FEBRUARY 5, 1976

THE FORD BUDGET: HOW MUCH FOR ELECTRONICS?/63

What designers should know about power Schottky diodes/85

Why TV broadcasters like digital techniques/94

FOUR DOLLARS A McGRAW-HILL PUBLICATION

Electronics

The Right DMM Decision Means Five-Function Autoranging for only $225*

Introducing HP's 3476A DMM

The price is a big story in itself. But performance and reliability play a large part too. Take a look at the 3476A:

Autoranging—a big plus in a low cost DMM. It lets you concentrate on the point of measurement... minimizes reading errors... and speeds readings too. All readings are made directly in volts, kilohms, or amps—on an LED display. And there's a rangehold button to speed and simplify repetitive measurements.

Five functions—all the functions you want and need in a low cost DMM. Simply push the appropriate button to read AC volts, DC volts, AC or DC current, and ohms. There's no worry about polarity or zero... they're both automatic.

Advanced design—both circuit and packaging. And both contribute to high reliability. One circuit board contains all the electronics.

Tantalum nitride on sapphire processing allows replacement of all front end precision resistors by a single chip. That means greater reliability and better temperature stability. Of course it's input protected.

Convenient size—just right to hold in your hand... take with you in a brief case... or use on your bench. An optional carrying case and probe kit let you hang the instrument from a strap for "no-hands" operation. The "A" version ($225*) operates from the AC line for lab use. And for portable applications, the "B" version ($275*) has built-in batteries and recharging circuitry.

The 3476A is backed by HP's service organization ...another big plus for a low-cost DMM. With these prices and features, why not put your hands on the 3476A for your 3-1/2 digit measurements? Your local HP field engineer can tell you how.

*Domestic U.S.A. prices only.

HP DVM's—the right decision

Actual Size

095/52

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Sales and service from 172 offices in 65 countries.
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Circle 900 readers service card.

Ask yourself 5 questions before you buy your next signal generator.

1. How much spurious signal output will my receiver test tolerate?
2. Do I require calibrated AM & FM?
3. Is continuous tuning along with phase lock best for my test procedure?
4. Do I need a separate, low RFI counter?
5. Could my transceiver be keyed during test?

1. Fundamental L-C type oscillator gives spectrally pure signals from 10-520 MHz in 6 bands. Sub-harmonic and non-harmonic spurious outputs are >100 dB down. No spurious "cross-overs" typical of synthesized or heterodyned generators.

2. Accurate, calibrated, metered modulation, both AM and FM. Internal source 400, 1000 Hz. AM: 0-90%. FM: 0-3, 10, 30, 100 kHz deviation. FM possible during phase-lock.

8654B with Option 003, 8655A

3. Continuous tuning along with phase-lock stability gives best human interface for many receiver tests. No step-tuning jumps typical of synthesized generators. Push 8655A Counter/Synchronizer phase-lock button for 0.1 ppm/hr. stability.

4. Well shielded counter circuits exhibit RFI less than 1.5μV for use near high-sensitivity receivers. Also use for external counting of transceiver output to 520 MHz.

5. Reverse power protect (Option 003) ensures against possible damage from accidental keying of transceiver to 25W. Output is levelled, calibrated, and adjustable from +10 to −130 dBm (0.7V to 0.07μV).

After you analyze your receiver test procedures, we think you'll find that the HP 8654B Generator can fill most, if not all, of your requirements. It has good spectral purity, low spurious, and calibrated AM and FM. The 8654B is really hard to beat for price and performance in an economy signal generator.

Add the 8655A Synchronizer/Counter and get high frequency accuracy, 500 Hz resolution, low drift, and low RFI. For most transceiver testing, this combination may answer all your questions.

HP 8654B, $2275*; Option 003 (reverse power), $300*; HP 8655A, $2075*; HP 8654A (FM uncalibrated), $1900*

For more information, give your nearby HP field engineer a call, or write.

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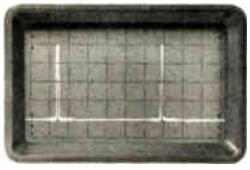
Dual Delay...Single Delay What's the difference?

Only HP offers Dual-Delayed Sweep.

And with Dual-Delayed Sweep, the difference is... the end of graticule counting... the end of mental calculations... the end of remembering the time reference line... and the beginning of faster, more accurate scope measurements.

A scope with single delay just can't compete in terms of speed, accuracy, and repeatability. Here's why: 1) Dual-Delayed Sweep cancels amplifier and CRT nonlinearities for greater accuracy. 2) There's no time reference line to adjust to. You simply set two intensified markers or overlap two traces and read the value directly on the LED display. 3) You can preset the time interval on the LED display and adjust your system to meet specs by aligning traces with the intensified markers... saving time in production.

Are you making single trace measurements such as rise-times, pulse durations, periods? Simply adjust the two intensified markers to coincide with the points you want to measure between. Your time-interval measurement (in seconds) is displayed instantly on the LED readout.



Suppose you're making dual trace measurements such as propagation delays, dual-clock phasing, transmission line matching, and cable length measurements. Then you simply overlap the two traces. Again, your time interval measurement is displayed instantly on the LED readout.

There's only one Dual-Delayed Sweep. It's from HP. And you'll find it on this new 1722A scope with a built-in microprocessor and on our lowest cost 1712A with voltage scaling output for direct reading on an external DVM.

The 275 MHz 1722A is priced at $4,750* and gives you Dual-Delayed Sweep plus easier, more accurate measurements of frequency, instantaneous and dc voltage levels and relative amplitude. In all of these measurements, you get direct readout in the units of seconds, Hertz, volts, and percent. The microprocessor automatically keeps track of dial settings and position-control rotation.

You can even convert the 1722A (option 101) to do Logic State Analysis. Simply couple the 1722A to an HP 1607A Logic State Analyzer, and you're ready to tackle problems in the data domain.

The 1722A simply outperforms many scopes costing twice as much. It offers unmatched capabilities.

Let your local HP field engineer give you all the details. Call him today or write for our informative eight-page brochure and our six-page App-Note #186.

*Domestic U.S.A. price only.

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Electronics
The International Magazine of Electronics Technology
Vol. 49, No. 3 • February 5, 1976

Highlights

Cover: The one-board computer's missing link, 77
Minus input/output interfaces, no boardful of chips deserves the name of computer. But only recently have large-scale integrated programable I/O circuits been available to build a truly single-board computer.

Cover design is by Art Director Fred Sklenar; assemblage is by Bob Strimban.

Ford primes pump through Pentagon, 63
If it passes, the record $112.7 billion military budget proposed for this year will get defense programs with sizable electronics contents off the ground. "Coincidentally," it will also add to defense industry jobs.

British debate putting 'magazine' on TV, 68
On trial in Britain is a system that enables viewers to call up pages of news and sports information on their TV screens. But even if the government okays Teletext, as it's named, how many people will pay $200 plus for the necessary decoder?

Digital techniques to sharpen TV image, 94
Television broadcasters are experimenting with equipment that processes signals digitally before transmitting them in analog form. Ultimate goal is a clearer picture for the viewer.

And in the next issue . . .
Special report on breadboards . . . preview of the International Solid State Circuits Conference . . . how diodes can damp line reflections in digital systems.

Electronics

Publisher's letter

Every year, in late January, a small mountain of documents turns the desk of Ray Connolly, our Washington bureau manager, into what looks like an accountant's bad dream. It's "Announcing the Federal Budget" time again, and Ray, along with most other members of the Washington press corps, has to do a lot of fast digging into the documents to be ready for Government agency press conferences scheduled only a few hours after the budget books are available to the press.

We think that the priorities reflected in the budget tell a lot about how the electronics industries will fare in the year to come. So, every year, we send a team of reporters and editors to Washington to help Ray both pull the details out of the budget and interview Federal agency representatives, congressmen and their staffs, and industry observers. This year's team included Howard Wolff, New York-based news section editor and Larry Armstrong, our Midwest bureau manager, who had formerly covered Washington beats with Ray. You'll find the budget reporting starting on page 63.

Over the years, our budget team has run into unexpected hurdles in trying to turn the raw numbers in the budget into a meaningful story in *Electronics*. This year, the unexpected was a sharp increase in security precautions.

Not for a quarter century had a President himself conducted the briefing for the press. So both Wolff and Armstrong, since they were not members of the regular Washington press corps, were stopped and challenged by three sets of security guards on their way to the press briefing.

"So tight was the security," says Wolff, "that when a network cameraman jumped up on the podium to take films of President Ford walking in, two Secret Service men closed in on him. Each grabbed him under an elbow, lifted, and walked him right off again. And every other cameraman was monitored closely to avoid letting anyone get too close to the President and point something—even a camera."

Microprocessors are fast becoming one of the most versatile items in a circuit designer's bag of tricks. Many readers of *Electronics* have tapped the potential of microprocessors in innovative circuits and sent reports of their work to our circuit design department. Others have written in asking for more material on how to harness microprocessors.

Because of the reservoir of interest in microprocessors, we plan to print more on microcomputer applications, especially at the circuit design level. We would like to remind readers that we welcome contributions to our Designer's Casebook and Engineer's Notebook departments and that we pay $50 for every item published. So, if you have developed an interesting circuit or design innovation based on microprocessors, send it to Don Blattner, Circuit Design Editor, Electronics, 1221 Avenue of the Americas, New York, N. Y. 10020.

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Circle 5 on reader service card

News update

■ The word last year at American Microsystems Inc. was "slim" in its drive to come up with advanced liquid-crystal formulations for displays. The idea was to cut drive requirements to the point where a single 1.5-volt battery could drive the display, timing circuitry, and an incandescent lamp for backlighting. The Santa Clara, Calif., company, a leader in LCD watch manufacturing, wanted to reduce its watch module more than half to 200 mils thick.

But the search has "gone out the window," says Robert Young, supervisor of new display technology at AMI. The company hoped to have its new module in production by the end of 1975 [*Electronics*, Feb. 6, 1975, p. 48], but, Young says, the materials that would have permitted low-voltage operation are too sensitive to processing and moisture. "In the long run," he says, "it's more economical to put an up-converter on the chip." Thus, AMI and the rest of the industry appear resigned to the use of doublers and tripler to handle voltage requirements, which remain at 4 V to 7 V.

■ Production of Intersil Inc.'s first field-programable logic array [*Electronics*, Feb. 6, 1975, p. 35] has remained low since its introduction last year, according to Gene Miles, director of memory marketing. Customers are using the IM-5200 arrays in prototype quantities, but Miles expects volume to pick up within the next six months when they find their way into video games.

Despite that, Miles says, "The device is not catching on as fast as I thought it would." The reason, he believes, is that it doesn't have enough of what he calls pizazz for design engineers. Using the IM-5200, says Miles, is "like driving a Volkswagen or a Pinto instead of a fast sports car."

What the device has got is 14 inputs, eight outputs, and a total of 48 product terms. It is pin-compatible with National Semiconductor's 7576, a mask-programable logic array with twice the capacity of the IM-5200.

HiNIL Interface

Keeping the bugs out of microprocessor systems with high noise immunity logic.

An MOS microprocessor system can be troubled by disastrous bugs unless it is protected against noise transients generated by switches, electromechanical peripherals and other nearby noise sources, such as lamps and machinery. But filters and shielding, the traditional cures, are often difficult to add to a microprocessor because of size and cost constraints.

These problems can be avoided by substituting HiNIL interface devices for conventional I/O logic. HiNIL—Teledyne's bipolar High Noise Immunity Logic—has a guaranteed DC noise immunity about 10 times that of TTL, for example (3.5 vs. 0.4V). Also, HiNIL blocks AC transients large enough to cause TTL malfunctions. Two additional advantages are superior output drive and, in low power systems, protection of CMOS memory and random logic inputs.

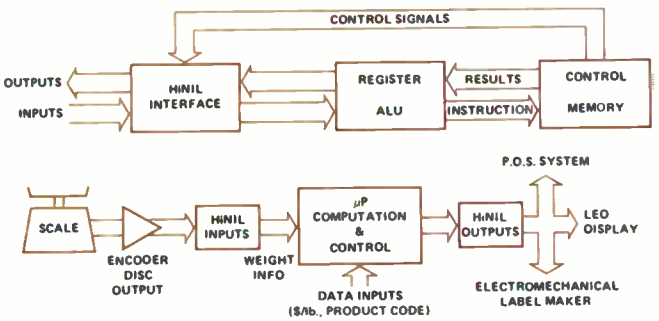

Figure 1. Use of HiNIL interfaces in POS systems with electronic scale. Top diagram shows basic microprocessor configuration.

One manufacturer of microprocessor-controlled electronic scales decided to use the configuration in Figure 1 because he was concerned about the consequences of incorrect weights and prices. The probability of errors resulting from noise transients was high because the scale would be used in a supermarket POS system, where the environment includes refrigerators, fluorescent lamps, meat grinders and electromechanical label makers.

In the system, the microprocessor receives weight codes from an encoder disc in the scale and operates a cash register interface, LED display, and relays of a receipt printer or label maker. The system designers put HiNIL interface logic on the microprocessor board to handle the I/O functions, suppress noise transients picked up along the transmission lines, and drive the peripheral devices. HiNIL output interfaces can drive long lines, relays, displays and lamps without additional components since they sink up to 65 mA and source up to 12 mA. (The new 390 buffer series will sink up to 250 mA.)

Manufacturers of systems requiring random logic are finding that HiNIL and CMOS are an ideal combination. They maximize system noise immunity and assure an excellent system function/power product. HiNIL and 54C/74C CMOS interface directly at V_{CC} voltages from 10 to 16 volts, the power supply range of HiNIL. Moreover, HiNIL protects CMOS inputs from destruction by static electricity and from harmful DC input levels that can exist before CMOS circuits are powered up.

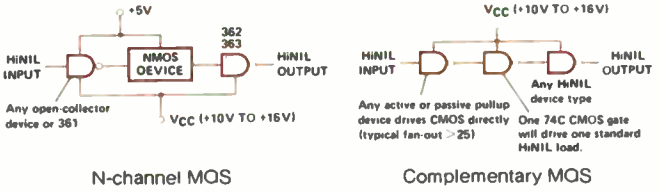

Figure 2. Typical HiNIL/MOS and HiNIL/CMOS interfaces

The rules for using HiNIL with MOS or with CMOS operating at lower voltages are simple. The pullup resistor of an open collector HiNIL device is connected to the desired high logic level voltage (see Figure 2). To use HiNIL with other bipolar logic, just plug in a Teledyne dual or quad interface circuit (see table). HiNIL is also compatible with most analog devices.

Examples of HiNIL Interface Devices

301 Dual 5-Input Power Gate 302 Quad Power NAND Gate (OC)	65mA relay or lamp driver
323 Quad NAND Gate (OC) 332 Hex Inverter (OC) 334 Strobed Hex Inverter (OC)	Input noise protection plus open-collector pullup to other logic levels
350 8-Bit Multiplexer 351 Dual 4-Bit Multiplexer	Drive longer lines than TTL with 10X noise immunity (I_{OH} = 12mA)
361 Dual Input Interface 362 Dual Output Interface 363 Quad Output Interface	361 directly connects HiNIL to DTL/RTL/TTL 362 and 363 connect DTL/RTL TTL to HiNIL
367 Quad Schmitt Trigger 368 Quad Schmitt Trigger (OC)	Suppress 100V 1μs spikes protect CMOS decode switches etc
380 BCD to Decade Decoder 381 BCD to Decade Decoder (OC) 382 BCD to Decade Decoder 383 BCD to 7-Segment Decoder	Provide decode/drive for lamps LEDs gas discharge displays etc
390 Interface Buffer Series	250mA HiNIL driver series will be available soon

If you need a simple, inexpensive solution to a difficult noise problem, write or call Teledyne Semiconductor for a copy of application notes and specifications on Teledyne's High Noise Immunity Logic family.

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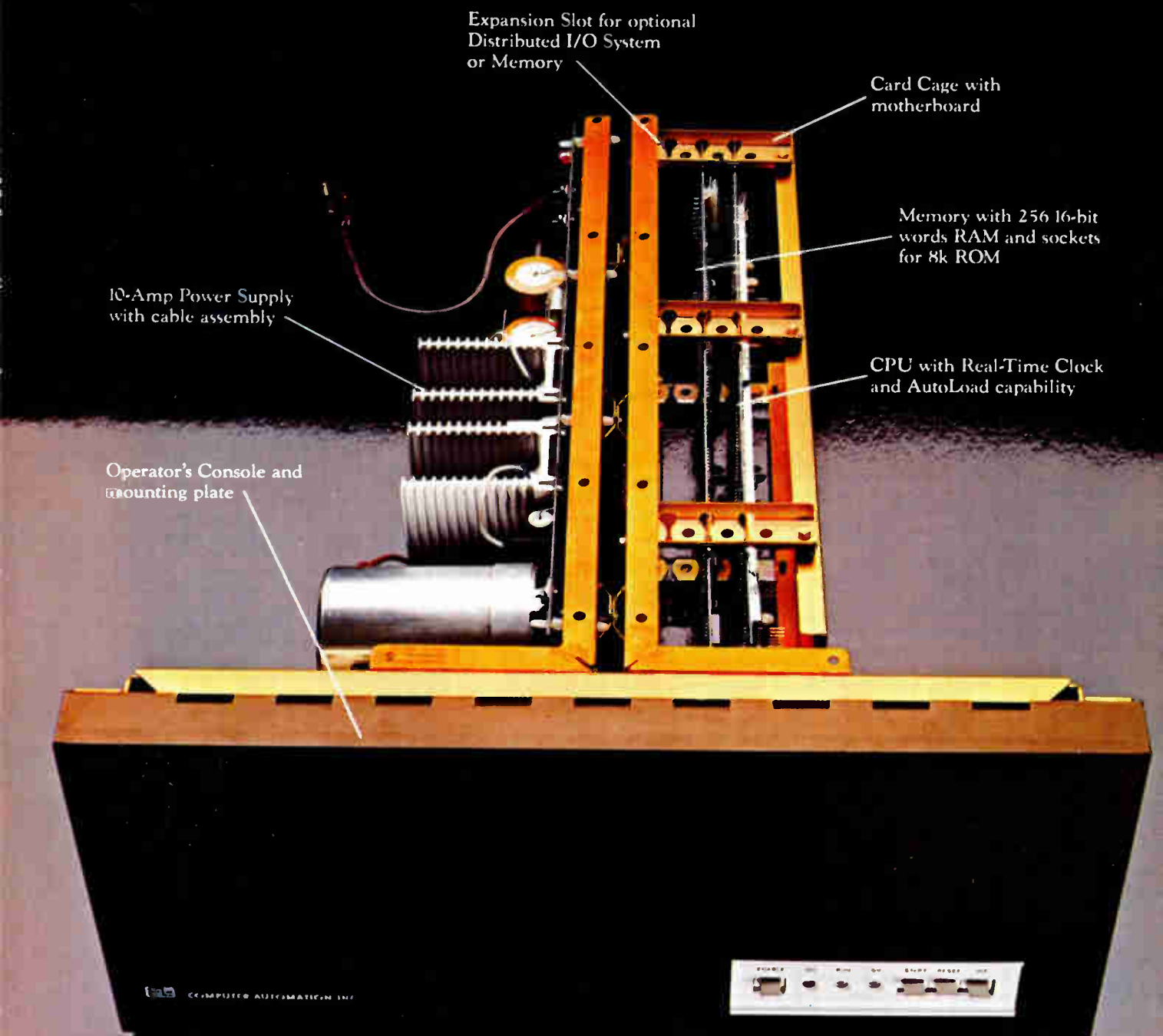

The ALPHA® LSI-3/05 Millicomputer.
The lowest priced, 16-bit, full-scale, packaged computer in the world.

...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.

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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?

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?

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

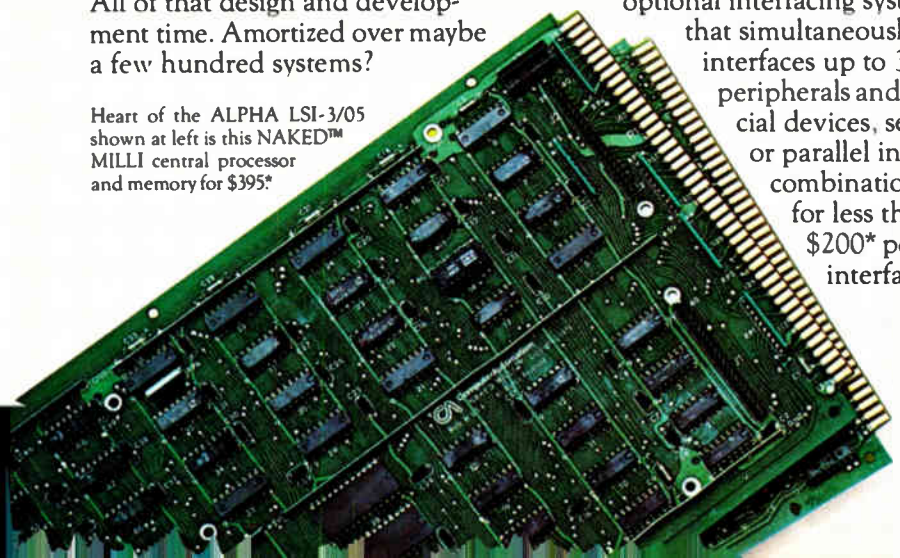
Computers vs. computerization

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.



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

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

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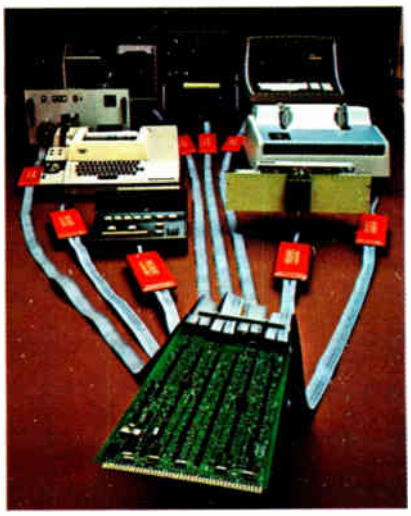

The ALPHA LSI-3/05 is offered in three series featuring a choice of card cages, consoles, memories and power supplies.

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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Patent Pending

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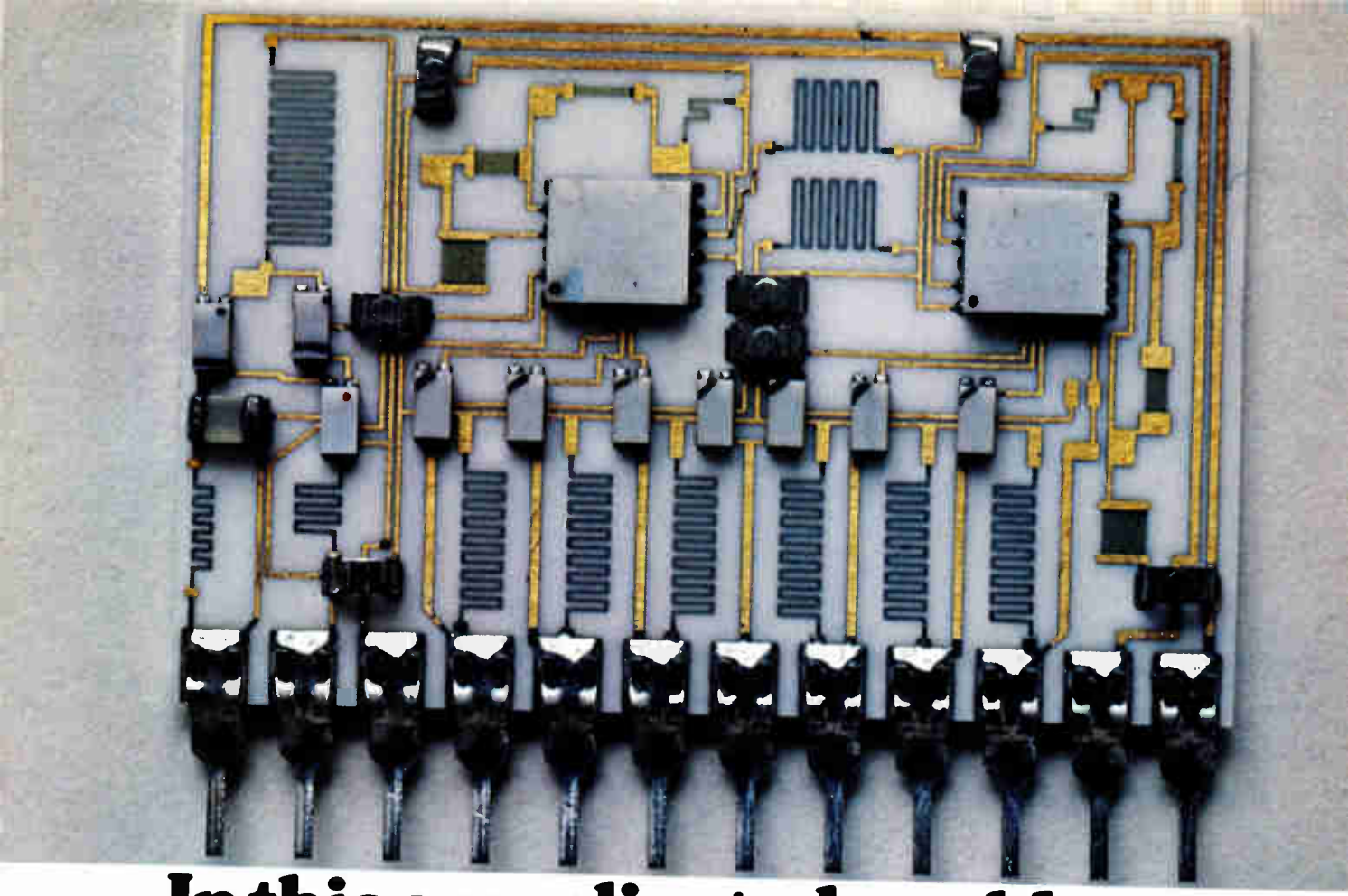


In this complicated world, you can't afford to be without us.

Introducing the GR 2230. The first computer-controlled network and module tester for under $20,000.

These days, multi-leaded networks and modules have become so complex, you simply can't get away with sample testing.

Yet in-house or calculator-based test systems are just too slow. And the computer-controlled ones cost an arm and a leg.

But now there's the GR 2230.

At the heart of this compact bench-top system is a small but powerful microcomputer. To give you computer-controlled speed, accuracy and flexibility. All starting at just $15,000.

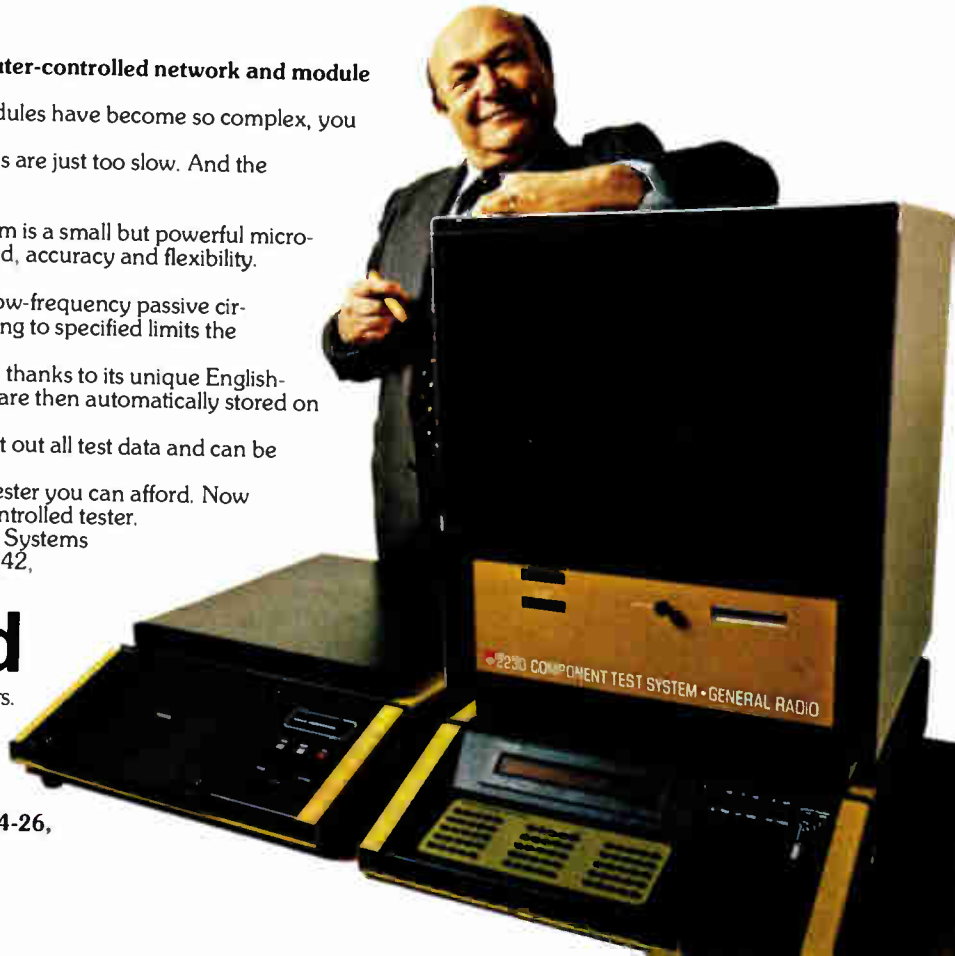
The 2230 will test networks, modules, and low-frequency passive circuits at speeds up to 80 tests per second, measuring to specified limits the performance of each circuit component.

It can be programmed by just about anyone, thanks to its unique English-language macro-instruction keyboard. Programs are then automatically stored on magnetic cards for easy retrieval.

In addition, the system will continuously print out all test data and can be easily interfaced to virtually any device handler.

The new GR 2230. A computer-controlled tester you can afford. Now that you can't afford to be without a computer-controlled tester.

GenRad, Inc. (formerly General Radio), Test Systems Division, 300 Baker Avenue, Concord, Mass. 01742, 617-369-8770.



GenRad

The difference in software is the difference in testers.

See the GR 2230 at NEPCON West, Feb. 24-26, Anaheim Convention Center.

Circle 12 on reader service card

Editorial

The Federal budget: priorities out of balance

Makers of military electronics are delighted, as they should be, with Federal spending plans for the fiscal year that begins Oct. 1. A lot of others in the electronics industries, though, have plenty to be concerned about.

As can be seen from President Ford's proposals for fiscal 1977, some nine new major weapon systems are scheduled to move from development to procurement. They and many of the other military buys have a high electronics content, as does weapons research development, which is budgeted for a 15% increase.

There is more significance to the defense budget than the fact that spending will top $100 billion for the first time. More important is that the commitments now being made will in years to come push Pentagon outlays steadily higher to a projected level of $151.5 billion by fiscal 1981—that is, 26% of the total Federal budget of $580.2 billion forecast for that year. There are many who challenge the Defense Department's need for such a disproportionate share of the budget. Yet there is very little to laugh at in the analysis of one Senate wit: the Pentagon program "isn't designed to defend the country against the Russians as much as it is to protect Ford from Ronald Reagan."

Cynics concerned more with the effect than the cause of Federal spending care little about President Ford's rationales. For them, the money is there. We urge they consider the other side of the coin, the nonmilitary side.

The stalled transfers

Nearly all of the programs that promised at the beginning of the decade to transfer Government-spawned advances in electronics and other technologies to civilian needs—such as law enforcement, education, and medicine—have disappeared. NASA, that shooting star of the 1960s, continues in a state of accelerated decay. Even the National Science Foundation's limited effort to broaden the opportunities for technology through its Research Applied to National Needs program is falling apart.

What troubles some Federal economic analysts about all of this is the limits it places on corporate options. "Companies should do more thinking about this than they are," says one. "It is easy not to think about it when there is a lot of military money around. Those who don't will just continue to back into the future. And I am afraid some of them will fall off a cliff one day."

Although none dispute that the nation is moving slowly up the road to economic recovery from the recession, many agree that the path proposed by President Ford is both narrow and treacherous. "Some of his assumptions are pretty rickety," says one economist, recalling that the Ford budget's forecast of $43 billion deficit may be about as accurate as last year's $52 billion, which turned out to be $76 billion.

Home-entertainment electronics makers, for example, would do well to ponder the budget's plan to counter inflation by letting unemployment languish at 7% for another year before beginning to come down slowly to 5% in 1981. They also might question the President's failure to provide greater stimulus for housing starts through the Department of Housing and Urban Development. More jobs and the formation of new households mean more sales of television, radio, and stereo receivers.

These are but a few of the questions industry should be asking about President Ford's economic priorities. A strong national defense is, of course, essential. But a strong national defense ultimately owes its strength to the health of the society it is designed to protect.

People

Mini/micro coexistence is good for Dave Methvin

Dave Methvin claims that the widely predicted threat of microprocessors destroying minicomputer makers is a lot of hot air. "A couple of years ago microprocessors threw a big scare into the industry," observes the president of Computer Automation Inc., an Irvine, Calif., firm specializing in the cheaper end of the minicomputer market. "But it was the Wall Street boys who cried about their wiping out the industry, especially on the low end. Now they're coming around to our way of thinking, which is that MPUs [microprocessor units] actually help minis."

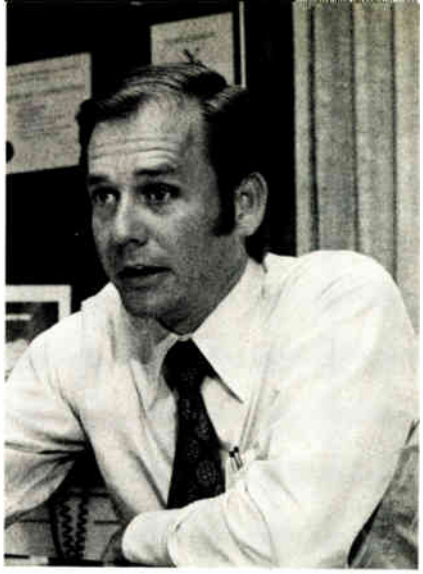
Number two. Computer Automation's recent record seems to confirm Methvin's confidence. Last month the company reported record quarterly earnings, bouncing back from recession-caused lows in 1975. Indeed, the strong recovery has pushed his firm to what Methvin claims is the second-place slot in number of minicomputers shipped, second only to Digital Equipment Corp. Deliveries now top 100 units a week, he says.

Basically, Methvin holds that microcomputers complement minicomputers [*Electronics*, Jan. 18, 1973, p. 142]. Many of the microprocessors designed into terminals and other remote peripheral equipment operate with minicomputers. Moreover, the increase in efficiency brought about by microprocessor control of peripherals has actually stimulated demand for minicomputers to direct them, he asserts.

But, although Methvin feels comfortable about co-existing with microprocessors, he's wary of the big semiconductor houses, which have not yet made a big move to penetrate his market.

Upturn here. As for general business prospects, Methvin sees "a healthy, slow, steady upturn," with customers ordering cautiously with shorter lead times than in the past.

Although Computer Automation has been selling Naked Minis almost entirely to original-equipment manufacturers, the company may be starting to bend its success formula a little by edging into end-user markets. A new Commercial System division is in a start-up phase to build small-business computers.



Mini helper. Computer Automation's Methvin detects an upturn that's slow but steady.

The company belt tightened by a cost-cutting program, Methvin pronounces his nine-year-old Computer Automation fit to face the fiercely competitive minicomputer industry. "It's been dog-eat-dog ever since we've been in it," he admits, relishing the next round of the struggle.

Beckman's Nesbit has knack for mixing technologies

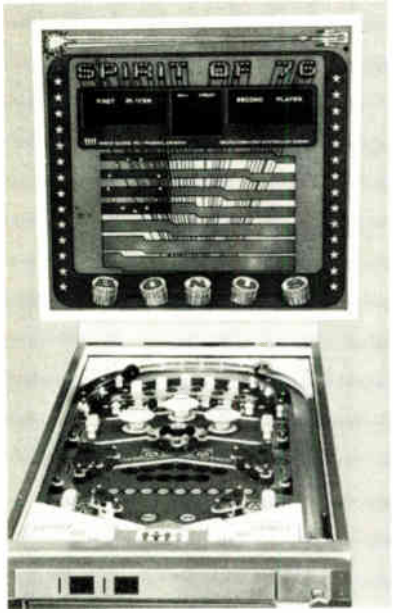
As the new director of research at Beckman Instruments Inc., Richard A. Nesbit occupies what has always been a hot seat. The Fullerton, Calif., electronics components and instrumentation manufacturer, which last year grossed $229 million, depends heavily on its own R&D to generate anywhere from 75 to 100 new products a year.

But to Nesbit, this pressure to produce, an $18 million budget, and some 600 scientists and engineers associated with research and new-product development represent an "especially exciting" opportunity. As the pleasant, soft-spoken Nesbit sees it, his challenge is to pace the volatile rate of change in electronics to the more settled technologies of the chemical and medical fields Beckman serves.

In electronics, the "micro-

They solved design problems with the MC6800 microprocessor

HEWLETT-PACKARD
The problem: build a desktop programmable calculator with alphanumeric keyboard and matrix printer, plus numeric display. Do this using the minimum of I/O chips, and reduce size and weight drastically from previous models. *Solution:* design with Motorola's M6800 Family to develop the HP9815A, only one-third the volume and weight of the HP9810. The HP9815A uses the MC6800 as its CPU. A single MC6820 PIA handles all internal and external I/O. Problem solved.



TERMIFLEX
The objective: utilize a compact, hand-held keyboard-display terminal for communication with digital systems.
Solution: Use Motorola's MC6800 microprocessor to control general purpose automatic test equipment so that the system may be programmed for specific user needs. Objective met.

MIRCO INC.
The problem: design a pinball with playing features that would be revolutionary in the coin machine industry.
Solution: the "Spirit of '76", a pinball using the MC6800 as the heart of the microcomputer that adds totally new playability to that of conventional machines. It has really scored.

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Motorola sales offices and authorized distributors are ready and able to respond to your inquiry. Call one. Start a revolution.

MOTOROLA M6800
Benchmark family for microcomputer systems.

Match maker. Nesbit will apply microprocessors only where really needed.

processor revolution is well under way," he points out. But other Beckman market areas "are still surprised at its potential." The firm pioneered the use of microprocessors in instrumentation two years ago, introducing the first microprocessor-controlled spectrophotometer.

It is in the role of "cross-pollinating" different technologies that Nesbit, who holds a Ph.D. in engineering from University of California at Los Angeles, believes he can be most useful. This paid off in his last post as senior staff scientist.

Displays. For example, Beckman's liquid-crystal displays for digital watches had the usual limitation of poor visibility in bright light. But Nesbit had the idea that Wilbur Kaye, the company's nationally known expert in spectroscopy, might be able to help. He was right; Kaye made suggestions that led to great improvements in the displays' electro-optical qualities. Without Nesbit, "that would have never occurred around here," an associate observes, adding that he has a knack for such suggestions. "He reads everything and tucks it away for when he needs it."

On looking over Beckman's future developments, Nesbit believes that probably the "most interesting things are coming along in biochemical instrumentation." He has in mind improvements in machines for automated blood analyses.

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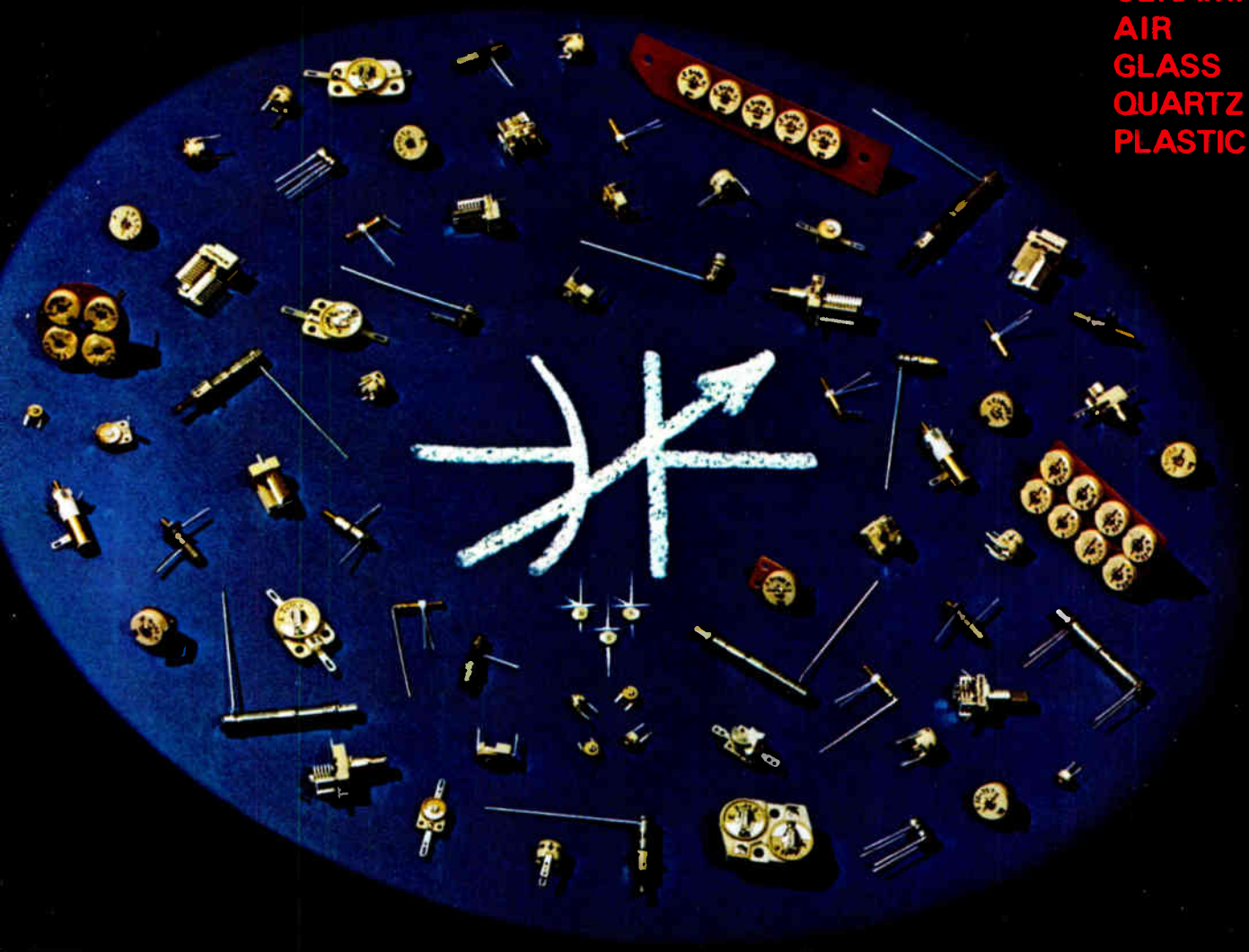

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Start by replacing hundreds of TTL packages with the three LSI circuits in the MCS-80™ CPU Group—the 8080A CPU, 8224 Clock Generator and 8228 System Controller. Built into the Intel 8224 and 8228 are many of the extra functions that most designs require, such as TTL & MOS clocks, auxiliary timing functions and current sinking capability that keeps memory and I/O interfaces simple.

MCS-80™ SYSTEM COMPONENTS

	Part No.	Description
CPU GROUP	8080A	8-bit Central Processor Unit, 2μs cycle
	8224	Clock Generator
	8228	System Controller
CPU OPTIONS	8080A-1	1.3μs cycle
	8080A-2	1.5μs cycle
	M8080A	2 μsec cycle (−55 to +125°C)
I/O	8212	8-bit I/O Port (15 mA drive)
	8251	Programmable Communication Interface
	8255	Programmable Peripheral Interface
PERIPHERALS	8205	1 out of 8 Binary Decoder
	8210	Dynamic RAM Driver (8107B)
	8214	Priority Interrupt Control Unit
	8216	Bidirectional Bus Driver, Non-Inverting (50 mA)
	8226	Bidirectional Bus Driver, Inverting (50 mA)
	8222	Dynamic RAM Refresh Controller (8107B)
	8253*	Programmable Interval Timer
	8257*	Programmable DMA Controller
	8259*	Programmable Interrupt Controller
PROMs	8604	512 x 8, 100 ns
	8702A	256 x 8 Erasable, 1.3 μs
	8704	512 x 8 Erasable, 450 ns
	8708	1K x 8 Erasable, 450 ns
ROMs	8302	256 x 8, 1μs
	8308	1K x 8, 450 ns
	8316A	2K x 8, 850 ns
RAMs	5101	256 x 4 Static CMOS, 650 ns
	8101A-4	256 x 4 Static, 450 ns
	8102A-6	1K x 1 Static, 650 ns
	8102A-4	1K x 1 Static, 450 ns
	8107B	4K x 1 Dynamic, 420 ns
	8111A-4	256 x 4 Static Common I/O, 450 ns

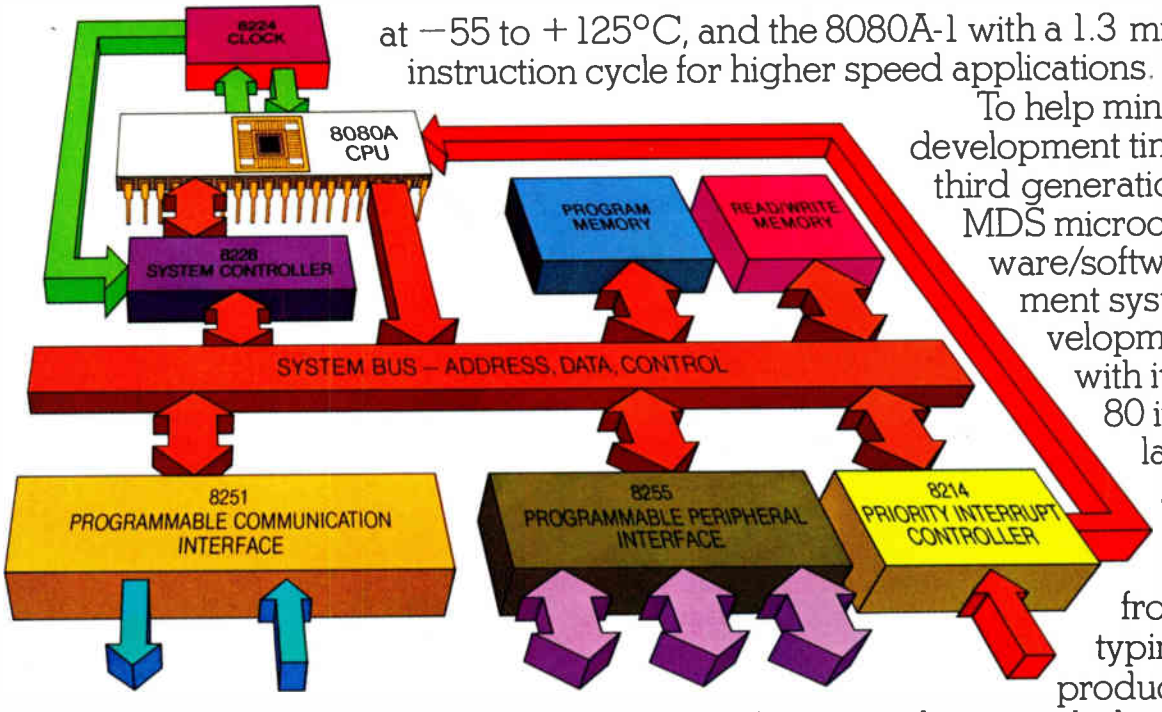
*Available 1st quarter 1976.

A dozen I/O and peripheral circuits that attach directly to the system bus make it easy to add on peripheral subsystems. Five are programmable LSI devices. These operate under software control in numerous modes and can often replace up to 75—or more—TTL packages each. For example, the Intel 8251 Programmable Communication Interface provides virtually all serial data transmission protocols in use today, including IBM Bi-Sync. Or, for easy interface to printers, keyboards, displays and motor drives, use the 8255 Programmable Peripheral Interface. You can reorganize its 24 I/O lines with software as your needs change.

You have thirteen options in performance matched standard memory circuits, such as 16K ROMs, 8K erasable PROMs and 4K RAMs for high density at low cost, plus CMOS RAMs for lowest power.

You also get four CPU choices, including the M8080A for operation

ıse the Intel 8080 system puters combined.



at −55 to +125°C, and the 8080A-1 with a 1.3 microsecond instruction cycle for higher speed applications.

To help minimize system development time use the third generation Intellec® MDS microcomputer hardware/software development system. This development system with its unique ICE-80 in-circuit emulator lets you simultaneously debug software and hardware, from initial prototyping right through production. The Intellec MDS is supported by six comprehensive software packages including a macro-assembler, ICE-80 interactive software driver and a diskette operating system.

In addition to the software packages in the development system, three cross product software packages are available on magnetic tape and on several time share networks. The Intel 8080 system is also supported by the industry's largest user's library, training courses and field applications assistance.

Start now with the new MCS-80 System Design Kit. It's a complete system for only $350 and includes: An 8080A CPU, Clock Generator, System Controller, Programmable Communications Interface and a Programmable Peripheral Interface. You also get two 1 of 8 binary decoders, 256 bytes of static RAM, two kilobytes of erasable PROM (with the system monitor supplied in one kilobyte), a PC board, clock crystal, connectors, other assembly parts, plus a user's manual and programming manuals.

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Meetings

ISSCC-76, International Solid State Circuits Conference, IEEE, Sheraton Hotel, Philadelphia, Feb. 18–20.

Nepcon '76 West and International Microelectronics Exhibition, Industrial & Scientific Conference Management Inc. (Chicago, Ill.), Anaheim Convention Center, Anaheim, Calif., Feb. 24–26.

ACM Conference on Programing Micro/Minicomputers, Association for Computing Machinery (New York, N.Y.), Delta Towers Hotel, New Orleans, March 4–6.

IECI '76—Industrial Applications of Microprocessors, Process Measurement, and Failure Mode Analysis, IEEE, Sheraton Hotel, Philadelphia, March 8–10.

Control of Power Systems Conference, IEEE, Ramada Central Convention Inn, Oklahoma City, Okla., March 10–12.

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

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

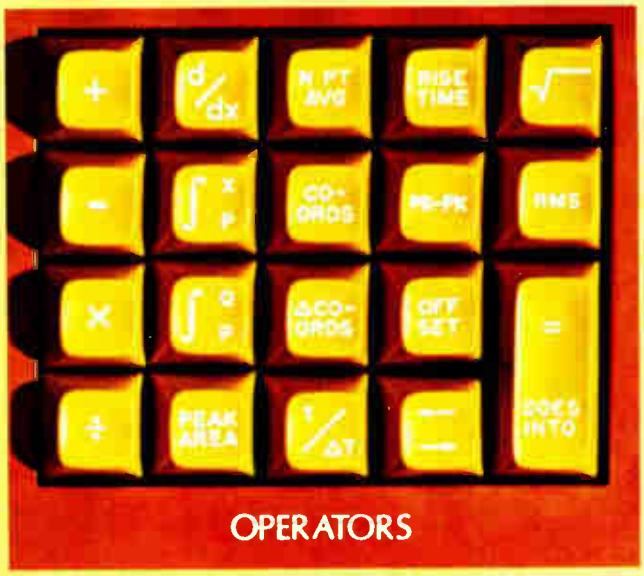
SPIE Technical Symposium East—Advances in Optics, Electro-optics, Photographic, and Laser Technology, Society of Photo-Optical Instrumentation Engineers (Palos Verdes Estates, Calif.), Sheraton Inn and International Conference Center, Reston, Va., March 22–25.

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.

NI 2001 Programmable Calculating Oscilloscope

17 of the most-used data calculations are available with a single keystroke



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Here is the ultimate instrument for the acquisition, processing and manipulation of electrical data. Available only from Norland Instruments, the NI 2001 combines all the capabilities of a digital oscilloscope and a microprocessor in a single mainframe. Its 81-key, interactive keyboard lets you perform engineering and scientific calculations — quickly and accurately — without interfacing with a mini-computer or programmable calculator.

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- ☐ Multiply voltage and current waveforms to produce a true power waveform.
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- ☐ Determine maximum peak-to-peak voltages.
- ☐ Calculate waveform rise times between voltage levels.
- ☐ Compute and display time and voltage relationships about user-selected points of waveforms.
- ☐ Calculate frequency of periodic waveforms.
- ☐ Convert thermocouple output to temperature — or strain gauge output to displacement values.
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The OPERATORS section of the NI 2001 keyboard, in combination with PROGRAMMING, DISPLAY, REGISTERS-ARRAYS, CURSOR MOTION and NUMERIC ENTRY sections, makes complex analysis of your waveforms easier than ever before. But don't take our word for it. Discover for yourself the complete versatility, convenience and accuracy of this new generation of instrument from Norland.

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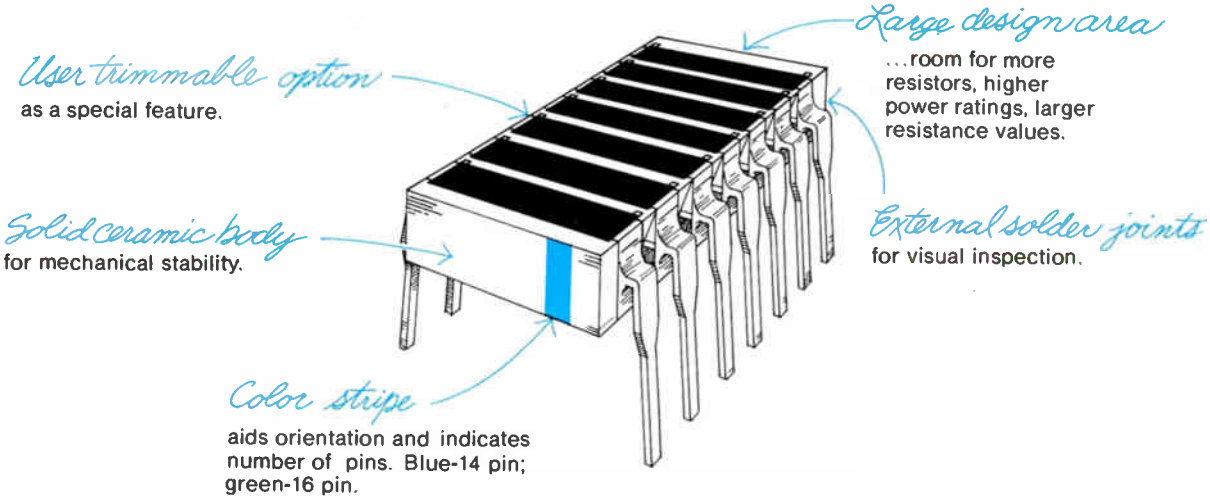

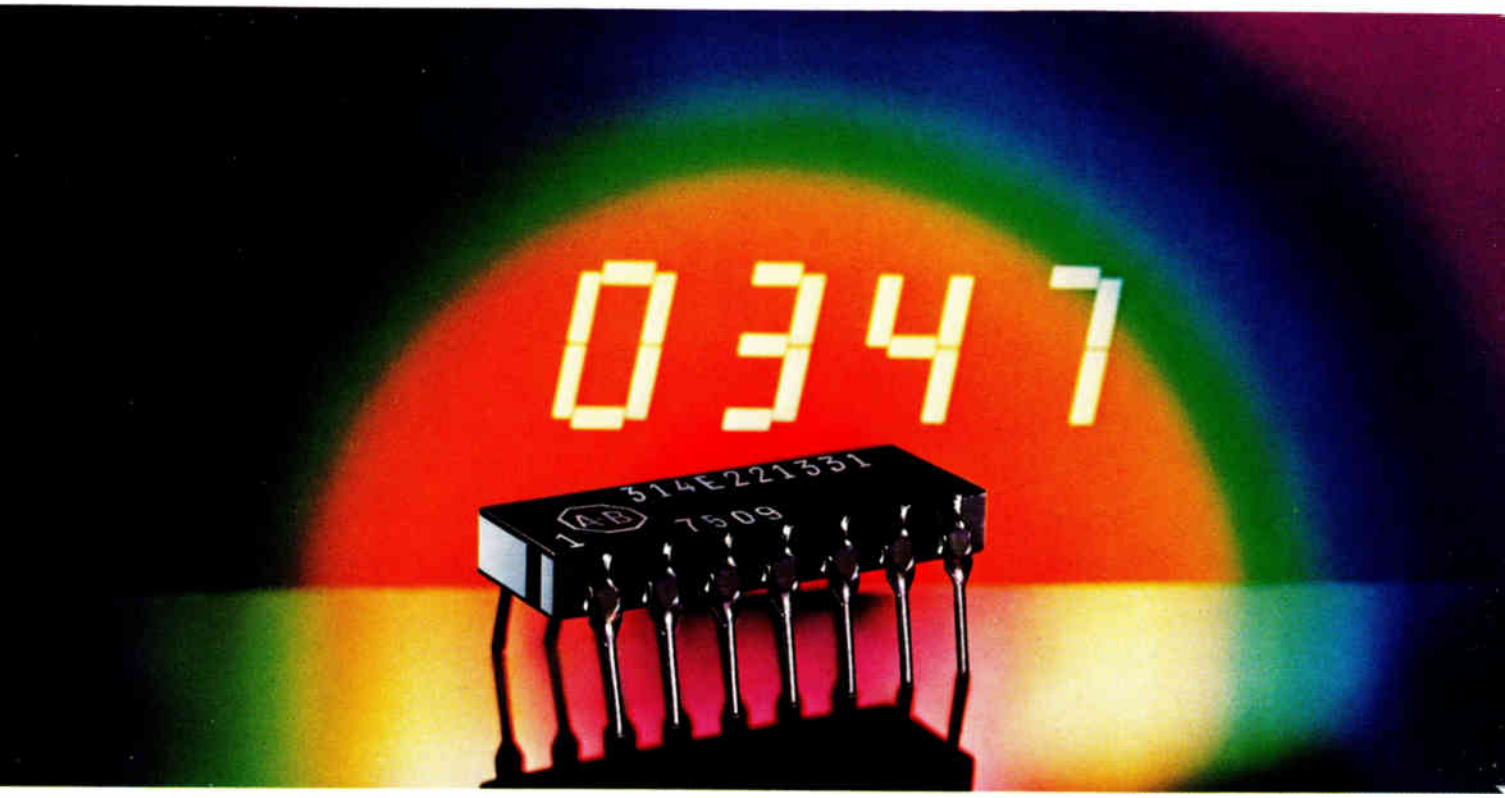

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Electronics newsletter

Intel prepares 8-bit processor for low end

Intel Corp.'s next 8-bit microprocessor is aimed at the low end. Described at a seminar in Paris, the 8048, a single-chip, 8-bit microcomputer, **packs enough memory, input/output, and computing power on the chip for a minimal system.**

Intel accomplished the job apparently by removing most of the registers and peripheral circuits from its 8080 design, and greatly increasing the chip's memory capacity with an 8-k erasable PROM and a 512-bit RAM. Also included on the chip are 27 input/output ports and an interval timer—leaving only a crystal and a single 5-volt power supply to complete the system. The 8048, which will be ready in sample quantities next summer, is software-compatible with the 8080.

