Circle 12 on reader service card

People

Poppa: Acquiring a loser takes care

How does a company go about taking over a slightly bigger one in deep financial trouble? "Very carefully," answers Ryal Poppa, 42, president of Pertec Corp., which is seeking to acquire Computer Machinery Corp. This cautious note seems warranted because CMC, which has made money only one year since it was founded in 1967, is in default on $33 million of debt and has lost most of its management in the past year.

Despite these obvious problems, Poppa, a 20-year veteran in the computer business, believes CMC will "save three to five years in building an end-user sales and service organization that we need."

Pertec has not put together such a force because it has been selling primarily to original-equipment manufacturers such computer peripherals as tape transports, disk drives and data-entry systems. On the other hand, CMC has a worldwide end-user sales network to handle its key-to-disk systems. Since both firms have annual sales of about $50 million, combined volume should top $100 million. This would bring the 10-year-old Pertec, of El Segundo, Calif., a giant step closer to the $500 million in sales that Poppa envisaged when he took over in the spring of 1973 [*Electronics*, June 7, 1973, p. 14]. At the time, Pertec was grossing about $30 million annually.

No surprises. But first, Poppa says, "We had to make sure that no more bad surprises lurked out there to come back and bite us down the line. We committed to a thorough investigation where we went out and talked to distributors and customers about the equipment."

Poppa singles out the continuing loyalty of its 22 distributors to CMC gear as the critical factor. "Their attitude now is [that] if the merged company is healthy, they'll continue to buy."

Doubler. For Poppa, $50 million plus $50 million equals a $100 million operation.

With the approval of both companies' shareholders expected at a special meeting on Feb. 24, a merger plan will go into effect about April 1. CMC sales and service will be a separate division, but engineering and manufacturing will be integrated with Pertec's Business Systems division.

Income from CMC's equipment-rental base will support the sales-service operation and cover the debt. Poppa thinks that economies of combined operations will make the CMC line profitable. "At any rate, we'll know whether it works in three quarters, at most."

Auto electronics taking off, says National's Jerry Crowley

"By 1980, the market for automotive electronics could reach a total of $2.7 billion," asserts Jerry B. Crowley, the director of National Semiconductor Corp.'s just formed Automotive Electronics Group in Santa Clara, Calif.

"And we don't plan to be second," adds the 37-year-old former vice president and MOS operations manager at Signetics Corp. "National is going for as much of it as possible."

A compelling enough reason, evidently, for Crowley to have left Signetics after 13 years. Though the semiconductor industry may have talked more about automotive electronics than actually profiting from it, this situation is changing rapidly, Crowley believes. The difference between 1976 and the early 1970s, he says, is that Detroit is now faced with pinched profits and increasing competition.

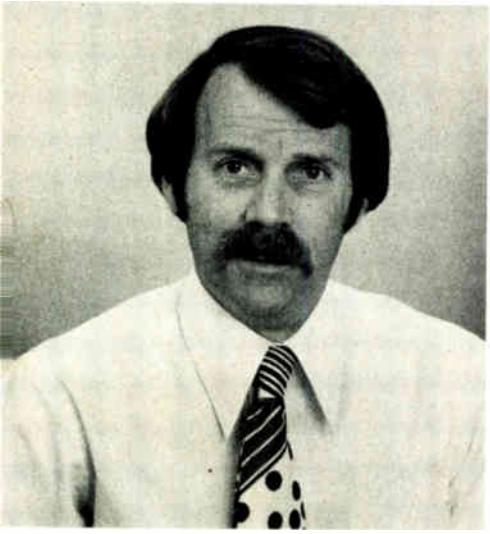
At first, "the only thing that motivated auto makers to look to electronics was Federal and state legislated mandates," he says. "Now competition is stiffer, the economy is tighter, and the consumer is more interested in saving fuel and money. And auto makers see in electronics a possible solution."

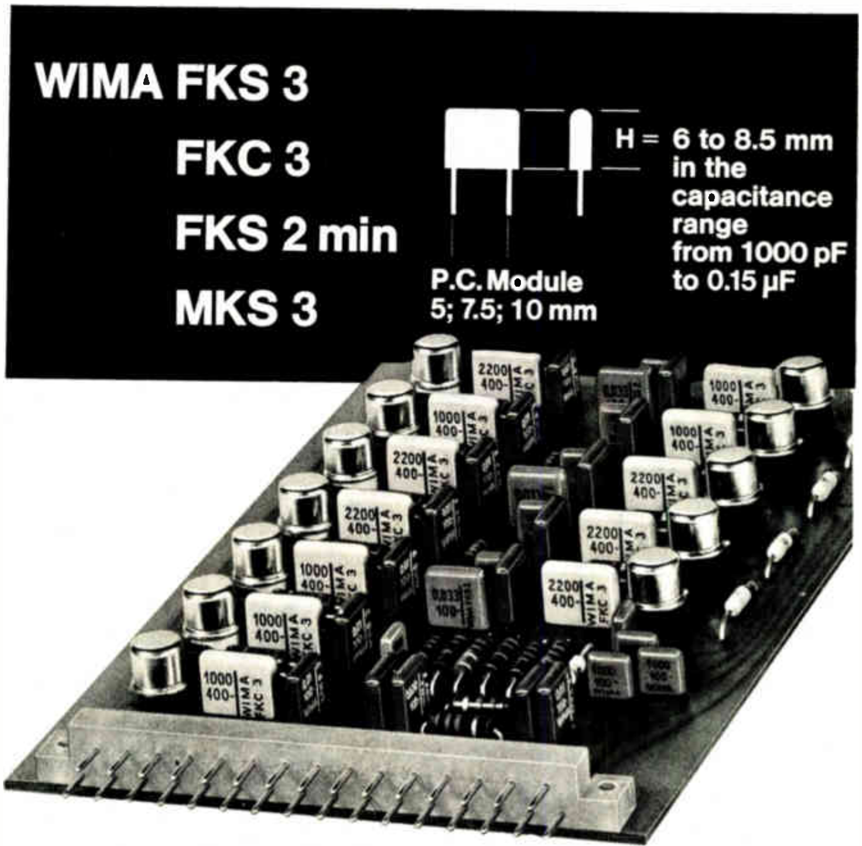
Subsystems too. National, says the lanky, relaxed Crowley, is planning to be more than just a supplier of semiconductors to the auto industry. In his new operation he'll also be integrating components into subsystems, much as his company has already done so successfully in calculators, watches, and games.

"One of the most obvious subsystem applications is in the area of dashboard or entertainment electronics," says Crowley. "It's very easy for the auto maker to add value with such things as a-m/fm stereo/clock modules, citizens' band radio transceivers, and miles-per-gallon and miles-to-go indicators."

Electronic-ignition subsystems are also a possibility for National, he says. Further down the line are so-called "closed-loop" electronic systems for regulating fuel-air mixtures and spark-plug timing.

Spur. The economic pinch will boost auto electronics, according to Jerry Crowley.





Editorial

The Washington logjam in East-West trade

Official barriers to East-West trade are tough enough for U.S. electronics makers to live with without Washington bureaucrats making things tougher. The way approvals for sales to the East are handled needs drastic overhauling. Now, the long path to approval is frustrating, at best, and futile, at worst.

The industries' frustrations begin to emerge when companies first file an application for export to a Socialist country with the Commerce Department's Office of Export Administration. The office's backlog of export license applications, many of them in the electronics field, now hovers at about 500. An additional delay is built in at the Operating Committee of the Advisory Committee for Export Policy, a group made up of representatives of the Commerce and Defense Departments, the Energy Research and Development Administration, and the CIA. The Operating Committee meets one day a week to review export license applications.

But most applications for electronics products with a high technological content are either delayed or turned down in the Defense Department, which by law must review all applications for export of goods and technical data to Socialist countries. IBM Corp.'s application to install a System 370/158 reservation computer for the Soviet Intourist agency, for example, was recently denied by DOD some two years after it was submitted, reportedly because of concern over the high number of disk drives covered by the order.

Key industry figures have testified before Senate hearings and House-Senate conference committees, on behalf of the industry trade association Wema, urging trade legislation that would further open the door to international markets for U. S. high-technology products. Unfortunately, little has changed in the almost two years since members travelled to Moscow to learn that the Soviet Union was still far from becoming a large customer for U. S. electronics.

It is very important, therefore, that the electronics industries' viewpoints continue to be brought to the attention to those in Government who are throttling—not simply controlling—legitimate trade. Wema and other industry associations have an ongoing obligation to communicate these views.

What's more, a recent study by the General Accounting Office bluntly criticized the present control process and urged a wide-ranging shake-up. The need to continue effective regulation of the export of strategic items is not at issue. But there is a need for the Federal Government to improve the decision process, to better judge what is strategic, and to develop fairer and speedier procedures for handling export license applications.

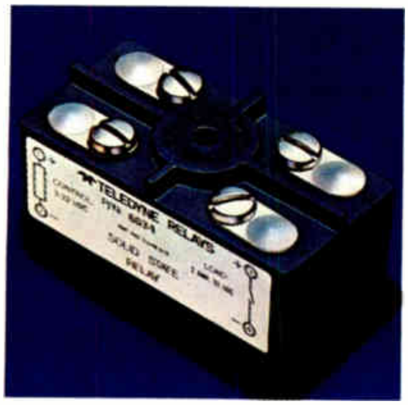
Healthy competition in IEEE

The entrance of Robert Rivers and Carleton Bayless as petition-seeking candidates for the presidency and executive vice presidency of IEEE is more than a sign of upheaval in the organization. It is a sign of healthy vitality, because the upcoming election may go a long way toward making the IEEE a stronger organization. If Irwin Feerst, the unsuccessful candidate who worked his way onto the ballot by petition last year, should again decide to run—as is virtually certain—the competition is bound to breathe new life into the institute, whatever the outcome.

However, it is vital that the campaign concentrate on the issues, not personalities nor trivia. And there will be substantial material for debate, because members are facing some of their most difficult problems right now.

It's not an overstatement to say that the actions taken now will affect the careers of future engineers. Nor is it an overstatement to say that the coming years will see drastic changes for the EE. Those seeking the IEEE presidency now will be remembered for how they responded to this challenge.

DC solid state update: new relays now handle five times the voltage.



Not long ago we introduced a line of 50VDC solid state relays. But a lot of circuit designers told us they needed higher voltage switching capability. To deliver meant coming up with an industry *first.* We did. Now Teledyne's new DC solid state relays provide a maximum load rating of *5 amps at 250VDC,* with two control voltage ranges.

PART NUMBER	OUTPUT CURRENT RATING (AMPS)	OUTPUT VOLTAGE RATING (VDC)	
603-1	2	50	
603-2	5	50	
603-3, -4	5	250	
603-21	2	50	Controlled Rise and Fall Time
603-22	5	50	

Our new 603-3 relay offers a TTL compatible 3-10VDC input, and the 603-4 a high level logic compatible 10-32VDC input. What's more, they feature transformer coupling to provide 1500V input/output isolation, and direct drive from the control source for low off-state leakage.

Package configurations provide three mounting options. You can select screw terminals, quick-disconnect terminals, or solder pins for direct pc board mounting.

All in all, Teledyne now has DC solid state relays to handle special high voltage switching problems —particularly for those heavy industrial machine and process control jobs.

For detailed information or applications help, contact your local Teledyne Relays people. They're sure to bring you up-to-date on high voltage DC switching.

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A 16 bit A/D.
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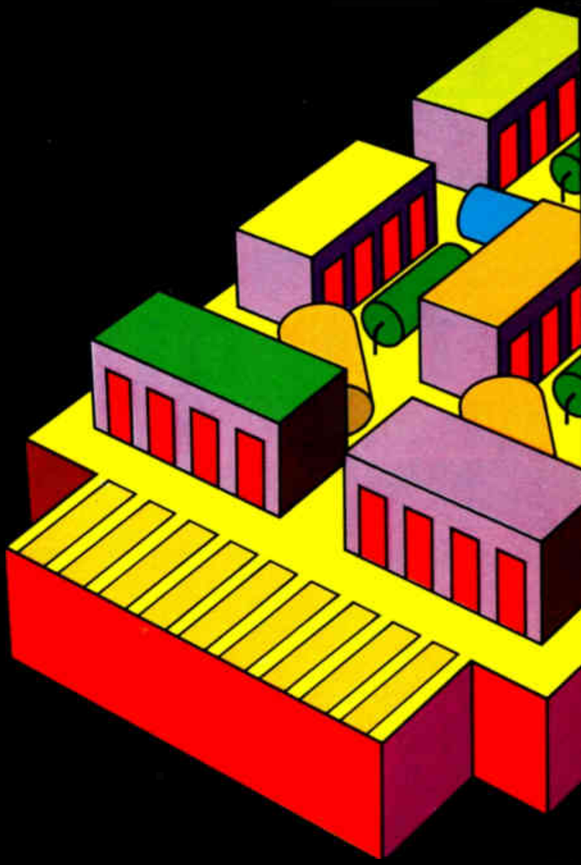


Performance you'd like to have at a price you'd like to pay.

Intersil's new 8052A and 8053A provide signal-conditioning and switch-network circuits for analog-to-digital converters, for use in DPM/DVMs and data acquisition systems.

Accuracy of the pair is surprising: up to 40,000 counts (16 bits). And the price is even more surprising. In production quantities the 8052A/8053A costs about what you'd pay for a 2,000 count (10 bit) device.

Part	Ordering No.	Temp. Range	14 pin DIP	Price (1000+)
8052A	ICL8052ACDD	0 to 70°C	ceramic	$8.00
8053A	ICL8053ACDD	0 to 70°C	ceramic	4.50
8052A	ICL8052ACPD	0 to 70°C	plastic	6.00
8053A	ICL8053ACPD	0 to 70°C	plastic	3.00

A simple system is a reliable system.

But the real savings are at system level. Intersil's high-scale integration places far more of the analog circuitry on-chip, so parts count for typical DPM/DVMs is cut by more than half. What's more, assembly is greatly simplified while component matching, tracking and board layout problems are minimized.

And a flexible one, too.

Using the 8052A/8053A, one basic PC board with a few jumper points can generate an entire family of instruments ranging from ±200.0 mV to ±4.0000 volts full-scale.

Or for data acquisition, one basic PC board provides binary or BCD output formats up to 16 bits.

Did we say accurate?

Buffer amplifier and integrator use J-FET input circuits which typically contribute less than 5 pA of input leakage. The 8053A switch layout holds charge-injection error to less than 5 μV referred to the input.

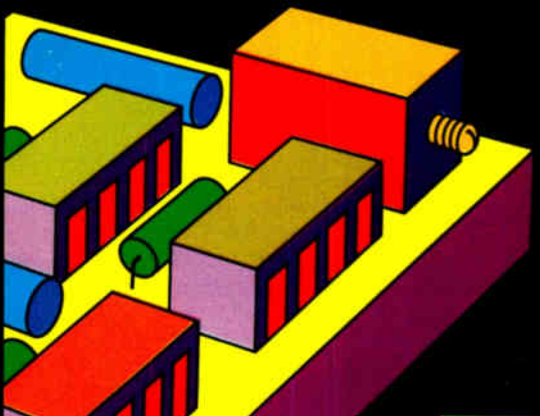
And because it uses dual slope integration, the system has high rejection of noise and AC signals, plus other advantages such as

- non-critical components
- non-critical clock frequencies
- true ratiometric readings

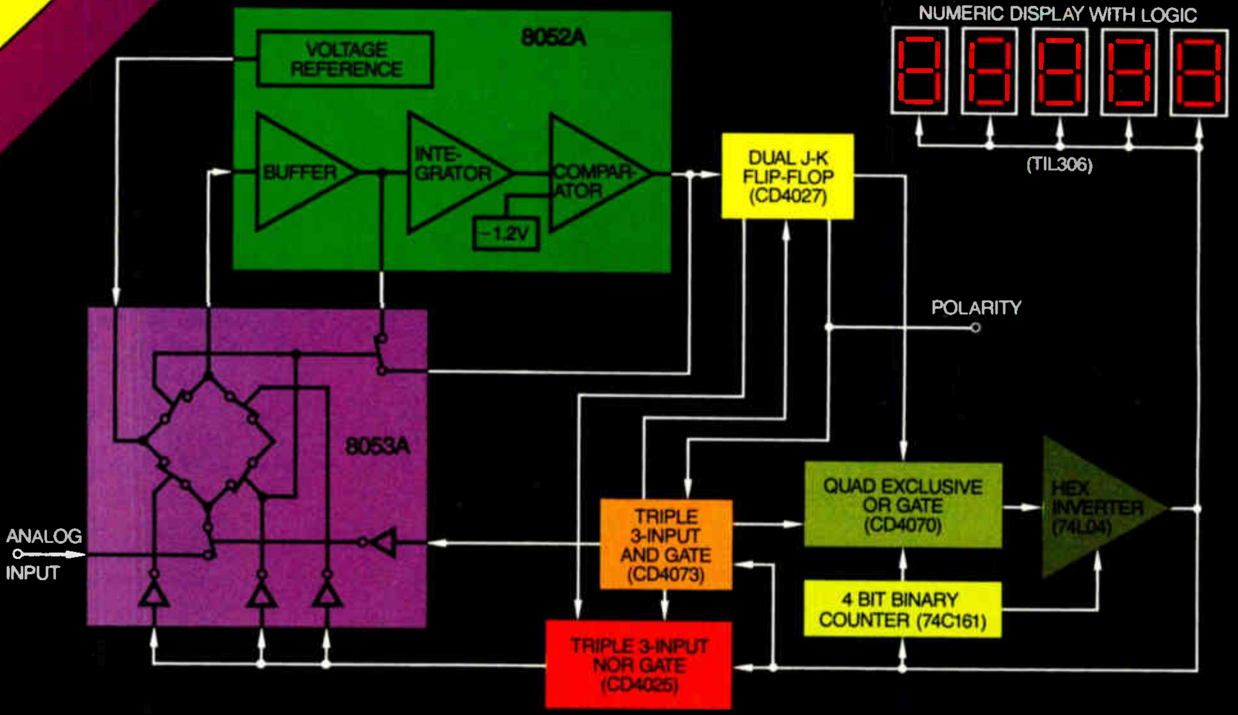
not to mention auto-zero, auto-polarity, zero-reading with zero volts input, true polarity at zero count for precise null detection, and much more...

Intersil stocking distributors

Arrow Electronics
Century Electronics
Elmar/Liberty Electronics
Kierulff Electronics (Mass.)
Marshall Industries (L.A., San Diego)
R.A.E. Ind. Elect. Ltd. (Van. B.C.)
Schweber Electronics
Sheridan Assoc. (PA)
Semiconductor Specialists
Southland (Fla.)
Weatherford
Zentronics (Canada)



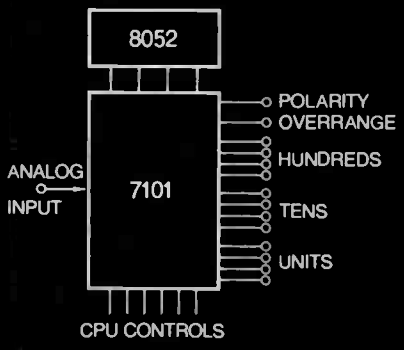
Typical application for Intersil 8052A and 8053A A/D converter pair is DVM circuit utilizing standard digital circuits and non-critical passive components.



Got a dedicated 12 bit BCD application?

Intersil also offers the 8052/7101 pair—the first A/D converter set designed to facilitate busing in data acquisition applications and provide the control and status pins for interfacing with microprocessors. These devices give you all the features of the 8052A/8053A plus on-board clock and reference, and full-time parallel BCD output. The 8052/7101 set will be available in March.

Only from Intersil, of course. 10900 North Tantau Ave., Cupertino, CA 95014. Get App. Note A014 for "How to do it" construction details.



Intersil

Intersil area sales offices
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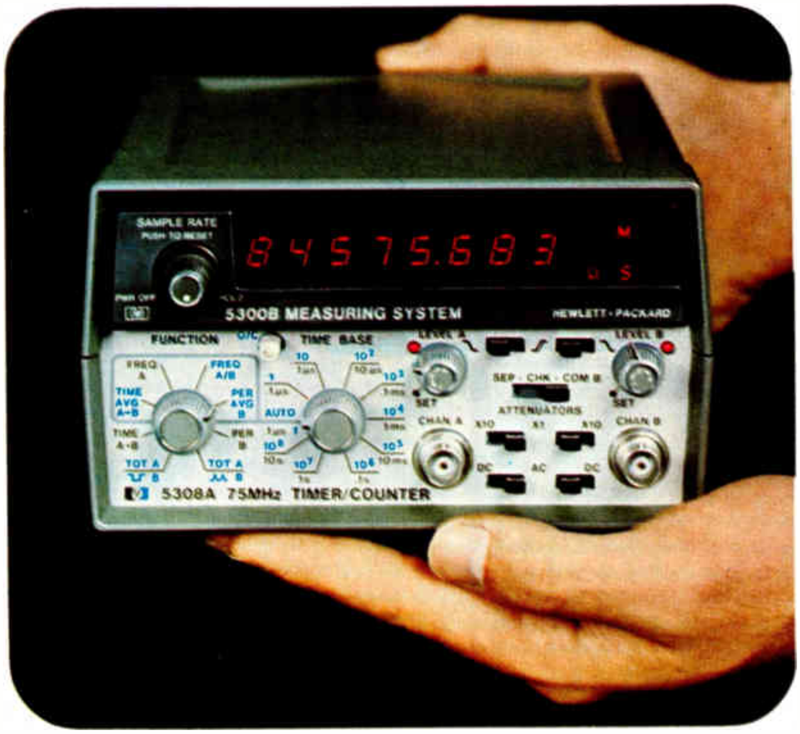
Chicago (312)986-5303
Dallas (214)387-0539
Los Angeles (213)532-3544
Miami (305)971-6160
Minneapolis (612)925-1844
New York (201)567-5585
San Francisco Bay Area (408)984-2170
Upstate New York/Canada (315)463-3368
Representatives in all major cities.

Circle 18 on reader service card



Meetings

Ninth Annual Simulation Symposium, Society for Computer Simulation, Association for Computing Machinery, and IEEE, Sheraton-Tampa Motor Hotel, Tampa, Fla., March 17-19.

54th Annual NAB Convention, National Association of Broadcasters (Washington, D.C.), McCormick Place, Chicago, March 21-24.

Eleventh Annual Meeting of Association for the Advancement of Medical Instrumentation, AAMI (Arlington, Va.), Regency-Hyatt House, Atlanta, Ga., March 21-25.

SPIE Technical Symposium East—Advances in Optics, Electro-optics, Photographic, and Laser Technology, Society of Photo-Optical Instrumentation Engineers (Palos Verdes Estates, Calif.), Sheraton Inn and International Conference Center, Reston, Va., March 22-25.

Data Communications Interface '76, Datamation magazine, Miami Beach Convention Center, Miami Beach, March 29-31.

Conference on Personal Communications, Electronic Industries Association, Las Vegas Hilton Hotel, Las Vegas, March 30-April 1.

NBS Seminar on Frequency Standards and Clocks, National Bureau of Standards, Boulder, Colo., April 6-9.

Acoustics, Speech, and Signal Processing International Conference, IEEE, Marriott Hotel, Philadelphia, April 12-14.

Computer Software Engineering: Reliability, Management and Design, IEEE, Barbizon Plaza Hotel, New York, April 20-22.

Reliability Physics International Symposium, IEEE, Caesars Palace, Las Vegas, April 20-22.

Electronic Components Conference, IEEE, Jack Tar Hotel, San Francisco, April 26-28.

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Our products are tough, but our people aren't... and that's the beauty of dealing with Cherry.

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Of course we're proud of our modern facilities and equipment...but what we're proudest of is our reputation for customer service. Try some.

Test a free sample "tiger" from the pussycats at Cherry. Ask for our latest catalog which contains complete information on all our switches and keyboards, and we'll include a free sample switch. Just TWX 910-235-1572...or PHONE 312-689-7700... or circle the reader service number below.

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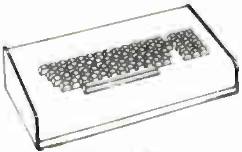
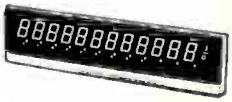


ELECTRONIC DATA ENTRY KEYBOARDS



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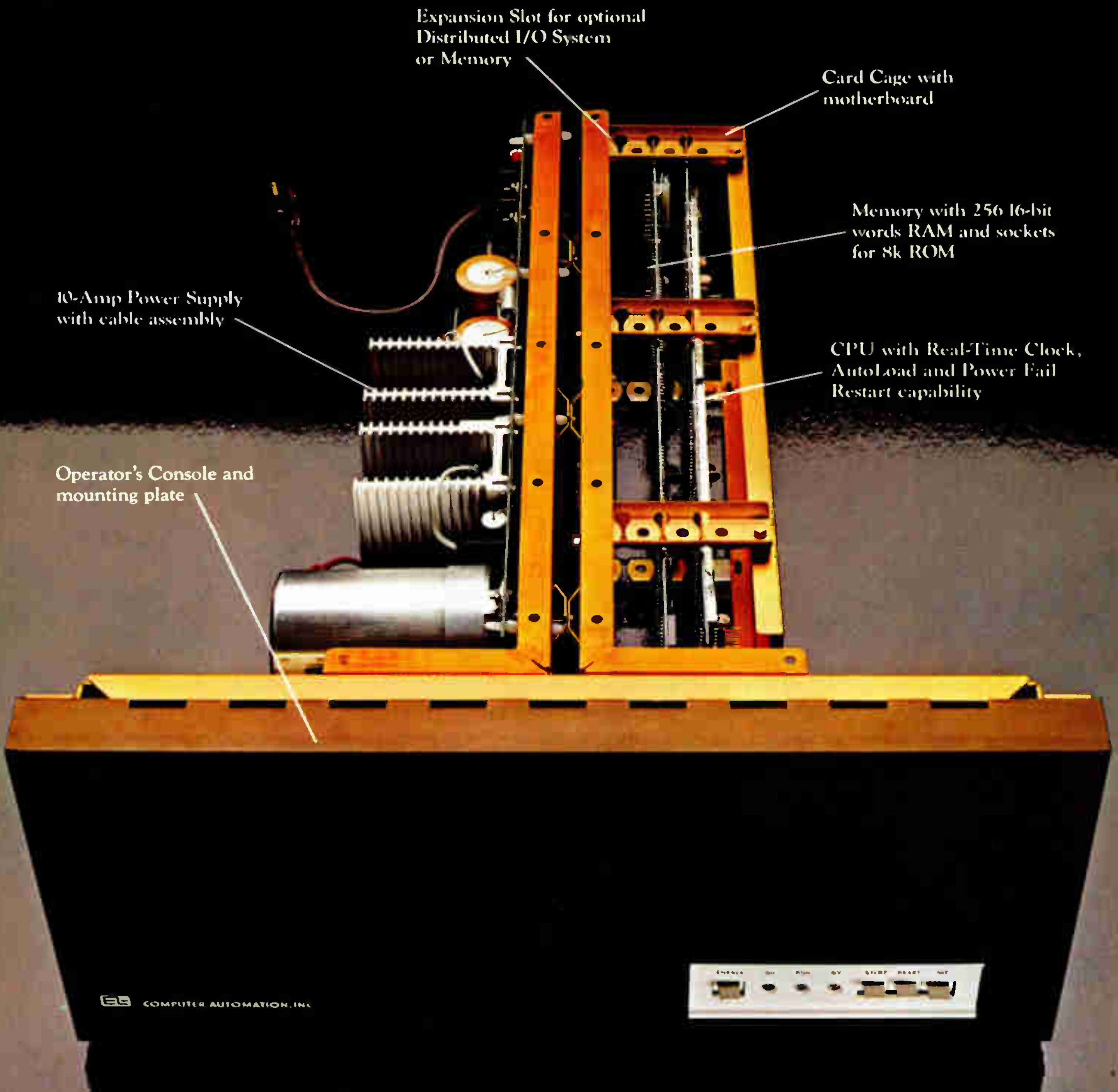

The ALPHA™ LSI-3/05 Millicomputer.
The lowest priced, 16-bit, full-scale, packaged computer in the world.

...building your own just doesn't add up.

Sum and substance. An unbeatable combination even for our competition, so you needn't feel too badly.

Especially when you consider everything we've got going for us.

Specialization, of course. OEM computers — *low-cost* OEM computers — are our only business. The NAKED MINI® people, remember? And when you do only one thing, you do it better.

Experience, too. Over 10,000 up-and-running, field-proven computers successfully integrated into all kinds of sophisticated OEM products.

Also, some things Henry Ford would have appreciated. Buying in volumes most OEM's can't manage. Building the same way.

Where all that gets you is on the down-hill side of the learning curve . . . where we get our pay-off and you get the lowest-priced, most reliable computers around.

That explains why we can, but not necessarily why you can't. Here's the rest of the rationale:

The chip shot: a hit or a myth?

The fallacy of the microprocessor is that a chip set isn't a computer. Even if you got your chip sets *free* you still couldn't build a computer equivalent to our ALPHA LSI-3/05 for $701.

Price out the subassemblies shown in the picture and see what we mean. CPU, memory, card cage, power supply and console. All of that design and development time. Amortized over maybe a few hundred systems?

Heart of the ALPHA LSI-3/05 shown at left is this NAKED™ MILLI central processor and memory for $395*

ComputerAutomation will build thousands of ALPHA LSI-3/05 systems.

Then there's the packaging and fabrication. Cable assemblies, too.

Just think about the procurement activity alone. The lead time.

Getting our picture?

The ALPHA LSI-3/05 is offered in three series featuring a choice of card cages, consoles, memories and power supplies.

Computers vs. computerization

How do you talk to a computer?

Mostly with money, it turns out. Interface money. And mostly a lot of it.

Interfacing a computer to one or two peripheral devices can easily cost as much or more than the computer itself.

Which is why we invented the Distributed I/O System. An optional interfacing system that simultaneously interfaces up to 32 peripherals and special devices, serial or parallel in any combination, for less than $200* per interface.

What you see is not exactly what you get

Here's what else you get when you buy an ALPHA LSI-3/05 millicomputer:

- ☐ 95 powerful instructions
- ☐ Individually vectored interrupts
- ☐ Direct Memory Access
- ☐ Memory expansion to 32K
- ☐ Maxi-Bus interchangeability for easy upward expansion to our full line of compatible minicomputers

Plus full-fledged minicomputer software.

From the people who brought you the NAKED MINI

The people with the largest line of compatible computers in the world.

Maxi-Bus compatible ALPHA LSI-3/05 achieves unprecedented cost-effectiveness with ComputerAutomation's new Distributed I/O System.

The people with the lowest-priced computers in the world.

The people with the first and only Distributed I/O System in the world.

The people who've been simplifying OEM build versus buy decisions for years.

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NAKED MINI Division

U.S.A. 18651 Von Karman, Irvine, CA 92715
(714) 833-8830
EUROPE Hertford House, Denham Way, Maple Cross, Rickmansworth WD3 2XD, Hertfordshire, England; Telephone: Rickmansworth 71211

*All prices shown are for lots of 100 (U.S.A. only)

Patent Pending

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Amplifier-per-channel or differential multiplexing. System 620 now gives you a choice.

Choosing the best multi-channel analog data acquisition system has always been a trade off between the high performance of an amplifier-per-channel or the lower cost of differential multiplexing. Now System 620 offers both! And whichever you choose you'll have a complete analog to digital package ready to plug into your computer, with specified end-to-end accuracy.

Amplifier-Per-Channel Series 100

Amplifier-per-channel is the recognized superior technique for the acquisition of low-level signals because of signal isolation, low noise, high speed channel sampling, high accuracy, and low crosstalk.

In just 4 short years, our Series 100 has become the industry standard. With features such as low pass active filters having selectable cutoff frequency, computer programmable input sensitivity, and continuous analog outputs. And four versatile differential input amplifier configurations: low level, high level, simultaneous sample and hold, and ± 300 volt common mode.

The price is right, too. About $200 per channel. And the system is compact — 64 channels plus control in 7 inches of cabinet space, expandable to 256 or 2048 channels.

Differential Multiplexer Series 400

For high performance at a low price, you can't find a better differential multiplexer than our Series 400. It has programmable input sensitivities from 5 millivolts to 10 volts, 10 kHz channel sampling rate, and 120 dB crosstalk rejection.

The solid state CMOS/FET differential input switches are preceded by a 2-pole low pass filter for each channel which reduces undesired signal frequencies and superimposed noise. Time and temperature drift is eliminated by auto-zero circuits in the programmable amplifier.

Series 400 is perfect for either small or large installations, with expansion to 2048 channels. Cost is about $55 per channel and 256 channels require only 7 inches of cabinet height.

Signal Conditioning Series 300

You asked for it. Now here it is. A companion 620 unit which provides transducer excitation and signal conditioning. Series 300 has constant voltage and constant current excitation. Plug-in mode cards make it easy to configure a channel for a particular bridge, thermocouple, resistance temperature device (RTD) or other types of transducers. Programmable calibration is standard and shares computer interface with either the amplifier-per-channel or differential multiplexed System 620.

The Essential Computer Interface

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Electronics newsletter

Deposition system hailed as replacement for silox process

Within five years, a silicon-nitride system for depositing insulating and masking layers on semiconductors will supplant the silox silicon-dioxide process, claims its developer, LFE Corp. of Waltham, Mass. The System 8000, priced at $70,000, handles 45 wafers with a nitride layer 4,000 angstroms thick in an hour; thinner layers boost the throughput. LFE is promising nine-month delivery to key semiconductor makers. A laboratory model, which accommodates only one wafer at a time and sells for $20,000, has a shorter delivery time. A spokesman claims that its automated System 8000 **could save its users millions of dollars per year in packaging costs alone,** depending on their volume, by allowing use of inexpensive plastic packages. The nitride deposition hermetically seals the chips.

LFE also claims that with its system the nitride layer is deposited much more uniformly than today's silicon dioxide over metal interconnects on a wafer, eradicating microcracking that often occurs in the oxide layer at the metal-to-silicon interface. Furthermore, LFE's use of nitrogen and diluted silane in the deposition process eliminates the problems possible with emerging-nitride deposition systems that use ammonia, which contains water vapor that can contaminate wafers.

International microprocessor tieups begin

Watch for a small spate of tieups during the next few months between European and U.S. manufacturers **to second-source each other's microprocessors.** One of the first was the late-January announcement that the Sescosem division of Thomson-CSF will begin this year to market its versions of the Advanced Micro Devices 2900 family of 4-bit slices.

West Germany's Siemens AG and Intel Corp., Santa Clara, Calif., have agreed to work together to develop hardware and software for present and future microprocessor systems. The deal, which is expected to accelerate development of microcomputers and to expand their applications, provides for the two firms to second-source each other's products.

Pacific Phone Co.'s all-digital network to be Bell's first

Pacific Telephone and Telegraph Co. plans to have the Bell System's **first all-digital data-communications network in at least partial operation by this summer.** The customer is the State of California's Communications department. The first user will be the state college system with 19 campuses scattered the length of California.

Only data sets will be supplied by Western Electric for the system, called the automatic telecommunications switching system and data service. Multiplexing and switching hardware has been procured on the open market by competitive bidding. The network's operation is being watched closely as an indicator of the telephone company's future in the non-voice data-communications market, especially because other operating companies in the Bell System are also looking at similar networks.

Data General readying new line

Expect a major announcement soon—probably of a new computer line—from Data General Corp. Company officials won't hint at what is coming but the best guess of analysts who follow the minicomputer manufacturer is that **a product at the low-price end of the mini spectrum is in the works.**

Electronics newsletter

Digital LED watches headed for Japan

TDK-Fairchild, the joint venture set up some years ago to market semiconductors in Japan, will soon begin selling Fairchild's new lines of digital electronic watches to the Japanese. The Japanese electronic-watch makers so far have marketed only models with liquid-crystal displays at price points a bit higher than in the U.S., so the Fairchild line could be the first sold in Japan with light-emitting-diode displays. Importantly, with its U.S. prices starting as low as $29.95, **Fairchild could also establish a new low price point for Japan,** even counting the cost of exporting.

National to offer 4-k static RAM

National Semiconductor will be sampling its version of a 4,096-bit static RAM in the second quarter of this year, **joining Advanced Micro Devices and Intel as early suppliers of the new high-density 5-volt part.** National's n-MOS design, which will be supplied in both 4-k by 1 and 1-k by 4 configurations, sits in an 18-pin package made possible by a compact design that lays out on a die less than 30,000 mil^2. Access time will be 250 nanoseconds maximum, standby power 200 milliwatts maximum, and active power 400 milliwatts maximum.

RCA may offer memory-saving processor language

Users of RCA's Cosmac microprocessor may soon be able to work with a high-level language that, the company says, **requires less memory than those popular high-level languages, Intel's PL/M or Motorola's MPL.** RCA Semiconductor of Somerville, N.J., has bought a software package for internal use from Forth Inc., Manhattan Beach, Calif. According to Robert O. Winder, RCA director of microprocessor products, the division is also evaluating it for possible use by customers.

Litronix to use Pulsar's LED watch patents

Litronix Inc. has signed a nonexclusive royalty-bearing patent licensing agreement with Time Computer Inc. (Pulsar) to permit Litronix to make and sell digital watches with light-emitting diodes, in addition to watch modules. The agreement covers the same patents **that are the subject of a pending Time Computer suit against Hughes Aircraft Co.** And in December, Time Computer also sued Fairchild Camera and Instrument Corp., alleging infringement of the same group of patents.

Addenda

Honeywell Inc.'s Test Instrument division in Denver has developed a modular patient-monitoring system, called Meddars (medical display analysis and recording), **its second product based on the 16-bit CP-1600** microprocessor developed jointly with General Instrument. . . . A new opto-isolator family from Fairchild bids to **obsolete the 500-to-2,500-volt distribution of present standard parts.** Guaranteed minimum isolation on the "Glassolated" parts couplers is 5,000 V. . . . RCA and Corning plan to build a color TV tube plant in Poland, pending approval of a loan to Poland from the Export-Import Bank. **Most of the production will be for the Polish market,** with the operation eventually being turned over to the Polish government.

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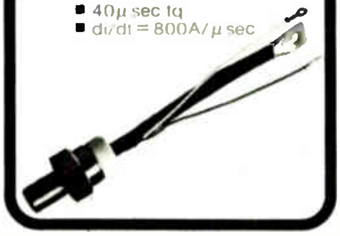

NEW

C386

400A up to 1200V

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- di/dt = 800A/μ sec

NEW

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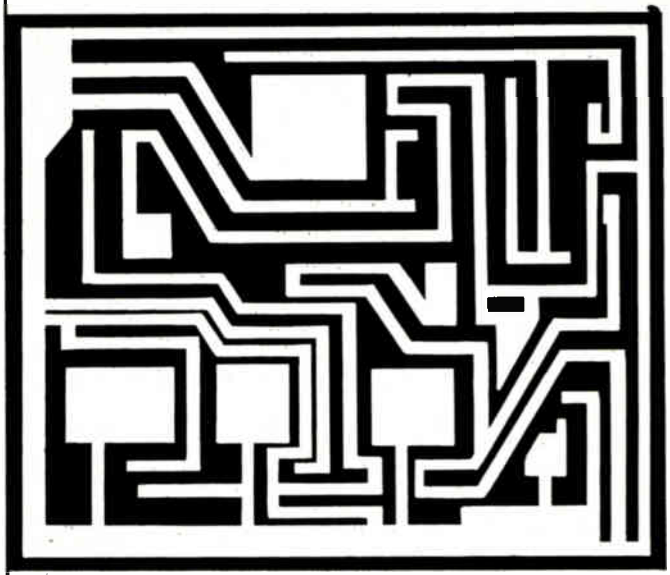

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Liquid crystals produce image for flat TV display

Air Force will try out 4-square-inch screen as multi-purpose display in aircraft cockpits

It measures only two inches on a side, but a liquid-crystal display being delivered this month might turn out to be the flat replacement for cathode-ray tubes for which the Air Force has been looking.

Developed by Hughes Aircraft Co., the reflective display is made up of liquid-crystal picture elements that have been deposited on a slice of silicon containing the excitation circuitry. Though the company demonstrated off-the-air television pickup for a 1-inch-square display more than two years ago [*Electronics*, Nov. 22, 1973, p. 34], it was only last summer that manufacturing defects caused during wafer fabrication were eliminated. And, in January, Hughes successfully butted together four of the 1-in. chips, each with a 100-by-100 array of liquid-crystal cells, into the 2-in.-by-2-in. display.

Multi purposes. The Air Force is particularly interested in the device for displaying TV, scan-converted radar, forward-looking infrared, and raster-generated symbology in the cockpits of tactical aircraft. Here, bright sunlight often washes out conventional cathode-ray-tube displays. But rather than a high-resolution panel display, the LCD may see its first application in a head-up display that's used for aiming guns and missiles. The Air Force plans to request proposals by the end of February for a HUD with a liquid-crystal display to form the image.

"With a reflective display, we can put a full raster image on the HUD with good contrast," says John O. Mysing, project engineer for the airborne LCD program at the Air Force Avionics Laboratory near Dayton, Ohio. "There's no way we can do that with a CRT."

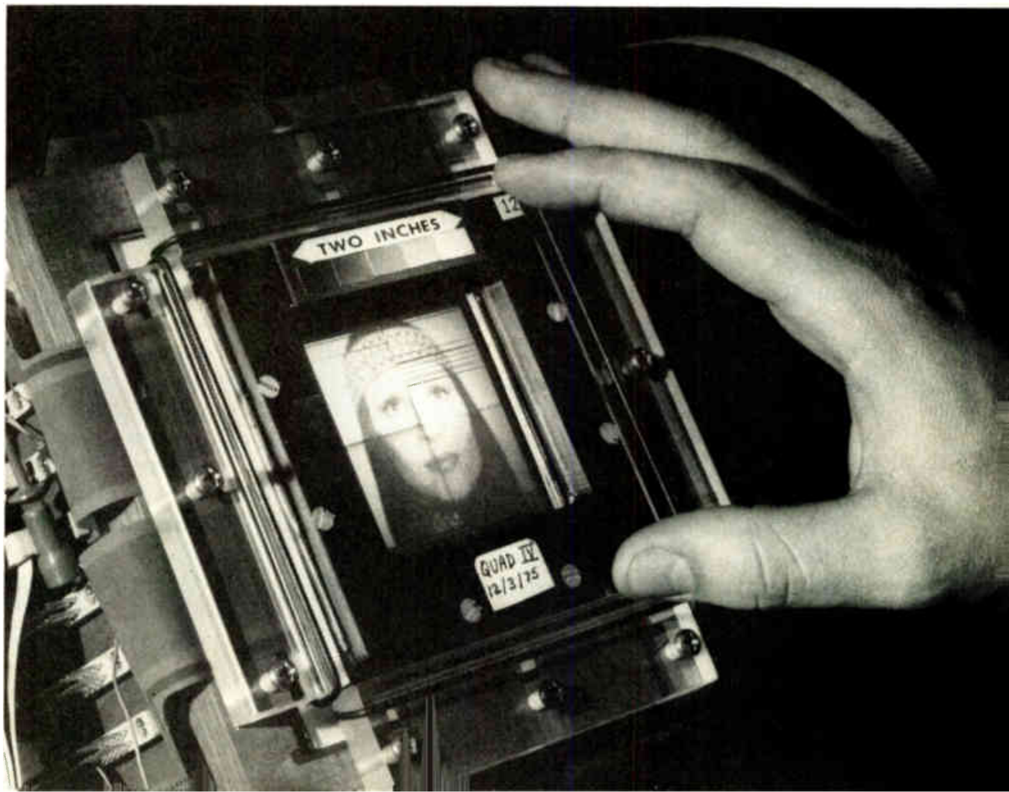
Also, the head-up display appears to be the most cost-competitive application, at least in the near future. "In the HUD, we have to drive the CRT very hard, so normally its lifetime is short," Mysing explains. "Then, every time we change the tube, the CRT has to be mechanically aligned, and the sweep circuitry electrically compensated."

Besides good contrast in high ambient light and probably reduced life-cycle costs, liquid-crystal displays offer other advantages:

- No distortion, since there's no worry about nonlinearity of electron beam sweep.
- Smaller size and weight and less power, attractive for saving space in a cockpit.
- Less chance of catastrophic failure.
- Lower-voltage operation—25 volts compared to thousands for a CRT.

The 4-in.^{2} array is large enough to project an image to a HUD, and to serve as a substitute for some of the small CRTs used in electronics coun-

Mini-TV. Four 1-inch-square liquid-crystal chips, each with 10,000 individual picture elements, were butted together by Hughes Aircraft Co. Apparent defects were caused after wafer manufacture as chips were mounted in the frame for laboratory experiments.



Army looking at flat electroluminescents

Though it has tried liquid crystals for a flat TV-like display, the Army Electronics Command at Fort Monmouth, N.J., has replaced one program with another to develop an electroluminescent display addressed by a matrix of thin-film transistors. Westinghouse Research Laboratories in Pittsburgh is developing the display for the Army's Tacfire fire-control program [*Electronics*, Oct. 31, 1974, p. 32].

Thin-film transistors—metal-oxide-semiconductor structures of cadmium selenide—are vacuum-deposited on a glass substrate and used to drive an electroluminescent layer. A resolution of 128 lines per inch has been shown in the lab, but "we're comfortably at 30 lines an inch now," says an ECOM program official. Advantages over liquid-crystal displays include a lower potential cost, lower-temperature operation, and a more rugged design. The display operates at 200 volts or more. The Army issued a request for proposals last November for manufacturing methods for the display; an award is expected soon.

In its earlier program, ECOM financed an effort by Texas Instruments to develop a 30-line/in. liquid-crystal matrix for displaying alphanumerics. The firm tried to integrate a large-area random-access memory, as well as drivers and decoders, on a silicon chip—eliminating the need for a separate refresh memory. But the firm could not deliver a chip that worked.

termeasures. But the Air Force is also interested in larger displays. By building the device from arrays cut from 3-inch silicon wafers, instead of the 2-inch wafers now used, Hughes is sure that it will have a four-chip pictorial display with a 5½-inch diagonal, about the usable size of a 6-inch CRT. That's about three years away, says Richard N. Winner, project manager for the Hughes team in Culver City, Calif.

The cost of that device should be in the $5,000 range, competitive with equivalent CRTs for military use, Winner estimates. Resolution will also improve in three years over the present display, from 100 lines per inch to 128 lines/inch, he says.

In fabricating the display, Hughes outlines a 100-by-100 matrix of elemental electrodes on the surface of a silicon wafer. Each silicon electrode serves as an optical reflector. The 1-in.^{2} arrays are cut from the wafers, trimmed, aligned, and mounted without a gap to form a 2-in.^{2} device. This is then covered with a thin layer of nematic liquid-crystal material, a transparent conductive electrode, and a cover glass.

Line-by-line addressing permits the use of the simplest addressing circuit, a field-effect transistor-capacitor sample-and-hold circuit that is integrated behind each reflective electrode in the matrix. The video storage capacitor allows a microsecond addressing pulse interval, but holds the MOSFET on for about a millisecond, long enough to excite the liquid crystal. The entire display is updated 30 times a second. ☐

Automated test equipment

Dynamic testing for the price of static

Dynamic testing of a digital system of any complexity at all is expensive.But a new add-on from Grumman makes a dynamic tester out of a computer-controlled static tester for hardly more than the static unit's price.

Computer-controlled static testers, which step the system through a series of inputs one at a time, cost a couple of hundred thousand dollars. And special-purpose dynamic testers, which check out the system at speeds it is likely to encounter in the field, may cost even more.

But it is dynamic testing that affords a manufacturer the greatest confidence his system will operate properly, points out John McDonald, systems technology manager in the ATE Systems section within Grumman Aerospace Corp.'s Product Support department, Bethpage, N.Y. The dynamic-test add-on for static testers developed by his section costs about $80,000 and replaces an interface panel costing almost as much that connects signal sources and measurement instruments to the unit under test.

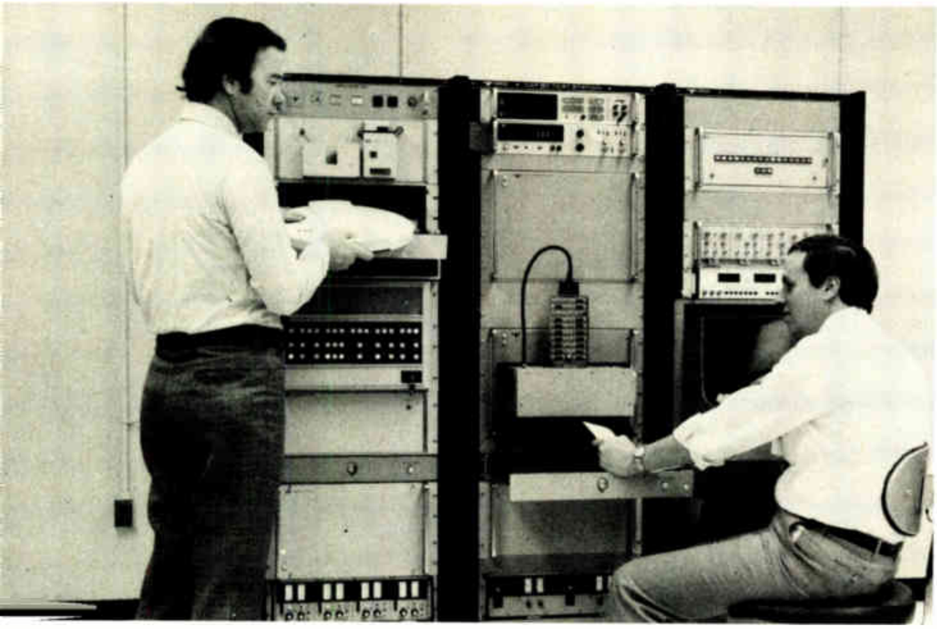
The add-on unit is a digital word generator that produces digital stimuli and receives responses from a printed-circuit board or other unit under test at clock rates as high as 10 megahertz. Test patterns can be either 256 or 1,024 bits long, while the new unit can accommodate up to 240 test pins in 24-pin increments; an extender module increases the capacity to 480 pins.

Each pin may act as either a driver or a receiver, and logic levels at each pin can be set at either transistor-transistor-logic levels or programed between –20 and +20 volts.

Bipolar memory. The new unit operates much like the digital word generator/receiver in the System 390 automatic tester made by Instrumentation Engineering Co., Franklin Lakes, N.J. [*Electronics*, June 26, p. 40]. Unlike the System 390, which uses shift registers, the Grumman unit stores, in bipolar random-access memory, test patterns fed to it by the static tester's computer.

Moreover, the tester can check out how tolerant the unit under test would be to normal variations in propagation delays among components. A pair of independent stimulus strobe sets allows test bits to be offset slightly in time, simulating propagation variations. Delay times between stimulus and response can be programed from 100 nanoseconds to 409.5 microseconds in 50-ns steps.

The word generator is compatible with Grumman's CAT-D static test system, which sells for about $400,000 and with Hewlett-Packard Co.'s series 9500 testers. The CAT-D system, in fact, uses an off-the-shelf minicomputer and other instruments manufactured by Hewlett-Packard. However, McDonald says Grumman could engineer the



Tester. A printed-circuit card or other unit under test plugs into digital word generator that's been added on to Grumman's computer-controlled CAT-D automated test system. The generator brings dynamic test capability to what would otherwise be a static tester.

generator to be compatible with other testers as well.

The company began building automated test equipment some 20 years ago as an outgrowth of its various aircraft programs. The CAT-D system is aimed at military and shipboard requirements and has been in production for about a year. It occupies three 19-inch-wide equipment bays. The digital word generator, available for a few months, is 12¼ inches high and 26 inches deep and fits into one of the bays. Peripherals include a line printer and cathode-ray-tube display [*Electronics*, Jan. 22, p. 40]. ☐

IEEE

Presidential race heats up early

Two- or three-way races are likely for both top offices of the 170,000-member Institute of Electrical and Electronics Engineers.

Within days of the selection late last month of the candidates for 1977 by the institute's board of directors, Robert A. Rivers, president of Aircom Inc., Union, N. H., made known his decision to seek the presidency. At the same time, Carleton Bayless of Pacific Telephone and Telegraph Co., Sacramento, Calif., disclosed that he will run with Rivers as candidate for executive vice president, though he will circulate a separate ballot petition.

Official nominees. The official candidates are Robert M. Saunders, professor of electrical engineering at the University of California (Irvine), for president, and Robert D. Briskman, assistant vice president of fixed systems at Comsat General Corp., Washington, D.C., for executive vice president.

All four candidates hold office in IEEE. Saunders is vice president for regional activities, Briskman is vice president for technical activities, Rivers is director of division IV (electromagnetics), and Bayless is director of region six, which covers the West Coast.

Meanwhile, Irwin Feerst, who ran in the presidential race last year, is on a speaking tour of institute sections in California and is contemplating the race again. He was a candidate by petition in the 1975 election, a first for IEEE, and pulled in over 19,000 votes in his loss to Joseph Dillard, who received about 31,000. Feerst, who is looking for a running mate for executive vice president, is expected to make it a three-way contest for president.

To get on the ballot by petition, a candidate must collect signatures of 1% of the eligible voters, which works out to 1,400 to 1,500 names. Feerst had no trouble getting the required number last year, and both Rivers and Bayless say they wouldn't have decided to run this year if there had been any doubt about getting the signatures.

The basis of the Rivers and Bayless challenge is their call to "redirect the institute to the membership's needs." Their program, as it were, is to put all of IEEE's weight behind the seven professional goals adopted last year by the institute (see "The seven goals.").

Rivers says, "At present the IEEE is not fulfilling these needs, except in the professional-activities area. There is little extension of these points—especially as it relates to regulation of the quality and quantity of engineers and positive incentives—to the rest of the institute."

Competitive aura. Feerst charges that Rivers was encouraged by the

The seven goals

Robert Rivers is basing his campaign for IEEE president on getting the institute to pursue seven points, officially accepted last year as goals:

- A lifetime engineering career with adequate compensation.
- Substantial support for the role of engineering in solving society's problems.
- Regulation of the quality and quantity of engineers in the profession.
- A positive incentive system for significant new contributions.
- A work environment that provides the chance to maintain technical proficiency.
- Peer recognition for the complete spectrum of professional contributions.
- Enhancement of the continued technical preeminence of IEEE.

board to run in order to provide an aura of competition, but both Rivers and Bayless deny the charge. Bayless says, "I had pretty well made up my mind to run prior to the board meeting on the nominations because none of the combinations of known potential candidates seemed right." And Rivers responds, "Only five or six board members knew that I was thinking about running, so there was no effort to make me a stalking horse."

Besides the candidates, this year's ballot may also carry a proposition and a proposed constitutional amendment. The proposition will spell out the means by which the institute will publicize in advance the content of any future proposition qualified to be on the ballot. The amendment would require that all future dues increases be put to a vote of the members for approval. This year, a $5 dues increase generated an angry response. ☐

Cutback in standards group spurs resignation of its director at IEEE

Shattering the quiet, dedicated atmosphere in which standards-setting groups usually operate, still another tumult has boiled up at the IEEE—this time around the headquarters-based standards group.

Early in January, two key members of the group were fired by general manager Herbert Schulke in a cost-cutting move. And by the end of the month director of standards Sava I. Sherr had angrily resigned after six years of building the institute's staff and reputation, not to mention a good income from the sale of standards publications. These deal with such things as electrical components, motors, and transmission structures.

But with the surprising departure of Sherr, the vice president of technical activities, Robert D. Briskman, who is responsible for standards, has been trying to smooth over the situation and the feelings of the 14 remaining staff members. At Briskman's instigation, one of the fired staff has already been rehired, and a committee is being organized to search for a new standards director of equal calibre to Sherr.

Income reduced. In his letter of resignation, Sherr points to the IEEE management, and by implication to general manager Schulke, as the reason for his departure. The letter states in part: "During the past year, largely due to changes in our management, I have had difficulty in maintaining the impetus which has been generated through the consistent growth of IEEE standards activities since I have assumed responsibility for their direction. However, as part of the personnel reductions announced in the first week of January, the cutback in my department, on which I as a manager had not been consulted, reduced income far more than it reduced expenses and has been a devastating blow to the standards operation."

The cutback mentioned by Sherr was part of a crash cost-reduction effort carried out by Schulke to balance the institute's budget [*Electronics*, Feb. 5, p. 32]. In reducing the headquarters staff, the net salary savings anticipated was $248,500. But Sherr disputes this claim. His estimate that the cuts in the standards staff would mean a loss to the IEEE of at least $100,000 helped to persuade the IEEE board of directors to undo the cuts. At least, that was his understanding of the situation last week.

Nevertheless, Sherr decided to move to a position as deputy managing director for energy programs at the American National Standards Institute. He accepted the post because "I felt I could no longer depend on my credibility with the staff. I felt it would be hard to restore morale, and I couldn't function. Also, I'm going to ANSI because the job is as important in setting standards as the one I'm leaving at IEEE."

Recommendations. With his departure March 1, Sherr leaves six recommendations for IEEE to wrestle with. Among these are that the IEEE standards board should report directly to the board of directors and that its chairman should be both a board director and a member of the board's executive committee. In addition, he proposes that the director of standards should have positive control over all items of the standards department budget.

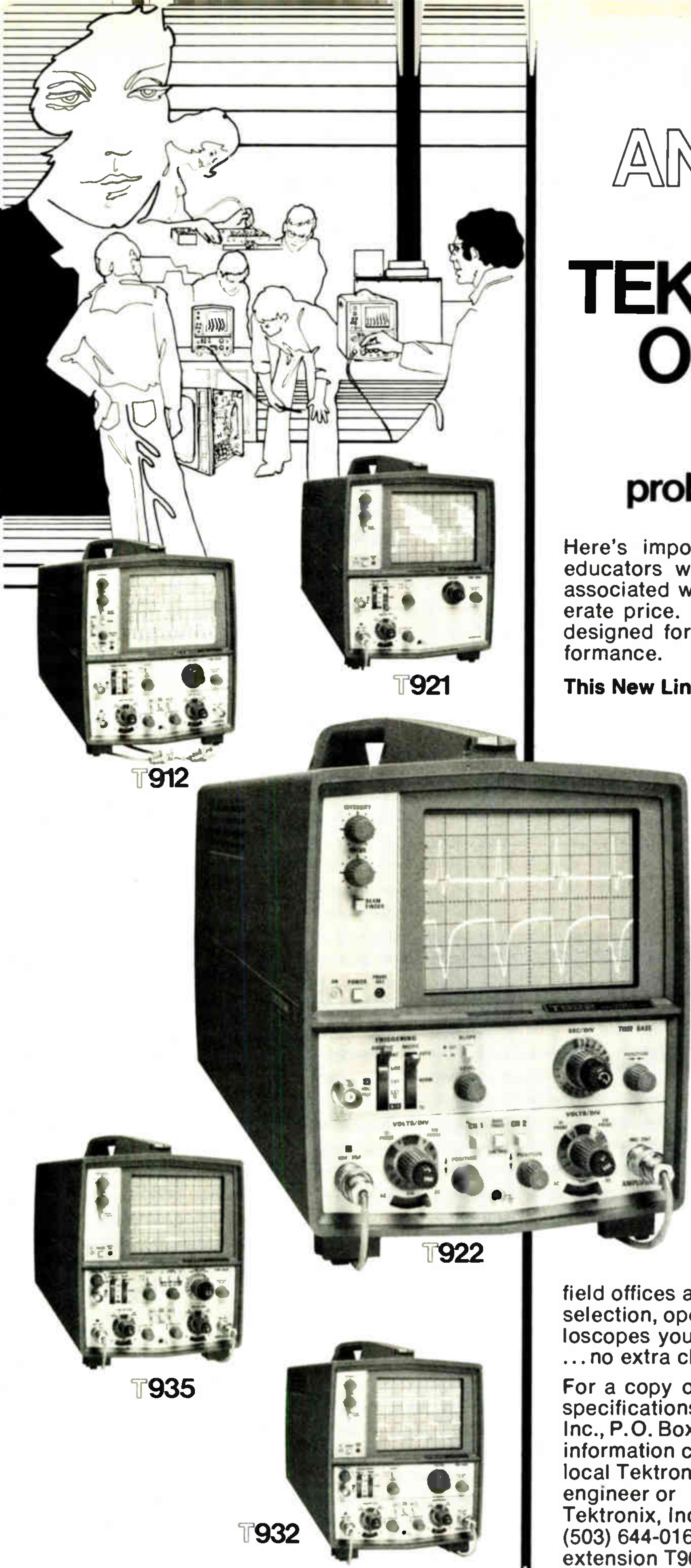
Quits IEEE. Standards chief Sherr left in anger over surprise staff cut.

