Electronic Design®

FOR ENGINEERS AND ENGINEERING MANAGERS — WORLDWIDE

VOL. 26 N

1

JAN. 4, 197

What's in the signs for 1978? More powerful μPs and a host of logic and μP analyzers, as well as digital testers. The stars also point to a conflux of larger memories, lower-cost peripherals and new architectures for minis. Analog LSI chips and complex hybrids are also on the rise. For a look into the future, see p. 40.

Another Colorful Innovation...

Conductive Plastic Trimmers at Carbon Prices.

Just when you thought "low cost" also meant "low performance", along comes the dazzling new Bourns® Model 3355. Compare it to the CTS 201, Mepco 46X or Piher PT15. Our revolutionary conductive plastic element vs. their carbon . . . fact is we outperform them all. To prove it, we spec important characteristics such as CRV at 1% and a TC of 500 PPM/°C . . . the others don't. And only the 3355 has board-wash capability, a UL-94V-1 flammability rating and an optional choice of nine rotor colors. The standard blue is priced at just 11¢ each (100,000 pieces). . . about what you'd expect to pay for the lower performance carbon types.

Send today for complete details on a colorful new way to design in superior performance for your cost effective needs — the Model 3355 Trimmer. Direct or through your local distributor.

TRIMPOT PRODUCTS DIVISION, BOURNS, INC., 1200 Columbia Ave., Riverside, CA 92507. Phone: 714 781-5050 — TWX: 910 332-1252.

CATALOG SHEET SPECIFICATION COMPARISONS

CHARACTERISTIC	BOURNS 3355	CTS 201*	MEPCO 46X*	PIHER PT15*
Element	Conductive Plastic	Carbon	Carbon	Carbon
Temperature Coefficient	500 PPM/°C	No Spec	No Spec	1000 PPM/°C
Contact Resistance Variation	1.0% max.	No Spec	No Spec	No Spec
Power Rating	.25 W at 70°C	.25 W at 55°C	.25 W at 55°C	.25 W at 40°C
Flammability	UL-94V-1	No Spec	No Spec	UL-94
Board Wash Capability	Yes	No Spec	No Spec	No Spec

*Source: CTS Series 201 Data Sheet, Mepco Data Sheet ME1004, Piher Data Sheet F-2002 Rev 7/73

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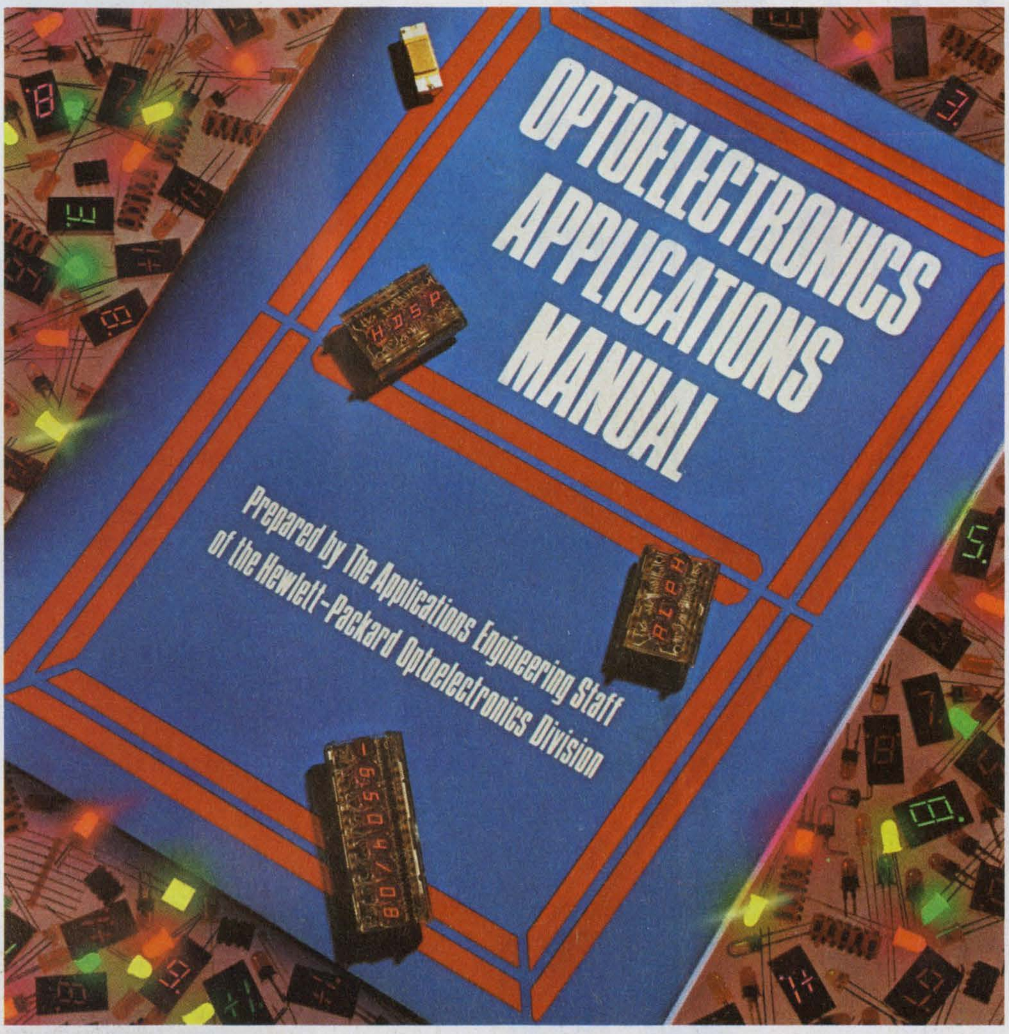
For Immediate Application — Circle 130
For Future Application — Circle 230

SURPRISE!



A Treasury of Opto Applications from HP.

Just published by McGraw-Hill and authored by the Applications Engineering Staff of Hewlett-Packard, this 279 page hardcover book is a practical guide to the use of optoelectronic devices and a foundation for the development of new design ideas. This volume demonstrates the broad potential for optoelectronic components and how to take full advantage of optoelectronics in your design.

In nine chapters you'll explore everything from theory of LED operation, design, packaging, contrast enhancement — even practical insights into photometry and radiometry.

You'll find this book not only invaluable, but will find it can save you time, effort and costs. Contact any HP franchised distributor for your copy — only $19.25* ask for HPBK-1000, Optoelectronics Application Manual. They're in stock right now. In the U.S., contact Hall-Mark, Hamilton/Avnet, Pioneer Standard, Schweber, Wilshire or the Wyle Distributon Group (Liberty-Elmar) for immediate delivery. In Canada, just call Hamilton/Avnet or Zentronics, Ltd. *U.S. Domestic price only

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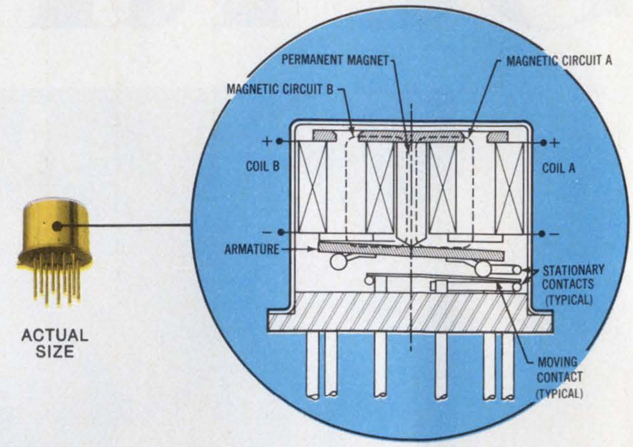
CIRCLE NUMBER 2

TO-5 RELAY UPDATE

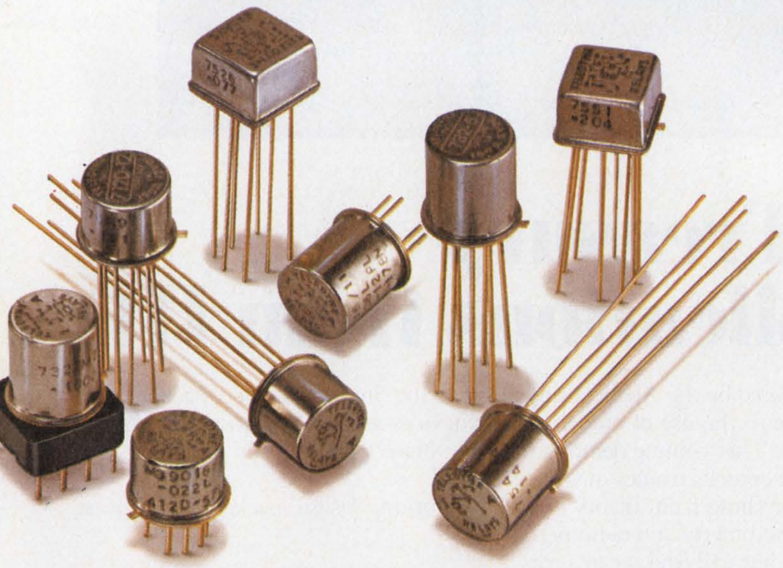
Maglatch TO-5: the relay with a mind of its own.



Whenever critical switching circuits call for reprogrammable non-destructible memory, choose Teledyne's magnetic latching TO-5 — the relay that remembers. Once set with a short pulse of coil voltage, it will retain its state until reset or reprogrammed — even if system power fails or is shut off. And you get the added advantage of reduced system power demands, since conventional relay holding power is not required.

But reprogrammable memory capability and low power consumption are not the only advantages of our TO-5 maglatch relays. Their subminiature size makes them ideal for high density pc board packaging, and they're available in SPDT, DPDT and 4PST contact forms. And for RF switching, their low intercontact capacitance and contact circuit losses provide high isolation and low insertion loss up through UHF.

Our magnetic latching as well as our complete line of TO-5 relays includes military and commercial/industrial types with MIL versions qualified to "L" and "M" levels of established reliability specs. For complete data, contact Teledyne Relays — the people who originated the TO-5 relay.



OTHER TELEDYNE TO-5 RELAYS

- **Hybrid "T" Series**
  SPDT & DPDT types with internal transistor driver and suppression diode. Military and commercial/industrial versions.
- **"D" and "DD" Series**
  With internal suppression and steering diodes. Military and commercial/industrial versions.
- **Centigrid® Series**
  World's smallest relay—only .225" (5.72mm) high x .370" (9.40mm) square. DPDT, with optional internal suppression and steering diodes.
- **Hi-Rel Series**
  Screened versions for space flight applications (NASA qualified).
- **High Environment Series**
  Hi-temperature, Hi-shock, and Hi-vibration types.

TELEDYNE RELAYS

3155 West El Segundo Boulevard, Hawthorne, California 90250
Telephone (213) 973-4545

CIRCLE NUMBER 3

Electronic Design®

FOR ENGINEERS AND ENGINEERING MANAGERS — WORLDWIDE

VOL. 26 NO. 1

JAN. 4, 1978

NEWS

TECHNOLOGY

PRODUCTS

DEPARTMENTS

Cover: Cover designed by Art Director, Bill Kelly.

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"Only one DIP socket gives you all the best features. And more.

New DIPLOMATE– from AMP."

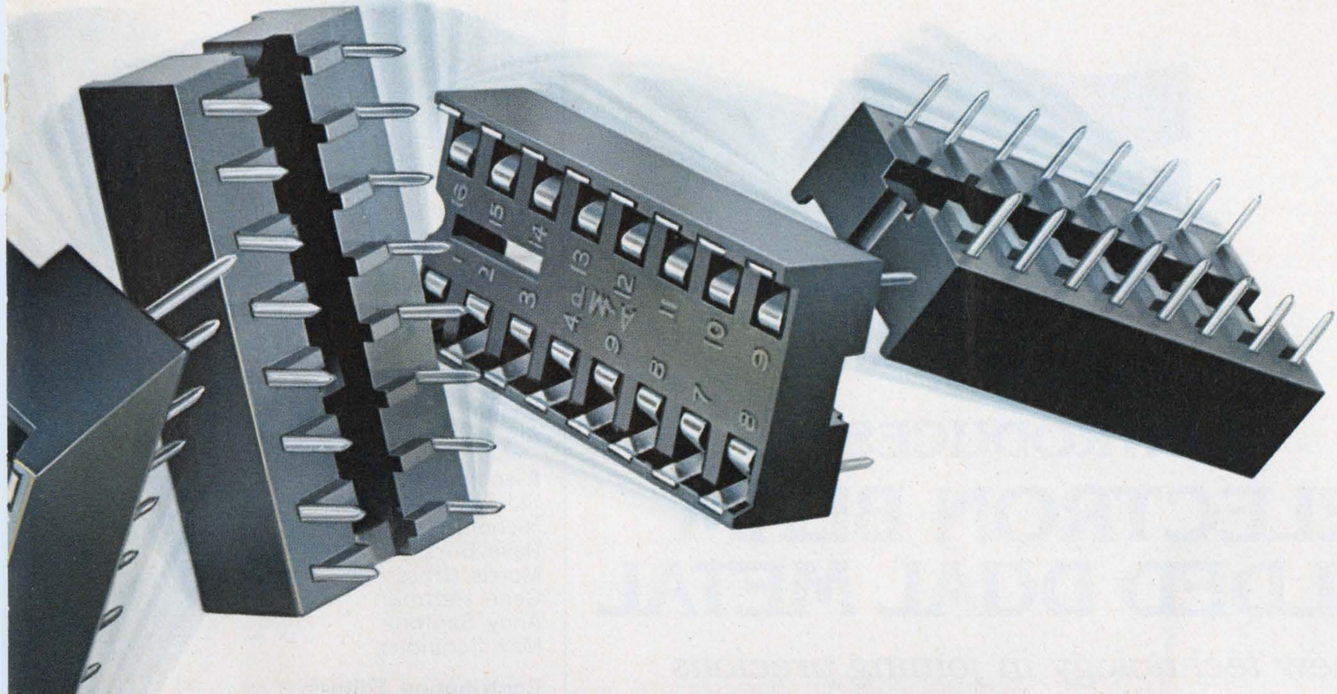
The new low profile Diplomate combines the best engineering features with AMP's own exclusive contact design innovations. Here are some of its outstanding advantages:

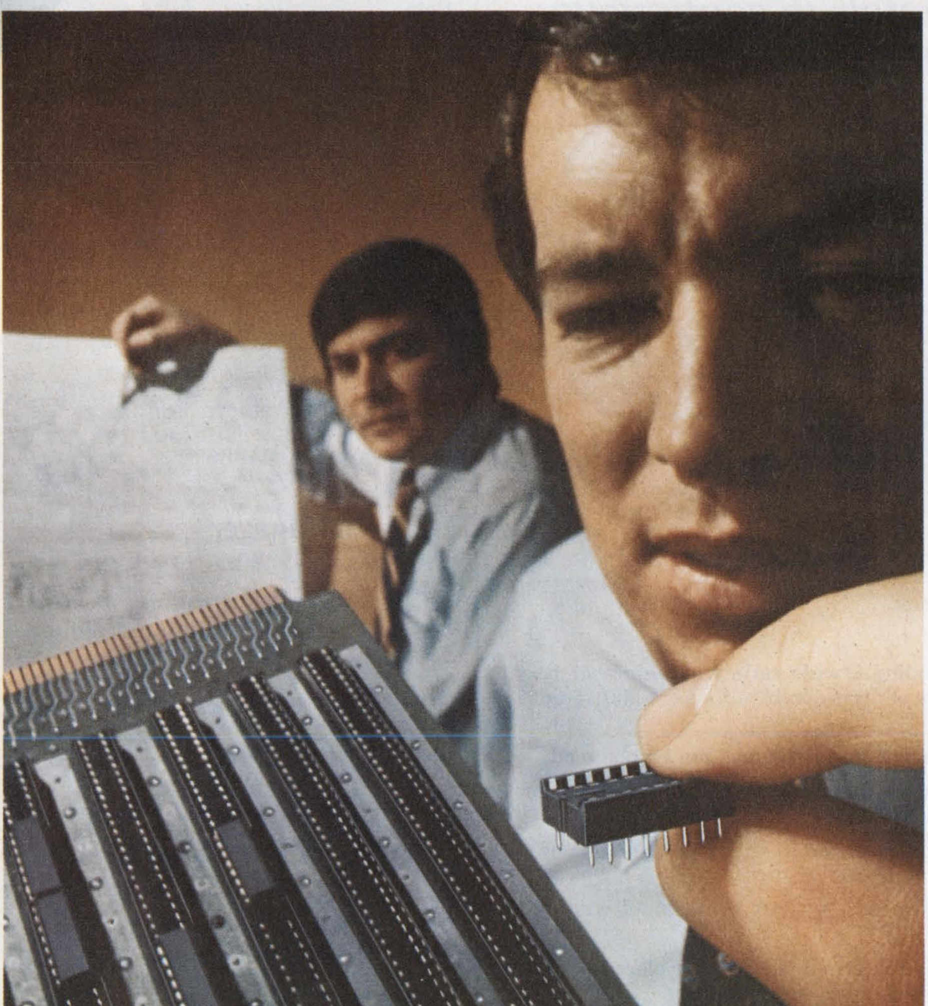
1. Metal-to-metal-to-metal contacts with dual side-wiping action ensure low contact resistance and excellent electrical reliability.
2. Unique closed bottom design prevents solder wicking and flux contamination for complete contact protection.
3. Exclusive tapered lead-in ramps in large target area make IC insertion faster and easier. Diplomate pc board insertion is also easy and compatible with virtually any automatic insertion equipment.
4. Anti-overstress contact design preserves contact spring integrity for continuous, long-term reliability.

New Diplomate sockets help you get the most from your designs in many other ways:

- Higher densities. Low profile packages are stackable end-to-end for more circuits in less space.
- Built-in reliability. Meets Computer Industry and EIA RS415 specifications as well as U.L. 1410 flame retardant specifications.
- Full variety of sizes. Complete family of sizes available ranging from 8 to 40 positions.
- Complete technical support. Solid engineering aid is yours for the asking from AMP. And it's available worldwide.

There are more reasons why new Diplomate is the better way, including its competitive prices. For more information, just call Customer Service at (717) 564-0100. Or write AMP Incorporated, Harrisburg, PA 17105.





Sr. Vice President, Publisher
William Maass

Editors
Editorial Offices
50 Essex St.
Rochelle Park, NJ 07662
(201) 834-0550
TWX: 710-990-5071
(HAYDENPUB ROPK)
Cable: Haydenpubs Rochellepark

Editor-in-Chief George Rostky

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Contributing Editors:
Peter N. Budzilovich, Jules H. Gilder, Sidney Moskowitz, Nathan Sussman

Editorial Field Offices
East

Jim McDermott, Eastern Editor
P.O. Box 272
Easthampton, MA 01027
(413) 527-3632

West

Dick Hackmeister, Western Editor
8939 S. Sepulveda Blvd., Suite 414
Los Angeles, CA 90045
(213) 641-6544
TWX-1-910-328-7240

Dave Barnes, Western Editor
465 S. Mathilda, Suite 302
Sunnyvale, CA 94086
(408) 736-6667

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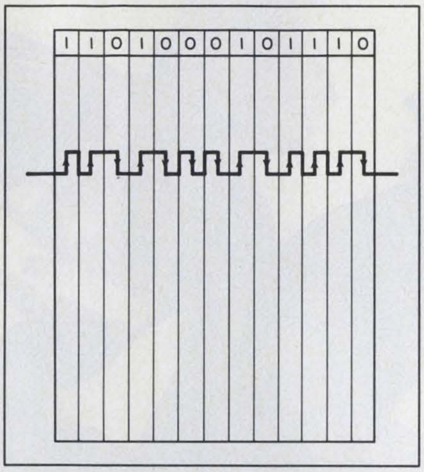
Across the desk

Does one sentence know what the other one says?

Your article, "Digital Tape Recording Is Denser, but Standardization Isn't Standard" (ED No. 21, Oct. 11, 1977, p. 28), included a box entitled "Flux Reversals" (p. 30). The last paragraph states:



"Phase-encoded recording solved the problem. At every bit time, at least one flux reversal occurs—one reversal indicates a ZERO, two reversals indicate a ONE. The flux reversal is in one direction for a ZERO, another for a ONE. This scheme provides a self-clocking mechanism that can track a string of repetitive bits, no matter how long it is."

First you imply that there are either one or two flux reversals per bit period, the ONE state being defined by two transitions, ZERO state by a single transition. Then you describe a transition-polarity-sensitive writing scheme where one "direction" defines the ONE state, and the other "direction" defines the ZERO state.

I cannot logically relate the second sentence of the paragraph to the third. Could you simply indicate the encoding scheme you intended to describe as "phase-encoding"?

C.O. Miller
Marketing Manager
Tape Products
Honeywell
Test Instruments Division
4800 E. Dry Creek Road
Denver, CO 80217

Ed. Note: Your point is well-taken; the sentences are indeed in conflict. The second half of the second sentence is the culprit and should be deleted. The proper relationships between phase-encoded ONEs and phase-encoded ZEROs are shown in the diagram (left).

Quasioptics caption was mixed up

The caption that ran beneath the two photos on p. 26 of "Radio Receiver Reaches 670 GHz..." (ED No. 23, Nov. 8, 1977) was incorrect. The quasioptical mixer was invented and built by Dr. J.J. Gustincic, an independent consultant from Marina Del Ray, CA. He was one of a team that developed the submillimeter imaging system. Others in the team were Prof. N.C. Luhmann Jr. of the University of California, Dr. T.H. DeGraauw of the Netherlands and Dr. D. Hodges of Aerospace Corp.

The WOM works

Using the WOM, we were able to manufacture our now famous RTL (right-turning light) and TTL (towards turning left) circuits for the Los Angeles Police Department. These circuits,

(continued on page 198)

Electronic Design welcomes the opinions of its readers on the issues raised in the magazine's editorial columns. Address letters to Managing Editor, Electronic Design, 50 Essex St., Rochelle Park, NJ 07662. Try to keep letters under 200 words. Letters must be signed. Names will be withheld upon request.

Intel delivers six single that provide economy

Intel leads the way with both the lowest cost and the highest performance single-chip microcomputers available. We now deliver the industry's broadest and most complete selection of compatible economy microcomputers. So there's no need to compromise your standards when your application requires low cost intelligence.

That's good news if you're designing for home appliances, automobiles, communications equipment, vending machines or any price-sensitive product. Now you can take advantage of microcomputer power to replace hardwired logic and electromechanical devices, and achieve unmatched design flexibility, improved reliability and reduced product cost.

At $3 in OEM quantities, our new 8021 is quite simply the world's lowest priced 8-bit microcomputer. It's a cost reduced version of our 8048, the microcomputer which won industry acceptance for the single-chip system concept. Then there's our new top-of-the-line 8049, the microcomputer that sets a new standard for single-chip system performance.

The entire line of MCS®-48 microcomputers is priced right and designed to lower your total system cost. For example, they all operate from a single 5V power source, and the 8021 has the broadest operating range in the industry (4.5V to 6.5V).

The 8021 also has an internal clock generator that lets you control system timing with a single 2¢ resistor. Built-in zero cross detection enables the 8021 to accurately control system

chip microcomputers without compromise.

timing operations and perform time-of-day accumulation.

For sheer performance, there's not a single-chip microcomputer anywhere that can catch our new 8049. With twice the on-chip memory of the 8048, the 8049 enables you to economically perform complex functions that previously required more costly multi-chip systems. And it's a drop-in replacement for the 8048, so you can upgrade 8048-based products with no redesign.

We've made MCS-48 microcomputers the easiest to use, too. Our 8748, for example, provides on-chip erasable and reprogrammable EPROM. That enables you to beat the ROM turnaround cycle during design and field testing. And its 100-piece prices start at just $39, making the 8748 economical for low to medium volume production. To ensure maximum flexibility, all members of the MCS-48 family are software compatible.

If you've taken advantage of our high performance multi-chip microcomputers, the 8080 and 8085, you know that Intel delivers the most in-depth and advanced development support. Now you don't have to go without that support, even for your most

MCS-48 Microcomputers

Model	Program Memory	Data Memory	I/O Lines	Instructions	Package Size
8021	1K Bytes ROM	64 Bytes	21	65	28 Pin
8048*	1K Bytes ROM	64 Bytes	27	96	40 Pin
8748*	1K Bytes EPROM	64 Bytes	27	96	40 Pin
8035*	(External)	64 Bytes	27	96	40 Pin
8049*	2K Bytes ROM	128 Bytes	27	96	40 Pin
8039*	(External)	128 Bytes	27	96	40 Pin

*Designed for easy expansion of program/data memory and I/O.

budget-minded applications. It starts with our PROMPT™48 Design Aid. Then there's Intellec®, the industry's most powerful microcomputer development system, with resident MCS-48 Macro Assembler and ICE™ In-Circuit Emulation with symbolic debugging. Plus applications assistance worldwide, full documentation, training classes, design seminars and a rapidly expanding users' software library.

The more important economy is to you, the more important it becomes for you to evaluate the 8021, 8049 and other members of Intel's MCS-48 economy microcomputer family. They're all available now through your nearest Intel distributor: Almac/Stroum, Component Specialties, Cramer, Hamilton/Avnet, Harvey Electronics, Industrial Components, Pioneer, Sheridan, L.A. Varah, Wyle/Elmar-Liberty and Zentronics. For complete technical information use the reader service card or write: Intel Corporation, 3065 Bowers Avenue, Santa Clara, CA 95051. Telephone: (408) 987-8080.

intel® delivers.

CIRCLE NUMBER 7

PMI's COMDAC™ companding D/A converter. When you think about what it can do, nothing seems very far-fetched.

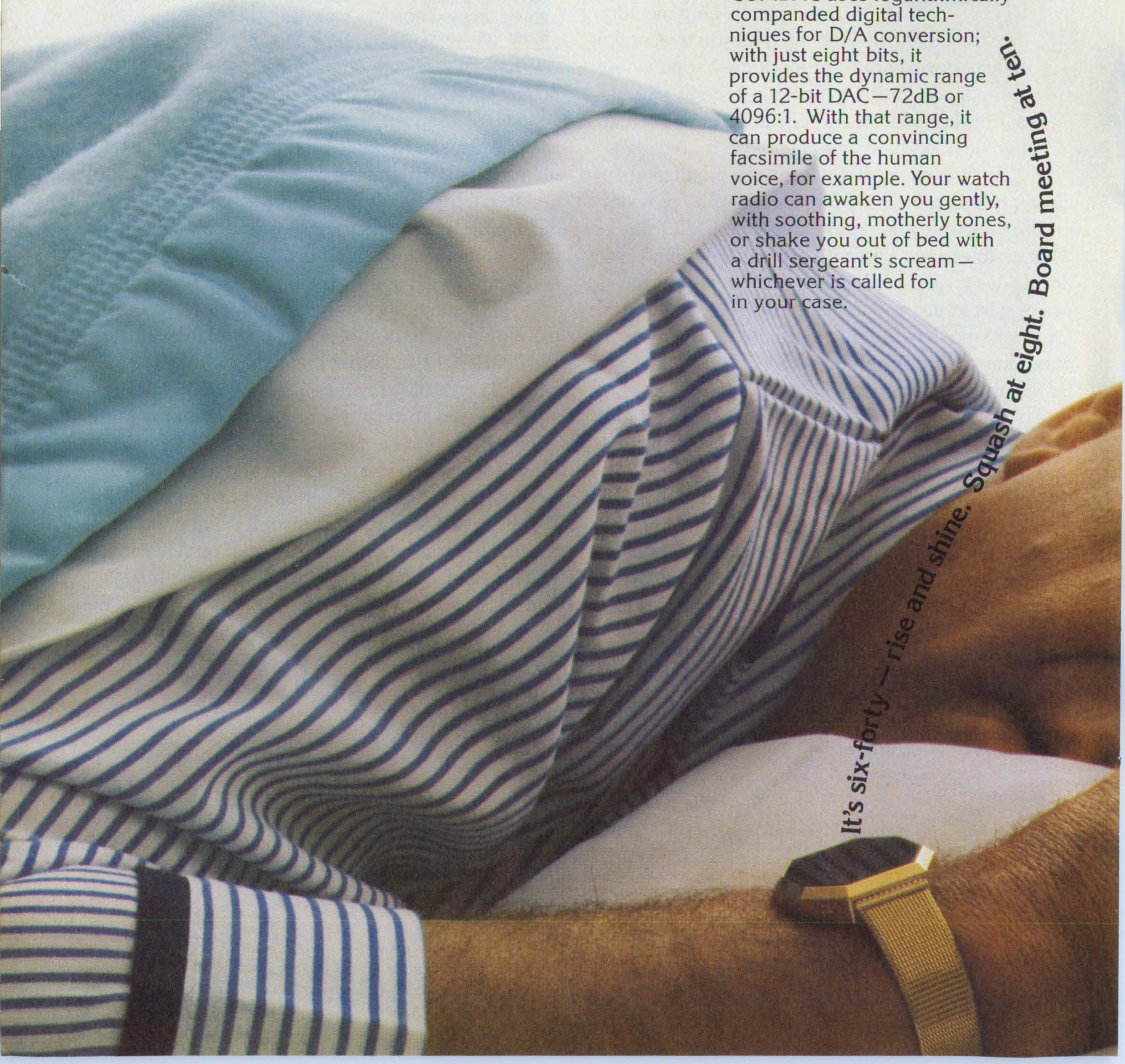
Not long ago, we ran a little contest in one of the electronics magazines. We asked engineers to come up with the most creative ideas they could think of to put PMI's unique COMDAC—the first and only companding D/A converter—to work. We got lots of responses with exciting ideas. But the interesting part is that no less than **five** engineers said they'd had terrific ideas—but they couldn't submit them because their corporate attorneys were starting patent searches.

That's the kind of brainstorming that COMDAC has generated since we first introduced it.

The reason is simple: nature is nonlinear. People, plants, animals, water, wind—we don't live in a straight-line world. We live in a world of curves, slopes, and human response systems (ears, eyes, touch) that do not follow straight-line paths. In trying to reduce these things to digital data, or to imitate them, we've always fallen short.

Until COMDAC.

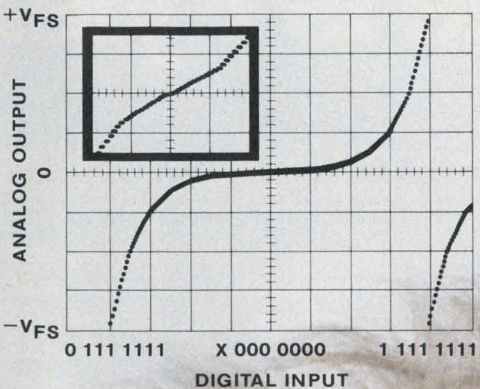
With the help of COMDAC you **can** linearize analog signals. COMDAC **can** supply the shades of grey, the sweeping curves, the "vive la différence!" of the natural world. COMDAC uses logarithmically companded digital techniques for D/A conversion; with just eight bits, it provides the dynamic range of a 12-bit DAC—72dB or 4096:1. With that range, it can produce a convincing facsimile of the human voice, for example. Your watch radio can awaken you gently, with soothing, motherly tones, or shake you out of bed with a drill sergeant's scream—whichever is called for in your case.



Consider these applications—some of which are already a reality:

- Digitized audio—music, sound effects, voice (μP controlled)
- XYZ positioning (automated drill presses, for example)
- Motor controls
- Echo/reverb devices (for electronic guitars, electronic organs, synthesizers)
- Voltage-controlled oscillators and filters
- Servo motor controls

COMDAC™
TRANSFER CHARACTERISTICS



- Altimeters
- Waveform generation (with PROM)
- VU meters (for better response)
- Voice recognition (imagine a typewriter you could dictate letters to!)
- Tone generators
- Voice encryption
- Voice warning systems (they're already using them in aircraft)
- LOG sweep generators
- Data acquisition
- Recording studios
- Verbal response systems (like, your car could give you the word when it's overheating)

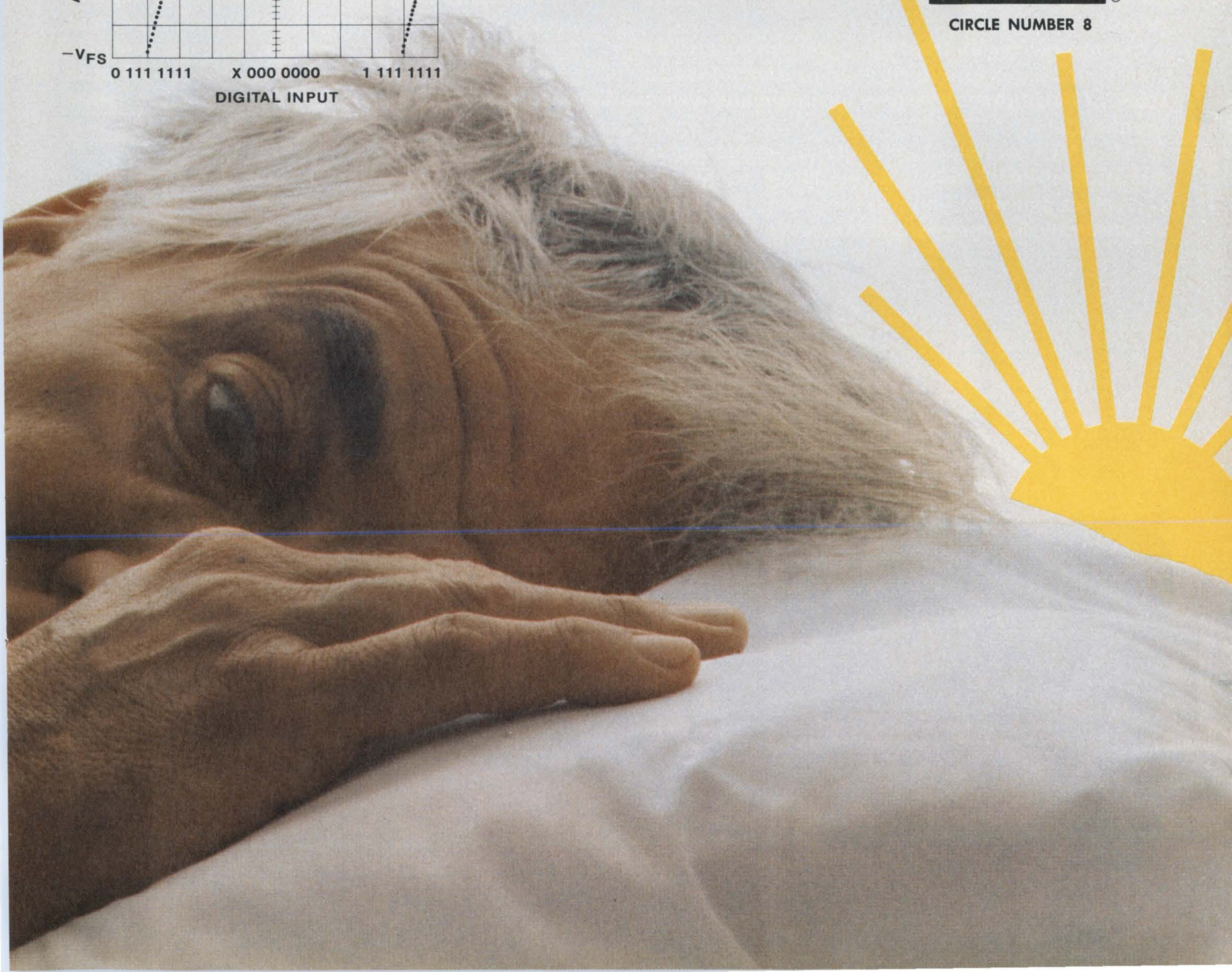
Keep in mind that COMDAC is not just a concept. It's a working reality. In the last two years, we've delivered half a million and cut the price in **half.** And since the 8-bit COMDAC can do many things a 12-bit DAC can do, think of what you will save by using a low-cost 8-bit system to do the job of the expensive 12-bit approach.

With a little bit of thought, a creative engineer—that's you—can come up with some really dazzling ideas. The surface has just been scratched. If you'd like a copy of all our contest entries, circle the bingo number below. We'll send technical literature that will help you with your application. Want a sample COMDAC? Send us a request on your letterhead.

Precision Monolithics, Incorporated
1500 Space Park Drive, Santa Clara, CA 95050 (408) 246-9222.
TWX: 910-338-0528 Cable MONO

PMI®

CIRCLE NUMBER 8



Someday someone will designed to let you design

That someday is now. And that someone is Pyle.

We call the connector the MC²™ (Modular Concept/Multi-Cell) and it brings a whole new dimension of design flexibility into commercial and industrial applications for multi-pin connectors. It's versatile, reliable, simple.

And now, for the first time, you can custom design your connectors to fit your precise needs, instead of having to take what's available and design around them.

The MC² consists of a "family" of components—4 shell sizes and 8 insertable modules—so that you can select just what you need to create practically any system-component interconnect you wish, without the expense of tooling for specialized applications. This combination lets you design any one of 28,672 connectors.

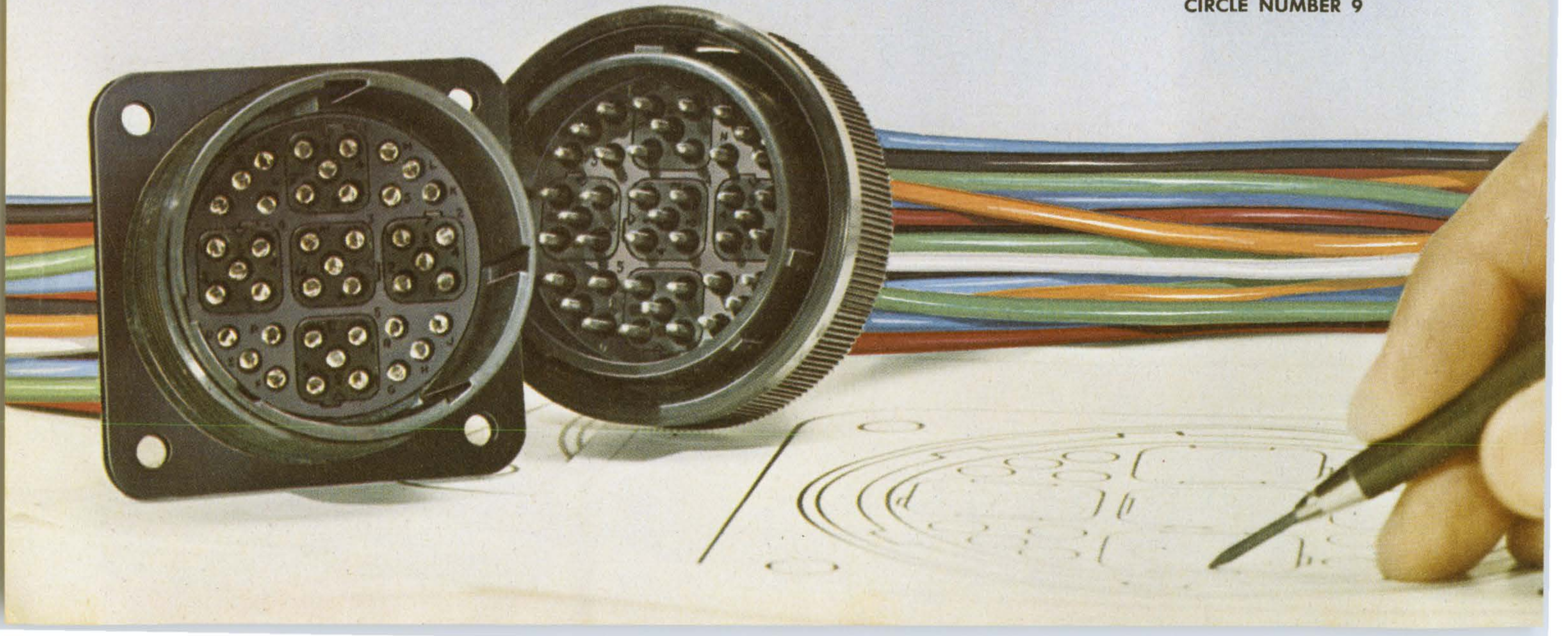
Featuring insertable and removable crimp contacts, the MC² has 5-key polarization for proper mating of the plug to the receptacle. And, because of its ratchet-lock coupling ring, it can't vibrate loose. Most important, though, is that a typical installed-cost analysis may show savings of up to 40% over present systems.

For more details on the remarkable concept of the MC², write us directly—or call the toll-free number on the next page.

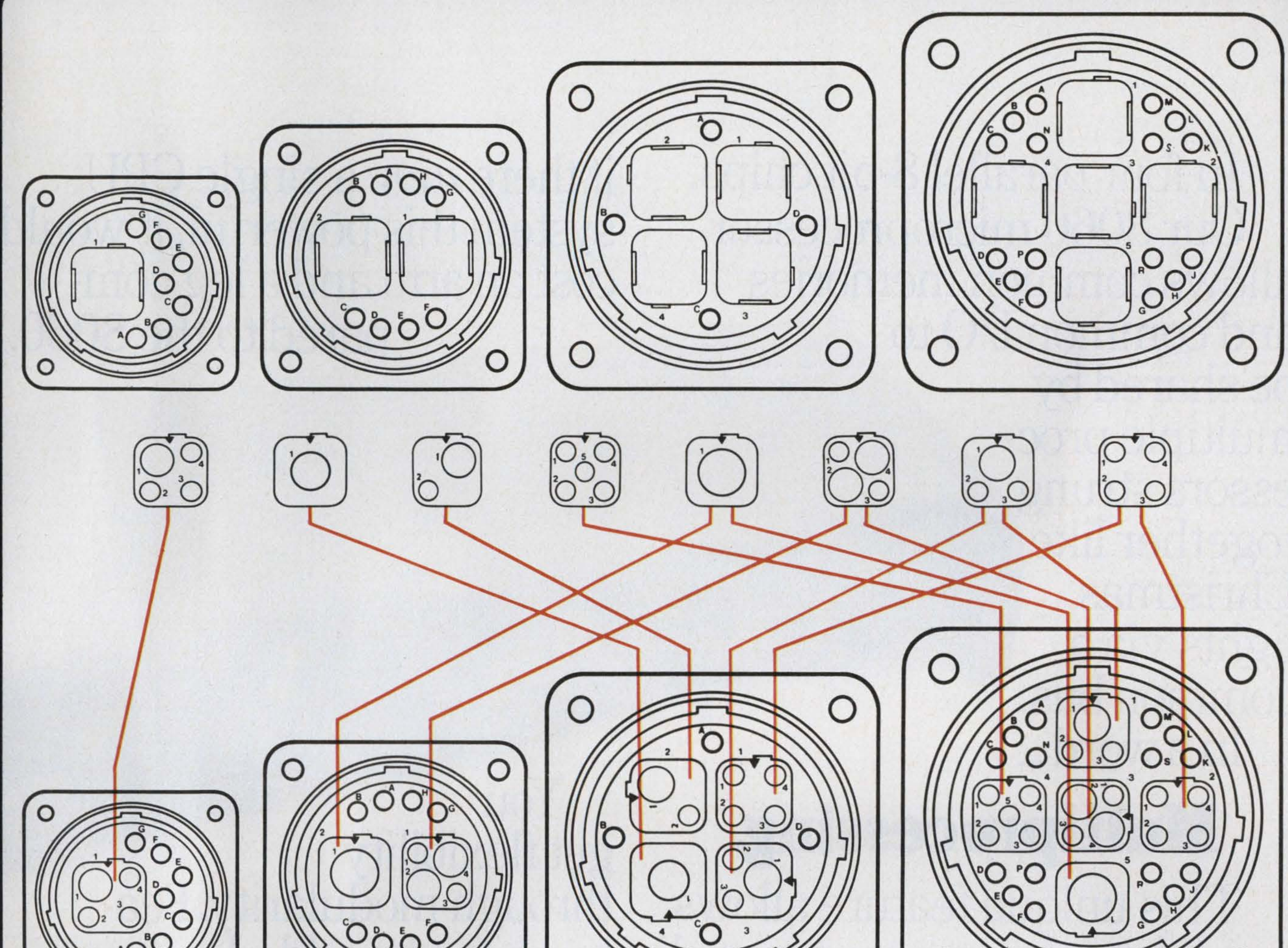
pyle-national company

A Division of Brand-Rex Company

CIRCLE NUMBER 9



come up with a connector your own connector.



These four shell sizes and these eight modules let you design your own connector, instead of having to design around an existing one.
Here are four examples.
If we had the space, we could show you 28,668 others.
It is possibly the most revolutionary concept in electrical connector history.
If you ever buy another connector not specifically designed for your application, you could be wasting your company's money.

Call this toll-free number: 800-621-6027*

***Illinois respondents call 312-342-6300**

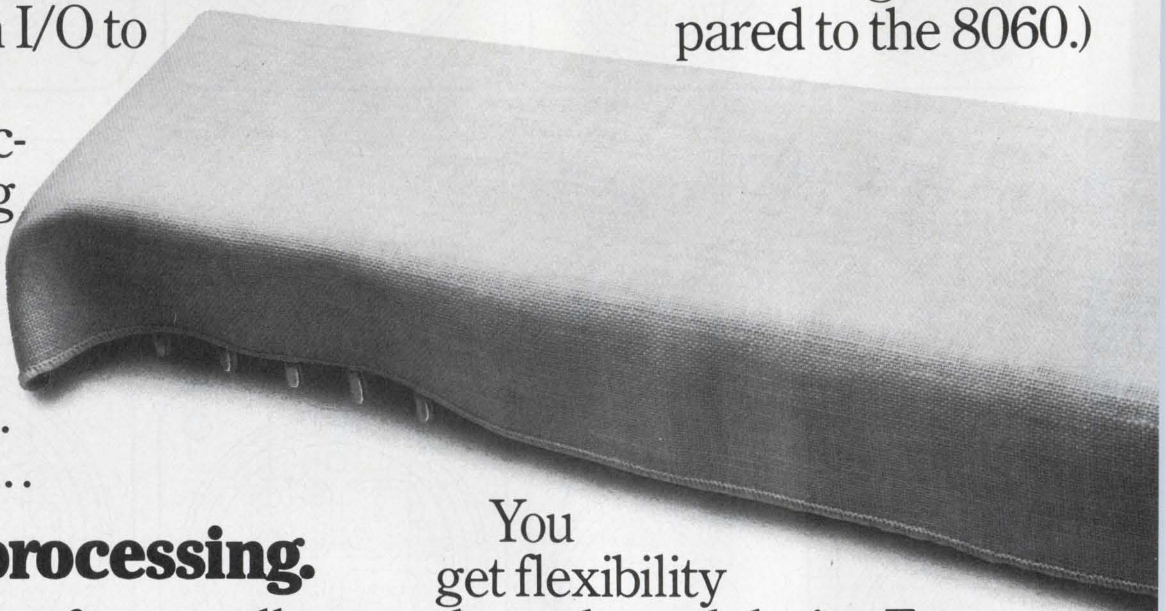
Pyle-National Company, 1334 N. Kostner Ave., Chicago, Ill. 60651. In Canada: Pyle-National of Canada, Ltd., 2560 S. Sheridan Way, Mississauga, Ontario. In Europe: Pyle-National (U.K.), Ltd., The Octagon, 143 Derby Road, Nottingham, England.

Presenting our 32-

In four parallel 8-bit chips.

Our 8060 microprocessor allows common memories and common I/O to be shared by multiple processors strung together like Christmas lights via a common bus.

In a word...



Multiprocessing.

This unique feature allows one 8-bit microprocessor application to be split into more easily manageable parts. So the whole job is easier.

Software development is easier. And cheaper.

What makes all this possible is built-in control circuitry and cycle interleaving.

The result is a machine more powerful than any single CPU system. (And even if there *were* a single CPU system this powerful, it would cost an arm and a leg compared to the 8060.)

You get flexibility through modularity. Features can be added to your system by just adding on an additional CPU rather than rewriting the whole program.

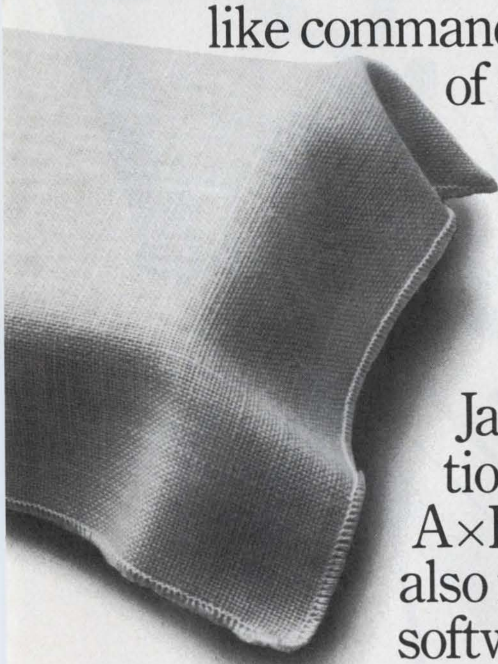
And serial I/O facilities allow several self-contained 8060 systems (with memory) to be bussed together.

But multiprocessing is just one of the appealing features of the 8060 (a member of the SC/MP family.)

bit microprocessor.

High level language.

The 8060 uses NIBL BASIC language. In one 8K x 8 ROM. This chip interprets English-like commands. Instead of a complex program, you can write simple Dick-and-Jane instructions such as A×B=C, which also reduces software costs.



Since NIBL is an interpreter, there's no expensive development system needed. All you need is the 8060 and the NIBL ROM.

A complete system in two chips.

To turn the 8060 into a system just add one chip.

This results in a system more powerful than a one-chip system, but at a price competitive with a one-chip system. The chip is INS8356, which combines a 2K x 8 ROM, 128 x 8 RAM, and I/O.

This basic 5-volt system is bus expandable, and compatible with standard memories and our arsenal of 8080A peripherals.

The 8060.

Multiprocessing. High level language. And a minimum system that works like gangbusters.

National Semiconductor
2900 Semiconductor Drive
Santa Clara, CA 95051

Gentlemen:

Please fill me in on your 8060 microprocessor.

Name ________ Title ________

Company ________

Address ________

City ________ State ________ Zip ________

ED1/4

National Semiconductor

Don't let offset voltage eat up your error budget!

Precision instrumentation can be only as precise as its components and the sum of their error specs. That's why we want you to consider specifying our monolithic OP-07—the industry's standard of Op Amp excellence—in your next system. Especially if you're working with low level (μV range) signals.

NO POT NEEDED! We zener-zap trim every OP-07 chip to give it the exact performance specs you find on the data sheet. There's no nulling, no trimming, and *no pot* to worry about. SPECS? Compare these to any real part:

V_{OS}	$10\mu V$
TCV_{OS}	$0.2\mu V/^{\circ}C$
Stability	$0.2\mu V$/mo.
Noise	$0.35\mu V$/p-p

SECOND SOURCE? You'll find an "equivalent" data sheet on page 12-184 of the 1976 Fairchild catalog. Our price is $7 (100's) and since we've been in high volume production for over two years, we deliver from stock. Send a P.O. Literature and application notes are yours by simply circling the reader card number; for a sample order, call your PMI distributor.

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Carving Out a Name for Solid Quality in Controls
Deltrol's relays, solenoids and timers come in hundreds of models and types. And they all measure up to your expectations for quality, performance and dependability — OUR REPUTATION DEPENDS ON IT.
See your local distributor or send for free engineering catalog.
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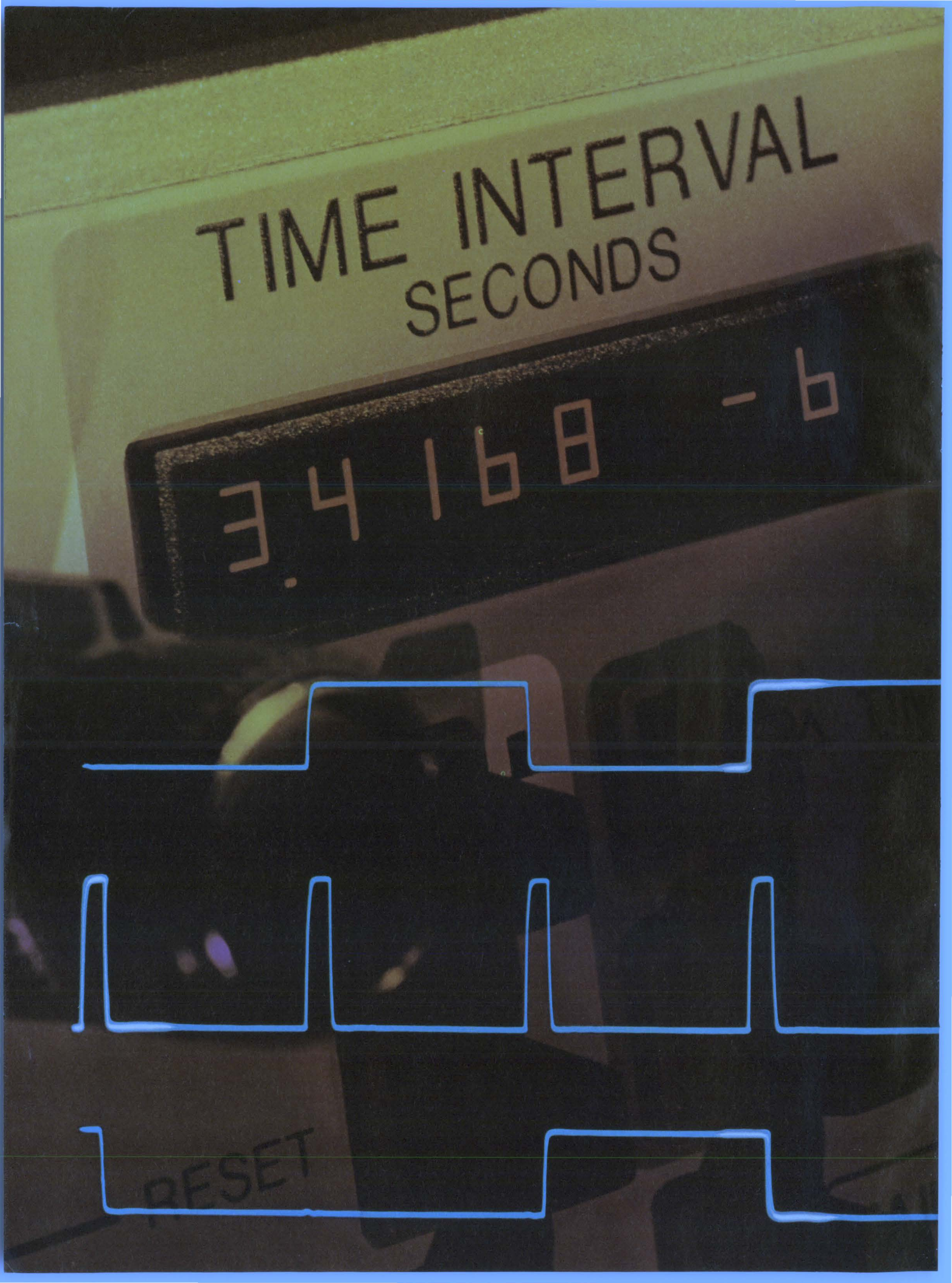
TIME INTERVAL
SECONDS
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RESET

Announcing a new standard in scope timing measurements.

For Δ-time measurements to 0.002% accuracy* and 100 psec resolution...

HP's the Answer.

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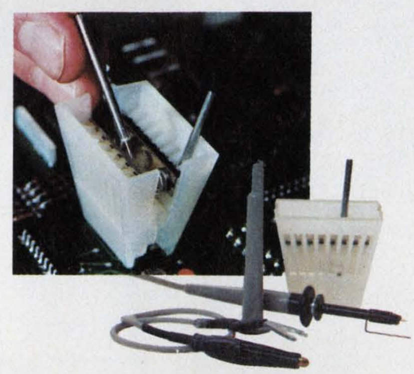

And here's something NEW for scopes. HP's **Easy-IC Probes.** A new idea for probing high-density IC circuits that eliminates shorting hazards, simplifies probe connection to DIP's and generally speeds IC trouble-shooting. The probes are standard equipment with this scope.

* ±0.002% of reading ±1 count from +15°C to +35°C.

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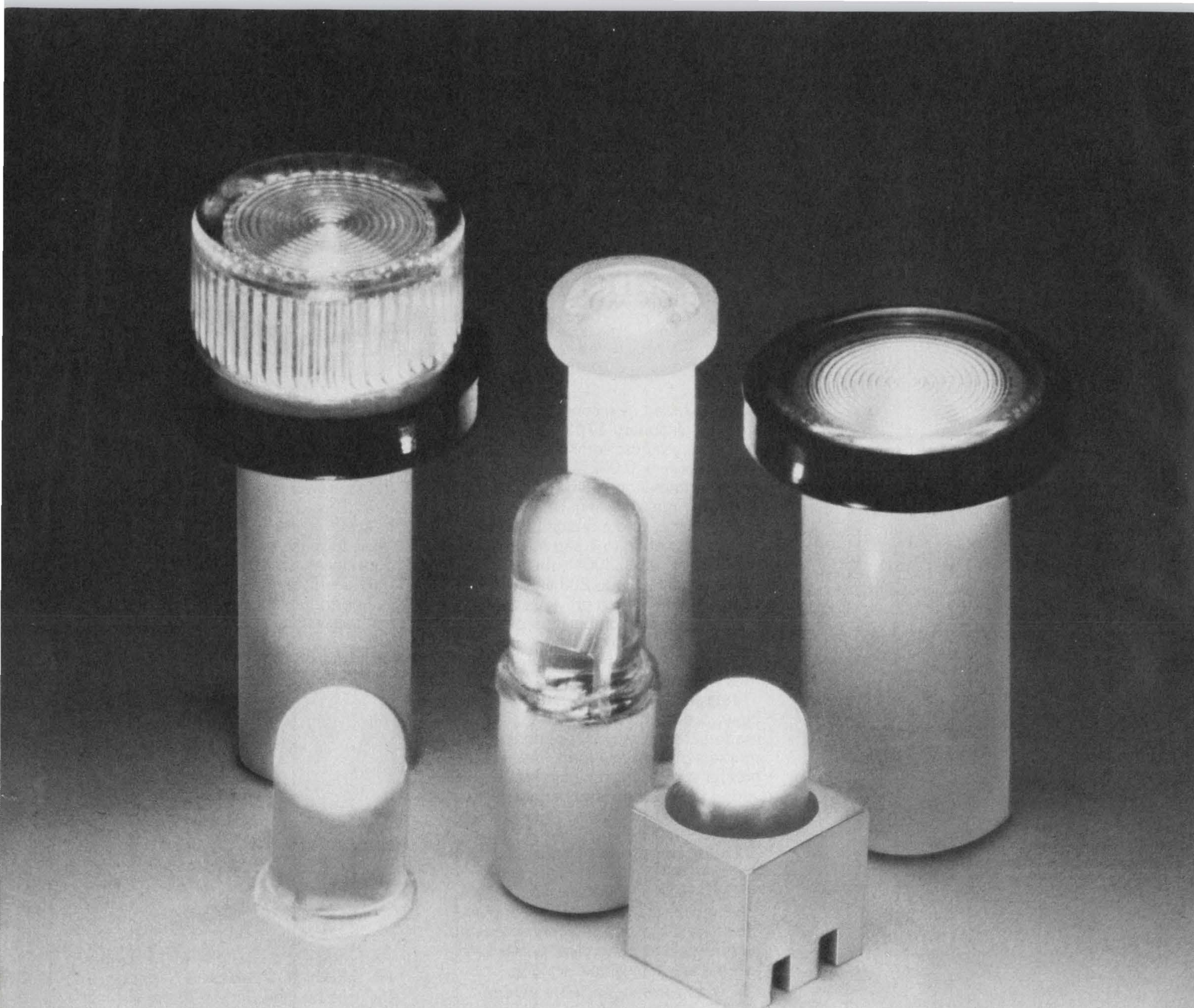
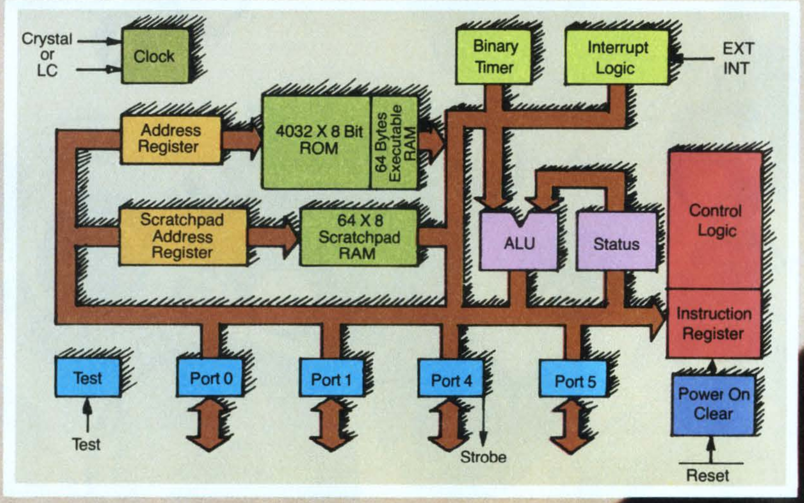
CIRCLE NUMBER 13

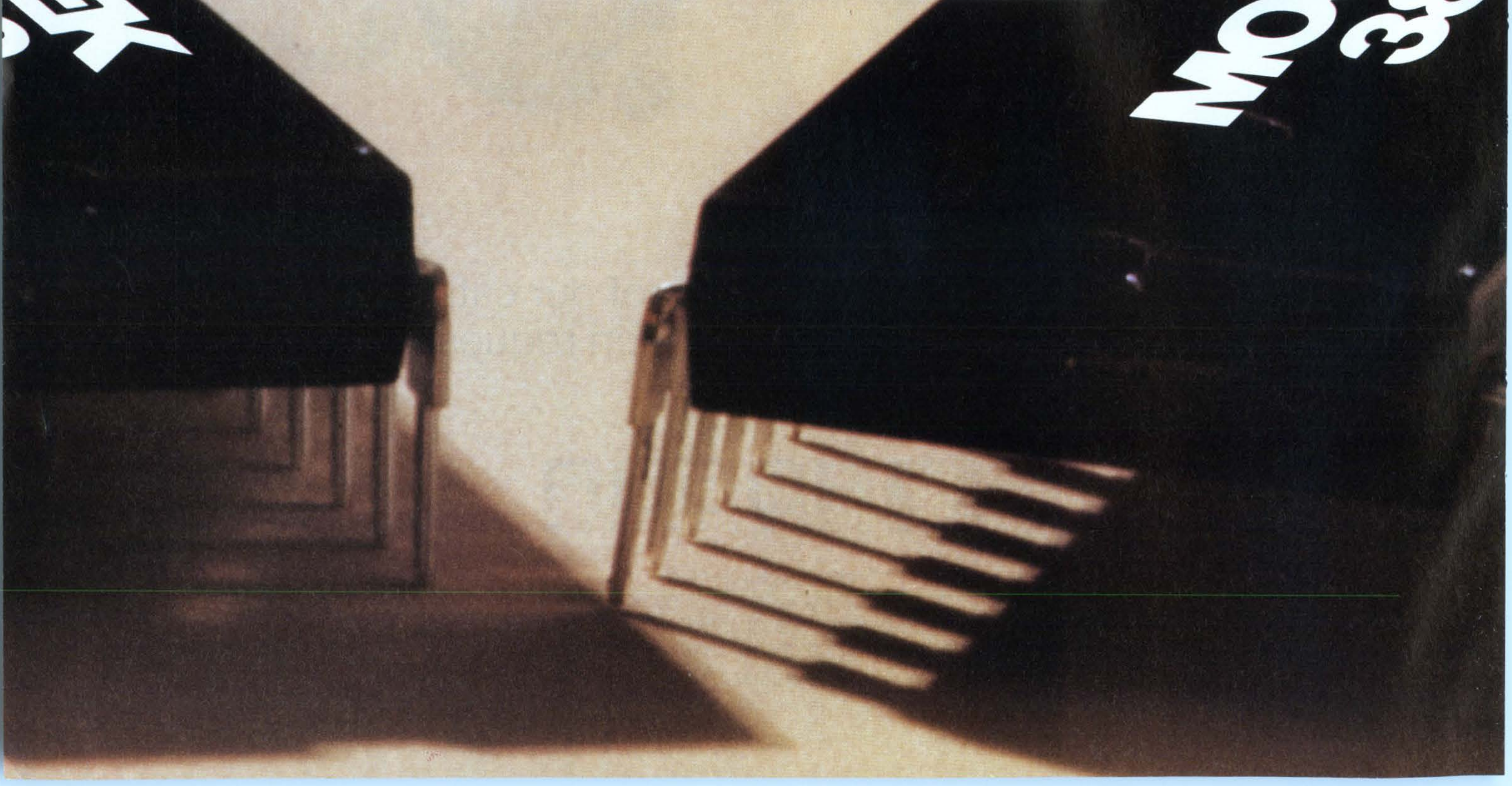


The Mostek 3872.

Double the ROM.*
Double the RAM.

Mostek's 3870 family means easy system upgrade and minimum investment in new designs.

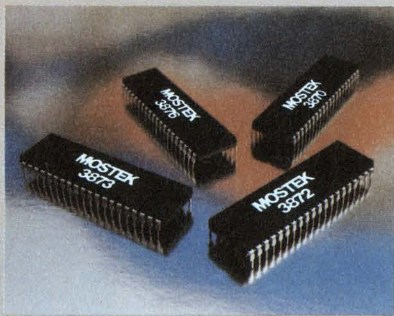




Mostek does it again! Mostek's 3870 single-chip microcomputer has led the industry in capability and performance for over a year. Now Mostek introduces another industry standard with double the 3870's ROM and RAM. Called the MK 3872, it is second in a growing family of single-chip microcomputer products from Mostek.

*The 3872 features include 4032 x 8 bytes of mask programmable ROM; 64 bytes of scratchpad RAM and an additional 64 bytes of executable RAM. Supporting the executable RAM is a stand-by power mode for easy battery backup.

These characteristics enable the 3872 to control sophisticated mechanical devices and instruments. Or the 3872 may be used to combine several programs into one system, thereby lowering manufacturing costs. In applications that require non-volatile data storage, the stand-by power mode makes expensive CMOS memories unnecessary. No extra components are required to trickle charge standby batteries.



Family design means system compatibility. When designing a microcomputer system, engineering time is one of your largest investments. The 3870 family design concept protects that investment by allowing system expandability while maintaining hardware and software compatibility.

You can start with the 3870's 2K of ROM and upgrade to the 3872's 4K of ROM. Or begin with 4K and then substitute 2K for lower cost applications. This versatility, while retaining a common system base, means new applications with faster development and lower costs.

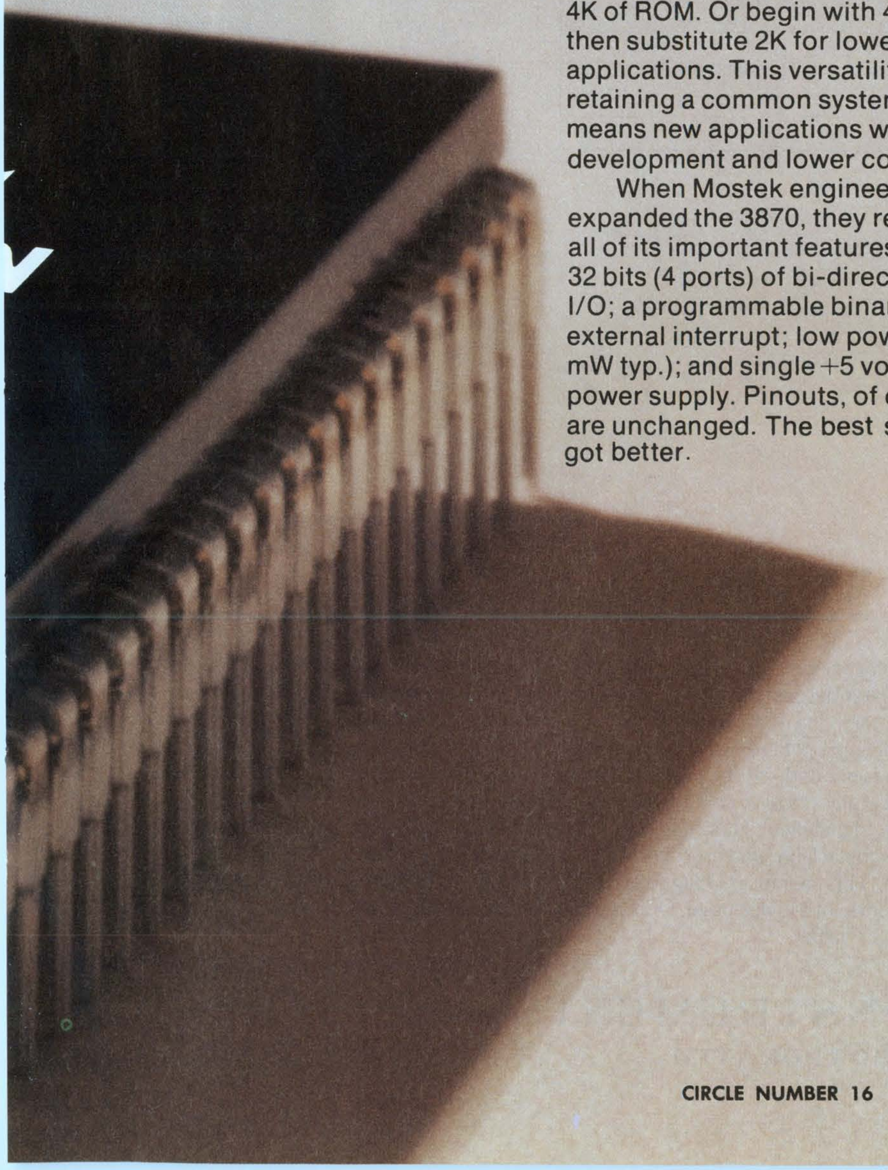
When Mostek engineers expanded the 3870, they retained all of its important features. Like 32 bits (4 ports) of bi-directional I/O; a programmable binary timer; external interrupt; low power (285 mW typ.); and single +5 volt ± 10% power supply. Pinouts, of course, are unchanged. The best simply got better.

Coming in '78. The Mostek 3870 family will continue to grow, giving you the flexibility and expandability required for new applications. The 3873 Serial I/O version will interface to serial devices such as shift registers and CCD memories, and allow implementation of an asynchronous serial I/O port making low cost multi-processing applications practical. The 3876 version will have the same ROM as the 3870 but with double the 3870's RAM, plus a standby power mode.

Complete Development Support. A full array of development aids is available from Mostek. This includes hardware/software support, complete documentation, field application engineers and 3870 microcomputer workshops.

The Mostek 3870 family. A total system with total support. From the source, Mostek. For more information, contact Mostek; 1215 West Crosby Road; Carrollton, Texas 75006. Telephone: (214) 242-0444. In Europe, contact Mostek GmbH, West Germany.Telephone: (0711) 701096.

MOSTEK



CIRCLE NUMBER 16

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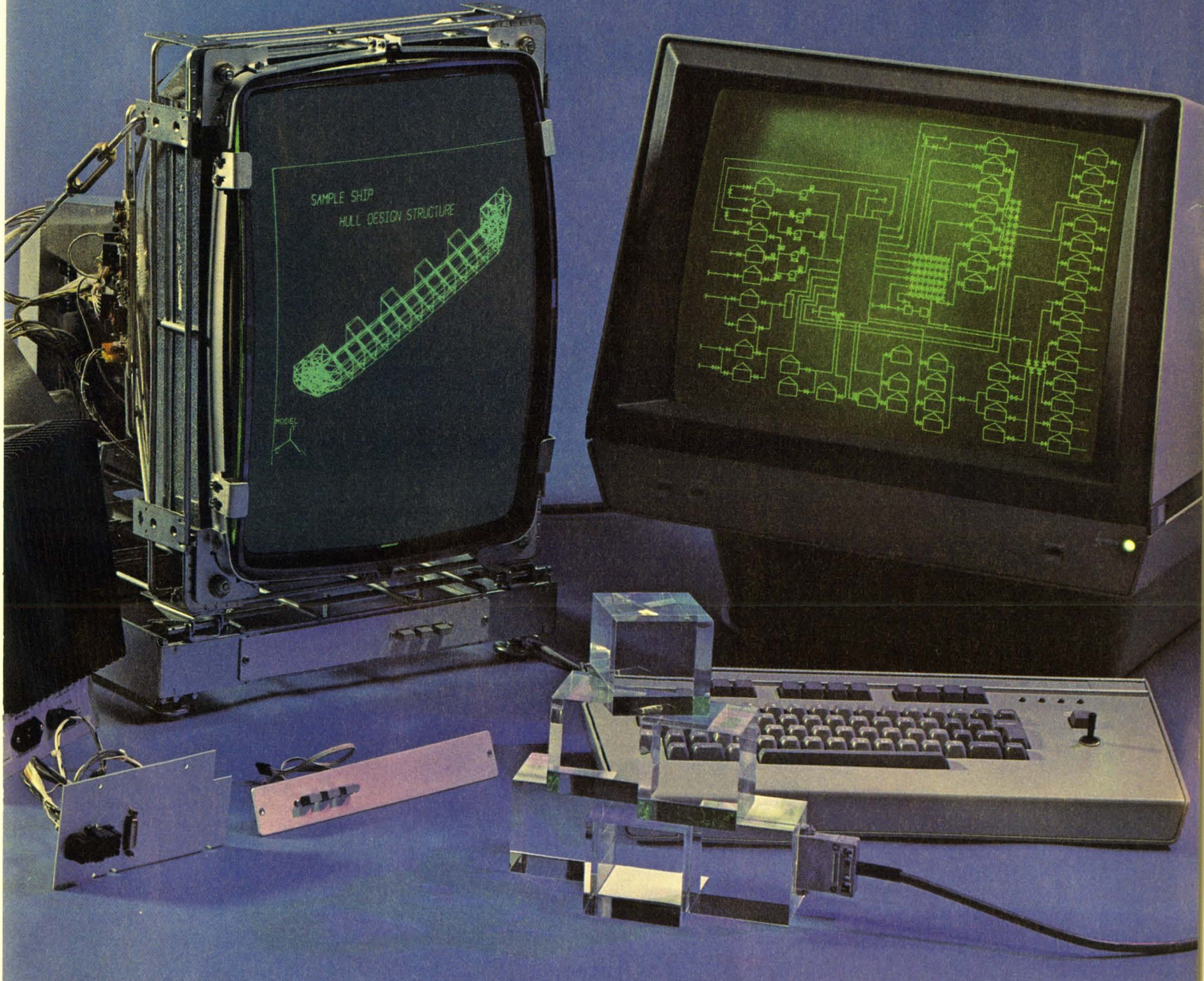
CIRCLE NUMBER 19



Ship hull display courtesy of University of Arizona

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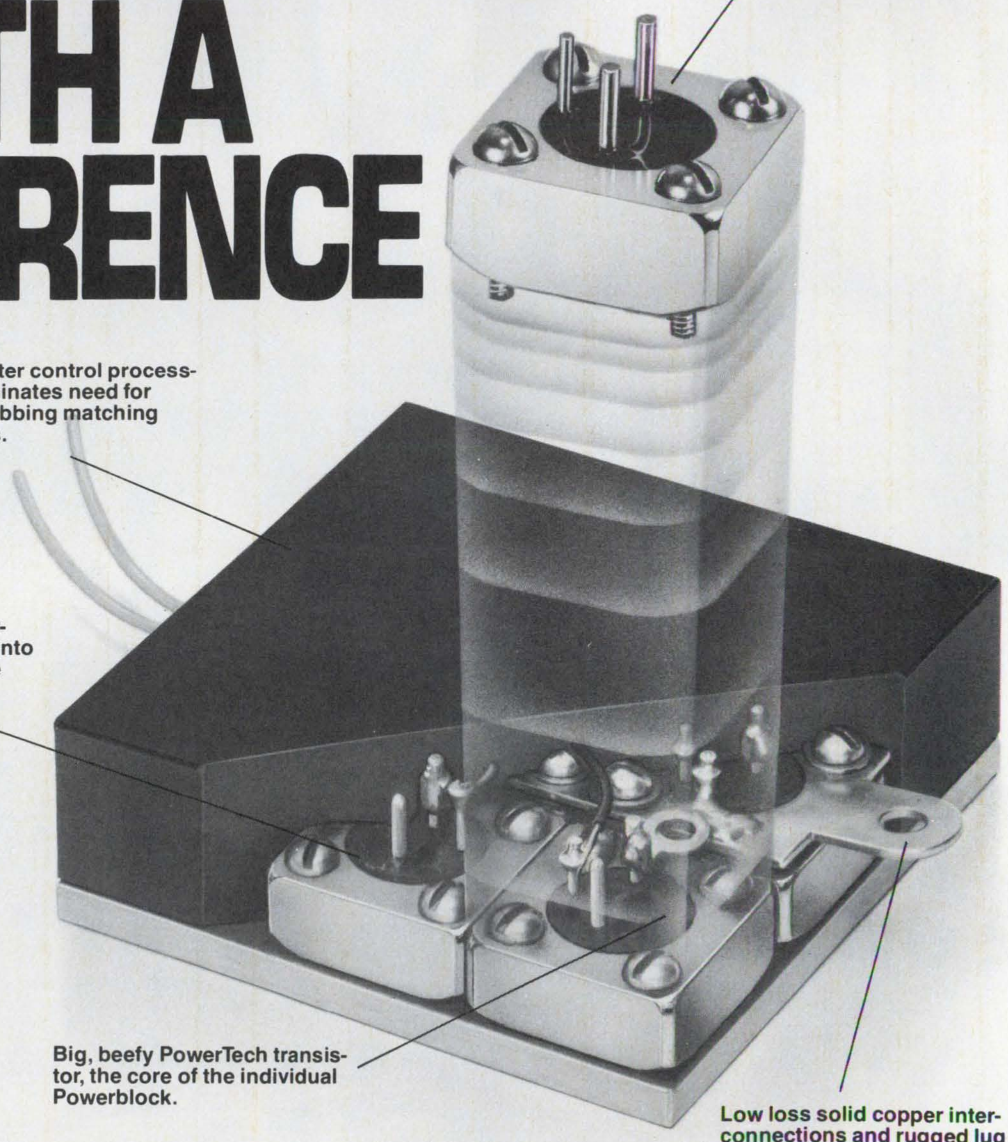
DARLINGTONS WITH A DIFFERENCE



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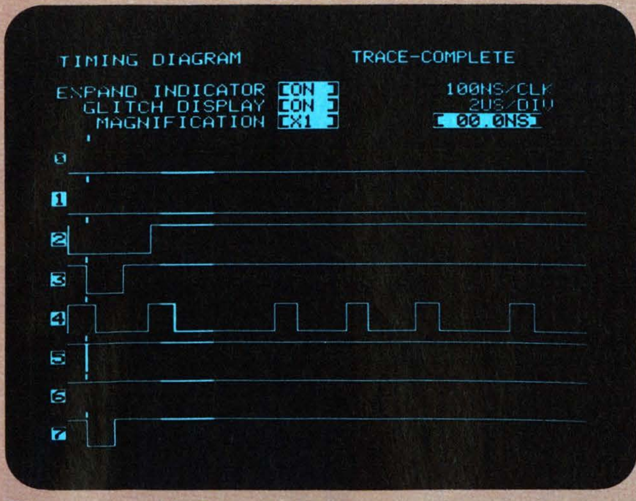
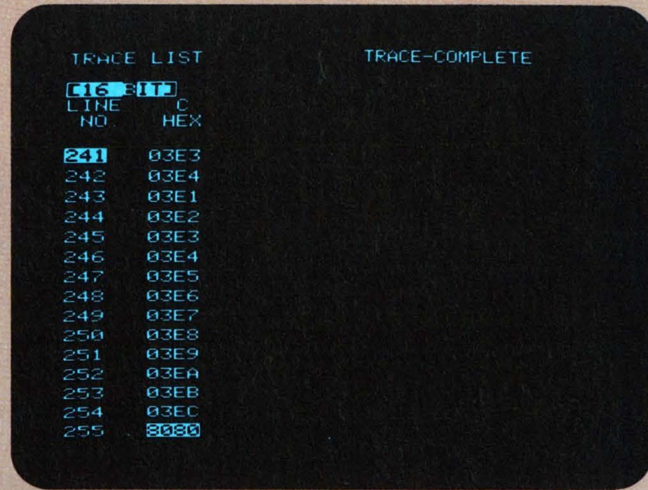
CIRCLE NUMBER 21

Timing Analysis—The hardware approach

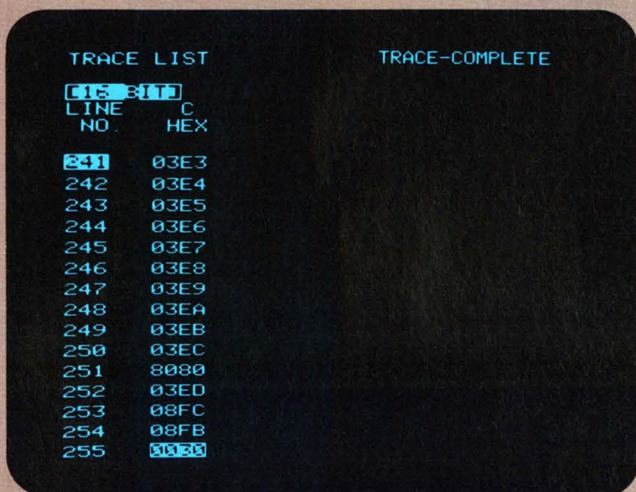


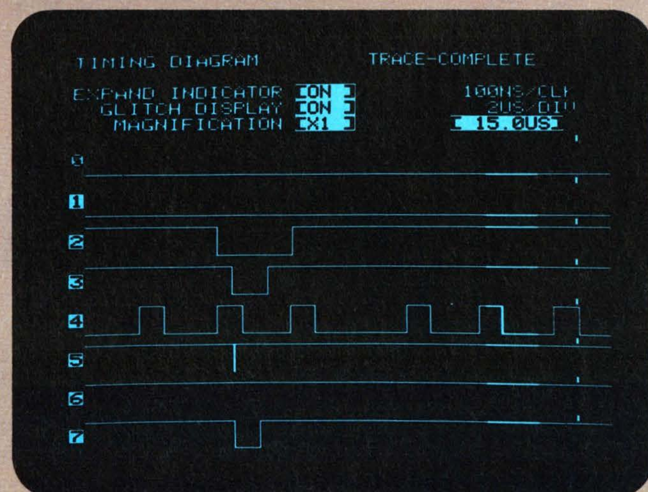


Trigger on glitches. A glitch on an input to a one shot (channel 5) is causing a false interrupt (channel 7). This glitch (which is intensified to distinguish it from data) can be used to trigger state as well as time displays.

Observing state display shows address flow at the moment the glitch occurs and reveals that the I/O port address 8080 always accurs at the same time. This would lead you to observe I/O related signals for transitions occurring simultaneously with the glitch.

State Analysis—The "Software" approach





Trigger on state. The interrupt vector (0030) can be used as the trigger point to observe address flow prior to the false interrupt. Evaluation shows that the I/O port address 8080 always appears four machine cycles prior to the interrupt vector.

Observing timing display of signals on I/O and one-shot shows that the glitch on the input to the one shot (channel 5) occurs four machine cycles before the trigger point and is coincident with the transition on I/O read (line 3) indicating possible capacitive coupling.

08812

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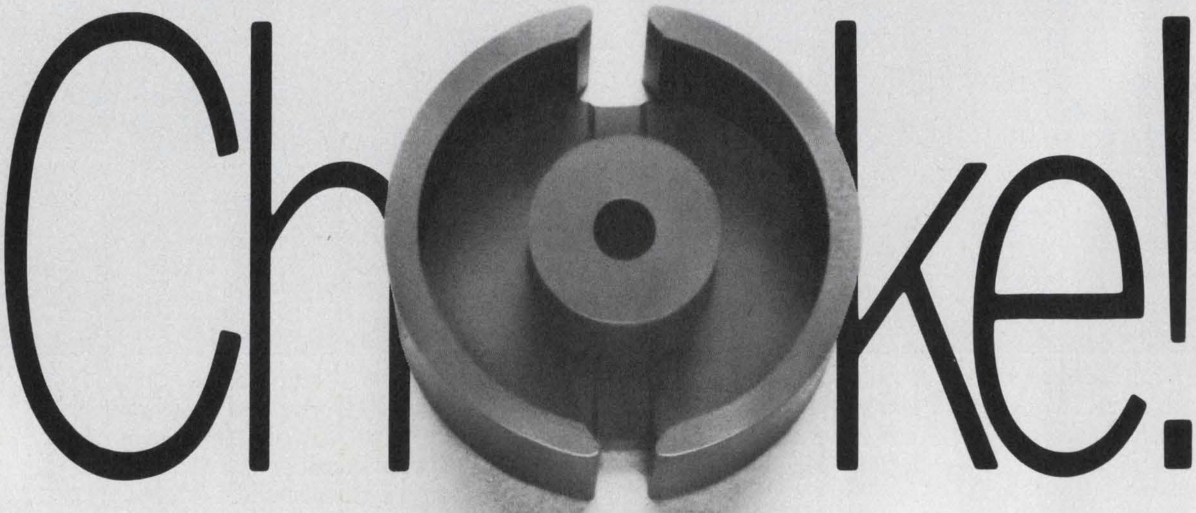

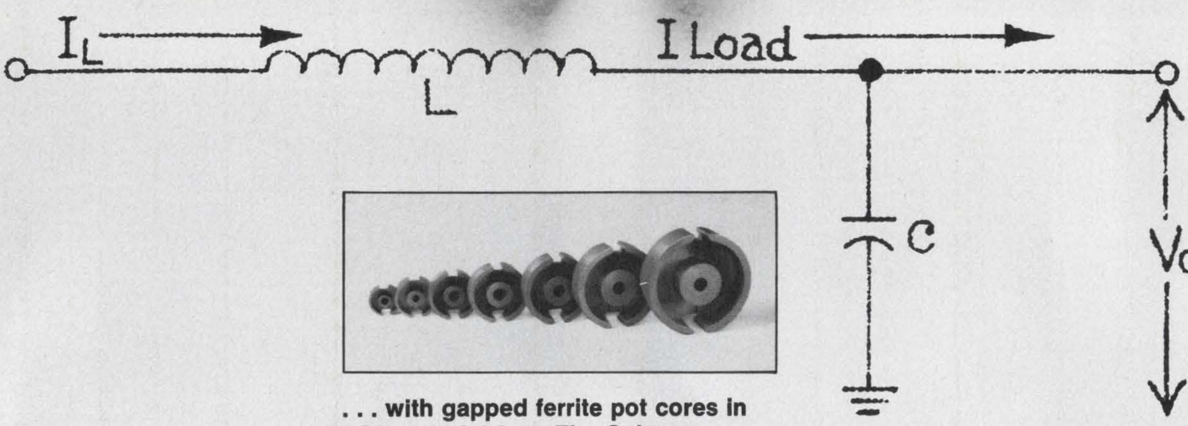

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CIRCLE NUMBER 25

Smart peripherals are getting smarter and better

Large-scale-integration has progressed to the point where semiconductor devices will take over complete CPU functions, spurring the trend toward more intelligent peripherals.

