

EDN

Power semiconductors

Fiber-optic couplers

High-speed comparators

Designer's Guide to:
Simulation and test vectors

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



Development tools
work wonders for
32-bit- μ P systems

now climbing to the top.

Intersil's accomplishments in data acquisition prove that no one comes close to us in the range and quality of CMOS data acquisition devices we offer.

And the story's the same whether you're talking data conversion, linear devices, analog switches, digital controllers, micro-peripherals or high-reliability.

Intersil led the way:

- to bring CMOS to precision analog products.
- to integrate analog and digital CMOS functions.
- to put systems on a chip.
- to put digital voltmeters on a chip.
- to develop precision A/D and D/A data conversion products.

Intersil is now head and shoulders above the pack, with:

- **Analog Signal Processing.** The broadest line of CMOS linear products, and an innovative line of data conversion products.
- **Analog Switching.** The widest range of analog switches and high-performance multiplexers.
- **Microperipheral and Digital Control.** The widest line of intelligent single-chip counters, display drivers/decoders and time-base reference products, with more functionality on a chip.
- **Microcontrollers.** Industry standard CMOS microcontrollers to serve the digital intelligence needs of your data acquisition systems.
- **High-Reliability.** Full military spec, fully screened and tested, our products are compliant with military specifications, with QPL-1 status equalling or exceeding

the demanding MIL-STD-883 and MIL-M-38510 specifications.

Intersil puts you first.

All of our firsts—and we've named just a few—are worthless if they don't help you do your job better.

And they do. Here's a short list of the things you can do with our broad range of data acquisition products:

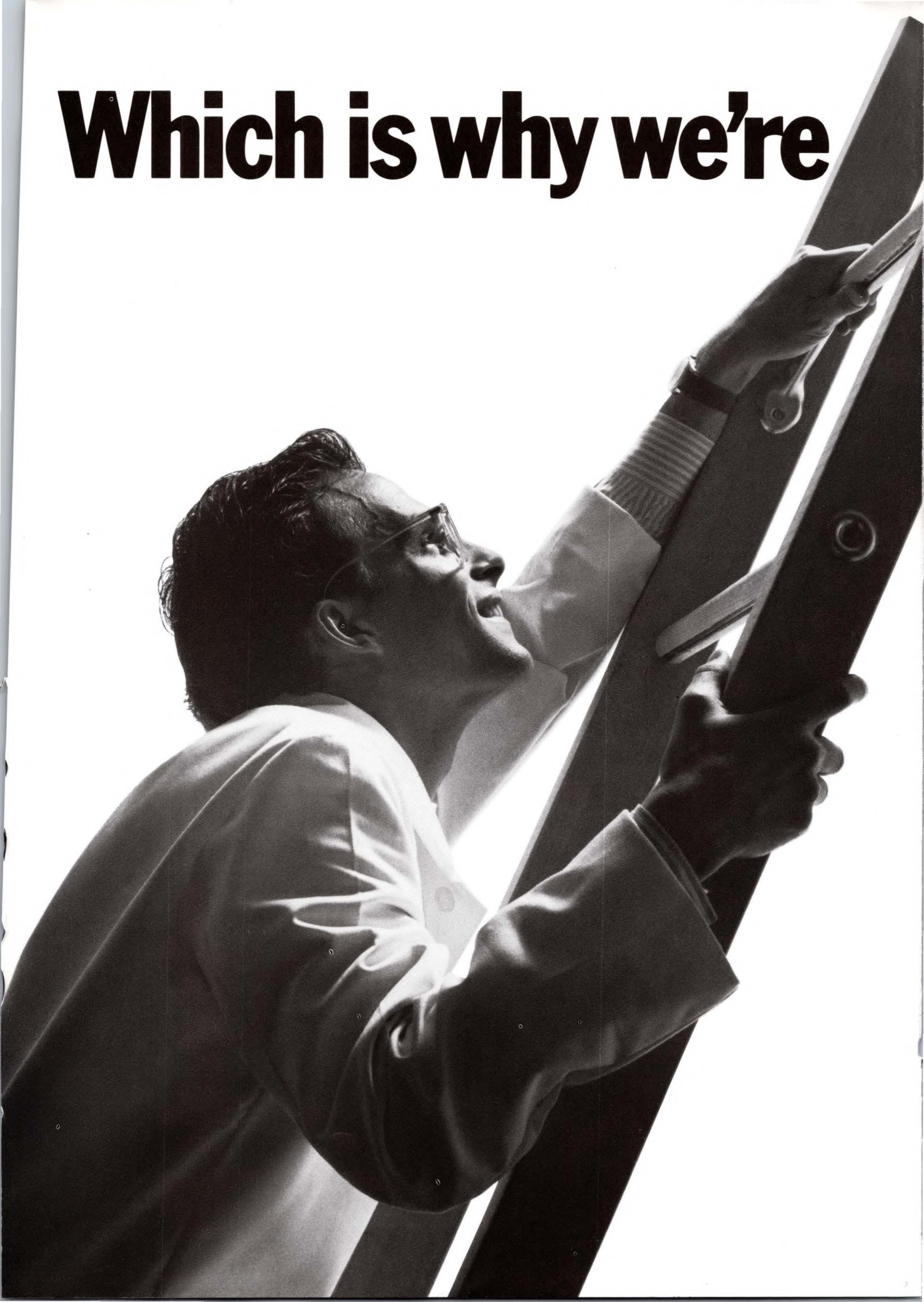
- Solve your difficult design problems. With Intersil products, you've got a complete set of "building blocks."
- Count on us. Of the last 25 data acquisition products we've introduced, 21 are now second-sourced. (As of February 21, 1985.)
- Think of us when you need total product solutions from one supplier. Whether it's linear products or analog solutions on a chip.
- Look to us for technological leadership. Other chip-makers do! That's why their copies of our industry standards are the sincerest form of flattery.
- Know we'll be there. It's taken nearly two decades of innovation and perspiration to get us to the top, and we intend to stay here. That's why we've invested \$20 million in new production facilities, including state-of-the-art wafer fab and assembly.

For more information about Intersil's fine line of data acquisition products, call: 800-626-2001 ext. 428. Or write to: Intersil, Inc., Mail Stop R1-26, 10600 Ridgeview Court, Cupertino, CA 95014

Signal processing is our business. Excellence is our goal. That's why we're climbing to the top. And why we can say, with pride: GE stands for Great Engineering.



Which is why we're



**GE
stands for
Great
Engineering
in data
acquisition:**

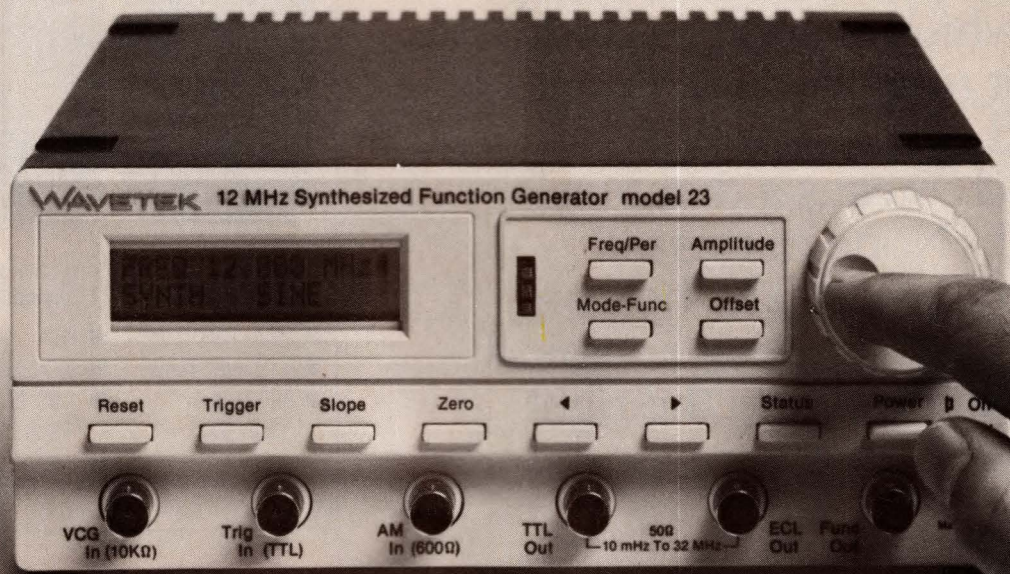
Take our low-priced synthesized function generator for a test spin.

You'll be amazed at how easily Model 23 can be controlled. Just push a button to select the parameter and turn the knob to increment or decrement the setting. A 16-character by 2-line display shows the value with 4-digit precision. Settings that can be displayed include frequency or period, function, offset and amplitude (in Vp-p, Vp, V RMS or dBm).

If you're more interested in performance than handling, Model 23 will keep you happy. It produces quartz-accurate waveforms from 0.01 Hz to 12 MHz, and the clock also provides accurate TTL or ECL outputs up to 32 MHz. Modes include AM, FM, trigger and gate.

Although the Model 23 is designed to be parked on a bench, it can be programmed via optional GPIB or RS232 interfaces.

The size is also impressive—like the \$1995 price, it's very small. To put your finger on the new Model 23, just contact Wavetek San Diego, P.O. Box 85265, 9045 Balboa Ave., San Diego, CA 92138. Phone (619) 279-2200; TWX (910) 335-2007.



And you need more than one way, because everyone's applications are different. Sometimes it's just a

Three different Z 80 multi-function CPU cards, because there's more than one way to make them talk.

Terminal-to-Printer conversation — which is one card.

Or it might be a long-distance conversation with a remote system 4000' away — which is another card.

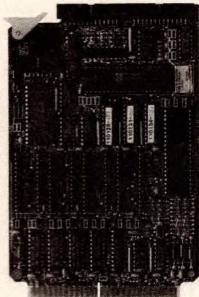
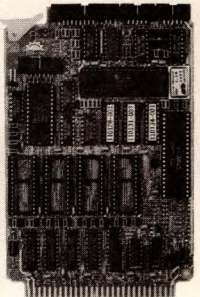
Or it might be a different kind of conversation — which means a different card. (None of this is complicated. The box on this page shows you typical applications and the right Z80 STD BUS card for the job.)

The card you pick depends on what you want to talk to what — and what about. We have a whole family of cards to pick from — so

whatever you're designing or managing, there's a Pro-Log card to make things work.

To order — call us for more

information — call us, write us. We have the latest in Z80 conversation pieces.

7806	7842	7807
		
Dual Channel Local Communications	Dual Channel Remote Communications	Terminal/Printer Communications
■ Up to 128K bytes ■ 3 Counter/Timers ■ 2 RS-232-C Channels	■ Up to 128K bytes ■ 3 Counter/Timers ■ 1 RS-422/RS-232-C Channel ■ 1 RS-422 Channel	■ Up to 128K bytes ■ 3 Counter/Timers ■ 1 RS-232-C Channel ■ 1 Centronics Port

THE DRIVING FORCE IN STD BUS



PRO-LOG®
CORPORATION

Pro-Log Corp., 2411 Garden Road, Monterey, California 93940 (408) 372-4593, TLX: 171879 Outside CA: (800) 538-9570 Australia (3) 836-3533; Benelux (76) 224128; Canada (416) 625-7752; England (276) 26517; France (3) 956-8142; Italy (2) 824-2112; Switzerland (01) 62 44 44



On the cover: With the aid of props like in-circuit emulators, you can easily conjure up products that incorporate 32-bit μ Ps. See pg 106. (Photo courtesy National Semiconductor)

DESIGN FEATURES

Special Report: Development systems for 32-bit μ Ps 106

With the introduction of 32-bit μ Ps, a microprocessor development system will no longer be limited to a single-user host coupled to an in-circuit emulator. Now such tools can range from software development systems made from board-level products to high-speed bit-slice hardware-development equipment.

Follow design rules for optimum use of fast comparator IC 129

To fully exploit a high-speed comparator IC's capabilities, you must understand both the IC's innate attributes and the influences of the circuit environment surrounding the device.

Designer's Guide to: Simulation and test vectors—Part 1 153

To evaluate logic designs correctly, logic simulators require accurate input vectors. You must generate the appropriate vectors to verify your logic's functionality and to determine dynamic operation, performance margins, and critical timing constraints.

Design a simple dual-UART-based network 163

With a dual UART and some simple circuitry, you can easily design an inexpensive network. Each network station has identical interface hardware and software; you can expand the network's function to cover binary-file transfer and electronic mail.

MTBF values aid in predicting component failures 177

The concepts of reliability, failure rate and mean time between component failures are frequently misunderstood and misused. Although related, each represents a different aspect of a component's projected operating life.

Understand probe resistance to ensure accurate measurements 187

When you choose a probe for an oscilloscope measurement, consider the effects of the probe's resistance on your circuit. By selecting the right probe, you can avoid measurement errors.

Continued on page 7

EDN (ISSN 0012-7515) is published biweekly with one additional issue in January, February, March, May, August and October, and two additional issues in April, June, September and November, by Cahners Publishing Company, Division of Reed Holdings, Inc., 275 Washington St., Newton, MA 02158. Norman L. Cahners, Chairman; Saul Goldweldt, 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. 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.

The best DMM in its class just got better.



The Fluke 80TK. One innovation leads to another.

First there was the 70 Series, which set a new standard for low-cost, high-performance, Fluke-quality multimeters.

And now, another first. The Fluke 80TK K-type Thermocouple Converter. A temperature measurement device that adds instant temperature measurement capabilities to the 70 Series DMMs.

Or any DMM, for that matter.

Feature for feature, the versatile 80TK is the most affordable unit of its kind. For quick comparison readings, it can measure °C or °F at the flick of a switch. It includes a built-in battery test. And the availability of 3 Fluke probes give you the flexibility to measure any

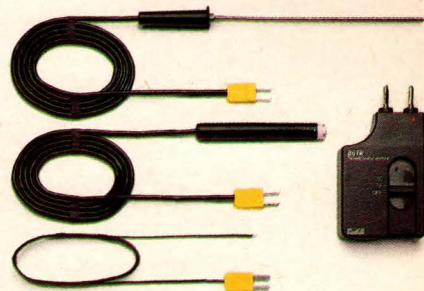
form of temperature, from freezer to furnace, with just one base unit.

No other thermocouple converter we know of offers DMM users so much for so little. Just \$59, including a general-purpose bead probe.

So even if you don't own a Fluke 70 Series multimeter, the 80TK will help the DMM you're now using measure up when things get hot. Or cold.

For more information, contact your local Fluke representative.

FROM THE WORLD LEADER
IN DIGITAL MULTIMETERS.



Surface, immersion and general-purpose probes with "mini" thermocouple connectors are available for the Fluke 80TK.

80TK SPECIFICATIONS

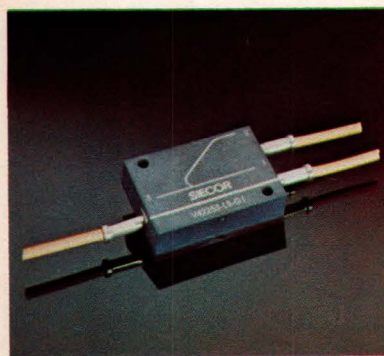
Temperature Measurement Range
-50 to 1000°C
-58 to 1832°F
Battery Life: 1600 Hours (9V)

FLUKE®

IN THE U.S. AND NON-EUROPEAN COUNTRIES: John Fluke Mfg. Co., Inc., P.O. Box C9090, M/S 250C, Everett, WA 98206. Sales: (206) 356-5400. Other: (206) 347-6100.
EUROPEAN HEADQUARTERS: Fluke (Holland) B.V., P.O. Box 2269, 5600 CG Eindhoven, The Netherlands. (040) 458045. TLX: 51846.
© Copyright 1985 John Fluke Mfg. Co., Inc. All rights reserved. Ad No. 4709-70/80



Gate-turn-off thyristors are reducing the cost and complexity of equipment that employs power semiconductors. But although the GTOs minimize the number of power components in such equipment, the drive-circuit complexity increases (pg 61).



Once mere laboratory curiosities, fiber-optic couplers are now available off the shelf in a variety of configurations and technologies (pg 75).

TECHNOLOGY UPDATE

Gate-turn-off thyristors spec new current/voltage highs 61

Gate-turn-off (GTO) thyristors are replacing silicon controlled rectifiers as solid-state switches in high-frequency power-conversion equipment. GTO thyristors are now available with voltage ratings as high as 4.5 kV.

Multiple-access fiber-optic couplers enhance data-link performance 75

Multipoint fiber-optic couplers (devices with three or more access points) can add flexibility and sophistication to your fiber-optic system and network designs: They allow for bidirectional transmissions; let you tap, split, and combine transmissions; and permit you to multiplex signals.