Quad-slope a-d converter packs 13 bits on chip

By using a patented new analog-to-digital conversion technique called quad slope, Analog Devices Inc. of Norwood, Mass., has built a **13-bit a-d converter on a single C-MOS chip.** Previously, this level of performance could be achieved only with discrete or hybrid converters. Like standard dual slope, quad-slope conversion is an integrating technique that achieves high accuracy by making errors cancel themselves. But quad slope goes further: it includes two additional integrating steps that comprise a digitally corrected auto-zero cycle. The effect is to reduce zero drive and gain drift to less than 1 ppm/°C.

Prime to use 16-k RAMs in systems in '76

While some potential users aren't convinced the semiconductor industry can deliver 16,384-bit RAMs in significant volume this year [*Electronics*, Jan. 8, p. 27], Prime Computer Inc., the Framingham, Mass., minicomputer maker, **expects to be delivering systems using the devices before year's end.** Prime is already assembling circuit boards using 16-k RAMs. William Poduska, Prime's vice president of engineering and programing, expects to get 128,000 words on a single board and more than a million words of 16-k RAM in a system.

He won't say precisely what quantities Prime is receiving from two suppliers, Texas Instruments and Intel Corp., but the volume is sufficient to allow board assembly in evaluation quantities.

Fluke to add pair of products based on micros

Taking advantage of microprocessor expertise gained in other product lines, John Fluke Mfg. Co. of Seattle will soon introduce a digital multimeter that depends on the device's power for computation as well as control. **And on the firm's drawing boards is a microprocessor-based counter.** Last March, Fluke introduced a frequency synthesizer using a microprocessor for input/output interface and control.

Sony to sell line of professional video equipment

Sony Corp. of America has formed a Broadcast division, to make its public debut at the National Association of Broadcasters' annual meeting on March 22 in Chicago with an entirely new line of professional video equipment, including a camera system, portable recorder, editing console, and time-base correctors. **To date, Sony's TV equipment activities have been confined essentially to the industrial market;** it sold only small cameras and recorders through distributors.

Electronics newsletter

ITT sets up telecommunications consulting group

International Telephone & Telegraph Corp.'s American Cable & Radio subsidiary has formed a new organization—ITT Corporate Communications Services Inc.—**to perform telecommunications consulting services for other companies.** The group, part of ITT's domestic communications operation, made a thorough study of ITT's total corporate communications system two years ago. The result: $1.4 million in savings to ITT in its telecommunications expenses in 1974, and another $3.4 million in '75. ITTCCS is aiming at the smaller users that don't have in-house telecommunications specialists.

IEEE general manager under fire over layoffs

After a little over a year on the job, **Herbert A. Schulke, general manager of the IEEE, may be on the way out.** The reason: some directors have become dissatisfied with the way IEEE is running and are particularly upset by the internal crisis created by Schulke's handling of the recent layoff of 25 institute employees.

Also, now that the precedent of a contested election for IEEE president has been set, **a campaign could develop again this year.** At least one member of the board of directors has sounded out the membership with the idea of getting on the ballot by petition. One or two other members may also consider this move. These plans spring from growing dissatisfaction with the way the IEEE has performed on the professional activities front and what some feel has been an indecisive stand concerning control of engineering graduates.

Field-effect liquid crystal rights awarded

Hoffman-La Roche, Inc., the Nutley, N.J.-based pharmaceutical and medical electronics house, has won approval from a U.S. District Court in Cleveland **to license the basic liquid crystal field-effect invention,** used in many displays in digital watches, digital panel meters, and other products.

C. J. Wiley, project director of Hoffman-La Roche, says his company intends to offer this technology immediately to the numerous companies that have already been in touch with Hoffman-La Roche. Originally, Ilixco of Warrensville, Ohio, filed its patent claim in the U.S. about a month before the New Jersey company, but assigned its patent to Hoffman-La Roche. Until final details of an agreement can be worked out, Federal Judge William K. Thomas has agreed to allow Hoffman-La Roche to license users of the technology and hold all royalties in escrow.

Addenda

To meet increasing demand for digital logic design and troubleshooting aids, Hewlett-Packard is offering a TTL/C-MOS logic probe with pulse memory, the model 545A. And, scheduled to be ready soon is **a complete new line of logic troubleshooting equipment.** . . . Also due soon from HP, this time from its new Microwave Semiconductor division, is the first in a line of low-noise, small-signal silicon bipolar transistors. **By using a new self-aligning mask technique,** HP designers have attained a worst-case noise figure of 3 decibels (2.7 dB typical) and an associated gain of 9 dB at 4 gigahertz; at 1.5 GHz, typical noise figure is 1.5 dB and associated gain is 15 dB.

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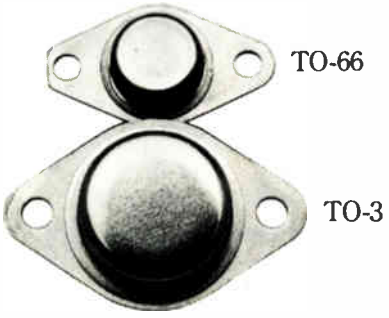

Our PIC-600 Series power switching circuits are now available in a TO-3 with positive and negative outputs, in current ranges up to 20 amps peak and voltage capabilities up to 100 volts.

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We've taken care of all that. And the power circuit is the one that can contribute most in terms of improving the regulator's performance. We've taken care of that, too. Thanks to our special design and packaging, you can expect faster response time and lower noise than you could design in yourself. And because of the faster switching time, you can reduce the size and cost of other components and operate at frequencies up to 100KHz.

To make your life even easier, we've got a 24-page booklet that'll tell you everything you need to know about designing a switching regulator. It's the only booklet of its kind available, and it's free. To get yours, along with detailed specs for our power switching circuits, circle our number on the reader service card.

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Parallel BCD output and digital control signal capability at *no extra cost.*

2. Ratio Measurements

DC/DC and AC/DC ratio measurement capability at *no extra cost.*

3. High Normal Mode and Common Mode Rejection

Model 3500 performance is significantly more effective in rejecting normal mode and common mode signals up to 80dB NMRR and up to 160dB CMRR.

4. Hi-Frequency Measurements

The Model 3500 AC voltage measuring capability is specified up to 100KHz.

5. High and Low Range ACV Measurement Capability

Provides a measurement capability of AC voltages on 5 range scales, including the low scale with 1μV resolution and a high scale to 700 volts RMS.

6. Zero Stability

Model 3500 incorporates Tri-Phasic ™ autozeroing performance eliminating the need for zero adjustment between measurements on any range and any function.

7. Price

High quality performance and accuracy for $995 complete.

The Model 3500 has a 6 months basic DC accuracy of ±0.007% of reading ±1 LSD, full autoranging from 1 microvolt to 1000V (DC or AC peak) and 1 milliohm through 12 Megohms resistance, 20% overranging and an easy-to-read ½ inch planar display.

The Model 3500 also features our Tri-Phasic ™ conversion cycle, Ratiohmic ™ resistance mode, and Isopolar ™ referencing, circuit techniques that increase performance and decrease price.

To arrange an immediate demonstration or for technical data and a comparative analysis of the Model 3500 contact: Data Precision, Audubon Road, Wakefield, MA. 01880 (617) 246-1600.

DATA PRECISION

...years ahead

Scan converter aims at the Air Force's radars and sensors

Programing changes will tailor the converter so aircraft sensors share single cockpit TV screen

This month, the Air Force will start flight-testing a modular digital scan converter (MDSC) that will work with almost any radar. The new scan converter uses a Hughes Aircraft Co. MMC military microcomputer [*Electronics,* Sept. 4, p. 32] to translate slow-scan radar signals to the fast scan rate of TV displays.

Scan converters are needed in today's aircraft because radars and electro-optical sensors, such as forward-looking infrared or TV, must now share a single TV screen in the cockpit.

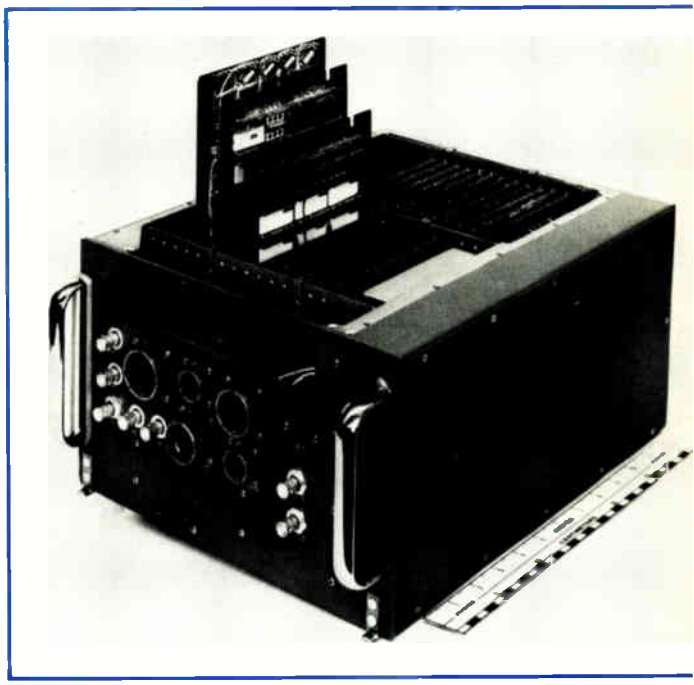
Programable. "We decided that the MDSC should be programable so that most format changes could be done in software or firmware," comments Stephen H. Young, MDSC project manager at the Air Force Avionics Laboratory, Wright-Patterson Air Force Base, Ohio. In this way, the "special hardware development needed for scan converters as new radars are introduced will be only a few custom interface modules. We estimate that 85% to 90% of the modules for each new application can be standard."

The development, performed under a $248,000 contract by Hughes' Aerospace Group, Culver City, Calif., is an outgrowth of an earlier program to develop a digital scan converter for the McDonnell Douglas F-4; this is now in production at Texas Instruments, Dallas. The Avionics Lab is pitching its modular version for retrofit to radars in aircraft that use analog scan conversion or the even older direct-view storage tubes. Candidates include the A-7 attack plane and fighter aircraft including the RF-4, F-111D, F-5, and F-106. "Both earlier techniques have proven to be difficult to service," Young says.

Newer aircraft, such as the B-1 bomber, F-15 and F-16 fighters, and A-10 attack plane, either don't use the electro-optical sensors that require a TV display or have dedicated digital scan converters. This month, an Air Force F-106B will flight-test the scan converter on the radar for an MA-1 fire control system; the MDSC is also scheduled for a May, 1977 flight test as part of the Joint Tactical Information Distribution System (JTIDS) program.

$800/board. Young projects the cost of digital scan converters built from the MDSC modules at about $800/board. The MA-1 fire-control system, for example, will use roughly 30 boards and cost between $25,000 and $30,000. "There's very little initial cost difference between this approach and a dedicated design," Young says. But the Air Force is interested because of savings that will come from life-cycle cost reductions in stocking and maintaining systems that are built from standard off-the-shelf modules.

Built around Intel Corp.'s 3000-series Schottky TTL microprocessor, the three-board MMC provides arithmetic, logic, registers, interface control bus allocation, interrupt control and program decode controls for running scan converter and symbol-generator modules. The MMC is coupled with 4,096 by 16 bits of random-access memory and 4,096 by 16 bits of programable read-only memory, which stores the application software. This month's tests will use 400,000 bits of Mostek 4-k RAM for storing range, azimuth, and gray-scale data to refresh the symbols and sensor signals to be shown



TV star. Modular digital scan converter changes sensor signals into a flicker-free TV display format. The three raised cards are a microcomputer capable of 500,000 operations per second with up to 64,000 words of memory.

on the TV screen. Sensor and symbol display refresh memory is configured in 4-k by 24 bits to the board, expandable to 64 boards.

Other modular components divide the radar signal into range and azimuth segments, convert them to digital, provide line-to-line video integration, add threshold controls and programable fade-erase control, and generate the standard EIA sync necessary for a TV composite signal. The video analog-to-digital converter, a Hughes-built emitter-coupled-logic hybrid, provides 4-bit, 40-megahertz conversion with gain control variable over a 64 to 1 range. Video digital-to-analog and mixer bandwidth is greater than 10 MHz.

An optional module can be used to "freeze" TV or forward-looking infrared images, or can mix symbology with an external TV image. The system can also convert line-scanning infrared sensors to the TV raster. □

Commercial

Color-TV camera achieves new low

An electronic color camera smaller and lighter than most film cameras used in television newsgathering has been developed by Thomson-CSF Laboratories Inc. in cooperation with the CBS television network. The portable camera, called Microcam, weighs eight pounds [*Electronics*, Jan. 22, p. 36].

Lightweight. Eight-pound color-TV camera from Thomson CSF drops the weight of electronic broadcast-quality cameras.

Renville H. McMann, president of the Stamford, Conn., firm, and Clyde Smith, director of audio-visual engineering, developed the Microcam. When they were working at CBS Laboratories, they were responsible for the Minicam, generally regarded as the first of a new generation of portable electronic TV cameras when it was introduced in 1968. The Minicam, in wide use, weighs 50 pounds with backpack and batteries.

For both electronic cameras, the significant advantage of recording directly onto videotape is that no processing before broadcasting is required—so the viewer gets news hours faster. Says Joseph H. Flaherty, general manager of engineering for the CBS-TV network, "The Microcam makes electronic newsgathering more flexible and more mobile than film usage."

Next generation. Why is this camera so much lighter and smaller than the Minicam? McMann says it is all in the circuitry. "It's a later generation of microcomponents. Also there is a lot more experience built into the Microcam. We spent a great deal of design time on this camera, and we learned a lot about simplifying circuitry design and packaging."

Portable TV cameras, for instance, often need fins to help take heat generated by the electronics away from the sensor optics. To eliminate this problem and to reduce the weight of the hand-held camera head, much of the electronics (including signal processing) is in a three-pound hip pack. Ten nickel-cadmium batteries account for 2.5 pounds of the pack's weight and provide one hour of operation.

Color balancing, normally a manual chore on portable electronic cameras, is performed automatically by digital complementary-metal-oxide-semiconductor memory latches. Before a shooting session, the camera operator sets the color balance by holding the Microcam's lens in front of a white card or surface and pressing a spring-loaded switch on the hip pack. This establishes the camera's color balance control in its memory. A light-emitting-diode indicator in the viewfinder lets the operator know when the balance is off. Another LED indicator warns of low batteries.

The Microcam uses three ⅔-inch Plumbicon tubes, although McMann expects future models to use three charged-coupled devices in place of the tubes. "Based on what I've seen so far, it may be three to five years before we use the CCDs. They're all right for industrial or military applications right now, but not for commercial broadcasting." The switch from Plumbicons to CCDs would also eliminate some mechanical assemblies, further reducing the camera head's weight from eight to five pounds, says McMann. A multi-conductor cable interconnects the camera head and the hip pack, carrying power and electronic signals.

McMann says the camera can be operated by coaxial cable or with a special microwave backpack (often used with the Minicam). Or CBS-TV may use a new 24-pound videotape recording pack developed recently by JVC America Inc., Maspeth, N.Y.

The first production Microcam will be delivered to CBS-TV in June. Its first use is scheduled to be at this year's national political conventions. After June, McMann expects to be turning out 10 to 20 Microcams a month for U.S. and foreign markets through Thomson-CSF Labs and Thomson-CSF S. A., Paris, France. The cameras will be priced at less than $30,000. □

Packaging & production

Aluminum, silicon radiation-proof IC

Nuclear radiation that evaporates gold leaves aluminum intact. So an all-aluminum metal system gives a complex hybrid circuit a much better chance of survival, particularly if

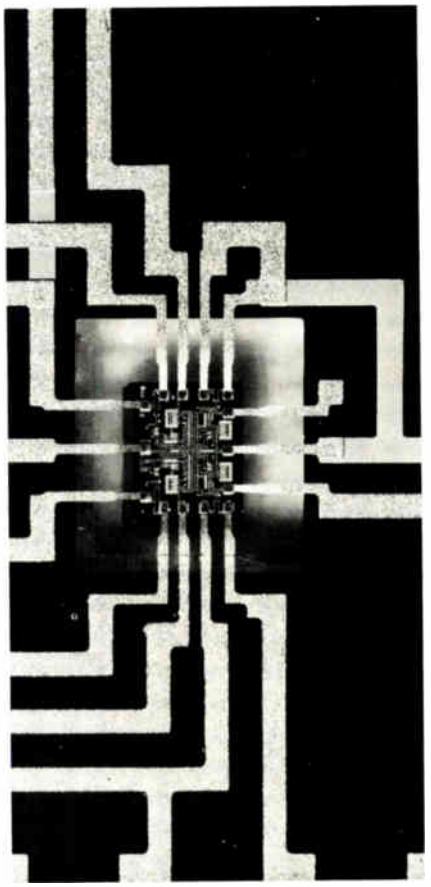
a beam-leaded silicon substrate is used, say engineers in the Hybrid Technology Development Laboratory at Raytheon Co.'s Equipment division, Sudbury, Mass.

When gold is used with semiconductors exposed to a nuclear blast, it absorbs low-level X rays, heating up so much in the process that it vaporizes and causes the circuit to fail. Aluminum exposed to the same dosage isn't harmed, say the Raytheon engineers.

They switched to the beam-leaded silicon substrate, after using chip-and-wire hybrids, in part because faulty wire bonds are still the main obstacle to reliability in military hybrids. And while they're not the first to put beams on the substrate or carrier, they believe their use of silicon for the substrate is new—it withstands X rays and there's no thermal mismatch between it and the ICs and transistors bonded to it.

Two-layer interconnects. According to Robert Michals, a design and development engineer in the laboratory, Raytheon buys silicon wafers cut 1.2 inches square and 12 mils thick and deposits an initial silicon dioxide layer, one layer of interconnect 0.8 mil thick, a second silicon dioxide insulator, and a second metal layer. Through holes are etched in the second oxide layer to allow contact between the two aluminum levels. This etch step also defines the periphery of the silicon substrate where the second metal layer will form the beam leads—at the edge of the substrate for connection to the package and at the windows that will hold semiconductor devices.

After masking and etching, the beam leads end up 3 to 5 mils wide and 0.6 mil thick. The substrate is then flipped over to accept a chromium layer atop the dioxide deposited in the first step. The chrome acts as the mask to define the device window and substrate edge patterns. Two etch steps create the windows: the first, using potassium hydroxide, stops about 10.5 mils through the 12-mil substrate, and the second, done with hydrazine, penetrates



Window. In hybrid circuit developed at Raytheon's Equipment division, integrated circuit aligned in one of the silicon substrate's windows has aluminum beam leads ultrasonically bonded to its bonding pads.

right through. Michals explains that the hydrazine etch is slower, but won't remove any aluminum on the top side of the substrate, as would potassium hydroxide.

Held in wax. The substrate is then electrically tested and readied to accept devices. An operator mounts the active devices in wax on a glass alignment fixture bearing an exact image of the second-layer interconnect and beam pattern. The wax hardens, holding the chips in place, and the operator places the silicon substrate over the chips in a final alignment.

The beams at the device windows are ultrasonically bonded to the bonding pads that are fabricated conventionally on the chips. Ultimately, the alignment plate is removed, and the beams around the substrate periphery are also ultrasonically bonded to the package that will hold it.

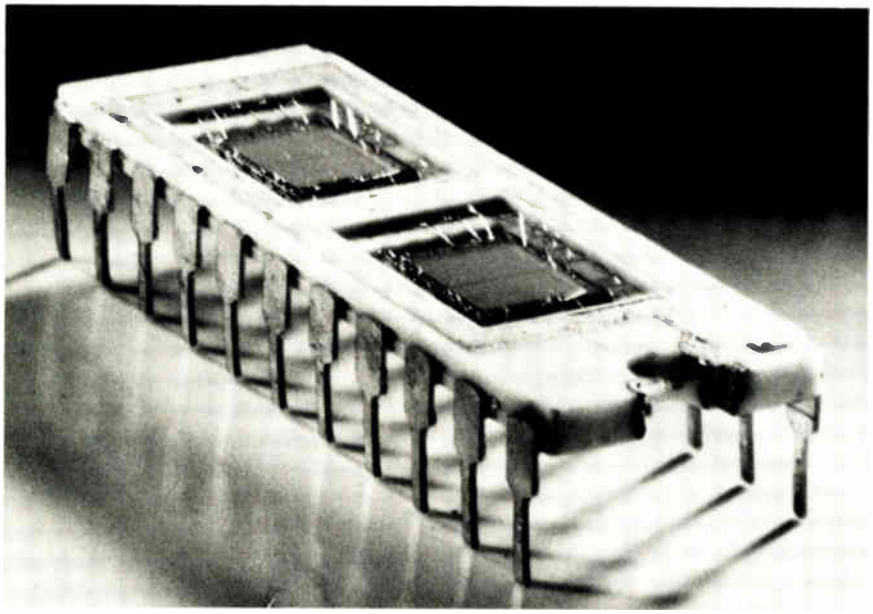
Michals says the most complex hybrid circuit assembled to date on a beam-lead substrate is a 1.2-inch-square sense amplifier that has 18 ICs and a variety of discretes and is used in a plated-wire memory. Raytheon hasn't applied this kind of hybrid in a system yet, but the fault-tolerant computer being developed by the company for the Air Force Space and Missile Systems Organization [*Electronics*, Dec. 25, p. 36] is a candidate.

Jack Murphy, manager of advanced electronics development in the division's Strategic Systems Directorate, points out that the hybrids are applicable "anywhere you're looking for a monometallic system integrating high-density MSI or LSI chips, but it must be a high-volume requirement," or the cost would be too high. He estimates that a substrate with 200 beams to the outside world costs $200 to process, including testing and sealing, but not including package or active device costs. □

Dual DIP doubles memory density

Despite competition from other types of packages, the ceramic dual in-line package remains the dominant carrier for large-scale-integrated memory chips. That dominance is likely to be increased by a dual version of the ceramic DIP being offered by the MOS division of Cambridge Memories Inc., Poughkeepsie, N.Y.

The package, which comes in two configurations, accommodates two cavities for chips in the same space as the single cavity in the standard DIP. Space is conserved by using common wiring wherever possible. The two cavities double circuit density for systems without increasing the area of printed-circuit boards. Happily, without modifying device technology or assembly lines, the dual DIP can be easily adapted to existing system design and replace



Double duty. Twin cavities built into a standard 22-pin ceramic dual in-line package by Cambridge Memories will accommodate a pair of integrated-circuit chips.

conventional DIPs in any manual or semiautomatic assembly line. The dual-cavity package not only cuts handling and testing costs by at least a factor of two, but the package also enables the addition of flexibility to memory organization, according to a company spokesman.

Two configurations. In one version, two identical cavities are designed into a standard 22-pin DIP. This package, built by the Electronic Products division of Minnesota Mining & Manufacturing Co., can accommodate separate chip-select lines or separate data-out lines. All common points of the two chips are connected within the ceramic package, which is of a multilayer design of conductive and insulating layers that 3M has built before. In another version built by Kyocera International Inc. of Cupertino, Calif., two unconnected cavities are of different size.

For system assembly, no additional tooling is required to use the dual DIPs because the pin spacing conforms exactly to that of the standard DIP. Localized heating mechanisms can be used for bonding each of the two independent cavities. In the version with identical cavities, wire bonding is the same for both cavities. After assembly, all automatic DIP handlers and burn-in systems can be used without modification.

Doubling. CMI is assembling its 1,024-bit and 2,048-bit random-access memories in the dual DIPs, which effectively doubles the memory size at the module level. CMI's 2-k static RAM, the 3702-2, has a maximum access time of 70 nanoseconds. And since the access time is the same in the dual-cavity module containing two of these devices, this is one of the fastest 4-k RAMs in existence.

CMI, which has applied for a patent, intends to license users. Paul Lin, engineering manager of CMI's MOS division, says, "As long as the electronics industry stays with the standard rectangular DIP, the lifetime of this particular technique will be fairly long." □

IEEE

Staff cuts stir uneasiness

In a move to close a gap in its 1976 budget, the Institute of Electrical and Electronics Engineers has dismissed 25 employees from its New York and Piscataway, N.J., offices. This reduction, hard on the heels of a dues increase, is expected to save IEEE $248,500 after subtracting all the separation costs involved.

However, reaction by some members of the board of directors and various influential institute members has not been favorable, either to the functions affected or to the manner of the layoffs. Cuts hit levels of the staff ranging from clerical to management. Most controversial were dismissal of key people in educational services, standards, and public relations, which critics contend will greatly weaken IEEE's effectiveness this year. Because of the suddeness of the announcement, they say it has lowered morale of the remaining 263 employees.

General manager Herbert A. Schulke Jr. insists, on the other hand, that the reductions were planned to minimize the drop in service to members. He further states that there will be no additional layoffs for the foreseeable future. Schulke explains that the cuts were reluctantly mandated by the executive committee when it became clear that this year's budget would run in the red. □

Consumer

Programable chip eyed for watches

One of the lessons semiconductor firms preach endlessly to prospective users of microprocessors is that a system controlled by software is better than one controlled by hardware. Increased functional flexibility at lower cost and reduced development time are the gains, they say.

In development. Perhaps, then, it should be no surprise that one semiconductor firm has taken this advice to heart and has begun development of a programable, software-controlled multifunction watch chip.

This radical departure from traditional complementary-MOS watch-circuit design comes from American Microsystems Inc. of Santa Clara,

New Tektronix Logic Analyzer Acquires 16 channels

Here's how the new TEKTRONIX LA 501 Logic Analyzer acquires more data than other analyzers in its price range; does it with a higher sampling rate; and provides improved ways of displaying that information.

Acquires up to 16 data channels simultaneously. In fact, you can select storage formats of 16 channels x 256 bits, 8 channels x 512 bits, or 4 channels x 1024 bits to best suit your appication.

Stores 4096 data bits on a single pass for display and study of large blocks of nonrepetitive information.

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Provides timing analysis with 15 ns resolution in the asynchronous (internal clock) mode. For logic state analysis, the LA 501 accepts external synchronous clocks with rates up to 50 MHz.

Compares timing between channels easily using the unique capability of selecting any one of the displayed channels and positioning it vertically.

Assures detailed views of logic timing with the unmatched capability of zooming in on any segment of the 4096 bits of data for full screen display. For maximum visual resolution display units with up to 6½" screens are available.

Offers selection of the data window to be stored and displayed. This is accomplished by delaying the store trigger with a DD 501 Digital Delay.

With all of this outstanding capability, the LA 501 is priced at only $3,250 and plugs into any of four TEKTRONIX TM 500 mainframes priced from $150. It works with virtually any x-y display.

For a demonstration of how the LA 501 provides solutions to your logic analysis problems, contact your Tektronix Field Engineer. Or for a descriptive brochure, including specifications, write: Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077. In Europe, write: Tektronix Limited, P.O. Box 36, St. Peter Port, Guernsey, Channel Islands.

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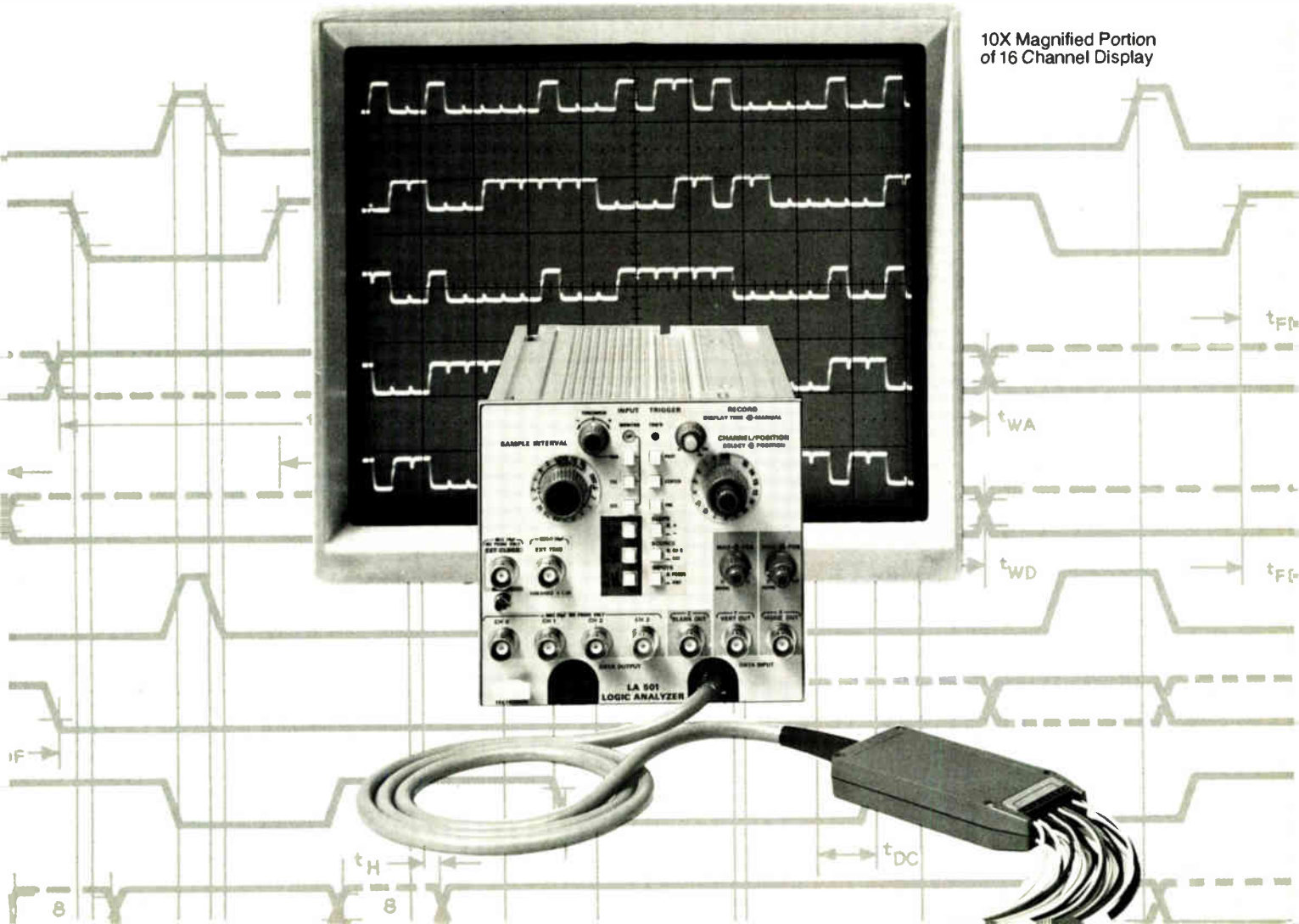


10X Magnified Portion of 16 Channel Display

Calif. Says Norman Grannis, vice president of standard products at AMI: "Manufacturing costs on present random-logic watch circuits are about as low as they are going to get. So, it seems obvious that the only way to reduce costs further is via a specialized microprocessor approach. For us, it will be the basis of AMI's 1977 line of standard digital timepieces."

Prototypes coming. With prototypes to be available during the second quarter of 1976, the 120-by-120-mil programable watch chip replaces the traditional random-logic timing circuitry with a binary-coded-decimal processor architecture roughly similar to that used in AMI's $10 S9202, a one-chip p-channel MOS display-oriented microprocessor. About half the silicon-gate complementary-MOS chip is taken up by a 6-bit-by-1,000-word read-only storage memory. Dynamic memory capability is provided via a 4-bit-by-28-word shift register. Performing the arithmetic/logic unit's function is a 4-bit BCD adder. Also on the chip is a 12-bit address/program counter.

The system, says James Kerins, manager of consumer products, has 12 basic 4-bit instruction words and a subset of 64 possible timing instructions. He says a typical instruction-cycle time is about 480 microseconds. "What this will give us is a universal watch chip that can be programed in the factory for a particular application. In the first versions, it'll be possible to program in at least eight to 10 different kinds of watch configurations, involving three, four, five, and six functions."

According to Grannis, the pinout on the watch chip will also be programable, allowing simulation of chips made by other manufacturers. "That will be a very powerful marketing tool as the watch market heats up," he says. The programable chip will fit the same pinouts as AMI's present five-function liquid-crystal-display watch circuit, the S1424.

Ratioed C-MOS. The present AMI C-MOS watch chips contain the equivalent of 2,500 transistors, but the 40%-smaller programable chip will contain about 8,000. This density is achieved, says Kerins, using "a ratioed static C-MOS circuit design." This is a quasi-complementary, pseudo-dynamic technique in which the chip is fabricated with a straightforward C-MOS process, but uses circuit designs other than those traditionally associated with the process.

In more or less constantly "on" areas of the chip, where power and current drain are a problem (the output latches and buffers, for example), the traditional complementary-transistor structure is used. In other areas, such as the 6,000-bit ROM, either n-channel elements or p-channel elements are used, with the two logically connected in varying ratios.

In the ROM, the core circuitry is n-MOS, and the decode is p-MOS; controlling each line or column of 32 n-type pull-down transistors is one p-type pull-up element. "A straightforward C-MOS structure in the ROM would make the chip three times as large," says Kerins. □

Navigation

Direction finder aids Channel ships

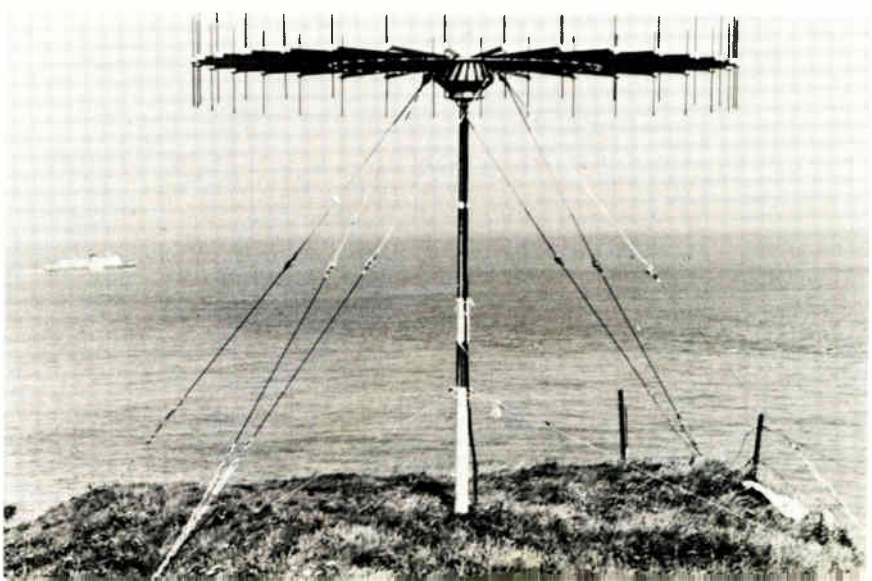
With several hundred ships plowing through it every day, the English Channel is said to be the most hazardous sea lane in the world. Identifying vessels in the Channel is therefore a major concern, and most recently the French maritime agency in charge of lighthouses and beacons—Service Technique des Phares et Balises—turned to a very-high-frequency direction-finding system to augment its radar equipment for guiding ships.

Radar alone, the experts say, is effective only if ships know exactly where they are and relay their position to shore so that radar operators can identify the vessels on their screens. But even this technique presupposes that closely spaced vessels can be positively identified as targets moving across the screen. With radar, it isn't always possible for shore personnel to correlate the target with the ship from which the position information was received.

The French service's system, NP7, made by West Germany's Rohde & Schwarz, has been put through its paces at Cape Gris Nez, between the seaports of Boulogne and Calais.

Already aboard. In contrast to other identification aids, R&S says its direction finders need no other equipment to operate with except vhf radio systems, which most ships have anyway. The Munich company says the French agency chose the NP7 because it is one of the few European-made high-performance direction finders that cover the range from 156 to 174 megahertz, used in maritime radio. The NP7 furnishes bearing indications with a max-

Channel view. Rohde & Schwarz antenna system for direction finder at Cape Gris Nez in France has 32 dipoles arranged around a six-meter-diameter circle.



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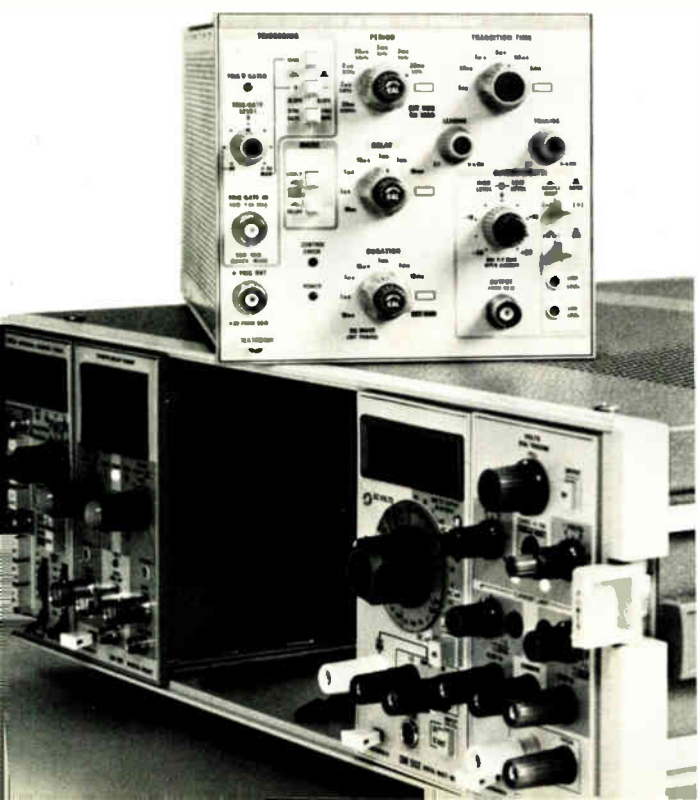

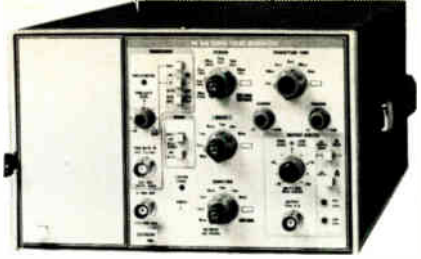

PG 508T (includes mainframe) . . . $1250

The Tektronix PG 508 50-MHz Pulse Generator is a general-purpose instrument with unique features innovated for versatility and ease of use.

It provides the high-level output required to drive MOS and CMOS (up to 20 V in a ±20-V window to hi Z and up to 10 V to 50 Ω).

A control error light helps in setting up the instrument by warning of improper switch or variable control settings of the parameters, which include period, delay, duration, and rise and fall time.

The PG 508 is the first pulse generator on the market to offer independent pulse top and bottom level control by three means: knobs, front-panel screwdriver adjustments, or external tracking. The low reactance 50-Ω output delivers clean waveforms to unterminated cables or reactive loads.

Trigger the PG 508 from your circuitry just as you would your favorite triggered-sweep oscilloscope . . . a selectable 50-Ω or 1-MΩ trigger/gate input lets you use a 1X or 10X oscilloscope probe. A three-state trigger light indicates proper external triggering.

The PG 508 will perform effectively as a pulse regenerator, sine-wave to pulse converter, or logic level translator, as well as a primary source of pulse waveforms. Use it to drive MOS, CMOS, DTL, HTL, I^2L, T^2L, or ECL.

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The PG 508, for example, can be combined with several other TM 500 instruments to provide a basic bench setup for CMOS. One suggested lineup includes a TM 506 6-compartment mainframe, DC 505A Universal Counter, DD 501 Digital Delay for counted burst operation, PG 508 Pulse Generator, DM 502 Digital Multimeter, and PS 503A Power Supply. While this is a typical setup, many variations are possible within the TM 500 family to create the optimum instrumentation for your particular needs.

PG 508 50-MHz Pulse Generator $1100

PG 508T (includes mainframe) $1250

For further information on the PG 508 and TM 500 Instrumentation, ask for a demonstration; a Tektronix Field Engineer will contact you. Ask for literature and you'll get the comprehensive PG 508 Data Sheet and TM 500 Catalog shown below.

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imum deviation of 1°. Toward the summer of this year, the R&S system will be used as standard equipment at the French agency's Cape Gris Nez navigation center.

As Ulrich Unselt, a system-marketing official at R&S explains it, the NP7 is based on doppler principles. Its antenna consists of 32 dipoles arranged along the perimeter of a circle six meters in diameter. A quarter-wavelength antenna at the center of the circle is used to implement the special compensation techniques employed in the NP7.

A pair of antenna commutators simulates the rotation of a single dipole turning at a speed of 170 rotations per second. This simulation adds 170 hertz to the frequency-modulated signal received from the ship. This signal is then applied to the direction-finding receiver, and a communications receiver is fed the ship's signals coming from the central antenna.

Getting the bearings. The intermediate-frequency signals of both receivers are sent to a common demodulator containing a double mixer. The original frequency-modulation envelope of the signal received from the ship is suppressed, but the frequency modulation generated by the simulated rotation of the antenna remains and produces a sine-wave signal at the demodulator output. The phase of this signal is compared with a reference signal to yield an exact bearing.

The measured result, averaged for 180 simulated antenna rotations, is then shown as a three-digit figure. The bearing indication can also be displayed on the radar screen as a line originating at the direction finder that intersects the target. □

Avionics

Hazeltine favored to win DABS pact

The Federal Aviation Administration has recommended Hazeltine Corp., Greenlawn, N.Y., to win the final round to develop the prototype

News briefs

Fairchild Semiconductor reorganizes

Fairchild Camera & Instrument Corp. has restructured its semiconductor components organization so that the responsibility for major product lines is now dispersed among several key executives. Vice president Thomas A. Longo, who as general manager of the now dissolved Memory and Logic Group was in charge of all digital-circuit product development, has been appointed chief technical officer of the corporation. He will be responsible for all research and development programs, including the Central Laboratory, and for technical liaison among the various divisions.

Vice president George D. Wells, formerly general manager of the Analog and Discrete Products Group, has been named general manager of the new Domestic Components Group. His old group becomes part of the new organization, along with the Digital Integrated Circuits division, till now part of the Memory and Logic Group. Longo and Wells continue to report to Wilfred J. Corrigan, president and chief executive officer. Also reporting directly to Corrigan instead of to Longo will be Richard Abraham, head of the Bipolar Memory division, and Alan Gregory, head of the MOS Products division, which from now on will incorporate the company's CCD operation.

Railroads to continue automatic car ID

After a series of successful tests, directors of the Association of American Railroads have voted to continue the controversial automatic car identification program for freight cars. After demonstrating that ACI performance can be enhanced by cleaning the car labels, increasing the intensity of trackside optical scanners, and placement of a second scanner on each track, the railroad association decided not to junk the $70 million system, but to explore alternate technologies [*Electronics*, Oct. 30, p. 49].

Blind man 'sees' through electrodes in brain

A totally blind volunteer who had an array of electrodes surgically implanted onto his brain's visual area six months ago, is able to "see" dots of light representing braille letters that he can read. In this effort [*Electronics*, Jan. 24, 1975, p 81], conducted jointly by research teams from the Universities of Utah and Western Ontario, Canada, sentences are fed into an external computer, which, in turn, translates the letters into the dots of light.

In another phase of the team's work, the volunteer uses a small television camera, which is connected to the electrodes via the computer to detect a simple pattern of vertical and horizontal lines.

AT&T shifts its top management

The early retirement of Robert D. Lilley, 63, as president of American Telephone & Telegraph Co., effective April 1, has triggered several shifts in AT&T's top management. William L. Lindholm, vice chairman and chief operating officer, will be the new AT&T president. William M. Ellinghaus, president and chief executive of New York Telephone Co., has been elected a vice chairman and director of AT&T. Charles L. Brown, an executive vice president, is also a vice chairman and director. He will continue as the company's chief financial officer. Also, on March 1, Morris Tanenbaum, an executive vice president of Bell Telephone Laboratories, will become AT&T vice president of engineering and network services, succeeding Jack A. Baird, who was named vice president for customer services.

Motorola enters CB market

Motorola Inc. expects to begin delivering its new line of citizens' band transceivers, both mobile units and base stations, in the second quarter of this year. Unlike General Electric Co. and RCA Corp., which plan to enter the CB market with Japanese imports [*Electronics*, Jan. 22, p. 46], Motorola's Communications Products division in Schaumburg, Ill., will engineer and produce its own equipment, and the company's Automotive Products division, Franklin Park, Ill., will market it. The first Motorola units will be under-the-dashboard models, although in-dash units are planned.

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.1 μF, 20%, 25WVDC	9¢	16¢	14¢
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2.2 μF, +80 −20%, 25WVDC	35¢	—	49¢

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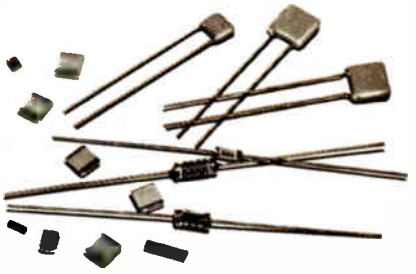

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Electronics review

discrete address beacon system for the air-traffic-control system of the 1980s. Texas Instruments, Dallas, is the other final contender for the pact. Long-term production potential of ground and airborne DABS hardware is expected to exceed $200 million.

Award of a contract "in excess of $10 million" for three prototype DABS packages is imminent, say Government sources, although deputy transportation secretary John W. Barnum, DABS source evaluation officer, would say near the end of January only that "a decision has yet to be made." At the same time, a senior Hazeltine official says the company has received no notification from the FAA.

DABS is a two-way digital communications link designed to track aircraft flight paths through ground interrogation of airborne transponders. To this, the FAA would later add an intermittent positive control (IPC) system to warn pilots of potential collisions and provide avoidance commands automatically.

New money. In its new budget request for fiscal 1977, which begins next Oct. 1, the FAA has requested $6 million more for the DABS program. The funds, less than industry had anticipated, are part of a $14 million package for research and development on collision-avoidance systems, part of the FAA's $76.7 million R&D request (see p. 63).

The value of the new DABS money, industry officials explain, will be diluted because it must also cover funds for the Mitre Corp., and Massachusetts Institute of Technology's Lincoln Laboratory, which have been providing technical advice and guidance on DABS to the FAA. Nevertheless, FAA sources contend that unexpended DABS funds carried over from earlier budgets are sufficient for the program.

Sources close to the program indicate that the agency will proceed with development of an IPC program for later use with DABS in a ground-based collision-avoidance system, particularly in those areas having high-density air traffic.

Development of DABS/IPC, sources point out, would mean widespread use of collision-avoidance systems by the mid-1980s. Till that time, however, it is believed the FAA proposes to use the so-called Litchford System, initially designed and developed in 1973 for the Air Force and tested at the Electronic Systems division, Hanscom Air Force Base, Mass. [*Electronics*, Oct. 30, p. 29]. Put under FAA contract last year, the Litchford CAS system has ground-based computers to interrogate an aircraft's air-traffic-control transponder for the radar-beacon system.

Reduction. Ideally, the Litchford system should be used in low-traffic areas. Such application could reduce earlier FAA estimates of the need for 250 to 350 DABS/IPC ground sites to possibly as few as 100, thus significantly reducing the cost of ground systems to less than $100 million. As for DABS/IPC avionics costs, the package of a DABS transponder, IPC display, and encoding altimeter is estimated to add up to more than $13,000 per plane for a commercial airliner, and a general-aviation-aircraft system would run close to $2,750. □

Military

360° phasing may be going to sea

The Navy, which already has ground-based and airborne versions of electronically scanning stationary antenna arrays with 360° coverage, now wants a shipboard antenna with the same capabilities. The doughnut-shaped electronically scanning antenna is being developed for the Naval Electronics Systems Command by Lockheed Electronics Co. in Plainfield, N.J.

According to Lockheed, the Navy wants to mount the antenna high on masts to eliminate "shadows" in the reception usually caused when it scans across the path of other shipboard antennas and structures.

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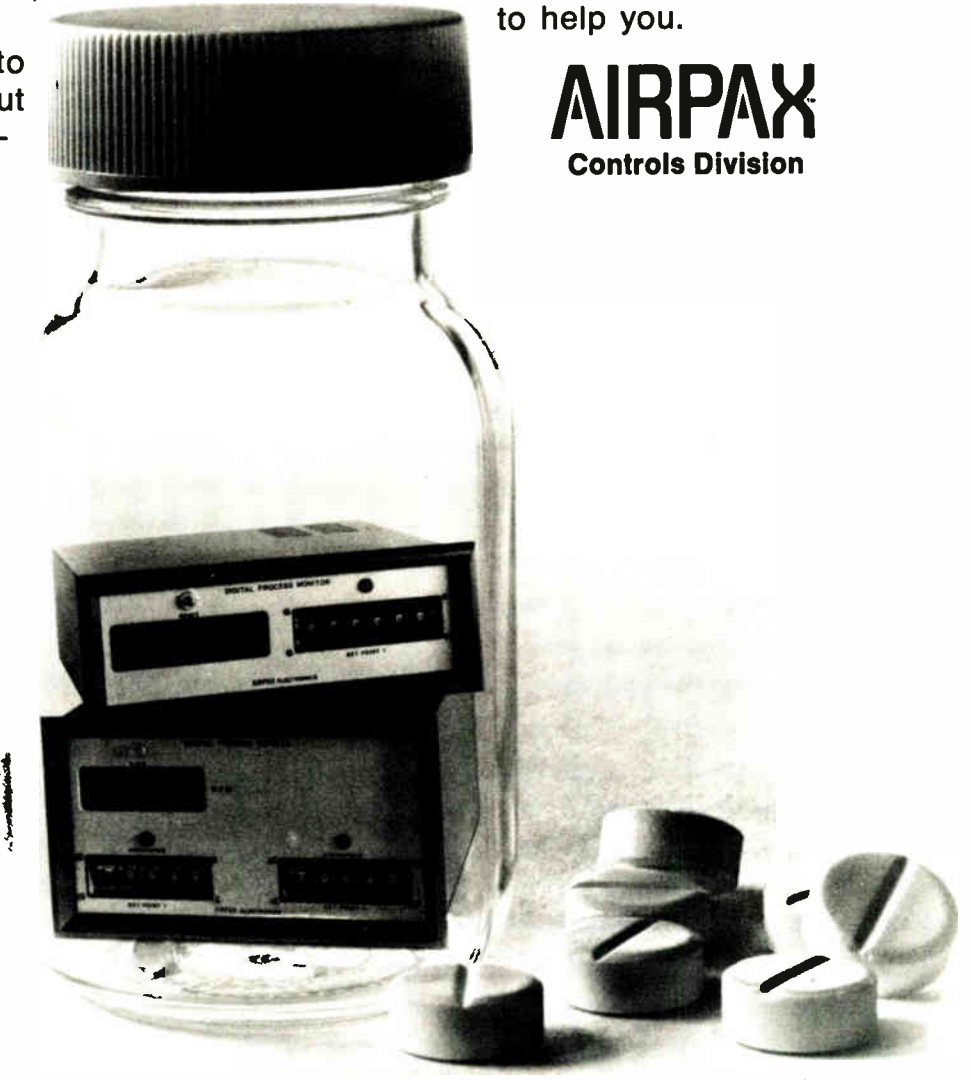

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Main sensor aboard America's new weather-watching satellite, the GOES-A (Geostationary Operational Environmental Satellite-A), is the VISSR (visible/infrared spin-scan radiometer). It uses eight channels in the visible light band and two in the infrared band, making images by reflected sunlight during the day and by radiated energy from land, sea, and clouds at night.

VISSR's clear, sharp photos, transmitted to earth stations every 30 minutes, enable meteorologists to observe the growth and movement of weather patterns that may lead to hurricanes. Santa Barbara Research Center, a Hughes subsidiary, built VISSR for NASA's Goddard Space Flight Center.

GOES-A and two sister spacecraft, slated for launch in 1977, will be the first used in an international atmospheric research program whose goal is accurate prediction of weather up to two weeks in advance. Spacecraft to be orbited by the European Space Research Organization, Japan, and Russia will complete a global network.

A technique for producing laser mirrors with 99.9% reflectivity has been developed by Hughes research scientists under contract to the U.S. Air Force Weapons Laboratory. Their multilayer dielectric enhanced reflector technology gives the mirrors maximum resistance to damage by irradiation from high-power 10.6-micrometer CO_2 laser systems. It minimizes cooling requirements, reduces weight, and improves high-power laser thresholds.

While scuba divers from Jacques Cousteau's Calypso measured ocean floor reflectivity and water transparency in a recent experiment in the Central Bahamas, the multispectral scanner aboard NASA's Landsat 2 satellite measured water depths at the test site. The two sets of data -- later compared and analyzed -- could be of significant aid to maritime traffic and marine science. Communications for the experiment were relayed via NASA's Goddard Space Flight Center ATS-3 satellite, which has been in service since 1967. Both the ATS-3 and the Landsat multispectral scanner were built for NASA by Hughes.

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100 isolated villages in Alaska will receive satellite communications through small earth stations which incorporate traveling wave tube amplifiers built by Hughes. The lightweight, compact amplifiers provide more than 35 watts of RF power at 6 GHz. They are being built under contract to Alaska's Office of Telecommunications.

of its new antennas to NESC later this year. One test model will be mounted around a ship's mast for aircraft interrogation. The other is destined initially for land-based tests as part of the Aegis program, the Navy's shipboard defense system against anti-ship missiles.

Lockheed claims its antenna uses a simplified scanning system and far fewer diodes than other electronically scanned phased arrays, resulting in a relatively low-cost antenna—although it hasn't released figures. Contracts for both test models for NESC are worth $835,000 to Lockheed, which was selected for the work over six other bidders.

Motorola's Government Electronics division has built both ground-based and airborne versions of electronically scanned arrays for the Naval Air Systems Command for target drone control, and a Hazeltine Corp. system is undergoing tests at the Federal Aviation Administration's test facility in Atlantic City, N.J.

Rf network. The 12.5-foot-diameter antenna with horn-shaped radiating elements around its perimeter will use a radio-frequency power distribution network developed by David S. Lerner, a senior staff engineer with Lockheed Electronics' Products and Systems division.

The control network integrates two 3-decibel couplers and two 6-bit phase shifters, which change the phase of energy applied to individual radiating elements, permitting the antenna's beam to bounce from one direction to another at 15-microsecond intervals.

Lerner says he expects the final antenna design to have 56 probes to feed 224 segments of the round array. A network of diode switches couples the probes to the feeds of the array. The beam is switched rapidly around the array by synchronizing its rotation with a four-way quadrant switch so that the 360° circumference of the scanner illuminates a 90° sector at any given time. Also, says Lerner, the height of the antenna's radial section is stepped to maintain constant amplitude and to improve impedance. □

Micros can beat the IBM 370-168

Microprocessors are the low end of the computing hierarchy. But if enough of them are placed in parallel, the over-all performance can outpace even the giant IBM 370/168 on certain problems, according to researchers at Grumman Aerospace Corp., Bethpage, N.Y.

Robert McGill, head of the computing sciences branch of Grumman's Research department, says that 10 to 20 microprocessor modules and a minicomputer can cut the time needed to solve a complex problem from several hundred hours on the 370/168 to a more manageable 2 to 20 hours [*Electronics*, Dec. 11, p. 67]. And they can cut costs dramatically as well.

Many computations. Grumman is studying the parallel-processor structure to solve gaming problems, such as simulations of aerial combat maneuvers, which require a large number of simple computations. John Steinhoff, also of Grumman, described the work last month at the Symposium on Computer Architecture in Clearwater, Fla.

The basic module that Grumman is building uses Intel Corp.'s 3000-series bipolar bit-slice microprocessors. The module has a 16-bit arithmetic/logic unit, a fast bipolar 256-word data memory, a microprogram control unit, and a 512-by-28-bit microprogram instruction memory. Central processor cycle time is 145 nanoseconds, about the same as that of the 370/168.

Grumman will use the system to study a new algorithm for evaluating the effectiveness of an aircraft and its weapons system. The host minicomputer, a Data General Corp. Nova 800, will direct the operations and transfer data to each microprocessor module. Each module performs the same program, but on different data.

The modules perform the computations of aerial combat simulation,

while the host minicomputer evaluates the microprocessors' results and adjusts the situation to a new set of variables for the next computation run. Actually many runs are necessary, each with different parameters such as maximum velocity or turning radius. This means that computation time for a single run must not be excessive.

Minicomputer command. The minicomputer is programed in a high-level language, and the microprocessor modules are microprogramed to carry out the repetitive calculations on command from the minicomputer.

McGill and Steinhoff figure that the individual modules cost less than $2,000, and this price could be lower by the time the system is finally completed in mid-year. With the minicomputer and peripherals, the total cost will be around $80,000 (not including development costs). As attractive as this cost is compared with the $4 million plus of an IBM 370/168, "the main point is you could not solve the problem otherwise," considering the time needed on the larger computer, Steinhoff insists. □

Prime unveils fast 16-bit mini

Minicomputer manufacturers have been lining up to introduce new, high-performance 16-bit machines, and to announce them with a good deal of fanfare. It was a departure, then, when Prime Computer Inc. without a press conference last week quietly took the wraps off its entry in the fray. It's called the Tempus system, and it incorporates a new central processor, the P-400, which the firm rates as three times faster than its P-300 processor.