These predictions were presented by Ralph Gabai at the Mini/Micro Computer Conference and Expo in Anaheim, CA.

Smarter peripherals will off-load the central processor and assume tasks like error detection and correction and local diagnostics, says Gabai, who is corporate vice president for Pertec Computer Corp. In fact, with the price of computing power dropping rapidly, 80% of a computer system's cost will go to its I/O peripherals by the next decade.

Real-time transfer of control to a CPU's smart peripherals can be done in a variety of ways, according to Applications Engineer R.J. Eufinger from Rockwell International's Electronic Devices Division. Loop polling, handshaking, peripheral interrupts and direct memory access (DMA) are some of the possibilities.

Meanwhile, the distinction between hardware and software functions continues to blur, and firmware solutions are becoming increasingly popular.

"Judging by a peripheral controller's functional specifications, it may not be possible to determine whether it is implemented with hardware or a programmed μP," says Eufinger.

Some of tomorrow's peripheral-controlling microprocessors will have variable instruction sets, Eufinger foresees. A μP will be customized for a particular task by opening all its internal data paths and having variable control over the way its instructions are executed. Such an LSI device would use a very wide control word—up to 40 bits—and contain the next control word's absolute address within the current control word. This technique is called "pipelining."

Rockwell expects to introduce a line of these microprogrammed controllers soon. The first one will be designed for controlling minifloppy-disc drives.

Why a controller for 5½-in.-diameter minifloppies and not for full-sized, IBM-compatible, 8-in. floppies? Because now that IBM-compatible floppies are outnumbered 3-to-1 by OEM floppies, according to Jim Porter, a Mountain View, CA, floppy-disc consultant, the 5½-in. minifloppy will "undoubtedly prevail" in applications requiring both low cost and moderate capacity.

Magnetic-shielding design does a better job for less

A "counter-field" technique for shielding photomultipliers, cathode-ray tubes and other devices sensitive to stray magnetic fields can cut shielding costs 30 to 80%. The proprietary design, developed by Edward Eul Jr., chief engineer at Eddytech Engineering, Addison, IL, produces a shielding configuration that, though much smaller than conventional high-permeability configurations, is just as effective.

Moreover, when made the same size as a standard configuration, Eul's design can reduce interfering fields substantially more than conventional shield structures can.

Eul's design lessens disturbing magnetic fields, such as those stemming from power transformers or from nearby ac lines in an industrial environment, by putting multiturn series and shunt windings in the area of highest impinging flux density. These counter-field windings are generally placed at the open ends of the high-permeability or mu-metal shields where flux penetration is greatest.

When the ambient magnetic field is ac, voltages are induced in the counter-field windings. The resulting currents cancel the fields that induce them, which markedly increases sealing effectiveness. As a result, not as much expensive shielding material is required. With this approach, shielding has been improved 5 to 10 times over that of conventional configurations.

When the interfering field is dc, the magnetic fields are canceled by applying dc to the counter-fields and adjusting the magnitude and polarity of the current to provide a field that is equal in magnitude and opposite in direction to the one interfering.

Narrow beam may triple satellite communications

Satellite communications may be increased from 15,000 telephone conversations per satellite to more than 50,000 using a narrow microwave beam to sweep a large land area rapidly—in much the same way as an electron beam scans a CRT screen. Instead of the wide-area, fixed beam currently used to cover a large area, researchers at Bell Labs propose reducing the beam to about 1% of the previously covered area.

The scanning/spot-beam concept proposed by Bell researchers breaks the microwave beam from the satellite into pulses. The beam can sweep over the entire lower 48 United States in one-hundredth of a second. During this period, each of the numerous earth stations, identified by unique "addresses," can be polled, and information can be transmitted to or received from them.

Bell Labs' concept may also permit the use of less expensive ground antennas with diameters as small as 10 ft. With small antennas, receiving stations could be placed in cities on top of large office buildings. As a result, low-cost communications would be available to local businesses.

Today's satellites transmit at frequencies up to 6 GHz. But to minimize interference with terrestrial microwave systems, the scanning spot beam satellite would use 11 and 14-GHz channels. And, with interference diminished, the antennas could then be set up in the middle of large cities rather than in less-populated areas.

Fiber-optic splicing made easier and quicker

Splicing fiber-optic cable is tricky and time-consuming. But with a new type of heat-shrink splice fitting, cable-splicing technicians can make high-quality splices after only a few hours' training.

The fitting, developed by Thomas & Betts of Elizabeth, NJ, has been used in a 2.6-mile fiber-optic telephone link connecting the MGM Grand Hotel in Las Vegas to the main telephone switching office.

The link's fiber-optic cable, from Comm/Scope Co., Catawba, NC, contains six individually-protected and reinforced, single-strand, 5-mil graded-index silica fibers. When these fibers are to be spliced, the protective tubing and coating are removed and the cleaved fiber ends are inserted into the ends of a splice fitting. A hole in the side of the fitting provides a view of the fiber ends, which are inspected through a 60-power microscope for properly-cleaved ends, alignment and cleanliness.

Power is applied to heating coils in a jig plate (also from Thomas & Betts), which holds the fibers and the splice fitting in alignment. To keep them aligned, heat causes translucent shrink tubing to squeeze three stainless steel pins around the fibers; the pins are parallel to the fiber. Epoxy can be added through the hole to reinforce the splice and fill the gap between the fibers with a material which matches their index of refraction.

Once the tubing is shrunk, a second piece of heat-shrink tubing covers the gap between the "buffer" tubes protecting the fibers. The result is a splice that can be handled without being damaged.

The fiber-optic system's emitters are diode lasers from L. D. L., a division of Valtec Corp., West Boylston, MA. Operating wavelength is 850 nm. Avalanche photodiodes serve as detectors. The system, operating with an ITT T-1 PCM carrier at about 1.5 Mb/s, uses bipolar/unipolar converters, also made by Valtec.

The Las Vegas link, which has no repeaters, is the first installation in which a telephone company purchased equipment from outside sources. In previous installations (by AT&T, ITT and GTE) telephone companies used their own equipment.

Illuminating μC simplifies air navigation

A hand-held prompting microcomputer for solving aircraft-navigation problems not only eliminates the need to remember complicated formulas, but also tells the pilot where he is in a sequence of calculations. As a result, distractions such as in-flight calls from radar controllers won't make him lose his place.

The Navtronic-16 has a standard eight-digit, five-function calculator, plus 20 preprogrammed functions for solving various prop-aircraft problems, including distance and fuel remaining, time on route, ground speed and true heading. The user is guided by the μC through a sequence of data inputs required to solve the problems, which are accessed simply by pressing one of 10 problem keys.

When a problem is selected, LEDs labeled with the required data inputs are illuminated to tell the user what data to enter next in the particular calculating sequence. When the last entry is completed, the LEDs go out and the answer appears in the digital display.

Instead of a calculator chip, the Navtronic 16, designed by Don Schwartz, engineering vice president of Specialized Electronics Corporation in Chicago, has a two-chip 4-bit microprocessor set consisting of the National 57129 34-k ROM/controller and the 5782 CPU and RAM.

Four custom bipolar chips are also incorporated. One contains the digit drivers, which are hexadecimal in and nine-digit out. Another chip is an I^2L segment driver with a hexadecimal-to-16 character decoder and an eight-segment output. A third is a switching voltage regulator, while the fourth senses low battery voltage.

Flat cable coming for fiber optics

Copper-wire flat cables will soon have a fiber-optic counterpart. A six-fiber flat cable that uses aluminum-clad glass fibers is in the late stages of development at the Connecting Devices Div. of Hughes in Irvine, CA.

The cable fibers are 85 μm in diameter, including the aluminum cladding, which protects them from moisture and physical damage. Their tensile strength is 100,000 lb/in.^{2}, and loss is less than 10 dB/km.

For support and further protection, the fibers are sandwiched between two layers of plastic film about 20 mils apart. An adhesive holds the sandwich together and the fibers in place.

However, the adhesive and the plastic film have not been specified yet. And multi-fiber connectors for this cable aren't available yet, so the fibers are fanned out at the ends to permit existing single-fiber connectors to be used.

Digital addressing cuts the neck from a CRT

Replacing a single electron gun and beam with a screen-size cathode array that delivers a cloud of electrons cuts the depth of a 6 × 8-in. cathode-ray tube from about 12 in. to about 2 in. The much thinner tube is under development at Texas Instruments Inc.'s Central Research Laboratories in Dallas.

Despite its greater complexity and cost—and lower resolution—the TI flat-tube display "is a strong competitor for the CRT in alphanumeric terminal applications, military displays, and other applications where a thin-line design offers an advantage," says William Holton, director of TI's Advanced Components Laboratory. With a great deal more development, Holton adds, the tube could be used for television reproduction since gray scale can be generated by pulse-width modulation of the input, signal and color can be achieved with a patterned phosphor faceplate.

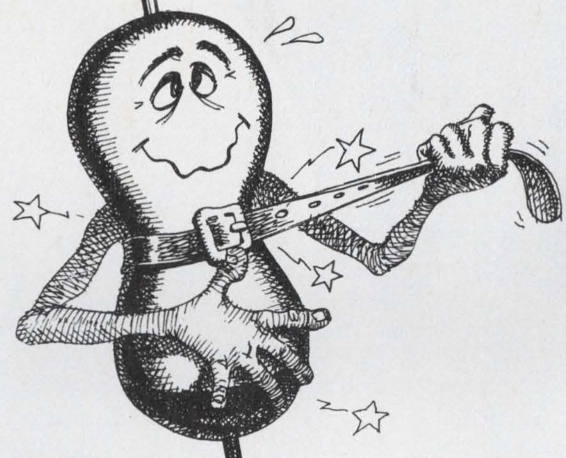
In the flat-tube display, a digitally-addressed switching stack controls and forms multiple electron beams. The electrons are generated by an area cathode that delivers to the switching stack a typical electron flux of 1 to 5 mA/cm, with a spatial uniformity of a few percent and near-normal incidence.

The display has four principal parts: a phospor-coated faceplate that is operated at about 18 kV, the switching stack, the cathode, and a metal-shell vacuum enclosure.

The switching stack is designed to control the brightness of each resolution element on the screen independently, explains Holton. By using multiple layers in the stack, individual points may be addressed by matrix techniques. This cuts the number of input leads for a panel with 1920 alphanumeric 5 × 9 dot-matrix characters from 590 on a plasma-panel display to 108 on the flat-tube display.

In an alphanumeric display containing 24 rows of characters and 80 characters per row, spot brightness of 500 foot-lamberts has been attained, says Holton, adding that brightness levels up to 4000 ft-L are possible for displays holding less information.

MINI STIC



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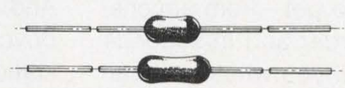

Type: FM50, 75, 100 & 150
PIV: 5,000, 7,500, 10,000 & 15,000V
Average Rectified Current @25°C:
25 & 10mA
Static Forward Voltage, 10mA @25°C:
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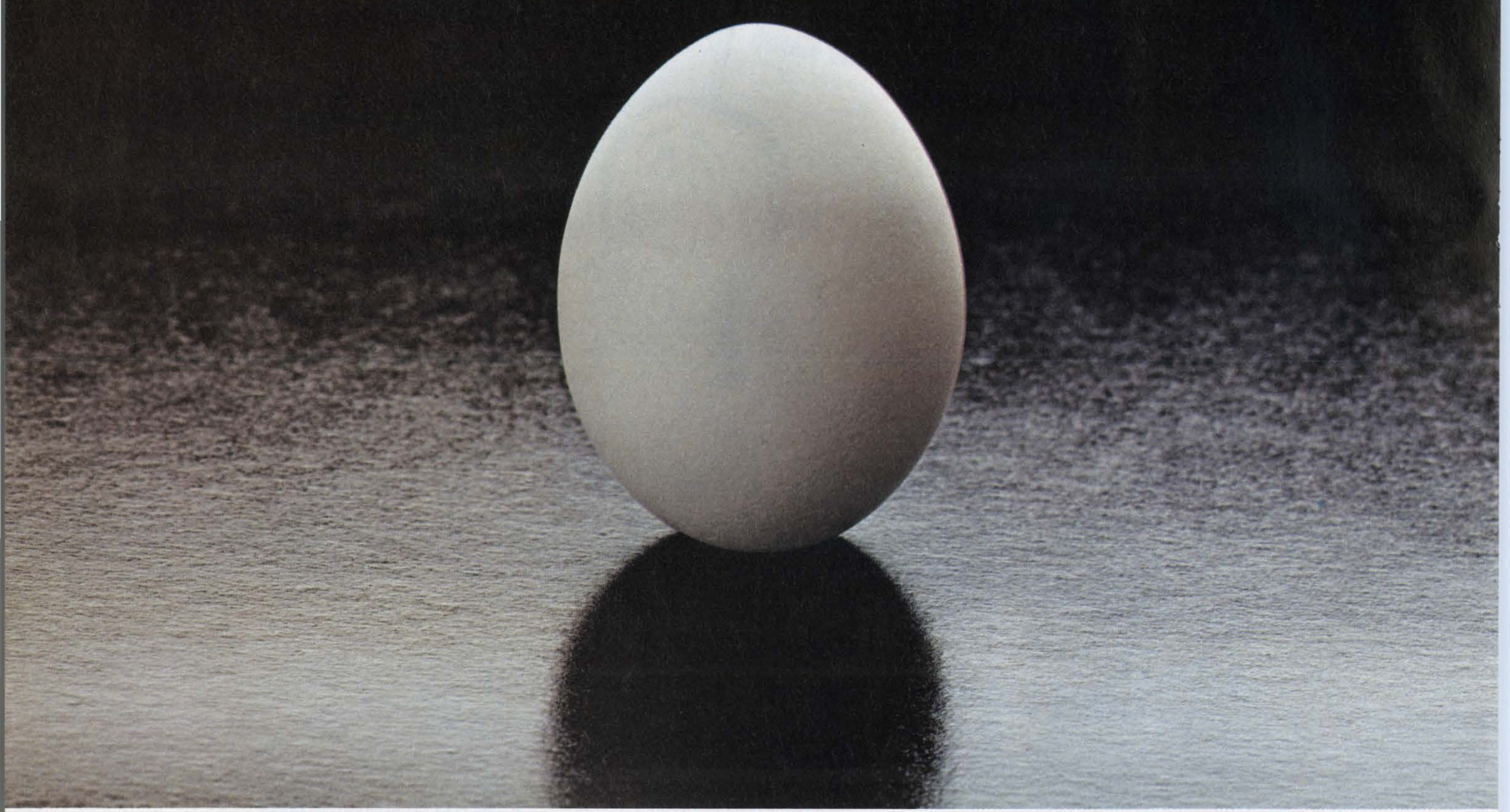
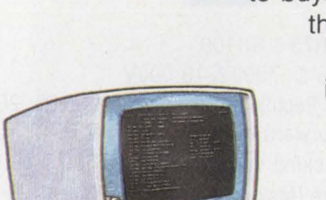
CIRCLE NUMBER 26

Someone has developed a more efficient resistor.



THE new Dale resistors are more efficient to buy. A network of computer terminals throughout our three resistor plants gives you more useful production information than you've ever been able to get—from anyone.



Place an order and in seconds we can tell you whether it can be shipped from stock. Inquire about an existing order and we can tell you its exact production status equally as fast. Discover a need for earlier delivery and we can instantly mark your order for expediting. That's resistor efficiency you can use. It's part of an expansion program that has seen our floor space devoted to resistors grow from 300,000 square feet in 1970 to more than 400,000 square feet today. And much of this expansion has been devoted to automated facilities. Multi-station winders let you specify the stability and power of wirewounds at a lower cost than ever...and batteries of laser spiralling machines turn out RN-style metal film parts at machine-gun speed. We're making the most efficient resistors you can buy—and we're ready to prove it.

μCs and minis will grow with multiprocessing, smart peripherals

Microcomputers and microcomputer peripherals will be where the action is in 1978. Eight and 16-bit microcomputers will emerge as systems rather than components, paralleling the evolution of minicomputer systems some several years ago:

- Distributed-processing architectures will become common, and spawn powerful 8-bit and 16-bit multiprocessing systems.
- Bus structures will become standardized.
- Both single and multiboard 8-bit microcomputers will increase, aided by the volume of software already generated for these systems.
- Intelligent peripherals, including printers, tape drives, discs and terminals, will result from the incorporation of microcomputers.
- Microcomputers will, for the first time, challenge minicomputers in applications like small business systems.
- Minicomputers will maintain their large lead in powerful software, but microcomputer operating systems and languages will be significantly improved.
- Microcomputer boards for process control will improve I/O interfaces with intelligence and make them easier for programmers to use.

Communications features that link distributed-processing minicomputer systems and peripherals are appearing in minicomputer systems like the HP 1000, which communicates with others over modems or hard-wire links.

μCs integrated into systems

The integration of independent microcomputer elements into a single system element will be a major trend in 1978, says Bill Sweet, microcomputer systems marketing manager at National Semiconductor (Santa Clara, CA). Pointing to a typical development system, Sweet explains:

"By the time you buy the processor, the power supply, PROM programmer, printer, CRT display, keyboard and cables, plus separate cabinets to hold each, the system may total \$8000 to \$15,000—of which the processor accounts for \$10. A high percentage of the rest of the cost is in boxes and associated hardware." So costs will be cut substantially by packaging the system units as a total system. Also, users will be saved the trouble of figuring out how to assemble the boxes in a system.

Another major trend foreseen will be the appearance of distributed-processing architectures in both 8 and 16-bit microcomputer systems, according to Mike Maerz, product line manager of OEM systems for Intel (Santa Clara, CA). A hierarchy of processing power will be developed for both the 8 and 16-bit machines, he believes.

In industrial control, for example, the level of computing power associated directly with the process will probably remain at eight bits. But the supervisory level will be controlled by 16-bit machines.

"I see the 8-bit machine being enhanced through the use of multiprocessing—multiple 8-bit single-board computers operating in parallel," Maerz states.

The power of the 8-bit μCs will be increased by new hardware and software and added in multiples. As part of this trend, instituted by Intel and being followed by other manufacturers, dual-port architecture will be used so that any processing done on a single-board computer does not tie up the bus. The bus will be used only when the processor wants to use a shared resource, like a peripheral device or bulk-storage memory.

Buses almost standardized

Speaking of buses, the evolution of a standard bus for microcomputers will accelerate in 1978. While the DEC Unibus has emerged as a pseudostandard for minicomputers, the Intel Multibus is gaining increased acceptance for microcomputers. Aside from the fact that 35 Intel products use it, as do microcomputers from 30 other manufacturers, multiprocessing will come

Jim McDermott
Eastern Editor

on strong during 1978, and the Multibus can support as many as 16 processors in parallel.

The powerful multiprocessing systems will contain not only several single-board computers, but also what Intel calls "intelligent slaves," or μC-controlled I/O devices. Microcomputer boards will contain a dedicated microprocessor, probably a single-chip μP, specifically for providing the intelligence to handle I/O functions, like communication. The μP will also serve as a processing front-end to handle arithmetic operations. As a result, processing power will be added to a system in a modular fashion simply by adding a single-board computer or a slave module.

Distributed processing will also help hasten the appearance of intelligent terminals and other peripherals in 1978. These peripherals may be called a second layer of distributed processing, with the first level designed in the processors.

More microprocessors and microcomputers—and minicomputers—will be designed into peripherals so that they can virtually stand alone from the standpoint of service and support capability. One example of this trend, the latest Hewlett-Packard 180-character/s printer, has an optional keyboard terminal. As Bob Puette, marketing manager for HP's Data Systems Division (Cupertino, CA) explains it, the printer contains a 16-bit silicon-on-sapphire μP, which permits much faster printing: The printer can not only decide whether to print backwards or forwards, but also locate blanks and the ends of lines.

In addition, the SOS microprocessor permits a complete set of diagnostics on a ROM to be built into the printer/terminal itself.

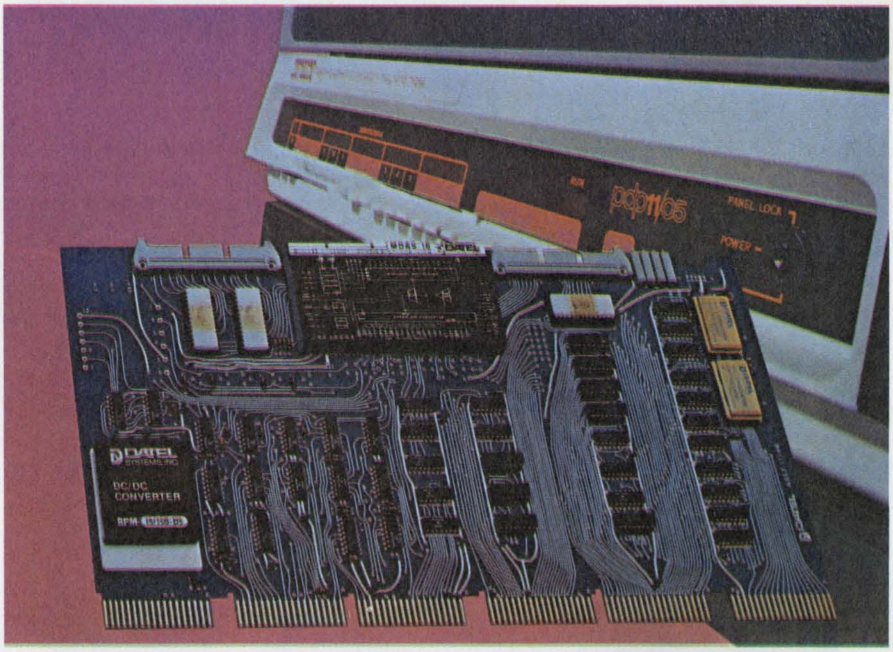
Intelligent peripherals—μC brain

Support won't be the only capability upgraded in peripherals. More control functions will be incorporated into such intelligent peripherals as tape drives and discs, according to Ralph Gabai, corporate vice president, Pertec Computer Corp. (Santa Monica, CA).

In disc drives, functions such as error correction and track reassignment will be programmed into the system to compensate for disc defects. This added capability will be necessary because both track and bit densities will continue to increase in 1978. In addition, the error-correction function will automatically provide byte-parallel rather than serial transfer of data, Gabai foresees.

Not only that, but a single, standard interface will be provided for tape and disc drives by incorporating a microprocessor and memory. In line with this, bus-type interfaces will be microprogrammed by OEM system manufacturers to match the tape or disc drive with their I/O channels or CPUs.

These design evolutions will have a great impact on minicomputers, too.



Analog-to-digital and digital-to-analog acquisition-system interface boards are appearing with new features. This Datel ST-PDP, which plugs into PDP-11 hardware, is supplied with diagnostic prototype software to speed use.

Because plug compatibility calls for microprogramming within a peripheral, the system manufacturer who assembles system components from a number of manufacturers will benefit because his peripheral controllers can be simple bus-coupler-logic types instead of the present complex types required to match the various tape and disc drives, whose performance characteristics differ.

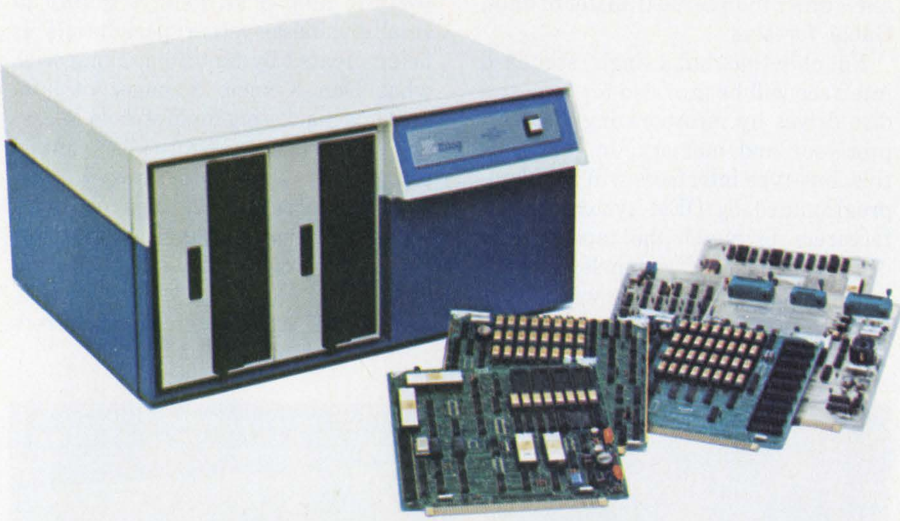
As a matter of fact, microformatted tape drives like those recently announced by Pertec can reduce costs about 30% because they don't have power supplies and other components needed by complex controllers.

Small business systems use μCs

Intelligent terminals and peripherals with microcomputer systems will be appearing in small-business systems that will cost a lot less than small-business mini-based systems, but will perform almost as well. A family of small-business-system peripherals is being created by Motorola, along with what Don Kesner, manager of subsystems marketing for Motorola Microsystems (Phoenix, AZ), calls "canned programs." These programs will be small-business applications packages featuring forms languages, text-editor languages and Cobol-oriented languages.

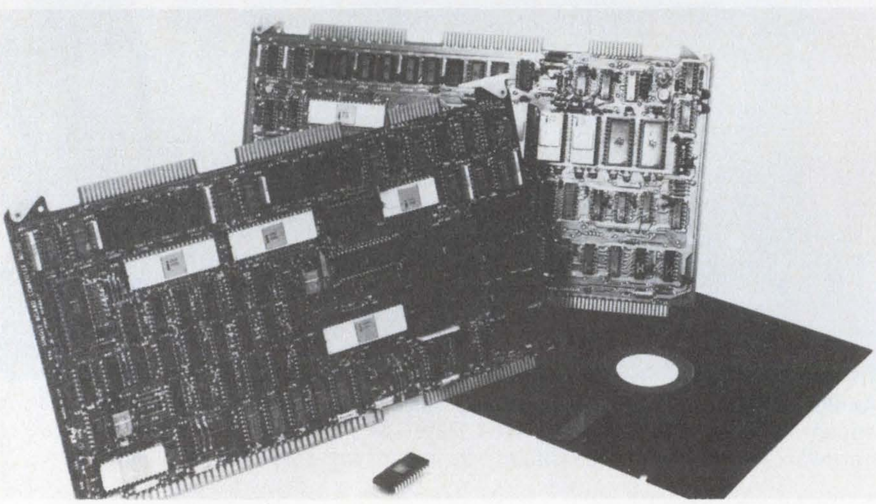
Motorola and other manufacturers will be bringing out peripherals throughout 1978. For example, Motorola's EXOR printer line will be updated. These printers will be used in an M6800-based CRT terminal system together with dual-floppy discs and the company's MDOS operating systems. But intelligent hard discs will be added to these systems within a year or so because flexible discs, even with their improved densities, won't hold as much data or be as reliable a storage medium. Zilog (Cupertino, CA), for one, will be interfacing its 16-bit Z8000 microcomputer, whose operating system compares with some lower-end minicomputers', to hard discs with storage capacity up to 96 Mbytes.

For on-line, transaction-oriented minicomputer systems, Frank Madren, manager of product programs for Data General (Southboro, MA) sees hard discs becoming the key element in communications and terminal-oriented multiprogramming in 1978. But



Eight-bit microcomputer systems are being refined to provide low-cost but powerful general-purpose computers. This Zilog MCZ-1 system uses high-level languages and has an operating system comparable to that of a minicomputer.

A dual floppy-disc system with on-line storage of a half-million 8-bit bytes, the Motorola EXORdisk II will be a component of M6800 systems tailored for small-business needs.



Software operating systems can be stored on Intel's SBC 80 single-board microcomputers internally in semiconductor ROM or externally on diskettes. This feature is possible thanks to Intel's new RMX/80 Real-Time Multi-Tasking Executive software package.

on-line transaction-oriented systems will be coming out with floppy-based microcomputers having two or three terminals, instead of the eight to 12 that the minis handle.

Here come 16-bit μCs

One microcomputer trend that will gather momentum in the coming year is 16-bit microcomputers. Three or four 16-bit μCs will be introduced this year. But 16-bits won't take over the 8-bit market for a while. For byte-oriented operations, an 8-bit μC will do a much better job for less money. And the latest 8-bit machines are easier to program because both their computing speed and instruction sets have been improved.

Not only that, but a great deal of high-quality software has already been generated for the 8-bit machines. So if a manufacturer has a sizable investment in a software library he won't be quick to change to a 16-bit.

On the other hand, Tom Walton, LSI-11 marketing manager for Digital Equipment Corp. (Maynard, MA) believes that for general-purpose computers costing $5000 or less, the 16-bit μC will become dominant over the next three or four years. And once the more complex architectures of the 16-bit machines are established, it won't be necessary to change software as the systems migrate towards higher and higher performance. For example, a 16-bit LSI-11 from DEC that sells in quantities of 50 for less than $500 uses software that can run on DEC's VAX 11/780, which costs about $250,000.

But it's still an open question as to whether the industry will develop the new 16-bit machine architectures with software than can be used by the simplest to the most complex systems.

Mating μCs for process control

One range of applications that will benefit from 16-bit μCs is industrial and process controls. But the improvements that will appear in 1978 won't show up as much in the improved performance of the microcomputer itself as in the input-output interface processing systems that mate with the microcomputer. These board-based a/d and d/a modules will have a variety of refinements to the conventional a/d and d/a techniques.

Conventional a/d microcomputer-interface boards don't permit any external control of operations. But a set of Micromodules from Motorola will not only perform the a/d and d/a but will also have on-board registers to give the user-programmer much more control over the conversion process, among other things.

For good reason, the 16-bit microcomputer will be applied more and more in 1978 to industrial controls, says Barry Glasgow, marketing manager for data systems at Analogic (Wakefield, MA). For one thing, a 16-bit working with a 12-bit a/d will require just one transfer, rather than a split transfer as required by an 8-bit. One obvious byproduct of 16-bit performance will be faster operation, which is heading towards the 50 to 60-kHz/s conversion range.

Like Motorola, Analogic is developing interface boards that simplify controller system operation. Called "Transparent I/O," the technique will allow an operator using the boards to initiate a conversion cycle, fetch the data, and operate on the data—with one instruction.■■

Improved processing will boost high-performance memories, μPs

High-performance memories, microprocessors and other digital LSI circuits will be pushed to their performance limits in 1978 by new process technologies such as vertical MOS, Schottky I^2L and silicon-on-sapphire, as well as by device scaling. In fact, MOS device scaling will probably be the most important LSI development this year. By shrinking the MOS transistors not only can more devices be packed on a chip, but propagation delays and power requirements per device can be reduced and chip area can often be cut 20 to 30%. Reduced area will bring higher yield and, as a result, lower device cost.

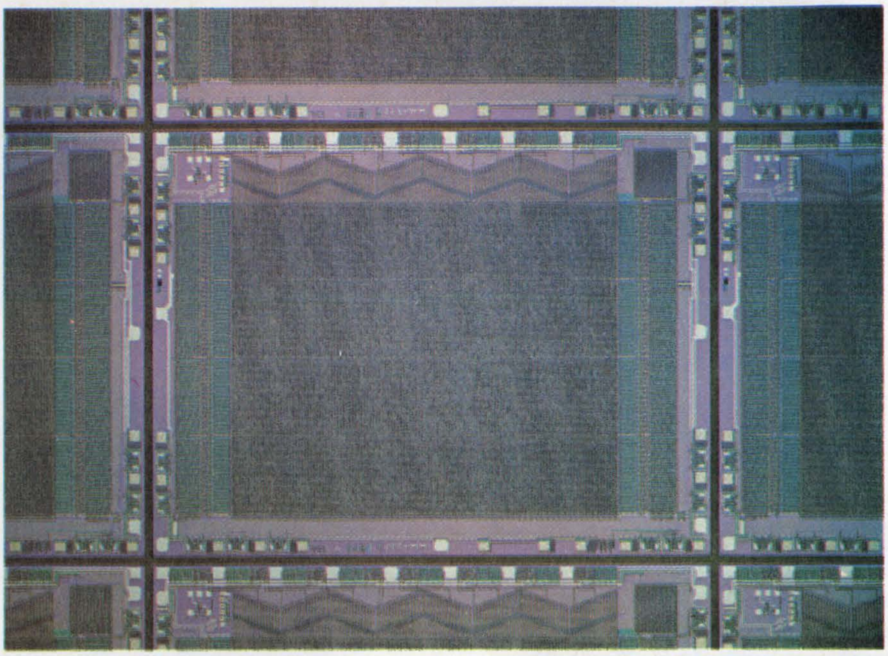
Although the process of device scaling (the size reduction of individual transistors in an IC) is not new, this year will stretch the scaling capabilities to the limits of current photolithographic processing technology. Improved computer modeling techniques are helping designers optimize performance of scaled down devices.

More devices, more performance

The increased performance that device scaling permits will enable MOS devices to compete with speedy bipolar circuits for many of the same applications. For instance, products in the high-performance-MOS-memory line (HMOS) from Intel (Santa Clara, CA) offer bipolar access times with MOS power levels. The 2147, an NMOS static RAM built with HMOS scaling techniques, stores 4-k × 1 bits and has a maximum access time of 70 ns. The 2147 also permits a power-down mode when the chip is not being accessed in a large system, so current can drop from an active 160 mA to a standby 20 mA.

Other companies taking the scaling route have developed memory circuits

Dave Bursky
Associate Editor



One of the densest ROMs available, the MM5235 from National Semiconductor, can store up to 65,536 bits in an 8-k × 8 array.

with densities equivalent to HMOS processing. One company that uses another design approach, though, is American Microsystems (Santa Clara). AMI uses a vertical MOS process, dubbed VMOS, that permits even higher densities than most of the scaling techniques, and without the 4-μm channel lengths and shallow 1-μm junction depths required by scaling. VMOS devices can use 5 to 6-μm channel lengths while acting as if they had a 1 μm channel. AMI currently has a 45-ns 1-k static RAM available in VMOS and has just announced a 64-k ROM.

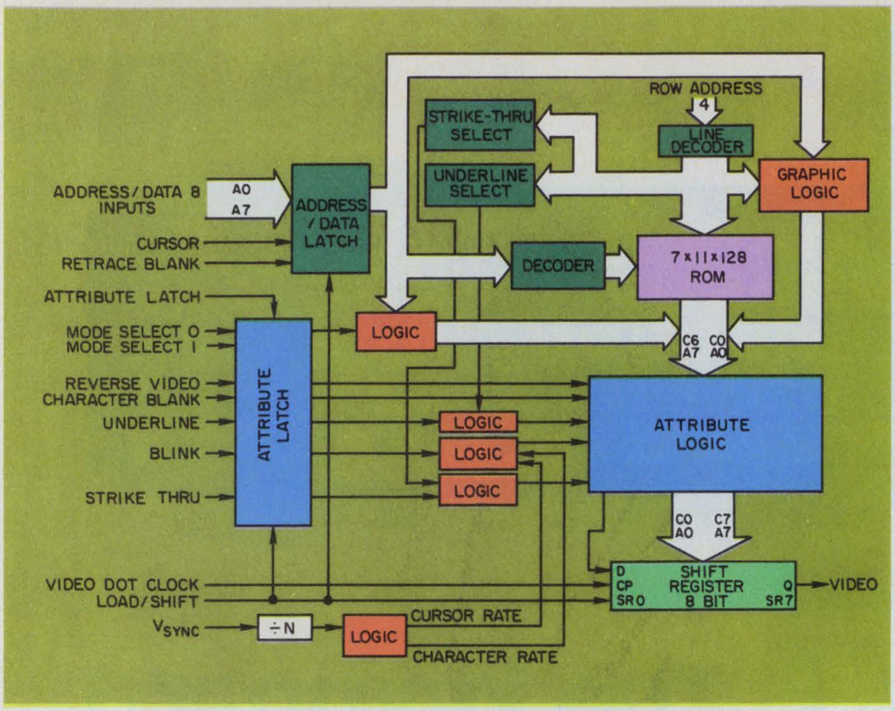
As a matter of fact, very large (32-k and larger) static ROMs will soon proliferate, claim many of the companies developing such products. The reason? Solid-state software.

National Semiconductor (Santa Clara) and Mostek (Carrollton, TX) have also developed 64-k ROMs, but with standard processing. Containing the equivalent of more than 80,000 transistors, the MM5235 from National is a 39,000 square-mil chip with an access time of 450 ns. The Mostek chip has an area under 35,000 square mils and an access time less than 200 ns.

Prices on large ROMs are expected to be in the $0.025/bit range in large-volume purchases—about 75% of the cost of an equivalent multichip memory. Complete high-level interpreters for languages such as APL or Basic can now be stored on a single chip. Towards the end of 1978 National officials expect to be able to offer 128-k and 256-k ROMs for 1979 equipment.

I^2L, a boon to ROM users

Meanwhile, a decidedly nonstandard technology will appear in commercial ROMs for the first time in 1978. The SBP8316 and the SBP9818 from TI (Dallas) will feature I^2L technology. The 8316 is a TTL-compatible 2-k × 8 ROM that has an access time of 175 ns and can operate over the full MIL temp



Capable of performing the attribute control and character generation for a CRT terminal, the CRT8002 developed by Standard Microsystems, further reduces the complex circuitry necessary to build a terminal.

range. The 9818 is a mask-option version of the 8316 that eliminates the injector current-limiting resistors. Since the injector current-limiting resistors are not on the chip, a user will be able to select the resistor and thus determine the access time and power dissipation of the ROM, as well as the operating voltage, which can be as low as 1.25 V. Access time can range from a speedy 60 ns at an injector current of 500 mA, to a rather lethargic 60 μs at 2 mA.

Indeed, bipolar PROM technologies have reached below 50 ns in access times and for large arrays, such as an 8-k memory, access times of 50 to 60 ns are available. To attain the speed improvements demanded by the systems under design, PROM manufacturers are heading in the direction of titanium-tungsten fuses instead of nichrome. Not only does the titanium-tungsten combination jack up speed, but it also permits a lower programming voltage, which lessens the voltage strain on the PROM.

Programmable memories are expected to grow during 1978 to 32 k in UV EPROM versions, with possibly even a 16-k fusible-link bipolar version towards the end of the year. But it looks like the largest impact on PROM design will come from electrically erasable (EEPROM) technology. General Instrument (Hicksville, NY), for one, expects the MNOS (metal-nitride MOS) technology to be brought under control so that programming voltages can be standardized to typical n-channel compatible levels. Commercially available devices are not really expected before 1979, however. The largest devices available to date in MNOS are 2-k × 4 EEPROMs—the ER2800 family—made by General Instrument.

Plastic-housed versions of the popular 2708 EPROM have started to appear on the market—and the good news is that the final product cost is down—the quartz-lidded PROM case was a big portion of the device cost. Since many of the EPROMs end up in the final system, the nonerasable EPROM will prove to be a cost-effective alternative to small-volume ROMs.

Dynamic RAMs are also facing the designer's knife. Chips will be smaller, which will quicken access times and boost yields. And in the long run higher yields will usually mean lower unit prices. Expected this year are limited quantities of 16-k RAMs with access times under 100 ns. For alternate sourcing, every company that makes a 16-k device will offer a version that is compatible with the new "industry standard" Mostek MK4116. Even Intel has finally acceded and has developed the 2117 version—a 16-k dynamic RAM that can operate in either a latched or unlatched mode.

Although the number of suppliers of 16-k RAMs is growing, production problems still limit the availability not only of premium devices with under 120-ns access times— but even of normal production devices with 150 to 300-ns access times. So naturally, no realistic U.S. manufacturer expects to see working samples of a commercially feasible 64-k RAM until early 1979, or production before 1980.

Japanese manufacturers have introduced a 64-k RAM, but since it uses several nonstandard voltage levels, it will probably not be readily accepted. Work is under way to bring the voltage levels more into line by making process changes and by lowering the threshold voltages and the supply voltages. Some RAM manufacturers are even predicting a complete new family of high-density circuits in the early 1980s that will use supply voltages as low as 3 to 4 V.

Large RAMs may be a ways off, but CCD memories (64-k) will make their commercial debut during 1978. Fairchild, Intel, Motorola, Texas Instruments and a few other companies are already sampling devices. However, most manufacturers feel that until even larger memories, like 256-k, are available, the CCD will not really be a cost-effective alternative to the 16 and 64-k dynamic RAMs.

To get the necessary densities, RAM and CCD makers are exploring two production technologies, X-ray and electron-beam photolithography. Both promise to quadruple the densities of current devices but as of now there are still some major problems that must be overcome before the process is economically attractive for production runs.

The bipolar RAM, long limited to densities of only 1024 bits, will appear with array sizes of 4096 bits and larger during 1978. And for the smaller arrays, speeds will be reduced so that the RAMs will work with the speediest of logic circuits.

For high-speed cache memory design, both Fairchild (Mountain View, CA) and Motorola (Phoenix, AZ) are tweaking their ECL RAM designs to provide access times of 10 ns and less for 1024-bit arrays. And, both companies are soon going to announce 4 k circuits with access times in the 20 to 40 ns range.

Other companies are exploring the use of I^2L in RAM arrays to keep the bipolar speed but achieve the densities necessary to stuff 4096 or even 16-k cells on a chip. The 16-k bipolar RAM promises to become a reality by the end of 1978.

Featherweight Miniature Panel Mount Thermal Printer

Datel's new model DPP-7 Digital Panel Printer uses only 2 moving parts for OEM reliability. At only 2.3 Lbs, (1,1Kg) it is one of the lightest panel-mounting recording instruments available.

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Fairchild has its patented Isoplanar I^2L, other companies such as TI are exploring a Schottky-based I^2L, and developments are also going on with other bipolar processes such as the Collector Diffusion Isolation process used by Ferranti (England). The CDI process offers the density of CMOS with performance close to that of I^2L. It is, however, restricted for now to supplies of less than 8 V.

Densities boost μP power

But with the added density that processes like HMOS already bring, microprocessor capability and performance have doubled in the last year and will probably double again in 1978. For instance, the 3872, a 4096-byte ROM version of the already "industry standard" 8-bit 3870 will be coming from Mostek. The 3872 has all the features of the 3870, but also double the memory capacity.

Intel will be releasing modified versions of its 8-bit 8048 one-chip microcomputer, some with larger ROMs, others with less I/O, etc. The latest introduction, the 8021, is a reduced I/O version of the 8048.

Another development from Intel, the 8748 combination EPROM and μP, has started a trend. Other companies are developing the necessary 5-V EPROM technology to join the fray.

In fact, TI's 9940, an EPROM-based version of its TMS9900 16-bit microprocessor, has already been announced. It will be the first all-in-one 16-bit microcomputer on the market.

Processor lines already on the market are being updated with higher-speed versions. For example, National Semiconductor has introduced an NMOS version of its PMOS SC/MP μP and is introducing the INS8900, an NMOS version of the PACE 16-bit PMOS microprocessor.

One high-speed technology that is on the rise is silicon-on-sapphire. RCA (Somerville, NJ), long a proponent of sapphire substrates, has shelved its plans to introduce a commercial SOS version of its 1802 μP. Instead, RCA is introducing the 1804—a CMOS SOS all-in-one microcomputer that will operate at roughly half the power level but double the speed of the 1802. Early details of the processor's specifications include a 2048-byte on-chip ROM, 64 bytes of RAM, a full 1802 CPU, 16 I/O lines, an 8-bit event-counter/timer, and an instruction-execution time of 1.2 μs at a 10-V supply level. The processor is expected to cost less than $8 each for 100 units.

By bringing down the cost of microprocessors, General Instrument has been able to design them into cost-conscious items such as this microwave oven controller.

Other companies are also exploring SOS technology because of its isolation capability coupled with the speed improvements possible stemming from lowered capacitance. Although few companies offer commercial SOS products, SOS R&D is going strong at many of the microprocessor vendor's labs.

Rumors are still flying about describing the Intel 16-bit processor, the 8086, which is expected to be introduced later this year. Industry sources indicate that the 8086 will be assembly language compatible with 8080 and 8085 μPs. The 8086 bus is designed around the 8085's partially multiplexed bus and is expected to have 10 times the throughput of the 8080.

Another 16-bit processor, the Z-8000 from Zilog (Cupertino, CA), is expected to appear by about the third quarter of 1978. Both the Z-8000 and the 8086 are expected to provide full minicomputer-like architecture and megabyte addressing capability.

While 16-bit processors promise increased performance and capabilities, smaller processors such as the dedicated 4 and 8-bit devices made by over half a dozen companies are finding their way into many consumer products. Unhampered by the high-speed processing demands of commercial applications, the units can be built into items such as small hand-held games, microwave ovens and cars.

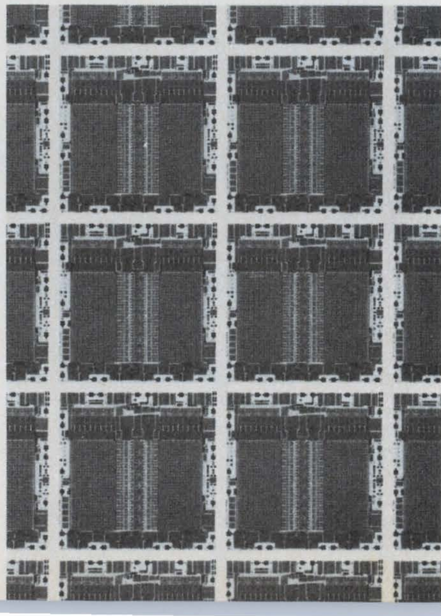
Peripheral controllers see action

Even though microprocessors seem to capture most of the limelight, there are many developments taking place in the peripheral chips used either with the processors or as stand-alone controllers. For instance a CRT controller circuit recently introduced by Standard Microsystems (Hauppauge, NY) permits a completely programmable CRT terminal to be built (programmable display formats, that is) with less than about a dozen chips. The CRT5027 permits the CRT format to be set for characters/row, rows/frame, cursor control, starting and ending points, and operating mode (interlaced or noninterlaced).

For direct processor support, many specialized peripheral chips are being developed that can remove some of the burden from the processor. For example, specialized chips are being included to support the processors for the newer video games to handle sound effects, video overlays or scoring.

For its 6802 processor, Motorola has developed the 6846, a combination ROM, timer and I/O peripheral that forms a complete two-chip computer system when used with the 6802.

A general-purpose chip, the 8041 from Intel, has been designed for controller-type applications and can be used as either a cassette recorder interface controller, a floppy-disc controller, a keyboard controller, and more. The chip holds both a bit-oriented and a byte-oriented processor, so the chip can easily handle serial or parallel interfaces. ■■



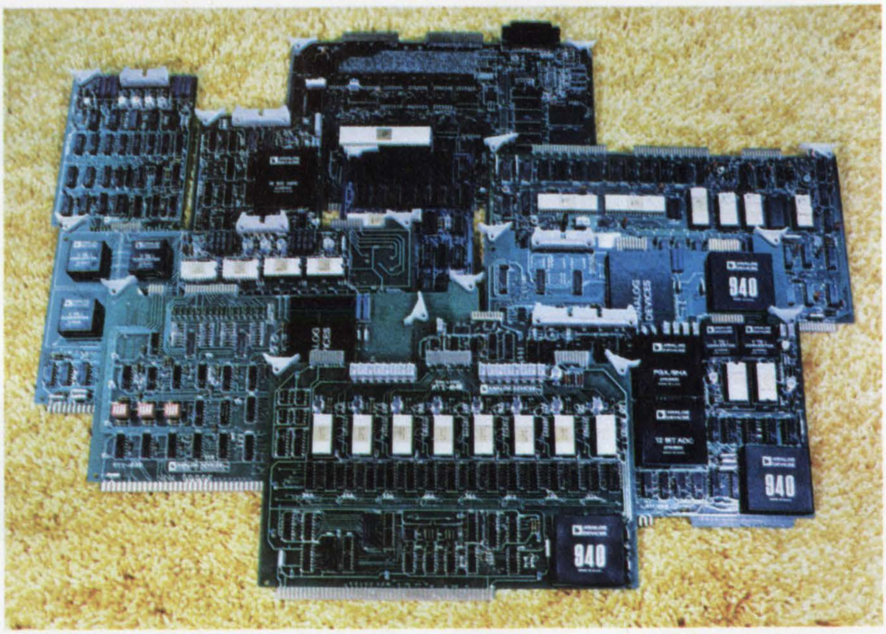
Silicon-on-sapphire products, such as this memory circuit from RCA, promise to keep speeds high without increasing power requirements.

Denser hybrids and PC boards mate with μPs—but watch those analogs

Modules, hybrids, PC boards and subassemblies looking for attention in 1978 had better be microprocessor-compatible—at least in name, if not in performance. And that includes products ranging from the power supply, the Sad Sack of the electronics world, to the data converter, the heavyweight of packaged electronics. But μP compatibility will have to share the stage in 1978 with three strong trends:

- Hybrid circuits are pushing to ever-higher complexities and performance levels.
- Analog and linear circuits are moving out of the back seat to regain long-lost, but necessary attention.
- Analog input/output (I/O) and other single PC boards for μC applications are making a bigger and bigger impression in system designs.

Spurred on by the competition of continuing, remarkable advances in monolithic circuits, hybrids are fighting fire with fire by incorporating the best commercial and custom chips into complex designs for superior performance. And the levels of complexity reached today—in both ICs and hybrids—make it hard to tell the components from the systems.



Up and coming: complete analog I/O subsystems on one PC card, and dedicated to a specific microcomputer. One of the newer output boards is the Analog Devices RTI-1243 (center card), which is designed for the Texas Instruments 990/100M 16-bit μC.

More and more in less and less

Already, entire data-acquisition systems (DASs)—with multiplexer, reference, a/d converter and other circuits—have been squeezed onto a single chip. But hybrids pack in even more, and do it in one or two IC-compatible packages. Whereas single-chip DASs now handle only eight bits, hybrids built by Datel Systems (Canton, MA), Micro Networks (Worcester, MA) and others cram in sixteen 12-bit channels plus a programmable amplifier, a sample-and-hold function and even system like capabilities like address registers and control logic. Complete I/O systems, like the 8-bit, thick-film unit designed by Burr-Brown (Tucson, AZ), now come in hybrid form.

Those circuits—call them components, building blocks, subsystems, systems or whatever—are just the beginning. Similar ones are coming from more vendors, and even newer, perhaps more startling designs are on their way from the technological leaders.

Major performance thrusts appear to be toward higher speeds, greater resolution and accuracy, and improved temperature coefficients. Much of the over-all improvements stems in part from the steadily shrinking hybrid package—components are closer together and propagation delays are shorter. Not only that, but with more and more circuits being placed on a common substrate, temperature gradients are becoming more uniform.

Remarkably, as circuits shrink so do prices. Dave Kress, product marketing specialist for Analog Devices Semiconductor (Norwood, MA), foresees data-acquisition systems with more channels, more accuracy, greater flexibility—at dramatically reduced prices. As Kress puts it, "the stuff is going to go below \$200."

Analog explosion coming

Exactly what "stuff" Kress is talking about remains to be seen, but at least one two-package DAS, from Micro Networks, now sells for under \$140 in quantity, while Datel's miniature 62-pin DAS carries a single-unit price tag just \$95 away from the \$200 mark.

Paul Brokaw, director of product planning for Analog Devices Semiconductor, gives a clue to what may be coming: while a μP increases digital "horsepower," it cannot solve analog problems. As a result, interest in analog signal conditioning is heating

Stanley Runyon
Senior Associate Editor

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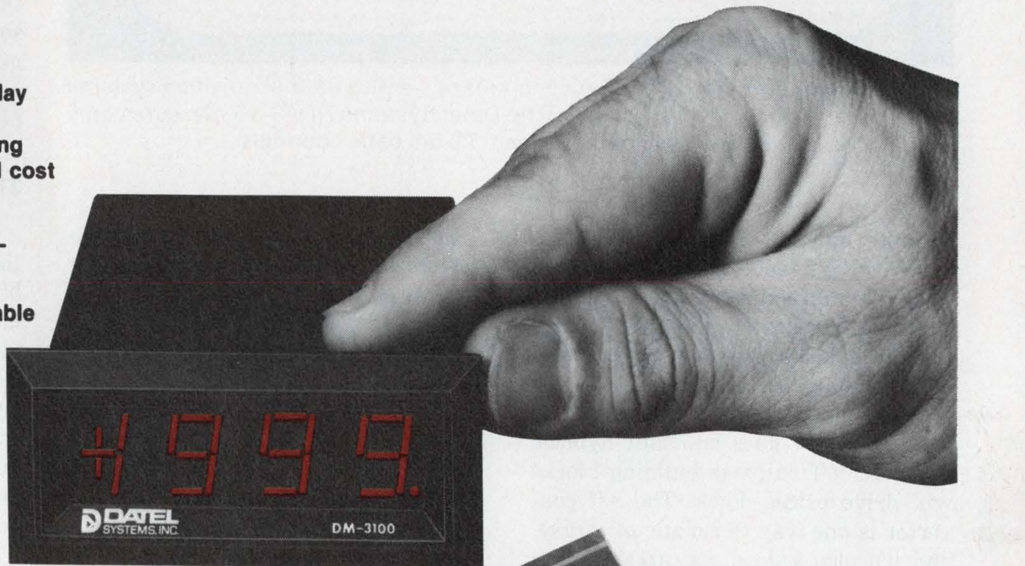

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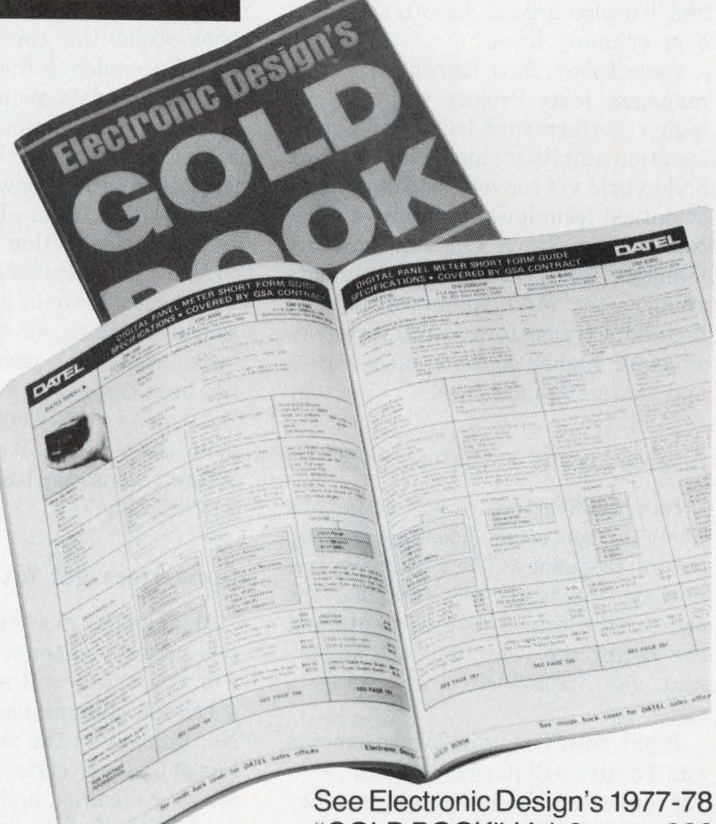

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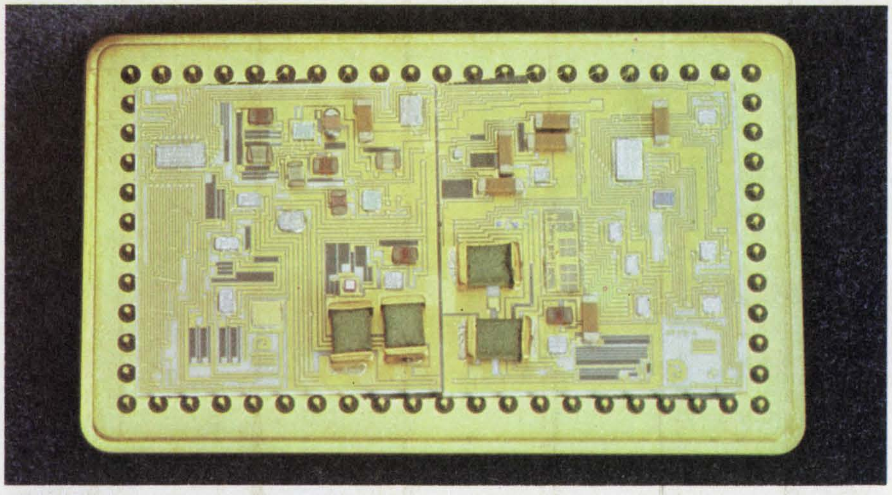
CIRCLE NUMBER 32



Hybrid-circuit complexity continues to amaze—entire data-acquisition systems now come in one or two packages. The Datel Systems HDAS-16 measures only 2.3 × 1.4 × 0.24 in., yet holds sixteen 12-bit data channels.

up once more.

"By year's end, both the IC and hybrid manufacturer will give birth to new instrumentation amplifiers, sample-and-hold amplifiers, v/f converters and the like," Brokaw predicts.

"Isolation amplifiers are expensive now," Brokaw goes on. "But hybrids using IC v/f chips as building blocks will drive prices down. The v/f converter is one way to isolate, of course, and it's also a good way to ship data over crummy lines."

Gene Tobey, Burr-Brown marketing manager, joins Brokaw in predicting higher performance levels for hybrid isolation amplifiers and for monolithic and hybrid v/f converters. Tobey hints at optical techniques to improve isolation, while Steve Conners, product manager for Dynamic Measurements (Winchester, MA), points to FET and high-beta transistors as being responsible for higher common-mode ratios and better tempcos.

Interest turns to better v/f's

In v/f converters, design activity is likely to center on boosting the top output frequency. The higher the frequency, the faster the tracking, the shorter the time between counts and the better the resolution—all important for industrial-control applications.

Right now, Dynamic Measurements and Teledyne-Philbrick (Dedham, MA) v/f converters share the top-frequency crown at 5 MHz. How much higher frequency will go is anybody's guess, but the limiting factors are accuracy, linearity and tempco, which must usually be compromised for speed.

Speed is essential in other data converters as well: Vendors are working on that parameter as fast as they can. In fact, Bob Jacobs, product manager at Teledyne-Philbrick, considers the boosting of speeds and bits *the* converter trend, and he justifies the race by the need for high performance, not just in the military arena but in industrial controls and in automatic test equipment.

But Jacobs is one of the few who pooh-poohs the converter-μP fusion that is so much in the news. He states that today's data-acquisition functions — conversion, sample-and-hold, etc.—have far outstripped the μP in response time. The future, however, may bring an internal-control μP in high-resolution data-acquisition systems.

Asked about specific converter hardware, Jacobs would only say, "As far as converters go, all the concepts have been around for years. The problem has been being able to build hardware. But you'll soon see super performance using an old idea. It couldn't be done before because the basic building block was missing."

Converters get faster

Meanwhile, new products like Datel's recently announced 8-bit, 20-MHz a/d converter continue to push the speed-bit compromise to new highs. Not unlikely in the near future are 12 bits at 2-μs conversion, and even faster. Micro Networks marketing engineer John Munn, for one, speaks of a coming conversion time in the "low hundreds of nanoseconds, packaged in a hybrid DIP."

Such a converter, Munn adds, probably will be housed under three or four roofs to spread out the power dissipation. But the converter will still use less power, and will be smaller and cheaper than card converters or instruments available in that speed range.

With monolithic converters already dominating the 8-bit market and making inroads into 12-bit units, the hybrid has but one recourse to stay ahead—it must escalate. Almost certainly, new 14 and 16-bit hybrid converters will grab attention in the coming months.

Hybrids are getting so good, in fact, that they are approaching—and in some cases surpassing—the performance of some modular converters, which still hold the ribbon for the ultimate in performance.

The μP connection

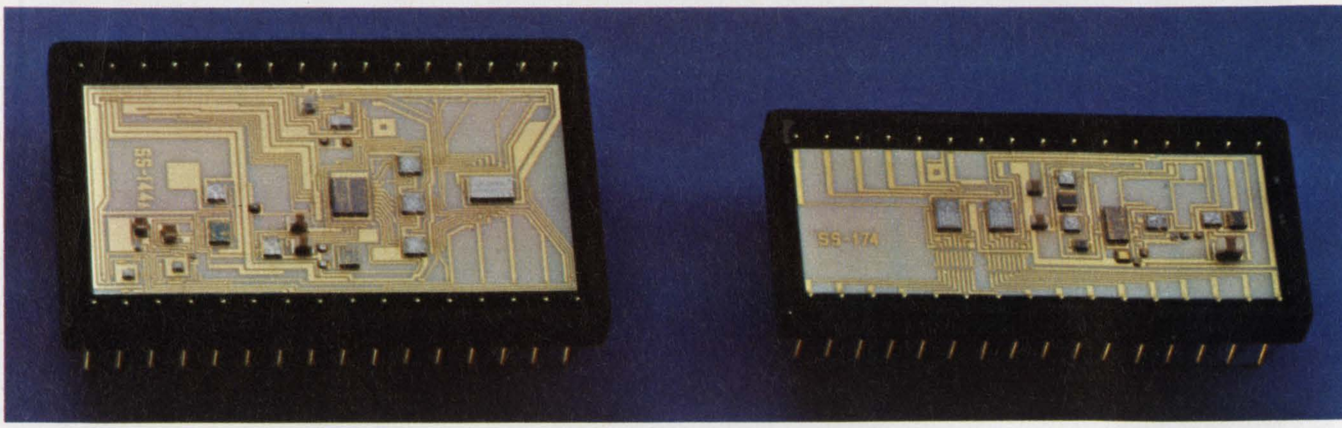
But of all packaged-circuit trends, the most pervasive could turn out to be μP compatibility. Be it IC, hybrid, module or PC board, if it's new, it's almost certain it will be designed to fit either on a specific μP data bus or to be "universally" compatible. Three-state outputs, latched inputs, double buffers and memory mapping already are becoming commonplace in converters, acquisition systems and other I/O circuits.

Memory mapping seems to have won out over accumulator I/O as the way to interface converters and other circuits with μPs. In mapping, a circuit is given a fixed address, and the μP treats the circuit like any other memory location. As a result, no special I/O instructions are necessary; nor are external circuits, registers (accumulators), or manipulations to funnel, say, 12 bits of data into an 8-bit bus, and vice versa. And, of course, a μP's entire memory-instruction repertoire is available to move data in and out.

Compatibility with μPs is a movement that won't fizzle out, according to L. Wayne Peacock, president of Hybrid Systems (Bedford, MA). But he also thinks the movement started too soon: Most people are still trying to figure out how to use a μP.

"Compatibility will be a key aspect of conversion," Peacock declares, "but in five years." For that matter, Peacock doesn't understand what the fuss in packaged DASs is all about since "the market isn't there."

The real problem in hybrid conversion products is not the circuit, but the package, according to Peacock—whose company primarily makes thin-film hybrids in hermetic DIP packages.



Microprocessor compatibility, a fast-moving trend in packaged modules and circuits, shows up physically as DIPs that can be mounted alongside a μP, and electrically as direct addressing and control by the μP. All this happens in the Micro Networks MN7130/ADC80 12-bit, 16-channel data-acquisition system.

"All the money is in the package—the circuit represents a fraction of the cost," Peacock explains. "That's where the breakthroughs are needed."

When asked if 1978 would see any such breakthroughs, Peacock replied "There are other techniques, which we are looking at from a research point of view."

However, new packaging isn't likely to receive as much attention as emerging analog I/O and other dedicated single-board microcomputer subsystems. Many such boards are now available, and more are on the way from both μC and analog-conversion-product vendors.

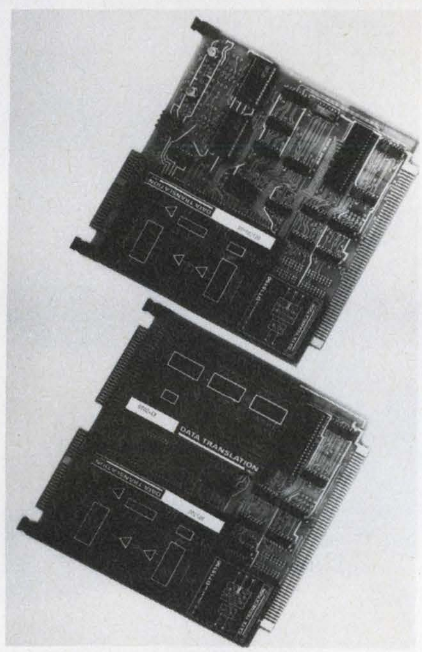
Dedicated boards are mixing it up

In some cases, compatible boards are being designed by traditional module makers for resale by a μC supplier; in other cases, the module vendor does the selling. Thus, many of the boards are made up of a mix of modular or hybrid devices, and ICs and other components.

Whatever the makeup, the prime features of most boards include self-containment (only a power supply is needed); a configuration that matches the other digital boards in a μC system; and, because of memory mapping, total compatibility—just plug-in the board and write the necessary programs with the μC's own language.

At the integration levels available, some boards offer only input channels and some offer only output channels. A few do provide both inputs and outputs, but in a limited number of output channels. As hybrids get more complex, however, the trend will be more and more channels of both types on one board.

Right now, interface boards are offered by Analog Devices, Analogic (Wakefield, MA), Burr-Brown, Datel, and Data Translation (Natick, MA), among others, and more vendors—Micro Networks, for one—are likely to jump in.



Boards for the Zilog Z-80 μC are based on Data Translation's DATAX modules and feature analog I/O and analog-input systems.

Moreover, those μCs for which compatible boards aren't yet available—mostly newer μCs and 16-bit ones—will soon get them.

Both Analogic and Analog Devices are now marketing boards compatible with Texas Instruments computers. Analog Device's new boards, the RTI-1240 family, are compatible with the TI 990/100M μC. Its first six offerings for the TI line include a 32-channel input subsystem, an 8-channel output card and an I/O board similar to the input version, but with two 12-bit d/a outputs.

Features of the Analog Devices boards include expandability of the input subsystem to 256 channels with on-board logic; software-programmable gains; memory-mapped interfacing; input fault protection; and software-enabled end-of-conversion.

The output boards provide 12-bit conversion and software-controlled logic-driver outputs. The reference can be on-board or external, but in both cases, one reference serves all converters for improved tracking.

Meanwhile, the Analogic I/O boards, the ASC 1080 and 81, are also aimed at the TI TM-990/100. Up to 64 single-ended input channels and four output channels are available. The input systems are designed around the company's 12-bit, successive-approximation DAS module, while the output boards provide a 12-bit voltage or current. Like the Analog Device's board, the Analogic interface features memory-mapping—but it goes on to provide an additional register to communicate with the μC.

Thus all the μC's memory instructions are available for data manipulation and conversion, and interrupt routines aren't necessary. Prices of the new I/O boards vary with the number of channels and range from \$445 to \$675 for the Analog Devices models, and \$331 to \$789 for the Analogic.

Fred Pouliot, manager of the company's real-time interface series of boards, feels that the 16-bit μC will gain rapidly on the present 8-bit leader, and so will be a center of intense activity in support boards. Judging from what is already happening, Pouliot's crystal ball seems tuned to the right wavelength. ■■

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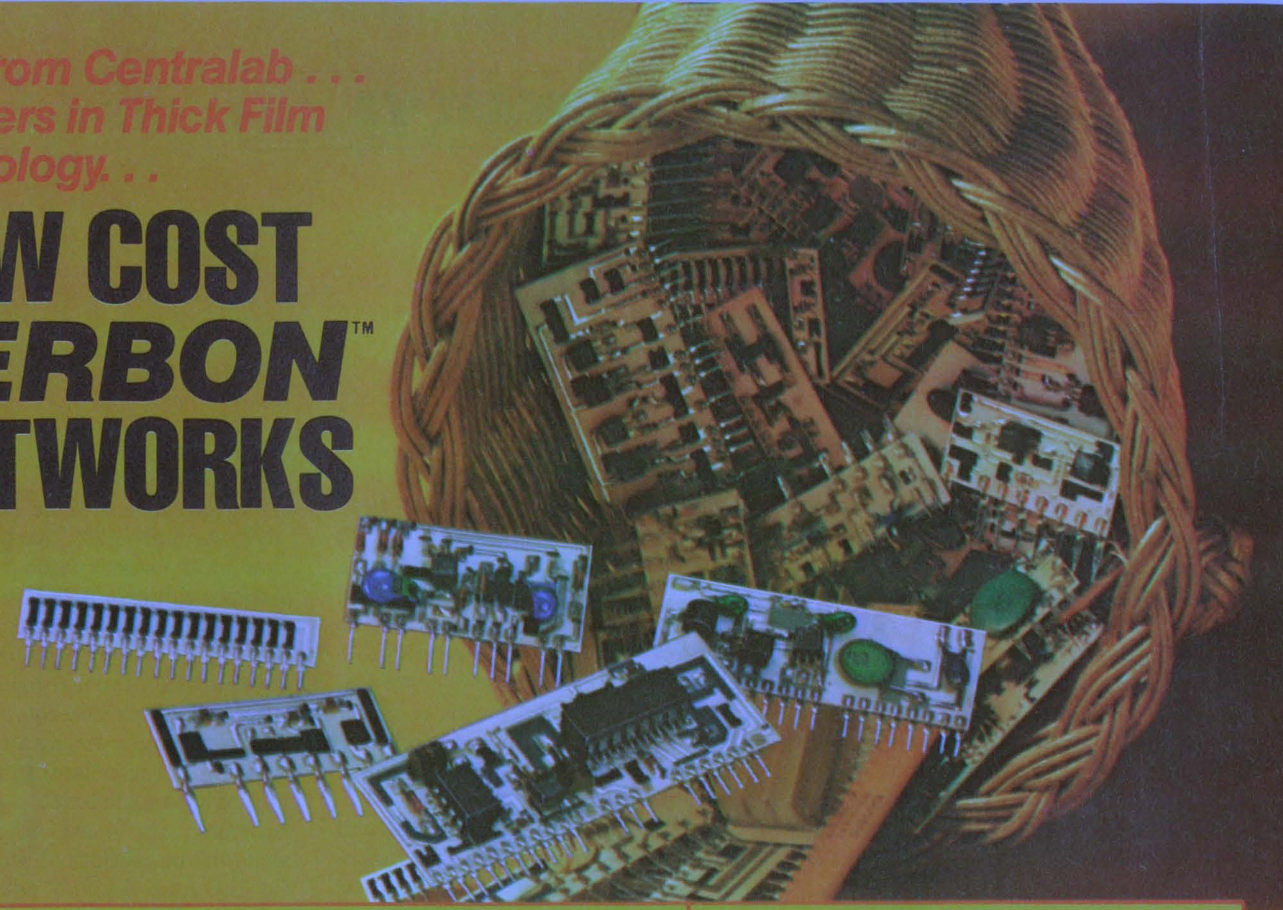

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CIRCLE NUMBER 34

Discrete-component development spurred by switching supplies

Advances in discrete components will continue to be spurred by the trend toward switching power supplies (regulators and inverters). Other incentives to component progress include automotive, industrial and home appliance applications.

The influence of switching power supplies on discrete designs is already being felt:

■ *Electrolytic filter-capacitor* designs are aiming for reduced impedances at the supply switching frequencies (20 to 60 kHz), and beyond. Values of less than 1 nH for equivalent series inductance (ESL) and less than 1 mΩ for equivalent series resistance (ESR) have already been achieved. And some capacitors can handle 50 A of ripple current at 85 C.

■ *Power semiconductors*—transistors and SCRs—are being designed with ratings for the fast, often low duty-cycle pulse signals in switching supplies. The semiconductor devices feature high current handling (5 to 30 A), low forward-voltage drop (0.6 V) and fast rise and fall times (0.2 μs).

And, automotive, industrial and home-appliance applications will have an impact as well on power semis.

■ *Asymmetrical silicon-controlled rectifiers* (ASCRs) promise to power future home induction-cooking, industrial-welding, TV-scanning and power-inverter applications.

■ *Gate turn-off SCRs* (GTOs) will control auto ignition and other automobile heavy-current systems, such as headlights and starters.

■ *Heat-pipe cooling techniques* (Transcalent designs) will permit very substantial power—100 to 400 A at 1200 V—to be handled by transistors, SCRs and rectifiers in relatively small packages. Semiconductor control of high power for vehicle drives and many industrial and military uses will become practical.

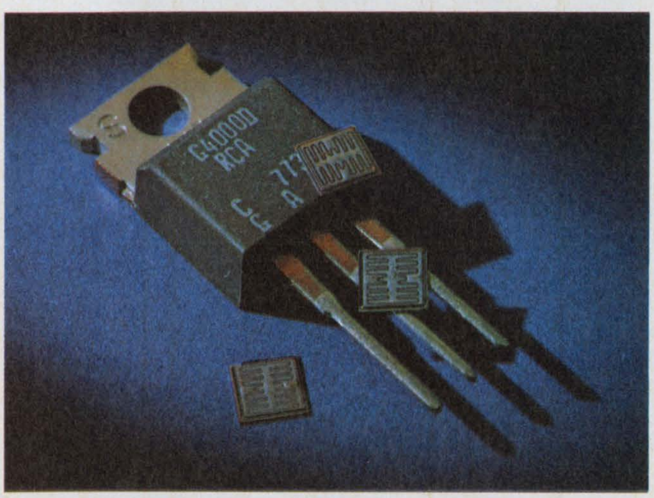
While development for special uses is a clear trend in capacitors and discrete power semiconductors, the main thrust in resistors is to improve general-purpose types: Film units with ±2% tolerance aim at replacing the ±5% through ±20% carbon-composition units over a wide range of resistance values—to 20 MΩ—within the same sized body and tolerance rating. And better over-all stability and lower noise are continuous goals.

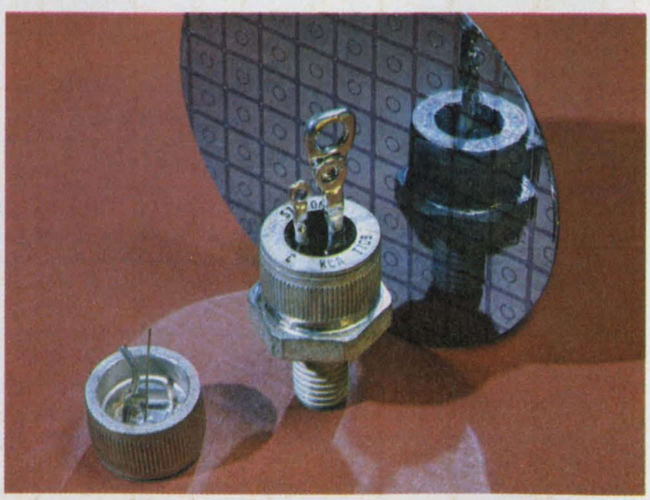
Although carbon-composition resistors are under strong attack by film-type units, the reliability and ruggedness of hot-molded carbon-composition resistors are hard to beat, and shouldn't be overlooked, when reaching for the next decimal point. A great many applications don't need the extra accuracy of film types, and the general-purpose hot-molded carbon-composition resistors are more than adequate.

General-purpose not good enough

General-purpose aluminum electrolytic capacitors, on the other hand, aren't adequate for switching power supplies. Helically wound, their internal inductance (ESL), though low, isn't low enough (about 10 to 100 nH) for EMI/RFI filtering at switching power-supply frequencies. And their

Morris Grossman
Associate Editor-





New thyristor designs: The G4000 Versawatt gate turn-off thyristor (left) simplifies turn-off, and the S7310 asymmetrical SCR (right) operates to 40 kHz. With easier control and higher speed, RCA pushes aside former SCR limitations and opens new application possibilities. Merely ground the gate of the G4000 and it turns off. And you can drive home-appliance induction cookers, switching regulators and power inverters with the S7310.

internal resistance (ESR) is too high, 1 to 500 mΩ, which limits ripple current because of capacitor [I_{ripple}^2 (ESR)].

Sprague (North Adams, MA) and Mallory (Indianapolis) have attacked the ESL/ESR problem by replacing the helical construction with stacked-foil designs. Sprague's 432D units have only 1 nH of ESL and less than 1 mΩ of ESR. Mallory's SFCs have similar characteristics.

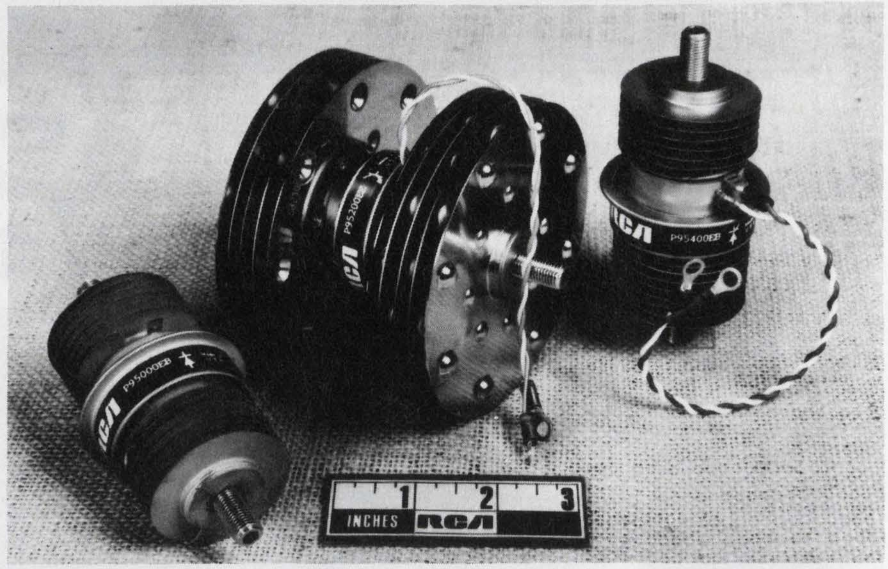
But according to Mepco (Morristown, NJ) application engineer Emory Deutsch, "Stacked-foil designs have relatively low capacitance-voltage (CV) products for a given case size." He claims that Mepco's new multiple-tab cylindrical electrolytics gives more CV at lower cost. For a 3 × 4⅛-in. case, 50-V unit, a stacked-foil capacitor delivers 6800 vs 25,900 μF for Mepco's STM171C.

However, Mepco's units still have a higher ESR, about 7 mΩ and higher inductance than stacked-foils. "Not for long," says Deutsch, noting that further improvements are expected soon in multiple-tab, cylindrical electrolytics. New automatic foil winding machines will produce capacitor elements with up to eight pairs of tabs, which should exhibit impedance characteristics as good as or better than stacked-foil units, without sacrificing CV.

"Ultrasonic-welding equipment under development for fusing individual cathode-foil turn ends will reduce both internal inductance and resistance even more," Deutsch adds. Aluminum foil is particularly difficult to solder or weld by ordinary means.

Specially designed terminations will help get rid of heat. Thus, lower ESL/ESR and superior heat dissipation will provide these capacitors with heretofore unattainable ripple-current ratings and low high-frequency impedances, Deutsch predicts. "In addition, great improvements in the electrolyte system are just around the corner—for operation at 105 C without derating."

Cornell-Dubilier (Newark, NJ) is also working to upgrade its FAM low-ESR computer-grade electrolytics. The goal is to lower inductances by improving terminations. A reduction of ESL from 15 nH to 4 to 6 nH is expected. Even so, the FAMs are pretty good right now, C-D believes. "The FAMs pack in three times more capacitance and have less than half the ESR of Sprague's stacked-foil 432D or Mallory's SFCs, and at lower cost," says Henry Cerretti of C-D. So, where high ripple currents and CV are needed, FAMs are better, but for ultralow, high-frequency impedance, the stacked-foils are still superior.



Transcalent cooling from RCA, which uses a heat-pipe technique to remove heat from semiconductor chips of diodes, transistors and SCRs, shrinks device sizes to as much as 1/7. A typical 16-lb assembly becomes only 10 oz. Some units handle as much as 400 A at 1200 V.

Schottky shoots at switchers, too

Power semiconductors, too, are aimed at the switching power-supply market. In 1978, TRW/Semiconductor (Lawndale, CA) expects to introduce dual-packaged (TO-3) Schottky power diodes that can handle up to 30 A in rectification and 60 A in commutation, which makes them particularly suited for low-voltage (5-V output) switching power supplies rated at 50 to 150 W. The low-voltage power sources need the low forward drop of a Schottky unit —just 0.6 V at 30 A.

Furthermore, switching power supplies need fast-switching transistors, so TRW will soon offer a 400-V, 15-A unit with a 200-ns fall time—a difficult combination of specs to achieve, according to Jagdish Chopra, TRW application engineer: "This device will reduce power-transistor count in half in many power-switching applications."

SCRs also promise to make the scene in such high-frequency applications. Transistors have traditionally outperformed SCRs in speed at any power level, and in forward-voltage drop and efficiency at low voltages. However, managing engineer Dale Baugher of RCA/Solid State Div. (Somerville, NJ) says it's no longer true necessarily. "RCA's newly developed ASCRs (asymmetrical silicon-controlled rectifier) have significantly higher speeds and lower switching losses than conventional SCRs." As a result, says Baugher, the new ASCRs not only handle the high currents and voltages of conventional SCRs—peak currents of several hundred amps with voltages over 800 V—but also do it at frequencies to 40 kHz, well into the switching-power-supply regions.

What's in a name?

Unfortunately, an ASCR has much less reverse-blocking voltage than forward blocking voltage: A 600-V forward-blocking unit typically has only 15-V reverse-blocking capability. "But if needed,"says Baugher, "a fast-reverse-recovery diode in series with an ASCR can provide the reverse-blocking. Usually, however, a series diode isn't needed. In many circuits, the normally required reverse-shunting (flyback) diode automatically prevents high reverse voltages, so the asymmetry is not a severe limitation."

Still, there's room for improvement. Better high-voltage (1000 V, and up), fast reverse-recovery diodes are needed to handle the flyback for the ASCRs, which can also use higher forward-voltage blocking (above 800 V).

Switching supplies are not the sole target of ASCRs. Electronic arc welding, 4.5 kW at 150 A, and even induction heating in home-cooking ranges are on the way to coming true. Old ideas, these applications can become practical because of low cost, high-frequency-handling ASCRs.

An ASCR allows 40-kHz power to be controlled simply and automatically. With home-induction cooking, merely lifting a cooking pot off the system's induction coil shuts off the power. Currents induced directly into the pot via special induction coils do the heating; thus, the stove top stays cool to the touch, while the meal cooks under easy and close control.

For an ASCR driven 150-A welder, only a 3-lb output-coupling transformer is needed, because of the high frequencies. But the transformer should have low leakage and be tuned with a small resonating inductor.

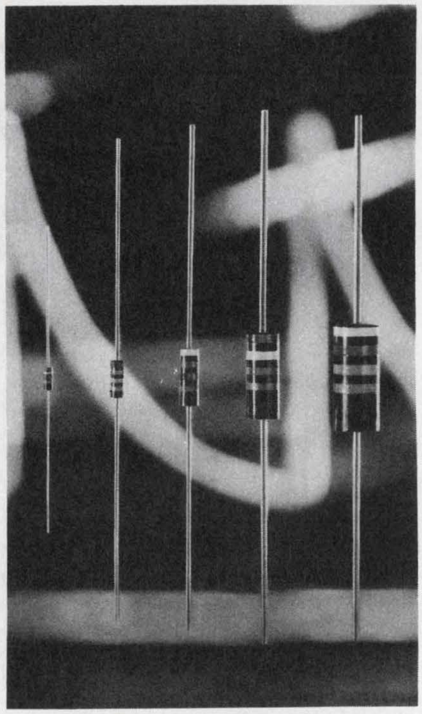
Turn off as easily as a turn on

But high-frequency operation is not the only direction for SCR development: Easy power control is also desirable. RCA will soon release an application note for its new family of gate turn-off thyristors (GTOs), Series G4000. Formerly, GTOs required very substantial current pulses from a usually isolated and special power source to turn them off. So even though GTOs could control dc power, engineers were discouraged from using them.

With the G4000s, however, the regenerative process associated with four-layer thyristors is interrupted by removing charge stored at its gate terminal by merely grounding it. As a result, current flow from anode to cathode switches off. The charge flow to ground produces a current pulse for a few microseconds with a peak value equal to 10 to 60% of the anode current. The GTO's anode current then falls near zero within 0.2 to 5 μs. Turn-on is as usual, with either a pulse or constant-current drive from the positive side of the power source.

With a constant-drive, turn-on resistor from V_{CC} to its gate, a G4000 GTO can be turned on and off with a single on-off input signal, and work like a high-gain transistor. However, a GTO can efficiently handle much more current than a comparably sized transistor. Or, with two separate input pulses the GTO can be turned on or off like a set-reset flip-flop.

Particularly adaptable to automotive applications, the G4000 series can work in ignition systems requiring 2 to 10 A of charging current, and without voltage clamping, because of its ability to block high voltage. Also, GTOs can control headlights and other heavy-current loads with small-gauge control wires: Carrying heavy currents directly over long routes through control switches to the load calls for large-gauge wire, wastes power in wire voltage drops and chews up switch contacts.



Hot-molded carbon-composition resistors, though under fire from film-type resistors, are here to stay, according to Allen-Bradley. Their ruggedness, reliability, low cost, and wide range of sizes and applications are hard to beat.

Handle more power in small sizes

Where the ASCR features improved speed and the GTO more convenient control, RCA's new "transcalent" design applied to SCRs handles hundreds of amperes with ¼ the size and 1/7 the weight of conventional SCRs. Similarly, transcalent power transistors and rectifiers handle more power than their conventional same-sized counterparts.

Integral-fin heat pipes bonded directly to the transcalent unit's silicon wafers drastically reduce the thermal resistance to the ambient, carry away heat that must be removed from the chips. Consequently, transcalent devices have a high reserve for overloads and surges. And they can operate at lower junction temperatures for a given load to get high reliability. Or, they can handle the unit's full rating at higher ambients than can the usual power semiconductor.

The RCA family of transcalents includes three series: P95400EB 400-A, 1200-V (blocking) SCRs; P95200EB 100-A npn transistors; and P95000EB 250-A, 1200-V (blocking) rectifiers—with more to come, no doubt.

Resistors heat up

Even in the staid discrete-resistor field there's more to come. A quiet battle ranges between metal or carbon-film and venerable carbon-composition resistors. John Covey, a spokesman for MEPCO/Electra, makes a case for the film resistors:

- The modern carbon and metal-film resistor is in many ways superior to the carbon-composition resistor and likely to remain superior, since carbon-composition technology is about as refined as it will get.
- By 1980, the carbon and metal-film resistors will dominate the general purpose ⅛ to ½-W market with ±2% initial tolerances at a tempco of 200 ppm/°C. And special MIL specs will be written for these resistor types.