PRODUCT UPDATE

IBM PC-compatible single-board controller	85
Thick-film data-acquisition hybrid IC	86
Low-power RS-232C and -423 line-driver IC	88
Library file of devices for CAD systems	90
Laser probing system for VLSI designs	92
Drawing digitizer and editor interface	95

DESIGN IDEAS

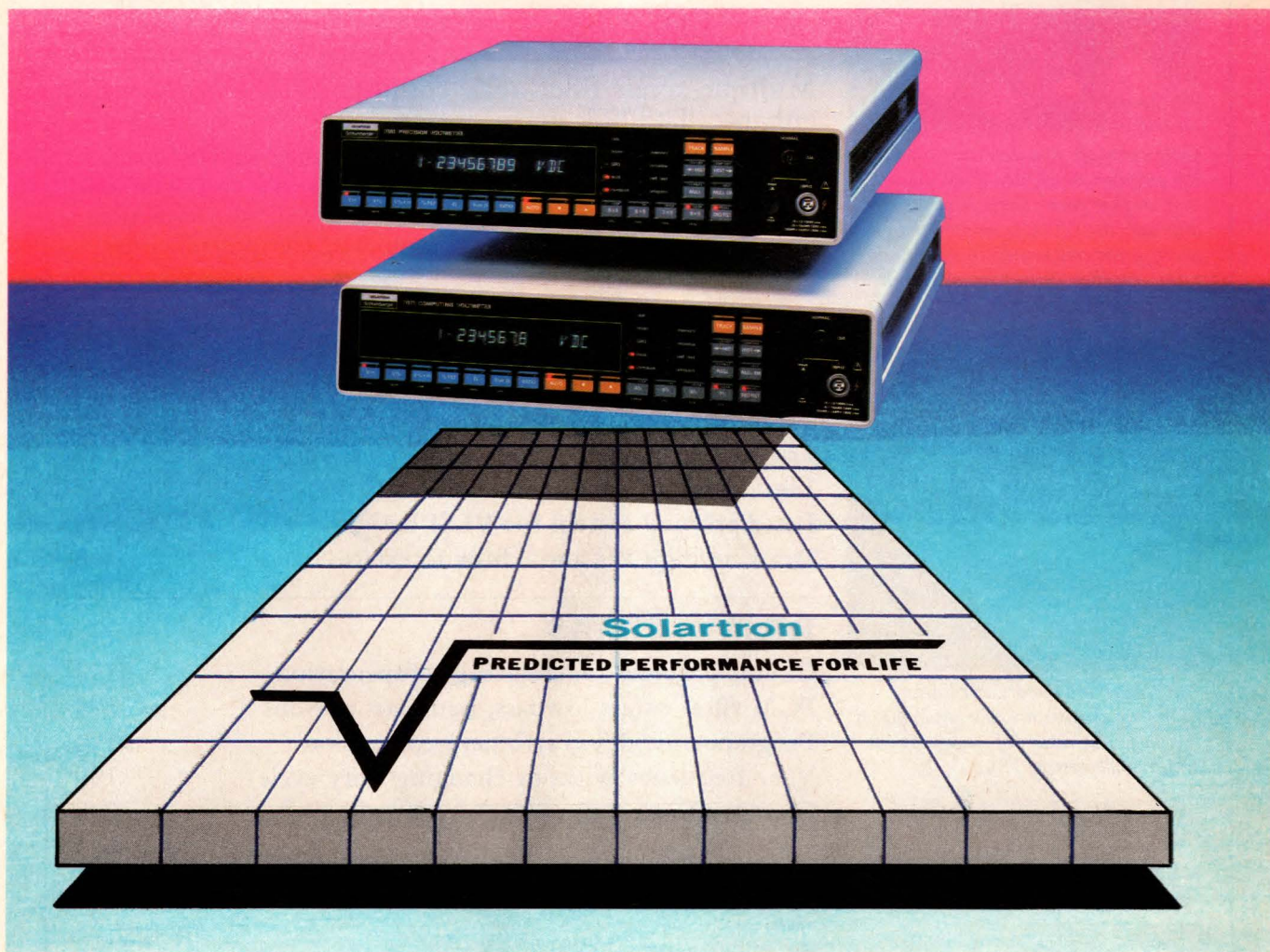
Circuit provides temperature compensation	193
PCM filter offers lowpass, bandpass options	194
Program provides gray/binary conversion	196
Vary frequency without changing duty cycle	199
Circuit measures capacitor's resistance	200

Continued on page 9

Advertising and editorial offices: 275 Washington St., Newton, MA 02158. Phone (617) 964-3030. Subscription offices: 270 St Paul St., Denver, CO 80206. Phone (303) 388-4511. EDN is circulated without charge to those qualified. Subscription to others: Continental US \$70/year, \$5/copy; Canada and Mexico \$80/year, \$6/copy; Europe Air Mail \$120/year, \$7/copy; all others surface mail \$120/year. Special issue prices may vary. Send requests for qualification forms and/or change of address to subscription office.
© 1985 by Cahners Publishing Company, Division of Reed Holdings, Inc. All rights reserved.

IN A CLASS BY THEMSELVES THE MOST ADVANCED 7½ & 8½ DIGIT DVMs PERFORMANCE PREDICTED FOR LIFE

Solartron Instruments



Solartron's 7081 is the world's first and only true 8½ digit DVM. Both the new 7071 and 7081 use highly controlled components to assure extremely long life without re-calibration. They are ideal for standards laboratory measurements and the testing and calibration of other electronic and measuring equipment. Both are equally equipped for use in ATE systems.

Both feature a comprehensive processing capability, 1500 Reading History File, full remote control via RS 232 and IEEE-488, electronic auto calibration... and much more.

Write for new technical literature for full details.

Solartron Instruments, 2 Westchester Plaza, Elmsford, New York 10523, (914) 592-9168 or call **1-800-CALL SOLARtron** Telex 145.487.

Function	Range	Accuracy	
		7081 (8½)	7071 (7½)
Volts dc	10 nV to 1000V	1.2 ppm/24 hr. 11ppm/1yr. 33 ppm/9yr	3ppm/24hr. 20ppm/1yr 66ppm/9 yr.
Volts, true rms ac Ohms Transfer Accuracy Linearity	1μV to 750V 10Ω to 1000MΩ	150 ppm 1.5ppm 0.4ppm 0.3ppm	150 ppm 1.5ppm 1ppm 0.5ppm

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
(275 Washington St., Newton, MA 02158
(617) 964-3030)

Tom Ormond, *Senior Editor*
Bill Travis, *Senior Editor*
Deborah Asbrand, *Staff Editor*
Joanne Clay, *Staff Editor*
Steve Cogger, *Associate Editor*
Eva Freeman, *Associate Editor*
Ken Marrin, *Associate Editor*
George D Miller, *Staff Editor*
J D Mosley, *Associate Editor*
Charles Small, *Associate Editor*
David Smith, *Associate Editor*
George Stubbs, *Staff Editor*
Chris Terry, *Associate Editor*
Jonathan Titus, *Associate Editor*
Clare Mansfield, *Assistant Editor*
Cynthia B Rettig, *Assistant Editor*
Steven Paul, *Production Editor*
Pat Tracy-Callahan, *Production Editor*

Editorial Field Offices
Denny Cormier, *Western Editor*
San Jose, CA: (408) 296-0868
Bob Cushman, *Special Features Editor*
Port Washington, NY: (516) 944-6524

Chris Everett, *Western Editor*
San Jose, CA: (408) 296-0868
Edward Teja, *Western Editor*
Santa Cruz, CA: (408) 425-4508
Maury Wright, *Western Editor*
San Diego, CA: (619) 748-6785
Peter Harold, *European Editor*
0603-630782
(St Francis House, Queens Rd,
Norwich, Norfolk NR1 3PN, UK)

Special Projects Editor
Andy Rappaport

Contributing Editors
Robert Pease, Bob Peterson, Don Powers

Editorial Services
Valerie DeSalvo, Kathy Leonard,
Deborah Millar, Laureen Ouellette,
Carole Smith, *Text Processor*

Art Staff
Susan Barrow-Williams, *Director*
Jennifer Newkirk Porter, *Assistant*
Susan Riley, *Illustrator*
Roseanne D Coveney, *Illustrator*
Chin-Soo Chung, *Illustrator*
Debi Queally, *Illustrator*

Production/Manufacturing Staff
William Tomaselli, *Production Supervisor*
Susan Shaver, *Production Assistant*
Donna Pono, *Production Assistant*
Jane White, *Production Assistant*
Diane Malone, *Composition*

Graphics Director
Norman Graf

Production Director
Wayne Hultizky

VP/Research
Ira Siegel

Marketing Communications
Deborah Virtue, *Manager*
Jennifer Ware, *Promotion Manager*
Corie Rand, *Promotion Coordinator*

EDITORIAL

47

Barely a decade ago, microprocessors were new and largely unknown. Then, in seemingly no time at all, μ Ps were everywhere. Now, only a decade later in time, but generations later in technology, 32-bit μ Ps are repeating some of the history written by their 4-, 8-, and 16-bit predecessors.

NEW PRODUCTS

Computer-Aided Engineering	203
Computers & Peripherals	207
Components & Packaging	213
ICs & Semiconductors	218
Computer-System Subassemblies	223
Instrumentation & Power Sources	229
International	233
Software	239

PROFESSIONAL ISSUES

NSF research centers open with high hopes for innovative technology, better-trained EEs..... 257

LOOKING AHEAD

275

Voice/data terminal sales to reach \$650M in '87.... Motion-control market to double in Europe by '89.

DEPARTMENTS

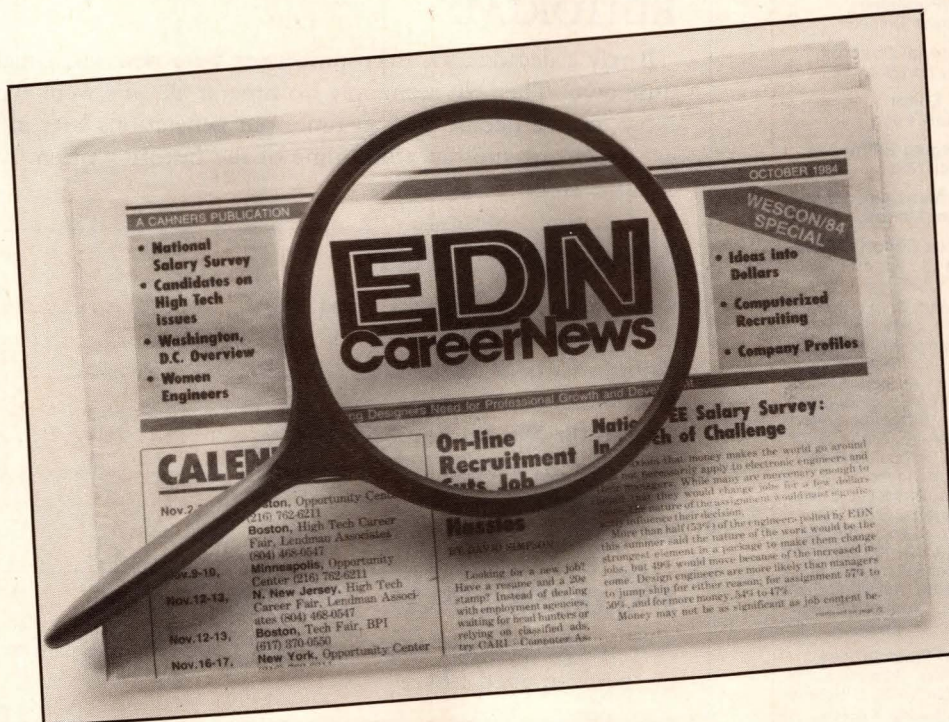
News Breaks	19
News Breaks International.....	22
Signals & Noise	31
Calendar	41
Leadtime Index	102
Literature	243
New Books	254
Career Opportunities	262
Business/Corporate Staff	272
Advertisers Index	273



VBPA ABP

Cahners Publishing Company ☐ Publishers of 32 specialized business magazines in Building & Construction ☐ Electronics & Computers ☐ Foodservice ☐ Manufacturing ☐ Medical/Health Care ☐

WE THINK YOUR CAREER NEEDS SOME CLOSE ATTENTION.



That's why we've created **EDN Career News**. It's the one publication focused entirely on the career concerns of electronics engineers. And it's the added source you need to find new career opportunities.

EDN Career News expands **EDN's** career coverage with the same first-rate editorial that's made **EDN** first among electronics engineering publications. **Career News** looks at the legal and government-related issues affecting the electronics industry. And at personal growth issues to help you reach your professional potential.

Join the 300,000 electronics engineers and engineering managers who pay attention to **EDN Career News** each month. It will make a difference in your career.

EDN CareerNews

Everything Designers Need for Professional Growth and Development

Roberta Renard, National Sales Manager
475 Park Avenue South, New York, N.Y. 10016 (212) 576-8045

Cahners Publishing Company

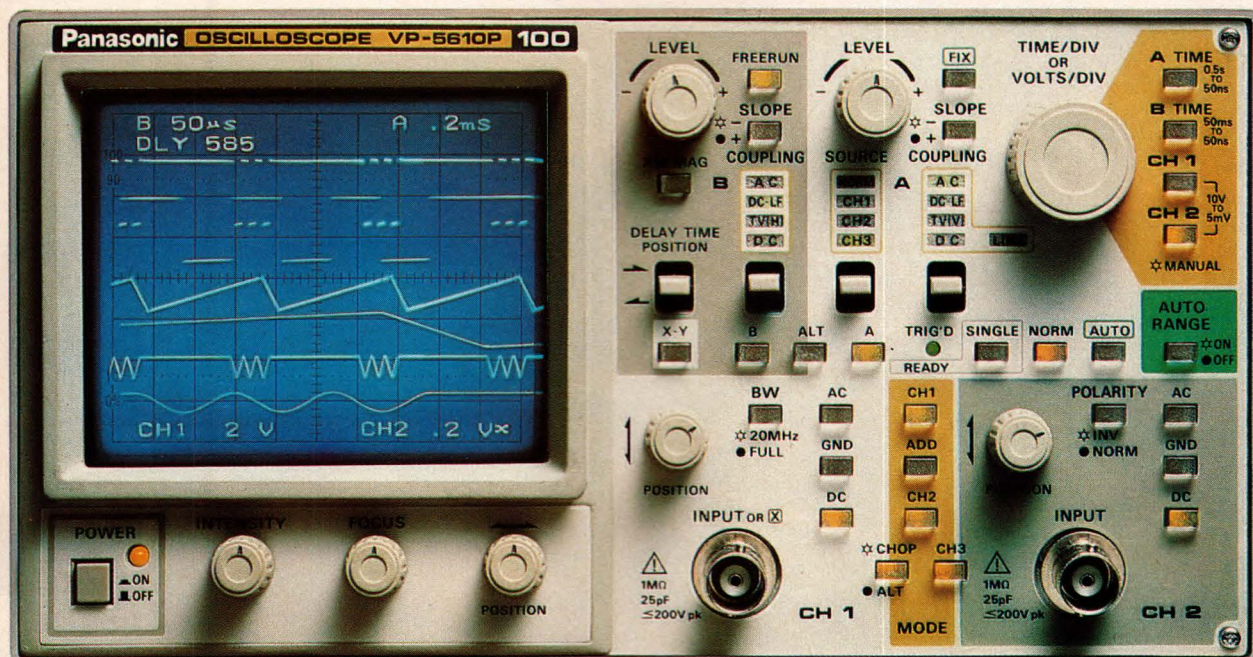
- Publishers of 32 specialized business magazines in Building & Construction
- Electronics & Computers • Foodservice • Manufacturing • Medical/Health Care

100MHz COMPACT SCOPE

**Extra Portability with AC/DC Operation;
Extra Features with Auto Ranging and Digital Readout.**

If you're looking for a really compact oscilloscope that travels anywhere and operates anywhere (AC universal input from 90 to 250V and DC), look no further. Our VP-5610P, with its advanced circuit design technology, can rest on one hand and still get the job done for you. For extra functions you get Auto Ranging which automatically specifies sweep range and vertical sensitivity best suited for

an unknown or indefinite input signal. You also get a handy probe with GND reference. The probe has a built-in switch right at your finger-tips for starting the auto ranging function. This plus 3-trace, an alternate sweep function, auto fix, hold-off, a drift compensation circuit, digital readout and much more make this versatile model a super scope, especially if you're busy and need something portable.



194(W)×102(H) mm

* This chart compares the necessary preparatory and measuring steps of a conventional oscilloscope (11 steps) to the advanced National/Panasonic VP-5610P (only 5 steps)

Measuring Made Easy*	Conventional Oscilloscope	National/Panasonic VP-5610P
Preparations		
1. Turn on power, adjust intensity and focus	•	•
2. Adjust V position	•	•
3. Set V range	•	•
4. Specify trigger mode	•	•
5. Specify sweep range	•	•
Measuring		
6. Connect probe and apply to measurement point	•	•
7. Refine V range	•	•
8. Adjust trigger slope	•	•
9. Refine trigger	•	•
10. Refine sweep range	•	•
11. Read out waveform	•	•
	11 steps	5 steps



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 148



SERIES 32000 IS A TRADEMARK OF NATIONAL SEMICONDUCTOR CORPORATION.



"I can tell by the look on your face. You've been talking to marketing about the new system again."

"That's not a problem—"

"We're going to use a complete 32-bit chip set—"

"I'm talking about the Series 32000 family. It's real. It's here. I like it and the software people love it. What more do you want?"

"How're we going to do it if you have to create memory management and floating point units out of thin air?"

"On time and on budget?"

"We can't make a system out of data sheets. We need product, not promises."

"Can we start today?"

Today, only one 32-bit microprocessor gives you all the power you want, and all the parts you need.

If you're building an extraordinary new system, you can't do it with less than extraordinary components. And you certainly can't do it on time without floating point and memory management units.

Of all the available 32-bit microprocessors, only one delivers supermini performance from a chip set you can work with today. Series 32000™ is the world's most complete 32-bit microprocessor family, with CPU, MMU, FPU, TCU, ICU and DMA controllers in place right now.

So instead of creating essential components from scratch, start your design today with Series 32000, the complete 32-bit family.

