INTERNATIONAL EDITION

NOVEMBER 29, 1984

A CAHNERS PUBLICATION

EDN

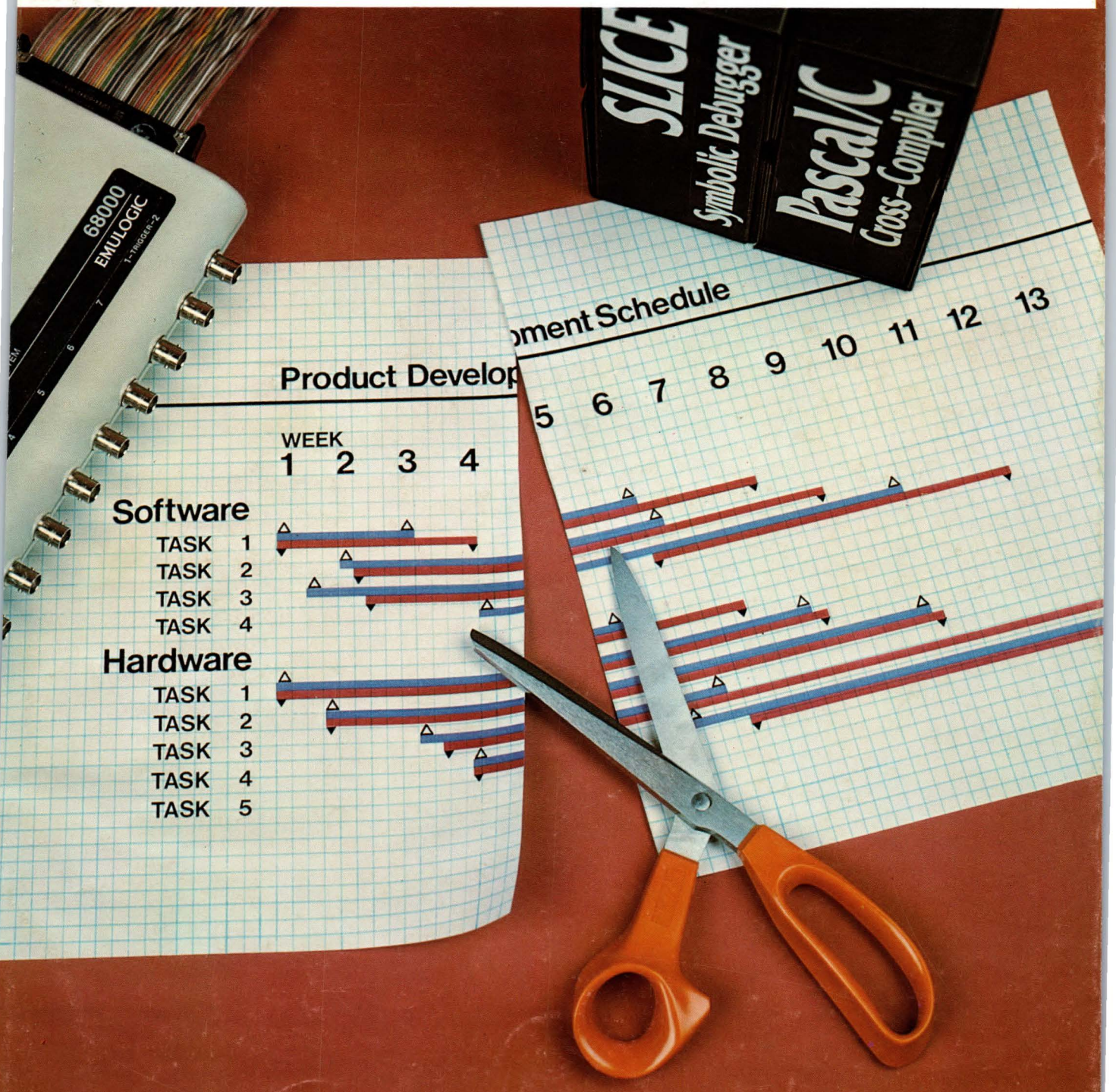
ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Driver ICs simplify μP-to-display interfacing

Extended processing units expand computing power

Converter circuits directly digitize low-level signals

Fiber-optic links

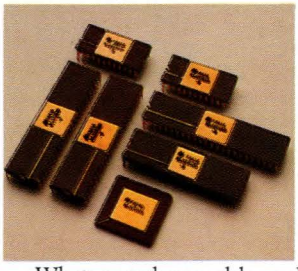


Integrated development tools

Presenting National's Series 32000.™

National's Series 32000™ (formerly known as NS16000) provides the most complete family of 32-bit CPUs, slave processors, systems peripherals, development systems and software. Today!

In today's fast paced high-technology marketplace, time equals money. And chances for product success often depend upon narrow windows of opportunity. So time-to-market becomes a critical ingredient in microprocessor selection.



When you thoroughly evaluate and compare available 32-bit options, we think you'll find that National's Series 32000 is the undisputed choice.

Full 32-bit Architecture.

In a world of over-stretched, band-aided microprocessor architectures, National provides a true 32-bit solution. The Series 32000 is the world's first commercially-available 32-bit microprocessor family that was designed as 32-bit. We've taken a systems solution approach to give you what you need: An innovative microprocessor family with the right performance. Current availability. And alternate sourcing by major manufacturers.

- *Advanced 32-bit architecture* is the basis of the Series 32000. This same 32-bit architecture is implemented in all Series 32000 CPUs. These CPUs also offer downward compatibility in 16 and 8-bit external data bus versions.
- *Fast floating point support* is available now with National's NS 32081, the *only* viable floating point unit to support your system's needs for floating point operations.
- *A powerful MMU, National's NS 32082, provides Demand Paged Virtual Memory support* and it's available today. This industry 'first' provides fast on-chip address translation and advanced operating systems support, making it the ideal choice for a UNIX™ environment.

The best UNIX Micro.

If your system design calls for UNIX, industry experts have called the Series 32000 "the best for UNIX."

National's GENIX,™ featuring optimized Demand Paged Virtual Memory support, is available today in source form for OEM adaption. The next generation of GENIX, with Ethernet™ support, is in test now. We have also delivered the Series 32000 version of UNIX System V (release 2.0) to AT&T for validation. National is your source for UNIX.

Our Series 32000 software catalog gives OEMs an opportunity to select from a wide variety of software, including offerings from independent software vendors.

Series 32000 is the only 32-bit solution today.

If your market window falls within the next twenty-four months, the Series 32000 provides you with product for your designs *today*. National is the only manufacturer that offers a complete 32-bit microprocessor family now. With an architecture designed to fully support high-level languages; a full 32-bit data bus to memory that increases memory bus bandwidth and thus the speed at which data can be transferred; a range of CPUs with total compatibility to 16 and 8-bit; a full range of peripherals; powerful evaluation tools; a multi-user, multi-tasking development system; a growing list of available third-party software; and the hardware, software, service and customer training that spell real long-range commitment.

All to assure you of the products and support you need *today* and into the future.

Truly a generation ahead.

We'd like to send you a copy of our brochure entitled: "The Specifics of 32-Bit Architecture and Implementation." And to answer any questions you might have about Series 32000. Write to National Semiconductor Series 32000, 2900 Semiconductor Drive, MS23-200, Santa Clara, California 95051.

Series 32000.

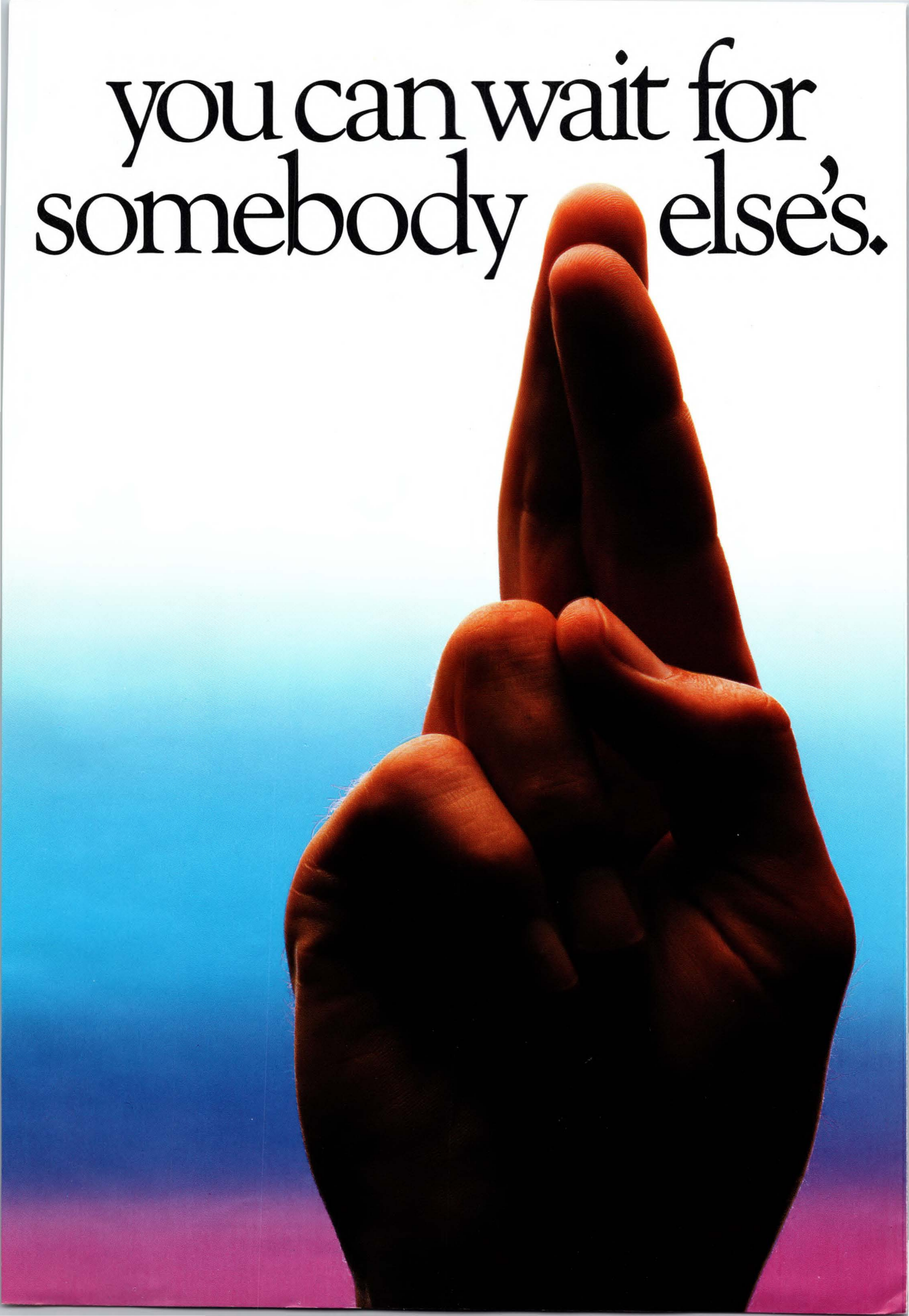
Elegance is everything.

CIRCLE NO 41

National Semiconductor

MICROCOMPUTER SYSTEMS DIVISION.

you can wait for somebody else's.



You can get our complete 32-bit microprocessor family today. Or...

WAVETEK®

Our new function generator makes frequencies 30 times easier to hold.

The typical function generator lets you dial in frequencies with ±3% accuracy. Our new Model 21 doesn't have a dial. Instead, a 3 1/2-digit display shows you settings over the 100μHz to 11 MHz range. And the accuracy equals the display resolution—an impressive ±.09%, thanks to a built-in counter and a digital memory circuit.

Push the Stabilizer button and that accuracy becomes long-term stability.

But that's only the beginning, because Model 21 is the most important new function generator design in the last 20 years.

For instance, it has digital synthesis of waveforms (including haverwaves and ramps) below 1.1 kHz, with 1000 horizontal points and 250 vertical points per cycle. You can stop a wave at any point, hold it, then resume.

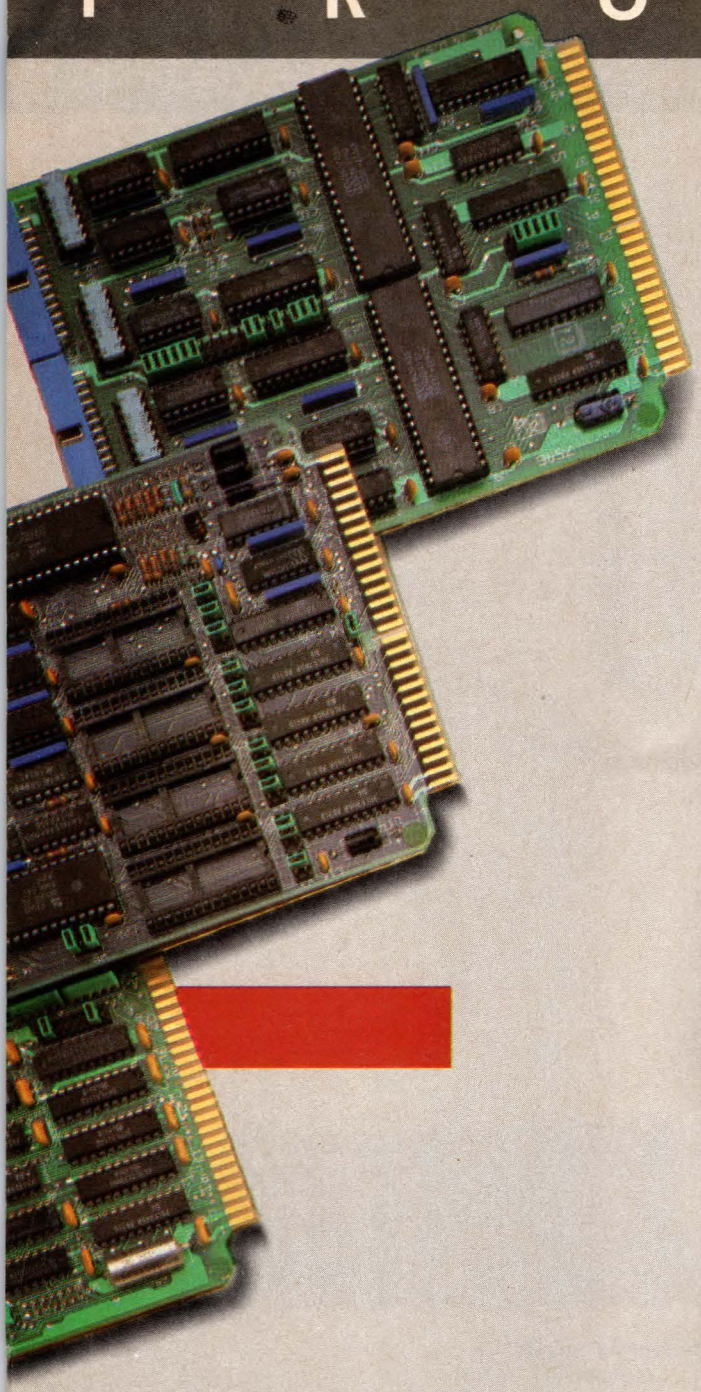
Or you can use the generator's output as a 1000:1 frequency divider for ultra-low frequency generation.

Sine, triangle, and square waveforms are available at all frequencies, and they can be triggered or gated.

A lot of capability for an instrument just a little over 3 inches high—and just a little under $1,000*. For details on how you can get your hand on one, contact:
Wavetek San Diego, Inc.
9045 Balboa Ave., P.O. Box 85265, San Diego CA 92138. Tel. (619) 279-2200;TWX 910-335-2007.
*U.S. price.

CIRCLE NO 7

P R O L O G



DEDICATED TO Z80? SO ARE WE.

NOT DEDICATED TO Z80? SO ARE WE.

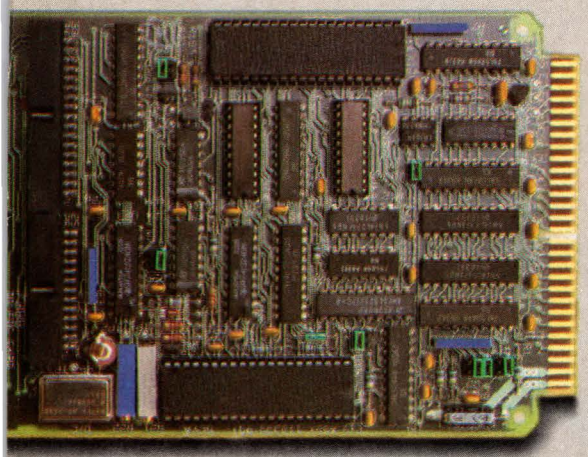
You're covered.
Every which way — in the STD BUS card world — which we (a) created, invented, started, and (b) influence with more cards, more versions, more solutions than anyone. Adding four new cards brings the Pro-Log card count to 59, which is a lot of ways to solve Z80 and non-Z80 problems. Speaking of Z80, one new card, the 7806, is a Z80A multifunction CPU 128K on-board memory and I/O.

The second card, a natural ally to the multifunction CPU card, is our new 128K dynamic ram card. 7707 to be exact. (64K memory is an option). The latest in high-density semiconductor memory. Compatible with Z80A, 8088, 8085A, 6809 and others.

The third card, 7606, is a versatile, four-port parallel I/O card designed specifically for Z80A-based STD BUS card systems. Starting with just these three cards gives you the nucleus of a Z80-based system.

Our fourth new card, 7388, is dedicated and not dedicated to Z80. It's a double-density floppy disk controller card with a most important — and exclusive feature. It runs 8", or 5¼" or 3½" drives without modifying the connectors. The soft-sectored diskettes can be single-sided, single-density, double-sided, double-density, or any combination thereof.

So you now have 4 new reasons and 55 original reasons to buy Pro-Log. You get unmatched quality, a 2-year warranty, prompt delivery and our total lack of dedication.



7806, Z80A MULTIFUNCTION CPU CARD, 128K on-board EPROM capacity, fully buffered Z80A processor, four 8-bit counter/timers, dual independent RS-232-C channels.

7707, 128K DYNAMIC RAM CARD with parity, compatible with Z80A, 8088, 8085A, 6809 and others, 64K option, cuts card count for large memory applications.

7606, PARALLEL I/O CARD, four operating modes, supports Z80 mode-2 interrupts, direct TTL interface.

7388, DOUBLE-DENSITY FLOPPY DISK CONTROLLER CARD, runs 8", 5¼", 3½" drives, uses a DMA controller for fast memory access, three user accessible DMA channels.

PRO-LOG® CORPORATION
INVENTORS OF THE STD BUS

2411 Garden Road
Monterey, California 93940
408-372-4593, TLX: 171879
Outside CA: 800-538-9570

Offices and Telex: Australia, 35494; France, 842-696379; Germany, 971624; Italy, 68071; Sweden, 13695; Switzerland, 55448 United Kingdom, 858618.

©1983 ADGroup International PL 033A

CIRCLE NO 8

S T D B U S

EDN

NOVEMBER 29, 1984 • VOLUME 29, NUMBER 24 • ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

DESIGN FEATURES

Integrated development tools 116
Development-system utilities that have uniform commands and compatible outputs smooth the transition from one design step to the next.

Extended-processing units expand μP computing power 139
Specialized parallel-processing chips tied to a Z8000 CPU get more computing power from the μP; the Z8000 family's extended-processing architecture increases the speed of slave interfaces.

Eliminating protection circuitry reduces switching-supply costs 157
Crowbar-type overvoltage and foldback-mode current-limit circuits are needless in many switching-supply applications. A study of supply circuitry shows how to eliminate such protection functions.

Driver ICs interface μPs with vacuum-fluorescent displays 169
Vacuum fluorescent displays suit commercial and industrial applications, and sequence- and segment-driver ICs ease the use of display devices in μP-based systems.

Circuits allow direct digitization of low-level transducer outputs 183
Designers like to digitize analog signals as far forward in the signal chain as possible. Part 1 of this 2-part series describes circuits that digitize low-level signals without preamplification.

Program automates error analysis of time-interval measurements 197
Calculating resolution and accuracy for a programmable counter's time-interval error can be a big job if done by hand. A program adaptable to any counter can relieve this burden.

TECHNOLOGY UPDATE

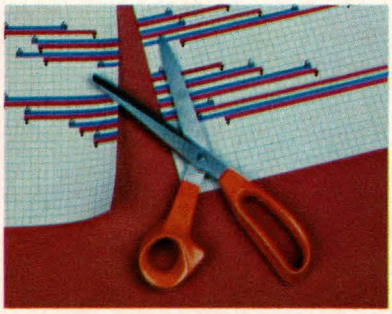
CAE design systems, functional testers combine to ease prototype-IC testing 61

Plastic-fiber-based optical links offer low-cost, short-haul data transfer 91

Continued on page 7

Instrumentation tailored to CAE systems *is simplifying test and verification of prototype chips. Such instruments combine stimulation, acquisition, and comparison capabilities (pg 61).*

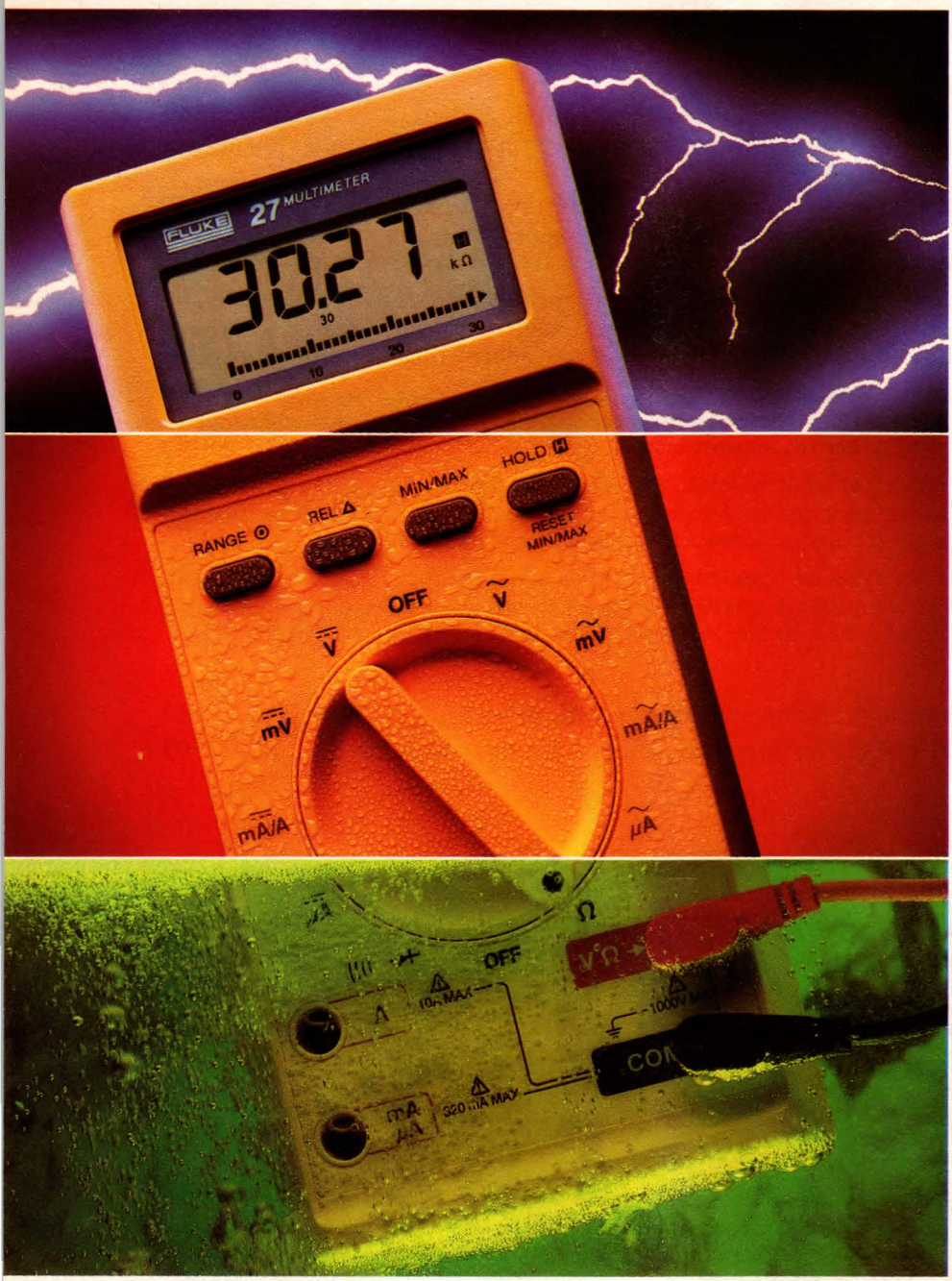
Plastic fibers offer an alternative *to coaxial cable or twisted-wire pairs in applications requiring a low-cost communications link. Moreover, the fibers are easy to use (pg 91).*



On the cover: *Cutting product-design schedules depends on more than your choice of development-system hardware; you must also select integrated software packages that work smoothly with your hardware. See pg 116. (Photo courtesy Emulogic)*

EDN (ISSN 0012-7515) is published biweekly by Cahners Publishing Company. Division of Reed Holdings, Inc, 221 Columbus Avenue, Boston, MA 02116. Norman L Cahners, Chairman; Saul Goldweitz, President and Chief Executive Officer; Ronald G Segel, Executive Vice President and Chief Operating Officer. EDN is published by the Cahners Magazine Division; J A Sheehan, President; William Platt, Executive VP/Group Publisher. Circulation records maintained at Cahners Publishing Co, 270 St Paul St, Denver, CO 80206. Second class postage paid at Denver, CO 80202 and additional mailing offices. Postmaster: Send address changes to EDN, 270 St Paul St, Denver, CO 80206. Advertising and editorial offices: 221 Columbus Ave, Boston, MA 02116. Phone (617) 536-7780. Subscription offices: 270 St Paul St, Denver, CO 80206. Phone (303) 388-4511. EDN is circulated without charge to those qualified. Subscription to others in the continental US: $4/copy (special issues may vary), $55/year; international subscriptions: $6/copy ($5/copy in Canada/Mexico) (special issues may vary), $120/year ($60/year in Canada/Mexico). Send requests for qualification forms and/or change of address to subscription office.
© 1984 by Cahners Publishing Company, Division of Reed Holdings, Inc. All rights reserved.

Tough enough to work anywhere you work.



The Fluke 20 Series. A tough new breed of Analog/Digital Multimeters.

Put them to the test.

The new Fluke 20 Series are the first lab-accurate analog/digital handhelds tough enough to withstand water, contaminants, chemicals, accidental drops, extreme temperatures, and severe electrical overloads.

They're also the first sealed meters to offer fast autoranging, an analog bar graph, a continuity/diode test beeper, and Fluke's unique "Touch Hold"* display.

All in your choice of two models, the Fluke 25, and the Fluke 27, which adds "Relative" (difference) and "Min/Max" recording modes.

Each features 0.1% basic dc accuracy and a unique combined analog *and* digital display for quick measurement of changing or stable signals.

So now you can get high performance under the harshest of working conditions.

With another first that's tough to beat. They're made by Fluke, first choice of professionals worldwide.

FROM THE WORLD LEADER IN DIGITAL MULTIMETERS.

FLUKE 25	FLUKE 27
$245†	$275†
Charcoal or yellow case	Charcoal or yellow case
Analog/digital display	Analog/digital display
0.1% basic dc accuracy	0.1% basic dc accuracy
100 μV to 1000V ac and dc	100 μV to 1000V ac and dc
0.1 μA to 10A, all fused	0.1 μA to 10A, all fused
−15°C to 55°C operation	−15°C to 55°C operation
Two year warranty	Two year warranty
	Relative (difference) mode
	MIN/MAX recording mode

*Patent pending.

†Based on worldwide suggested price, including freight and duty effective November 1, 1984. Your price may vary slightly due to exchange rates, taxes and duties.

IN THE U.S. AND NON-EUROPEAN COUNTRIES:
John Fluke Mfg. Co., Inc.
P.O. Box C9090, M/S 250C
Everett, WA 98206
(206) 356-5400, Tlx: 152662

IN EUROPE:
Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB
Tilburg, Netherlands
(013)673973, Tlx: 52237

FLUKE®

Copyright © 1984, John Fluke Mfg. Co., Inc. All rights reserved. Ad No. 4705-20

EDN NOVEMBER 29, 1984

VP/Publisher
F Warren Dickson
VP/Editorial Director
Roy Forsberg
Editor
Gary Legg
Managing Editor
Rick Nelson
Assistant Managing Editor
Joan Morrow

Home Office Editorial Staff
(617) 536-7780
(221 Columbus Ave, Boston, MA 02116)
Tom Ormond, *Senior Editor*
Bill Travis, *Senior Editor*
Eva Freeman, *Associate Editor*
Ken Marrin, *Associate Editor*
J D Mosley, *Associate Editor*
Charles Small, *Associate Editor*
David Smith, *Associate Editor*
George D Miller, *Staff Editor*
George Stubbs, *Staff Editor*
Deborah Asbrand, *Assistant Editor*
Robert M Clarke, *Assistant Editor*
Joanne Clay, *Assistant Editor*
Cynthia Rettig, *Assistant Editor*

Editorial Field Offices
Bob Cushman, *Special Features Editor*
Port Washington, NY: (516) 944-6524
Chris Everett, *Western Editor*
San Jose, CA: (408) 243-8838
Jim McDermott, *Special Features Editor*
Easthampton, MA: (413) 527-3643
Edward Teja, *Western Editor*
Santa Cruz, CA: (408) 425-4508
William Twaddell, *Western Editor*
Elk Grove, CA: (916) 685-2231
Maury Wright, *Western Editor*
San Diego, CA: (619) 748-6785
Peter Harold, *European Editor*
0603-630782
(Deben House, Magdalen St,
Norwich, Norfolk NR3 1JE, UK)

Special Projects Editor
Andy Rappaport
Contributing Editors
Robert Pease, Bob Peterson,
Paul G Schreier
Editorial Services
Valerie DeSalvo, Deborah Millar,
Laureen Ouellette, Carole Smith, *Text Processor*

Art Staff
Susan Barrow-Williams, *Director*
Joan Joos, *Assistant*
Susan Riley, *Illustrator*
Roseanne D Coveney, *Illustrator*
Michael McGovern, *Illustrator*
Wayne Grincewicz, *Illustrator*
Production/Manufacturing Staff
William Tomaselli, *Production Supervisor*
Susan Shaver, *Production Assistant*
Donna Pono, *Production Assistant*
Diane Malone, *Composition*

Graphics Director
Norman Graf
Production Director
Wayne Hulitzky
VP/Research
Ira Siegel
Marketing Services
Deborah Virtue, *Manager*
Corie Rand, *Assistant*

Reprints of EDN articles are available on a custom printing basis at reasonable prices in quantities of 500 or more. For an exact quote, contact Art Lehmann, Cahners Reprint Service, Cahners Plaza, 1350 E Touhy Ave, Box 5080, Des Plaines, IL 60018. Phone (312) 635-8800.

Continued from page 5

TECHNOLOGY UPDATE: NEW PRODUCTS
FFT analyzer achieves 25.6-μHz resolution 105

DESIGN IDEAS
Reduce display codes to byte-size pieces 233
Build a two-IC programmable power supply 234
Dual-mode timer serves many applications 238
Change any base to decimal and vice versa 240
Circuit handles multiple sync characters 244

NEW PRODUCTS
Computer-Aided Engineering 251
Software 254
Components & Packaging 269
Computer-System Subassemblies 279
Computers & Peripherals 291
ICs & Semiconductors 303
Instrumentation & Power Sources 313
International 319

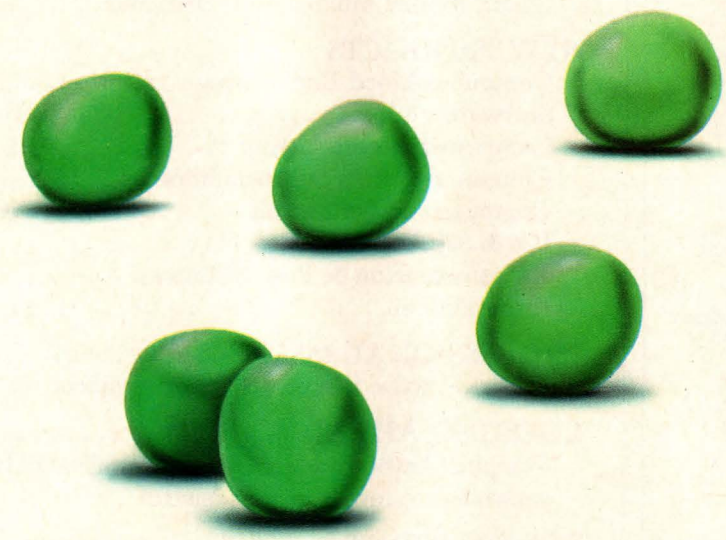
PROFESSIONAL ISSUES 339
Politically active EEs prove that government isn't just for lawyers.

LOOKING AHEAD 353
Computer-keyboard sales to total $769 million in 1987 . . . Programmable controllers to invade process control.

DEPARTMENTS
News Breaks 17
News Breaks International 20
Signals and Noise 29
Calendar 45
Editorial 55
Leadtime Index 110
Literature 325
Business/Corporate Staff 335
New Books 336
Career Opportunities 346
Advertisers Index 351
Market Forecast 352

BPA ABP
Cahners Publishing ☐ Publishers of 30 specialized business magazines in Building & Construction ☐ Electronics & Computers ☐ Foodservice ☐ Manufacturing ☐ Health Care ☐

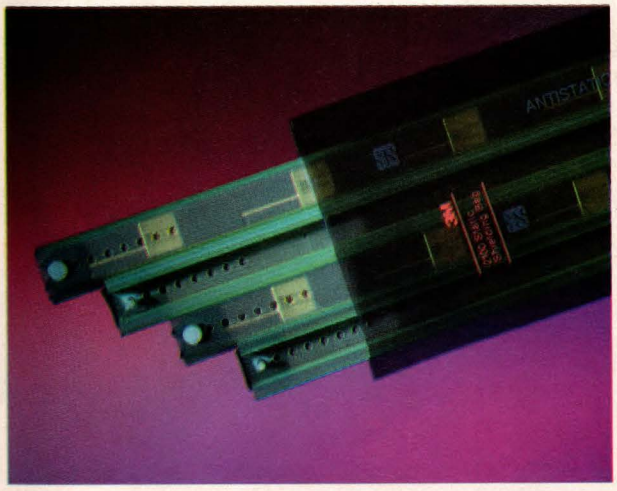
There's quality...



...and there's protected quality.

When you really need top quality and reliability down to assembly line level, even the best AQL's and PPM's are not enough.
Quality has to be protected.
Protection begins with design, continues in fabrication and is guaranteed in shipping.
SGS MOS products, such as memories, high speed CMOS, microprocessors, etc., are designed with full protection against electrostatic discharge.
But that's just the starting point.
All SGS MOS devices are shipped in antistatic DIL chip carriers which are in turn vacuum sealed into conductive shielding bags.
This gives 100% protection against electrical fields, humidity or oxidizing agents.
Super quality deserves super protection down to assembly line level. You get it with SGS MOS products.

SGS MOS PRODUCTS: TOP QUALITY, TOP PROTECTION.

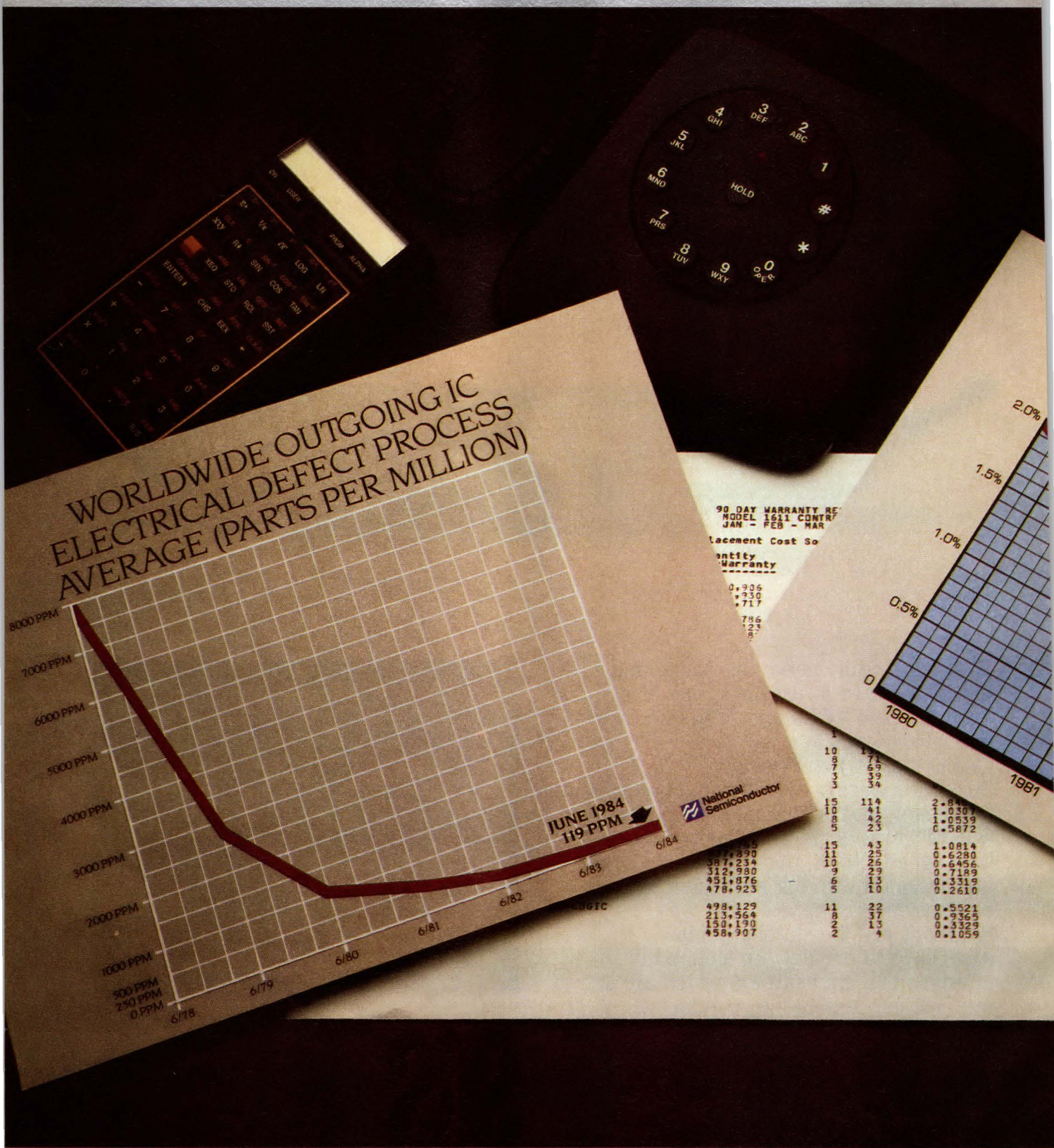


SGS® Technology and Service

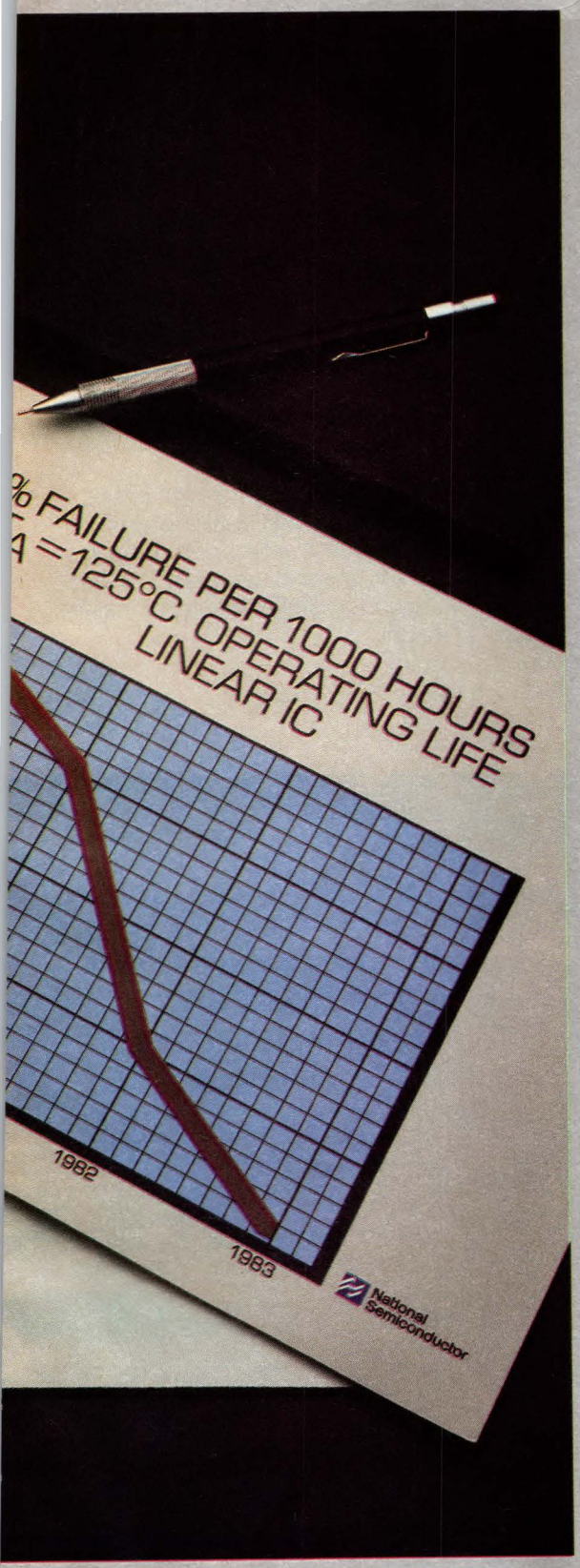
SGS-ATES Componenti Elettronici SpA
Via C. Olivetti, 2 - 20041 Agrate Br. (Italy). Tel. 039-65551

CIRCLE NO 10

$R = {}^{Q}/_{T}$. THE DEFINITION OF RELIABILITY IS QUALITY OVER TIME.



1983. National redefines quality. And then redefines it again. 1984. Now, National defines reliability.



Everyone is talking about quality. But at National, we give you quality you can rely on year after year. That's reliability.

In the last two years, National has twice redefined the industry's standards for quality.

By 1983, after only four years, we dropped from 8,000 ppm to a mere 174 ppm. Then we went even further. To 119 ppm.

And now we're doing the same in a different, but no less critical area. Reliability.

Quality is important because it measures how well a product will perform. But you also need to know how long it will perform. Because the more reliable our components, the more reliable your product. And, of course, the less you spend on warranty claims.

The chart on the left illustrates what we've done. It measures reliability as a Linear IC failure rate tested under severe conditions. The 1,000-hour test is equivalent to 20 years of operation under normal usage. Ours has plummeted from 2.0% to just 0.15%. That's an exceptional 92.5% reduction in our failure rate.

Results like these don't happen overnight. They happen over time. And at National it started with our people.

They're responsible for the quality and reliability of our products at every stage of development —from the very start to final shipment.

We've developed a Fast Reaction Program that catches latent defects before they ever leave a National plant. More importantly, feedback for corrective action solves the problem once and for all.

We've developed corrosion prevention techniques. Automated manufacturing lines to all but stop unit defects. Statistical quality control. The list goes on.

And so does our commitment to the most important service we can provide: delivering you exceptionally superior products, time after time.

Remember, National gives you the quality you've come to expect. And the reliability you'll come to depend on.

National Semiconductor
We're doing it.

CIRCLE NO 11

The K105-D analyzer with Trace Control™ helps you find faults quickly and easily.

For most engineers, the frustration is not in solving the problem. But in finding it.

Not anymore. Take the Gould K105-D logic analyzer. It can help you isolate errors and their causes quickly and easily. Because now you can capture and examine several possible cause areas with a single pass.

Advanced program tracking and data capture.

Flexibility is the key.

With 8 levels of Trace Control, you can follow every bend and turn in your program flow. No matter how complex. And capture widely-separated slices of code better than any other triggering method.

Although faults and their causes may be separated by thousands of lines of code, the K105-D records only what you want to see.

Once captured, the K105-D brings these windows of information directly to the screen for your analysis.

This selective recording conserves memory. While it helps you get at the problem—and solve it—in less time than ever before.

An analyzer that speaks your language.

The K105-D speaks simple assembly language, not complex object code. Quite fluently, we might add.

With our disassembly modules for the 68000, 8086, 8080, 8085A and Z80® B microprocessors, you need only one analyzer for debugging most popular processors.

Clear, concise pattern definitions.

With the K105-D, you can define all your event patterns with symbolic labels. These labels can represent address locations, data values, fetched instructions or any control signal you're monitoring.

And since you create them, they're easier to understand and remember.

What's more, Trace Control uses English-like commands which make for shorter set-ups. Quicker comprehension. And a more productive engineer.

To make debugging even easier, add the optional dual floppy disk drive. With it, you can store up to 35 set-ups and associated recordings on a single diskette for instant recall.

Now, capture up to 4 segments of complex program flow to pinpoint problems fast.

You won't get caught in a loop.
By using the K105-D's loop counter, you can follow a sequence of events for a specific number of iterations. Then stop at will.

It's a quick way for you to test the repeatability of a program function. And verify that your code is having the predicted effect.

Integration made easy.
For the hard part (hardware/software integration), now there's a simpler solution. The K105-D's 100 MHz high speed link.

It's an extremely precise way to see how timing affects software execution. And vice-versa.

Again, for this task, Trace Control can help you track down hard-to-find faults. So you end up with a program that flows smoothly. Error free. In a fraction of the time it used to take.

Performance above all the rest.
At Gould, we engineer every instrument to be clearly the best in its class.

So now with your insight and the K105-D analyzer, you can capture the problem. And solve it. Fast.

For the name and number of your nearest Gould sales representative or for a detailed brochure and application notes, call us toll-free at **(800) 538-9320.** In California, call **(800) 662-9231** or **(408) 988-6800.** Or write Gould Inc., Design & Test Systems Division, 4600 Old Ironsides Drive, Santa Clara, CA 95054-1279.

United Kingdom: Gould Inc., Design & Test Systems Division, Hainault Operation, Roebuck Road, Hainault, Essex 1G6 3UE, United Kingdom. Phone: (44) (1) 500-1000.

West Germany: Gould Inc., Design & Test Systems Division, Dieselstrasse 5-7, D-6453 Seligenstadt 3, West Germany. Phone: 06182/801-1.

™ Trace Control is a trademark of Gould, Inc.
® Z80 is a registered trademark of Zilog, Inc.

The K105-D gives you two levels of HELP at the touch of a button. First, step-by-step operating instructions that appear along the bottom of the analyzer screen. Second, a menu that allows you to select more detailed "help" should you need it.

© 1984, Gould, Inc.

GOULD
Electronics

CIRCLE NO 12

LEADER

Leader Smart Signal Generators make tough tests fast, easy, accurate.

When it comes to test equipment, being smart makes a big difference.

We equipped these two new Leader Smart Generators with programmability and a 2K memory to end time-wasting repetitive set ups. The LSG-215A & LSG-216 general purpose AM/FM signal generators recall at the touch of a button the 100 test conditions you use most often. Just set frequency, output level and modulation once for each situation. You never need to do it again, even if the ac is lost. Fail-safe battery backup protects the RAM memory against power outages lasting up to one full month.

Unequalled performance, features and ease-of-use.

Both of these Leader Smart Signal Generators are ideal for general, communications, AM/FM radio receiver, TV-VIF, and cordless telephone applications. Whether you choose the LSG-215A (0.1 to 120 MHz frequency) or the LSG-216 (0.1 to 30 MHz and 75 to 115 MHz ranges), each has a high visibility digital display and large peak modulation meter to make error-free readings a cinch. Its one-touch front panel keyboard enables you to easily control frequency, output level and modulation mode. A precise PLL synthesizer provides oscillation frequency and drift stability accurate to an incredible $5x10^{-5}$. AM/FM modulation is available internally at 1 kHz and at 400 Hz as well as externally. And FM Stereo MPX is standard on the LSG-216. There are many more features, too numerous to list. You can even add an optional remote control and for identical programming of multiple test stations, a plug-in EPROM Cartridge.

Leader Smart Signal Generators cost no more than many dumb ones.

Yet they are backed by our two-year warranty, factory service depots on both coasts and the 30-year reputation for reliability and precision which has made Leader famous. Compare Leader Smart Generators to the rest. We think you will agree, Leader is the only smart choice.

Call toll-free

(800) 645-5104

In New York State

(516) 231-6900

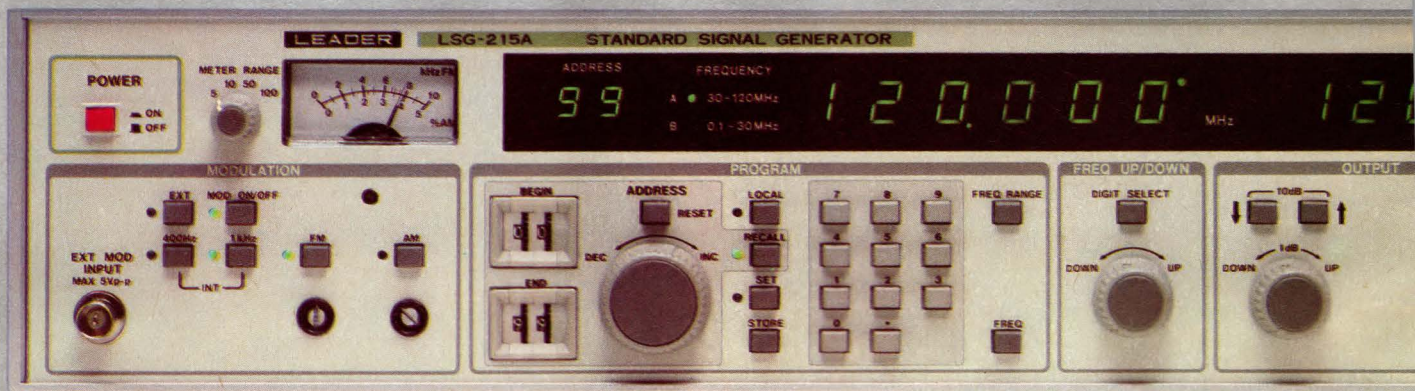
Request an evaluation unit, our latest test equipment catalog, the name of your nearest "Select" distributor, or additional information.

For professionals who know the difference.

LEADER Instruments Corporation

380 Oser Avenue
Hauppauge, New York 11788
Regional Offices:
Chicago, Dallas, Los Angeles, Boston.
In Canada call Omnitronix Ltd.
(514) 337-9500

CIRCLE NO 13



MITSUBISHI

Optical Vision

Extending the Commitment of Excellence into the Future.

It didn't happen by accident.

Reliability

When a semiconductor laser's life exceeds a million hours (@ 25°C), it is more than just a coincidence. MITSUBISHI quality and reliability standards are renowned throughout the world.

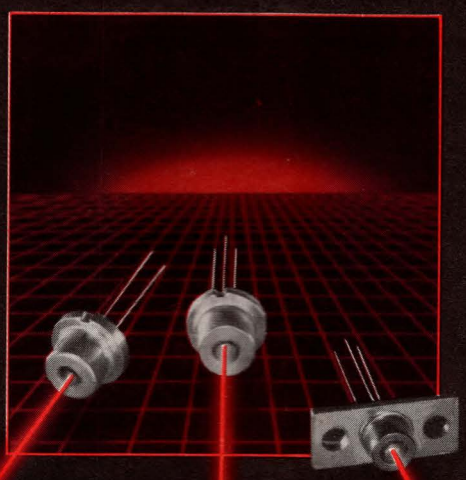
Leading-Edge Applications

The most advanced recording, print/scan and communications systems rely on these devices. State-of-the-Art, yet only forerunners of more powerful, highly integrated optical devices now under development. Envisioned today, destined to impact tomorrow's society.

Search for Performance

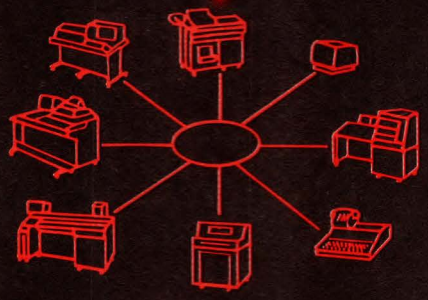
MITSUBISHI Optical Semiconductors are designed and developed by industry's most regarded scientists, answering and prepared to answer the requirements of a new breed of high technology minds. High performance: a part of MITSUBISHI's commitment to the future.

MITSUBISHI ELECTRONICS AMERICA, INC., Optical Semiconductor Products, 777 North Pastoria Avenue, Sunnyvale, CA 94086. (408) 730-5900.



OPTICAL RECORDING

- High reliability
- Power from 3 to 15 mW
- Low threshold current and noise characteristics
- Higher output power under development



FIBER OPTIC COMMUNICATIONS

- Long wavelength laser diodes at 1.3 μm
- Multimode and Singlemode pigtail modules
- Short wavelength, low cost laser diode for LAN
- 1.3 μm LED, 1.3 μm LED Transmitter/Receiver module and 1.3 μm LD module with DIP and high speed package under development.

LASER PRINTING BAR CODE READING

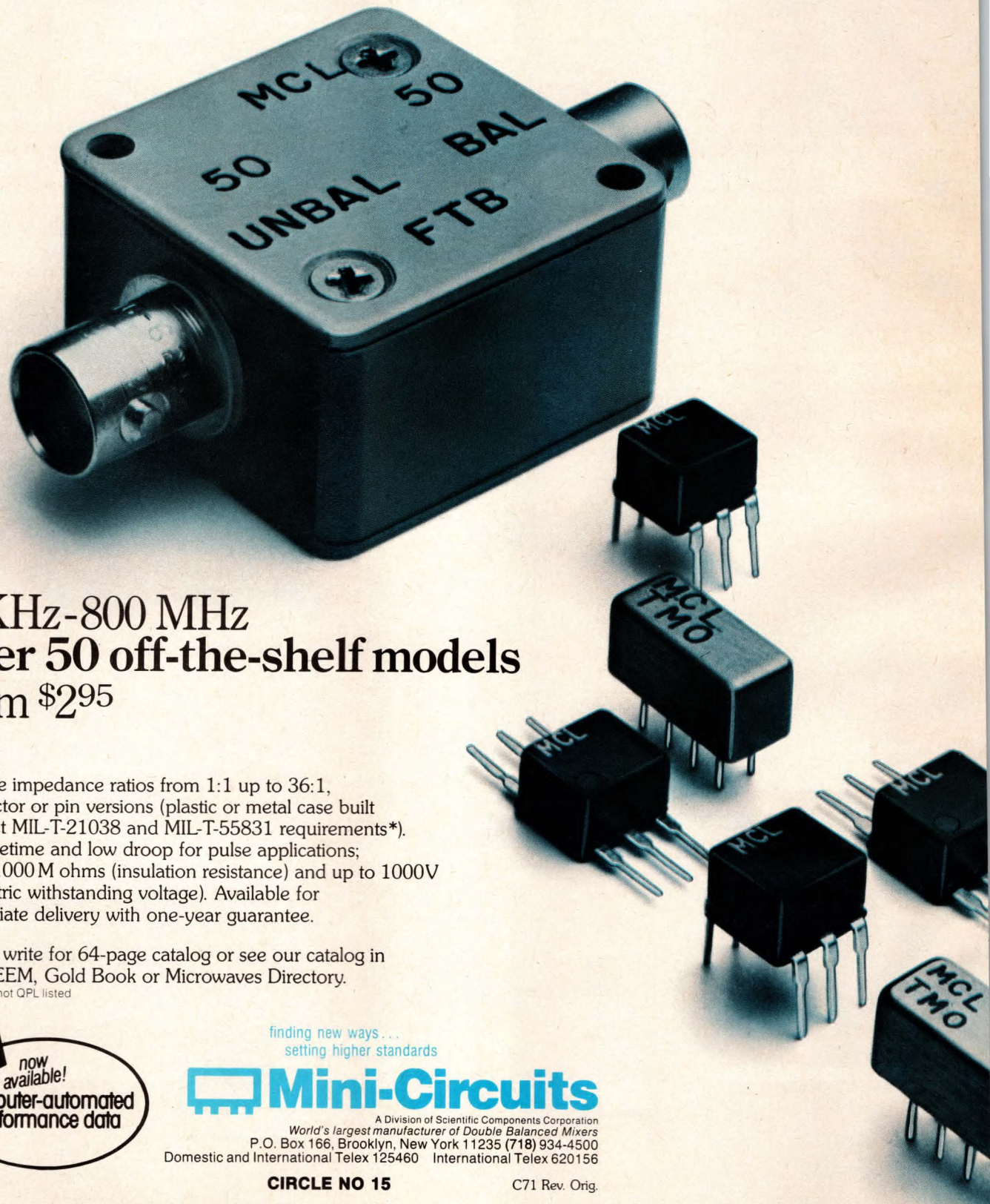
- Wavelength in the 780 nm region
- Single and multi-longitudinal mode
- Low cost, high volume production device
- Low threshold current.

MITSUBISHI ELECTRONICS
ADVANCED AND EVER ADVANCING

Optical Semiconductor Products

Circle 14

RF transformers



3 KHz-800 MHz
over 50 off-the-shelf models
from 2^{95}

Choose impedance ratios from 1:1 up to 36:1, connector or pin versions (plastic or metal case built to meet MIL-T-21038 and MIL-T-55831 requirements*). Fast risetime and low droop for pulse applications; up to 1000 M ohms (insulation resistance) and up to 1000V (dielectric withstanding voltage). Available for immediate delivery with one-year guarantee.

Call or write for 64-page catalog or see our catalog in EBG, EEM, Gold Book or Microwaves Directory.
*units are not QPL listed

CAPD
now available!
computer-automated performance data

finding new ways...
setting higher standards

Mini-Circuits

A Division of Scientific Components Corporation
World's largest manufacturer of Double Balanced Mixers
P.O. Box 166, Brooklyn, New York 11235 **(718)** 934-4500
Domestic and International Telex 125460 International Telex 620156

CIRCLE NO 15

C71 Rev. Orig.

NEWS BREAKS

Edited by Joan Morrow

PORTABLE SYSTEM TESTS 5¼- AND 3½-IN. WINCHESTER DRIVES

Flexstar's (San Jose, CA, (408) 946-1445) FS-5000 self-contained portable test system tests 5¼- and 3½-in. Winchester disk drives, and it can test any Winchester drive that uses ST-506/412-type interfaces. It's designed to test two drives at a time by taking advantage of the overlap seek mode.

The FS-5000 has a built-in 2 line × 40-column LCD, a 50-character keypad, and a 40-column printer. It also has dc power capable of powering up one disk drive. The FS-5000 performs both phase-margin and phase-margin surface-scan testing to 1-nsec resolution. It measures 15 × 15 × 4 in. and weighs 15 lbs.—Chris Everett

MS-DOS OR CP/M COMPUTER HOSTS μP DEVELOPMENT TOOLS

The MPDS family of hardware/software μP development tools from Microtek (Gardena, CA, (213) 538-5369) supports the 80186, 80188, 68000, and 14 other widely used CPUs. A portable μC controls operation and executes the CP/M (MPDS I) or MS-DOS (MPDS II) operating system. A typical $8595 system includes choice of computer, in-circuit emulator, and cross assembler, as well as symbolic debugging and software performance analysis.—Maury Wright

COMMERCIAL IC EMPLOYS 1-μm CMOS PROCESSING

Touted as the first commercially available product to use 1-μm CMOS processing, the $120 (1000) Model TMC2110 from TRW's LSI Products Div (La Jolla, CA) is a 16 × 16-bit multiplier/accumulator. The IC directly replaces the company's bipolar TDC1010. At full operating speed, the device performs a multiply/accumulate operation in 90 nsec; ie, it attains an 11.1-MHz throughput rate. This speed represents a 2:1 increase over the speeds of previous products. In some systems, this increased operating speed can entail the use of higher speed supporting-memory chips. Thanks to the IC's CMOS process, the device draws essentially zero power in static mode; at full operating speed, the power draw increases to slightly less than 350 mW.

The device employs a bulk ion-implanted CMOS technology that uses eight mask layers. The TMC2110 performs two's-complement or unsigned-magnitude multiplication to yield a full-precision 32-bit product. —Bill Travis

MICROWINCHESTER DISK DRIVE PROVIDES 10M BYTES OF STORAGE

Fitting the 3½-in. form factor and furnishing 10M bytes of storage, Hewlett-Packard Co's first Winchester disk drive suits the rough treatment that portable and transportable computers experience. The unit uses sputtered thin-film media and withstands as much as 50g without external shock mounts. High-quality read/write electronics ensure data integrity. The drive provides 25-msec track-to-track access times and a 75-msec average access time.—Ed Teja

VOICE-OUTPUT CARD CONTAINS OWN DEVELOPMENT SYSTEM

The M520 voice-output card from Microcontrol (Kogarah, NSW, Australia) costs less than $400 and allows implementation of a custom vocabulary with the addition of only an RS-232C terminal and an EPROM programmer. The board contains a 6802 μP, a 3k-byte monitor program, and audio-input and -output lines to allow recording, editing, and playing of sounds with cassette-recorder quality. On-board memory sockets allow storage of 46 sec of sound.—Gary Legg

NEWS BREAKS

SINGLE EUROBOARD FEATURES DEC J11 CHIP SET

Adding to its G-64 line of computer and peripheral boards, Gespac (Mesa, AZ, (602) 962-5559) brings DEC's 15-MHz J11 processor chip set to the single-Eurocard form factor. The on-chip memory-management unit extends the G-64 bus's physical address space to 512k bytes. The board also contains a DEC-compatible serial port, triple 16-bit timer, and interrupt controller. The interrupt controller supports 10 interrupts—four external interrupts and six on the processor board. Samples of the GESMPU-11 board cost $1750.—Maury Wright

DMA CONTROLLER ACTS AS COPROCESSOR FOR iAPX 286 DESIGNS

Systems based on the iAPX 286 μP can now move data blocks more efficiently by employing the 82258 advanced direct-memory-access (ADMA) controller from Intel (Santa Clara, CA, (408) 987-7197). The ADMA device functions like a coprocessor and was jointly developed with Siemens. When used with the iAPX 286 family's pipelined architecture, the 82258 specs an 8M-byte/sec data-transfer rate. The 4-channel chip supports operation with high-speed transfer on all channels, or one of the four can act as a multiplexed channel supporting 32 lower speed channels. The 82258 will cost $170 (100).—Maury Wright

μP FAMILY OFFERED IN SURFACE-MOUNTED PACKAGES

SGS Semiconductor Corp (Phoenix, AZ) now offers its Z8, Z80, Z8000, and Z8500 product lines in quad-in-line, J-bend chip-carrier packages. The packages are one-third the size and one-fifth the weight of corresponding dual-in-line housings. The ICs come in commercial, industrial, and military temperature ranges, and in plastic or ceramic packages. In addition, versions accommodating ±10% power-supply variations are available.—Bill Travis

SINGLE-BOARD μC SPORTS VME EXPANSION SLOTS

The 68010-based VSF 1605 single-board computer includes 512k bytes of RAM, demand-paged virtual memory, a memory-management unit, bootstrap PROM, I/O interfaces, and five VME Bus-compatible expansion slots. Called the VME system foundation, the $5995 board from Interphase (Dallas, TX, (214) 350-9000) only requires peripherals to function. Disk interfaces provided include ST506, ESDI, and ST412HP Winchester devices and IBM-compatible 5¼-in. floppy disks. The board comes standard with eight serial ports that support a variety of protocols. In addition, four general-purpose programmable timers provide separate interrupt vectors to the CPU.—Maury Wright

DISK- AND TAPE-STORAGE DEVICES INTRODUCED AT COMDEX

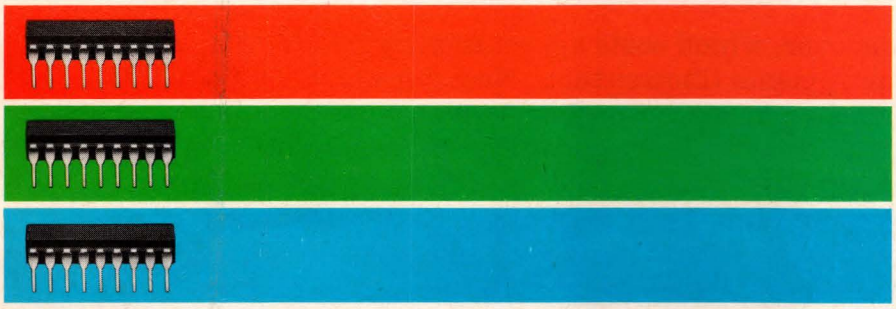
At the COMDEX/FALL '84 show (Las Vegas, November 14 to 18), Seagate Technology (Scotts Valley, CA) was among a number of companies to announce new lines of disk-drive products. Its 10M-byte ST112, a 3½-in. Winchester drive that costs $450 (1000), provides a 65-msec average access time; the ST225 packs 20M bytes in a 5¼-in. form factor for $495 (1000).

The company's most significant introduction may have been its ST4000 Series, a line that uses a closed-loop servo and voice-coil actuator to achieve as much as 40M bytes of storage in a 5¼-in. package. Furnishing 960 tpi, the ST4000 Series has 977 cylinders and provides an ST412 interface that features the error-correction circuitry available in the ST412HP interface.—Ed Teja

New 4-bit raster DAC sharpens graphics

(and it's in an 18 lead DIP)

125MSPS, guaranteed, "graphics ready," just $15*



Give yourself a head start with a monolithic DAC designed specifically for raster scan systems—the TRW TDC1034 4-bit, 125 MSPS D/A converter. It directly drives CRTs to video compatible levels. Save on circuitry—no extra registering, buffering or deglitching. Save space—the 4-bit TDC1034 is an ultra-thin 18 lead DIP.

And you get terrific performance. This monolithic 4-bit DAC is ideal for either monochromatic or RGB color raster graphics (4096 colors!). Its high speed scans more pixels per picture to produce razor sharp high resolution displays. And because it's built with TRW's OMICRON-B™ 1-micron bipolar process, you get high reliability and low power consumption (600mW).

The low-cost 4-bit TDC1034 is your one chip solution to high volume production of CAD/CAM work stations, computer graphics, and high resolution video. If your application needs all the options that an 8-bit, 24 lead DIP offers, consider the TDC1018—the first monolithic 8-bit, 125MSPS D/A converter.

Check these key performance features:

- Blank, sync and bright video controls
- Directly drives standard 75Ω load
- Inherently low glitch
- Registered data and control inputs
- Power supply rejection ratio>50dB
- Differential logic for maximum speed, minimum noise
- RS-343 compatible
- Low power dissipation
- Single −5.2V power supply
- 1/8 LSB linearity (4-bit TDC1034)
- 1/2 LSB linearity (8-bit TDC1018)
- ECL compatible data and control inputs

These DACs are available from Arrow Electronics, Hall-Mark, and Hamilton/Avnet.

Remember, you always get FULL SPEC PERFORMANCE from TRW LSI.

For a full data sheet or immediate information about our "graphics ready" DACs, call or write our Literature Service Department:

LSI Products Division,
TRW Electronic Components Group,
P.O. Box 2472, La Jolla, CA 92038,
619.457.1000

In Europe, call or write:
TRW LSI Products,
Konrad-Celtis-Strasse 81,
8000 Muenchen 70, W. Germany,
089.7103.115

In the Orient, phone:
Hong Kong, 3.856199;
Tokyo, 03.461.5121; Taipei, 751.2062

*U.S. price in 1000s: TDC1034 CERDIP $15; TDC1018 CERDIP $36.00

© TRW Inc. – 1984 TRS-4116

TRW

LSI Products Division
TRW Electronic Components Group

CIRCLE NO 16

NEWS BREAKS: INTERNATIONAL

by Peter Harold

INTERNATIONAL TEST AND MEASUREMENT SHOW HIGHLIGHTS

The ITAME (International Test and Measurement Exhibition), which was held in London on October 30 to November 1, was the occasion for a variety of new-product introductions. For instance, Solartron Instruments (Farnborough, UK, TLX 858245) displayed its $5295 7½-digit 7071 digital multimeter. The device shares the same measurement, processing, and remote-control facilities as the company's 7081, but it's specified to require no recalibration for more than 10 years. The instrument's drift is proportional to the square root of time, resulting in a 1-year dc voltage accuracy of ±20 ppm of the reading, ±1 ppm FS. For nine years that spec is ±60 ppm of the reading, ±1 ppm FS. The unit achieves accuracies per square root of one year on its other functions as low as ±20 ppm of the reading, ±1 ppm FS for resistance, and ±0.02% of the reading, ±0.005% FS for ac voltage.

Philips S & I Div (Eindhoven, The Netherlands, TLX 51573) displayed its $2400 PM3302 digital storage oscilloscope. The scope features a sampling rate as high as 20 MHz and captures waveforms at time-base speeds from 10 μsec/div to 50 sec/div with a maximum vertical sensitivity of 1 mV/div. Its dual 2k × 8-bit memories, each capable of capturing 25, 50, 75 or 100% pretrigger information, can be separately displayed or updated as required. You can generate trace data to an X-Y recorder or via an optional IEEE-488 interface to compatible devices. A direct-display mode with time-base resolution from 200 nsec/div to 0.1 sec/div is also available.

The PALAS 40C50 logic analyzer, which costs approximately 13,900 DM, was exhibited by Dolch Logic Instruments (Dietzenbach, West Germany, TLX 4191550). It provides 32 channels of 1k-bit acquisition memory; 16 of those channels capture glitches as short as 5 nsec. In timing mode, it has a maximum resolution of 20 nsec (10 nsec with an optional high-speed probe). For state analysis, it operates with external clocks as fast as 25 MHz. Each 16-channel block has its own clock input and three clock qualifiers. The 40C50 has 4-level sequential triggering with eight trigger qualifiers. A full-size reference memory allows you to perform automatic trace and compare operations with optional rearming of the analyzer.

Marconi Instruments Ltd (St Albans, UK, TLX 23350) introduced the 800X in-circuit tester, which tests high-density digital or hybrid circuit boards that contain VLSI devices. The 800X is equipped with 2048 nonmultiplexed test pins, each capable of performing digital stimulus/response or analog measurements. The system features a synchronous logic tester for the examination of VLSI device operation; you can synchronize the unit under test to the 800X at speeds as high as 16 MHz. For functional board testing, additional instrumentation can be connected via the system's IEEE-488 bus. The fault-report database generated is suitable for access by automated repair stations. The 800X is software and test-fixture compatible with 80X Series testers. System price starts at £176,000; delivery is 16 to 20 weeks ARO.

You Owe It To Yourself To Choose From The Best.

Choosing the right logic analyzer can be tough. But one thing is clear—you want all the advantages you know you can count on from the performance leaders.

Even Among The Leaders, The Differences Can Be Significant.

For example, not all the top logic analyzers give you 200 MHz timing. Or highly sophisticated linkage and interactive analysis. Or 1000-word deep data collection and auxiliary memories. Or an easy-to-use ASCII keyboard. Or floppy disk data storage. *Only Nicolet's 800 series gives you all these advantages.* In the end, though, it's Nicolet's unmatched price/performance ratio that's the most important difference.

Some Logic Analysis Systems Grow With Your Needs. Some Don't.

Only Nicolet makes it easy and inexpensive to enhance *performance*—not just add channels—any time you need it. And the NPC-800 Series gives you *five* instruments to choose from, and more options than anyone else in the industry: Waveform Recorder, Performance Analysis, CT/SA, Computer/IEEE-488 Controller, Printer Software, Non-Volatile Memory, Dot Matrix Printer, and Second Disk Drive.

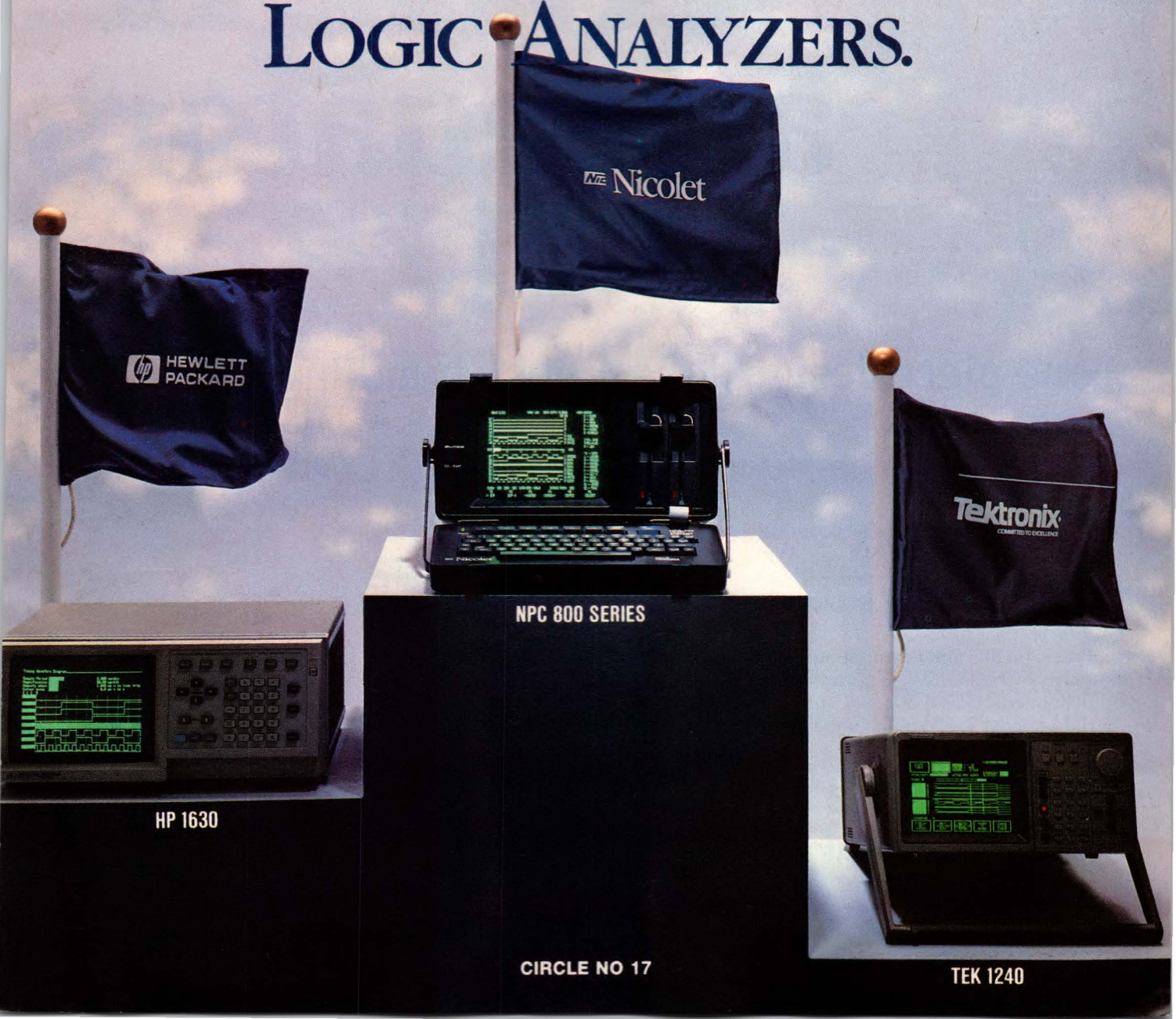
Put The Leaders To The Test.

When you really think about it, the only way to be sure is to let the best logic analyzers prove what they can do—for *you*. When it comes to capability, versatility, and performance, there's really only one choice. For a Logic Analyzer Comparison Chart, call: **(800) NICOLET** or **(415) 490-8300** (inside CA). Nicolet Paratronics Corporation, 201 Fourier Ave., Fremont, CA 94539.

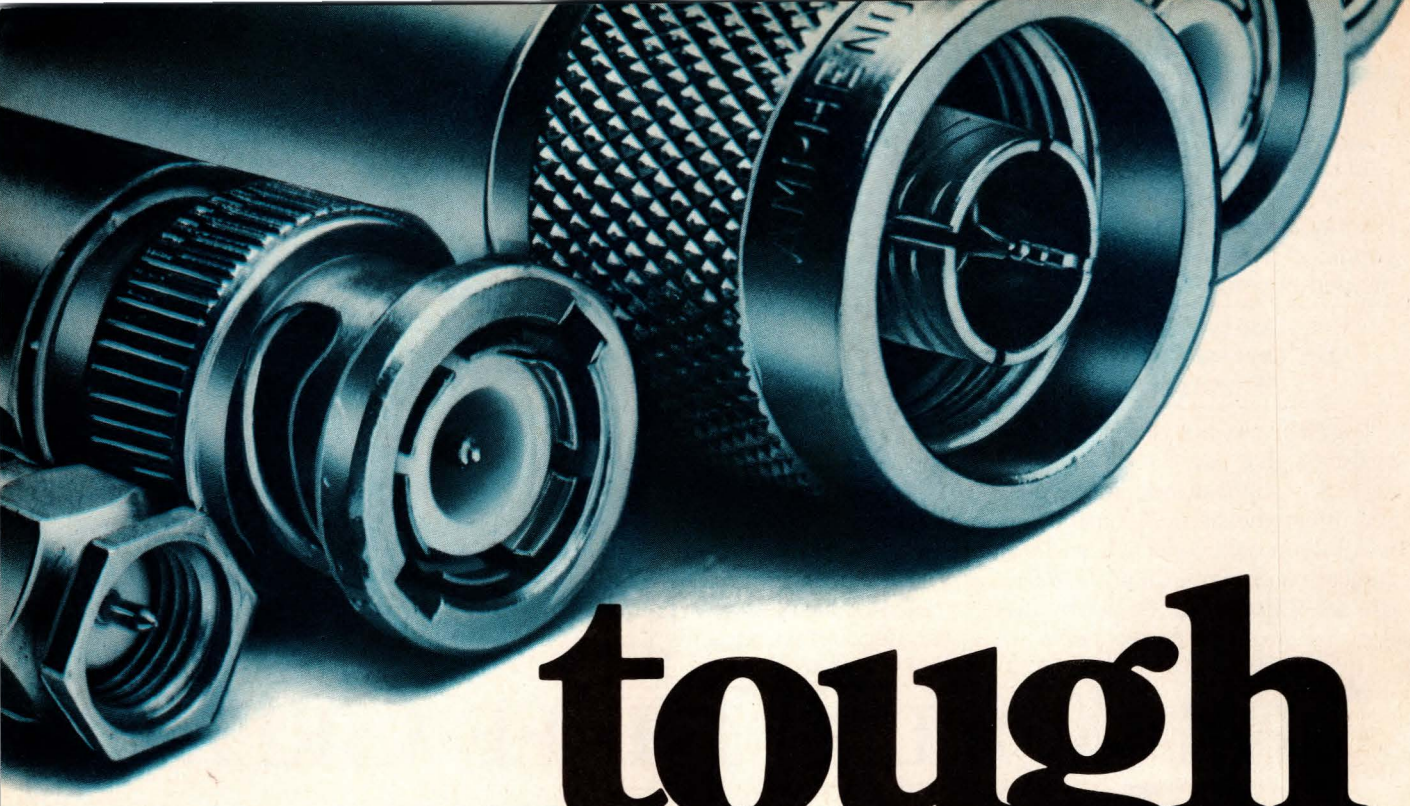
Think of us!

Nicolet

The World's Three Great Logic Analyzers.



CIRCLE NO 17



tough attenuators

from $11.95 (1-49)

one-piece design defies rough handling

Check these features:

- ✓ Each unit undergoes high-impact shock test
- ✓ Available from 1 to 40 dB
- ✓ DC to 1500 MHz
- ✓ Unexcelled temperature stability, .002 dB/°C
- ✓ 2W max. input power (SMA is 0.5W)
- ✓ BNC, SMA, N and TNC models
- ✓ Immediate delivery, 1-yr. guarantee

NEW!
Precision 50-ohm terminations ... only $6.95 (1-24)
DC to 2 GHz, 0.25W power rating, VSWR less than 1.1
BNC (model BTRM-50), TNC (model TTRM-50)
SMA (model STRM-50), N (model NTRM-50)

*Freq. (MHz)	Atten. Tol. (Typ.)	Atten. Change, (Typ.) over Freq. Range		VSWR (Max.)	
		DC–1000	1000–1500	DC–1000 MHz	1000–1500 MHz
DC-1500 MHz	±0.3	0.6	0.8	1.3	1.5

*DC–1000 MHz (all 75 ohm or 30 dB models) DC-500 MHz (all 40 dB models)

MODEL AVAILABILITY
Model no. = a series suffix and dash number of attenuation.
Example: CAT-3 is CAT series, 3 dB attenuation.
■ denotes 75 ohms; add –75 to model no.
● denotes 50 ohms

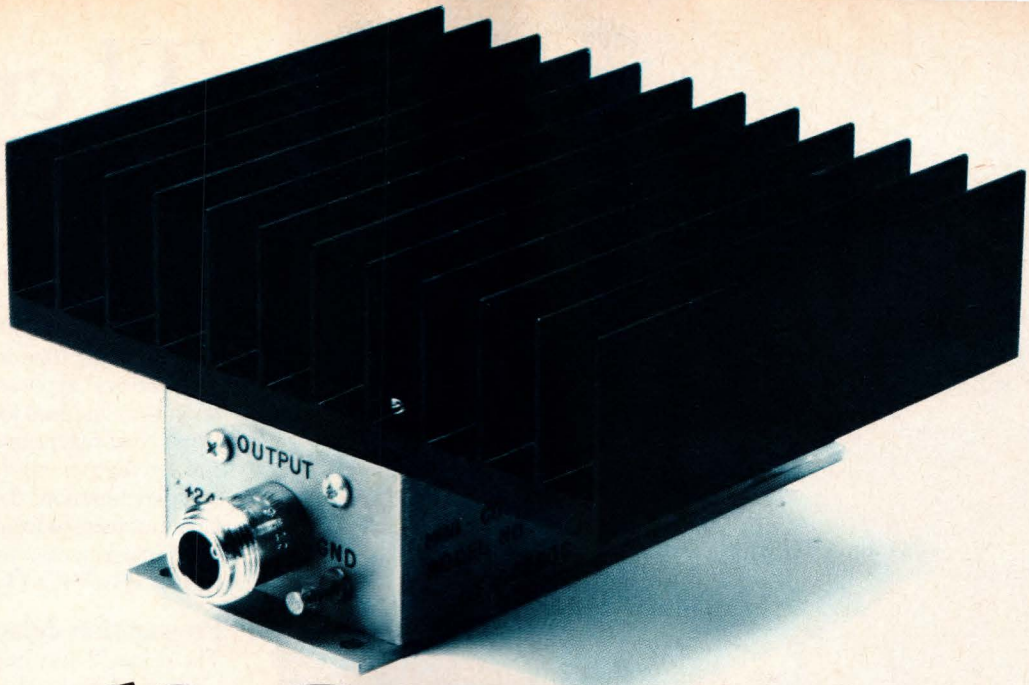
ATTEN	SAT (SMA)	CAT (BNC)	NAT (N)	TAT (TNC)
1	●	●	●	●
2	●			
3	●	●■	●	●
4	●			
5	●			
6	●	●■	●	●
7	●			
8	●			
9	●			
10	●	●■	●	●
12	●			
15	●			
20	●	●■	●	●
30	●	●	●	●
40	●	●	●	●

PRICING (1-49 qty.): CAT (BNC)..$11.95, SAT (SMA)..$14.95
TAT (TNC)..$12.95, NAT (N)..$15.95

finding new ways ...
setting higher standards

Mini-Circuits
A Division of Scientific Components Corporation
World's largest manufacturer of Double Balanced Mixers
P.O. Box 166, Brooklyn, New York 11235 (718) 934-4500
Domestic and International Telex 125460; International Telex 620156

C 92 REV. A



power amplifiers

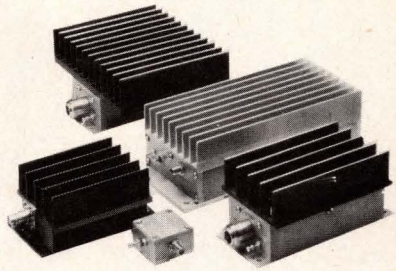
up to 2 Watts linear output
50 KHz to 4200 MHz from $199

If your application requires up to 2 watts for intermodulation testing of components . . . broadband isolation . . . flat gain over a wide bandwidth . . . or much higher output from your frequency synthesizer or signal/sweep generator . . . Mini-Circuits' power amplifiers will meet your needs, at low prices.

These ultra-linear Class-A amplifiers are unconditionally stable and can be connected to any load impedance without amplifier damage or oscillation.

For low power (50 mW), 22dB gain and 40dB isolation, consider the ZFL-2000; for operation up to 4200MHz with 1-watt output, specify the ZHL-42.

So select the amplifier for your application from the chart below. We'll ship in one week, with, of course, our one-year guarantee.



Model No.	Freq. MHz	Gain dB	Gain Flatness dB	Max. Power Output 1dBm Compression	Noise Figure dB	Intercept Point, Typ. 3rd Order	DC Power Voltage	DC Power Current	Price $ Ea.	Price Qty.
ZHL-32A	0.05-130	25 Min.	±1.0 Max.	+29 dBm Min.	10 Typ.	+38 dBm	+24V	0.6A	199.00	(1-9)
ZHL-3A	0.4-150	24 Min.	±1.0 Max.	+29.5 dBm Min.	11 Typ.	+38 dBm	+24V	0.6A	199.00	(1-9)
ZHL-1A	2-500	16 Min.	±1.0 Max.	+28 dBm Min.	11 Typ.	+38 dBm	+24V	0.6A	199.00	(1-9)
ZHL-2	10-1000	15 Min.	±1.0 Max.	+29 dBm Min.	18 Typ.	+38 dBm	+24V	0.6A	349.00	(1-9)
ZHL-2-8	10-1000	27 Min.	±1.0 Max.	+29 dBm Min.	10 Typ.	+38 dBm	+24V	0.65A	474.00	(1-9)
ZHL-2-12	10-1200	24 Min.	±1.0 Max.	+29 dBm Min.	10 Typ.	+38 dBm	+24V	0.75A	599.00	(1-9)
ZHL-1-2W	5-500	29 Min.	±1.0 Max.	+33 dBm Min.	12 Typ.	+44 dBm	+24V	0.9A	495.00	(1-9)
ZHL-42	700-4200	30 Min.	±1.0 Max.	+29 dBm Min.	7.5 Typ.	+38 dBm	+15V	0.69A	895.00	(1-9)
ZHL-7-2W	600-800	28 Min.	±1.0 Max.	+33 dBm Min.	12 Typ.	+43 dBm	+24V	0.9A	525.00	(1-9)
ZFL-2000	10-2000	20 Min.	±1.5 Max.	+17 dBm Min.	7 Typ.	+25 dBm	+15V	0.1A	179.00	(1-9)

C70 REV. B

50 ohm impedance,
input and output VSWR 2: 1 max.

Price and specifications
subject to change without notice.

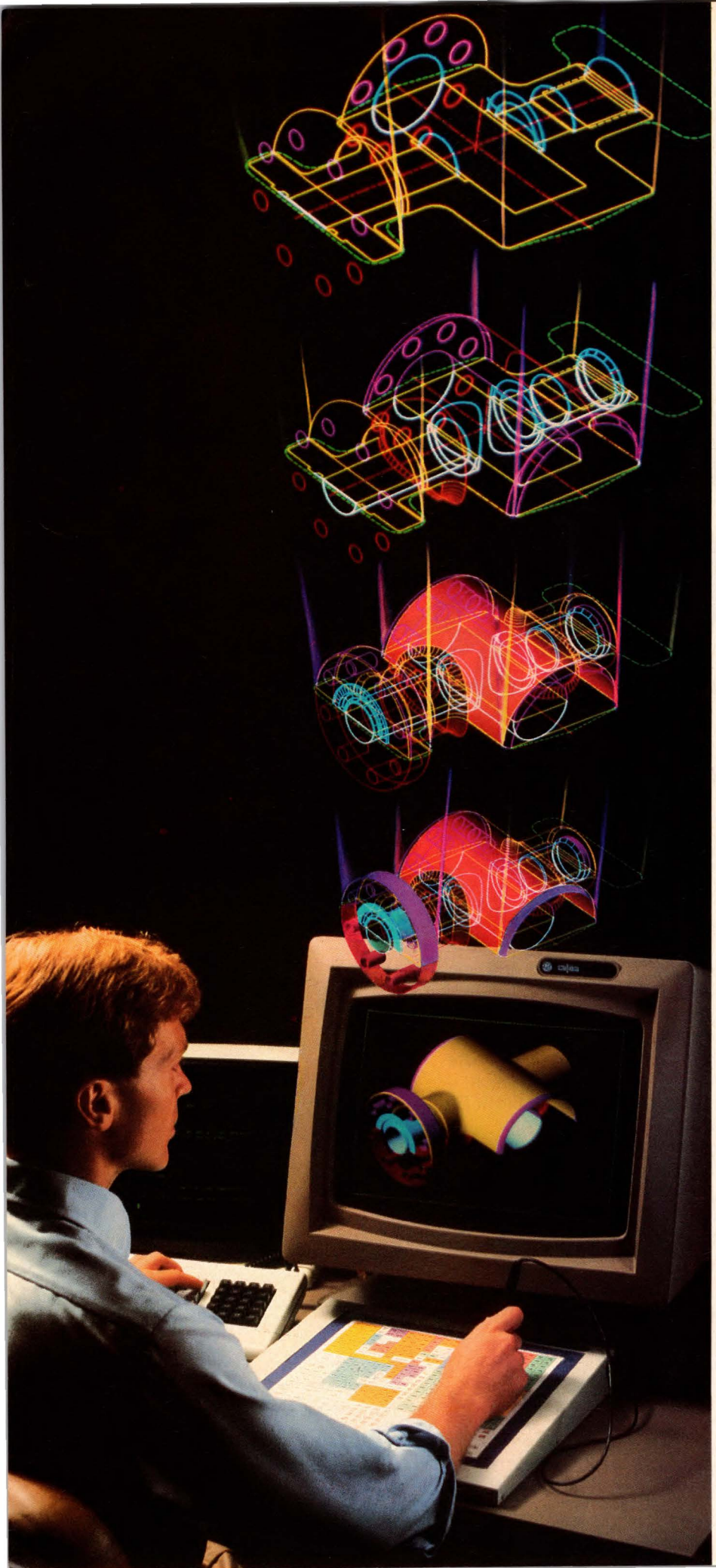
Refer to EEM and Gold Book for detailed specs.

CAPD now available! computer-automated performance data

finding new ways...
setting higher standards

Mini-Circuits
A Division of Scientific Components Corporation
World's largest manufacturer of Double Balanced Mixers
P.O. Box 166, Brooklyn, New York 11235 (718) 934-4500
Domestic and International Telex 125460 International Telex 620156

CIRCLE NO 194



TI creates IMPACT

These pace-setting devices from Texas Instruments operate at unprecedented clock speeds up to 50 MHz. They can cut processing time in half for such speed-critical applications as high-resolution graphics for CAD/CAM systems. New superminicomputers. Artificial intelligence machines. Wherever complex functions demand extremely large numbers of logic operations for rapid image access, use TI's new IMPACT bipolar PAL® ICs (TIBPAL-15 Series).

Propagation delay cut by 40%

TI's unique 2-μm Implanted Advanced Composed Technology (IMPACT) dramatically reduces the size and the sidewall capacitance of circuit elements (see facing page). Establishes a new performance standard with propagation delay cut to 15 ns, maximum, at 180 mA—*versus* 25 ns at 180 mA for the fastest PAL ICs formerly available.

Space requirements cut by up to 83%

With their extremely dense circuitry, TIBPAL-15 Series devices can bridge the gap between SSI/MSI and LSI gate arrays. Now a single PAL IC can replace as many as six SSI or MSI circuits. And give you the flexibility of user-programmable logic in such fields as telecommunications and automotive control, where space constraints—as well as processing speed—are often critical.

Fast and easy programming

Programming TIBPAL-15 Series bipolar logic circuits, with their reliable titanium-tungsten fuses, takes only seconds using widely available software and inexpensive device programmers. And you can implement logic-design changes in minutes, without vendor retooling.

For any logic application where superspeed, high density, and immediate availability are design criteria, your best—and only—answer is a 15-ns PAL IC from Texas Instruments.

◀ **Processing 50 megabits of digitized data per second,** TI 15-ns PAL ICs will find widespread application in advanced, high-resolution graphics for CAD/CAM systems. These new superspeed PAL ICs can enhance performance by increasing both the speed and the size of the graphics-display processor.

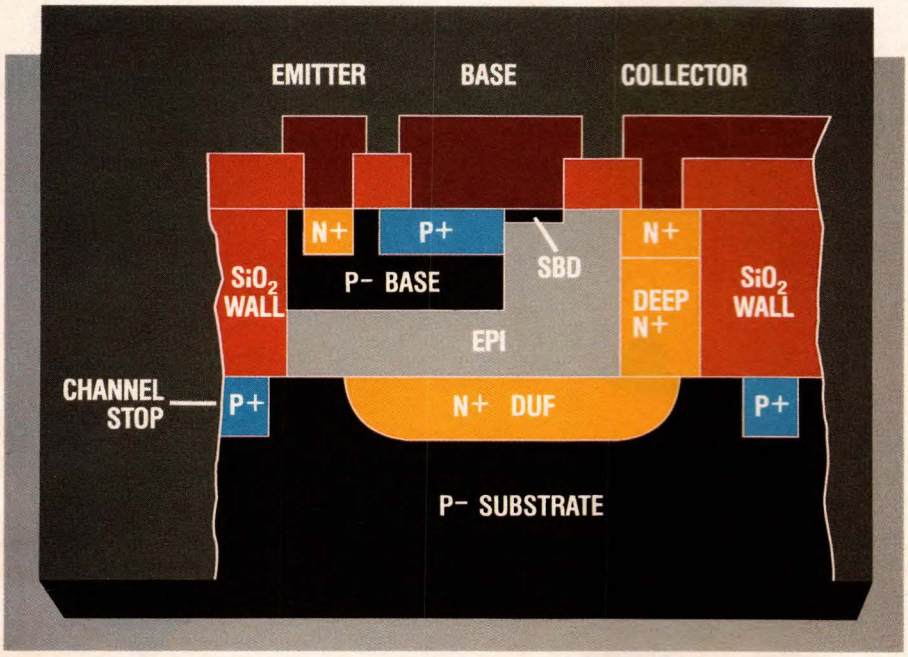
Demonstration software courtesy of Calma Company.

® PAL is a registered trademark of Monolithic Memories, Inc.

27-4990

©1984 TI

the world's fastest PAL ICs: New process delivers 15-ns speed.



A highly significant reduction in capacitance results from the 2-μm feature size which TI's IMPACT processing makes possible. Silicon dioxide is the isolation material. Switching speed is further enhanced by utilizing this silicon dioxide for emitter and base sidewalls.

Also from TI: The world's fastest FPLAs.

In addition to superspeed TIBPAL-15 Series ICs, Texas Instruments offers the industry's fastest Field Programmable Logic Arrays (FPLAs), with 20-ns maximum gate delay.

Whereas PAL ICs have a programmable AND array feeding a fixed OR array, the universal structure of the FPLA includes programmable AND and OR arrays. The FPLA provides the ultimate flexibility for implementing logic functions in the "complexity gap" between standard SSI/MSI and LSI/VLSI logic.

The wide range of programmable-logic devices available from Texas Instruments is described in the table below. In addition, military versions of the PAL16XXA/A-2 are available, with TIBPAL-15 Series and TIFPLA839/840 soon to come.

TI's Broad PAL/FPLA Family

	t_{pd}(max) (ns)	I_{CC}(max) (mA)	Registered Outputs
PAL ICs			
TIBPAL16L8-15	15	180	0
TIBPAL16R8-15	15	180	8
TIBPAL16R6-15	15	180	6
TIBPAL16R4-15	15	180	4
PAL16L8A/A-2	25/35	180/90	0
PAL16R8A/A-2	25/35	180/90	8
PAL16R6A/A-2	25/35	180/90	6
PAL16R4A/A-2	25/35	180/90	4
FPLAs			
TIFPLA839	20	190	0
TIFPLA840	25	190	0

For more information on Texas Instruments PAL ICs and FPLAs, call your local TI distributor. To receive a data-sheet collection on all the new TI high-performance, user-programmable products, call Texas Instruments Incorporated at 1-800-232-3200 Ext. 201.

TEXAS INSTRUMENTS

Creating useful products and services for you.

TI's new IMPACT technology boosts circuit density and performance levels.

IMPACT is a unique innovation of Texas Instruments, capitalizing on the advantages of composed-masking techniques to increase the speed and density of bipolar integrated circuits.

Composed masking yields high density

In composed masking, critical components are placed on the chip with a minimum number of masks. Thus they can be more tightly defined and more densely spaced than by conventional masking, which requires more precise registration.

The process also makes it possible to insulate critical base and emitter components with oxide walls. This insulation reduces sidewall capacitance, which at the dimensions of IMPACT features can represent as much as half the overall capacitance. Small size and oxide walling together contribute significantly to the increase in switching speed.

Other important features of IMPACT technology are independently controlled base resistance and double-level metal with a 7-μm pitch at the first level.

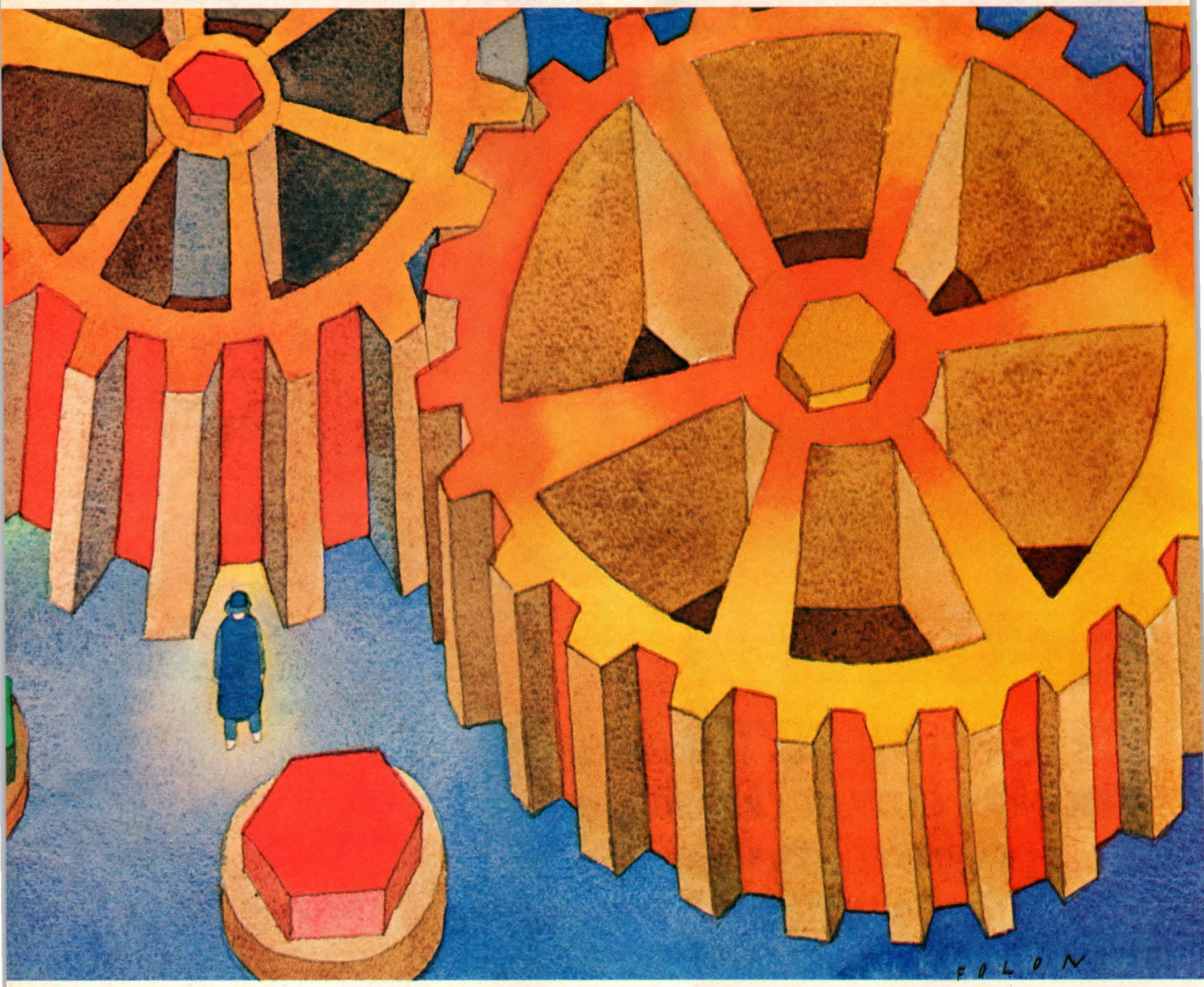
Exceptional reliability built in

The high speed, low power, and potential for large-scale integration that IMPACT makes feasible are valuable characteristics for chips used in harsh environments. Improved electrostatic-discharge (ESD) tolerance has been designed in. Copper-doped aluminum in the first-level interconnection eliminates electromigration during programming. Current densities, metal spacing, and contact sizes are all conservatively designed to add reliability to the process.

CIRCLE NO 254

TURNING YOUR PC INTO A FASTER TOOL FOR MODERN TIMES.

This is the 3rd in a series of technical papers from Zilog, designed to give engineers new insights into Zilog microprocessors—what advantages they provide for particular products and why they are the choice among engineers who need optimum performance.

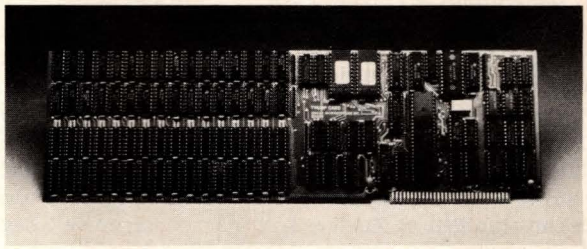


IBM® and other compatible PC computers are fast enough for general home and office use. But, for hardware and software development applications, the gears turn slowly.

What you need is a faster "gear" to co-process with the Intel 8088 inside IBM's PC. Like Zilog's Z8001® CPU. Now, there's a way to increase throughput for the IBM PC—as well as test the performance of the Z8001 CPU for your high-performance applications with a Z8001 CPU-based board called the "Trump Card" from Sweet Microsystems. And it proves dramatically how powerful Zilog's 16-bit CPU really is.

The new device is a peripheral board that plugs into any expansion slot on an IBM PC or compatible PC computer. Trump Card is addressed as an I/O device that communicates through the expansion bus. It is powered by Zilog's Z8001 CPU.

The Trump Card increases the computational power of the IBM PC, and provides maximum performance with a minimum of board space.



The Trump Card, shown from the front.The left side of the board contains 512 K-bytes of type-4164 dynamic RAM; the right side contains the Zilog Z8001 and an interface to the IBM PC I/O-expansion bus.

Z8001 COMPILER BASIC IS 80 TIMES FASTER THAN IBM INTERPRETIVE BASIC.

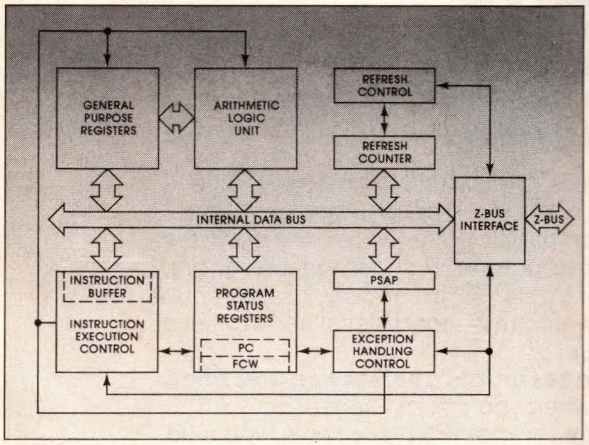
Essentially a monolithic minicomputer central processing unit, the Z8001 CPU is characterized by an instruction set more powerful than many minicomputers. As the programmer sees it, the Z8001 contains sixteen 16-bit general-purpose registers (for addresses or data) that may also be used in groups to form as many as eight 32-bit registers or four 64-bit registers. The low-order halves of the registers may be used for byte operations, thus the Z8001 CPU is able to manipulate data in 8-, 16-, 32-, and 64-bit pieces.

The Z8001 CPU, running at 10 MHz, can execute the same programs 4 to 10 times faster than the Intel 8088. What's more, the Z8001 CPU, with its large 8-megabyte memory range, makes the Trump Card's 512K bytes of memory easy to design with. (To use this memory in the card, you simply load a BASIC, CP/M-80, or C program from PC-DOS and type "RUN.")

Apple II	Apple III	TRS-80 Model II	IBM PC	IBM PC (with Trump Card)
224	222	189	190	2.4

A comparison of execution times (in seconds). Running on IBM's interpretive BASIC, a Sieve program takes 190 seconds to execute. Running the same program under TBASIC on the Trump Card Compiler takes only 2.4 seconds.

The eight addressing modes are register, indirect-register, direct-address, indexed, immediate, base-address, base-indexed, and relative-address. The instruction set utilizes data types ranging from single bits to a 32-bit long word. What's more, the processor executes 110 distinct instruction types that, when permuted by all the addressing modes and data types, create a set of more than 400 instructions.



A Z8000 CPU functional block diagram of the internal structure of the Zilog Z8000 family of high-performance microprocessors.

ALL THE PROPER SUPPORT FOR 512K BYTES OF MEMORY.

The wide range of software written for the Z8001 CPU is proven by all the programs you can run on the Trump Card. With the Z8001-based Trump Card, you can run the following software on your IBM or other compatible PC:

BASIC Compiler—TBASIC is PC BASICA-compatible. Most instructions are implemented without modification.

CP/M-80 Emulator—Allows you to run CP/M-80 Z80 assembly language programs directly. Just download your Z80 programs and run them.

C-Compiler—The industry standard version of C is available.

Debugger—Intended to aid in program development, you can examine and change memory and register contents and more.

Screen-editor—Has many word processing features, including ASCII text file development.

Multilevel Language Compiler—Allows Pascal-like control and data types, arithmetic expressions with automatic or specified allocations of registers, and more.

RAM Disk—Can allocate 128K to 387K bytes of on board memory to function as an intelligent RAM disk.

COPROCESSING IS JUST PART OF THE STORY.

The Z8001-based Trump Card is just one example of a successful application design for the Z8001 CPU. But there's far more to the Z8000 family than this.

Today, Z8000 CPU's are used in a wide range of applications, from industrial and medical products to computers and graphics imaging machines. And Zilog stands behind every application with service and software support that makes your Z8000-based products get to market on time.

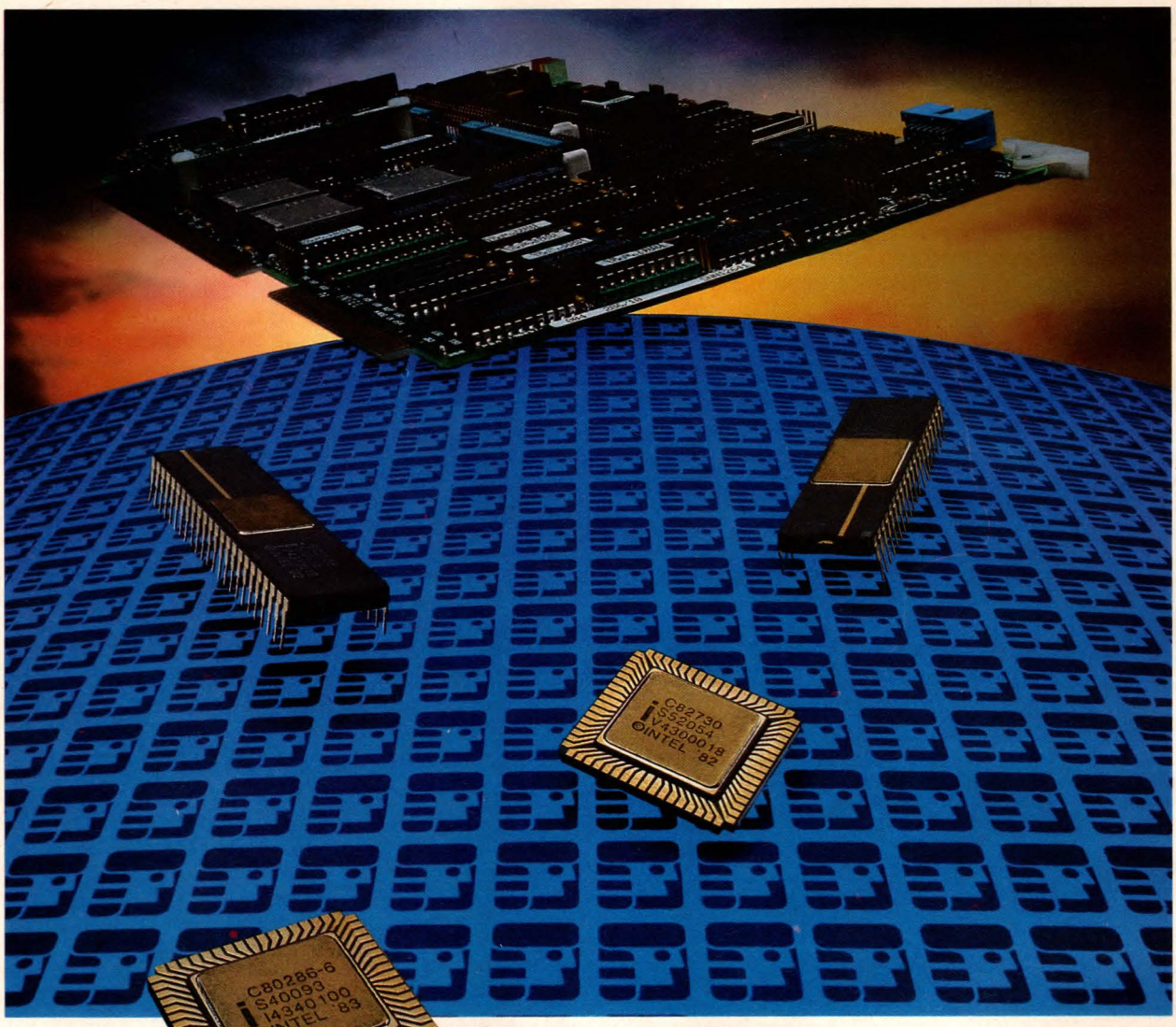
Find out for yourself how much power Zilog packs into every Z8000 CPU by turning your IBM PC into a faster tool for modern times.

To get your own Trump Card and complete instructions, call Sweet Microsystems at (401) 461-0530.

For information about the Z8000 CPU, send for our complete overview or call our Literature Hot Line at 800-272-6560. For seminar dates and locations, or information on Zilog training, call 408-370-8091. Or write: Zilog, Inc., Technical Publications, 1315 Dell Avenue, MS C2-6, Campbell, CA 95008.

The Z80, Z8000, Z8001 are registered trademarks of Zilog, Inc.
CP/M is a registered trademark of Digital Research Inc.
IBM is a registered trademark of International Business Machines Corporation.

Zilog Pioneering the Microworld.
an affiliate of
EXXON Corporation



ACCELERATE YOUR DESIGN.

The Intel 286 and Pioneer's technical back-up speed you into production.

Intel's 286 Family is the new standard in 16-bit technology, and Pioneer is ready to bring it to you now.

A complete family. The family is based on the 80286 microprocessor, which offers 1-gigabyte of virtual memory and true multitasking capabilities. The 286 family also includes a full line of peripherals:

□ The 80287 numerics co-processor, a "turbocharger" that provides high-speed processing for high-volume mathematical calculations.

□ The 82730 text/graphics co-processor for high-quality, fast-response graphics.

□ The 82586 LAN co-processor, the "chip of choice" for ethernet and IBM-PC compatible communications systems.

In stock now. Pioneer has the entire line of Intel 286 Technology in stock now —components, board-level and box-level products.

The technical assistance you need. And when you select Pioneer as your source for Intel 286 products, you also get OEM-grade technical assistance. Our Intel-trained engineers are thoroughly knowledgeable and prepared to help you discover how much you can accomplish with this breakthrough microprocessor.

Pioneer

intel

For more information, call your local Pioneer office or mail the coupon today!

ALABAMA
Huntsville 205-837-9300

CONNECTICUT
Norwalk 203-853-1515

FLORIDA
Altamonte Springs 305-834-9090
Ft. Lauderdale 305-428-8877

GEORGIA
Norcross 404-448-1711

ILLINOIS
Elk Grove Village 312-437-9680

INDIANA
Indianapolis 317-849-7300

MASSACHUSETTS
Lexington 617-861-9200

MICHIGAN
Livonia 313-525-1800

MINNESOTA
Minnetonka 612-935-5444

NEW JERSEY
Pine Brook 201-575-3510

NEW YORK
Fairport 716-381-7070
Woodbury 516-921-8700
Vestal 607-748-8211

NORTH CAROLINA
Charlotte 704-527-8188

OHIO
Cleveland 216-587-3600
Dayton 513-236-9900

PENNSYLVANIA
Horsham 215-674-4000
Pittsburgh 412-782-2300

TEXAS
Austin 512-835-4000
Dallas 214-386-7300
Houston 713-988-5555

WASHINGTON, D.C.
Gaithersburg 301-921-0660

Pioneer-Standard Electronics, Inc.
4800 E.131st Street
Cleveland, OH 44105
Attn: Jamie Feldkamp

Name _____
Title _____
Company _____
Address _____
City _____
State _____ Zip _____
Phone _____

- ☐ Please rush me the Intel 286 Datapak.
- ☐ I'm interested in the 286 Designer Kit.
- ☐ I'm interested in attending a seminar on the 186, 188, and 286.
- ☐ Please have an applications engineer call me.

Pioneer intel®

SIGNALS & NOISE

MTBASIC compiles 100 statements per sec

Dear Editor:

I was very pleased to see the review of Softaid's MTBASIC in the September 6 issue of EDN (pg 284). There was one small error, however, that I would like to correct. The review states that MTBASIC "translates the program to Z80 code and executes it at 100 BASIC statements/sec typ." In fact, MTBASIC *compiles* 100 BASIC statements/sec typically, making it one of the fastest compilers around. It executes far in excess of this rate.

Sincerely,
Catherine L Ganssle
Vice President
Softaid Inc
Columbia, MD

BASYS adapts BASIC to data acquisition

Dear Editor:

I have just read with interest your Technology Update regarding hardware-specific software packages that adapt BASIC to data acquisition (EDN, September 6, pg 55). I'd like to point out that ADAC Corp manufactures a family of microcomputers for data acquisition and control called the BASYS systems. These computers are compatible with DEC-11 systems and with the IBM PC/XT, and they link via an RS-232C interface. The software supplied with the system uses I/O BASIC, which includes I/O statements for analog, digital, and serial cards, timers, optically isolated boards, DMA cards, and a variety of sensors. I/OBASIC is a line-compiled language that permits A/D conversion and other I/O to proceed simultaneously, allowing A/D conversion to take place at hardware speeds of as high as 100,000 conversions/sec. The software includes a communications utility program that allows handshaking between the ADAC unit and the associated IBM or DEC computer. BASYS systems can operate as stand-alone units, hosts, or satellites.

Sincerely,
Lawrence Pelavin
Marketing Support Manager
ADAC Corp Woburn, MA

GE supplies power conditioners

Dear Editor:

It was with a great deal of interest that I read the article on line conditioners in the July 12 issue (pg 218). I was disappointed to see that General Electric was not listed among the leading suppliers. General Electric has a full line of power conditioning equipment, including line conditioners for application with desktop computing equipment.

Sincerely,
J S White
Manager, Power Conditioning Market
General Electric Co
Fort Wayne, IN

"NO, HE MAY BE MISINFORMED . . . PERHAPS BULLHEADED . . . EVEN STUPID . . . BUT NEVER, NEVER, WRONG."

Copyright© 1984, Tektronix, Inc. All rights reserved. KSA-458-1

Tek's Plug-in Programmable Digitizer: dividends beyond space and time!

Just plug the 7D20 Waveform Digitizer into your Tek 7000 Series mainframe to add a new, fully programmable dimension to your scope. It's a dimension that requires no additional space on the bench or rack.

It takes less time to learn, because it's part of the familiar 7000 Series package.

It not only makes better use of your space and time. It helps you get more out of your automated test system, your personnel, and your system investment, all for the price of a plug-in.

Not least, it assures you the superb documentation and long-lived product support that's made Tek scopes the choice for all kinds of automated test systems. Tek engineering has also meant long life cycles—to which you can add our reliable, long-term service and component availability worldwide.

And because it's part of the Tek 7000 Series, it's also part of a multi-dimensional, reconfigurable, continually expandable instrument line.

In performance, programmability and ease of interfacing, the 7D20 eclipses far more costly digitizers. Configure it with as much or as little operator control as required.

The 7D20 command set conforms fully to TEK Standard Codes & Formats for easy to write self documenting programs which simplify system integration.

You can record, display and compare two channels of simultaneous events, store up to six waveforms and front panel setups with on-board memory. Bandwidth is up to 10 MHz for single-shot phenomena and 70 MHz for repetitive signals, with a sampling rate of up to 40 MHz.

The 7D20's envelope mode automatically captures subtle variations among random events and reveals difficult-to-detect amplitude and frequency deviations such as jitter or a missing pulse.

Of course, Tek Standard Codes & Formats considerably simplifies your interfacing efforts. It goes far beyond the electrical and mechanical conventions defined by IEEE-488 by assuring a consistent interface between all Tek instruments and a logical, mnemonic program language syntax.

The 7D20 is designed to fit both benchtop and rackmount 7000 Series mainframes. The 7D20 and the rackmount R7603 make an excellent package for automated or computer-controlled test systems. As the 7D20T, it is mounted in a lightweight, half-rack modular package that saves space, provides rear access to inputs, improves portability. Rack two 7D20T units side by side, or one next to a monitor or other device.

Your Tek sales representative will be happy to tell you more about the 7D20. And about our many other test system components. For literature and complete technical specifications, contact:

U.S.A., Asia, Australia, Central & South America, Japan
Tektronix, Inc.
P.O. Box 1700
Beaverton, OR 97075
Phone: 800/547-1512
Oregon only: 800/452-1877

Europe, Africa, Middle East
Tektronix Europe B.V.
Postbox 827
1180 AV Amstelveen
The Netherlands
Telex: 18312-18328

Canada
Tektronix Canada Inc.
P.O. Box 6500
Barrie, Ontario L4M 4V3
Phone: 705/737-2700

Tektronix
COMMITTED TO EXCELLENCE

CIRCLE NO 20

Fluorinert® Liquids prevent rejects from boxing in profits.

Product failure can come from a lot of different sources. Unreliable solder joints. Ineffective defect testing. Inefficient component cooling. All together, that can add up to a lot of rejects. And a lot of lost profits. Fluorinert® Liquids reduce the risk of product failure. And increase your chances for profits and productivity.

Vapor phase soldering with Fluorinert® Liquids provides a faster, more reliable soldering method for electronic components and assemblies. This results in a higher yield and reduced costs.

Direct contact cooling with Fluorinert® Liquids removes heat rapidly so component temperatures are kept lower, reducing failure rates and increasing reliability. At the same time, components can be packaged closer together, maximizing power density and miniaturizing the package.

Gross leak, thermal shock, and liquid burn-in testing with Fluorinert® Liquids detect more defects before they have a chance to become rejects.

Fluorinert® Liquids don't make problems while they're solving problems, either. They leave essentially no residue, so no clean-up is necessary. They're colorless, odorless, non-flammable, non-explosive, non-corrosive, and will not remove markings.

FC numbers (FC-72, FC-77, FC-70, FC-40, etc.) identify individual Fluorinert® Liquids. They offer a wide range of boiling points, making it easy to select the liquid that's right for your application. FC numbers are solely 3M designations for our fluorochemical products.

And in addition to making Fluorinert® Liquids easy to choose, we make them easy to use. We offer comprehensive technical assistance, including recommendations for fluids and application equipment; testing and production methods; evaluation of results; an extensive service bulletin program covering technological advances; and on-site applications seminars.

3M developed perfluorinated liquids 35 years ago, and we've been supplying them to the electronics industry for the past 25 years. So you can trust us, the industry leader, to help you select and use the right Fluorinert® Liquid for peak performance. And peak profitability.

For more information, write: Commercial Chemicals Division/ 3M, Building 223-6SE, St. Paul, MN 55144. Or call our hotlines: 612/733-6282 (testing/cooling) 612/733-7424 (soldering).

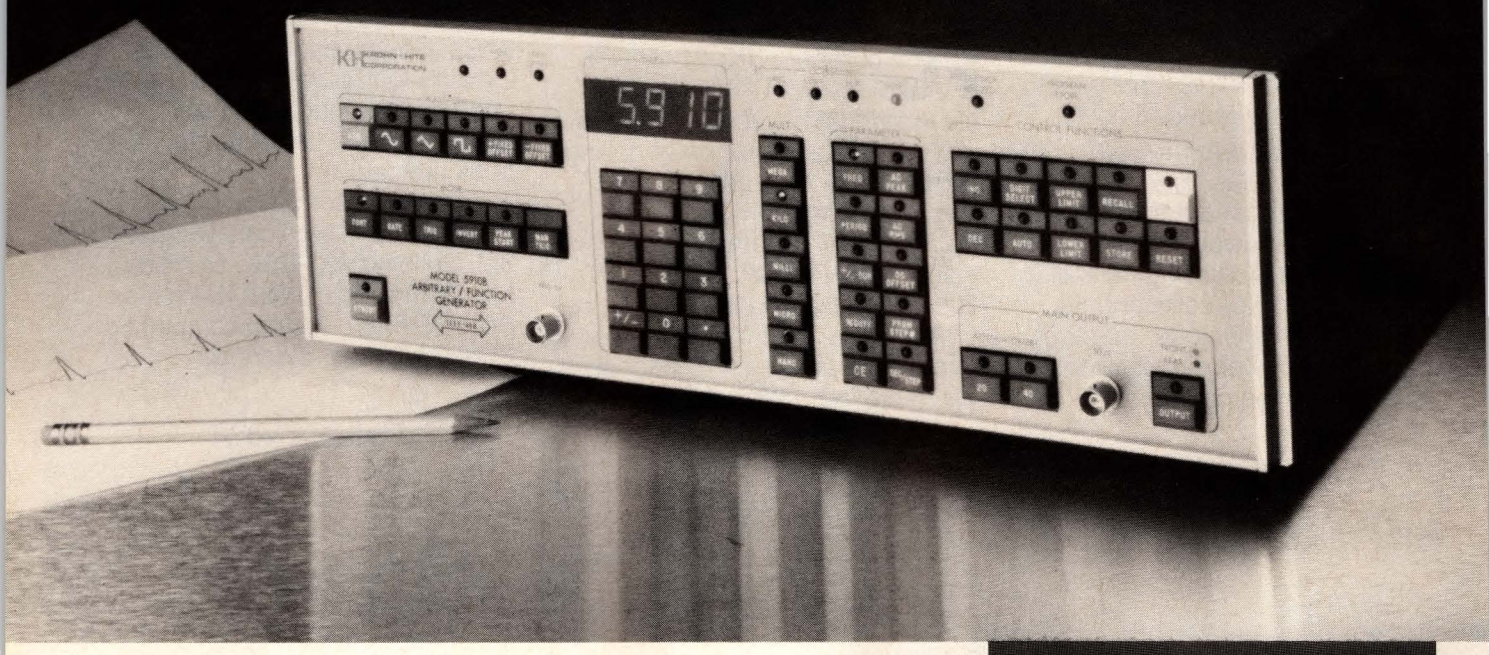
CIRCLE NO 21

3M Hears You...

3M

What is the "most wanted" feature in a programmable function generator?

The Arbitrary Waveform Function



And Krohn-Hite makes the function generators wanted most.

As the most accurate, the most versatile, and least expensive in today's market, the Krohn-Hite Model 5910B is the ultimate in arbitrary function generators. By defining a waveform point by point directly in voltage levels, the 5910B allows the user to construct a waveform of complexity previously unattainable. Complemented by its Auto-Programmer, the 5910B lets the user generate signals composed of multiple, arbitrary, and/or standard waveforms and repeat those waveforms at any given rate. Finally, the 5910B has an impressive frequency/accuracy of better than 0.05%—unheard of in an arbitrary function generator—until now.

- ☐ 0.0001Hz to 5MHz
- ☐ Frequency accuracy: 0.05%
- ☐ Points defined directly as voltage levels
- ☐ Non-volatile memory
- ☐ IEEE-488 interface

If the arbitrary capability is not in your future, the Model 5900B is. This generator has all the capabilities of the 5910B with the exceptions of the arbitrary function and non-volatile memory.

Because Krohn-Hite makes a complete line of quality function generators, you'll find the perfect instrument for your needs. Krohn-Hite designs function generators you wanted most.

Krohn-Hite . . . Benchmark of Quality in Instruments

SALES OFFICES

NEW ENGLAND, McBar Assoc., (617) 890-0233, (203) 865-4376; **METRO NY, NJ, EASTERN PA,** Sci. Devices (E), (201) 871-3916, (215) 643-3335; **UPSTATE NY,** Labtronics, Inc., (315) 455-7314; **MID ATLANTIC,** Sci-Rep., (703) 385-0600; **SOUTHEASTERN US,** Gentry Assoc., (305) 859-7450, (305) 791-8405, (919) 227-3639, (803) 772-6786, (205) 837-0692, (404) 998-2828, (504) 367-3975, (813) 886-0720, (615) 584-0281, (901) 683-8072; **GREAT LAKES (E),** EQS Systems, (216) 729-2222, (313) 961-3042, (614) 228-3453; **GREAT LAKES (W),** Berndt Assoc., (312) 283-0713, (317) 844-0114, (414) 545-8400, (612) 546-2021; **MIDWEST,** Ramsey Assoc., (314) 878-5042, (913) 649-6996; **SOUTHWESTERN US,** Kemp Engineering, (214) 931-7100, (713) 466-1465, (918) 663-4501, (501) 826-5869; **ROCKY MOUNTAIN,** Odyssey 1, (505) 265-6645, (303) 773-8176, (602) 246-8846; **CALIFORNIA, NEVADA,** L + M Engineering, (408) 246-7330, (213) 674-6850; **NORTHWEST US,** McLaren, (206) 454-3400, (503) 297-2248; **CANADA,** Webster Instr., (416) 625-0600, (613) 725-1931, (514) 744-5829, (604) 434-2611, (403) 437-5450;

KROHN-HITE CORPORATION

Avon Industrial Park, Avon, MA 02322
(617) 580-1660 TWX: 710 345 0831

CIRCLE NO 22

CALENDAR

Semicon/Japan '84, Tokyo International Trade Center, Tokyo, Japan. Semiconductor Equipment and Materials Institute, 625 Ellis St, Suite 212, Mt View, CA 94043. (415) 964-5111. December 3 to 5.

Digital Avionics Systems Conference, Baltimore Convention Center, Baltimore, MD. AIAA, 1633 Broadway, New York, NY 10019. December 3 to 6.

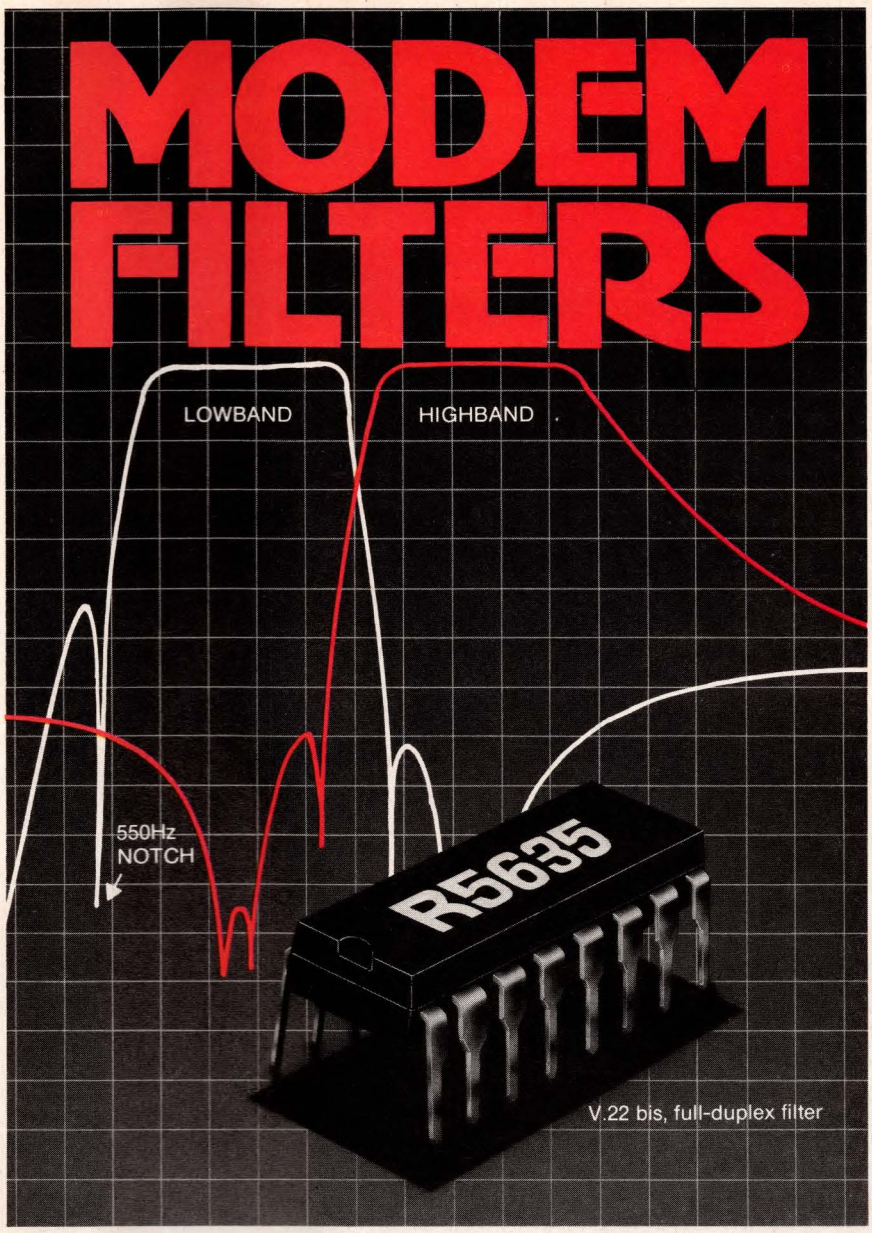
Armed Forces Communications and Electronics Association: Artificial Intelligence (unclassified), Washington, DC. AFCEA, Professional Development Center, 5641 Burke Centre Parkway, Burke, VA 22015. (703) 425-8500; (800) 336-4583. December 4 to 6.

Videodisc, Optical Disk, Compact Disc Conference & Exposition, Washington, DC. Mark Roseman, Meckler Communications, 11 Ferry Lane W, Westport, CT 06880. (203) 226-6967. December 4 to 7.

Course on Electronic Materials, Stouffer's Concourse Hotel, Washington, DC. Palisades Institute for Research Services Inc, 225 Varick St, New York, NY 10014. (212) 242-6864. December 5 to 7.

California Computer Show, Hyatt Hotel, Palo Alto, CA. Norm DeNardi Enterprises, 289 S San Antonio Rd, Suite 204, Los Altos, CA 94022. (415) 941-8440. December 6.

IEEE International Electron Devices Meeting, San Francisco Hilton Hotel, San Francisco, CA. Melissa Widerkehr, Courtesy Associates Inc, 655 15th St NW, Suite 300, Washington, DC 20005. December 9 to 12.



NEW

R5635 CCITT V.22 bis, full-duplex Switched-Capacitor Filter I.C. with MUXes.
R5636 Bell 201/CCITT V.26 combo filter I.C.
R5637 Bell 208/CCITT V.27 combo filter I.C.
R5638 Bell 209/CCITT V.29 combo filter I.C. (available Dec.'84).
R5630 Bell 103, full-duplex filter I.C. with MUXes.
R5631 CCITT V.21, full-duplex filter I.C. with MUXes.
R5632 Industry Standard, Bell 212A/CCITT V.22 full-duplex combo filter I.C.
R5633 Selectable filter array I.C. for 103, V.21, DTMF and Videotex applications.
R5626 Mask programmable to your specification.

Contact: EG&G Reticon 345 Potrero Avenue, Sunnyvale, CA 94086-4197 (408) 738-4266 TWX 910 339-9343; or, Chicago (312) 640-7713; Boston (617) 745-7400; Japan 03-343-4411; England (0734) 788666; Germany (089) 92692-666.

EG&G RETICON
WHERE VISION AND TECHNOLOGY MEET

CIRCLE NO 38

ULTIMATE

FERRORESONANT

LINEAR

SWITCHING

POWER SUPPLIES

When You Require The Highest Quality Supply, NJE Has The Power... to supply you with reliable, high-performance switchers. We offer over 30 standard models, each made to our exacting standards that meet (actually exceed) CSA and UL requirements.

Backed By The Most Dedicated Customer Support Team In The Industry. From our 5 year warranty on *every* power supply to on-going product development to our unsurpassed customer support, our commitment to quality is second to none. We offer the power to deliver. To customize. To provide the support you need. Whether you need quality switchers, or linears and ferroresonants. Our technology coupled with dedicated service adds up to providing you with the ultimate in power supplies.

Call us today for our complete catalog, for specs., quotes or for any other information your application may require. Call (800) 526-2439 TODAY.

NJE POWER SUPPLIES
329 Culver Road
P.O. Box 669
Dayton, NJ 08810-0669

POWEReliability. Guaranteed.

CIRCLE NO 39

CALENDAR

1984/1985 Strategic Issues Conference, Americana Canyon Hotel, Palm Springs, CA. InfoCorp, 20833 Stevens Creek Blvd, Cupertino, CA 95014. (408) 973-1010. December 10 to 13.

Cadcam International Show, National Exhibition Center, Birmingham, England. EMAP International Exhibitions Ltd, Durrant House, 8 Herbal Hill, London, EC1R 5JB, England. (01) 837-3699. January 8 to 10.

MOS A/D Interface Circuit Design for VLSI Digital Systems, San Francisco Airport Hilton Hotel, San Francisco, CA. University of California Extension, Continuing Education in Engineering, 2223 Fulton St, Berkeley, CA 94720. (415) 642-4151. January 9 to 11.

Microcomputers in Control Systems: Hardware, Software and Interfacing, George Washington University, Washington, DC. Chip Blouin, Continuing Engineering Education, George Washington University, Washington, DC 20052. (800) 424-9773; (202) 676-8527. January 14 to 18.

Mecom '85, Bahrain. Kallman Associates, 5 Maple Ct, Ridgewood, NJ 07450. (201) 652-7070. February 2 to 4.

Computer Business Graphics, Bonaventure Intercontinental Hotel, Fort Lauderdale, FL. Carol Every, Frost & Sullivan, 106 Fulton St, New York, NY 10038. (212) 233-1080. February 20 to 23.

National Electrical Manufacturers Association (NEMA) Liability Seminar, Hyatt Regency Tampa, Tampa, FL. NEMA, 2101 L St NW, Washington, DC 20037. (202) 457-8400. March 4 to 5.

Circuit-Board-Design Without the Tedium

smARTWORK™ lets the design engineer create and revise printed-circuit-board artwork on the IBM Personal Computer.

Forget tape. Forget ruling. Forget waiting for a technician, draftsman, or the CAD department to get to your project. smARTWORK™ software turns your IBM Personal Computer into a professional, high-quality drafting tool. It gives you complete control over your circuit-board artwork — from start to finish.

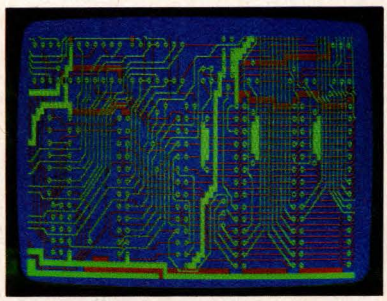
smARTWORK™ transforms your IBM PC into a CAD system for printed-circuit-board artwork. Display modes include both single-layer black and white and dual-layer color.

What makes smARTWORK™ so smart is that it understands electrical connections. Conductor spacing is always correct, lines don't become too narrow, and connecting lines do not intersect other conductors. smARTWORK™ can automatically find and draw the shortest route between two conductors. Or you can specify the route.

smARTWORK™ is the only low-cost printed-circuit-board artwork editor with all these important advantages:

- ☐ Complete interactive control over placement and routing
- ☐ Quick correction and revision
- ☐ Production-quality 2X artwork from pen-and-ink plotter
- ☐ Prototype-quality 2X artwork from dot-matrix printer
- ☐ Easy to learn and operate, yet capable of sophisticated layouts
- ☐ Single-sided and double-sided printed-circuit boards up to 10 x 16 inches
- ☐ Multicolor or black-and-white display
- ☐ 32 user selectable color combinations; coincident points can be displayed in contrasting colors.
- ☐ Can use optional Microsoft Mouse as pointing device

Twice scale hardcopy of your artwork is produced using the Epson dot-matrix printers or the Houston Instrument DMP-41 pen-and-ink plotter. Quick 1X check plot is also available from Epson printers.



Dual-layer color display of a 2" by 4" section of a 10" by 16" circuit board

The Smart Buy

At $895, smARTWORK™ is an exceptional value, particularly when compared to conventional engineering workstation costs.

Call or write us for more information on smARTWORK™. We'll be glad to tell you how smARTWORK™ helps us design our own circuit boards and what it can do for your business.

Send a purchase order, or major credit card number, and smARTWORK™ can be working for you next week.

System Requirements

- ☐ IBM PC or XT with 192K RAM, 2 disk drives and DOS Version 2.0
- ☐ IBM Color/Graphics Adapter with RGB color or b&w monitor
- ☐ Epson MX-80/MX-100 or FX-80/FX-100 dot-matrix printer
- ☐ Houston Instrument DMP-41 pen-and-ink plotter (optional)
- ☐ Microsoft Mouse (optional)

WINTEK

"smARTWORK" and "Wintek" are trademarks of Wintek Corporation.

WINTEK CORPORATION, 1801 South St., Lafayette, IN 47904-2993, Phone: (317) 742-8428, Telex: 70-9079 (WINTEK CORP UD)

CIRCLE NO 45

For ferrites come to the source...

The Philips range of ferrites goes right across the board. Covers all application areas and is backed by extensive support such as computer aided design programs for motor segments and loudspeaker rings, nomograms for power transformers and lab kits, with step-by-step instructions, for interference suppression. They're available in over thirty different material types and thousands of different shapes and sizes and are made at the world's largest production facilities. So whatever your needs in 'hard' and 'soft' ferrites, you'll be sure of finding the answer at Philips . . . the ferrite source for over thirty years.

The products illustrated have been grouped into four main product/application areas. From left to right these are:

Ferroxcube rods, rings, tubes and beads. Available in over 200 standard sizes and in twenty different materials. Ideal for small transformers, screening and interference suppression.

PHILIPS

Electronic
Components
and Materials

the biggest range...the best support

Ferroxdure loudspeaker rings. Ferroxdure products are pressed and sintered from ferrite powders, so they behave like 'ceramics' but have superior magnetic characteristics. The material is ideal for loudspeaker rings, which are available in sizes from 36 to 224 mm.

Ferroxcube cores for transformers and chokes. Here too Philips offer a wide range of types and sizes for all power applications, including wideband and switched mode transformers.

Permanent magnets for DC motors. With Ferroxdure ceramic magnets you're no longer limited to small motors, but can now benefit from a permanent magnet design for powers up to 10 HP.

For more information please write to the address below giving details, if possible, of your application.

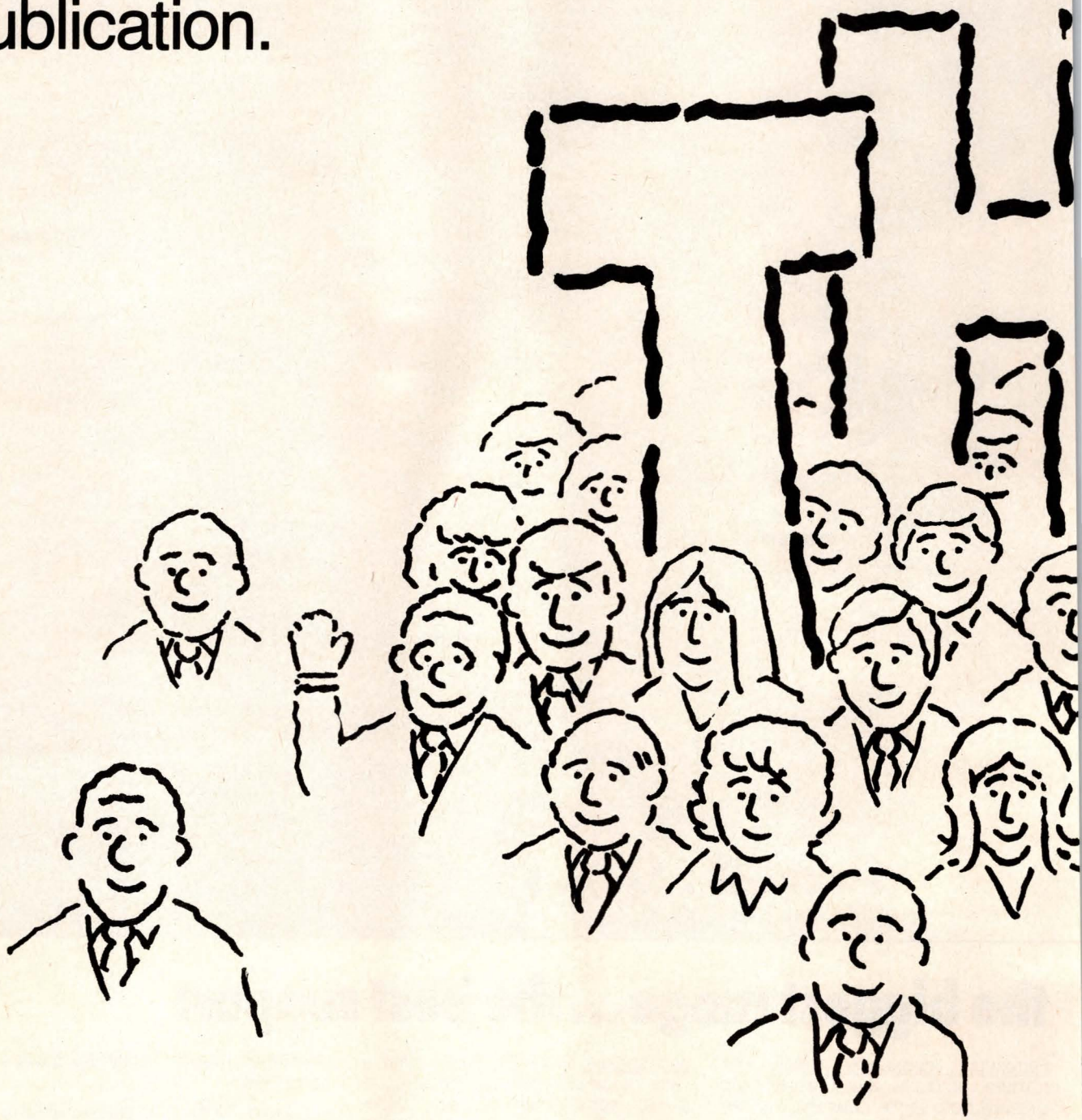
Philips Industries, Electronic Components and Materials Division, Eindhoven, The Netherlands.

First in Ferrites

PHILIPS

CIRCLE NO 47

To EDN readers, for consistently votin
EDN your favorite electronics
publication.



From the staff of EDN

In 64K DRAMs, INMOS high performance and flexible ...including 8K x 8.

Look to INMOS for a wide selection of 64K DRAMs. We offer access times from 100ns. By-1, by-4, and by-8 organizations. Plus features that boost performance and simplify design. This is the family that lets you avoid compromises by giving you the performance and organization you want...at costs you can afford.

8K x 8 — The cost and space saver. This newest member of the INMOS 64K DRAM family, available in a plastic package, offers access times of 120 and 150ns. The by-8 organization is a natural for microprocessor designs and other applications that require word width rather than memory depth...in process controllers, intelligent terminals, and buffer memories for example. And its pin 1 refresh makes it a very attractive alternative to 8K x 8 static RAMs. Because it combines low power and low cost with minimal support circuitry.

16K x 4 — The performance chip. With 100, 120, and 150ns access times, this organization makes a lot of sense in high-performance systems, such as high-resolution graphics, where high data rates are required. Packaged in plastic DIPs, the IMS2620 also gives you the right combination of cost, organization, and speed for microprocessor systems, terminals, and even arcade and home games. If you're upgrading from 16K x 1 chips, it provides a factor of four reduction in chip count. And its "$\overline{\text{CAS}}$ before $\overline{\text{RAS}}$" refresh assist function minimizes required support circuitry for cost and space savings.

64K x 1 — The big-system choice. This DRAM also gives you a choice of 100, 120, and 150ns access times. What's more, it includes "Nibble Mode," which allows effective cycle times below 85ns. Available in a variety of packages, including plastic DIPs, ceramic DIPs, and chip carriers, it's ideal for systems requiring lots of memory depth.

Check the chart. You'll find the industry's broadest family of 64K DRAMs...and the right device for your requirements. Then call an INMOS distributor for all the details.

Organization	Access Time (ns)	Cycle Time (ns)	Part No.
8K x 8	120	190	IMS2630-12
	150	240	IMS2630-15
16K x 4	100	160	IMS2620-10
	120	190	IMS2620-12
	150	240	IMS2620-15
64K x 1	100	160	IMS2600-10
	120	190	IMS2600-12
	150	230	IMS2600-15

INMOS Distributors: Anthem Electronics, Arrow Electronics, Falcon Electronics, Future Electronics, Lionex Corp.

inmos

P.O. Box 16000 • Colorado Springs, CO 80935 (303) 630-4000
TWX 910/920-4904 • Burlington, MA (617) 273-5150 • San Jose, CA (408) 298-1786 • Torrance, CA (213) 530-7764 • Minneapolis, MN (612) 831-5626 • Baltimore, MD (301) 995-0813 • Dallas, TX (214) 669-9001 • Atlanta, GA (404) 475-0709 • Whitefriars • Lewins Mead • Bristol BS1 2NP • England Phone Bristol 0272 290 861 • TLX: 444723

inmos and IMS are trademarks of INMOS Group of Companies.

CIRCLE NO 49

neans
rganizations
16Kx4
64Kx1
8Kx8

actual size

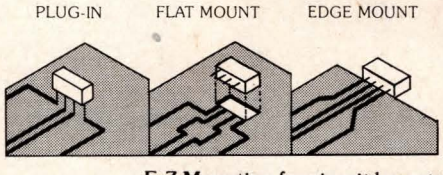
tiny TFM

the world's smallest hermetically-sealed mixers from $11.95
40 KHz to 3 GHz, MIL-M-28837 performance*

Increase your packaging density, and lower your costs... specify Mini-Circuits miniature TFM Series. These tiny units 0.5" x 0.21" x 0.25" are the smallest, off-the-shelf Double Balanced Mixers available today.

Requiring less PC board area than a flat-pack or TO-5 case, the TFM Series offer greater than 45 dB isolation, and only 6 dB conversion loss.

Manufactured to meet the requirements of MIL-M-28837*, the tiny but rugged TFM units have become the preferred unit in new designs for military equipment.



E-Z Mounting for circuit layouts
Use the TFM series to solve your tight space problems. Take advantage of the mounting versatility—plug it upright on a PC board or mount it sideways as a flatpack.

MODEL	FREQUENCY, MHz		CONVERSION LOSS dB, TYPICAL		ISOLATION dB, TYPICAL						PRICE	
			1 Octave from Band Edge	Total Range	Lower Band Edge		Mid Range		Upper Band Edge		$	
	LO/RF	IF			LO-RF	LO-IF	LO-RF	LO-IF	LO-RF	LO-IF	EA.	QTY.
TFM-2	1-1000	DC-1000	6.0	7.0	50	45	40	35	30	25	11.95	(1-49)
TFM-3	.04-400	DC-400	5.3	6.0	60	55	50	45	35	35	19.95	(5-49)
TFM-4	5-1250	DC-1250	6.0	7.5	50	45	40	35	30	25	21.95	(5-49)
•••TFM-11	1-2000	5-600	7.0	7.5	50	45	35	27	25	25	39.95	(1-24)
•••TFM-12	800-1250	50-90	—	6.0	35	30	35	30	35	30	39. 95	(1-24)
▪▪TFM-15	10-3000	10-800	6.3	6.5	35	30	35	30	35	30	49.95	(1-9)
▪▪TFM-150	10-2000	DC-1000	6.0	6.5	32	33	35	30	35	30	39.95	(1-9)

•••If Port is not DC coupled
▪▪+10 dBm LO, +5 dBm RF at 1dB compression
*Units are not QPL listed

For complete specifications and performance curves refer to the Goldbook, EEM, EBG, or Mini-Circuits catalog

CAPD now available! computer-automated performance data

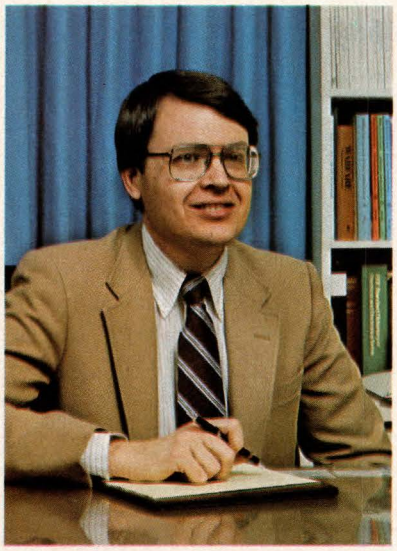
finding new ways...
setting higher standards

Mini-Circuits
A Division of Scientific Components Corporation
World's largest manufacturer of Double Balanced Mixers
P.O. Box 166, Brooklyn, New York 11235 (718) 934-4500
Domestic and International Telex 125460 International Telex 620156

CIRCLE NO 50

C68 REV C

EDITORIAL



Automation revisited

Two months ago on this page we discussed a key benefit of automation in electronics manufacturing companies: the maintenance of a competitive edge against inexpensive foreign labor. Automation also has benefits at the personal level, though, as our just-completed trip to the Far East demonstrated very nicely. We found even in Taiwan—noted for its cheap assembly labor—that automation improves workers' jobs and lives without, in general, reducing the number of jobs available.

As related by the president of an electronics company in Taiwan, labor costs in that country have increased tenfold in the last decade. Thus, even though these costs are still low by US standards, some degree of automation is necessary to stem further increases. But in Taiwan, as in the US, automation's increased efficiencies often mean more production by the same number of workers—not less production by fewer workers. And, most important, workers' jobs become less tedious, more meaningful, and more satisfying.

Throughout history the pattern has been consistent: The use of newly developed tools, whether flint knives or robots, has improved the worker's lot. (The Industrial Revolution is a notable exception, but the worst aspects of it, fortunately, were transient.) Today's rapid changes in the work environment do create a potential for temporary injustices, but time will surely prove, as it has in the past, that improved productivity and increased freedom from boring, repetitive tasks will lead to improvements in job quality.

And so, to those who say that automation is unfair to workers, we say "Nonsense!" An adjustment period may be necessary, but the result is worth it. We should do all we can to minimize automation's problems, but otherwise we should let automation proceed on its course. There's no point in standing in the way of progress.

Gary Legg

Gary Legg
Editor

Jesse H Neal
Editorial Achievement Awards
1981(2), 1978(2), 1977, 1976, 1975
American Society of
Business Press Editors Award
1983, 1981

© 1984 Advanced Micro Devices, Inc.

Advanced Micro Devices • **Bruxelles** (02) 771 99 93 • **Hannover** area (05143) 53 62 • **Hong Kong** (852) 3 695377
London area (04862) 22121 • **Manchester** area (0925) 828008 • **Milano** (02) 339 0541 • **München** (089) 40 19 76
Paris (01) 687.36.66 • **Stockholm** (08) 98 12 35 • **Stuttgart** (0711) 62 33 77 • **Tokyo** (03) 329-2751

CIRCLE NO 51

CELEBRATE THE FIRST.

The first 512K EPROM is here.

You think Fujitsu came out with the world's first 512K EPROM? No, gomenasai. You think Intel's got the first chip big enough to hold an entire operating system? No way.

It's Advanced Micro Devices.

And the Am27512 is just the latest reason our memory family is skyrocketing.

There's also our world record speedster, the 256K EPROM, as well as our really hot 128K and 64K EPROMs.

We've got the biggest family of EPROMs there is. From 2K to 512K.

And our other products are just as hot.

We'll put you as far ahead of the competition as we are.

Controllers. Bipolar and MOS microprocessors. Communication circuits. Signal processors.

And nobody makes as many peripherals for as many microprocessors as AMD.

The International Standard of Quality guarantees a 0.1% AQL on all electrical parameters, AC and DC, over the entire operating range.

INT·STD·1000

And every single chip meets or exceeds the International Standard of Quality.

Next time you need an EPROM, give AMD a call.

We'll give you something to celebrate.

Advanced Micro Devices

For a sales agent nearest you, write the word "EPROM" on your letterhead and mail it to Advanced Micro Devices, Mail Operations, P.O. Box 4, Westbury-on-Trym, Bristol BS9 3DS, United Kingdom.

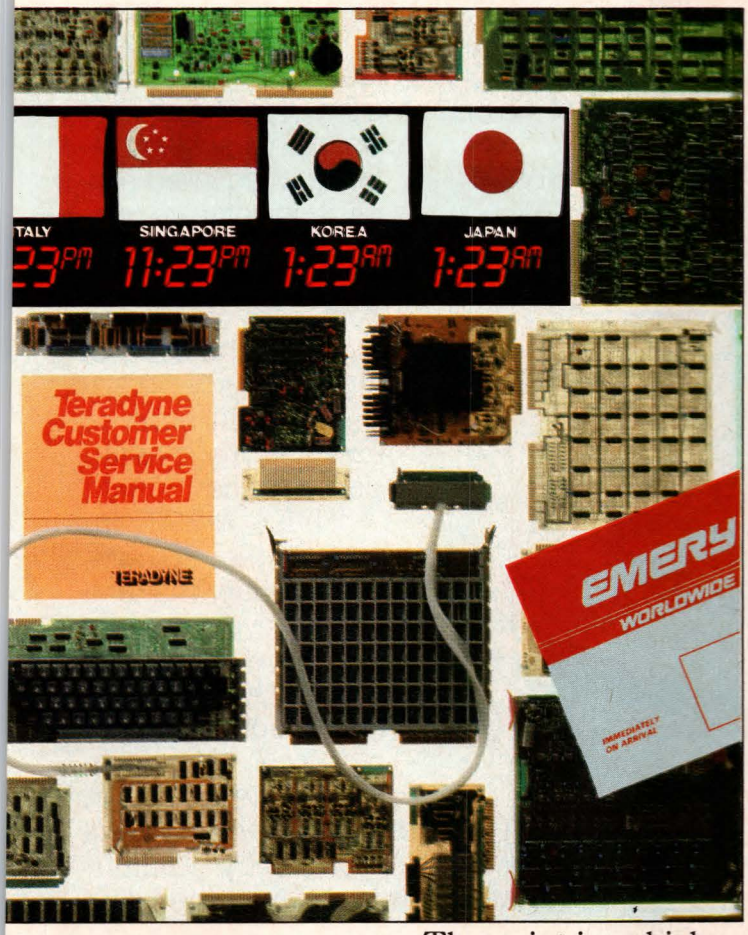
"Teradyne systems may occasionally break down. Teradyne service will not."

Alex d'Arbeloff, President
Teradyne

Nobody likes mistakes. That's why Teradyne has spent more than 20 years building automatic test equipment that roots out and eliminates errors.

Nobody's perfect, however, and in one of life's great ironies, even Teradyne products sometimes fall down on the job.

But not to worry. We can be absolutely candid about this for two reasons. First, we know that within any reasonable framework, Teradyne equipment performs superbly.



Second, when the inevitable problem does occur, we also know that you can't find better service than ours anywhere. And we're very proud of that.

Only Teradyne offers such a variety of service options. For instance, you can contract for complete on-site service to be delivered within a specified time. If we don't come through, you don't pay.

Or you may choose to be more self-reliant, in which case we'll analyze your needs and help train and equip your people to handle almost anything that comes up. You'll go from downtime to uptime in no time.

The point is, whichever option you choose, we'll give you all the support you need. And in this unpredictable world that kind of assurance can be very comforting.

So there you have it. Admitting we're not perfect may be a bit unusual, but then at Teradyne we never follow the pack.

We lead it.