Memory

No pinout standard likely for 16-k RAM

Despite the so-called agreement on a 16-pin "standard" package for the 16,384-bit random-access memory, pinouts may be just as diverse as they are for 4,096-bit RAMs, possibly even more so. On one side are companies like Intel Corp., Mostek Corp., Motorola Semiconductor Products, American Microsystems Inc., and Fairchild Semiconductor which are sampling the high-density, n-MOS devices in 16-pin packages. They want to make 16-k designs functionally compatible with the older 16-pin 4-k products. [*Electronics*, Dec. 25, p. 29].

On the other side are semiconductor houses like Texas Instruments, reported to be developing the memories in 16-, 20- and 22-pin versions, Advanced Memory Systems Inc., developing both 16- and 22-pin configurations, and National Semiconductor Corp., which is investigating all the options—packages



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Mauri Morin, director of memory products marketing at National, says: "If the 4-k RAM experience has taught us anything at all, it's that there's no such thing as a standard anything. It's not just a choice between high-board-density 16-pin memory system and high-performance 22-pin devices," he points out. "There's a whole spectrum of pinout, functionality, and organization options in between, and pinout will be a lesser consideration than [the other two]."

20-pin package. Morin says that a 20-pin 16-k RAM is being investigated seriously at National because it is ideal for a memory organized in a 4-k-by-4 array. "And there are an awful lot of customers for whom 4-k word chunks are about as much as they want to deal with at one time."

Like Intel's 16-k-by-1 part, the 20-pin part would be multiplexed, as would an 18-pin package. "But an 18-pin package gives you the option of either a 16-k-by-1 or an 8-k-by-2 configuration and adds several control functions not available on the 16-pin 16-k RAM," says Morin.

Moreover, the 16-pin 16-k RAM package has some serious disadvantages from a technical and reliability point of view, points out Jeffrey Kalb, director of memory-component operations at National. These would be resolved totally in a 22-pin configuration and partially in a 20-pin package, he says.

A 16-pin part has a thermal resistance that is 20°C per watt higher than a 22-pin part and a refresh time that's a factor of four lower, Kalb says. "A 16-pin, 16-k part is at least 14° hotter than a 22-pin part and has to be refreshed every half a millisecond, rather than every 2 milliseconds. Users are having enough problems with refresh margins on 4-k parts. Think of the fun they'll have with a 16-k part with 75% of that margin removed."

Using a double-layer polysilicon approach, a 35,000-square-mil, 16,384-bit die is achievable. But, says Kalb, putting it into a 16-pin package with a 170-mil-wide cavity limits cavity length to about 240 or so mils and therefore predetermines the aspect ratio of not only the die but each individual cell as well.

By going the 16-pin route, says Andrew Varadi, director of memory components engineering, the designer is forced to use polysilicon fanouts because they take up less space than metal fanouts. Polyfanouts cause pattern-sensitivity problems in several 4-k RAMs now on the market. With a 22-pin RAM, metal fanouts can be used.

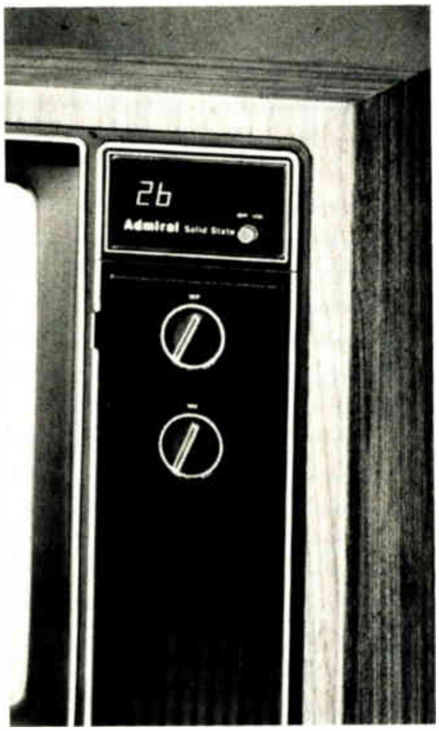
"In addition there is the increased design flexibility," says Kalb. "You have a choice of either standard n-MOS or double polysilicon as the technology and it [the 22-pin RAM] is large enough for any array, without multiplexing."

If there is to be an industry "standard," it will be a 16-k RAM that offers not only increased density, but is also more reliable than the 4-k, concludes Thomas Klein, memory-components process-engineering manager. "And it is not at all certain that the 16-pin approach will give you that." ☐

Channels get gas display

Electronics Operations of the Admiral group has updated the conventional mechanical tuner section on a 19-in. television receiver that it put into production last month by adding a two-digit gas-discharge channel indicator. Industry observers believe the move is a prelude to all-electronic tuning—not now in the Chicago-based firm's line—expected on some new chassis in June.

The Rockwell International subsidiary has added rotary wafer switches to its conventional ultra-high- and very-high-frequency turret-type tuners and has dropped the two windows for displaying mechanical channel digits. Instead, the binary-coded-decimal output from the switches drives the neon display. Diode switching on the display's decoder—driver board allows a single display to be used for the pair of tuners.



Communications

FCC study would open Bell to bids

The drive to open the Bell System's telecommunications-equipment market to industry-wide competition got a major boost earlier this month in a study released by the Federal Communications Commission's trial staff.

Bell should open its telecommunications-equipment purchases to competitive bidding under the supervision of the FCC's Common Carrier Bureau, recommends the trial staff, pending AT&T's divestiture of Western Electric. Further, purchases from Western Electric, AT&T's manufacturing arm, that were not open to competition should be disallowed from the Bell System's rate base, which is used to determine the profit Bell may earn.

The recommendations were the highlights of a four-volume, 1,500-page effort that took several years to

Motorola Makes 4K RAMs

22-Pin...The Low Power Leader

Motorola Makes 4K RAMs

16-Pin...The Industry Standard

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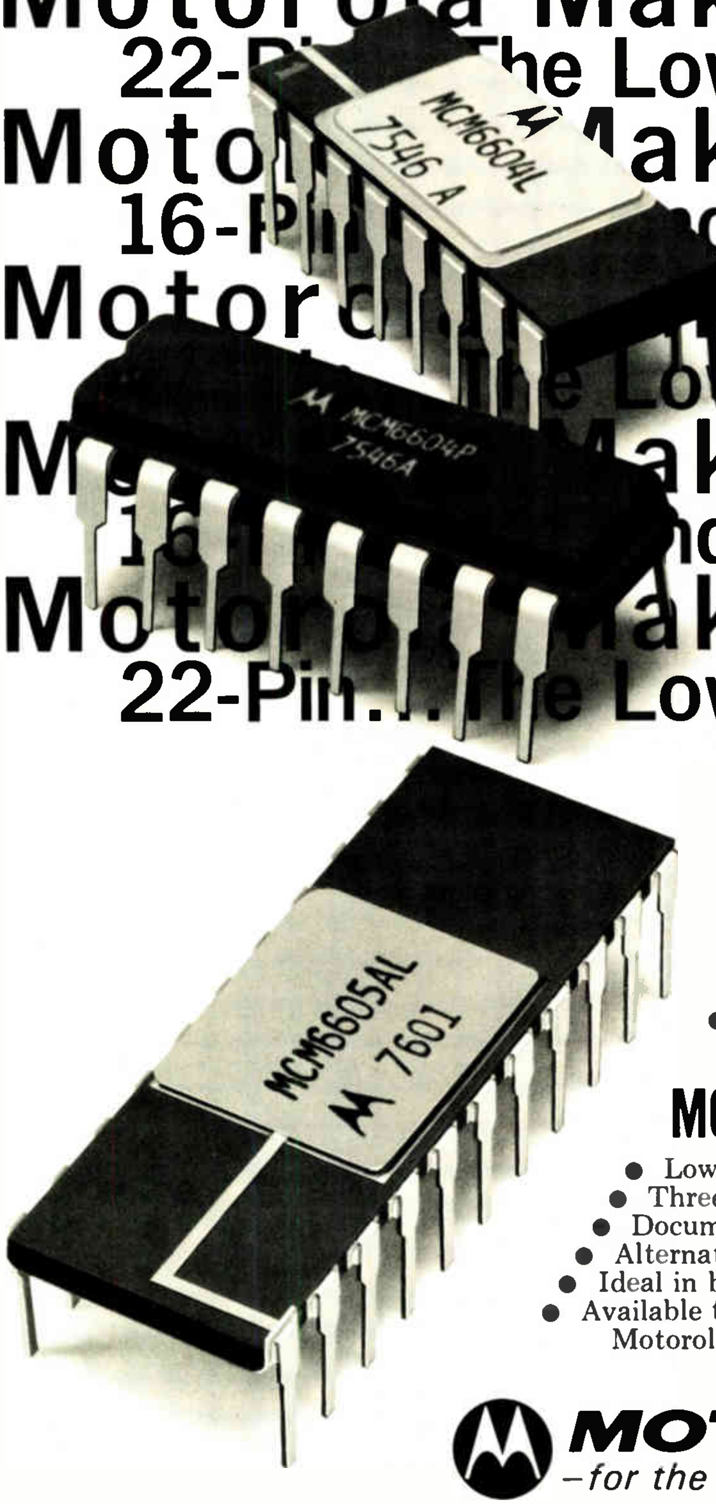

MCM6604, the 16-Pin 4K

- Industry standard
- Multi Sourced — Directly replaces 2104, MK4096, 4096, and S4096
- Three speed selections
- Small package — Optimum system density
- Available today from Authorized Motorola Distributors and Motorola Sales Offices

MCM6605A, the 22-Pin 4K

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MOTOROLA MOS

–for the advantage in memory systems

Motorola Makes 4K RAMs

Circle 35 on reader service card

complete. It wraps up phase II of Docket 19129, the telephone-rate inquiry conducted by the FCC's specially organized trial staff. Next step is for the FCC's administrative law judge, David Kraushaar, to consider the recommendations when he rules on the inquiry next Sept. 15. A final decision by the full commission is not expected before April 1977.

Spinoff. In the view of the trial staff, divestiture of Western Electric by Congressional amendment of the Communications Act of 1934 is the best way to achieve competition in the telecommunications industry. The trial staff rejected other alternatives "because they . . . would require too much of an intrusion by Government into the affairs of private business." An exception is the mandatory solicitation of competitive bids "as a temporary expedient prior to divestiture."

AT&T, which has until April 1 to reply to the trial staff's findings and conclusions, rejected the recommendations, particularly the proposed divestiture of Western Electric. That proposal was described by AT&T vice president James Billingsley as "an old, old contention that has never survived the test of reasoned evidence before any regulatory agency or court of law."

Other comments. At the same time that the trial staff's study was released, the FCC also made available nearly a dozen other findings and conclusions in the case. These came from the Department of Defense, representing itself and other Federal agencies, five telecommunications service companies and equipment makers, the three U.S. television networks, and others.

The Defense Department concluded that Western Electric's rate of return should be held down to that of the Bell System in interstate operations, since "the business and economic risks of Western are considerably below those of other manufacturers." And International Telephone & Telegraph Corp. called for making the "fundamental research, systems engineering and design" of Bell Laboratories "available to all manufacturers."

Fiber optics

Single-fiber 'wire' ready at $1/meter

The first commercially available glass fiber for optical communications is now being sold by Corning Glass Works. Representing to fiber-optic communications what copper wire is to electrical conduction, the unjacketed Corning fiber is priced at as little as $1 per meter or about 30 cents per foot. This is for a 1-kilometer minimum order of a 20-megahertz fiber whose attenuation is 10 decibels per km. A more expensive 6-dB/km fiber is also being

News briefs

CAS to get airborne tryout in March

The ground-based collision-avoidance system developed by consultant George Litchford and built by Megadata Computer and Communications Corp., Bohemia, N.Y. [*Electronics*, Oct. 30, p. 29], will get its first test early in March. Flights will be made from the Federal Aviation Administration's National Aviation Facilities Experimental Center near Atlantic City, N.J., says Megadata president Robert Richards. The system has already been tested for two years in a stationary position atop Manhattan's Pan Am building. Richards claims that range and bearing tests that had been made from other buildings show deviations of less than 0.5° for bearings and less than 100 feet in range.

RCA forms domestic satellite subsidiary

RCA Corp. has formed a wholly owned subsidiary—RCA American Communications Inc.—to own and operate its domestic communications satellite system. Philip Schneider, former executive vice president and director of RCA Global Communications Inc., the international communications carrier that has been responsible for development, marketing, construction, and implementation of RCA's satcom system, has been named president of RCA Americom.

Harold W. Rice, who had been responsible for services and special projects at RCA Globcom, was named vice president, operations, for the new subsidiary. RCA Americom was formed after a Federal Communications Commission order aimed at separating domestic and international communications activities.

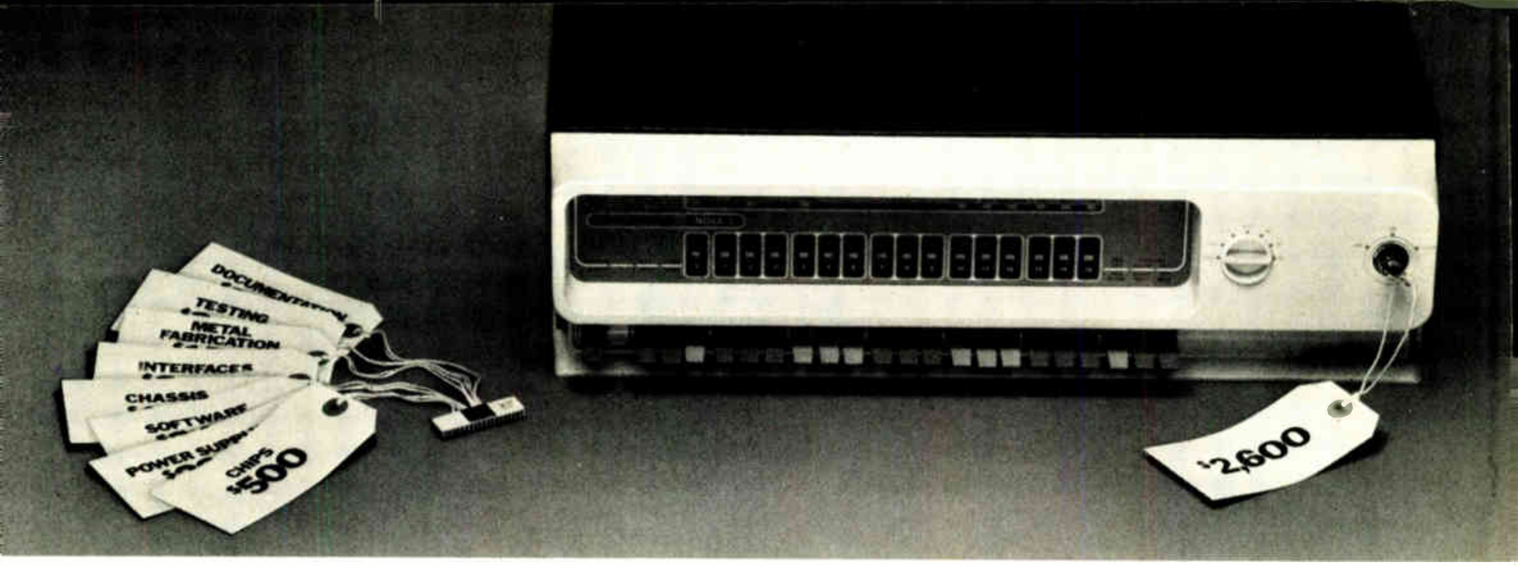
TI sells credit terminal

Texas Instruments is introducing its first credit-authorization terminal. Called Tinet (for Texas Instruments numeric-entry terminal), the unit can be connected to a host computer and a data base to determine the account status of customers. Tinet consists of a clerk's terminal, a station controller, and a modem.

The first Tinet customer is the Wells Fargo Bank in San Francisco, which has ordered 1,100 terminals, 1,000 modems, and 50 station controllers, with an option for additional units. TI expects to deliver the new terminals to Wells Fargo during the second quarter. The terminals are priced at $500 each in quantities of 1,000 or more.

N. Y. court extinguishes fire law—temporarily

A state Supreme Court justice has stayed enforcement of New York City's Local Law No. 5, which requires some 873 high-rise office building owners to install electronic fire-warning and control systems [*Electronics*, Nov. 28, 1974, p. 78]. Justice George Postel issued his order only two days after the Feb. 7 deadline for compliance, and ordered a court trial on the issue on April 5. This "market by legislation," as it has been called, is worth more than $200 million in electronics equipment and services, according to suppliers. But as the deadline passed, only 10 buildings in the city were complying with the code, regarded as the most stringent high-rise fire-safety law in the nation. Not even Police Department buildings qualify.



Has your $500 micro ended up costing more than our $2,600 mini?

If you've had to spend a lot of money on a low priced micro, you may be in a position to appreciate the cost advantages of a higher priced computer.

Our $2600 Nova 3.*

When you buy a Nova 3, you don't have to put as much into it to get it to do your job.

You don't have to create your own operating systems. Nova 3 is software compatible with our other Novas. So you get to use all the existing Nova operating systems, language processors and utilities.

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You don't have to buy more computer than you need. Nova 3 has the broadest range of compatible configurations you can get in an OEM minicomputer line. There's a 4 slot Nova 3. A 12 slot Nova 3. (It has an optional expansion chassis that gives you 12 more slots of I/O.) And you can configure multiple processor Nova 3 systems.

You don't have to worry about Nova 3 availability. We're manufacturing virtually every part of the Nova 3. Including the silicon gate N-channel MOS RAM memories. (They're coming from our Sunnyvale, California facility.)

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Write or call for the Nova 3 brochure. It may persuade you to buy more and spend less.

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For the PDA-80 we have a full line of resident software. Or, we can give you a full line of cross software, available on national timesharing services or installed on your own computer system. This includes our unique Macro Maintenance Program (MMP) for storing common macros and sub-routines for use with our Macro Assembler.

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The μCOM-8 package also includes complete documentation, an ever-expanding library of Applications Notes, and a responsive, in-depth applications engineering service, available nationwide.

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made available for about $1.50/m.

Corning has been using the fiber in its Corguide cable, a six-channel optical waveguide introduced commercially last May [*Electronics*, May 15, p. 121]. And it has been supplying only the fiber to about eight companies around the world for the last year or so.

Experience counts. "We now have the experience to produce our fiber commercially," says David B. Stout, supervisor of administrative services at the Telecommunications Products department in Corning, N.Y. He also feels that the time is right to introduce fiber because of the progress being made in other optical components. "High-radiance sources are now available, lasers are getting more reliable, and field installations of telephone systems are coming up all over the world," he points out.

Although the fiber is not jacketed, it is coated with a 50-micrometer-thick layer of ethylene vinyl acetate that protects it from impact, abrasion, and environmental contaminants. The coating also mechanically isolates the fiber from the small geometrical irregularities and distortions that may occur as it is handled during the standard cable-making processes.

Corning expects that potential users, such as the U.S. military or worldwide telephone and data-communications companies, would be able to set up the equipment for putting the fiber into a protective casing of their own design.

Patented process. To fabricate the fiber, Corning uses its patented doped-deposited-silica process. Vapors of silicon tetrachloride and a dopant, such as titanium oxide or germania (a compound of germanium and oxygen), are oxidized to form a piece of glass. The glass is then drawn down to form a fiber with a diameter of about 125 μm. By varying the doping-level profile, Corning is able to control the refractive index of the glass.

Six varieties of the fiber are available: two step-index versions with a minimum bandwidth of 20 megahertz and a maximum attenuation of 6 or 10 dB/km, and four graded-index versions with a bandwidth of 200 or 400 MHz and an attenuation loss of 6 or 10 dB/km. Nominal numerical aperture is 0.18 for the step-index fibers, 0.15 for graded-index versions. Price depends on fiber characteristics and quantity. ☐

Trade

GAO criticizes export controls

If the United States is going to develop a coordinated policy on trade and effective controls on high-technology exports to the Soviet Union and the East Bloc, Congress will have to do it.

This became evident after Senate Commerce Committee hearings earlier this month, in which the General Accounting Office sharply criticized the way export control authority is divided among the Departments of Commerce, Defense, and State. Further, the congressional investigative office offered 18 recommendations, none of which has been accepted by the three Executive-branch agencies.

A coordinated agency response, prepared by the Treasury Department's East-West Foreign Trade Board and the Pentagon, called "the tone of the report misleading" and said "many of the major conclusions on critical and controversial issues are not supported by the facts." What GAO sees as protracted interagency disputes on export authority, the trade board calls "thorough and vigorous interagency discussions" that have produced policies that "are realistic and effective."

Proposals. Specifically, the GAO study calls for strengthening Commerce's role as lead U.S. agency in the export licensing and control of strategic commodities. GAO wants the powers and staff of Commerce's Office of Export Administration upgraded. With seven divisions and 141 staffers, the OEA is now subject to jurisdictional disputes, says the report. These lead to "confusion and policy differences" on proposed exports of products such as "computers, computer peripherals, semiconductors, and the technological interrelationships to telecommunications equipment and numerically controlled machine tools."

GAO also suggests that the OEA's Advisory Committee on Export Policy should acquire a larger and better technical staff, to better meet the timetables of Cocom, the Coordinating Committee on trade made up of NATO partners and Japan. The committee should also revert to majority rule by U.S. agencies participating in its operating committee. The unanimous rule in effect at present gives the Pentagon a veto on proposed technology exports—a veto that GAO suggests it exercises too readily.

The Office of Export Administration should also have greater discretion in granting export licenses without interagency review, GAO says. It should also decide if it's possible to prevent strategic goods from being rerouted to the East Bloc after they leave the U.S.

As for the Pentagon, it should narrow its consideration of export controls to priority cases and broaden its technical criteria "to probable rather than possible military uses" in weighing effects on U.S. security. ☐

Industrial

Phone tie-in speeds radiation check

Anyone working around nuclear materials knows immediately when he receives a massive radiation dose, thanks to color-sensitive badges and radiation counters. But the answers to the flood of questions that follows exposure to less severe contamination can take days, unless computerized analysis is available. Now even the smallest nuclear facility can have such techniques.

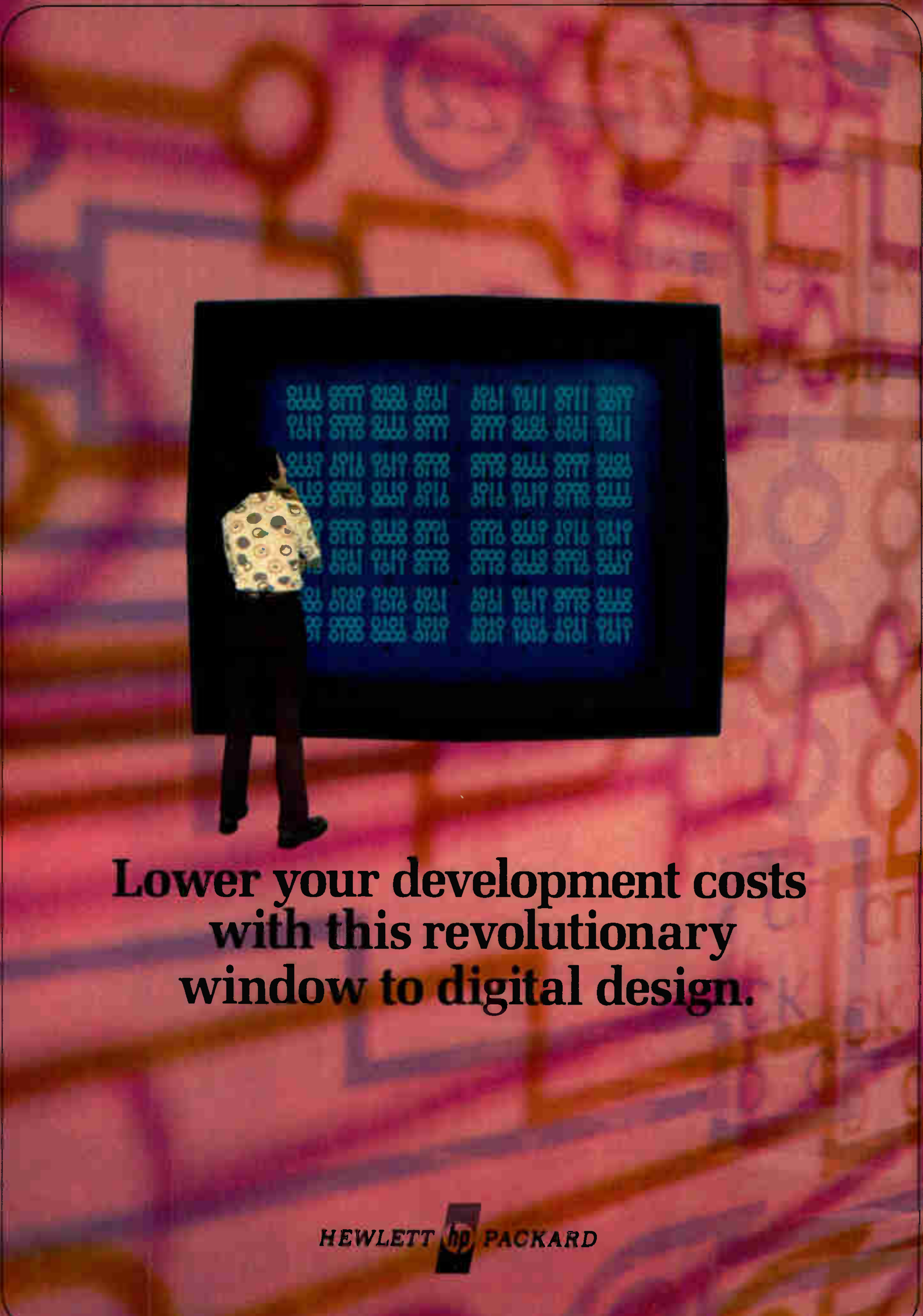
A computerized, remote radiation-monitoring service offered by Helgeson Nuclear Services Corp. in Pleasanton, Calif., promises to reduce the time lag to hours and even minutes. Helgeson ties a scanning system at the plant site to a data-processing center via phone lines. Says Edward DeMeritt, a health physicist at a Rochester (N.Y.) Gas and Electric Co. nuclear power plant, "If I want a detailed count I can now have a worker tested in 15 minutes and the results back in a few hours."

Weeks of waiting. Company president George Helgeson says that until recently obtaining detailed information about radiation levels inside the body required weeks of complex chemical and radio-analytical testing of urine and feces. Computerized counting techniques are available, but these could be supported only by large facilities.

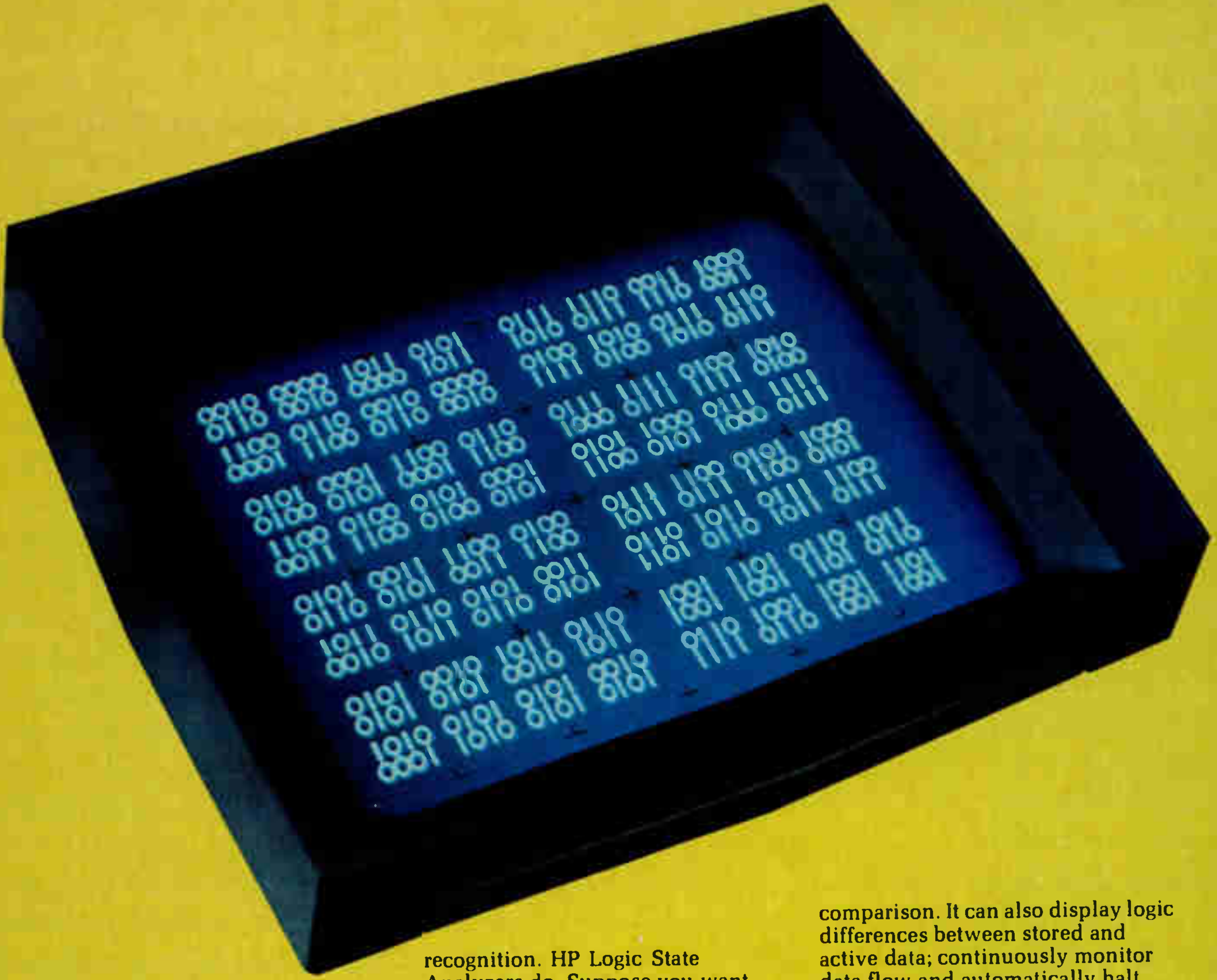
At the user's end Helgeson installs a lead-shielded container resembling a square bathtub in which the person being tested lies. A moveable detector, an 8-inch-diameter, 4-inch-thick sodium iodide crystal mounted in a photomultiplier assembly, passes over the container. A Digital Equipment Corp. PDP-8/M minicomputer, linked to a teletypewriter, handles the flow of data. The minicomputer also prints out step-by-step instructions so that no trained operator is needed.

Dial-up. Once a body count is completed, the system dials the telephone number of Helgeson's computer complex in Pleasanton. Data, including 255 channels of the kind and amount of body gamma radiation, 255 channels of background gamma radiation, 192 channels indicating the specific locations of each of these radiations, is transmitted at 120 characters per second.

Another PDP-8 with 32 kilobits of memory processes and statistically analyzes the data and displays it on an incremental plotter and a high-speed line printer. Typical reports include the kind and amount of radionucleides in the body and their location by organ. "If any abnormalities or danger points are indicated, we telephone the subscriber right away," Helgeson says. ☐


Lower your development costs with this revolutionary window to digital design.
HEWLETT hp PACKARD

If you rely primarily on
we think you're



Now we're not advocating that you stop using your scope. You've always needed one and you always will. But if a scope is all you're using, you're probably wasting a lot of time. A couple of years of field experience with logic state analyzers has shown us that about 85% of digital troubleshooting problems can be solved faster with a logic state analyzer than with a scope.

Think about it. When you want to observe action on address or data buses, or on control lines, which instruments give you more meaningful data—a scope with four input channels or a logic state analyzer with 12, 16, or 32 channels?

You need a trigger that's related to program steps. Scopes by themselves simply don't have the capability of triggering on pattern recognition. HP Logic State Analyzers do. Suppose you want to delay the data display to a specific point after the trigger word. The scope's analog time delay system has the inherent problem of display jitter. This is completely eliminated by the stable clock-pulse delay of a logic state analyzer. And when you're viewing data, would you rather mentally convert waveforms to digital words (1's and 0's) or have the instrument do the conversion for you?

Obviously, the scope is the logical choice for electrical measurements such as voltage level, rise time, and timing measurements. But when you're viewing state flow, there's no substitute for a logic state analyzer.

For example, one of HP's Logic State Analyzers can store one table of digital words and display it next to your active word display for comparison. It can also display logic differences between stored and active data; continuously monitor data flow and automatically halt when the active data does not equal the stored data.

A new technique called mapping gives you an entirely new view of operating logic circuits—over 65,000 data words can be displayed as discrete dots, each representing one input word. You can easily recognize these dot patterns after some familiarization, thus providing a rapid way to spot system irregularities. And for locating "lost programs," the map provides unequaled speed.

But these aren't just interesting measurement techniques, HP Logic State Analyzers provide more

a scope for digital design.
making a mistake.

capability than any other digital troubleshooting instrument can deliver.

The Logic State Analyzer is the only economic alternative when it comes to digital system design.

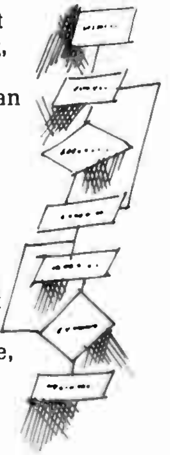
Your digital system operates in the data domain. You know all about time domain and frequency domain measurements, but how do you define data domain measurements? Basically they are measurements of logic state as a function of discrete intervals of time —clock cycles, for example. The emphasis is on word parameters. While the scope gives you an analog display of amplitude vs. time (time-domain dimensions), the logic state analyzer gives you a display of digital words vs. clock cycles.

But what are the other requirements of a data domain instrument? Obviously you need sufficient channels to see what's happening on address and data buses. With today's systems, that means 16 channels or more. You need data registration — the ability to trigger on a specific bit pattern and the ability to position the display window as a function of clock cycles (pattern recognition triggering and digital delay). Because you often encounter events that occur only once in a program, you need a method of internal storage. Obviously, you want the ability to look at bit patterns after the trigger point, but you also want to see what happens before that point . . . in other words, you want negative time display; and even the ability to look on both sides of the trigger word at the same time. It's essential that you be able to qualify both the trigger point and the display so you won't trigger on, or display, unwanted data. You'll still need to observe time-domain waveforms on your scope for detailed electrical measurements such as rise times, logic levels, and for locating glitch-generating race conditions. Your data domain instrument should therefore be able to drive a time-domain instrument —providing a trigger upon pattern recognition. Finally, you want data displayed in a functional format (a display of states) to simplify analysis.

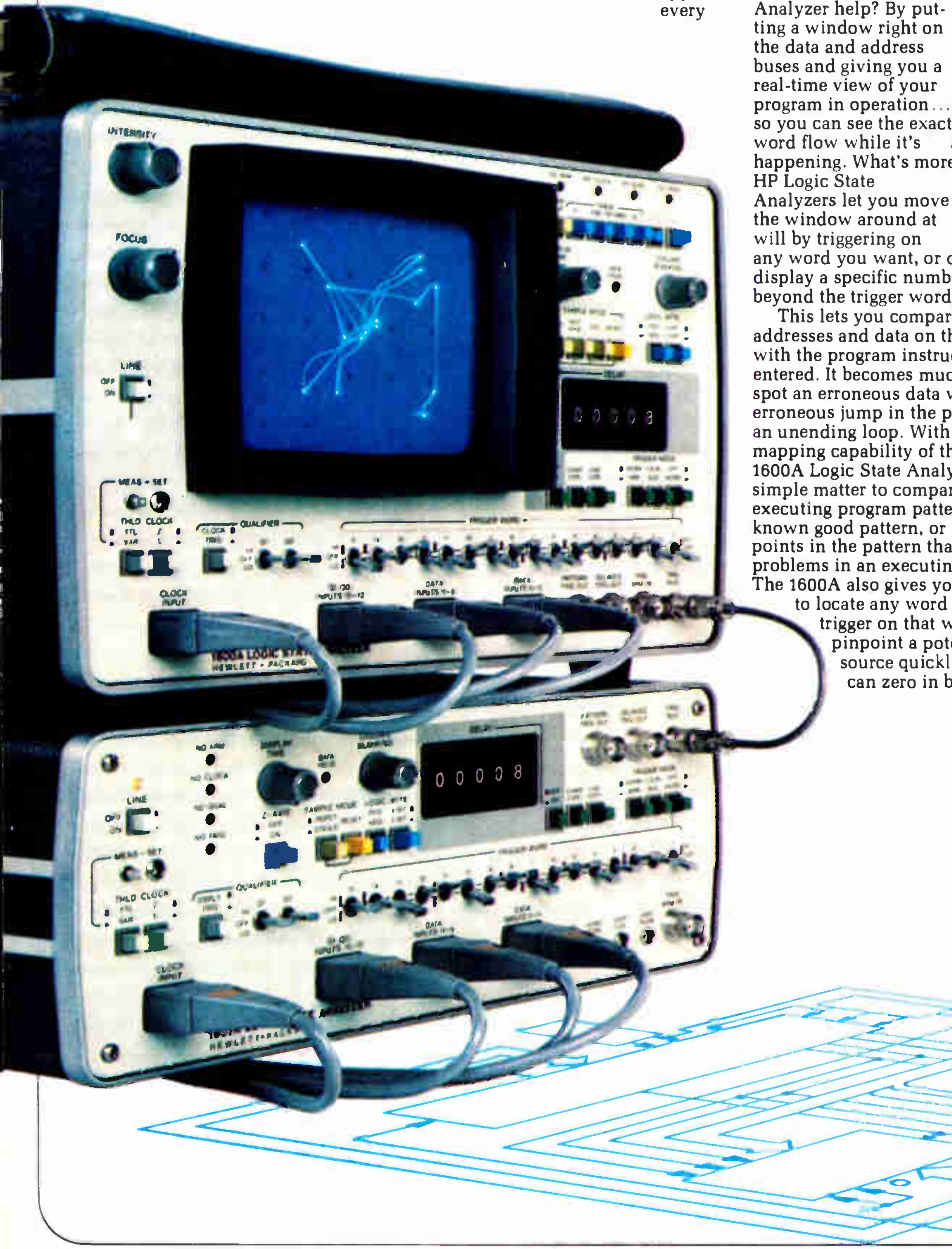
From the previous comparison with a scope, you can see that these are the requirements we've used at HP in developing our family of Logic State Analyzers. Obviously, some members of the family have more capability than others, and prices vary accordingly. But the point is, all have been designed specifically to help speed digital design and debugging by giving you a better view of your system's operation. A view in the data domain . . . where your program flow is happening.

HP's Logic State Analyzers

Software debugging. It's great if you write a program that works right the first time it's implemented in hardware. But you know that it doesn't happen every time. And when you get into program debugging, it's usually a time consuming task. How can an HP Logic State Analyzer help? By putting a window right on the data and address buses and giving you a real-time view of your program in operation... so you can see the exact word flow while it's happening. What's more, HP Logic State Analyzers let you move the window around at will by triggering on any word you want, or delaying the display a specific number of words beyond the trigger word.



This lets you compare the actual addresses and data on the buses with the program instructions you entered. It becomes much easier to spot an erroneous data word, an erroneous jump in the program, or an unending loop. With the mapping capability of the HP Model 1600A Logic State Analyzer, it's a simple matter to compare an executing program pattern to a known good pattern, or spot unique points in the pattern that indicate problems in an executing program. The 1600A also gives you the ability to locate any word on the map and trigger on that word so you can pinpoint a potential error source quickly. Then you can zero in by



speed digital design.

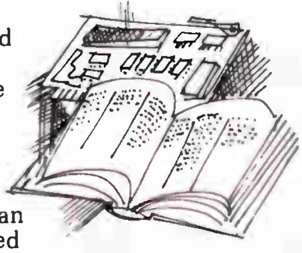
using the table display (1's and 0's), and digital delay to examine the program sequence in detail.

Watching your software in action ...it gives you a big edge in problem solving.

Hardware/software marriage. In digital design, you often discover incompatibilities between hardware and software – particularly when separate design teams have responsibility for these two aspects of the system.

It's not uncommon for the software to command the hardware to look for a signal (such as a request for interrupt) that apparently never occurs. Failure to get the signal may be a timing problem – the signal may occur too early or too late. The signal may exist at the right time, but at the wrong place – on the wrong data line for example. Or perhaps the signal was omitted altogether in hardware implementation. With microprocessors, the problem may be due to lack of understanding of CPU peculiarities.

Whatever the case, you could spend an inordinate amount of time looking for the answer with the channel and triggering limitations of time-domain instrumentation.



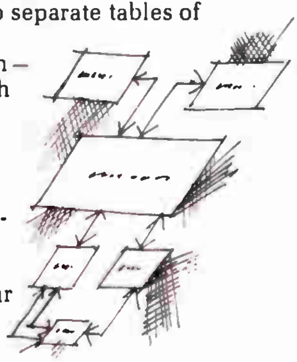
However, with an HP Logic State Analyzer, you can tie into both the address and data buses at the same time, plus flag or qualifiers (up to 32 channels can be displayed on one screen). You can then run a short test program, trigger on a specific word at the beginning of the program, and view the program implementation leading up to the problem.

With this detailed picture of software in action, it's a simple matter to observe the displayed program sequence and see what's happening to that signal at a specific point in time. Then it's usually easy to spot the problem and apply a software or hardware solution – whichever is more appropriate.

System interaction. Additional problems frequently show up when you start transferring information across an I/O port. And your troubleshooting problems are compounded because you have two sources of data to monitor at the same time. They may have independent clocks ...be asynchronous...but require a common trigger signal.

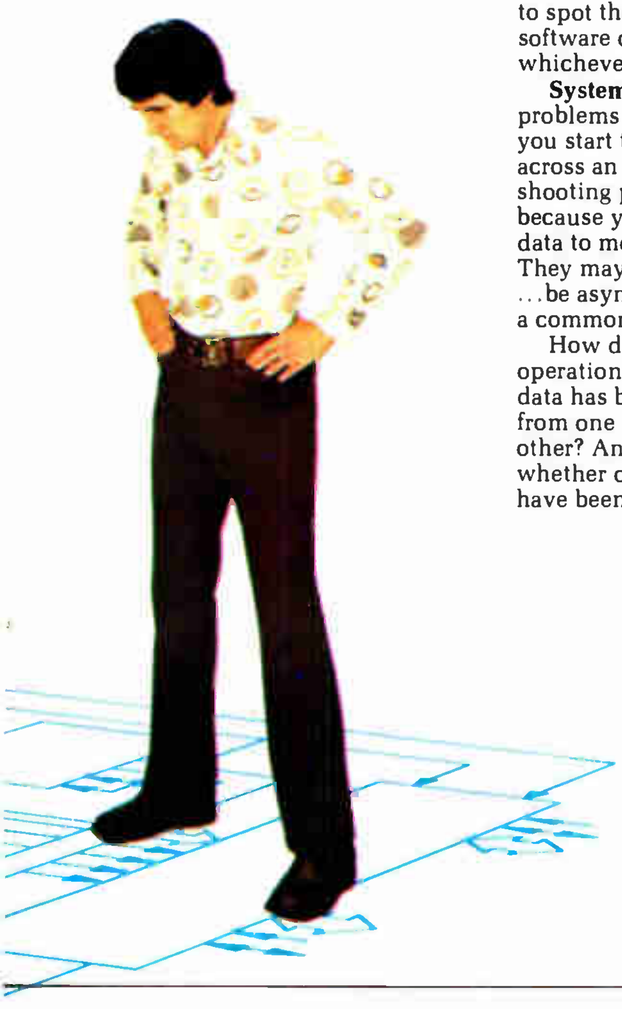
How do you verify overall system operation? How do you find out if data has been properly transferred from one part of the system to the other? And how do you determine whether or not the instructions have been executed properly?

Suppose, for example, you've designed a microcomputer-controlled test system for production. How do you know that the software is giving proper instructions to the instruments under test? Or that the instruments are inputting data correctly to the microcomputer? Unless you can verify the states in your program flow and look at digital inputs and outputs during the test cycle, your test could be meaningless. But with your microcomputer operating at one clock rate and the monitoring instrumentation at some other rate, how do you observe both and relate microcomputer software to hardware output.



The answer is HP's 1600S Logic State Analyzer. It lets you display two separate tables of data on the same screen – even though clock rates are different or one system is asynchronous. One table can display your microcomputer software sequence while the other displays the hardware output and input resulting from that software. With program flow displayed alongside the input and output states of the instruments being controlled, there's no doubt about a correct testing sequence...or about the information being fed back to the microcomputer. Furthermore, if there is a fault, you have adequate information to diagnose problems for correction.

In all of these phases of digital design – from the time you input software right through system checkout – an HP Logic State Analyzer can give you a clear view of program flow and hardware logic states to simplify design and debugging.



Pioneers in the data domain are convinced.

Our customers have been using HP Logic State Analyzers since 1973. And we've talked to quite a number of users to find out what designers need in data-domain instrumentation. We've also found out how these data-domain pioneers feel about the HP Logic State Analyzers.

Here's a sampling:

"With the 1600A analyzer, I can do in an hour what I couldn't do in 3 months otherwise, and that's a fact."

"I designed a buffer interface that allows us to make real time tests using a slower tester. With my $20,000 interface, the $100,000 tester and your $4,000 logic analyzer, we can do the job of a $400,000 real time tester."

Don Glancy,
Principal Engineer

"We encountered some severe software problems on a real time 4K system where we were at a loss as to how to approach the problem. Because it was a real time system we were unable to stop it to use the standard software debug techniques. By coincidence your salesman called on the same day to demonstrate the 1601 Logic Analyzer. We hooked the analyzer to the system under test and wound up solving the problem that same afternoon. We were so thoroughly convinced of the potential power of the 1601 as it applied to software debug that we ended up buying two of them."

"Even though we had limited experience with microprocessor design, there's no question the logic analyzer saved us valuable design time."

Ken Fiske,
Senior Design Engineer

"When a parity error does occur, our equipment re-reads the data block fifteen times. In order to initiate that search routine, many sequential logic events must occur. Problems occasionally arise in that logic flow and it's been very difficult to analyze using just a scope. The logic analyzer allows us to troubleshoot logic flow in parity error problems about twenty times faster than the scope does. In addition to being faster, it's also easier to interpret the 1's and 0's than it is to interpret waveforms."

Don Stewart
Coordinator of Service Planning

You've just read actual testimonials from users who have achieved significant time savings with an HP Logic State Analyzer — savings ranging from a factor of 20 to well over 400 compared to other methods, (Don Glancy's comment, "I can do in an hour what I couldn't do in three months otherwise.") And equipment savings of a factor of 3 or more.

If you or your people spend significant numbers of hours in the development of bus-structured systems such as computers and microprocessor-based systems, consider what those time savings could mean to you:

Convince yourself.

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For more technical data, simply mail the attached reply card, indicating the data sheets you want. Or, for even faster action, contact your local HP field engineer and ask him for more details about the instruments or seminars. Give him a call today and join the data domain revolution.

086/4

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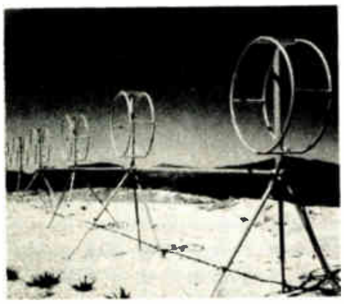

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Circle 50 on reader service card

Washington newsletter

Industry share of military R&D to rise 20%

Military R&D contractors' $7.94 billion share of the proposed $10.94 billion Pentagon budget for research, development, test, and engineering in fiscal 1977 **represents a gain of about 20% for industry** from this year's $6.63 billion, according to new figures disclosed by Malcolm R. Currie, chief of the Directorate of Defense Research & Engineering. Briefing Congress on long-term DDR&E plans, Currie said proposed RDT&E expenditures in fiscal 1978 will run to $11.9 billion, of which industry will get $8.8 billion.

Currie's breakout by budget activity shows no change in relative priorities, even though funding is higher across the board. Missiles, at $2.55 billion, get the biggest share, followed by aircraft at $2.27 billion.

Laser defense for B-1 boosts Air Force R&D

The Air Force is budgeted for a 41% boost to nearly $90 million for high-energy-laser R&D in fiscal 1977 as a result of two major projects. One springs from the Pentagon's conviction that **on-board laser systems have a high potential for defending the B-1 strategic bomber** from missile attacks; the other is directed at their use to destroy ballistic missile warheads as they re-enter the atmosphere.

Of the $187 million proposed for all defense high-energy-laser R&D in fiscal 1977—a 20% boost—the Air Force's share is by far the largest. The Navy's $46.3 million share reflects only a $1 million gain, while the $26.5 million programed for the Army reflects a $2 million cutback. The Defense Advanced Research Projects Agency will get 20% more, or $25.4 million. The high-energy-laser program of all three services and DARPA is now coordinated directly by the Directorate of Defense Research and Engineering under Robert Cooper, assistant director for space and advanced systems.

Litton takes lead in Navy DDG-47 destroyer program

Litton Industries Inc. has the inside track with the Naval Sea Systems Command on development of a proposed DDG-47 destroyer to be equipped with RCA's Aegis surface-to-air missile system [*Electronics*, Feb. 5, p. 66]. The first ship, a 9,000-ton derivative of Litton's 7,600-ton DD-963 destroyer, is budgeted for $858.5 million in fiscal 1977, plus another $11 million for R&D. The Navy, which is spending $15.5 million for DDG-47 R&D in fiscal 1976, says a contractor has yet to be named. But Litton officials confirm they are already working with Navsea on the ship's design under a small contract: "less than $100,000."

90 GHz imager pushed for all-weather use

A new passive microwave imaging system developed at the Naval Research Laboratory is exciting interest in the Directorate of Defense Research and Engineering. The reasons: **it has potential for all-weather use and its resolution is better than that of existing models.** The system will be pushed into advanced development this year.

The imager can operate at frequencies up to 90 gigahertz, compared to the 10 to 37 GHz range of earlier passive microwave systems. It permits resolution of 50 feet at an altitude of 1,500 ft, and offers flexible configurations by use of different antenna-radiometer combinations.

Washington commentary

The opposition to open markets

Replacing Federal regulation of private industries like telecommunications with the self-regulation of a free and competitive marketplace is proving to be one of the most popular issues in the 1976 election campaign. However, Thomas E. Kauper, U.S. assistant attorney general for antitrust, sees some "shortsighted opposition" to deregulation on the part of some regulated industries and a consequent threat to technological innovation. Highlights of his recent remarks on the subject to the N.Y. State Bar Association follow.

—Ray Connolly

The danger of excessive governmental intrusion upon individual freedoms and wasteful overregulation of the economy have been consistent themes of this Administration. This concern is apparently shared by the public.

And so, the broad contours of a new coalition have been taking form. The businessmen want shackles removed, and the consumer demands more value for his dollars. The President realized that both objectives could be furthered by reducing governmental interference in industries where competition will deliver the best results.

Notwithstanding these early signs of momentum and the broad constituency attracted by regulatory reform, we are beginning to see signs that substantive progress will come more slowly. When we seek an explanation for this lag, we are met most often by the opposition of business interests to any tampering with the cozy regulatory environment in which they and the regulators have co-existed through mutual accommodation for so many years. To too many businessmen, regulatory reform has come to mean "get rid of the regulations I don't like, but keep the regulations I like."

The litany of arguments

Sometimes it seems that opponents of regulatory reform are guided by a common playbook. The same litany of arguments is heard over and over again, despite fundamental differences between regulatory schemes and industries. Review with me, if you will, the rallying cries of regulated industries and their regulators.

- "We have the most sophisticated X (or Y or Z) industry in the world. Don't tamper with it."

Virtually every industry subject to a regulatory reform initiative seeks to rely on this kind of argument, which is but one form of the traditional argument for the *status quo*. The fact that we have a relatively sophisticated industry—even if true—whether it be transportation or communications, insurance or agriculture, should not be the end of the inquiry but rather the beginning. I suggest to you that it would be unusual in any other context to urge that the relative sophistication of a particular product or program should itself prevent review and study. The fact that we may have a good system is no indication of how good that system could or should be.

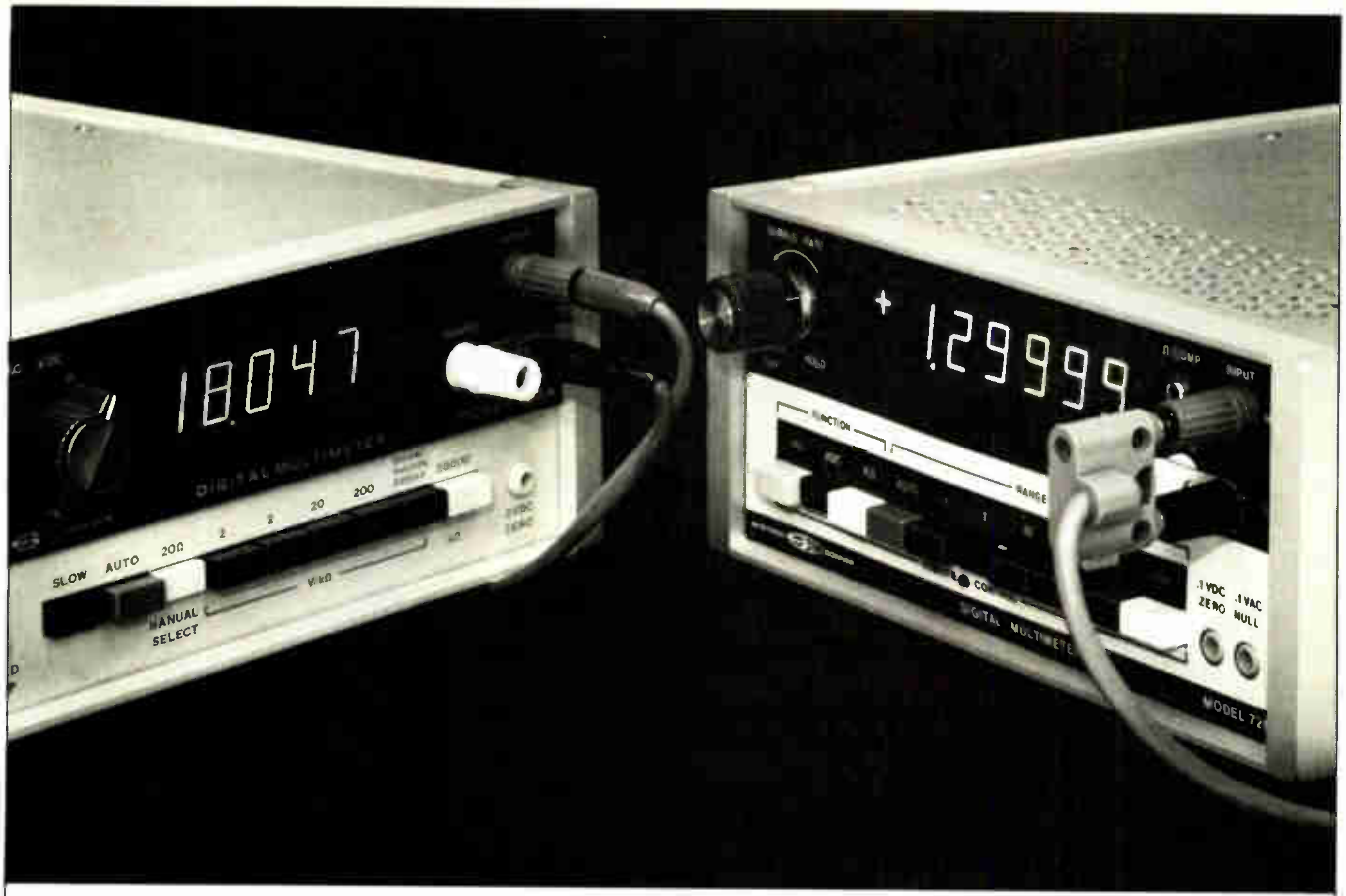
- "If regulation is so good for business, then why are we not making excessive profits?"

The operation of the marketplace forces businessmen, through the pricing mechanism, to seek more efficient and innovative production methods in order to reduce costs. When the market no longer sets the price, the incentives for businessmen to innovate and seek technological development are considerably reduced. And when price levels are determined by reference to a rate base in terms of a return on invested capital, for example, regulated industries can be expected to shy away from new processes that would render existing capital equipment obsolete.

The hidden costs

Although clearly more difficult to quantify, the costs to business and the consumer of retardation of innovation by regulation cannot be ignored. The profit picture in regulated industries may well reflect technological lethargy more than the vigilance of the regulator. Indeed this may represent the most serious danger of regulation to our economic well-being.

Industry objections to regulatory reform would be more credible if they were less dramatic. The credibility of our economic system is vitally involved in this controversy, and it does not seem to me that its cause is served by exhortations to repeal social, health, and environmental legislation in the name of regulatory reform while opposing all attempts to reduce economic regulation. The shortsightedness of such a position is becoming evident, and the result may be even more regulation—imposed without regard to costs. It need not be thus, and friends of the business and legal communities had better convey this message before the credibility of both is destroyed.



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No, we're not sure whether all aspirin is alike or not, but we do know that all DVM's aren't. For complete details on the DVM's with a difference, call Scientific Devices or contact S-D at 10 Systron Drive, Concord, California 94518. Phone (415) 676-5000. Overseas, contact Systron-Donner in Munich; Leamington Spa, U.K.; Paris (Le Port Marly); Melbourne.

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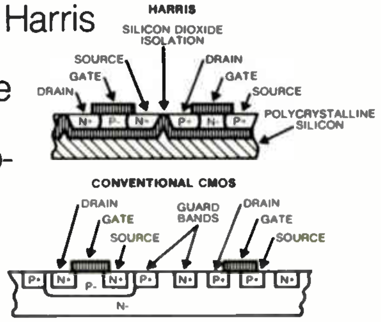
CAN THE ANALOG SWITCHES SYSTEM PASS THE HARRIS

The Harris Personality Test asks important questions about the behavior pattern of your system. In doing so, it'll help you determine whether your analog switches and multiplexers are as trouble-free as they should be. Of course, our own popular pin-for-pin compatible CMOS switches and multiplexers will be used as the standard of comparison. Why not see how your system measures up (Test results on opposite page).

1. Does your system have a latch-up problem that it can't cope with?

With the Harris devices, you have nothing to worry about. They're problem-free. That's because each MOS transistor on the chip is surrounded by an insulating layer, so no four-layer parasitic SCR's could ever be created.

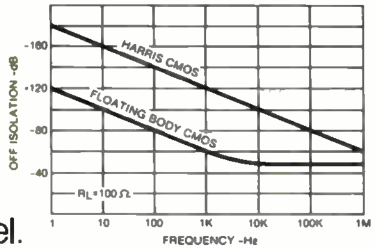


2. Does your system ever feel restricted on the sequence of power?

If it does, your system may have a slight disorder. The Harris analog switches and multiplexers never feel any restriction on sequence of power. And that goes for signal application or removal as well.

3. Does your system compromise its performance to achieve latch-free operation?

Harris has no such maladjustment. Leakage currents, capacitances, AC crosstalk are equal or better than the best of the other brands. And switch parameters are essentially independent of analog level.

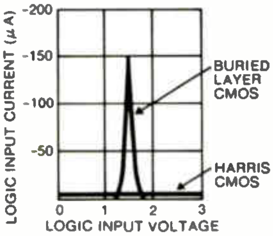


4. Does your system need extra support in order to give you on-board resistor-diode protection in all digital address inputs?

(In order to prevent failures during the handling of loose PC cards.) Harris doesn't need any. We have all the support we need on the same device.

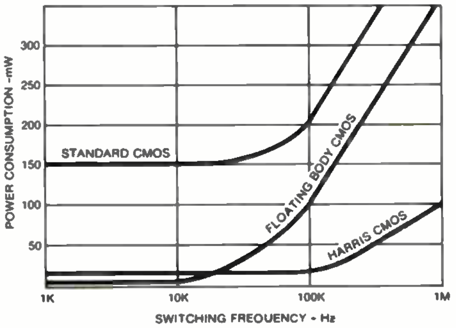
5. Do your systems' digital address inputs have severe negative resistance characteristics in their personality?