The new model embodies the first move by Prime, in Framingham, Mass., beyond traditional minicomputer applications in data acquisition and control to computational and business data processing.

William Poduska, vice president for engineering and programing, says the P-400 processor will compete in performance with Digital Equipment Corp's PDP-11/70, although he says it's faster, and with Data General Corp.'s Eclipse series. He's measuring the improvement in terms of a scientific Gibson mix of instruction execution times—a standard way of providing benchmarks for computer performance. Where the main memory cycle time in the P-400 is effectively 411 nanoseconds because of a fast bipolar cache memory, the P-300, without a cache, has a cycle time of 750 ns.

Reasons. The three steps chiefly responsible for the P-400's speed improvement are: incorporation of 2,000 bytes of Schottky transistor-transistor-logic cache memory with an 80-nanosecond access time: broadening the data paths to 32 bits instead of 16, and use of 8,000 bytes of writeable control store with 64-bit words also implemented in 80-ns Schottky TTL. Using 32-bit data paths, "allows address formation and multiply operations to go much faster" than with 16-bit data paths, Poduska says.

Poduska explains that segmentation techniques in the system allows each user to have multiple segments of virtual address space—up to 4,096 64-bit words. The P-400 offers 512 million bytes of virtual memory addressing for each user. It also offers on-line disk capacity greater than 1.2 billion bytes.

A source at Data General says of the P-400 that Prime seems to have taken the right step in both hardware and software for a virtual memory machine in a multiprograming environment, "but there's nothing unique here." DEC refuses to comment on the Prime announcement.

The P-400 with 256 kilobytes of main metal-oxide-semiconductor memory will sell for $71,200. The main memory is built with 22-pin 4,096-bit random access memories supplied by Texas Instruments, Intel, and Signetics. A Primos operating system will be sold separately at $12,000 per system. Main memory in additional 64-kilobyte increments is $11,000. □

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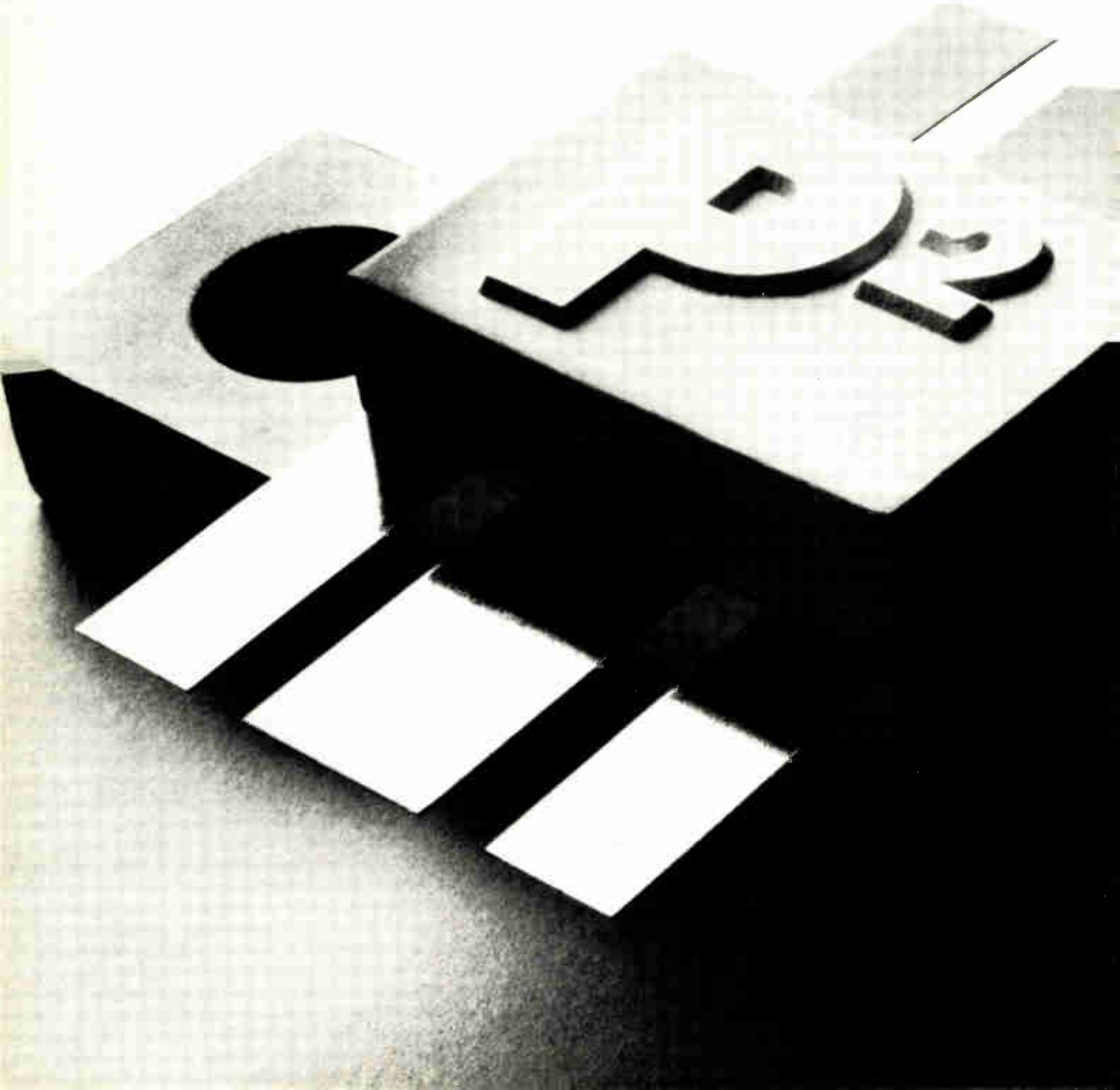

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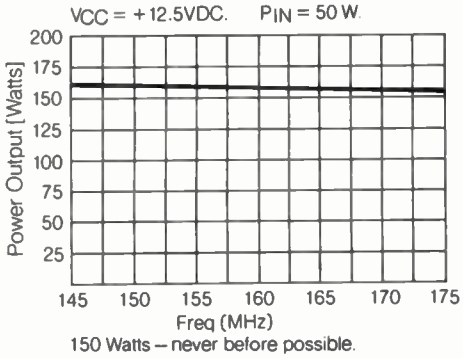

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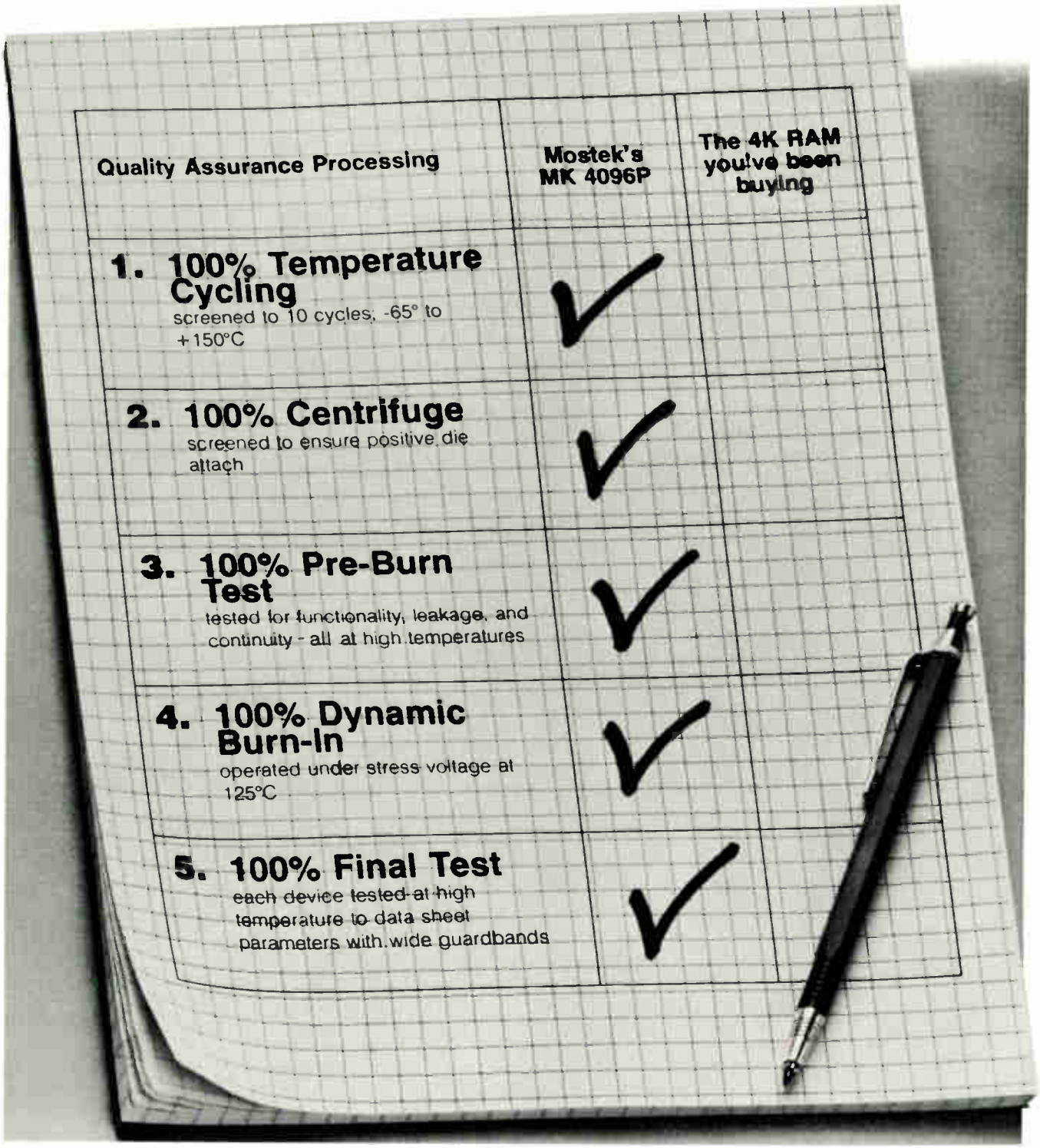

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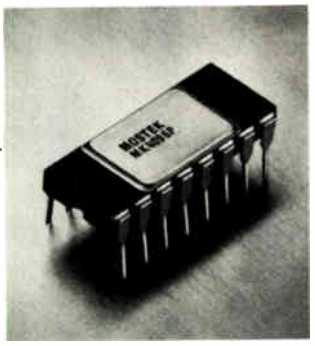

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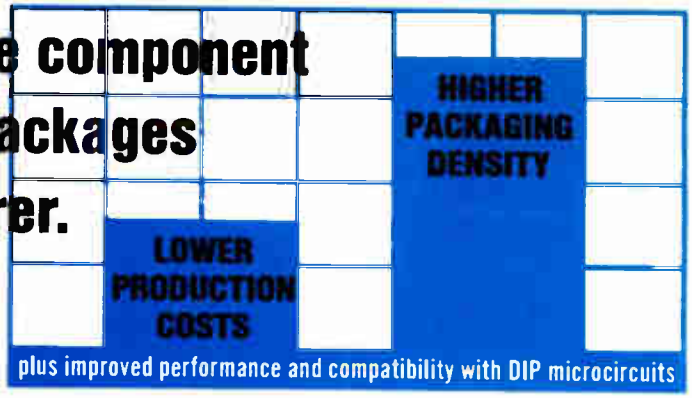

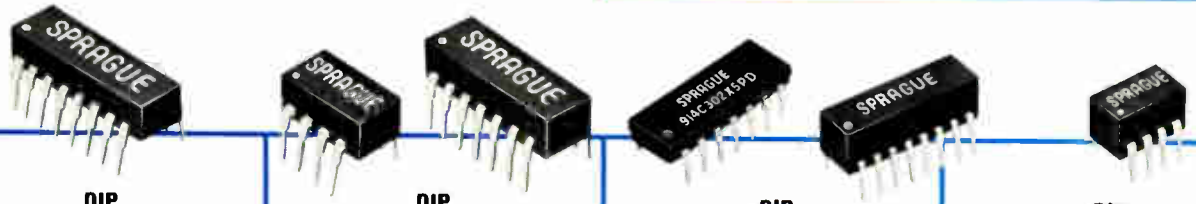

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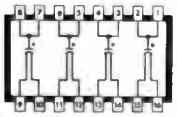

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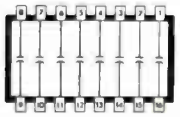
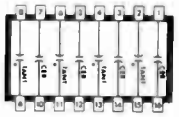


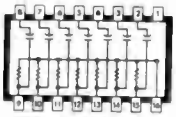
Monolythic® construction . . . alternate layers of ceramic dielectric material and metallic electrodes are fired into a solid homogenous block. 2, 4, 7, or 8 capacitor sections per package. Standard ratings, 18 pF to 0.1 μF @ 100V. Capacitance tolerance, ±20%. Write for Bulletin 6242 or circle 170 on reader service card.

DIP TANTALUM/CERAMIC CAPACITOR ASSEMBLIES



Solid tantalum and Monolythic® ceramic alternating isolated sections. Choice of 4 or 8 sections per package. Standard tantalum ratings, 6.8 μF @ 35V, 15 μF @ 20V, 22 μF @ 15V, 33 μF @ 10V. Ceramic ratings .01, .047, .1 μF @ 100V. Cap. tol., ±20%. Write for Engineering Bulletin 6642 or circle 171 on reader service card.

DIP RESISTOR/CAPACITOR NETWORKS



(1 of 3 designs)

Metanet® metal-film resistors and Monolythic® ceramic capacitors in bypassed pull-up, R-C coupling, speed-up, and active terminator networks. Resistor ratings, 100 to 6800 Ω with 125 mW power dissipation. Capacitor ratings, 100 pF to .01 μF @ 100V. Write for Engineering Bulletin 6612 or circle 172 on reader service card.

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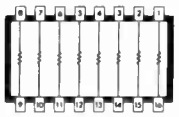
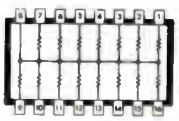


Noble metal film resistors encased in protective glass. Choice of 7 or 8 resistors per 14- or 16-pin package. Resistance values, 50Ω to 100,000Ω. Power dissipation, 125 mW. Standard resistance tolerance, ±5%. Operating temperature range, −55 C to +70 C. Write for Bulletin 7042 or circle 173 on reader service card.

DIP PRECISION RESISTOR NETWORKS



(1 of 5 designs)

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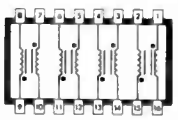

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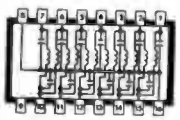
Four transformers in 16-pin package. All cores have exclusive protective coating. Inductance values from 10 to 1000μH. ET product values of 5 volt-μsec. Choice of four turns ratios . . . 1:1, 2:1, 3:1, 4:1. Operating temperature range, 0 C to +70 C. Write for Engineering Bulletin 40400 or circle 175 on reader service card.

DIP TAPPED DELAY LINES



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Washington newsletter

Navy to award $6 million for Sircs studies

The Naval Sea Systems Command plans to divide more than $6 million among four companies in May for parallel nine-month definition studies of its new Shipboard Intermediate Range Combat System. **Sircs will protect ships up to cruiser size from missile and gun attacks** and is to be ready in the mid-1980s. Its development is expected to cost close to $400 million.

Two competing contractors should be named by the second 1977 quarter from the four initially selected. Navsea has received proposals from General Electric, General Dynamics, Grumman Corp., Hughes Aircraft, and teams composed of McDonnell Douglas and Sperry Management Systems, RCA and Martin Marietta, and Raytheon, Lockheed Electronics, and Sperry Univac.

Aerosat satellites get go-ahead; proposals due June 15

Comsat, the European Space Agency, and the Canadian government **have finally agreed to go ahead with the much-debated Aerosat communications satellite project.** Proposal requests for the project, which will put a pair of experimental satellites over the Atlantic, will be issued March 1. Proposals must be filed by June 15, with a contract award scheduled for Nov. 15. The RFPs will be issued by the Paris-based Aerosat Segment Board.

The multifrequency satellites will be for communications between aircraft and ground control stations. Comsat will lease its share to the FAA, which is budgeting $5.8 million in fiscal 1977 for research, engineering, and development on Aerosat.

Major battle over cable TV seen in Congress

Television-set makers are quietly but carefully monitoring a major assault by the National Association of Broadcasters **on a congressional proposal to relax Federal Communications Commission restrictions on cable TV.** "Cable has enormous market potential if it is allowed to develop," remarks one set maker's capital representative, "but that's not going to happen right away. The NAB is very powerful. This fight is as bitter as gun control regulation."

A House communications subcommittee report at the end of January called for greater support of cable development, including enactment of a rural telecommunications act providing low-cost loans to encourage and support extension of cable to rural areas and removal of FCC restrictions on cable TV's retransmission of over-the-air programing. NAB struck back sharply, calling the 110-page study "an effort by three members" of the subcommittee staff "to replace the great system of over-the-air broadcasting" with "a wired nation which could cost over $200 billion in construction costs alone" for which the nation's taxpayers would be assessed.

Guidance system proposals sought for Navy's Erase

The Navy expects to select two or more contractors later this year for advanced development of a new multimode guidance system for **anti-radiation, air-to-air missiles to be used against high-performance aircraft.** Thirteen qualified contractors are being asked to submit proposals for seeker hardware on the project known as Erase—for electromagnetic

radiation source elimination—in order "to select and validate the optimum approach" for a baseline system, according to the Naval Regional Procurement Office, Long Beach, Calif. The next step will be R&D awards to two or more companies to build brassboard flight test systems for the Naval Electronics Laboratory Center in San Diego. Erase is budgeted for $5 million in R&D this fiscal year, and tentatively for another $3.3 million in fiscal 1977.

Qualified contractors include: Cutler-Hammer's AIL division, Bendix Aerospace Systems, General Dynamics/Pomona, Hughes Aircraft, ITT/Sunnyvale, Lockheed Missiles & Space, Martin-Marietta, Motorola/Scottsdale, Aeronutronic Ford, Raytheon/Los Angeles, Rockwell International/Columbus, Teledyne Ryan, and Texas Instruments.

FDA sees slow regulation of medical devices

Regulation of medical-electronic devices by the Food and Drug Administration will proceed slowly, **even though enactment of legislation seems certain to pass Congress before summer.** The House bill (H.R. 11124) to amend the Food, Drug, and Cosmetic Act to bring instruments and devices of all kinds under FDA jurisdiction was approved in committee late in January and is expected to pass when it comes up for a floor vote early next month. Rep. Paul G. Rogers (D., Fla.), health subcommittee chairman of Interstate and Foreign Commerce, wrote the bill and has worked closely with Sen. Edward Kennedy (D., Mass.) on a similar Senate bill.

Nevertheless, FDA Commissioner Alexander Schmidt says enforcement of a new law will come "slowly and in measured stages" because of FDA's fiscal 1977 budget limitations. FDA wants $1 million and 30 new staffers in its Bureau of Medical devices and Diagnostic Products in the new fiscal year. But 15 of the new jobs will be field workers, so the other 15 home-office personnel will be hard put to implement the new rules quickly.

NASA seeks better hf capacitor-diode voltage multipliers

The National Aeronautics and Space Administration wants industry "to extend available technology" **to include "control and regulation circuitry and higher multiplication factors"** in hf capacitor-diode voltage multipliers used in space flight. Proposals for the R&D program are due in early March at NASA's Lewis Research Center in Cleveland.

Addenda

The Food and Drug Administration is **recalling nearly 2,000 General Electric dental X-ray machines** for repairs to prevent "unnecessary radiation exposure." The GE-1000 and the Panelipse models, produced in Milwaukee, are expected to be repaired by August. . . . At the same time, the FDA reversed itself on the largest TV-receiver recall in history, notifying Zenith Corp. that its more than 1 million color sets suspected of radiation hazard last October were now considered safe. The problem involved a capacitor that could fail over a period of time, emitting radiation between the time of failure and the time of picture loss. Data from Zenith has convinced the FDA that the threat is minimal because the leakage is "quite small."

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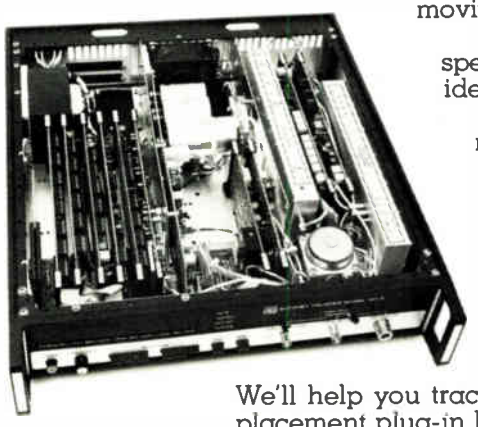

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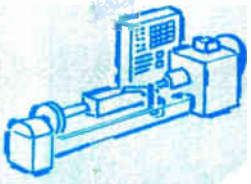
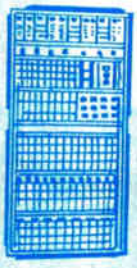


VARIABLE SPEED DRIVES
MACHINE TOOLS

INDUSTRIAL CONTROLS



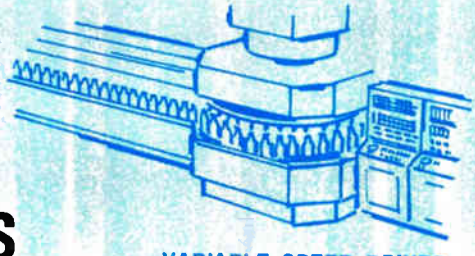
INVERTERS

POWER SUPPLIES

POWER CONTROLS

VARIABLE SPEED DRIVES
MOTOR CONTROL CIRCUITS

PLATING POWER SUPPLIES



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Light beams conserve typing energy for quiet, modular teletypewriter

A new modular teletypewriter for international communications and computer networks has a keyboard that operates by light beams, rather than mechanical levers. When a key is depressed, the pattern of signals from light-emitting diodes at one side of the keyboard is changed as it passes through a matrix to phototransistors at the other side. This change generates the signal to be typed and transmitted.

ITT's West German subsidiary, Standard Elektrik Lorenz AG in Stuttgart, sells the Teleprinter LO 2000 for about $5,330, or rents it for $85 a month. No larger than an electric office typewriter, the LO 2000 operates even less noisily because there are no contacts or code rails to provide inertia in the transmitter, and the jerkless movement of the printing unit minimizes printing noise. Transmitter and receiver may be separated and operated individually.

In the teletypewriter, SEL has eliminated the rotary dial used in conventional machines for calling other numbers. Instead, another subscriber's number is signaled by hitting the appropriate figure keys on the keyboard. The electronic circuitry in the built-in subscriber unit converts these keyboard signals into signaling pulses.

Compact. The LO 2000, which makes extensive use of large-scale integrated circuits for signal processing and machine control, has had the number of parts reduced to a few modular assemblies. The teletypewriter also contains the paper-tape punch and reader, together with the tape reel and paper roll.

In the transmitter's optoelectronic keyboard, each key is connected to a coding element, which is essentially a small spring-suspended shutter-like plastic plate with a pattern of holes corresponding to the symbol of its key. Arranged side by side, these plates and their holes form the light channels into a pattern.

A keystroke requires only 3 milliseconds to generate a signal—far faster than the fastest keyboard operator. Errors caused by simultaneous depression of two or more keys are recognized and suppressed by circuitry in the transmitter unit. Electronic storage keeps the keyboard's input rate independent of the transmission rate, which may be set at 50, 75, or 100 bauds. For use in other countries, the keyboard can easily be adapted for different key and letter configurations. Merely by changing certain coding elements, special characters such as the three German umlaut letters are converted by electronic circuitry into character sequences for transmission. □

Around the world

Holographic system checks credit cards

To make it tougher to get away with using stolen or falsified credit and identification cards, Siemens AG in Munich, West Germany, has developed a prototype card system based on holographic-storage techniques. With the Holo-secure-system, the visible information on a card is compared with a holographic duplication on the card that becomes visible only when the card is inserted into a special reader. Any tampering with the data is immediately obvious to the viewer. The prototype is being demonstrated to banks, department stores and similar institutions. If the demand is big enough, the equipment will be further refined.

The card is filled out with the owner's pertinent data and scanned with the red light of a helium-neon laser. The laser produces a hologram of the card on a small piece of film, which is then combined with the card and covered permanently on both sides with a protective plastic. Since each point of the hologram's storage area contains all the information in the card, a tiny hole in the card just over the film is enough to make the entire image visible to the laser beam used in the checking process.

When a customer presents his credit card in a department store or at a bank counter, the clerk or teller inserts it into a table-top reader fitted with a helium-neon laser. The reader's liquid-crystal, ground-glass display shows two images—one is the actual card and the other the holographic reproduction blown up to the same size. Any difference between the two images is cause for further security check.

Modular audio-control board is adaptable

A new modular audio-control board enables musicians to build a system to meet their own special requirements—from a simple mixer for a rock group to a complex microprocessor-controlled system for orchestral composers. The System 3000 modular board is being offered by Dataton AB of Linkoeping, Sweden, in a total of 14 modules of four types—power and control, editing, source, and manipulating. None of the modules is much larger than a cigar box—1.40 by 5.30 by 7.50 inches.

The modules, priced $250 to $500 each, are fitted with standard connectors for input/output cables and plugging together. No rack or back panel is needed. Dataton says that the program-sequencer module with built-in editing instructions allows a total of 1,000 program steps to be stored in the random-access memory. The user can replay sequences as needed by linking the sequencer to a sound-generator module. The memory capacity can be expanded by linking it to a standard audio-cassette tape recorder.

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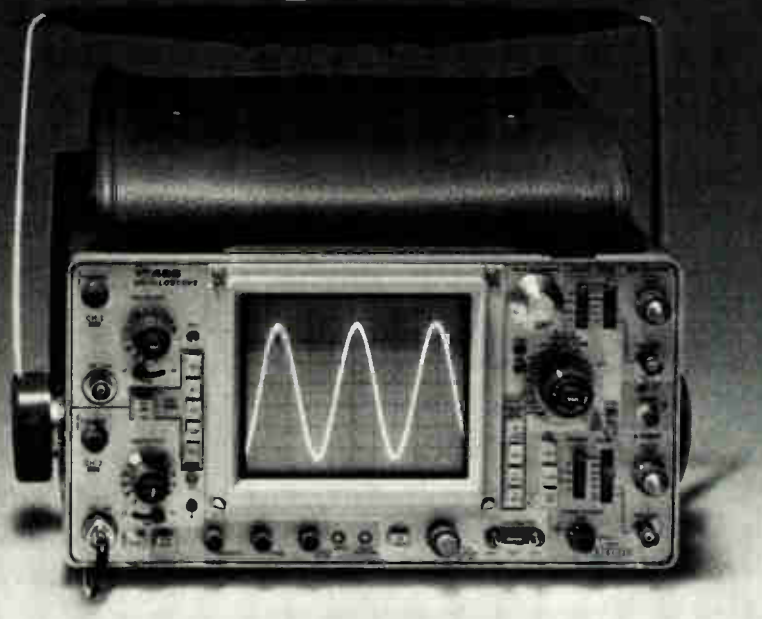

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International newsletter

Philips to market two more C-MOS memories in U. S.

Watch for Philips in the Netherlands to come out with a couple of 1,024-bit static random-access memories made by its LOCMOS (for local oxidation of C-MOS) technology. Philips claims that its C-MOS static **RAMs outperform similar American-made devices in the combination of wider voltage range, smaller chips, and faster access times.** The devices will be marketed in the U. S. by subsidiary Signetics Corp., Sunnyvale, Calif.

One device, the HEF4721, of 256 by 4 bits, will be available in sample quantities by March, and the other, the HEF4736, of 1,024 by 1 bit, will follow a few months later. A smaller LOCMOS RAM, the HEF4720, organized 256 by 1 bit, was introduced in January. Both the HEF4721 and HEF4736 operate on 3 to 15 volts. Access times are 400 nanoseconds at 5 V and 100 ns at 15 V. The HEF4721 chip area is only 16.6 square millimeters, and the HEF4736 covers only 15.9 mm^2.

French groups vie for government aid in digital watches

French electronics companies and watchmakers are scrambling for government funds to build a group to manufacture digital watches as a bastion against the flood of foreign imports that topped 100,000 units last year. **Three separate groups are offering alternative projects to the Ministry of Industry and Research, which is expected to choose one before mid-February.** Financially troubled watchmaker Lip and its holding company, Société Européen d'Horlogerie et d'Equipements Méchaniques, are reported to be looking for as much as $2 million to float a project with chips from National Semiconductor Corp. in the U.S.

Meantime, a new group of about a dozen watchmakers, Montrelec, led by French electronics giant Thomson-CSF, has decided to invest about $500,000 in a rival digital-watch project. This group is hoping for $1 million more to start business. In addition, Electronique Marcel Pizon, which claims to be the only electronic watchmaker in France now, plans to produce 40,000 to 50,000 units this year. But if Pizon can raise $650,000 in government funds, it hopes to boost the target to 400,000 a year by 1980. As a second stage, Pizon plans a joint venture with a foreign—probably U.S.—semiconductor company to develop suitable electronic-watch chips in France.

Japan to buy one of 3 U. S. fighter planes

Japan will choose its next mainstay fighter for the Air Self-Defense Force from among three U. S. planes—the F-14, F-15, and F-16. The choice was narrowed to those three after consideration of seven U.S. and European planes. Now known by code name FX, the planes will be selected by July when the defense agency submits its budget draft to the government for fiscal 1977, which starts April 1, 1977. **The self-defense force hopes to buy about 100 FXs, to be deployed in six squadrons.** The fighters are to be produced locally under license from the manufacturer.

In April, the defense agency will dispatch to the U. S. a mission that will include pilots to make flight tests. The Japanese want their plane to be capable of taking off and landing at present Japanese air bases, operating in all weather conditions, taking on other jet fighters and bombers at altitudes from extremely low to 17,000 meters, and continuing combat operations even when their own ground radar is destroyed.

International newsletter

Five firms unite on transducer systems in UK

Five companies in the UK are teaming up **to combat the threat of outside competition in specialized data-logging and measurement systems.** Transducers (CEL) will design the systems; Solartron-Schlumberger will supply the computer-based data-logging gear; Tinsley-Telcon, the strain gages; S&P Aldridge Electronics, the dynamic strain-measuring equipment, and Astech Electronics, the transducers and shaft telemetry gear.

Patent procedures in Europe may be simplified

Procedures for the granting of patents in Europe will be greatly simplified by 1977, predicts the West German Government's Ministry of Justice. **Bonn expects that the recent common-patent agreement will soon be ratified by the nine Common Market countries and seven other European nations.** The long-awaited European patent office could be established next year in Munich, Germany. Because patents would be granted according to common standards and be valid in all of the 16 signatory states, inventors would have to apply only once for patents for the different countries.

Tiny voice cassette adopted by Sony for pocket recorder

A tape cassette about the size of a small matchbox will become the *de facto* standard for pocket-size voice recorders when Sony Corp. introduces its recorder in the near future. The cassette, only 33.5 by 50.2 by 8.1 millimeters, was pioneered by Olympus Optical Co., which is already marketing a recorder. Matsushita Electrical Industrial Co. is also selling a machine containing the cassette.

These small recorders, which retail for an average of $150 in Japan, are being carried in the pocket for handy recording of memos and language study. Tape speed is 2.4 centimeters per second. Sony hopes to capture about 30% of the market for this type of recorder within a year—from market expansion rather than at the expense of its competitors. Total production of the recorder is now about 20,000 a month.

National readies two C-MOS circuits for TV displays

Add National Semiconductor Ltd. in the UK to the list of manufacturers introducing clock and channel-display circuits for television sets this year. At mid-year, National expects to announce the $5 MM58106, a single-chip combination of digital clock and display-generator circuits operated by standby current to keep the clock running while the set is switched off. That product is to be followed by the $10 battery-powered two-chip package consisting of the MM5388 clock circuit and the MM5840 readout circuit run by a 1.5-volt battery. **Both complementary-MOS packages contain the new 5840S flip-flop control, which limits the time a channel number is displayed.** The single-chip circuit is aimed for export sales, and National says it is prototyping the battery-powered package for a TV-set maker.

Matsushita plans to form subsidiary to make components

If stockholders approve, Japan's Matsushita Electric Industrial Co. will spin off 11 components-manufacturing divisions and subsidiaries to form a wholly owned components subsidiary capitalized at $40 million. Six subsidiaries in outlying districts will become subsidiaries of the new components company, which will have 8,000 employees of its own and be responsible for another 4,000 at its six subsidiaries. **The shift to independent status is to facilitate sales to other companies.**

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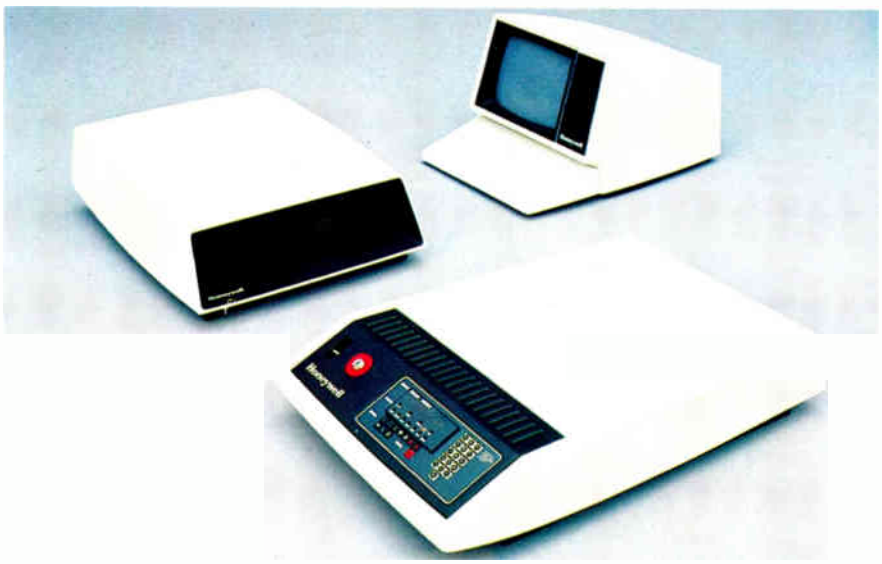
- Microprogrammed instruction set with writeable control store available to the user.
- Direct addressing up to 8 million words of memory.
- Minimum of 18 programmable hardware registers.
- Bit, byte, word and multi-word addressing.
- Hardware stack and queue management.
- Proven N-channel MOS memory in 8K by 16-bit modules, with byte parity and up to 32K words on a single board. Cycle time is 650 nanoseconds.
- Error detection and correction (Corrects single bit, detects two-bit errors).
- Memory management hardware.
- Over 100 basic instructions, with more than 600 variations.
- High-performance scientific and commercial instruction set extensions.
- Common asynchronous Megabus™ operating in an interleaved mode, with a bandwidth of 6 million bytes per second.
- Vectored interrupt capability with up to 64 interrupt priority levels.
- Separate trap structure with more than 20 unique entry points.
- Microprogrammed input-output controllers.
- Multiprocessor and networking capabilities.

The benefits include the ability to write compact and efficient programs, increased processing speed, reduced memory utilization and memory management overhead, reduced software overhead, increased throughput, and the capacity to handle large and versatile configurations.

Models 6/34 and 6/36 incorporate subsets of the above features and are immediately available. These models are well suited for OEM and system-builder applications. Maximum memory for the 6/34 is 32K words, and for the 6/36, 64K words.

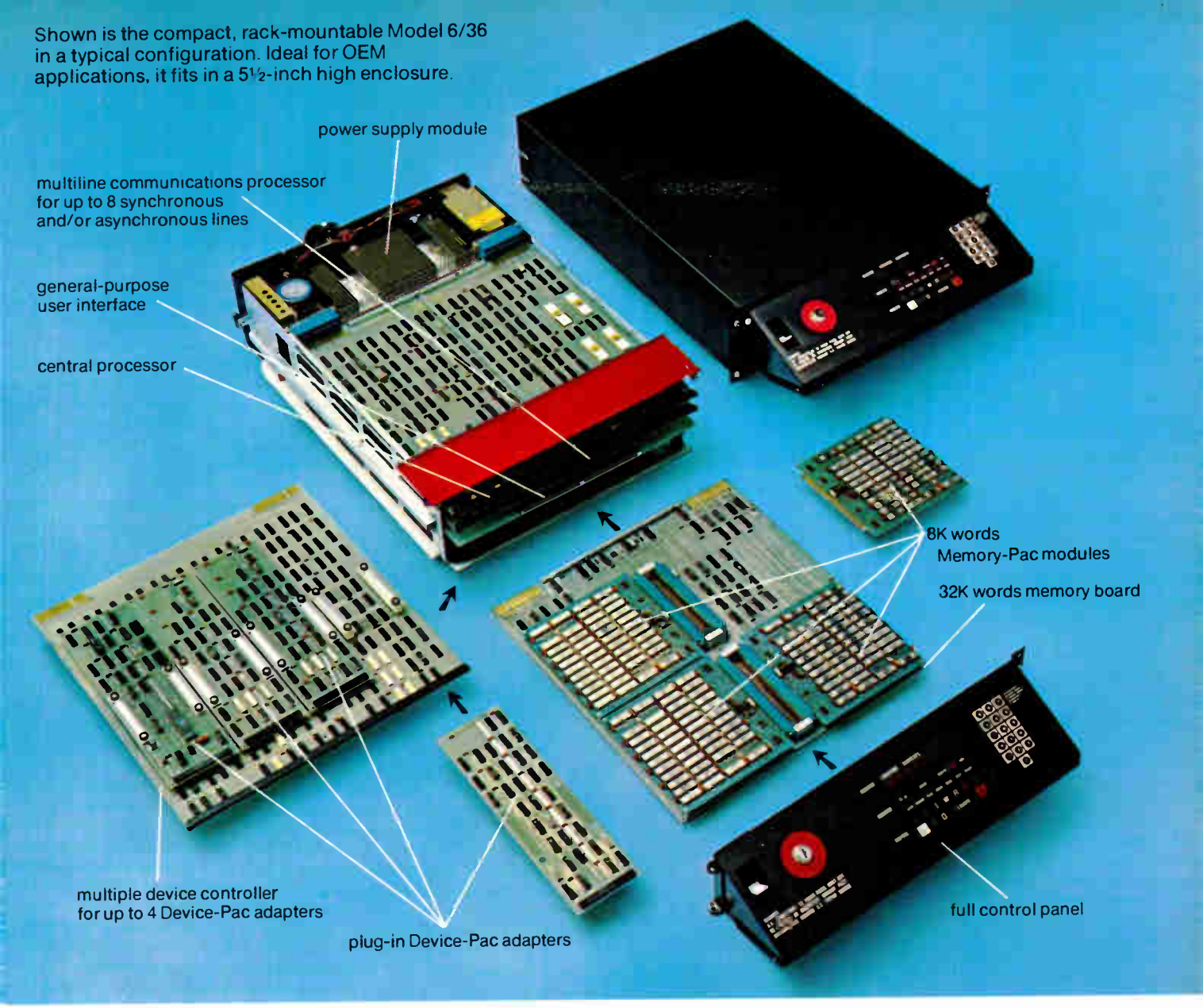
Advanced modularity: Level 6 combines TTL logic, LSI and MSI circuitry, firmware-driven microprocessors, MOS memory, and etched wire connections in a new way to achieve plug-in modularity with optimum configurability and replaceability. Specifically:

- The entire central processor is contained on a single board 15″x16″.
- Other 15″ x 16″ boards are devoted to the memory, communications processor, peripheral controller, and user interface.
- Functional modules (i.e. device adapters and memory modules) plug into the 15″ x 16″ boards.
- Boards fit into the bus without backplane wiring.



Level 6 offers a choice of rack-mountable, cabinet and tabletop models. Level 6 also includes a new full line of low-cost peripherals in both tabletop and rack-mounted versions. Shown are the tabletop minicomputer, diskette and CRT.

*U.S. price in quantities of 50 for rack-mountable Model 6/34. Includes 8K words of MOS memory, with parity, multiply/divide, realtime clock, and bootstrap loader.



These features offer the following benefits: The sharing of costly logic elements such as controller microprocessors and memory error correction lowers the system cost. A system can be easily configured through the selection of a minimum number of appropriate boards and modules. Fewer components and connections mean increased system reliability. And serviceability is improved by having fewer — as well as more easily replaceable — components.

Microprogrammed communications processor: Honeywell's multiline communications board functions as a true front-end processor. It offers unusually powerful communications capability at moderate cost.

- Separately programmable memory allows tailoring to individual requirements.
- Usable memory of 4096 bytes enables execution of complex line-handling procedures with no central processor involvement.
- Each board handles up to eight full-duplex lines.
- A variety of modules adapt the communications processor for different line types and speeds (up to four modules per board, line types and speeds may be mixed on the same board).

As a result, the central processor is relieved of most of the data communications overhead, and the user has maximum application flexibility.

Built-in test and verification: The Level 6 system provides an automatic configuration integrity check and self-diagnosis:

- Light-emitting diodes on the central processor and each controller board verify logic quality.
- A console indicator verifies that boards, terminators, and bus cabling are properly connected at time of system initialization.

By means of these features, together with the simple replaceability of boards and plug-in modules, the Honeywell Level 6 system is designed to be the most serviceable minicomputer ever built.

Efficient system-building software: Honeywell has gained considerable system building experience through the application of minicomputers within the general purpose computer and control system segments of its business. This experience, together with the expertise gathered in ten years of

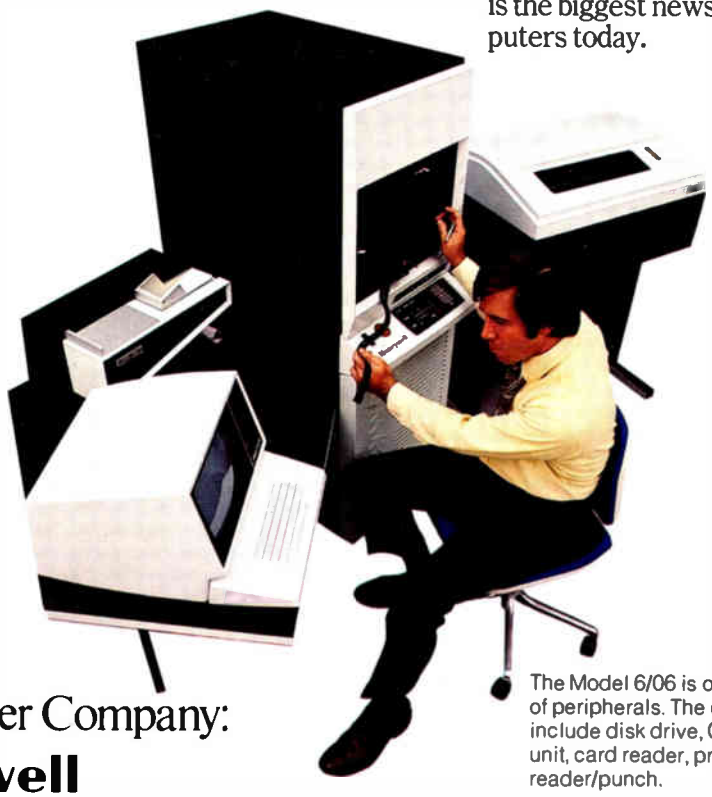
building minicomputers, has been applied to Level 6 hardware and software design to produce integrated system products particularly well-suited to a wide variety of jobs. The initial software includes:

- Stand-alone program development system.
- Stand-alone multitasking realtime executive.
- Disk-based multitasking realtime operating system.
- Assembler, FORTRAN and utilities.

These are the first results of a comprehensive software development program. Scheduled for future release are additional higher level languages, communications software enhancements, and operating system extensions.

System 700 compatibility: Level 6 offers System 700 compatibility via the Model 6/06. The 6/06 incorporates the packaging and technology advances of Level 6 and supports the full range of System 700 software and peripherals. Memory is available in 8K word increments up to 64K. Systems are available for immediate shipment.

For more information, please mail us the coupon or circle number 125 on reader card. We'd like to show you why Honeywell's Level 6 is the biggest news in minicomputers today.



The Model 6/06 is offered with a variety of peripherals. The configurations shown include disk drive, CRT, tape cassette unit, card reader, printer, and paper tape reader/punch.

The Other Computer Company:

Honeywell

Honeywell Information Systems, 200 Smith Street, MS 440, Waltham, Massachusetts 02154

☐ Please send me more information about Level 6 minicomputers.
☐ Please have a salesman call.

Name_____

Title_____

Company_____

Address_____

City_____ State_____ Zip_____

Phone_____

To help you answer my request more effectively, here's some basic information:

I'm an ☐ OEM ☐ End-user ☐ I have a need for _____ minicomputers during 1976.

My intended application(s) is_____

I am interested in Model(s) ☐ 6/34 and 6/36 ☐ 6/06

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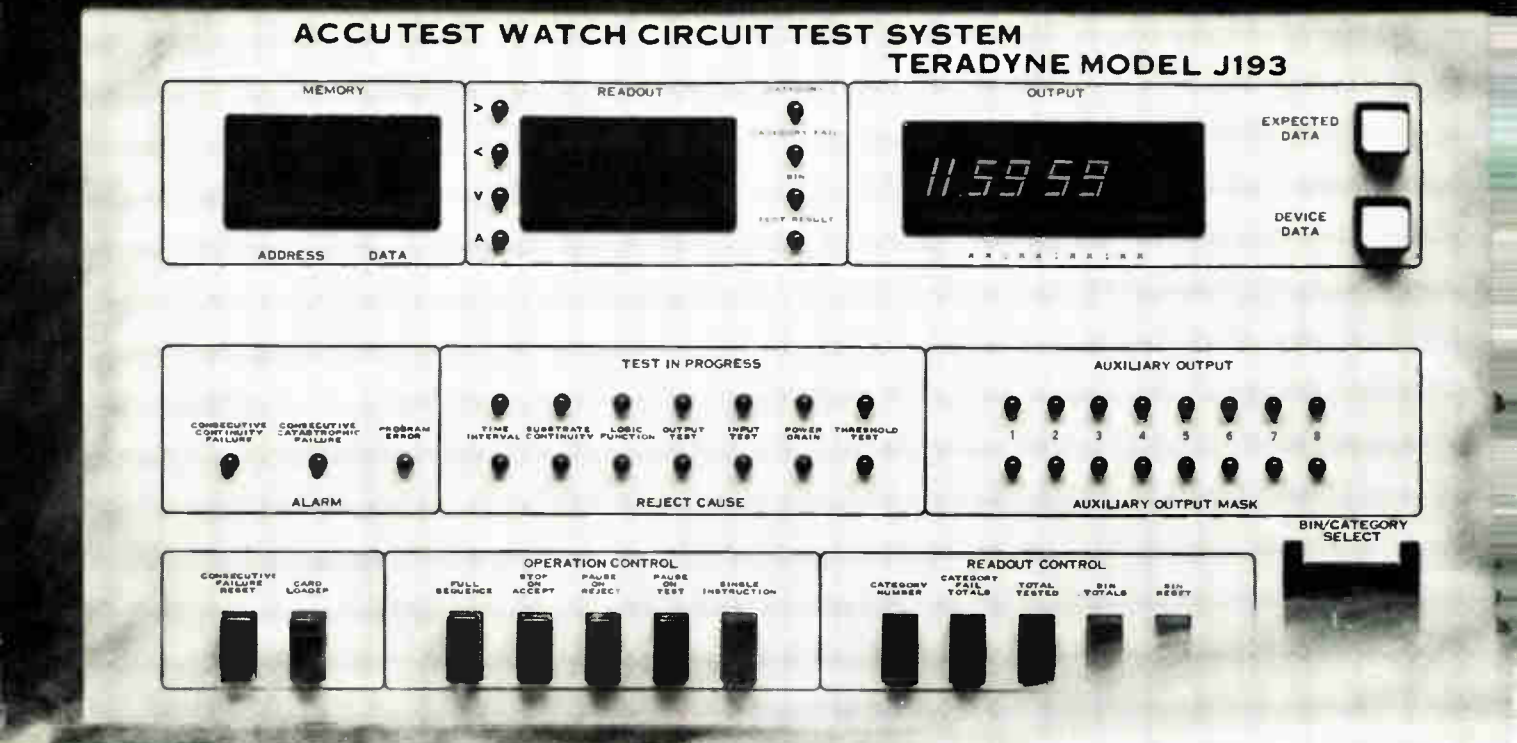

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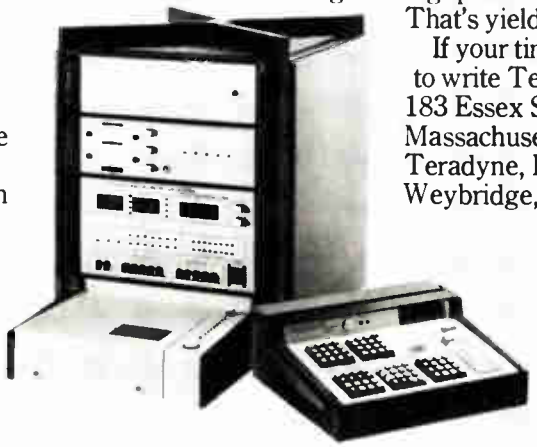

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THE BUDGET
Ford primes pump through Pentagon

by Ray Connolly, Washington bureau manager

"This budget does not contain any gimmickry whatsoever," said Gerald R. Ford, bristling slightly. The President's assertion at an extraordinary 90-minute press briefing on his fiscal 1977 spending plan failed, not surprisingly, to convince his political opponents in Congress. However, with economic recovery still moving slowly in an election year, Ford is taking no chances.

His conservative 5.5% increase in Federal spending to $394.2 billion will lead to "a balanced budget in three years" on "a growth path that we can sustain," he claimed. In a clear challenge to the Democratic majority in Congress, Ford declared his budget for the year beginning Oct. 1—one month before the elections—"is not a policy of the quick fix." (See p. 13.)

On a clear day. President Ford, shading his eyes from TV lights at budget briefing, foresees a balanced Federal budget three years down the road.

But some quick fixes for the economy seem apparent in the record $112.7 billion military budget, of which $100.1 billion is proposed to be spent in the coming year. And the Washington analysts for those aerospace and military electronics contractors who saw them were not unhappy. "The quickest way to hypo the economy is with Government contracts, and the Pentagon does that job best," one said. "They are talking about 120,000 more defense industry jobs next year, as spending goes up. That is an increase of 7.5% to 1.75 million people. For contractors like us that could be good; it won't solve unemployment generally, but it helps."

That rationale was quickly rejected by Defense Department Comptroller Terence McClary as the reason for the proposed 37% jump in procurement to $29.3 billion, as well as the 15% hike to $10.9 billion for research, development, testing, and engineering—both records. "This is simply the time—and the right time—for a number of programs to go from full-scale development to production," he said. The associated increase in defense industry jobs is no more than coincidental, McClary said.

The United States' defense budget has accounted for one fourth of Government spending in recent years. It is almost always the subject of controversy in Congress and it should be this year. But it is far from the only controversy Ford will have with the heavily Democratic majority. The President's proposal to consolidate some 60 education, medical, food, and social welfare programs into four block grants to be distributed to and spent by the 50 states is already under heavy congressional fire. Though the chances of that proposal, which requires new legislation, seem dim, it does make it clear that the Federal education and medicine markets for electronics will continue to be small and scattered throughout the bureaucracy.

As things stand, identifiable HEW programs with significant electronics content have been virtually static for two years, and will continue that way. For example, the National Institutes of Health's proposed $9.7 million research services fund for hardware will not grow enough to cover inflation. In even worse shape is the Health Services Administration, whose $25.1 million for emergency medical services systems has not changed in two years.

There are other losers on the civil-

ian side of the Federal electronics budget beyond HEW, however. Like HEW, none of them comes as a surprise to industry representatives in the capital. Among them were the National Aeronautics and Space Administration, and the Justice Department's Law Enforcement Assistance Administration. The LEAA's technology programs were effectively wiped out after suffering deep cuts in last year's budget.

Winners. The good news is that there are some winners for electronics beyond the defense program in the Ford budget. For example, the General Services Administration, which buys or leases all data-processing equipment except those used in weapons, says its ADP fund's capital outlays in fiscal 1977 will top $12.5 million, nearly double this year's. Moreover, GSA estimates its equipment lease fund will climb 400% to more than $20.6 million next fiscal year. That money is repaid to GSA by the other agencies that it serves.

Similarly, the National Science Foundation's computer research effort will jump 25% to $15.8 million, exploring areas where commercial technology has done limited work. The technology of maintaining system privacy and security is one example. Others cited by NSF include studies of the structure and management of very large data banks, work on system fault tolerance, and improvements in software reliability. In other areas, NSF plans increased support of electron-beam and X-ray lithography techniques for fabricating new electronics and optics that could lead to smaller computers and lasers.

Smooth sledding for defense outlay

When President Ford said, as he presented his fiscal 1977 defense budget, that it "contains all the programs [former Defense] Secretary Schlesinger recommended," he told only part of the story. The $112.7 billion plan now being defended in Congress by Donald Rumsfeld, Schlesinger's successor, contains all of the programs but not all of the $116.8 billion that Schlesinger wanted.

Nevertheless, say Schlesinger loyalists, his fight over the Office of Management and Budget's decision to cut the Pentagon request to $110 billion—a dispute that led to his dismissal—prompted White House restoration of part of the funds. And, in view of the fractured, leaderless Democratic majority's apparent inability to stand together, most of the Ford programs are expected to pass.

New buys. Plans to move nine major weapons from development into production—most of them loaded with electronic subsystems—account for much of the 37% rise in procurement to $29.3 billion (see table).

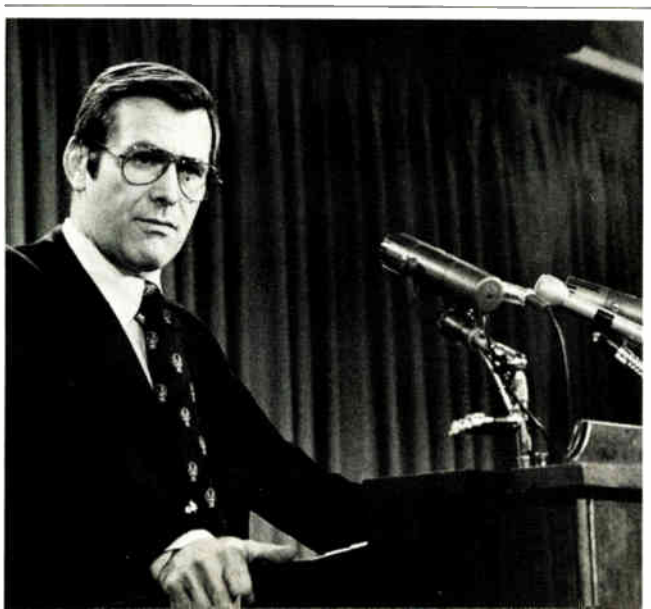
Most vulnerable to elimination is the Air Force B-1 bomber, for which $1.5 billion is sought. Two-thirds of that request is budgeted for the first three production models from Rockwell International, even though a Pentagon production decision is not expected before November. The remaining $500 million is proposed for continued R&D.

Other aircraft set to move into production are: the General Dynamics F-16 fighter for the Air Force at just under $20 million apiece; the $10 million Navy CH-53 Super Stallion helicopter by Sikorsky and United Technologies Corp., and the Army's $9.2 million helicopter known as UTTAS—for Utility Tactical Transport Aircraft System—by either UTC or Boeing.

Missiles. The Navy ranks far above the Army and Air Force as a customer for missiles, with nine major programs on which it wants to spend nearly $2.4 billion. But almost $1.7 billion of this is tied to the planned first buy of 80 Trident I fleet ballistic missiles from Lockheed Missiles & Space Co. to replace the aging Polaris system.

Of the Army's six major missile programs proposed to cost $543 million in fiscal 1977, the only big new production start called for is the General Dynamics Stinger, a portable, shoulder-fired missile for low-altitude air defense. The first 445 will cost $51.2 million, equivalent to $115,000 each. The first 360 medium-range Lance missiles from LTV, designed to replace the surface-to-surface Sergeant and Honest John systems, will cost the Army the equivalent of $208,000 each on the first buy.

The Air Force missile budget of $572 million for four systems is roughly half of last year's program, largely as a result of plans to end production of the Boeing Minuteman III program. Fiscal 1977 funds for the big ICBM are all programed for RDT&E and force modernization. Offsetting the proposed Minuteman production phaseout—and the Pen-



On the spot. Defense Secretary Rumsfeld (left) must defend Pentagon request from congressional budget cutters. Washington press corps, shown below at budget briefing, feels the splintered Democratic majority will not slash much from that figure.

tagon is hinting it could be resumed if Strategic Arms Limitation Talks flop—are increased R&D funds for the next generation M-X, a mobile ICBM. Work on the program is in the Air Force advanced ICBM technology R&D budget, which calls for $84 million—more than double the fiscal 1976 outlay.

The biggest new Air Force missile production start is the AGM-65C, the laser-guided version of the Hughes air-to-ground Maverick, for which $48 million is sought for the first 100 to replace the TV-guided AGM-65A/B models. Still another $11.2 million is proposed for ongoing R&D. Also proposed is $20.8 million for first production of Boeing's air-to-surface SRAM missile for short-range attack using a nuclear warhead. Another $15.5 million is sought for SRAM R&D.

The Air Force and Navy cruise missiles appear less vulnerable to cancellation as a result of a new SALT agreement this year, defense officials believe. The Navy's Tomahawk SLCM continues in R&D with a $182.5 million budget request nearly double the fiscal 1976 level, as LTV and General Dynamics continue to compete. The Air Force ALCM R&D effort, on which Boeing is contractor, calls for $79.2 million next year, a 60% increase over 1976.

Ships. Three Navy ship programs account for much of the service's ship production funds—all padded with big cushions against price escalation, an element sure to produce congressional criticism. The second new Trident ICBM submarine, for example, is tagged at $1.04 billion—a 40% jump from the $745 million price for last year's boat from General Dynamics. Close to one quarter of the new request, some $244 million, is set aside as a hedge against inflation and overruns. Similarly, the $1.3 billion sought for three SSN 688 attack boats from Newport News Shipbuilding and General Dynamics includes $365 million to cover "escalation and cost growth," says the Pentagon.