TERADYNE

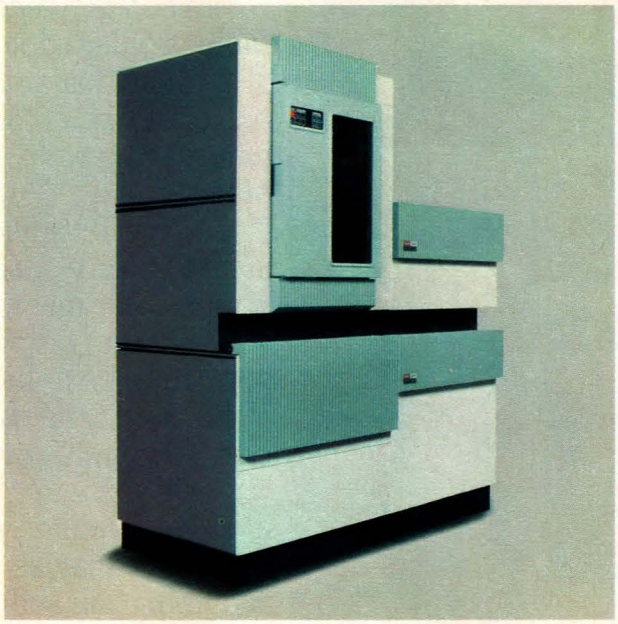
We measure quality

INTRODUCING THE OLIVETTI-AT&T 3B SUPERMINICOMPUTERS WITH UNIX SYSTEM V.

LOOK HOW FAR ADVANCED TECHNOLOGY HAS PROGRESSED

The 3B superminicomputers are the fruit of the agreement for worldwide cooperation between Olivetti and AT&T. Designed in the research centres of AT&T Bell Laboratories, they are distributed, sold, guaranteed and assisted technically by Olivetti.

CAPACITY. These superminicomputers can connect from 2 to 50 work stations, providing true 32-bit chip processing in addition to 256 Kbit memory. Depending on the model, you can get up to 2 or 8MB of main memory, plus a wide choice of fixed and removable disks. Feature-after-feature, including the upgrading of I/O units and a variety of communication interfaces.



FLEXIBILITY. The connection possibilities of the 3B line is extensive. To Ethernet* compatible local area networks. To simple, windowed, or graphics terminals, personal computers, and a wide selection of heavy-duty or quality printers. The 3B line is available in two models, the 3B2 and 3B5, offering a vast range of solutions within a totally compatible family.

SOFTWARE. One of the many interesting aspects of the 3B line is the UNIX** System V operating system offering unequalled simplicity in software portability. It is emerging as a standard in the computer world, and for which the 3B systems were specifically designed in order to exploit its insurpassed performance.

INVESTMENT. Invest in the 3B systems today, make a sound investment for tomorrow. And not just because they offer you authentic technological advances. But also because both Olivetti and AT&T are committed to protect your investment in software by continuing the upward compatibility of the UNIX System V.

*Ethernet is a trademark of the Xerox Corporation.
**UNIX is a trademark of AT&T Bell Laboratories.

olivetti

JOIN THE PARTY- OPENINGS FOR OEM AND VAR

Olivetti invites you to find out more about the 3B Systems through this invitation to attend a discussion conference. OEM and Value Added Resellers please fill out coupon, and mail to, your nearest Olivetti representative.

Name_____

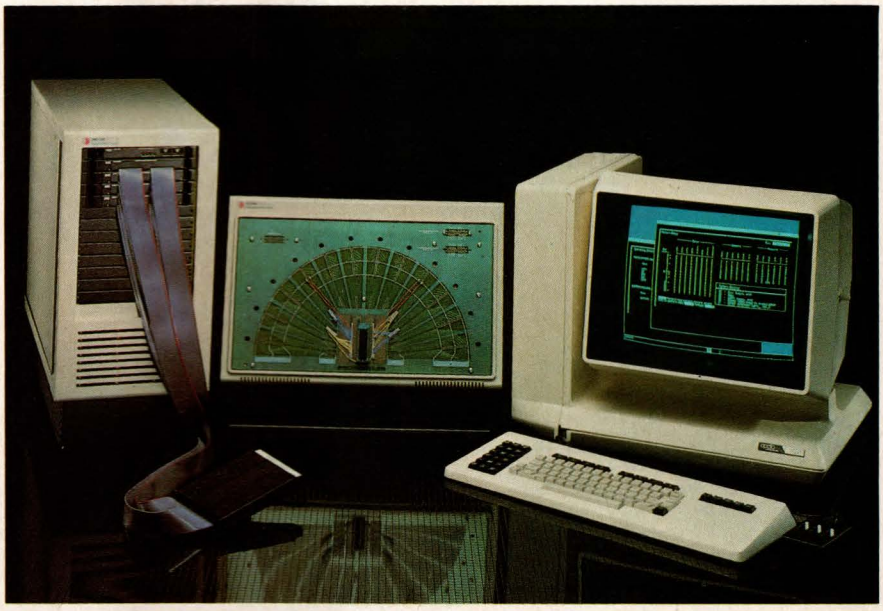
Address_____

Company_____

CAE design systems and functional testers combine to ease testing of prototype ICs

David Smith, *Associate Editor*

The growing complexity of semicustom and custom ICs is aggravating the problem of testing and verifying prototype chips. Fortunately, vendors of computer-aided engineering (CAE) systems and instrumentation systems are introducing products that simplify the solution to this problem. These products help you create and edit test patterns, and they apply the patterns to your IC. They also combine stimulation, acquisition, and comparison capabilities for less than what you would spend on a production ATE system or a GPIB-based instrument cluster. Most important, they interface to your CAE equipment so you can create, control, and evaluate your tests within your existing design system.



By performing tests under CAE control, *the Logic Master from Integrated Measurement Systems brings prototype IC testing to the designer's workstation. Tests created on the workstation download to the Logic Master over a GPIB or RS-232C connection, while test results return to the workstation for analysis.*

For the problem of the prototype test, the obvious solution would be a low-cost IC test system designed specifically to interface with CAE systems. The Logic Master Series of functional testers (formerly the Design Master; the name was changed because of trademark considerations) from Integrated Measurement Systems (Beaverton, OR) fits this description. These testers include a controlled-impedance environment for the device under test (DUT), a mainframe containing plug-in testing modules, and software that supports close interaction with many CAE systems over an RS-232C interface or a GPIB bus. (**Ref 1** supplies more information about the Logic Master and describes the role of hardware verification during IC design.)

As an IC tester, the Logic Master expands to meet your I/O requirements. The mainframe accepts 16-channel modules that perform pattern generation, data acquisition, or real-time data comparison. As many as 12 modules can fit in one mainframe, resulting in 196 testing channels. In addition, two mainframes operate in parallel to provide the ultimate system limit of 392 channels. Incidently, the mainframes are small enough to fit beside or below your desk.

The test modules operate at frequencies high enough to verify the operation of most ICs. The pattern-generator module applies test vectors at 20 MHz, but you can add an accessory that enables 40-MHz clocking. The timing resolution for all modules is 1 nsec, so the data-acquisition module can measure waveforms with the accuracy of a 1-GHz logic analyzer. If you attach a data-comparison module to a data-acquisition module, you can compare acquired data with expected results, even at 20 MHz. Therefore, you can generate tests that not only sense but also identify bugs in your chips by including branching and triggering techniques.

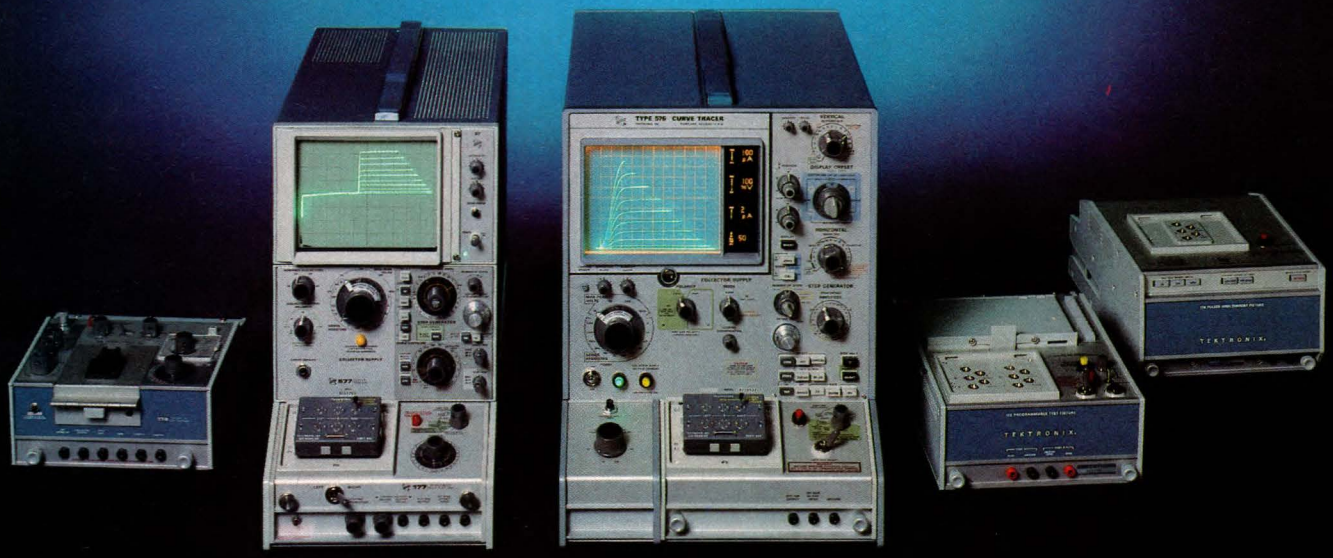
The cost of using the Logic Master depends on what modules you need to provide the test capabilities that you require. The lowest price configuration, at $29,000, offers 32 patterns of stimulation backed by 8k bits of pattern memory per channel. It also includes 32 channels of acquisition (also with 8k bits of associated memory) that compare acquired and expected data in real time.

If you need to evaluate your ICs more closely, the more sophisticated Logic Master II increases channel memory to 16k bits and supports programmable capabilities in the stimulus channels. In addition, the driver and receiver probes can operate at voltage levels defined in 10-mV increments. These added features bring the starting price to

TEK CURVE TRACERS

THE ANSWER BY ANY MEASURE

Tek curve tracers: No other measurements cost so little and save so much!



Affordable and easy to operate, Tek curve tracers visually document the performance characteristics of semiconductor devices.

For tightening design parameters and protecting yourself against the high cost of component failure, nothing compares with the Tek family of curve tracers.

Tek curve tracers help you quickly test semiconductor devices like diodes, transistors, opto isolators, thyristors and operational amplifiers. They can help you design, analyze and evaluate . . . to detect problems early, before they become far more costly to remedy.

Curve tracer mainframes include the 576, with both CRT display and scale factor readout . . . and the 577, with storage and non-storage CRT displays.

Test fixtures compatible with the 576 include the 176 pulsed high current test fixture that can supply up to 200 amps or 1000 watts to the device under test and the 172 programmable test fixture that offers the convenience and high throughput of semi-automated measurements. Compatible with the 577 are the versatile 177 standard test fixture and the 178, designed to test the performance of linear ICs.

Two curve tracer plug-ins are also available for Tek laboratory oscilloscopes: the 7CT1N for 7000 Series and the 5CT1N for 5000 Series scopes.

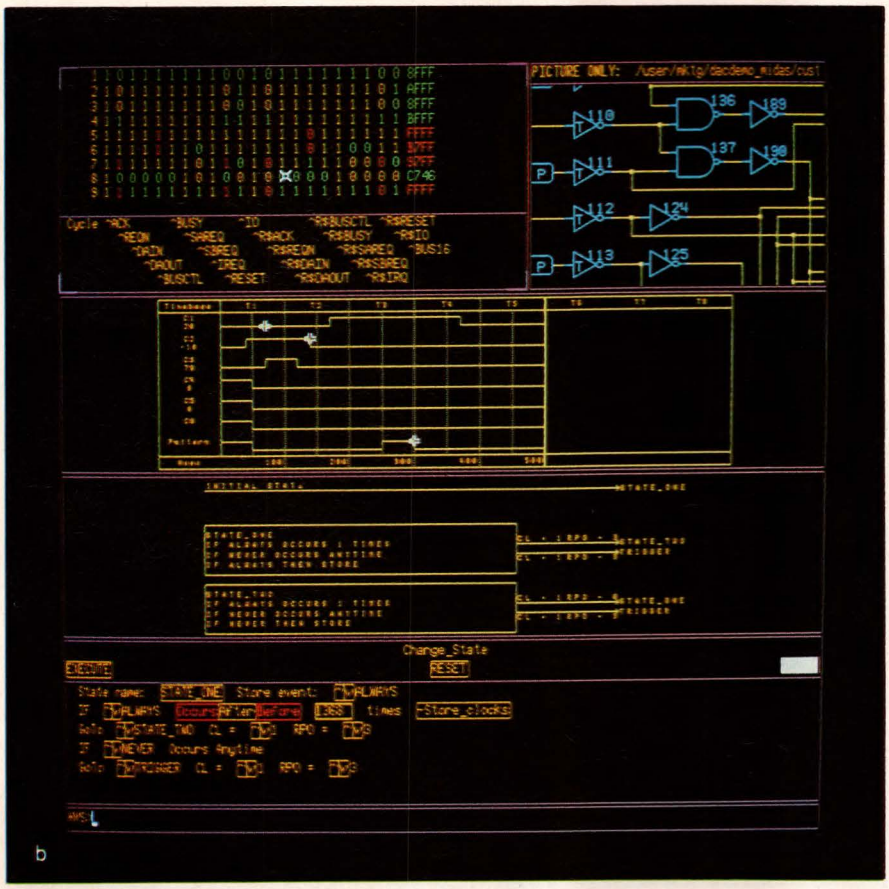
Learn more about how Tek curve tracers save you time and money. See your local Tek sales representative or contact:

Tektronix, Inc.
P.O. Box 1700, Portland, OR 97075.
Call 1-800-547-1512.
In Oregon, 1-800-452-1877.

Tektronix
COMMITTED TO EXCELLENCE

Copyright © 1984, Tektronix, Inc. All rights reserved. SCA-410-1

CIRCLE NO 54



The HVS tests prototype ICs *under the control of a Mentor Graphics workstation. The setup* ***(a)*** *puts creation and control of the test into a window on the workstation screen* ***(b).*** *The similarities between the simulation and test interfaces simplify the development and analysis of the tests.*

$39,000. In comparison, Integrated Measurement Systems estimates that a GPIB-based system with a controller can cost from $40,000 to $80,000, not including setup time. Furthermore, a production ATE system with similar timing capabilities costs more than $150,000.

The test-CAE interface

For the IC designer, the Logic Master's software places test generation and application within the CAE interface. This software resides on both the Logic Master mainframe and the CAE system. On the tester mainframe, the software controls each of the modules during the test procedure. In addition, it responds to a set of commands received from the CAE system over either an RS-232C interface or an IEEE-488 (GPIB) bus. The software at the CAE system allows you to control the testing (ie, issue those commands) using whatever data-entry techniques the system uses. For example, if the CAE system uses a menu-driven format, the test interface also uses it, allowing one user interface for both design and test.

To apply the CAE-supported test to the DUT, you must configure the test apparatus for your requirements. First, you select and insert the modules containing the stimulation and acquisition modules. Ribbon cables connect the I/O channels from the modules to the test fixture, allowing the mainframe to sit away from the fixture. For each I/O channel, the test fixture and ribbon cables provide a controlled impedance from the mainframe to terminals that are only centimeters from the DUT's socket. Briefly then, to configure the test fixture for the DUT, attach short wires from the socket to the terminals, and plug in the appropriate modules in the mainframe.

With the tester set up, you can create, execute, and evaluate tests on your system while sitting at your workstation. Initially, you transform your simulation patterns di-

rectly into suitable test patterns and download these into the tester. Next, you identify those channels in the modules that drive specific pins on the IC. You command the tester to run the test and to return the test results over the GPIB to the CAE workstation. Finally, a conversion program can translate the test results into a format that allows automatic comparison with the outputs of your simulation.

Integration vs resolution

The Hardware Verification System (HVS) brings similar capabilities to Mentor's Ideas series of CAE workstations. It also tests under workstation control, fits beside or on top of your desk, and provides a controlled-impedance environment for the DUT. You can select the test capabilities you need with plug-in modules. The creation, control, and evaluation of tests occurs at your workstation. Of course, the HVS, built for Mentor by Northwest Instrument Systems (Beaverton, OR) operates only with Mentor products.

In comparison with the Logic Master, the HVS has a more clearly defined interface with the CAE environment. This stems from Mentor's cooperation with the test-equipment supplier during the development of the product. As a result, the Idea workstation contains some of the conversion and comparison software you need to generate for the Logic Master. For example, the HVS includes the programs that both translate simulation data into test patterns and compare test output with simulation output.

In contrast, the HVS tests at lower frequencies than the Logic Master. Pattern generation proceeds at speeds to 20 MHz, and the 32-channel state (data) acquisition module operates at 10 MHz. By adding a timing-analysis option, however, you can achieve a 100-MHz sampling speed in 16 acquisition channels. Still, the sampling resolution is less than the resolution of the Logic Master.

Your required sampling resolution depends on how specifically you must determine the timing behavior of your DUT. Purely functional testing, with ICs based on static-circuit designs, does not need full clock speed to be accurate. In this case, an IC functions in the same manner at 1 MHz as it does at 10 MHz, unless you have demanding clocking or strobing signal relationships. Therefore, you should examine the extent to which you must specify signal timing when you test prototypes in your design environment. The integration and lower cost (starting at $24,000) of the HVS may outweigh the higher test rates of the Logic Master, particularly if you already use the Mentor Idea workstations.

The pattern-generation module in the HVS is available from Northwest Instrument Systems as an add-on to the IBM PC; it's known as the 2300 Series. One 2300 chassis offers as many as 160 channels for random-logic testing or as many as 120 channels for random-logic and memory testing. Coupled with Northwest Instrument's 2400 Series 20-MHz data analyzer, you can get 48 channels of pattern generation and 48 channels of data analysis for approximately $22,000 (without the PC). However, until logic simulators migrate to the PC and develop interfaces to the add-ons, this approach won't provide the CAE-test interaction of the HVS, although it's certainly competitive in price.

Simulators test functionality

Other CAE vendors support prototype testing through their simulation systems. Specifically, Daisy Systems and Valid Logic offer a hardware extension to their software-simulation capabilities. The primary use for these extensions is the virtual breadboarding of systems comprising many LSI or VLSI chips (**Ref 2**). However, the virtual breadboard is a suitable environment for the functional testing of your ICs.

To realize a virtual breadboard, the Daisy PMX and the Valid Realchip use plug-in boards similar in

By hooking an instrumentation system to a VAX, *the Tektronix DAS 9100 with the 91DVV software package links VAX Unix-based CAE tools to a variety of test configurations. The DAS (lower right) operates using local input from its own keypad or remote data from a VAX terminal.*

Discover HP's revolutionary answer to your measurement needs

Introducing an extremely versatile solution to your measurement needs: The HP 7090A Measurement Plotting System. By merging several technologies –waveform recording, digital plotting, analog recording, and automated measurement–the HP 7090A provides a powerful solution to a broad range of measurement problems. Imagine... significantly increasing your ability to measure and display low frequency phenomena and, at the same time, *substantially improving your real-time recording and digital plotting results. All in one* low-cost *system!*

Hewlett-Packard's new 7090A– the single-instrument solution for low frequency measurement, analysis and documentation

Now you can capture low frequency (<3kHz) signals.

The HP 7090A precisely measures, stores and displays signals through simultaneous sampling on each of three channels, with 12-bit resolution, a bandwidth of dc to 3kHz (33.3k samples/s maximum) and a 1000 word memory per channel.

You get 6 trigger mode flexibility.

Virtually any signal change can now initiate signal capture through HP's six trigger modes Even decaying repetitive signals, such as faults in a power line voltage or in a transducer's carrier, can be captured. And combined with our pretrigger capability, the HP 7090A Measurement Plotting System is your ideal system for turn-on/turn-off characterization, fault monitoring and mechanical motion analysis.

Plus, it's a system component.

All panel functions of the HP 7090A are programmable via the HP-IB interface. And data can be streamed at up to 500 points/s from either the internal 1K buffers, or in real time from the analog-to-digital converters. A menu driven software package is available for HP Series 200 computers, allowing you easy data manipulation, storage/retrieval, and system integration.

And the HP 7090A gives you much more...

The HP 7090A is also a high performance real-time X-Y recorder, digital plotter and DVM. In a stand-alone mode, it annotates setup conditions, date and time, selected data points from memory and even the trigger time. Plus, you can even make overhead transparencies for technical presentations!

The HP 7090A is your low-cost, one-stop system.

From its 3 analog inputs to its 6-pen writing system, the HP 7090A adds a totally new dimension to low-frequency measurement, analysis and display. And with a price tag of only $4400,* the HP 7090A is your complete measurement plotting system.

Send today for your free information package.

Clip out and mail the coupon below to receive–absolutely free– a complete information package, including our detailed brochure and specifications.

*Domestic U.S. price only

HEWLETT PACKARD

1101405

YES! I need a one-stop breakthrough solution like this in my lab. Please send me more information about Hewlett-Packard's new HP 7090A Measurement Plotting System.

Name

Title

Address

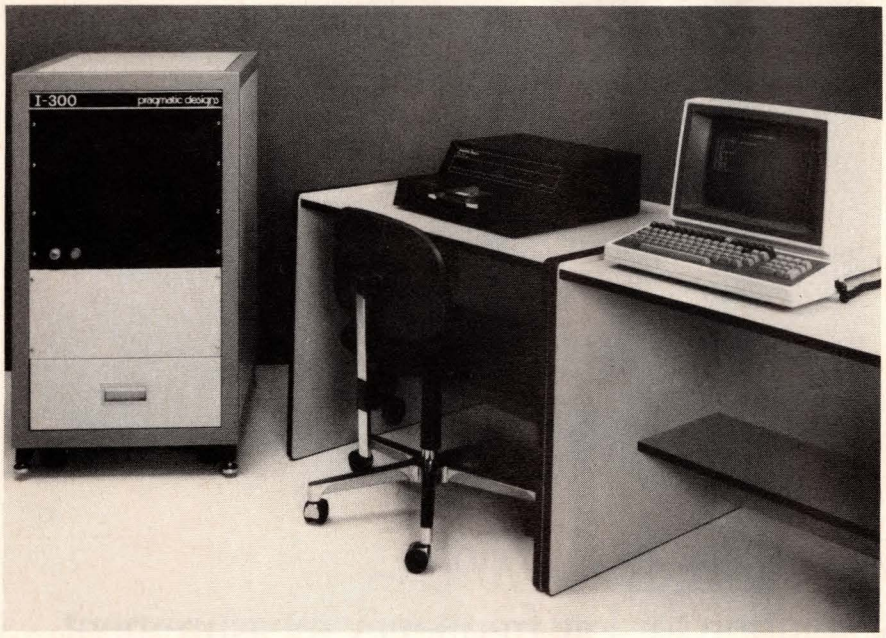
City State Zip

Phone ( )

Detach and mail to:
Hewlett-Packard
16399 W. Bernardo Drive,
San Diego, CA 92127

Attn: Marketing Communications **11405 EMX**

CIRCLE NO 55



By adding simulation software, *the Inspector 200 and 300 testers from Pragmatic Test Systems integrate CAE and testing. The Eplog software accepts net-list input, simulates the design, and generates test vectors for prototype IC test.*

function to those in the Logic Master and the HVS. Driver and receiver circuits on the boards compose a simple functional-test system for the ICs you include in the system simulation. During simulation, these ICs are equivalent to IC models in software. The simulator can therefore query the IC instead of the software model for functional information. Because the IC responds more quickly than the software model, the simulation time decreases.

With regard to the functional verification of ICs, the equivalence between the IC in the virtual breadboard and its software model allows you to apply to a prototype IC the same stimulus patterns you used to functionally test the software representation of your design. In other words, by inserting your prototype into the hardware extension, you can run the same test patterns on it as you ran on your logic design.

There are some advantages to this method. First, the test patterns require no translation: If the response of the prototype differs from simulation results, translation errors are not to blame. Next, the Realchip and PMX can cost less than the Logic Master or the HVS depending on which options you purchase. They start at $29,000 and $15,000, respectively. Finally, you have the resources for system simulation and debugging available. The verified IC can immediately operate in a simulation of the system for which you have designed that IC.

On the other hand, these hardware extensions for simulation can provide information concerning only functional behavior. They are not test systems; you cannot analyze timing behavior. In addition, Realchip and PMX clock the ICs at 3 and 1 MHz, respectively, and these frequencies are lower than the clock rates of many IC-based systems. If your verification effort requires running the prototypes at full speed, or if you must verify signal waveforms as well as levels, you need more testing capabilities.

Integrated-instrument control

Traditionally, instrumentation manufacturers have supplied the logic analyzers that perform the waveform analysis. Now they see the CAE workstation as a direct link between their test instruments and the designers who use the workstations for the design of complex, hard-to-test electronics. These companies have been integrating pattern generation and analysis functions into instrumentation systems for a few years. Now some are providing the interfaces that integrate the instrumentation systems with the CAE workstations.

One example, the Tektronix DAS 9100, uses a variety of instrumentation plug-ins that provide the resources for functional and timing analysis of digital ICs and board-level systems. In addition, it includes a local processor, a keyboard, and a built-in monitor (color optional). The plug-ins are similar to the modules previously discussed—with pattern generation, data acquisition, and timing analysis—but you can test your DUT using only the keyboard and monitor without the need for a host computer system for test entry and control. As a result, the DAS 9100 has usually operated independently of the design system.

This year Tektronix has complemented the DAS 9100 with the 91DVV software package that, over an RS-232C connection, allows you to create and control test procedures for the DAS 9100 from your VAX terminal. The software for the VAX, written in C, runs under Unix 4.1; therefore, the 91DVV software can interface with any CAE software written for the VAX Unix 4.1 environment. In particular, the 91DVV compresses simulation vectors into DAS pattern-generator programs, downloads these programs to the DAS 9100, uploads the results of the test into the VAX, and finally compares hardware responses with simulation output.

VAX governs instrumentation

This package aims at VAX-based design groups that need timing analysis as well as functional verification. For a 25-MHz maximum test rate, the DAS mainframe can support 80 pattern-generation channels

"Our applications engineers always want me to buy 'the latest this' or 'the latest that.' How come USIR's never satisfied?"

Because newer, better electronic test instruments are introduced all the time, Bob, and we want to make sure we have the latest equipment for our customers.

As the leader in the electronic test equipment rental business, we have a reputation to uphold. That's why we constantly survey the industry, to make sure when new, state-of-the-art equipment is developed, we have it. We also stock our inventory in depth to make sure you can have exactly what you want when you want it.

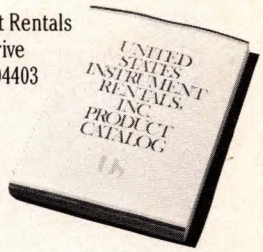
We offer state-of-the-art financing, too, with lots of options. You can rent, lease, or buy. And you can choose from a variety of financing plans, all with very flexible terms.

Don't settle for anything less than the latest. Call us.

To receive our new, 1984 catalog, circle the number below. This 264-page catalog is a valuable reference book, with thousands of test equipment listings, guidelines for matching applications, and suggestions for financing. And it's yours, free.

We go the extra mile.

U.S. Instrument Rentals
2988 Campus Drive
San Mateo, CA 94403
415/572-6600



United States Instrument Rentals, Inc.
A U.S. Leasing Company

Call toll-free

For the number of your nearest sales office, call toll-free 800-242-USIR, ext. 932.

© 1984 U.S. Instrument Rentals, Inc.

and 96 acquisition channels. For more exact timing analysis, you can insert 91A08 data-acquisition modules for 32 channels of synchronous or asynchronous sampling at 100 MHz. You can switch to 91A04A modules for asynchronous sampling at 660 MHz (1.5-nsec sample interval) or synchronous sampling at 300 MHz of as many as 16 channels. A typical DAS 9100 system configured for IC verification costs about $40,000.

Though these sampling rates may satisfy timing-analysis requirements, they may be excessive (and costly) for a basic functional test. Remember that you can select the modules you need for the DAS; less powerful acquisition modules cost less.

For the DAS, the more restrictive criterion is the software providing the CAE-test interface. First, you need to write a program to convert your simulator's output into the TLOGS format for the 91DVV input as well as one to translate the results of the test back into your simulator's format for comparison to simulation results. Though this is a minor task, it does require some familiarity with both formats. More importantly, if your CAE tools run under any operating system but VAX Unix, you cannot use the 91DVV. Tektronix promises to start expanding the range of compatible hosts and operating systems by the end of 1984.

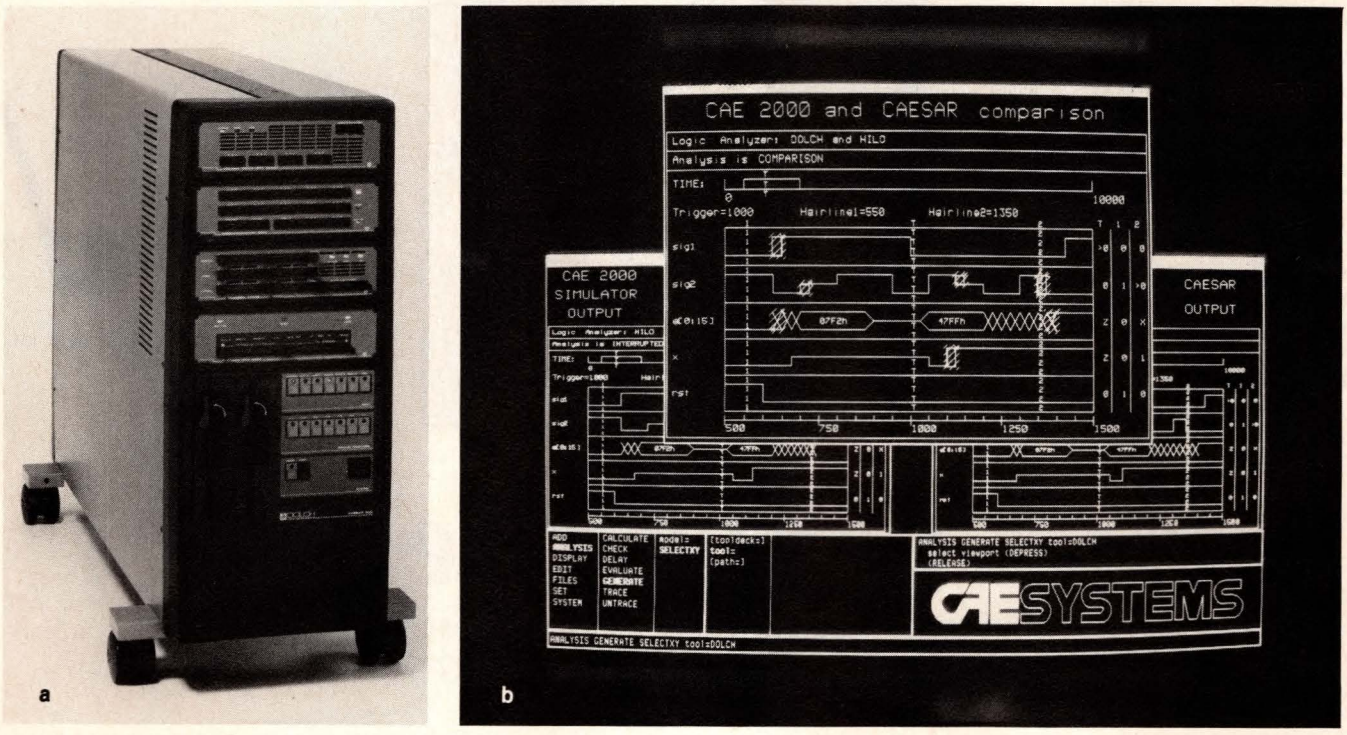
Tester uses existing modules

If you use workstations made by CAE Systems (Sunnyvale, CA), Dolch Logic Instruments (San Jose, CA) offers an integrated instrumentation system that interfaces with your design system. The Caesar 400 can accept four plug-in modules of the set already offered for Dolch's Atlas and Colt instrumentation systems. These modules can put 96 channels of 20-MHz pattern generation, as well as 96 channels of 20-MHz acquisition (or 64 acquisition channels at 100 MHz, or 32 acquisition channels at 300 MHz) in one Caesar mainframe. The test procedure, including test-pattern generation, pin assignment, prototype test, and comparison with simulation data, occurs in the windows of the CAE Systems' user interface.

As a result of the close cooperation of Dolch and CAE Systems, expect the Caesar to interact closely with the CAE Systems environment, much as the HVS from Mentor does. Also, Caesar costs roughly the same (for similar capabilities) as the HVS, ranging from $13,000 to $25,000. Obviously, at this time, the HVS works only with Mentor products, and the Caesar only with products from CAE Systems, so the choice of functional testers depends on your choice of CAE vendors.

CAE enters test systems

Instead of depending on your CAE vendor for an interface to test equipment, you can bring the design database to a testing system. Pragmatic Test Systems (Milpitas, CA) brings a package of simulation and test software to its Inspector 200 and 300 Series test systems. This package, Eplog, simulates logic designs that you enter as net lists. Next, it converts the simula-



Four instrumentation plug-ins provide flexibility *for the Caesar test system* ***(a).*** *When the plug-ins are connected to a CAE Systems workstation, test patterns and results appear in a test window* ***(b).*** *In addition, simulation results can be combined with the test results (middle window) for easy comparison.*

PRECISION At Precision Monolithics, only three things count: precision, precision, and precision.

We believe quality control isn't just the last step before shipping. It's the last, the first, and every step in between.

If you already specify our analog ICs, precision is part of your philosophy. But for us, it's even more.

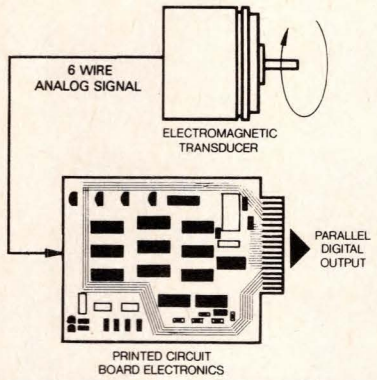
It's our name.

Precision Monolithics Inc.
1500 Space Park Drive, Santa Clara, California 95050, USA.

A Bourns Company.

® PMI

LOW-COST ABSOLUTE ENCODERS



ASI's ECONOCODER.® AVAILABLE WITH RUGGEDIZED TRANSDUCERS INCLUDING EXPLOSION-PROOF.

ECONOCODER position detectors/controllers provide precise digital output proportional to angular shaft position. Because the output is absolute, it is unaffected by power outages and surges. And, equipped with the explosion-proof housing option, ECONOCODER is ideal for use in volatile applications such as paint spraying and grain storage.

ECONOCODER consists of an electromagnetic transducer and a printed circuit board or panel-mounted enclosure. Just 6 wires connect the transducer to the PC board which can be located up to 1000 ft. away. Binary and BCD digital outputs with programmable controller interface are available with resolutions as high as 1000 counts per 360°.

ECONOCODER is just one economy model of Astrosystems' broad line of resolver-based systems. Many thousands of ASI systems are at work in industry today providing measurement data wherever accuracy and reliability are required. We also offer a complete line of encoders and limit switches utilizing NEMA standard and environment-resistant transducers.

Check ASI first. Call or write today for our technical bulletin on ASI ECONOCODER.

ASI Econocoder®

Advanced Position Measurement Systems for Industry

asi
astrosystems. inc.

6 Nevada Drive, Lake Success, NY 11042
516-328-1600 • TEX 510-223-0411

CIRCLE NO 57

TECHNOLOGY UPDATE

For more information . . .

For more information on the products discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

CAE Systems Inc
1333 Bordeaux Dr
Sunnyvale, CA 94089
(408) 745-1440
Circle No 732

Daisy Systems Corp
139 Kifer Ct
Sunnyvale, CA 94086
(408) 773-9111
Circle No 733

Dolch Logic Instruments Inc
2029 O'Toole Ave
San Jose, CA 95131
(408) 945-1881
Circle No 734

Integrated Measurement Systems Inc
9525 SW Gemini Dr
Beaverton, OR 97005
(503) 626-7117
Circle No 735

Mentor Graphics Corp
8500 SW Creekside Pl
Beaverton, OR 97005
(503) 626-7000
Circle No 736

Northwest Instrument Systems
Box 1309
Beaverton, OR 97075
(503) 645-5151
Circle No 737

Tektronix Inc
Box 500
Beaverton, OR 97077
(503) 644-0161
Circle No 738

Valid Logic Systems Inc
2820 Orchard Parkway
San Jose, CA 95134
(408) 945-9400
Circle No 739

tion data into test vectors that run on Inspector test systems. Without much of the burden of test generation, you benefit from the flexibility and programmability of a test system.

Using this approach for prototype verification pays off in environments where budgets are tight and timing requirements are loose. For as little as $50,000, you can own the hardware and software both to simulate designs and to test prototypes. In comparison, a CAE Systems design workstation without the Caesar product costs $50,000 to $150,000 depending on the software options. However, the Inspectors' test clocking peaks at 1 MHz, so many chips run at less than maximum frequency. Still, the Inspectors' programmable resolution (5-mV increments) and current measurement allow you to characterize IC parametrics; logic analyzers and hardware-simulation extensions don't provide this capability.

The net result of bringing CAE programs to the test computer is the same as that of introducing test capabilities into CAE systems—making prototype test as easy for the designer as the rest of the design process. To simplify testing, these products link integrated testing capabilities with a CAE environment. The choice of which products to use depends on your existing CAE tools, your testing requirements, and particularly your budget. Unfortunately, predicting your future test needs can be as hard as predicting your budget, so the choice depends more on the efficiency and productivity you can achieve with a particular functional tester integrated into your design environment. **EDN**

References

1. Palmquist, Steve, et al, "Hands-on IC testing aids chip designers," *EDN*, October 18, 1984, pg 253.
2. Freeman, Eva, "Physical modeling systems let you plug VLSI chips into your workstation's logic," *EDN*, November 15, 1984, pg 69.

Article Interest Quotient
(Circle One)
High 500 Medium 501 Low 502

Need to Know?

EDN's advertisers stand ready to provide you with helpful design information and other data on their products. Just circle the appropriate numbers on the Information Retrieval Service card. If your need is urgent, contact advertisers directly, and mention EDN.

EDN: Everything Designers Need

LEADERSHIP Since 1969 Precision Monolithics has been a leader in the world of precision bipolar analog ICs.

We invented the DAC-08, the REF-01, the OP-07, the OP-27 and more. All industry standards. Soon we'll be bringing precision to the world of analog CMOS, and again we'll establish new standards. Technological leadership is more than being the first.

It's being the best.

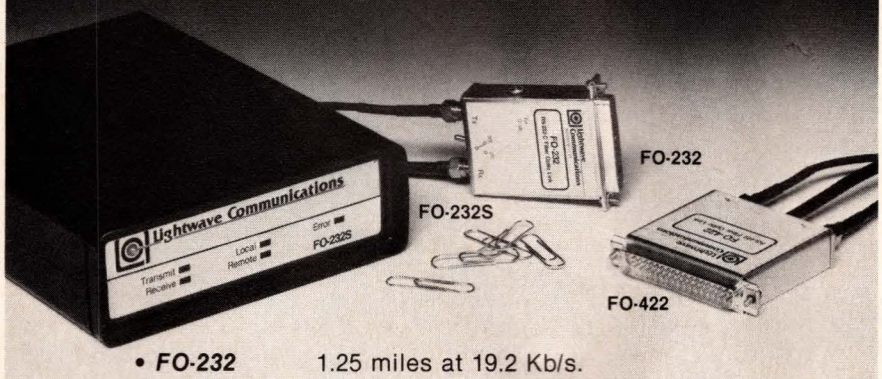
Precision Monolithics Inc. 1500 Space Park Drive, Santa Clara, California 95050, USA.

A Bourns Company.

PMI®

FIBER OPTIC DATA LINKS

Our FO-SERIES offers longer signal distances and greater data rates without modems or line drivers.

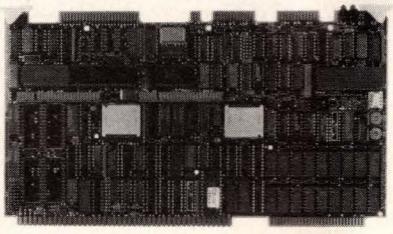


- **FO-232** 1.25 miles at 19.2 Kb/s.
- **FO-232LD** 2.5 miles at 19.2 Kb/s.
- **FO-232E** 250 ft. at 19.2 Kb/s.
- **FO-232S** Synchronous/1.25 miles at 19.2 Kb/s.
- **FO-422** 1.25 miles at 10 Mb/s.

Lightwave Communications, Inc.
650 Danbury Road, Ridgefield, CT 06877 • (203) 438-3591

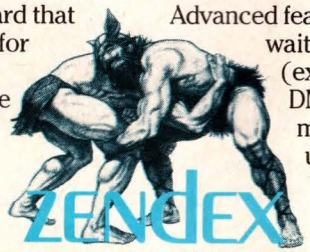
CIRCLE NO 58

Reason #34
to call Zendex 2nd
(If you insist on calling Intel first.)



ZX-186/30 CPU Board

An 80186-based CPU board that is an ideal replacement for the iSBC-86/30 or iSBC/86/12A. It is fully software compatible with the ZX-86 and the entire iSBC-86 family.



Advanced features: 256KB zero-wait-state on-board RAM (expandable to 1MB) two DMA channels, Dual multi- protocol USART, up to 128KB PROM and two iSBX connectors.

The other giant in the Multibus Market.™

6700 Sierra Lane, Dublin, CA 94568, Phone: (415) 828-3000 TWX: 910 389 4009. Zendex products are available worldwide.
Intel, iSBC and iSBX are trademarks of Intel Corp.

CIRCLE NO 59

WHERE CAN I FIND PERFORMANCE?

PMI International Offices

France
Bourns-OHMIC-PMI
01-203 96 33

Germany
Bourns-PMI
0711-21 740

Netherlands
Bourns-PMI
070-87 44 00

Switzerland
Bourns-PMI
042-33 33 33

United Kingdom
Bourns-PMI
01-572 65 31

Hong Kong, Korea, Taiwan, and Singapore
Bourns Asia Pacific
(03) 724-0386

Japan
Nippon-PMI
(03) 234-1411

Australia
RIFA Pty. Ltd.
(02) 570-8122

Austria
Ing. Otto Folger
0222-43 26 39

Belgium
Vekano N.V.
02-720 92 04

Denmark
Tage Olsen A/S
02-65 81 11

Finland
Insele Oy
80-73 57 74

Greece
Germanis Co.
01-821 58 25

Israel
Rapac Electronics Ltd.
03-47 71 15

Italy
Technic S.R.L.
02-569 57 46

Norway
A/S Kjell Bakke
02-83 02 20

Portugal
Telectra S.A.R.L.
19-68 60 72

South Africa
Allied Electronic Components
52 86 61

South Africa
Associated Electronics Ltd.
011 839 18 24

Spain
Sonelco S.A.
01-409 46 34

Sweden
Bexab Elektronik AB
08-768 05 60

Turkey
Nel, Nuekleer Elektronik Ltd.
041-30 15 10

Yugoslavia
Jugomineral
041-42 37 46

Eastern Europe
Ing. Gerhard Stoits
0222-245 74 12

PMI®

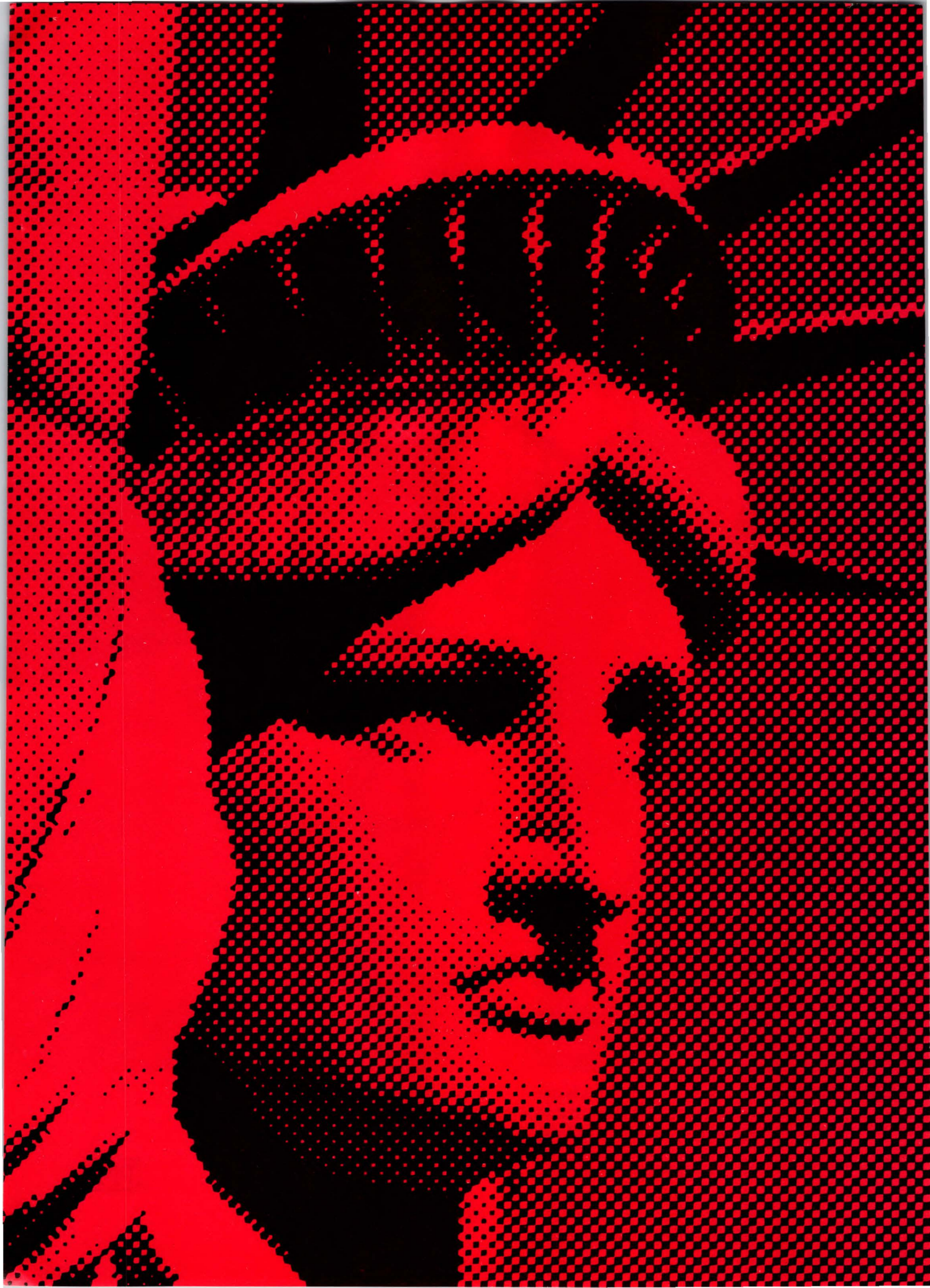
PERFORMANCE Precision Monolithics is one of those rare companies that would rather help you than sell you. We know if our analog ICs do what we say they'll do, you'll be sold.

So we offer sales engineers—technical problem solvers—who take the time to understand your application. And we support them with people who care.

Why? Because your success is our success.

Precision Monolithics Inc.
1500 Space Park Drive, Santa Clara, California 95050, USA.
A Bourns Company.

PMI®



Give me your inefficient, your overpriced.

Announcing liberation from oppressive gate-array production costs:

The Universal Netlist Translator, only from INTERNATIONAL MICROELECTRONIC PRODUCTS, INC.

Just give us the netlist from your current gate-array design. In ten weeks, you'll have a standard-cell circuit, fabricated in our silicon-efficient three-micron CMOS process.

The Universal Netlist Translator converts any semicustom circuit to our library of fully characterized standard cells. That can mean substantial savings over what you now pay for gate arrays, particularly if your production volumes are increasing. And it opens up an alternative source for your standard-cell circuits, which could save your business during a backorder.

To learn more about how the Universal Netlist Translator will set you free, call or write:

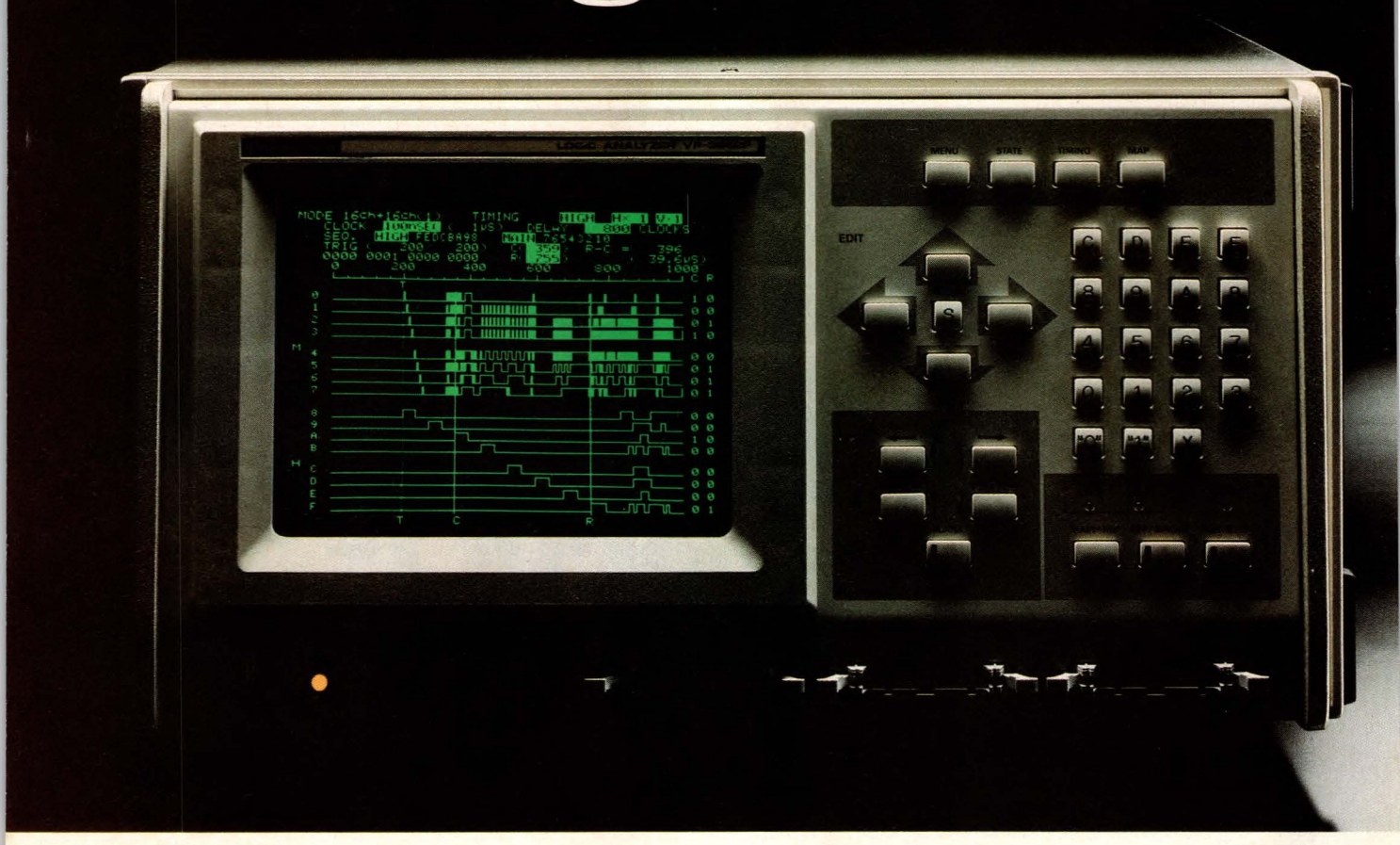
INTERNATIONAL MICROELECTRONIC PRODUCTS
2830 North First Street, San Jose, CA 95134
(408) 262-9100

For every netlist translated before March 1, 1985, INTERNATIONAL MICROELECTRONIC PRODUCTS, INC., will donate $1000 in your name to the Statue of Liberty restoration fund.

INTERNATIONAL MICROELECTRONIC PRODUCTS

CIRCLE NO 60

The Logical Choice



Logic Analyzers with Multiple Functions— Simultaneous Hardware and Software Analysis/ Disassembled Mnemonic Display

When the chips (or other logic devices) are down, you need fast, accurate logic analysis, high-speed performance and multichannel capacity. Where can you get all this at a price you can afford? From Panasonic, of course. We give you a choice of 3 logic analyzers—the VP-3662A, VP-3661A and VP-3620A —to meet virtually any need in timing, state and microprocessor analysis. The sophisticated **VP-3662A** is the top choice with 100MHz high-speed resolution, 48 channels and real-time analysis, plus simultaneous 16-bit/8-bit microprocessor analysis and 100MHz/16-channel peripheral equipment timing analysis.
All 3 models feature an optional disassembled mnemonic display for 16-bit and 8-bit microprocessors (VP-3661A: 8-bit only), and optional RS-232-C serial data analysis. So whether you choose the VP-3620A, the VP-3661A or the VP-3662A, you can be sure that you've made the logical choice.

VP-3661A
- 32-channel high-speed analysis with maximum resolution of 100MHz.
- Disassembled mnemonic code display for 8-bit microprocessor software.
- Simplified data analysis with NAME display for each channel.
- Multiple display modes plus flexible trigger functions for easier debugging.

VP-3620A
- 32-channel high-speed analysis with maximum resolution of 20MHz.
- Disassembled mnemonic code display for 16-bit/8-bit microprocessor software (optional).
- Flexible trigger and versatile display functions for powerful debugging.
- Glitch trigger function for transients as narrow as 10ns.

National/Panasonic

Matsushita Electric Trading Co., Ltd. Industrial Electronics Section, P.O. Box. 18, Trade Center, Tokyo 105, Japan Telex: 522-8771 "METOSK J"

CIRCLE NO 62

Motorola Reports

NOVEMBER ISSUE 1984

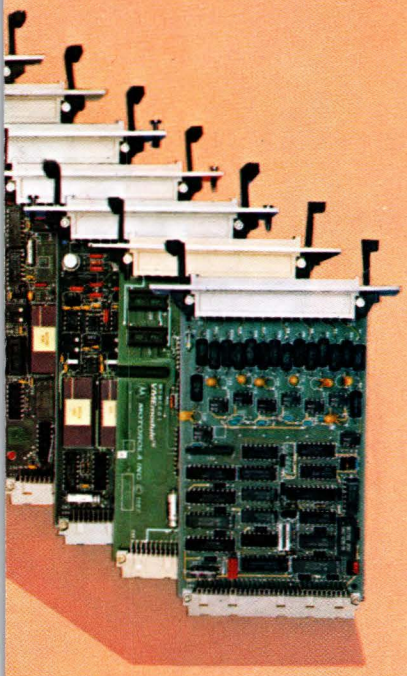
VMEmodules: valuable system investments

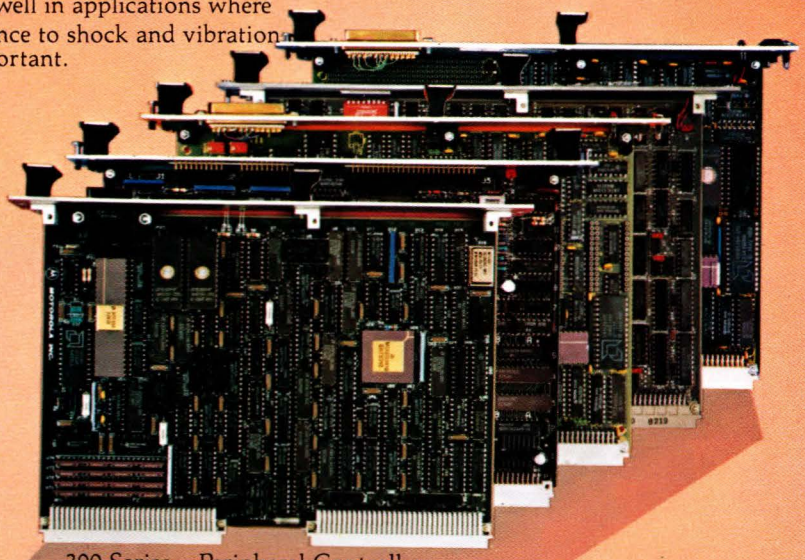
- ☐ RGB encoder generates studio color
- ☐ MC68010 now on VERSAmodule monoboard
- ☐ Evaluate MC68020 with the Benchmark 20
- ☐ Software flood for VME/10 microcomputer

MOTOROLA

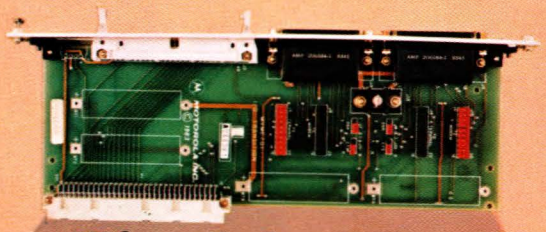
)verview

Adopting the popular Eurocard mechanical format, VMEmodules are available in two pin-out compatible sizes. Single high and double high board are used to afford a high degree of space flexibility for system configurations. Pin/socket connectors, card cages, backplanes, and plug-in power supplies all meet rigid DIN and IEC standards, and perform especially well in applications where resistance to shock and vibration is important.

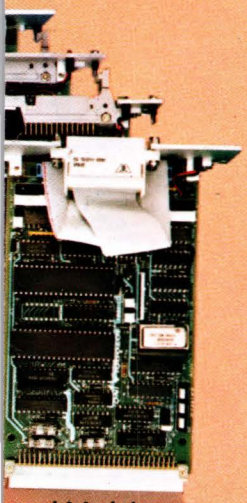




300 Series — Peripheral Controllers
GPIB, universal IPC, SASI, Winchester/floppy, Ethernet, serial and parallel I/O controllers
SASI, I/O channel interfaces



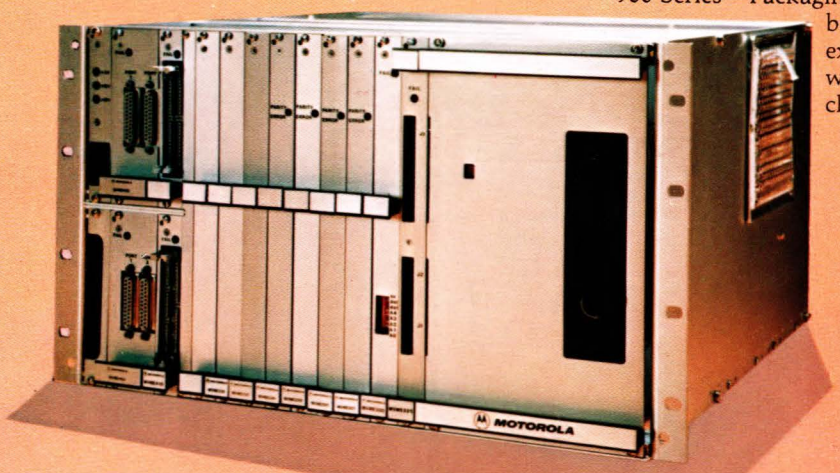
700 Series — Non-Eurocard I/O
wire wrap boards
connectors
mass storage extenders



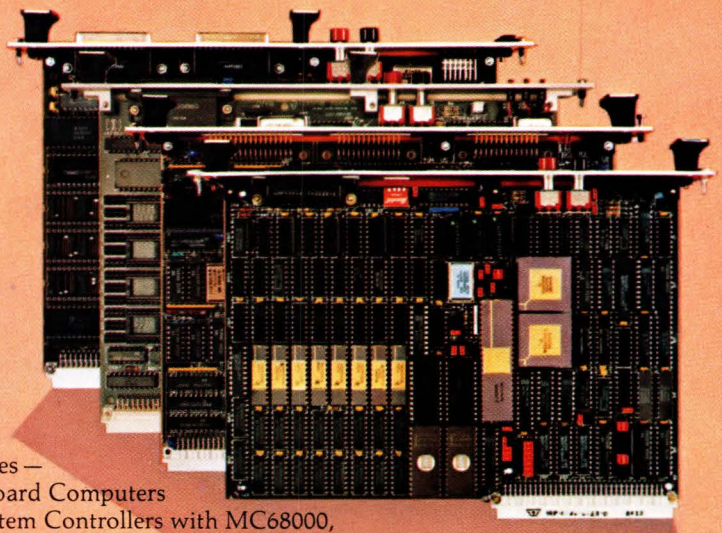
annel Modules
parallel ports
printer

pe adapters

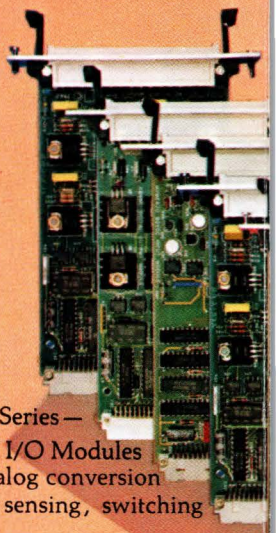
900 Series — Packaging Hardware
backplanes
extender boards
wire wrap boards
chassis



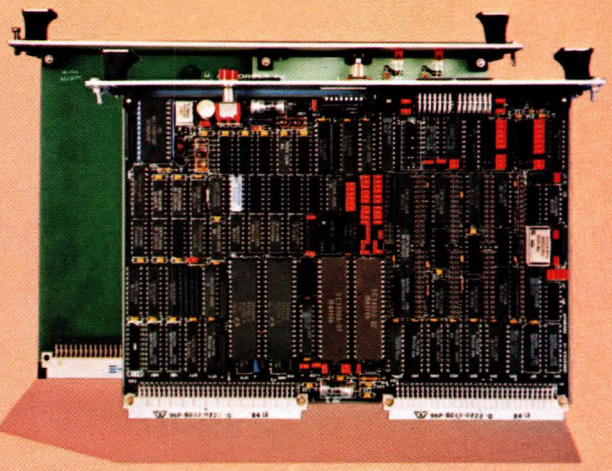
VMEsystem Components C



100 Series —
Monoboard Computers
and System Controllers with MC68000,
MC68010, and MC68020 Processors

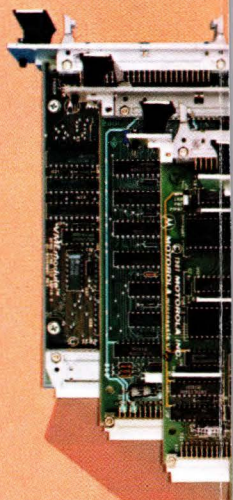


600 Series —
Industrial I/O Modules
analog conversion
sensing, switching

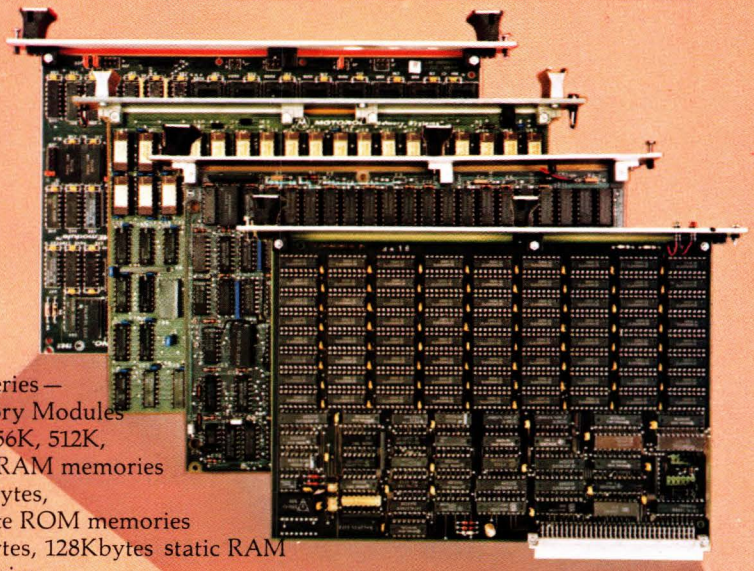


800 Series — Mass Storage Support
Products
15 Mbyte Winchester
1 Mbyte DS/DD 5¼" floppy

(not shown)



400 Series — I/O C
dual channel serial or
Centronics compatible
interface
SASI™ ½" magnetic ta



200 Series —
Memory Modules
64K,256K, 512K,
2M DRAM memories
128Kbytes,
1Mbyte ROM memories
32Kbytes, 128Kbytes static RAM
memories

Readily available cache enriches VMEmodules.

Having cash handy makes good financial sense. Quick access to cache makes good computing sense. With the new VME120 monoboard microcomputer, 4 Kbytes of instruction cache are provided along with a choice of 128 or 512 Kbytes of on-board dual port RAM. The on-board cache memory increases overall system processing speed by allowing faster access and minimizing off-board activity. This is especially important in performance-sensitive applications, such as image processing and high-speed scientific data acquisition.

With an optional 12.5 MHz MC68010 MPU, the VME120 provides throughput of up to 3 million instructions per second.

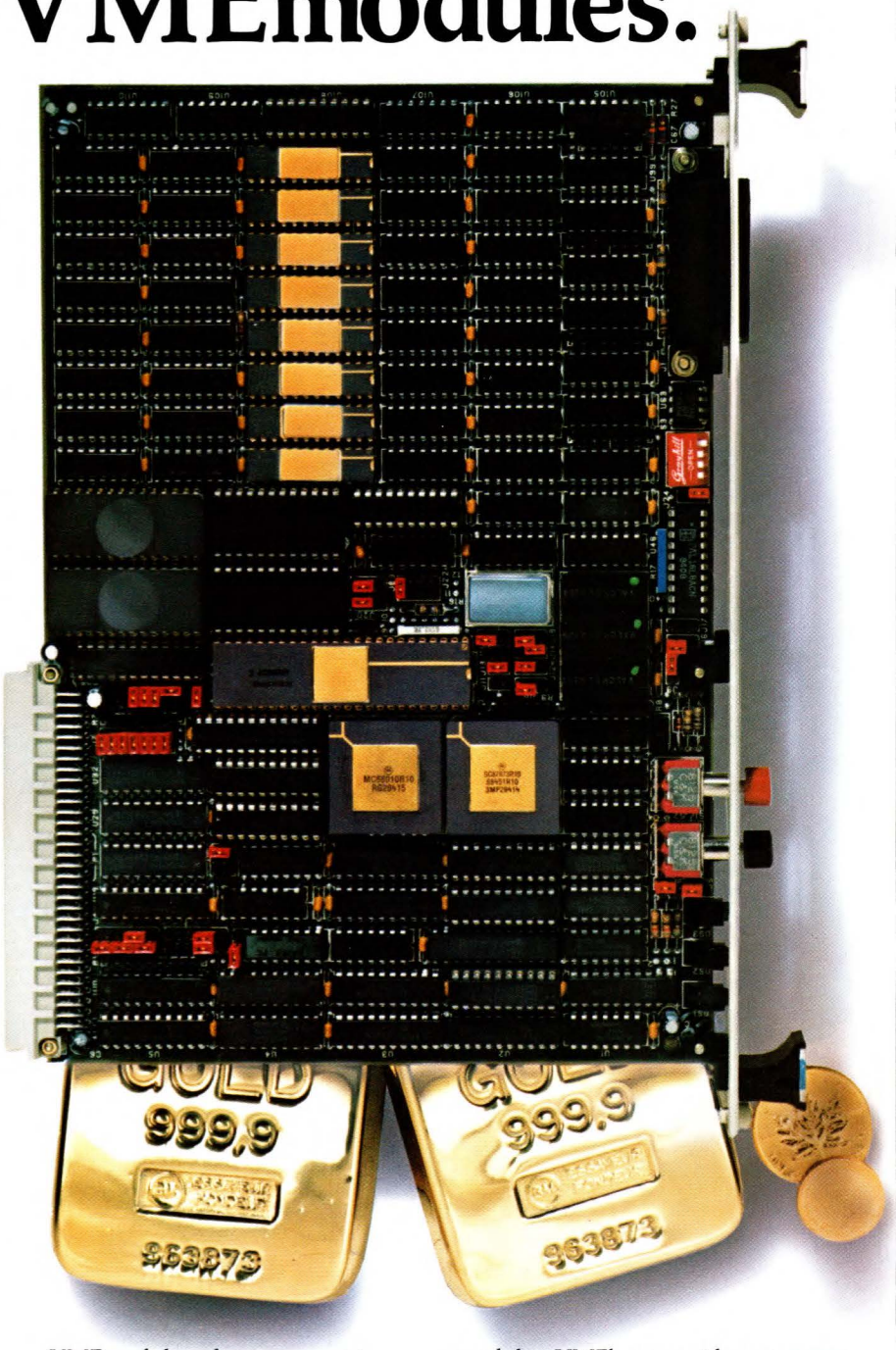
Additional new VMEmodule products allow integration of powerful application systems with a minimum number of system components.

The VME050 system controller may be used with the VME120 processing module to provide global interrupt generator, system clock, serial clock and time-of-day clock functions. It also houses eight 28 pin sockets, two RS-232C serial ports and one parallel port.

The VME320 disk controller is a double-high Eurocard module for adding mass storage capacity to a VMEbus system. It provides high performance DMA data channels between system memory and Winchester hard disk drives and/or floppy disk drives. This disk controller is used in applications having intensive real-time disk I/O or multiprocessing structures to reduce VMEbus traffic and increase system throughput.

For VMEmodule applications requiring mass storage, the VME820 is an integrated module incorporating a disk controller board, plus both a Winchester and floppy disk drive, all in a convenient Eurocard format plug-in unit.

The VME943 chassis provides 9 VMEbus slots and 6 I/O channel slots in the front, with room for 16 I/O channel or 80mm slots provided in the rear. The chassis uses a tranverse, mid-chassis 400 watt power supply. It is 19 inches deep and designed for mounting in a standard 19 inch rack.



VMEmodule software support includes VERSAdos, Motorola's real-time, multi-tasking, multi-user operating system that includes M68000 Family macro assemblers, a full screen editor, linker and symbolic debugger.

For efficient software evaluation and debug, VMEbug is one of Motorola's debug/monitor firmware products supporting various processor modules. VMEbug provides an assembler/disassembler feature, commands to examine or modify memory, and terminal I/O, disk I/O and boot capabilities.

These new boards add additional system building block features to the broadest line of VMEbus compatible boards available.

Check ☐ A for information.

We're on your design-in team.

Of special interest...

VME 331*
serial I/O controller
- MC68000 based
- 2 asynchronous ports
- 4 synchronous or asynchronous ports
- all 6 RS-232C or RS-422
- 128/512 Kbyte RAM
- 2 28 pin sockets

VME 050
system controller
- used with VME 115, 120, 128 and 130
- 8 28 pin sockets
- 2 RS-232C serial ports
- 2 parallel ports
- provides: interrupt handlers
  system clock
  serial clock, and
  time-of-day clock

VME 211
static RAM/ROM
- 16 28 pin sockets
- backed up from +5 standby
- up to 1 Mbyte ROM
- up to 128 Kbyte SRAM
- mix static RAM and ROM
- selectable access time

VME 315
intelligent SASI™ interface
- floppy controller for 4 5¼" or 8" floppies
- DMA access
- 1 RS-232C debug port

VME 300
GPIB controller
- meets full IEEE488-1979 standard
- DMA interface
- selectable byte or burst transfers
- up to 500 Kbyte/Sec transfer rate

VME 316
VMEbus to I/O channel interface
- converts I/O channel interrupts to VME interrupts
- converts VMEbus RESET to I/O Channel RESET
- selectable address block

VME 202/222
512K/2M DRAM
VME 203*/223*
512K/2M DRAM with VMXbus
- byte parity
- on-board refresh
- selectable memory map

VME 320
Winchester/floppy controller
- up to 2 5¼" Winchesters
- up to 4 floppies
- DMA access
- 32 bit ECC code

*To be introduced in 1985.
SASI is a trademark of Shugart Associates.
Ethernet is a trademark of Xerox Corp.

VME 128*
monoboard microcomputer with cache
- MC68010 (12.5MHz)
- 2 28 PIN sockets
- 4 Kbyte instruction cache (optional)
- 256 Kbyte dual port RAM
- 1 RS-232C debug port
- triple programmable timer
- VMXbus interface
- uses VME 050 system controller

VME 130*
32-bit monoboard microcomputer
- MC68020 (16MHz)
- MC68851 PMMU (optional)
- MC68881 co-processor (optional)
- 2 28 pin sockets
- 512 Kbyte dual port RAM
- VMXbus interface
- uses VME 050 system controller

VME 330
Ethernet™ 2.0 LAN controller
- complete transceiver interface
- MC68000 (10MHz)
- LANCE chip and SIA devices
- 128K dynamic RAM
- 32K EPROM
- 1 RS-232C debug port

Check ☐ B for information.

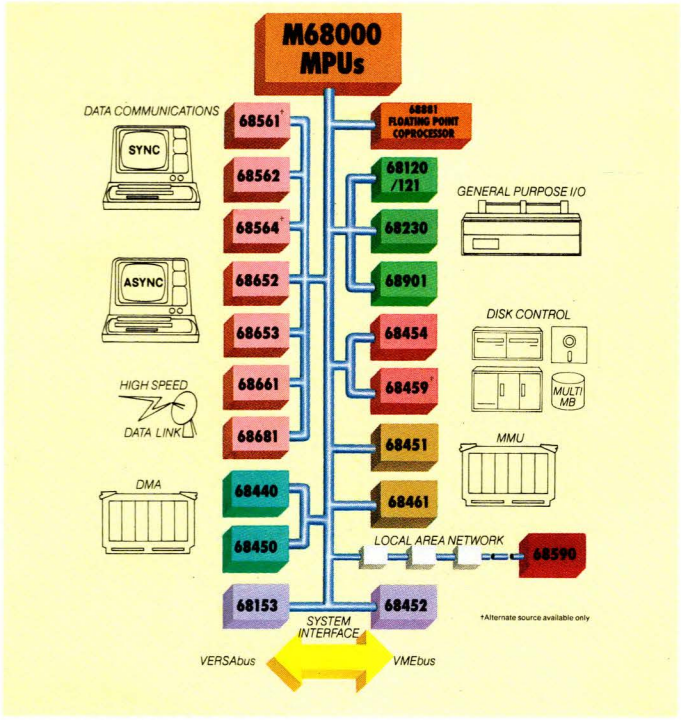
Be the envy of your industry.

You, too, can take high-capability advanced systems to market and be the envy of your industry.

The answer lies in the rich resources of Motorola's M68000 Family of high-performance 8-, 16- and 32-bit microprocessors and system peripheral circuits. Chances are, once you design in the M68000 Family and experience the success that follows, you'll be a family friend for good.

The extensive M68000 Family of compatible, easy-to-use MPUs and peripherals is available from Motorola and the most comprehensive complement of contractual alternate sources.

Data Comm, DMA Control, Local Area Network Control, Parallel, Serial and General Purpose I/O, Memory Management, Bus Control and more are available to help you raise your systems above the competition in a hotly competitive marketplace.



Move data fast.

Moving data around fast with minimal intervention from the processor is the province of the 68440 Dual DMA and the 68450 DMA Controller. The two-channel 68440 is capable of 5 Mbyte/sec transfer and the 68450 offers four independent channels and extensive support for the movement of complex data structures.

Links to the outside world.

M68000 Family data communications devices link your system efficiently to the outside world, be it terminal, transmission line or another system, and free the processor for other important work in the process.

One of the most popular data comm devices available is the 68661 Enhanced Programmable Communications Interface. It's a universal synchronous/asynchronous chip that interfaces easily to M68000 MPUs and directly to most 8-bit MPUs. Another important available family communications device is the 68681 Dual UART that provides two completely independent full duplex receiver/transmitter channels.

Extensive flexibility is achieved with the 68652 Multi-Protocol Communications Controller. Basic system functions are contributed by the 68901 Multi-Function Peripheral. Other family data comm functions include Intelligent Peripheral Controllers, Polynomial Generator Checker and Parallel Interface/Timer. Additional 68000-compatible data communications parts are available or under development at other leading VLSI manufacturers.

Memory management and disk control.

Data-storage device management is the domain of the 68454 Intelligent Multiple Disk Controller. It can control any combination of up to four single- or dual-density floppy and hard disks of various formats. Our 68451 MMU is a seasoned veteran in multi-user, multi-task systems, and now, the requirements of 32-bit demand-paged virtual environments are immediately satisfied by the 68461 Memory Management Controller.

Network and bus control.

The M68000 Family is growing to meet expanding demands in network and bus control. The 68590 is designed to meet all IEEE Ethernet™ specs for M68000 systems, and a new VME Controller will be added as VMEbus becomes a standard.

Floating point.

A companion processor to the 32-bit 68020 MPU is scheduled for introduction soon as well. The 68881 is designed to support the latest revision of the IEEE specification for floating point high-level calculations. It can also be used with the 16-bit M68000 Family processors.

You can see, now, why M68000 Family systems will make you the envy of your industry. You owe it to yourself and your customers to act now. Check ☐ C for information.

Ethernet is a trademark of Xerox Corp.

☐ ☐ ☐

Think of a DO-41 without leads.

....and you've pictured total flexibility of choice in surface-mount zener diodes.

No one is stronger in zeners than us and you now have easy access to this total capability and sourcing in 1 W surface-mount zeners.

This newest, most sophisticated packaging technology is revolutionizing circuit boards. Cutting cost, increasing density and speeding manufacturing operation, surface-mount is re-shaping boards of the future. And we're leading, not only in zeners but in hundreds of other discrete and IC-packaged types.

We were first with SOTs. And a full line of SOICs. Plus chip carriers.

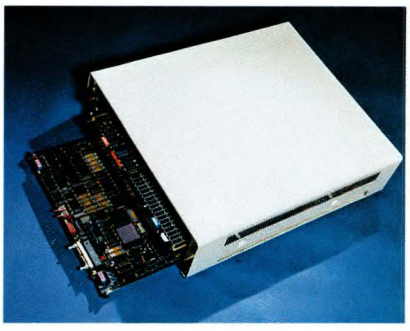
The MLL4728-4764 zener series ranges from 3.3 to 100 V. Tolerance is 10% for the standard version and 5% for the "A" version. It's available in bulk, or in 12mm tape and reel in both T1 and T2 configurations.
T1 — Cathode facing sprocket holes.
T2 — Anode facing sprocket holes.

Even more practical placement is reflected in the pricing: it's comparable to leaded packages.

Think of them as the right stuff for your PCBs and we'll send you a data sheet and new brochure.

Check ☐ D for information.

Benchmark 20: First to evaluate. First to market.



System integrators thinking about using the new 32-bit MC68020 MPU now have an excellent testbed for system evaluation: Benchmark 20!

This MC68020-based system package provides a variety of hardware and software tools to allow streamlined 32-bit benchmarking, code development and debugging. Packing a lot of power into a small space, the Benchmark 20 system contains a single-board microcomputer with the MC68020 MPU, plus an auxiliary 1 Megabyte RAM module, all configured with powerful debug/monitor firmware in a 4-slot chassis.

The result? You reduce time-to-market for your new 32-bit system product. Benchmark 20 is configured and ready to use alongside an appropriate software development host to trim your schedule for MC68020 benchmarking and code debugging.

The VM04 VERSAmodule CPU board utilizes the capacity of this new 32-bit performance standard to achieve speeds in the 2-3 million instructions per second (MIPS) category. 4K long words of on-board instruction/data cache reduces off board memory accesses to insure top performance.

The companion VM13 dynamic RAM module provides 1Mbyte of random access memory dual ported with both RAMbus and VERSAbus. A perfect system mate for the VM04 32-bit monoboard, the VM13 RAM board has error detection and diagnostic capability.

To help you quickly evaluate the MC68020 and the VM04, the Benchmark 20™ system package incorporates the 020bug™ debug/monitor firmware package to allow you to do benchmarking and to debug code. The 020bug resident package allows full speed execution of system and user developed programs operating out of the Benchmark 20 system package. Powerful software and system debug command set allows access to all VM04 I/O, control, and memory facilities plus the full 4 gigabyte direct address range of the VERSAbus system bus.

Benchmark 20, 020bug and VERSAbus are trademarks of Motorola.

Check ☐ E for information.

Turbo-charge operating systems with MC68010 monoboard.

The VERSAmodule line of 16- and 32-bit system components now includes a MC68010-based monoboard just right for hosting today's high-end operating systems including the UNIX™ System V operating system.

The VM03 monoboard utilizes an MC68010 microprocessor running at 10 MHz combined with an MC68451 memory management unit. Your choice of 256Kbytes or 1024Kbytes of on-board dynamic RAM with parity check assures outstanding local high-speed storage needed for "heavyweight" applications in image processing, artificial intelligence and supervisory control.

The optional 1 Mbyte of on-board memory increases operating system efficiency by allowing larger segments of code and data to be accessed, minimizing off-board activity. This performance benefit pays off in applications such as software development where large operating systems are used. An I/O channel interface is also provided for adding off-board resources in incremental amounts.

The VM03 monoboard is complemented by additional new support modules for high-end system applications.

Used for high speed storage in VERSAbus systems, the VM12 is a 4096Kbyte or 1024Kbyte dynamic RAM module with parity. It attains its capacity options and performance using high density HMOS 256K or

64K dynamic RAM chips. The VM12 supports the full 32-bit address of the M68000 family.

For system applications requiring high-capacity rotating mass storage, the VM22 disk controller supports 4 SMD drives and 4 SA400/800 floppy disk drives. Data transfer speeds up to 3 Mbytes/sec between system memory and hard disk drives and floppy disk drives are maintained by the direct memory access feature of the disk controller.

The VERSAmodule line is supported by both of Motorola's M68000 operating systems: the VERSAdos operating system for real-time applications, and the SYSTEM V/68 operating system where a UNIX™ operating system environment is desired. Full operating system support, including VERSAdos real-time device drivers, are available now for the MC68010-based VM03 monoboard.

Add to all this Motorola's expertise, proven products, training and service support and you can understand why VERSAmodule system components continue to be your best choice for the highest performance board-level applications.

UNIX is a trademark of AT&T Bell Laboratories.

SYSTEM V/68 is a trademark of Motorola.

Check ☐ F for information.

Time and cost saving E²PROM operates from single +5V supply.

The MCM2833 is a 32K E²PROM, Electrically Erasable Programmable Read Only Memory, that can save time and money in many data-handling applications. And, it operates from a single +5V supply.

Where non-volatile memory and in-system programming are required the MCM2833 fits perfectly, with in-system erase and reprogram capability that can cut costs and conserve time.

In addition, the MCM2833 derives outstanding data retention and endurance from the technologically advanced Motorola floating-gate electron tunneling MOS, FETMOS, fabrication. Data integrity is 10 years, and data is protected during power up and power down.

Fast access and low-power operation are characteristic. Maximum standby power dissipation is 35 mA, and max. active P_D is 125 mA. Speeds of 150 and 200 ns are available. Byte erase or write is 9 ms.

A choice of erase modes, bulk, byte, row or column, helps optimize system erase/write time and makes the MCM2833 easier to use. Latched addresses, data and controls create microprocessor-friendly operation, allowing the MPU to work on other jobs while the MCM2833 is erasing or programming.

Not the least of the MCM2833 E²PROM's attractiveness is its relationship as a member of Motorola's industry-standard byte-wide non-volatile memory family, providing opportunities for cost-effective density upgrades.

Engineering samples are available.

Check ☐ G for information.

One MC1377P RGB encoder generates broadcast color, pure and simple.

Simple things are best, and nowhere is this more true than video color encoding with the unique new MC1377P.

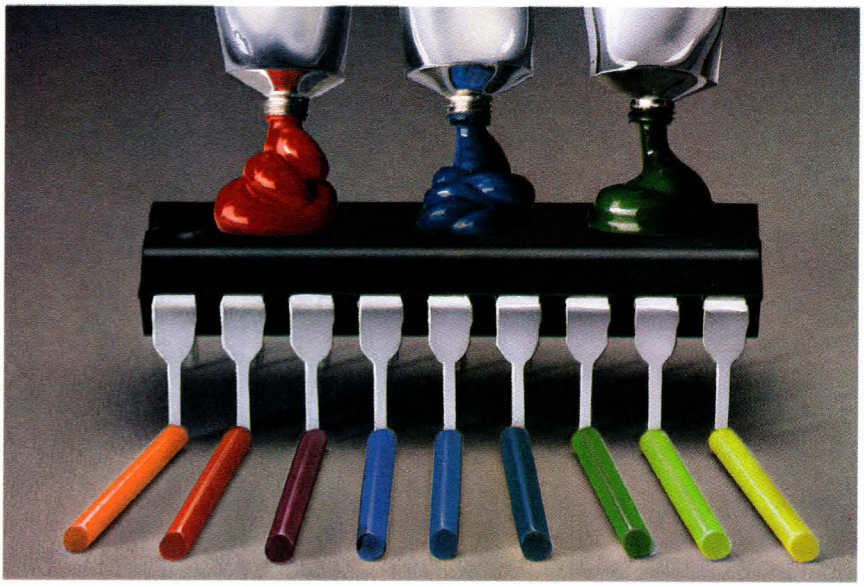
Just one 18-pin DIP does it all. With the addition of only a crystal and a few external resistors you have what used to a boardfull of time- and cost-consuming discretes and/or ICs.

Superior phase linearity and well-controlled color vectors provide the purity of color found only in complex, high-level studio broadcast equipment. And you can design the extraordinary performance features of the monolithic MC1377P into a wide variety of color cameras, graphics computers and teletex generators for about one-tenth the cost of the "maze" approach.

A major system simplification leap.

The MC1377 combines red, green and blue video information into a composite signal in either NTSC (U.S.) or PAL (Europe) formats. Used with the MC1374 color-modulated oscillator and a few components to generate a modulated RF carrier, you've actually got a miniature TV station.

Design it with the TDA3300 decoder family and you can separate, modify



or enhance R, G or B for a rainbow of special effects. Simply, easily, economically.

The MC1377P contains a sub-carrier oscillator, voltage controlled 90° phase shifter, two double-side-band modulators, RGB input matrices and blanking level clamps. Its oscillator can be used as the "master" in a system, or it can be driven by an external source. R, G and B inputs are ac-coupled to simplify interfacing. A 1.0 V p-p input level produces full saturation of colors in the output.

The only other input required is a composite sync signal, which is combined with the encoded video to produce the composite video output. The sync is also used to trigger the generation of color (burst) reference. Both chroma and luma signals are "looped out" of the chip to permit tailoring bandwidth and delay to the designer's taste. This permits very elegant applications as well as very simple ones.

The MC1377P production line is running. Price is in focus too.

Check ☐ H for information.

Floodgates open for VME/10 software.

Industry standard operating systems such as the UNIX™ System V allow greater than ever software portability for users of Motorola's VME/10 OEM Microcomputer system.

Software support within the UNIX™-derived SYSTEM V/68 operating system includes 400-plus utilities plus an optional optimizing Pascal compiler, M68000 macroassembler, and facilities to store and update all versions of a source code module.

The SYSTEM V/68 operating system comes with full screen editors and spelling checkers for full screen text processing. The "mm" memorandum macrocommands automatically format standard footnotes; number pages, lists, and paragraphs; and produce headings and footings.

Additional application software availability will grow as agreements between Motorola and Digital Research Inc. bear fruit in coming months. These DRI agreements call for a total of 25 software packages for the M68000 Family in SYSTEM V/68, Concurrent DOS™-68K and CP/M® 68K. Nine of the packages to be developed will be supported under SYSTEM V/68.

Concurrent DOS-68K, which is written in C language, is a multi-tasking operating system with widowing, LAN support and graphics. It is designed for multiuser or single user microcomputers and includes an IBM PC-DOS™ mode. This means application programs written in standard high-level languages on the IBM PC can be re-compiled on Concurrent DOS-68K without any modification. DRI is developing a system of compilers for a range of machines that operate under SYSTEM V/68, CP/M-68K, Concurrent CP/M and Concurrent DOS-68K.

CP/M is one of the most popular microcomputer operating systems for which hundreds of applications have been written.

Application programs written in any of the covered languages—Pascal, FORTRAN, C, BASIC and PL/I—should then run on any computer in the M68000 Family under CP/M-68K, Concurrent DOS-68K or SYSTEM V/68.

Languages to be available on the VME/10
Under CP/M 68K
Digital Research C Pascal MT+ CBasic Compiler
Under Concurrent DOS-68K and SYSTEM V/68:
Digital Research C Pascal MT+ CBasic Compiler FORTRAN 77 BASIC Interpreter GSX Graphics Software

UNIX is a trademark of AT&T Bell Laboratories.
CP/M is a registered trademark of Digital Research Inc.
Concurrent DOS is a trademark of Digital Research Inc.
IBM PC and PC-DOS are trademarks of IBM.

Check ☐ L for information.

☐ ☐ ☐

Sharpen Macrocell Array design skills.

Two new Macrocell Array design manuals are now available from Motorola to assist you in understanding and easily generating optimized semi-custom ECL application specific ICs.

The MCA2500ECL Macrocell Array Design Manual is all new. It covers just about everything a trained MCA designer needs to carry out the design. There's a review of the Macrocell Array concept and technology, and a run-down of MCA features supplemented by an explanation of cell types.

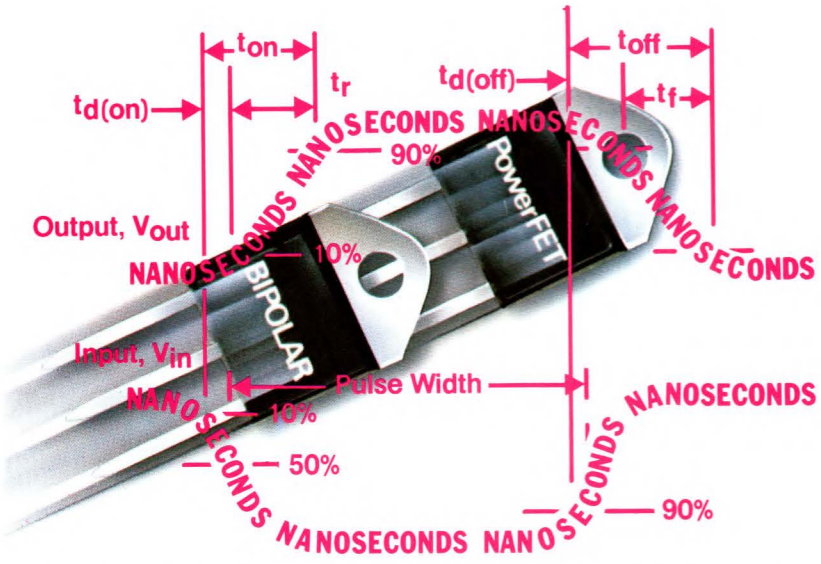
Logic design considerations and performance guidelines are examined in detail. CAD layout, array option development and various hardware subjects are reviewed. A large section is devoted to the Macrocell Library and MCA2500ECL specification plus individual cell descriptions.

Order the MCA2500ECL Design Manual as BR165.

MCA600ECL and MCA1200 ECL are Macrocell Arrays similarly served by the eagerly awaited revised design manual, BR107/D R1. This is an updated replacement for a preliminary edition.

Both of these Macrocell Array design manuals are available at modest cost. Please contact the appropriate Motorola sales office for prices and ordering information.

Fastest, highest-voltage bipolar pushes powerFETs.



It may not quite catch them, but it's so close you can virtually ignore the difference in speed.

The complete new MJH16000 series of 850 to 1,500 V Switchmode III bipolar power devices switches big loads in nanoseconds — about 10 times faster than other bipolars — just like power MOSFETs, without sacrificing ruggedness.

Ideally suited for high-frequency inductive switching where high-temperature RBSOA is a major concern, these 5, 8 and 15 A units feature a higher periphery-to-area ratio and hollow emitter structuring to give the designer a needed edge in ruggedness and speed and improve design efficiency and compactness.

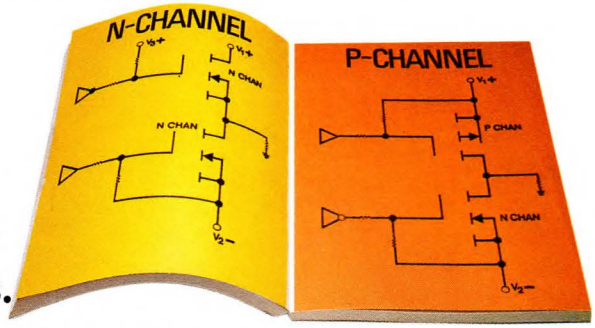
The TO-218 packaged units are suitable for both U.S. and European power supply designs. Unique lead-spacing and package dimension features allow regulatory agency approval in both domains enabling you to design one supply accepted for both markets.

Use the 450 V units for line-operated half-bridge, full-bridge and push-pull configurations and the higher-voltage types for single transistor flyback and forward converter topologies.

Additionally-packaged in TO-204 (TO-3), the series is molehill priced for mountains of performance.

Check ☐ M for information.

P-Channel powerFETs add new chapter to drive circuit applications.



When you want to cut power supply or charge pump requirements to your power MOSFET in bridge cascode or push-pull applications, go Motorola P-Channel.

This extension of the MTM/MTP8PO8, -2P45 family is available from Motorola to make your design job simpler and more cost-effective.

A simple load that requires only one-side grounding to a negative bus can easily be switched with P-Channel technology eliminating extra, expensive componentry. V_3, which biases gate above source to hold the MOSFET on, is no longer necessary.

Schottkys extend efficiency to 12 V.

The world's best Schottky rectifier process introduces an expanded Schottky rectifier voltage — 60 V.

You now have the option of designing 12 V supplies with Motorola devices to improve efficiency and reduce recovery noise associated with other rectifier types.

Packaged in TO-220, the 10 A MBR1060 Schottky offers 0.7 V_F and less than 6% power loss, or 94% efficiency, at 120 W P_O. Ordinarily, you'd lose twice that with a slower rectifier, up to now your only choice for higher output power applications.

With the MBR1060, you gain the same advantages for 12 V supplies as you've enjoyed with Schottkys in 5 V supplies.

Cool by nature, calm by comparison, Motorola's broad TO-220 Schottkys exhibit lowest correlation of temperature rise vs. forward drop of any other types. You gain more, lose less with Motorola.... up to 175°C operating temperature.

Add a guaranteed avalanche surge, built-in PN guard rings, freedom from trace anomalies and virtually perfect working barrier processes and you've got the highest quality going in nanosecond rectification.

Discipline power with efficiency: Motorola Schottkys.

Check ☐ N for information.

☐ ☐ ☐

The new nanosecond-switching series is fabricated utilizing the same N-Channel TMOS™ III process that results in optimized cell density and cost factors. It's the best silicon utilization process in the industry and offers you the ultimate design advantage: price.

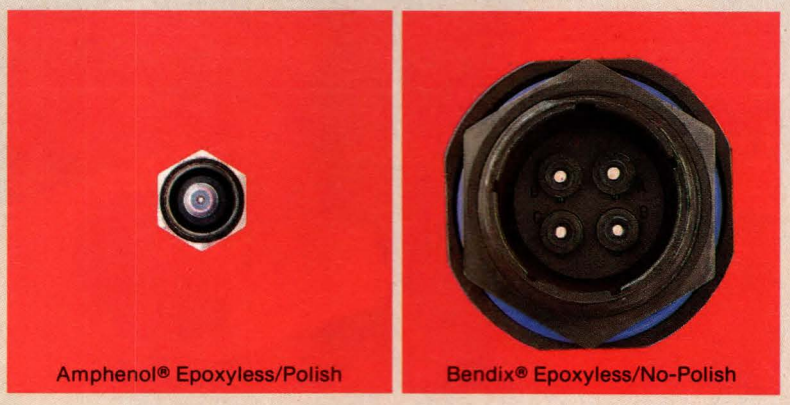
There's no sacrifice in reliability or performance. AOQ levels measure out at less than 100 ppm, guaranteed. And $r_{DS(on)}$ as low as 0.1Ω is available for very high efficiency operation.

Prices for the 50 to 500 V, 2 to 25 A family are low in hermetic, TO-204, (TO-3) or low-cost TO-218 and TO-220 plastic packaging.

We'll send you Designers™ data sheets and a new TMOS brochure.

Check ☐ P for information.

Look into these fibre optic connections



You'll see efficient interconnection solutions from Amphenol Products. Aerospace. Computer. Telecommunications. Industrial controls. No matter how demanding your application or environment, we can give you maximum design flexibility and the performance you need for reliable data transmission.

We offer a broad range of fibre optic interconnection technologies and styles. Amphenol® and Bendix® connectors. From epoxy/polish, to expoxyless/polish with resilient captivator, to epoxyless/no-polish lens-to-lens terminations. From single-channel, to duplex, to 29 channels in a single connector. From low-cost plastic connectors, to SMA styles. From rectangular styles, to environmental circular connectors. We have connectors for most common fibre/cable types. For virtually all mounting variations. Complete factory assembled and tested cable assemblies are available too. If one of our Amphenol or Bendix standard products isn't the solution, we'll customize a connector or assembly for you.

Look into all we can do for you, by contacting our nearest sales office.

©1984 Allied Corp.

Amphenol Products world headquarters:
Lisle, Illinois 60532—USA—Telex 190-215

CANADA: Montreal, (514) 482-5520 • Ottawa, (613) 226-2727 • Toronto, (416) 291-4401 • Vancouver, (604) 278-7636

EUROPE: Austria—Vienna, (0222) 925166, Telex: 132661 • **England**—Whitstable, (0227) 264411, Telex: 96157 • **France**—Paris, (01) 5888682, Telex: 360264 • **W. Germany**—Heilbronn, (07131) 4861, Telex: 728816 • **Italy**—Arese, (02) 9385161, Telex: 334899 • **Sweden**—Upplands Vaesby, (0760) 88035, Telex: 17890

FAR EAST: Hong Kong—Kowloon, (3) 681283, Telex: 39289 • **India**—Poona, 83363, Telex: 145337 • **Japan**—Tokyo, (03) 379-2111, Telex: 232-2285

ALLIED Amphenol Products

CIRCLE NO 23

Integrated Technology . . .

State-of-the-art power MOSFET technology, high quality standards and highly automated high-tech HEXFET processing contribute to an expected operating life of 200,000 years at 70° C.

Environmental Security . . .

State-of-the-art epoxy enables an average HEXFET to withstand 28,000 hours of continuous exposure at 85° C and 85% relative humidity. (V_{DS}=10V).

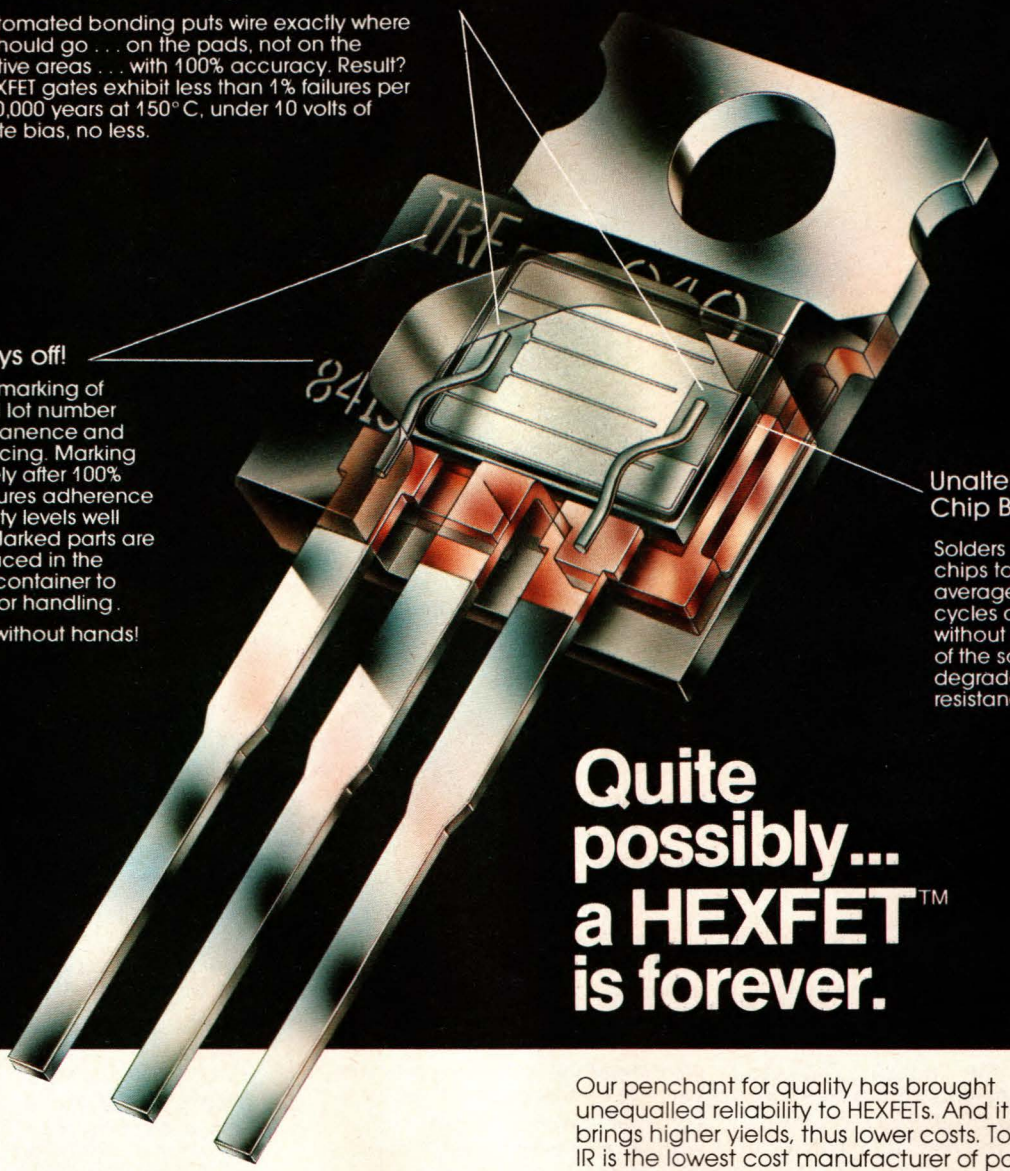
Bullseye Wire Bonding . . .

Automated bonding puts wire exactly where it should go . . . on the pads, not on the active areas . . . with 100% accuracy. Result? HEXFET gates exhibit less than 1% failures per 500,000 years at 150° C, under 10 volts of gate bias, no less.

"Hands-Off" pays off!

Automated laser marking of part number and lot number guarantees permanence and legibility for lot tracing. Marking made immediately after 100% electrical test assures adherence to outgoing quality levels well under 100ppm. Marked parts are automatically placed in the correct shipping container to eliminate mixing or handling.

And it's all done without hands!



Unalterable Chip Bonding . . .

Solders that bond HEXFET chips to bases permit an average 32,000 power cycles at ΔT=70° C without decrystalization of the solder or other degradation of thermal resistance.

Quite possibly... a HEXFET™ is forever.

Our penchant for quality has brought unequalled reliability to HEXFETs. And it also brings higher yields, thus lower costs. Today, IR is the lowest cost manufacturer of power MOSFETs. That can mean a lot to you when you're buying.

When you order, ask for "International Rectifier HEXFETs."

Only HEXFETs are forever.

NUMBER 1 IN POWER MOSFETs!

International IOR Rectifier

WORLD HEADQUARTERS: 233 KANSAS ST., EL SEGUNDO, CA 90245, U.S.A. (213) 772-2000. TWX 910-348-6291, TELEX 472-0403

EUROPEAN HEADQUARTERS: HURST GREEN, OXTED, SURREY RH8 9BB, ENGLAND TELEPHONE (088 33) 3215/4321. TELEX 95219

CIRCLE NO 24

Plastic-fiber-based optical links offer low-cost, short-haul data transfer

Tom Ormond, *Senior Editor*

Cost has been the barrier to using fiber-optic links in low-data-rate, short-haul applications of less than 5M baud and 300 ft. New fiber-optic links made of plastic (acrylic) fiber, however, provide a cost-effective alternative to coaxial cable and twisted-wire pairs in such applications. These large-core fibers—approximately 1000 μm—don't require the tight alignment tolerances needed in glass- or plastic-clad silica fibers for reasonable light coupling at the source and detector interfaces. Looser alignment tolerances also let manufacturers package transmitters and receivers in plastic housings, thus lowering component costs.

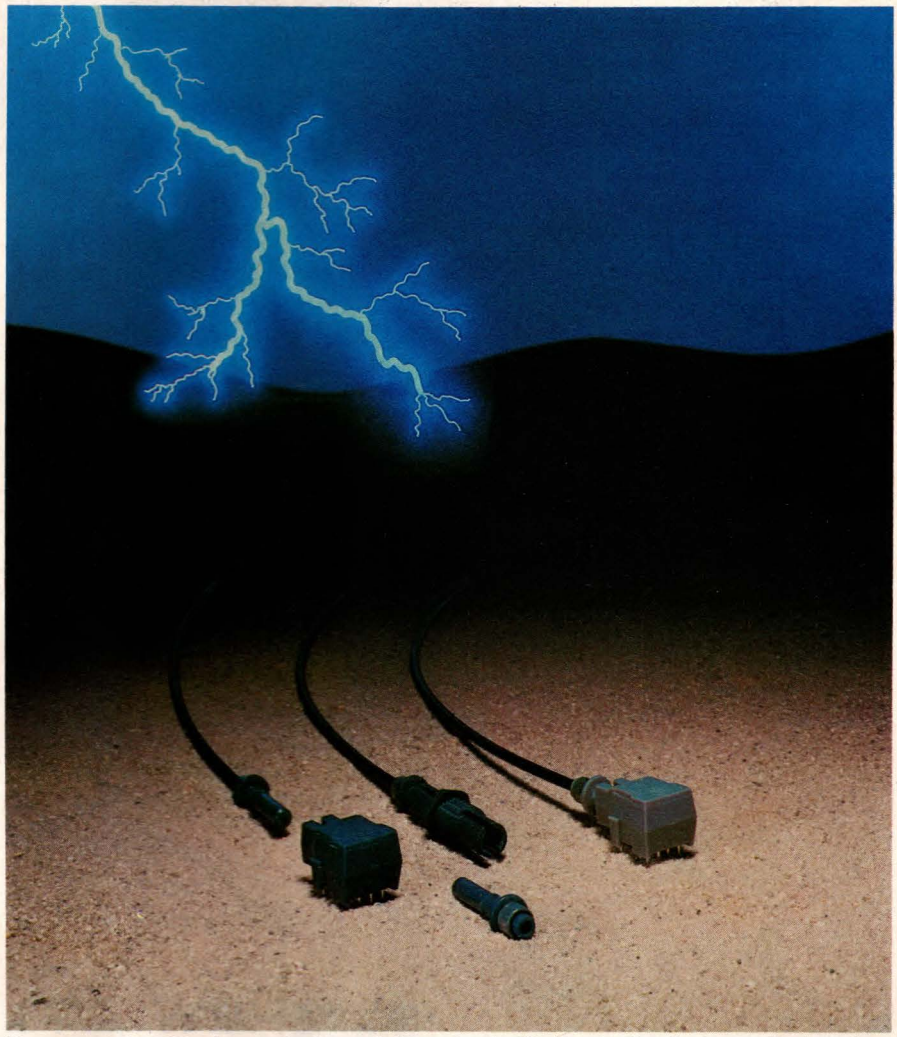
In addition, plastic-fiber-based optical links are not affected by (nor do they emit) EMI or RFI. The fiber is nonconductive, so there's no operational problem in explosive atmospheres. Optical systems also provide a high degree of data-transmission security because the fiber is difficult to tap.

Acrylic fiber is also user friendly. Although most link manufacturers offer ready-to-go systems, you can buy the cable yourself. You'll find the cable-termination process quite simple, and it requires no special tools or expertise. You can cut the fiber with a razor blade, for example, and polishing requirements are minimal. Acrylic fiber is available from DuPont (Wilmington, DE) and Nissho-Iwai (Los Angeles, CA).

The fiber has one additional advantage: Although plastic fiber is lossy, it has a relatively low attenuation window, around 650 nm. Most link systems operate at this wavelength, and the visible-light transmissions make system troubleshooting easy: There's no optical mystique involved.

Because the fibers available from DuPont and Nissho-Iwai have similar transmission characteristics, most link manufacturers spec their systems to accommodate either one. As a result, gross link-performance specs are similar. However, there are some subtle differences in data-rate and distance capabilities, and there are some not-so-subtle differences in price. An examination of current data-link offerings shows how they measure up in these categories.

Hewlett-Packard's Snap-In optical-link line includes three transmitters (HFBR-1510, -1502, and -1512), three receivers (HFBR-2501, -2502, and -2503), simplex and duplex fiber cables in lengths of 500 to 999m (HFBR-3510 simplex costs $0.75/m; HFBR-3610 duplex is $1.50/m), and connectors—$0.40 (100). When you combine the -2503 with the -1512 transmitter (with 60-mA drive current), you'll have a link that accom-



You can realize 60m transmissions *at data rates to 40k baud using the transmitter/receiver components available in Hewlett-Packard's Snap-In data-link line. Over shorter distances, link components will accommodate 5M-baud (12m) and 1M-baud (24m) data rates.*

Design in performance with HP's family of fiber optic components.

Choose from three fiber optic families.

Hewlett-Packard gives you price/performance flexibility with fiber optic components. There are three product families to choose from, so there's one that offers a practical solution for your application. And you can count on HP to meet your volume manufacturing needs, today and tomorrow. Because we're committed to fiber optics.

What's more, HP specifies and guarantees the performance of each fiber optic component so you know what to expect every time. Our fiber optic components are easy to use, cost-effective and provide consistent and reliable performance.

HP offers three families of products to give you solutions for a variety of distance and data rate applications.

HFBR-0500 Series Plastic Snap-In Link components.

Data rates to 5 Mbaud, distances to 60 metres and low cost make this family ideal for connecting computers to peripherals and for industrial control applications. HP's Snap-In links use rugged, 1-millimetre diameter plastic fiber and have connectors that are quick and easy to attach. Introduce yourself to the advantages of this easy-to-use, low-cost family. Try HP's HFBR-0500 Snap-In Link evaluation kit.

HFBR-0200 Series Miniature Link components.

This family provides cost-effective solutions for LANs, and computer-to-peripheral connections. The optical port design provides precision optical coupling to small diameter glass fibers. This family achieves data rates of up to 100 Mbaud. Evaluate the performance of this family with the HFBR-0200 kit.

HFBR-0010 Series High Performance modules.

This family offers transparent TTL-TTL communication independent of data format at data rates of up to 10 Mbaud. A link monitor on the receiver provides a digital indication of link continuity. The HFBR-0010 evaluation kit is your introduction to this family.

A commitment beyond quality products.

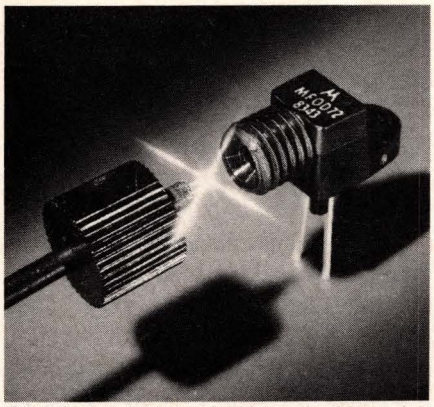
Ten years of experience and a substantial investment in quality is only part of our commitment to fiber optics. Wherever fiber optics can provide a solution, from computer to industrial applications, HP backs you up with worldwide service and technical support.

For pricing and delivery, contact your local Hewlett-Packard authorized components distributor. In the U.S., call Hall-Mark, Hamilton/Avnet or Schweber. In Canada, call Hamilton/Avnet or Zentronics, Ltd. For more information, call your local HP sales office listed in the telephone directory white pages and ask for the Components Department.

HP: The right choices for performance in fiber optics.

HEWLETT PACKARD

CG08410



Significant cost reductions *in Motorola's FLCS line are made possible through a combination of an all-plastic packaging system and a permanently affixed, pc-board-mountable interconnect receptacle that eases assembly.*

modates 40k-baud data rates over 60m max transmission distances. You can operate this same combination with only 2 mA of transmitter drive current and realize an 8m link.

The -1512 transmitter module—$8.10 (100)—incorporates a 665-nm LED and is easily interfaced to standard TTL devices. With a 60-mA drive current, guaranteed output power (measured at the end of a 0.5m cable) ranges from −11.2 to −5.4 dBm at 25°C and −13.6 to −4.5 dBm over 0 to 70°C. Rise and fall times (10 to 90%) spec at 50 nsec.

The -2503 receiver module—$11.05 (100)—has a −39-dBm sensitivity spec. It features an integrated photodetector and dc amplifier for high EMI immunity. The output is an open collector with a 150-μA internal-current-source pull-up resistor and is compatible with TTL/LSTTL and most CMOS families. For minimum rise time, you should add an external pull-up resistor of at least 3.3k—V_{CC} must be greater than or equal to the supply voltage for the pull-up resistor.

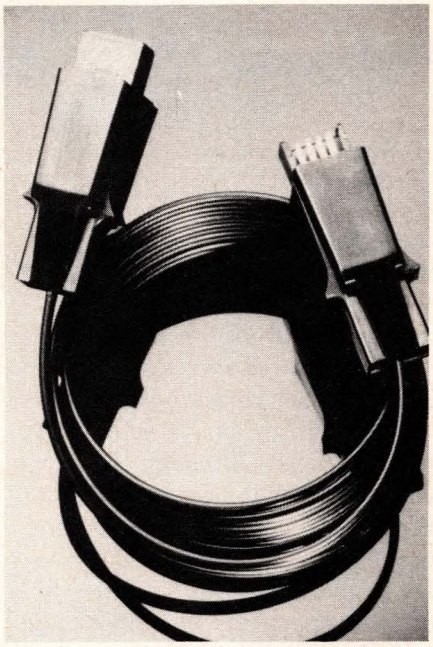
Depending on the transmitter/receiver combination, you can develop 5M-baud/12m and 1M-baud/24m links with the other modules in the Snap-In line. All the active devices are housed in plastic DIPs and feature single 5V operation. For all link combinations, bit-error rate (BER) specs at 10^{-9}.

Interoptics' 100 (simplex) and 200 (duplex) Series data links provide a 50m max transmission capability. The 100 Series consists of the OPTO101 transmitter (driver plus a 660-nm LED) and the OPTO102 receiver (photo diode and a receiver IC) for $14.37 each. The 200 Series transceiver ($27.47) incorporates both the LED/receiver IC and the photo diode/driver IC in one package (OPTO212). Data rates for either link range to 1.5M bps RZ and 3M bps for NRZ; BER measures 10^{-9}.

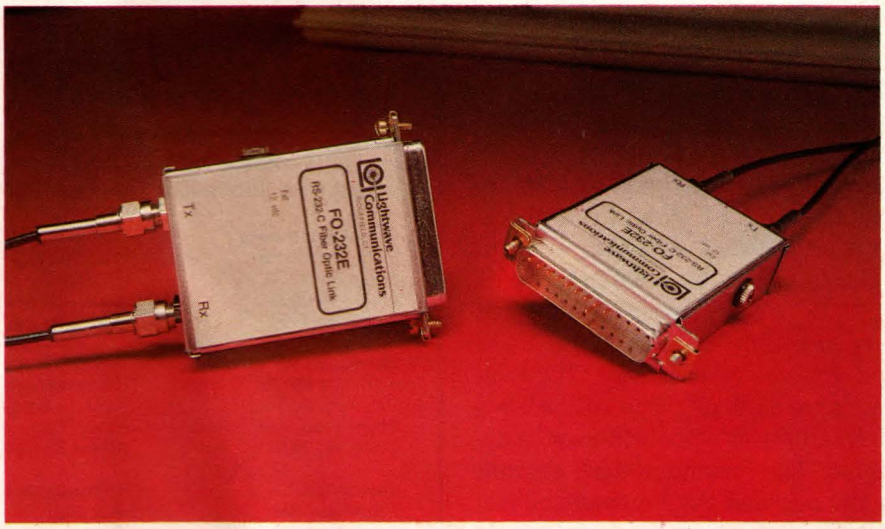
Power coupled to the fiber at the transmitter output ranges from −15 to −10 dBm. Typical minimum and maximum receivable power levels are −30 and −13 dBm, respectively. The modules are designed for pc-board mounting, feature single-supply operation (7V max), and operate over 0 to 70°C.

The plastic-fiber cable—$1/m (10m)—has a 0.5 numerical aperture (NA), 60-MHz bandwidth, 7-nsec/m max propagation delay time, and 0.4-dB/m attenuation at 660 nm. You install the connector with a crimping tool, so epoxying and extensive polishing are not required. The connectors, which cost $6.26 (25) and $10.62 for simplex and duplex types, respectively, have a coupling key to prevent reverse-direction coupling.

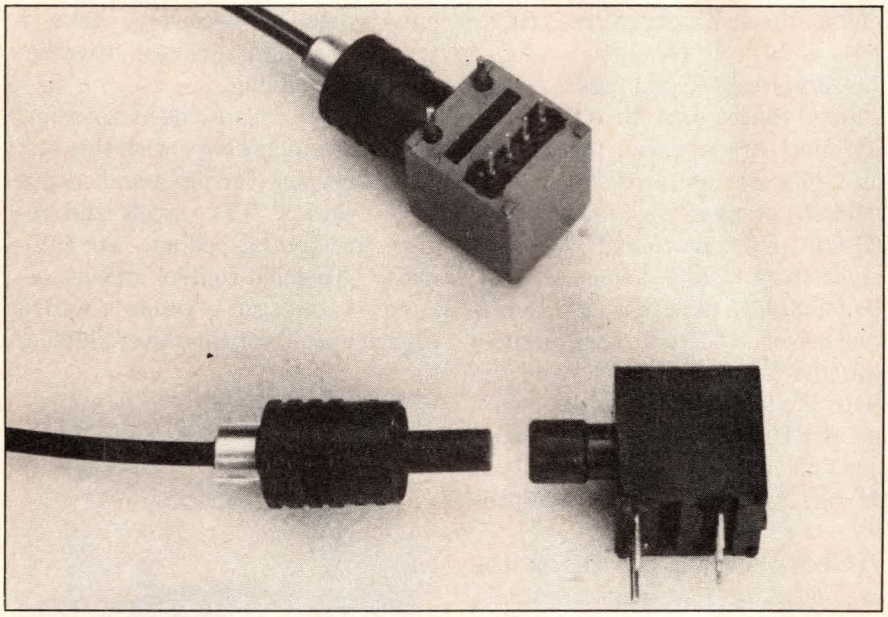
The user doesn't need to know fiber-optic technology with this link design because the input and output signals are at TTL levels and require no special coding. An automatic threshold-control circuit assures constant pulse width regardless of optical power fluctuations.



Handling analog or digital signals, *Molex's fiber-optic-link components are sealed against dust and moisture. The systems transmit 40-kHz analog or 10k-baud square-wave signals over 60m.*



Plug-to-plug compatible with RS-232C connectors, *the FO-232E from Lightwave Communications offers an inexpensive way to get complete EMI/RFI immunity when interconnecting terminals, printers, and other peripherals with computers.*



Available in simplex and duplex versions, *optical links from Interoptics accommodate dc to 3M-baud data rates and feature a 50m transmission capability.*

Motorola recently introduced its Fiber Optics Low Cost System (FLCS), which consists of a GaAlAs infrared emitter and three detector configurations. Although the system provides high performance with greater than 10-MHz bandwidth, the design concept is simple. System application doesn't require you to have experience with fiber-optic technology.

The $1.30 (100) MFOE71 emitter has an 820-nm peak wavelength and features a molded lens to maximize coupling efficiency. Typical launched power is 165 μW (110 μW min); optical rise and fall time measures 25 nsec.

A PIN photodiode, the MFOD71 detector costs $0.98 (100). It has a spectral response that's matched to the MFOE71 LED, and it also features a molded lens for efficient light coupling. Dark current specs at 0.06 nA and responsivity and response time measure 0.2 μA/μW and 1 nsec, respectively. Total capacitance is 3 pF. The MFOD72—$0.87 (100)—is a phototransistor detector. The maximum dark current is 100 nA, and the minimum collector-to-emitter breakdown voltage specs at 30V. Typical responsivity measures 125 μA/μW, and turn-on and turn-off times are 10 and 60 μsec, respectively. The $0.98 (100) MFOD73 photo-Darlington detector features dark current and breakdown voltage of 100 nA max and 60V min, respectively. Typical responsivity measures 10 mA/μW, and turn-on and -off times are 125 and 150 μsec, respectively.

Typical transmission distances, with 100-mA drive current through the emitter, extend to 32m for the MFOD73, 17m for the MFOD72, and 10m for the MFOD71. Each emitter/detector configuration provides trouble-free performance at the maximum specified cable lengths.

The FLCS package includes all necessary components: active device, connector, locking nut, and mounting (pc-board) flange. You don't need special tools or procedures to terminate either DuPont's or Nissho-Iwai's cable. You cut the fiber with a sharp blade or hot knife and use an 18-gauge wire stripper to expose 0.10- to 0.18-in. of bare fiber core. Then insert the prepared cable through the locking nut and into the connector on the module housing until the core tip butts against the molded lens inside the package. You tighten the locking nut to lock the cable firmly in place.

Aborn Electronics also offers a short-distance, low-cost link. The AFL 1000 uses AMP's DNP snap-in connector system to provide an easy-to-terminate, easy-to-use fiber-optic link. Available in both simplex and duplex versions, it accommodates dc to 5M-baud data rates and has a 22m maximum transmission distance. Housed in low-cost plastic DIPs, the transmitter and receiver require single 5V supplies and operate over 0 to 70°C.

Each link ($18 for a 5m version) contains an LED transmitter with a 665-nm peak output wavelength and a Schmitt trigger receiver with an

For more information . . .

For more information on the fiber-optic-link products discussed in this article, contact the following manufacturers directly or circle the appropriate numbers on the Information Retrieval Service card.

Aborn Electronics
3675 Enochs St
Santa Clara, CA 95051
(408) 746-0505
Circle No 740

Hewlett-Packard Co
640 Page Mill Rd
Palo Alto, CA 94304
Phone local sales office
Circle No 741

Interoptics
770 Airport Blvd
Burlingame, CA 94010
(415) 347-7727
Circle No 742

Lightwave Communications Inc
650 Danbury Rd
Ridgefield, CT 06877
(203) 438-3591
Circle No 743

Molex Inc
2222 Wellington Ct
Lisle, IL 60532
(312) 969-4550
Circle No 744

Motorola Semiconductor Products Inc
Box 20912
Phoenix, AZ 85036
(602) 244-4912
Circle No 745

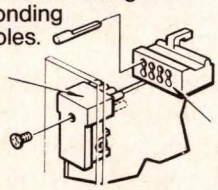
The KM6 Subrack System will never be complete...

The KM6 Subrack System has always been years ahead of its time

1981

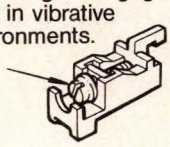
Polarising/PCB Mounting Bracket

Secured to front panel or direct to PCB. Mating half fitted to front of PCB guide during assembly. Polarisation by breaking spills and filling corres ponding holes.



Security PCB Retainer

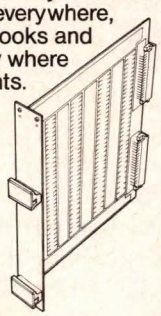
Ensures PCB's stay electrically mated to connectors within sub rack. Easily assembled. Prevents PCB's becoming disengaged even in vibrative environments.



1982

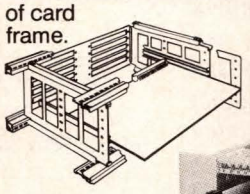
Front Panels

An increased variety of front panels for PCB mounting. Just look around . . . you'll notice them everywhere, good looks and quality where it counts.



Horizontal Mounting Kit

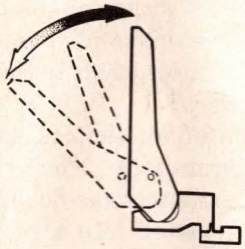
Horizontal Mounting Kit accommodates any size of PCB within width of card frame.



1983

PCB Ejector/ Injector

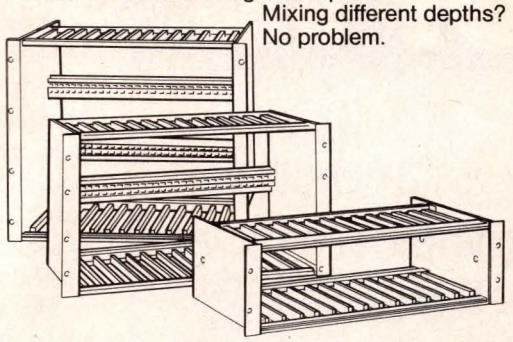
Unique saddle operated Injector/ Ejector means increase in number of connector contacts without difficulty of inserting and retracting PCB's from subrack.
Unit operates within confines of subrack, utilising normal front panels, hinged or otherwise.



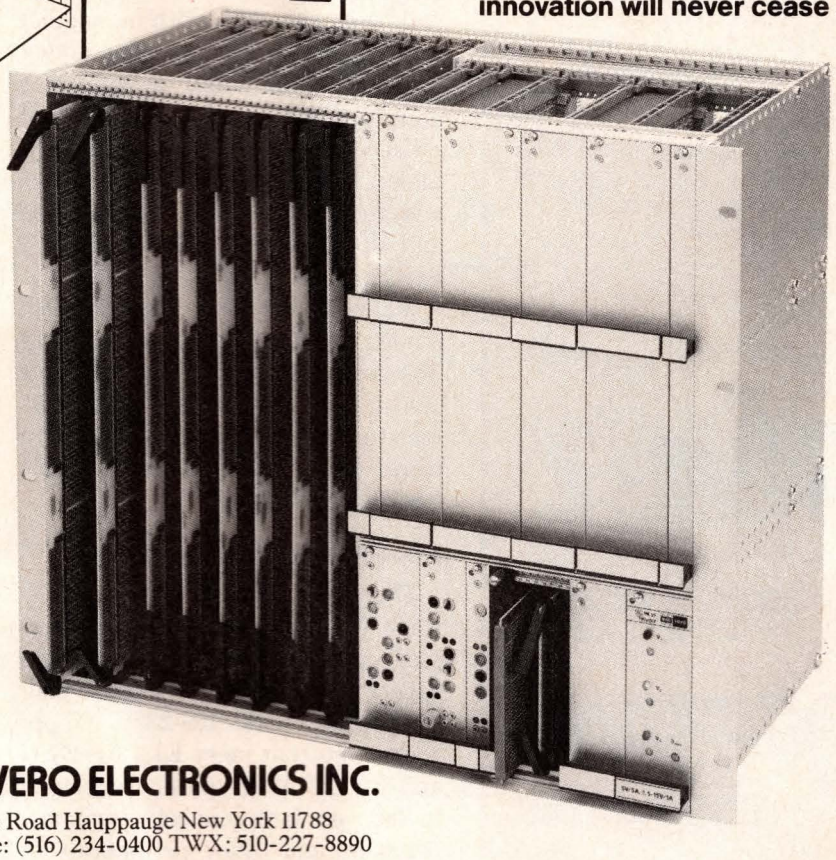
1984

9U KM6. Flexibility in Packaging Triple High Eurocards

Anticipating packaging needs has always been our strong point.
KM6 is now available in 9U heights for those who need the extra 'real estate' a triple high Eurocard offers.
Needless to say you can also mix single and double Eurocards along with triples.
Mixing different depths? No problem.



It will never be complete because our programme of improvement and innovation will never cease . . .



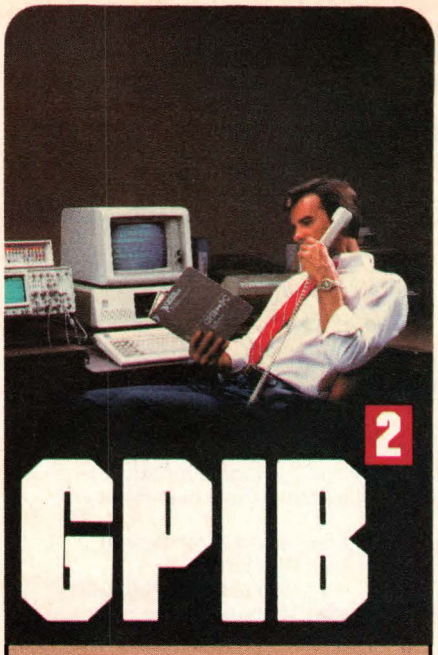
BICC vero

BICC-VERO ELECTRONICS INC.

171 Bridge Road Hauppauge New York 11788
Telephone: (516) 234-0400 TWX: 510-227-8890
4001 Leaverton Court Anaheim California 92807
Telephone: (714) 630-2030 Telex: 277732

Leaders in packaging technology

CIRCLE NO 26



IBM PC, PCjr & COMPATIBLES

DEC UNIBUS, Q-BUS & RAINBOW 100

MULTIBUS, VMEbus STD & S-100

Full IEEE-488 functionality, with the most comprehensive language and operating system coverage in the industry. It takes experience to make IEEE-488 systems work with nearly 4000 devices available from more than 500 different manufacturers, and experience is what enables National Instruments to take the GPIB to the second power and beyond.

2 Your personal guarantee of unsurpassed customer support and satisfaction. CALL 1-800-531-GPIB for instant access to 100 + man-years of GPIB experience.

NATIONAL INSTRUMENTS
12109 Technology Blvd.
Austin, TX 78727
1-800-531-5066 512/250-9119
Telex: 756737 NAT INST AUS

IBM and PCjr are trademarks of International Business Machines. MULTIBUS is a trademark of Intel. DEC, UNIBUS, Q-BUS, and Rainbow 100 are trademarks of Digital Equipment Corporation.

CIRCLE NO 27

TECHNOLOGY UPDATE

open-collector, LSTTL/TTL-compatible output. An external resistor lets you adjust receiver sensitivity (threshold). The receiver will drive eight TTL loads. Propagation delay is 140 nsec max.

Digital or analog applications

Molex specifies end-to-end electronic performance of its links so you don't have to worry about fiber-optic technology. The firm's initial TTL-compatible offering handles 40-kHz analog signals or 10k-baud square waves. Transmission capabilities range to 60m.

A proprietary connector design integrates the alignment mechanism into the optoelectronic devices and the outer jacket of the acrylic cable. The device-to-fiber interface is sealed and uses a lens to conserve optical power.

The firm offers simplex and duplex configurations. The simplex system's optoelectronic devices can be wave soldered into a pc board and then covered with a rugged cable-retention housing. The duplex system is built into a connector housing and is interfaced to external electronics through a standard Molex 7990 connector. Transmitters and receivers require 5V supplies and operate over −30 to +80°C. System BER specs at 10^{-9}.

Molex offers kits (simplex, $30; duplex, $60) to help you evaluate link performance. Each kit contains a transmitter, a receiver, a 3m terminated cable assembly, and a pc board that contains the electronic interface circuitry.

Providing dedicated service

The $90 FO-232E from Lightwave Communications is a full-duplex optical modem that transmits asynchronous data. It's plug-to-plug compatible with RS-232C 25-pin connectors that meet EIA RS-232C and CCITT V.24 specs. Developed to let you interconnect terminals, printers, and other peripherals to computer equipment, the FO-232E offers a simple, inexpensive solution to maintaining data integrity in hazardous environments, plus complete immunity to EMI/RFI, without sacrificing speed.

Housed in a 0.625×2.125×2.75-in. package, the modem can transmit data over 250-ft distances at 19.2k bps. Available in both DTE and DCE versions, it specs a 10^{-9} BER. Operating range spans 0 to 50°C, and power requirements are 12V dc at 100 mA. Source and detector functions are provided by LED and PIN photodiodes, respectively. Receive sensitivity measures 50 nW.

Standard models feature SMA-type fiber connectors; AMP Optimate devices are optional. The electrical interface employs a male 25-pin D-subminiature connector, but female units are also available. You can also order preterminated cable assemblies. **EDN**

Article Interest Quotient
(Circle One)
High 503 Medium 504 Low 505

HOW'S YOUR PROFESSION?

EDN wants to know about you and your profession.

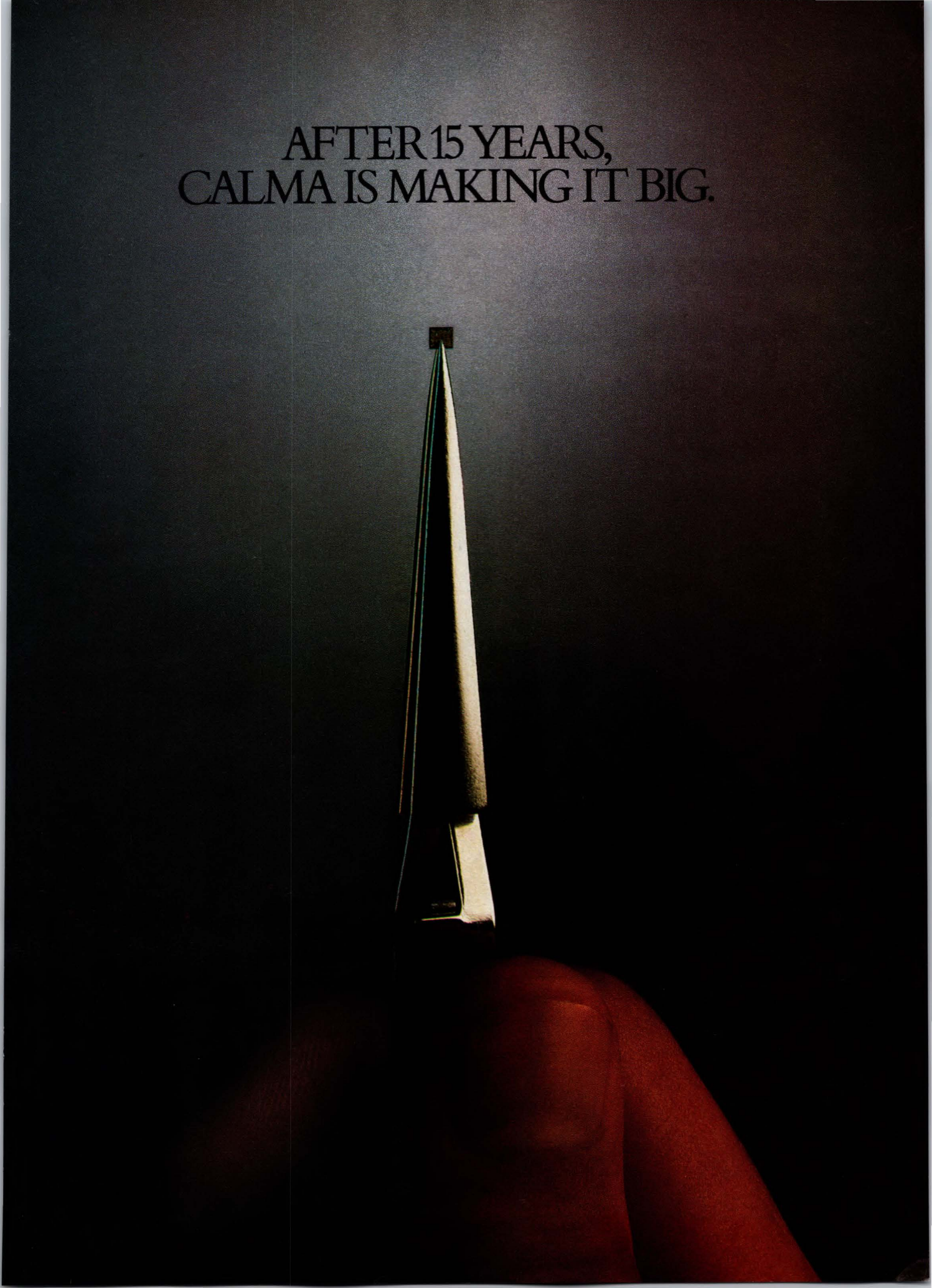
Are you completely satisfied with your career? Would you like to see changes in your working environment or the electronics industry? Is your company treating you fairly? Thinking about changing your job or geographical living area for career growth? Getting enough support from IEEE or other electronics industry associations? Want to pass along some of your management techniques to others in your field?

We'd like to hear what you have to say. By understanding some of the problems you face, EDN can call attention to important issues affecting your profession.

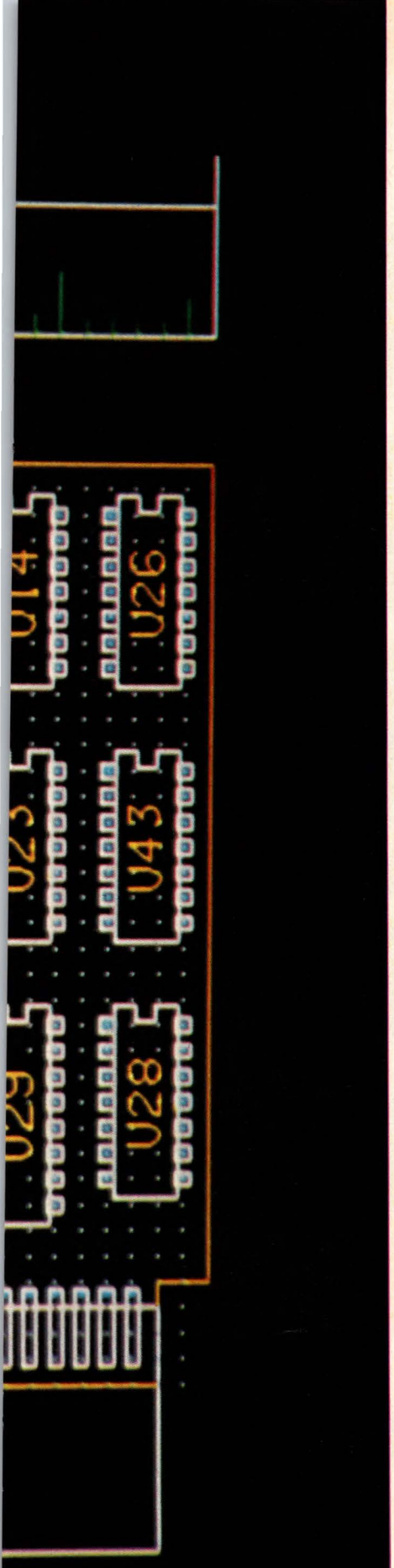
Professional Issues is your section. But we can't address critical topics without your help. Write or call section editor Deborah Asbrand with your ideas.

EDN: Everything Designers Need

AFTER 15 YEARS, CALMA IS MAKING IT BIG.



TOP
BOT
I1
I2
U69
U49
U24
U8
U48
U20
U67
U47
U36
U10
U50
U7
U11
U46
U68
U12
U45
U21
U22
U13



For 15 years, Calma's been the big fish in a microscopic pond—the intricate world of computer aided IC layout.

Now we're going into business on a much larger scale—PCB layout.

INTRODUCING T-BOARDS—A BIGGER HELP.

Our new T-BOARDS™ software can give you more help than any other PCB layout software.

What other system, for instance, can give you fast automatic interactive routing of up to eight layers simultaneously.

And automatic interactive placement.

And on-line connectivity and clearance checking.

And a full color view of multiple layers.

And correct-by-construction methodology.

All in one package.

T-BOARDS is capable of handling 32"x 32," 32-layer boards, and features pop-up menus, real-time checks to make sure layout mirrors design, and 1 mil precision.

BIGGER AND BIGGER HELP.

T-BOARDS alone can cut your workload down to a manageable size.

But it doesn't stop there.

When brought into Calma's full TEGAStation™ environment, you'll have a complete front-end workstation system for schematic capture, advanced simulation and testability analysis—all using just one database.

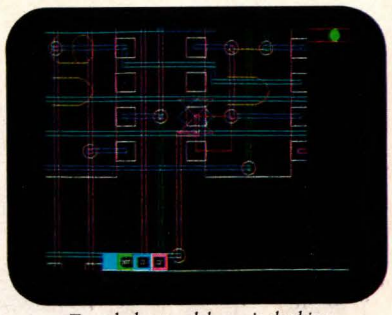
SERVICE AND SUPPORT—MAYBE THE BIGGEST HELP.

For 15 years, Calma's been putting a comprehensive service and support organization in place.

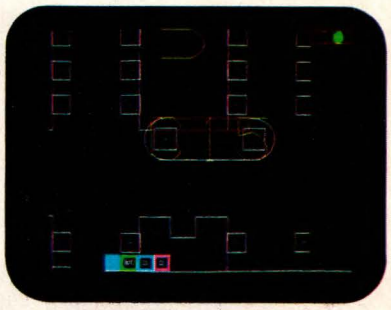
In 60 places, for that matter.

All over the world.

We offer a variety of service plans, hardware and software support, education programs—even a hotline.



Error lockout and dynamic checking.



Red rectangle shows clearance violation.

BIG COMPANIES HAVE BIG ADVANTAGES. ONE OF OURS IS GE.

PCB layout systems are a long range commitment.

No way do you want the company you're buying them from to fold in the short run.

Calma's been here for 15 years—an institution in this mercurial business.

General Electric, our parent company, has been here over 100 years. And firmly believes electronics is the foundation for the next 100 years.

Giving Calma the resources and commitment to be here much longer.

Which, if you plan on future growth in total automation, makes a big difference.

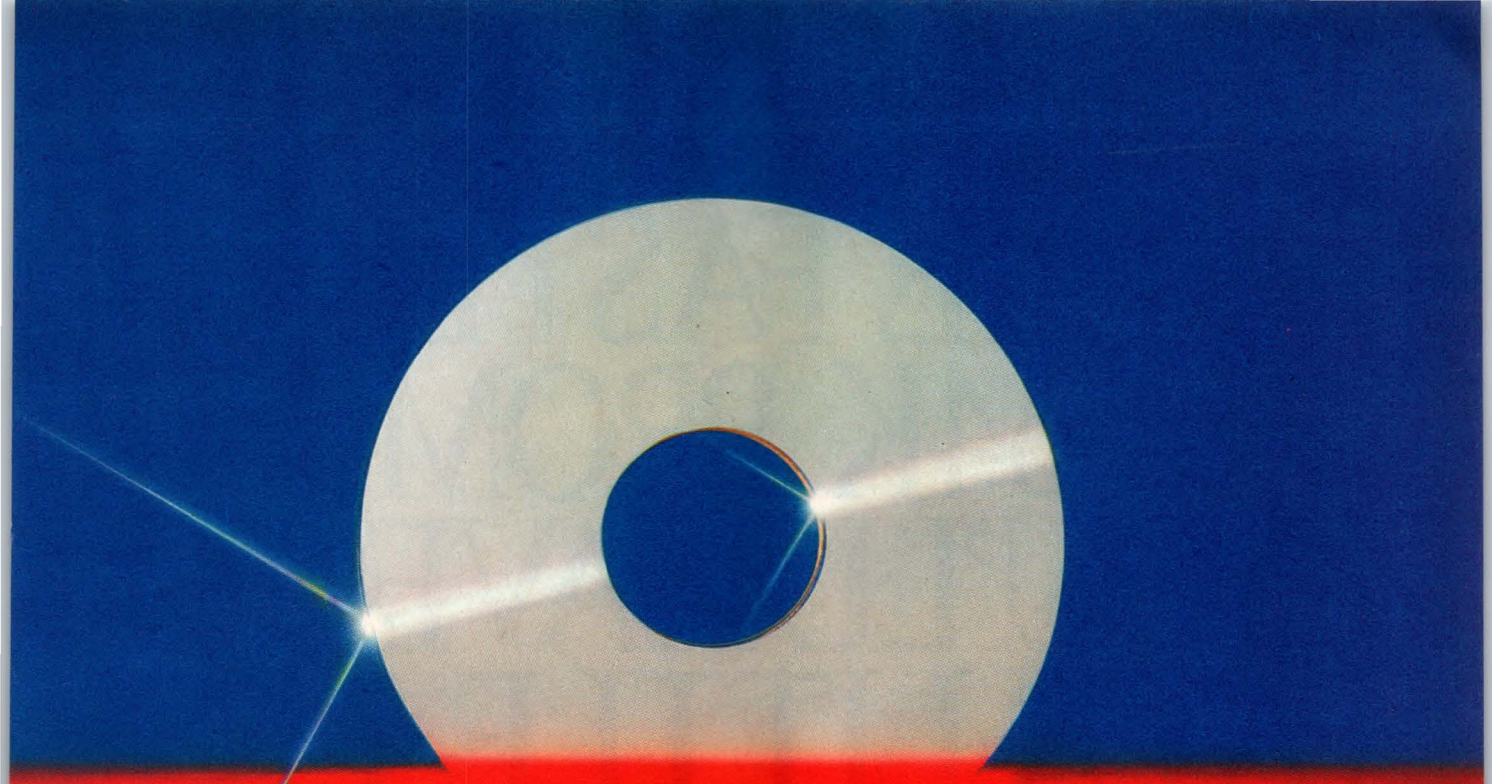
Call (800) 626-2001 extension 801 for specifics.

calma

Calma Company is a wholly-owned subsidiary of General Electric Company, U.S.A. GE is a registered trademark of General Electric Company, U.S.A.

CIRCLE NO 28

THE QUALITY OF OUR THIN FILM DISCS IS AS GOOD AS GOLD.



Our Gold Standards. Superior discs. In resolution. In signal to noise ratio. In amplitude and modulation. In overwrite and missing/extra pulses. Discs by which we measure all other discs. At Ampex, we develop a Gold Standard and thorough test plan for every customer's disc-head combination. An ALAR® thin film disc that doesn't meet our Gold Standard of quality isn't shipped. No ifs. No ands. No buts.

In fact, every disc we ship has survived a quality assurance program so stringent it's unparalleled in the industry. With ten major process control checks during manufacturing. We test and retest. From substrate to finished product. Then we test our tests. So you don't have to.

It takes experience to make quality thin film discs. We have more. Today, with over one million discs working in over 300,000 systems. And a $30 million commitment to produce the volume to meet tomorrow's demand. So ride on our shoulders. We've made a name in magnetic media that's as good as gold. Ampex. Disc Media Operations, 960 Rincon Circle, San Jose CA 95131 (408) 945-5600 Telex 348464.

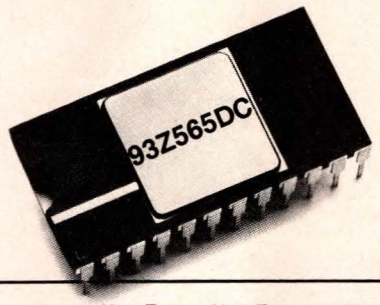
AMPEX

Ampex Corporation • One of The Signal Companies

WE'RE THE HEAVYWEIGHTS IN THIN FILM MEDIA.

ALAR® is a registered trademark of Ampex Corporation. Copyright 1984 Ampex Corporation.

IF YOU WANT THE FASTEST 64K PROM, YOU'LL HAVE TO PAY A LITTLE LESS.



	Max. T_{AA} Commercial	Max. T_{AA} Military	Max. ICC
64K (8Kx8)			
93Z565	55 ns	65 ns	180 mA
93Z565A	45 ns	55 ns	180 mA
16K (2Kx8)			
93Z511	45 ns	55 ns	175 mA
8K (1Kx8)			
93Z451	40 ns	55 ns	135 mA
93Z451A	35 ns	45 ns	135 mA

Available in 24-pin dual-in-line and 28-pin leadless chip carrier. 8K and 16K also available in 24-pin flatpak and 300 mil DIP.

The Fairchild 93Z565A. One of the first 64K PROMs on the market and still the fastest. Giving you access time of 45 ns.

But that's not all.

Since we've been making them for over two years, we also know how to make them more cost-effective for your application. Which means you can confidently design with our 64K now and realize a lower cost-per-bit at the system level. And you'll find one 64K to be significantly more efficient than several 8K, 16K or 32K devices.

If you have an application requiring high speed at a lower density, we have a 16K PROM at 45 ns and an 8K PROM at 35 ns. Both in space-saving 300 mil DIPs.

It all adds up to the fastest PROM family ever built. PROMs that use Fairchild's Isoplanar-Z™ technology. With vertical fuse technology giving you one of the highest programming yields in the industry.

Our family of high-speed, low-cost PROMs is available now. For more information, contact our local sales office or your nearest authorized Fairchild distributor today.

MEMORY AND HIGH SPEED LOGIC

From Puyallup, WA.

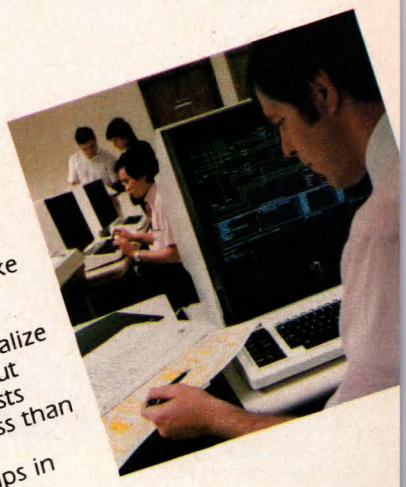
FAIRCHILD

A Schlumberger Company

Fairchild Memory and High Speed Logic Division, 33309 1st Way South, Federal Way, WA 98063-9701

Isoplanar-Z is a trademark of Fairchild Camera and Instrument Corporation.

Welcome to the New Silicon Valley



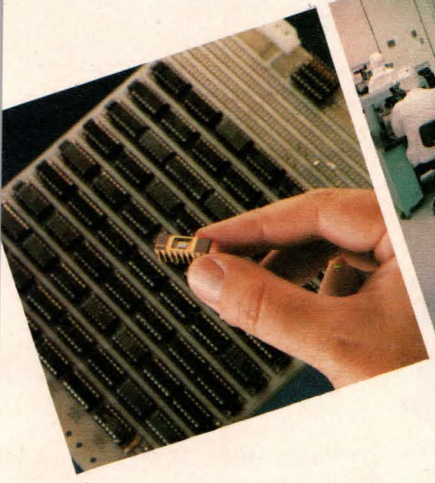
You're looking at Iowa — home of the Electronic Technology Corporation. We design, test, and deliver semicustom integrated circuits. Very well.

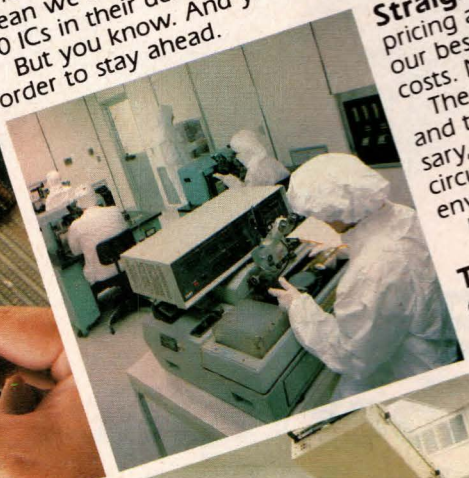
The **old** Silicon Valley really snickered when we took their best design technology — plus software for gate arrays, linear arrays, standard cell and full custom — and put it out here in Cedar Rapids.

Maybe they didn't want to admit that when 1600 electronics staffs take lunch in the old Silicon Valley, commercial secrets get spilled.

Tall Corn. Low Overhead. The old Silicon Valley probably didn't realize that our Midwestern operating costs are about half theirs. (They'll find out when we give out competing bids. So will you.) Or that those lower costs mean we can make a semicustom chip worthwhile to someone with less than 10 ICs in their design. (Not 25, like in the old Silicon Valley.)

But you know. And you're the ones who need semicustom microchips in order to stay ahead.





Straight Dealing. We believe in turn-key pricing around here. That means we give you our best estimate and stick to it. No hidden costs. No surprises.

Then we don't just take your schematic and turn it into chips. We study it. If necessary, we'll recommend ways to improve your circuits' performance in the semicustom environment. **Before** the layout stage.

It's just the way business is done in Iowa.

Talk to an engineer. You can talk directly to ETC engineering by dialing our **Engineering Hot-Line, 319/395-0747.** A design engineer will be ready to talk with you. About semicustom technology, about applications, or about your project if you'd like. No obligation, just straight talk.

Go ahead. And get up to date on the New Silicon Valley.

ElectronicTechnologyCorporation

2037 N. Towne Lane NE
Cedar Rapids, Iowa 52402
Phone 319/395-0567
Telex 753611
Engineering Hot-Line 319/395-0747

☐ Rush more information about ETC.
☐ Have a representative contact me.
My business card is attached

Your Midwest Source for Microcircuits. And Straight Talk.

CIRCLE NO 30

Still First. Still Best. The Toughest Fiber Optic Connectors in the World.

The military specifies only the most reliable fiber optic connectors for use in field, shipboard and undersea communications. So they choose Hughes.

They demand rugged bodies, super sealing, low insertion loss, precise alignment, repeatability, field termination and simplicity. The ultimate in performance.

We're proud to be first with the military, for their land, sea and undersea fiber optic connector applications.

So if you need the toughest fiber optic connectors in the world, contact your Hughes representative or phone Jack Maranto at 714-660-5759. Or write Hughes Aircraft Company, Connecting Devices Division, 17150 Von Karman Avenue, Irvine, CA 92714. In Europe: Hughes Microelectronics, Ltd., Clive House, 12/18 Queens Road, Weybridge, Surrey KT13 9XD, England.

HUGHES

HUGHES AIRCRAFT COMPANY
CONNECTING DEVICES DIV.

CIRCLE NO 31

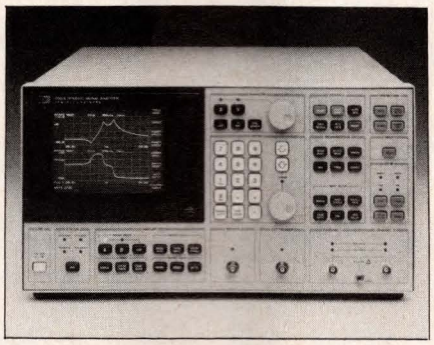
Analyzer packs waveform, spectrum, and network analysis in one box

Integrated measurement tools are not unusual; however, finding one aimed at analog-circuit design is. Model 3562A dynamic signal analyzer combines a waveform recorder, spectrum analyzer, and network analyzer in a benchtop instrument that analyzes signals from near dc to 100 kHz. It doesn't stop at data collection but also does extensive data and design-parameter manipulation and display as well.

The signal analyzer itself is a dual-channel, fast Fourier transform (FFT) analyzer. Its two channels are closely matched to a ±0.1 dB and ±0.5° frequency- and phase-response accuracy. They feed the incoming signals to two 13-bit analog/digital converters that have 80 dB of dynamic range, 10 dB better than previously available.

As a waveform recorder, the 3562A digitizes waveforms containing frequencies to 100 kHz with complete antialias protection. Each recording is 2k words long, and the instrument stores as many as 10 recordings internally. For subsequent time-domain or frequency-domain analysis, you can recall either a single time-domain record at a time or a concatenated display of as many as 10 records. The 3562A directly controls external disk drives (IEEE-488 compatible) and stores as many as 32,000 records per recording session without needing an IEEE-488 controller.

As a dual-channel spectrum analyzer, the unit achieves 25.6-μHz resolution anywhere within its 64-μHz to 100-kHz measurement range. Because it is a dual-channel unit, you can display the full 100-kHz spectrum on one channel and a magnified or "zoom" spectrum on the other for more detailed analysis. Or you can display both time and frequency traces simultaneously.



You can store as many as 32,000 recordings on *disk during a single analysis session when using Model 3562A. It can extract design parameters like the open-loop or impulse response from measured data. It also serves as a design tool by accepting design parameters like pole and zero locations and generating displays like Bode plots from them.*

Single-channel accuracy is ±0.15 dB with 80 dB of dynamic range. You can resolve 0.001 dB using the single-point harmonic and sideband markers. You can also do modulation analysis and demodulate AM, FM, or PM signals having carrier frequencies to 99.9 kHz.

In its role as a network analyzer, the instrument brings into play its built-in signal source. The source generates either random noise for nonlinear device testing or sine waves for linear devices. Both types of input signals are band-limited and band-translated to reduce out-of-band effects.

The instrument has three modes for frequency-response measurements: linear-resolution FFT, logarithmic resolution FFT, or true swept-sine. With the linear-resolution FFT technique, the 2k-word time records get transformed into 801-line frequency spectra. Frequency-response magnitude and phase as well as input and output power spectra get measured with 801 lines of resolution to accuracies of ±0.1 dB and ±0.5° over an 80-dB dynamic range. For display of response over two to five decades of frequency, the logarithmic-resolution FFT mode combines the linear resolution points to create 80-point/decade measurements.

To allow the instrument to function as a true swept-sine frequency-response analyzer, the source makes programmable linear or logarithmic sweeps with increasing or decreasing frequencies. An autoranging sweep function makes it possible to test active devices with more than 130 dB of dynamic range.

The computational capabilities of the 3562A are extensive. For example, you can first model the expected response of your system on the instrument before you test it. The HP 3562A will accept a system description in a pole/zero, pole/residue, or ratio-of-polynomials format and generate a display of magnitude and phase over a specified frequency span. Or you can work backwards and extract as many as 40 poles and 40 zeros from your measured frequency-response data.