Many times this can cause double triggering or oscillations with TTL drive. Harris is free of this personality defect.



6. Do your systems' supply currents sometimes get very high when they shouldn't?

You can count on Harris supply currents to remain low, even when switching at 100 KHz rates!



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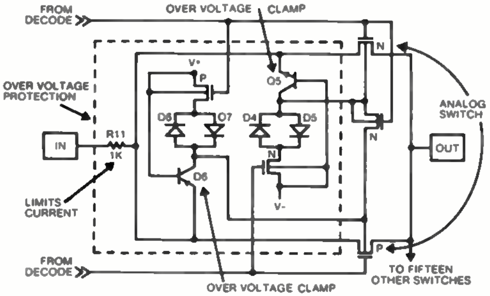
AND MULTIPLEXERS IN YOUR PERSONALITY TEST?

7. **Do you find that your system has more burnouts from voltage transients than it should for its age?** Harris devices are much more immune to those kind of things. In fact, we invite you to test our devices side-by-side with yours in the usual breadboard environment, and you'll see what we mean.

8. **Does your system feel insecure because it can't offer you extra protection in critical situations?** For example, in a system where multiplexer input signals come from outside the equipment and the signal lines could pick up induced voltage spikes, static electricity, or have signals present when the MUX power is off. Well Harris feels very secure with its HI-506A/507A/508A/509A Overvoltage Protected Multiplexers which can withstand up to ± 35 volts continuously or over 1000 volts momentarily on an analog input. The internal protection networks not only prevent system damage, but prevent the overvoltage spikes from appearing at the MUX output. As a result, the only tradeoff is added ON resistance, which you'd have to create externally to protect any other MUX. So, if you need overvoltage protection, Harris can give it to you. On the chip, featuring the same low leakage currents with inherent low error, but without additional cost. If protection is not your problem, then you can choose from the industry's largest selection of switches and multiplexers, which retain all the other personality traits.

PROTECTED MULTIPLEX SWITCH



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8x2 "	HI-507A				227
8 "	HI-508A	DG-508			228
4x2 "	HI-509A	DG-509 non-protected			229
Non-protected, low ron					
16 Channel	HI-506	DG-506	IH-5060	AD 7506	230
8x2 "	HI-507	DG-507	IH-5070	AD 7507	231
8 "	HI-1818A			AD 7501* /7503	232
4x2 "	HI-1828A			AD 7502*	233
SWITCHES					
Dual DPST	HI-1800A				234
Quad—SPST—(600 Ω)				AD 7516 AD 7519	
75 Ω: Dual SPST	HI-200	DG-200	DG-200	AD 7513	235
Quad SPST	HI-201	DG-201 (150 Ω)		AD 7501* /7511*	236
SPST	HI-5040		IH 5040		237
Dual SPST	HI-5041		IH 5041		238
SPDT	HI-5042		IH 5042		239
Dual SPDT	HI-5043		IH 5043	AD 7512*	240
DPST	HI-5044		IH 5044		241
Dual DPST	HI-5045		IH 5045		242
DPDT	HI-5046		IH 5046		243
4PST	HI-5047		IH 5047		244
30 Ω: Dual SPST	HI-5048		IH 5048		245
Dual DPST	HI-5049		IH 5049		246
SPDT	HI-5050		IH 5050		247
Dual SPDT	HI-5051		IH 5051	*not pin for pin interchangeable	248
DPDT	HI-5046A				249
4PST	HI-5047A				250

Test score results.

If you've answered "yes" to any of the Harris Personality Test questions about your system, then maybe it's time you talked to a Harris distributor or representative. We offer a complete line of analog multiplexers and CMOS switches. Available now. All with healthy, trouble-free constitutions.

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Now, for the first time, you choose the font, and the numeric style. Put together symbols, outline pictures, words, numbers. In any way necessary to make your point . . . and to make your display the focal point of your product.

When you understand this concept, you'll probably say, "they made that just for me." Or, "I can do practically anything I want with that display package." And, you can.

Screened Image Displays offer display areas of up to 10″ by 2″ . . . with characters that can range from ¼″ to 2″ in height. In other words, you're no longer limited to a certain number of digits, or even character size and style. Within reason, virtually anything goes. At your direction, we will develop a display to fit your product's personality and specific requirements.

At last, there's a display medium that fits your message.

Screened Image Displays are like a breath of fresh air compared to the rigid confines of standard display formats. You choose your own special message — composed of numbers, characters, symbols, in your preferred style. Position the elements of your message as you like within the display area, to maximize the sales appeal of your product. We'll do the rest; and, with the fastest turnaround possible for custom displays.

Besides the versatility of visual effects, Screened Image Displays also offer technical flexibility. They can be operated Multiplexed or pulsed DC, and require, nominally, 180 Volts DC with standard drives (our own DD-700 for example). And, you can make connections with flying leads, or go with our edgeboard connector. Screened Image Displays also shine when it comes to brightness; and, they provide comfortable viewing angles as well (our 1″ high character gives you a minimum of 150°).

It's like neon on a screen . . . to light-up your message in vivid oranges . . . filterable to red; and, it provides outstanding visibility, letter-perfect numbers and natural, flowing lines.

And, it's all in one very reliable package!

Given the 25-year reliability history of Planar Gas-discharge displays, you can almost calculate life-expectancy. More importantly, there's Beckman's long record of reliable products, fostered by outstanding materials R. & D. and enviable mass-production capability. As a result, we can give you a warranty that's good for 1 year. (Or, you may qualify for our Warranty Plus option.)

Whether you're designing a cash register, instrumentation panel, digital scales, electronic games, or highlighting a message of any kind, Screened Image Displays give you a new way of communicating your *total* message. In your style. A style that stands out from all others. Beckman Displays. The Visible Edge.

Even with this flexibility, we can deliver a truly cost-effective product. Imagine the savings you can achieve simply by incorporating in *one* integrated package *all* the display functions of your equipment. To introduce you to this new concept, we've developed a kit that contains a wealth of information about Screened Image Displays. It also contains the means for you to tell us about your design requirements. We'll respond promptly with a proposal that will make your eyes light up . . . like Screened Image Displays!

To get your Information Kit, write: "Screened Image Displays", Beckman Instruments, Inc., Information Displays Operations, P.O. Box 3579, Scottsdale, AZ. 85257: or call (602) 947-8371.

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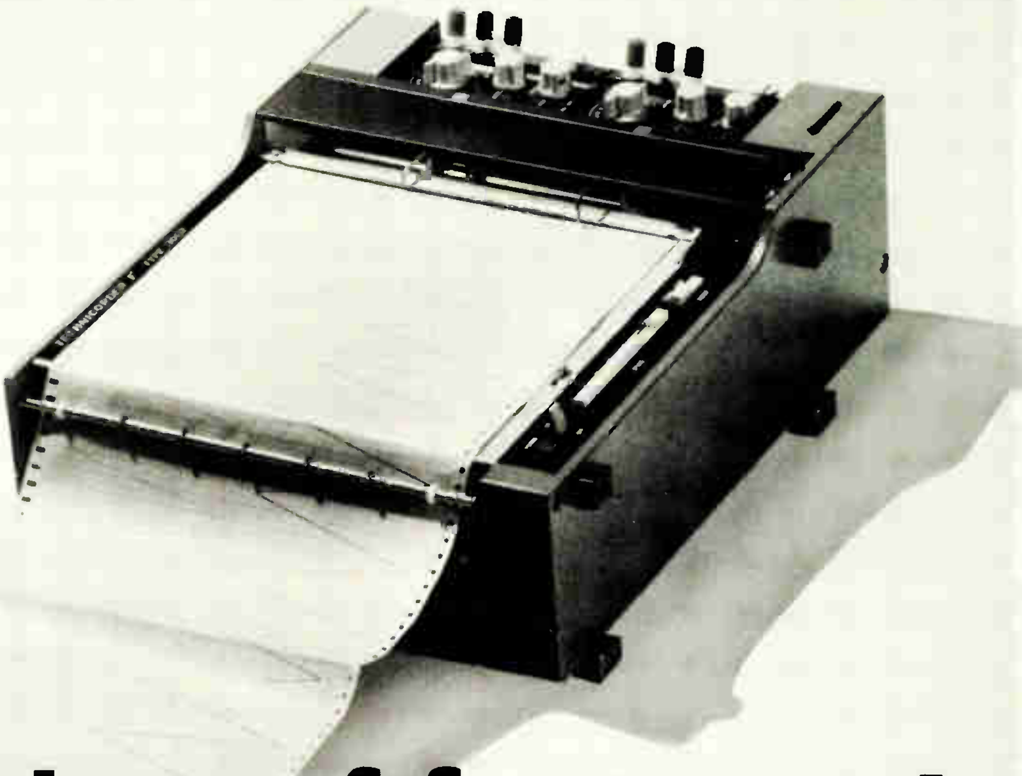

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* plus its new temperature modules

There are even more features but we just don't have room to list them all. The new YEW 3051/52 are truly the most flexible strip chart recorders available today. What's more, they are backed by YEW's 60-year old reputation for offering the very finest recorders that money can buy. If you're now using a number of recorders for different applications, it could be that the new 3051/52 can replace them all. Write for the rest of our features and complete technical information.

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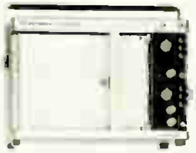

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French digital system tells when conditions are safe to land plane

Air France plans to equip its aircraft with a digital system that monitors and evaluates analog data from all main flight-control systems. The airline has ordered from Télécommunications Radioélectroniques et Téléphoniques (TRT) 60 ground-approach warning systems that analyze digital data to alert pilots to emergency flight situations and assist them in interpreting instrumentation data. Analog instruments can indicate misleading results and trigger false alarms, the developers explain.

With help from France's civil-aviation authorities, TRT, a Philips subsidiary, designed the system, called APS-500, around a 16-bit Pace microprocessor from National Semiconductor Corp. in the U.S. TRT needed only two and a half months to build the APS-500 and begin testing it in a French Caravelle jet airliner. But it may be a long while yet before such hardware is adopted as standard equipment in the world's commercial aircraft.

The APS-500 system falls outside international-agency control, and the French government has not yet made such emergency warning systems obligatory. TRT is trying to persuade U.S. aircraft manufacturers Boeing and McDonnell Douglas to follow Air France's lead by fitting the same hardware to their aircraft.

Evaluation. The APS-500 evaluates input that indicates five flight parameters—radio altimeter, barometric-pressure readings giving the rate of descent, instrument-landing systems and navigation aids, undercarriage position, and mechanical flight-control equipment such as flaps and rudder. Data from all these sources is converted into 12-bit digital signals and then filtered to eliminate false readings, parasitic echoes, and other interference. The microprocessor enables the pilot to modify the desired amount of deviation from ideal flight parameters and specify what conditions are to trigger the alarm.

The microprocessor also ascertains if the combined data matches any one of five emergency situations—sudden and excessive loss of altitude, too high ground-approach speed (often indicated when an aircraft is heading for a mountain in poor visibility), loss of altitude after take-off, failure of landing gear, or incorrect glide path for landing. Any of the first four emergencies will trigger a flashing light on the pilot's instrument panel, and a synthetic voice simultaneously transmits over the aircraft communications system a warning sound, followed by "pull up". When the aircraft is off course on landing, the warning is "glide slope." □

Around the world

Teletext decoder combines IC types

Texas Instruments Ltd. plans to introduce its new Teletext decoder, called Tifax, for home-television receivers in the UK. The decoder plucks digital data from the TV signal and displays it in color on demand as alphanumeric "pages" on the TV screen. Teletext [*Electronics*, Feb. 5, p. 68] presents some tricky design problems because it's basically a fast digital system in an analog TV world. But TI combines Schottky LSI, integrated injection logic, and n-channel MOS logic to yield the best possible tradeoff in speed, power dissipation, and packing density. The resulting 14-chip package works in the low-power, stable environment needed in a TV set.

First announced last year, Tifax has linear bipolar circuitry of 40-megahertz bandwidth at the input to slice and digitize the analog input signal and generate the digital clock. Not strictly a digital circuit, the chip uses linear bipolar techniques because of their high transition frequencies. Integrated injection logic for the 1,300-gate computing-logic chip combines processing and, like other chips in the module, other undisclosed functions. TI says the circuit is equivalent to its SPB 0400 microprocessor in complexity.

Seven low-threshold, 1,024-bit n-channel silicon-gate MOS random-access-memory chips are used instead of two 4,096-bit chips to keep power and access times low. A mixture of advanced Schottky LSI and low-power Schottky circuits with modified geometries accounts for the rest of the ICs.

Infrared system helps teach deaf children

Sound transmission over infrared rays is beginning to be used in non-consumer applications. To instruct children whose hearing is impaired, Siemens AG is readying an infrared communications system using two-channel stereophonic transmission. Sound signals are modulated onto a separate carrier for each ear—one of 200 kilohertz and the other of 280 kHz—and then transmitted via infrared beams to a receiving unit in the headset assembly worn by the pupil. And since the transmission is wireless, pupils can move around freely in the classroom as they listen. The first two prototype systems are intended for schools in Hamburg and West Berlin.

The equipment, developed with the aid of West German acoustic-device producer Sennheiser Electronic, consists essentially of a transmitter unit, four infrared radiators, each containing 12 IR diodes, and the receiver/headset assembly worn by the pupil. Radiation from the 48 diodes is enough to provide optimum reception throughout a classroom as large as 80 square meters. The total transmission power is 10 watts, of which only 500 milliwatts is accounted for by optical power. This value, Siemens says, is harmless. The headset can also function as a high-quality hearing aid.

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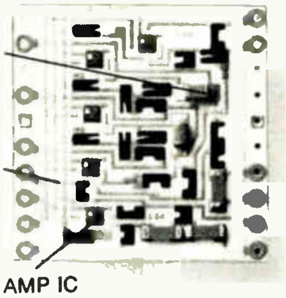

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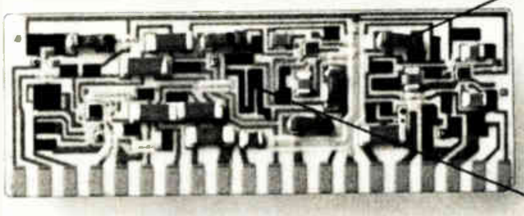

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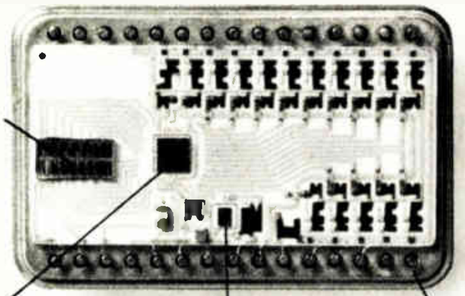
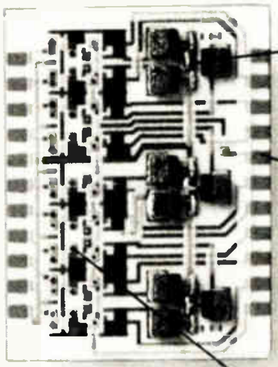


MULTICHANNEL TIME DELAY



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International newsletter

Data net to handle technical queries in Common Market . . .

An international public data-communications system, Euronet, is to be activated in June 1977 by the nine Common Market countries. The packet-switched network is to provide access at "reasonable" rates to more than 20 scientific technical data bases for about 700 research centers, technology-oriented private firms, and public organizations—national and community. In its first phase, Euronet will install switching centers and terminal concentrators in Rome, Frankfurt, Paris, and London, plus remote concentrators in Brussels, Amsterdam, Copenhagen, and Dublin. **These centers will provide access to computers in Germany, Italy, and Luxembourg. Requests are to be answered within 3 seconds.**

Commission experts expect connections to Scannet, the new Scandinavian scientific and technical data network, the United Kingdom post office's experimental packet-switching system, and the proposed French Tranpac public data network. The consortium of the nine Post and Telephone authorities of the Common Market countries is headed by France, which is in charge of designing and operating the system. The European Commission is to finance the estimated $3 million that will be needed by the end of 1977 for hardware and software development.

. . . as Nordic nations ready data network to serve all four

An international public switched data network is being planned to link subscribers in the Nordic nations in the mid-1980s. Telecommunications officials of the four—Sweden, Norway, Denmark, and Finland—are to meet next month to award the contract for first phase of the project, expected to cost about $250 million when completed. L M Ericsson has the favored position among the seven companies that bid for the **first-stage $45 million contract to install an exchange and data concentrator by early 1978 in each of the four capitals.** However, Japan's Fujitsu is still a strong contender.

Winner of the first contract would have the inside track for the remainder, which is to offer data communications over existing public telephone lines and microwave systems to any subscriber in the four nations. **About 19,500 subscribers are expected by 1985.** By then, there are to be 13 exchanges in the switched network, which is to operate at 600, 2,400, 4,800 and 9,600 bits per second. The 12 trunks are to operate at 60,000 b/s. The system later is to operate at 64,000 b/s with pulse-code modulation over asynchronous terminals. Signals may also be converted for 600-b/s synchronous terminals. The data format is 8 information bits plus 1 status bit and 1 envelope-alignment bit.

Video-disk system from Thomson aimed at commercial uses

An expensive optical video-disk player and long-lasting disks are now going into production in France for applications in education, intracompany communications, and other limited markets. The manufacturer, the Thomson group, has not revealed the price. However, Thomson says that sales for home entertainment won't be feasible until production volume and competition cut the price of players to the level of color-television sets.

That market has been pegged four years in the future by a Thomson executive, who says that **cheap throw-away disks that last only about three plays will be sold at kiosks like magazines.** Thomson is negotiating with West Germany's AEG-Telefunken for a possible agreement on a joint disk design.

International newsletter

French, British firms mull joint automotive drive

Whether or not to launch a joint drive throughout Europe in automotive-electronic equipment will be decided by the end of this month by Lucas Electrical of the UK and the Thomson group of France. **The proposed venture, now under study, would be limited to production of electronic subassemblies in volume sufficient to compete Europe-wide with Robert Bosch of Germany.**

TV-set sales spur upsurge in German semiconductors . . .

Stepped-up ordering, primarily by West Germany's television industry, is causing West Germany's semiconductor industry to rebound. Because of the favorable business climate, TV producers plan to increase the monthly rate of set production for at least the first part of this year. One of the country's half-dozen or so manufacturers—**the ITT Semiconductor group's Intermetall GmbH—after a long period of reduced work weeks, is going back to full production in all of its lines.** Sales of color-TV sets during the final months of last year have "far exceeded production, so that, by year's end, the industry's inventories had been significantly reduced," Intermetall says.

. . . as Britain banks on exports to boost power semiconductors

Britain's manufacturers of power semiconductors are optimistic that the growing North American market for industrial controls, high-frequency heating, and mass-transit applications can spur their industry out of its lethargy. **Leading the upturn will be power transistors rated up to 200 amperes and 600 to 1,000 volts,** which are expected to displace power thyristors in many applications. New processing techniques that use neutron-bombarded silicon are boosting the ratings of power transistors and high-frequency silicon controlled rectifiers, say officials of the Semiconductor division of the British Westinghouse Brake & Signal Co.

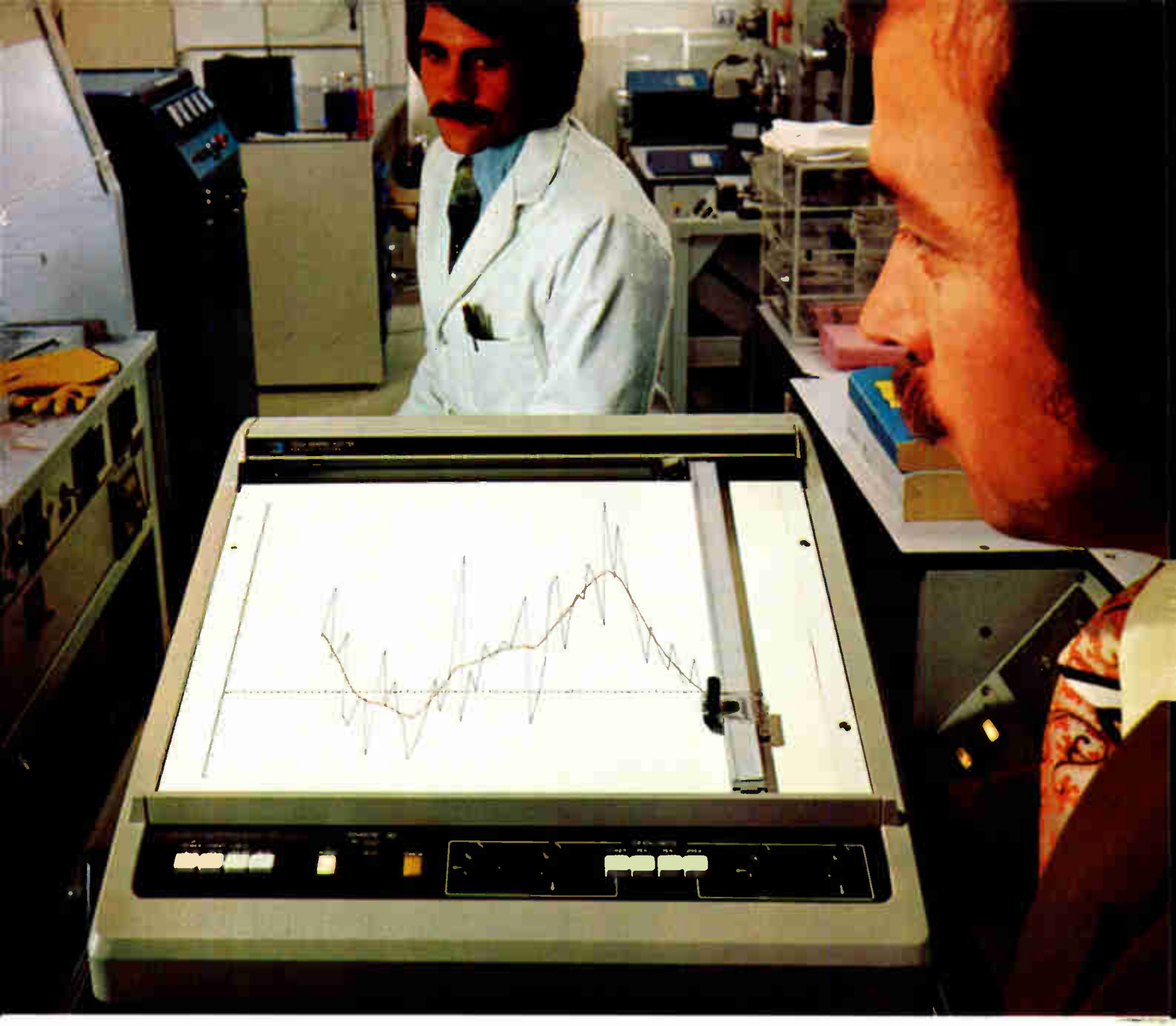
Honeywell Italia to get 1,000 disks from Japanese firm

Nippon Electric Co. will soon ship the first of the 1,000 OEM magnetic-disk memories it is supplying to Honeywell Information Systems Italia during the next three years. The 60-megabyte disks will operate with Honeywell 60-62 computers, to be delivered throughout Europe.

The Honeywell order is about the same as domestic demand, and doubling of production will cut costs. The total retail price of the disks is about $26.7 million. NEC says that these are substantially the same disks it is delivering with the medium-size and small ACOS computers it developed jointly with Toshiba with aid of a subsidy granted to make Japanese computers competitive with imports.

UK controller for machine tools has 2 microprocessors

A new concept in machine shop automation allows a machine tool to be remotely programed for its next job while it is operating. The system, developed by Plessey Numerical Controls Ltd., is called RUSC. It consists of a portable editor for programing and the machine-tool controller, each containing an Intel 8080 microprocessor from the U.S. and associated programable read-only memory and random-access memory. The editor, which contains a display for debugging programs, can be plugged in to quickly transfer a machine-tool program. **Basic prices are $5,400 for the controller and $6,000 for the editor.** General Electric in the U.S. makes a similar system built around a microprocessor for the controller and a minicomputer for the editor.



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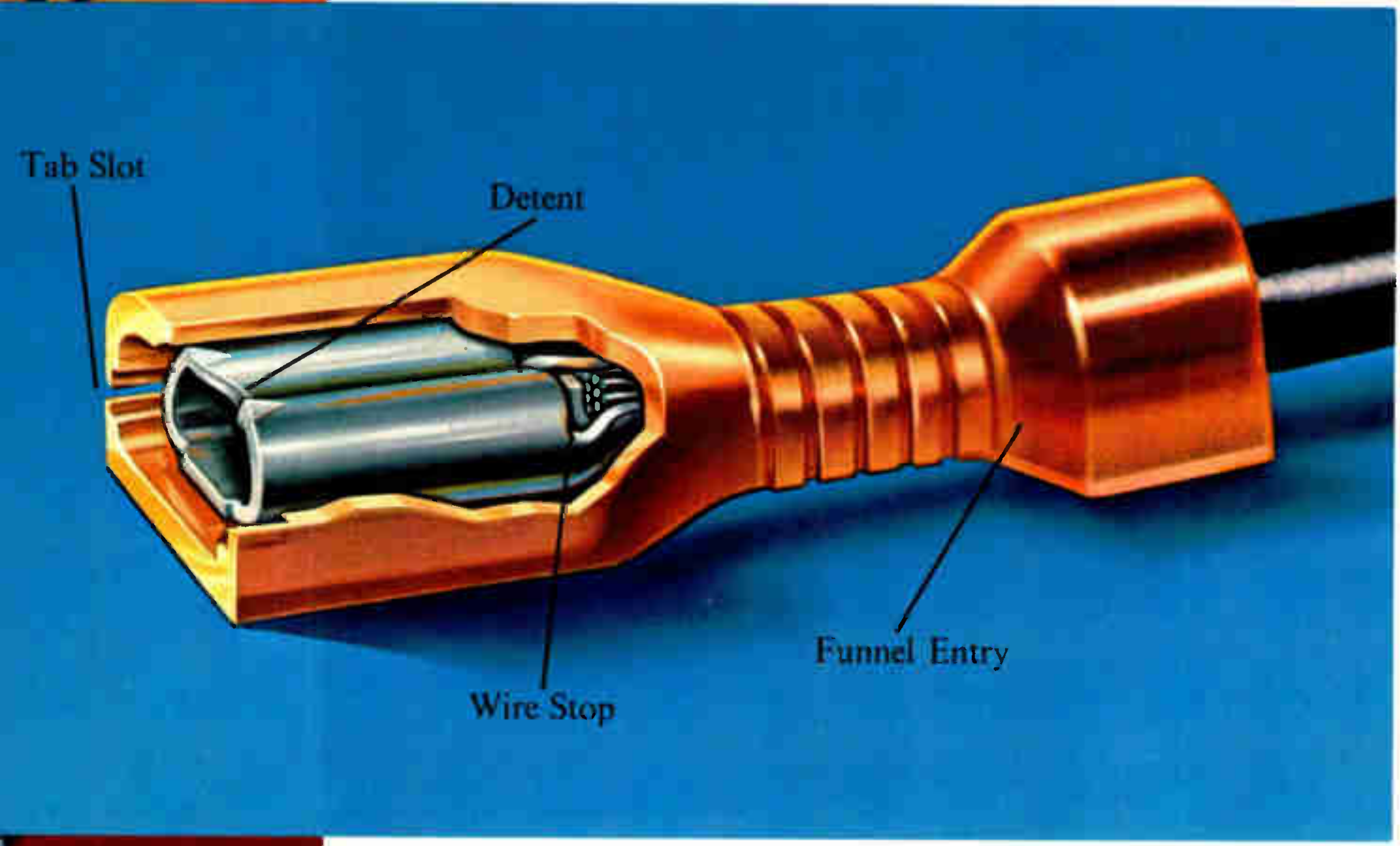

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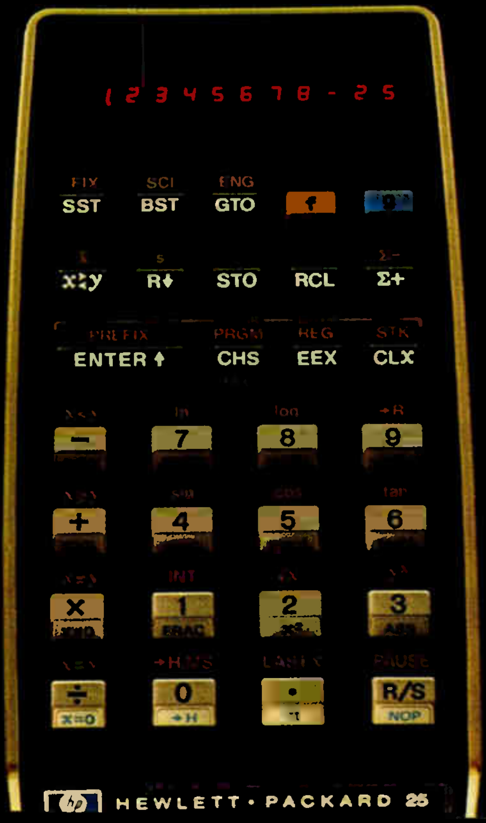
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Is an HP calculator an engineering work of art?

It depends on how you look at it.

Stand outside, and you see a collection of parts, a tool – full of utility, but not much more.

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You discover that intermediate answers tend to appear automatically, as if on cue. An HP designer saw what could be gained by combining RPN with a 4-register stack.

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Another thing that sets HP calculators apart from the welter of machines available today is the support that comes with them.

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Since Macrodata introduced its MD-107 every significant computer mainframe manufacturer has been using this remarkable test system on such devices as the MK4096, the 2107 Series, the MC6605, the 4030, the 4050's, and the 4060.

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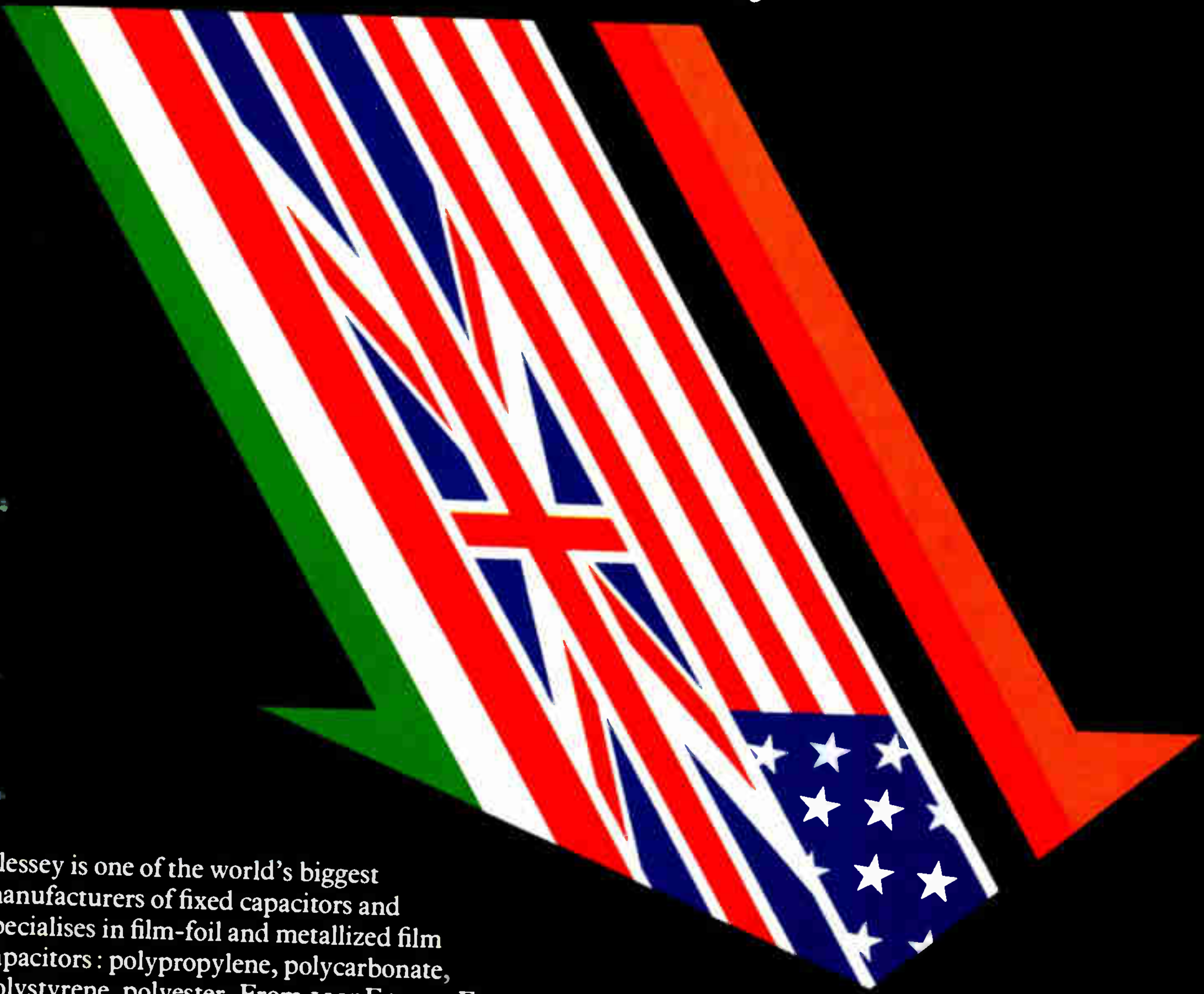

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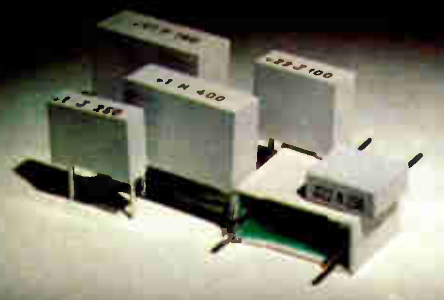

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Probing the news

Analysis of technology and business developments

Venture capital harder to get

Most financiers agree money is available,
but have grown wary of sketchy plans;
others say new laws are removing incentives

by Judith Curtis, San Francisco bureau

After 20 years of seeding and nurturing the rapid growth of the electronics industries, venture capitalists are becoming wary and hesitant about funding new companies.

An atmosphere of depressed business conditions and entrepreneurial timidity, plus what some venture capitalists view as uncalled-for Federal tinkering in the form of pension and tax restrictions, have combined to dry up a good deal of venture enthusiasm. In the long run, this could put the brakes on the kind of growth that has pushed electronics to its present advanced state: the startup of small, high-technology companies willing to try to create a market for the likes of minicomputers, microprocessors, and large-scale integrated circuits.

"Venture capital is not so venturesome anymore," declares Harry J. Healer Jr., vice president of the First Capital Corp. of Boston. "Venture capitalists are more reluctant to invest in startups because, with the decline in public offerings, they have no place to go to obtain liquidity and less turnover in their portfolios." As a result, the investor's return on his investment, normally 10 times the original dollar input, takes longer to appear. Notes Donald T. Valentine, president and director of Capital Management Services Inc. of Los Angeles: "The question of liquidity has changed. If I know my money is going to be tied up for three years, I take a different risk than if it's going to be tied up for 10 years." In that case, he says, "maybe I don't want to take that risk at all."

In recent years, many venture capitalists have taken the latter course, says E.F. Ned Heizer, chairman of the National Venture Capital Association and president of Heizer Corp. of Chicago, the nation's largest venture-capital firm. "There's money around, but many people in the industry reached the same conclusion we did: we'd better help the companies we're in. They couldn't get the growth money from anyone else." Two years ago, in fact, Heizer announced his company would no longer finance startups.

Changed attitudes. Others in the venture-capital business haven't gone so far as that, but their attitudes about what constitutes a likely prospect for investment have changed. "There is a heated interest in investing in young companies with a track record of three to five years and a management that's doing well," says J. Burgess Jamieson, general partner in Dennis, Jamieson, McCurtry & Norris of Menlo Park, Calif., and a prime investor in Electronic Arrays Inc. [*Electronics*, Jan. 22, p. 80]. In addition, the market for the product must exist. "There was a time," recalls William H. Congleton, partner in the Palmer Organization of Boston, "when people could raise money with a clever idea. Today," he says, "an entrepreneur must have

Money men. Venture capitalist Arthur Rock, top, sees a trend toward socialism, while Donald Valentine, middle, feels that "the question of liquidity has changed." For E.F. Heizer, bottom, it's a case of helping the companies he has already put his money into.

Stymied. Harry Healer Jr. of Boston says there's no place to go to obtain liquidity.

a business plan that can stand study and scrutiny."

Some venture capitalists complain, however, that the innovators are not coming forward. "The economic squeeze has hurt the entrepreneurial urgency to get out and try something new," says William H. Draper, general partner at Sutter Hill Ventures of Palo Alto, Calif. "The capable people in management have said 'Boy, I better not leave the protection of an HP or TI in order to go out and start on my own because I hear there's no money, the stock market is down, and the Government is squeezing the advantages of capital gain.' "

But all venture capitalists claim money is available for the good idea. Capital Management Corp.'s Valentine estimates there is as much as $100 million available for risk investment in Northern California alone on enterprises with "a highly capable, well-organized management." But, he notes, "for every 100 investment opportunities I see, maybe there's one that has the characteristics of a company worthwhile to finance."

The "dismal results" of recent ventures have frightened away venture capital, says Richard L. Geiger of the New York venture capital firm of Geiger & Fialkov. Too many people, he adds, "jumped into things without exhaustive investigation. Prior to 1961, venture capitalists made rather thorough investigations before they went in. From 1961 to 1968, people jumped in with both feet and then investigated. From 1969 on the results of this jumping in became apparent, and when they went to the till for more money it wasn't there."

Blames Congress. It is no accident, suggests Heizer, that good innovations are scarce. "Congress has cut off the funds to all the bright young people in the country," he says. The new pension law makes it prohibitive to invest in people, "which is what we do when we start a new company," he says. "I think it's a most ridiculous situation. Venture capital is at the heart of the free-enterprise system."

Such disincentives, says a pessimistic Arthur Rock, one of the San Francisco Bay Area's renowned investors, clearly point to a "trend towards socialism." "The capital is still available," he says, "but the rewards are getting less and less." The amount of capital required to start a company has jumped, he says, and taking a company public, in these days of a lagging stock market, takes longer than it once did. In addition, he says, the Government puts a burden on the innovator.

In a speech he gave to the Securities Industry Association last summer, Rock commented, "How can incentives be created for people to sell their low-basis stocks and pay the capital gains tax in order to invest the proceeds in companies where the risk/reward ratio is fast becoming unfavorable?"

Also pointing to Washington is Richard Hanschen, a general partner in New Business Resources Inc. of Dallas and head of the National Venture Capital Association's incentives committee. Says Hanschen: "The problems of the venture-capital industry are caused by the whole trend to big Government." Hanschen condemns recent tax policies, singling out as an example 1969's bargain purchase law that requires a company's founder to pay ordinary income tax on the spread between the cost of his stock and fair market value, and to pay that tax at the time of the purchase.

Cash is there. More optimistic is Charles J. Coulter, president of American Research and Development Corp. of Boston, the firm that originally invested $61,400 in a company called Digital Equipment Corp. Coulter insists that "money is available today for any quality, potentially useful, business." But Coulter cautions that a fledgling company now must find its market more quickly.

Despite the gloom in some corners, most venture capitalists expect things to change as the stock market livens up. "More companies will start in the next five years than in the last five," predicts Valentine. And Heizer, who invested early in Amdahl Computer, Control Data Corp., and Memorex Corp., among others, believes that within three years, "there may be money coming back into younger companies and new formations." He adds, though, "it's going to take some time." □

Proposed SEC change seen as threat

While venture capitalists complain that natural business forces are making it difficult for them, they also are unhappy about Federal policies—and one proposed policy change could make them even less venturesome.

Last September, the Securities and Exchange Commission proposed an amendment to its Rule 144, that section of the Securities Exchange Act that enables new-venture investors to get out of an investment by reselling their shares. It permits sale of 1% of the total capitalization of a company that is publicly held, but not exchange-listed, every six months after two years. Thus, if the company has 3 million shares, an investor can sell 30,000 shares every six months.

However, under the proposed amendment, the volume limitation figure for securities traded over the counter would be 1% or the average weekly trading volume for the previous four calendar weeks, whichever is less. But venture capitalists say that many ventures don't trade at all for a week or two, or only trade 100 shares a day. This, they claim, would make it virtually impossible for a venture capitalist to get out of a situation that is not actively traded, making it less desirable to risk capital on new ventures.

—Ron Schneiderman

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Communications

CB component makers in quandary

Strain for word from FCC on expansion, which could mean changes in technology; meanwhile, business is booming

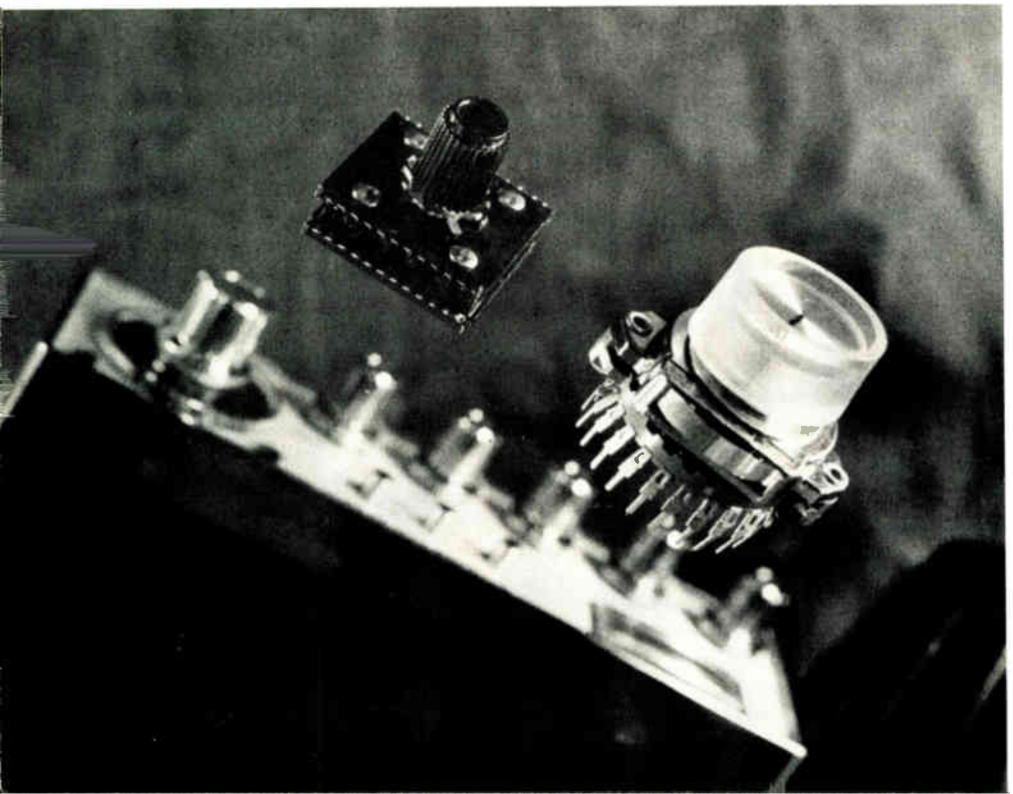
by Larry Armstrong, Midwest bureau manager

No one is more concerned about the impending expansion of the Class D citizens' band service than components suppliers, who have been awaiting what the FCC calls an "imminent" move for more than a year now. Rotary switches, filters, jacks, meters, and even hardware have been in short supply from time to time since the CB boom began [*Electronics*, Aug. 21, 1975, p. 62].

But no component has been as scarce as crystals. And crystal makers are reluctant to expand, fearing the technology changes the class D expansion will bring. Switch manufacturers, too, see the specter of increasing competition from electronic channel-select approaches. For crystal suppliers, the expansion from 23 channels to what is expected to be 50 forebodes a faster move to digital frequency-synthesis techniques that require fewer crystals. And they've been through it before—the advent of frequency heterodyning in the mid-1960s reduced the number of crystals needed for a 23-channel set to 13 or 14 from 46. The ultimate promise of digital synthesis is to pare that to a single crystal.

"The CB business has been great, but the expansion is a cloud on our horizon," says Delbert M. Gaines, president of M-Tron Industries Inc., the Yankton, S.D., firm that supplies domestic CB manufacturers with perhaps as many as 80% of their crystals. "The total CB market would have to expand fourfold to make up the difference as the number of crystals per set drops from 14 to three or less—and that's just not going to happen." The change to digital synthesis of frequencies will not happen overnight, however. "If the FCC decision came today, I don't know how fast the switchover would be," says Case Mooibroek, marketing manager for CTS Knights Inc., Sandwich, Ill. "But I know there will be a lot of crash programs, and I know that there will be fewer crystals sold two years from now than today."

For citizens' band. Two switches from Oak Industries' Switch division are (left) a model capable of multichannel operation when used with hybrids, and a 50-position rotary unit.



Last quarter. Mooibroek figures that maybe 50% of the CB sets sold in the fourth quarter will be phase-locked-loop sets. (Phase-locked loop is the description that the industry and public have settled on to portray next-generation CB gear, which includes phase-locked-loop circuitry as well as digital frequency synthesis.)

M-Tron's Gaines puts the figure quite a bit lower. "Even after the announced rule-making, there's the question of what the effective date will be," he says. So by the end of the year, maybe as much as 15% of the market will be served by phase-locked-loop equipment, but it will be 24 months before it takes over the major part of the market."

Crystal makers may get a boost from the FCC if it allocates bandwidth around 220 megahertz for Class E service. "The 27-MHz band will be in for real problems in 1979, as sunspots make communications at current power levels impractical," Mooibroek says. "We expect that many Class E sets will use a crystal filter in the intermediate-frequency

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strip; it's a common design approach in fm receivers." CTS is expanding another 20,000 square feet, he says. "We would have built the plant anyway to handle the higher demand for all types of crystals; CB just provided the catalyst." The addition represents a 25% expansion in floor space, and probably more than that in terms of capacity.

Holding steady. M-Tron, however, doesn't manufacture as broad a crystal line as CTS Knights and is more reluctant to expand. "We're taking a hard look at our other crystal markets, but right now we have no plans for further expansion," Gaines says. "Even if we did," says the company's president, "I'm not sure we could get enough quartz to support an expansion."

"We could sell more quartz if we had it," agrees John Whalen, executive vice president of Sawyer Research Products Inc., which produces more than half the cultured quartz used in the world. The Eastlake, Ohio, firm is breaking more ground and has ordered 45 more autoclaves. The 16% expansion "was prompted by generally good growth in communications markets, including CB," Whalen notes, adding, "There's no question that fewer CB crystals will be used by manufacturers in the future."

Crowding on the circle. Rotary-switch makers are in a somewhat different quandary as they try to anticipate the FCC move. "It's tough to crowd 50 positions around a circle—it's only 7.2 degrees per switch position," says P.M. Hassett, marketing vice president at Oak Industries Inc.'s Switch division in Crystal Lake, Ill.

Proposed solutions include conventional or coded rotaries interfaced to mechanical or electronic displays, two 25-position rotaries or one with a high/low switch, and two 10-position rotaries, one for tens and the other for units.

Even push-button keyboards are being considered, although one CB manufacturer notes that "while satisfactory, present keyboards are a little expensive for our tastes." Still, with design changes seemingly becoming a rule, don't write it off.

Rotary manufacturers seem to think that CB channel selection will always be by a rotary switch: "Up to now, the whole radio communications business, including navigation equipment, primarily uses rotary control," Hassett says. So the problem, for them, boils down to how many channels the FCC allows.

Onward and upward. "We've made it our *cause cèlèbre* for the past year," says Roy H. Slavin, president of Standard Grigsby Inc., Aurora, Ill. "We designed a conventional rotary with 32, and then 36, positions. "We actually hand-tooled parts for a 40-position switch, and now the CB makers are saying they want 50 channels." Echoes Hassett, "Six months ago we sampled a 40-position switch; now the popular switches are 50- and 54-position." The manufacturers playing the numbers game, in short, are simply awaiting the arrival of the dealer—the FCC.

Both started showing samples of new switches this month. Standard Grigsby has spent $70,000 for the tooling on a rotary that will be available in production quantities in June. By changing a star wheel, the switch will accommodate up to 55 detents. Its binary-coded-decimal output is programable to any code the customer wants.

Choice of displays. The firm also is developing a mechanical display to interlock to the switch, or a switch wafer can be added that contains a light-emitting-diode complement code. With the LED capability, it will sell for around $2.25; without it, $1.75. Oak will not divulge details of the 50-position rotaries it is shipping in sample quantities, but they're expected to be available in both coded and conventional versions.

Another major supplier to domestic CB makers is the Centralab Electronics division of Globe-Union Inc., which has decided to wait for the FCC before committing to a design. "People came to us over a year ago with ideas for switches," says Dwayne MacDonald, marketing manager for the Electronic Controls group, Milwaukee, "If we'd reacted then, the product would be obsolete now." ☐

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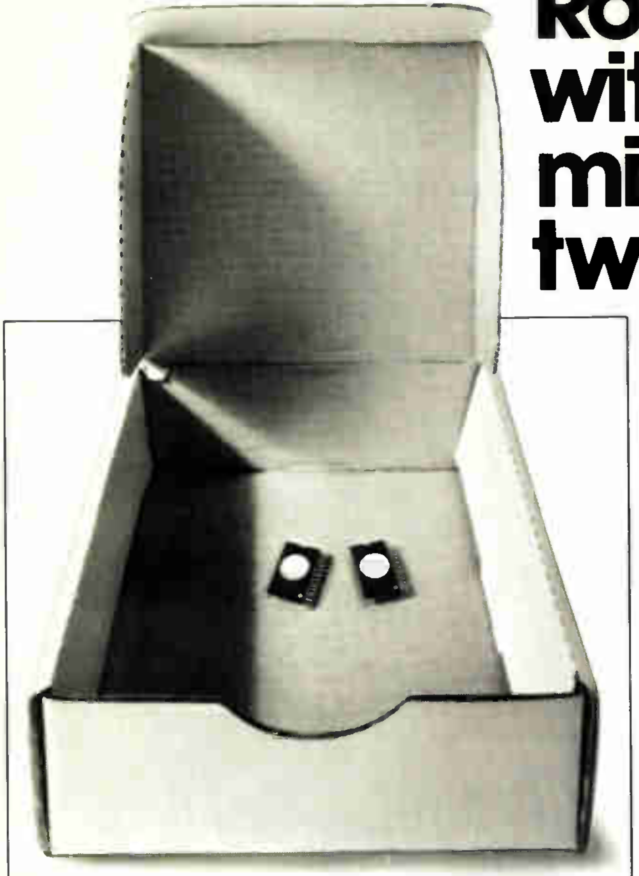

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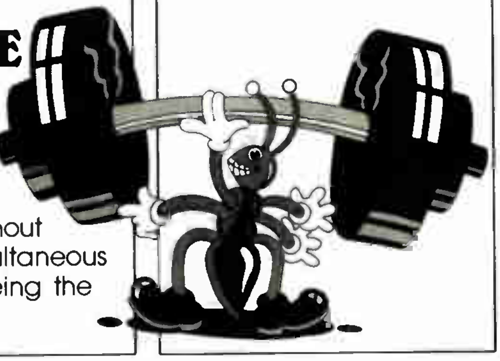

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Microprocessors

Will 16-bit devices grab the market?

Makers of 8-bit processors say no, that price is key factor; but competitors predict that cost soon will be equalized

by Howard Wolff, Associate Editor

Now that 16-bit microprocessor systems are emerging in rapid succession, industry watchers are wondering how much territory they can capture from the entrenched 8-bit devices in a market dominated by Intel Corp.'s 8080 and Motorola Semiconductor's 6800. At the same time, Intel and Motorola are counterattacking with enhanced 8-bit processors.

Advantages offered by 16-bit devices are clear for many applications. Prime among them is the speed with which the new processor generation executes a program. While 8-bit units can handle 16-bit data words and instructions, these must be multiplexed in two cycles; the 16-bit units perform such operations in one cycle. This advance simplifies the surrounding circuitry as well as the programs that must control the internal shuffling of data between registers.

Predictably, makers of 16-bit parts are optimistic about their future, pointing to evolution as their greatest ally and characterizing enhanced 8-bit processors as stopgap measures. But the 8-bit houses counter with the argument that, while a small share of the market will be available for the bigger processors, evolution to 16 bits is not as natural as the advance from 4 to 8 bits. What's more, they say, users with cash invested in 8-bit software will turn to enhanced 8-bit systems when they need more speed, rather than write off their software investment in order to buy 16-bit systems.

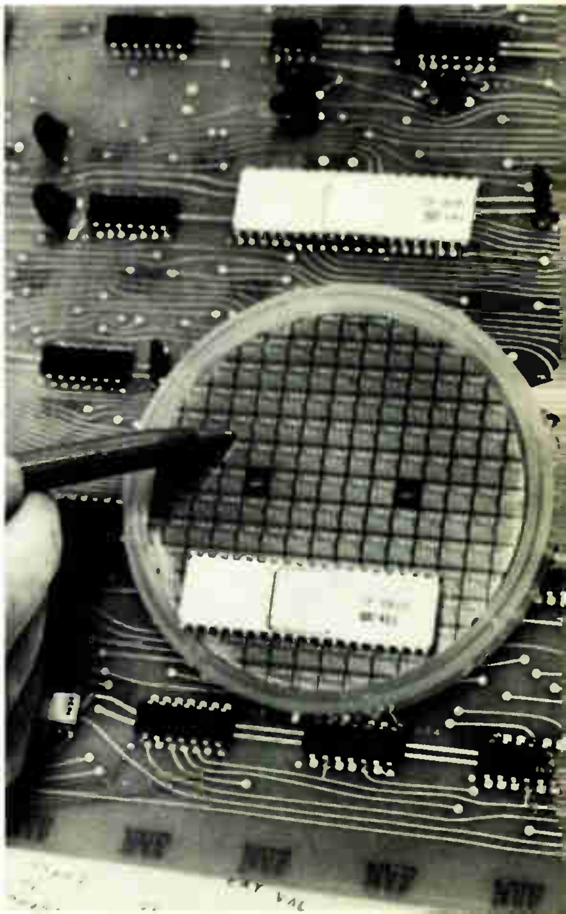
At Motorola Semiconductor in Phoenix, product planners don't consider the 16-bit processor a nose-to-nose threat to their 8-bit 6800 line, either right now or five years from now. Their recently completed study of the market into the 1980s convinces them that the high end of the processor market represented by the 16-bit device will capture only 5% to 6% of total dollars. The mainstream, the study goes on, will be occupied by the 8-bit processors with 30% to 35% of the dollars and an even higher percentage of units sold.

In the view of Thomas Bennett, Motorola's manager of product planning for the Integrated Circuit division, the 16-bit processor is finding a niche in minicomputers and mainframes. However, adds Bennett, as 8-bit processors improve their performance and come down in price, they should eat away at new applications in the 16-bit market.

Sees price drop. But a 16-bit man disagrees. Jeffrey Stein, General Instrument Corp.'s manager for microprocessors and memories, says that the 8-bit and 16-bit products will be priced about the same before too long. "It's straight silicon pricing," he says. "It takes no more silicon to make a 16-bit machine than an 8-bit machine." GI, which saw no point in slugging it out with the strongly positioned Motorola and Intel in the 8-bit market, introduced the 16-bit CP1600 a year ago. It was jointly developed with Honeywell's Process Control division.

Striking at the heart of the 16-bit device's performance, Motorola's Bennett says that prospective customers are placing accuracy above speed of throughput. "Since accuracy is the thing," he says, "this can be achieved in a cost-effective way with 8-bit devices by going through the loop twice or even three times." And distributed processing also will make 8-bit use even cheaper, adds Bennett: "Customers can't afford the extra real estate of 16 bits at lower-end uses."

Intel's William Davidow, manager of microcomputer development, says he has found his customers unenthusiastic about 16-bit processors. "The impression I get," says Davidow, "is that for most user applications the 8-bit processors



Sweet 16. The CP1600 microrocessor, designed by General Instrument and Honeywell, permits user to access 65,536 words. It processes numeric or byte-oriented data.

have the performance they require. The only thing many of them are concerned about is the cost of solving their problems."

While Davidow says the world is oriented toward solving a particular problem at the lowest possible cost, he admits there are certain jobs the 16-bit does better than the 8-bit—in theory. "For example," he says, "it would appear that applications requiring a certain amount of precision in a relatively short time would be better handled on a 16-bit machine."

Andrew Allison of Advanced Micro Devices Inc. expects minicomputers to move up in capability and take over the bottom of what was previously mainframe domain. Then, says the Sunnyvale, Calif., company's MOS-microprocessor marketing manager, microprocessors will move in at the bottom of the mini spectrum to fill the vacuum. Much of the latter market will be taken over by 16-bit machines, says Allison. They will handle computation jobs that minis now handle, as well as non-computation, high-throughput applications beyond the range of 8-bit units.

Perhaps Texas Instruments Inc., which straddles the market with its 16-bit 9900 and its second-sourcing of the 8080, puts it best. Says an official at its MOS facility in Houston: "No machine will be most efficient for most applications. However, in the general class of byte-oriented applications, the 16-bit architecture of the 9900, with its 15 index registers and multiaddressing modes, offers significant advantages over 8-bit architectures in calculating addresses and performing extended precision arithmetic. This capability, coupled with the comprehensive set of byte instructions included in the 9900 instruction set, and the ability to move two bytes at one time, ensures that the 9900 will operate very efficiently in an 8-bit microprocessor environment."

Enhancement options. As for enhancing the 8-bit processors, Intel's Davidow says that the 8080A already does perform certain key 16-bit operations. But there are other options, he notes. One might be to go to a 16-bit implementation of the 8080A; another would be further improvements of the 8080A. However, he won't say which way Intel plans to go.

AMD's Allison says the market for enhanced 8-bit microprocessors will depend on how fast the 16-bit machines are introduced during the next year or so. His view: "If they don't come along as fast as expected, enhanced 8-bit machines will be a good way in the interim for many micro makers to gain at least a share of the low-end 16-bit market. If not, enhanced 8-bitters will just be a good idea bypassed due to market demands." Which way is AMD going? The company isn't actively developing either an enhanced 8-bit or a 16-bit unit, says Allison. "What we do depends on what happens this year." ☐

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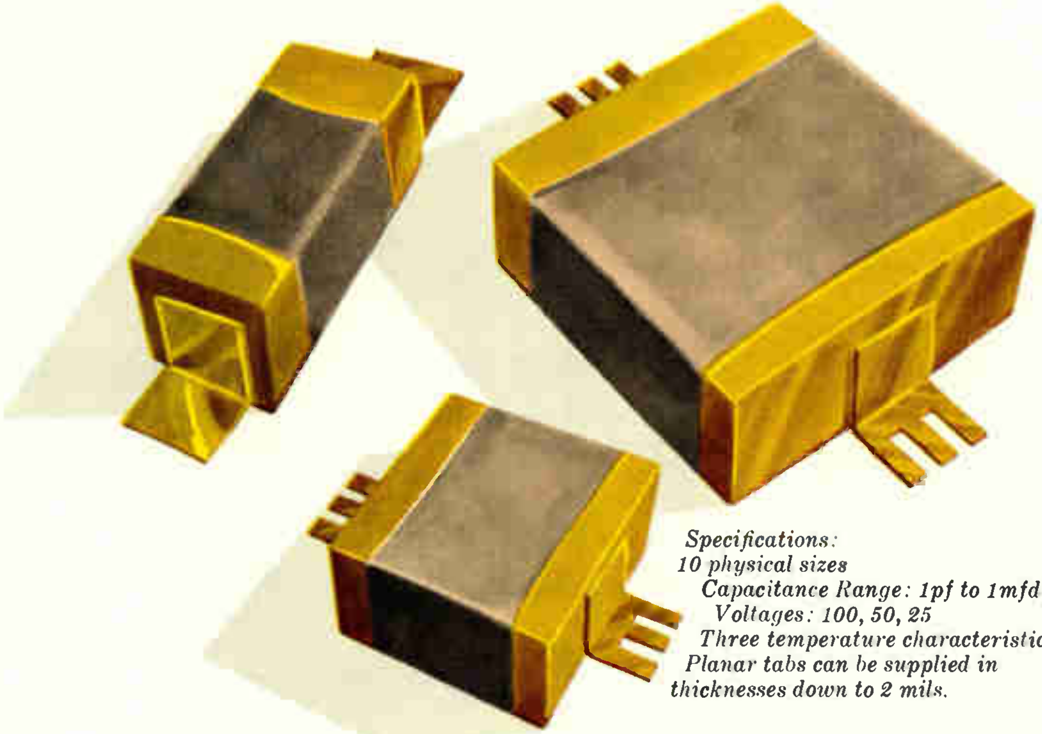

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People

AT&T: a taste for competition

Tanenbaum, new top technology executive, looks toward future of satellites, fiber optics, bubbles

Morris Tanenbaum has somehow managed to maintain a low profile in a very high-profile organization—American Telephone & Telegraph Co. But that should change on March 1, when Tanenbaum moves out of his Bell Laboratories office in Murray Hill, N. J., where he has been an executive vice president since last April, to take on the top technical job at AT&T as vice president for engineering and network services.