"Not so!" say Allen-Bradley (Milwaukee, WI) engineers. "The pending demise of carbon-composition resistors is highly exaggerated. Hot-molded carbon-composition resistors are here to stay, and the films have a long way to go to beat their ruggedness and reliability. The Allen-Bradley resistors have exceeded 750 $\times 10^6$ life-test hours without a single failure, and all five sizes (⅛, ¼, ½, 1 and 2 W) are warrantied to meet or exceed the S level (best) of MIL-R39008B.

"Furthermore, both NASA and Jet Propulsion Laboratory data show that the carbon comp has the lowest failure-rate and highest-reliability record of any passive component. And per-piece price is lower than the unit-resistor cost of standard thick-film networks. When tested by NASA/Ames Research Center, our carbon comps showed a failure rate of only 0.8%, compared with 7.3% for film types.

"In addition, these resistors can take much higher energy pulses than the others and not change characteristics or even blow up like film resistors.

"For example, energy from a 10-μF capacitor charged to 600 V (1.8 joules) will have no significant effect on a ¼-W, A-B unit," say A-B engineers. "In addition our carbon-comps have a tempco less than 200 ppm/°C over the normal operating temperature range of 15 to 75 C.

"Hot-molded carbon-composition resistors, with proper manufacturing and quality control are not only healthy and vigorous now, but we promise their continued excellence well into the future."■■

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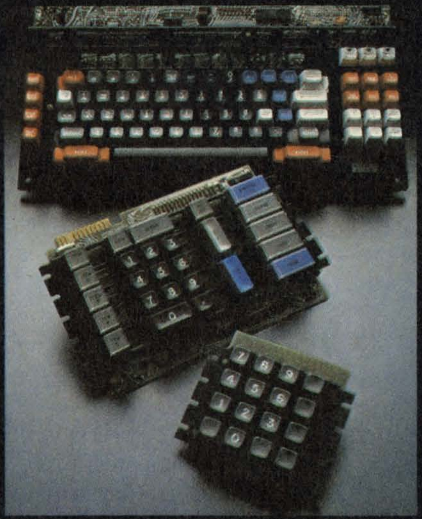

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CIRCLE 38 FOR DATA

Instrument cost and weight cut for new applications and users

Design engineers will benefit from lower instrument costs as well as added measurement capabilities this year. Instrument manufacturers are actually aiming at production-line and field-service testing applications carried out by customers who buy dozens of instruments at a time. But low cost, low weight, compactness, and easy use are the requirements as valuable in the lab as in the field. As a result, smaller and lighter cabinets will make it easier to move instruments around in both places.

"Low cost" will be a familiar description this year on data sheets for new digital multimeters. Where last year's minimum outlay for a 3-1/2-digit instrument was about $100, this year's price will be half that. Sinclair Radionics Ltd. (St. Ives, Cambs., UK) has already introduced its Model PDM35, a $49.95 DMM aimed squarely at hobbyists, but also useful around the design lab for a quick check on a power supply bus or for finding shorts and opens in cables.

In the medium price range for DMMs, the emphasis will be on adding features without adding money. For example, the new Model 1750 from Data Precision Corp. (Wakefield, MA) will go for $279—high these days for a simple 3-1/2-digit instrument, but not for one with true-rms response, dB scales, and high/low excitation on resistance ranges, as well as a 0.1% basic accuracy rating on dc ranges.

Plastic "outweighs" metal

To trim costs, molded plastic cabinets will replace more expensive and heavier metal boxes, and LSI circuits will replace many of the components not only in DMMs, but also in other instrument product lines. The main objective is to make the instrument more attractive for field-service applications. For example, the Model 920-D logic analyzer from Biomation Corp. (Cupertino, CA) is a 20-MHz timing monitor with eight channels and a ninth input that can serve as an extra signal line or a trigger marker and qualifier. At $1295, it costs a third of what older units cost, and two reasons are a less-costly plastic box and LSI circuitry.

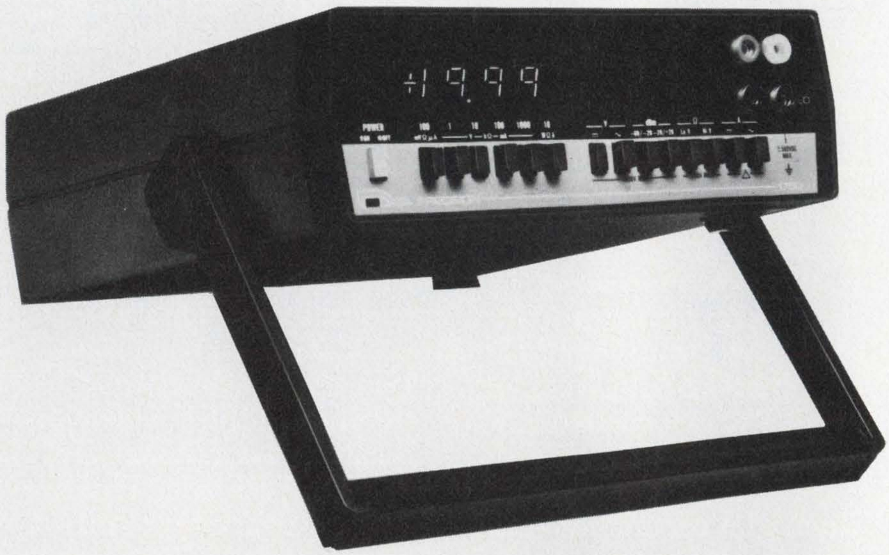
For production-line testing, a logic analyzer must have a comparison mode; the timing diagram or state table from a known-good board or system is stored in one memory, and the data from a unit under test in a second memory so that the two sets or responses can be compared. Many logic analyzers have a comparison mode built-in so that an operator can spot variations easily—differences between two units show up as bright spots on the analyzer's screen.

One product line—the LM208/LM216 monitors from E-H Research Laboratories Inc. (Oakland, CA)—even adds a comparison mode to analyzers that lack this feature. But even these new units require that a known-good system be available to feed "correct" data to the analyzer. It may not happen this year, but soon there will be a programmable logic analyzer that can accept "good" patterns from a mag card or tape, making production-line logic analysis even easier.

In the meantime, logic-analyzer operation is being simplified by giving the user a "menu" much like that of a time-shared computer terminal. These prompting routines list each feature available and allow the user to pick one. Under microprocessor control, the Model 1615A from Hewlett-Packard Co. (Palo Alto, CA) can be configured in one of three ways with keyboard entries: as a 24-bit state analyzer 256 words deep, as an 8-bit timing analyzer 256 words deep, or as a combined 16-bit state and 8-bit timing analyzer, each 256 words deep.

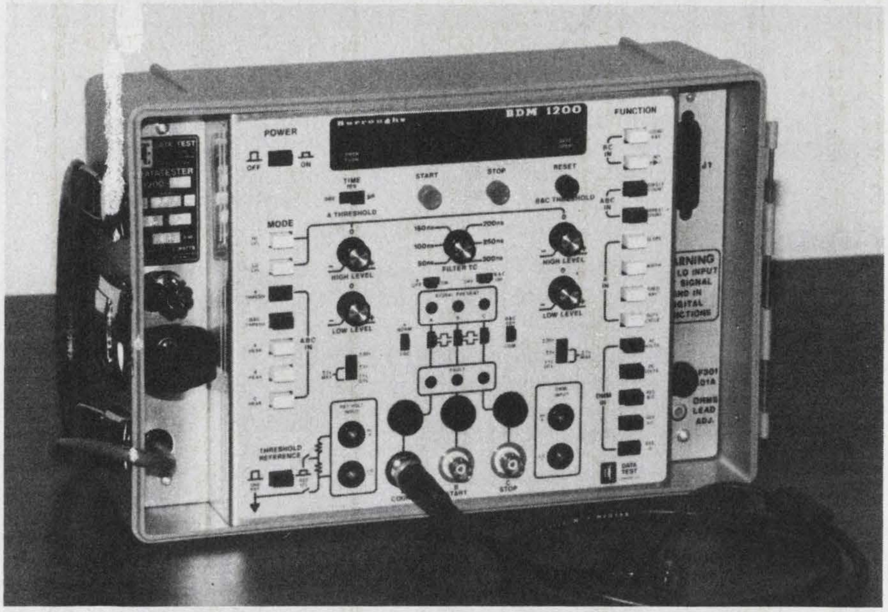
Combinations cut cost

Simplifying an instrument's controls as well makes it easier and



More features for the dollar is the trend in digital multimeters like this Data Precision 1750. For $279, it includes dB scales, true-rms response, and 0.1% basic dc accuracy.

Andy Santoni
Associate Editor



A useful combination for digital-circuit testing, frequency and transition counters, a voltmeter, and a logic probe, are built into the Data Test 1200. This one is built especially for Burroughs.

quicker—and therefore less costly—to operate. So instrument makers are combining the functions of many instruments into a single unit. This has been done in the past. But unlike previous combined instruments, which would merge standard instruments like a scope, multimeter, and counter into one box, today's combined instruments are more clearly aimed at solving particular types of problems. In digital-circuit troubleshooting, for example, an oscilloscope may not be as valuable an adjunct to a frequency counter and voltmeter as a transition counter and logic probe would be. In the Model 1200 tester, designed for Burroughs Corp. by Data Test Corp. (Concord, CA), a frequency counter, transition counter, logic probe, voltmeter and ohmmeter are all built into a single cabinet that, together with a high-frequency scope that is already in the field-service technician's arsenal and would be too expensive to include in a multifunction instrument, is about all a technician needs to get a computer up and running. A similar combination of functions is also available in the Model 851 digital tester from Tektronix Inc. (Beaverton, OR).

Tektronix is the leader in another area of instrument design aimed at low cost and convenience—modular packaging. The firm's TM500 series includes modular signal sources and measuring instruments that plug into a mainframe containing the necessary power supplies. Other companies are already making special-purpose modules to plug into the TM500-series mainframes to perform functions not provided by Tektronix units, and more modules are on the way.

Another approach to instrument system modularity is E-H Research's Model 8200. The mainframe contains a controlling microprocessor and calibration circuitry as well as power supplies, and the "instruments" that plug in are uncased cards that perform measurement functions. A card can be the equivalent of a digital multimeter or a counter.

Making different measurements

Speaking of measurements, along with voltage and frequency, emphasis in 1978 will be placed on measuring other, less frequently used, parameters such as temperature and current. Current is useful to study when looking for shorts and opens in printed-circuit boards, especially in digital circuit boards that have multiple outputs connected to a single bus. So current-tracking instruments like the Model 2220 Bug Hound from GenRad Test Systems Division (Concord, MA) and the Model 547A current tracer from HP are destined to become commonplace.

Temperature measurement, too, is likely to become routine as engineers begin to feel more comfortable with the available techniques. Varying temperature across a printed-circuit board can help pinpoint trouble spots, sometimes before they happen. The Inspect automatic test system from Vanzetti

When a bus stops, the source of the failure must be found. Hooked up to the 1602A logic analyzer, this special probe from HP helps engineers visualize problems on the standard instrument interface.

Infrared & Computer Systems (Canton, MA) uses heat sensing to track down faults and, in manual testing, engineers will be using temperature scales built into a number of available multimeters or separate temperature meters like the T-meter from ECD Corp. (Cambridge, MA). For process monitoring and control applications, more engineers will be using multiple-input digital thermometers like the Model AD2036 from Analog Devices (Norwood, MA).

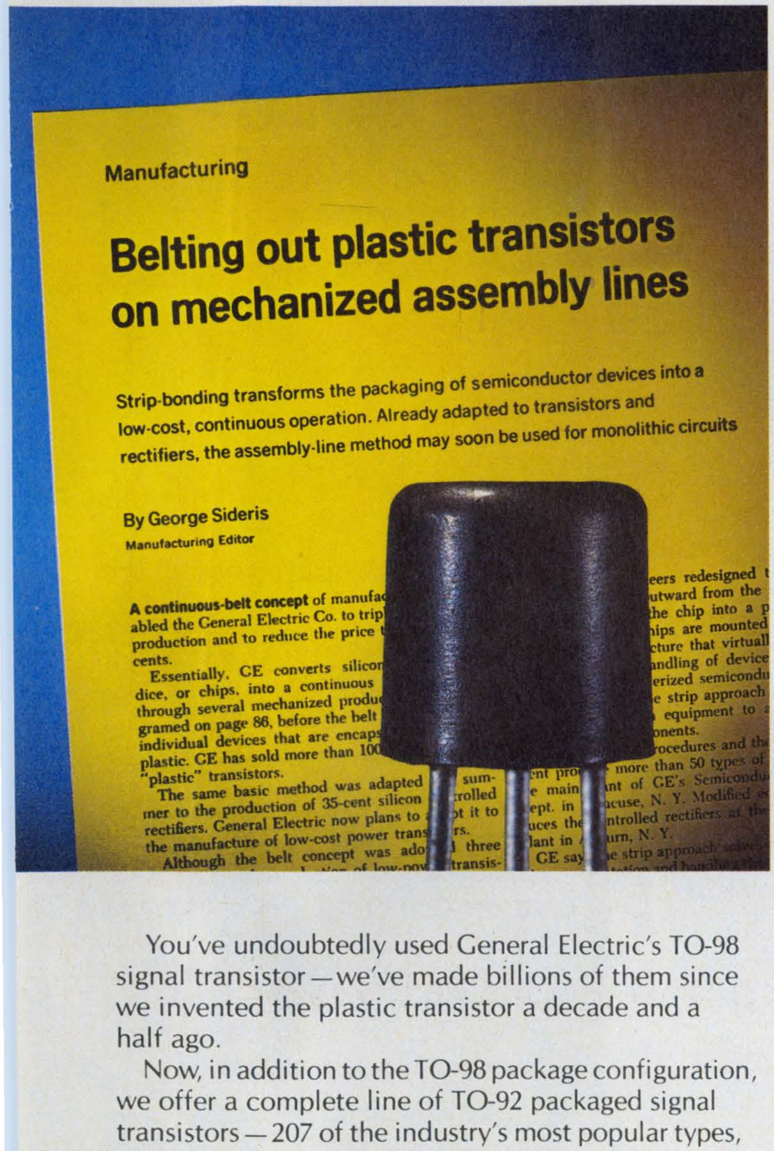
One simple reason for checking the temperature of a product is to see if it is safe enough to touch. This concern for safety will be reflected in instruments this year as Underwriters Laboratories Inc. (Chicago) completes its proposed safety standard for test and measuring instruments. More instruments will sport safety-related features, such as fully insulated test-probe connectors used by some multimeter suppliers and soon to be available from Simpson Electric Co. (Elgin, IL).

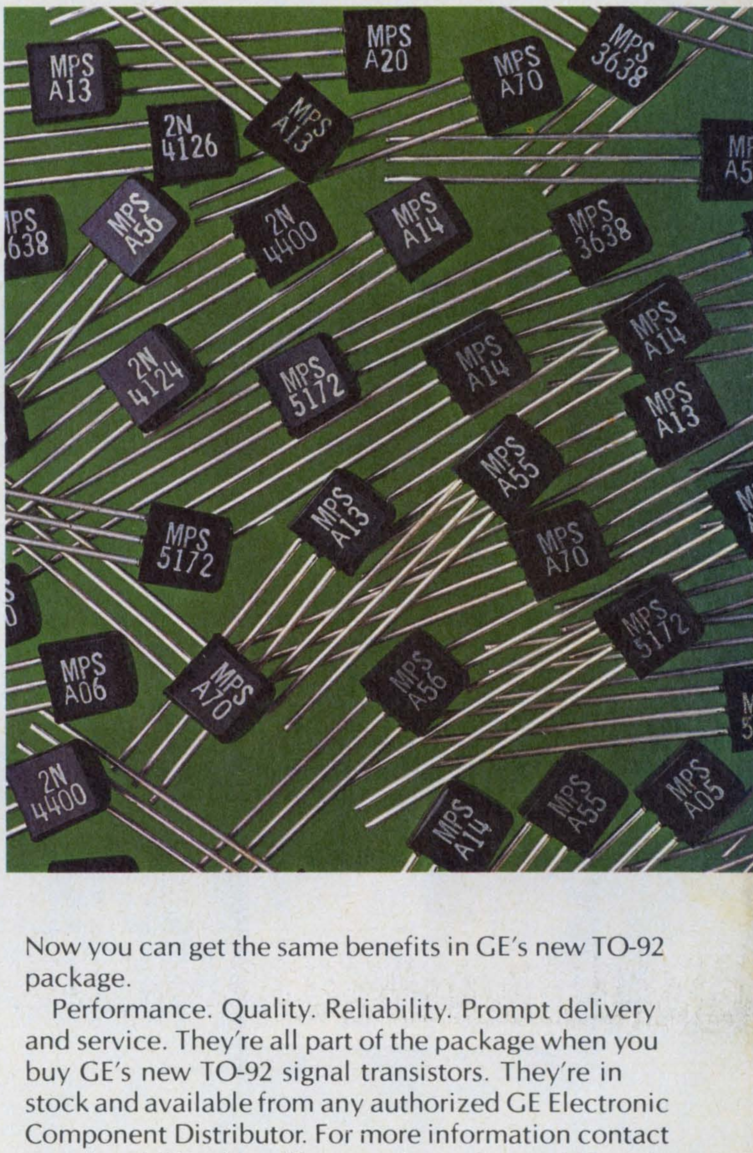
More instruments, too, will have facilities for the IEEE-488 standard interface bus. Today, the demand is for instruments that, if they do not have the interface as a standard feature, can at least be upgraded to include it. Soon, most instruments designed for systems will have the interface.

As the standard interface becomes more common, ways to test the interface in working systems must be devised. Hewlett-Packard, which developed the bus, has now developed one way to test it. With the 10050A adapter and 10051A test probe, the Model 1602A logic-state analyzer can be converted to check the bus in any instrument system to see if the timing of the data and command signals passing between instruments and the system controller are correct. ■■

How did GE match its invention of the TO-98 plastic transistor?

207 types of the TO-92.





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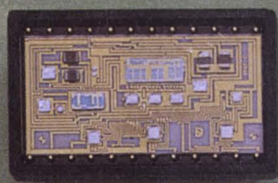

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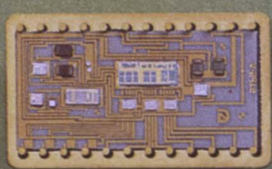

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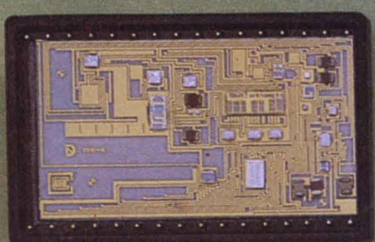

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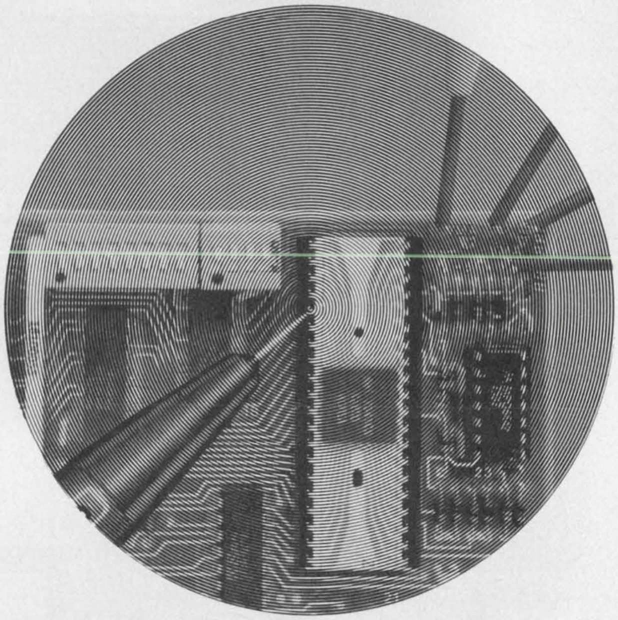
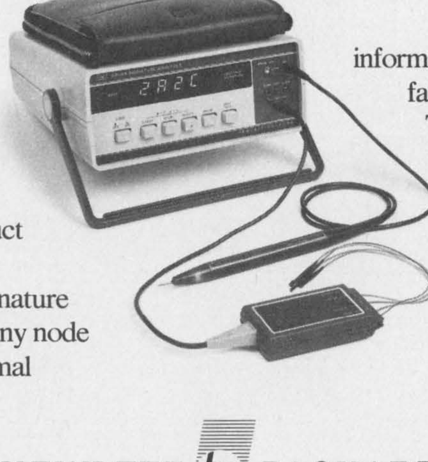


right down to the component level.

Here's HP's new Signature Analyzer. It makes it economical to find the faulty component in a microprocessor-based product both in production and in the field. No longer is it necessary to make a large investment in expensive modules or boards for service. And no longer do you have to troubleshoot by conventional and costly hit-and-miss methods. It could even eliminate the need to partition your product for modular service.



The concept is simple. The 5004A Signature Analyzer converts lengthy bit streams at any node in a circuit into short, four-digit, hexadecimal "signatures." Just activate a digital exercise routine in the circuit under test, and compare the bit stream "signature" at each data node with the known good signatures previously written into your manual. This information lets you backtrace right down to the faulty component. Quickly and confidently.

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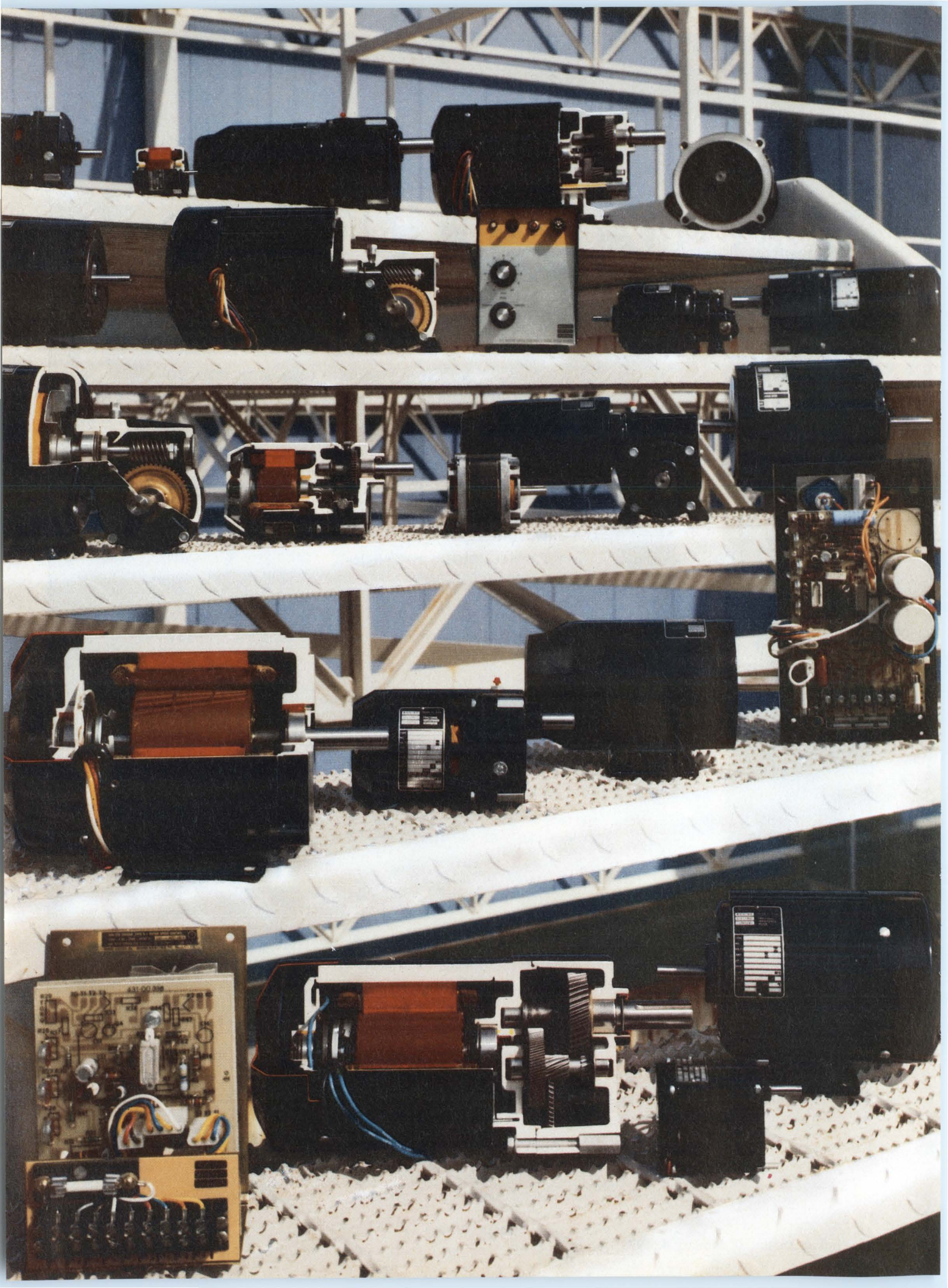

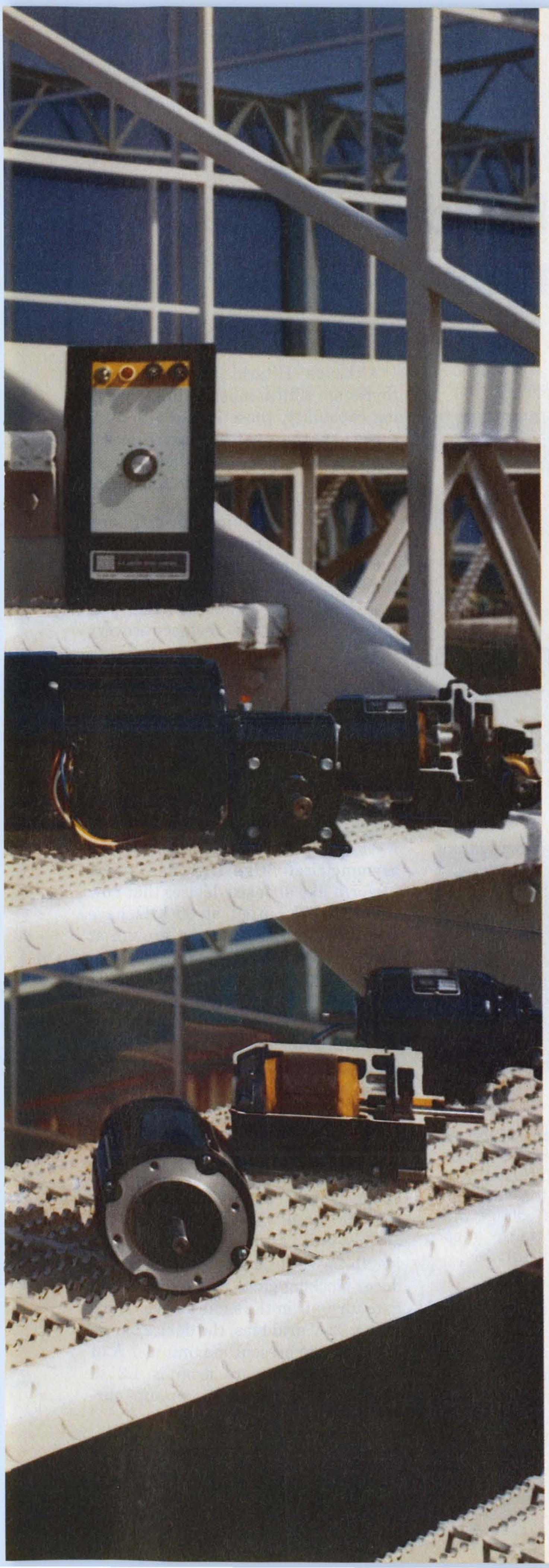

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CIRCLE NUMBER 43

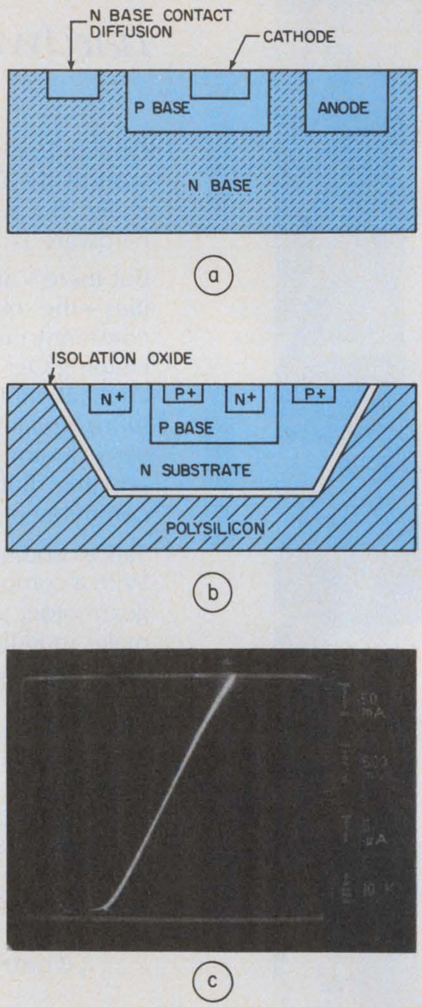
At the International Electron Devices Meeting

Power semi devices handle more power in all ranges

Power performance of solid-state devices is taking giant steps forward. At the highest power levels, both large-area and asymmetrical thyristors are switching more power, higher voltage and greater current—and faster than ever. At moderate power levels, IC SCRs promise revolutionary size reductions, speedier gate-turn-off thyristors are heading for automotive applications, and improved FETs of all kinds—CMOS, V-groove and GaAs—pass more precise linear or switched power than ever, and all over the spectrum. And even where no power is used—in an EPROM—a VMOS structure brings greater density and lower programming voltages.

ICs now can switch high voltages and handle high current densities. The reason? A process whereby islands made by dielectric isolation (DI) protect diffused SCRs from interacting with the substrate. As a result, 350-V, 1-mA per mil^2 chip-area power-output stages at last can share the same chip with low-power analog and digital circuits.

The DI technique comes from Harris Semiconductor, Melbourne, FL, which has used it so far in its Hi-Rel linear products. But now the company is ready to use this technique for custom ICs, according to the developer of the DI IC SCR, James D. Beasom, who is Harris's Section Head for Linear Device Engineering. He reports IC SCRs with 350-V breakover, 1 to 6-V drop at an anode-current density of 100 mA per mil^2, 10-Ω on resistance, and cathode-gate turn-off capability.



1. Conventional planar SCRs (a) aren't suitable for ICs. Harris' dielectric isolation prevents diffused SCRs from interacting with the substrate (b). A DI SCR's forward voltage with both gates floating is fairly linear when plotted vs current (c).

Meet the champ

Meanwhile, the power-handling crown goes to a 1.5-kA, 4-kV thyristor from Hitachi in Ibaraki, Japan. This large-area device will probably find its most immediate use as a replacement for the company's 800-A, 4-kV thyristors, around which converters for high-voltage transmission lines are now built. But, the more potent device won't be available commercially for about a year, says Hitachi's K. Morita, one of the developers of the new high-power thyristor.

Although Hitachi has even made thyristors with as much as 10-kV blocking capability, those in the 4 to 5-kV range have the greatest power-converting capability. The new device owes its improved characteristics to four principal factors:

- Improved aluminum-diffusion techniques that raise the accuracy of the diffusion and lengthen carrier lifetimes.
- Gamma-ray irradiation that precisely controls the reverse-recovery charge.
- An impurity profile (the result of computer-aided design) that improves dynamic characteristics.
- A sigma-shaped edge contour (with both forward and reverse junctions beveled positively) that raises the effective conducting area to 80% of the wafer area.

At somewhat lower power levels, asymmetrical SCRs (ASCRs), which perform like diffused devices that now deliver 4-kW output at 30 kHz have been produced by epitaxial growth at RCA, Somerville, NJ. If these epitaxial devices are ever made commercially available they promise many more watts per dollar than the company's diffused S7310s which cost more to make than epitaxials.

Epitaxial refilling has been used at GE's R&D center in Schenectady, NY, to produce a vertical-channel field-controlled thyristor with high gain. This process produces long and deep grid channels that don't impinge on the cathode area. The GE thyristor's surface-grid structure has a high length-to-width aspect ratio that produces blocking gains as high as 50 and gate turn-off in the same device. Thus, with a 32-V grid bias, the device blocks 1 kV. At the present maximum 1 A of current, the forward drop is 1.2 V. Devices with higher maximum currents are being fabricated.

Another new type of thyristor has been produced at the semiconductor lab of Mitsubishi Electric in Hyogo,

Sid Adlerstein
Andy Santoni
Associate Editors

Japan. It's a static-induction thyristor that combines an n-channel static-induction transistor and pnp transistor, and has both turn-on and turn-off capability via its gate. Not only that, but a forward blocking of 700 V and 0.1 μs current-fall time are reported.

Much of the performance stems from optimized minority-carrier life in the N^- base region achieved through heavy-metal implantation.

Meanwhile, the gate-turn-off (GTO) thyristor is alive and well at RCA. Here, an EPI-base GTO device with 4-mil-wide cathode geometry shows 400-ns rise time and 140-ns fall time for 8-A forward current and 200 V between the drain and cathode, all at a junction temperature of 125 C.

These characteristics are comparable with those for bipolar power-switching transistors. With this in mind, Dr. Hans W. Becke, Engineering Leader for Advanced Devices and Processes at RCA, sees different power devices being most economical for three frequency ranges:

- Dc to 1 kHz—ordinary thyristors.
- 10 to 50 kHz—GTO thyristors.
- Beyond 100 kHz—transistors, probably high-frequency power FETs like V-groove and GaAs devices.

Also on the way from RCA are GTO thyristors for automotive use. The first of these should perform like a solid-state relay (2 to 3-μs switching speed). Though automotive use requires these GTOs to withstand only 12 V, they will have 500-V blocking capacity. According to Dr. Becke, 500-V GTO devices that will be capable of 100-ns switching aren't very far off.

FETs get into the act

Latch devices like SCRs and thyristors aren't the only ones moving into power applications, FETs are on the way as well. The first pair of complementary matched high-power MOSFETs—from Hitachi in Tokyo—has audio engineers humming. Both MOSFETs use an offset-gate structure with an additional ion-implanted channel to get 200-V breakdowns and 10-A capabilities. With this construction, high breakdown voltages can be developed with relatively low-resistivity material. Thus the usually opposed characteristics of high breakdown voltage and low on resistance come together in this one device.

An audio amplifier described by Hitachi is made with two pairs of these complementary power MOSFETs. Working into an 8-Ω load, the amplifier delivers 100 W of continuous output with only 0.01% total harmonic distortion—up to 100 kHz. And all this is done without the thermal runaway that plagues many bipolar amplifiers at high frequencies.

For that matter, power bipolars are also starting to get serious competition at video frequencies—and perhaps even below—from V-groove power FETs. These devices are intrinsically fast because they conduct via majority carriers, which shortens transit time. And switching speed increases further because there is no minority-carrier storage. Another advantage of V-groove power FETs is negative tempco, which makes thermal runaway impossible. Several new V-groove structures described by C. A. T. Salama, Professor of Electrical Engineering at the University of Toronto (Ontario) produce enhanced frequency response, power handling and voltage-standoff capability.

At the semimagical microwave frequencies, GaAs power FETs are popping out of the hat in every frequency band and at increasingly high power levels. According to William R. Wisseman of Texas Instruments in Dallas, a single device has produced over 5 W cw output at 9 GHz, and 1 W at 16 GHz. Fujitsu of Japan and Bell Laboratories, NJ, have obtained 10 W at 4 GHz, Wisseman adds.

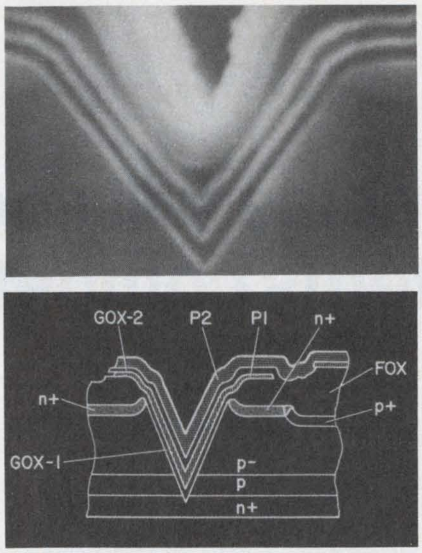
Fully ion-implanted GaAs FETs developed by Hewlett-Packard. Santa Rosa, CA, deliver 1 W with 5-dB gain at 6 GHz. The planar processing used will probably lower the cost of these FETs, previously made by more expensive mesa etching.

Semis are hot for no power too

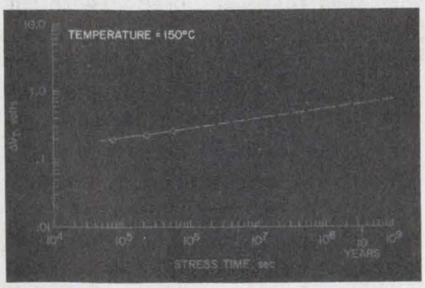
At the lowest level of power consumption—none at all—American Microsystems, Santa Clara, CA has developed a VMOS EPROM device. Using the buried-gate structure, similar to that of its VMOS dynamic RAM, the EPROM boasts a packing density twice that of the densest similar device—the dual-polysilicon NMOS. The VMOS basic cell occupies even less surface area than its intersecting address lines.

Moreover, programming the VMOS EPROM requires lower voltages than other EPROMs—even if the device is to be read out with a common 5-V drive. The VMOS EPROM programs to better than 6 V in 50 ms with 15 V on the gate and 8.5 V on the drain. The charge loss, which, of course, determines the data-retention time, is less than 1 V in 40 years.

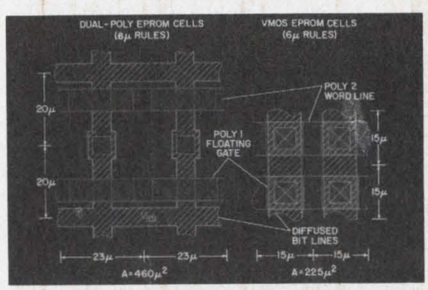
According to Don Trotter, AMI Vice President of R&D, the VMOS EPROM should be commercially available by the end of 1978. The delay is due primarily to the extensive qualification testing the company plans for this special device.■■



2. The EPROM cell (photomicrograph at top, schematic at bottom) is a short-channel VMOS device crossed by the word line, P2, and the n+bit line.



3. The stress-vs-time curve shows that American Micro Systems' VMOS EPROM will lose less than 1 V after 40 years at 150 C.



4. A VMOS EPROM cell (right) takes less than half the area needed by a conventional NMOS dual-polysilicon EPROM cell (left).

Higher efficiencies will soon make solar-cell systems competitive

A concentrator solar cell has efficiencies high enough to make photovoltaic power generation economically acceptable within the next three years. Meanwhile, work continues on more efficient metal-insulator-silicon solar cells for large-area power panels.

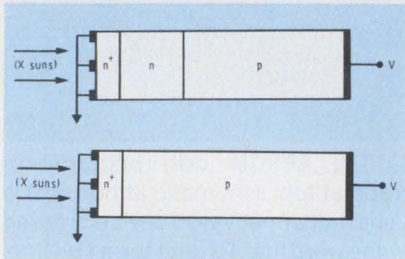
Concentrator solar cells are small units that sit under parabolic, fresnel, or optical lenses that gather and focus the sun's energy. They are most valuable where sunlight is direct and commonly available, as in the southern United States, says Jerry Fossum of Sandia's semiconductor device design and processing group (Albuquerque, NM), which developed the new concentrator solar cell.

The potential conversion efficiency of the Sandia concentrator cell is better than 20%, says Fossum. This efficiency is achieved when the concentrator provides an illumination at the cell's surface that is 50 times as powerful as the sun's normal illumination through the atmosphere at sea level.

The Sandia cell's efficiency is greater than the threshold efficiency at which power generation by concentrator photovoltaic systems becomes cost effective—18%, according to James Hutchby, chairman of the subcommittee on quantum electronics and energy conversion devices of the IEEE's Electron Devices Society. At 18% efficiency, the projected cost for power in 1985 is 5 to 7 ¢/kWh, he says.

Solar cells near competition

The Sandia cell increases its efficiency by adding an n-type region between the n^+ and p-type layers found in conventional cells. One problem with a conventional cell is that the resistance of the layer cuts the efficiency of the cell. The resistance can be reduced, but only at the expense of other parameters. In the n^+-n-p structure of the Sandia cell, the added n layer acts as a shunt resistance, and increases the current flow out of the wafer.



A high-efficiency solar cell (top) has an additional layer of n-type material between the n^+ and p-type layers of the normal solar cell. The extra layer acts as a shunt for electrons flowing toward the left-hand electrodes.

The increase in efficiency is about 40% at 50-suns illumination and about 15% at 1-sun illumination.

The Sandia solar cell will be economically competitive in the early 1980s, projects Fredrik Lindholm, Fossum's coauthor and professor of electrical engineering at the University of Florida in Gainesville. If everything were to go smoothly—as it almost never does in research and development—the Sandia cell would be ready for production within a year, says Lindholm. Two or three years is a more realistic estimate, he says. Even then, the cost of the concentrator would have to drop by a factor of three from the present $150 per square meter—a possibility, but not a certainty.

In the diffuse illumination common to most parts of the country, concentrators have little value since there is little direct sunlight. Advances are being made, however, in solar cells to be used in large arrays and are inexpensive to make.

Insulation improves conversion

One solar cell structure that is being developed for large-area arrays is the metal-insulator-semiconductor (MIS) structure. Says D. L. Pulfrey of the University of British Columbia (Vancouver, Canada): "Both theoretical and practical investigations indicate that this structure offers a means of overcoming the principal deficiency of Schottky-barrier solar cells, namely low open-circuit photovoltage, while maintaining the attractive features that have led the metal-semiconductor junction to be considered as a possible alternative to the p-n junction for large-area, terrestrial solar cell applications."

Explaining the operation of an MIS cell, Pulfrey goes on, "The thin insulating layer allows control over not only the magnitude of the dark current flowing through the diode, but also the dominant type (majority or minority carrier) of this current." Unfortunately, while Hutchby agrees that "MIS cell technology offers a potentially low-cost process," MIS cells are far from competitive with other power-generation techniques. Work does continue, though, on improving MIS devices.

For example, at the Jet Propulsion Laboratory, California Institute of Technology (Pasadena), an MIS solar cell using gallium arsenide and an oxide insulation has shown an efficiency up to 17%. The AMOS (antireflecting metal oxide semiconductor) cell has been fabricated using an improved process that includes a new chemical surface preparation, a new form of oxide layer and an improved antireflecting coating.

AMOS cells treated with two chemicals—NHH and SHH—prior to oxidation achieve much better performance than cells treated with the standard bromine-methanol solution, according to JPL's R. J. Stirn. The performance of AMOS cells made by physically depositing oxide layers is comparable to, if not better than, that of water-vapor grown oxide cells, he says. And the application of antireflection coatings has been improved by laser flash evaporation.

In all, cell efficiency has been improved from 13.4 to 15.7% in the older cells to between 15.5 and 17% using the new techniques. ■■

Now electrophoretic displays have a fighting chance against CRTs

By cutting drastically the number of wires needed to interface with an electrophoretic display, Philips has brought closer to commercial reality a possible alternative to the CRT for such applications as computer terminals and, eventually, television sets.

Electrophoretic display technology promises to eliminate the CRT's fragile and space-consuming neck. In addition, contrast is excellent and the viewing angle is virtually that of the printed page, according to Alan Sobel, a researcher at Zenith Radio Corp., Glenview, Il, speaking at IEDM.

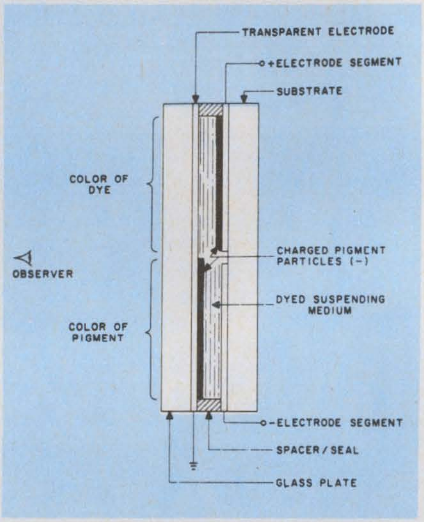
But the electrophoretic display has had two major difficulties, says Barry Singer, senior member of the technical staff at Philips Laboratories division of North American Philips Corp., Briarcliff Manor, NY. "One is that there is no readily accessible threshold for x-y addressing, and the other is that the applied voltages for the present displays require 40 V or more in order to get acceptable speeds."

Without matrix operation, a standard panel of 24 lines, 80 characters per line, would require some 147,000 separate leads—"totally impractical," notes Singer.

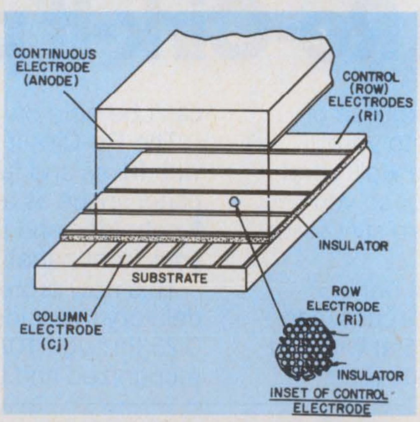
Normal matrix addressing techniques won't do for electrophoretics: When one array element—pigment-carrying particles suspended between electrodes—is chosen by applying voltages to a row and a column electrode, the other elements in the same row or in the same column see only half the select voltage. In an electrophoretic display, this would cause the half-selected elements to move to half-brightness, which would reduce the total contrast.

Philips has cut the leads to about 750 by designing an electrophoretic image display (EPID) panel so that the elements seem to have a threshold level, a voltage at which they switch from one state to another.

"A threshold may be designed into the EPID cell by introducing a third electrode," says Singer. One side of the cell is a continuous transparent electrode. The other side of the cell has another transparent electrode that is patterned into a set of isolated electrode strips that serve as column electrodes. An insulator covers these column electrodes, and an electrode layer on top of the insulator is divided into a set of isolated electrode strips called the row electrodes. The row electrodes are formed into a dense array of holes. Underneath, the exposed insulation is removed, and wells are formed.



A small voltage change on electrode segments changes the colors observed in an electrophoretic display by moving charged pigment particles forward and backward in the display.



A switching point from one color to another is established by adding a control electrode so that each element is either on or off, not in between.

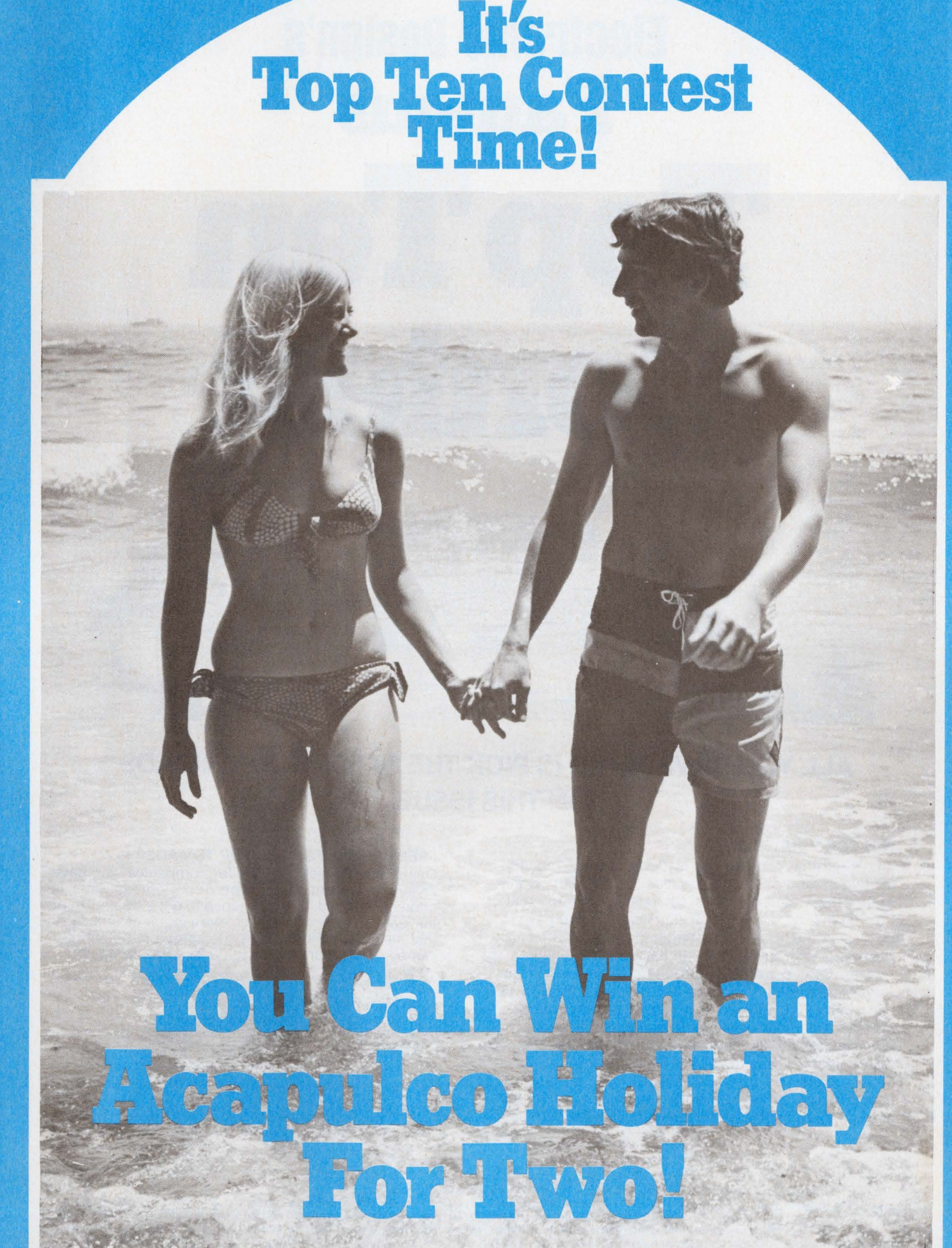
If the pigment is negatively charged and the column electrodes are set at 30 V, the row electrodes at 0 V and the continuous electrode is set at about 50 V, the pigment will remain in the potential wells because of the 30-V difference in the potential wells. This constitutes a Hold condition.

To address an element, the potential on its column electrode is cut in half and the potential on its row electrode is brought higher than that on its column electrode. The pigment in this element will be transported by the electric field due to the positive charge on the continuous anode electrode.

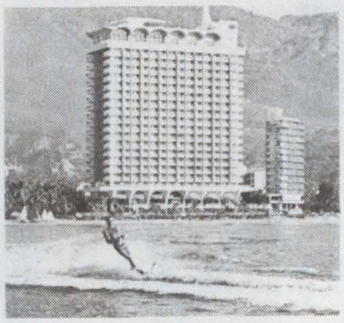
When one element is addressed, the potential difference between row and column electrodes for the other display elements in the same row or column is less than half that in the Hold condition. But the geometry of the potential wells and the voltage levels have been chosen to maintain the Hold condition.

An additional benefit of Philips' EPID is memory. Once an element is selected, it remains in the new state until a new set of voltage levels moves it back to Hold. In fact, the addressing-voltage levels on the rows and columns during a write operation need only be applied for as long as it takes the pigment to leave the potential wells and not for the entire transition time. So display response quickens to about 5 ms per line, which can be improved to about 10 μs per line—fast enough for typewritten-page displays like those used in text-editing applications.

When fully developed, electrophoretic displays will be produced for less than $50 per panel, Singer projects, with another $30 or so for drive electronics. Then such displays will be competitive with CRTs, which consume tens of watts to the EPID's 2 or 3 mW. ■■


It's
Top Ten Contest
Time!
You Can Win an
Acapulco Holiday
For Two!

Electronic Design's Famous Top Ten Contest



ALL YOU HAVE TO DO IS PICK THE 10 TOP SCORING ADS IN THIS ISSUE

WIN FOR YOURSELF

That's right ... you can win a 10-day prepaid vacation for two in fabulous Acapulco *plus* $1,000 cash or one of 99 other valuable prizes. There's nothing to write; no slogans; no drawings or gimmicks. All you have to do is pick the 10 advertisements that our readers will best remember having seen in this issue.

Acapulco is paradise. You'll stay at the exotic Paraiso Marriott — an "island" 22 stories high. You can sun, swim, sail, skin dive, take a parachute ride over Acapulco bay or browse through quaint shops. In the evening you can choose from sizzling night life or take a relaxed moonlight stroll on the beach. It's a perfect blend of casual sophistication, carefree excitement and spirited adventure. *And* you get $1,000 cash to cover air transportation, bar bill or incidentals!

FREE RERUNS FOR THE TOP TEN ADS

One of the biggest bonuses for companies who have an advertisement in the Top Ten Contest issue is often overlooked. It's the chance to get a free rerun of that ad with the extra impact, extra inquiries and sales that can result. (For a two-page spread in full color it can be worth more than $5,000 for your company.)

HERE'S HOW TO ENTER:

(1) Read the rules contained in this issue.

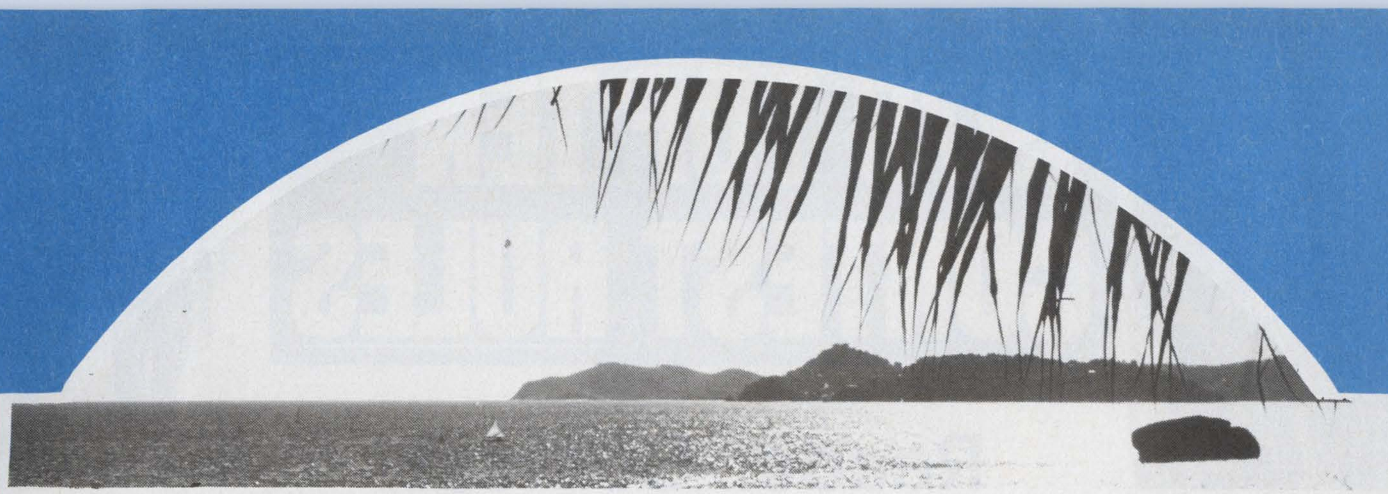
(2) Pick the 10 ads that you think *Electronic Design's* readers will best remember having seen.

(3) List these ads by company name and Reader Service Number on the entry card. Mail before February 28, 1978.

Your selections will be checked against Reader Recall, *Electronic Design's* method of measuring readership.

NOTE: SEPARATE CONTEST FOR ADVERTISERS AND THEIR AGENCIES

If you are an advertiser or an advertising agency, there's a separate "advertiser" contest for you with separate prizes for the top three winners. First and second prizes are the same in both the advertiser and reader contests. That means you can win an Acapulco holiday for two plus $1,000 cash or a $600 personal computer. Third prize is a digital wristwatch, $100 value. The free reruns for the winning ads and extra readership for *all* advertisements in the issue make the Top Ten Contest issue one of the year's outstanding advertising opportunities.



First Prize! 10-Day Vacation for Two at the Exotic Paraíso/Marriott in Acapulco Plus $1,000 Cash!

Includes first class air conditioned accommodations for two, plus modified American plan meals (breakfast and dinner) for 10 days, 9 nights. Subject to space availability May through Dec. 1978. The $1,000 cash award may be used for incidental expenses, luncheons, local transportation, air transportation etc.

2nd PRIZE

PET PERSONAL COMPUTER

The Personal Electronic Transactor computer by Commodore Business Machines is a complete home data processing system that features BASIC language, a CRT display and cassette-tape mass storage. You can do your taxes, balance your checkbook, plus much, much more.

$600 VALUE

3rd PRIZE

WIDE FIELD TELESCOPE

There's no other telescope like it! Edmund's Astroscan® 2001 4¼″ F/4.4 Newtonian wide field reflector gives clear, bright, spectacular wide-angle views of stars, moon, comets. It's portable, easy to use. No complicated set up. Just insert the eye piece and focus. Top quality optical system.

$150 VALUE.

4th & 5th PRIZES

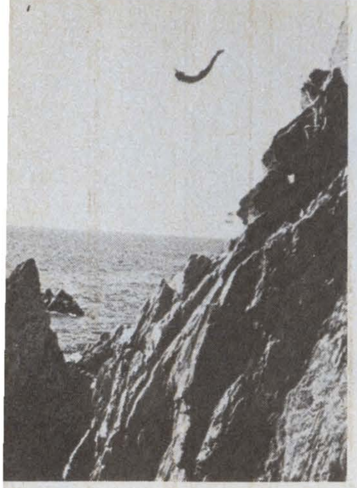
DIGITAL WRISTWATCH

$100 VALUE

6th through 100th PRIZES

Hayden Technical Books

SEE NEXT PAGE FOR RULES
(Entry blanks bound in front & back of this issue.)



1978 TOP TEN CONTEST RULES

Reader Contest

PICK THE TOP TEN ADVERTISEMENTS IN THIS ISSUE... WIN A 10-DAY ACAPULCO HOLIDAY FOR TWO ...$1,000 CASH...$600 PET PERSONAL COMPUTER...$100 DIGITAL WRISTWATCH...100 PRIZES IN ALL.

Examine this issue of *Electronic Design* with extra care. Pick the ten advertisements that you think your fellow engineer-subscribers will best remember having seen. List these ten advertisements on the special entry form bound in this issue. *(Be sure to check the box marked "Reader Contest.")*

This year your selections will be measured against the ten ads ranking highest in the "Recall Seen" category of Reader Recall, *Electronic Design's* method of measuring readership — see item 6.

In making your choices do not include "house" advertisements placed by *Electronic Design* or Hayden Publishing Company, Inc. (such as this ad describing the contest). Don't miss your chance to be a Top Ten Winner! *All entries must be postmarked no later than midnight, February 28, 1978. Winners will be notified in March, 1978.*

READER CONTEST RULES

1. Enter your *Top Ten* selections on the entry blank bound in this issue or on any reasonable facsimile. Be sure to indicate the name of the advertiser and *Information Retrieval Number* for each of your choices. Do *not* use page number. (House ads placed by Hayden Publishing Company in Electronic Design *should not* be considered in this contest.)

2. No more than one entry may be submitted by any one individual. Entry blank must be filled in completely, or it will not be considered. The box on the entry blank marked "Reader Contest" must be checked. *Electronic Design* will pay postage for official entry blanks only.

3. To enter, readers must be engaged in electronic design engineering work, either by carrying-out or supervising design engineering or by setting standards for design components and materials.

4. No cash payments, or other substitutes, will be made in lieu of any prize, (except the $1,000 prize).

5. Contest void where prohibited or taxed by law. Liability for any taxes on prizes is the sole responsibility of the winners.

6. Entries will be compared with the "Recall Seen" category of Reader Recall (*Electronic Design's* method of measuring readership). That entry which in the opinion of the judges most closely matches the "Recall Seen" rank will be declared the winner.

7. In case of a tie, the earliest postmark will determine the winner. Decisions of *Top Ten* contest judges will be final.

8. First prize includes first class air conditioned accommodations for two, double occupancy, plus modified American plan meals (breakfast and dinner) for 10 days, 9 nights at the Paraiso Marriott in Acapulco. Subject to availability May through December 1978. Void after December 1978. The $1,000 cash award may be used toward all other incidental hotel expenses, luncheons, bar, baggage, tips, etc. or for local or air transportation.

USE SPECIAL ENTRY BLANK BOUND IN THIS ISSUE
(Blanks are bound both in front and back of this issue)

Advertiser Contest

PICK THE TOP TEN ADVERTISEMENTS IN THIS ISSUE ... WIN A 10-DAY ACAPULCO HOLIDAY FOR TWO ...$1,000 CASH...$600 PET PERSONAL COMPUTER...$100 DIGITAL WRISTWATCH.

There's a separate contest open to all marketing and advertising personnel in companies, and to advertising agencies.

Examine this issue of *Electronic Design* with extra care. Pick the ten advertisements that you think will be best SEEN by *Electronic Design's* readers. List these ten advertisements on the special entry blank bound in this issue. (Be sure to check the box marked "Advertiser Contest".)

FREE RERUNS FOR THE TOP TEN ADS

In addition to valuable contest prizes, all ads that place in the Top Ten will be given free reruns. These free reruns will be made only from existing plates or negatives. If the advertisement qualifying for a free rerun is an insert, the winner may run up to a two-page spread from existing plates or negatives in up to 4-colors. Hayden Publishing Company, Inc. reserves the right to schedule reruns at its discretion.

ADVERTISER CONTEST RULES

1. All rules for the Reader Contest will similarly apply for this contest, with two exceptions: readers engaged in electronic design engineering work, as defined in the reader contest rules, are *not* eligible to participate in this special contest. The box on the entry blank marked "Advertiser Contest" must be checked.

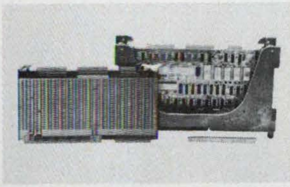
2. Entrants in this contest may use the official reader contest entry blanks or any reasonable facsimile.

3. This special contest is open to marketing and advertising personnel only at all manufacturing companies and advertising agencies whether or not their companies or agencies have an advertisement in the contest issue.

FOR A COMPLETE DESCRIPTION OF PRIZES FOR BOTH READER AND ADVERTISER CONTESTS SEE PAGES 78 AND 79

USE SPECIAL ENTRY BLANK BOUND IN THIS ISSUE
(Blanks are bound both in front and back of this issue)

NEW GARRY SBC 80/10 UNIVERSAL MICRO-PROCESSOR WIRE-WRAP INTERFACE BOARD



Garry Manufacturing Company now has available their new SBC 80/10 Universal Microprocessor Interface Board designed to plug directly into the Intel SBC 604 Modular Cardcage/Backplane bus system with power interface connections for ±5 and ±12 volts dc.

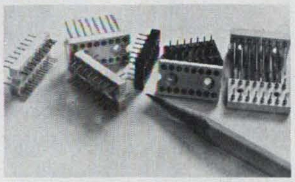
The Garry SBC 80/10 Universal Wire-Wrap board provides 38 columns of 44 low-profile socket terminals per column, with alternate rows of committed ground and voltage wire-wrap terminations. The P/N EP 272-38-15 interface board will accommodate up to 95 16-position I.C. chips or an equivalent mix of 14, 16, 18, 22, 24, 28 or 40-position I.C. chips.

For complete information concerning the SBC 80/10 and other Universal Microprocessor/Minicomputer Wire-Wrap Interface boards, please contact Garry Manufacturing Company, 1010 Jersey Avenue, New Brunswick, NJ 08902, 201-545-2424.

CIRCLE NUMBER 151

NEW SERIES OF SOCKETS FOR PACKAGING 8, 14, 16, AND 18 CONTACT DIPs

Has approved MIL-Spec 5-83734



A new series of packaging sockets that accommodate 8, 14, 16, and 18 contact DIPs, as well as round-lead ICs with 0.016 to 0.020 inch diameter wires is now available from Garry Manufacturing Company of New Brunswick, NJ. The new sockets have an ultra-low profile, for the most compact packaging of components.

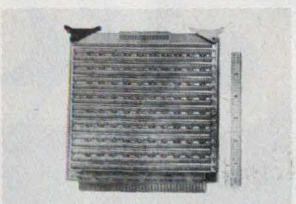
The insulating bodies of these parts are of SE-O Grade Valox: the individual socket terminals are in two precision-machined pieces. The inner contact is gold-plated beryllium copper. The outer contact is brass, available in a variety of platings, including gold and tin. Both printed-circuit bifurcated and wire-wrappable terminations (pins) are offered; the ends are closed to eliminate danger of solder or flux wicking.

The new DIP sockets are available off-the-shelf.

For complete information contact Garry Manufacturing Company, 1010 Jersey Avenue, New Brunswick, NJ 08902. 201-545-2424.

CIRCLE NUMBER 152

MULTI-UNIVERSAL HIGH-DENSITY WIRE-WRAPPABLE PACKAGING PANELS



A new line of Multi-Universal High-Density wire-wrappable packaging panels, particularly suitable for use in microprocessor and digital-circuit applications, is now available from the maker, Garry Manufacturing Co., of New Brunswick, NJ.

These universal panels will accommodate:

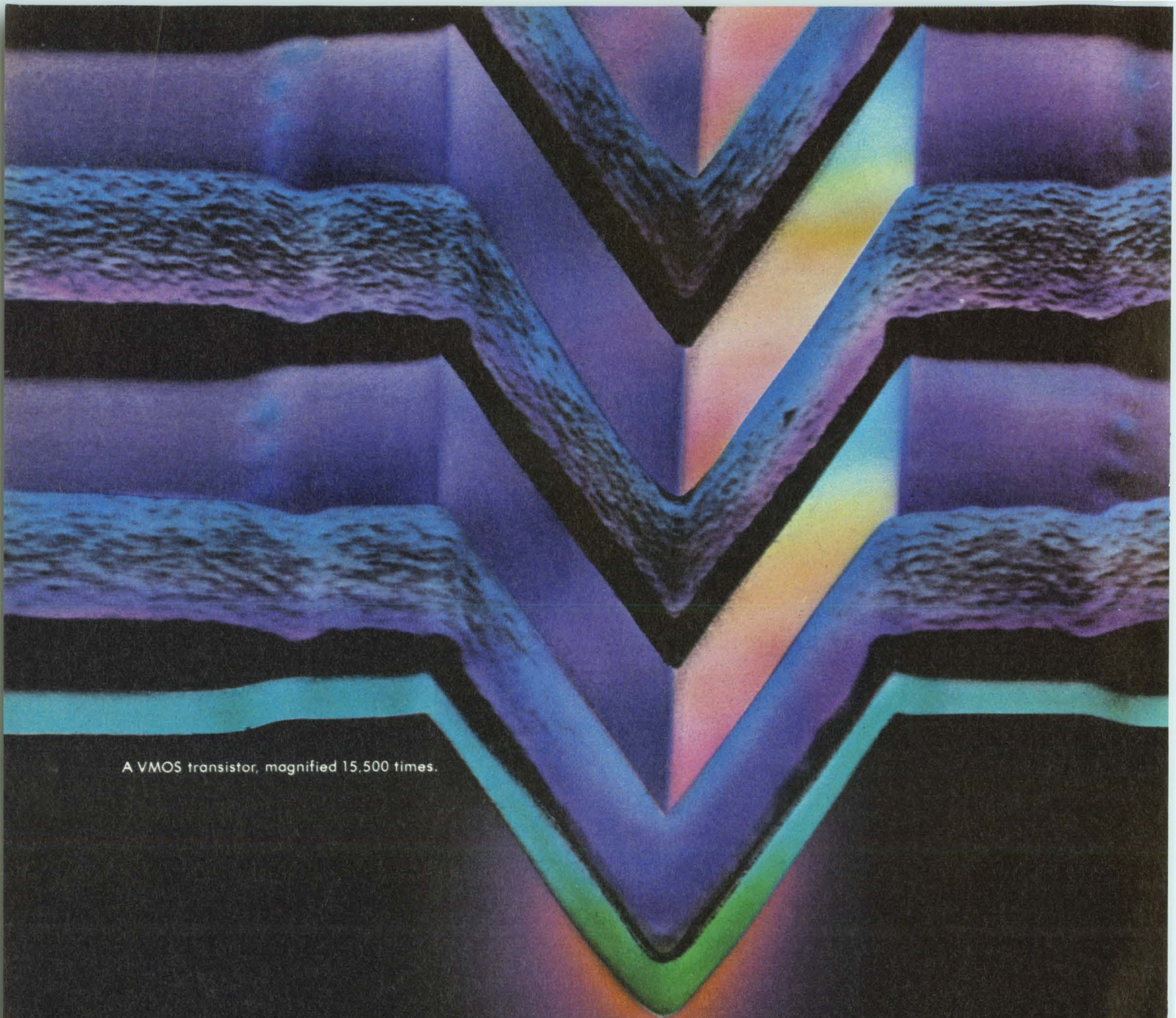
.100-inch spacing (SIP) Single-in-line packages
.300-inch spacing (DIP) Dual-in-line packages
.400-inch spacing (4K Ram) Memory packages
.500-inch spacing (UART)
.600-inch spacing (LSI) Large Scale Integrated Circuits

Designated the MU Series, the new packaging panels are available with 18 columns of 55 terminals per column, as plug-in modules P/N EP/80-18/55-15 or they can be manufactured to a customer's individual "slot" requirements. These panels are available in two to four weeks.

For complete information contact Garry Manufacturing Company, 1010 Jersey Avenue, New Brunswick, NJ 08902. 201-545-2424.

CIRCLE NUMBER 153

CIRCLE NUMBER 154



A VMOS transistor, magnified 15,500 times.

VMOS packs

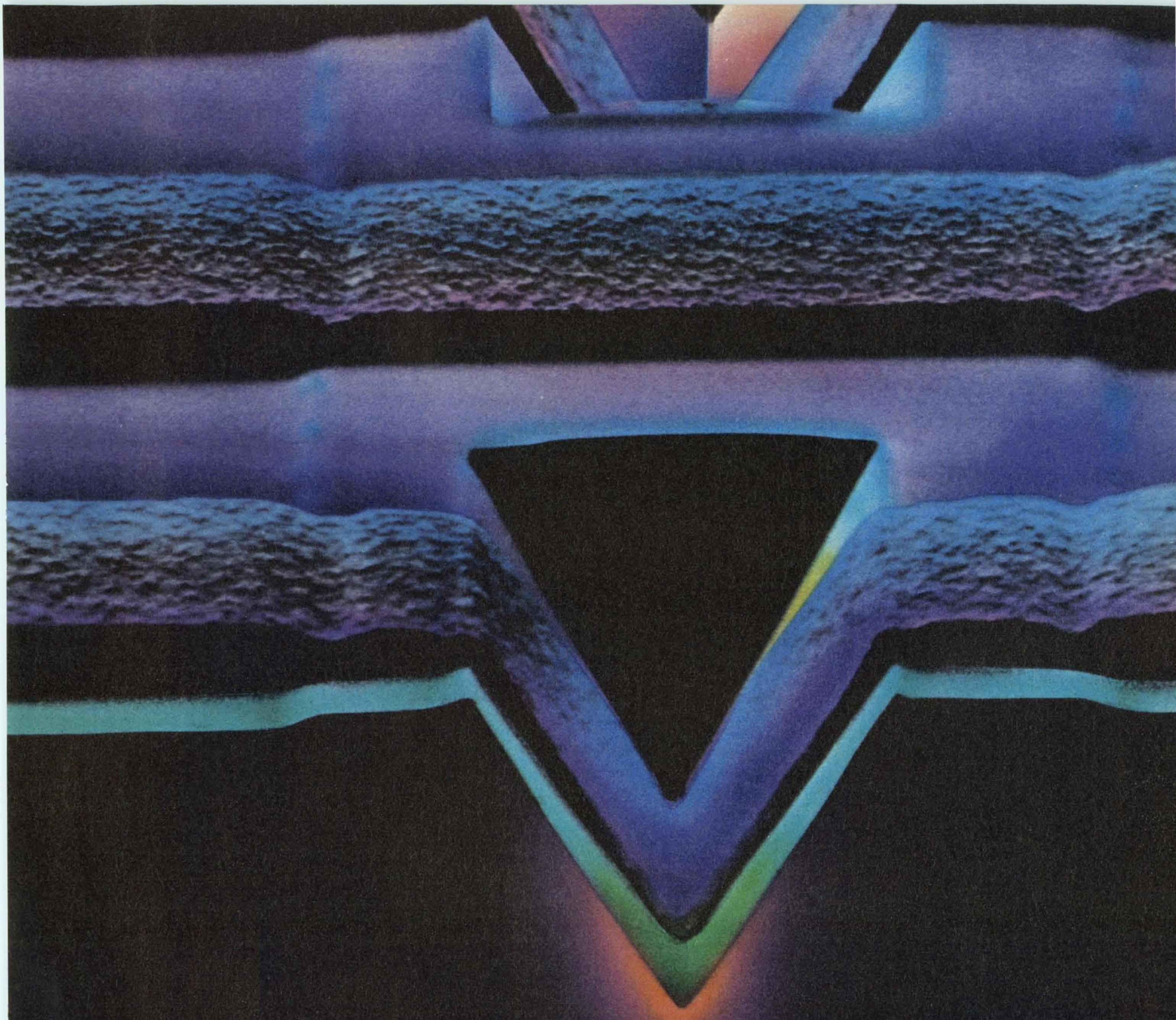
64K ROM in the smallest chip yet.

Nobody has ever made a semiconductor memory this dense before. By using high-density VMOS technology, we've packed 65,536 bits of fully-static ROM into a chip less than 175 mils square.

We call it the S4264. And for a ROM this big, it's no slowpoke. With a maximum cycle and access time of 400 ns, this new ROM delivers the best speed/density combination you can buy.

It could only happen with VMOS, AMI's patented three-dimensional transistor etched into the silicon. This process yields circuits which are as fast as other technologies and about half the size. And smaller chips are more cost-effective.

Our S4264's 3 MHz data rate makes it an ideal companion for your fast microprocessors. And by replacing four conventional 16K ROMs with one 5 volt S4264, you can cut your system's power consumption by at least fifty percent.



them in.

If you need even more speed, take a look at our 16K VMOS ROM. Our low-cost S4216B checks in at 250 ns. And for medium-speed applications, we offer our S6831 16K NMOS ROM at 450 ns.

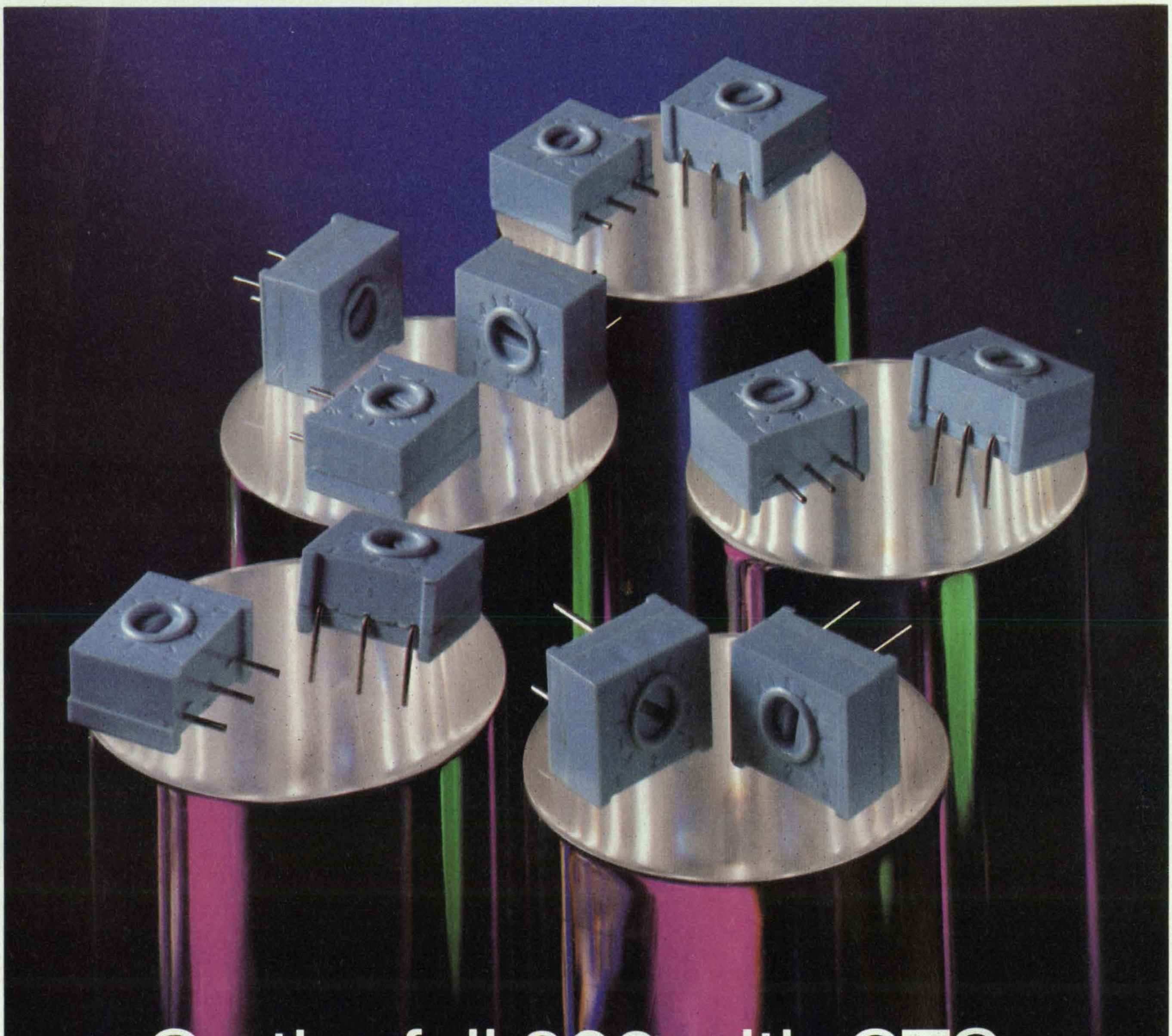
All our ROMs come in 24-pin packages that plug right into your 16K sockets, conforming to the JEDEC semiconductor pinout spec. They are compatible with the 2708 and 2716 EPROMs you're using for development.

Our VMOS ROMs give your systems the punch they need. So join us on this new frontier of semiconductor technology. For evaluation units, contact your nearest AMI sales office, or write to AMI Marketing, 3800 Homestead Road, Santa Clara CA 95051. Phone (408) 246-0330. You'll be getting smarter by getting denser.

V|MOS: the high performance technology from AMI

AMERICAN MICROSYSTEMS, INC.

CIRCLE NUMBER 241



Go the full 360 with CTS...

Series 360 single turn cermet trimmers. You couldn't travel in better trimmer circles than CTS. With the CTS Series 360 family, 1 of the 11 pin styles is sure to satisfy your trimmer needs. And that's especially true if you're designing for digital voltmeter-ammeter-ohmmeter applications, TWX equipment, sweep generators, oscilloscopes, aircraft radio and navigation equipment, computer peripheral equipment, automotive braking equipment, calculators, engine and emission control analyzers or fire detection equipment. Plus our latest application, the speaker phone.

How's that for a full circle of satisfied needs!

You get all-around performance from the CTS 360 cermet trimmers. Eleven popular grid spacings including top and side adjust on .100", .125", .150" and T0-5 centers. Power rating 1 watt @ 25°C, ½ watt @ 85°C. Standard TC ±150 ppm/°C throughout the resistance range. Settability .03%. New gold plated multicontact wiper for lowest possible noise level. Mini dimensions: .360" x .434" x .298".

The price of each 360 style is low; your CTS distributor's inventory is high—call him today; get it promptly.

For nonstandards—and for complete information—write directly to the company that has put millions into electronics for industry. **CTS of West Liberty, Inc., 6800 County Road 189, P.O. Box 266, West Liberty, Ohio 43357. Phone (513) 465-3030.**

CTS CORPORATION
ELKHART, INDIANA

A world leader in cermet and variable resistor technology.

CIRCLE NUMBER 242


VACTEC Couplers
For putting it together, VACTEC is second only to RODIN*.
Vactec Optical Couplers (T.M. Vactrols) put together incandescent lamps, neon lamps or LEDs with photoconductors in a wide variety of packages and capabilities.
Couplers using photoconductive cells are useful for isolation where speed requirements are in the order of milliseconds. Applications include noiseless switching, noiseless potentiometers, signal modulators for audio.
For hospital beds, an LED Vactrol gates a triac for forward and reverse motor operation. A neon Vactrol is used to sense telephone ringing for automatic answering or computer interface — offers light line loading ($< 300\ \mu A$, $> 200\ K\Omega$ input). A very low cost *true* RMS sensor using an incandescent Vactrol as a sense and feedback element — to control constant wattage for heater or *true* RMS voltage regulator.
VACTEC really does put them together — we make our own photoconductive cells, phototransistors, photodiodes, silicon solar cells, CMOS and bipolar camera controls, selenium cells, and couplers at our only factory near St. Louis. Write for bulletins of interest.
*Reproduction of The Kiss by Rodin.
VACTEC, INC.
2423 Northline Industrial Blvd.
Maryland Heights, Mo. 63043 U.S.A.
(314) 872-8300 TWX 910-764-0811
CIRCLE NUMBER 243

Put up any resistance...

ESI's new digital ohmmeter nails it to the wall.

Model 1700 with the 1705B plug-in is a versatile, easy-to-operate unit for automatically measuring resistance accurately over a wide range. Its capabilities cover an exceptional number of applications, both on the production line and the design bench.

Three measurement techniques are offered: Switched dc, continuous dc and single pulse measurement. Continuous dc allows measurement of inductive components such as transformers and motors. Single pulse is useful for measuring thermistors or when prolonged application of current will cause temperature drifting. Switched dc offers error cancelling circuitry for low ohm measurements.

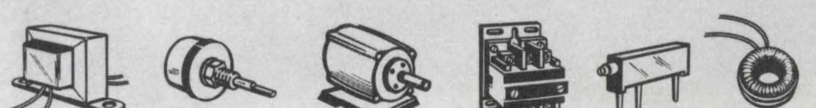
Model 1700/1705B Digital Ohmmeter
$2235 U.S.A. only

esi ELECTRO SCIENTIFIC
13900 N.W. Science Park Dr.
Portland, OR 97229
Tel. 503/641-4141

ESI's Model 1700 series Digital Ohmmeter is available both with other lower range plug-ins (down to 0.1 microhm resolution) and with a companion Digital Comparator for fast sorting. A 4-terminal parts handler is also available.

- **switched dc mode**
- **continuous dc**
- **single pulse**
- **10 $\mu\Omega$ resolution**
- **autoranging up to 20 MΩ**
- **0.02% basic accuracy**
- **remote operation and BCD output**
- **4-terminal connection**

CHECK OUT A MULTITUDE OF PARTS!



CIRCLE NUMBER 244

Available Now!