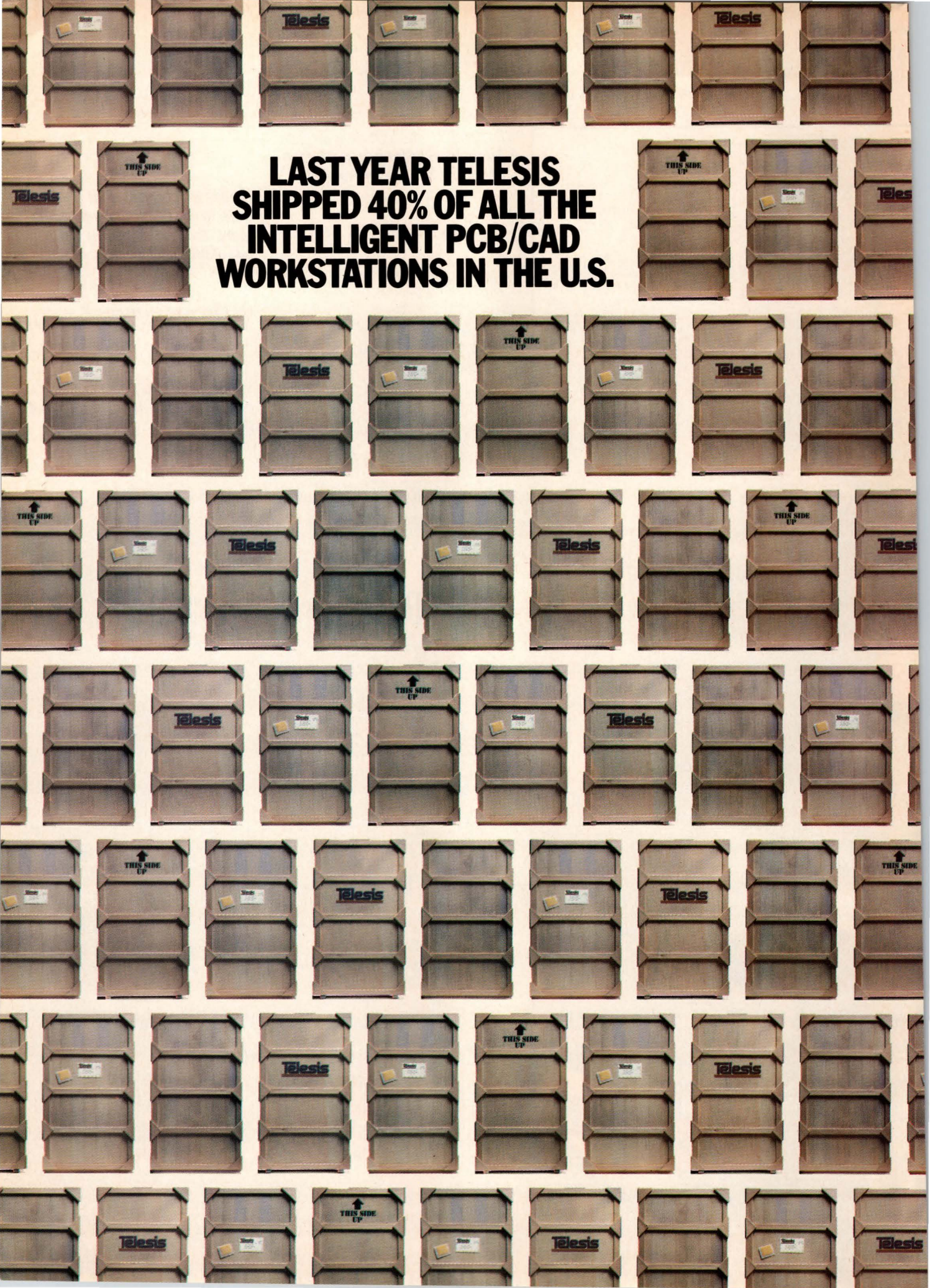
For all the facts, write to:
Series 32000, MS 23-200
National Semiconductor
2900 Semiconductor Drive
P.O. Box 58090
Santa Clara, CA 95052-8090



**National
Semiconductor**
We're doing it.

THE SUPERMINI ON A CHIP

CIRCLE NO 14



**LAST YEAR TELESIS
SHIPPED 40% OF ALL THE
INTELLIGENT PCB/CAD
WORKSTATIONS IN THE U.S.**



THIS YEAR WE'VE GOT OUR DESIGNS ON CAE.

Our Telesis EDA-300 is simply the best PCB/CAD workstation in the industry.

That's because it thinks like a designer.

It handles just about any board technologies you can throw at it. Digital, analog, surface mount, hybrid, ECL and more.

And virtually any size board or density.

Our powerful automatic placement and 32-bit routing capabilities are exceptionally fast and fully re-entrant for easy editing.

All of which explains why Telesis has the largest installed customer base of intelligent PCB/CAD workstations in the U.S.

But that's just the beginning.

Because now Telesis is the first company to apply a systems orientation to Computer-Aided Engineering.

Our new Design Capture software runs on the low-cost IBM Personal Computer family. Since our software is fully integrated with the EDA-300 you can capture your schematics and forward net lists to PCB/CAD. As well as automatically back annotate and update the schematic.

You may transfer the details of your design directly to Teradyne's LASAR™ simulation software, which runs on our 32-bit Co-processor with the IBM PC. LASAR allows you to verify system designs with advanced features like true worst-case timing analysis and the most extensive model library available. Using LASAR for both design and test can typically save months in time.

Then with our unique Thermal Analyzer you can pinpoint hot spots on your board in just minutes. So board layout and packaging can be designed for optimum heat dissipation, leading to increased system reliability.

In short, no other CAE system can help you get your PCB product to market faster than Telesis.

Like to know more about our integrated products? Call (617) 256-2300. Or write

Telesis, Two Omni Way,
Chelmsford, MA 01824.

Once you do, you'll have your designs on us.



*Dataquest Inc., based on total numbers of Standalone Workstations shipped in U.S. 1984.

™Teradyne

Telesis

CIRCLE NO 15

Introducing the HP 54100A/D 1 GHz General Purpose Digitizing Oscilloscope. Now see waveforms you've

The waveform you see displayed here was captured by the new HP 54100A/D 1 GHz Digitizing Oscilloscope. It shows an unstable clock (top trace) and the resulting data at the Q output of a D flip-flop. Plus, it automatically positions the event of interest in the center of the display and shows the events in negative time that led up to the trigger. The new HP 54100A/D can easily capture rare events like this and hold them for you to analyze with no blooming or fading. What's more, you get this with 10 psec resolution and 1 GHz bandwidth necessary to capture subnanosecond transitions in today's high speed logic designs. And it does all this at the touch of a button.

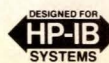
The first truly general-purpose digitizing scope for dc to ECL.

With logic speeds pushing faster all the time, you need a scope that can deliver reliable measurement

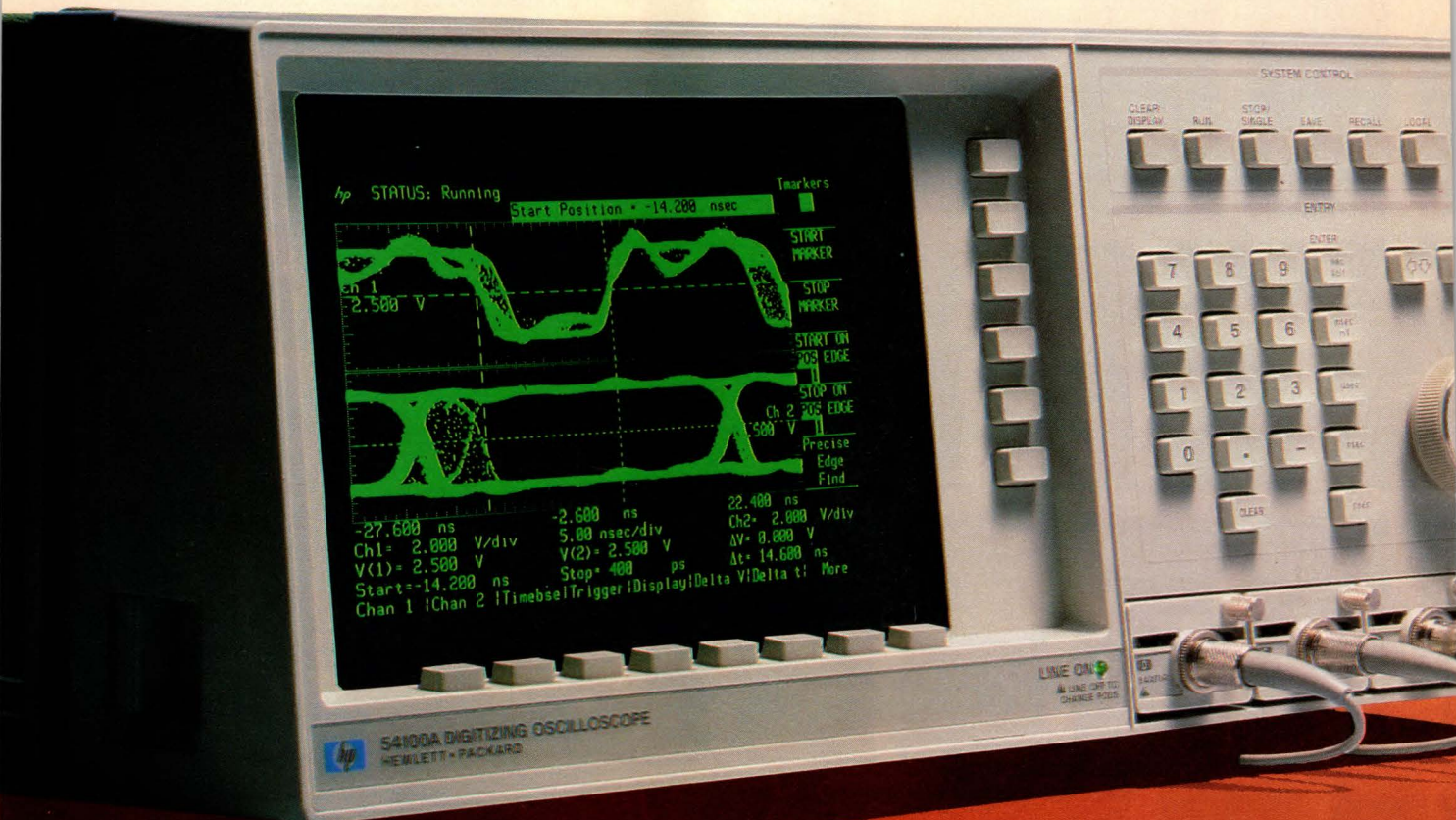
results from dc all the way to ECL. The new HP 54100A/D 1 GHz Digitizing Oscilloscope gives you that versatility. It combines a fast 350 psec rise time with a crystal-controlled timebase, sophisticated on-board analysis firmware, and easily re-configured inputs. It lets you see low duty-cycle signals with clarity and brightness not previously possible. You can even take it out of the lab into production. Make it a vital part of your computer-based ATE test system for even greater productivity and usefulness through HP-IB.

Complete one-button characterization of your high-speed waveforms.

With the HP 54100A/D Digitizing Oscilloscope, you can be productive as soon as you sit down in front of it. Simple keystroke sequences give you automatic pulse parameter measurements, automatic signal scaling and instrument setup, automatic hardcopy output (over HP-IB) and more. You can trigger on logic patterns,



HP-IB: Not just IEEE-488, but the hardware, documentation and support that delivers the shortest path to a measurement system.



never seen before.



time-qualified patterns or state, or you can delay the trigger by edge count or absolute time. The HP 54100A/D unloads much of the setup and test burden

from you so you can devote your time to designing.

Expanded probing capability and convenience.

Designed as a companion product to the HP 54100A/D, the new HP 54300A Dual 8:1 Probe Multiplexer expands your scope's two inputs to a total of 16. Use it as a front-end interface for your production ATE test system or as a bench test system for design characterization in your R&D lab.

High frequency, high impedance probing.

Whether you're in R&D or production engineering, you know the need for better, more flexible probing schemes. With the HP 54100A/D or the HP 54300A Probe Multiplexer, you can choose from 1 GHz minia-

ture probes, 50 ohm BNC inputs, or high-impedance 1 Mohm/300 MHz probes. Automatically setup and recall up to 100 test sequences of up to 99 steps each (3700 steps maximum), either from the front panel or under HP-IB control.

Call HP today. 1-800-835-5577.

Call between 8:30 a.m. — 5:00 p.m. MDT for more information on the HP 54100A/D Digitizing Oscilloscope or the HP 54300A Probe Multiplexer. Or contact your local HP sales office listed in the telephone directory white pages. Ask for the electronic instruments department.



HEWLETT PACKARD

CIRCLE NO 16

DS15504 B



"There has to be a better way to manage my tests."

Now there is.

The new Honeywell Test Management Systems are integrated system solutions that:

Simplify data acquisition, analysis and control.

Reduce the time needed to configure and run tests through powerful test management software.

Provide a wide range of measurement capability with programmable signal conditioning from dc to 2 kHz, with higher bandwidths to come.

Monitor and analyze data for on-site test results. Employ the Unix™-like operating system for increased flexibility.

Expand system performance to meet



Honeywell Test Management Systems

specific testing requirements through user-developed software.

Produce immediate test reports complete with graphics. Utilize IEEE-488 and Dual RS-232/422 ports for equipment compatibility.

The new Honeywell Test Management Systems are truly a better way to manage your tests.

And they're backed by Honeywell, the company that has been delivering service, support, train-

ing and performance for 100 years.

For a brochure detailing the many benefits of Honeywell Test Management Systems, call 1-800-255-5550, Ext. 850.

Unix is a trademark of AT&T Bell Laboratories.



Together, we can find the answers.

Honeywell

CIRCLE NO 17

NEWS BREAKS

EDITED BY JOAN MORROW

LOW-COST 32-BIT SUPERMICRO MATCHES MINICOMPUTER POWER

Based on the MicroVAX 78032 μ P, Digital Equipment Corp's (Maynard, MA) MicroVAX II supermicrocomputers and VAXstation II workstations deliver performance levels comparable to those of the company's VAX-11/780. Although you can't form VAX clusters with the new systems, you can link as many as 16 MicroVAX IIs in a LAN. All systems operate under VMS and Ultrix, DEC's implementation of Unix.

The company also released field-upgrade kits for the MicroVAX I microcomputer, as well as compact optical disks, each of which can store as many as 200,000 single-spaced typewritten pages. The single-user MicroVAX II system is available now; other systems will begin shipping in July. Prices for the MicroVAX II range from \$18,840 to \$43,780; the basic VAXstation II starts at \$26,500.—Eva Freeman

RAM-DISK SUBSYSTEM INCLUDES FAIL-SAFE FEATURE

The Model 7900 semiconductor disk subsystem (SCD) from National Advanced Systems (Mountain View, CA, (415) 962-6000) will combine the data-access speed and capacity of a RAM disk with a built-in hard-disk device for emergency storage. In the event of a power loss to the RAM disk, the hard disk will record all the data stored on the SCD. The SCD, which is scheduled for release in August, will consist of a control unit, as many as four semiconductor memory units, and a battery backup unit with a built-in magnetic disk.

Each memory unit will be available in 32M-byte increments for a maximum of 128M bytes per unit, or 512M bytes per SCD. The memory units will also feature dual ports that provide the system with an aggregate 6M-byte/sec data-transfer rate. A typical configuration with 128M bytes of memory will cost \$498,800.—J D Mosley

TEKTRONIX OFFERS CUSTOM AND SEMICUSTOM SERVICES

Tektronix (Beaverton, OR) has opened its Integrated Circuits Operation to outside customers by offering semicustom linear arrays and custom foundry services. Both the semicustom and custom ICs will feature high-bandwidth bipolar transistors ($f_T = 6.5$ GHz), laser-trimmable resistors, and fast turnaround—three weeks to fabricate a Quickchip from layout and eight weeks to fabricate a full custom IC, which is roughly one-half the industry average.—David Smith

NORTHEASTERN UNIVERSITY OPENS TECH CENTERS IN CALIFORNIA

Northeastern University (Boston, MA) has announced plans to open six regional technology centers in Silicon Valley this September. Nearly 100 specialized high-technology courses will be offered in a continuing-education program for professional engineers, scientists, and managers. Northeastern will pattern its Bay Area Regional Technology Centers (Santa Clara, CA, (408) 986-8480) after its continuing-education programs in the Boston area, which started in 1963.

To accommodate the rapidly changing nature of high technology, courses will be taught by working engineers who deal with state-of-the-art devices and processes. Topics will range from IC fabrication to software management and development. The centers will schedule courses to suit working engineers' timetables.—Denny Cormier

NEWS BREAKS

INDUSTRY LEADERS REVIEW DISK HEAD/MEDIA TECHNOLOGY

On July 14, industry leaders will meet in Chicago to discuss such issues as media corrosion; static and dynamic friction; whether overcoating of media is necessary; and the special problems related to sub-4-in. disk heads. The review, which will coincide with NCC/85, is sponsored by Peripheral Research Corp ((805) 963-8081) and Don Mann Magnetics Inc ((805) 496-2999). Speakers from Ampex, Applied Magnetics, Brown Disk, Cyberdisk, Information Magnetics, Read-Rite, and 3M will participate.—Ed Teja

TWO SUPERMINICOMPUTERS TARGET ENGINEERING AND CAD

Harris Computers' (Fort Lauderdale, FL) 7-MIPS HCX-7 and 5-MIPS H1200 superminicomputers are designed for scientific and engineering applications. Operating under a native AT&T Unix V system, the HCX-7 is the first 32-bit computer developed by the vendor. By using a reduced instruction set (160 instructions), the HCX-7 can implement most instructions in one 100-nsec machine cycle. Prices for the HCX-7 begin at \$225,000; shipments start in July.

The H1200 boosts its performance by incorporating ECL memories and by implementing many scientific and mathematical functions in hardware. Designed around an 80M-byte/sec ECL bus structure, the memory units feature either 270- or 135-nsec cycle times. The H1200 starts at \$294,000, and shipments will begin in September.—Eva Freeman

ALL-ELECTRONIC UNIVERSITY SIGNS FIRST COMPANY-WIDE SPONSOR

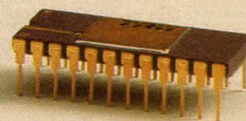
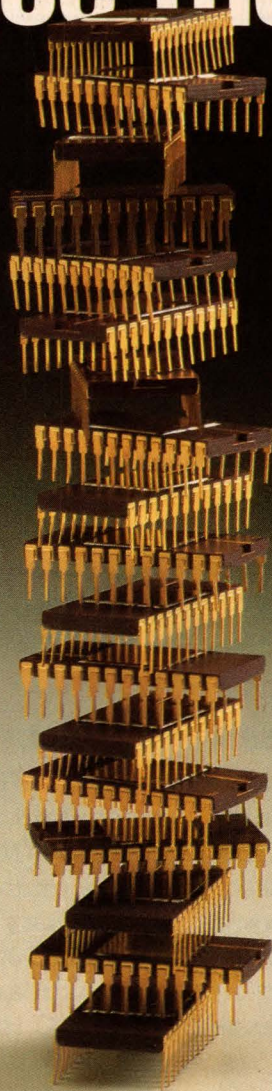
Hewlett-Packard Co (Palo Alto, CA) recently became the first National Technological University (NTU) corporate client to take out a company-wide subscription. Based in Fort Collins, CO, NTU is an all-electronic university offering videotaped graduate-level engineering courses to companies enrolled as corporate clients. Among its corporate subscribers are Digital Equipment Corp, IBM, Eastman-Kodak, and Motorola. Typically, corporate subscribers pay a fee for each company facility that accesses the videotaped courses. Hewlett-Packard is the first client to open up the use of NTU to employees at all of its facilities.