Of the nearly $1.3 billion proposed to buy eight more guided-missile frigates, more than $100 million is set aside to hedge against cost increases. Another inviting congressional target is the $1.6 billion the

MAJOR REQUESTS FOR WEAPONS PROCUREMENT

(in millions of dollars; quantities in parentheses)

	FY 1976†	FY 1977	Contractor
Army aircraft			
C-12A cargo	$ 13.8	$ 16.2 (20)	Beech
AH-1 G/S Cobra/Tow	87.6	128.9 (82)	Bell Helicopter
*UTTAS	110.6	213.0 (15)	Boeing/UTC
Navy aircraft			
A-4M Skyhawk, USMC	22.8	102.4 (21)	McDonnell
A-6E Intruder	160.3	7.1	Grumman
EA-6B Prowler	129.0	139.9 (6)	Grumman
A-7E Corsair II	208.4	235.4 (30)	Vought
F-14A Tomcat	758.1	708.2 (36)	Grumman
*CH-53E Super Stallion	31.5	116.3 (10)	Sikorsky/UTC
UH-1N Iroquois	36.8	20.3 (12)	Bell Helicopter
AH-1J Sea Cobra	38.2	64.2 (23)	Bell Helicopter
P-3C Orion	221.7	241.9 (12)	Lockheed
S-3A Viking	504.5	0	Lockheed
E-2C Hawkeye	184.7	170.9 (6)	Grumman
Air Force aircraft			
*B-1 bomber	812.5	1,532.2 (3)	Rockwell
A-10 close support	537.7	617.8 (100)	Fairchild
F-15 Eagle	1,929.4	1,540.4 (108)	McDonnell
*F-16 ACF	285.4	619.7 (16)	Gen. Dynamics
E-3A AWACS	545.6	584.3 (6)	Boeing
Army missiles			
Chaparral, surface-air (1)	45.1	65.8 (2,000)	Aeronutronic Ford
Hawk, surface-air (1)	105.6	107.0 (526)	Raytheon
*Stringer, surface-air (1)	25.3	71.5 (445)	Gen. Dynamics
Dragon, antitank (1)	180.8	113.7 (16,000)	Multiple
TOW, antitank/assault	163.6	109.2 (13,051)	Hughes/Emerson
*Lance, surface-surface	0	75.7 (360)	LTV
*AN/TSQ-73, air defense control	6.8	42.2 (12)	Litton
Navy missiles			
Poseidon, FBM	33.8	25.4	Lockheed
*Trident I (C-4), FBM	1,280.9	1,671.1 (80)	Lockheed
Sparrow, air-air (2)	145.5	156.4 (1,530)	Raytheon/GD
Sidewinder, IR air-air (2)	95.4	93.2 (1,420)	Raytheon/Aeronutronic
Phoenix, air-air	128.2	84.0 (240)	Hughes
Shrike, air-surface	56.7	51.3 (1,337)	Various
Condor, E-O cruise	101.4	12.7 (40)	Rockwell
Harpoon, anti-ship	200.8	186.0 (350)	McDonnell
Standard, surface-air	125.1	108.6 (256)	Gen. Dynamics
Air Force missiles			
Minuteman II/III, ICBM	908.6	471.6	Boeing
*AGM-69A, SRAM, air-surface	5.4	36.3	Boeing
AGM-65A/B, E-O Maverick, air-ground	118.1	4.9	Hughes
*AGM-65C, Laser Maverick	25.1	59.3 (100)	Hughes
Navy vessels			
Trident SSBN	1,249.4	1,261.9 (1)	Gen. Dynamics
SSN 688, attack	807.2	1,337.6 (3)	Newport News/GD
CGN-38, missile cruiser	62.1	84.4	Newport News
*CSGN, strike cruiser (Aegis)	19.5	203.3	Newport News
*DDG-47, Aegis destroyer	19.2	869.5 (1)	Not selected
DD-963, destroyer	661.6	210.0	Litton
PHM, hydrofoil/missile	155.8	42.6	Boeing
FFG, missile frigate	973.4	1,282.1 (8)	Bath Iron
Other procurement			
M60A1/M60A3 tank (1)	613.5	503.6 (927)	Chrysler/GM
XM1, main battle tank	91.3	141.0	Not selected
*AN/GVS-5, laser rangefinder (1)	0	13.4 (1,708)	Not selected
MK-48, torpedo	134.6	139.9 (214)	Gould
Captor, ASW mine	43.2	73.0 (480)	Goodyear Aero
CIWS (Phalanx), ship gun	15.0	38.9	Gen. Dynamics

WEAPONS R&D FUNDS

Army			
Advanced Scout Helicopter (ASH)	$ 12.0	$ 26.0	Hughes
Advanced Attack Helicopter (AAH)	66.5	112.1	Bell/Hughes
Ballistic Missile Defense Technology	125.0	118.0	McDonnell
BMD Advanced Technology	122.3	106.9	Multiple
Pershing II missile	25.0	36.3	Martin-Marietta
U.S. Roland, surface-air	66.5	85.0	Hughes
SAM-D, surface-air	160.0	180.0	Raytheon
Cannon-launched guided projectile	17.1	36.1	Martin-Marietta
Tri-Tac, joint tactical communications	70.0	37.9	GTE-Sylvania
Navy			
V/STOL aircraft developments	27.5	44.0	Multiple
LAMPS helicopter	28.3	83.2	Multiple
F-18 strike fighter	132.9	346.9	McDonnell/Northrop
AEGIS, surface-air	75.6	26.3	RCA
CSEDS, land test site for AEGIS	51.6	80.9	
HABM, air-surface radiation missile	31.6	33.5	TI
SLCM, cruise missile	130.9	182.5	LTV/GD
ELF communications (Seafarer)	18.3	29.8	Not selected
Surface Effect Ship	55.3	48.0	Aerojet
Air Force			
Advanced medium STOL transport	96.3	29.3	Boeing/McDonnell
EF-111A, electronic warfare aircraft	9.8	36.8	Grumman
Advanced ICBM technology	48.9	84.0	None
ALCM, cruise missile	63.2	79.2	Boeing
Navstar global positioning satellites	87.6	62.0	GD/Rockwell
Close Air Support Weapon, air-ground	28.3	41.0	Rockwell/Hughes
Precision Location Strike System (PLSS)	11.8	30.0	Not selected
Space Shuttle (NASA support)	28.3	60.1	

† 15-month funding includes 3-month transition to new fiscal year
* First major production or new R & D effort
(1) Includes Marine Corps procurement
(2) Includes Air Force procurement

Basic research in for 11% boost

Renewed White House emphasis on basic research is reflected by National Science Foundation programs. Of the foundation's own 11% rise in fiscal 1977 obligations to $812 million, a large proportion will go to colleges and universities. Yet while funds are restored to academia, long slighted by the Nixon Administration, applied research funds under NSF's Research Applied to National Needs will be cut for the second straight year. RANN monies are programed to drop another 11% to $69 million.

Energy R&D continues to be a bright spot, budgeted this year for $2.6 billion, a whopping 38% over fiscal 1976. Activity is concentrated in the fledgling Energy Research and Development Administration, which plans to spend $73 million on solar electric applications, including photovoltaic device development. Its total solar energy budget, including thermal heating and cooling applications, runs $116 million. Short-term ERDA goals include achieving a cost of less than $2,000 per peak kilowatt for concentrating photovoltaic systems by fiscal 1979. Planar solar cell arrays should meet that cost by 1983.

Navy wants to cover increased costs of ships already under contract.

New to the ship procurement program is the DDG-47 destroyer. All but $11 million of the $869.5 million request will be used to buy the lead ship; the rest is for RDT&E. Displacing 9,000 tons, the DDG-47 will be larger and more heavily armed than the 7,600-ton DD-963. A contractor has yet to be selected for the new destroyer, which will carry the RCA Aegis missile for air defense, plus the Harpoon and Standard missiles, torpedo tubes, and two five-inch guns.

Losers. Not everyone proved a winner in the Pentagon's fiscal 1977 spending plans, however. Except $1.2 million for RDT&E and $41.4 million to cover past overruns, no production money was sought for Boeing's Patrol Hydrofoil Missile ship for a second year.

Space and FAA have lean look

Military cutbacks were minor, however, compared to those at NASA. The $3.69 billion proposed for the new fiscal year's spending is no more than 4% above last year's—insufficient to match the 6% inflation—and some $200 million under President Ford's commitment to NASA a year ago.

Rockwell International, one of NASA's largest vendors, was the principal industry loser as the Office of Management and Budget cut $85 million in proposed Space Shuttle Orbiter buys from the budget request. Fletcher said it was one of many in the $184.5 million in spending programs rejected by OMB.

Rejected for another year was a $12 million start on development of the Space Telescope, leaving its optics contractors—Itek Corp. and Perkin-Elmer—empty-handed when the current fiscal year ends. Support systems contractors, Boeing, Lockheed, and Martin-Marietta, also are expected to be cut off.

Face savers. Nevertheless, NASA was able to tout three new starts for fiscal 1977, though they are widely regarded by industry as face-saving programs. Included is the Solar Maximum Mission satellite, resurrected after its OMB rejection last year. The SMM will begin development at Goddard Space Flight Center with $21.3 million in fiscal 1977. By its 1979 launch on the Space Shuttle, the SMM program will have cost $75–90 million. It will study solar activity at its peak through 1980.

Also revived was a new earth resources observation platform called a Thematic Mapper. The satellite is budgeted for $4 million in fiscal 1977, Fletcher said, while another called Magsat will get $2 million for beginning development of a third Applications Explorer Satellite to map the earth's magnetic variations as an aid to navigation and possible location of mineral deposits.

The Federal Aviation Administration, once the bright electronics star in an otherwise dull Department of Transportation, will lose a bit more of its glitter in President Ford's fiscal 1977 budget. That means FAA plans to spend only $2.35 billion in the fiscal year that begins Oct. 1, a fractional gain on this year's $2.27 billion but not enough to match the 6% inflation rate.

The numbers are a bit better at the department's Urban Mass Transportation Administration, but the electronics content isn't. The $1.58 billion programed to boost UMTA outlays by 18% includes $67.5 million for R&D, raising that category by 25% from a year ago. "It's great if you sell bus bodies and tires," says one UMTA technologist. "That's what we mean by 'proven technology.' But there is not much there for rapid rail systems, and there is even less for electronics."

At the Coast Guard there is more electronics business as the agency's outlays are budgeted for a 14% boost to nearly $812 million. Procurement of search and rescue systems—including $33 million for six all-weather, medium-range surveillance aircraft—is budgeted for a $5.7 million boost to $53.3 million.

Hooker. The biggest potential trouble spot for DOT is the White House hooker in the FAA budget that requires new legislation extending the Airport and Airway Development Act of 1970. It would let 8% of the airline ticket tax now in effect be diverted from state and local airport use to support federal purchases for airport and en route air traffic control and navigation equipment. Funds for these three equipment categories in the new year are budgeted at just under $200 million, down $13.3 million from fiscal 1976. Facing the stiffest cut are en route traffic control centers, whose funds dropped 15% to $69.2 million.

On the R&D side, however, FAA officials reported an 11% hike to $77.2 million. Air-traffic-control R&D money is programed for a 22% drop to just $18 million. Considering the mixed procurement and R&D bags for electronics that FAA is placing before Congress while asking it to provide new revenue sources to pay for them, the agency seems almost to be flying blind. □

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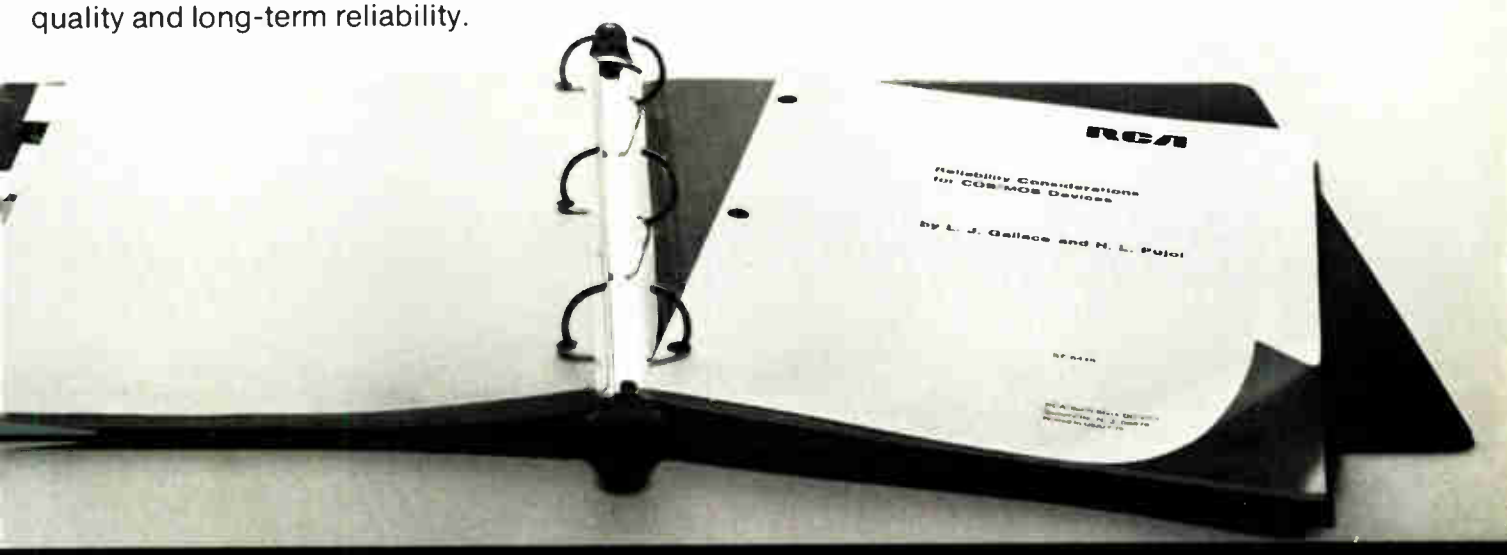

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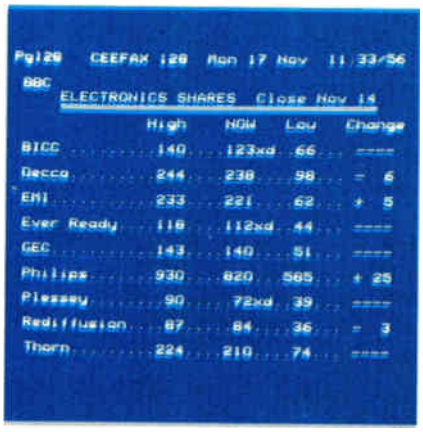
Circle 67 on reader service card

Consumer electronics

Britons mull 'magazine' via TV

Companies there, led by TI subsidiary, debate demand for devices to be used with TV system that calls up 'pages' of data for display

by William F. Arnold, London bureau manager



In the picture. Britain's TI Ltd. is bringing out a $260 decoder for the new Teletext service, dubbed Ceefax by BBC. Mullard, British GE, and Motorola also are readying decoders. But there is some question about the size of the market, and when it will materialize. Shown are typical transmissions.

The "electronic magazine" is close enough to reality in Britain that it has a name: Teletext. And the exciting if not new idea is attracting keen industry interest and investment, plus some controversy.

Now undergoing public trial, Teletext is a system that will let home viewers call up "pages" of alphanumeric information such as news, sports, and weather maps for display on their specially equipped TV sets (see "Turning Teletext's pages").

This spring Texas Instruments Ltd. plans to market its custom-designed, LSI-based TIfax decoder to sell for around $260, which should help make Teletext's price more attractive to makers. Mullard Ltd. says it will have sample LSI chips for decoders this year while the British General Electric Co. (no connection with the American GE) and Motorola Semiconductors Ltd. confirm they also are readying modules.

Watching the market intently are General Instrument Microelectronics, ITT Semiconductors, and Plessey Semiconductors, all of whom have done some design studies. And $2,000 TV sets with discrete-based decoders are now available from British GE, Jasmin Electronics Ltd., and Decca Ltd.

However, three questions cloud Teletext's future. An important one is: will the British government approve the system for regular operation? Almost everyone expects the government to continue the service when the trial period ends this September. But should it merely agree to another test period, it could dull the appetites of set makers for a while.

Another question worrying many in the industry: just how big is the market for Teletext decoders? TI thinks it's about 50,000 over the next two years in Britain, according to Geoff Shrank, manager of TI's Advanced Technology Centre. If that is true, some competitors say, TI is just trying to be first, since the market doesn't justify custom LSI circuits. Shrank says, "We'll write off most of our development costs in the first 50,000" and have a jump on competitors. Then it will be "a problem in meeting the demand."

Optimistic survey. A new market survey by the British Radio Equipment Manufacturers Association indicates that about 10% of British set owners interviewed would pay about $200 for a decoder. If even half that number actually goes out and plunks down money for decoders, then the market could be several times TI's estimate.

There may someday be a market, but not yet, say others. "It's coming from the engineers upwards and not from the commercial people downwards," comments Alan D. Hall, marketing manager for ITT Semiconductors, Foots Cray, Sidcup,

Kent. "It's not commercially viable yet—unless it breaks out in Europe. Then we're talking about something different." Terry Barnes, production manager at Plessey Semiconductors, agrees: "You'll need a market upturn to justify that kind of money" to develop circuits. Even if Teletext gets going in Europe, there'll be a problem with common standards, he adds.

Europe is showing some interest, though actual regular broadcasting seems some time away. Sweden, using borrowed BBC equipment, and West Germany, which would be a huge market, have conducted some trials. Belgium is interested, say the British who are submitting proposals for common standards. But it will be a number of years before a go-ahead is given, predicts a Swedish broadcasting official. TI's Shrank sees little problem with common standards; he predicts European broadcasting within three years.

As for potential U.S. involvement, British branches of U.S. semiconductor makers report no interest. And there's some disagreement among industry figures and broadcasters about the difficulty of converting the circuitry from the 625-line, 50-phase PAL system to the 525-line, 60-phase U.S. system.

There will be room in the marketplace for only two manufacturers for the next four or five years because of the low volume and relatively high cost of decoders, observes Plessey's Barnes. Others share his opinion.

Disagreeing, Peter J. Mothersole, adviser to Mullard's distribution service, points to calculators as an idea catching on to produce a high-volume market and lower per-unit costs. And others say that the decoders might just provide that extra gimmick to lure buyers back into Britain's depressed TV salesrooms.

Which way? The final question is how to go LSI. Everyone agrees that present decoders using a trayful of discrete components are too costly, but opinion divides on what to do. TI bit the bullet and is coming out with its 14-chip custom-design module of integrated injection logic, two forms of Schottky logic, and MOS. Mothersole says Mullard's LSI components will use MOS and parent Philips' Locmos logic to produce a 12-chip module. Even here, TI will offer setmakers a complete module whereas Mullard feels it's better to supply the components so that the setmakers can make their own modules.

Conversely Motorola thinks reprograming standard microprocessors is the way to go. GEC, say industry sources, soon will announce a decoder based on Intel's 8080 microprocessor capability and its own interface expertise. But the company also may be working on an LSI-based version. General Instrument says that cost will be the final yardstick between LSI and its CP1600, and Decca Ltd. is studying both approaches, according to Jeff Schaffer, head of Decca's digital television laboratory. □

Turning Teletext's pages

Teletext is the name for a system that enables home viewers to request "pages" of alphanumeric information displayed on their encoder-equipped TV sets. It is broadcast experimentally as Ceefax by the British Broadcasting Corporation and as Oracle by three companies of the commercial Independent Broadcasting Authority.

Digital teletext signals, riding piggyback on the analog TV transmission, are transmitted in two lines of each blanking period of the 625-line 50-field transmission. The data pulses, transmitted at 6.937 megabits per second, are enough for one 40-character row of the 24-row page in each 50-microsecond line. Thus, it's somewhat like a magazine of up to 800 pages that the "reader" can flip through at the rate of four full pages per second.

The decoders are under rather severe technical constraints. Once a viewer has requested the page number he wants, the decoder must search for the right lines for the page, then grab and store them until it can display the whole page. The data stream is sent as 8-bit words, including addressing and control information, and collected in a 6,720-bit memory for the complete page. Each page also displays the page number and time of day.

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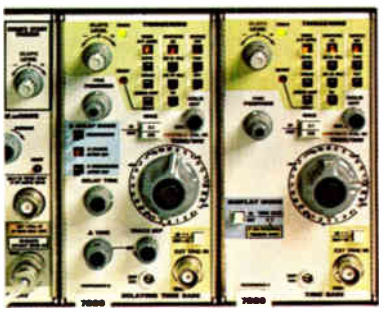

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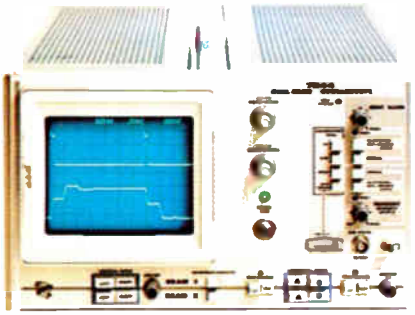

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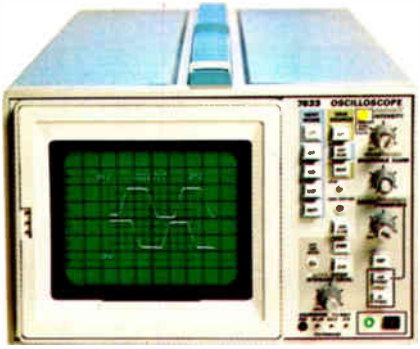

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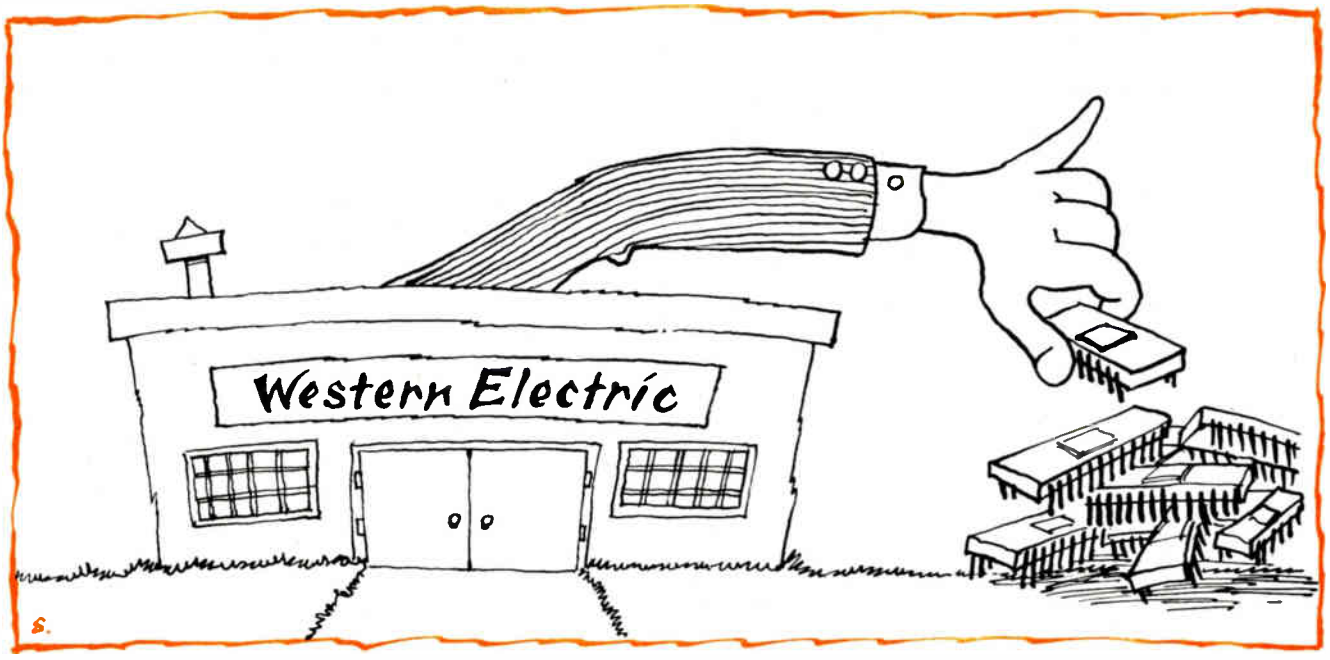


Western Electric buys more outside

Lower prices plus falling demand from operating companies also forces WE to utilize new technologies faster

by Ron Schneiderman, New York bureau manager

Western Electric Co., the giant manufacturing arm of AT&T, is accelerating semiconductor purchases from outside manufacturers. Forced to compete with independent telephone-equipment suppliers for declining orders from Bell System operating companies, Western Electric has taken a hard look at its semiconductor-purchasing plans and decided that future make-or-buy decisions will be a toss-up. "It's going to be a horse race," says Warren S. Search Jr., director of purchasing.

WE's purchases from outside sources for electronic components, including discrete devices, large-scale integrated circuits, memory devices, and microprocessors, are expected to climb from the $17 million level in 1975 to at least $19 million this year. And these purchases will continue to grow at a solid annual rate of 10% to 15% for at least the next two to three years, says Search. IC buys are expected to increase at the expense of discretes.

But he indicates that these figures could shift dramatically upward if semiconductor prices continue to fall at their present rates. "We'll have to stay competitive," says Search. "We can't expect Bell companies to pay us more than they would pay someone else." Competition, meanwhile, has forced WE to go outside immediately for the most advanced devices.

Lagging. Because of the volume of its purchases of parts other than electronic components and raw materials—about $3 billion worth this year, from some 50,000 different suppliers—few companies, if any, can manufacture as economically as WE. And it has virtually no marketing costs. It also has the longest production runs in the industry. But the company has been slow to adopt new technologies in its telephone-terminal equipment. In private-branch-exchange (PBX) telephone switchboard systems, where competitors have been incorporating the most advanced features in their new computer-controlled systems, WE has only recently begun to meet the demands of business phone users for those features.

As a result, the Bell System's 23 operating companies have generally had to rely on equipment from other suppliers to remain competitive with independent systems. Bell companies have been buying PBXs from most major suppliers, telephone handsets from International Telephone & Telegraph Corp., and a new type of telephone-computer terminal, called VuSet, from Plantronics Inc. of Santa Clara, Calif., to replace the more expensive typewriter-like terminals Bell companies have been offering for years. "Western Electric has made a definite commitment to Plantronics for a certain number," says Search.

Admittedly, 1975 was a particularly difficult year for Western Electric. As operating companies pared their requirements to match the slower growth they experienced, WE production levels fell sharply. WE officials claim that because of the recession and product charges resulting from improved technology, orders for Bell telephone equipment have declined sharply in the past two years. As a result, WE today is operating at only 60% of its

total companywide manufacturing capacity.

To correct this overcapacity as quickly as possible, the company is moving its Buffalo operations into space available at some of its other, more modern plants. In North Carolina, where a precipitous drop in government business in the past three years has been an additional cause of WE's excess capacity, the company plans to consolidate its remaining government manufacturing work in Burlington, while simultaneously consolidating its Bell manufacturing work at Winston-Salem. Moreover, its leased offices in East Orange, N.J., which house its corporate purchasing and transportation activities, will move into the WE-owned Greensboro, N.C., facility by early July.

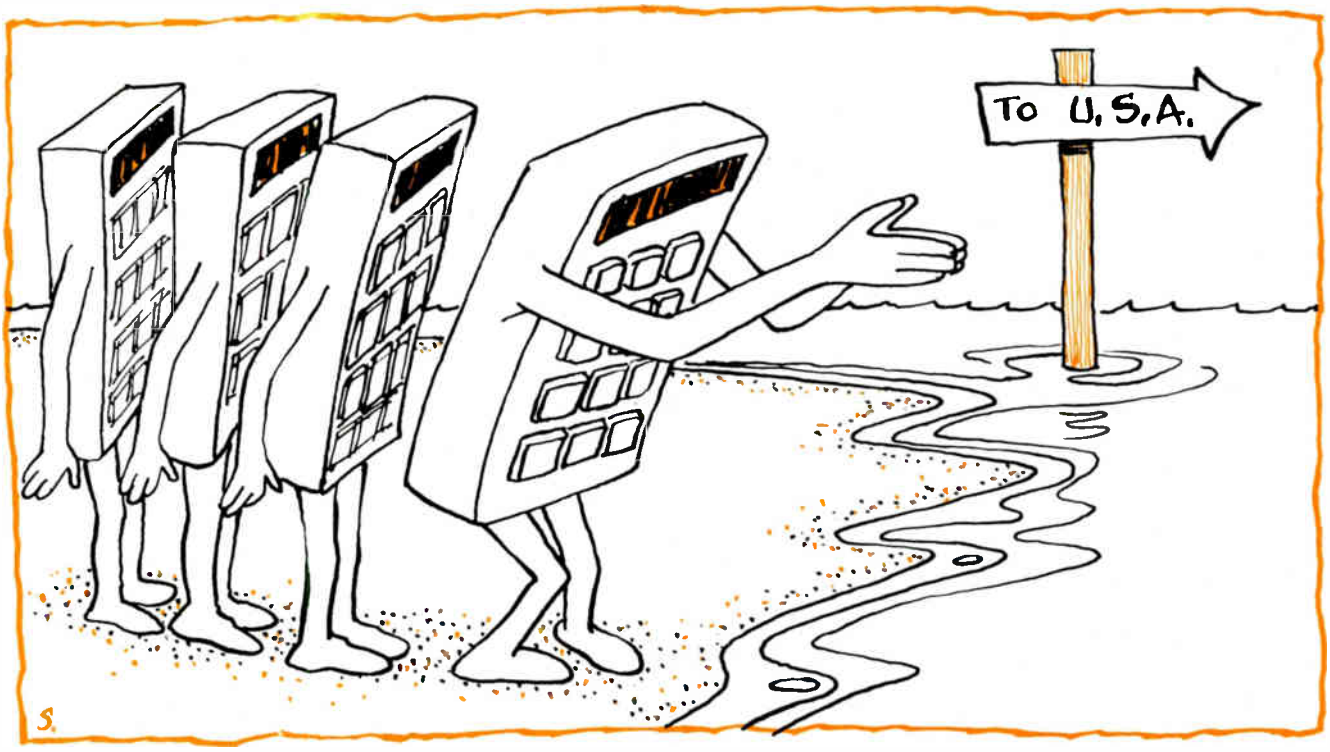
In another setback, WE's profits have been sharply reduced. In fact, the company is coming off its first loss in a three-month period in 25 years. In WE's defense, Search says "We reflect the general economy pretty well. When plants close and the construction of apartment houses slows down, for example, that reduces our requirements."

To keep a tighter rein on its bottom line, and its telephone-terminal market share, WE engineers are keeping a closer watch on technology, particularly semiconductor technology, and prices.

Dimension. Although Bell Laboratories is currently developing microprocessors for WE equipment, WE couldn't wait. One instance is the new Dimension stored-program PBX [*Electronics*, Oct. 2, 1975, p. 75], which uses Intel Corp. microprocessors. So far, Bell has installed only about 85 Dimension systems, although company officials expect to be in full production next year.

To date, WE has bought only about $750,000 worth of microprocessors. "We expect to buy a lot more for some new equipment we're developing," says Search, "but at the rate the price is dropping on these devices our overall costs for them may stay fairly constant."

"In the late '70s we're going to have to make a lot of crucial make-or-buy decisions," says Search. "By 1980, we're going to be in a very interesting arena, technologically." □



Calculators take offshore trip

by Gerald M. Walker, Consumer Electronics Editor

The domestic hand-held calculator market has matured. It must have—more than half the production has been moved offshore. Like the radio, tape recorder, and black-and-white television set before it, calculator manufacturing efficiency has replaced technical development on the priority list.

Estimates of the number of calculators now manufactured offshore for sale in the U.S. range from 50% to 80% in 1975, and the percentage is expected to go higher this year. But comparison of the production ratio depends on who is providing the statistics. Disagreement is characteristic of the statistics collected by the U.S. Commerce Department, the Electronics Industry Association of Japan, and the foreign and domestic calculator makers.

A major U.S. calculator maker estimates that about 20 million calculators were sold in the United States in 1975. Domestic U.S. production amounted to only about 4 million to 5 million units. Some 6 million were Japanese, and the rest—almost 10 million machines—came from non-Japanese offshore facilities.

The Japanese, however, claim that they export well over 6 million calculators to the United States and are gaining every month. The EIA-J estimates that during the first nine months of last year, more than 700,000 calculators a month were exported to the United States. By September 1975, the monthly rate exceeded a million units, to boost the total to approximately 10 million units from Japan alone.

The U.S. Commerce Department's statistics differ from those of the Japanese—not an unusual situation. Commerce says that, of the 7.4 million calculators imported through last September, 4.3 million were from Japan, 500,000 were from Taiwan, 550,000 were from Hong Kong, 750,000 were from Malaysia, and 1.1 million were from Mexico.

Representing an American producer's viewpoint, Joseph Obot, calculator-marketing manager for National Semiconductor Corp. in Sunnyvale, Calif., remarks, "For 1975, I'd guess that 11 to 12 million calculators were shipped into this country, and about 10 million of those were sold. Another 8 million were produced domestically."

On one point, all industry observers agree—cheap models account for most of the trade. The dollar value of imports has fallen despite the increase in number of units. EIA-J figures indicate that the average value of calculators exported to the U.S. in December 1974 was $26.35 a unit. By September 1975, their value had declined to $13.19 each.

Yet another Japanese manufacturers' group reports that the value of machines exported to America during the first 10 months of 1975 declined to $15.47 a unit—62% lower than the price in the same 10 months in 1974.

As with other consumer-electronics products, as the prices decline, offshore assembly becomes attractive. Initially, after the U.S. companies overcame the early lead in electronic calculators established by the Japanese in 1970, manufacturers in America had the edge in the technology of large-scale integration, and domestic assembly was cost-effective. However, the rest of the world has caught up in LSI technology, and the Japanese have concentrated on automating their production to threaten once more to dominate the U.S. market. □

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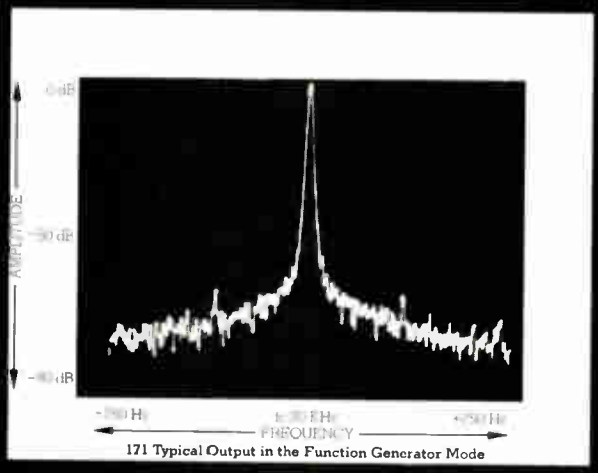
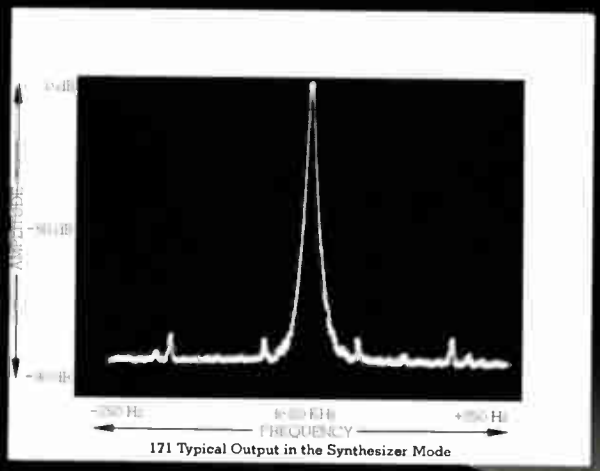
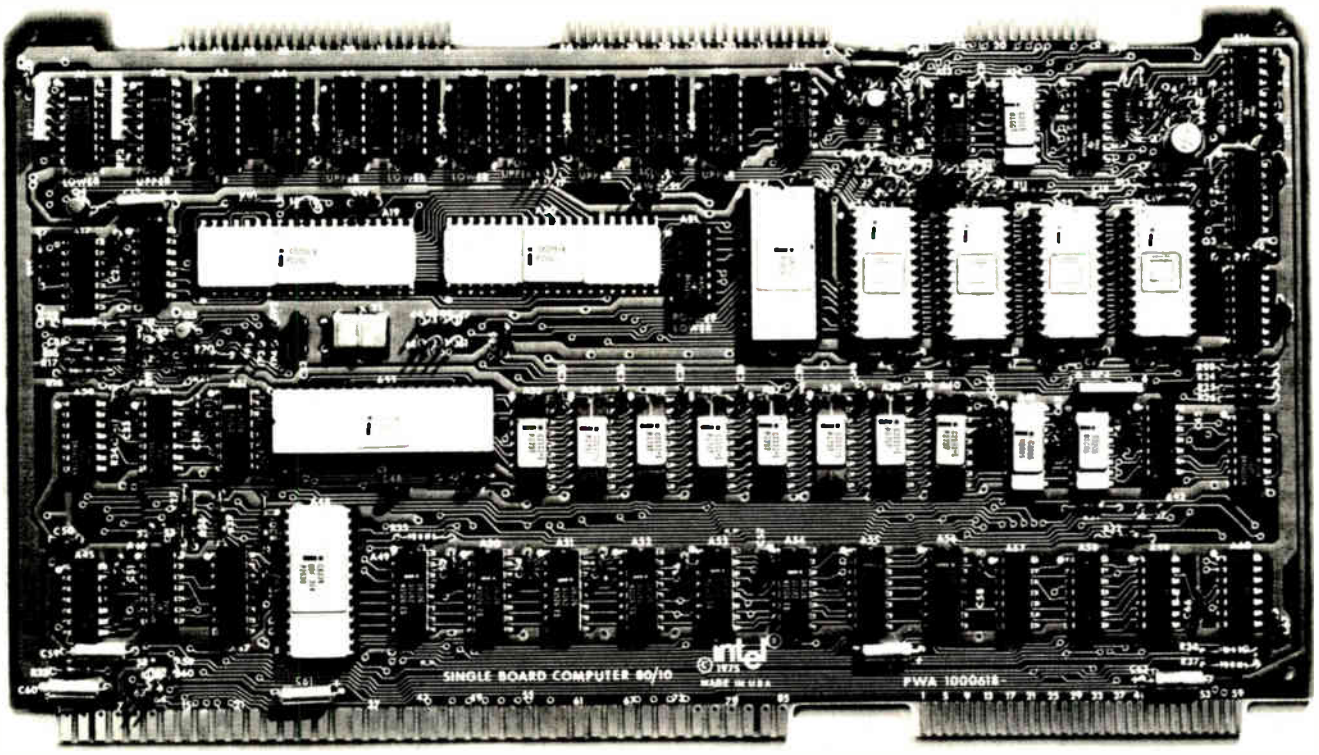


171 Typical Output in the Function Generator Mode



171 Typical Output in the Synthesizer Mode

Actual spectrum analyzer photographs showing the improved waveform characteristics in the synthesizer mode.



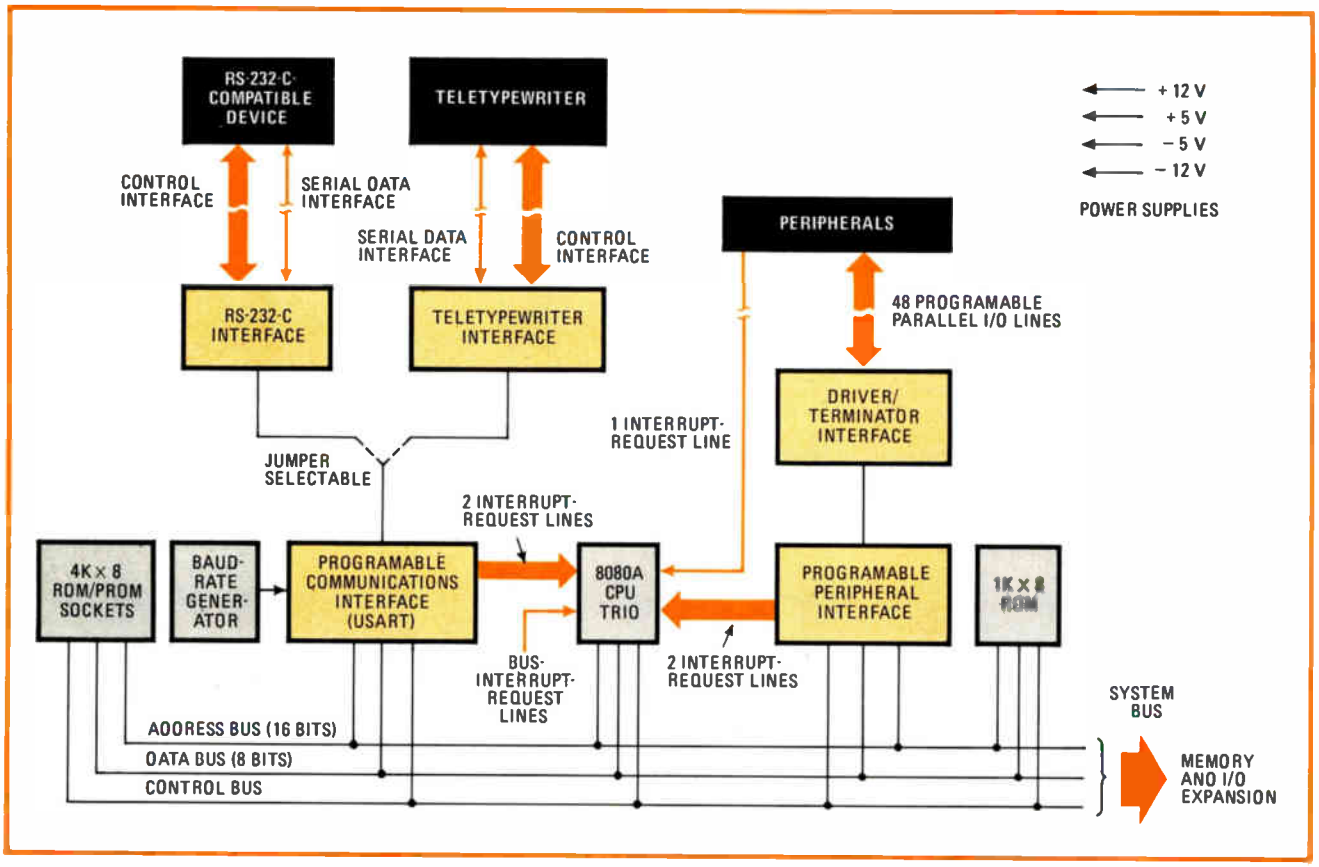
The 'super component': the one-board computer with programable I/O

New class of LSI devices—programable input/output interface chips—enables an 8-bit computer to be built as a subsystem on one printed-circuit board

by Bob Garrow, Jim Johnson, and Mike Maerz,
Intel Corp., Santa Clara, Calif.

☐ A complete general-purpose computer subsystem that fits on a single printed-circuit board has been a major goal all through the steady evolution of LSI technology. Such a computer, consisting of a central-processing unit, read/write and read-only memories, and parallel and serial input/output-interface components, could satisfy most processing and control applications needed by original-equipment manufacturers. A single-board computer could greatly extend the range of computer applications by providing a single solution to three problems that have often precluded the use of conventional computers:

- Cost. The primary reason for use of a single assembly of LSI devices rather than a multiboard subsystem is economic. Extra board assemblies are costly in themselves and need related equipment, such as backplanes and housings, that also adds to cost.
- Size and power. Compactness and low power consumption are often prerequisites for products. Using LSI



1. One board. The SBC 80/10 computer, with the Intel 8080A microprocessor and 1 kilobyte of random-access memory, has a capacity of 4 kilobytes of read-only memory and drivers for bus expansion. Programable parallel and serial I/O interfaces offer unparalleled flexibility.

for all key computer functions reduces power consumption and provides a higher functional density than conventional subsystem designs.

- Design specialization. But a board containing all generally needed computer functions could be used by many equipment manufacturers as a standard subsystem component throughout their product lines.

Until now, two components have been lacking—a high-density nonvolatile program memory and a flexible input/output interface that preserves the general-purpose nature of the computer as a programable component. The I/O interface should provide a large number of parallel I/O lines in configurations flexible enough to handle a variety of peripheral devices as well as a versatile serial I/O port for use in data communications.

In the rush to apply large-scale integration to computers built for original-equipment manufacturers, most developments have concentrated on central processing units and memories. This focus is rather ironic because the throughput and versatility of most computer systems depend heavily on their input/output capability. Until now, the necessity for scores of transistor-transistor-logic packages and other discrete circuitry in I/O subsystems has made the so-called single-board computer an euphemism for a system that actually requires two, three, or more boards so that the computer subsystem can interface with the remainder of the system.

However, the single-board computer—a standard plug-in "super component"—has become a reality with the introduction of 8,192-bit erasable programable read-only memories (EPROMs) and programable LSI I/O-interface components. The new programable interfaces allow the OEM to use software to customize the parallel I/O ports and communications interfaces, eliminating the previous need for inefficient hard-wired ports or I/O boards specially designed and manufactured for a custom application.

The new Intel SBC 80/10 single-board computer is just such an OEM subsystem. The general-purpose 8-bit computer, based on the widely used 8080A microprocessor, satisfies most OEM processing and control requirements for processing power, memory storage, capacity, and I/O capabilities.

Because both SBC 80/10 parallel and serial I/O interfaces are programable, this design requires no customized interface hardware for the vast majority of OEM applications. The system is supported by a complete line of development aids, macro assemblers, compilers, text editors, operating systems, and a comprehensive program library.

Examining the computer

The basic SBC 80/10, which will be sold for $295 in quantities of 100, uses many more mass-produced LSI components than previous OEM computers, which have used LSI only in central processors and memories. The computer contains these subsystems on a single printed-circuit board of 6.75 by 12 inches (Fig. 1):

- Central processor with interrupt control, bus-control

logic, crystal-controlled clock, high-current drivers for memory and I/O-bus expansion, and other CPU-related control functions. Most of this circuitry is implemented with the 8080A n-channel MOS CPU and two Schottky-bipolar LSI devices. Typical cycle time for instruction-execution is 1.95 microseconds.

- Read/write memory. The board contains 1 kilobyte of static random-access memory.
- Read-only memory. The board contains sockets for 4 kilobytes of interchangeable Intel 8708 EPROMs, or Intel 8308 ROMs, and read-only memory may be added in 1-kilobyte increments.
- Parallel I/O. Two LSI devices, called programable peripheral interfaces, provide 48 software-configurable I/O lines. In addition, sockets are provided for interchangeable quad line drivers and terminators. This provision enables the OEM to choose sink currents, polarities, and other characteristics appropriate to his unique application.
- Serial I/O for data communications. This interface includes a programable synchronous and asynchronous communications-interface device, variable baud-rate generator, and jumper-selectable RS-232-C and teletypewriter drivers and receivers.

Three types of memories

Most conventional CPU boards contain read/write memory, but nonvolatile program storage has often required an additional core-memory module or a separate solid-state read-only-memory board. In most OEM systems, programs are stored in nonvolatile memory to eliminate the need to reload read/write memory every time the system is turned on.

However, the SBC 80/10 provides all three types of necessary memory right on the board: EPROM for program development, small-volume system production, and applications where programs are subject to change after the system is manufactured; masked ROM for moderate-volume production of system with unchanging program requirements; and RAM to store data, variable parameters, and subroutines that are subject to dynamic change.

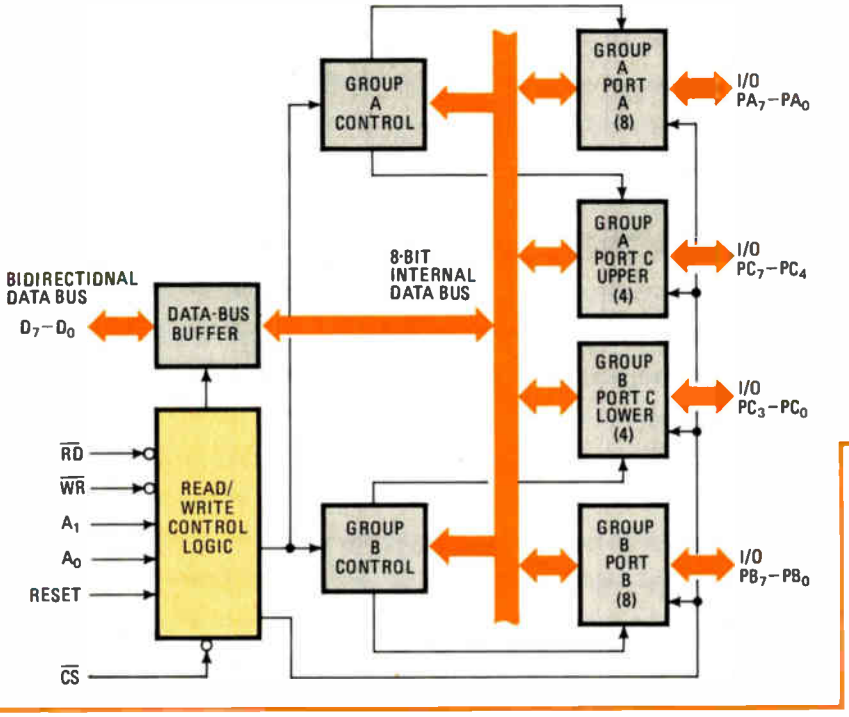
The recent development of the 8,192-bit Intel 8708 EPROM, which stores 1,024 bytes, has made practical the packaging of all three types of memory on one board. Four 8708s, which are two to four times as dense as previous designs, can be plugged into the SBC 80/10 board, and they are interchangeable with Intel 8308 8,192-bit masked ROMs.

The system's EPROM/ROM sockets allow the user to plug in program memories in 1-kilobyte increments by simply inserting as many as four of the 8,192-bit devices. The EPROMs are normally used for program development because they can be erased and reprogramed through all the development cycles of the OEM's system prototype. Also, many manufacturers prefer to ship new products with EPROMs to accommodate special customer requirements.

Manufacturers with unchanging programs and large production volume can reduce costs by plugging in masked ROMs after the programs have been developed. The 1-kilobyte read/write memory contains eight Intel 8111 1,024-bit (256 × 4) static RAMs.

I/O can be easily customized

Computers for OEM use must be capable of interacting with an enormous variety of external devices, including switches, motor drives, bistable sensors, analog-to-digital and digital-to-analog converters, lamps, displays, keyboards, printers, teletypewriters, communications modems, cassettes, and other computers. The CPU must have access to these devices to obtain system



PIN NAME	PIN FUNCTION
D_7-D_0	Data bus (bidirectional)
RESET	Reset input
$\overline{CS}$	Chip select
$\overline{RD}$	Read input
$\overline{WR}$	Write input
A0, A1	Port address
PA7–PA0	Port A (bit)
PB7–PB0	Port B (bit)
PC7–PC0	Port C (bit)

2. Parallel I/O interface. The programable peripheral-interface chip, Intel type 8255, has 24 parallel I/O lines organized into three 8-bit ports, one of which (port C) can be separated into two 4-bit sections. The read/write control logic interprets commands from the system program and sets up the configurations of the ports. The chip is n-channel MOS in a 40-pin package.

information and to respond with control, status, and numerical information.

Because the possible combinations of devices, modes, and techniques are virtually unlimited, the programable-LSI interface components were designed to implement most combinations that an OEM might want to use. Programable configurations can accommodate the various operating modes and protocols for data transfer. Their applications are primarily limited only by the room available on a board for the devices, interconnection traces, line drivers, and terminators.

The programable LSI devices enable the OEM to customize the I/O interface with control words contained in the system program. The appropriate words are placed in the initialization section of the program, and the CPU transfers the words to registers in the two Intel 8255 peripheral-interface devices (Fig. 2). The only additional customization required is to plug suitable line drivers and terminators into the sockets associated with the parallel I/O ports.

In previous computers, parallel I/O subsystems have often been accommodated simply by providing optional hard-wired—and thus predefined—input and output interfaces. Although many OEM requirements for I/O configurations can be met in this way, often the available configurations in I/O subsystems are inefficient because they do not directly match the desired application. For example, a standard parallel I/O-board option might provide, say, 16 inputs and 16 outputs, but the OEM requires four inputs and 18 outputs. Hence, two I/O boards would be needed, even though only one third of their capacity could be used.

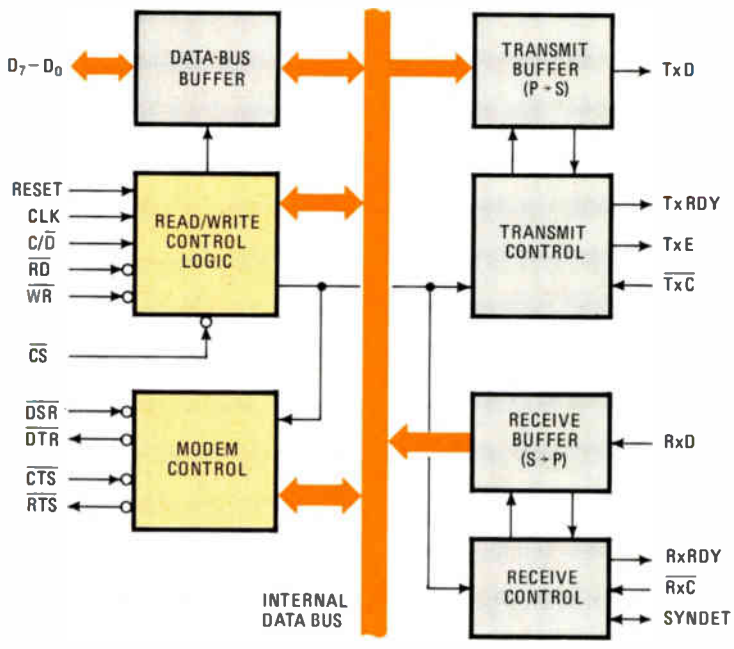
Besides avoiding such inefficiencies, software-configurable I/O interfaces increase the OEM designer's free-

POSSIBLE CONFIGURATIONS OF PARALLEL I/O PORTS

Port	No. of lines	Mode of operation					
		Unidirectional				Bidirectional	Control
		Input		Output			
		Unlatched	Latched and strobed	Latched	Latched and strobed		
1	8	X	X	X	X	X	
2	8	X	X	X	X		
3	8	X		X			X*
4	8	X		X			
5	8	X		X			
6	4	X		X			
	4	X		X			

* Port 3 must be used as a control port when either Port 1 or Port 2 are used as a latched and strobed input or a latched and strobed output or Port 1 is used as a bidirectional port.

PIN NAME	PIN FUNCTION
D_7-D_0	Data bus (8 bits)
C/D	Control or data is to be written or read
$\overline{RD}$	Read data command
$\overline{WR}$	Write data or control command
$\overline{CS}$	Chip-enable
CLK	Clock pulse (TTL)
RESET	Reset
$\overline{TxC}$	Transmitter clock
TxD	Transmitter data
$\overline{RxC}$	Receiver clock
RxD	Receiver data
RxRDY	Receiver ready (has character for 8080)
TxRDY	Transmitter ready (ready for char. from 8080)
$\overline{DSR}$	Dataset ready
$\overline{DTR}$	Data terminal ready
SYNDET	Sync detect
$\overline{RTS}$	Request to send data
$\overline{CTS}$	Clear to send data
TxE	Transmitter empty
V_{cc}	+5-volt supply
GND	Ground



3. Serial I/O interface. The programable communications interface chip, Intel type 8251, is a universal synchronous/asynchronous receiver/transmitter. Mode instructions in the user program set the 8251 to operate in either synchronous or asynchronous mode while command instructions, also in the system program, control the actual operations of the device. The n-MOS chip comes in a 28-pin package.

The central processor

The single-board SBC-80/10 computer is built around Intel's 8080A n-channel MOS microprocessor, which, along with two bipolar LSI chips—a system controller and a clock generator—constitute the heart of the SBC 80/10's central processing unit. The 8080A is an 8-bit microprocessor, but its registers can also be addressed in pairs for 16-bit operations.

A 16-bit program counter enables direct addressing of up to 65,536 bytes, and a 16-bit stack pointer allows any portion of random-access memory to be used as a last-in/first-out stack. The external stack, which provides a subroutine-nesting capability that is limited only by memory size, also facilitates interrupt-handling. The stack can store the contents of the program counter, flags, accumulator, and all six general-purpose registers.

Arithmetic, logical, and shift/rotate operations are performed by the ALU. Arithmetic and logical operations set and reset four testable flags. A fifth flag allows arithmetic operations in either binary or decimal modes. The flags identify status (e.g., carry, zero, sign, parity) after arithmetic and logical operations. On subsequent instructions, the flags can be queried for jumps to program sections specified by flag conditions. The on-chip control logic decodes instructions and coordinates instruction execution with memory and I/O operations, which are managed by the system controller.

The CPU selects memory locations and I/O devices by means of a three-state, 16-line address bus. The system controller operates a three-state, eight-line, bidirectional data bus and the control bus. A high-current bidirectional driver built into the bipolar controller sinks bus current and drives the CPU data inputs at levels that exceed the CPU's input-noise-immunity requirement. This driver supports all local bus requirements, but extension off the board is augmented by independent bidirectional and unidirectional drivers.

Timing comes to the controller from both the CPU and clock generator. The clock generator provides MOS clocks for the CPU and a TTL clock for the communications baud-rate generator, plus auxiliary timing functions. The clocks, which are crystal-stabilized, run at 2.048 megahertz ±0.1% and 18.432 MHz ±0.1%, respectively. Four MOS clock periods form the basic instruction cycle time of 1.95 microseconds.

dom. If he changes types of peripherals and data-transfer techniques during system development or in different models of the system, the OEM often accommodates these changes simply by modifying system software.