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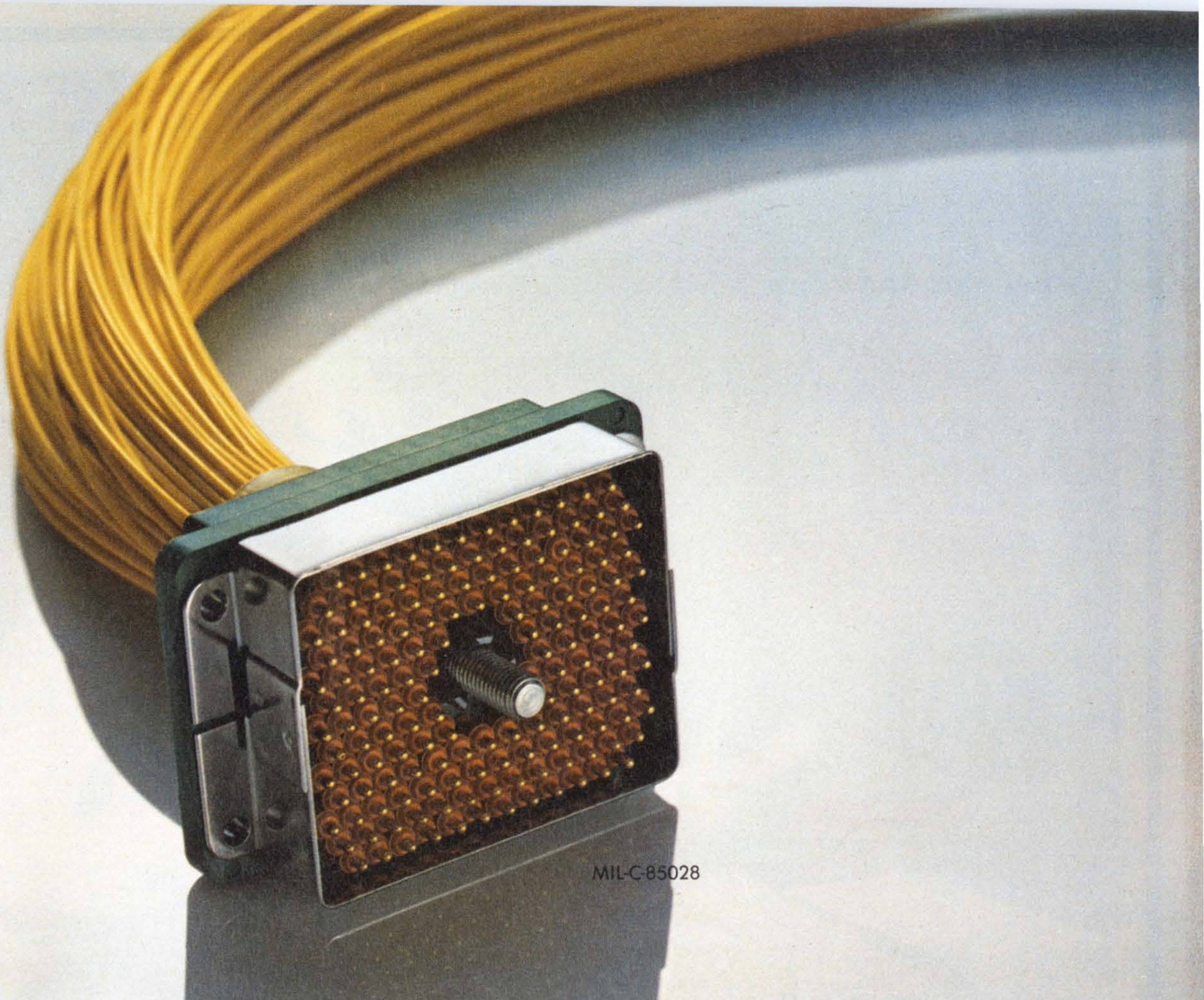

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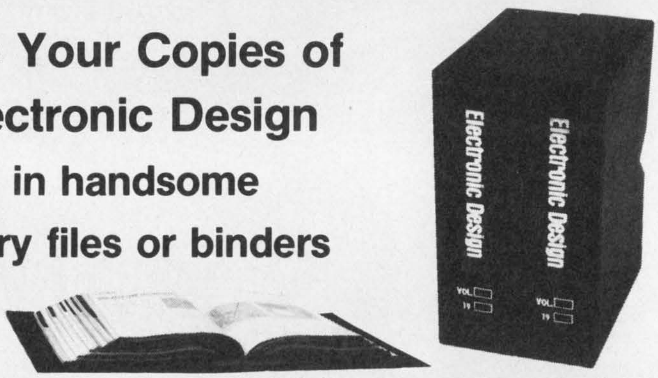

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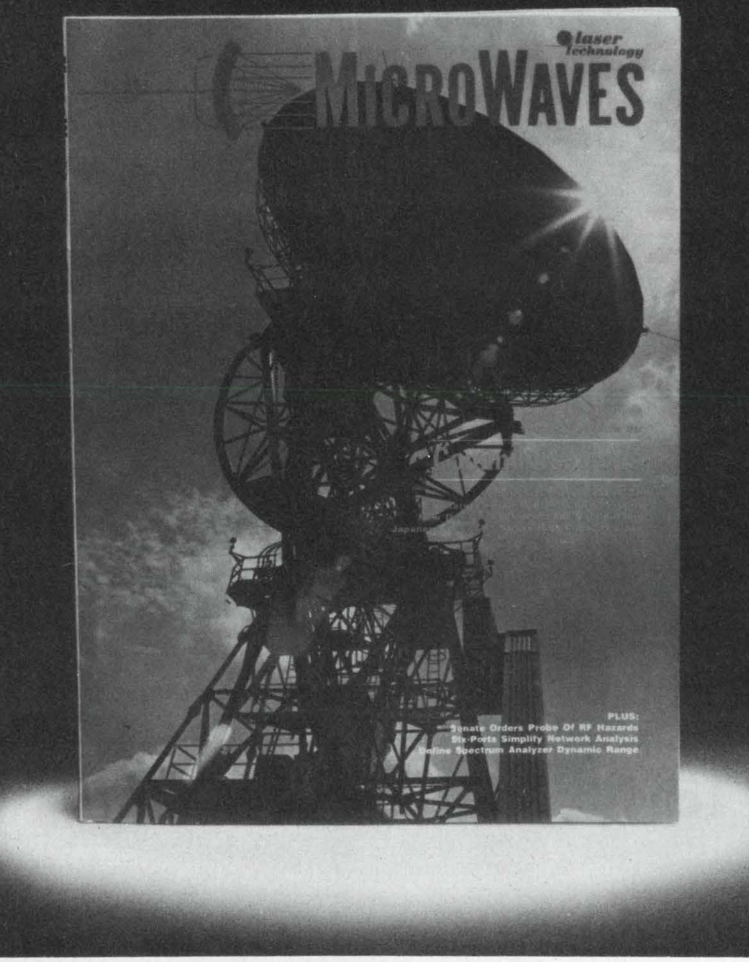

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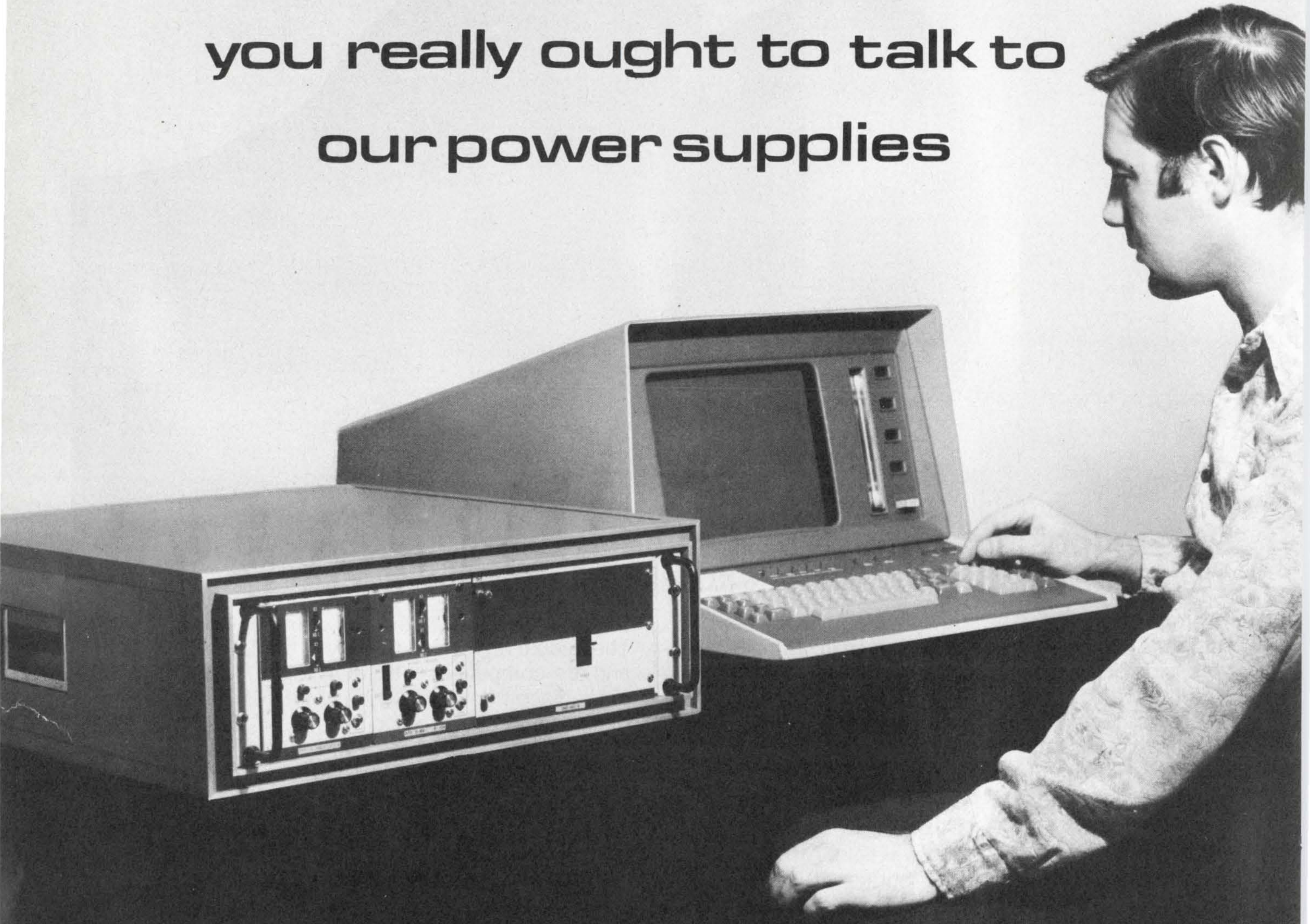

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More competition planned for defense contracts

Only slightly more than half the Defense Department's procurement dollars are awarded after competition, a top defense official has told the Joint Congressional Committee on U.S. Defense Production. So the Pentagon is taking steps to encourage more competition at the subcontractor level.

In fiscal 1976, 57% of contract dollars were awarded after price, technical or design competition, according to Dale W. Church, recently named deputy director for acquisition policy in the expanded Directorate of Defense Research and Engineering (DDR&E). The remaining 43% went mostly to single-source selections where effective competition was difficult to obtain. The Carter administration has made DDR&E responsible for overseeing all procurement in addition to its traditional role as the focal point for research and development.

To increase competition among subcontractors, the Defense Department is encouraging prime contractors to buy subsystems outside rather than making them in-house, avoid "lock-ins" and "data rights situations," which may lead to sole-source contracts, tailor subcontracts to reduce technical and administrative burdens, and make subcontractual arrangements that are potentially as profitable as prime contracts.

U.S. microwave landing system scores in tests

A Federal Aviation Administration time-reference scanning-beam microwave landing system has successfully completed a week of tests at Aeroparque Jorge Newbery in downtown Buenos Aires, Argentina. So claims the FAA. Developed by Bendix, the system is competing with a British Doppler microwave landing system for global standard.

The Bendix basic narrow aperture system was installed and operating Oct. 27 and was used for automatic landings of Argentine and U.S. aircraft until the tests were completed Nov. 4. The landing system permitted the aircraft to employ a curved approach path and steep descent.

West German, Italian, British and Latin American representatives observed the demonstration. The British had been invited to demonstrate their own Doppler MLS side-by-side at Buenos Aires, but declined on the grounds that the site was not challenging enough and that comparative tests there would serve no useful purpose.

More value-engineering savings, urges GAO

About $700-million has been saved over 13 years with value engineering, a program devised by the Defense Department to encourage contractors to propose cost-saving changes to their contracts. But it should be saving a lot more, according to a critical report just issued by the General Accounting Office.

"Defense managers' lack of acceptance and support has been the basic factor weakening the program," GAO reported, adding that the lack "has been most pronounced in the Navy and Air Force." About $1-billion could be saved by the

Defense Dept. over the next four years if this support were forthcoming, estimated the Federal auditing agency, which urged Defense Secretary Harold Brown to require his service secretaries and program managers to promote VE actively and report the results to Congress.

The Air Force's F-15 fighter plane being built by McDonnell Douglas is a "notable example" of how substantial savings can be realized through VE, according to the GAO. More than $50-million has been saved over the past six years, including $14.1-million in fiscal 1976, when it led the list of all defense programs in the VE category. Also in 1976, the latest year for which VE statistics are available, McDonnell Douglas saved $1.3-million on the Dragon antitank missile it is building for the Army.

Galactic X-rays discovered by satellite

The Uhuru satellite has uncovered 339 sources of X-ray emissions both inside and outside the Milky Way galaxy since it was launched seven years ago, according to the Smithsonian Institution's Center for Astrophysics. The largest category is galactic clusters.

Fifty-three clusters have been found in the X-ray band, each containing as many as 1000 galaxies that, like the Milky Way, are composed of 100-billion stars. Within these galactic clusters, X-ray emissions were observed in huge clouds of hot gases a million light years across.

Federal R & D will hit $26.3-billion

Federal funding of research and development will total $26.3-billion during this government fiscal year (1978), according to recent estimates of the National Science Foundation. That's an $8.9-million increase over fiscal 1974 expenditures, but only $2.2-billion after adjusting for inflation.

As usual, defense R & D leads the list with 49% of the total. Space R & D will get 12%; energy, 11%; health, 10%; environment, 4%; technology base, 4%; transportation and communications, 3%; natural resources, 2%; and agriculture, 2%.

The estimates come from "An Analysis of Federal R & D Funding by Function, Fiscal Years 1969-1978," which is available from NSF's Division of Science Resources Studies.

Capital Capsules: **Dr. Robert Ross Fossum has been named the new director of the Defense Advanced Research Projects Agency (DARPA), the Pentagon's in-house "think tank" for new-weapons studies.** He succeeds Dr. George H. Heilmeiser, who resigned. Fossum is former vice president of ESL, Inc., an electronic warfare firm in Sunnyvale, CA, which was founded by Dr. William Perry, who is now director of research and engineering at the Pentagon. . . .Lear Siegler Inc. has delivered **its first two ARN-101 digital modular avionics systems to the Air Force for installation on RF-4C and F-4E fighters.** The ARN-101 is intended to improve military-aircraft guidance and weapon delivery. . . .**Dr. Russell W. Peterson, former Republican governor of Delaware and former chairman of the White House Council on Environmental Quality, will become director of the Office of Technology Assessment on Jan. 16.** The office is Congress's watchdog to oversee technical programs of the executive branch. It was headed since its inception four years ago by former Rep. Emilio Q. Daddario (D-CT) until he resigned last July.

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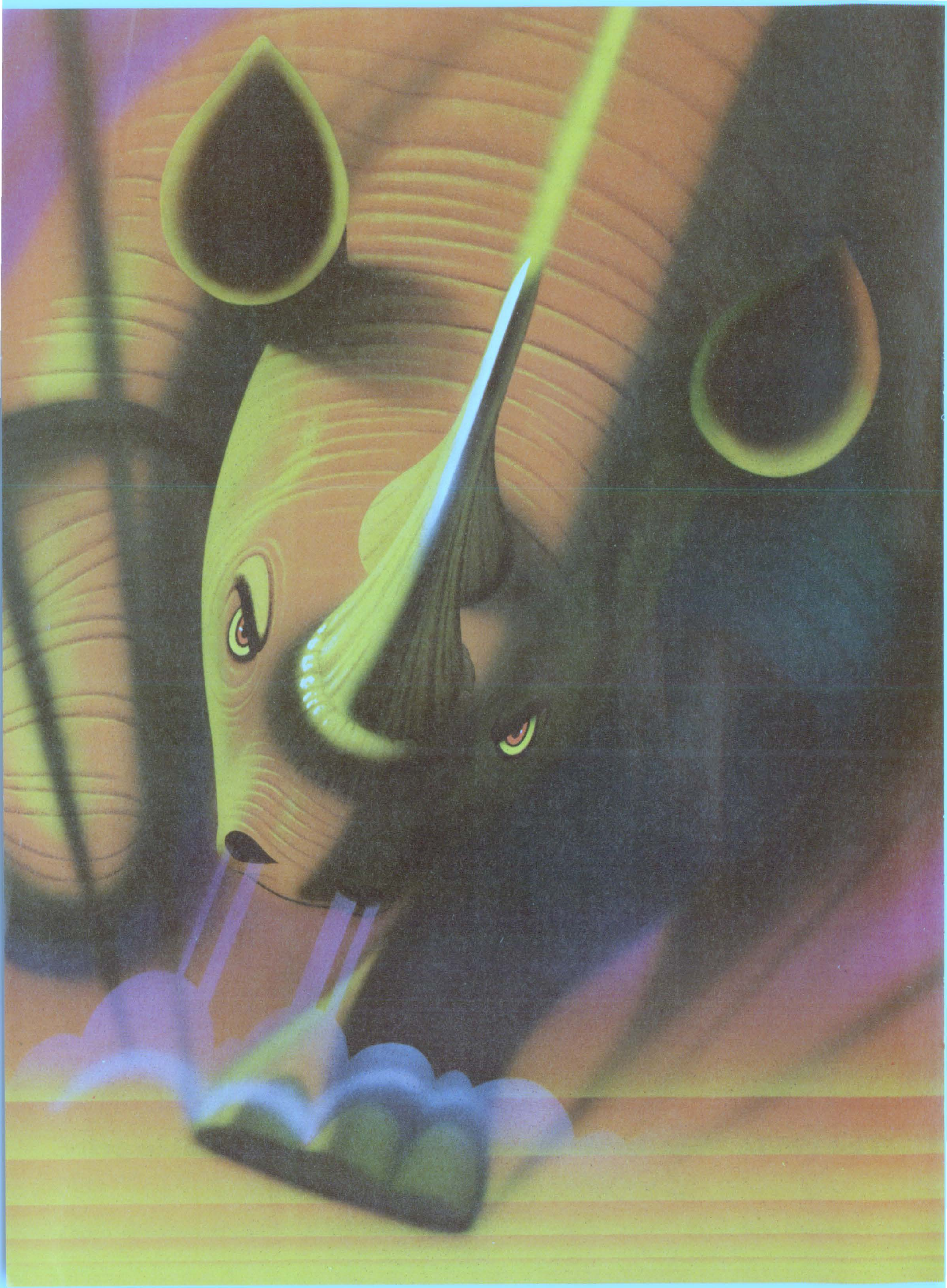

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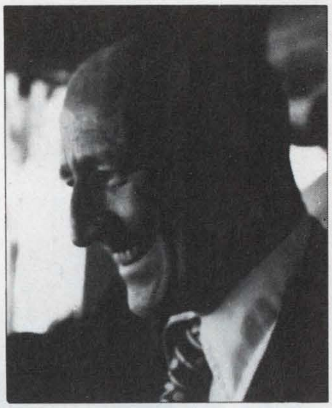
CIRCLE NUMBER 52

Editorial

Changes



This may be hard to believe, but many of our values are changing. Modes of behavior that used to be fashionable are becoming less so. It wasn't long ago, for example, that many of us thought it proper, even laudable, to use any means to achieve some lofty goal—like getting elected, staying elected, winning a contract or getting richer. But now, many of us don't feel quite the same.

We're changing other values, too. Many of us no longer feel that hard work always pays off. This attitude change may be one cause of the 2-percent-per-year growth in absenteeism in our shops and in the doubling of welfare rolls over the past four years.

Even our attitudes toward sex are changing, which may be the best thing that's happened to sex since its discovery some time ago. And on a national scale, many people no longer accept without question the notion of American moral, economic and military superiority.

In industry, as well as government, there's a large gap already between existing practices and ideal standards. And it's growing. Recent history has done a great deal to shatter many of our ideal images.

Such value changes can have a profound influence on the way corporations conduct themselves—internally as well as externally. So it's encouraging and stimulating to find that 19 major American companies are the founding sponsors of a program conducted by The Diebold Group, management consultants, to study management practices needed to respond to new socio-political attitudes and demands.

The program will study eternal truths like the quintessential holiness of profitability—or profit growth. It will assay the profit-and-loss statement as the ultimate arbiter of corporate behavior. It will examine executive compensation and executive goals, organizational structures, techniques for improving the sensitivity of line managers to changing employe values, corporate accommodation of these changing values, employee participation in decisions and financial rewards, and changes in other aspects of corporate behavior—substantive as well as cosmetic.

Now all this is very exciting. But it's scary, too. I wonder how many of us can ever adjust to a corporate value system that corresponds to the way people really feel.

George Rostky

GEORGE ROSTKY
Editor-in-Chief

IC op amps have evolved from general-purpose differential-input amplifiers into many specialized types. Precision, high-speed, power and programmable versions abound.

Op amps have evolved from low-performance general-purpose devices to high-performance units, some highly specialized for specific needs. But no one type completely approaches all the properties of an ideal op amp.[1] These ideal properties include:

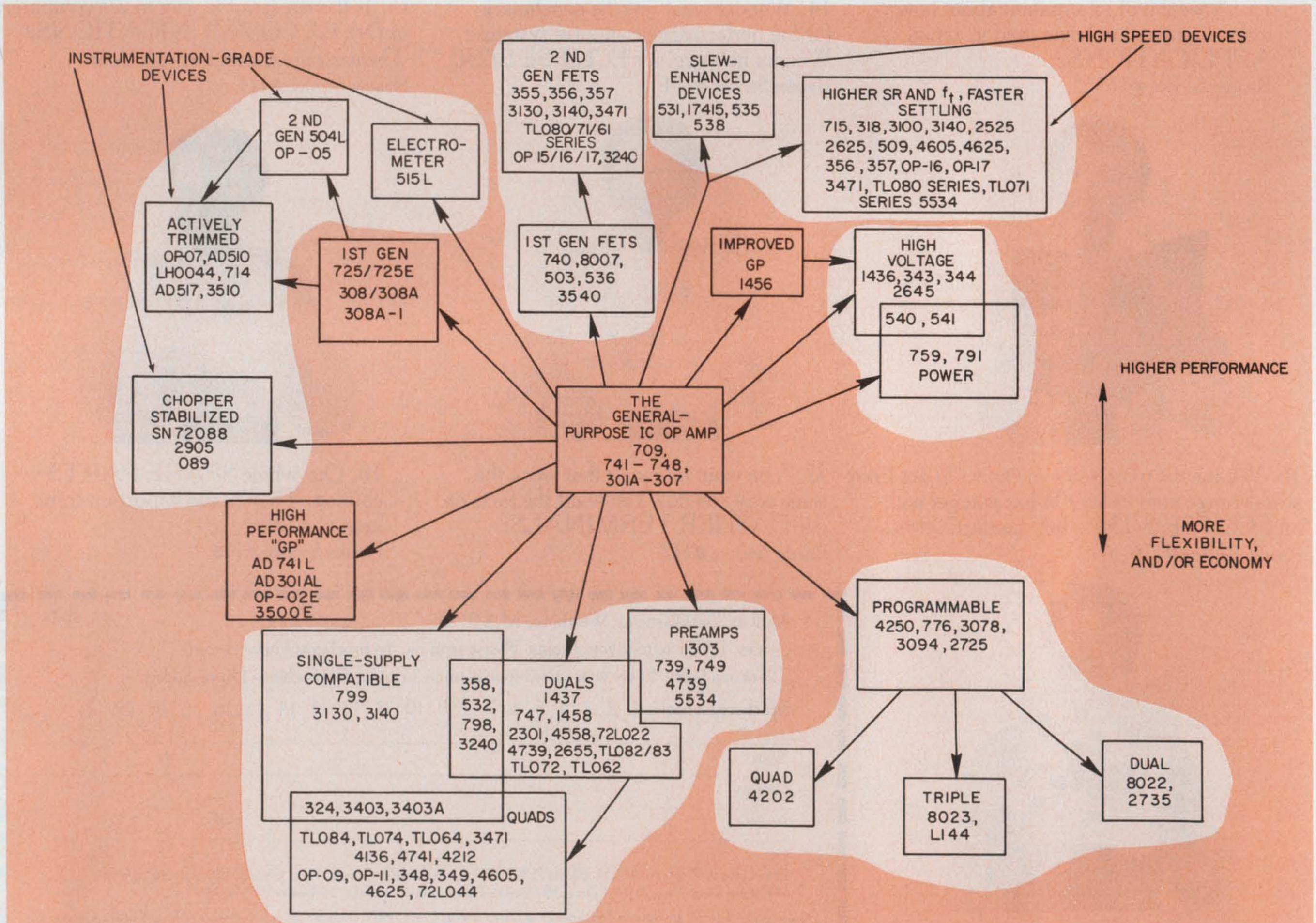
- Infinite voltage gain.
- Infinite input resistance.
- Zero output resistance.
- Infinite bandwidth.
- Zero offset voltage.

While these characteristics will never be completely attained by real op amps, continual improvements are bringing ideal performance closer and closer. As op amp prices come down, particularly in IC units, new applications crop up—from electrometers to audio amplifiers. And major advances—some by many orders of magnitude—have been made since the first widely used general-purpose 709 IC op amp.

Right now, you can choose from thousands of IC op-amp types. However, certain units stand out, because either they have attracted a large market with their wide applicability, low price and multiple-source availability or because their performance capabilities are unique.

So-called general-purpose types are typified by 709,

Walter G. Jung, Consultant, Pleasantville Laboratories, Forest Hill, MD 21050.



1. **General-purpose IC op amps have evolved in numerous directions.** Many units now emphasize high speed, others are precision instrument-grade units, and some offer high voltage and power outputs. Dual and quad units save space and money in circuits that require several op amps, such as active filters and in data-gathering systems.

Table 1. General-purpose op amps

Typical specs

Input Characteristics									
Bias nA	Offset nA	Offset mV	Drift μV/°C	Common - mode RR dB	Power - supply RR dB	Gain dB	Slew rate V/μs	Unity - gain BW MHz
100	20	2	10	90	90	100	0.5	1

NOTE: Specs are for commercial units for operation in a 0-to-70-C ambient with ±5 to ±18-V supply voltage and 2-kΩ load. Standard supply is ±15 V. Premium versions of these op amps cover wider temperature ranges.

(a) Single unit devices

Internally compensated	Externally compensated
μA741 LM307	μA709 μA748 LM301A

(b) Dual devices

Moderate speed	Improved speed	High speed	Preamplifier
μA 747 MC 1458 (8) LM 358, LM 358 A (2) (3) (5) (8) NE 532 (2) (3) (5) (8) μA 798 (3) (8) SN 72L022 (5) (8) MC 1437 (7) LH 2301 (7)	RC 4558 (1) (8) RC 4739 (1) (8)	HA 2655 (8) TL 082 (8) TL 083 TL 072 (8) TL 062 (8) CA 3240 (3)	MC 1303 (1) (7) (15) μA 739 (1) (7) (15) μA 749 (1) (7) (15) RC 4739 (1) (8)

(c) Quad devices

Moderate speed	Improved speed	High speed
LM 324, LM 324A (2) (3) (5) MC 3403 (3) LM 348 (4) MC 4741 (4) SN 72L044 (5)	RC 4136 (1) HA 4741 (1) XR 4212 LM 349 (DEC) (4) RC 3403A (3) OP-09 (1) (10) OP-11 (1) (10) RC 4156 (1) TL 064	TL 084 MC 3471 HA 4605 (1) (9) HA 4625 (1) (DEC) TL 074 TL 075

(d) High-performance devices

Type	Input characteristics						
	Bias nA	Offset nA	Offset mV	Drift μV/°C	Common - mode RR dB	Power - supply RR dB	Gain dB
OP-02E **	30	2	0.5	8	90	90	100
AD 741L	50	5	0.5	5	96	90	94
AD 301AL (7)	30	5	0.5	5	90	90	98
3500E **	50	30	0.5	1	88	100	100

Note: These specs are worst-case values at 25 C. **Available as matched pairs.

Notes applicable to all tables:

(DEC) Decompensated unit, not stable at unity gain

(1) Specified low input noise
(2) Class B output stage
(3) Input(s) (Output) will operate to V- (or ground)
(4) "True 741" inputs
(5) Low power operation
(6) Low supply voltage max limit
(7) External compensation (or components) required
(8) No offset null provision
(9) Specified for settling time
(10) Selections available which improve parameter(s)
(11) Slew enhanced device
(12) Not specified as such, observed on typical samples
(13) Individual programming
(14) Common programming
(15) Single-ended output
(16) Limited common-mode

741 or 301A devices. Table 1 lists the popular units, including dual and quad versions, and some high-performance units. The typical specifications in Table 1 are composites of those for general-purpose op amps. Certain units may differ somewhat in one or two details, but these spec values are what experienced design engineers consider necessary for many of today's demanding applications.

The evolutionary route

Advanced op amps have evolved from the single-unit general-purpose types (Table 1a) to meet specific needs (Fig. 1). One path in the figure has led simply to multiple-unit packages that save money and space. For example, the 1437 and 2301 dual op amps are merely two units of types 709 and 301As, respectively, in a single package (Table 1b). And the very popular 741 boasts of many versions in both dual and quad packages, for example, the 747 is a dual and 348 a quad version (Table 1c).

Eight-pin mini-DIP configurations are almost universally used for dual units and 14-pin DIPs for quads (Fig. 2). Consequently, duals and quads usually lack an offset-null capability because of pin limiting.

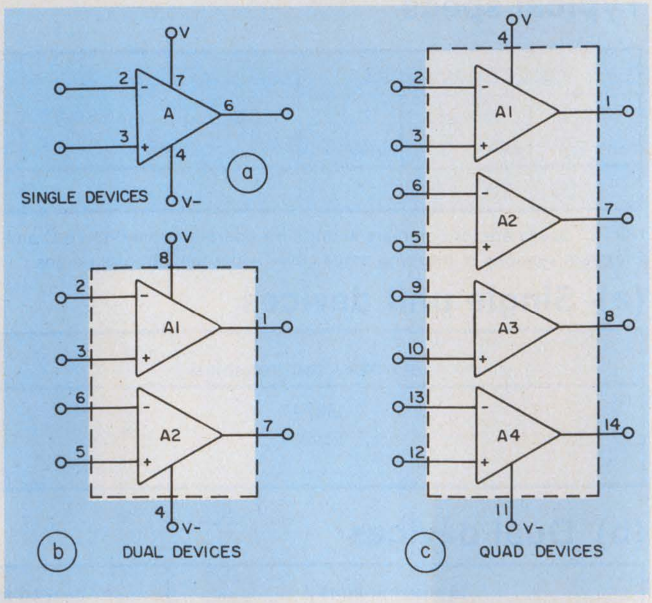
Other evolutionary paths have led to moderately over-all improved performance units, such as the "high-performance" general-purpose devices listed in Table 1d. Some paths led to specialized new designs whose performance in specific areas is vastly improved over general-purpose types (Tables 2 to 6).

Not only do dual and quad-packaged op amps save space and money, but many of them are improved-performance versions. In fact, manufacturers have increased the speed of some dual general-purpose op amps without major design changes.

Moderate-speed general-purpose op amps have a typical slew rate of 0.5 V/μs and f_t of 1 MHz. But in improved-speed types, the slew rate doubles to 1 V/μs and f_t triples to 3 MHz. Such improvements sometimes can change a marginally satisfactory circuit to one that performs brilliantly. Units with improved speed include the dual 4558, which is a pin-for-pin version of the moderate-speed 1458—another dual version of the 741.

To get speeds much higher than provided by the improved-speed, general-purpose devices, you must use a more specialized unit such as the 2655, whose slew rate is 5 V/μs and unity-gain bandwidth, 8 MHz. Instead of the common-junction isolation usually used in general-purpose op amps, the 2655 features dielectric isolation, which accounts for most of the speed improvement. Performance details of other fast op amps are covered in Table 4.

A number of dual op amps, though they have general-purpose operational specs, have specialized features such as single-power-supply compatibility and class-B outputs. Types 358 and 532 operate satisfactorily on single supplies, because their input and output voltage ranges can include their negative-supply rail, even when grounded. Furthermore, these op amps provide class-B outputs, which allow low-power consumption when quiescent and efficient performance when operating.



2. **Many single-unit op amps packaged in DIPs are pin-standardized** (a). Unfortunately, the limitations of 8-pin mini-DIP and 14-pin DIP packages for dual (b) and quad (c) devices don't allow for a nulling capability.

While the 798 has characteristics similar to the 358 and 532, it has a class-AB output stage, which reduces class-B crossover distortion, but consumes higher quiescent power. For exceptionally low quiescent power, however, you should consider the 72L022—the lowest powered among the units listed (Table 1b).

Although specialized for preamplifier applications and in a strict sense not true op amps, the 1303, 739 and 749 devices are included in the dual-device Table 1b, because of their design similarity to op amps. These three preamplifiers feature common pinouts and are generally similar to each other. But the 4739, though listed as a preamplifier, can be used also as an improved-speed, general-purpose op amp. Originally designed as a replacement for the 1303, 739 and 749 units, the 4739 features something the others don't have—internal compensation.

Quad-packaged op amps, a logical extension of dual units, give further savings in cost and space—and some have even had their performance boosted (Table 1c). The 348 and MC4741, closest to quad versions of a 741, all have similar npn input stages—the other bipolar quads have pnp inputs. And the 4136, one of the first available quads, is equivalent to two dual improved-speed general-purpose 4558s.

Send in the quads

Another early quad, the 324, is single-supply compatible for low-power operation and works like two dual 358s. The 3403, also single-supply compatible, features a class-AB output stage for low crossover

Table 2. Instrument-grade op amps

	Type	Input characteristics							
		Bias nA	Offset nA	Offset mV	Drift μV/°C unnulled	Drift μV/°C nulled	Common-mode RR dB	Power-supply RR dB	Gain dB
1st gen.	μA 725E (1) (7)	75	5	0.5	2	1	120	106	120
	LM 308 A-1 (5) (7) (8)	7	1	0.5	1	—	96	96	98 (R_L=10 k)
2nd gen.	AD 504 L (1) (7)	80	10	0.5	2	1	110	100	120
	OP-05E (1)	4	3.8	0.5	2	0.6	110	94	106
Actively trimmed	OP-07E (1)	4	3.8	0.075	1.3	1.3	106	94	106
	AD510L (1)	10	2.5	0.025	2	0.5	110	100	120
	LH0044AC (1) (8)	15	2.5	0.05	0.5	0.5	120	120	120 (R_L=10 k)
	3510CM (1) (7)	15	10	0.06	0.7	0.5	110	110	120
	OP-12E	2	0.2	0.15	2.5	2.5	104	104	94
	AD517L ** (1)	1	0.25	0.025	0.5	0.5	110	110	120
	μA714E **	4	3.8	0.075	1.3	1.3	106	94	106
Chopper stabilized	SN72088 (7) (16)	10	0.6	0.15	1 (typ)	—	80 (typ)	70 (typ)	100
	HA2905 (7)	0.15 (typ)	0.05 (typ)	0.02 (typ)	0.2 (typ)	—	120 (16)	120	174 (typ)
	TL089 (7)	1	0.6	0.1	0.2 (typ)	—	100	100	100
Electrometer	AD515L (1) (5)	75 fA	—	1	25	—	70	74	88

NOTE: Specs are worst-case values at 25C. **Newly introduced — final specs not available.

distortion, like the dual 798. And quad unit 72L044, a dual 72L022 in quad form features very low-power operation, lower than the 324.

Of course, speed-improved devices also have their quad counterparts: the speed-improved quad 4136, HA4741, 4156, 4212 and 3403A units are similar to each other and have pinouts like the moderate-speed quad 324 (Fig. 2c). But the 349 is a decompensated unit, which means that it is unstable at unity gain, unlike most other op amps, but stable above some higher specified gain.

The high-speed quad devices in Table 1c are aimed mainly at active-filter applications, where speed and the availability of several devices in a single package are great assets. The 084, 074, 075 and 3471 FET units are particularly suitable for active-filter circuits, because they offer very low input-bias currents and high-input impedances, so they don't load tuning networks and reduce the circuit's Q. And their high slew rates and wide bandwidths provide low distortion and high accuracy at high frequencies.

High-performers swing with singles

Nevertheless, to improve the over-all performance of general-purpose op amps substantially, manufacturers are forced to stay with single-amplifier units. Table 1d lists key worst-case performance specs of high-performance op amps. Note the across-the-board tightening of all dc parameters, when compared with the Table 1a specs and worst-case limits. The OP02E, AD741L and 3500E are upgraded "pin-for-pin replacements" for the 741. And the AD-301AL is an improved 301A that features not only improved dc accuracy, but also the external-compensation flexibility of the basic 301A.

Even better accuracy can be achieved, by using some units in matched pairs. For instance, matched pairs of OP02Es, designated OP04E, and 3500Es, designated 3500MP, are often used as instrumentation amplifiers.

But for the highest precision, special instrument-grade amplifiers go past general-purpose units with vastly improved input dc characteristics along with higher open-loop gain (Table 2). Such op amps are used in very accurate dc and low-frequency measurement, control and analog-computing systems.

Instrument op amps drift less

The first widely used IC instrumentation op amp, the 725, provided substantially lower offset voltage and drift, and higher power-supply rejection ratio (PSRR), common-mode rejection ratio (CMRR) and gain over then existing devices. However, it didn't dramatically improve input-current requirements. This problem was taken care of by the super-beta 308 series, whose 308A-1 provides general-instrumentation quality, but at somewhat lower PSRR, CMRR and gain.

A second-generation instrumentation op amp, the 504L, comparable to the 725 in dc specs, features external single-component compensation and more predictable drift characteristics. The OP05E, however, is internally compensated, needs much lower bias current, and exhibits slightly less drift than the externally compensated 504L.

But active-circuit trimming techniques with lasers and other methods now make possible nearly the ultimate in "as-delivered" input-offset voltage specs —about 50 μV—and also reduced drift rates, typically less than 0.5 μV/°C. Active-circuit trimmed op amps such as the OP07E, 510L and 0044AC compare favorably with the more complex chopper-stabilized amplifiers in both offset voltage and drift.

Table 2 lists some chopper-stabilized IC op amps, the 72088, 2905 and 089, which have FET inputs for low bias current. The oldest IC chopper amp, the 72088, possesses relatively poor specs. The newer 2905 has a good all-around collection of specs, and the 089, the most recently announced device, is similar, pin-for-pin, to the 2905.

Finally, electrometer-instrumentation op amps must operate with ultra-low input bias currents—less than 1 pA. Few amplifiers of any kind, let alone ICs, are suitable for such use. Nevertheless, the 515L IC op amp, which has a maximum input-bias current of 75×10^{-15} A, amply fills this requirement. The 515L represents the state of the art for low input-bias current. Fortunately, the device's remaining specifications are still reasonably good, although short of other instrumentation units.

FETs solve input-current problem

But not all applications require the extremely low input-current characteristic of an electrometer. Many uses merely need a reduction from the 10 to 100 nA of general-purpose op amps to, say, 10 to 100 pA. Unfortunately, the first monolithic FET-input op amps had notably poor dc characteristics (Table 3), although their input currents were less than 100 pA. Matching FETs in the op-amp differential inputs was difficult, so offsets and drift were high, and CMRR and PSRR were low. Nevertheless, these early units had slew rates over 10 times better than general-purpose 741s.

Second-generation units, however, offer low input current together with high slew rate and bandwidth without severe penalties in drift and other dc specs. For example, 3130s and 3140s with MOSFET inputs combine very low input current—5 to 10 pA—with reasonably low offset voltages and drifts, comparable to general-purpose units. Note: The 3140 is similar to the 741, but with FET-input characteristics, and the new 3240 is a dual 3140.

Ion-implanted JFETs in IC op amps, moreover, can be matched extremely well—like bipolar devices. The specs in Table 3 of the 355, 356 and 357 devices with ion-implanted JFETs clearly show the drift and offset improvements. The "A" versions have especially low offset voltages and drifts. Although not quite at the level of instrumentation-quality op amps, these devices are decidedly better than general-purpose units. Further details on the ac performance of FET units are included in Table 4.

The best over-all performance combination for FET-input op amps is provided by OP15/16/17 units, where well known current-mirror cancellation techniques keep bias currents low even at elevated temperatures. They are patterned after the 355/356/357 units, but offer greater speed and much lower dc errors, in many ways comparable to instrumentation-quality amplifiers.

Two of the newest FET op-amp types, the TL series and the 3471, are multi-unit devices. The 3471 is quad-packaged, has a particularly good slew rate—a minimum of 20 V/μs—and a 10-MHz unity-gain bandwidth. Both types are well suited to active-filter design. The TL080 is available in singles, duals and quads, and internally and externally compensated.

Table 3. FET - input op amps

Type		Input bias pA	Input offset mV	Input drift μV/°C	Common-mode RR dB	Power-supply RR dB	Slew rate V/μs	Unity-gain BW MHz
	μA 740	100	30	N.S.	80	83	6	1
1st	AD 503 (10)	15	20	30	90	74	6	1
gen	ICL 8007 (10)	3	20	N.S.	95	83	6	1
	NE 536	30	30	N.S.	80	80	6	1
	3540	50	50 (max)	75 (max)	90	64 (min)	6	1
	CA 3130 (3) (6) (7) (9)	5	8	10	90	90	10	4
	CA 3140 (3) (9)	10	5	N.S.	90	80	9	4.5
	LF 355, 355A (5) (9)	30	3, 1	5, 3	100	100	5	2.5
	LF356, 356A (1) (9)	30	3, 1	5, 3	100	100	12	5
2nd	LF 357, 357A (DEC) (1) (9)	30	3, 1	5, 3	100	100	50	20
gen	LF 351, 353, 347 (1) (9) (10)	50	10	10	100	100	13	4
	OP-15G, OP-15E (9) (10)	15	3, 0.5 (max)	15, 5 (max)	100	100	15, 17	5.4, 6
	OP-16G, OP-16E (9) (10)	15	3, 0.5 (max)	15,5 (max)	100	100	23, 25	7.2, 8
	OP-17G, OP-17E (DEC) (9) (10)	15	3, 0.5 (max)	15, 5 (max)	100	100	62, 7	26, 30
	TL 080 series (10)	30	15-3 (max)	10	86	86	12	3
	TL 071 series (10)	30	10-3 (max)	10	86	86	12	3
	TL 061 series (10)	30	15-3 (max)	10	86	95	3.5	1
	MC 3471 (8)	20	6 (max)	N.S.	80 (min)	70 (min)	20 (min)	10

NOTE: Specs are typical except as noted. Recently introduced FET op amps whose data were not available — CA 3240 (dual 3140), μAF 771, 772, 774 (single, dual, quad), LFT 356A (trimmed LF 356).

The LF 351/353/347 units also come in singles, duals and quads. Other TL versions, such as the TL071, feature low noise; the TL061 offers low power.

For high speed—specialized op amps

But if it's fast response you're mainly interested in, concentrate on selections from Table 4. These op amps emphasize one or all of the three major speed-related specs: slew rate, unity-gain bandwidth and settling time. Slew rate and bandwidth are closely related and well understood, but since settling time depends on many factors, it's difficult to pin down specific performance effects. Furthermore, settling time isn't always specified by the manufacturer. And when it is specified, seldom do the specs include your particular conditions.

The 3100 high-speed op amp combines bipolar and MOS techniques. External compensation helps to optimize its speed. The somewhat slower 3140, another combination device, has a MOSFET input and is internally compensated.

But the fastest device listed, the 2525, is a dielectrically isolated unit. It slews at 100 V/μs, has a correspondingly wide 20-MHz unity-gain bandwidth, and settles quickly, within 0.2 μs. These values are state of the art—the best combination of speed specs in an amplifier for both the inverting and noninverting operating modes.

However, another dielectrically isolated unit, the 2625, can be specially compensated to a bandwidth as high as 100 MHz. And the 715, one of the first high-speed IC op amps, is notable for very wide bandwidth. When compensated at high gain, its bandwidth can reach 3000 MHz.

For more of a compromise between slew rate and bandwidth, look to the 4625, a decompensated 4605 with a 70-MHz bandwidth and a 25-V/μs slew rate. (Note: bandwidth and slew rate in op amps usually increase with reduced compensation.)

For primarily improved slew rates regardless of bandwidth, a slew-enhanced device such as the 531 slews at 30 V/μs, but it's bandwidth is only 1 MHz. More recent units include the internally compensated 1741S and 535 devices; also the 538, a decompensated version of the 535.

If settling time is your concern, the 356 and 357 FET units stand out—only 1.5 μs with an error band of 0.01%—which can provide the high precision needed for such applications as d/a and a/d converters. The OP16 and OP17 offer the same general features as the 356 and 357 plus somewhat better dc properties, but the OPs' listed faster settle times—0.8 and 0.5 μs —have a wider error band, 0.1%, compared with 0.01% for the 356 and 357 FET units.

You can even get power op amps

Some general-purpose op amps have evolved into power-output devices (Table 5). For instance, the general-purpose 1456, which features super-beta input transistors for low bias current, has evolved into the

Table 4. High-speed op amps

Type	Slew rate* V/μs	Unity-gain bandwidth MHz	Settling time** μs	Input offset mV	Input bias nA
CA 3100 (7)	≥ 25	≥ 30	0.6 (0.5%)	1	700
CA 3140 (3)	9	4.5	1.4	5	0.01
HA 2525 (7)	100	20	0.2 (Av = 3)	5	125
HA 2625 (7)	≥ 7	≥ 12	N.S.	3	5
HA 4605 (1) (8) (quad)	4	8	4.2 (0.01%)	0.5	130
HA 4625 (1) (8) DEC (quad)	25	70	N.S.	0.5	130
AD 509 (7)	120	20	0.2	5	125
LF 356 (1)	12	5	1.5 (Av = −1, 0.01%)	3	0.03
LF 357 (DEC) (1)	50	20	1.5 (Av = −5, 0.01%)	3	0.03
OP-16 (1)	23	7.2	0.8 (Av = −1) 1.8 (Av = −1, 0.01%)	3	0.015
OP-17 (DEC) (1)	62	26	0.5 (Av = −5) 1.6 (Av = −5, 0.01%)	3	0.015
LM 318	≥ 70	≥ 15	0.8	4	150
MC 1741S (11)	12	1	3	2	200
MC 3471 (8) (quad)	20 (min)	10	N.S.	6 (max)	0.02
NE 531 (7) (11)	≥ 30	≥ 1	2.5 (0.01%)	2	300
NE 535 (11)	15	1	3	2	65
NE 538 (DEC) (11)	60	6	1.2	2	65
NE 5534 (1) (7) (10)	≥ 7	≥ 10	N.S.	0.5	500
TL 080 (7) (10)	≥ 12	≥ 3	N.S.	15-3 (max)	
TL 071 (10)	13	3	N.S.	10-3 (max)	0.03
μA 715 (7)	≥ 18	≥ 15	0.8 (Av = −1, 5 V)	2	400

NOTE: Specs are typical except where noted. *Unity gain, except for variable-compensation units that can reach high speeds indicated by ≥ symbol.
** With 0.1% error band for a ± 10-V step into a unity-gain follower, except as noted.

Table 5. High-voltage and power-output op amps

	Type	Supply voltage V (max)	Output voltage V (min), RL = 5 kΩ	Slew rate V/μs*	Gain dB	Input offset mV	Input bias nA
High voltage	MC 1436G	± 34	40 V p-p @ V_S = ± 28 V	2	114 (R_L = 100 kΩ)	5	15
	LM 343	± 34	40 V p-p @ V_S = ± 28 V	2.5	105 (R_L = 100 kΩ)	2	8
	LM 344 (7)	± 34	40 V p-p @ V_S = ± 28 V	≥ 2.5	105 (R_L = 100 kΩ)	2	8
	HA 2645	± 40	70 V p-p @ V_S = ± 40 V	5	106 (R_L = 100 kΩ)	2	12

	Type	Supply voltage V (max)	Output current mA	Output power W at 25 C	Slew rate V/μs	Gain dB	Input offset mV	Input bias nA
High power	NE 540 (DEC) (1) (7) (8)	± 20	± 100	1	≥ 4 (x 10 comp) (12)	(90,R_L ≥ 10 k) (12)	7	2000
	NE 541 (DEC) (1) (7) (8)	± 42	± 65	1	≥ 4 (x 10 comp) (12)	(90,R_L ≥ 10 k) (12)	7	2000
	μA 759 (3)	± 18	± 350	Int. limit	0.5	106, R_L ≥ 50 Ω	1	50
	μA 791 (7)	± 18	± 1000	Int. limit	≥ 0.5	86 min, R_L = 10 Ω	2	80

NOTE: Specs are typical except as noted. *Unity gain, except for variable-compensation units that can reach high speed indicated by a ≥ symbol.

Table 6. Programmable op amps.

Single		Dual		Triple	Quad
Moderate speed	High speed	Moderate speed	High speed		
4250 ICL 8021 μA 776 MC 3476 CA 3078 (7) (8) (10) CA 3094 (7) (8) (15)	HA 2725	ICL 8022 (13)	HA 2735 (13)	ICL 8023 (8) (13) L 144 (8) (14)	XR 4202 (8) (14)

1436, the first IC op amp to handle "high" voltages —a ±34-V maximum supply voltage. And it can supply a ±20-V output with a ±28-V supply and 5-kΩ resistive load.

Like most high-voltage op amps, however, the 1436 can't supply load currents much greater than a typical general-purpose unit. Still, even with its high-voltage capability, the 1436's remaining specs remain quite reasonable—better in fact than many general-purpose devices. Like the 1456, its bias current is low and its slew rate is high. But the LM 343/344 and HA 2645 have still lower offsets and input-bias currents.

Still you can get both high voltage and current (high power) in some op amps. Four high-power units are listed in Table 4. The 540 and 541 give you a choice of lower voltage and higher current, or the converse. The 540 provides ±20 V at ±100 mA and the 541, ±42 V—the highest voltage output on the list—at ±65 mA. However, both the 540 and 541 are decompensated and have no offset-null provisions, and thus, may not be flexible in use. The 540 can be compensated externally to a minimum gain of 10, with a resulting respectably high slew rate of 4 V/μs.

The 759 offers a conventional supply-voltage rating, but a high output current, 350 mA. And it can operate on a single supply with inputs whose difference can swing to ground.

The highest output current on the list, 1 A max, is supplied by the 791. Furthermore, the 791 is externally compensated so speed can be optimized—and its dc specs are similar to those listed for general-purpose operational amplifiers.

Program your own performance

Perhaps the most interesting of the IC op amps are some so-called specialized types that are programmable—which, ironically, makes them rather *un*specialized. The operating characteristic of programmable IC op amps can be adjusted with a control current, I_{set}, so that a single device can assume the operating characteristics of many devices. Input currents, bandwidth, slew rate and power dissipation are some of the key parameters directly adjustable by I_{set}. Also, programmable op amps can be used in micropower modes and in switched, on/off modes.

Programmable devices can be single, dual, triple or quad units (Table 6). The most popular single units include the 4250, 776, 8021 and 3476, which are internally compensated and pinned like a 741 (Fig. 2a), but with an extra pin (pin 8) for programming. The 3078 and 3094 are externally compensated and feature unusual capabilities, such as very low voltage (the 3078) and very high output current (the 3094).

Some IC op-amp manufacturers

Manufacturer	Typical op-amp number	Circle No.
Advanced Micro Devices, 901 Thompson Pl., Sunnyvale, CA 94086.	Second sourcing	**501**
Analog Devices, P.O. Box 280, Route 1 Industrial Park, Norwood, MA 02062.	AD504L, AD741L	**502**
Burr-Brown Research Corp., Int'l Airport Industrial Park, Tucson, AZ 85734.	3500E	**503**
Exar, 750 Palomar Ave., Sunnyvale, CA 94086.	XR4202	**504**
Fairchild Semiconductor, 464 Ellis St., Mountain View, CA 94040.	MA741, MA725E	**505**
Harris Semiconductor, Inc., P.O. Box 883, Melbourne, FL 32901.	HA2525, HA4741	**506**
Intersil, 10710 N. Tantau Ave., Cupertino, CA 95014.	ICL8007	**507**
Motorola Semiconductor, Box 20924, Phoenix, AZ 85036.	MC1456, MC4741	**508**
National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051.	LM301A, LF356, LH0044	**509**
Precision Monolithics, 1500 Space Park Dr., Santa Clara, CA 95050.	OP-05, OP-15, 16, 17, OP-09, OP-11	**510**
Raytheon Semiconductor, 350 Ellis St., Mountain View, CA 94040.	RC4558, RC4156	**511**
RCA Solid State Div., Route 202, Somerville, NJ 08876.	CA3140, CA3240, CA3130, CA3160	**512**
Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086.	NE531, NE535, NE538, NE5534	**513**
Siliconix, 2201 Laurelwood Rd., Santa Clara, CA 95054.	L144	**514**
Solitron Devices, Semiconductor Div., 8808 Balboa Ave., San Diego, CA 92123.	UC4250	**515**
Texas Instruments, Dallas, TX 75222.	SN72088, TL081, TL071, TL061	**516**

For high speed, the 2725 is about 10 times faster than the moderate-speed programmable units, because of its dielectric-isolation construction.

The duals, 8022 and 2735, are versions of their single counterparts, the 8021 and 2725. And the 8023 is a triple 8021, with individually adjustable programming in each section. But the L144 triple has common programming for its sections. So does the 4202, the only programmable quad—it's like four 4250s. ■■

Reference

1. Jung, W.G., *IC Op Amp Cook Book,* Howard W. Sams, Indianapolis, IN, 1974.

Everything you need to

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Put BIFETs into your linear circuits.

These mixed-technology monolithic op amps perform so well they leave the standard bipolars far behind.

Complex linear circuits like instrumentation amplifiers, active filters, quadrature oscillators and even demanding high-fidelity amplifiers are only as good as their op amps. Use BIFETs instead of simple bipolar monolithics, and you will improve many of these linear circuits—for practically no additional cost.

BIFETs combine high speed and input impedance with low input offsets, drift, distortion and noise. And so, they bring monolithics much closer to the ever elusive ideal operational amplifier.

The first monolithic op amps fell far short: While they did have good uniformity, they were lacking in input impedance and gain, and were unstable to boot. These negative characteristics were upgraded in bipolar op amps like the 741, 1458 and 301A.

Bipolars had their day

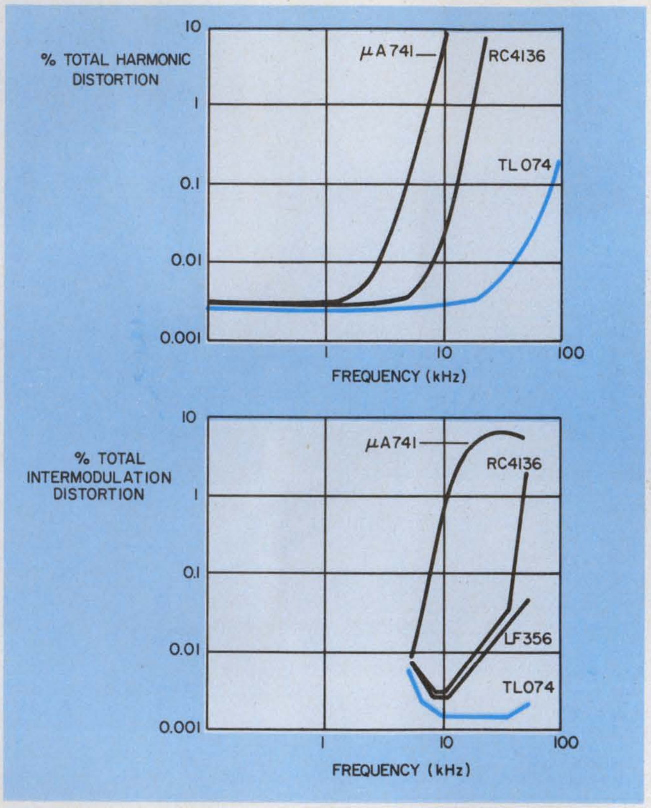
These basic bipolars performed reasonably and for a reasonable price. But low input impedance and slew rate, narrow bandwidth and high input offsets sent designers scurrying to the more expensive hybrid circuits. But hybrids weren't always the answer. Though they usually provided good performance per dollar, often cost blocked high-volume use.

But now that ion implantation has overcome the stumbling block of high input-offset voltage, BIFET op amps outperform their monolithic bipolar counterparts. Important characteristics of some common bipolar and BIFET (and BiMOS) operational amplifiers are compared in Table 1.

General purpose BIFETs are available from National Semiconductor in Santa Clara, and Texas Instruments in Dallas. National currently produces the LF355 and LF356, single op amps which are internally compensated. National also offers the LF13741, which is basically a 741 but with a JFET input stage. A low-cost quad, the LF347, is imminent.

TI has five general-purpose BIFETs: the uncompensated single TL080 and compensated single TL081; the compensated dual TL082 and TL083, and the compensated quad TL084.

Dale Pippenger, Linear Applications Manager, and **Dave May,** Linear Applications Engineer, Texas Instruments, Dallas, TX 75222.



1. **The BIFET TL074 boasts less distortion,** both harmonic and intermodulation, than common bipolar op amps.

Besides general-purpose BIFETs, TI offers low-power units. The single TL061, dual TL062 and quad TL064 draw 250 μA max. And TI's TL066 consumes even less because of its power programming. This op amp can operate on mere microwatts, what's more its supply voltage can go as low as ±1.5 V.

In selecting a BIFET op amp, noise and distortion are usually major considerations. Low distortion and noise are crucial to data multiplexing, transducer preamps, instrumentation amplifiers, medical preamplifiers and high-fidelity amplifiers. Op amps with

Table 1. Characteristics of common monolithic op amps

Device		r_i (typ) Input impedance (Ω)	I_{ib} (max) Input-bias current (nA)	V_{io} (max) Input-offset voltage (mV)	I_{io} (max) Input-offset current (nA)	B_1 (typ) Unity-gain bandwidth (MHz)	S_r (typ) Slew rate (V/μs)	I_{cc} (max) Supply current (each amplifier) (mA)
Single, Uncompensated	TL080C	10^{12}	0.4	15	0.2	3	13	2.8
	TL080AC	10^{12}	0.2	6	0.1	3	13	2.8
	CA3130	1.5×10^{12}	0.05	15	0.03	4	10	15
	LM301A	2×10^6	250	7.5	50	1	0.5	3
	LM308	4×10^7	7	7.5	1	1	0.3	0.8
	μA748	2×10^6	500	6	200	1	0.5	2.8
Single, Compensated	TL081C	10^{12}	0.4	15	0.2	3	13	2.8
	TL081AC	10^{12}	0.2	6	0.1	3	13	2.8
	TL071C	10^{12}	0.2	10	0.05	3	13	2.5
	TL071AC	10^{12}	0.2	6	0.05	3	13	2.5
	TL061C	10^{12}	0.4	15	0.05	1	3.5	0.25
	TL061AC	10^{12}	0.2	6	0.05	1	3.5	0.25
	LF13741	5×10^{11}	0.2	15	0.05	1	0.5	4
	CA3140	1.5×10^{12}	0.05	15	0.03	4.5	9	5.5
	CA3160	1.5×10^{12}	0.05	15	0.03	4	10	15
	LF355	10^{12}	0.2	10	0.05	2.5	5	4
	LF356	10^{12}	0.2	10	0.05	5	12	10
	LF351	5×10^{11}	0.2	10	0.05	5	13	4
	μA741	2×10^6	500	6	200	1	0.5	2.8
	LM307	2×10^6	250	7.5	50	1	0.5	3
Dual-compensated	TL082C	10^{12}	0.4	15	0.2	3	13	2.8
	TL082AC	10^{12}	0.2	6	0.1	3	13	2.8
	TL072C	10^{12}	0.2	10	0.05	3	13	2.5
	TL072AC	10^{12}	0.2	6	0.05	3	13	2.5
	TL062C	10^{12}	0.4	15	0.05	1	3.5	0.25
	TL062AC	10^{12}	0.2	6	0.05	1	3.5	0.25
	MC1458	2×10^6	500	6	200	1	0.5	2.8
	RC4558	5×10^6	500	6	200	3	1	2.8
	μA747	2×10^6	500	6	200	1	0.5	2.8
Quad-compensated	TL084C	10^{12}	0.4	15	0.2	3	13	2.8
	TL084AC	10^{12}	0.2	6	0.1	3	13	2.8
	TL074C	10^{12}	0.2	10	0.05	3	13	2.5
	TL074AC	10^{12}	0.2	6	0.05	3	13	2.5
	TL064C	10^{12}	0.4	15	0.05	1	3.5	0.25
	TL074AC	10^{12}	0.2	6	0.05	1	3.5	0.25
	LF347	10^{12}	0.2	10	0.05	5	15	2.8
	MC3471	10^{12}	0.2	6	0.02	10	20	10
	MC4741C	2×10^6	500	6	200	0.8	0.5	1.75
	LM324	2×10^6	250	7	50	1	0.5	3
	RC4136	5×10^6	500	6	200	3	1	2.8

(Continued from page 104)

a high slew rate can considerably reduce a system's harmonic and intermodulation distortion totals.[1] To this end, TI's TL081 general-purpose and TL071 low-noise series boast 13-V/μs slew rates. The result is a harmonic distortion of less than 0.01% at 10 kHz. As Fig. 1 illustrates, the high slew-rate TL074 has the lowest total harmonic and intermodulation distortion of the popular op amps.

BIFETs hold down the noise

Op amps must contend with three kinds of noise: burst, broadband and root-hertz. For each category, BIFET levels are lower than or comparable to those of the bipolar "jelly beans."

BIFETs reduce the burst or "popcorn" noise that can be a nightmare in audio, data-acquisition, instrumentation and preamp work. These rail-to-rail jolts are related to input-stage contamination. Though other factors may affect burst noise, generally the IC design isn't the culprit. Clean IC processing has reduced burst noise in many monolithic op amps. Passivation has also helped. But in BIFETs, burst noise is reduced even further because of the inherently clean ion-implantation process for the JFETs.

The JFET input stage would ordinarily spell caution to designers concerned with broadband, or reciprocal-frequency (l/f) noise. FETs are notoriously noisy in the broadband range. But BIFETs draw low input-bias current, which lowers the equivalent input noise in accordance with the following relation for the broadband-noise spectral density:

$$\xi_x(\omega) = kI^{\alpha}/\omega^{\beta},$$

where I is the dc through the device, ω is the radian frequency and k, α and β are constants ($\alpha \approx 2$, $\beta \approx 1$).

Root-hertz noise is expressed in nV/$\sqrt{\text{Hz}}$ and is usually specified at spot frequencies from 10 Hz to 100 kHz. The level of this noise is typically 10 times higher at 10 Hz than it is at 1 kHz but it remains relatively flat from 1 to 100 kHz. For designs in which root-hertz noise must be minimal, the low-noise TL071 (single), TL072 (dual) and TL074 (quad) BIFETs boast, at 1 kHz, 18 nV/$\sqrt{\text{Hz}}$, as opposed to 47 for the noisier general-purpose TL081 BIFETs.

BIFETs measure up for instrumentation

Low noise and minimal distortion are important in instrumentation amplifiers, which amplify differential ac or dc signals precisely. Such amplifiers also require high common-mode rejection and high input impedance. Even with BIFET op amps, instrumentation amplifiers still aren't perfect. But as Table 2 shows, a TL081 BIFET op amp outshines the widely used bipolar 741s in this application.

Examine the 100-V common-mode instrumentation amplifier in Fig. 2. Here, the design depends on the BIFET op amp's low input-bias current. The TL080A accepts high-value input resistors. The input-bias currents are so low that the input resistors do not appreciably affect the offset voltage or circuit balance.

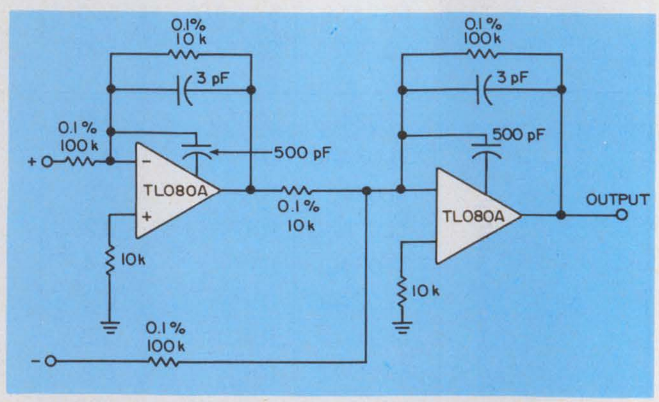
Another instrumentation amplifier, the circuit in Fig. 3, uses high-value input resistors to minimize source reflections. In this differential-input variable-gain circuit, as in the circuit in Fig. 2, low input-bias current produces low input-offset voltages, despite the high resistances in the input leads.

The TL071s at the input assure low noise. Offset controls connected to the TL081B, the output-buffer amplifier, provide the circuit adjustments. The TL080 is the heart of an active-feedback circuit that controls the amplifier's over-all gain and frequency response. The external components set the total bandwidth.

If the instrumentation amplifiers in Figs. 2 and 3 were to use bipolar op amps instead of BIFETs, the resulting circuits would have less capability. For example, the bipolar versions would have power bandwidths of only 60 kHz, compared to 1 MHz for the BIFET circuits. The input impedance with bipolars would be 4 MΩ, vs 10^{12} Ω with BIFETs. What's more,

Table 2. BIFET vs bipolar op amps

Characteristic	741	TL081
Input impedance	2×10^6 Ω	10^{12} Ω
Input-bias current	500 nA	0.4 nA
Input-offset current	200 nA	0.2 nA
Unity-gain bandwidth	1 MHz	3 MHz
Slew rate	0.5 V/μs	13 V/μs
Total harmonic distortion	0.01% to 2 kHz	0.01% to 35 kHz
Power bandwidth	10 kHz	100 kHz

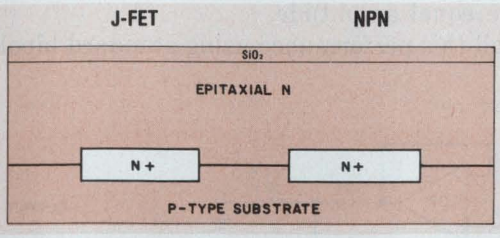


2. **This instrumentation amplifier handles ±100 V** of common-mode signal. Also, the BIFETs provide a power bandwidth of 1 MHz at a gain of 10, plus the BIFET specialty —an input impedance of 10^{12} Ω.

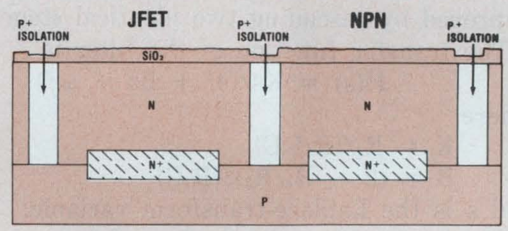
Ion implantation: The cornerstone of the BIFET process

Ion implantation is the great difference between BIFET and standard bipolar processing. In BIFETs, both p-type and n-type ions are implanted into the wafer. Because the ion implantation between the drain and source of the JFETs is so precise, the resulting FET pairs (input stage) are closely matched.

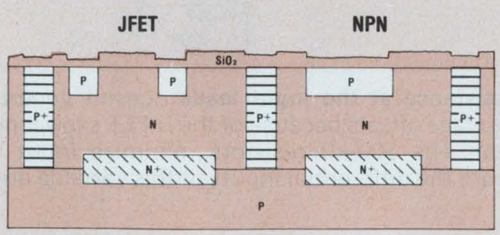
The ion-implanted FETs provide very high input impedance, controlled pinch-off voltage for maximum common-mode-input range, and matched input characteristics for low input-offset voltage. The JFETs also deliver adequate drive to the second stage for maximum pk-pk output and wide power bandwidth.



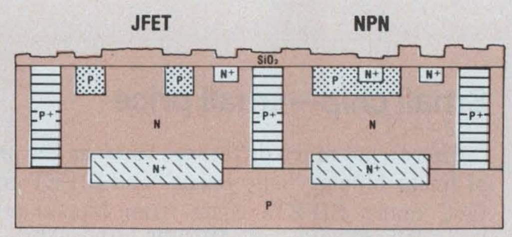
To start, n^+ is diffused into the substrate's n-type epitaxial layer:



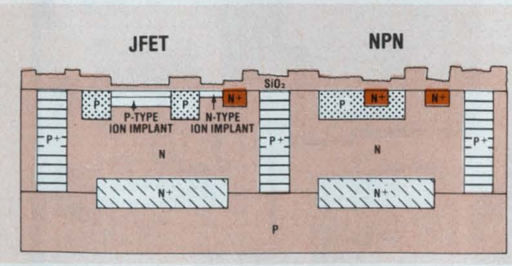
Then p^+ is diffused into the epitaxial layer. These p^+ areas separate the chip's JFET and bipolar sections:



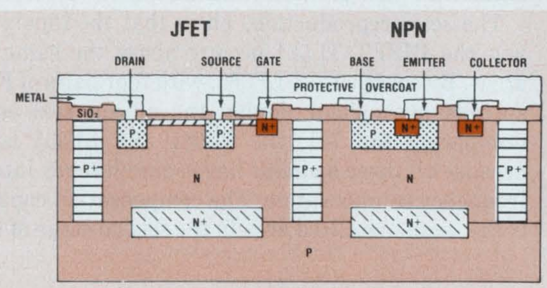
Next, p-type diffusion forms the JFET drains and sources as well as the bipolar bases:



The n^+-type diffusion forms the JFET gates plus the bipolar emitters and collectors:



Now comes the crucial step—both p-type and n-type ion implants form the JFET gates.



To end the process, the electrodes are metalized and a protective coating is applied over-all.

(Continued from page 106)

with the same 10-times gain, bipolar input-bias currents would produce greater offset voltages.

BIFETs activate filter designs

Precise active filters—whether low-pass, high-pass, bandpass or notch—can make circuit designers cringe—especially filters for kHz center frequencies. With standard bipolar op amps, active filters often have problems with input impedance, bandwidth, crossover and harmonic distortions as well as speed. Fortunately, a BIFET op amp like the TL074 can often defuse active-filter design problems.

For example, consider the positive-feedback bandpass filter (Fig. 4a) whose Q and gain have been improved by cascading two identical stages.

The transfer function of the filter is

$$H(s) = Ks/(s^2 + Bs + \omega_o^2)$$

where

$$K = R_4/(R_1^2\ C),$$
$$B = (2 - R_4/R_3)/(R_1C)$$

and s is the Laplace-transform variable.

The center frequency is figured by

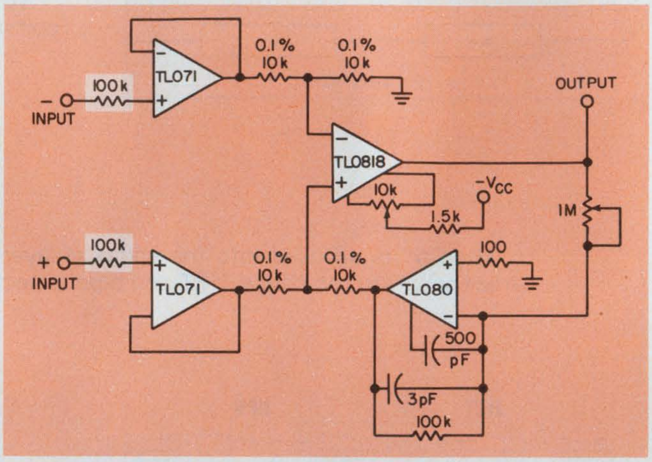
$$f_o = \sqrt{1/R_1^2 + 1/(R_1R_2) + 1/(R_1R_3)}/2\pi C.$$

The Q of the filter can be increased, without appreciably changing f_o, either by cascading additional filter stages or by varying the value of R_4.

The output of a single filter stage, e_i, has a Q of 30 and a gain of 4 (Fig. 4b). The cascade output, e_o (Fig. 4c), has a Q of 69 and a gain of 16. And all this performance is at a 100-kHz center frequency, thanks to a TL074 BIFET.

Often, a quadrature oscillator, a fixed-frequency circuit that provides both sine and cosine outputs, must combine low distortion with stable amplitude, phase and frequency. In addition, both outputs must often have equal amplitude.

To get all this performance using standard bipolar



3. **High resistance at the input leads** doesn't generate excessive voltage offsets because of the BIFET's low input-bias current. The 100-kΩ resistors minimize input reflections from the differential inputs of this variable amp.

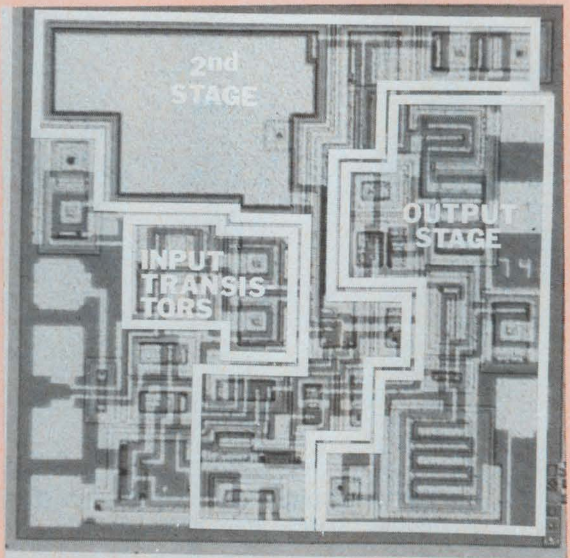
Small chip—small price

There's not much difference between the processing of linear bipolar "jelly beans" and BIFET devices. In fact, many BIFETs come from bipolar-production lines. What's more, the BIFET's relatively small chip suits high-volume production. Not surprisingly, then, BIFETs cost only slightly more to manufacture than the most economical of the bipolars.

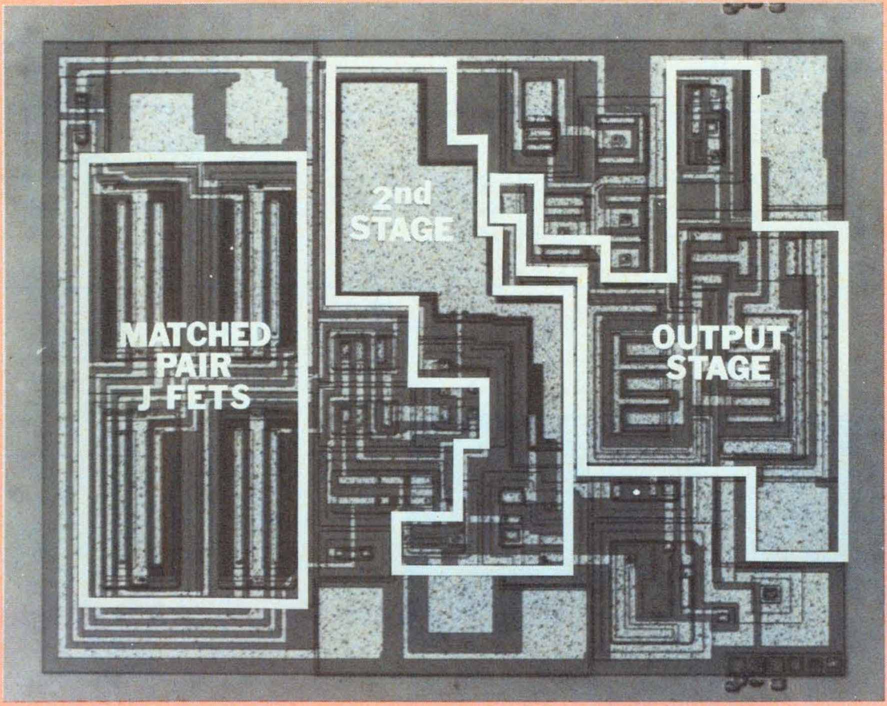
As a result, BIFET op amps are priced close to the most popular bipolar, the 741. These "jelly-bean" prices wouldn't be possible without high yields. A maxim from the early days of bipolar ICs still holds—the smaller a device, the more good chips from each slice. And this greater yield means lower cost.

The scale reproductions show that the bipolar 741 and the BIFET TL081 occupy about the same chip areas. By contrast the LF355, with four pairs of FETs, spreads over about double the silicon real estate. Comparing the 741, the TL081 and LF355 is fair because all three op amps have space-hungry internal frequency compensation. The compensation capacitor is the large metalized area in the second stage of each.

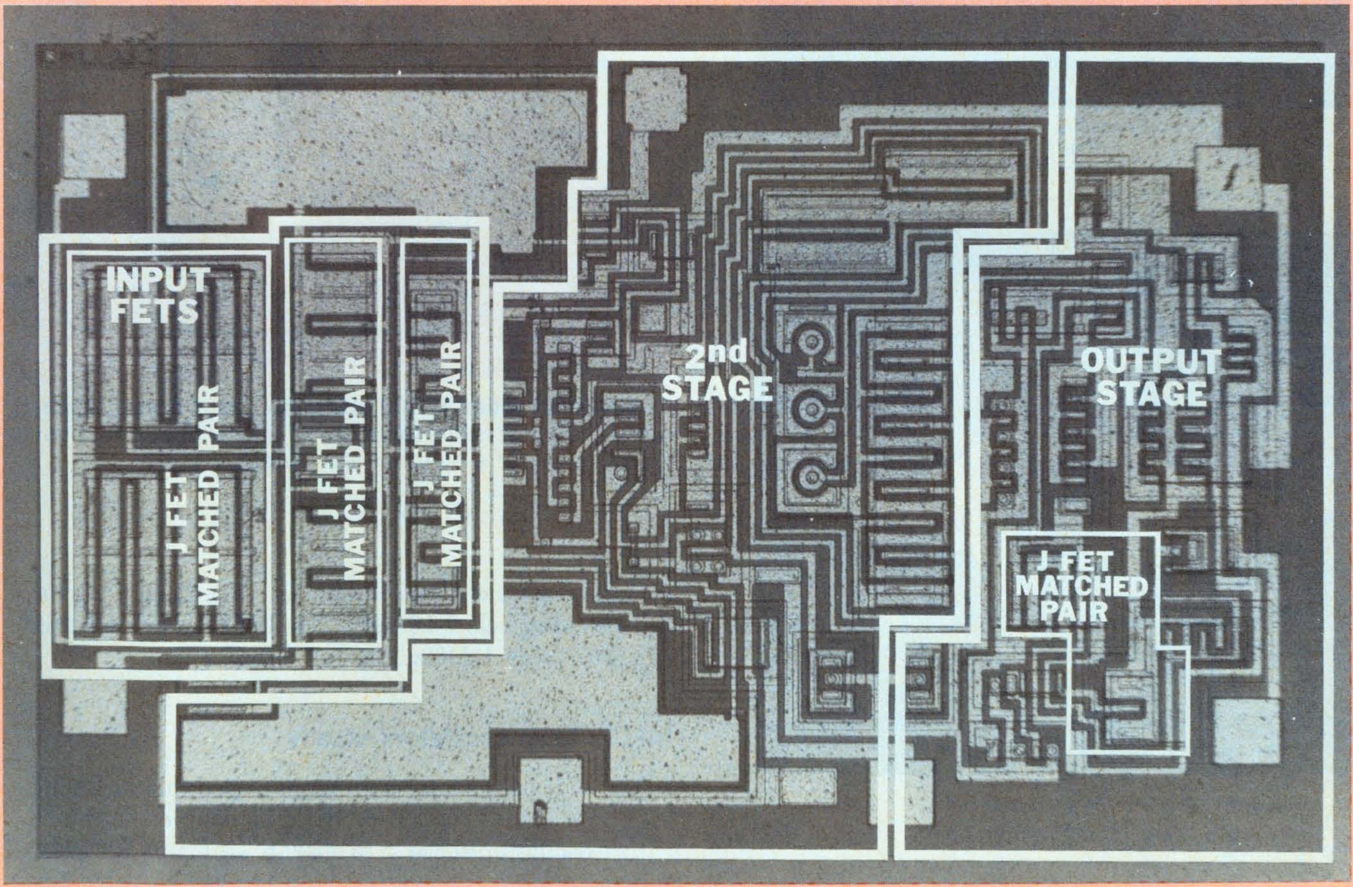
μA741



TL081


MATCHED PAIR J FETS
2nd STAGE
OUTPUT STAGE

LF355


INPUT FETS
J FET MATCHED PAIR
J FET MATCHED PAIR
J FET MATCHED PAIR
2nd STAGE
OUTPUT STAGE
J FET MATCHED PAIR

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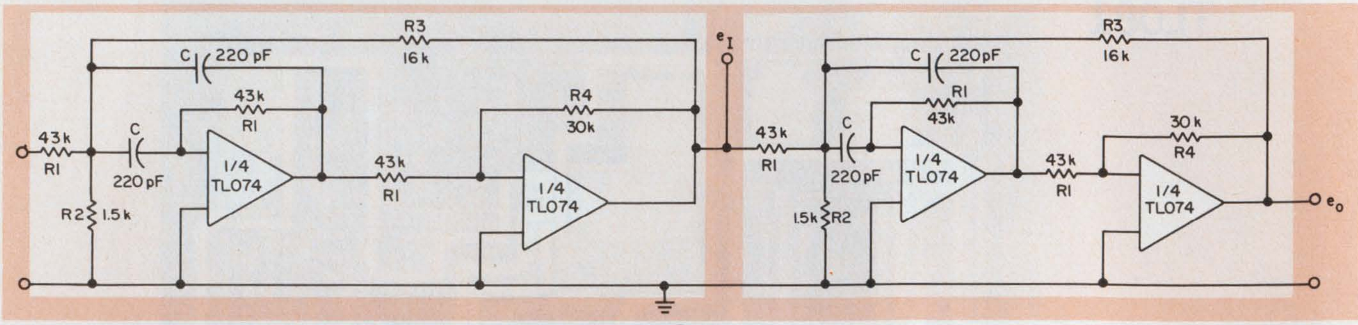
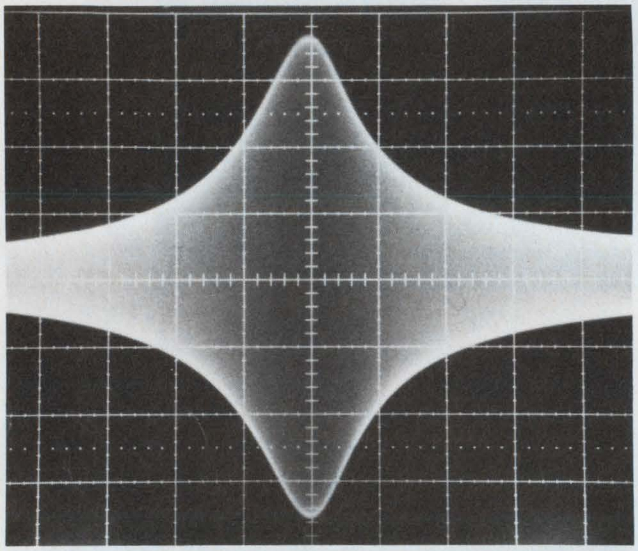
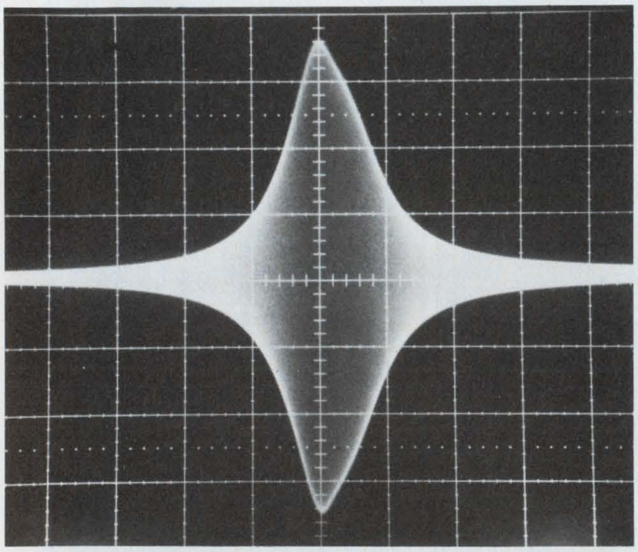


a

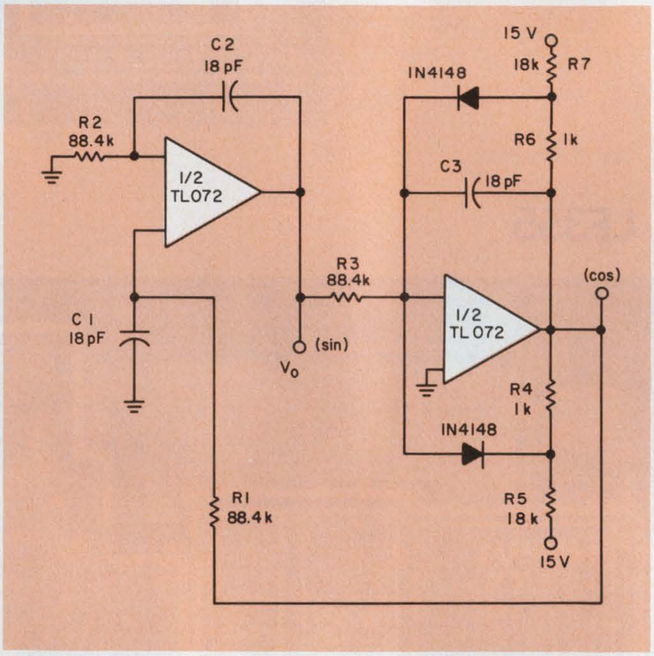


b



c

4. **BIFETs ensure stable operation at 100 kHz** for this cascade of two positive-feedback bandpass filter sections (a). The Q of 30 and the gain of 4 for each section (b) compound into a Q of 69 and a gain of 16 (c).



5. **Stable operation at 100 kHz** from this precision quadrature oscillator is due to the BIFETs. Only R_5 and R_7 must be trimmed for a symmetrical output.

op amps, a quadrature oscillator's frequency would have to stay below 10 kHz. But BIFETs extend this range to over 1 MHz, comfortably.

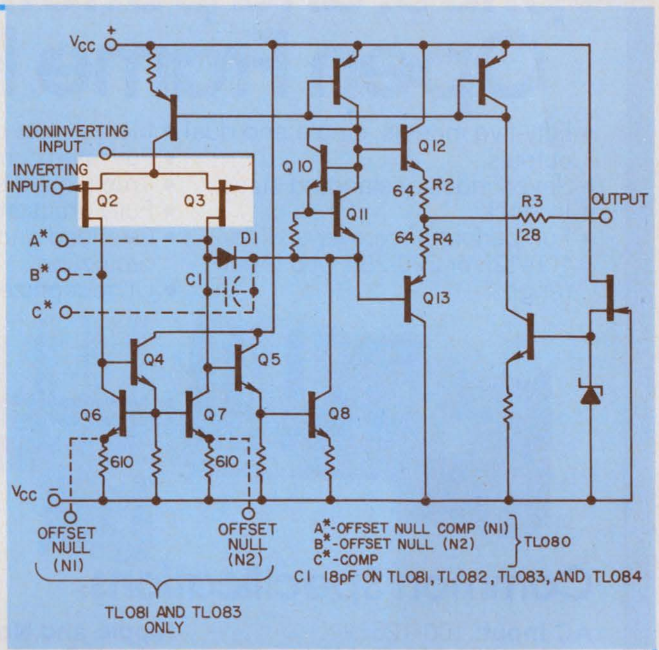
BIFETs keep oscillators steady

The wide bandwidth, high input impedance and slew rate, and low distortion of BIFETs enable the quadrature oscillator in Fig. 5 to operate stably at 100 kHz. A regenerative integrating loop is used to solve for v_o in the following differential equation:

$$\delta^2 \ v_o/(\delta t^2 + \omega_o^2 \ v_o) = 0.$$

The solution is

A typical BIFET circuit



On one chip, BIFET op amps combine high-impedance FET inputs with low-distortion bipolar-output circuitry. The result is performance previously available from hybrid devices only.

Consider TI's TL080 and TL081 (singles), TL082 and TL083 (duals) and TL084 (quad) BIFET op amps. As the family schematic shows, each op amp uses only two FETs—those at the very input. This stinginess minimizes chip size and FET matching. The result—high yields.

As the schematic also shows, the input stage consists of JFETs Q_2 and Q_3, which operate into the active load of Q_4, Q_5, Q_6 and Q_7. Current imbalance and input-offset voltage can be adjusted on the 081 and 082 via connections to the emitters of Q_6 and Q_7. Devices 081 through 084 contain compensation capacitors (C_1). The 080 can be compensated externally.

Each JFET provides 10^{12} Ω of typical input impedance and a high common-mode input-voltage range. Matching the two JFETs results in low input-offset voltage. Also, the JFETs drive the second stage hard enough to get a high pk-pk output voltage and a wide power bandwidth.

The collector of Q_7 drives the second stage. Here the clamp, D_1, across Q_5 and Q_8 prevents saturation of Q_8 and excessive current in Q_5. Bipolars Q_5 and Q_8 form the high-gain second stage. The collector Q_8 drives the output stage consisting of bias transistors Q_{10} and Q_{11} and output drivers Q_{12} and Q_{13}.

Output transistors Q_{12} and Q_{13} get their Class AB bias from Q_{10} and Q_{11}. The result is near-zero crossover distortion and low total-harmonic distortion at the output. The output is protected from short circuits by the R_2, R_3 and R_4 network.

$$v_o = A \sin(\omega_o t + \Theta),$$

in which Θ is the phase angle.