NTU offers masters-degree programs in computer engineering, electrical engineering, and engineering management. All of its courses are available on videotape. This fall, however, the school expects to begin broadcasting its classes via satellite.—Deborah Asbrand

GRAPHICS SOFTWARE PACKAGE IMPLEMENTS ANSI AND ISO LEVEL 2B

The GSS-Toolkit Kernel System is a linkable library of graphics routines that lets you write programs in C, Fortran, or Basic and use one set of interfaces to the graphics routines. An implementation of the ANSI and ISO specification level 2b, the package from Graphic Software Systems (Wilsonville, OR) is available to OEMs using MS-DOS, PC-DOS, Unix System III, V, or 7, or Unix Berkeley 4.2. Versions for other operating systems are available on a custom basis.—Ed Teja

Replace these... with this!



Why fill your digital delay design with unnecessary components, when you can have all the capability you need in one small, low-cost IC?

TRW LSI Products Division, the industry leader in high performance digital signal processing products, gives designers an edge with the TDC1011. The TDC1011 is a high-speed, 8-bit wide shift register, programmable to any length between 3 and 18 stages. It operates at an 18MHz shift rate (56ns worst case), is TTL compatible, and dissipates a low 750mW.* The TDC1011 operates from a single +5V power supply and is available in a 24-lead DIP.

The beauty of the TDC1011 is that this single chip performs the same functions that would require as many as 18 alternative chips — instead of 18 shift registers, you can use just one in a variety of digital delay applications. This translates into lower component costs, less board space and reduced power dissipation. Built with

TRW's OMICRON-B™ one-micron bipolar process, the TDC1011 provides the system designer with a unique variable delay capability at video speed.

You can use the TDC1011 for telecom, sonar, radar, CAT scanners, computer graphics, TV special effects, and a host of other digital delay applications. And, as with all of our products, the TDC1011 is backed by our extensive network of in-house and field applications engineers, application notes and our full line VLSI DATA BOOK. The U.S. price in 1000s for the TDC1011 is \$23 (commercial Cerdip). Available off the shelf from Arrow Electronics, Hall-Mark and Hamilton/Avnet.

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

To receive a data sheet without delay, or for super-fast information, 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

*0 °C to 70 °C (–55 °C to 125 °C also available)
©TRW Inc. 1985 — TRS-5103

The TRW logo, consisting of the letters 'TRW' in a stylized, bold, red font.

LSI Products Division
TRW Electronic Components Group

NEWS BREAKS: INTERNATIONAL

BY PETER HAROLD

UNIX SUPERMICRO EMPLOYS THREE SEPARATE PROCESSORS

The Unix-based multiuser Mentor supermicrocomputer from Integrated Micro Products (Consett, UK, TLX 53429) incorporates three separate VME Bus processor cards. The ET-68020 CPU card features a 16-MHz 68020 μ P and a memory-management unit, which is implemented using TTL logic and static RAM to provide high-speed address translation. Local processor memory resides on as many as four memory cards, each holding 2M bytes of 32-bit memory. The memory cards reside in VME card slots adjacent to the CPU and are accessed via a dedicated high-speed memory bus.

For processor-intensive tasks, the CPU and memory system execute benchmarks three times faster than a VAX 780. The CT-68VIDC intelligent disk controller and CT-68VICP intelligent communication controller each incorporate an onboard 68000 processor. The CT-68VIDC features a disk cache buffer of 512k bytes max of dual-ported RAM and an SCSI bus to support multiple drives. The communication controller has 128k bytes of onboard RAM and supports 16 asynchronous serial ports, two synchronous serial lines, and 48-bit parallel I/O. Prices for the Mentor system start at approximately £15,000.

PASCAL COMPILERS ARE VALIDATED TO CLASS A STANDARDS

The 3L range of Pascal compilers from Lattice Logic (Edinburgh, UK, TLX 72465, Attn Lattice) includes versions for the DEC VAX running under VMS and Unix, the Perkin-Elmer 3200 running under OS32 and Unix, the Whitechapel MG-1 running under Genix, and the Acorn NS32016 second processor running under Panos. The compilers, written to port the company's CAE software onto a variety of CAE workstations, are all class A validated to the Pascal standard BSI-6192 Level 1 (ISO) 7185. Versions are currently under development for Apollo Domain and Sun workstations and IBM 370-type machines. Prices range from £1000 to £6000 depending on machine.

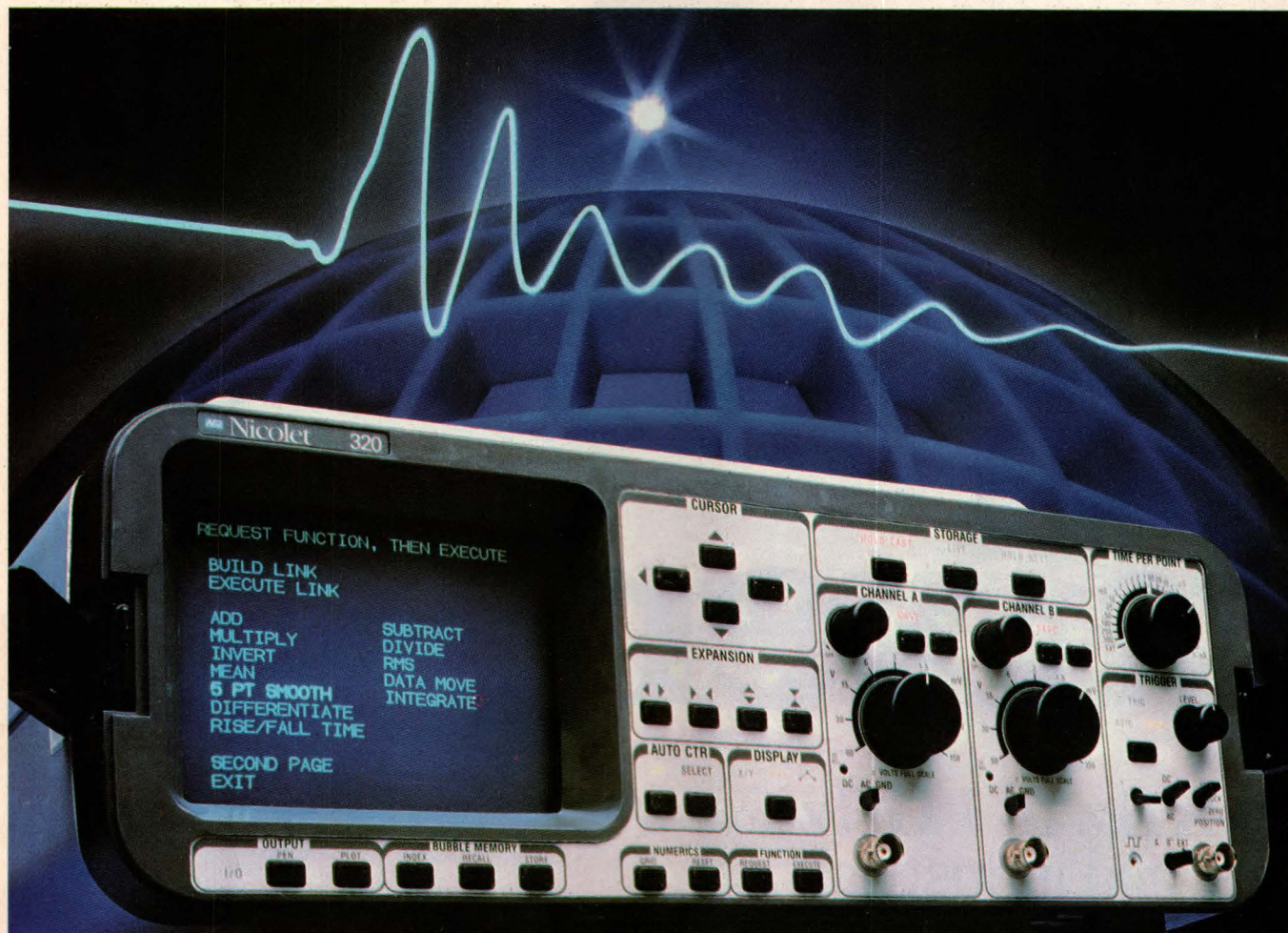
COLOR CRT CONTROLLER MANIPULATES 16 IMAGES

The 82716 video-display controller, separately manufactured by Matra-Harris Semiconductors (Nantes, France, TLX 711930) and Intel Corp (Santa Clara, CA), allows you to define as many as 16 variable-sized, colored object images, and to move them around in or out of a video frame. Object images can be bit-mapped graphics or alphanumeric characters, and you can program them to have prioritized overlap and transparency attributes. Maximum screen resolution is 640 x 512 pixels with four bits/pixel, allowing you to select 16 colors from a palette of 4096 in an on-chip color look-up RAM. The 82716 is NAPLPS and CEPT compatible. Silicon is currently being run by Matra-Harris; the company expects the device to have a sample price of around \$80 and a target volume price of \$20.

PATTERN GENERATORS SERVE ALL MAJOR TV STANDARDS

Philips Test & Measurement Div's (Eindhoven, The Netherlands, TLX 35000) PM-5515, -5516, and -5518 TV test-pattern generators are adaptable to PAL, NTSC, and SECAM standards. The instruments cover IF and VHF bands I and III, S-band cable channels S1 to S20, and UHF bands IV and V. Versions are available for testing Teletext/Antiope, and PAL stereo FM receivers. Options include RGB outputs.

Announcing the Nicolet 320 Digital Oscilloscope. Faster, Smarter and Easier.



Faster.

Two channels, each with up to 200 MHz effective digitizing rate for repetitive signals, 10 MHz for transient signals. See before or after the event with up to 100% pre-trigger and up to ten seconds of post-trigger delay.

Smarter.

Manipulate stored waveforms via a menu of mathematical routines using only two buttons. Set-up fully automatic sequences for unattended operation. Store up to four 4,000 point waveforms and examine in detail using digital expansion and the annotated display.

Communicate data via the built-in GPIB and RS232 interfaces. Output for hardcopy to XY or YT recorders or digital plotters.

Easier.

The 320 is so easy to use the manual is almost superfluous. Easy to carry too. The lightweight package includes storage for probes, power cable and, just in case, the manual.

It even blows bubbles.

Store up to twenty-one waveforms per cassette with the optional bubble memory. Storage and recall can be incorporated into an automatic sequence.

For more information call toll free 1-800-356-3090 (Wisconsin: 608/273-5008). In Canada, call 416/625-8302. Or write: Nicolet Oscilloscope Division, 5225 Verona Rd. Madison, WI 53711.

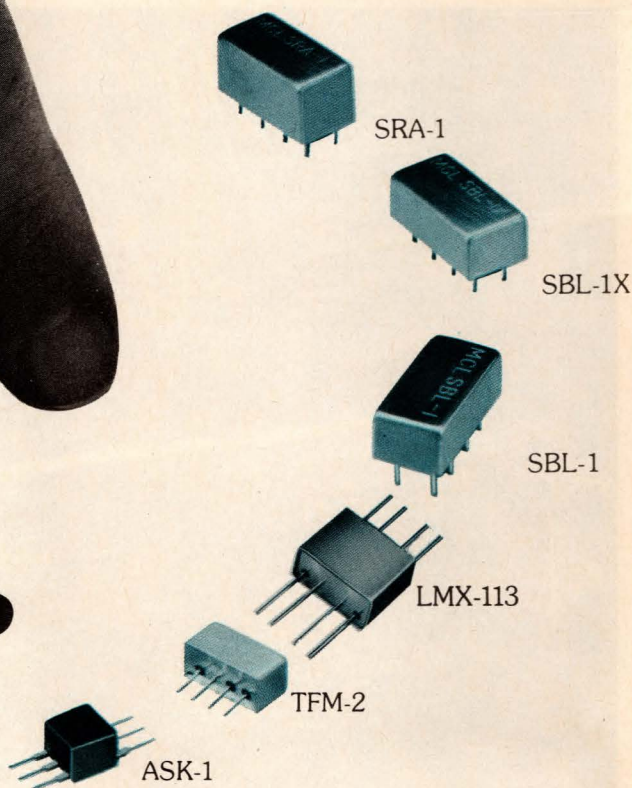


Nicolet



Copyright ©1985, Nicolet Instrument Corporation. All rights reserved. 122R

pick a mixer



500 KHz to 1 GHz from \$3⁹⁵
hi-rel and industrial
miniature, flatpack, and low profile

MODEL	FEATURES	Freq. (MHz)		†Conversion Loss (dB)		L-R Isolation (dB)			Price/Qty.
		LO-RF	IF	one octave bandedge	total range	lower bandedge	mid range	upper bandedge	
SRA-1*	the world's standard . . . HTRB tested hi-rel 3 year guarantee	.5-500	DC-500	5.5 typ.	6.5 typ.	50 typ.	45 typ.	35 typ.	11.95 (1-49)
TFM-2*	world's tiniest hi-rel mixer only 4 pins for plug-in/flatpack mounting,	1-1000	DC-1000	6.0 typ.	7.0 typ.	50 typ.	40 typ.	30 typ.	11.95 (6-49)
SBL-1	world's lowest cost industrial mixer, only \$4.50, metal case	1-500	DC-500	5.5 typ.	6.5 typ.	50 typ.	45 typ.	35 typ.	3.95 (100) 4.50 (10-49)
SBL-1X	industrial grade, rugged all-metal construction	10-1000	5-500	6.0 typ.	7.0 typ.	50 typ.	40 typ.	30 typ.	5.95 (10-49)
ASK-1	world's smallest DBM flatpack mounting, plastic case	1-600	DC-600	5.5 typ.	6.0 typ.	50 typ.	35 typ.	30 typ.	5.95 (10-49)
LMX-113*	rugged flatpack, hermeticity tested thermal shocked to MIL-STD-202	5-1000	DC-1000	6.5 typ.	7.0 typ.	50 typ.	40 typ.	35 typ.	14.95 (6-24)

*meets MIL-M-28837/1A performance
units are not QPL listed

†LO = +7 dBm



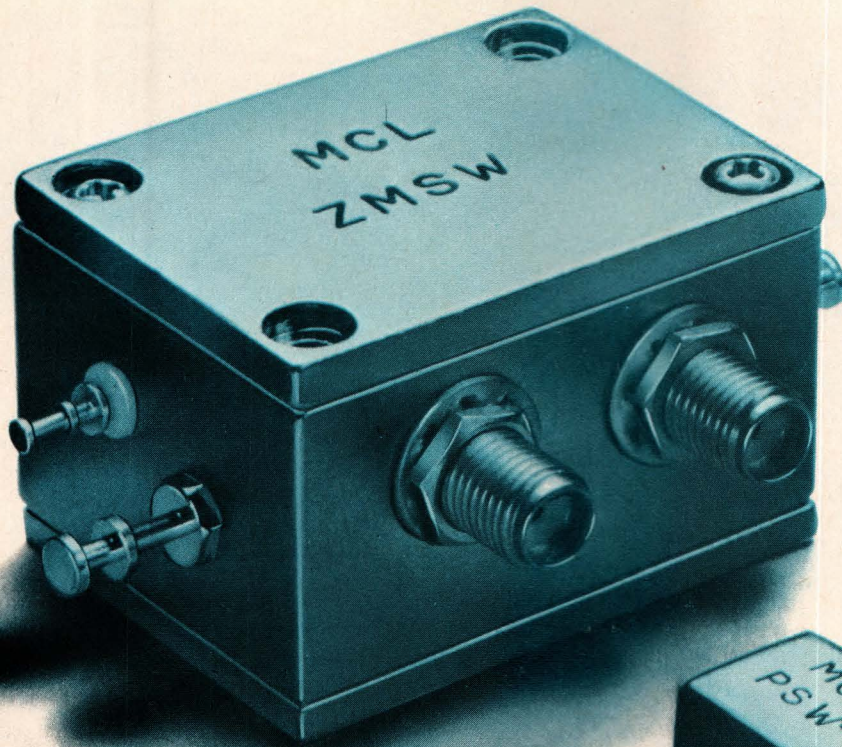
CIRCLE NO 19

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

RF switches



10 to 2500 MHz
from \$19⁹⁵ PSW 1211 (500 qty.)

Now, for your wideband systems design, under —\$20.00 SPST and SPDT pin diode switches that operate over the 10 to 2500 MHz range with less than 1 dB (typ.) insertion loss at 1000 MHz, 1.5 dB at 2500 MHz.

No waiting, immediate delivery . . . with one year guarantee. Call or write for 64-page, catalog or see our catalog in the Gold Book, EBG, EEM or Microwaves Product Data Directory.

SPECIFICATIONS for PSW 1111 (SPST) and PSW 1211 (SPDT)

FREQUENCY RANGE	10-2500 MHz
INSERTION LOSS	
10-2000 MHz	1.7 dB max.
2000-2500 MHz	2.7 dB max.
ISOLATION	
10-500 MHz	40 dB min.
500-1000 MHz	30 dB min.
1000-2000 MHz	25 dB min.
2000-2500 MHz	20 dB min.
SWR	1.5 max. ("on" state)
SWITCHING SPEED	1 μ sec. (max.)
MAXIMUM RF INPUT	+20 dBm
CONTROL	+5 V (5 mA max.)
OPERATING TEMPERATURE	-54°C to +100°C
STORAGE TEMPERATURE	-54°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

PRICE (6-24)

PSW 1111	\$29.95
PSW 1211	\$29.95

CIRCLE NO 20

C80 REV. ORIG.