Data transfer between a CPU and communications channels or terminals requires a serial I/O interface. In a conventional system, an extra board is needed to provide the control logic, serialization logic, and communications clocks. The SBC 80/10's programable communications-interface device provides a universal synchronous/asynchronous receiver/transmitter (USART) on a single Intel 8251 LSI chip (Fig. 3). This USART is programed by system software to operate in synchronous or asynchronous mode with user-defined data formats and "handshaking" sequences. The inclusion of the USART jumper-selectable RS-232-C and teletypewriter interfaces, together with a variable baud-rate generator on the SBC 80/10, eliminate the need for an additional board.

Parallel I/O structure

As used in the SBC 80/10's parallel I/O subsystem, each of the two programable peripheral-interface devices provides three general-purpose 8-bit I/O ports. Although the devices are identical, they are used differently. The user specifies port characteristics by programing the modes (latched or unlatched and strobed or not strobed) and data-transfer directions (input, output, or bidirectional).

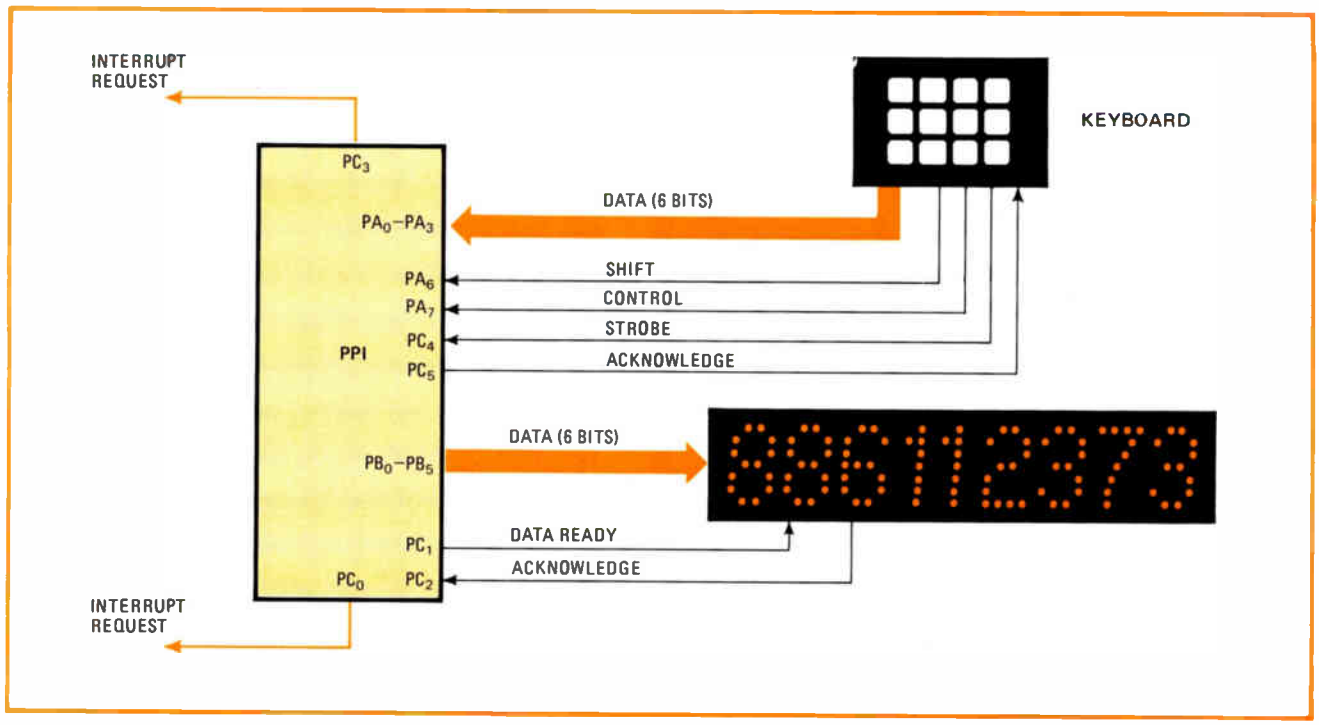
By choosing various I/O line drivers and terminators, the user specifies such electrical characteristics as sink currents and polarities of the parallel I/O lines in the system. The sockets on the board accept many types of standard 7400-series TTL quad drivers and pin-compatible Intel line-terminating resistor networks. Also, the I/O lines are interlaced with ground lines and brought out to edge connectors that mate with either industry-standard flat or round cable. Since the sockets accept interchangeable quad drivers and terminators, the OEM designer can choose the combinations of sinking currents, polarities, and other interface characteristics appropriate to the external devices and cables he plans to use.

The possible programable configurations of the six parallel I/O ports are shown in the table. Port 1 can operate as a unidirectional or bidirectional 8-bit port. As an input, it can either be unlatched or latched and strobed. Similarly, as an output, it can either be latched or latched and strobed. As a bidirectional I/O, it operates in a latched-and-strobed mode.

Port 3 is used as a control interface when ports 1 and/or 2 are configured as latched input ports, latched-and-strobed output ports, or when port 1 is bidirectional. In other applications, port 3, which operates independently, can be used as an 8-bit port with its own mode options. Ports 4, 5, and 6 can be used as unidirectional input or output ports in the modes shown. Also, port 6 may be used as two independent 4-bit ports.

As an example, the configuration in Fig. 4 is suitable for interfacing a control panel's keyboard and display. This particular interface requires the eight lines of port 1 for keyboard inputs, six lines of port 2 for display outputs, and six lines of port 3 for control and interrupts, using 20 of the 48 lines available.

In Fig. 4, port 1 is programed as a latched-and-strobed input port, port 2 as a latched-and-strobed output port, and port 3 as a control and interrupt-request-generation port (the SBC 80/10 board has jumper-selectable interrupt paths to the CPU). To establish the device's configuration, the CPU sends out a control word, generated from the initialization section of the system software, to a control register on the programable peripheral-interface chip. On-chip control logic



4. Keyboard and display. The programable peripheral interface can control such peripherals as a keyboard and gas-discharge numeric display. The two parallel interfaces required in this configuration take up 20 of the available 48 input/output lines.

then interprets the control word and configures the interface accordingly.

The six keyboard data-input lines and two control lines are brought in through port 1, the six display-output lines are sent out through port 2, and the remaining I/O functions are provided by port 3. The LSI device generates both keyboard and display-interrupt requests and sends them to the CPU via two lines of port 3.

Interrupt requests can be initiated whenever the keyboard has a data input to be sent to the CPU or whenever the display is ready to receive data from the CPU; that is, when an input buffer on the chip is full or an output buffer is empty. Also, the CPU can query the programable peripheral interface to obtain data defining either peripheral's status. Four other lines of port 3 are used for handshaking with the two peripherals. In that way, 20 parallel I/O lines are needed to complete the interface, and there are 28 lines available for other interface applications in the OEM system.

Serial I/O organization

A serial I/O interface is a valuable addition to an OEM computer system for two reasons:

First, the interface permits man-machine communications devices to be used with the system during development, production trouble-shooting, and field maintenance. By attaching a cathode-ray-tube display (see Fig. 5) or teletypewriter to the serial I/O, the OEM design engineer or field engineer can gain access to the entire OEM system for functional testing. He may use this interface to load diagnostic programs and then command and interrogate any part of the system.

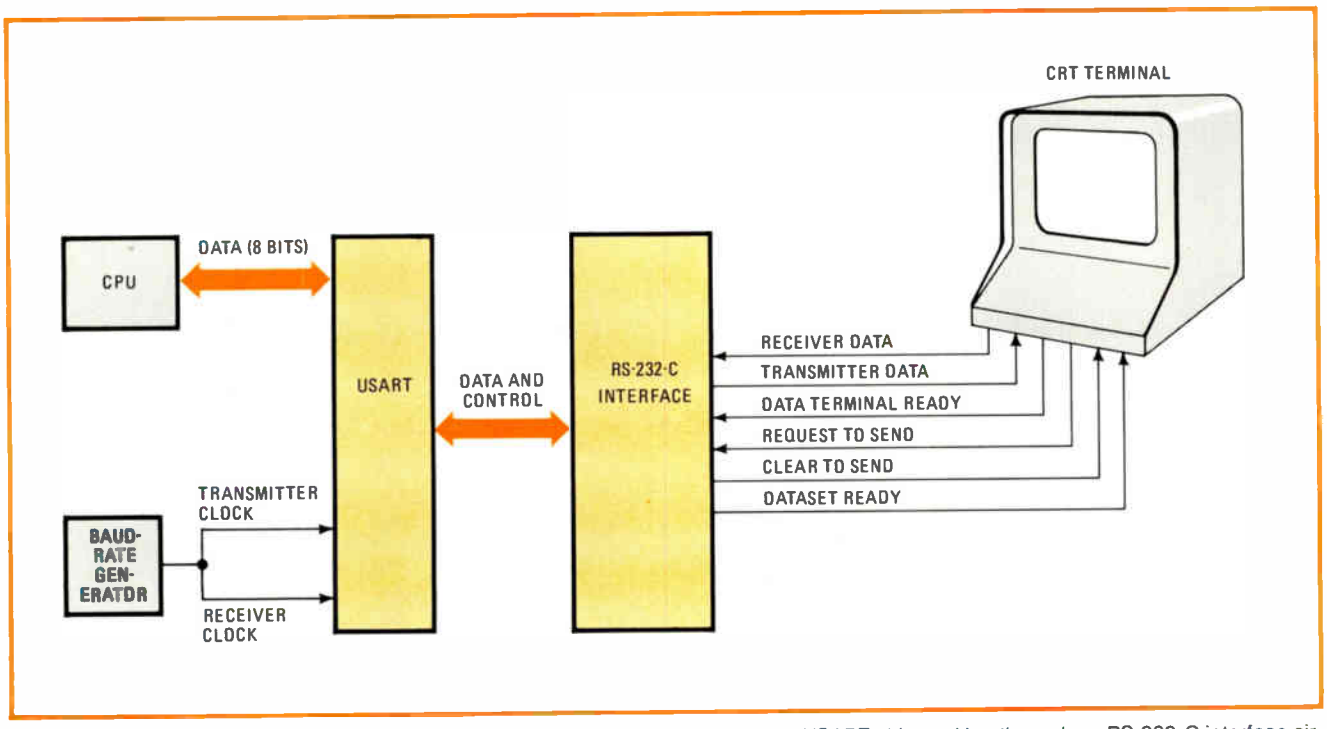
Second, the computer may have to communicate with terminals or remote equipment via serial data-transmission links. In applications such as distributed processing, an interface to a standard serial data-communications channel is usually essential. Such channels are most commonly used to link a host processor to remote satellite processors.

The programable USART's standard RS-232-C interface can be used to connect both synchronous and asynchronous communications devices to the SBC 80/10 (the other jumper-selectable interface connects to standard teletypewriter lines). The USART provides full-duplex operation; that is, serial/parallel data conversions can be made simultaneously in both directions.

The USART chip contains both receiver and transmitter buffers and control sections (see Fig. 3). As a transmitter, it converts data bytes (8-bit parallel data) into serial characters 5 to 8 bits long and inserts the desired control bits or characters. As a receiver, it strips out the control characters and assembles the data into parallel bytes, which are sent to the CPU. In its synchronous mode, the device also transmits characters to keep remote units in sync when the CPU is not sending data.

The system software specifies mode, number of sync characters, asynchronous rate (after the basic baud rate is jumper-selected, divisions of one, 16, or 64 can be programed), character length, number of stop bits, and odd/even parity. During initialization, mode-instruction words are sent by the CPU to a register on the USART chip.

Once the mode instructions (and sync characters if the synchronous mode is used) are loaded, the interface is ready for use. A command instruction controls the operation of the selected format. Functions such as enable, transmit/receive, error-reset, and modem controls are provided by the command instruction, Also, the CPU can read the status of a communications device at any time during operation. In data communications, a pro-



5. Serial application. A typical asynchronous communications application uses the USART chip working through an RS-232-C interface circuit to control a cathode-ray-tube terminal. Standard CRT control signals are processed by the USART via the RS-232-C interface.

cessor must often read device status to ascertain if errors have occurred or if other conditions require the processor's attention.

Generating and controlling interrupts

The USART can generate an interrupt request whenever a character is ready in the receiver buffer for the CPU or whenever the transmitter buffer is empty and the CPU can send out a character. A processing-and-control computer often must perform some specific task as soon as a set of parameters changes. Such changes include a control or keyboard-switch depression, an input from a sensor, or completion of a character-printing cycle by a terminal. Interrupt requests from the interface devices signify that such changes have occurred.

The SBC 80/10 has a single-level interrupt subsystem with as many as six potential sources that may be polled by a service routine: two in the parallel I/O (input buffer full, output buffer empty), two in the serial I/O (transmit, receive), and two that can come directly from specified devices via the I/O connector and system bus.

By means of maskable interrupt control, the SBC 80/10 CPU can determine whether or not an immediate response to the request is necessary. If so, the CPU accepts the interrupt, disables further interrupts, suspends the routine being executed, stores all pertinent system information in a RAM, and branches to a predesignated subroutine. When the interrupt has been processed and reset, the system information is retrieved from memory, and the interrupted routine is resumed.

The SBC 80/10 can be used in both small and large control systems. Figure 6 shows its use in a large distributed-processing system. For example, a pipeline company that already has a master control center might want to expand the control network by buying several remotely controllable systems from an OEM and linking them by telephone lines to the master control. Or, the OEM might use a similar host-satellite organization with other serial data channels for master and local control in a large multiphase process plant.

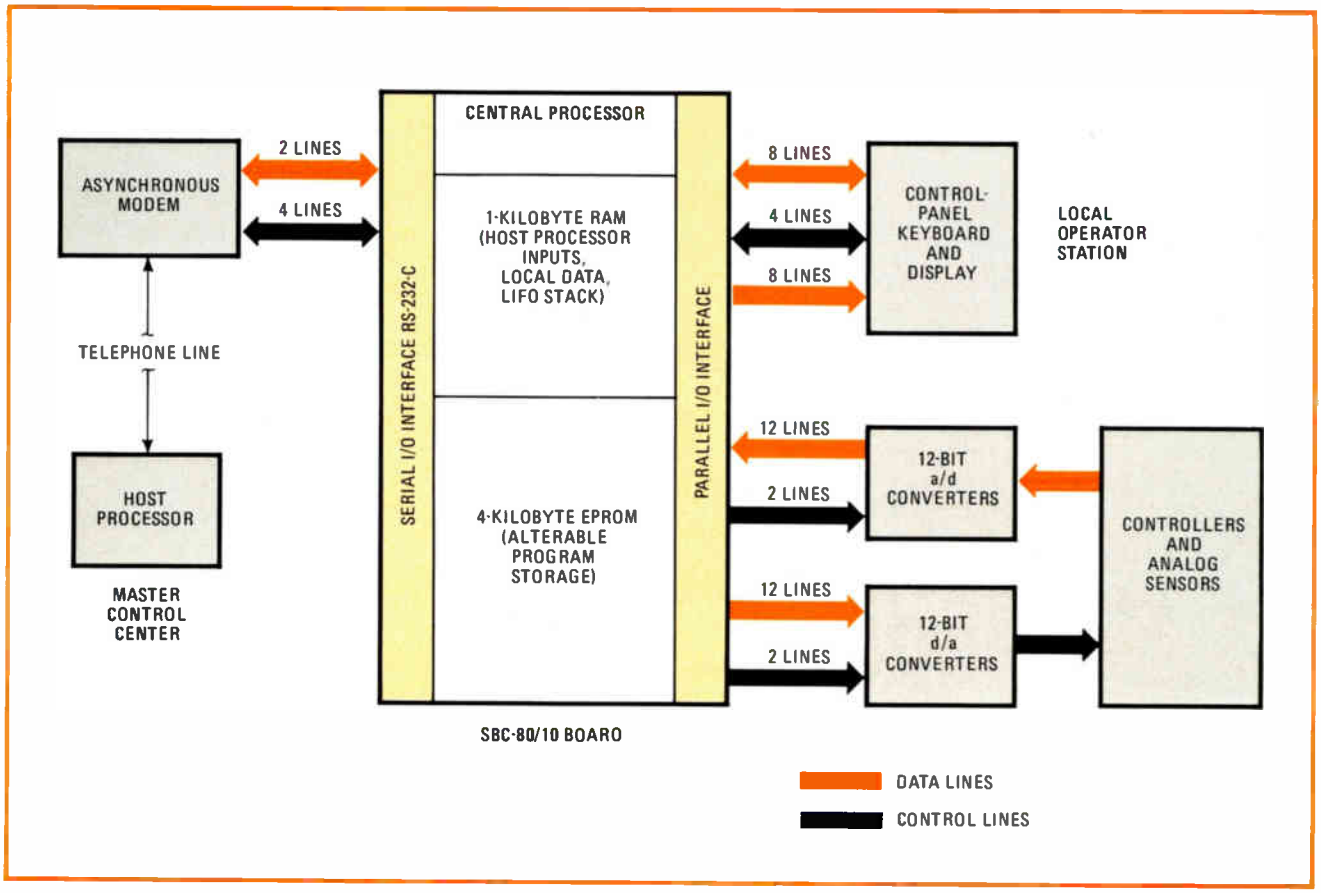
In this example, the OEM computer subsystem must communicate with the master control, calculate process-control parameters, transfer data to and from local controllers via d-a and a-d converters, accept information from a keyboard, and display system status. These requirements can all be met by variations of the I/O configurations previously discussed, so a single SBC 80/10 board in each satellite system can implement all the required functions, as in Fig. 6.

A communications link to the host processor is established throught the USART, RS-232-C line interface, an asychronous modem, and telephone lines. Through this channel, the host processor "down-loads" into the board's 1-kilobyte RAM critical process parameters such as those generated by supervisory commands. The USART's interrupts ensure that this information is processed as soon as it becomes available. Other data and control information are exchanged locally via the programable parallel I/O.

For example, a local operator may enter control information via the keyboard and observe system status on the display. The a-d converters may serve as interfaces for temperature and pressure transducers that provide process-feedback information to the computer. The d-a converters may provide the interface to controllers that modify flow rate and other parameters.

Expanding the system

The entire program for an application of this complexity can be stored in the 4-kilobyte ROM. Since con-



6. OEM system. A typical OEM system based on the SBC 80/10 computer would take inputs from remote controllers and analog sensors, as well as from a local keyboard, to transmit serial data through an asynchronous modem to a master control center.

trol algorithms are subject to occasional change, the OEM would probably use EPROMs in the ROM sockets.

Expansion boards are available for applications requiring memory or I/O capacity beyond that of the SBC 80/10. A modular backplane and card-cage unit can house and interconnect the basic SBC 80/10 board and a maximum of three expansion boards. These boards can be mounted in a standard Retma rack 3.5 inches high. Card-cage units may be expanded by plugging two or more sections together via backplane male and female extension connectors.

The following enhancements can be added by means of one special "combination board:"

- Four more kilobytes of RAM.
- A maximum of 4 more kilobytes of EPROM or ROM.
- A total of 48 additional programable parallel I/O lines with sockets for interchangeable line drivers and terminators.
- Another programable communications interface compatible with RS-232-C drivers and receivers.
- Eight interrupts channeled through one SBC 80/10 level. A register on the combination board contains all pending interrupts and allows the CPU to go to the appropriate service routine without polling the interrupt sources.

System development aids

The OEM may also choose optional 6-kilobyte or 16-kilobyte EPROM/ROM boards, a 16-kilobyte RAM board, or a general-purpose I/O-expansion board to expand the SBC 80/10 memory and I/O capacity.

The OEM may develop, debug, and execute software directly on the SBC 80/10 by means of the Intellec MDS and its In-Circuit Emulator, ICE-80 [*Electronics*, May 29, 1975, p. 91]. Program development is facilitated by a resident macro assembler, text editor, and optional diskette operating system. Debugging is accomplished by the execution of interactive English-language-type ICE-80 commands from the Intellec MDS system console. Debugging is further simplified by the capability to refer to critical programs, labels, and parameters by their symbolic names instead of absolute memory locations.

PL/M, Intel's high-level programing language [*Electronics*, June 27, 1974, p. 103], allows SBC 80/10 programs to be written in a natural algorithmic language. Also, PL/M eliminates the need to manage register usage or allocate memory. The Intel user's library contains numerous programs for OEM applications. Examples are peripheral drivers and test programs.

With all this support, the SBC 80/10 is a single-board computer that the OEM can easily integrate into his total system. Programable I/O allows designers to modify existing products and develop new products using the same computer-subsystem hardware. Finally, OEMs can begin product-line development with a standard low-cost computer subsystem and concentrate on meeting new end-user requirements. □

Power Schottky diodes—a smart choice for fast rectifiers

by David Cooper, Bryan Bixby, and Larry Carver,
International Rectifier Corp., El Segundo, Calif.

Recovery times are so much shorter than in junction diodes that Schottkys can operate two to three times faster

☐ In rectifier circuits that must switch at high speed with high efficiency, power Schottky diodes are ideal. They can switch on and off much faster than pn junction diodes, and they can operate with much lower power losses because they have about half the voltage drop of junction devices.

Admittedly, the Schottkys work over a narrower range of circuit conditions than junction diodes, so that they are more vulnerable to overstress from transients and the like. This gives them only a slender margin of safety beyond their maximum ratings: they will operate reliably only in a well-defined electrical environment.

Many designers, though, are not too clear on how Schottkys differ from junction diodes, including fast-recovery types. As a result, they may avoid Schottkys altogether or they may misuse them in their systems. But anyone who understands the basic characteristics of the Schottky diode finds it as easy to use as any other diode.

Inside the Schottky diode

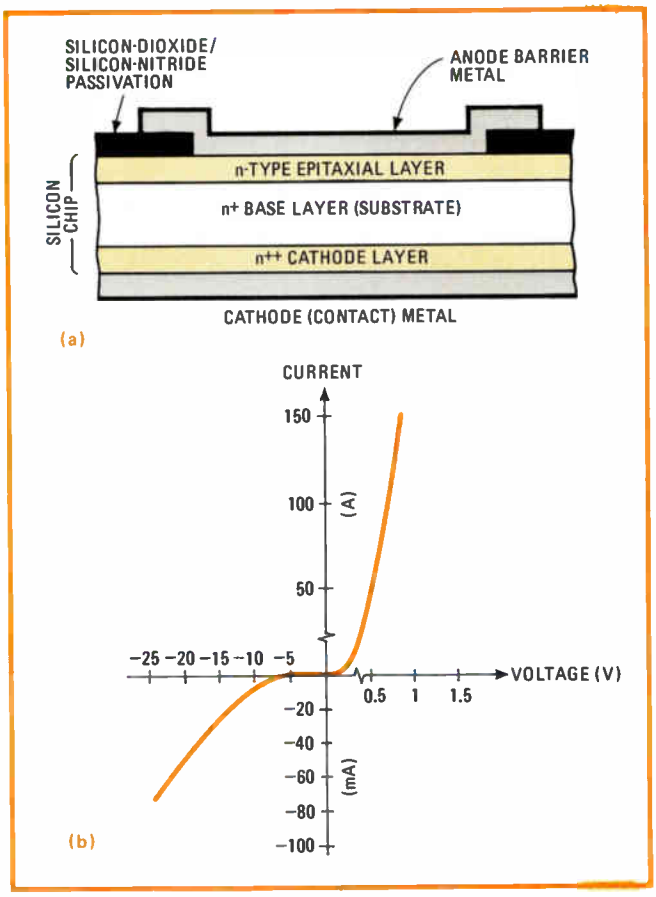
Figure 1(a) shows the basic device structure of a typical power Schottky diode. An n-type epitaxial substrate has a layer of metal deposited on it, and the interface between these two substances creates a large energy barrier. This barrier blocks electron flow until sufficient forward bias is applied.

In today's power Schottkys, arsenic commonly serves as the substrate dopant, and molybdenum is usually the barrier metal. The structure is generally designed to minimize forward voltage drop, rather than maximize reverse blocking voltage, a parameter determined by the chip's thickness.

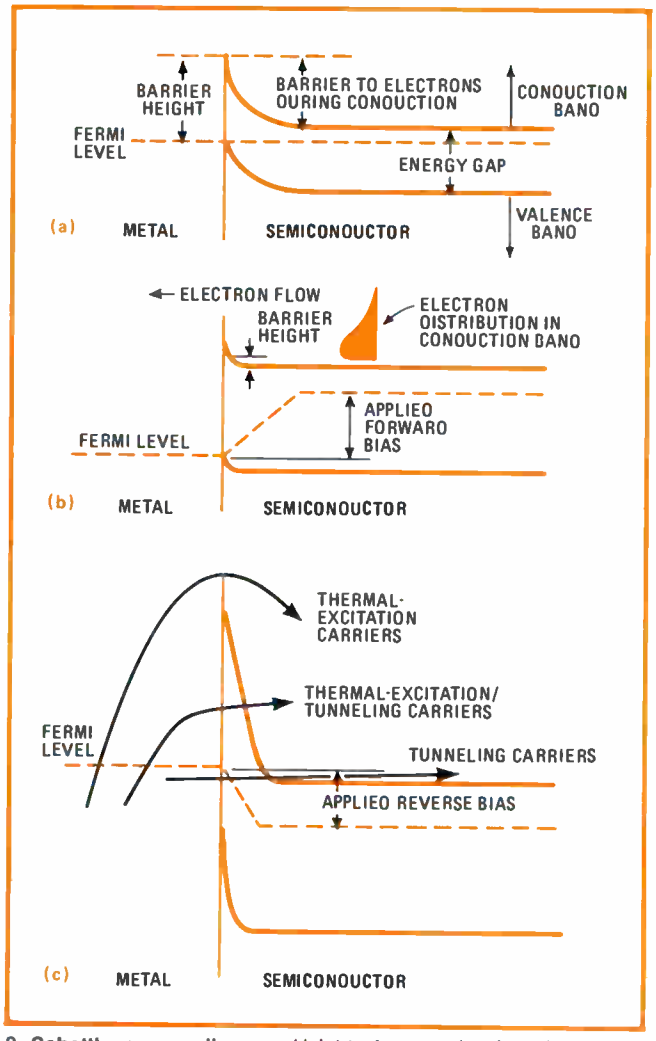
In the figure, the metalization overlaps the insulating oxide at the edge of the barrier region and acts as a guard ring. This guard ring, by reducing the electric field at the chip's surface, limits ion migration. It also makes the Schottky better at recovering from reverse voltages, even sudden ones, without any of the current crowding that could cause a device fault by melting the barrier metal. The recovery time of a diode is a measure of how quickly the device can switch from its full-conduction state to its full-blocking state.

The I-V characteristic of a typical power Schottky diode is shown in Fig. 1(b). In this case, the device's forward voltage drop is only 0.65 V for a forward current of around 100 amperes. For a similarly rated junction diode, the forward voltage drop generally would be from 0.3 to 0.6 V higher, making its forward dissipation also much higher. In a diode, forward dissipation is the power dissipated within the device—in other words, the forward voltage drop across the diode multiplied by the forward current through the diode.

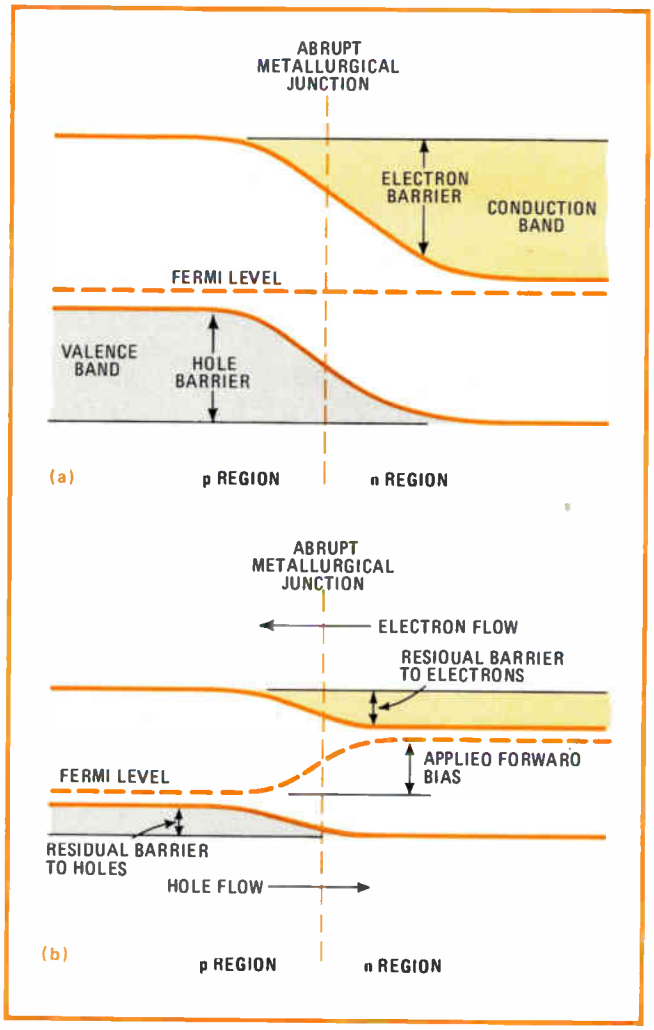
The energy-band diagram of Fig. 2(a) illustrates the relative height of the metal-semiconductor barrier in the Schottky when the device is unbiased. If a forward bias is applied as shown in Fig. 2(b), the height of the



1. Profile. Metal-semiconductor structure (a) of Schottky diode is usually fabricated to minimize forward voltage drop, not to maximize blocking voltage. I-V characteristic (b) of typical device shows that forward drop may be only 0.65 V even at forward current of 100 A.



2. Schottky energy diagram. Height of energy barrier (a) between metal and semiconductor is lowered by applied forward bias (b), permitting electrons to flow. In reverse direction (c), barrier height remains unchanged, and only small leakage current occurs.



3. Junction diode. When unbiased (a), this diode has energy barriers on either side of junction, making its forward drop higher than the Schottky's. Minority carriers, created during forward conduction (b), must be cleared out before the diode can block.

barrier is lowered, and the energy level of the conduction band in the semiconductor rises. Electrons can now surmount the barrier and pass into the metal.

If the applied forward bias is increased still further than in Fig. 2(b), even the small remaining barrier will be entirely wiped out. The only limit to current flow then is the series resistance of the over-all metal-semiconductor structure. Since no holes (mobile positive charges) are present in the metal, none can be injected into the semiconductor. The Schottky diode, therefore, is a majority-carrier device, in which only electrons are involved in the conduction mechanism.

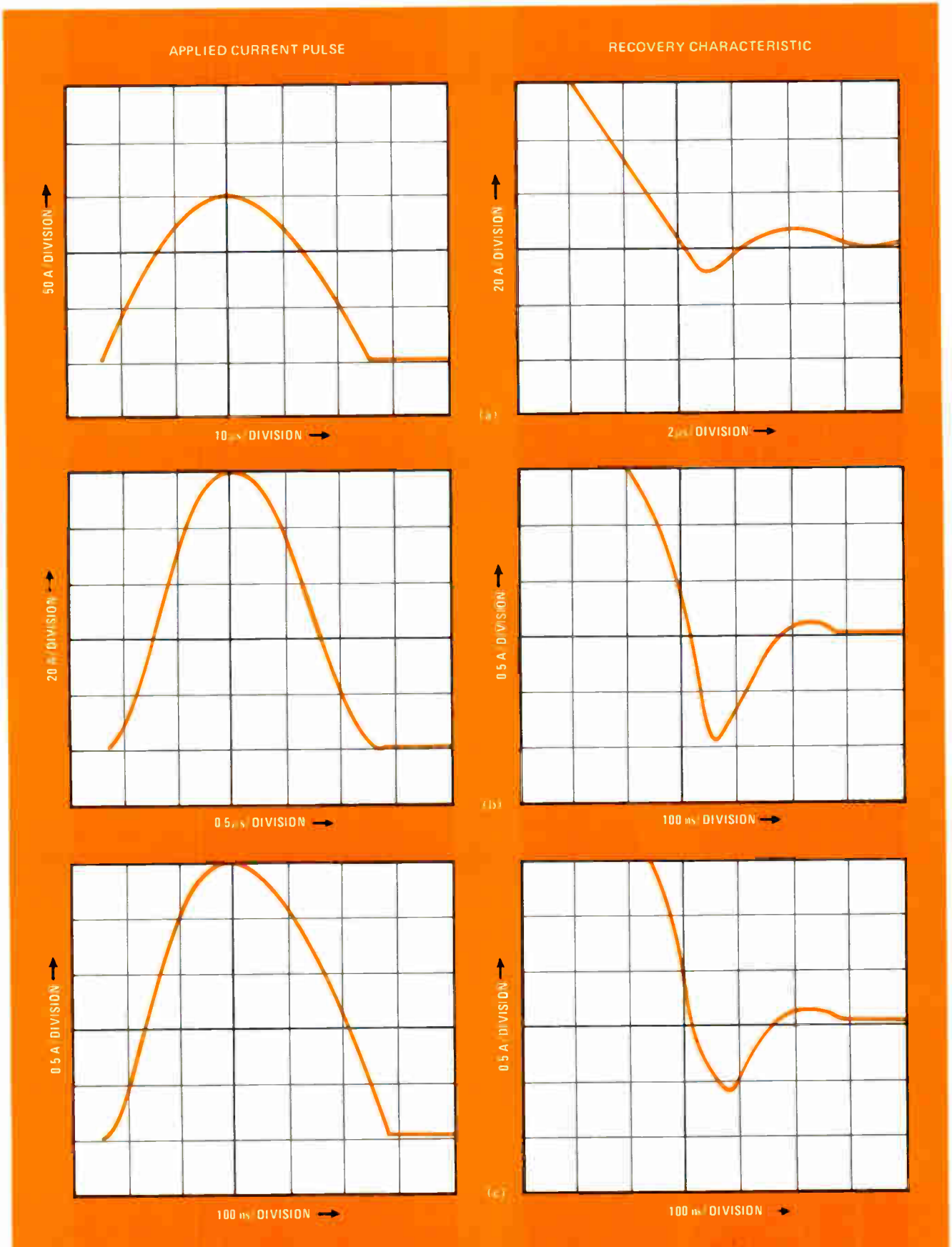
When the Schottky is reverse-biased, as in Fig. 2(c), the energy level of the conduction band in the semiconductor drops, and very little current flows since no change occurs in the height of the barrier. Only thermally excited carriers or tunneling carriers—those whose energy level is so high that they can tunnel through the barrier—are involved in the conduction mechanism. Therefore, reverse leakage current is relatively small in the Schottky diode.

In the device structure itself, the height of the barrier between the metal and the semiconductor can be adjusted to give the best compromise between forward voltage drop and reverse leakage current. Also, contact resistance must be very low to keep diode losses down and optimize operating speed. Furthermore, the interface between the barrier metal and the insulating layer creates a small capacitance that stores charge under reverse-bias conditions, thereby limiting the diode's ultimate recovery time. And since the Schottky is a majority-carrier device, the high-resistivity epitaxial layer must be very thin in order to minimize the device's series resistance.

Charge storage limits junction-diode speed

As shown in the energy-band diagram for the junction diode in Fig. 3(a), a barrier on each side of the junction gives rise to a much larger over-all forward-conduction barrier than exists in the Schottky diode. This is why the forward voltage drop of the junction diode is higher than that of the Schottky.

When the junction diode is forward-biased as shown in Fig. 3(b), holes in the n region and electrons in the p

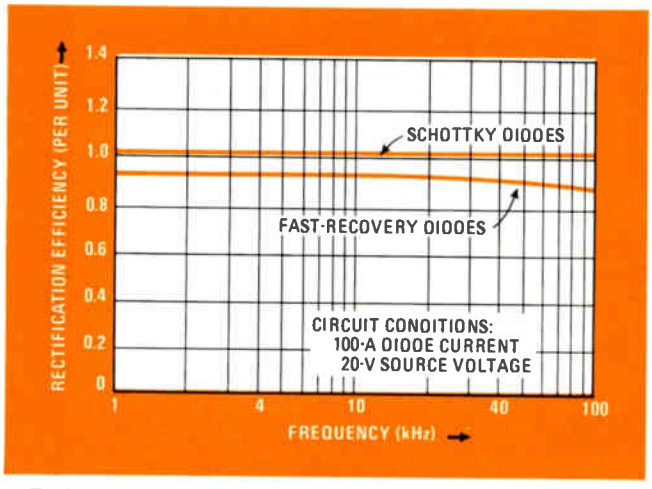


4. Recovery vs applied current. Recovery time of Schottky depends on amplitude of applied forward current pulse. Here, recovery time falls from about 2.5 μs for wide 150-A pulse (a) to approximately 175 ns for 100-A pulse (b) to around 150 ns for narrow 2.5-A pulse (c).

COMPARING SCHOTTKY AND FAST-RECOVERY DIODES

Frequency of operation (kHz)	Fast-recovery diode					Schottky diode				
	Static losses (W)	Switching losses		Total losses (W)	Rectification efficiency (%)	Static losses (W)	Switching losses		Total losses (W)	Rectification efficiency (%)
		Per cycle (W-s)	Total (W)				Per cycle (W-s)	Total (W)		
1	115	0.5×10^{-3}	0.5	115.5	81.2	65	3×10^{-6}	0.003	65.003	88.5
5	115	0.5×10^{-3}	2.5	117.5	81	65	3×10^{-6}	0.015	65.015	88.5
10	115	0.5×10^{-3}	5	120	80.6	65	3×10^{-6}	0.03	65.03	88.5
20	115	0.5×10^{-3}	10	125	80	65	3×10^{-6}	0.06	65.06	88.5
40	115	0.5×10^{-3}	20	135	78.4	65	3×10^{-6}	0.12	65.12	88.5
100	115	0.5×10^{-3}	50	165	75.2	65	3×10^{-6}	0.3	65.3	88.4

Circuit conditions: 500-W two-diode full-wave center-tapped rectifier, 20-V square-wave source voltage, 5-V output at 100 A



5. Evaluating efficiency. Over operating range of 1 to 100 kHz, efficiency of rectifier built with Schottky diodes changes hardly at all. But under same circuit conditions, rectification efficiency of fast-recovery diodes begins to drop off noticeably at around 30 kHz.

region become minority carriers that must be swept out before a blocking condition can be established. Storage of these minority carriers, rather than device capacitance, is what principally limits the operating speed of the junction diode. Like the Schottky, the junction diode also exhibits some capacitance under reverse bias, but the delay of recovery time due to this capacitance is very small compared to the effect of minority-carrier storage.

In the junction diode, the residual barriers that are formed on either side of the junction during forward conduction can be removed by increasing the applied bias further. Forward current flow then becomes limited by the series resistance of the over-all system.

The Schottky, on the other hand, because of its short recovery time, can rectify at relatively high operating frequencies. Of course, the size of the applied forward current influences the device's recovery time, as well as its reverse current.

Figure 4 shows the reverse recovery characteristics of a typical power Schottky at three different forward currents—for a 150-A, 50-microsecond pulse (a), for a 100-A, 2.5-μs pulse (b), and for a 2.5-A, 500-nanosecond pulse (c). Here, for the 100-A forward pulse, the device's recovery time is on the order of 175 ns, and its reverse or recovery current is below 1 A.

As already indicated, the speed with which a Schottky recovers is limited only by its capacitance, while the recovery speed of a junction diode is limited by minority-carrier storage. As a result, even under the same circuit conditions, there will be a significant difference—perhaps on the order of 150:1—between the recovery times of a Schottky and a junction diode. For example, for identical conditions, recovery time may be approximately 75 ns for a Schottky, but as much as 12.5 μs even for a fast-recovery junction diode.

Examining power losses

The shorter the recovery time of a diode, the smaller will be its average dissipation (the power consumed over time). The table compares the power losses and efficiency of two 500-watt full-wave center-tapped rectifiers, one built with two fast-recovery junction diodes and the other with a pair of Schottky diodes. The source voltage is a 20-V square wave, the rectifier output voltage is 5 V, and the rectifier output current is 100 A. The data is given for rectification frequencies ranging from 1 to 100 kilohertz.

(For this comparison, power loss was measured by calibrating a heat sink in terms of temperature rise, which can be related to diode losses. The test diode was then installed in the heat sink, and the temperature rise was measured while maintaining a constant output power at a given switching frequency. The actual losses dissipated in the diode were then read directly from the heat-sink calibration curve.)

The table shows both static losses and switching losses. Static losses are those incurred in the diodes when they are in either their full-conduction state or their full-blocking state. Switching losses, on the other hand, are those incurred in the diodes during their transition from one static state to the other. Because each diode recovers once each half cycle, the switching losses per cycle are simply double the switching losses per pulse. (Both static losses and switching losses can be

computed by simply multiplying the current through the diode by the voltage across it.)

As the data indicates, total losses for the junction-diode rectifier are about twice as large as those for the equivalent Schottky-diode circuit. Even at relatively low frequencies, Schottky diodes perform more efficiently than junction diodes. At 1 kHz, for instance, power loss is 50 W lower for the Schottky circuit. Furthermore, the efficiency of the Schottky rectifier changes by only 0.1% between 1 and 100 kHz. For the rectifier built with fast-recovery diodes, on the other hand, efficiency drops by 6% over the same frequency range.

The data in the table is illustrated graphically in Fig. 5, with the rectification efficiency normalized to the efficiency of the Schottky circuit. These curves show that the efficiency of the Schottky rectifier remains essentially constant over the entire frequency range, while that of the other rectifier decreases noticeably, by a factor of around 0.15.

A closer look at recovery

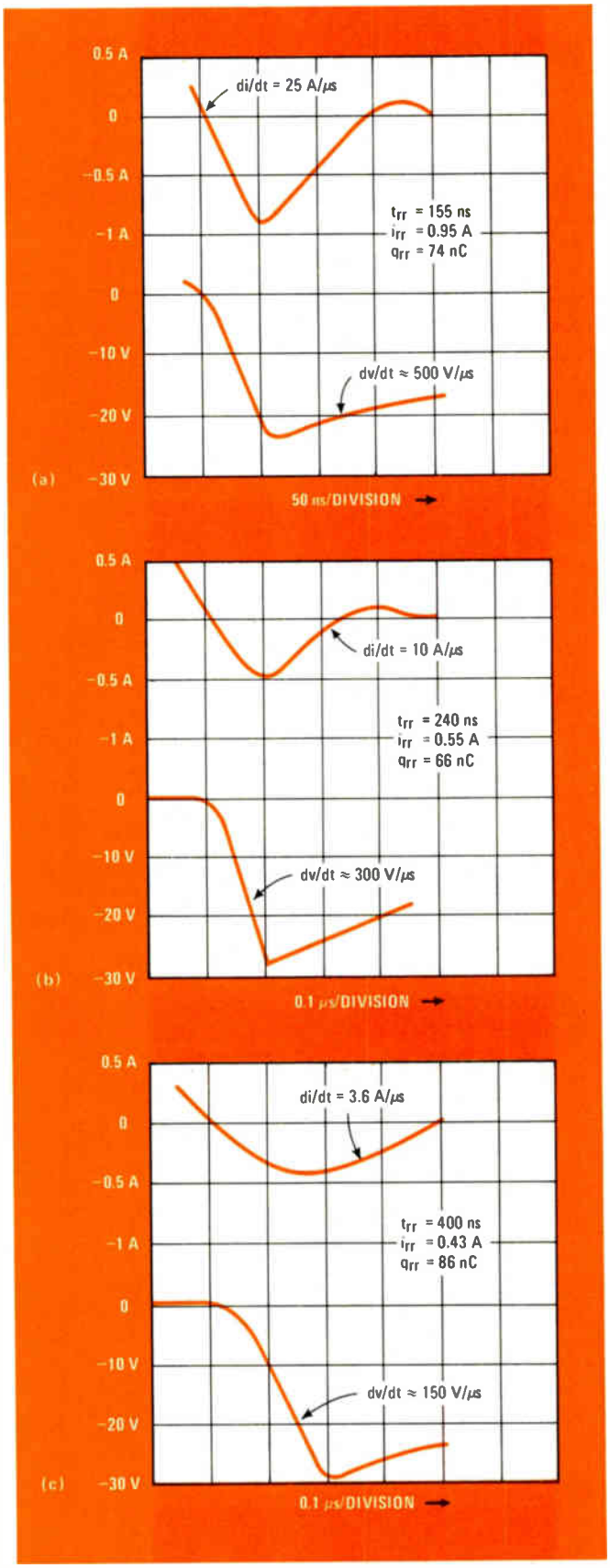
Because the diodes in a high-speed rectifier must switch on and off very quickly, the rate of change of the applied voltage that drives them off also influences diode recovery time and reverse current. The diodes must be able to respond to this steep applied reverse bias with as small a reverse current as possible in order to minimize switching losses.

Figure 6 shows the variation of recovery time (t_{rr}) and reverse current (i_{rr}) of a typical power Schottky for three different rates of change of the diode's off-state current (di/dt) and off-state voltage (dv/dt). In this case, the device's recovery time is 155 ns (a) for a di/dt of 25 A/μs and dv/dt of 500 V/μs, 240 ns (b) for a di/dt of 10 A/μs and dv/dt of 300 V/μs, and 400 ns (c) for a di/dt of 3.6 A/μs and dv/dt of 150 V/μs.

Despite this variation in recovery time, the amount of charge present during recovery ranges only between 66 and 86 nanocoulombs. This near-constancy of the charge is due to the near-constancy of the Schottky's capacitance. Therefore, although the recovery time becomes longer, the reverse current will be smaller. This means that the average dissipation through the Schottky will not increase, and switching power losses will be minimal.

In contrast, minority-carrier storage in the junction diode increases as the rate of change of its off-state current becomes steeper. As a result, the faster the di/dt of a junction diode, the greater will be the amount of charge present during recovery, the higher will be the reverse current, and the longer will be its recovery time. Under the same circuit conditions, recovery charge may vary by a factor of 10 in a junction diode, whereas it would stay essentially constant in a similarly rated Schottky.

Although power Schottky diodes are not available in as broad a range of ratings as power junction diodes, commercial Schottky devices now offer continous-current capabilities of 50 to 60 A at voltage ratings of up to 40 to 45 V. They are a wise choice for the designer who must build fast and efficient rectifier and switching-power-supply circuits. □



6. Closeup of recovery. The faster a Schottky is driven off, the shorter its recovery time. For typical device, recovery time increases from 155 ns (a) to 240 ns (b) to 400 ns (c) as rate of change of diode's off-state current (di/dt) and voltage (dv/dt) decreases.

Low-distortion oscillator uses state-variable filter

by Walter G. Jung
Forest Hill, Md.

The state-variable filter, which in any case excels as a flexible active-filter design block, can also be made to oscillate with only a little additional circuit complexity. With high-performance quad op amps now readily available, a single integrated circuit makes a ultra-low-distortion sine-wave oscillator with a output frequency of up to 5 kilohertz and three output phases for driving servo or instrumentation systems.

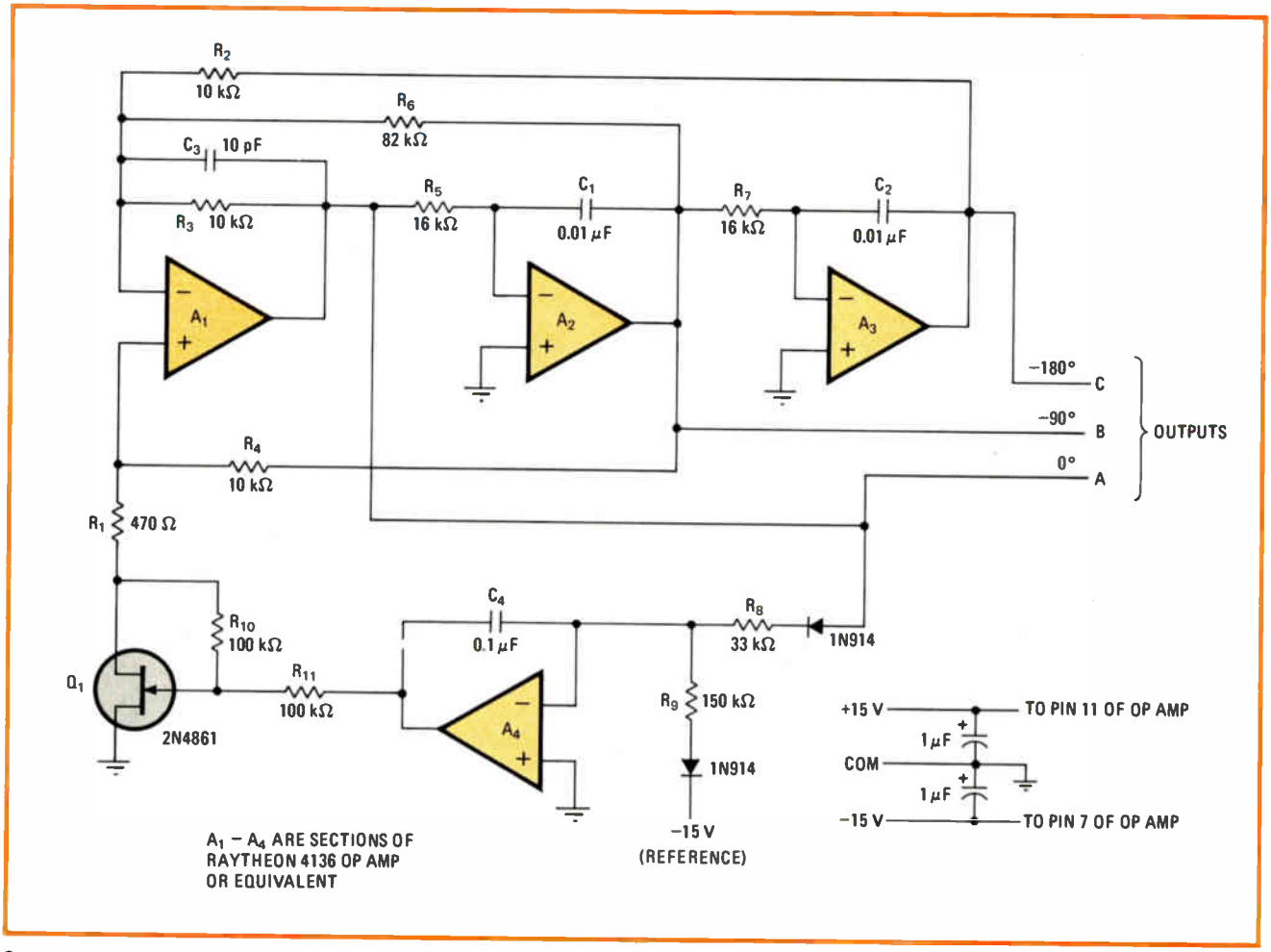
The schematic diagram shows the circuit of the oscillator. Operational amplifiers A_1, A_2, and A_3 comprise the state-variable filter, with its normal negative feedback path via R_4; positive feedback to sustain oscillation is provided by R_6. The oscillation frequency is given by:

$$f = \frac{1}{2\pi RC}$$

where R is the value of equal resistors R_5 and R_7 and C is the value of equal capacitors C_1 and C_2. For the circuit shown, f is 1 kilohertz.

As in other sine-wave oscillators, the positive and negative feedback paths must be carefully balanced to attain—and sustain—low-distortion operation. The balance is achieved by use of some type of automatic gain control; in this circuit the mechanism is the variable channel resistance of field-effect transistor Q_1.

The agc circuit in itself comprises an active loop that serves several important purposes. The integrator A_4 filters and smoothes the rectified output to provide a dc control voltage for the gate of Q_1. Low ripple on this control voltage is necessary to prevent modulation distortion on the output. The high dc gain of the integrator automatically adjusts the loop to the required dc bias for Q_1 in spite of parameter variations, thus eliminating



State-variable oscillator. Addition of regenerative feedback via R_6 changes state-variable filter into sine-wave oscillator with three phases of output. Filter uses three of the amplifiers in a quad op amp IC; the fourth amplifier is part of agc loop that ensures ultra-low distortion.

the necessity for device selection. The output voltage is regulated to a value that causes the average current in R_8 to be equal to that in R_9. Thus R_9 and the −15-v supply serve as a reference, and the agc loop tracks this reference to maintain the output peak voltage at about 10 v.

Resistors R_{10} and R_{11} provide a local feedback path around Q_1, to reduce distortion drastically below the straightforward connection. The high values of feedback resistance (100 kilohms) in relation to Q_1's "on" resistance (nominally 100 ohms) prevent undesirable interaction of the ac and dc signals.

In operation, the total harmonic distortion at the A output is on the order of 0.02%, and distortion in the B and C outputs is considerably less because of the low-pass filtering in the A_2 and A_3 integrator circuits. All outputs appear at the same level, with the phase relations shown.

The prototype of this circuit uses a Raytheon 4136 quad op amp, which has a 3-megahertz bandwidth. The Harris 4741, with similar ac characteristics, is another suitable unit. The Motorola 3403 and National 348, both 1-MHz devices, provide ultra-low-distortion performance at frequencies up to 2 kHz. The main asset of a quad device for this circuit is its cost-effectiveness—the entire circuit can be built for $10 or less. □

Two ICs make low-cost video-distribution amp

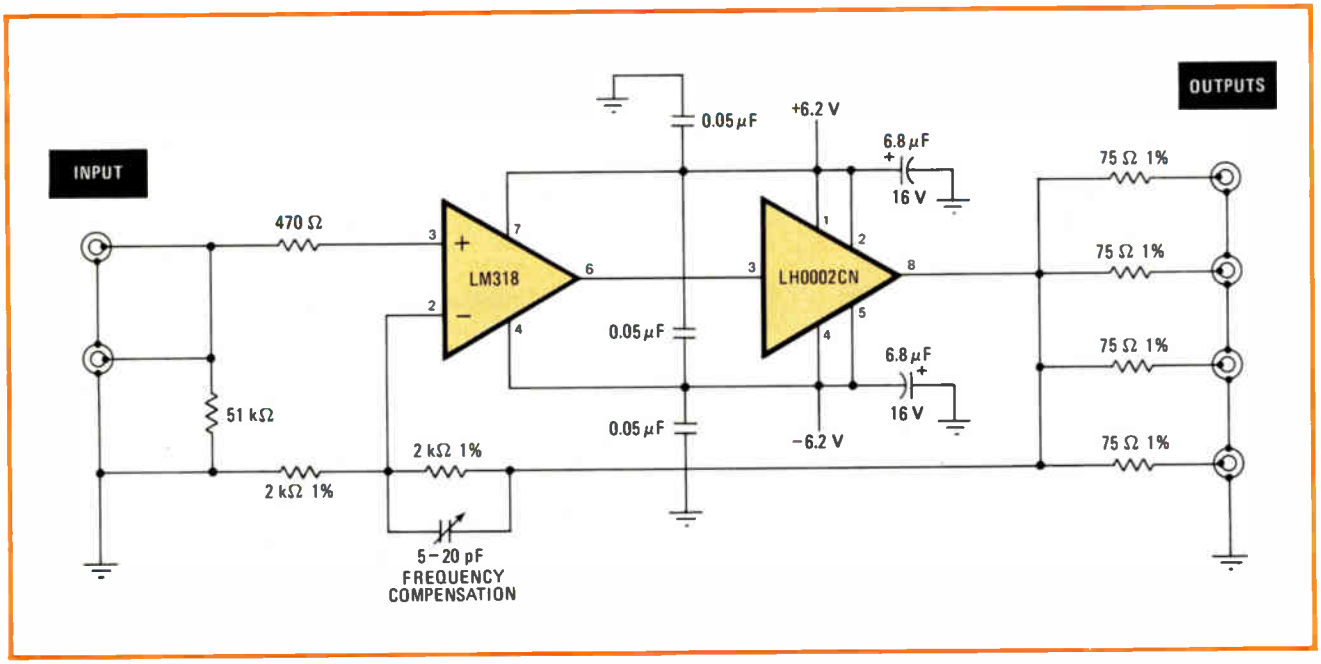
by M. J. Salvati
Sony Corp. of America, Long Island City, N.Y.

For less than $25 in parts, a video distribution amplifier can be constructed with all the features of commercial models selling for over $300. The circuit shown in Fig. 1 takes the 1-volt peak-to-peak output of a standard video signal generator or TV camera and provides four or more independent outputs that each deliver 1-v pk-pk video into 75-ohm loads. Two input connectors are mounted in parallel because the 50-kilohm impedance is high enough to permit "loop-through" connection, in which a second distribution amplifier is paralleled with the first by means of the second connector. If not used for loop-through, the second connector should be terminated with 75 ohms. The frequency response of the unit is flat from dc to 4 megahertz.

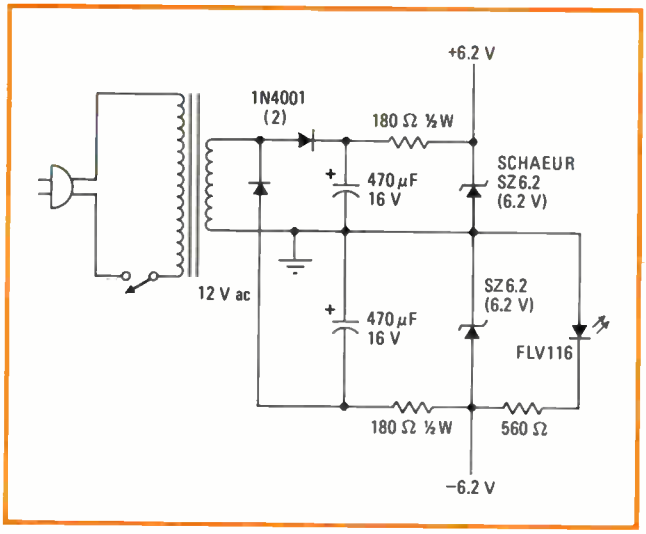
The video distribution amplifier circuit in Fig. 1 uses a National LM318 high-speed operational amplifier and a National LH0002CN current driver in a feedback loop. The resulting output impedance is so low that the output approximates a zero-impedance voltage source, so loads connected to the output resistors have no effect on each other. The 75-ohm output resistors provide the proper drive-source impedance for coaxial cable, short-circuit protection for the LH0002CN, and increased isolation between loads.

The only adjustment required is the frequency-response compensation capacitor. This trimmer is set to provide the same output amplitude with a 1-MHz sine-wave input as is obtained with a 10-kilohertz sine wave input.