Despite his rapid rise within the company—his only employer since he received his Ph.D. in physical chemistry in 1952 from Princeton University—it will be Tanenbaum's first job at the corporate level. At Bell Labs, Tanenbaum contributed to the early research in semiconductor materials and devices and developed the first successful silicon diffused-base transistors. He was closely associated with the work that led to the discovery of materials for superconducting magnets, and has been granted several patents on fabrication of semiconductor devices and the preparation of semiconductor and magnetic materials.

As Tanenbaum explains it, at AT&T he will be responsible for "engineering, very broadly, and technology, very specifically." Significantly, too, he will oversee Bell Labs' budget.

Acknowledging that AT&T has been criticized for being slow to adapt new technologies, Tanenbaum says, "There are new technologies in the network itself that the customer doesn't see, and they will provide opportunities for new services. We are pushing technology into telecommunications today as fast as we know how. And we were doing that 30 or 40 years ago."

To obtain Tanenbaum's views on competition and a status report on several of the company's key R&D programs, the editors of *Electronics* recently interviewed him. Here are some of his key points:

Q. In your view, how does competition affect AT&T's plans?

A. It is made and viewed as much more of a factor outside than it really is. From where I sit, there has always been a heck of a lot of competition in the basic technology itself, starting with the basic technology of electronics. The new element today is that others are starting to push technology because they can borrow from other areas to get that technology into telecommunications. From our point of view, though, in terms of the pressures we feel to push new technology into telecommunications as soon as it is feasible from both demand and economic points of view, that pressure has always been intense.

Q. But wasn't your decision to develop a communications satellite program a competitive response, at least in terms of its timing?

A. Look back and see who did the first satellite communications experiments. It was Bell Labs—first with Echo, then with Telstar.

Q. In the area of advanced technology, do bubble memories still fit into your plans?

A. We still think it has very large potential, particularly where we want a very low-cost, highly reliable nondestructive memory. Bubble technology holds a lot of promise for bulk memory applications, as well as for some specialized small applications where nonvolatility is particularly important.

Q. How far off is fiber optics?

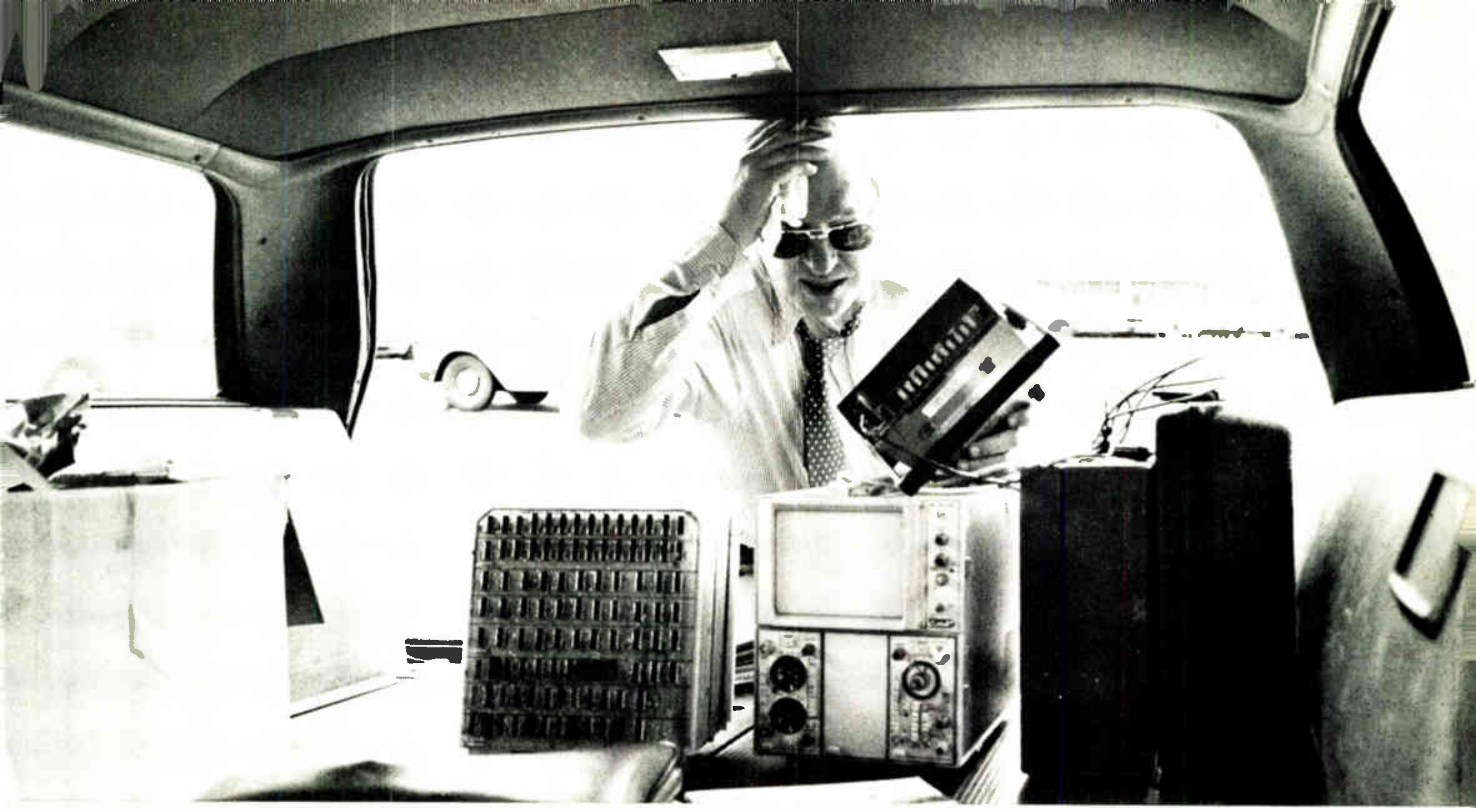
A. There are a lot of problems to be solved, but we've been very heartened by the progress that has been made. The really important thing is what are the costs of fiber cables in the ground—connected. We would like further improvement in the life of laser sources.

Q. AT&T and its subsidiaries have always made broad use of computers; do you see any new applications in the near future?

A. One of the advantages of stored-program electronic computers is their internal diagnostic capabilities and the fact that diagnostic information is available in data form. We are just now establishing the first groups of centralized computer centers for maintenance and switching machines. We may have in one center the data linking-in of all the diagnostic and maintenance information of many switching centers, so we can remote the maintenance and detect difficulties before a human would be able to see them.

Q. And microprocessors?

A. We are keeping a very, very close eye on developments in this area, and we have our own R&D activity in microprocessors to assure that we have the kind of microprocessors that are best suited for telephone use. We will make them if that's the best way to get them, or purchase them if that is best. ☐



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The 8000A is designed to be the good right arm of any field service man or utility maintenance man.

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It's truly a rough and tumble instrument.

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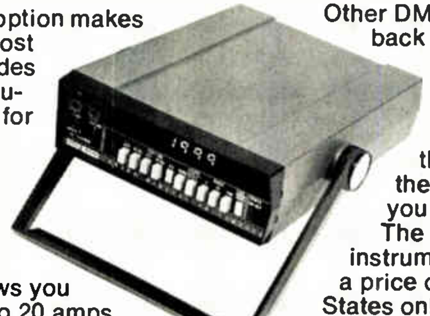
A unique set of low cost options and accessories.

Compare the 8000A's versatility to your own DMM, and watch your eyebrows rise.



Its low ohms option makes it the only low cost DMM that provides 0.001 ohm resolution (invaluable for checking pcb lands, motor windings, heating elements, shunts, etc.).

The high current option allows you to measure up to 20 amps with no external resistors or shunts—a must for power supplies where 5 amps is the common measurement.

It offers 100 and 500 MHz rf probes, a high voltage 40 KV probe, and a 600 amp clamp-on AC current probe.

And the built-in rechargeable battery gives you complete line isolation capability.

There's new high voltage protection on all ac/dc voltage ranges. The instrument will take transients up to 6 KV, 10 μ seconds wide over a duty cycle of 60 per second.

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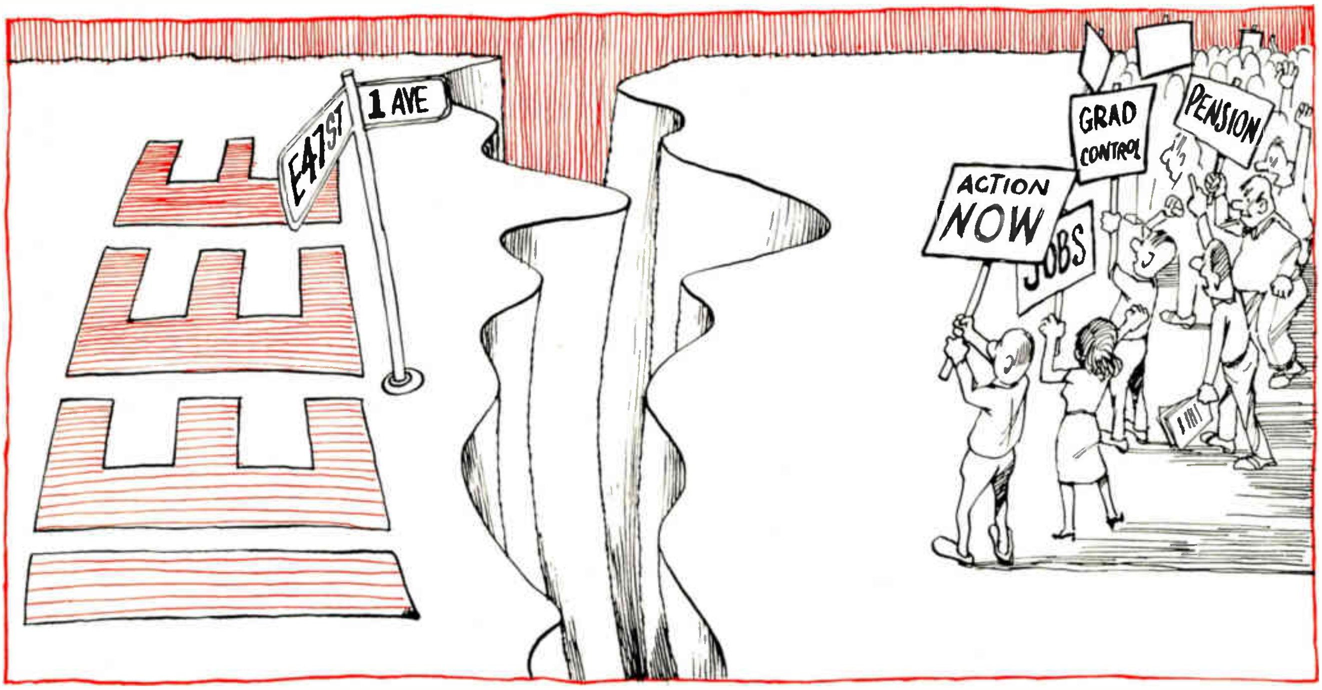

You and your career

Professional activities split IEEE

by Gerald M. Walker, Associate Editor

A gap between local professional-activities committees of the IEEE and their national leaders could tear apart that venerable institute. Or if statesmanship can prove the leaders equal to the challenges, their efforts could be beneficial to all EEs.

The controversy started when the IEEE changed its constitution in 1972 to permit it to engage in career-related activities. Since then, the ball has been carried at the national level by the U. S. Activities Board and at the local level by professional activities committees. However, since their creation in 1972, these groups have been the center of the controversy in the 170,000-member institute.

Extremes. The grass-roots bitterness is summed up this way by a member of one Florida chapter's professional activities committee: "The present IEEE leadership, because of its failure to meet our real needs, will have to share the responsibility if engineers go union."

But Robert Cotellessa, IEEE executive vice president, says: "The program [of the U. S. board] represents the best effort to achieve a continuity lacking in the past. Many good things, such as pensions, came from individual efforts. We wanted to provide an organizational framework for these things to continue."

Robert Bruce, chairman of the Long Island professional activities committee, says that the basic difference between the U.S. board and the local groups is that the national organization is looking outward to Washington and other segments of society to enhance the engineering profession, and the local committees are looking inward to the IEEE to improve the EE's professional standing. "IEEE treats the symptoms rather than the causes of our problems," he says.

How the U. S. board and the section committees resolve their differences will be influenced by the ever-increasing number of members who are becoming responsive to issues that only a handful of grass-roots members had been discussing in the past. As Jack Hoagland, chairman of the Los Angeles Council professional activities committee points out, the growing demand for professional improvement is being boosted by members who in the past had been secure, but have experienced recent layoffs. These are members in the public utility and Government ranks who seldom faced the loss of jobs with the resulting problems that are more familiar to aerospace engineers.

Size cuts speed. A rift between headquarters and local activists is not unusual in an organization as large as the IEEE. Stemming from the common complaint of no communication and the failure of both sides to understand the other's position, it covers both the substance and style of how best to serve the professional needs of the EE. But for the IEEE, this year is critical for a number of reasons. Among them:

- The very size of the IEEE, which, on the one hand, offers the potential for political clout and money-raising power, but on the other hand, slows down its movement. As the result, the national organization is trying to move carefully to keep in step with as many members as possible.
- Local chairmen have felt left out. Unable to penetrate the national organization, they have joined informally across the country to gain more attention from the board of directors. At the same time, they are

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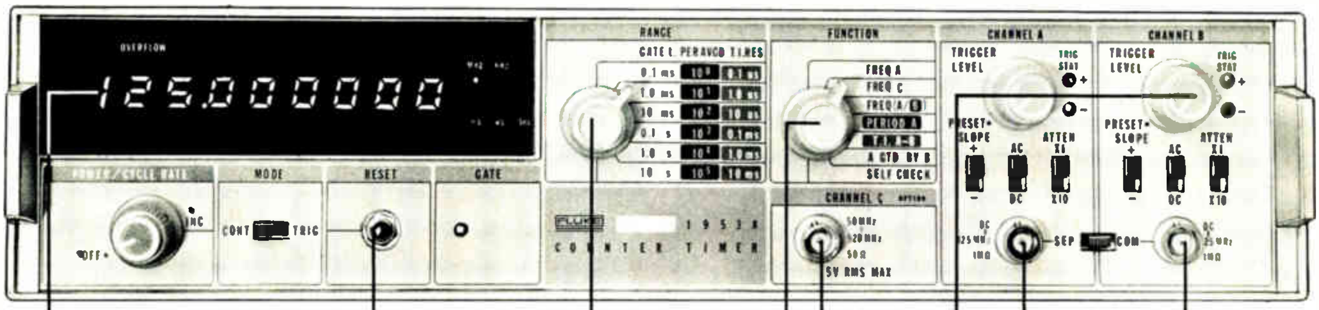

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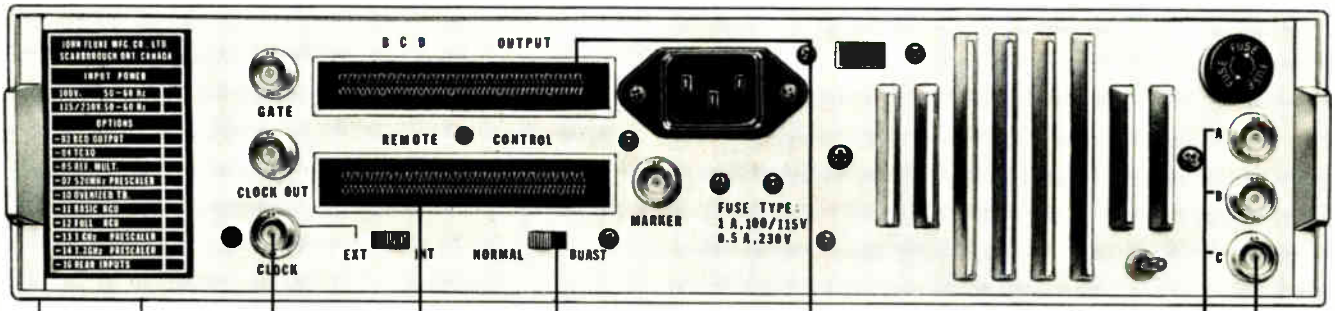

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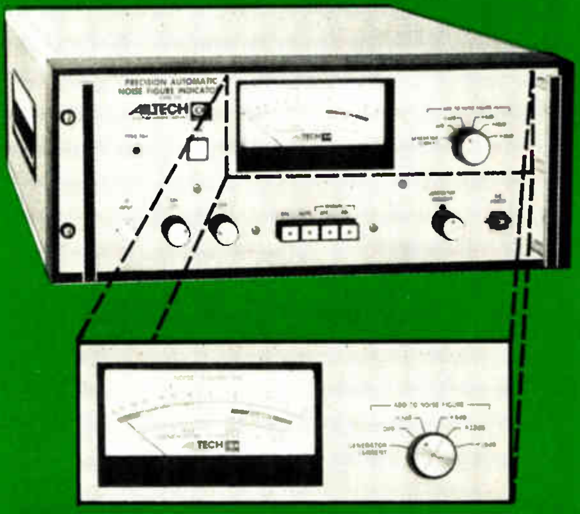

directing local programs along practical, career-oriented lines.

Proposal: control education. Perhaps no issue has been more controversial than whether or not to try to control the quality and quantity of engineers graduating from the nation's universities. Basically, the working EEs in the membership want immediate action by the IEEE to control the number of graduates. For now, a program of this magnitude and import does not appear to be in the works—at least judging from an outline of this year's objectives by the U. S. board.

That program, backed by a budget of more than $1 million, has five points: improvement in financial and economic benefits covering pensions, patent rights, and continuing education; improvements in career conditions and opportunities covering employment assistance, career-guidance centers, forecasting manpower needs, and planning for a manpower data base; improvement in professional status—including professional identification and qualifications, certification and licensing, and code of ethics; improvements in Government relations and other interfaces relating to a role in Government decision making by seeking an office of science and technology, as well as setting standards and designation of congressional fellows, and improvement in communications with employers, members, and the various public sectors.

Whether or not this year's relatively fast start will impress the local members remains to be seen—particularly because there is no direct mention of the control of graduates. "It's still milktoast," comments one former chairman in California.

"I can only feel pessimistic about USAB until the people of the 'old guard' are out of there," he adds. "It's too late for the present generation of EEs to get enough work, financial security, adequate retirement, and the rest. But I'd like to see this profession left a little better for the next generation. And none of that thinking is very much in evidence." ☐

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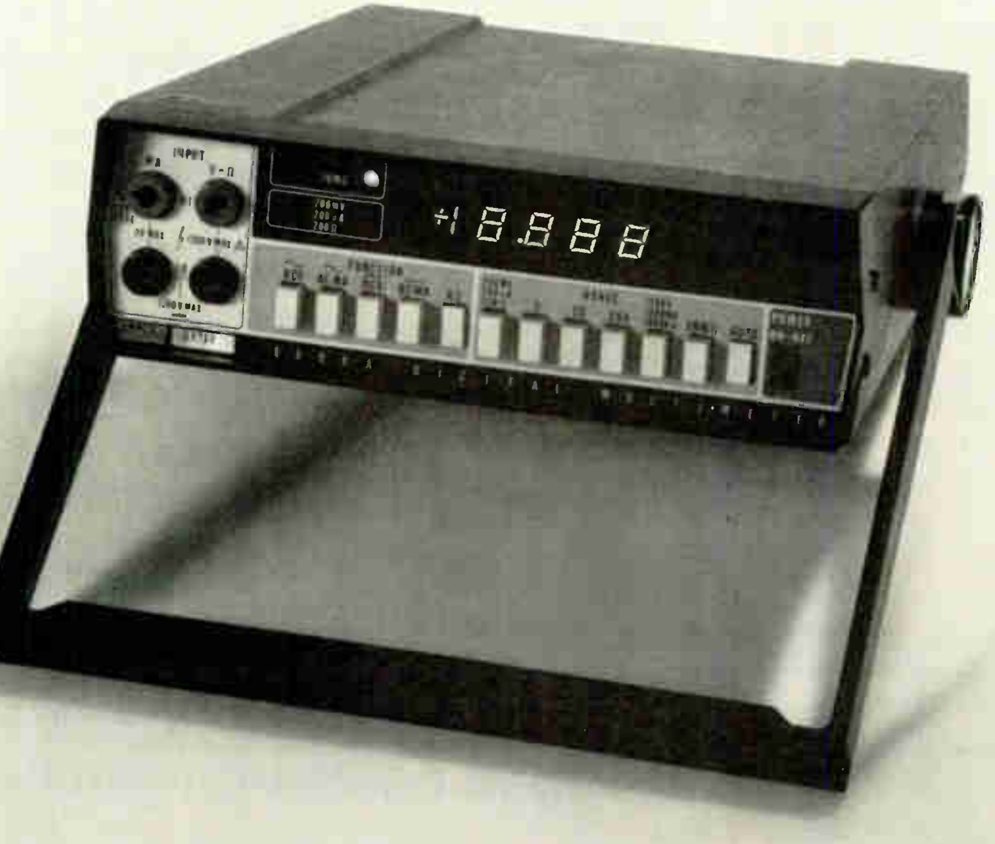

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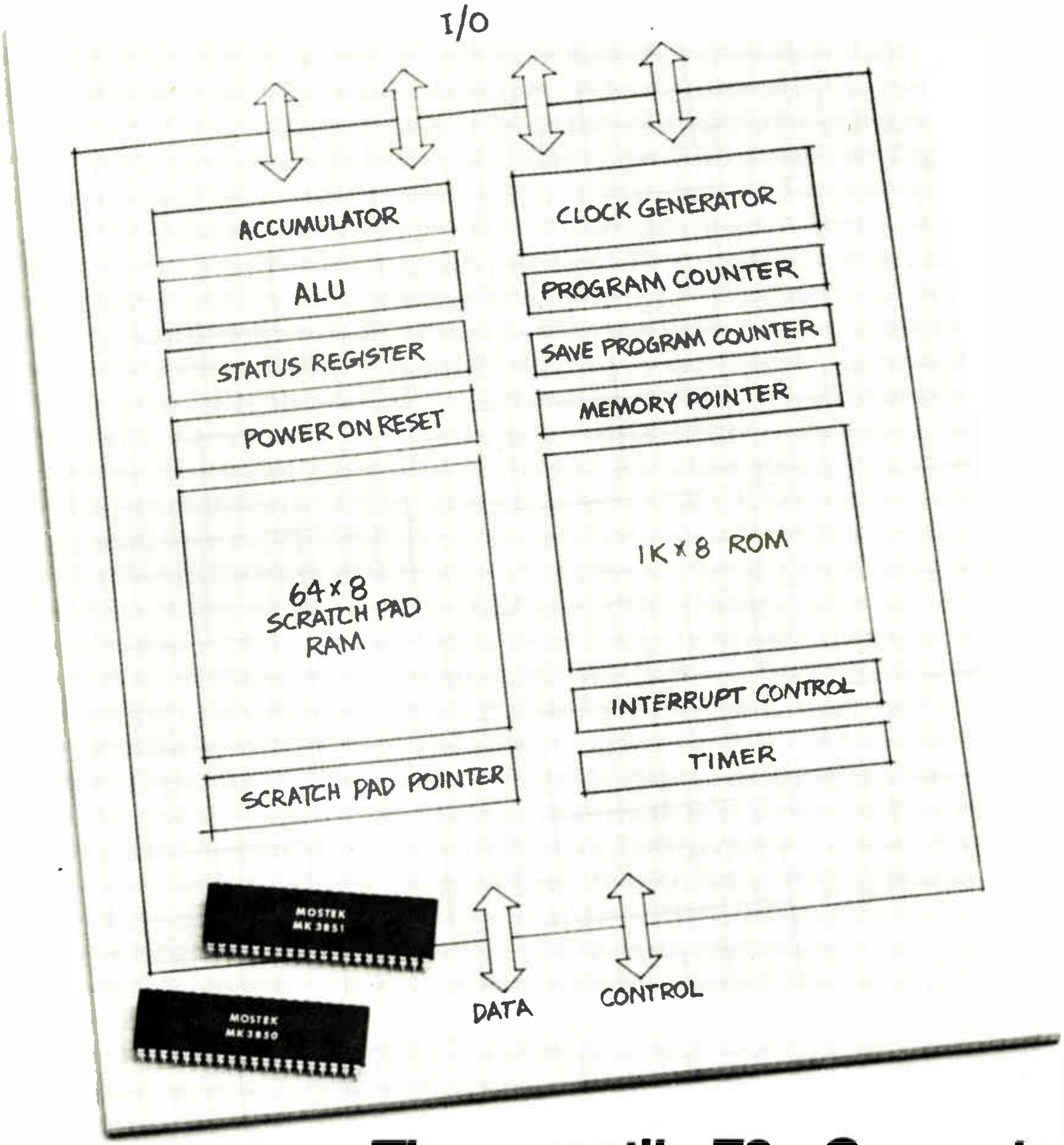

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MK 3702/1702A	Ultraviolet PROM	1st Quarter

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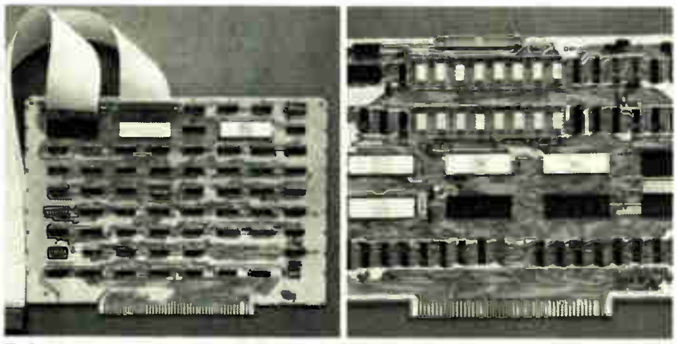
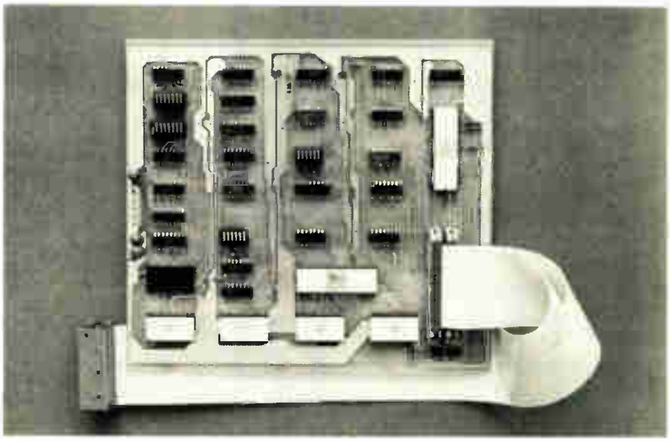


ROM Development Board and Software Development Board

Development aid for in-circuit debugging of PSU firmware. The RDB is similar to the Emulator except that the 1K x 8 of program storage is in RAM instead of PROM allowing interactive monitor and debug of "PSU" software in actual hardware configuration, when used with the SDB.

With the RDB/SDB you can execute and debug software, create and edit "source" listings (using the resident text editor) and assemble them into corresponding object listings (using the resident assembler).

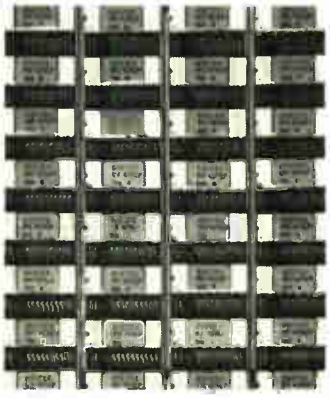


The Emulator

Mostek's F8 Emulator is a stand-alone development aid for designing and testing F8 µP systems utilizing MK 3851 PSU(s). The Emulator is electrically equivalent to the PSU but is field programmable, enabling users to obtain programming verification prior to ordering custom PSU circuits.

Software and Documentation

- Resident Assembler
- Resident text editor
- Fortran IV Cross Assembler
- Designers Debugging Tool 1 (DDT-1)
- DDT-2 (included with the SDB)
- User's guides, data books programming manual.



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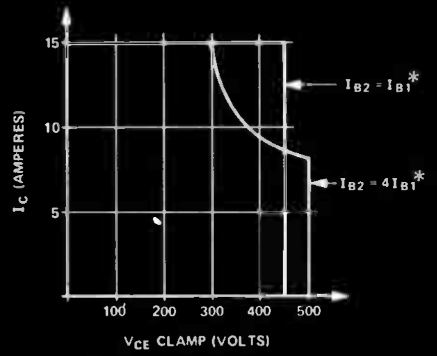

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WITH I_C = 8A I_{B1} = 2A

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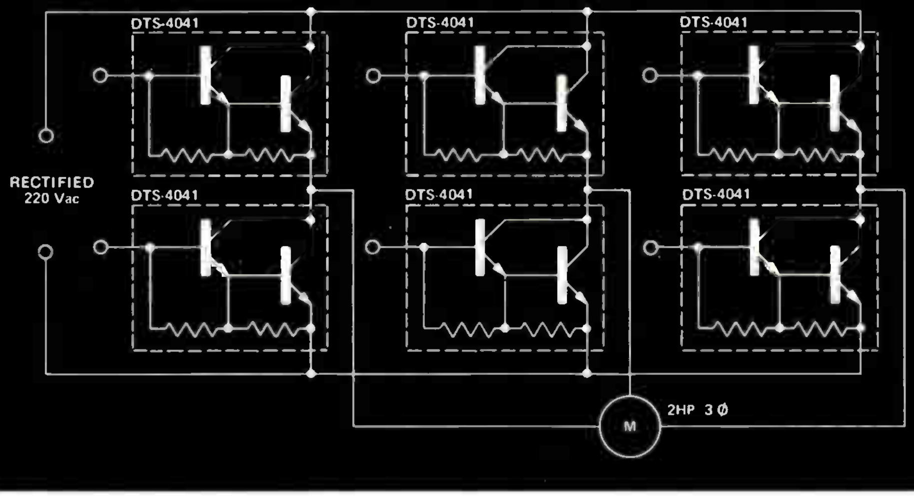

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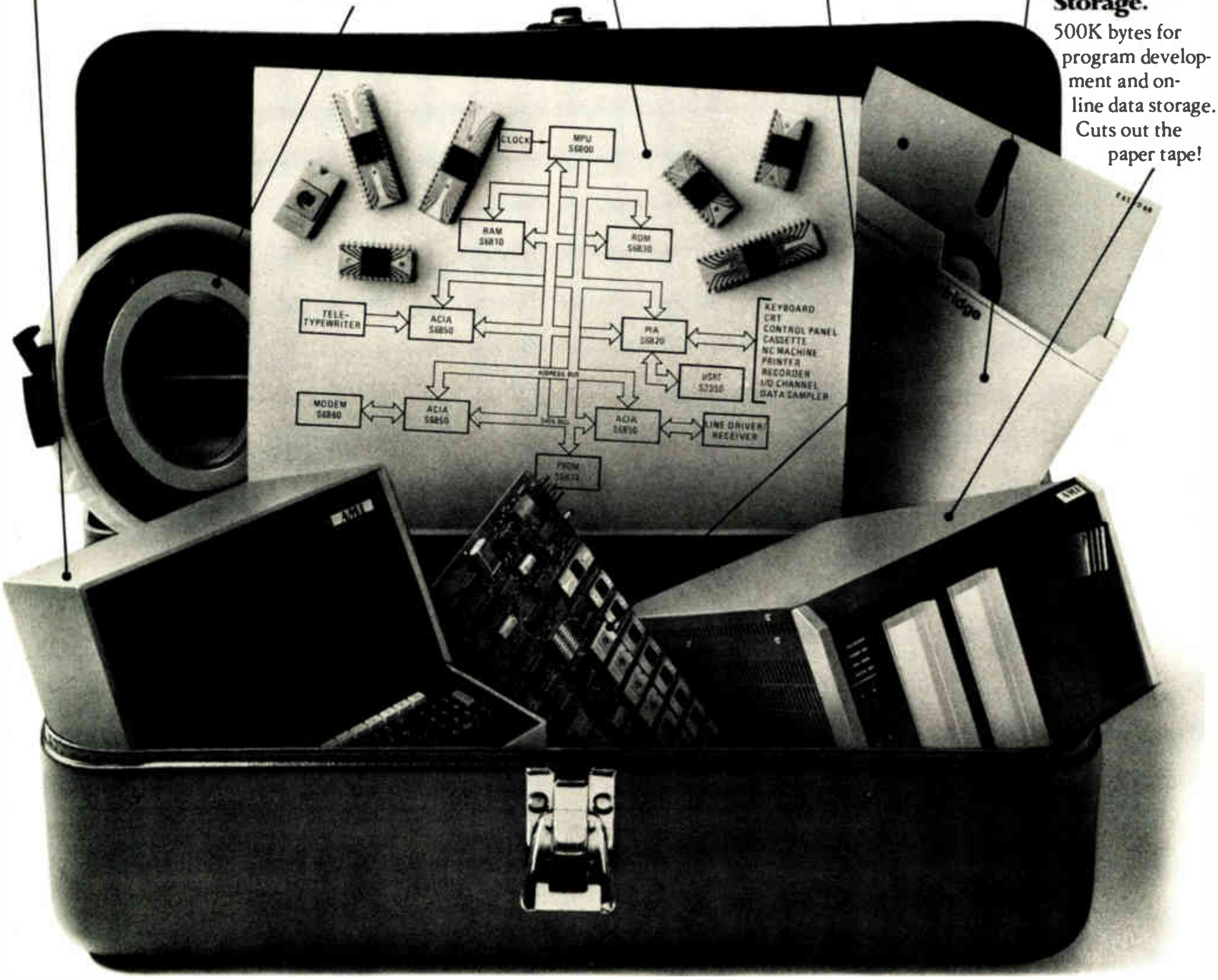

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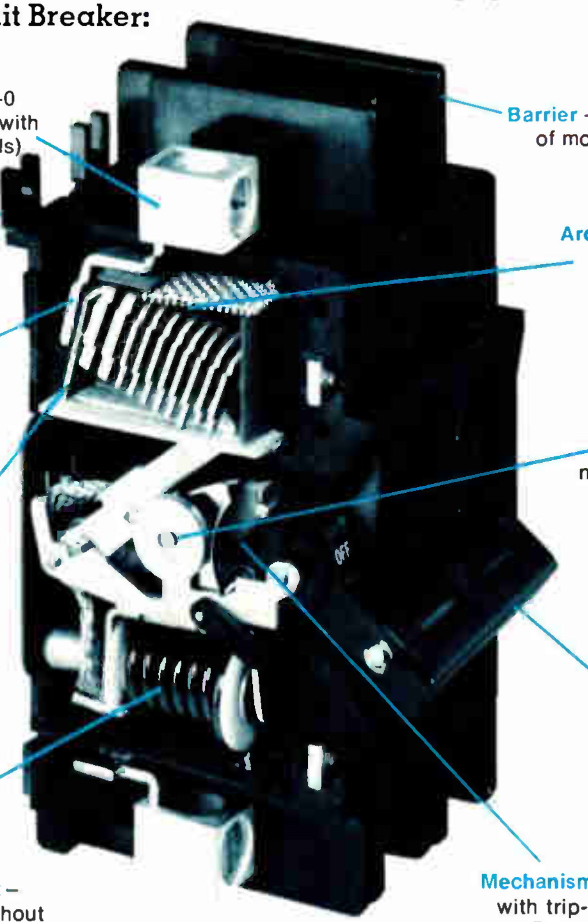

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Handy breadboard systems speed the development of prototypes

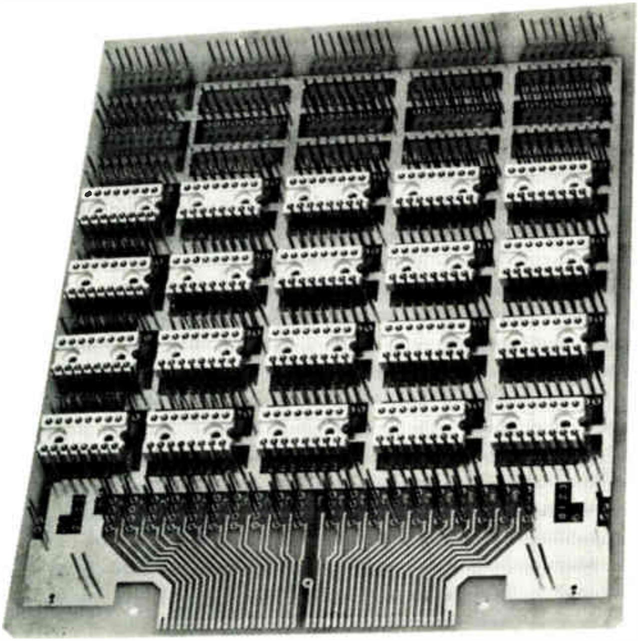
by Jerry Lyman, *Packaging & Production Editor*

With five major types to select from, designers are able to putter and probe in the style that suits best

☐ The classic "rats-nest" homemade breadboard—the age-old proving ground where designers checked out their designs—is no more. In response to the growing complexity and density of today's electronic components, a whole new generation of breadboard systems is speeding circuit development from paper to production.

The functions of the breadboard are the same: to let designers make quick wiring changes repeatedly without damage, insert new component values, and provide easy access for measuring instruments to any point in the circuit.

Ideally, it should approximate the actual circuit environment the system will face, and it should be inexpensive. It should be laid out in one plane with a reasonably good wiring density. Wiring should require no



1. Low profile. This Garry custom IC-socket panel has a 0.5-inch profile because its wire-wrapping pins are mounted on the same side as the DIP sockets. Standard IC panels, with pins and sockets on opposite sides, have 1.2-inch profiles.

special tools. And a breadboard should be easily connected to other breadboards and should be suitable for analog and digital work.

Important characteristics not all users may need include easy conversion to production printed-circuit form, interchangeability with a pc in the production configuration, and good resistance to actual operating temperatures.

There are five main breadboard systems, sold by a variety of firms:

- The IC-socket panel in which rows of wire-wrappable IC sockets or socket pins are mounted in a glass-epoxy board.
- Glass-epoxy circuit boards with hole patterns for accepting dual in-line packages plus plated-on ground and power busses.
- Perforated plastic boards for push-in wiring terminals.
- Solderless plastic breadboard sockets.
- Glass-epoxy panels with rows of DIP sockets, wiring plugs and special wiring jumpers. The table on p. 99 compares the five systems.

The most popular breadboard

Of course, no type has all the primary and secondary characteristics, but the IC-socket panel comes closest. Digital circuits with ICs in 14- and 16-pin DIPs are the basis for much electronic equipment, and this may account for the success of the IC-socket panel, which is the most widely used breadboard system. Also called logic panels, they appeared in 1965 when Augat Inc., Attleboro, Mass., combined three technologies to produce a solderless breadboard: printed circuits, DIP sockets, and Wire-Wrap, a wiring method developed by Gardner-Denver, Grand Haven, Mich., in which a special tool wraps several turns of insulated wire so tightly around a square metal pin that a gas-tight connection is formed.

The panel is a board with rows of holes on 0.1-inch centers, plated-on pc-connector fingers, and etched copper ground and supply buses. The holes can accept special DIP sockets with square pins at the bottom or square, wire-wrappable pin sockets that will accept DIP pins.

Dick Grubb, vice president of marketing at Augat, says the highly reliable wire-wrapped connections and sockets mean the IC socket panel is easily transported and can withstand the environment as well as the final design will. In fact, some manufacturers are staying with the panels in production rather than converting to a pc. If the breadboard and production models share the same package and wiring format, then the breadboard test data can be used to check production units.

Logic panels also have a high IC density, are easily modified, and fairly easily convertible to a pc. They have low noise characteristics because of their ground planes. Usually they are used with transistor-transistor logic, metal oxide semiconductors, and complementary MOS. Special multilayer versions are available for high-speed logic families such as emitter-coupled logic and Schottky TTL. The newest development is panels designed for specific microprocessor chip sets.

Logic panels are designed primarily for the digital circuitry in DIPs. However, all the manufacturers supply blank DIP headers to mount passive and active discrete components.

The panels cost $1 to $1.50 per IC position, so they are expensive compared to other breadboard techniques. They also have high profiles (the distance from the top of the highest component to the bottom of the deepest pin). And high profiles don't permit a one-to-one replacement of a panel and pc board.

"There is a way to get around the high panel profile," says Jim Aaron, vice president of manufacturing for Garry Manufacturing Co., New Brunswick, N.J. "We have supplied special custom panels on which both sockets and 0.450-inch Wire-Wrap pins are mounted on the same side [Fig. 1]. This results in a 0.5-to-0.6-inch profile, allowing the customer to interchange panels and the final board." Augat has similar models. A possible drawback to these low-profile panels is the impossibility of wrapping them with fully automatic equipment.

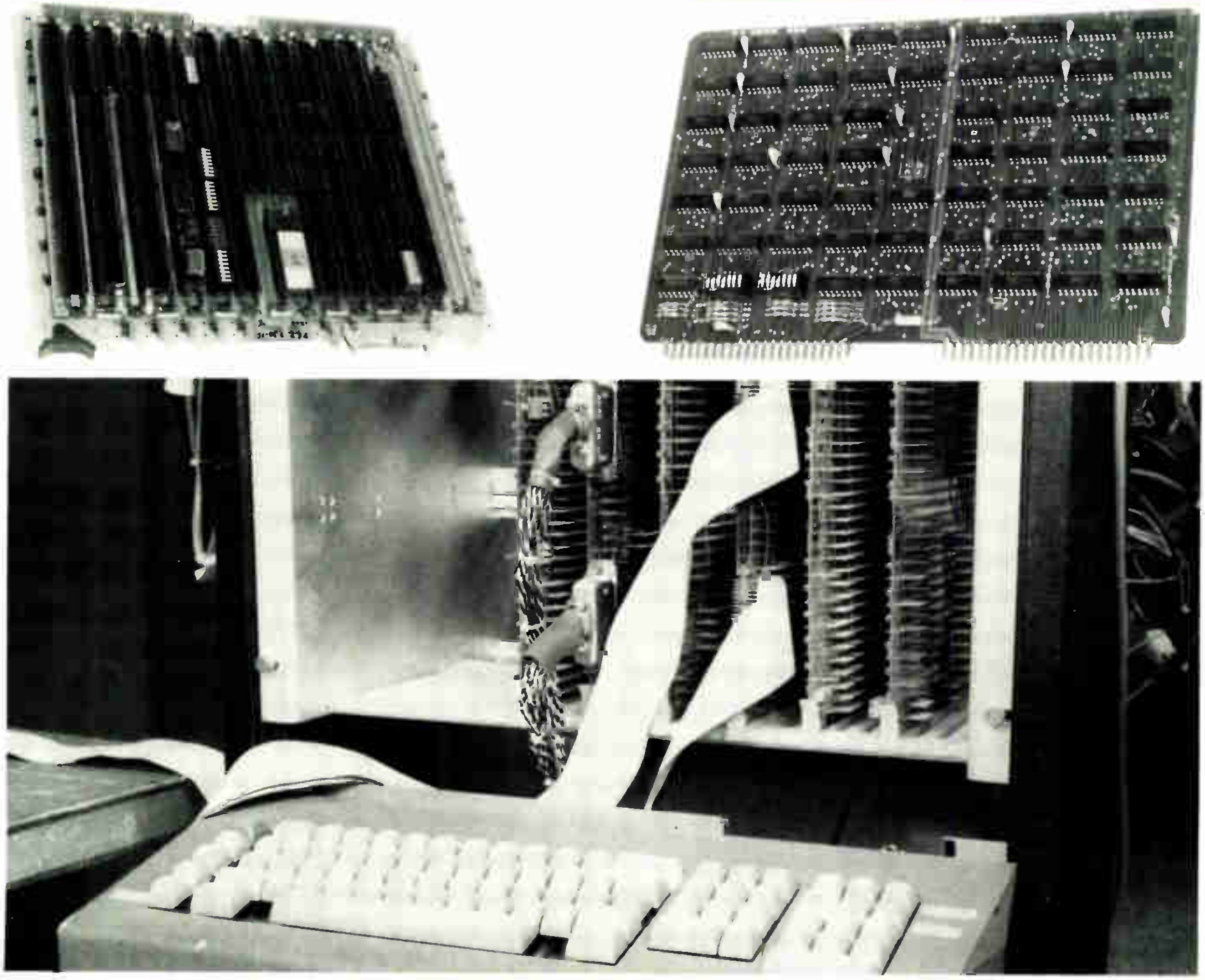
A typical use of panels is the breadboarding procedure used in designing cathode-ray-tube terminals at Applied Digital Systems Inc., Hauppauge, N.Y. Figure 2 shows the highlights of the conversion from breadboard to final-system pc board.

IC-socket panels are expensive, but they can accommodate anywhere from 30 to 180 14-pin DIPs. However, many circuits and subsystems can fit onto circuit boards, which have room for 20 to 50 14-pin DIPs.

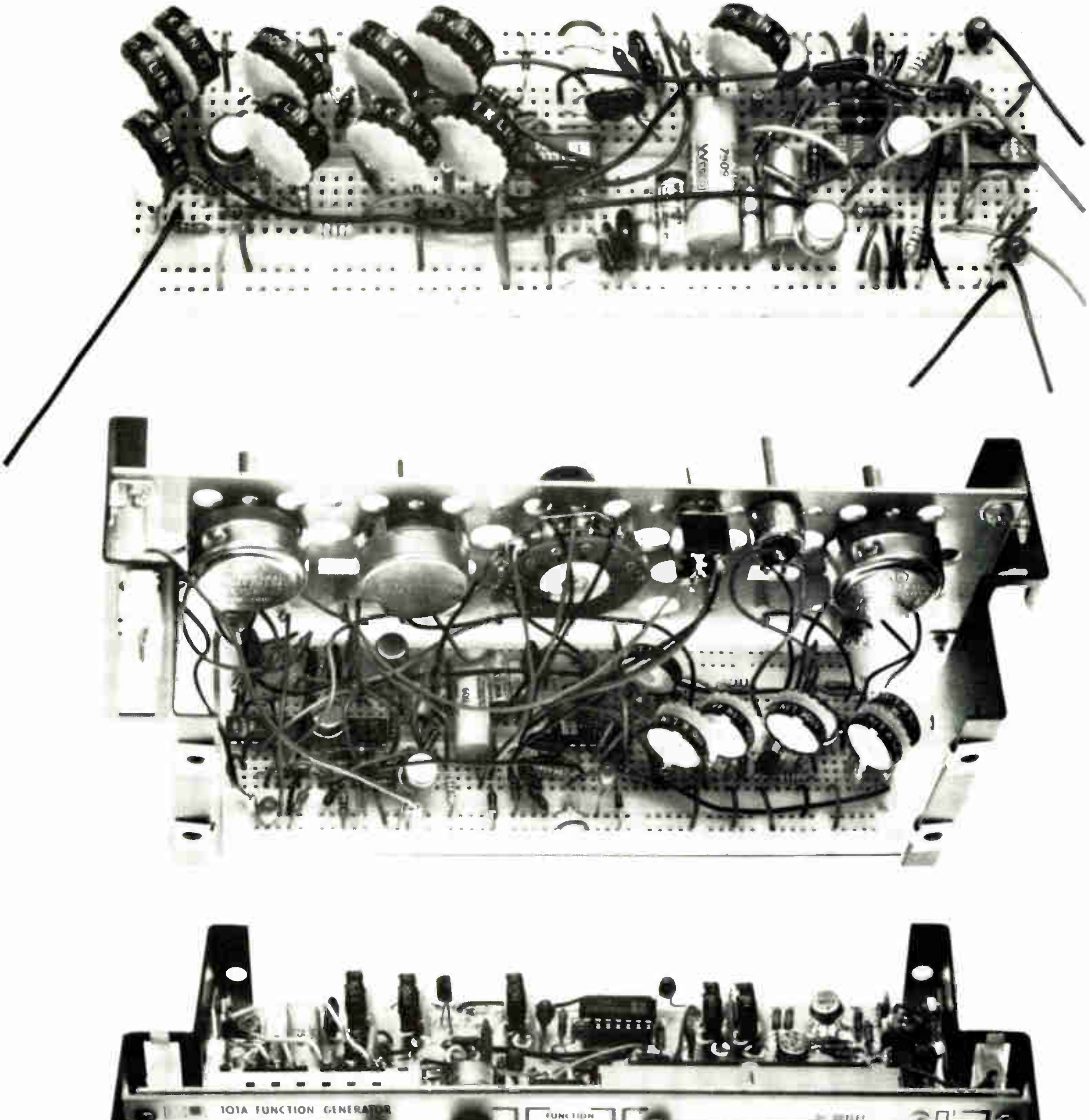
The fastest-growing breadboard

These circuit boards are the fastest-growing system in the breadboard market, according to Floyd Hill, vice president of marketing for Vector Electronic Co., Sylmar, Calif. The other two main suppliers are Vero Elec-

COMPARING BREADBOARD TECHNIQUES								
Hardware type	Used by	Circuit suitability		Digital logic allowable	Hardware price	Profile	Method of mounting passive components	Wiring method
		Digital	Analog					
IC-socket panel	Industry, laboratory	Good	Fair	Schottky TTL, ECL with multilayer panel	High	High	Requires special adapters	Wire-Wrap
Circuit board	Industry, laboratory	Good	Fair	Schottky TTL, ECL	Low	Low if soldered	Direct	Soldering, Wire-Wrap
Perforated board plus push-in pins	Industry, laboratory, hobby	Fair	Good	TTL	Lowest	High	Direct	Soldering, but can accept Wire-Wrap pins
Solderless breadboard socket	Industry, laboratory, hobby, education	Good	Good	TTL	Low	Low	Direct	Push-in, stripped, solid wire into special contacts
Jumper panel	Laboratory, education	Good	Fair	TTL	High	High	Requires special adapters	Specially purchased jumpers into on-panel posts



2. **Trying out a CRT terminal.** Working from a circuit-board schematic, Applied Digital Data System Inc. wire-wraps an IC-socket panel (above, left). After the panel is tried out on a logic-card tester, it is put into the system breadboard (bottom). After the system is debugged, the panels are converted into double-sided pc boards (above right) for use in production terminals.



3. Solderless action. Pressing components and stripped interconnecting wires onto an E&L Instruments solderless socket (top) forms a breadboard—minus the controls—of the circuits of a function generator. The breadboard is combined with a universal instrument module to make a fully functional model (middle). The finished product is an E&L function generator (bottom).

tronics Inc., Hauppage, N.Y., and Douglas Electronics Inc., San Leandro, Calif.

All versions have a grid of holes on 0.1-inch centers and plated-on connector fingers. The most heavily used of the many varieties has rows of isolated plated pads for DIPs and copper strips for ground and voltage. Often there are test points and uncommitted pads for passive discrete components. The voltage and ground strips usually are interleaved to cut circuit noise with distributed capacitance.

The most common way to assemble circuit boards is to solder DIP sockets and passive components into place, wire them according to the circuit schematic, and then insert the ICs. An alternative method solders the ICs directly without sockets. A third uses DIP sockets with wire-wrappable pins and additional wrappable pins as needed.

The circuit board has a low profile and is fairly inexpensive—30¢ per IC position. It is suitable for TTL and linear applications, although special versions with a continous ground plane on one side work with ECL and analog designs up to 100 megahertz.

Since circuit boards require soldering, their reliability is only as good as the solderer's. Repairs require unsoldering, and the board's pads are like any pc in their inability to withstand many repairs. Wiring density is good, but it cannot compete with, say, two-level wrapped wire.

Transfer from breadboard to production pc is easy, especially if the dimensions and the connectors of the two devices are the same. Many firms use circuit boards from breadboarding right through to production.

Circuit boards and IC-panel sockets are the only commercial breadboard systems designed for out-of-lab environments, so they are the only ones seen in production equipment. Their sturdiness also makes them ideal for military "brassboards," which are breadboards that can be taken from the lab and tested under field conditions. Industry is beginning to use brassboards in demonstrators or rush field modifications.

The cheapest breadboard

Not all designs call for IC-socket panels or circuit boards. For example many analog systems with bulky discrete components and relays may be better suited to perforated boards—the so-called "perf board."

Pioneered by Vector in 1948, perf boards are made of phenolic or glass-epoxy, or sometimes of copper-clad glass-epoxy for high-frequency work. The original format was 0.093-inch-diameter holes on a 0.265-inch grid. A newer version has 0.042-inch holes on a 0.1-inch grid.

Special metal pins or terminals that accept components with large lead diameters are staked into the boards for all wiring and component mounting. The staking operation usually requires a special tool. The older version is used mainly for analog work with fairly large discrete components, while the newer version can accept DIP components. Soldering is the principal means of interconnecting perf boards, but spring-loaded press-in pins are available.

A 25-square-inch perf board costs 44¢, and 100 pins cost $1.60, so this is the cheapest of the five breadboard systems. It probably is the slowest construction technique, but it is the most flexible, because any analog circuit can be assembled. It can be used for TTL, but the lack of a ground plane limits some applications.

Perf boards with plated-on connection fingers are interchangeable with similar-sized pc boards. With care, they may be substituted temporarily for the pc boards.

CAD vs breadboards

Computer-aided design can bypass the breadboard stage of large digital systems. For instance, at Digital Equipment Corp., Maynard, Mass., only single- or double-sided boards using TTL are tried out on DEC-designed wire-wrappable panels.

"For highly complex pc boards like a multilayer board with high-speed logic, the IC panel cannot duplicate the MLB performance," says Ray Moffa, DEC's engineering manager for components. "Because of this, we go to computer-aided design to produce a prototype board quickly."

The CAD boards are tried out on the bench and then revised as necessary by computer. Certain boards (such as memory boards, which have a regular repeating pattern) are almost always designed by the firm's CAD department, regardless of complexity.

The easily wired breadboard

The three systems described so far need special tools to interconnect wire and components. The solderless breadboard socket, originated in 1967 by A. P. Products Inc., Painesville, Ohio, is wired simply by pushing the stripped ends of 20- to 26-gauge insulated solid wires into grids of spring contacts molded in a plastic body.

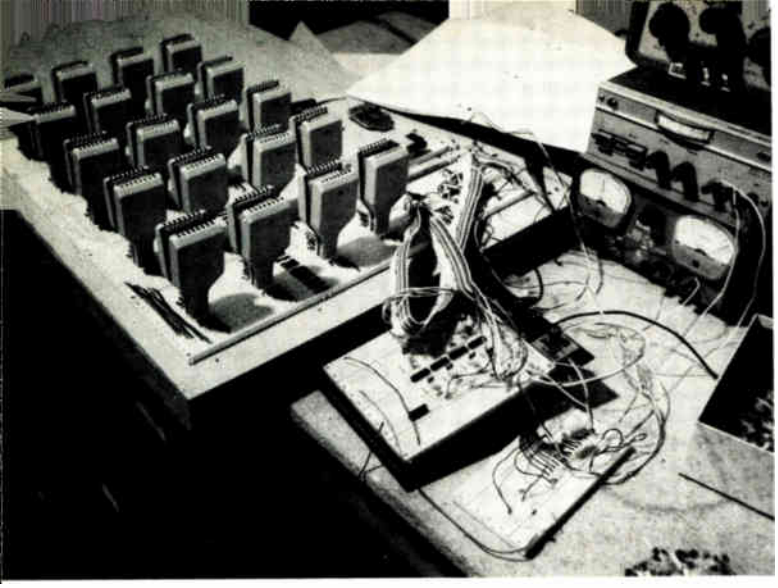
They are designed to accept almost any electronic component, from passive to 40-pin DIP large-scale integration. The limiting factor is the diameter of components' leads. Besides A. P. Products, two other companies supply full-sized versions of the breadboard sockets—E&L Instruments Inc., Derby, Conn., and Continental Specialities Corp., New Haven, Conn. Vector offers a version with 8 to 24 positions that plugs into perfboard.

A typical breadboard socket, the E&L SK-10, is shown in Fig. 3a. The entry holes in the acetal copolymer body are on 0.1-inch centers. Running full length are two rows of vertical contacts, which are used for component wiring. On each outside edge are two rows of common busses for voltage and ground distribution. There are eight separate busses, because each of the four rows is split at the middle point of its length.

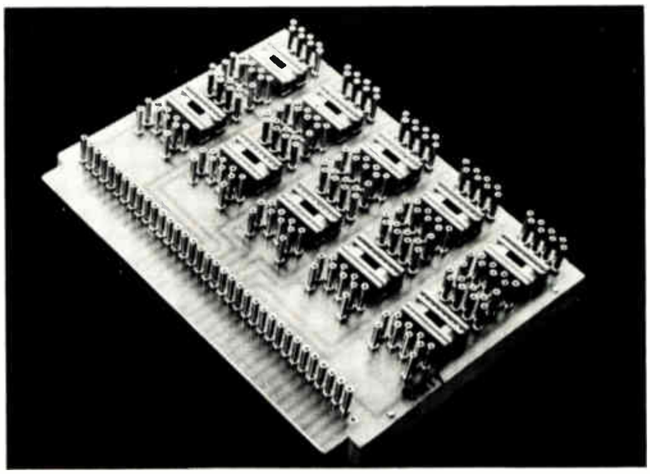
Breadboard sockets cost about $2 per IC-socket position, so the version pictured, with nine 14-pin DIP sockets, costs around $18.50. However, there is no need for special tools or mounting equipment.

Main advantages of this system are wiring speed without special skills needed, reusability, and ability to accept most components. Since the parts layout is on a 0.1-inch grid, conversion to a pc board with the same grid is easy.

The plastic body more or less limits the breadboard



4. Burn-in. Using solderless sockets in burn-in tests allows quick replacement of the units under test. Continental Specialities Corp. tests its logic probes on a setup of its own sockets.



5. Jumpering. Special jumpers (not shown) make quick interconnections to the wiring posts of this Garry jumper panel. Soldering and wire-stripping or wire-wrapping aren't necessary.

socket to the laboratory, so temperature testing must be done with a different breadboard system. The socket is fine for TTL, MOS, and C-MOS, but the 3-picofarad capacitance per contact is too much for ECL or Schottky TTL.

Figure 3 shows a typical application, in design of a function generator. First, a breadboard socket is wired and loaded with components. Next, it is attached to a special panel that holds large potentiometers or other controls. Finally, the breadboard design evolves into the modular instrument.

In other breadboard systems, models vary only in the number and types of DIPs accommodated. But the breadboard socket is available in many forms: packages of multiple sockets on metal ground planes; packages with test equipment, power supplies, signal generators, and switches, and packages for digital or operational-amplifier design exclusively.

To facilitate transfer from breadboard to pc board, solderless sockets may be mounted on epoxy-glass boards with connectors. E&L Instruments even has printed-circuit boards with the interconnection pattern of its breadboard sockets.

The system also is used as a simple connector, as an IC socket in tests, and as a simple burn-in fixture for light-emitting diodes, pilot lights, discrete transistors, and the like. Figure 4 is an example of a breadboard socket used as a burn-in fixture.

The low cost, small size, and ease of wiring of breadboard sockets make them popular with hobbyists and engineers who like to experiment at the desk or at home. The Heath Co., Benton Harbor, Mich. includes a breadboard kit in its catalog of do-it-yourself electronic devices. Other retail outlets carry the socket only.

There are times when an engineer wants to try out a circuit in a hurry and then quickly tear it down. Soldering, wirewrapping, or even stripping a wire will slow him up. So he turns to the jumper panel, the breadboard system designed for fast construction and reuse.

Supplied by Augat, Garry and Cambridge Thermionic Corp., Cambridge, Mass., jumper panels have integral DIPs, flatpacks, or TO-5 sockets. Also on the top are rows of posts connected to each socket pin with printed wiring (Fig. 5). Special jumpers plug into the posts and interconnect the sockets.