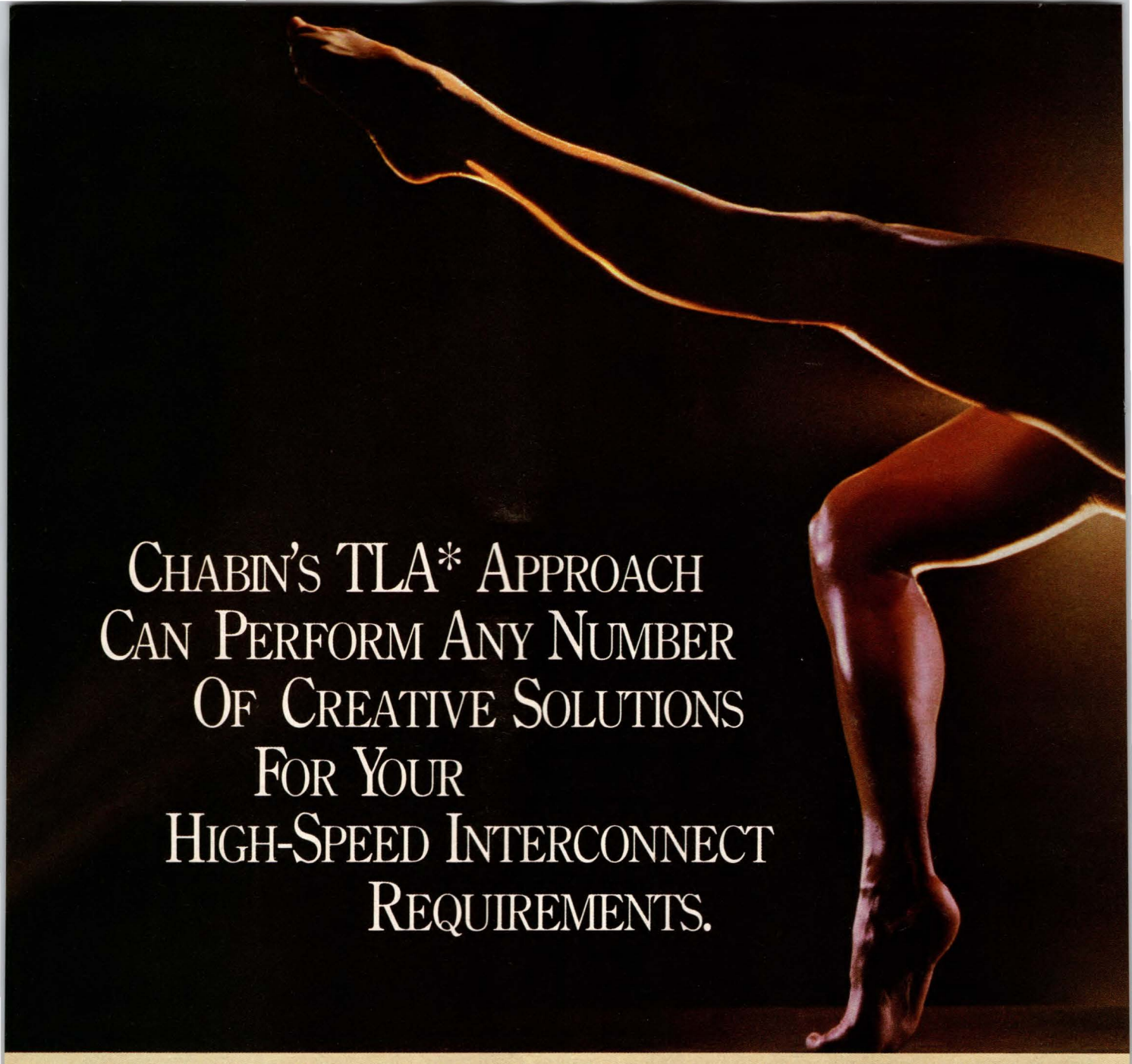
Also, the built-in waveform math lets you manipulate entire blocks of data. For instance, you can convert closed-loop measurements to open-loop responses for stability analysis. Or you can use the inverse FFT function to derive the impulse response of a system from measured data.

In addition, a number of application-specific programs are provided by the manufacturer as well as by third-party vendors for structural-vibration analysis, acoustic-intensity measurements, and rotating-machinery analysis. Prices start at $22,500. Delivery, 16 wks ARO.

—Chris Everett

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

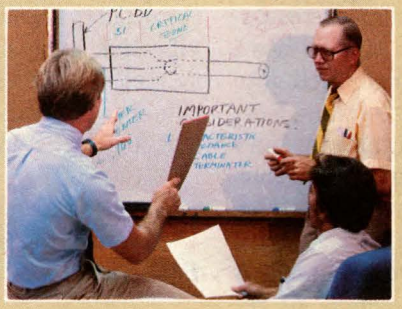
Circle No 716



CHABIN'S TLA* APPROACH CAN PERFORM ANY NUMBER OF CREATIVE SOLUTIONS FOR YOUR HIGH-SPEED INTERCONNECT REQUIREMENTS.

Your problem didn't come off the shelf. The answer shouldn't either.

It's problem-solving flexibility that brings all the major manufacturers to Chabin Corporation. Besides understanding high-speed, high-frequency data transmission and the associated problems of signal fidelity and high-density packaging, we know how to anticipate, adapt, and move quickly in an ever-changing industry. Equally important, we're small enough to give your problem the personal attention it requires, but large enough to meet sophisticated production demands.



Chabin provides complete support for the design engineer. We're *consultants.* Supplying technical information when you need answers. We're *innovators.* Charting new courses in design, electrical, and packaging engineering, just like you. We're *manufacturers.* Offering a state-of-the-art tooling, testing, and production facility, all in one. But more than anything else, we're *people.* A team of professionals who believe interconnects are more than just wire, cable, and connectors.

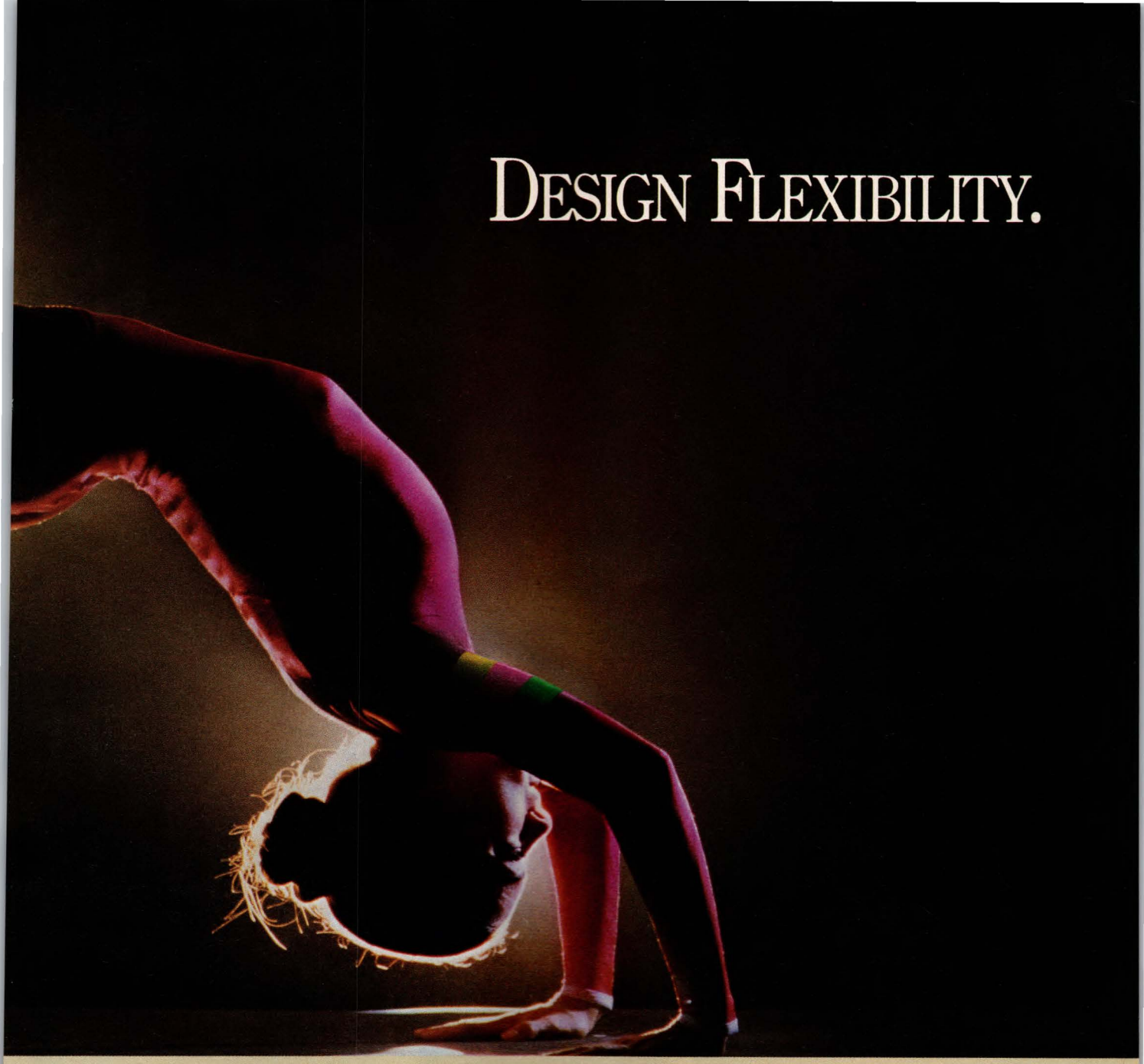
In the many years Chabin has been in business, we've solved all kinds of serious noise problems and prevented many potential disasters. In the process, we've perfected the most flexible concept in cable/connector design available to the design engineer. One that will lead you to think in terms not of *limitations* but of *possibilities.* That concept is the Transmission Line Assembly (TLA™).

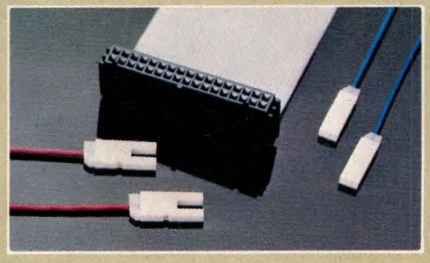
Chabin's TLA™: Functionally designed, gracefully executed.

The TLA™ is no run-of-the-mill cable assembly intended for just any application. It was developed expressly to meet the complex demands of high-speed logic data transmissions, and now to tackle the uncompromising signal-purity requirements

Copyright 1984, Chabin Corporation

DESIGN FLEXIBILITY.





of the electronics industry.
And Chabin's compact, elegant packaging solutions makes our TLA™ the ideal choice for any application requiring high-density cabling within strict space limitations.

Chabin's TLAs are available in "standard" configurations which can be easily adapted to your single or multiple signal applications. And because our connectors are designed to accept a wide range of cable types, we gain the flexibility to choose the perfect cabling to meet your electrical requirements and mate it to the ideal connectors to meet your mechanical requirements.

It's Chabin's design flexibility that will help you meet the rising challenge of higher speed and smaller size in advanced circuit technology. So bring us your toughest cabling requirements. We'll develop solutions — *before* you face even the first problem.

CIRCLE NO 32

**TLAs are a family of cable assemblies value engineered to address the needs of high-speed ditigal electronics. Impedance-controlled cabling with a high velocity of propagation is used to minimize waveform distortions. The connectors are intricately designed to allow for high-signal density and molded onto the cable to guarantee reliability.*

Chabin Corporation
890 Fortress Street, Dept. E
Chico, California 95926
916/891-6410

CHABIN

PREVENTIVE DESIGN FOR THE PROGRESSIVE ENGINEER.

*TLA is a registered trademark of Chabin Corporation

© 1984 Solarex

Why would a company that has all the oil it needs use solar power?

To save money, that's why.

Today, cost-conscious oil companies are using Solarex modules to power remote telemetry units by the thousands – in oil and gas fields all over the U.S.

These modules are photovoltaic power cells, which convert sunlight directly into electricity.

What makes them so economical? Well, compare solar power to primary batteries.

Batteries die, and have to be replaced frequently.

(In fact, when you consider what it costs to replace a battery – including labor and disposal – you end up paying many times the original price.)

Photovoltaics, on the other hand, last 20 years.

There are no fuel costs, obviously. And with no moving parts, the systems require little or no maintenance.

That means a Solarex installation pays off quickly – often in two years or less.

Plus, we're experts at tailoring our technology to yours – no matter what the application. So from the start, we make your job easier.

And now's the perfect time to buy solar. Photovoltaic power costs half of what it did, even four years ago.

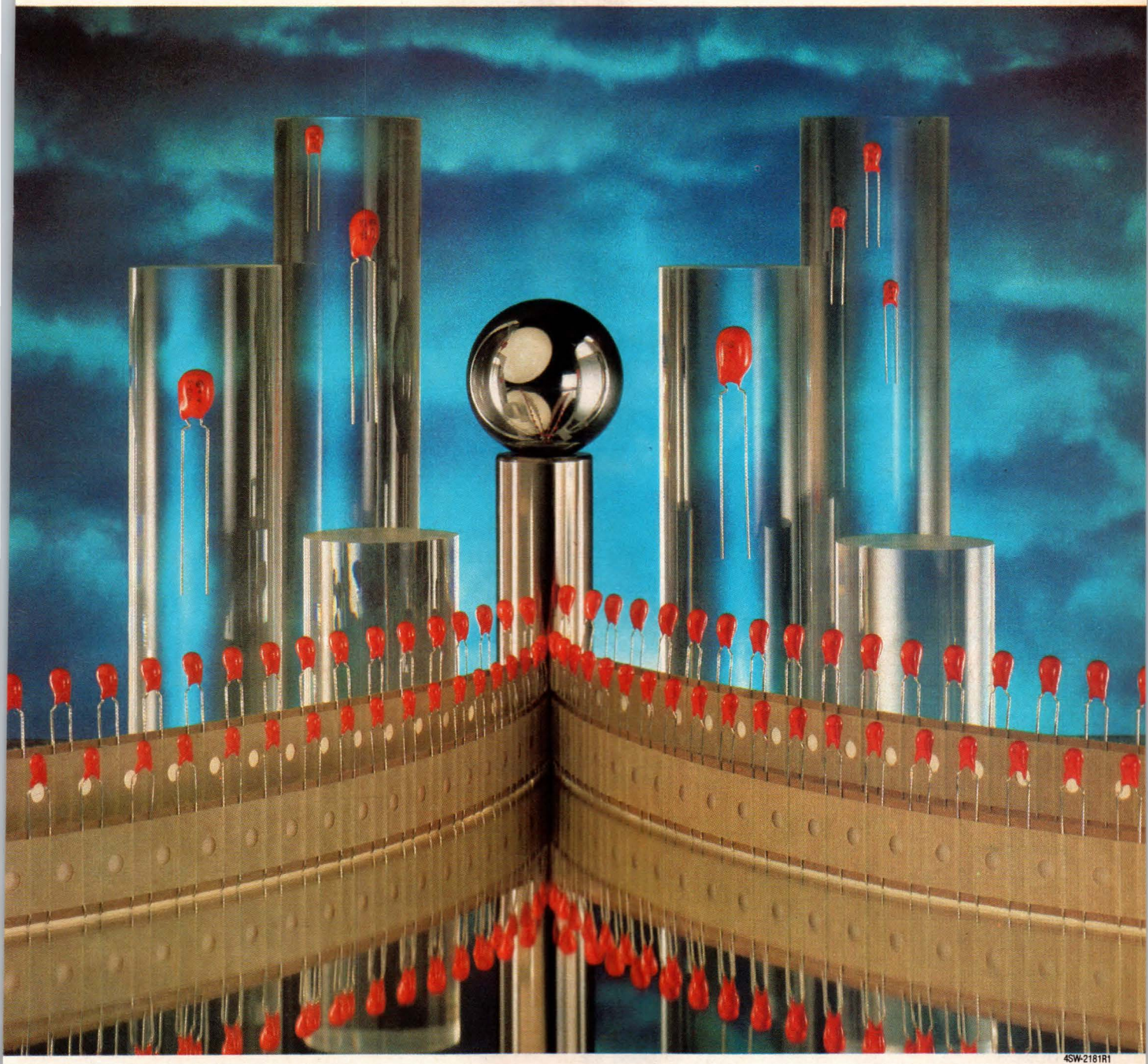
What other kind of energy can make that claim?

Write Solarex Corporation, Dept. S-701, 1335 Piccard Drive, Rockville, MD 20850, USA.

SOLAREX

CIRCLE NO 33

CHOICE.



4SW-2181R1

SPRAGUE MAKES IT EASY.

The choice is Sprague for solid tantalum capacitors! Sprague Type 199D Epoxy-Coated Solid Tantalum Capacitors, the first of their kind, are now better than ever...lower leakage current...higher operating temperature to +125°C with voltage derating...new smaller sizes. Four lead styles to meet your needs... also taped and reeled for low-cost automatic insertion on printed wiring boards. All delivered on time at competitive prices. Write for Engineering Bulletin 3547C to Sprague Electric Company, **491** Marshall St., North Adams, Mass. 01247.

SPRAGUE
THE MARK OF RELIABILITY

CIRCLE NO 34

LEADTIME INDEX

Percent of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last months average (weeks)
TRANSFORMERS								
Toroidal	—	27	33	20	7	13	12.2	11.8
Pot-Core	9	18	9	28	18	18	15.8	12.5
Laminate (power)	—	18	46	12	6	18	13.1	11.5
CONNECTORS								
Military panel	—	9	35	28	—	28	16.1	14.9
Flat/Cable	11	47	26	5	—	11	7.2	6.5
Multi-pin circular	—	30	40	10	—	20	11.6	13.9
PC	—	46	31	8	—	15	9.3	6.6
RF/Coxial	—	42	24	17	—	17	10.8	8.5
Socket	20	55	15	—	—	10	5.4	5.9
Terminal blocks	4	52	26	9	—	9	7.4	5.7
Edge card	6	62	13	6	—	13	7.3	7.0
Subminiature	8	50	25	—	—	17	8.3	8.3
Rack & panel	—	55	18	9	—	18	9.6	8.4
Power	13	26	36	—	—	25	11.2	5.7
PRINTED CIRCUIT BOARDS								
Single sided	—	29	42	29	—	—	8.6	8.1
Double sided	—	25	50	25	—	—	8.5	9.0
Multi-layer	—	—	33	67	—	—	13.4	14.4
Prototype	—	61	17	22	—	—	6.1	3.6
RESISTORS								
Carbon film	38	31	15	12	4	—	4.8	3.6
Carbon composition	13	25	37	21	4	—	7.9	5.7
Metal film	18	25	43	14	—	—	6.2	5.0
Metal oxide	11	37	26	26	—	—	7.0	3.8
Wirewound	—	17	54	29	—	—	9.3	7.5
Potentiometers	—	41	37	22	—	—	7.3	8.5
Networks	—	29	32	29	5	5	10.6	7.6
FUSES	48	29	18	5	—	—	2.8	2.5
SWITCHES								
Pushbutton	26	21	32	16	5	—	6.8	6.9
Rotary	6	41	35	18	—	—	6.5	10.0
Rocker	—	50	20	30	—	—	7.4	6.6
Thumbwheel	9	18	18	55	—	—	11.0	9.8
Snap action	—	36	28	36	—	—	8.7	7.7
Momentary	—	33	42	25	—	—	8.0	7.2
Dual-in-line	—	62	13	25	—	—	6.3	6.9
WIRE AND CABLE								
Coaxial	11	50	22	11	6	—	6.1	5.9
Flat ribbon	20	45	25	5	5	—	5.0	5.2
Multiconductor	—	31	50	13	6	—	8.3	5.7
Hookup	46	29	17	4	4	—	3.6	3.6
Wirewrap	36	29	14	14	7	—	5.8	3.1
Power cords	17	38	33	6	6	—	5.9	4.6
Other	—	20	40	20	20	—	12.0	4.7
POWER SUPPLIES	0	13	42	37	4	4	11.8	11.2
CIRCUIT BREAKERS	11	16	28	39	6	—	10.4	9.4
HEAT SINKS	17	44	13	26	—	—	6.1	4.3

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last months average (weeks)
RELAYS								
General purpose	28	22	17	33	—	—	7.1	6.8
PC board	6	22	33	39	—	—	9.3	10.3
Dry reed	—	29	29	42	—	—	9.6	14.5
Mercury	—	14	57	29	—	—	9.5	16.7
Solid state	—	20	50	20	10	—	10.2	10.9
DISCRETE SEMICONDUCTORS								
Diode	13	30	27	10	20	—	9.6	9.2
Rectifier	—	31	31	6	26	6	12.7	8.5
Thyristor	—	37	37	14	6	6	9.4	10.3
FET	—	21	40	27	6	6	11.4	11.9
Zeners	5	30	39	13	5	8	9.6	8.5
INTEGRATED CIRCUITS, DIGITAL								
CMOS	—	4	12	36	32	16	20.1	14.8
TTL	—	6	11	39	22	22	19.8	14.3
LS	4	4	4	54	17	17	18.7	17.0
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	—	—	20	54	13	13	17.7	16.6
OP amplifier	6	17	22	44	—	11	12.6	14.6
Voltage regulator	—	19	24	33	10	14	14.5	12.0
MEMORY CIRCUITS								
RAM 16K	—	—	37	25	25	13	17.5	17.6
RAM 64K	8	8	23	23	23	15	16.3	19.7
RAM 256K	17	—	33	—	33	17	16.5	—
ROM/PROM	17	—	25	42	8	8	13.3	16.6
EPROM	12	—	29	35	12	12	14.8	16.7
EEPROM	—	—	50	40	—	—	10.4	19.5
DISPLAYS								
Panel meters	8	42	25	17	8	—	7.6	9.2
Fluorescent	13	25	25	25	12	—	9.6	9.6
Incandescent	13	13	36	25	13	—	10.5	6.0
LED	6	6	52	18	18	—	11.8	7.9
Liquid crystal	—	25	34	25	8	8	11.8	13.7
MICROPROCESSOR ICs								
8-bit	17	6	11	33	22	11	15.4	—
16-bit	—	10	10	40	30	10	18.3	—
FUNCTION PACKAGES								
Amplifier	—	—	55	27	9	9	13.9	10.8
Converter, analog to digital	—	—	33	45	11	11	16.1	12.0
Converter, digital to analog	10	—	40	30	10	10	13.7	10.8
LINE FILTERS	10	10	40	30	—	10	11.3	9.0
CAPACITORS								
Ceramic	8	29	42	17	—	4	7.9	7.2
Ceramic monolithic	—	33	33	22	6	6	10.2	9.0
Ceramic disc	17	33	33	11	—	6	6.9	6.7
Film	—	39	39	14	—	8	8.6	7.2
Electrolytic	8	34	25	25	4	4	9.0	9.4
Tantalum	5	35	35	20	—	5	8.3	10.1
INDUCTORS	—	—	50	33	—	17	14.6	11.0

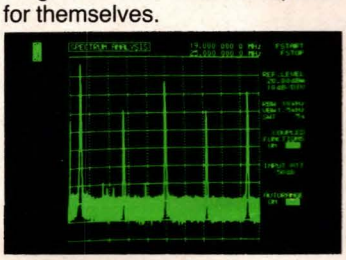
Source: *Purchasing* magazine's electronic business survey

Spectrum and Network Analysis Simpler and greater accuracy, at last!

Precision, even with simpler operation? The SNA-1 Spectrum and Network Analyzer, 100 Hz to 180 MHz, offers both at the optimum.

Simple operation:
For overview measurements, the "analog" settings with three knobs for center frequency, sweep width, and level range are obviously useful. On the other hand, known parameters are best entered exactly and easily via the keypad. Thanks to the "softkeys", the rest is easy. Complete standard setups can be stored, or else setting and evaluation are taken care of by computer via the IEC 625/IEEE 488 Interface.

Accurate measurements:
The SNA-1 offers the stability of a synthesizer and the high accuracy of our classical level measuring setups, with which we have achieved such worldwide success. Indeed, bandwidths starting at 3 Hz and a level measuring range down to −130 dBm speak for themselves.



The evaluation? Very easy: calibrated electronic graticule, parallax-free readings, two digital measurement curve stores (measurement, reference/difference), superimposed measuring traces and tolerance limits as well as alphanumeric display of all important parameters.
For easy documentation, the complete formatted measurement results are shown on the video screen and are available as hardcopies from a graphics/video plotter or by photographic recording.
Are you looking for such an instrument? Then just request detailed information about the SNA-1 and its interesting price.

Please send me:
☐ Information about the SNA-1
☐ An applications engineer to advise me

EM/11-29

Name .....
Firm .....
Address .....
.....
Tel. No. .....

Wandel & Goltermann
P.O.Box 45 · Abt. VW
D-7412 Eningen u. A.
Fed. Rep. of Germany
Tel. +(49) 7121-89 11
Telex 7 29 833 wugd

CIRCLE NO 44

We Understand That Engineering

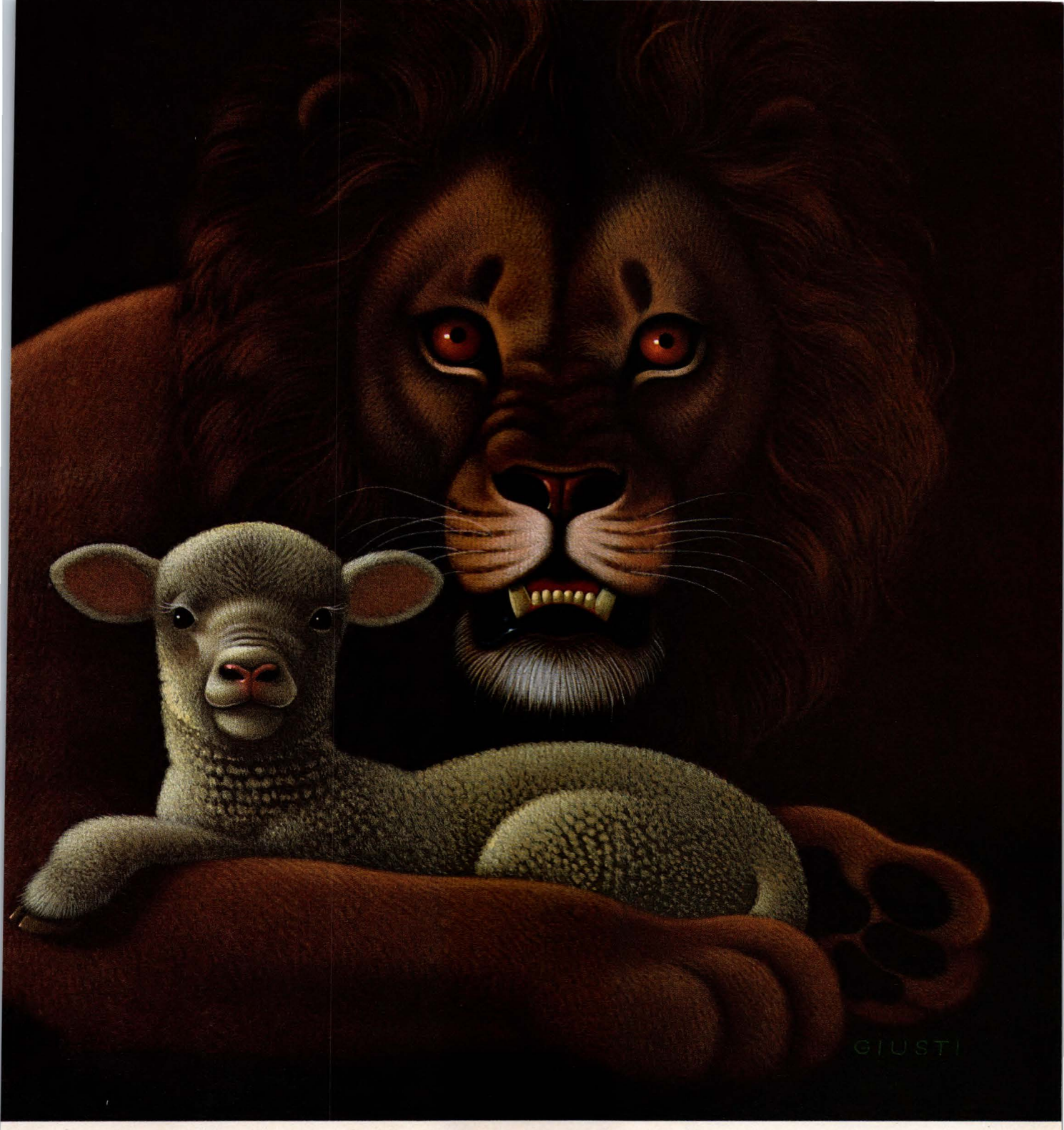
You're facing an inhuman workload. Tomorrow's electronic designs are going to be increasingly complex. And you've got even less time to get them to market.

Still, it's a problem you can tame.

Because at CAE Systems, we integrate all your design engineer's tools. Right on his desk top. And thanks to a unique human interface, it's remarkably easy to use. In fact, it actually shows engineers what to do next. So you maximize the effectiveness of your design engineers and the remote tools they use.

And with CAE System's exclusive approach to team engineering, you partition designs like never before. Because all engineers have concurrent access to individual design elements, as well as the overall

Sales Offices: Dallas Minneapolis Framingham Los Angeles Austin Chicago New York Phoenix Houston



Integration Can Be a Beastly Problem.

project. Which means your engineers actually work together harmoniously—whether they're side-by-side or far apart. And that allows each engineer in your team to simultaneously see what other members are doing. So the pieces fit together.

The first time. And in less time.

The result: increased productivity, better communication and fewer errors. Contact CAE Systems, Inc. today at: 1333 Bordeaux Drive, Sunnyvale, CA 94089, (408) 745-1440. Get the ideal integration of man and tools to conquer tomorrow's beastly electronic design problems.

CAE SYSTEMS INC.

We Understand Engineering Integration

St. Louis Washington, D.C. Portland Atlanta Detroit Orlando European Headquarters: Switzerland

CIRCLE NO 35

BRILLIANT ON YOUR BENCH. LIGHT ON YOUR BUDGET.

New 5½-digit Keithley 197 DMM brightens a bench for under $600.

5½ IS ONLY THE START.

This Keithley starts by giving you the versatility you expect in a general-purpose meter. Then, add 1μV, 1mΩ, 1nA sensitivity and 0.011% DCV accuracy to 5 full functions, and you've got an unexpected combination of versatility and sensitivity.

But the latest technology takes it even further beyond the expected in performance, convenience, and value.

5½ + EXTENDED PERFORMANCE.

The 197 offers voltage measurements from 1μV to 1000 V, TRMS AC to 100 kHz, automatic 2/4 wire ohms from 1mΩ to 220 MΩ, and current from 1nA to 10A on 6 ranges. This extended capability is easily read on the 220,000 count display, with full annunciators for your beyond-the-ordinary measurements. Digital calibration locks in this performance.

5½ + CONVENIENCE.

The fast AUTORANGING and front panel simplicity will make the 197 your favorite meter. But there's more.

The 100-point DATA LOGGER lets you store readings at 6 different rates or by manual trigger.

The RELATIVE reference button lets you zero out any on-scale reading with one touch.

There's also MIN/MAX reading hold and direct-reading dB. For portability, the 197 can be ordered with a rechargeable battery option.

5½ + IEEE-488 + ANALOG OUTPUT.

Here's the low-cost way to put the 197 on the GPIB with range programmability on volts and ohms, talk/listen capability, trigger, SRQ, and other commands. Order the IEEE option alone or with the isolated analog output.

5½ + VALUE.

Add it all up. We think you'll agree the new 197 is a highly sensitive, accurate, and versatile tool that belongs on your bench. All for a base price of $595. IEEE option: $225.

For complete details, contact Keithley Instruments Telemarketing Dept. at (216) 248-0400, or 28775 Aurora Rd., Cleveland, OH 44139.

KEITHLEY

CIRCLE NO 36

"People developing software for the TMS 320 . . .
should not be without this book and the accompanying software"**

DIGITAL SIGNAL PROCESSING SOFTWARE

with advanced applications on the

TI TMS 320 DSP MICROCHIP

consists of a 500 page, tutorially-orientated text and programming/users' manual; more than 50 tested FORTRAN, MACRO-11, and TMS 320 programs in machine readable DEC or MS/PC-DOS source floppy format; and a powerful TMS 320 cross assembler. Of course, all TMS 320 cross assemblers can assemble TMS 320 code! But, only *DSPS-Macro*, because it runs under *MACRO-11* or *Microsoft Macro*, allows the user to invoke the powerful *repeat* [.REPT], *concatenation* ['], and *numeric conversion* [\] operators for *user* macros. The following examples vividly demonstrate what these capabilities buy you in terms of ease of generation of time-efficient '320 code such as DSPS' FFT's, with 64/128/256 complex point transforms executing in 0.53/2.4/6.1 msec.

128'th Order FIR Filter: Only two short macros and a 5-line repeat sequence generate the complete nucleus of a 128'th order, 400 nsec-per-tap, finite impulse response filter, assuming that a file containing COEF 1,*c*1; COEF 2,*c*2; . . . COEF 128,*c*128 (where the *c*'s are scaled, 13-bit integers) has been generated by any high level language filter design package, such as those in the *IEEE Programs for DSP* book:

```
.MACRO COEF I,J          .MACRO TAPGEN I          I = 128.
CF'I = J                 LTD  *-                  .REPT 128.
.ENDM                    MPYK  CF'I               TAPGEN \I
                         .ENDM                    I = I-1
                                                  .ENDR
```

What could be simpler?

Variable Shift of a 32-bit Integer, plus Exponent Adjustment: In TI's *Floating-Point Arithmetic* DSP Application Report, the 30 required subroutines occupy about 10 pages of code (over 400 source lines) vs. only 1 page of code (about 50 lines) required for *DSPS-Macro*. Although both programs assemble into the same amount of object code, the compact DSPS approach is easier to write, debug, and maintain, and results in a much smaller and thus more readable source program.

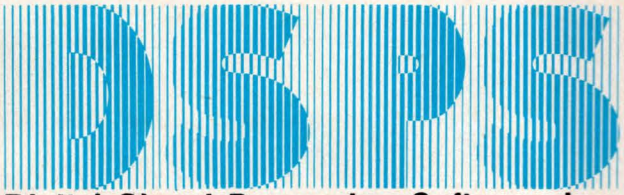
10'th Order Leroux-Gueguen LPC Matrix Inversion (included in our package): The lack of indexed data addressing on the TMS 320 makes our *autogen* technique both attractive and realistic for programming "non-array-like", looped algorithms involving indexed data access. In the L-G program, about 60 lines of clear, readable, "looped" code — which reflect the structure of the original FORTRAN prototype program — generate about 600 lines of TMS 320 in-line code which execute in 300 *u*sec (including 10 calls to divide): nearly 3x faster than a leading $50,000 floating-point array processor. The alternative, a "looped-at-run-time" version, would execute more than twice as slowly. *And, writing a correct in-line version manually would be very difficult indeed, and totally inappropriate in view of the power of DSPS-Macro.* Similarly, in our 535 *u*sec *64 complex-point FFT (DSPS-2)*, about 150 source statements — which again echo the structure of the FORTRAN prototype — expand into 2900 lines of object code, with all control, addressing, and trig coefficients absorbed into the code at assembly time.

And, **DSPS-Macro** allows use of other powerful features such as conditional assembly, macro nesting, and macro calls within macro definitions (including recursion). Finally, while we guarantee that *DSPS-Macro* assembles TMS 320 code correctly, DEC and Microsoft guarantee the long-term support, stability and availability of the *MACRO-11* and *Microsoft Macro* "supervisors".

BOOK CONTENTS/REVIEW

• Digital Signal Processing Algorithms & General Purpose Computers • PDP-11 & Macro-11 Assembler • Structures For Control, Data Access & Data Manipulation • Compilers, Computers, & High-Level DSP Software • Systematic DSP Programming & DSP Systems Programming • TMS 320 DSP Microchip: Architecture: instruction set; address modes; page, pointer, and data manipulation. Arithmetic sequence programming: data and coefficient scaling; addressing and instruction ordering strategies; utilities. Modular programming: subroutines and argument passing, case branch, threaded code, interrupt service routines, memory overlays. Input/output. Data and coefficient scaling techniques. Time/space tradeoffs via *autogen*. DSP case studies: A/D, D/A, *u*law mapping, windowing, FFT butterfly, convolution, biquad filter, modems, square root, software sine & divide. LPC: limited-memory, 32-bit autocorrelation (3 msec for 200 point, 10 lag); L-G matrix inversion (300 *u*sec for 10'th order); lattice speech synthesis (20 *u*sec/point, 10'th order); pitch detection. Comparative performance: TI vs. Fujitsu vs. J-11. Software development systems: Software emulators. MACRO-11 and MS-DOS cross assemblers; TI EVM board/host communication. Next generation TMS 320. **A Tale of Two Architectures: PDP-11 vs TMS 320 • The Future: New Technologies •**

The reviews are now in on our DSPS-3 package; in the Jan/Feb 1984 issue of *Speech Technology*, Dr. E. Randolph Cole at the Information Sciences Institute, U. of S. California, states: "People developing software for the TMS 320 . . . should not be without this book and the accompanying software",** "the software is a bargain for those who can use it", "the techniques of real-time software writing are the strength of the book", and "we're talking about powerful real-time software here", and "this is the clearest, most concise tutorial on the TMS 320 I have seen anywhere". We appreciate Dr. Cole's remarks, and we know that the hundreds of copies of the DSPS-3 book and software now in the field have easily saved their owners the purchase price in the first week or two of software development on the TI TMS 320.



Digital Signal Processing Software, Inc.
P.O. Box 5348, Station F, Ottawa, Canada K2C 3J1

Complete package (DSPS-3), only US$299. Includes 500 page book and floppy with cross assembler, EVM/XDS loader, and 50 source programs (e.g., TMS 320 windowing, IIR, FIR kernels; LPC autocorrelation, L-G matrix inversion, & lattice synthesis). Send cheque or PO specifying PDP-11/VAX-11 or MS/PC-DOS version. SPECIAL: DSPS-2, the 64/128/256 point FFT software is now only US$199 if ordered with DSPS-3. Guaranteed off-the-shelf delivery by first class air mail upon receipt of order. Phone (613) 825-5476 for information.

CIRCLE NO 37

Integrated development tools *lubricate the software design cycle. (Photo courtesy Zax)*

INTEGRATED DEVELOPMENT TOOLS

Projects go faster if your development system is more than a disjointed collection of tools. Development-system utilities that have uniform commands and compatible outputs smooth the transition from one design step to the next.

Charles H Small, *Associate Editor*

You can't spot an integrated development system by looking at its hardware. A collection of hardware might plug together easily, but that doesn't mean the system's integrated. Actually, you need to be concerned with hardware compatibility only when you're hooking the development system up to your target system. From then on, it's the *software* that you use as you step through the software design cycle (**Fig 1**). Therefore, the degree of integration of the software tools determines just how integrated a development system is.

In fact, integrated software needn't be entirely dependent on hardware; many sets of integrated development utilities can run on more than one manufacturer's hardware. One product offering a high level of integration is Tektronix's suite of integrated software that runs on the firm's 8500 Series development systems, whose hardware comprises a terminal, a controlling Model 8560 computer, and an emulator box. The computer's heart is a DEC LSI 11/23, so the code also runs on the DEC VAX (although a system incorporating the VAX won't exhibit the hardware integration of the all-Tektronix system).

You can thus run the same software and do the same tasks on two vastly different physical systems. Except for the fact that the Tektronix/DEC system has greater speed and bigger disks, you can't tell if you're using the Tektronix or the DEC computer. Similarly, Motorola's development software for the firm's HDS-400 and HDS-200 emulators will run on a DEC mainframe or the firm's VME/10. Further, Kontron makes both a Unix box that complements its KDS development system and a hard-wired link to DEC mainframes. Indeed, you can expect virtually every development-system maker who hasn't done so already to come out with DEC-compatible software tools soon.

In addition to manufacturers of complete development systems that run integrated software suites, consider firms that make stand-alone emulators: for example, Zax, Microtek Lab, Huntsville Microsystems, Relational Memory Systems, and Applied Microsystems. A simple dumb terminal can control these firms' in-circuit emulators. But they all now offer control programs that run on common personal computers. The software for these systems resembles that of early

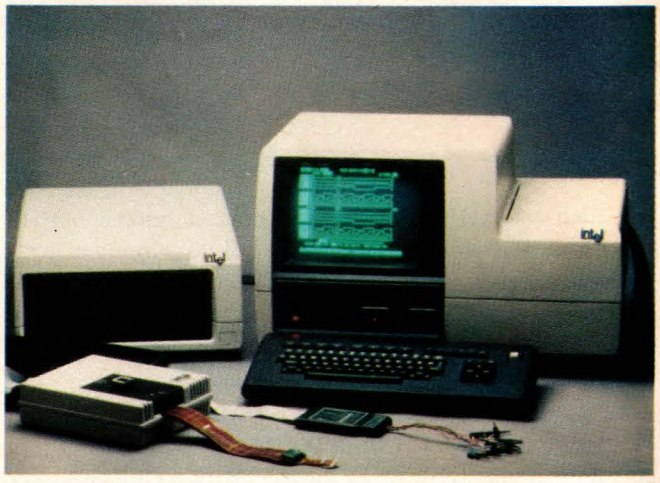
Whether running on a DEC mainframe *or on the firm's 8560 development station, the integrated software for Tektronix's 8500 series supports a project from definition through debugging.*

development systems from IC vendors. You can integrate your own development system if you add the newer high-level-language compilers available for personal computers.

Whether you choose to call such a collection an integrated development system is up to you. The Sophia Systems SA700, for example, has a built-in CRT, keyboard, processor, and floppy disk. It also sports in-circuit emulators and a PROM burner. The processor can run some CP/M-based or Intel development software. Yet, the firm prefers to call it a stand-alone in-circuit emulator rather than an integrated development system.

ZAX (which was, until recently, considered to be a maker only of stand-alone in-circuit emulators) now also offers a controlling computer, called the Box, that runs several operating systems, including Unix. This computer controls the firm's stand-alone in-circuit emulators.

This spectrum of available products, running the gamut from superminicomputer-based systems to stand-alone emulators, can make selecting a development system a tough chore; no consensus exists relative to the best choice for specific applications, as the viewpoints expressed in the accompanying **boxes** indicate. Nevertheless, all recent offerings overcome many of the problems that earlier versions exhibited.



Combining in-circuit emulation with *100-MHz logic analysis, Intel's I²ICE handles as many as four of the firm's 16-bit processors at once.*

Early systems lacked focus

The first development systems were integrated physically because you could get, from a single vendor, a complete hardware/software package for μP development. The hardware comprised a more-or-less garden-variety controlling computer with CRT, keyboard, floppy disks, and perhaps a printer, along with other equipment more specific to μP development, like a PROM burner, a logic-analyzer-like program-trace analyzer, and an in-circuit emulator (ICE). The software comprised program-development tools like assemblers and compilers and μP-development utilities for running the PROM burner, setting up the trace analyzer, and manipulating the ICE's memory and the μP's internal registers and breakpoints.

But none of the software tools was integrated. Each subsystem had its own command language and procedures. The text editors had one set of commands while the emulator and the trace analyzer used others. The linker and loader worked one way and the software that downloaded to the PROM burner had differing syntax and options. And the software wasn't particularly easy

With either a Unix box or a hardwired, high-speed link *to a DEC mainframe, the Kontron KDS gains access to high-level tools previously unavailable on its 8-bit controlling computer.*

Offering a choice of high-level-language *software debuggers, Hewlett-Packard's 64000 system has both software emulation and real-time hardware emulation.*

to use. The emulator-control software, for instance, often looked like a crude monitor. These monitor-based command languages had low-power, atomistic commands for examining and changing the contents of registers and memory locations, running and halting the program at breakpoints, and patching code.

Specs set the tone

Regardless of the development tools you choose to use, a design project begins with setting specifications. Studies of sources of error in programs consistently reveal that bad specs cause a significant percentage of all software failures. In these cases, the code performs exactly as specified; the specs themselves are out of line. Bad specifications arise partly from human limitations and partly from the way the specs are promulgated. Usually the marketing and software engineering departments get together to hammer out the initial product specs because no one person has a complete grasp of both the customers' needs and the software's possibilities. The marketing department (presumably) understands the customers' needs but doesn't understand programming. The software engineers know all about programming but probably don't understand the end product's application very well.

For example, one emulator company had a team of experienced C software engineers develop a new software product. Following the usual C convention, the product printed out all hex numbers in lower-case

Based on the DEC Professional, *the Emulogic 3200 features system-control software that resembles the C programming language.*

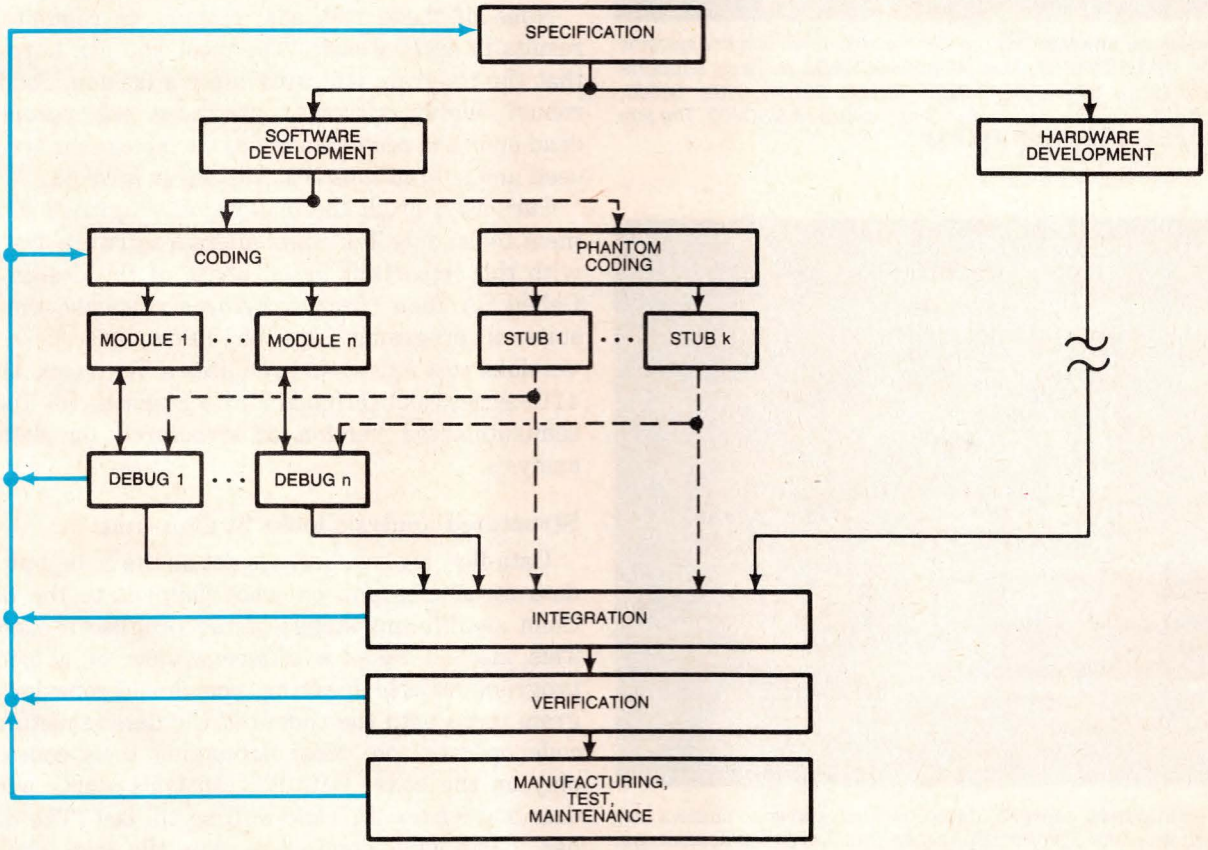


Fig 1—At every step in a software project, *you can use an integrated development tool. Note that the path between coding and debugging is bidirectional. These are the stages that benefit the most from integration of software tools.*

characters: for example, "fed0." More accustomed to seeing "FED0," every beta-site evaluator complained, and the output routines had to be changed.

This is not to say that programmers and software engineers are the only ones to blame for poorly done specs; they claim with some justification that it's not uncommon for marketing departments to change the specs frequently while the software engineers are writing the code.

The other problem with specs is the form in which they're promulgated. Specs often come out loosely worded and incompletely detailed, perhaps merely written in plain English. Such specs may look good right up to beta-site testing, but they often prove inadequate when potential customers try the product.

A stand-alone emulator *can rival integrated development systems using an IBM PC or PC clone. Microtek's MPDS currently supports the 8048/49/50, 8085, 8086, 8088, 80186, 80188, 6809, 68000, 68010, 6502, 65SC02, 65C02, 65SC802, Z80, and NSC800. The firm plans to include the 68020 and 80286.*

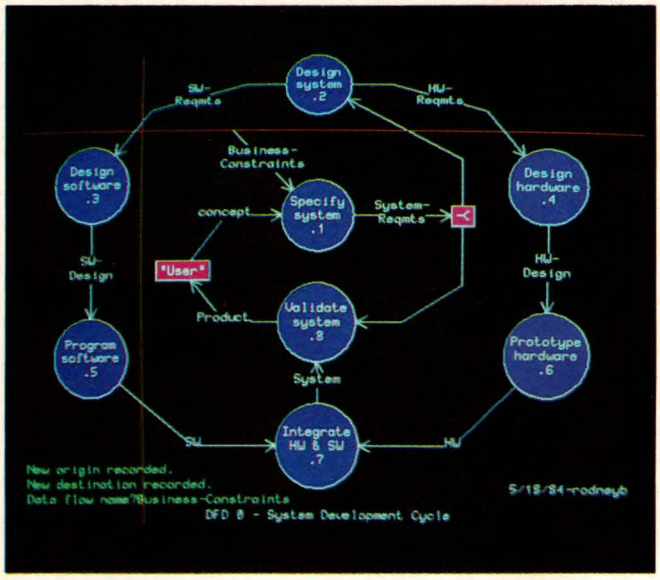


Fig 2—Structured analysis (data-flow analysis) *is an efficient way to set up specs for a project. Every data structure and its contents get specified. Relationships between processes are also spelled out. The finished analysis suits structured walkthroughs, which test the project's functions before any code gets written.*

Hidden bugs trip you up

Such inadequacies can be prevented—many structured methods can be used to effectively detail software specs. Instead of loosely worded English, some firms employ schemes like structured English, program-description languages (PDL), or structured analysis (data-flow analysis). These more rigorous methods of expressing a program's functioning allow you to test the program in advance. Although these methods are clearly amenable to computerized checking of things like module interfaces and both data-structure patterns and usage, most firms currently do them manually.

Indeed, some *overdo* them. A recent IEEE study found some firms generating as little as 1.15 to 1.3 lines of real code for every line of pseudocode (program-description language or structured English) in the software spec. A ratio of one line of real code for one line of pseudocode would mean you've achieved a zero level of abstraction and, in essence, written the program twice. A ratio of 1.3:1 isn't much better.

None of these methods, manual or computerized, results in optimal code. The most you can hope for is that the program will work after a fashion. Studies of robust, highly optimized programs still reveal such dead ends and redundancies as variables that are never used and subroutines that are never invoked.

Curiously, of all the makers of integrated development tools, only Tektronix offers a software tool to aid with this important initial phase of the design cycle. Called SA Tools (from structured analysis), the $9500 suite of programs runs on Tektronix's 8560 (VAX versions cost extra) and requires a Tektronix 4100- or 4110-series color terminal for its graphics. SA Tools is a semiautomated version of structured (or data-flow) analysis.

Structured analysis looks at data first

Data-flow analysis focuses not on the code, but on the data structures and on what happens to the data in them at different stages of the program's execution. This method takes a different view of a computer program; strictly speaking, you should consider a program to be both the code *and* the data structures the code operates on. Most debugging tools concentrate only on the code. Data-flow analysis starts with the data and leaves the code-writing till last. The method has found wide application over the last ten years. Tektronix applications engineers report that users manually maintain data-flow analysis schemes that

have more than 2000 constituent modules.

Tektronix's programs provide a graphics editor for naming modules (the blue circles in **Fig 2**) and connecting them with labeled arrows to show how they relate. This results in a directed graph that resembles a graph for a classical finite-state machine. Clearly, there's room for only so many blue circles on a given screen. Therefore, the editor encourages you to do a top-down

Why ICE isn't enough

Terry Larson, Dolch Logic Instruments Inc

Traditional test and measurement instruments used in digital-system design are undergoing dramatic changes. The primary purpose of development aids such as logic analyzers, in-circuit emulators (ICE), and pattern generators is to increase engineers' efficiency by simplifying engineering tasks. To facilitate testing of complex designs, instrumentation systems in the past combined several stand-alone instruments with an IEEE-488 (GPIB) controller. However, a new breed of truly integrated instruments provides real-time testing capabilities that were previously impossible with the GPIB approach.

Typical of these is Dolch's ATLAS 960 personal-instrument workstation, which integrates digital test instruments within a single controller and allows real-time interaction between all instruments. Because the ATLAS is a modular system, you can combine a variety of instrument plug-ins.

Another example is Intel's I²ICE, which is slaved to a dedicated μP-development system to bring logic analysis and in-circuit emulation together in a fashion that allows cross-triggering between instruments. Most in-circuit emulators provide some logic-state analysis capabilities for software debugging purposes; I²ICE incorporates an asynchronous analyzer for true timing and off-the-bus event tracing. Similarly, the Tektronix DAS 9100 is a configurable logic analyzer that incorporates a digital pattern (word) generator. This combination provides the hardware stimulus for logic-analysis testing.

Although these examples are all properly termed integrated instrumentation, there are significant differences between them. I²ICE requires the host system to drive all test and debugging functions. This approach is expensive, and it lacks several instruments vital for testing. These include a digital-pattern generator, serial-data analyzer, and waveform analyzer. You are limited to a single 16-channel analyzer for each I²ICE chassis, making multiple-channel logic-analysis applications expensive.

The I²ICE approach lacks hardware-stimulus capability; for instance, there's no pattern generator to drive asynchronous circuitry or circuitry off the μP's bus. There is no logic-simulation capability, and all testing must be done under development-system control, tying up a very expensive software-development system for an often lengthy debugging effort. Finally, I²ICE has no IEEE-488 to integrate other instruments into the system. It can only supply triggers for external instruments.

Dedicated and universal development systems are being replaced by general-purpose computers running development software. I²ICE wasn't designed to be slaved to general-purpose computers (from PCs to minis and mainframes).

With the emergence of CAE systems, highly sophisticated hardware and software support for all facets of the engineering design cycle will be included in the engineering workstation of the future. System-test instruments must be flexible enough to interface to CAE systems and be remotely controllable from the CAE system. Only with such an approach will the computer and simulation power resident in CAE systems be able to interface, in a high-level fashion, to the target system. Design and testing needs are becoming so complex that it is mandatory to remove the engineer from the mechanical loop linking the simulator to the actual target system's operation.

Admittedly, enhancing software-development systems with hardware and software troubleshooting capabilities is necessary, but it will be obsolete in a few years. A new approach to integrated digital-system testing, illustrated by the Dolch ATLAS and CAESAR systems, allows flexibility to mix and match instrumentation plug-ins to fit the application. Such an instrument can operate either as a stand-alone unit or slaved to a CAE-system workstation. It is with this approach that future systems designers will truly be able to marry the computer and simulation power to automated product-development test needs while retaining a degree of hands-on control over traditional digital-instrument test capabilities.

The author is vice president of marketing for the San Jose, CA, firm.

hierarchical design by numbering all the blue circles on a given screen at the same level—say, 1.0, 2.0, 3.0, etc. To expand the hierarchy downward, you select a circle and engage the screen underlying that circle in the hierarchy. If you were to select circle 2.0, for example, all the circles underlying circle 2.0 would get labeled 2.1, 2.2, 2.3, etc. You can continue this process ad infinitum.

At your option, you can append a "minispec" to each circle. Tektronix recommends that you write this minispec using some form of structured English or program-description language (PDL). However, none of the SA Tools does any syntax checking on your structured English, though they do enforce some rules. Specifically, they check your circles and arrows for consistency, and they require you to define the contents of every data structure or item mentioned. When the analysis is complete, each member of a programming team has a complete description, either on screen or on printouts, of his module's functions and interface.

Automated spec'ing ensures consistency

The real value of this kind of automated tool becomes apparent only after you've done your initial layout and have begun to modify it. Although top-down hierarchical design sounds and looks impressive, in the real world, most hierodules (slaves in the service of a hierarchy) work not from the top down (or from the bottom up, for that matter) but from the middle out. Therefore, the structured analysis is bound to be restructured frequently as the project progresses and the software engineers find that their initial ideas need rethinking. Just like any other coordinated combination of engineering drawings and engineering documents (for example, schematics, pc-board layouts, bills of material, and net lists), a complex data-flow analysis and its accompanying minispecs and data dictionary can get hopelessly fouled if they're not modified and updated very carefully, thoroughly, and consistently. Computerized tools make a good deal of the thoroughness and consistency automatic.

Industry sources report that firms who have been using manual structured-analysis methods eagerly embrace the computerized version. Characteristically, firms that haven't don't seem to be able to grasp the value of the method.

Once you've done the structured analysis, you can try the proposed program manually with a structured walkthrough, a paper analysis of the program's operation. But specifications and structured walkthroughs are only the beginning of a project. The real grunt work begins with writing the code.

At the dawn of the μP age, most 8-bit μP code was written in assembler instead of in high-level code. And the amount of code was small enough that just a few software engineers could complete the entire project. While you can't go so far as to say that nobody writes just 4k of code and ships a product anymore (the

The personal-computer development system: A less expensive alternative

Robert Hsieh, Microtek Lab Inc

A personal-computer-based development system is the least expensive way to handle system development chores. You need a computer like the IBM PC, compilers and assemblers that run on it, and stand-alone in-circuit emulators.

Microtek's MPDS, for example, provides the same power as full microprocessor development systems like those made by Intel, Hewlett-Packard, Tektronix, and Kontron, but at a fraction of their cost. MPDS performs emulation with easy-to-learn, single-letter commands.

The cost of a microprocessor development systems depends on the processor. The **table** shows the complete cost of a Microtek system for the 80186 μP.

To emulate the 80188 on that system you need only replace the 80186 chip with an 80188. To emulate a microprocessor belonging to a different family you need a personality card and the corresponding software. The 68000 personality card, for example, costs $2395, and the software package is $1300.

The author is vice president of the Gardena, CA, firm.

COST OF A DEVELOPMENT SYSTEM FOR THE 80816 μP

HARDWARE	
MS-DOS HOST	$2600
MICE 8086 (32k ICE)	$4395
BREAKPOINT PROCESSOR BOARD	$1795
MICE POWER SUPPLY	$250
SUBTOTAL	$9040
SOFTWARE PACKAGE (CROSS ASSEMBLER, SYMBOLIC DEBUGGER, LOGIC-STATE ANALYZER, AND SOFTWARE-PERFORMANCE ANALYZER)	$1300
TOTAL SYSTEM	$10,340

semiconductor industry sells far too many single-chip μPs to support that claim), you can say that many μP-development projects are much larger than they were because of the new 16- and 32-bit μPs.

Software projects getting bigger

The move to more powerful μPs profoundly affects the way you must organize your project and the tools you need. The tools include:

- Software-version control
- Target-system simulation
- Assemblers
- Compilers
- Target-compilation utilities
- Symbolic debuggers
- Program trace and trap utilities
- Software verification tools.

Version-control systems are familiar to software engineers who work on large projects; Unix's "sccs" (source-code control system) is the best known. These systems keep track of program modules as they evolve. They record the identity of the person who modifies a module and the date and time of the modification. After the initial entry of a module, the version-control systems record only the changes to a module; they don't overwrite the old version with new versions. That way, you can reconstruct any previous version of a module.

Version control keeps modules on tap

Coupled with a "make" utility that reconstructs and links selected versions of modules, version-control systems have obvious value for large projects. Engineers who write small test programs to exercise hardware usually don't think they need an elaborate software-control system. That is, they don't think so until a member of their team takes off for a long weekend and leaves his floppy disk—containing a critical module—locked up in his desk. Version control also proves useful for keeping track of the "phantom code" (or "stubs") that gets written to stand in the place of real modules that aren't working yet. These stubs are essential for getting segments of a large project running well enough to check them out. Yet despite their importance, few projects make allowances for the time it takes to write and debug the stubs or provide for keeping track of them.

Intel's I²ICE has a version-control system that has a novel feature you can't get on mainframe systems. It links version control with electronic mail. When a module comes due, the manager gets an electronic-mail reminder of the fact. And if a module is updated, all members of the team who depend on that module get notified that it's been changed.

Although some engineers might doubt that they need version control, there's no doubt that in-circuit emulation is currently accepted (although complex systems offer a wider view into the target system than ICE provides). In today's large, modularized development programs, the integrated development system's ability to mimic the eventual target system is important because hardware and software development often proceed in parallel. Therefore, in the early stages of the project, the software engineers may have no working target system on which to try out their code.

Development system mimics target

The integrated development system's mappable memory is the primary mechanism for simulating the target system. With this scheme, the address and data lines of the emulator's μP get switched back and forth from the target system's memory to the overlay memory in the development system. Further, all integrated development systems can make portions of their RAM read-only, thereby simulating the target system's ROM. In the limiting case, you can have all memory reads and writes occur in the integrated development system's memory and none in the target system's. In other words, you need no target system at all. No target system at all, that is, if your project communicates *only* with memory.

Most μP projects don't communicate exclusively with memory, however. Most integrated development systems, by virtue of their monitor heritage, have little routines embedded in their operating systems for doing character-by-character I/O to the development system's CRT. It's not too hard to embed a small routine in your code that first initializes the necessary registers and memory location that the development system's I/O routines need and then jumps out of your program into the development system's ROM. Some systems have disk I/O routines you can jump to as well. Tektronix's 8500 integrated development systems have a more regular mechanism. They allow you to patch the integrated development system's terminal and disk I/O into your target system's programs. The price you pay is eight consecutive memory locations that you load with a Tektronix-specified array of information.

The Emulogic ECL-3200 Series provides, on the other hand, no patchable I/O routines. The firm claims that this points up the difference in application between Tektronix and Emulogic systems. Applications for the Tektronix integrated development systems presuppose a conventional general-purpose computer with the usual sort of terminal, printer, and disk I/O. Emulogic integrated development systems, the firm says, suit target systems with embedded processors that don't do such I/O—a robot, for example. I/O simulation for these kinds of systems is necessarily very application depen-

dent, and it must be done by each user. Emulogic further notes that its 16-bit emulators don't usurp or share any target-system resources.

Some systems intrude

Not all integrated development systems can make the claim that they don't usurp or share any target-system resources. For example, both Tektronix 8500 series and HP 64000 series 16-bit emulators need a small chunk of target-system memory—about 2k—for their own routines. You can't use this space for your code because that's where routines like the ones for dumping the μP's registers reside. Further, the Tektronix and HP emulators, as well as ones made by Zax, share the μP's nonmaskable interrupt (NMI) pin with the target system. That's how their emulators regain control of the emulator's μP from the clutches of the target system's code. Emulogic 16-bit integrated development systems put no code in the target system's space and don't use the NMI pin.

In defense of their schemes, HP and Tektronix point out that not using any target-system memory is important for 8-bit μPs with their limited memory space. For 16-bit μPs, with their extensive memory space, usurping a small relocatable chunk of target-system memory isn't so bad. Also, the firms claim that most engineers don't use the NMI pin for ordinary run-time functions. Instead, the NMI gets hooked to the power-up reset or watchdog timer. In these cases, they claim, the user has no problem distinguishing whether the integrated development system stopped the processor or whether the power failed.

But where does the code you're trying out come from? Industry sources estimate that 80% of all code for 8-bit μPs is written in assembler, while the remaining 20% is written in high-level languages. They expect the percentages to reverse for 16- and 32-bit μPs. But engineers aren't likely to use just any high-level language; they're more likely to write time-critical code than the average programmer is. Engineers are also more likely to use cross assemblers and cross compilers than are applications programmers. That is, engineers will write code on one computer that will eventually run on some other machine.

Engineers eschew protection

This means that engineers now need more than mere assemblers. They also need powerful system-implementation languages that don't attempt to protect programmers from making mistakes or from encountering the actual hardware of the native machine. Software engineers need these low-level facilities because the target machine often doesn't have an operating system. Therefore they cannot depend on an existing operating system's routines to handle the work of I/O, scheduling, intertask communication, and the like; instead they must write these low-level facilities themselves.

Software tools ignore time

But even though assemblers and certain high-level languages supposedly suit system implementation, a critical element is missing: time. All software-oriented tools suppress time. Yet time is critical in much of the software that engineers write. There's no intrinsic reason why software tools can't deal with time. It's not hard to conceive of a software simulator that would calculate a routine's run time, or an assembler directive that would pad out a module with NOPs (dummy execution cycles) so that the module would execute in a preset amount of time. But these things don't exist. That's why software engineers turn to hardware-based simulation. They write the code, try it out, measure critical timing parameters, and then return to the software domain and amend their code. In fact, speeding up this iterative, cyclic process of writing, loading, running, and amending lies at the heart of all claims that integrated development systems are powerful.

However, no two manufacturers have exactly the same view of just what steps make up the software-design cycle. Take target compiling, for instance: For a program written on a development system to run on a different target system, many things must be done to match the program to the new hardware. You have to assign some code to RAM and some to ROM, load interrupt vectors, assign stacks, and so on. Of all the firms making integrated development systems, only Tektronix views this target compilation as a task in itself. Tektronix supplies a specific utility that matches the software to the hardware. Other firms spread target compilation over three areas: assembling or compiling, linking, and loading.

Target compiling hits the mark

Tektronix's ICS (Integration Control System) is a part of the LANDS (LAnguage Development System) package. it prompts you for all the information the linker needs to assign code and data properly. It also handles patches for resets, I/O and other interrupt-driven processes that you might want to simulate back in the development system rather than in your target system. Finally, it goes beyond target compilation to include emulator setup. After you answer all the prompts, ICS yields a command file that links and loads your code as well as initializing the emulator.

However a given development-system maker structures its software and hardware, speeding through the design cycle means scaling successive levels of abstraction as painlessly as possible. Even the most elementa-

ry assembler allows you the abstraction of labels. High-level languages expand this repertory of abstractions to include not only symbolic names for various segments of your program but also various data constructs and special objects (linked entities of code and data, such as arrays defined by a DIM command). By the time you run the code with the aid of your integrated development system's in-circuit emulator, all these abstractions have long since been converted to machine code and machine-readable data. Consequent-

An integrated approach to microprocessor development

John Marshall, Hewlett-Packard Inc

Today's competitive environment demands that new products move quickly through the design cycle. Conflicting with this demand is the growing complexity of and increasing emphasis on quality and maintenance for both hardware and software. Design teams are responding to this need by using automated design tools that accelerate the design process and help locate and eliminate errors at the earliest stage possible.

Cross assemblers and compilers, for example, are essential automated software-design tools that have been available for a long time. Unfortunately, because software-design automation seldom extends beyond this point, software analysis and system integration are now the major throughput bottlenecks. While individual simulators, emulators, and logic analyzers are available to address the problems of software debugging and system integration, in most cases the process is as disjointed as the instruments themselves, and it's far from automated. Instead, the process is labor-intensive and prone to error, and it often fails to identify bugs early in the design cycle. (The later in a design cycle you find a bug, the more expensive it is to eliminate.)

The Hewlett-Packard Model 64000 logic-development system automates the entire process of software design and system integration. For this purpose, not only are the necessary software-design, debugging, and analysis tools provided, but they're tightly linked into an integrated design and analysis system. Because it is a modular system, the 64000 has no fixed price. Generally, however, a 6-station system with a fast hard disk costs about $12,500 per user (two users per station). The advantage of this approach becomes apparent as we trace through a typical design cycle.

The workstation does program assembly and compilation at high speed, which provides fast turnaround from source-code editing to native object code. You can begin software debugging immediately with the emulator before target hardware exists, and you can analyze a separately compiled module in terms of the C or Pascal source code. You can also do software-performance analysis to get an overview of program activity or to optimize the module's performance. Meanwhile, the emulator can control the processor and observe activity in registers within the processor. You can also simulate nonexistent I/O with the workstation's I/O devices. Program changes and enhancements are made and bugs are removed at the source-code level; the tight coupling of the instruments allows rapid context switching between the software-design and system-integration environments.

As the design progresses and hardware is developed, emulation provides a vital link between the target system and the software-design environment. Now it becomes important to observe the cause-and-effect relationship between the program running on the target processor and corresponding activity at I/O ports, coprocessors, or peripheral devices.

You can evaluate even complex multitasking software with an integral state-analysis subsystem. The analyzer's trace specifications and displays get labeled similarly to the high-level source code because the tight coupling provides the integral state analyzer with access to the software's symbol tables. An integral high-speed timing analyzer verifies critical timing specifications and identifies glitches. You can correlate the analyzer's and emulator's displays to help identify problems.

The key advantage to the integrated approach is that you find bugs early in the design cycle, where you can remove them at the lowest cost. You can produce accurate documentation quickly because you make all changes and repairs at the source-code level instead of the assembler level. As a result, software-maintenance costs are lower. Designer efficiency is greatly increased because all the compatible software-design and system-integration tools are accessed from the same keyboard with a common syntax. Software is designed and debugged and measurements are made in terms of the same high-level language.

The author is a product manager for the firm's Logic Systems Div in Colorado Springs, CO.

ly, the makers of integrated development systems have tried to provide a path back from the bit patterns to your initial abstractions with symbolic debuggers. Symbolic debuggers make it easier to backtrack from what's happened in your hardware simulation to your original code.

Symbols get plugged in

The simplest symbolic debuggers work with assemblers and linkers. If, for example, you ask your in-circuit emulator to disassemble a string of activity it captured in your target system, it can ask the controlling computer to see if any disassembled op codes' arguments correspond to labels in your program. That way, the disassembled stream of program activity will show your original labels as arguments of the disassembled op codes instead of uninformative hex numbers. This scheme works fine for jump addresses or declared constants. But it can sometimes blow up. Take, for example, a jump table comprising the starting addresses of subroutines. These simple symbolic debuggers can't do a dump of the table and translate the raw addresses into their corresponding labels. The best they could do would be to try to disassemble the jump table. The resulting output wouldn't be executable code, it would just be garbage.

Symbolic debuggers that work with high-level languages have considerably more power. Instead of working with just raw addresses or labels of addresses, you can set a breakpoint corresponding to specific lines of code in your source program. Many, like HP's 64000 system, can print out and display a mixed listing of high-level code along with the compiled assembly-level codes and machine codes. They all disassemble executed code in terms of the high-level labels, and some allow you to examine and change the physical target-system memory using the high-level terms.

For example, Tektronix's LANDS works with C and Tektronix's enhanced Pascal. LANDS takes advantage of Pascal's strong type checking. Suppose, for instance, you define a data type DOG that embraces the set of TERRIER, BOXER, and POMERANIAN and then define a variable of the type DOG named DOGHOUSE. You can then interrogate DOGHOUSE to find out what dog is currently in the DOGHOUSE. You can also, with simple commands, kick the BOXER out of the DOGHOUSE and replace it with, say, the POMERANIAN.

If you were to look at the actual code compiled by the Pascal compiler, you'd find that it probably assigned the numbers 1, 2, and 3 to TERRIER, BOXER, and POMERANIAN. And if you got the address of DOGHOUSE from a cross-listing and inspected the contents at DOGHOUSE's address, you'd simply find a 1, 2, or 3 and not some DOG's name. The simpler symbolic debuggers could find DOGHOUSE all right, but they wouldn't be able to tell you what kind of DOG was in the DOGHOUSE.

Of course, debugging high-level code involves more than looking at variables. High-level languages and elaborate operating systems employ things like dynamically defined variables and overlays, which baffle simple debuggers. Simple debuggers expect a given memory location always to be used for the same purpose. Smarter symbolic debuggers handle these cases. For instance, Emulogic's SLICE (Source Language In-Circuit Emulator) debugging system works with C and Pascal. SLICE has tools for determining how modules get called. For example, the first thing a C routine does when it gets called is to allocate space on the stack for its local variables. It also puts a link on the stack so that subsequently called modules can return control to the calling module. After the Emulogic emulator recognizes a breakpoint and freezes the target system, SLICE can analyze the stack's contents. Then it can display a list of module names in the order in which they were called. This allows you to backtrack from the observable symptoms to the offending module.

Symbolic debuggers go slowly

HP offers high-level symbolic debugging with both a software simulator and a hardware execution-vehicle. The 64330 software simulator is similar to Tektronix's LANDS system and can trace, trap, and break on changes to high-level constructs like variables and arrays as well as by program lines or modules. It doesn't run in real time.

The software that runs HP's 64620S logic-state/software-analyzer module in a 64000 system accomplishes these tasks in a slightly different manner. You can set up trace, trap, and breakpoint sequences on fixed addresses or definable states of the target μP using some, but not all, high-level constructs—much like a logic analyzer. You can also set up what HP calls "windows" to troubleshoot overlays. Simple debuggers would trace, trap, or break if the processor accessed a preset memory area. They can't distinguish among overlays operating in a common area. The HP window feature recognizes activity of a certain kind in a certain area of memory and thereby deduces that a particular overlay is active. The trace, trap, and breakpoint commands for a given window become active only if the appropriate overlay is running.

When the analyzer finally halts the process, the 64000 system first displays the disassembled code of the captured trace along with a column showing elapsed time. Then, right under the assembly code, the system displays a segment of the source code that corresponds to the decompiled captured activity. The system can do

this because it keeps a table of pointers from the source code to the assembled code. The net effect is similar to that of software-based high-level debuggers: You can get back and forth quickly from the high-level code to the low-level machine code.

Furthermore, the software supplies a setup screen that the firm claims allows you to coordinate the 64620A with virtually any compiler and not just the C and Pascal compilers that HP supplies with the 64000 system.

Meanwhile, Intel's PSCOPE also solves problems inherent in debugging high-level languages that dynamically assign variables on the stack. While languages like FORTRAN preassign fixed memory locations to each data construct, languages like Pascal and C keep local variables in temporary stack locations. When the module using the local variables quits, its local variables get popped off the stack and dropped. A simple symbolic debugger couldn't find a given dynamically defined variable, but PSCOPE can trace, trap, and break on dynamically defined variables.

Dynamic variables befuddle debuggers

While simpler monitor-based debuggers can single-step through an assembly-code program, PSCOPE—like most other high-level debuggers—can single-step by source-code line or by module. You can command most simple debuggers to execute a given number of lines of code. Similarly, PSCOPE will execute a given number of lines of source code or a given number of

Using superminicomputers for μP-software development

Michael P Kendall, *Digital Equipment Corp*

The key points of a supermini-computer approach to μP development are as follows:

- **Cross-development tools**—Many companies sell cross-development software for superminis. The tools support a wide range of μPs, including the latest 16- and 32-bit products. Cross-development tools include relocatable macro cross assemblers; compilers such as Pascal, C, PL/M, and FORTRAN; language-syntax-checking editors; symbolic and high-level-language debuggers (not in real time); utilities such as linkers, cross-reference librarians, version-control systems, and program profilers; object-format converters and peripheral interfaces; and bit-slice development tools. Various emulator and analysis tools are also available.
- **Computing power**—Superminis can quickly handle computationally intensive activities such as compiling and linking the large 16- and 32-bit μP-development tasks.
- **Large disks**—Superminis' large, high-speed disks can store the numerous files from complex projects. Available disk capacities range to tens of gigabytes.
- **Multitasking/multiuser operating systems**—Because superminis have multitasking and multiuser operating systems and large address spaces, they support software-development teamwork. The team can easily share program, documentation, and specification files.
- **Revision control systems**—Because sharing occurs under one operating system, you can employ a revision-control system. DEC has DEC/Code Management System and DEC/Module Management System software under the VMS operating system. In addition, software-revision-control systems are also available under Unix.
- **Multiple application support**—Because superminis are general-purpose machines, they can run other software that complements and augments μP-software development. Available software includes project-management and CAD/CAM. CAD/CAM packages can include those for pc-board layout and routing, logic and circuit simulation, IC layout, and mechanical design. Others offer electronic mail and word processing.
- **Low cost per user**—For the supermini approach, cost per development station compares favorably to other methods of μP-software development.

Relative to this last point, consider that a VAX 11/750 computer with 4M bytes of physical memory, 456M bytes of disk storage, a ½-in. magnetic tape, a 300-LPM printer, 16 CRTs, and an operating system handles 16 simultaneous developers. The cross-development software includes a C or Pascal compiler, cross assemblers, utilities such as linker and cross-reference checker, debugger, and integration link to emulation hardware. The total typical cost of such a system is about $150,000—$9375 per user.

In comparison, emulators range from approximately $4,200 (for simpler units) to $24,000 or more. For four developers per emulator, total per-user cost can range from $10,425 to $15,375.

The author is a senior marketing specialist for the firm's CAE/CAM group in Marlboro, MA.

modules. That way you can single-step line-by-line to get a detailed view of one portion of your program's execution and then execute a group of lines or modules to jump over known-good or uninteresting portions of the program.

But even the fanciest debuggers can't handle some of the problems posed by powerful computer systems. The reason is that some so-called high-level programming constructs are actually in hardware. For example, National Semiconductor's 16000 and 32000 family of 16- and 32-bit μPs and peripheral chips includes an external memory-management chip that supports demand-paged virtual memory. The μP itself includes hardware that simplifies multitasking context switching. The external memory-management chip imposes a propagation-delay penalty on the series compared to μPs that have their memory management on board. Therefore, National could not build a full-speed emulator without having the μP, memory-management, and clock chips in the emulator. Only National's SYS32 hydra-headed development system emulates all of these chips in one unit.

Debuggers have limits

The timing constraints that dictated the layout of the emulator have a beneficial side effect for tracing and trapping high-level software systems. Because the SYS32 integrated development system can see the pins of both the μP *and* the memory-management chip, the emulator can trace and trap on physical as well as virtual addresses. Other emulators see only the address lines coming out of the emulated μP; therefore, unless your emulator has some nondedicated inputs that you can hook to the memory-management circuitry, you can't be sure just what portion of memory the μP is accessing.

Similarly, if your multitasking software system swaps tasks into and out of off-line memory, the μP's address lines again do not uniquely define the state of the system. You must also factor in the state of the multitasking system's pointers and tables to figure out which module is running. In other words, memory management renders the μP's state ambiguous with respect to the linear memory space; multitasking renders it ambiguous with respect to time.

Other areas where hardware does software-like functions include dedicated I/O processors (especially ones that run asynchronously to the main processor), hardware floating-point processors, multitasking context switchers, and multiprocessor architectures.

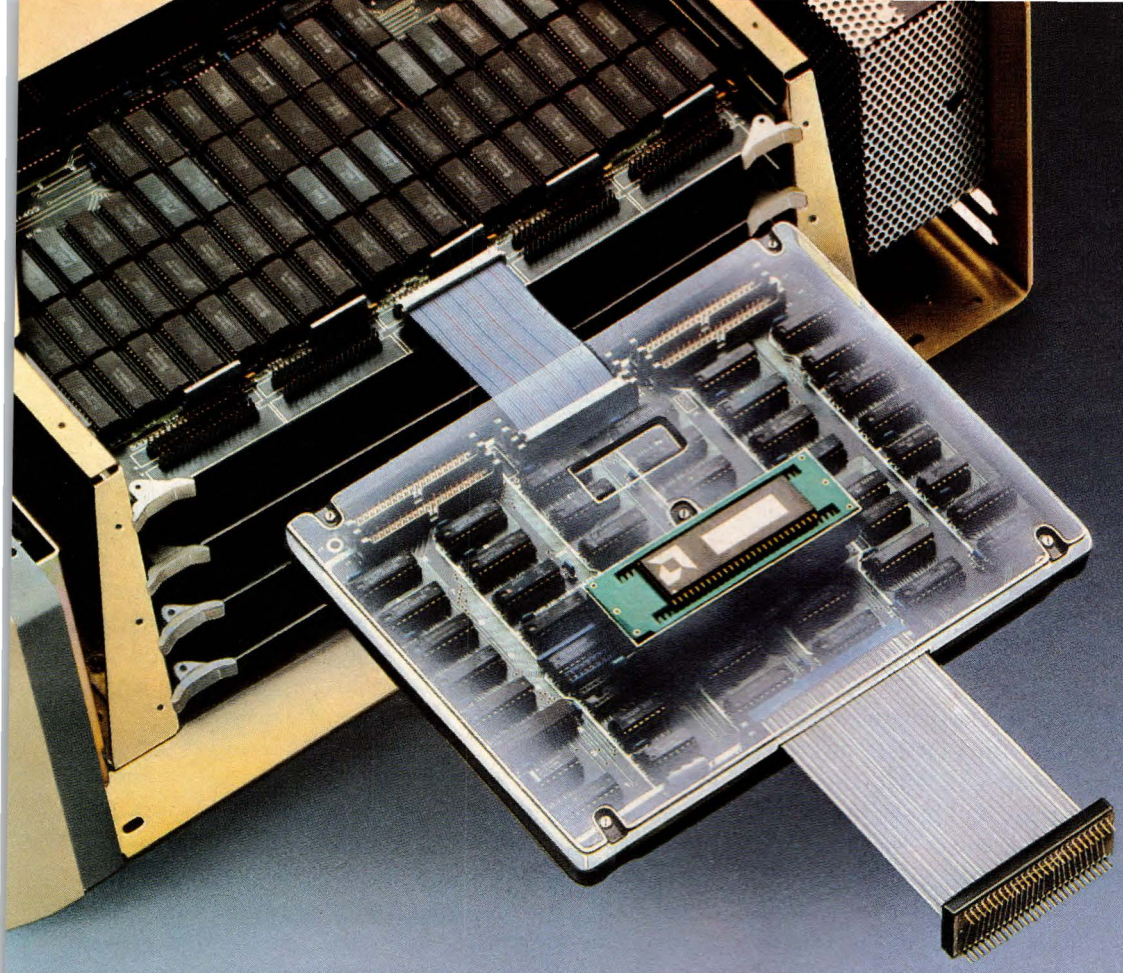
Although it is true that you can run multiple emulators in a multiprocessor system using Intel's I²ICE, for example, the emulators are only loosely linked. Most emulators have output lines incorporated in their word-recognizer circuitry that can cross-trigger another emulator. If one emulator's word recognizer sees a predefined machine state, it can toggle its output line. You can use this output line from one emulator as an input to another emulator's trace, trap, and breakpoint word recognizers. Further, Intel's systems also have a high-speed time stamp so that you can reference the events captured in the multiple emulators to a common time base. At present, Intel doesn't have a utility that will take this raw information and display the activity of multiple, asynchronous processers in a time-aligned manner, the way the Tektronix 1240 dual-time-base logic analyzer does; with the Intel device you have to puzzle that out for yourself.

Math coprocessors are no problem

While custom hardware floating-point processors are a headache, math coprocessors aren't. In the case of Intel processors, most firms' emulator pods have a socket for a math coprocessor. The pods do not, however, provide a bond-out emulating coprocessor. The firms having 8087 sockets in their emulators' pods claim that the math coprocessor is so tightly coupled to the main processor that you can do all the tracing, trapping, and breaking by monitoring the main processor's interaction with the coprocessor; you don't need to emulate the 8087 itself. National makes the same claim for the math coprocessor in the SYS32.

Because of the limited view that emulators have of the total software system, complete, real-time symbolic debugging is at present beyond the capability of existing hardware. Consider high-level symbolic debuggers like Kontron's or Zax's. These are actually software simulators running on the host development-system computer. Although these debuggers can easily get at all the high-level constructs of the program, they do not run at anything approaching real time. Tektronix's LANDS and HP's 64330 are software simulators that run on the target system's μP. But to get at the high-level constructs, they sometimes have to interrupt execution.

Therefore, although you get access to all the target-system resources, the code still doesn't run in real time. HP's 64620 analyzer (which works in real time) and some postcapture processing give you a pointer *back* into your source-code file. For C programs that aren't highly type-checked, this is not much of a penalty. (A type-checking compiler makes sure that the data written into a data construct is the kind of data that's been defined previously as allowable for that construct.) But for Pascal programs, HP's 64620 can't work forward from the source file to read and write from data constructs using high-level objects as Tektronix's LANDS can.



STEP-27 SERIES

Bit-Slice
Microprogramming
ROM-Simulation
Support

29116 & 2910 Emulation? Only from STEP!

Since STEP Engineering has always been a "Step Ahead" in quality high-speed processor development support, it's only natural to be the first with these emulators. The STEP-27, a complete development station, includes the following:

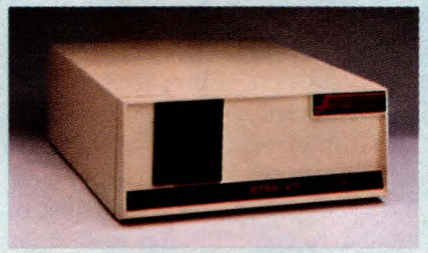
Disassembler? The First For the Microprogrammer! No need to convert ones and zeros into mnemonics. Poly-Meta-Symbolics (PMS)™ does it for you. It even enters your patches symbolically.

Fast, Bug-Free Programs? Simple! STEP-27's powerful logic analyzer includes a 20-MHz, 16-level-state machine with five, 54-bit matchword/qualifiers for each level. The 4K buffer uses PMS to disassemble and display its contents in mnemonics.

Software? The Best! In addition to full software support for either a local or a remote host, STEP provides a general-purpose meta-assembler.

Poly-Meta-Symbolics (PMS) is a trademark of STEP Engineering.

Writable Control Store (WCS)? The Fastest! STEP's ten nanosecond WCS provides real-time execution of the most demanding high-speed designs. With any number of arrays (each up to 512-bits wide by 64K deep), the STEP-27 supports the largest micro-program requirements.



Communications? Of course! Using an RS232 linkup, the STEP-27, with a unique, general-purpose, menu-driven communication program, easily interfaces with the IBM® PC, VAX®, PDP-11® or CP/M®-based and other operating systems.

PDP-11 & VAX are registered trademarks of Digital Equipment Corporation.

CPM is a registered trademark of Digital Research Inc.

Are We Interested In Your Questions? You Bet! Our sales engineers quickly respond to all inquiries. Mail coupon or call **Toll Free (800) 538-1750; in California (408) 733-7837.**

☐ Please send more information. ☐ Please schedule STEP-27 demo ASAP.

Name _____

Title _____

Company _____ M.S. _____

Street _____

City _____ State _____ Zip _____

Phone _____

STEP Engineering

Post Office Box 61166 Sunnyvale, Ca. 94088

CIRCLE NO 63

The solution to all the problems of real-time symbolic debugging of high-level software systems awaits a rather strenuous hardware-design effort. The solution might be something like a dual-ported stack or perhaps a phantom stack area operating in parallel with the real stack. You could switch the phantom stack off line as needed and analyze its state while the real stack continues to operate. While this provides you with one look at the stack, multiple looks leave you the problem of updating the phantom stack to correspond to the present state of the real stack and putting the phantom stack back on line. Similar phantom hardware could prove useful for other hardware that handles high-level software-system tasks like context-switching hardware.

Although such features await future designs, designers have expended considerable effort on user interfaces for the development systems. In fact, the user interfaces that control trace, trap, and break hardware exhibit the greatest range of ingenious design of any aspect of these instruments. No two manufacturers' setup and control schemata are at all alike. Each system has myriad possibilities, tricks, and wrinkles. Instead of getting bogged down in a welter of specs and claims that don't correspond to one another, you can evaluate each manufacturer's schema beter if you keep in mind what it is you actually do when debugging code.

Debugging mirrors initial analysis

How you actually debug software is very similar to the data-flow analysis (structured analysis) method of software design. With data-flow analysis, a program gets defined in terms of *both* the data constructs and the code that operates on them. Most of the features of a debugger concentrate on the sequential execution of the code and deal with data structures inferentially or secondarily. However, this bias doesn't concur with the way a lot of debugging gets done. Very often, the symptom of bad code is corrupted data or improper outputs. Therefore, debugging begins with finding the bad data or identifying the improper outputs and then trying to find the code that's at fault. This is especially true in large modular programs where many different modules operate on common data structures or output ports.

This software debugging situation is similar to considering glitches as a symptom during hardware debugging. Logic analyzers can trigger either upon recognizing defined states in a digital machine or upon spurious, short-duration signals (glitches). Every digital machine has lots of glitches. It's hard to find a point to probe that doesn't have some. Most glitches don't cause problems. Therefore, it doesn't pay to trigger on glitches and look for problems. Rather, you have to trigger on the problem and look for suspicious glitches around the problem.

Similarly, you can single-step forever through a piece of code without figuring out which portion is the culprit. It's far better to run the code and trap or break on its erroneous outputs. If you've done your initial design using data-flow analysis, you'll find it easy to check the program's functioning against the design. Most debugging tools (Kontron's is the exception) aren't set up to do explicit data-flow monitoring; they are set up to do program-flow monitoring. You have to build your own data-flow system on top of the program-flow primitives of the development system. So that you can appreciate the enhancements of integrated systems, consider how you'd monitor data flow with a simple, monitor-based debugger.

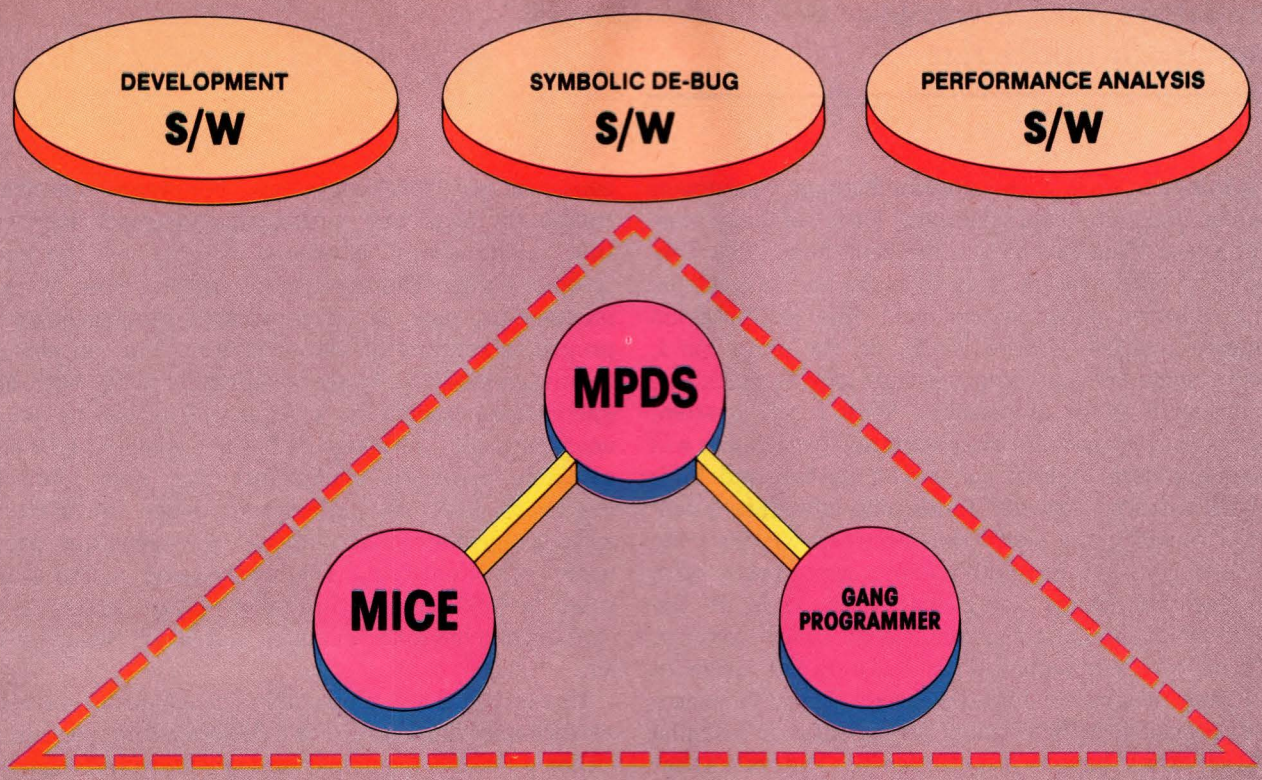
Begin with basic monitor

These debuggers usually allow you to execute to a breakpoint or to single-step. They also have commands for examining and changing sequential memory locations. So you'd step through your program—one line at a time or perhaps many lines at a time—and after each step you'd dump the relevant memory areas on screen. As you'd probably repeat this sequence many times, hitting the same sequence of keystrokes over and over could prove annoying and lead to errors.

Therefore, even a simple monitor-based emulator like the Gould 9508A has a command buffer that you can load with a command string that does your data-flow monitoring. That way you can repeat the sequence you need over and over with just one command. And with one keystroke, the 9508A can redirect its input to the output of a host computer. That way, the host computer can send it a long string of commands as well. With some effort, you could program your host computer to send a command string to the 9508A that would download code, set up the emulator's memory and CPU registers, and command it to run. Then your host program could wait for the emulator to break. After the break, your program could send further command strings to interrogate the emulator. Based on an analysis of the results of the interrogation, your host program could restart the cycle or branch to another setup-and-test routine.

You really don't have to write all this software yourself anymore because most of the current crop of stand-alone in-circuit emulators, such as those made by Applied Microsystems, now have driver programs for common personal computers that do just these jobs. In addition, most of these emulators incorporate a simple assembly-language symbolic debugger.

The integrated-development-system makers go beyond these rudimentary facilities. They have three



NOW MICROTEK GIVES YOU AS MUCH DEVELOPMENT/ DEBUG CAPABILITY AS YOU NEED— NO MORE, NO LESS

If you need a complete development system, our MPDS is your cost-effective answer. It includes MICE II, the proven in-circuit emulator (with execution breakpoint), and the Break Point Processor (4 additional break points with external triggering). It includes the portable microcomputer. And it includes complete integrated software for development, symbolic de-bugging, logic analysis and performance analysis.

If you have only the microcomputer, adding the MICE II and the software will convert it into an integrated, economical development system.

Or if you already have your software, just the addition of MICE II will give you the essential, reliable, real-time in-circuit emulation you need. And it supports all popular target microprocessors: **8048 • 8085 • 8086/88 (MAX) • 8086/88 (MIN) • 80186/80188 • 6809/6809E • 68000 • 68008 • 68010 • 6502F • 65SCXX • 65SC1XX • Z80/R • NSC 800.**

In any case, you'll need our GP-256, the most practical, economical gang/set EPROM programmer you can buy.

That's why we say we can give you as much development/ de-bug capability as you need—no more, no less. Call or write today for full details.

MICROTEK

U.S.A. & Canada
MICROTEK LAB, INC.
17221 South Western Avenue, Gardena, CA 90247
Telephone: (213) 538-5369/Telex: 696334 BENNY GDNA

Outside U.S.A. & Canada
MICROTEK INTERNATIONAL, INC.
2-1 Science Road 1, Science-Based Industrial Park
Hsinchu, Taiwan, 300, R.O.C. Tel: (035) 772155
Telex: 32169 MICROTEK

CIRCLE NO 64

basic things to work with: program listings, instrument setup screens, and captured data. Each company massages these elements into a different form. The Tektronix LANDS system tries to make the target system's captured data look as much like the program listing as possible. Intel's I²ICE, on the other hand, tries to make the instrument setups look as much like the program editor as possible. With Intel's system, about 80% of the editor's commands and procedures will also manipulate objects on the emulator's and logic analyzer's control screens. In keeping with Intel's concept of blurring the distinction between writing code and testing it, you can patch your targeted code with high-level constructs using the editor right in the middle of an emulation session. With other systems, you'd have to exit emulation and fire up the editor to patch your program in high-level code. If you've done a lot of patches directly to the program image in machine code, you would have to use utilities like Motorola's that reconcile the source code to such changes.

Emulogic also seeks to make writing the program and testing it as much alike as possible. The firm has two ways to do instrument setup. One way is via the usual sort of simulated instrument front panel displayed on a CRT, where fields take the place of knobs and switches on a physical instrument. You move the cursor around on the screen to these areas and enter the setup information. The other method is to enter command strings. In Emulogic's case, these command strings look very much like C programs. The commands have some of the attributes of Unix command-shell utilities. You can redirect the input and output for your commands to various areas of the screen, disk, or printer. You can keep a log of all your command entries in a file. When you get a command sequence you like, you can edit the log and subsequently use it for a command file.

Kontron's control software comes set up for data-flow analysis, and it can dump data structures to a variety of predefined windows on the CRT's screen. Setup menus let you choose from several combinations of windows of different sizes. You also select the data format for each window. When the Kontron emulator breaks, you automatically get a look at the state of your data constructs. In other development systems you have to enter an explicit command string in order to get data dumps of various areas printed on the CRT's screen.

Integration shades into verification

As you test and integrate more and more of the project's modules, software integration merges imperceptibly into software verification. Most software gets tested with other software. But there are other ways to test software—ways that are very important to time-conscious software engineers. For years mainframe computers have had software-performance hardware that unintrusively monitored activity on the mainframes' buses. These parasitic gadgets kept track of memory use and run times without slowing down the programs running on the computer. You can now get hardware-based software verification along with integrated development systems, as well as with most logic analyzers. But although software analysis is widely available, industry sources say that many software engineers don't yet understand or see the utility of software-performance analysis. The technique proves useful for identifying frequently used modules that could benefit from optimization. Even better, it can spot orphan modules, modules that aren't being used at all.

Hewlett-Packard alone offers a range of software-performance hardware. For a 64000 system, you can get either a 64620S (combination logic-state/software-performance analyzer board) or the 64310A (dedicated software-performance analyzer). The combination 64620S logic/software board shows that there's considerable overlap in function and hardware between a logic-state analyzer and a software-performance analyzer. Both machines look at the target system's address bus. Both also look at qualifiers to determine what kind of bus cycle is going on. The difference between the two is that the logic-state analyzer's primary purpose is to *capture* bus activity while the software analyzer's primary purpose is to *count* various classes of bus events. Of course, most logic-state analyzers have at least one counter (Emulogic's integrated development system has four, for example), so they can do software-performance analysis as well.

HP's 64310A dedicated software-analysis board is optimized for software analysis and hence can do some tricks that logic analyzers can't. The board's hardware is not too complex; it has a pair of word recognizers that toggle a bank of counters. The 64000 system automatically sets up the board to correspond to the target system's μP. You can program the board to monitor as many as 12 address ranges. Because the board has only one pair of word recognizers, it obviously can't look for all 12 ranges simultaneously. Instead, the board periodically (you choose the period) gets its word recognizers reloaded with a new pair of address-range limits.

Software analysis takes time

This is why you may have to run a software analysis for hours or even days; the software has to run long enough for the software analyzer to be sure to get a statistically valid sample of activity for each range—especially if some of the ranges are used infrequently.

You program the board to look for various classes of

Manufacturers of integrated development tools

For more information on integrated development systems, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

Advanced Digital Technology
13400 Northrup Way, Building 27
Bellevue, WA 98005
(206) 642-2382
Circle No 717

Applied Microsystems
5020 148th Ave NE
Redmond, WA 98052
(206) 882-2000
Circle No 718

Dolch Logic Instruments
3052 Orchard Dr
San Jose, CA 95134
(408) 945-1881
Circle No 719

Emulogic Inc
Three Technology Way
Norwood, MA 02062
(617) 329-1031
Circle No 720

Gould Inc
Design & Test Systems Div
4600 Old Ironsides Dr
Santa Clara, CA 95050
(408) 988-6800
Circle No 721

Hewlett-Packard Inc
1820 Embarcadero Rd
Palo Alto, CA 94303
Phone local office
Circle No 722

Huntsville Microsystems
Box 12415
Huntsville, AL 35802
(205) 881-6005
Circle No 723

Microcosm Inc
Box 624
Hillsboro, OR 97123
(503) 648-6400
Circle No 724

Microtek Lab Inc
17221 S Western Ave
Gardena, CA 90247
(213) 538-5369
Circle No 725

Motorola
Box 20912
Phoenix, AZ 85036
(602) 244-6900
Circle No 726

National Semiconductor
2900 Semiconductor Dr
Santa Clara, CA 95051
(408) 737-5000
Circle No 727

Relational Memory Systems Inc
1640-B Berryessa Rd
San Jose, CA 95131
(408) 729-3011
Circle No 728

Sophia Systems
3337 Kifer Rd
Santa Clara, CA 95051
(408) 733-1571
Circle No 729

Tektronix Inc
Box 500
Beaverton, OR 97077
(503) 627-7111
Circle No 730

ZAX Corp
2572 White Rd
Irvine, CA 92714
(800) 421-0982
Circle No 731

events—reads, writes, instruction fetches, etc. Because the target-system's clock rate is known, the integrated development system's computer can calculate time from the number of bus cycles captured. Then you decide how you want them counted. The board's word recognizers and counters can count events or bus cycles basically three ways: They can count the number of events or bus cycles either within a given range of addresses or outside a given range, and they can count the number of times two given addresses were accessed in a specific order.

From this relatively simple data, the 64000 can calculate a number of interesting statistics on your program and display the results in histograms labeled with module names right from your source program. It can calculate statistics (for as many as 12 modules) on how often an individual module gets used, how long the module takes to run, and how much time *isn't* consumed by a module. And, using the software analyzer's ability to increment its counters when it sees two particular addresses occur in succession, you can determine the order in which modules run and thereby get statistics on which modules are calling which other modules.

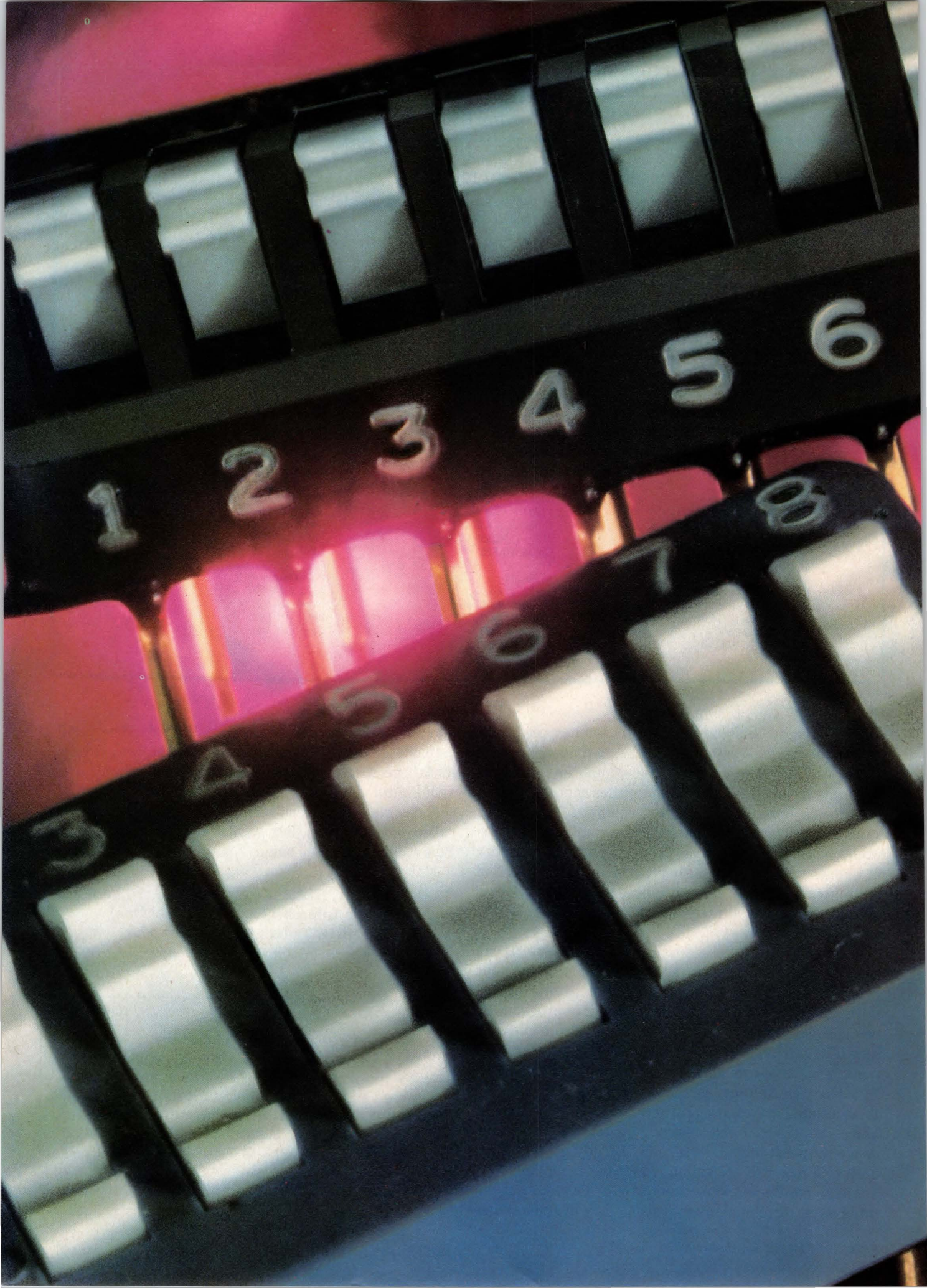
Thus, software verification is the last step in an integrated development system's suite of tools. Once started, the design cycle never really ends. The verification step can feed right back all the way to the initial-specification stage and start the cycle all over again. And after the initial shipments of the product, the design cycle doesn't end; it's just renamed—it's called *maintenance*. But whatever the name, the cycle's steps remain the same. **EDN**

Article Interest Quotient (Circle One)
High 470 Medium 471 Low 472

Need to Know?

EDN's advertisers stand ready to provide you with helpful design information and other data on their products. Just circle the appropriate numbers on the Information Retrieval Service card. If your need is urgent, contact advertisers directly, and mention EDN.

EDN: Everything Designers Need


1 2 3 4 5 6
3 4 5 6 7 8

Everything you demand in DIP switches is now available from the people who invented them.

Total reliability, immediate delivery, competitive prices—you can get all this *and* design superiority from AMP.

Our selectively plated wipe/back wipe contacts give you 30 micro-inches of precise, dependable gold. To eliminate contamination and solder wicking, our switches are all epoxy bottom-sealed and available with tape or plastisol top sealant, as well.

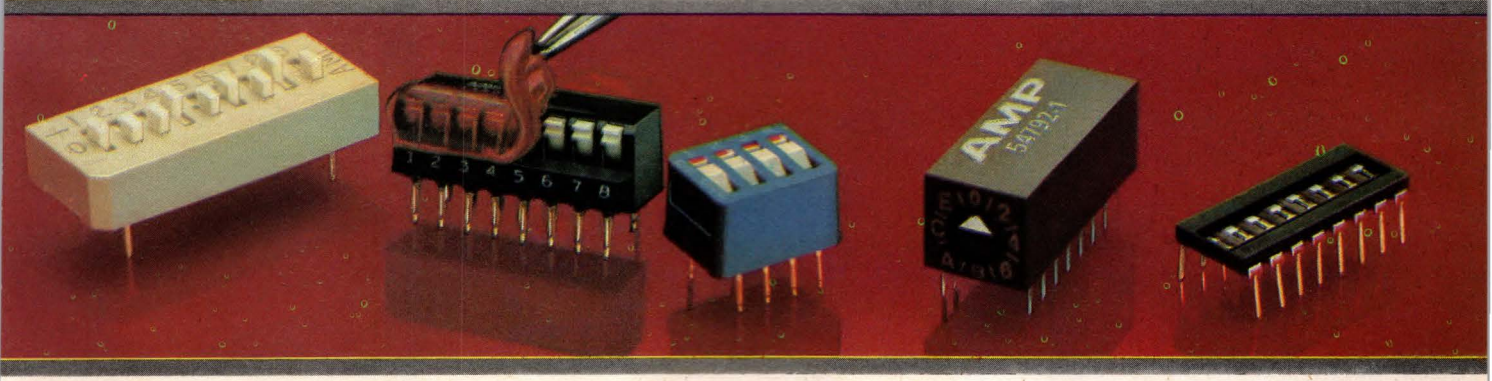
We also make them easy for you to get. Computerized regional delivery guarantees you shipment of all popular styles.

Our prices? Thanks to automation, you'll be impressed. Just ask.

For more information, call the AMP DIP Switch Desk at (717) 780-4400. AMP Incorporated, Harrisburg, PA 17105

CIRCLE NUMBER 40

AMP means productivity.



3 x 9 switch offers over 19,000 code combinations.

Plastisol sealing withstands high pressure aqueous cleaning techniques.

Hexadecimal and BCDs are among our style variety.

Low-cost DIP shunts are AMP exclusives.

AMP is a trademark of AMP Inc.

Value

Marconi microwave instruments give you more for your money.

Compare for yourself.

Hewlett-Packard	Marconi Instruments
Reputation	
Undisputed leader in electronic instrumentation among U.S. firms. Began in the 1930's. Now produces automatic microprocessor controlled microwave instruments.	Undisputed leader in electronic instrumentation among U.K. firms. Began in the 1930's. Now produces automatic microprocessor controlled microwave instruments.
Performance	
Microwave counter HP-5342A Option 011 Frequency coverage 10 Hz to 18 GHz Maximum resolution 1 Hz Sensitivity at 1 GHz −25 dBm, at 18 GHz −20 dBm Maximum input damage level +25 dBm peak Automatic acquisition time 530 ms (normal FM)	**Microwave counter** MI-2440 Frequency coverage 10 Hz to 20 GHz Maximum resolution 0.1 Hz Sensitivity at 1 GHz −25 dBm, at 18 GHz −20 dBm Maximum input damage level +27 dBm Automatic acquisition time 200 ms typical
Power meter HP-436A Option 022 Technology: TTL logic Instrumentation accuracy ± 0.5% or ± 0.02 dB ± .001 dB/C° Power range with available detectors −70 to +35 dBm Frequency range 100 kHz to 26.5 GHz Calibration: adjustment manual screwdriver Response time fixed by range Panel height 5¼″	**Power meter** MI-6960 Option 001 Technology: microprocessor controlled Instrumentation accuracy ± 0.5% or ± 0.02 dB Power range with available detectors −70 to +20 dBm Frequency range 10 MHz to 20 GHz Calibration: adjustment automatic, key or GPIB Response time is user selectable Panel height 3½″
Scalar analyzer HP-8756A Frequency range 0.01 to 40 GHz Electronic graticule; 401 point display, line only Dynamic range +10 to −50 dBm Fast screen dump and direct digital plotter output Sweeper control exclusive HPIB port to HP8350B or HP8340A Minimum sweep time 150 ms Logarithmic conversion by analog circuitry	**Scalar analyzer** MI-6500 Option 001 Frequency range 0.01 to 40 GHz Electronic graticule; 422 point display, line and histogram fill-in Dynamic range +16 to −55 dBm Fast screen dump and direct digital plotter output Sweeper control coax cable to all popular sweepers Minimum sweep time 70 ms Logarithmic conversion by digital circuitry
Price	
HP-5242A-011 Microwave Counter **$ 6,850** HP-436A-022 Power Meter **$ 3,400** HP-8756A Scalar Analyzer **$11,000**	**$5,290** MI-2440 Microwave Counter **$2,690** MI-6960-001 RF Power Meter **$8,195** MI-6500-001 Scalar Analyzer

Specs and prices aren't everything. We made Marconi instruments as simple as possible to use, so you can make measurements quickly and comfortably with complete confidence in the results.

Thousands of Marconi instruments are now used by satisfied customers throughout the world.

They testify to the value inherent in Marconi instruments–reputation, reliability, performance, and price.

Discover Marconi value for yourself. Call today for a demonstration by phoning (201) 934-9050 or in the Western U.S. (714) 895-7182.

marconi instruments

U.S.A.: Marconi Instruments, 3 Pearl Court, Allendale, NJ 07401, (201) 934-9050. U.K.: Marconi Instruments, Longacres, St. Albans, Herts., England AL4 OJN Phone 44 (727) 59292. Telex 23350.

Data on H-P instruments from their 1984 catalog. H-P prices are as of July, 1984. Marconi prices are as of July 1984 domestic U.S.A. only.

CIRCLE NO 67

Our newest design center for gate arrays.

Yesterday it was just another IBM* PC.

Today it's a powerful workstation for gate array design.

What happened? We did.

We're LSI Logic Corporation. Our LDS mainframe design system has guided more than 600 gate array designs from the drawing board to the assembly line.

With a 95% hit rate, first time out.

And now, with our Software Data Book™ macrocell library and the FutureNet DASH-1 Schematic Designer,* you can create schematic designs on your PC or XT.

Just see your local Wyle or Hamilton/Avnet distributor. They stock the stuff to help you design great gate arrays.

Without ever leaving your desk.

LSI LOGIC CORPORATION

*IBM is a registered trademark of International Business Machines.
*FutureNet DASH-1 Schematic Designer is a registered trademark of FutureNet Corporation.

Extended-processing units expand μP computing power

Specialized parallel-processing chips tied to a Z8000 CPU let you get more computing power from the μP, and the Z8000 family's extended-processing architecture increases the speed of slave interfaces.

Stephen R McMahan, *Olympic Synthesis*

The extended-processing architecture of Zilog's Z8000 provides a flexible, modular approach for expanding CPU hardware and software capabilities with parallel-processing add-on chips called extended-processing units (EPUs). When you tie an EPU like the Z8070 arithmetic-processing unit to the CPU, the Z8070 performs floating-point mathematics while the CPU operates in parallel. By adding interface hardware, instruction coding, and timing logic, you can also create a generalized hardware EPU interface that is separate from memory or I/O spaces. This interface can be used for data and instruction passing to slave processors, for system-overhead control, and for other such functions.

In addition, you can use the EPU block move in a LAN Controller for Ethernet (LANCE) interface to provide a generalized memory-to-memory transfer mechanism. The EPU block move lets the CPU share a pair of RAM buffers with the LANCE and still transfer data continuously by running the buffers in an interleaving mode.

The EPU structure, combined with the EPU flag in the Z8000's flag and control-word (FCW) register, is a special type of instruction trap. When you reset the EPU flag (EPU not selected), the Z8000 recognizes certain instructions as EPU instructions, and it vectors to a preset point in the software. This vectoring allows the software either to emulate an EPU (for example, one floating-point software package emulates the Z8070) or to execute a program (such as a system-overhead routine).

With a Z8002 CPU or a Z8004 virtual-memory processing unit (VMPU), this vector point resides in the program-status-area header, +0002H, and consists of two words—the new FCW and the new program counter. With a Z8001 CPU or a Z8003 VMPU, the vector point is located at the program-status-area header,

TABLE 1—EPU INSTRUCTION FORMATS

FCW TO EPU	
:1000:1110:NU	:10:XX:
:NU :0000:NU	:00 00:
EPU TO FCW	
:1000:1110:NU	:00:XX:
:NU :0000:NU	:00 00:
CPU TO EPU	
:1000:1111:0:NU	:10:XX:
:NU :DST :NU	: N-1 :
EPU TO CPU	
:1000:1111:0:NU	:00:XX:
:NU :SRC :NU	: N-1 :
MEMORY TO EPU	
:Md:00:1111:SRC	:01:XX:
:NU :NU :NU	: N-1 :
EPU TO MEMORY	
:Md:00:1111:DST	:11:XX:
:NU :NU :NU	: N-1 :
EPU INTERNAL INSTRUCTION	
:1000:1110:NU	:1:XX:
; NOT USED	:: N-1 :

+0004H, and consists of four words. Three of these words contain the FCW, the program-counter segment, and the program-counter offset; the first word is reserved by the manufacturer for internal use.

When you set the EPU flag, the CPU recognizes EPU instructions and acts on them accordingly. Each EPU monitors the instruction-fetch cycle and recognizes its own instructions; then it performs the internal setup required to implement the instructions. As shown in the following EPU instruction structure, all EPU instructions are in double-word format.

M1 CYCLE-:XXXX :XXXX :XXXX :XX:XX-EPU ID#
Mn CYCLE-:XXXX :XXXX :XXXX :XXXX:

C B A N
NIBBLE NIBBLE NIBBLE FIELD

The two least significant bits (LSB) of the first word make up the EPU ID number; this leaves room for four EPUs in a system. Generally, the C and A nibbles don't affect EPU instructions. However, you can use these nibbles to expand the capabilities of a hardware extended-processing unit (HEPU). The N field holds the number of words moved (expressed as N−1) in transfers either between the memory and the EPU or between the CPU and the EPU. For transfers between the memory and the EPU, the E field designates the CPU register that points to the memory position at which the transfer initializes. For transfers between the CPU and the EPU, the B nibble specifies the

TABLE 2—EPU ASSEMBLER STATEMENTS

```
        INTERNAL OPERATION—
XCTL    EPU0—3, #BYTE, #BYTE
        EPU TO CPU MULTIPLE—
XLDM    dstREG, EPUO—3, # OF WORDS, #BYTE
        CPU TO EPU MULTIPLE—
XLDM    EPUO—3, srcREG, # OF WORDS, #BYTE
        EPU TO MEMORY MULTIPLE—
XLDM    dst REG,EPUO—3,#of words,#byte
        Memory to EPU multiple—
SLDM    EPUO—3, srcREG, # OF WORDS, #BYTE
        FCW TO EPU
XLDCTL  EPUO—3, FLAGS, # BYTE
        EPU TO FCW
XLDCTL  FLAGS, EPUO—3, # BYTE
```

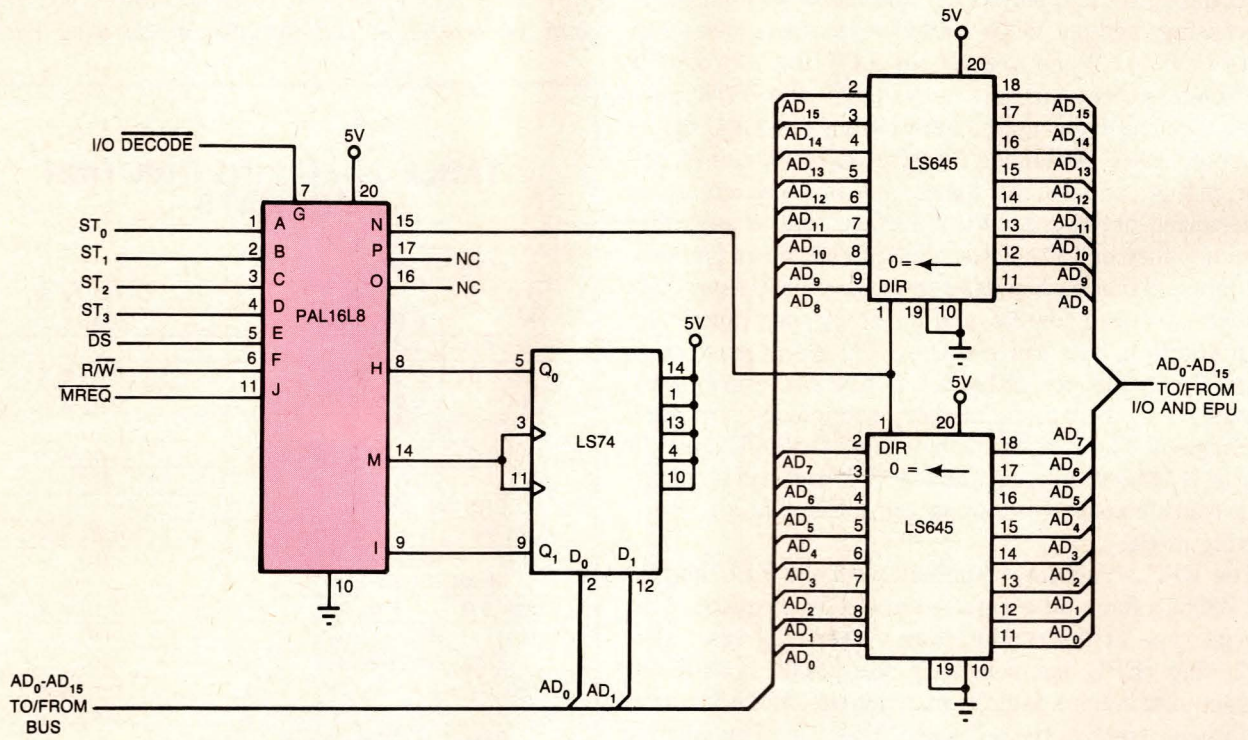


Fig 1—Instead of being included *with the CPU buffers, an EPU can share a board with I/O. A PAL controls this simple circuit.*

starting register from which (or to which) the transfer occurs. The multiple register transfers shift through the registers (R0-R15) and then wraps around, so that R0 follows R15.

Table 1 provides the specific formats of each of the EPU instructions. **Table 2** lists the Western Wares (Placerville, CO) ZAS 2.0 assembly-language statements for these EPU instructions. The first byte (#byte) following the source in each statement corresponds to the C and A nibbles. The second byte refers to the B-nibble, N-field combination.

Plan your timing and control signals

The main timing and control signals for the EPU are Read/Write (R/$\overline{W}$) and Data Strobe ($\overline{DS}$). Timing and control during FCW and CPU transfers are much the same as in a normal I/O or memory transfer. The difference between them is that you must code the CPU status (ST_0 through ST_3) for EPU transfers. The difference between CPU cycle timing and the timing for the transfers between the CPU and the EPU is that the CPU doesn't recognize any wait states for EPU transfers.

When the EPU resides outside the CPU buffers, EPU decoding must also control the EPU buffer direction and data strobing. But the situation changes for transfers between memory and the EPU; R/$\overline{W}$ is now referenced to the memory end of the transaction. When memory is the source, R/$\overline{W}$ is High; when memory is the destination, R/$\overline{W}$ is Low. The CPU provides timing and status for the transfer and transfers the data between the EPU and the memory in flyby fashion. The CPU also provides the address, which is relative to the memory end of the transfer, and sets the address/data lines (AD_0 through AD_{15}) to 3-state during the data transfer. When the EPU resides outside the CPU buffers, you must set the CPU buffers to 3-state during the data transfer.

When memory is the source, the EPU grabs the data on the rising edge of $\overline{DS}$. When the EPU is the source, it must put the data on the bus prior to the falling edge of $\overline{DS}$.

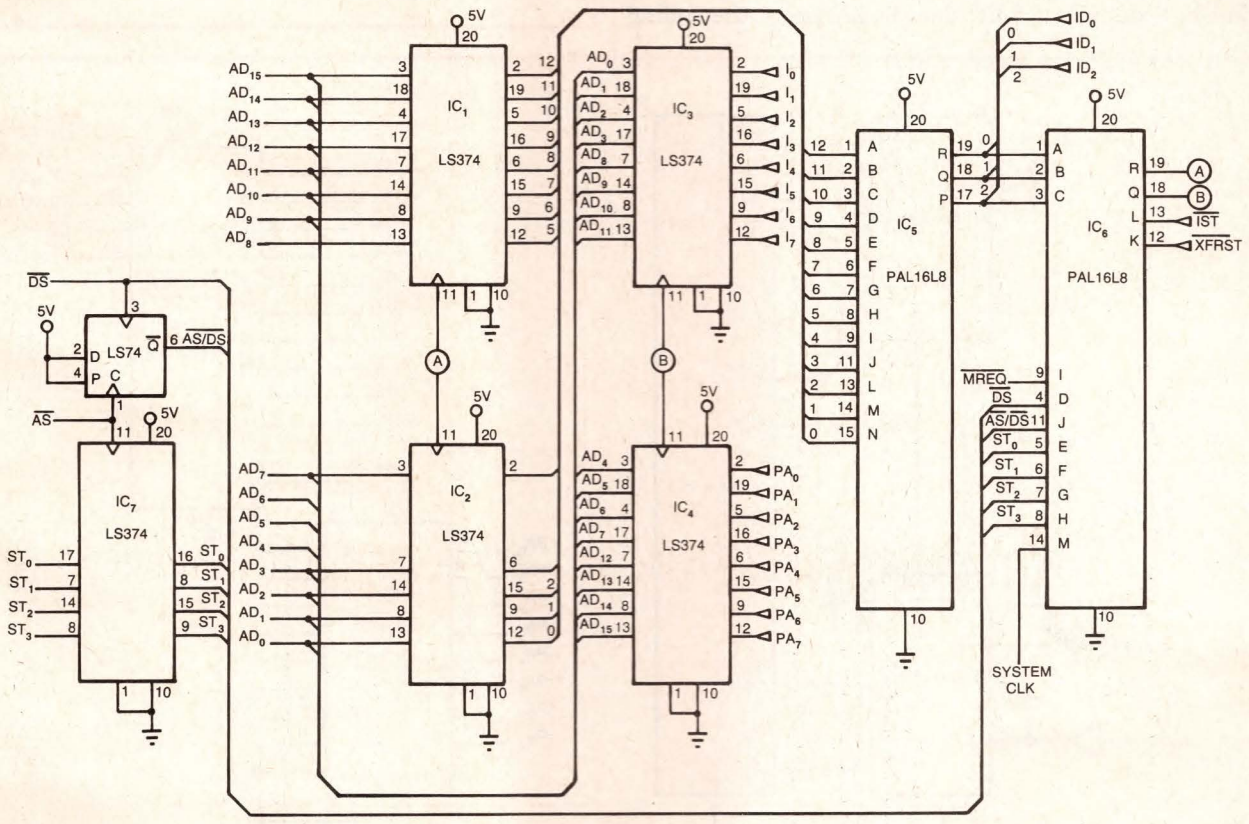


Fig 2—You can use EPU architecture *to build a generalized hardware EPU interface. Flag and control-word transfers are not permitted in this circuit.*

Hardware EPUs must decode EPU instructions

The code must specify which EPU is going to be active. This look-ahead function, combined with the ST_0-through-ST_3 decode and R/$\overline{W}$, steers the data path. The status codes, ST_3 through ST_0, for calling EPUs are:

1010 DATA MEMORY REQUEST
1011 STACK MEMORY REQUEST
1110 CPU, EPU TRANSFER.

The status lines do not indicate EPU internal operations, which may require as many as 16 cycles to execute. The N field determines the instruction length.

Internal operation is typically synchronized with the nth machine cycle, Mn. At the end of each T3 (a full machine cycle) during an EPU internal instruction, the CPU monitors the Stop line. By pulling the Stop line low, the EPU forces the CPU to wait until the EPU has finished its internal instruction. The CPU runs through a series of memory-refresh cycles until the EPU releases the Stop line, enabling the CPU to download a process to the EPU and wait for the result without an interrupt.

EPU decoding is straightforward

For an example of EPU decoding, look at the coding for an EPU that resides outside the CPU buffers and shares a board with I/O. **Fig 1** illustrates such an interface. To catch the EPU ID number, the interface must latch AD_0 and AD_1 on the rising edge of $\overline{DS}$ during the M1 cycle. By clocking the LS74 with the PAL output M, you can latch the EPU ID number.

You can assign the EPU an ID of 0. If you use an EPU like the Z8070, the EPU will respond to all instructions directed to EPU #0.

During transfers between memory and the EPU, the

TABLE 3—PAL EQUATIONS FOR FIG 1 CIRCUIT

```
PAL16L8
EPU/DEC1
A B C D E F G H I GND
J K L M N O P Q R VCC
/M = /E + /F + /A + B + /C + /D
/N = /E * /G * F + /O
/P = B * /C * D * /F * /J * /H * /I
/O = /P + /A * B * C * D * F * /E * /H * /I
```

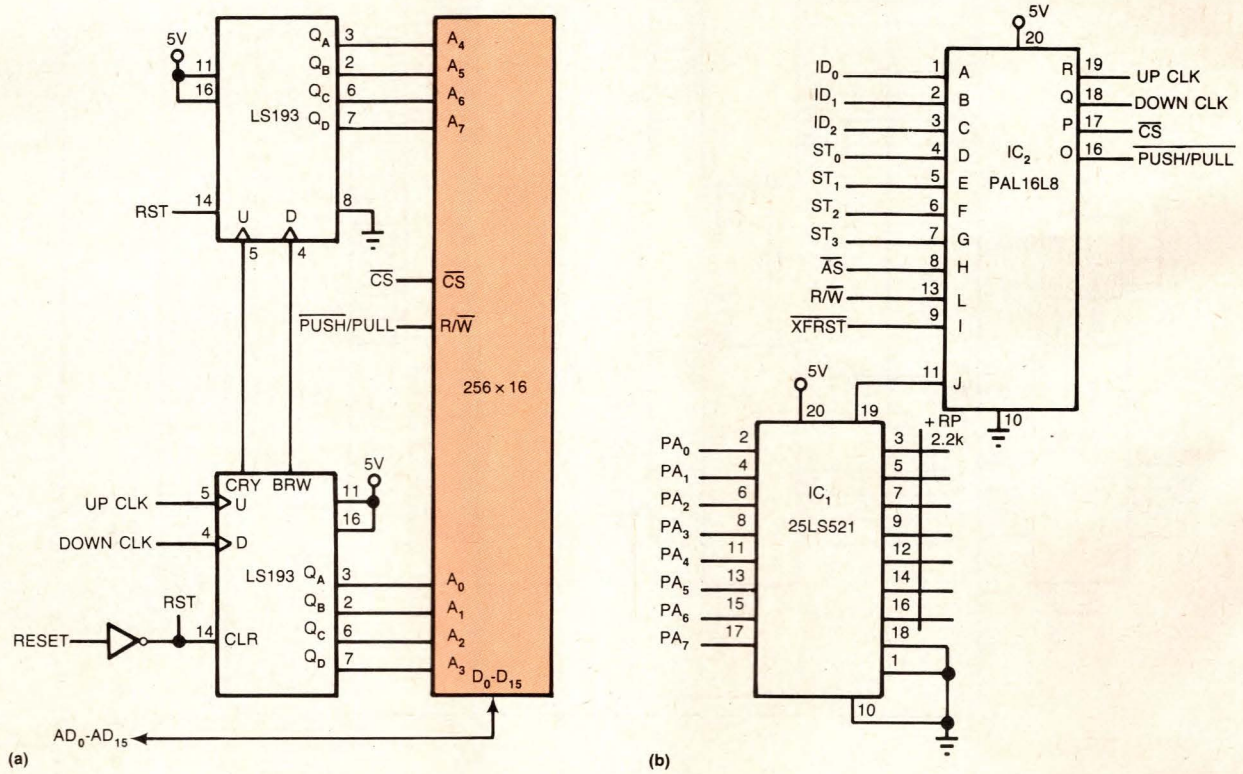


Fig 3—A simple push-pull stack *is easily built with a hardware EPU interface* ***(a).*** *The interface between the HEPU interface and the push-pull stack is illustrated in* ***b.***

data flows counter to the direction of the R/$\overline{W}$ line. When the EPU is the source, it feeds data onto AD_0 through AD_{15} prior to the falling edge of $\overline{DS}$ (but after the address floats). During transfers between the CPU and the EPU, the data follows the direction of R/$\overline{W}$, with $\overline{DS}$ gating the data out of the buffer.

PAL output N (**Fig 1**) controls the data direction. When the EPU is the source for a memory transfer, the P—O—N chain delays Memory Request ($\overline{MREQ}$) to prevent a bus contention. **Table 3** gives the PAL equations.

In the /N equation, the /E*/G*F term steers the I/O data and the /O term steers the EPU data. The /P term steers the EPU memory data. In the /O term, gates in the PAL delay /P. The rest of the equation controls data between the EPU and the CPU.

After you've worked with the EPU decoding, you can try using the EPU structure to do some non-EPU work. With the addition of some instruction decoding and timing logic, you can create a generalized HEPU interface. You can use such an interface to facilitate data and instruction passing to slave processors, implement system-overhead control, provide a parallel-processing interface to dedicated processors (such as I/O processors or high-efficiency bit-slice peripherals), establish a workspace outside of memory or I/O, create

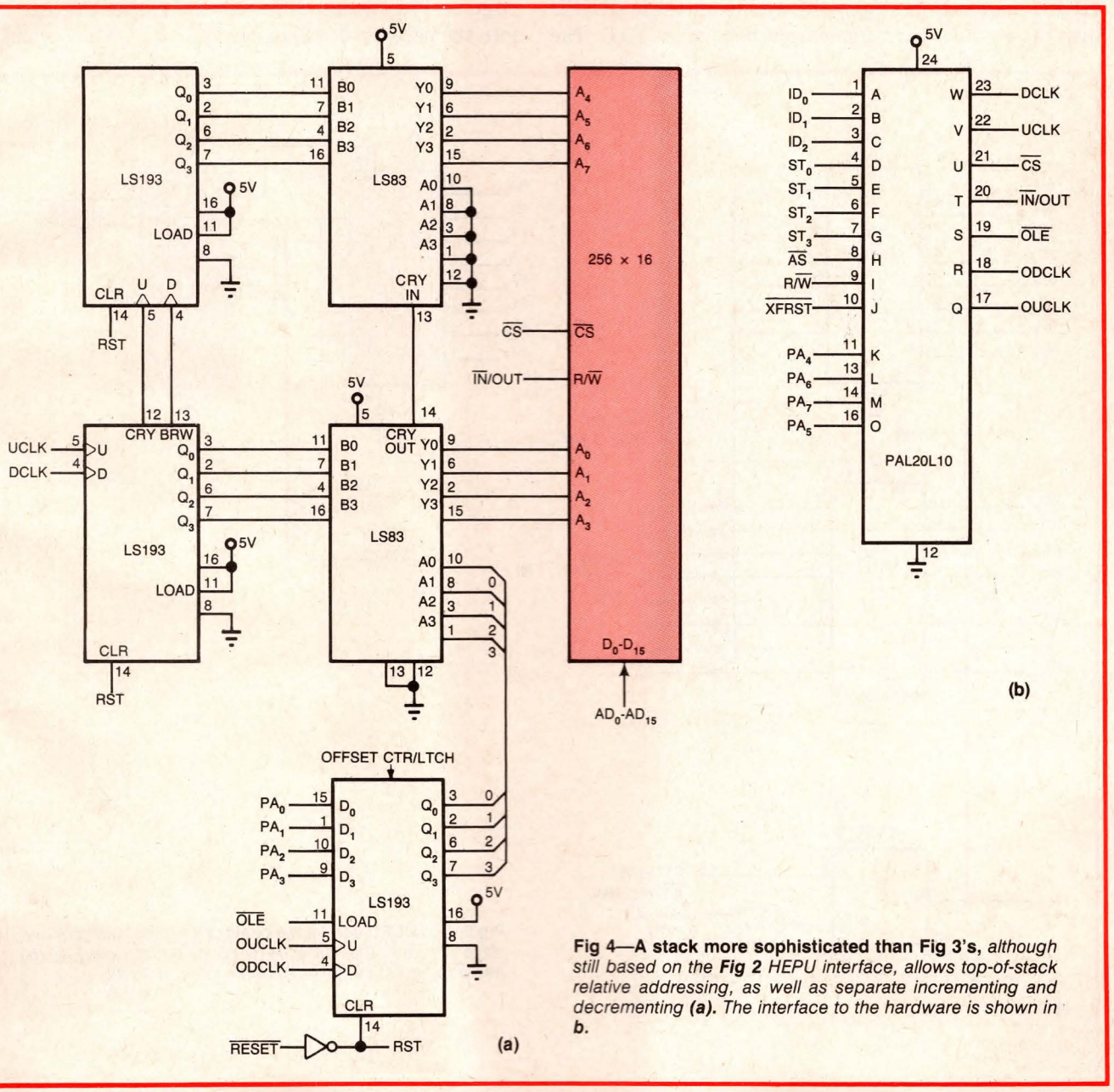


Fig 4—A stack more sophisticated than Fig 3's, *although still based on the* ***Fig 2*** *HEPU interface, allows top-of-stack relative addressing, as well as separate incrementing and decrementing* ***(a).*** *The interface to the hardware is shown in* ***b.***

multiple stacks, and support RAM and ROM disks. These are only a few examples; you'll find many more uses for HEPU interfaces.

For non-EPU hardware, the interface must monitor and decode the EPU instructions, provide timing and control to the hardware, and pass pertinent information to the hardware. **Fig 2** shows a generalized HEPU interface operating in EPU_3 space. Disallowing FCW transfers is the only restriction on this HEPU interface. **Table 4** lists the PAL equations used to build the circuit in **Fig 2.**

On the falling edge of T3, during M1, the CPU clocks the AD lines into the first set of latches (IC_1, IC_2). IC_5 decodes these lines to indicate the presence and type of HEPU instruction. The CPU encodes these HEPU instructions onto the three output lines of the PAL. The identification lines (ID_2-ID_0) are encoded below.

000 HEPU TO MEMORY
001 MEMORY TO HEPU
010 HEPU TO CPU
011 CPU TO HEPU
110 HEPU INTERNAL INSTRUCTION
111 NO HEPU INSTRUCTION

The CPU passes these lines to the HEPU bus and the second stage of the HEPU interface. For transfer instructions, this status arrives three clock cycles before the actual transfer if the CPU doesn't use any wait states during the instruction-fetch cycles. On the falling edge of T3, during Mn, the CPU clocks the AD lines into the second set of latches (IC_3, IC_4). The second set

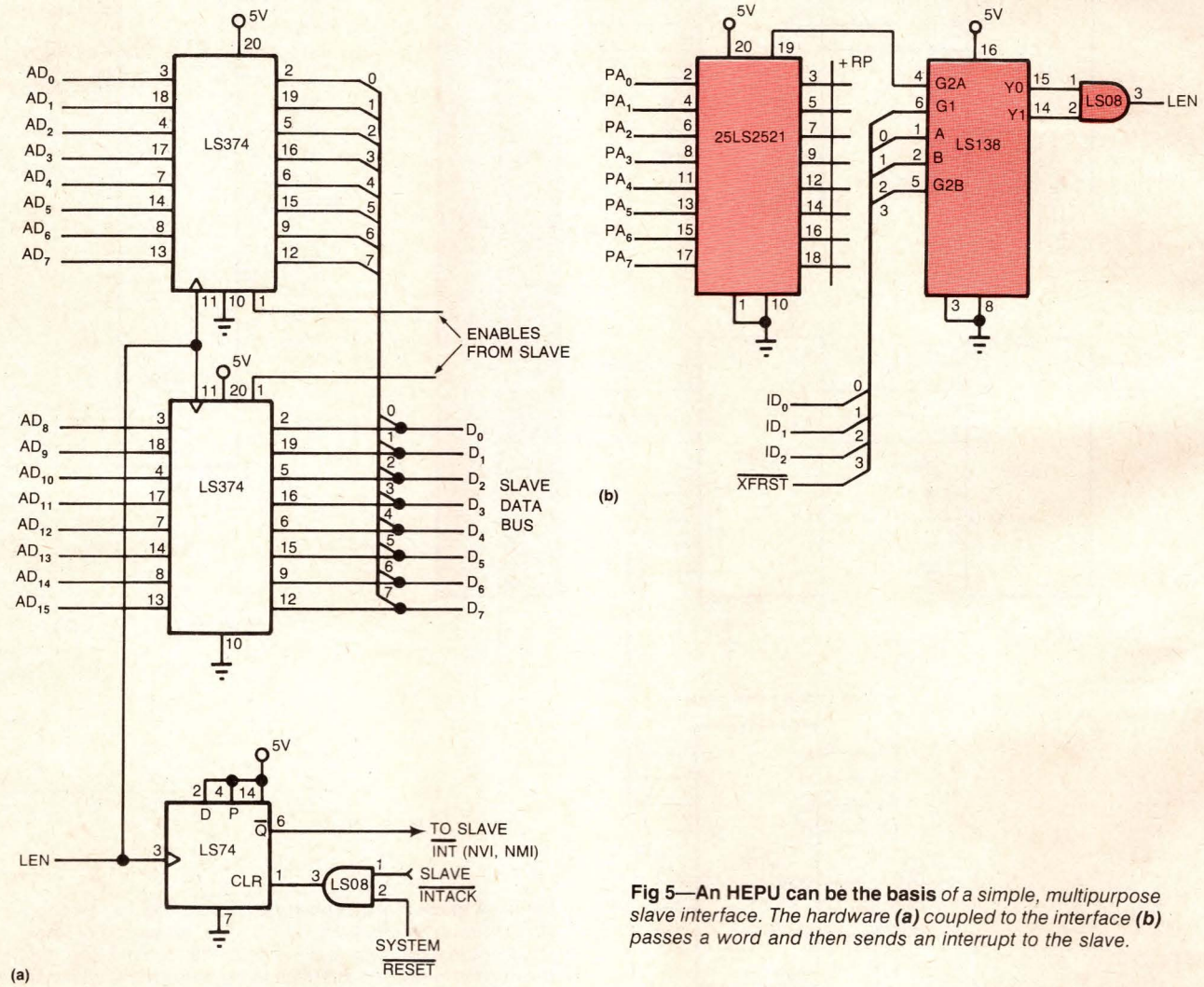


Fig 5—An HEPU can be the basis *of a simple, multipurpose slave interface. The hardware* ***(a)*** *coupled to the interface* ***(b)*** *passes a word and then sends an interrupt to the slave.*

of latches passes all the lines to the HEPU bus.

IC_6 provides the timing for the HEPU bus and interface. For an internal instruction, IC_6 generates the internal instruction strobe ($\overline{IST}$) that goes low with the rising edge of $\overline{DS}$ and high with the falling edge of the address strobe, ($\overline{AS}$). The transfer strobe ($\overline{XFRST}$) is the gated result of $\overline{DS}$ and the EPU transfer decode from the CPU status lines.

HEPU interfaces transfer data to CPU

For memory-to-HEPU transfers, IC_6 generates XFRST with the output from $\overline{DS}$ gated with R/$\overline{W}$ and the CPU status. Generating $\overline{XFRST}$ for the HEPU-to-memory operation is not as straightforward as the reverse operation. You need to gate R/$\overline{W}$ and either EPU memory request or EPU stack request with MREQ, creating both a delay to avoid contention with the address output from the CPU and a data setup time for the memory. The HEPU interface outputs pass to the HEPU bus, which you can add to the mother bus or the backplane. The HEPU bus comprises the following signals:

HEPU INSTR. ID	ID_0-ID_2
HEPU PORT ADDRESS	PA_0-PA_7
HEPU PORT INSTR.	PI_0-PI_7
TRANSFER WORD COUNT	XW_0-XW_3
INTERNAL INSTR. STROBE	$\overline{IST}$
TRANSFER STROBE	$\overline{XFRST}$
ADDRESS-DATA STROBE	$\overline{AS}$-$\overline{DS}$.

Using the internal HEPU instructions, you can design your own instruction set. The following are assembly-language mnemonics for the internal instruction.

```
XCTL    EPU 3, #(PA-7), #(PI-7)
```

The parentheses highlight the immediate bytes but are not part of the ZAS 2.0 syntax. This instruction lets you pass 16 bits as two bytes. The HEPU interface passes both bytes in the second word of the instruction fetch. The first byte contains the C and A nibbles; the second byte contains the B nibble and N field. You can split these bytes into any field configuration at the destination, so you can pass 16 bits throughout the system or eight bits to 256 ports. You can also pass 12 bits to 16 ports, and so on. The application determines the format, rather than the converse.

LIFO interfaces feature high performance

Now that you have completed the interface, you can try a few applications. The simplest stack is the classic push-pull, last-in/first-out (LIFO) structure. The hardware includes up/down counters and RAM. **Fig 3a** illustrates such a push-pull stack; **Fig 3b** gives the interface to the stack from the HEPU interface. The PAL equations are presented in **Table 5.**

ZAS 2.0 defines a push as

```
XLDM    EPU3, SRC, #(NO WORDS PUSHED), #7F
```

and a pull as

```
XLDM    DST,EPU3, #(NO WORDS PULLED), #7F.
```

Before each push, the up clock cycles once. $\overline{AS}$, gated

TABLE 4—PAL EQUATIONS FOR FIG 2 CIRCUIT

```
PAL16L8
HEPU PAL1
A B C D E F G H I GND
J K L M N O P Q R VCC
/R = N * M * /A * /C * /D * E * F * G * H * J * L
   + N * M * A * /B * /C * /D * E * F * G * H * /I * /J * /L
   + N * M * A * /B * /C * /D * E * F * G * /H * L
/Q = N * M * /A * /C * /D * E * F * G * H * L
   + N * M * A * /B * /C * /D * E * F * G * H * L
/P = N * M * /A * /C * /D * E * F * G * H * L
   + N * M * A * /B * /C * /D * E * F * G * H * /I * /L

PAL16L8
HEPU PAL2
A B C D E F G H I GND
J K L M N O P Q R VCC
/R = D + /E + F + /G + /H
/Q = D + E + F + /G + /H
/L = /A * B * C * /J
/K = A * /C * /D * F * /G * H
   + /A * /C * /I
```

TABLE 5—HEPU SIMPLE STACK PAL EQUATIONS

```
PAL16L8
STACK 1
A B C D E F G H I GND
J K L M N O P Q R VCC
/R = /J * /H * /C * A * E * /F * G
/Q = /J * /I * /C * /A * E * /F * G
/P = /J * /C * B * /I
   + /J * /C * /B * /A * /I
/O = /L * /C * B
   + L * /C * /B * /A
```

Apply auxiliary stacks to Forth-based systems

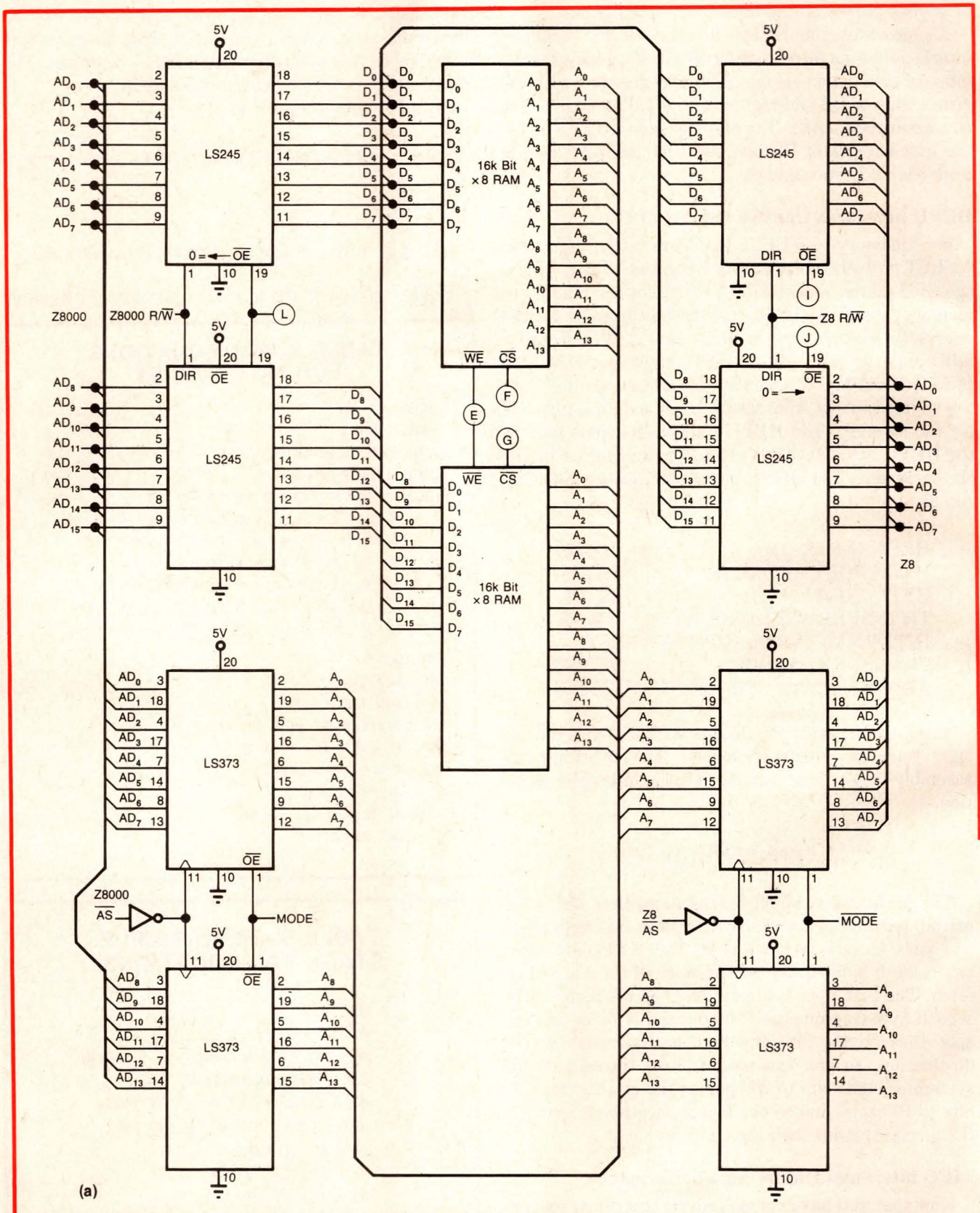


Fig 6—Although more sophisticated, this slave buffer *is functionally similar to* ***Fig 5's*** *interface. The hardware is illustrated in* ***a,*** *the interface in* ***b.***

with the look-ahead status and decode—and in conjunction with the correct CPU status decode—generates the up-clock signal. The down clock cycles once after each pull. $\overline{XFRST}$, in conjunction with the correct decode, creates the down clock.

Combined with the correct stack decode, $\overline{XFRST}$ creates the Chip Select ($\overline{CS}$). The RAM needs to be less than 70 nsec.

Top of stack reads/writes relatively

A more complicated stack permits Top-Of-Stack (TOS) relative addressing and separate increment and decrement handling. **Fig 4a** illustrates the core of such a stack; **Fig 4b** shows the interface to the stack. **Table 6** lists the PAL equations for this stack.

This type of stack can function as a normal push-pull stack and as a stack that allows multiple read/writes in TOS relative mode—without affecting the TOS. You structure the immediate byte (PA_0-PA_7) as:

	OFFSET	TOS	OFFSET
STACK	INC/DEC	INC/DEC	
DECODE	ENABLE	ENABLE	
XX	X	X	XXXX-LSB.

A Forth-based system is a good application for an auxiliary stack. **Table 7** shows how you would code typical Forth stack manipulations.

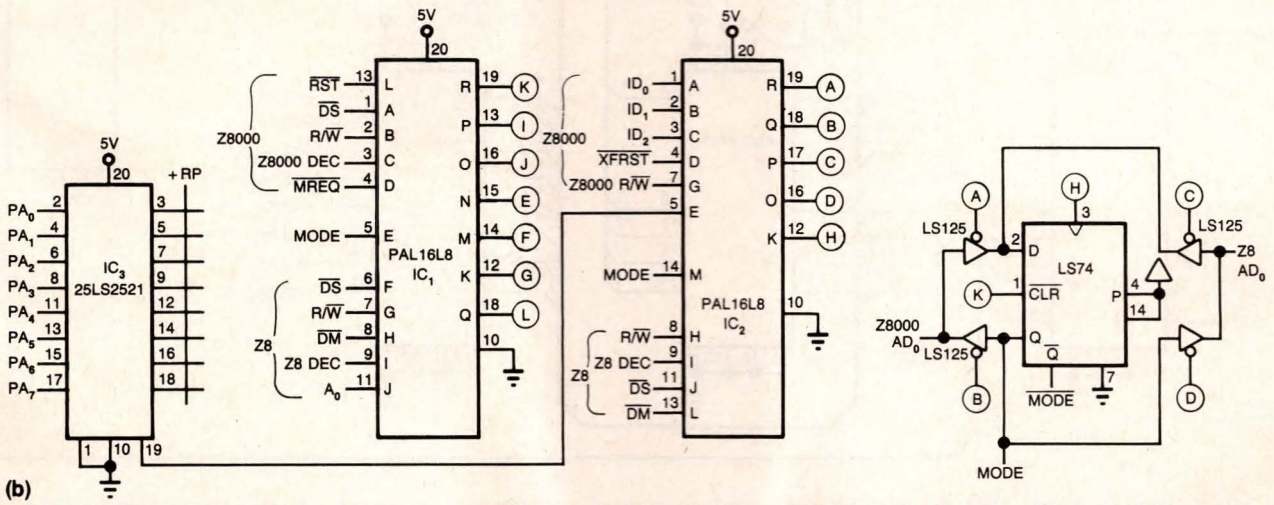
Next, you can try slave interfacing. The simplest

TABLE 6—TOP OF STACK PAL EQUATIONS

```
PAL20L10
STACK 2
A B C D E F G H I JK GND
J K L M N O P Q R STUV VCC
/V = /O * A * E * /F * G * /C * L * /H * K *M
/W = /O * /A * E * /F * G * /J * K * /C * L * M
/U = L * /J * /C * B * M
   + L * /C * /J * /B * /A * M
/T = /I * /C * B
   + I * /C * /B * /A
/S = /D */E * F * G * I
/R = O * /K * L * A * /C * E * /F * G * /H * M
/Q = O * /K * L * /J * A * /C * E * /F * G * M
```

TABLE 7—TYPICAL FORTH MANIPULATIONS

DUP		EX	R2,R3
XLDM	R2,EPU3,#%00,#%C0	XLDM	EPU3,R2,#%01,#%D0
xLDM	R2,EPU3,#00,#D0	2SWAP	
SWAP		XLDM	R3,EPU3,#%03,#%E0
XLDM	R2,EPU3,#%01,#%D0	EX	R3,R4
EX	R3,R2	EX	R5,R6
XLDM	EPU3,R2,#%01,#%D0	XLDM	EPU3,R3,#%03,#%E3
ROT		2ROT	
XLDM	R2,EPU3,#%02,#%D0	XLDM	R2, EPU3,#%05,#%E0
LD	R5,R4	EX	R6,R7
LD	R4,R2	EX	R2,R5
XLDM	EPU3,R3,#%02,#%D0	EX	R3,R4
OVER		XLDM	EPU3,R2,#%05,#%E5
XLDM	R2,EPU3,#%00,#%C1	2OVER	
XLDM	EPU3,R2,#%00,#%D0	XLDM	R2, EPU3,#%01,#%E2
2DUP		EX	R2,R3
XLDM	R2,EPU3,#%01,#%E0	XLDM	EPU3,R2,#%01,#%D0



slave interface (**Fig 5a**) passes one word and then interrupts the slave. Typical slave operations include local-area-network (LAN) controllers and intelligent disk controllers. **Fig 5b** is an example of an interface decoder.

Using this type of slave interface has one advantage over direct CPU or DMA access—it doesn't create holes in the memory map. **Fig 6a** shows a more realistic slave buffer than the simple one in **Fig 5a**. **Fig 6b** gives the interface decoder for this improved slave buffer, and **Table 8** provides the programs for both PALs.

CPU polls parallel boards

The structure for transferring data between the CPU and the HEPU allows the CPU to test or set bits on the Z8000 side of the buffer. At power-up, the mode latch resets to Z8000 mode. The CPU can test the mode latch on the Z8000 side at data bit 0 in an HEPU-to-CPU transfer. The CPU can set the mode latch to Z8 mode by a CPU-to-HEPU transfer. When the interface is in the Z8000 mode, data bit 0 provides the data for the mode latch.

The Z8000 can poll and set as many as 16 parallel boards, each of which has been assigned to a different data bit. On the Z8 side of the buffer, the Z8 performs the test and reset functions, and it reads and writes the data in a single memory location. As before, the Z8 uses data bit 0 to pass data. The Z8000 and Z8 may poll the mode latch in either mode, but they can only set the mode latch in their respective modes.