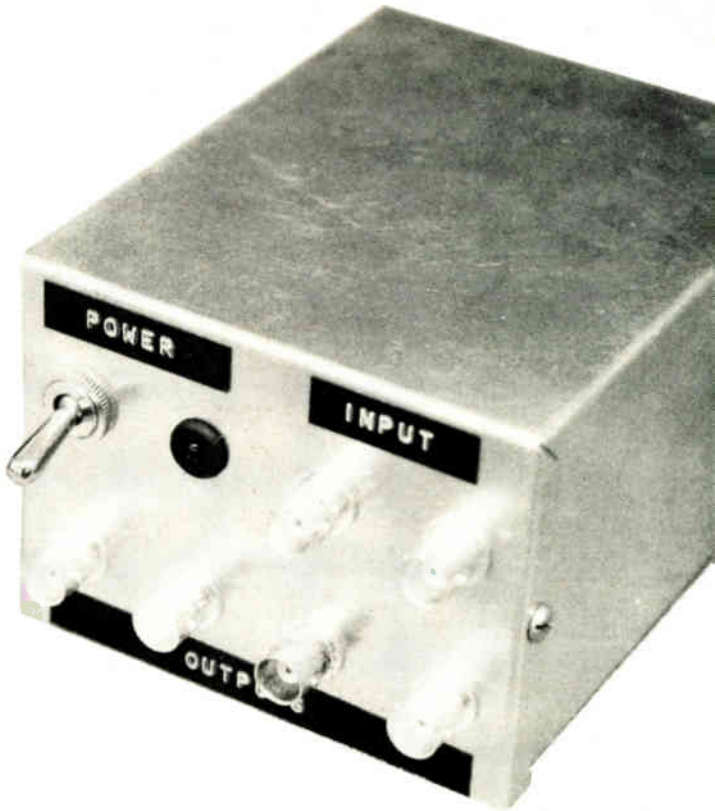
The 6.8-microfarad bypass capacitors should be tantalum electrolytics and should be installed close to the



1. Video distribution amplifier. Signal from TV camera or video signal generator is amplified to provide 1 v peak-to-peak at each of four outputs matched to 75-ohm loads. Second input connector can be used for "loop-through" connection of a second distribution amplifier or for a terminating resistor. Frequency-compensation adjustment balances stray capacitances, providing flat response from dc to 4 MHz.



2. Power supply. Compact supply uses zener-diode regulation to provide ±6.2 volts required for video distribution amplifier. This power supply and the amplifier shown in Fig. 1 are capable of driving more outputs than the four shown.



3. All packed up and ready to go. Amplifier-and-power-supply unit for 4-way distribution of video signals is packaged in metal box. Parts cost for complete assembly is less than $25.

LH0002CN pins. The 0.05-μF bypass capacitors should be disk ceramics installed as close to the LM318 pins as possible. The 75-ohm and 2-kilohm precision resistors must be noninductive types, such as metal film or carbon film.

The outstanding feature of this design is the low cost of the ICs implementing it. Although the slewing ability of the LM318 is insufficient to handle reliably a 2-V pk-pk output swing at 4 MHz, the amplitude of the highest-frequency component (color burst) in a standard composite video signal is only a small percentage of the overall amplitude, so the LM318 can easily handle a standard video signal.

The power supply recommended for use with this amplifier is shown in Fig. 2. Fig. 3 shows the complete video distribution amplifier and power supply unit packaged in a metal box. □

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.

Four-bit a-d converter needs no clock

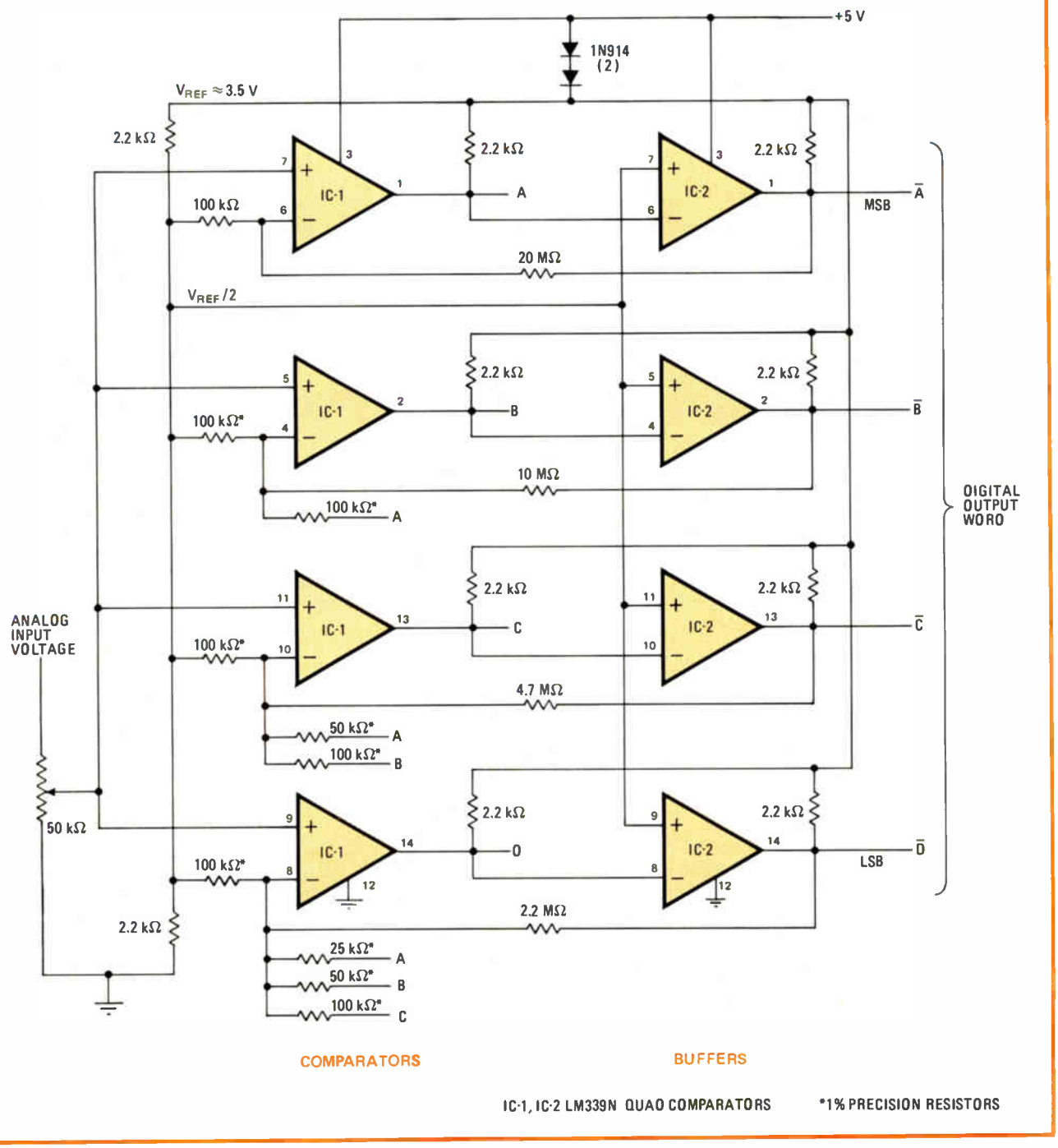
by Craig J. Hartley
Baylor College of Medicine, Houston, Texas

Many analog circuits utilize digitally controlled solid-state switches or multiplexers to adjust filter roll-off, amplifier gain, and the like; and in many such cases the adjustable parameter is itself a function of some analog voltage. As it happens, the 3-bit or 4-bit analog-to-digital converter required in such applications can be built from only three parts—a 5-volt supply and two quad comparators.

Other a-d converter designs generally include a counter, a clock, a d-a converter, a comparator, and other associated digital circuitry. In the design described here, however, the elements of one quad are used as comparators, while the elements in the other quad serve as buffers. The four outputs can drive TTL loads directly.

In operation the state of each output bit is determined in sequence, starting with the most significant bit. The reference voltage for each bit is determined by a resistor network at the inverting input of each comparator. The resistors are connected in a 1, ½, ¼ . . . sequence to ½ V_{ref} and the outputs of each of the more significant bits. The reference voltage for bit A (MSB) is always ½ V_{ref}. For bit B the reference voltage is ¼ V_{ref} if bit A (MSB) is low, or ¾ V_{ref} if bit A is high. The reference for bit C is ⅛, ⅜, ⅝, or ⅞ V_{ref}, depending on the states of bits A and B. The reference for bit D, the least significant bit, is 1/16, 3/16, . . . 15/16 V_{ref}. To eliminate unwanted output switching on input noise, hysteresis of about 0.02 volt is provided at each reference input by the 20-, 10-, 4.7-, and 2.2-megohm feedback resistors.

The full-scale input voltage is V_{ref}, which in this circuit is approximately 3.5 V. (The 50-kilohm potentiometer scales down higher input voltages.) The two diodes set V_{ref} at about 1.5 V below the 5-V supply to satisfy the maximum input conditions of the National LM339



Four-bit a-d converter. This conversion circuit uses negative feedback to match the digital output word to the analog input voltage one bit at a time. It distinguishes 16 voltage levels between 0 and 3.5 V. This converter does not require a clock, a d-a converter, or digital signals for operation, which makes it convenient for driving a digitally controlled switch in a system where all other elements are analog.

comparators and also to make the output voltage compatible with TTL. The output voltage is approximately 0.14 V (low) or 3.5 V (high). Because the comparator-buffer pairs are complementary (one is off while the other is on), the current through the diodes is nearly constant, making V_{ref} independent of the output states. Total supply current is about 8 milliamperes.

The digital outputs track the analog input with a worst-case acquisition time equal to the sum of the propagation delays of each comparator. This sum ranges from 1 microsecond up to 5 μs for the 339 comparator, depending on the rate of change of the input. A faster comparator would shorten the acquisition time significantly. Accuracy is controlled by the matching of the resistors indicated by an asterisk in the figure.

Compatibility with other logic forms can be achieved by adjusting the supply voltage, V_{ref}, and the load resistors on each comparator. □

Digital techniques promise to clarify the television picture

While broadcasters like digital television for its advantages in signal processing, the ultimate payoff will be to improve picture quality for the viewer

by A. A. Goldberg, *CBS Technology Center, Stamford, Conn.*

☐ Digital technology is now invading the biggest bastion of the analog world—television. However, television broadcasts, at least in the United States, will remain analog for many years to come because the 120 million home-television receivers are analog. Broadcasters, regulated by the Federal Communications Commission, must adhere to the specifications of the National Television Standards Committee.

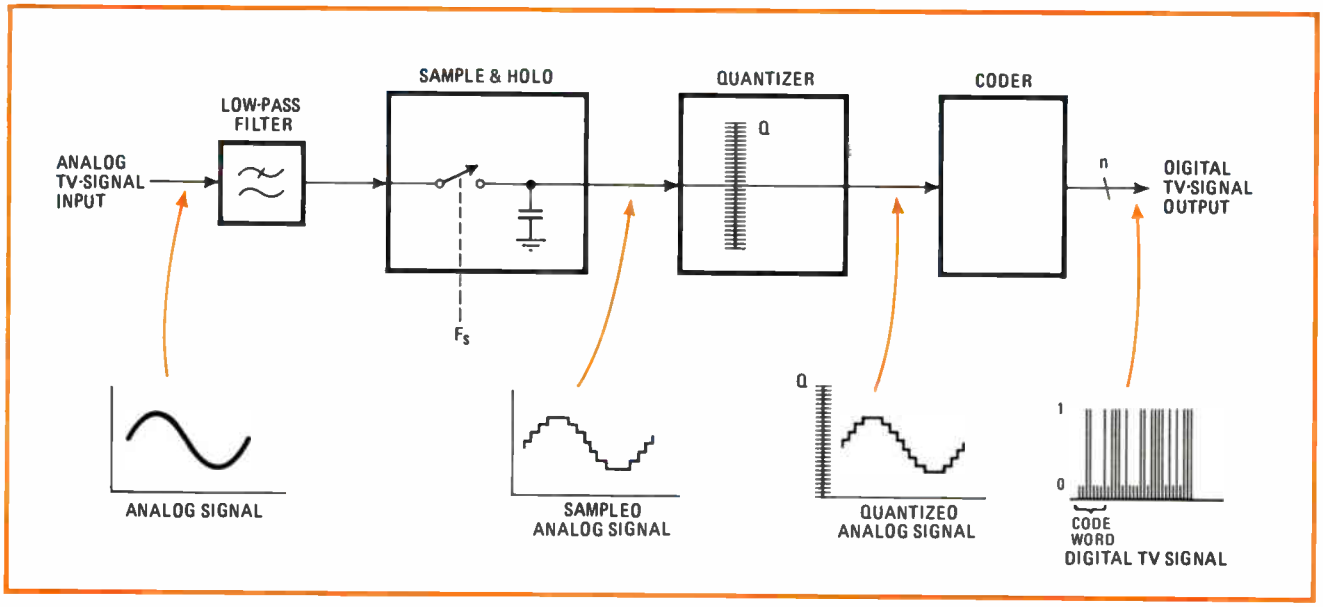
Nevertheless, broadcasters—abroad, as well as in the U. S.—are developing the technology for digital processing of TV signals before they are transmitted in analog form. The primary advantage of digital processing would be that negligible controllable distortion is substituted for the less controllable signal distortion to which analog signal processing is susceptible.

Digital television signal processing would also be better than analog processing because:

- Digitial circuitry, which is more reliable and stable, is immune to noise. These characteristics improve picture quality.
- Selected video information can be stored in digital memory for any length of time and read out in real time or at higher or lower speeds.
- Digital signals can be delayed, time-stretched, or compressed easily.
- Digital television facilitates conversion between the various types of international television signals—NTSC, PAL, and Secam.
- Digital television lends itself more readily to automation of broadcast stations through control by digital computers.
- In digital television, the channel-information capacity is proportional to bandwidth. On the other hand, in analog systems, the signal-to-noise ratio is improved at the expense of bandwidth so that the channel-information capacity is proportional to the logarithm of bandwidth.

The most telling argument against digital television is that high bit rates require greater bandwidth. For instance, a channel of W hertz can carry 2W bits per second. As a result, the 8-bit pulse-code-modulated signal of 86 megabits per second would require at least 43 MHz, which is 10 times the base bandwidth of the analog NTSC signal.

Nevertheless, circuit costs depend not only on bandwidth, but also on signal-to-noise ratio; that is, the cost



1. Conversion. Converting the continuous analog TV signal to the discontinuous "steps" of the digital signal requires three procedures: sample and hold, quantizing, and encoding. The analog TV signal is sampled at a constant rate, F_s, in a sample-and-hold circuit.

of channel information capacity in bits per second at a given error rate. And modified binary codes can be employed to reduce the bandwidth at the expense of the bit-error rate. However, the desired bit-error rate of 44.736 megabits per second is now being achieved only in the laboratory.

Examining digital processing

In digital television, picture and sound signals are transmitted by pulse-code modulation in the form of digital numbers much like data signals used by digital computers. In contrast to the continuum of the analog signal, the digital signal is discontinuous and is handled one sample at a time.

Signals in binary encoded form can be transmitted any distance through multiple circuits so long as the digital coding can be recognized. Although errors and distortion can result when the digital wave forms are excessively warped by noise, errors can be corrected by adding a few bits of redundant information. One error in every 10^8 bits, or an error rate of 10^{-8} is practically undetectable in a digital TV picture. Error-correction techniques will permit the channel error rate to be 10^{-5}, which still makes acceptable pictures.

Digital signal processing requires that analog sound and color pictures be converted to digital forms and back again before broadcasting. The conversion to digital signals involves three basic steps—sampling, quantizing, and conversion of the quantized samples (Fig. 1).

The analog TV signal is sampled at a constant rate (F_s on the flow chart) in a sample-and-hold circuit. This constant rate is usually locked to an integral multiple of either 3 or 4 times the 3.58-megahertz NTSC color subcarrier, F_c.

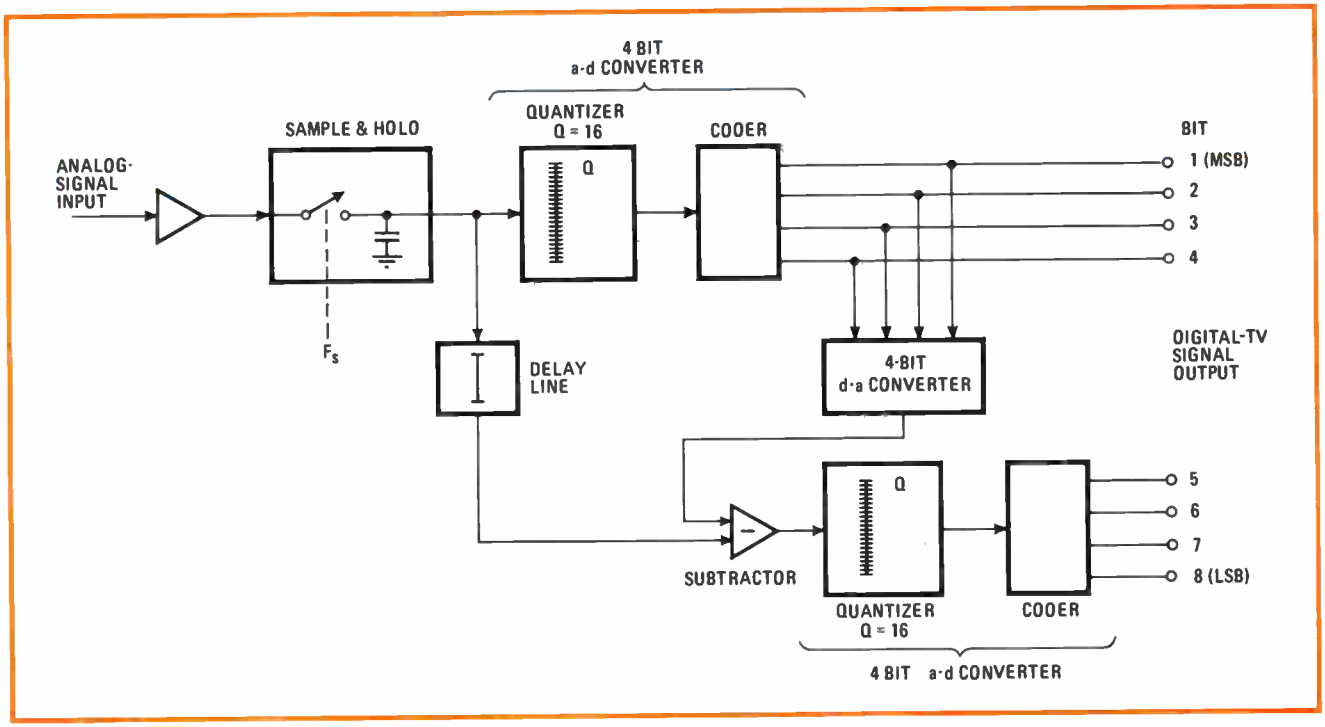
The amplitude of each sample is measured and assigned to one level of a total quantity, Q. The quantity, Q, is the number 2 raised by an integral power n, which is the number of bits in the binary code word. Thus, $Q = 2^n$, so that a 6-bit code word can describe 64 quanta; 7 bits, 128 quanta; 8 bits, 256 quanta, and so on. The value of Q doubles whenever n is increased by 1 bit.

Each quantized sample is converted into a binary number or code word of n bits. A code word may be transmitted in parallel over parallel lines where each of the n bits occurs simultaneously, or the code-word bits can be handled serially over a single line. The bit rate, nFs, for pulse-code-modulated NTSC color television signals ranges from 75 to 114 megabits per second unless some means of bit-rate reduction is employed.

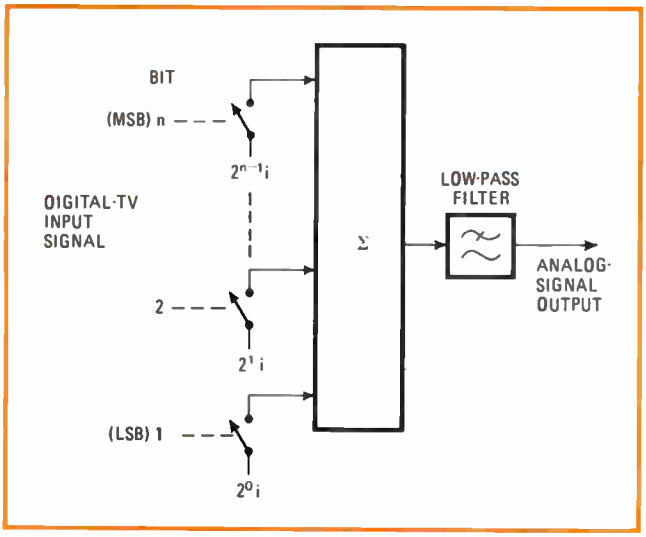
CBS Technology Center has developed an 8-bit analog-to-digital converter for color-TV transmission that operates at a 20-MHz encoding rate. It's organized in a 4-bit-by-4-bit feed-forward configuration. The 4 most significant bits (MSBs) are encoded first, then each of these is more finely encoded to produce the 4 least significant bits (LSBs) (Fig. 2).

The digital-TV signal is returned to analog form in a digital-to-analog converter (Fig. 3). Each code word operates a set of electronic switches controlling the summation of binary weighted currents. The LSB current is 2^0i, and the next most-significant-bit current equals 2^1i. The nth MSB then equals $2^{n-1}i$. This decoding is complementary to the coding process that takes place in the a-d converter. A low-pass filter following the d-a converter removes the high-frequency sampling components from the video signal.

On a black-and-white television screen, the digital picture can be described as a rectangular array of elements, called pixels, each of which has a quantized brightness corresponding to the average luminance of



2. Analog In. This 8-bit a-d converter, developed by CBS Technology Center, encodes at the rate of 20 MHz for color-television applications. It is organized in a 4-bit-by-4-bit feed-forward configuration so that the 4 most significant bits are encoded first.



3. Digital in. To get digital TV signal back to analog, each code word operates a set of switches that control summation of binary weighted currents. A low-pass filter removes sampling components.

the scene around each pixel. Enough pixels are quantized finely enough to closely approximate the original scene. A color-TV picture is similar, except that the red, green, and blue chromaticities are shown at the correct intensity at each pixel.

Deciding code-word size and sampling rate

An 8-bit PCM television signal that has been quantized to 256 levels differs from the original analog signal by a maximum of ±0.2%, or ±½ LSB. The continuous analog signal is replaced by a series of digital "steps," in this instance, 256. This source-dependent uncertainty, where the digital "step" follows the analog "line," is called the quantizing error, Eqe. It's also called quantizing noise because Eqe appears random to the eye when encoded with 6 or more bits.

However, the source-dependency of Eqe becomes quite obvious in pictures encoded with words shorter than 6 bits. For example, the photograph of the TV monitor of a composite NTSC video signal encoded by 8-bit PCM signals (Q = 256) is indistinguishable from the original analog picture (Fig. 4). The quantizing errors that result when the same signal is encoded with 3-bit words (Q = 8) are clearly visible in Fig. 4.

Mathematically, the quantizing error, Eqe, can be expressed as the root-mean-square value of Q, and it is approximately equal to $(Q^2/12)^{1/2}$, where 12 is a constant of a triangular approximation of the wave form.

The equivalent signal-to-error ratio (SER) of a pulse-code-modulated signal is the ratio of the signal's peak-to-peak value to the rms value of Eqe. For codes of 4 or more bits, the SER is 6.02n + 10.8 dB. Theoretically, when n = 8 bits, the SER is 59 dB, and for each 1-bit reduction in resolution, the SER is reduced by 6 dB.

Actually, the unweighted SER of a composite PCM color-TV signal is about 4 dB poorer because of the bandwidth-limiting of the quantizing error, safety factors in the quantizing range, and the way NTSC signals are measured. Thus, 8-bit PCM encoding of a noise-free NTSC composite color signal yields a SER of 55 dB.

Digital signal processing begins

Although much of the activity in digital television to date has been experimental, digital equipment became available three years ago to television-broadcasting plants in the form of digital time-base correctors.

To eliminate the film-processing time, teams of newsgatherers have begun to use small color-TV cameras instead of film cameras. Information is recorded on compact helical video-tape recorders, but these images are usually not stable enough for broadcasting until the reproduced signals have been time-base corrected. A digital time-base corrector consists of a PCM coder/decoder combination (codec) to detect the timing errors of the video signals, together with digital variable delay lines to cancel timing errors.

Another piece of equipment, the digital standards converter, which converts NTSC 525-line, 60-field TV signals to PAL 625-line, 50-field TV signals is also being used in England. With it, accurate digital stores replace a complicated analog standard converter that requires numerous quartz ultrasonic delay lines. Similar devices will soon be used in the U. S. to facilitate the international exchange of TV programs.

With the advent of the digital signal synchronizer, it is no longer difficult to time-lock video signals from remote points to local programing. This device is basically a variable-length digital store that automatically delays the remote signal from zero time to one TV frame (0 to 33.3 milliseconds) to synchronize precisely the remote and local TV signals.

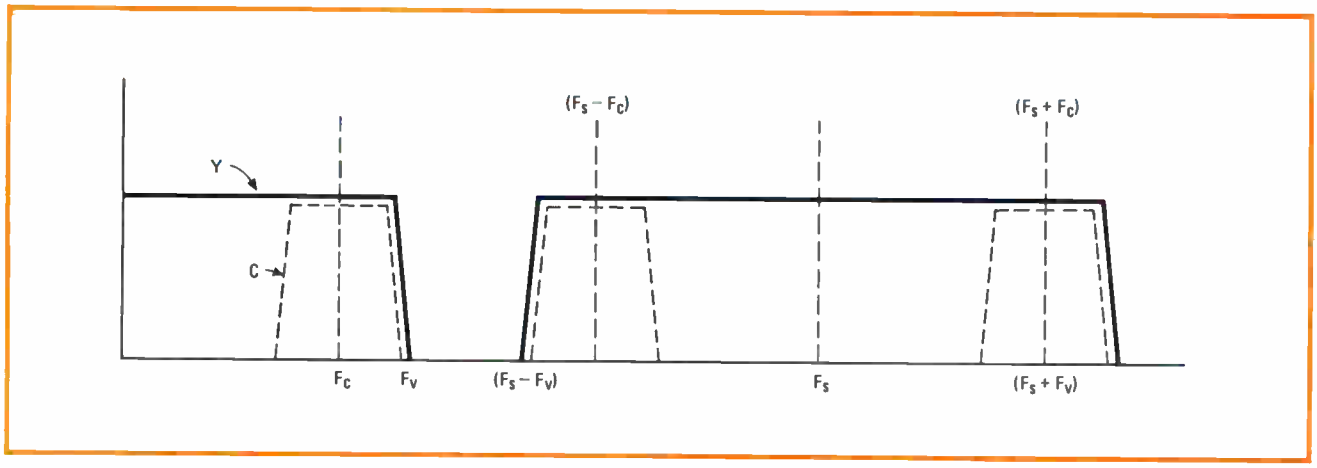
Installation of these "digital boxes" into television plants poses a major problem, however. Each digital device introduces another codec in the signal path with a resulting increase in quantizing error. To keep the quality of TV pictures acceptable, usually no more than three or four codecs should be connected in tandem.

However, if these digital boxes are eventually interconnected via digital links, the problem of too many codecs will be solved. It will be necessary to develop digital standards for the entire broadcast industry before these digital links can be formed, and that, unfortunately, may take years.

When a single analog-to-digital and digital-to-analog combination, called a codec (for coder/decoder), was used in a circuit, 7-bit PCM encoding produced acceptable pictures in subjective tests by the British Broadcasting Corp. of PAL-standard TV pictures and by CBS of NTSC pictures. However, because three or four codecs may well be used in a circuit, 8-bit encoding is recommended to ensure an acceptable SER (see "Digital signal processing begins," above).

Also to limit the bandwidth, it is desirable to minimize the bit rate by using the lowest possible encoding rate, F_s. However, the Nyquist sampling limit requires at least two samples per cycle of the highest video frequency, F_v, so that F_v can be reconstructed in continuous form. Therefore, F_s equals or is greater than 2 F_v, and if F_v = 4.2 MHz for NTSC signals, then F_s equals or is greater than 8.2 MHz. However, F_s should be at least 20% higher, or about 9.8 MHz, to compensate for the re-

4. Clear picture. A composite NTSC video signal that has been encoded by 8-bit pulse-code modulation produces a good picture (top) on TV monitor. But same picture (bottom) with 3-bit encoding shows disturbing quantizing errors that would make it unsuitable for broadcasting. Therefore, it is necessary to find optimum bit-code rate without increasing bandwidth.



5. Keep it clean. The frequency spectrum of the video signal, F_v, sampled at the rate F_s, shows that the video signal can be recovered without distortion if the lower sideband, $(F_s - F_v)$ does not overlap F_v. If there's overlap, comb filters are required to remove alias-distortion.

sponses of the low-pass filters before and after the codecs.

The frequency spectrum of the video signal F_v sampled at the rate F_s is shown in Fig. 5. The base-band frequencies to F_v can be recovered without distortion if the lower sideband $(F_s - F_v)$ does not overlap F_v. There is no overlap when F_s is equal to or greater than $2F_v$. When there is overlap, the alias-distortion products cannot be removed by ordinary filters; relatively complicated comb filters are required.

Theoretically, the encoding rate can be as low as 9.8 MHz, but fewer beats will be visible if F_s is an harmonic of the NTSC color subcarrier frequency, F_c. Saturated colors represent significant energy at F_c, as well as at the sidebands $(F_s \pm F_c)$. Circuit deficiencies can cause these components to beat against each other, but the beat frequencies become zero wherever F_s is locked to an integral multiple of F_c to eliminate the spurious patterns.

The two encoding frequencies of interest, therefore, are $F_s - 3F_c = 10.74$ MHz, and $F_s = 4F_c = 14.32$ MHz. The former affords the lower bit rate, and the latter provides the higher video frequencies through the digital TV system. An encoding frequency $F_s = 2F_c = 7.2$ MHz would be below the required Nyquist rate. More than $4F_c$, on the other hand, would be a wastefully excessive bit rate. The broadcasting industry is presently examining whether the $3F_c$ or $4F_c$ encoding rate is better.

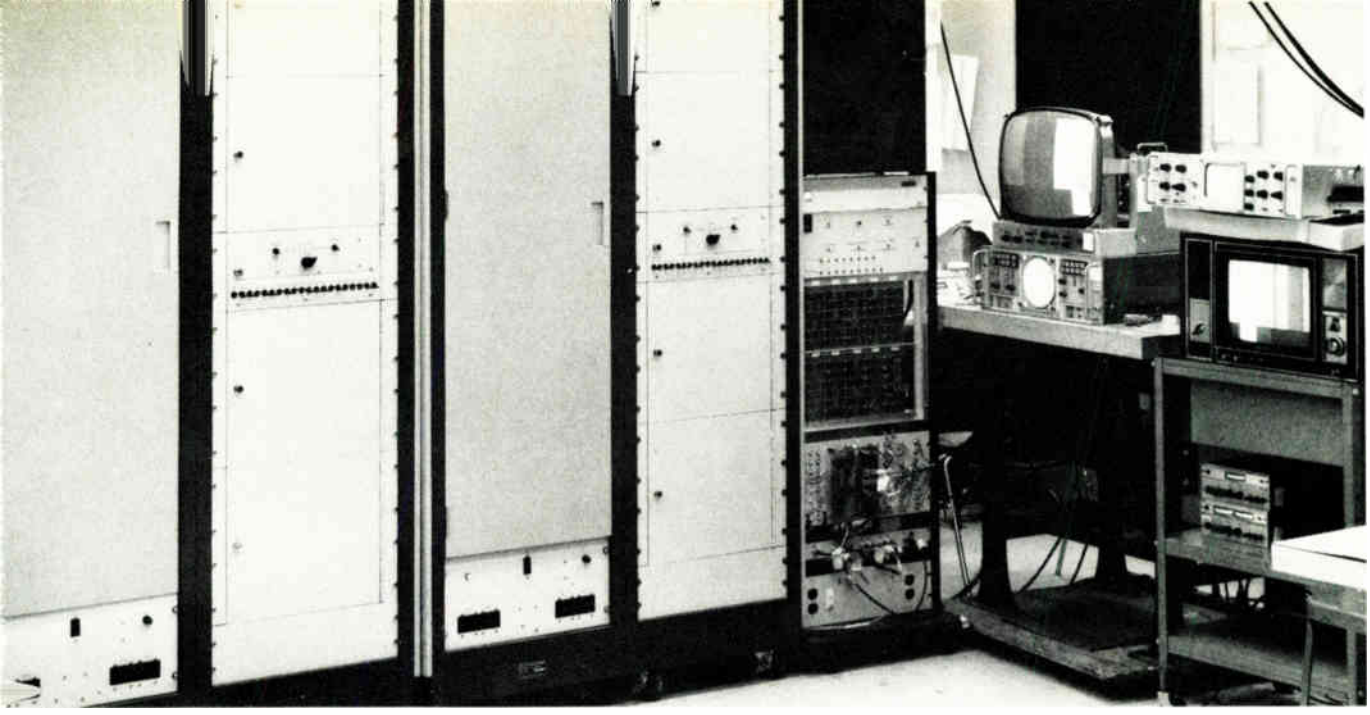
As noted earlier, a bit-error rate of 10^{-8} is practically undetectable in digital-TV pictures. To limit the circuit to that error level, the SER may be 21 dB (Fig. 6). When error-correction bits are added, Fig. 6 shows that the SER on a channel may go as high as 18 dB.

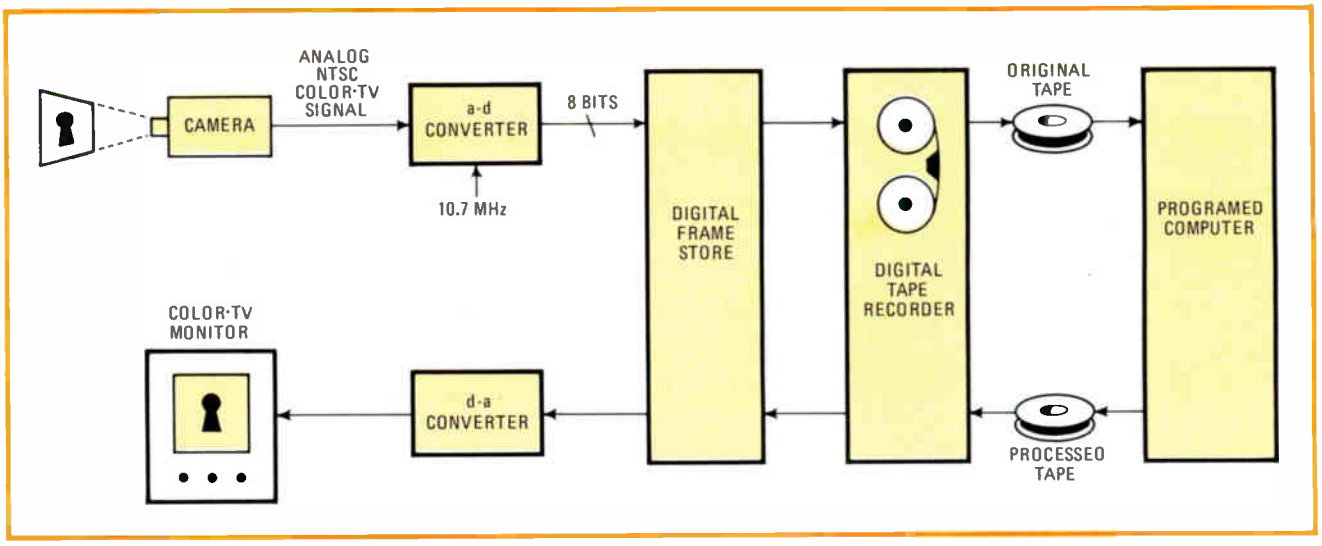
According to these criteria, the 86-Mb/s PCM signal can be transmitted on one wideband 43-MHz channel or multiplexed on 10 narrow-band 4.3-MHz parallel channels. Either way, the SER need not exceed 18 dB for ac-

6. Correction. Because digital errors can be corrected in television signals, error rate, p_e can be increased to 10^{-5}, and channel signal-to-error ratio may go to 18 dB without destroying picture.

FOUR-LEVEL CODING		EIGHT-LEVEL CODING	
SIGNAL LEVEL	BIT GROUP	SIGNAL LEVEL	BIT GROUP
4	1,1	8	1,1,1
3	1,0	7	1,1,0
2	0,1	6	1,0,1
1	0,0	5	1,0,0
		4	0,1,1
		3	0,1,0
		2	0,0,1
		1	0,0,0

7. Bettering binary. It's possible to reduce bandwidth—at the expense of increased error rates—by using four-level 2-bit coding or eight-level 3-bit coding, which cuts bandwidth to one half and one third, respectively, of that needed for transmitting binary coding.





8. Simulation. The digital frame-store-to-computer interface (top) is part of a computer-simulation procedure set up to examine the effectiveness of bit-reduction algorithms. A semiconductor frame store is used to grab and circulate one frame of TV signal in real time.

ceptable pictures when error-correction bits are added.

In comparison, an analog TV signal requires one 4.3-MHz channel with a SER of 55 dB for pictures of the same quality. And it's impossible to send analog signals through the 10 parallel 4.3-MHz channels because of excessive noise. Whenever two channels are connected in parallel, the signal will be 6 dB greater, while the random noise increases by 3 dB, to yield an SER of no more than 28 dB—far from the required 55 dB.

Although channel capacity is proportional to bandwidth for transmitting digital television signals, binary coding can be modified to reduce the bandwidth at the expense of the bit-error rate. As shown in Fig. 7, four-level coding halves the bandwidth by defining four levels with a 2-bit code. What's more, eight-level coding defines eight levels with 3 bits per level and reduces bandwidth to a third.

Since digital standards do not exist for NTSC television broadcasting, researchers are free to work with any format they like. Most have chosen parallel 8-bit PCM with an encoding frequency of either 10.7 or 14.3 MHz, locked to the color subcarrier.

Admittedly, the resulting 86 to 114 Mb/s rates are excessive for cost-effective storage and transmission circuits, and extensive efforts are being made to reduce bit rates. The International Telecommunications Union, a United Nations standards group, has established four digital rates for use in digital communications networks in North America. These are 1.544 Mb/s, 6.312 Mb/s, 44.736 Mb/s, and 274.176 Mb/s. The third level of 44.736 Mb/s has been the target for researchers. If they can't get the rate that low, broadcasters may have to settle for the rate of 274.176 Mb/s, which would be wasteful for television alone.

The CBS Technology Center is working on two ways to reduce the data rate—sub-Nyquist encoding and transform-coding. In sub-Nyquist encoding, PCM encoding rates are kept below the level needed to ensure at

Britain tries digital TV

How digital techniques can enhance television broadcasting with additional services for the viewer is uniquely embodied in a project of the British Broadcasting Corp. (BBC) and three companies of the commercial Independent Broadcasting Authority (IBA) in the United Kingdome. These broadcasters are now in their second year of testing Teletext, a digital "magazine of the air" that offers home viewers immediate access to breaking news, financial information, sports and weather reports, and other data. The broadcasters are confident that the government will either extend the trial period or declare the all-day service operational when the test period ends this September.

Essentially, Teletext rides piggy-back on the conventional analog TV signal. Digitally coded signals are transmitted to construct a "page" of alphanumeric text during the blanking interval of the TV picture. In that way, a viewer can use a special decoder and keypad attached to his home receiver to punch up the page number of the text he desires.

A decoder memory or shift register stores the digital signals for the page, two rows of 40 characters each in a 5-by-7-matrix, and displays it on the TV screen within seconds. In the British PAL system of 625 lines and 50 fields, the Teletext-encoded pulses in two lines are sent during the field-blanking interval of the TV waveform—lines 17 and 18 in one field and 330 and 331 in the next. Since each line carries the coded information for one row of display, a full page will take 0.25 second to display. However, the pages are sequentially cycled through the Teletext transmission so that a viewer may have to wait some seconds to get a display.

The first row of a page is the page heading, which shows page number, date, and time to the second. The Teletext receiver, looking for the requested page, picks it out from the timing information contained in the page heading. The Teletext pulses are raised cosine in shape, approximately 70% of the black-to-white incursion in amplitude, and clocked at the rate of 6.9375 MHz. Information is transmitted in two streams of 8-bit groups to define the page heading and the characters in each row.

Another successful British application of digital television is Digital Intercontinental Conversion Equipment (DICE) which converts the PAL signals into the NTSC system of 525 lines, and 60 fields used in the U.S. and Japan. The system can also convert NTSC signals to the PAL format. Developed by the IBA and made under license, DICE converters cost about $500,000 each.

In conversion from the U.S. NTSC to European PAL signals, DICE samples the analog signal and digitally encodes at three times the NTSC subcarrier or 10.7 megabits per second. Then, to remove jerkiness of the signal caused by changing from 60 to 50 fields, it is fed alternately into one of two field stores of p-channel MOS dynamic shift registers that have a total capacity of 2.5 million bits. Averaging bits from the two field stores eliminates the jerkiness. The line rate is changed by using a low-pass filter on the line structure and then resampling the result to reconstruct the output line rate.

So that the difference between luminance and chrominance coding does not conflict, spatial filters separate the two codes, which, in theory are handled separately, but in practice are multiplexed and processed serially. The arithmetic in the 8-bit system, goes up to 12 bits to allow for round-off, and the bit rate varies from 10.7 megabits to 18 megabits.

least two samples per cycle of the video signal. Until now, this rate has been impossible for the composite NTSC color-TV signal because the alias distortion thus induced could not be separated from the desired signals. However, a newly developed sub-Nyquist encoding system produces acceptable pictures at a bit rate of 57 Mb/s.

Transform-coding is also used to reduce the bit rate by removing a large amount of redundant information in television images that can be spared without significantly impairing the reproduced pictures. Redundancy is effectively identified by multiplying a signal vector (a finite length of signal data) by a matrix. The matrix transforms, or maps, the vector into a new space with different types and numbers of dimensions. Walsh-Hadamard transforms, which are orthogonal functions, are uniquely adaptable to digital-TV images because they consist only of the values +1 and −1, compatible with binary arithmetic.

The transformed signal contains the same number of samples as the original vector, but the distribution of sample values is different. Most of the sample values will be zero, or a few small numbers will represent redundant information. Most of the image information will be contained in the few large-value samples. Statistical coding of these transformed samples permits the signal to be sent with fewer bits to attain the goal of less than 44 Mb/s for a clear image at minimum bandwidth.

A valuable feature of the Walsh-Hadamard transform is that, with proper scaling, it becomes its own inverse; that is, if the transformed signal vector is post-multiplied by the same matrix, the original signal will be generated. Despite greater equipment complexity, increased vulnerability to channel errors, and some reduction in picture quality, these two bit-reduction techniques can be cost-effective when large digital memories and long links are involved.

To examine the effectiveness of bit-reduction algorithms, CBS Technology Center uses computer simulation (Fig. 8). A semiconductor digital-frame store is used to grab and circulate one frame of the digital signal at a time. The frame is written on computer-compatible magnetic tape at approximately 13 seconds per frame.

Individual frames are transferred into an IBM System/370 computer, premultiplied by the transform matrix, and channel errors are added if desired. The data is then post-transformed back to the signal format and written back on magnetic tape, which is used to load the frame store. The processed picture, which circulates in real time, can be viewed on the color-TV monitor. Statistical analysis of the transformed data, performed by the computer, indicates how effective each algorithm is for bit-reduction techniques. □

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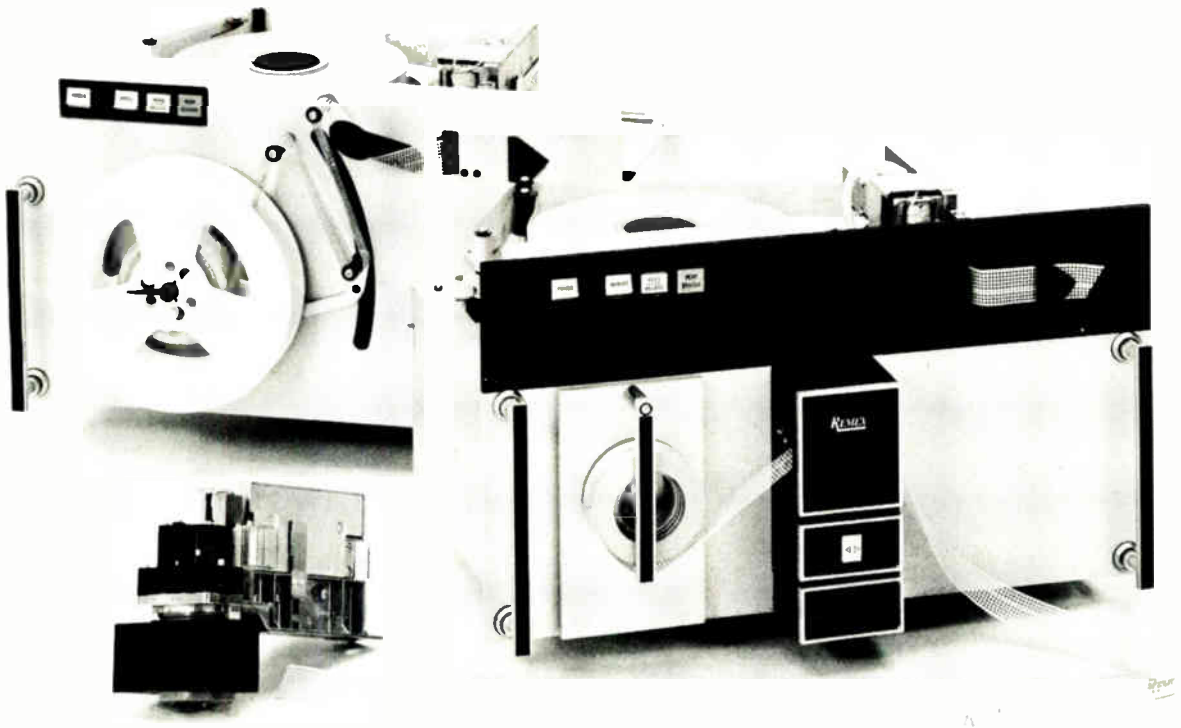

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DIPs verify strobe within time window

by Robert A. Dougherty
RAD Technical Consulting, Dunedin, Fla.

It is often necessary, in testing digital equipment, to ascertain that the equipment under test can deliver a pulse (strobe) during a particular time interval (window). The circuit shown here can verify the presence of a strobe pulse coming from equipment under test during a window pulse from the test set; if the strobe does not appear, an error signal goes high. This circuit operates with no external clock, and uses only two dual-in-line-packaged integrated circuits.

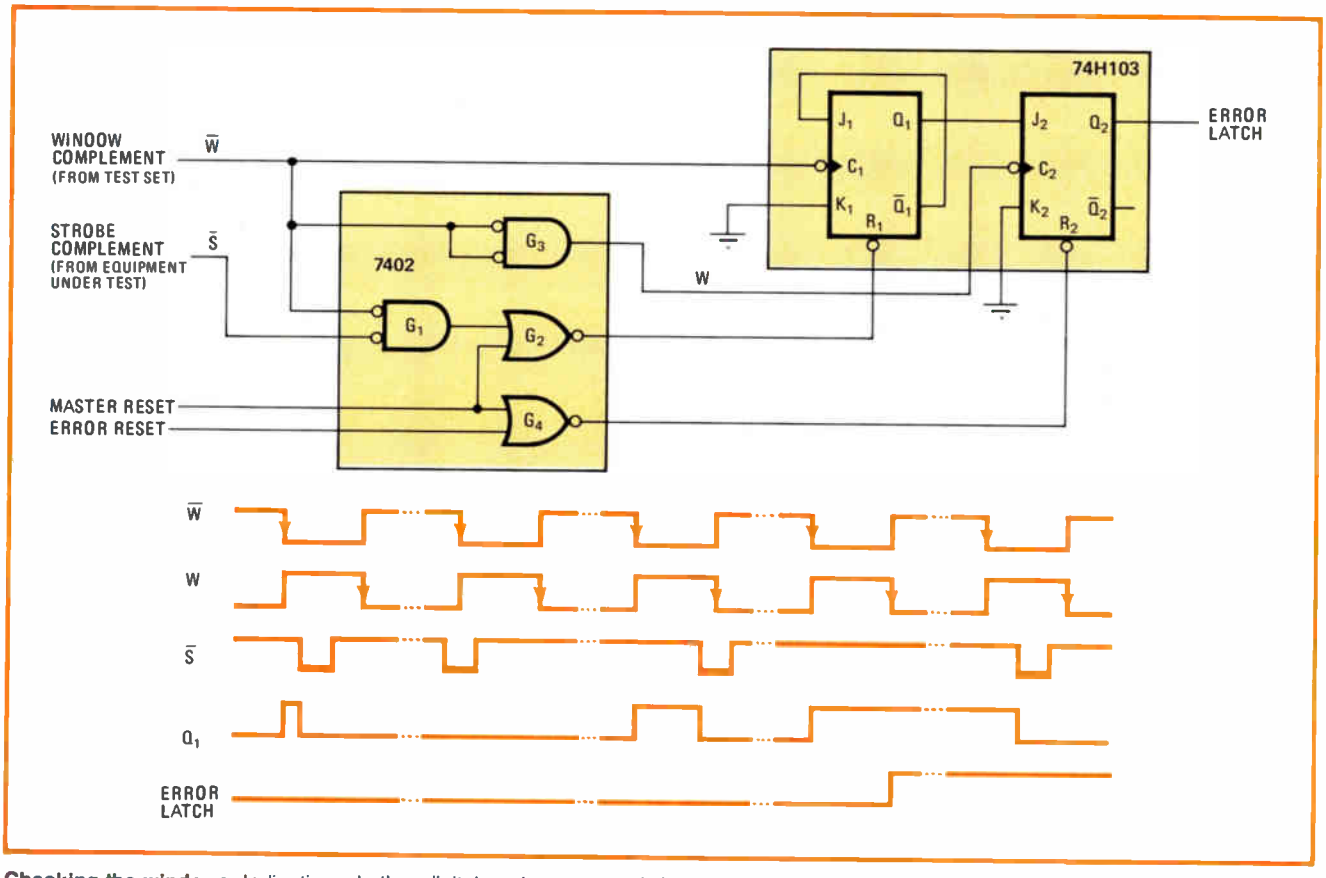
As shown in the diagram, one of the ICs is a dual edge-triggered J-K flip-flop; the other is a quad NOR gate. Assume that both J-Ks are initially in the reset condition—that is, Q_1 and Q_2 are both low. In this case the falling leading edge of a window complement pulse, $\overline{W}$, sets Q_1 high. Also, the low condition of $\overline{W}$ enables gate G_1. Therefore if a strobe complement pulse, $\overline{S}$, appears while $\overline{W}$ is low, G_1 goes high and resets J-K$_1$ through G_2.

The output from inverter G_3 is the window pulse, W. Its falling trailing edge clocks the condition of Q_1 (which is also J_2) to Q_2, which is the error latch. Therefore, if Q_1 is low, the error latch stays low. If Q_1 is high, the error latch goes high and remains high until cleared by the error reset or the master reset.

The master reset initializes both J-Ks. The error reset clears the error latch through G_4.

The timing diagram illustrates the operation of the circuit. Note that the error latch stays low if a strobe is totally within the window, or if it overlaps the beginning and/or end of the window. But if a strobe does not coincide with any portion of the window, the latch goes high; it can ring a bell, light a light, or otherwise indicate that the equipment under test has failed to deliver a pulse when one was required. □

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.



Checking the windows. Indicating whether digital equipment can deliver a pulse at the proper time, this circuit signals an error if a strobe pulse does not coincide with a window pulse generated by the test station. Note that 74H103 J-K flip-flops are clocked by falling edge of pulse. Gates in the 7402 quad NOR are drawn to indicate their function; by DeMorgan's Theorem, a negative NAND is equivalent to a NOR. Timing diagram shows that error latch goes high on falling edge of window pulse (W) unless strobe pulse has occurred some time during W.

One's complement adder eliminates unwanted zero

by John F. Wakerly
Digital Systems Laboratory, Stanford University, Stanford, Calif.

To enable an adder to subtract, a binary system can use the one's complement representation for negative numbers. However, since the negative of a number is created by replacing 1s by 0s and 0s by 1s, two forms of zero result—00 . . . 0 and 11 . . . 1—to the complication of later zero-checking operations. Fortunately, it's possible to eliminate the 11 . . . 1 version if a NAND gate is included in the adder circuitry.

In a one's complement binary system, the most significant digit in a positive number must be 0 and in a negative number must be 1. Thus the eight possible values that can be represented by 3-bit number are no longer 0, 1, . . . 7. Instead, they are −3, −2, −1, −0, +0, +1, +2, +3. The following table shows why both +0 and −0 occur:

One's complement form	Value represented
111	−0
110	−1
101	−2
100	−3
011	+3
010	+2
001	+1
000	+0

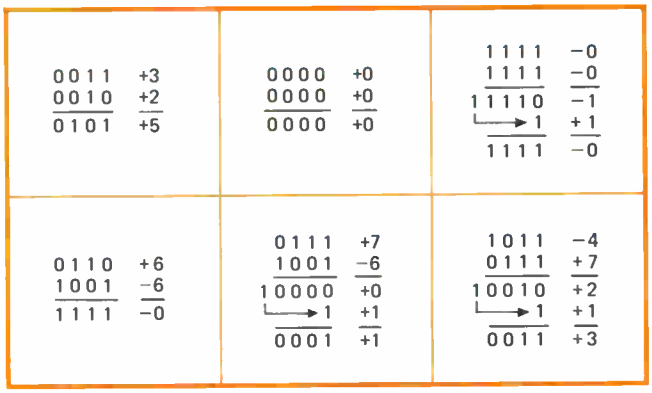
More generally, positive zero is represented by 00 . . . 0, and negative zero by 11 . . . 1.

When two numbers are added in this representation, any carry from the most significant position is added into the least significant position—a process termed "end-around carry." As it happens (see Fig. 1), positive zero is produced only when positive zero is added to itself.

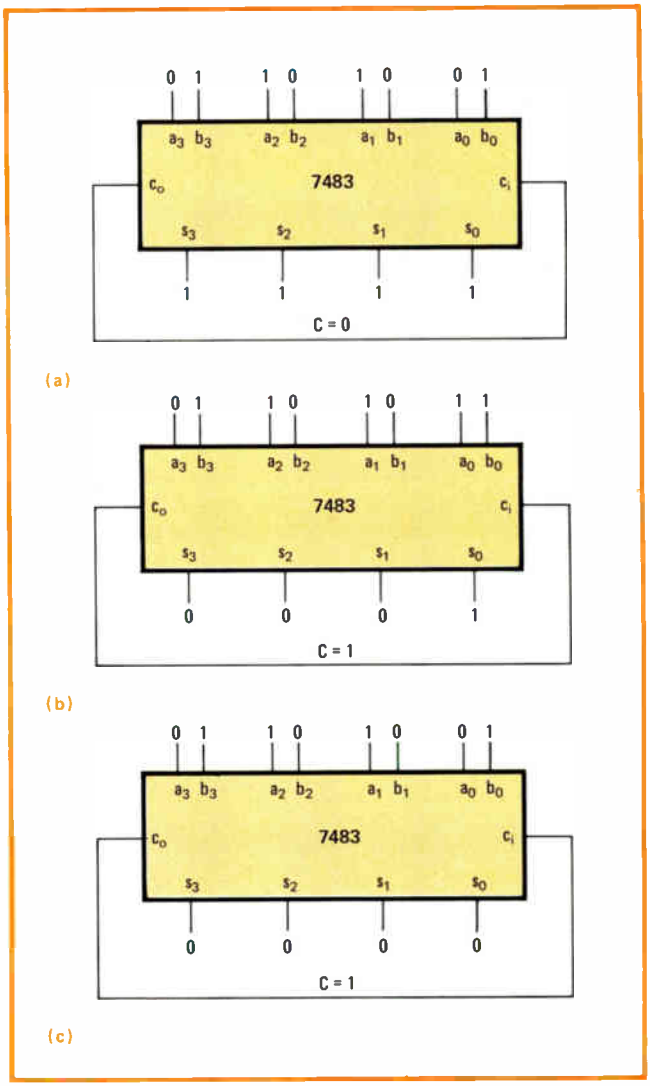
The standard implementation of a one's complement adder uses a conventional binary adder with the carry output connected to the carry input to achieve the end-around carry. This direct connection of the carry output to input in effect turns the adder into an asynchronous sequential circuit, whose state depends on its previous state. (A D-type flip-flop is a familiar example of a sequential circuit.)

To see this, consider Fig. 2(a), which shows a 4-bit one's complement adder that can be implemented with a single MSI circuit such as a 7483. The two input numbers are A = $a_3a_2a_1a_0$ and B = $b_3b_2b_1b_0$, the carry input is c_i, and the carry output is c_o. The state of the sequential circuit is the state of the carry line C.

In Fig. 2(a), A equals 0110, B equals 1001, and C equals 0, making the output is 1111 as expected. In Fig. 2(b), A is changed by one bit to 0111, C changes to 1, and the output changes to 0001. When A is changed back to 0110, as shown in Fig. 2(c), the carry line C, which was 1 before the change, produces the sum of



1. One's complement addition. Examples show the one's complement representation in which a negative number is just the bit-by-bit complement of the positive number; the "end-around carry" rule for addition, and the two forms of zero.



2. Unpredictable zero. Standard binary adder has carry output connected to carry input for "end-around carry" in adding one's complement numbers. A result that is zero may come out as 1111 (negative zero) or 0000 (positive zero), depending upon prior condition of circuit. In both (a) and (c), computation of (6 − 6) is represented by (0110 + 1001); results are 1111 and 0000, respectively, because intervening computation in (b) changed state of circuit.