Jumper panels are expensive, since the user pays for both board and the jumpers. With the other breadboard systems, inexpensive wires do the interconnections. The jumpers cost 30¢ to 40¢ each, and the boards cost $2 to $2.50 per IC position. However, the entire system is reusable.

A jumper panel has a high profile and a low component density because of the posts on the board top. The system is used in R&D labs and in the classroom, but rarely in industry.

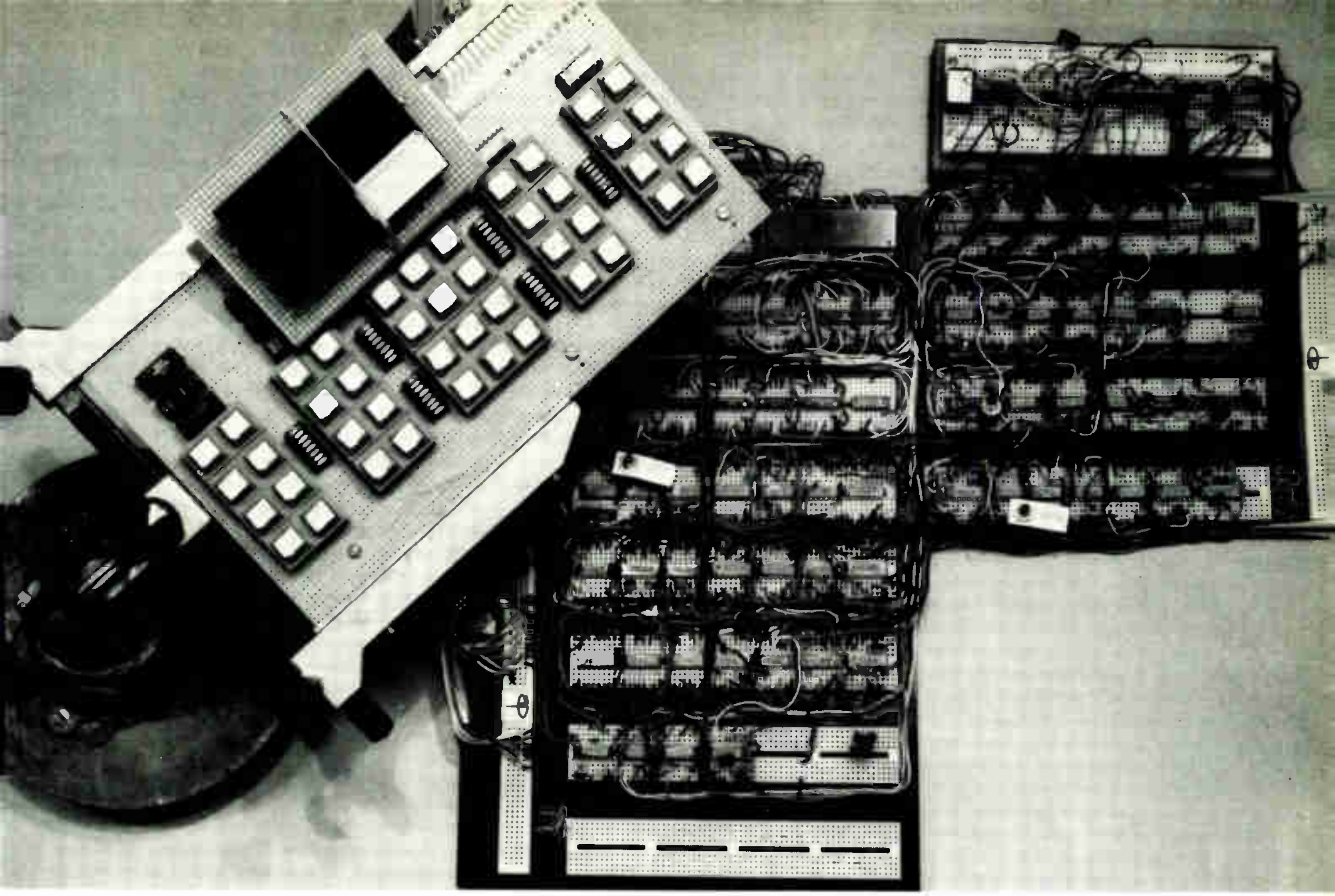
Combining breadboard systems

Breadboards aren't limited to standardized applications of the commercial systems. There are more exotic uses, including combinations of systems, breadboards of more specialized circuits, and homemade breadboards.

Many companies try to settle on one breadboard system for all their designs, but quite a few find that only a combination can work. For instance, American District Telegraph Co., New York, N.Y., tries out large digital systems on IC-socket panels and smaller systems on circuit boards. The cover shows a panel and a circuit board from ADT.

Sometimes ADT's engineers will mount a circuit board on a logic panel to add a small amount of logic quickly to an existing circuit. They often build a power supply module on a perf board in order to power IC-socket panels.

Figure 6 shows another example of combining breadboard systems. The instrumentation division at the U.S. Army's Picatinny Arsenal, Dover, N.J., built the breadboard of a programable calculator with solderless breadboard sockets, a perf board, and a stick-on circuit pattern from Instant Instruments Inc., Haverhill, Mass. (The stick-on is a copper-plated pattern on a 1/16-in.-thick, adhesive-bottomed epoxy-glass board that can be combined with blank boards and soldered



6. A mixture. This breadboard for a programable calculator from Picatinny Arsenal combines different systems. At left, a perforated board with the keyboard and display circuitry is mounted on a holding fixture. Other circuits and the wiring are on the two ranks of solderless breadboard sockets to the right. A stick-on copper wiring pattern serves as connector to the perforated board circuitry.

components and wiring to form a sixth, sometimes-used kind of breadboard.)

The keyboard and the digital readout of the Picatinny design are mounted on the perf board with wire-wrapped connections underneath. Most of the electronic circuitry is on the solderless breadboards. One end of a tape cable is pressed into a socket breadboard. The other is soldered onto a pc board connector that plugs into the stick-on pattern, which is pressed onto the perf board as a connector to its circuitry.

Not always look-alikes

Production models may resemble the breadboards, but they can just as easily differ radically, notably in such applications as development of LSI chips, hybrid circuits, and analog instruments.

Ray Kozak, a design engineer at Teleglobe Pay-TV System Inc., New York, N.Y., is using an E&L solderless breadboard to design complex custom LSI chips. He is developing TTL and analog circuitry in the video frequency range with the sockets. After the circuits have been tried out on the breadboard, they are laid out on an E&L circuit card with the same wiring pattern.

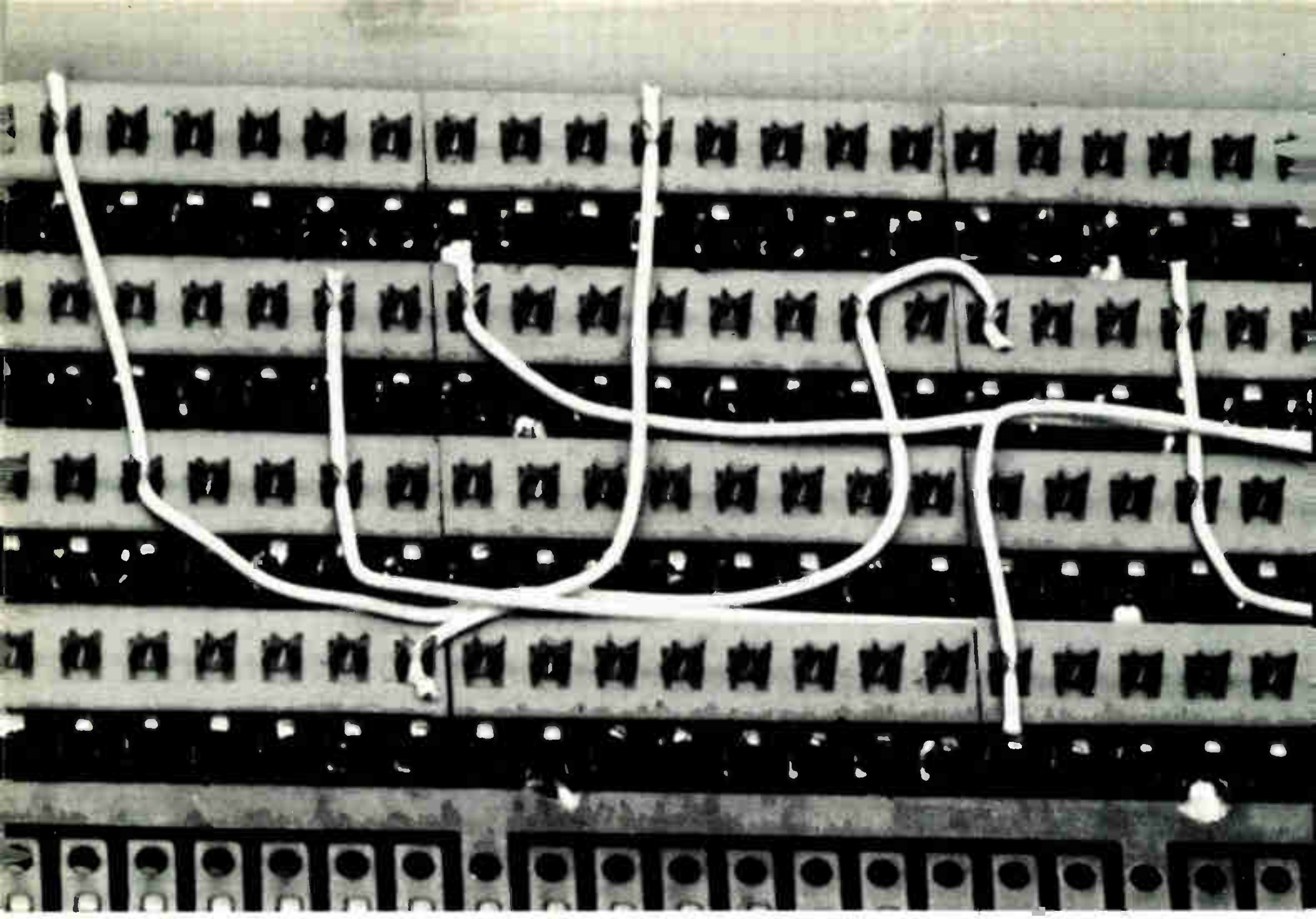
Then the pc board is tested environmentally and used in a demonstration model. Once it is proven out, it goes to an IC manufacturer for conversion to a custom LSI chip used in Teleglobe's production models.

ILC Data Device Corp., Bohemia, N.Y., tries out thick-film circuits on perf boards. Discrete or passive chips are mounted in TO-5 headers, which are then mounted on sockets of a small perf board that simulates the ceramic hybrid substrate and parts layout as nearly as possible. Using a breadboard this way can save the cost of design problems or component failures in the prototype stage.

In analog work, ICs can be in TO packages or DIPs. Discrete semiconductors at all power levels must be accommodated, as must larger components like transformers, potentiometers, relays, and even motors. In many cases, an analog breadboard has no resemblance to the final package, so a board with a connector and provision for many DIPs is not needed.

A case in point is Gull Airborne Instruments Inc., Smithtown, N.Y., whose main product is aviation instruments. These mostly analog instruments are laid out on large perf boards that house discrete passive components, transformers, linear ICs, digital-to-analog and analog-to-digital converters, and the like. Since the boards are big and open, it is easy to make the many measurements necessary to check out a precision instrument design.

After the breadboard passes the tests, Gull's engineers build a prototype, often a small rectangular or cylindrical container with the circuitry of four perf boards



7. **Piercing the wires.** A new breadboard type from Bell Labs is wired by pressing the wires into rows of special insulation-piercing terminals on the bottom of an epoxy-glass board. DIP components are inserted in rows of pin sockets on the board's top side (not shown).

on one flexible or rigid printed circuit.

At times engineering firms have to develop their own breadboards. For instance, Comtech Labs Inc., a Smithtown, N.Y., firm specializing in satellite communication equipment, tries out low-frequency analog work on perf boards and digital circuitry on IC-socket panels. But analog circuit design in the 1-gigahertz area is tried out on home-built pc boards, because none of the commercial breadboards will work at such high frequencies. The Comtech boards have special printed wiring on one side and a full ground plane on the other.

High-frequency breadboards

At AIL, a Cutler Hammer Inc. division, much of the radar and rf work isn't adaptable to commercial breadboards because of the high frequencies involved. Engineers at AIL in Deer Park, N.Y. try to approximate the final configurations in breadboards. With radar circuitry, special double-sided boards with plated-through holes and most components mounted on standoffs are designed . To simulate rf operational conditions, a rectangle is machined out of an aluminum blank, and a circuit board with components mounted on standoffs is dropped in.

At Bell Laboratories, Holmdel, N.J., the breadboard usually is the prototype, since there is no production there. Charles Von Roesgen, supervisor of optical systems, has tried several breadboard systems in packaging digital prototypes—solderless breadboard sockets, jumper panels, and IC-socket panels.

"With solderless sockets, ICs go in easily, but wire has to be stripped to plug it in," he says. "Larger-size wires often require considerable force and bend rather than engaging the socket contact. Also, when changes are necessary, too many wires often come up.

"Jumper panels can be wired up fast, but they're expensive and have an extremely high profile due to the jumper wires looping above the board." He has found that solderless sockets and jumper panels tend to develop intermittent contacts when stored for any length of time.

For a while, Von Roesgen settled on IC-socket panels, but he discarded them because of their high profile and the difficulty of repairing. "The wrap to be removed always was under two other wraps."

Finally, he invented a new breadboard [*Electronics*, Nov. 27, p. 48] that is wired by just pressing the wires onto insulation-piercing terminals (Fig. 7). It has a 0.42-inch profile, allowing it to replace a pc board directly in a system. It is a printed-circuit board with socket pins to accept DIPs on one side and the special terminals on the other. Bell Labs doesn't make this breadboard for outside firms, but there is nothing to prevent a firm from seeking a license to produce it commercially. ☐

ISSCC PREVIEW:

Memories score new highs in speed and density

Device watchers convening at Philadelphia are previewing improved memories to bow later this year, as well as advances in logic, converters, and microwave devices

by Laurence Altman, Solid State Editor, and Lucinda Mattera, Components Editor

☐ Designers of integrated circuits save their most exciting ideas for the International Solid State Circuits Conference in Philadelphia. They have outdone themselves at the conference being held this week.

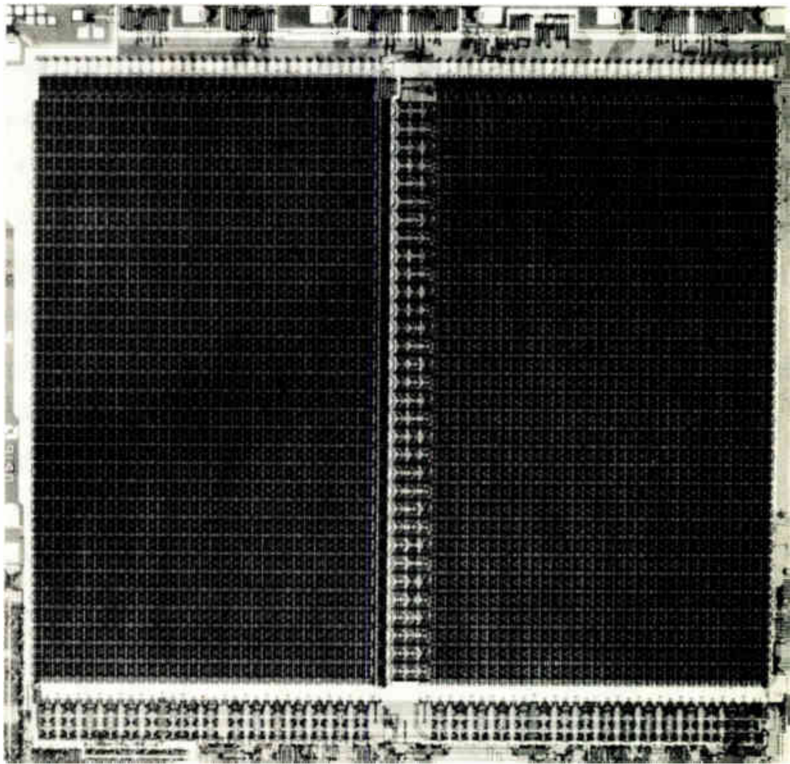
Both digital and analog technology have advanced significantly. But the memory developments are truly outstanding. Here's what the attendees are being treated to in this area alone:

- The first disclosure of the 16,384-bit random-access memory—the type of device that's expected to get more use during the next five years than all other RAM types. Sampling has already begun, and production should begin this year.
- The first dynamic bipolar RAM to reach the 4,096-bit level and also the first bipolar RAM to be built with integrated injection logic. With projected speeds of less than 100 nanoseconds, this device type, which could significantly reduce costs of add-on and buffer memories, should go into production before the year ends. Depending on what it costs to build, this memory also has the best chance of any of the bipolar RAMs to grab a piece of the booming main-memory market.
- The first 5-volt static RAM to reach the 4,096-bit level. This device has the same high speed and low power dissipation as the popular 1,024-bit statics. It will certainly become a new standard for military systems and make inroads into microprocessor static-memory systems. The beginning of production is promised for this year.
- The fastest n-channel MOS static RAM, a 1,024-bit device that's capable of speeds in the 70-ns range. It's expected to give bipolar RAMs a run for their money in the fast-memory market.
- The first charge-coupled memory chip to hit the 65-kilobit level. This complexity puts CCDs right on target for replacing mechanical magnetic mass memories—drums and disks.
- A new RAM concept called on-chip refresh or self-refresh. Most, but not all, of the dynamic device's advantages—high density and speed plus low power—are retained, while the device is easier to use and less sensitive to high-temperature effects than RAMs using conventional refresh methods. The concept is being applied to 4,096-bit n-MOS and partially-populated complementary-MOS designs, but don't look for commercial production of these device types this year.
- A new MOS technique called V-MOS saves space by using a V-groove gate structure to access the source region. V-MOS applied to read-only memories results in 16-kilobit chips that are considerably smaller and faster than other 16-k MOS ROMs. The technique can also be applied to logic. ROM production is expected to begin this year.

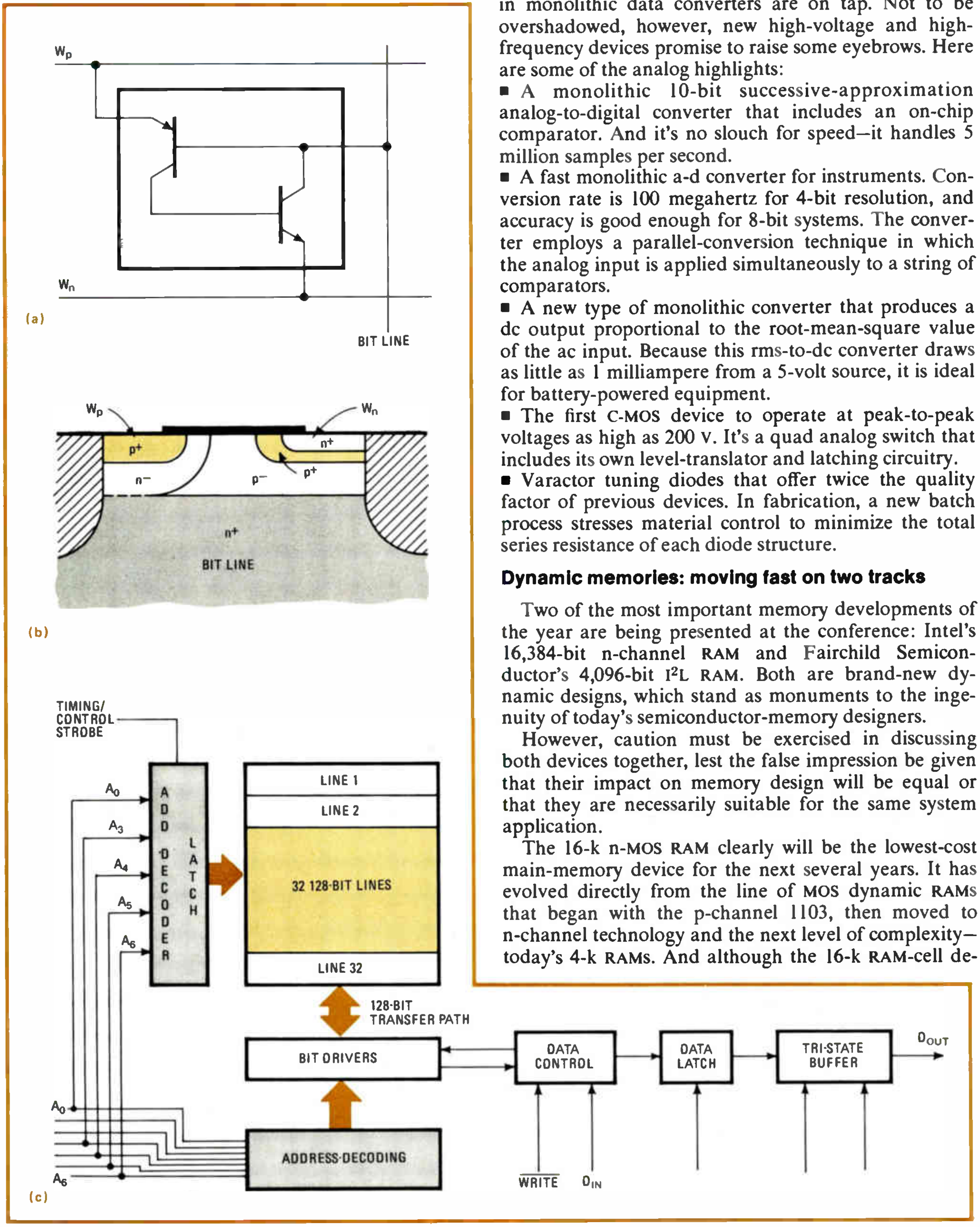
Two outstanding developments in logic circuits are also of interest:

- A 16-bit n-channel controller for a minicomputer has typical cycle time of 300 ns (five times faster than today's n-MOS microprocessors). Built with a new silicon-gate technique, the gate-oxide method [*Electronics*, Nov. 27, p. 99], it contains 16 registers and 255 input and output ports that can access 16 kilobytes.
- A microprogram sequencer that's built with inte-

Improvements. This 5-volt 4-kilobit static RAM from Advanced Micro Devices is typical of the memory advances exciting designers at ISSCC. It joins the 16-k dynamic RAM, 4-k I²L dynamic RAM and 65-k memory as this year's standout developments.



1. I^2L RAM cell. The small size of this bipolar cell comes from Fairchild's injection-logic structure—a compact walled npn device and a double-diffused high-quality lateral pnp device. Speed and current capacity are 10 times those of previous I^2L structures.



grated injection logic—the first time a function that complex has been designed onto a single LSI chip. Device performance is impressive: gate delays of less than 10 ns and power-delay product of 0.1-picojoule.

Among analog devices, several significant advances in monolithic data converters are on tap. Not to be overshadowed, however, new high-voltage and high-frequency devices promise to raise some eyebrows. Here are some of the analog highlights:

- A monolithic 10-bit successive-approximation analog-to-digital converter that includes an on-chip comparator. And it's no slouch for speed—it handles 5 million samples per second.
- A fast monolithic a-d converter for instruments. Conversion rate is 100 megahertz for 4-bit resolution, and accuracy is good enough for 8-bit systems. The converter employs a parallel-conversion technique in which the analog input is applied simultaneously to a string of comparators.
- A new type of monolithic converter that produces a dc output proportional to the root-mean-square value of the ac input. Because this rms-to-dc converter draws as little as 1 milliampere from a 5-volt source, it is ideal for battery-powered equipment.
- The first C-MOS device to operate at peak-to-peak voltages as high as 200 V. It's a quad analog switch that includes its own level-translator and latching circuitry.
- Varactor tuning diodes that offer twice the quality factor of previous devices. In fabrication, a new batch process stresses material control to minimize the total series resistance of each diode structure.

Dynamic memories: moving fast on two tracks

Two of the most important memory developments of the year are being presented at the conference: Intel's 16,384-bit n-channel RAM and Fairchild Semiconductor's 4,096-bit I^2L RAM. Both are brand-new dynamic designs, which stand as monuments to the ingenuity of today's semiconductor-memory designers.

However, caution must be exercised in discussing both devices together, lest the false impression be given that their impact on memory design will be equal or that they are necessarily suitable for the same system application.

The 16-k n-MOS RAM clearly will be the lowest-cost main-memory device for the next several years. It has evolved directly from the line of MOS dynamic RAMs that began with the p-channel 1103, then moved to n-channel technology and the next level of complexity—today's 4-k RAMs. And although the 16-k RAM-cell design is new and elegant—it is built with a double level of polysilicon borrowed from charge-coupled techniques (for details of the 16-k RAM, see p. 116)—it's an extension of the basic silicon-gate technology that started semiconductor-memory activity, rather than a breaking of new ground. That's why the 16-k device is expected to reach production so quickly—probably this year—and have such a swift impact on memory-system design through the spectrum—from mainframes to terminals and microprocessor systems.

On the other hand, the 4-kilobit bipolar RAM is a pioneer device. As the first dynamic bipolar RAM intended for commercial production, it combines the new circuit-design techniques of I^{2}L with one of the industry's most advanced circuit-fabricating technologies—walled oxide-isolated bipolar structures—and the result is elegant and extremely compact.

The bipolar chip is no larger than today's 4-k dynamic-MOS equivalents (less than 20,000 mil^2), and as production matures, its operating speed is intended to fall below 100 ns. What's more, power dissipation (typically 400 milliwatts active and 80 mW standby) is no greater than today's MOS RAMs.

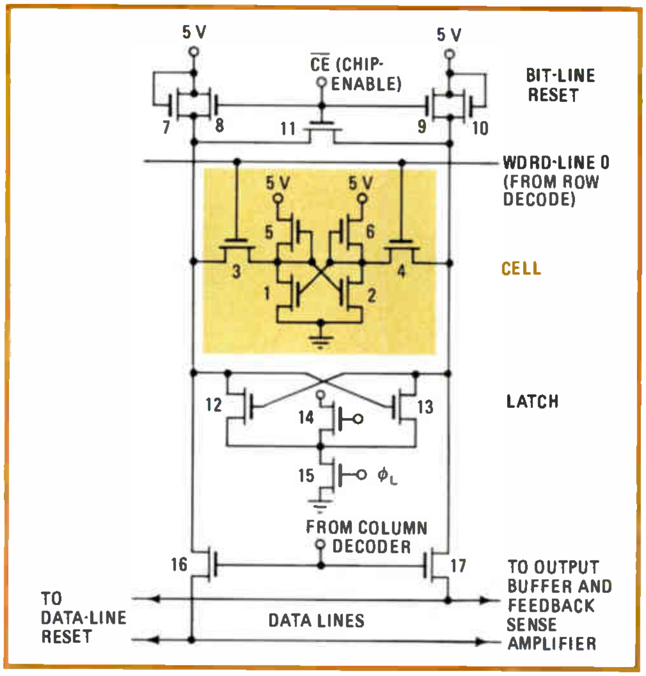
Cost will be decisive

The performance is impressive, but what does it cost to build? The answer will determine where the I^{2}L RAM fits into the memory design. The device is certainly destined to have a major impact on today's bipolar-memory systems: cache, buffers, scratch pads, add-on memories, and some ECL-controlled main memories, in which high speed requirements usually come before cost considerations.

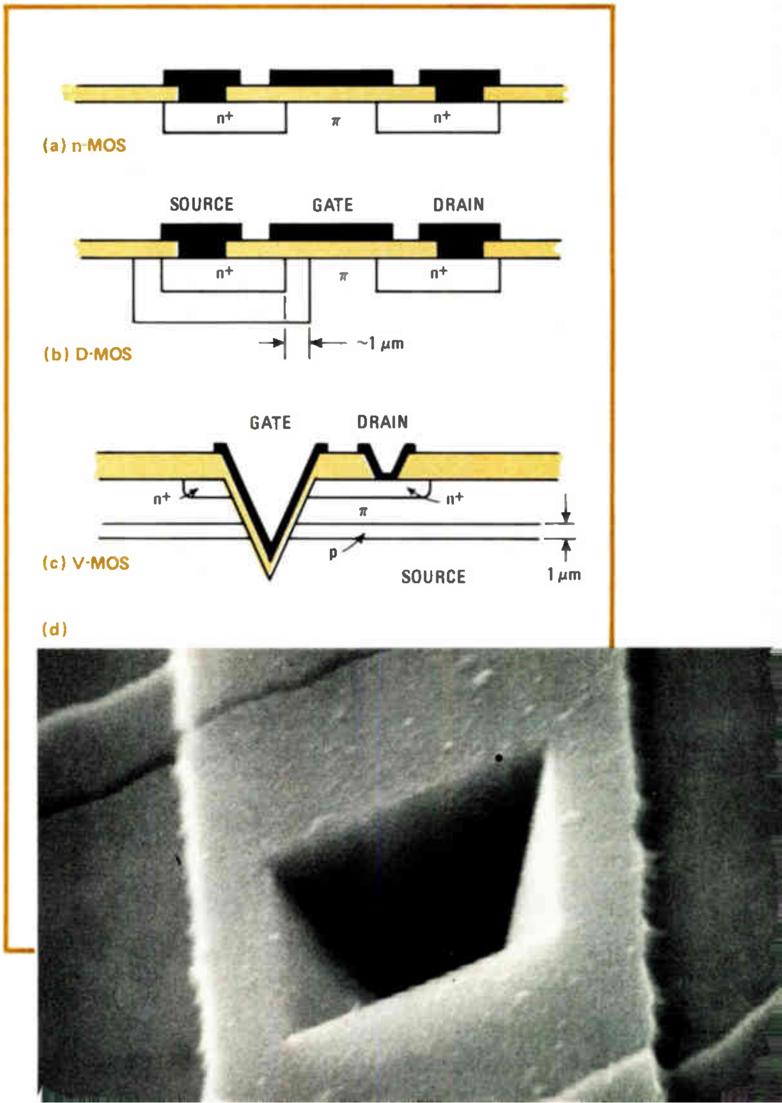
A major question is whether or not this type of device will make an impact on the larger lower-cost memory segments—the n-MOS devices used in mainframe memories and microprocessor-based systems. The answer will be determined by the costs of building complex LSI bipolar structures that need narrow (micrometer) base dimensions and yet provide high yields many times across each wafer. The production experience that manufacturers like Fairchild and Texas Instruments accumulate with this type of memory will determine just how much of a footing bipolar memories and logic will get outside of the high-performance market.

The cell structure of the 4,096-bit I^{2}L RAM (Fig. 1a) shows its conceptual simplicity. Composed of a transistor pair made up of lateral pnp and npn devices, its cross section (Fig. 1b) is no larger than a one-transistor MOS-RAM cell. That compactness was achieved by using Fairchild's Isoplanar II process, which produces the highly compact npn device with walled emitters, together with a double-diffusion process, which produces the narrow, high-concentration, high-quality base element that's needed for the lateral device.

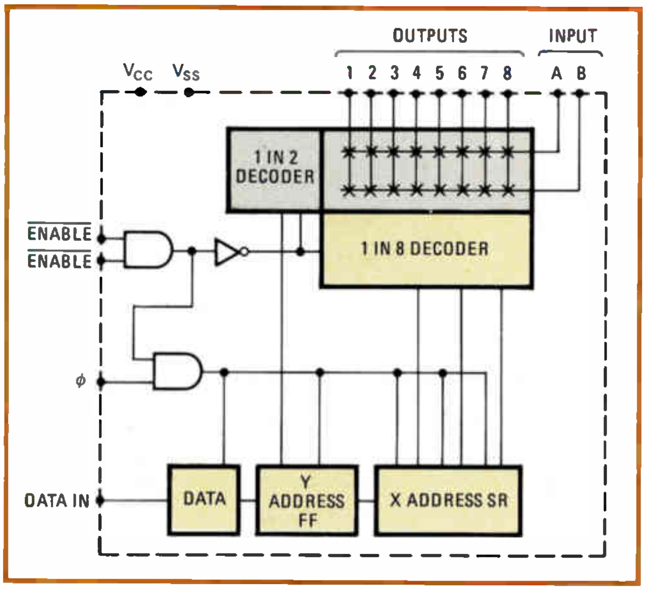
This base fabrication is crucial because it provides lateral devices with tenfold higher speed and current ca-



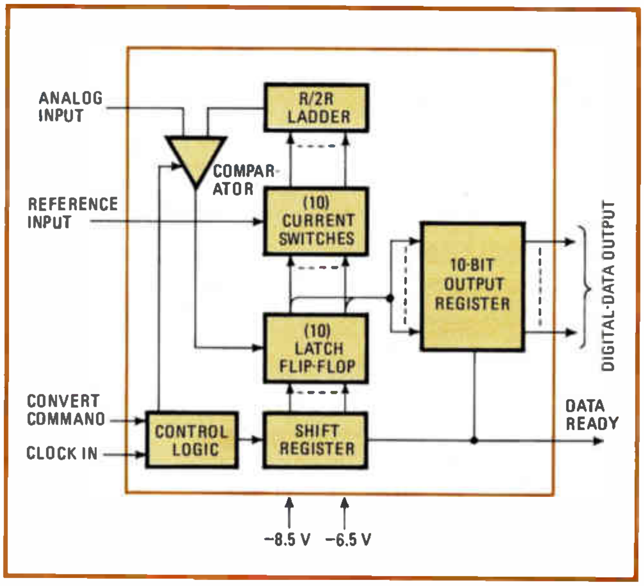
2. The 4-k static. AMD achieved 4-k density in static RAMs with a six-transistor cell and a proprietary oxide-isolated process. The 5-V device, contained on a die of about 40,000 mil^2, will be available in a 22-pin package that has a typical access time of 150 ns.



3. New MOS. Two new ways are being evaluated for making 1-micrometer MOS devices (a). The D-MOS structure from Signetics (b) has a second p region in the channel, and AMI uses a V-groove gate arrangement (c). Microphotograph shows V-MOS details (d).



4. D-MOS crosspoint switch. This 8-by-2-crosspoint switching network is built with D-MOS transistors because they offer better isolation and lower parasitic capacitance than conventional MOS transistors. In this Signetics chip, crosstalk is typically less than 105 dB.



5. Just about complete. Ten-bit successive-approximation analog-to-digital converter from TRW, which includes on-chip comparator, requires only external clock and reference source. The chip is fast, too—it samples the analog input 5 million times a second.

pacity than conventional n-type epitaxial base elements. That configuration allows the pnp to be used, not only as a current source, but also as a signal switch, and yet provide exceptionally high performance in the bargain.

Like all dynamic RAMs, three lines make contact to each cell. In the normally biased condition, one of the write lines, W_N, and the bit line are both at 3 V, while the other write line, W_P, is kept near ground. To write a 1, the W_N line is pulled to the W_P level near ground, while the bit line is kept at 3 V; that charges the collector-base capacitor, C_B. To write a 0, the W_P line is pulled up to the W_N level of +3 V, while the bit line is held at +2 V so that C_B is discharged through the pnp. To read, the W_N line is simply pulled near ground. If C_B contains a charge, the bit line is unaffected. If C_B is discharged, its β− multiplied charge couples to the bit line after the npn emitter-base junction is forward-biased; this pulls down the bit line so that its potential can be sensed and latched either to +3 V for a 1 or +2 V for a 0.

The block diagram of the whole memory is shown in Fig. 1c. All output signals, which have low capacitance, can drive transistor-transistor-logic interfaces. The chip, even though it is dynamic, requires only a single +5-V power supply.

Static but not stagnant

Circuit innovators also have improved MOS processing to achieve the 4,096-bit 5-V static RAM. The design, developed at Advanced Micro Devices Inc. of Sunnyvale, Calif., uses enhancement- and depletion-load silicon-gate technology with AMD's oxide-isolation process called Linox. The combination produces a 5.3-mil^2 six-transistor static cell (shaded area in Fig. 2). Everything fits on a chip measuring slightly less than 40,000 mil^2—large by dynamic-RAM standards, but not bad for a 4-k static design. (Fully static cells need five or six transistors, but dynamic cells need only one transistor.)

The performance of the 22-pin RAM is exceptional. Operating from a 5-V supply, the 4,096-bit has a typical access time of 150 ns and dissipates only 350 mW. The static RAM is configured 1,024 words by 1 bit, but it will also be available in 4,096 words by 4 bits. Easy to use, it runs from a single low-capacitance transistor-transistor-logic clock that has no maximum pulse width. For a thrifty power-down capability, the supply voltage can be dropped to 1.5 V, which reduces dissipation by 80%. Moreover, the device will operate over full military voltage and temperature ranges.

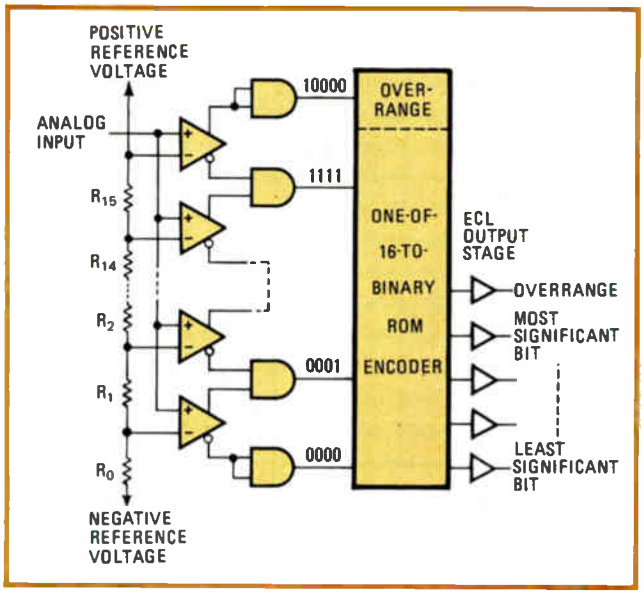
The fast access time is achieved through static storage and pipelined peripheral-circuit techniques generally found only in dynamic RAMs. Again referring to Fig. 2, the chip-enable (CE) selection initiates and controls all memory operation. When CE is low, all cells are deselected, and the bit and data lines are equalized to an intermediate voltage (Q_7 through Q_{11} and Q_{14} through Q_{22}). When CE goes high, the address and chip-select inputs are latched into on-chip buffers.

When the selected row decoder is then clocked by an internally generated timing signal, the selected cell begins to discharge the heavily capacitive bit and data lines. Q_{12} through Q_{15} form a latch that assists the cell in discharging the capacitance.

In a new memory capability, a timing signal is then generated from a reference row of cells, energizing the latch at precisely the right moment. The data-line voltage is then detected and presented to the output buffer by a feedback differential amplifier, which is compensated for process, temperature, and voltage variations.

Looking ahead: V-MOS and D-MOS

Two new MOS techniques are now being applied to digital devices. One, called V-MOS, uses a V groove to access the source element in the MOS structure, and the



6. Emphasis on speed. Parallel-conversion design permits monolithic 4-bit analog-to-digital converter from Tektronix to operate at 100 MHz with sufficient accuracy for 8-bit systems. The analog input is applied simultaneously to comparator-chain links and then encoded.

other, called D-MOS, uses a double-diffused gate region. Both processes provide the MOS channel lengths of only 1-µm needed for the next round of increases in memory- and logic-device complexity and performance.

Cross sections of D-MOS, V-MOS, and standard silicon-gate n-channel devices are shown in Fig. 3. In the standard silicon-gate structure, present photolithographic procedures must be stretched to their utmost to yield the necessary narrow channels. Today, the practical limits of these processes are 4- and 5-µm lines, especially for making large LSI chips, where narrow lines can reduce yields drastically.

But in both the D-MOS and V-MOS production, narrow channels are produced by diffusion or implantation, rather than by squeezing photomasking limits. In the D-MOS structure, a second lightly doped p diffusion, called a π region, together with a heavily-doped p-region, are made in the channel, as shown in Fig. 3b, so that channel lengths can be controlled down to 1 µm.

With the V-MOS structure, an n^+ substrate is the common source for all devices, and a p layer 1 µm or less thick determines the effective channel length in the saturated regions. This dimension, which is vertical, can be more easily controlled than in the D-MOS production. Moreover, a π layer lowers the drain capacitance and increases the drain breakdown, so that reliable devices that have a 25-V breakdown are being produced. And because the source is essentially the substrate plane and contact made from above via the groove, V-MOS gate geometry is highly efficient. The device shown in Fig. 3c, for example, has a channel width of 25µm, and yet its gate area is only 10 µm by 10 µm.

Designed by American Microsystems Inc. into a read-only memory, the V-groove MOS process produces a 16,384-bit 5-V static device that fits on a chip less than 17,000 mil^2, compared to present n-channel ROM dice larger than 22,000 mil^2. Moreover, the speed of AMI's V-MOS ROM is at least doubled; worst-case access time is 200 nanoseconds.

The V-MOS ROM process does require seven masking steps—one more than is needed for straight depletion-load n-MOS devices. The extra mask is used for the V grooves, while the various surface structures are made in a conventional manner by the other six masks.

The D-MOS process has been used by Signetics Corp., Sunnyvale, Calif., to build a crosspoint array for telephone switching on a single chip. Because of the demanding requirements of low crosstalk and low insertion loss, that application has long resisted IC techniques. But its low parasitic capacitance makes the D-MOS technique ideal for the job. Switches made with this technology have an on resistance three to five times smaller than conventional MOS devices, and crosstalk is typically only about −105 dB.

The array (Fig. 4) is an unbalanced 8-by-2 switching network. The decoder selects one of the 16 switches as predetermined by a 4-bit code loaded serially into the 5-bit shift register. The fifth bit determines whether the switch is to be turned on or off. To turn a switch on or off, the chip is enabled for five clock cycles and then disabled. Approximately 2 milliseconds later, the latch associated with that switch has been set, and the chip is ready to receive.

For operation at a 1-MHz rate over an 8-bit cycle there is a switch update every 8 µs, or 125,000 switch updates every second. The crosspoint array has been designed to interface with a microprocessor control. All digital inputs are compatible with both TTL and C-MOS, and the chip is operated from a single + 15-V supply.

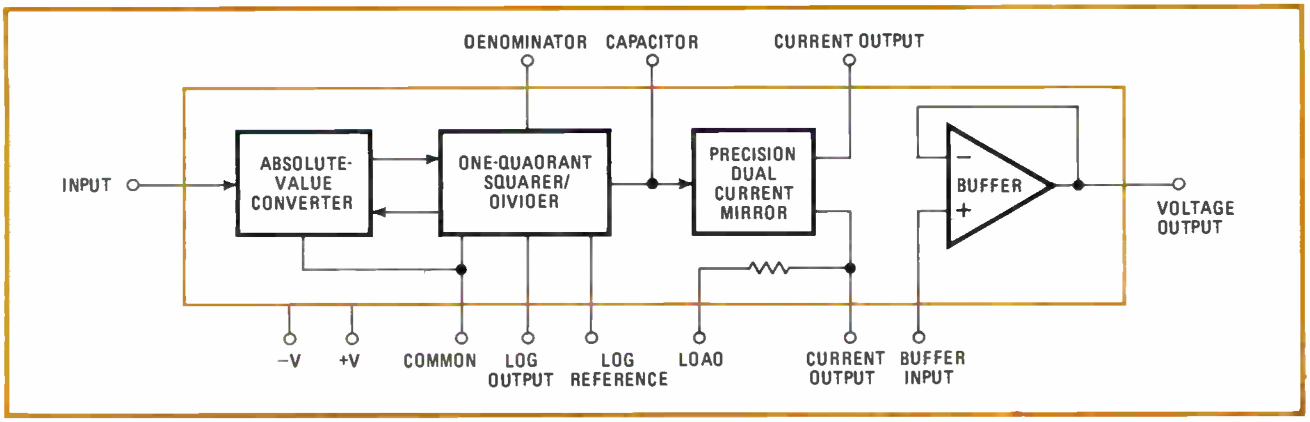
IC converters improved

Data acquisition in real time is often limited by the speed of the analog-to-digital converter. However, new circuit techniques are being used to build monolithic data converters that operate at higher speeds, provide higher accuracy, and require fewer external components than previous converters. Happily, because they are easier to manufacture, they are also less expensive.

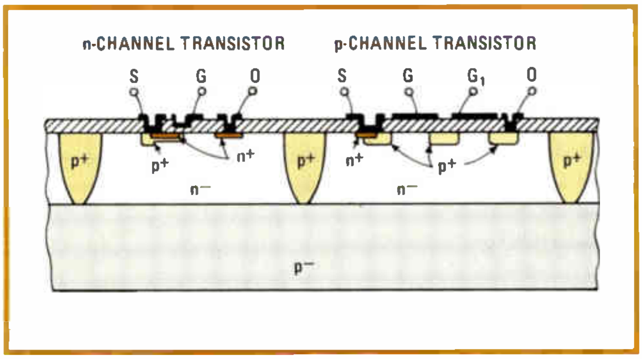
In successive-approximation a-d converters, the TRW Systems Group, Redondo Beach, Calif., has developed a 10-bit bipolar LSI chip that requires only the addition of an external clock and reference source. In contrast, previous monolithic 10-bit a-d converters generally needed an outboarded comparator. The new device quantizes an analog signal into 10 bits, within ±¼ least significant bit. Moreover, it operates at the respectable processing rate of 5 million samples per second. Total power consumption is only 2.7 W.

A block diagram of the chip is shown in Fig. 5. The current-summing ladder, which is made up of cermet thin-film resistors, and the 10 differential-pair current switches, which are made up of bipolar transistors having a crossover frequency of 1 GHz, form a digital-to-analog converter. A two-level titanium-aluminum metalization structure connects the resistors to the transistors, and a silox-oxide layer acts as the dielectric between the two metalization levels.

A new bipolar a-d unit from Tektronix Inc. of Beaverton, Ore., delivers all-out speed at some sacrifice in



7. Rms-to-dc. Converter chip from Analog Devices develops dc output current or voltage that is proportional to true root-mean-square value of ac input. Essentially a self-contained unit, it requires only the addition of an external averaging capacitor.



8. High-voltage C-MOS. Quad analog C-MOS switch built by Stanford University can handle up to 200 V at 300 mA. Each switch consists of one D-MOS n-channel and two series-connected p-channel transistors. Level-translator and latching circuitry are included.

resolution. When operating at a conversion rate of 100 MHz, its resolution is only 4 bits, but it can provide sufficient accuracy for 8-bit data-acquisition systems.

The unit employs a parallel a-d conversion technique, as indicated in its block diagram (Fig. 6). The analog input is applied simultaneously to all the comparators, which have equally spaced reference inputs that are derived from a string of thin-film resistors. The converter has 16 comparators, as well as a 4-bit binary encoder. Each comparator cell, which includes binary encoding, is made up of only 15 transistors. The power dissipation of a single cell is only 32 mW, and the crossover frequency for the transistors is 3 gigahertz.

A different kind of converter chip

Other types of data converters are starting to appear in monolithic form. On a single chip, Analog Devices Inc., Norwood, Mass., has fabricated a complete rms-to-dc converter. The device converts an ac input voltage or an ac-plus-dc input voltage to a dc output voltage or current that is proportional to the true root-mean-square value of the input. The unit is fully trimmed and requires only one external component—an averaging capacitor. It can be used to find the rms, absolute, squared, or mean-squared value of an input.

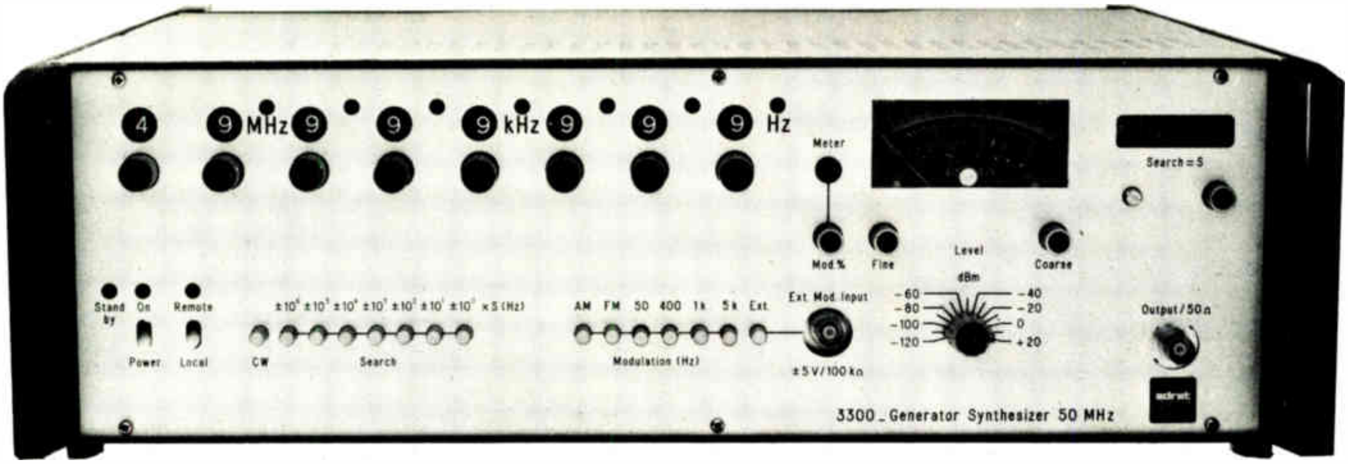
A straightforward technique is used to make the rms-to-dc conversion. As shown in the block diagram of the device (Fig. 7), a precision full-wave rectifier first obtains the absolute value of the input voltage. This signal is then converted to a current and applied to a single-quadrant current-mode squarer/divider. The chip includes a separate buffer amplifier for obtaining a voltage output, as well as a logarithmic output for directly reading out rms levels in decibels.

The new converter can operate over a 60-dB dynamic range and a bandwidth of 500 kilohertz. When powered by a dual supply of ±15 V, the unit has an input range of ±20 V and an output range of 0 to 10 V. When powered from a single 5-V supply, the unit operates over an input range of ±2 V and an output range of 0 to 2 V. With a 5-V supply, power dissipation can be as low as 5 mW.

Also, C-MOS is breaking down its traditional small-signal barriers and entering the high-voltage domain. The Integrated Circuits Laboratory of California's Stanford University has developed a monolithic quad C-MOS analog switch (Fig. 8) that is capable of handling voltages of up to 200 V, yet can be controlled by low-level signals of between 0 and 15 V, which is the normal operating range of standard C-MOS circuits. This means that the new analog switch can operate directly from a rectified ac line voltage while performing any linear or digital function commonly implemented by conventional low-voltage C-MOS devices. The new switch may even displace discrete transistors in such applications as driving high-voltage displays and transducers.

The chip, which measures only 3 by 3.6 millimeters, contains four analog switches, each with its own associated level-translator and latching circuitry. A single switch is composed of a pair of high-voltage transistors—an n-channel and a p-channel device. Each switch is capable of handling 200 V peak to peak at a maximum current level of 300 milliamperes.

In high-frequency devices, varactor diodes are offering twice the quality factor they used to. Because of a new batch-processing technique and tight materials control, a family of gallium-arsenide Schottky-barrier tuning varactor diodes from the Microwave Semiconductor division of Hewlett-Packard Co., Palo Alto, Calif., provides a quality factor (Q) that is double that of existing devices. Yields are also higher for the new diodes, and the new process is more reliable than earlier ones, claims HP. For 30-V devices, Qs of around 15,000 can be obtained at 50 MHz. ☐



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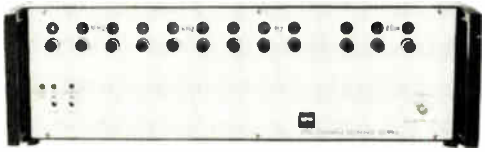

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Video detector stores peak for minutes

by Stephen Hayes
Altadena, Calif.

In slow-scan image processing, a video signal often must hold its peak value for longer than the few seconds provided by diode peak rectifiers. But a rectifier that can retain a peak value of a video signal for up to four minutes can be built from two operational amplifiers and two transistors, avoiding the cost and complexity of digital storage for a sample-and-hold circuit.

In the circuit shown in Fig. 1, the CA3100 op amp compares the input signal (between 0 and 6 volts) to the voltage on a 0.47-microfarad plastic capacitor. The output of the CA3100 is an amplified error signal used to adjust the charge on the storage capacitor.

The storage and output sections are conventional. A MOSFET operational amplifier, the CA3130, with the twin assets of low cost and low input bias current, acts as a unity-gain buffer between the capacitor and the output terminal. The 2.2-kilohm resistor lowers the output impedance from the very high level of the 3130.

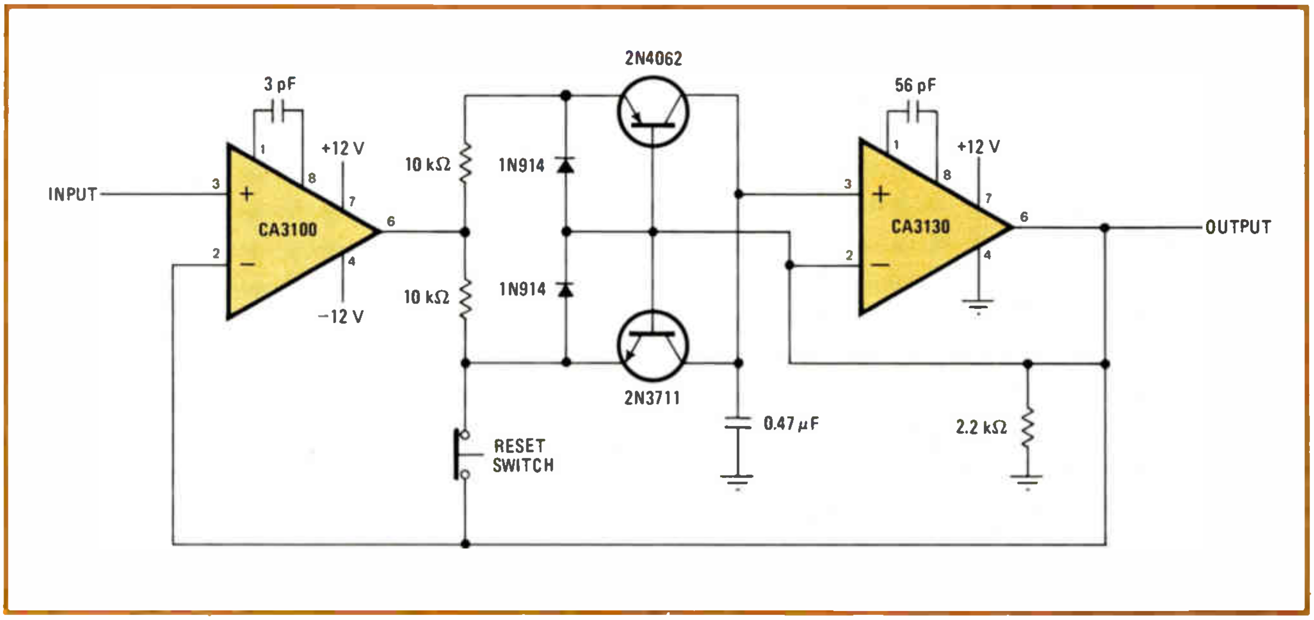
The key feature of the circuit is the unusual method of transferring charge into and out of the capacitor. Normally, a peak rectifier uses a series diode for this purpose. However, the diode has a reverse leakage current that is unpredictable, temperature-dependent, and often on the order of several nanoamperes. To avoid this leakage, the circuit shown uses the base-collector junction of a pnp transistor to transfer charge. The current is injected into the emitter, with the base connected to the output of the buffer amplifier. As a result, the base-collector voltage is close to zero, and collector leakage current is small.

An npn transistor is added to allow the capacitor to be discharged. Normally, this transistor does not conduct because its base-emitter junction is shorted by the switch. Thus, when the switch is closed, the output voltage (which is equal to the voltage across the capacitor) is determined by the most positive level applied to the input terminal. When the switch is open, the output voltage tracks the input signal (Fig. 2).

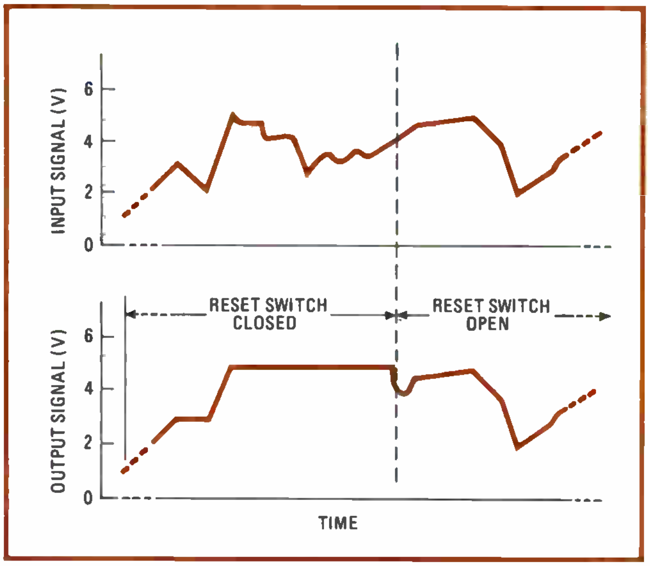
Holding performance of the circuit is quite good. If a 3-V signal is applied and removed, the output decays less than 10 millivolts in 10 minutes. This implies that the total leakage current into the capacitor is less than 10 picoamperes.

A drawback is the low slew rate. The minimum slew rate is set by the 10-kilohm resistors, the 0.47-μF capacitor, and the difference between the maximum output voltage of the CA3100 and the maximum signal voltage. With a 6-V input signal, the slew rate is about 850 V/s.

Several variations on the circuit are possible. The switch could be replaced by an electronically controlled device, such as a relay or a CD4016 complementary-metal-oxide-semiconductor transfer gate. This change



1. Stores maximum level. Peak detector circuit accepts analog input signals of 0 to 6 V in amplitude, provides output level that is maximum value of input. Use of pnp transistor for rectification minimizes charge leakage from capacitor, so peak level can be held for several minutes. Switch and npn transistor allow circuit to be reset. While reset switch is open, output signal follows input signal. If the reset switch is relocated to short the emitter to the base on the pnp transistor, the circuit is a minimum level detector, storing the lowest level of the input signal.



2. Holding the peak. Output from circuit of Fig. 1 is the highest level that has been applied to the input since switch was closed. If switch is opened, output slews down to input level, and then follows input. Circuit was developed for determining dynamic range of low-bandwidth scanning signal from an electron microscope, but is useful for any peak rectifier that requires low decay rate.

would allow electronic control of the reset function.

If the switch is moved to the emitter of the npn transistor, the circuit stores the lowest level of the input signal. If switches are placed in both locations, the circuit can function in four modes: tracking (both switches open), positive peak detector, minimum level detector, and holding (both switches closed).

By using both a positive peak detector and a minimum level detector in a circuit, maximum and minimum voltage levels can be stored for such purposes as setting the gains of variable-gain amplifiers, or storing the levels of transient peaks in a signal. ☐

Mark/space modulator drives acoustic coupler

by Jack D. Dennon
Computerphone Systems, Renton, Wash.

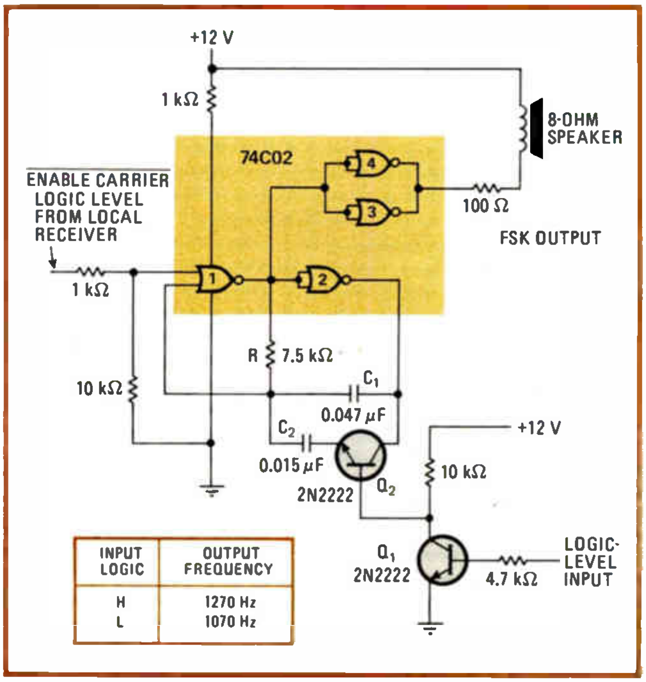
When data must be transmitted over a voice channel, the circuitry used to translate the logic lows and highs into audio-frequency signals usually includes frequency-trimming potentiometers. But precise enough mark and space audio signals can be obtained from a circuit that uses only standard resistor and capacitor values, provided the supply voltage is well-regulated.