The circuitry described to this point works with either a 4- or a 6-MHz CPU, but the timing is incompatible with a 10-MHz CPU. **Fig 7** shows an HEPU interface modified to run at 10 MHz with the PAL codes listed in **Table 9.**

You can see several changes to the interface, compared with the original. The PALs perform basically the same functions, but Schottky parts pass the timing, with the PALs providing a look-ahead function to the timing. Some other components included are Am29845s

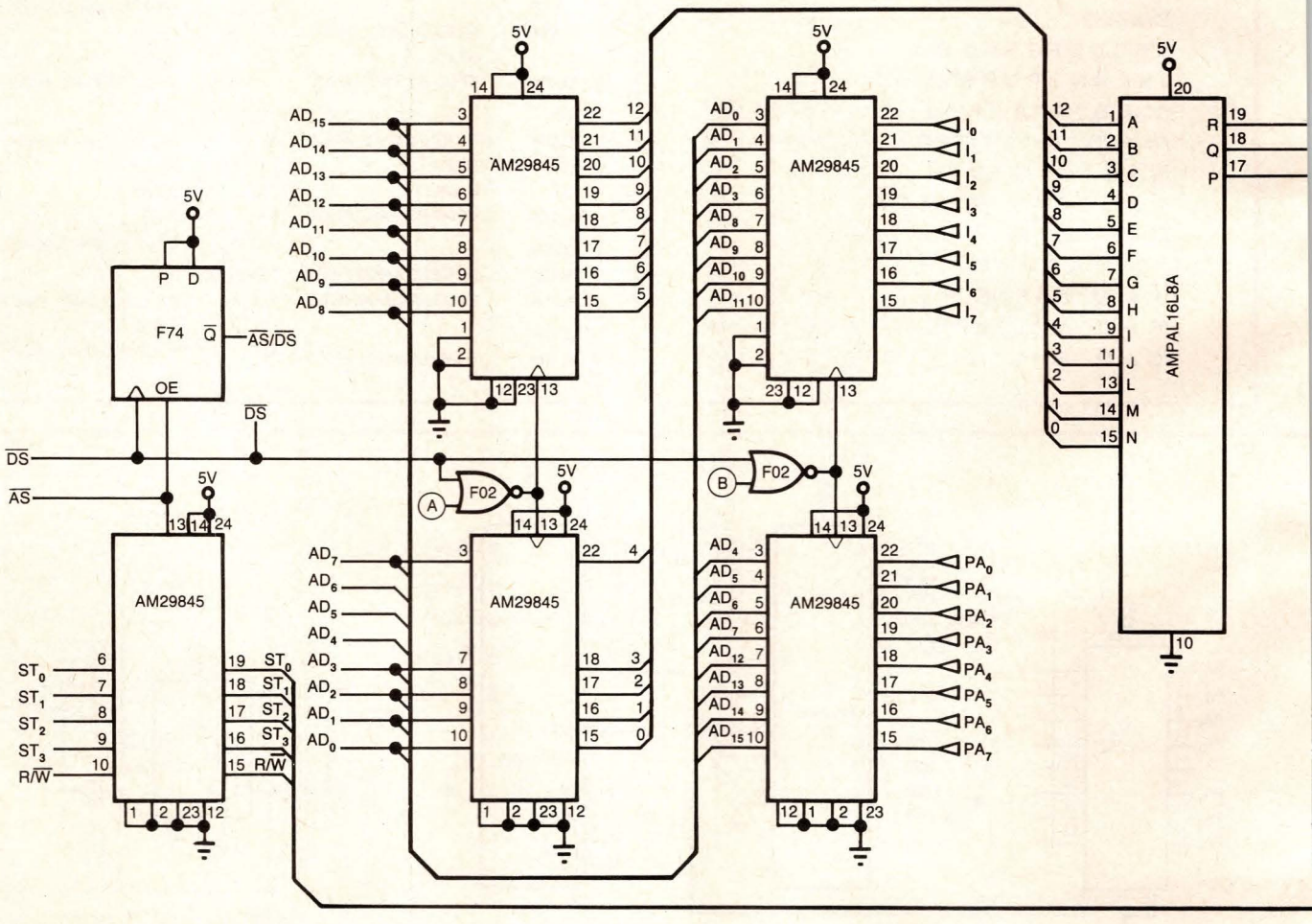


Fig 7—Operating at 10 MHz, *this modified HEPU interface improves performance with Schottky devices and high-speed PALs.*

and AmPAL16L8As. The Am29845s are fast transparent latches, optimized for suppressing metastates. The AmPAL16L8As are also fast devices.

10-MHz HEPUs

The next HEPU application targets 10-MHz Z8000 applications. The Z8000 family doesn't have a direct-memory-access (DMA) chip that runs at 10 MHz. That leaves you with three options: You can adapt the Z8016A for use at 5 MHz, rely on the CPU block-transfer instructions, or use the EPU structure. The first choice requires extensive hardware modification and provides a throughput of only about 1.7M bytes/sec. The second choice offers a throughput of about 2.2M bytes/sec. The third choice is capable of giving you a throughput of about 3.9M bytes/sec. (Throughput figures are calculated based on a transfer of 32k bytes in word mode, assuming the Z8016A runs in a flow-through mode.)

In an application such as a LANCE interface, the EPU block move allows the CPU to share a pair of RAM buffers with the LANCE and still transfer data continuously by running the buffers in an interleaving mode. The speed of the EPU block transfer permits the CPU to fill one buffer and load the task to the LANCE. While the LANCE is transmitting from one buffer, the CPU can monitor the buffer's status and fill the other buffer. The same holds true for the receive mode. The only interruption in the process arises when the LANCE issues an interrupt to the CPU.

This application is a generalized memory-to-memory transfer mechanism. **Fig 8** is a schematic of the hardware that implements a fast block transfer between the EPU and memory.

EPUs access parallel blocks

You might think that **Fig 8** shows a lot of hardware for just 64k bits of RAM. But keep in mind the speed of transfer and the cost of 55-nsec RAM. By adding two more PALs and appropriate RAM decoding, you can

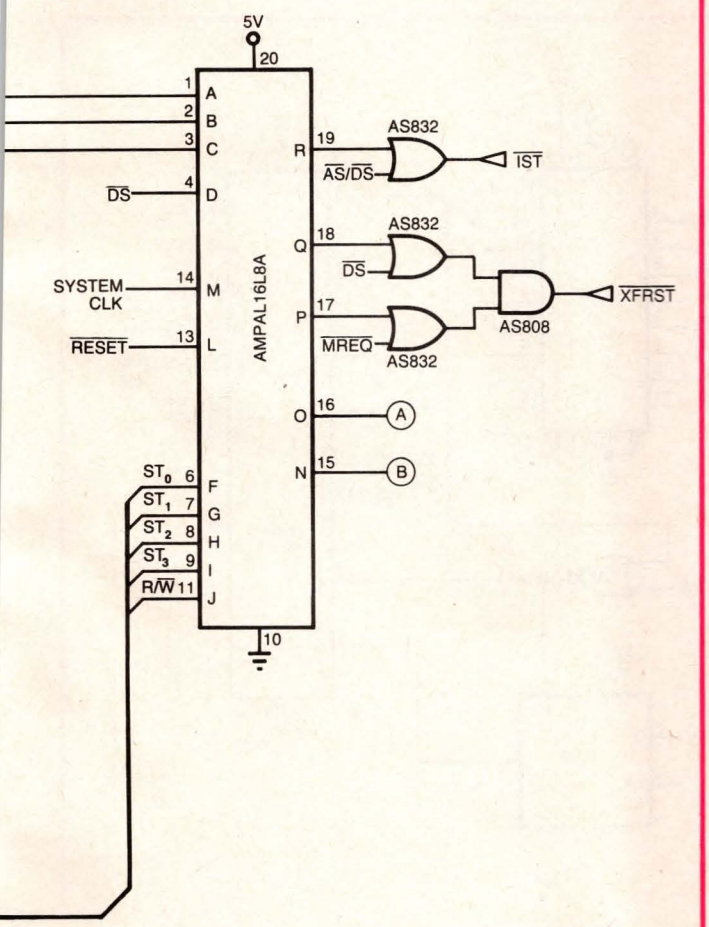


TABLE 8—Z8000 - Z8 BUFFER PAL EQUATIONS

PAL16L8
Z8K-Z8PAL1
A B C D E F G H I GND
J K L M N O P Q R VCC
/R = /L
/P = E * J * L * /I * /H * /F * G
+ E * L * /G
/O = E * /J * L * /I * /H * /F * G
+ E * L * /G
/N = /E * /A * /B * /C * D
+ E * /F * /G * /H * /I
/M = /E * /A * /B */D
+ E * /F * /H * /I * J
/K = /E * /A * /B * /D
+ E * /F * /H * /I * /J
/Q = /E * /A * /C * B * L
+ /E * /B * /C * /D * L

PAL16L8
Z8K-Z8PAL2
A B C D E F G H I GND
J K L M N O P Q R VCC
/R = /M * /G * A * B * /C * /E
/Q = /M * G * /A * B * /C * /E * /D
/P = M * /L * /H * /I
/O = M * /L * /H * /I * /J
/N = M * /L * /J * /I * /H
+ /M * A * B * /C * /D * /E
/K = N

access 256 of these 64k-bit RAM disks.

The interface works as a RAM disk, using the EPU structure for setup and accesses. When it's not enabled by $\overline{\text{mode decode}}$, the bus accesses the RAM in normal memory space. The HEPU interface latches the $\overline{\text{mode decode}}$ signal from the I_0 HEPU line using the $\overline{\text{IST}}$ signal in conjunction with the P_0-P_7 $\overline{\text{decode}}$. The $\overline{\text{mode decode}}$ is active-Low, which enables transfers between the CPU and the HEPU and between the HEPU and the memory. The interface always responds to its internal operation.

When $\overline{\text{mode decode}}$ enables data exchange, a transfer between the CPU and a HEPU port loads the counters with the origin address. (When not enabled, the counters act as address latches.) From then on (until the bus disables $\overline{\text{mode decode}}$), the CPU transfers data between memory and the HEPU in flyby fashion, with the PAL in **Fig 8** automatically incrementing the RAM disk address. The $\overline{\text{XFRST}}$ signal compensates for the destination, source (dst,src) differential in timing.

The manufacturer plans to include EPU capabilities on the Z800 and Z80,000 processors. Because of the

TABLE 9—10 MH HEPU INTERFACE PAL EQUATIONS

```
PAL16L8
10MPAL1
A B C D E F G H I GND
J K L M N O P Q R VCC
/R = N * M * /A * /C * /D * E * F * G * H * J * L
   + N * M * A * /B * /C * /D * E * F * G * H * /I * /J * /L
   + N * M * A * /B * /C * /D * E * F * G * /H * L
/Q = N * M * /A * /C * /D * E * F * G * H * L
   + N * M * A * /B * /C * /D * E * F * G * H * L
/P = N * M * /A * /C * /D * E * F * G * H * L
   + N * M * A * /B * /C * /D * E * F * G * H * /I * /L

PAL16L8
10MPAL2
A B C D E F G H I GND
J K L M N O P Q R VCC
/R = L * J * /A * B * C * /F * /G * H * I
/Q = /C * /B * L * /F * G * H * I
/P = /C * /B * L * G * /H * I
/O = L * J * /D * F * /G * H * I * M
/N = L * J * /D * /F * /G * H * I * /A * B * C * M
```

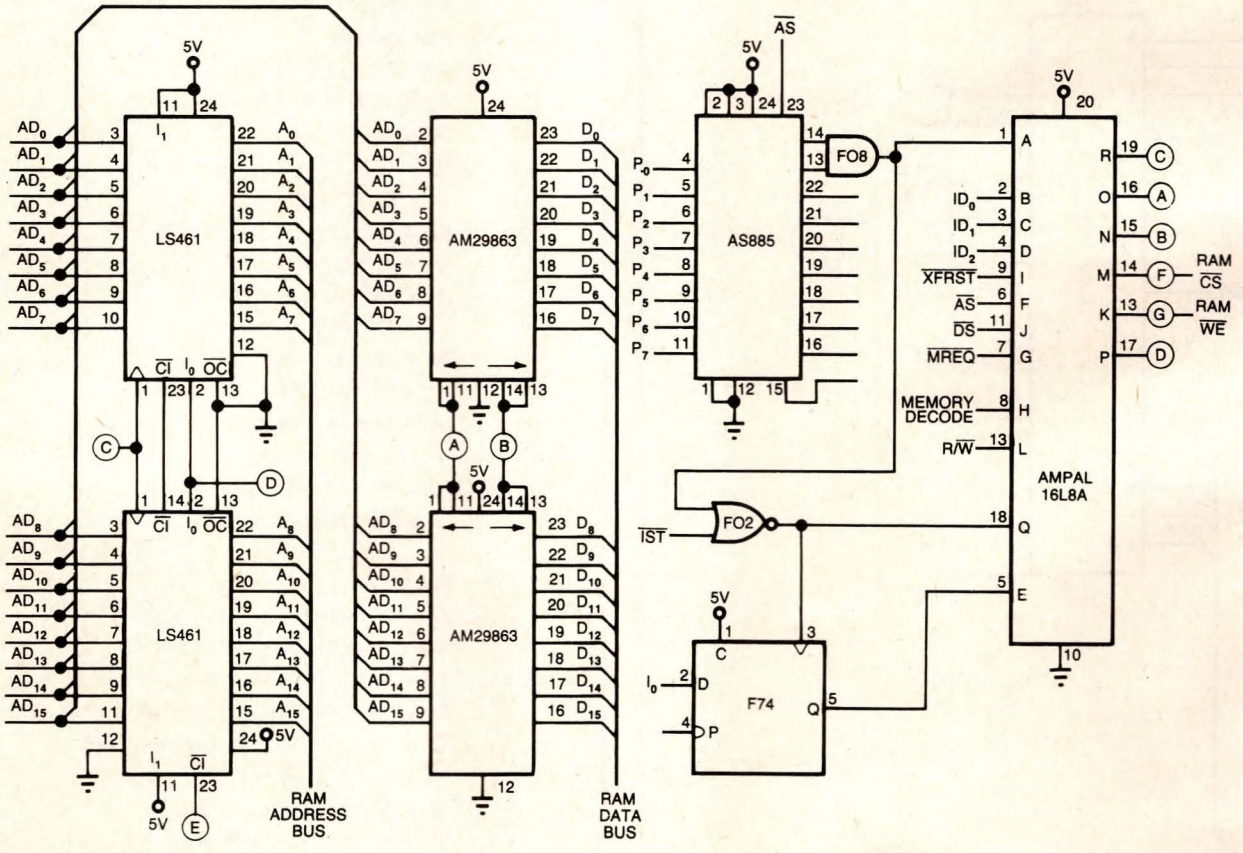


Fig 8—This block-transfer circuit *speeds communication between the EPU and memory. The design is related to a RAM-disk circuit.*

REF LEVEL
10 dBm
INPUT ATTEN
10 dB ATTEN
LOG SCALE
10 dB/
Many of today's complex instrumentation systems depend on programmable frequency synthesizers. Varian Instrument Division, Palo Alto, is using PTS 160 and PTS 200 low noise sources in their state-of-the-art-products.
The reliability record established by these synthesizers over the years has been outstanding.
If you need VHF-UHF Synthesizers for precision frequency control in your system or lab, follow the leaders, specify PTS with confidence.
PTS
FREQUENCY SYNTHESIZER MODELS
40 MHz, 160 MHz, 200 MHz, 500 MHz
PTS 500
LOCAL
REMOTE
FREQUENCY CONTROL
LEVEL
OUTPUT
ON
OFF
PTS
PROGRAMMED TEST SOURCES, INC.
Littleton, MA, 617-486-3008
CIRCLE NO 69

RS-232-C opto-modem
TR2000

Here is the ultimate Fiber Optic interface for full-duplex transmission of data and control signals between datacomm devices.

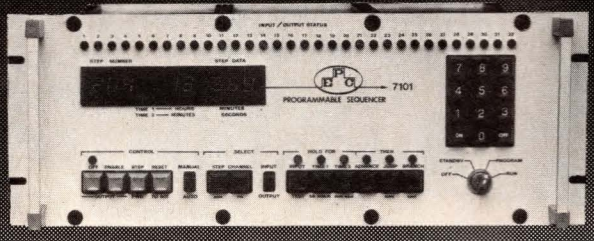
- Low Power Consumption
- DTE/DCE Operation
- Long Distance/High Speed

For more information and prices, contact:

American Photonics Inc.
71 Commerce Drive, P.O. Box 289
Brookfield Center, CT 06805 (203)775-8950

CIRCLE NO 70

PROVEN CONTROL



EPC-7101 PROGRAMMABLE SEQUENCER

Over the last five years the EPC-7101 PROGRAMMABLE SEQUENCER has established itself as a reliable and efficient controller for plasma systems. the built-in programming panel allows programs to be entered and modified easily.

- UP TO 32 INPUTS AND 32 OUTPUTS
- UP TO 999 STEPS
- 2 TIME RANGES - .1 SEC TO 100 HRS. PER STEP
- INDUSTRIAL INTERFACE RACK
- CASSETTE LOADER FOR PROGRAM STORAGE

For more information contact Jim Mellen
CALL 1-800-635-3435

ENCODER PRODUCTS CO
1601B Dover Road • Sandpoint, ID 83864

CIRCLE NO 71

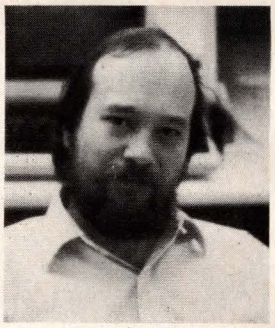
With an HEPU, the Z8000 polls 16 parallel boards

design of their respective instruction-fetch cycles, HEPU interfaces are most easily implemented on the Z8000; the Z80,000 implementation is more difficult, and the Z800 is the most complex. **EDN**

Acknowledgments

The author wishes to thank Gary Beals of Zilog Inc for information and technical review and Rich Hollenbeck of Western Wares for improvements to the design of the ZAS assembler.

Author's biography



Stephen McMahan is owner of Olympic Synthesis (Seattle, WA), a firm specializing in digital audio and synthesizer designs. He has worked for the past three years as a design technician in the market development products department at Data I/O Corp (Redmond, WA). Stephen enjoys music composition and electronic music.

Article Interest Quotient (Circle One)
High 473 Medium 474 Low 475

THE CHOSEN FEW

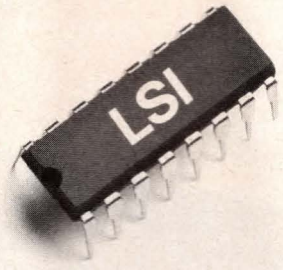
You can be among the chosen few to have their technical articles appear in EDN. We're constantly looking for good articles that cover state-of-the-art technology and applications.

If you've got an innovative application for a hot new device, why not immortalize it in print? It's easier than you think. Just send an outline of the proposed article to Bill Travis, Senior Editor, EDN, 221 Columbus Ave, Boston, MA 02116. Or, you can call him and discuss the application at (617) 536-7780.

Don't miss this opportunity to become one of the chosen few.

EDN: Everything Designers Need

FAST ON ITS FEAT.



The 74F402 Serial Data Polynomial Generator/Checker

Introducing the first LSI way to go FAST™: The new 74F402 Serial Data Polynomial Generator/Checker from Fairchild.

Whether you're designing local area networks, data storage equipment or Ethernet-compatible equipment, this is the part for you. It delivers a guaranteed 30 MHz at commercial temperatures. It's expandable to generate polynomials up to a 56th order fire code with the addition of CRC16 and CCITT codes. So you can make short work of errors in long serial data streams.

Plus, no external logic is necessary. And the F402 comes in one neat 16-pin DIP. That means less board space, fewer parts and reduced design time.

The F402 from Fairchild. We're putting our best feat forward.

For data sheets, samples or more information, contact your nearest sales office or authorized distributor.

FAST™

From Portland, ME.

FAIRCHILD

A Schlumberger Company

Fairchild Digital Division, 333 Western Avenue, South Portland, Maine 04106

FAST (Fairchild Advanced Schottky TTL) is a trademark of Fairchild Camera and Instrument Corporation.

CIRCLE NO 72

A 100mm, DIGITIZED, 4 CHANNEL, FIXED THERMAL PRINTHEAD RECORDER THAT:

• OFFERS USER PROGRAMMABLE CHART SPEEDS • PROVIDES ELAPSED TIME PRINT OUT • GENERATES ITS OWN GRID • ACCEPTS ANALOG INPUTS • IDENTIFIES TRACES

FOR LESS THAN $200 PER CHANNEL.

Gulton's Supertrak® 4100 does all that and more. It offers four analog input channels for multiple signal recording and lets you select signal polarity for industrial or inverted inputs. An event marker channel is also provided. Programmable chart speeds make system integration easy and user driven chart speeds provide special system integration.

The ST-4100 is microprocessor based for complete system coordination. An internal clock provides accurate time/data correlation and allows for the additional feature of elapsed time printout in the chart margin.

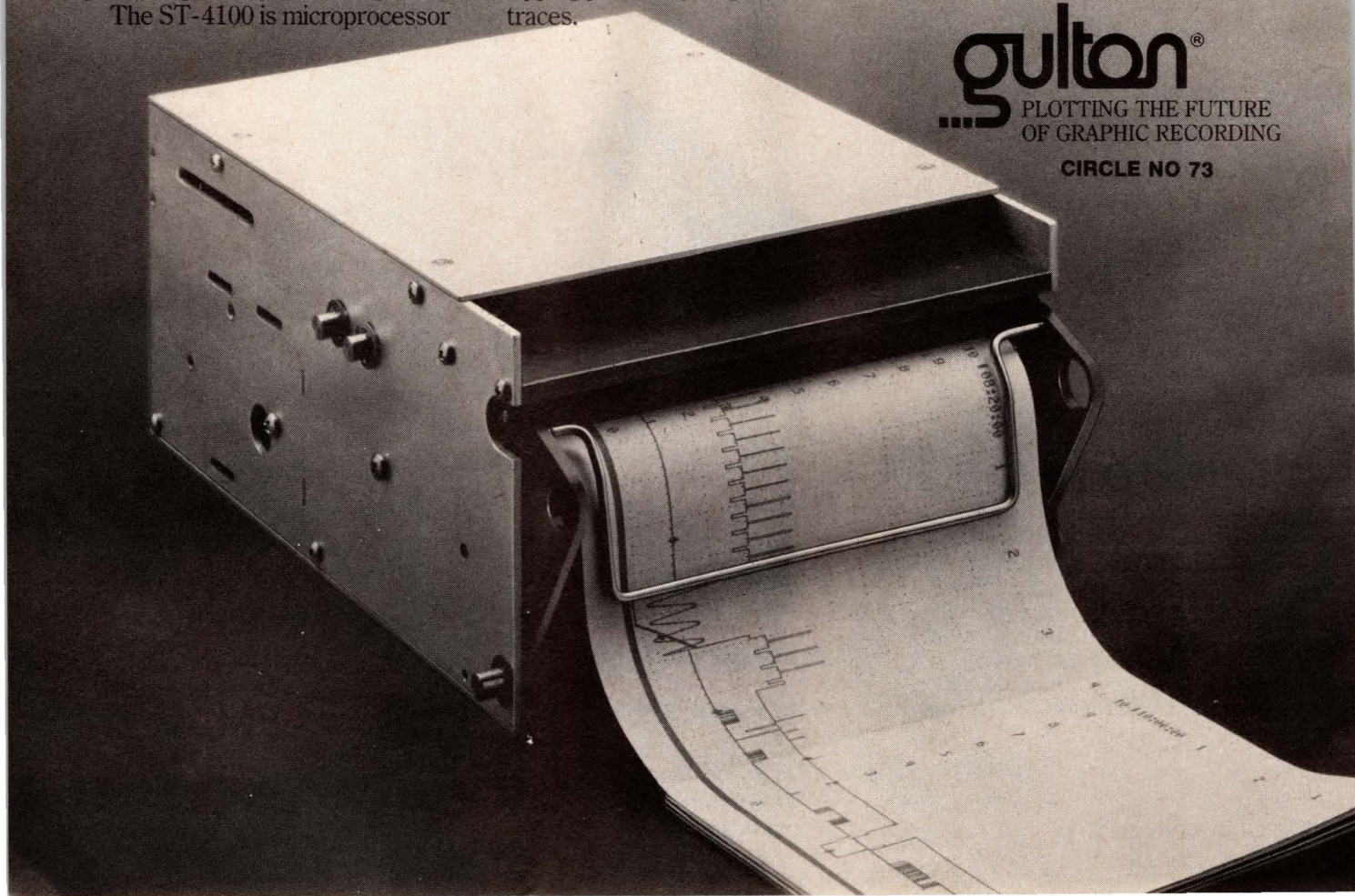
Reliable fixed thermal printhead ends between-channel time errors inherent in servo-drives with overlapping pens, so you get accurate traces.

Never before has so much been designed into a single recorder for less than $200 per channel. For complete details and specifications write GRAPHIC INSTRUMENTS DIVISION, Gulton Industries, Inc., East Greenwich, RI 02818. For a demonstration, call (401) 884-6800, (800) 343-7929 toll free or TWX 710-387-1500.

gulton®

PLOTTING THE FUTURE OF GRAPHIC RECORDING

CIRCLE NO 73



Actual size switch

New! CTS AUTO-DIP™ Switches for AUTOMATIC INSERTION!

You'll realize immediate cost savings in board production with the New CTS Series 207 AUTO-DIP™ Switch.

Because they are the same size as your IC's—these new Series 207 AUTO-DIP™ switches can be used in your automatic insertion equipment right along with IC's...without machine adjustment. You get economical high speed board production. You'll save significant board space as well! This new switch takes only 37% of the volume of a standard DIP switch allowing for closer board stacking and space savings.

Wave solderable! Board washable! The AUTO-DIP™ design eliminates bottom sealing. And, a lead frame housing construction with time-proven tape top seal keeps contaminants out of the switch through wave soldering and solvent or aqueous cleaning.

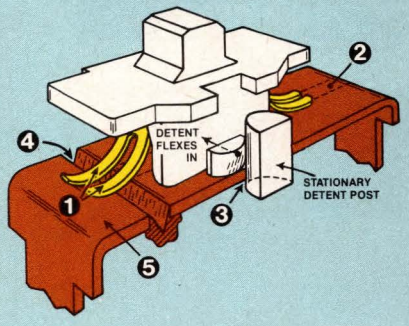
Reliability you can count on. During the fully automated assembly process, each Series 207 DIP Switch is 100% machine tested for continuity and contact resistance. In addition, statistical process control used in every step during manufacturing assures unvarying part quality and final reliability. Available in 2-position to 12-position switches.

WRITE TODAY for full technical data on these new Series 207 AUTO-DIP™ switches.
Contact: CTS Corporation,*
Paso Robles Division,
Electromechanical Group,
500 Linne Road,
Paso Robles, CA 93446.
Phone: (805) 238-0350

*In Calif. dba CTS Electronics Corporation

CIRCLE NO. **1**

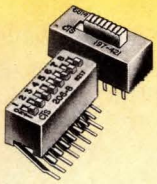
Switch reliability that is the best ever!



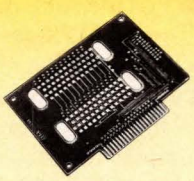
1. Redundant gold inlaid contacts dramatically enhance contact reliability.
2. Positive wiping contacts assure low and consistent contact resistance. (.050" travel)
3. Detent function separated from contacts to optimize both designs.
4. Gold contacts never abraded or contaminated by sliding over polymer surfaces. Contacts never touch a nongold surface
5. No contactor deflection for the life of the switch. Constant contact force eliminates overstressing of contacts for greater reliability.

CTS means Reliability

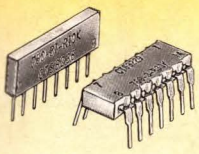
CTS CORPORATION • ELKHART, INDIANA



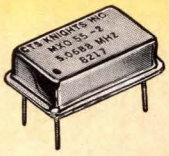
Series 206RA & 197 Right angle and 4PDT slide actuated DIP switches.
Phone: (805) 238-0350
CIRCLE NO. 2



PC Boards Complex double-sided and multilayer.
Phone: (415) 964-5000
CIRCLE NO. 3

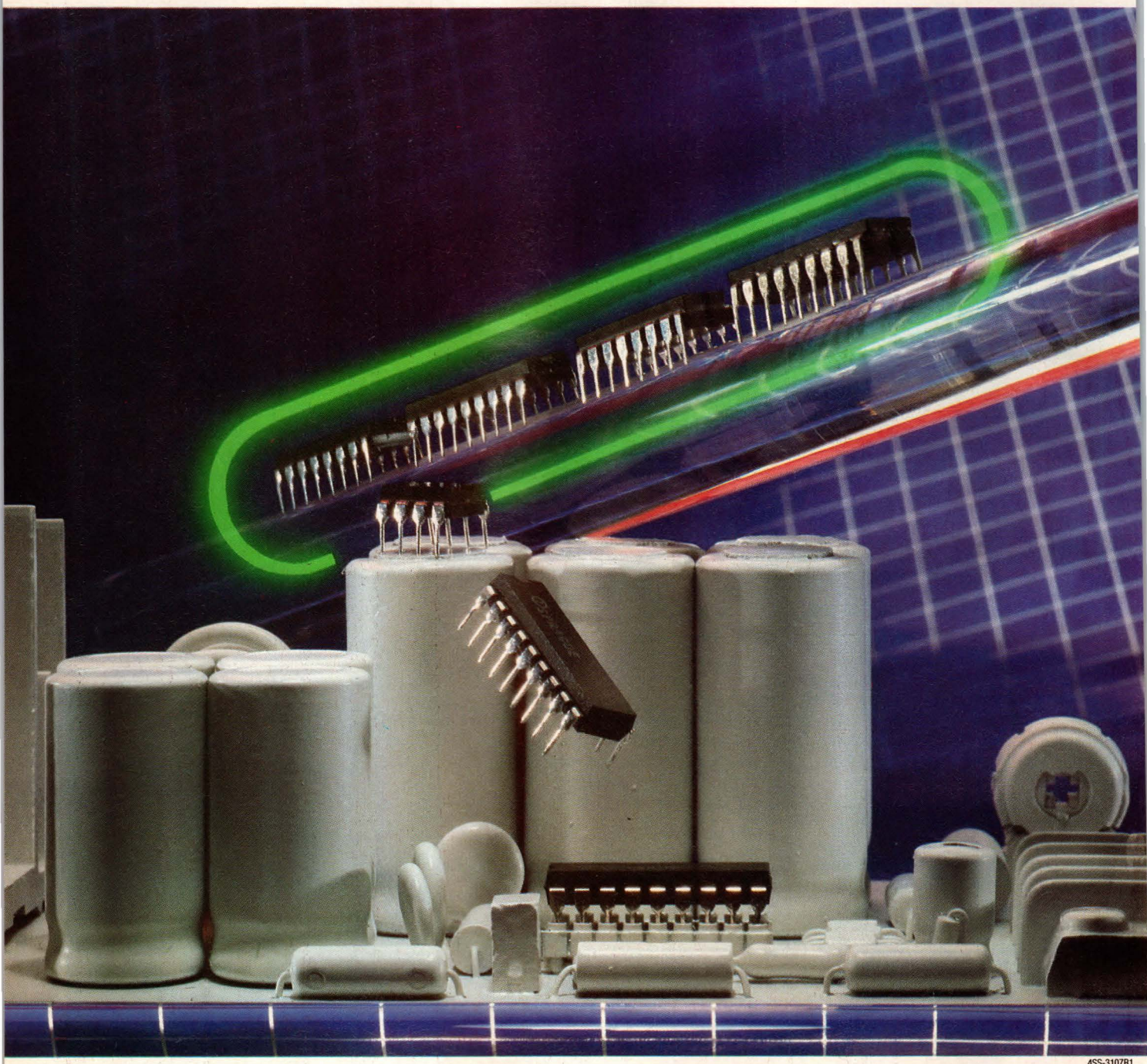


Series 750 & 760 Solid ceramic SIP and DIP resistor networks.
Phone: (219) 589-8220
CIRCLE NO. 4



Series MX055 Low profile hybrid clock oscillators.
Phone: (815) 786-8411
CIRCLE NO. 5

COST-EFFECTIVE.



4SS-3107R1

SPRAGUE ICs FOR SMPS CONTROL.

Make it a rule to use Sprague Series 8126, 8160 and 8161 control circuits in your switched-mode power supplies. For the same reason you use other Sprague components. These SMPS devices are reliable and available at reasonable cost. Choose the one that fits your needs. For detailed technical data on these high-performance SMPS ICs, write for Engineering Bulletin Group 27466 to Technical Literature Service, Sprague Electric Company, **491** Marshall Street, North Adams, Mass. 01247. For application assistance, call Ron Lutz at 617/853-5000.

SPRAGUE
THE MARK OF RELIABILITY

CIRCLE NO 74

Eliminating protection circuitry reduces switching-supply costs

Crowbar-type overvoltage and foldback-mode current-limit circuits are needless in many switching-supply applications. A study of supply circuitry shows why you can often eliminate such protection functions.

D J Becker, *Lorain Products*

If you design or specify switching-regulator-based power supplies, you can often realize cost savings by eliminating the crowbar-type overvoltage and foldback-characteristic current-limiting circuitry used in many such supplies. What's more, you can dispense with these circuits without compromising the safety of the supply or its load.

The cited protection schemes owe their existence to previous necessity; they were generally an outgrowth of linear-power-supply characteristics. A comparative study of the attributes and failure mechanisms of linear and switching-regulator supplies shows why the costly protection circuits are often unnecessary in switching supplies.

Linear-supply development

To see why voltage and current limiting are needed in linear supplies, it's important to understand how these supplies operate—specifically, how they relate to their respective loads. The linear power supply (**Fig 1**) has a single series element that's responsible for the output regulation. This element is usually a bipolar transistor or a power MOSFET. The supply regulates the output by using some kind of electronic control to vary the conductivity of the series transistor.

The transistor is in series with the unregulated input line; it continuously adjusts the excess voltage between input and output. Some of the linear supply's advantages are that it regulates well, it's relatively simple, and it has very low output noise. A major drawback, however, is that if the series pass element fails (and bipolar transistors usually fail dead short), the total potential of the unregulated input source appears across the supply's output terminals. This high voltage can result, for example, in the failure of all logic elements connected to the supply. This dead-short failure mechanism is the reason for the development of the crowbar circuit.

Crowbar overvoltage limiting

You can consider the crowbar circuit the last-resort effort by the power supply to protect any critical load connected to the output terminals. **Fig 2a** shows that failure of the series-pass element results in a rapid voltage rise across the load. Failure to contain this voltage within a specified limit (eg, 6V for TTL circuits) is catastrophic: Excess voltage can burn out the load circuitry. The purpose of **Fig 2b**'s crowbar circuit is to

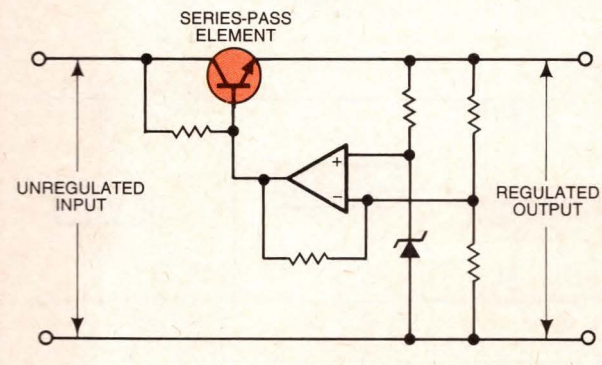


Fig 1—A linear power supply's series-pass element *is subject to dead-short failure if overloaded. This fact mandates foldback current limiting (to protect the pass element) and crowbar overvoltage protection (to protect the load).*

detect the fast-rising voltage front and provide a high-conductivity path to the return.

The conductive path is designed to draw enough current from the unregulated input source to prevent the voltage from damaging the load. The crowbar must be of sufficient size to handle the large current drawn from the unregulated line, for at least the time it takes for some sort of protection device (eg, a fuse or circuit breaker) to activate. The conditions that trigger a crowbar circuit are rarely caused by any supply-electronics fault other than failure of the series-pass element itself. Typical causes of failures of the series device are thermal breakdowns caused by excess power dissipation.

Foldback current limiting

A second consideration in linear supplies is the use of a foldback current-limiting circuit. As **Fig 3a** shows, the nomenclature "foldback current limiting" is appropriate: The output current folds back in value, and the output voltage decreases when the load demands exceed a preset value. The foldback characteristic owes its development to the needs of the series-pass element, which dissipates most of the power during a fault condition.

Consider, for instance, the condition shown in **Fig 3b.**

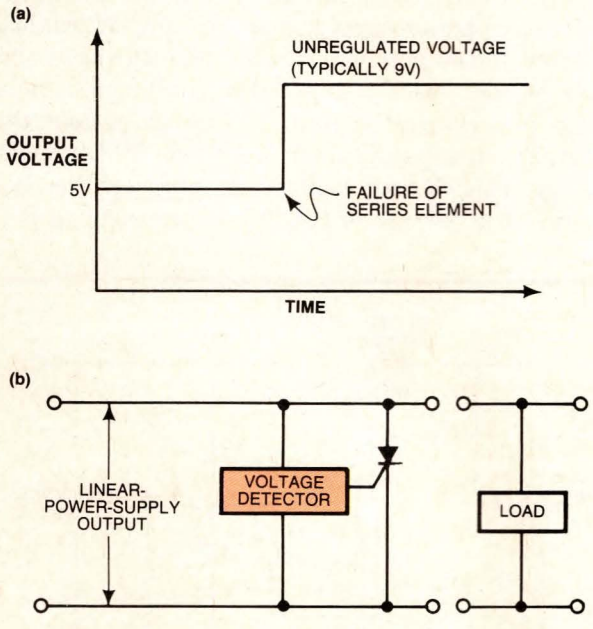


Fig 2—Failure of the series-pass element *in a linear supply could result in application of the full unregulated input voltage to the load* ***(a).*** *A crowbar circuit* ***(b),*** *though, detects the series-pass element's failure and immediately short circuits the power-supply output.*

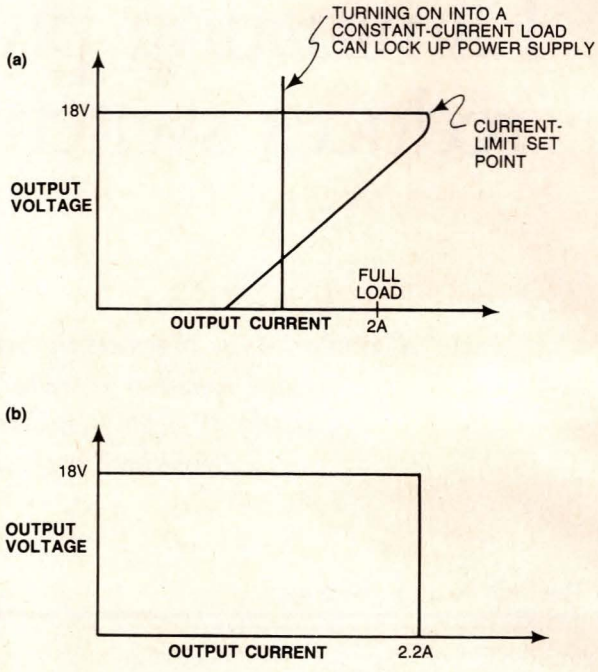


Fig 3—Foldback (a) and straight (b) current limiting *differ markedly. In the former, exceeding the preset rated current causes both the supply's output voltage and the current to decrease according to the load line. The straight limiter, on the other hand, allows the full input-output differential to appear across the series-pass element at currents as high as the full-load limit.*

Assuming a 24V raw input voltage, the drop (the difference between output and raw input voltages) across the series device is 6V. If the supply is delivering 2A, the power dissipation in the series-pass element is 12W. In providing for this 12W power, you must consider the capabilities of the selected series-pass device and also the thermal path necessary to keep the device's dissipation within the specified limits.

A standard TO-3 transistor (eg, the 2N3054) has a 7°C/W junction-to-case thermal-resistance specification. You must therefore select an appropriate heat sink to keep the transistor's junction temperature within operational limits. If you choose a heat sink with 2°C/W thermal resistance, the total junction-to-air thermal resistance is 9°C/W. This resistance results in a temperature rise of 108°C (9°C/W×12W) from junction to air. For a device that operates at 40°C ambient temperature, the 108°C gradient produces a 148°C junction temperature, roughly 74% of the 2N3054's operating-temperature capability.

Consider now a thermal analysis for a short circuit. The total 24V unregulated input voltage appears across

the series-pass element. If, under these conditions, you use a nonfoldback scheme (**Fig 3b**) that limits current to 110% of the nominal 2A full-load current, the total power dissipation in the series-pass device is 52.8W. Assuming use of the previously described transistor and heat-sink system, the total gradient from air to junction is 475°C, and the transistor fails quickly.

The short-circuit example demonstrates the reason for the development of foldback current limiting. In this protection mode, a fault forces a reduction in output voltage; the output current is also forced back to some lower value, thereby keeping the junction temperature of the series-pass transistor within the manufacturer's ratings. If, in the example given here, the junction-temperature rating is 200°C, you can calculate what the short-circuit current limit must be to maintain the 200°C limit.

The allowable rise in a 40°C ambient temperature is 160°C. Using the 9°C/W transistor/heat-sink thermal resistivity, the total power allowed in the series-pass element comes to only 17.7W. With 24V unregulated input voltage, the total allowable output current in a short-circuit condition is thus 0.74A. These figures indicate that the current-limiting circuitry must start its foldback action at approximately 2.2A; by the time the output voltage falls to 0V, the current must decrease to about 0.75A.

Remember that during a short-circuit condition, the foldback current-limiting circuit's purpose is to protect the linear power supply's series-pass element and not the critical load. Even if your power-distribution system has some sort of fuse protection, the fuses are not able to sense the fault condition because the foldback circuit limits the available current and thus prevents the fuses from operating.

Although linear supplies by nature need either crowbar-type overvoltage or foldback-mode current-limiting protection, switching power supplies generally don't. However, you should consider two types of switching-regulator topologies in your assessment of the need for one or both of the protection options. The first topology is embodied by the chopper-type circuit in **Fig 4,** in which there is no transformer connection between the unregulated input and the regulated output.

The schematic shows that there can be a direct connection between the input and output, similar to that of the previously discussed linear (series-pass) supply. If the switching element in series with the load fails in short-circuit mode, the unregulated voltage appears across the output leads. In this case, the protective features of the crowbar are beneficial.

The chopper circuit, however, differs from the linear regulator in its requirement for foldback current limiting. As explained earlier, foldback current limiting controls the temperature rise in the dissipative linear element. In the chopper's case, though, the series element serves as a switch with variable duty cycle for regulation purposes.

Should an external fault occur, the switching element sees little difference between a short-circuit and normal-load condition: Peak currents for the short-circuit condition are slightly higher, and the duty cycle is shorter. When the series element switches on, there is little voltage drop across it. Therefore, the increased current during the short-circuit period has little or no adverse effect on the series-pass device's junction temperature. Of course, when the switching device is not conducting, the temperature doesn't rise.

For the chopper circuit, the considerations that usually lead to the requirement for foldback current limiting do not apply. Many specification writers, however, aren't familiar with the derivation of foldback-mode current limiting and automatically include it in a

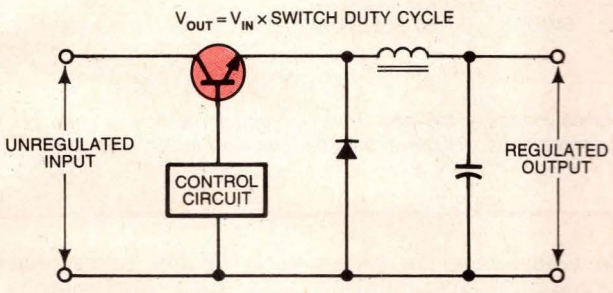


Fig 4—A chopper-type switching power supply *needs no transformer between input and output. Like linear supplies, the chopper supply uses a series-pass element. Therefore, a crowbar protection circuit could be required to protect the series element.*

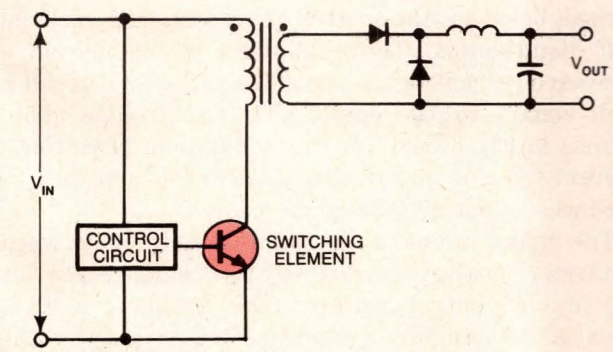
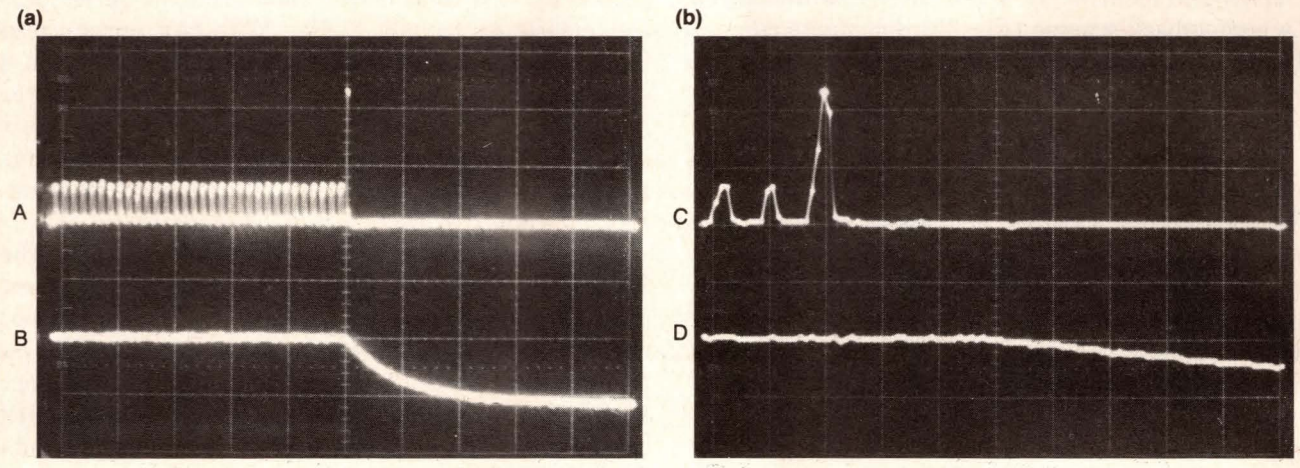


Fig 5—In forward-converter switching supplies, *the transformer provides inherent protection that eliminates the need for crowbar and foldback current-limiting circuitry.*

Crowbar protection circuits need high-V detector, high-I SCR



TRACE	WAVEFORM	VERTICAL	HORIZONTAL
A	SWITCHING-TRANSISTOR CURRENT	2A/DIV	250 μSEC/DIV
B	POWER-SUPPLY OUTPUT	5V/DIV	250 μSEC/DIV
C	SWITCHING-TRANSISTOR CURRENT	2A/DIV	50 μSEC/DIV
D	POWER-SUPPLY OUTPUT	5V/DIV	50 μSEC/DIV

Fig 6—A failed switching transistor in Fig 5's circuit *produces no excess voltage at the load. The short circuit results in a large current spike* ***(trace A)*** *in the transformer primary; magnetic saturation prevents the transmission of the overload to the load. The traces in* ***(b)*** *are those of* ***(a)*** *with a fivefold expanded time scale.*

switching supply's specifications. The result is increased parts cost and lowered reliability with no attendant system benefits.

Eliminate crowbar with a forward converter

Having determined that a chopper-type switching power supply could need a crowbar but no foldback limiting, consider a different switching-supply topology: the simple forward converter in **Fig 5.** This supply uses a transformer between the regulator's input and output portions. The transformer plays a key role in eliminating the need for crowbar and current-limiting circuits.

Recall that the crowbar circuit was developed to protect the load against failure of the series-pass element in the power supply. The counterpart to the crowbar in **Fig 5**'s switching regulator is the switching device itself. In the case where a transformer is connected between the circuit's input and output sections, the failure of the switching element does not cause the same kinds of problems as does the failure of a series-pass element.

Should the switching transistor fail in the short-circuit mode, the result is the application of the full bus voltage across the primary of the power transformer. If this transformer is designed according to standard practices, it takes slightly more than one switching period for the transformer to saturate and draw a large current from the input. Typically, the result is the activation of whatever input-protection device (eg, fuse or circuit breaker) is in the power supply.

If the supply has no input-protection device, the wire bonds in the power transistor blow open and thereby open the circuit. As far as the output circuit is concerned, however, the shorted transistor produces minimal disturbances. The application of one period of excessive current to the transformer does not result in high voltage at the output. The oscilloscope photographs in **Fig 6** bear out this contention: Note that a current spike of approximately 5A vs the nominal 1.5A produces no output-voltage increase.

The major problem to guard against in forward-converter supplies is a runaway control circuit, resulting in high output voltage. This problem is easily resolved with a simple shutdown of the primary transistor; large and expensive high-current-SCR circuits are not needed.

Even if the transistor-shutdown circuitry fails, the circuit's action can be controlled through a simple inhibit-type network. Because of the way the system

MULTI-CAGE® Card Cages for the MULTIBUS:

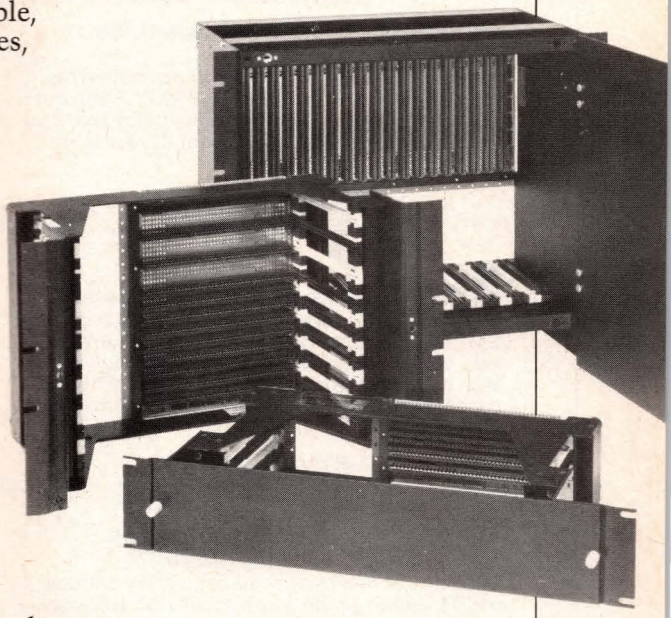
MULTI-CAGE®: the industry standard Multibus card holder and backplane system. Designed for performance, built with precision.

Choose from the widest selection available from any manufacturer. The durable, anodized aluminum cages, featuring single mother board backplanes, are available in 17 slot sizes:

3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 20, 21, 24, and 26 slots.

Choose from free-standing, horizontal and vertical rack mount cage designs. Choose card spacing of either 0.6 or 0.75 inch. There's even special slot spacing models for efficient use of three-level wire wrap or iSBX 300/340 modules. Every model is UL-recognized. Multi-Cage is electrically and dimensionally interchangeable with Intel's iSBC-80 cages.

Choose, too, from a huge variety of packaging options and accessories, such as P2 connectors and backplanes, Parallel Priority Resolution Circuitry (PPRC), cooling fans and power distribution boards.



Whatever your Multibus packaging needs, give us a call on one of our toll-free numbers. You'll find the best selection in the industry, along with competitive prices, quick delivery, and an unmatched THREE YEAR WARRANTY on every Electronic Solutions product.

All units UL recognized.

Electronic Solutions

9255 Chesapeake Drive
San Diego, CA 92123
(619) 292-0242
Telex II (TWX): 910-335-1169

Call TOLL FREE
(800) 854-7086
in Calif.:
(800) 772-7086

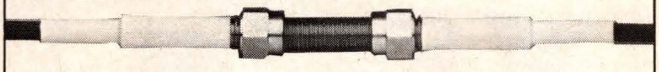
™Multibus, iSBX, and iSBC-80 are trademarks of Intel Corp.
®Multi-Cage is a trademark of Electronic Solutions

CIRCLE NO 75

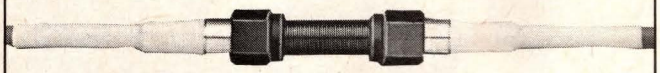
5 TOUGH QUESTIONS AN OEM SHOULD ASK BEFORE BUYING FIBER OPTIC CONNECTORS.

1 "Will I get the quality I need?"
Specifically, will you get precise connector construction and dB tolerances that other manufacturers claim but *only* OFTI delivers? Will you get the intermateability* and ease of connector/cable installation that reduces termination losses *and* labor costs?

2 "Will I get dependable service again and again?"
Can you count on your orders being filled on time, the way you can with OFTI? Will you get the attention and product consistency that you have to have in order to turn out dependable equipment yourself?



3 "Will I get the best possible price?"
Not only do you have to have the most reliable SMA FO connectors, you can't afford unreasonable costs. That means that you have to work with a company dedicated to helping you succeed by bringing you a *true* value. A company like OFTI!



4 "Will I get innovations to keep me ahead of competition?"
What if you need a special-design FO connector? Is your supplier a *specialist* with the engineering expertise and production facilities to put you out front and keep you there? OFTI is and always has been!

5 "Will I get faster deliveries anywhere else?"
You simply can't afford to wait around for your SMA FO connectors. Compare OFTI delivery times (5 to 7 days for up to 100 pieces ARO) with everyone else's. Then go with the winner—OFTI!

You know that your total system has to be as good as the FO connectors you specify. It's your decision—you've asked the *tough* questions, now you have an *easy* answer—OFTI, *the FO connector specialists!*

Optical Fiber Technologies, Inc.
P.O. Box 148, Nutting Lake, MA 01865
(617) 663-6629 Telex: 948-288

Nobody Makes a Better Fiber Optic Connector

*Amphenol 905 or 906, and AMP intermateable.
Amphenol is an Allied Company. AMP is a trademark of AMP, Inc.

CIRCLE NO 76

Foldback current limiting protects series-pass element

fails in the event of either a control-circuit or power-switch failure, a crowbar circuit is not needed to protect the load against high voltages.

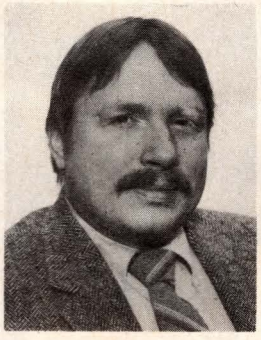
Foldback limiting still not needed

The previous discussion of foldback current limiting applies equally well to forward-converter switching power supplies. In the presence of a short circuit on the output terminals, the current passing through the switching device naturally increases. However, because the switching device operates as a switch (either fully On or Off), the power dissipated in that device is a very small portion of the overall power in the supply. For this reason, foldback current limiting is unnecessary in this or any type of switching supply.

Freedom from the need for foldback limiting gives the switching regulator certain advantages over linear power supplies. For example, the switching regulator is capable of delivering enough current to blow protective fuses under most conditions. Moreover, foldback current limiting has a disadvantage in that it can cause a power supply to lock up in a low-output-current mode if the supply encounters a constant-current load during turn-on. In this case, the intersection of the load line and the regulation line are such that the supply can become trapped in a low-voltage, low-current mode and cannot exit from this mode. This situation can arise, for example, during an attempt to charge a capacitor upon the initial voltage application. Because a switching regulator itself runs in a constant-current-limit mode, you can drop foldback limiting and thereby avoid the possibility of lock-up. **EDN**

Author's biography

D J Becker is manager of research and development at Lorain Products. Employed by Lorain for 14 years, he holds BSEE and MSEE degrees from Cleveland State University and an MBA from Baldwin Wallace University. He is a member of the IEEE and Eta Kappa Nu; his free-time pursuits include sailing, personal computing, reading, strategic games, and camping.

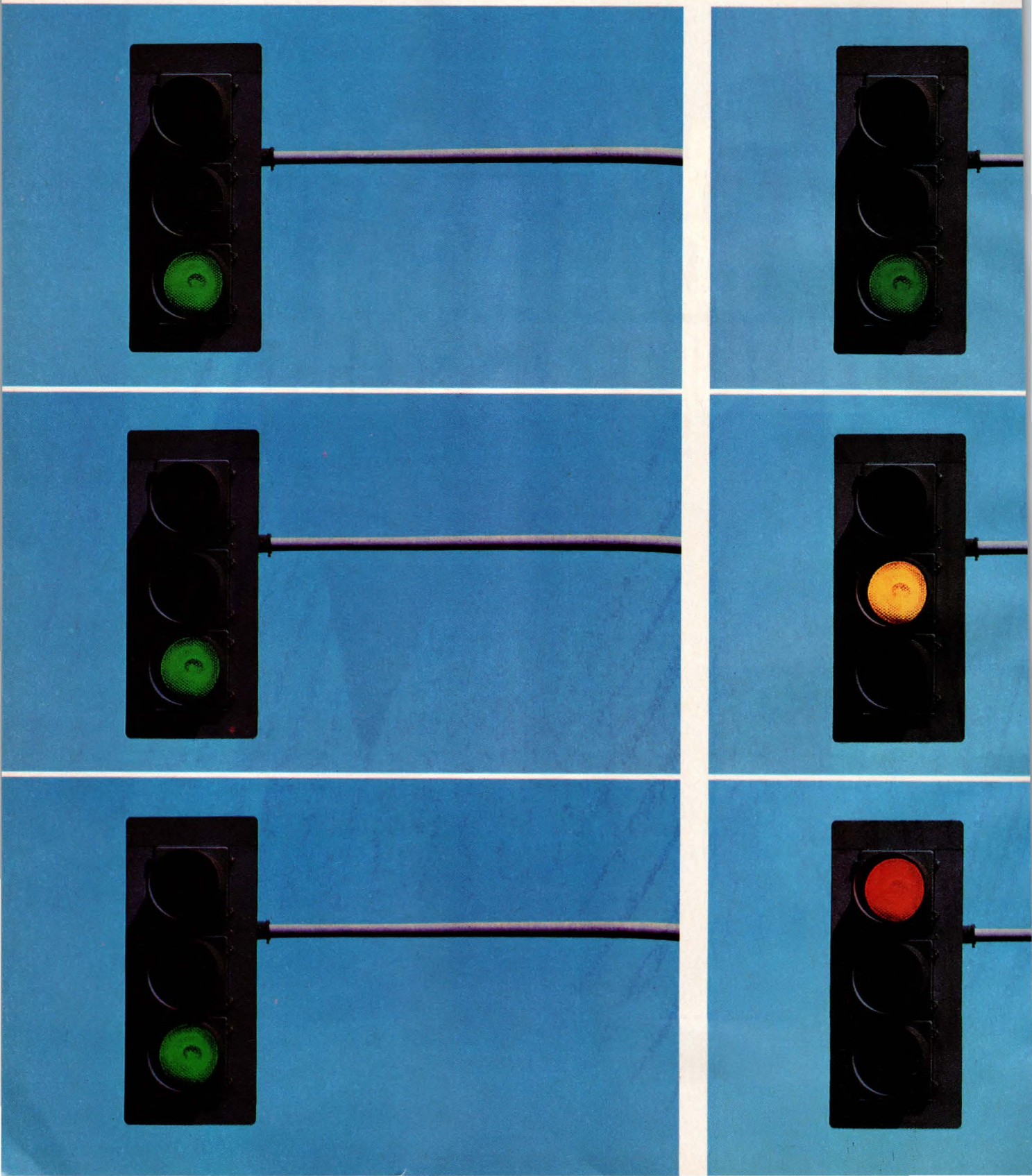


Article Interest Quotient (Circle One)
High 476 Medium 477 Low 478

TWO WAYS OF LOOKING AT MULTITASKING.

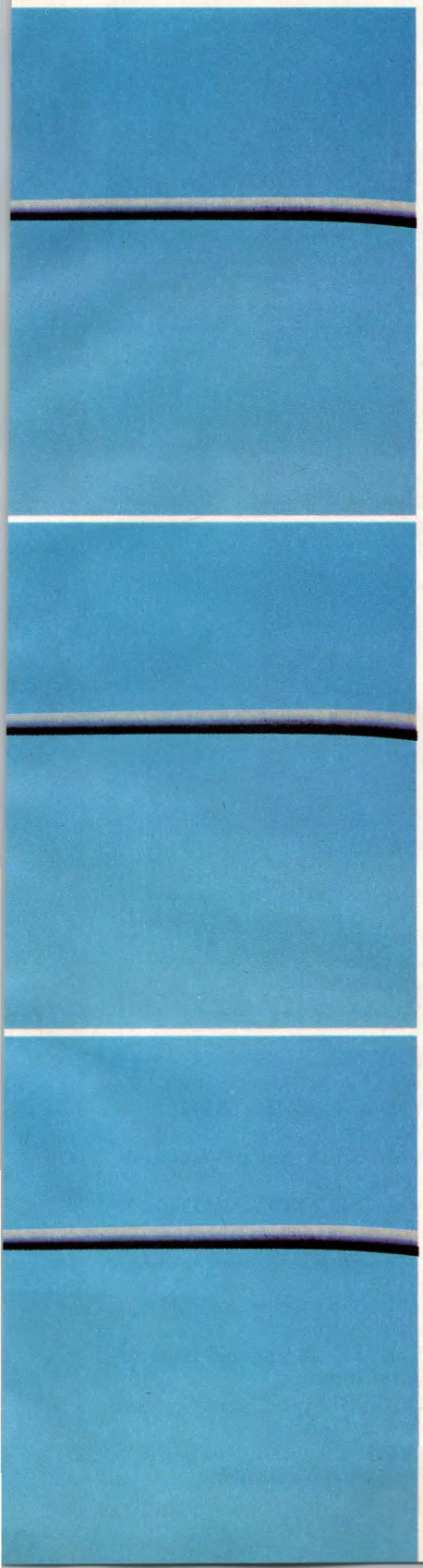
OURS.

THEIRS.



Their way puts all the burden on you to develop complex multitasking software. Software which can slow system performance.

Our way is to handle multitasking support on-chip.



Their way can take a whopping 120 microseconds to switch tasks. Whereas our iAPX 286 supermicro requires only a single instruction to switch from task to task in a mere 21 microseconds.

That gives you up to 80% more time to manage multiple robot arms, concurrent windows on a PC, hundreds of telephone calls on a PBX, or even thousands of packets on a network.

And when it comes to keeping your tasks from crashing into each other, our 286 on-chip memory protection gives you your own micro-traffic cop to prevent the system from coming to a full stop.

On the other hand, their way requires still more software and additional hardware, stalling system performance and system design.

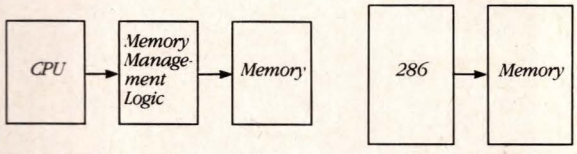
The 286 also gives you 16 megabytes of physical memory and 1 gigabyte of virtual memory. Which is more than enough space to accommodate your future application software needs.

There aren't any red lights when it comes to running your tasks at high speed either. The 286 has a pipelined architecture that's turbocharged by our family of coprocessors. Like the 80287 Numerics Coprocessor that gives you 80-bit floating point math in a flash.

The result is a sleek, swift design that makes the system faster. For builders *and* users. With no drag to slow productivity. And no shortcuts in quality. Because every part is built to quality levels that have set industry standards.

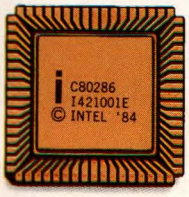
What's more, as a member of the 86 family of processors, it gives you access to the entire 86/88 software base. That's over a billion dollars worth of software at your fingertips.

ACHIEVING PERFORMANCE MEMORY MANAGEMENT



iAPX 286 integrated Context Switch, memory management and protection offers a fast, consistent, and highly portable multitasking solution.

You'll also have the benefit of Intel's massive field support staff. Comprehensive technical training. And all the development tools and support you need to accelerate your design and speed you into production.



For the whole iAPX 286 story, call toll-free (800) 538-1876; in California, (800) 672-1833. Or write Intel, Lit. Dept. M-12, 3065 Bowers Avenue, Santa Clara, CA 95051.

Intel's iAPX 286 — the world's only true multitasking supermicro.

Any way you look at it.

intel®

© 1984 Intel Corporation

VMEbus I/O. Xycom offers you the most. And the best.

When choosing VMEbus Industrial I/O, consider this: Xycom offers you the widest choice of modules in the world. With a common system architecture that can save you substantial design and programming time... while greatly increasing your system's design flexibility. You can also count on Xycom's team of technical support engineers — before and after the sale.

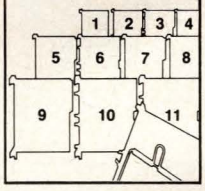
Each module is backed by a full two-year warranty and Xycom's 15 years experience in designing and manufacturing industrial microcomputers.

So make the right VMEbus I/O choice, right now. Call us toll-free (1-800-367-7300) for details, or write for our free I/O module brochure. Then put our better VMEbus mousetrap to work for you.

xycom xycom®

Look closer. We deliver added value.

Xycom's I/O Selection



1) XVME 010 System Resource
2) XVME 085 VMEbus Prototyping
3) XVME 560 64/32 Channel Analog Input
4) XVME 680 10MHz 68000 Processor
5) XVME 530 8 Channel Isolated Analog Output
6) XVME 240 64 Channel Digital TTL I/O
7) XVME 260 32 Channel Relay Output
8) XVME 080 Intelligent VMEbus Prototyping
9) XVME 210 32 Channel Isolated Digital Input
10) XVME 230 Intelligent Counter/ Motion Control
11) XVME 420 Intelligent Serial Peripheral Controller

The Hardhat Computer People. 750 North Maple Road, Saline, Michigan 48176, Phone: (313) 429-4971, TWX 810-223-8153 **Regional Offices:** Boston (617) 246-2544 • Chicago (312) 963-7272 • Cleveland (216) 499-2555 • Philadelphia (215) 536-0810 • San Francisco (415) 573-0404 • Detroit (313) 794-7427

CIRCLE NO 77

Pay less for more.

VP4801 APT, $348*

Get RCA quality and performance.

OEM designers and systems integrators can now utilize the many performance features of RCA communication terminals, at most attractive prices.

The RCA APT (All-Purpose Terminal).

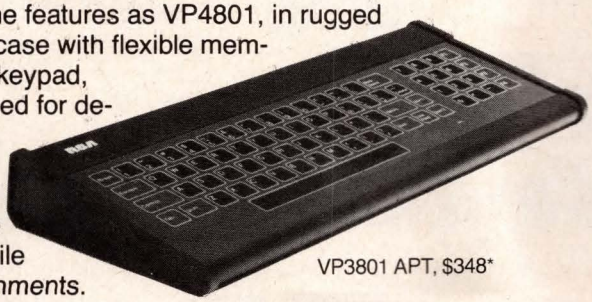
Professional quality RCA APT terminals are designed for remote data base timesharing and direct computer-connected applications. They feature a built-in 300 baud direct-connect modem, an RS232C interface for high speed modem and other accessories, and a parallel printer port for hard copy. Menu controlled operation and a "programmable personality" can match specific requirements for each data base.

VP4801 APT, $348*

Full 60-key typewriter-style keyboard with 16-key calculator keypad. Auto-dial (tone or pulse) of up to 26 stored numbers for voice or data base calls. Programmable sequences initiated automatically after log-on. Two user keys for selection of printer or other operating modes; four programmable function keys, shiftable for a total of eight functions. APT can be programmed to match the communications requirements and control commands of many other (and more expensive) terminals. Briefcase size (17″ × 7″ × 2″), light weight (under 6 lbs.) and memory backup (minimum 48 hrs., without batteries) enhance portability. Many other user-friendly features.

VP3801 APT, $348*.

Same features as VP4801, in rugged metal case with flexible membrane keypad, designed for dependable performance in hostile *environments*.



VP3801 APT, $348*

VP3301 Interactive Data Terminal, $307*.

58-key flexible membrane keyboard with finger positioning overlay includes two definable user keys. Full RS232C interface for direct modem and computer connection. Six switch-selectable baud rates from 110 to 19.2 kilobaud. Full color graphics and reverse video. 40 character × 20 lines or 20 × 12 display formats. Video output for 525-line color or standard monochrome monitor. Size: 13.1″ × 7″ × 2″. Weight: approx. 5 lbs.

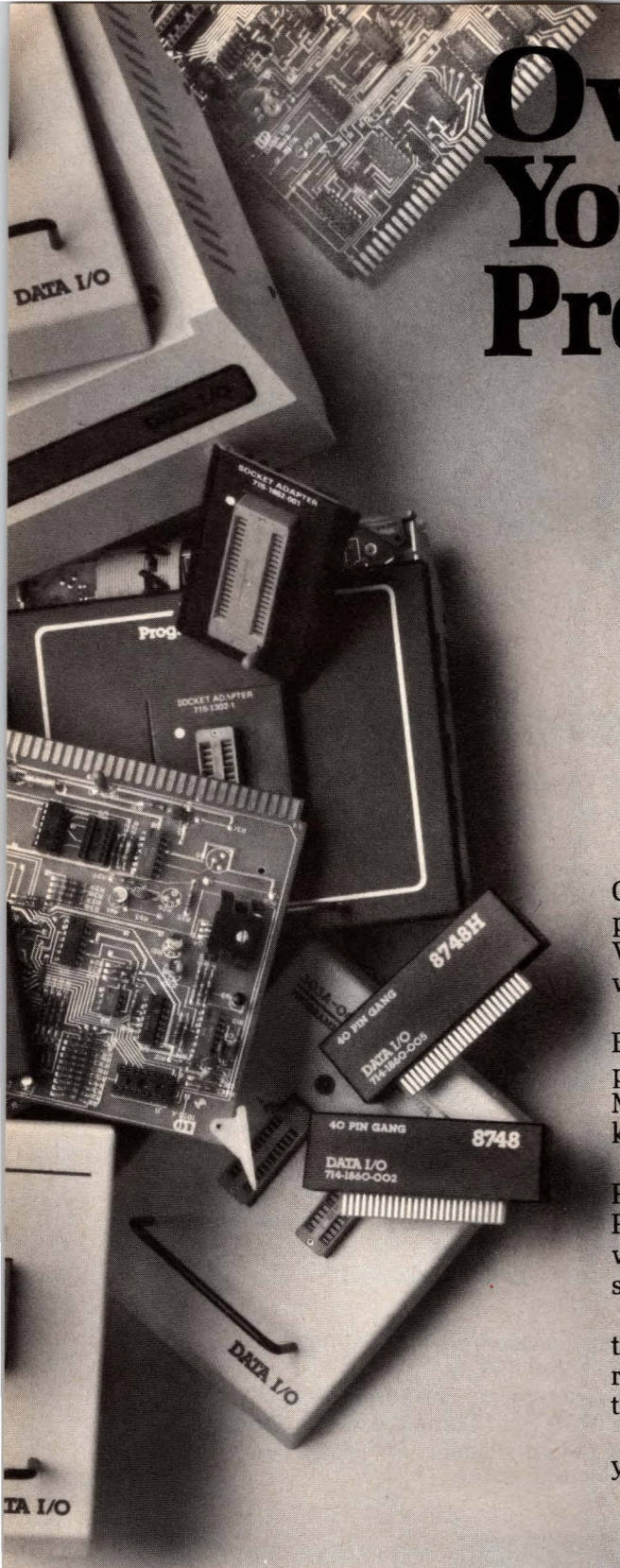
VP3301 IDT, $307*

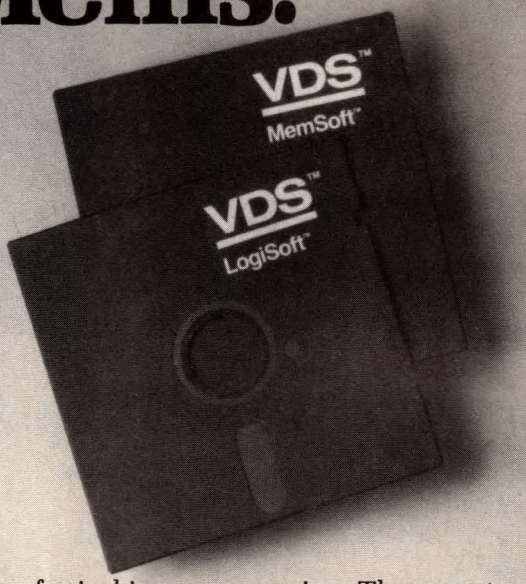
To order, call toll-free 800-233-0094.
(In PA, 717-295-6922.)
For more information, call 800-233-0187.
Or write: RCA Data Communications Products,
P.O. Box 3140, Lancaster, PA 17604-3140.
*OEM quantity prices, 25 units.

VP4801 APT with optional display monitor.

RCA

Overcome All Your Personality Problems.





Gain peace of mind in programming. Throw out your personality modules, socket adapters, and 'paks'. Move in a Valley Data Sciences (VDS) IBM PC-based programming workstation.

Work faster. No more juggling of hardware adapters. Everything from programming algorithms and electrical parameters to pin-signal assignments, is stored on floppies. Masters and backups included. Also, VDS menu-based, single-key commands with self-prompts in English are easy and fast.

Get more designing and programming flexibility. Design PAL® and IFL logic arrays, EPROMs, EEPROMs, Bipolar PROMs, and EPROM-based microcomputers. Support devices with up to 40 pins now. Our expandable architecture will support up to 96 pins for future devices.

Stay current. We work with semiconductor manufacturers to quickly convert the latest devices and programming algorithms to floppy. So you'll receive new device updates rapidly through the VDS **Software Subscription Service.**

Get more value. Call for a demo. Find out how much more you get with the Valley Data Sciences programming solution.

Distributed by
Kierulff Electronics

ValleyDataSciences

Charleston Business Park, 2426 Charleston Rd., Mountain View, CA 94043

415/968-2900

Circle No. 66 for literature

VDS, Valley Data Sciences, trademarks of Valley Data Sciences. PAL trademark of Monolithic Memories, Inc. IBM PC registered trademark of International Business Machines Corporation. UniPak 2 and LogiPak trademarks of Data I/O Corporation.

Circle No. 79 for sales contact

Driver ICs interface μPs with vacuum-fluorescent displays

Vacuum fluorescent displays suit a variety of commercial and industrial applications, and sequence- and segment-driver ICs make it easy to use the display devices in μP-based systems.

Antonio Rodrigues, *RCA*

When developing a μP-controlled vacuum-fluorescent-display (VFD) system, you can employ sequence- and segment-driver chips to interface the low-level μP circuitry with the display devices. Such a system has relatively low power requirements and a minimal number of components. The μP provides the code to generate characters and graphics, and it refreshes the display. The sequence and segment drivers increase the typical 5V μP-supplied power to a 35 to 55V level, suitable for VFDs used in such applications as audio equipment, appliances, digital clocks, and automotive displays. To optimize μP efficiency, the μP can execute the display code when not occupied with tasks unrelated to display control.

VFD principles

The VFDs now being manufactured include 7-segment patterns, starburst 14-segment grids, and 5×7-dot matrices. Operating in much the same way as a triode vacuum tube, the VFD consists of three electrodes: a cathode, an anode, and a grid. The cathode is a small-diameter, oxide-coated tungsten filament that is heated to emit electrons; the anode is an array of segments, dots, or symbols formed on an insulating base and coated with fluorescent phosphor; and the grid is a thin screen of metal that accelerates the electrons toward the anode. A vacuum-sealed glass envelope encloses the three electrodes.

The VFD functions when a voltage that's positive with respect to the filament is applied to the grid and anode. The resulting electrical field accelerates the electrons emitted by the filament toward the grid. Because the grid is a mesh, most of the electrons pass through it and are accelerated toward the anode. When electrons strike the phosphor coating, it emits a bright light, which is typically blue-green, although other colors are available.

Static and dynamic driving

VFDs operate in static or dynamic driving modes (**Fig 1**). In static driving modes, used with nonmultiplexed displays, the grids are continuously biased at a certain level. In dynamic driving modes, used with multiplexed displays, each grid is pulsed at a rate high enough so that the resulting illumination appears to be continuous.

Displays suitable for static-drive circuits are formed with each anode and grid independently driven; thus, multiplexing is not required. With this construction, one pin is needed for each display element. For complex, multiple-character displays, the common segments of each character are connected, and the independently driven grids are used to address individual characters. In dynamic-drive circuits, the grids are sequentially pulsed at a flicker-free rate to allow for multiplexing. The phosphor-coated anode segments are individually biased in both types of displays.

VFDs operate in static- or dynamic-driving modes

A CDP1802 μP is suitable for controlling these displays, as are other popular μPs. You can use a serial-to-parallel driver to provide the input voltage and current that VFDs require at levels greater than the typical 5V μP-supplied power. The CA3207 sequence driver and the CA3208 segment driver (see **box,** "VFD driver ICs") fulfill the VFD voltage and current requirements, as do similar devices. **Fig 2** illustrates a μP-based scheme for both multiplexed and nonmultiplexed displays.

Multiplexed display circuits

Fig 3 shows a 28-character multiplexed display with one CA3207 and two CA3208 drivers controlled by a CDP1802 μP. The display consists of 14 grids, each addressing two characters simultaneously and each connected to an output of the CA3207 sequence driver. Each of the 14 segments of the starburst-display characters is driven by the output from one of the CA3208 segment drivers.

Fig 4 illustrates the interface circuit used between

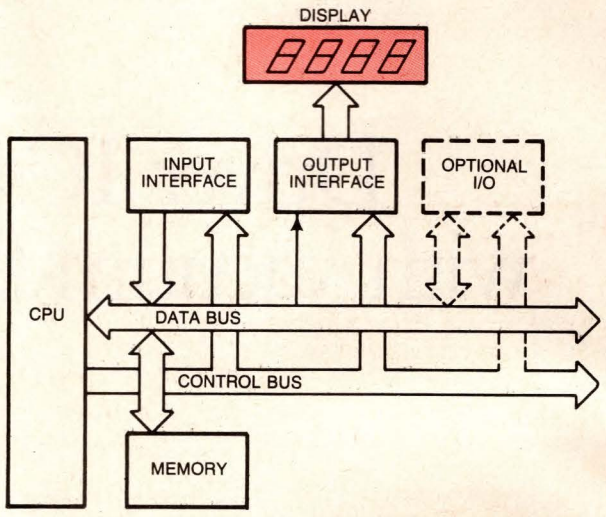


Fig 2—This basic μP-controlled display system *provides serial input to the segment drivers for use in both multiplexed and nonmultiplexed displays.*

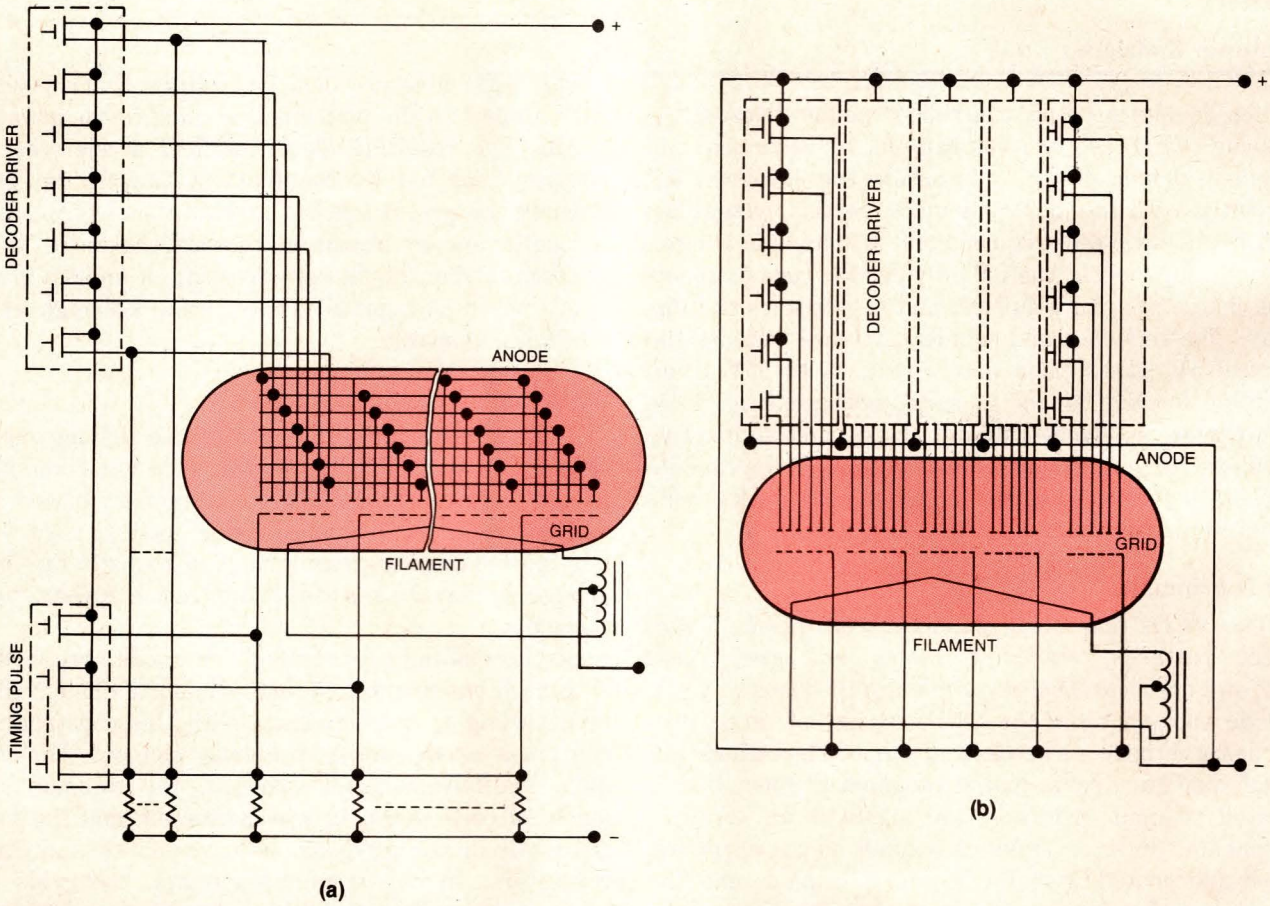


Fig 1—Vacuum-fluorescent-display devices *come in multiplexed and nonmultiplexed versions, which can operate in dynamic-drive* ***(a)*** *and static-drive* ***(b)*** *circuits, respectively.*

the displays and the μP. The segment drivers, IC_2 and IC_3, control the 14 segments of the upper and lower rows, respectively. When data representing a character is strobed, all the characters in that row have the same anodes biased.

The sequence driver, IC_1, drives one of the grids so that only one character per row is displayed at any time. IC_2 and IC_3 are connected so that each driver is alternately enabled and disabled. This step is accomplished by connecting the strobe signal to the IC_2 active-Low Clock Enable ($\overline{CE}$) and to the IC_3 active-High Clock Enable (CE).

The strobe signal is obtained from the output of the 4013 flip flop, IC_5, which is toggled On every fourteenth clock pulse by the 4516 counter, IC_6. The strobe signal is also the clock input to the IC_1 sequence driver; it runs at 1/14th of the IC_2 and IC_3 clock rates. To obtain the signal, outputs from the N_1, TPB, and $\overline{MRD}$ pins of the controlling microprocessor are combined through an AND gate (IC_7).

IC_1's Sync input is the Q-Flag output of the μP and is under software control. The Q-Flag output is also the Preset Enable input of IC_6 and the Reset input of IC_5.

Fig 5 depicts the pertinent waveforms. The TPB positive pulse occurs in each machine cycle. The $\overline{MRD}$ pulse appears during a memory-write cycle. The N_1 line is activated by execution of an "Out" instruction to Port 1. Line N_1 remains Low at all other times. Upon execution of the "Out" Port 1 instruction, the IC_6 counter receives a clock pulse when the AND gate's output is a positive pulse equal to the union of the N_1, TPB, and MRD outputs. The IC_6 clock pulse toggles flip flop IC_5 on every fourteenth pulse decoded by IC_{4B}, while IC_{4A} resets counter IC_6.

The data that represents the 28 display characters is stored in 56 adjacent memory locations. Each character code is 14 bits long and requires two locations per code because the CDP1802 provides only 8-bit processing. Each location holds seven bits of the code, and this results in a simpler display subroutine.

The display subroutine

The subroutine starts by setting and then resetting the Q-Flag output. This pulse syncs the sequencer IC_1 so that the last grid is on. This pulse also resets IC_5 and presets IC_6. An output loop routine determines the

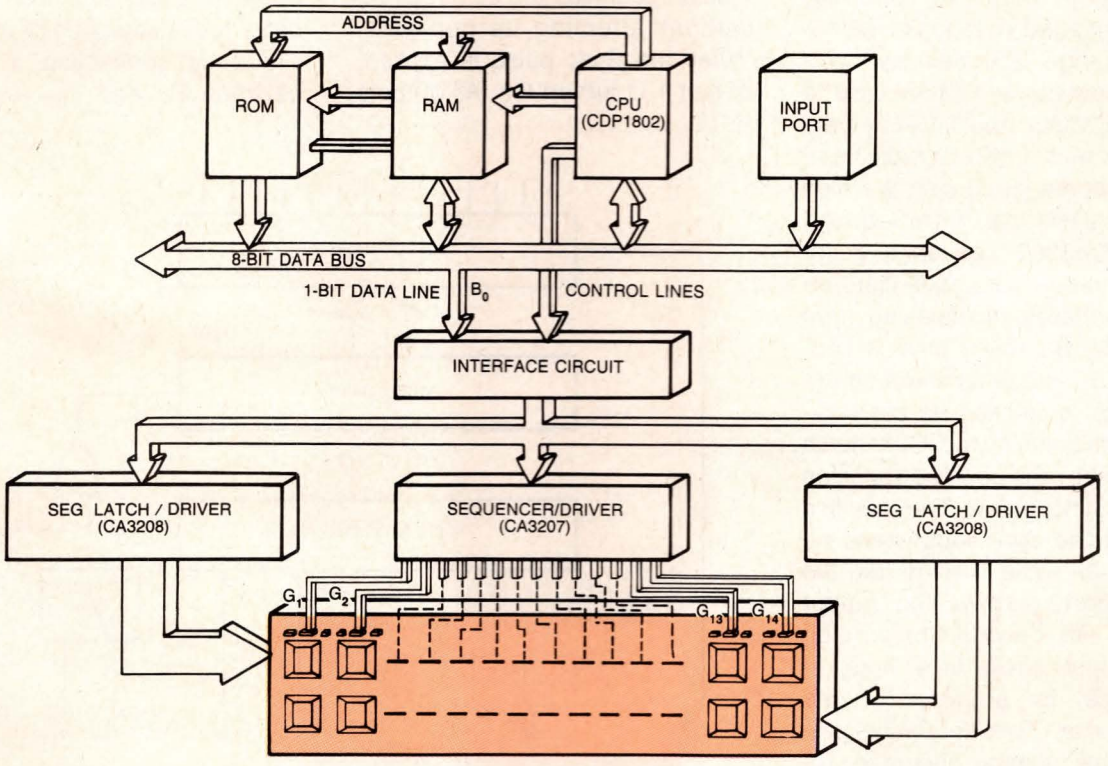


Fig 3—To drive a 28-character multiplexed display, *one sequence driver and two segment drivers are controlled by a μP. The sequence driver controls the 14 display grids by simultaneously addressing two characters per grid. Each segment driver controls the 14 segments of a VFD character.*

least significant digit of the code. The first-out instruction toggles the flip flop's output High, which enables the upper-row segment driver IC_2. IC_3 is simultaneously disabled, while the output loop shifts the code and consecutively presents each bit.

After all 14 bits are generated, IC_6 toggles IC_5's output Low and thus enables IC_3 and disables IC_2. When the next 14 bits are clocked into IC_3, the output from IC_5 is toggled High. This causes a positive pulse edge to strobe the data in both the IC_2 and IC_3 shift-registers to the output drivers, biasing the 14 segments of all the characters in the upper and lower rows.

The pulse edge also clocks the sequence driver, IC_1, advancing it by one count and turning on the first grid. As a result, the first characters in both the upper and lower rows are displayed. IC_2 is now enabled to receive the next 14 bits, and all remaining characters are displayed in the same manner.

The display subroutine used by the CDP1802 μP to generate the codes corresponding to the 28 characters is shown in **Fig 6.** The subroutine starts by setting and then resetting the Q-Flag output to ensure that each character is displayed in the proper position.

The starting location of the section of memory that holds the codes is stored in register R_7. The two counters for registers RE and RF are then initiated. Register RE is set to 56 (38_{16}), the number of locations. Register RF is set to 7, the number of code bits per location.

The output loop furnishes one bit and shifts the contents so that each bit is individually presented. When there is output for only half of a character, two additional shifts are required before the original data can be restored to its memory location. The 7-bit counter is reset, the character counter is decremented, and the location pointer is incremented so that the next

VFD driver ICs

The CA3207 sequence driver and CA3208 segment-latch driver are BiMOS devices that drive vacuum fluorescent displays requiring anode and grid voltages in the 35- to 55V range. Both devices incorporate low-power CMOS logic to accept CMOS- and TTL-compatible input and control signals; bipolar output stages furnish the high voltage levels that VFDs require.

The CA3207 sequence driver **(Fig A)** creates a sequential output for display multiplexing from the G_1 to G_{14} driver pins. It consists of a 7-stage Johnson counter, which is clocked on the positive transitions of the CLK pulse and reset by the positive transition of the Sync pulse. The positive edge of the Sync input turns on output G_1 while turning off the remaining 13 outputs. The counter outputs are decoded to turn on one output driver at a time, in sequence, for a period of one clock pulse. This sequence provides the voltage increase required to drive one of the VFD grids: Each output is normally connected to the grid of the VFD and is capable of sourcing 40 mA at 55V.

$Gate_1$ and $Gate_2$ are active-High inputs that inhibit the shift register without affecting its contents. When the Sync pulse is applied, output 1 is turned On. All outputs are turned Off if a High level is present at either $Gate_1$ (pin 5), or $Gate_2$ (pin 6), although the counter operation is not affected. You can delay the falling edge of the $Gate_1$ signal by connecting a resistor between R_D and V_{DD} to provide

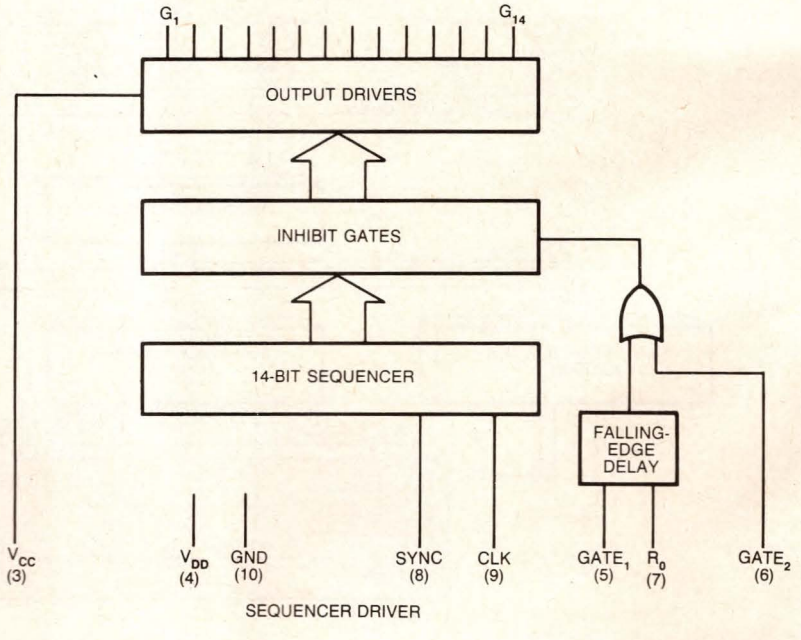


Fig A—The CA3207 sequence driver *selects a display character by driving only one display grid High at any time. It is particularly suited to use with multiplexed displays.*

half-character can be processed. When all 56 locations are processed, the program counter returns to the main program.

The program structure

The main program controls the display by providing the proper information and control signals. In a nonmultiplexed display, the μP addresses the display only when a digit or a character needs to be updated. All digits remain displayed because the outputs of the segment drivers are latched; thus, they continuously bias the anodes. In a multiplexed display, however, the μP must dedicate a considerable amount of processing time to refresh the display at a flicker-free rate because only one grid is biased at any time by the sequence driver.

You can minimize μP display-related overhead by interleaving the display subroutine's execution with the execution of other subroutines. **Fig 7** shows the difference between the program structures for a multiplexed and a nonmultiplexed display. The simple routines shown drive the display of a digital thermometer.

The major difference is that in a nonmultiplexed display, the subroutine needs to be addressed only with each change in temperature. The μP is thus available most of the time for additional processing, such as controlling other peripherals whose operation depends on a specific temperature. Conversely, in a multiplexed display, the subroutine must be addressed even when the temperature remains constant. The μP must control any peripheral in conjunction with the processing of the display routine.

Frequency requirements

Several factors dictate the minimum frequency for VFD operation: type of display, number of characters,

proper shutdown timing. You can also apply a pulse signal to $Gate_2$ for display dimming. Variations in the duty cycle result in variations in brightness.

The CA3208 segment driver **(Fig B)** drives any combination of the 14 segments selected by the data input. A 14-bit shift register that has latched outputs addresses the 14 output drivers with serial-to-parallel data conversion. The output drivers then alter each of the 14 segment-driver outputs (*a* through *n*) to the voltage level required to control each associated display anode; maximum output current equals 7.5 mA at 55V.

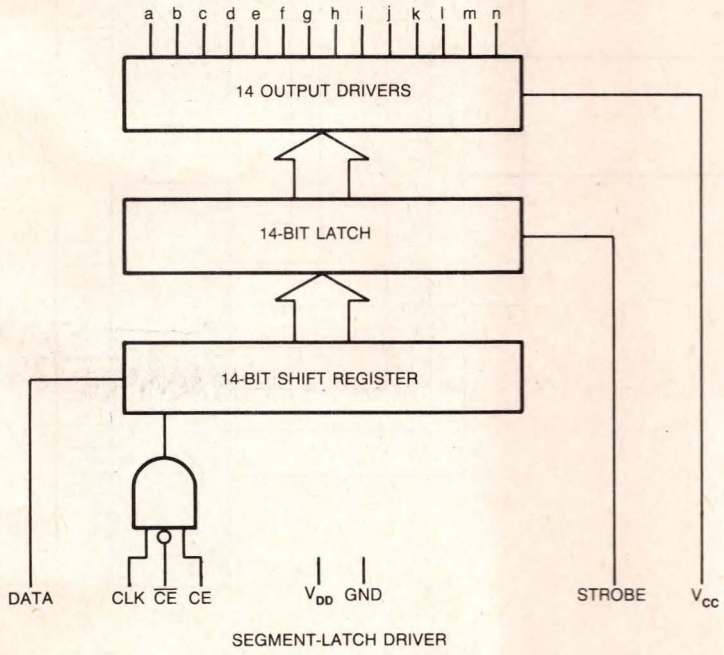


Fig B—The CA3208 segment-latch driver *lets you interface a μP with a VFD in either a multiplexed or a nonmultiplexed configuration.*

The signal at the data input is shifted through the 14-bit shift register with every positive edge of the clock signal. Input from a positive-edge-triggered strobe provides a parallel shift of the data from the register to the 14-bit latch, which turns each of the 14 outputs On or Off according to the control data. The Clock Enable lines (CE and $\overline{CE}$) are especially useful for driving a multiplexed display: CE operates as an active-High input and $\overline{CE}$ is active Low.

In combination, the CA3207 and CA3208 can drive a 14-character starburst, multiplexed display. The CA3208 turns on the desired segments of any character, although all 14 characters have the same segments activated by the driver. The CA3207 selects the desired character by driving only one of the grids at any time. Nonmultiplexed VFDS can also be driven by the CA3208.

Memory locations hold seven bits and simplify display subroutine

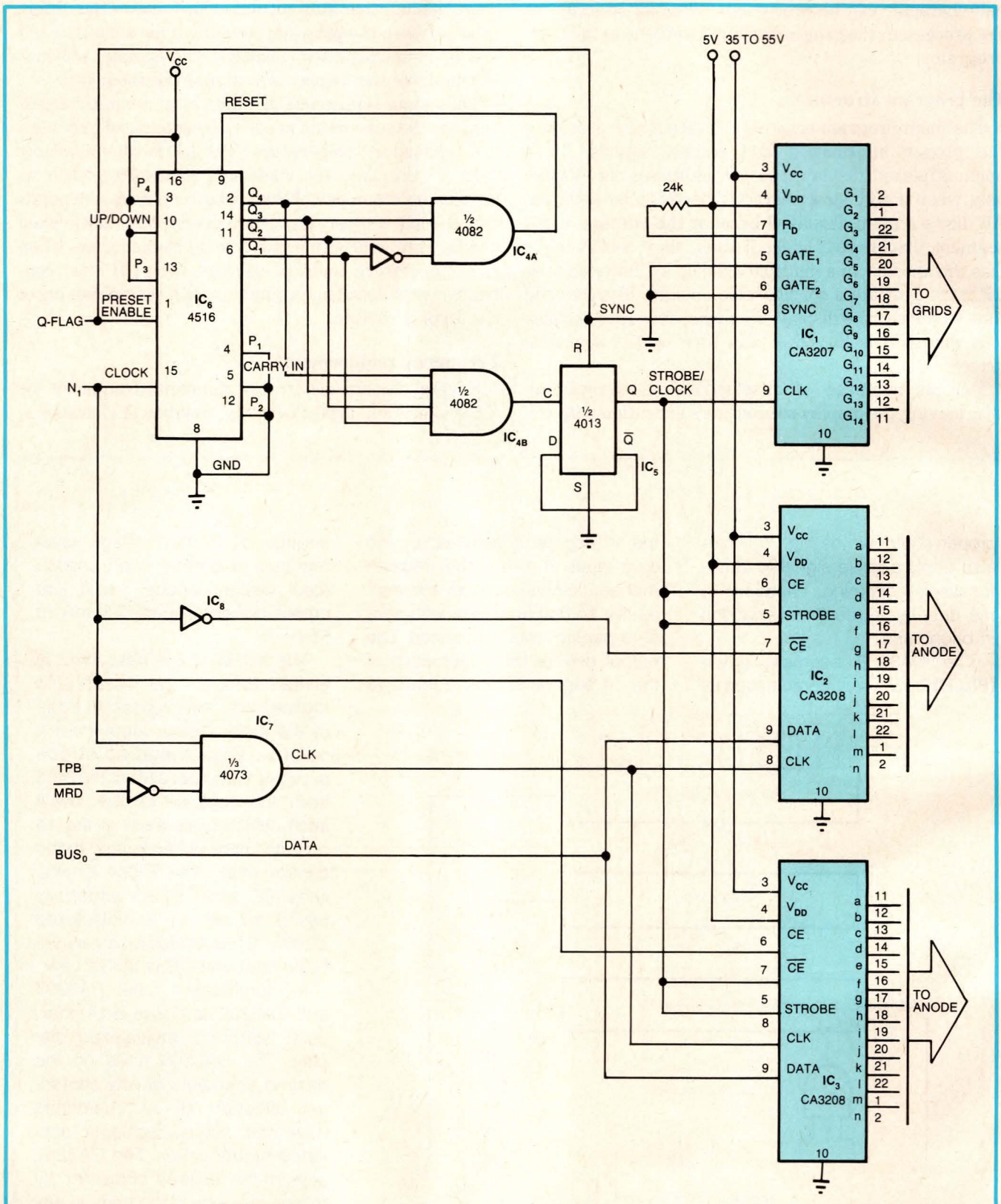


Fig 4—This µP-to-VFD interface circuit *includes three drivers: The two segment drivers (IC_2 and IC_3) bias the display anodes; the sequence driver (IC_1) drives the grids so that only one character per row is displayed at any time.*

number of segments, and the program routines themselves. Because VFDs have a high persistence, frequencies lower than those required in other types of displays can yield flicker-free performance.

In the **Fig 4** circuit, a minimum frequency of 60 Hz is suitable. This is the rate at which each grid must be pulsed. Because the display contains 14 grids, the minimum clock frequency for the sequencer is 14×60, or 840 Hz. Within one period of this signal, 28 pulses are required to furnish data to the shift registers of both segment drivers.

Eight instructions are required for each half-character that responds to loop 1 in **Fig 6.** In loop 2, 18 additional instructions are required to restore the first half character into memory and retrieve the second half for processing. In total, 264 instructions are used to load each character code into the two drivers.

LOCATION	INSTRUCTION	MNEMONIC	COMMENTS
	E7	SEX R7	
	7B	SEQ	
	7A	REQ	SYNC OUT
	F8 XX	LDI XX	
	A7	PLO R7	SET STARTING LOCATION XX
	FE 38	LDI 38	
	AE	PLO RE	
LOOP 2	F8 07	LDI 07	
	AF	PLO RF	7 BITS PER LOCATION
LOOP 1	61	OUT 01	OUTPUT BIT BO
	27	DEC R7	
	07	LDN R7	
	76	SHRC	SHIFT RIGHT
	57	STR R7	
	2F	DEC RF	
	8F	GLO RF	
	3A	BNZ LOOP 1	
	07	LDN RF	
	76	SHRC	
	76	SHRC	TWO ADDITIONAL SHIFTS
	57	STR R7	RE-STORE
	17	INC R7	INCREMENT POINTER
	2E	DEC RE	DECREMENT COUNTER
	8E	GLO RE	
	3A	BNZ LOOP 2	
	D5	SEP R5	RETURN

Fig 6—This display subroutine, *by processing 56 memory locations, can be used by a microprocessor to produce display codes corresponding to 28 characters.*

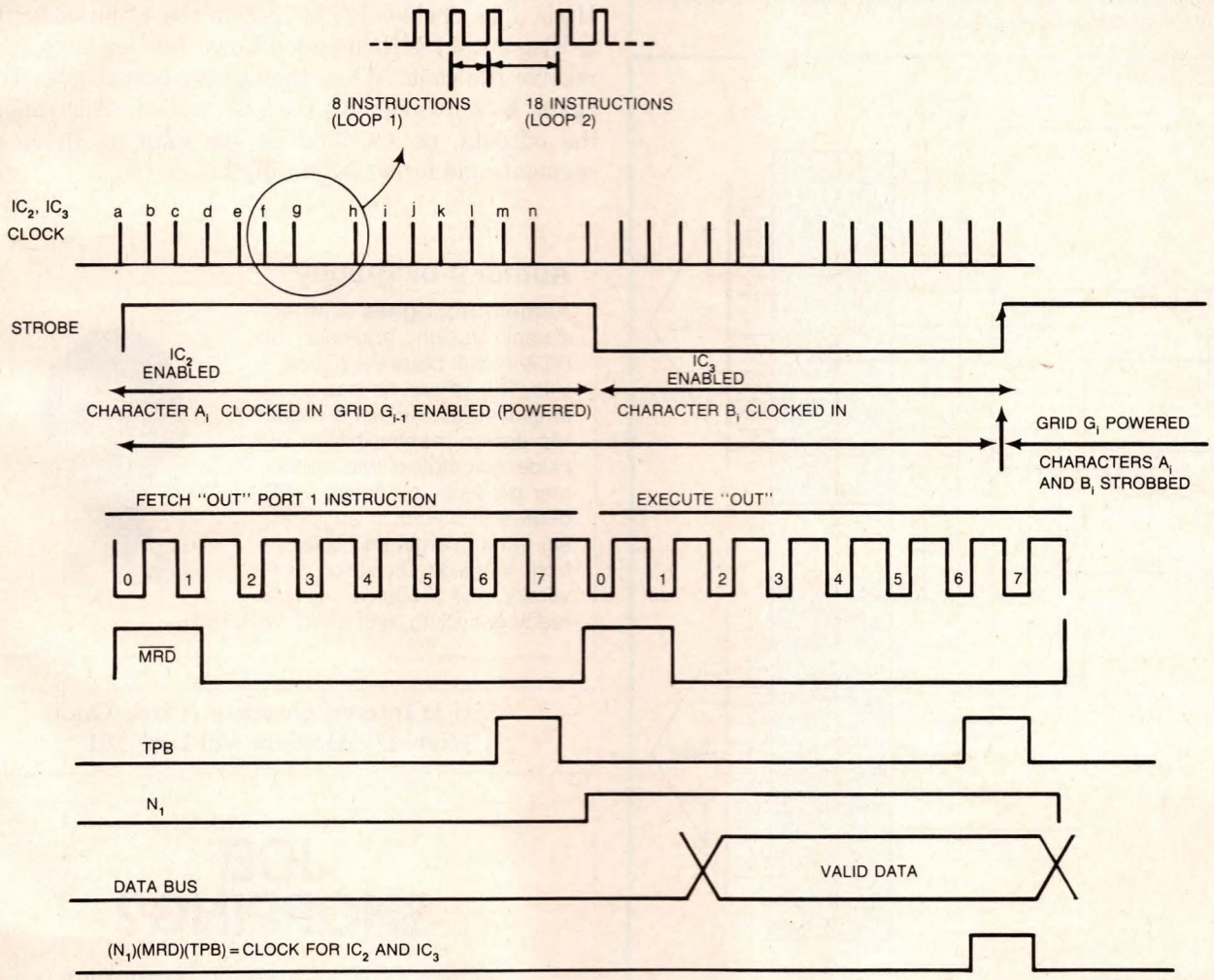


Fig 5—These waveforms *illustrate the μP/driver-IC timing relationships for the* **Fig 5** *circuit. Note that the clock that drives IC_2 and IC_3 is derived from the N_1, TPB and MRD signals; execution of an Out to Port 1 instruction activates N_1.*

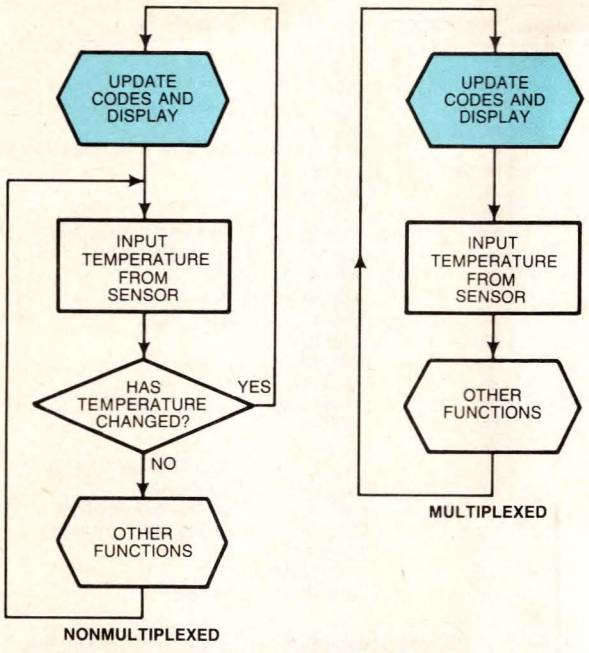


Fig 7—These temperature-display flowcharts *show the major differences between a multiplexed and a nonmultiplexed display routine. Note that, with a nonmultiplexed display, the subroutine needs to be called only when temperature changes.*

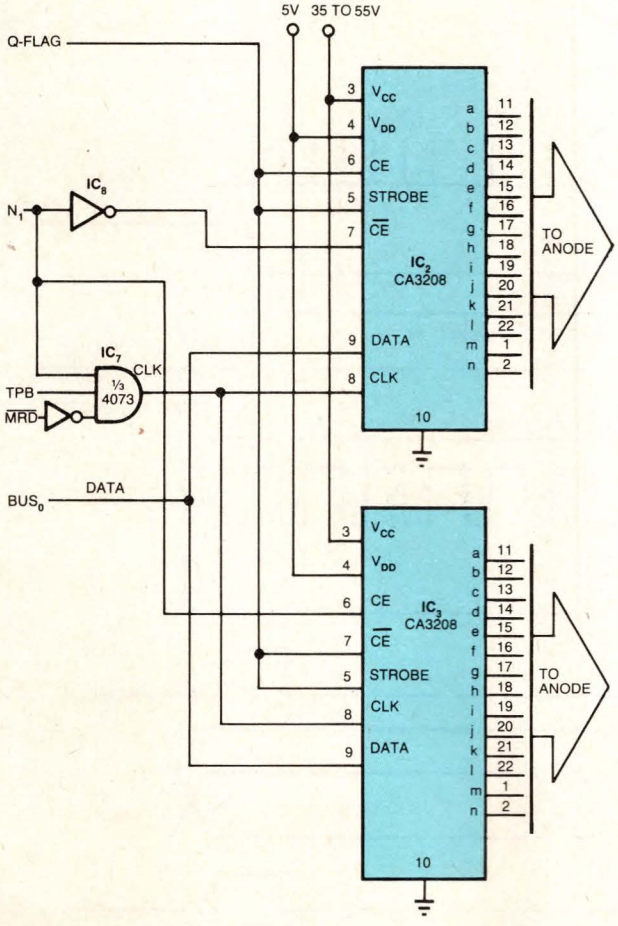


Fig 8—In this μP-to-VFD interface circuit, *two CA3208s drive a 4-digit, 7-segment, nonmultiplexed display. Note that the clock signal for IC_2 and IC_3 is obtained by combining the N_1, TPB, and MRD outputs via an AND gate (IC_7).*

Subroutine ensures that characters are displayed in proper positions

In the CDP1802 μP, each instruction requires 16 clock cycles for fetching and executing an instruction. Therefore, during two consecutive positive edges of the sequencer clock signal, 4224 clock cycles are used. So for the display routine to remain flicker-free, the minimum frequency needed to drive the μP is 4224×840 or 3.5 MHz.

A nonmultiplexed design

Fig 8 illustrates the use of two CA3208s to drive a 4-digit, 7-segment, nonmultiplexed display. Because multiplexing is not required, the circuit is relatively simple. The clock signal is obtained by combining the N_1, TPB, and $\overline{MRD}$ outputs via an AND gate. The Q-Flag output from the μP provides the strobe signal. The μP is also connected to the CE input of IC_2 and the $\overline{CE}$ input of IC_3. The data representing the digits is stored in eight adjacent locations.

The subroutine starts by setting the Q-Flag output High. This enables IC_2 to receive the 14-bit code. The Q-Flag output is then pulled Low, thus enabling IC_3 to receive the code. When the Q-Flag output goes High again, both IC_2 and IC_3 data is strobed. This changes the outputs, as specified by the data, to drive the segments and form the four digits. **EDN**

Author's biography

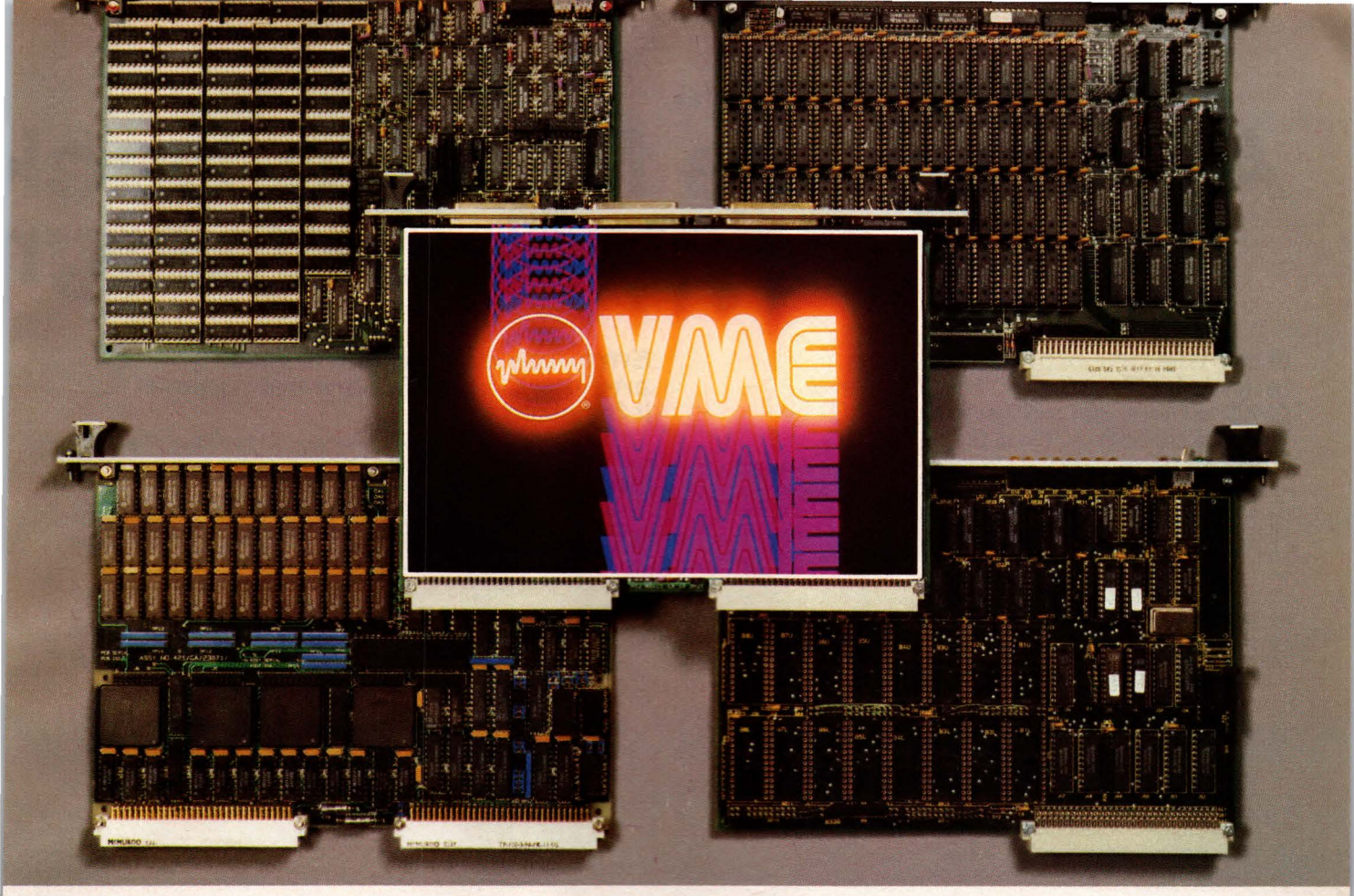
Antonio Rodrigues is an assistant design engineer at RCA's Solid State Div (Somerville, NJ) where he has been employed for the last 3 years. His design responsibilities include automotive and consumer products. He holds a BS degree in electrical engineering and computer science from Fairleigh Dickinson University. His hobbies include reading, cycling, and short-wave radio.

Article Interest Quotient (Circle One)
High 479 Medium 480 Low 481

JOB SHOPPING?

Check EDN's Career Opportunities

EDN: Everything Designers Need



THE PEOPLE WHO GIVE VMEbus WHAT IT NEEDS MOST, GIVE YOU THE MOST VMEbus MEMORIES. PLESSEY.

Plessey Microsystems makes life easy for the VMEbus designer with the most comprehensive range of VME memories in the world. All backed by Plessey's worldwide resources, technical support services and total corporate commitment to VMEbus.

Plessey VME Memories for your systems. The Plessey VME memory range includes every popular memory technology, including DRAM, ROM/EPROM and fast static RAM. As shown in the accompanying table, our capacity range spans 128 Kbytes to 3 Mbytes with EDC and 4 Mbytes with parity DRAM. Plessey VME memories are available with full 32 bit support to take advantage of the MC68020 and NS32032. So, no matter what VME route you're taking, there's a Plessey memory to take you there better.

PLESSEY VMEBUS MEMORIES

Maximum Capacity	Plessey Memory	Parity	EDC	Data Bits	Write Access nS	Read Access nS
4 Mbyte DRAM*	PME 2EP	•		8/16/32	150	270
3 Mbyte DRAM*	PME 1EA		•	8/16/32	150	300
2 Mbyte DRAM	PME 048D	•		8/16	190	300
1 Mbyte DRAM*	PME 512EP	•		8/16/32	150	270
3/4 Mbyte DRAM	PME 256EA		•	8/16/32	150	300
512 Kbyte DRAM	PME 012D	•		8/16	190	300
512 Kbyte EPROM or ROM; 128 Kbytes SRAM	PME CRR-1†			8/16	User Adjustable	
128 Kbytes SRAM	PME 128S†			8/16	140	140

* with optional daughter board
† on-board battery backup

Plessey VME: a continuing commitment. Plessey VME memories are just a part of the rapidly expanding range of Plessey VMEbus board level products which also includes single board computers; controllers, graphics and I/O boards; backplanes; power supplies; software and firmware, including languages, operating systems and drivers; and of course that famed Plessey guarantee and backup. With even more Plessey VME on the way.

For details on Plessey VME memories or our other VMEbus products and capabilities, call or write your nearest Plessey Microsystems Office, or use the coupon below.

PLESSEY MICROSYSTEMS

UK
Water Lane
Towcester
Northants
NN12 7JN
(0327) 50312

USA
One Blue Hill Plaza
Pearl River
New York 10965
(914) 735-4661

France
BP74
7-9 rue Denis Papin
78190 Trappes Cedex
051.49.52

Germany
Bahnhofstraße 38
D-6090 Russelsheim
(0 61 42) 6 80 04

For additional information, clip and mail to Plessey Microsystems Ltd., Water Lane, Towcester, Northants, UK NN12 7JN

Name
Company
Address
Phone
Title
Postcode

CIRCLE NO 83

Announcing...

A complete front-to-back your electronic design

Now the price/performance leader in Printed Circuit Board CAD offers an advanced CAE Workstation—The CDX-9000.

Cadnetix now provides a design automation tool for every member of your design team. The CDX-9000 Workstation—Cadnetix proprietary hardware with all electronics built into one compact monitor housing. The Cadnetix Logic Design and Verification System—a complete design analysis package, with hierarchical schematic design, the CADAT™ 12-state logic simulator, a SCALD-based timing analyzer and a comprehensive technical publications package. And for program development, an open architecture and Berkeley 4.2 UNIX™ with a C compiler.

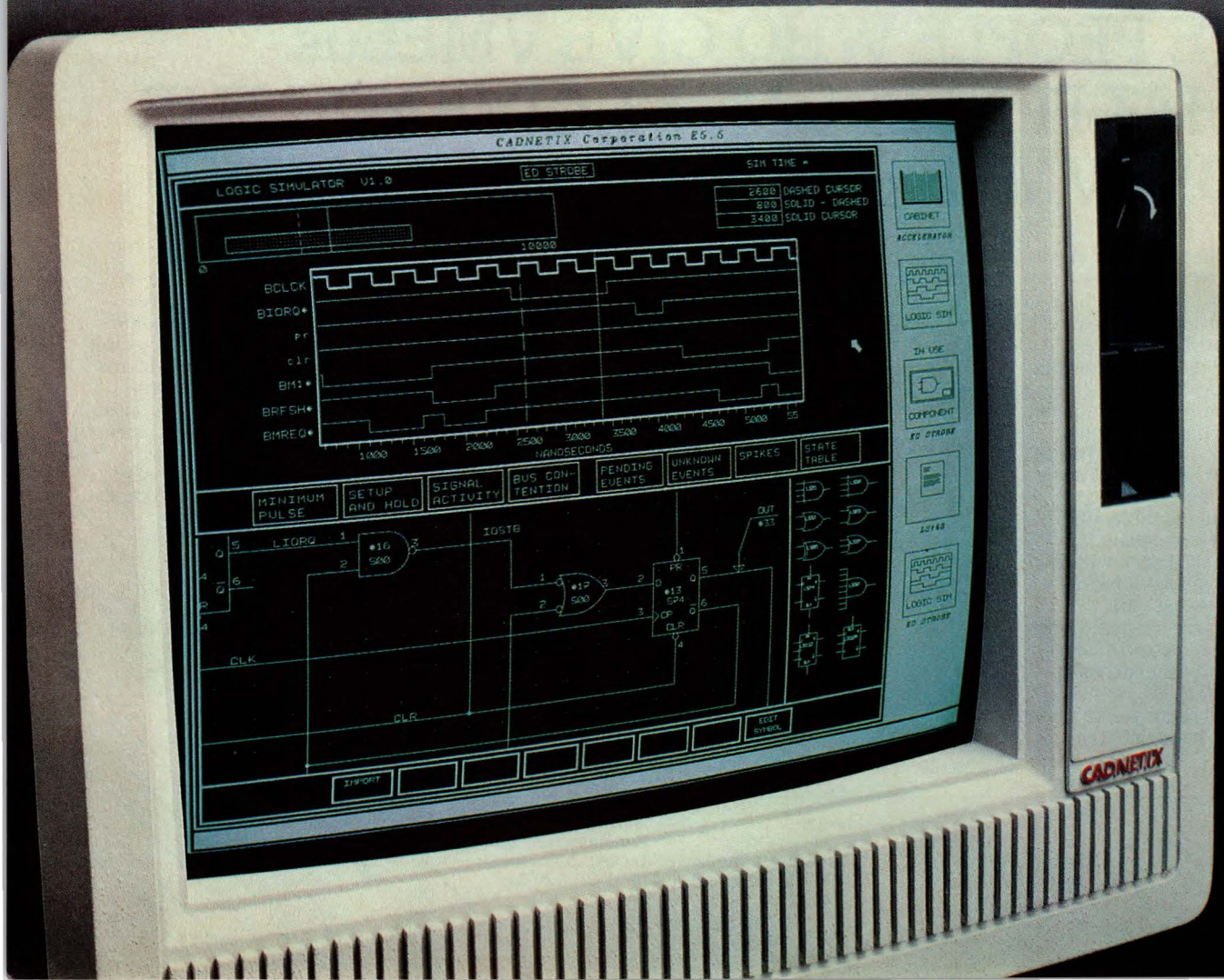
Together, the CDX-9000 CAE Workstation and the CDX-5000 Printed Circuit Board CAD Workstation provide a comprehensive electronic design tool set.

Error-free design is the goal and the Cadnetix tool set makes it feasible.

Start with flexible component creation and comprehensive component libraries. Add full support for hierarchical schematic design and a simulator that allows you to verify any portion of your design, at any stage of development. Automatic revision control and library management features ensure that you are always working with current versions of components and schematics. And, to keep your designs on track, the system has automatic forward and back annotation between the schematic and PCB designs and among all nodes in the network.

You are on the leading edge with the innovative Graphic Waveform Editor.

Cadnetix has significantly advanced simulation technology with a unique graphic approach. Simulator inputs are created graphically—output signals generated during execution are viewed graphically—and can be edited for use as inputs to



solution for team.

other portions of your circuit design. No coding or repetitive textual input of data is required. The display format is familiar and easy-to-use, because it closely resembles a logic analyzer. And the waveform display can be used to view and edit outputs from any type of logic simulation.

Still the leader in PC board layout.

Think of the toughest PC board layout problem you've come up against. With the Cadnetix system, you can handle it. And with an ease of interaction that first time Cadnetix users find frankly unbelievable. You get fully automatic placement and routing. We support surface mount components, analog devices, and the upcoming fine-line geometries. In short, in one compact workstation, we give you more power and ease of use than anyone else in the market.

Tightly-coupled CAE/CAD in one practical, high-performance electronic design solution.

A total solution to your problem. Schematic entry, design verification and PC board layout in one easy-to-use system. The Ethernet™ Network and Cadnetix File and Peripheral Servers to tie system resources together. And forward and back annotation to protect the integrity of your design. With proprietary Cadnetix hardware and the user-interface that made us famous, your imagination is the only limit to your design. And Cadnetix offers the workstation options (color or black & white) that you need to suit your design schedule and your budget.

To find out more, call or write today. Cadnetix, 5757 Central Ave., Boulder, CO 80301 (303) 444-8075.

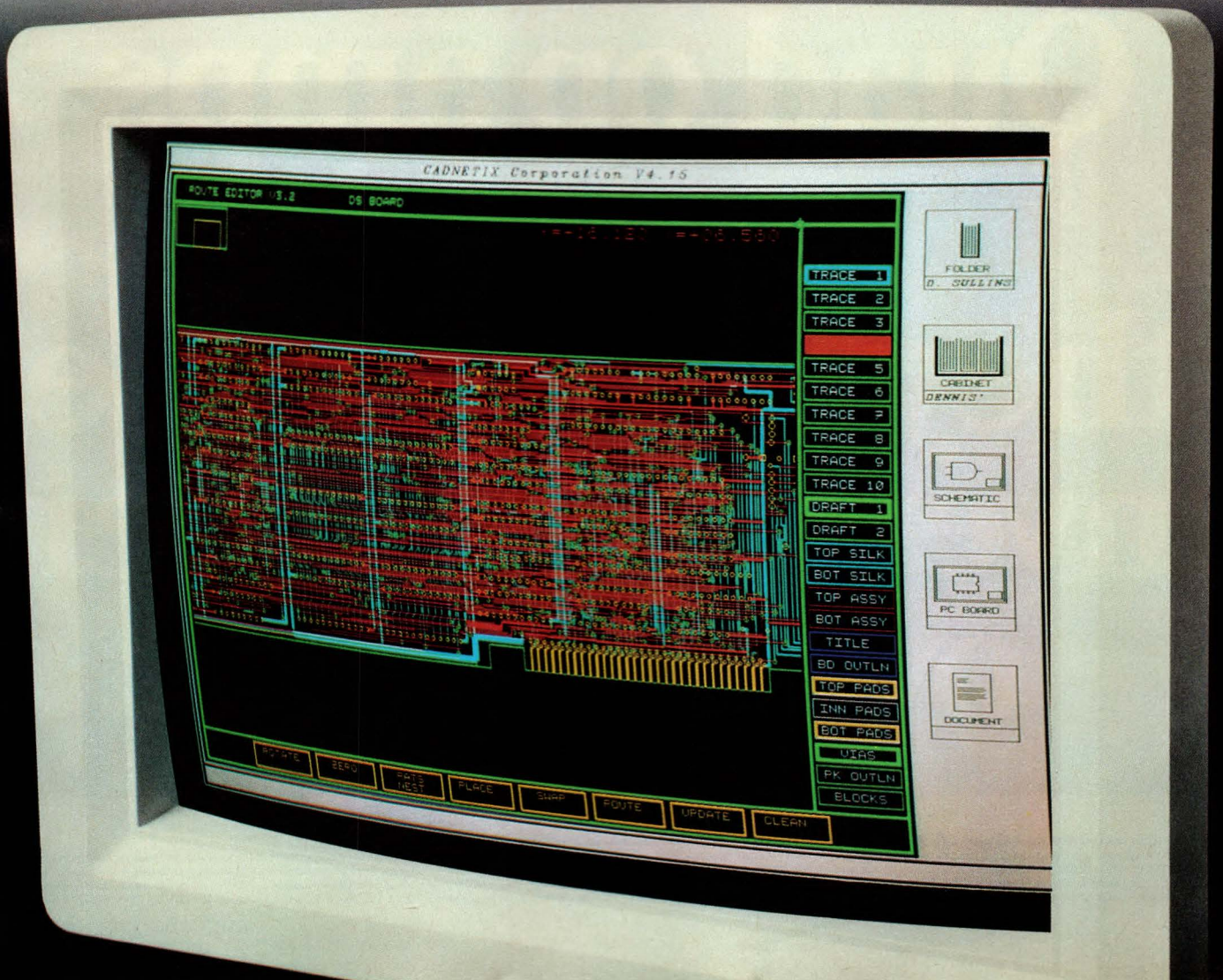
CADNETIX

5757 CENTRAL AVENUE • BOULDER, CO 80301 • (303) 444-8075

CADAT is a trademark of HHB SOFTRON,Inc.
UNIX is a trademark of AT&T BELL LABORATORIES.
ETHERNET is a trademark of XEROX CORPORATION.

CIRCLE NO 84

08406



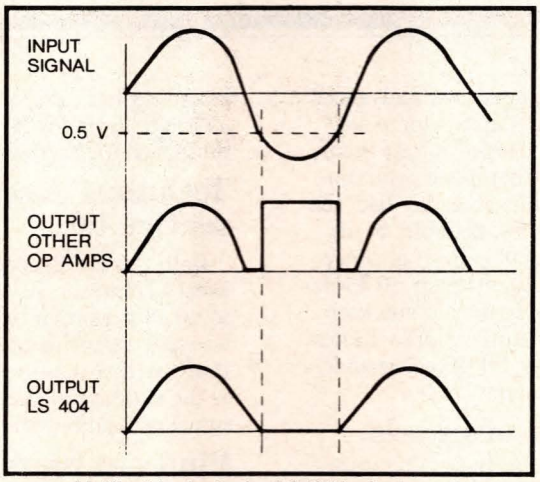
SGS make Quad op amps so good they don't phase invert even when overdriven.

INTERNATIONAL HEADQUARTERS SGS-ATES Componenti Elettronici SpA, Via C. Olivetti 2, 20041 Agrate Brianza-Italy. Tel: 39-65551 Telex: 330131-330141-SGSAGR
Benelux SGS-ATES Componenti Elettronici SpA Sales Office: B-1180 Bruxelles, Winston Churchill Avenue, 122 Tel: 2-3432439 Telex: 24149B · **Brazil** SGS Semicondutores LTDA Sales Office: 05413 Sáo Paulo, Av. Henrique Schaumann 286-CJ33 Tel: 11-853-5062 Telex: 37988 UMBR BR · **Denmark** SGS Semicondutor A.B. Sales Office: 2730 Herlev, Herlev Torv, 4 Tel: 2-948533 Telex: 35411 · **France** Société Générale de Semiconducteurs, F92120 Montrouge, 21-23 Rue de la Vanne Tel: 1-6571133 Telex: 250938 F · **Hong Kong** SGS Semiconductour Asia Limited, 9th Floor, Block N, Kaiser Estate, Phase III. 11, Hok Yuen St., Hunghom, Kowloon Tel: 3-644251/5 Telex: HX 63906 ESGIE HX · **Italy** SGS-ATES Componenti Elettronici SpA Direzione Italia e Sud Europa, 20090 Assago (MI), V. le Milanofiori-Strada 4-Palazzo A/4/A Tel: 2-8244131 (10 linee) Telex: 330131-330141 SGSAGR · **Korea** Douil Incorporated, Central P.O. Box 7636, Seoul, Korea Tel: 712-7071/2/3 Telex: K26493 · **Singapore**

A small input voltage swing below the negative supply is enough to upset any standard Quad op amp, sending the output into phase inversion.

The SGS LS404 is different. It has a special, patented input stage design that allows the input signal to go below the lowest supply voltage without causing phase inversion at the output.

Particularly useful in active filters, the design also guarantees stability when driving highly capacitive loads.



Unlike it's rivals the LS404 isn't phased by a negative input voltage.

PERFORMANCE COMPARISON: LS404 vs COMPETITION

	LS404	RM4156	SE5532A	TL084	LM324 (Low Cost)
Quality Factor $\left(\frac{B_w}{I_s}\right)$	9	3.1	2.5	2.1	2.1
Max input Noise voltage ($nV/\sqrt{Hz}$) $R_g = 10k\Omega$	15	14	6	25	—
Harmonic Distortion (%)	0.04% max @ 1kHz 0.03% typ @ 20kHz	Not Specified	Not Specified	Not Specified	Not Specified
Ground Compatibility of Inputs	—0.5V (protected against inversion)	$2V_{BE}$	$V_{BC}+V_{CESAT}$ $2V_{BE}$		—0.3V
Current Consumption I_s (mA)	1.3	4.5	8	5.6	1.5
Cost	Med	Med	High	Med	Low

The LS404 is ideal for use in single supply applications and industrial or automative control circuits.

What's more its performance/cost ratio is hard to beat.

It offers low noise with total input noise voltage only $10nV\sqrt{Hz}$.

Low distortion with a maximum total harmonic distortion of 0.04% at 1kHz.

High gain-bandwidth. Low consumption of 1.3mA. Low input offsets.

And an output current limiting capability that protects against short-circuits.

All these features make the SGS LS404 the Quad op amp to specify in your designs.

It comes in a choice of three packages: the standard plastic DIP, a ceramic DIP and a compact, small outline DIP.

And this is just one of a broad range of SGS operational amplifiers.

Send for leaflet about them and make sure when it comes to a better Quad op amp specify the one that's better value for your money.

Technology and Service

s Semiconductor (Pte) Ltd., Singapore 2056, 28 Ang Mo Kio, Industrial Park 2 Tel: 482-1411 Telex: RS 21412 ESGIES · **Sweden** SGS Semiconductor A.B. 19500 Märsta, Bristagatan, 16 Tel: 760-40120 Telex: 0024-10932 · **Switzerland** SGS Semiconductor S.A. es Office: 1218 Grand-Saconnex (Genève), Chemin François-Lehmann, 22 Tel: 22-986462/3 Telex: 28895 · **Taiwan-Republic of China** SGS-ATES Singapore (Pte) Ltd., Taipei Sec 4, 6th floor, Pacific Commercial Bldg, 285 Chung Hsiao E Road 2-7728203 Telex: 10310 ESGIE TWN · **United Kingdom** SGS Semiconductor Limited, Planar House, Walton Street, Aylesbury, Bucks. Tel: 296 5977 Telex: 041-83245 · **USA** SGS Semiconductor Corporation, Phoenix AZ 85022, 1000 East Bell Road 602 867 6100 Telex: SGSPH-UR 249976 · **West Germany** SGS Halbleiter Bauelemente GmbH, 8018 Grafing bei München, Haidling, 17 Tel: 8092-690 Telex: 05 27378.

The HP family of pulse/function generators

The shortest route to a long term solution.

Whether your job involves designing tomorrow's advanced digitally-based products, or whether it's up to you to configure the sophisticated ATE systems needed to test them, you can count on Hewlett-Packard for complete solutions to many of your measurement equipment needs. Take the HP 8116A Pulse/Function Generator for example, or its companion the HP 8112A Pulse Generator. Both generate an extensive repertoire of signals throughout their 50 MHz range. Both have the power and versatility to help you keep pace with state-of-the-art developments until well into the next decade. They're exceptionally easy to use, HP-IB compatible, and take up only half the standard rackmount space.

Versatility for a wide range of signals.

Both instruments provide accurate and repeatable waveforms that can be internally shaped. The HP 8112A can be externally modulated for period, width, delay, and level. The HP 8116A in addition to width modulation, provides AM, FM, log sweep and external amplitude hold. Both instruments feature counted bursts.

Use these capabilities to test slew rate and hysteresis of amplifiers, output characteristics of switching power supplies, measure the reverse recovery time of diodes, magnetic recording head performance and head/media interactions, terrain-following radar accuracy, laser transmission lines, process control systems, and more.

DESIGNED FOR HP-IB SYSTEMS

HP-IB: Not just IEEE-488, but the hardware, documentation and support that delivers the shortest path to a measurement system.

Technical excellence for a long service life.

Both the HP 8116A and the HP 8112A are based on the latest advances in IC technology. One reason we can offer you so much performance in such a compact package is because we make extensive use of custom HP-developed high density ICs. Another reason is our over 30 year leadership position as the supplier of the world's most technically-advanced signal generation equipment.

Find out more today.

At $4,780* for the HP 8112A, and $3,950* for the HP 8116A (including burst and sweep), they're the price/performance leaders. We have a complete set of literature including our new "Precision Waveform Sources" brochure. To get your package call your local HP sales office listed in the telephone directory white pages. Ask for the electronic instruments department.

*U.S.A. list price only.

CIRCLE NO 86

HEWLETT PACKARD

0801405

Circuits allow direct digitization of low-level transducer outputs

Designers like to digitize analog signals as far forward in the signal chain as possible, but many believe that dc preamps are mandatory. Part I of this 2-part series describes circuits that digitize low-level signals without preamplification.

Jim Williams, *Linear Technology Corp*

Almost all transducers produce low-level signals, and designers typically use signal-conditioning amplifiers to boost the output prior to further processing or transmission. However, many systems now transmit transducer outputs digitally to reduce noise and eliminate the inaccuracy problems associated with analog transmission over long cable runs. In fact, designers want to digitize signals as far forward in the signal chain as possible, and although you might believe that dc preamplification of transducer outputs is still mandatory, such is not the case: New components and design techniques allow you to digitize directly at the transducer.

This 2-part series details such circuit techniques, which you can use to digitize low-level transducer outputs and eliminate the traditional dc gain stage without sacrificing performance. The circuits produce serial frequency outputs that you can transmit over one wire with the characteristic noise immunity of digital systems. Part I discusses methods of handling the most common transducer quantities: temperature and force. Part II (scheduled for January 10, 1985) will discuss similar methods for handling light, humidity, level, and acceleration.

Obviating dc preamplification

Before moving on to these techniques, it's worthwhile to examine the reason why most designers feel dc preamplification is necessary. Classical A/D-conversion techniques emphasize high-level input ranges to keep LSB step sizes as large as possible and thus minimize offset and noise errors. For this reason, A/D LSB size is almost always greater than a millivolt, with 100- to 200-μV/LSB step sizes in some 10V FS devices.

Now consider the minimum A/D-converter step size required for direct digitization of the output of a typical strain-gauge transducer. The device's full-scale output is 30 mV, so a 10-bit A/D converter must have an LSB increment of only 30 μV. Performing a 10-bit conversion on a type-K thermocouple monitoring a 0 to 60°C environment proves even more stringent. The thermocouple generates 41.4 μV/°C over the 0 to 60°C range. The following equation determines the LSB increment:

$$\frac{41.4\ \mu V/°C \times 60°C}{1000} = 2.48\ \mu V/LSB.$$

These step sizes are far smaller than those found in commercially available A/D converters, leading some designers to conclude that it's impossible to digitize the step sizes without dc preamplification. But circuitry designed specifically for that task directly digitizes the outputs from these transducers (and others) to stable 10-bit resolution.

Start with an IC temperature sensor

The straightforward circuit shown in **Fig 1** converts an LM134 temperature sensor's current output to a corresponding output frequency. The sensor pulls a temperature-dependent current (0.33%/°C) from IC_1's positive input node. This point, biased from the LM329-driven resistor string, responds with a temperature-dependent voltage that varies the operating point of IC_1, which is configured as a self-resetting integrator. IC_1 integrates the LM329-referenced current into its summing point and produces a negative ramp. When the ramp amplitude becomes large enough, the transistors turn on, thereby resetting the feedback capacitor and forcing IC_1's output to zero. When the capacitor's reset current goes to zero, the transistors turn off, and

IC_1 again begins to integrate negatively.

This oscillation's frequency depends on IC_1's dc operating point, which varies with the LM134's temperature. The circuit's dc biasing values are such that a 0 to 100°C temperature excursion produces a 0- to 1-kHz output. In addition, a voltage of only 2V appears across the LM134, minimizing sensor errors related to power dissipation.

For interfacing purposes, the differentiator/transistor network at IC_1's output provides a TTL-compatible output. To calibrate this circuit, place the LM134 in a 0°C environment, and trim the 0°C adjustment for a 0-Hz output. Then put the sensor in a 100°C environment and set the 100°C adjustment to a 1-kHz output. Repeat this process until both points are fixed. When properly constructed and calibrated, this circuit achieves a stable 0.1°C resolution with 1°C accuracy.

If you prefer thermocouples to IC temperature sensors, consider the temperature/frequency converter shown in **Fig 2,** which uses the popular type K thermocouple. That sensor's extremely low output (41.4 μV/°C) and the requirement for cold-junction compensation make it one of the most difficult transducers to digitize directly. This approach uses the 50-nV/°C input offset drift of the LTC1052 chopper-stabilized amplifier (IC_1). Besides providing cold-junction compensation for the thermocouple over a 0 to 60°C range, the design achieves ±1°C accuracy with 0.1° resolution.

In this approach, the thermocouple biases IC_1's positive input. IC_1 then drives a crude V/F converter (IC_2) comprising several 74C04 inverters and associated circuitry. Each V/F output pulse causes the 100-pF capacitor to dispense a fixed charge into the 1-μF capacitor via the LTC1043 switch. The larger capacitor integrates the charge packets and produces a dc voltage at IC_1's negative input. That amp's output forces the V/F converter to run at a frequency that balances its inputs. This feedback action eliminates drift and nonlinearities in the V/F converter, and the output frequency is a function only of the dc conditions at the amp's inputs.

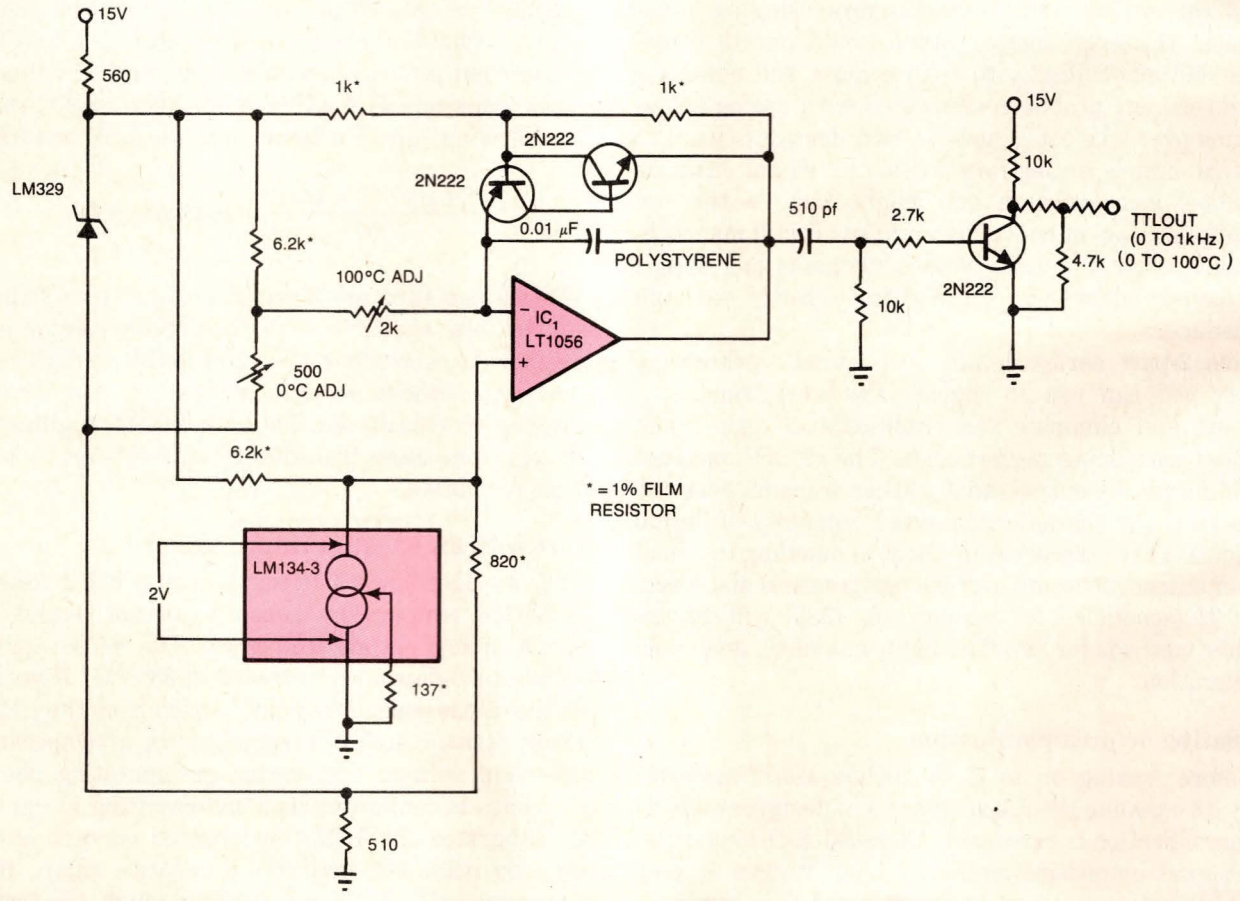
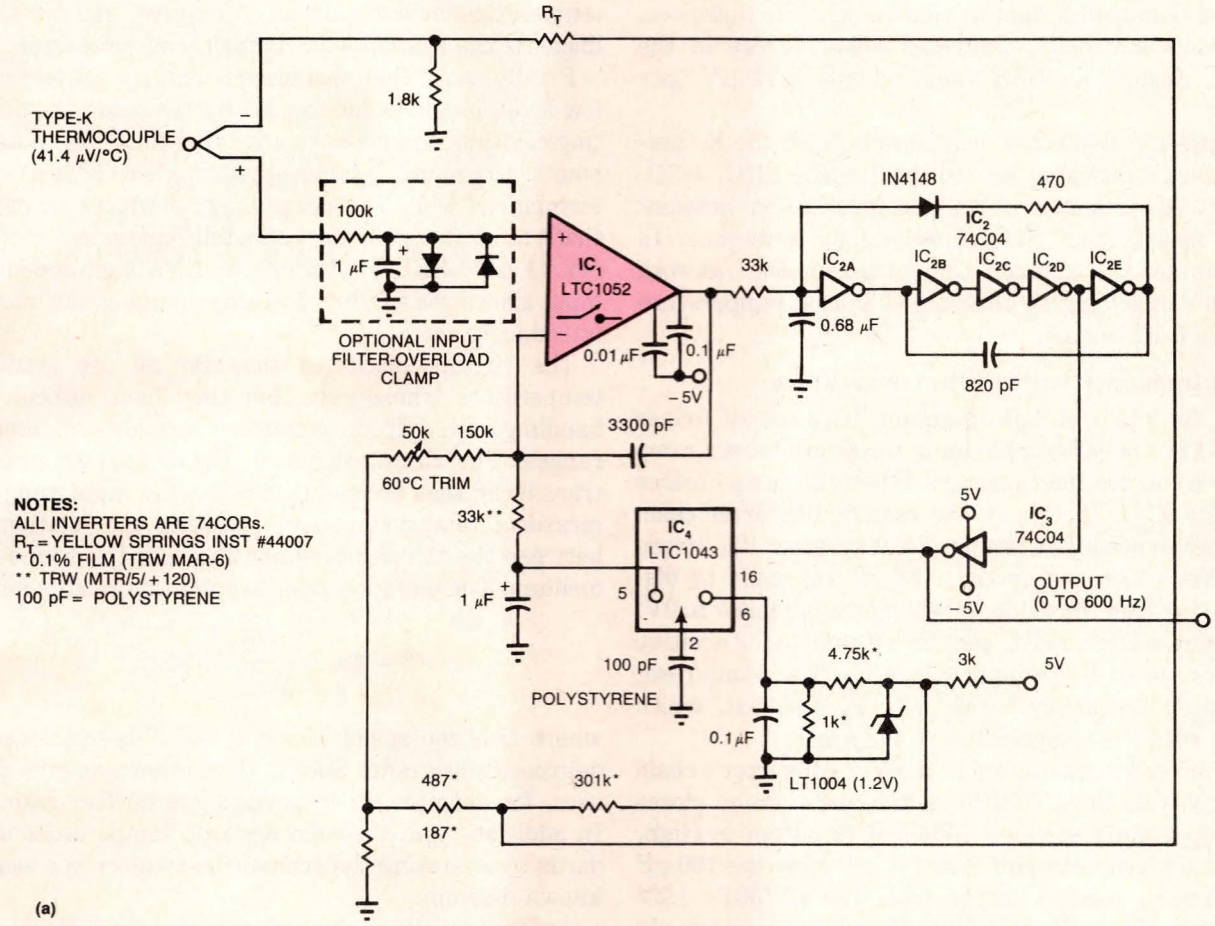
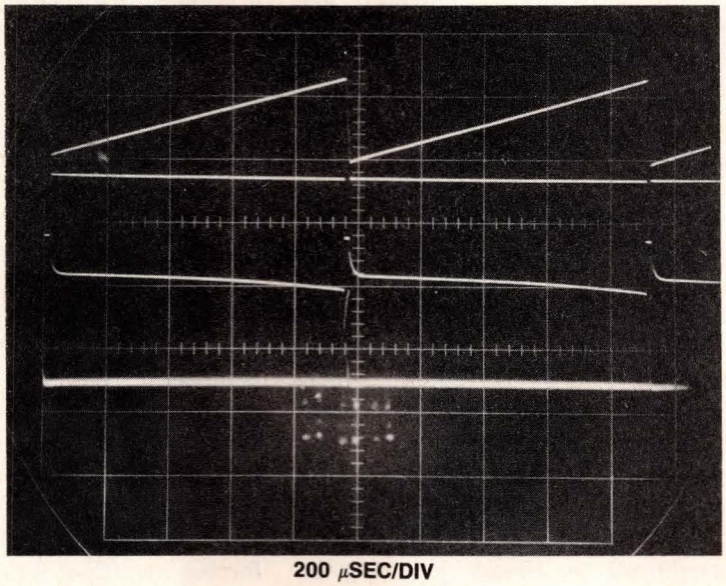


Fig 1—IC_1's dc operating point *determines oscillation frequency, causing the transistors to toggle and produce an output that corresponds to the sensor's temperature. This design directly digitizes the sensor's output and maintains 0.1°C resolution with 1.0°C accuracy.*



NOTES:
ALL INVERTERS ARE 74CORs.
R_T = YELLOW SPRINGS INST #44007
* 0.1% FILM (TRW MAR-6)
** TRW (MTR/5/+120)
100 pF = POLYSTYRENE

(a)



A = 100 mV/DIV

B = 10V/DIV

C = 10V/DIV

D = 10μA/DIV

200 μSEC/DIV

(b)

Fig 2—The low output levels and cold-junction compensation requirements *of K thermocouples render those devices' outputs tough to digitize directly. This circuit relies on IC_1's low input offset drift to accomplish that task. The thermistor and several resistors perform the cold-junction compensation and offsetting functions.*

Sensor outputs are much lower than typical A/D LSB size

To stabilize the feedback loop, the 3300-pF capacitor forms a dominant response pole for IC_1. Furthermore, the amp's low drift eliminates offset errors in the circuit, despite an LSB value of only 4.14 μV (per 0.1°C).

To effect cold-junction compensation for the K thermocouple, thermistor R_T and the 1.8-kΩ, 187Ω, 487Ω, and 301-kΩ resistors form a compensation network that's biased from the LT1004's 1.2V reference. In addition to cold-junction compensation, the network provides offsetting so that a 0°C sensor temperature yields a 0-Hz output.

Ramp frequency varies with temperature

Fig 2b details circuit operation. IC_1's output drives the 33-kΩ/0.68-μF combination, which produces a ramp (trace A) across the capacitor. When the ramp crosses inverter IC_{2A}'s threshold, the cascaded inverter chain switches to produce a low output at inverter IC_{2E} (trace B). This action causes the 0.68-μF capacitor to discharge through the diode, resetting the capacitor to 0V. To ensure a clean reset, the 820-pF unit sends positive ac feedback to IC_{2B}'s input (trace C). This ramp/reset sequence's frequency varies with IC_1's output, which varies with the temperature at the sensor.

The inverter not located in the V/F converter's chain (IC_3) controls the LTC1043 switch and thereby closes the loop around the amp. When IC_3's output is High, the switch connects pins 2 and 6, allowing the 100-pF capacitor to receive charge from the LT1004's 1.2V reference. When IC_3 goes Low, the switch connects pin 2 to pin 5, and the 100-pF capacitor completely discharges (trace D) into the 1-μF unit. Because the amount of charge the capacitor delivers is constant for each cycle (Q=CV), the voltage to which the 1-μF capacitor charges is a function of frequency and discharge-path resistance.

This voltage is summed with the LT1004-derived offsetting potential at IC_1's negative input, thus closing the amplifier loop. The −120-ppm/°C drift of the 100-pF, charge-dispensing polystyrene capacitor is compensated by the opposing temperature coefficient of the resistors in the 1-μF capacitor's discharge path. This selection achieves a typical circuit gain drift of 20 ppm/°C, allowing less than 1 LSB (0.1°C) output drift over a 0 to 70°C ambient operating range.

The thermocouple's characteristics, combined with IC_1's low offset and the components specified for the cold-junction/offsetting network, eliminate the need for zero trimming. You calibrate the circuit by placing the thermocouple in a 60°C environment and adjusting the 50-kΩ potentiometer for a 600-Hz output. Beyond 60°C, the cold-junction network departs from the thermocouple's response, and output error increases rapidly. And, although the digital output varies with thermocouple temperature over hundreds of degrees, you must still linearize the system with a monitoring processor.

Finally, note that this circuit directly converts any low-level, single-ended signal. By removing the offsetting/cold-junction network and tying the 50-kΩ potentiometer to ground, you can apply inputs to IC_1's positive terminal as well. The design then produces an output that's accurate to 10 bits with a full-scale range of only 1 mV (1 μV/LSB). Furthermore, IC_1's high-impedance input allows you to filter or clamp input signals without introducing error.

The circuits discussed thus far all use standard temperature transducers, but they have difficulty in handling such extreme conditions as wide temperature ranges. The circuit shown in **Fig 3** uses an unusual transducer that accommodates a wide input range; it measures temperature by exploiting the relationship between the temperature and the speed of sound in a medium. The equation representing this relationship is

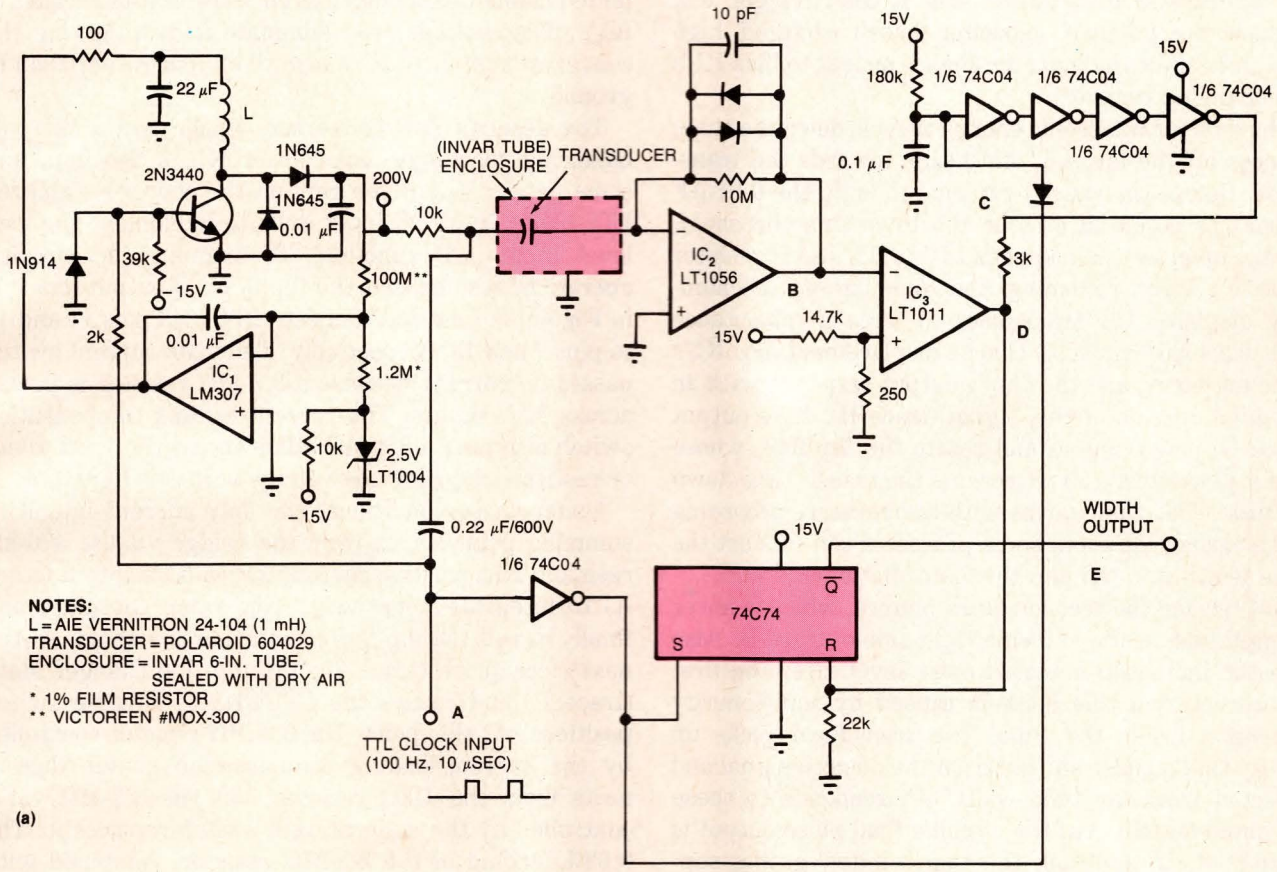
$$C = 331.5\sqrt{\frac{T}{273}}\ \text{M/SEC},$$

where C is the speed of sound and T is expressed in degrees Centigrade. Such acoustic thermometry finds uses, for example, in cryogenics and nuclear reactors. In addition, you can build acoustic temperature standards by operating the acoustic transducer in a sealed, known medium.

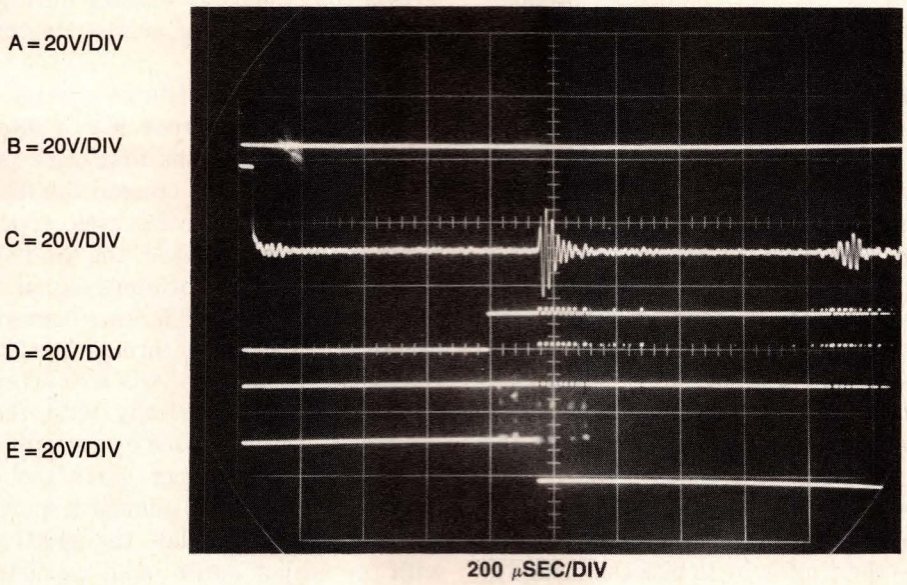
An acoustic thermometer's inherent time-domain operation suits direct digitization. In **Fig 3a**'s circuit, IC_1 and the inductor form a simple flyback, regulated 200V source that biases the acoustic transducer, which is a Polaroid ultrasonic element. You mount the transducer at one end of a sealed, 6-in.-long Invar tube; the Invar material minimizes mechanical tube deformation that occurs as a function of temperature. The medium inside the tube is dry air. In this configuration, you may think of the ultrasonic element as a capacitor, composed of an insulating disk with a conductive coating on each side.