For equal time constants

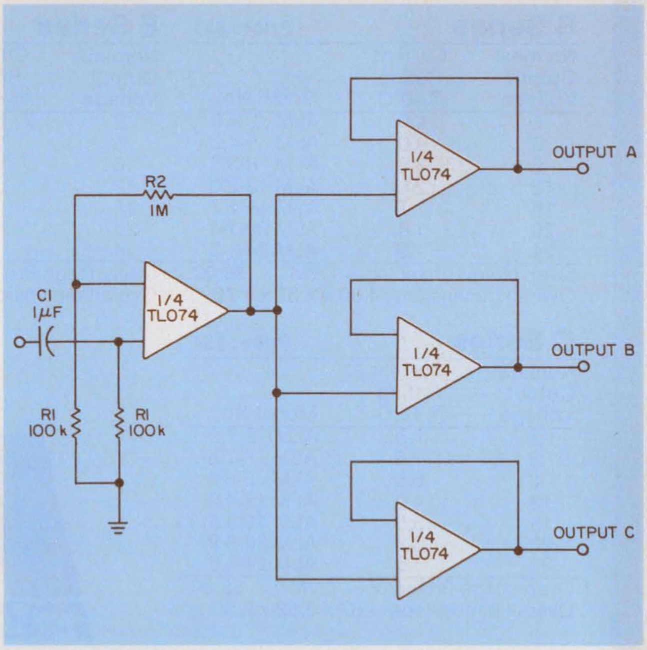
$$(\tau_1 \equiv R_1C_1 = \tau_2 \equiv R_2C_2 = \tau_3 \equiv R_3C_3),$$
$$f_o = 1/(2\pi RC).$$

A tradeoff must be made between amplitude limiting and distortion in this circuit. While the amplitude is limited by making τ_1 greater than τ_2, the difference should be only slight because the mismatch between these time constants also determines the degree of distortion in the output.

Still another circuit that can benefit from BIFETs is an audio-distribution amplifier. Using only one BIFET quad, the audio-distribution amplifier in Fig. 6 boasts a 100-kΩ input impedance, low distortion and flat frequency response over the entire audio range. The BIFET gives this audio circuit the versatility to buffer a microphone input, distribute audio signals throughout a studio or form the heart of an intercom system.■■

Reference

1. Jung, Walter G.; Stephens, Mark L.; and Todd, Craig C., "Slewing Induced Distortion in Audio Amplifiers," *The Audio Amateur*, Peterborough, NH, 1977.



6. **Process audio signals** with 100-kΩ input impedance plus low distortion and noise over the full audio bandwidth, with only one BIFET quad.

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Stability: ±0.2%.

ALM Single Output Units:

A Series — Price: $27

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	1.5	ALM 2-1.5
5	1.5	ALM 5-1.5
6	1.3	ALM 6-1.3
12	0.7	ALM 12-0.7
15	0.7	ALM 15-0.7
20	0.5	ALM 20-0.5
24	0.5	ALM 24-0.5

Overvoltage Protector — OVM-1 $8.00
Overall dimensions: 3.03 x 3.78 x 1.28.

D Series — Price: $72

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	11.0	ALM 2-11
5	11.0	ALM 5-11
6	10.0	ALM 6-10
12	6.0	ALM 12-6
15	5.0	ALM 15-5
20	4.0	ALM 20-4
24	3.8	ALM 24-3.8

Overvoltage Protector — OVM-2 $16.00
Overall dimensions: 4.90 x 7.03 x 2.78

F Series — Price: $106

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	20.0	ALM 2-20.0
5	20.0	ALM 5-20.0
6	17.0	ALM 6-17.0
12	13.0	ALM 12-13.0
15	10.7	ALM 15-10.7
20	9.0	ALM 20-9.0
24	8.2	ALM 24-8.2

Overvoltage Protector — OVM-2 $16.00
Overall dimensions: 4.88 x 4.88 x 13.75

B Series — Price: $31

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	4.0	ALM 2-4.0
5	4.0	ALM 5-4.0
6	3.3	ALM 6-3.3
12	2.0	ALM 12-2.0
15	1.7	ALM 15-1.7
20	1.4	ALM 20-1.4
24	1.3	ALM 24-1.3

Overvoltage Protector — OVM-1 $8.00
Overall dimensions: 4.00 x 4.87 x 1.76

E Series — Price: $88

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	15.0	ALM 2-15.0
5	15.0	ALM 5-15.0
6	12.5	ALM 6-12.5
12	8.8	ALM 12-8.8
15	8.0	ALM 15-8.0
20	7.0	ALM 20-7.0
24	6.5	ALM 24-6.5

Overvoltage Protector — OVM-2 $16.00
Overall dimensions: 4.87 x 9.00 x 2.75

G Series — Price: $128

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	25.0	ALM 2-25.0
5	25.0	ALM 5-25.0
6	23.0	ALM 6-23.0
12	16.0	ALM 12-16.0
15	14.0	ALM 15-14.0
20	11.5	ALM 20-11.5
24	10.5	ALM 24-10.5

Overvoltage Protector — OVM-2 $16.00
Overall dimensions: 4.88 x 4.88 x 16.75

C Series — Price: $54

Nominal Output Voltage	Current Rating @ 40°C.	Model No.
2	7.5	ALM 2-7.5
5	7.5	ALM 5-7.5
6	6.5	ALM 6-6.5
12	4.0	ALM 12-4.0
15	3.5	ALM 15-3.5
20	3.2	ALM 20-3.2
24	3.0	ALM 24-3.0

Overvoltage Protector — OVM-1 $8.00
Overall dimensions: 4.87 x 5.62 x 2.50

ALM Dual Output Units:

Adjust Range	Current Rating @ 40°C.	Model No.	Series	Price
12-15	0.55	ALM 15D-0.55	B	$ 45.00
12-15	1.10	ALM 15D-1.1	C	55.00
12-15	2.20	ALM 15D-2.2	D	68.00
12-15	3.30	ALM 15D-3.3	E	91.00
12-15	4.40	ALM 15D-4.4	F	114.00
12-15	8.00	ALM 15D-8.0	G	136.00

Overvoltage Protector — Two OVM-1 $8.00 Each.

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CIRCLE NUMBER 57

FIXED RESISTORS

Type BB, CB, EB, GB, HB: Hot molded. 1.0 ohm to 100 megs. Tolerance ±5%, 10%, 20%. ⅛W, ¼W, ½W, 1W, 2W at 70°C. Pub. EC21.

Type CC: Cermet film. 10 ohms to 22.1 megs. Tolerance ±0.5 and 1%. TCR ±50 and ±100 PPM/°C. ⅛W at 125°C. ¼W at 70°C. ½W at 70°C. Pub. EC33.

Type FM: Metal film. 20 ohms to 357K ohms. Tolerances from ±1% to ±0.05%. TCR ±25, ±15 and ±10 PPM/°C. ¼W at 70°C. 1/10W at 125°C. Pub. EC54.

RESISTOR NETWORKS

I-DIP: Thick film (Cermet). 10 ohms to 1 meg. Tolerance to ±1%. TCR to ±100 PPM/°C. 542 standards, 14 and 16 pins. Pull-ups, ladders, terminators, O-pads. 18 pin and user trimmable options. Pub. 5840.

Thin Film: Custom packages and chips. Chrome/cobalt film. Tolerance to ±.015%. TCR ±25 PPM/°C. Tracking to ±5 PPM/°C. Ladders, dividers, customs.

POTENTIOMETERS

Type J: $1\frac{5}{32}$" diameter. Hot-molded. 50 ohms to 5.0 megs. 2.25W at 70°C. 100,000 cycle rotational life. Single, dual, triple sections. SPST switch optional. Pub. 5200.

Series 70: ⅝" square MOD POT.® Hot-molded, cermet, conductive plastic. 50 ohms to 10 megohms. 100,000 cycle rotational life. Single, dual, triple, quad sections. Options include switches, vernier drives, concentric shafts. Pub. 5217.

Type G: ½" diameter. Hot-molded composition. 100 ohms to 5.0 megs. 0.5W at 70°C. 50,000 cycle rotational life. SPST switch optional. Many other options. Pub. 5201.

Type M: 10.0 MM (.394") cube. Conductive plastic element. 100 ohms to 1.0 meg. 25,000 cycle rotational life. Single, dual sections. Switches optional. Case, bushing, shaft are non-metallic. Pub. 5239.

TRIMMERS

Type A: ¼" diameter, single turn. 10 ohms to 2.5 megs ±10%, 0.5W at 85°C. Immersion sealed, 6 terminal options. TCR ±35 PPM/°C typical. Pub. 5238.

Type E: ⅜" square, single turn. 10 ohms to 2.5 megs ±10% 0.5W at 70°C. Immersion sealed, 14 terminal options. TCR ±35 PPM/°C typical. Pub. 5219A.

Type D: ⅜" dia., single turn. 10 ohms to 2.5 megs ±20%, 0.5W at 70°C. Dust cover, 8 terminal options. TCR ±35 PPM/°C typical. Pub. 5240.

Type RT: ¾" long, 20 turn. 10 ohms to 2.5 megs ±10%, 1.0W at 40°C. Immersion sealed, 4 terminal options. TCR ±35 PPM/°C typical. Pub. 5237.

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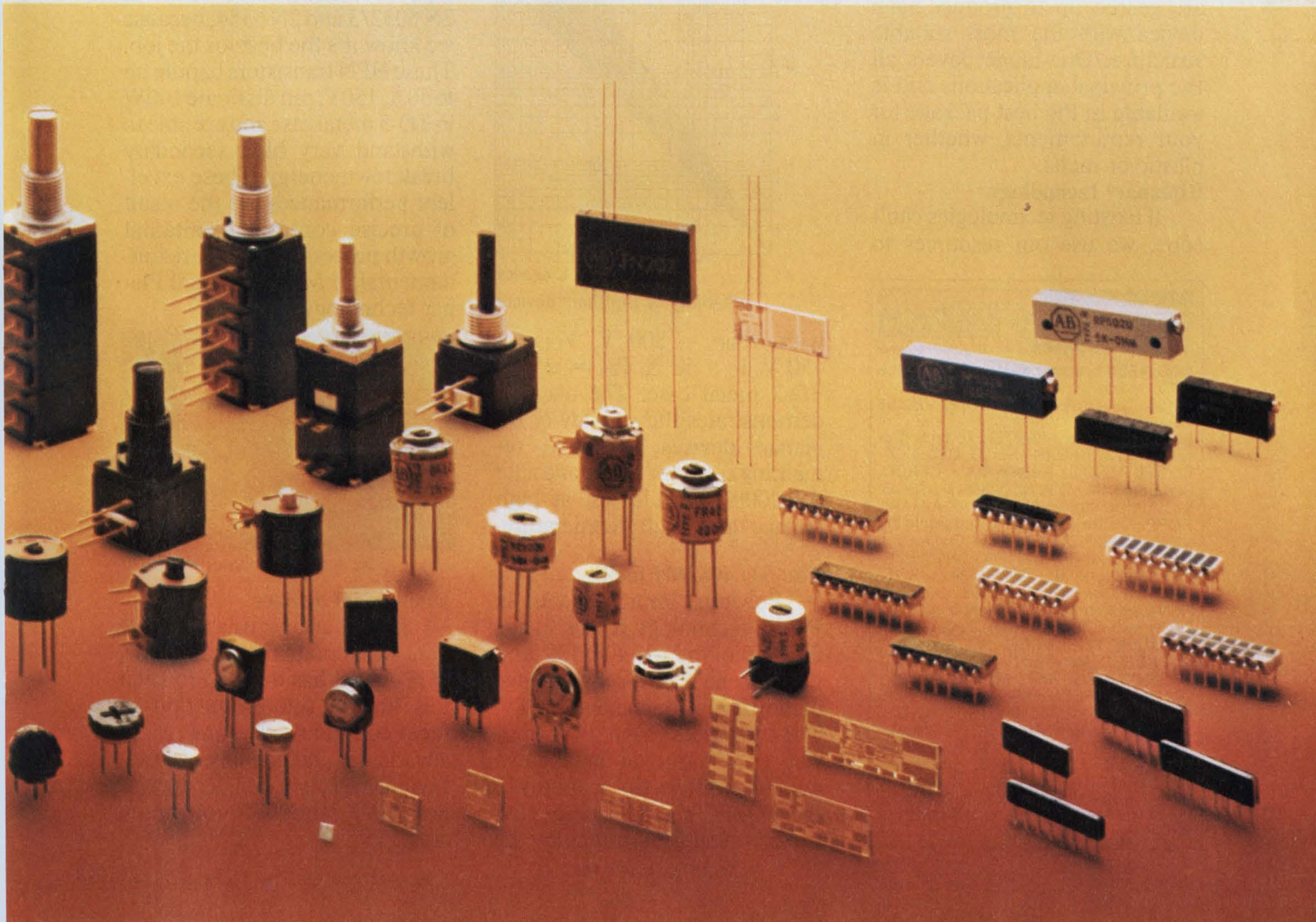
EC168



SPECIAL ISSUE JOURNAL OF SEMICONDUCTOR PROGRESS

PLANAR NEWS

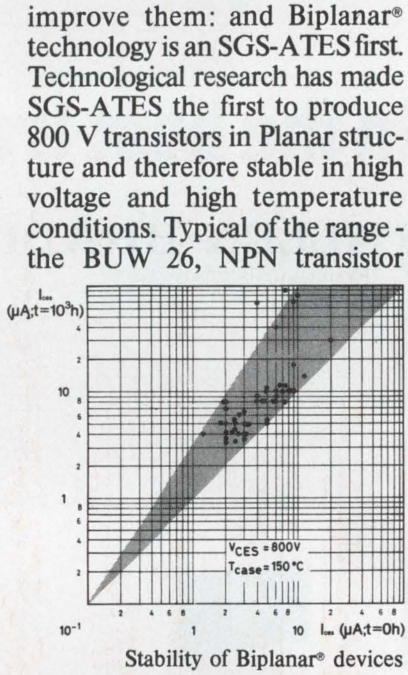
FROM SGS-ATES

Discrete power devices: SGS-ATES announces a comprehensive range of more than 200 types of Darlingtons and transistors.

SGS-ATES, through research, investment, and experience, has accumulated a wealth of technological know-how in the field of discrete power devices. By having at our disposal such technologies as Multi-epitaxial Biplanar® HV, Multi-epitaxial Planar, Epitaxial Planar, Epitaxial base, and Hometaxial, we are geared up to produce each device with the most suitable structure. Our range covers all the principal applications and is available in the best package for your requirements, whether in plastic or metal.

Biplanar® technology

If existing technologies can't cope, we use our resources to improve them: and Biplanar® technology is an SGS-ATES first. Technological research has made SGS-ATES the first to produce 800 V transistors in Planar structure and therefore stable in high voltage and high temperature conditions. Typical of the range - the BUW 26, NPN transistor



Stability of Biplanar® devices

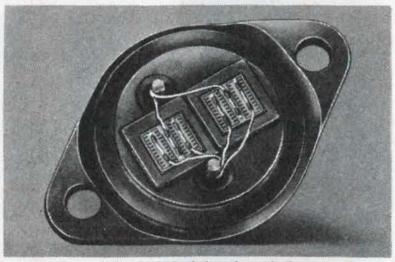
with V_{CBO} = 800 V, V_{CEO} = 450 V, I_C = 10 A, P_{tot} = 125 W, TO-3 metal case. The diagram demonstrates the stability of Biplanar® devices, with I_{CES} remaining constant before and after the 1000-hour life test at high voltage and high temperature.

The BU 406/409 family

Previous improvements in Planar technology led us to the creation of the BU 406/409 family, Europe's best-selling range of horizontal deflectors for TV. These devices have high resistance to flashover breakdown and, in addition, the economy of the TO-220 plastic package, the use of which is permitted by the surface passivation intrinsic in Planar technology. Versions with integrated damper diodes are also available, together with equivalent types in TO-3 metal case (BU 606/608).

Multi-epitaxial Planar devices

Despite the simpler alternatives, we use Planar structure for types 2N 5038/9, 2N 5671/2, 2N 6032/3 and 2N 6354, because we know it's the best for the job. These NPN transistors handle up to 50A, 150V, can dissipate 140W in TO-3 metal case and are able to withstand very high secondary breakdown energy. These excellent performances are the result of precise control of epitaxial growth processes, which are fundamental to Multi-epitaxial Planar technology.

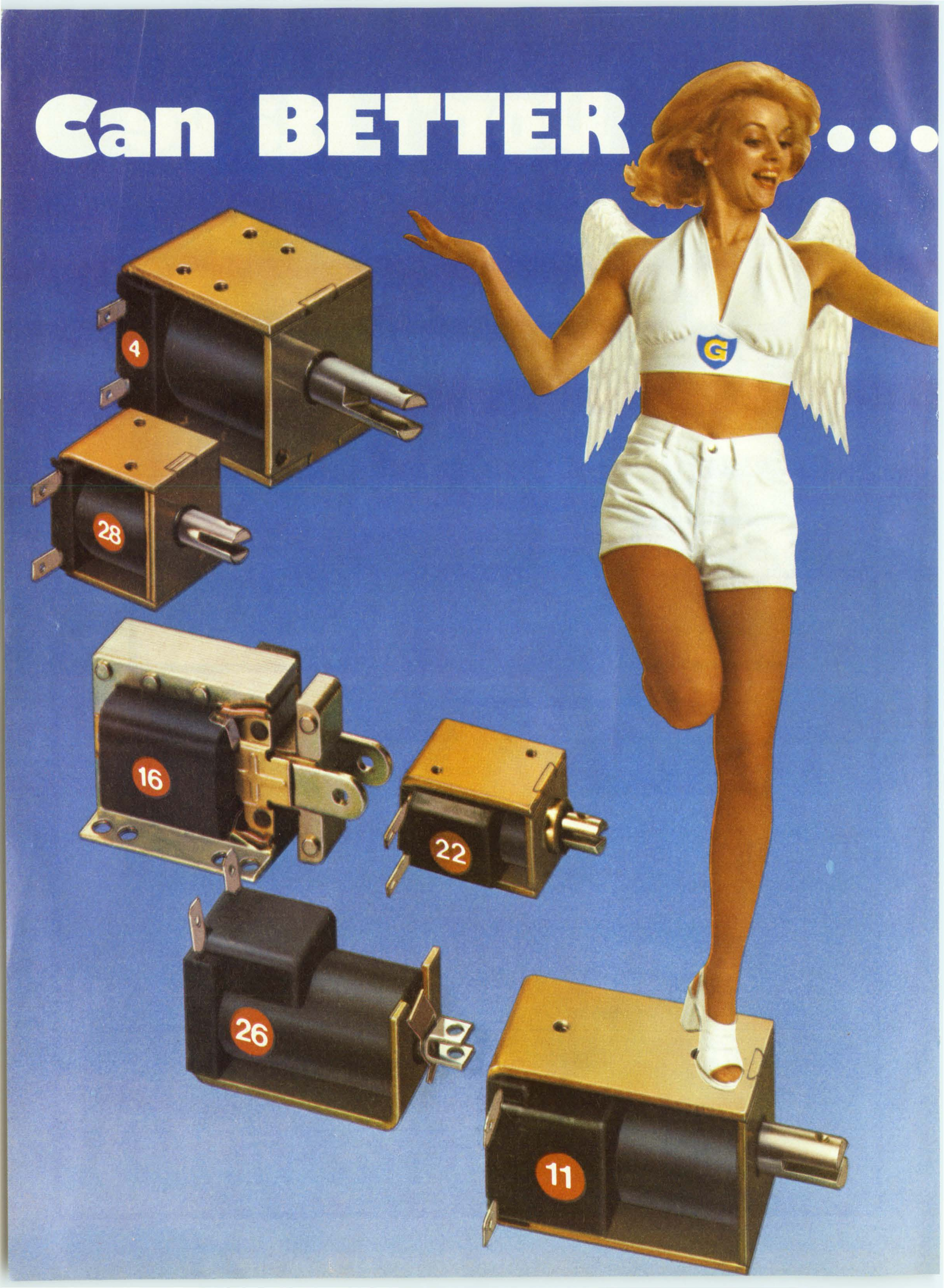


50 A Multiepitaxial transistor

Hometaxial devices

Always an enthusiastic exponent of Hometaxial technology, SGS-ATES has decided to keep this line in full production to meet continuing demand. Main advantages include low saturation voltage, very high ruggedness and large safe operating area.

CIRCLE NUMBER 167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Guardian Number	Overall Dimensions	Coil Voltage	Duty	Power Ratings @ 25°C. Minimum Stroke	Maximum Stroke
4 No. 4 Box Frame	2 1/16" x 1 7/16" x 1 5/8"	12J AC	Inter.	36 oz. at 1/8"	26 oz. at 1"
		120 AC	Cont.	8 oz. at 1/8"	7 oz. at 1"
		24 DC	Inter.	115 oz. at 1/8"	16 oz. at 1"
		24 DC	Cont.	63 oz. at 1/8"	6 oz. at 7/8"
11 No. 11 Box Frame	1 7/8" x 15/16" x 1 3/16"	120 AC	Inter.	21 oz. at 1/8"	11 oz. at 3/4"
		120 AC	Cont.	12 oz. at 1/8"	6 oz. at 3/4"
		24 DC	Inter.	40 oz. at 1/8"	6 oz. at 3/4"
		24 DC	Cont.	24 oz. at 1/8"	3 oz. at 3/4"
16 No. 16 Laminated	1 5/8" x 1 1/4" x 1 1/2"	120 AC	Inter.	110 oz. at 1/8"	28 oz. at 3/4"
		120 AC	Cont.	63 oz. at 1/8"	15 oz. at 3/4"
22 No. 22 Box Frame	1 5/32" x 3/4" x 3/4"	120 AC	Inter.	20 oz. at 1/16"	2 oz. at 3/8"
		120 AC	Cont.	12 oz. at 1/16"	1.7 oz. at 3/8"
		24 DC	Inter.	20 oz. at 1/16"	2 oz. at 3/8"
		24 DC	Cont.	12 oz. at 1/16"	1.7 oz. at 3/8"
26 No. 26 U-Frame	1 3/4" x 27/32" x 1 3/16"	120 AC	Inter.	32 oz. at 1/16"	4 oz. at 7/8"
		120 AC	Cont.	17 oz. at 1/16"	6 oz. at 5/8"
		24 DC	Inter.	46 oz. at 1/16"	4 oz. at 3/4"
		24 DC	Cont.	26 oz. at 1/16"	3 oz. at 1/2"
28 No. 28 Box Frame	1 1/8" x 1 7/32" x 1 3/16"	120 AC	Inter.	40 oz. at 1/16"	7 oz. at 1/2"
		120 AC	Cont.	24 oz. at 1/16"	5 oz. at 1/2"
		24DC	Inter.	40 oz. at 1/16"	3 oz. at 1/2"
		24DC	Cont.	25 oz. at 1/16"	2 oz. at 1/2"

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CIRCLE NUMBER 169

Yup. PMI's Howard Autry is **it.** There are lots of **Managers** of Quality Assurance, but Howard's the only VP we know of.

That tells you something about how strongly PMI feels about quality. But there's more in it for you than quality alone.

Howard can save you a bundle.

When somebody keeps stressing that they make higher-quality parts, you might get the impression that what they make is more expensive. Not true, in PMI's case. Our prices are competitive. You get the extra quality as a bonus. And you wind up paying a lot less. Here's why.

Not long ago, NASA made the statement that it costs 100 times the purchase price of a part to reject it. And if you think about it, that's pretty realistic. You have to identify the system problem, track down the faulty component, remove it, replace it, return it. You lose production time, troubleshooting time, administrative time and maybe your cool. It could wind up costing field service and warranty time, too.

Obviously, at that rate, parts that are more likely to break down are never a bargain. And that's where Howard Autry comes in.

Howard is paid to be fussy. When we recognized the importance of his function and elevated him to Vice President of Quality Assurance to give him greater clout, we already had a low reject rate. It was 3.2%. Howard has since cut that rate to less than .5%. (The estimated industry average is 5.0%).

Got your calculator handy? Suppose you bought a thousand IC's at $1.00 apiece and got 5% rejects. Using NASA's numbers, the rejects cost you $5000. But even if your costs are a tenth NASA's, what would you save by buying the IC from PMI at the **same price**—with a **tenth** the rejects?

Now, Howard may be lonely when the VP/QA club meets. And he often finds himself taking an unpopular stand at company meetings. But he usually wins the big arguments. Our customers love him. And he likes being a vice president.

Who knows? He may start a whole new trend.

If you'd like to know how he does it, send Howard a request on your letterhead for our QA Program documentation. Address it to VP, QA, Silicon Valley, USA. There's only one.

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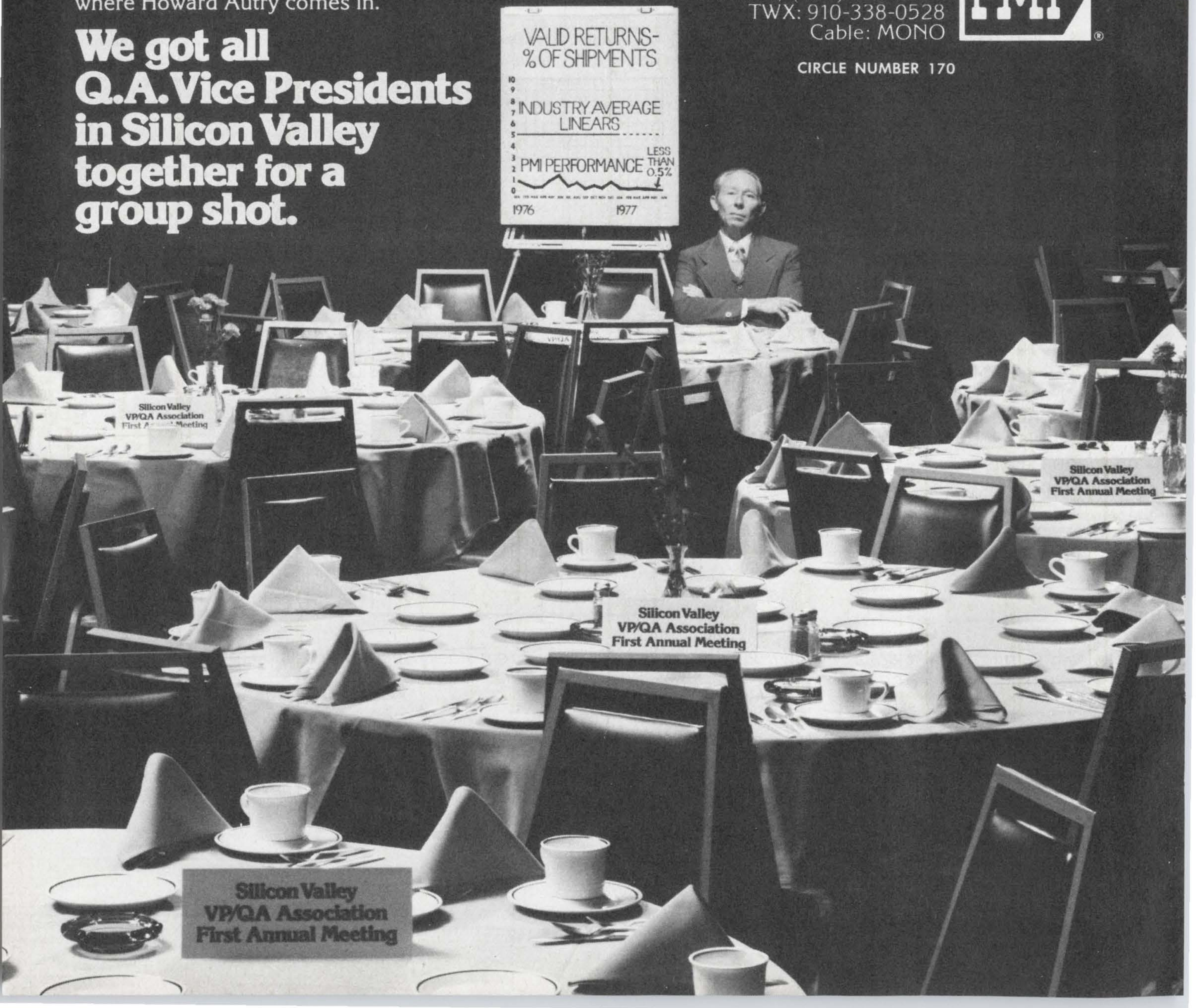
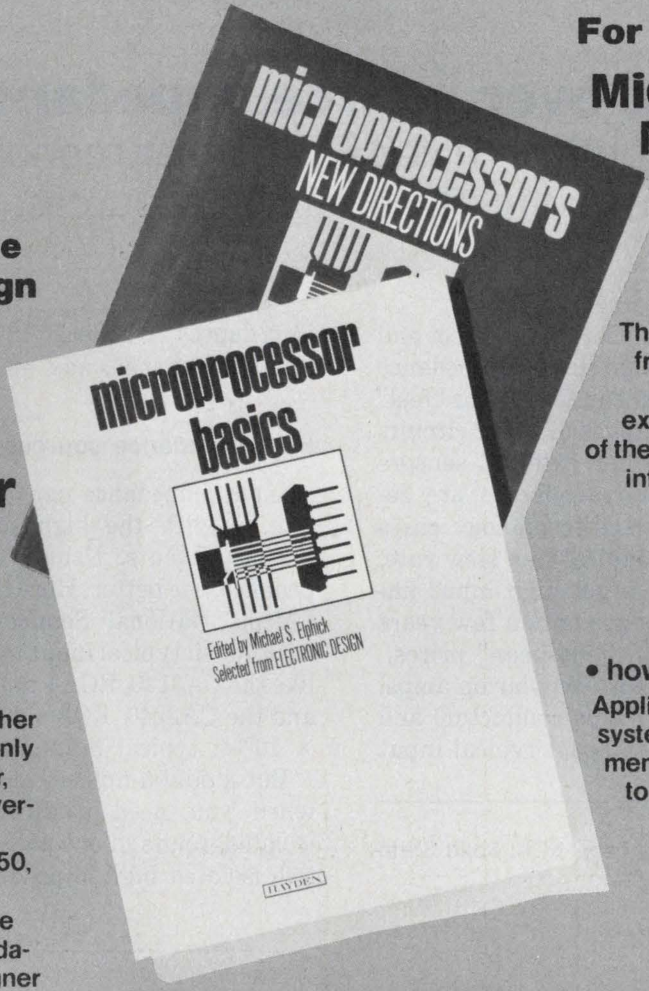
CIRCLE NUMBER 170

We got all Q.A. Vice Presidents in Silicon Valley together for a group shot.



More than just the ABC's...



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77-44

Don't stumble over source impedance.

High-impedance inputs of mixed FET-bipolar monolithic op amps mate circuits directly to sensitive sources.

Monolithic op amps containing both field-effect and bipolar devices provide the high input impedance needed by a class of circuits that can "touch" or "feel" their environment. The input stages of these circuits often double as sensors. But when external sensors are needed, only the simplest transducers are required. What's more, these mixed-technology chips don't sacrifice other op-amp qualities like slew rate, bandwidth, offsets and drifts to get high input impedance. And even though they are only a few years old, these op amps now sell at "jelly-bean" prices.

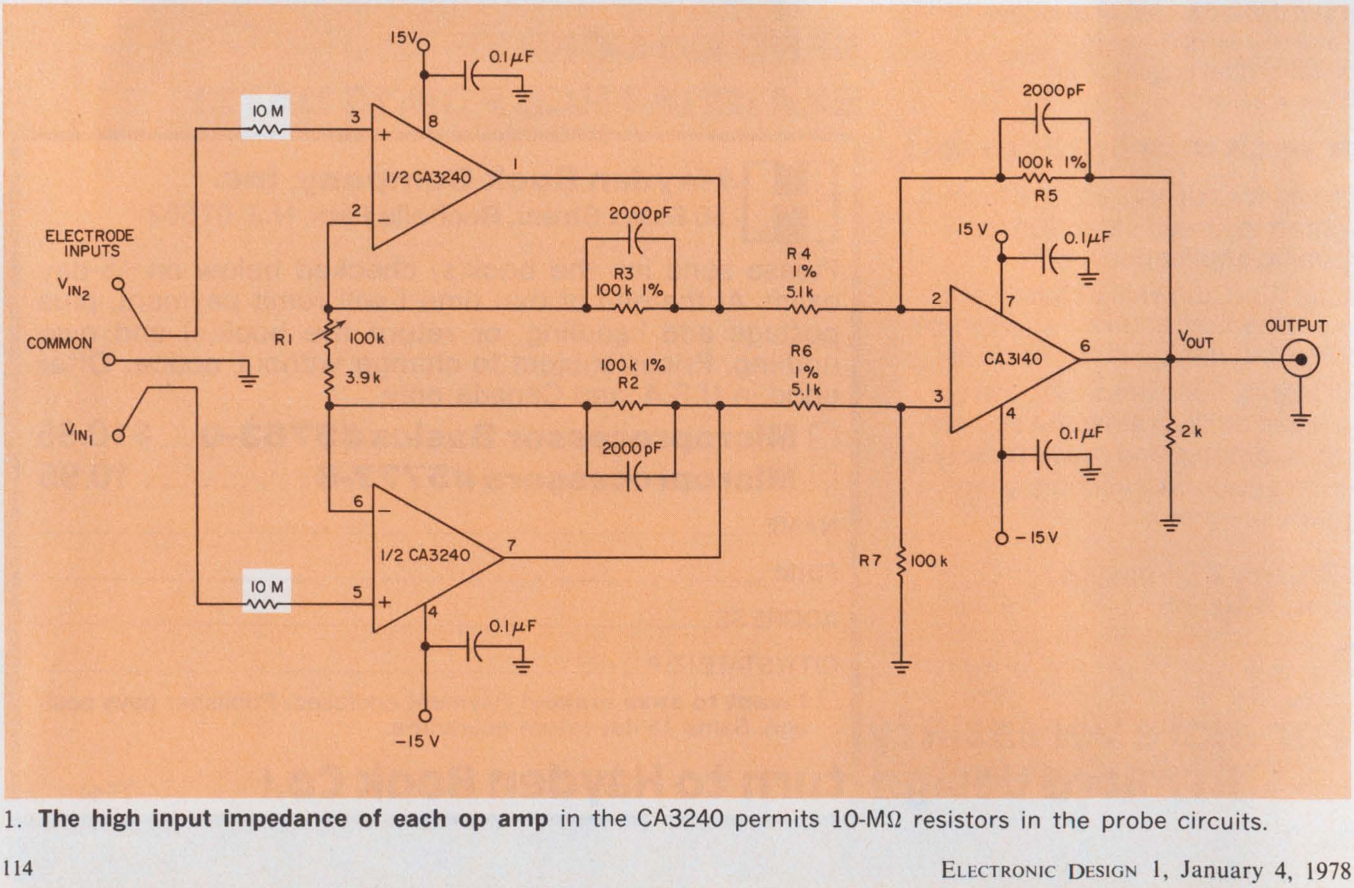
The two types of single-chip FET-bipolar op amps, BiFETs (from TI and National Semiconductor) and BiMOS (from Intersil and RCA), boast typical input impedances of at least 10^9 Ω (see table). So, for high input impedance, any op amp in the table will do.

Robert D. Baird, Applications Engineer, RCA, Solid State Div., Somerville, NJ 08876.

High-impedance sources can't resist

Input impedance can be critical, especially when mating with the high source impedance of many physical events. Usually the higher the input impedance, the better. Here the standouts are the BiFET LM356, National Semiconductor's single amplifier with 10^{12}-Ω typical input impedance, or BiMOS devices like the CA3140, RCA's and Intersil's single amplifier, and the CA3240, RCA's dual amplifier. Both have 1.5×10^{12}-Ω typical input impedances.

But a dual-amplifier chip offers an additional plus when you need a differential-input circuit—two isolated inputs in one package. One circuit that needs two isolated high-impedance inputs is a differential



1. **The high input impedance of each op amp** in the CA3240 permits 10-MΩ resistors in the probe circuits.

amplifier for biomedical instrumentation (Fig. 1).

A biomedical amplifier needs a high impedance to match the source impedance of bioelectric events. In addition, the test subject must be protected against the hazard or even the discomfort stemming from excessive input current.

In Fig. 1, BiMOS input buffers are used in an otherwise conventional instrumentation amp. Because the CA3240's input current is only 50 pA max, you can use 10-MΩ resistors in series with the input probes. Even under a fault condition, these resistors limit current to 2 μA. In addition, because the input current is so low, the effective input-offset voltage is low—even when the contact resistance of the electrodes is noticeably unequal.

To minimize hum and other noise pickup, the circuit must have a high common-mode-rejection ratio. So, match the following critical resistor pairs by using 1% resistors: R_2 and R_3, R_4 and R_6, R_5 and R_7.

With the resistors matched, compute the differential gain from

$$V_{out} = (V_{in1} - V_{in2})\ (1 + 2\ R_3/R_1)\ (R_5/R_4).$$

With an oscilloscope, the biomedical amplifier in Fig. 1 produces electrocardiograms. The electrodes have been placed with V_{in1} at the left side of a human chest, V_{in2} at the center, and Common at the left ankle.

A typical display for such an instrument is shown in Fig. 2. This waveform reflects a total sensitivity, including the scope, of 1 mV/div for which the differential gain of the instrumentation amp is set, via R_1, at approximately 40 dB.

Even water passes enough current

Another circuit that uses the high input impedance of BiMOS op amps, a dual liquid-level detector, is shown in Fig. 3. Most liquids, including tap water, have enough ions in solution to conduct a slight current. Measuring this current, though, does demand high input impedance.

The ion current passes through either of two metalized-grid sensors, which can be etched on PC boards or deposited on glass wafers. When liquid covers either sensor, current produced by an applied 0.5 V flows between the immersed grid's two poles and shifts the output voltage of one of the CA3240's op amps. The voltage shift equals the product of the grid current and the feedback resistance.

Because the op amp's input current is low, even the minuscule current passing through the sensor can be processed in a conventional current-to-voltage converter. With a 12-MΩ feedback resistor, just 1 μA of sensor current changes the converter's output as much as 10 to 12 V.

This 10 to 12-V swing is the input to the second stage. Here, the converter outputs combine so that the indicator LED is off when the liquid covers the lower but not the upper sensor. When the liquid covers neither or both of the sensors, the LED goes on.

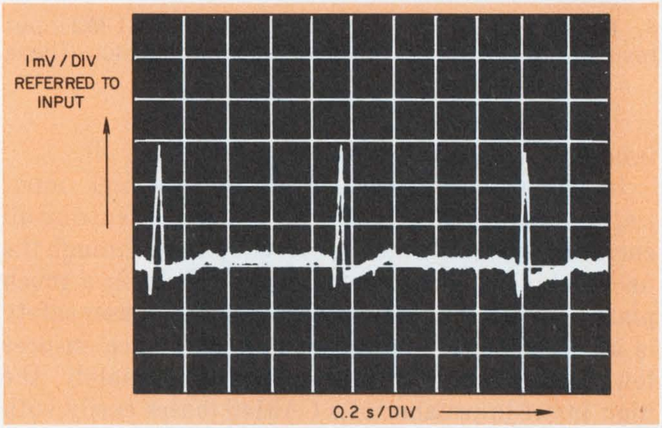
With appropriate relays or triacs, the third and final stage can control pumps that raise or lower the liquid. To reduce the response time of the PC-type sensors, prevent liquid from soaking into the board by coating the spaces between the grids with wax. Because the input impedance is so high, even the little water that a PC board absorbs will have an effect.

Let your fingers do the conducting

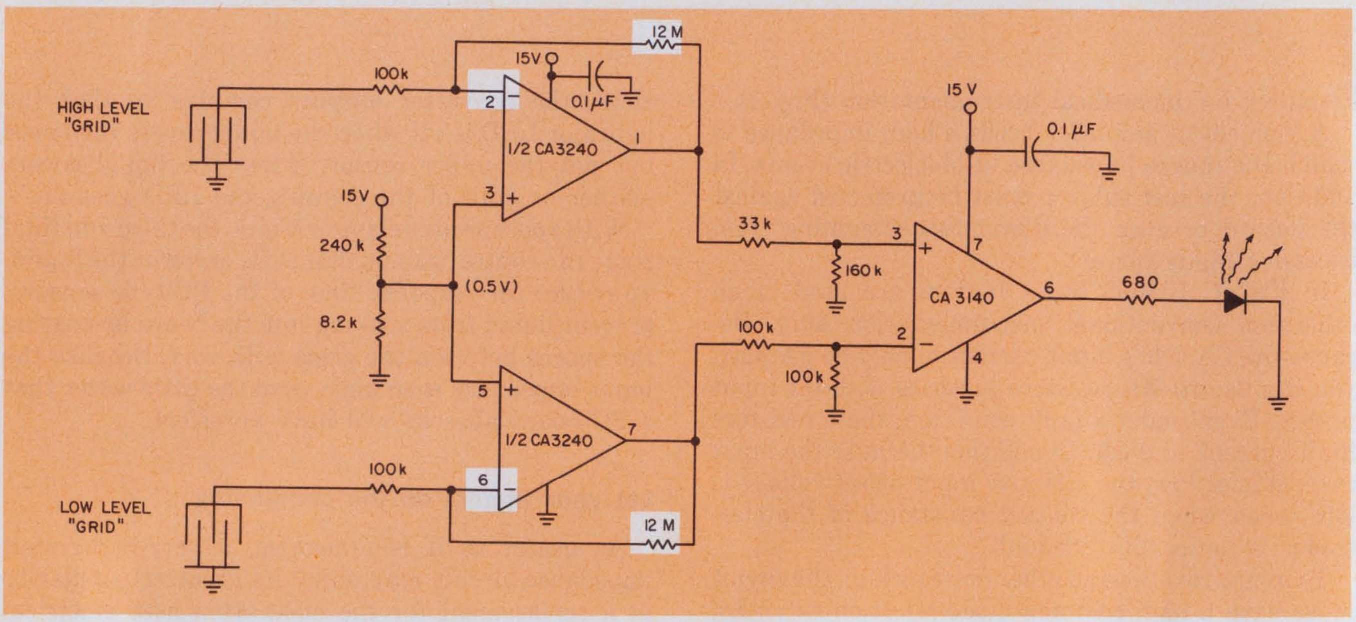
As useful as it is otherwise, a very-high input impedance circuit may enjoy its greatest popularity as a replacement for the most often used electrical component—the simple switch. Besides user appeal stemming from its almost magical operation, a non-mechanical switch would solve the reliability problem

Input impedances of mixed-technology monolithic operational amplifiers

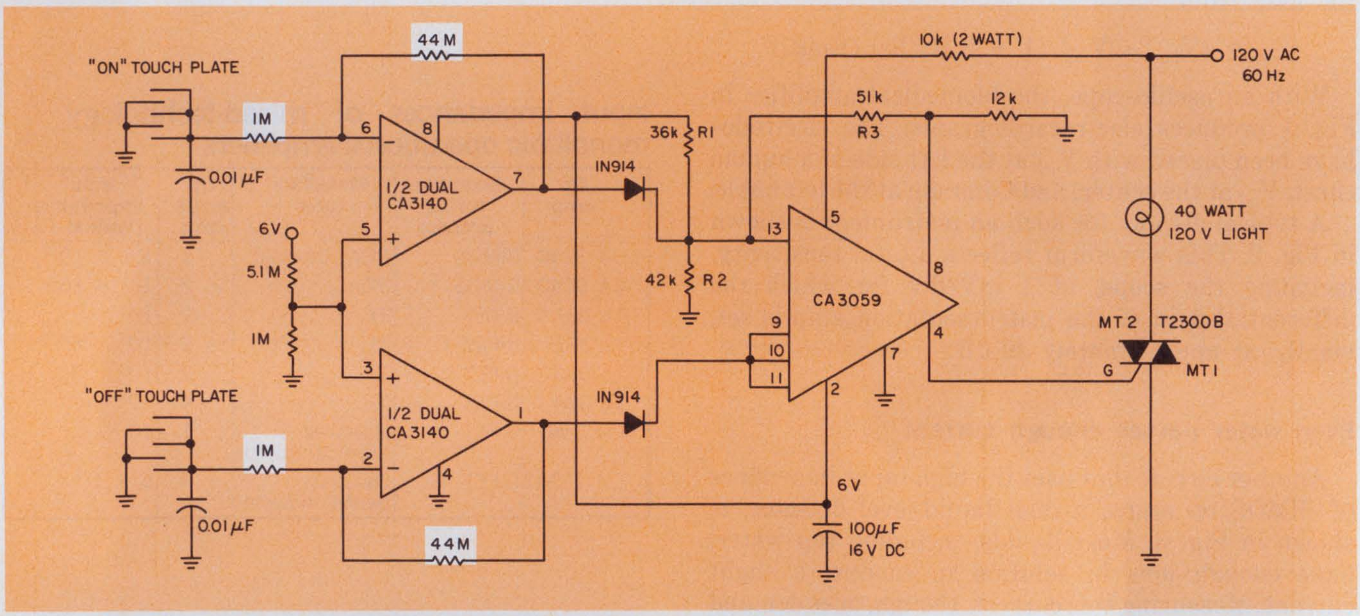
Op amp	Manufacturing process	Manufacturer	Op amps /pkg	Input impedance (typical Ω)
CA 3140	BiMOS	RCA, Intersil	1	1.5×10^{12}
CA 3240	BiMOS	RCA	2	1.5×10^{12}
TL 081	BiFET	TI	1	10^9
TL 082	BiFET	TI	2	10^9
TL 083	BiFET	TI	2	10^9
TL 084	BiFET	TI	4	10^9
LM 356	BiFET	National Semiconductor	1	10^{12}
LM 13741	BiFET	National Semiconductor	4	5×10^{11}



2. **This electrocardiogram's low "grass" and hum** levels result from matching resistors in the circuit of Fig. 1 for a high common-mode rejection ratio.



3. **In a liquid-level sensing system,** high feedback resistances yield the required high gain.



4. **The op amp's high input impedance allows 1-MΩ** input resistors to be used in this nonmechanical switch. These resistors in turn limit the shock hazard as well as the current that passes through the skin of the user.

inherent with moving parts once and for all.

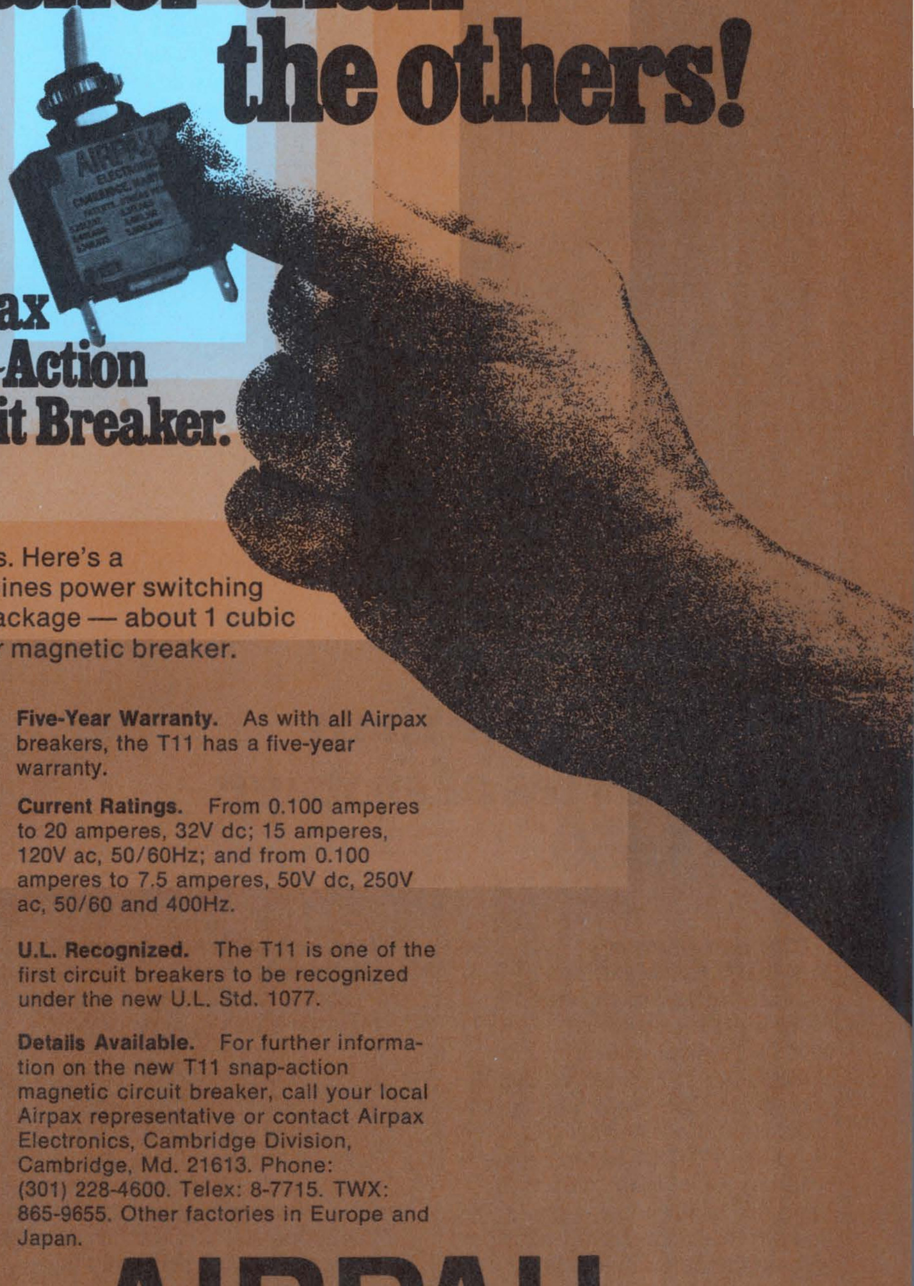
In the switch circuit of Fig. 4, the high input impedance of the CA3240 is again used to sense small currents. But this time the current passes through the user's skin when he contacts two points on a touch plate. As with the biomedical amp in Fig. 1, user safety is all important. And again high resistance ensures low current and shock protection. Fortunately, the high input impedance of a CA3140 mates easily with the megohm resistance needed.

The input stages for the On and Off touch plates are inverting amps. The resistors determine the output swing. With the resistance values in Fig. 4, a completed circuit at the input swings the output to the positive rail. Each positive transition actuates the CA3059 zero-voltage switch, used here as a latching circuit and zero-crossing triac driver.

A positive pulse on pin 7 of the CA3240 causes the triac to conduct. The triac is then held in conduction by the CA3059 and its associated positive feedback circuit consisting of R_1, R_2 and R_3. A pulse at pin 1 of the CA3240 turns off the triac. Note that the power supply, internal to the CA3059, also supplies the CA3240.■■

NOW

A magnetic circuit breaker smaller than the others!



Airpax T11 Snap-Action Magnetic Circuit Breaker.

Just think of the design possibilities. Here's a magnetic circuit breaker that combines power switching and circuit protection in one tiny package — about 1 cubic inch! That's smaller than any other magnetic breaker.

Smaller Price Tag, Too. With all its advantages, the T11 sells for under \$5.00 in small quantities. And, of course, the price goes down even further as the quantity increases.

Replaces Three Conventional Components. The T11 does the job of a power switch, fuse, and fuse holder — all in one tiny package — with immediate resetability. In addition, it can be operated at either dc or 50/60Hz, eliminating the need to specify, order, and stock separate units.

Patented Snap-Action. The T11 is the only small magnetic circuit breaker with snap-action for immediate and positive opening or closing of the contacts. This snap-action results in an increase in operational life of up to 5 times that previously available. It also eliminates possible operator "teasing" of the contacts and minimizes arcing.

Enhances Panel Appearance. With a choice of six attractive handle colors and a variety of mounting hardware, the T11 blends well into any panel color scheme and layout.

Five-Year Warranty. As with all Airpax breakers, the T11 has a five-year warranty.

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CIRCLE NUMBER 60

Implement ALUs with functional blocks

to get high-speed systems. With 20-pin Schottky circuits, you can tailor your design for the speed or cost you want.

By building an arithmetic logic unit (ALU) with arithmetic functional blocks, you can choose schemes to satisfy almost any speed requirement of digital systems. High-speed performance of ALU systems depends greatly on how you perform arithmetic operations. In low-speed applications ripple-carry-type adders can perform acceptably. But high-speed applications require more sophisticated methods. With arithmetic functional blocks, you can choose not only ripple-carry but also carry-lookahead or a combination of those schemes.

While a 4-bit microprocessor slice is often the more economical way to implement an ALU function, system requirements may compel you to build your ALU one step at a time. Arithmetic functional blocks, made with low-power Schottky technology, have the speed of bipolar devices but dissipate much less power. And their slim 20-pin packages occupy less than half the PC-board area of older 24-pin Schottky ALUs.

Start with simple adders

The most basic device within an arithmetic functional block is the full adder. This well-known circuit adds together three binary-input bits—two individual operand bits of the same binary weight and a carry bit from the next less significant adder circuit. Adding the three bits produces a sum bit, S, and a carry bit, Co, to be fed forward to the next more significant full-adder carry input. The full-adder truth table is shown in Fig. 1. From it emerge the familiar logic equations for the sum and carry terms:

$$S = A \oplus B \oplus C \quad (1)$$

$$Co = AB + BC + AC, \quad (2)$$

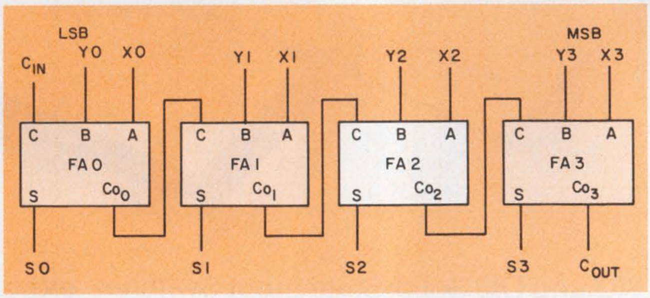
where S is the sum output, Co is the carry output, A and B are the operand inputs, and C is the carry input.

To add together larger numbers of operand bits, additional full adders can be interconnected to form a ripple-carry adder. For example, four adders are cascaded to form the 4-bit, ripple-carry full adder shown in Fig. 2. Here, FA_0 represents the least-significant-bit (LSB) adder, and FA_3 the most-significant bit (MSB) adder. Note that the sum-output bit of any full adder (S_2, for example) depends not only on the values of that adder's operand bits (X_2, Y_2), but also on the values of the less-significant-operand bits (X_0, Y_0 and X_1, Y_1), because of their possible carry outputs (Co_0 and Co_1).

Ripple-carry adders are slow because all the final sum bits are unavailable until the carries, from LSB to MSB, have rippled through the entire chain. When you design a 16-bit, ripple-carry full adder, propagation delays will build up since the carries must ripple through all 16 adder devices. Therefore, you would like to be able to anticipate a carry, so that you don't have to wait for it to propagate through the chain. With

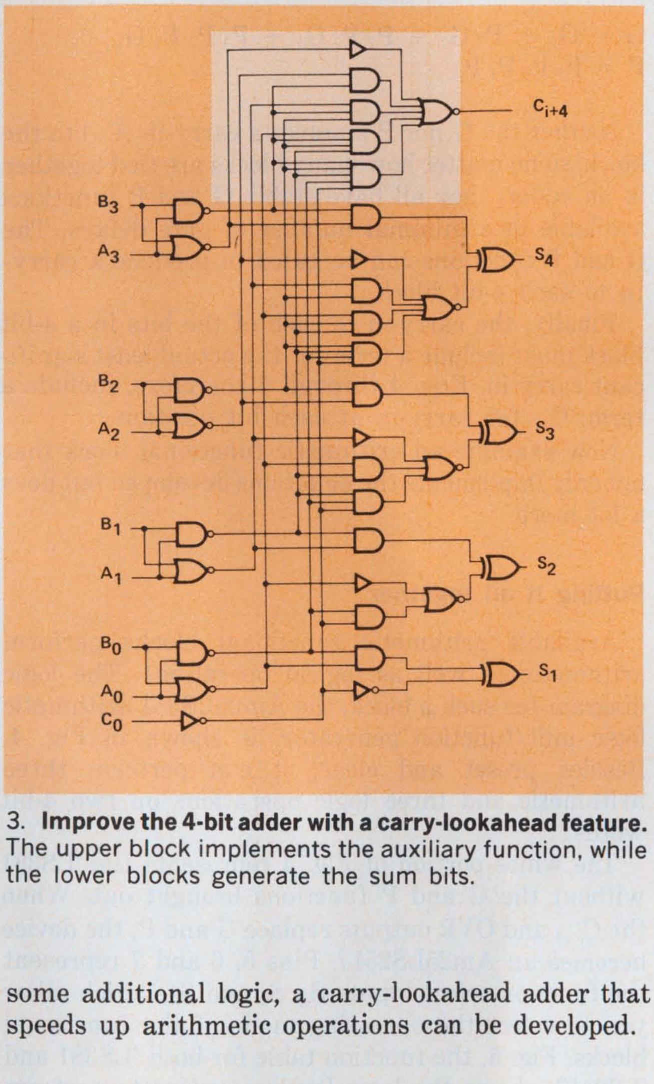
INPUTS			OUTPUTS	
A	B	C	S	Co
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

1. **Sum and carry-logic equations are generated** from this truth table for a full adder.



2. **Four-bit, ripple-carry full adders are slow** because carries from LSB to MSB take time to ripple through.

John R. Mick, Manager, Digital Applications, Advanced Micro Devices, 901 Thompson Place, Sunnyvale, CA 94086.



3. **Improve the 4-bit adder with a carry-lookahead feature.** The upper block implements the auxiliary function, while the lower blocks generate the sum bits.

some additional logic, a carry-lookahead adder that speeds up arithmetic operations can be developed.

Lookahead with functional blocks

ALU functional blocks can operate with a carry-lookahead generator to perform multilevel full carry-lookahead over any number of bits. But the block must be able to generate the necessary signals when a carry is anticipated. So, a lookahead feature should be built-in. For this purpose, carry-generate and carry-propagate signals are provided by the arithmetic functional block.

Defining the carry-generate (G_i) and carry-propagate (P_i) terms takes you back to the carry-out term for a full adder. Assuming that you're dealing with the i[th] adder in an arbitrarily long chain, the carry-out from Eq. 2 can be written as

$$C_{i+i} = A_i B_i + B_i C_i + A_i C_i,$$

after the C_i term is factored out,

$$C_{i+i} = A_i B_i + C_i (A_i + B_i).$$

Now you can define the carry-generate term:

$$G_i = A_i B_i,$$

and the carry-propagate term:

$$P_i = A_i + B_i.$$

Both G_i and P_i are called auxiliary functions. By implementing them, an anticipated carry can be provided at any stage of an adder. If G_i is true, a carry is immediately produced for the following adder stage. If P_i is true, there will be a carry into the next adder stage if there is a carry into the one you're looking at. Substituting the G_i and P_i terms in Eq. 3 gives

$$C_{i+1} = G_i + P_i C_i.$$

Since the carry equation can be written in terms of G_i and P_i, use these terms in the sum equation. From Eq. 1, the i[th] bit-adder sum term is:

$$S_i = A_i \oplus B_i \oplus C_i.$$

or,

$$S_i = (A_i + B_i)(\overline{A_i B_i}) \oplus C_i = P_i \overline{G_i} \oplus C_i$$

Now you can write all sum and carry equations for a 4-bit carry-lookahead adder in terms of input variables A_i, B_i and C_i:

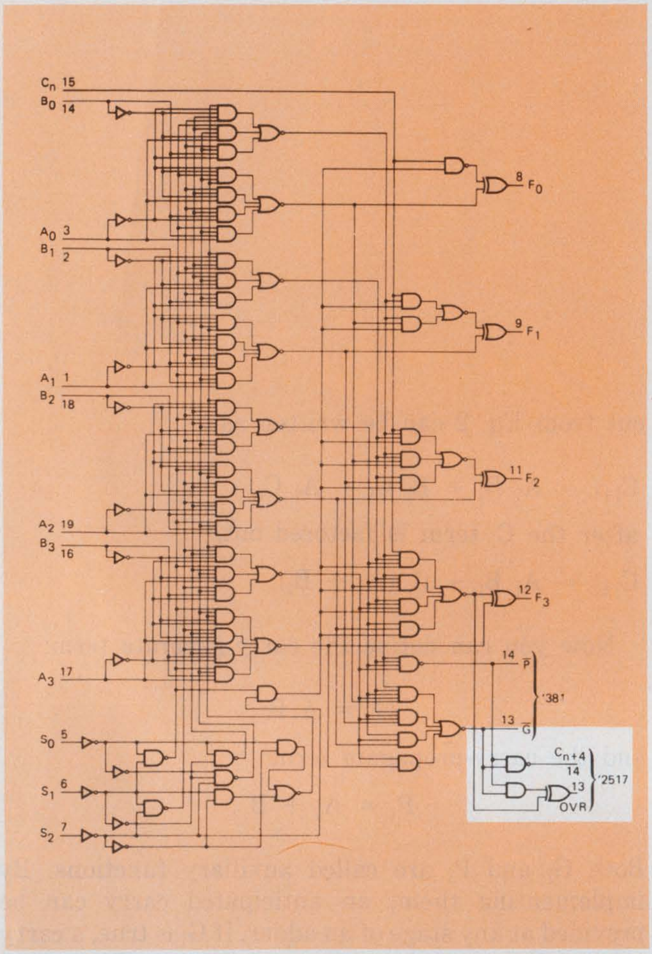
$$S_o = A_o \oplus B_o \oplus C_o \quad (4)$$

$$S_1 = A_1 \oplus B_1 \oplus (G_o + P_o C_o) \quad (5)$$

$$S_2 = A_2 \oplus B_2 \oplus (G_1 + P_1 G_o + P_1 P_o C_o) \quad (6)$$

$$S_3 = A_3 \oplus B_3 \oplus (G_2 + P_2 G_1 + P_2 P_1 G_0 + P_2 P_1 P_0 C_0) \quad (7)$$

$$C_{n+1} = G_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 G_0 + P_3 P_2 P_1 P_0 C_0 \quad (8)$$



4. **Outputs determine how the Am25LS381/Am25LS2517 is used.** The highlighted portion is the Am25LS2517 configuration, which can be used for ripple-carry applications either between blocks or over block groups.

SELECTION S2	S1	S0	ARITHMETIC/ LOGIC OPERATION
L	L	L	CLEAR
L	L	H	B MINUS A
L	H	L	A MINUS B
L	H	H	A PLUS B
H	L	L	$A \oplus B$
H	L	H	A + B
H	H	L	AB
H	H	H	PRESET

H = HIGH LEVEL, L = LOW LEVEL

5. **This table applies to both the Am25LS381 and Am25LS2517 configurations.** Eight different functions are provided by the functional block in Fig. 4.

Fig. 3 shows an implementation of Eqs. 4 through 8. Note that the number of terms in Eq. 8 can become very large if the world length is longer than four bits. Eventually, this term becomes difficult to implement because of the large number of interconnections and heavy loading of the G_i and P_i functions.

However, you can solve this problem by dividing the word into increments of four bits. For a 4-bit block, G can be defined as the carry-out generated with the block and P, the carry-propagate over the block. Then the auxiliary functions for this block can be defined by the two equations.

$$G = G_3 + P_3 G_2 + P_3 P_2 G_1 + P_3 P_2 P_1 G_o$$
$$P = P_3 P_2 P_1 P_o$$

Neither the G nor P involves a carry-in (Co) to the block, so no matter how many blocks are tied together in an adder, they all have stable G and P functions available in a minimal number of gate delays. The G and P functions can be gated to produce a carry-in to each 4-bit block.

Finally, the carry-in to each of the bits in a 4-bit block must include a term for the actual least significant carry-in. Eqs. 4 through 8 therefore, include a term, C_o, for carry-in at each bit position.

Now examine an arithmetic functional block that not only implements the equations developed but does a lot more.

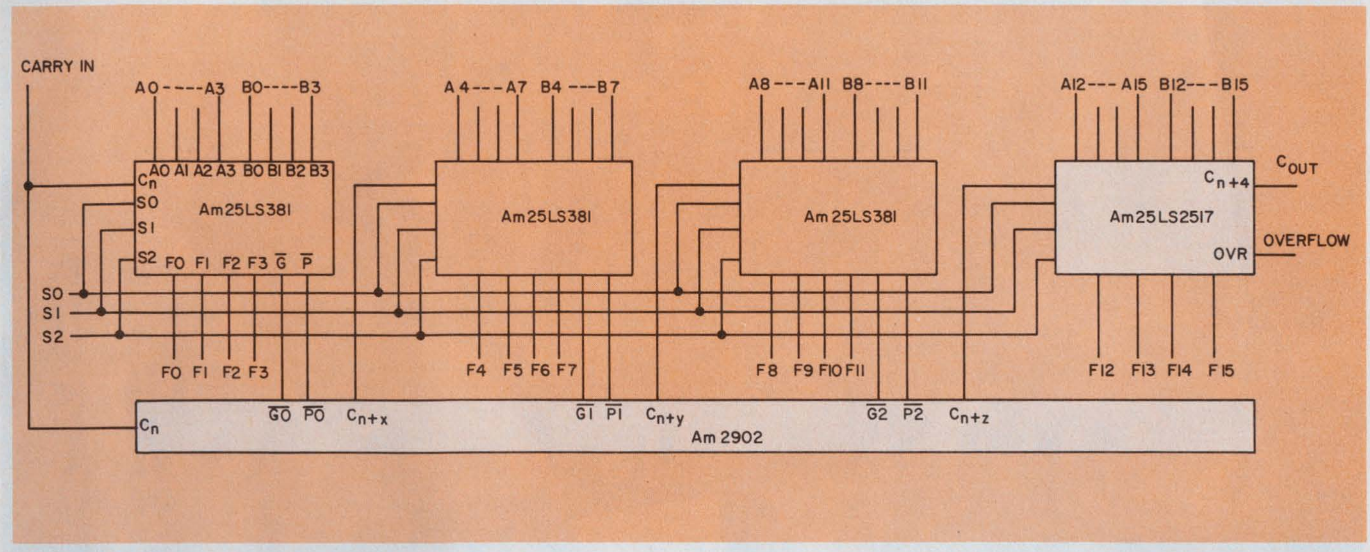
Putting it all together

Available arithmetic functional blocks perform arithmetic as well as logical operations. The logic diagram for such a block, the Am25LS381 arithmetic logic unit/function generator, is shown in Fig. 4. Besides preset and clear, it can perform three arithmetic and three logic operations on two 4-bit words.

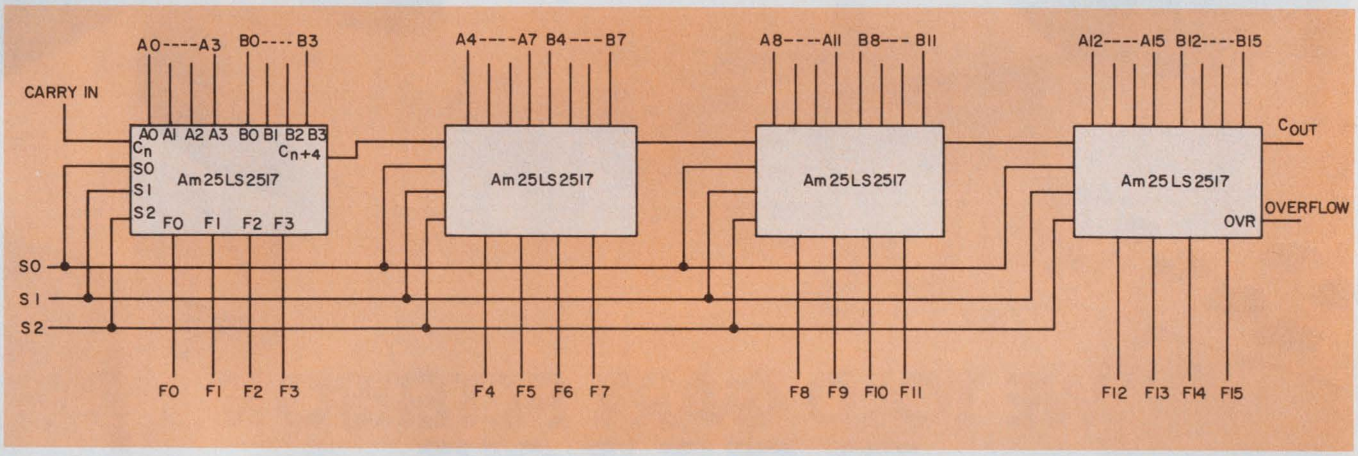
The white portion of Fig. 4 represents the 'LS381 without the G and P functions brought out. When the C_{n+4} and OVR outputs replace G and P, the device becomes an Am25LS2517. Pins 5, 6 and 7 represent the function-select inputs S_o, S_1 and S_2, which allow you to select the operating mode of the functional blocks. Fig. 5, the function table for both 'LS381 and 'LS2417, shows the logic levels required to perform any of the three arithmetic or three logical functions.

Full carry-lookahead is used over the 4-bit field within the functional blocks themselves. And when 'LS381 units are cascaded, the G and P functions can be fed to an Am2902 high-speed look-ahead-carry generator.

A full lookahead-carry, 16-bit adder/subtractor is shown in Fig. 6, using the '2902 lookahead-carry generator. Carry-in from the next-less significant-adder block is supplied to the LSB device. Carry-out to the next-more-significant-adder block is available from the output of the 'LS2517 MSB adder. (An 'LS2517 is used in the MSB position since a ripple-



6. **High-speed arithmetic is achieved** by using a lookahead carry generator such as the Am2902 with arithmetic functional blocks in a 16-bit configuration. Ripple-carry is used between 16-bit blocks.



7. **Ripple-carry 16-bit adders are slow,** but they do cut down the amount of hardware needed. They may be fine for low-speed applications where cost is important. Carry-lookahead is used in each Am25LS2517 block.

carry scheme is assumed between 16-bit blocks.)

This 16-bit adder is a high-speed system, since full-carry lookahead is performed within each adder device and also over the 16-bit block. Even more lookahead over even larger blocks is possible since the '2902 itself has G and P outputs that can be fed forward to higher-order stages. Remember also that the function-select lines are available to program in whatever arithmetic or logic function you need.

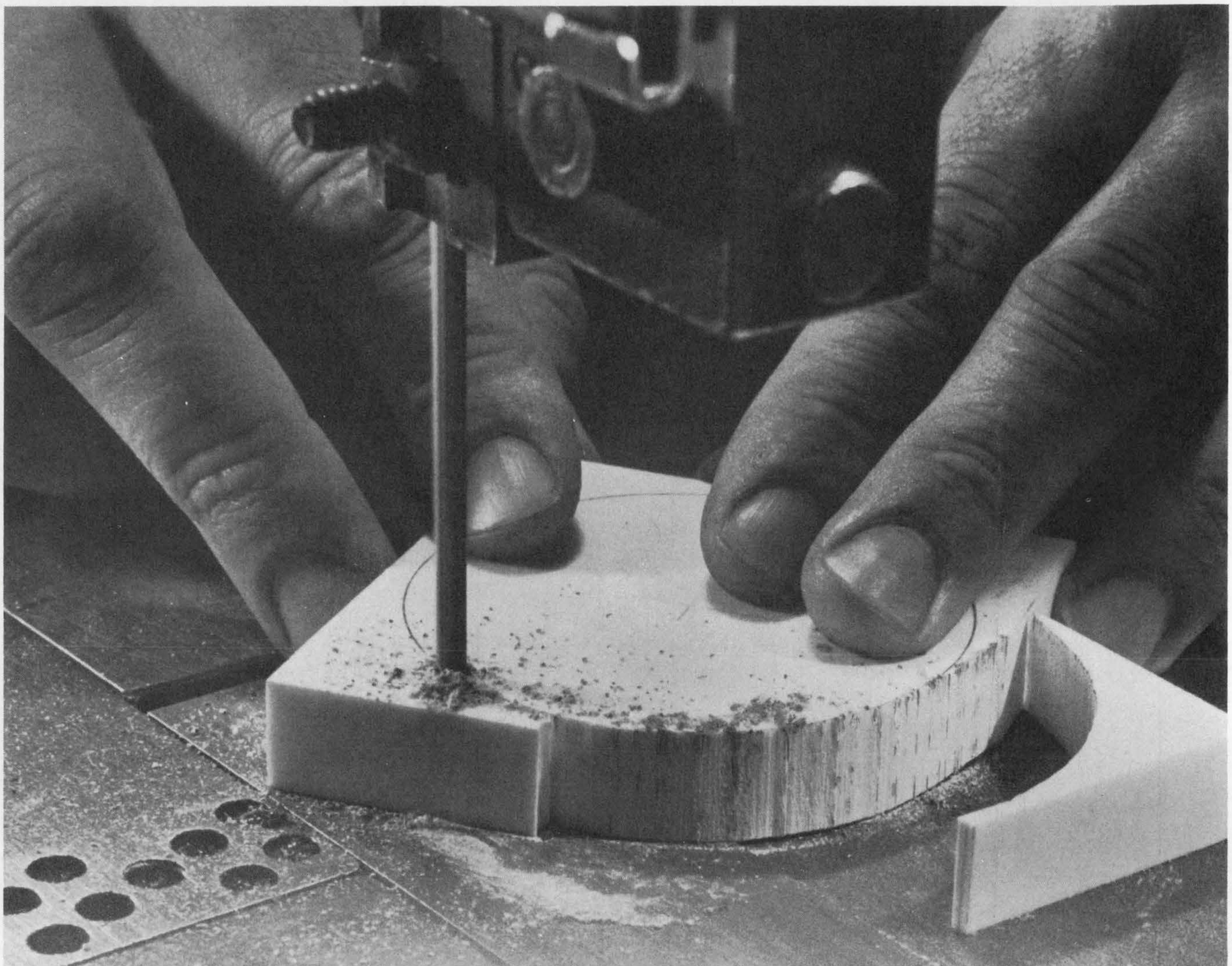
Of course, you may not always need a very high-speed system. In that case, refer to Fig. 7, which is a 16-bit adder using only ripple-carry between the blocks. Carry-lookahead is still performed over each 4-bit adder, since the 'LS2517 and 'LS381 both have that internal capability. But this system is slower than that of Fig. 6 because only ripple carry is used from block to block. Notice that the 'LS2517 is used for all the adder blocks in this system—it has the C_{n+4} output available to provide ripple-carry between adders.

The ripple-carry method, then, can be used with the lookahead technique in two ways:

1. Lookahead-carry over sections of the adder and ripple-carry between those sections can be used for lower-speed applications (Fig. 7). Since a lookahead-carry generator is not required, this method is often the most efficient in terms of hardware.

2. Lookahead-carry across 16-bit blocks with ripple-carry between 16-bit blocks produces high-speed arithmetic (Fig. 6). This technique, called two-level carry-lookahead addition, results in a reasonable tradeoff between speed and hardware for word lengths greater than 16 bits.

The *highest*-speed ALU uses full lookahead-carry across all block levels, and all block sizes can be used. For word sizes up to 64 bits, this lookahead-carry is referred to as three-level lookahead-carry addition. It requires the most hardware, but this is the price you pay for very high-speed performance. ■■



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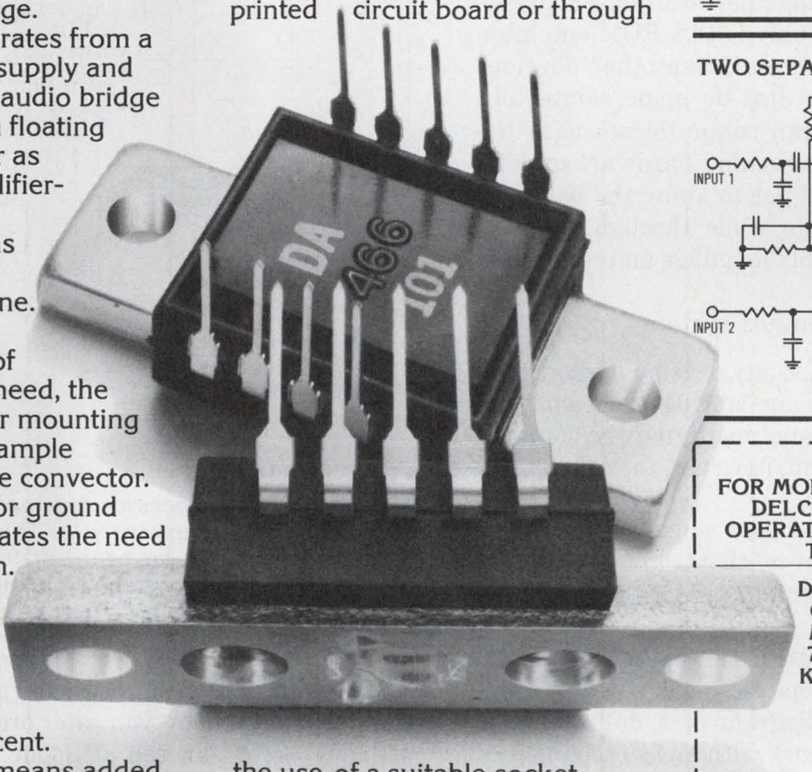

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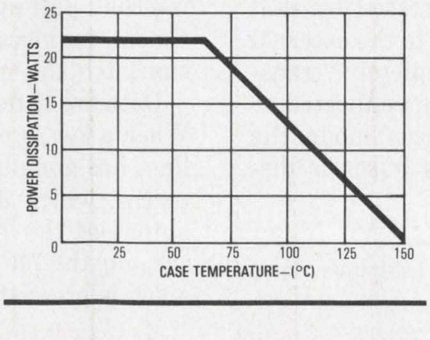

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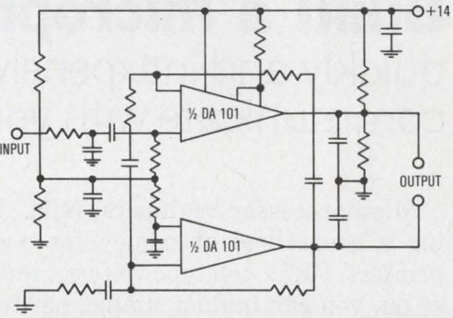

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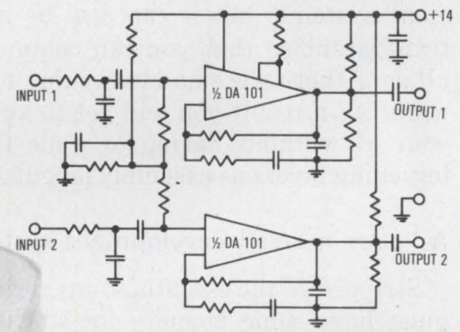

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A "poor man's" development system

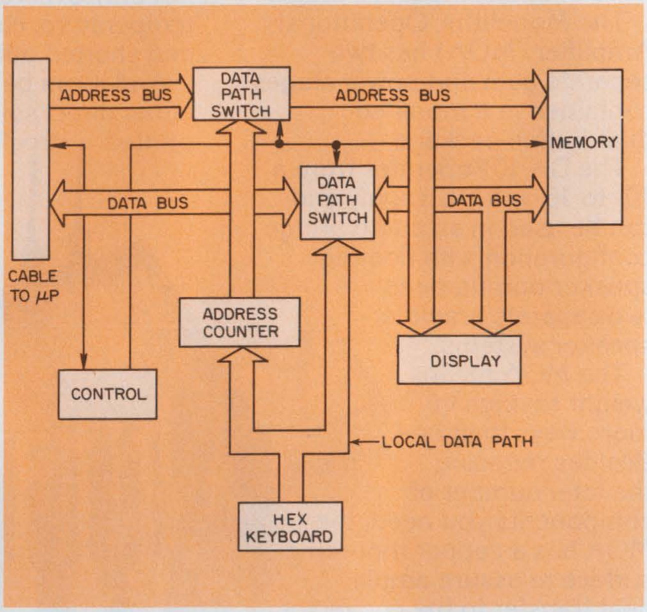
Stripped to the essentials, any development system must have some memory for storing programs and some means for entering and modifying the contents of that memory. In addition, however, there are a few necessary "luxuries";

- Some kind of display to show addresses in memory and the data contained at those addresses.
- A convenient hexadecimal keyboard for entering the data or programs.
- Some circuitry to control the operation of the μP (make it run, halt, step, etc.)

Fig. 1 shows a block diagram of a do-it-yourself ROM emulator that will work with MOS Technology's 6502 microprocessor. With some fairly simple modifications it can be used with other μPs. The system includes the three "luxuries." The main elements are address and data buses that lead to and from the local memory (1-k × 8). These buses can be connected by means of data-path selectors to an external μP or to an internal keyboard source (manual mode).

When the buses are connected to the keyboard, you can use the keyboard first to load a number into the address counters, then to write a data or program word into the portion of memory accessed by that address. When the buses are connected to the external μP (μP mode), the device becomes completely "transparent"—the μP knows only that it is connected to a memory containing programs. In either mode, the information on the data and address buses is displayed.

Dr. William Wilke, Instrument Designer, Tektronix, Inc., Beaverton, OR 97077



1. **A simple microprocessor development system** can be built quickly and inexpensively. The memory connects either to an internal keyboard or to an external μP. In either mode, the information on the address and data buses is displayed on a simple, calculator-like display.

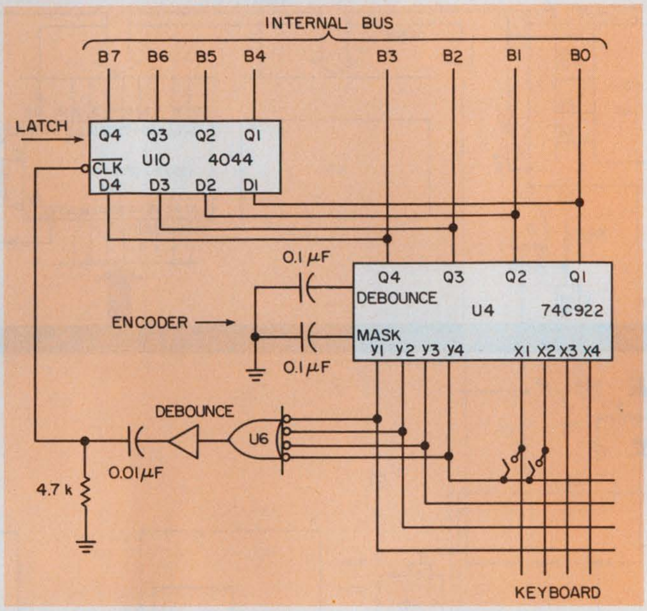
A control section is also shown in Fig. 1. In the manual mode, it helps you enter programs quickly and with few errors. In the μP mode, it permits you to operate the μP at full speed or in any of several step modes for debugging.

Filling in the blocks

To decrease errors and to speed operation, data and addresses are entered by means of a hex keyboard, rather than by individual binary switches. The keyboard is wired as a 4 × 4 matrix and is encoded by a 74C922 circuit (Fig. 2). This versatile chip has internal pull-ups and internal scan and debounce timers, requires no diodes in the switch matrix, and can latch the most recent entry.

Data are entered one hex digit (four bits) at a time. When a key is pressed, U_6 senses that one of the row lines has gone Low. Immediately, a pulse is sent out to U_{10}, which latches the digit being stored at the output of the 74C922. Due to an internal debounce scheme, the 74C922 waits for a millisecond or so after a key is pressed before it encodes and stores the new number. Thus, what U_{10} sees and stores is the digit entered before the present keyboard entry. In other words, if you were to observe the internal bus (where B_0 through B_3 are the outputs of the 74C922 and B_4 through B_7 are the outputs of the latch), and were to start with zeros in both devices, the following sequence would occur:

Immediately after a new digit is received—say, 7—the original 0 from the low-order four bits of the internal bus is transferred to the high-order four bits.



2. **The internal bus, B_0 to B_7,** is the source of data and addresses while the memory is being loaded.

Several milliseconds later, the number 7 appears on the low-order bits, and 07 on the bus. If a second entry—say, F—is made, then first the 7 is transferred to the high-order bits, then the F appears in the low-order bits, with 7F appearing on the bus.

The eight bits of the internal bus are routed to several places. One destination is the path selector that controls the data lines (Fig. 1). The output of this path selector goes to the memory. One set of path-selector inputs connects to the internal bus (for loading the memory) while its other set of inputs connects, via ribbon cables, to an external micro for actual program running. The path selector is built from analog switches (CMOS 4053s) to permit bidirectional data flow (reading and writing). Using this capability, you could allow the μP to access a portion of the 1-k memory to be used as RAM. However, this feature has not been implemented in the present system since it would involve some modification of the Write line.

The internal bus also goes to the "jam" inputs of an 8-bit presettable counter (Fig. 3). The outputs of this counter form the lower eight bits of an address code. To transfer the pair of hex digits on the internal bus to the counter, pulse the Load-Address button.

Once an address is entered, it can be incremented one count at a time by circuitry that pulses the clock line of the counter. Higher-order address bits (the exact number depending on memory size) are not entered via the keyboard but by means of slide switches. This method isn't inconvenient since the slide switches have to be changed only when going from one memory "page" (256 words) to another.

The outputs of the counter and the switches appear together at the inputs of another data selector whose other inputs come via the ribbon cable from the address lines of the external μP. The outputs of this data selector go to the memory and display. Both the data and address-path selectors are controlled by a μP/Local switch.

The eight bits of the data bus and the 16 bits of the address bus are displayed as two and four-digit hex numbers, respectively. The display for the development system is multiplexed to save power and costs a mere $5. These displays, intended for calculators, are eight or nine digits long, typically. So you can use digits 1 and 2 for data, skip digits 3 and 4, then use digits 5, 6, 7, and 8 for addresses.