The circuit shown translates serial logic-level data into audio-frequency analog frequency-shift-keyed signals for transmission by telephone, radio, or other voice channels. The modulation function, including provision for a logic-level data input and an active-low enable-carrier input, is implemented with a single complementary-MOS 74C02 quad NOR gate. The output buffer, which consists of gates 3 and 4 of the integrated circuit, has four n-channel transistors paralleled to ground for driving an 8-ohm speaker. The speaker provides acoustic coupling to a telephone handset.

Logic low at the data input turns off transistor Q_1 and turns on transistor Q_2. With Q_2 on, C_2 is switched into the circuit. The frequency of the audio oscillator, made from gates 1 and 2 of the integrated circuit, is proportional to $1/RC$ where $C = C_1 + C_2$. Switching C_2 into the circuit causes the output frequency to shift from K/RC_1 to $K/R(C_1+C_2)$ where K is a constant. With the component values shown, $K/RC_1 = 1{,}269$ hertz, and $K/R(C_1+C_2) = 1{,}052$ Hz. These frequencies have been found to be sufficiently close to the specified 1,270-Hz mark frequency and 1,070-Hz space frequency for reliable transmission at a data rate of 110 bits per second to a Bell 103 dataset.

The circuit draws about 30 milliamperes from a regulated 12-volt supply. With appropriate changes in the values of components R, C_1, and C_2, supply voltages from 6 to 15 V can be used.

The enable-carrier input to the modulator is driven from a companion receiver circuit to complete the "handshake" sequence at the beginning of a data call; that is, the local receiver asserts the active-low enable



FSK modulator. C-MOS quad NOR gate is audio-signal generator and output driver/buffer for transmitting data over voice channel by frequency-shift-keyed audio signals. The logic-level enable-carrier input must be taken low for the modulator to operate; this input is driven by the local receiver and is used to properly sequence the initial exchange of signals called "handshaking." The enable carrier should be taken low about half a second after the dataset at the other end of the line answers the call with its 2,225-Hz marking tone.

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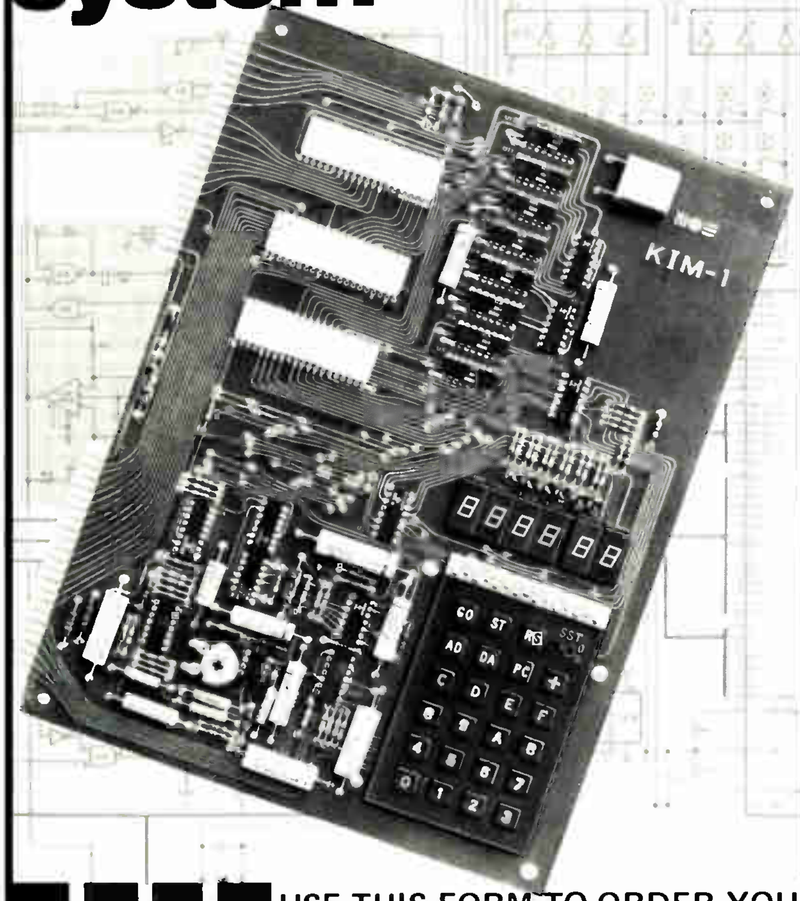

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City ____________________ State ______________ Zip ________ carrier shortly after it first hears the 2,225-Hz marking tone coming from the dataset at the other end of the phone line.

Bell 103 line protocol calls for frequency-division-multiplexed simultaneous two-way transmission. The modem originating the call sends 1,270-Hz mark and 1,070-Hz space frequencies and receives 2,225-Hz mark and 2,025-Hz space frequencies from the answering dataset. At the beginning of the call, the answering dataset immediately places its 2,225-Hz mark signal on the line. On a long-distance call, this tone should be allowed to reside alone on the line for at least 400 milliseconds to disable any one-way-at-a-time devices (echo suppressors) on the telephone trunk lines. ☐

Common-gate, common-base circuits shift voltage levels

by Peter J. Bunge
Atomic Energy of Canada Ltd., Chalk River, Ontario

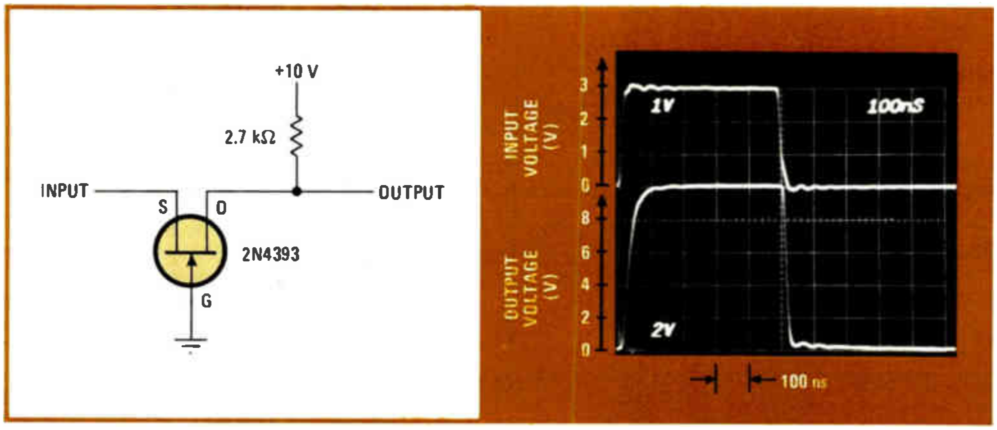
The voltage-shifting interface needed between incompatible logic systems can be quite straightforward—just a field-effect transistor in a common-gate circuit or a bipolar transistor in a common-base circuit. Both circuits are fast, uncomplicated, and economical in both parts cost and power drain.

The common-gate FET circuit shown in Fig. 1 can couple the active outputs from any logic family to a voltage level higher than the V_{CC} of the logic—an impossibility with pullup resistor interfacing or complementary-metal-oxide-semiconductor buffer (4009, 4010) interfacing. It uses much less power than open-collector transistor-transistor-logic interfacing, especially when only one signal is involved, and it is much faster than some commercial level shifters (e.g. 100 nanoseconds versus 900 ns for the Solitron CM410AE). For the 2N4393 FET shown, the input range is 3 to 40 volts while the output range is 0 to 40 V (determined by the pinch-off and breakdown voltages of the device.)

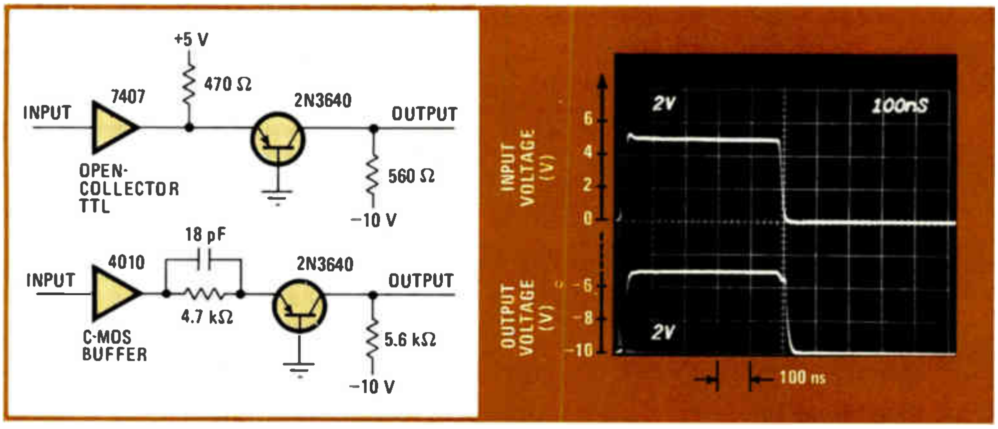
The common-gate circuit provides only positive output voltages. A typical application is in interfacing an n-MOS random-access memory, which has 0-V and 3-V output levels, to C-MOS circuitry. Interfacing is necessary in this case because the 3-V level is just at the operating threshold of C-MOS when it is operating from a 5-V supply.

Common-base transistor circuits are used to interface positive voltage levels to negative-referenced logic. Figure 2 shows arrangements for translating 0-V or +5-V TTL or C-MOS levels to −10 V or −5 V. These methods are simple, require little power, and can be used with either active outputs or open-collector outputs, as shown. ☐

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. Level translator. A field-effect transistor in the common-gate configuration can provide output voltages that are higher than the supply voltage of the driving logic. Here the FET voltage-shifter accepts input levels of 0 or 3 V and delivers outputs of 0 or 10 V. The fast transitions and short delays that are demonstrated in the oscilloscope photo are achieved by minimizing the load capacitance.



2. Signal polarity inversion. Common-base level translator interfaces positive voltages to negative-referenced logic. Circuits here accept levels of 0 or 5 V and deliver outputs of −10 or −5 V. Waveforms shown are for circuit driven by open-collector TTL. Speed is sacrificed to conserve power in the circuit driven by a C-MOS buffer. The 18-pF speed-up capacitor charges input capacitance of transistor.

Enter the 16,384-bit RAM

The densest-yet random-access-memory chip has a two-level cell structure, plus a 16-pin package that can slip straight into a 4-k socket

by James E. Coe and William G. Oldham, *Intel Corp., Santa Clara, Calif.*

☐ A triumph of semiconductor device technology, the 16,384-bit random-access memory has arrived. Its bit density is unprecedented and springs from an enhanced n-channel silicon-gate technique, in which a double level of polysilicon conductors shrinks the memory cell to 450 micrometers square. That's less than half the cell size in the densest 4,096-bit RAM.

The achievement is the latest in a long line of achievements that have doubled memory-chip bit density virtually every year since 1969 (Fig. 1). That year witnessed the arrival of Intel's 1101 256-bit p-channel RAM. Then came the three-transistor cell of the p-channel 1103, adopted by industry as its 1,024-bit standard, and most recently the silicon-gate process produced the one-transistor-cell n-channel 4-k RAM.

As for memory costs, the 16-k RAM promises to cut them dramatically. Compared to present 4-k designs, the 16-k device offers the designer four times as much memory at no increase in equivalent system costs. An example of a 1-million-bit memory system built around 16-k RAMs is shown below: 64 packages, plus all the required peripheral circuitry, fit on a board of the size that today accommodates only a quarter of a million bits of 4-k RAM. And to judge by previous experience, which indicates at least a two-to-one cost savings as each new device generation matures, the 16-k system will become even more attractive.

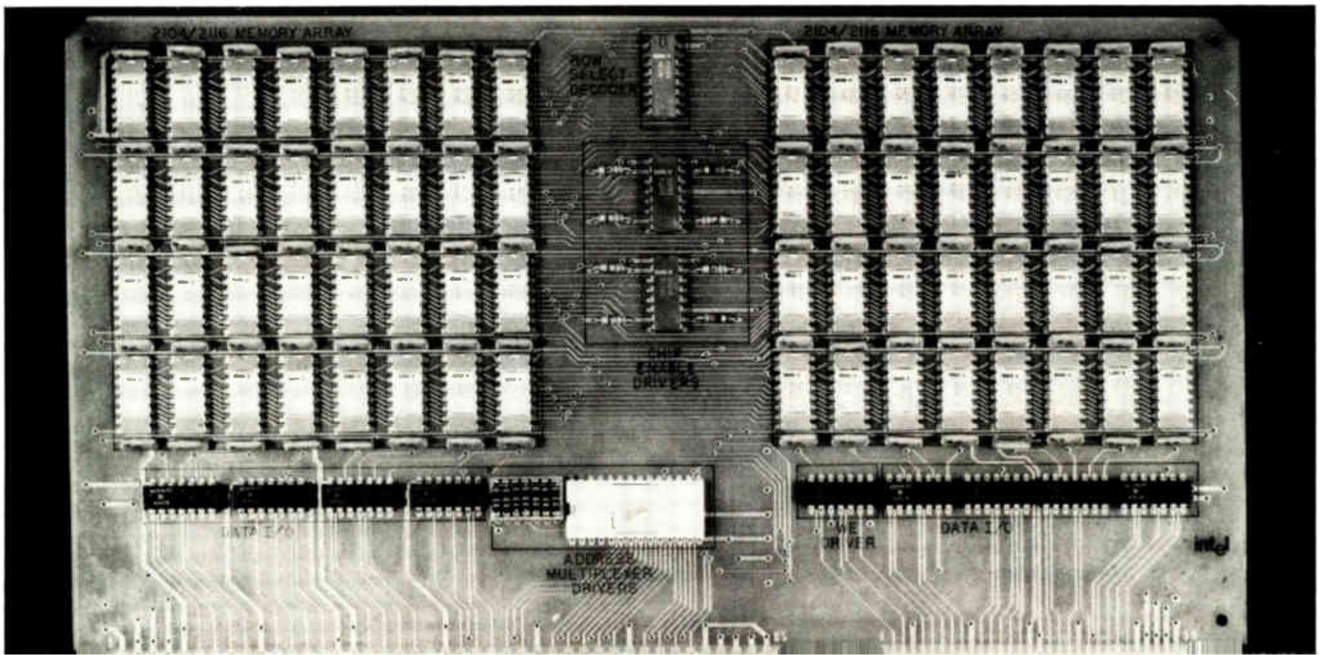
Moreover, system specialists can expect the 16-k technology to mature much faster than did the 4-k RAM technology. The new chip is an extension of, rather than a radical departure from, the n-channel process used in today's standard 4-k devices. Even its most innovative feature—the double polysilicon level—is borrowed from charge-coupled block-memory designs that are already in production. So a high degree of 16-k reliability should build up quickly.

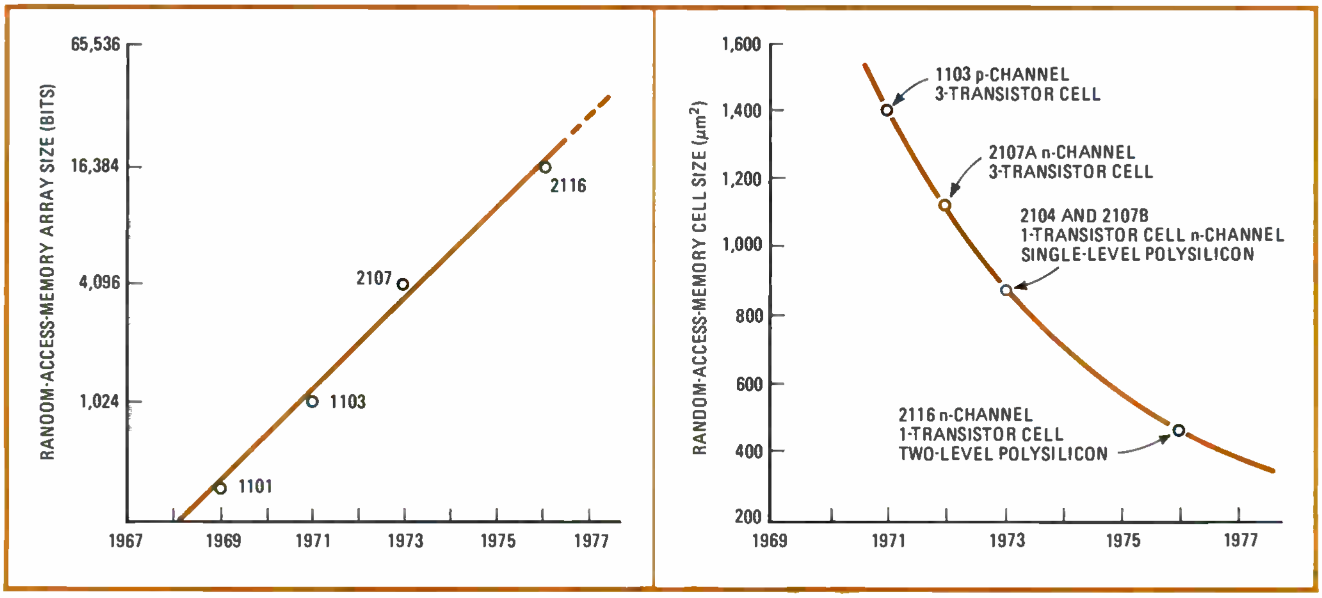
Why the cell shrinks

Basically, there are two elements in a one-transistor cell: the storage capacitor, which holds the charge quantity appropriate to a logic 1 or 0, and the transistor itself, which acts as a switch, dumping the capacitor's charge onto the bit sense line for sensing. In the cell of a 4-k RAM (Fig. 2a), transistor and capacitor sit side by side in the same plane, and a single level of polysilicon is used both as an interconnection and as one capacitor element. Clearly, space could be saved if the capacitor sat under the transistor and a second level of polysilicon made the interconnection.

That's what's done in the cell of the 16-k RAM (Fig.

Four times the memory. Intel's new 16,384-bit random-access-memory chip, the 2116, packs 1 million bits onto a memory board of the size that now holds 250,000 bits of 4,096-bit RAM. The two 16-pin RAM chips are pin-compatible. Board is organized as 64,000 16-bit words.





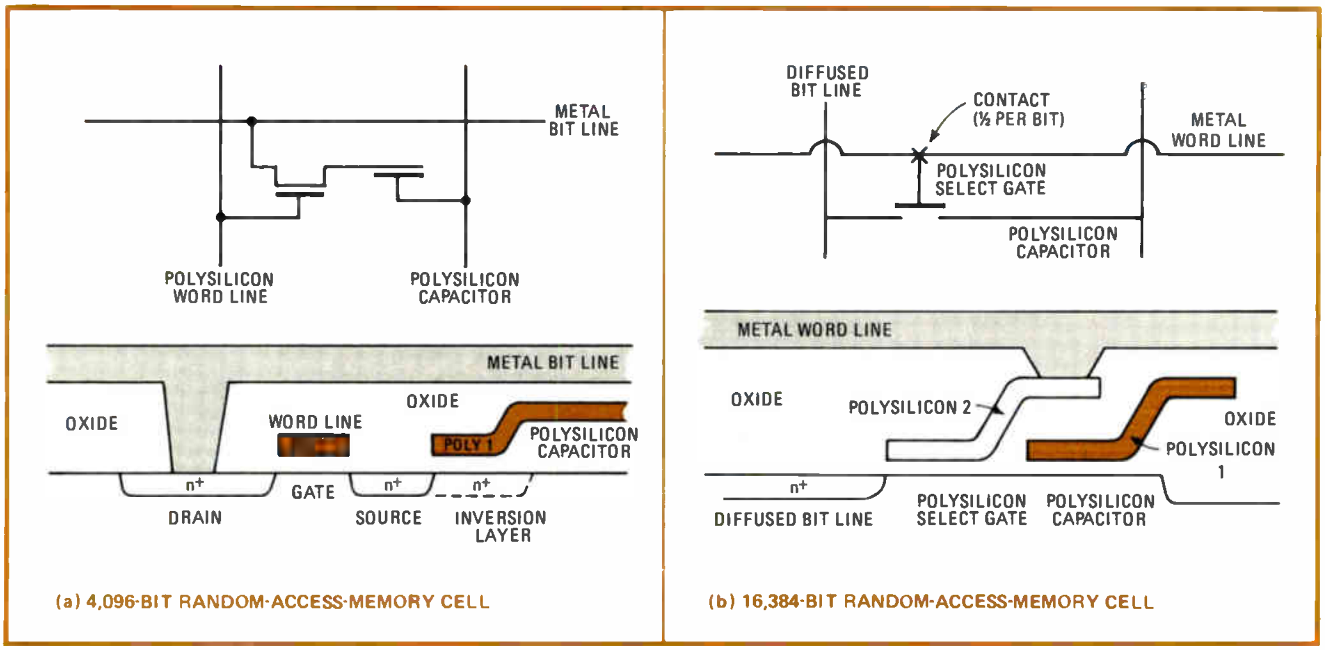
1. Onward and upward. Borne along by an evolutionary MOS technology, RAMs have increased their bit density by almost five orders of magnitude since 1969. The first p-channel three-transistor cell has developed into today's double-polysilicon one-transistor n-MOS cell.

2b). The first polysilicon layer serves as one capacitor element, while the second serves as the gate contact and interconnection. Since a diffused region (transistor source) is no longer needed between gate and capacitor, still more space is saved. What's more, the cell even operates more efficiently because a diffused bit-sense line can be used rather than a deposited metal one, which has higher parasitic capacitance. The entire cell squeezes into an area that is only about 450 micrometers square, or about half the area occupied by the 4-k RAM's cell (Fig. 3).

A side result of the smaller cell is that the storage capacitor in the 16-k cell has about half the capacitance of the 4-k cell. Actual figures are 0.03 picofarad as against 0.07 pF. This could result in smaller bit-sense-line signals to the sense amplifier if it weren't for the fact that the 16-k cells are both smaller and closer together than in the 4-k RAM. This tightened geometry reduces the per-cell parasitic capacitance of the bit line still further and compensates for the lower cell capacitance. The 16-k RAM therefore presents its sense amplifiers with differential signals of about 200 millivolts—no smaller than those found in the 4-k RAM.

Designing the 16-k chip

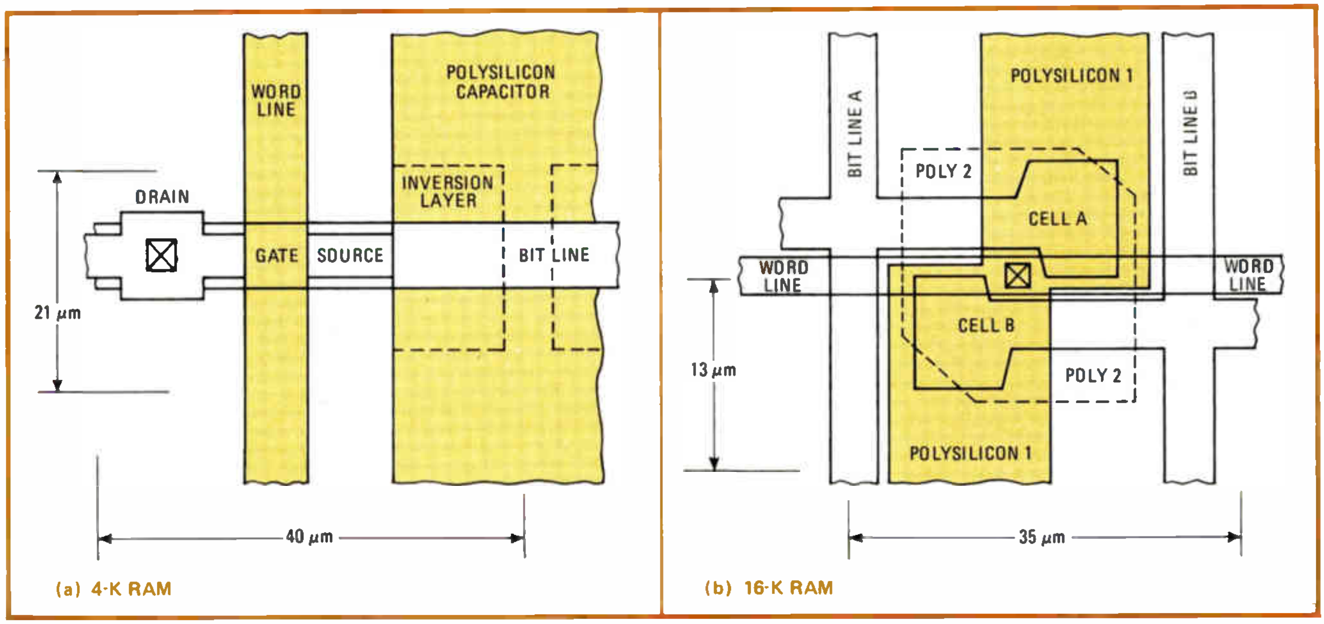
The Intel 2116 RAM uses the kind of double-level polysilicon cell just described. Although a 16,384-word-by-1-bit RAM could have fitted in a 20- or 22-pin pack-



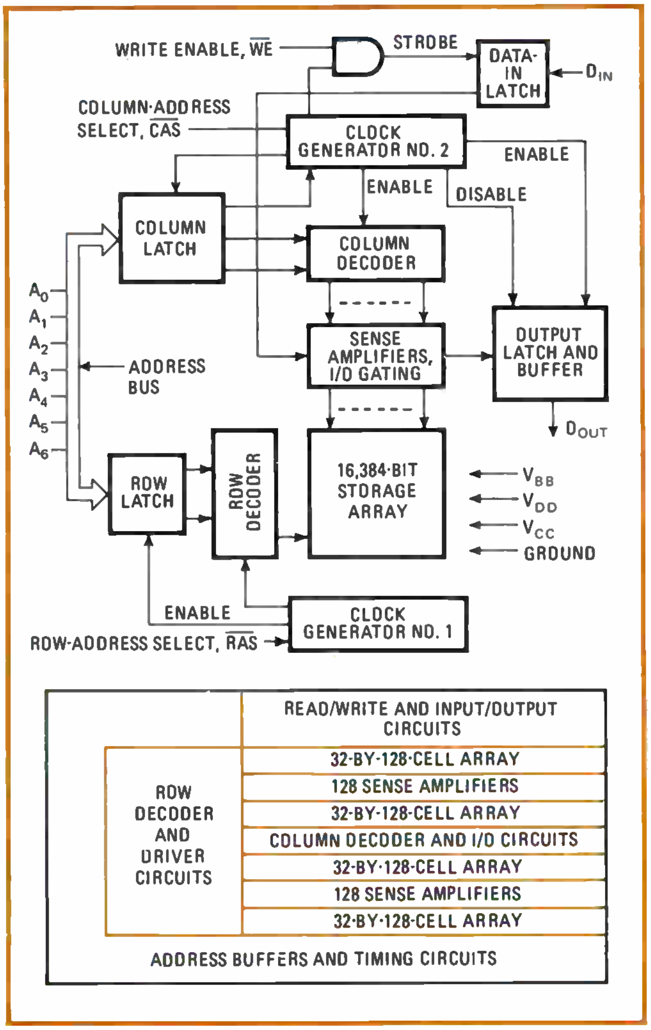
(a) 4,096-BIT RANDOM-ACCESS-MEMORY CELL

(b) 16,384-BIT RANDOM-ACCESS-MEMORY CELL

2. Double layer. The memory cell of the 16-k RAM saves space by placing the capacitor element beneath the transistor and using two separate polysilicon interconnections. In 4-k RAMs, a single polysilicon layer serves both transistor and capacitor, which are on the same plane.



3. Compact layout. Thanks to its two levels of polysilicon, the 16-k cell occupies half the area of a 4-k cell with its single level. The 16-k cell needs only 450 square micrometers and has about 0.03 pF of capacitance, but still presents a 200-mV data signal to the sense amplifier.



4. Organization. The 2116 chip is laid out as two 8,192-bit RAMs sharing a column decoder. Each 8-k RAM consists of two balanced 32-by-128-bit arrays sharing 128 sense amplifiers. Address A_6 selects the top or bottom 8-k half, leaving the other half inactive.

age, the 2116 was chosen to be compatible with existing 16-pin 4-k RAMs. This configuration affords greatest memory density and lowest package cost. For instance, like the 16-pin 4-k, the 16-k's address lines are multiplexed. But that is now standard practice for users of 4-k 16-pin devices, such as Intel's 2104. Fourteen addresses are multiplexed on seven of the 2116's pins, with the seventh address pin obtained by eliminating the chip-select input used on the 2104.

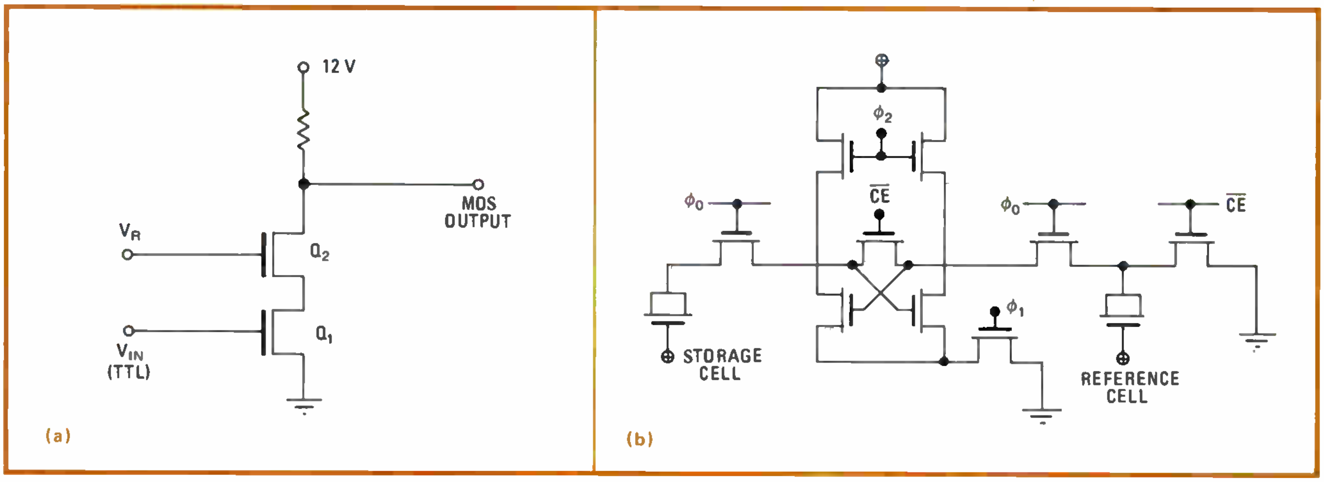
The block diagram and chart of Fig. 4 explain the organization of the 2116. The chip is arranged as two 8-k RAMs sharing a column decoder. Each 8-k RAM is organized as two balanced 32-by-128-bit arrays, sharing 128 sense amplifiers. In normal operation, address A_6 selects the top or bottom 8-k half, and the other 8-k half is kept inactive to conserve power.

Like the 4-k RAM, the 2116 generates all clock signals internally. A static input buffer converts the TTL level of the row address select, RAS to MOS levels (Fig. 5a). To reduce the effect of the large capacitance associated with the drain of the input device Q_1, a transistor operating in a common-gate configuration (Q_2) is inserted between the MOS output and the drain of Q_1. This scheme permits fairly high buffer speed with minimal standby power consumption—typically, 40 ns delay with 1-milliampere standby.

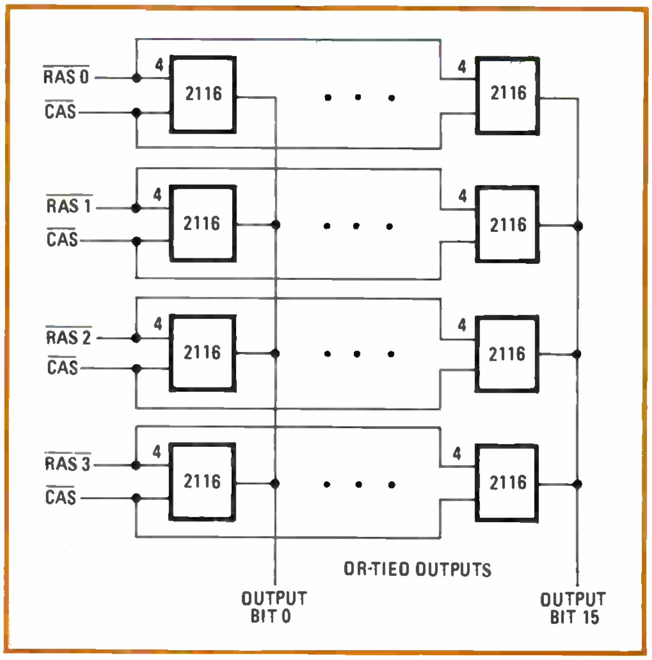
Sensing the small signal

Shown in Fig. 5 is a schematic of the data sense amplifier. Its design is key to the proper operation of a 16-k device. It must detect the small, 200-mV signals read out from the cell, and it must also keep power consumption low—after all, there are 256 such amplifiers on the chip and large unit power dissipation would be disastrous.

In order to pick up the small signals, the otherwise straightforward flip-flop sense amplifier incorporates a reference cell. In order to reduce the power consumption, the load devices of the sense amplifier switch off after information has been written into or restored to



5. The periphery. The static buffer (a) converts TTL column select signals to higher MOS levels. To sense low-level data, a reference cell teams up with a flip-flop sense amplifier (b). To save power, load devices switch off when sense amplifier is idle.



6. Power cut. This 64-k-by-16 word system has OR-tied outputs—a good way to save power in 16-pin random-access-memory designs that use more than 4,096 words. Row-address-select pin is used instead of chip-select pin to select devices.

the cell. The load devices also serve to precharge the bit line, to minimize device count and input capacitance.

The 16,384 memory cells of the 2116 could increase the overhead time needed to refresh the memory. To minimize this overhead, the 2116 organization is modified in the refresh mode. The refresh signal is multiplexed on the column-address-select signal $\overline{CAS}$ (Fig. 4). That is, if $\overline{CAS}$ is valid at the leading edge of the row-address-select signal $\overline{RAS}$, it's recognized as a refresh operation. The output then goes to the high-impedance state, A_6 is ignored, and all cells on the word line selected by A_0 to A_5 are refreshed in both 8-k halves of the RAM. Only 64 refresh cycles are therefore required to refresh the entire memory. (The various refresh modes available with the 2116 are discussed in detail later.)

As for device characteristics and performance, the 2116 operates from standard dynamic-RAM power-supplies (+12 volt, +5 V, and -5 V) over an ambient temperature range of 0°C to 70°C. All its input and output signals, including its two clocks, are TTL-compatible. Its three speed ranges are identical with those of 4-k RAMS like the 2104: maximum access times are 250, 300, or 350 ns, and read/write cycle times are 375, 425, or 500 ns. Typical operating power is less than 700 milliwatts, and typical standby power is less than 12 mw.

The upwardly mobile system design

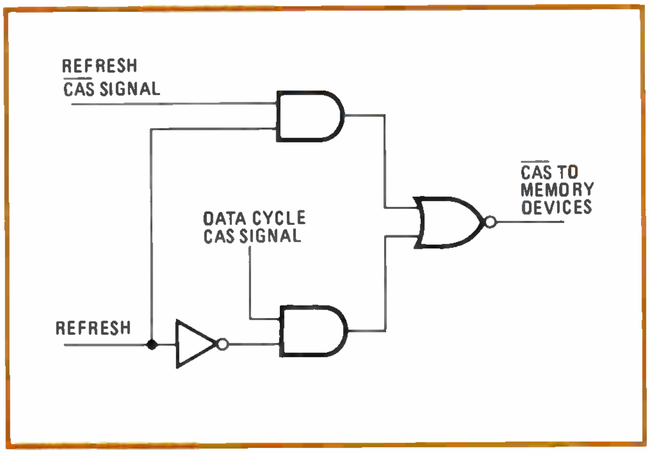
Because the 2116 fits the same socket as the 2104 and other 16-pin 4-k RAMS, an engineer can design a system around the 4-k device for later, easy upgrading into one based on the 16-k device. His reward then will be a quadrupled bit density.

The compatibility between the two memory chips depends on making the 2104's chip-select input the equivalent of the seventh multiplexed address input (A_6) of the 2116 device (Fig. 4). Since in the 16-k part each address input pin is used twice in the multiplexed address mode, the single new address input yields the additional two bits required to address 16,384 bits rather than 4,096 bits.

However, the fact that the chip-select pin on the 4-k RAM will later be used for address A_6 on the 16-k RAM changes the system design rules. For device selection, it's now preferable to use the row-address select ($\overline{RAS}$) instead of chip select ($\overline{CS}$). It's done by applying $\overline{RAS}$ only to selected 2104/2116 devices while the column-address signal is applied to all devices.

Figure 6 illustrates this arrangement in a 64-k-by-16-bit system with OR-tied outputs. The same design is used in the photograph of the 1-megabit board on page 116. In fact, the configuration is already in most 16-pin 4-k RAM system designs of greater than 4,096 words. Its advantage is substantial power savings over system designs that employ the chip-select pin for the job of device selection.

However, if a designer wants to use $\overline{CS}$ for device selection in his 4-k/16-k design, then the chip-select line should be distributed to all devices and terminated so



7. Keeping in time. An OR function in the column-address logic prevents refresh cycle timing from conflicting with data cycle timing. It guarantees that the column-address signals will always occur before the row-address signals for refresh and after them for data.

that it can serve as an address line when needed. He can do that in the 4-k design by connecting the chip-select line to a signal driver. That forces $\overline{\text{CS}}$ to a high level (V_{IH}) during column-address hold time (t_{AH}) during refresh cycles, and to a low level (V_{IL}) during data cycles. Later, when he substitutes the 2116 for the 2104 in his upgraded design, the chip-select line becomes the A_6 line and is properly jumpered to an address driver.

A refreshing difference

In refreshing a 4-k/16-k system, a designer has even more leeway than in refreshing a straight 4-k system. Two refresh modes are available with the 2116: 128-cycle and 64-cycle refresh, each taking 2 milliseconds. Any 2104/2116 designs which employ 128-cycle refresh should provide for a 7-bit refresh address counter and a three-wide, 7-bit address multiplexer. Both are needed for the 16-k system, although only 6 bits are used with the 4-k system.

The designer can choose from two timing conditions for the 128-cycle refresh: a read-cycle and a row-address-select-only timing condition. Read-cycle timing is recommended when only one row of the 2116 devices is used—16-k words by n bits. But if two or more rows of RAMs are used with OR-tied outputs, as on the 1-megabit board, read-cycle timing is not recommended unless each row of RAMs can be refreshed separately. Refreshing all rows simultaneously could turn on all the OR-tied outputs at the same time, causing the output buffers to conflict. For instance one output might be high while three are low, and so on.

This condition will not degrade the device outputs. Data out is not normally expected to be valid during refresh cycles. The problem is that it increases the current drawn from the V_{CC} supply and may result in supply noise that can affect the TTL in the system.

For an OR-tied output system it's better to use the second 128-cycle refresh timing condition, the row-address-select-only timing. $\overline{\text{RAS}}$-only timing is when the 2116 receives $\overline{\text{RAS}}$ but no $\overline{\text{CAS}}$ during a cycle. In this mode, the data stored in the addressed row of 128 cells will be refreshed, but the data output will not change. Suppose two or more RAMs were OR-tied at the outputs. Then the RAM that had last performed a data cycle (i.e. received both a $\overline{\text{RAS}}$ and $\overline{\text{CAS}}$ input) would remain with its output buffer turned on (high or low), while the remaining RAMs would have their outputs in a high impedance state. This obviates data output buffer conflicts and their associated power-supply noise for systems above the 16-kiloword level. In addition, output data from RAMs accessed prior to refresh is valid during and after the refresh cycle.

Maximizing memory availability

The second refresh mode of the 2116 requires only 64 refresh cycles every 2 milliseconds instead of 128 cycles. This mode simultaneously refreshes corresponding rows in each half of the 2116. To the system designer, it increases memory availability, making it equal to that of a 4-k RAM's. For instance, for a 500-ns refresh/data cycle time (t_{cyc}) and a 2-ms refresh period (t_{ref}), 64-cycle refresh yields a percent availability of $(t_{ref} - 64\ t_{cyc})/t_{ref}$, or 98.4%. In contrast, 16-k RAMs refreshed in 128 cycles have only 96.8% availability, which could be a reason for avoiding this mode in a high-throughput memory.

The timing requirements for 64-cycle refresh are hardly more complex than for 128-cycle refresh. The important thing is to assure that the column-address-select signal is valid (low) at the leading edge of the row-address-select signal and remains valid during address hold time, just like refresh addresses. Under these conditions, the A_6 address input pin on the 2116 is ignored, and the data output buffer is set to the high-impedance state. Consequently, no conflict can occur in this mode between data outputs since they are at high impedance during and following the 64-cycle refresh operation.

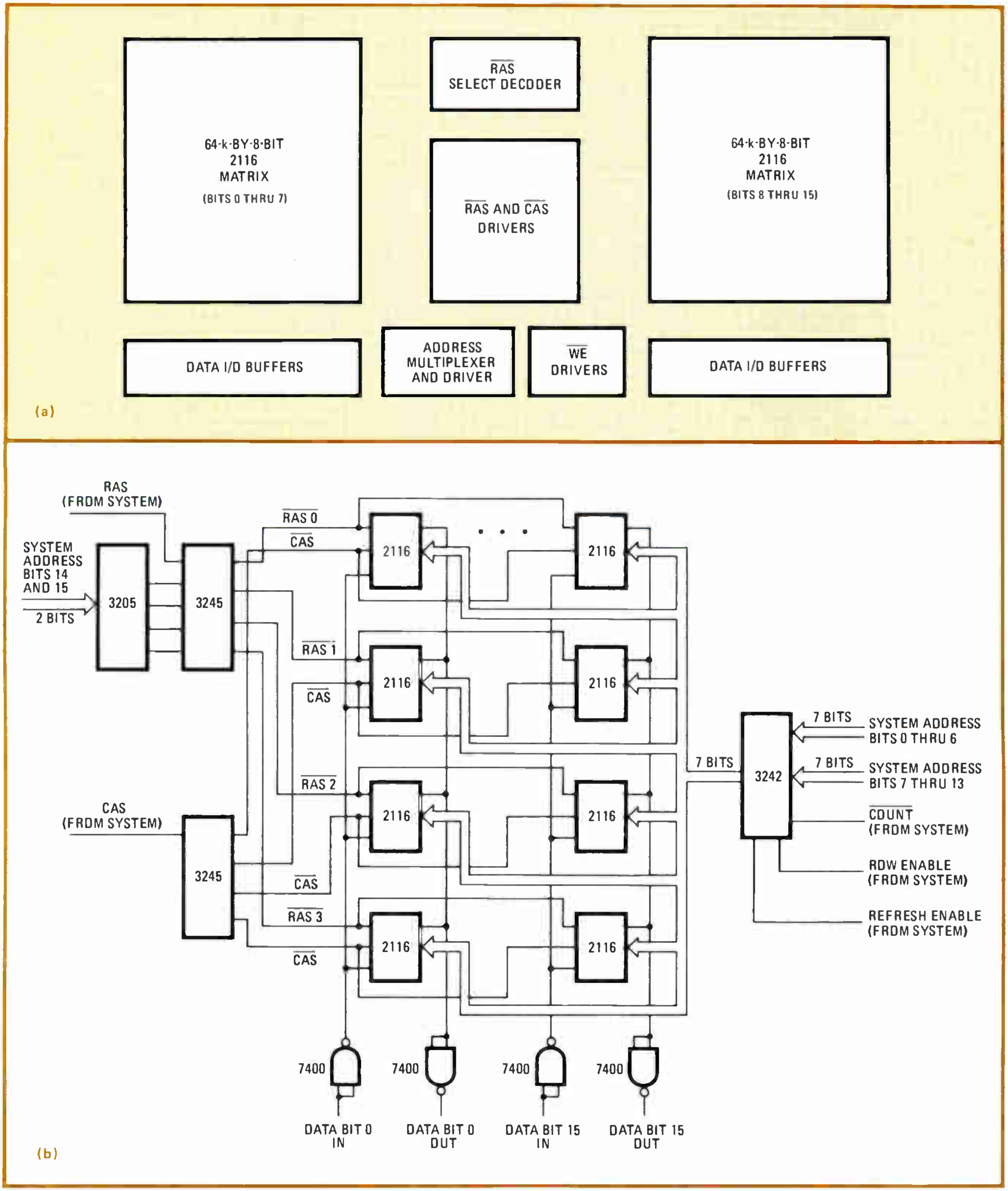
The high-impedance output state in the refresh mode also benefits standby power consumption, always a major concern of the system designer. As in 4-k RAMs, the 2116's standby current is 2 mA maximum, and as in system designs based on 4-k RAMs, this low level is obtained only when the device is deselected (that is, when its data output is in the high-impedance state). If data output is active (high or low), then the standby current is typically 3 mA.

Once the timing is worked out, the 2104/2116 system designer should consider incorporating an OR function (Fig. 7) in his column-address-select logic, such that $\overline{\text{CAS}}$ can be made to occur prior to row-address select for refresh or after $\overline{\text{RAS}}$ (delayed by the refresh cycle time, t_{cyc}) for data cycles. By so doing, he will guarantee that the refresh cycle timing will not clash with the data cycle timing.

At last, the 1-megabit memory system

To evaluate the 2116 in a system environment, Intel's applications group built the 1-megabit unit pictured on page 116. Figure 8 shows its block program (a) and a schematic (b). The system, which has been undergoing testing since June 1975, is arranged as 64-k 16-bit words and uses either 64- or 128-cycle refresh modes.

A key peripheral chip in the setup has been especially designed for 16-k RAM systems. The Intel 3242 serves as the address multiplexer and refresh address counter



8. Megabit memory. Block diagram (a) and simplified system schematic (b) show arrangement of the elements of a 64-k-by-16-bit system. This setup, which contains over 1 million bits of memory, has been operated successfully in a system environment. It uses either 64-cycle or 128-cycle refresh modes. The 64-cycle option maximizes memory availability in systems that need high throughput.

and is a TTL, single-supply (+5-V) device that comes in a 28-pin package. It multiplexes 14 bits of externally supplied system address plus the 7-bit refresh address from the internal-refresh address counter to the seven-output address pins.

The 3242 also includes an internal zero-detection circuit to indicate when the refresh address is all zeroes. This saves logic and board space by allowing users of "burst mode" refresh to determine when the burst is complete without having to count the refresh cycles. ☐

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The light measurement people

Diodes damp line reflections without overloading logic

As line terminations in digital-logic systems, diodes keep pulses almost as sharp as resistors would, yet they dissipate hardly any power

by E.E. Davidson and R.D. Lane, *IBM System Products Division, Hopewell Junction, N.Y.*

☐ In a digital-logic system, diode-terminated interconnections are a much better choice than resistively terminated lines. The diodes suppress multiple line voltage reflections almost as effectively as a resistor. Yet unlike a resistor they dissipate very little power and run no risk of overloading the logic circuitry.

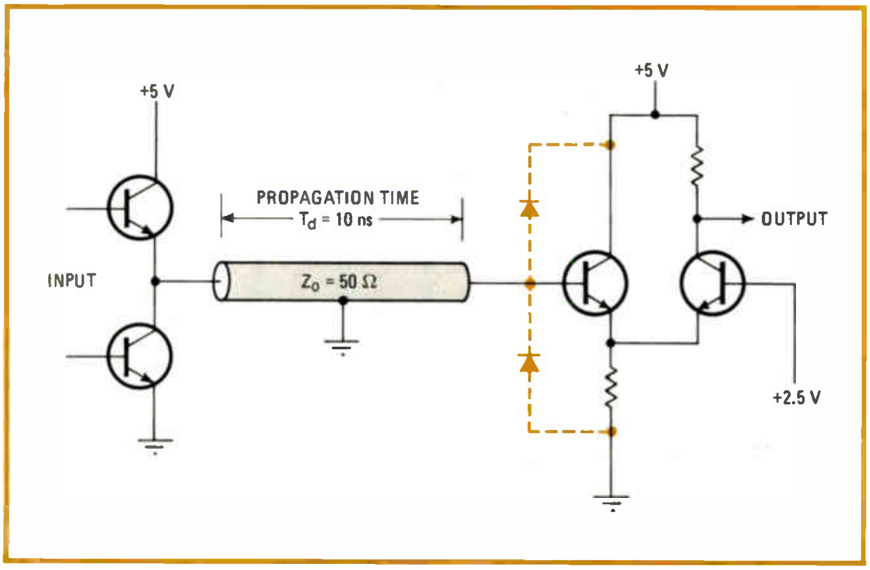
Multiple line reflections are a problem in a digital-logic system with high signal frequencies and long communication paths, because the interconnections behave much like transmission lines. If these lines are left unterminated, a signal pulse is reflected so often that stable switching can occur only after a long settling time. Moreover, the voltage doubling at the far end of such a line may exceed the breakdown values of the devices located there. Terminating the line with its characteristic resistance is the obvious and standard solution, yet it can be shown to be less satisfactory than using a pair of diodes. Therefore industry is turning to diode terminations (see "The diode story").

A typical logic interconnection circuit is shown in Fig. 1. The circuit arrangement consists of a push-pull driver, a transmission line, and a receiver/current switch. The input impedance of the switch is much greater than the characteristic impedance Z_0 of the line, so in the absence of the terminating diodes the line would see an open circuit. If the output impedance of the driver is assumed to be 7 ohms, the equivalent circuit for the logic stage, in which the signal voltage and source resistance (R_S) replace the driver, would be the one that is shown in Fig. 2(a).

A signal voltage (E_S) of a given level entering this line would eventually charge it to the same voltage level, but only after the line had oscillated considerably above and below that level. With an E_S of 5 volts, for example, the voltage at the near end of the line (E_n) at time zero works out to be:

$$\begin{aligned} E_n &= E_S Z_0/(R_S + Z_0) \\ &= 5 \times 50/(7+50) = 4.4\ V \end{aligned} \qquad (1)$$

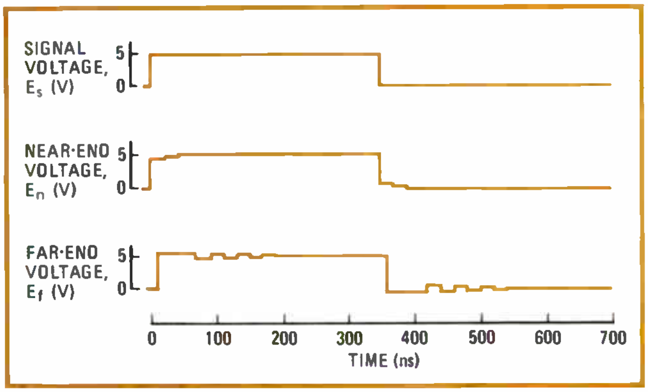
This incident voltage waveform E_i travels down the line until it reaches the open-circuited far end. There, the boundary condition requires zero current flow, so a reflected voltage waveform (E_r) of equal value cancels the incident current and travels back up the line to the near



1. Interconnection. This logic circuit uses a transmission-line interconnection down which push-pull driver sends voltage pulses to a receiver/current-switch. Reflections on the line upset switching performance and may damage transistors in both driver and receiver, but terminating diodes (dotted color lines) suppress the reflections.

The diode story

Resistive terminations are standard elements in the logic networks that the computer industry uses at present. But the advantages of diode terminators have not escaped notice by designers elsewhere. For example, Motorola's MECL System Design Handbook suggests use of diode terminations on circuit interconnections for its 10,000-series ECL. Fairchild's 10-k series includes the F10014 active terminator, a 16-pin dual in-line package that contains 14 "bilateral clamps" with the external characteristics of diode pairs. Moreover, an integrated logic circuit that's now being considered by IBM includes integral terminating diodes.—**D.J.B.**



5. **Happy endings.** Voltages at near and far ends of diode-terminated line vary only slightly though for same 5-V signal as in Fig. 3. Diodes alter reflection mechanism to produce smoother pulses and stable switching, with no more power dissipation than for unterminated line. Resistive termination would eliminate reflections totally, but dissipate 33 times as much power.

stage with terminating diodes is shown in Fig. 4(a). The diodes are the Schottky variety with a forward voltage drop of 0.6 V. The upper diode handles positive-going transitions, and the lower diode handles negative-going transitions.

If a 5-V input is applied to the circuit, the voltage-divider effect at the near end again impresses 4.4 V onto the line, and this voltage travels to the far end. There it tries to double, because the line appears instantaneously unterminated, but fails, because the upper diode turns on and clamps the line as soon as the far end voltage exceeds 5.6 V. This 5.6 V now generates a 1.2-V reflected voltage, to satisfy the voltage boundary condition, which requires the sum of the incident and reflected voltages to equal the change in the far-end voltage (5.6 V). The corresponding reflection coefficient may be evaluated from Eq. 2. It may also be given by:

$$\rho_V = (V_C/E_i) - 1 \qquad (6)$$

where V_C represents the change in the far-end voltage as determined by the clamping action of the diode when the diode is forwarded-biased. Here:

$$\rho_V = (5.6/4.4) - 1 = 0.273$$

As shown in the reflection diagram of Fig. 4(b), the 1.2-V far-end reflection returns to the near end after 20 ns. The near-end re-reflection is governed by Eq. 3, so the new voltage reaching the far end at 30 ns becomes −0.755 × 1.2 V, or −0.905 V. Since the upper terminator diode is on, the far end acts as though the line were short-circuited, and a full negative reflection occurs. The line continues to behave as if shorted until the diode turns off.

The corresponding current diagram in Fig. 4(c) illustrates the launching of a current wave of 88 milliamperes (4.4 V ÷ 50 ohms) onto the line. When this current reaches the far end, it is modified by a reflection coefficient that is the negative of the corresponding ρ_V at 10 ns. The reflections continue as if the line were shorted until there is no net positive current at the far end of the line. When this occurs, the diode stops conducting, and the line reverts to open-circuited behavior. In this case, the line becomes an open circuit after 70 ns.

The net line current at the far end must be zero when the diode is off. As a result, the current reflection when the diode turns off must dissipate any residual line current (I_x). This boundary condition leads to an equation for the current-reflection coefficient at this point that is analogous to Eq. 6 and is given by:

$$\rho_{if} = -(I_x/I_{if}) - 1 \qquad (7)$$

where I_{if} is the last current value incident upon the far end before the diode turns off. Here I_x is 0.4 A and I_{if} is −10.7 A, so ρ_{if} is −0.963. The voltage-reflection coefficient at the instant that the diode stops conducting is the negative of the value given by Eq. 7.

(For example in Fig. 4(c), the value of ρ_{if} calculated from Eq. 7 at 70 ns happens to be very close to the open-circuit value to which the line subsequently reverts. But this kind of coincidence seldom occurs.)

After the diode ceases to conduct, both the voltage and current reflections at the far end are governed by the reflection coefficients for an open line. As illustrated in Fig. 4(b) and (c) these reflections continue until the current dies out and the line attains a level of 5 V throughout its length.

Non-ideal behavior of the diodes causes changes in the clamping voltage as the line current is made to vary by the current reflections. As a result, there are actually small deviations from the theoretical short-circuit behavior exhibited by the line in the example during the time the diode was on. But if the diode forward-voltage changes are small compared to the voltages on the line, the results are close to those predicted by Fig. 4(b) and (c). If the voltage changes are significant, Eq. 6 can be used to calculate each successive value for the reflection coefficient when the diode is on.

The marked improvement that is made by diode termination becomes very obvious when the information contained in Fig. 4(b) is transformed into a near-end and far-end voltage waveform diagram for positive and negative signal transitions (Fig. 5). The negative reflection information is obtained from Fig. 4(b) by following the procedure discussed previously; for negative-going transitions, the bottom diode in Fig. 4(a) takes over the role that the top diode played for positive-going transitions.

The voltage waveforms in Fig. 5 show that the terminating diodes have eliminated the large voltage excursions at the far end, so that the far-end voltage reaches the full signal level after one line-delay time. The near end steps up gradually to +5 V with no significant overshoot, and does so even when the source resistance is higher. Finally, the effects of the reflections die out much faster than in the unterminated case.

The matter of power

Energy must be delivered to the line to charge it up to the signal voltage level. A diode-terminated line needs much less than a resistor-terminated line and in fact is as economical in this respect as an unterminated line.

In the case of an open-circuited line, energy is stored on the capacitance of the line. In order to calculate the power needed to fully charge a line, the transmission line is replaced by its equivalent capacitance (C_L):

$$C_L = T_d/Z_0 \tag{8}$$

where T_d is the propagation delay of the line. (The replacement is justified because both the line and the lumped capacitance store the same final energy.) The equivalent circuit of Fig. 6(a) can then be used to determine the power delivered to the line while a finite signal voltage is being applied. This value for the power delivered to an open-circuited line (P_{OC}) is given by:

$$P_{OC} = \frac{1}{T}\int_0^T E_S[(E_S/R_S)exp(-t/R_SC_L)]dt \tag{9}$$

where the term in brackets is the current that flows during the charging interval and T is the time period. The integration in Eq. 9 yields:

$$P_{OC} = (E_S^2C_L/T)[1 - exp(-T/R_SC_L)] \tag{10}$$

After the charge-up process is complete, i.e., when T is much larger than R_SC_L, the exponential term becomes zero and Eq. 10 reduces to:

$$P_{OC} = E_S^2C_L/T \tag{11}$$

Equation 11 represents the total power delivered by a power supply to a charged-up open-circuited transmission line during a period of time that exceeds the charging time. Half of this power is dissipated when the line is charged, the other half when the line is discharged. Note that the open-circuit power is not a function of the driving resistance, R_S.

For example, assume that the open-circuited line of Fig. 2(a) is fully charged and fully discharged during one cycle time of 700 ns. From Eq. 8, the line's capacitance is 200 picofarads. Substituting the appropriate numbers into Eq. 11 yields a value of 7 milliwatts for the power dissipated by the line.

When the transmission line is terminated with a resistance R_T, a steady-state current (I_{SS}) flows. Now energy is no longer stored only in the line's capacitance, but also stored in its inductance (L_L), given by:

$$L_L = T_dZ_0 \tag{12}$$

By following the procedure used for deriving Eq. 11 and referring to the equivalent circuit of the terminated line, as shown in Fig. 6(b), a general expression for the total power delivered to a terminated transmission line (P_T) can be written as:

$$P_T = I_{SS}^2R_SF + E_{SS}^2F/R_T + C_LE_{SS}^2/T + L_LI_{SS}^2/T \tag{13}$$

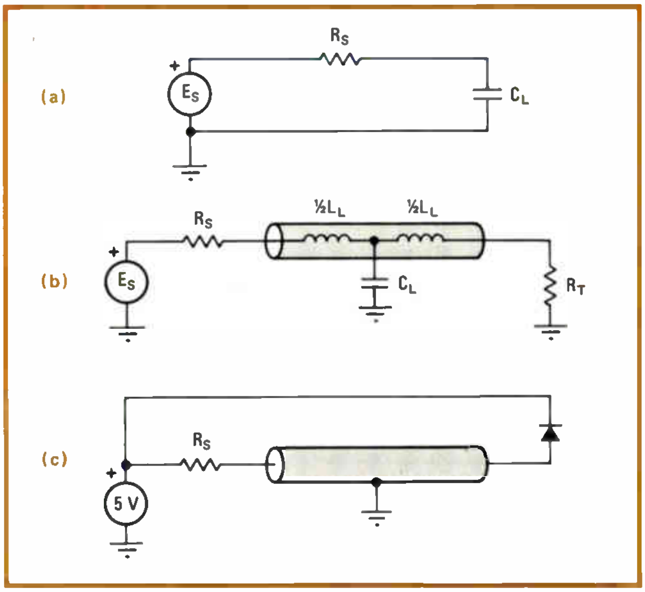
where F is the fraction of time T that the signal is applied, I_{SS} is the steady-state current, and E_{SS} is the steady state voltage on the line. The value of E_{SS} is determined by the voltage divider:

$$E_{SS} = E_SR_T/(R_T + R_S) \tag{14}$$

From Fig. 6(b) the expression for the steady-state current may be seen to be:

$$I_{SS} = E_{SS}/R_T \tag{15}$$

The first term in Eq. 13 accounts for the dc power dissipated in the source resistance, the second term for the dc power dissipated in the load or termination resistance. The third term represents the power used to charge the capacitance of the line, the fourth the power that charges the inductance of the line. As in the case of the open-circuit power of Eq. 11, the total power of Eq. 13 represents the power dissipated in charging and discharging the line during a period T.