The circuit operates in this fashion: Each time the TTL clock (trace A in **Fig 3b**) goes High, the transducer receives ac drive from the 0.22-μF capacitor. This drive causes the disk to move and emit ultrasonic energy. Simultaneously, the clock input sets the 74C74 flip flop's output (trace E) Low and pulls the 0.01-μF capacitor to ground. This discharge cuts off drive to the comparator IC_3's 3-kΩ output pullup resistor (trace C), forcing its output (trace D) to zero.

When the clock's output is positive, IC_2 saturates (trace B). When the clock pulse returns to zero, IC_1 amplifies in a linear manner. The ultrasonic transducer now acts like a capacitance microphone, with the 200V



(a)



(b)

Fig 3—An ultrasonic sensor *measures temperature by exploiting the relationship between the speed of sound in a medium and temperature. The sensor uses an ultrasonic element as its active transducer element. The flip flop's output pulse width varies with temperature, and you can use digital circuitry to convert it to temperature information.*

supply providing bias voltage. Residual disk ringing now appears at IC_2's output, but it can't trigger IC_3, because the 0.01-μF capacitor hasn't charged high enough to allow the inverter chain's output to bias IC_3's output pullup resistor.

The emitted ultrasonic energy travels down the tube, bounces off the far end, and heads towards the transducer. Before the energy returns, though, the 0.01-μF capacitor's potential crosses the inverter's threshold, and the inverter chain applies 15V to IC_3's 3-kΩ resistor (trace C). Upon returning, the sonic energy mechanically displaces the transducer to force a capacitance shift. This shift causes a charge displacement into IC_2's summing point, and the amp's output responds with an amplified version of this signal (trace B). IC_3's output (trace D) now triggers and resets the flip flop, whose output pulse (trace E) represents the transit time down the tube. This time varies with temperature according to the earlier equation, and a processor can convert the pulse width into temperature information.

You can see the second return bounce, which is lower in amplitude, at the extreme right side of trace B. Also note the increased detected noise level after the first bounce returns; this noise is caused by sonic-energy dispersion inside the tube. The transducer picks up energy that's phase shifted from the desired signal and deflected from the tube walls. IC_3 responds to these unwanted signals, but the circuit's final pulse output is unaffected. In addition, the time-window gating supplied to IC_3's pullup resistor greatly reduces the likelihood of false triggering that may be caused by noise coming from outside the tube.

No strain to measure force

One final example deals with another common transducer variable: force. Strain-gauge transducers, which typically handle pressure or force, are often bridge-based sensors that produce full-scale outputs of 3 mV/V of bridge drive. **Fig 4** shows one way to digitize directly a strain-gauge bridge's output to 10-bit accuracy, although the bridge's differential output complicates the required converter input structure. With this resolution, you achieve a 25-μV LSB increment for a 7.5V bridge drive, which is considerably larger than that of the thermocouple examples but is still far below the requirements of conventional A/D converters.

IC_1 and the 2N2905 transistor drive the bridge. One of the bridge's outputs connects to IC_1's negative input, and that amp drives the transistor to bias the bridge at a voltage that brings its negative input to ground potential. Voltage drops from the diodes in the bridge's −5V return line allow the transistor to force the voltage on the bridge's positive end high enough to balance IC_1's inputs. This arrangement permits sensing of the bridge's other output in a single-ended, ground-referred fashion. Although a slight error exists because of IC_1's offset voltage, you eliminate it by referring the converter's input to IC_1's negative input rather than to ground.

The design's A/D converter, which uses a current-balancing technique, consists of IC_2, a flip flop, and some gates. Again, you rely on the chopper-stabilized LTC1052's 50-nV/°C input drift to implement the low-level input A/D function. To examine the circuit's operation, assume that the flip flop's Q output (trace B in **Fig 4c**) is Low and connects LTC1043 pins 11 and 12 to pins 7 and 13, respectively. The main current switch passes no current because a 3.3-MΩ resistor is placed across IC_2's inputs. The current-loading compensation switch also puts a 3.3-MΩ value across the 1-kΩ divider/resistor, reducing the voltage across it by 0.03%.

Under these conditions, the only current into IC_2's summing point comes from the bridge via the 470-kΩ resistor. This positive current forces IC_2's output (trace A) to integrate negatively. This ramp continues and finally passes the flip flop's switching threshold. At the next clock pulse (trace C), the flip flop changes state (trace B) and causes the LTC1043 to reverse switch positions. At this point, the 3.3-MΩ resistor controlled by the current-loading compensation switch disconnects from the 1-kΩ resistor, but the 3.3-MΩ value controlled by the main current switch replaces it. The 0.03% loading of the 3.3-MΩ resistor, combined with this switching scheme, eliminates sags or loading effects across the 1-kΩ resistor during switching. As a result, a quickly rising, precise current flows from IC_2's summing point.

This current, scaled to be greater than the bridge's maximum output, forces IC_2 to integrate positively. Switching occurs at the first clock pulse that appears after IC_2's output has crossed the flip flop's triggering threshold, and the entire cycle repeats. Because the reference current is fixed, the flip flop's duty cycle is a function only of the bridge's signal current into IC_2's summing point. The reference current comes from the bridge drive indirectly through the 22.3-kΩ/1-kΩ divider. Consequently, the A/D converter's reference current varies ratiometrically with the bridge output, eliminating errors caused by variations in bridge drive.

The flip flop's output gates the clock to produce output A (trace D). To eliminate spurious output pulses caused by flip-flop delay, the 10-kΩ resistor combines with the output gate's input capacitance to delay the clock signal slightly. To extract the circuit's data output (the ratio of output A to the clock frequency), you can use counters.

You must observe several facts when setting up and using this circuit. First, because the output is ex-

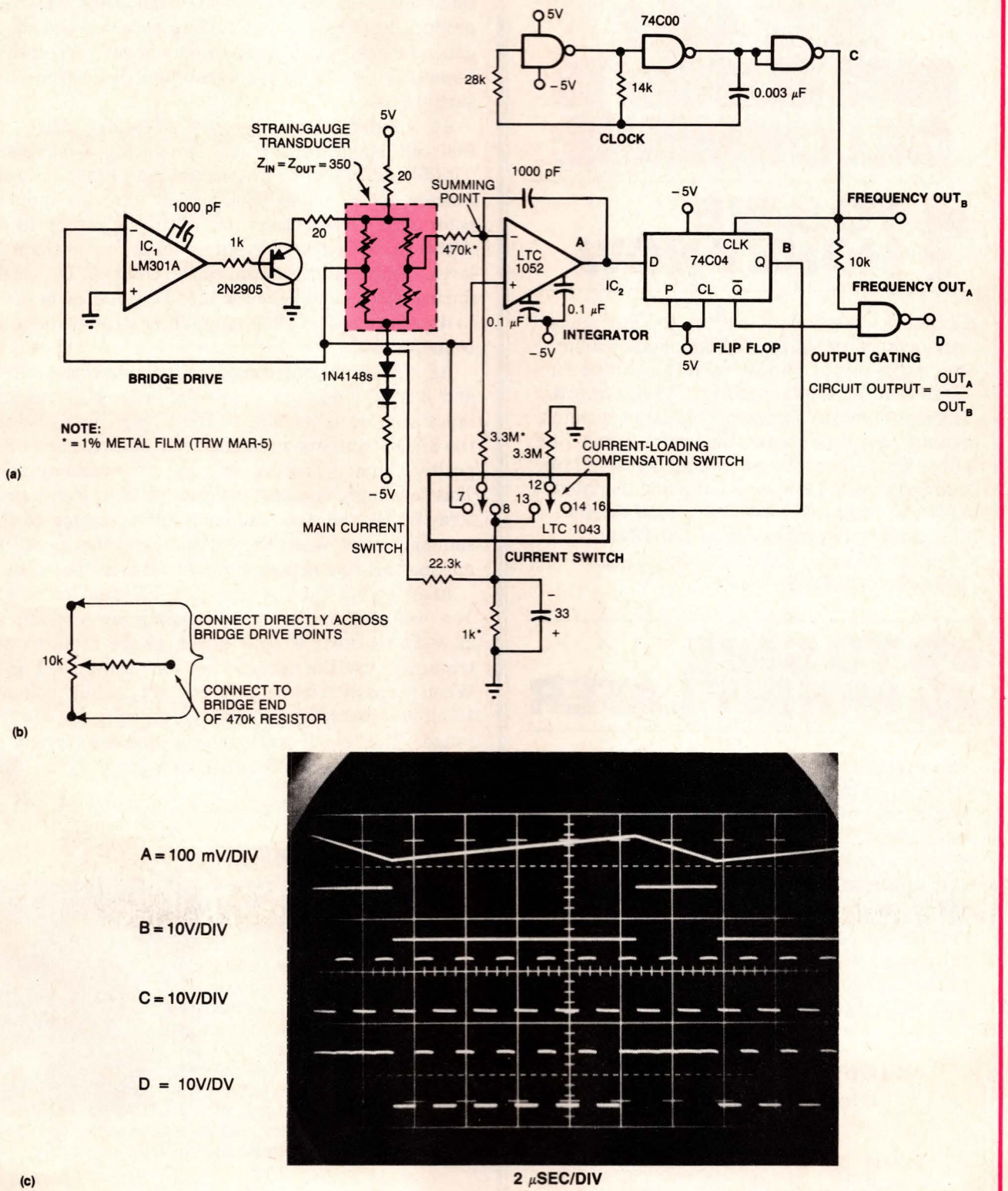


Fig 4—Although a strain-gauge bridge transducer's output *is larger than that of a thermocouple, it's still too small for most A/D converters. This direct-digitization circuit maintains 10-bit accuracy, and if your transducer requires it, you can accomplish transducer zero trimming with an optional network* **(b).**

NEED FCC TEST SERVICES?

THERE ARE 2 GOOD REASONS TO CALL CHOMERICS:

1 TO SAVE MONEY NOW

Chomerics' Radiation Test Service Engineers can locate your unit's EMI/RFI susceptibility and emissions to comply with FCC limits for Class A and B digital products. With our four test sites, we can accommodate large systems, within your time frame. Enclosure, cable, line surge and ESD problems can all be solved by our experienced engineers utilizing the latest EMI test equipment in our shielded rooms. Shielding effectiveness up to 120 dB can be determined for units operating in the 150 KHz to 12.4 GHz range.

2 TO SAVE MONEY LATER

Our on-site or in-house design consultations have saved many digital manufacturers time (which is money) during the initial design of equipment. Thus, manufacturers of PBX's, robotic systems, modems, minis, micros, and even electronic organs were able to meet the FCC regulations without costly redesign.

Whether you have an existing product that must meet FCC limits, or are just in the design phase, call our marketing coordinator at (617) 935-4850, Ext. 355.

CHOMERICS
RADIATION TEST SERVICES
77 Dragon Court, Woburn, Mass. 01888
Tel: (617) 935-4850 TWX: 710-393-0173

CHOMERICS

Talk to us first

CIRCLE NO 87

Use the medium's speed of sound to measure temperature

pressed as a ratio, clock frequency stability is unimportant. Next, you select a 470-kΩ input resistor at IC_2 to produce less than 1-LSB loading error on the strain-gauge bridge, which receives only about 7.5V of drive because of the deliberate resistor and diode drops in its supply lines.

At a 3-mV output per volt of bridge drive, the full-scale signal is 22.5 mV, producing a current of 0.0225V/470 kΩ, or 48 nA. To maintain 10-bit accuracy, leakage and amplifier bias current into A_2's summing point must be less than 0.1% of this figure, or 48 pA. Although IC_2's bias current is much lower than this level, board leakage can cause trouble. Be careful during layout, and keep the board clean. The best way to do so is to use a Teflon standoff for all summing-point connections.

As another layout consideration, place the 470-kΩ and 3.3-MΩ resistors associated with IC_2's negative input as close as possible to the IC pin. Note also that the 3.3-MΩ current-summing resistor switches to IC_2's positive input when not sourcing the summing point. This seemingly unnecessary connection prevents small, stray 60-Hz and noise currents from coupling to IC_2's summing point when the current reference is off; not making this connection produces jitter in the LSB.

After laying out the circuit, you'll want to trim it. You can accomplish gain trimming by varying the 22.3-kΩ resistor. If your strain gauge requires zero trimming, use the optional network shown in **Fig 4b.** When properly trimmed, the circuit typically maintains 10-bit outputs within 1-LSB accuracy over the 0 to 70°C range. This small error arises primarily from the tracking errors of the starred resistors. **EDN**

Author's biography

Jim Williams, staff scientist at Linear Technology Corp (Milpitas, CA), specializes in analog-circuit and -instrumentation design. He has served in related capacities at National Semiconductor Corp, Arthur D Little Inc, and the Instrumentation Development Lab at the Massachusetts Institute of Technology. Jim is a former student of psychology at Wayne State University, and he enjoys tennis, art, and collecting antique scientific instruments.

Article Interest Quotient (Circle One)
High 482 Medium 483 Low 484

Two things are certain:

1. One of you will win a new Fiero.
2. The excitement begins with TMOS.

Win a Fiero with TMOS™

The chance of a lifetime in the powerFET design contest of the year.

Imagine a brilliant new 1985 Fiero SE by Pontiac in your garage.

Or carport. Or driveway.

Whatever you park it in, or on, it'll be yours if you win first prize in our TMOS power MOSFET design contest.

The stylish, sporty Fiero is the first mid-engine car in the world to use a space-frame chassis—a bold benchmark in automotive engineering. Its unique design concepts, gleaned from race-car designs, have caught on with everyone interested in advanced, mass-produced American cars.

If you've seen one and admired its innovative styling, performance and handling, you've already started your TMOS design.

The excitement begins with TMOS.

TMOS powerFETs are today's version of the ideal switch.

Voltage-driven, low-loss, majority carrier devices, they are comprehensive, state-of-the-art solutions to high-frequency power applications requiring fast, efficient performance.

Independent of operating temperatures and fully biased with only 10 V to the gate, TMOS powerFETs simplify drive circuits and can be driven directly from CMOS and T^2L to control high-power loads. Secondary-breakdown-free, they're virtually immune from thermal runaway and represent an almost unlimited evolutionary progression towards the perfect power switch.

Look how complete the line is.

Over 400 TMOS types comprise the broadest offering available.

Performance extends to 200 A, 1,000 V and leaves the also-rans behind. No one can touch our 0.009 Ω $r_{DS(on)}$ specs for leading-edge TMOS III products. We even have P-channel for ultra-simple drive circuits.

And there are eleven different package styles to choose from, including small-signal TMOS.

Guaranteed lowest cost.

There's a direct TMOS replacement for more than 700 industry-available powerFETs. Spec for spec, package for package.

During October, November and December, we're guaranteeing you 10% off any other source's equivalent device quote or invoice.

Take any bona fide supplier's invoice or quote up to 30-days old to a Motorola factory representative and if it's for any of the 727 types we second-source, we'll price the order and/or quote at 10% less. Guaranteed.

Win a car or a computer.

All it takes to qualify is your imagination and a circuit design using one or more TMOS power MOSFETs in an unusual, or cost-effective, or efficient way. We'll send you details.

1st Prize: Fully-equipped, 1985 Pontiac Fiero, 4- or 6-cylinder engine, automatic or manual transmission.

2nd Prize: M68000-based, Lisa Professional Computer plus up to $1,000 of software and accessories.

Five 3rd Prizes: M68000-based, Macintosh Personal Computers plus up to $500 of software and accessories.

Five Additional Prizes: Macintosh Personal Computer plus up to $250 of software and accessories.

All entrants will receive the official TMOS Design Contest entry package of free TMOS Data Book, contest rules, free sample offer, brochure, price list, and a handy new TMOS slide-chart Selector Guide.

Send coupon or facsimile to Motorola Semiconductor Products, Inc. P.O. Box 20912, Phoenix, AZ 85036.

Let the excitement build.

We're on your design-in team.

LISA AND MACINTOSH ARE TRADEMARKS OF APPLE COMPUTER, INC.

MOTOROLA

To: Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, AZ 85036

Please send me your Official TMOS Design Contest Entry Kit. 211EDN112984

Name

Title

Company

Address

City State Zip

Call me ( )

▪ Resolution to 23 bits ▪ Dynamic range to seven full decades
▪ Lower cost—Simpler circuits

V/F DATA CONVERSION THE DMC WAY.

From more than a decade of experience in designing, manufacturing and using voltage to frequency converters:

- Full-scale ranges from DC→20MHz down to DC→1KHz
- Full-scale linearities to within 0.005% max.
- Gain TC's to 5 ppm/°C max.
- Single-ended inputs
- Differential inputs
- High performance—high reliability military types
- General purpose types... even some hybrids that are **price and size competitive with monolithic**, system-for-system, with immensely better performance.

AND... we have complementary F/V Converters.

For complete V/F converter information and evaluation samples, Call DMC toll-free 1-800-225-1151

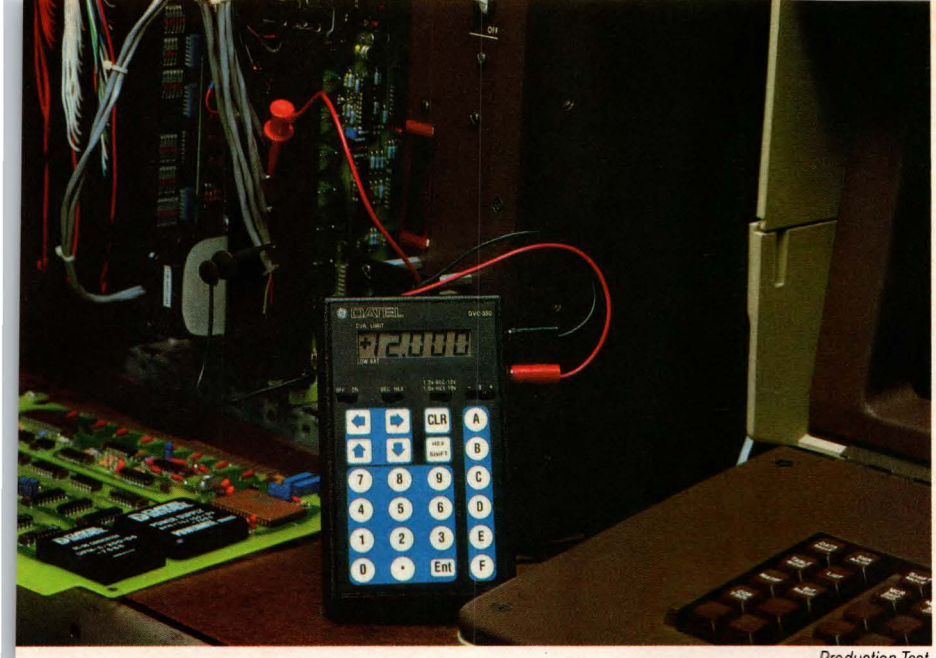
Let us show you what today's VFC's can do for data conversion... the DMC way!

DMC

Dynamic Measurements Corp.

8 Lowell Ave., Winchester, MA 01890. (617) 729-7870. TWX (710) 348-6596

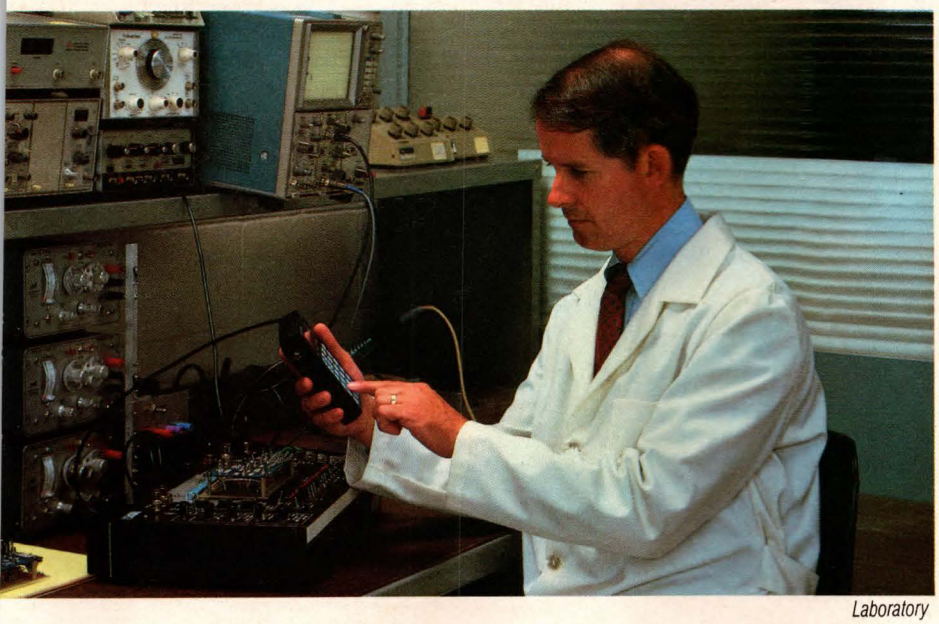
CIRCLE NO 191



Production Test

Field Service

The DVC-350. A precision instrument.



Laboratory

DATEL

At last, benchtop accuracy and stability in a portable voltage calibrator.

The smallest, most dependable and most accurate microprocessor-based voltage calibrator on the market today is Datel's Model DVC-350.

Don't let its size fool you. The DVC-350 is a precision instrument. Its overall accuracy of 0.015% @ 25°C traceable to the National Bureau of Standards is comparable to many expensive benchtop instruments.

The DVC-350 is the choice of engineers, scientists and field service technicians who appreciate "true" portability but who can't afford to sacrifice accuracy.

The DVC-350 is ideal for remote site calibration and laboratory use for the calibration of DPM's, strip chart recorders, oscilloscopes, data acquisition systems, A/D and V/F converters, test set-ups, breadboarding and many other applications. Wherever accuracy and portability are required.

Why pay more for less performance? The DVC-350 offers...

- *True portability*
- *Battery operation*
- *Laboratory accuracy of ± .015%*
- *± 12.000 volt output range*
- *100 μV resolution*
- *20mA current limited drive capability*
- *Inherent isolation*
- *Micro-processor controlled functions*
- *Decimal and hexidecimal output modes*

ONLY $369.00. *Price includes: DVC-350 Calibrator; Case; 9V Alkaline Battery; Test Leads; Operations Manual and Certificate of NBS Traceability.*

○ ***YES!*** *Send me _____ DVC-350(s) at $369.00 each. Add $2.00 each for shipping. (Mass. & Calif. residents add applicable state sales tax.)*

○ *Check enclosed* ○ MasterCard ○ VISA

P.O. # _____

Card # _____ *Exp. Date* _____

Signature _____

To order by telephone call 617-339-9341.

○ *Please forward FREE literature only at this time.*

Name _____

Title _____

Company _____

Address _____

City/State _____ *Zip* _____

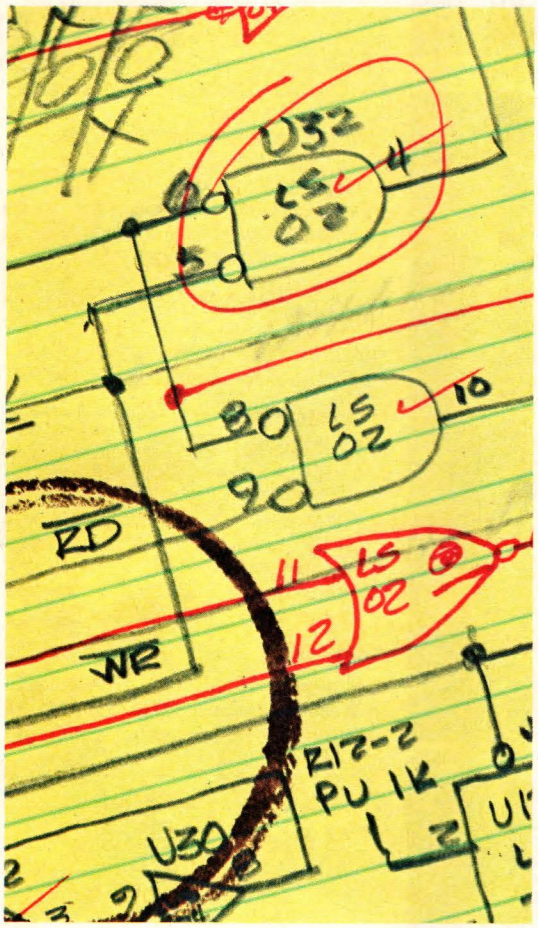
EDN 112984

Mail to: *Datel, 11 Cabot Blvd., Mansfield, MA 02048*

DVC-350

CIRCLE NO 193

DON'T WASTE YOUR TIME ON SEMICUSTOM.



Let's face it. Your logic diagram is just one big doodle if your semicustom vendor can't take it and turn it into silicon fast.

With Mostek, you won't have time to waste. We have the design tools, technical assistance, and manufacturing muscle needed to quickly take you from concept to completion.

For example, our Semicustom Design Centers give you access to extensive libraries of gate arrays and standard cells. And our Highland 2[SM] design automation system is easy to learn and use.

You can select gate arrays up to 10,000 gates. Standard cell libraries at your disposal will include analog, RAM, ROM, and PLA's. All implemented in double level metal CMOS with performance down to 1.5 ns per gate.

Before you know it, you'll be creating system level designs from our precharacterized macrocells with the confidence that comes from guaranteed performance. And you can count on Mostek performance as well.

During your design phase, our staff is available to answer any questions you have regarding Highland 2, the cell libraries, testing or packaging. Then Mostek's extensive production facilities will take you and your design smoothly through prototyping and manufacturing.

We have a comprehensive second source agreement with Gould/AMI, so you can be confident of support at every stage of the process.

The final result? You save time, trouble, and can lower the cost of new product development. Stop wasting your time. Contact Mostek Corporation, 1215 W. Crosby Road, MS2205, Carrollton, Texas 75006, or call (214) 466-6000. In Europe, call (32) 02/762.18.80. In Japan, 03/496-4221. In the Far East (Hong Kong), 5-681157.

Highland 2 is a service mark of Mostek Corporation.

UNITED TECHNOLOGIES MOSTEK

Program automates error analysis of time-interval measurements

Calculating resolution and accuracy for a programmable counter's time-interval error can be a big job if done by hand. A program that's adaptable to any counter can relieve much of the burden.

Johnnie Hancock, *Hewlett-Packard Co*

When using a counter to make time-interval measurements, you often need information about a measurement's resolution and accuracy as much as you need the measurement itself. Most counters don't provide such information, and to determine worst-case error for a single measurement by hand, you might have to spend days studying theory and working through an equation with 20 or 30 factors. You can save considerable time and effort, though, if you implement an error-analysis program in your counter.

Error analyses can be deceptively complex. Time-interval specifications consist of many components; each contributes error to varying degrees under different conditions. Counter users often assume that a time-interval measurement's accuracy approximately equals the systematic error spec (the difference between the delays of each input channel) on the counter's data sheet. Although true in some cases, this assumption doesn't always hold, because the real world doesn't contain infinitely fast rise- and fall-time waveforms. Consequently, you're forced into analyzing your setup's accuracy and taking other factors into account.

Error-analysis program for any counter

A programmable counter that has a built-in error-analysis program measures and computes resolution and accuracy for any time-interval measurement. Such error-analysis programs often reveal facts about timing accuracy that users usually don't consider. Recognizing these facts can save time and money by eliminating redesign and rework. You can take this capability one step further by using a computer with your programmable counter and the error-analysis program.

Such a program can find time-interval errors on any counter; a program written for the HP 1965A gated universal counter (an expansion module for the HP 1980 oscilloscope measurement system) demonstrates the calculations required for time-interval error analysis. (The program is one of 49 subprograms that constitute the HP 19800/19801 waveform-measurement library.)

The 1965A gated universal counter includes built-in features—for example, internal measuring of trigger hysteresis and trigger-level offset—that enhance error analysis and eliminate some error components. Although these features aren't in all counters, you should have little trouble writing an error-analysis program for your particular unit.

PROGRAM VARIABLES

Ti	TIME INTERVAL
Ace	ACCURACY
Res	RESOLUTION
Lsd	LEAST-SIGNIFICANT-DIGIT ERROR
Se	SYSTEMATIC ERROR
Ne	NOISE ERROR
He	HYSTERESIS ERROR
Tle	TRIGGER-LEVEL ERROR
Nea	NOISE ERROR OF A
Neb	NOISE ERROR OF B
Sra	SLEW RATE OF A
Srb	SLEW RATE OF B
Ha	HYSTERESIS OF A
Hb	HYSTERESIS OF B
Osa	OFFSET ERROR OF A
Osb	OFFSET ERROR OF B

You need resolution and accuracy as well as the measurement itself

The program comprises subroutines for measuring and computing each component of the time-interval specification. The entire time-interval specification consists of the following components:

resolution = ± least-significant-digit error
± noise error
accuracy = ± least-significant-digit error
± noise error ± time-base error
± hysteresis error ± systematic error.

Time-base error is negligible in nearly all time-interval measurements. You can easily see why it's often insignificant: The accuracy of a typical oscillator's counter is spec'd at one part in 10^6, yielding a 0.0001% error in a time-base measurement. Time-base error does play a significant role, though, in frequency measurements and in those time-interval measurements requiring an interval that's seconds long.

Each component in the time-interval equation is a function of various test-setup conditions. A component varies with such factors as the number of averages, the trigger levels, and input conditioning. In the 1980 measurement system, the system controller determines the instrument's setup with a Learn string that defines the instrument status. You can enter variable settings directly with an IEEE-488 commmand (the nearby **table** lists the variables used in the program). If your counter doesn't offer these Learn strings, you must define setup conditions as inputs in the error-analysis program.

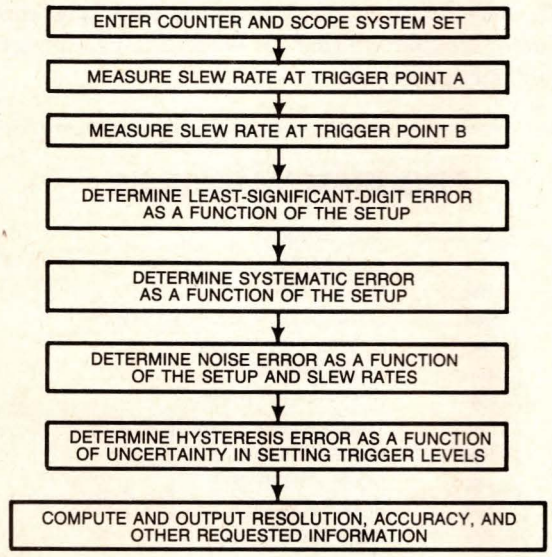
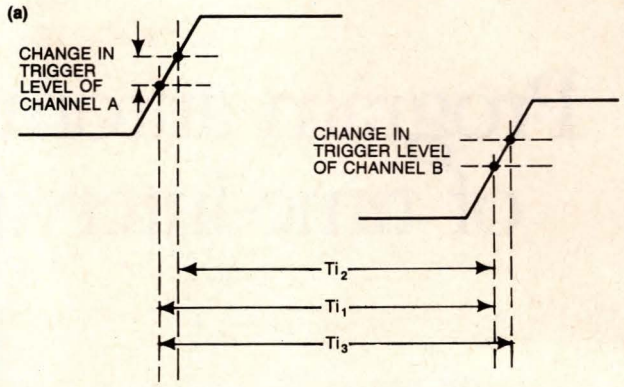


Fig 1—A simplified flowchart *for calculating time-interval error specifications points out the various error sources you must take into consideration.*



(b)

```
3100 CALL Read65(Ti1)                    ! Read current time interval
3104   IF ABS(Ti1)>1.E+90 THEN Abort     ! Ensure measurement is valid
3108 Shft=20                             ! Trigger level shift 0.2 div
3112 IF SGN(Tla)>0 THEN Shft=-Shft       ! Ensure shift in right direction
3116 OUTPUT @Scope;Lvl$&VAL$             ! Change 1980 trigger level
     (Tla*100+Shft)
3120 CALL Read65(Ti2)                    ! Read time interval
3124   IF Ti2>1.E+90 THEN Abort          ! Ensure measurement is valid
3128 Dt=ABS(Ti2-Ti1)                     ! Change in time
3132 IF Dt=0 THEN Dt=1.0E-11             ! Avoid division by 0
3136 Sra=ABS(.01*Shft*Sna/Dt)            ! Slew rate at trigger point A
```

Fig 2—To calculate slew rate, *change the trigger level slightly and measure the difference between the time intervals* ***(a).*** *The subroutine* ***(b)*** *increments trigger levels by 0.2 divisions.*

Though some components depend solely on instrument setup, others are affected primarily by the characteristics of the signals under test. Therefore, prior to computing the specifications, you must describe the system setup and characterize the signal under test. The flowchart in **Fig 1** can guide you in writing a program that measures and computes time-interval specifications.

Adjust triggers to measure slew rates

Because most error components are functions of the system setup and the input slew rates of the reference system's A and B input channels, you must measure those slew rates first. Some counters provide built-in slew-rate routines, but you should read the spec sheet carefully to see whether the slew-rate figure those routines determine is a function of a small incremental change at the trigger-level point or of the 10 to 90% rise and fall times. Remember, a 10 to 90% calculation doesn't really yield slew rate and can introduce inaccuracies into your results; the slew rate represents the instantaneous rate of change at one point, not the average rate over 80% of the waveform range. For best results, you must determine the slew rates at the trigger points of the signals in channels A and B.

Measuring the slew rate in this manner is a simple process: You perform only three time-interval measurements (**Fig 2a**). First, you measure the time interval for the current setup and label this answer Ti1. Second, you change the A input's trigger level by a small incremental voltage relative to the input signal's peak-to-peak amplitude and measure the time interval; label it Ti2. Finally, return the A input's trigger level to its original setting and change the B input's trigger level by a small incremental amount. Measure the time interval and label it Ti3.

As you can infer from **Fig 2a,** the slew rates are defined as follows:

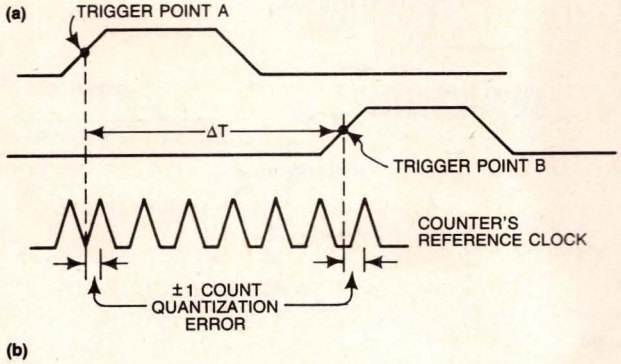
$$\text{slew rate}_A = \frac{\Delta V}{Ti2 - Ti1}$$

$$\text{slew rate}_B = \frac{\Delta V}{Ti3 - Ti1.}$$

The portion of the error-analysis program that measures and determines the slew rate (**Fig 2b**) uses this setup information for determining the channel A signal's slew rate. In the code,

- Tla stands for the trigger level of A.
- Sna stands for the input sensitivity of A in volts per division.
- Lv1$ is the string that indicates which trigger level to adjust.

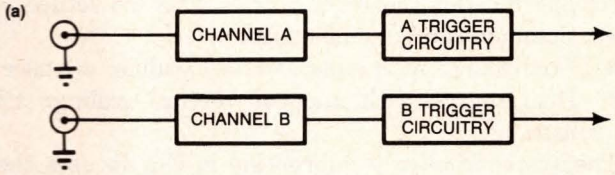
This subroutine increments trigger levels by 0.2 div. The reference system's controller reads input vertical scaling to convert trigger-level changes into volts. Furthermore, the 1980's continuous vertical scaling ensures that the 0.2-div trigger-level change is small relative to the peak-to-peak waveform. For example, if you scale the input waveform so that the screen displays 10 div, then 0.2 div is only 2% of the peak-to-peak waveform. Also note that **Fig 2b**'s listing determines the slew rates' absolute values; before the program ends, however, it assigns the proper signs to the slew rates of A (variable Sra) and B (variable Srb).



(b)

```
3252 !  COMPUTES LEAST SIGNIFICANT DIGIT
3256 !
3260  Avg=10^((Rsl-1)*2)    ! Number of averages selected
3264  Lsd=1.0E-8/SQR(Avg)   ! Least significant digit
```

Fig 3—Least-significant-digit error *arises from the counter's reference clock or single-shot time-interval capability* **(a).** *Averaging can reduce the error if you avoid coherence with the counter's clock.*



SYSTEMATIC ERROR = DIFFERENCE OF DELAYS OF EACH CHANNEL

(b)

```
3392 ! DETERMINES THE SYSTEMIC ERROR FOR THE SETUP
3396 !
3400  Se=2.E-9                    ! Worst case system error = 2 nS
3404  IF Sna=Snb THEN Se=1.E-9    ! If equal scaling, then 1 nS
3408  IF As=Bs THEN Se=5.00E-10   ! If common source, then 500 pS
```

Fig 4—Systematic error is the difference in delay *between the two input channels* **(a).** *It's often (mistakenly) assumed to be approximately equal to the counter's time-interval error.*

Averaging reduces LSD error

The next step is to find the least-significant-digit error (**Fig 3a**); you determine this error level from the counter's reference clock or single-shot time-interval specs. Averaging can statistically reduce least-significant-digit error if the signals aren't coherent (see **references**). In the test setup used here, the 1965A's reference clock is phase modulated to break coherence every time it occurs.

The following equation determines least-significant-digit error:

$$\text{least-significant-digit error} = \pm \frac{\text{reference-clock period}}{\sqrt{\text{number of averages}}}.$$

The 1965A's system reference-clock period is 10 nsec, and you can select a single-shot mode or one, 100, 10,000, or 1,000,000 averages, resulting in resolution as high as ±10 psec. The counter also has an autoresolution feature that automatically selects the most averages possible without exceeding a maximum waiting time of 2.3 sec for an updated measurement.

Fig 3b shows the error-analysis subroutine that calculates the least-significant-digit error (variable Lsd). Rsl is a setup variable, ranging from 1 to 4, that defines the number of averages selected.

Systematic error is often predefined

Next you examine systematic error, which is the difference between the delays of each channel (**Fig 4a**).

Time-interval error equations can contain 30 factors

For most counters, systematic error is a single factor, like ±1 or ±2 nsec. The 1980/1965 system's systematic-error specification, however, varies with the setup:

- Common source: ±500 psec
- Dual source with equal vertical scaling: ±1 nsec
- Dual source with unequal vertical scaling: ±2 nsec.

The systematic-error subroutine in **Fig 4b** uses the following variables to define the setup: Sna and Snb stand for the input sensitivities of A and B in volts per division, and variables As and Bs stand for the trigger sources of A and B (main or delayed). The subroutine as shown accounts for the 1980/1965 system's setup. For other counters, you can simplify the subroutine to add one term regardless of the setup conditions.

Noise error from trigger circuitry

The noise component in the error equation arises from noise in the input signal and the counter's trigger circuitry **(Fig 5a).** The error-analysis subroutine in **Fig 5b** is based on the assumption that input noise is minimal, and it uses the following equations to compute the error caused by system noise:

$$\text{noise error} = \sqrt{(\text{noise error}_A)^2 + (\text{noise error}_B)^2}$$

where

$$\text{noise error}_A = \pm \frac{\text{noise of A (in volts)}}{\text{slew rate}_A \times \sqrt{\text{number of averages}}}$$

$$\text{noise error}_B = \pm \frac{\text{noise of B (in volts)}}{\text{slew rate}_B \times \sqrt{\text{number of averages}}}.$$

In reviewing the subroutine that determines timing error caused by noise (variable Ne), add the following setup variables to those previously defined:

- Na and Nb stand for the noise in channels A and B.
- Sra and Srb stand for the slew rates of A and B in volts per second.

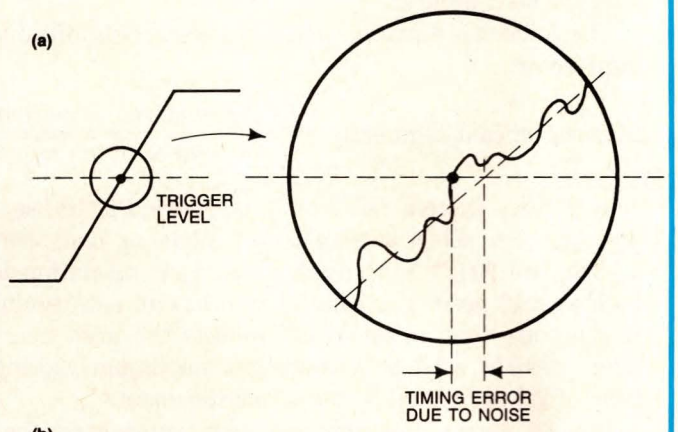
The reference system's worst-case noise specification is 0.02 div. The 1980's actual noise in each trigger channel is typically less than 0.02 div, so the controller can measure it and enter it into the program. If you don't include the noise data, the program defaults to the 0.02-div worst-case specification.

Equal slew rates don't cancel hysteresis

Hysteresis error—the timing error induced by the trigger circuitry's inherent hysteresis—is more difficult to calculate. Although hysteresis prevents false triggering on noise, it produces a timing error that varies with the slew rates **(Fig 6a):**

$$\text{hysteresis error} = \frac{\text{hysteresis}_A/2}{|\text{slew rate}_A|} - \frac{\text{hysteresis}_B/2}{|\text{slew rate}_B|}$$

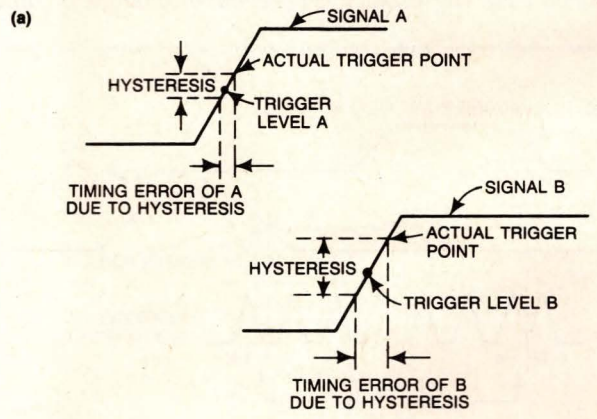
Some counter manufacturers don't publish hysteresis specifications, and most don't distinguish possible differences in the hysteresis of A- and B-channel triggering circuitry. In many cases, the difference in hysteresis contributes most significantly to the error, especially when the slew rates of A and B are equal.



(b)

```
3272 ! COMPUTES TIMING ERROR DUE TO NOISE OF SYSTEM
3276 !
3296  Nea=Na*Sna/(Sra*SQR(Avg))    ! Noise error of A in seconds
3300  Neb=Nb*Snb/(Srb*SQR(Avg))    ! Noise error of B in seconds
3304  Ne=SQR(Nea^2+Neb^2)          ! Total RMS noise error in seconds
```

Fig 5—Noise error arises from noise in the input signal *and the counter's trigger circuitry* ***(a).*** *The subroutine* ***(b)*** *assumes that noise is minimal.*



(b)

```
3320 ! COMPUTES TIMING ERROR DUE TO HYSTERESIS
3324 !
3376  He=ABS(Ha/2*Sna/Sra-Hb/2*Snb/Srb)   ! Total hysteresis error
```

Fig 6—Hysteresis error arises from the trigger circuitry *and is a function of the slew rate* ***(a).*** *It's the difference in hysteresis of each channel's triggering circuitry that contributes most to the error equation. After the subroutine* ***(b)*** *computes the error, the counter stores the hysteresis values in nonvolatile RAM.*

```
3420 ! COMPUTE TIMING ERROR DUE TRIGGER LEVEL ERROR
3424 !
3428  Tle=ABS(.03*Tla*Sna/Sra)+ABS(.03*Tlb*Snb/Srb)+ABS(Osa*Sna/Sra-Osb*Snb/Srb)
3432  IF As=Bs THEN Tle=0                    ! No timing error if common source
```

Fig 7—The timing error caused by the uncertainty *in setting trigger levels can be the largest error component for signals with slow slew rates. You can use the hysteresis and offset values that this routine calculates to provide trigger-level compensation and eliminate their error contributions.*

According to some counter specifications, if the slew rates were equal, the hysteresis-error component would always cancel out. This condition obtains only when both the A and B inputs use the same trigger circuitry, which is the case for common-source measurements taken by the reference counter.

Fig 6b's error-analysis subroutine computes the error stemming from hysteresis (variable He). To use the subroutine, define the following setup conditions and parameters and combine them with those previously defined:

- Ha is the hysteresis of trigger channel A in divisions.
- Hb is the hysteresis of trigger channel B in divisions.

The reference system automatically measures the actual hysteresis of each trigger channel of the 1980 and stores those values in nonvolatile memory. These values are accessible over the IEEE-488 bus and are used in this error-analysis subroutine. You can also use hysteresis values to provide trigger-level compensation and, as a consequence, reduce the hysteresis-error component.

From the setup conditions, you can determine not only the proper hysteresis values but also the proper offset levels for A and B (variables Osa and Osb), which you need to determine trigger-level error. Uncertainty in setting trigger levels can generate timing errors. Most time-interval specs don't include this component as a part of the accuracy, but you must add it for a true error analysis. In fact, for signals with slow slew rates, the error caused by uncertainty in setting trigger levels can be the largest component of time-interval error. **Fig 7**'s subroutine generates this component as a separate variable and makes it available to the user.

Autocompensate for trigger-level error

You can determine trigger-level error with the following equation:

$$\text{trigger-level error} = \pm \frac{\text{trigger accuracy}_A}{\text{slew rate}_A} \pm \frac{\text{trigger accuracy}_B}{\text{slew rate}_B}.$$

Note that, for common-source measurements taken by the reference-system counter, the trigger-level error is zero.

The subroutine uses variables already defined plus the following setup data and measured parameters:

- Tla and Tlb stand for the trigger levels of A and B in divisions.
- Osa and Osb stand for the offset error of A and B in divisions.

The reference system automatically measures and stores trigger-offset errors in RAM. This subroutine uses these actual error values in computing the trigger-level error (variable Tle).

Hysteresis and offset values are also accessible over the IEEE-488 bus. You can use these values to provide

```
3444 ! TOTAL ERROR COMPUTATION
3448 !
3452  Acc=Lsd+Ne+He+Se     ! Total possible error
3456  Res=Lsd+Ne           ! Measurement resolution
```

Fig 8—To calculate total error *you merely sum up the contributions of the individual sources determined earlier.*

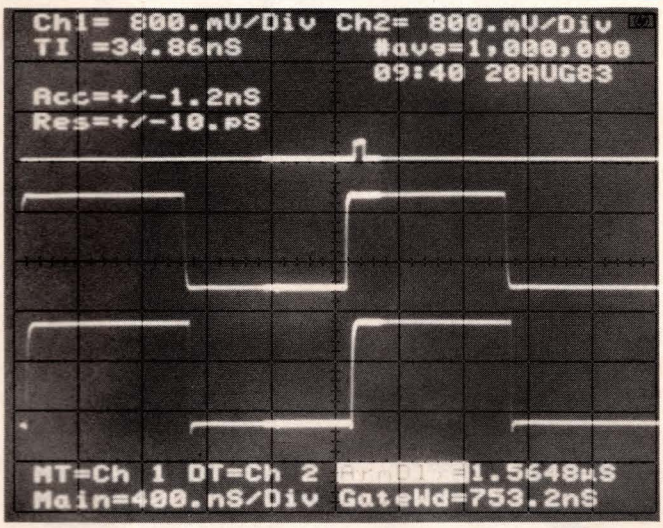


Fig 9—This CRT output from the error-analysis program *shows the resolution and accuracy for a typical propagation-delay measurement taken by the reference system (1980 oscilloscope and 1965A gated universal counter).*

Which LMI shielded room do you need for TEMPEST • EMP Hardening RFI/EMI Testing • Shielded Anechoic Chambers • Biomedical?

LMI can supply them all.

Shielded anechoic chambers provide more than 100 dB of RF shielding over a total frequency range of 1.0 KHz to 10 GHz, and up to 100 GHz on special applications. Meet MIL-STD-461/462.

All-welded shielded rooms with RFI/EMI shielding effectiveness to 120 dB– 140 dB+. Meet TEMPEST and other secure requirements. Ideal for EMP hardening.

Lectroshield® Clamp-together rooms with shielding effectiveness to 100 dB+. 1.0 KHz to 10 GHz attenuation for MIL-STD-285, NSA 65-6 and FCC testing. Prefabricated, modular.

Chambers for Nuclear Magnetic Resonance (NMR). For biomedical uses.

LectroMagnetics has the shielding solution for you. Write or call for additional information.

LectroMagnetics, Inc.
6056 West Jefferson Boulevard
Los Angeles, California 90016
Telephone (213) 870-9383
Toll-Free (800) 325-9814

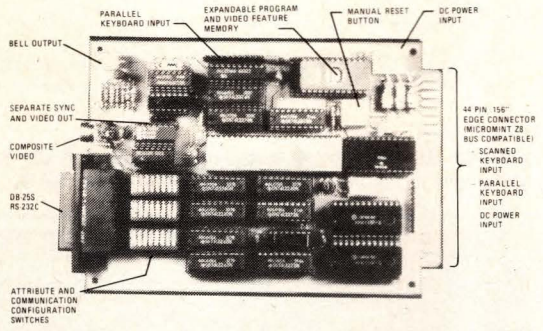
Nationwide representatives

LMI LectroMagnetics, Inc.

CIRCLE NO 90

A SMART TERMINAL
in a small (and inexpensive) package

The TERM-MITE ST
price: $214*
size: 4½" x 6½"



Why pay $1000 or more for a comparable smart terminal? The TERM-MITE ST featuring the new NS405 terminal management processor offers you all of the following on a single 4½" x 6½" board:

- -128 displayable characters
- -11 graphics characters
- -24 lines by 80 characters
- -25th line reverse video status display
- -21 escape functions
- -14 control functions
- -CRT refresh at 50 or 60 Hz
- -Separate transmit & receiver baud rates (110 - 19,200 bps)
- -Supports scanned or encoded keyboards
- -Directly drives composite video or separated sync monitors
- -Video attributes - reverse video half intensity double height double width underlined blinking and blank characters

*in 100 quantity.
Single quantity price $284.

— TO ORDER —

The TERM-MITE ST video display terminal board item #BCC22 . . . $284.00 postpaid

Orderline 1-800-645-3479
Information: 1-516-374-6793

THE MICROMINT, INC.
561 Willow Avenue, Cedarhurst, NY 11516

CIRCLE NO 91

Systematic error alone doesn't define total system error

trigger-level compensation and thereby eliminate timing errors caused by the uncertainty in setting trigger levels. The following formulas show how to determine trigger levels that compensate for errors induced by trigger-level offset errors and hysteresis:

$$\text{Tl (to set)} = \text{Tl (desired)} + \text{offset error} - \frac{\text{hysteresis}}{2}$$

(for a positive slope)

$$\text{Tl (to set)} = \text{Tl (desired)} + \text{offset error} + \frac{\text{hysteresis}}{2}$$

(for a negative slope).

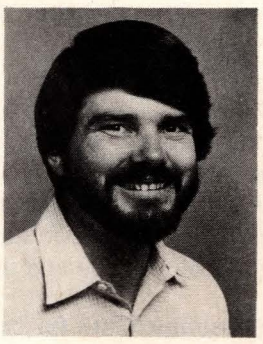
Complete program generates any variable

At this point, you can take all the individual components derived thus far and execute the complete error-analysis program. It measures, calculates, and displays resolution and accuracy specifications on the oscilloscope's CRT. **Fig 8** shows the part of the program that computes the final resolution and accuracy and sends that data to the CRT. **Fig 9** shows a typical propagation-delay measurement made using the error-analysis program. You can send the analysis of any variable to a CRT screen for immediate evaluation, and you can easily modify the program to generate other specified information. **EDN**

References

1. Chu, David C, "Time-interval averaging: theory, problems, and solutions," *HP Journal,* June 1974, pg 12.
2. Hancock, J, "Innovative design techniques yield optimum counter oscillator," *EDN,* October 13, 1983, pg 209.

Author's biography

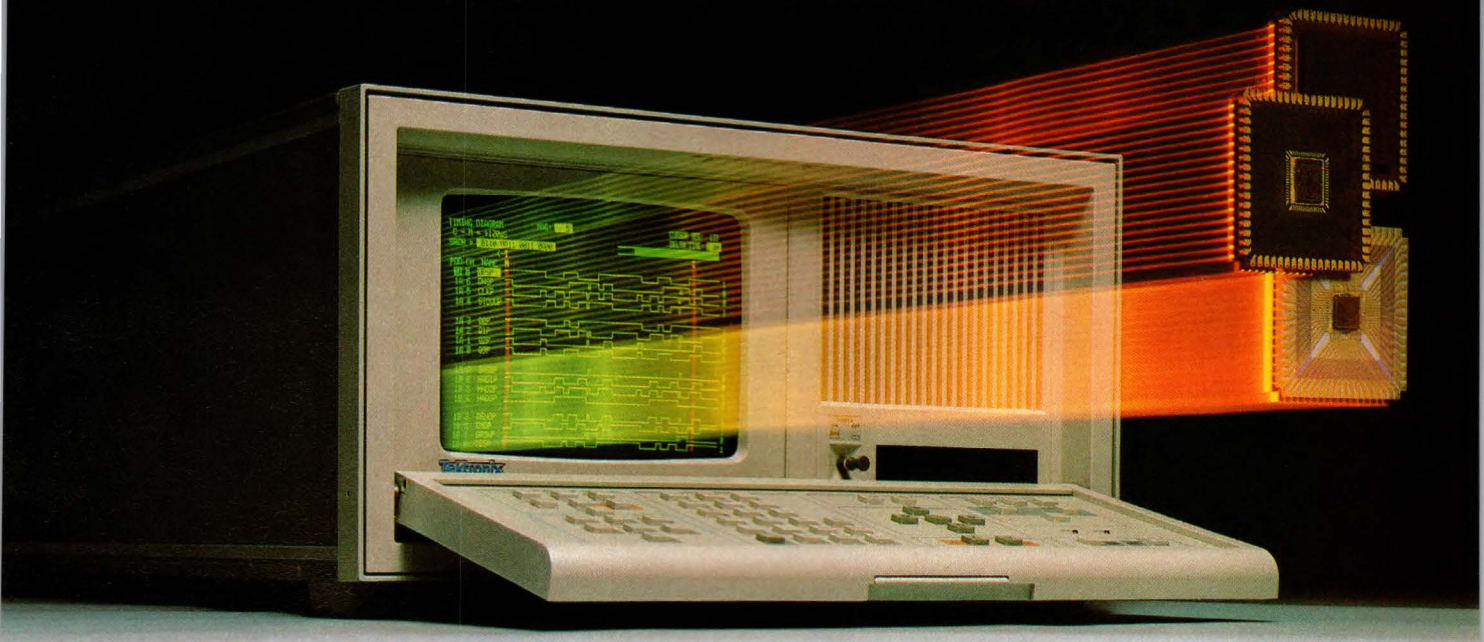


Johnnie Hancock is an R&D hardware-design engineer for Hewlett-Packard's Colorado Springs Div, where he is currently working on the analog and digital design of digitizing oscilloscopes. He has a BSEE degree from the University of South Florida and is a member of Tau Beta Pi. In his spare time, Johnnie enjoys skiing.

Article Interest Quotient (Circle One)
High 485 Medium 486 Low 487

TEK DESIGNLINK™ VLSI VERIFICATION SOFTWARE

VLSI VERIFICATION: NOW YOU CAN REALLY PUT THE DAS TO THE TEST!



If you thought the DAS 9100 was a powerful logic analyzer before, wait til you see what it can do now: VLSI prototype testing!

Tek's new 91DVV DesignLink™ VLSI Verification Software Package ties the DAS to a VAX computer to let you do interactive functional testing right at your benchtop.

Only the DAS, with its unique channel width and stimulus capability, could develop into this kind of personal test station.

91DVV software converts test vectors used by your simulator into a compressed DAS pattern generator program, then downloads to the DAS for stimulation of the prototype. Resultant outputs are automatically acquired and uploaded to the host, where 91DVV compares actual to simulator-predicted responses and displays the differences.

When it comes to VLSI prototype testing, DesignLink software now lets you bring the test to your bench. Call us today for all the facts on the first VLSI personal test station: 1-800-547-1512. In Oregon, 1-800-452-1877.

*VAX is a registered trademark of Digital Equipment, Inc.

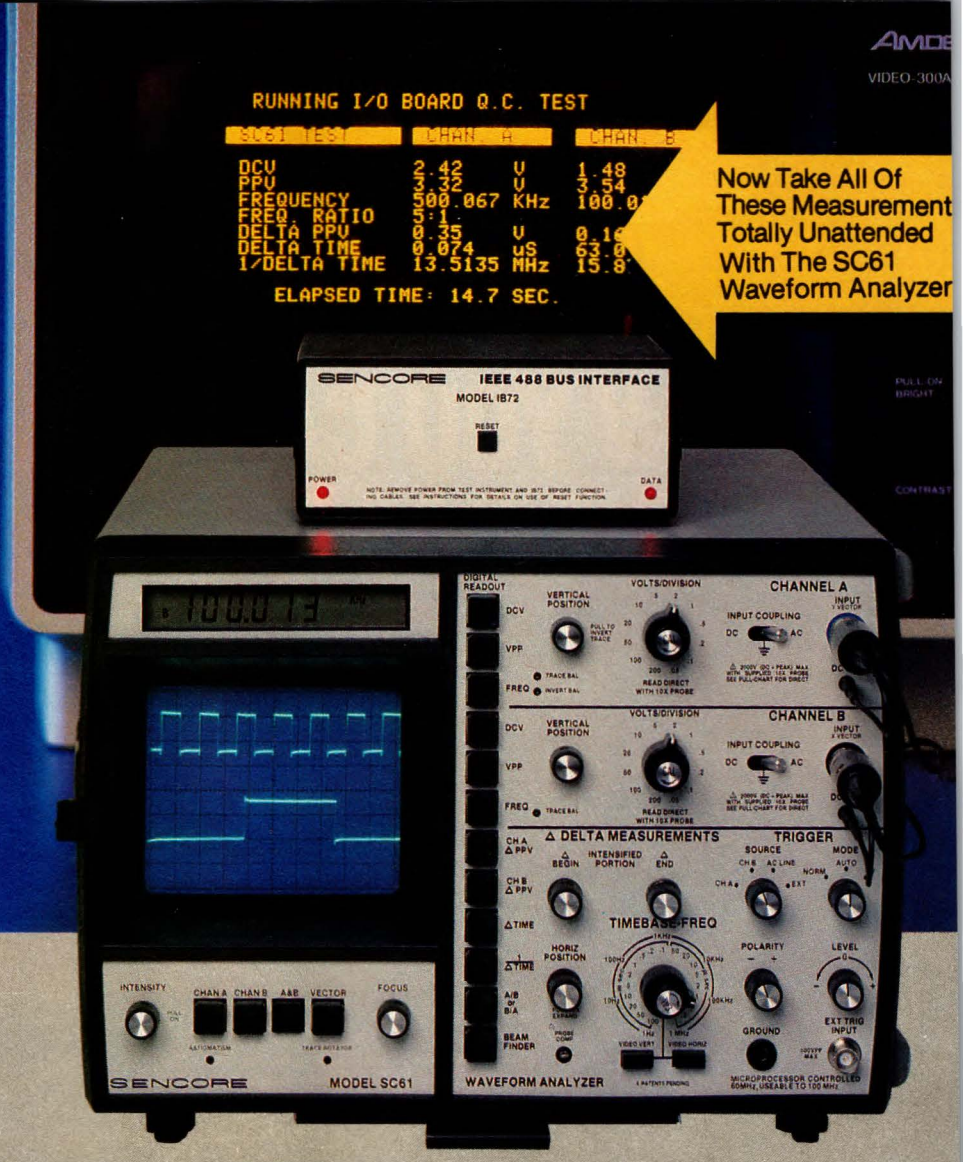
Copyright © 1984, Tektronix, Inc. All rights reserved. LAA-134

Tektronix®
COMMITTED TO EXCELLENCE

Circle No. 118 for literature

Circle No. 157 for sales contact

Simplify Your GPIB* System Designs Like Never Before



*General Purpose Interface Bus

Introducing The All New IEEE 488 Bus-Compatible SC61 Waveform Analyzer — A Total GPIB Measuring Center In One Unit

If you'd like to reduce that big rack of test equipment on your next GPIB test setup, eliminate the messy maze of cables and complex interconnections, and use one uniform programming syntax for all of your measuring functions, the all-new SC61 GPIB Waveform Analyzer is for you.

IT'S A TOTAL GPIB MEASURING CENTER IN ONE UNIT: The SC61 replaces up to seven separate GPIB instruments all in one unit including:

- Two DC volt meters autoranged to 2,000 VDC
- Two Autoranged frequency counters to 100 MHz.
- Two exclusive PPV meters — good to 60 MHz
- One special △ (Delta) tester for time, frequency or PPV for any waveform section you select for either scope channels A or B.

GPIB Talker & Listener COMPATIBLE

And you program any or all of these measurements with only one programming syntax — eliminating the confusion and frustration associated with multiple piece programming.

Plus the SC61 is both a talker and listener meaning true unattended operation for your ATE test station.

A TRUE VALUE: At $2,995 ($625 additional for the IB72 488 Bus Interface) you get a lot more for your budget dollar with the SC61 compared to buying individual pieces. And when not on the bus, the SC61 doubles as an excellent digital readout scope (3dB at 60 MHz, 12dB at 100 MHz) stretching your budget dollar even further.

CIRCLE NO 92

LIMITED OFFER - 15 DAY TRIAL: We're so convinced that after even a few hours of use you will make the SC61 the heart of your next GPIB test setup that we want you to try an SC61 and IB72 for 15 days to convince yourself. There is absolutely no obligation. If you do return the SC61 at the end of 15 days, there will be no questions asked.

We've set 100 units aside for this trial period, so act quickly — first come, first served. Simply mail the enclosed return card, or . . .

PHONE TOLL-FREE 1-800-843-3338

In Canada Toll-Free 1-800-665-4871
South Dakota, Alaska, and Hawaii call collect at 605-339-0100
Sencore, Inc., 3200 Sencore Drive
Sioux Falls, South Dakota 57107

SENCORE

AND THE WINNERS ARE...

Below are the twelve advertisers and their agencies voted to be the most informative, attractive and helpful by EDN readers in the August 9, 1984 issue.

EDN READER VOTE CONTEST WINNERS

Advanced Micro Devices

Keye, Donna, Pearlstein

Harris Semiconductor

The Downs Group

Hewlett-Packard

Tallant/Yates

National Semiconductor

Foote, Cone & Belding

Rockwell International

Campbell-Ewald

Tektronix

Young & Roehr

Teradyne Connection Systems

Quinn & Johnson/BBDO

Texas Instruments

McCann-Erickson

Toshiba America

Michelson Advertising

Valid Logic

Gary Silverstein Associates

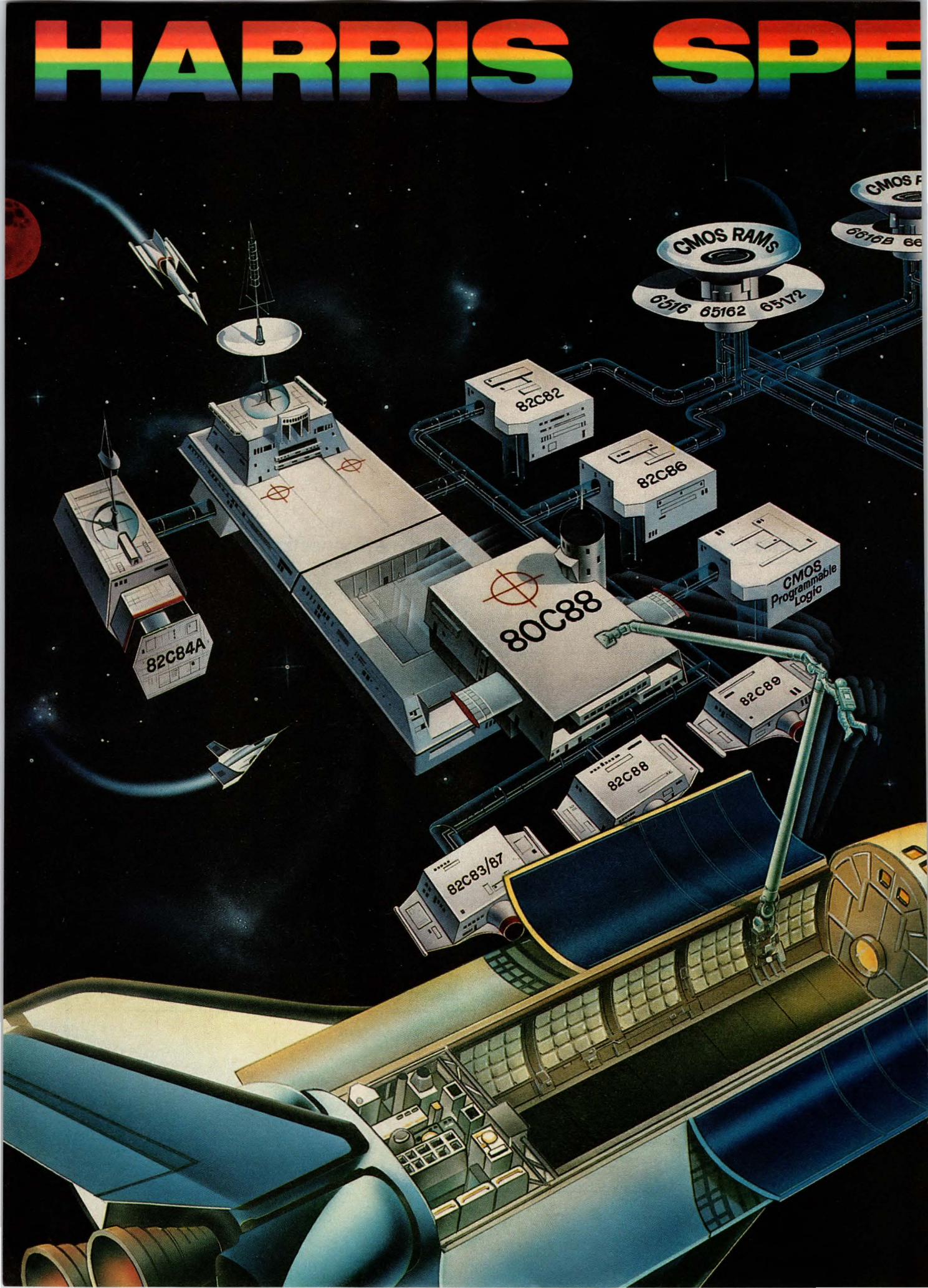
Zilog

Pinne, Garvin, Herbers & Hock

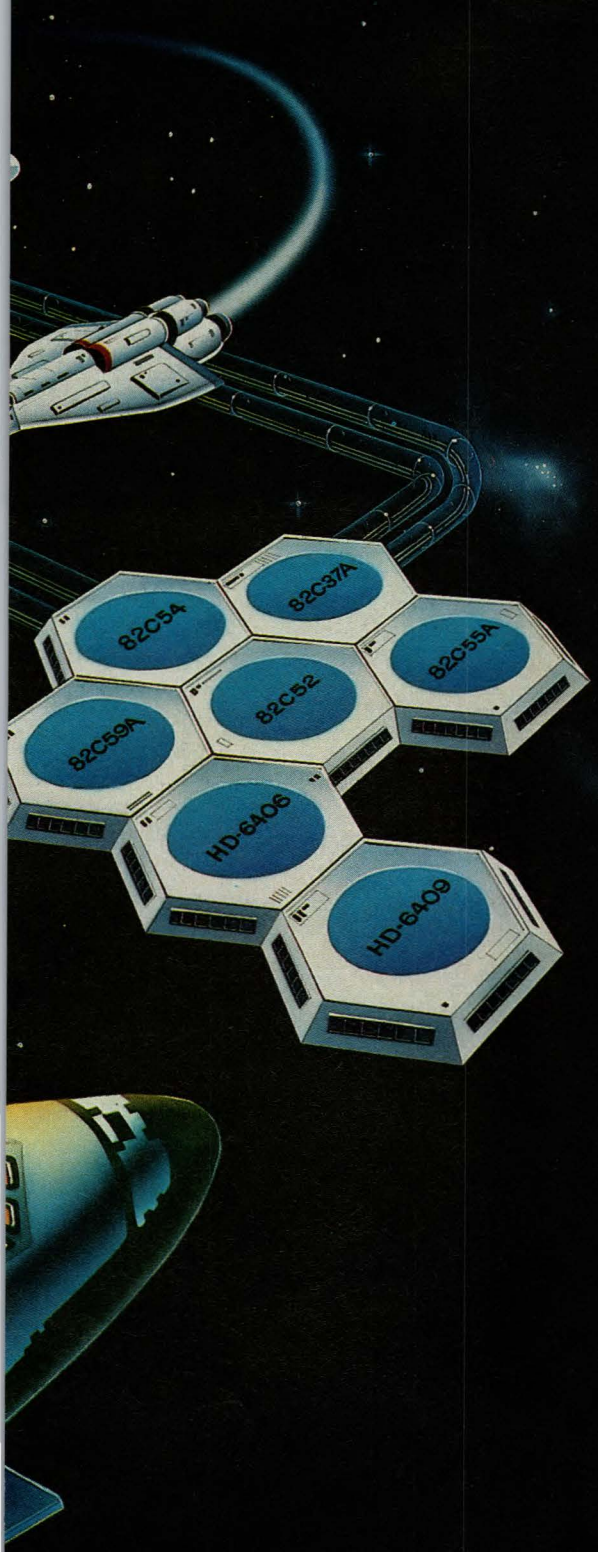
Zytrex

Ernst Associates

EDN


HARRIS SPE
CMOS RAMs
6516 65162 65172
82C82
82C86
80C88
CMOS Programmable Logic
82C84A
82C89
82C88
82C83/87

CTRUM



Introducing the Harris 80C88.

New CMOS Microprocessor gives 100% output with 10% power input.

Get the new Harris 80C88 8/16-bit CMOS CPU into your system. It's fully compatible with your present NMOS 8088 designs, yet consumes only 10% of the power. And the 80C88 16-bit architecture interfaces with memory and I/O via an 8-bit bus, making system design simple and efficient.

The 80C88 is a cool customer. It needs no heat sinks or cooling fans. And its completely static design gives you the freedom to run at a full 5 MHz or at reduced speed to conserve power.

You can even stop the clock to the 80C88 and put the system into a minimum-power standby mode.

There's no need to rework hardware or software. The new Harris 80C88 can execute programs designed for 8088, 8086 and 80C86 systems without any changes. Its industry-standard operation allows simple system upgrades, using your existing NMOS 8088 design and new Harris 80C86 peripherals.

Minimum and maximum operation modes let you configure your system to achieve the highest possible performance level. Over commercial, industrial and military temperature ranges. Guaranteed.

For out-of-this-world performance, get the new Harris 80C88 CMOS μP into your system—data processing, robotics, industrial controls, portable computers, telecommunications, harsh environment or military applications. It's the high-powered, low-energy successor to NMOS 8088 design. From Harris, of course.

For more information, contact: Harris Semiconductor Digital Products Division, P.O. Box 883, MS 53-035, Melbourne, Florida 32902-0883.

Harris Semiconductor Sector: Analog · Bipolar Digital · CMOS Digital · Gallium Arsenide · Semicustom · Custom

For your information, our name is Harris.

HARRIS

CIRCLE NO 93

There's always a way out with The High Density Plus Backplane System.

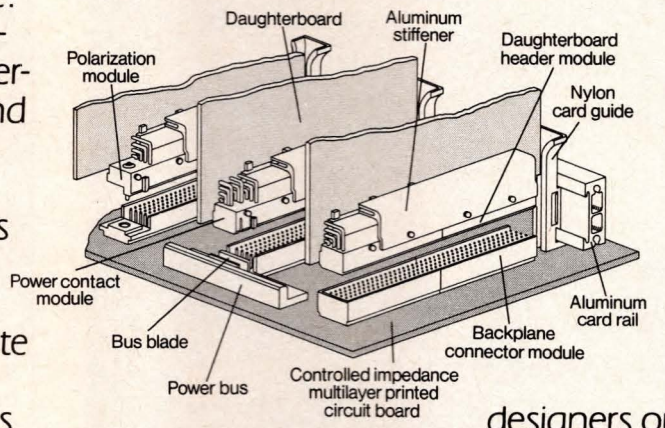
Interconnect density. Signal integrity. Power distribution. The world of VLSI can be a real jungle.

Design engineers feeling trapped by these interconnection demands and time-to-market pressure now have a way out.

The High Density Plus Backplane System.

If you're using ECL, Schottky TTL, CMOS, gate arrays, or standard cell arrays, High Density Plus addresses density, speed, and power management needs better than any product available.

Completely modular, its building block approach lets you customize designs to best meet your needs. Our engineers stand ready and able to help you tailor-make your system. Whether you need the whole system completely assembled and tested, or as individual components, we have what it takes to get you out of any jam.



As the leader in the field, we understand that electronic packaging can be the deciding factor that determines or limits performance, cost and reliability.

So don't delay. We created High Density Plus to get cornered designers out of tight spots. Call us for help today.

Teradyne Connection Systems, 44 Simon Street, Nashua, NH 03060. (603) 889-5156.

TERADYNE

Connecting problem . . . and solution

CIRCLE NO 94

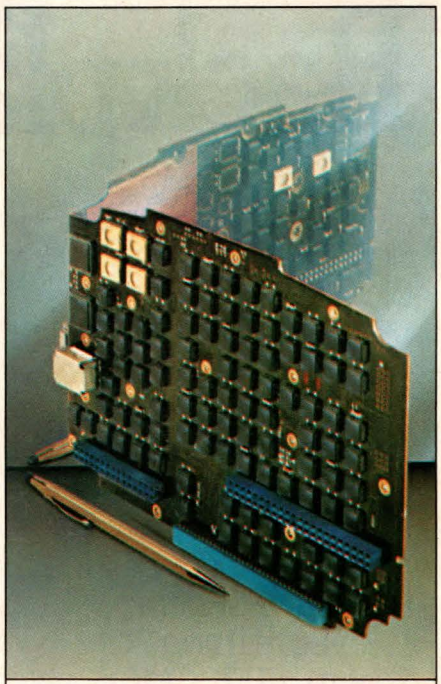
Texas make

As Collins Avionics and Singer-Kearfott developed JTIDS*, the new communications system for the F-15 fighter, Texas Instruments helped solve a severe circuitry packaging problem.

The new system utilizes the most advanced chip packaging technology, the leadless chip carrier. Design objectives called for 191 components to be surface mounted on both sides of a 6″ × 8.5″ printed circuit (PC) board—and to dissipate up to 40 watts of power.

But, during thermal cycling tests, the difference in the thermal coefficient of expansion (TCE) between the ceramic chip carriers and the conventional PC

*Joint Tactical Information Distribution System



Successful application of high-density packaging was achieved in the PC boards of the F-15's new communications equipment. TI's clad metal system solved thermal expansion mismatch. This mirror-reflection photo shows how ICs were mounted on both sides of the PC boards.

◀ **Improved reliability** in the F-15's new communications system (JTIDS) is achieved with TI's copper-clad Invar used to prevent solder joint breakage on densely populated PC boards. TI teamed up with Collins Avionics and Singer-Kearfott to meet the demanding packaging requirements of the fighter's receiver/transmitter.

Instruments and Collins Avionics dense circuit reliability soar.

board caused the solder joints attaching the components to the board to break.

TI's solution: A composite metal core of low-TCE Invar that is clad on both sides with copper. Thin, polyimide-glass, multilayer boards were bonded to each side of the metal, to provide the circuitry function.

With a TCE match between the board and the chip carriers, the PC boards easily passed the exacting thermal cycling tests.

And the metal core in the board dramatically improved thermal conductivity and overall rigidity.

Solves thermal mismatch problems

As Collins Avionics discovered, the advantage of using chip carriers to achieve high-density, high-performance circuitry also imposes stringent demands for increased thermal management, structural integrity, as well as TCE compatibility—demands met by Texas Instruments copper-clad Invar.

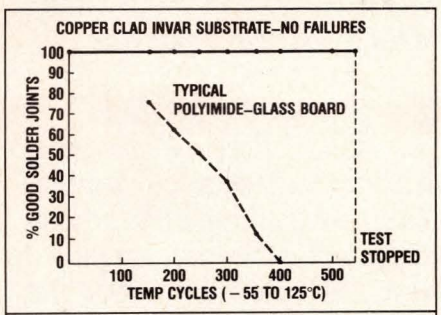
By combining TCE compatibility with high lateral thermal conductivity. And mechanical rigidity.

All at lower cost than alternate approaches. ■

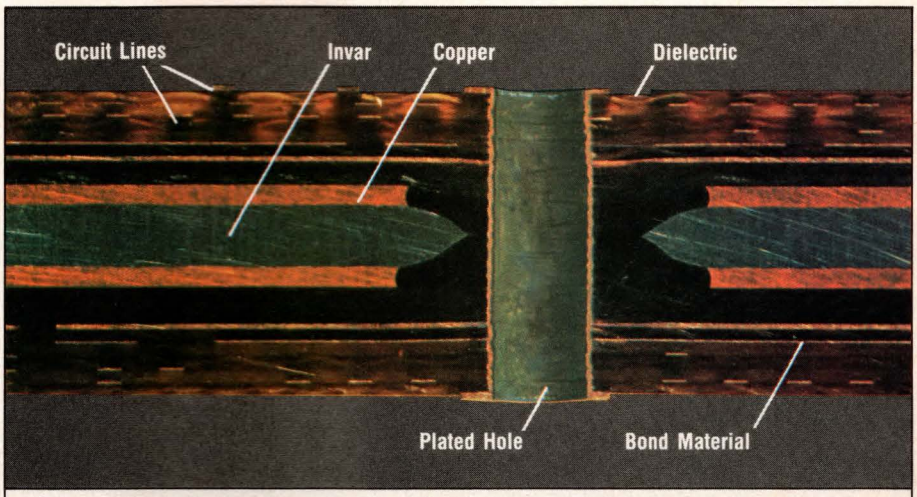
The solution is a trilayer metal.

TI's process involves roll bonding copper foil to Invar—a 36% nickel/64% iron alloy. The bonding to each side of the Invar is accomplished by the same process used to make thermostat metal and coins. No adhesives or brazing alloys are required to achieve a permanent bond.

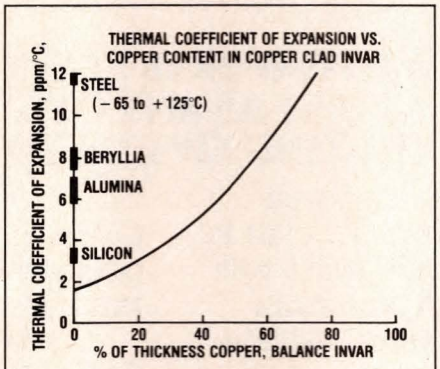
By varying the ratios of the high thermal conductivity copper to the ultra-low TCE Invar, the TCE of the clad metal can be tailored to match that of silicon, alumina, or beryllia.



After 540 thermal cycles from −55° to 125°C failed to break chip carrier solder joints, Collins Avionics halted tests of PC board used in F-15 communications system. Reliability goals had been surpassed by a wide margin.



Effective thermal management is achieved with a copper-clad Invar core that acts as a support for circuitry in the PC board. Heat dissipation characteristics of the copper are excellent, and the Invar contributes rigidity and strength.



Matching the TCE of the metal core of a PC board to chip carrier ceramic is accomplished by bonding the correct ratio of copper to Invar.

This material is available in thicknesses from 5 to 62 mils (.13 to 1.57 mm). You can get it in widths up to 24 inches (610 mm).

Copper-clad Invar is being developed for many other applications: From ground and power planes in multilayer boards, to heat sinks and covers for multichip ceramic modules, and more.

A clad remedy to packaging challenges

TI's innovative clad metal solutions can solve your circuitry packaging problems—with a variety of materials.

You can get copper-cored electron tube materials; nickel-clad stainless steel transistor can materials; copper-clad stainless steel lead frame materials; precious metal, aluminum, and solder selective cladding on base metals for lead frame and connector applications; copper-clad steel, aluminum, and Alloy 42 wire products; and high-speed precision stamping and assembly.

In fact, TI—the world's leading clad metals manufacturer—can help you develop a clad metal solution to many electronic materials problems.

For information, contact Texas Instruments Incorporated, Dept. MMJ9Ø3ED, P.O. Box 401560, Dallas, TX 75240. **1-800-341-5202.**

TEXAS INSTRUMENTS

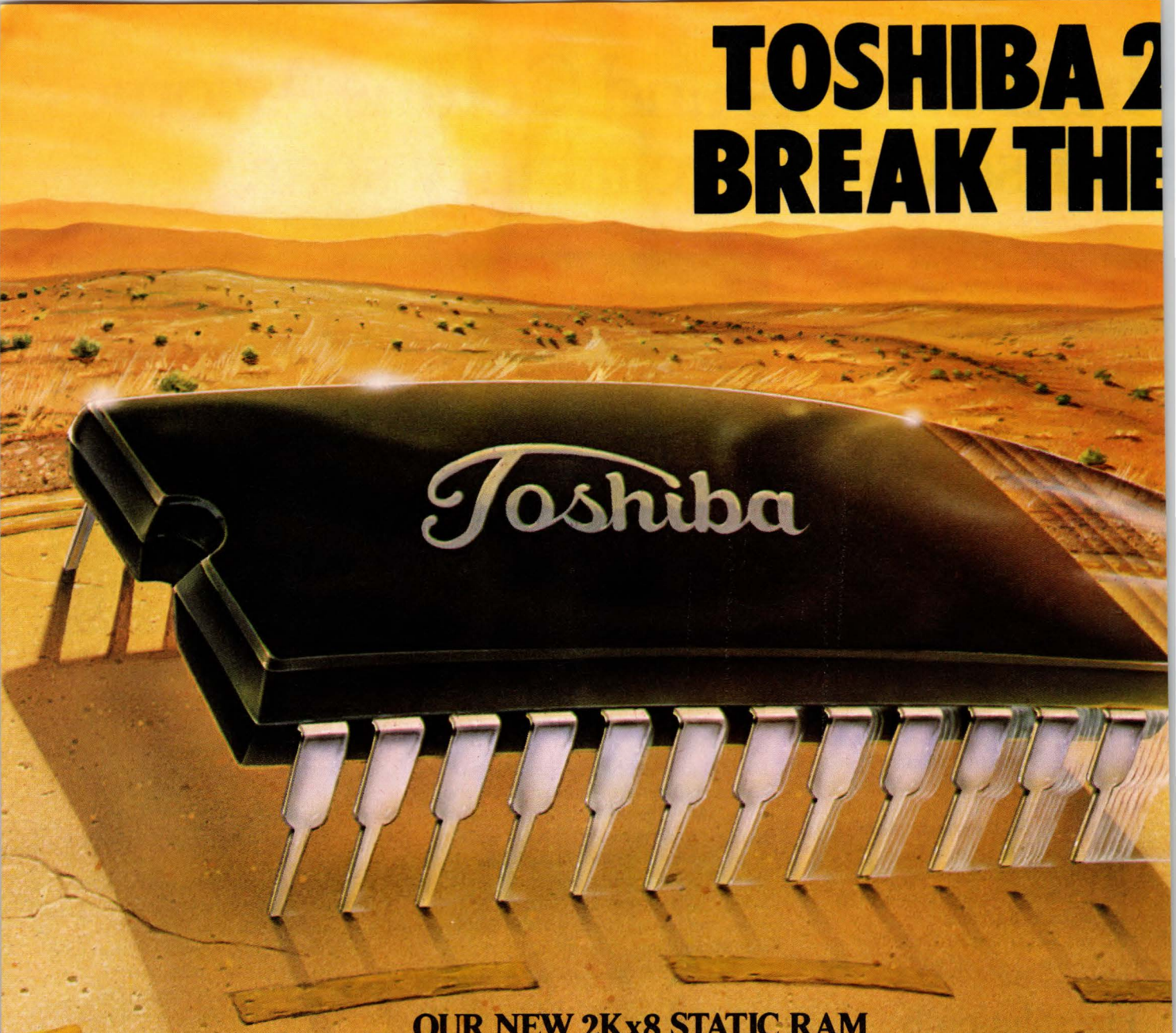
Creating useful products and services for you.

©1983 TI

27-9216

CIRCLE NO 228

TOSHIBA 2
BREAK THE



OUR NEW 2Kx8 STATIC RAM IS TWICE AS FAST AS ANY OTHER BYTE-WIDE. HITTING SPEEDS TO 45ns.

Toshiba has the world's fastest 2K x 8 Static RAM. With speeds as fast as 45ns and other byte-wide units with power consumption as low as 1μA, your range of design options just got twice as wide as before.

Our new TMM2018D provides both high-speed and low-power features with an access time of 45ns. This, along with high density, explains why they're rapidly displacing bipolar devices.

All our high-speed *NMOS* and *CMOS* 2K x 8's are designed for maximum compatibility with microprocessor bus structures.

In fact, ours were the first 16K CMOS RAMs on the market. We designed them for a maximum 1μA standby current.

Operating from a single 5V power supply, our byte-wide RAMs are available in a 24-pin package, DIP (.300″ or .600″), flat pack and a variety of other configurations.

AREA SALES OFFICES: WESTERN AREA, Toshiba America, Inc., (714) 752-0373; **CENTRAL AREA,** Toshiba America, Inc., (612) 831-2566; **EASTERN AREA,** Toshiba America, Inc., (617) 272-4352; **NORTH-WESTERN AREA,** Toshiba America, Inc., (408) 244-4070. **REPRESENTATIVE OFFICES: ALABAMA,** Glen White Associates, (205) 883-7938; **ARIZONA,** Semper Fi Sales Company, (602) 991-4601; **ARKANSAS,** Technology Sales Company, (214) 380-0200; **CALIFORNIA** (Northern), Elrepco, Inc., (415) 962-0660; **CALIFORNIA** (Southern), Bager Electronics, Inc., (714) 957-3367; **COLORADO,** Duffy Associates, (303) 595-4244; **CONNECTICUT,** Datcom, Inc., (203) 288-7005; **DELAWARE,** Vantage Sales, (609) 663-6660; **FLORIDA,** Donato & Associates, (305) 522-2200, (305) 352-0727, (813) 785-3327; **GEORGIA,** Glen White Associates, (404) 441-1447; **IDAHO,** Components West, (206) 271-5252; **ILLINOIS,** L-TEC, (312) 773-2900; **INDIANA,** Leslie M. DeVoe Company, (317) 842-3245; **IOWA,** J.R. Sales Engineering, (319) 393-2232; **KANSAS,** R.R. Burton & Associates, (816) 763-5385; **KENTUCKY,** Leslie M. DeVoe Company, (317) 842-3245; **LOUISIANA,** Technology Sales Company, (214) 380-0200; **MAINE,** Datcom, Inc., (617) 891-4600; **MARYLAND,** Glen White Associates, (301) 252-6360; **MASSACHUSETTS,** Datcom, Inc., (617) 891-4600; **MICHIGAN,** R.C. Nordstrom & Company, (313) 559-7373; **MINNESOTA,** Quantum Sales, Inc., (612) 884-4700; **MISSISSIPPI,** Glen White Associates, (205) 883-7938; **MISSOURI,** R.R. Burton & Associates, (816) 763-5385; **MONTANA,** Components West, (206) 271-5252; **NEBRASKA,**

K x 8 RAMs SPEED LIMIT.

If you're designing cache memory, high-speed storage, hand-helds and other high-density memory applications, write for more information to Toshiba America, Inc., 2441 Michelle Drive, Tustin, CA 92680, (714) 730-5000. Or call your local distributor or sales representative.

Toshiba America broke the speed limit so there'll be fewer design limitations for you.

Part No.	Type	Access Time (Max)	Operating Current (Max)	Standby Current (Max)
2016AP-90	NMOS	90ns	80mA	7mA
2016AP-10	NMOS	100ns	65mA	7mA
2016AP-12	NMOS	120ns	65mA	7mA
2016AP-15	NMOS	150ns	65mA	7mA
*2015AP-90	NMOS	90ns	80mA	7mA
*2015AP-10	NMOS	100ns	65mA	7mA
*2015AP-12	NMOS	120ns	65mA	7mA
*2015AP-15	NMOS	150ns	65mA	7mA
*2018D-45	NMOS	45ns	120mA	20mA
*2018D-55	NMOS	55ns	120mA	20mA
**5516AP	CMOS	250ns	55mA	30 μA
**5516AP-2	CMOS	200ns	55mA	30 μA
**5516APL	CMOS	250ns	55mA	1 μA
**5516APL-2	CMOS	200ns	55mA	1 μA
**5517AP	CMOS	250ns	55mA	30 μA
**5517AP-2	CMOS	200ns	55mA	30 μA
**5517APL	CMOS	250ns	55mA	1 μA
**5517APL-2	CMOS	200ns	55mA	1 μA
5517BP-20	CMOS	200ns	25mA	30 μA
5517BPL-20	CMOS	200ns	25mA	1 μA
5518BP-20	CMOS	200ns	25mA	30 μA
5518BPL-20	CMOS	200ns	25mA	1 μA

*.300" wide dual in line package.
**Also available in a plastic flat pack (small outline package).

TOSHIBA AMERICA, INC.

A WORLD STANDARD IN MOS.

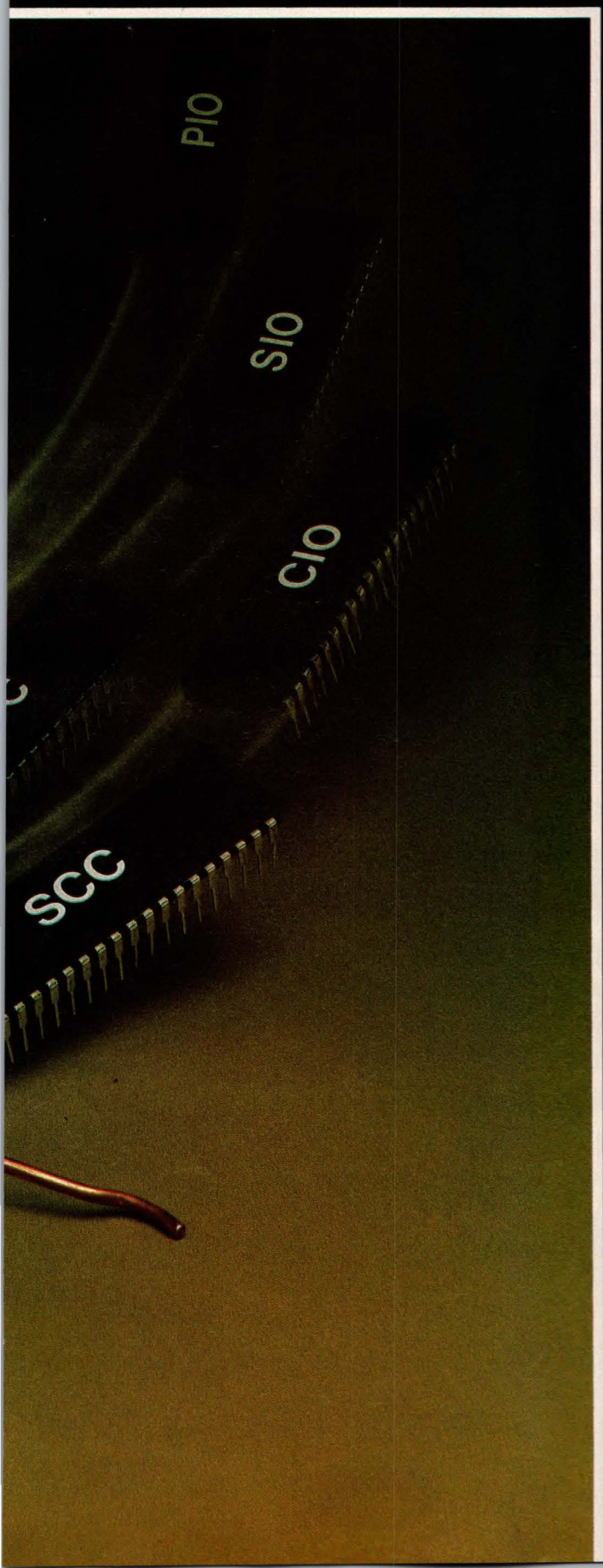
CIRCLE NO 96

ANDREWS

R.R. Burton & Associates, (816) 763-5385; **NEVADA,** Elrepco, Inc., (415) 962-0660; **NEW HAMPSHIRE,** Datcom, Inc., (617) 891-4600; **NEW JERSEY,** Necco 1, (201) 461-2789, Vantage Sales, (609) 663-6660; **NEW MEXICO,** Semper Fi Sales Company, (602) 991-4601; **NEW YORK,** Necco 1, (201) 461-2789, PI-tronics, (315) 455-7346; **NORTH CAROLINA/SOUTH CAROLINA,** Glen White Associates, (919) 848-1931, (615) 477-8850; **NORTH/SOUTH DAKOTA,** Quantum Sales, Inc., (612) 884-4700; **OHIO,** Del Steffen & Associates, (216) 461-8333, (419) 884-2313, (513) 293-3145; **OKLAHOMA,** Engineering Sales Company, (918) 493-1927, Technology Sales Company, (214) 380-0200; **OREGON,** Components West, (503) 684-1671; **PENNSYLVANIA,** Del Steffen & Associates, (412) 276-7366, Vantage Sales, (609) 663-6660; **RHODE ISLAND,** Datcom, Inc., (617) 891-4600; **TENNESSEE,** Glen White Associates, (615) 477-8850; **TEXAS,** Technology Sales Company, (512) 346-9940, (713) 266-2473, (214) 380-0200; **UTAH,** Duffy Associates, (303) 595-4244; **VERMONT,** Datcom, Inc., (617) 891-4600; **VIRGINIA/WEST VIRGINIA,** Glen White Associates, (804) 237-6291, (804) 295-0435, (804) 224-7764, (804) 224-0404; **WASHINGTON,** Components West, (206) 885-5880; **WISCONSIN,** L-TEC, (414) 774-1000; **WYOMING,** Duffy Associates, (303) 595-4244; **CANADA,** Electro Source Inc., (416) 675-4490.

You'll never get trapped into dead-end designs with

Zilog's high-speed Z80B CPU's and Peripherals.



Here's more proof that nobody does more to extend the life of your 8-bit designs than Zilog. Because now you can increase 8-bit Z80® performance up to 6 MHz with the high-speed Z80B CPU and its family of peripherals. You can join the hundreds of design engineers that have already tested this claim with winning results. Or wonder...

Is there something here they know that you don't?

Like the fact that the Z80B CPU has the same 158 instruction set and the elegant registers and interrupts that you're used to working with, but runs them 50 percent faster than the Z80A chip?

That the Z80B processor is completely software compatible with the rest of the Z80 family, permitting you to upgrade to higher performance without getting trapped into software redevelopment? That software compatibility also means you can use the Z80B device in co-processing and/or multi-processing environments along side our other Z80 processors?

And consider the fact that you can surround our Z80B CPU's with a complete family of Z8400 and Z8500 peripherals and really boost system performance. They help you keep your parts and space requirements to a minimum and increase system throughput because we build more functions into every device. The peripherals include a PIO, a CTC, an SIO, an SCC, an FIO, an FIFO, a CIO, and a UPC.

For complete specifications and applications data on the Z80B and peripherals, fill out the coupon and mail to: Zilog, Inc., Components Tech. Publications, 1315 Dell Avenue, MS C2-6, Campbell, CA 95008. Or call our TOLL FREE Literature Hot Line at 800-272-6560. For information on Zilog's other components, call (408) 370-8000.

Z80 is a registered trademark of Zilog, Inc.

☐ I'd like more information at this time. EDN 11/29/84
☐ Please have a salesman contact me.

Name_____

Title_____

Company_____

Address_____

City_____ State_____ Zip_____

Phone_____/_____

Z80B/Peripherals

Zilog
an affiliate of
EXXON Corporation

Pioneering the Microworld

CIRCLE NO 97

ROCKWELL SEMICONDUCTOR TECHNOLOGY BREAKS THE CMOS SPEED BARRIER.

Rockwell's R65C21, R65C24, R65C51 and R23C64 are the latest members of our high-speed, low-power CMOS family.

500 ns instruction time is our CMOS microprocessors' record-breaking speed—two times faster than NMOS—with power consumption of only 80mW. And now Rockwell International offers peripheral devices such as the R65C21 (PIA), R65C24 (PIAT) and the R65C51 (ACIA) for your system design.

Our low-power, high-speed combination is not all you get from Rockwell's CMOS; you also get latch-up immunity, a bit manipulation and byte operation instruction set, power and temperature variance toleration, low noise generation, high noise immunity and a small die size. All these features combine to save you design time, lower your costs and improve system performance.

If all that doesn't convince you, write on your letterhead for a free sample of our R65C02 CPU. (It's pin- and bus-compatible with the popular R6502). Using is believing.

For your high-speed CMOS storage, we're accepting codes now for our R23C64 CMOS Static ROM. This 64K ROM has an access time of 150 ns and consumes only 10mW active, 50μW passive. With 24-hour code approval and competitive lead times, too, you won't find CMOS any faster.

Find out how our breakthrough CMOS family can perform for you. Contact your local Rockwell distributor or sales representative today.

Rockwell Semiconductor Products Division
Rockwell International, P.O. Box C,
MS 501-300, Newport Beach, CA 92660.
Call Toll Free (800) 854-8099.
In California, (800) 422-4230.

Rockwell International

...where science gets down to business

CIRCLE NO 98

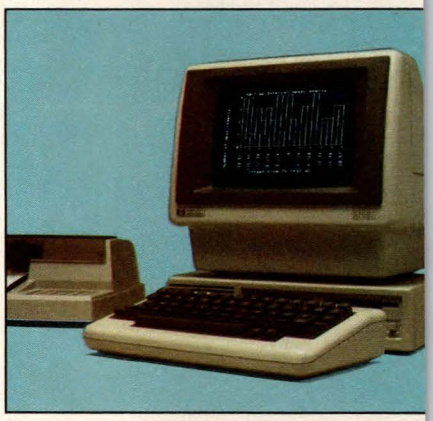
The HP 1980 Time Domain Measurement System...

Speed production throughput an by automating your time-domai

The HP 1980 System combines key test instruments with powerful computers, flexible software, and comprehensive support for a total test solution.

The modular HP 1980 Time Domain Measurement System integrates four essential test instruments — a fully programmable oscilloscope, a waveform digitizer, a universal counter, and analog comparators — into a single, compact instrument mainframe. We then combine that with an appropriate HP computer and an extensive software library that lets you start making measurements of many test waveforms the very first day you have your system. Finally, we back it all up with in-depth support that includes application notes, seminars, and optional consulting services from HP's System Engineering Organization.

The result is a flexible automatic test system that can be configured to perform virtually all your time domain measurements below 100 MHz. Whether used as a total test solution, or as a core for a larger ATE system, the HP 1980 System reduces your test equipment investment several ways. It reduces your equipment costs compared to buying individual test instruments.

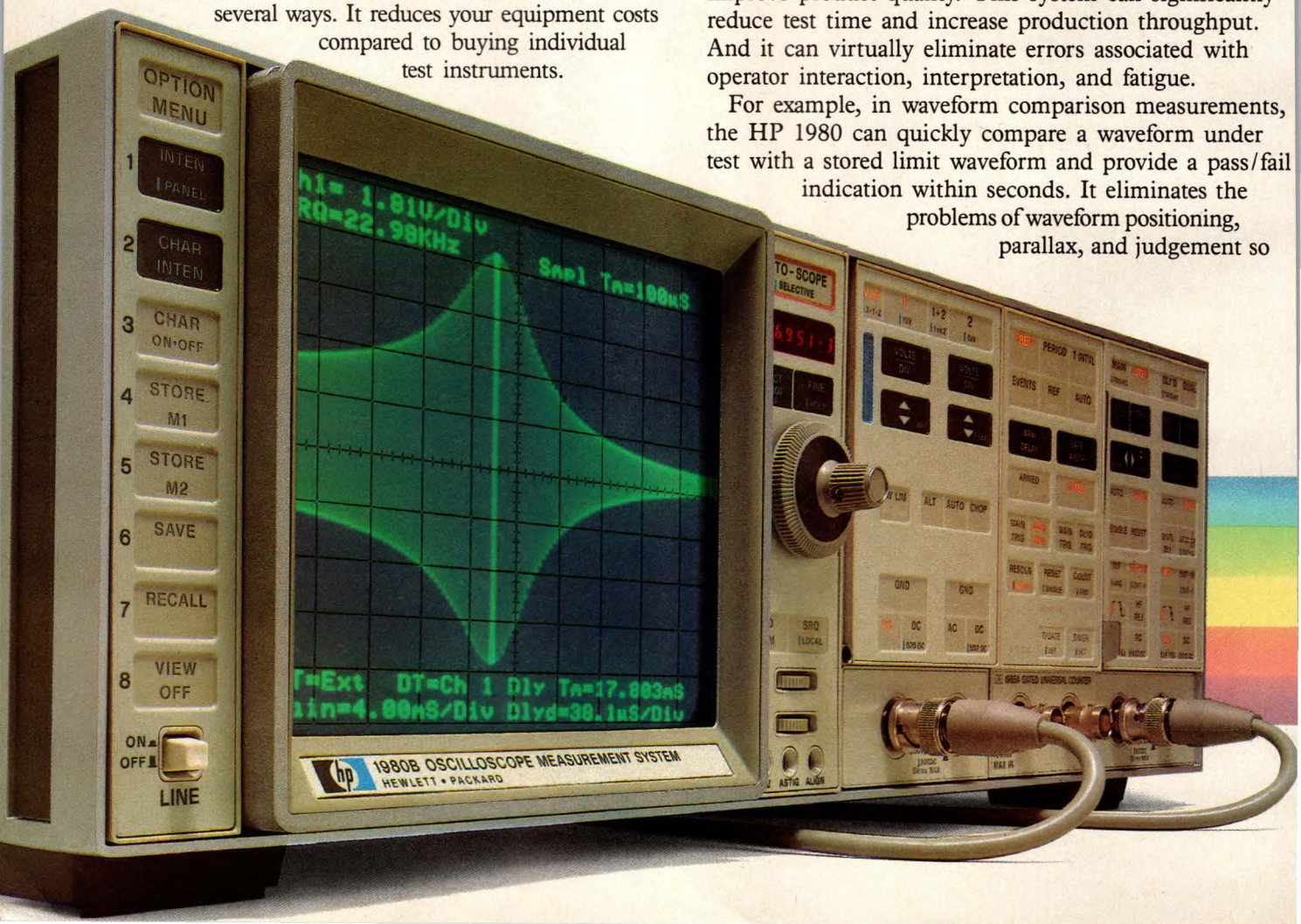


It eliminates or greatly reduces the time you spend in system integration effort and software development. And the HP 1980 reduces test equipment space requirements.

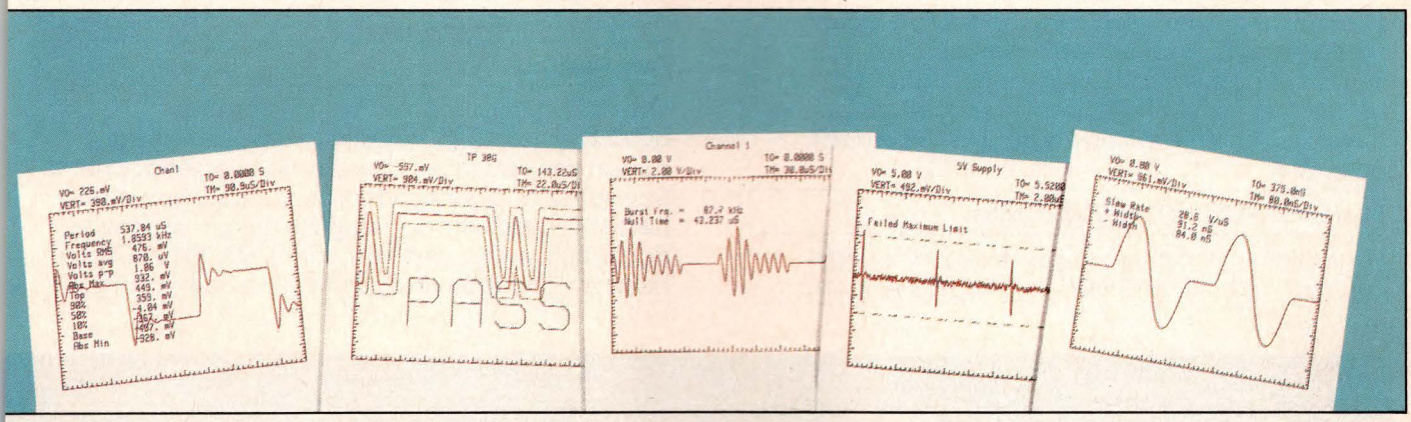
The HP 1980 System saves test time and assures high product quality through consistent waveform comparison and characterization.

Automate production measurements with the HP 1980 System, and tackle two of the biggest problems facing industry today...how to reduce manufacturing costs and improve product quality. This system can significantly reduce test time and increase production throughput. And it can virtually eliminate errors associated with operator interaction, interpretation, and fatigue.

For example, in waveform comparison measurements, the HP 1980 can quickly compare a waveform under test with a stored limit waveform and provide a pass/fail indication within seconds. It eliminates the problems of waveform positioning, parallax, and judgement so



improve product quality measurements.



you get consistently accurate results. Comparison measurements with the HP 1980 are orders of magnitude faster than manual testing. For example, parametric tolerance tests, such as comparing peak amplitude to preset limits, can be performed within several hundred milliseconds.

Waveform characterizations that used to be difficult and time consuming are now performed quickly and accurately with the HP 1980. For total waveform characterization, there's a first-day measurement program in the software library that automatically determines peak-to-peak voltage, frequency, period, pulse width, rise time, and fall time on repetitive signals. For specific applications, you can use the subprograms contained in the software library to determine the fundamental frequency or period of a waveform, count events, and, with the HP 1980's flexible gating capability, measure the time between bursts.

The HP 1980 Time Domain Measurement System. When you want a complete, low-cost waveform measurement solution that goes right to work.

Perhaps you've felt that ATE was out of reach. Then this is the system that can make low-cost automated test a reality.

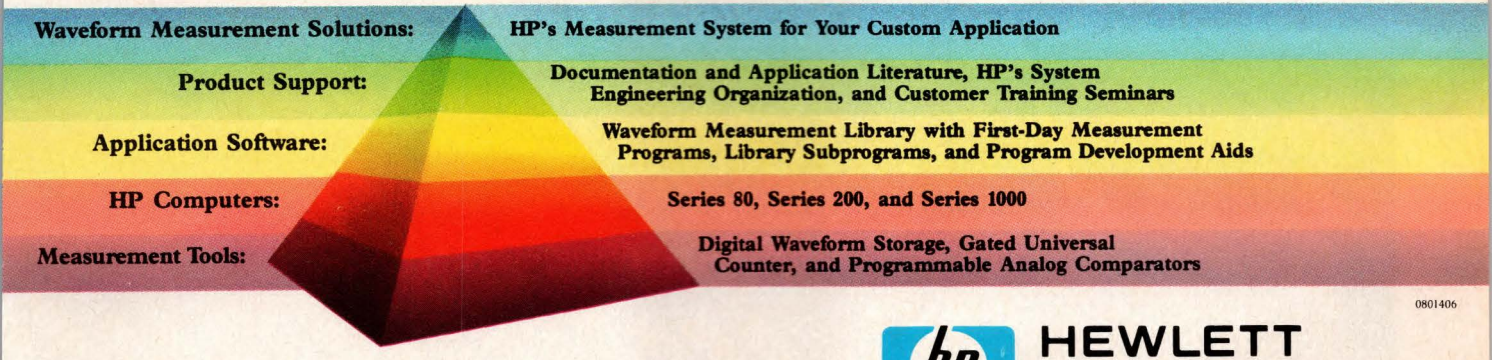
If you need a more sophisticated test system, now or in the future, the HP 1980 can be a powerful core system that you can easily expand via HP-IB. HP can even provide consulting assistance through our System Engineering Organization.

As you plan for the future, the HP 1980 will dovetail with your long-term networking objectives. As a part of HP's Manufacturing Productivity Network, the HP 1980 allows you to integrate production test data with information from other manufacturing operations. The ability of various departments to access a timely, accurate, integrated data base can have far-reaching impact on productivity, manufacturing costs and product quality.

Whether you're concerned with today's testing needs, tomorrow's manufacturing network, or both, the HP 1980 can make a valuable contribution toward improving your company's product quality and manufacturing productivity. To find out more, contact your local HP sales office listed in the telephone directory white pages. Ask for the electronic instruments department.

DESIGNED FOR HP-IB SYSTEMS

HP-IB: Not just IEEE-488, but the hardware, documentation and support that delivers the shortest path to a measurement system.



0801406

HEWLETT PACKARD

CIRCLE NO 99

Simulating VLSI chips is tough.

If your designs contain microprocessors or complex VLSI peripheral chips, most CAE systems just can't handle them. But Valid does—with our revolutionary new Realchip™ modeling system.

A New Concept.

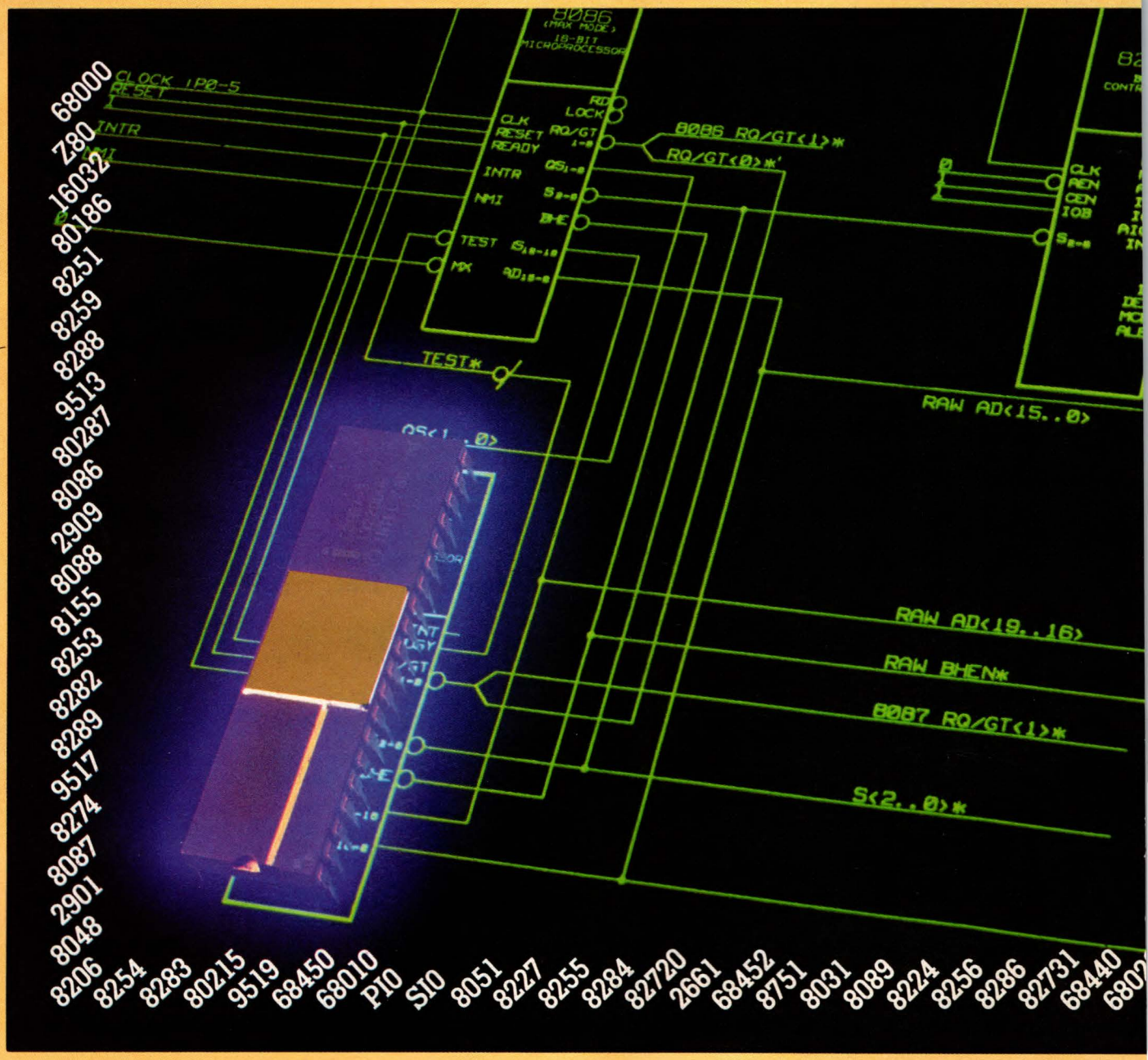
Realchip is a completely new modeling concept, where real chips model their own behavior when simulating a design. Software models just won't work at the complex VLSI chip level: they take too long to develop, simulate too slowly, and usually aren't accurate.

Perfect Models of Any VLSI Chips.

No matter what complex VLSI chips your design contains, Valid's Realchip Modeling System can handle them: for example, Motorola's 68000 microprocessor family; Intel's 8085/6/7/8/9, and their 80186/286; AMD's 2900 and 29116 bit-slice parts; Zilog's Z80; and National's 16032—even your own custom chips and gate arrays. Models are perfect, because real chips model themselves. And they are fast, because they model themselves at hardware speeds.

Any Design.

Valid's Realchip, teamed with the proven SCALDsystem CAE workstation, will handle any design you can throw at it—from schematic capture through timing verification, logic simulation, and net list generation—to complete design validation. Realchip models work with over 2,000 TTL, ECL, memory, and gate array software models in the



So tough that only Valid does it.

SCALDsystem's device libraries to handle any design you may have.

For Immediate Delivery.

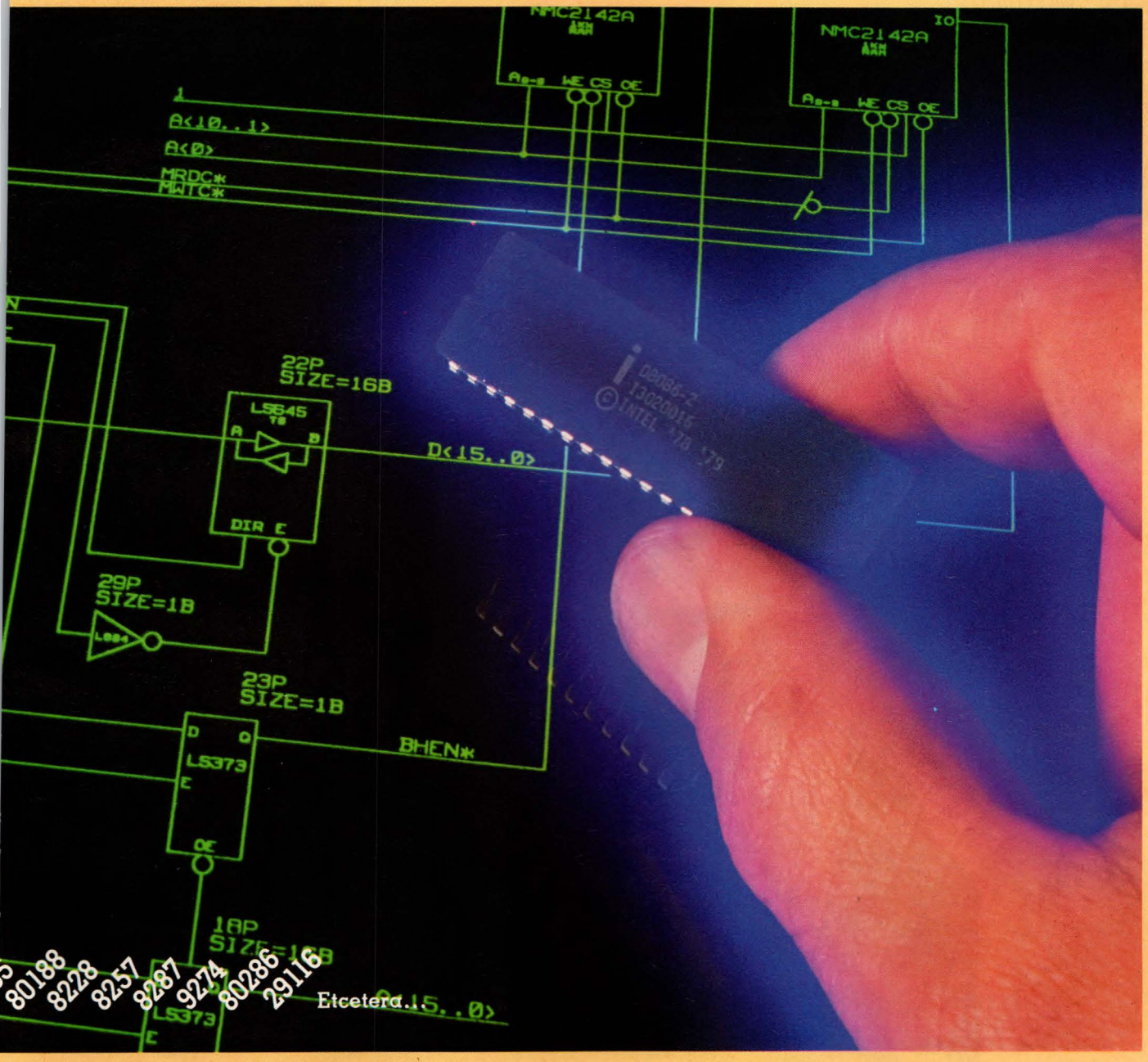
You can get the Realchip Modeling System right now. No vague promises. No excuses. Delivery is 30 days ARO. SCALDsystems are also 30 days ARO.

From the Engineers Who Invented CAE.

It isn't surprising that Realchip comes from Valid. After all, our engineers invented the whole SCALD concept for which Dr. Curt Widdoes and Dr. Tom McWilliams, two of Valid's founders, received the 1984 IEEE McDowell award). Look to Valid for leading-edge CAE tools. We give you products; not vague promises.

ELECTRONIC DESIGN carried the whole Realchip story in its March 22, 1984 issue. For a free reprint of that article, plus more detailed information, call us toll-free at **800-891-9441** (408-945-9400 in California), or write Valid Logic Systems, 2820 Orchard Parkway, San Jose, CA 95134.

VALID



CIRCLE NO 100

BIPOLAR BIT

Bipolar is on its way to that big computer in the sky.

And it's all because of Zytrex.

Our new CMOS process is just as fast as anything low power Schottky has to offer. And we mean anything.

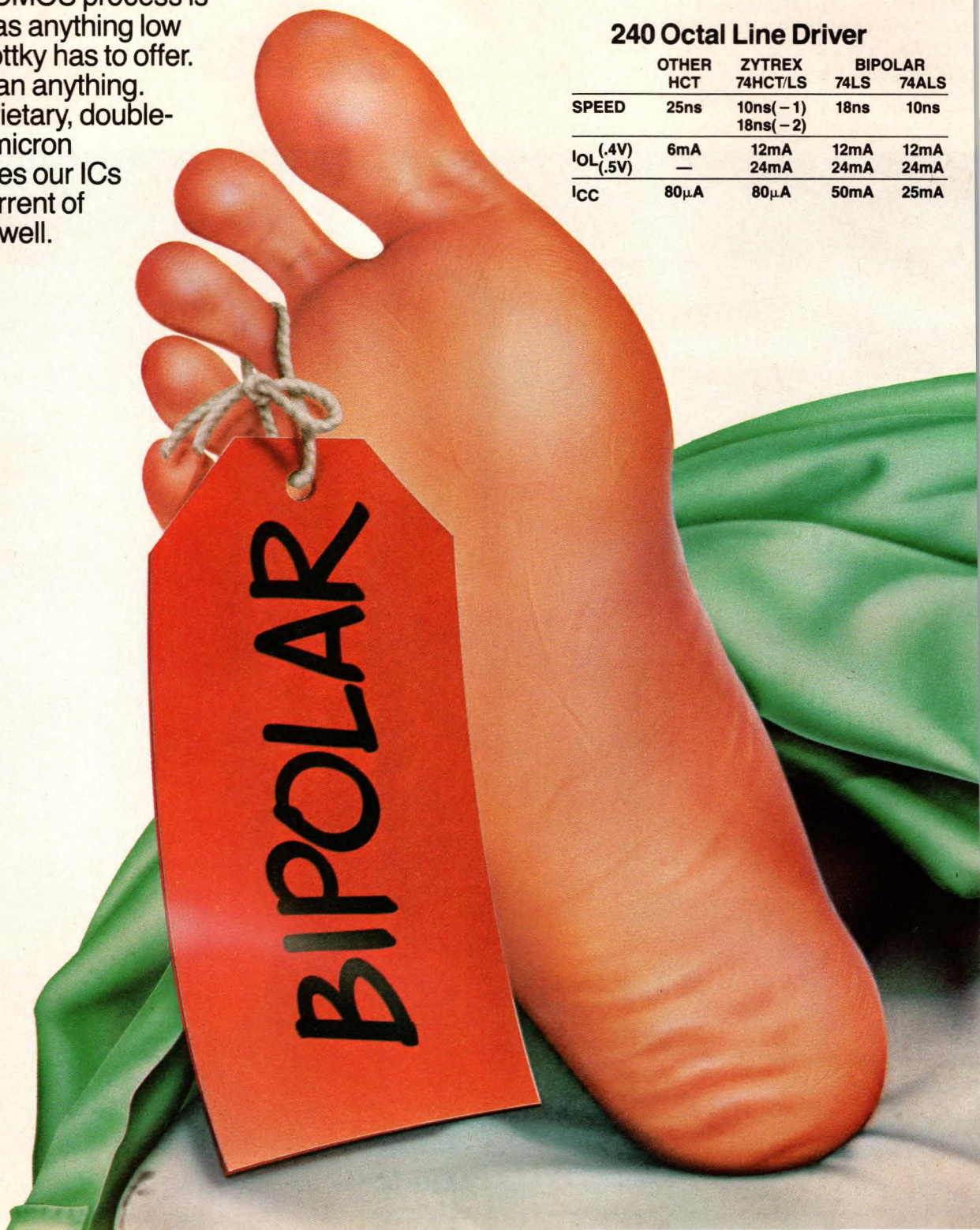
Our proprietary, double-metal, two micron process gives our ICs the drive current of LS/TTL, as well.

All our parts are created equivalent.

Our parts aren't just compatible with LS/TTL. They're equivalent.

240 Octal Line Driver

	OTHER HCT	ZYTREX 74HCT/LS	BIPOLAR 74LS	BIPOLAR 74ALS
SPEED	25ns	10ns(−1) 18ns(−2)	18ns	10ns
I_{OL} (.4V)	6mA	12mA	12mA	12mA
I_{OL} (.5V)	—	24mA	24mA	24mA
I_{CC}	80μA	80μA	50mA	25mA



ES THE DUST.

Just plug 'em in and go.

And that goes for our buffers, counters, latches, flip-flops. Even our CALs.™ As for voltage, the only time we use the word pull-up is when we're trying to get the competition off the floor.

So stop kicking a dead technology.

CAL (CMOS Array Logic) is a registered trademark of Zytrex Corporation.

Call 408-733-7703, or write us and ask about our new high-speed, double-metal CMOS.

It'll make your next design come alive.

Zytrex

THE FASTEST CMOS ALIVE.

750 East Arques,
Sunnyvale, CA 94086

CIRCLE NO 101

Your know-how. Our systems. Tell us your needs and we can show you a thing or two.

Copyright © 1984, Tektronix, Inc. All rights reserved. SPA-440.

When it comes to measurement systems, there are no pat answers, not from us or from any vendor. We know as well as you do that you understand your unique application requirements better than anyone.

To solve your special measurement problems with minimal groundwork and without guesswork, you need systems and system components that are compatible with equipment you have. Easy to interface. And open to options.

Even as you take a strong hand in your system design, know that no one is more qualified than Tektronix to help. Not just with system components, but with counsel and advice, comprehensive documentation and system support that keeps you in charge.

You and Tektronix. A partnership that pays off... in more ways than one.

1. We'll show you depth and breadth in system choices. From our TEK EZ-TEST™ software to the most sophisticated waveform acquisition and processing measurement systems in the world, we're equipped to match your application with the right capability at just about any level of automation.

You call the shots. Tek system offerings can be purchased as individual components, pre-configured measurement packages which you integrate and install yourself, factory-integrated measurement systems with on-site installation and system warranty, or as custom systems.

And if another vendor's instrument is more appropriate for a portion of your application, we'll make a recommendation.

2. We'll show you interfacing ease that you've never encountered. With Tek's acquisition units, controllers, software and documentation, you can move quickly to solving your own problems, not the system's. Tektronix Standard Codes and Formats make set-up and instrument control refreshingly logical, consistent, simple and straightforward.

3. We'll show you a world of outstanding support. We provide extensive and ongoing documentation that includes hardware and software manuals, programming guides, instrument interfacing guides and application notes. Our worldwide organization of service technicians, trainers, sales and applications engineers assures you of the help you need when you need it. You stay in charge.

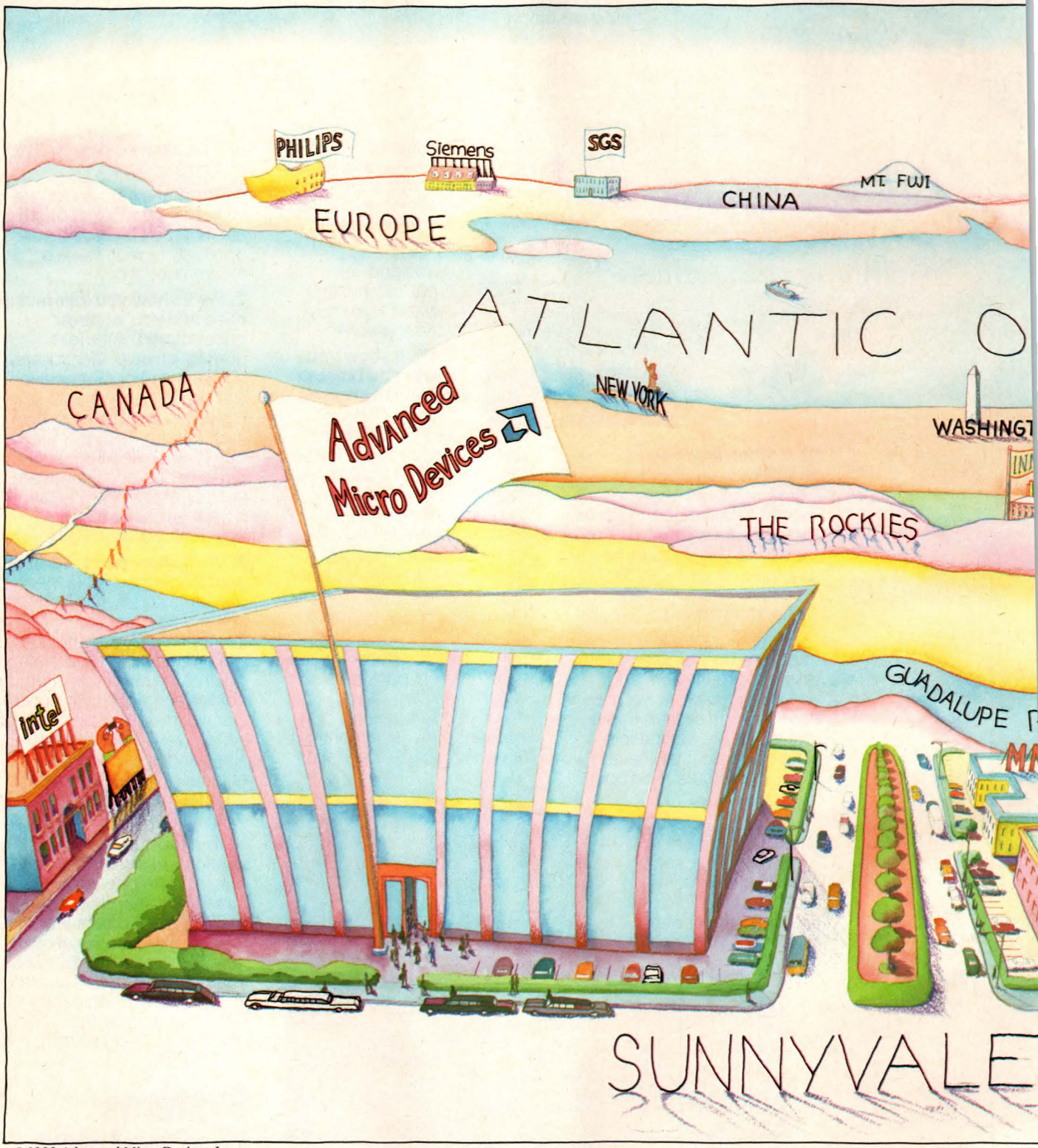
You know your application better than anyone. And no one knows systems instrumentation better than Tektronix. Let's work together! For a copy of our new 38-page, full color systems brochure, contact your local Tek Sales Engineer. Or write Tektronix, Inc., P.O. Box 1700, Beaverton, OR 97075.

Systems that put you in charge

Tektronix®
COMMITTED TO EXCELLENCE

Circle No. 120 for sales contact ***Circle No. 159 for literature***

MEMORIES.



© 1983 Advanced Micro Devices, Inc.

Advanced Micro Devices • **Bruxelles** (02) 771 99 93 • **Hannover** area (05143) 53 62 • **Hong Kong** (852) 3 695377
London area (04862) 22121 • **Manchester** area (0925) 828008 • **Milano** (02) 339 0541 • **München** (089) 40 19 76
Paris (01) 687.36.66 • **Stockholm** (08) 98 12 35 • **Stuttgart** (0711) 62 33 77 • **Tokyo** (03) 329-2751

A WORLD PERSPECTIVE.

If you're looking for the world's fastest MOS static RAMs, don't look in Holland.

Searching for the world's fastest bipolar PROMs? Forget Texas or Arizona.

And you won't find the world's fastest EPROMs anywhere near Mt. Fuji.

They're all right here in Sunnyvale. At Advanced Micro Devices.

Everything we make is fast. Including the Am27256, the world's fastest 256K EPROM.

The Am27256 is 170ns fast. It's the only EPROM quick enough to keep up with a 10MHz MPU without a wait state.

And we've got the 40ns Am27S43A, the world's fastest 32K bipolar PROM. And the 35ns Am2167, the world's fastest 16K static RAM.

With leading-edge parts like these, it's no wonder memories account for half our total sales.

And our other products are just as hot.

Controllers. Bipolar and MOS microprocessors. Communications circuits. Signal processors. We've got 'em all, and then some.

And every single chip meets or exceeds the International Standard of Quality.

The International Standard of Quality guarantees a 0.1% AQL on all electrical parameters, AC and DC, over the entire operating range.

INT·STD·1000

Next time your design demands high performance memories, or any high-performance parts, look us up.

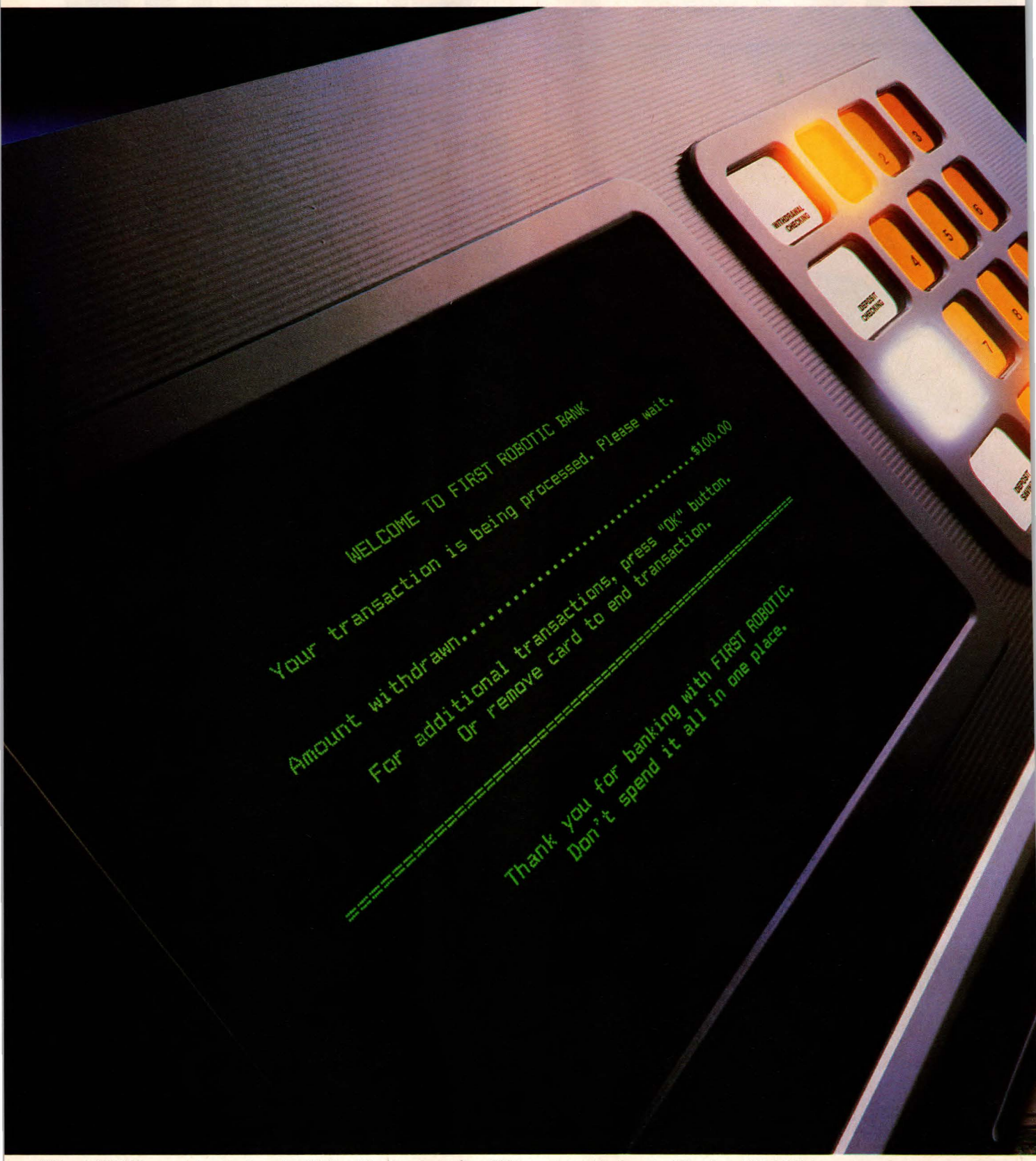
We put high performance on the map.

Write or call for a free Sunnyvale poster and all the facts on our memories.

Advanced Micro Devices

For more information, contact the sales office nearest you or write the word "Memories" on your letterhead and mail it to Advanced Micro Devices, Mail Operations, P.O. Box 4, Westbury-on-Trym, Bristol BS9 3DS, United Kingdom.

CIRCLE NO 102



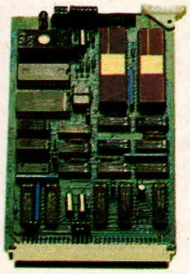
CIM and CIMBUS are registered trademarks of National Semiconductor Corp. Z80 is a registered trademark of Zilog Corp. MULTIBUS is a trademark of Intel Corp. CP/M is a registered trademark of Digital Research Corp. **Standard Microsystems Corp. is a licensed second source for National Semiconductor CIMBUS products.**

Better brains for machines that think.

Now you can afford CMOS for all your intelligent products.

You know CMOS gives you better reliability than NMOS while consuming far less power. But you may think it's too expensive for normal applications. National Semiconductor's CIM™ (CMOS Industrial Microcomputer) boards make CMOS the right choice for every microcomputer based product.

Built to the compact Eurocard standard, modular CIM boards take up less space in your system and consume 25 to 30 times less power than NMOS STD or Multibus™ boards. That means you can reduce enclosure and power supply costs for an average 19% installed cost savings over comparable NMOS systems.



The low power consumption of National's micro CMOS technology makes CIM boards perfect for battery operation or battery back-up. Impervious to temperature fluctuations, electrical noise, vibration, and power failures, rugged CIM boards are the right choice for harsh environments, too. But they're great for any application, from airport to bank lobby to lab to clean room. No matter where you put them, CIM boards deliver the extra measure of reliability that you expect from CMOS. Reliability that's backed by National's exclusive three year warranty.

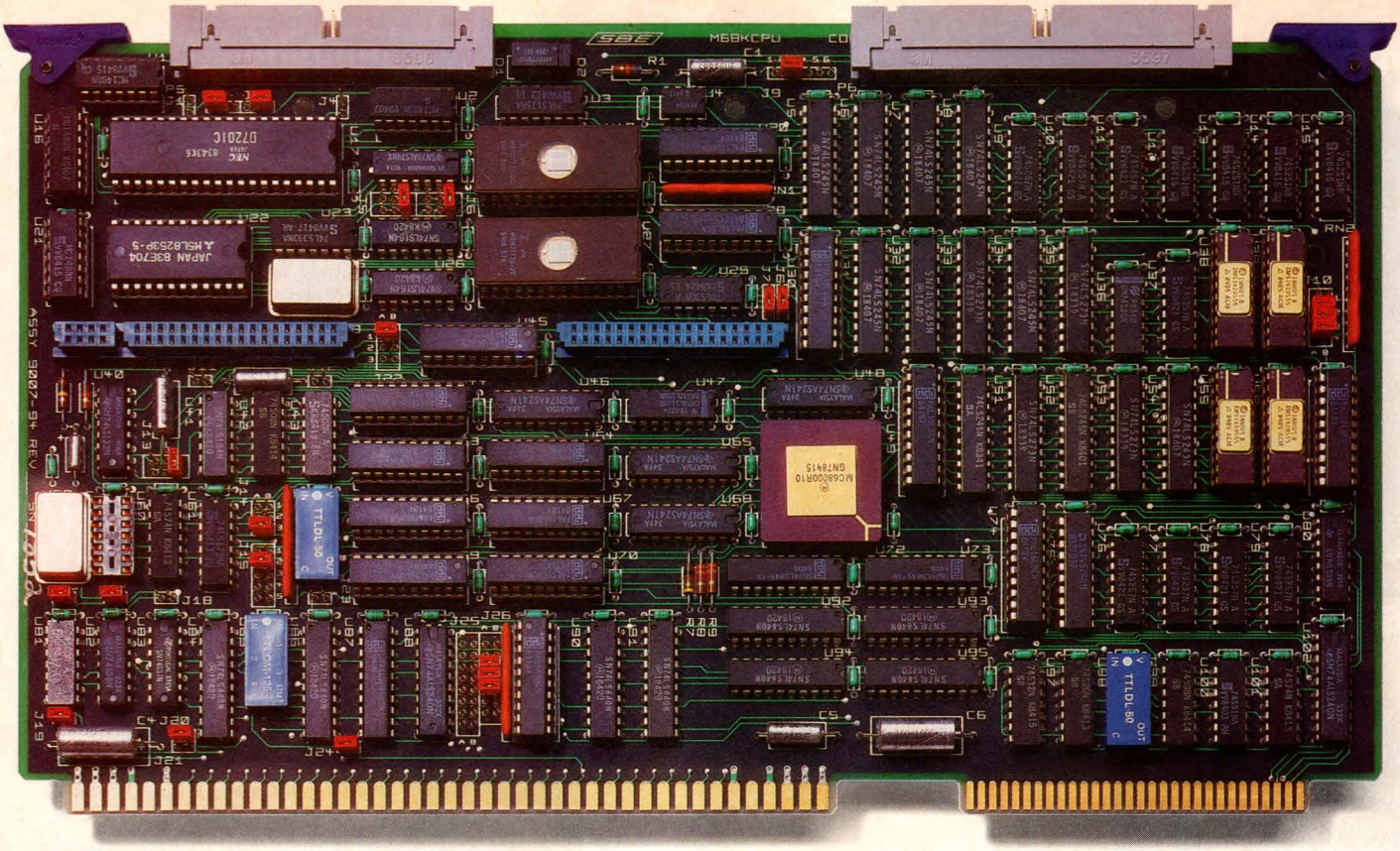
To take full advantage of microCMOS performance, CIM boards feature the superior CIMBUS™ bus structure. For access to the vast library of software written with the Z80® instruction set, they use National's NSC800 microprocessor. Or you can develop your own software under CP/M® or BLMX-80, National's real-time, run-time, event-driven operating system.

National Semiconductor is the only industrial microcomputer board supplier with more than 60 CMOS products available today, from CPU's and memory boards to digital and analog I/O boards, including card cages and software. CIM products are also available from our licensed second source.

So if you're looking for better brains for your products, call National Semiconductor for the CIM solution. For a complete CIM guide, call 800-538-8510. In California call 800-345-4006.

National Semiconductor
We're doing it.

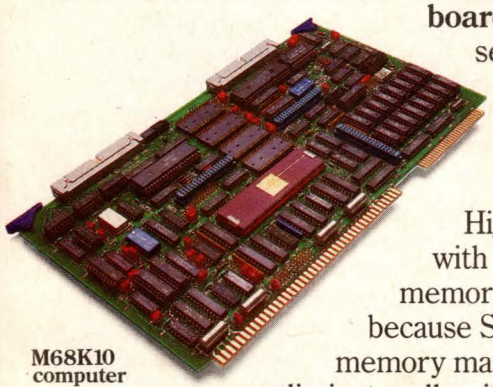
CIRCLE NO 103



Now 68000 computers cost less, do more. $1095.

SBE Multibus computers bring out all the power of the 68000 in a highly adaptable form.

The M68CPU above runs at 10 MHz, accessing 512 KB to 8 MB RAM on companion boards. This CPU sets a new standard for multi-user, real-time applications. High speed with multi-megabyte memory is now possible because SBE's unique memory management unit eliminates all wait states. It contains 32 independent maps for task sizes from 4 KB to 8 MB, permitting rapid real-time task switching.



M68K10 computer

Our M68K10 runs at 10 MHz, accessing 128 KB to 1 MB RAM on the same board. This CPU is an amazingly powerful single-board computer for communications, process control, data analysis, ATE, and other systems applications. Contains up to 1 MB of dual-ported RAM accessible with no wait states. Has a 16-bit counter/timer and 24-bit parallel port right on board.

Both fit in almost anywhere. Both are Multibus/IEEE 796 compatible. With two iSBX Multimodule connectors. Two multiprotocol serial I/O ports. And options like a 68010 in place of the 68000.

All from stock in batches of 100 for $1095. A super competitive price. One we can offer because we manufacture in-house, in volume. And we offer on-going software support hard to find elsewhere. All from SBE, Inc., 4700 San Pablo Ave., Emeryville, California 94608. TWX 910-366-2116.

Phone free 800-221-6458 for literature mailed today. In California call (415) 652-1805.

SBE

Computer boards and systems.

Edited by Robert M Clarke

Reduce display codes to byte-size pieces

Kenneth Knaell
Silver Spring, MD

You can use logic to eliminate the redundant information in 7-segment display codes (**figure**); transmitting the resulting data to a computer then becomes as efficient as transmitting BCD. This display-to-computer interface handles suppressed leading zeros and decodes sixes and nines with or without horizontal tails (**Table 1**).

As the **figure** shows, you can transmit a 3½-digit DMM's TDM display over a byte-wide bus. The display provides a sync pulse for each digit. The computer's software polls the input port; it reads and stores the four bytes—one per digit—and then decodes them per **Table 1**. Because the leading digit is a special case, its transmission code is modified slightly and is decoded according to **Table 2**. **EDN**

To Vote For This Design, Circle No 746

TABLE 1—DISPLAYS D_3, D_2, D_1

DISPLAY	$F_3\ F_2\ F_1\ F_0$ (HEX)
BLANK	B
0	4
1	9
2	2
3	A
4	D
5	F
6	7
6	7
7	8
8	6
9	C
9	E

TABLE 2—DISPLAY D_4

DISPLAY	$F_3\ F_2\ F_1\ F_0$ (HEX)
BLANK	B
+ BLANK	B
− BLANK	F
1	9
+ 1	9
− 1	D

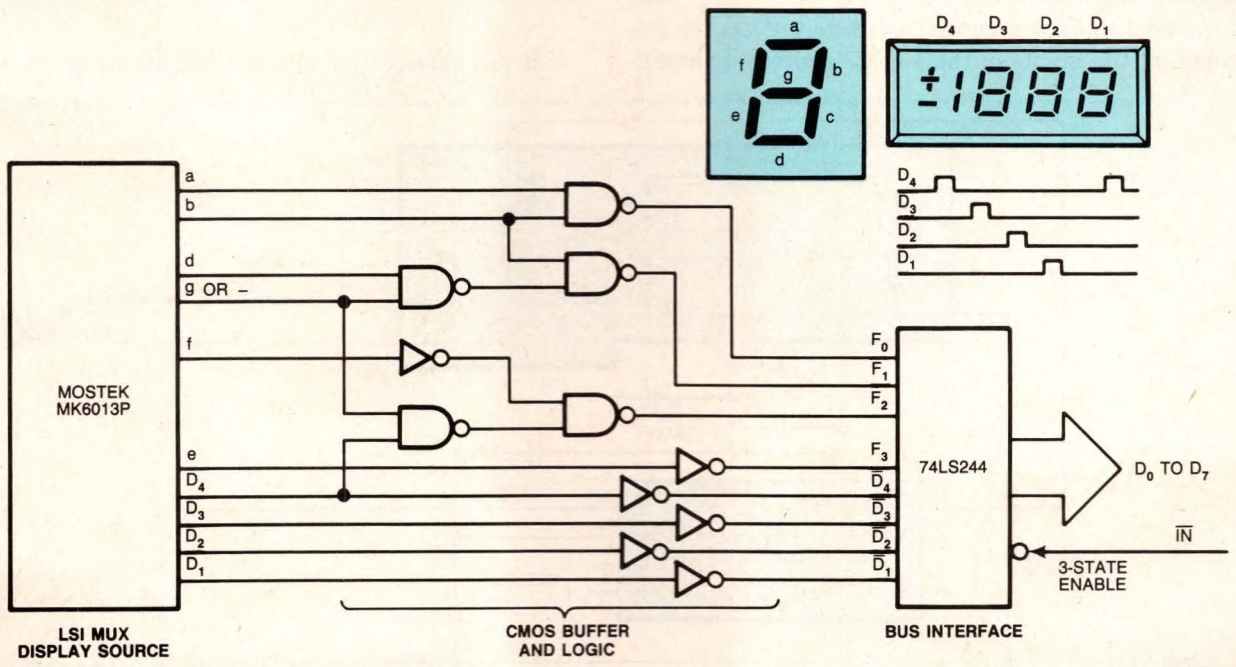
*NOTE:

$F_3 = \overline{e}$

$F_2 = \overline{F} + D_4 \cdot g$

$F_1 = \overline{b} + d \cdot g$

$F_0 = \overline{a \cdot b}$



Eliminating redundant information from 7-segment codes *lets you transmit data to a computer at one byte per digit, simplifying this display-to-computer interface.*

Build a two-IC programmable power supply

Philip Burton
National Institute for Higher Education, Limerick, Ireland

You can use a CMOS D/A converter and an LM723 voltage regulator to make a digitally programmable power supply. This design uses a bootstrap technique to eliminate the dual supplies often required in these applications and, in its simplest form, requires no additional active components.

The design's AD7548 12-bit D/A converter has TTL-compatible inputs and interfaces directly with most μP buses. You can use a different D/A converter, but you should be sure that it has separate analog and digital ground terminals and TTL-compatible inputs.

The **Fig 1** circuit can produce outputs from 7.15 to 14.3V. The LM723's internal 7.15V reference, V_{REF}, drives the LM723's noninverting input through R_1 and fixes the AD7548 D/A converter's analog ground (A_{GND}) reference at 7.15V. (Note that although both the LM723 and AD7548 have terminals designated V_{REF}, this discussion refers only to that of the LM723.) The AD7548's supply voltage must be at least 5V higher than V_{REF} for the IC to operate correctly, and the voltage shouldn't exceed 17V.

R_1 minimizes errors caused by different source impedances at the inputs of the LM723's internal amplifier. The converter's internal feedback resistor, R_F, and the converter itself form a voltage divider across the circuit's output between V_{OUT} and A_{GND}. This divider, controlled by a digital input to the converter, provides the feedback from the supply's output to the inverting input of the LM723's internal amplifier. When the LM723 regulates, it tries to force the noninverting input of its amplifier to V_{REF}. Thus, the D/A converter operates with OUT_1 and A_{GND} at the same potential—a necessary condition to insure converter linearity.

The D/A converter's input resistance at the OUT_1 node (pin 1) is equal to $R_{DAC} \div D$, where D is the fractional binary input to the D/A converter (eg, D=2048/4096 when the input is 1000 0000 0000 and D=4095/4096 when the input is 1111 1111 1111) and R_{DAC} is the D/A converter's input resistance. The equation for the circuit's output voltage is thus

$$V_{OUT} = \frac{V_{REF}\,(1 + R_F D)}{R_{DAC}},$$

and, because the R_F and R_{DAC} values usually match within 0.5%, this expression reduces to

$$V_{OUT} = V_{REF}(1 + D).$$

You can change the supply's output range to 3.6 to

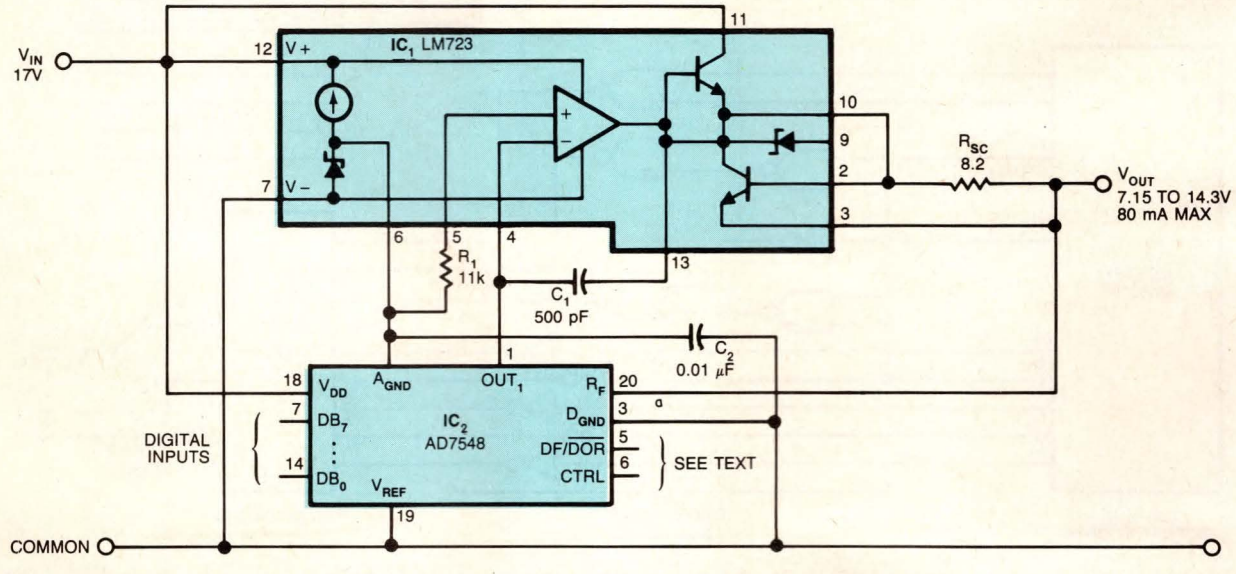
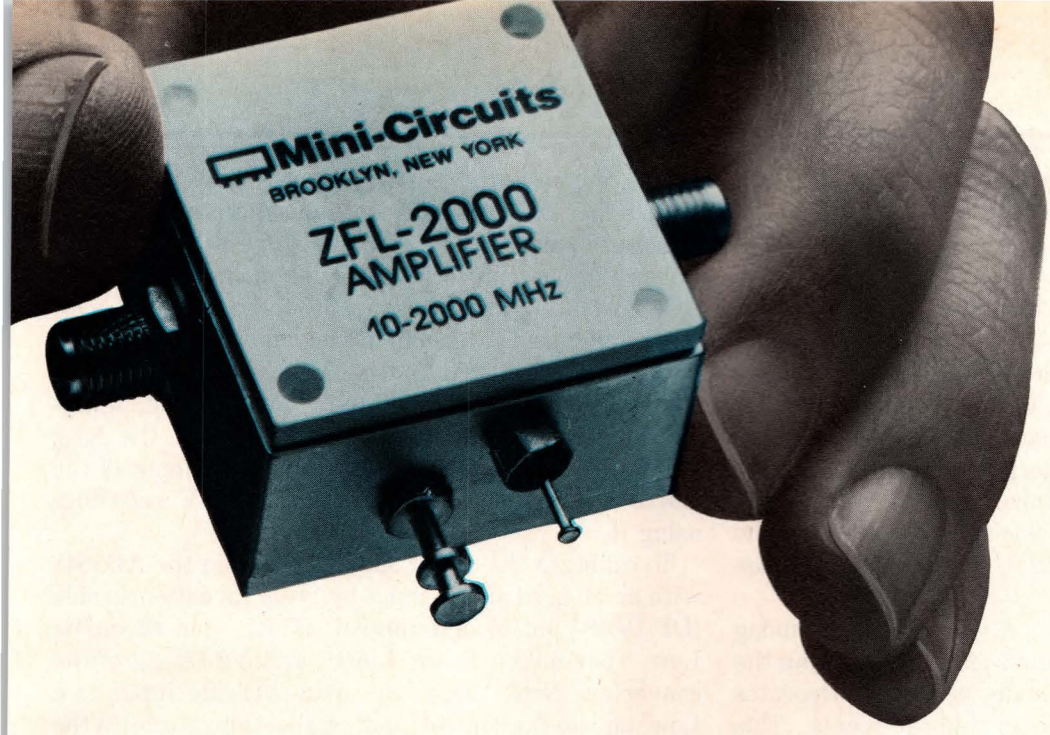


Fig 1—By using two ICs and several discrete components, *you can build a digitally programmable power supply that furnishes outputs to 14.3V at 80 mA.*



amplify or isolate? it does both.

22 dB gain and 40 dB isolation, 10-2000 MHz... only $179

Either way, the ZFL-2000 miniature wideband amplifier is an engineer's problem solver. Some examples of solutions offered by the ZFL-2000 are

- Boosting signal/sweep/synthesizer outputs to 50 mW.
- Achieving broadband isolation, especially when combining 2 signal generators for a two-tone intermodulation measurement.
- Increasing the dynamic range of spectrum analyzers.
- Driver for power amplifiers, such as Mini-Circuits' 1 and 2 watt ZHL series.
- Extending the frequency range of signal generators when using a frequency doubler, filter and then amplifying.
- Creating multiple output ports for one signal generator when amplifying and then adding a Mini-Circuits power splitter or divider.

These unconditionally stable wideband amplifiers are available with SMA connectors and are housed with an internal heat sink in a rugged 1.25 in. sq. by 0.75 in. high RFI shielded case.

Meets MIL-STD 202, these units operate from −55°C to +100°C.

One week delivery and a one-year guarantee, of course.

For complete specifications and performance curves refer to the Goldbook, EEM, EBG, or Mini-Circuits catalog

ZFL-2000 SPECIFICATIONS

FREQUENCY	10-2000 MHz
GAIN	20 dB
GAIN FLATNESS	±1.5 dB
OUTPUT POWER (1 dB compression)	+17 dBm
NOISE FIGURE	7.0 dB
INTERCEPT POINT (3rd order)	25 dBm
VSWR, 50 OHMS	2:1
DC POWER volt, current	+15 V, 100 mA
HEAT SINK	Internal
OPERATING TEMP	−55°C to +100°C

finding new ways...
setting higher standards

Mini-Circuits
A Division of Scientific Components Corporation
World's largest manufacturer of Double Balanced Mixers
P.O. Box 166, Brooklyn, New York 11235 (718) 934-4500
Domestic and International Telex 125460 International Telex 620156

CAPD now available! computer-automated performance data

C98 REV. A

CIRCLE NO 104

7.15V by connecting the voltage divider—the D/A converter—between V_{REF} and ground, with the divider's center tap connected to the noninverting input of the LM723's amplifier. A_{GND} (pin 2 of the AD7548), the output voltage V_{OUT}, and the amplifier's inverting input (pin 4 of the LM723) are tied together.

The LM723's maximum power-dissipation spec limits the circuit's output current. The value shown for R_{SC} limits the current to the recommended 80-mA value for the plastic LM723 when it operates without a heat sink at a 25°C ambient temperature. You can increase the supply's output current by placing a heat sink on the LM723 and, as in **Fig 2**, using an external pass transistor.