Running in manual mode

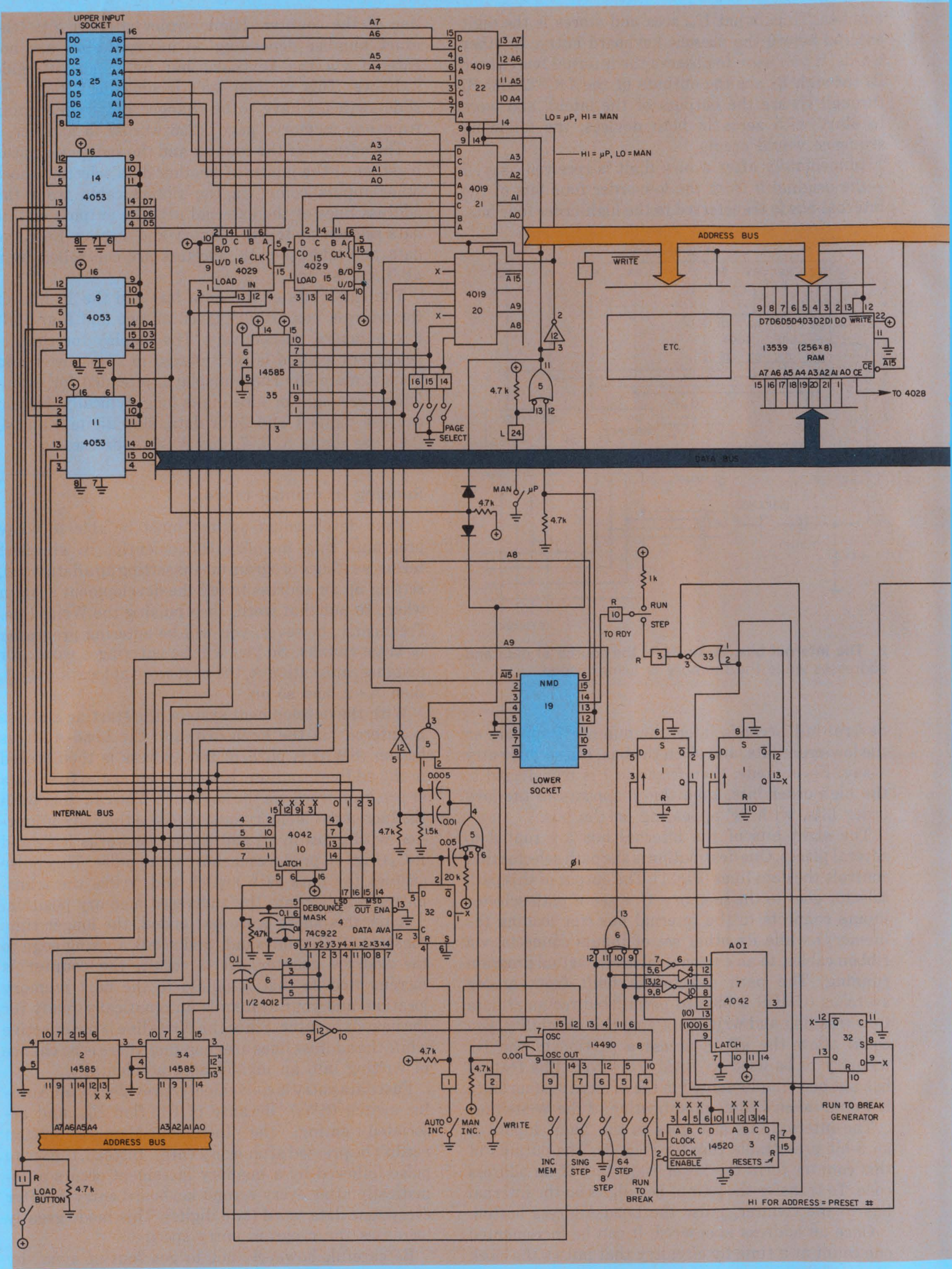
Your development system must be able to write programs into memory conveniently. In simplest terms, writing a program means setting up a data word, setting up an address to tell the development system where to put that word, then pulsing the Write line. Frequently, however, you will be entering programs in large chunks. So you will be entering a word, for instance, at location A, the next word at location A+1, then A+2, and so on.

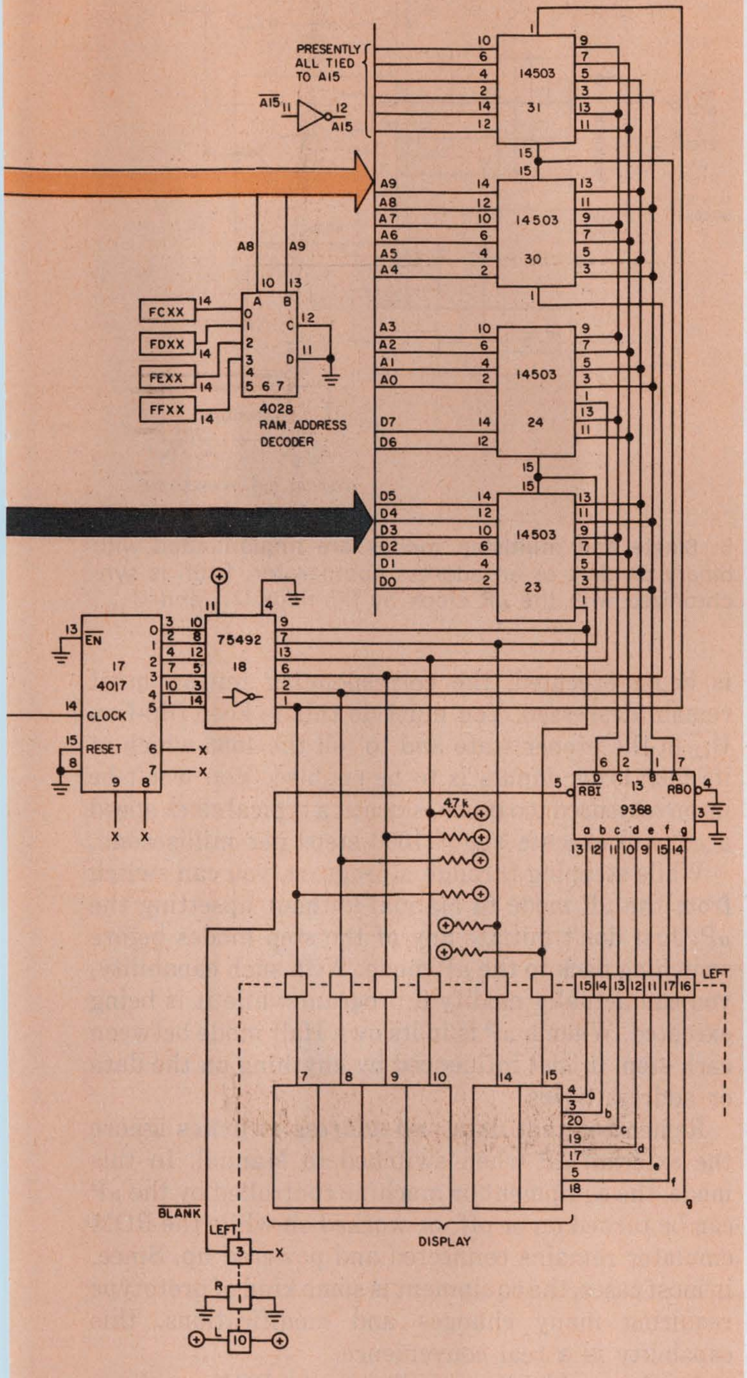
With the development system, the starting address is entered via the keyboard, and the Load-Address button (SW_{11}) is pushed; the address is then stored in the address counter. Next, you enter the first data or program word via the keyboard. You can then push the Increment Memory button (SW_9) that, in conjunction with gates in U_5 and timing networks R_1C_1 and R_2C_2 (Fig. 4), produces a short write pulse. This pulse enables the data-path switch and writes the transmitted number into the addressed memory position.

After this short pulse has ended, the longer time constant (R_2C_2) times out, and sends a rising edge to the address counter. As a result, the counter is incremented so that it points to the next memory location, and your system is automatically ready for the next data entry. Since the Write line is never active while the address lines are changing, there is no chance of writing into an invalid area accidentally.

Fast data entry is conveniently provided by an Auto-Inc switch (SW_1). Because of flip-flop U_{32}, and associated gating, the Increment-Memory button needn't be pressed after every entry. Instead, the write pulse followed by a memory increment occurs automatically after every second keyboard entry or after every new data word (two digits). This mode greatly increases the program entry speed.

Be careful, however, not to get "out of sync" by





3. **Thirty chips and a few other components** are all that's needed to build a complete ROM emulator, or development system for a microprocessor.

entering one or three digits, thinking that two digits have been entered.

Controlling the μP

Fig 3. shows the circuitry used to control the external μP while the program actually runs. Since the do-it-yourself system is designed to work with a 6502, this control is exercised by means of the RDY line, one of the connections to the external μP. When this line is High, the μP will run. When the line is brought Low, the μP will halt (after finishing an instruction in process). In the simplest mode, then, the μP will run at full speed when the Run switch is set on Run and the RDY line is held High.

To slow the process down, you may set the Run switch to Step. Now one of several buttons can be pushed (Fig. 5). The Single-Step button executes one program instruction. The button is debounced by a 14490 hex debouncer, U_8, passes through a quad OR gate, U_6, and arrives at the "D" input of flip-flop U_{1A}.

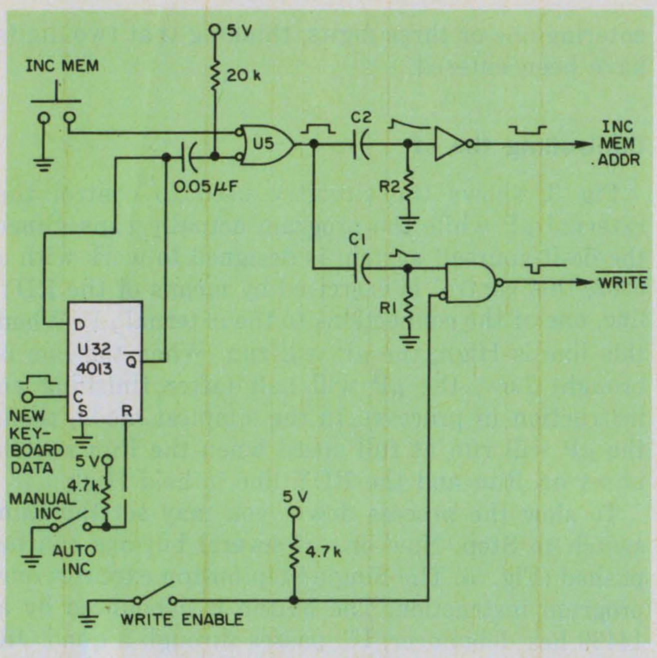
The first phase of the μP's clock, PHI-1, has been transported from the μP to this flip-flop and is used as its clock input to ensure that the RDY line goes High and Low at the proper times in the micro-instruction cycle. So U_6 and U_{1A} cause the RDY line to go High on the first positive edge of PHI-1 after any button is pushed and held. The RDY line will then stay High until a High-going signal is inverted in the quad AOI (U_7) and reaches the D input of U_{1A} in time for another positive edge.

For single-step, the RDY line goes High after the first PHI-1pulse edge. Almost immediately, the Low-going signal reaches the second flip-flop, (U_{1B}), where the second PHI-1 edge sends RDY Low again, thus completing one μP step.

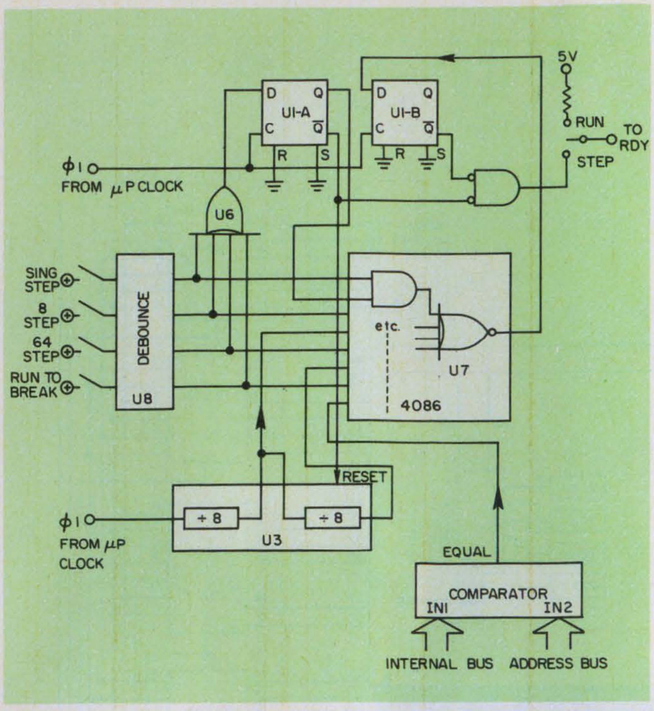
If the Eight-Step button is pushed, the very next PHI-1 positive edge will cause RDY to go High. It will also release a Reset line to enable a 14520 dual binary counter, U_3, which starts counting PHI-1 cycles. When it reaches the eighth cycle, its first MSD line goes High. This signal passes through the 4086 to U_{1B}, so that the very next PHI-1 edge clocks the flip-flop and sends RDY Low again. When the button is released, the counter and the two flip-flops go back to their initial states.

If the 64-Step button is pushed, the third input (pin 6) of the 4086 is selected. This chip will produce an output only when the MSD output of the second binary "decade" of the 14520 has gone High—after 64 clock pulses. In other words, the RDY line will stay High for 64+1 clock pulses.

Multistep buttons are very useful when you want to step through a program that contains many loops (for instance, a loop that zeroes out a large block of memory). Once a loop has been stepped through one time to verify that it is working, you don't have to keep checking it. But usually, for subsequent portions of the program to work, the loop must be executed. The multistep buttons let you proceed through such



4. **Memory-write control is simple** and straightforward. When the write-enable switch is closed, pressing the Inc-Mem button will generate first a write pulse (through C_1R_1), then a positive edge to increment the memory address through C_2R_2.



5. **Single and multistep modes are implemented** with binary dividers or an address comparator. Each is synchronized with the μP clock by flip-flops U_{1A} and U_{1B}.

loops very quickly and get on to other portions of a program that you're debugging.

A very useful button

The final button—Run to Break—is perhaps the most useful. Frequently, it is desired to single-step through a small, specific section of the code, which is often far into the body of the program. One way is to use the eight-step and the 64-step buttons to leapfrog to the desired portion. But an even faster way is to let the μP run full speed until it recognizes a desired address on the address bus and stops to wait for additional button commands.

A group of 4-bit comparators, U_2, U_{34}, and U_{35}, perform the desired address recognition. First, enter a two-digit stop address via the keyboard and set the slide swiches to the desired page. Then hit the Run-to-Break button. Line RDY goes High and remains so until all three comparators sense that the address that has been loaded onto the internal bus is equal to the one loaded on the address bus. Once an equality is sensed, a signal passes through a flip-flop, U_{32}, then through the AOI, and finally to U_{1B}, so that the next positive edge of PHI-1 can send the RDY line Low. Thus, the μP runs at top speed until it stops at the desired address plus 1.

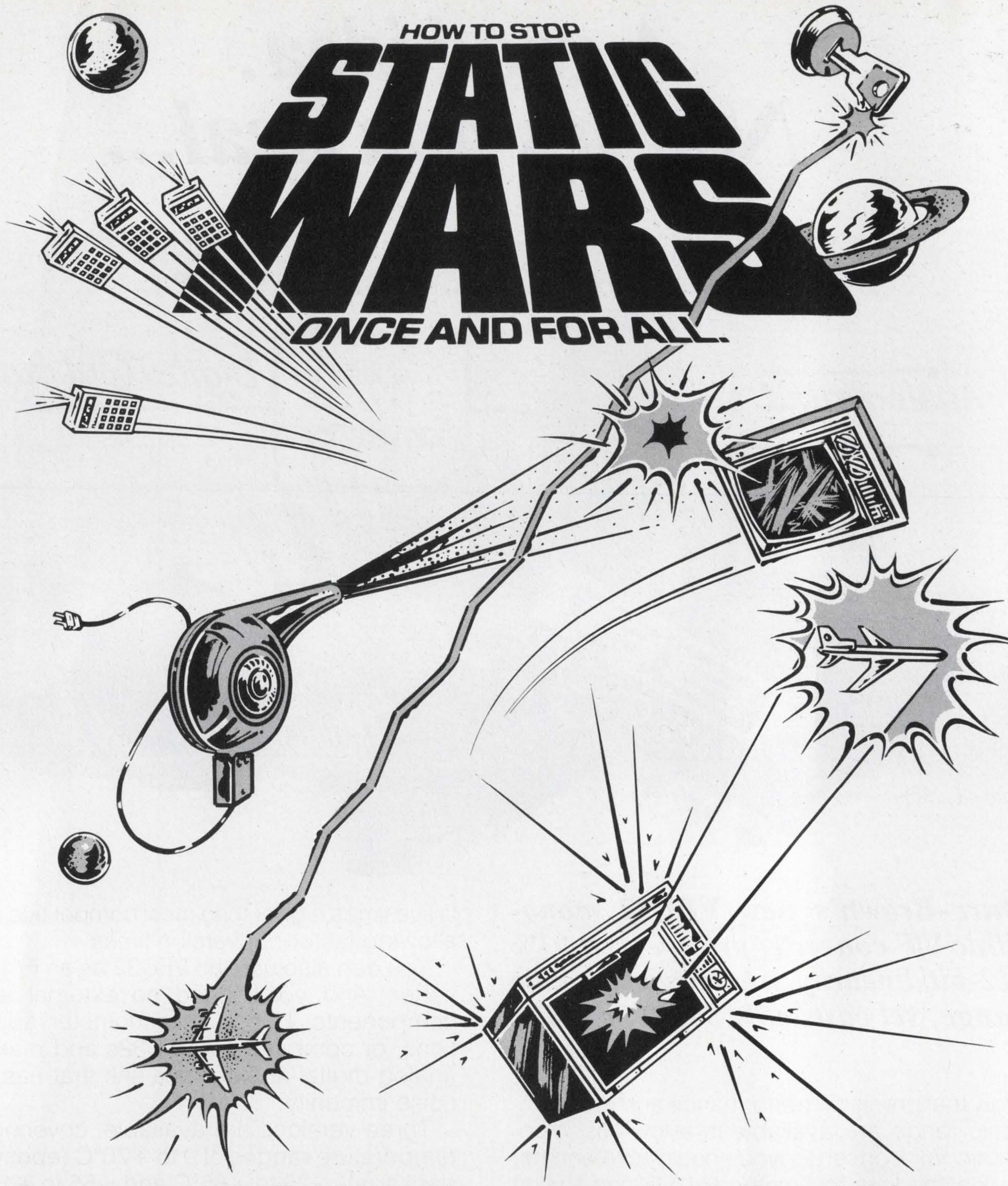
As useful as this mode is, however, it cannot replace the multistep modes completely. These latter still provide the only convenient way to get into the middle of a long loop. A Run to Break wouldn't do any good here since the same addresses are repeated over and over.

Note that while one of the various stepping modes is being executed, the corresponding button must remain depressed. You must do this to keep flip-flop U_{1A} in the proper state and to tell the 4086 which of its four lower inputs is to be enabled. You won't be inconvenienced too much, since at a typical clock speed a μP will execute about 1000 steps per millisecond.

While stepping through a program, you can switch from the μP mode to Manual without upsetting the μP. Just don't initiate any of the step modes before switching back to the μP mode. With such capability, you can actually modify a program while it is being executed. When a μP is in its own Halt mode between each step, it isn't influenced by anything on the data or address buses.

Remember that data and address switches ignore the external μP when switched to Manual. In this mode, the equipment or machine controlled by the μP can be turned on or off, or worked on while the ROM emulator remains connected and powered up. Since, in most cases, the equipment is some kind of prototype requiring many changes and modifications, this capability is a real convenience.

A safeguard has been built into the ROM emulator to guard against your forgetting to switch to Manual before turning off power to the equipment controlled by the μP. One of the wires in the ribbon cable to the external μP is connected to its +5-V supply, which becomes one of the inputs to gate 5 (Fig. 3). The other input comes from the μP/Manual switch. The output of gate 5 controls both the data and address-path switches. Thus, it will disconnect the μP path and connect the manual path whenever the switch is set to Manual, or when the equipment controlled by the μP is shut down.■■


HOW TO STOP
STATIC WARS
ONCE AND FOR ALL.

Statistical tolerancing of complex systems can optimize component-tolerance budgets for a given risk. Conventional worst-case design allows only zero risk.

Statistical tolerancing, unlike worst-case tolerancing, allows you to establish economical component tolerances and thus minimize the cost for a specified system performance. Worst-case tolerancing, by assigning component tolerances on the basis of zero probability of system malfunctioning, often requires expensive precision parts. Relaxing this strict policy, statistical tolerancing allows the malfunction probability to be a calculated small risk, thus saving a lot of money.[1,2,3]

Moreover the statistical-tolerancing method can be used to

1. Determine the over-all tolerance of a complex system with just the high and low tolerances of its individual components.
2. Compute the risk involved quantitatively.
3. Allocate tolerances optimally among system components.
4. Establish the best calibration requirements for a complex measurement system.

The component variables are independent

To analyze a system with statistical tolerancing, let the relationship between the performance parameter, Q, of a system and the component variables, x_1, x_2, $x_3 ... x_n$, be represented by

$$Q = f(x_1, x_2, \ldots x_n).$$

For simplicity, consider the component variables to be statistically independent, or uncorrelated.[1]

For such uncorrelated variables the variance, or dispersion, about the expected value of Q is

$$\mathrm{Var}(Q) = \sum_{i=1}^{n} \left(\frac{\delta f}{\delta x_i}\right)^2 \mathrm{Var}(x_i) + \sum_{i=1}^{n} \left(\frac{\delta f}{\delta x_i}\right)\left(\frac{\delta^2 f}{\delta x_i^2}\right) \mu_3(x_i),$$

where x_i denotes a typical component, $\delta f/\delta x_i$ and $\delta^2 f/\delta x_i^2$ are evaluated at the mean values of x_1, and $\mu_3(x_i)$—the third central moment—measures the distribution skewness of x_i. This expression for Var (Q) is derived by expanding $f(x_1, x_2 \ldots x_n)$ into a multivariable Taylor series to the second order. Since higher-order terms are omitted, the expression is approximate.[4]

The last term in the expression may be omitted if any of the following statements are true:

- The function $f(x_1, x_2 \ldots x_n)$ is approximately linear over the range of interest.[2]
- All the component variables are approximately normal; therefore, the third central moment, $\mu_3 (x_i)$, is approximately zero.[4]
- The system has many variables, none of which predominate.

When the Var (Q) equation is expressed in terms of standard deviations (σ) with the final term omitted, you get the so-called propagation-of-error equation,

$$\sigma_Q^2 = \left(\frac{\delta f}{\delta x_1}\right)^2 \sigma_1^2 + \left(\frac{\delta f}{\delta x_2}\right)^2 \sigma_2^2 + \ldots \left(\frac{\delta f}{\delta x_n}\right)^2 \sigma_n^2. \quad (1)$$

Standard deviations $\sigma_1, \sigma_2 \ldots \sigma_n$ refer respectively to the $x_1, x_2 \ldots x_n$ component values, and σ_Q is the over-all standard deviation of the system.

Since standard deviation σ_i measures a component's deviation from its mean, μ_i, a component's high-and-low-limit specifications relative to the mean can be expressed as $\pm L_i = \pm k_i \sigma_i$. The proportionality factor, k, represents the number of standard deviations the limits spread over.

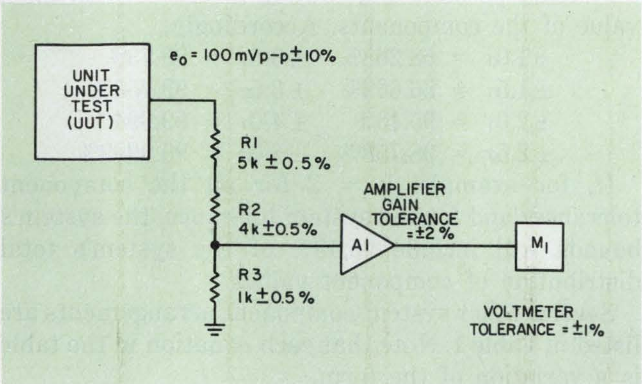
If a component variable is normally distributed, k = 2 includes 95.45% of the component values, and k = 3 includes 99.73%. But to apply standard deviations to a practical system design, you must express the deviations as percentages, $\pm T_{\mu_i}$, of the components' mean values, μ_i. For example, 50 Ω ±5%, 10 V ±1%, etc., corresponds to $\mu_i \pm T_{\mu_i}$. The component high and low limits, $\pm L_i$, relative to the mean are expressed as $\pm T_{\mu_i} \mu_i$, then

$$\pm L_i = \pm T_{\mu_i} \mu_i = \pm k \sigma_i$$

and

$$\sigma_i = \frac{T_{\mu_i} \mu_i}{k}. \quad (2)$$

Dale D. Brady, Project Engineer, and **Dominick J. Odorizzi,** Section Head, Ground Support Equipment Systems Engineering, Hughes Aircraft Co., Canoga Park, CA 91304.



1. **Only the tolerance limits of each system component are needed** to establish the over-all accuracy of the readings taken in a measuring system.

System-component configurations can take many forms. But the most common relationships include:

1. $Q = x_1 x_2$, the gain of two cascaded amplifiers.
2. $Q = x_1 + x_2$, two resistors in series.
3. $Q = x_1{}^m x_2{}^n$, power measurements, $P = I^2R$, where $m = 2$, $n = 1$.
4. $Q = \dfrac{x_1}{x_1 + x_2}$, a voltage divider.
5. $Q = \dfrac{x_1 x_2}{x_1 + x_2}$, two resistors in parallel.
6. $Q = \dfrac{1}{\dfrac{1}{x_1} + \dfrac{1}{x_2} + \dfrac{1}{x_3}}$, three resistors in parallel.

However, parameters x_1, x_2, x_3 . . . don't have to be individual components. They can represent complex networks or even subsystems.

Put the equations to work

To put Eqs. 1 and 2 to work, let's compute the percent tolerance of a system, $Q = x_1 x_2 x_3 \ldots$, with component mean values a, b, c . . ., and specified percent tolerances, $\pm T_a$, $\pm T_b$, $\pm T_c$ . . . . Obtain the partial derivatives and evaluate them at their mean values, as follows:

$$\frac{\delta Q}{\delta x_1} = bc \ldots, \frac{\delta Q}{\delta x_2} = ac \ldots, \frac{\delta Q}{\delta x_3} = ab \ldots, \text{ etc.}$$

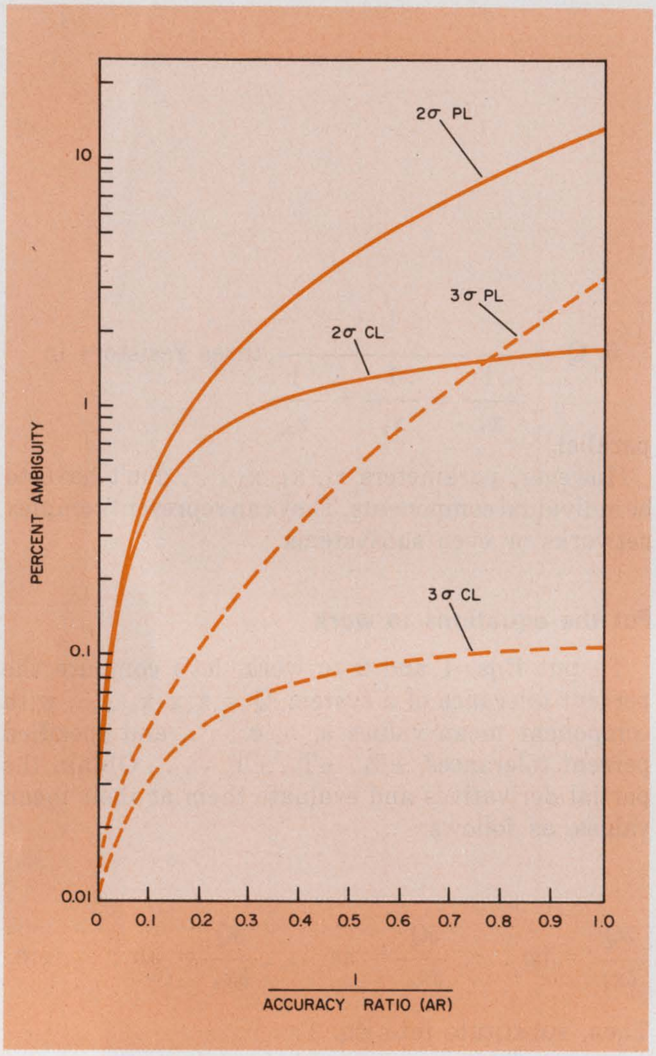
Then, substitute into Eq. 1:

$$\sigma_Q{}^2 = b^2c^2\sigma_1{}^2 \ldots + a^2c^2\sigma_2{}^2 \ldots + a^2b^2\sigma_3{}^2 \ldots + \ldots$$

Table 1. Equations for computing system tolerances

System configuration	Tolerance equations	
$Q = x_1x_2x_3 \ldots$	$T_Q = \sqrt{T_a{}^2 + T_b{}^2 + T_c{}^2 + \ldots}$	(3)
$Q = x_1 + x_2 + \ldots$	$T_Q = \dfrac{1}{a + b + \ldots}\sqrt{(aT_a)^2 + (bT_b)^2 + \ldots}$	(4)
$Q = x_1^m x_2^n x_3^p \ldots$	$T_Q = \sqrt{(mT_a)^2 + (nT_b)^2 + (pT_c)^2 + \ldots}$	(5)
$Q = \dfrac{x_1}{x_1 + x_2}$	$T_Q = \dfrac{b}{a + b}\sqrt{T_a{}^2 + T_b{}^2}$	(6)
$Q = \dfrac{x_1 x_2}{x_1 + x_2}$	$T_Q = \dfrac{1}{a + b}\sqrt{(bT_a)^2 + (aT_b)^2}$	(7)
$Q = \dfrac{1}{\dfrac{1}{x_1} + \dfrac{1}{x_2} + \dfrac{1}{x_3}}$	$T_Q = \dfrac{1}{ab+bc+ac}\sqrt{(bcT_a)^2 + (acT_b)^2 + (abT_c)^2}$	(8)

Note: a, b, c. . .represent the component mean values of x_1, x_2, x_3. . .; $\pm T_a$, $\pm T_b$, $\pm T_c$. . ., represent the component percent tolerances of a, b, c. . .



2. **In this risk-assessment graph,** the consumer loss (CL) or producer loss (PL), each expressed in percent, depends on the system's over-all accuracy ratio (AR) and the quality of the components as measured by the number of standard deviations, $k\sigma_i$, that the component limits, $\pm T_{\mu_i}\mu_i$, are spread over.

Divide both sides by Q^2, which equals $a^2b^2c^2 \ldots$, and you get

$$\left(\frac{\sigma_Q}{Q}\right)^2 = \left(\frac{\sigma_1}{a}\right)^2 + \left(\frac{\sigma_2}{b}\right)^2 + \left(\frac{\sigma_3}{c}\right)^2 \ldots$$

Now apply Eq. 2 by substituting

$$\sigma_Q = \frac{T_Q Q}{k};\quad \sigma_1 = \frac{T_a a}{k};$$

$$\sigma_2 = \frac{T_b b}{k}; + \ldots \text{ etc.,}$$

to get

$$\left(\frac{T_Q}{k}\right)^2 = \left(\frac{T_a}{k}\right)^2 + \left(\frac{T_b}{k}\right)^2 + \left(\frac{T_c}{k}\right)^2 + \ldots$$

Finally,

$$T_Q = \sqrt{T_a{}^2 + T_b{}^2 + T_c{}^2 + \ldots} \quad . \qquad (3)$$

Note that the number of standard deviations, k, cancels from the equation when the number is the same for each component. Nevertheless, the likelihood that the over-all percentage tolerance, T_Q, includes a system's possible distribution increases with the k value of the components. Accordingly,

$\pm 1.0\sigma = 68.268\%$ $\pm 3.0\sigma = 99.73\%$
$\pm 1.5\sigma = 86.638\%$ $\pm 3.5\sigma = 99.753\%$
$\pm 2.0\sigma = 95.45\%$ $\pm 4.0\sigma = 99.994\%$
$\pm 2.5\sigma = 98.758\%$ $\pm 5.0\sigma = 99.9999\%$

If, for example, $k = 2$ for all the component tolerances and for the system tolerance, the system's bounds will include 95.45% of the system's total distribution of component values.

Several other system-component arrangements are listed in Table 1. Note that each equation in the table is a variation of the form,

$$T_Q = \beta\sqrt{(\alpha_1 T_1)^2 + (\alpha_2 T_2)^2 + \ldots (\alpha_n T_n)^2}\,.$$

Calculating a system's tolerance

Armed with these equations, consider the measurement system in Fig. 1. It includes a voltmeter, M_1, an amplifier, A_1, and a voltage divider, R_1, R_2 and R_3. To obtain the over-all percent tolerance for the system from the tolerances of the components, first determine the system's transfer function, Q. From an inspection of Fig. 1,

$$Q = G_D\ G_A\ G_M,$$

where
G_D = gain of the voltage divider R_1, R_2 and R_3,
G_A = gain of the amplifier A_1,
G_M = gain of the voltmeter M_1.
Since the transfer function has the form $Q = x_1 x_2 x_3$, then Eq. 3 in Table 1 determines the system tolerance.

But first calculate the tolerance of the series combination of resistors R_1 and R_2, using Eq. 4 of Table 1. Accordingly,

$$T_{(R1\,+\,R2)} = \frac{1}{R_1 + R_2}\sqrt{(R_1 \times T_{R_1})^2 + (R_2 \times T_{R_2})^2}$$

$$= \frac{1}{5k + 4k}\sqrt{(5k \times 0.005)^2 + (4k \times 0.005)^2}$$

$$= \pm 0.356\%.$$

Now the divider's gain tolerance, T_{G_D}, may be determined with Table 1's, Eq. 5, which applies to a two-resistor voltage divider. Treating the series combination of resistors R_1 and R_2 as a single resistor R_T, you get

$$T_{G_D} = \frac{R_T}{R_3 + R_T}\sqrt{(T_{R_3})^2 + (T_{R_D})^2}\ ,$$

where

$$R_T = R_1 + R_2 = 9k \pm 0.356\%$$

and

$$G_D = \frac{R_3}{R_3 + R_T}.$$

Therefore,

$$T_{G_D} = \frac{9k}{1k + 9k}\sqrt{(0.005)^2 + (0.00356)^2}$$

$$= \pm 0.55\%.$$

Finally, the system's percent tolerance is

$$T_Q = \sqrt{(T_{G_D})^2 + (T_{G_A})^2 + (T_{G_M})^2}\ .$$

And, where $T_{G_A} = \pm 2\%$ and $T_{G_M} = \pm 1\%$,

$$T_Q = \sqrt{(0.0055)^2 + (0.02)^2 + (0.01)^2}$$

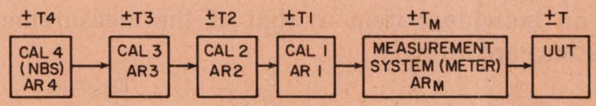
$$= \pm 2.3\%$$

This example was solved with just the equations in Table 1, but other problems may require direct application of the basic equations, Eqs. 1 and 2.

Assessing measuring-system risk

Since in the statistical tolerancing method, the probability that the system will function properly is less than 100%, how do you quantitatively determine the risk resulting from measurement errors? You may address the problem in terms of "consumer loss" (CL) and "producer loss" (PL), where CL is the joint probability that a randomly selected nonconforming item to be tested will be accepted by the inspection system; PL is the joint probability that a conforming item will be rejected.[5]

The probability that nonconforming items are accepted and conforming are rejected, increases as the measurement system's tolerance widens. A figure of merit for evaluating measurement-system quality is accuracy ratio, AR, which is defined as the ratio of



a

$$T_Q = \sqrt{T_M^2 + T_1^2 + T_2^2 + T_3^2 + T_4^2}$$

$$AR_M = \frac{T}{T_M};\ AR_1 = \frac{T_M}{T_1};\ \text{etc.,}$$

$$T_M = \frac{T}{AR_M};\ T_1 = \frac{T_M}{AR_1} = \left(\frac{T}{AR_M}\right)\left(\frac{1}{AR_1}\right);\ \text{etc.}$$

For budget "A," $AR_1 = AR_2 = \ldots 4:1$, then

$$T_M = \frac{T}{4},\ T_1 = \frac{T}{16},\ T_2 = \frac{T}{64},\ T_3 = \frac{T}{256},\ \text{and } T_4 = \frac{T}{1024}$$

$$T_Q = \sqrt{\left(\frac{T}{4}\right)^2 + \left(\frac{T}{16}\right)^2 + \left(\frac{T}{64}\right)^2 + \left(\frac{T}{256}\right)^2 + \left(\frac{T}{1024}\right)^2}$$

$$AR_Q = \frac{T}{T_Q} = 3.87:1$$

b

	Accuracy-ratio budget (AR_j)				
Echelon	A	B	C	D	E
UUT/Measurement System	T/4	T/4	T/5	T/6	T/9
UUT/CAL_1	T/16	T/16	T/9	T/9	T/9
UUT/CAL_2	T/64	T/64	T/16	T/12	T/9
UUT/CAL_3	T/256	T/64	T/16	T/12	T/9
UUT/CAL_4 (NBS)	T/1024	T/64	T/20	T/12	T/9
Over-all Accuracy Ratio $AR_Q = T/T_Q$	3.87/1	3.86/1	3.99/1	4.05/1	4.02/1

T_j = Tolerance of Unit Under Test (UUT) or each measurement step.
T_Q = Over-all tolerance of measurement system including calibration tolerance uncertainty.
AR_j = Accuracy ratio of UUT or each.

c

3. **In a typical meter calibration sequence** (a), the tolerances of all the steps must be included in calculating the over-all accuracy ratio (b). By judiciously assigning the accuracy-ratio budget (c), the accuracy of no single step need have an impractical accuracy (budget "A"), and at the same time the over-all accuracy ratio (AR_Q) can be maximized (budget "D").

the tolerance of the measured item (Ω, μF, V, A, etc.), expressed in percentage to the tolerance of the measurement system. In the example of Fig. 1,

$$AR = \frac{T_{e_o}}{T_Q} = \frac{10\%}{2.3\%} = 4.35:1\ ,$$

where T_{e_o} is the tolerance of the measured output voltage e_o.

Accuracy ratio compares the high and low tolerance of an individual item to that of the measurement system; accordingly,

$$AR = \frac{T_i}{T_{MS}} = \frac{k_i \sigma_i}{\mu_i} \div \frac{k_{MS}\sigma_{MS}}{\mu_{MS}}.$$

When the "k" constants are all equal, and the mean of the parameter distribution, μ_i, is equal to the mean of the measurement-system distribution, μ_{MS}, the measurement system is considered "calibrated," and

$$AR = \frac{\sigma_i}{\sigma_{MS}}.$$

Accuracy ratio can't be used directly to compute CL and PL, but it can determine the relationship between σ_i and σ_{MS}.

Fig. 2 shows the result of computing CL and PL by a CL/PL formula[5] performed on an IBM 370. Manual calculation of CL and PL is an involved task,[5,6,7] and best done with a computer.

Budgeting calibration accuracies

Calibration is required to verify that a measurement system is within specified tolerances and to establish traceability to a recognized standard like the National Bureau of Standards. Since several levels of calibration may be involved, with each contributing to the total uncertainty, the accuracy of all levels must be included in the over-all AR of the system.

Calibration requirements imposed by military specifications require a minimum acceptable AR of 4:1.[8,9,10] But applying statistical tolerancing to the study of calibration tolerances shows that the 4:1 AR can be reduced.[11]

In Fig. 3, a block diagram of a typical military calibration sequence, each calibration level contributes a tolerance uncertainty to the subsequent level. Since the form, $Q = x_1 x_2 x_3 \ldots$, applies, then Eq. 3 in Table 1 can determine the system's over-all tolerance and AR for any measurement. Calculations show how an over-all AR of 3.87:1 is obtained for the budget of each AR listed in the sequence in column A of Fig. 3c. Note the AR for UUT/CAL_4 is a high 1024:1—almost impossible to achieve.

Column B of the table, however, shows that the higher-echelon calibration facilities hardly affect the over-all AR (3.87:1 vs 3.86:1). And columns C, D and E show that proper budgeting can significantly reduce the AR required at particular echelons and at the same time improve the over-all result. Note that a more uniform set of UUT-to-measurement-system ARs not only reduces extreme calibration requirements on some of the levels, but also provides a slightly better over-all AR.

To establish a proper budget for a complex measuring system, therefore, use the following procedure:

- Decide on the allowable risk for each UUT measurement in terms of an acceptable CL and PL percent ambiguity (Fig. 2).

Example: Assume a PL ambiguity of 0.15% and CL of 0.058% are acceptable with 3σ, or better, components in the UUT and the measurement system; consequently, 1/AR = 0.25, or AR = 4:1 (Fig. 2).

- Select a calibration plan to provide AR = 4:1.

Example: For a four-echelon calibration system, budget plans C, D and E in Fig. 3 are typical. Select plan C, and the UUT/measurement system's AR must be 5:1 or better. If the UUT's tolerance is ±10%, in the measurement-system tolerance must be at least ±2% to achieve an AR = 5:1, or better. But if your measurement system can't meet this criterion—for instance, in Fig. 1 the AR is only 4.35:1—you must re-examine the budget plan.

- Optimize the results by re-evaluating the risk requirements, by considering other system designs, or by re-allocating tolerances. Repeat the procedure as often as necessary.

Example: You must decide whether you can live with the AR of 4.35:1, which produces an over-all AR of 3.64:1, hence a PL of 0.17% instead of the desired 0.15%. Or, you must redesign the measurement system to provide the desired AR of 5:1—or try to fit another tolerance budget to the existing design.■■

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Acknowledgments

We are thankful to Dr. S. A. Hovanessian and T. Mukaihata for their very constructive comments during preparation of this paper and to R. D. Moreno for assistance in programming the CL/PL calculations.

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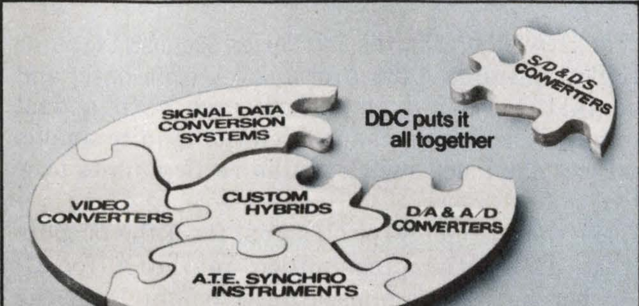

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Stretch your sampling scope's capabilities

by adding as many vertical channels as you need. Keeping the original time base simplifies the modification.

You can get more out of your sampling oscilloscope by expanding the number of input channels. The extra channels can be displayed simultaneously with the original one, with a fixed time difference. Any combination of channels can be displayed, and the system can be made computer-compatible.

Expansion is fairly simple. The original display and time base control the additional vertical systems. If you need only one extra vertical unit, you can probably make use of the existing power supplies. For more than that, a separate supply will be needed. In that case, it might be better to replace the mainframe and the display with a large-screen display and a separate power-supply frame for plug-in units.

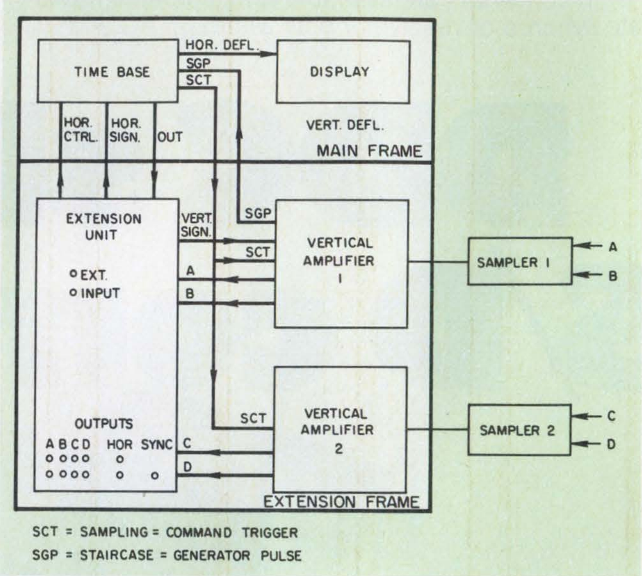
A four-channel unit shows you all the modifications (Fig. 1). As in a conventional scope, the mainframe contains the time-base plug-in unit. However, the vertical amplifier is replaced by a dummy plug-in that provides the interconnections for the extension chassis mounted below the mainframe. That chassis houses the extension unit and two vertical amplifiers, each containing two channels.

Remote samplers connect to the vertical amplifiers as usual. (Channels for vertical unit 1 are labeled A and B, and those for unit 2, C and D.) The vertical signals must be interrupted at some suitable point between the preamplifier and the main vertical amplifier, and routed to the extension unit. The time-base signal (staircase) is treated similarly.

Breaking into the scope

Adding, multiplying, mixing and chopping are all simple because all the input signals to the extension unit are low-frequency. The instrument's versatility can be further enhanced with normalized outputs (ratios) and an external low-frequency input for display of a reference.

Since channels are better selected in the extension unit, you should disable existing channel-selection devices and divert control signals to the extension unit. The horizontal and vertical signals that result from processing and selection are fed back to the points where the original time-base and A-channel signals were interrupted.



1. **Four channels of sampling** require two vertical input amplifiers. The extension unit contains the channel logic, control signals and output amplifiers.

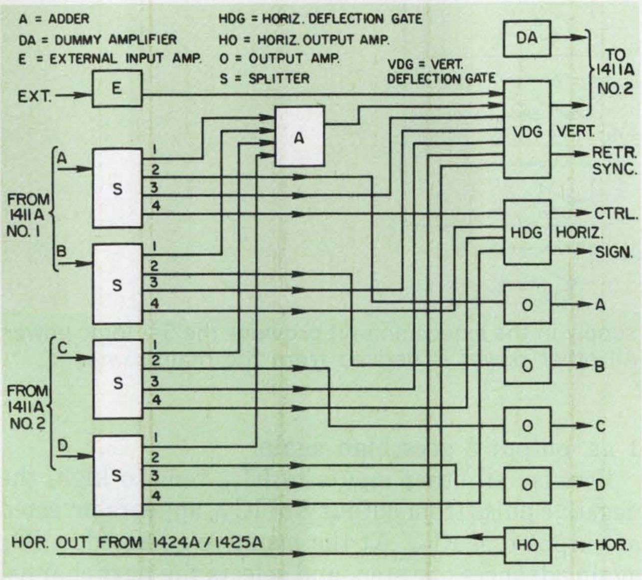
The time base controls the sampling process by sending a sampling-control trigger (SCT) to the vertical unit. But add a second vertical unit, and the SCT must be split. By adjusting the length of coaxial lines after the split, you can control the time difference between the two input pairs. Inserting a line stretcher in one of the SCT lines allows cross-correlation measurements. The staircase generator in the time base must be triggered by a pulse (SGP) from one of the vertical units.

Modifying a commercial scope

For Hewlett-Packard's 140 series scopes (141 A or 141 B mainframe, 1424 A or 1425 A time base, and two 1411 A vertical amplifiers, each with a dual sampler) disabling the channel selector is quite simple: Just lock the mode switch on the vertical units to A vs B.

Take the channel A (or C) signal from the outputs of the differential preamplifier on the A (or C) stretcher board. Disconnect these points from the

Hans R. Brands and **Rob G. van Welzenis,** Physics Dept., Eindhoven University of Technology, Eindhoven, The Netherlands.



2. **Outputs from the vertical-input amplifiers are split** in the extension unit, then combined and shaped into the required horizontal and vertical signals.

input current isolator of the main vertical amplifier —a minor modification since you only have to detach the board connectors and rewire the points to free pins on the plug on top of the vertical unit. Installation of an internal switch allows you to use the vertical unit in the conventional two-channel combination.

Thanks to the A-vs-B mode, the channel B (or D) signal is directly available at the plug at the back of the vertical amplifier. Normally, this signal replaces the staircase, which is suppressed with a 100-V control voltage (through the same connector). The B (D) signal and control voltage are diverted to the extension unit, and the SCT is available at the bottom connector in the time base. In this case, the SCT can be split with a simple T-junction—if a time jitter increase by a factor of $\sqrt{2}$ is allowable.

The four differential-current-source inputs from the vertical plug-in units (channels A to D) are treated alike (Fig. 2). Each is led to a splitter (S) that produces four independent output signals. Signal 1 becomes the input of a four-term adder (A). Signal 2 is amplified (O) to produce an external-output signal. Signal 3 connects to the vertical-deflection gate (VDG), and signal 4 to the horizontal-deflection gate (HDG).

Besides the four high-bandwidth sampler inputs, you can provide for an extra 500-kHz external input (E). This dc-coupled, differential-input channel can display a reference signal or the result of external manipulations on the low-frequency outputs.

Select channel from the front panel

The output of the external-input amplifier connects to the VDG. The four inputs to the differential adder contain diode gates controlled by front-panel selection switches. The output of the adder also goes to the VDG, whose output, in turn, goes to the main vertical amplifier in unit 1. With front-panel selection switches, you can enable one or more of the six available signals, which then can be chopped or alternated. The retrace trigger needed in the alternate mode is derived from the horizontal-output amplifier (HO), and also comes out on a BNC jack (TTL-level) for external use (retrace sync).

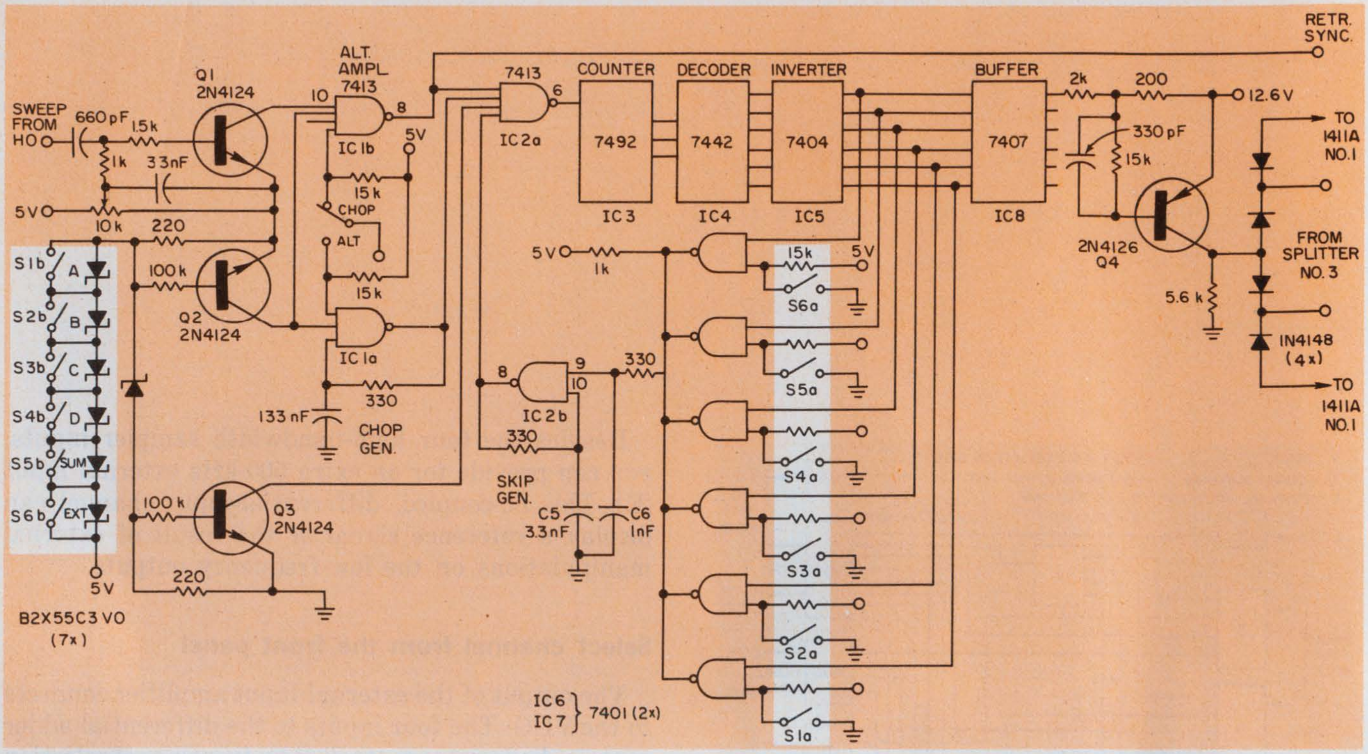
The HO amplifier gets its input from the time base's record differential amplifier, which produces a true copy of the resulting horizontal signal. Amplitude, balance and level controls are contained in the O and HO circuits. To prevent circuit damage, a dummy amplifier (DA) provides an appropriate input signal for the output stage of the No. 2 vertical unit.

The horizontal signal is determined by the HDG. In the HDG, a multideck rotary switch blocks the 100-V control voltage to the time base, so the horizontal signal is formed by the original staircase signal. Alternatively, the 100 V is enabled, and one of the four splitter outputs is gated on.

The most complex subassembly (Fig. 3) is the VDG. Switches S_1 to S_6 open for the selected signals; otherwise, they stay closed. The A deck on the switches serves the enabling channel, while the B deck generates "single channel" or "zero channels" information. If only one B switch is open, Q_2 is driven into conduction and the "single-channel" line goes low. When all B switches are closed, Q_3 also conducts and "zero channels" goes low.

Handling many channels

Now assume that more than one channel is selected, so that both "single-channel" and "zero-channels" are



3. **Front-panel controls switch dc levels** to control the various functions of the vertical-deflection gate. A 1-A supply in the extension unit provides the 5-V logic power. All other power is derived from the mainframe.

high. You can either alternate or chop the selected channels. First, set S_7 to "alt." Normally, Q_1 keeps conducting, but when it is triggered by the negative-going retrace part of the horizontal-output signal, it goes into the blocking state for about 6 μs. As a result, input 10 of IC_{1b} goes high and—because the other inputs are also high—output 8 goes low (retrace-sync output). After 6 μs, this output goes high again. If you assume that output 8 of IC_{2b} is high at this moment, then output 6 of IC_{2a} goes low because the other inputs to IC_2 are also high. Consequently, divide-by-six counter IC_3 advances a step.

Circuit IC_4 translates the BCD output of the counter to a one-out-of-six negative code, which is then inverted by IC_5. The selected gate driver, Q_4, opens the corresponding diode gate through buffer IC_8, so the selected channel can be displayed. At the end of the horizontal sweep, a new retrace starts and the cycle starts again by displaying the next selected channel.

Tracing the logic

To see how output 8 of IC_{2b} goes high, assume that the counter is in position x, which makes the output of IC_5 for channel x high. If this channel is selected, the corresponding switch S_{xa} is open. Thus, the output of IC_6 (or IC_7) goes low, and triggers IC_{2b} high.

If channel x is not selected (switch S_{xa} is closed), the output of IC_6 or IC_7 is high; input 9 to skip-channel generator IC_{2b} also becomes high after charging C_6. Since output 8 of IC_{2b} starts high, C_5 is charged and input 10 is also high. With C_6 charged, output 8 goes low and C_5 discharges. Since input 10 goes low in about 1 μs, output 8 goes high again.

Because all other inputs to IC_{2a} remain high, the negative pulse from output 8 of IC_{2b} appears inverted at output 6 of IC_{2a}. At the negative-going edge, IC_3 again advances one step, and selects the next channel (x+1). So a channel not selected is skipped rapidly in about 1 μs.

In the chopped mode, channel selection is the same as in the alternate mode, but each channel stays on for only about one cycle of the now-activated (by S_7) chop generator, instead of during a whole sweep as in the alternate mode. The chop frequency is fixed—independently of the sampling frequency—at about 23 kHz, which doubles the dot density on the screen of the A & B mode provided by the manufacturer.

If "single channel" is low, then both the "alternate" amplifier, IC_{1b}, and the chop generator, IC_{1a}, are disabled. Skip-channel generator IC_{2b} advances counter IC_3 until the selected channel is reached and displayed continuously. If "zero-channels" is low, IC_{2a} locks, and counter IC_3 stops at a random channel.

In this case, IC_{2a} must be locked because the skip-channel generator, IC_{2b}, free-runs (all the S_{xa} switches are closed), and keeps input 9 of IC_{2b} high regardless of the counter's position. Otherwise, IC_3 will follow at the rate of generator IC_{2b}, and all channels will be opened sequentially for a short time—but long enough for a messy display of all six channels. ■■

Detailed schematics are available from Mr. van Welzenis. During short successive periods, Harry van den Broek, André de Paepe and Johan Wever assisted with the construction of the units.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low profile

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force

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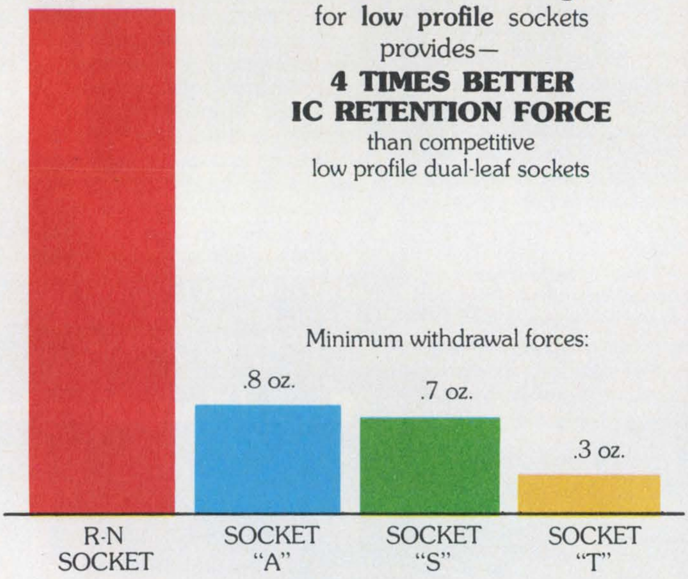

* In "Fat-Skinny test," withdrawal forces are measured using the smallest size (.008") lead **after** insertion of **largest** size (.012") lead.

Representative NORMAL FORCE Test Scores for 10 R-N ICL low profile sockets

TEST SOCKET	NORMAL FORCE*
1	410 grams
2	465 grams
3	480 grams
4	465 grams
5	395 grams
6	425 grams
7	465 grams
8	395 grams
9	410 grams
10	425 grams

AVERAGE—430 grams
This force is 4 to 5 times greater than average dual contact socket NORMAL FORCE

* NORMAL FORCE means force perpendicular or at right angles to IC lead. The single ICL contact exerts this kind of force against the IC lead when inserted into the socket.

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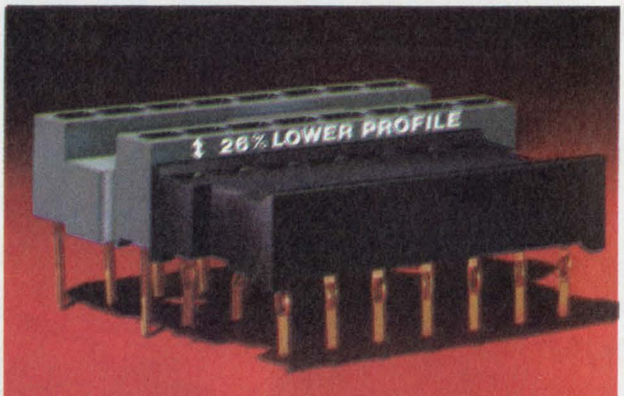
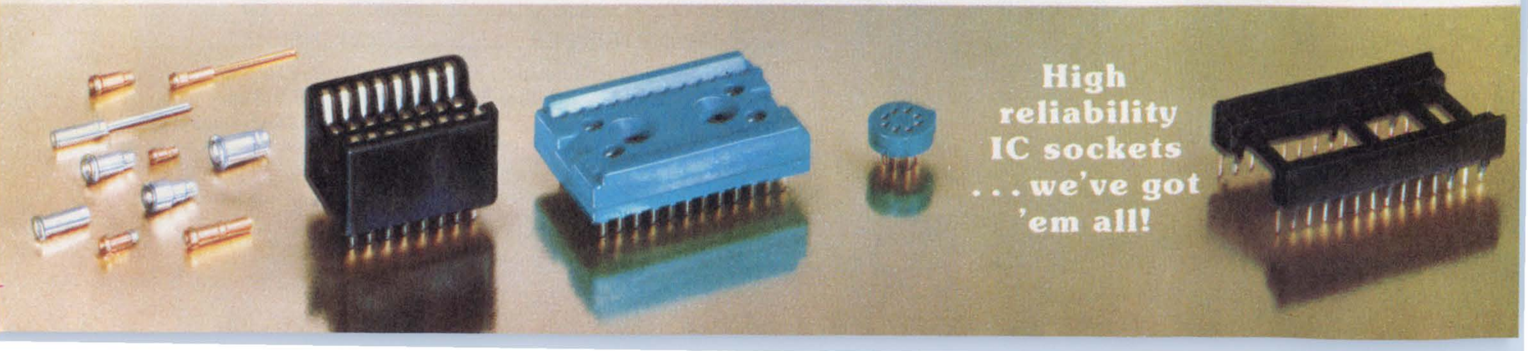
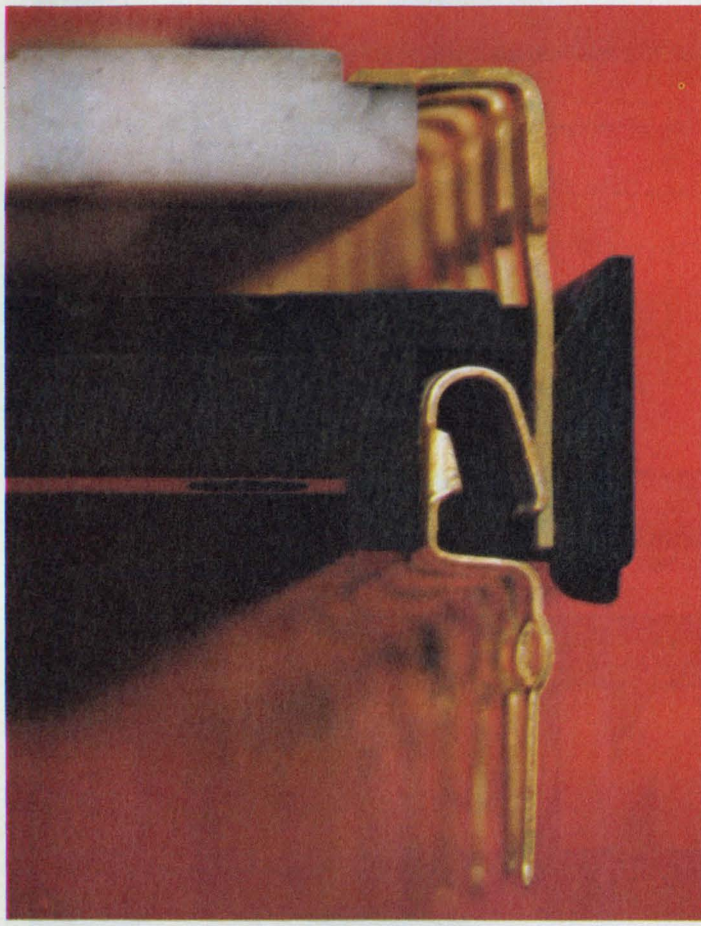


Low .150" profile of ICL socket reduces board density by 26%.



DEBUNKS

DIP socket MYTH



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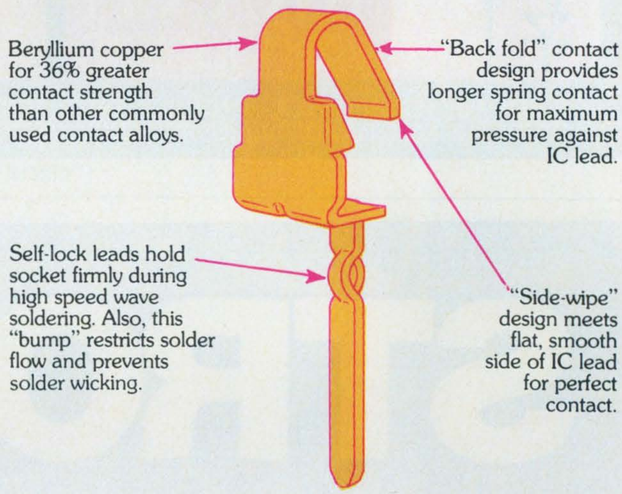

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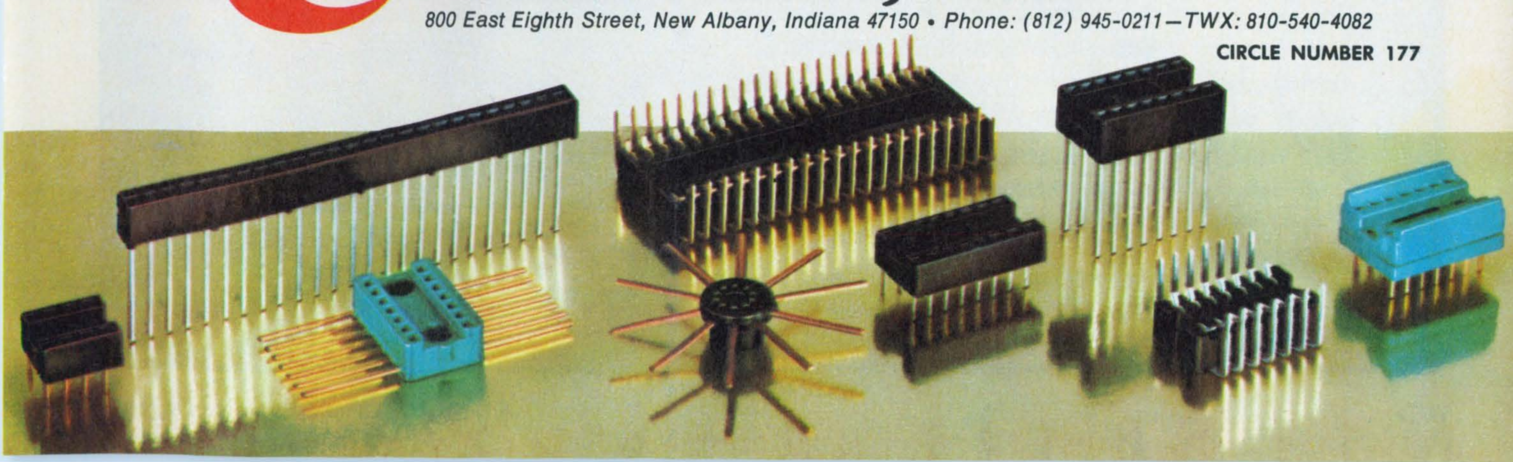

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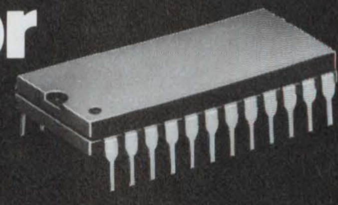

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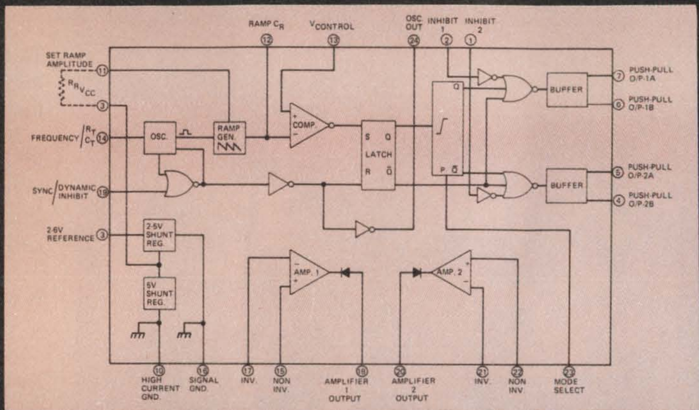

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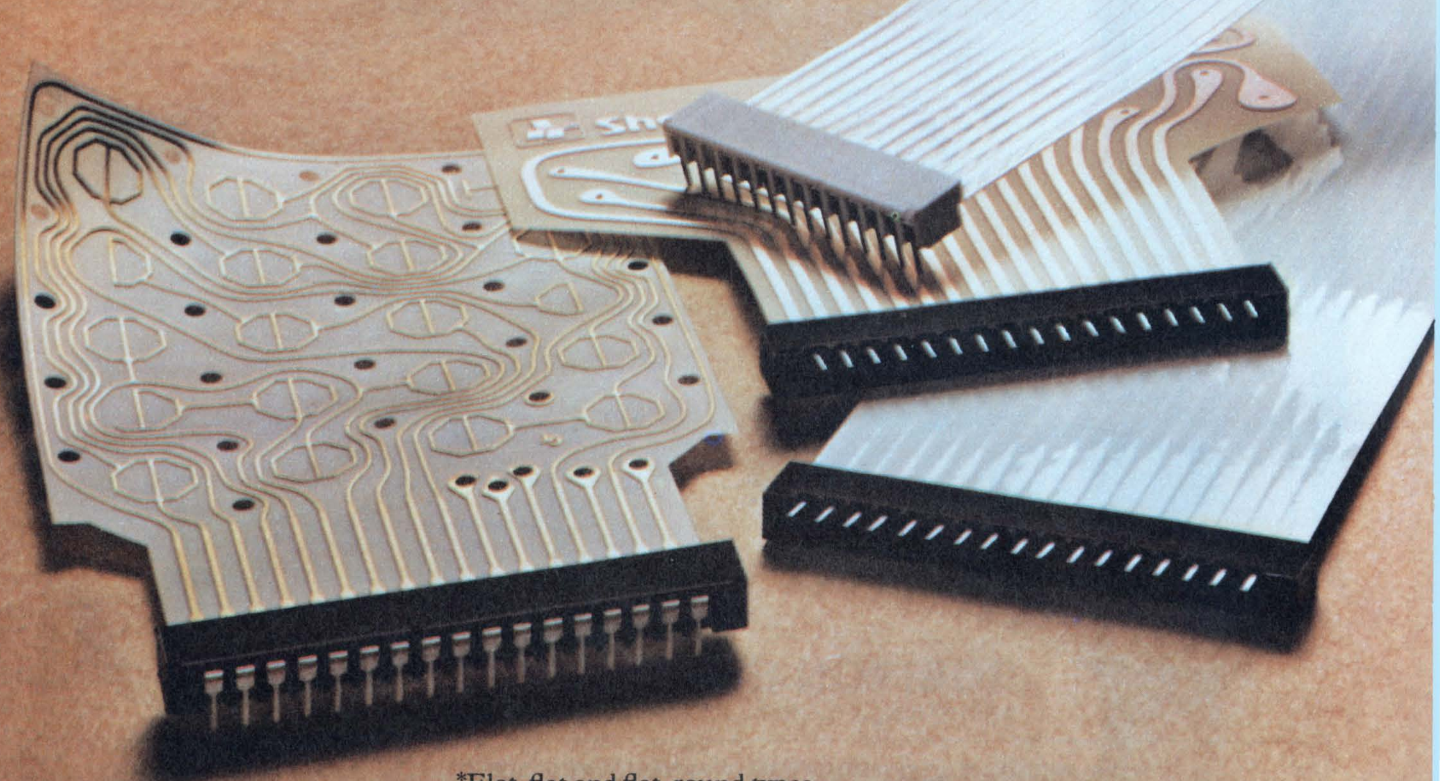

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FLEXLOK COST COMPARISON

	GTH Flexlok FC & RC	Clamp Type Pressure Tin	Insulation Displace-ment	Insulation Piercing	Solder Connections
Piece Price* (per line)	**1¢†**	2¢-3¢	3¢-5¢	5¢-10¢	5¢-10¢
Special Conductor Preparation	**None**	Required	None	None	Required
Installation Tooling (Purchase/Rental)	**None**	Yes	Yes	Yes	Yes
Operator Training Required	**None**	None	Skilled	Skilled	Skilled

*In Quantity †Average price.

FLEXLOK DESIGN FEATURE COMPARISON

Design Simplicity	**1 piece**	2 pieces or more	2 pieces or more	2 pieces or more	2 pieces or more
Conductor Types Accommodated	**Round Flat Flex. P.C.**	Flat Flex. P.C.	Round	Round Flat	Round Flat Flex P.C.
Top or Side Entry Available	**Yes**	No	No	No	No

FLEXLOK PERFORMANCE DATA

	Contact Resistance Test Data	MILLIOHMS MIN.	MAX.	AVG.
Test Group 1	Initial Contact resistance	7.00	7.60	7.26
	After thermal shock	7.10	7.50	7.25
	After durability (5 cycles)	7.10	7.80	7.39
	After moisture resistance (10 days)	7.20	8.70	7.68
	After vibration	PASSED		
	After mechanical shock	8.20	25.20	12.30
	Insulation resistance (megohms X 10^6)	.002	9.50	5.26
	Dielectric withstanding voltage No breakdown @ 500V AC	PASSED		
Group 2	Initial contact resistance	7.00	7.50	7.25
	After thermal shock	7.20	7.90	7.46
	Ammonium Sulfide exposure (3 min.)	7.20	8.00	7.59
Grp. 3	Initial contact resistance	7.10	7.50	7.25
	After gas tightness	7.00	7.60	7.24

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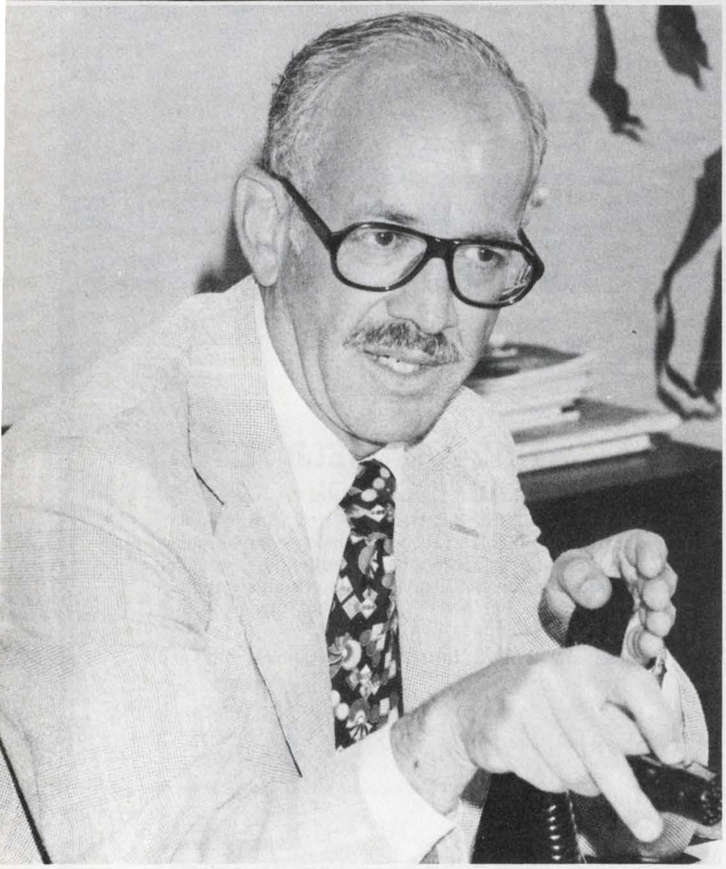
David Dibner of Burndy Speaks On



Your design engineers can help your company book new business. I don't mean that the engineers should become salesmen. But they can help bring in lots of sales, as engineers, and become better engineers in the process. You need a system to make this happen.

We have one at Burndy and it works splendidly. What we do—in very special cases—is send one of our design engineers to work with the customer while the customer is trying to develop an important design that doesn't lend itself to obvious or catalog solutions.

This isn't the same as the conventional approach, where the salesman calls the customer design engineer, late in the game, when he's in trouble.

In the conventional working arrangement, the engineer is back at the home office and he gets a letter or a phone call from the field—and not always first hand. It's routed through the usual channels of communication. The field salesman reports a problem to his district manager, who reports it to the marketing manager back at the home office, who reports it to the chief engineer, who then brings it to the attention of the engineer working on the project.

Is it any surprise that the information is often distorted and that the design engineer doesn't feel any particular commitment or involvement? Somebody comes to him and says: "Harry, this is what the customer wants. He wants an interconnect with 37 conductors and 100-mil spacing."

As you can imagine, there's often a small but critical item that somebody failed to transmit. And Harry is often ticked off because he feels the field man didn't get the whole story. Harry goes back and says, "Did you ask him this. . .?" And the field salesman says, "I didn't get into that much detail."

Or think of the common case where communications take place in the form of writing letters, telephoning, going back for clarification, working up a sketch, sending it to the customer and having him send back a different sketch.

Now look at the difference when we have an eyeball-to-eyeball relationship. Our design engineer is involved with the customer's engineer from the beginning. He has a professional responsibility to ask pertinent questions when he is in the field. He comes home committed, motivated and clearly identified with whatever solution comes up.

He has a deep appreciation of the customer's problem. He has personally tasted the climate and need in the field. He is identified with the customer and his application.

It greatly increases the engineer's awareness of the customer's total expectation. The engineer develops a strong commitment to success, so the job moves faster and better.

There's a further advantage. The system can provide insight for both our inside and outside people. The field sales people develop greater respect and tolerance for the home-office engineering people.They have less tendency to feel: "Those guys back home are always fouling up and taking forever to get things done. They always misinterpret my directions." We all know how common it is for the field guy to say: "I'm sweating

Getting Your Engineers To Get Business

it out on the firing line. I do the work. If it weren't for me, where would this company be?"

Meanwhile, the engineer back home, wrestling with what he feels are incomplete data from the field, says: "That guy lives a soft life out there, drinking all his lunches. Where would he be if it weren't for the great products I'm designing?"

So these people develop a greater appreciation for each other's problems. That's a terrific morale booster. And since it helps people work better together—and in the same direction—it helps the company operate more smoothly and effectively.

This procedure doesn't come about by accident. It starts with the field people—the field engineer, the district and area sales managers. They sense that a particular customer has a very significant product-development opportunity.

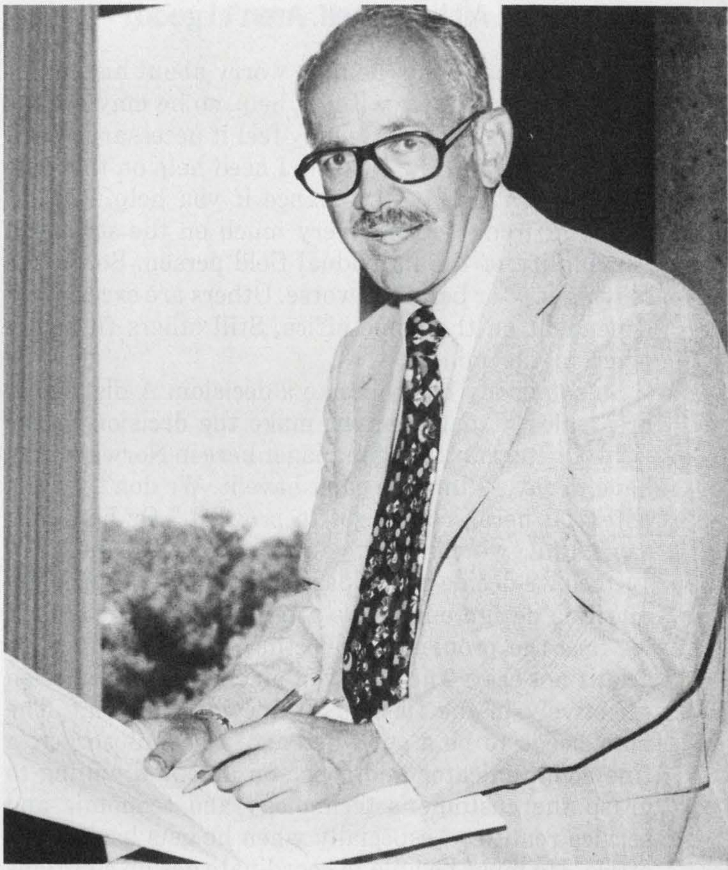
This must be an interconnection requirement that can't be solved by the local man pointing to a catalog drawing and saying, "Look, we have just what you need." Or, "We can just slip in those extra contacts you want."

The field man must recognize that this is a very different requirement that requires the intimate involvement, from the beginning, of our design engineer who, with the customer's engineer, will conceive of a total packaging solution.

I'll give you an example. According to one of the largest CB radio manufacturers, the average life of a CB radio in a car is 12 days. That is, the CB will stay in the car an average of 12 days before it's stolen.

Well, Ford, and its supplier, Motorola, decided to address this problem by offering, as an option, a CB that could be hidden in the trunk of a car with nothing on the front dash panel but a connector that's cabled to the CB. When he's not using his CB, a user simply unplugs the cord and microphone, which has all the controls, and hides it in the glove compartment.

Right away our field people thought of using our Metalok connector, a plastic-bodied, circular, bayonet type. But Ford and Motorola wanted 5000 connects and disconnects and the Metalok couldn't take that without a high-cost contact plating like rhodium. Further, Ford and Motorola had a house spec that said:



"The connector must be engaged by a 95-pound woman with cold cream on her hands."

When you think about it, that's realistic. A housewife rushes out to run her husband to the station and her hands are all greased up. She turns something on the dashboard and her hands slip off. Our Metalok wouldn't do that job. How do we know? We gooed up somebody's hands and tried it.

Well, we involved one of our key design engineers in that project, with Ford/Motorola engineers, right from the start. He remembered that we had been supplying so-called "entertainment" connectors to the commercial-aircraft industry, first to Boeing, then to Lockheed and Douglas, as well. The connectors join a bank of seats to the multiplex audio system when the plane's configuration is changed from cargo to passenger use.

We modified that concept, added some new ones, and came up with a simple dead-faced receptacle with a wiping lubrication system and a simple plug that can be snapped in place with almost no effort. And that was the concept that Ford selected of the three we offered. It was a great victory for our concept and, in fact, for the field man.

We must recognize that the field salesman is faced with conflicting pressures. On one side, he wants to be a hero. He wants to land the big fish.

The field man wants to come back and say: "Look at what I did; I brought in this honey of an order. All by myself. Aren't I good?"

On the other hand, he may worry about his ability to land the big order without help, so he may cut his ego satisfaction a bit. He may feel it necessary to call home and say: "Hey, fellows. I need help on this one. I'll have a much better chance if you help."

The attitude depends very much on the style and personality of the individual field person. Some like to wing it—for better or worse. Others are excessively dependent on the home office. Still others fit someplace in the middle.

So somebody has to make a decision. A district or area sales manager might make the decision in the field. Or the marketing manager here in Norwalk may have to say, "Phil, you can't have it. We don't see the potential here. You've got to prove it." Or he might say, "Phil, we can't let you do this one alone."

Once we decide that a particular customer problem merits a design engineer's attention from the outset, we face the problem of selecting the right engineer. That's not easy. The ability of an engineer to function effectively in the field is an uncommon talent. The man needs to be a good listener, a keen observer, a fine communicator and a person able and willing to grasp the customer's technology and economic and service realities—especially when he gets back to his office. He must be able to coordinate design solutions with commercial aspects—things like price, delivery and other things the average designer would rather not be concerned with.

Further he's got to be the kind of person who can work closely with the field marketing or sales people. He's got to be tolerant and flexible so that he can come back and work with a committee. And he's got to be persuasive. He'll have to work with other engineers, production people, draftsmen, technicians and his marketing people as well as the customer's people.

Most important, he must be able to subordinate the typical technical arrogance—the attitude that only his solution is it. He must resist the tendency to say, "Here I come. Everybody out of the way. I have the solution."

Too often, because his design might, indeed, be brilliant, management says, "Right on." And we fund the design, tool it, manufacture it and bring it to the marketplace. And the marketplace comes back and says, "That's not what we want." It's too heavy. Or too costly. Or too weak. Or too something. And the product flops.

Obviously, the design engineer didn't really grasp what the real world was like. Some engineers learn a lesson here. And some never do. They simply tell themselves that the world is not smart enough to recognize the superiority of their design. "If only they realized how good my design is. . ."

So how do we get from the reality of most engineers to the kind of person and behavior we want? In part, it's by trial and error, by experience. And in part, the answer is that doing tends to make it so.

We realize that some engineers don't like the disruptive professional experience. They don't like to spend a few days or a week in the field. But many do.

When we find the right people—the engineers with the necessary style, flair and scope—they get enormously motivated. This has become an exceedingly exciting professional opportunity for a number of our engineers. It's an opportunity that stands as a goal for others.

Now there's an obvious question: Does the system really work? That's precisely what I posed the other day to Mike Lazar, the director of engineering for our Components Division. "Mike," I asked, "are we really getting solutions faster? Are we delivering prototypes and production quantities faster than we would have with the conventional system?"

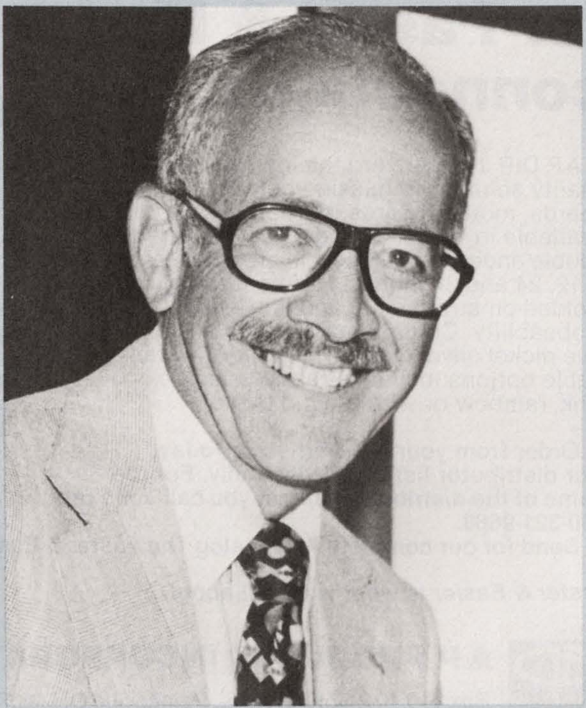
Mike's answer was simple: "Absolutely. There's no question about it." The system is much faster than the conventional one, he told me. It makes for tremendous savings in time and money because the direct communications path saves loads of false starts. We eliminate a lot of waste.

You might think we're misusing the time of the engineer who should be back home designing instead of flying airplanes or waiting in airports. Should we spend his time in selling—something he's not trained to do? You bet.

In fact, he becomes even more effective as an engineer because he doesn't go through so many iterations to find out what the customer really wants. He doesn't waste time redesigning to what his latest concept is of what the customer wants, as translated through a traditional and poor transmission link. Mind you, the traditional system wasn't all that terrible. We still use it with most customers—those whose projects don't warrant this kind of attention. Why don't we use this new system with all our customers? Well, there are economic limits. The requirement must have sufficient technical complexity and sufficient dollar volume to warrant it.

So we choose those projects very carefully. But when the customer has an application that's important enough, we provide an extraordinary service.

Who is David Dibner?



Because of his wise choice of parents, it was considered appropriate that David Dibner acquire broad operating experience as well as a good education. His father, Bern Dibner, had founded Burndy Corp. in 1924 and, today, the Dibners retain about 20% of the equity in the company which, in 1976, enjoyed revenues exceeding $130 million.

Bern felt that David should never have any responsibility he wasn't fully prepared for. So David did prepare. After he took a BS in Industrial Engineering at Columbia University in 1950 (when he married Frances Kessler), he took a Certificate in Business Administration at the London School of Economics (which Frances attended also), then worked as an analyst at IBM in Poughkeepsie till he joined Burndy when he was 25 and the company was 28.

He started in Burndy's engineering-training program and, in time, was involved in a wide range of responsibilities including engineering, manufacturing, sales and marketing, advertising and plant management. In the process he acquired seven domestic patents and more abroad.

In 1966, when he was Director of Corporate Planning and responsible for several Burndy subsidiaries, he was elected to the board of directors. Two years later, as part of a continuing Burndy program, he completed Harvard's Advanced Management Program, which he describes as a superb finishing school for senior business executives.

Soon after his return, he was elected vice-president for Power Products, then vice-chairman in 1971 and chairman of the board in 1972, when his father retired from that position to spend most of his time running the Burndy Library, one of the world's greatest libraries in the history of science and technology.