MULTI-TEC

How to multiply your technology and shorten R&D time.

Your ability to put ideas into practice—take technology to the marketplace—is the single most critical factor in your success.

Emerson & Cuming's Multi-Tech System capabilities are based on five technologies, each individually unique but capable of working together for cost-effective solutions to your materials problems.

We manufacture a *comprehensive range of standard and custom polymer systems*, such as resin/syntactics for aerospace applications, and hybrid silicones for high frequency electronics. Our conductives technology includes cost-effective "quick-fix" products for EMI/RFI shielding in production and field repair. We also maintain a *Value in Use Program*—matching product performance with cost factors.

Our *RAM-Scan (Radar Absorbing Materials Scan)* provides microwave application analysis that can eliminate prototyping or further experimentation. Our *finite element analysis* program measures materials/properties for finished parts applications. We also maintain materials applications software for polymers and conductives problem solving.

Our client assistance services include our MDT team (*Multi-Discipline Task Force*) of

chemical, electrical and mechanical engineers. Assigned specifically to you, the MDT team works with your engineers to provide tactical and strategic design research, and systems development.



Production-quality prototyping is possible with composite systems, which include ERM® (Elastic Reservoir Molding). ERM allows for a wide variety of materials and structural components to meet design criteria—all in one step. Finished parts production is possible with ERM prototype tooling.

Testing capabilities extend through the design process, and include our Applications Laboratories for each discrete technology.

Compounded polymers and resins.

Our Polymer Systems incorporate materials with properties critical to contemporary design. These include epoxies,

silicones, urethanes, and polyesters with technical features that provide you with more than 1,600 standard solutions and infinite applications.

Electromagnetic wave absorbers.

Our Microwave Systems represent the leading edge in this growing industry. We manufacture materials in many forms, for reducing radar cross section (RCS), improving antenna performance, and developing communications systems. We also have the experience to design and manufacture the world's most sophisticated anechoic chambers.

Lightweight syntactic materials.

Our Lightweight Systems are comprised of hollow, synthetic bubbles that combine with



HSYSTEMS

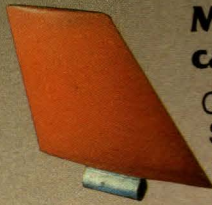


specially-formulated resins to create lightweight, syntactic foam.

These materials offer superior strength; they withstand high compressive pressures; and they're usable in applications from hydrospace to aerospace. New developments in syntactic technology provide ready-to-use materials for avionics, telecommunications, and aerospace.

Conductive shielding applications.

We manufacture a range of shielding materials for EMI/RFI, ESD, EGP and EMP. Our product line includes adhesives, coatings, sealants, gaskets, tapes and materials such as conformable foams and heatless solders. We also provide you with a comprehensive line of "quick fix" products for production and field repair.

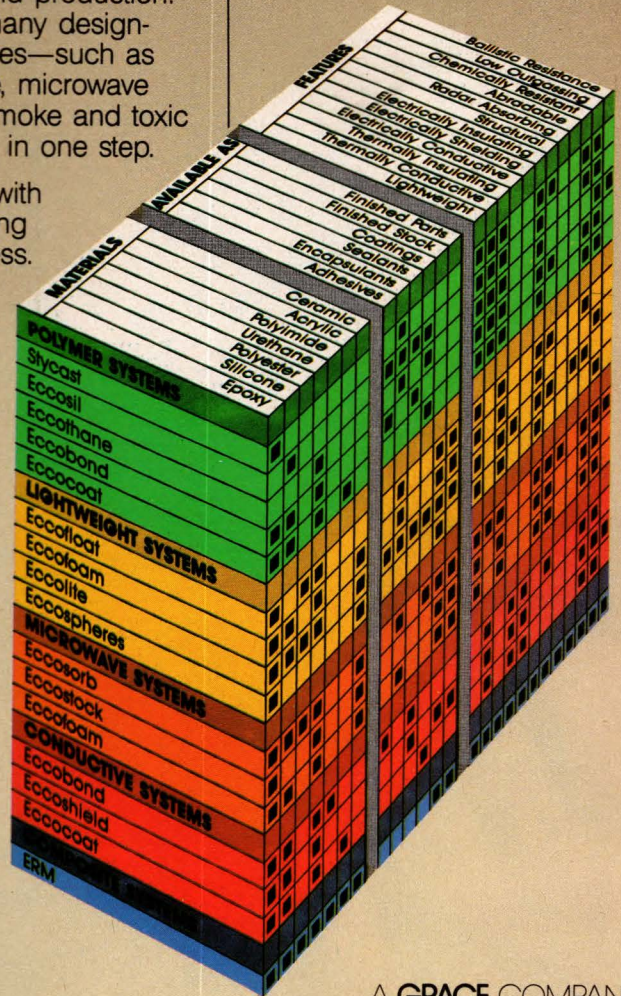


Molded parts capability.

Our Composite Systems offer prototyping and finished parts production in a simple, cost-effective process. ERM provides you with finished parts that exhibit superior materials strength, greater versatility, and cost-efficient tooling and production. ERM allows for many design-engineered features—such as ballistic resistance, microwave absorption, low smoke and toxic gas emission—all in one step.

Your possibilities with Emerson & Cuming are virtually limitless. From conceptual research and development, to finished parts production, you have the resources to succeed.

For complete details about our Multi-Tech Systems, write for our free product literature c/o: Marketing Services Department, Emerson & Cuming, Canton, MA 02021. Or call our toll-free number, 1-800-TECHWAY (832-4929).



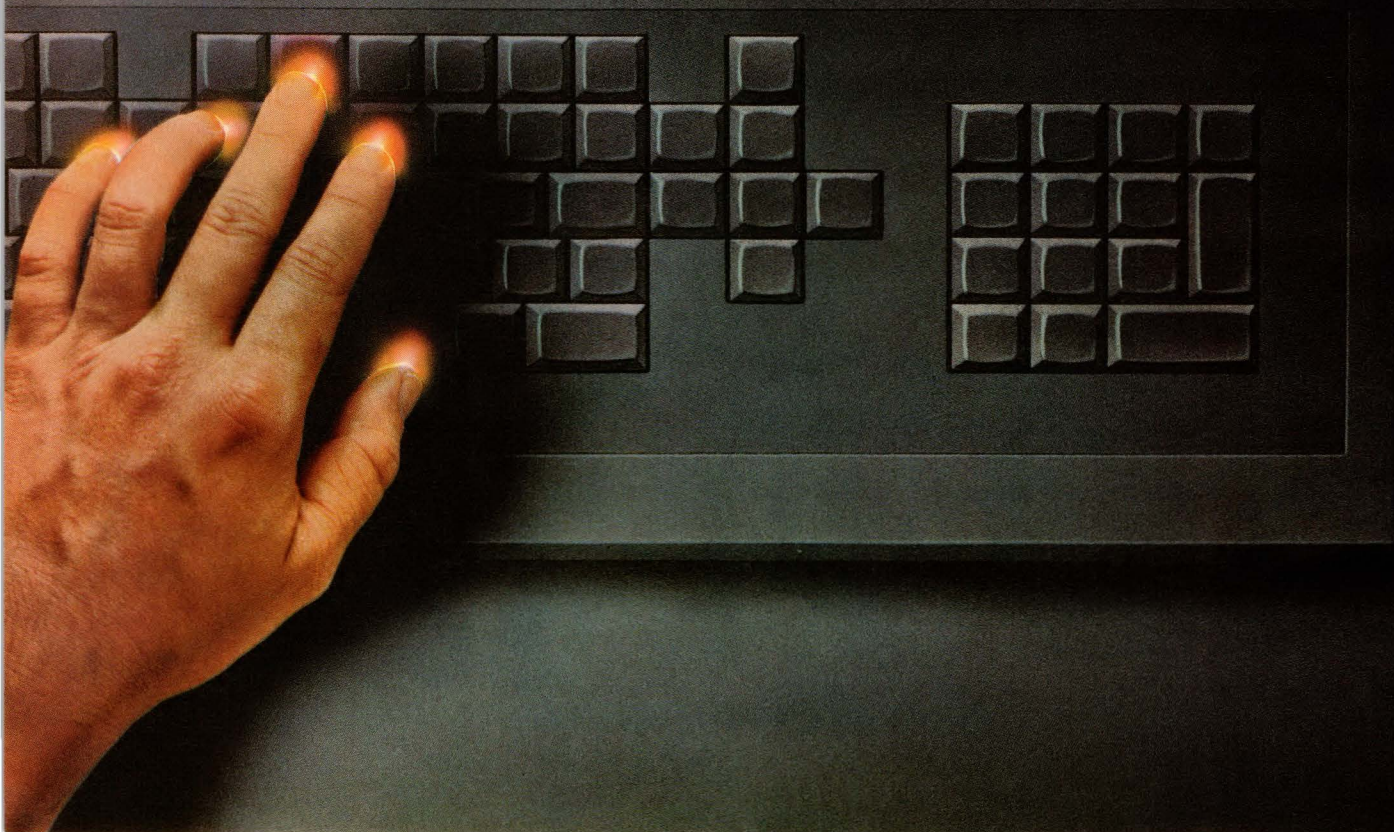
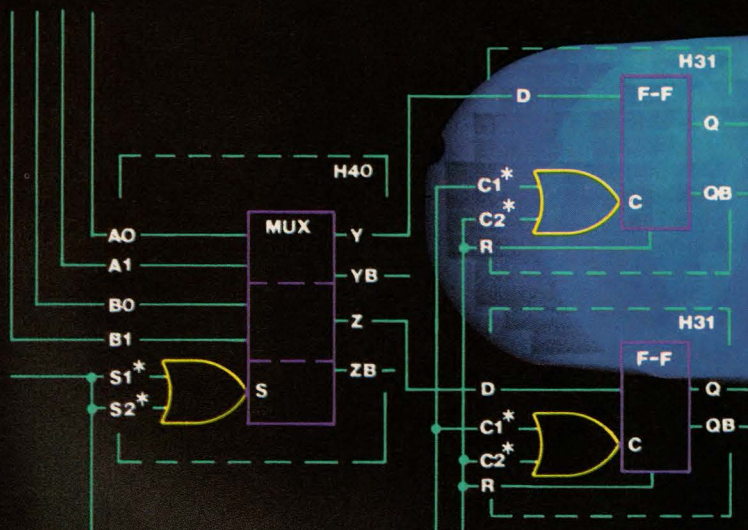
A GRACE COMPANY

EMERSON & CUMING

Where there's a way.



MOTOROLA



Semicustom since 1972

Motorola's commitment to Macrocell Arrays carries you surely from concept to silicon.

Describe your "ideal" semicustom array supplier. You'll insist on flexible, efficient cell libraries, easy-to-use CAD interface, a broad, adaptable product mix in varied technologies, and convenient CAE workstation accessibility.

You'll want effective training and field support, alternate sourcing and timely delivery of reliable, high-quality product. Wrap it up with experienced people plus commitment to growth and the future.

That's Motorola.

Motorola's been in the semicustom array business since 1972, and was first to introduce the macrocell concept commercially. Since that time Motorola's Macrocell Arrays have set the pace for those who've come to the semicustom business more recently.

We pioneered semicustom in the slower, early years. Now, we're thoroughly prepared and committed to serving the rapidly expanding

semicustom requirements of a dynamic industry's future.

You're the beneficiary.

As experience grew into expertise, an entire division dedicated to application-specific products evolved within Motorola. Semicustom products are the operation's backbone, and you're the beneficiary.

How many semicustom suppliers can take you from first contact, in the field or at the factory, clear through the entire experience from design to delivered product in house? Motorola can, and does.

The Motorola Macrocell libraries for both bipolar and HCMOS are the result of years of development and refinement. Ultra high-speed ECL- and ALS-compatible arrays are available from 500 to 2900 gate equivalency. One even incorporates a fast RAM with the array. High density HCMOS arrays currently offer up to 4800 gate equivalency.

Motorola's CAD is recognized as the leader. Don't take our word for it. Ask around. Design automation tools to support your program range from mainframes to Daisy and Mentor workstations to low-cost desk-top personal computer-based systems. How conveniently accessible can support be?

Design Centers extend accessibility.

In addition to the access to libraries in our main computer via CAD tools in your own location, Motorola has opened

Regional Design Centers in strategic locations throughout North

America and around the world. Still others will be established as events dictate.

These design centers are staffed with qualified Macrocell Array application engineers, and are equipped so these specialists can help you successfully through the development of your design.

Design centers presently are located in Boston, the Washington/Baltimore and New York City areas, Atlanta, Florida, Dallas, Chicago, Minneapolis, Denver, the Anaheim/Los Angeles area and San Jose. International centers are established in Toronto, Munich, Tel Aviv, Tokyo and Hong Kong.

The man/machine assistance extended to designers by Motorola is further supplemented by an extensive training program maintained by the renowned

Motorola Technical Training Group.

Worldwide factory support assures total program control.

Motorola's support extends beyond design assistance in the field to assignment of an Option Development Engineer for every project in the factory. This individual is directly responsible for all factory support of your specific design.

Another advantage Motorola brings to semicustom arrays is our comprehensive factory system. Motorola factories in the U.S., Europe and Asia support fabrication, assembly and test for both bipolar and HCMOS arrays. We're committed to your project from start to finish, and our reputation for quality is proven in the product.

One-on-one design-in help.

You can get an engineer-to-engineer update and technical literature on the Macrocell Arrays or any of our latest semiconductor products and technologies fitting your unique designs.

Call your local Motorola sales office for the application assistance and literature that will get you to market. Faster.

We're
on your
design-in
team.



MOTOROLA

HEADQUARTERS:
Geneva, Switzerland, 16 Chemin de la
Voie-Creuse, P.O. Box 8, 1211 Geneva 20,
Switzerland

SALES OFFICES:
Austria Vienna
Denmark Copenhagen
France Paris, Grenoble,
Rennes, Toulouse
Germany Munich, Hannover,
Nuremberg, Wiesbaden,
Sindelfingen

Italy Milan, Bologna, Rome
Netherlands Maarsse
Norway Oslo
Spain Madrid
South Africa Johannesburg
Sweden Stockholm
Switzerland Zurich
United Kingdom Wembley (Middlesex),
East Kilbride (Scotland)

**Eastern Europe/
Middle East** Geneva

Write To: Motorola Ltd., European Literature Center, 88 Tanners Drive, Blakelands, Milton Keynes MK14-5BP, United Kingdom.
Please send me more information on the Benchmark 20 evaluation system.

Name _____

Title _____

Company _____

Address _____

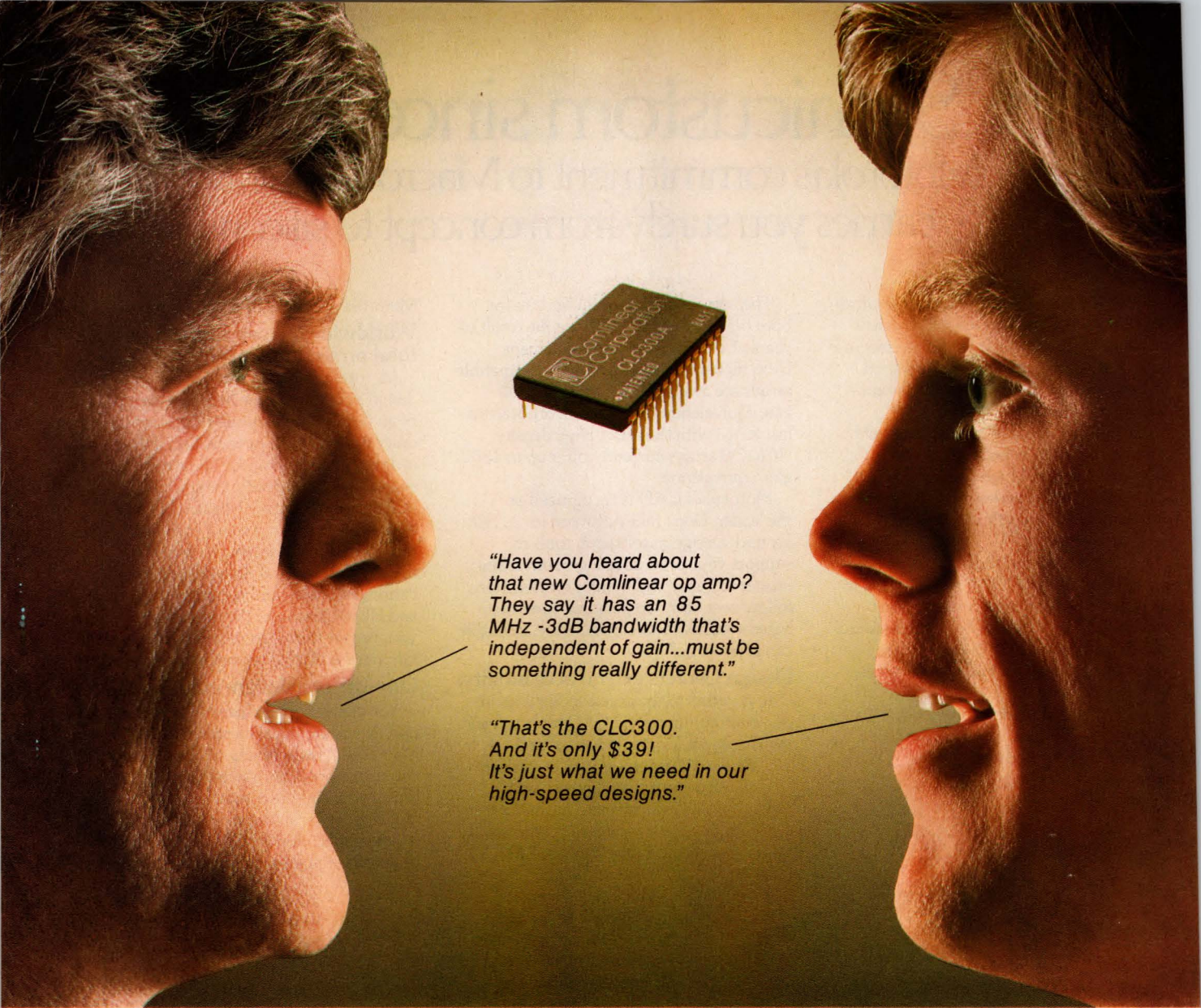
City _____

State _____

Zip _____

Call Me () _____

238EDN061385



"Have you heard about that new Comlinear op amp? They say it has an 85 MHz -3dB bandwidth that's independent of gain...must be something really different."