To compensate for the V_{REF} variation among LM723s, you can include a provision for calibrating the power supply. **Fig 2** shows a circuit that incorporates this provision as well as other improvements. This supply operates from input voltages as high as 35V, and you can program its output in the range from 4.096 to 20.48V (ie, 16 mV per bit for 10-bit resolution). The R_{SC} value limits the output current to 100 mA, but you can change its resistance value to limit at other current levels using the expression

$$R_{SC} = \frac{0.675}{I_{SC}} \text{ for } T_A = 25°C.$$

If you increase the output current level, you must ensure that the external pass transistor can handle the necessary power dissipation.

The **Fig 2** circuit includes a dual op amp, the AD644 (IC_{3A} and IC_{3B}), and a pass transistor, a TIP 31A (Q_1). IC_{3A}, configured as a noninverting amplifier with a gain of 2.1, supplies 15V to the V_{DD} input of the D/A converter. IC_{3B}, connected as a noninverting, unity-gain buffer, supplies a 4V reference to both the A_{GND} input of the AD7548 and the noninverting input of the LM723's amplifier. You can adjust the 4V reference using R_7.

To calibrate the power supply, program the AD7548 with an all-zero digital input by tying its data-override (DF/$\overline{\text{DOR}}$—pin 5) and control (CTRL—pin 6) inputs Low. Then adjust R_7 for 4.096V at pin 2 (A_{GND}) of the converter. Next, leave the data-override input tied Low, but tie the control input High—this programs the chip with an all-one digital input. Now adjust R_8 so that V_{OUT} equals 20.476V, which is the supply's maximum output. Finally, set the AD7548 for normal operation by tying both the data-override and control inputs (pins 5 and 6) High by connecting them to a 5 to 15V supply.

EDN

To Vote For This Design, Circle No 747

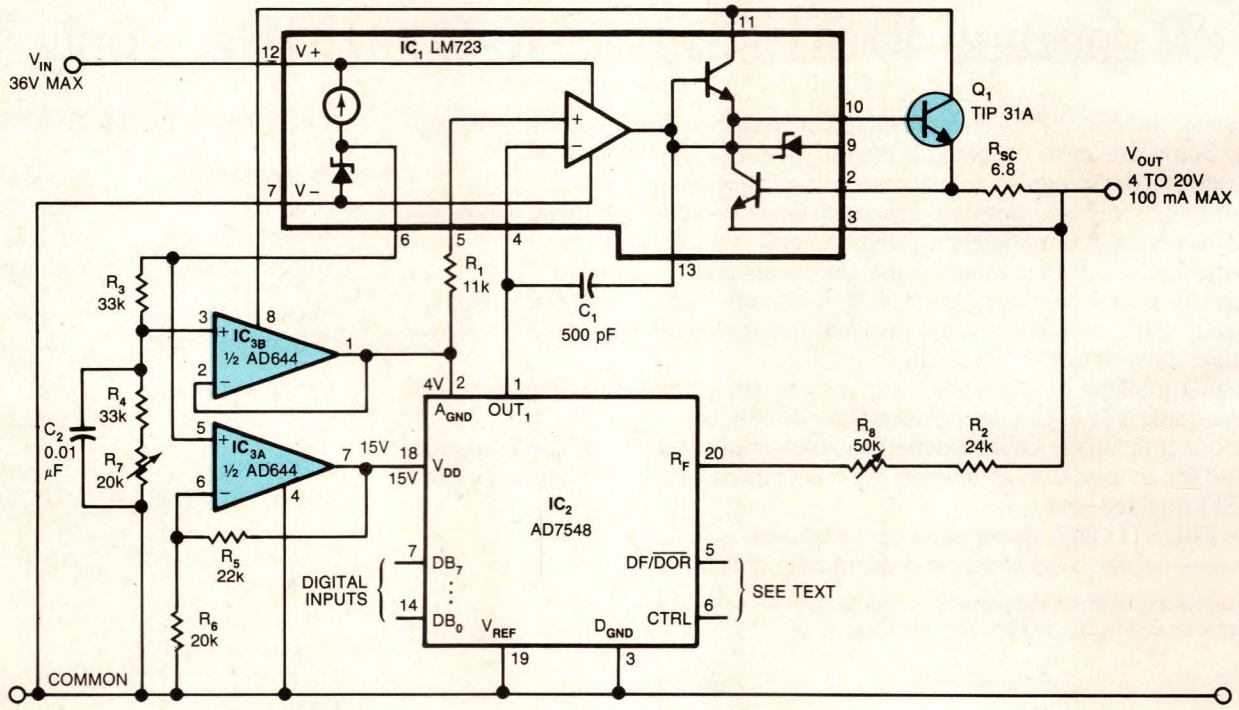


Fig 2—You can increase the Fig 1 *programmable supply's output current and voltage range by adding a dual op amp (IC_3) and a pass transistor (Q_1).*

New McGill Lighted Rocker Switches. At the quality, price and delivery you want. Here are the switches that have the capacity to assure maximum contact life. They also feature famous McGill quality, reliability and performance. McGill Lighted Rocker Switches are designed to fit a wide range of style and functional requirements. If our standard models won't do the job, we'll modify them so they will. Choose from angled or curved rocker lens caps with one or two lights. Rocker lens caps are also available in red, green, blue, amber and clear. To change colors, just snap out one cap and snap in another. McGill's 15-amp. models provide maximum reliability. There's a variety of single- or double-pole circuitry to meet any switching requirement.

Shed new light on your switch reliability problems

Terminals, circuitry and actuators can be engineered to meet your special needs. Standard spade terminals are ¼" wide. Also available are .187" wide spade terminals, printed circuit board, solder or screw terminals and wire leads. All McGill Lighted Rocker Switches are CSA approved and listed with Underwriters' Laboratories. They're available in 6-amp., 125-volt AC models, as well as 15-amp. See the light? Then call 219/465-2200. Or write McGill Manufacturing Co., Inc., Electrical Division, 1002 N. Campbell St., Valparaiso, Indiana 46383.

McGILL®
ENGINEERED SWITCHES

Circle No. 42 for literature

Circle No. 81 for manufacture contact

Dual-mode timer serves many applications

Bob Neidorff
Unitrode Integrated Circuit Corp, Merrimack, NH

Long-term timers can serve many applications. They can operate sprinkler systems periodically, maintain machines regularly, and turn lights on and off in homes to discourage burglars. A dual-mode timer, like the circuit in **Fig 2**, suits these applications better than a common 24-hour mechanical timer does.

As **Fig 1** shows, the dual-mode timer activates a load cyclically, with an individually controllable Output Enable and Off times; during the Output Enable time the output pulses On and Off at a programmable duty cycle.

Consider one application for such a circuit: an underground irrigation system for watering trees. The best way to water trees is to leave the water flowing for 12 hours at an extremely slow rate so the trees' roots absorb all the water, leaving no standing water, which can cause root decay. You could use a pipe that emits water through small holes, but a tree's feeder roots would clog these quickly. Temperature change also affects such devices, making the holes expand and contract, which causes shifts in the flow rate.

To eliminate the problems associated with emitters that have small holes, you can use an emitter with large holes and make the water flow faster, pulsing it on and off for 5 min every hour. The actual volume of water delivered to the tree would be the same. The circuit in **Fig 2** produces such a timing sequence.

Referring to **Fig 2**, note that the dual-mode timer consists of a power supply, a 60-Hz waveform shaper, a divider string, data-selector latches, and a load control. Three switches control the timer's operation: an On/Off switch, an optional reset switch, and 12 programming switches. The logic ICs are MC14000 Series CMOS devices, and the triac is a T2301PB. To furnish isolation, you can add an MOC3011 optotriac to the circuit.

The power supply accepts 24V ac at 60 Hz. A half-wave rectifier circuit, filter capacitors, and an MC7812CT 3-terminal regulator apply 12V to the CMOS logic and the triac. A single 1N4001 rectifier diode and a resistor-capacitor filter act as a waveform shaper; the shaped waveform is the 60-Hz clock for the MC14040 counters. The three cascaded MC14040s form a divider. MC14512 data selectors, controlled by the 12 programming switches, select the divider output that drives the latches.

Monostables and NAND gates form two edge-triggered S/R latches. The divider outputs set and clear the latches to select the correct On time and duty cycles. The outputs from the two latches are ANDed together by another IC that drives the triac (or optional optotriac and isolator). Thus, both latches must be set to allow the triac to be on.

A snubber circuit, consisting of a 0.1-μF capacitor in series with a 100Ω resistor, protects the triac from voltage spikes caused by the load. You can change these values if you expect to encounter highly inductive loads.

The **table** shows the effects of the programming switches on the times represented in the timing diagram of **Fig 1**. Although you can't use all of the 4096 possible switch positions (some combinations are invalid), you have a multitude of times to choose from. For example, you can select On times from 17 seconds to 36 minutes and total-cycle times from approximately 0.8 to more than 100 days. **EDN**

Editor's Note: The author was employed at Motorola Linear ICs Inc when this Design Idea was accepted.

To Vote For This Design, Circle No 748

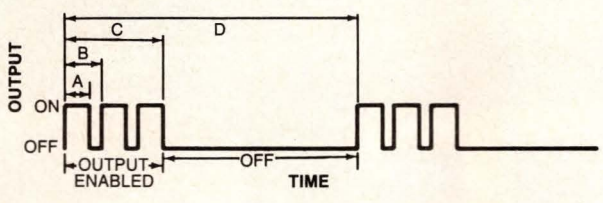
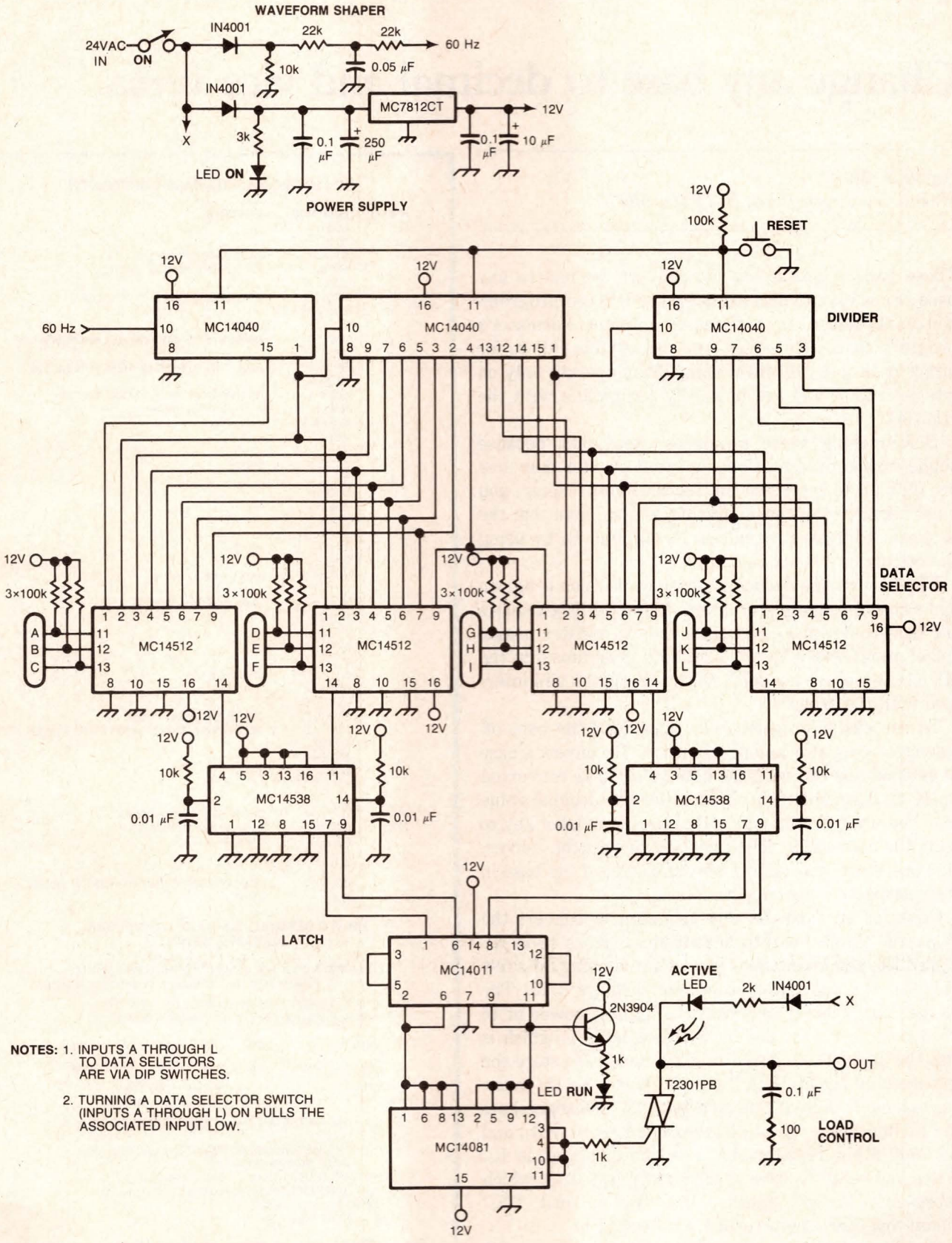


Fig 1—The Fig 2 circuit *allows you to program times A, B, C, and D.*

TABLE—TIMES AVAILABLE FROM THE DUAL-MODE TIMER

SWITCH C B A	TIME A	SWITCH F E D	TIME B	SWITCH I H G	TIME C	SWITCH L K J	TIME D
0 0 0	17 SEC	0 0 0	1.1 MIN	0 0 0	1.2 HR	0 0 0	19.4 HR
0 0 1	34 SEC	0 0 1	2.3 MIN	0 0 1	2.4 HR	0 0 1	1.6 DAY
0 1 0	1.1 MIN	0 1 0	4.6 MIN	0 1 0	4.9 HR	0 1 0	3.2 DAY
0 1 1	2.3 MIN	0 1 1	9.1 MIN	0 1 1	9.7 HR	0 1 1	6.5 DAY
1 0 0	4.6 MIN	1 0 0	18.2 MIN	1 0 0	19.7 HR	1 0 0	12.9 DAY
1 0 1	9.1 MIN	1 0 1	36.4 MIN	1 0 1	1.6 DAY	1 0 1	26 DAY
1 1 0	18.2 MIN	1 1 0	1.2 HR	1 1 0	3.2 DAY	1 1 0	62 DAY
1 1 1	36.4 MIN	1 1 1	2.4 HR	1 1 1	6.5 DAY	1 1 1	104 DAY

NOTES:
1. ONLY THOSE SWITCH POSITIONS THAT OBEY THE FOLLOWING INEQUALITIES ARE VALID. OTHER SWITCH SETTINGS WILL CAUSE UNPREDICTABLE RESULTS.
   TIME A < TIME B
   TIME B < TIME C
   TIME C < TIME D
   THESE TIMES ARE LABELED IN THE TIMING DIAGRAM OF FIGURE 1.
2. 0 REPRESENTS A SWITCH THAT IS ON, IE, A LINE THAT IS PULLED LOW.
   1 REPRESENTS A SWITCH THAT IS OFF, IE, A LINE THAT IS AT A LOGIC HIGH.
3. TIMES SHOWN ARE APPROXIMATE, AND ARE ALL BASED ON A DIVISION OF THE 60 Hz POWER LINE BY A POWER OF 2.



NOTES: 1. INPUTS A THROUGH L TO DATA SELECTORS ARE VIA DIP SWITCHES.

2. TURNING A DATA SELECTOR SWITCH (INPUTS A THROUGH L) ON PULLS THE ASSOCIATED INPUT LOW.

Fig 2—Using a 60-Hz timebase, *counters, data selectors, latches, and a few other logic devices, the dual-mode timer switches loads to 200V ac at 1.5A.*

Change any base to decimal and vice versa

David M Acre
McDonnell Aircraft Co, St Louis, MO

These two programs let you convert decimal to any base or any base to decimal using the HP-11C programmable calculator. Both fit easily into the calculator's program space. Moreover, you can combine them for direct base-to-base conversions. They operate only on integer values and are upwardly compatible with the HP-15C.

Before using these programs, note that because single-digit representations for bases greater than nine are difficult to represent on the calculator display, you must use their decimal equivalents. Also, note that the program addresses memories R_0 through R_9 by using the calculator's index register.

Fig 1 shows the decimal-to-base conversion program and a chart of its register usage. Likewise, **Fig 2** shows the base-to-decimal conversion and its register usage. Label assignments let you load both programs into the HP-11C program memory; neither program will interfere with the other.

To use either program, you must load the base-of-conversion register before execution. To convert a base to decimal, load R_3 with the base value to be converted to (ie, hexadecimal=16). Then enter the decimal value that you want to convert, and press the f_A label key to start the conversion. The calculator makes the conversion and stores the factors of each power of the base in their respective memory registers.

Consider an example: Say you want to convert the value 255 (in decimal) to hexadecimal. Store 16 in R_3. Enter 255, and press the f_A key. After running for a few seconds, the calculator stops and displays 1.15. The integer part (the 1) says that the highest power of 16 needed to represent 255 in hexadecimal is 1, which is also the highest numbered register needed to store the hexadecimal result. The fractional part (the 15) is the decimal equivalent of a hexadecimal "F" and represents the 16^1 multiplier. The 1.15 is stored in register R_1, and the only other register that need be displayed is R_0. When you recall R_0, the calculator displays 0.15, which represents 15×16^0, another hex "F," or just "15." Taken together, these results give you "FF."

Consider another example: Instead of converting 255 to hex, let's convert it to octal (base 8). Doing so yields the following sequence:

HP-11C DECIMAL-TO-BASE CONVERSION

```
PREFIX  FUNCTION    COMMENTS
  f     LBL A       :
        STO .0      :
        STO .2      : SAVE ENTERED VALUE
  f     FIX 8       : FIX FOR ROUNDING FUNCTION
  g     LOG         :
        RCL .3      : GET THE BASE OF CONVERSION
  g     LOG         :
        /           : DIVIDE
  g     RND         : ROUND THE RESULT TO GET PROPER VALUE
  g     INT         :
        STO .1      : SAVE THE NUMBER OF MEMORIES NEEDED
        STO I       :
  f     LBL 0       : RE-ITERATIVE CALCULATION SECTION
        RCL .2      : <z> r.2 - r(i) *BASE I
        RCL .3      : <y>
        RCL I       : <x>
        Yx          :
        /           : DIVIDE
  g     INT         :
        STO (i)     :
        RCL .3      :
        RCL I       :
        Yx          :
        X           : MULTIPLY
        RCL .2      :
        x<->y       : EXCHANGE X AND Y
        -           :
        STO .2      : SAVE NEW NUMBER
        RCL (i)     :
        1           :
        0           :
        0           :
        /           : DIVIDE BY 100
        RCL I       :
        +           :
        STO (i)     : STORE THE FINAL VALUE
  f     DSE         : DECREMENT TO THE NEXT LOWER POWER
        ENTER       :
        ENTER       :
        RCL I       :
        1           :
        +           :
  g     x<>0        : CHECK TO SEE IF FINISHED
        GTO 0       : <no> GOTO LABEL 0
  f     FIX 2       : <yes>
        RCL .1      :
        STO I       :
        RCL (i)     : DISPLAY COEFFICIENT OF HIGHEST POWER
        R/S         : STOP
```

HP-11C DECIMAL-TO-BASE CONVERSION REGISTER USAGE

R0 TO R9 : STORE THE RESPECTIVE FACTORS FOR EACH POWER FOR THE NUMBER IN THE BASE CHOSEN.

IE, IF b = BASE TO BE CONVERTED TO, THEN THE REPRESENTATION ON THE CALCULATOR DISPLAY IS:

MEMORY	R4	R3	R2	R1	R0
DISPLAY FORMAT	4.ee	3.dd	2.cc	1.bb	0.aa
VALUE	... + (b^4) *ee + (b^3) *dd + (b^2) *cc + (b^1) *bb + (b^0) *aa				

R.0 — HOLDS THE DECIMAL NUMBER ENTERED BY THE USER
R.1 — HIGHEST NUMBERED REGISTER USED FOR NEW BASE REPRESENTATION
R.2 — INTERMEDIATE CALCULATION REGISTER
R.3 — BASE OF CONVERSION (HEXADECIMAL = 16)
R.4 TO R.9 — NOT USED
RI — INDEX REGISTER

Fig 1—This program makes decimal-to-base *conversions and stores the factor for each power of the base chosen in the respective register.*

developing a million gate system that is correct by design.

Until now, electronics design engineers involved in major projects usually would access one system for logic design; another for layout; and a third for analysis. Each might have operated on a different mainframe. The applications usually did not share data with each other. And management had no clear overview of how the project was shaping up.

Control Data imagined a better way...MIDAS.

MIDAS is a modular integrated design automation system with the power to encompass the development of the project's entire architecture. An "engineering data manager" in the heart of the MIDAS system manages all the information. So designers, fabricators, layout technicians—the entire team—share data from the same base. They prove their functional and physical designs through automated logic simulation, fault analysis, and design-rule checking prior to the fabrication of any part, thus minimizing rework cycles and improving product quality...all through one integrated system.

Most important, MIDAS provides on-going configuration management and up-to-date development status of the project, every step of the way.

Control Data imagined, and is now delivering a full range of integrated systems, services and delivery options. This includes everything from designer workstations through superminis to mainframes—all from a single source to help you keep pace with advancing technology.

Call or write today.

Learn more about MIDAS and all the ways we can help you increase electronic design productivity. Call toll-free 1-800-253-4004, ext. 1430. In Minnesota, call collect 1-612-921-4400, ext. 1430. Or write Control Data, Electronic Marketing, P.O. Box 0, Dept. HQW09A, Minneapolis, MN 55440.

CONTROL DATA

Addressing society's major unmet needs as profitable business opportunities.

```
DISPLAY   KEYS PRESSED
  8.      STO .3
255.      f A
RUNNING
  2.03    RCL 1
  1.07    RCL 0
  0.07
```

Thus, 255_{10} equals FF_{16} and also equals 377_8. You can pick any base, but a judicious choice of bases may give you a greater conversion range (eg, as in picking base 16 rather than base 2).

By the same token, you can enter a number's base and digits into their respective registers. Then you just enter the number of the highest register used (ie, enter 1 for R_1) and press f_B. The number's decimal equivalent will then appear on the display. Here's an example:

```
DISPLAY   KEYS PRESSED
 16.      STO .3
  0.15    STO 1
  0.14    STO 0
  1.      f B
RUNNING
254.
```

It shows that hexadecimal "FE" equals 254.

The order in which you store the digits is the only important aspect of setting up the registers prior to conversion. In the decimal-to-base routine, the numeric values displayed to the left of the decimal point tell you which digit in the conversion process is being displayed. You don't need the numbers to the left of the decimal point when making entries in the base-to-decimal conversion.

The next step you can take is to make the two programs into subroutines by replacing *R/S* with a *RETURN*. You can then call them from a top-level program. This would let you convert one base directly to another. **Fig 3** shows a short top-level program stored just above the two subroutines. The order of operations goes as follows: Store the number in registers R_9 through R_0, respectively. Then, store the number's present base in R_3. Store the base to which the number will be converted in R_4. Next, enter the highest register used to store the original number and press f_A to begin execution. The calculator displays the results in the same format as does the decimal-to-base routine output.

Each time you run a program, you have to enter new data and bases. Consider this example:

```
DISPLAY   KEYS PRESSED
  0.15    STO 1
  0.14    STO 0
 16.      STO .3 PRESENT BASE
  8.      STO .4 NEW BASE
  1.      f C    NUMBER OF REGISTERS USED
RUNNING
  2.03    RCL 1  RESULTS OF DIRECT CONVERSION
  1.07    RCL 0
  0.06
```

This shows that hex "FE" equals octal 376. Note that, with this version of the programs, the calculator performed the hex-to-octal conversion without operator intervention. **EDN**

To Vote For This Design, Circle No 749

HP-11C BASE-TO-DECIMAL CONVERSION

PREFIX	FUNCTION	COMMENTS
f	LBL B	:
	STO .1	: SAVE THE USERS NUMBER OF DIGITS
	STO I	: SAVE ENTERED VALUE
	0	:
	STO .2	:
f	LBL 1	:
	RCL (I)	:
	FRAC	: USE FRACTIONAL PART OF THE ENTERED NUMBERS
	1	:
	0	:
	0	:
	X	: MULTIPLY BY 100
	INT	: <z> CONVERT FRACTION TO INTEGER
	RCL .3	: <y> GET THE BASE OF CONVERSION
	RCL I	: <x> GET INDEX VALUE
	Y^x	:
	X	:
	RCL .2	:
	+	:
	STO .2	:
f	DSE	: GO TO NEXT LOWEST REGISTER
	ENTER	:
	ENTER	:
	RCL I	:
	1	:
	+	:
g	x<>0	: CHECK TO SEE IF FINISHED
	GTO 1	: <no> GO BACK TO LABEL 1
f	FIX 0	: <yes>
	RCL .2	: DISPLAY DECIMAL RESULT
	STO .0	: SAVE IN .0 FOR USE WITH OTHER ROUTINE
	R/S	: STOP

HP-11C BASE-TO-DECIMAL CONVERSION REGISTER USAGE

R0 TO R9 : STORE THE RESPECTIVE FACTORS FOR EACH POWER FOR THE NUMBER IN THE BASE CHOSEN.

IE, IF b = BASE TO BE CONVERTED TO, THEN THE REPRESENTATION FOR ENTRY ON THE CALCULATOR DISPLAY IS (x = DON'T CARE)

MEMORY	R4	R3	R2	R1	R0
DISPLAY FORMAT	x.ee	x.dd	x.cc	x.bb	x.aa
VALUE	$\ldots + (b^4) * ee + (b^3) * dd +$ $(b^2) * cc + (b^1) * bb + (b^0) * aa$				

R.0 — HOLDS THE EQUIVALENT DECIMAL VALUE
R.1 — HIGHEST NUMBERED REGISTER USED FOR OLD BASE REPRESENTATION
R.2 — INTERMEDIATE CALCULATION REGISTER
R.3 — BASE OF CONVERSION (HEXADECIMAL = 16)
R.4 TO R.9 — NOT USED
RI — INDEX REGISTER

Fig 2—Complementing the Fig 1 program *this base-to-decimal program stores the factor for each power of the number chosen in the respective register.*

PREFIX	FUNCTION	COMMENTS
f	LBL C	:
	GSB B	: CONVERT BASE TO DECIMAL
	RCL .4	: GET USER STORED BASE TO CONVERT TO
	STO .3	: STORE NEW BASE
	R v	: ROLL DOWN STACK ONCE
	GSB A	: CONVERT DECIMAL TO NEW BASE
	RET	:

Fig 3—Using the Fig 1 and 2 programs as subroutines, *this short program makes direct nondecimal base-to-base conversions.*

workstations that integrate in-house systems on every engineer's desk.

Maximize Productivity.
Control Data looked at the need to integrate the design, layout, analysis and logic simulation functions ... saw a way to place low-cost design tools in front of your engineers...and developed the Electronic Design Workstation.

IBM PC Compatible.
The Control Data Electronic Design Workstation offers full IBM PC and XT compatability and complete system integration that can speed you through 80 to 90% of your design tasks at about 1/5th the cost of functionally equivalent systems.

Broad Applications.
SCALD Hierarchical Design Concepts at about 1/4th the cost of conventional workstations ... and more :

- Advanced Schematic Entry
- Documentation
- Logic Simulation
  36 State Multi-Level Simulation
- Netlist Extraction:
  TEGAS • SPICE • ASPEC • SYSCAP • SCICARDS • LOGIS *
- Project Management

Easy Custom Interface.
All drawing and netlist files are in a readable ASCII file format that makes developing interfaces to your in-house codes easy. You can do it yourself or we can do it for you.

Find out how you can integrate your system and put Electronic Design Workstations in front of your engineers. Call toll-free 1-800-253-4004, ext. 1430. In Minnesota, call collect 1-612-921-4400, ext. 1430. Or write Control Data, Electronic Marketing, P.O. Box 0, Dept. HQW09A, Minneapolis, MN 55440.

*TEGAS is a registered trademark of Calma Div., General Electric Corp. SYSCAP is a registered trademark of Rockwell International, Inc. SCICARDS is a registered trademark of Scientific Calculations, Inc.

CONTROL DATA

Addressing society's major unmet needs as profitable business opportunities.

CIRCLE NO 106

Circuit handles multiple sync characters

Yadagari Gunda and B Vasantha
ISRO Satellite Centre, Bangalore, India

In TDM telemetry systems or synchronous data-communication systems, a long frame length makes the most efficient use of a communications channel. But as the frame length increases, so does the length of the frame sync code. You can use the technique outlined in **Fig 1** to handle any number of sync characters or bits, and you can program the number of errors allowed in the sync code. In contrast, commercially available interfaces can handle at most two sync characters with no allowable error margins.

In **Fig 1**'s circuit, the CPU checks the sync code. After each frame ends, the serial interface is programmed for External Sync and Enter Hunt mode. The CPU uses the RAM registers to store received data and uses the synchronous clock as the interrupting input. This clock will interrupt (via line RST 7.5) the system at every Low-to-High transition; the interrupt is enabled only during the frame-sync checking.

When an interrupt occurs, the CPU goes to the CHKFSC (Checking For Sync Characters) routine. **Fig 2** shows a flowchart of the routine; **Fig 3** contains a program listing. The routine causes the CPU to read data into the accumulator and rotate the RAM registers (**Fig 4**). The CPU then compares the RAM registers to the frame-sync code to find the transmission errors, if any. If the number of errors found is less than the programmed limit for errors, the CPU will apply a SYNDET input to the serial interface and disable the RST 7.5 input. On the other hand, if the number of errors exceeds the programmed limit, the system will wait for another data bit to arrive, and this process will continue until the correct frame-sync code arrives. The CPU uses a frame-length counter to detect the end of the frame. Because the CPU executes the CHKFSC for every bit, the serial-data rate is limited. **EDN**

To Vote For This Design, Circle No 750

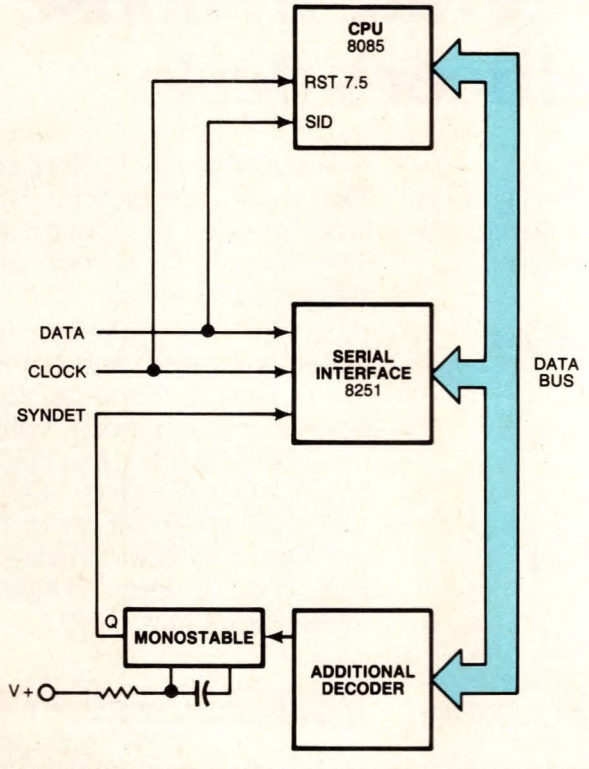


Fig 1—Using the technique illustrated here, *you can handle multiple sync characters and set the allowable number of data-transmission errors.*

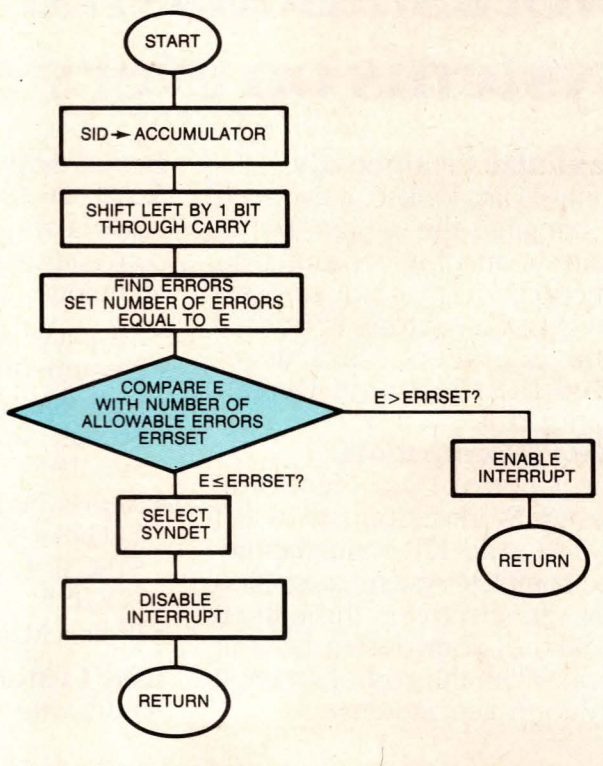


Fig 2—This checking-for-sync-characters *routine is executed by the* ***Fig 1*** *circuit's CPU for each data bit transmitted over a synchronous communication channel.*

```
LOC   OBJ          LINE   SOURCE STATEMENT
                     1 ;
                     2 ;
                     3      ; THIS ROUTINE 32BIT LENGTH FRAME SYNCH CODE (4 BYTES)
                     4 ;
2003                 5 TEMREG  EQU   2003H    ; TOP ADDRESS OF THE TEMPARARY REGISTERS
3003                 6 FSCODE  EQU   3003H    ; TOP ADDRESS OF THE FRAME SYNCH CODE
0004                 7 REGLEN  EQU   04H      ; FRAME SYNCH CODE LENGTH
0000                 8 ERRSET  EQU   00H      ; ADDRESS OF THE ERROR PORT
0001                 9 SYNDET  EQU   01H      ; ADDRESS OF SYNDET PORT
000B                10 DISFSC  EQU   0BH
                    11         CSEG
0000  210320        12 START:  LXI   H, TEMREG
0003  20            13         RIM
0004  1604          14         MVI   D, REGLEN
0006  07            15         RLC              ; SID → CARRY
0007  7E            16 LOOP 1: MOV   A, M       ; ROTATES REG. SET BY ONE BIT
0008  17            17         RAL
0009  77            18         MOV   M, A
000A  2B            19         DCX   H
000B  15            20         DCR   D
000C  C20700      C 21         JNZ   LOOP1
000F  23            22         INX   H
0010  010330        23         LXI   B, FSCODE
0013  1604          24         MVI   D, REGLEN
0015  1E00          25         MVI   E, OH
0017  0A            26 LOOP:   LDAX  B          ; FINDS NUMBER OF ERRORS IN RECEIVED DATA
0018  CD2E00      C 27         CALL  COUNT
001B  0B            28         DCX   B
001C  15            29         DCR   D
001D  C21700      C 30         JNZ   LOOP
0020  DB00          31         IN    ERRSET     ; ALLOWABLE NO. OF ERRORS
0022  BB            32         CMP   E
0023  D22800      C 33         JNC   CORRECT    ; JUMPS IF RX DATA HAS LESS ERRORS THAN PROGRAMMED
0026  FB            34         EI
0027  C9            35         RET
0028  D301          36 CORRECT: OUT   SYNDET
002A  3E0B          37         MVI   A, DISFSC
002C  30            38         SIM
002D  C9            39         RET
002E  D5            40 COUNT:  PUSH  D          ; COMPARES EACH BYTE—FINDS ERRORS
002F  1608          41         MVI   D, OSH
0031  07            42 LOOP2:  RLC
0032  D23600      C 43         JNC   SKIP
0035  1C            44         INR   E
0036  15            45 SKIP:   DCR   D
0037  C23100      C 46         JNZ   LOOP2
003A  23            47         INX   H
003B  D1            48         POP   D
003C  C9            49         RET
0000              C 50         END   START
```

Fig 3—This CHKFSC code, *whose operation is outlined in the* **Fig 2** *flowchart, runs on the 8085.*

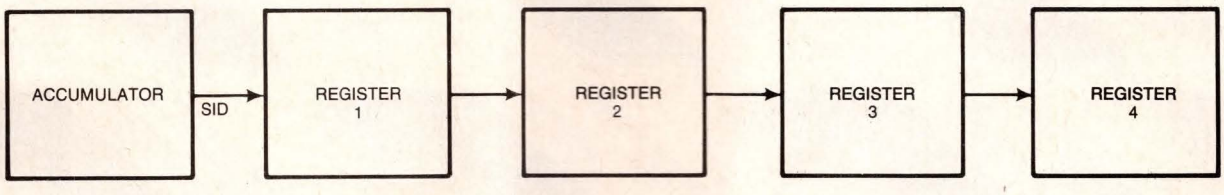


Fig 4—On every interrupt of the Fig 1 CPU, *RAM registers are shifted one bit.*

One out of every two companies building Ethernet-compatible products builds them with Seeq Ethernet components.

That's because our 8003 Ethernet Data Link Controller and 8023 CMOS Manchester Code Converter are the industry's most practical Ethernet shortcuts.

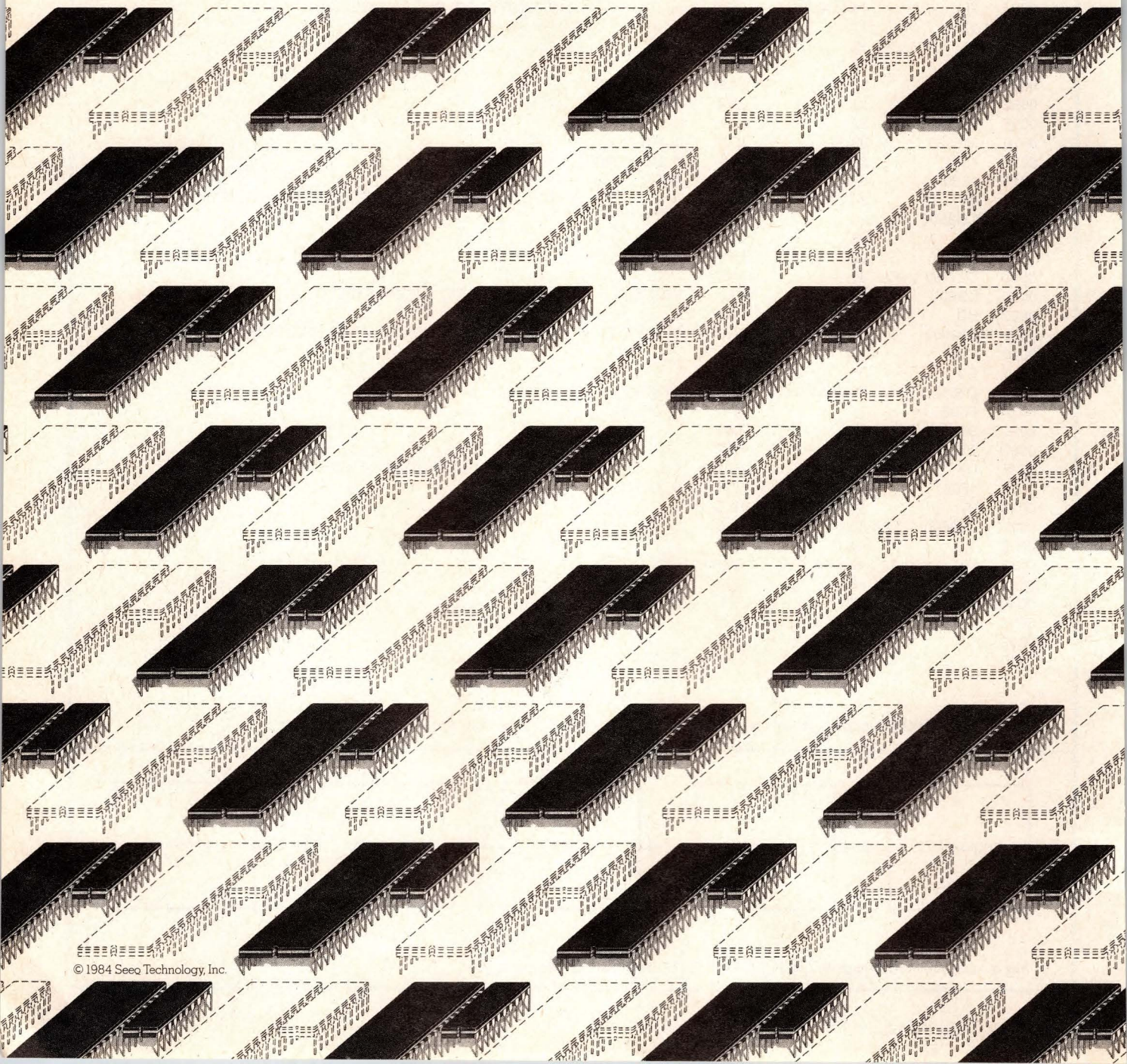
Why?

Simple logic.

Instead of wrestling with the dark side of Ethernet—boards full of components, lost weekends, algorithms written by committee—you drop in two VLSI packages.

A few coffee breaks later, transmission, reception, backoff and code conversion are up and running in the best way possible.

EVERY OTHER COMPANY APPRE



© 1984 Seeq Technology, Inc.

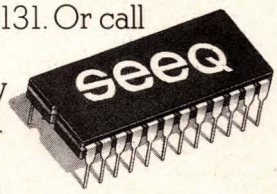
Trouble free.

And that promise is backed by millions of hours of on-the-job performance. Plus 100% off-the-shelf availability. No wonder our Ethernet family is so widely appreciated.

Give yourself the same chance. Send for our free Ethernet data package. Fifty pages of theory and practice for putting your project online.

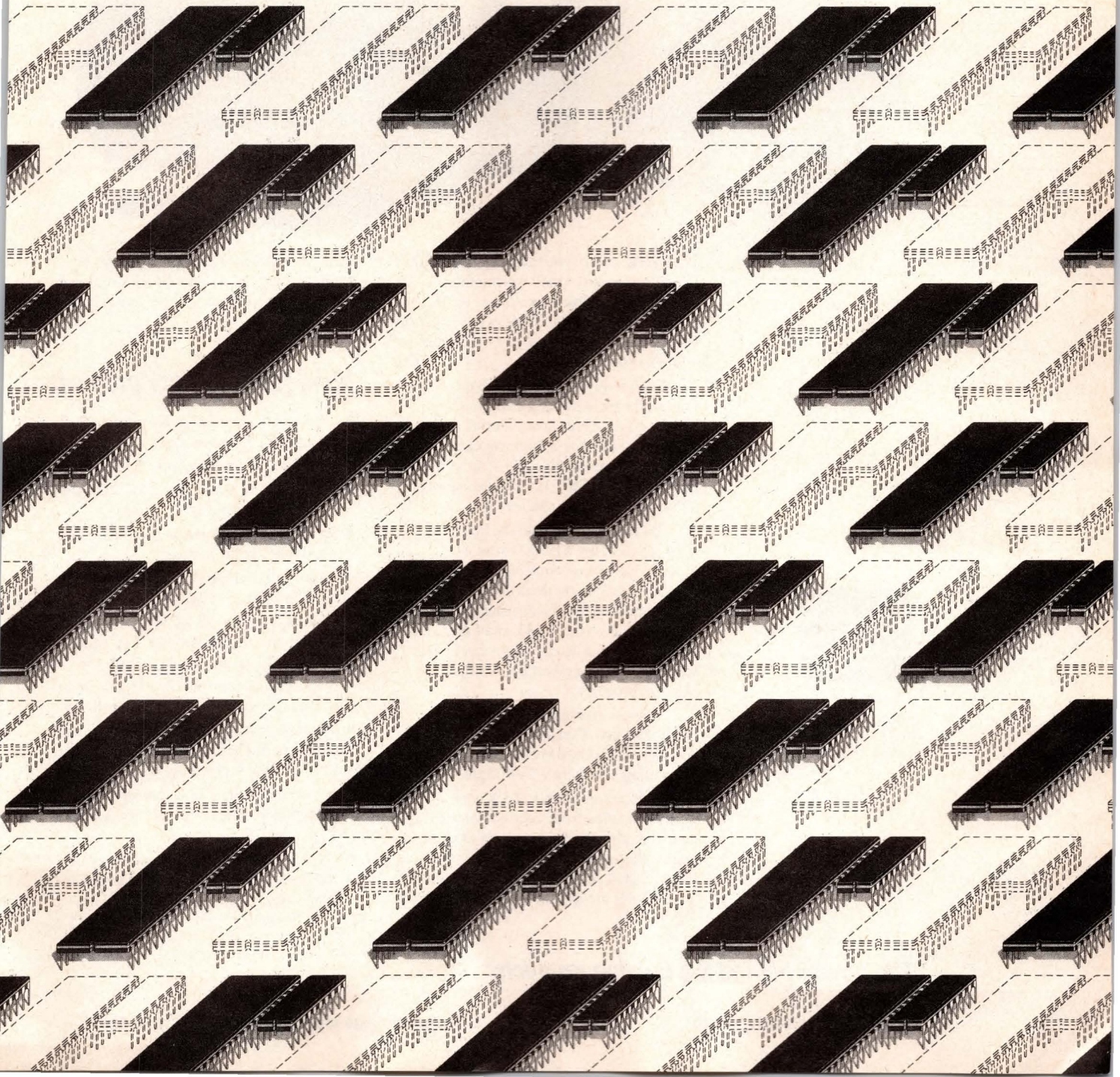
Just write Seeq Technology, 1849 Fortune Drive, San Jose, California 95131. Or call (408) 942-1990.

And appreciate what every other company already does.



CIRCLE NO. 270

CIATES SEEQ'S PART IN ETHERNET.



With 500 models available from stock . . .

Bodine makes it easy to buy top-quality gearmotors, motors and electronic motion controls

Bodine offers you the industry's widest line of top quality small gearmotors, motors and electronic motion controls available off-the-shelf. And wide selection and local availability are just the start of your Bodine benefits.

Bodine gives you the high reliability you need for critical applications. High-quality components and materials, realistic ratings, and manufacturing excellence produce exceptionally consistent performance and long life. It's most economical to buy products you can rely on!

Bodine gives you all the help you need to select the right gearmotors, motors and motion controls. Comprehensive technical literature is augmented by expert application engineering assistance. Customers both large and small rely on our guidance as well as on our products. It's logical to buy a product you know will perform properly!

Choice. Immediate availability. Dependability. Consistency. Technical assistance. It's the easy buy, because everything you want is built right in.

Bodine top-quality stock gearmotors, motors and electronic motion controls are available through 103 stocking Distributors and Authorized Service Centers in the USA, Canada and Europe. Modifications and specials are available through your local Manufacturer's Representative or from the factory. Ask for Stock Catalog S or European Voltage Stock Catalog SME.

BODINE®
ELECTRIC
COMPANY

2500 W. Bradley Place
Chicago, IL 60618 U.S.A.
Tel: (312) 478-3515
Telex: 25-3646

Mini-guide to stock products

- 400 USA/Canadian models, plus 100 European voltage models
- New 24 VDC gearmotors and motors
- Parallel shaft gearmotors: AC, DC; up to 341 Lb.-in. torque
- Right-angle shaft gearmotors: AC, DC; up to 340 Lb.-in. torque
- Motors: 10 and 30 AC, DC, universal; HP 1/2000 to 1/2; dia. 2.27″ to 6.00″
- 1.8° DC stepper; 72 RPM HY-Sync™; instrument, torque, floppy disc motors
- Matched SCR and Thyristor DC speed/torque controls for PM and shunt wound drives; DC stepper controls
- Synchronous and non-synchronous, split phase, permanent split capacitor, shunt wound, PM, series wound
- All stock products U.L. construction recognized, many CSA-certified and VDE-approved
- Other models and modifications available built-to-order in small or large quantities

© Bodine Electric Company 1984

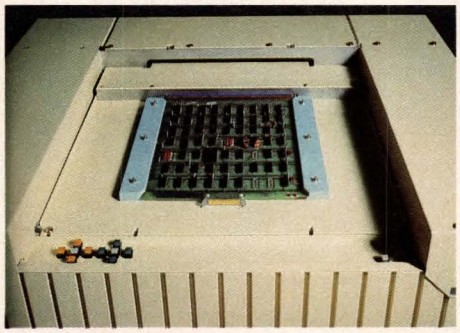
The power behind the leading products®

Stock Products Circle No. 107 **European voltage stock products Circle No. 108**

The Best Cost-To-Performance ATE Solutions Anywhere

Vanwell can serve as your *one* source for *all* your ATE requirements—including ATE Systems, Automatic Guided Probes, Tape Analyzers, Turnkey Systems, Applications Software and Testing Services.

VDS 8000L AUTOMATIC TEST SYSTEM
This one test set can perform a variety of digital/analog or hybrid tests—on VLSI-based PCB's, as well as devices such as Gate Arrays and Microprocessors.



ROBOPROBE™ GUIDED PROBE SYSTEM
The industry's premier microprocessor-driven automated guided probe. It is capable of operating either with the VDS 8000L test system or with other commercially available test systems equipped with the IEEE 488 bus or RS-232 serial port. RoboProbe is also available as a stand-alone test station, driven by its dedicated microprocessor for such applications as incoming inspection and screening.

TAPE SYSTEM ANALYZER
Designed to provide real-time assessment of multi-track high density digital record/replay magnetic tape systems. It generates and analyzes data used to detect signal faults in tape systems.

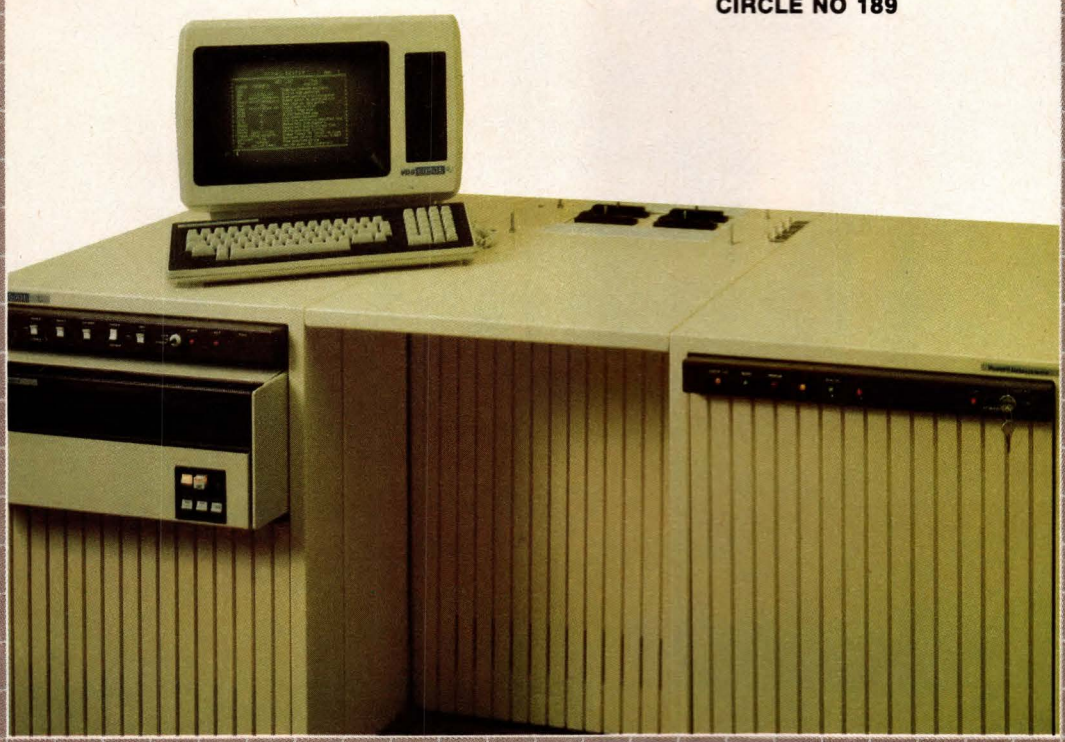
TEST PROGRAMS AND SERVICES
At Vanwell, you will find a comprehensive lineup of test services. These include test program sets and application-based programs for a wide range of host test systems which use any of the commercially available software simulators. You may also consider Vanwell as your off-premises test systems house for testing VLSI-based printed circuit boards as well as gate arrays, microprocessors and other critical components.

For more details and technical literature, contact:

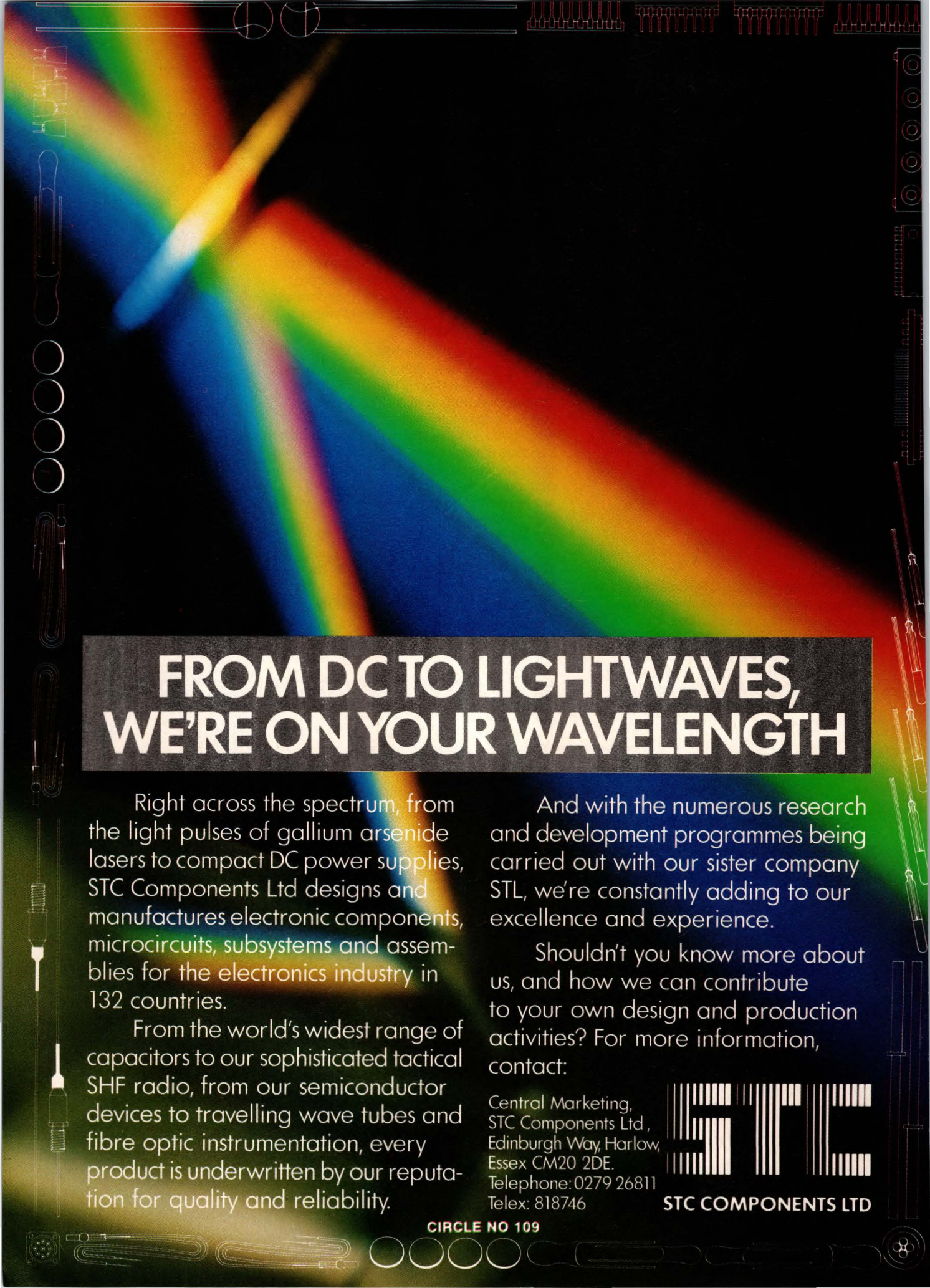
THE VANWELL CORPORATION
83 Hanover Road
Florham Park, New Jersey 07932
201-966-6270 TLX-960127 SWIFT NYK VWL

BRINGING MODERN SOLUTIONS TO TESTING PROBLEMS

CIRCLE NO 189



VANWELL



FROM DC TO LIGHTWAVES, WE'RE ON YOUR WAVELENGTH

Right across the spectrum, from the light pulses of gallium arsenide lasers to compact DC power supplies, STC Components Ltd designs and manufactures electronic components, microcircuits, subsystems and assemblies for the electronics industry in 132 countries.

From the world's widest range of capacitors to our sophisticated tactical SHF radio, from our semiconductor devices to travelling wave tubes and fibre optic instrumentation, every product is underwritten by our reputation for quality and reliability.

And with the numerous research and development programmes being carried out with our sister company STL, we're constantly adding to our excellence and experience.

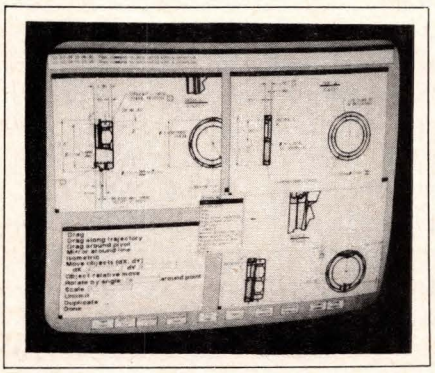
Shouldn't you know more about us, and how we can contribute to your own design and production activities? For more information, contact:

Central Marketing,
STC Components Ltd,
Edinburgh Way, Harlow,
Essex CM20 2DE.
Telephone: 0279 26811
Telex: 818746

STC

STC COMPONENTS LTD

CIRCLE NO 109



CAD DRAFTING. Expert Drafting 2.42 adds 2-D mechanical drawing to 8014 workstations. CAD features include drawing icons, pop-on menus, command accelerators, user-definable grids, a line-creation mode, forms design, template libraries, and IGES translators. Panning and zooming simplify drawing manipulation. The system draws points, lines, arcs, curves, circles, and filled or crosshatched areas. Hard copy is plotted on laser printers. A mouse-directed cursor selects the editing commands, which include copy, delete, dynamic drag, mirror move, rotate, and trim. Incorporating ANSI and ISO standards, dimensioning may be in ft, in., mil, m, cm, mm, °, min, sec, or rad. The software runs concurrently with schematic, simulation, and placement/routing routines. $7900. **Versatec,** 2710 Walsh Ave, Santa Clara, CA 95051. Phone (408) 988-2800.

Circle No 402

SOFTWARE TOOLS. Compatible with Data General's 32-bit Eclipse MV systems, two CAE tools speed software development. Change and Configuration Control keep track of all changes and configurations of source code, object code, test data, documents, and drawings. The software management tool supports programs in all languages. Programming Environment automates debugging, testing, documentation, and optimization. Users can write application programs from prefabricated code and deliver products that are checked out, documented, and standardized. Both programs run under either the AOS/VS or the MV/UX operating systems. $30,000; $15,000 for program subsections. **Softool Corp,** 240 S Kellogg Ave, Goleta, CA 93117. Phone (805) 964-0560.

Circle No 403

CAE PC BOARDS. AUCIM links FutureNet's IBM PC-compatible schematic-entry programs to a wiring and pc-board facility. Netlists from a workstation can be telephoned to the factory and fabricated as wire-wrap prototypes, pc boards, or unilayer boards. $25. **Augat Interconnection Systems Div,** Box 1037, Attleboro, MA 02703. Phone (617) 222-2202.

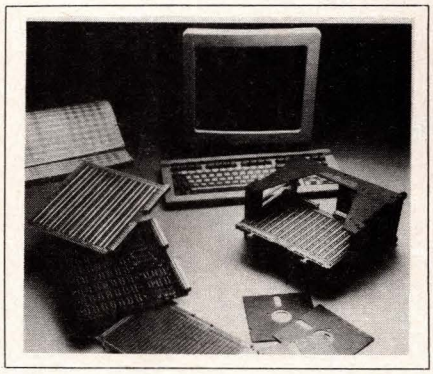
Circle No 404

PROGRAMMABLE LOGIC. CUPL 2.0 specializes in detailing programmable logic. Designers can describe logic in state diagrams, Boolean equations, or function tables. State machines include D, JK, and RS latches. A minimizer option reduces the product terms to fit the target device or reduces the terms to the lowest possible level of minimization. The bit-field notation capability supports the function-table approach. CUPL 2.0 implements logic for IFLs, PLAs, and PROMs. For PROMs, the language converts fuse patterns to PROM-programmer input. The software operates under CP/M, MS/DOS, Unix, and VMS. $895. **Assisted Technology Inc,** 2381 Zanker Rd, Suite 150, San Jose, CA 95131. Phone (408) 942-8787.

Circle No 405

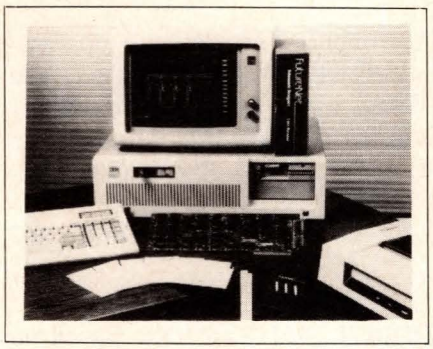
ROBOT SIMULATION. Based on the 32-bit Apollo Domain computer, Robocam simulates and programs robots. The Rise language instructs robots on line and off line. Robocam evaluates alternative robot models, as well as facilities for work-cell design. It also evaluates new robot programs and graphically displays robots in operation. Robot models include dynamics, geometry, and kinematics parameters. $60,000. **Silma Inc,** 1800 Embarcadero, Palo Alto, CA 94303. Phone (415) 493-0145.

Circle No 406



MODELING SYSTEM. See Why is a Cromemco μC-based visual interactive simulation package for computer-aided modeling. Intended for the design and control of manufacturing processes, the system lets users create plant diagrams and watch units passing through their factories on an Intecolor 8051 terminal. By varying layouts and control rules, engineers can optimize the design of factory equipment and processes. $50,000. **BLSL Inc,** 83 Cambridge St, Burlington, MA 01803. Phone (617) 272-7333.

Circle No 407



SCHEMATIC DESIGNER. The Dash-1 schematic-design-entry system now runs on the IBM PC/AT and the TI Professional personal computers. The IBM PC/AT can also operate Dash-2, a version of Dash-1 that offers a larger library and enhanced on-screen help. The Dash schematic designer features a graphics controller board, an RS-232C mouse, a printer, and software. The software includes net lists, a list of materials, and a hierarchical design package that extends design capability to gate-array and VLSI design levels. The parts library furnishes users with standard TTL, CMOS, and ECL parts. In addition to ROMs, RAMs, and μPs, the component library contains symbols for transistors, diodes, zeners, capacitors, resistors, potentiometers, relays, LEDs, and inductors. Dash1/TIPro, $4980; Dash1/AT99-MAP, $5380; Dash2/AT99-MAP, $6280. **FutureNet Corp,** 6709 Independence Ave, Canoga Park, CA 91303. Phone (818) 700-0691. TWX 910-494-2681.

Circle No 408

Ulti•Mate-D®

The only 1980's Solution To A 1980's Problem.

Symbex Designed the Ulti•Mate-D® from the Ground Up... for Total Electromagnetic Compatibility.

Retrofit a 50 year old connector design to solve a 1980's problem? Symbex wouldn't think of it. Instead, Symbex started with a fresh approach, incorporating the latest "molded-in" connector technology for total Electromagnetic Compatibility.

The Ulti•Mate-D series consists of three basic models. The Special Purpose Shielded types, with a 60-70 dB rating, exceed FCC standards. The General Purpose Shielded assemblies satisfy RS-232 and RS-449 requirements. And the General Purpose Unshielded variety is designed for non-critical environments. All models UL-style.

The Symbex Ulti•Mate-D... for compliance and reliance. A solution, not just a fix, for today's applications.

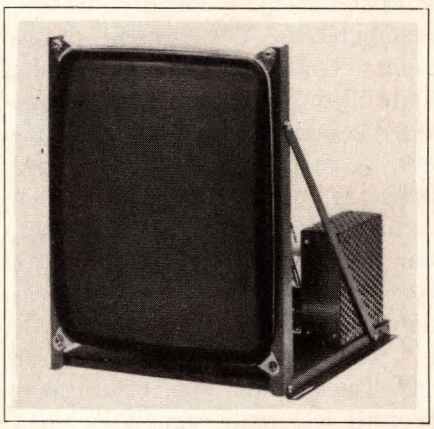
Call or write today for more information.

SYMBEX

72 Corwin Dr., Box 938
Painesville, OH 44077
800-321-7075 except OH
(216) 354-0925 collect

890 Fortress St.
Chico, CA 95926
800-824-4129 except CA
800-822-8160 CA only,
or (916) 891-6410

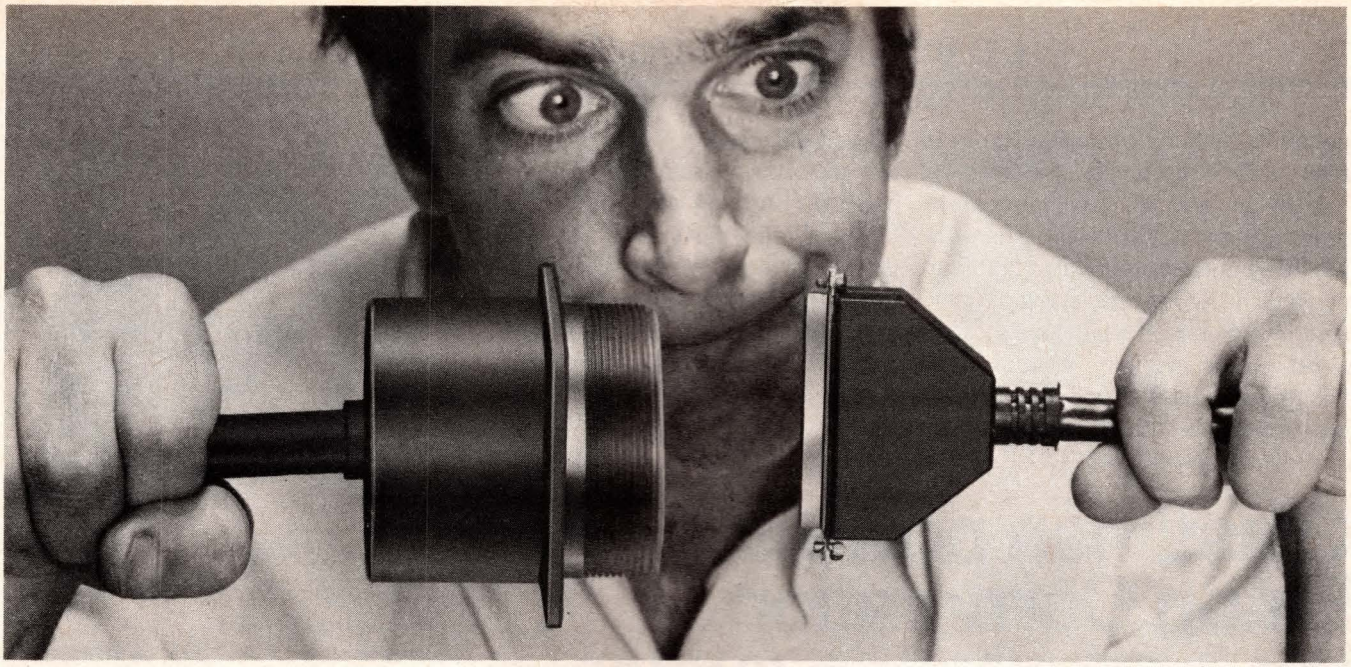
CIRCLE NO 110



CAE DISPLAY. With a 1024×1024-pixel resolution, the DTH operates at a 25- to 65-kHz horizontal line rate. The 15-in. unit takes TTL and ECL video inputs, as well as 1-bit and 2-bit video inputs. Frame and kit versions are available. Less than $400. **Dotronix Inc,** 160 E 1st St, New Brighton, MN 55112. Phone (612) 633-1742.

Circle No 409

HUMAN-FACTORS CAD. Mechanical designers can use SAMMIE to evaluate operator comfort, viewing parameters, and movements. The package represents individuals of any size or shape and includes a human model with built-in reach and sight capabilities. Three inde-



HERE'S WHY CABLE ASSEMBLIES SHOULD BE DESIGNED, ENGINEERED, AND MANUFACTURED UNDER ONE ROOF!

Sometimes it seems impossible to get things together. Try hard as you may, when push comes to shove you just can't make the right connection. Take heart! *Cable Systems, Inc.** goes all the way to ensure trouble-free engineered cable assemblies and interconnect systems for both Industrial (FCC Docket #20780) and Military markets. And all the way means just that – all the way from state-of-the-art design on through to engineering, manufacturing, quality control and 100% computer testing – *all under one roof!*

This single-source capability is why so many customers rely on our innovative skills for custom-engineered interconnect systems. Add, under the same roof, the most sophisticated production and test equipment available operated by *certified* personnel, and know why customers have come to expect *on-time delivery of molded and unmolded cable assemblies at competitive prices!*

Connect with confidence – call *Customer Service* at 617/389-7080 for prompt delivery of the Cable Systems DESIGN INFO kit, or please circle the appropriate reader service number below for Industrial or Military applications.

*Formerly known as *Cable Systems & Assembly Co., Inc.*

CABLE SYSTEMS, INC.
210 Broadway, Everett, MA 02149
Tel: 617/389-7080 TWX: 710-348-1760

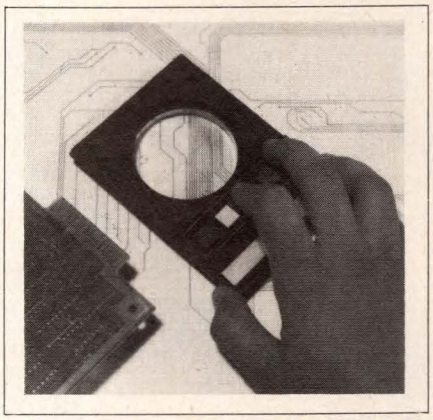
THE ONLY CONNECTION YOU'LL EVER NEED TO MAKE.

INDUSTRIAL DIVISION
CIRCLE NO 121

DEFENSE GROUP
SYSTEMS DIVISION
COMPONENTS DIVISION
CIRCLE NO 160

pendent modules comprise the system—a 3-D assembly modeler, a human model, and visibility and mirror-analysis facilities. The 3-D module builds models of equipment or workplaces by specifying and assemblying geometrical shapes, with perspectives visible around and within the model. The human model consists of 19 links representing a skeleton, surrounded by a predefined human body. The system moves the human's position and indicates comfort and the extreme limits of joint movement. The third module assesses visibility from 360° in the horizontal plane and 180° in the vertical plane. From $40,000. **Prime Computer Inc,** Prime Park, Natick, MA 01760. Phone (617) 655-8000.

Circle No 410



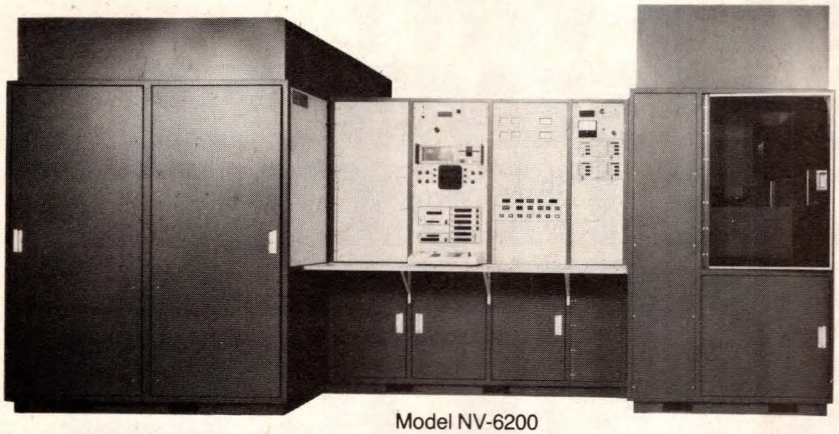
CAD DIGITIZER. The black and gray Digi-Grid system improves layout registration. Users lay out designs with the black layout grid and then digitize with the gray registration grid. The pin bar registration system correlates the black and gray grids. The system eliminates visual parallax and reduces electronic parallax. After you erase grease-crayon markings, you can reuse Digi-Grid. D size, $76; E size, $135. **Fotel Inc,** 41 W Home Ave, Villa Park, IL 60181. Phone (312) 834-4920.

Circle No 411

VAX-BASED LAN. Designed primarily for factories, Inplant connects VAX and other computers to automation equipment and related peripherals. The system uses Ethernet, broadband cabling, or fiber-optic lines for physical transmission and also employs the Semiconductor Equipment Communications Standard protocol. Inplant accommodates thousands of devices in its network, with a maximum of 240 devices on each VAX. Ungermann-Bass 150 or 2As network interface units and proprietary software are included in the package. Inplant's driver software is written in VAX microassembler; the network processor code is in C and Z-80 assembler. The system handles RS-232C and parallel interfaces. **Incyte/Schlumberger,** 4 Main St, Los Altos, CA 94022. Phone (415) 949-3860.

Circle No 412

Glassman powers Eaton Corporation ion implantation systems



Model NV-6200

Darrell Dullnig, Eaton Corporation

"The quality of Glassman's equipment has just been excellent—that's basically why they have become our preferred vendor for high voltage power supplies," says Darrell Dullnig, Materials Manager, Eaton Corporation, Ion Beam Systems Division, Austin, Texas. "Every medium current ion implantation system we build includes three different Glassman High Voltage power supplies," continues Mr. Dullnig, "so we have had a lot of experience with Glassman and their products. It has been a very satisfactory business relationship."

"Our engineers have been pleased with the advanced design of their equipment, and Glassman has always been very responsive to me. Whenever I have to accelerate a scheduled delivery, they work with me to get the supplies to me when I need them."

Let Glassman work with you to meet your high voltage DC power requirements. Call John Belden at 201-534-9007, or write today.

Innovations in high voltage power supply technology.

GLASSMAN HIGH VOLTAGE INC.

Route #22 (East), Salem Industrial Park, P.O. Box 551, Whitehouse Station, N.J. 08889
(201) 534-9007 • TWX 710-480-2839

CIRCLE NO 112

TEK 200/300 SERIES
ULTRA-PORTABLE SCOPES

THE ANSWER
BY ANY MEASURE

Small Wonders

From battery-operated, hand-held mini-scopes to sophisticated, menu-driven digital storage scopes, only Tektronix packs so much capability in such compact, go-anywhere packages!

Tough, precise and totally self-contained: the Tek 200 Series. At no more than 3.7 pounds, these easy-to-use mini-scopes are impact resistant and isolated up to 600 V for floating measurements. They include a rechargeable internal battery pack, viewing hood, attached probes, rugged carrying case and convenient neckstrap. You can keep both hands free to use the integral probes, or to steady yourself on ladders or catwalks, with the CRT clearly readable.

A full measure of performance at 11 pounds or less: the Tek 300 Series. Here is high performance unmatched by any other same-size scopes. Select bandwidths to 50 MHz and sensitivity to 5 mV/div. Optimum trigger control. Either ac or dc power.

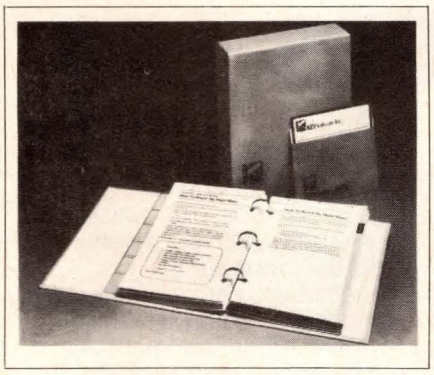
And for both digital and non-storage capabilities, plus optional GPIB interface, pick up the new Tek 336. Its 1 megasample/sec. digitizing lets you capture single event signals up to 100 kHz. You can signal average, automatically record minimum and maximum values in envelope mode, use cursors and waveform processing to obtain direct digital readouts, and more. All with pushbutton, menu-driven ease.

For more information
Call toll-free:
1-800-426-2200,
Extension 418
In Oregon, call collect:
(503) 627-9000, Ext. 418

CIRCLE NO 113

Tektronix®
COMMITTED TO EXCELLENCE

Copyright © 1984, Tektronix, Inc. All rights reserved. LVA-436



DATABASE MANAGEMENT. RESQ is a database management system that runs on the IBM PC and PC-compatibles and features a plain English menu-driven format. The software requires no programming experience to use. Error trapping capabilities detect improper user inputs. Its sort routine sorts as many files as your floppy or hard disk can support. The tutorial provides a sample database and prompts the user through all functions with step-by-step instructions. The software allows you to join and concatenate files, select records with as many as eight statements, and produce automatic calculations in the body of a report on as many as eight levels. RESQ can import and export ASCII files, thus allowing it to interface with software like Lotus 1-2-3 and Wordstar. It is also file compatible with national databases like Dow Jones, the Source, and Compuserve. $295. **Key Software Inc,** 1000 Skokie Blvd, Suite 200, Wilmette, Il 60091. Phone (312) 256-6776.

Circle No 384

DATA TRANSFER. pcMainframe Release 1.2.0, for OS and DOS environments, is an update of the pcMainframe intelligent data-transfer system, which allows personal-computer users to download and upload generalized files in a real-time environment between personal computers and a host IBM mainframe computer. The release features enhanced support for 3278/9 terminal emulators and for protocol, can access a database or multiple files, and can upload and update key-sequenced data-set (KSDS) files. The system supports such protocols as IBM's 3101, the ADM36I, TeleVideo 950, and the VT100. The system reformats data in BASIC, FIXED, or DIF (the data-interchange format used by Lotus 1-2-3 and Visicalc). The 1.2.0 release features controlled system access and supports character sets in English, French, German, Swedish, Italian, and Dutch. You can interface the package to the company's on-line electronic spreadsheet. To run the software, you need an IBM PC or compatible, MS-DOS or PC-DOS (1.1 or 2.0), and a 3270 protocol converter or similar board. For OS environments, including an 8-computer license, $12,000. For DOS environments, including 8-computer license, $9000. License for each additional computer, $300. **Oxford Software Corp,** 174 Boulevard, Hasbrouck Heights, NJ 07604. Phone (201) 288-1515.

Circle No 385

CROSS ASSEMBLER. The SX-68 cross assembler lets you develop 68000 software on the Apple II, II+, and IIe. The package consists of an editor and an assembler. Using the editor, you can write both 68000 assembler programs and text files and either save them on disk or use them as input to the assembler. The assembly process takes two passes: The assembler defines all symbols on the first pass, and on the second pass it generates the object code and listing. It reports errors on both passes. The assembler can evaluate expressions consisting of symbols and constants expressed in decimal, hexadecimal, octal, and binary. Expressions may consist of the following operators: +, −, *, and /. The program's limits are 24k-byte max text, 4k-byte max object code, 450 symbols max, and 9999 statements max. You can also access DOS 3.3 from the software. The program comes on a 5¼-in. disk. $100. **Allen Systems,** 2151 Fairfax Rd, Columbus, OH 43221. Phone (614) 488-7122.

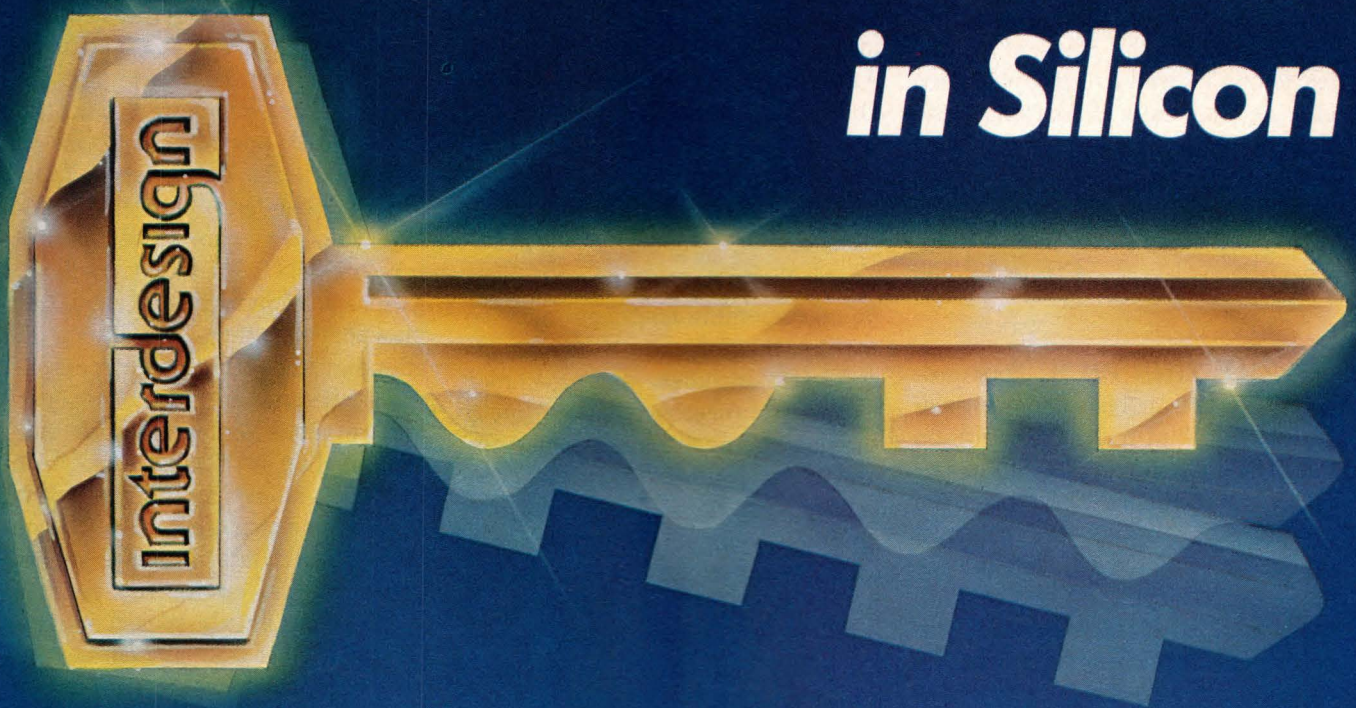
Circle No 386

UNIX OS. VENIX/86 Encore, an update of VENIX/86, runs on the IBM PC and PC/XT, the AT&T 6300, the Zenith 150, the Compaq Plus and Desk Pro, the TI Professional computer, the Eagle Spirit, 1600, and Turbo, the Columbia MPC, the Sharp PC 5000, the MAD 1 and the Sperry, Leading Edge, NCR, TeleVideo, and Corona personal computers. Its C compiler lets programs of more than 64k bytes run on personal computers. The operating system can copy MS-DOS and UNIX files among the partitions of a hard disk, making it possible to write UNIX files in a DOS format and vice versa. The system has the UNIX debugger adb, kernel libraries for adding new peripherals, support for the Berkeley VI editor, and such options as FORTRAN-77 and the Berkeley Pascal interpreter. With System V UNIX license, $800. **VenturCom Inc,** 215 First St, Cambridge, MA 02142. Phone (617) 661-1230.

Circle No 387

C EXECUTIVE. C Executive Release 1.5, a real-time monitor that can be stored in ROM, features C support and a built-in C library. The monitor lets multiple C or Pascal tasks (or both) run concurrently, and it features intertask communication, resource coordination, and formatted I/O. The real-time preemptive scheduler is sensitive to both task priority and system events. The package can support multiple-user terminals. It also includes real-time clock support and time-based task initiation. The software comes in both binary and source form. The binary version includes C source code for several

Solutions in Silicon



Custom LSI. The key to today's hardware design.

One company has the expertise and experience to solve all your custom LSI problems.

Interdesign. Bringing you separate LSI solutions in analog, digital, and one-chip analog/digital configurations.

A complete application spectrum from 75 mask programmable chips. Custom LSI benefits but with the fast turnaround time you need to get your product to market ahead of the competition.

The most experienced analog and digital engineering teams work with you to provide the right silicon solution to your problem. From system design to silicon hardware, we support your LSI silicon solution with advanced CAD systems.

Interdesign has been solving LSI problems in silicon since 1972. Over 5,000 of them.

Whether you want to integrate an automotive stereo system, a 60MHz digital phase-detector for a computer peripheral or a switched-capacitor filter, Interdesign will have the solution for you.

Call us today and let us solve your LSI problems. Interdesign, Inc., 1500 Green Hills Road, Scotts Valley, CA 95066, Phone: (408) 438-2900.

interdesign
A FERRANTI COMPANY

CIRCLE NO 195

device drivers, including the IBM PC's asynchronous serial port, keyboard/CRT, and clock. The release supports the 1M-byte physical address space of the 8086/8088/80186 μP family as well as 64k bytes each of code and data. Program, $500. Documentation and media, $75. **JMI Software Consultants Inc,** Box 481, Spring House, PA 19477. Phone (215) 628-0846.

Circle No 388

OPTICAL THIN FILM. Four programs for the analysis and design of optical thin-film multilayers run on the IBM PC, the Apple IIe, or the Apple Macintosh. One program computes and displays the transmittance vs wavelength through as many as 200 layers on one or both sides of a substrate. Another derives the optimum Chebyshev blocking-filter design. A third computes the Herpin equivalent layers of arbitrary index, and the fourth simulates optical monitoring to determine manufacturability. Data-transfer utilities link all four programs. $4000. **Boston Electronics Corp,** 72 Kent St, Brookline, MA 02146. Phone (617) 566-3821.

Circle No 389

BASIC INTERPRETER. Developed for the IBM PC/AT, the MEGABASIC language and interpreter addresses 1M byte of RAM and is compatible with MS-DOS, CP/M-86, MP/M-86, and TURBODOS. The package allows users to load libraries of programs, subroutines, and functions into memory and execute them at run time using a single statement. The software features variables with as many as 250 characters, trace and edit functions, and BCD arithmetic to eliminate rounding errors. Other features include a semicompiler that speeds execution by as much as 50%; a cross-reference program that provides listings of all variables, strings, arrays, subroutines, and functions; a compaction program that reduces program size by as much as 40%; and a scramble utility that protects the source code. **American Planning Corp,** 4600 Duke St, Alexandria, VA 22304. Phone (800) 368-2248; in VA, (713) 751-2574.

Circle No 390

CROSS ASSEMBLER. XMAC68K is an assembly-language development package for the MC68000. The software includes an assembler, macro preprocessor, link editor, librarian, symbol report generator, and several utility programs. Accepting standard 68000 assembly language as input, the software produces hexadecimal object-code files for Intel, Motorola, and Mostek formats. Other features include macro capability and structured assembly statements, cross referencing, and plain-English diagnostics. $595 under CP/M, CP/M-86, PC DOS, and MS DOS. Unix versions are planned. **Avocet Systems Inc,** 10 Summer St, Rockport, ME 04856. Phone (207) 236-8227.

Circle No 391

BISYNCHRONOUS COMMUNICATIONS. Two Bisync Exchange packages provide a personal-computer-to-mainframe link by allowing an IBM PC, PC/XT, or PC-compatible system to emulate an IBM 3274/6 cluster controller and the IBM 3278 and 2780 terminals. The software also permits PC-to-PC communications at 4800 baud over voice grade or leased lines equivalent to one typewritten page per second. An automatic recovery feature ensures that data-transmission errors are detected and corrected immediately. Other features include electronic mail and telephone management. $795. **Intelligent Technologies International Inc,** 151 University Ave, Palo Alto, CA 94301. Phone (415) 328-2411.

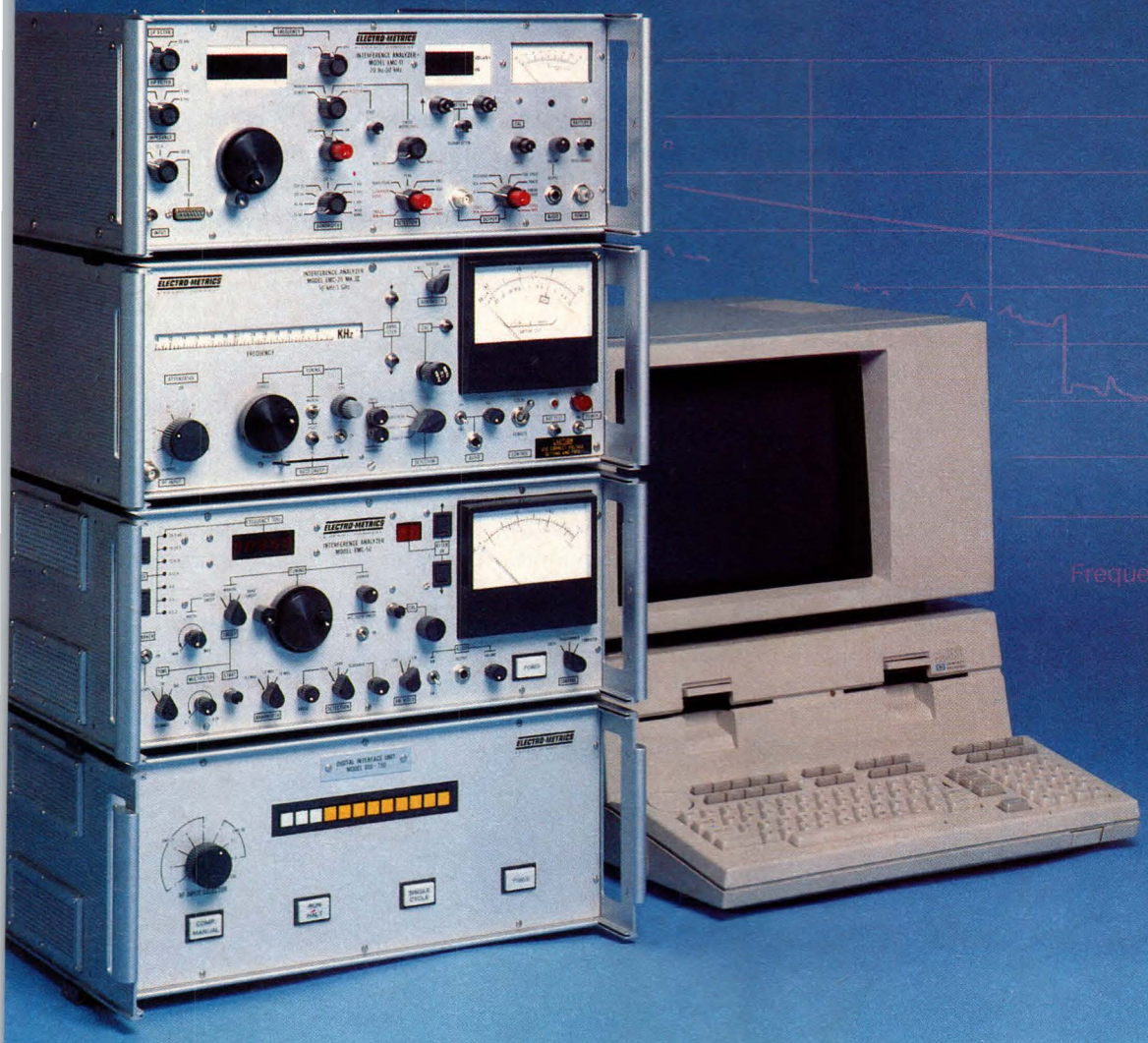
Circle No 392

GRAPHICS. The SP80/SP82 Siggraph Core, SP84 Contouring, and SP86 Metafile software systems run on the manufacturer's MC-500 family of computer systems and workstations. The software operates under that company's real-time Unix (RTU) operating system and provides users with virtual input, device-dependent 2D/3D graphics capability. The core system is written in FORTRAN, supports 2D/3D graphics primitives, 2D window-to-viewport mapping, 3D viewing and clipping, and a variety of perspectives. It also includes temporary and retained segments with fully controllable attributes. The contouring system is a set of specialized subroutines that generates 2D contours and 3D data. It allows generation of contour points from randomly located or evenly spaced data and produces plots from any perspective with hidden-surface removal in real-time applications where 2D contours and 3D plots are used often. Metafile saves graphics sessions created via the Core system in a device-independent Metafile. The Metafile can subsequently be used to position, scale, superimpose, or assemble several graphics sessions. The Core system is priced at $1200. The Contouring system is priced at $450; the Metafile, at $350. **Masscomp Corp,** One Technology Park, Westford, MA 01886. Phone (617) 692-6200.

Circle No 393

DATA ACQUISITION. Labtech Notebook is a general purpose menu-driven software package that runs on the IBM PC and compatibles and performs data aquisition, monitoring, and real-time control. The software operates with a hardware analog/digital interface, but insulates the user from the low-level instructions that this interface normally requires. Data can be collected at speeds as high as 20 kHz depending on the hardware and streamed to disk at 400 Hz. A pro-

Electromagnetic Compatibility Testing from 20 Hz to 18 GHz



Electro-Metrics CCS-750 computer-controlled system provides faster, more comprehensive EMC measurement and offers the flexibility to handle virtually any application. The system includes a desk-top computer system, a Digital Interface Unit and three EMI receivers to cover a frequency range of 20 Hz to 18 GHz (expandable to 40 GHz!).

The CCS-750 system displays signal strength vs. frequency directly, with automatic correction for antenna factors and RF attenuation. And all data can be stored for later use. An IEEE-488 Interface Bus controls signal sources as well as all other test parameters, and facilitates integration with other automated equipment.

CCS-750 Features

- ☐ 20 Hz to 18 GHz/40 GHz frequency coverage
- ☐ Automatic calibration for improved accuracy
- ☐ Automatic antenna selection
- ☐ Control of all test parameters
- ☐ Reduced data tabulation time
- ☐ EMI emissions and susceptibility tests per FCC/VDE/CISPR and Mil-Std 461/462 requirements

Automate your emissions and susceptibility testing with Electro-Metrics complete CCS-750 system. Call or write today for more information.

100 Church Street
Amsterdam, New York 12010

ELECTRO-METRICS

A PENRIL COMPANY

Tel.: (518) 843-2600
TWX: 710-446-4798

CIRCLE NO 114

gramming option allows you to customize the software. You can interface the software with the Lotus 1-2-3 and Symphony spreadsheets. The software also performs real-time graphic data display; open- and closed-loop process control; data manipulation, reduction, and analysis; and curve fitting using as many as 10 parameters to model data. Other features include compatibility with the 8087 coprocessor and an on-line Help facility. $795. **Laboratory Technologies Corp,** 328 Broadway, Cambridge, MA 02139. Phone (617) 497-1010.

Circle No 394

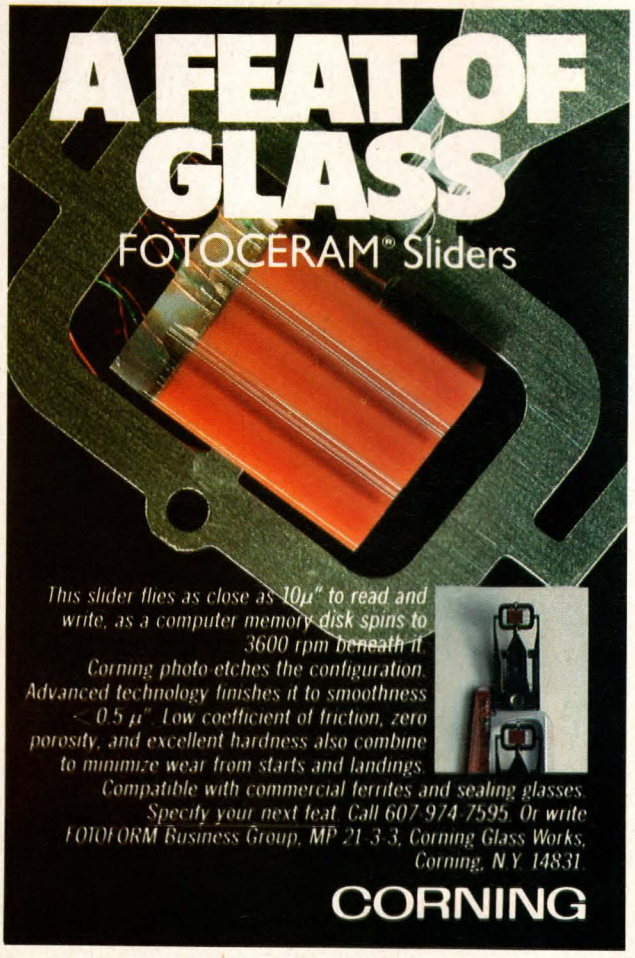
LOGIC SIMULATION. HILO-2 is a logic simulation system that runs on the Hewlett Packard 9000 Series 500 computers. The software is also available for the IBM, Apollo, Prime, Digital Equipment Corp, Computervision, CAE Systems, Metheus Corp, and Valid Logic Systems workstations. HILO-2 aids in the test of cell arrays, custom circuits, and Merchant VLSI devices. Features include hierarchical simulation, race testing, worst-case and hazard-spike analysis, and fault simulation at the functional and gate level. $50,000. **GenRad Inc,** 300 Baker Ave, Concord, MA 01742. Phone (617) 890-4900.

Circle No 395

DATABASE MANAGEMENT. The Integrator is an improvement on Alpha Software's Database Manager II. One of its most significant features is a utility program called Alphakey. This utility allows you to create keyboard macros, store a brief description of each macro, and call up a menu of macros in a window. Another important feature is the ability to summarize a database. This allows you create a single record for a number of database records that share at least one common field. The summarize feature also allows you to summarize more than one field. For example, if there are nine records for one company, but three of them are located at a second address, you can create two new records: one for the first address and one for the second. $295. **Alpha Software Corp,** 30 B St, Burlington, MA 01803. Phone (617) 229-2924.

Circle No 396

DEBUGGER. Pfix 86, a dynamic debugger, and Pfix86 Plus, an enhanced version with symbolic debugging and overlayed program debugging capabilities, suit use with the Intel 8088/86 family running PC DOS or MS DOS. The software is an addition to the company's Toolkit package, which already includes a linkage editor, Plink86, and text ed-



CIRCLE NO 115

Snap-Action Pushbuttons

Moisture and dust is sealed out with OTTO's new internal silicon rubber rolling sleave at button; epoxy at case and terminals. Positive tactile feed-back actuation. High contact pressure patented design assures < .025 Ω contact resistance for dry circuits while offering a big 10 ampere rating. Available in a variety of bezels and contact arrangements, in MIL-S-8805 and commercial construction. Write for Catalogs P1 and P3. Call for samples.

OTTO® CONTROLS

2 East Main Street, Carpentersville, Illinois 60110
Phone: 312/428-7171 Telex: 72-2426

CIRCLE NO 116

DDC NEWS

ABOUT SYNCHRO-CONVERSION • HIGH-SPEED, HIGH ACCURACY D/A & A/D CONVERSION • DATA BUS DEVICES

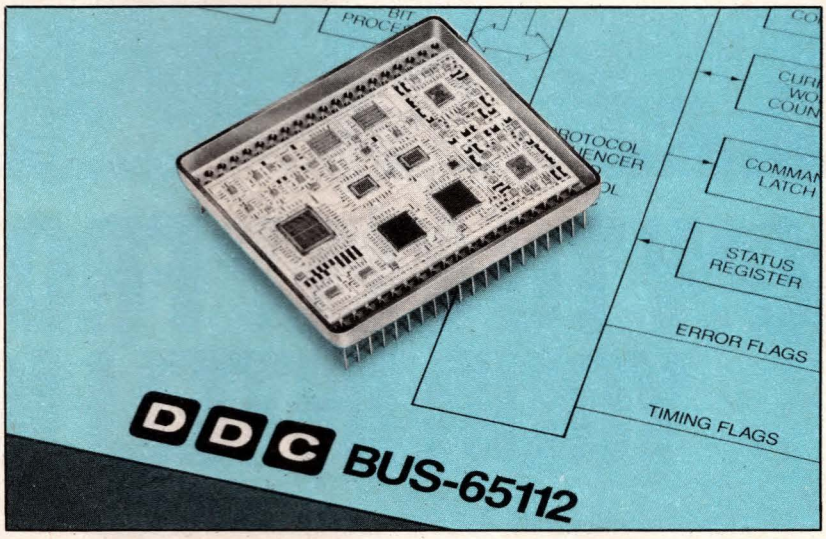
PUBLISHED BY ILC DATA DEVICE CORPORATION NOVEMBER 1984

THE LOWEST COST DUAL REDUNDANT 1553 RTU IN A SINGLE PACKAGE

DDC is pleased to announce the availability of BUS-65112, its new low cost intelligent Remote Terminal Unit (RTU). Based upon DDC custom monolithics, BUS-65112 is packaged in a small 1.9" x 2.1" hybrid and includes 2 transceivers, 2 encoder/decoders, 2 bit processors, RTU protocol, data buffers and timing control logic. It includes complete Remote Terminal protocol and supports all 13 mode codes for dual redundant operation, any combination of which can be illegalized. At $1436,* the BUS-65112 is the price/performance leader in its class.

Data is transferred to and from the subsystem host CPU over a 16 bit parallel highway, which is isolated by a set of bidirectional buffers. BUS-65112 is compatible with most host CPUs, with its data transfers of request, grant, acknowledge DMA type handshaking. For those subsystems interfacing directly to RAM memory, read/write and data strobe control signals are provided to simplify the interface. BUS-65112 also provides latched outputs for the command word and word count. These signals can be used as address lines to map 1553 messages directly to and from RAM.

Inputs are provided to the host CPU to control 6 of the bits in the RTU Status Word. Particularly useful is the Illegal Command line, which may be used to set the message error bit and illegalize any combination of the 13 mode commands that the BUS-65112 executes. An external PROM, programmed with illegal mode commands, monitors the latched Command Word.



When the PROM identifies a mode command that is illegal, it drives the Illegal Command line LOW. The other Status Word bits that are host CPU controlled are: Subsystem Request, Accept Dynamic Bus Control, Remote Terminal Flag, Subsystem Busy, and Subsystem Flag.

Four error flags are provided to the host CPU to aid in assessing its condition. These error flags are Message Error, Remote Terminal Failure, Handshake Failure, and RT Address Error. The RT Failure flag reports the results of the BUS-65112 continuous online self-test. Each transmitted message is wrapped around to the decoder and compared to the correct message.

The BUS-65112 includes a 14 bit Built-In-Test (BIT) word register. The stored BIT Word contains information about the state of the Remote Terminal. When a Mode Command is received to transmit BIT Word, the contents of this register are transmitted over the 1553 data bus. Individual bits provide information relating to transmitter timeouts, loop test failures, transmitter shutdown, subsystem handshake failure, and the results of individual message validations.

BUS-65112 is available screened to the requirements of MIL-STD-883, and it operates over the full −55°C to +125°C temperature range.

Learn more about DDC's new BUS-65112 and how it can efficiently improve your 1553 data bus designs while cutting costs at the same time. Call the nearest DDC office listed below for prompt sales and applications assistance. □

DDC FULLY CERTIFIED TO MIL-STD-1772

Domestic prices, 25-49 units

DDC

ILC DATA DEVICE CORPORATION

HEADQUARTERS AND MAIN PLANT: ILC Data Device Corporation, 105 Wilbur Place, Bohemia, N.Y. 11716, (516) 567-5600, TWX: 510-228-7324
WEST COAST: ILC Data Device Corporation, Woodland Plaza, 21243 Ventura Boulevard, Suite #123, Woodland Hills, CA 91364, (818) 982-6454, TWX: 910-499-2674
WASHINGTON, D.C. AREA: ILC Data Device Corporation, 2110B Gallows Road, South Tysons Corner Office Park, Vienna, VA 22180, (703) 893-7989, TWX: 910-997-0967
EUROPEAN OFFICE: ILC Data Device Corporation, 40 Triton Square, London NW1 3HG, England, 01-387 4599, TLX: 851-261967
UNITED KINGDOM: DDC United Kingdom Ltd., 128 High Street, Hungerford, Berkshire, RG17 ODL, England, (44) 488-82141, TLX: 851-848826
FRANCE: DDC Electronique, 4 Rue de l'Abreuvoir, 92400 Courbevoie, France, (1) 333-5888, TLX: 842-630609
WEST GERMANY: DDC Elektronik, GmbH, Vorderer Anger 286, P.O. Box 1212, 8910 Landsberg A.L., West Germany, Tel: (08191) 3105, TLX: 841-527128
JAPAN: DDC Electronics K.K., 1-32-3, Nishi-Gotanda, Shinagawa-Ku, Tokyo 141, Japan, Tel.: (03) 490-0203, TLX: 781-34158

Circle No. 122 for sales contact **Circle No. 161 for literature**

HOW TO KEEP FROM LOSING YOUR INTELLIGENCE.

Here's a chilling thought:

What if all the computer-stored intelligence you're responsible for suddenly disappeared?

It could happen with a severe drop in temperature.

Which is why Singer's Librascope Division designed their new battlefield C³ equipment with the most reliable bubble memory subsystem available.

Intel's BPK-70-5.

The only bubble that won't leave you out in the cold. Because it's already converted to the lowest cold threshold in the industry. And already fortified to take the blistering heat of battle.

Along with the dirt, shock and vibration of a hostile environment.

It's also the only bubble that comes with a full array of the most sophisticated, wide temperature range VLSI support chips. So it's much easier to design into custom configurations.

256K byte of Intel bubble memory fits into each compact, removable cassette.

And once it's in service, you can count on us to keep the supply line open. In fact, we've already expanded production to meet future needs.

You can count on our tactical engineering support as well. For Librascope, we supported the use of Intel's bubble memory in their Tactical Computer System (TCS) and Communications Control System (CCS).

And a fully militarized Intel bubble cassette was tested and approved for use in their Communications Terminal AN/UGC-137.

Which brings us to another cold fact: Intel supplies the military with more extended temperature bubbles than any other manufacturer.

Another good reason to make Intel your ally. Call toll free for more information on bubbles: (800) 538-1876. In California (800) 672-1833. Or write Intel Corporation, Lit. Dept. Y9, 3065 Bowers Ave., Santa Clara, CA 95051.

You'll be making an intelligent move.

Librascope's Communications Terminal uses a fully militarized Intel bubble memory subsystem.

intel®

© 1984 Intel Corporation

itor, Pmate. Symbolic debugging eliminates linker maps by accepting symbol names whenever the user would normally have to type in an address. The software features a multiple-window display for simultaneously viewing program code and data, breakpoint settings, and current machine and register stack contents. It also provides breakpoint capabilities including permanent and temporary settings, an in-line assembler, and single-keystroke tracing. Pfix86, $195; Pfix86 Plus, $395. **Phoenix Computer Products Corp,** 1416 Providence Highway, Suite 220, Norwood, MA 02062. Phone (617) 762-5030. TLX 710-345-0199.

Circle No 397

DISK FORMAT/COPY. Using Transmute, which runs on CP/M TeleVideo computers, you can copy data between disks that have different formats. As many as 30 formats from Avatar to Zorba are supported, and you can even add new formats. The program presents a menu of available disk formats. You then choose between formatting a disk or allowing the drive to read and write non-TeleVideo-formatted disks. The format software produces a disk that's a mirror image of the one produced on the original computer including special headers where neccessary. Two versions of the software are available. A single-drive version allows you to reconfigure drive B, and the multidrive version allows you to move data between two non-TeleVideo formats. Single-drive version, $75. Multidrive version, $100. **Elliam Associates,** 24000 Bessemer St, Woodland Hills, CA 91367. Phone (818) 348-4278.

Circle No 398

PROLOG SOFTWARE TOOLS. For developing software in the language PROLOG, the DEC-10/20 PROLOG development package is now available for Sun and VAX workstations. The software includes an incremental compiler, an interpreter, and a run-time debugging system. The system runs under TOPS10 and TOPS20. While the system's in the debug mode, the screen is split with the debugging environment displayed at the bottom of the screen and the source code displayed at the top of the screen. Many editor commands are included in the debugger. Also included in the package is a library of public-domain utilities including a natural language geography query program called CHAT. The system is distributed on a 9-track tape. $10,000 per CPU. **Quintus Computer Systems Inc,** 2345 Yale St, Palo Alto, CA 94306. Phone (415) 494-3612.

Circle No 399

Finally, a line of servo-mount potentiometers with true transducer performance that tells your machine where it really is. Waters' new HQ-5M International Standard Series uses our newly designed "ZB"™ zero backlash wipers (patent pending) that provide true positional output in high speed, dynamic feedback or measuring systems.

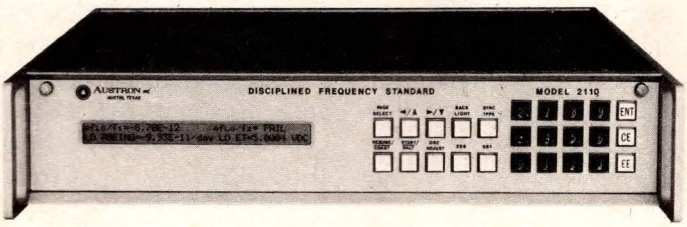
- Long life with Waters' MystR® conductive plastic resistance elements — 250×10^6 cycles, minimum
- Dither life 10^9 cycles, minimum
- Hysteresis less than 0.01 degrees
- Accuracy $<0.1\%$ APA (Absolute Positional Accuracy)
- Meets all applicable MIL-R-39023 specifications

HQ-5M series are available from stock in 4 standard servo sizes 9, 11, 13 & 20 (7/8", 1 1/16", 1 7/16" and 2").

WATERS MANUFACTURING, INC.
Longfellow Center, Wayland, MA 01778 (617) 358-2777 • Telex 948441

CIRCLE NO 117

THE LONG-TERM STABILITY OF A CESIUM. THE SHORT-TERM STABILITY OF A RUBIDIUM.



AUSTRON MODEL 2110 DISCIPLINED FREQUENCY STANDARD

Announcing

THE FIRST MICROPROCESSOR CONTROLLED DISCIPLINED FREQUENCY STANDARD.

Austron's Model 2110 is the first microprocessor controlled Disciplined Frequency Standard. It offers an economical solution to the most difficult and demanding applications.

The Model 2110 automatically locks the frequency of its internal oscillator to an external reference that has superior long-term stability. Through the use of a third-order servo oscillator control technique, the instrument corrects the frequency offset and aging of the internal oscillator. Should the reference fail, the Austron 2110 can limit the frequency offset to parts in 10^{12} for several days.

A SOLUTION FOR DEMANDING APPLICATIONS

- in communications systems where spectral purity and redundancy are of paramount importance
- in metrology where stable frequencies to parts in 10^{12} accuracy are required
- in clock systems where a stable clock with accuracies to $\pm$100 ns is necessary
- in frequency measurement where there is a need to quickly set oscillators to very high accuracies

OFFERING STATE-OF-THE-ART FEATURES

- microprocessor controlled
- high-stability internal oscillator
- third-order servo oscillator control system
- frequency measurement to parts in 10^{-12} with 100 sec averaging times
- 1 PPS clock output (externally synchronizable)
- spectrally pure output signals
- optional IEEE-488 interface
- optional dual reference frequency input allowing a choice of external references

The Austron Model 2110 microprocessor controlled Disciplined Frequency Standard is a first and it's from Austron. The 2110 can solve your most difficult timing and frequency application problems.

CALL OR WRITE FOR MORE DETAILED INFORMATION.

LEADERS IN TIMING AND FREQUENCY MANAGEMENT

AUSTRON INC.

P.O. BOX 14766 AUSTIN, TEXAS 78761•(512) 251-2313•TWX 910/874-1356

CIRCLE NO 123

SOFTWARE

C COMPILER. MWC86 is a C compiler for the DOS 2.0 environment and features a source-level debugger, common-code elimination, peephole optimization, and register variables. The manufacturer claims that this is the fastest C compiler for the DOS 2.0 environment. The software supports the full C language including recent enhancements such as the "void" and "enum" data types and structure assignments. Also supported are large and small models of compilation, the 8087 coprocessor, and DOS 2.0 path names. In the debugger, you can set tracepoints on variables and expressions or step interactively an expression at a time. Full history capability is included. Other debug functions allow you to walk through the stack; debug graphics programs without disturbing the program under test; and access online Help instructions, programs, and history windows. $495. **Mark Williams Co,** 1430 W Wrightwood Ave, Chicago, IL. Phone (312) 472-6659.

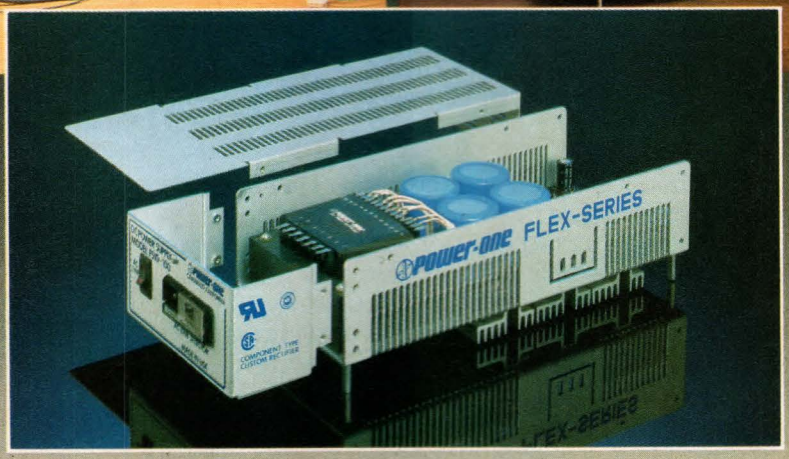
Circle No 400

C CROSS COMPILER. The Destek C compiler is a multipass optimizing compiler written in C that acts as a cross compiler between the DG 4000 and the MC68000. The software includes a compiler, assembler, linker, loader, and run-time library and is compatible with Unix version 7, Unix system 5, and OS/RT, the company's real-time operating system. You can use the system to produce ROMable code or disk-based programs. The compiler features 32-bit pointers, data initialization, absolute load maps, and global symbol listings. Options include a Unix-like run-time library written in either source or object code. $9600. **The Destek Group,** 830 E Evelyn, Sunnyvale, CA 94086. Phone (408) 737-7211.

Circle No 401

BRAND-X *or* POWER-ONE FLEX?

"An Unfair Comparison"



You Shouldn't Compare Apples and Oranges

We apologize for our unfair comparison. But when it comes to POWER-ONE's new FLEX-Series D.C. power supplies, there really isn't anything comparable on the market.

Based on 11 pre-designed case sizes, with power ratings from 10 to 400 watts, the FLEX-Series dramatically simplifies the development of custom power supplies. You can specify the exact output ratings and options you want... *at a fraction of the cost and time of a full custom design!*

Built to Your Exact Requirements

With the FLEX-Series you pay only for the features you specify. And using our "Total Package" concept there's no additional assembly labor, no extra parts to buy. As for options, you name it. Virtually any output voltage and current combination is available. There's connectors, fans, covers, front panel assemblies; there's power fail monitoring, high surge current capabilities and much, much more.

Safety Approved Worldwide

The FLEX-Series is certified to the world's toughest safety agency requirements. Which means you can take delivery of an internationally approved power supply, built to *your exact specifications*, in the *shortest leadtime* in the industry!

Call for a Quotation

Whatever your quantity needs — large or small — the FLEX-Series will save you time and money. Plus, it's POWER-ONE proven. So call today for a FLEX-Series quotation. Or get the full FLEX-Series story in our new 1985 Catalog. You'll agree that all other custom power supplies are nothing more than BRAND-X when compared to the flexible FLEX-Series.

"Innovators in Power Supply Technology"

POWER-ONE

D.C. POWER SUPPLIES

POWER-ONE LINEAR PRODUCTS
740 Calle Plano • Camarillo, CA 93010-8583
Phone: (805) 987-8741 or (805) 987-3891
Call Toll Free from California: (800) 421-3439
Outside California: (800) 235-5943

CIRCLE NO 124

SO FAR, ENGINEERS HAVE COME TO DIALIGHT WITH

Helping thousands of you find the perfect switch for your front panels has taught us a few things about engineers.

For one, you're an incredibly creative bunch. So for many of you choosing a switch is an important personal statement.

Just like choosing a tie.

But that's not all we've learned. We've also learned over a million ways to make a better switch.

WE HAVE THE SWITCH THAT'LL TURN YOU ON.

For example, we've learned how to make switches more reliable. So when one engineer needed a switch for a heart monitor, naturally he came to Dialight.

He knew we make all our switches here in the U.S.A. Where we can keep an eye on quality. And we test every single switch we sell before we ship it.

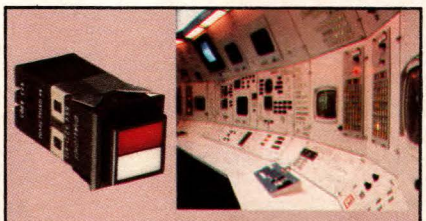
When reliability is critical, depend on Dialight's 100% testing.

We suggested a rugged little lever with a full 25° of motion. He flipped. Because not only was it reliable, doctors can check the monitor's status at a glance.

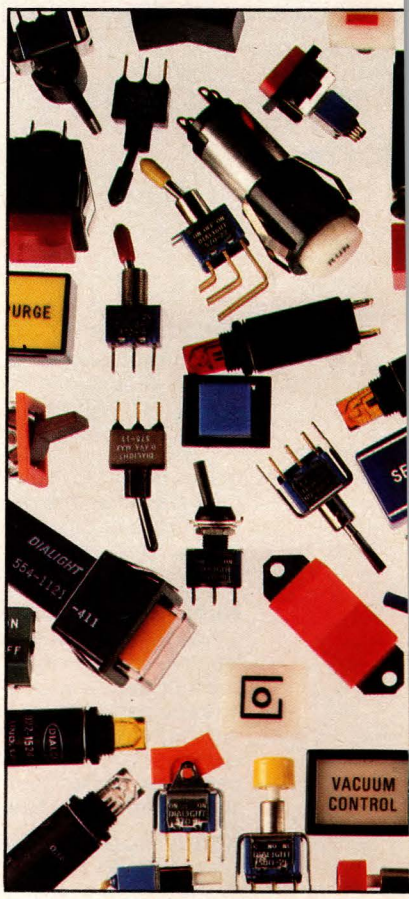
DRESS UP YOUR DESIGN IN A DIALIGHT ORIGINAL.

As you can see, Dialight knows it takes an enormous variety of designs to suit every engineer.

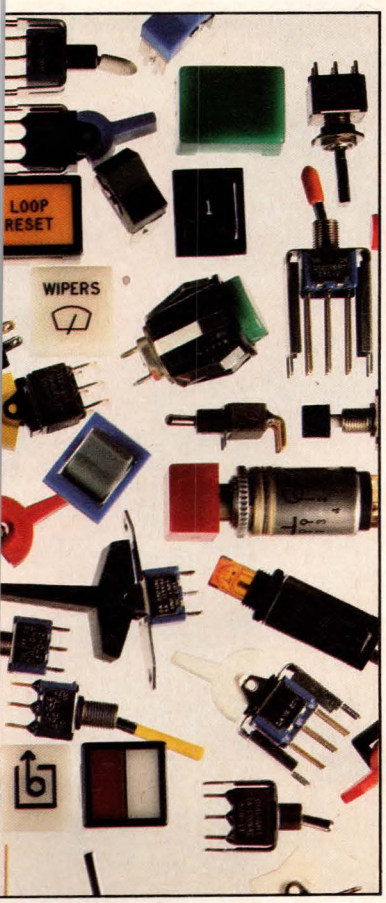
That's why we offer you



This split-screen lighted pushbutton installs in a snap.



1,000,000 DIFFERENT IDEAS OF WHAT A SWITCH IS.



thousands of styles in pushbuttons. With momentary or alternate action. Neon or LED illumination. Hot stamped or engraved graphics. And legends from the word GO to HALT.

We've even come out with illuminated pushbuttons with built-in resistors, to help button down wiring costs.

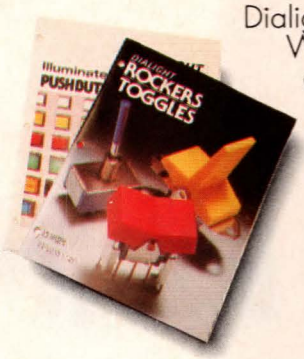
If you're in the market for rockers, toggles or levers Dialight can show you over a million combinations of actuators, terminations, contact ratings, functions, mounting styles and colors.

Should you need to mount one on a circuit board, our sealed switches can save production steps. You just insert them along with other components and automatically wave solder and clean the finished board. That can save a lot in manufacturing costs.

You can automatically insert, solder and clean our sealed switches.

Which brings us to our final point. Dialight switches can save you money. We can supply you with exact equivalents for C&K switches, for example. At a fraction of the cost. And we can send you a sample within 48 hours.

So call us at 718-497-7600. Or write Dialight Corporation, 203 Harrison Place, Brooklyn, NY 11237-1587 and we'll send you our catalogs. When you have some time, browse through them. And, please, if you don't see exactly what you like, just ask.



A North American Philips Company

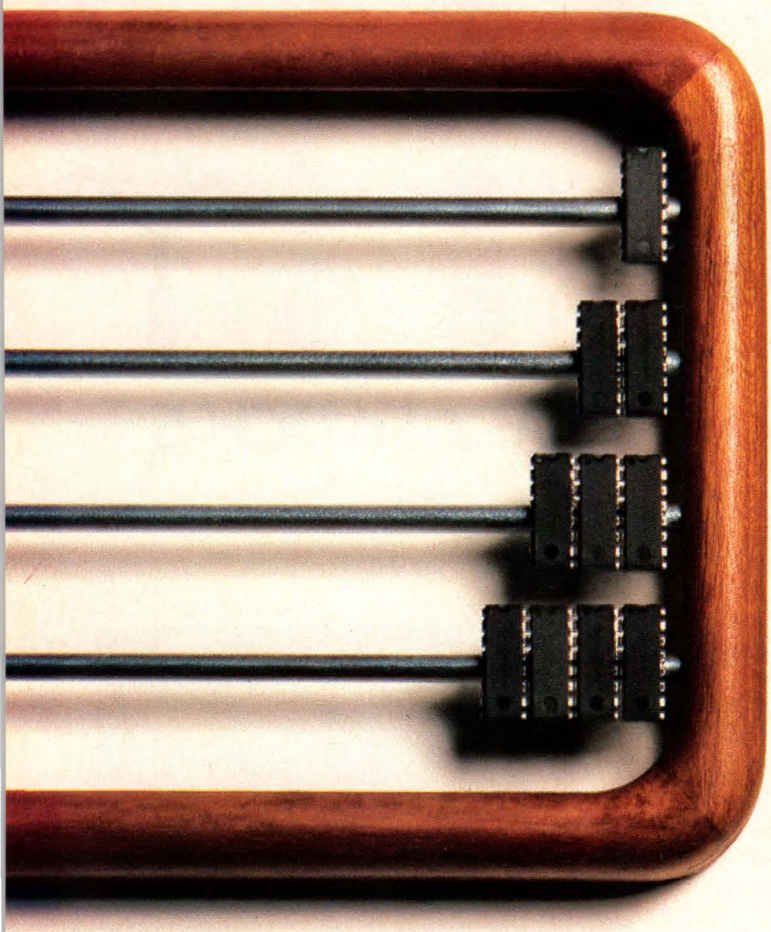
DIALIGHT SWITCHES

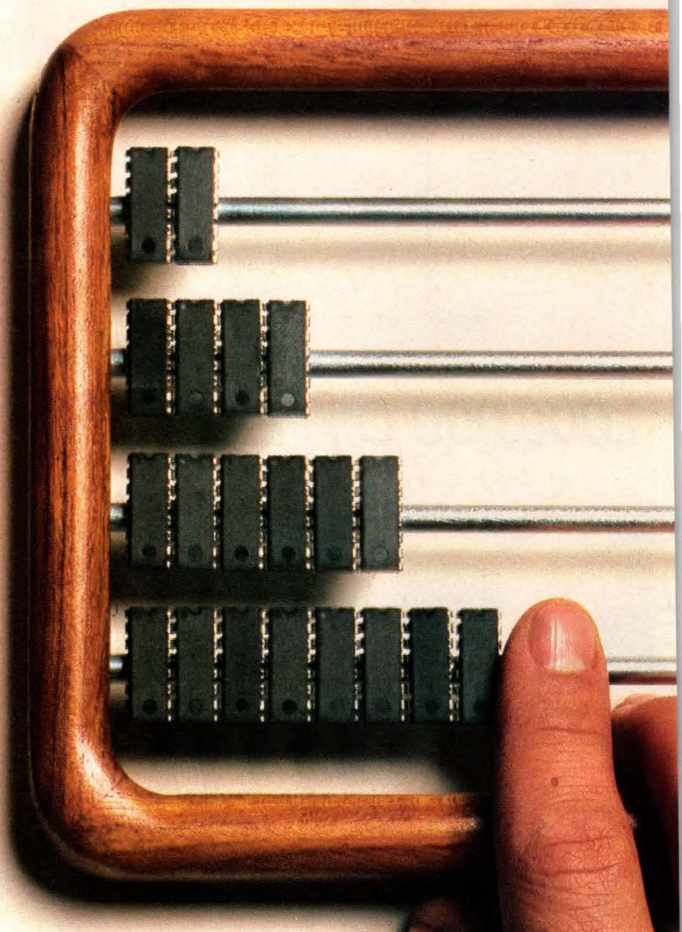
Products of your imagination.

CIRCLE NO 125

WHEN THEY TEST:

WE TEST:



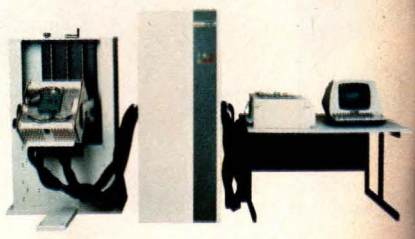


Parallel testing. Nobody's been doing it longer than us. And nobody does it better. Because our advanced 5588 memory test system is capable of testing up to eight devices. In parallel. In full production environments. At speeds of up to 25MHz.

In fact, when it comes to throughput, the 5588 outperforms every tester on the market. Two to one.

The 5588's innovative hardware design allows it to accurately test 64k and 256k devices. And beyond. In bit, nibble or byte-wide configurations. With flexible features like pattern generation for a wide range of memory tests. And selectable "on-the-fly" timing to ensure accuracy in dynamic environments. We've even developed an option for testing high-speed ECL devices.

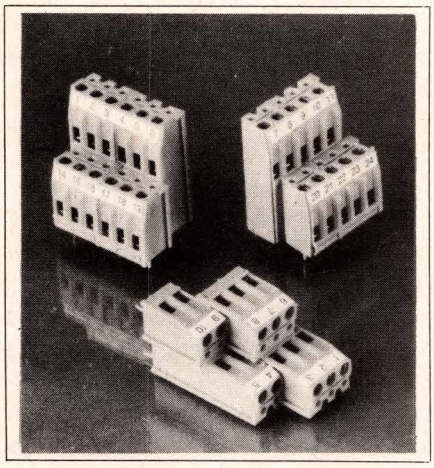
If you'd like to know more about the 5588, write us at Memory Test Systems, 3850 Royal Avenue, Simi Valley, CA 93063. Or call (805) 583-5290.



FAIRCHILD

A Schlumberger Company

CIRCLE NO 126

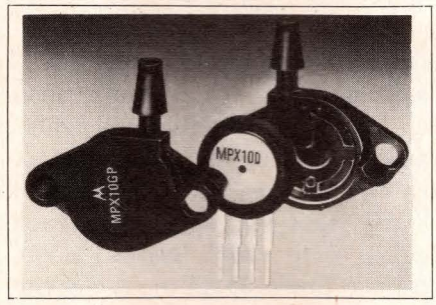


TERMINAL STRIP. 8190E Series terminal strips feature 2, 3, 8, or 12 poles. They have 5-mm pin spacing and two tiers of connectors that are separated by half of the pin spacing. Molded of Polyamide 6.6, the connectors withstand continuous-service temperatures to 100°C and are rated for 300V ac at 15A. The CSA Certified (10A) and VDE rated (0110 GR C) connectors are awaiting UL approval for both field and factory wiring. All metal parts are either recessed or enclosed in the connectors' insulating body to provide circuit protection and dead-front safety. The wire-clamping connectors handle wire sizes 12 through 22 AWG. Clamping connectors and screws are zinc-plated, chromated steel. The connectors' electroplated-copper, tin-plated solder pins come with or without markings. 3-pole terminal, $237.88 per 100. **Electrovert Inc,** 399 Executive Blvd, Elmsford, NY 10523. Phone (914) 592-7322. TLX 646186.

Circle No 460

CONNECTORS. Series III cylindrical threaded connectors, which comply with MIL-C-38999, are self-locking and have an antidecoupling mechanism. 360° rotation of the coupling nut mates the connectors. They have RF and EMI shielding that's effective from 0.1 to 10 GHz. Interfacial silicone gaskets provide an environmental seal. The connectors operate over −65 to +175°C, come in 33 versions in shell sizes 9 to 25, and accommodate 129 Size 22 contacts max. Medium-sized shell pairs, from $50 (OEM qty). **The Deutsch Co,** Municipal Airport, Banning, CA 92220. Phone (714) 849-7822.

Circle No 461

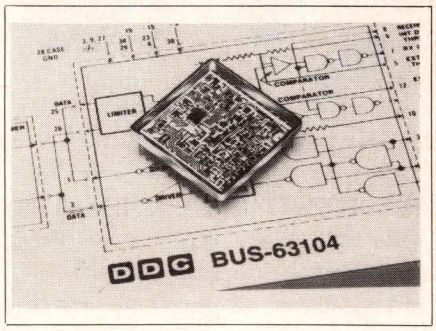


PRESSURE SENSORS. MPX10, MPX11, and MPX12 differential pressure sensors measure 0 to 1.5 psi differential pressures. Their full-scale outputs range from 20 to 50 mV for the MPX10, 30 to 60 mV for the MPX11, and 45 to 70 mV for the MPX12. Typical sensitivities spec at 24, 34, and 38 mV/psi, respectively. The MPX10 features ±1.0% min linearity; the MPX11, −0.5 to +3%; and the MPX12, 0 to 5%. The sensors are available as bare elements for custom packaging or housed in plastic cases. For differential applications (suffix DP), the element has a port for the vacuum side and one for the pressure side. For other applications, the elements come with the port on either the pressure side (suffix GP) or the vacuum side (suffix GV). MPX10, from $30; MPX11, from $26; MPX12, from $22 (25). **Motorola Semiconductor Products Inc,** Box 20912, Phoenix, AZ 85036. Phone (602) 244-6786.

Circle No 462

SOLID-STATE RELAYS. 110R1D and 110R2D Series solid-state relays can handle 110A rms loads (resistive or inductive) and 2000A 1-cycle surge currents. They measure 2.25×1.75×1.1 in. and weigh 4 oz. The units operate on voltages from 48 to 248V ac rms. The 110R1D is a zero-crossing turn-on version that specs a 8.3-msec max turn-on time. It has a 3.5 to 32V dc control-voltage range and a 32V max reverse voltage. The 110R2D, a random phase-controllable turn-on version, specs a 0.02-msec max turn-on time and a 3.5 to 26V control-voltage range. Both relays have an 8.3-msec max turn-off time, a 3.5V dc must-turn-on voltage, and a 1.0V must-turn-off voltage. When turned Off, the switched voltage changes at 200V/μsec. The devices have a 12-mA max leakage current and an on-state voltage drop of 1.5V. $50. **Silicon Power Cube Corp,** 2725 Seaboard Lane, Long Beach, CA 90805. Phone (213) 634-9390.

Circle No 463

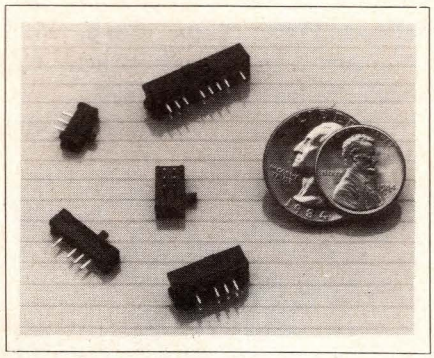


DATA TRANSCEIVER. The BUS-63104 data-bus transceiver meets all MIL-STD-1553A and -1553B specifications. It's a pin-compatible replacement for the CT3231. Its receiver section accepts Manchester phase-modulated bipolar data at the input and produces a biphase TTL signal at the output. The unit's transmitter section accepts TTL biphase data as input and produces a nominal 30V p-p differential signal across a 145Ω load. Measuring 1.25×1.25×0.2 in. and weighing 0.4 oz, the data transceiver comes in a 24-pin hybrid package. It operates over −55 to +125°C and requires 5V±5% at 30 mA. $295. **ILC Data Device Corp,** 105 Wilbur Pl, Bohemia, NY 11716. Phone (516) 567-5600. TWX 510-228-7324.

Circle No 464

POSITION SENSOR. Series 11000 position sensors use an inductively coupled input shaft that is sealed from the transducer body. The shaft travels from 3 to 25 mm, depending on the model. The transducer produces a TTL-compatible, 50% duty-cycle pulse-train output; the period is 100 μsec at one limit of the shaft's travel and 200 μsec at the other. The transducers draw 5 mA at 5V and operate over −40 to +125°C. $35 (1000). **Technar Inc,** 205 N Second Ave, Arcadia, CA 91006. Phone (818) 447-1187.

Circle No 465



SLIDE SWITCHES. MMS and SSJ slide switches have silver-plated double-wipe contacts rated for 100 mA at 30V dc. Their small size (the SSJ-12 measures 0.394×0.157×0.26 in.) suits them for pc-board applications where space is limited. The switches' plastic cases have a snap detent. The MMS Series consists of 1-, 2-, and 4-pole versions. The 1-pole version has an upright actuator with an On-On function. The 2- and 4-pole types come with upright or side actuators and a 2- or 3-position On-On function. Two-position types have shorting contacts; nonshorting versions are available upon request. The SSJ Series comes in 1- or 2-pole versions with upright or side actuators. The 1-pole version comes with a 2- or 3-position On-On function. Spdt MMS version, $0.36 (1000). **Augat/Alcoswitch,** 1551 Osgood St, North Andover, MA 01845. Phone (617) 685-4371. TWX 710-342-0552.

Circle No 466

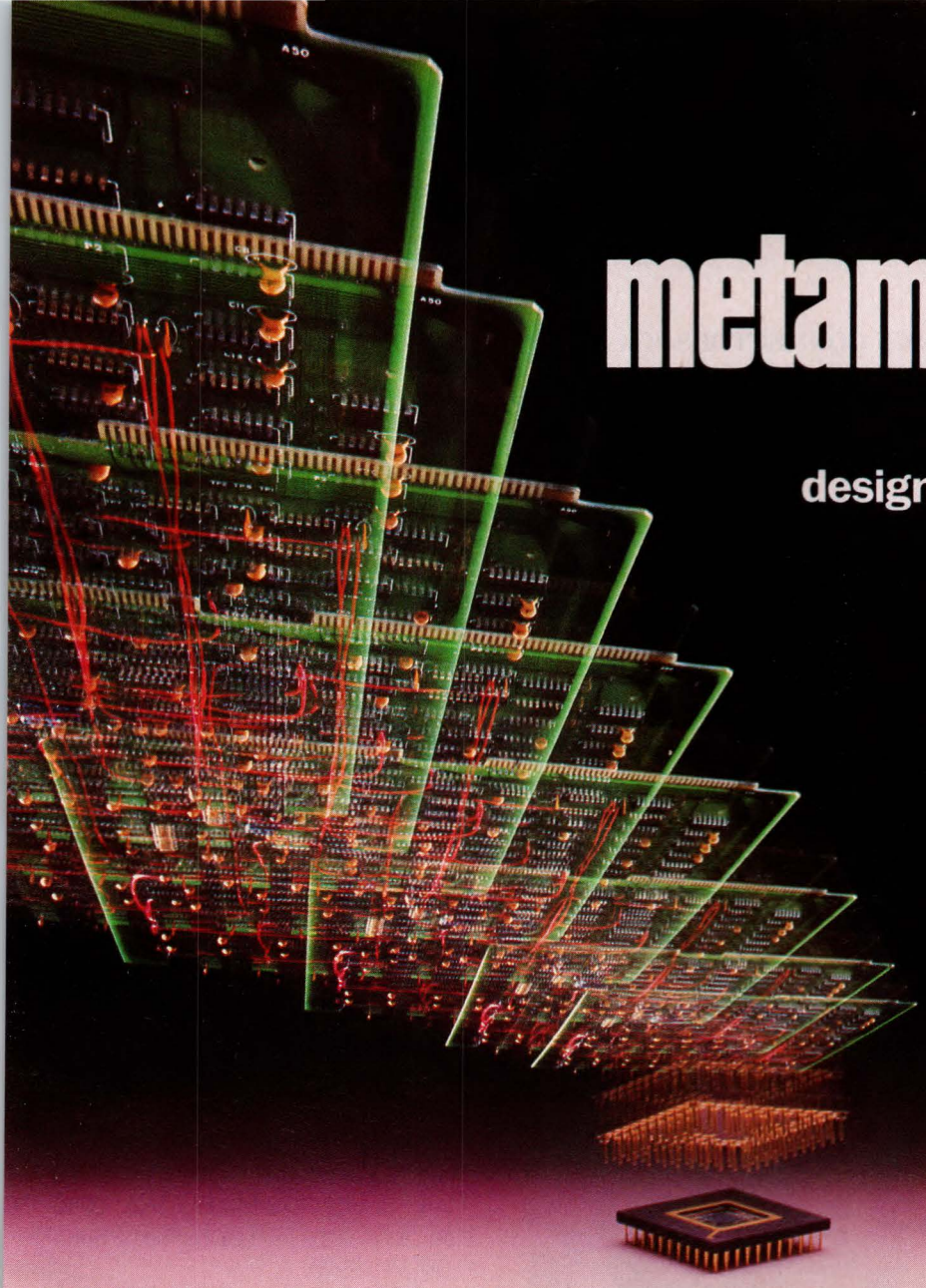
BRIDGE SENSOR. Model 465, a self-contained bridge-sensor module, contains a differential amplifier and an adjustable-output bridge-excitation source. The module has a 3-MΩ input impedance, adjustable gain (10 to 1000), and <3-μV/°C drift. It draws 30-nA input-bias current and has 106-dB CMRR and ±10V output swing. Its 3-dB response point occurs at 5 Hz. The module measures 2×3.75×2.9 in. You can adjust the bridge's excitation power supply from 4 to 15V; it delivers 150 mA max. The supply features 0.005% line and load regulation and 0.5-mV rms noise, and it operates from 115V ac. Other input voltages are available. $245. **Calex Mfg Co Inc,** 3355 Vincent Rd, Pleasant Hill, CA 94523. Phone (415) 932-3911. TLX 338506.

Circle No 467

TRIMMERS. The 1208 is a rectilinear RJ12-style trimmer (1¼ in. long) whose different versions spec 20, 50, or 100Ω resistance values at 20% tolerance or range from 200Ω to 10 kΩ at 10% tolerance. The 1268 (⅜ in.^{2}) comes in versions that have resistance values ranging from 20 to 100Ω at 20% tolerance and 200Ω to 10 kΩ with 10% tolerance. The 1248's versions measure ¼ in.^{2} and have resistance values from 20Ω to 5 kΩ at 10% tolerance. All three trimmers feature a ±20-ppm/°C temperature coefficient and 0.1% typ and 0.5% max change in settling stability. They can be set within 0.1%. Model 1268 5- to 10-kΩ versions, $3.41. Model 1248 5- to 10-kΩ versions, $4.75. Model 1208L 20Ω version, $3.62 (1000). **Vishay Resistive Systems Group,** 63 Lincoln Hwy, Malvern, PA 19355. Phone (215) 644-1300.

Circle No 468

A/D CONVERTERS. Models DAS1157, DAS1158, and DAS1159 sampling D/A converters feature 14-, 15-, and 16-bit resolution, respectively, and consume 650 mW max. The DAS1157 and DAS1158 serve as second-source replacements for the A/D/A/M-834 and A/D/A/M-835. Rated for operation from −25 to +85°C, the DAS Series combines an A/D converter, an S/H amplifier, a 10V reference, and 3-state output buffers in a 2×4×0.375-in. package. Maximum key specs for the DAS1157 include ±0.003% differential nonlinearity (DNL), ±0.005% integral nonlinearity, ±2-ppm/°C DNL temperature coefficient, and ±8-ppm/°C gain temperature coefficient. Maximum key specs for the DAS1158 and DAS1159 include ±0.0015% DNL, ±0.003% integral nonlinearity, ±1-ppm/°C DNL temperature coefficient, and ±8-ppm/°C gain temperature coefficient. Dynamic specs for the series include 55-μsec max conversion time, 18-kHz min throughput, 250-nsec aperture delay, and



AMCC metamorphosis

rapidly reduces your designs to high performance ECL/TTL logic arrays

At AMCC, metamorphosis means a lot more than just reducing board real estate, material cost and assembly time. AMCC metamorphosis transforms your designs from net lists to prototypes in as little as four weeks. It means a dramatic semicustom evolution using AMCC's system oriented logic arrays.

AMCC metamorphosis pushes aside past limitations in high performance system applications by offering high density logic at sub-nanosecond speeds; ECL, TTL or mixed I/O on the same chip; up to 95% gate utilization; advanced MSI/LSI macro libraries; automatic place and route software; the highest commercial and military quality and reliability standards (Mil. Std. 883); Class 10 fabrication; and mask compatible alternate sourcing.

Our engineer-to-engineer full service commitment plus complete CAD capability helps provide you with fast flexible design solutions. To us full service means support . . . a design implementation group; Daisy™ and Mentor™ engineering workstations; Tegas™ via Cybernet™; field applications engineering; on-site training courses; complete documentation; portable design centers; complete wafer fabrication; and quick turn-around assembly and test.

AMCC ECL/TTL LOGIC ARRAYS

	Q3500S	QH1500A	Q1500A	Q700	Q710	Q720
Equivalent Gates	3500	1700	1500	1000	500	250
Typ. Gate Delay (ns)	.3 - .7*	.9	.9	.9	.9	.9
Typ. Power (W)	3.5	2.8	2.5	2.0	1.2	.6
I/Os	120	120	84	76	56	36
Gate Utilization	95%	95%	95%	85%	85%	85%

*programmable

AMCC . . . dedicated to high performance semicustom. Make us perform for you.

Call or write for full information on how AMCC's metamorphosis can provide high speed silicon solutions to your system problems.

AMCC
APPLIED MICRO CIRCUITS CORPORATION
5502 Oberlin Drive
San Diego, California 92121
Telephone (619) 450-9333 • TWX/Telex: 910-337-1136

CIRCLE NO 127

1-nsec aperture jitter. The converters operate from ±15 and 5V power supplies. They have pin-selectable input ranges of 5, 10, ±5, or ±10V. Output coding is binary, offset binary, or 2's complement. Hi-Enable and Lo-Enable pins select connections to 8- or 16-bit buses. DAS1157, $219 (100); DAS1158, $263; DAS1159, $289. **Analog Devices Inc,** Three Technology Way, Norwood, MA 02062. Phone (617) 329-4700.

Circle No 469

DIN CONNECTORS. These female DIN connectors mate with straight or right-angle DIN 41612 form E male sockets that are soldered to pc boards. Available with 32 or 48 gold-plated contact points and axial screw clamps, the connectors handle 14- to 24-AWG solid or stranded wire with one or two wires per pole. They're rated for 250V at 5A and are keyed to avoid mismatched multiple combinations. The 32-pin connector, $39.90 (500). **Entrelec,** Two Ram Ridge Rd, Spring Valley, NY 10977. Phone (800) 431-2308; in NY, (914) 425-7460. TLX 996619.

Circle No 559

AC POWER...
AT YOUR COMMAND

It's no surprise that California Instruments is the leader in AC power sources ...after all, our Invertron® line has set the industry standard for over 20 years by providing the broadest, most versatile, and reliable product line available.

Our on-going dedication to advancing AC power source technology has resulted in many firsts, including programmable AC power for ATE applications. Another innovation is our modular building block concept that gives you the flexibility of selecting the equipment needed to fulfill your specific requirement. No more — no less.

We are committed to maintaining our leadership in AC power source technology and to deliver the most in value, reliability and support. Call or write for our latest catalog.

Be in control of your AC power with—

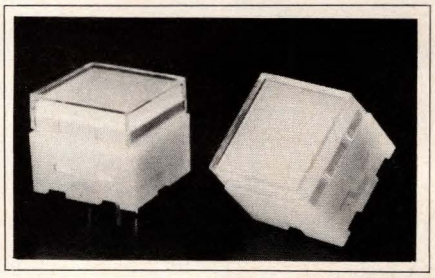
AC VOLTAGE SOURCES
100VA to 36KVA
10, 20 or 30

AC CURRENT SOURCES
1 amp to 200 amps

OSCILLATORS
20Hz-20KHz
Fixed Frequency, Manually Adjusted and Fully Programmable
IEEE-488 or BCD INTERFACE

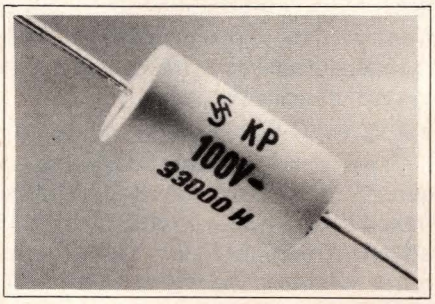
PRECISION LINE CONDITIONERS
1KVA — 3KVA

An affiliate of Amstar CORPORATION
California INSTRUMENTS
A Division of Amstar Technical Products Company, Inc.
5150 Convoy Street, San Diego, CA 92111-1266/(619) 279-8620/Telex 695047



ILLUMINATED SWITCHES. SMP Series switches (0.591 in.^{2} and 0.512 in. high) let you use hot-stamped legends or film messages, which are illuminated by the switches' LEDs. Featuring a 10^6-cycle lifetime and operation over −10 to +65°C, the switches come with red, green, or yellow LEDs. Switch, $1.89. Matching indicator, $1.45 (500). **Shelly Associates Inc,** 2942 Dow Ave, Tustin, CA 92680. Phone (714) 544-9970.

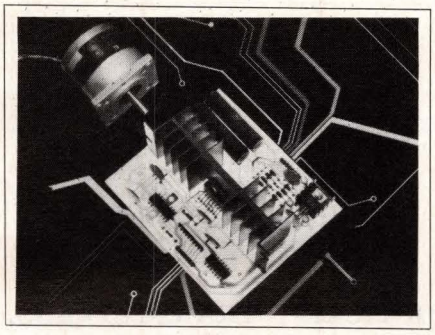
Circle No 560



FLAME-RESISTANT CAPACITORS. Series B33074 polypropylene capacitors have an enclosure that complies with the requirements of UL-1414. The capacitors have axial leads and come in cylindrical shapes from 6.4×13 mm to 9.7×19 mm. They have capacitance values

from 100 pF to 0.1 μF and possess temperature coefficients from −150 to −300 ppm/°C. Specs include −40 to +85°C operation and a 100V dc voltage rating. Typical pricing is $0.20 (1000). Delivery, 10 to 12 wks. **Siemens Components Inc,** 186 Wood Ave S, Iselin, NJ 08830. Phone (201) 321-4842.

Circle No 561

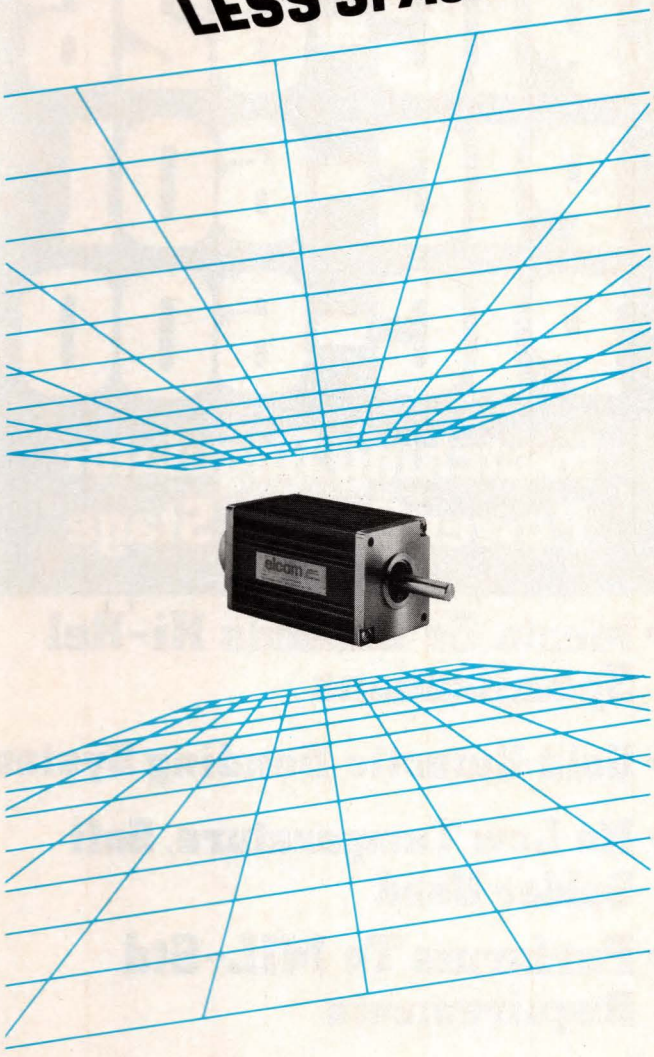


DRIVER CARDS. Models LR-BP-20-35 and PW-BP-50-45 stepper-motor driver cards have half- and full-step capability and are TTL compatible. They have direction, clock, inhibit, and reset inputs. LR-BP-20-35, a bipolar-driver card, uses a 35V input and has a 2A per phase output. It can accommodate series resistors to increase torque at higher step rates. PW-BP-50-45, a pulse-width-modulation driver card, uses a 45V supply, has a 5A per phase output, and doesn't require series resistors. LR-BP-20-35, $100; PW-BP-50-45, $350 (OEM qty). Delivery, 60 to 90 days ARO. **Clifton Precision,** Box 160, Murphy, NC 28906. Phone (704) 837-5115.

Circle No 562

HV RELAY. Pressurized with an electronegative gas that quenches arcs in hot-switching applications, Model K61C spdt relay switches 35 kV dc at 10A continuous current. It measures 3.75×2.5 in., is potted, and comes with high-voltage leads. The device operates on 26.5V dc and

MORE POWER
IN
LESS SPACE



Pittman Elcom™ (electronically commutated) D-C servo motors pack more power. Offer more precise control. Fit in less space than conventional brushless or brush-commutated motors. Take the Series 5113, for example, it develops 1/3 hp, continuous duty, in less space than a can of condensed soup (50mm square frame, 100.4mm long).

It's what sets Pittman apart. An unmatched capability to provide mechanical control and precision drive functions where minimum space and high reliability are vital. Even in adverse atmospheres. For more information on the Pittman line of motion control products and their one-of-a-kind performance characteristics call (215) 256-6601 or write to **The Pittman Corporation, Harleysville, PA 19438-0003.**

PITTMAN

A subsidiary of Penn Engineering & Manufacturing Corp.

©The Pittman Corporation, 1984 18-C

CIRCLE NO 130

Now Available From Solitron

PIC-626
PIC-601
PIC-600

Switching Regulator Power Output Stage

- **Meets Or Exceeds Hi-Rel Specifications**
- **Gold Eutectic Bonding Systems**
- **No Low Temperature, Soft Solder Used**
- **Performs To MIL-Std Requirements**
- **100% Screening Available**

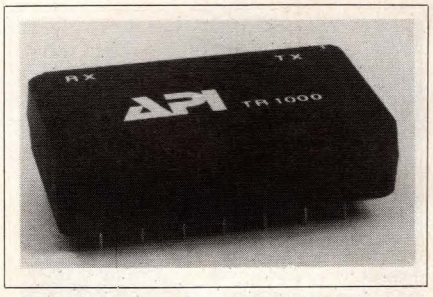
For complete information, contact Sales Dept. toll-free 1-800-327-8462.

Solitron DEVICES, INC.
1177 Blue Heron Blvd.
Riviera Beach, Florida 33404
(305) 848-4311
TWX: (510) 952-7610

CIRCLE NO 131

has a 120Ω coil. Its operation, including bounce, takes 15 msec. Withstanding temperatures from −55 to +85°C, the relay can endure 20G shock and 10G vibration at 55 to 500 Hz. $235 (10). **Kilovac Corp,** Box 4422, Santa Barbara, CA 93103. Phone (805) 684-4560. TWX 910-336-1141.

Circle No 563



OPTICAL TRANSCEIVERS. TR1001S Series fiber-optic transceivers transmit data at rates to 100M bps NRZ. The TR1001SA version has an 8-dB system margin; the TR1001SB version has a 17-dB margin. TR1001SA, $275; TR1001SB, $550. **American Photonics Inc,** Box 289, Brookfield Center, CT 06805. Phone (203) 775-8950.

Circle No 564

ELECTROLYTIC CAPACITORS. Series 3195 aluminum electrolytic capacitors come in values from 2800 μF to 1.2F and are rated for operation for 1000 hrs at 85°C at full-rated dc voltage. The capacitors range from 5 to 100V dc and come in 39 standard case sizes from 1⅜ to 3 in. in diameter. They operate over −40 to +85°C and come in pc-board mounting or standard screw-terminal configurations. Typical pricing for a 16,000-μF, 50V unit with −10, +75% tolerance is $3.75 (1000). **Mepco/Electra Inc,** Columbia Rd, Morristown, NJ 07960. Phone (201) 539-2000. TWX 710-986-7437.

Circle No 565

HURRY, THEY'RE GOING FAST.

All new and nearly 700 pages, this is the biggest and best *FAST™ Data Book* ever! Everything you need to know about the high speed/low power Fairchild Advanced Schottky TTL family. With current specs on over 160 devices. All in one fabulous, *free* book.

Packed with pertinent product information, the 1985 *FAST Data Book* features full data sheets, including connection diagrams on SOICs and PCCs. Plus an expanded packaging section with detailed dimensional drawings on all devices, including surface mount and plastic and ceramic leadless packages.

For your free copy, just send us the coupon along with your company letterhead.

FAST™

From Portland, ME.

FAIRCHILD
A Schlumberger Company

Or contact your nearest Fairchild sales office or authorized distributor.

FILL ME IN FAST.

Name _____

Title _____

Company _____

Address _____

City _____

State _____ Zip _____

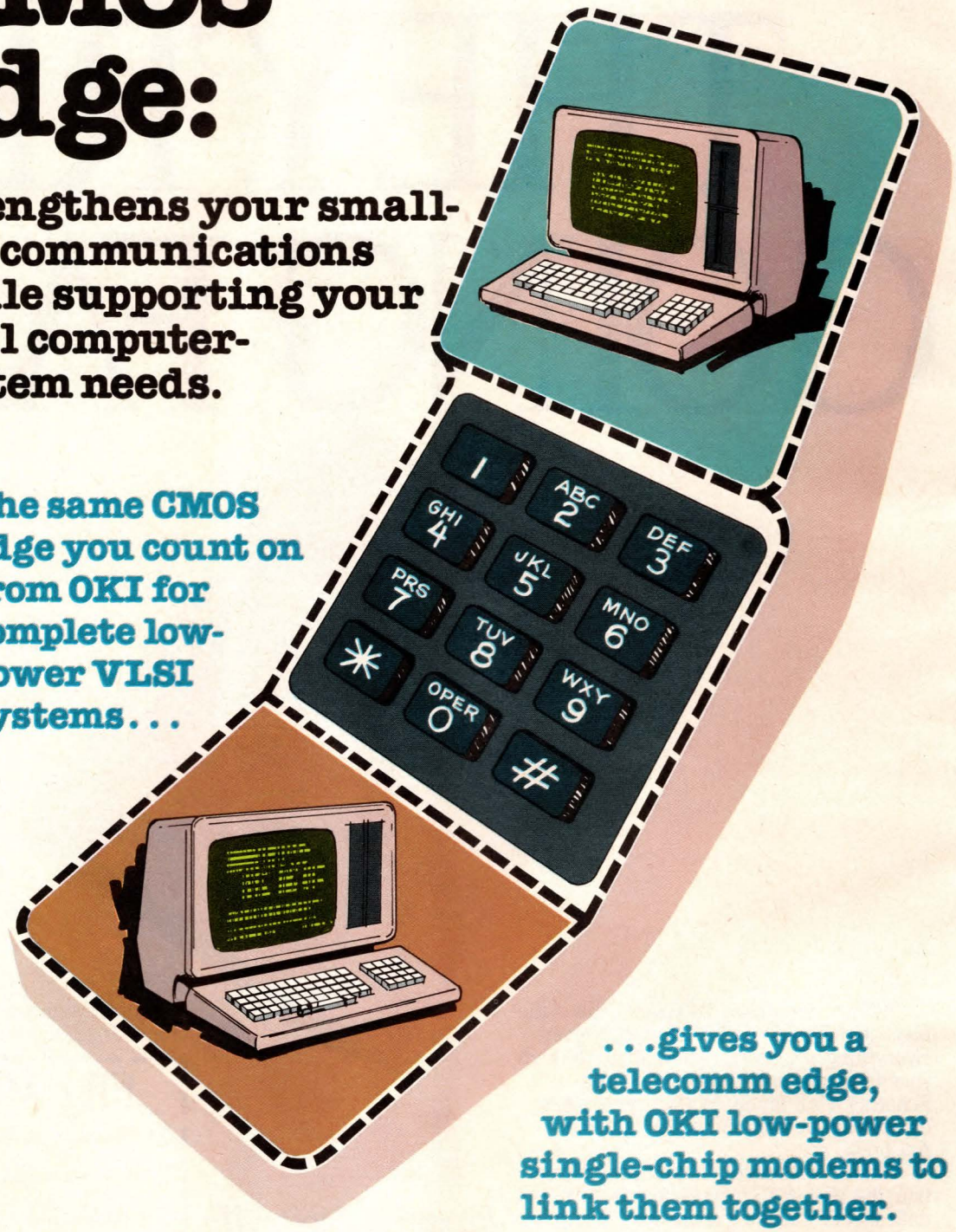
305999 EDN-11-29

Fairchild Digital Unit, 333 Western Avenue, South Portland, Maine 04106

FAST (Fairchild Advanced Schottky TTL) is a trademark of Fairchild Camera and Instrument Corporation.