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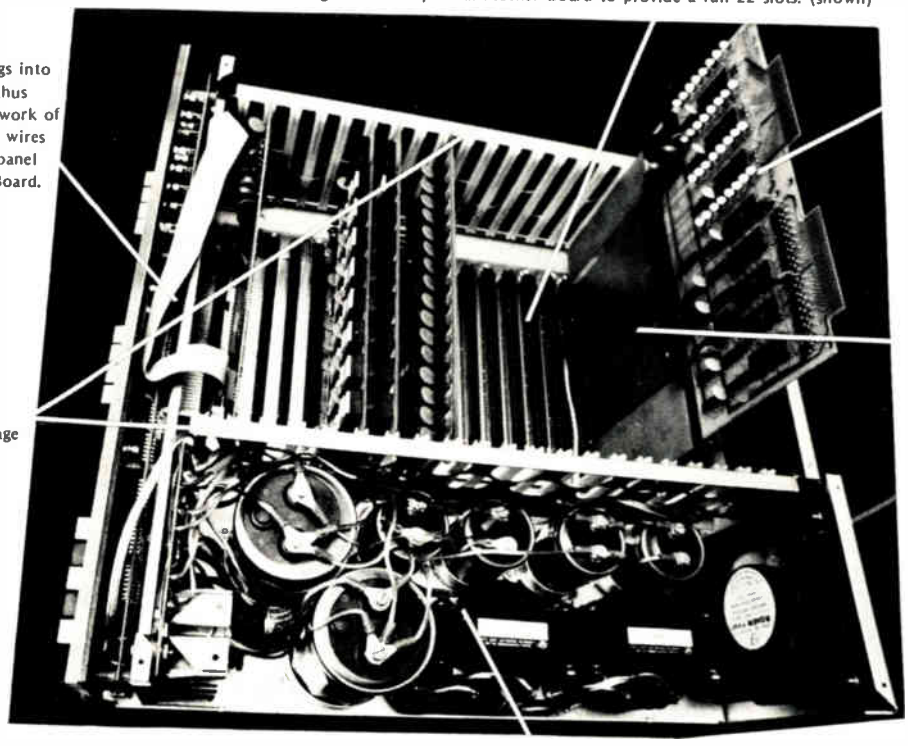

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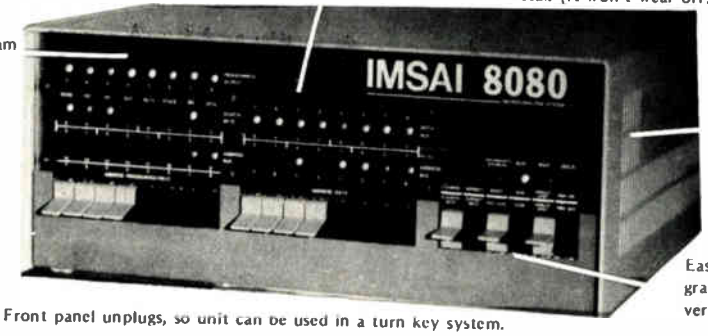

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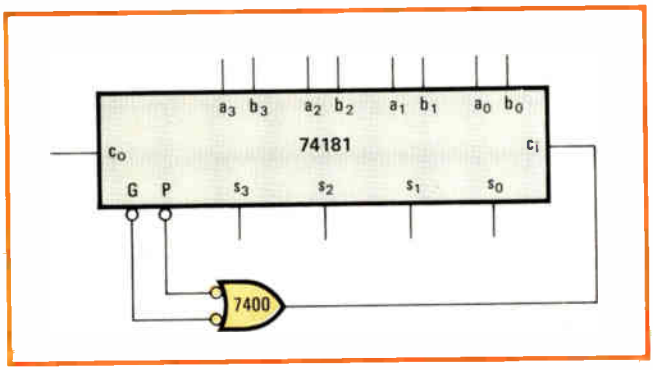
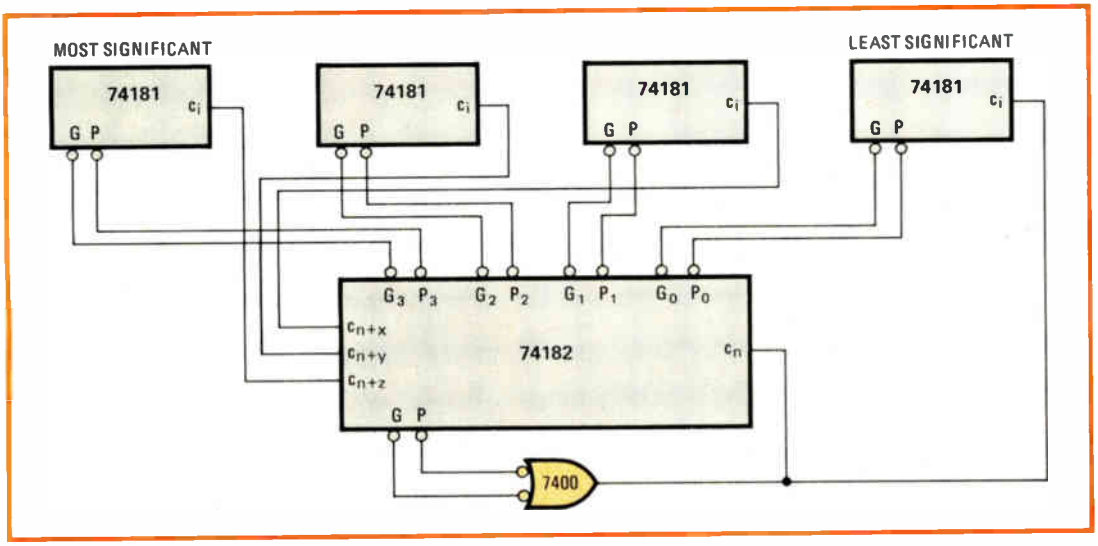


3. Eliminates negative zero. This 4-bit one's complement adder has only one form of zero—0000. The 1111 representation of zero is eliminated by use of NAND gate and arithmetic logic unit that has carry-generate (G) and carry-propagate (P) outputs.

4. More bits. Here a 16-bit one's complement adder uses NAND gate to assure that zero appears as 00 . . . 0. NAND-gate arrangement introduces no more delay than the conventional end-around carry.



0110 + 1001 + 1 = 10000 after the change, so that C remains 1 after the change.

Thus the circuit has two stable states, either C = 0 or C = 1, for any input combination having exactly one 0 and one 1 at each bit position (that is, a number and its one's complement are being added). Which state the circuit attains for a particular input combination depends on the state of the carry line C for the previous operation. Unless the inputs of the adder are set to a known value (say 0) before each operation, it is quite impossible to predict which form of zero will be produced by adding a number and its complement.

Nevertheless, despite its unpredictability, the unwanted form of zero (11 . . . 1) can be eliminated very easily with most MSI and LSI arithmetic logic units (ALUs) and data path slices. MSI circuits such as any 74181, 74S281, and 74S381 ALUs, and LSI circuits such as Monolithic Memories' 6701, Intel's 3002, and Advanced Micro Devices' 2901 data path slices, all have carry-generate (G) and carry-propagate (P) outputs for fast carry lookahead, in addition to the normal ripple carry output (c_o). Examination of the carry-propagate equations shows that P equals 1 if a number and its one's complement are being added, i.e., the sum equals 11 . . . 1. Therefore the 11 . . . 1 representation of zero can be eliminated by producing a carry input of 1 whenever a carry is generated (G = 1) or P equals 1. For typical devices this process requires a single two-input NAND gate, as shown in Fig. 3 for a 4-bit one's complement adder using one 74181.

For larger adders, the G and P outputs of the carry lookahead generator may be used, as shown in Fig. 4 for a 16-bit one's complement adder using four 74181's and one 74182 lookahead carry generator. In all cases the resulting circuit is no longer a sequential circuit, because generate and propagate outputs do not depend on the carry input.

The total propagation delay of a one's complement adder using a conventional end-around carry is $t_{ADD} = t_{ICO} + t_{CIS}$, where t_{ICO} is the propagation delay from any data input to the carry output and t_{CIS} is the propagation delay from the carry input to the sum output.

For the scheme illustrated in Fig. 3, the delay is $t_{ADD} = t_{IPG} + t_N + t_{CIS}$, where t_{IPG} is the delay from any data input to the P and G outputs and t_N is the NAND-gate delay. Typical values for standard 7400-series parts are t_{ICO} = 28 ns, t_{CIS} = 13 ns, t_{IPG} = 17 ns, and t_N = 11 ns. Hence the total delay for both schemes is the same: t_{ADD} = 28 + 13 = 17 + 11 + 13 = 41 ns.

For larger adders, as in Fig. 4, the delay for both schemes is still approximately the same, since the delay of the external NAND gate is comparable to the delay of the internal gate used to compute the ripple carry output from P, G, and c_i in the ALU or lookahead generator.

The scheme of Fig. 3 or Fig. 4 automatically converts all arithmetic results of 11 . . . 1 to 00 . . . 0. However, it should be noted that in logic operations a result of 11 . . . 1 is not converted. In most applications this is the desired behavior. □

Engineer's newsletter

Start designing with 16-k RAMs now . . .

Now that 16,384-bit random-access memories are starting to appear [*Electronics*, Dec. 25, p.29], it's time to assess their effect on dynamic-RAM pricing, especially in relation to today's 4,096-bit memories. Above all, the designer of memory systems must realize that prices of the initial 16-k RAMs will have no bearing on pricing of the mature devices—they never do. That's why users should not worry if price tags are $50 plus, or 10 times today's 4-k prices. That won't last. In relation to 4-k RAMs, **16-k RAM technology will evolve faster than 4-k RAMs did in relation to 1-k units** (which, after all, went from p-channel to n-channel designs). And once volume production and multi-sourcing begins in earnest, 16-k units will race down the price curve even faster than did 4-k prices, which started above $50 two years ago and now rest in the $5 to $8 range.

. . . they could enter mass production next year . . .

But when will the 16-k RAM reach production maturity? Different semiconductor manufacturers have different opinions.

Early suppliers of the part see some volume production starting this year, and if volume then builds, 16-k parts may be selling in the $7 to $10 range by the end of next year. That would represent a 75% reduction in memory-component costs—**parts for a fully loaded 16-k memory board containing 1 million bits would cost only $350, a level unattainable by 4-k chips.** If this prediction is to be believed, then serious 16-k board prototyping should begin at once.

On the other hand, some suppliers predict a much slower pace, with the industry at least three years away from volume production and four years away from the magic $10 unit price that would make 16-k memory designs incontrovertibly cheaper than 4-k designs. These suppliers are counseling their customers to **discount this year's early activity in 16-k RAMs, calling it "premature and confusing."**

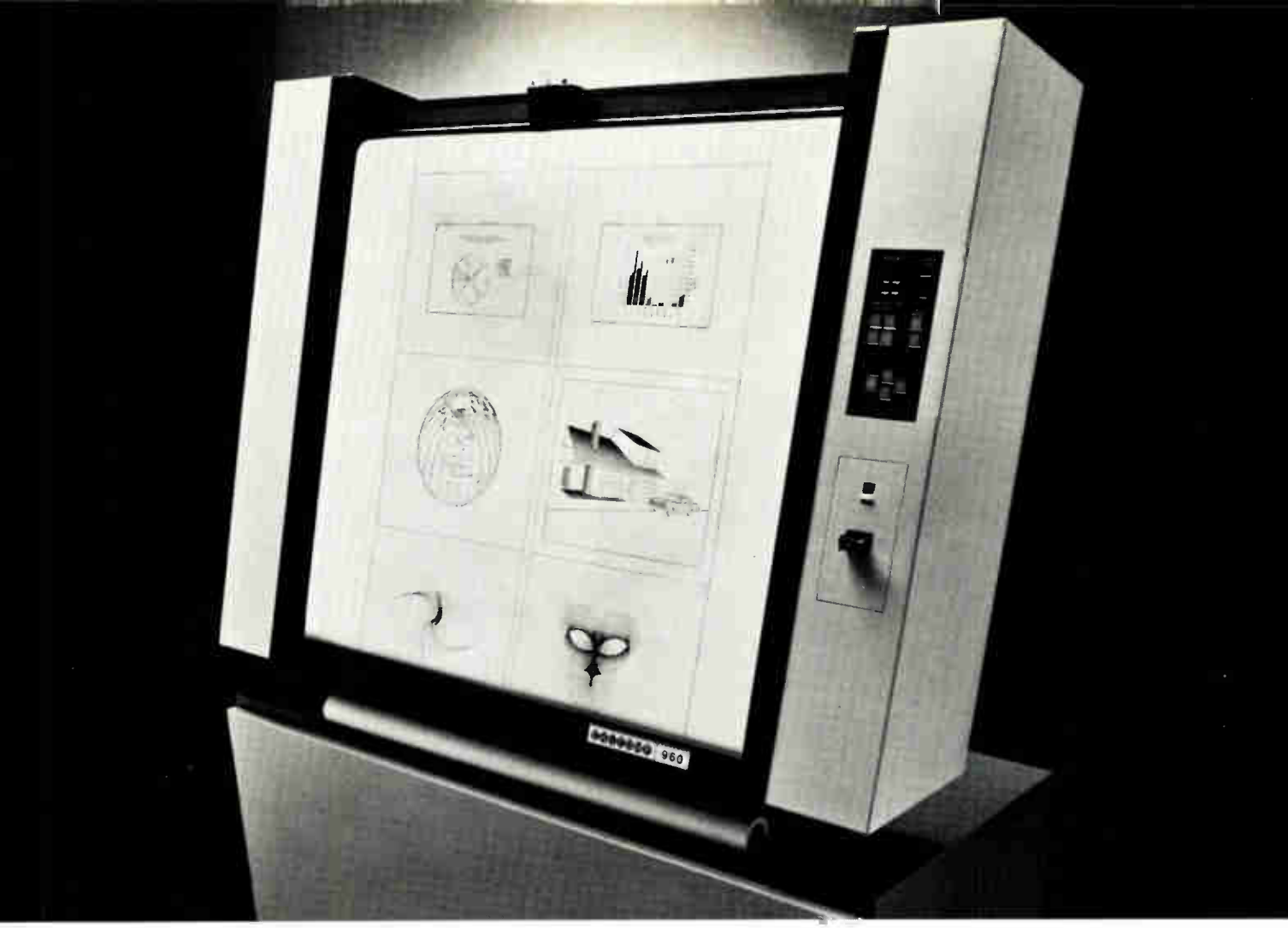
. . . and should hold the memory stage for years

In any event, users should be aware of one inevitability: the 16-k device will be king for some time. The next level of RAM integration, **65,536 bits, appears to be beyond the reach of a straightforward silicon-gate n-channel process.** The innovations in both circuit design and technology that will be required, like charge coupling or bit sharing or multi-level memory planes, will resist quick translation into production devices.

So whether the 16-k device is one, two, or three years away from volume production, memory-system builders could do themselves no harm beginning 16-k design prototyping now—evaluating data sheets, shaking down device quirks, and setting up 16-k test procedures, which are much more complex than 4-k procedures.

Smoking pot? Here's the answer

And for those of us who've been burned by potentiometers (and vice versa), there's a new book called "The Potentiometer Handbook." Written by engineers at Bourns Inc., a leading supplier of potentiometers, the 300 pages are **a thorough documentation of potentiometer theory and practice.** McGraw-Hill publishes it, and its price is $14.50.—**Laurence Altman**



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Series 90 shown with personality module installed and with optional MOS PROM erase light.

Close-up of Series 90 control panel.

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LCR meter offers very wide ranges

Digital instrument measures inductance, capacitance, and resistance over about 10 decades, simultaneously displays dissipation factor

by Charles Cohen, Tokyo bureau manager

Automatic operation and extremely wide measurement ranges are the key features offered by Hewlett-Packard's model 4261A digital LCR meter. Featuring two 3½-digit (1,900-count) LED displays—one for resistance, inductance, and capacitance, the other for dissipation factor—the autoranging instrument is extremely easy to use. And its accuracy is quite good: typically within 0.2% of reading ±2 counts.

The new instrument is designed to make measurements both at the widely used frequency of 1 kilohertz and at the 120-hertz frequency specified for testing electrolytic capacitors.

Selectable test signal. Moreover, it can apply an internal or external bias voltage. The usual test voltage is 1 volt, but a 50-millivolt signal, selectable by a panel switch, allows the capacitance of semiconductor devices to be measured, too. Use of the 120-Hz frequency shifts capacitance and inductance measurement ranges upward by one decade.

At 1 kilohertz, capacitance can be measured from 0.1 picofarad to 1,900 microfarads, inductance from 0.1 microhenry to 190 henries, and resistance from 1 milliohm to 19 megohms. The meter displays dissipation factors ranging from 0.001 to 1.9.

The new instrument, which was developed at the Japanese joint-venture company, Yokogawa Hewlett-Packard, uses a voltage-ratio-measurement configuration that has been used previously by others. But the YHP engineers have added two major refinements that give a wide range of measurements and better accuracy at no increase in cost. Basically, in a voltage-ratio measurement, a voltage or current of reference frequency is applied to the series connection of a standard resistor and an unknown impedance. Voltages across the standard and the unknown are each synchronously rectified and the two compared. Synchronous rectification enables separation of in-phase and quadrature components of voltage, and comparison of appropriate voltages yields reactance and dissipation measurements.

One refinement is the use of parallel and series-equivalent circuits (of unknown resistance and equivalent-loss resistance) over different parts of the measurement range. The parallel equivalent circuit is useful when reactance is high—that is, for measurements of small capacitors and large inductors—and the series equivalent circuit, when reactance is low—that is, for large capacitors and small inductors. Besides improving precision, the use of these two modes lowers the instrument cost by reducing the required number of standard resistors, the company points out.

For parallel-equivalent-circuit measurements, a constant voltage is applied to the unknown. Only a small resistor is used in series with the signal source to protect the in-

New products

strument. For series-equivalent-circuit measurements, a constant current is passed through the unknown, and a large resistor used in series with the signal source. Although the change from series- to parallel-equivalent circuits is normally made automatically, there is a range of two decades over which the equivalent circuit may be selected manually if desired.

The other major refinement is to use direct dual-slope comparison of voltages being measured rather than separate voltage measurements and manipulations. This is facilitated by logic control that includes four kilobits of read-only memory and about 50 MSI low-power Schottky circuits. In this unit, one voltage is integrated for a time equivalent to 1,000 counts of the system clock, and the second is integrated until the integrator output returns to zero. The clock count for second value provides the user with the desired reading directly.

Speeds tests. Although the 4261A is an autoranging instrument, it has a range-hold switch which can speed production testing of similarly valued components. The five terminals—including a guard—provided on the panel of the instrument simplify making three- and four-terminal measurements.

Although made in Japan, the 4261A is completely integrated into Hewlett-Packard design standards. It is completely compatible with American-made instruments and can be utilized in systems designed around other HP instruments. Expansion options start with a printer and extend to the full HP-IB system, the company says.

Price of the instrument in the United States is $1,740. Test fixtures are additional.

The price in Japan is $1,535. This is also the international base price—or the price FOB Japan—from which the prices quoted in all other markets are derived.

Inquiries Manager, Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, Calif. 94304 [338]

In Japan: Yokogawa Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-Ku, Tokyo, 151 [340]

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Military converters' prices tumble

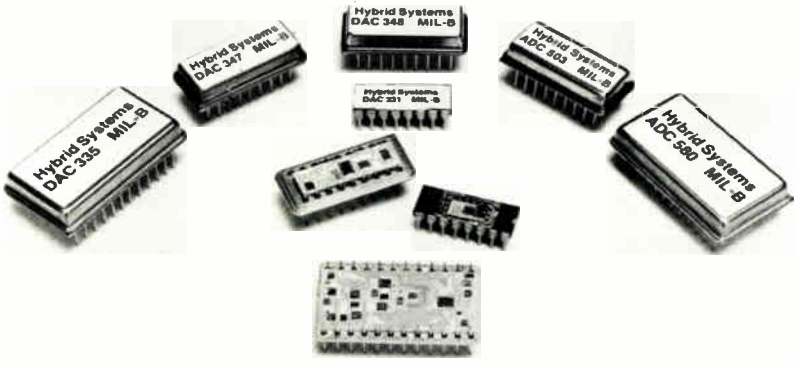
Family of hermetically sealed hybrid analog-to-digital and digital-to-analog converters sells for as little as $49

by Lucinda Mattera, Components Editor

Prices of most data-converter products—except for military units—have been steadily dropping the last few years, usually without any degradation in performance and often with a significant improvement in one or more specifications. Now, however, even the prices of these military units are beginning to tumble, with the introduction of a new family of "low-cost" hybrid data-conversion devices from Hybrid Systems Corp. In unit quantities, the new devices are priced from $49 for a 10-bit digital-to-analog converter to $195 for a 12-bit analog-to-digital converter.

All of the devices are processed to the class B or C requirements of MIL-M-38510 through 100% screening per method 5004 of MIL-STD-883. The family includes: 8-and 10-bit multiplying d-a converters (DAC331 series); 10- and 12-bit general-purpose d-a converters (DAC335 series); 10- and 12-bit low-power and general-purpose d-a converters (DAC347 series); 10- and 12-bit multiplying d-a converters (DAC348 series); an 8-bit successive-approximation a-d converter (the ADC503); 10- and 12-bit successive-approximation a-d converters (ADC580 series); a fast sample-and-hold amplifier (the SH702); and an 8-channel analog multiplexer (the MUX202).

The DAC331 multiplying d-a converters can perform ac or dc multiplication over all four quadrants. They can operate from a single supply voltage of 3 to 10 v and offer a maximum settling time of 2 microseconds to within 0.05% of the final output value. Over the temperature range of -55°C to +125°C, maximum linearity error is ±0.2% of full-scale range for 8-bit units, ±0.05% for 10-bit units. These current-output devices are supplied in a hermetically sealed 16-pin ceramic dual in-line package. In quantities of 1-9, price is as low as $49 each for 10-bit models, and delivery is from stock to within four weeks.



The DAC335 d-a converters include both an internal reference and output amplifier. Their settling time (to 0.01%) is typically 5 microseconds. For 10-bit models, maximum linearity error is ±0.05% of full-scale range from -25°C to +85°C, and ±0.1% from -55°C to +125°C. For 12-bit models, linearity error is ±0.025% maximum from -25°C to +85°C, ±0.03% max from -55°C to +125°C. All units are housed in hermetically sealed 24-pin metal DIPs. In lots of 1-9, 12-bit models sell for about $89 each.

Like the DAC335 series, the DAC347 d-a converters come complete with both internal reference and output amplifier. All the DAC347 models are built with matched C-MOS current switches and supplied in hermetically sealed 18-pin metal DIPs. Low-power versions in this series hold total power dissipation to less than 150 milliwatts. Settling time (to 0.01%) is 20 μs max for low-power units, 10 μs max for the others. Maximum linearity error is the same as that for the DAC335 series. In quantities of 1-9, price starts at $99 each for 12-bit models, $125 each for 12-bit low-power models. Delivery time is four to eight weeks.

The DAC348 multiplying d-a converters may operate in all four quadrants and will accept either an ac or dc reference input. Their settling time (to 0.01%) is 5 μs max for an analog change, 10 μs max for a digital change. Maximum linearity error is identical to that of the DAC335 series, while the temperature coefficient of linearity is 2 ppm/°C max from -55°C to +125°C. The units are supplied in DIPs. For 12-bit models, price is as low as $99 each in quantities of 1-9, and delivery is four to eight weeks.

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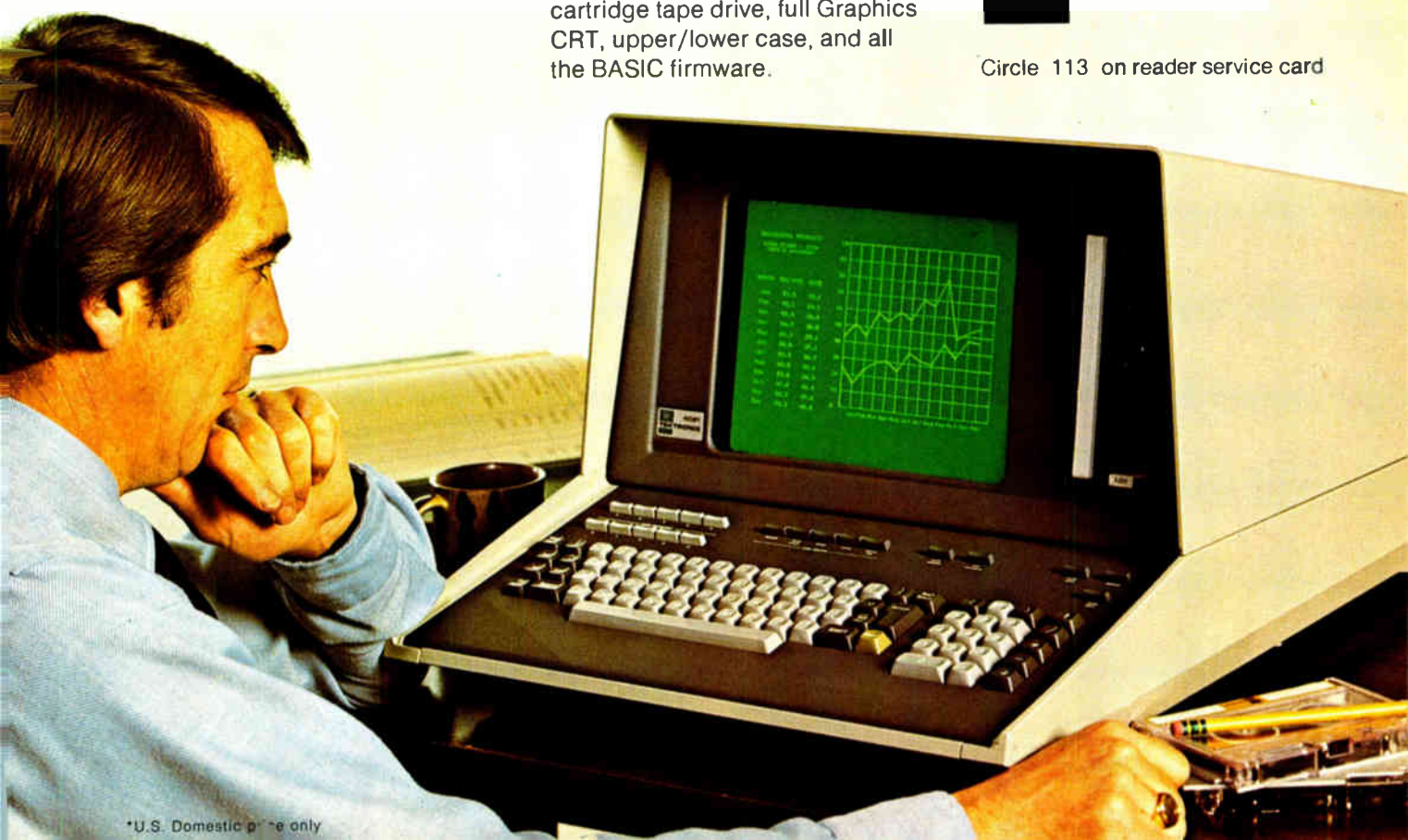

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New products

external clock, the ADC503 is a complete 8-bit a-d converter that operates with a maximum conversion time of 12 μs. Its linearity error is ±0.2% max over the range of −55°C to +125°C. The unit is packaged in a hermetically sealed 18-pin metal DIP. It sells for from $95 each in lots of 1–9, and delivery is from stock to within four weeks after receipt of order.

The ADC580 series a-d converters are also complete units and even include an internal clock. Their conversion time is 50 μs max. From −25°C to +85°C, maximum linearity error is ±0.1% of full-scale range for 10-bit models, ±0.02% for 12-bit models. From −55°C to +125°C, maximum linearity error is held to ±0.15% of full-scale range for 10-bit units, ±0.04% for 12-bit units. The converters are housed in hermetically sealed 24-pin metal DIPs. For 12-bit models, price starts at $195 each for 1–9; delivery is six to eight weeks.

Designed as a companion to the ADC580 12-bit a-d converter, the SH702 sample-and-hold amplifier offers a maximum linearity error of 0.015%. It can acquire a 10-V input (to 0.01%) within 10 μs max, and it slews at 5 V/μs when used with a 2,200-picofarad external holding capacitor. Maximum droop rate is 1 microvolt/μs, while aperture time and uncertainty time are 50 nanoseconds and 5 ns, respectively. The unit, which is packaged in a hermetically sealed 14-pin metal DIP, sells for $65 each for 1–9. Delivery is from stock to within four weeks.

Finally, the MUX202 eight-channel analog multiplexer features a channel-sequence rate (to 0.01%) of 750 kilohertz and an addressing time of 300 ns. It is compatible with both the SH702 sample-and-hold amplifier and the ADC580 12-bit a-d converter. The unit provides break-before-make switching action and operates over a ±10-V input range. It is supplied in a hermetically sealed 16-pin metal DIP and is priced at $65 each for one to nine.

Hybrid Systems Corp., 22 Third Ave., Burlington, Mass. 01803. Phone (617) 272-1522 [339]

The Ten Most WANTED INSTRUMENTS

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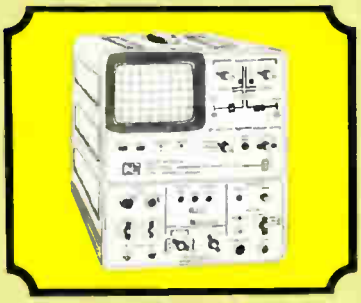

Nicolet
Digital Storage Oscilloscope

Hewlett-Packard 5302 A

Data Research
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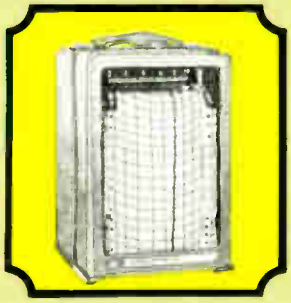
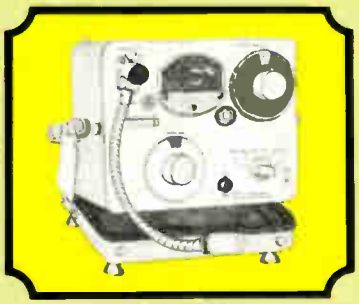
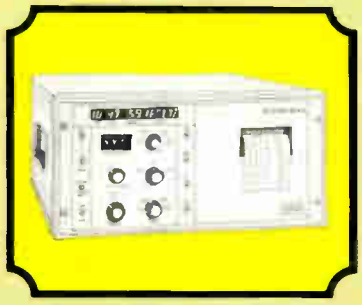


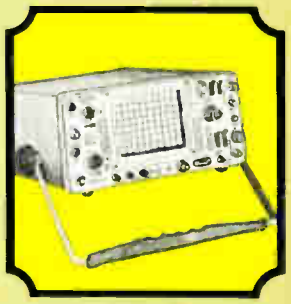
Esterline Angus Chart Recorder



General Radio
Sound Level Analyzer



Kaye Data Acquisition System



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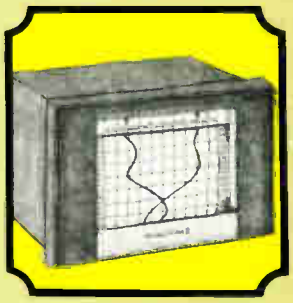

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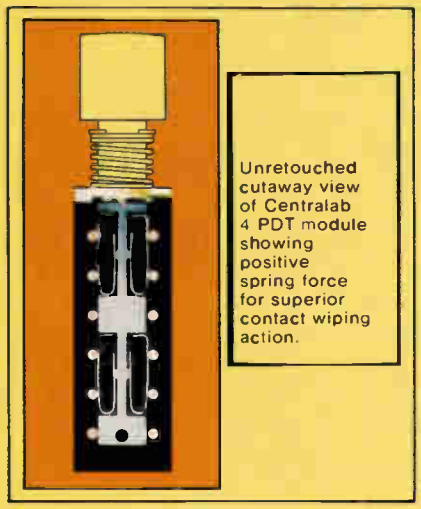

Unretouched cutaway view of Centralab 4 PDT module showing positive spring force for superior contact wiping action.

Centralab pushbutton switches meet these demanding specifications:

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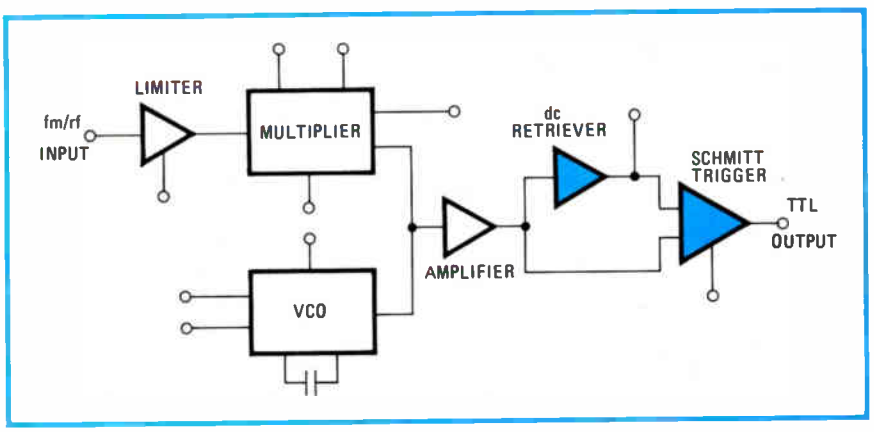
IC phase-locked loop hits 50 MHz

Chip in 16-pin package uses 5-volt supply, is compatible with TTL, offers low noise

New technological approaches are boosting the capabilities of phase-locked-loop ICs and widening their applications in communications and signal generation. Among the first on the market with what it calls the "next generation" of monolithic PLLs is Signetics Corp. Next month, the company will begin offering samples of a new device that can operate up to 50 megahertz, doubling the capacity of most conventional units.



Designated the NE564, the 60-by-90-mil chip has a 16-lead pinout and requires only a single 5-volt supply. In addition, says Lew Johnson, director of marketing for discretes and linear ICs, the Signetics device has TTL-compatible inputs and outputs, is able to demodulate standard fm signals and frequency-shift-keyed signals without additional external circuitry, and has low noise and reduced carrier feedthrough.

In previous PLLs, he says, operation above 25 MHz was difficult if not impossible, and demodulation of FSK without elaborate external filtering was difficult due to the dc drift in the output voltage. The presence of zeners in the level-shift circuitry made PLLs noisy and thus limited their usefulness in demodulating fm signals, and additional circuitry was required to interface with transistor-transistor logic. In addition, most previous PLLs required high voltages, anywhere from 10 to 18 V.

Potential applications of the 50-MHz unit are in citizens' band radios, high-speed modems, FSK receivers and transmitters, frequency synthesizers, and signal generators, Johnson says.

Key to the device's TTL-compatibility is the use of Schottky-clamped pnp transistors at the inputs and outputs. This also allows considerable flexibility in the way the PLL's internal circuitry is laid out and implemented.

As shown in the block diagram, the NE564 consists of a voltage-controlled oscillator, a limiter to improve a-m rejection, and a phase comparator. There is provision for external control of the loop gain. To obtain a demodulated signal that is TTL-compatible, a post-detection processor is also provided on-chip, consisting of a dc retriever and a Schmitt trigger with variable hysteresis. These reduce the effects of dc variations and carrier feedthrough on the digital output signal.

For high data rates, a considerable amount of carrier signal is present at the output of a PLL, due to the wideband nature of the loop filter. To recover the signal buried in

New products

this noise often requires complex external filtering. Since the output voltage varies from system to system, the filtering required must be adjusted for each system. But to achieve the same effect, Signetics engineers found that all that was necessary was to add a Schmitt trigger with adjustable hysteresis to the on-chip circuitry.

Another factor that had to be considered, says Johnson, was the drift in free running time of the VCO. If this time is changed by temperature, it will lead to a change in the dc level of the PLL output and thus to errors in the digital output signal. He says this effect is eliminated if the dc, or average value, of the signal is retrieved and used as the reference for the Schmitt trigger. In this manner, variations of the dc level of the PLL output do not affect the FSK output.

The NE564 has a power consumption of 500 milliwatts, a lock range of ±50% at 25°C, a frequency drift of 200 parts per million, a frequency drift with power supply of 1% per volt, a 10%-to-90% hysteresis control range, and an output voltage linearity of ±0.5%.

Signetics Corp., 811 E. Arques Ave., Sunnyvale, Calif. 94086 [411]

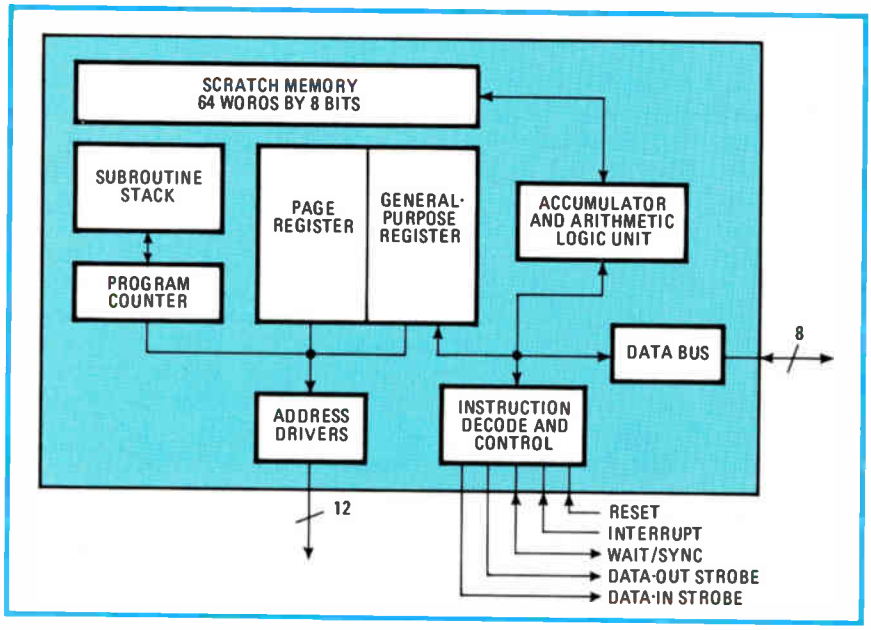
8-bit machine with 2-μs execution time to compete with 4-bit microprocessors

Aiming at the low-end control- and logic-replacement market now dominated by 4-bit machines, Electronic Arrays is introducing an 8-bit parallel microprocessor. Available in sample quantities, the EA9002 is scheduled for volume production in late March, company president Don Bell says.

The device will be offered in a 28-lead package and will plug into peripheral chips from Motorola's 6800 and Intel's 8080 microcomputer families. Bell points out that the EA9002 requires only a single +5-volt supply and a single-phase clock input.

The EA9002 addresses all external circuits as memory devices, providing for storage and retrieval of instructions and data in ROM, RAM, or peripheral devices. The 12-bit parallel address bus provides direct addressing of up to 4,096 locations.

Other features are a 2-microsecond instruction fetch and execution time; a 64-byte internal scratchpad memory; binary or self-correct-

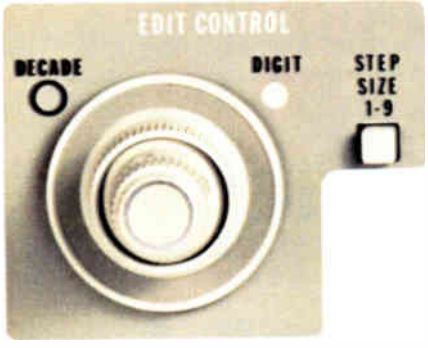


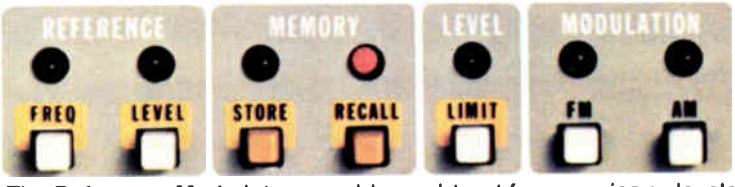
Understanding the most revolutionary Signal Generator of our time.

Learn how the feature-packed Fluke 6011A gives you new levels of capability and flexibility.

Storing and recalling nine different frequencies and amplitudes is just the tip of the iceberg. Fluke's new 6011A is loaded with features and functions to save users' time and cut costly measurement errors. A microprocessor calculates most of the computations you once worked.

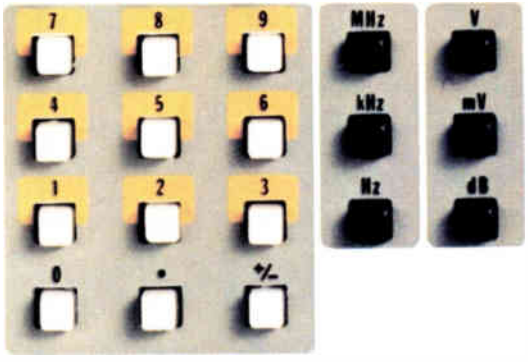
Edit Control lets you easily modify your frequency or amplitude with a simple turn of a dial. After you "call up" or enter a setting, change any decade—indicated by the bright digit—using the edit control. Increment or decrement with complete carry-over and borrow capability. What's more, a recalled frequency or level may be modified without changing the original stored entry.



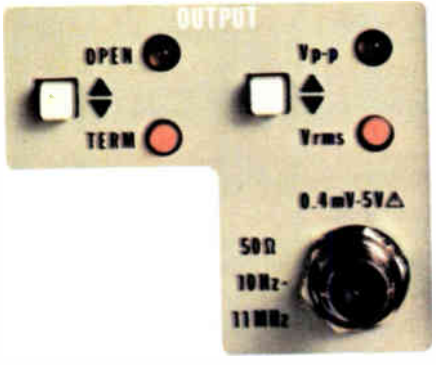


The **Reference Mode** lets you add or subtract frequencies or levels relative to previously entered references.

For frequently used settings, **Memory Mode** not only stores and recalls frequency and amplitude combinations, but remembers output and modulation settings as well. **Level Limit** eliminates damage to sensitive devices. An operator can't use an output greater than a pre-programmed "safe" limit.



Take a look at the keyboard. You'll like free form entry of volts, millivolts, dBm, Hz, kHz and MHz. And for memory tasks, you'll like storage through the numeric keys for nine combinations of output settings. Recall settings in any order by simply pressing the appropriate button.



Simplify testing by defining the output in terms of volts peak-to-peak or rms volts terminated in 50 ohms or open circuit. An rms sensor controls the output accuracy to better than ±0.05dB. Frequency response is flat to within ±0.025dB from 100 Hz to 5MHz.

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ing binary-coded-decimal arithmetic instructions; an 8-bit parallel input/output data bus; full address flexibility, including direct, indirect and register; interrupt; a set of 55 instructions, and a seven-level subroutine stack.

In addition to the usual instruction-decoding and control, the 9002 has a 12-bit program-address counter; a seven-level, 12-bit subroutine address stack; an 8-bit arithmetic/logic unit; eight general-purpose, 8-bit registers; eight 4-bit page registers; five control flags; and maskable interrupt.

Electronic Arrays Inc., 550 E. Middlefield Rd., Mountain View, Calif. 94303 [412]

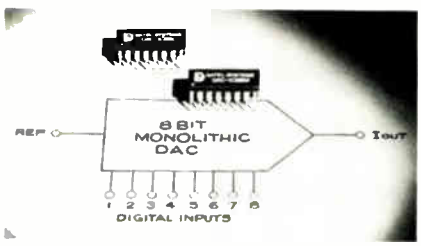
Four-decade counter runs at 5.5 megahertz

A fully programable four-decade counter that uses integrated injection logic can operate at speeds up to 5.5 megahertz. The model SP8210 LSI device, which consumes only 10 milliwatts, may be programed to divide by any number from 11 to 15,999. Its inputs and outputs are compatible with TTL levels, and it will operate with supply voltages as low as 1 volt. The price of the SP8210 is $10.56 in 100-piece lots.

Plessey Semiconductors, 1674 McGaw Ave., Santa Ana, Calif. 92705. Phone Dennis Chant at (714) 540-9979 [413]

8-bit d-a converter sells for $8.95

An 8-bit monolithic digital-to-analog converter, the DAC-IC8B, consists of a bias circuit, a stable reference amplifier, eight fast current switches, and an 8-bit diffused-resistor R-2R ladder network. Priced at only $8.95 in small quantities, the unit operates over the temperature range from 0°C to 70°C. A companion unit, the DAC-IC8BM, operates



from −55°C to 125°C and sells for $12.75 in small quantities. The converters deliver either a 2-milliampere unipolar output or ±1 mA bipolar. Compliance voltage is −0.6 V to +0.5 V. Maximum error is half a least significant bit. The converters can perform one-, two-, and four-quadrant multiplication between moderately fast digital and analog signals. The digital response accommodates a 3.3-megahertz update

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rate with the output settling to within half a LSB in 300 nanoseconds.

Datel Systems Inc., 1020 Turnpike St., Canton, Mass. 02021. Phone (617) 828-8000 [417]

1-k n-MOS static RAM is cheap and fast

A 1,024-bit n-channel MOS static random-access memory from Fairchild offers a maximum access time of 120 nanoseconds at a price of $4.90 each in hundreds and a maximum access time of 150 ns for $4.45 in similar quantities. Both the 150-ns model 3542 and the faster 3542-2 are organized as 1,024 words of 1 bit each, and both operate over the temperature range of 0°C to 70°C from a single 5-V power supply. Using Fairchild's Isoplanar technology, the memories are completely compatible with standard TTL circuitry.

MOS Products Division, Fairchild Camera and Instrument Corp., 464 Ellis St., Mountain View, Calif. 94042. Phone (415) 962-3816 [415]

Npn switching transistors can withstand up to 400 V

A family of three high-voltage npn switching transistors has a rise time to 3.5 amperes of less than 200 nanoseconds, a fall time of less than 200 ns, and a current gain of 15 at 3 A. The model KP3794 has a collector-emitter breakdown voltage of 300 V, the KP3796 has a BV_{CEO} of 350 V, and the KP3798 is rated at 400 V. Intended for use in switching-type power supplies operating at frequencies as high as 50 kilohertz, the transistors are capable of dissipating 35 watts at a case temperature of 25°C. Prices of the three transistors, in order of increasing voltage rating, are $12.50, $14.95, and $16.50 each in lots of 100.

Kertron Inc., 7516 Central Industrial Dr., Riviera Beach, Fla. 33404. Phone (305) 848-9606 [416]

Why Parylene works where other microelectronic protection fails:

Crevice penetration in hybrids

This beam lead has a 0.3 mil parylene coating all the way to the weld. Parylene penetrates deep within small crevices, maintaining clearance while putting a coherent coating under beam leaded chips and air bridges. No area is left unprotected, preventing shorts and allowing the designer great latitude in component spacing and sizing. And parylene secures loose debris while preventing breakoff of pigtails during shock and vibration loadings.

Controlled conformality

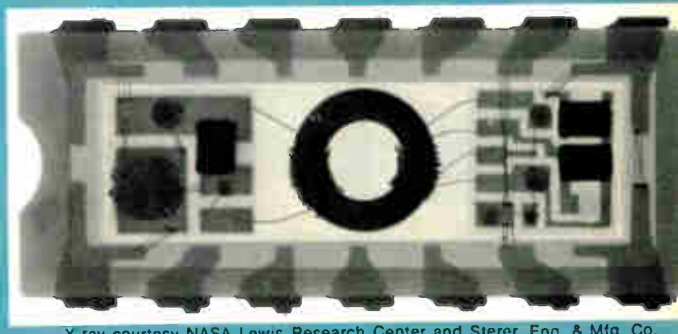
There's a uniform coating of parylene all the way around the half-mil tip of this phonograph needle. That's true conformality, and only parylene gives it, in precisely controlled thicknesses from .002 to 3 mils, in one step. Unlike spray or dip coatings, parylene won't bridge or puddle, or thin out at sharp edges, creating potential failure points. The parylene coating is completely uniform, no matter how dense or intricate the module. And because it's applied at room temperature, there's no component discomfort.

Lead Strengthening

It took up to 75 grams pull to break these 1 mil wires. Bare 1 mil aluminum wires, for instance, exhibit bond strengths of 3-5.5 grams; coated with 1 mil of parylene, pull strength increases by 60-70 grams. So wire and bond are stronger, and sideward shorts and loop collapse during extreme g-loads are prevented. Parylene coatings will penetrate the less than 1 mil clearance between beam lead bonded chips and the substrate, giving such strong coating coverage that the chip cannot be lifted without destroying it.

△200 C thermal shock protection

This hybrid microelectronics relay has undergone 200 45-minute cycles from −120 to 80°C, simulating earth-orbiting conditions. This X-ray shows all leads remain intact. Parylene protection was at work, on the transformer core and then the whole assembly before packaging (TO-116). There was no appearance of corona up to 5000 V_{dc}; leakage was reduced from 10μA to <.001μA at 1000V. RTV encapsulation suffered dimensional mismatch, straining and snapping leads, with 500 V/mil bulk breakdown.



X-ray courtesy NASA Lewis Research Center and Sterer Eng. & Mfg. Co.

Broad cost effectiveness

These are some of the circuit modules now being protected with a conformal coating of parylene. Because nothing else offers parylene's combined protection against thermal cycling, shock, vibration, humidity, solvents, radiation, ionic contamination. Better barrier protection than liquid coatings like silicones, epoxies, and urethanes. On hybrids you can combine parylene with a hermetic seal for optimum environmental protection . . . and parylene alone will often do the job, and at less cost than hermetic seals. Parylene is compatible with active devices, and meets the tough requirements of MIL-I-46058C. For long term reliability, parylene provides a cost-effective solution.

Union Carbide invented the parylene system. Various patents apply; commercial use of the patented technology is licensed. Write for our 16-page brochure: Union Carbide Corp., 270 Park Avenue, Dept. RFB-65, New York, N.Y. 10017. For instant communication, and information about a trial run at reasonable cost, call Bill Loeb at (212) 551-6071.

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In Europe: Mr. H. Torre, Union Carbide Europe S.A., 5 Rue Pedro-Meylan, 1211 Geneva 17. In Japan: Mr. N. Fusada, Tomoe Engineering Co. Ltd., Shin Shin Kai Bldg. 14-1 Nihonbashi 3-Chome, Chuo-Ku, Tokyo

Circle 123 on reader service card

Data handling

Honeywell adds line of minis

New series is aimed at distributed-processing, industrial-control uses

With its sights set initially on the market for distributed-processing systems, Honeywell has introduced a family of minicomputers that will enable the company—one of the major general-purpose computer manufacturers—to range down into very small systems.

Three products, designated Level 6 and priced upwards from $2,600, were introduced within what Honeywell calls the "lower mid-range" of its series 60 line shown last April. The new machines include an 8,192- to 32,768-word model 6/34 and 8,192- to 65,536-word models 6/36 and 6/06. They contain semiconductor storage, with as many as 32,768 words made up of 4,096-bit metal-oxide-semiconductor dynamic random-access memories on one 15-by-16-inch board; single-board processors and microprocessor-driven input/output subsystems.

According to the company, a 5¼-inch-high chassis can contain a central processor, 32,768 words of memory, and peripheral controllers for console terminals, dual diskettes, four cartridge disks, and a line printer or controllers for up to eight full-duplex communications lines. The new 16-bit machines are designed to compete with such minicomputers as Digital Equipment Corp.'s PDP-11, Hewlett-Packard Co.'s HP-21MX and Data General Corp.'s Nova.

Among the most important features of the Level 6 design are maintainability and accessibility, points out Michael D. Simon, manager of hardware-systems planning for the computer-engineering operation of Honeywell in Billerica, Mass. Each functional unit—memory, central processor, input/output controller and power supply—can be plugged out of the chassis if a failure should occur. And locating failures is simplified by microdiagnostic programs, he says. Simon also points out that Honeywell will be able to introduce new components and circuit designs into the system "without a system redesign, simply by adding them to a functional board and plugging in the board."

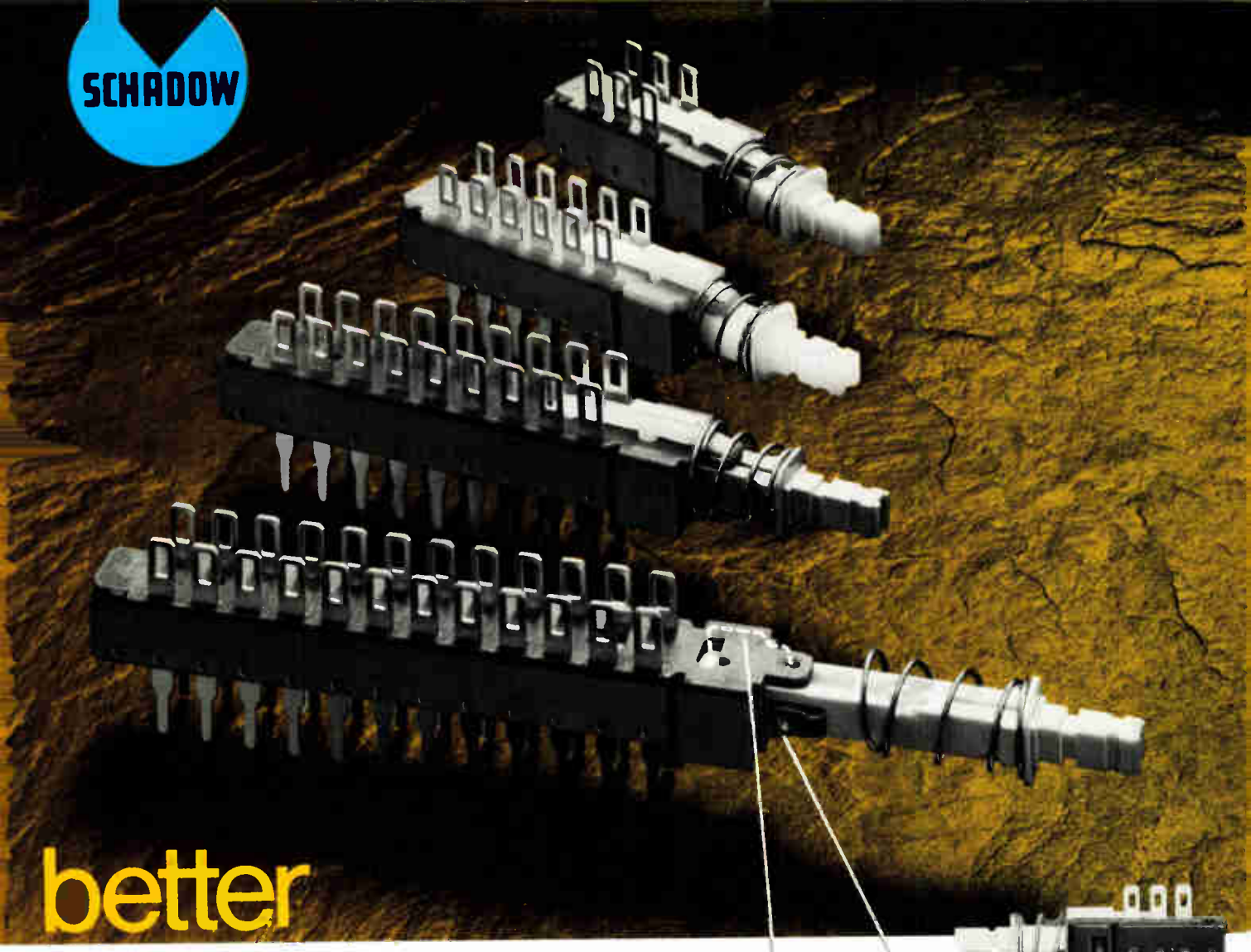
A bidirectional asynchronous interleaved data bus architecture, called the Megabus, provides the Level 6 with transfer capability of up to 6 million bytes per second. Cycle time is 300 nanoseconds. In addition, up to 1,024 addresses are available for attaching peripheral and communications devices.

Another important feature, Honeywell points out, is a split-read cycle that makes transfer time independent of response time or speed of communicating devices. And the 24-bit address width of the Megabus provides capacity for directly addressing up to 16 million bytes. Fast response time for real-time applications is possible through use of up to 64 priority-interrupt levels.

A basic set of more than 100 instructions combined with bit, byte, word and multiword direct-addressing capabilities provides more than 600 instruction variations. Firmware-driven preprocessors are used for input/output control.