6. Equivalent charging circuits. For calculation of power required to charge up unterminated transmission line, line is replaced by capacitor in equivalent circuit (a). For similar calculation for terminated transmission line (b), line is represented by both inductance and capacitance; R_T is terminating resistor. Diode-terminator equivalent circuit (c) shows diode dissipates no additional power.

In one of the above examples, the unterminated power for a 700-ns interval for the circuit of Fig. 2(a) was given as 7 milliwatts. Equation 13 shows that the terminated power for the same interval is 232 mW when the line is terminated in its characteristic impedance of 50 ohms and operates at a 50% duty factor. The terminated line dissipates 33 times as much power as the unterminated line; this disparity accounts for the desirability of using diode terminators.

Although the diode terminator consists of active devices that develop terminal voltages when current passes through them, they do not add to the total power associated with driving the line. To understand why this is so, consider Fig. 6(c), the effective circuit for the positive signal transition. Any current that flows through the diode emanates from 5 V and returns to 5 V. In other words, the power dissipated by the diode does not require additional power to be delivered from the power supply. Some of the power that would be dissipated in the source resistance for the unterminated case is instead dissipated in the diode for the diode-terminated case.

Since the total energy delivered to the diode-terminated line is required to charge the capacitance of the line, the power for the diode-terminated line is the same as that for the equivalent unterminated line as given by Eq. 11. In other words, a diode terminator dissipates no more power than an open line. ☐

Comparator circuit makes versatile Schmitt trigger

by Phil Sherrod
Vanderbilt University Computer Center, Nashville, Tenn.

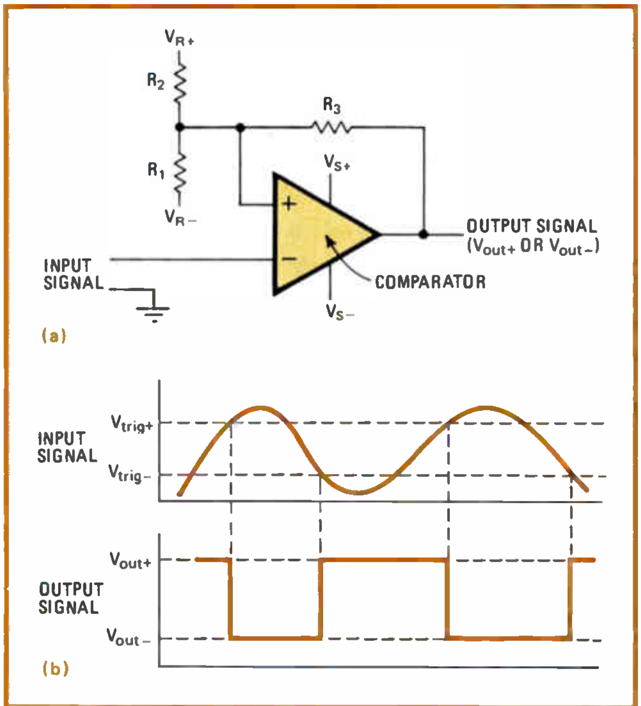
Just three resistors added to a monolithic comparator or operational amplifier are enough to build an inverting Schmitt trigger. What's more, the trigger voltages for switching the output state may easily be set at any values desired if the resistor values are chosen according to the formulas in Fig. 1.

The operation of the circuit is straightforward. When the input signal falls below the voltage at the comparator's noninverting input, the comparator switches on into the output-high state. The high output voltage is fed back through resistor R_3 to the voltage divider circuit R_1R_2, which is connected to the noninverting input. This positive feedback causes the trigger-voltage level to swing to a higher value (V_{trig+}). When the input signal rises to a level above this voltage, the output of the comparator goes to its low value (V_{out-}), pulling the trigger voltage to a lower value (V_{trig-}).

The relative values of resistors R_1, R_2, and R_3 set the trigger points; circuit operation is unaffected if all three are multiplied by a constant. Consequently the formulas yield values for R_2 and R_3 that are ratios of these resistances to the value of R_1, taken to be 1 ohm. Then all three values may be multiplied by a constant to scale them to reasonable resistances. Anything in the range of 1,000 to 50,000 ohms is usually acceptable. In general, each of the resistance values should be less than 1/10 the input resistance of the comparator.

The output voltages of the comparator (V_{out+} and V_{out-}) typically swing within 1 or 2 v of the comparator supply voltages (V_{s+} and V_{s-}). Thus, the desired output-voltage levels determine the supply voltages and hence the choice of comparator.

Figure 2 is an example. The Schmitt trigger in this

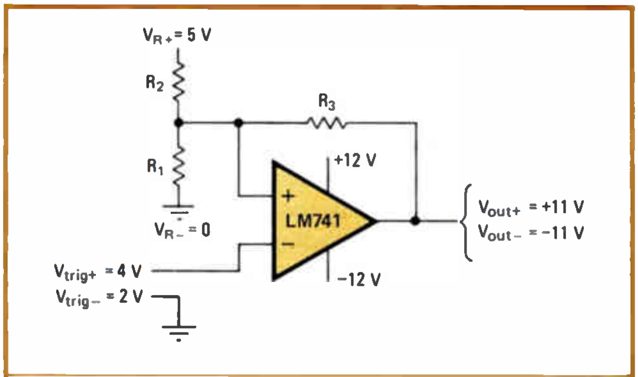


LET $R_1 = 1\,\Omega$

$$R_2 = \frac{(V_{trig-} - V_{R+})(V_{out+} - V_{trig+}) - (V_{trig+} - V_{R+})(V_{out-} - V_{trig-})}{(V_{trig+} - V_{R-})(V_{out+} - V_{trig-}) - (V_{trig-} - V_{R-})(V_{out+} - V_{trig+})}$$

$$R_3 = \frac{R_2 (V_{out+} - V_{trig+})}{R_2 (V_{trig+} - V_{R-}) + V_{trig+} - V_{R+}}$$

1. Design equations. Inverting Schmitt-trigger circuit (a) has triggering voltages and output levels as shown in (b). The circuit diagram and the waveforms illustrate the terms used in the design equations for resistors R_1, R_2, and R_3. The resistance values found from these equations are then scaled up to match the comparator.



LET $R_1 = 1\,\Omega$

$$R_2 = \frac{(2-5)(11-4) - (4-5)(-11-2)}{(4-0)(-11-2) - (2-0)(11-4)} = 0.515\,\Omega$$

$$R_3 = \frac{(0.515)(11-4)}{(0.515)(4-0) + 4 - 5} = 3.40\,\Omega$$

SCALING BY 10,000 GIVES CIRCUIT VALUES

$R_1 = 10{,}000\,\Omega$
$R_2 = 5{,}150\,\Omega$
$R_3 = 34{,}000\,\Omega$

2. Example. Here is an inverting Schmitt circuit intended for trigger voltages of 2 and 4 V, output levels of ±11 V, and a 5-V bias supply. The design equations yield resistance values that are then scaled up by 10,000 to match the National LM741 op amp, chosen because its ±12-V supply voltages bracket the desired output levels.

design requires positive- and negative-going trigger voltages of 4 v and 2 v, respectively, bias voltages of +5 v and ground, and output levels of +11 v and −11 v. The formulas then supply values for R_1, R_2, and R_3 as shown. The supply voltages selected are +12 v and −12 v, making a National LM741 op amp appropriate. Resistor values are then scaled up by a factor of 10,000 to complete the design. ☐

Pulsed transistor test simulates linear operation

by Glenn Filler
Westinghouse Semiconductor Division, Youngwood, Pa.

Linear operation of high-power output transistors in audio systems may subject them to heat failure. Yet most reliability tests pulse the transistors into saturation, rather than subjecting them to the sudden, simultaneous high current and high voltage they will actually experience. The solution is simulation of operating conditions by pulsing the transistor in the unsaturated mode with the circuit used by audio manufacturers.

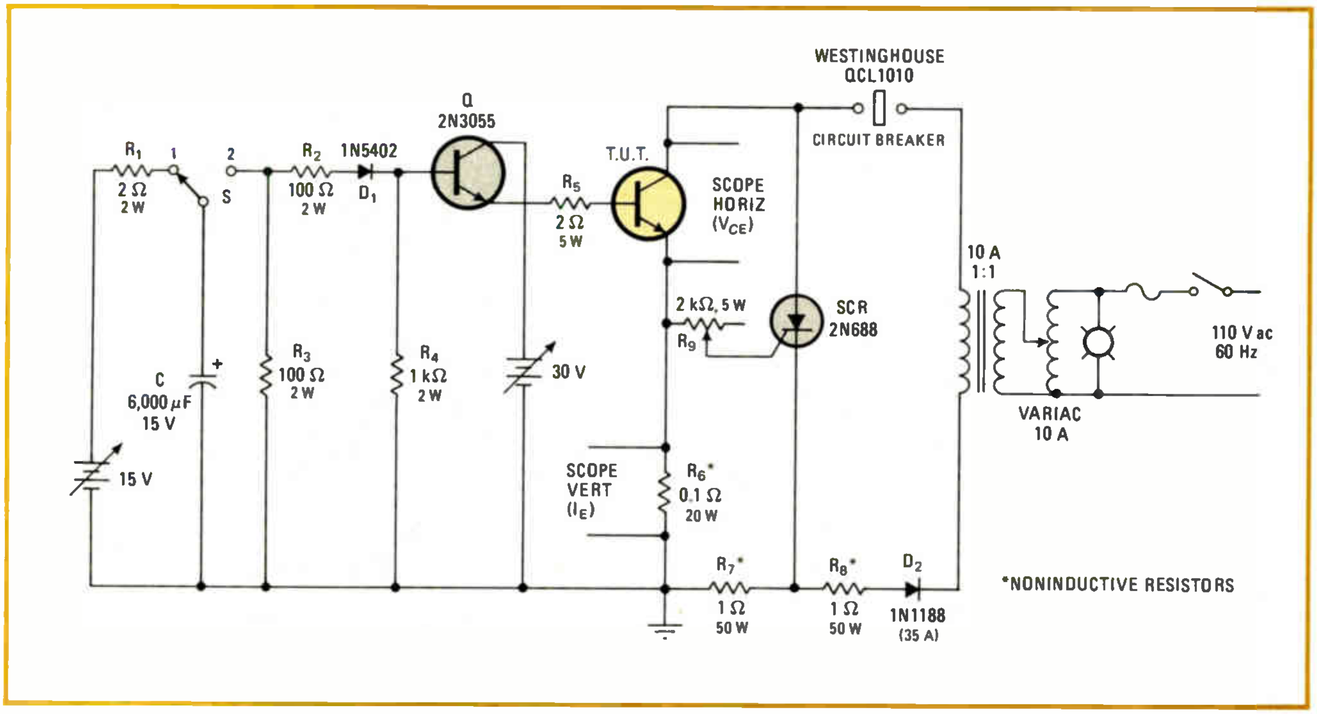
The circuit (Fig. 1) simulates the pulses of high power that elevate junction temperatures, particularly when the amplifier must produce high outputs at high frequencies. Prolonged high junction temperatures often cause collector-to-emitter shorts, and the transistors fail.

The transistor under test is pulsed at a low repetition rate. Capacitor C is charged to a preset voltage through resistor R_1 with switch S in position 1. When the switch is moved to position 2, C discharges through R_2 and D_1 to turn on the driving transistor Q. Resistor R_3 is included in the circuit to allow C to discharge fully (instead of down to the sum of forward drops in D_1 and the base-to-emitter junction of Q); R_4 furnishes a path for the turn-off current of Q, and diode D_1 prevents R_3 from serving as a low-resistance shunt of R_4 for collector-to-base leakage currents.

The duration of the discharge pulse in the drive circuit is on the order of half a second; it can be varied by changing the values of C, R_2, and R_3. The long pulse of collector current from Q drives the base of the transistor under test.

The collector of the transistor under test is pulsed at a 60-hertz rate by a half-wave supply that consists of the Variac output and diode D_2. The peak collector voltage can be as high as 75 volts, and the current as high as 10 amperes (depending on the values of R_7 and R_8). The duration of the base drive covers many cycles of the collector voltage; therefore the transistor is subjected to extended pulsing that tests its high-power operating capability.

The self-triggered X-Y oscilloscope is set to a vertical range of 0.1 volt per division (corresponding to an emitter current of 1 A/div) and a horizontal range of 10 V/div (which measures the collector-to-emitter voltage). The base drive and the collector supply are first adjusted to provide a low-current, low-voltage display. When the transistor turns on, the base and collector



1. Operating ability. Circuit tests high-power audio output transistors for ability to perform at the high current and high voltage levels they'll meet in linear operation. Transistor under test is pulsed with collector voltage at 60 Hz; base drive is applied from 2N3055 for a duration determined by discharge of C. Failure mode is most likely to be second breakdown caused by heat dissipation at junctions.

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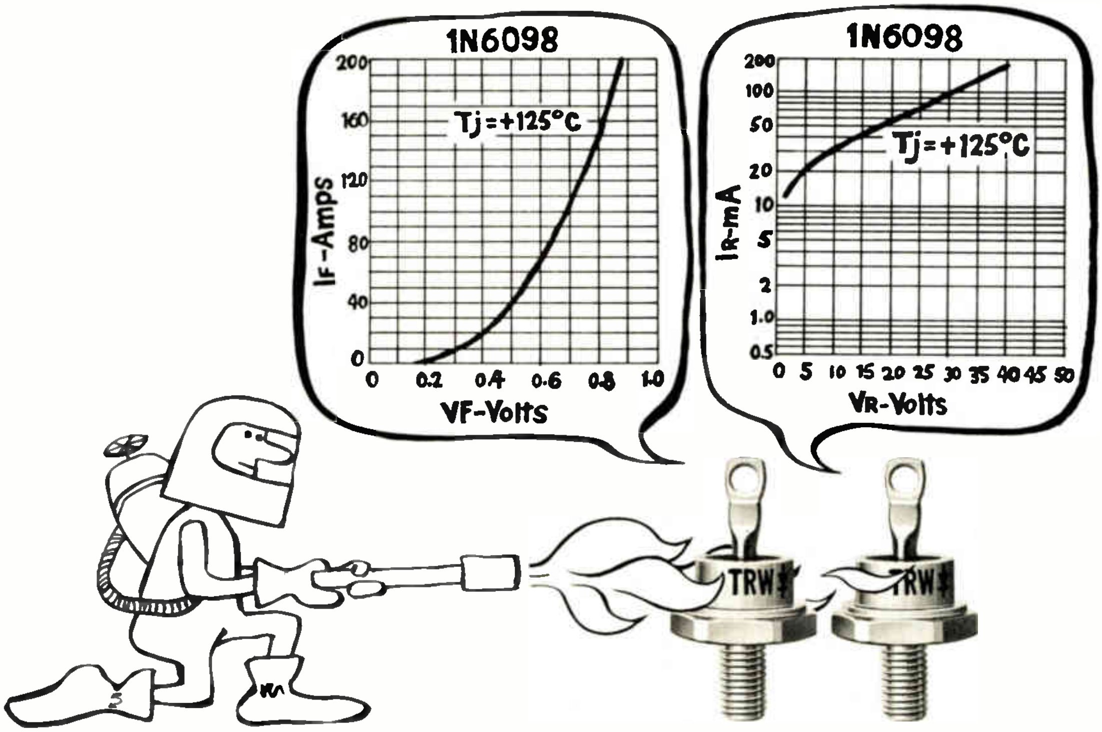

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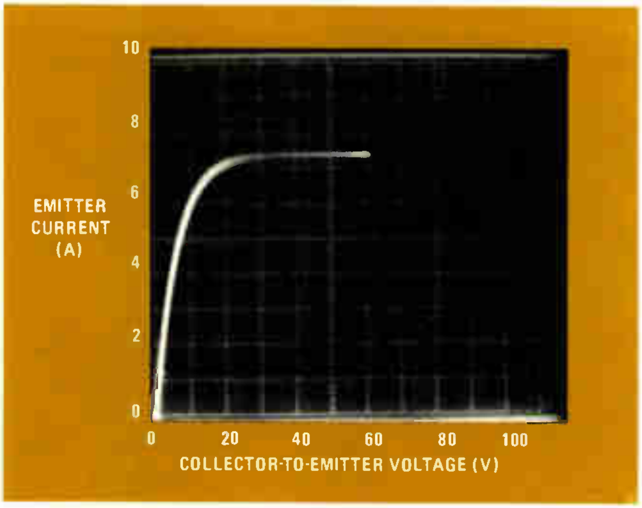
The triggering level of the SCR is set before base drive is applied. With the transistor under test shorted out, potentiometer R_9 is adjusted to let the SCR fire at the desired current level. ☐



2. Here's the picture. Audio transistor performance in circuit of Fig. 1 is monitored by oscilloscope display. Here transistor shows satisfactory behavior. If second breakdown causes collector-to-emitter short circuit, oscilloscope trace drops back to zero.

Bistable action of 555 varies with manufacturer

by Robert W. Bockstahler
General Dynamics Corp., Pomona, Calif.

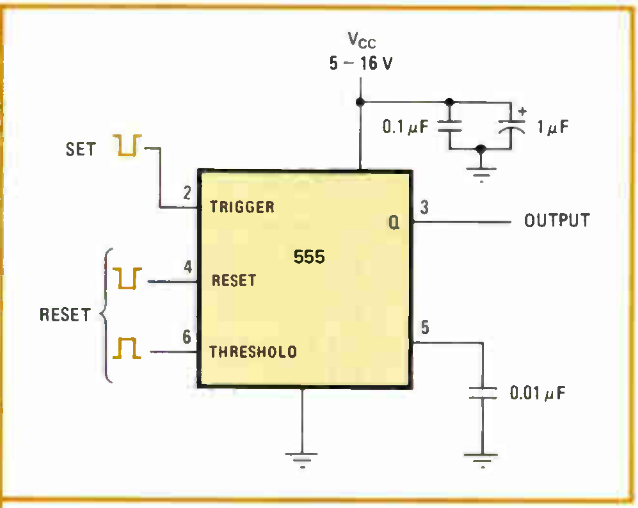
The 555 integrated circuit, which has myriad uses as a timer and oscillator, can also function as a bistable flip-flop in such applications as TTL-compatible drivers for displays or latch elements for burglar alarms. This flip-flop operates from many different supply voltages, uses little power, and requires no external components other than bypass capacitors in noisy environments.

Pin 2 (the trigger pin of the 555) is an active-low SET function. Pin 4 (the reset of the 555) serves as an active-low RESET, and pin 6 (threshold) as an active-high RESET. Both the RESETs can be used, or just one, with the other connected in its inactive state. The table shows how the output responds to various input signals.

It is important to know the detailed characteristics of the particular 555 used as a bistable element because the circuitry differs from manufacturer to manufacturer, and certain functions, therefore, interact differently. The table points out, for example, that the threshold overrides the trigger on the LM555H, but the trigger overrides the threshold on the NE555V. ☐

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.

INPUTS			OUTPUT	
PIN 4 (RESET) (ACTIVE-LOW)	PIN 6 (THRESHOLD) (ACTIVE-HIGH)	PIN 2 (TRIGGER) (ACTIVE-LOW)	NATIONAL LM555H	SIGNETICS NE555V
⊔	0	1	RESETS (└)	RESETS (└)
⊔	1	1	0	0
⊔	0	0	⊔	⊔
⊔	1	0	0	⊔
1	⊓	1	RESETS	RESETS
1	⊓	0	⊔	1
0	⊓	1	0	0
0	⊓	0	0	0
1	0	⊔	SETS (┌)	SETS (┌)
1	1	⊔	0	⊓
0	0	⊔	0	0
0	1	⊔	0	0



Bistable operation. A 555 timer can be used as a set/reset flip-flop, with pin 2 as the active-low SET input. Pin 4 can be used as active-low RESET input, with pin 6 inactive (i.e., low), or pin 6 can be used as active-high RESET input, with pin 4 inactive (high); in the latter case, an LM555H performs somewhat differently from an NE555V. Flip-flop operation with both pin 4 and pin 6 as control inputs is also possible; for example, pin 4 might be the RESET and pin 6 a power-on CLEAR.

Engineer's newsletter

Beware of VOMs in selecting semiconductors

If you think you can fine-select diodes, SCRs, and other semiconductor components with a volt-ohmmeter—forget it. The only meaningful readings you can get from a VOM when checking out a diode or an SCR are "open" and "short." That's because semiconductor measurements made with a VOM involve the device's blocking-voltage rather than its on-state characteristics. So **any attempt to segregate devices on the basis of actual resistance readings is almost certain to be invalid.** For the whole story, plus a couple of cautionary notes, see Tech Tips 5-5, free from Westinghouse Electric Corp.'s Semiconductor division, Youngwood, Pa. 15697.

Phone-status circuit uses only two parts

Circuits that indicate which of several phones are in use can be downright elaborate, containing a dozen or so devices. But this telephone-status circuit deserves a prize for simplicity. It consists of **a light-emitting diode and a current-limiting resistor hooked across the telephone line.**

"When the phone is on the hook," says J. Lafreniere of Ottawa, Ontario, "the LED is on. When the phone's off the hook, the LED goes off. And when the phone rings, the LED flashes." Lafreniere says he's operated his LEDs at 0.5 to 1 milliampere with good results. Of course he advises checking with the telephone company before going ahead.

Adhesive holds wafers more firmly than wax

Dicing wafers has always been a chancy business—one slip of the saw, and a whole batch of chips is lost. The villain is usually the wax on the under side of the wafer. It's intended to hold the chips in place during the sawing, but it often softens under the saw's heat and allows the chips to become misaligned. The answer could be a new pressure-sensitive, adhesive-coated Kapton material developed by Rexham Industrial Corp., Matthews, N.C. The adhesive **holds the wafers immovably to rigid substrates until it's dissolved by a special solvent.**

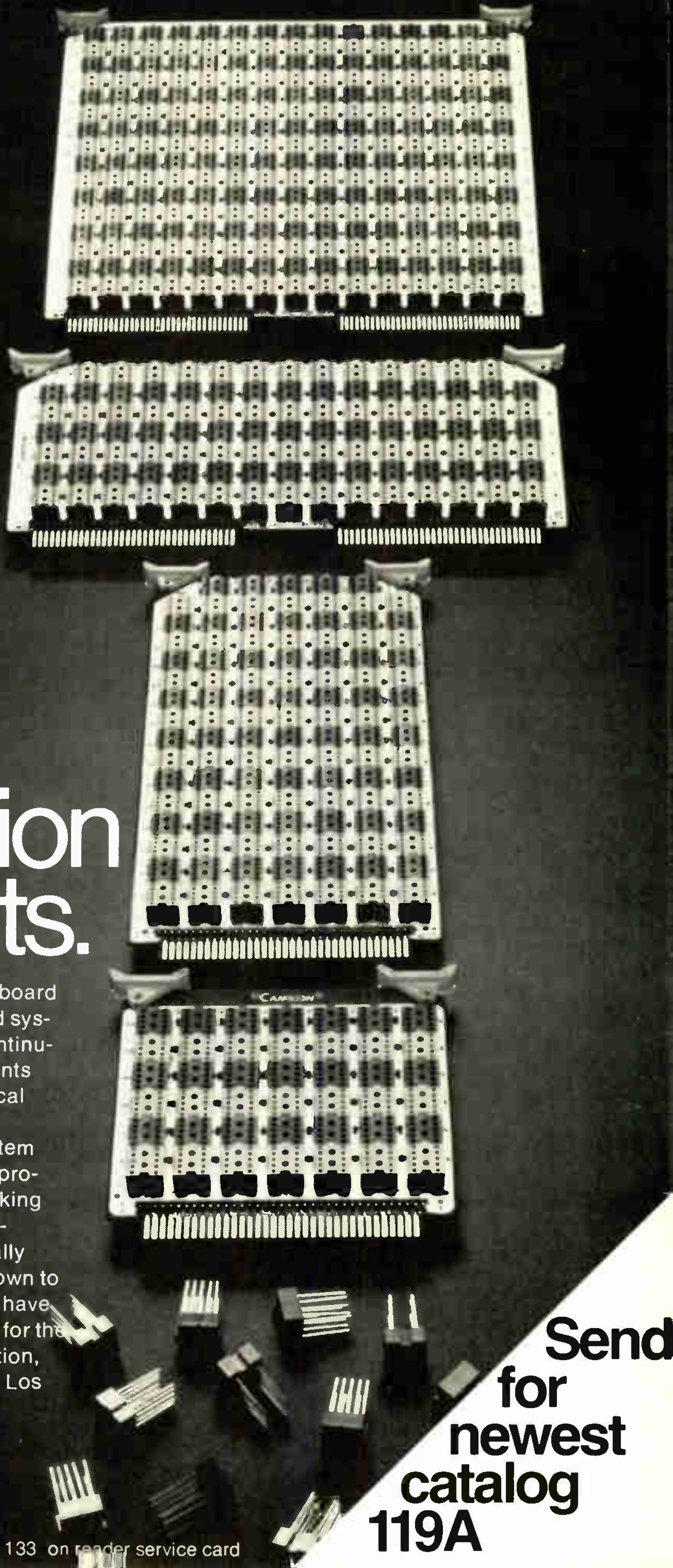
Look forward to one-chip computers costing under $10

Designers who've yet to see just what they want in low-price microcomputers can look forward to **a flurry of new single-chip systems designed to sell for less than $10.** Intended for small to medium control applications, these little 4- or 8-bit microcomputers will contain typically 8,192 bits of ROM (or PROM), 512 bits of RAM, and just enough computational logic and control registers to handle about 30 instructions. Performance, flexibility, and, of course, price will be well below those of general-purpose multichip sets.

IEEE's spring fever—microprocessors

Speaking of microprocessors, did you note that no fewer than seven—yes, seven—of the 35 technical sessions scheduled for IEEE's spring show (Electro/76) will be devoted to the little darlings? Speakers at the Boston convention, May 11-14, **will cover all aspects of microprocessors**—descriptions of chip and system basics; new applications in test gear, medical equipment, process-control systems, and EDP hardware; design and design aids, not to mention testing, debugging, and programing.

—Laurence Altman



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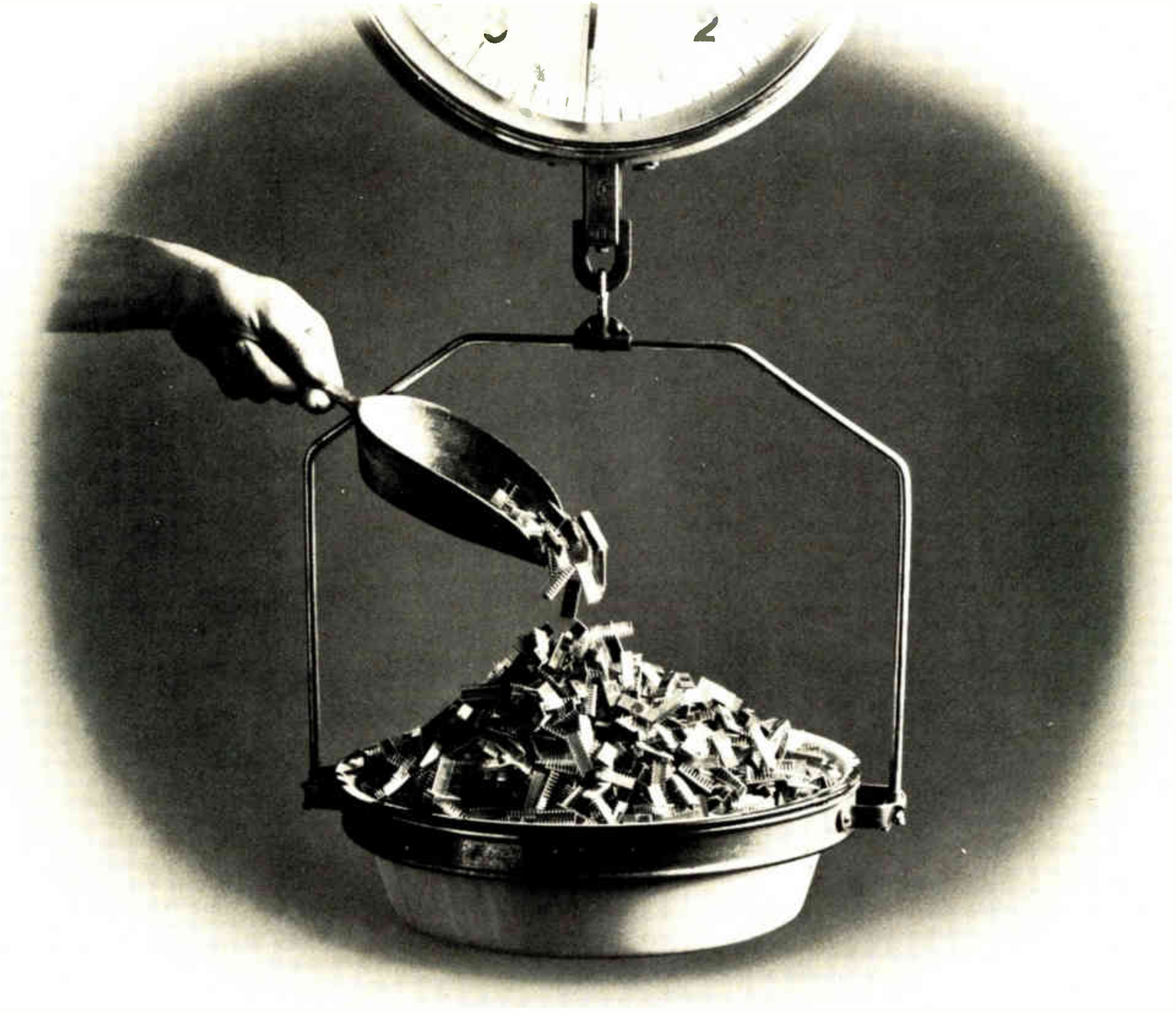

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4096X1	7005* (250ns) Mostek 4096	7270 (200ns) Nat'l 5270	7280 (200ns) Nat'l 5280 Intel 2107B TI4060
		7271** (240ns) TTL Clock	7281** (240ns) TTL Clock
8192X1			7008* (125ns) Pin for pin with 7280
Static RAMs			
256X4	7112* (250ns) Intel 2112	7111* (250ns) Intel 2111	7101* (250ns) Intel 2101
1024X1			7001 (60ns)
2048X1			7003* (60ns)

*Second quarter 1976 Access time in ( )

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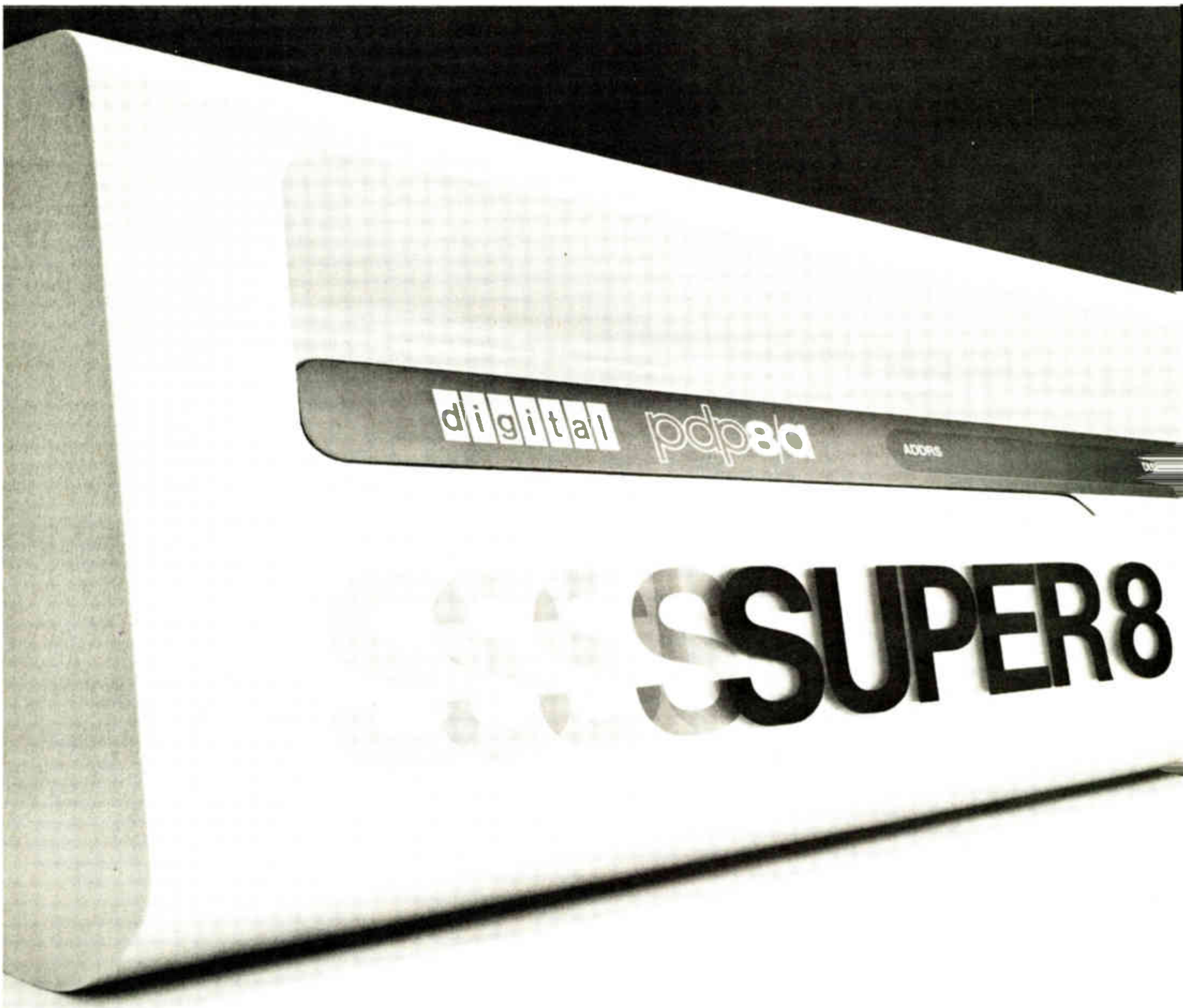

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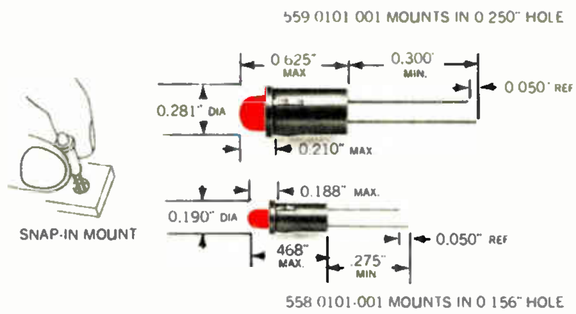

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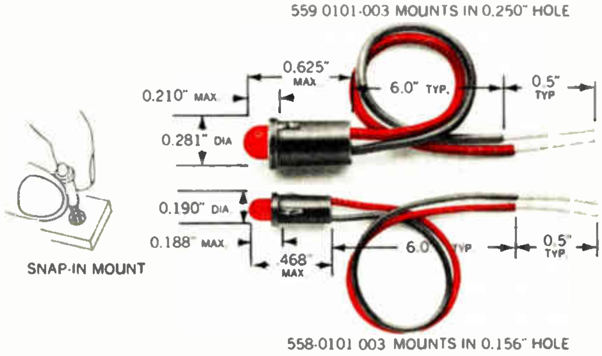

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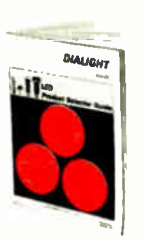

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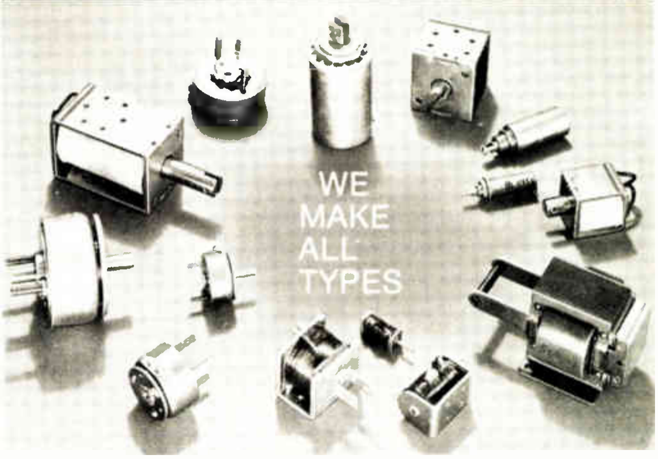

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New products

Converter stresses stability

Quad-slope technique permits integrating analog-to-digital C-MOS chip to compensate automatically for temperature effects

by Lucinda Mattera, Components Editor

Integrating analog-to-digital converters are primarily used in precision measurement applications, where conversion accuracy is essential and conversion time need not be especially short.

Although existing monolithic integrating a-d converters offer resolutions of 10 bits or more, they generally require external compensation for the effects of temperature. But a new complementary-metal-oxide-semiconductor chip from Analog Devices automatically compensates itself for temperature variations, in addition to providing a number of other advantages.

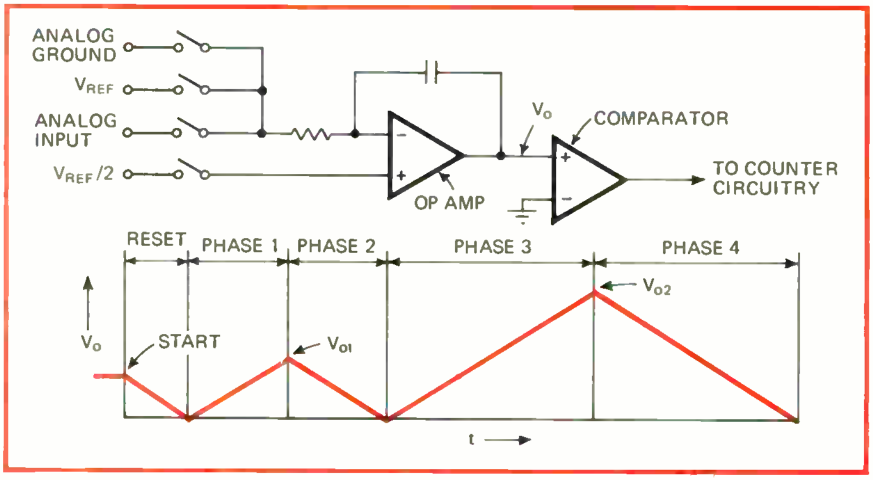
Besides being directly compatible with microprocessors, the new 13-bit converter holds gain and offset drift to a mere 1 ppm/°C. Moreover, the AD7550 has its own amplifier, comparator, clock, and digital logic, so that it requires only an external resistor, capacitor, and reference voltage for operation. And pricing is low—in 100-unit lots, the device sells for $25 each.

The AD7550 employs a conversion technique called quad slope, which involves a four-phase integration period in addition to a reset phase, as shown in the figure. In contrast, most existing integrating a-d converters operate with only a two-phase (dual slope) integration period.

The additional two phases of the AD7550's integration period are put to good use, and the integrating time includes a digitally corrected auto-zero cycle. This means that the new converter automatically compensates for offsets, making its temperature stability excellent with gain and offset drifts that are practically unmeasurable, claims Analog Devices. Furthermore, because of quad slope, the device can accept bipolar inputs, and its output is inherently monotonic, as well as free of the problem of missing codes.

Since the AD7550 is a C-MOS chip, measuring only 118 by 125 mils, its power dissipation is low—typically just 8 milliwatts total. At a clock frequency of 1 megahertz, the unit makes about 40 conversions per second. Its clock input can be driven externally, or the clock can be self-generated through an external capacitor.

An overrange output warns of input voltages that are beyond the bipolar input range, which extends over about plus and minus half the reference-voltage level. An external positive pulse can be applied to start a single conversion cycle, or the AD7550 can be wired in its self-starting mode for continuous conversion by connecting a capacitor to the "start" pin of the device.

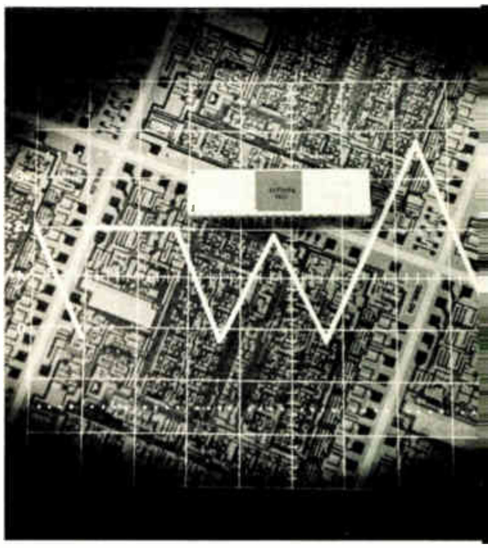


Stability through quad slope. Monolithic 13-bit C-MOS integrating a-d converter (top) includes digitally corrected auto-zero cycle in its four-phase integration period (bottom).

The unit furnishes 13 bits of parallel binary data in microprocessor-compatible two's-complement code, which can be interfaced directly with the eight-bit microprocessor data-bus lines through its three-state buffers. Its digital outputs are also compatible with both C-MOS and transistor-transistor logic.

Additionally, the AD7550 provides a serial linear output pulse stream, which contains 8,192 (or 2^{13}) pulses for a full-scale input. Since it develops both parallel and serial outputs, the AD7550 is equipped to provide the simultaneous digital data needed for microcomputer data acquisition, as well as the serial data needed for a digital display involving, say, a counter and a light-emitting-diode decoder/driver.

The new converter can accurately digitize signals as large as one half the value of the applied reference voltage. And it can convert very



low-level signals, too. This low-level capability is limited only by the ability of the unit's internal amplifier to integrate small microvolt signals accurately, without errors due to noise, notes Analog Devices.

What's more, the AD7550 can operate over a wide range of supply voltages. It requires a drain (V_{DD}) supply of 5 to 15 V, a source (V_{SS}) supply of -5 to -15 V, and a logic (V_{CC}) supply of 5 V to the V_{DD} level, depending on whether TTL or C-MOS logic-level interfacing is needed. The device can also be wired for operation from a single supply.

Potential applications for the new converter are vast, including those in which previous monolithic converters could not be used, says Analog Devices. They range from battery-operated single-supply a-d conversion systems to sophisticated microprocessor-controlled analog interface peripherals. And because the converter's response is very stable, it can be used in automotive and industrial applications, where harsh environments formerly precluded the use of digital techniques.

The AD7550 is housed in a 40-pin ceramic dual-in-line package. Its operating temperature range is -25°C to +85°C. In quantities of 1-49, it sells for $35 each, dropping to $25 each in lots of 100. Delivery is from stock.

Analog Devices Inc., P.O. Box 280, Route 1, Industrial Park, Norwood, Mass. 02062
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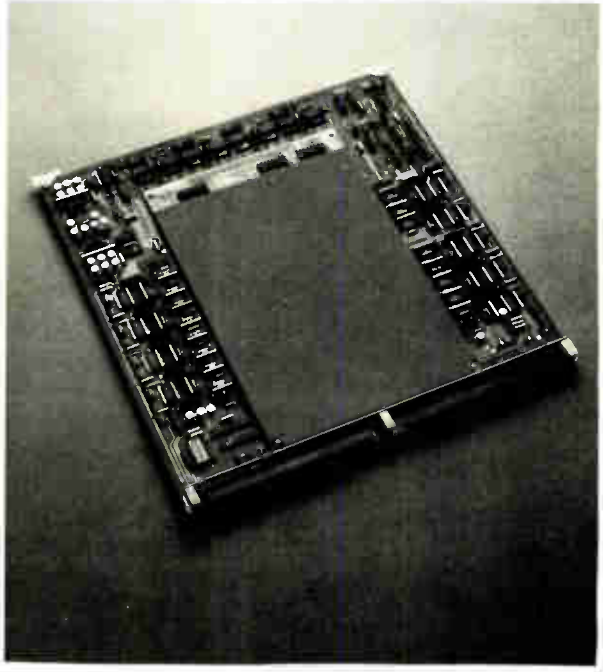


THE PLESSEY PM-716

Circle 141 on reader service card

Logic analyzer catches 5-ns spikes

Digital tester samples bit streams at rates up to 50 MHz; stores and reads out 512 bits on each of eight channels

by Andy Santoni, Instrumentation Editor

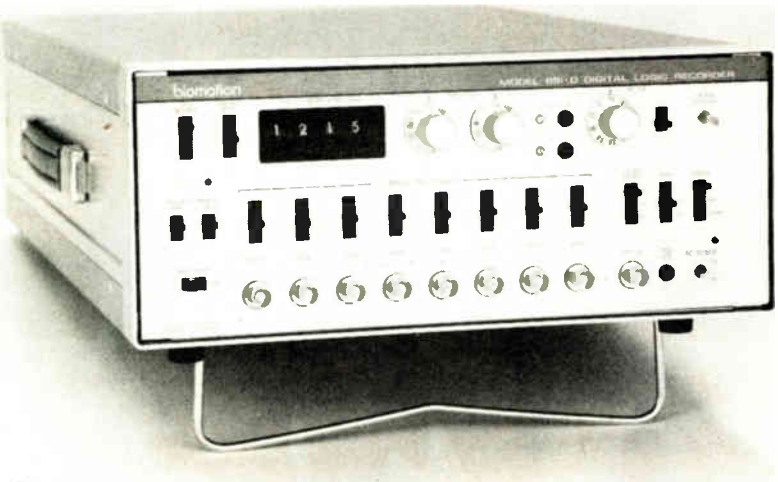
Just as oscilloscopes are invaluable for time-domain testing and spectrum analyzers are required for frequency-domain testing, so are logic analyzers a prerequisite for testing in the data domain. Although they are a relatively new type of instrument, they have already proven their usefulness in troubleshooting digital systems such as computers and peripherals, both in the laboratory and in the field.

Almost all logic analyzer applications can be handled by an instrument that operates up to 50 megahertz. That's where the Biomation 851-D fits in. The $3,600 model 851-D is an eight-channel timing analyzer that has a 50-MHz maximum clock rate, a memory length of 512 bits per channel, and a latch mode that catches glitches as brief as 5 nanoseconds. It has the speed and the resolution to find timing errors in almost any digital circuit.

The 851-D also features preset or adjustable thresholds that are separately controlled for channels 1–4 and 5–8 to facilitate testing systems containing more than one logic type. It can be triggered on words up to 8 bits in length, has a pretrigger mode to permit viewing events before or after a given logic state, and has a delayed trigger mode to hold off the display until a set number of clock cycles has passed.

In the latch mode, glitches occurring at random times between sample clock-transitions can be captured. A glitch occurring between samples causes an input to latch and be stored at the next sample space.

In the sample mode, input levels are clocked into the 851-D's memory as logic high or low, based on the signal level with respect to the selected threshold at the time of the rising edge of the clock cycle.



The input threshold levels can be at preset transistor-transistor-logic or emitter-coupled-logic levels, at a special preset level, or at a variable level set by screw adjustment on the front panel. Switching is provided to allow use of × 1 or × 10 probes, and ordinary oscilloscope probes can be used because of the analyzer's 1-megohm, 10-picofarad inputs.

The sample clock may come from an external source or from an internal one with intervals from 0.02 to 20 microseconds or milliseconds in 1-2-5 sequences.

A front-panel switch is provided for manual triggering. External triggering is accomplished by rear-panel connectors, a BNC type for ECL levels, or an input/output type for TTL levels. Internal triggering occurs when the inputs correspond to the setting of the eight trigger-select switches on the front panel, or to the negation of that setting.

In the pretrigger mode, the recording process starts when the 851-D is armed, and stops when the trigger occurs. In the delayed-trigger mode, recording starts with the trigger event and stops when the memory is filled with new data.

The 851-D also features a movable cursor to simplify making timing comparisons between channels. The cursor position also corresponds to the starting position for a horizontally expanded display of 5, 10, or 20 times normal. A mixed-sweep mode is provided to present the display in normal perspective to the left of the cursor and expanded to the right of the cursor.

Biomation Corp., 10411 Bubb Road, Cupertino, Calif. 95014 [339]

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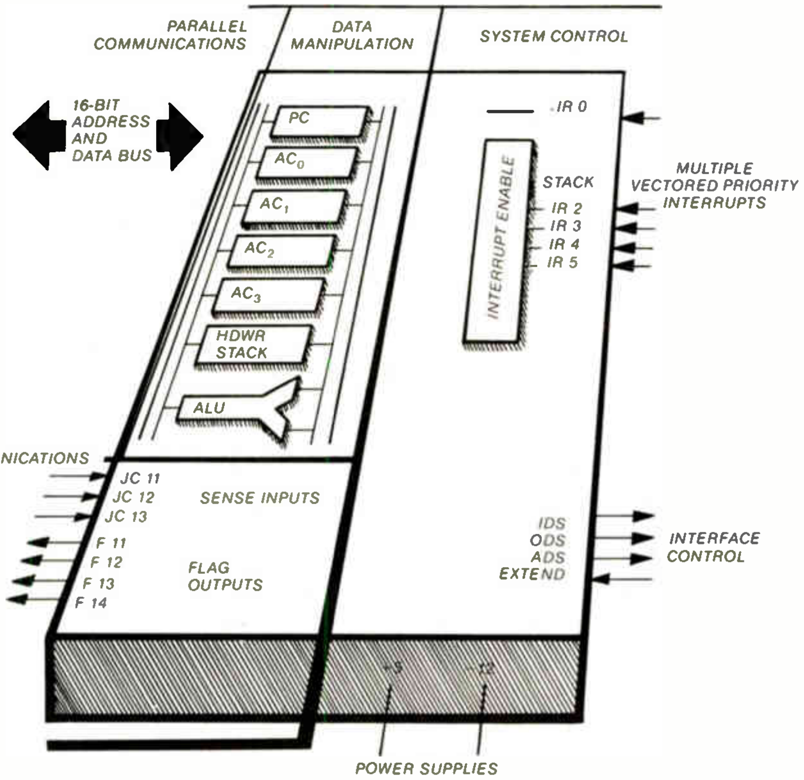

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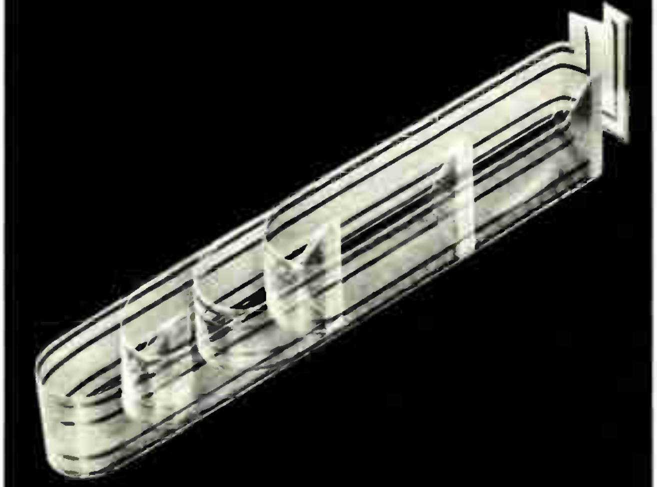

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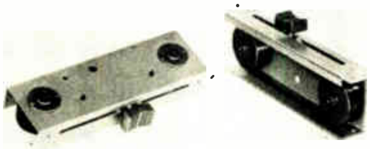
Components

Attenuator runs four channels

Four different circuits are controlled by one knob in a device that combines the advantages of a sealed rotary attenuator with the convenience of linear motion. The rotary-slider attenuator simultaneously controls four signal or control channels in industrial, information-handling and medical applications.

The unit consists of two sealed dual rotary potentiometers driven by a common linear-slide mechanism. An optional single-pole, double-throw switch provides positive switch action at one end of the linear travel. Already available are the 1,000-ohm models F66820 and the 10,000-ohm F66821. Other resistance values from 100 ohms to 5 megohms with linear, modified linear, modified log and special tapers are also available.



Resistance values of the attenuators are specified at ±10%. Working attenuation is 65 decibels; slide travel, 4 inches; maximum continuous power, 0.5 watt; and maximum ac or dc working voltage, 350 volts.

Robins/Fairchild, Robins Industries Corp., 75 Austin Blvd., Commack, N.Y. 11725. Phone Sam Jones at (516) 543-5200 [341]

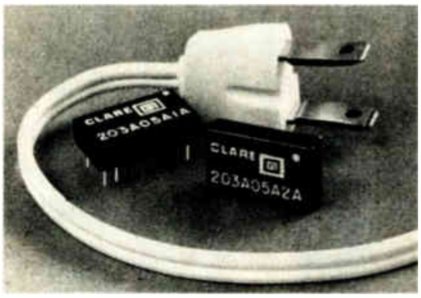
Chip resistor offers tolerance of ±0.02%

Designed for hybrid microcircuits, a chip resistor called the Vishay 5×5 has a standard resistance tolerance of ±0.02% and a temperature coefficient of resistance of 0±5 ppm/°C over the range from −55°C to +150°C. The V5×5 measures only 0.050 by 0.050 by 0.015 inch and is available in resistance values from 1 ohm to 5 kilohms. Gold-plated pads are provided for termination via thermal pulse-welded 1-mil-diameter gold wire. The resistor has a rise time of only 1 nanosecond, tracking to 3 ppm, and no measurable noise. The 100-piece price for the top-of-the-line resistors with ±0.02% tolerance is $2.84 each in the range of 1 ohm to 2 kilohms and $3.12 each in the 2-5-kilohm range. Evaluation quantities of the chip resistors are available in 8 to 12 weeks; delivery time for volume orders is 12 to 16 weeks.

Vishay Resistive Systems Group, 63 Lincoln Highway, Malvern, Pa. 19135. Phone (215) 644-1300 [343]

Solid-state relays withstand 2,000 V ac

Load-voltage and dielectric-withstanding-voltage ratings have been improved, without an increase in price, in the series 203 solid-state DIP relays. The series includes two models, featuring an rms load rating of 240 volts ac as well as the original 140 V ac. Both provide dielectric-withstanding-voltage ratings of 2,000 V ac, increased from the original 1,500-V ac rating. The upgraded units, both normally open spst devices, offer zero-crossing synchronous switching and opto-isolation in a compact, molded package, sized to accommodate circuit-board mounting on high-density 0.500-inch centers. The package measures 0.218 in. high by 0.880 in. long by 0.500 in. wide. Rms load current ratings run from 10 milliamperes to 750 mA, with peak one-cycle surge current rating of 7.5 amperes and peak 1-second surge current rating of 3.75 A. Power factor is rated at 0.35. Turn-on and turn-off time at 60 hertz is 8.33 milliseconds. Priced at $7.20 each in 1,000-piece lots, both models are available from stock.



C. P. Clare & Company, 3101 W. Pratt Ave., Chicago, Ill. 60645. Phone George Neeno at (312) 262-7700 [344]

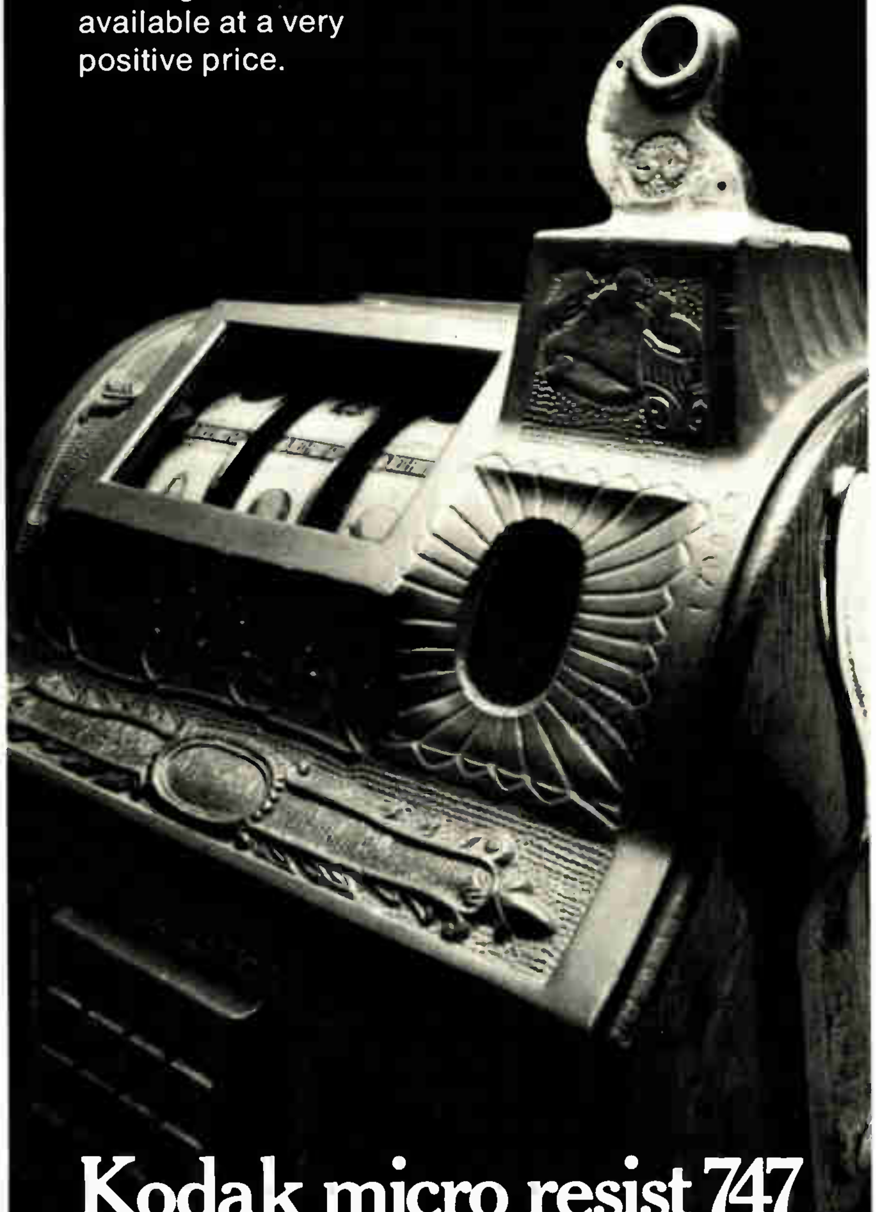
High-density switch reduces front-panel area

A high-density, multiple-lever switch called the SAE (side and edge) consists of multiple switching positions actuated with a lever that interconnects opposite sides of a circuit board with a horseshoe-shaped terminal. Depending on the board layout, the switch allows for single-pole single-throw, single-pole double-throw and SPST-DB contact closures. Other closures, such as double-pole double-throw, are accomplished by tripping two ganged levers. The switch mounts in a horizontal or vertical position, reduces overall front-panel area, and eliminates the need for interconnecting cables, connectors, and knobs and dials.

Stanford Applied Engineering Inc., 340 Martin Ave., Santa Clara, Calif. 95050. Phone Robert Hecton at (408) 243-9200 [346]

High-voltage resistors dissipate up to 20 W

A family of high-voltage metal-oxide resistors is offered both in tubular style with axial leads and in flat style with radial leads. The resistors, types RCX, REX, RFX, RNX, and ROX, have ratings from 0.5 to 20 watts at 25°C. Standard tolerance is 5%, but tolerances to 0.5% are available. Standard temperature coefficients of ±800, ±400 and ±200 ppm/°C are offered, with special tempcos to ±50 ppm/°C. Voltage ratings are 1,600 volts to 40 kilovolts, and resistance values range



from 100 ohms to 8 gigohms. Leads may be specified as tinned copper or bare nickel. Tubular-resistor lengths vary from 0.400 to 4.050 inches and diameters from 0.155 to 0.270 in. Flat styles vary from 0.530 by 0.190 by 0.080 in. thick to 2.030 by 0.310 by 0.080 in. thick. Prices range from $9.68 to 45 cents, depending on specifications and quantity. Delivery time is stock to eight weeks.

American Components Inc., RPC Division, Eighth Ave. at Harry St., Conshohocken, Pa. Phone William A. Mulligan at (215) 825-6200 [345]

Microwave capacitors use silicon-nitride dielectric

Replacing the conventional MOS silicon chip capacitor in the GHZ line of devices, a series of microwave chip capacitors uses silicon nitride for their dielectric layer. The GC-84000 series MNS capacitors are more reliable and more rugged, the company says, and they permit smaller size because of higher capacitance per unit area. The high-Q capacitors are used in rf circuits for dc blocks, capacitive coupling, and rf bypass.