"That's the CLC300. And it's only \$39! It's just what we need in our high-speed designs."

Announcing the new CLC300 Op Amp.

The "gain/bandwidth product" that has everybody talking.

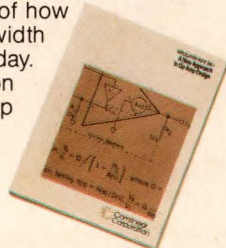
At Comlinear, we'd like to clear the air with some straight talk on gain/bandwidth products. Our CLC300 op amp delivers a fixed -3dB bandwidth of 85MHz. No more gain/bandwidth product. To do that, we've had to rewrite the book on op amp design and gain/bandwidth relationships. In fact, unlike most op amps, all key specs remain unchanged across a wide range of gains. Now you have an op amp that delivers the performance you need under real circuit conditions. And if that's not good enough, try this: the CLC300 is available for only \$39* in 100-piece quantities.

The CLC300's full-power bandwidth of 45MHz (at 20V_{p-p} into 100 ohms) and its 100mA *continuous* output current capability put it in a class by itself. For many applications it means you don't have to include power buffers to drive downstream

circuitry. Its slew rate is a fast 3000V/ μ s. Plus, its 4ns rise time and less than 3° deviation from linear phase (dc to 45MHz), make the CLC300 a natural choice for high-speed communications applications.

For more information on the new Comlinear CLC300 op amp, and for an engineering discussion of how we managed to achieve an 85MHz bandwidth virtually independent of gain, contact us today. We'll send you a free copy of our application note AN300-1: A New Approach To Op Amp Design. Call (303) 669-9433. Or write: Comlinear Corporation, 2468 East 9th Street, Loveland, CO 80537.

*Domestic USA price only.



**Comlinear
Corporation**

CIRCLE NO 22

SIGNALS & NOISE

Misleading statements about digital encoders

Dear Editor:

"Sensor, ADC specs set angular-measurement system's performance" (EDN, January 24, pg 165) by Geoff Boyes of Analog Devices contained some statements which I believe to be misleading.

The statement I object to most appears in the top right-hand column on pg 166, where Mr Boyes states: "Although absolute encoders overcome the problem of absolute-position certainty at power-up, transmitting those encoders' parallel digital outputs through noisy environments is far from easy. Long distances necessitate the addition of line drivers, repeaters, or both; moreover, wide digital words drive up wiring costs."

In current engineering practice, which is easier, transmitting analog signals over long distances, or transmitting digital signals over long distances? The main basis of acceptance of digital telephony or pulse-code modulation has been that once a signal is digitized, it can be transmitted in virtually an error-free state. When noise is added to an analog signal within the passband of the signal, it can never be removed. The portion of the state-

ment relative to noise in Mr Boyes's article is nonsense.

Mr Boyes's remarks also contained a misstatement about wiring complexity. Modern encoders with either serial or data-bus output formats can interface the encoder with as few as five wires. Note that in Fig 2 of the article, six wires are shown between the resolver and the converter. Ittek has discovered through its experience in dealing with customers in the aerospace industry that most high-accuracy resolvers using compensation windings require 10 to 12 wire interfaces.

Sincerely,

Donald H Breslow

Director of Engineering
Ittek Measurement Systems
Newton, MA

Author's response

Dear Editor:

Mr Breslow is, of course, quite correct to state that once noise is added to an analog signal within its passband, it can never be removed. The same is also true of digital signals, unless some form of error correction is incorporated. The key point here is to consider the effective passband of a resolver-to-digital converter.

The output signal from a resolver consists of amplitude information modulated onto an ac carrier waveform. To decode all this, modern tracking converters of the type described in my article include a phase-sensitive demodulator that will respond only to signals that are phase and frequency coherent with the known carrier signal. When you combine the phase-sensitive demodulator with the second-order lowpass-filter characteristic inherent in any type II tracking converter, the result is an effective noise passband that is a narrow slot (typically a few hundred hertz wide) in the frequency spectrum.

To assert that the transmission of digital data is inherently more secure than the transmission of analog data, irrespective of the technique employed, is fatuous. The noise-rejection performance of digital-data-transmission systems that include comprehensive signal conditioning and error detection (LANs and modems are good examples) can be very high indeed. Similarly, the ability of a resolver-to-digital converter to reject, for example, noise breakthrough from a PWM motor drive (often found alongside angle transducers) can be demonstrated to be excellent. However, to attempt to transmit unconditioned TTL signals over any significant distance, relying on no more than a few hundred millivolts of hysteresis in standard line receivers, is clearly asking for trouble. This is the point I was making: With a resolver and converter, the data-transmission system is built in. With most optical encoders that are available, users must add the data-transmission system themselves.

Regarding the number of interconnections necessary for various angle-measurement transducers, resolvers need only six wires. The compensated devices to which Mr Breslow refers are intended for trigonometric computing applications and not for simple angle measurement. The comment I made about interconnect costs for encoders was aimed at true absolute encoders that output parallel data. Given that resolver-to-digital converters have resolutions of 10 to 16 bits, a comparable absolute encoder must always have more interconnections. Incremental encoders can certainly have fewer output connections, but these devices have other problems, as I pointed out in the article.

Sincerely,

Geoff Boyes

Analog Devices Ltd/
Memory Devices Ltd
East Molesey, Surrey, England



SIGNALS & NOISE

Using digitizing oscilloscopes

Dear Editor:

I enjoyed the Special Report on digitizing instruments (EDN, March 7, pg 112), and I recommend it to anyone who works with automatic test equipment.

I would like to stress that perhaps the most difficult aspect of using a digitizing oscilloscope is the development of efficient algorithms for analysis of the data that represents the digitized waveform.

One is seldom so fortunate as to simply have to determine frequency or pulse width, especially since an electronic counter can measure such parameters directly. Usually, you must determine whether a noisy, jittery waveform has a certain amount of overshoot, ringing, droop, or rise time, or a complex form. An operator can determine such characteristics by observation,

but an automated system must analyze a large number of data points in a way that gives the correct answer within a reasonable time. Coming up with straightforward and accurate techniques to do the job can present a formidable challenge to any engineer.

Sincerely,
Allan C Stover
Ellicott City, MD

Analog input bandwidth is important for digitizing tools

Dear Editor:

The Special Report on digitizing instruments by Charles H Small (EDN, March 7, pg 112) was well done and very comprehensive. Especially interesting was the editorial box on pg 116 and 117. One could consider this to be a *Consumer Re-*

ports-style selection guide.

Having worked at Biomation (now Gould Santa Clara) in marketing/applications in the early days of transient recorders (Biomation was a pioneer in the field), I wish to discuss a few points that Mr Small brought out in the box.

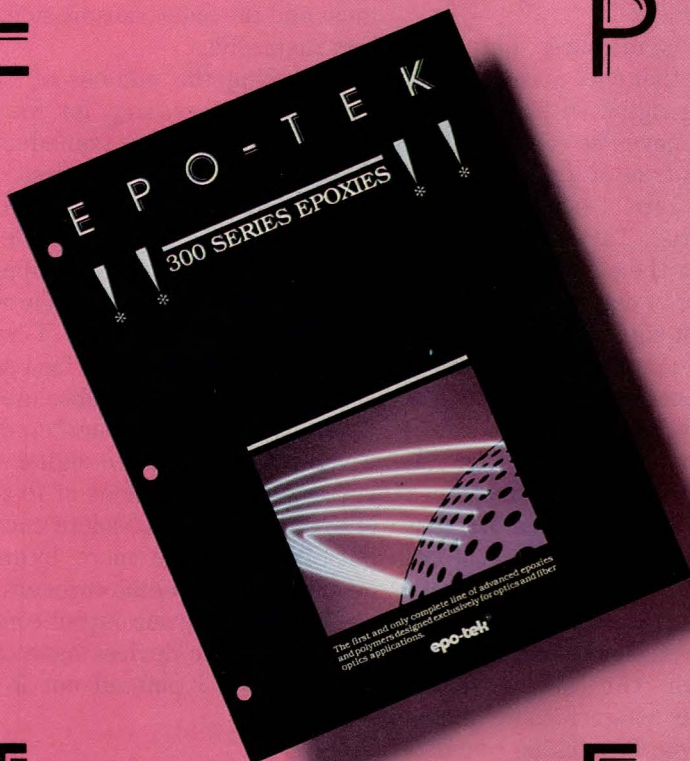
First, it is true that, for capturing transient events, the most important spec is digitizing rate. However, the analog input bandwidth is another important consideration.

When you look at transients in the frequency domain, you find that they're wideband signals. The input bandwidth is little more than an indication of how the transient pulse will be softened. On the other hand, the most important aspect of the input bandwidth is how close it is to the maximum sample rate.

The analog bandwidth should be $\frac{1}{3}$ to $\frac{1}{4}$ of the sampling frequency, because this tends to minimize ali-

E

P



300 SERIES EPOXIES FOR OPTICS AND FIBER OPTICS.

The first and only complete line of advanced epoxies and polymers designed exclusively for optics and fiber optics applications. Send for our 300 series brochure, listing complete product specifications and recommended applications.

epoxy
technology
inc



World leader in epoxies for optics and fiber optics.

T

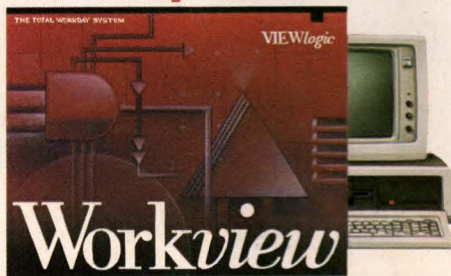
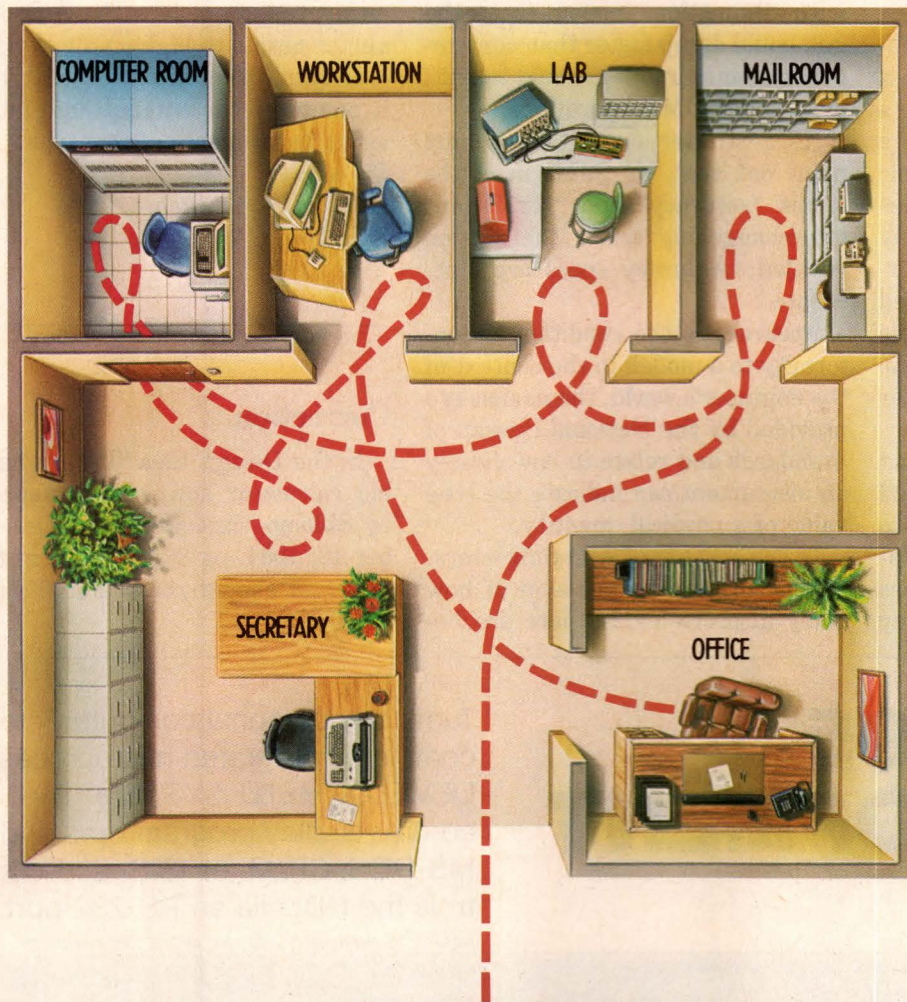
E

K

P.O. Box 567, Billerica, MA 01821 Tel. (617) 667-3805, 1-(800) 227-2201, Telex 94-7140

CIRCLE NO 23

**FOLLOWING A DESIGN ENGINEER
AROUND ON A TYPICAL DAY
CAN LEAD TO ONLY ONE CONCLUSION.**



On any given day, design engineers are apt to be out of their offices as often as they're in.

To do design work, they have to park themselves in front of a workstation somewhere. For their documentation needs, they have to hover over a secretary. And it's back and forth throughout the organization to dispatch copies of their schematics.

Not only is this extraordinarily inefficient. Thanks to Workview,TM it's also entirely unnecessary.

Eminently affordable, Workview is the first and only IBM PC-based software program that addresses the three fundamental aspects of the design engineer's job—design, documentation and communications. All *integrated* under one easy to use, multi-windowed user interface, it's The Total Workday System.™

Workview supports analog, semicustom chip and design with standard parts. Its design facilities include a schematics editor and an interactive simulator with waveform I/O editing. Its documentation facility allows you to merge graphics and text. Finally, through Ethernet, Workview's communications facility provides for instant communication, pc to pc and pc to host.

For more information, call us toll-free at 1-800-CAE-VIEW. In MA, the number is 617-480-0881.

VIEWlogic™

asing, which is a source of inaccuracy in measurement. Input bandwidth closer to the sample rate is permissible only if the input filter in the analog stages before the A/D converter has a very sharp cutoff.

The desire for more bits of resolution in the A/D converter is often a result of the user's desire to have a wide dynamic range, because a 10-bit A/D converter has a dynamic range (1 in 1024) that's four times that of an 8-bit unit (1 in 256). Many transients are only generally characterized before they're captured and examined, so it pays to be able to capture more information in one shot—and a 10-bit A/D converter captures more information.

Mr Small also discussed the dead time between one capture cycle and the time the instrument is ready to capture again. There are two probable reasons why manufacturers didn't supply this information; they

have never measured it, or they realized that the time is completely dependent on how fast the mass-storage device can accept the data. This was always the limiting factor with Biomation instruments; the unit could dump faster than contemporary minicomputers could take it, even under DMA operations.

As a stickler for detail, I must point out that Mr Small used the terms "accuracy" and "resolution" interchangeably under the section entitled "Accuracy specs are inaccurate."

Accuracy is the condition of conformity to a model; in the context of the engineer's world, the models are provided by the National Bureau of Standards and relate to how closely an instrument can indicate the true value of a physical quantity.

In the context of A/D converters, resolution is an expression of how many discrete levels there are be-

tween the instrument's plus and minus full-scale input range; resolution has nothing to do, per se, with accuracy as defined above. Effective resolution is, as Mr Small implied, an expression of how the A/D converter reacts to high dV/dt signals.

In sum, the article was great, and it points up the current high interest in instruments of this type.

*Sincerely,
Edward S Jacklitch
San Jose, CA*

Correction

In the Design Idea "Programmable calculator solves congruence," by Shlomo Varsano (EDN, December 13, 1984, pg 368), line 13 of the program should read "ST*Y", not "STO Y".

THE \$2995 I² DEVELOPMENT SYSTEM

Turns any personal computer into a complete, integrated microprocessor DEVELOPMENT SYSTEM. The control/display program runs under MS-DOS, CP/M, or ISIS, and controls the UDL via an RS-232 port.

ADAPTERS AVAILABLE FOR VAX, APPLE CP/M AND PDP-11



IN-CIRCUIT EMULATOR

32K bytes of EMULATION ROM (128K max) allows you to make program patches instantly. You can stop the program at break-point, single-step, and display or change registers, ports and memory. The target processor stays in its socket for perfect transparency.

BUS STATE ANALYZER

Features four-step sequential triggering, selective trace, and pass and delay counters. Symbolic trace disassemblers and debuggers are available for Z-80, NSC-800, 8048, 6301, R65, 6500, 6800, 6801, 6802, 6805, 6809, 8051, 8085, Z-8, 1802, 8088/80188, 8086/80186, and 68000/8.

EPROM/EEPROM PROGRAMMER

Doubles as a stimulus generator during system checkout. Handles 24 and 28 pin devices up to 27256.

FOR FURTHER INFORMATION
TELEPHONE JOHN STANLEY

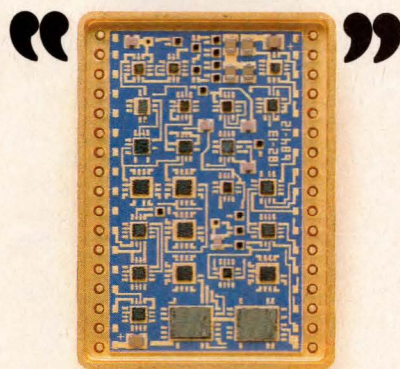
(415) 361-8883

OR WRITE:

ORION INSTRUMENTS, INC. 702 MARSHALL STREET • SUITE 614 • REDWOOD CITY, CA 94064

CIRCLE NO 25

What's Boeing's answer to small space circuitry when you can't risk failure?



In today's military and aerospace applications, you don't get a second chance. You need systems that are small, light and, above all, reliable.

That's why the F-18, AWACS and Air Launched Cruise Missile use custom hybrid microcircuits from Boeing.

Whatever the microcircuit requirement, wherever the application, Boeing has the solution.