According to Honeywell board

SCHADOW



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- Solder lugs on top for hand wiring
- PC spikes at bottom for flo-soldering

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- Ease of maintenance...switch plunger with sliding contacts is removable from the front without disturbing electrical connections
- Enclosed housing protects inner contact area from dust and foreign intrusions
- Fixed terminals are "staked" in position, providing an extra seal to help prevent wicking of solder or flux
- Molded PC Board Standoffs, front and back, on bottom side, assure parallel mounting

Technical Data

Contact Resistance . . . . . 4-6 mOhms
...after 25,000 cycles . . . . . 6-20 mOhms
Lifetime Expectation Interlocked (50,000)
Momentary, Push Push (100,000) cycles
Material Of Construction
Fixed contact . . . . . Brass/Silver Plated .0002"
Moving contact . . . . . Bimetal Brass/Silver .0004"
Plunger Material . . . . . Delrin
Contacts . . . . . Non-shorting
Housing Material . . . . . Glass Reinforced Nylon/or Poly Carbonate
Terminal Board Material . . . High Grade Paper Phenolic

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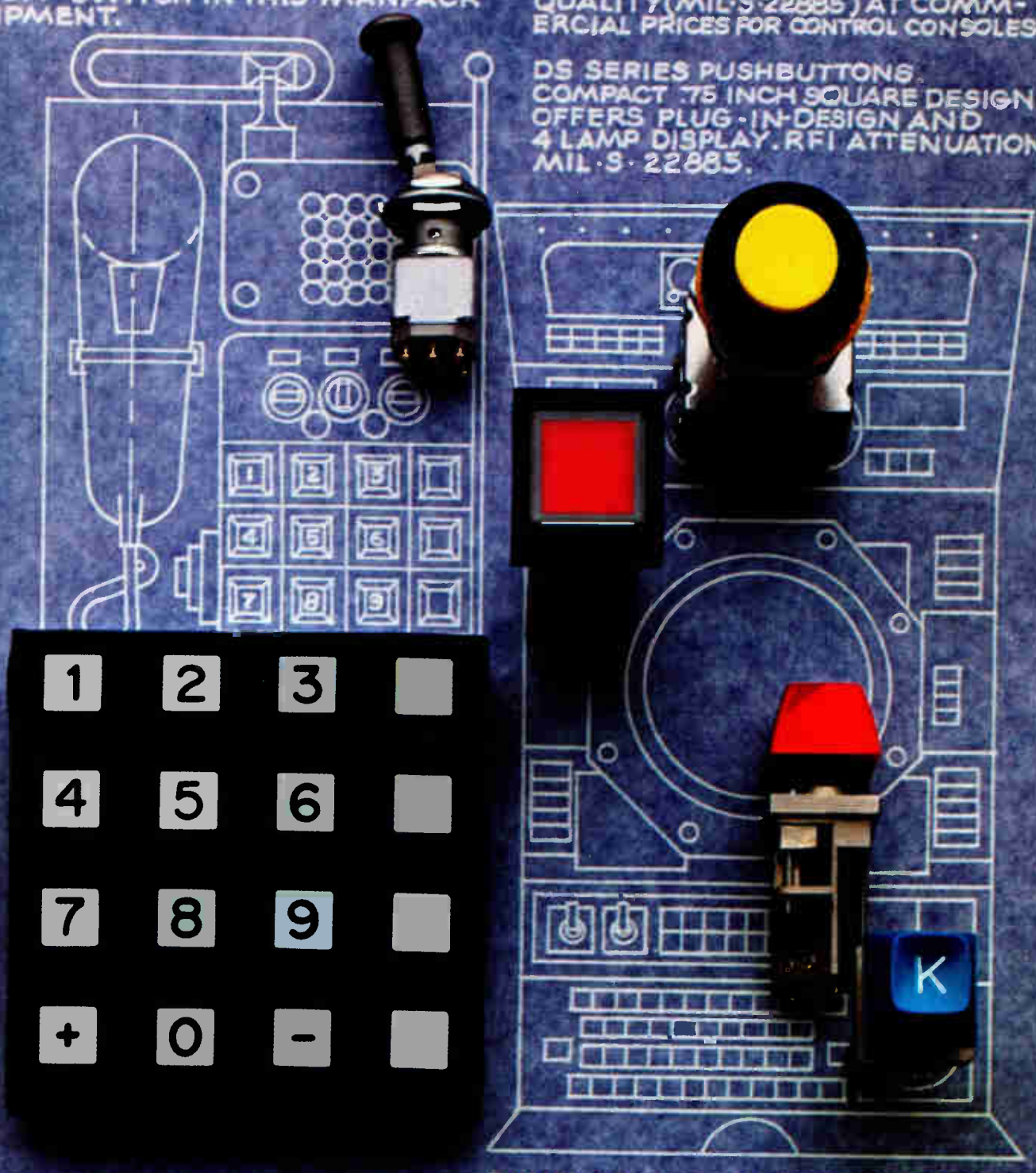

PX KEYBOARDS. TOTALLY SEALED WHEN MOUNTED, WITH ZERO DEPTH BEHIND PANEL, PX IS A NATURAL CHOICE FOR MANPACK EQUIPMENT SWITCH MATRICES.

PANEL SEALED KS KEY SWITCHES. USE OF SPDT SNAP-ACTION SWITCHES (MIL-S-8805) AND FRONT-OF-PANEL REPLACEMENT, MAKE KS IDEAL FOR RUGGEDIZED CONTROL PANEL KEYBOARD APPLICATIONS.

chairman Stephen F. Keating, "The Level 6 will be enhanced with other models beginning later this year." In addition to distributed-processor applications, in which remote systems are linked together to work both independently and share centralized computer resources, Keating says that the minicomputers will be used to support other Honeywell products. These include environmental controls for buildings, aerospace systems, traffic controllers, and anti-pollution devices.

Honeywell Inquiry Service, 200 Smith St., Mail Station 440, Waltham, Mass. 02154 [361]

Multiplexer simplifies access to computer memory

Expanding the capabilities of its 32-bit computers, Interdata Inc., a subsidiary of Perkin-Elmer Corp., is offering as an option a memory-access multiplexer (MAM). Essentially, MAM simplifies the handling of large numbers of high-speed communications lines by interfacing data directly with system memory. It also increases system throughput and the number of external character-interrupting devices that can be accommodated.

The option is contained on two 15-by-15-inch circuit boards that plug into the input/output slots of the Interdata processor chassis. Typically, each MAM increases system throughput from approximately 30,000 to 195,000 characters per second in byte-transfer mode. Each selector channel could previously accommodate only one device at a time with data flow in one direction, but the MAM accommodates up to 63 devices, and transmission is possible in either direction. When the devices are interrupted on a two-byte basis, throughput increases to 370,000 characters per second for each MAM. Up to seven may be attached to a system.

The multiplexer also performs communications character recognition and provides automatic buffer-switching and interrupt-handling. Built around high-speed Schottky logic, MAM recognizes any of the four binary synchronous codes: EBCDIC, ASCII, a six-bit code, or a user-specified code. When monitoring incoming data and on detection of a special character, the MAM automatically activates the required protocol-mode change or completes either an intermediate or a delayed termination. MAM also has an automatic flagging procedure to alert the processor when an error or overrun has occurred. The memory-access multiplexer is priced at $4,500 plus an integration charge and is available for installation immediately, the company says.

Interdata Inc., 2 Crescent Pl., Oceanport, N.J. 07757. Phone (201) 229-4040 [362]

Video RAM connects microcomputer to TV monitor

The VRAM video random-access memory is a modular device designed to provide an interface between a microcomputer system and a TV monitor. Its inputs behave like those of any other static RAM organized as 128 words of 8 bits each, while its output is a video signal that can be fed to any standard TV monitor. Up to 25 TV monitors can be driven by one VRAM. The VRAM has a large repertoire of characters, including ASCII upper- and lower-case alphanumerics, Greek letters, and various symbols. Housed in a module measuring 3 by 4 by 0.6 inches, it draws less than 1 watt from a single 5-volt supply and can operate over the range from 0°C to 70°C. Various models are available with prices as low as $94 each in large quantities. Delivery time for

New products

the RAM is two to eight weeks.
Matrox Electronic Systems, P. O. Box 56, Ahuntsic Stn., Montreal, Que. Canada H3L 3N5. Phone Lorne Trottier at (514) 481-6838 [363]

Compact data printer has few moving parts

By reducing the number of moving parts and employing nonimpacting electrosensitive print heads instead of the more conventional mechanical drums and wheels, the makers of the EDP1600 have produced a data printer that is both compact and reliable. The unit converts 4-bit binary data to printed form at a rate of up to two 16-character lines per second. Its printout paper is standard 6-cm electrosensitive tape. The printer measures only 4.87 in. high by 5.04 in. wide by 10.25 in. deep. It sells for $550.
C-Tek Inc., 4 Railroad Ave., Wakefield, Mass. 01880. Phone (617) 246-1720 [367]

TOPICS

Data Handling

Signetics Corp., Sunnyvale, Calif., is offering a bipolar microprocessor designer's evaluation kit. Priced at $230, the kit contains all needed parts for building a fast 8-bit microcomputer or controller. . . . **Microcomputer Associates Inc., Cupertino, Calif.,** has announced the availability of a single-pass resident assembler for its JOLT microcomputer systems. . . . **Hewlett-Packard Co., Palo Alto, Calif.,** has introduced the first of a series of CRT computer terminals adapted for foreign markets. The first unit, the HP 2640C, is capable of displaying the full 128-character cyrillic set in addition to the standard 64-character (or optional 128-character) Roman font. . . . **Triple I, a division of the Economy Co., Oklahoma City, Okla.,** has added a variable-speed model to its line of cassette tape transports. The four-motor device sells for less than $100.

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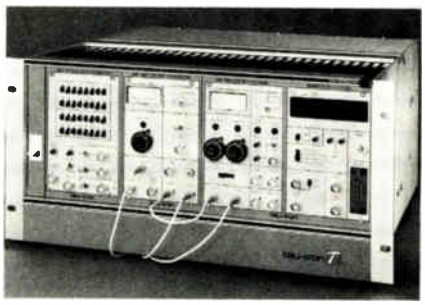
Communications

Data tester runs to 1 GHz

New receiver, transmitter in communications series use thin-film hybrid circuits

Communications test systems that operate at speeds as high as 1 gigahertz are usually custom-designed and produced in house for a specific application. But Tau-Tron Inc. is now marketing a test system with a new transmitter and receiver



that both operate at speeds from 200 megahertz to 1 gigahertz.

The company sees applications for the system in high-speed data communications, in fiber-optic, laser and other communications systems, and in digital multiplex, magnetic-disk and tape recording.

Both the MN-1001 transmitter (second from left in photo) and the MB-1001 receiver (third from left) are part of the Tau-Tron modular instruments (TMI) line. To reduce parasitics and increase speed, they use thin-film chip and wire hybrid microcircuits and multilayer printed circuits made by the company. To generate signals of 1 GHz, they also incorporate a proprietary technique based on new Motorola and Fairchild integrated circuits that in conjunction with discrete parts can operate up to 500 MHz.

Because of IC limitations, code generators traditionally have used a low-frequency code that is multiplexed to reach higher frequencies. With the new ICs, the signal needs less multiplexing, resulting in fewer errors and less jitter. The clock and data channels use SMA connectors designed for use with uhf signals.

The MN-1001 transmitter is clocked from an external source and provides selectable pseudorandom or fixed-word test patterns. Errors may be injected automatically or externally and offset to control for clock and sync output may vary by more than a volt.

The MB-1001 may receive incoming data either automatically or manually and requires no clock input. Once synchronization between the incoming sequence and the locally generated pseudorandom codes is made, error measurements are computed bit by bit. Data and clock phases are adjusted at the input to move together; a taped-delay-line microcircuit provides phase adjustments in 1.2-nanosecond steps, and the duty cycle at 1 GHz is only 1 ns.

The receiver also includes an error-rate counter with a three-digit display for automatic time-rate measurement and a four-digit display for manual measurements, in addition to indicators for gate, overflow, and over-threshold. A display control determines the amount of time the display can be frozen before another count is taken.

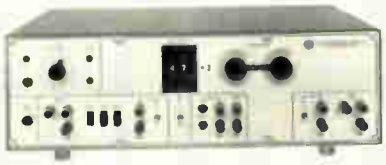
The system can be tailored to specific customer needs by adding extra modules, such as a code converter to change its NRZ-format code to some other signal such as bipolar, signal conditioning modules to give different signal levels, or modules for multiplexing or inserting other data.

The MN-1001 and MB-1001 cost $35,000 for the pair, and delivery takes 90 days.

Tau-Tron Inc., 11 Esquire Rd., North Billerica, Mass. 01862 [401]

Delay generator simulates satellite-channel echoes

Capable of simulating the echo-impairment characteristics of a communications satellite channel over a



wide range of delays, amplitudes, and return losses, the model FA-1755A delay generator also functions as a recirculating memory for the storage of transient data. Developed for the testing of such data-communications equipment as modems and facsimile systems, the instrument makes it easy to evaluate equipment under repeatable calibrated line conditions. Operating over the voice-channel band from 200 hertz to 3,400 Hz, the generator provides delays up to 100 milliseconds in steps of 1 ms. It can provide attenuation up to 49 decibels in 1-dB steps.

The unit delays the analog input signal by first digitizing it and then clocking it through a long shift register. Analog signals are converted to digital form to a resolution of 8 bits at a 12-kilohertz rate. An output adder on the generator allows the user to add the input signal to its delayed attenuated counterpart to produce an accurate simulation of a true echo condition.

Comstron SEG, 120-30 Jamaica Ave., Richmond Hill, N. Y. 11418. Phone (212) 441-3200 [403]

Short-haul modem runs at 230,400 bits/second

The PSH 230.4 is a short-haul modem that can send data at rates up to 230,400 bits per second for distances to five miles. A synchronous device designed for full-duplex operation over four-wire shielded

New products

pairs or dual video coaxial cables, the modem has a typical error rate of less than 1 in 10^8. Features include loopback circuits for both the digital (interface) and analog (line) circuits, a built-in test-pattern generator for error-testing of the modem and line, and automatic line equalization. The modem can be installed and tested by non-technical personnel without external test equipment.

Penril Corp., 5520 Randolph Rd., Rockville, Md. 20852. Phone (301) 881-8151 [404]

Interface adds channels in computer communications

The programable asynchronous triple-line adapter (Patla) is a communications interface device designed to work with Interdata computers. Like earlier single-line adapters, the Patla requires only one CPU chassis slot, but unlike them, it provides three RS-232-C asynchronous communications channels with 13 switch-selectable, crystal-controlled rates from 50 bauds to 9,600 bauds. The interface allows either half- or full-duplex operation, and, because of its use of low-power Schottky logic, it draws only 1.5 amperes from the computer power supply. The Patla sells for $900 in small quantities, dropping to $558 in hundreds. Delivery is from stock to 60 days.

R D V Engineering, 14914-D Newport Ave., Tustin, Calif. 92680 [405]

Remote unit allows checks of duplex communications

The Link/Chek 202 system consists of a master unit and a remote, unattended device that can test both full-duplex and half-duplex communications systems from one end. Especially useful for dial-up systems, where poor lines may be encountered, the system verifies the performance of a link by transmitting a pseudorandom sequence from the master unit to the remote

Big, fast and low-power news on the latest static NMOS RAMs.

If you use RAMs, have we got news.

Three terrific state-of-the-art devices to handle almost any NMOS RAM need.

All with N-channel, Isoplanar fabrication for high yields, low cost.

And all with a super-low speed-power product.

BIG NEWS.
Our 3539 NMOS RAM.
- 256 x 8 Organization
- Bus-structured
- Separate bus-control pin
- Static – no clocks
- TTL compatible
- +5-volt power supply
- 2 Chip Selects
- 22-pin package

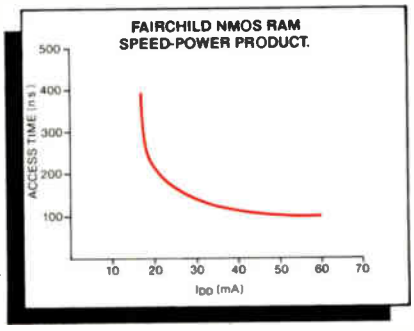
FAST NEWS.
Our 3542-2 NMOS RAM.
- 120ns max access time
- Static – no clocks
- 270mW max power
- +5-volt power supply
- 16-pin DIP with 2102 pin-outs
- Industry's best price/performance ratio
- $2.50 @ 10K piece level

Take our big 2K 3539. It's the first 256 x 8-bit static RAM available anywhere. With just 22-pins, because we've multiplexed the I/Os. Note the list of other outstanding features below. It's available in quantity from Fairchild today.

Then, check our speedy low cost 3542-2. With just 120ns max access time, no competitively priced MOS device is faster. And power dissipation is only 270mW max.

And don't overlook our low-power 2102L. At operational voltage, it beats the power requirement of other devices by almost a factor of two – without sacrificing performance.

LOW-POWER NEWS.
Our 2102L NMOS RAM.
- 132mW max power
- Static – no clocks
- 2102 pin-outs
- Fast Access (350ns max: 2102L)
- No price premium



So whatever you need in MOS RAMs, call your Fairchild Distributor, Sales Office or Representative today.

And tell him you got the news.

Semiconductor Components Group, Fairchild Camera & Instrument Corp., 464 Ellis St., Mountain View, CA 94040. Phone (415) 962-3941. TWX: 910-379-6435.

FAIRCHILD
No.1 for logic and memory.

Circle 133 on reader service card

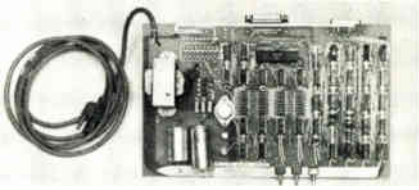
New products

unit, and then having the remote unit send back a bit-error count. The master unit sells for $595 while the remote unit goes for $395. Delivery time is 90 days.

Com/Tech Systems Inc., 44 Beaver St., New York, N. Y. 10004. Phone (212) 425-0733. [406]

Serial data interface receives and stores data

Capable of receiving serial information over communications lines and either storing it or transmitting it directly to paper-tape punches or similar equipment, a serial data interface from Victor Associates can receive and retransmit data at different baud rates simultaneously.



Available as a free-standing unit in a cabinet, as an uncased module, and with or without a power supply, the interface is priced from $500 to $1,100, depending upon configuration and quantity. Delivery time is six weeks.

Victor Associates, 1400 Worcester Rd., Framingham, Mass. 01701. Phone (617) 879-5710 [408]

Solid-state amplifier is fully redundant

Designed for communications applications in which reliability is of the utmost importance, a 400-to-470-

What makes Gallium from Arkansas so special?

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The reason: Alcoa has just completed a new plant in Bauxite, Arkansas. The plant is in full operation . . . processing large quantities of gallium from our own gallium-rich reserves of Arkansas bauxite.

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So there's now an ample supply of gallium for optocouplers, LEDS, injection lasers, magnetic bubble memories or anything else. So don't hesitate in designing with, specifying and purchasing devices utilizing gallium.

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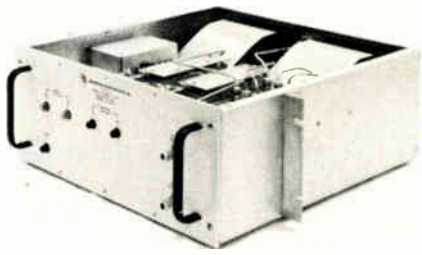


megahertz 70-watt solid-state amplifier actually consists of two complete amplifiers, one of which is maintained in a standby condition while the other is working. If the operating unit fails, the standby unit is switched in automatically. Protected against output shorts and opens, thermal overloads, and power-supply reversal, the amplifier requires a maximum of 14 amperes at -24 volts to put out 70 w (saturated). Required rf input power for full output is 12 to 16 w.

Microwave Power Devices Inc., Adams Court, Plainview, N. Y. 11803. Phone R. J. Sheloff at (516) 433-1400 [407]

TOPICS

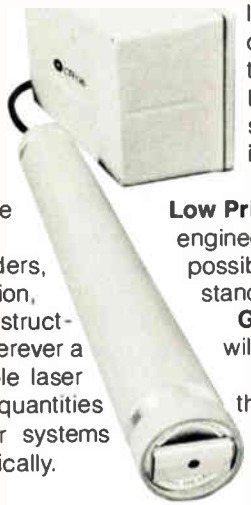
Communications

General Electric Co., Waynesboro, Va., is now offering a variety of lease plans for its recently introduced TermiNet-30 matrix teleprinter. On a one-year lease, the monthly rate for an 80-column keyboard send-receive model is $88, including maintenance. . . . **Computer Communications Inc., Torrance, Calif.,** is offering users of its CC-70 communications processor system the capability to upgrade their systems to the level of the company's new CC-80. A typical conversion will cost $35,000. . . . **Northeast Electronics, Concord, N. H.,** has expanded its Call Disposition Analysis (CDA) system by adding a plug-in microprocessor option, which adds a call memory and processing capability to the system. . . . **Frequency Devices Inc., Haverhill, Mass.,** is expanding its 500 Series line with the addition of the 581 Series C-Message weighting filters.

The CR 136 Eyelite™. The first industry-standard OEM laser.

Standard number, standard package, standard specs.
The new CR 136 Eyelite is the first 2mW HeNe laser developed specifically for high volume OEM applications.

Video disk recorders, facsimile transmission, POS scanners, construction alignment—wherever a standardized reliable laser is needed in large quantities to help take your systems to market economically.



Like peas in a pod. Every CR 136 Eyelite is absolutely identical. That means consistent, reliable performance from system to system, even if you're making them by the thousands. And because it's a standardized component, interchangeability is light-bulb easy.

Features for the OEM:

Low Price, on one or 100,000. Second generation engineering for mass production gives you lowest possible unit cost without sacrificing strict QC standards.

Guaranteed beam alignment. The beam will point to the same spot everytime.

Easy removal and replacement without the need for optics realignment.

Adjustable power output. Less than 1mW to greater than 2mW. Optional polarized output, 200:1 linear polarization is available.

Long life. Up to 20,000 operating hours is standard with no adverse effect from frequent ON-OFF switching or long off periods.

Small physical size, low power consumption and hermetically sealed head make the CR 136 Eyelite your most versatile system component.

Make the right choice for your application. Contact your nearest Coherent Radiation representative today for free literature and more information about the CR 136 Eyelite, the new standard OEM HeNe.

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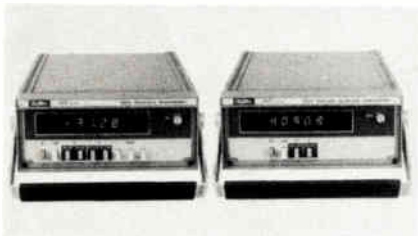
New products

Industrial

Thermometers read in F and C

Digital units offer single-line enable for convenient use in systems

As the U.S. proceeds along the painful path toward metrication, equipment designers and purchasers are constantly having to choose between short-term convenience and long-term suitability. In temperature



measurement, the problem is more acute because both the celsius and fahrenheit scales are in current use in different areas. Electronics engineers, for example, tend to use the celsius scale when they talk about semiconductor processing and temperature sensitivity, but they think fahrenheit when dealing with printed-circuit-board plating and soldering.

Obviously then, for maximum usefulness, a digital thermometer should be able to show either °C or °F at the flick of a switch. The 5500 series from United Systems does just that. The series consists of two models (shown above): the 5510 thermistor thermometer and the 5530 platinum resistance thermometer.

The thermistor thermometer reads to a resolution of 0.01° on both scales. It covers −30°C to +100°C (and the approximate fahrenheit equivalents) with a maximum room-temperature error of less than 0.5°C and a temperature coefficient of 0.004°/°C. The instrument accepts up to three United Systems Corp. or Yellow Springs Instrument series 700A thermistor probes. Front-panel push buttons make it easy to display any one of three independent temperatures.

The platinum resistance thermometer covers a wider range than does the thermistor unit. It goes from −100°C to +600°C with a maximum room-temperature error of 0.3°C and a tempco of 0.04°/°C. It accepts USC models 550 and 551 platinum probes. Temperature resolution of the 5530 is 0.1° on both scales.

Both thermometers have 4½-digit LED displays. Both also have analog outputs for trend recording.

A useful option is an optically isolated binary-coded-decimal output that features single-line multiplex-enable. Thanks to this feature, either unit can readily be incorporated into an automatic test system being set up to check thermostats, automobile engines, or semiconductors, or to control temperature in the preparation of anything from food and beer to plastics and pharmaceuticals.

The model 5510 thermistor thermometer sells for $650, while the 5530 is priced at $725. Option N, BCD output, adds $175 to the price of either. Delivery is from stock.

United Systems Corp., 918 Woodley Rd., Dayton, Ohio 45403. Phone Richard Pitner at (513) 254-6251 [371]

Intelligent multiplexer cuts cabling needs

The remote intelligent multiplexer (RIM) is a microprocessor-based device for use in distributed data-acquisition and control systems in the processing industries. In addition to providing the communications, security, and error-recovery capabilities of similar units, the RIM, with its greater computational power, can significantly lighten the data-processing load of the main computer. Among other things, this device greatly reduces the need for expensive cabling between the main computer and the RIM. For example, in one situation, a 32-conductor cable

Rockwell is there with a complete microcomputer on two chips.

WE'VE CUT THE NUMBER OF COMPONENTS

One chip of our new PPS 4/2 contains a clock, CPU, and 12 I/O lines.

The other holds 2K x 8 ROM, 128 x 4 RAM and 16 bidirectional I/O lines.

There you have it: a complete microcomputer on two chips. For many applications, that's all you'll ever need.

SO YOU CAN CUT COSTS

For example, the complete PPS 4/2 system is priced at less than $35 in quantities of 1000.

As your needs grow, you can add any of seventeen I/O, memory, or peripheral controller chips to your system at similar cost savings.

EIGHT-BIT PERFORMANCE FROM A FOUR-BIT MICROPROCESSOR

Rockwell's parallel processing and independently intelligent I/Os throughout the microprocessor system permit simultaneous performance of various functions, freeing the CPU for system thinking. In fact, with Rockwell's unique parallel processing system (PPS), your 4-bit system will actually outperform many 8-bit systems.

APPLICATIONS GALORE

The PPS 4/2 will control any number of mechanical or electromechanical devices — office machines, vending machines, electronic games and low-end cash registers to name a few.

It will also serve well as peripheral controller on larger microprocessing systems, including non-Rockwell CPUs you've already programmed.

For samples, specs or sage advice, call

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Because Rockwell's applications people and engineers all have backgrounds in systems and product design, they'll be able to give you specific answers as to how the PPS 4/2 relates to your product. Just call (714) 632-3729 and ask for Scotty Maxwell.

For technical literature or samples — without the advice — just drop us a line:

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New products

with an installed cost of $6 per foot, exclusive of terminations, could be replaced with four twisted-pair telephone cables at a total installed cost of less than $1 per foot. The basic RIM, which includes a GA-16/220 microcomputer with 8,192 words of memory, sells for $5,500. It can accommodate up to 10 input/output cards. With additional I/O enclosures, up to 256 analog inputs, 128 analog outputs, and any combination of up to 512 digital inputs and outputs can be handled.

General Automation Inc., 1055 South East St., Anaheim, Calif. 92805. Phone (714) 778-4800 [373]

Cycling controller lowers electricity bills

A load-cycling controller for industrial and commercial users reduces consumption of electrical energy, and hence electric bills, by automatically turning off individual electrical loads for predetermined periods. It could be used, for example, to turn off the lights and air conditioning in a cafeteria when food is not being served. The controller has an override switch to turn power on at any time desired. Available in 13- and 27-load versions, the controller can be independently programed for each load. The new model 310 duty cycle controller can work in conjunction with a power-demand controller (which limits peak-demand charges) for even bigger energy savings. The 13-load models sells for $1,195, and the 27-load unit is priced at $1,475. Delivery time is 45 days.

Pacific Technology Inc., 235 Airport Way, Renton, Wash. 98055. Phone Don Hall at (206) 623-9080 [374]

Miniature force transducers handle up to 2,500 newtons

Capable of measuring dynamic and quasistatic forces from 0 to 2,500 newtons (about 560 pounds), two quartz-crystal force transducers

Now our expandable line offers DC to 4 million bits per second!

We offer PCM capability, in addition to Direct and FM electronics, in three of our recorder/reproducers. There's the 7 to 14 channel Sabre III and the 28/32 channel Sabre V, both IRIG all-band portable recorders; and the Sabre IV, a 7 to 48 channel laboratory recorder/reproducer.

In addition our line includes the new Sabre VI which offers superior performance plus ultra-portability, and the Tandberg TIR-115, a 4-channel, FM, 25-pound system.

Those basic five recorders are actually an almost unlimited line because each is designed and built to adapt to an amazing variety of functions. Just tell us what you want one to do!

For information write: Sangamo Electric Company, Data Systems Division, P.O. Box 3347, Springfield, Illinois 62714. Area Code 217, 544-6411. Telex 406-461. Sales and service representatives worldwide.

SANGAMO RECORDERS

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Circle 141 on reader service card

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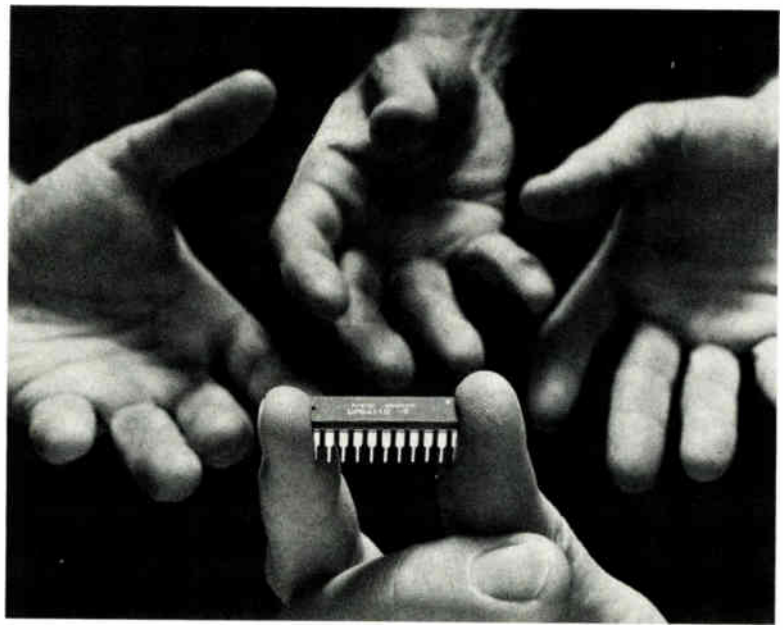
OUR 4K RAMS ARE SO GOOD, EVEN THE COMPETITION CAN'T RESIST.



Our μPD411 series of 4K dynamic RAMs is so much better than anything else on the market, even people who make their own 4K RAMs are buying ours. For their add-on memory systems.

Here's why:

First, speed. While everyone else is only talking about speeds of around 200ns, we're delivering 4K RAMs with speeds down to 150ns and less.

Second, reliability. Our 4K RAMs are made to the highest standards of reliability in the business. Yields on incoming inspection are honestly amazing. And MTBFs are over 5 million hours.

Third, delivery. We can deliver this state-of-the-art technology and incredible reliability right now. In whatever volume you want.

So if you need 4K RAMs, take a look at our μPD411 series — the best 4K RAMs you can buy.

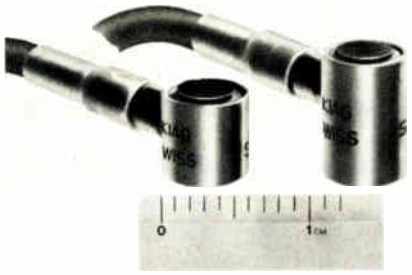
But don't take our word for it.

Ask our competition.

NEC Microcomputers, Inc., Five Militia Drive, Lexington, Massachusetts 02173. 617/862-6410.

NEC microcomputers, inc.

New products

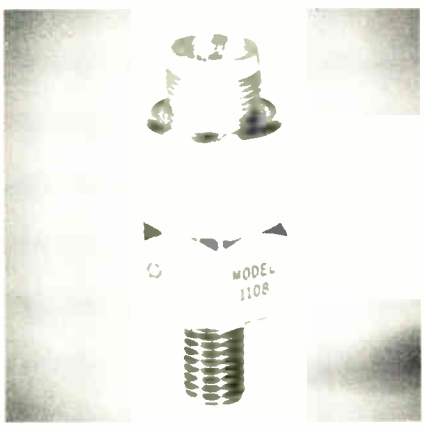


measure only 6 millimeters in diameter. The type 9211 is only 6 mm high, and the 9213, which has a mounting thread on one side, is 8.5 mm high. Both units come equipped with high-temperature cables. Because of their small size, the transducers have an unusually high natural frequency—about 200 kilohertz.

Kristal Instrument Corp., 2475 Grand Island Blvd., Grand Island, N. Y. 14072. Phone Ronald F. Lochocki at (716) 773-4150 [375]

Lightweight accelerometers need no excitation

Piezoelectric-semiconductor accelerometers for measuring shock and vibration are self-contained devices that need no external excitation or special low-noise cable for proper operation. The 1100 series of accelerometers has more than 40 models with widely varying specifications. All of the models are small and lightweight, and most of them have a flat frequency response out to 8 kilohertz. The devices can be connected through standard cable to an oscilloscope, voltmeter, or recording instrument without degradation of signal-to-noise ratio or loss of low-frequency response.



Columbia Research Laboratories Inc., MacDade Blvd. and Bullens Lane, Woodlyn, Pa. 19094. Phone (215) 532-9464 [377]

Digital process monitor reads in engineering units

The model 203P process receiver is a digitizing and display device with offset and span adjustments that allow scaling of the display in any desired engineering units. Designed to accept the voltage or current outputs of industrial process-control transmitters, the 203P is a 3½-digit (2,000-count) instrument. It uses 0.5-inch light-emitting-diode displays and includes parallel BCD outputs as a standard feature. The 203P has a small-quantity price of $135.

Newport Laboratories Inc., 630 E. Young St., Santa Ana, Calif. 92705. Phone Charles N. Hasley at (714) 540-4914 [376]

Optical isolator protects lasers

Acting as an optical diode—a unilateral optical device—the model 170 optical isolator is a Faraday-rotation device that will protect high-power lasers from potentially damaging reflections. The model 170 has a forward/reverse transmission ratio in excess of 200:1, which it can maintain for as long as 200 microseconds. The device consists of a pair of polarizers, a Faraday rotator, a power supply, and electronics to drive the rotator. Powers up to 300 megawatts per square centimeter at repetition rates up to 10 hertz may be transmitted through the model

New products

170. Transmission loss is less than 15%. The isolator was designed for use with lasers operating at 1.06 micrometers, although other models are available for use at other wavelengths. Measuring 10 inches long by 3 in. in diameter, the model 170 sells for $4,950. Delivery time is 60 days.

General Photonics Corp., 3004 Lawrence Expressway, Santa Clara, Calif. 95051. Phone Raquel Bernard at (408) 736-7114 [378]

Low-profile sequencing relay is long-lived

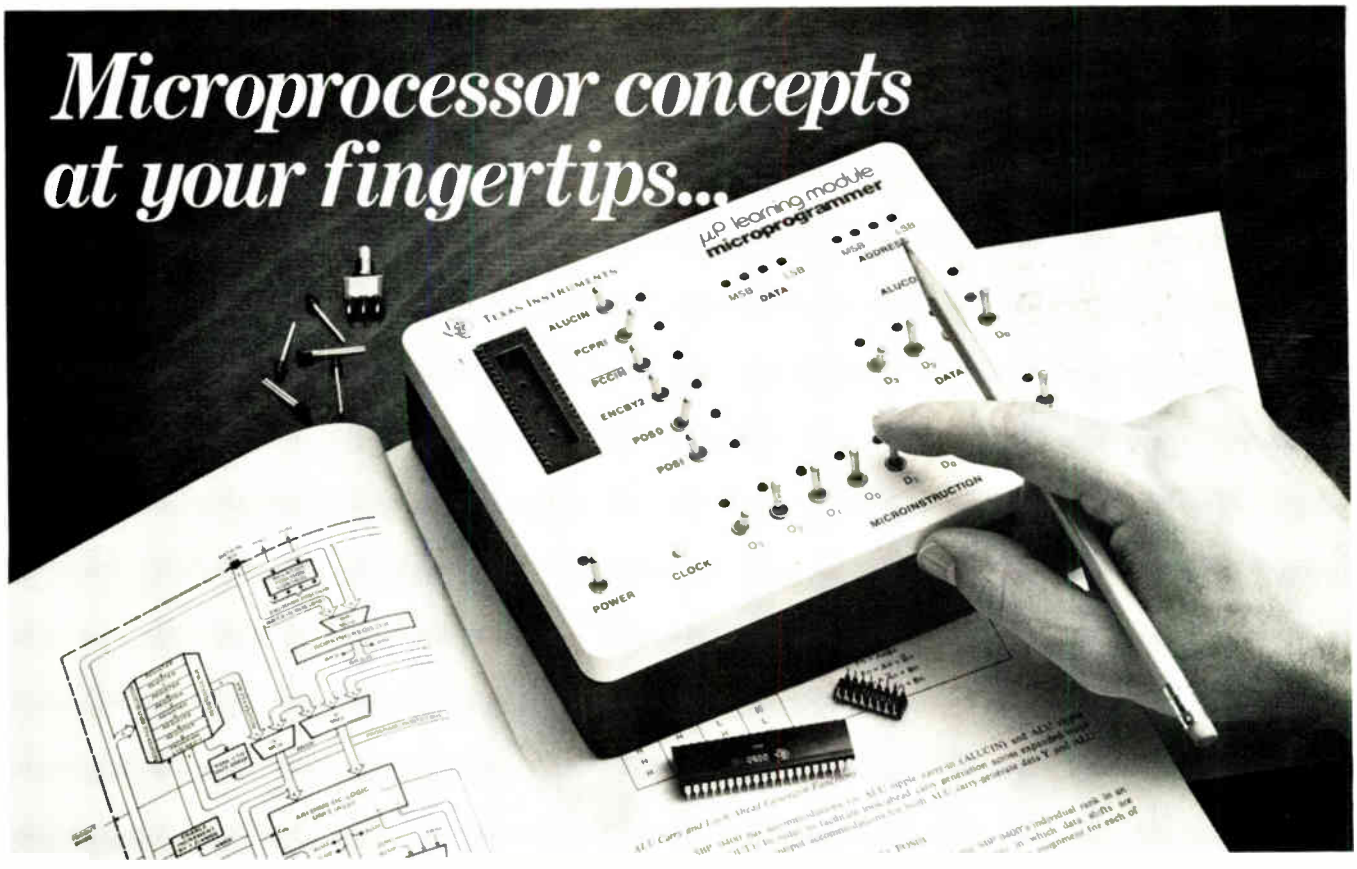
Rated at 10 million mechanical operations—twice the life of comparable devices—the model A311 is a low-profile, sequencing relay. In addition, it has the necessary contact configurations to replace three Struthers-Dunn Frame 211 models and fits into their sockets.

Struthers-Dunn Inc., Lambs Rd., Pitman, N. J. 08071 [379]

TOPICS

Industrial

The use of a high-intensity LED has increased the range of the model MLS2A photoelectric control unit to 700 feet. The two-part system, which sells for $385, is made by **Micro Switch, a division of Honeywell, Freeport, Ill.** . . . The Microautostat bar is a compact version of the Autostat static-electricity neutralizing bars made by **Static Inc., Lee, Mass.** The new device is only 0.25 inch thick and 0.5 in. wide. . . . The Metri-Gap 300-5A from **Lion Precision Corp., Newton, Mass.,** is a noncontacting instrument for the measurement of total indicated runout (TIR) on rotating and vibrating members. . . . **I-T-E Imperial Corp., Spring House, Pa.,** has introduced a line of oil-tight push-button switches, selector switches, and pilot lights for use in dusty and oily industrial environments.



Introducing Texas Instruments Microprocessor Learning Modules

Now there's a quicker, easier way to provide basic "hands on" experience with microprocessors—the TI μP Learning Module Microprogrammer (LCM-1001). There's nothing to build, no kit to assemble. Just open the comprehensive instruction manual, turn on the module, and you are in the learning mode quickly and easily. From the basics to advanced learning, you set the pace.

Learn hardware/software relationships

By following the manual and applying the module you will become thoroughly familiar with fundamental hardware/software relationships that are essential to successful microprocessor utilization. In addition, the unit will:

- Teach microprogramming
- Enable you to develop simple algorithms
- Help you to develop fixed instructions
- Establish foundation for controller design techniques
- Build insight into microprocessor evaluation techniques
- Better prepare you to effectively employ applications "kits" on specific microprocessors.

Economical self-contained system

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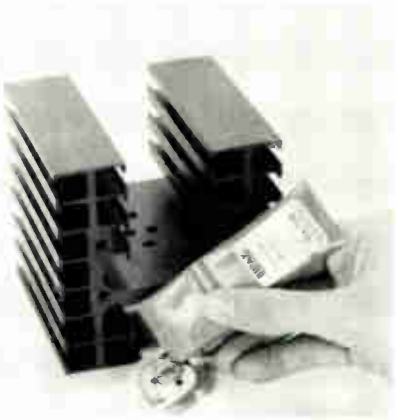
Circle 145 on reader service card

New products/materials

Recommended for bonding transistors, diodes, ICs and other heat-sensitive components to circuit boards, radiators and heat sinks, a two-part thixotropic epoxy adhesive mixes quickly to a smooth paste with plenty of slump-resisting body for fast assembly. Called Tra-Bond 2151, it cures overnight at room temperature and forms a thermally



conductive yet electrically insulating bond to a variety of materials. The material is available from stock in premeasured Bipax packages that are said to take the uncertainty out of mixing and metering epoxy systems.

Tra-Con Inc., Resin Systems Division, 55 North St., Medford, Mass. [476]

Circuit-board etchant is described as a low-cost replacement for ammonium or sodium persulfate. The material, named Electro-Brite PCB etchant, has an indefinite bath life, eliminating the waste treatment associated with the periodic dumping of other etchants. With Electro-Brite, continuous removal of copper is possible by crystalization, and the copper can then be recovered electrolytically.

Electrochemicals, Division of Dart Industries Inc., Chemical Group, 751 Elm St., Youngstown, Ohio 44502 [477]

Thick-film resistor pastes for firing at 600°C offer high stability after thermal aging or power-loading. For screen-printing applications on soda-lime glass or alumina substrates, 600-series formulas are available in values from 100 to 1

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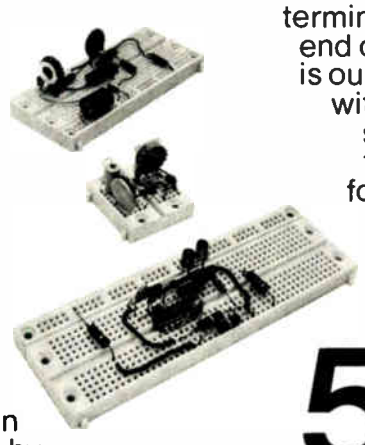

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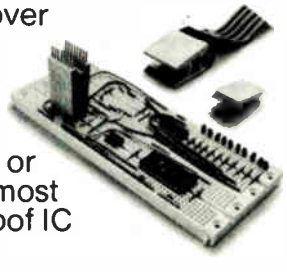

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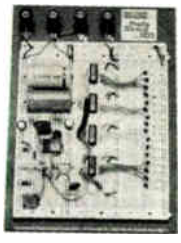

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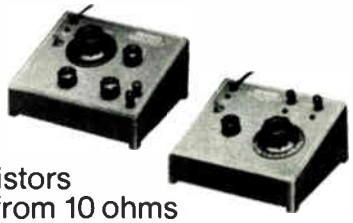

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Thick Film Systems Inc., 324 Palm Ave., Santa Barbara, Calif. 93101 [478]

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Rhenium Alloys Inc., P.O. Box 245, Elyria, Ohio 44035 [479]

Rapid-cure diallyl-phthalate (DAP) molding compounds are said to reduce molding-cycle times by 50% compared with conventional DAP materials. The new series of compounds, called Dapex, can improve processability and cycle times for compression, transfer and screw-injection operations. According to the maker, Acme Resin Co., a circuit-board connector that previously required 65 seconds to transfer-mold needs only 40 s with one of the new compounds.
Acme Resin Co., 1401 South Circle Ave., Forest Park, Ill. 60130 [480]

Because it is water-soluble, a temporary adhesive that is used to hold substrates and semiconductor materials for dicing, drilling, and machining is said to be more convenient than materials that require dissolving in acetone or MEK. The new material, Crystalbond 555, is a thermoplastic monomer that melts at 125°F and flows at 130°F, producing a very low-viscosity adhesive.
Aremco Products Inc., P.O. Box 429, Ossining, N.Y. 10562 [341]

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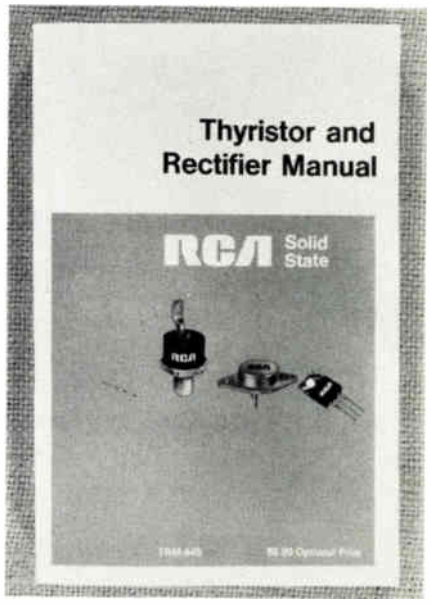
New literature

Guarding. Application bulletin AB-20 describes how guard circuitry reduces common-mode effects and thus reduces measurement errors. The bulletin distinguishes between situations which do and do not require guarding, and explains the importance of never leaving an instrument's guard terminal disconnected. Copies are available from John Fluke Mfg. Co. Inc., P.O. Box 43210, Mountlake Terrace, Wash. 98043. Circle reader service number 421.

Thyristors and rectifiers. RCA's new "Thyristor and Rectifier Manual" is a 376-page book that covers basic theory, performance, and circuit applications of thyristors and



silicon rectifiers. TRM-445 has an optional distributor price of $5 and may be ordered from RCA Solid State distributors or by sending checks or money orders to RCA Solid State Division, Box 3200, Somerville, N. J. 08876 [422]

Optics. A 192-page document from Melles Griot (formerly Optical Industries) presents basic formulas, optical-parameter tables, and design tips for designers of systems that use lenses, lens systems, beam-splitters, prisms, optical flats, filters, reflectors, and other optical components. Included in the "Optical Guide" is a

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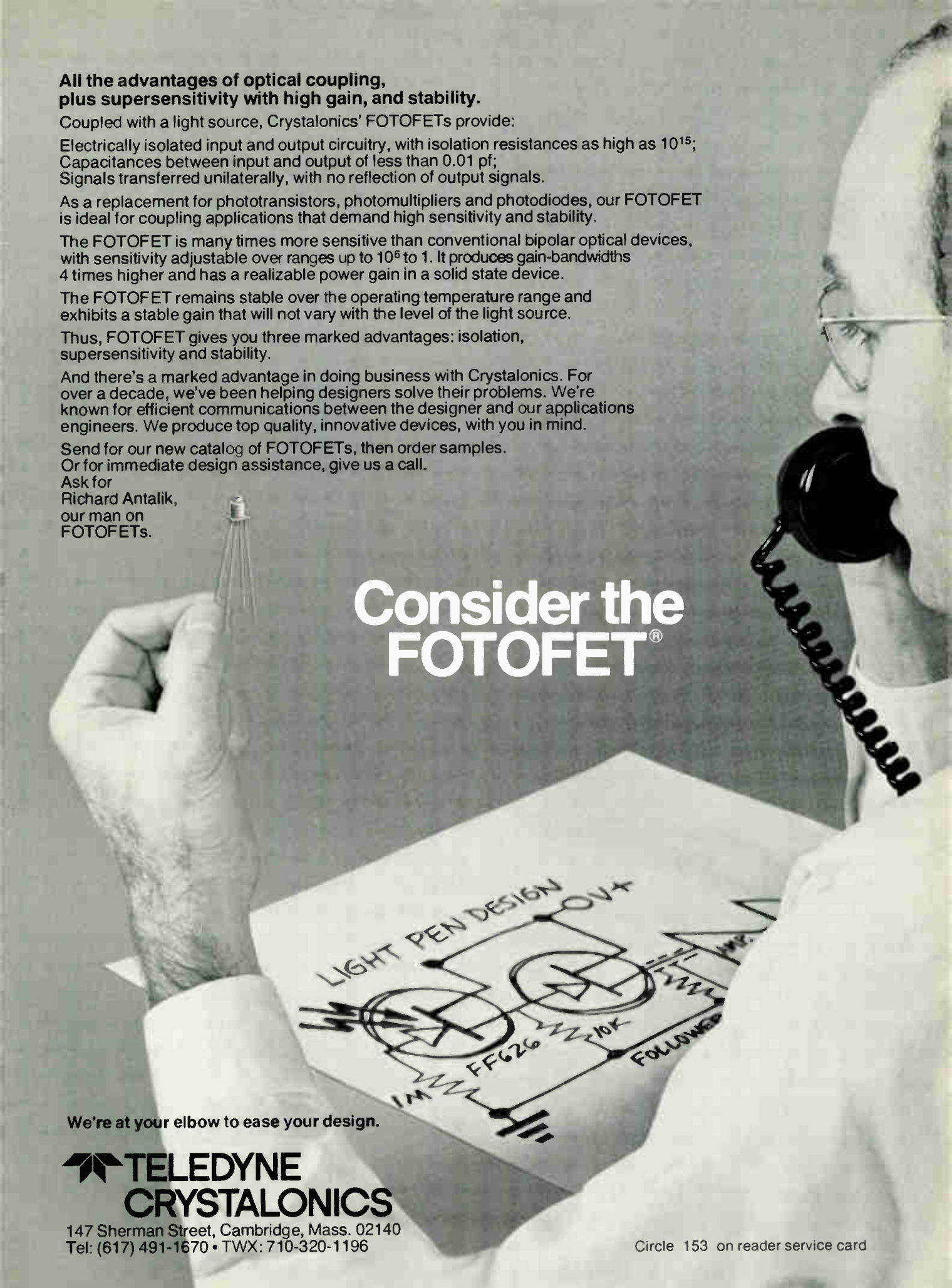

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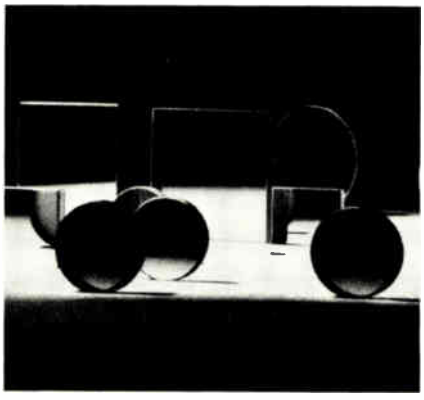
Circle 153 on reader service card

New literature

catalog of the Melles Griot line of optical products. Available to qualified users, the guide can be obtained from Melles Griot, 3006 Enterprise St., Costa Mesa, Calif. 92626 [423]

Soft-recovery rectifiers. Although soft-recovery rectifiers are not supposed to cause destructive commutation voltage spikes, as do abrupt-recovery units, an abrupt change in current during a slow recovery may generate spikes. Tech Tips 4-5, "Soft-Recovery Rectifiers Can Cause Commutation Voltage Spikes," explains how this situation can occur and tells how to specify rectifiers that will overcome the problem. The publication is offered by the Semiconductor Division, Westinghouse Electric Corp., Youngwood, Pa. 15697 [424]

Optical components. A catalog of off-the-shelf optical components such as lenses, mirrors, prisms, polarizers, retarders, and beam-splitters is available from Optics for Research, Box 82, Caldwell, N. J. 07006 [425]



Lights and switches. Condensed catalog No. 91 describes the switches and indicator lights made by Control Switch, a Cutler-Hammer Co., 1420 Delmar Dr., Folcroft, Pa. 19032 [426]

Burr-Brown catalog. The 1976 general product catalog from Burr-Brown includes data on the company's lines of data-acquisition and microcomputer input/output systems, data-conversion products, op-

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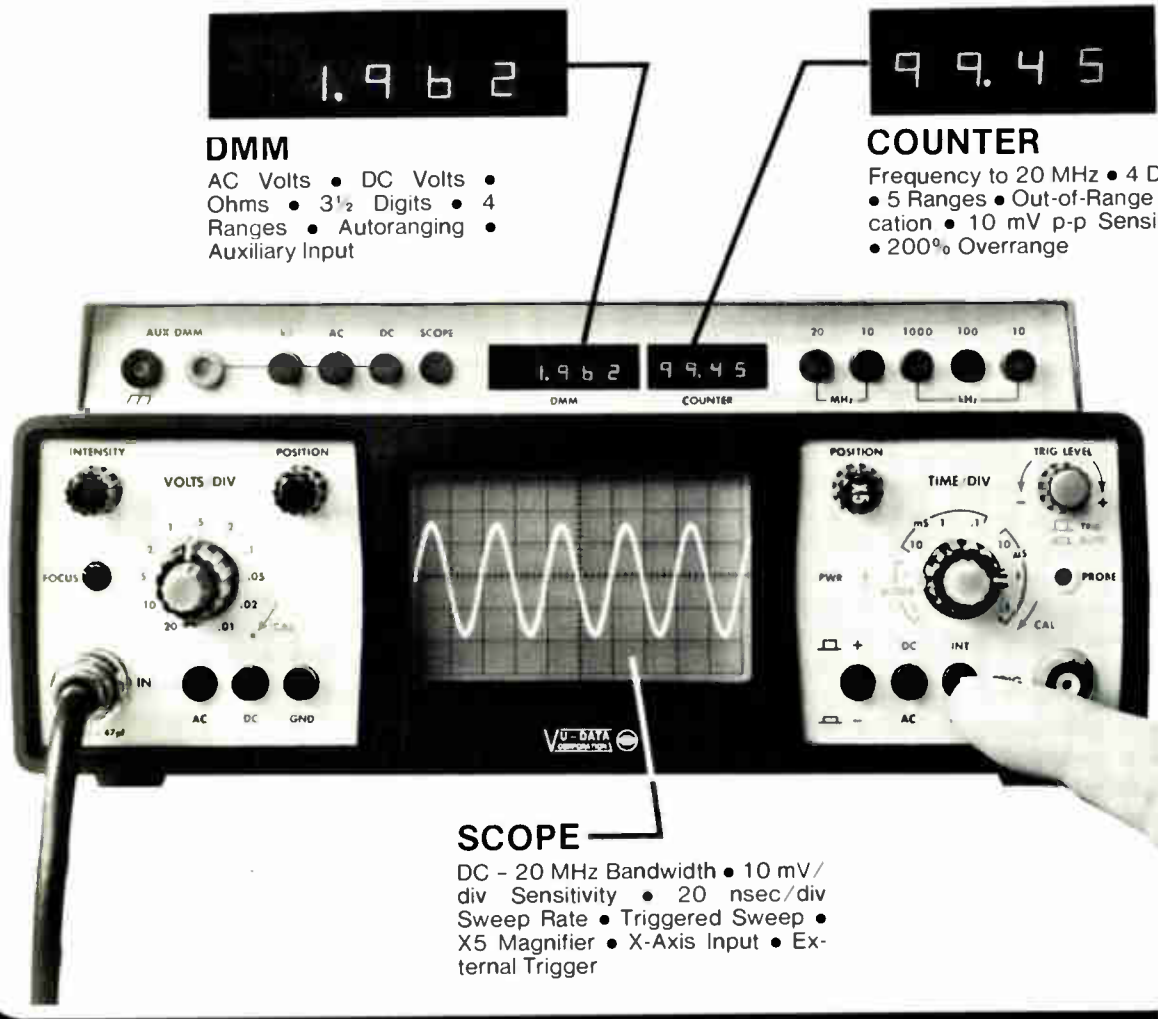

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Circle 155 on reader service card

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2/5/76

New literature

erational amplifiers, instrumentation amplifiers, analog modules, power supplies, active filters, etc. The 116-page catalog can be ob-

tained from Jerry Athey, Advertising and Sales Promotion Manager, Burr-Brown, Box 11400, Tucson, Ariz. 85734 [427]

Lighted devices. A 56-page catalog from Chicago Miniature/Drake, 4433 N. Ravenswood Ave., Chicago, Ill. 60640, lists the company's full line of LED, neon, and incandescent indicator lamps. Ask for "Lited Devices" catalog 7603 [428]

Corona Detection. A 12-page brochure both discusses the significance of corona and lists equipment available for its detection. Brochure HP7110 is offered by Hipotronics Inc., Brewster, N. Y. 10509. It includes both ac and dc generators, two detectors, and various accessories. [429]

Ceramic capacitors. A substantial addition to the line of resin-coated multilayer ceramic capacitors made by Sprague is described in 12-page engineering bulletin No. 6201G, which is available from the Technical Literature Service, Sprague Electric Co., 35 Marshall St., North Adams, Mass. 01247 [430]

Polypropylene. The case for polypropylene against competing materials is made in a 20-page brochure, that is put out by Rexene Polymers Co., P.O. Box 37, Paramus, N.J. 07652 [431]

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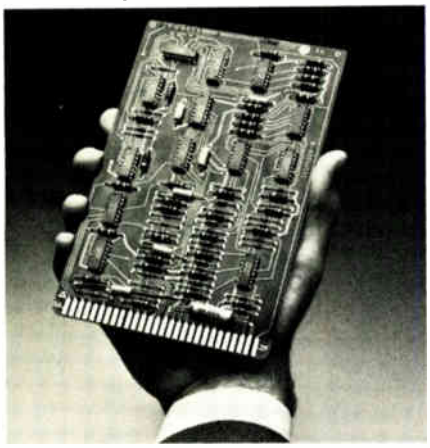

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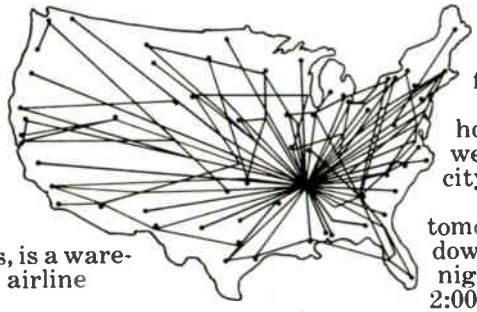

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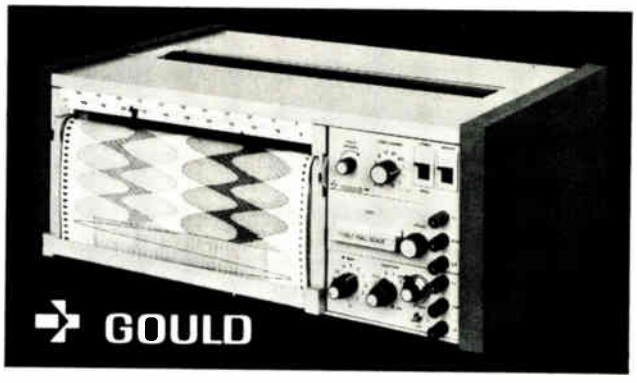

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3 18 33 48	63 78 93 108	123 138 153 168	183 198 213 228	243 258 273 350	365 380 395 410	425 440 455 470	485 500 705 720
4 19 34 49	64 79 94 109	124 139 154 169	184 199 214 229	244 259 274 351	366 381 396 411	426 441 456 471	486 501 706 900
5 20 35 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
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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
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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
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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
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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
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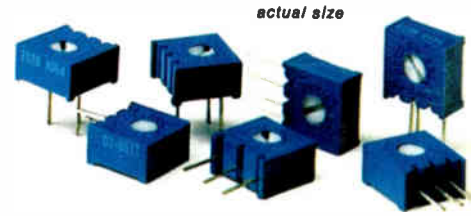

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