They are applicable from uhf through Ku bands and exhibit less than 0.1-decibel insertion loss. Capacitance range is from 1 to 600 picofarads with a standard ±10% tolerance. They are available as chips or in bonded-wire or ribbon-lead packages. The capacitors are handled and assembled using conventional chip-and-wire bonding techniques.

GHZ Devices Inc., 16 Maple Rd., Chelmsford, Mass. 01824. Phone (617) 256-8101 [348]

Thermistors have long-term stability, high accuracy

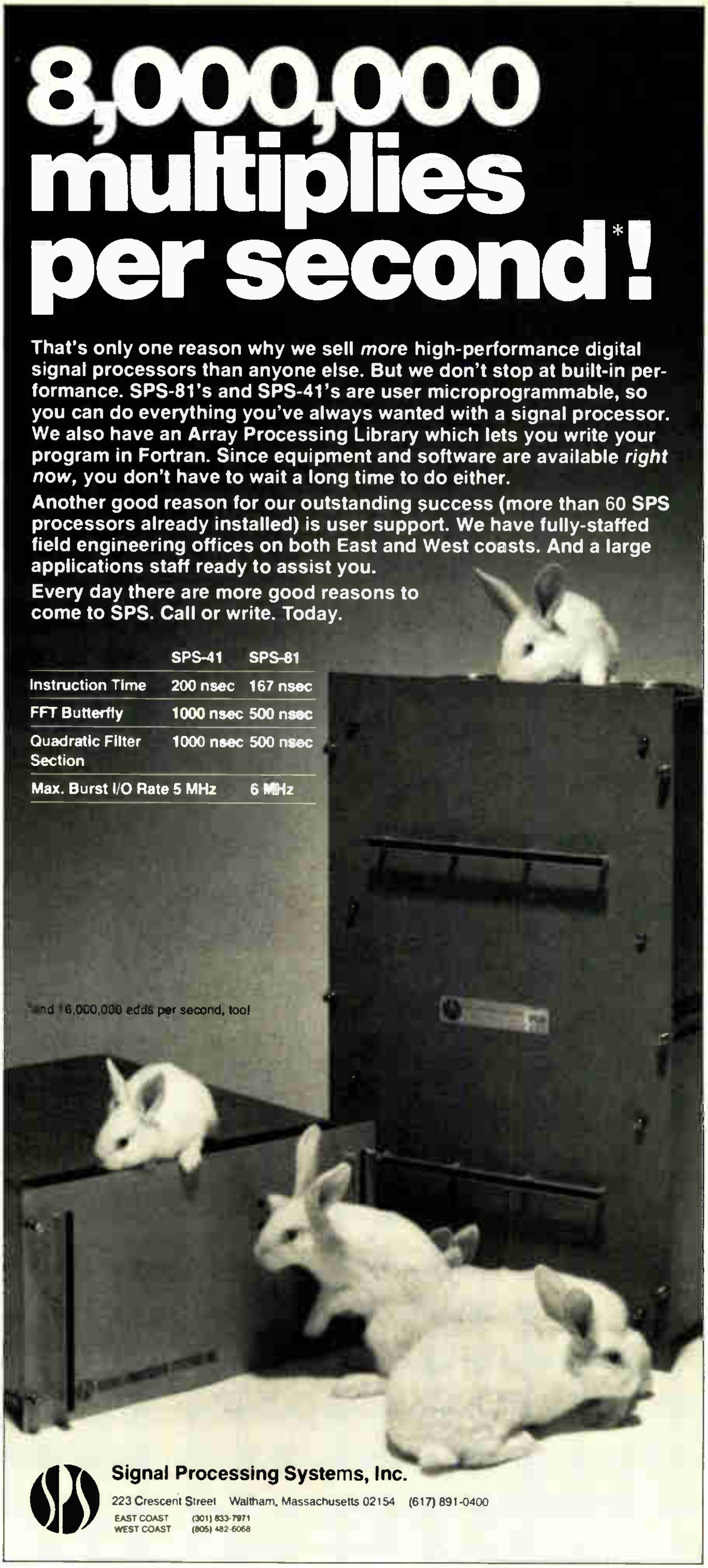
Novel techniques in processing, aging, and testing are credited with yielding a line of thermistors with stability to 0.02% or 0.005°C guaranteed for a full year. Designated the S-1 series, the thermistors take the form of cylindrical glass rods 0.600 or 0.100 inch in diameter.

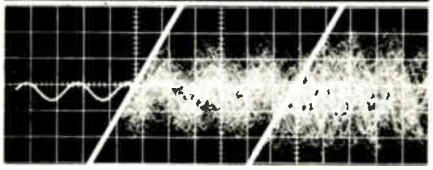
Thermometrics Inc., 15 Jean Pl., Edison, N.J. 08817. [347]

TOPICS

Components

Weston Components of Archbald, Pa., a division of Schlumberger, has introduced a line of cermet trimmers that is qualified for military applications. . . . A readout assembly from **Master Specialties Co., Costa Mesa, Calif.,** uses fiber-optic light pipes to transmit the light from LEDs in the back of each readout to the display screen. . . . For those who need a 12-volt indicator, **Dialight, Brooklyn, N.Y.,** offers green and blue Datalamp cartridges with neon lamps. . . . A helium-neon laser tube that is only 1.1 inch in diameter and 9.25 in. long has been developed by **Coherent Radiation, Palo Alto, Calif.** Power output is above 2 milliwatts. Applications include video disks, point-of-sale readers, optical bar-code readers, measurement and alignment. Volume price is less than $70.



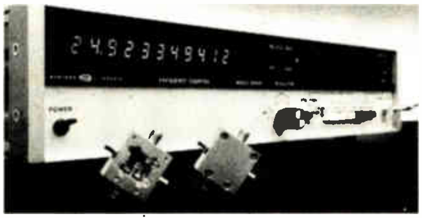


Instruments

Counter reaches 24 gigahertz

Microwave frequency device also eliminates need to select proper range or input

The first commercially available automatic microwave frequency counter that measures up to 24 gigahertz is being offered by Systron-Donner. To add to the design accomplishment, the model 6054B performs without range-switching. The counter, which is sensitive to -30 dBm, can accept complex signals, including those that have large amounts of fm.



To achieve this performance, the 6054B contains a new thin-film input sampler, as well as the Flacto (frequency lock automatic computing transfer oscillator) technique, which Systron-Donner introduced in an earlier counter.

The 6054B measures from 0.02 to 24 GHz in one band and has one input connector, so that the operator doesn't need to worry about which range or which input to select. The advanced technology used in the sampling mixers gives the 6054B a sensitivity rating of -30 dBm from 20 megahertz to 10 GHz, -25 dBm from 10 GHz to 18 GHz and -20 dBm from 18 GHz to the top of its specified 24-GHz range. Thus the instrument can operate continuously in a test setup without significantly loading the system under test.

An extremely low level of noise is generated in the counter itself because of the advanced sampling mixer, which is inherently quiet because it is balanced to the local oscillator. Typical tests have shown the unit's output noise to be less than -65 dBm.

High fm is not a problem, because of the Flacto technique. By using a frequency-lock method instead of the more conventional phase-lock, the counter can tolerate large amounts of frequency modulation and is virtually immune to the rate at which modulation occurs. Because the counter is rated at 10 MHz peak-to-peak fm at any rate from 0 to 10 MHz, carriers not previously measurable by automatic counters can be measured. For example, the counter can handle a 6.5-GHz carrier with 1,200 channels and full data-under-voice.

Also designed into the 6054B is a special "wide" mode for tracking changing signals; the local oscillator tracks the input signal. Coupling this design characteristic with the fm tolerance of the i-f amplifier yields broad tracking responses. If an input frequency of, say, 18 GHz were measured and the signal were swept at a rate of 100 hertz, the input could vary up to 3,000 MHz without loss of lock. Because of this capability, input signals containing white noise or any complex modulation can be measured. Since the direction of the deviation has no effect on the counter, the operator may sweep the frequency either higher or lower and be assured of fast valid readings.

High-power applications are provided for in the design of the 6054B. To eliminate the possibility of damaging the instrument, overloading it, or obtaining a wrong answer, the counter was designed to guarantee operation with any input signal at power levels from the rated sensitivity all the way to 1 watt (+30 dBm). This characteristic is called the operative dynamic range.

In the normal mode of operation, the 6054B provides 1-Hz resolution with a sampling speed of 1 second from 20 Hz to 24 GHz. Faster sampling speeds can be obtained by selecting one of the other resolutions from 1 MHz to 1 Hz. With this capability of measuring 24 GHz to a resolution of 1 Hz, an 11-digit display is required. Such a standard display, using 0.4-inch amber light-emitting diodes, meets all requirements for mercury-free environments.

The 6054B weighs 30 pounds and is 3.5 in. high, 16.76 in. wide and 17.50 in. deep. It operates from 115 or 230 volts ac, consumes approximately 106 watts, and will operate over a range from 0°C to +50°C. Price is $6,200.

Systron-Donner Corp., Instrument Division, 10 Systron Dr., Concord, Calif. 94518 [351]

Synthesizer provides sequential tones

The model 822 dual-tone generator is a direct digital synthesizer and provides single- or two-tone sequential outputs for testing communications systems with tone-selective signaling.

The $850 unit's frequency can be set to four significant digits in three ranges from 10 to 9,999 hertz full scale with a frequency uncertainty of less than ±0.005%. The output is a sine wave with separate controls for both level and duration for each tone. Output levels may be varied from 0 to 2.45 V rms terminated into a 600-ohm load.

Independent controls set the interval delay between the two tones and the repeat delay at the end of the second tone. The minimum intertone delay is zero, and a single, continuous tone can also be generated.

The model 822 also offers automatic output sequencing. Front-panel switches control events in the

GPD high-current copper TO-3

GPD high-power TO-36

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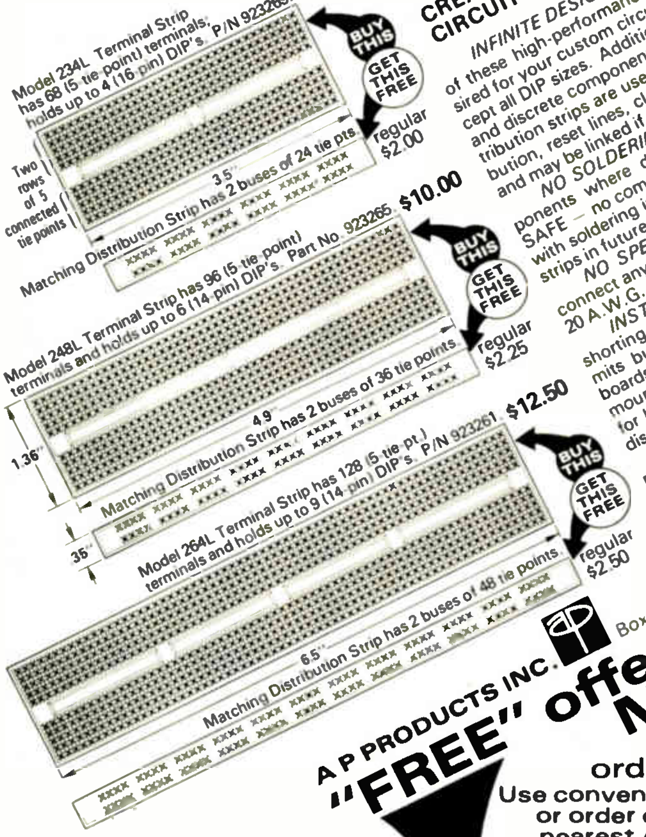

CREATE CUSTOM BREADBOARDS FOR FAST CIRCUIT BUILD-UP AND CHECK-OUT

INFINITE DESIGN FLEXIBILITY. Arrange any number of these high-performance Strips — in any positions desired for your custom circuit projects. Terminal strips accept all DIP sizes. Additionally, all models accept TO-5's and discrete components with leads to .032" dia. Distribution strips are used for voltage and ground distribution, reset lines, clock lines, shift command, etc., and may be linked if desired.

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INSTANT MOUNTING. New, non-shorting "peel and press" backing permits building even large-scale breadboards in minutes. (Instant-removal mounting screws are also included for boards up to 1/8" thick where disassembly may be required.)

MATERIALS. Non-corrosive nickel-silver contacts; rugged acetal copolymer dielectric.

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100.01 to 200.00	3.00

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Total Amount Enclosed

run cycle mode. An external gate level may control step or select sequencing, which is convenient for mobile telephone servicing. A push button controls one-cycle or fixed-cycle sequencing. The output tones of the model 822 can simulate radio-system transmitter signals by modulating a-m or fm signal generators. The sinusoidal output wave form has less than 1% distortion and phase jitter is less than 2° peak to peak.

Exact Electronics Inc., 455 S.E. Second Ave., Hillsboro, Ore. 97123 [352]

Selective-level meter checks carrier operation in U. S.

For selective measurements of U. S. transmission parameters from 1 kilohertz to 18.6 megahertz, Siemens is introducing the D2008US meter, to be manufactured in Iselin, N. J. The meter, priced at $5,395, can be expanded into a complete transmission-measuring system by adding the W2008US tracking generator, priced at $2,600. An equipment cart is also available for mobility.

The 30-pound meter is suitable for making selective in-plant measurements on carrier-transmission systems and carrier-frequency equipment for balanced and coaxial lines. Simple to operate, the instrument provides 10-hertz frequency resolution, 0.02-decibel expanded-scale resolution, and single-sideband phase-jitter output. It is equipped with a built-in monitoring speaker and contains a C-message-equivalent 1.74-kHz effective-noise bandwidth filter, an 80-Hz pilot pick-off filter, and an optical search indicator, which is a hit or spurious-

tone detector. Power consumption is low, according to the company.

Siemens Corp., Communications Equipment Division, 186 Wood Ave. South, Iselin, N. J. 08830. Phone Martin Weitzner at (201) 494-1000, Ext. 338. [353]

Spectrum analyzer delivers 512-line FFT resolution

The model 4512 fast-Fourier-transform real-time spectrum analyzer sells for $6,900. Standard frequency ranges for 512-line narrow-band FFT analysis in real time are dc to 10 hertz and dc to 40 kilohertz. Ranges as small as dc to 5 Hz are optional. Digital techniques enable the 4512 to update the full spectrum every 35 milliseconds, providing real-time analysis to 16 kHz. A two-tone dynamic range of 60 decibels is guaranteed. Transient-capture and spectrum-averaging modes are standard, and the temporal signal and spectrum can be displayed simultaneously. A four-digit LED display reads out frequency and amplitude.

Princeton Applied Research Corp., Box 2565, Princeton, N.J. 08540. Phone Sy Letzter at (609) 452-2111 [354]

Remote displays enable DPMs to work in tight spots

A flat flexible cable connects remote displays to the analog-to-digital processor assembly of digital panel meters that offer the user 3 to 4½ digits. The standard cable is 7 inches long, but lengths to 18 inches are available. These remote-display DPMs are particularly useful in a number of situations—when there is minimal space behind a panel, when everything is mounted behind the panel

without a bezel, when the panel location would interfere with other subassemblies, when the front panel is hinged or slides out, or when it is desirable for the display units to be movable.

Electrical specifications are identical with standard Velonex Impac DPMs. Units are available in three standard display heights, 0.2, 0.33 and 0.5 inch, as well as a choice of display colors. Delivery of the DPMs is from stock.

Velonex, a division of Varian, 560 Robert Ave., Santa Clara, Calif. 95050. Phone Steve Rose at (408) 244-7370 [355]

TOPICS

Instruments

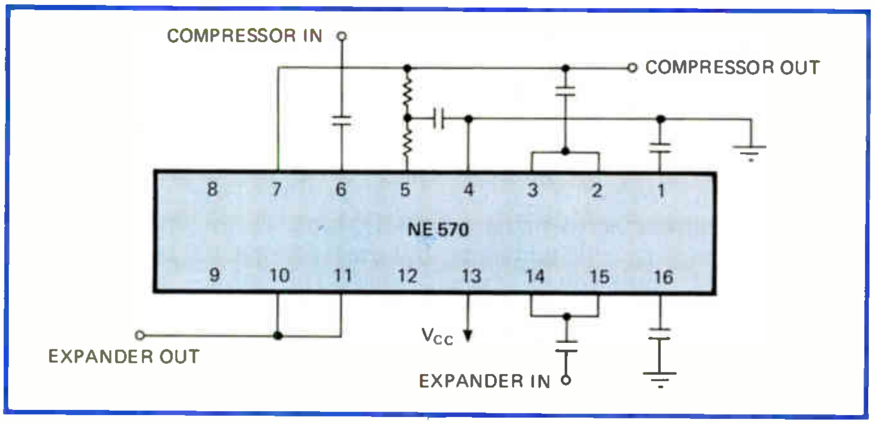
Wavetek, San Diego, Calif., is offering its $795 model 186 phase-lock generator, which adds phase control as well as amplitude and frequency modulation to standard generator functions. . . . The "gold-button" option introduced with the 100-MHz 1740A oscilloscope from **Hewlett-Packard Co., Colorado Springs, Colo.,** is now available on four other models to interchange their time-domain display with the data-domain display. The models are the 200-MHz 1710B, the 200-MHz dual delayed-sweep 1712A, the 275-MHz 1720A, and the 275-MHz dual-delayed-sweep 1722A, equipped with a microprocessor. A logic table of 0s and 1s is fed to the scope by an associated logic-state analyzer. . . . The Alarm-Store software option has just been released by **Doric Scientific division of Emerson Electric Co., San Diego, Calif.,** to provide 4,000 setpoints and relay contacts for on-off control of alarms in the Digitrend 220 smart data-acquisition system. . . . The new model RA-3 add-on ranging amplifier from **Electronic Development Corp., Boston,** extends the digitally controllable range of the company's 501J voltage standard to 200 volts dc in increments of ±200 microvolts at response times of 500 microseconds to settle within 0.01% of final value.

Semiconductors

IC compandor uses 400 mW

Wide range, low distortion make expander-compressor suitable for CB, other uses

The advantages of integrated circuits are seldom as apparent as in the circuitry that compresses or expands analog signals in telephone trunk lines. Bipolar monolithic "compandors" capable of performing either function [*Electronics*, June 26, 1975, p. 117] have reduced the parts count to a few capacitors and two ICs on each end of the line and cost three to five times less than discrete systems with their 150 or more parts.



Taking bipolar-monolithic-compandor technology several steps further, Signetics Corp. has introduced the NE 570/571 that reduces the number of ICs to one on each end. It is also said to widen the performance range by five to six times over other devices.

Most monolithic compandor circuits have gain changes of about ±1 decibel over a frequency range of 300 hertz to 3.5 kilohertz and a dynamic range of about 60 dB. But the 570/571 operates over a 0-to-20-kHz range, with a gain change of less than ±0.2 dB and a dynamic range that is 30 to 50 dB wider. Distortion also is reduced, at ±1% or ±2% over a 20-kHz bandwidth compared with 3% over 3 to 5 kHz in earlier devices. Power dissipation in the 88-by-92-mil, 16-pin chip is only 400 milliwatts, which the company says is a 30% to 50% improvement over most monolithic compandors.

According to its designer, Craig Todd, this means that the device not only meets the specifications for telephone trunk lines (the 570), but it can also be used for subscriber lines (the 571). "In addition, its range and low distortion make it suitable for use in hi-fi audio systems and in citizens' band radio as well as in similar communications systems," according to Todd.

To do this, the 6-to-16-volt 570/571 uses a dual-gain control circuit. Two independent signal channels are fabricated on-chip using a full wave rectifier, a variable gain cell, and an operational amplifier. Circuit gain is set internally via a resistor bias network and a bandgap reference voltage. The rectifier provides a gain-control current that is proportional to the average value of the input signal. The output current of the variable gain cell, which flows to to the operational-amplifier summing node, is proportional to the product of the input signal and the gain-control circuit.

"As an expander, both the rectifier and variable gain cell are tied to the input voltage," says Todd, "so that when the input voltage falls 6 dB, the gain drops 6 dB and the output drops 12 dB." The compressor is essentially an expander placed in the feedback loop of an operational amplifier. If the input rises 6 dB, the output can rise only 3 dB. Thus, only a single device is necessary to expand or compress the signal at each end of the line.

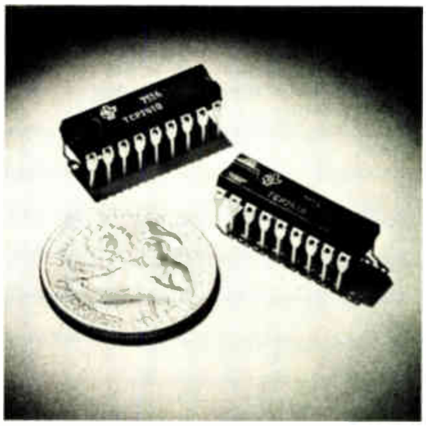
A bandgap reference provides the reference voltage for all summing nodes and a regulated supply voltage for the rectifier and variable gain cell, as well as the bias current for the latter. "The low temperature coefficient of this type of reference provides very stable biasing over a wide temperature range," Todd says. "Gain change over a range of -40°C to +70°C is ±0.3 dB for the 570 and ±0.5 dB for the 571."

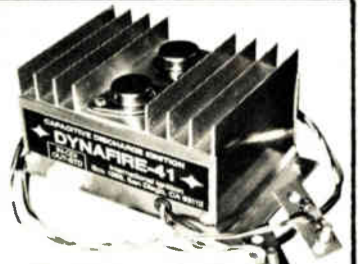
Available now, the NE 570 trunk-line compandor is priced at $6.33 each for 100 to 999. The NE 571 subscriber-line version sells for $5.88 each.

Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. 94086 [411]

Monolithic array contains eight SCRs

An array of eight low-power silicon controlled rectifiers for use in display latching, analog switching, or as a crosspoint switch uses dielectric isolation to minimize crosstalk between the SCRs. Housed in an 18-pin plastic dual in-line package, the device consists of eight SCRs and eight holding-current resistors on the same monolithic chip. In its standard form, the model TCP 2410 comes with diode protection from the cathode to the gate. For appli-





cations requiring on/off control, the device is offered without diode protection, and then it is designated the TCP 2411. The devices are designed to operate at 20 volts with a maximum current of 100 milliamperes. Holding current typically is 350 microamperes. Both units sell for $2.95 each in hundreds. Delivery time is two weeks.

Texas Instruments Inc., Inquiry Answering Service, P. O. Box 5012, Mail Station 308, Dallas, Texas 75222 [413]

Subminiature LED lamps can be tightly stacked

Offered in three colors—red, yellow, and green—a line of subminiature light-emitting-diode lamps consists of tiny units that can be mounted as arrays (stacked) on 2.21-millimeter (0.087-inch) centers. Three of the five LEDs in the 5082-4100 line are red; with a current of 10 milliamperes, they vary in axial luminous intensity and forward voltage drop from 0.7 millicandelas at 1.6 V for the 5082-4100 to 3 mcd at 2.2 V for the 5082-4160. Prices for the lamps range from 15 cents each in thousands for the low-output red LED to 59 cents apiece for the high-efficiency red unit and for the green and yellow devices. Delivery is from stock.

Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [414]

Large-scale ROMs cut access times

Two n-channel MOS read-only memories are factory-programed devices that combine high capacity with high speed. The Am9208 is a 8,192-bit device, organized as 1,024 words of 8 bits each, with access times as low as 300 nanoseconds. The Am9216 is a 16,384-bit memory, organized as 2,048 words of 8 bits each. Currently available access times on this unit are as low as 400 ns. Both units operate from +5-V and +12-V supplies, and both have two fully programable chip selects. Pricing on the ROMs depends, of course, on quantity and number of patterns. Typical delivery time is six to eight weeks for prototypes plus an additional four to five weeks for production quantities.

Advanced Micro Devices Inc., 901 Thompson Pl., Sunnyvale, Calif. 94086. Phone (408) 732-2400 [415]

CCD area image sensor contains 46,360 elements

A charge-coupled-device area image sensor with a 190-by-244-element sensing array is intended for use in video systems that require low power, small size, high sensitivity, and high reliability. Containing 46,360 sensing elements organized in an array of 190 vertical columns and 244 horizontal lines, the CCD211 has a resolution equal to a quarter of that of standard television. The device is built using Fairchild's ion-implanted, buried n-channel technology with a gapless polysilicon-gate structure. It is housed in a 24-pin DIP. Prototype quantities are available from stock.

CCD Dept., Fairchild Camera & Instrument Corp., 4001 Miranda Ave., Palo Alto, Calif. 94304. Phone (415) 493-8001 [418]

FET-input op amp has 75-fA bias current

An electrometer FET-input operational amplifier has a maximum bias current of 75 femtoamperes (75 $\times$ 10^{-15} amperes). Built using laser trimming and a thermally balanced chip layout, the op amp has a maximum offset voltage of 1 millivolt, a maximum offset-voltage drift of 15 microvolts per degree celsius, and peak-to-peak voltage noise of 4 microvolts from 0.1 to 10 hertz. Internally compensated and free of latch-up problems, the AD515 is protected against short circuits and includes a case guard connection to minimize leakage and shield the in-

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Find out more about the Model 8030 filter for your application. Write for descriptive literature.

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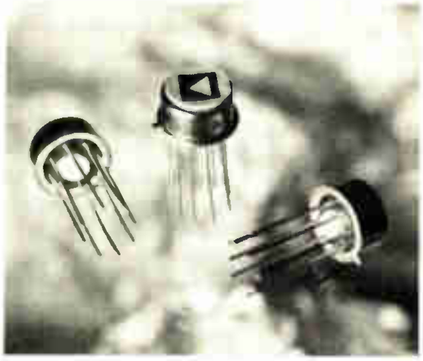
333 West Commercial Street
East Rochester, N.Y. 14445 (716) 385-1440

Circle 178 on reader service card



put from external noise and supply transients. Rated for operation from 0°C to 70°C, the AD515L is housed in an hermetic TO-99 package. Its price, in hundreds, is $18. Versions with higher bias currents are available at lower prices; the AD515J, for example, has a bias current of 300 fA and a price of $9.90.

Analog Devices Inc., P.O. Box 280, Route 1 Industrial Park, Norwood, Mass. 02062. Phone Lowell Wickersham at (617) 329-4700 [416]

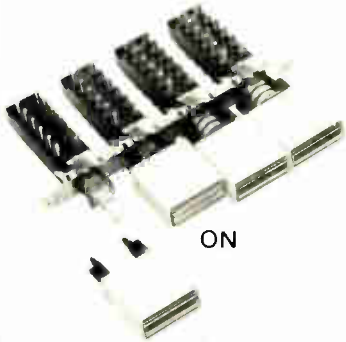
TOPICS

Semiconductors

National Semiconductor Corp., Santa Clara, Calif., has reached an agreement with **Synertek Inc., also of Santa Clara,** for Synertek to second-source National's full line of 4,096-bit RAMs. National previously made similar agreements with **Advanced Memory Systems** and with **Monolithic Memories**. At the same time, National announced that it is now offering five models of 4-kilobit RAMs from stock. . . . **Siemens AG, Erlangen, West Germany,** has developed a green light-emitting diode with a luminous intensity of 30 millicandelas at a forward current of 10 milliamperes. Its predecessor produced only 5 mcd at 20 mA. Called the LD 57 C, the new LED is able to appreciably illuminate its surroundings. . . . **International Rectifier, El Segundo, Calif.,** has a series of Hockey-Puk diodes with current ratings to 2,000 amperes and voltage ratings to 2,000 volts.

When it's your move check Centralab

Visual display



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PCB, device testers bow

GenRad introduces low-cost logic-circuit analyzer, component checkout system

Logic-circuit analyzers—testers that isolate and diagnose faults on circuit boards—often have price tags running into six figures. That's not true of the model 1795 computer-controlled logic-circuit analyzer being unveiled next week at Nepcon '76 West by GenRad Inc. (formerly General Radio).

The basic system will sell for less than $30,000, says Robert Szpila, product marketing manager for GenRad's Test Systems division. It will function as a stand-alone tester or as a programing station for the company's earlier, more sophisticated model 1792 digital/analog test system. The 1795 (shown in photo) does not include the 1792's CAPS (computer-aided programing software simulator program), which simulates pin-output states, but it will accept the CAPS program output to exercise circuit boards.

The basic 1795 does include a PDP-8/A minicomputer with 16,000 words of core memory, a dual floppy disk and paper-tape reader for program loading, a cathode-ray-tube terminal, control panel, and 72 driver-sensor pins that can be designated as input or output pins under program control. The system's capacity may be expanded to more than 400 pins with additional driver/sensor boards. Other options include a line printer, a variety of power supplies, an ASCII bus-interface card, and a guided-probe that may be either a single-point type or a multipoint logic chip.

Szpila points out that use of the guided probe may be combined with a more conventional fault dictionary used in other logic analyzers. This gives the 1795 a "smart probe" that quickly isolates board faults down to four or five bad nodes, the point at which the guided probe isolates the faulty node.

Besides the 1795, GenRad will introduce a component test system, the 2230, at Nepcon West. Eric Mudama believes the 2230 is the first microcomputer-controlled component tester priced between $15,000 and $20,000 that is designed as a complete system for testing a range of passive networks, passive components and some active networks.

Mudama, the marketing manager for the Test System division, expects the 2230 to be used by both makers and users of passive components and networks. The 1795 analyzer, he says, will find its way into both production-line and depot- or incoming-testing for military and industrial users.

Key features of the 2230 are its speed, which results chiefly from incorporation of Digital Equipment Corp.'s LSI-11 microcomputer. The 2230 will measure resistance, capacitance, inductance, voltage and current and will also force or generate current.

Both systems will be ready for delivery in early spring.

GenRad Inc., 300 Baker Ave., Concord, Mass. 01742. Phone (617) 369-8770 [391]

Wafering machine slices hard and fragile materials

The model 686 wafering machine, priced at about $18,000, accurately slices virtually any material, regardless of its hardness or fragility. The cutter is already producing piezoelectric quartz crystals for oscillators and crystal filters to be used in citizens' band radios and digital watches. Lead time for delivery is eight to 10 weeks.

Wafers as thin as 0.005 inch can be cut without breakage or chipping. Yield from even the most critical atomic-plane cutting is usually 90% to 95%. In addition to conserving material, the cutting technique eliminates subsequent grinding and lapping operations, reduces surface damage, and ensures high production rates.

The 686 produces as many as 160 quartz crystals an hour. As many as seven machines can be operated by one person. The large work area of 7½ by 8 inches permits the simultaneous wafering of several bars for high output.

Because the cutting action of the 686 is similar to a lapping process, the need for subsequent lapping or grinding is reduced, and the parts can be cut close to their final thickness. And virtually no heat is gener-

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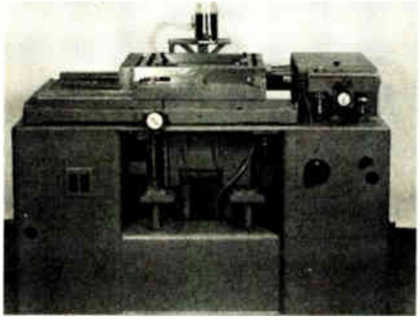


ated because the cutting action is extremely gentle.

Varian Industrial Equipment Group, 121 Hartwell Ave., Lexington, Mass. 02173. Phone Dave Cloues at (617) 861-7200. [393]

Coaxial connectors fulfill military high-power specs

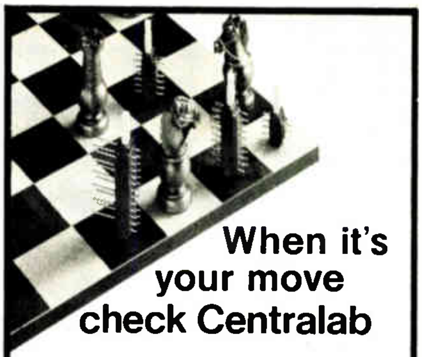
Series SC medium-size coaxial connectors, which meet high-power requirements of avionics and electronic-warfare equipment, are qualified to MIL-C-39012/35 through 42 specifications. Price is $2 each in lots of 1,000. Delivery time for standard items is eight weeks, with four additional weeks needed for special or modified designs.

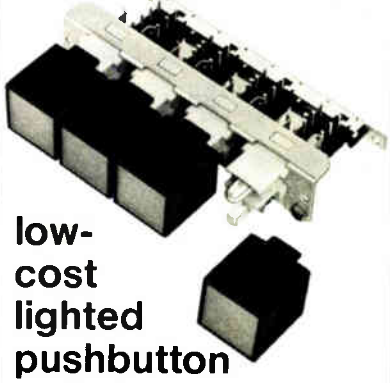
Straight plugs, angle plugs, and straight jacks are available for RG/U 214, 225, 393, 142B and 400 cables. All have captivated contacts and Teflon insulation. Both the center contact and the outer ferrule are crimped with the MIL-M-22520 die sets and Amphenol's Twin Hex crimp tool. A screw-thread coupling mechanism provides secure connector mating. Cable plugs have safety-wire holes to ensure secure contact between connectors.

Amphenol RF Division, 33 E. Franklin St., Danbury, Conn. 06810. Phone (203) 743-9272 [394]

Circuit board is prewired for microprocessor chip set

To save time in interconnection and evaluation of Motorola's M6800 evaluation chip set, the Cambion





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* Per station cost at 1000 pieces, $1.36 ... 2 PDT switch includes bulb.

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GLOBE-UNION INC.
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Circle 157 on reader service card

P/N 787-2000-03-03 circuit board is completely wire-wrapped and ready to accept the chips. Price of the board, which is the first in a series to be produced for use with microprocessors, is $197.50 each in lots of one to 99. The board is available from stock.

Included in a separate package are a Wire-Wrap tool and instructions for its use, a selection of precut and stripped wire for wrapping, the edge-card connector, and the standoffs and their mounting hardware. Also included are insertion and withdrawal tools for both 0.3- and 0.6-inch integrated circuits to minimize the possibility of damaging their leads during insertion or removal from sockets.

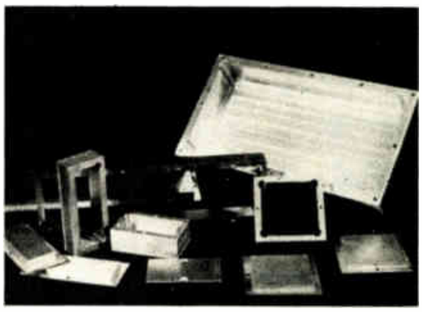
The circuitry includes an interface to a teletypewriter. For the addition of memory, sockets are prewired to accept three additional MC6810L-1 random-access memories.

Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass. 02138 [395]

Blank frame assemblies speed circuit packaging

Blank circuit-frame assemblies offer the microwave engineer a convenient method of packaging microstrip circuits at lower than the usual in-house cost. Blank assemblies, available for either hermetic or nonhermetic applications, come in six standard sizes as large as 2 by 4 inches. Most blank assemblies are available from stock to three weeks.

Because the frames have no ports or connectors, the engineer need not determine port locations until he is ready to mount the circuit in the package. To help determine the



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Circle 187 on reader service card

number and location of ports, drawings are supplied for designing prototype circuit packages and for configuring test packages. Special tools and accessories for drilling ports and inserting connectors into frame walls are also available.

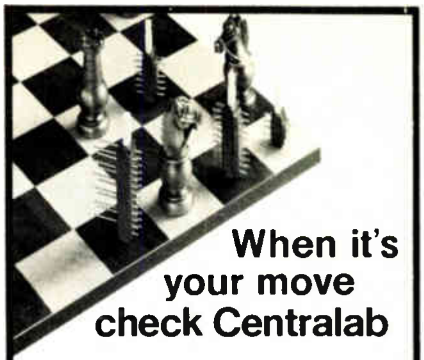
Materials offered for the new blank assemblies include aluminum/iridite or aluminum/gold plate. The proper frame material and finish depend upon whether the frame will be used for a hermetic or nonhermetic package. Hermetic package assemblies are supplied with Tekiseal heat-activated gaskets for high-quality hermetic sealing with strong mechanical bonds. Leak rate of sealed frames is less than 10^{-8} cc/second. Tekiseal gaskets also permit testing before circuit packaging, as well as frame cover reopening and resealing for fast field repairs and circuit updating.

Tek-wave Inc., subsidiary of Frequency Electronics Inc., 3 Delaware Dr., New Hyde Park, N.Y. 11040. Phone (516) 328-0100. [398]

TOPICS

Production

The DCS 15 dual-function AD-MU-78 dust cover/magnetic shield from **Ad-Vance Magnetics Inc., Rochester, Ind.**, protects small-aircraft radar displays from distortion caused by radiation from nearby instrumentation. . . . **Logic Dynamics Inc., Gardena, Calif.**, has introduced a clip bus that can carry more than 30 amperes for backplane busing of terminals 0.025 inch square and 0.022 by 0.036 in. Inlaid 18-karat gold and nickel in contact areas reduce gold-plating costs. . . . A wire-wrappable packaging assembly for interfacing with **Intel** 8080 and 8080A microprocessors is now available from **Garry Manufacturing Co., New Brunswick, N.J.** The board, which fits the standard **Intel** processor rack, includes two input/output connectors to mate with external wiring.



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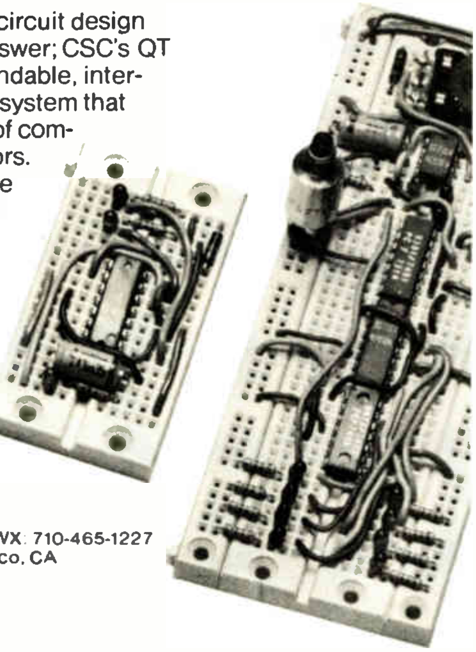

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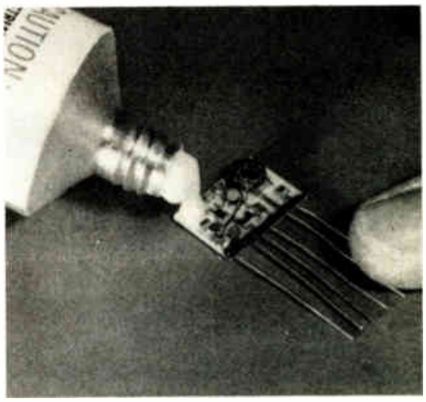
New products/materials



A silicone adhesive/sealant, specially formulated to be noncorrosive, is suited for applications such as a coating for discrete and integrated semiconductor circuits and for copper connections on electronic assemblies. The material, called RTV162, is a one-part, ready-to-use, paste-like adhesive/sealant that cures to a tough, durable, resilient silicone rubber. It bonds to most clean surfaces without the use of a primer.

Silicone Products Dept., General Electric Company, Waterford, N.Y. 12188 [476]

Solvent for removing oil and grease from electric motors, switches, panels, and instruments is noncorrosive and nonflammable. Parts and surfaces to be cleaned may be brushed or sprayed with Metro Solvent EM, or they may be dipped in it. Intended to replace highly toxic and flammable compounds, the solvent will not harm most plastics and is said to be effective where water cannot be tolerated.

Metropolitan Refining Co., 50–23 Twenty-third St., Long Island City, N.Y. 11101 [477]

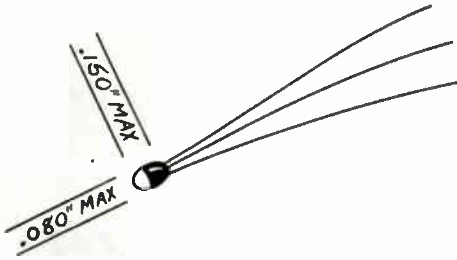
Tungsten-wire single crystals with purities in excess of 99.99% come in diameters ranging from 0.050 inch down to 0.005 in. and are usually supplied in 2-in. lengths. Other sizes are available on request. Various orientations including 110, 100, 111, 211 and 310 may be specified. A typical tungsten single-crystal wire, 0.005 in. in diameter and oriented, is priced below $100 per inch.

Aremco Products Inc., P.O. Box 429, Ossining, N.Y. 10562 [478]

Thick-film platinum/silver conductor compositions are available in a variety of price-performance combinations for use in hybrid and passive microcircuits. The conductors contain newly developed chemical and glass bonding agents that provide high initial and aged adhesion and desirable soldering properties. The platinum/silvers have a broad firing range, with 850°C optimum.
Electronic Products Division, Photo Products Dept., Du Pont Co., Wilmington, Del. 19898 [479]

Medium-flow epoxy molding powder, named Eccomold 20T, is efficient at encapsulating delicate inserts and penetrating coil windings. Resistant to thermal shock and moisture, the material will encapsulate units that operate up to 350°F. Application features claimed for the powder include high strength for bobbins and similar components; good adhesion to flexible-lead wire, permitting moisture-proof leads; and resistance to thermal shock for components such as relays. Price is $1.49 per pound in large quantity.
Emerson & Cuming Inc., Canton, Mass. 02021 [480]

Conductive tape called Confuzz consists of two special silver-impregnated tapes—one covered with a myriad of finely woven monofilaments formed into permanent hooks, and the other covered with soft loops. When pressed together, the tapes form a highly conductive, tightly fastened bond that can be separated and repositioned quickly, reestablishing both conductivity and bond.
Technical Wire Products Inc., 129 Dermody St., Cranford, N.J. 07016 [401]



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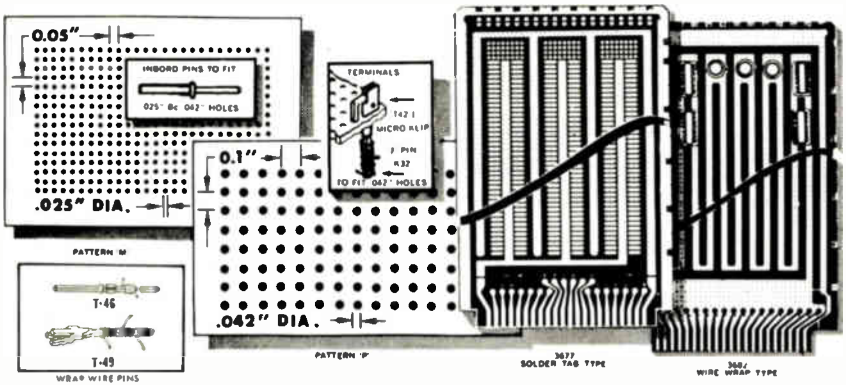

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New literature

Low-glare plastic-sheet materials, used as filters with LED, liquid-crystal, plasma-discharge, and incandescent displays and readouts are described in a two-page applications bulletin that provides design data and complete specifications on the material, designated Homalite-LR. The bulletin discusses display readability, enhanced contrast between on and off segments, inset of display for maximum shading, use of contrasting color bezels, and other design considerations. The bulletin may be obtained by writing to SGL Homalite, division of SGL Industries Inc., 11 Brookside Dr., Wilmington, Del. 19804. Circle 421 on reader service card.

Meters and converters. A 32-page catalog describes a line of frequency meters and signal converters. All units, of miniaturized, ruggedized design, are recommended for military and industrial applications. Solid State Electronics Corp., 15321 Rayen St., Sepulveda, Calif. 91343. Phone (213) 894-2271 [423]

Telecommunications products. A broad line of video, voice, and data-transmission systems is described in a 36-page booklet from GTE Lenkurt. The booklet is divided into sections covering microwave radio transmitter/receivers, microwave-radio subsystems, coaxial-cable transmission systems, multiplex systems, and other equipment. GTE Lenkurt Inc., Dept. C720, 1105 County Rd., San Carlos, Calif. 94070 [428]

Microwave equipment. A 102-page catalog from Sivers Lab contains microwave components and instruments, including YIG-tuned oscillators, filters and tuning heads; electromechanical coaxial switches, waveguide switches, couplers, attenuators and detectors. A special section describes rotary joints, single- and multichannel, covering most waveguide bands. Double-ridge waveguide components are also included. Sivers Lab, Box 420 18, S-126 12 Stockholm 42, Sweden [429]

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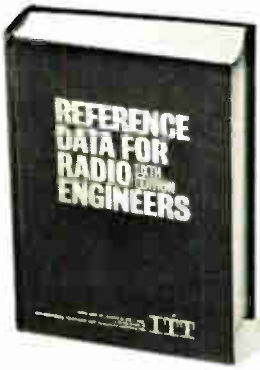

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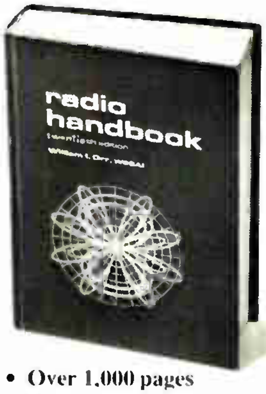

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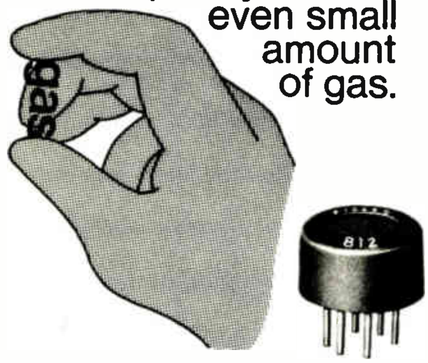

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Frankfurt/Main: Fritz Krusebecker
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Electronics Buyers' Guide

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MFE's 250B Digital Tape Transport
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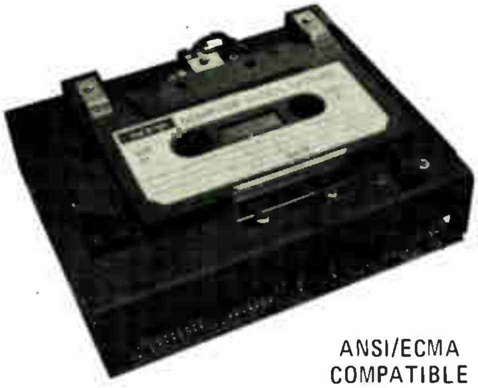

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☐ 15,000 Hr. MTBF ☐ 1 Year warranty ☐ Two moving parts ☐ Reel to reel ☐ Constant tape tension and constant tape speed – servo controlled ☐ ±5VDC operation ☐ Guaranteed cassette interchangeability ☐ Up to 800 BPI ☐ Read after write heads ☐ Bi-directional read/write operation ☐ Size: 4.39" X 5.46" X 2.42" Call or write Jim Saret

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Electronics' Industry Newsletter tells you which firms have current employment opportunities, in the field of Electronics, for all types of Engineers, Sales Representatives, Technicians, Executives, Computer Personnel and others. Latest product information is also reported. For information write: Electronics' Industry Newsletter, Dept. 304A, 23573 Prospect Avenue, Farmington, MI 48024.

Where can you find a remote controlled cassette tape transport for under $100?

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2. Data recording/logging/storage
3. Programming
4. Instrumentation
5. Industrial Controls
6. Data duplicating
7. Security/automatic warning systems
8. Test applications
9. Audio Visual/Education
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With Features Of:
- 4 motor reliability
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- Completely programmable-Logic
- No tape coasting
- Low power—AC or battery

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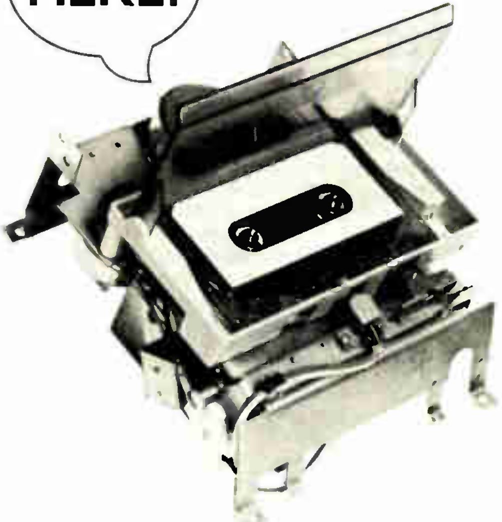

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The Economy Co., III Division
Oklahoma City, Oklahoma 73125

The Phi-Deck is the first American-made tape transport with remote control capabilities and features including standard and nonstandard functions — selling for under $100 in quantities of one.

The Economy Co., III Division
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Oklahoma City, Oklahoma 73105
(405) 528-8444 Ext. 71

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☐ I am interested in application no. ____
☐ Have Representative call
☐ Send application notes

Name ____ Title ____
Company Name ____
Address ____
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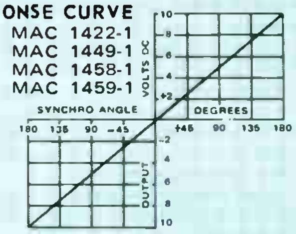
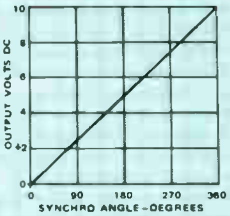
SOLID STATE 3 WIRE SYNCHRO TO LINEAR D.C. CONVERTER



RESPONSE CURVE
MAC 1422-1
MAC 1449-1
MAC 1458-1
MAC 1459-1



RESPONSE CURVE

MAC 1460-1
MAC 1461-1

FEATURES:

- Develops a DC output voltage linearly proportional to a synchro angle over a ± 180° range.
- Completely solid state with all of the inherent advantages over a mechanical system such as:
  - High reliability (since there are no moving parts)
  - Light weight–6 ozs.
  - Small size
  - All units hermetically sealed
- Wide temperature range operation
- Output short circuit protected
- Three wire inputs isolated from ground
- Package size may be altered at no extra cost
- Units can be altered to accept different line to line voltages or different operating frequencies at no extra cost
- Not affected by reference voltage or power supply variations.

UNIT	MAC 1422-1	MAC 1449-1	MAC 1458-1	MAC 1459-1	MAC 1460-1	MAC 1461-1
TRANSFER EQUATION	± IV/18°	± IV/18°	± IV/18°	± IV/18°	+IV/36°	+IV/36°
ACCURACY (+25°C)	½%	½%	½%	½%	½%	½%
ACCURACY (−25°C-+85°C)	1%	1%	1%	1%	1%	1%
L - L SYNCHRO INPUT (VRMS)	11.8	90	11.8	90	11.8	90
FREQUENCY (Hz)	400	400	60	60	400	400
FULL SCALE OUTPUT	± 10V	± 10V	± 10V	± 10V	+10V	+10V
OUTPUT IMPEDANCE	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω	<1Ω
L - L INPUT IMPEDANCE	>10K	>30K	>2K	>10K	>10K	>30K
REFERENCE VOLTAGE (VRMS)	26	115	26	115	26	115
OPERATING TEMP. °C	−25 - +85	−25 - +85	−25 - +85	−25 - +85	−25 - +85	−25 - +85
D.C. SUPPLY	± 15V	± 15V	± 15V	± 15V	± 15V	± 15V
D.C. SUPPLY CURRENT	± 75MA	± 75MA	± 75MA	± 75MA	± 75MA	± 75MA
BANDWIDTH	10Hz	10Hz	OPT.	OPT.	10Hz	10Hz
WEIGHT	6 oz.	6 oz.	6 oz.	8 oz.	6 oz.	6 oz.
SIZE	3.6x2.5x0.6	3.6x2.5x0.6	3.6x3.0x0.6	3.6x3.0x1.0	3.6x2.5x0.6	3.6x2.5x0.6

A.C. LINE REGULATION

A new method has been developed which allows us to provide a low distortion highly regulated AC waveform without using tuned circuits or solid state active filters of any kind.

The result is a frequency independent AC output regulated to 0.1% for line and load with greater than 20% line variations over a wide temperature range.

FEATURES:

- 0.1% total line and load regulation
- Independent of ± 20% frequency fluctuation
- 1 watt output
- Extremely small size
- Isolation between input and output can be provided

Specifications: Model MLR 1476-1
AC Line Voltage: 26V ±20% @ 400Hz ± 20%
Output: 26V ± 1% for set point
Load: 0 to 40ma
Total Regulation: +0.1%
Distortion: 0.5% maximum rms
Temperature Range: −55° C to +125°C
Size: 2.0" x 1.8" x 0.5"

Other units are available at different power and voltage levels as well as wider temperature ranges. Information will be furnished upon request.

SOLID-STATE SINE-COSINE SYNCHRO CONVERTER - NON VARIANT

This new encapsulated circuit converts a 3 wire synchro input to a pair of dc outputs proportional to the sine and cosine of the synchro angle independent of a-c line fluctuations.

- Complete solid state construction
- Operates over a wide temperature range
- Independent of reference line fluctuations
- Conversion accuracy–6 minutes
- Reference and synchro inputs isolated from ground

Specifications Model DMD 1508-2
Accuracy: Overall conversion accuracy 6 minutes. Absolute value of sine and cosine outputs accurate to ± 30MV
Temperature Range: Operating −40°C to +85°C, Storage −55°C to +125°C
Synchro Input: 90V RMS ± 5%LL 400Hz ± 5%
DC Power: ± 15V DC ± 10% @ 50MA
Reference: 115VRMS ± 5% 400Hz ± 5%
Output: 10V DC full scale output on either channel @ 5ma load
Temperature coefficient of accuracy: ± 15 seconds/°C avg. on conversion accuracy ± 1 MV/ °C on absolute output voltages
Size: 2.0" x 1.5" x 2.5"
Units are available with wider temperature ranges and 11.8V LL, 26V reference synchro inputs. Information will be supplied upon request.

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GENERAL MAGNETICS • INC
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Electronics

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Complete entire card.

Please print or type.

Circle the number on the Reader Service postcard that corresponds to the number at the bottom of the advertisement, new product item, or new literature in which you are interested.

To aid the manufacturer in filling your request, please answer the three questions.

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Electronics **February 19, 1976** This Reader Service card expires April 19, 1976

NAME________________ TITLE________________

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CITY________________ STATE________________ ZIP________

Industry classification (check one):
a ☐ Computer & Related Equipment
b ☐ Communications Equipment & Systems
c ☐ Navigation, Guidance or Control Systems
d ☐ Aerospace, Underseas Ground Support
e ☐ Test & Measuring Equipment
f ☐ Consumer Products
g ☐ Industrial Controls & Equipment
h ☐ Components & Subassemblies
j ☐ Independent R&D Organizations
k ☐ Government

Your design function (check each letter that applies):
x ☐ I do electronic design or development engineering work.
y ☐ I supervise electronic design or development engineering work.
z ☐ I set standards for, or evaluate electronic components, systems and materials.

Estimate number of employees (at this location): **1.** ☐ under 20 **2.** ☐ 20-99 **3.** ☐ 100-999 **4.** ☐ over 1000

1 16 31 46	61 76 91 106	121 136 151 166	181 196 211 226	241 256 271 348	363 378 393 408	423 438 453 468	483 498 703 718
2 17 32 47	62 77 92 107	122 137 152 167	182 197 212 227	242 257 272 349	364 379 394 409	424 439 454 469	484 499 704 719
3 18 33 48	63 78 93 108	123 138 153 168	183 198 213 228	243 258 273 350	365 380 395 410	425 440 455 470	485 500 705 720
4 19 34 49	64 79 94 109	124 139 154 169	184 199 214 229	244 259 274 351	366 381 396 411	426 441 456 471	486 501 706 900
5 20 35 50	65 80 95 110	125 140 155 170	185 200 215 230	245 260 275 352	367 382 397 412	427 442 457 472	487 502 707 901
6 21 36 51	66 81 96 111	126 141 156 171	186 201 216 231	246 261 338 353	368 383 398 413	428 443 458 473	488 503 708 902
7 22 37 52	67 82 97 112	127 142 157 172	187 202 217 232	247 262 339 354	369 384 399 414	429 444 459 474	489 504 709 951
8 23 38 53	68 83 98 113	128 143 158 173	188 203 218 233	248 263 340 355	370 385 400 415	430 445 460 475	490 505 710 952
9 24 39 54	69 84 99 114	129 144 159 174	189 204 219 234	249 264 341 356	371 386 401 416	431 446 461 476	491 506 711 953
10 25 40 55	70 85 100 115	130 145 160 175	190 205 220 235	250 265 342 357	372 387 402 417	432 447 462 477	492 507 712 954
11 26 41 56	71 86 101 116	131 146 161 176	191 206 221 236	251 266 343 358	373 388 403 418	433 448 463 478	493 508 713 956
12 27 42 57	72 87 102 117	132 147 162 177	192 207 222 237	252 267 344 359	374 389 404 419	434 449 464 479	494 509 714 957
13 28 43 58	73 88 103 118	133 148 163 178	193 208 223 238	253 268 345 360	375 390 405 420	435 450 465 480	495 510 715 958
14 29 44 59	74 89 104 119	134 149 164 179	194 209 224 239	254 269 346 361	376 391 406 421	436 451 466 481	496 701 716 959
15 30 45 60	75 90 105 120	135 150 165 180	195 210 225 240	255 270 347 362	377 392 407 422	437 452 467 482	497 702 717 960

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e ☐ Test & Measuring Equipment
f ☐ Consumer Products
g ☐ Industrial Controls & Equipment
h ☐ Components & Subassemblies
j ☐ Independent R&D Organizations
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1 16 31 46	61 76 91 106	121 136 151 166	181 196 211 226	241 256 271 348	363 378 393 408	423 438 453 468	483 498 703 718
2 17 32 47	62 77 92 107	122 137 152 167	182 197 212 227	242 257 272 349	364 379 394 409	424 439 454 469	484 499 704 719
3 18 33 48	63 78 93 108	123 138 153 168	183 198 213 228	243 258 273 350	365 380 395 410	425 440 455 470	485 500 705 720
4 19 34 49	64 79 94 109	124 139 154 169	184 199 214 229	244 259 274 351	366 381 396 411	426 441 456 471	486 501 706 900
5 20 35 50	65 80 95 110	125 140 155 170	185 200 215 230	245 260 275 352	367 382 397 412	427 442 457 472	487 502 707 901
6 21 36 51	66 81 96 111	126 141 156 171	186 201 216 231	246 261 338 353	368 383 398 413	428 443 458 473	488 503 708 902
7 22 37 52	67 82 97 112	127 142 157 172	187 202 217 232	247 262 339 354	369 384 399 414	429 444 459 474	489 504 709 951
8 23 38 53	68 83 98 113	128 143 158 173	188 203 218 233	248 263 340 355	370 385 400 415	430 445 460 475	490 505 710 952
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11 26 41 56	71 86 101 116	131 146 161 176	191 206 221 236	251 266 343 358	373 388 403 418	433 448 463 478	493 508 713 956
12 27 42 57	72 87 102 117	132 147 162 177	192 207 222 237	252 267 344 359	374 389 404 419	434 449 464 479	494 509 714 957
13 28 43 58	73 88 103 118	133 148 163 178	193 208 223 238	253 268 345 360	375 390 405 420	435 450 465 480	495 510 715 958
14 29 44 59	74 89 104 119	134 149 164 179	194 209 224 239	254 269 346 361	376 391 406 421	436 451 466 481	496 701 716 959
15 30 45 60	75 90 105 120	135 150 165 180	195 210 225 240	255 270 347 362	377 392 407 422	437 452 467 482	497 702 717 960

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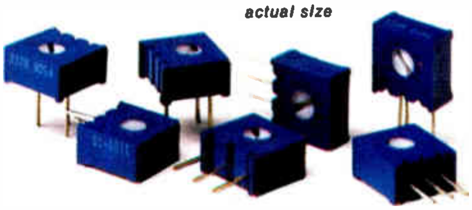

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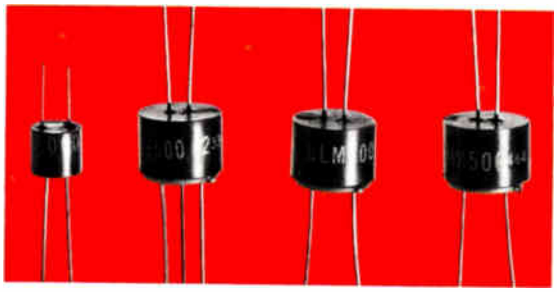

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