David is extremely active in community and industry affairs. He is a director of Caldor Inc., and has served as chairman of the board of the Norwalk Hospital; he's a Towers Fellow of the University of Bridgeport, and a national associate of the Boy's Club of America.

He's a lover of the outdoors, too, with a particular fondness for skiing, tennis and sailing his Hobie-12 —a hot little sailboat—on a lake in Maine. He loves to sail with his wife and three sons, Brent, 25, Daniel, 22, and Mark, 16, and almost anybody else who's willing to get wet.

He's also addicted to traveling—especially where there's wilderness and natural beauty—and to capturing some of the experiences of his travels on film.

And this is one of the obvious weaknesses of our system. The customer enjoys the process of exposing his own engineers to the component supplier's engineers. He sees that his own engineers become more effective than they would be if they were simply dealing with a salesman. So he may get to expect this kind of service routinely. A man has made a mark in his company by getting remarkable response from a component supplier, so he feels he can make his mark that way with each project.

He may always want the one-customer special and may get himself oriented that way, even when he might do very well with a catalog product that's already been designed and tooled.

He may tend to look for solutions only in terms of the design of the interconnection, rather than the business or commercial need. Yet he's often better off if we modify something that's already available. Of course we don't want the unnecessary special. It would make the product too costly and it would proliferate our inventory of specials when it's not necessary.

Finally, there's the most awkward problem. The customer may become excessively dependent on a particular design engineer and try to bypass the normal relationship with the field engineer or salesman. He's been happy with design-engineer Harry, who demonstrated that he could get things done and get them done well. So whenever he has a problem, he phones Harry. Harry then must use great tact to let the customer know that he really should go through Phil in the Minneapolis office.

So you can see that our system is not without drawbacks. Nothing is. But its advantages are enormous. ■■

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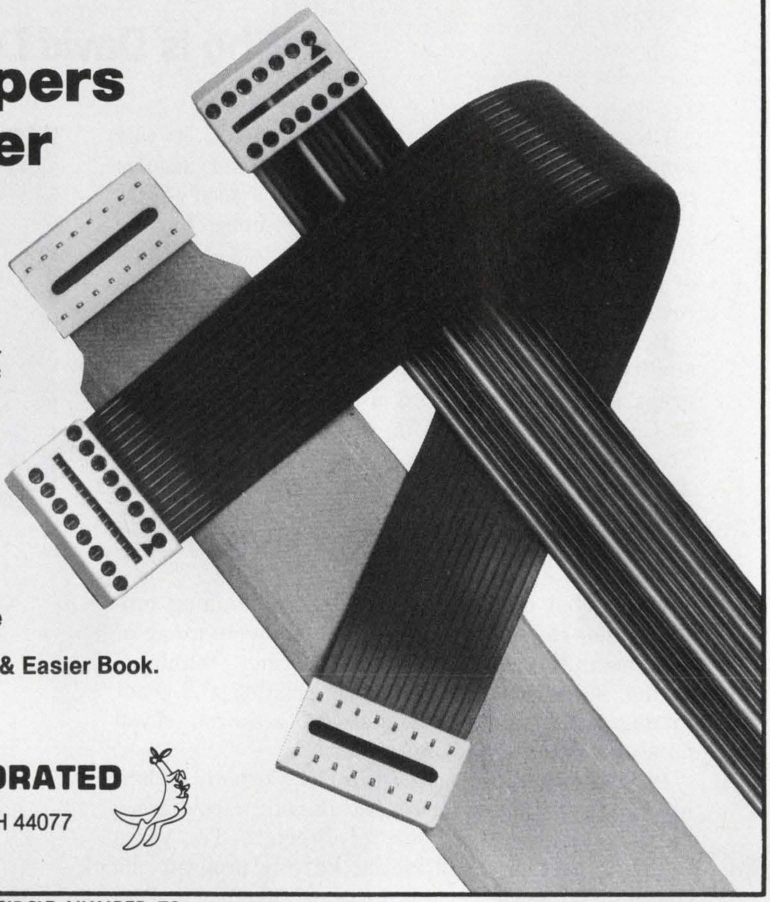

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CIRCLE NUMBER 73

Solve test problems caused by switching-type power supplies

You can get clean, EMI-free test setups with standard test instrumentation, even when working very close to switching power supplies. Unlike linears, switchers generate high-frequency EMI/RFI noise. Often inadequately suppressed, or shielded, this noise is conductively and inductively coupled into nearby test setups causing erroneous readings.

You can expect such a problem especially when you make unbalanced measurements with high-frequency, EMI-sensitive instruments such as DVMs, counters and scopes. How do you know if you have a problem? For a quick check, short the instrument's probe to its signal-return lead, while the return remains connected in the test setup. Any significant reading change with the switcher on and off means you have a problem.

Getting rid of the common-mode conductive EMI that splashes into your probes would be easy if you could make only balanced measurements. Unfortunately, scopes and other instruments have mostly unbalanced inputs—where input-signal and signal-return leads have unequal impedances to chassis ground. Therefore, common-mode signals turn into unwanted differential signals.

So design your own probes. Such instruments usually have high-gain, high-impedance and high-frequency front ends. One or more of these features can often be sacrificed to reduce sensitivity to EMI. Sacrifice impedance and switch to RG58 coaxial 50-Ω terminated probes. Or, perhaps better, use RG55B double-braided 53-Ω coaxial cable.

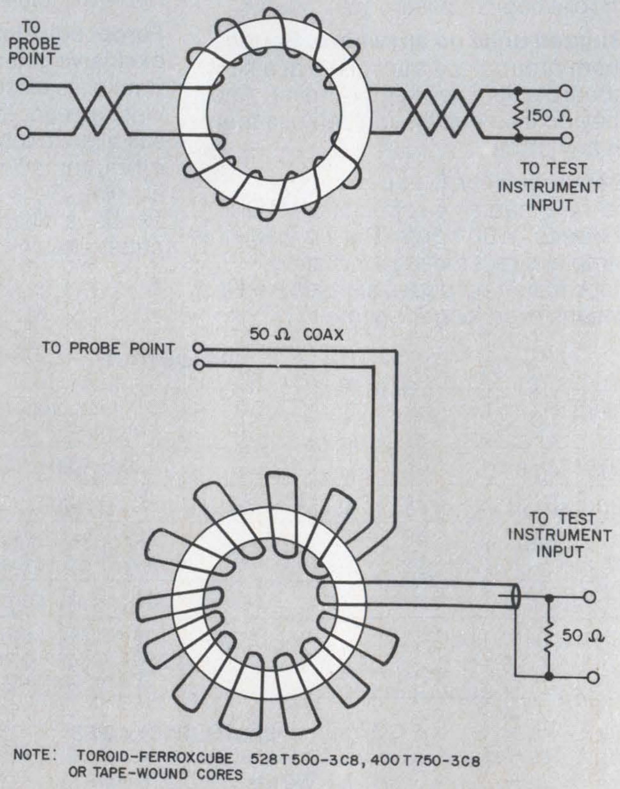
A ferrite balun—balanced-to-unbalanced coil—can block out the common mode (Fig. 1). Or consider a low-pass filter for your probe, which cuts down on high-frequency response.

Needless to say, using good shielding and grounding and observing rf-signal-layout rules will help. Remember the following rules:

- Don't run high-level and low-level signals together.
- Run signal and return lines very close together; use coaxial and twisted pairs.
- Use separate signal return paths to a single ground point. Don't use daisy-chain connections, shields or chassis for signal-return paths. You avoid ground loops this way.
- Use power-line filters. Operate an instrument from a power-line branch other than the switcher. And float the instrument's frame with an ac cheater plug and bond each chassis separately to the disturbing source.

David Weigand, Consulting Engineer, 904 Tyson Dr., West Chester, PA 19380.

CIRCLE NO. 311



Ferrite-cored baluns can eliminate common-mode interference signals when ahead of test probes in unbalanced-input test instruments.

Precision sample-and-hold circuit drives output with a current source

To design highly accurate sample-and-hold circuits, you usually use maximum feedback and high gain. But this combination can result in unstable performance. However, a current-source output stage following an input differential amplifier can provide high precision without high gain.

In the circuit of Fig. 1a, if the amplitude of the input signal is less than ±5 V, the circuit's over-all accuracy is better than 0.01% with a sampling time of 4.5 μs. The voltage droop is less than 1 μV/μs. Power-supply sensitivity is much less than 0.1 mV/V. What's more, although built with discrete parts, the circuit can easily be redesigned for integration without loss of quality.

The circuit's behavior (Fig. 1b) can be expressed as follows:

$$V_0 + \left(\frac{R_0C_h}{A}\right)\left(\frac{dV_0}{dt}\right) = V_i \qquad (1)$$

One solution to Eq. 1 is

$$V_0 = \frac{I_{max}\,R_0}{A}\exp\left(-\frac{A}{R_0C_h}\,t\right) + V_i.$$

As t increases, V_0 approaches the value of V_i.

When operating in its linear region, the circuit contains a rapidly damped oscillation in its output:

$$V_0 = \frac{I_{max}\,R_0}{A}\cos(\omega_s\,t)\exp(-t/\tau_s) + V_i.$$

The time constant, τ_s, is determined by the time constants of the input differential pair, Q_1/Q_2, and inverter Q_4, and by the over-all delay of the circuit. With the components in Fig. 1a, the circuit provides the following performance:

I_{max} = 40 mA.
R_0 = 82 Ω.
A = 100.
τ_s = 80 ns.
ω_s = 12×10^6 rad/s.

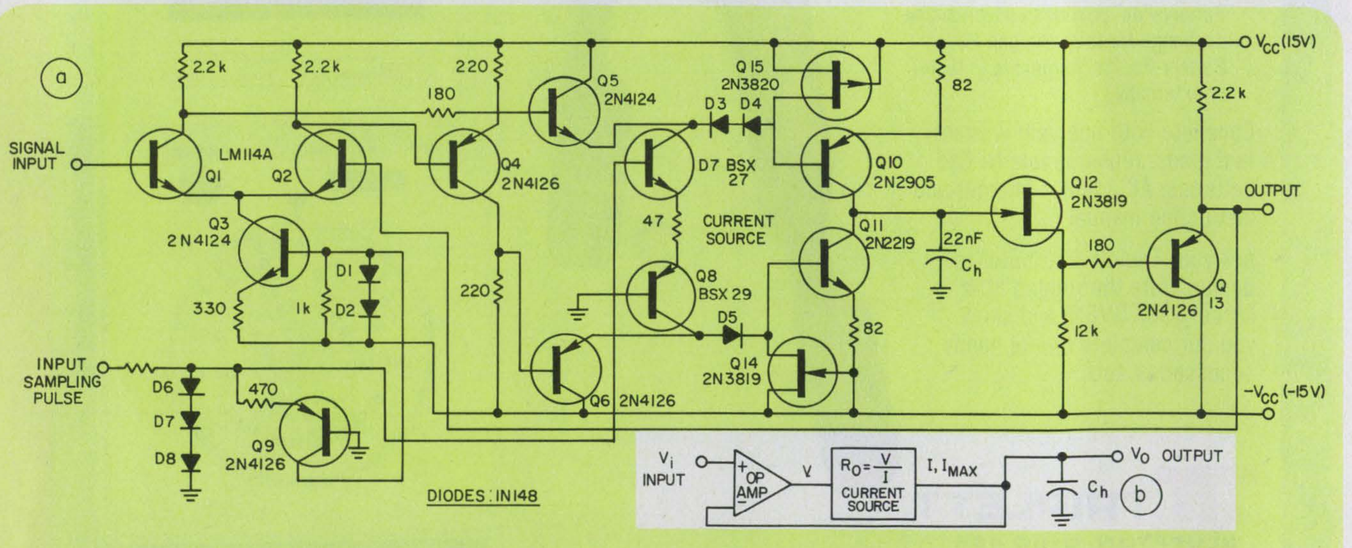
To sample an input signal, a positive pulse at the circuit's sample input turns on the current-source transistors, Q_7/Q_8 and Q_{10}/Q_{11}, which charge hold capacitor C_h. The current varies linearly with the emitter voltages of Q_5 and Q_6, which are proportional to the differential voltage on the collector of Q_1 and Q_2. Transistor Q_4 merely inverts the output from Q_2. Impedance transformer Q_{12}/Q_{13} couples the hold-capacitor voltage to the output and feeds it back to the Q_2 inverting input of the differential pair.

During sampling, the hold capacitor charges (or discharges) until V_0 equals V_i. During hold, output current from Q_{10}/Q_{11} is zero. After sampling, constant-current (about 5 mA) circuits Q_{14}/Q_{15} contribute to fast turn-off of Q_{10} and Q_{11}. Diodes D_3, D_4 and D_5 help prevent Q_{10} and Q_{11} from conducting during hold. And the extra diode, D_4, in series with D_3, helps charge and discharge the hold capacitor symmetrically.

Transistor Q_9 switches off Q_3 during hold, to minimize development of a temperature difference between Q_1 and Q_2 because of different dissipation in Q_1 and Q_2. A temperature difference would cause excessive offset voltage. Note: To minimize sampling offset, Q_1 andd Q_2 are tightly matched in an LM114A monolithic array made by National.

T. Algra, and P.J.J.A. Wolters, Twente University of Technology, Dept. of Electrical Engineering, P.O. Box 217, Enschede, The Netherlands.

CIRCLE NO. 312



1. This sample-and-hold circuit (a) provides an over-all accuracy better than 0.01% with a voltage droop less than 1μV/μs. A current source drives holding capacitor, C_h, and provides the feedback (b).

Wally DeShon of Applied Automation wins annual 'Ideas for Design' award

Your picture could be here, too. All you have to do is send Electronic Design your clever Ideas for Design and you're in the running for the $1000 prize. (See box pg. 158.)

Wallace DeShon was asked by his boss to come with him to *his* boss's office. Having experienced the aerospace layoffs of the 1960s and 1970s, DeShon was prepared for anything...anything but what followed.

As DeShon remembers it, "I was surprised, to say the least, when Dale Tolin [manager of research and product development] presented me with a plaque and informed me that I was ELECTRONIC DESIGN's "Ideas for Design" winner for 1976. The photographer, who had been hiding, started flashing pictures and I was speechless. When Mr. Tolin presented me with ELECTRONIC DESIGN's $1000 check, I think I managed a 'Thank you.' "

DeShon received $20 when ED published "Use TTY or CRT Interchangeably on μP System" in ED No. 24, Nov. 22, 1976. Soon after, he received another $30 when readers chose his idea the best of the issue. Interestingly, it was the first design idea DeShon had ever submitted to a magazine. He'd thought about submitting one several times, but like many of his fellow engineers, he just never got around to it. "Must have been beginner's luck," DeShon said.

The award-winning idea—his first design project after joining Applied Automation—stemmed from a project that required him to design the hardware and write the operating software for an M6800 microprocessor system, which would be used to control propane-distillation columns at Phillips' Borger refinery. DeShon had to program the M6850 ACIA with one or two stop bits, depending on whether a teletypewriter or some other terminal was being used.

Having worked with microprocessors, DeShon firmly believes that for μPs to be used properly, the hardware and software design can no longer be segregated. He also believes that microprocessor systems should be designed by firmware engineers.

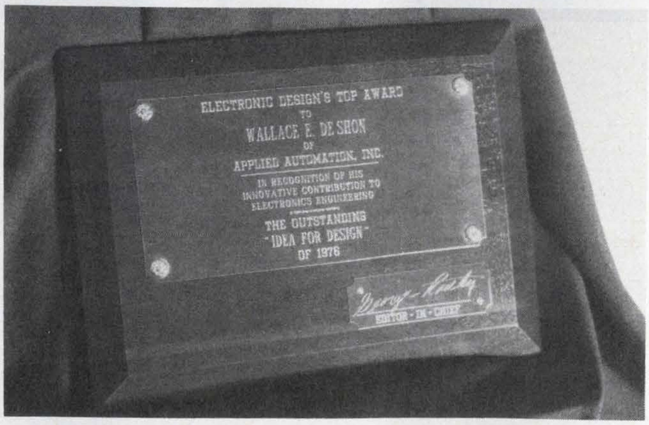
A computer products engineer specializing in microcomputer applications, DeShon joined Applied Automation, Inc., a Bartlesville, OK, subsidiary of Phillips Petroleum Co., in 1975 after spending four years with Sperry Flight Systems in Phoenix, AZ.

DeShon received his BSEE and MSEE from the University of Missouri at Rolla, "with my wife's help." After graduating, he worked for Collins Radio in Cedar Rapids, IA. Before joining Sperry, he spent two years with the U.S. Army, in the Panama Canal Zone.

An active member of the Eastern Heights Baptist Church, DeShon lives with his wife Joyce and three sons, Clark, Gary and Ryan, in Bartlesville.

"Joyce and I were born and raised on farms near St. Joseph, Missouri," DeShon says. "I remember walking about three miles to and from a one-room school that had one teacher for eight grades and outdoor toilets."

As for the $1000 check, he and his wife are trying to decide between dining room furniture and a bass boat.



Annual IFD winner Wally DeShon, holding plaque, receives congratulations from Dale Tolin, Applied Automation's manager of research and product development. Looking on are DeShon's boss, M.H. Beauford (left), and T.J. Pemberton, director of computer products.

More muscle for your microprocessor: Now there's a simpler way to trigger a triac, drive a digit, or light up a lamp.

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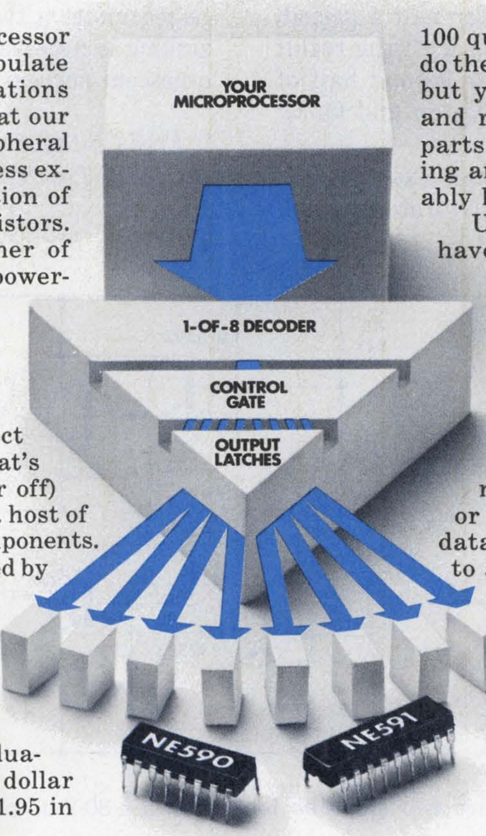

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OTHER SIGNETICS DRIVERS

Part No.	Description	Output Current	No. of Drivers
NE582	LED digit drivers	400mA	6
ULN2001 series	Power drivers	500mA	7
NE5501 series	High-voltage power drivers	500mA	7
DS3611 series	Peripheral drivers	300mA	2
UDN5711 series	Peripheral drivers	300mA	2

To: Signetics Information Services, 811 E. Arques Ave. P.O. Box 9052, MS 27, Sunnyvale, CA 94086

☐ Send me your NE590/591 Data Sheet
☐ Send me a sample of the NE590 for evaluation.
☐ I need data on these other devices shown in the table: ____________

☐ I have an urgent requirement. Please have an applications specialist phone me at once: (   ) ________

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CIRCLE NUMBER 77

Dc-to-ac power inverter drives ac cooling fans

You can drive ac fans from a ±80-V-dc power supply with a simple inverter that you can build with only a handful of components costing about \$5 (see figure).

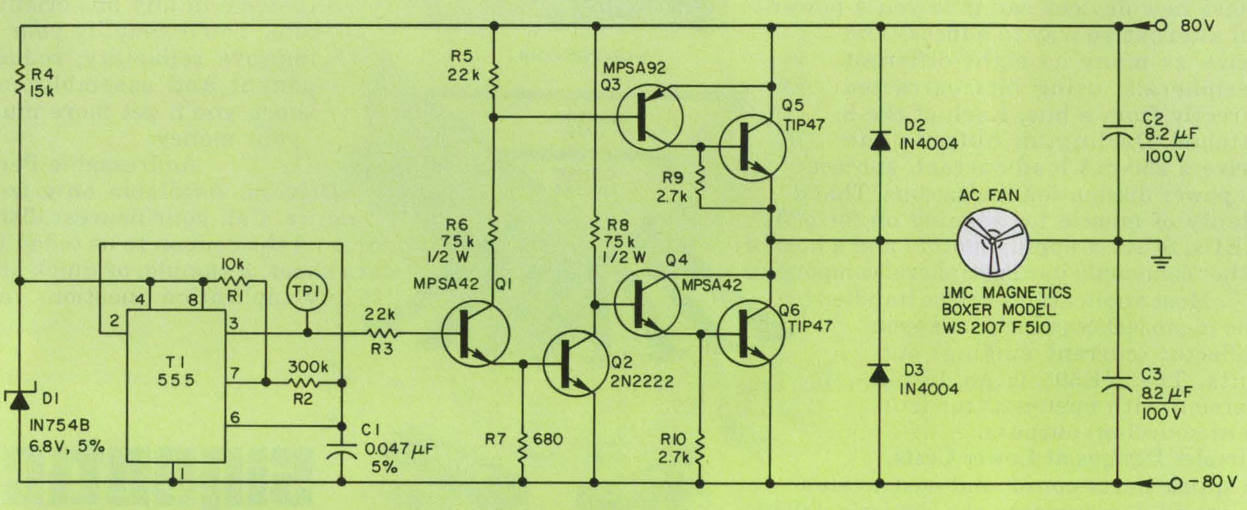
Normally, the ac fan, rated 115 V, 50 to 60 Hz at 1/4 A, rotates at 3100 rpm. But when operated from a ±80-V, 50-Hz square wave, the fan operates at a satisfactory 2500 rpm.

Resistor R_4 and zener D_1 provide 6.8 V for a 555 timer, T_1, and its associated components. A 50-Hz square wave from pin 3 of T_1 drives transistors Q_1 and Q_2. Transistors Q_1 and Q_2, off for half a period, turn the Q_3/Q_5 pair off and Q_4/Q_6 on with the result that the fan sees −80 V. During the second half of the period, with Q_1 and Q_2 on, Q_3/Q_5 on and Q_4/Q_6 off, the fan sees +80 V.

The duty cycle of the output is not exactly 50%, because of a built-in bias in the multivibrator, as well as a difference in the turn-on and turn-off times of the transistors. Capacitor C_2 and diode D_2 protect Q_3 and Q_5 from the fan's inductive kickback, should only the −80-V supply be connected, Similarly, C_3 and D_3 protect Q_4 and Q_6, should only the +80-V supply be connected.

The inverter can deliver 1/2 A of ac current, which is adequate to drive two of the specified fans. A fan draws about 200 mA at approximately 50% duty cycle from each supply. The circuit has been temperature-tested under a two-fan load up to 70 C, and no heat sinking is necessary for Q_5 and Q_6. With no load, the quiescent current drawn from each supply is 15 mA.

Fred Chitayat, Design Engineer, Canadian Marconi Co., 2442 Trenton Ave., Montreal, Canada H3R 261.
CIRCLE NO. 313



A low-cost power inverter can drive two small ac fans from a ±80-V-dc power source.

IFD Winner of September 1, 1977
Vijay B. Tandon, Electrical-Mechanical Engineer, American Foundation for the Blind, Inc., 15 West 16 St., New York, NY 10011. His idea "Two Voltage Comparators Provide Null Detection for Bridge Circuits" has been voted the Most Valuable of Issue Award.

Vote for the Best Idea in this issue by circling the number for your selection on the Reader Service Card at the back of this ussue.

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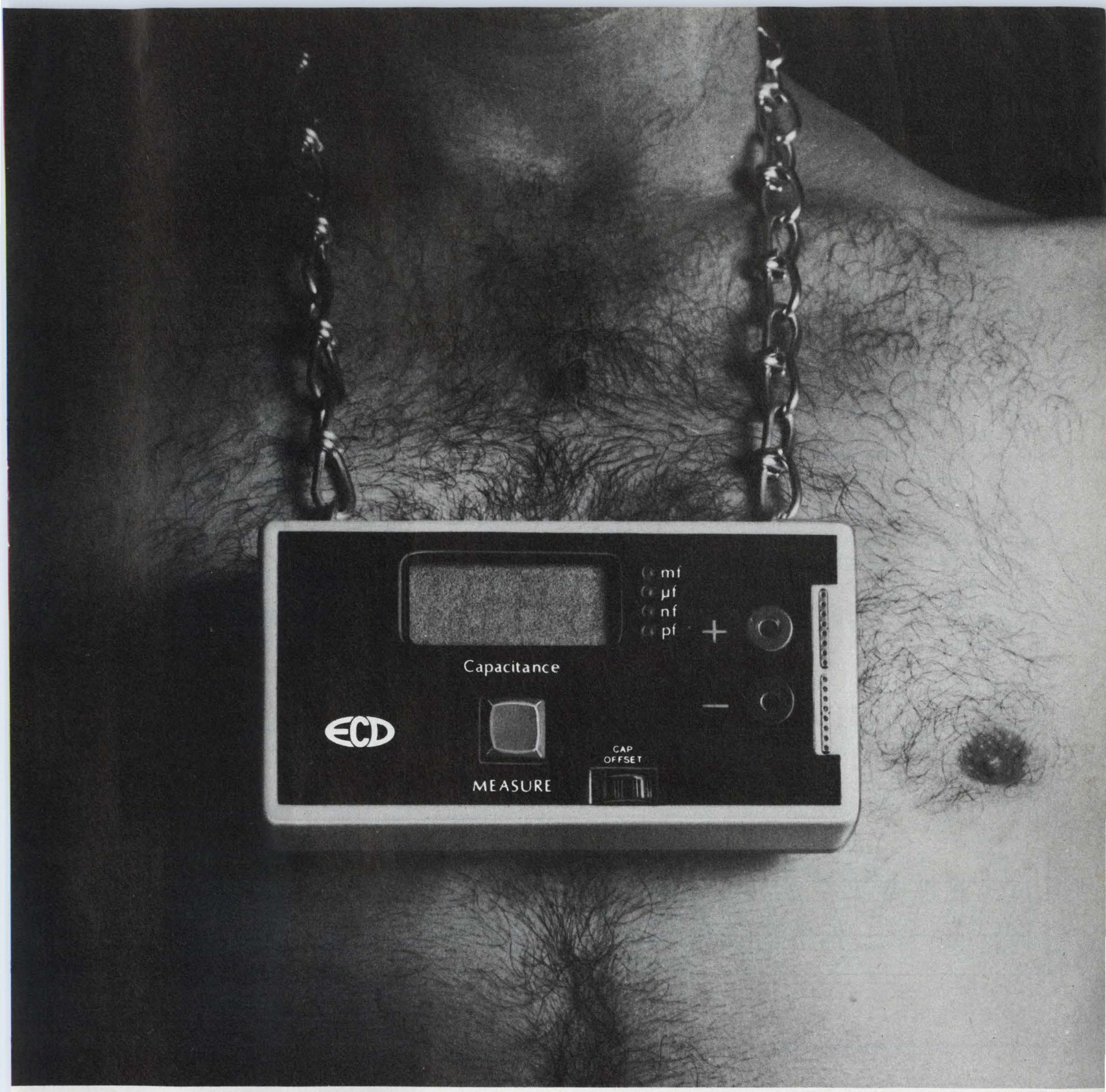

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CIRCLE NUMBER 78

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Ferrite gives whip performance at vhf

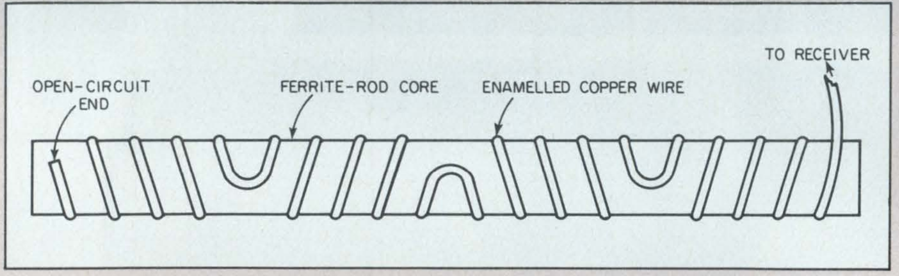
A small ferrite-rod antenna can replace conventional whip antennas on portable vhf transceivers. Devised at the Royal Military College of Science, Shrivenham, England, the antenna benefits from a new kind of winding that overcomes a prime limitation of previous ferrite rod radio antennas, too short an effective length at vhf.

A continuous conducting wire is wound onto a ferrite rod in alternate groups of left and right-handed turns (see diagram) so that the rod and wire act as a quarter-wave resonator. The rod is tuned to a desired frequency by winding excess turns and then successively clipping off turns from the open-circuit end. Similar antennas may be made with dielectric or with conducting cores.

In laboratory tests with a large ground plane, the gain of the aerial is markedly less than that of a whip aerial at the same frequency. However, without the ground plane, as would be the case in small, portable equipment, the performance of the aerial approaches that of a whip antenna and is less directional.

An antenna using a 200-mm-long ferrite rod has a bandwidth of 5 MHz at 79 MHz. A 130-mm aerial with a similar bandwidth has been used at about 94 MHz.

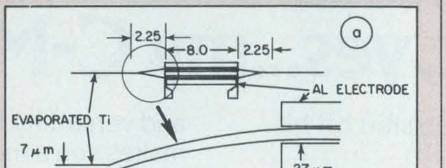
The performance of the new design is influenced by the wire geometry as well as the shape, size and material of the central rod.



Electro-optic modulators may be easier to make

Branched-waveguide electro-optic modulators have long been noted for their broad bandwidths and low power consumption—but fabrication difficulties have restricted their use. However, an efficient lithium-niobate modulator has been built with standard low-cost evaporation and lift-off techniques.

This product of investigators at the University of Glasgow, Scotland, consists of titanium-diffused channel waveguides with aluminum electrodes (see Fig. 1a). A titanium-film pattern, 170 Å thick, is formed by evaporation. The film is then diffused in air at 990 F for 4.5 hours to form a waveguide that branches into two parallel waveguides. These guides are then recombined into a single waveguide. Aluminum electrodes are formed on the parallel portion of the waveguide.



Performance depends heavily on the radiation losses at the Y junctions and at any bends. In the modulator shown, the Y-junction half-angle is 0.57° and three bends are incorporated, each with a bending angle of 0.19°. In this way, over-all loss from input to output is kept to about 5 dB.

The intensity of the light emerging from the device varies as a sinusoidal function of applied voltage. It is controlled by applying 20-μs pulses at about 1 kHz to the aluminum electrodes. The normalized output intensity is close to a maximum with zero voltage (Fig. 2b); at a peak-pulse 2.2 V, the output approaches zero.

Two-antenna radar cuts CRT bandwidth with CCDs

Charge-coupled devices in a new type of scanning radar greatly reduce the bandwidth requirements of the CRT display. The radar itself has two antennas: the transmitting beam of a conventional radar and a separate receive-only array.

As the radar's transmitting beam rotates, its returns sequentially illuminate two blocks of eight receive beams, provided by an i-f beam-forming network. Each receive beam, 0.34° wide, corresponds to a separate spatial position. Examing individual receive channels achieves high angular resolution.

With CCDs time-expanding the video data from each channel, the eight beams can be examined simultaneously without using a special eight-gun CRT. As a result, real-time radar data can be signal-processed.

The transmitter, a commercial marine unit, operates at 9445 MHz, with a beamwidth of 3° in azimuth. The receiving array was developed at the Royal Signals and Radar Establishment at Malvern, England.

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No refresh circuitry.
No waiting.
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CIRCLE NUMBER 79

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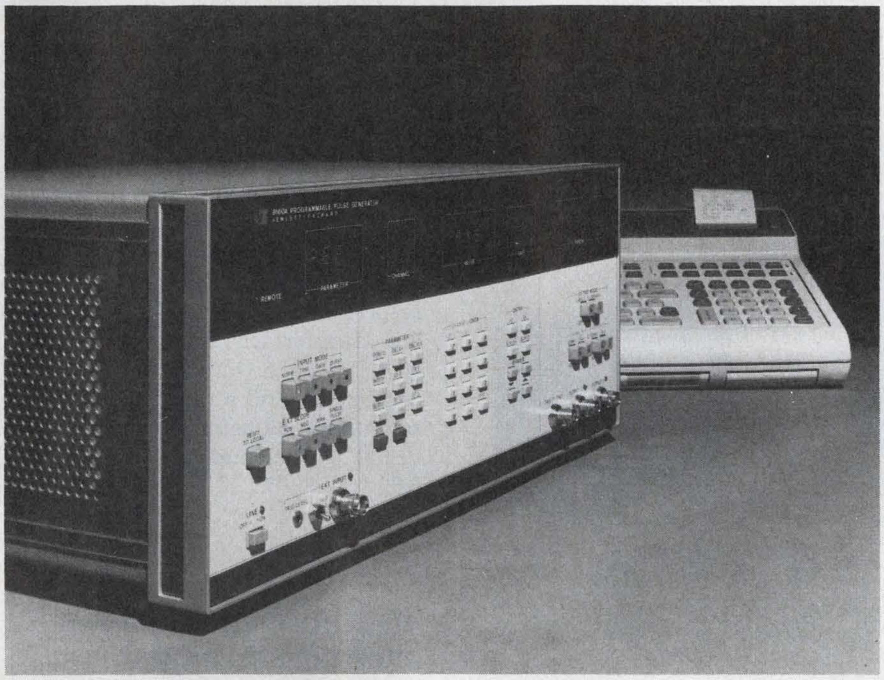
CIRCLE NUMBER 80

Programmable pulse gen gives best setting accuracy



Hewlett-Packard, 1501 Page Mill Rd., Palo Alto, CA 94304. (415) 493-1501. P&A: See text.

The most accurate pulse generator to date lets you program period to ±1%, width and delay to ±1% ±100 ps and accuracy to ±1% ±30 mV—all at ±0.5% repeatability of the programmed value. Hewlett-Packard's 50-MHz 8160A provides both bus (HPIB/IEEE-488) and keyboard operation, and can memorize up to nine control or parameter settings that can be recalled either by a front-panel pushbutton or through the interface.

Transition times are also programmable—both leading and trailing edges, and independently—but with an accuracy of ±5% and repeatability of ±1%. Periods can be set from 10 ns to 999 ms, width from 3 ns to 999 ns, and delay from 0 to 999 ms—all with three-digit resolution. Transitions take from 5 ns to 9.99 ms, also with three-digit resolution. Settling to rated accuracy takes less than 40 ns.

Both the lower and upper output levels of the HP generator are programmable—the lower from 9.89 to −9.99 V and the upper from 9.99 to −9.89 V. The maximum difference between levels is 9.99 V, and the minimum is 0.10 V. All specs assume a 50-Ω load.

Output modes include normal, complement and a 50-Ω or 1-kΩ internal-load. The output level can be doubled by operating into an open circuit or disabling the internal load. Another version of the 8160A, a two-channel model, offers an A+B mode that swings 20 V within a ±20-V window, from 50 Ω into 50 Ω.

How good are the 8160A's pulses? Overshoot and ringing stay below 3% of the peak-to-peak amplitude. Transition slopes, measured between the 10% and 90% points, remain linear to within 3% for transition times above 30 ns. Delay jitter, width and rep rate stay below 0.1%.

Other features include built-in batteries to hold the stored information when power is turned off, internal and external trigger modes, and external gating and counted bursts.

The single-channel 8160A sells for $11,000, the dual-channel for $4800 more. Delivery is 60 days.

CIRCLE NO. 301

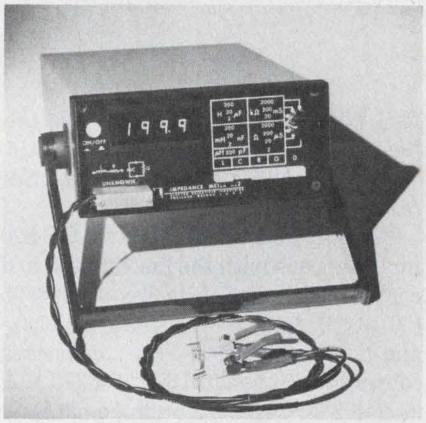
Panel meters read true rms

Data Tech, 2700 S. Fairview St., Santa Ana, CA 92704. Dick Tassone (714) 546-7160. $119/$149 (100 qty); stock.

Model 83 (3-1/2 digits) and Model 84 (4-1/2 digits) read true-rms voltage on LED displays and are housed in standard NEMA cases. BCD output, external read-rate control, programmable decimal points and selectable conversion rates are provided. Specs for the Model 83 are: 0.2% accuracy, 90 ppm tempco, frequency range of 35 Hz to 10 kHz, 80-dB common-mode rejection ratio and 1000-MΩ input impedance. Specs for the Model 84 are the same except for 0.16% accuracy and 50 ppm tempco. The meters are available in full-scale ranges of 200 mV, 2, 20 and 200 V ac rms.

CIRCLE NO. 307

Measure L, R and C at two tests per second

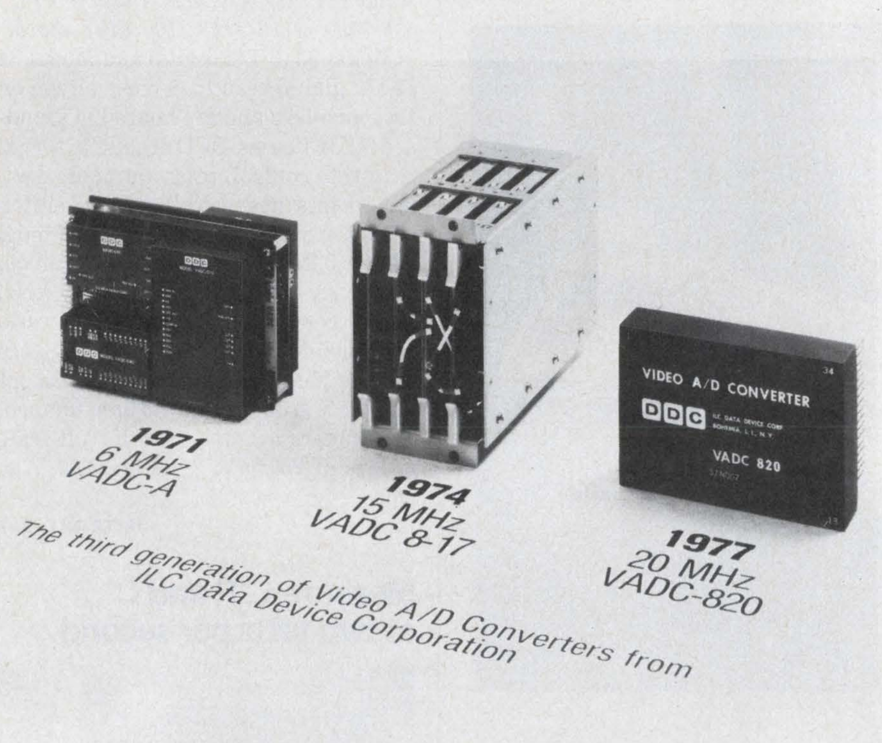


Electro Scientific Ind., 13900 N.W. Science Park Dr., Portland, OR 97229. Jim Currier (503) 641-4141. $695.

Model 252 digital impedance meter gives values for L, R, C and G (even D) over wide ranges at 0.25% accuracy and at a speed of two measurements per second. Test frequency is 1 kHz, and the meter features external bias, analog outputs, input protection and a low-power design. Ranges and resolutions are: capacitance, 199.9 μF (0.1 pF); resistance, 1999 kΩ (1 mΩ); inductance, 199.9 H (0.1 μH); conductance, 1999 ms (1 ns); dissipation factor, 1.999 (0.001). Optional versions with autoranging and 120-Hz frequency are also available.

CIRCLE NO. 308

20-MHz a/d converter keeps speed high and cost low



ILC Data Device Corp., Airport International Plaza, Bohemia, NY 11716. Jim Sheehan (516) 567-5600. P & A: See text.

Not only does the 20-MHz VADC-820 match speeds with the fastest 8-bit a/d converters, it also costs less—just $995 (50 qty.). And, with a built-in track-and-hold amplifier, the converter comes in a compact 6.375 × 4.375 × 1 in. (16.2 × 11.1 × 2.5 cm) module.

Acquisition of an analog signal to within 0.2% of full scale takes 20 ns, while the aperture uncertainty is 20 ps. And, the track-and-hold amplifier can slew at speeds of up to 500 V/μs.

Amplifier input impedance is 75 Ω although 49.9 or 93.1 Ω input impedances are optionally available. A ±10% gain adjustment for the amplifier accommodates voltages of 1.024 and 2.048 V, which are often used in video conversion systems.

Gain-error has been kept to just ±0.5 LSB, max and can be trimmed to zero. Gain tempco is at most ±100 ppm/°C, while amplifier offset tempco is 400 μV/°C.

Converter bandwidth is a wide 100 MHz, and the minimum signal-to-noise ratio is a reasonable 45 dB. There are four pin-programmable input voltage ranges—0 to +1 V, or 0 to +2 V with binary coding; and ±0.5 V, or ±1 V with offset-binary coding. Logic outputs are TTL-compatible. Both a Start-Conversion input and a Data-Ready output are available for digital control.

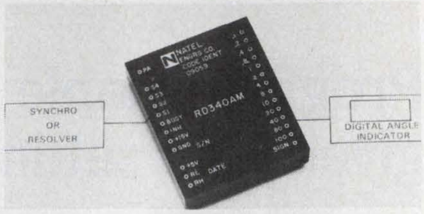
The VADC-820 requires +5 V at 700 mA, −5.2 V at 1.7 A, ±15 V at 0.2 A, all ±5%. The converter can operate over −20 to 70 C.

Competitors are scarce. Two major rivals are the 20-MHz ADC-TV8B module from Datel (Canton, MA) and an 18-MHz two-card converter from Computer Labs (Greensboro, NC). Both units also deliver 8-bit data words, but cost about $1900 or more apiece. The Datel unit measures 7.5 × 4.25 × 0.875 in. and comes in an aluminum case with a subminiature D connector for power and digital signals and a 3-mm rf connector for the analog input.

Delivery of the ILC Data Device VADC-820 takes four weeks.

ILC Data Device	**CIRCLE NO. 303**
Computer Labs	**CIRCLE NO. 304**
Datel	**CIRCLE NO. 305**

Synchro/BCD converters give 3 or 4-digit output

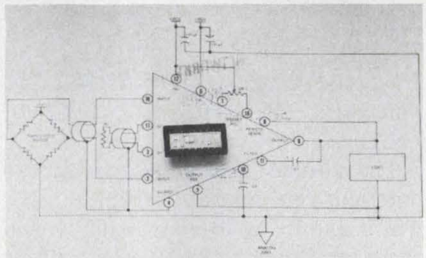


Natel Engineering, 8954 Mason Ave., Canoga Park, CA 91306. Ed Berman (213) 882-9620. $395/$495; stock to 8 wks.

Models 331 and 341 synchro-to-BCD (s/BCD) converters provide 3 and 4-digit unipolar outputs of 0 to 359° and 0 to 359.9°, respectively. The Models 330 and 340 provide 3 and 4-digit bipolar outputs of ±179° and ±179.9°, respectively. These s/BCD converters are transformer isolated and accept 400-Hz inputs. Outputs are DTL/TTL compatible, and a pin is available for zero-offset adjustment with an external potentiometer. Size is 3.12 × 2.62 × 0.82 in.

CIRCLE NO. 309

Instrument amp allows internal gain adjust



Micro Networks, 324 Clark St., Worcester, MA 01606. John Munn (614) 852-5400. $59 (100 qty); stock to 4 wks.

The MN2200 DIP instrumentation amplifier includes internal gain-setting resistors and an optional two-pole Butterworth filter. Gain error due to a combination of TC and thermal differences between the internal and external gain-setting resistors is eliminated by using all thin-film laser-trimmed resistors for the critical gain-setting elements. Internal resistors are for gains of 1, 10, 100 and 1000, settable with a single external resistor. Common-mode rejection ratio better than 80 dB, initial offset voltage less than 200 μV. Input offset drift 6 μV at G = 1, 2 μV at G = 1000. Gain linearity at G = 1 better than 0.005%, accuracy better than 0.01%. Full power bandwidth is 750 kHz at G = 1.

CIRCLE NO. 310

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CIRCLE NUMBER 81

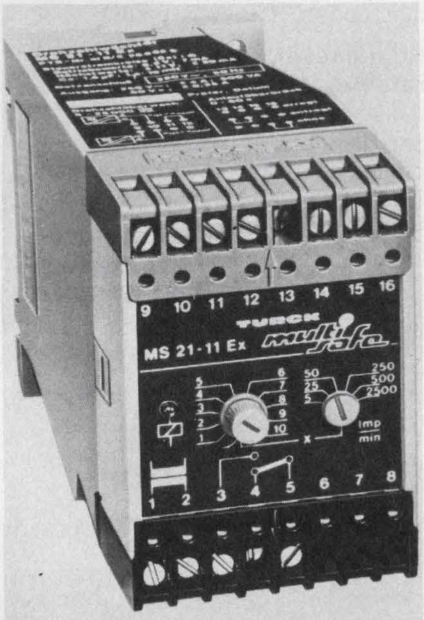
Hybrid PAD works with charge producers

AMPTEK, 6 Angelo Dr., Bedford, MA 01730. John Pantazis (617) 275-2242. $155 (100 qty); stock to 6 wks.

A charge-sensitive preamplifier-discriminator and pulse shaper (PAD), Type A-101, can be used with charge-producing detectors in the pulse-counting mode. The TO-8 packaged hybrid can be mounted at a detector anode. The power required is 15 mW and the unit interfaces directly with CMOS and low power TTL logic. Both the input sensitivity and the output-pulse width are externally adjustable.

CIRCLE NO. 320

Rotational-speed monitor senses without contact



Turck Multiprox, 9710 Tenth Ave. N., Minneapolis, MN 55441. Bob Johnson (612) 544-7977. $217; 6 to 8 wks.

The MS21-12EX rotational-speed monitor scans drives without contact or feedback and can be programmed for underspeed or overspeed monitoring. The device monitors from 5 to 25,000 pulses/min. Start-up time delay is adjustable from 0 to 60 s to inhibit speed monitoring during drive start-up. The unit is housed in plastic and includes two removable 8-position terminal blocks for replacement without disconnecting hard wiring. Units may be track-mounted on a 1.38 in. rail, or base mounted.

CIRCLE NO. 321

Digital combiner boasts high accuracy

Natel Engineering, 8954 Mason Ave., Canoga Park, CA 91306. (213) 882-9620. $249; stock to 6 wks.

The TSL1036 digital combiner takes the output from a 7-bit coarse s/d converter and a 14-bit fine s/d converter and combines them into a single 19-bit output, giving a ±½ LSB accuracy. The device accepts signals from any binary-output converter including all tracking and sampling types as well as multiplexed systems. The combiner accommodates speed ratios of 36:1, 36:2, 18:1, or 9:1. The size is 3.1 × 2.6 × 0.42 in.

CIRCLE NO. 322

2-bit d/a has built-in storage register

Analogic, Audubon, Rd., Wakefield, MA 01880. Dick Ferrero (617) 246-0300. $135; 12 wks.

The MP1480 12-bit current-loop d/a converter has a built-in storage register and acts as a digitally controlled current valve, or as a voltage-output d/a. The conversion accuracy is ±0.012% of FSR, settling time to ±½ LSB is 10 μs for a full-scale input and slew rate is 2 mA/μs. When current-loop operation is not required, pin-programmable unipolar or bipolar-voltage outputs are available. Internal noise is 2 μA rms, in a 10 Hz to 100 kHz bandwidth, and gain tempo is 1 μA/°C.

CIRCLE NO. 323

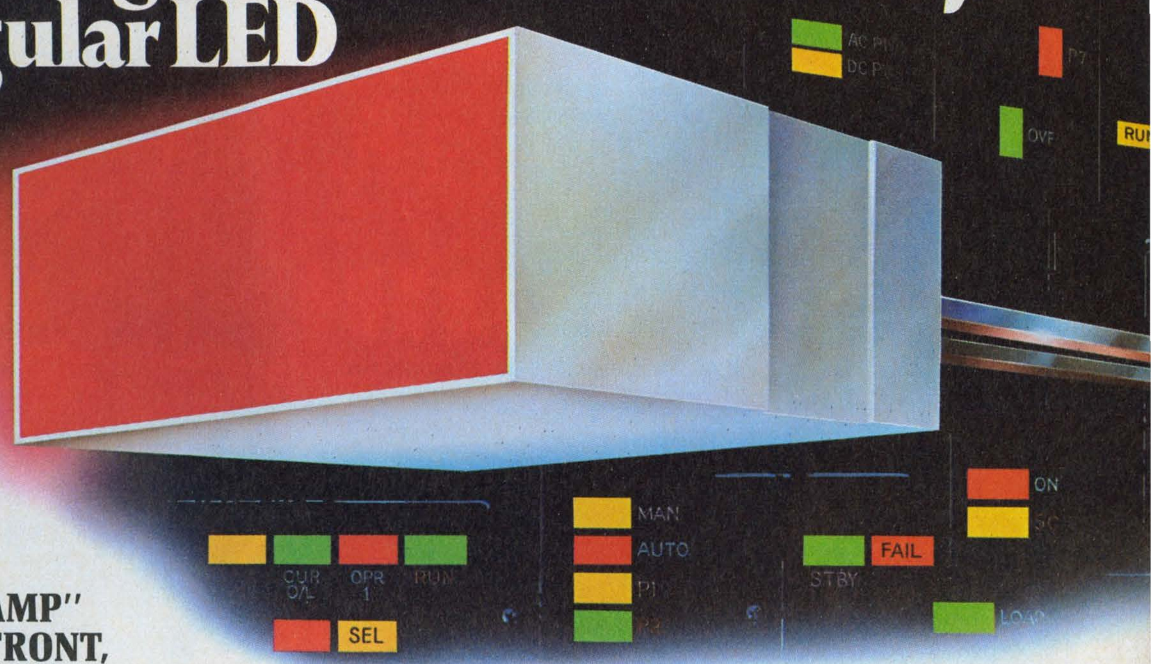
Crystal clock uses IC design

Solid State Electronics, 15321 Rayen St., Sepulveda, CA 91343. Ed Polit (213) 894-2271. $98 (50 qty); 4 to 10 wks.

The Model CXO-115 crystal-clock oscillator uses a solidly encapsulated IC design to achieve a stable, miniature timing source. Any frequency can be ordered between 1 and 15 MHz. The output is fully compatible with most TTL or DTL families (maximum fan-out is 10 for 54/74 TTL loads). Rise and fall time is 75 ns maximum. Operation is from a nominal 5-V supply. The oscillator plugs into a 14-pin DIP socket or it can be wired or soldered directly to a PC board.

CIRCLE NO. 324

No one has ever seen a lamp like this. It's our bright, new, revolutionary rectangular LED



OUR "LEGEND LAMP" PUTS LIGHT UP FRONT, WHERE YOU NEED IT.

The MV57124 rectangular LED from Monsanto gathers light from a high brightness chip and focuses it on a flat front surface. The shape of the lamp and the uniform illumination across a large emitting area (.15"x.25") makes the "legend lamp" an exciting, aesthetically pleasing element in your modern industrial panel design. It's available now in high brightness red and will soon be available in other colors.

STACKABLE: SIDE-BY-SIDE, OR END-TO-END.

The unique design of the MV57124 utilizes a special plastic to house the LED assembly, so that no light is emitted from the sides or edges of the unit. All of the light is concentrated on the viewed surface. This means that lamps can be stacked, side-by-side in an X or Y direction, without light interference between units.

4 MCD BRIGHT. UNIFORM.

The MV57124 "legend lamp" uses Monsanto's high efficiency red emitter. The carefully engineered package makes maximum use of that emitted light, minimizing unusable light. Light output is a *very bright* 4 millicandelas at 20 mA forward current. That's up to 3 times the output of other rectangular lamps. So you can use the MV57124 as a legend backlight, a panel indicator, or a bargraph meter.

ANOTHER PERFORMANCE PRODUCT FROM MONSANTO.

This unique new product is a development from the technology and experience that is Monsanto. Our history as being one of the first suppliers of LED's has led to the features and characteristics of the "legend lamp."

FREE SAMPLE.

Write today, on your company letterhead, for a free sample. We'll also send you full specifications on our new MV57124.

Monsanto Commercial Products Co., Electronics Division, 3400 Hillview Ave., Palo Alto, CA 94304. Telephone: (415) 493-3300.

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CIRCLE NUMBER 82

Model 178

Now... the next generation of bench DMMs!

Two New Keithley Models offer uncompromising performance and outstanding value.

- Accuracy 3½'s can't match: 0.04% + 1 digit on dc volts and ohms.
- Large, bright, 20,000-count LED display that's quick and easy to read.
- Convenient bench size that won't get "lost" yet doesn't crowd.
- Exceptional reliability.

Model 178 offers functions and ranges for most measurements: 100μV to 1200V dc, 100μV to 1000V ac, 0.1Ω to 20MΩ. At $199* it is a remarkable value!

Model 179 is a full-function, multi-feature model offering the same advantages as the 178. Plus TRMS AC; 10μV Sensitivity; Hi and Lo Ohms; AC and DC Current. Yet it's still half the price you'd expect. Only $289*!

Model 179

Both models feature designed-in reliability.

Rugged circuits use a minimum of parts—high quality, off-the-shelf parts—carefully assembled and tested by Keithley (we've been making sensitive laboratory instrumentation for more than 30 years.)

Outstanding overload protection and rugged mechanical design keep both units going even after severe abuse. One-year accuracy specifications minimize recalibration costs. Local assistance keeps downtime to a minimum should service ever be needed.

A battery option, user installable, gets you off "line" for critical measurements or for field use. Nine other accessories add versatility.

Keithley's 178 and 179 are designed, built and supported to provide continuous usability at the lowest total cost of ownership.

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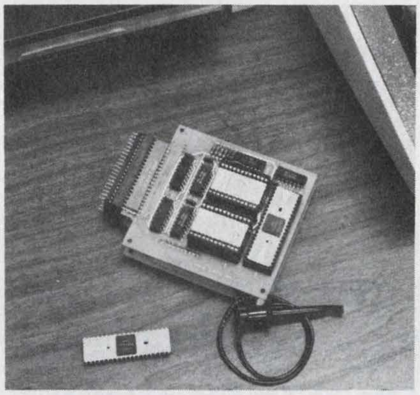
Data buffer provides 2048-character memory

Techtran, 200 Commerce Dr., Rochester, NY 14623. Judith Monje (716) 334-9640. $625; 8 to 12 wks.

The Model 300 data buffer, a digital storage unit, consists of a 2048-character memory for a variety of store and forward uses. The device is RS-232 plug compatible, has switch-selectable baud rates of 110 and 300, on-line/off-line capability, and manual or remote control. The data buffer weighs 4.5 lb.

CIRCLE NO. 325

Computer-on-a-chip has 4-μs cycle time

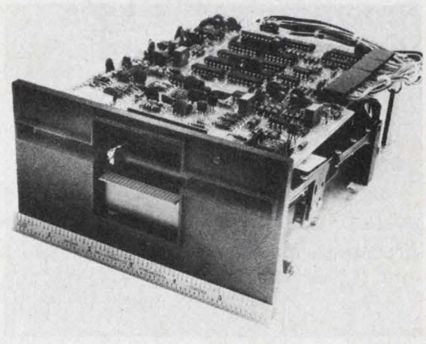


American Microsystems, 3800 Homestead Rd., Santa Clara, CA 95051. Tom Edel (408) 246-0330.

A 4-μs cycle time computer-on-a-chip microprocessor, the S2000, has 8192 bits of ROM and 256 bits of RAM, input/output, and a clock oscillator, all on one chip. The TTL-compatible device includes 13 outputs, eight inputs and eight bidirectional three-state I/O lines, a seven-segment display decoder and LED drivers. Also included are an arithmetic logic unit, a control section and three registers for addresses and intermediate values. The μC operates with either a 9-V-dc power supply or dual supplies of +5 and +9 V dc. Typical power dissipation is 360 mW. The S2000 is available in 40-pin plastic or ceramic packages. Prices are negotiated, and depend on quantities and development costs.

CIRCLE NO. 326

Floppy-disc drive offers more storage

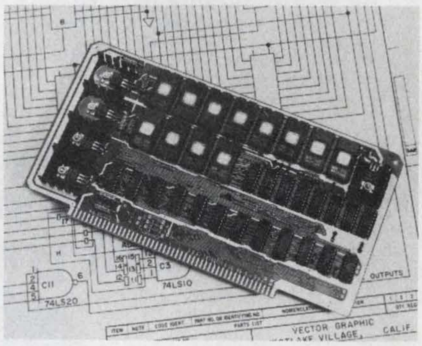


Micropolis, 7959 Deering Ave., Canoga Park, CA 91304. (213) 703-1121. $299 (500 qty); 4 wks.

A 5-¼ in. floppy-disc drive, Model 1015, offers three to four times the storage capacity of competitive units on standard diskettes. The drive is available in either 35 or 77-track models, with single or double density, to a total maximum storage of 480 kbytes per drive. Track-to-track access time is about 30 ms, and data transfer rates can be as high as 250,000 bytes/s.

CIRCLE NO. 327

PROM/RAM board comes assembled or as kit



Vector Graphic, 790 Hampshire Rd., Westlake Village, CA 91361. Lore Harp (805) 497-6853. $135 (kit), $175 (assembled); stock.

A PROM/RAM board, compatible with the S-100 bus, comes either assembled or in kit form. The board occupies two independently addressable 8-k blocks and has a 1-k onboard RAM and capacity for up to 12-k 2708-type EPROMs. Complete addressing flexibility is provided via address jumpers. Video or disc-operating systems can be nested in the 3 k of unused space. MWRITE logic and jump-on-reset allow operation without a front panel. A 24-command PROM monitor is available to interface with most popular I/O boards.

CIRCLE NO. 328

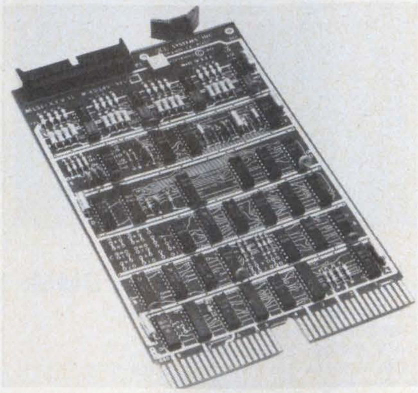
Programmmable-logic unit is on single card

Pro Log, 2411 Garden Rd., Monterey, CA 93940. (408) 372-4593. $185 (100 qty); 2 to 4 wks.

A single-card programmable-logic system based on the 6800 microprocessor, Model PLS-868, includes 1 k of 2114-type RAM and sockets for up to 8 k of 2716-type EPROM. The system executes all 6800 processor instructions and the user can jumper-set either RAM or I/O into memory-base page 00 for use with the 6800s fast "memory direct" instructions. The card also includes a crystal clock, two interrupt inputs, power-on and external reset, three 8-bit output ports and two 8-bit input ports.

CIRCLE NO. 329

Plotter interface board fits into LSI-11



MDB Systems, 1995 N. Batavia St., Orange, CA 92665. Gene Sylvester (714) 998-6900. $550; 2 wks.

The MLSI-XYV-11 board provides a parallel interface to XY plotters from the DEC LSI-11 μP bus. The board includes data, control, and status registers. The data register contains these instructions: right, left or middle pen down; raise all pens; step pen carrier left or right; and step drum forward or back. Jumper selection of +5 V or +12 V provides power to eight control lines through differential or TTL line drivers to permit plotter operation at up to 100 ft from the LSI-11 bus. The interface is a dual module needing one-half quad slot of the LSI-11 backplane.

CIRCLE NO. 330

Expandable computer is based on LSI-11 CPU

RDA, 5012 Herzel Pl., Beltsville, MD 20705. W.R. Davies (301) 937-2215. See text; 4 wks.

Model RD-11A computer uses the LSI-11 CPU and is configured on a 9-quad-slot backplane. The nine mounting slots offer expansion capability. Memories include dynamic and static RAM, core RAM, EPROM and PROM. The unit has 62 kbytes of addressable memory and core memory expansion to 56 kbytes without the need for expansion boxes. A representative system with 62 kbytes of nonrefresh, fixed and floating point arithmetic, dual 1.2-Mbyte floppy disc, 24-line video display console, 180 char/s line printer, rack enclosure and RT11 operating system is priced at $15,945.

CIRCLE NO. 331

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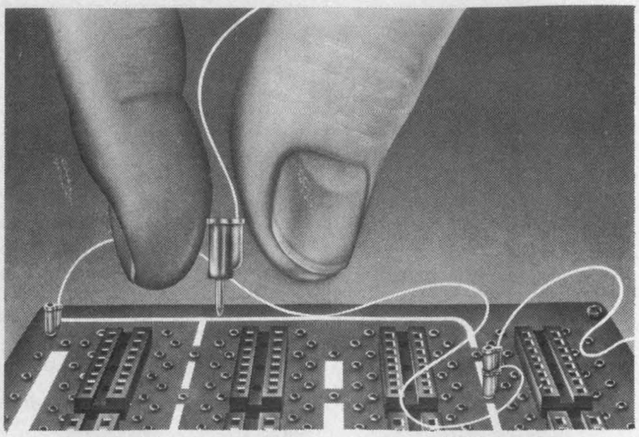

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CIRCLE NUMBER 86

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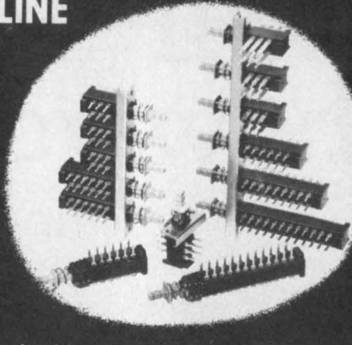
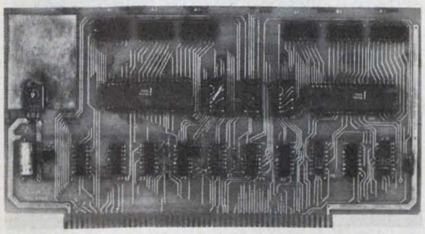


The JP-7000 Series Multi Push-Button Switches include interlocking, self-locking, momentary or reset type switches that are available with either 15 or 20MM spacing in DPDT, 4PDT, 6PDT, and 8PDT configurations. The switches are rated at 300mA @ 30V DC and operate from −10°C to +70°C with a mechanical life expectancy of 30,000 cycles. Up to a maximum of 6 switch stations can be interlocked if desired, and up to 12 switches can be mounted on the same frame. Representatives throughout the U.S. Call, write or wire:

SMK Electronics Corporation of America
118 East Savarona Way Carson, California 90746
Tel: (213) 770-8915

CIRCLE NUMBER 88

I/O controller ties into six parts



IOR, Box 28823, Dallas, TX 75228. (214) 358-2671. $149. (kit); stock.

A six-port programmable I/O controller, the PI04800, comes on a 5 × 10-in. PC board. All data transfer is handled in parallel; a single input or output being accomplished by executing one processor instruction. The board is compatible with the S-100 bus and will interface a computer to any parallel device with or without handshaking strobes. The device has two channels with three different modes for each channel. Each channel may be programmed for up to three 8-bit ports, which may be operated simultaneously. Whether a port is to be an input, an output, or a bidirectional port is determined by a control word. This control word determines the mode of each port, the direction, strobes, and interrupt capabilities.

CIRCLE NO. 332

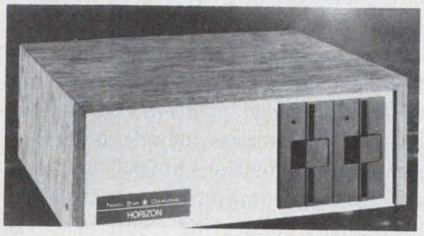
Mini and peripheral interfaces are for OEMs

Bytronix, 2751 E. Chapman Ave., Fullerton, CA 92631. N. Clark (714) 871-8763. $5500/$8175; 6 to 8 wks.

A series of interface packages for OEMs includes a 16-bit central processor with 64 kbytes of MOS memory, a disc controller, line-printer controller and multiplexer. The basic package consists of three 15 × 15-in. circuit boards contained in a 6-slot, 5.25-in. high rack-mountable chassis with power supply. Series 1000 includes a CPU, real-time clock, 64 kbytes of addressable memory, a disc controller that handles up to four 10-Mbyte drives, a controller for one line printer, a multiplexer with four channels for CRTs, a TTY channel, power supply and interconnecting cable to first disc. The series 2000 has the same CPU, a storage module controller that handles up to four drives and an 8-channel multiplexer with TTY channel.

CIRCLE NO. 333

μP system uses floppy-disc memory

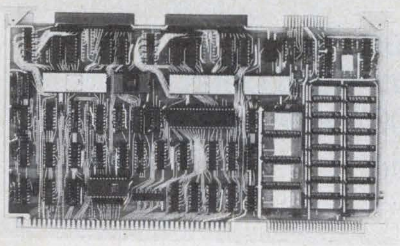


North Star Computers, 2465 Fourth St., Berkeley, CA 94710. (415) 549-0858. $1899; 4 wks.

A complete μP system, called Horizon, with integrated floppy-disc memory can be programmed in extended disc BASIC with the addition of a CRT or hard-copy terminal. The system includes sequential and random disc files, formatted output, a powerful line editor, strings and user-defined functions. Two models are available. Horizon-1 includes a Z80 processor, 16-k RAM, minifloppy disc and 12-slot S-100 motherboard with serial terminal interface. Horizon-2 includes a second built-in disc drive. The systems can load or save a 10-kbyte disc program in less than 2 s. Each diskette can store 90 kbytes.

CIRCLE NO. 334

Computer mates with SBC-80 systems



Monolithic Systems, 14 Inverness Dr. E., Englewood, CO 80110. Dick Lorimor (303) 770-7400. $845; 6 wks.

The Model MSC 8001 is an SBC-80 Multibus compatible computer featuring 8-k static RAM and 8 k of EPROM sockets with serial and parallel I/O ports. The single board computer uses the Z-80 processor with up to 4-MHz clock speed. Using the Z-80 processor, 158 instructions are provided, including the 78 instructions of the 8080A for total compatibility with indexed, bit and relative addressing modes. A dual set of internal registers improves multiprocessing capability. A serial I/O port supports RS232C, TTL, or current-loop-compatible serial I/O devices with programmable baud rate.

CIRCLE NO. 335

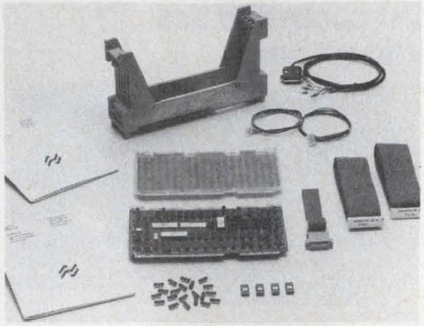
Computer system sports low price tag

Applied Data Communications, 1509 E. McFadden Ave., Santa Ana, CA 92705. (714) 547-6954. $9500 to $30,000.

Advent 1000 is a small business computer system with a price tag under $10,000. The system consists of a microprocessor-based CPU with 32 k of RAM, an IBM-compatible floppy disc and a CRT terminal. Its 32-k memory is expandable to 64 k, and up to eight floppy-disc drives, four 10-Mbyte disc cartridges, eight CRT or printing terminals, eight magnetic-tape drives and three high-speed printers can be supported. Capabilities include asynchronous communications at 9600 baud and synchronous communications at 19,200 b/s. The operating software is MicroDOS/BASIC, an amplification of Dartmouth BASIC.

CIRCLE NO. 336

Prototype package speeds Series-80 μP design



National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. Don Schare (408) 737-5166. $878; stock.

A prototyping package, BLC 80P, lets designers quickly construct and debug custom interface systems using National's BLC 80/10 board-level computers. The package consists of a BLC 80/10 computer board with 1 k words of RAM and 2 k words of blank programmable ROM. An additional 2 k words of PROM contains the system monitor. The BLC 80/10 has 48 programmable parallel I/O lines socketed to accommodate interchangeable line drivers and terminators. The package includes ten DM 7437 open-collector line drivers, ten BLC 902 1-kΩ terminating resistor networks, and ten BLC 901 220/330-Ω terminating resistor networks. For developing custom interface circuits, the kit contains a universal prototype board with space for 114 16-pin sockets or the equivalent mix of 14, 16, 18, 22, 24, 28 and 40-pin sockets.

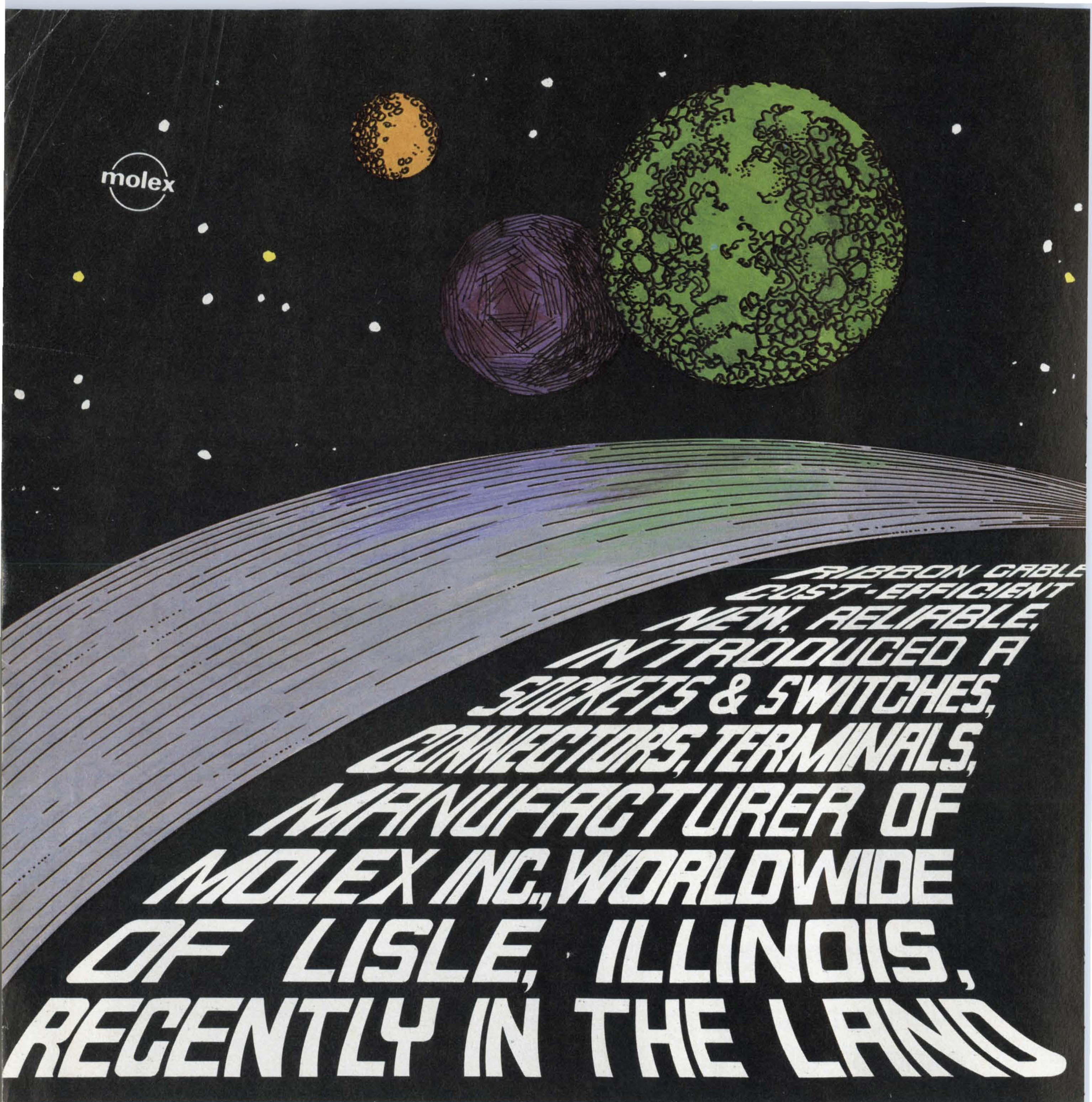
CIRCLE NO. 337

Dual Z80-based μC has 80-k RAM capacity

Digi-Log Systems, Babylon Rd., Horsham, PA 19044. (215) 672-0800. $4950 (100 qty).

A dual Z80-based multifunction workstation, called Microtherm II, has 80-k RAM of storage. The system allows use of a full 24 × 80 char 12-in. CRT, a 2200 char/s nonimpact printer, and single or dual minidiskettes. Using two Z80A microprocessors, the system has 80 kbytes of RAM capacity in a single desktop cabinet. The internal printer, dual diskettes, and memory expansion beyond 32 k are optional. An external printer feature is available to accommodate value-added business applications.

CIRCLE NO. 338



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Mag-tape controller mates with Interdata μC

Western Peripherals, 1100 Claudina Pl., Anaheim, CA 92805. Jack Olson (714) 991-8700. $3100; 4 wks.

Compatible with the Interdata family of minicomputers, the TC-140 is a plug-in, single-board, dual-density magnetic-tape controller with all interface and formatting electronics for both PE and NRZ. Up to four drives can be handled in any combination of seven-track NRZ, nine-track NRZ, nine-track PE, or nine-track PE/NRZ at any two speeds in the range of 12.5 to 125 in./s. The device also has an extended command register and an enhanced status register.

CIRCLE NO. 339

Hand-held cassette unit acts as data recorder

Techtran, 200 Commerce Dr., Rochester, NY 14623. Judith Monje (716) 334-9640. $825.

Porta 200 hand-held recorder is a digital cassette unit for large-capacity portable data entry. As the operator enters data on the 16-key pad, it is displayed for verification and recorded on a digital cassette. Each cassette will store 85,000 characters and can be read on any RS-232 plug-compatible cassette unit for transmission to both local and remote terminals and CPUs. The battery-powered device weighs 3 lb, and will operate for about four days between charges.

CIRCLE NO. 340

Device makes TV set a time-sharing terminal

Micon Ind., 252 Oak St., Oakland, CA 94607. Bill Northfield (415) 763-6033. $500.

The TIGER (Television Interface General-Purpose Economy Remote terminal) turns any standard television set into a low-cost time-sharing terminal. The device contains an acoustic coupler, full ASCII keyboard, and TV electronics that provide interconnection to a TV set via the antenna input. Up to 1024 characters may be displayed in switch-selectable formats for 8 or 16 lines of 32 or 64 char/line. The unit has a built-in power supply, eight selectable baud rates from 110 to 9600, TTY compatibility, an RS-232C connector for hook-up to a computer and an optional, self-contained memory.

CIRCLE NO. 341

Video imaging system works alone or with minis

Lexidata, 215 Middlesex Tpke., Burlington, MA 01803. Martin Duhms (617) 273-2700.

System 6400 is a full refresh raster-scan video imaging system that will stand-alone or interface with most minicomputers. The video image processor has a dedicated minicomputer and a bipolar microprocessor operating in tandem to provide a wide-intensity spectrum and high-resolution display. It is programmable on both processor levels and stores 5.24 Mbits of data that can be expanded. Resolution is up to 1280 × 1024 pixels, with up to 16 bits of intensity and overlay data. Up to 256 gamma-corrected gray-scale levels or up to 1024 colors may be displayed at once, and the scan rate is 60 Hz. Alphanumerics may be superimposed over the image display.

CIRCLE NO. 342

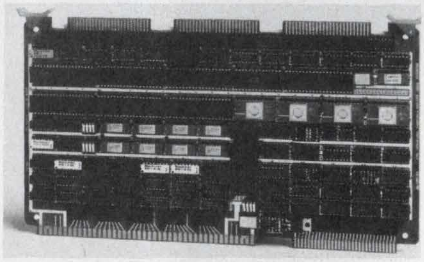
Puter/troller serves development and product

PAIA Electronics, 1020 W. Wilshire Blvd., Oklahoma City, OK 73116. (405) 842-5480. $90 up.

The Model 8700 computer/controller can be used as a development system and a processor board in the final product. The board has space for 1 kbytes of RAM in 256-byte increments and 1 kbytes of PROM in 256-byte increments, five 8-bit parallel-input ports and one 8-bit parallel-output port. A feature provides system checkout by floating the MPU data bus while forcing the execution of an address-incrementing NOP instruction. An interactive editor debugger monitor program gives control of code entry and debugging and has a relative-address computer for automatic calculation of relative branches, a back-space key for stepping through memory backwards and "pointer high," "pointer low" keys that make twin 7-segment displays serve the multiple functions of address and data display.

CIRCLE NO. 343

μC board has on-card floppy-disc interface



Heurikon, 700 W. Badger Rd., Madison, WI 53713. Chris Priebe (608) 255-9075. $350.

In addition to being a general-purpose Z-80 based microcomputer with a 4-k RAM and up to 8 k of ROM, the MLZ-80 board contains an on-card floppy-disc interface for standard or mini-floppy disc drives. The 6.75 × 12-in. card has dual-serial asynchronous/synchronous ports with separate software-controllable baud rates up to 19,200 baud, RS-232C or current-loop interface, four 8-bit parallel ports and DMA logic for memory and I/O data transfers. Four counter/timers, selectable power-on-jump starting address, full Z-80 vectored interrupt support and multiprocessor capability are also included.

CIRCLE NO. 344

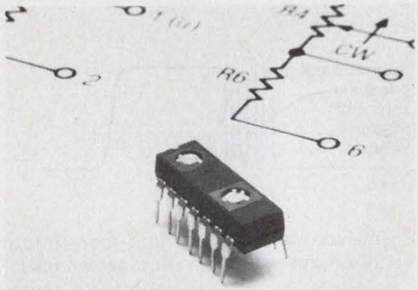
Trimmer and resistor network combined in a DIP

Bourns, 1200 Columbia Ave., Riverside, CA 92507. Bill Galvan (714) 781-5204. P&A: See text.

Combinations of cermet trimming potentiometers and resistor networks are available in dual-in-line pin configurations. The MFT series of multifunction trimmers perform entire subsystem functions and are designed to replace combinations of conventional discrete resistive components.

Five basic trimmer configurations are available and these come in nine different models. Various combinations of trimmers and resistor networks are offered in 6-pin, 8-pin, 14-pin and 16-pin DIPs. Two models are available for op-amp gain-trim applications.

MFT Model 7104D offers four single-turn trimmers in a 16-pin DIP. Available total resistances are 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ and 500 kΩ. MFT Model

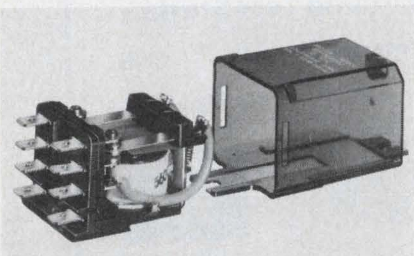


7105A offers one single-turn trimmer with one series-fixed resistor in a 6-pin DIP. Model 7107C is designed for op-amp gain-trim applications. It consists of one single-turn trimmer with two series fixed resistors and one discrete fixed resistor in a 14-pin DIP.

All nine models are priced between $0.65 and $2.20 in 1000 quantities. Sample quantities are available in three weeks.

CIRCLE NO. 302

Power relay at 20 A fills product gap

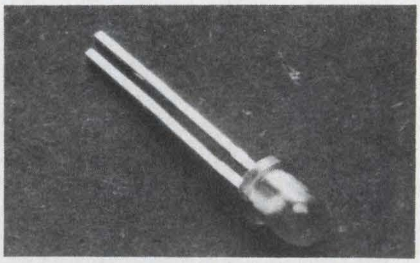


Midtex, 1650 Tower Blvd., North Mankato, MN 56001. L. Bremmer (507) 625-6521. $3.59 (2500 qty); 6 wks.

The Type 187 power relay is rated at 20 A and fills the product void between the standard 10-A relays and the much larger 30-A versions. The relay is available in DPDT style with ratings of 20 A at 28 V dc or 120 V ac, and 3/4 hp at 120 V ac or 1-1/2 hp at 240 V ac. Open stud-mounted or dust-covered versions with 1/4-in. QDC terminals can be provided. Coil voltages are 6 to 110 V dc and 6 to 220 V ac.

CIRCLE NO. 345

LED lamps come in four colors



Opcoa, 330 Talmadge Rd., Edison, NJ 08817. (201) 287-0355. See text.

The OPL series GaP T-1 sized LED lamps are available in red (OPL-209A), green (OPL-211), deep orange (OPL-209S), and yellow (OPL-212). The lamps have a broad range of viewing angles and intensities, and they are IC compatible. Typical luminous intensities range from 1 to 3 mcd at a forward current of 20 mA. Price for the 1-mcd red OPL-209A is $0.33; the 3-mcd deep orange OPL-209S is $0.39 in quantities of 1 to 99.

CIRCLE NO. 346

16-position DIP switch acts as mechanical PROM

EECO, 1441 E. Chestnut Ave., Santa Ana, CA 92701. Dane Henriksen (714) 835-6000. $1.60 (10,000 qty); 8 wks. (proto).

Micro-DIP is a screwdriver-actuated mechanically programmed ROM and is available in a 16-position (hexadecimal) model. Its 2-pole binary (with separate commons) to not-true-bits code can be used with LSI devices such as μPs. The switch occupies only one-half the space of other rotary DIP switches, and requires six terminal pins for the hexadecimal-code output. The 0.142 × 0.376 × 0.280 glass-filled nylon housing is color-coded yellow with large characters. Contacts are gold plated with terminals on 0.100 × 0.300 centers, allowing direct mounting to a PC board or in a DIP socket.

CIRCLE NO. 347

DIP ceramic capacitors have low profile

Sprague Electric, 347 Marshall St., North Adams, MA 01247. (413) 664-4411.

Low-profile multilayer ceramic capacitors are available in 2, 4, 8, 14 and 16-pin DIPs with a seated height of 0.200-in. The PC Multi-Comp monolithic ceramic capacitors permit closer stacking of PC boards on which these capacitors are used with ICs. Capacitance between 47 pF and 0.1 μF at 100 WV dc, to 0.22 μF at 50 WV dc and to 0.47 μF at 25 WV dc are available. Operating temperature is −55 to 85 C.

CIRCLE NO. 348

Two-pole sync motors drive tapes and discs

Brevel Motors, 203 Broad St., Carlstadt, NJ 07072. Jack Dominice (201) 933-0220. $4 to $10 (5000 qty); 14 wks.

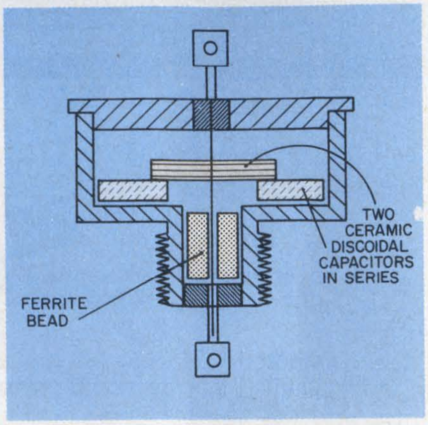
Audio and video tape or disc drives and digital printers employ the Series M two-pole synchronous motors. Running at synchronous speeds of 3600 rpm for 60 Hz and 3000 rpm for 50 Hz, the motors are also available with gear heads for lower speeds. Pull-out torque is up to 7 oz-in. maximum. Electrical specs include the standard 120 V at 60 Hz and a range of 12 to 240 V at 50 or 60 Hz.

CIRCLE NO. 349

Twin capacitors boost feedthrough-filter reliability

Centralab/USCC, 4561 Colorado Blvd., Los Angeles, CA 90039. Jack Smith (213) 240-4880. $10; 6 to 8 wks.

By putting two capacitors instead of one inside a conventional threaded-stud package and connecting them in series, Centralab/USCC has produced an ultrareliable feedthrough filter with a mean-time-between-failure rating well past a million hours.



The package contains an L-section filter with a ferrite bead providing the inductance, as well as two series-connected disc-shaped ceramic capacitors. Each filter capacitor is rated at 10^6 hours MTBF, and also at the package's full rated voltage, either 50 or 100 V dc.

When operating normally, the two capacitors share voltage stress equally, which alone can boost reliability. But should one capacitor short, the second one takes over to prevent the EMI-filtered conductor from shorting to the bulkhead mount.

As a matter of fact, a one-cap short will increase filtering capability because then the total capacitance isn't divided. Moreover, a one-cap short reportedly doesn't affect insertion loss, which ranges from 1 dB at 30 kHz to 70 dB at 10 GHz.

The ultrareliable filter meets or exceeds all applicable requirements of MIL-F-15733, is rated for the full −55 C to 125 C, features 1000-MΩ insulation resistance, carries 15 A dc and displays a dc resistance of less than 6 mΩ. The filter can have a 0.375-in. diameter and is fitted with a ¼-28 threaded mounting stud.

Two over-all capacitance/working voltage selections are available: 250 nF/50 V dc and 150 nF/100 V dc. A wider choice will soon be offered, and the present L-section will be joined by other circuits—T, π, and double-L configurations, according to Centralab/USCC.

Several competing firms produce high-reliability feedthrough filters, including Acushnet, Erie, RF Interonics, Sprague and Spectrum, but none provides the fail-safe capacitor, for which a patent is pending.

CIRCLE NO. 306

Solid-state relays have integral heat radiators

International Rectifier, 1521 Grand Ave., El Segundo, CA 90245. (213) 322-3331. $9 to $10 (50 qty).

The 4-A solid-state S37 Series relays for PC-board mounting provide integral heat radiators and internal snubbers. Additional features include high surge current, photoisolation, zero-voltage crossover and a 4-A rating at 40-C ambient without any additional heat sink. The S3714 is a 120-V-ac device and the S3724 is rated at 240 V ac.

CIRCLE NO. 356

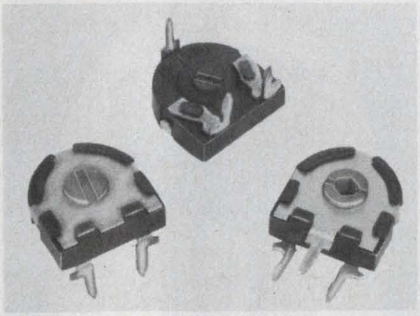
Slow-blow fuses resist vibration and shock

San-O Industrial, 35 Orville Dr., Bohemia, NY 11716. Shoji Kimura (516) 567-5556.

Glass-tube slow-blow fuses, SD3 (pigtail style) and SD4 (cartridge), resist vibration and shock. They are UL listed under 198-6 and rated for 250 V with 200% overload protection for 7 s. Other specs include a current carrying capacity of 110% of rating and short-circuit capacity of 10 kA, and a clearing time at 135% rating of 60 min and at 200% rating of 5 s maximum.