From hybrids with 500,000-hour MTBF to hybrids with 150 integrated circuit chips. From 14 hybrids in the Air Launched Cruise Missile to over 70 in the 767.

What's more, our state-of-the-art test facility assures that the hybrids you receive are virtually defect-free. Which is why in the last three years, the rate of return has been a remarkably low 0.001%.

Whatever your hybrid problem, Boeing delivers: performance, reliability and quality.

For more information, contact Bette Zimmerman, Boeing Electronics Company, P.O. Box 3707, MS 9A-10, Seattle, WA 98124. Telephone (206) 575-5755. **BOEING**

**The world's only 14 GHz
digital storage oscilloscope.
Let your imagination loose!**

Imagine digital storage to 14 GHz with 10-bit resolution and simultaneous real-time display. Imagine limitless powerful waveform processing. Imagine an oscilloscope that can follow wherever your imagination leads. Only the Tek 7854 lets you take all that and build from there!

Whether your measurement needs are basic or exceptional, the 7854 can be configured to a perfect fit. No other digital storage oscilloscope begins to encompass such a range of capabilities, or to give such free rein to your own ingenuity.

No other oscilloscope makes it so easy to calculate measurements like rise time, delay and width; to multiply one waveform by another; to integrate, differentiate and smooth—all at the push of a button.

No other oscilloscope puts such powerful waveform processing at your fingertips: use the companion waveform calculator to automate any repetitive measurement, or connect via GPIB to all the documentation, storage and processing advantages of a controller-based analysis system.

The 7854 readily adapts to your changing measurement needs. From basic amplifiers, time bases and counters to the prodigious 14 GHz sampling units, Tek 7000 Series plug-ins let you focus your imagination to the task at hand.

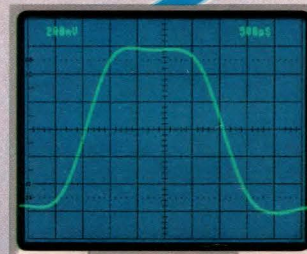
Contact your local Tek Sales Engineer to learn more about configuring the world's most general-purpose digital storage oscilloscope to your exact demands. For the name of the Tek sales office nearest you, contact **Tektronix, Inc.** P.O. Box 1700, Beaverton, OR 97075. In Europe: Tektronix Europe B.V., Postbox 827, 1180 AV Amstelveen, The Netherlands.



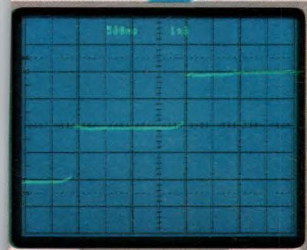
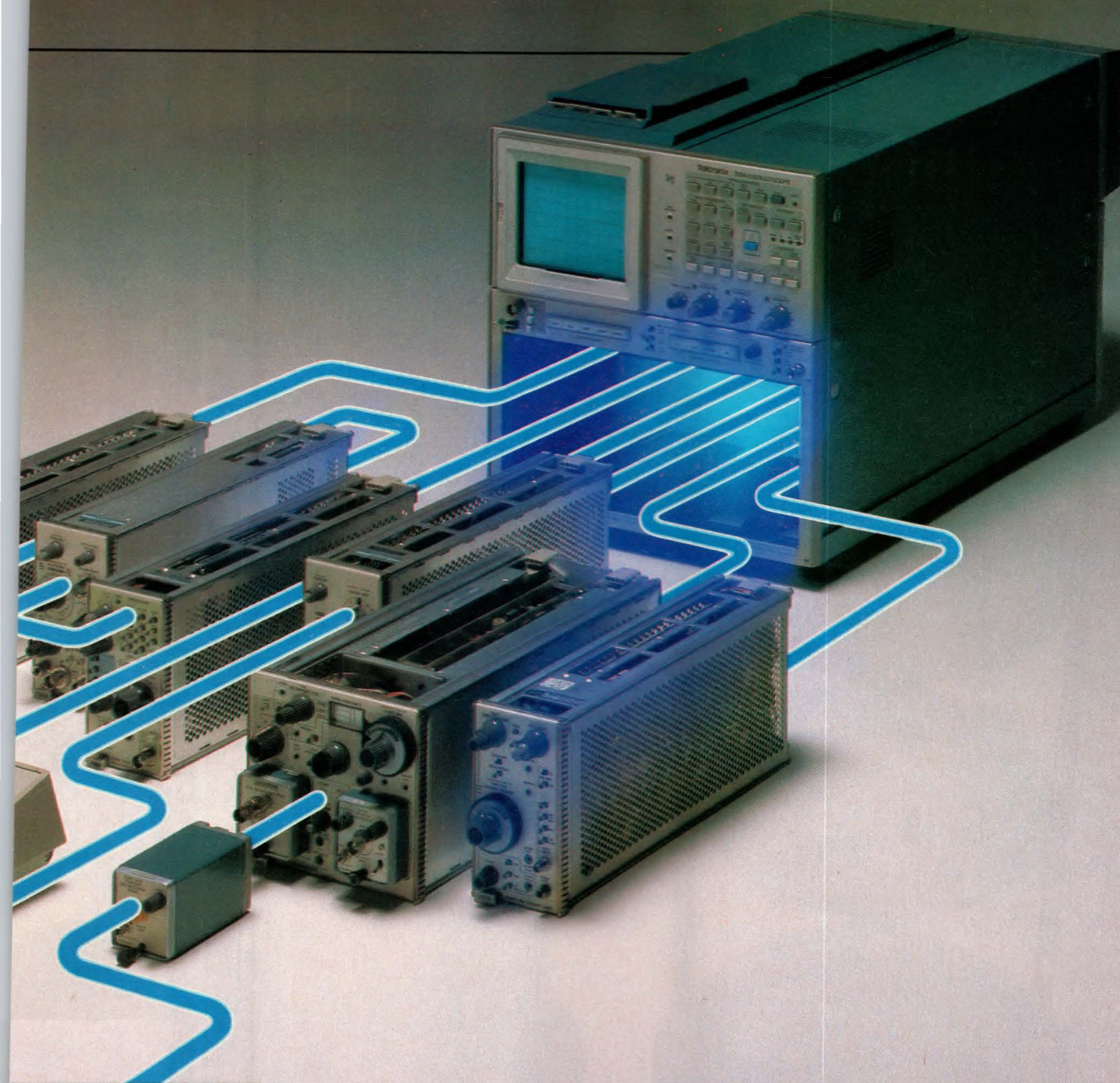
Multi-Waveform Storage and Calculation—Simplifies circuit design. Allows simultaneous viewing of calculated results and acquired waveforms. **System:** 7854 with 7A22 differential amplifier and 7B87 Time Base.



Waveform Processing—Key stroke programming enables user to design measurement routines tailored to individual tests or experiments. **System:** 7854 with Waveform Calculator Keyboard.



Real Time—allows quick and easy viewing of signal presence as well as changes as they occur. **System:** 7854 with 7A24 High Bandwidth plug-in and 7B80 Time Base.



Time Domain Reflectometry
— Open transmission line reflects pulse; time of reflection represents the electrical length of line. **System:** 7854 with 7S11 Sampling Unit, 7S12 TDR/Sampler.

Tektronix®
COMMITTED TO EXCELLENCE

CIRCLE NO 27



Eliminate design bottlenecks
with accelerators from Daisy.

Two accelerated Daisy CAE workstations help you spend more of your time *designing*, less time *waiting*.

Daisy's MegaLOGICIAN™ accelerates you through simulation bottlenecks.

The MegaGATEMASTER™ addresses layout bottlenecks.

Your design cycle shortens significantly.

MegaLOGICIAN. Crunches simulations, timing verification, and fault grading bottlenecks down to interactive speeds.

Power: The Mega hardware accelerator speeds up Daisy's highly accurate, mixed-mode simulation software with an advanced data flow architecture optimized for event-driven algorithms.

The accelerator: Micro-coded, and customizable for new Mega Series systems that will address new design bottlenecks.

The heart of the Mega accelerator: Three dedicated bit-slice processors operating in parallel, with up to 48 Mbytes of private memory.

The result of the Mega accelerator: *Accurate* simulations that used to take a workstation 2 hours now take about 70 seconds.

You get the answer before you forget the question.

No 'batch and wait' for mainframe turnaround.

Interactively make design changes. Then run the simulation again. Like working with a breadboard, but with more accuracy, and in *real time*.

Mega-tize the GATEMASTER®. Control your large gate array design.

Now you don't have to hand over your design to a silicon vendor for placement and routing—not even for a 5000+ gate array.

With a MegaGATEMASTER, *you* define the critical design relationships. *You* drive the crucial placement decisions. *You control* the design. Shorten interconnects. Improve performance.

MegaGATEMASTER is an expert system for gate array design with the placement power to ensure 100% auto-routing of even the densest gate arrays.

You crunch through all the alternatives in a 5,000 or 10,000-gate design and come up with the best possible interconnect length at large mainframe speeds.

So you can try more alternatives in less time, for the best design.

Daisy systems architecture: Planned acceleration.

From day one, Daisy accelerators were planned into the hardware and software architecture.

Tightly knit hardware, software, and accelerators move you through the design cycle faster.

Don't clock just the accelerator.

Clock the design cycle.

Daisy will put you ahead *fastest*.

The Daisy Engineering Environment™: How to accelerate your entire design team.

Daisy connects your Personal LOGICIAN (based on the IBM XT or AT) to Mega resources.

You get affordable access to the Mega-accelerators, no matter which Daisy system you have on your desk.

Do you want to take the hurry-up-and-wait out of your engineering design cycle?

Call today for more information on Daisy's product line, including the growing Mega Series of acceleration systems.

1-800-556-6661-Dept 5N

In CA:

1-800-824-2385-Dept 5N



**DAISY IS
ENGINEERING**

Corporate Headquarters: 700 Middlefield Road, Mountain View, CA 94039-7006, Telephone: 415-960-0123, Telex: 858262
European Headquarters: Berk House, Basing View, Basingstoke, Hampshire, England RG21 2HQ, Telephone: 256-464061, Telex: 858071 DAISY G

Now get in-depth, at-speed IC characterization when and where you need it!

Meet the HP 81800S Digital Circuit Test System.

Whether you're evaluating new IC designs, conducting QC. checks on production ICs, or checking incoming devices, the HP 81800S Digital Circuit Test System provides fast and precise access to IC parameters.

You get a complete look at your ICs.

The HP 81800S offers you a unique 100 picosecond and 10 mV resolution for optimum performance. A 50 MHz system data rate for at-speed testing. And a test head/performance board with 50 Ohm technology right up to the test pins for accurate, repeatable characterization.

You get easy setup and operation.

Using an HP Series 200 controller, you can test many different ICs quickly and easily. The programs that come with the system are both ready to run and easy to learn, keeping your cost of ownership at a minimum. Plus, the HP 81800S is modular and expandable, so it will meet your exact needs today and keep on meeting them tomorrow.

Call HP today!

See how the HP 81800S enhances productivity and IC quality in your company. For details, call your local HP sales office listed in the telephone directory white pages and ask for the electronic instruments department.



HP-IB: Not just IEEE-488, but the hardware, documentation and support that delivers the shortest path to a measurement system.



**HEWLETT
PACKARD**

CIRCLE NO 66

0801505



CALENDAR

Fiber Optics to the Year 2000, Monterey Conference Center, Monterey, CA. Eloise Beckett, Electronicast Corp, 40 Birch St, Redwood City, CA 94062. (415) 365-1322. June 17 to 18.

Nepcon East, Bayside Exposition Center, Boston, MA. CEG, Box 5060, Des Plaines, IL 60018. (312) 299-9311. June 19 to 21.

Society of Women Engineers National Convention, Minneapolis, MN. SWE, 345 E 47th St, New York, NY 10087. Phone (212) 705-7855. June 23 to 30.

International Electronic Printer Industry Conference, Brussels, Belgium. CA Pesko Associates Inc, 1 Snow Rd, Marshfield, MA 02050. (617) 837-1341. June 24 to 26.

Programming in C: A Hands-on Workshop, Boston, MA. Ruth Dordick, Integrated Computer Systems, Box 45405, Los Angeles, CA 90045. (800) 421-8166; in CA, (800) 352-8251. June 25 to 28.

Semicon/Osaka '85, Osaka, Japan. William Galarneau, SEMI, 625 Ellis St, Suite 212, Mountain View, CA 94043. (415) 964-5111. June 25 to 26.

Management Skills for New and Prospective Managers (seminar), New York, NY. New York University, School of Continuing Education, 575 Madison Ave, New York, NY 10022. (212) 580-5200. June 26 to 28.

Legal Issues in Acquiring and Using Computers (seminar), New York, NY. New York University, School of Continuing Education, 575 Madison Ave, New York, NY 10022. (212) 580-5200. June 27 to 28.

Writing Better User Manuals, Denver, CO. Battelle Memorial Institute, 4000 NE 41st St, Seattle, WA 98105. (800) 426-6762; in WA, (206) 527-0542. June 27 to 28.

FIVE COLD FACTS ABOUT THE NEW ICECUBETM *high-efficiency, military-grade power supplies*

1. The ICECUBE is the first standard line built under the Navy's guideline for power supply design (NAVMAT publication P-4855-1).
2. The ICECUBE line provides minimum full-load efficiencies of better than 70% over the full MIL operating temperature range of -55°C to 100°C *with no derating*. (How many power supplies do you know of that can support such a claim?).
3. The ICECUBE is the first line of standard military-grade power supplies to use the UC-1846J current-mode control IC.
4. The ICECUBE line offers, unit-for-unit, more desirable performance and size/weight characteristics than any comparable standard module.
5. The ICECUBE was designed from the ground up to provide extraordinary reliability. In most cases, it will outlast the equipment it powers.

For detailed specs, contact

POWERCUBE
A DIVISION OF UNITRODE CORPORATION

8 Suburban Park Drive
Billerica, MA 01821
(617) 667-9500
TWX: 710-347-6792



CIRCLE NO 30

DID YOU KNOW

EDN's editorial staff is backed by 158
cumulative years of technical experience and
nearly 200 years of journalistic experience.

EDN

Cost-efficient DC-to-DC converters

For powering gas discharge displays
and many other applications



For multi-segment, bar graph or matrix gas discharge displays...or for any power need on the PC board up to 25W...specify ERG DC-to-DC converters.

Compact, economical, reliable. Up to 4.2 W/cu. in., as low as \$1/W. Eliminates need for 200-250V DC line in display applications. Unregulated (you don't pay for regulation where it's not needed). Over 1,500,000 ERG units shipped already! Made in U.S.A.

Free "Finder Chart" matches our converters to your needs. For special applications, contact John Peterson, ERG Engineering, today.

Power for
displays
starts here!



Endicott Research Group, Inc.

2601 Wayne Street, P.O. Box 269
Endicott, NY 13760

TM 607-754-9187 TWX 510-252-0155



CIRCLE NO 31

CALENDAR

CADMAT-Asia '85 (Computer-Aided Design, Manufacture, and Test), Mandarin Hotel, Singapore. Bryman-Bull Ltd, 1716 Monticello Rd, San Mateo, CA 94402. (415) 345-3603. July 9 to 11.

How to be Effective as a Technical Manager, Washington, DC. Ruth Dordick, Integrated Computer Systems, Box 45405, Los Angeles, CA 90045. (800) 421-8166; in CA, (800) 352-8251. July 9 to 12.

Principles of Microcomputers and Microprocessors (short course), Ann Arbor, MI. University of Michigan, Continuing Engineering Education, 300 Chrysler Center/North Campus, Ann Arbor, MI 48109. (313) 764-8490. July 15 to 19.

Programming in C: A Hands-on Workshop, Los Angeles, CA. Ruth Dordick, Integrated Computer Systems, Box 45405, Los Angeles, CA 90045. (800) 421-8166; in CA, (800) 352-8251. July 16 to 19.

Computer Simulation Conference and Exhibits, Westin Hotel, Chicago, IL. Charles Pratt, The Society for Computer Simulation, Box 2228, La Jolla, CA 92038. (619) 459-3888. July 22 to 26.

How to be Effective as a Technical Manager, San Diego, CA. Ruth Dordick, Integrated Computer Systems, Box 45405, Los Angeles, CA 90045. (800) 421-8166; in CA, (800) 352-8251. July 23 to 26.

1985 Microelectronics Interconnect Conference, Rippling River Conference Center, Welches, OR. International Society for Hybrid Microelectronics, Box 3255, Montgomery, AL 36109. July 29 to 31.

Programming in C: A Hands-on Workshop, Washington, DC. Ruth Dordick, Integrated Computer Systems, Box 45405, Los Angeles, CA 90045. (800) 421-8166; in CA, (800) 352-8251. July 30 to August 2.

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.



We read everything so you don't have to.

ElectronicDesign

Electronic Engineering
TIMES

**SEMICONDUCTOR
INTERNATIONAL**

IEEE
SPECTRUM

**solid state
technology**

**Integrated
Circuits**

**SOLID-STATE
CIRCUITS**

EDN

**Electronic
Products**

VLSI
DESIGN

DIGITAL DESIGN
SYSTEMS ARCHITECTURE, INTEGRATION AND APPLICATIONS

ELECTRONICS
Bulletin

ELECTRONIC
Synopsis

P.O. Box 3029, Saratoga, CA 95070

CIRCLE NO 33



We read everything in every publication on your electronics must-read list. Including editorials, feature articles, new items, surveys, product reviews, people and company profiles, and more. Everything.

Then we detail each article. And tell you where to find it. Cross-indexed by publication, product category, author, company, and people. Plus everything is listed alphabetically with publication, date, and page number.

We're Electronic SYNOPSIS. The one magazine that can keep you current on everything that's happening in your field. And drastically reduce the time you spend each month keeping current.

A one-year subscription to Electronic SYNOPSIS (12 monthly issues) is only \$40. Far less than the value of the time you'll save with the very first issue. Subscribe now.