The OKI CMOS edge:

Strengthens your small-box communications while supporting your total computer-system needs.



The same CMOS edge you count on from OKI for complete low-power VLSI systems . . .

. . . gives you a telecomm edge, with OKI low-power single-chip modems to link them together.

Now you can use OKI's optimized CMOS VLSI to reach out and touch every base in your system.

All from a single source: the easy-entry CMOS computer technology so essential to small-system market expansion today, **plus** the easy-to-apply CMOS communication technology needed to enhance it.

All from OKI Semiconductor, the major IC supplier uniquely qualified to respond to small-box maker demands in both areas—as a world leader in low-power, battery-backup VLSI components, whose product innovators can draw upon a 105-year history in the research, development and mass production of successful telecommunication electronics.

From a position of strength, OKI can offer the small-system designer not only all the CMOS devices required for total low-power system integration, in order to improve portability, compactness and cost-efficiency. We can also help you tie in those critical telecomm functions through our CMOS single-chip modems and VLSI communication products. With the same systemwide concern for ease of use, development support and volume availability which has accompanied every big OKI CMOS move:

Software-compatible CMOS 4, 8 and 16 bit microprocessors, CMOS 4 and 8 bit MCUs. Pacesetting CMOS high-density memories and CMOS gate arrays. Extending this commitment throughout your system to include CMOS speech chips, real-time clock, and a full range of peripheral products.

Now we're opening up to world markets OKI's long-established communications capabilities, combined with our CMOS know-how, to give you a double-edged tool against your competition.

OKI TELECOMM CMOS MODEMS

SPEED	APPLICATION	PART NUMBER	AVAILABILITY
300 Baud	Bell 103, FDX CCITT V.21, FDX	MSM6946 MSM6926	Now Now
1200 Baud	Bell 202, HDX CCITT V.23, HDX	MSM6947 MSM6927	Now Now
300/1200 Baud Auto-Switch	Bell 212A, FDX	Hybrids Chip Sets	4Q84 1985
2400, 4800, 9600 Baud	Application-specific high-speed data exchanges	Modem Boards Chip Sets	Now TBA

The OKI CMOS edge: line access through line-powered modems . . .

OKI brings uncommon design ease and flexibility to your common standard modem applications through the special advantages offered by our advanced CMOS VLSI processes:

Telephone line-access with lower line-power requirements. Battery backup for higher reliability. And the small single-chip modem saves significant board space—it's so compact you can now integrate the modem function into your system itself at a very low cost.

The Bell-compatible 6946/6947 and the CCITT-compatible 6926/6927 modem ICs will transmit and receive serial, binary data over the switched telephone network using FSK modulation. With a much lower bit error rate than similar devices on the market. The signal to noise ratio is only 7 dB, with a bit error rate of 1×10^{-6}.

To simplify design-ins, OKI has put on-board these single-chip devices all the modulation, demodulation and filtering functions required to implement a serial, asynchronous communication link—with no special telecomm experience or expertise necessary.

On-chip: CMOS analog and digital signal processing; selectable built-in delay timers and an external delay-timing capability; plus originate and answer modes (at 300 baud). Application ease is internally reinforced by an integral crystal oscillator, and a TTL-compatible digital interface. OKI's single-chip modem design assures compatibility with a broad installed base of low speed modems and acoustic couplers; the OKI CMOS edge assures you of an easy-to-use low-cost alternative to the less-efficient standard discrete modem approach.

Plus expanding telecomm support

OKI's on the move in low-power communication products, with still more OKI CMOS solutions for your small-system telecomm needs.

CODEC

MSM6910	CMOS Codec/Filter Combo
MSM6912	CMOS PCM Audio Filter
MSM6932	CMOS Codec, u-Law (USA), with Filter
MSM6933	CMOS Codec, a-Law (Europe), with Filter
MSM6913	Parallel to Serial/Serial to Parallel
MSM6914	Space Switch
MSM6917	M-255 Companding Codec
OCS30/31	Hi Voltage Cross Point Switch

Dialers

MSM6224	CMOS DTMF, Keyboard
MSM6234	CMOS DTMF, Keyboard or Up
MSM5249	CMOS Pulse Dialer
MSM6052	Pulse/Tone Dialer

DTMF Decoder

MSM6920	Digital PABX (1/85)
MSM6945	END to END (12/85)

Tell me more about OKI Telecomm

Send complete technical data on:

( ) OKI CMOS Modem chips, Bell data sets
( ) OKI CMOS Modem chips, CCITT data sets
( ) Development data for application-specific high-speed modems
( ) Other OKI modem/telecomm requirement: _____

OKI SEMICONDUCTOR

Name _____

Title _____

Please attach coupon to business card or letterhead and return to:
OKI Semiconductor, 650 North Mary Avenue, Sunnyvale, CA 94086
Tel: **(408) 720-1900.** (Please note new address and phone.)

EDN

OKI-71-984

We've Earned The Right To Be #1

By Being First So Often

When it comes to being FIRST with technology-leading products, ***Advanced Digital*** wears its #1 button with pride. We were ***FIRST*** to introduce an 8-Bit, single board S-100 computer... We were ***FIRST*** to introduce a 6MHz, 128KByte single board computer ... We were ***FIRST*** to introduce a 6MHz, 128KByte Slave Processor board. And our record for being FIRST continues with...

- The introduction of SUPER EIGHT – an 8MHz master with Winchester and Floppy disk controller on one board.
- The introduction of SUPER SLAVE II – A dual slave processor that will support two users under TurboDOS.
- The introduction of our new SUPER 186 – the ***FIRST*** 16-Bit, single board S-100 computer that performs at twice the speed of older technologies. Loaded with features such as on-board floppy disk controller and up to 1MByte of RAM, the SUPER 186 is designed to function as a bus Slave or Master. Advanced Digital's SUPER 186 permits you to take advantage of vast libraries of sophisticated applications software.

Advanced Digital boards are IEEE 696 compatible, run under a variety of operating systems such as CP/M 2.2,* CP/M 3.0, Concurrent CP/M, MP/M,* OASIS,* and TurboDOS*

(Top row L to R: Super Slave 128, HDC-1001, Super Slave 64, Bottom row L to R: Super Quad, Super 186, Super Six)

and are available with CPU speeds of 4, 6, or 8MHz. On-board memory capacities range from 64KBytes to 1 MByte.

When it comes to selecting your S-100 boards, go with Advanced Digital – The Company that earned the right to be #1.

See your local computer dealer or contact Advanced Digital today ... We'll help you become #1.

ADVANCED DIGITAL CORPORATION

Leading the Microcomputer Technology

Advanced Digital
5432 Production Drive, Huntington Beach, CA 92649
Tel. (714) 891-4004 • Telex 183210 ADVANCED HTBH

In Europe:
Advanced Digital U.K. Ltd.
27 Princess St., Hanover Square
London WIR8NQ • United Kingdom
409-0077 • 409-3351 Telex 265840 FINEST

CIRCLE NO 134

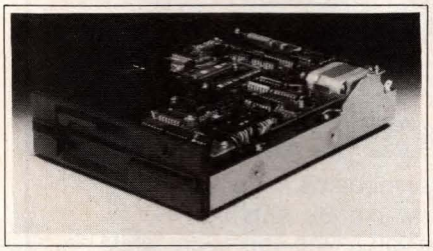
*CP/M is a trademark of Digital Research
*TurboDOS is a trademark of Software 2000
*MP/M is a trademark of Digital Research
*Oasis is a trademark of Phase One Systems

PC/AT EXPANSION. An internal-expansion kit for the IBM PC/AT consists of a hard disk and a ¼-in. tape drive. The hard disk uses IBM's controller for AT software compatibility and is available in capacities of 40M, 65M, 140M, and 280M bytes. The integral tape unit backs up 65M bytes in 12 min. According to the manufacturer, this subsystem operates 30% faster than does IBM's 20M-byte hard disk, provides incremental database file growth beyond 32M bytes, and allows user-configurable disk caching of as much as 4M bytes. The system supports DOS 2.0, 2.1, 3.0, QNX, Concurrent DOS, UCSD-P System, PC/IX, and other PC-compatible networks. All necessary cables, a back-up and restore utility, and menu-driven hard-disk installation software are included. From $1950. **Emerald Systems Corp,** 4901 Morena Blvd, San Diego, CA 92117. Phone (619) 270-1994.

Circle No 521

MEMORY EXPANSION. The 1M-byte iSBC 010CX and the 2M-byte iSBC 020CX expand the system memory for products based on the iSBC 286/10 CPU board. In addition, prices on other boards in the series—the 256k-byte iSBC 056CX and the 512k-byte iSBC 012CX—have been reduced 14 and 37%. Compatible with Multibus and their manufacturer's iLBX (local bus exchange) product family, the 010CX and 020CX models include 256k-bit dynamic RAMs and on-board ECC; they feature 1-wait-state performance. 056CX, $1750; 012CX, $2250; 010CX, $4750; 020CX, $8250. **Intel Corp,** 5200 NE Elam Young Parkway, Hillsboro, OR 97113. Phone (503) 640-7147.

Circle No 522

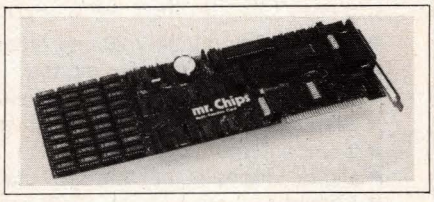


DUAL-SPEED DRIVE. The YD-380-1714 is a dual-speed, half-height 5.25-in. floppy-disk drive. The dual-speed feature allows you to use either the standard 1M-byte double-density, double-track format or the IBM PC/AT high-capacity 1.6M-byte disk format. Because the IBM high-capacity format is compatible with the standard 8-in. media format, using the 5.25-in. YD-380-1714 to replace an 8-in. drive does not require that the data be put on several 5.25-in. disks. You can interchangeably use data and programs written on either standard or high-capacity media. The drive can read and write data at a track density of 96 tpi. The unit measures 1.63×5.75×8 in. and includes a disk pop-up mechanism, a disk lever clamp, an in-use indicator, and daisy chaining for as many as four drives. It also features steel-belt head positioning and a brushless direct-drive motor. $200 (OEM qty). **C Itoh Electronics Inc,** Box 66903, Los Angeles, CA 90066. Phone (213) 306-6700. TLX 652451.

Circle No 523

PDP-11 UPGRADE. You can increase the effective memory size and CPU speed of your PDP-11 system with the Microverter. This quad-width card plugs into the Q Bus backplane and addresses up to 4M-bytes of Q Bus memory while driving 19 Unibus loads. The Microverter, a modified Unibus backplane, and a voltage regulator compose a Microverter Plus. The Plus version, coupled with the 11/73 or 11/73+, transforms a PDP-11 system into a higher-speed Unibus system. Both products are compatible with current versions of RSTS/E and RSX-11. Microverter, $2300. Microverter Plus, $3575. **Able Computer,** 1732 Reynolds Ave, Irvine, CA 92714. Phone (714) 979-7030.

Circle No 524



IBM PC ADD-IN. Add Mr. Chips to your PC and monitor or control a variety of external devices. Its Real World Interface, a fully addressable 12-bit port, comprises an 8-bit bidirectional TTL bus as well as four bits of programmable output that communicates with thermostats, moisture detectors, photocells, and other devices. Another port monitors four resistive inputs and four digital inputs. In addition, an ac line controller sends ultrasonic signals to a BSR X-10 unit that controls up to 16 ac devices. Other features include a clock, calendar, serial and parallel printer ports, and a 1-year warranty. $449. **Orange Micro Inc,** 1400 N Lakeview Ave, Anaheim, CA 92807. Phone (714) 779-2772.

Circle No 525

Z80 SYSTEM CLOCK. The ZTIME I installs in any Z80-based computer to provide a calendar and clock with battery backup. The hardware installs in the CPU socket and moves the Z80 onto the ZTIME I board. Resident software accesses the clock in both binary and ASCII formats and allows the console to set and display the time and date. The

new from AETA...

limited distance modems

Here is a pair of 19.2Kbps short haul modems for local data distribution—that are surprisingly low in price, and high in performance. The AEMOD 15 gives you async operation, while the AEMOD 20 offers sync/async operation. Both types give you:

- RS-232-C and V.24/V.28 interfaces
- Full duplex and simplex modes
- Point-to-point and multipoint environments
- Stand-alone and rack-mounted versions
- Compact and ruggedized
- Digital loopback test and LED status indicators
- Scrambler option (AEMOD 20 only)
- UL listed and 1-year warranty

Call or write for more details and prices.

AETA

AETA Corporation
16 Taylor Avenue
Bethel, CT 06801
(203) 748-8688

CIRCLE NO 135

Sprague-Goodman. Nobody Offers a Broader Selection of Trimmer Capacitors.

When it comes to high-quality trimmer capacitors, nobody comes close to Sprague-Goodman.

We have the world's largest selection of models, styles and dielectrics: sub-miniature glass, quartz and sapphire Pistoncaps® plastic Filmtrims® or Ceramic single-turn, Mica compression, Airtrim® air dielectric, multi-turn plastic and miniature LC tuners and Stab-L® metalized inductors.

So whether you need standard or custom products, you can count on Sprague-Goodman. The first and last name in trimmer capacitors.

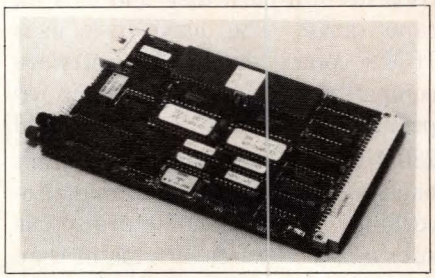
Sprague-Goodman Electronics, Inc.
SPRAGUE GOODMAN
(An affiliate of the Sprague Electric Company)
134 Fulton Avenue,
Garden City Park, NY 11040
516-746-1385
TLX: 14-4533

CIRCLE NO 136

COMPUTER-SYSTEM SUBASSEMBLIES

software comes in BDS C, Turbo Pascal, KRT Pascal, and Microsoft BASIC. It works on any Z80-based computer whose clock speed is less than 5.5 MHz. Bare board, $29; complete kit, $69; fully assembled and tested, $99. **Kenmore Computer Technologies,** Box 635, Kenmore, NY 14217. Phone (716) 877-0617.

Circle 526



MICROCOMPUTER BOARD. The GESMPU-4A is a 68000-based 16-bit system on a standard single-height Euroboard (100×160 mm). The system offers two disk operating systems—CP/M 68K and OS-9—and clocks at 8 MHz. Fully G-64 Bus compatible, the board has four JEDEC-standard sockets that accommodate as much as 128k bytes of EPROM and 16k bytes of RAM. Finally, you also get a triple 16-bit timer and an RS-232C serial interface with a fully programmable baud rate. $475. **GESPAC Inc,** 550 E Grandview, Mesa, AZ 85203. Phone (602) 962-5559. TLX 386575.

Circle No 527

SINGLE-BOARD COMPUTER. The OB68K/MSBC1 uses the 68000 μP operating at 12.5 MHz on the IEEE-796 Multibus. The board carries 256k bytes of dual-ported, zero-wait-state RAM with parity. When 256k-byte RAM is available, you can upgrade the memory to 2M bytes. Also included are four JEDEC-standard sockets for monitor, boot, or program PROMs, and you can configure the board for up to 128k-bytes of ROM. Four serial ports run at rates to 1000k baud, with addi-

THIS KEITHLEY STARTS MEASURING CURRENT WHERE YOUR DMM STOPS

Now you can stop guessing at currents below a microamp and measure down to picoamps.

Fact: In research, design, and testing, both the components and the technology keep breaking lower current barriers.

The days when you could trust your DMM to make these measurements are long gone.

With today's new tighter criteria, you can't risk working with uncertain data. You have to be able to make these measurements precisely.

You can, with Keithley's new Model 485.

SYNOPSIS

- 0.1pA sensitivity
- 4½ digits
- Fast autoranging
- Analog output
- Zero suppress
- Full IEEE interface option
- 100-point data storage
- Linear or log display
- Digital calibration

NICE COMBINATION

You not only get the most capability that's ever been built into a picoammeter, you also get it with all the convenience of a DMM, and at an exceptional value.

Whether you use it on the bench or in a system, for research, design, component testing, Q.A., Q.C., or production, you get the sensitivity you need today (and tomorrow).

You get the confidence you need for measuring op amp inputs and leakage currents in analog switches, capacitors, and MOS and JFET gates, as well as for making measurements in the research lab.

THE TOOL FOR THE TASK

Unlike a DMM which is too coarse for this level of work, and which can create errors due to its high voltage burden, the 485 offers resolution down to 1.9999nA, with only 0.2mV burden. (The effects of voltage burden are covered in the Application Note offered below.)

INEXPENSIVE INSURANCE

For all its capability and simplicity, the new 485 Picoammeter is priced at just $695. The IEEE option is $225. That's a small price to pay for the confidence and control you get.

CALL NOW

For complete specifications on the 485, along with a Low Current Application Note, contact Keithley Telemarketing Dept. at 216/248-0400 or write: Keithley Instruments, 28775 Aurora Rd., Cleveland, OH 44139.

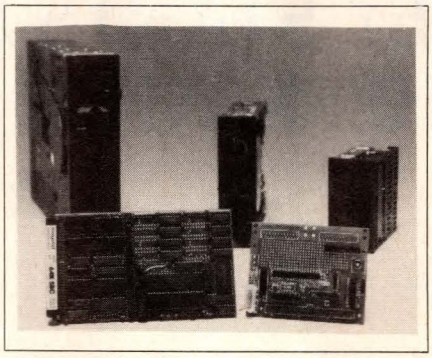
1A
1mA
1μA
1nA
1pA

KEITHLEY

CIRCLE NO 137

tional I/O ports through the IEEE P959 (iSBX) expansion connector. Daughter boards for memory management and different microprocessors are options for this IEEE 796-compatible board. 256k-byte version, $2495; 512k-byte version, $2995. **Omnibyte Corp,** 245 W Roosevelt Rd, West Chicago, IL 60185. Phone (312) 231-6880.

Circle No 528



SINGLE-BOARD COMPUTER. The 64K SBC includes a variety of features on 4×6-in. board: a video-display controller, a floppy-disk-drive controller, a 6-MHZ Z80B CPU, 64k bytes of RAM, and serial and parallel I/O. The video-display controller can connect directly to a composite or TTL monitor to display bit-mapped graphics or an 80-column×35-line alphanumeric display. Also, the floppy-disk-drive conroller can run up to four drives. Among its I/O capabilities, the board contains 22 general-purpose parallel I/O lines, a Centronics-compatible parallel printer port, two RS-232C serial ports, and a peripheral expansion interface that accesses the CPU's data, address, and control lines. CP/M 2.2 with utilities, terminal and disk handlers, and an installation utility accompany the hardware on 8 or 5¼-in. diskettes. The 64k SBC, transition board, connector, CP/M 2.2 license, installation software, and source code, $375. **Megatel Computer Technologies,** 1051 Clinton St, Buffalo, NY 14206. Phone (416) 745-7214.

Circle No 529

Low Cost Microprocessor Development System

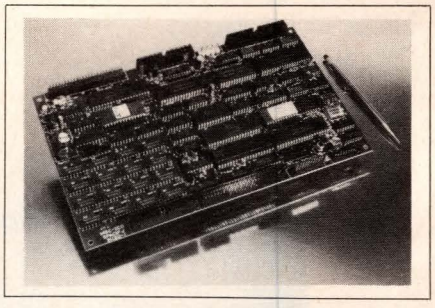
Huntsville Microsystems offers a line of high performance in-circuit emulators and linking software packages which will turn any computer into a full microprocessor development system. The emulators feature real-time transparent emulation, mappable memory, hardware breakpoints, RS232 interface, in-line assembler/disassembler, upload/download hex files and complete debugging facilities. The units can operate stand-alone with a CRT or when combined with the power of your computer, form a full microprocessor development system.

Software packages are available to allow operation with any IBM™PC, CP/M™ or ISIS™ system including the Intel™iPDS.™ Cross-assemblers are available for the IBM PC and CP/M systems. Prices start at under $2000. For complete specifications write to Huntsville Microsystems, Inc., 8200 S. Memorial Parkway, P.O. Box 12415, Huntsville, AL 35802 or call (205) 881-6005.

HMI

Z80 is a registered trademark of Zilog, Inc.
CP/M is a trademark of Digital Research.
ISIS, Intel and iPDS are registered trademarks of Intel Corp.
IBM and IBM PC are registered trademarks of International Business Machines Corp.

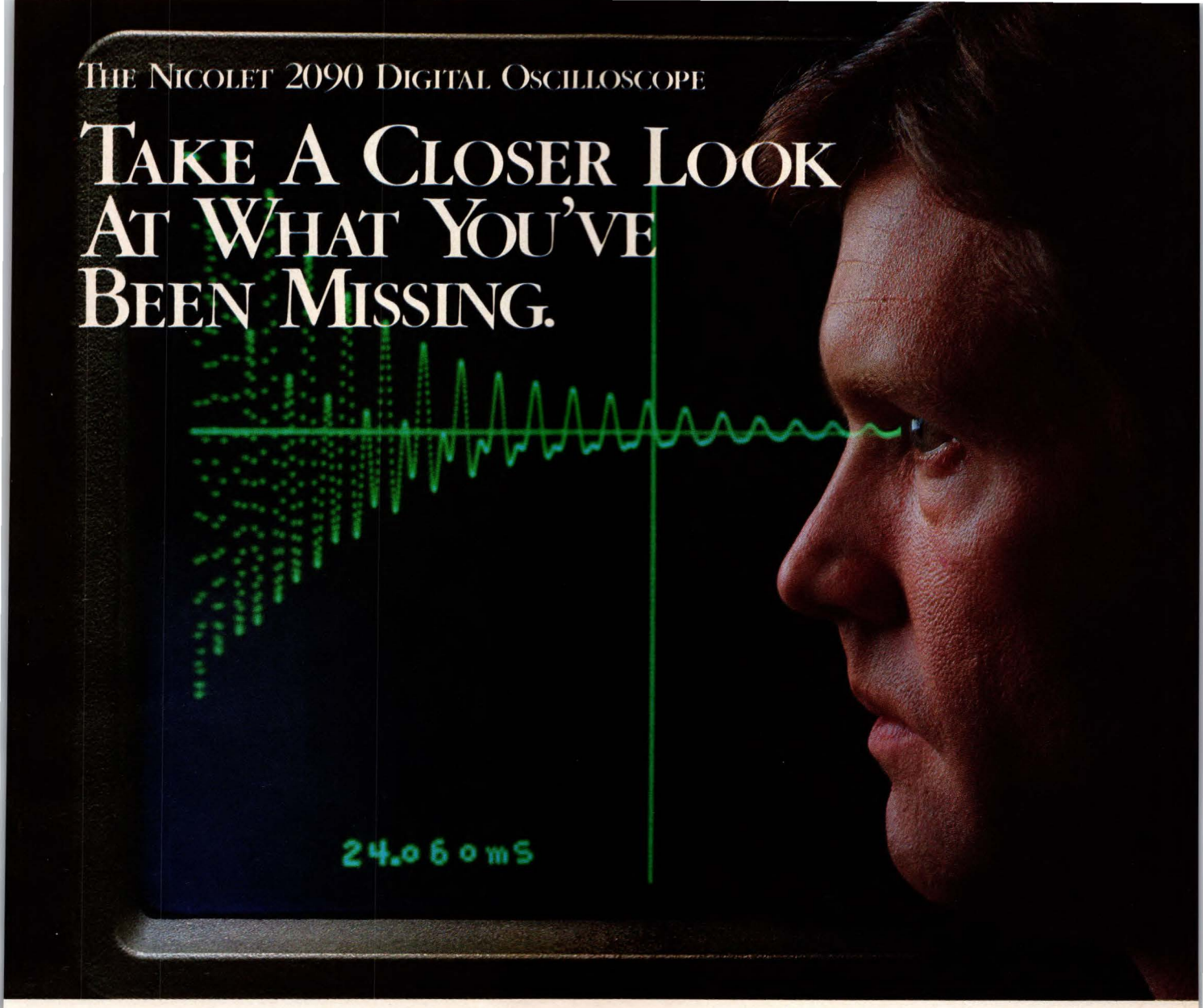
CIRCLE NO 138



SINGLE-BOARD COMPUTER. The MSC-ICO packs many features onto a board measuring less than 10×6 in.: a Z80 CPU, a 128k-byte RAM, an 80-character×24-line video controller, a floppy-disk controller, two RS-232C ports, a Centronics-compatible port, a 16-bit I/O port, a keyboard port, a clock/calendar, and CP/M Plus 3.0. The floppy-disk controller handles as

THE NICOLET 2090 DIGITAL OSCILLOSCOPE

TAKE A CLOSER LOOK AT WHAT YOU'VE BEEN MISSING.



DIGITAL PRECISION AND RESOLUTION LIKE YOU'VE NEVER SEEN.

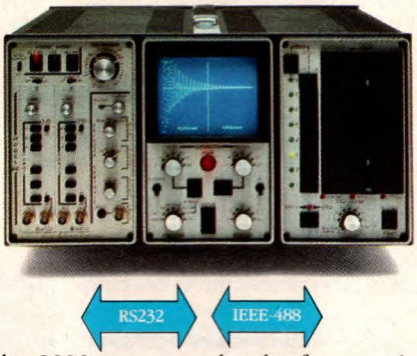
Picture this. The smallest detail in *12-bit resolution,* expansion to X64, with voltage and time coordinates alphanumerically displayed. Plus the ability to record 4K data points at *speeds up to 50MHz,* with the 205A plug-in. It's what you'd expect from the digital oscilloscope that's still setting the standards—Nicolet's 2090.

DON'T MISS ANY TRANSIENTS.

The 2090 offers push button transient capture, at speeds selectable from 20 nanoseconds to 200 seconds per point, so you can record fast or slowly changing signals with ease. And *pre- and post-trigger capture* lets you see what led up to an event as well as what followed. Built-in floppy disk allows unattended operation . . . just set and forget.

THE VERSATILITY YOU'VE BEEN LOOKING FOR.

Optional RS232 and IEEE-488 bidirectional interfaces give you the ability to coordinate and manipulate data by remote computer. That means



the 2090 scope can be the front end of an entire analysis system. Not only that, the 2090's modular design allows you a choice of *four different plug-ins.* Pick the digitizer that's designed for your present application, and add other plug-ins to fit your expanding needs in the future.

SEE FOR YOURSELF.

Let us show you how easy the 2090 is to use. It's time *you* started benefiting from the tremendous digital advantage. Call us: **(608) 273-5008.** Or write: Nicolet Oscilloscope Division, 5225 Verona Road, Madison, WI 53711.

BRINGING DIGITAL PRECISION TO AN ANALOG WORLD

Nicolet

For more information Circle No. 139

TAKE CONTROL

Kepco Power Managers™ give you more and better control over your power than anything else around

More control, because our Power Managers have a combination of capabilities unique compared to other, similar devices on the market. Better control because they're built without resort to dissipation-limiting tricks that compromise performance.

By more control we mean that the Kepco Power Managers, our linear, programmable power supplies, series ATE, BOP, APH, BHK, and JQE, can be used as self-powered oversized op amps, as servo amplifiers, or as feedback stimulated current or voltage stabilizers. With the help of our SN or TLA digital interfaces, their voltage or current can be computer-controlled via the IEEE bus, or, for really fast programming, via data buses having bit-parallel data transfer.

Kepco's ATE and BHK Power Managers can be selectively configured for fast programming or configured conventionally to deliver a stable voltage. Kepco's BOPs can deliver either negative or positive voltage, skipping from plus to minus and back without a glitch, and can act as either sources or sinks.

When we say our Power Managers don't resort to performance-compromising tricks, we mean that there are no auto ranging transformer taps that create forbidden zones right where you need the power supply to work. There are no switching pre-regulators to slow things down and create noises in a sensitive test system, no SCRs to limit dissipation (and your speed). You can control the voltage (to 0.001%) and the current (to 0.005%) from zero through their full range, and get maximum rated voltage and current at the same time. The Kepco Power Managers are fast. The BOP's output time constant, in response to programming step inputs, is 80 μsec or better over their full current and voltage ranges. The ATE's program time constant is as fast as 3.0 μsec. They have this remarkable capability because in creating their design Kepco accepts the responsibility for dissipating internally the heat that full range high speed operation demands. We use enough power transistors to deal with it safely. We cool them off with a patented, high efficiency finned heat sink using an integral fan. It gets rid of that heat with a temperature rise of less than 0.1° per Watt. So they run cool for high reliability.

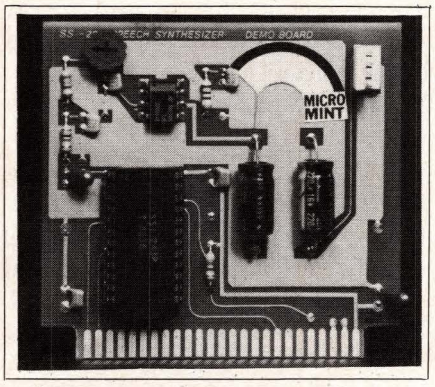
Surprisingly, for systems that do so much so well, prices of the Kepco Power Managers start under $800, for the quarter-rack-size ATE. We have a lot more to tell you, and most of it's in a new brochure we've prepared called "The Kepco Power Managers," which we'd be delighted to send you. Just write to Dept. GZF-12., KEPCO, INC., 131-38 Sanford Avenue, Flushing, NY 11352 USA • (718) 461-7000 TWX #710 582 2631 • FAX (718) 767-1102.

KEPCO®
POWER SUPPLIES

CIRCLE NO 140

many as four drives. The computer also includes an expansion port for options such as more RAM, a hard-disk controller, or a 68000 coprocessor. $599. **Artisoft Inc,** Box 41436, Tucson, AZ 85719. Phone (602) 327-4305.

Circle No 530

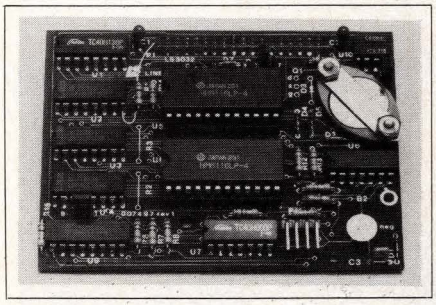


SPEECH SYTHESIZER. The Sweet Talker speaks for itself. Using the SSI 263 speech-synthesizing IC, the Sweet Talker produces music, sound effects, and speech at data rates between 50 and 70 bits/sec. It includes 256 phoneme equivalents, 4096 pitch variations, and an on-board 1W amplifier with volume control. Built on a 3×3¼-in. board, the Sweet Talker has control inputs for connection to a computer bus or a parallel port. Also, it has 16 speed settings and 255 variations of frequency response for the vocal-tract filter. $104. **Micromint Inc,** 561 Willow Ave, Cedarhurst, NY 11516. Phone (516) 374-6793.

Circle No 531

I/O EXPANSION SUBSYSTEM. To expand the I/O capacity of your MPA-2000 CPU, plug in the MSX-2000 modular I/O expansion system. The MSX-2000 supports eight I/O-system applications that use the MSX plug-in I/O adapter modules. In a daisy-chain configuration, up to 64 plug-in sites connect to one Multibus slot in the MPA-2000, which is an iAPX-186-based CPU and intelligent I/O controller for the Multibus. $1375. **Metacomp Inc,** 9466 Black Mountain Rd, San Diego, CA 92126. Phone (619) 578-9840.

Circle No 532



BATTERY-BACKUP MEMORY. For iSBC-based systems, the LS3032 battery-backup memory module stores 4096 bytes of data for as long as five years. A lithium cell keeps data in the CMOS memory devices intact during power loss.

Approved by Intel

The ESP E9A EPROM Programmer/Copier

- **Technically innovative**
- **Cost effective**
- **User friendly**
- **Highly reliable**

The Electronic System Products' E9A Programmer provides complete computer interface and editing capability **plus** 8 copy sockets for your development **and** production use.

Approved by Intel. ESP thrusts forward with capability to program 512K EPROMs in its field-proven E9A editor/copier. And this programmer is already approved by Intel for their 512K EPROM!

Cost Effective. For one of the lowest prices in the industry for an eight copy socket EPROM programmer, you can have the highly featured ESP E9A. You also get sales and applications support other manufacturers are reluctant to give.

User Friendly. The simulation capability in our E11 attachment to the E9A Programmer allows you to **instantly** see the effects of your design changes. No waiting and no confusion.

Highly Reliable. An impressive array of EPROM checks assures you that your devices will function properly in your equipment — including the industry's only built-in access time testing to verify EPROM speed.

The E9A is only one of ESP's versatile line of fast programmers, editors, copiers and simulators. At ESP we have to stay in front . . . to ensure you stay in front. Talk to us soon about your EPROM and EEPROM programmer requirements.

ESP

Electronic System Products, Inc.
1135-C San Antonio Road
Palo Alto, CA 94303
Telephone: (415) 964-5338

EPROM Expertise

CIRCLE NO 141

SOLITRON — YOUR PRIME SOURCE FOR

FET's

We Make All of Them:

- N & P Channel Junction FET's
- N & P Channel MOS FET's
- N Channel D-MOS FET's
- 1N's, 2N's, 3N's JAN's & Specials

Design and Build your circuit around them:

Low Leakage Amplifiers
High Speed Switching
UHF-VHF Amplifiers
Differential Amplifiers
Low Noise Amplifiers

Look forward to our NEW Series of Power MOS products

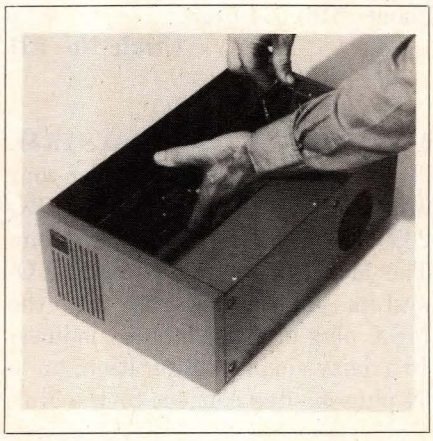
Solitron DEVICES, INC.
8808 Balboa Avenue,
San Diego, CA 92123
(619) 278-8780
TWX: (910) 335-1221
CALL TOLL FREE:
(800) 854-2021

CIRCLE NO 142

COMPUTER-SYSTEM SUBASSEMBLIES

The vendor positions the LS3032 as an alternative to the iSBC 094 board for systems based on the iSBC 86/12, the iSBC 86/30, or the iSBC 86/40 single-board computers. $290 (OEM qty). **Computer Modules Inc,** 1190 Miraloma Way, Suite Y, Sunnyvale, CA 94086. Phone (408) 737-7727.

Circle No 533



IBM PC EXPANSION CHASSIS. The B106 6-slot expansion chassis and card cage expands the number of cards you can add to the bus of an IBM PC, PC/XT, 5531, or compatible computers. You need two Action bus expansion cards and an Action ribbon cable pair, which you can purchase as the B120 IBM PC Bus interface kit. Attach one card to the computer, the other to the expansion chassis, and use the remaining five chassis slots as a parallel extension of the computer's bus. The B106 and the B120 have a 3-year warranty. **Action Instruments,** 8601 Aero Dr, San Diego, CA 92123. Phone (619) 279-5726.

Circle No 534

IMAGING BOARD FOR PC. Turn your IBM PC or PC/XT into an imaging system with the DT2803 video-frame grabber and display board. The DT2803 captures a 256×256×8-pixel black-and-white video image 30 times a second from RS-170 (60 Hz) or CCIRR (50 Hz) input signals. It digitizes the input into 6-bit pixels representing one of 64 possible gray levels. Through the use of look-up tables, the DT2803 can alter the output color and intensity of the stored and displayed images. When used with the Videolab software package, the PC can perform frame operations such as baseline correction, merge, difference, and histogram as well as real-time image acquisition and display. Videolab comprises Videotutor, an interactive tutorial on DT2803 use, and Videosub, a comprehensive library of subroutines for user-defined applications. DT2803, $1495; Videolab, $995. **Data Translation,** 100 Locke Dr, Marlboro, MA 01752. Phone (617) 481-3700. TLX 951646.

Circle No 535

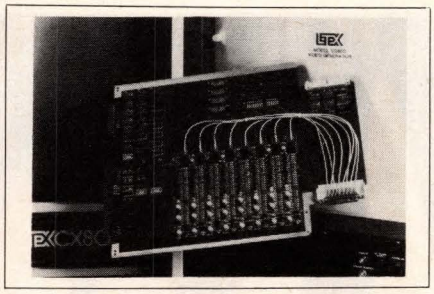
PC/AT EXPANSION. The Advantage multifunction expansion board adds memory and ports to the IBM PC/AT. The user-upgradable memory holds either 64k-byte or 256k-byte RAM ICs to allow you to add as much as 3M bytes of memory. In addition, Advantage offers an IBM-compatible parallel printer port, two serial ports, and a game port. The basic 128k-byte version costs $495. **AST Research Inc,** 2121 Alton Ave, Irvine, CA 92714. Phone (714) 863-1333.

Circle No 536

STATIC-RAM BOARDS. The RAM 23 static-RAM board adds as much as 128k bytes of memory to systems based on the 8086, 8088, and 80286 CPUs. Operating at rates to 12 MHz, it consumes less than 4W typ at a nominal 8V bus voltage. It meets all IEEE 696/S-100 bus specs and transfers both 8-bit bytes and 16-bit words. Two configurations are available: One operates as a 64k×8-bit or a 32k×16-bit memory ($400), and the other as a 128k×8-bit or 64k×16-bit memory ($775). **Compupro,** 3506 Breakwater Ct, Hayward, CA 94545. Phone (415) 786-0909.

Circle No 537

COMPUTER-SYSTEM SUBASSEMBLIES



VIDEO-CIRCUIT TEST BOARD. To test television, VTR/VCR, and teletext ICs and modules, you can add the VG600 video generator to the LTX Integrated Test System through the CX80 Consumer Extension. The VG600 stores multiple sets of test patterns, in NTSC or SECAM formats, coded into a 32k-word memory—16k words of control memory and 16k words of event memory. Pattern-looping capabilities expand the size and complexity of the test patterns. The VG600 has a single-pass sample rate of 250 kHz and a multiple-pass sample rate of greater than 7 MHz. An integral, mutliple-measurement scheme collects up to 256 data samples in a single pass of the video line. $45,000. **LTX Corp,** LTX Park at University Ave, Westwood, MA 02090. Phone (617) 329-7550.

Circle No 576

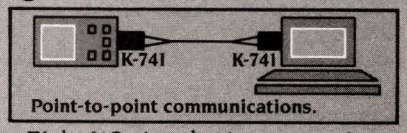
VIDEO CROSS-HAIR BOARD. The AMS CHG-4 cross-hair generator superimposes as many as four adjustable indicator lines on a video image and produces a digitized video signal. Providing separate dual-axis sync outputs, the board produces a 1-bit digitized output for pattern recognition or image processing. Also, it automatically adjusts the shades of generated lines to meet contrast requirements of background images, enhances the area of interest, and allows remote position/threshold adjustment. An STD bus powers the board. $240. **Advanced Micro Systems Inc,** 9 Executive Dr, Hudson, NH 03051. Phone (603) 882-1447.

Circle No 577

New Optical Modem

Uses RS-232-C port for error free communication in high noise environments.

Now fiber-optic communications links can be accomplished easily, effectively and economically. The new K-741 Optical Modem plugs into the RS-232-C port of any computer or piece of instrumentation.



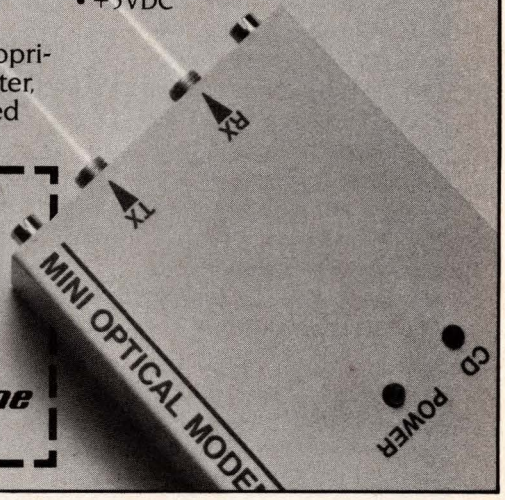
Point-to-point communications.

- Eight I/O signals (4 outputs, 4 inputs).
- 0-20KBPS transmission speed.
- Up to 320 ft. between modems.
- +5VDC

Or, buy our VLSI.
The K-741 is based on our proprietary VLSI receiver/transmitter, which can be easily designed into your system.

Evaluation Kit: $385
Write for an evaluation kit to see how effective the K-741 is. Includes two K-741 modems, 33 ft. of optical cable and two DC adaptors. For more information, attach your business card to this coupon. Or, to order, send your check to: Crane Associates, Inc. 3928 S. Sepulveda, Culver City, CA 90230 (213) 390-9840.

Crane
A Division of Kanto Denshi Corporation.



CIRCLE NO 143

A CHOICE!

Flexible metal-core conduit systems with a wide selection of EMC shielding properties.

Glenair offers flexible conduit systems for mechanical protection of wiring and for electromagnetic compatibility applications.

Unique shielding of flexible metal-core conduit meets virtually any EMI/RFI suppression requirement, from H and E field shielding to TEMPEST, EMP and Lightning.

New Series 75 System.

Glenair's new Series 75 metal-core conduit system offers unsurpassed mechanical integrity

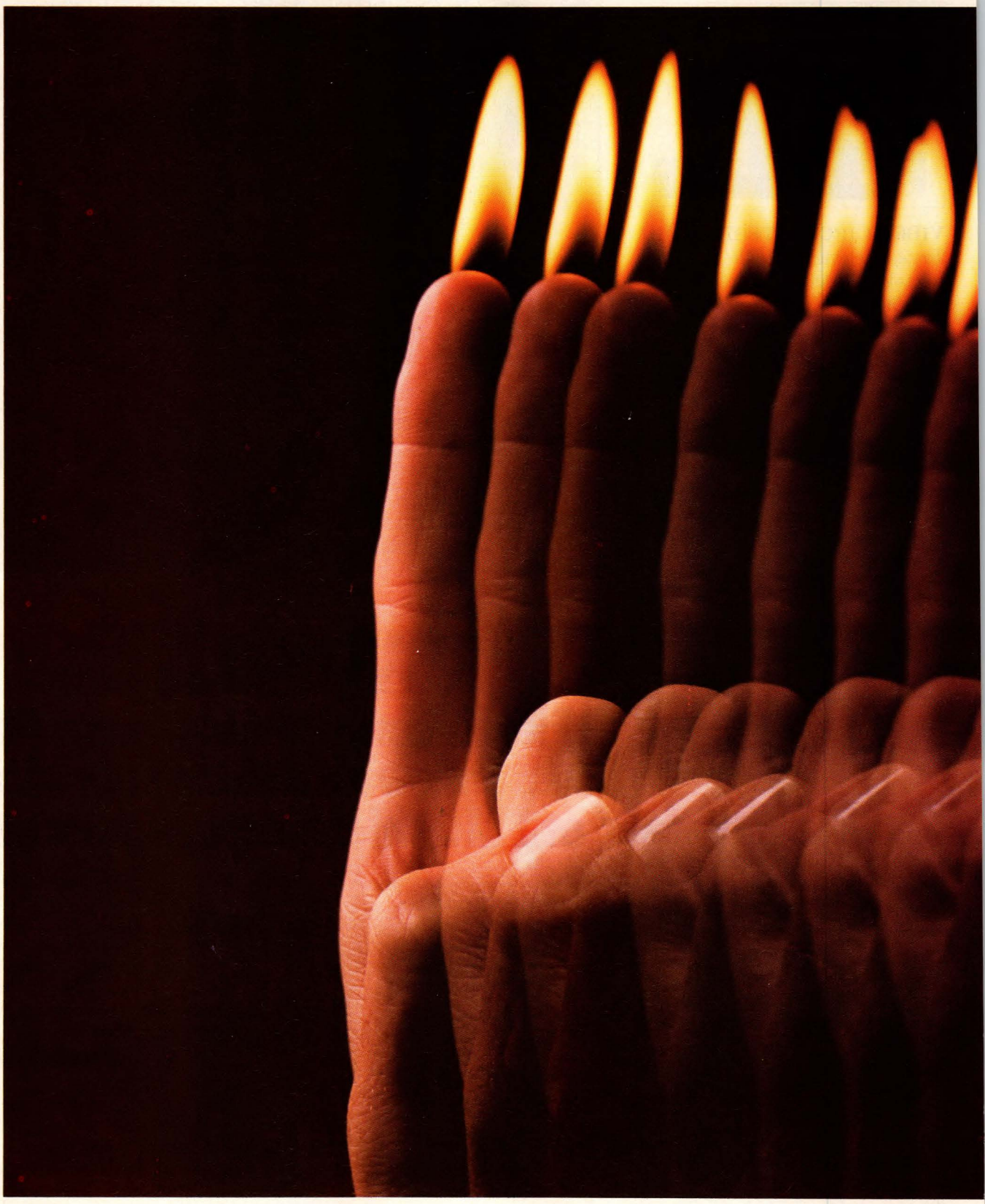
and compatibility. Supplied unjacketed or with a Neoprene jacket for complete waterproofing and environmental sealing. Other jacketing materials available. Conduit construction qualified to MIL-C-13909.

In-house capabilities and facilities.

Glenair has over 25 years experience producing solutions to special electrical interconnection problems. If you're looking for a cost-effective answer to a conduit problem, call or write:

GLENAIR, INC.
1211 Air Way • Glendale, California 91201-2497 • (818) 247-6000

CIRCLE NO 144



NO ONE, BUT NO ONE, OFFERS THE NEW FR PLASTICS CHOICES WE DO.

We could fill up this page (and then some) with names and facts on all the flame retardant* plastics we make. But we want you to send for the book. And we want to help you make the selection.

If you tell us what properties you need: impact strength, color stability, strength-to-weight ratio, processability, gloss, finishing. If you tell us what processing technique you use: extrusion, injection molding, structural foam. We've got just what you're looking for. Choose the one source who can provide the exact combination of properties you want. We're the one. Borg-Warner Chemicals. Send for your free copy of our flame retardant plastics booklet. Borg-Warner Chemicals, Inc., International Center, Parkersburg, WV 26101.

*The term "flame retardant" identifies those grades of thermoplastics which meet specific laboratory test requirements. The testing authority, procedure and results are identified in supporting technical literature. Any representations do not necessarily typify the performance of plastic resin under actual fire conditions.

BORG WARNER®

BORG-WARNER CHEMICALS WE'RE THE ONE.

Renoir
LE DÉJEUNER
DES CANOTIERS

The Phillips Collection, Washington

Applied Microsystems Corporation:
Changing your ideas about emulation.

MYTH 3

ALL IN-CIRCUIT EMULATORS NEED A HOST

If you walk into your engineering department and see a group gathered around the development system or computer it's either because they are planning your surprise birthday party, or that they're simply waiting to log-on.

That's why it's so important that in-circuit emulators have the capability to accept software developed on a host system and then function as a stand-alone instrument. This allows you to *disconnect* from the host to debug software and integrate it with hardware, leaving the host system free for other development tasks. Which means better utilization of manpower and computerpower, and more time for birthday parties (or "product released on time" parties).

OUR EMULATORS INVITE MORE USERS.

Because in-circuit emulators from Applied Microsystems have stand-alone capabilities they can be used for more than just new product development.

Hand one over to the manufacturing test department and see how delighted those engineers are to find out they can use existing test routines.

Or if you're jumping from one type of microprocessor-based project to another you won't have to learn an entirely new system. We offer real-time emulation capability for Intel, Motorola, National and Zilog 8-bit and 16-bit microprocessor families.

It makes more sense to add another emulator when you add more staff to your department, rather than another computer workstation or MDS.

DON'T KEEP YOUR ENGINEERS WAITING.

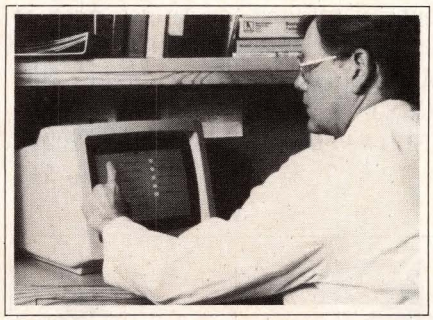
Free-up your traditional development tools by taking advantage of stand-alone in-circuit emulation from Applied Microsystems Corporation. Contact us at:

A.M. Kirchenhölzl 14
8032 Gräfelfing
West Germany
c/o Steve Thatcher
Telefon 49-89-854-3290
Telex 841-5242/INSTR

Stand alone
in-circuit emulation
for 8-bit and 16-bit microprocessors

Applied Microsystems CORPORATION

CIRCLE NO 146

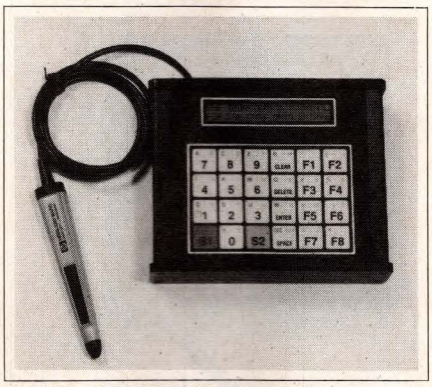


TOUCH CRT. DEC Kits are a series of touchscreen kits specifically designed for the Digital Equipment Corp line of terminals and personal computers. These kits allow you to select from menus, position the cursor, and create and manipulate graphics merely by touching the display. The screen offers a resolution of 1024×1024 touch points. So that you can accurately manipulate even a single letter with your finger, the touchscreen controller electronically averages the entire area of contact to a single, discrete point. The controller is programmable and is available with an EEPROM for the storage of calibration values and other parameters. You can choose to install the kit yourself, or let the manufacturer provide that service. Each kit includes a touchscreen, a controller, and standard firmware. Software and firmware support is also available from the manufacturer. From $1095 (OEM qty). **MicroTouch Systems Inc,** 400 W Cummings Park, Woburn, MA 01801. Phone (617) 935-0080.

Circle No 538

GRAPHICS. The UI-100 Series raster-imaging microcomputers operate by accepting graphical object information via an RS-232C port from a language driver in the host-computer software, and then converting the description into a bit map. Each microcomputer features a Motorola 68000 CPU and the capability to perform image manipulations such as zoom, rotation, overlay, and half-toning. Three memory-configuration options provide varying levels of graphics complexity. Option 1 lets you use a variety of business-software graphics packages to access as many as 55,000 polygon and vector vertices in your UI-100 μC. Option 2 is a 110,000-vertex package that is suitable for use with mainframe graphics software such as IBM's GDDM, SAS/GRAPH, and Precision Visual's DI-3000. With Option 3's 220,000 polygon and vector vertices you can handle images produced with CAD and mapping software. UI-100, from $3500; Option 1, $1995; Option 2, $4450; Option 3, $6350. **Lasergraphics,** 17671 Cowan Ave, Irvine, CA 92714. Phone (714) 660-9497. TLX 753527.

Circle No 539



DATA TERMINAL. The TransTerm 5 compact, keyboard/display teminal unit suits general-purpose data entry. The unit features a 24-key membrane keyboard—including eight programmable function keys and a 48-character LCD with a 2-line, 5×7 dot-matrix font that supports a 96-character upper- and lower-case ASCII set. You can choose from eight baud rates, specify the number of bits per character, determine function-key codes, and select other parameters via keyboard commands that are saved in nonvolatile memory. Three operating modes allow for full- or half-duplex teletypewriter-compatible operation or for polled multidropping with as many as 128 units per 4-wire circuit. The standard communications interface is full-duplex RS-232C serial asynchronous ASCII, but optional RS-422 and 20-mA current loop interfaces are available. The unit can support an optional bar-code wand. The terminal measures 6.9×5.6×1.75 in. and consumes 6W using either a 115V ac plug-in transformer or a 12V dc external source. $249. **Computerwise Inc,** 4006 E 137th Terrace, Grandview, MO 64030. Phone (816) 765-3330.

Circle No 540

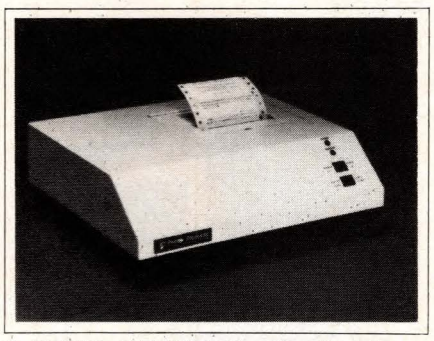
AUDIO COMMUNICATION. The Model T347B fiber-optic voice-communications set suits applications for which conventional audio circuits are not available. Communication is provided via a single-mode or multimode fiber. Typical ranges are 25 dB at 40 km for single-mode fiber and 40 dB at 10 km for multimode fiber. The set features a voice-activated headset, rechargeable battery, and call-alert button. $6800. Delivery, 8 wks ARO. **Plantronics Wilcom Inc,** Box 508, Laconia, NH 03247. Phone (603) 524-2622. TWX 510-298-1120.

Circle No 541

VOICE MESSAGE SYSTEM. Model IV is a small-capacity voice message-exchange system. The 4-port system provides voice storage and forwarding for 100 to 500 users and can be upgraded to serve as many as 1000 users with the addition of extra ports and memory. The system is small enough for you to incorporate it into an equipment rack as an integral component. Op-

tional features include call answering and a message function. Model IV can also be linked to other voice message exchanges through the manufacturer's proprietary network, Voicenet. $50,000. **VMX Inc,** 1241 Columbia Dr, Richardson, TX 75081. Phone (214) 699-1461.

Circle No 542

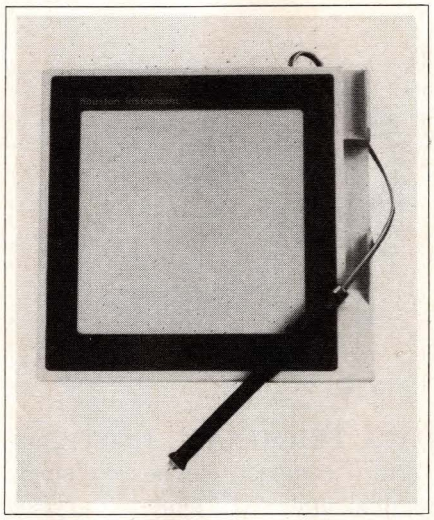


LABEL PRINTER. A 40-column dot-matrix label printer, the S400L flexible-format device incorporates an optical sensor, which ensures accurate data placement, regardless of label size or shape, by seeking the position of the top of the label and automatically advancing the label stock to its first data print position. The S400L operates at 72 lpm and provides the full 96-character ASCII set, printing upper- and lower-case characters in standard or elongated modes. You can choose from an RS-232C, Centronics parallel, or 20-mA current-loop interface to the host. $800 (OEM qty). **Printer Products,** 25 Denby Rd, Boston, MA 02134. Phone (617) 254-1200. TLX 951589.

Circle No 543

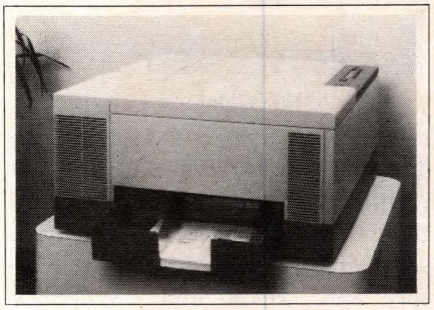
DUAL-68000 μP. A Unix-based, 32-bit-processor system, Model 1124 suits on-line information processing. According to the manufacturer, this system runs 30% faster than the VAX-11/780 at one-third the cost because of the system's multithread architecture, which tightly couples the dual processors. Features include mirrored disk drives, power margining, a 33.3M-byte data-transfer bus, and redundant cooling. In addition to supporting the Unix System V operating system, the 1124 also supports RM/COS, a COBOL-compatible operating system that offers high-speed file access. The unit measures 14×28×54 in. and has 10 card slots: three for CPU and memory cards, six for I/O expansion, and one for a memory controller that manages the data flow among system cards. Memory is available in 2M-byte increments. From $60,000. Delivery, 60 days ARO. **Areté Systems Corp,** 2040 Hartog Dr, San Jose, CA 95131. Phone (408) 263-9711.

Circle No 544



DIGITIZER/MOUSE. The PC Pad dual-function graphics data-entry device operates either as a digitizer (to translate drawings into computer-readable data) or as a mouse (for cursor-control applications). The 8×7-in., wedge-shaped unit has a 5×5-in. active area that lets you address over 1 million points (1024^2) with a resolution of 200 points/in. Host interface is accomplished via an RS-232C-compatible connector. You can select the digitization rate according to baud rate and data format to a maximum of 19.2k baud for a serial, binary format. Point, triggered, stream, switch-stream, and delta operating modes are offered. A 15V dc input is standard, but an optional ac transformer is available. $395. Delivery, 60 days ARO. **Houston Instrument,** Box 15720, Austin, TX 78761. Phone (512) 835-0900. TWX 910-874-2022.

Circle No 545

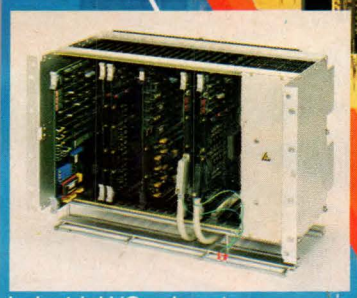


INK-JET PRINTER. The Dijit 1 ink-jet office printer offers full-page, all-points-addressable printing that combines graphics and text at speeds to 18 pages/min. It includes 128k bytes of internal buffered RAM storage, a resident font set, automatic dual-sided printing, a Centronix interface, Xerox 2700 emulation, 500-sheet bin capacity, and self-test and operator diagnostics. In letter-quality print mode, the Dijit provides a resolution of 300×300 dots/in.; the draft-quality mode allows high-speed operation. You can combine type sizes ranging from 4 to 36 points within any document. Graphics and text can be combined or overlaid on the same page, and formats are controlled by the host terminal. The Dijit 1 uses binary-deflection, multiple-array ink-jet technology with continuous-flow imaging and accommodates plain bond, cut sheet paper, or transparencies. From $5000 (OEM qty). **Diconix Inc,** Box 3230, Dayton, OH 45431. Phone (513) 898-3644.

Circle No 546

SHORT-HAUL LAN. This device connects RS-232C and RS-422A devices to multiple host computers located as far as 7000 ft away using RG62A/U cable (or 3000 ft via telephone station wire) at a 19.2k-baud asynchronous, full-duplex data rate. It uses on-off keyed technology and

Our VMEbus/68000 boards can get your new product to market more quickly



Industrial I/O subsystem

- Analog I/O board
- 4 x V24/V11 data-communication-controller
- Central-processor board with MMU option
- ROM/RAM memory board
- Disc controller
- System controller and extender to I/O subsystems
- CPU board (multi-processing)
- 256 Kbyte DRAM memory board

VMEbus VMXbus VMEbus

Let's face it. Your success in selling new systems and equipment depends more than ever on your speed in getting them to market. Take time to design from scratch, and you'll be left at the post!
The answer? VMEbus/68000 boards by Philips.
Our line-up is already extensive. Computing nucleus. Memory boards. System controllers. Data-communication controllers. I/O modules. Even industrial I/O subsystems and assemblies. And new boards are being added continuously.
Our handy rack holds up to 14 double VMEbus Eurocards and provides the power required. Speeding design of everything from simple controllers to the most complex multi-processor systems.
To sum up, the VMEbus is the most powerful for designing 16-bit systems today and 32-bit systems tomorrow. And Philips' VMEbus/68000 Family – including chips, boards, software and development tools – is the most powerful in getting them to market! For proof, contact

PHILIPS
VMEbus/68000 product line
Marketing Services, Building TQ III-4
5600 MD Eindhoven, The Netherlands
Telex: 35000 PHTC (NL)

PHILIPS

CIRCLE NO 82

ONE-CHIP TELECOM SOLUTIONS: MODEMS, FILTERS, TONE SIGNALING IC's

In telecom application-specific IC's, Silicon Systems stands alone as the innovator in standard, semicustom, and full custom products. Not only were we the first to fully integrate Touch-Tone® receiver electronics onto a single chip, but we're also the company that has developed switched capacitor filter design to the present state-of-the-art. In fact, we are the telecom chip company with a proven ability that is unmatched for producing analog, digital, and analog/digital designs on a single chip.

Our present broad line of standard telecom application-specific circuits includes a family of high performance DTMF receivers, transceivers, and band-split filters; a selection of medium-to-high-speed modems, speech synthesizer IC's, and switched capacitor filter arrays.

But beyond those standard IC's, Silicon Systems offers the industry's most advanced and complete semicustom and full custom capability. We wrote the book on innovative IC design. And we have the newest and most efficient, automated wafer fab for production at optimum yields. In fact, we're one of the few companies with both Bipolar and CMOS multi-process capability in the same wafer fabrication facility.

For more information on our DTMF's, modems, speech synthesizers, and switched capacitor filter arrays, send for our Telecom Integrated Circuits brochure.

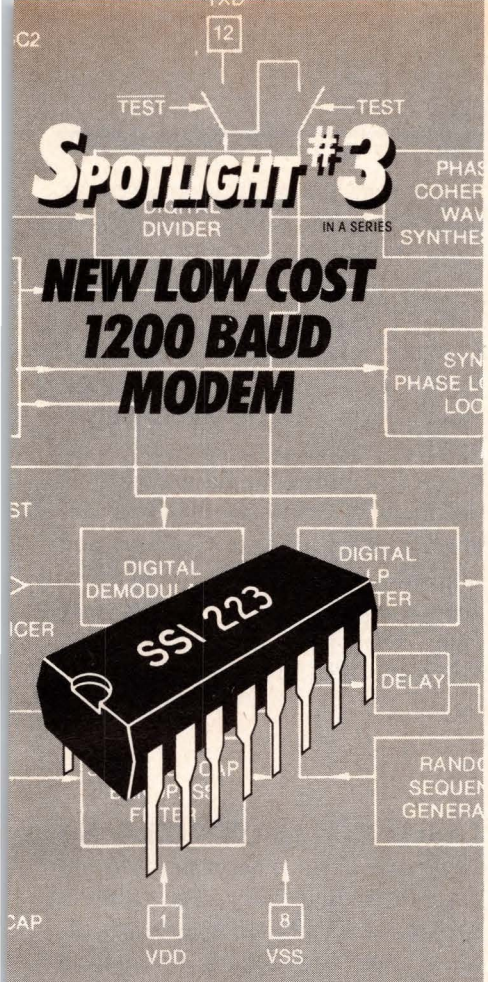
Silicon Systems, 14351 Myford Road, Tustin, CA 92680. (714) 731-7110.

®Touch-Tone is a registered trademark of AT&T.

silicon systems™
INNOVATORS IN INTEGRATION

Circle No. 162 for production information

Circle No. 201 for career information



Silicon Systems now introduces a low-cost 1200 baud FSK modem IC that is ideally suited for use with interactive terminals, videotex, personal computers, credit verification systems, point-of-sale terminals, and remote process control.

The new SSI 223 integrated circuit receives and transmits serial binary data over existing telephone networks using a frequency shift keying (FSK) design. It operates at 1200 baud and provides the filtering, modulation, and demodulation to implement a serial, asynchronous, data communication channel.

By utilizing advanced CMOS switched capacitor filter technology, Silicon Systems has been able to produce a chip that minimizes size and power consumption and maximizes reliability. Capable of simultaneous transmission and reception, the SSI 223 can be used for half-duplex operation over a single line system or full duplex operation over a two-line system.

For more information on this low-cost modem, contact: **Silicon Systems,** 14351 Myford Road, Tustin, CA 92680, **(714) 731-7110,** Ext. 575.

silicon systems
INNOVATORS IN INTEGRATION

CIRCLE NO 197

digital-correlation techniques for protocol matching. Internal buffering, X-on/X-off, automatic line turnaround, and multilayered error detection with correction algorithms provide reliable data transmission over simple telephone lines. The unit's limited token-passing network protocol allows connected host computers to communicate with any of 255 RS-232C or RS-422A devices. All connections have polarity insensitive transformer coupling, which eliminates the requirement for dc continuity and removes most routine restrictions in noisy, common-mode high-voltage areas. The unit supports star, multidrop, and daisy-chain network configurations, individually or in combination. $1220. Delivery, 6 to 8 wks ARO. **Centrolonics Corp,** Nonwire Div, 4 Kidder Rd, Chelmsford, MA 01824. Phone (617) 256-1918.

Circle No 547

MICROCOMPUTERS. The 400 Series 68000-based, VME Bus microcomputers support multiuser local-area-networking applications with true vectored interrupts and optionally polled I/O. The 10-MHz systems' 256k bytes of RAM are standard, with maximum RAM capacity extending to 3M bytes. A 640k-byte floppy-disk drive is provided on each system, and an optional second drive is offered. The high-end Model 460 accommodates a maximum Winchester disk capacity of 448M bytes. A maximum of 15 users can use a variety of operating systems and languages, but the standard offering of software includes the Liaison operating system, p-System IV.2 with LAN software, a screen editor, communications software, and several utilities. These microcomputers have a real-time clock with battery backup. Options include a 12-MHz processor with 120-nsec CPU RAM, a floating-point unit, and a memory-management unit. From $2900. **Stride Micro,** 4905 Energy Way, Reno, NV 89502. Phone (702) 322-6868. TWX 910-395-6073.

Circle No 548

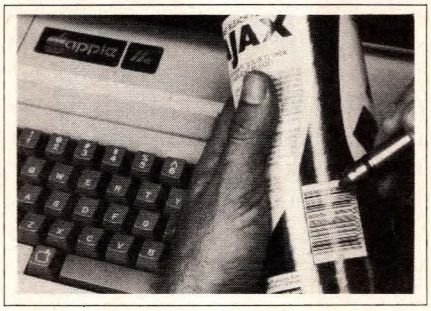
HIGH-SPEED PRINTERS. Models 2565A and 2566A dot-matrix devices print at 600 lpm and 900 lpm, respectively. You can install as many as 14 character fonts simultaneously and mix them in a single line of print. Both models print bar codes, provide high-speed graphics, and handle multipart forms. The standard ASCII character set and 11 European languages are supported. You can choose from the various character sets by using the printer's front control panel or via software commands. Optional OCR-A and OCR-B character sets are available to meet Department of Defense and European postal service standards for optical character codes. The manufacturer's IEEE-408 interface bus is included, but optional RS-232C, RS-422A, Centronics parallel, and 2608A interfaces are also available. 2565A, $18,766; 2566A, $21,766. Delivery, 24 wks ARO. **Hewlett-Packard Co,** 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 549

MODEMS. The Series/900 modems feature speed ranges from 1200 to 14,400 bps. The 911 is a full-duplex dial-up modem that's suitable for use in a 2-wire general-switched telephone network. It operates at 1200 or 2400 bps with automatic-calling and -answering functions through

the RS-232C interface. This unit has an integrated line monitoring speaker and meets CCITT V.22 and Bell 212A standards. The 910 (CCITT V.26, 1200/2400 bps), 920 (CCITT V.27, 2400/4800 bps), 930 (CCITT V.29, 4800/7200/9600 bps), and 940 (CCITT V.29, 4800/7200/9600/14,400 bps) are leased-line modems that operate over regular phone lines and contain an equalizer that adapts continuously to transmission-line characteristics, bridging line interruptions that last as long as 2 sec. Seven LEDs permit continuous monitoring of modem operation and DTE interface. An integral test-pattern generator and bit-error-rate detector are included. The 920, 930, and 940 also feature an eye pattern generator to provide a standard pattern on an oscilloscope that gives a visual indication of how the signal is being received. The 930 and 940 modems also allow you to control port speed for local and remote modems from one central site. From $1095. Delivery, 60 days ARO. **Digital Communications Associates Inc,** 303 Technology Park, Norcross, GA 30092. Phone (404) 448-1400. TLX 261333.

Circle No 550



BAR-CODE READER. With the Symbtrak scanning system, your Apple IIe can read and print bar codes. The system includes a handheld scanning wand, ROM-based software, a tutorial diskette, and instructions for application software integration. Software is available under DOS 3.3, ProDOS, or Pascal 2.0. Available code protocols include Code 3-of-9, Interleaved 2-of-5, Codabar, UPC, MSI Plessey, and Labelcode. Symbol-printing software allows you to mix symbols with text. Printer routines are written in assembly code for a variety of dot-matrix printers. Options include multiple scanner support and multiple code support. From $495. **Advanced Business Technology Inc,** 1180 Coleman Ave, San Jose, CA 95110. Phone (408) 275-9880.

Circle No 551

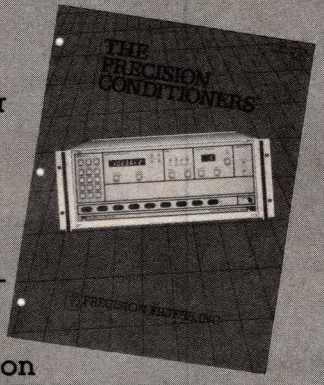
LASER MICROCOMPUTER. The LPC-1000 laser microcomputer incorporates laser video-disk technology in an 8086-based microcomputer system to support interactive training and simulation applica-

BEGONE, CURSED ALIAS

80 dB/octave attenuation. Time delay filters superior to Bessel. 1° phase match or better. Standard computer interfaces. Serial, parallel and GPIB.

We set these industry standards, and we keep extending the choice of Precision systems for HP, LP, TD, BP, BR and anti-alias filters. 2 channels to 64. Choice of cut-off frequencies, resolution, amplification and other features to match your needs precisely.

Read about them all in our summary catalog, **The Precision Conditioners.** Call 607-277-3550 or write.

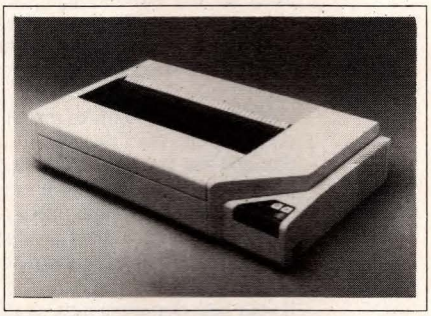


PRECISION FILTERS, INC.
240 Cherry Street, Ithaca, New York 14850

CIRCLE NO 150

tions. The 12-in. read-only laser disk provides 2G bytes of storage for text, software, video, and audio data. Benefits of this technology include high data security, long archival storage life, media durability, and a low cost/bit of information manufacture and distribution. One video disk can hold more than 100,000 still images, more than 100 hrs of audio, or 1 million pages of alphanumeric text. Any of these information forms, including digital data, can be combined on one laser disk. You can use the Pilot-Plus authoring language to premaster a tape with development software or data for replication onto an optical disk. The LPC-1000 includes a high-resolution color-graphics generator that you can use to overlay images on a laser-disk picture. The LPC-1000 includes 650k bytes of RAM, an RGB monitor, a keyboard, a joystick, the CP/M-86 operating system, Pascal, FORTRAN, and C. $9750. Delivery, 16 wks ARO. **Tomax Inc,** 5800 Andover Ave, Montreal, Quebec, Canada H4T 1H4. Phone (514) 735-6541.

Circle No 552



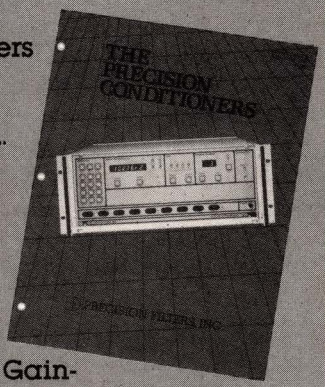
PRINTER. The OT-700 dot-matrix printer provides a 700-cps draft-quality print speed. You can also select correspondence quality printing at 350 cps. The unit offers dot-addressable graphics printing in two operating modes—50×69 dots/in. for high-speed output or 100×69 dots/in. for higher resolution copies. Several foreign-language and special character sets are available. Protocol configuration is provided via menu-driven program commands. The printer has a carriage width of 136 columns with adjustable sprocket-feed tractors. The paper path can originate from the front or the bottom of the unit. The control panel features membrane switches and LED indicator lights. $1495. **Output Technology Corp,** 606 110th Ave NE, Bellevue, WA 98004. Phone (800) 468-8788.

Circle No 553

GRAPHICS DISPLAY. You can use Model 2010 single-board, graphics display system as a stand-alone or host interactive device with Ethernet, Multibus, and Q Bus data networks. Pictures and images can reside locally without the need for continuous retransmission from the host. You can modify pictures by

BEGONE, OTHER PESKY PROBLEMS

From Precision Filters we grew to many Precision Conditioners. All multichannel. All programmable. All for the care and preservation of signals between transducer and A/D converter.



Instrumentation and filter amplifiers. Gain-ranging amplifiers and preamps. Multimode conditioners for strain, charge and voltage. Switching matrices. Frequency-band translators for super BP applications, as well as providing analog zoom for spectrum analysis, modal analysis and beam forming.

Read about them all in our summary catalog, **The Precision Conditioners.** Call 607-277-3550 or write.

PRECISION FILTERS, INC.
240 Cherry Street, Ithaca, New York 14850

CIRCLE NO 151

"How to specify optical encoders. #2 of series"

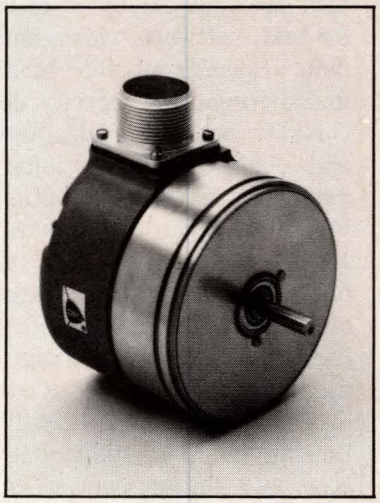
WHEN CHOOSING OPTICAL ENCODERS, CONSIDER...

The resolution/accuracy relationship

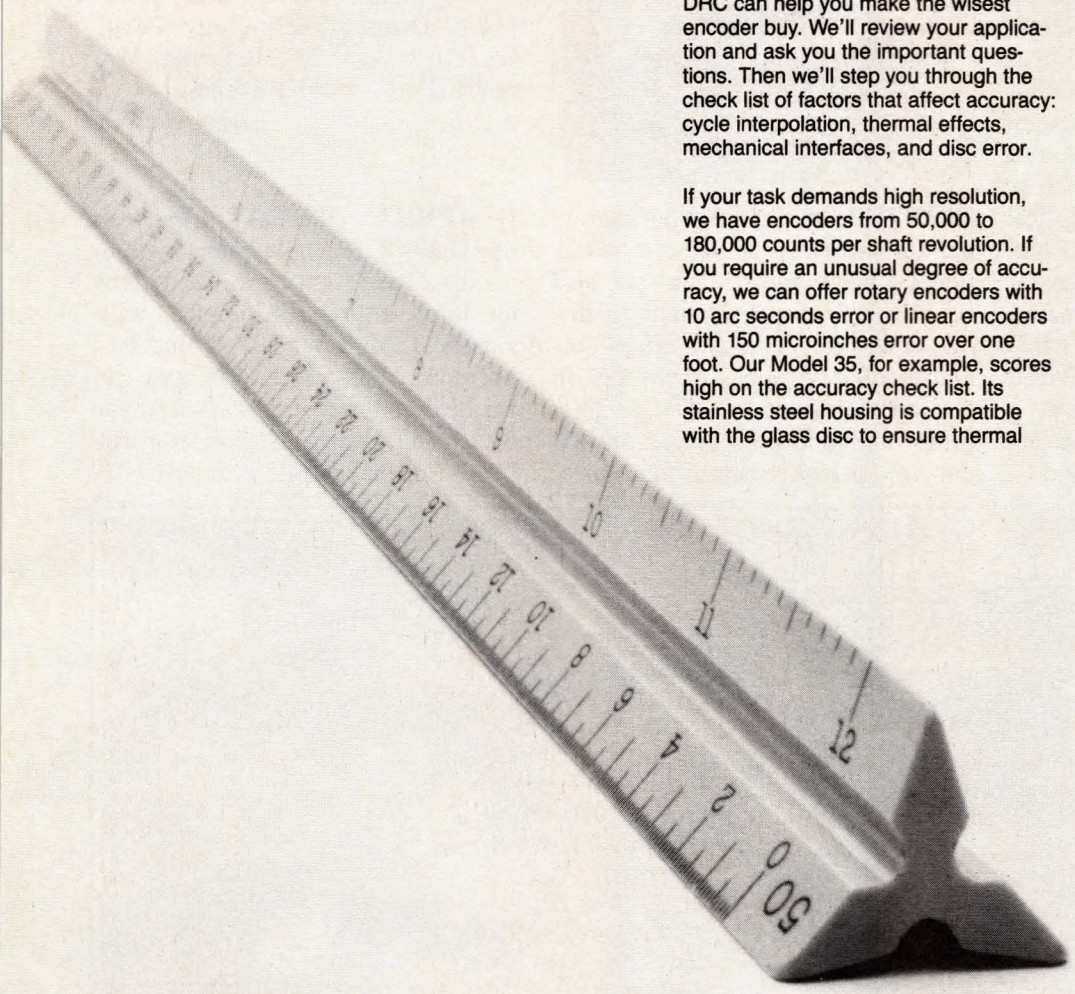
Resolution and accuracy—they often get confused. Accuracy is the deviation of the actual position from the correct position expressed as error. Resolution defines the smallest measurable change in position. There is no guarantee that a product promising high resolution automatically ensures high accuracy. Nor can increased resolution compensate for low accuracy. If you want both, you have to specify both.

DRC can help you make the wisest encoder buy. We'll review your application and ask you the important questions. Then we'll step you through the check list of factors that affect accuracy: cycle interpolation, thermal effects, mechanical interfaces, and disc error.

If your task demands high resolution, we have encoders from 50,000 to 180,000 counts per shaft revolution. If you require an unusual degree of accuracy, we can offer rotary encoders with 10 arc seconds error or linear encoders with 150 microinches error over one foot. Our Model 35, for example, scores high on the accuracy check list. Its stainless steel housing is compatible with the glass disc to ensure thermal stability. Its dual read-head cancels disc eccentricity and bearing errors. The Model 35 may be perfect for your needs. If your needs for accuracy and resolution aren't that exacting, we'll recommend another encoder to do the perfect job.



It's good to know there are DRC encoders that fit your applications exactly. Talk with us at DRC. We're the encoder people.



DRC

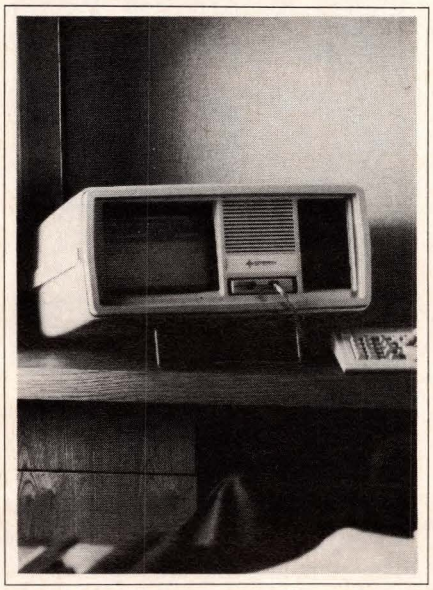
CIRCLE NO 152

THE ENCODER PEOPLE

DYNAMICS RESEARCH CORPORATION
60 CONCORD STREET
WILMINGTON, MASSACHUSETTS 01887
TEL. 617/658-6100 TWX. 710/347-0611

using parametric variables and simultaneous writing in any or all graphics memory planes. Display manipulation is accomplished through a variety of features such as local scaling, translation, rotation, view porting, highlighting, programmable color indexes, and segment copy operations. The 2010 provides a 7220 graphics processor with a 1M-byte video RAM, an 8086/87 processor, a 667-nsec per pixel vector-write rate, and a 19-in. monitor. The system comes in tabletop or rack-mount versions. $8500. **Aydin Controls,** 414 Commerce Dr, Fort Washington, PA 19034. Phone (215) 542-7800. TWX 510-661-0518.

Circle No 554



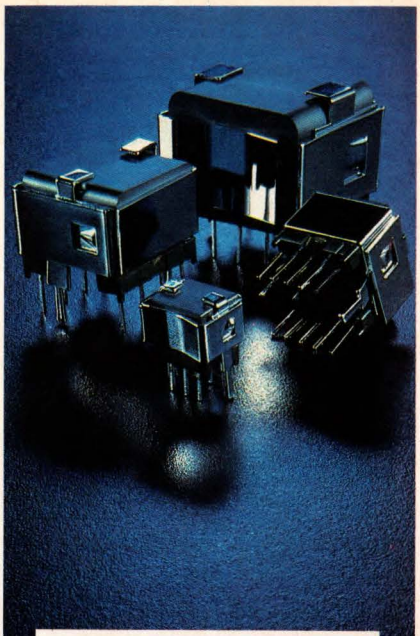
FACILITY NETWORK. An integrated, expandable energy management and facilities automation system, the Alpha/Net 4000 system can be configured to control a facility with as few as 64 or as many as 10,000 monitor points. Hardware includes a CPU, a P4000 distributed processing unit, an operator's interface, and a printer. The P4000 provides a direct interface between the system and the monitor points via I/O cards and T4000 submultiplexers. The system's software handles communication among the operator, the central system, and the monitor points. The control programs let the Alpha/Net 4000 perform functions such as electric demand limiting, adaptive optimized starting and stopping, duty cycling, point calculating, event controlling, trend logging, and report generating. From $10,000. **AMF Control Systems,** Box 59469, Dallas, TX 75229. Phone (214) 241-9016. TLX 751948.

Circle No 555

PORTABLE μC. The SP Series of 8088-based portable microcomputers offers a minimum of 256k bytes of RAM, expandable to 640k bytes. Floppy-disk storage is 360k bytes per disk, and the SPX model features a 10M-byte fixed disk. Also included are as many as four internal expansion slots, one parallel port, and one RS-232C serial port. The 9-in., green-phosphor, nonglare screen has a 640×400-dot density. The system comes with a built-in monochrome graphics board; an optional color board lets you use an external monitor for color graphics. The SP Series uses the MS-DOS 2.11 operating system, and GW Basic is included. From $2685. **Sperry Corp,** Computer Systems Div, Box 500, Blue Bell, PA 19424. Phone (215) 542-4213.

Circle No 556

COLOR GRAPHICS. The Rascol dedicated color-raster image processor translates your computer's graphics into full-resolution, halftoned color pictures at full printer speed. Color-raster, ink-jet printers supported by the Rascol include the Tektronix 4695, the Diablo C-150, and the Xerox 1770. The Rascol uses a Motorola 68000 CPU to convert graphics generated by the host computer's software into dot-matrix commands at 120 dots/in.; maximum output speed is 5 min/page. Because the Rascol assumes the computer-intensive process of rasterizing im-



PACKAGED PERFORMANCE.

The high-frequency, low-loss EP cores from Ferroxcube were designed for communication devices that require a wide bandwidth, from audio to MHz frequencies. The innovative shape and hardware were developed for high density packing with simplified winding, easy assembly and automatic insertion. The shape of the EP core also minimizes the effect of air gaps in the magnetic path. To shield against EMI, the wound bobbin is completely enclosed within the core.

Available in 3C8 material, that offers low losses under high excitation levels; 3E2A material with superior wideband characteristics, and 3E5 material for high permeability applications. Prototypes for engineering evaluation are now available in five sizes, EP7 through EP20, with hardware and bobbins. For more information, call the Cube.

FERROXCUBE®

Division of Amperex Electronic

Saugerties, NY:	(914) 246-2811
Boston:	(617) 769-6884
Atlanta:	(404) 458-2835
Chicago:	(312) 860-7290
Los Angeles:	(818) 998-7311

A material difference.

CIRCLE NO 153

Looking for the RIGHT SWITCH to exactly match YOUR application?

Here are a few thousand possibilities!

They are contained in our new Catalog EMC-2...64 pages of detailed specs, drawings, logic charts, etc. to give you all the facts you need to design with and specify heavy-duty snap, detent and cam action switches. The possible combinations of switch types, ratings, options, etc. run literally into the tens of thousands.

Includes switches rated from 5A/600V to 200A/600V...with up to 16 positions! It's a "must" for your idea and reference files.

Use inquiry card or call us direct for your copy.

ELECTROSWITCH
Weymouth, Massachusetts 02188
Telephone: 617/335/5200 • TWX: 710/388/0377

CIRCLE NO 171

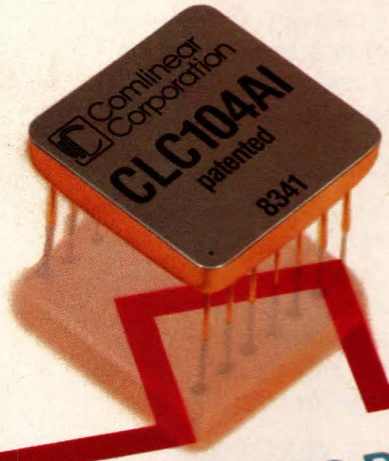
ages, your computer can transmit an image in a few seconds via an RS-232C interface and then be available for other tasks. When it isn't generating images, the Rascol operates as a 200k-character print buffer. Instead of the stick figures typically generated by standard color plotters, the Rascol provides six fonts that resemble typeset characters. $1995. **Lasergraphics Inc,** 17671 Cowan Ave, Irvine, CA 92714. Phone (714) 660-9497.

Circle No 557

MULTIUSER µC. A 68000-based multiuser, multitasking microcomputer, the Sun-Beam, supports four users and includes the Pick operating system, a relational database-management program, spreadsheet software, and word processing. The 22M-byte Winchester disk system includes an 11M-byte fixed disk and an 11M-byte removable disk. Options include 1M bytes of internal memory, a 140M-byte hard disk, a ½-in. tape drive, a color-graphics package, and a 16-user system upgrade. The Sun-Beam comes configured to run laser video-disk and laser printer peripherals. From $4995 (OEM qty). **Climax Computer,** 4790 Irvine Blvd, Suite 105-172, Irvine, CA 92715. Phone (714) 557-2398.

Circle No 558

For unmatched performance and price...



DC-1.1GHz 325PSEC RISE/FALL TIME
14dB GAIN 1.4:1 VSWR

The Comlinear CLC104 linear amplifier. With these specs it may be the closest thing to an ideal amplifier on the market today. And it's priced at only $315.

If you're working in high-speed data communications, fiber optics, broadband video, or radar/EW, then you should be using the Comlinear CLC104 Linear Amplifier. Simply add power supplies to achieve DC-1.1GHz -3dB bandwidth and 14dB gain.

At Comlinear, we've rethought the whole concept of linear amplifier design. And what we have come up with is a quantum leap in performance.

Our bandwidth is just one example. Combine that with 325 psec rise/fall times, 1.2:1 VSWR (DC-750 MHz), and <3% overshoot, and you have an amplifier ideally suited for applications involving high-speed pulsed information. Deviation from linear phase of less than 3 degrees contributes to the overall low distortion displayed by the CLC104. The result is a versatile new building block that can handle the fastest digital traffic with assurance, even when the demodulation scheme or the digital coding format requires that DC be maintained.

Just as important is our price. You might expect to spend countless man-hours and thousands of dollars to develop these features and capabilities. But the CLC104 is now available off the shelf at a single unit price of only $315. It comes in a ¾" square 14-pin DIP, in both military (MIL-STD-883B) and industrial versions.

Plug-in ease of use, low cost, and world-class performance specs. That's the Comlinear CLC104. Call or write us today for more information. Comlinear Corporation, 2468 East 9th Street, Loveland, CO 80537 (303) 669-9433.

Comlinear Corporation

CIRCLE NO 170

FUNCTION × 6

New Keithley 195A Programmable Multimeter gives you temperature capability as a bonus.

Now, you can get the five measurement functions you expect from a Keithley system DMM, plus °F and °C temperature. Just add an RTD probe and you've got a full six-pack of measurement capabilities.

FRONT OR BUS

All six functions are available via the front panel and the IEEE-488 bus. And the new programmable 195A is fully compatible with our full line of IEEE instruments.

DIGITAL CAL

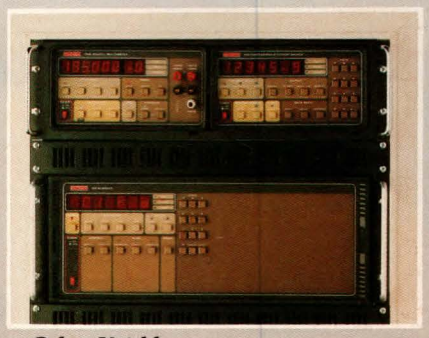
We use no trim pots in the 195A calibration circuitry. Constants for each range and function are stored in a non-volatile memory. On-the-bus calibration is time efficient. Or you can use the simple front panel procedure.

100-POINT BUFFER

The internal memory stores up to 100 readings at 9 selectable rates. You can also recall High, Low, or Average at any time. Rates and recall can be programmed either right from the front panel or over the bus.

UNIQUE ZEROING

The 195A uses Keithley's unique approach to the Zero. A single button lets you create a new baseline for relative measurements, or for compensating offset voltage or lead resistance.



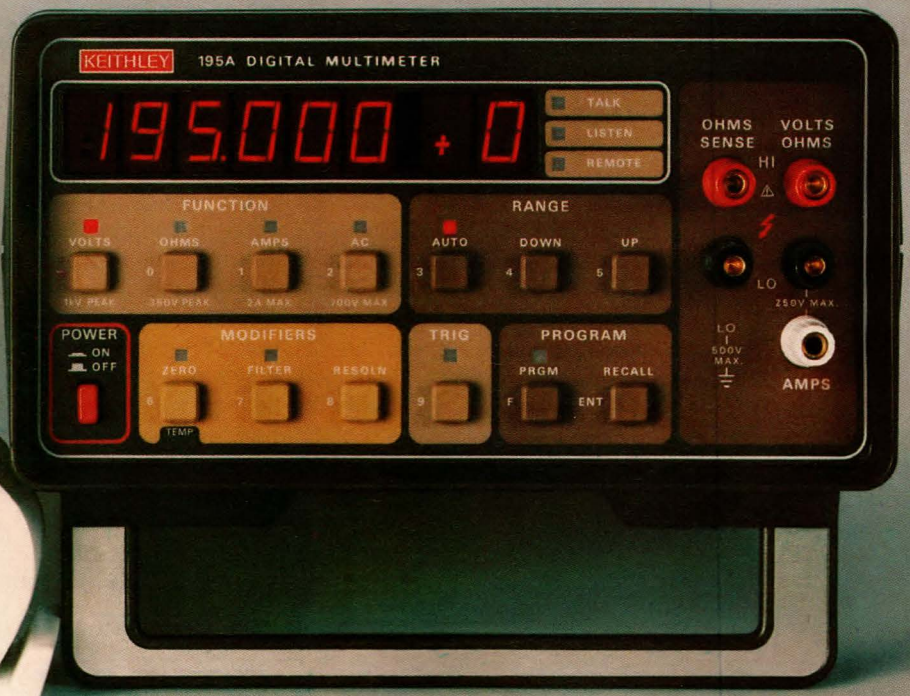
Other Keithley system components include: (bottom) New 100-channel 706 scanner for programmable high-density switching; (top right) 220 Programmable Current Source (or its twin, the 230 for voltage).

A VERY FUNCTIONAL PRICE

The base price of $1K includes DCV, Ω , and temperature. Call or write for a brochure and Programming Guide. And add six full functions to your measurement system. Keithley Instruments, Telemarketing Dept., (216) 248-0400, 28775 Aurora Rd., Cleveland, OH 44139.

KEITHLEY

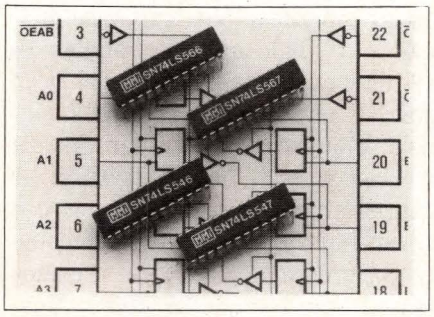
°F
V
Ω



CIRCLE NO 154

VOLTAGE REGULATOR. The LT1038 supplies 10A at voltages from 1.2 to 32V. Packaged in a TO-3 case, the regulator is pin compatible with the company's LM117 and LM138. The IC's current-limiting circuitry allows it to supply 23A for 500 μsec before current limiting occurs. It also has thermal limiting. The chip features 0.01%/V line regulation and 0.04% load regulation. It uses a 1.25V±0.8% internal reference. The -MK suffix version operates from −55 to +150°C, and the -CK suffix version operates from 0 to 125°C. LT1038CK, $9.95 (100). LT1038MK, $39 (100). **Linear Technology Corp,** 1630 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 942-0810. TLX 172110.

Circle No 430



INTERFACES. SN54/74LS546 and SN54/74LS547, both 8-bit registers, and the SN54/74LS566 and SN54/74LS567, both 8-bit latches, provide 32-mA output drives. The devices' input pins incorporate readback capability—the chips can return stored values to those pins while the output pins continue to function normally. Featuring 3-state output lines, these bidirectional devices come in plastic and ceramic DIPs. Ceramic, $7.25. Plastic, $6.18 (100). **Monolithic Memories Inc,** 2175 Mission College Blvd, Santa Clara, CA 95050. Phone (408) 970-9700. TWX 910-338-2374.

Circle No 431

NONVOLATILE RAMs. NVR2, organized in a 2k×8-bit configuration, is compatible with the HM6116 and the TC5517. NVR8, in an 8k×8-bit configuration, is compatible with the HM6264 and TC5565. Each draws 5-μA standby current. To safeguard vital areas of memory, each device has a plated-on write-inhibit bar that is incorporated within the molding at one end. When you connect this optional feature, it prevents unauthorized data changes. NVR2, $27.30. NVR8, $65 (1000). **LMS Electronics,** (Representing Greenwich Instruments Ltd,) 3401 Monroe Rd, Charlotte, NC 28205. Phone (704) 376-7805. TLX 358905.

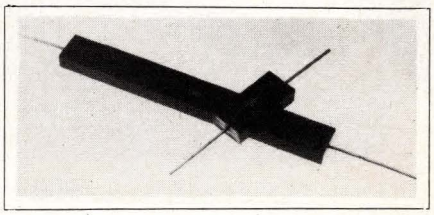
Circle No 432

D/A CONVERSION. The MP5528 or the MP5529, when combined with a 12-bit multiplying D/A converter, provides a complete voltage-output D/A converter with a reference. Each chip contains a 10V reference, a programmable negative-current source, an output amplifier, and a set of matched resistors. The units can provide unipolar or bipolar outputs. The ICs' output amplifiers are an OP-37 op amp with a 15V/μsec slew rate and 60-MHz f_T for the MP5528 and an OP-27 op amp with a 2.5V/μsec slew rate and 8-MHz f_T for the MP5529. Both devices have 100-μV typ initial offset voltages and 0.3-μV/°C typ offset drifts. Their reference-voltage temperature coefficients are 10, 20, and 30 ppm/°C and are available in commercial, industrial, and military temperature ranges. Depending on grade and temperature range, from $5.75 to $40.50. **Micro Power Systems Inc,** 3100 Alfred St, Santa Clara, CA 95050. Phone (408) 727-5350.

Circle No 433

64k EEROM. M52B33, in an 8k×8-bit configuration, is specified for operation over the military temperature range. It requires a single 5V±10% supply for all operational modes, including byte erase, write, read, and chip erase. All modes use TTL inputs. The chip comes in a 28-pin DIP or a 32-pin LCC. Both packages' pinouts conform to JEDEC-approved pin configurations for byte-wide memories. Key specs include 1- or 10-msec byte-write times, 10,000-byte write/erase-cycle endurance, and 300-nsec byte-read time. M52B33H-300, in a 28-pin DIP and with 1-msec byte-write time, $359.45. M5233-300, in a 28-pin DIP and with 10-msec byte-write time, $312.55 (100). **Seeq Technology Inc,** 1849 Fortune Dr, San Jose, CA 95131. Phone (408) 262-5041.

Circle No 434



RECTIFIER STACKS. SSCHE Series rectifier stacks have PIV ratings from 4 to 20 kV, a 0.25A average current rating, and a 70-nsec reverse recovery time. The Series consists of assemblies of glass hermetically sealed diodes enclosed in an epoxy mold. 4-kV version, $112 (100). Delivery, 8 wks ARO. **RSM Electron Power Inc,** Sensitron Semiconductor Div, 221 W Industry Ct, Deer Park, NY 11729. Phone (516) 586-7600.

Circle No 435

FILTER IC. R5635, a CCITT V.22 BIS full-duplex modem-filter IC, contains two switched-capacitor bandpass filter channels centered at 1200 and 2400 Hz, respectively. TTL or CMOS input to the chip switches the filters between transmit and receive modes using the chip's internal MUXes. Using a TTL or CMOS input, you can select between the chip's 550- and 1800-Hz guard-tone notch filters. There's a TTL or CMOS-compatible input pin

Welch Allyn Fiber Optics
bring your bright ideas to light.

If you're looking for a way to turn a brilliant idea into a functional, economical fiber optic component, look to Welch Allyn.

Need bulk fiber? We draw it from a variety of optical quality glasses. Or we can supply you with jacketed bundles, sensors, readers, even thick or thin lines of light — in high or low volumes. We can also take fiber and bond it, encapsulate it, polish it and integrate it with a wide range of electronic components.

Don't wait or wonder over your project. Define your requirement. Present us a challenge. Pose us a question. If the answer involves short distance fiber optics, we can design, develop and deliver it. Contact us today for new, full color literature on our total fiber optic capabilities. Welch Allyn, Inc., Jordan Rd., Skaneateles Falls, NY 13153-0187, Tel. (315) 685-8351, TWX (710) 545-0203.

CIRCLE NO 155

YOU LIKE TO WRITE, RIGHT?

Then EDN wants you, providing you also have an EE degree and at least two years' circuit-design experience. We seek individuals who want to be Boston-based technical editors for this top electronics publication.

To qualified individuals, EDN offers an attractive salary, industry-wide recognition, high job satisfaction, and the ability to keep abreast of . . .

- Advanced Technology
- Exciting New Products
- State-of-the-art circuit and system-design techniques.

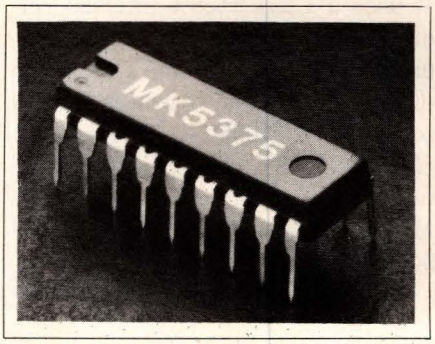
If you thrive on meeting challenges head-on . . .

If you are an effective, technical communicator . . . then send your resume and salary requirements in strict confidence to: Roy Forsberg, Editorial Director, EDN, 221 Columbus Avenue, Boston, MA 02116.

An Equal Opportunity Employer

to activate the device's self-test mode. The chip also has lowpass clock filters in the transmit and receive paths. The IC requires ±5 to ±10 supplies and a TTL or CMOS 153.6-kHz clock input for operation. <$15. **EG&G Reticon,** 345 Potrero Ave, Sunnyvale, CA 94086. Phone (408) 738-4266. TWX 910-339-9343.

Circle No 436



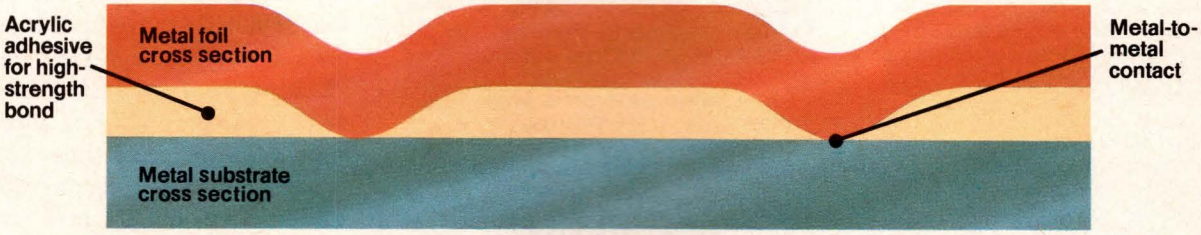
DIALER. The MK5375 repertory dialer combines tone and pulse dialing in a single unit. It handles 10 16-digit numbers and can dial both star (*) and pound (#) DTMF signals. For security, you can disable its last-number redial feature. A chip-disable function lets you use several of these chips simultaneously to increase memory size. It comes in an 18-pin DIP. $6.35 (1000). **Mostek Corp,** 1215 W Crosby Rd, Carrollton, TX 75006. Phone (214) 466-6000.

Circle No 437

128k ROM. NCR 23128S, a static ROM, which features a 16k× 8-bit organization, operates from a 5V supply, is TTL compatible, and has a 250-nsec access time. In its power-down mode, it reduces consumption from 75 mA (active) to 10 mA (standby). The chip comes in a 28-pin DIP with JEDEC-standard pinouts for byte-wide devices. $4.85 (10,000). Delivery, 6 wks ARO. **NCR,** Microelectronics Div, 8181 Byers Rd, Miamisburg, OH 45342. Phone (800) 543-5618; in OH, (513) 866-7217.

Circle No 438

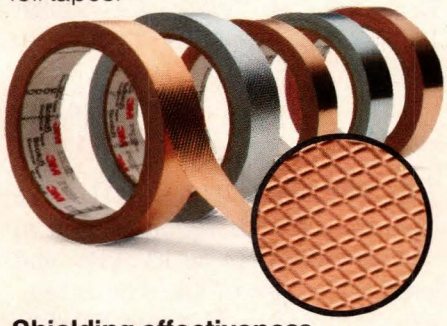
How bumps in our foil tape



can shield you against bumps from the FCC

When you got hit with the stricter EMI regulations of FCC Docket 20780, there was probably a bump in your manufacturing costs from design changes and increased materials and assembly steps.

For effective relief from the ongoing pressure of meeting those regulations, look to our foil tapes.



Shielding effectiveness

The embossed contact pattern of our 1245 foil tape—a first in the industry—reduces adhesive gap and provides reliable metal-to-metal contact for ready FCC compliance. Static charge is also safely drained away.

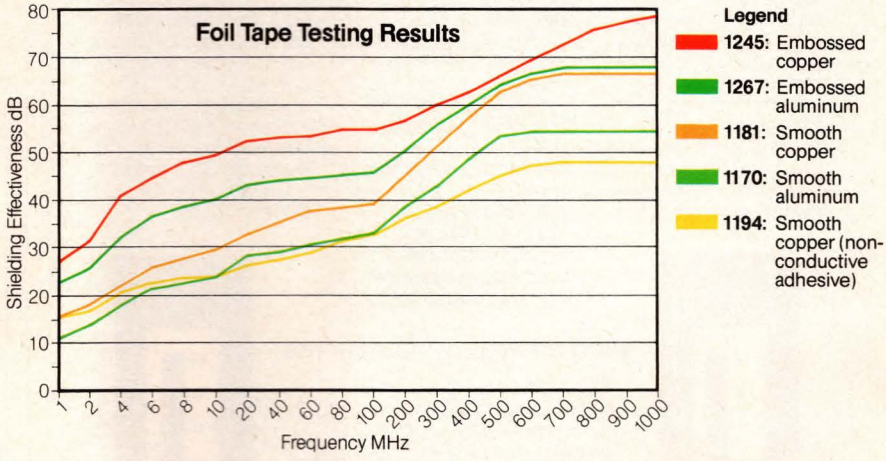
We also offer smooth foil tapes for aesthetic considerations, and a choice of conductive or non-conductive adhesives. All of our tapes are durable and adhere securely.

Cost effectiveness

The convenience of tape will ease your cost burden. Just tape on what you need. No need for expensive redesign and no waste, clean-up, special skills or expensive equipment. Plating, painting and soldering can be eliminated.

You can also avoid costly product recalls. Just apply the tape on-site.

To shield your electronic products from EMI and RFI, and to shield yourself from the FCC, contact Electro-Products Division/ 3M, 225-4N, St. Paul, MN 55144.



3M Hears You...

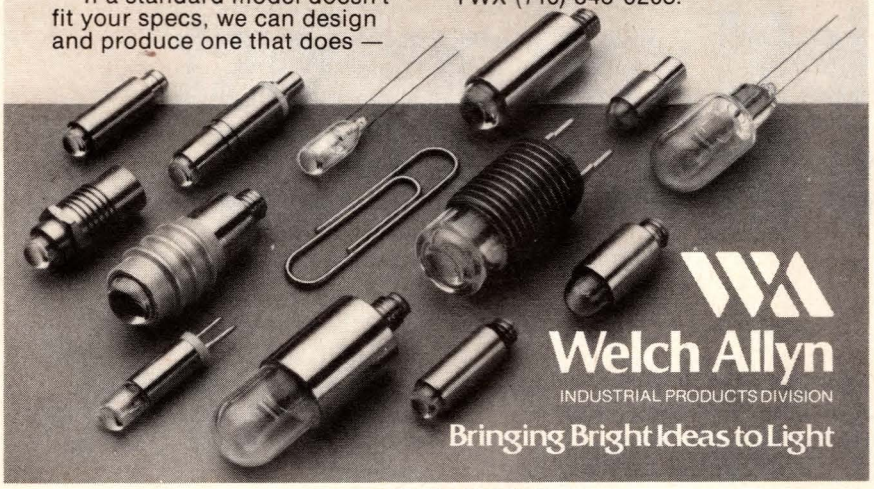
3M

CIRCLE NO 163

Welch Allyn Miniature Lamps
Your reliable light source.

If you need a lamp that's small in size but high in output, Welch Allyn halogen and vacuum lamps shine above the rest. Our standard vacuum lamps and our longer life, higher output halogen cycle lamps range from 2.5 to 15V, .275 to 2.3A, 2100 to 3250°K and .5 to 35W. Wire terminal lamps as well as smooth, threaded and specialty bases are available along with various envelope configurations, including lensed ends.

If a standard model doesn't fit your specs, we can design and produce one that does — economically in large or small volumes. Since 1965, we've manufactured quality lamps — in our own dedicated facility — for data processing, medical, transportation, instrumentation and many other applications. Depend upon us to meet your needs today and tomorrow. Contact us for more data on all our standard and custom lamp capabilities. Welch Allyn, Inc., Jordan Rd., Skaneateles Falls, NY 13153-0187, Tel. (315) 685-8351, TWX (710) 545-0203.



CIRCLE NO 156

Bright, colorful, easy-reading.

New Verigraph™ panel meters and meter relays, the first using high-definition vacuum fluorescent displays (VFDs), are now ready for your electronic product or control panel.

In both vertical and horizontal formats, solid-state Verigraph meters provide a 2" bargraph display made up of 50 extra-wide segments. Standard bargraph is blue-green; yellow, green, and blue displays are optional.

Costing 40% less than many comparable d'Arsonval units, Verigraph meter relays provide two alarm setpoints and a 1-amp output. Setpoints flash on alarm condition — entire bargraph flashes on over/under range.

Microprocessor-controlled; ±2% FS accuracy; 5 Vdc supply at 300 mA (max); edge-card-connector (or barrier-terminal) installation; 0° C to 50° C operating temperature; meets ASA C39.1 vibration requirements; fits standard 3½" cutout.

Call or write for Bulletin 8016.

International Instruments
DIVISION OF GENERAL RESISTANCE, INC.
Twin Lakes Road, P.O. Box 185
North Branford, CT 06471
(203) 481-3450 • TWX 710-452-3092

8025

CIRCLE NO 164

ICs & SEMICONDUCTORS

256k DRAM DESIGNER KITS. The HM-DK1 designer kit contains four HM50256 dynamic RAMs and a data sheet. The HM-DK2 designer kit contains four HM50256-16 dynamic RAMs and a data sheet. The chips achieve access times from 120 to 200 nsec and consume 350 mW while active and 23 mW while on standby. HM-DK1, $124.99. HM-DK2, $109.95. **Hitachi Ltd,** 2210 O'Toole Ave, San Jose, CA 95131. Phone (408) 942-1500.

Circle No 439

DISPLAY CONTROLLER. The μPD7220A generates video signals at rates to 128 MHz and performs read-write-modify display-memory operations in 500 nsec. It can address as many as 4M bytes of video-display memory, program vertical and horizontal timing, and generate vectors for drawing arcs, circles, rectangles, and characters. It also includes such features as DMA control, zooming, panning, scrolling, and split screening. The 7220A comes in 6-, 7-, and 8-MHz versions. $130 (100). **NEC Electronics Inc,** Box 7241, Mt View, CA 94039. Phone (415) 960-6000. TWX 910-379-6985.

Circle No 440

RECTIFIERS. These MIL-type custom rectifier assemblies come in voltage ratings to 50 kV PRV and current ratings to 3A. The assemblies incorporate JAN and JANTX, MIL-S-19500-grade rectifiers. From $25. **Electronic Devices Inc,** 21 Gray Oaks Ave, Yonkers, NY 10710. Phone (212) 965-4400.

Circle No 441

DIALER. The MA527 repertory dialer stores and dials 10 18-digit numbers and has a 21-digit redial memory. Using the chip as a pulse dialer, you can connect it for 2:1 or 3:2 make/break ratios and 400- or 800-msec interdigit pauses. In the

Presenting the power supply line that money couldn't buy.

In 1979 Boeing couldn't find a reliable electronic power supply for a demanding Space application. So we built our own. And kept right on building.

Today, Boeing units are proven performers on the B-1B, Inertial Upper Stage, AWACS, Air Launched Cruise Missile, and the 757 & 767.

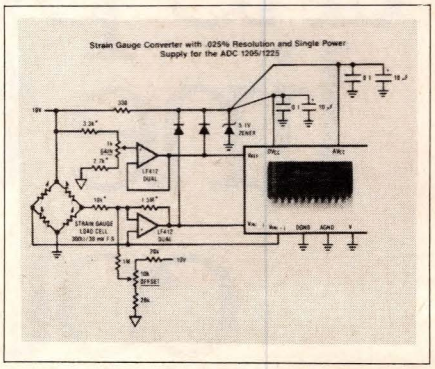
And now for the first time Boeing will build your next power supply. With radiation hardening, high density packaging, built-in test and modular designs.

Whatever your power supply problem, Boeing comes through with innovation, performance and reliability.

For more information, contact Al Mateu, Boeing Electronic Systems, P.O. Box 24666, MS-87-11, Seattle, WA 98124. Telephone (206) 773-0818. **BOEING**

DTMF mode, you can use an on-board unity-gain amplifier to facilitate tone filtering. Both operating modes can provide a flash to the telephone line—you have a choice of 100- and 600-msec flashes. You also have a choice of last-number redial: Either the dialer saves the last dialed number when the phone is placed on the hook or you manually save a number by activating the chip's Save input. The chip has an optional output port to drive an LCD. It's active during dialing, and you can use it to check the contents of the redial and repertory memories. The IC's debounce circuitry considers keyboard inputs valid only if they have been present more than 14 msec. Standard 18-pin version, $5.10; 20-pin version with filter amplifier, $5.25; 24-pin version with filter amplifier and LCD output, $5.85. **Circuit Technology Inc,** 160 Smith St, Farmingdale, NY 11735. Phone (516) 293-8686.

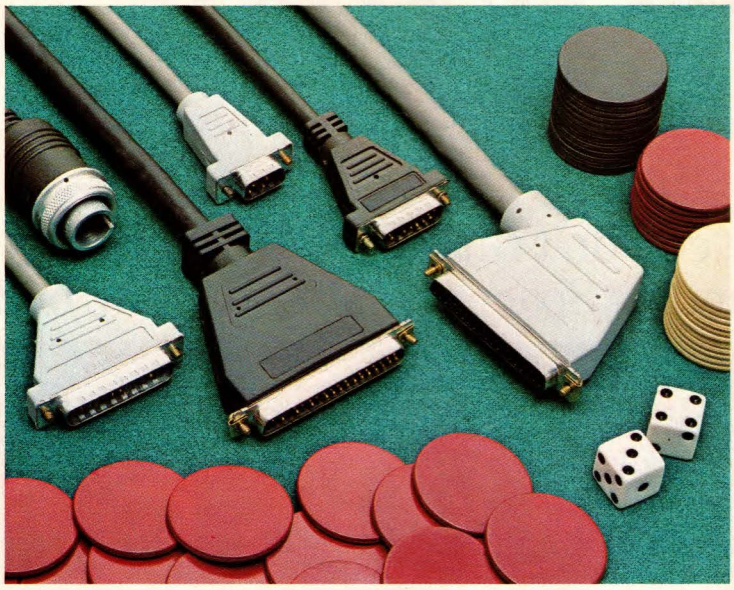
Circle No 442



A/D CONVERTERS. The ADC1205 and the ADC1225 CMOS 12-bit-plus-sign successive-approximation A/D converters interface directly to 8- or 16-bit data buses and operate from a 5V supply. The 24-pin ADC1205 produces a 13-bit result in two 8-bit bytes, formatted high-byte first with sign extended. The 28-pin ADC1225 produces a 13-bit word in parallel for direct interface to a 16-bit data bus. Negative numbers are represented in two's complement, and all digital signals are TTL and CMOS compatible. The two converters feature a 100-μsec conversion time using a 1-MHz clock. The devices have differential analog inputs, consume 25 mW, can accommodate a unipolar input while operating from a unipolar supply, and can handle a ±5V input range when operated from ±5V supplies. The -B versions of the converters exhibit a 0.012% FS nonlinearity; the -C versions, 0.024%. The ADC1205 comes in a 24-pin DIP; the ADC1225, in a 28-pin DIP. ±1-LSB nonlinearity ADC1205CCJ-1 and ADC1225CCJ-1, $19.95 (100). **National Semiconductor Inc,** 2900 Semiconductor Dr, Santa Clara, CA 95051. Phone (408) 721-5226. TWX 910-339-9240.

Circle No 443

DON'T GAMBLE WITH FCC DOCKET 20780 GOVERNING CONDUCTED AND RADIATED EMI



USE TOTALLY SHIELDED AND MOLDED CABLE ASSEMBLIES FROM HARBOR ELECTRONICS

Harbor has responded to the new shielding requirements with a low profile totally shielded cable assembly configuration that is available for 9, 15, 25 and 37 position "D" subminiature connectors. Custom molds are available for circular, edge and coaxial connectors also.

Harbor has complete molding and assembly facilities as well as engineering and customer service that is always at your disposal.

STANDARD SHIELDED ASSEMBLY FEATURES:

- Low profile (only .620″ high)
- Total cable stress-relief
- Permanent contact seating
- Total connector shielding
- EMI tested (30 MHz to 1 GHz) for FCC 20780
- Conductive tinned connectors for positive grounding
- Customer logo molded in (if desired)
- Selective pinning according to customer specifications
- Low cost, high performance

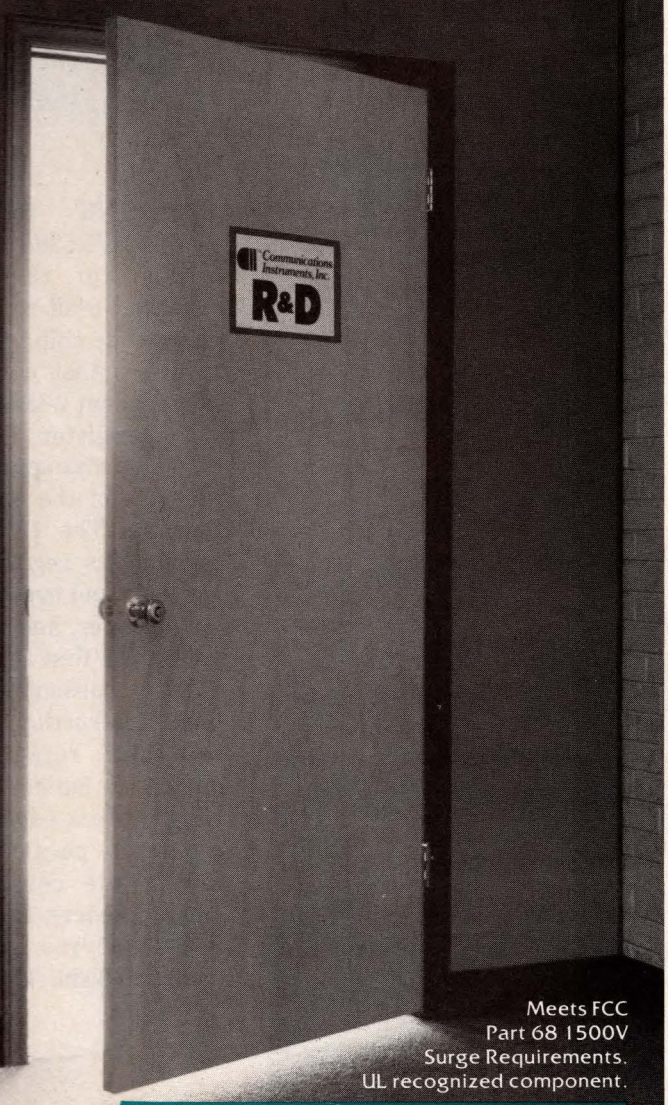
Harbor Electronics

650 Danbury Road, Ridgefield, CT 06877

Toll Free 800-243-4794, in Ct. (203) 438-9625 • TWX: 710-467-0699

CIRCLE NO 166

WHAT WERE WE DOING AT CII WHILE EVERYBODY ELSE RUSHED P C BOARD RELAYS INTO PRODUCTION?

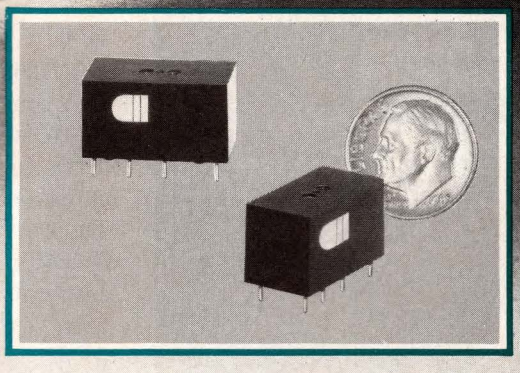


WE WERE DESIGNING OURS RIGHT.

The result? A superior DIP relay from CII. Here's why:

- **Ours is a true low-level switching relay. (CII's contact performance range is from microwatt power levels up to 2.0 AMP.)**
- **Stable contact resistance throughout life of the relays.**
- **Highest shock and vibration specifications in the industry.**

Meets FCC Part 68 1500V Surge Requirements. UL recognized component.



CII P C Board relays are 100% inspected at the factory—just like our quality Mil-spec crystal can and telephone type relays. Our standard MDL type P C Board relays have bifurcated cross-bar contacts of gold-clad silver palladium, and each is nitrogen filled and sealed for automatic circuit board processing.

CALL CII NOW for quick delivery on P C Board relays in standard models at voltage ratings from 5 to 48 VDC. We can meet your requirements from a handful to thousands immediately. No delays. We have them in stock.

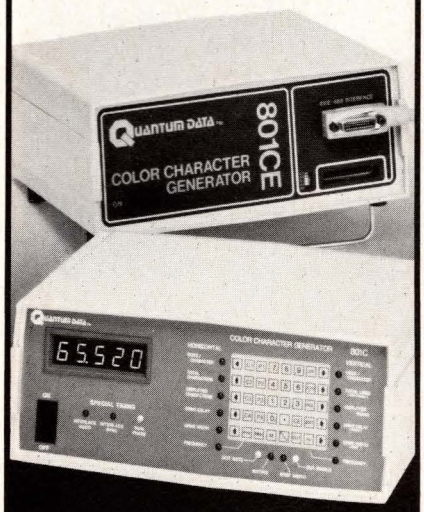
PHONE (704) 628-1711

CII™ Communications Instruments, Inc.

P.O. Box 520 • Fairview, North Carolina • 28730

CIRCLE NO 167

Simplify CRT Testing.



Color character generators...

Designed for bench use— Model 801C

- Easily programmed through the front panel keyboard
- Quick recall of up to 18 formats or make up your own
- Select from five monochrome patterns and 16 color patterns
- A 64 character library to choose from or make your own characters

Designed for automated test systems— Model 801CE

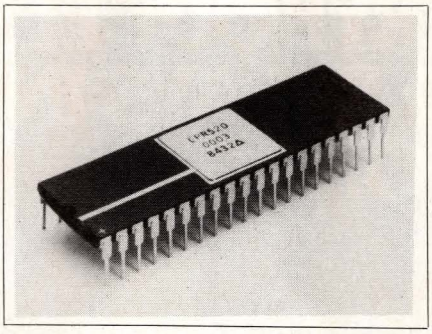
- Easily programmed via the IEEE-488 GPIB
- Same functions as the 801C
- 34 additional color patterns
- Custom patterns can be downloaded from the GPIB

Call or telex us for information:

QUANTUM DATA
455 Kehoe, Carol Stream, IL 60188
(312) 668-3301 TELEX 206 725

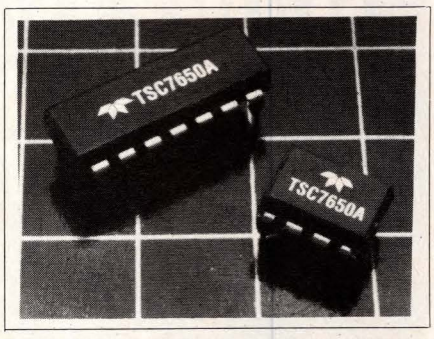
9876543210

CIRCLE NO 148



PIPELINE REGISTER. The CMOS LPR520/LPR521 is a 16-bit version of the AM29520 and AM29521 8-bit registers. The TTL-compatible chip features four 16-bit registers that can operate as two independent 2-level registers or one 4-level register. The IC operates at a 25-nsec max access speed. The two versions of the circuit operate differently: The LPR520 shifts data through its registers as new data comes in and overwrites data in the last register, and the LPR521 overwrites the first register and retains data in subsequent registers. An input instruction code determines the chips' register configuration, and data is latched into a register on a rising clock edge. 40-pin commercial-grade plastic DIP, $20. Military-grade ceramic, $64 (100). **Logic Devices Inc,** 628 E Evelyn Ave, Sunnyvale, CA 94086. Phone (408) 720-8630. TLX 172387.

Circle No 444



CMOS OP AMP. The TSC7650A, pin-compatible with the ICL7650, features 2.5-mA max power-supply current consumption, a 4V/μsec typ slew rate, and 0.2 μV/°C voltage drift. The chopper-stabilized op amp's key specs include 15-pA max input-bias current, a 120-dB open-loop voltage gain, a 1-MHz f_T, and a −5 to +1.5V common-mode voltage range when operating from ±5V supplies. The amplifier's output-voltage clamp reduces circuit gain when necessary to prevent output-stage saturation; this prevents overload-recovery delay. The device comes in 8- and 14-pin plastic or ceramic DIPs for 0 to 70°C and −25 to +85°C operation. From $2.75 (100). Delivery, 6 to 8 wks ARO. **Teledyne Semiconductor Inc,** 1300 Terra Bella Ave, Mt View, CA 94043. Phone (415) 968-2941. TWX 910-379-6494.

Circle No 446

D/A CONVERTERS. The DAC1265A and the DAC1265 12-bit D/A converters have a 35-nsec max 10 to 90% FS transition time and settle to <½ LSB in 200 nsec. The chips have a bipolar current output. Their gain temperature coefficient is ±15 ppm/°C. The converters incorporate thin-film resistors for use with external devices. DAC1265 ACJ, $19.95; DAC1265LCJ, $12.95 (100). **National Semiconductor Corp,** 2900 Semiconductor Dr, Santa Clara, CA 95051. Phone (408) 721-5000. TWX 910-339-9240.

Circle No 445

THE CHOSEN FEW

You can be among the chosen few to have their technical articles appear in EDN. We're constantly looking for good articles that cover state-of-the-art technology and applications.

If you've got an innovative application for a hot new device, why not immortalize it in print? It's easier than you think. Just send an outline of the proposed article to Bill Travis, Senior Editor, EDN, 221 Columbus Ave, Boston, MA 02116. Or, you can call him and discuss the application at (617) 536-7780.

Don't miss this opportunity to become one of the chosen few.

EDN: Everything Designers Need

Now, new micropower op amps offering the best power consumption/speed ratio and the lowest noise!

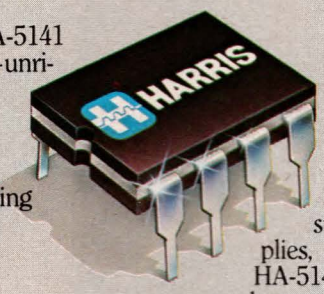
Presenting the Harris HA-5141 family—the HA-5141 (single), HA-5142 (dual) and HA-5144 (quad)—unrivaled for low power, low noise and speed.

Micropower op amps that provide the AC and DC performance of general-purpose op amps yet draw only 1/20 the power.

They're all available now with these outstanding performance characteristics:

- 50 μA supply current (per op amp)
- Low noise (20 nV/$\sqrt{\text{Hz}}$)
- 400 kHz gain-bandwidth product
- 0.5 mV input offset voltage
- Low (50 nA) input bias current
- High (100 kV/V) open loop gain

Combine these with a 1.5 V/μs slew rate and single or dual supply operation capability, and you have an op amp family that demands very little and produces a lot—in your low-power instrumentation, audio amplifier and active filter design applications.



The high-speed/low-power characterisitics of the HA-5141 family are ideal for portable system applications such as dictation equipment, medical monitoring systems and remote electronic sensors. And they are your best choice for all battery-powered equipment.

They operate over a wide range of power supplies ($\pm$15 V down to $\pm$1.5 V with dual supplies, +30 V down to +3 V with single supply).

HA-5141 and HA-5142 are available in can or minidip packages; HA-5144 comes in a 14-pin dual-in-line package. All with industry-standard pinouts that are pin-compatible with most other op amps.

For more details, write: Harris Semiconductor Analog Products Division, P.O. Box 883, MS 53-035, Melbourne, Florida 32902-0883.

Harris Semiconductor: Analog - Bipolar Digital
CMOS Digital - Gallium Arsenide - Semicustom - Custom

HARRIS

For your information, our name is Harris.

CIRCLE NO 168

for DTMF receivers ring aptek

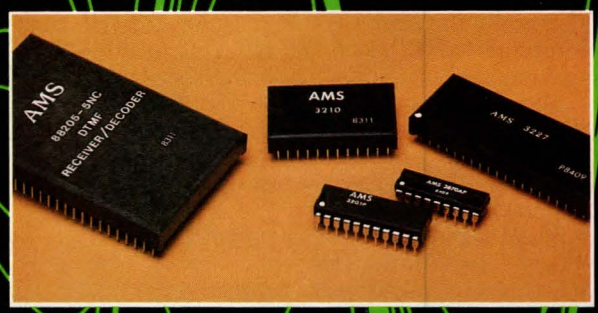
60% less power...and we deliver off-the-shelf

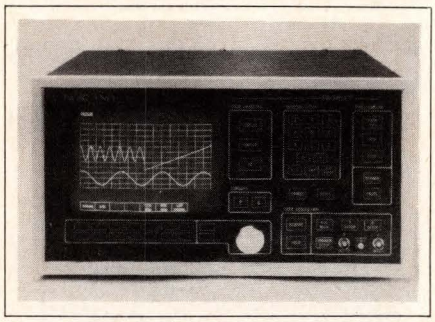
A call to Aptek will answer your need for DTMFs in quantity. Better yet, our proven tone receivers consume 60% less power than competitive types, with no compromise in quality. We offer both plastic and CERDIP packaging, very competitively priced. In addition, we make other DTMFs and a full line of MF generators and receivers. For pertinent information, just give us a ring.

CIRCLE NO 169

aptek microsystems

700 N.W. 12th Avenue, Deerfield Beach, FL 33441
(305) 421-8450 TLX: 441020 Ans Bk Aptek MS DRBE.





50-MHz DIGITIZER. Model N4009 is an 8-bit, 50-MHz digitizer module for the Prowler digital oscilloscope. The N4009 specs sample rates to 50 MHz with 4k (or optional 16k) data points per channel. The Prowler can have one or two channels. Model N4009 digital module, $2500. Delivery, 60 to 90 days ARO. **Norland Corp,** Norland Drive, Fort Atkinson, WI 53538. Phone (414) 563-8456.

Circle No 447

8-PEN PLOTTER. The DXY-880 8-pen intelligent X-Y plotter features Hewlett-Packard Graphics Language emulation. The plotter van sits flat or at a 60° angle, and it plots on 8½×11-in. or 11×17-in. paper or acetate. Features include a RS-232C and a parallel Centronics interface, multispeed digitizer, 3k-byte buffer, 24k-byte ROM, 0.05-mm resolution, 200-mm/sec speed, and a selection of international character fonts. $1295. **Roland DG,** 7200 Dominion Circle, Los Angeles, CA 90040. Phone (213) 685-5141.

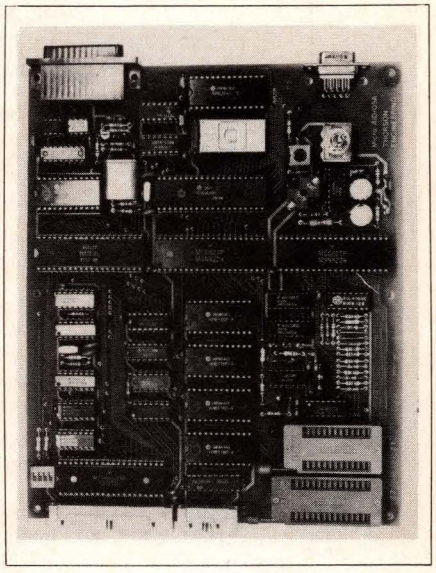
Circle No 448

100-MHz TRANSIENT RECORDER. Model SA1600 waveform analyzer uses a bit-slice processor to interleave waveforms digitized with an 8-bit, 100-MHz transient recorder. The result is an equivalent sampling rate of 1.6 GHz that enables signal capture with a time resolution of 625 psec; the system averages 500 waveforms/sec. The averaged waveform can contain as many as 8k data points, and the 24-bit averaging memory can handle more than 64,000 waveforms. The instrument measures repetitive signals in the nanosecond time region and can be used as a standard 100M-sample/sec transient waveform analyzer. On-screen manipulations include curve normalization and subtraction, overlay of waveforms, peak search routines, horizontal axis calibration, and display of selected regions for detailed observation. Data archives are kept is on floppy disk, and an RS-232C serial port is standard. The system is a CP/M-based computer permitting further data manipulation. FORTRAN or BASIC is provided. $27,900. Delivery, 10 wks ARO. **LeCroy Research Systems Corp,** 700 S Main St, Spring Valley, NY 10977. Phone (914) 425-2000. TWX 719-577-2832.

Circle No 449

HEAVY-DUTY DMM. The 20 Series handheld DMMs are guaranteed to retain their calibration and operate for one year despite drops, shock, vibration, or water and chemical spills. A fused 10A range and a separate battery/fuse door make the meters easy to keep sealed. Operating-temperature range is −15 to +55°C; the DMMs will operate to −49°C for 20 min. Typical continuous operating temperature range is −20 to +60°C. A rotary switch on the front panel selects voltage, current, resistance, or diode test. Autoranging automatically selects the correct measurement range. A continuity beeper assists in wiring, diode, and transistor checks. The 3200-count display offers up to 10 times greater resolution than do conventional 3½-digit, 2000-count multimeters. $229 (Fluke 25); $259 (Fluke 27, with min/max and relative modes). **John Fluke Mfg Co Inc,** Box C9090, Everett, WA 98206. Phone (206) 342-6300. TWX 910-445-2943.

Circle No 450



6805 EMULATOR. The Micro-AID 05A is an accessory for the IBM PC that supports the 6805 μP family. It includes a 6805 cross assembler, in-circuit emulator, symbolic debugger, and EPROM/EEPROM programmer. The cross assembler, running on the IBM PC, processes 6805 source code into object and symbol-table files used by the emulator. The emulator features hardware and software breakpoints, instruction and register tracing, disassembler, and real-time execution timer. Emulator hardware includes 8k bytes of overlay RAM and eight real-time break points. The system emulates the MC146805E2 μP, and an interface pod is available for 14 types of single-chip 6805 μPs. The EPROM programmer handles 16 varieties of EPROMs or EEPROMs, both NMOS and CMOS, from 8k to 256k. The Micro-AID/05A command set is a Forth extension. The Micro-AID/05A, $1200; interface pod, $250 (unit quantity). **Thorson Engineering Co,** 6225

The Complete Conference and Exposition for Electronics Engineers in the Southeast

Design! Packaging! Production! Testing! PCB Fabrication!

National Electronic Packaging and Production Conference

nepcon southeast Conference/Exhibition

Packaging
Production
Testing

April 23-25, 1985
Orange County Convention Center
Orlando, Florida

The region's largest array of equipment

Production equipment, tools, hardware, instruments, materials, supplies.

Over 200 displays and demonstrations geared to your needs.

Supplier personnel will provide valuable technical advice.

User-Oriented Conference

11 technical sessions, professional advancement courses and workshops examine today's most pressing production problems . . . provide efficient, effective solutions.

Hundreds of ideas for increasing your company's productivity.

"InSurf" Comes to the Southeast!

Demonstrates insertion and surface-mounting on the same PC board. A NEPCON EXCLUSIVE!

Highlights up-to-date equipment, PCB processing methods, test procedures.

Operates daily during exhibit hours.

Free Admission to Concurrent Testing Exposition

Visit ElectroTest '85, the Southeast's only exposition devoted to testing in electronics manufacturing. Related equipment and technologies in action.

ORGANIZED BY

CEG **Cahners Exposition Group,** Cahners Plaza, 1350 E. Touhy Ave., P.O. Box 5060, Des Plaines, IL 60018 (312) 299-9311

TO: **Cahners Exposition Group,** Cahners Plaza, 1350 E. Touhy Ave., P.O. Box 5060, Des Plaines, IL 60018

☐ I am interested in attending Nepcon Southeast '85 and the concurrent ElectroTest exposition. Please send details.

Name_____

Title/Function_____

Company_____

Address_____

City_____ State____ Zip____

Phone(____)_____ Telex_____

PHOTOCOPY COUPON FOR YOUR ASSOCIATES

INSTRUMENTATION & POWER SOURCES

76th St SE, Snohomish, WA 98290. Phone (206) 334-4214.

Circle No 451

FUNCTION GENERATOR. Model 627 13-MHz programmable function generator offers sine, square, triangle, and haver waveforms, inverted waveforms, variable-symmetry waveforms, and dc. You can select frequencies from 100 μHz to 13 MHz using nine overlapping ranges. You can vary the frequency within each range over a ratio of 1300:1 remotely, from the front panel, using an external voltage, or over the IEEE-488 bus. Frequency, amplitude, offset, symmetry, and calibration sequence number get displayed on a 3½-digit LED display. Amplitude range is 10 mV p-p to 10V p-p into 50Ω, offset range is 0V to ±5V peak into 50Ω, and symmetry range is 5%:95% to 95%:5% with 1% resolution. Model 627 gets calibrated from the front panel or under IEEE-488 bus control. Additional autocalibration sequences include frequency calibration to accuracies of 0.1% of setting. The unit measures 3.45×8.7×14 in. and weighs 7 lbs. $1995. Delivery, 6 to 8 wks ARO. **Exact Electronics,** Box 1925, Carson City, NV 89702. Phone (800) 648-7952.

Circle No 452

1-GHz CLOCK DRIVER. A series of high-power clock drivers that provide clock rates from dc to 1 GHz generate precise pulses even when over-driven. A nominal 4-dBm sinusoidal input is sufficient to overdrive the clock drivers; they also accommodate nonsinusoidal inputs,

Announcing:

A very important engineering event for designers of electronics

the premier presentation of:

Automated Design and Engineering for Electronics

February 26-28, 1985
Anaheim Hilton and Towers
Anaheim, California

CAD/CAE tools for electronics design can radically affect the way you do your job.
This technical conference and exhibition will offer the insight of leading authorities and provide an opportunity to explore the newest equipment.

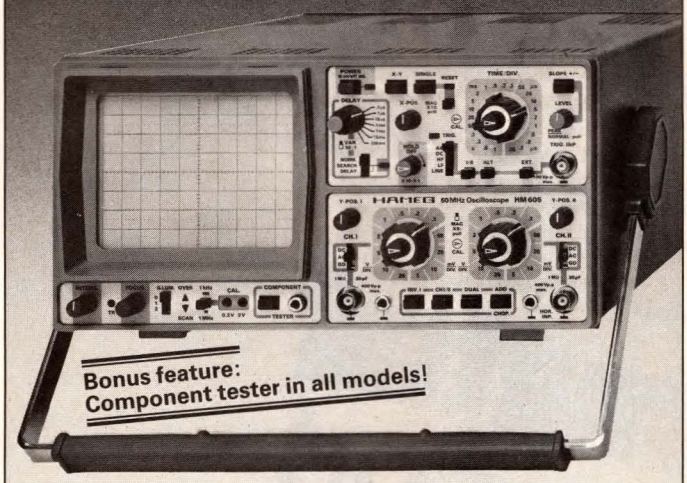
Sponsored by:
EDN
ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Endorsed by these leading publications:
Electronic Packaging and Production
Electronic Business
Design News
Semiconductor International

Call or write:
CEG
Cahners Exposition Group
Cahners Plaza, 1350 E. Touhy Avenue
P.O. Box 5060; Des Plaines, IL 60018
(312) 299-9311 TLX: 256148 CEGCGO DSP

HAMEG®
Oscilloscopes

For Field Service and Laboratory



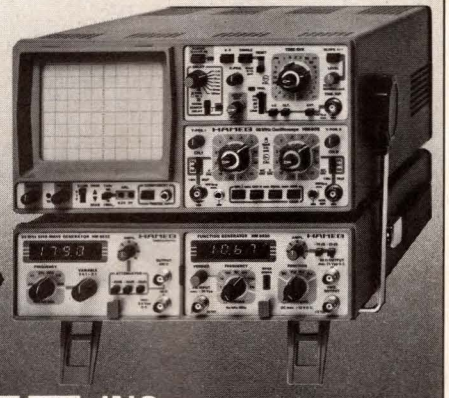
HM605 60 MHz Dual Trace · US$ 965,-
Sensitivity 5 mV-20 V/div at 60 MHz, **1 mV** at 5 MHz • Automatic peak-value or normal triggering to 80 MHz • Delay line • Variable sweep delay from 100 ns-1 s • Timebase range from 2.5 s/div to max. 5 ns/div • Unique fast-rise-time 1 kHz/1 MHz calibrator • Bright high-resolution 14 kV CRT.

HM204 20 MHz Dual Trace · US$ 758,-
Sensitivity 5 mV-20 V/div • **1 mV** at 5 MHz • Timebase range 1.25 s/div-10 ns/div • Automatic peak-value triggering to 50 MHz **Delay line** • Variable sweep delay • Single sweep mode • Y-Output • Z-modulation • Overscan indicator • Unique 1 kHz/1 MHz calibrator.

HM203 20 MHz Dual Trace · US$ 605,-
Western Europe's best selling 20 MHz-Scope! • Sensitivity 2 mV-20 V/div • Triggerbandwidth 40 MHz • Timebase range 0.2 s – max. 20 ns/div

HM103 10 MHz Single Trace · US$ 410,-
Small, compact service scope • Sensitivity 2 mV-20 V/div • Timebase range 0.2 µs-0.2 s/div • TV-V and TV-H triggering.

Modular System HM 8000
An expanding range of signal generators, multimeters, counter/timers, etc. ...



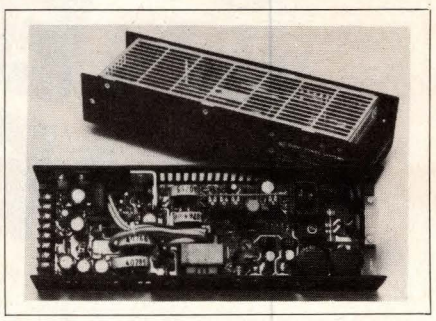
For more details write or call collect:

HAMEG, INC.
88-90 Harbor Road · Port Washington N.Y. 11050
Phone (516) 883.3837 · TWX (510) 223.0889

CIRCLE NO 172

both single-ended and differential. At lower clock rates the rise/fall times increase because of the limited gain of the clock drivers. For the 4-dBm sinusoidal input, the rise/fall times increase at frequencies less than 10 MHz for the model CD5A clock driver and at frequencies less than 200 MHz for the CD5B and CD5C. When the clock drivers get driven with pulses having rise/fall times of <5 nsec, the fastest output rise/fall times are obtained. The CD5A operates at clock rates to 350 MHz; the CD5B, to 1 GHz. Both operate down to dc. The CD5C, an ac-coupled version of the CD5B, allows a programmable dc-output offset level between −5V and +5V. Power supply requirements for all models (within 2%) are 15V (400 mA) and −15V (350 mA). CD5A, $1450; CD5B, $2400; CD5C, $2600. **Colby Instruments Inc,** Box 84379, Los Angeles, CA 90073. Phone (213) 450-0261.

Circle No 453



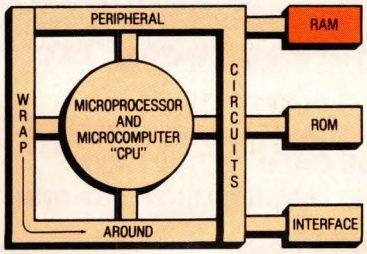
210W SWITCHER. This 210W multiple-output magnetic-amplifier switcher tolerates high peak loads so that it can power hard-disk computers. The MASS210-1 has output configurations of 5V at 15A (20A peak), 12V at 6A (8A peak), and −12V at 1A (1.5A peak) packaged in a 2.5×4.25×13-in. U-channel chassis. The unit powers multiple 5¼-in. hard disks and floppy disks from one 12V output. Mag-amp design with isolated outputs provides initial start-up current for the drives without degradation of regulation characteristics. Other features include power-failure-detection circuitry

High-performance CMOS Static RAMs. There's never been a better deal.

The Game
High performance. Reliable delivery. And a fair price. When it comes to CMOS Static RAMs, the stakes are too high to gamble on anything less.

Our Hand
That's why S-MOS offers the two most popular CMOS Static RAM types for large volume users: the SRM 2064 64K (8K × 8) and the SRM 2016 16K (2K × 8). Pin-compatible with 6264 and 6116 device families, respectively, they're designed for performance that meets or exceeds other vendors' premium grade products. But at prices equivalent to their standard grades.

Take our powerful 64K CMOS SRAM. It features an access time of just 150ns,



The S-MOS system

SRAM COMPARISON CHART

16K (2K × 8) 150ns	OPERATING (1) CURRENT (TYP)	MAX	STANDBY (2) CURRENT (TYP)	MAX	STANDBY (3) CURRENT (TYP)	MAX
LEADER'S STD, 6116	35mA	70mA	5mA	15mA	20μA	2000μA
LEADER'S LP, 6116	30mA	60mA	4mA	12mA	2μA	50μA
S-MOS' STD, 2016	20mA	35mA	.3mA	2mA	1μA	50μA
64K (8K × 8) 150ns						
LEADER'S STD 6264	60mA	110mA	1mA	3mA	20μA	2000μA
LEADER'S LP 6264	60mA	110mA	1mA	3mA	2μA	100μA
S-MOS' STD 2064	25mA	40mA	1.5mA	3mA	2μA	100μA

(1) AVERAGE: MIN DUTY CYCLE, $\overline{CS1}$ = VIH, CS2 = VIL (64K)
$\overline{CS}$ = VIH (16K)
(2) $\overline{CS1}$ = VIH OR CS2 = VIL (64K)
$\overline{CS}$ = VIH (16K)
(3) $\overline{CS1}$, CS2 ≥ VCC − 0.2V OR CS2 ≤ 0.2V (64K)
$\overline{CS}$ ≥ VCC (VDD) − 0.2V (16K)

Based on published data sheet parameters

worst case. Plus power consumption that's a mere 25mA operating; 2μA standby.

What's more, the device utilizes 2-micron selectox silicon gate CMOS technology. It's a proprietary process that optimizes speed and power while cutting production costs. So while you're increasing performance, you're also saving money.

The SRM 2016, like its 64K counterpart, cuts down on energy consumption and has an access time of just 150ns.

Both SRAMs feature industry-standard pinouts and a choice of either plastic flat pack, cerdip, or plastic DIP packaging.

Our Raise
For outstanding reliability, our SRAM parts are 100% burned-in and temperature tested. And they are fabricated by Suwa Seikosha, one of the world's largest, most automated CMOS LSI manufacturers.

And remember, these premium devices are delivered at a price that's equivalent to the competition's standard grade. Now that's one sweet deal.

Our Call
So when the chips are down and you need more, stand pat with S-MOS. We've got a full house of 64K and 16K CMOS Static RAMs ready for immediate delivery.

S-MOS Systems.
Nothing beats a winning hand.

S-MOS SYSTEMS

S-MOS Systems, Incorporated
50 West Brokaw Rd., Bldg. 7
San Jose, CA 95110
(408) 993-1212

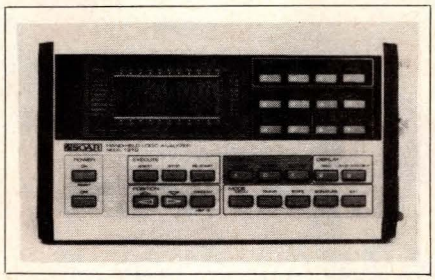
CIRCLE NO 190

and a hold-up time of 50 msec min at nominal input voltage and maximum output power. An isolated-output design eliminates cross-regulation effects. $185 (OEM qty). **Elpac Power Systems,** 3131 S Standard Ave, Santa Ana, CA 92705. Phone (714) 979-4440.

Circle No 457

16-MHz 68000 LOGIC POD. A 68000 μP pod for the ML4100B logic analyzer clips directly over a 68000 or 68010 DIP and collects and formats data, filtering it for logic analysis and program disassembly. Features include full disassembly, including all exceptions and all bus cycles; hardware that implements Filtered mode (which deletes unused prefetches and prevents activation of unwanted trigger events, eliminating storage in memory); Jump mode, which records only changes in program flow; Transparent mode, which passes all bus cycles; and support of 68000 and 69010 μPs at speeds to 16 MHz. The 16-MHz 68000 μP logic pod, $1860. **Atrium Corp,** 1931 Wright Circle, Anaheim, CA 92806. Phone (714) 978-9531.

Circle No 458

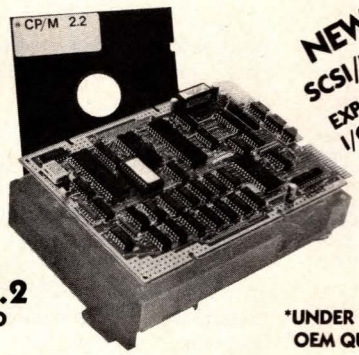


LCD LOGIC ANALYZERS. Models 1310 (10 MHz) and 1320 (20 MHz) perform logic timing, logic state, and signature analyses. These handheld, battery-powered units have 16-channel×256-word main and reference memories. Their 16-channel inputs also have one clock and one clock-qualifier line. They measure 10×5.5×1.5 in. Their LCD (2688 pixels) contrast adjusts for viewing in varied light. Other features include word trigger, glitch detection, external trigger, and qualifier (all TTL level); minimum glitch width is 15 nsec. Data gets displayed eight channels in parallel at one time. With the display system's scaling function, any portion of the data sequence expands four times. Hexadecimal, octal, binary, and ASCII-code displays are available. Compare and Search functions allow retrieval of a specified word, counting the number of specified words, or comparison with the reference data, which can also be displayed. Model 1310 (10 MHz, 16 channels, 256 words), $1995; Model 1320 (10 MHz, 16 channels, 256 words), $2495. **North American Soar Corp,** 1126 Cornell Ave, Cherry Hill, NJ 08002. Phone (609) 488-1060.

Circle No 459

The Little Board™...$349*

The world's simplest and least expensive CP/M computer



NEW SCSI/PLUS™ EXPANSION I/O OPTION

CP/M 2.2 INCLUDED

***UNDER $200 IN OEM QUANTITIES**

- 4 MHz Z80A CPU, 64K RAM, Z80A CTC, 2732 Boot ROM
- Mini/Micro Floppy controller (1-4 Drives, Single/Double Density, 1-2 sided, 40/80 track)
- Only 5.75 x 7.75 inches, mounts directly to a 5 1/4" floppy drive
- 2 RS232C Serial Ports (75-9600 baud & 75-38,400 baud), 1 Centronics Printer Port
- Power Requirement: +5VDC at .75A; +12VDC at .05A/On-board -12V converter
- CP/M 2.2 BDOS • ZCPR3 CCP • Enhanced AMPRO BIOS
- AMPRO Utilities included:
  - read/write to more than 2 dozen other formats (Kaypro, Televideo, IBM CP/M86....)
  - format disks for more than a dozen other computers
  - menu-based system customization
- BIOS and Utilities Source Code Available
- SCSI/PLUS Adapter:
  - Mounts directly to Little Board • Slave I/O board control • Full ANSC X3T9.2
  - 16 bidirectional I/O lines • $99/Quantity 1

AMPRO COMPUTERS, INCORPORATED

Distributor/Dealer/Reps Inquiries Invited

Z80A is a registered trademark of Zilog, Inc.
CP/M is a registered trademark of Digital Research.

67 East Evelyn Ave. • Mountain View, CA 94041 • (415) 962-0230 • TELEX 4940302

CIRCLE NO 173

IMMEDIATE DELIVERY ON

VARIABLE RF COILS

CHIP INDUCTORS

AXIAL INDUCTORS

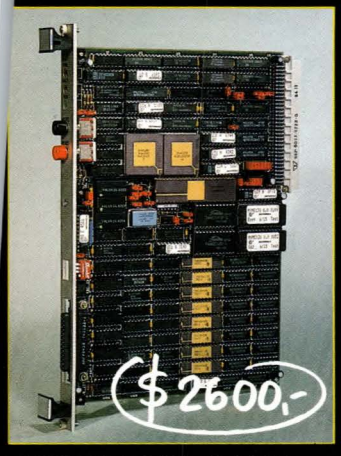
ALL MAJOR BRANDS

Inductive Products, Inc.

714-891-2572
NORTH. CALIF. 800-821-3235
OUTSIDE CALIF. 800-421-4830
11733 MARKON DR., GARDEN GROVE, CA 92641

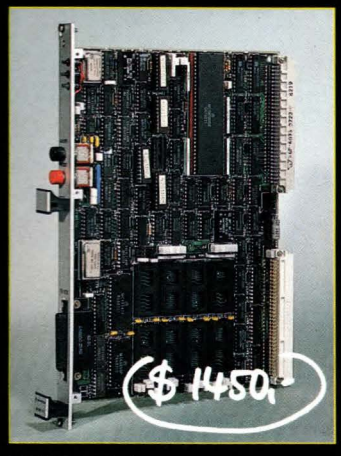
CIRCLE NO 174

The Motorola VME Challenge

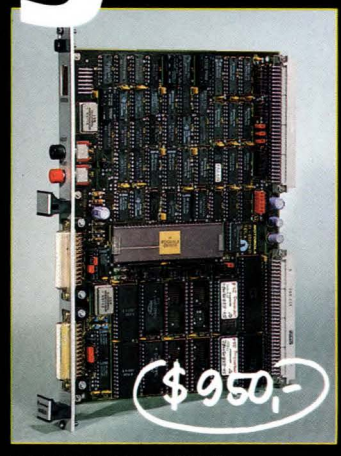


MVME120 MC68010; MMU
4KB Cache; 128KB(512KB)RAM

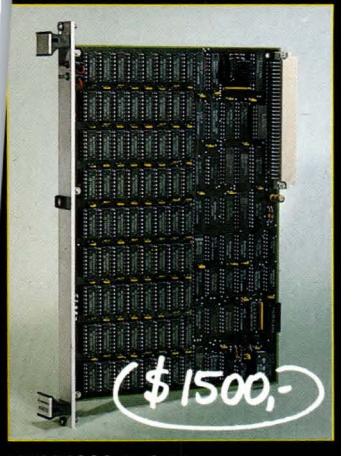
MVME115M
MC68010 with MMU



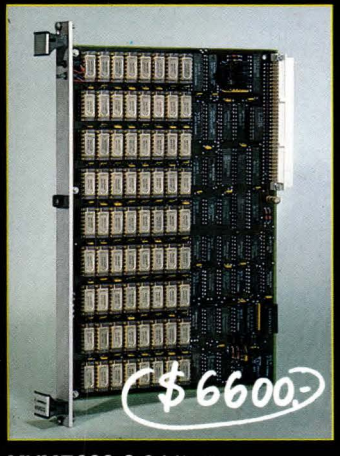
MVME110-1
MC68000 with I/O Channel



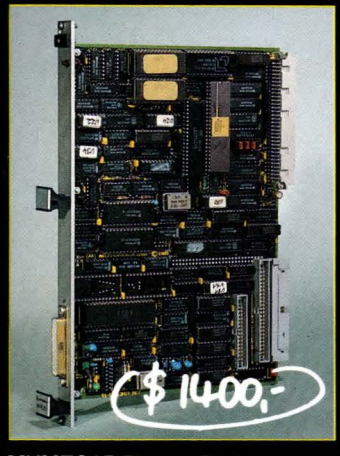
MVME101 MC68000
Single Board Computer



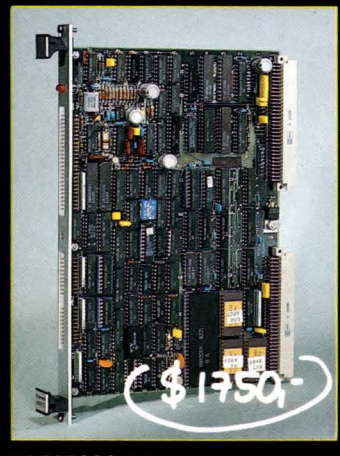
MVME202 512 Kbyte
High-Speed Dynamic RAM



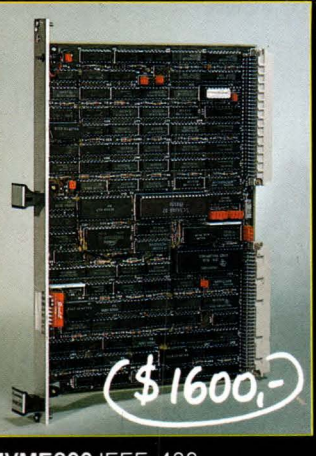
MVME222-2 2 Mbyte
High-Speed Dynamic RAM



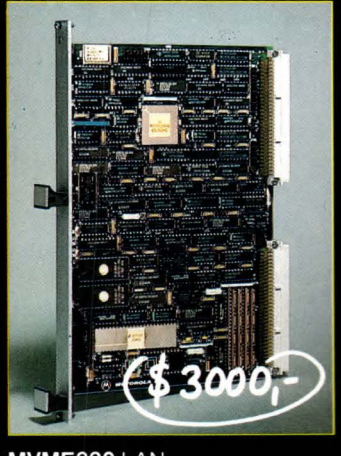
MVME315 Floppy Disk
Controller/SASI Interface



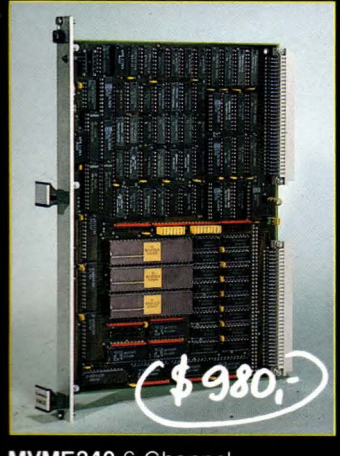
MVME320 Winchester and
Floppy Disk Controller



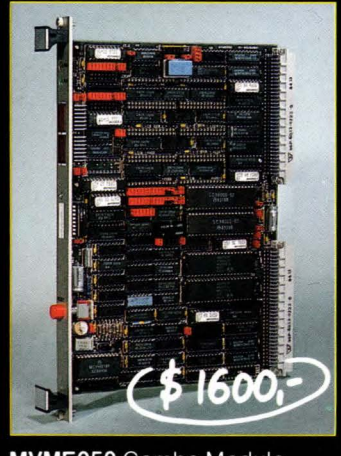
MVME300 IEEE-488
PIB Controller



MVME330 LAN
Ethernet Controller



MVME340 6-Channel
Parallel I/O Module



MVME050 Combo Module
Controller; I/O; Memory

ices valid in Europe only

rcle 271 on reader service card

MOTOROLA

VMEbus Products from Motorola

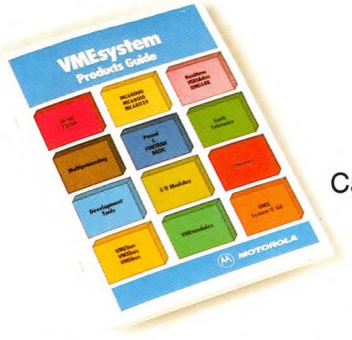
PRODUCT REFERENCE	DESCRIPTION
VME/10	
M68K102B2	VME/10 microcomputer system with 15 Mbyte Winchester disk, 655 Kbyte floppy disk, 5-slot VMEbus backplane and 4-slot I/O channel backplane
M68K102C2	As M68K102B2 with 40 MB Winchester
Processor Modules	
MVME101	MC68000 with 256 KB on-board memory space, system controller functions, 1-level bus arbiter, VMEbus interface, parallel I/O, 2 serial I/O ports, timer
MVME110-1	MC68000 with 256 KB on-board memory space, 1-level bus arbiter, VMEbus interface, I/O channel interface, 1 serial I/O port, timer
MVME115M	MC68010 with MC68451 192 Kbytes on board memory
MVME120	MC68010, MC68451, 64 Kbytes ROM area. 128 Kbytes dual ported RAM, 4 Kbytes Cache
MVME121	As MVME120 but with 512 Kbytes RAM
MVME128	MC68010/MC68451, 256 Kbytes dual ported RAM VMXbus interface
Memory Modules	
MVME201	256 Kbytes dynamic RAM with parity
MVME202	512 Kbytes dynamic RAM with parity
MVME222-1	1 Mbyte dynamic RAM with parity
MVME222-2	2 Mbytes dynamic RAM with parity
MVME211	1 Mbyte static CMOS RAM/ROM/ EPROM module
System Controllers	
MVME025	VME system controller
MVME050	VME system controller with memory and I/O

PRODUCT REFERENCE	DESCRIPTION
Peripheral I/O (VMEbus)	
MVME300	IEEE-488 GPIB controller with DMA
MVME310	Universal intelligent Peripheral Controller (UIPC) with free user area
MVME315	Intelligent floppy disk controller and SASI/SCSI interface with DMA
MVME316	VMEbus to I/O channel adapter
MVME319	Floppy disk controller and SASI tape controller interface
MVME320	Winchester/Floppy disk controller
MVME330-UX	Ethernet controller module with UNIX S/W
MVME330-VX	Ethernet controller module with VERSAdos S/W
MVME331	6-Channel intelligent serial communications module
MVME333	4-Channel intelligent high speed communications module
MVME340	64-bit parallel interface module
Peripheral I/O (I/O Channel)	
MVME400	Dual-Channel serial I/O
MVME410	Dual-Channel 16-bit parallel I/O
MVME420	SASI peripheral adapter
MVME435	Buffered 9-track magnetic tape adapter
Industrial (I/O Channel)	
MVME600	16-Channel analog input
MVME601	16-Channel expansion for MVME600
MVME605	4-Channel analog input
MVME610	120V/240V 16-Channel AC input
MVME615	120V/240V 16-Channel AC output Zero cross-over switching
MVME616	120V/240V 16-Channel AC output Non-zero-cross-over switching
MVME620	30V DC input
MVME625	30V DC output

Software Support

VERSAdos Realtime Multi-tasking Operating System.