CIRCLE NO. 357

Trimmer resistor is only 10 mm wide

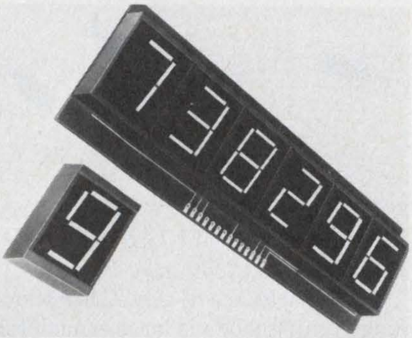


CTS, 1142 W. Beardsley Ave., Elkhart, IN 46514. Ray McCuddy (219) 295-3575. $0.10 (OEM qty).

A completely enclosed 10-mm composition trimmer, Type 265, is available in two PC mounting styles—horizontal or vertical. The units have a low-height profile, front and rear screwdriver-slotted rotor and a composition element. Electrical specs include a resistance range of 500 Ω to 2.5 MΩ, 0.15-W power rating at 40 C (derated to no load at 100 C), resistance tolerance of ±30% and a voltage rating of 350 V dc.

CIRCLE NO. 358

LED digits boast of unequalled eye appeal

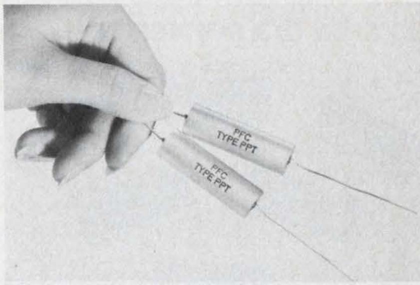


Litronix, 19000 Homestead Rd., Cupertino, CA 95014. Jim Futer (408) 257-7910. $1.65/digit (1000 qty); stock.

LED display, DL-840, creates evenly lit and sharply defined 0.8-in. digits with good eye appeal. The displays come packaged as 1-digit DIPs, with polarity indicator and overrange digit, also in DIPs, and in 2-to-6-digit modules with PCB edge connectors. The units feature a decimal point after each digit, common-anode or common-cathode terminals, and they are available with a red or clear plastic caps.

CIRCLE NO. 359

Poly-film capacitors serve critical uses

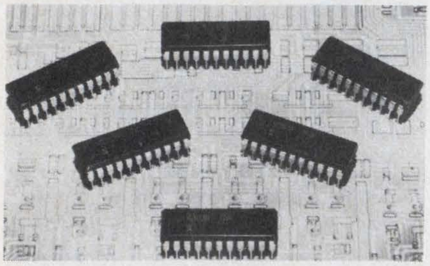


PFC, 100 Community Dr., Great Neck, NY 11022. (516) 487-9320. $1.10: 5% units, $2.05: 1% units at 100 V (unit qty).

Polypropylene-film capacitors, Type PPT, provide high insulation resistance and Q, extreme stability, close tolerance, and low dielectric absorption and dissipation factors. Tempco is −200 + 30 ppm/°C from 25 to −55 C and −350 + 30 ppm/°C from 25 to 105 C. They can be used in continuous operation from −55 to 125 C without derating. Standard production tolerances from 1/4% to 10% can be specified.

CIRCLE NO. 360

One chip functions as 8-bit d/a converter



Signetics, 811 E. Arques Ave., Sunnyvale, CA 94086. (408) 739-7700. $6.95 (100 qty); stock.

A μP-compatible 8-bit d/a converter is self-contained on a single monolithic chip. The large-scale linear circuit, NE5018, uses input latches controlled by a latch-enable pin. The chip, 24,000 sq mils in size, includes a stable voltage reference, a high slew rate buffer amplifier, a d/a converter, and an 8-bit input latch. Settling time is 2 μs, accurate to within ±½ LSB. Minimum latch-enable pulse width is 300 to 400 ns. Power dissipation is 270 mW.

CIRCLE NO. 361

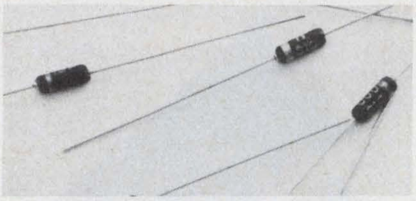
Remote-control chip set takes 31 commands

American Microsystems, 3800 Homestead Rd., Santa Clara, CA 95051. Tom Edel (408) 246-0330. $10.50 (100 to 999 qty).

A 31-command remote-control chip set has keyboard inputs, oscillators, and both analog and digital receiver outputs all on board the chip. Consisting of an S2600 transmitter and an S2601 receiver, the set eliminates the need for external crystals; only a resistor and a capacitor are required externally for a frequency reference. Eleven outputs (six digital, three analog, a pulse train and an on/off) are available from the receiver. Five binary outputs present the five-bit command code received; the sixth digital output is a "data valid" signal. The analog outputs can independently provide up to 64 distinct dc levels. The transmitter has an on-chip oscillator, 11 keyboard inputs, a keyboard encoder, a shift register and control logic. Its output is a 40-kHz square wave which is pulse-code modulated. A 12-bit message including sync frame, preamble, 5-bit command code, and end of message bits every 38.4 ms can be transmitted.

CIRCLE NO. 362

Wide-range tuning diodes handle lower frequencies

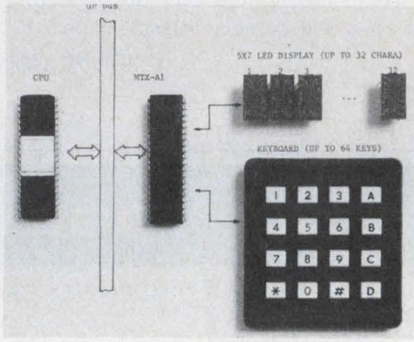


MSI Electronics, 34-32 57th St., Woodside, NY 11377. A. Lederman (212) 672-6500. $5.30 (100 qty); 2 wks.

The capacitance of the ZC 809 wide-range tuning diode is large enough for use at low frequencies and can be varied from 250 pF at 2-V bias to 50 pF at 20-V bias. The Q is greater than 100 at 3-V bias, measured at 20 MHz, and the reverse voltage rating is 25 V. The diode is in a DO-14 glass package meeting MIL-S-19500.

CIRCLE NO. 363

Display controller chip handles keyboard inputs

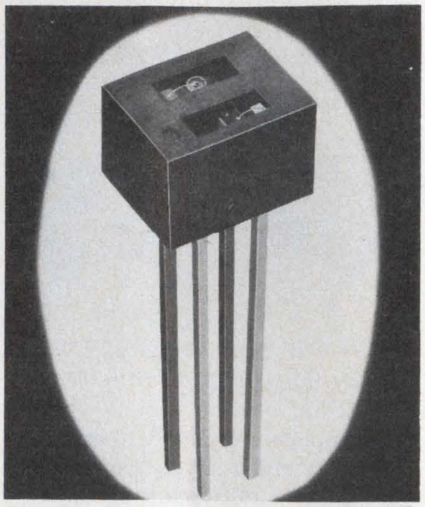


Matrox Electronic Systems, P.O. Box 56 Ahuntsic Stn., Montreal, Quebec 43L3N5. Lorne Trottier (514) 481-6838. $29 (100 qty); 4 wks.

A programmable alphanumeric display and keyboard interface circuit, the MTX-A1, provides all the timing and refresh to handle a 32-character, 5 × 7 dot-matrix LED display. The keyboard portion of the circuit provides all signals necessary to scan, debounce and decode up to a 64-key keyboard (debounce time is 16 ms). A 5-V, 60-mA supply is required by the MTX-A1 and aside from the upper case ASCII character set included in the units memory, there are several commands available: clear display, shift display left/right, blink cursor, read/write display, self test, and more. Display and keyboard parameters are fully programmable. The circuit comes in a 40-pin DIP, operates over a 0-to-70-C range and can interface to most microprocessor buses.

CIRCLE NO. 364

LED/transistor combo senses reflective objects



Optron, 1201 Tappan Circle, Carrollton, TX 75006. (214) 242-6571. $2.38/$2.61 (1000 qty); stock.

Two reflective object sensors for noncontact sensing combine a GaAs infrared LED with a silicon npn phototransistor (OPB 706) or maximum sensitivity photo-Darlington (OPB 707) in a plastic package. The photosensor senses radiation from the LED only when a reflective object is within its field of view. With LED current of 20 mA, the output of the OPB 706 is 750 μA when the device is positioned 0.05 in. from a 90% reflective surface. Under similar operating conditions, the output of the OPB 707 is 34 mA. With no reflective surface, the maximum sensor output is 0.2 μA and 10 μA for the OPB 706 and OPB 707, respectively.

CIRCLE NO. 365

10-A Darlingtons handle VCEOs of up to 160 V

Solitron Devices, 1177 Blue Heron Blvd., Riviera Beach, FL 33404. (305) 848-4311. See text; 4 to 6 wks.

Single-diffused-Darlington power transistors have collector current ratings of 10 A. The SDM 4001-2-3-4 transistors are replacements for 2N3054 units driving 2N3055s. This family has VCEO from 40 to 100 V and h_{FE} of 1000 min at I_C of 4 A. The SDM 5011-12-13 transistors are replacements for 2N3442s driving 2N3773s. VCEO is from 120 to 160 V and h_{FE} is 1000 min at I_C of 4 A. The SDM 4001-2-3-4 cost $1.25 to $2.25 in 1 to 99 quantity; the SDM 5011-12-13 from $2.05 to $3.25 in like quantity.

CIRCLE NO. 366

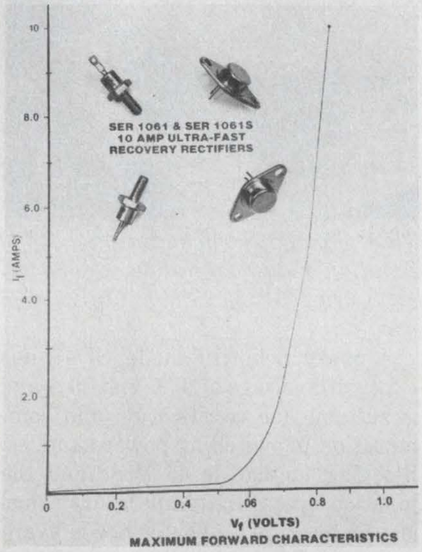
Rectifier bridge handles 25 A in 1-in. square

Motorola, P.O. Box 20912, Phoenix, AZ 85036. Cliff Peterson (602) 244-4624. $1.90 to $2.10 (100 qty); stock.

The MDA2500 full-wave bridge rectifiers require only a 1-in. square mounting surface to handle 25-A continuously, and 400-A surges. Bridges are available in voltage ratings from 50 to 400 V. The thermally conductive case is for single-bolt heat-sink mounting, and has terminals suitable for either soldering or 0.25 in. slip-on connectors.

CIRCLE NO. 367

Rectifiers provide 10 A with guaranteed delta V_F



Solid State Devices, 14830 Valley View Ave., La Miranda, CA 90638. (213) 921-9660. $3.40 to $4.00 (100 qty); stock to 4 wks.

Two fast-recovery rectifiers, types SER1061 and SER1061S, have linear guaranteed forward-voltage drops throughout their 1 to 10-A operating range. The max instantaneous forward-voltage drop, at 10-A forward current, is 0.9 V. Three delta forward drops are guaranteed: a difference of 0.25 V between 1 and 10 A; 0.15 V between 1 and 5 A; 0.1 V between 5 and 10 A. The devices have a 50-ns reverse-recovery time when measured from 0.5-A forward-current, traversing to −1 A and recovery to 0.1 A. Peak repetitive reverse voltage is 50 V and peak surge current is 200 A at 100 C. The SER0161 is housed in a TO-66 package while the SER1061S is housed in a DO-4 stud-mounted package.

CIRCLE NO. 368

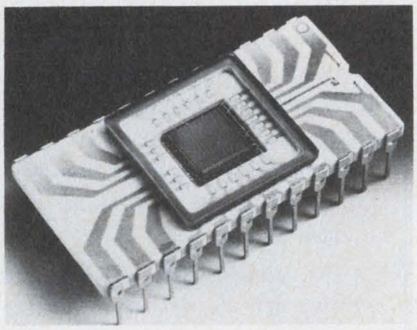
Octal buffer is suited for high-speed PROM use

Monolithic Memories, 1165 E. Arques Ave., Sunnyvale, CA 94086. John Birkner (408) 739-3535. $4.40; 5 wks.

Working with popular data widths of 8, 16, 24 and 32 bits, the 5N54/74S240, 241 and 244 octal buffers are suited for high-speed PROM. The buffers are second sources for TI's like-numbered Schottky TTL parts. The buffers have eight high-current bus drivers, high-output current drive (I_{OL} = 64 mA, I_{OH} = −15 mA) and high-speed (6-ns typical propogation delays). The units are in 20-pin "Skinny-DIPs."

CIRCLE NO. 369

Photodiodes come in square matrix



Integrated Photomatrix, 1101 Bristol Rd., Mountainside, NJ 07092. Marie Rozar (201) 233-6010. $530 (25 qty); 4 wks.

A square matrix of a 64 × 64 array of photodiodes, Model ZD1, is for digital imaging in systems requiring precise definition in a small size. All 4096 silicon diodes are mounted under glass in a 24-pin DIP package that contains TTL logic and shift registers to interface the video signal from the array to external MOS logic. An image formed on the photodiodes will dissipate the charge on each diode in linear proportion to the intensity and duration of the light. To access the information, two X-direction shift registers transfer the charge signals to storage capacitors which are then sampled at up to 3 MHz by a Y-direction shift register. The sequence of charge signals becomes usable video output after integration to a voltage swing from 0 to 1 V, which is proportional to the light intensity.

CIRCLE NO. 370

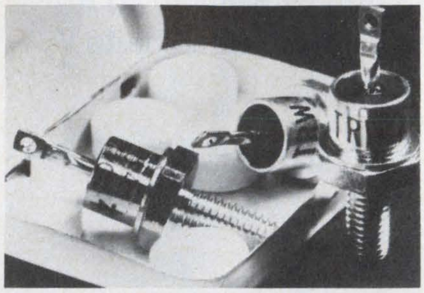
Low-noise μW transistor is stripline packaged

NEC Microwave Semiconductors, P.O. Box 915, Burlingame, CA 94010. Jerry Arden (415) 342-7744. $15 (10-99 qty).

A low-noise microwave bipolar transistor, NE64535, is available in a hermetically sealed stripline metal-ceramic package. The transistor operates from 0.5 to 4 GHz. The 2-GHz noise figure increases from 1.6 dB at 7 mA to its optimum bias point of 2 dB at 20 mA. The resulting associated gain increases from 12 to 13 dB.

CIRCLE NO. 371

Schottky diode boasts low forward voltage



TRW Power Semiconductors, 14520 Aviation Blvd., Lawndale, CA 90260. (213) 679-4561. $5.25 (100 qty); 4 to 8 wks.

A power Schottky diode, SD41, has a forward voltage of 0.55 V at 30 A and is suitable for rectification and commutation in switching power supplies. Blocking voltage is 45 V dc and the junction operating temperature range is −55 to +150 C. The device is available in a DO-203AA (formerly DO-5) package.

CIRCLE NO. 372

MC14512 data selector has second source

National Semiconductor, 2900 Semiconductor Dr., Santa Clara, CA 95051. Bob Bennett (408) 737-5683. $0.98 (100 up); stock.

The CD4512 is a second-source version of Motorola's MC14512, a 16-pin 8-channel CMOS data selector. The device has a quiescent current of 5 nA at 5 V dc, a supply range from 3 to 18 V and a noise immunity that is 45% of the supply voltage. Featuring a three-state output, the device is capable of driving two low-power TTL loads, one low-power Schottky TTL load or two HTL loads over the rated temperature range.

CIRCLE NO. 373

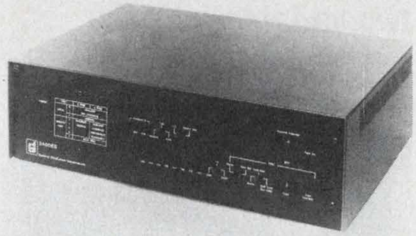
Display terminal uses ac plasma panel

SAI Technology, 4060 Sorrento Valley Blvd., San Diego, CA 92121. Bill McCreary (714) 452-9150.

Plasmascope display terminals with ac plasma panels use a gas-discharge principle to produce an array of luminescent 10-mil spots. The individually energized and addressed spots yield alphanumerics and graphics. Plasmascopes are available with 7.2 × 2.4 and 8.6 × 8.6 in., with up to 420 and 5120 characters, respectively. Contrast ratio is 25:1 and the terminal can generate 8333 char/s.

CIRCLE NO. 374

Send and receive data with 2400-baud modem

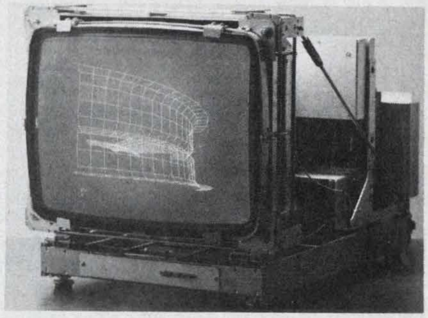


General DataComm, 131 Danbury Rd., Wilton, CT 06897. (203) 762-0711.

The 2400ES synchronous modem transmits and receives binary serial data over a switched network or leased lines at 1200 or 2400 bits/s. It can be used for half-duplex point-to-point dial network operation with automatic call answering and for two-wire, half duplex or four-wire full-duplex point-to-point and multipoint leased line operation. The modem is fully compatible with CCITT recommendations and may be used with an optional 110-bit/s backward channel. An answering circuit automatically connects the modem to the telephone line when a ring signal is received.

CIRCLE NO. 375

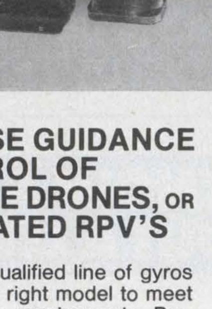
Graphic display keyed to OEM market



Tektronix, P.O. Box 500, Beaverton, OR 97077. John Kadel (503) 638-3411. $6175.

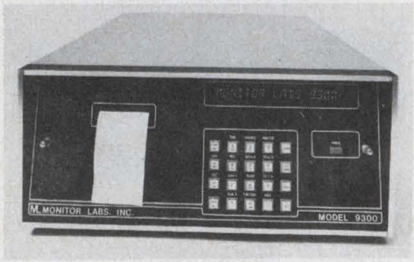
A high-speed 19-in. graphics peripheral for the OEM market displays up to 1575 in. of refreshed vector in the combined store-refresh mode. Permanent parts of a graphics and alphanumeric image can be stored without memory refresh on the display phosphor, while at the same time interactive picture elements can be displayed in refresh. System designers and users thus have significant interactive graphic capability at their disposal.

CIRCLE NO. 376



DATA PROCESSING

Smart logger handles two variables at once



Monitor Labs, 4202 Sorrento Valley Blvd., San Diego, CA 92121. Peter Delroy (714) 453-6260. $2500; 8 wks.

System 9300, a smart logger, handles temperatures and voltage side-by-side, autoranges, produces averages and provides up to four different alarm levels per channel. An alphanumeric display leads the operator through the set-up with step-by-step English language questions. An optional "Mag-Check" uses an integral data buffer and provides true read-after-write of magnetic-tape records. Operator-entered instructions are stored in an optional electrically alterable ROM. A self-test feature causes end-to-end check by digitizing a known reference voltage, displaying the result.

CIRCLE NO. 377

TTY printer offered with mag-tape buffer

Western Union Data Services, 70 McKee Dr., Mahwah, NJ 07430. Frank Squitteri (800) 631-7050. $219/mo lease; 8 wks.

The EDT 1232 teleprinter is equipped with a mag-tape cassette buffer for off-line data entry. The teleprinter offers high print quality, heavy-duty use, 120-char/s throughput, 132 print positions and both front and rear loading of paper. With a storage capacity in excess of 50,000 char, the cassette buffer writes, reads, rewinds and edits under remote computer or local control. For data search, the tape can be stopped after each character, word or line. Forward and back-skip controls facilitate high-speed data search.

CIRCLE NO. 378

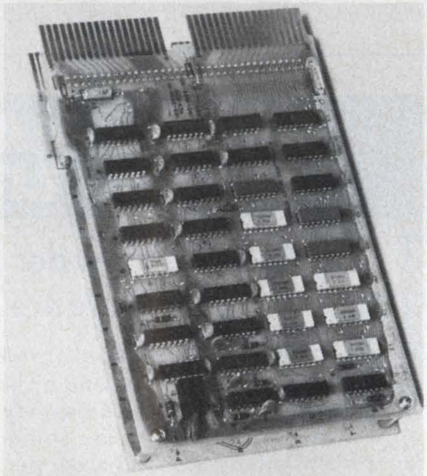
Remote printers provide rapid turnaround

Data 100, 6110 Blue Circle Dr., Minneapolis, MN 55435. Gerald Hendin (612) 941-6500. $7900 to $8975; 8 wks.

A series of remote communications printers receives and prints data transmitted under standard communication protocols and provide rapid turnaround at remote locations. The printers are available in speeds from 125 to 300 lines/min, and use a controller that interfaces them with lines supporting Honeywell VIP 7700, IBM 2780, 3780, 3270, PARS 2946 and Xerox SDS 7670 protocols. The controller operates with any RS232C compatible data set in multidrop or switched-line applications. The printers feature buffer sizes of 1024 and 2048 characters, auto-answer, reverse channel, synchronous or asynchronous operation and automatic sign-on.

CIRCLE NO. 379

Cache buffer enhances memory of PDP-11



Fabri-Tek, 5901 S. County Rd. 18, Minneapolis, MN 55436. Orval Larson (612) 935-8811. $4250; stock to 4 wks.

Model 920/981 cache buffer is a high-speed memory enhancement for DEC PDP-11 computers. The device provides 2048 bytes of memory on two PC cards, forming a single plug-in module measuring 8.25 × 5.2 × 2 in. The dual number refers to elements in the DEC CPUs which are replaced by the cache buffer. In PDP-11/35 and 11/40 computers, the cache buffer replaces the M981 Unibus Terminator module. In PDP-11/34 and other PDP-11 series processors, the M920 Unibus Jumper module is replaced.

CIRCLE NO. 380

Transfer switch can sub for UPS

Cyberex, 7171 Industrial Park Blvd., Mentor, OH 44060. Dave Griffith (216) 946-1783. $40 to $200/kW; 12 to 16 wks.

Ultimate, a system that provides the continuous conditioned power capability of a static UPS, is for installation sites having two separate commercial power lines. The system combines a solid-state, sub-cycle transfer switch with a line voltage regulator. In event of failure of either incoming power line, the switch transfers the load to the other line in less than 4 ms. The line-voltage regulator will accept voltage within +10% to −20% of nominal, and deliver output regulated to ±0.5%. Power ratings are 2.5 to 750 kVA.

CIRCLE NO. 381

Power converters give more power at less cost

Intronics, 57 Chapel St., Newton, MA 02158. Dick Sakakeeny (617) 332-7350. $46 (100 qty); stock to 4 wks.

Series DCE low-cost dc power converters provide ±15-V-dc, 150-mA outputs from 5, 12, 24, or 28-V dc buses. Regulation is 0.02% for line, and 0.05% for load. The units are multiple shielded to reduce EMI/RFI radiation to a negligible amount. Size is 2.02 × 2.02 × 0.38 in.

CIRCLE NO. 382

Switchers supply dual, triple, quad outputs

Switching Power, 19 Daell Lane, Centereach, NY 11720. Mel Kravitz (516) 981-7231. $519 up; stock to 4 wk.

Multiple-output dc power supplies, Type FS, are provided with dual, triple and quad outputs. Packaged in 5 × 8 × 12 in., they operate from 90 to 256 V ac, 47 to 63-Hz input. Power output is rated at 375 W at 50 C. Standard features include: remote sensing; surge limiting; overvoltage, current and thermal protection. Optional features are remote on-off control and an EMI filter to conform to VDF0875. Load and line regulation is ±0.25% and if ac fails entirely, all dc outputs remain in regulation for 20 ms.

CIRCLE NO. 383

PACKAGING & MATERIALS

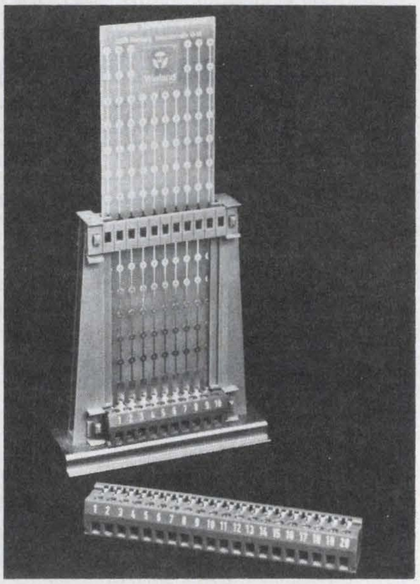
Fiber material makes plastic act like metal

Lundy Technical Center, 3901 N. E. 12th Ave., Pompano Beach, FL 33064. (305) 943-1500.

A material called RoMHOglas fiber reinforces plastics, dissipates electrostatic charges, shields against electromagnetic radiation and improves heat transfer. The fiber strands of fine parallel metal-coated filaments are combined into rovings of various sizes or twisted and plied into yarn-type materials. Individual fibers are coated with a finishing agent that bonds effectively with the common types of polymers by conventional techniques.

CIRCLE NO. 384

Edge connectors for PC boards are compact

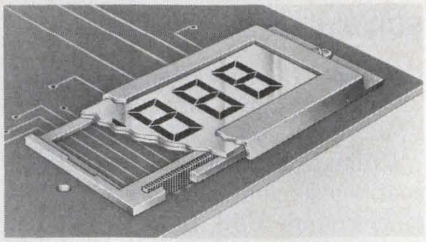


Electrovert, 86 Hartford Ave., Mount Vernon, NY 10553. April Benson (914) 664-6090.

A line of compact edge connectors for PC boards measures 1.4 to 1.8 mm thick, including contact surfaces. They are available in any number of poles from 2 to 20 with or without solder lugs. Pressure connectors will take up to 16 AWG wire. Molded of fiberglass-reinforced polycarbonate, the bottom cover is ultrasonically sealed. Silver-plated, phosphor-bronze contact springs are spaced 5 mm apart. All poles are consecutively numbered. The edge connectors can be secured with end clamps or, if the PC board is large, with guide brackets.

CIRCLE NO. 385

Connector mates LCD to PC board

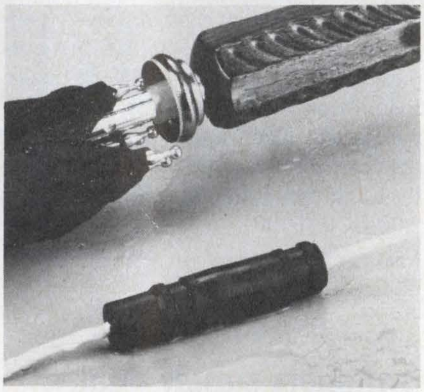


Technical Wire Products, 129 Dermody St., Cranford, NJ 07016. (201) 272-5500. $3.50 (10 qty), $0.59 (10,000 qty).

Flat-mount single in-line LCD connectors assemble 2-in. single-edge LCDs flat to a PC board. The connector-frame holder contains a Zebra conductive-elastomeric connector made of alternating layers of conductive and nonconductive rubber silicone. The frame aligns the LCD with the PC board through two locating studs, and provides a 0.060-in. space between the LCD and the PC board to allow mounting a chip under the LCD.

CIRCLE NO. 386

One-pin connector added to environmental line

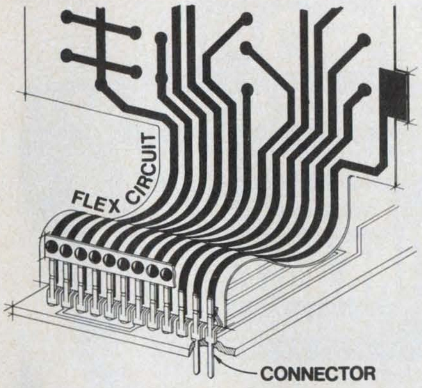


Amphenol, 900 Commerce Dr., Oak Brook, IL 60521. Ray Hayer (312) 986-3749. $0.90 (100 qty); stock.

A one-pin connector, for better circuit protection than in-line splices or terminal connections in environmentally exposed applications, has been added to the 44 Series environment-proof connector line. A resilient body acts to dampen the effects of shock and vibration and withstands temperature extremes from −40 to 105 C. One-piece construction minimizes failure modes, enhancing reliability. Waterproof seals protect the entire connector mating face plus the contact area from contamination. A simple push-pull coupling permits fast, positive connect/disconnect action.

CIRCLE NO. 387

Low-cost connectors fit flexible circuits

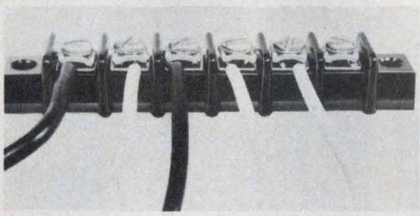


Precision Concepts, 1595B Ocean Ave., Bohemia, NY 11716. Bob Nicoli (516) 567-0995. $0.007/line; stock.

Available with any number of contacts on a single strip, Model M-1255 Flex Circuit connectors have contact spacing on 0.1-in. centers. The connectors have a circuit-gripping design that make mechanical and electrical contact with flexible circuits without the need for soldering or mounting hardware. Connectors are available in copper-based alloys and with a pretinned finish. Contact pins for insertion into PC boards are available at various angles for almost any mounting configuration.

CIRCLE NO. 388

Terminal design needs no bending of wire ends



Kulka Electric, 520 S. Fulton Ave., Mount Vernon, NY 10551. Mort Gelfand (914) 664-4024.

Terminal boards can be obtained with "Wire Clamp" terminals that accept straight-ended wires. Special ridged washers built into each terminal firmly lock wires in place without any looping or wrap around. When a wire is inserted, it is securely confined between the washer and the top of the terminal block merely by screwing the terminal down. Wire Clamp terminals are available on seven series of terminal boards: numbers 602, 812, 672, 601, 1600 and 671. They are also available as separate replacement terminals with either 8-32 or 6-32 threads for existing boards.

CIRCLE NO. 389

50 Million operations

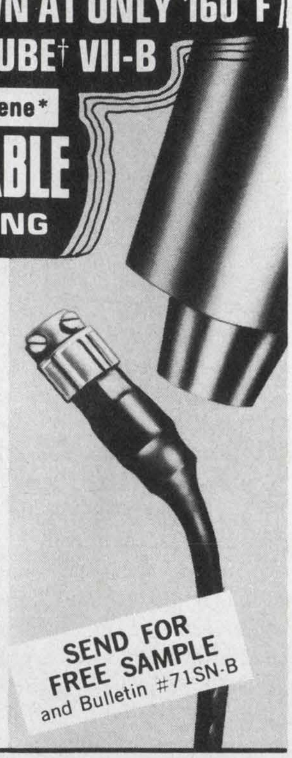
With TTL loads, our new reed relay offers maximum contact resistance of 0.12 ohms, after more than 50 million operations. And a contact resistance delta of 0.01 ohms, maximum. Sticking and missed operations are essentially eliminated.

Call or write for information on the RX-1.

EAC Electronic Applications Company
4918 Santa Anita Ave., El Monte, CA 91734
213/442-3212 TWX 910/587-3351

CIRCLE NUMBER 132

UP TIGHT 50%
SHRINKDOWN AT ONLY 160°F with PENNTUBE† VII-B
Neoprene* SHRINKABLE TUBING



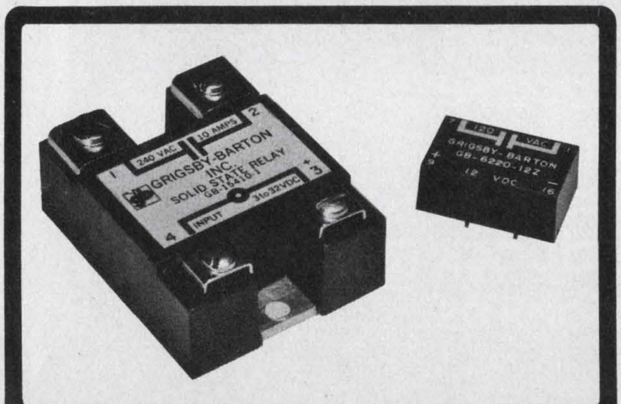
Tough! Flexible! Protective! Inexpensive! Shrinks down in hot water above 140°F. Good electrical and mechanical strength. Resists corrosion and chemicals and will not support a flame. Used for electrical insulation on wires, mechanical protection for pipes and fittings. Effective as scuff resistant jacketing for electrical cables and harness . . . and much more. Sizes 1/4" to 4". Black only.

PENNTUBE
PENNTUBE PLASTICS CO.
Division of Dixon Industries
A Bundy Company
Clifton Heights, PA 19018
(215) 622-2300

SEND FOR FREE SAMPLE and Bulletin #71SN-B

CIRCLE NUMBER 134

SOLID STATE RELAYS

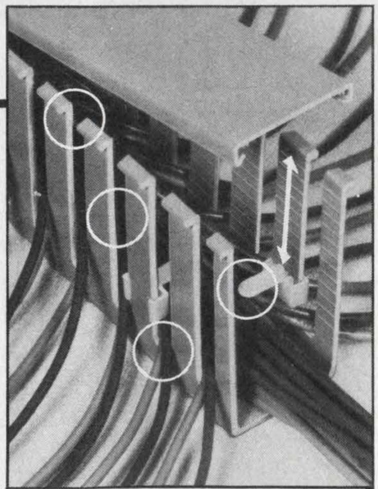


- .5 to 40 AMP RMS Outputs
- Photo Coupled all Solid State
- Zero Voltage or Random Turn-On
- 24 to 280 VRMS Line Ratings
- 3 to 32 VDC or 90 to 270 VRMS Inputs
- Internal RC and MOV Protection
- Panel, Socket or PCB Mount
- 600 V Blocking Available
- 3750 VRMS Isolation Available
- U.L. Recognized & CSA Certified

For more details on our line of SSRS, contact
GORDOS/GRIGSBY-BARTON INC.
1000 N. Second Street, Rogers, Arkansas 72756, U.S.A. • Telephone (501)636-5000; TWX: 910-720-7998

CIRCLE NUMBER 133

NEW! Y-R-LOC™ OPEN-SLOT WIRING DUCT



The new open-slot Y-R-LOC vinyl wiring duct by Taylor offers all the benefits below, and more. Unique Y-R-LOC nylon clips ratchet on duct ribbing to provide selective wire control with no interference. Write for details from the originator of plastic wiring duct.

Recognized under the Components Program of Underwriters' Laboratories, Inc.

MEETS ALL J.I.C. STANDARDS

Approved by CSA

- Wider, non-tapering slots
- Faster wire placement
- Deeper slot openings (FOR "FLAT" WIRING)
- Greater wiring density (MORE OPENINGS PER FOOT)
- Simpler wire insertion

TAYLOR ELECTRIC, INC.
DIV. OF TAYLOR INDUSTRIES, INC.
P.O. BOX 729 MARBLE FALLS, TEXAS 78654

CIRCLE NUMBER 135

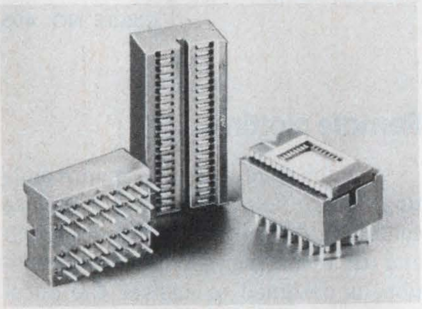
Card guides are more fire retardant

Bivar, 1617 E. Edinger Ave., Santa Ana, CA 92705. (714) 547-5832.

Temp-O-Gide is a line of PC-board card guides that use Vydyne M-340 nylon resin. This material has a 94V-0 UL rating down to 1/64 in. and 94-5V down to 1/32 in. The guides are for 1/16-in. PC boards and snap into 11/64-in. holes in plates or channels. Lengths range from 2.5 to 14 in. in ½-in. increments.

CIRCLE NO. 390

DIP test sockets take high density ICs



Robinson-Nugent, 800 E. 8th St., New Albany, IN 47150. J. Griffins (812) 945-0211.

TSD Series DIP sockets handle 0.05-in. lead-spaced high-density IC packages on standard PC-board spacing of 0.1 in. Contact design allows an IC chip to be plugged in directly. And contact terminations are staggered on 0.1-in. spacing to fit the board spacing. Socket contacts are gold-plated beryllium copper; body material is glass filled Ryton. The sockets are available in 24, 30 and 44-pin models.

CIRCLE NO. 391

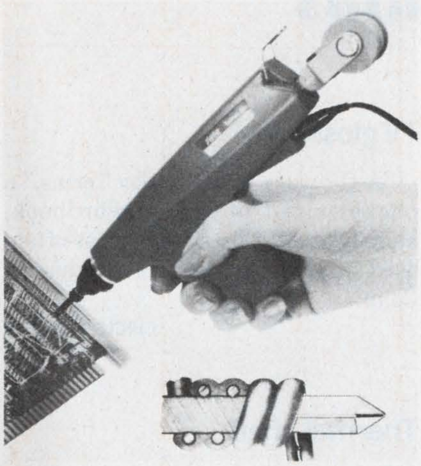
One-part foam epoxy has long pot life

Emerson & Cuming, Canton, MA 02021. (617) 828-3300. $4/lb; stock.

Stycast 1091 is a one-part, high-temperature, low-density, syntactic-foam casting epoxy. The curing method allows a three-month shelf life at 25 C and a pot life of several days at temperatures up to 65 C. The resin has a dielectric constant of 1.91 at 1 MHz, a specific gravity of 0.62 and it may be used to 200 C without deteriorating.

CIRCLE NO. 392

Wrapped-wire tool needs no prestripping

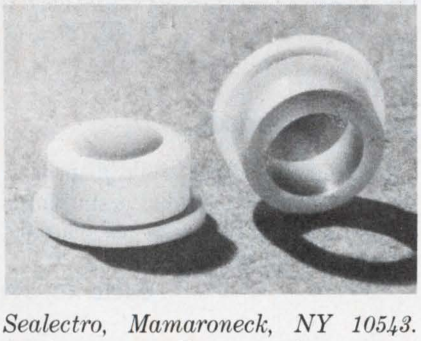


Vector Electronic, 12460 Gladstone Ave., Sylmar, CA 91342. Floyd Hill (213) 365-9961. $29.50; stock

A manually operated wrapped-wire tool, Model P184, makes gas-tight interconnections with Tefzel insulated wire without measuring, cutting and stripping. The device's bit uses 28-gauge silver-plated copper wire with 5-mil-thick Tefzel insulation fed from a spool on the tool's shaft. A hardened cutting edge slits the insulation longitudinally at the wrapping point. During wrapping, wire bending further opens the slit, allowing gas-tight termination on 0.025-in. or 0.028-in. square posts. Seven wrapped turns have approximately 0.003-Ω between post and wire. Pull-off force is over 10 lb. Electrically operated tools are available.

CIRCLE NO. 393

Teflon bushing provides strain relief for wires



Sealectro, Mamaroneck, NY 10543. (914) 698-5600. Free samples.

A Teflon bushing, Type 119-0167, with a 0.12-in. dia. throughhole provides strain relief for wires fed through a metal chassis. The bushing also functions as an insulator and protects wires from the metal edges of the chassis. It installs easily into a chamfered metal-chassis hole with a simple arbor press.

CIRCLE NO. 394

Design aids

TV glossary

"A Glossary of Television Terms," a pocket-sized 44-page wordbook, alphabetically lists the most-often-used words in the television industry. Cohu.

CIRCLE NO. 395

Thermal chart

A six-page chart gives the thermal classification for several types of laminated electrical insulation. Chase Foster Div., Keene Corp.

CIRCLE NO. 396

Insulated wire

Thirty-six different types of high-temperature insulated wire are shown in an 18 × 24-in. wall chart. Radix Wire Co.

CIRCLE NO. 397

Slide rule

An energy cost-saving calculator in slide-rule form determines lighting-energy costs and indicates savings per lamp for all standard energy-saving lamps now available. The slide rule costs 50 cents. GTE Marketing Services Center, 70 Empire Dr., West Seneca, NY 14224

CIRCLE NO. 398

Liquid dispenser

Picking the correct fluid dispenser, valve and valve controller is simplified using this quick-reference catalog. Electron Fusion Devices.

CIRCLE NO. 399

1978 calendar

A 1978 calendar and fraction-decimal-metric equivalent chart shows the decimal and metric equivalents of fractions in increments of 1/64 in. and also the English equivalents of metric dimensions. Boker's.

CIRCLE NO. 403

Application notes

GP interface bus

A comprehensive description of the GPIB with a detailed explanation including design, program listing and schematics, is given in a 36-page pamphlet. Tektronix, Beaverton, OR

CIRCLE NO. 404

Power amplifiers

A 10- page practical guide defines and explains the characteristics of broadband power amplifiers. Amplifier Research, Souderton, PA

CIRCLE NO. 405

Remote plotting

An eight-page study on remote plotting, which points out the sometimes confusing differences in remote-batch and time-sharing plotting configuration, is designed to answer the questions of the person newly interested in automated graphics and as well as the "old hand" in graphics. Houston Instrument, Austin, TX

CIRCLE NO. 406

Power supplies

"Power Supply Application Guide," 10 pages, provides technical information on various applications, enumerating power requirements, e.g., specific designations in voltage, current, overvoltage protection and other electrical parameters. Standard Power, Santa Ana, CA

CIRCLE NO. 407

Microwave measurements

"100-dB Dynamic Range Measurements Using the HP 8755 Frequency Response Test Set" describes how to achieve "automatic substitution." This permits detection and display equipment with 60-dB range to measure to 100 dB without physically performing rf substitution. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 408

Vendors report

Annual and interim reports can provide much more than financial position information. They often include the first public disclosure of new products, new techniques and new directions of our vendors and customers. Further, they often contain superb analyses of segments of industry that a company serves.

Selected companies with recent reports are listed here with their main electronic products or services. For a copy, circle the indicated number.

Beckman. Laboratory analytical instruments, process analysis and control instruments, specialty biological and fine chemicals, precision electronic components.

CIRCLE NO. 409

Tandy Corp. Consumer electronics.

CIRCLE NO. 410

Digital Equipment. Computer systems, computer-peripheral equipment, software and associated computer-accessory equipment.

CIRCLE NO. 411

Lafayette Radio Electronics. Electronic products.

CIRCLE NO. 412

California Computer Products (CalComp). Graphics products, memory products and data-processing products and services.

CIRCLE NO. 413

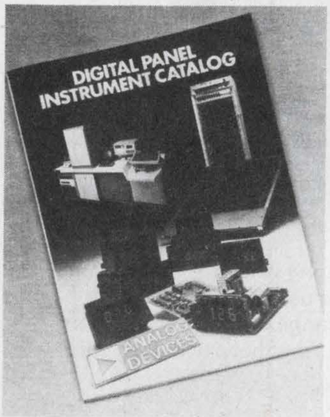
Litton Industries. Business machines/POS products, typewriters/copiers, specialty paper/printing, machine tools, material handling, electronic components, microwave ovens, medical and electronic products, publishing, resource exploration, navigation systems, communications/data systems and marine engineering.

CIRCLE NO. 414

Polarad Electronics. Test and measuring instruments, clinical and diagnostic instruments.

CIRCLE NO. 415

New literature



Digital panel instruments

An 80-page catalog provides descriptions, application information, and pricing (U.S. only) for each of more than a dozen line or logic-powered digital panel meters and panel instruments. Analog Devices, Norwood, MA

CIRCLE NO. 416

Computer systems

An overview of HP 3000 Series I and Series II computer systems in business applications is provided in an 8-page brochure. Hewlett-Packard, Palo Alto, CA

CIRCLE NO. 417

Magnetic components

Technical data on the use of custom magnetics as required in modern circuits are provided in a 14-page booklet. Polyphase Instrument, Bridgeport, PA

CIRCLE NO. 418

Fuses

Diazed fuses, used to protect against overloads, are described in an eight-page brochure. Siemens, Power Engineering Div., Iselin, NJ

CIRCLE NO. 419

Terminal system

Specifications for the 700/UETS terminal are given in a four-page brochure. Megadata, Bohemia, NY

CIRCLE NO. 420

Power supplies

Encapsulated modular power supplies are described in an eight-page catalog. Calex Manufacturing, Pleasant Hill, CA

CIRCLE NO. 421

Thermistors

A 20-page catalog presents the complete story on the use of thermistors in the self-heat mode and is complemented with graphs, charts, working tables and practical problems with solutions. Fenwal Electronics, Framington, MA

CIRCLE NO. 422

Silicon photodiodes

A 16-page guide, "Solid State Silicon Photodiodes," provides tabulated data and outline configurations for silicon photodetectors. RCA Electro-Optics and Devices, Somerville, NJ

CIRCLE NO. 423

One-chip microcomputer

P-channel MOS and CMOS 4-bit microcomputers that include a ROM, a RAM and an arithmetic-logic unit on a single semiconductor chip are described in an eight-page brochure. Texas Instruments, Houston, TX

CIRCLE NO. 424

Decoder/driver

The Model DD-700 decoder/driver for use with SP-300 Series 7-segment gas-discharge displays is described in a four-page brochure. Diagrams illustrate interior logic-package outline, typical dc and multiplex applications, and a typical schematic for zero suppression. Beckman Instruments, Inc., Scottsdale, AZ

CIRCLE NO. 425

Potentiometers

Precision and trimming potentiometers, concentric and digital turns-counting dials, and miniature switches are shown in a 12-page catalog. The catalog includes design details, photos, specifications, application data, and prices. Spectrol Electronics, City of Industry, CA

CIRCLE NO. 426

Pushbutton switches

Computer-grade pushbutton switches are detailed in a 16-page brochure. Electrical and mechanical specifications and other selection data cover more than 240 switch variations and 3000 cap options. Dialight, Brooklyn, NY

CIRCLE NO. 427

Switches and knobs

Fifty different series of switches, switch and resistor assemblies, and knob and accessories are featured in a 52-page catalog. In addition to conventional dimensions, metric dimensions are also shown for every switch. Cross-reference charts are included. RCL Electronics, Irvington, NJ

CIRCLE NO. 428

Power converters

Specifications and price information on more than 1000 power converters are given in a 32-page catalog. Tecnetics, Boulder, CO

CIRCLE NO. 429

Interconnection system

Specifications on a connector and backplane system are detailed in a 12-page design catalog. Edge-card connector configurations, insulators and contacts are given with dimensional drawings and part numbers. Methode Electronics, Chicago, IL

CIRCLE NO. 430

Fans

Applications, performance curves and specifications for 27 different fans are contained in an eight-page brochure. Rotron, Woodstock, NY

CIRCLE NO. 431

Solderless terminals

Solderless-terminal products are listed in a 56-page guide. Mallory Distributor Products, Indianapolis, IN

CIRCLE NO. 432

Clad materials

An 18-page handbook describes various configurations of clad materials and offers many clad-parts design ideas. Plessey, Material Div., Melville, NY

CIRCLE NO. 433

Across the desk

(continued from page 7)

when used with police radar units, can tell when a car is switching lanes, and not signaling. Further, they can tell if the car is not signaling left, or not signaling right. If the car is stationary, they can tell if the emergency flashers are not on.

We have also discovered that by reversing the polarity of the WOM—making it a MOW—and adding a one-wire strapping, our device can differentiate between red and yellow turn signals. It looks like we finally have built a better MOWstrap.

Larry Edell
Teledyne Camera Systems
131 N. Fifth Ave.
Arcadia, CA 91006

More than one maker of piezoceramic transducers

Your article on smoke detectors (ED No. 22, Oct. 25, 1977, p. 24) was a well-written, informative article on this rapidly expanding market. However, you mentioned that Gulton Industries in Fullerton, CA, manufactures piezoceramic transducers being used as the horn in smoke detectors. Gulton by no means has a monopoly on this business. Linden Laboratories also manufactures these piezoceramic transducers. We have been working closely with several smoke-detector manufacturers, many of whom were mentioned in your article! Linden has also been working with one of the companies you mentioned that has developed an IC chip designed for use in smoke detectors.

Linda C. Feltman
Marketing Supervisor
Linden Laboratories, Inc.
Box 920
State College, PA 16801

Some Belgian boards for the real world

In our report on subsystems for interfacing microcomputers with the real world of analog signals (ED No. 19, Sept. 13, 1977, p. 26), we overlooked a Belgian company that offers a comprehensive line of 8080-based microcomputers and interface boards. The company is Data Applications International S.A., Dreve Des Renards 6, Bte 8, 1180 Brussels, Belgium. For more information on the company's products,

CIRCLE NO. 315

Rapid transit not too swift

Why can't America's scientists and engineers design a rapid-transit system? I live in the area served by the new BART system and I can report that reliability is so poor that it cannot be used for timed arrivals, such as commuting or appointments. For example, when it rains, the brakes don't work. Didn't we solve that one 50 years ago? The Model A had this problem. BART is a space-age computer-controlled system designed for 90-second train spacing. But the best it can do is 10 minutes.

Is the problem political? BART is managed by a board of elected supervisors—none of whom are engineers. When they have a problem, they hire a team of consultants, usually university professors who study the problem and a year later publish a thick report. The supervisors file the report and still don't know what to do. Is this the way a high-technology engineering system should operate?

But more to the point: Why doesn't the system perform as designed? Why didn't designers consider wet brakes and tracks? Certainly not because of a shortage of money—$1.6-billion. Certainly not because of a shortage of time—15 years. Should the engineering community be held responsible?

The new Mexico City and Montreal systems seem to work. Does this say something about the quality of American engineers? What has happened to our American ability in the 100 years since the New York subway?

Richard C. Bowers
Electronics Engineer, retired
6408 Claremont Ave.
Richmond, CA 94805

Judge Murphy presiding

As the leading authority on Murphy's Law as it applies to the technical world, I thought you might like to have a few as they relate to our social lives:

"The amount of gas left in an almost empty tank will be consumed at a rate equal to the length of the traffic jam in which you are caught."

"Lumps in gravy tend to increase proportionately to the number of guests expected at your dinner party."

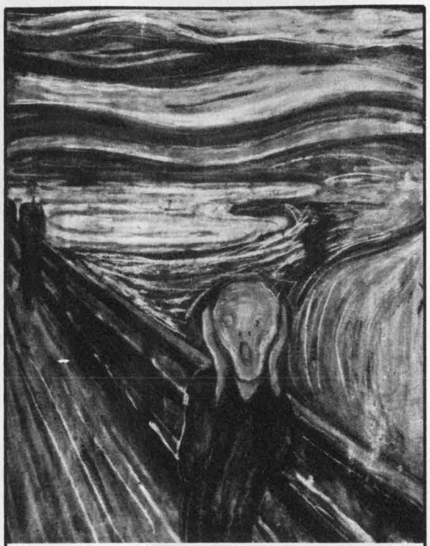
"The probability of a heavily buttered slice of bread falling face down increases with the cost of the carpet."

"A cordless electric razor will stop running halfway through a heavy beard during a vacation in Serbia."

"If your wife is a regular reader of 'Dear Abby' your mistress will be one of the regular contributors."

L.M. Brain
Director of Communications
Burndy
Norwalk, CT 06856

Misplaced Caption Dept.



You should expect a period of adjustment when you transfer to a new group.

Sorry. That's Edvard Munch's "The Cry," which hangs in the Munch-Museet, Oslo, Norway.

The winner The winner

Readers who responded to ELECTRONIC DESIGN'S 24th Annual Brand Recognition Survey are no doubt eagerly awaiting the announcement of the winners of the drawing. Hold your breath no longer. E.L. Rohm of HRB Singer in Reston, VA, won the Clarion 40-channel CB radio. And Ed J. Garstka of Ball Brothers in Boulder, CO, won the National Semiconductor liquid-crystal watch.

Space specifics

I really enjoyed the historical articles in ELECTRONIC DESIGN's "Communications" issue, but let me point out a few discrepancies concerning the space activities:

1. The Minitrack network was established in 1957 for Project Vanguard—not Mercury.

2. The Echo I balloon did, in fact,

(continued on page 199)

Across the desk

(continued from page 198)

carry a tracking beacon that enabled the Minitrack network to determine its orbit.

3. Telstar was not the first solar-powered satellite. Vanguard I had a solar battery in addition to a chemical power source: The solar-powered transmitter operated on a different frequency and continued to function for many years.

Joseph G. Griffin
Bendix Field Engineering Corp.
9250 Route 108
Columbia, MD 21045

Another Joe

So Schiller was saddled with that kind of name, too! (ED No. 17, p. 10.)

I remember vividly, as a kid, trying to look up Wolfgang Amadeus Mozart in the Music Room of the Boston Public Library. What I found was a man christened Joannes Chrysostomus Wolfgangus Theophilus. (He later acquired Amadeus, the Latinized version of Gottlieb.) Since then, I've won a lot of bets that *"Eine kleine Nachtmusik"* was written by Joe Mozart.

Dan Sheingold
Analog Devices
Norwood, MA 02062

Try our time machine!

If you are ever pressed for time, you should try ELECTRONIC DESIGN's revolutionary time machine. Its description was hidden in Part 6 of our Software series (ED No. 10, May 10, 1977, p. 80), and were it not for the vigilance of reader Doe Lake of Princeton, NJ, it may never have come to light. The relevant passage on p. 81, column left, nine lines from the bottom, reads: "...to time a three-minute egg, you need a 360-second delay...."

For a complete schematic, send us a self-addressed envelope and enclose *one* 200-cent dollar.

Me an editor?

If you'd like to be among the first to know (and write about) what's going on in the electronics industry, you might enjoy being an editor.

We have openings at our home office in Rochelle Park, NJ. Call Ralph Dobriner at (201) 843-0550.

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■ To give the electronic design engineer concepts and ideas that make his job easier and more productive.

■ To provide a central source of timely electronics information.

■ To promote communication among members of the electronics engineering community.

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If you change your address, send us an old mailing label and your new address; there is generally a postcard for this in the magazine. You will have to requalify to continue receiving ELECTRONIC DESIGN free.

The accuracy policy of ELECTRONIC DESIGN is:

■ To make diligent efforts to ensure the accuracy of editorial matter.

■ To publish prompt corrections whenever inaccuracies are brought to our attention. Corrections appear in "Across the Desk."

■ To encourage our readers as responsible members of our business community to report to us misleading or fraudulent advertising.

■ To refuse any advertisement deemed to be misleading or fraudulent.

Individual article reprints and microfilm copies of complete annual volumes are available. Reprints cost $6.00 each, prepaid ($.50 for each additional copy of the same article), no matter how long the article. Microfilmed volumes cost $23 for 1976 (Vol. 24); $30 for 1973-75 (Vols. 21-23), varied prices for 1952-72 (Vols. 1-20). Prices may change. For further details and to place orders, contact Customer Services Dept. University Microfilms, 300 N. Zeeb Rd., Ann Arbor, MI 48106. (313) 761-4700.

Want to contact us? If you have any comments or wish to submit a manuscript or article outline, address your correspondence to:

Editor
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Rochelle Park, NJ 07662

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Oldest and largest manufacturer of Environmental Equipment

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CIRCLE NUMBER 155

IM1000 UNIVERSAL PROM PROGRAMMER

- HIGHEST PERFORMANCE/PRICE RATIO
- CAPABILITY TO PROGRAM ANY PROM FROM ALL MANUFACTURERS
- COMPACT FOR PORTABILITY
- TWO RS232 I/O PORTS FOR INTERFACING TO MICROCOMPUTER DEVELOPMENT SYSTEM OR TIMESHARE COMPUTERS
- 32000 BIT RAM FOR FULL EDITING OF PROM DATA

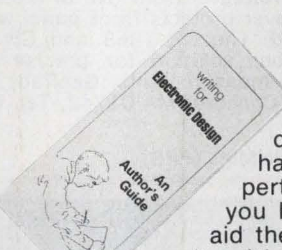
The **IM1000** sells for $1695. Personality Modules $330. Contact us for a demonstration by our nationwide representatives.

TEL: 301/340-7505

IM International Microsystems, Inc.
638 Lofstrand Lane
Rockville, Md. 20850

CIRCLE NUMBER 156

AUTHOR'S GUIDE



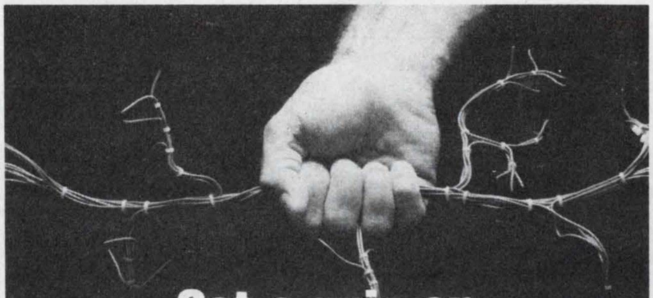
If you've solved a tricky design problem, if you have developed special expertise in a specific area, if you have information that will aid the design process... share it with your fellow engineer-readers of *Electronic Design*.

Articles you have authored not only raise your own professional status, but help build your company image as well. The readers benefit, your company benefits.

To help you prepare material that meets *Electronic Design's* high editorial standards, our editors have prepared a special author's guide entitled *"Writing for Electronic Design."* It covers criteria for acceptability, form, length, writing tips, illustrations, and payment for articles published. It's available without cost.

It's easy to write for *Electronic Design,* but it's often hard to get started. Send for your copy of our Author's Guide today.

Circle No. 250



Get a grip on wire harness rejects with Gudebrod's new "Z" Finish tapes!

The costliest of all harness room problems—rejects, often result from tie slipping and bunching caused by vibration. Improperly coated tapes and plastic ties just can't be trusted to stay put under vibration, but *Gudebrod's Nomex and Dacron* tapes with the new *"Z" Finish* provide the most secure grip possible to insure that a harness maintains its proper configuration and that tie slipping is virtually eliminated.

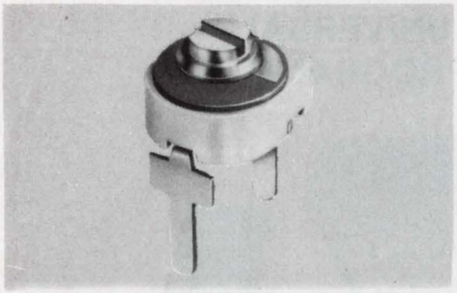
Talk to your Gudebrod rep about "Z" Finish tapes or write:

Gudebrod, Inc., Dept. 8EPP
12 South 12th St., Phila., Pa. 19107
Phone (215) 922-1122 or (516) 825-4616

CIRCLE NUMBER 157

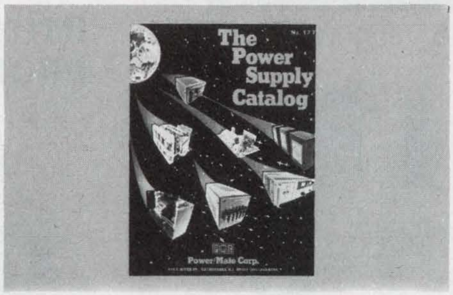
quick ads

New and current products
for the electronic designer
presented by their manufacturers.



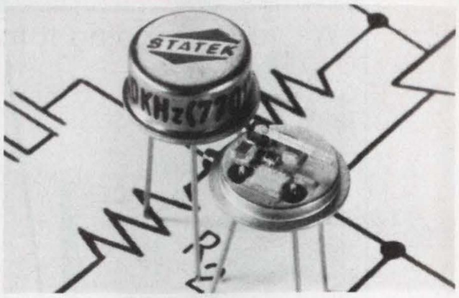
MINIATURE CERAMIC TRIMMER CAPACITORS 9371 series of ceramic trimmer capacitors are compact, economical and rugged. They are 50% smaller than other trimmers of this type yet provide high capacitance values. Available in 4 capacitance ranges, 1.5 to 4, 3.0 to 10, 3.5 to 18 and 5.0 to 25 pf with Q's > 300 at 10 MHz. They have an overall diameter of .225" with .215" above board height. JOHANSON MANUFACTURING CORPORATION, Rockaway Valley Road, Boonton, N.J. 07005 201-334-2676

TRIMMER CAPACITORS 181



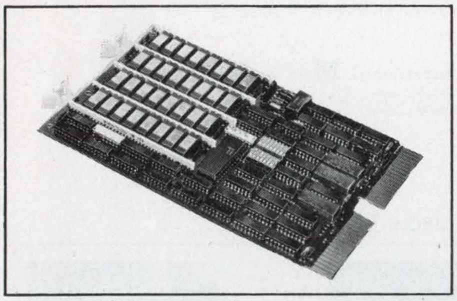
Free New catalog contains over 34,500 quality power supplies from the world's largest manufacturer, Power/Mate Corp. Power Supplies for every application including submodulars, open frame, varirated, encapsulated, laboratory & system. All units UL approved and meet most military and commercial specs for industrial and computer uses. Power/Mate Corp., 514 S. River St., Hackensack, NJ 07601 (201) 343-6294

POWER SUPPLIES 184



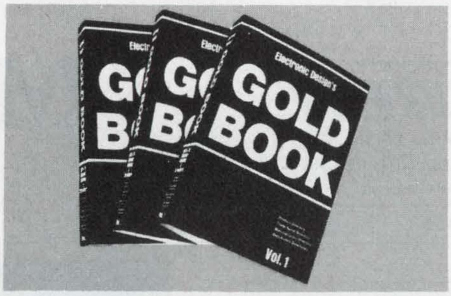
CMOS Crystal Oscillators in Low profile TO-5. Frequency range is 10 kHz to 300 kHz (divided outputs to 1 kHz, low as one cycle per month available). Low milliamp current consumption. Accuracy ±0.01%. Shock 1000 g. Hybrid thick and thin film chip and wire design is rugged and ideally suited for portable equipment. Details in Gold Book & EEM * STATEK CORP * 512 N. Main, Orange, Ca. 92668 * (714) 639-7810 * Telex 67-8394.

CRYSTAL OSCILLATOR 187



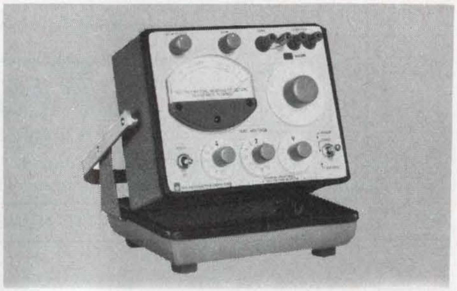
MINI/BUS® HELPS PACKAGE up to 32K words on a single high density add-in expansion memory. Low cost, low-inductance, high-capacitance bus bars can solve your printed circuit space problems and shorten assembly time while reducing and isolating noise. Call or write Rogers Corporation, Chandler, AZ 85224. Phone: (602) 963-4584. (EUROPE: Mektron NV, Gent, Belgium; JAPAN: Nippon Mektron, Tokyo.)

MINI/BUS 182



THE '77-'78 GOLD BOOK IS NOW OFF THE PRESS. Contains 2,496 pages of up-to-the-minute information about the entire electronics industry. Complete with Product,. Trade Name, Manufacturers, Distributors Directories and Catalogue Compendium. Price: $30–U.S., Canada and Mexico. Other countries $40–Overseas postage included. To order either circle Reader Service no. and we'll bill you later, or send payment to GOLD BOOK, Dept. #437-R, Hayden Publishing, 50 Essex St., Rochelle Park, NJ, 07662.

'77-'78 GOLD BOOK 185



PORTABLE MEGOHMMETERS. Measure leakage on semis, capacitors, wire/cable, printed circuit cards and other insulating materials. GenRad's megohmmeters provide a wide resistance range from 50 kΩ to 200 TΩ (2 × 10^{14} Ω) with up to 200 test voltages from 10 to 1090 V. Flip-tilt cover protects front panel when transported. The GR 1863 and GR 1864 can be your solution for precise high-resistance measurements. GenRad, 300 Baker Ave., Concord, MA 01742, Tel. (617) 369-8770

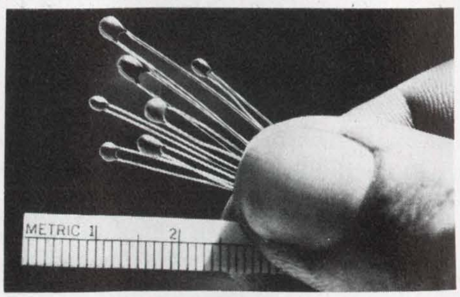
MEGOHMMETERS 188

New 48-Page Magnetic Shielding/Problem Solving Comprehensive Reference Manual. 28-Page Engineering Section includes two engineering reports on shielding effectiveness of AD-MU Tape Data Protectors, standard inspection procedure for AD-MU foil, calculation assists in shield design, magnetic data on shielding alloys, Helmholtz testing of finished shields, various basic tables. 20 Pages product/facilities also included. AD-VANCE MAGNETICS, INC., 226 E. Seventh Street, Rochester, Indiana 46975. (219) 223-3158.

MAGNETIC SHIELDING 183

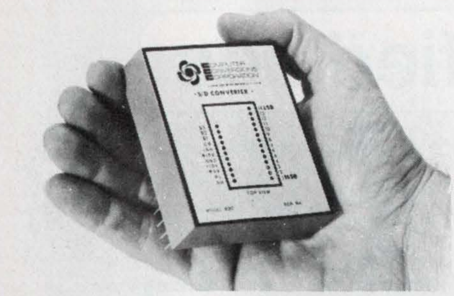
BROAD RANGE FLUXMETERS Analyze magnetic circuits; measure residual, stray, absolute and differential fields, and plot field uniformity. Very low Drift for DC measurement, High Frequency Response for AC measurement. Flexible scale to read Flux or Flux density in kilomaxwells or kilogauss. Complete linearity assured. Not sensitive to vibrations or positioning. Model MF—3A Analog display. Model MF-3D Digital display. Write Walker Scientific, Inc., Rockdale St., Worcester, MA 01606/ (617) 852-3674.

MF 3A/D FLUXMETERS 186



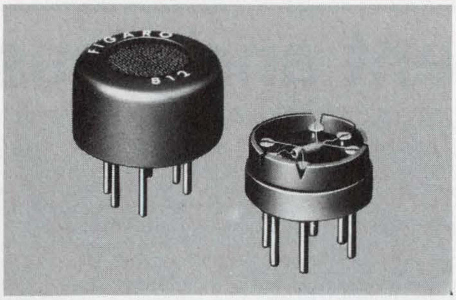
THERMISTORS with leads and coating are highly reliable low cost components in small dimensions more compatible with modern circuit design. R @ 25°C 100Ω to 1 meg Ω ±10% to ±1%. CURVE MATCHED INTERCHANGEABLES to ±.25°C. POINT MATCHED INTERCHANGEABLES to ±.2°C. Call or write for HP97 or TI SR52 THERMISTOR LINEARIZATION PROGRAM. WESTERN THERMISTOR CORPORATION, 354 Via Del Monte, Oceanside, CA 92054. (714) 433-4484.

THERMISTOR 189



"Synchro to digital converters - 10, 12, or 14 bit output, errorless tracking up to 4 r.p.s., accuracy ±4 min. of arc ±.9LSB, resolution - 1.3 minutes, 60 or 400 Hz input, Module 2.6 x 3.1 x .82" H, Price From $350 in qty. Other CCC products are Synchro to BCD or DC, Digital or DC to Synchro Converters, Solid State C.T.'s or CDX's, and Absolute Encoders. Send for Free Catalog & Application Notes. Computer Conversions Corp., East Northport, NY 11731 (515) 261-3300.

SYNCHRO TO DIGITAL 190



FIGARO GAS SENSOR TGS is a gas sensitive semiconductor. When combustible gas is absorbed on the sensor surface, a marked decrease of electrical resistance occurs. Major features of the sensor include high sensitivity, long term reliability and low cost. The applications are: GAS-LEAK ALARM, AUTOMATIC FAN CONTROL, FIRE ALARM, ALCOHOL DETECTOR, etc. Figaro Engineering Inc., North America Office-3303 Habor Boulevard, Suite D-8, Costa Mesa, Calif. 92626 Tel: (714) 751-4103 Telex: 678396

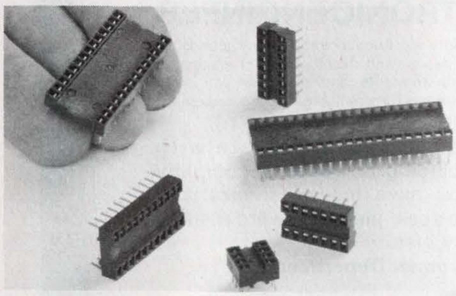
GAS SENSOR 193

MAGNETIC SHIELDING Take advantage of Eagle's 23-year background in shield design and production. Custom and standard models. Full service includes design, engineering, fabrication, heat treating, finishing, testing. Also wide selection of sheet and foil so you can form your own shields. For helpful design and cost data, request Bulletin E-77. Eagle Magnetic Co., Inc., Box 24283, Indianapolis, IN 46224, 317-297-1030.

MAGNETIC SHIELDING 191

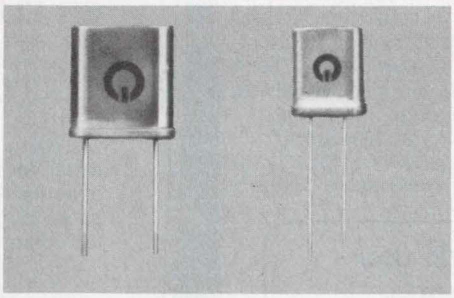
EXTREMELY SHOCK-ABSORBENT CASES. These polyethylene cases protect your delicate product better than metal or fiberglass cases (and far cheaper). Shock-damping outer shell first absorbs some impact energy, then foam absorbs even more. Result: your product suffers fewer g's. Airtight and waterproof. Meet military/airline/ASTM specs. Unbelieveable prices. 64 sizes. Also custom — send dwgs. Thermodyne International Ltd, 12600 Yukon Ave, Hawthorne, CA 90250 (213) 679-0411.

SHOCK-ABSORBENT CASES 194



METHODE IC SOCKETS are end and side stackable for ultra-high density packaging. Sizes for all standard DIP packages are available on .300", .400" and .600" centers. Anti-wicking contact design with stand-off makes soldering and clean-up easy. Large ramped lead-in for simple assembly and field repairs. Insulators are glass filled nylon and contacts are tin-plated brass. Methode Manufacturing Corp. 1700 Hicks Road, Rolling Meadows, IL 60008, (312) 392-3500.

IC SOCKETS 192



HIGH STABILITY LOW COST QUARTZ CRYSTAL for μ-processor and clock oscillator. Accuracy is ±0.002% at 25°C, Frequency change over −10 to +55°C is within ±20ppm. 1.000, 1.8432, 2.000, 2.097152, 2.4576, 3.2768, 4.0000, 5.0000, 5,0688, 5.1850, 5.7143, 6.5536, 10.0000, 18.0000, 18.4320, 20.0000, 22.1184 Immed. Dlvy. $1.85 ea. 10 MHz up in HC-18/u; (Min. 100 pcs.) Q-MATIC CORP., 3194-D Airport Loop Dr., Costa Mesa, CA 92626, (714) 545-8233, Telex 678389

CRYSTAL 195

Electronic Design

Advertising Sales Staff
Susan G. Apolant
Sales Coordinator

Rochelle Park, NJ 07662
Robert W. Gascoigne
Thomas P. Barth
Stan Tessler
Constance McKinley
50 Essex St.
(201) 843-0550
TWX: 710-990-5071
(HAYDENPUB ROPK)

Philadelphia
Thomas P. Barth
(201) 843-0550

Boston 02178
Gene Pritchard
P.O. Box 379
Belmont, MA 02178
(617) 489-2340

Chicago 60611
Thomas P. Kavooras
Berry Conner, Jr.
200 East Ontario
(312) 337-0588

Cleveland
Thomas P. Kavooras
(312) 337-0588

Los Angeles 90045
Stanley I. Ehrenclou
Burt Underwood
8939 Sepulveda Blvd.
(213) 641-6544

Texas
Burt Underwood
(213) 641-6544

San Francisco
Robert A. Lukas
465 S. Mathilda, Suite 302
Sunnyvale, CA 94086
(408) 736-6667

England
Constance McKinley
50 Essex St.
Rochelle Park, N.J. 07662
Phone: (201) 843-0550

Europe
Sanders, W. J. M.
Raadhuisstraat 24
Graft-De Ryp, Holland
Phone: 02997-1303
Telegrams: Euradteam-Amsterdam
Telex: 13039-SIPAS

G. Nebut
Promotion Presse Internationale
7 ter Cour des Petites Ecuries
75010 Paris, France
Telephone: 5231917, 1918, 1919

Dieter Wollenberg
Erikastrasse 8
D-8011 Baldham/Muenchen
Germany
Telephone: 0 8106/4541

Tokyo
Haruki Hirayama
EMS, Inc.
5th Floor, Lila Bldg.,
4-9-8 Roppongi
Minato-ku, Tokyo, Japan
Phone: 402-4556
Cable: EMSINCPERIOD, Tokyo

ABP BPA

Electronic Design

recruitment and classified ads

PLACE YOUR AD AT ONLY **$55** PER COLUMN INCH IN

Electronic Design

— *GET A REPEAT AD FREE!*

With our 2 for 1 plan, your net cost in *Electronic Design* is only $27.50 per column inch, lowest among all the national newspapers and electronics media. You get a total of 165,418 exposures to EOEM engineers and engineering managers (not counting 11,668 more among general or corporate managers) at only 33¢ per thousand! You can't beat the price. You can't beat the coverage *and* you can't beat the quality.

YOU REACH ENGINEERS WITH TITLES LIKE THESE:

• Chief Engineer • Development Engineer • Design Engineer • Project Engineer • Electronic Engineer • Engineer-Supervisor • Section Leader • Staff Engineer • Systems Engineer • Test Engineer • Standards Engineer • Master Engineer

Electronic Design RECRUITMENT ADVERTISING RATES

15% commission to recognized agencies supplying offset film negatives. 2% 10 days, net 30 days. Four column makeup. Column width 1-3/4" x 10".

SPACE	DIMENSIONS Wide	Deep	COST
One column inch	1-3/4"	x 1"	$55.
2 col. in.	1-3/4"	x 2"	$110.
1/16 page (1/4 col.)	1-3/4"	x 2-1/2"	$130.
1/8 page (1/2 col.)	1-3/4"	x 5"	$275.
1/4 page (1 col.)	1-3/4"	x 10" Vert.	$550.
	3-1/2"	x 5" Hor.	
1/2 page (2 cols.)	3-1/2"	x 10" Vert.	$1100.
	7"	x 5" Hor.	
3/4 page (3 cols.)	5-1/4"	x 10"	$1650.
1 page	7"	x 10"	$2200.

NOTE: EACH RECRUITMENT AD YOU PLACE WILL BE REPEATED FREE OF CHARGE!

LATE CLOSING DATES

Electronic Design is mailed every two weeks. Because of its timeliness, personnel recruitment advertising closes only two weeks before each issue's mailing date.

Issue Date	Recruitment Closing Date	Mailing Date
Jan. 18	**Dec. 23**	Jan. 6
Feb. 1	**Jan. 6**	Jan. 20
Feb. 15	**Jan. 20**	Feb. 3
Mar. 1	**Feb. 3**	Feb. 17
Mar. 15	**Feb. 17**	Mar. 3
Mar. 29	**Mar. 3**	Mar. 17
Apr. 12	**Mar. 17**	Mar. 31

HOW TO PLACE YOUR AD

CALL THE RECRUITMENT HOT LINE 201-843-0550

Camera-ready film (right reading negatives, emulsion side down) or camera-ready mechanicals must be received by deadline. Or, if you wish us to set your ad (typesetting is free) simply pick up the phone and call our RECRUITMENT HOT LINE — (201) 843-0550. Ask for:

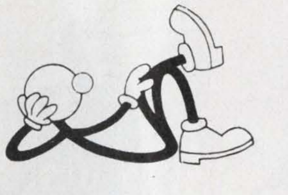
Constance McKinley
RECRUITMENT ADVERTISING MANAGER
ELECTRONIC DESIGN
50 Essex Street, Rochelle Park, New Jersey 07662

Recruitment Ads Pull

Advertiser's index

RECRUITMENT

**Advertisers in non-U.S. edition*



EFFORTLESS . . .

If you're ready to move on with your career, it can be a lot easier than you expect.

We are the members of

National Personnel Associates®

who work extensively with electronics industry leaders. The companies we service have many openings and pay for us to search you out.

Send your resume to the office nearest you. Then sit back and relax while we do the work.

SOUTHERN MANAGEMENT REGISTRY
P.O. Box 4036
Charlotte, North Carolina 28204
(704) 372-7640

ALDEN ASSOCIATES, INC.
414 Hungerford Drive
Rockville, Maryland 20850
(301) 424-3522

POWER SERVICES, INC.
Northgate Office Building
5861 Rivers Avenue
North Charleston, South Carolina 29405
(803) 747-0955

STAFF DYNAMICS, U.E.
26 Sixth Street
Stamford, Connecticut 06905
(203) 324-6196

CAREER SPECIALISTS, INC.
4600 El Camino Real, Suite 206
Los Altos, California 94022
(415) 941-3200

BRENTWOOD PERSONNEL ASSOCIATES
1280 Route 46
Parsippany, New Jersey 07054
(201) 335-8700

190 associates internationally

seeking new career opportunities?

- Circuit Design
- Computer Systems
- Digital Systems
- Systems Simulation
- Signal Processing
- Radar Systems
- ASW Systems
- Pattern Recognition
- Surface Ship Sonar
- Real Time Programmers
- Weapons Systems
- Command/Control
- Electro-Optical
- Reliability/Test
- Avionics Systems
- Electronic Warfare
- Communications
- Mini-Computers
- Submarine Systems
- Microprocessor Systems

We are a Professional Search Firm representing a number of prestigious employers throughout the United States. Our clients include research and development laboratories, defense contractors, government contract research centers, major commercial and industrial corporations and leading management consulting firms. Starting salaries range from $15,000 to $40,000 with our fees, and all interview and relocation expenses fully paid by our clients.

If you wish to be considered for current and future opportunities, please send your resume, including current salary and technical strengths, to L. J. Clavelli or R. Beach . . . today!

WALLACH associates, inc.

1010 Rockville Pike, P.O. Box 2148
Rockville, MD 20852 (301) 762-1100

A licensed recruitment organization

Electronic Design

BRINGS YOU THE HIGHEST NUMBER OF QUALIFIED EOEM ENGINEERS AND ENGINEERING MANAGERS *ANYWHERE* . . . AT THE LOWEST COST *ANYWHERE!*

Constance McKinley
RECRUITMENT ADVERTISING MANAGER
ELECTRONIC DESIGN
50 Essex Street, Rochelle Park, New Jersey 07662
(201) 843-0550

I'm interested in placing recruitment advertising in *Electronic Design*

Issue ______________ Size of ad ______________

☐ My copy is enclosed ☐ I need more information

Name ______________

Title ______________

Company ______________

Address ______________

City ______________ State ______ Zip ______

Telephone ______________

ENGINEERS & EDP

MEET 26 EMPLOYERS

Interviewing Soon in
MAJOR MARKETING AREAS

MANY REQUIREMENTS FOR AFFIRMATIVE ACTION APPLICANTS INCLUDING PROFESSIONAL WOMEN

At an Opportunity Center, you have a unique opportunity to meet representatives of top firms in private interviewing sessions all in a single day or evening. When you apply, your resume minus your name and present employer, is reviewed by representatives of Opportunity Center sponsoring firms. You are notified as to which firms would like to meet you. Your identity is revealed only after you have expressed interest in this corporation. Private interviews are scheduled at your convenience.

COMPANIES WHO HAVE ATTENDED

Allen Bradley
Ashland Oil
Automatic Sprinkler
American Air Filter
Bendix
Borg Warner
Burroughs
Carborundum
Combustion Engineering
Commonwealth Associates
Computer Science
Digital Equipment
Dravo
Emerson
Fairchild
General Electric
Gilbert Associates
Gould, Inc.
Goodyear
G.T.E.
Harris Electric
Honeywell
I.T.T.
Jos. Schlitz
Koppers Company
Litton
Martin Marietta
3M
McDonnel Douglas
Monsanto
Miles Laboratories
NCR
Owens Illinois
Picker X-Ray
Simmonds Precision
Singer
Stone and Webster
Sundstrand
Teledyne
Texas Instruments
TRW
Union Carbide
Westinghouse
Xerox

NO FEES OR CHARGES TO APPLICANTS

SEND RESUME TO:

OPPORTUNITY CENTER

Akron Savings Bld., Suite 1113
7 W. Bowery St., Akron, Ohio 44308

1978 TOP TEN CONTEST RULES

Reader Contest

PICK THE TOP TEN ADVERTISEMENTS IN THIS ISSUE... WIN A 10-DAY ACAPULCO HOLIDAY FOR TWO ...$1,000 CASH...$600 PET PERSONAL COMPUTER...$100 DIGITAL WRISTWATCH...100 PRIZES IN ALL.

Examine this issue of *Electronic Design* with extra care. Pick the ten advertisements that you think your fellow engineer-subscribers will best remember having seen. List these ten advertisements on the special entry form bound in this issue. *(Be sure to check the box marked "Reader Contest.")*

This year your selections will be measured against the ten ads ranking highest in the "Recall Seen" category of Reader Recall, *Electronic Design's* method of measuring readership — see item 6.

In making your choices do not include "house" advertisements placed by *Electronic Design* or Hayden Publishing Company, Inc. (such as this ad describing the contest). Don't miss your chance to be a Top Ten Winner! *All entries must be postmarked no later than midnight, February 28, 1978. Winners will be notified in March, 1978.*

READER CONTEST RULES

1. Enter your *Top Ten* selections on the entry blank bound in this issue or on any reasonable facsimile. Be sure to indicate the name of the advertiser and *Information Retrieval Number* for each of your choices. Do *not* use page number. (House ads placed by Hayden Publishing Company in Electronic Design *should not* be considered in this contest.)

2. No more than one entry may be submitted by any one individual. Entry blank must be filled in completely, or it will not be considered. The box on the entry blank marked "Reader Contest" must be checked. *Electronic Design* will pay postage for official entry blanks only.

3. To enter, readers must be engaged in electronic design engineering work, either by carrying-out or supervising design engineering or by setting standards for design components and materials.

4. No cash payments, or other substitutes, will be made in lieu of any prize, (except the $1,000 prize).

5. Contest void where prohibited or taxed by law. Liability for any taxes on prizes is the sole responsibility of the winners.

6. Entries will be compared with the "Recall Seen" category of Reader Recall (*Electronic Design's* method of measuring readership). That entry which in the opinion of the judges most closely matches the "Recall Seen" rank will be declared the winner.

7. In case of a tie, the earliest postmark will determine the winner. Decisions of *Top Ten* contest judges will be final.

8. First prize includes first class air conditioned accommodations for two, double occupancy, plus modified American plan meals (breakfast and dinner) for 10 days, 9 nights at the Paraiso Marriott in Acapulco. Subject to availability May through December 1978. Void after December 1978. The $1,000 cash award may be used toward all other incidental hotel expenses, luncheons, bar, baggage, tips, etc. or for local or air transportation.

USE SPECIAL ENTRY BLANK BOUND IN THIS ISSUE
(Blanks are bound both in front and back of this issue)

Advertiser Contest

PICK THE TOP TEN ADVERTISEMENTS IN THIS ISSUE ... WIN A 10-DAY ACAPULCO HOLIDAY FOR TWO ...$1,000 CASH...$600 PET PERSONAL COMPUTER...$100 DIGITAL WRISTWATCH.

There's a separate contest open to all marketing and advertising personnel in companies, and to advertising agencies.

Examine this issue of *Electronic Design* with extra care. Pick the ten advertisements that you think will be best SEEN by *Electronic Design's* readers. List these ten advertisements on the special entry blank bound in this issue. (Be sure to check the box marked "Advertiser Contest".)

FREE RERUNS FOR THE TOP TEN ADS

In addition to valuable contest prizes, all ads that place in the Top Ten will be given free reruns. These free reruns will be made only from existing plates or negatives. If the advertisement qualifying for a free rerun is an insert, the winner may run up to a two-page spread from existing plates or negatives in up to 4-colors. Hayden Publishing Company, Inc. reserves the right to schedule reruns at its discretion.

ADVERTISER CONTEST RULES

1. All rules for the Reader Contest will similarly apply for this contest, with two exceptions: readers engaged in electronic design engineering work, as defined in the reader contest rules, are *not* eligible to participate in this special contest. The box on the entry blank marked "Advertiser Contest" must be checked.

2. Entrants in this contest may use the official reader contest entry blanks or any reasonable facsimile.

3. This special contest is open to marketing and advertising personnel only at all manufacturing companies and advertising agencies whether or not their companies or agencies have an advertisement in the contest issue.

FOR A COMPLETE DESCRIPTION OF PRIZES FOR BOTH READER AND ADVERTISER CONTESTS SEE PAGES 78 AND 79

USE SPECIAL ENTRY BLANK BOUND IN THIS ISSUE
(Blanks are bound both in front and back of this issue)

RCA first in CMOS.

First in CMOS microprocessors.

RCA 1800 combines elegant COSMAC architecture with CMOS benefits. Result: the performance you want—plus maximum flexibility with minimum parts count.

Cost-effective COSMAC architecture. Since our CDP1802 CPU accepts compact 1-byte instructions, you need less memory. Registers store data with 1-byte access. And they act as pointers, so individual instructions don't need addresses.

Built-in I/O. The CPU has interrupt, DMA, flags in and bit control out, so you need less I/O. And we offer a wide range of low-cost I/O devices, including our unique 2-mode UART.

The RCA 1800 Microprocessor Family

CDP 1802	COSMAC CPU
CDP 1821S	1024x1 High-speed RAM
CDP 1822	256x4 Low-cost RAM
CDP 5101	256x4 Industry-standard RAM
CDP 1822S	256x4 High-speed RAM
CDP 1824	32x8 RAM
CDP 1831, 2	512x8 ROM (with or without latch)
CDP 1833, 4	1024x8 ROM (with or without latch)
CDP 1852	Byte I/O
CDP 1853	I/O decoder
CDP 1854	UART
CDP 1856, 7	Bus buffer/separators
CDP 1858, 9	Address latch/decoders
CDP 1861	TV interface
	Coming in 1978
CDP 1823S	128x8 High-speed RAM
CDP 1851	Programmable I/O
CDP 1855	Multiply/Divide Unit

And these major parts: 4K RAM, 4K EPROM, 1-chip COSMAC microcomputers—all in CMOS.

Easily expandable memory. Build up to 65K without adding any address management parts. RCA offers the ROMs you'll need and CMOS RAMs as well.

Full-range design support. From the basic Microtutor learning tool to a complete COSMAC Development System with floppy disk. All geared to help you translate the CMOS advantage into true system cost effectiveness.

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When you say CMOS, say RCA first.

CIRCLE NUMBER 232