UNIX, System V/68 Standard UNIX release jointly developed by Motorola and A.T.&T.



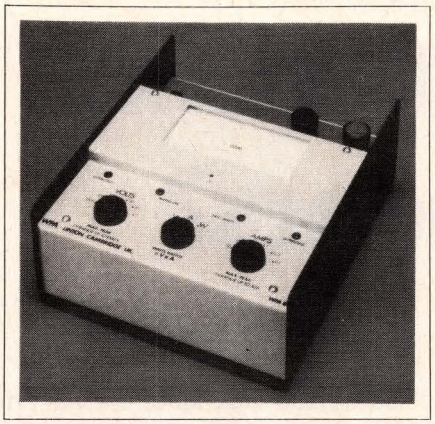
Call for more information included in this 28-page brochure.

Circle 271

MOTOROLA
Semiconductor Products Sector

European Distributors: Austria: Elbatex (2 22) 88 56 11/**Belgium:** Diode (02) 2 16 21 00/**Denmark:** Danelec (01) 69 05 11/**Finland:** Field (80) 6 92 25 77/**France:** Alfatronic (1) 7 91 44 44 · Feutrier (77) 74 67 33 · FIF (1) 7 72 46 46 · SCAIB (1) 6 87 23 13 · SCT (61) 22 04 22/**Germany:** Distron (0 30) 3 42 10 41 · EBV (0 89) 61 10 51 · Elkose (0 71 41) 48 71 · Prosystem (0 61 07) 7 50 30/**Greece:** Comptel (1) 3 61 43 00/**Italy:** Celdis (2) 6 12 00 41/**Netherlands:** Manudax (0 41) 39 29 01/**Norway:** OTE (02) 26 99 55/**Spain:** Comelta (1) 7 54 30 01/**South Africa:** ASD (011) 8 02 58 20/**Sweden:** Traco (08) 13 21 60/**Switzerland:** Elbatex (56) 27 01 27 · Omni Ray (1) 8 35 21 11/**Turkey:** Era 64 65 00/**United Kingdom:** Crellon (0 62 86) 44 34 · Hawke (01) 9 79 77 99 · New-Tek (02 23) 22 12 21 · Thame (0 84) 4 21 45 61/**Motorola Offices: Asia and Pacific Region:** Hong Kong (0) 22 31 11 · Tokyo (3) 4 40 33 11

VERSAdos, VME/10 and System V/68 are trademarks of Motorola Inc. Ethernet is a trademark of Xerox. SASI is a trademark of Shugart Associates. UNIX is a trademark of A.T.&T. Price information subject to change after 31 Dec. 1984.

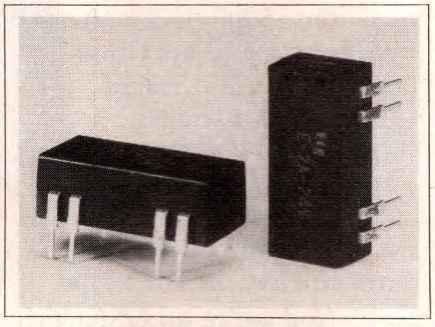


AC/DC TEST SET. The WM81 ac/dc test set features an overload capability of 1000V and 30A on any range. It also features audible and visible overload warning. The instrument has 6 rms voltage ranges from 3 to 1000V and 6 rms current ranges from 0.1 to 30A. You can also use it to measure power from 0.3W to 30 kW. The unit specs an accuracy of 2% of FS for voltage and current and 3% of FS for power. Bandwidth specs at dc to 20 kHz. Independent voltage and current inputs allow you to make 3-phase power measurements; an LED indicates negative power situations. £444. Delivery 4 to 6 wks ARO. **Walden Precision Apparatus Ltd,** Linton Station, Linton, Cambridge CB1 6NW, UK. Phone (0223) 892688.

Circle No 413

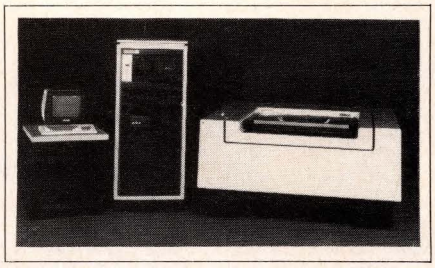
LOGIC ANALYZER. Effectively three separate logic analyzers in a single unit, the 7610's 32 or 48 channels can be split up into three groups, each with its own independent clock. Alternately, you can control each group by a combination of clocks. Any of the five clock qualifiers can be associated with the clocks via a Boolean expression. Maximum clock frequency measures 20 MHz, and memory depth equals 1024 bits/channel. You can reconfigure the 32-channel version to 8 channels of 3072 bits and the 48-channel version to 16 channels of 2048 bits or 8 channels of 3072 bits. Logic thresholds are TTL, ECL, or variable between ±12.7V in 100-mV steps or ±16.35V in 50-mV steps. Eight sequential trigger levels are provided. The last seven of these each comprise two ORed conditions, and you can delay enabling of the next trigger level by number of occurrences, clock cycles, or real-time interval. Glitch detection can be incorporated into the trigger conditions. The 7610 includes a reference memory that you can automatically compare with captured data, optionally rearming the analyzer, depending on the result. A graph-mode display plots data values against time, giving, for example, a clear indication of address excursions in microprocessor-based systems. Its timing-diagram display is capable of showing 16 labeled channels, and it includes clock traces so that you can phase-relate the data. Personality probes and disassemblers are available for 8- and 16-bit μPs and for the IEEE-488 bus. £6100 for the 32-channel version; £7600 for the 48-channel version. **Solartron Instrumentation Group,** Victoria Rd, Farnborough, Hampshire GU14 7PW, UK. Phone (0252) 544433. TLX 858245.

Circle No 414



REED RELAY. The E-2A series of DIP reed relays has a 10-VA load rating and an MTBF of 4.7×10^8 operations. Available with one or two normally open contacts, the units switch currents as high as 0.5A and carry 1A continuously. Maximum contact voltage measures 100V dc or ac peak and typical contact resistance equals 70mΩ. Coil voltages of 24, 12, or 5V can be supplied. The epoxy-resin encapsulation, which is suitable for flow soldering, meets the flammability requirements of UL94VO. From £1.11 (100). **Erg Components,** Luton Rd, Dunstable, Bedfordshire LU5 4LJ, UK. Phone (0582) 62241. TLX 82349.

Circle No 415



PHOTOPLOTTER. The EMMA 85 photoplotter features a plot accuracy of better than 0.015 mm over its entire plot area of 734×581 mm (28.9×22.9 in.). Resolution is 0.0025 mm. For less critical applications the unit has a high-speed plot facility. Because it uses film that is preloaded into a pallet impenetrable by light, the plotter does not require darkroom operation and is controlled via a local terminal. Input takes place via a magnetic-tape unit or through its RS-232C interface. Other interfaces are available. £57,500. **Marconi CAE Systems,** Quest House, Princes Rd, Ferndown, Dorset BH22 9HQ, UK. Phone (0202) 891010. TLX 41358.

Circle No 416

DIODE BRIDGE. The MB25 range of 25A, single-phase diode bridges includes versions with peak voltage ratings from 100 to 1200V. They handle 6A without a heat sink and 33A if the case temperature is limited to 55°C. Maximum operating-case temperature is 85°C. The bridges withstand a 350A surge for 10 msec. Excluding terminals, the package measures 28.5×28.5×11 mm. **Marconi Electronic Devices Ltd,** Power Div, Carholme Rd, Lincoln LN1 1SG, UK. Phone (0522) 29992. TLX 56163.

Circle No 417

You might feel good about buying Tektronix®. But do your engineers?

Ask them.

Ask them about triggering stability. About display contrast. Demonstrated reliability. Service turnaround. And availability.

And then, if they haven't already told *you* about us, you tell them.

We're Kik® Number four in worldwide scope sales.

And we've got a full line of high reliability oscilloscopes.

Our 6100 Series 100 MHz scope gives you three vertical channels, two simultaneous trigger views, a patented linear autofocus and a demonstrated MTBF over 20,000 hours.

Tektronix® doesn't. Not at any price.

Our 5000 Series 60 MHz scope offers three channels, eight traces (including a trigger view), and a demonstrated MTBF over 10,000 hours.

Tektronix doesn't match that. In any scope.

And we're on GSA with both of these series. Tektronix isn't.

Our 5000 Series storage scope gives you a 20 MHz bandwidth (theirs, only 10), a high contrast display and a vertical sensitivity of one millivolt per division.

Tektronix can't compare. No one does.

As for service, we're established in every major city in the country. With more than 100 nationwide sales offices and Honeywell, G.E. and independent service centers.

But in case you're still not convinced, we've built something into Kik company policy designed especially for you.

We give you 30 days to decide whether you like our product. And then, if you don't, just return it and we'll tear up the invoice.

If you've read the writing on the wall, and would like to make your own comparisons, write or call Kikusui International, 17819 S. Figueroa St., Gardena, CA 90248.
800-421-5334. In Alaska, California and Hawaii, call 213-515-6432. Leasing available.

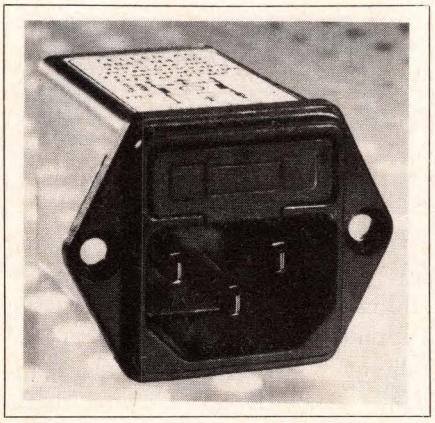
KIK®

We're not riding on a reputation. We're making one.

"SEE US AT WESCON BOOTH #1133"

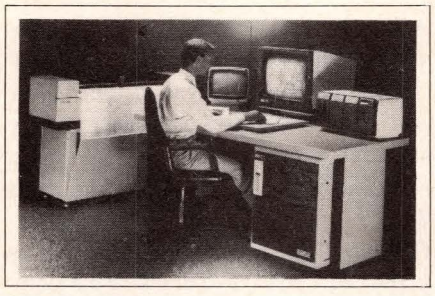
Tektronix is a registered trademark of Tektronix Inc.

© Kikusui International Corp. 1984. Subsidiary of Kikusui Electronics Corp., Japan.



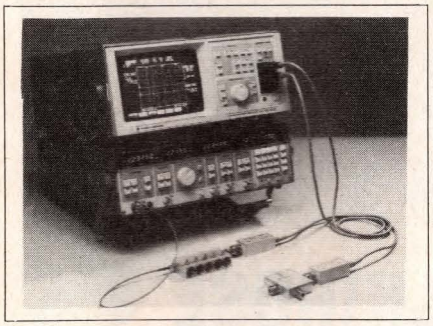
POWER CONNECTOR. To simplify the assembly of power-input components, this CEE22 power connector has an integrated RFI filter and cartridge fuseholder. The thermoplastic body of the connector is encased in a metal housing with three 6.3-mm tab terminals. The single-pole fuse holder accepts standard 5×20-mm cartridge fuses. For safety, the fuse holder cannot be accessed with the power cord in place. The connectors are suitable for use on Class 1 250V ac appliances and have SEV, VDE, UL, SEMKO, and CSA safety approval. **Feller AG,** Bergstrasse, 8810 Horgen, Switzerland. Phone (01) 7256565. TLX 53218.

Circle No 418



PC-BOARD CAD. Based on a Data General Model 10 computer, the MicroQuad pc-board-design workstation does more than generate board-layout artwork; it also produces parts lists, schematics, and assembly/drilling drawings. In addition, it compiles a database suitable for input into computer-aided-manufacture and test equipment such as NC-controlled drills, component-insertion machines, and in-circuit testers. After design capture, which you can carry out on an IBM PC/XT, Multiroute software performs automatic component placement or allows you to predefine component positions and designate no-go areas. Using elastic-band techniques, you can then move components either individually or in groups. An output spooler allows you to plot at any stage in the board's design without interrupting the design process. From £30,000. Delivery, 6 wks ARO. **Marconi CAE Systems,** Quest House, Princes Rd, Ferndown, Dorset BH22 9HQ, UK. Phone (0202) 891010. TLX 41358.

Circle No 419

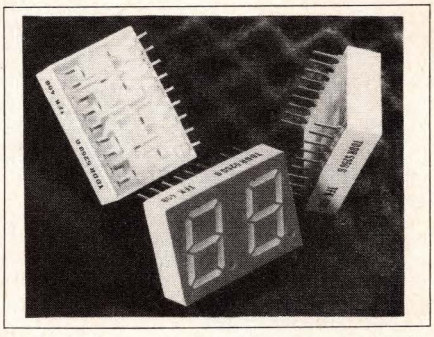


NETWORK ANALYZER. The ZAS scalar network analyzer performs scalar 2- and 4-wire voltage, transmission, and matching measurements in the 0.1- to 2500-MHz range, as well as swept-frequency and group-delay measurements. With a suitable sweep-frequency generator, you can make measurements on narrowband devices, such as crystal filters with a frequency resolution of 10 Hz. The unit's probes have a dynamic range of 95 dB and achieve an accuracy of ±0.5 dB. Three inputs provide you with two measurement channels and a reference channel. You can average data and display cursor, horizontal reference lines, frequency markers, reference curves, and tolerance graticules. 30,000 to 35,000 DM. Delivery from 1st qtr of 1985. **Rohde & Schwarz GmbH & Co KG,** Muehldorfstr 15, Postfach 801469, 8000 Munich 80, West Germany. Phone (089) 41292625. TLX 523703.

Circle No 420

MULTIMETER. The B1042 multimeter measures dc and rms ac voltages to 1 kV and 750V, respectively; dc and rms ac currents to 5A; and resistance to 50 MΩ with a scale length of ±5400 digits. You can select ranges manually or allow the instrument to autorange. Computational modes allow you to display percentage deviation or dB ratio, to offset readings by a given amount, or to limit-check the readings. Able to trigger readings at predefined time intervals, the B1042 stores the last ten measured values for subsequent examination. The multimeter has an IEC-625 (IEEE-488) interface and meets Class II requirements of DIN5744 and VDE0411. **Siemens AG,** Zentralstelle fuer Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025.

Circle No 421



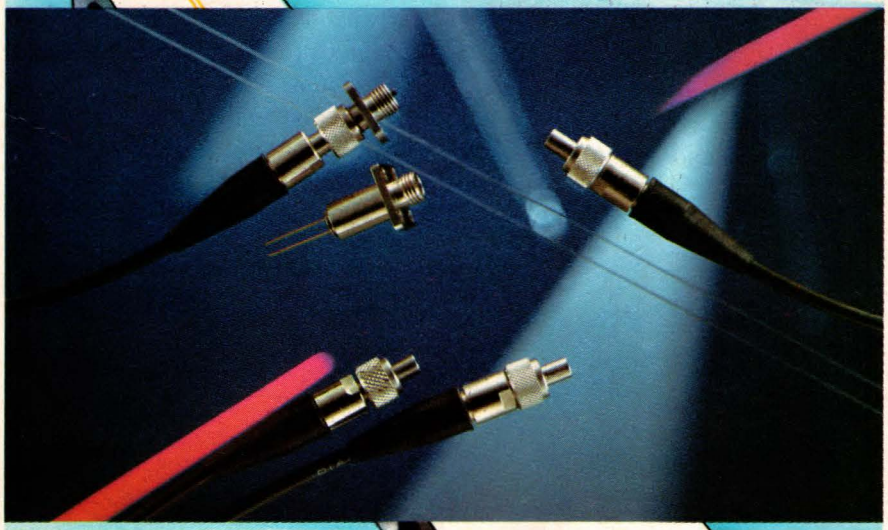
LED DISPLAY. The TDD Series 7-segment, dual-digit LED displays have a 13-mm character size. Housed in 18-pin packages, they are pin compatible with CQX87 dual-digit displays. Red, orange-red, yellow, and green versions are available in either common-anode or common-cathode configurations. **AEG Telefunken,** Theodor-Stern-Kai 1, 6000 Frankfurt/M 70, West Germany. Phone (0611) 6001.

Circle No 422

Bridge the technological gap with Hirose Fiber Optics

FROM *military applications*

... Army ... Navy ... Air Force ...
E.G. F15 & F18 Fighter Planes



TO *new commercial and industrial uses*

Telecommunications
Data Communications
Local Area Networks
Eliminate RFI/EMI
Computers
Peripherals
Custom Designs

HIROSE
Fiber Optics

Metal & Plastic Connectors
DNP Type Connectors
Transmitters
Receivers
Coherent Connectors
Incoherent Connectors
Custom Assemblies
Special Requirements

Be among the First to Bridge that Gap! Contact ...

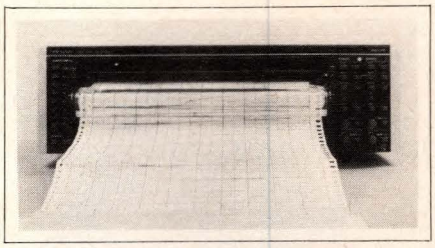
HRS HIROSE ELECTRIC U.S.A., INC.

9254 Deering Avenue
Chatsworth, CA 91311
Telephone (818) 709-1247

Creative Links to World Electronics

CIRCLE NO 176

INTERNATIONAL



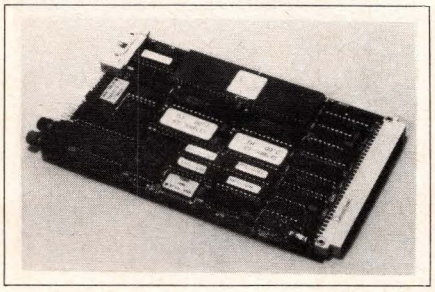
RECORDER. The PM8251A and PM8252A are (respectively) single- and double-line recorders featuring 15 input ranges from 1 mV to 50V full span, <0.2% of full scale deadband, and <2 μV/°C zero drift. Input impedance is 1 MΩ. Variable controls allow you to alter sensitivity between 95 and 250% of range and to shift the zero reference between −110 and +210% of span. The recorders use 250-mm-wide paper running at chart speeds between 10 and 300 mm/min or mm/hr. Additional features include channel inversion, servo kill, externally controlled dipmarker, and an output proportional to pen position. Both instruments can be supplied to stand alone or for 19-in. rack mounting, and both conform to IEC-348 safety requirements. **Philips (S & I Div),** Box 523, 5600 AM Eindhoven, Netherlands. Phone (040) 757005. TLX 51573.

Circle No 423

A/D, D/A CONVERTERS. Designed for video-processing applications, the PNA7507 A/D converter and PNA 7518 D/A converter have sampling rates of 15 and 30 MHz, respectively. The PNA7507 has 7-bit resolution with separate overflow and underflow outputs provided. You can select two's complement or binary coding for measured data. The converter has TTL-level outputs and operates from 5 and 12V supplies; typical power consumption is 350 mW. The unit is housed in the 24-pin SOT-101A DIP. The PNA7518 8-bit multiplying D/A converter has transparent latch, TTL-level inputs, 12-MHz bandwidth, and an output with a linearity of ±½LSB. Its settling time, to

±1 LSB, is typically 40 nsec with a 200-kΩ/6-pF load. The PNA7518 operates from a 5V supply and dissipates 300 mW typ. It is packaged in a 16-pin SOT-84B DIP. **Philips (Elcoma Div),** Box 523, 5600 AM Eindhoven, Netherlands. Phone (040) 757005. TLX 51573. **Signetics Corp,** 811 E Arques Ave, Sunnyvale, CA 94086. Phone (408) 739-7700.

Circle No 424



POWER TRANSISTORS. DT100, DT150, and DT200 transistors are available with peak- and continuous-current ratings as high as 800A. They cover a V_{CEX} range of 300 to 1050V and a $V_{CER(SUS)}$ range of 275 to 850V. Minimum forward current gain is 7 to 10 at 100 to 400A at a V_{CE} of 2V and typical $V_{CE(SAT)}$ is <0.5V at rated current. Housed in the button R package, which allows double-sided cooling, the transistors have a mounting thermal resistance of <0.05°C/W. Suitable fast-recovery diodes can also be supplied. £95 (100+). Delivery, 3 to 4 wks for small quantities. **Marconi Electronic Devices Ltd,** Power Div, Carholme Rd, Lincoln LN1 1SG, UK. Phone (0522) 29992.

Circle No 425

DIE ADHESIVE. Replacing silicon-gold eutectic bonding and organic adhesives, Ausub is designed for the void-free bonding of large-area silicon chips in the production of hermetically sealed components such as ceramic DIPs, Sidebraze, pin-grid arrays, and ceramic chip carriers. The adhesive is a silver-loaded glass paste in an organic solvent/resin medium. The organic components burn out at temperatures below 300°C, leaving a completely inorganic and inert bond. You can apply Ausub to substrates at room temperature. It is also suitable for use on alumina and beryllium-oxide ceramics as well as low-expansion alloys such as Nilo 42 and Kovar. Because the adhesive layer absorbs stress between the chip and substrate during manufacture, it reduces the possibility that the die will crack. You can obtain an introductory pack containing 15g of Ausub, as well as processing information, for £100. **Johnson Matthey Chemicals Ltd,** Orchard Rd, Royston, Herts SG8 5HE, UK. Phone (0763) 44161. TLX 817351.

Circle No 426

The smartest, fastest, easiest, most reliable way to connect instrumentation to DIP IC's is with A P PRODUCTS Logical Connection.

A Logical Connection combines the performance proven IC Test Clip with a complete, tested, ready-to-use cable assembly. On one end, a pair of single row socket connectors attach to the pins of a connector compatible model Test Clip. On the other end, choose from among the four industry standard connector types, or order open-ended to terminate with your own connector. In sizes to accommodate DIPs from 14 pin to 64 pin.

The Logical Connection is available from our stocking distributors. Or ask an A P rep how we can make a custom Logical Connection for you.

Call TOLL FREE, 800-321-9668 for the name of the distributor near you. (In Ohio, call collect: (216) 354-2101)

® A P PRODUCTS INCORPORATED
9325 Progress Parkway
P.O. Box 540
Mentor, Ohio 44060
(216) 354-2101
TWX: 810-425-2250
In Europe, contact A P PRODUCTS GmbH Baeumlesweg 21 • D-7031 Weil 1 • W. Germany

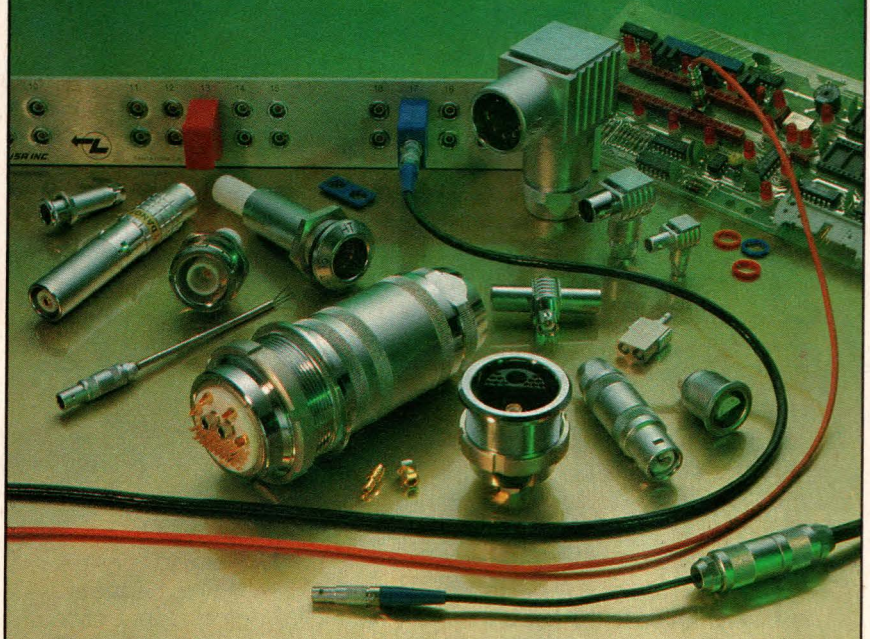
CIRCLE NO 177

BOARD COMPUTER. An enhanced SKC 85 Eurocard computer provides 8k bytes of EPROM space, 2k bytes of battery-backed nonvolatile CMOS RAM, and an 8085 CPU running at 3.072 MHz. The board also has two 14-bit counters and 46 I/O pins, and it will accept four prioritized interrupts. **Siemens AG,** Zentralstelle fuer Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025.

Circle No 427

CPU CARD. Providing an 8-MHz 68000 CPU for G-64 bus systems, the GESMPU-4A single Eurocard has four memory sockets that you can load with 128k bytes of EPROM, 16k bytes of RAM, or a RAM/EPROM mix. It also includes a baud-rate-programmable RS-232C serial interface and a triple timer. Debugging firmware and CP/M (68k) and OS-9 operating systems are available for the board. 1250 SFR. **Gespac sa,** 3 Chemin des Aulx, 1228 Geneva/Plan-les-Ouates, Switzerland. Phone (022) 713400. TLX 429989. **Gespac Inc,** 550 E Grandview, Mesa, AZ 85203. Phone (602) 962-5559. **Circle No 428**

The Quality Choice is LEMO Electronic Connectors



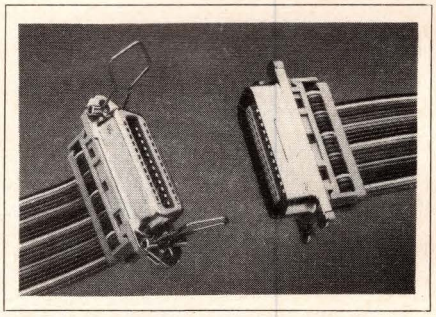
S-Series cylindrical "Quick-Lok" connectors for diversified applications:
Subminiatures • Coaxial: 50Ω, 75Ω, and 100Ω • Triaxial • PC board mount • Multipin to 106 contacts • Robotic • Thermocouple • High voltage • Mixed high voltage, coaxial and multipin configurations • Audio-video • Aluminum or stainless steel optional • Custom design

- RELIABILITY
- SPACE SAVINGS
- RUGGED CONSTRUCTION
- QUICK CONNECT & DISCONNECT
- AESTHETIC/FUNCTIONAL DESIGN

For technical data and catalog, as well as the name of your local representative, please call or write LEMO U.S.A., INC. (707) 578-8811, TELEX 340-933, P.O. Box 11006, Santa Rosa, California 95406.

LEMO USA INC

CIRCLE NO 178



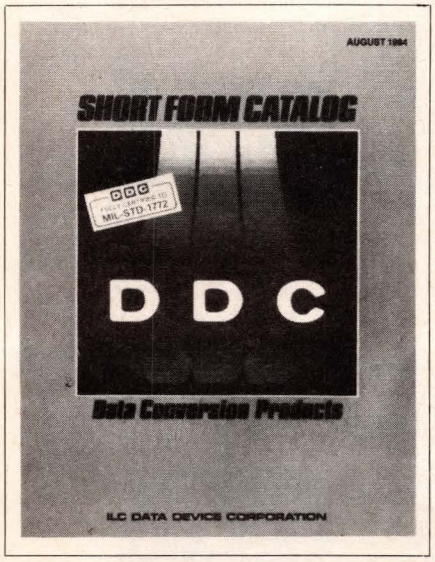
CONNECTOR. Available in 24- or 36-contact versions, the Delta range of plug and socket connectors is suitable for connection to ribbon cables or discrete wires or for direct soldering to pc boards. Ribbon-cable versions accommodate 0.050-in., 28-AWG stranded, or 30-AWG solid conductors. They incorporate strain-relief clips and can be supplied with metal or metallized-plastic shells. Discrete-wire types have solder-eyelet terminations, metal shells, and metal back shells that include a cable clamp. PC-board-mounting types include a vertical, plastic-shell version and a horizontal, plastic- or metal-shell type. The metal shell has a solder tag for grounding to the pc board. All Delta connectors have a temperature rating of −55 to +105°C, a current rating of 3A at 85°C, and a mechanical-endurance rating of 500 operations. Around £3 (100). **Bicc-Vero Electronics Ltd,** Hedge End Industrial Estate, Flanders Rd, Hedge End, Southampton SO3 3LG, UK. Phone (04892) 81424. TLX 477984. **Bicc-Vero Electronics Inc,** 40 Linderman Dr, Trumbull, CT 06611. Phone (203) 372-0038.

Circle No 429

Terms and definitions for software management

Management Bulletin No 4-1A, entitled *Configuration Management for Digital Computer Programs*, defines the terms and definitions to be used during the development, documentation, verification, and delivery cycles of new and modified software. It lists and defines common terms currently used in software-configuration management. This bulletin updates and replaces Configuration Management Bulletin No 4-1 (published in May 1982). $15. **Electronic Industries Association** Standard Sales Office, 2001 Eye St NW, Washington, DC 20006.

INQUIRE DIRECT



Data conversion and MIL-STD-1553 products

This 8-pg short-form catalog describes data-bus products, A/D and D/A converters, S/H amplifiers, synchro-to-digital and digital-to-synchro converters, T/H amplifiers, synchro and selsyn instruments, and MIL-STD-1553 components. Other products listed included control transformers, a synchro booster amplifier, SEM modules, and Inductosyn-to-digital converters. **ILC Data Device Corp,** 105 Wilbur Pl, Bohemia, NY 11716.

Circle No 375

4-volume set lists battery data

Eveready Battery Engineering Data is a 4-volume set that contains technical data and descriptions of the company's line of batteries. *Volume I* covers miniature batteries such as silver-oxide, mercuric-oxide, and manganese-dioxide types, and mercuric-oxide cylindrical types. *Volume II* describes alkaline cylindrical batteries and manganese-di-oxide miniature batteries. *Volume III* details general-purpose and heavy-duty carbon-zinc batteries, and *Volume IV* covers nickel-cadmium batteries. For a given battery family (eg, mercuric oxide), the text describes the devices' construction, electrochemistry, temperature range, and applications. The booklets also give discharge curves (voltage vs time at a given temperature), dimensional drawings, and battery specifications. 4-volume set, $20; individual volumes, $5. **Union Carbide Corp,** Battery Products Div, Section B-2-155, Old Ridgebury Rd, Danbury, CT 08817.

INQUIRE DIRECT

Tools for RF testing

A pamphlet entitled *Accessories for RF Testing* describes broadband antennas, TEM cells, field-sensor systems, leveling preamplifiers, fiber-optic telemetry systems, directional couplers, power combiners and dividers, matching transformers, computer-interface modules, and system-assembly kits. It lists specifications for each device and includes B&W photographs. **Amplifier Research,** 160 School House Rd, Souderton, PA 18964.

Circle No 376

Booklet explains solder preforms

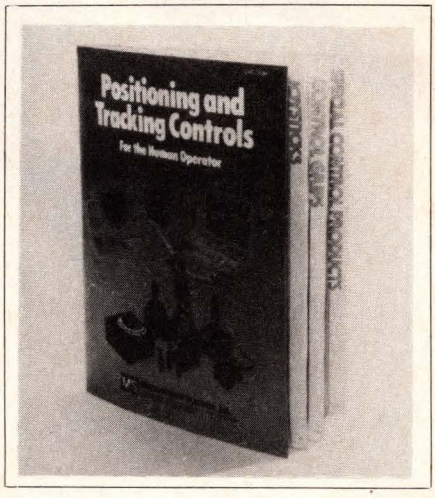
Solderforms Design and Specification Handbook discusses the pros and cons of using preforms and lists the specifications of the company's Solderforms that are made from foil solder, wire solder, and wire spheres. The 12-pg booklet contains a chart that lists the alloy compositions, their melting range, specific gravities, and tensile strength. The booklet also offers tips on when to use flux-coated or flux-cored preforms. **Kester Solder,** 4201 Wrightwood Ave, Chicago, IL 60639.

Circle No 377

See what's available in surface-mount components

The 2-color, 24-pg *Surface Mount Components* illustrates the company's products. Types include multilayer ceramic and solid-tantalum capacitors; resistor networks; transistors, rectifier diodes, and Zener diodes; and interface linear and Hall-effect designs. **Sprague Electric Co,** Technical Literature Service, Marshall St, North Adams, MA 01247.

Circle No 378



Mice and joysticks

Positioning and Tracking Controls describes a variety of man/machine interfaces, such control as mice, joysticks, force sticks, trackballs, and control grips. The 24-pg booklet also describes interfaces for these products. **Measurement Systems Inc,** 121 Water St, Norwalk, CT 06854.

Circle No 379

MicroVAX DEVELOPMENT SYSTEM from ZAX

ZAX Corporation is proud to introduce the first, true 32-bit Universal Microprocessor System, featuring **ZAX** in-circuit emulators and DIGITAL'S newest super-microcomputer; the MicroVAX™ 1. This combination along with our powerful development software gives you the most powerful development system available.

- **HIGH LEVEL LANGUAGES**
  - **'C'**
  - **PASCAL**
  - **PL/M 86**
- **MANUFACTURER COMPATIBLE ASSEMBLERS**
- **FULL SYMBOLIC DEBUGGING CAPABILITY**
- **BATCH FILE CONTROL OF EMULATOR**
- **AUTOMATIC JOURNALING OF EMULATOR COMMANDS**
- **EXTENSIVE HELP FEATURES**

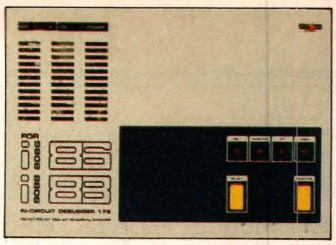
For your complete development needs contact

Zax Corporation

your leader in MICROPROCESSOR DEVELOPMENT SYSTEM

800/421-0982 • 714/474-1170

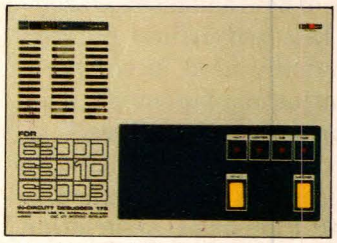
*VAX, MicroVAX are trademarks of Digital Equipment Corporation.



i8086/88

i8086
i8087
i8088

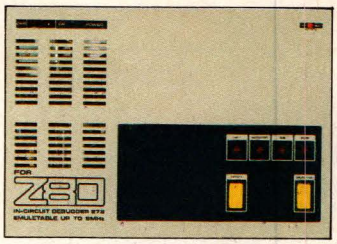
Co-emulation of 8086 and 8087 or 8088 and 8087 processors to 5 MHz. Realtime emulation to 8 MHz for 8086/88 processors. Features; 128K bytes static RAM - expandable to 1 Mbyte, 4K deep x 40 bits deep realtime trace buffer, 30 different debugger commands.



68000

68000
68010
68008

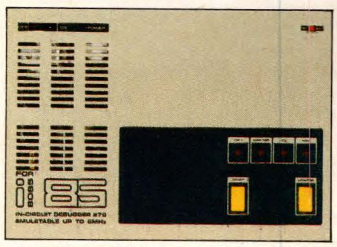
Emulates 68000, 68008 and 68010 in one unit to 10 MHz. Features; 128K of emulation memory - expandable to 256K, 4K deep x 48 bits wide realtime trace buffer, 30 different debugger commands.



Z80

Z80
Z80B
Z80H

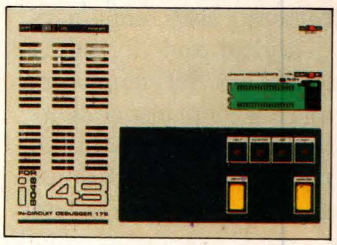
Emulates Z80B microprocessors to 6 MHz and Z80H to 8 MHz. Features; 64K byte user emulation memory, 2K deep x 32 bits wide realtime trace buffer, 29 different debugger commands.



i8085

i8085A
i8085A-1
i8085A-2

Emulates 8085 processors up to 6 MHz. Features; 64K byte user emulation memory, 2K deep x 32 bits wide realtime trace buffer, 29 different debugger commands.



i8048

i8048
i8049
i8050
i8748
i8749
i8039
i8035
i8040

Emulates entire 8048 family in one unit to 11 MHz. Features; 4K emulation memory, 2K deep x 32 bits wide realtime trace buffer, 29 different debugger commands. 8748 and 8749 units feature a built-in EPROM programmer.

CIRCLE NO 179

Capacitor compendium

Capacitors describes mica (dipped, radial taped, chip, metal clad, and variable compression), ceramic-disk, monolithic-ceramic, aluminum-electrolytic, dipped-tantalum, polyester, and metallized-polyester capacitors and printer-filter capacitor networks. The 56-pg catalog also includes photographs, mechanical specifications, performance curves, and charts. **Arco Electronics,** 9822 Independence Ave, Chatsworth, CA 91311.

Circle No 380

Standard tests for fiber-optic cables

RS-455-45, *Microscopic Method for Measuring Fiber Geometry of Optical Waveguide Fibers,* describes a method of measuring the five fiber-geometry parameters—core diameter, core ovality, cladding diameter, cladding ovality, and core-to-cladding offset—that characterize the electric joint loss you can expect when you join two fiber-optic waveguides by fusion or with a mechanical connector. $8. **Electronics Industries Association,** Standard Sales Office, 2001 Eye St NW, Washington, DC 20006.

INQUIRE DIRECT

Papers on switched-capacitor filters

MOS Switched Capacitor Filters: Analysis and Design brings 50 published papers on this technology together in one volume. The papers place emphasis on the basic principles, analysis, design, and implementation of practical filters as opposed to network theory. In addition, the papers include methods and circuits used in current design. IEEE members, $40.15; nonmembers, $66.95. **IEEE,** Service Center, 445 Hoes Lane, Piscataway, NJ 08854.

INQUIRE DIRECT

Note discusses CRT recovery problems and cures

Recovery in CRTs is the controlled dissipation of stored energy in the deflection system. *Application Note No 6* details the ways the mechanical layout of magnetic components, chassis components, and shields can affect CRT recovery. In particular, the pamphlet discusses the ac components of recovery (a function of resonant frequencies, deflection-yoke core characteristics, shields, and mounting structures) and the dc components (yoke design, core shape, and materials). **Syntronic Instruments Inc,** 100 Industrial Rd, Addison, IL 60101.

Circle No 381

Circuit-design techniques for power semiconductors

The 152-pg *Semiconductors Applications Handbook* provides design techniques, examples, and applications covering power-switching techniques for on-card dc-to-dc conversion and secondary regulation of single- and multiple-output power circuits. It also covers dc-motor control, with constant-speed and constant-torque applications together with half-bridge and stepper-motor drives. In addition, the handbook discusses line-operated switching supplies. **Lambda Semiconductors,** 121 International Dr, Corpus Christi, TX 78410.

Circle No 382

How to use the moon for antenna measurements

An Error Analysis for the Use of Presently Available Lunar Radio Flux Data in Broadbeam Antenna-System Measurements (TN1073) describes how you can make satellite earth-station G/T measurements using the moon as a noise source. The method is useful for antennas receiving signals on frequencies between 1 and 10 GHz.

CIRCLE NO 129

OMNIBYTE™

Real Time development/target system

OB68K/SYS+™

Here is a Multibus* based system designed for your real time applications, such as process control/monitoring and data concentration. With it you get:

- Our OB68K1A™ 10MHz 68000 single board computer with 128K bytes of zero-wait-state, dual-ported RAM (addresses 16MB).
- 6 RS232C serial ports, 4 can be RS422.
- 3 (16 bit) parallel ports (1 configured as a Centronics compatible printer port).
- 1 QIC-02 compatible tape interface.
- 20/40/80 MB 8″ hard disk.
- 1.2 MB 8″ floppy disk.
- 8 slot IEEE 796 card cage (5 slots user definable) with 200 Watts available.
- Calendar clock with battery back-up.
- DMA disk controller.

Software packages from Omnibyte address your real time needs. These include polyFORTH/32**, a 32-bit compact operating environment (ideal for process control) with operating system, high level language, assembler and development tools. Also available, is Idris† , a Unix††-like operating system with real-time enhancements. High level language support includes C, PASCAL, BASIC compiler, FORTRAN 77, C Executive, 68000 Native Assembler, hardware floating point support and more!

For more specifics, call Peter Czuchra, Marketing Manager.

*Multibus is a trademark of Intel Corp.
**polyFORTH/32 is a trademark of Forth Inc.
†Idris is a trademark of Whitesmith, Ltd.
††Unix is a trademark of AT & T Bell Laboratories

A Look at Today. . .
A Vision of Tomorrow.

™OMNIBYTE CORPORATION
245 W. Roosevelt Rd.
West Chicago, IL 60185
(312) 231-6880
Intl. Telex: 210070 MAGEX UR

CIRCLE NO 65

LITERATURE

Stock No 003-003-02555-1, $2. **Superintendent of Documents,** US Government Printing Office, Washington, DC 20402.

INQUIRE DIRECT

Get on board with stick-on patterns

Microelectronics Artwork Patterns, Catalog 601, describes patterns for hybrid surface-mounted devices, ICs, small-outline transistors, and small-outline artwork for high-density applications. **Bishop Graphics Inc**, Box 5007, Westlake Village, CA 91359.

Circle No 383

IEC standard covers time-delay switches

This standard, Publication 669-2-3, applies to hand- and remote-control operated time-delay switches with rated voltages to 440V and rated currents to 63A. Specifically, it covers those switches that have a mechanically, thermally, pneumatically, hydraulically, or electrically operated time-delay device or any combination thereof. 31 Swiss francs. **International Electrotechnical Commission,** 1, Rue de Varembé, 1211 Geneva 20, Switzerland.

INQUIRE DIRECT

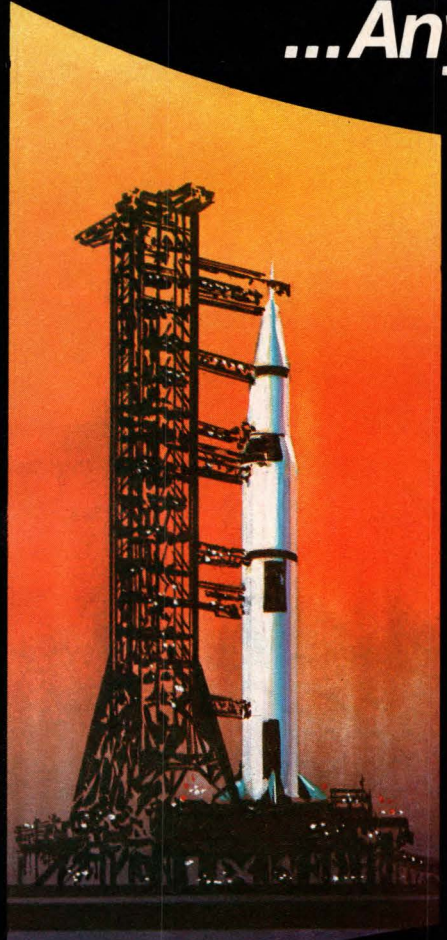
How to design GHz and THz mixers

Microwave and Millimeter-Wave Mixers gathers papers on aspects of mixer theory and practice such as accurate modeling and computer-aided analysis of Schottky-diode mixers, practical mixer implementations, harmonic mixers, intermodulation, cryogenic Schottky-barrier mixers, superconducting junction mixers, and FET mixers. The book includes a detailed introduction on mixer theory. IEEE members, $35.95; nonmembers, $66.95. **IEEE,** Service Center, 445 Hoes Lane, Piscataway, NJ 08854.

INQUIRE DIRECT

datron INSTRUMENTS

Is Pushing Traceable Standards Calibration ...Anywhere You Need It!



PORTOCAL

A fully automated, Portable Standards Lab for on-site calibration*:

- **Calibrates ANY voltmeter currently available**
- **5 function, DCV; ACV; DCI; ACI; Ω**
- **User-friendly software which is IBM PC compatible**
- **Compact and mobile**
- **One time test connection with a single set of leads (a feature unique to DATRON)**
- **Fully automatic recalibration of DVM's with AUTOCAL™, the world's first complete electronic calibration technique**

(NOTE: PORTOCAL can automatically recalibrate other major manufacturers' designs which followed the introduction of AUTOCAL™)

*PORTOCAL may be purchased as a totally integrated system or in component form to supplement customer owned Datron equipment.

IBM PC is a registered trademark of International Business Machines Corp.

datron INSTRUMENTS

IEEE-488

THE AUTOCAL™ PIONEERS

Datron Instruments Inc. 3401 S.W. 42nd Avenue, Stuart, Florida 33494 1-800-327-0938 (305) 283-0935 Telex 525724

Datron Instruments Ltd. Hurricane Way, Norwich Airport, Norwich NR6 6JB England (0603) 404824 Telex 975173

CIRCLE NO 180

Get Ahead of the VLSI Test Game

Ando Delivers Cost-Effective 256-Pin IC Testing At Real 40MHz Speed

Testing random logic VLSI chips and memory and linear IC's? The name of the game is throughput. And that's just where Ando can help you roll up the score.

Ando testers feature parallel testing of many devices at the same time. And all our testers, auto-handlers, even our unique cable-free connectors, are designed to be compatible with each other—so your line runs more smoothly, efficiently. It all adds up to more chips tested—and a better throughput tally.

But throughput isn't everything; on a per-chip basis, you'll find Ando testers can actually **lower** your charges for testing and development. Here are some of the reasons:

- **Real test speed:** Ando has more than just clock speed—we actually **test** as many as 256 pins at up to 40MHz.
- **Variety:** Testers for random logic IC's, VLSI memory chips, even analog IC's.
- **Versatility:** All Ando testers are ready for expansion into a distributed test hierarchy. All use the same programming language. And all are ready for ANDONET, the networking capability that speeds test, production or availability data across town or across the ocean—in real time.
- **And a few other little things:** Like a color graphic display for debugging. Like reliability and compactness.

So score a few points with your boss—and the accounting department. Call or write Ando to find out how you can get ahead of the game.

ANDO

ANDO ELECTRIC CO.,LTD.
19-7, Kamata 4-chome, Ota-ku, Tokyo 144 Japan Phone: (03) 733-1151 Telex: 246-6425 Cable Address: ANDELEC TOKYO

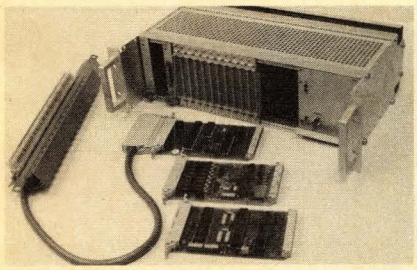
ANDO CORPORATION
2022 Bering Dr., San Jose, CA 95131, U.S.A. Phone: (408) 287-2636 Telex: 172709 ANDO SNJ

ANDO ELECTRIC EUROPE OFFICE
"Rivierstaete" Amsteldijk 166, 1079 LH Amsterdam, Holland Phone: 020-447891 Telex: 18514 ANDO NL

EDN PRODUCT MART

This advertising is for new and current products.

Please circle Reader Service number
for additional information from manufacturers.



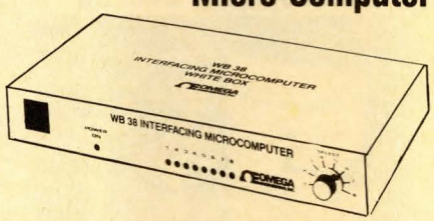
DATA ACQUISITION/CONTROL UNIT

Reliable low cost Eurocard based unit takes up to 256 Analog or Digital I/O points. Unit will monitor, alarm, control (also PID), communicate with hosts and may be programmed in BASIC by user. Base unit $1970, consits of • CPU with BASIC INT. 4K RAM, 8K EPROM space, RS-232 and 24 TTL I/O lines • PLUG IN SUPPLY (110/220 VAC or 24 VDC input, 5/±15/24VDC out) • Card rack with 16 slots for I/O modules and 2 slots for extra memory, serial ports etc. Wide variety of 16 channel I/O modules available including: – THERMOCOUPLE $495, RTD, $660, VOLT/CURRENT INPUT $595 (all 12bit) – VOLT/CURRENT OUT $725 (4ch), CONTACT In $495 and Out $495 – TIMER In/Out $825 (4ch), TTL I/O $495 (32ch), VAC $495, isolated – SERIAL (2ch) RS-232/422/423/485, 1 MBIT, ASYNC/HDLC/SDLC

MEGASYSTEMS, 1075 Broken Sound, Boca Raton, FL 33431, (305) 994-6700

CIRCLE NO 203

NEW FROM OMEGA! WB-40 Interfacing Micro-Computer

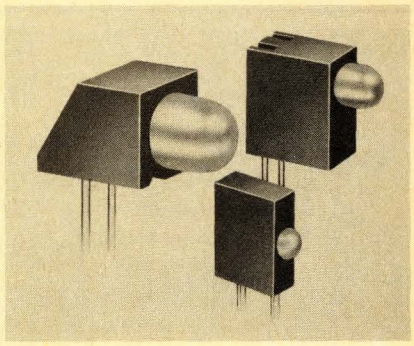


The White Box™ 40 stands alone or converts up to 8 analog signals to RS-232C format for full two-way communications with any compatible computer.

OMEGA ENGINEERING, INC.
One Omega Drive Box 4047 Stamford, CT 06907 U.S.A.
Telex 996404 Cable OMEGA FAX (203) 359-7700

(203) 359-RUSH

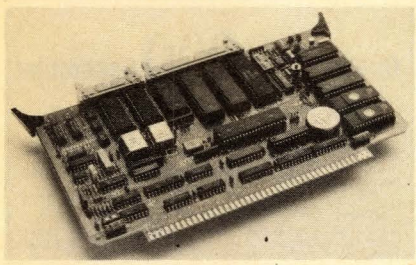
CIRCLE NO 204



"No-Fault" Status LEDs

Leecraft designed to exact PC mount requirements, from 1.8 to 12 VDC, with high bright and super bright intensities and in broad current range. Various heights, widths and configurations available. In T-1-3/4, T 1 & Mini-Axial LEDs; 4 colors, bicolor, flashers. Other LEDs available. FREE Lighting Guide, **Leecraft**, 21-02 44th Road, Long Island City, NY 11101, (212) 392-8800.

CIRCLE NO 205



SINGLE-BOARD EXORbus™ MICROCOMPUTERS

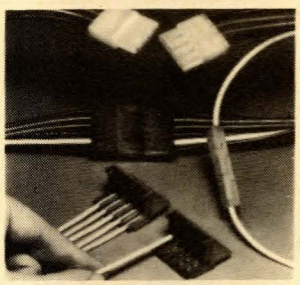
• The 9619A Single Board Micro Module • A MC68B09 Based Module • Four Parallel Channels • Two RS 232-C Serial Channels • From 48K of EPROM and 16K RAM To 8K of EPROM and 32K RAM • A Quartz Time/Date Subsystem • Includes A Resident Monitor

For catalog, pricing and quantity discount information contact:

CREATIVE MICRO SYSTEMS
3822 Cerritos Avenue
Los Alamitos, CA 90720
213/493-2484

CMS

CIRCLE NO 206



NEW 12 AMP, 1 THROUGH 6 CIRCUITS "JAGUAR" POWER CONNECTORS

Series 2300 general purpose, wire to wire connector utilizing insulation displacement termination in a hermaphroditic housing. One housing configuration fulfills both the male and female interconnection. New design saves cost of wire stripping, crimping and stuffing contacts. Reduces handling & inventory. Accommodates #16 through #22 AWG wire. Unique multi-circuit disconnect on .250 centers.

METHODE ELECTRONICS, INC.
INTERCONNECT PRODUCTS DIVISION
1700 Hicks Road, Rolling Meadows, Illinois 60008
312-392-3500 TWX 910-687-0760

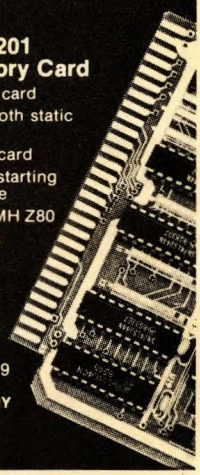
CIRCLE NO 207

STD BUS USERS!

Add as much memory as you need to your 8-bit STD bus system.

The New STD80201 512K Bank Memory Card

- •Works with any CPU card
- •Banks may contain both static RAM and EPROM
- •Up to 128 banks per card
- •Programmable bank starting address and bank size
- •No wait states with 4MH Z80
- •Any Number of cards per system
- •Qty. 1 price—$219 without memory

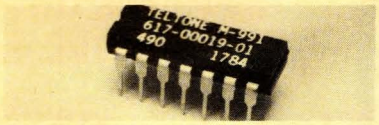


Call **TOLL FREE** for a data sheet
1-800-521-0714 Ext. 229

M.K. HANSEN COMPANY
634 Industry Drive
Seattle, WA 98188

CIRCLE NO 208

To advertise in **Product Mart** call:
Joanne Dorian, (212) 576-8015 or **Diane Turco, (212)** 576-8016

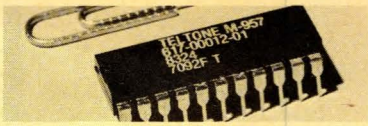


New IC Generates Call Progress Tones

Now you can generate dial tone, busy tone, reorder tone, audible ringing, and other call-routing tones with just one 14-pin CMOS chip. Teltone's unique new M-991 call progress tone generator will produce combinations of seven frequencies from 350 to 1209 Hz using a single 5V to 12V supply. Binary input generates pure tone output with harmonics at least 35dB below the call progress frequency band. Currently the only call progress tone generator on the market, the M-991 utilizes a 3.58 MHz crystal timebase and is available for immediate delivery.

IC Detects Call Progress Tones

Teltone's new M-980 is a CMOS call progress tone detector. It monitors dial tone, circuits-busy, station-busy, audible ringing, and other call-routing tones in the telephone progress supervision band (300–640 Hz). It's sensitive to signals from 0 dBm to –40 dBm and detects tones which vary by location or call destination. It operates from a single 5V supply and uses an inexpensive 3.58 MHz crystal or external clock.



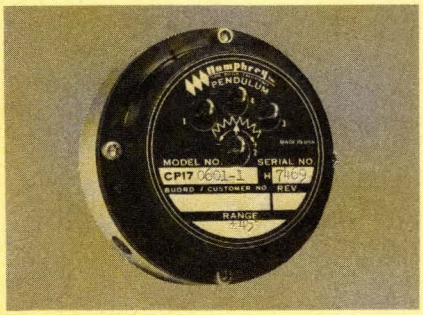
CMOS DTMF Receiver Simplifies Designs and Saves Board Space

Teltone makes it easier and less expensive to design a DTMF receiver into your products. The new M-957 is a monolithic CMOS 22-pin DTMF receiver that operates at 5 VDC. Fewer support components are needed so designs are simpler and occupy less space. This means you'll save design time and still get Teltone's high quality, performance, and product reliability.

The M-991, M-980 and M-957 join Teltone's complete telecommunications family of hybrid and single-chip generators, and detectors, receivers and relays. For product and pricing information, call Teltone today: **1-800-227-3800, ext. 1130.**

TELTONE® P.O. Box 657, Kirkland, WA 98033

CIRCLE NO 210



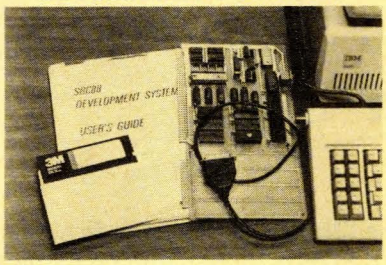
LOW COST PENDULUM

CP17-0601-1 provides vertical references for monitoring and control of pitch and roll angular displacements. Replaces expensive vertical gyros. Potentiometric output; hermetically sealed; fluid damped; range of ± 45°; resolution less than 0.20°; linearity within 0.5; total error band of ± 1% full scale. Wide range of models.

Humphrey Inc., 9212 Balboa Ave., San Diego, CA 92123. Telephone 619/565-6631.

CIRCLE NO 212

IBM PC - 8088 PROTOTYPE DEVELOPMENT SYSTEM

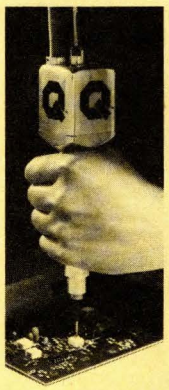


$500 Package Includes:

- SBC88 Board with 8088, iRAM, monitor ROM, Parallel and Serial I/O, Interrupt Controller, Timers and WW area.
- Software: Assembler, utility program; develop program on PC, down load and on-line debug.
- Cable: SBC88 to IBM PC Serial Port
- User's Guide

Meridian Systems
321 Aviador Street, Suite 111
Camarillo, CA 93010
805/484-8696 TWX 910-332-1292

CIRCLE NO 213



CAT 2000

COMPUTERIZED ADJUSTMENT TOOL

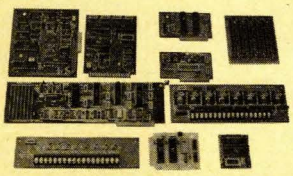
- Adjusts pots, coils and trimmers
- Accuracy greater than .03 degrees
- Computer interfaced by the IEEE-488 GPIB

The CAT 2000 will improve your adjustment speed, consistency and precision, resulting in lower production costs. For more information, call or write:

QUANTUM DATA
455 Kehoe, Carol Stream, IL 60188
Phone: (312) 668-3301 Telex: 206 725

CIRCLE NO 214

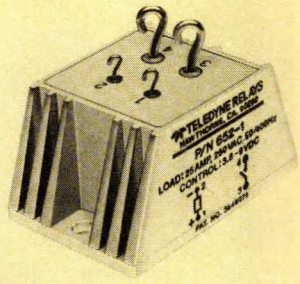
MICROCOMPUTERS AND INTERFACES



We have six single board computers, two video boards and interfaces for the IBM-PC and APPLE IIe computers. You can use our products for security systems, heat control, light control, automated slide show, traffic lights, irrigation systems, home computer systems, automated process control, and robot control just to name a few. OEM prices available. For catalog call or write to:

JOHN BELL ENGINEERING, INC.
400 OXFORD WAY
BELMONT, CA 94002
(415) 592-8411

CIRCLE NO 215



25AMP MIL SOLID STATE AC RELAY

Teledyne's 652 AC relay features load rating of 25A at 250VRMs over frequencies of 45-440Hz. Synchronous "zero voltage" turn-on and zero current turn-off result in significantly lower EMI levels compared with mechanical relays. Highly immune to transients. Optical isolation is 1500VRMS. Control range is 3.8 to 32VDC @10mA. Logic compatible. Case is 1.57 in. x 2.41 in. x 1.30 in. QPL to MIL-R-28750/10. Meets MIL-STD-704B. Model 653 is the DC version. **Teledyne Solid State Products**, 12525 Daphne Ave., Hawthorne, CA 90250 (213)777-0077

CIRCLE NO 216

Quelo™ 68000 Assembler

New 5.0 Release — First Commercial Release January, 1983

The **Quelo**™ portable 68000 assembler conforms to the Motorola resident assembler, publication M68KMASM[D4].

Quelo™ 68000 Assembler Package Features:

Input file concatenation, include function, macros, global parameter substitution from command line, listing date-time stamp, up to 31 character symbols, conditional assembly, structured programming directives, instruction optimization, 68010 instructions, relocation and linking, complex expression linking (all operators), DB-DW-DL directives for Z80 byte order data generation, object library utility, software configuration tracking, conditional linking, options for assembler and linker to write complete symbol table to a file, detailed symbol table listings, assembler symbol cross-reference, linker global symbol cross-reference, object library symbol cross-reference, superb linker load map, various HEX load formats produced by linker, error messages in English, extensive typeset manual with index, readily transported to any system with a C compiler and "UNIX like" system interface.

Ready to run in various disk formats for **CP/M-80, -86, -68K, MS-DOS and PC-DOS**	$595
Portable source version with detailed installation and testing instructions.	$750 and license agreement.

For more information or to order write or call Patrick Adams

Quelo™
2464 33rd Ave. W., Suite #173
Seattle, WA 98199
(206) 285-2528

COD, Visa, MasterCard.

CP/M-80, CP/M-86, CP/M-68K TM DRI. UNIX TM Bell Labs. MS-DOS TM Microsoft. PC-DOS TM IBM.

CIRCLE NO 217

To advertise in **Product Mart** call:
Joanne Dorian, (212) 576-8015 or **Diane Turco, (212)** 576-8016

EMI PROBLEMS?

Let Eagle Magnetic CURE your magnetic shielding problems!

For more information write or call:
P.O. Box 24283 • Indianapolis, Ind. 46224
Phone (317) 297-1030

EAGLE MAGNETIC COMPANY INC

CIRCLE NO 218

ENGINEERING SOFTWARE

CPM-80 • MSDOS • TRSDOS • PCDOS*

Free Catalog and Signal Processing Booklet

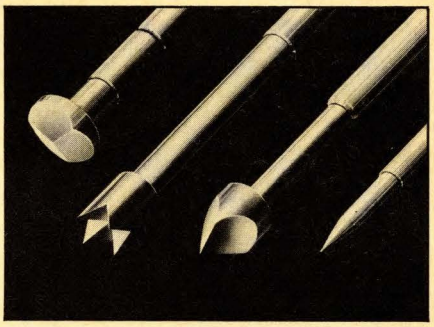
Professional — Affordable

PLOTPRO	— Scientific Graph Printing Program	$49.95
ACNAP2	— AC Circuit Analysis Program	$69.95
DCNAP	— DC Network Analysis Program	$59.95
SPP	— Transient Signal Processing	$59.95
PCPLOT	— Pixel Resolution Graphics Program	$59.95

*96 Computers and formats, 8087 Co-processor versions of ACNAP2, DCNAP, SPP available for $10.00 more.

BV Engineering
Professional Software
2200 Business Way, Suite 207 • Riverside, CA 92501
(714) 781-0252

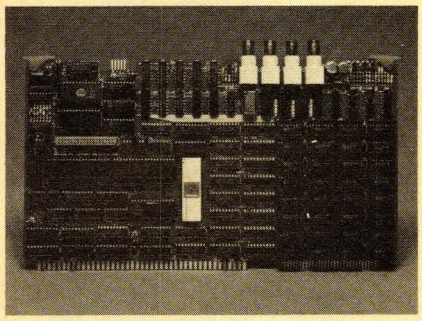
CIRCLE NO 219



GUARANTEED RELIABILITY FOR PCB, HYBRID AND COMPONENT TESTING. Over 150 different types of high quality spring probes for testing PCBs, connectors, components or hybrids available from stock for immediate delivery. Ask for the best...ask for Everett/Charles Contact Products, 700 E. Harrison, Pomona, CA 91767. Toll Free: National 800-848-7161, California 800-537-1783.

EVERETT/CHARLES
CONTACT PRODUCTS
PROBING DESIGNS FOR THE FUTURE

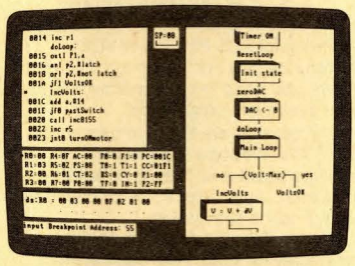
CIRCLE NO 220



The MLZ-VDC intelligent graphics controller sports Z-80A CPU, DMA, 132 byte FIFO on Multibus™, up to 32K of EPROM/ROM and 16K of RAM, 24 bit addressing, master/slave or multimaster operation, Intel iSBX™ connector, NEC uPD7220 GDC, 1024 × 1024 × 4 video RAM, 640× 480 × 4 display (interlaced or non-interlaced), 4096 pallete, 16 color display, light pen I/F. For more information, contact **Heurikon Corporation,** 3201 Latham Drive, Madison, WI 53713.

CIRCLE NO 221

Simulator/Debugger for IBM-PC for 8048 - 8051 - 7000 µCs



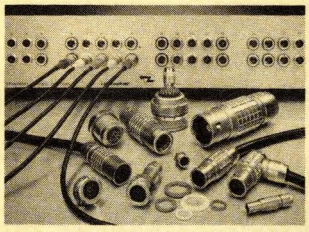
Execute and debug code for popular single chip microcomputers on your IBM PC. Dynamic display with windows for source code, control flow, registers, flags, memory, commands, and more! Set breakpoints, traps, etc. Cross-assembler & EPROM programmers, too.

	8048	8051	7000	Z8	
X-Assembler	✓	✓	✓	✓	$195
EPROM Prog	✓	✓	✓	✓	$245
Simulator	✓	✓	✓		$395

Demo disk and manual for simulator only $39.50

Cybernetic Micro Systems
Box 3000 • San Gregorio, California 94074 U.S.A.
(415) 726-3000 • Telex 171-135 Attn: Cybernetics

CIRCLE NO 222



LEMO "B" SERIES CONNECTORS

Lemo U.S.A., Inc.'s newest line of high quality electronic connectors is the "B" Series.

"B" Series connectors have the greatest contact density, permitting increased space savings compared to other Lemo cylindrical connectors. Also, the unique "Quick-Lok" mechanism, which is totally enclosed within and protected by the rugged outer shell, allows connection and disconnection without twisting or turning the connector, thus requiring less space for finger clearance. The key-keyway guiding system assures proper alignment prior to contacts and insulator touching.

The outer shell is designed and machined aesthetically and functionally to enhance any front panel application.

Contact configurations range from 2 to 64 contacts. Also available is mixed coaxial, multi-contact; or, high voltage and mutli-contact configurations. The inserts can be provided with either solder or crimp contacts for simple cable assemblies. Other features of the "B" series are a variety of keying patterns for keying exclusivity, and optional color coding for both mounting washers and cable bend reliefs.

For a copy of the Lemo U.S.A., Inc. "B" Series catalog and assistance in specifying Lemo connectors, please call or write **Lemo U.S.A., Inc.**, P.O. Box 11006, Santa Rosa, CA 95406, telephone 707/578-8811, telex 340-033 LEMO USA SARO.

CIRCLE NO 223

CROSS-DEVELOPMENT SOFTWARE TOOLS

C COMPILERS (with ROM support)

host	target	
IBM/PC, PDP-11, 6809	6809	

MACRO ASSEMBLERS

host	target	
IBM/PC, PDP-11, 6809	6801, 6805, 68HC11, 6809, 16000, 68000	

IBM/PC: TM of Int'l Business Machines.
PDP-11: TM of Digital Equipment Corp.

iNTROL CORPORATION
647 W. Virginia St.
Milwaukee, WI 53204
(414) 276-2937

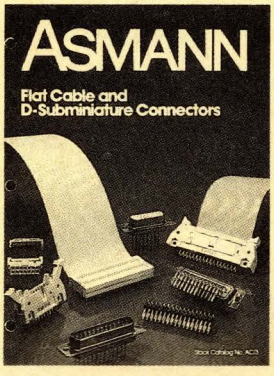
CIRCLE NO 224

FREE PRINTED CIRCUIT DRAFTING MANUAL

Bishop Graphics New 200-page PC Drafting Technical Manual & Catalog 107 features a separate, technical manual packed with "how-to" tips, tables and techniques for creating PC artworks. Describes the world's largest selection (over 20,000) of PC drafting symbols, tapes and accessories. Call TOLL-FREE 800-222-5808.

BISHOP GRAPHICS, INC.
5388 Sterling Center Drive
Westlake Village, CA 91359

CIRCLE NO 225



Your New Connector Source

A complete line of flat cable and D-Subminiature connectors. Also socket and pin connectors with solder, PC Board, or wire wrap terminals. Previously available only in Europe, these superior quality Asmann connectors are here in the U.S., and in plentiful supply, ready for delivery. For more information, write to: **Asmann Inc.**, 525 New Britain Ave., Unionville, CT 06085 or call us at 203-674-0118.

CIRCLE NO 226

To advertise in **Product Mart** call:
Joanne Dorian, (212) 576-8015 or **Diane Turco, (212)** 576-8016

8051

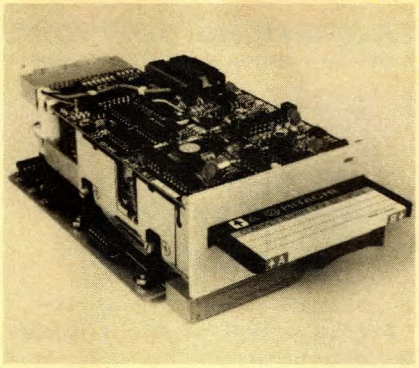
- SIM51 software simulates the 8051/8031. For validation & debugging of 8051 programs.
- Runs on IBM-PC, CP/M-80, MS-DOS
- Supports ALL 8051 on chip functions; full 128K external code & data memory
- One year FREE updates
- $250., manual without software $20., shipping & handling included
- Formats — PC DOS DSDD, CP/M-80 8" SSSD, Kaypro II SSDD
- 8048 Simulator also available

Logical Systems

6184 TEALL STATION
SYRACUSE, NY 13217
(315) 457-9416

• Trademarks SIM48 (LSC), IBM-PC (IBM), CP/M-80 (DRI), MS-DOS (Microsoft)

CIRCLE NO 227

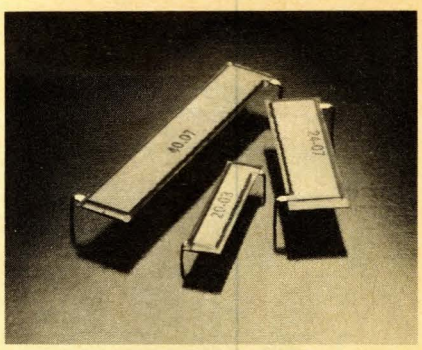


STD bus Microfloppy Subsystem

Plug a disk drive directly into your STD bus installation. Choice of 3" or 3.5" system. Western Digital disk drive controller. Low power, 2.5" high, 5 VDC only option. Complete STD bus development and control systems available with 8088 master and ROMmed BASIC or FORTH and CP/M-86.

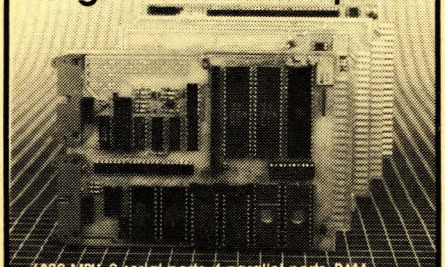
Vesta Technology, Inc., 1777 S. Bellaire, Suite 211, Denver, CO 80222 (303) 759-4988.

CIRCLE NO 236



CUT IC NOISE WITH MICRO/Q HIGH-FREQUENCY DECOUPLING CAPACITORS
Reduces voltage and ground spikes by up to 90%. The first flat capacitor that fits directly under ICs or sockets. Available to fit under most IC package configurations. Shares the same power and ground holes so board modification is unnecessary. **Rogers Corporation,** Q/PAC Division, 2400 South Roosevelt, Tempe, AZ 85282. (602) 967-0624.

6809
Single Board Computer



6809 MPU, 2 serial ports, 4 parallel ports, RAM, EPROM, real-time clock, watchdog timer, 44-pin 4.5" × 6.5" PCB
EXPANSION MODULES: RAM, EPROM, CMOS RAM/battery, analog I/O, serial I/O, parallel I/O, counter/timer, IEEE-488, EPROM programmer, floppy disks, cassette, breadboard, keyboard/display.

WINTEK Wintek Corp. 1801 South Street Lafayette, IN 47904 317-742-8428

CIRCLE NO 230

Guaranteed FCC/VDE Compliance!

Testing for FCC Part 15J or VDE compliance may not be enough. *In case of failure, you need to know exactly how to bring your device into compliance.*

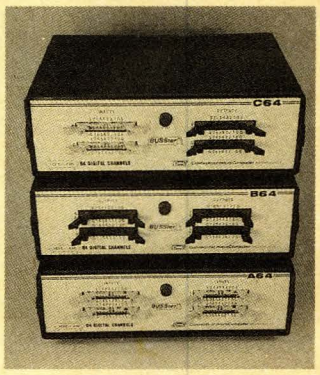
Our test sites are tested to be identical to the FCC's. We show you inexpensive, effective board level fixes to satisfy the regulation. If you need to file for certification, we will do the submission.

We are also your complete one-stop U.S. test facility for VDE (West Germany) regulations. We can give total assistance on overseas submissions, too.

The internationally recognized compliance specialists. Fixed price, agreed upon in advance. No surprises or hidden extras.

Dash, Straus & Goodhue, Inc.
593 Massachusetts Avenue
Boxborough, MA 01719
(617) 263-2662

CIRCLE NO 231



LABORATORY INTERFACES FOR COMPUTERS
Analog and Digital Input/Output
Analog and digital connections for any computer with an RS-232 or IEEE-488 interface; built-in timer and buffer allow data acquisition while your computer is busy with other tasks. $495.00 each. BUSSter A64-64 digital in: B64-64out: C64-32 in/32out: D16-16 analog in.

Connecticut microComputer, Inc., 150 Pocono Road, Brookfield, CT 06804 Tel: (203) 354-9395 TWX: 710456 0052.

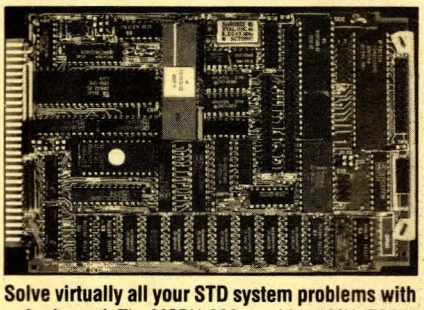
CIRCLE NO 232

TDK MULTILAYER CERAMIC CHIP CAPACITORS

TDK's multilayer ceramic chip capacitors for automatic mounting are available in three kinds of packaging and like all other TDK products, are manufactured under strict quality control conditions.

CALL or WRITE for FREE BROCHURE
TDK CORPORATION OF AMERICA
4711 Golf Rd., Skokie, IL 60076
(312) 679-8200

CIRCLE NO 233



Solve virtually all your STD system problems with a single card. The MCPU-900 provides 4 MHz Z80A, 64K RAM, and up to 16K ROM. 1797 disk controller handles four floppy drives with all-digital data separator. Also on board are a programmable serial port and 24 bit parallel port that may be used for SASI/SCSI control with the SASI-100 board. Three 10 MHz counter/timers and Centronics printer port round out the interfacing capabilities. The $795 single quantity price includes 100 hour burn-in and 200 page manual packed with software. Available from stock. **Miller Technology, Inc.**, 647 N. Santa Cruz Ave., Los Gatos, CA 95030, (408) 395-2032.

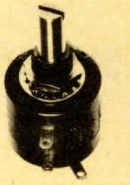
CIRCLE NO 234

ETI SYSTEMS

THE 10-TURN, NO WORRY POTENTIOMETER

Find High Quality, Low-Cost Performance
In ETI SYSTEMS' MW22 Multi-turn Potentiometer

- Most Standard Values stocked
- 1,000,000 Rev. Rotational Life
- ±5% Resistance Tolerance
- 100 to 100K Std. Resistance Range
- 2 Watts



The MW22 offers more non-standard variations at a lower price than any comparable pot, including:

- High Torque, 1 to 8 oz. in.
- Dual Gang
- Shaft Extensions
- Flatted Shaft
- Slip Clutch
- Metal Bushings

For more information, contact:

ETI SYSTEMS
215 Via Del Norte
Oceanside, CA 92054
Tel (619) 757-7770 • TWX (910) 322-1396

• See EEM •

To advertise in **Product Mart** call:
Joanne Dorian, (212) 576-8015 or **Diane Turco, (212)** 576-8016

EDN BUSINESS/CORPORATE STAFF

F Warren Dickson
Vice President/Publisher
Boston, MA 02116
(617) 536-7780

Peter D Coley
National Sales Manager
Boston, MA 02116
(617) 536-7780

NEW ENGLAND
Bob Sommer, Regional Manager
8 Lakeside Office Park
Wakefield, MA 01880
(617) 246-2293

STAMFORD 06904
George Isbell, Regional Manager
8 Stamford Forum, Box 10277
(203) 328-2580

NEW YORK CITY 10016
Daniel J Rowland, Regional Manger
Robert A Poggi, Regional Manager
475 Park Avenue South
(212) 576-8014
(212) 576-8017

PHILADELPHIA AREA
Steve Farkas, Regional Manager
999 Old Eagle School Rd
Wayne, PA 19087
(215) 293-1212

CHICAGO AREA
Clayton Ryder, Regional Manager
Randolph D King, Regional Manager
Cahners Plaza
1350 E Touhy Ave, Box 5080
Des Plaines, IL 60018
(312) 635-8800

DENVER 80206
John Huff, Regional Manager
Joseph A Vitiello, Regional Manager
270 St Paul St
(303) 388-4511

DALLAS 75234
Don Ward, Regional Manager
13740 Midway, Suite 515
(214) 980-0318

SAN JOSE 95128
Walt Patstone, Regional Manager
Bill Klanke, Regional Manager
Philip J Branon, Regional Manager
Mark Holdreith, Regional Manager
Sherman Bldg
3031 Tisch Way, Suite 100
(408) 243-8838

LOS ANGELES 90064
Charles J Stillman, Jr.
Regional Manager
12233 W Olympic Blvd
(213) 826-5818

ORANGE COUNTY/
SAN DIEGO 92715
Ed Schrader, Regional Manager
2041 Business Center Dr, Suite 109
Irvine, CA
(714) 851-9422

UNITED KINGDOM
Peter D Coley, Regional Manager
Jan Dawson
475 Park Avenue South
New York, NY 10016
(212) 576-4171

BELGIUM/FRANCE
Robert Broekman
American Publishers Representatives
4 Rue Robert de Flers
75015 Paris, France
609-95-95
Telex: 270560

GERMANY/SWITZERLAND
Wolfgang Richter
Sudring 53
7240 Horb/Neckar
West Germany
49-7451-7828

AUSTRIA
Igal Elan
Elan Marketing Group
Neutor g 2, Box 84
1013 Vienna, Austria
43222-663012, 638461

SCANDINAVIA
Igal Elan
Elan Marketing Group
Humlegardsgatan Nr 5
11446 Stockholm, Sweden
46 8 677243, 676243

SOUTHERN EUROPE
Igal Elan
Elan Marketing Group
13 Haifa St, Box 33439
Tel-Aviv, Israel
Tel: 25 29 67

HOLLAND
Igal Elan
Elan Marketing
Boschijk 199B
5612 HB Eindhoven, Netherlands
31-40-45 32 02

TOKYO 106
Kaoru Hara
Trade Media Japan Inc
Suite 412, Azabu Heights
1-5-10 Roppongi, Minato-ku
Tokyo 106
Tel: (03) 587-0581
Telex: J28208 MEDIAHS

TAIWAN
Owen Wang, Gen Mgr
Ace Marketing Inc
Box 26-578
Taipei, Taiwan
Republic of China
86-2-703-4272
Telex: (785) 14142

PRODUCT MART
Joanne Dorian, Manager
475 Park Avenue South
New York, NY 10016
(212) 576-8015

Diane Turco, Manager
475 Park Avenue South
New York, NY 10016
(212) 576-8016

CAREER OPPORTUNITIES
Roberta Renard
National Sales Representative
475 Park Avenue South
New York, NY 10016
(212) 576-8048

Jennifer Purinton
Eastern Sales Representative
475 Park Avenue South
New York, NY 10016
(212) 576-8049

Brenda Stillman
Western Sales Representative
12233 W Olympic Blvd
Los Angeles, CA 90064
(213) 826-5818

Cahners Magazine Division
J A Sheehan, President
William Platt, Executive Vice President
Terry McDermott, Group Vice President/
Electronics/Computer Group
Tom Dellamaria, VP/Production &
Manufacturing

Circulation
Denver, CO: (303) 388-4511
Earl Mosley, Group Manager
Barbara Pike, Manager

YOU LIKE TO WRITE, RIGHT?

Then EDN wants you, providing you also have an EE degree and at least two years' circuit-design experience. We seek individuals who want to be Boston-based technical editors for this top electronics publication.

To qualified individuals, EDN offers an attractive salary, industry-wide recognition, high job satisfaction, and the ability to keep abreast of . . .

- **Advanced Technology**
- **Exciting New Products**
- **State-of-the-art circuit and system-design techniques.**

If you thrive on meeting challenges head-on . . .

If you are an effective, technical communicator . . . then send your resume and salary requirements in strict confidence to: Roy Forsberg, Editorial Director, EDN, 221 Columbus Avenue, Boston, MA 02116.

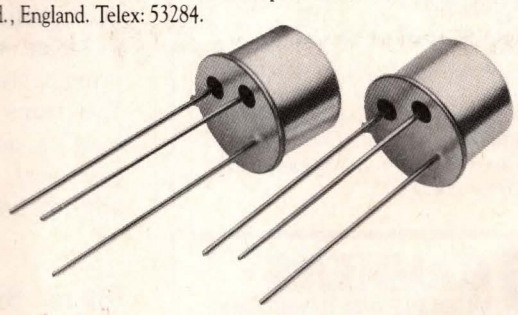
An Equal Opportunity Employer

Introducing:
The world's first TO-5 Thermal Switch.

Elmwood 3600 Series Thermal Switches provide a cost-efficient solution to the growing challenge of thermal density.

Designed for logic level circuits, devices serve as reliable temperature controls against damage caused by hazardous temperatures that result from thermal density of components on PCB's, backplanes, flexible circuitry and sophisticated time-based units. 3600 Series Thermal Switches are packaged in a standard JEDEC TO-5 transistor housing and are wave solderable.

For more on the 3600 Series TO-5 Thermal Switch, contact: Elmwood Sensors, Inc., 500 Narragansett Park Drive, Pawtucket, RI 02861. U.S.A. Tel. (401) 727-1300, **TOLL FREE: 1-800-ELMWOOD.** Telex: 681-4066. European Div., Elmwood Sensors, Ltd., England. Telex: 53284.



Elmwood Sensors Inc.
Subsidiary of Fasco®

CIRCLE NO 183

CAHNERS PUBLISHING COMPANY

Cahners Magazine Division
publishes the following 32 specialized business magazines, directories and newsletters:

Building/Construction Group
Brick & Clay Record
Building Design & Construction
Building Supply & Home Centers
Ceramic Industry
Construction Equipment
Corporate Design
Interior Design
Professional Builder
Security Distributing & Marketing
Security World
Specifying Engineer

Foodservice Group
Foodservice Equipment Specialist
Hotels & Restaurants International
Restaurants & Institutions

Electronic/Computer Group
Business Computer Systems
EDN
Electronic Business
Electronic Packaging & Production
Mini-Micro Systems
P.C. Products
Semiconductor International

Manufacturing Industries Group
Appliance Manufacturer
CPI Purchasing
Design News
Design News Directories
Modern Materials Handling
Packaging
Plastics World
Purchasing
Traffic Management
U.S. Industrial Directory

Medical-Health Care Group
Cardiovascular Medicine
Emergency Medicine

Newsletter Division
Electronic Business Forecast
Plastics Business News
Buying Strategy Forecast
Early Warning Forecast
Transport (De)Regulation Report
Hazardous Materials Transportation
Oil Spill Intelligence Report
Tradeshow Week
Energy Design Update
CIM Strategies

Cahners Exposition Group
is the largest producer, operator and manager of trade and consumer shows in the world . . . with over 100 shows, 6,000,000 square feet of exhibition space and total annual attendance of over three million.

CAHNERS PUBLISHING COMPANY
221 Columbus Avenue
Boston, MA 02116
617/536-7780

NEW BOOKS

Hybrid Microelectronic Technology, Peter Moran, editor. 225 pgs; $60 (hardcover); Gordon and Breach Science Publishers, New York, NY, 1984.

Volume 4 of the Electrocomponent Science Monographs series is a comprehensive guide to the newest techniques in the manufacture and industrial use of hybrid microelectronics. Included is a survey of state-of-the-art technology, with emphasis on methods of design, packaging, processing, application, and quality control.

Introduction to Integrated Circuit Layout, by Brian Spinks. 177 pgs; $19.95; Prentice-Hall Inc, Englewood Cliffs, NJ, 1985.

Using the working vocabulary of the trade, this book examines the basic theory behind the layout of semiconductor integrated circuits as it leads you through a typical design cycle. Converting a logic diagram to a composite drawing is the main objective; the book also emphasizes chip planning, MOS transistors, test sites, packaging, logos, and input protection.

Engineering SOFTWHERE. 353 pgs; $29.95; Moore Data Management Services, Minneapolis, MN, 1984.

This directory lists hundreds of programs from leading software vendors for a variety of applications. It contains a description of each program as well as information on price, training, hardware, operating systems, and source language. Programs are listed under such categories as database management, electrical, mechanical, aerospace, and math/statistics.

Digital Systems, 3rd edition by Ronald J Tocci. 591 pgs; $31.95; Prentice-Hall Inc, Englewood Cliffs, NJ, 1985.

The third edition of *Digital Systems* retains features from the previous books but includes modifications, extensions, and new applications for the material. The updated information reports on the latest devices and uses illustrations of actual ICs, timing diagrams, and waveforms as examples. Counters and registers, logic circuits, gates, flip flops, and memory devices are a few of the topics examined. Also covered are digital IC families, such as TTL, CMOS, MOS, ECL, and 3-state logic.

Basic Technical Writing, 4th edition, by Herman M Weisman. 414 pgs; $20.95; Charles E Merrill Publishing Co, Columbus, OH, 1980.

In addition to detailing the fundamentals of technical writing, this edition includes new chapters on preparing oral reports and proposals. The author illustrates and analyzes examples of good and bad technical writing and includes problems and exercises for the reader to practice with. The chapter on semantics offers a strong foundation for understanding technical language, and there's an improved and expanded guide to punctuation, style, grammar, and usage.

Kierulff Designer's Guide. 350 pgs; $75; Kierulff Electronics Inc, Los Angeles, CA, 1984.

This reference targets computer systems designers who must select products that help meet their design goals of function, performance, and cost. Included is a technical overview of products from a variety of companies, lists of specifications and performance features, data sheets, and photographs. The book also provides information on computer products and systems, software, peripherals, data communications equipment, and accessories from 25 of the leading manufacturers.

The Dry and the Mighty.

Dry film caps eliminate fluids that can leak, give the TRW-35 and TRW-61 capacitors higher current capability, lower ESR, and special high current terminations.

Our dry film capacitors leave the aluminum electrolytics all wet.

Used as input and output filter capacitors on switch mode power supplies, the TRW-35 and TRW-61 capacitors contain no fluids. So they can't leak. And they don't have to be put in metal cases as do some competitive film capacitors.

Our caps employ special patented high current terminations helping achieve controlled ESR. Other big pluses: lower change of capacitance with temperature, self-healing properties, and 200% overvoltage protection of film.

© TRW Inc. 1984 C84-10

TRW
Capacitor Division
TRW Electronic Components Group
301 W. "O" Street, Ogallala, NE 69153

Yes, I want better performance for my switch mode power supplies. Please send me data on your TRW-35 and TRW-61 capacitors.

Distributed by Arrow • Bell • Carsten • Electronics Marketing • Future • Gerber • Hall-Mark • Peerless • Philadelphia Electronics • RAE Industrial • Weatherford

Name _____

Company _____

Div./Dept. _____ Mail Code _____

Address _____

City _____ State _____ Zip _____

EDN

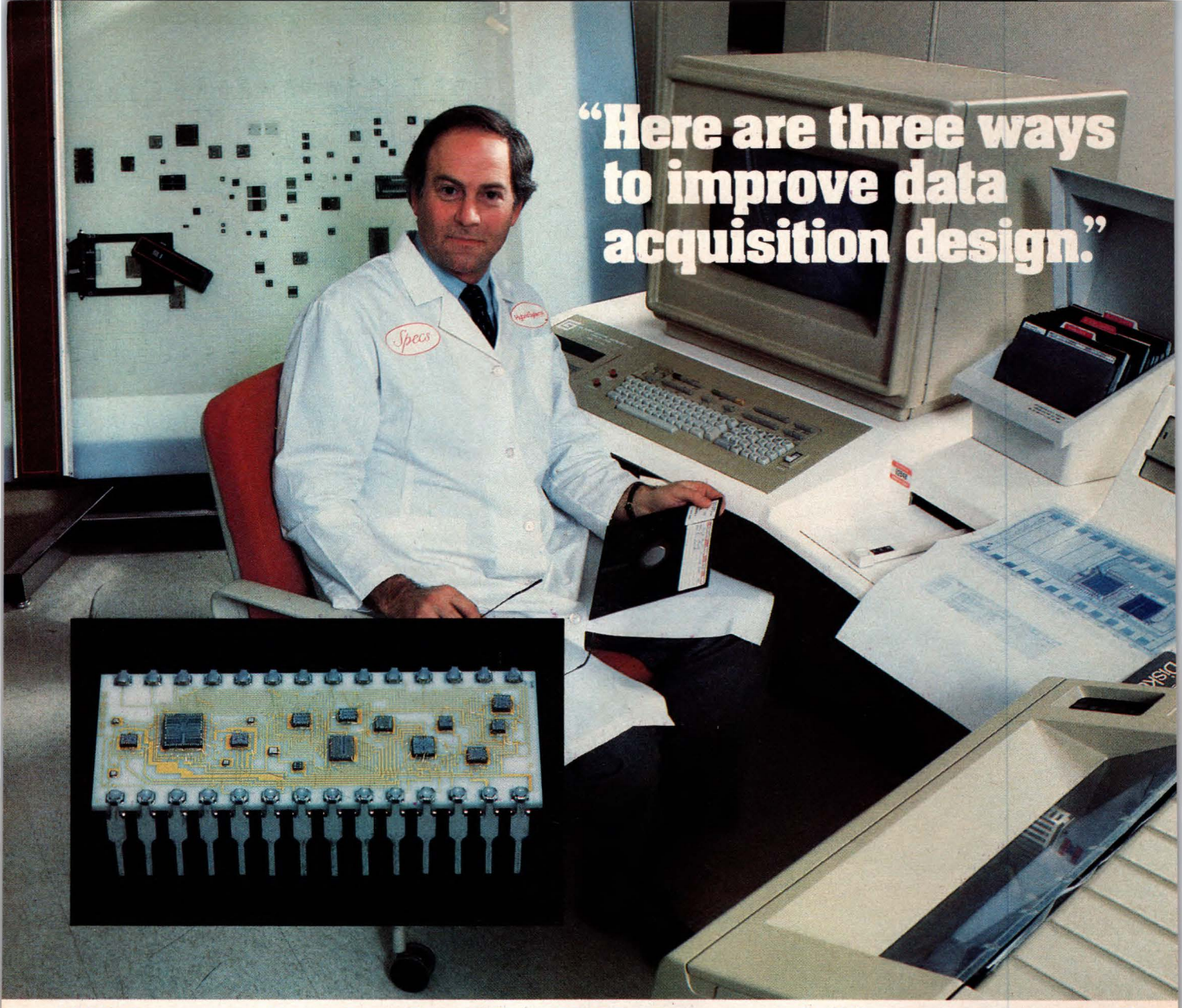
Use the TRW-35 Metallized Capacitor for SMPS applications where high current, high capacitance range and low ESR values are important . . . the TRW-61 Metallized Polyester Capacitor for applications requiring low ESR and current capability up to 4 amps.

If you need to determine which TRW part to use, contact your TRW capacitor engineer.

Send in coupon or call us at (308) 284-3611.

TRW

Capacitor Division
TRW Electronic Components Group



"With a complete family of 8 to 12 bit data acquisition components."

"I'm Bob 'Specs' Spector of Hybrid Systems. We've engineered our innovative family of hybrid data acquisition systems (DAS) to combine several discrete components into a single package, with a *single* specification.

"You no longer have to wrestle with different specifications from competing vendors. Hybrid Systems' components eliminate the risk of interfacing mismatched solutions. The result is *total system accuracy.*

"Here are three DAS's that will save you time and help you produce a better final design.

"The HS9410 is a complete 8 channel, 12 bit DAS with MUX, sample-and-hold amplifier and 12 bit ADC. Throughput rates of 22 khz are achieved, and tri-state outputs allow direct 150ns interface to 8 or 16 bit microprocessors.

"And the HS362, a 16 channel multiplexer with precision sample-and-hold that serves as a complete front end for 12 bit DAS's. The HS362 is flexible enough to be user configured to accept either 8 differential inputs or 16 single ended inputs. It features 7 µsec acquisition time to .01%, hold mode settling time of 600ns, and 10ns aperture uncertainty.

"Our new HS9460 is the industry's first complete hybrid I/O subsystem. Incorporating the functionality of up to 15 individual components, the HS9460 contains four analog input channels, CMOS 8 bit ADC, complete µP interface, and 4 channels of 8 bit DAC output. Advanced thin-film and LSI technology help package all this functionality in a single 28 pin dual in line package.

"Because we design and manufacture components strictly for use in data acquisition design, we're experts at making them accurate, reliable, and easy to use. If you'd like to know how Hybrid Systems can help you with special design problems, just call. And ask for 'Specs'."

Hybrid Systems Corporation,
22 Linnell Circle, Billerica, MA 01821.
(617) 667-8700.

Hybrid Systems CORPORATION

Precision Data Converters, Hybrid Data Acquisition Systems, and Thin-Film Products.

CIRCLE NO 185

Written and edited by Deborah Asbrand

Politically active EEs prove that government isn't just for lawyers

Every January, while most engineers are trying to avoid the post-holiday doldrums, George Dean takes his engineering skills and experience to the state capitol building in Wichita, KS. Dean then spends the next three months as the representative from the 96th district to the Kansas House of Representatives.

Dean has served for the past six years as a representative in the state legislature, and this fall, he's campaigning for his fourth term. When the legislature isn't in session, he works as a guidance and control engineer for Beech Aircraft Co, where he has been employed for the past 19 years.

Dean disagrees with the notion that engineers tend to be apolitical and have technical backgrounds that leave them unprepared for activity in politics. At one time, as many as four members of the state legislature were trained engineers, Dean says. And although many people assume most legislators are lawyers, only 16 of his 125 fellow representatives are attorneys.

Engineers, he says, are no different from other professionals. "I think many engineers are interested [in the political process]. They just don't take that extra step [to become involved]," he says. "Engineers are more critical of themselves than they ought to be. I think they're interested in a lot of different things; they're no different than anybody else." In fact, in Dean's office at Beech Aircraft, his colleagues include one engineer who serves as a city commissioner and another who is a school-board member.

To work as both a politician and an engineer, Dean has had to juggle a hectic schedule and make personal and professional sacrifices. "There are a lot of different prices to pay and one price is economics. You take time away from your job . . . and you lose money." Dean takes a 3-month leave of absence from his job to attend the legislative sessions. Although he's not paid while on leave, his company continues his seniority. Kansas legislators do draw a salary, but it's a relatively small compensation compared with Dean's engineering salary.

IEEE Congressional fellow Joe Edminister (left) *spent the past year working with Ohio Democrat Rep Dennis E Eckart (right) on environmental and energy issues.*

The time he has devoted to his political activities has impinged on Dean's professional status as well as his finances. Because he's away a quarter of each year, he has had to sacrifice some responsibilities and advancements. Even a company that's tolerant of your periodic leaves can't put you in a supervisory position, he acknowledges. "You can't be a supervisor," he says, "and be off for three months."

After five years as a representative to a neighborhood-based advisory council to Wichita's city commissioner, he made a successful bid for a seat in the House of Representatives in 1979. In the three terms he has served since, he has been a member of several committees: Public Health; Transportation; Local Government; Energy; and Computers, Communications, and Technology.

Kansas's need to dispose safely of hazardous waste became an important issue for the Energy Committee during Dean's second term. For example, toxic wastes in barrels buried underground were leaching into the water system. It was a key issue for Dean, who represents the urban southwest portion of Wichita and industrial constituents such as Boeing, Cessna, Gates Learjet, and his own employer, Beech Aircraft. Solid waste, such as the paint sludge that's generated during the

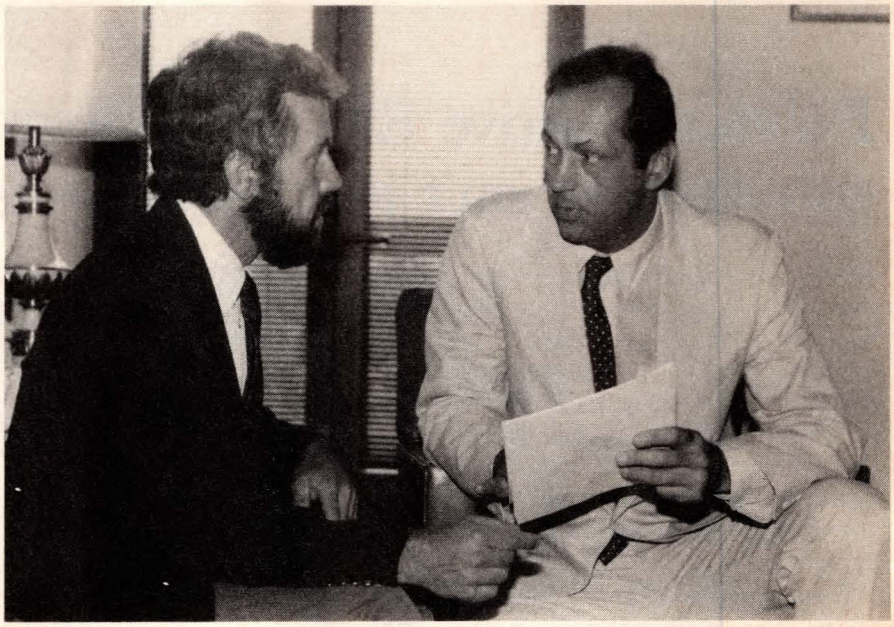
manufacture of airplanes, is currently stored in above-ground tanks, and the problem is "in limbo," says Dean. Safe disposal of wastes is expected to be a key issue in the 1985 legislative session.

As the ranking minority member of the Computers, Communications, and Technology Committee, Dean spoke before the House in support of a bill that proposed adding a math and science specialist to the staff of the state department of education. He was instrumental in the success of the bill, which provided assistance to the school department in upgrading math programs and organizing a computer-education curriculum.

Dean expects the Computers, Communications, and Technology Committee's goals will include improving the engineering programs at the state's universities and upgrading math and science programs in secondary schools. In addition, the committee expects to improve the state's telecommunication division and improve the three Centers of Excellence located at state universities. Dean's Democratic party needs to gain 10 seats in the election to become the controlling party in the House; if the party succeeds, Dean could become chairman of the Computers, Communications, and Technology Committee.

Although a political career does have its disadvantages, it also has given Dean opportunities he would not otherwise have had. For example, his alma mater, the University of Kansas, invited him to serve as a member of the Industrial Advisory Committee, which reviews and evaluates the school's computer curriculum. "I wasn't a great student and I haven't achieved great position in industry," he says, "so that was a neat perk."

As chairman of the IEEE/USAB Government Activities Council, Dean is a member of the Congressional Fellows Committee, which gives engineers an opportunity to witness the political process at the national level. Congressional fellows spend one year on Capitol Hill as staff assistants to a senator or representative or to a committee. During that time, they continue to draw full salary, half of which is paid by the IEEE and the other half by their employer.



Because of his work on Capitol Hill as a legislative assistant *to Sen Bill Bradley (D-NJ) (right), George Swetnam (left) says his Congressional experiences will benefit him when he returns to his job at Mitre Corp, a consulting firm to the US government.*

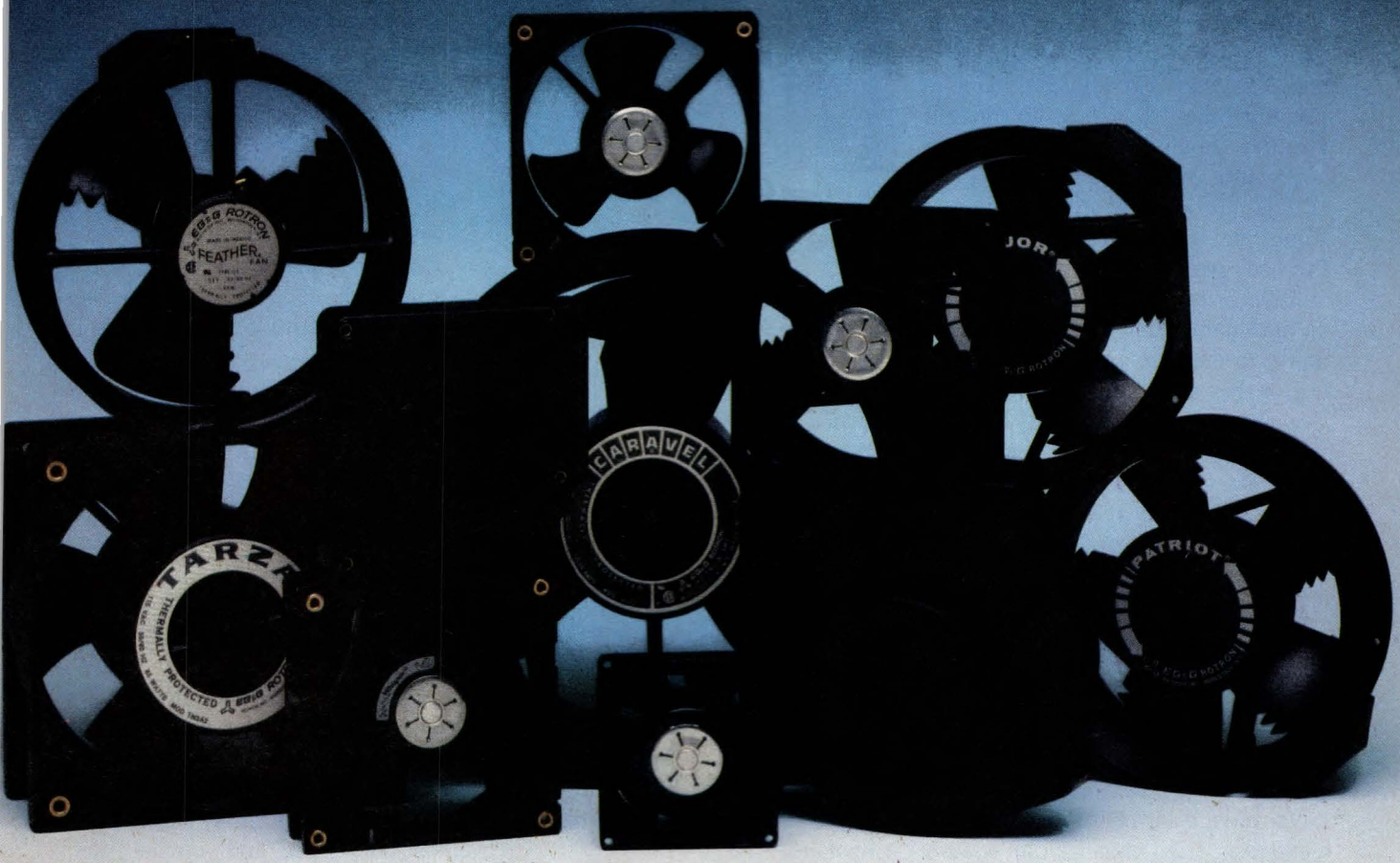
The American Association for the Advancement of Science (AAAS) provides two to three weeks of orientation for the IEEE Congressional fellows and for 35 or 40 other professionals from the "hard" and "soft" sciences. Once they've been schooled in the intricacies of life in the Capitol, the fellows are counseled in how to approach a US senator or representative about working with him or her. "One of the things AAAS coached us on is that you can be really unhappy working for somebody if you're a right-wing conservative and you wind up in the office of a left-wing liberal; you're going to be uncomfortable supporting most of the things he is supporting," says George Swetnam, an IEEE Congressional fellow who spent the past year as a legislative assistant to Senator Bill Bradley (D-NJ).

Swetnam, 47, specializes in command and control systems and communications at Mitre Corp in McLean, VA, and has done work on environmental pollution, solar energy, and urban transportation.

A close observer of Washington politics for many years, Swetnam was interested in witnessing federal decision making first hand. "I had a deep personal interest in Congress after living in the Washington suburbs for 15 years. You get to see Congress fairly close up, and it's a fascinating place. One of the reasons I chose a job on the personal staff of a member was that, for me, the member's office is where it's at; that's where the votes are and where the decisons are made, and I wanted to see how those decisions were influenced."

Swetnam has experienced "not one dull or boring day" during the past year. He has worked 50 hours a week, but only about 5% of his responsibilities have required an engineering background. "You don't come in here and do differential equations," he says. Swetnam was Bradley's troubleshooter in the areas of environment and transportation. His first responsibility was to be aware of any legislation in

Rotron. The Brand Name in Fans.



We at EG&G Rotron are more than a little pleased that several of our airmovers have become the standards by which all other fans for electronics are judged.

Our world-famous fans carry names like Muffin®, Sprite®, Whisper®, Feather®, and Caravel®. Hallmarks of excellence in concept, design and manufacture, these and Rotron's other AC and brushless DC fans are unequalled in reliability, long life and quality.

The fans we manufacture are often used as prototypes when designing forced air cooling. Our customers rely upon Rotron for the best in engineering know-how, testing, and customer service. And no other company offers Rotron's ability and willingness to customize fans for precise cooling needs.

As the world leader in fan technology for nearly forty years, we are constantly working to identify your future requirements, and to develop the fans that will fill those needs.

Contact us today. We'll send you detailed information on all of Rotron's brand name fans.

EG&G ROTRON

Commercial Division
ROTRON INC., SHOKAN, NEW YORK 12481
TEL: (914) 657-6661 TWX: 510-247-1941

For literature only, call (800) 431-6033.
In NYS and for product or technical assistance, call our Application Engineering Department at (914) 657-6661.

CIRCLE NO 186

either topic area and to know when it was scheduled for a committee vote or a floor vote. He would also tell Bradley what it meant nationally and what it meant to New Jersey, and which groups in the country supported and opposed it. If Bradley's office had received constituent mail on the legislation, Swetnam summarized what the constituents were saying. Finally, he made a recommendation on how he thought Bradley should vote.

Senator John Warner of Virginia is one of only three members of Congress with electrical-engineering backgrounds. Because of his activities in technological issues such as national security and energy, he has two engineering fellows working on his staff. Army Lt Col Guy Copeland, a research-and-development project manager, spent the past year working as an IEEE Congressional fellow in Warner's office.

Learning how Congress thinks

"My educational background was pretty good in understanding the viewpoint of industry and understanding the viewpoint of the government, at least the executive branch. But project managers, by the nature of the business these days, have a lot of interaction with Congress. I felt that I didn't have a good founding background in that area, so I applied for the fellowship," Copeland says.

Copeland spent much of his time studying issues of command and control, technology, and electronics for Warner, who is active in national security and foreign affairs. When the Armed Services Committee, of which Warner is a member, broke into working groups to examine the Department of Defense, Copeland represented Warner on a group studying procurement policies and helped draft the group's final report. Most of Copeland's contact with Warner occurred during informal meetings several times each week. But when Warner's legislative assistant for national security

Rep George Dean, a guidance and control engineer *at Beech Air Craft Co, addresses the Kansas State Legislature.*

entered the hospital during a critical period for the 1985 Defense Authorization Bill, Copeland pinch-hit and spent a great deal of time with Warner during the Senate hearings.

There "very definitely" is a role for engineers in the political process, Copeland says. While working in Warner's office, Copeland regularly received material from the Energy Committee of IEEE's Professional Activities Committees for Engineers (PACE). The group has been very effective in presenting its position papers on energy issues, he says. "There is definitely a role for the engineers. In fact, if anything, they're not active enough," says Copeland.

Joe Edminister is a former IEEE PACE chairman who spent the last year as a Congressional fellow working for Democrat Dennis Eckart, one of Ohio's 21 members in the House of Representatives. Edminister had known several Congressional fellows while serving as the PACE coordinator for his region, which included Washington, DC. When he opted for a career change last year after teaching electrical engineering at the University of Akron for 26 years, it seemed like the right opportunity to apply for a fellowship himself.

Edminister became interested in working for Eckart because of the representative's activity in environmental and energy issues. Eckart is a member of the House Energy and Commerce Committee, which recently passed a bill to safeguard drinking water from possible contamination by deteriorating underground storage tanks.

The switch from engineering to national politics required "playing catch-up ball," and, once he arrived in Washington, he spent many hours reading to educate himself on the workings of the government. "It's like total immersion," he says. "There are so many things about the federal government that, as engineers, we just don't know."

Most engineers don't realize that simply talking with their representatives is "a totally useless" effort, Edminister says. "You have to find out whether the congressman is in a position to do anything of any substance. That means he's got to be on the subcommittee where that legislation is being fashioned. Then you also have to be very timely, you have to be talking to his staff . . . He's got one person on his staff who will be the principal one to help guide the legislation and put the amendments on. If you want someone to know your position on a bill, you've got to get it in right there at the subcommittee level."

Time is the limited resource for most politicians, and you need clarity to make even a brief meeting with a legislator or a staff assistant work to your advantage. It's easy for professionals like engineers to lapse into technical jargon and weaken their presentation by inundating their representative with material. "You don't tell them everything you know," Edminister advises. "They don't want to know what you know. They only need to know . . . what it is you want and how it fits into the bill. It also helps if you let a congressman know how many engineers he's got in his own district. That catches his attention."

Ken McGowan, who has been involved in politics in Washington state for 10 years, educates engineers on how to avoid making these

Run INTEL software
and full-screen symbolic debugger
on your IBM-PC

- Get our complete development solution: compilers, assembler, linker, debuggers, and emulators for the entire 8086 family: 8086, 8087, 8088, 80186, . . .
- Run under MS-DOS with our GenePak®-PLM package, containing Intel's PLM86, ASM86, LINK86, LOC86, LIB86, and OH86. Options include PASCAL86, FORTRAN86, and C86. Or use the Intel software you already own.
- It takes less than 6 minutes to recompile a 1000-line PLM86 module and relink it with 34 others to regenerate a 40K program.
- Use GeneScope®, our interactive, fully symbolic debugger and emulator line. It features macros, help, on-line assembly, automatic disassembly and trace with scrolling, simultaneously supporting separate screens for debug and source-file viewing during one debug session. GeneScope is easier to use and faster than PSCOPE*, ICE-86*, and I²ICE*, loading 100K programs in under 15 seconds. Its powerful user interface runs in your PC, either connected to your target system with GeneProbe®, our full in-circuit emulator, or as a software-only debugger for programs in your PC or your target system.
- Use our PC ◄—► MDS datalink program to bring over your existing libraries or store back your new modules. It transfers files of any kind, in either direction.

Call us today.

Genesis™
Microsystems

196 Castro Street, Mountain View, CA 94041 (415) 964-9001

Genesis is a licensed OEM of Intel Corp.

*are Trademarks of Intel Corp.

INTERNATIONAL DISTRIBUTORS • Instrumatic: **Deutschland**—München, Tel. 89/85 20 63 • **España**—Madrid, Tel. 1/250 25 77—Malaga, Tel. 5/221 38 98 • **Schweiz**—Rueschlikon, Tel. 1/724 14 10—Geneve, Tel. 022/36 08 30 • **United Kingdom**—High Wycombe, Tel. 494 450 336 • **Israel**—Savyon: Micro-Bit, Tel. 03-380098 • **Japan**—Tokyo: Asahi Business Consultant Co., Tel (03) 543-3161; Showa System Laboratory, Tel. (03) 361-7131.

CIRCLE NO 187

Now . . . for the electronic industry executive who must have accurate, advance information to compete effectively . . .

ELECTRONIC BUSINESS FORECAST

A monthly newsletter from **Cahners Economics** and **Electronic Business** Magazine

Here's what you get:

- Reports and analyses of significant developments in top consuming markets for electronic components and products, with tips on new marketing opportunities.
- Updates on component price movements.
- Tracking and forecasts of every major electronic indicator.
- Forecasts of leadtimes for electronic components and products, plus recommendations of actions you should take as supplier or buyer.
- The unique and exclusive Consumer Electronic Index.
- Updates on the world market, including advice on the best competitive strategies.

The subscription price is only $22.25 a month, payable annually—just $267 per year.

FREE TRIAL OFFER

Return this coupon and we'll begin your no-obligation trial subscription. We'll send you the next two issues for your review, free. If not entirely satisfied, simply write "cancel" on the special offer form. You will owe nothing, and the two issues will be yours to keep. But, if you wish to become a subscriber, return the offer form with your payment. As a bonus, we'll send you the new Report, **A GUIDE TO THE ELECTRONICS MARKET: CURRENT STATUS & FUTURE TRENDS**, free.

Mail this coupon to:

Electronic Business Forecast
P.O. Box 716, Back Bay Annex,
Boston, MA 02117

☐ Yes, I wish to begin a trial subscription to **Electronic Business Forecast.**
☐ My check or money order is enclosed, please send the Special Report right away.

Name

Title

Firm

Address

City

State Zip

PROFESSIONAL ISSUES

For more information . . .

"The Engineer in Politics: The IEEE and State Legislative Activity" is a 26-pg publication with information on how to form a State Intersociety Legislative Advisory (SILA) group. It discusses a recommended organizational structure, legislative planning matrix, forms for rating bills and assigning priorities, and other support documents. For more information on forming an SILA or to request a copy of the booklet, contact Ken McGowan, Coffman Engineering, 1021 112th Ave NE, Bellevue, WA 98004; phone (206) 453-8092 or (206) 643-6560.

mistakes. McGowan is IEEE's PACE government-action facilitator and the vanguard of the IEEE's efforts to organize legislative action groups in each state.

McGowan is a representative to the Architects and Engineers Legislative Council (AELC), an intersociety organization that monitors state legislation pertaining to high-technology, taxation, environmental, and energy issues. AELC representatives meet once each week when the legislature is in session and once every other week when the legislators have adjourned. They retain a full-time lobbyist who sifts through the approximately 4000 proposed bills and selects 300 or 400 bills for the group to review. The group has a 100% success rate on bills they take priority on.

McGowan hopes to encourage other IEEE members to consolidate their state legislative efforts by forming State Intersociety Legislative Advisory groups (SILAs), using the AELC as a prototype. It's much more effective, he says, for the IEEE to "consolidate its efforts with the other technical and professional organizations to perform this technical input and review legislation. When you go down to the legislature and say that you represent 10,000 engineers that are concerned about energy issues, it's kind of like EF Hutton is talking. People stand back and listen."

In addition to their regular meetings, AELC members appear at caucuses and fund raisers. On the basis of the group's success in the last few years, McGowan has taken more of an interest in the political process. "Engineers by nature tend to be conservative," he says. "Even on the national level, they've been one of the last learned professions to become experienced on the [Capitol] Hill...They've begun to realize they have to become a part of the solution to life's problems, particularly now that we're in a high-tech phase of development."

Swetnam's time on Capitol Hill was more than just an interesting way to spend a year. "The fellowship experience has sensitized me both to political issues and to professional ones," he says. "And I hope that I can do more in both those areas." He predicts his Congressional experience will make him a better consultant when he returns to Mitre. "My 15 years of experience have been with a variety of federal agencies. I've always seen the government from the executive-branch point of view. My belief is that most executive-branch agencies don't really understand the way Congress thinks. I knew I didn't, and most of the people I had advised didn't. I felt that if I could see that interface —the executive/legislative interface —from the other side, when I went back to consulting I'd be a better consultant. And I think that's going to be true." **EDN**

Section Interest Quotient
(Circle One)
High 518 Medium 519 Low 520

528 WAYS TO SHINE.

HERE'S VIRTUALLY EVERYTHING YOU NEED TO BRING YOUR BEST IDEAS TO LIGHT.

A full spectrum of products.

Active semiconductor devices and passive fiber optics components. Connectors. Data links. Even gas lasers. Both air-cooled Argon-Ion and Helium-Neon types.

All from NEC.

And you thought we were only a leader in semiconductors.

In fact, we've been in the business of light transmission for over 15 years.

Light years ahead.

Today, NEC is creating even better, faster, more reliable ways to move information at the speed of light. So you can build the systems and products that people need now. And for the future.

Products like high-capacity, long-distance, single-mode telecommunications systems. Short-haul, low-cost networks. Laser printers, scanners and optical memory systems. More precise alignment equipment. Plus countless other marketable ideas.

Like the one you have in mind.

Where to find the light.

For more information about our complete line of opto-electronic products, call us toll-free at 1-800-556-1234, ext. 188. In California, call 1-800-441-2345, ext. 188.

Because in light of all this, why would you call anyone else?

WE'RE TAKING ON THE FUTURE.

CIRCLE NO 188

©1984, NEC Electronics Inc.

NEC

NEC Electronics Inc.

CAREER OPPORTUNITIES

FEDERAL EXPRESS

TECHNICAL ADVISOR PRODUCT SPECIFICATION

Federal Express has opportunities for you to work with our absolutely, positively, incredible technology. Rapid growth of our Electronic Products Division has created the need for a Technical Advisor - Product Specification.

You will be responsible for conceiving, defining, and developing technical specifications and operational procedures for new electronic communication products and services; assessing state-of-the-art technologies and coordinating new product specifications with technology specialists and external hardware/software vendors. A Bachelor's degree in Electrical or Electronic Engineering, Math, Physics or Computer Science and seven years professional experience in technical development of electronic information products and services is required. MBA, project management and international experience is preferred.

This is your opportunity to work with a company on the leading edge of high technology. Federal Express offers a highly competitive benefits package. Please rush a letter indicating your experience and salary history. (Include your resume if you have one.)

FEDERAL EXPRESS CORPORATION
Electronic Products Division
P.O. Box 727, Dept. 3514-430
Memphis, TN 38194

Equal Opportunity Employer M/F

EDN's Recruitment Team...

Roberta Renard
Nat'l Recruitment Sales Manager
212-576-8048

Jennifer Purinton
East Coast Recruitment Sales Manager
212-576-8049

Brenda Stillman
West Coast Recruitment Sales Manager
213-826-5818

Call your nearest **EDN** Sales Representative today, to reserve space.

NATIONWIDE
ELECTRONICS

Positions Available
Technical Placement Specialists

HARDWARE • SOFTWARE
SYSTEMS • COMPONENTS

Serving Industry for 12 years.

Alexander & Associates Inc.

P.O. Box 30, Elkhart, IN 46515
(219) 264-9629

RF PRODUCT DEVELOPMENT ENGINEER

Phonic Ear Inc. is an electronics company located in beautiful Marin County, just north of San Francisco. We have been developing and manufacturing electronic devices for the speech and hearing impaired for the past 20 years. We employ 200 people worldwide and offer excellent salary and benefits.

If you have experience in FM communications and enjoy working with radio projects, we may have a position for you on our technical staff. This is an exciting opportunity to work with state-of-the-art sophisticated products and equipment and to use your FM expertise to help hearing impaired children function in a normal society.

If you are interested in this rewarding opportunity, please send your resume to the Personnel Manager at:

Phonic Ear

250 Camino Alto / Mill Valley, California 94941

ENGINEERS
Software, Hardware & QA

Do You Qualify?

We have more jobs than we can fill for graduate engineers with experience in the computer, communications, aerospace and military electronics fields. Many U.S. locations. Interview, relocation and agency fee paid by companies. Send resume & latest salary or call for confidential application...toll free, 7 days/24 hours. (800) 523-2906, in PA (215) 735-4908.

A.L. Krasnow, (USNA, MIT)
Electronics Department
Atomic Personnel, Inc.
Suite P-4, 1518 Walnut
Philadelphia, PA 19102

Engineers Helping Engineers since 1959

ENGINEERS, DESIGNERS, EDP SPECIALISTS, MANUFACTURING MANAGERS

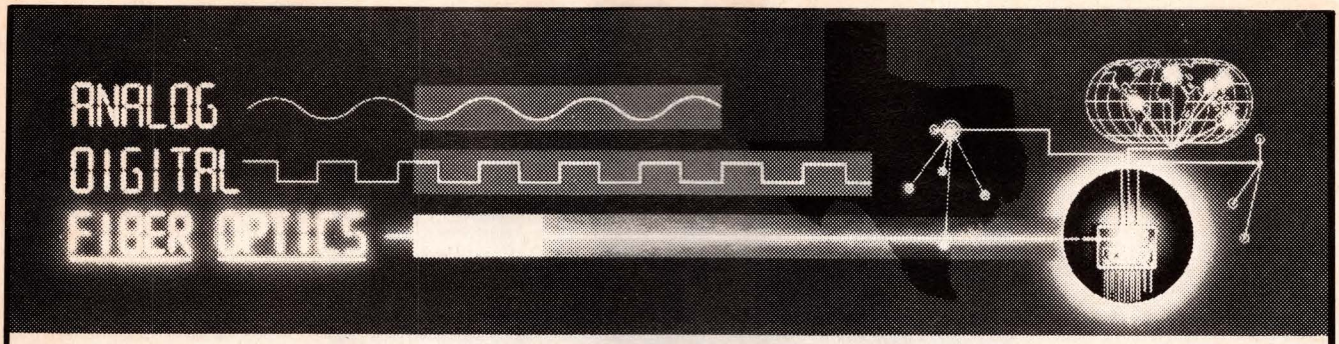
We bring great people (like you) and great companies together. Tap our NATIONAL contacts, job listings and resources for your best career move. ALL FEES COMPANY PAID. Call (616) 458-1817... or send your resume, in confidence to:

BARMAN PERSONNEL
Suite 544-G, Trust Building • Grand Rapids, MI 49503

Sunbelt and Nationwide
ENGINEERING PROFESSIONALS
Design Software Hardware

Send Resume with Current Salary or Call
800-845-0436 (toll free) **803-572-3000** (in S.C.)

Technical Careers
2162 Credit Union Lane, Suite 504, Dept. B
N. Charleston, SC 29418
All Fees Paid By Client Companies



Telecommunications

Technology. Strength. Leadership.

Our Organization is Your Opportunity

Today, technology is not enough.
In our high-tech business climate, success requires strategic marketing and a balanced organization. At Rockwell International's **Collins Transmission Systems Division in Dallas, Texas,** the balance of our technology, business strength and tradition of strategic leadership has been a key to our growth. As the largest independent supplier of telecommunications transmission systems, our products span the spectrum from "DC to light." With 30 years of experience behind us, we're organized, ready and qualified to meet today's and tomorrow's industry challenges.

Collins Transmission Systems Division is a leading supplier to the telephone, other common carrier, private, industrial and international markets. We are noted for our business-oriented management, aggressive research and development activities, quality products and timely product introductions.

Organization. It's part of our success. It can also be part of your own advancement. Join us today in Dallas, Texas-one of the fastest growing high-tech centers in the Sunbelt. We have opportunities for your talents in advanced analog, digital and fiber optics:

Analog

Analog Product Administration
BSEE with minimum 8 years experience in microwave systems engineering and analog R&D design. Position involves monitoring the analog transmission product line, conducting competitor product analysis and long range product planning.

Digital

Gigabit Circuit Design
BSEE with minimum 6-8 years experience in ultra-high frequency digital logic design. Must be familiar with ECL/gigabit logic (500 Mb/s to 2 Gb), LSI/VLSI design, semiconductor device applications, GaAs, gate arrays and PCM.

Advanced RF Design
PhD/MSEE with minimum 6-8 years experience in 4-26 GHz RF component design. Knowledge of GaAs amplifiers, GaAs FET's, DRO's, GUNN's and microwave monolithic integrated circuits required. Record of scientific accomplishment and publication desired.

Signal Processing Hardware Design
MSEE/BSEE with minimum 4 years experience in digital signal processing design. Requires knowledge of digital filtering, multiplex voice processing, signal processing between time and frequency domains and error detection methods.

Microprocessor Software Design
BSEE with minimum 2-4 years experience in telecommunication software design. Knowledge of 6800/68000 family microprocessors, assembly language and higher languages such as C or PASCAL required.

Fiber Optics

Lightwave Product Administration
PhD/MSEE with minimum 4-6 years experience in lightwave or digital product planning, local area network applications and telecommunication networks.

Lightwave Component Design
MSEE/Physics and minimum 2-4 years experience in optical light sources, optical detectors, and wave division multiplex. Knowledge of guided wave optics, coherent wave optics, classical optics, optical alignment, lens and mirrors required. Position involves the design, test and measurement of WDM, laser diode to fiber couplings and optical attenuators.

Transmitter & Receiver Design
MSEE with minimum 4-6 years experience in lightwave transmitter and receiver design. Requires knowledge of UHF analog and digital circuits , optical hybrids, and modulation and detection techniques. Experience with IC technology desirable.

Lightwave System Design
BS/MSEE with minimum 4 years experience in low or high capacity transmission product design. Positions involve defining system requirements, circuits design and module development. Position requires knowledge of digital signal processing, gate arrays, PCM's, optoelectronic device interface and analog/digital circuit design theory.

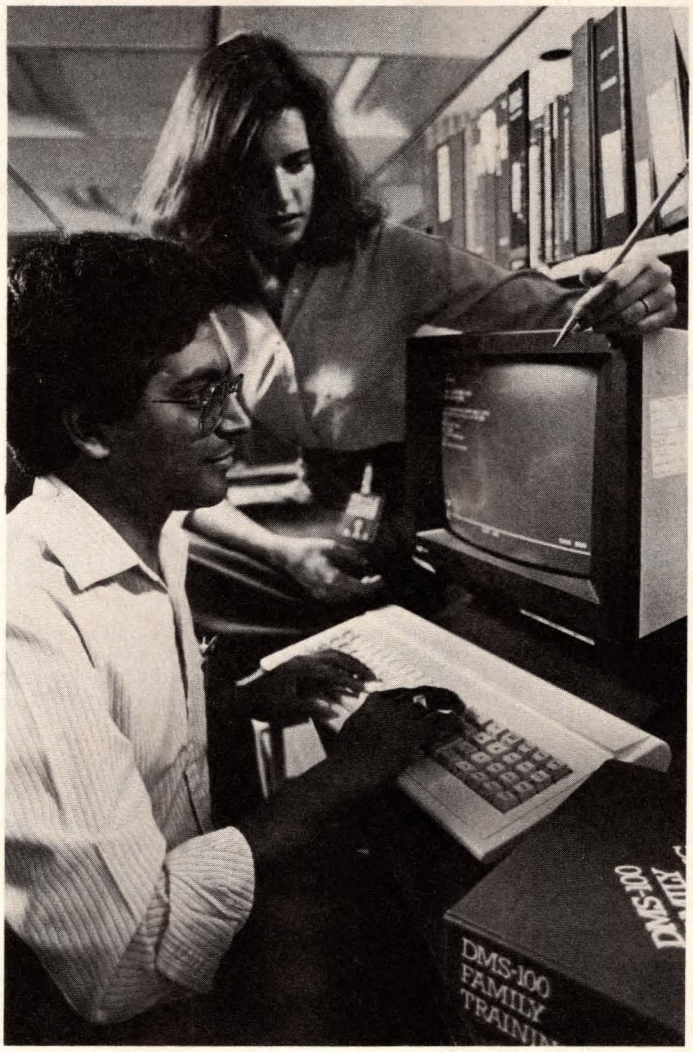
Light Source Design
PhD/MSEE/Physics and 4-6 years experience in 1.3-1.5 micron single mode semiconductor laser design. Experience in LPE/MOCVD, LED's, indium phosphite compounds, or DFB/EFB lasers desired.

As you would expect from an industry leader, Collins Transmission Systems Division offers an excellent salary and benefits package and **no state income tax.** If you are interested in advancing with an organization that's intact and prepared for the future, send your resume without delay to: **Professional Staffing, Rockwell International, Collins Transmission Systems Division, M/S 401-152, #8340, P.O. Box 10462, Dallas, Texas 75207.** Permanent residency required. An equal opportunity employer.

Rockwell International

. . . where science gets down to business

THE TECHNOLOGY INNOVATORS



Product Integrity Engineers
Ann Arbor, Michigan

BNR, a subsidiary of Northern Telecom, is one of North America's leading telecommunications research and development organizations. The current rapidly changing technologies of our industry have created career positions for Engineers in the Product Integrity area.

Positions now available in the office switching and mass memories/terminal group offer an exciting opportunity to participate in development of integrated voice and data office systems.

These challenging opportunities require a minimum of three years' experience in analog/digital circuit design and analysis. Experience in product testing, components and reliability engineering would be an asset.

BNR is located in Ann Arbor, Michigan, just 45 minutes west of Detroit. Ann Arbor is a unique and charming city, offering year-round recreational and cultural activities, and home of the University of Michigan.

We intend to meet the changing needs of business communications throughout the 1980s and beyond. The future of our industry is filled with exciting challenges for experienced and creative professionals.

Qualified applicants may forward a resume, including salary history, in confidence, to: BNR/Carolyn Williams/P.O. Box D/100 Phoenix Drive/Ann Arbor, MI 48104. An Equal Opportunity Employer M/F/V/H.

BNR

BNR is located in Ann Arbor, MI, Mountain View, CA, Richardson, TX, and Research Triangle Park, NC.

Engineers

Helicopter Avionics

If you want to be where the technology and environment are state-of-the-art and where there's room for your ideas, then make your move to Sperry's Flight Systems group here in Albuquerque. Our defense operation is designing some of the world's most sophisticated avionics systems for the advanced aircraft that are breaking technology barriers. You can be part of our elite team. We have career opportunities with:

• Analog/Digital Design

Our customized multiplex units interface with the vehicle avionics, radios and sensors. Current designs are Z8002 based with design efforts towards the 1750 microprocessor. The conversion between the vehicle subsystems and the 1553 bus offers many design challenges, both analog and digital.

• Software Development

Software development is a team effort minimizing hardware needs and maximizing system performance and capabilities. Programming needs are for flight software and test.

• Product/Test Engineering

The product engineer must ensure a smooth transition from development into production to ensure on-time deliveries to customers. Automated test equipment is a must for today's sophisticated equipment.

We require a BSEE degree and two or more years experience in one of the following areas: systems/human factors design, software development, analog/digital circuit design, including microprocessor-based systems, 1553B bus architecture and data processing.

• Systems/Human Factors

Get involved in the latest CRT cockpit display designs. Our experience on the AH-64, AV-8B, AHIP, ADAS, HH-60D provides the base for many new exciting programs.

We also have openings in the following areas:

- **Flight Controls**
- **Power Supply Design**
- **CRT Display Design**
- **Reliability/Components**
- **Electronic Packaging**
- **ATE Hardware Design**

Join us...

...In Albuquerque, where you'll find the people pleasant and hospitable, the culture thought-provoking, the scenery inspiring and the wide variety of recreation exciting.

We have a comprehensive benefits package and offer competitive salaries. If you have the talent we're looking for, send your resume right away with salary requirement, in confidence, to Brandon Harwood (EDN-530-B), Sperry Corporation, P.O. 9200, Albuquerque, NM 87119.

SPERRY

Equal Employment Opportunity/Affirmative Action Employer.
U.S. citizenship required.

HIGH TECHNOLOGY CAREER OPPORTUNITIES

Systems Research Laboratories, Inc., is a 30-year-old R&D company. We're a growing company, and because of our continued expansion we have these professional career opportunities available:

Principal R&M Engineer — Lead the corporate R&M efforts. 5-8 years working knowledge of MIL-SPECS 217, 756, 790, 470 & 472. History of successful R&M program development and implementation is a must.

Analog/Video Engineer — Experience designing complex systems, flight training simulators, electro-optic systems and high resolution display systems.

Managers of Systems Engineering — 10 or more years of experience in logic design, digital systems design and digital signal processing. Current experience in Radar, Avionics, EW, ELINT/SIGINT.

Sr. Electrical Engineer — 5 years diverse experience in such areas as computer interfacing, software, circuit design, electro-optics, displays and video circuitry.

Project Engineers — 2 or more years experience in project management in an area of government electronics systems; previous analog and digital design experience.

Quality Assurance Engineers — 3 or more years current experience in QA/QC with government electronics systems.

Digital Design Engineers — 3 or more years experience designing digital signal processors, digitally controlled receivers, radar video scan converters, real-time graphic display systems.

Anechoic Chamber Engineers — 3 or more years experience in analog and digital circuit design for real-time ECM/radar simulation chamber: the second largest in the nation.

Scientific Programmers and Scientific Systems Analysts — Multiple opportunities available for individuals with experience in scientific real-time environment. Includes math modeling, simulation and analysis on minicomputers and microprocessors.

Investigate a high technology career position with us. We offer competitive salaries based on experience, comprehensive benefits, advancement opportunities, and a working atmosphere that encourages personal responsibility in a high technology environment. If you are unable to see us in Phoenix, please send your resume in confidence to A. J. Davis, SRL Human Resources Department.

E.O.E./M.F.V.H.
Principals only

SYSTEMS RESEARCH LABORATORIES, INC.
2800 INDIAN RIPPLE ROAD, DAYTON, OHIO 45440-3696 • (513) 426-6000

ADVERTISERS INDEX

Acopian Corp 76
Advanced Digital Corp 278
Advanced Micro Devices 56-57, 228-229
AETA Corp 280
AMCC 271
American Photonics 152
AMP Inc 134-135
Ampex 100-101
Amphenol Products, An Allied Co 89
Ampro 318
Ando Electric Co Ltd 330
Applied Microsystems Inc 290
AP Products 323
Aptek Microsystems 312
Astrosystems Inc 273
Austron Inc 264
John Bell Engineering 332
BICC-Vero Electronics Inc 95
Bishop Graphics Inc 333
Bodine Electric Co 248
Boeing Aerospace 307
Borg Warner Chemicals 288-289
B V Engineering 333
Cable Systems Inc 253
Cadnetix Corp 178-179
CAE Systems Inc 112-113
Cahners Exposition Group 315
California Instruments 272
Calma GE 97-99
Chabin Corp 106-107
Chomerics Inc 190
Comlinear Corp 301
Communications Instruments 309
Connecticut Microcomputer 334
Control Data Corp 241, 243
Corning Glass 260
Crane Associates 287
Creative Microsystems 333
CTS Corp 155
Dash, Straus and Goodhue 334
Data I/O C2
Datel 195
Datron 329
Dialight Corp 266-267
Digital Signal Processing Software 115
Dynamic Measurements Inc 194
Dynamic Research Corp 298
Eagle Magnetic 333
Ebm Industries 333
E G & G Reticon 45
E G & G Rotron 341
Electronic Solutions 161
Electronic Technology Corp 103
Electro-Metrics 259
Electronic Systems Products 285
Electro Switch Corp 300
Elmwood Sensors 335
Encoder Products 152
ETI Systems 332
Everett/Charles Inc 333
Fairchild Digital 153, 275
Fairchild Memory and High Speed Logic 102
Fairchild Test Systems 268
Ferroxcube 299
John Fluke Mfg Co Inc 6
Fujitsu Microelectronics Inc* 49
Genesis Micro Systems 343
Glassman High Voltage Inc 254
Glenair Inc 287
Gould Inc, Design & Test Div 12-13
Gulton Industries Inc 154
Hameg Inc 316
Harbor Electronics Inc 308
Harris Semiconductor 208-209, 311
Heurikon 333
Hewlett-Packard Co 65, 92, 182, 220-221
Hirose Electric USA 322
Hitachi America Ltd* 8-9
Hughes Connecting Devices 104
Humphrey Inc 332
Huntsville Microsystems 282
Hybrid Systems 338
ILC Data Device 261
Inductive Products 318
Inmos Corp 52-53
Intel Corp 262
Intel-Micro 163-165
Interdesign Inc 257
International Instruments 306
International Microelectronic Products 74-75
International Rectifier 90
Introl 333
Keithley Instruments Inc 114, 302
Keithley Scientific Products 281
Kepco Inc 284
Kikusui International Corp 320
Krohn-Hite Corp 34
Lambda Electronics Corp* 35-44
Leader Instruments Corp 14
Lectromagnetics 202
Leecraft Manufacturing Co Inc 331
Lemo USA 324, 333
Lightwave Communication 72
Loctite Corp 214A-B
Logical Systems 334
LSI Logic Corp 138
3M Commercial Chemicals 32-33
3M Electro Products 305
Marconi ATE 136-137
Matra Harris Semiconductor** 50-51
Matsushita Electric Trading Co Ltd** 76
McGill Electrical Div 237
Mega Systems Inc 331
Meridian Systems 332
Methode 331
Micromint 202
Microtek Lab 131
Miller Technology 334
Mini-Circuits Laboratories 16, 22-23, 54, 235
Mitsubishi 15
M K Hansen 331
Molex 354
Mostek 196
Motorola Inc** 314A-B
Motorola Semiconductor Products Inc 50-51, 77-78 180-181, 191-193
National Instrument 96
National Semiconductor C2, 10-11, 230-231
NEC Corp* 293
NEC Electronics 345
Nicolet Instrument Corp/Oscilloscope Div 283
Nicolet Paratronics Corp 21
NJE 46
Oki Semiconductor 276-277
Olivetti OPE** 60
Omega Engineering Inc 331
Otto Controls 260
Panasonic* 60
Philips Elcoma** 48-49
Philips Science & Industries** 293
Pioneer Standard Electric 28-29
Pittman Corp 273
Plessey Microsystems 177
Power One 265
Precision Filters Inc 296, 297
Precision Monolithics Inc 69, 71, 72, 73
Pro-Log Corp 4
PTS Communications 151
Quantum Data Corp 310,332
Quelo 332
RCA-DCP 167
Rockwell International 218-219
Rogers Corp 332
SBE Inc 232
Seeq Technology Inc 244-245
Sencore 204, 205-206
SGS-Italy** 8-9
SGS/ATES Group of Companies 180-181
Siemens Corp* 111
Silicon Systems 294-295
S-MOS 319
Solarex 108
Solitron 286
Solitron Devices Inc 274
Sprague Electric Co 109, 156
Sprague-Goodman Electronics 280
Stantel/STC 250
Step Engineering 129
Symbex 252
Tadiran C3
TDK Corp of America 334
Tektronix Inc 62, 30-31, 203, 226-227, 255
Teledyne Solid State 332
Teradyne Corp 58-59
Texas Instruments Inc 24-25
Toshiba America 214-215
TRW/Capacitors 337
TRW/EIS 48
TRW/LSI Products 19
Tusonix Inc 327
US Instrument Rentals 67
Vaild Logic 222-223
Valley Data Sciences 168
Vanwell Corp 249
Wandel & Goltermann** 111
Waters Mfg 263
Wavetek San Diego 3
Welch Allyn Inc 304, 306
Wintek Corp 47, 334
Xycom Inc 166
Zax Corp 326
Zendex Corp 72
Zilog Inc 26-27, 216-217
Zytrex Corp 224-225

*Advertiser in US edition
**Advertiser in International edition

This index is provided as an additional service. The publisher does not assume any liability for errors or omissions.

MARKET FORECASTS

Impact of Technology Trends on Workstations (#1520). $1500; Strategic Inc, Box 2150, Cupertino, CA 95015.

This market study analyzes current issues and the future impact of new technologies on the workstation market. It deals with all aspects of workstation development and the effects on software and packaging.

Micro/Minicomputer Power Equipment (#1322). 193 pgs; $1500; Frost & Sullivan Inc, 106 Fulton St, New York, NY 10038.

The increased use of computers in daily life has escalated the demand for protection from electrical power disturbance. This report forecasts the market for power-conditioning equipment for micro and minicomputers and computer-based equipment. It offers a technology overview, describes the equipment and its uses, and looks at market trends and manufacturer strategies in the industry.

The Personal Robot Market (#615). 255 pgs; $1650; International Resource Development Inc, 6 Prowitt St, Norwalk, CT 06855.

This extensive study of the present state and future growth of the US market for personal robots includes 10-year forecasts for personal robotics in the education, home, industry and commerce, medical, and hobby markets. It profiles key vendors and their products and examines opportunities for growth in the market.

Trends and Opportunities in Fourth-Generation Languages. $750; Input, 1943 Landings Dr, Mt View, CA 94043.

Fourth-generation languages have aroused vendors' interest because they promise to increase employee productivity and lessen software development backlogs. This report analyzes the market for fourth-generation languages and examines how the languages are used, their impact on organizations, and their strengths and weaknesses. The report provides a 5-year forecast detailing fourth-generation-language growth in related industries.

Henderson Electronic Market Forecast. $750 per year; Henderson Ventures, 101 First St, Suite 444, Los Altos, CA 94022.

The August issue of this monthly publication highlights the major applications for GaAs semiconductors and provides a comprehensive forecast of the market for the next five years. The report emphasizes the difficulties passive-component manufacturers will face because of the rapid growth of the GaAs market.

Telecom Bypass Markets (#612). 193 pgs; $985; International Resource Development Inc, 6 Prowitt St, Norwalk, CT 06855.

This report analyzes the growth of the telecom-bypass market and gives 10-year forecasts for the industry. It also describes the available technologies, including cable TV, digital termination systems, private microwave, satellite communications, and other local-loop alternatives.

Laser Market Opportunities (#606). 206 pgs; $1285; International Resource Development Inc, 6 Prowitt St, Norwalk, CT 06855.

This analysis probes the governmental and commercial segments of the laser market for likely applications and discusses basic laser technology. In addition, it examines the market and industry structure and provides the reader with 10-year forecasts in each area.

Future Skills Requirements for Software Development. $750; Input, 1943 Landings Drive, Mt View, CA 94043.

The increasing need for humanistic as well as technological training in the field of systems analysis makes this a timely report for design managers in information systems. The report forecasts the development of the software environment and predicts the types of software skills that corporations will need to have in their information systems departments in the next few years.

Market for Add-on Boards, Systems & Equipment for the IBM PC. 241 pgs; $1850; International Resource Development Inc, 6 Prowitt St, Norwalk, CT 06855.

Along with a complete review of IBM's personal computers and a listing of present and potential suppliers, this report assesses the market for add-on printers, storage devices, displays, communications products, input equipment, and boards. A 10-year market-growth forecast is provided for each area.

Large-Scale Systems Directions: Mid-Year Update-1984. $750; Input, 1943 Landings Dr, Mt View, CA 94043.

This report analyzes IBM mainframe hardware and provides residual-value forecasts for the next five years. It delves into the large-scale systems strategies of IBM, Amdahl, and NAS. Questions about the future use of large mainframes are discussed in depth. Forecasts to 1989 are also included.

The Optical Memory Report, 1984 Edition. 372 pgs; $1995; Rothchild Consultants, Box 14817, San Francisco, CA 94114.

This report includes market forecasts to 1990 on the US market for optical storage products and presents information on the products and their technology and marketing. It lists manufacturers and their products and specifications, prices, shipments, and development projects.

LOOKING AHEAD

Edited by Joanne Clay

Computer-keyboard sales to total $769 million in 1987

Computer and business-equipment manufacturers will continue to be the principal consumers of keyboards in 1987, accounting for 63.8% of a projected $769 million market. Keyboard sales in 1982 reached $282.9 million; computer and business-equipment makers reportedly accounted for $180.5 million of that total and the same 63.8% of the market, according to Venture Development Corp, a Wellesley, MA market-research firm.

The next largest market for computer keyboards is in instrumentation applications. But instrumentation manufacturers will have different keyboard needs from those of computer and business-equipment manufacturers. Keyboard manufacturers with an understanding of the diverse needs of keyboard consumers will be well positioned to offer products appropriate for the different markets.

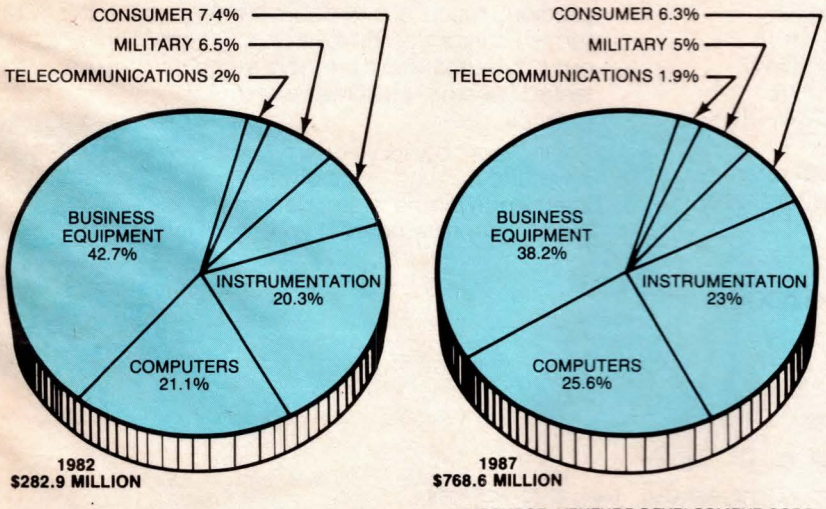
In the computer and business-equipment segment, for instance, OEMs who purchase keyboards for use in high-growth products are looking for keyboard manufacturers who can fill large orders. They're also paying attention to ergonomic considerations: They want to maximize productivity with office-automation keyboards that are comfortable and easy to use.

Another design consideration is the appearance of the keyboard: Consumers will seek the sophisticated, high-technology appearance associated with a smaller, lighter keyboard. Business-equipment consumers will be concerned with environmental considerations, too. For most applications they'll require a keyboard impervious to liquid spills, but some consumers will also be looking for resistance to chemicals and grease. Switch coverings to prevent pencil punctures will be important to many buyers.

The market will also see an increase in demand for user-definable function keys in business and computer keyboards. Users of electronic cash registers, for instance, are increasingly requesting dummy keys by which they can add their own classifications or new departments. Finally, business keyboard consumers indicate almost no demand for keyboard lighting except for the shift-lock light on some alphanumeric terminals.

Significant opportunities for growth also exist in sales of keyboards to instrumentation manufacturers. Their share of the market is expected to rise from 1982's 20% to 23% in 1987—from $57.4 million to $177.2 million. Instrumentation products include such tools as process- and factory-control devices, medical instrumentation, and test and measurement devices.

SHIPMENTS OF KEYBOARD BY INDUSTRY SEGMENT



(SOURCE: VENTURE DEVELOPMENT CORP)

Programmable controllers to invade process control

Annual shipments of batch-control systems based on programmable controllers will more than triple in the next seven years, according to Venture Development Corp, a management consulting firm based in Wellesley, MA. Currently at $70.5 million per year, total sales are expected to climb to $214.9 million by 1990.

Shipments of programmable-controller-based systems are expected to increase at the rate of 17.3% per year, while the average growth rate of all batch systems will be 12.4%.

VDC attributes the rapid growth of programmable controllers in the batch-process-control market to several factors. Principally, the major manufacturers of programmable controllers also offer complete integrated control systems that include communications networks, an operator interface and the ability to perform regulatory control. Also, programmable-controller-based systems cost less than distributed or centralized systems.

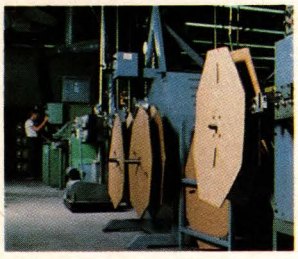
The biggest markets for these batch systems are the pharmaceutical and food and beverage industries, and programmable controllers are suited to the simple, straightforward applications in these environments. Also, because these industries are not highly automated at present, they offer a great opportunity for the future growth of the market for systems based on programmable controllers.

Molex cable: Our best kept secret is out!

.050"Foil Shielded/ Foil Ground Plane Cable with zip-lines for fast, easy jacket removal.

.100" and .156" Poly-shield Cable. The unique shielding can be stripped in one simple step.

.050", .098" (2,0mm), .100" and .156" PVC insulated ribbon cable. Available with solid, stranded and top-coated conductors.



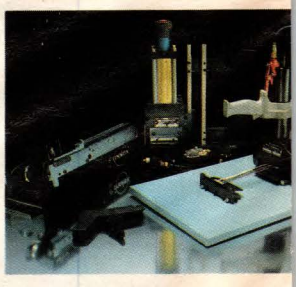
The word is out. Molex now makes over 20 types of planar cable on .050", .098" (2,0mm), .100" and .156" centers. Today our growing line of cable products extends from solid and stranded-conductor flat cable to our latest foil shielded cable for longer distance, high frequency EMI/RFI shielding applications. All are available in bulk quantities for the high volume cable user.

To accompany these cable products, Molex also offers a broad range of compatible connector products and application tools.

Molex has long been a leader in the manufacture of interconnection systems. Our combined cable, connector and application tooling capabilities means that Molex can b your single source for a perfectly compatible interconnecti system.

Moreover, for customers who wish to avoid committing precious resources to cable harness assembly, Molex can furnish custom assemblies to your exact specifications. Wit our fully automatic assembly machines, we can give you tested assemblies at the lowest possible price.

To find out how Molex can lower the applied costs of your interconnection system, contact the Molex office nearest you.



Service to the Customer ...Worldwide

molex

Corporate Headquarters: 2222 Wellington Ct., Lisle, IL 60532 Phone: (312) 969-4550 Telex: 27-0072/25-4069
European Headquarters: Molex House, Church Lane East, Aldershot, Hants, England GU113ST Phone: 252318221 Telex: 851-858988
Far Eastern Headquarters: 5-4, 1-Chome, Fukami-Higashi, Yamato-Shi, Kanagawa Pref., Japan 242 Phone: 462-614500 Telex; 781-03872486

CIRCLE NO 192

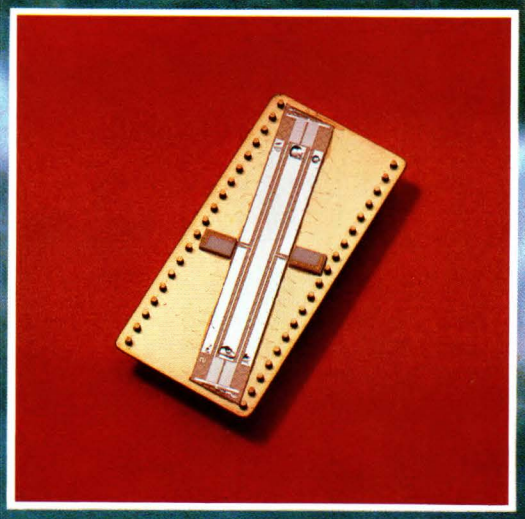
We've been making waves since 1977

Tadiran makes surface acoustic wave devices, SAW to its friends, for the componental requirements of a wide variety of Tadiran systems and equipment... and that's not all. Tadiran can also produce the SAW device you want, to meet your particular specifications, quantities needed and delivery deadlines.

Tadiran can offer SAW devices for analog signal processing at frequencies from 10-1000 MHz with 0,1-40% fractional bandwidth.

Tadiran's SAW family includes:

- □ Bandpass Filters
- □ Vestigial Sideband Filters
- □ Delay Lines
- □ Chirp Compressors/Expanders
- □ Phase Coded Matched Filters
- □ Monolithic Convolvers



TADIRAN
(UNITED STATES) INC.
350 5th Ave., New York N.Y. 10018, U.S.A. Telephone: 212-947-4600
201 Timberview Drive, Lewisville TX 75067, U.S.A. Telephone: 817-430-1650
6312 Variel Ave., Suite 203, Woodland Hills, CA 91367, U.S.A. Telephone: 213-884-3884 or 213-884-3885 TLX W.U. 67-4842

TADIRAN
ISRAEL ELECTRONICS INDUSTRIES LTD
11, Ben-Gurion Street, Givat-Shmuel, P.O.B. 648, Tel-Aviv 61006, Israel, Telex: 341692

CIRCLE NO 80

150 LOGICAL CHOICES.

ONE LOGIC PROGRAMMER.

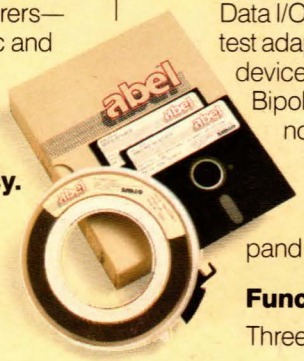
When it comes to choosing the right programmable logic device for the right job, you should be the one to choose. Not your logic programmer.

That's why Data I/O's Programmable Logic Development System now supports more than 150 different logic devices from more than seven different semiconductor manufacturers—including the new CMOS logic and 32R16 Mega PALs®.

That's what we call choice. And you call freedom.

Logic design made easy.

Taking advantage of programmable logic has never been easier, especially with ABEL™, Data I/O's high-level design language.



ABEL turns your IBM® PC or VAX™ into a powerful logic design center, letting you express your designs in Boolean equations, truth tables, state diagrams or any combination . . . whatever works for you.

Full-support options.

Data I/O PLDS programming/test adapters give you many device support choices. Bipolar, CMOS, new technologies and packages, PAL or IFL—you choose what you need today and expand support tomorrow.

Functional testing.

Three-step testing ensures your programmed devices are functioning correctly. An automatic fuse verify confirms all fuses have been programmed as specified. A structured vectors test compares actual device output with expected results. And Data I/O's unique Logic Fingerprint™ test compares signatures of newly programmed logic devices with those of known-good masters.

Call toll-free 1-800-426-1045 for a demo or details.

If you're an engineer who likes to make choices, make your first choice a Data I/O.

ABEL™ and Logic Fingerprint™ are trademarks of Data I/O Corporation, and VAX of Digital Equipment Corporation. IBM is a registered trademark of International Business Machines and PAL® of Monolithic Memories, Inc.

Data I/O Corporation, 10525 Willows Road N.E., P.O. Box 97046, Redmond, WA 98073-9746. For immediate action, contact us directly, **CALL TOLL FREE:** 1-800-426-1045. In Washington, Alaska and Hawaii, call 206-881-6444. Europe: Vondelstraat 50-52, 1054 GE, Amsterdam, The Netherlands, Tel: (20) 186855. Germany GmbH: Bahnhofstrasse 3, D-6453 Seligenstadt, West Germany, Tel: (6182) 3088. Japan: Ginza Orient Building 6-F, 8-9-13, Ginza Chuo-ku, Tokyo 104, Japan, Tel: (03) 574-0211.

DATA I/O

CIRCLE NO 119