Please enter my subscription to Electronic SYNOPSIS.
P.O. Box 3029, Saratoga, CA 95070

NAME _____ TITLE _____
COMPANY _____
ADDRESS _____

CITY _____ STATE _____ ZIP _____

☐ Please invoice my company. P.O. # _____
☐ Bill me.
☐ Check enclosed.*

I'm not sharing, mail Electronic SYNOPSIS to my home.

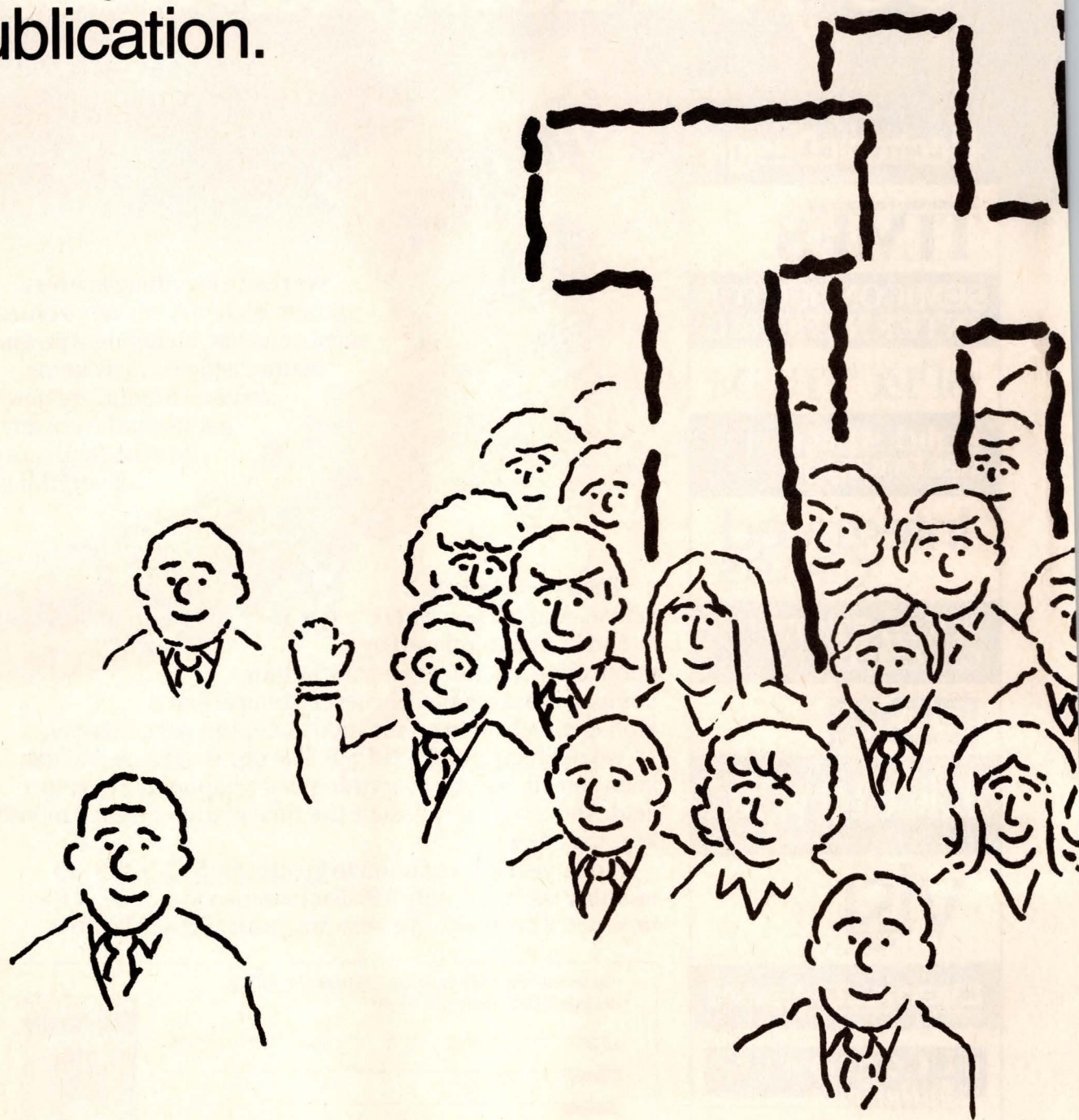
ADDRESS _____

CITY _____ STATE _____ ZIP _____



*Best value: include your check with this coupon and pay only \$32 and save 20% off the regular subscription price.

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





From the staff of EDN

We can blow the doors off an F-15.

Imagine what we can do for you. We're Ensign-Bickford Optics Company and whether you want to blow the canopy off an F-15 jet with laser initiation, or blast plaque from a coronary artery, we've got the optical fiber system for you. Today.

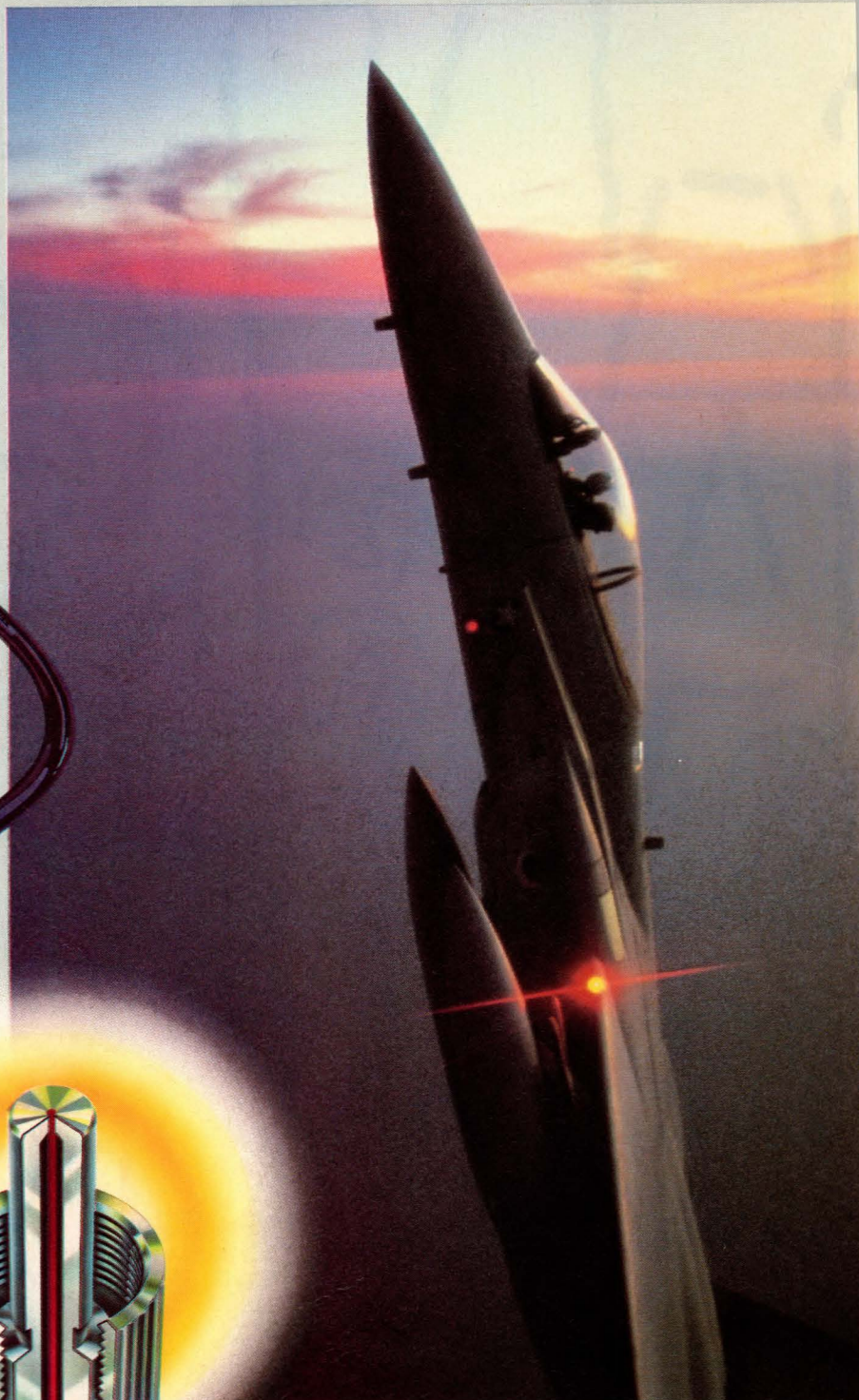
At the heart of our complete system of fiber, cables and connectors is our Hard Clad Silica (HCS)[™] optical fiber. Twice as strong as conventional fiber (250 KPSI),

HCS allows us to use a unique, time and money saving *crimp and cleave SMA connector*.

Our fiber cladding doesn't need to be dissolved, stripped away or reclad like traditional plastic clad fibers. For military and medical applications, our optical fiber system can be manufactured radiation-resistant, as well as ultra high proof — 500 KPSI.

Ensign-Bickford's technology has been at the forefront of

the specialty optical fiber industry since 1968. So if you have medical, military, industrial process or data communication applications, we have the products to meet your needs. Call us. After all, fiber optics isn't just for the telephone company.



Ensign-Bickford Optics company

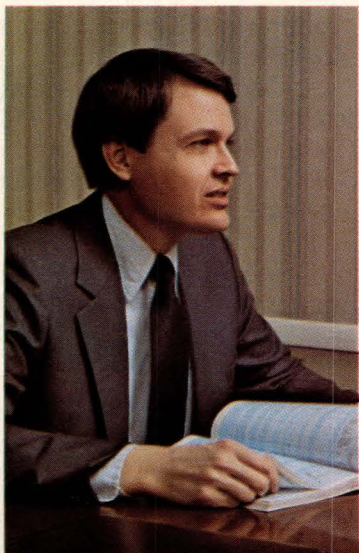
16-18 Ensign Drive, Avon, CT 06001, 203-678-0371

Imagine what we can do for you.

CIRCLE NO 34

EDITORIAL

μ P history repeats itself



Barely a decade ago, microprocessors were new and largely unknown. Except for a small cadre of technology leaders, engineers were still evaluating the new devices and learning how to apply them. Then, in seemingly no time at all, μ Ps were everywhere—in such visible applications as personal computers and in countless invisible roles ranging from home appliances to industrial machinery. Now, only a decade later in time, but generations later in technology, 32-bit μ Ps are repeating some of the history written by their 4-, 8-, and 16-bit predecessors. And many of the lessons that we learned a decade ago are lessons that we must learn again today.

One of the most important lessons is that a new technology will eventually find uses that aren't immediately obvious. Just as the early μ Ps found uses beyond calculators and personal computers, so will the new 32-bit devices find applications beyond workstations and minicomputers. Like their predecessors, 32-bit devices will play numerous invisible roles in embedded systems—in robotics, for example, where rapid, real-time response and high precision are essential, or in machine-vision systems, where image processing requires high-speed, high-precision number crunching. And like 4-, 8-, and 16-bit embedded- μ P systems, 32-bit embedded systems will require special hardware and software development tools, a topic that we address in this issue's cover story.

If you're one of the relative few who are already designing 32-bit systems, you know that your choice of 32-bit development systems, like your choice of 32-bit μ Ps, is still limited. As associate editor Charles Small points out in his article, however, not all approaches to 32-bit-system development require traditional in-circuit emulation. Your options, depending on the type of application you're developing, can include ROM emulation or even software development directly on your target system. In the latter case, an off-the-shelf, ROM-resident, real-time operating-system kernel might allow you to begin developing application software immediately.

So the outlook today, in many ways, is much as it was a decade ago. New μ Ps can help you solve previously unsolvable problems and create entirely new applications, but choosing the right μ P is just as difficult as it was then, if not more so. In addition, learning how to apply 32-bit devices—devices that are at least an order of magnitude more complex than their immediate predecessors—is a challenge comparable to applying the first, revolutionary μ Ps. In this issue of EDN and in issues to come, we'll help you meet that challenge.

Gary Legg

Gary Legg
Editor

PS. Cahnners Publishing Co has moved to a new location. You can now contact EDN magazine at 275 Washington St, Newton, MA 02158; phone (617) 964-3030.

The new HP engineering drawing system.

You may think you're looking It could pay you to look again.

Actually, you're looking at a new computer-aided drawing system. We call it the HP Engineering Graphics System or HP EGS. And fortunately, it fits right in between time-consuming drawing boards and full-blown CAD systems — which makes it very affordable.

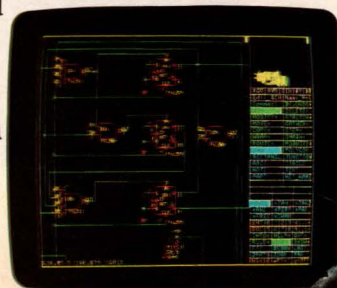
Whether you're involved in circuit or PC board design, mechanical engineering, technical writing or drafting, HP EGS can significantly reduce your manual drawing time and labor costs. And if you've been using a CAD system for technical drawing, HP EGS can eliminate waiting periods and free the CAD system for its more specialized tasks.

The right tools for schematics and PC board layouts.

When preparing schematic drawings, HP EGS makes your task faster and easier. You'll have access to a sample library that contains over 50 already drawn components. And simple English commands allow you to create and save new parts.

When it comes to drawing PC board layouts, HP EGS offers more time-saving features. For example, a Rat's Nest Generator will automatically make all appropriate connections between PC board components. All components can be moved and traces rerouted while your connections remain intact. A step and repeat command saves time when your PC board design includes many ICs in a symmetrical pattern. And you save more time by using a sample library of over 40 PC board elements. Options, such as tooling outputs for photo-plotters and NC drills, are also available.

Once you've completed your schematic and PC board layouts, HP EGS will generate parts and connection lists. And there's a Connect List Compare



at a CAD system.



function to verify that your schematic and PC board connection lists are equivalent.

In addition to preparing PC board layouts and schematics, you can also use HP EGS to create other engineering artwork, such as detailed product and assembly drawings. And with an optional document editor, you'll be able to merge text and graphics for technical documentation.

A system you can tailor to your present and future needs.

Even if you have no prior programming experience, you can customize HP EGS to your exact needs. Customizing can include simple screen menu changes,

additions to the parts libraries, and the development of new drawing environments. And of course, you have a variety of Hewlett-Packard computers and peripherals to choose from.

Teamed up with our MC68000-based workstations, HP EGS offers networking capabilities that allow users to share data and peripherals. In addition, an optional IGES (Initial Graphics Exchange Specification) translator lets you transfer your drawings between HP EGS and CAD systems.

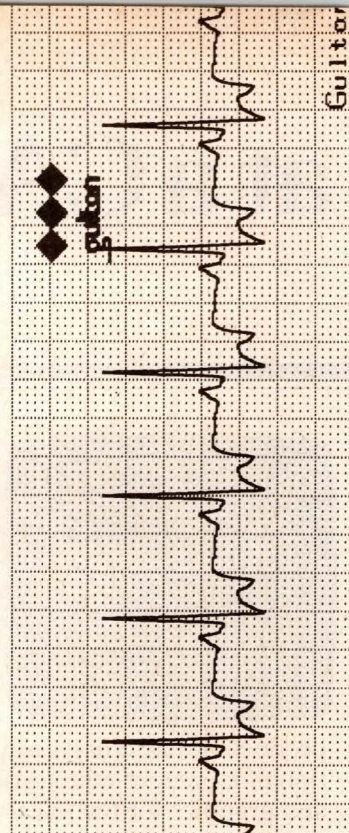
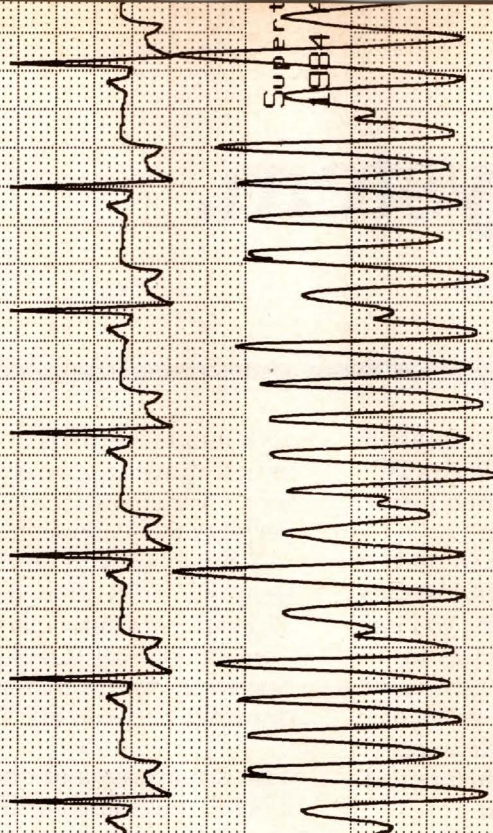
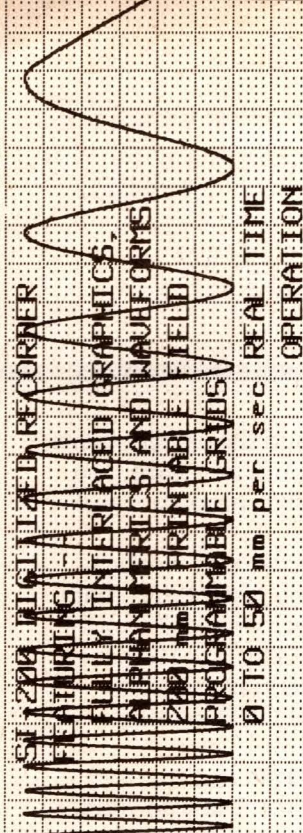
The advantages of choosing HP.

There's still more to HP EGS. You can also count on documentation, training, plus worldwide support and service. For complete information on HP EGS, call your local HP sales office. You'll find us listed in the telephone directory white pages.



HEWLETT PACKARD

CIRCLE NO 35



SHOWN ACTUAL SIZE

Simultaneous interactive waveforms, alphanumerics and high speed graphics...

**ALL IN ONE INSTRUMENT...
ONLY FROM GULTON.**

The Gulton Supertrak® recorder family combines a graphic plotter, a high-speed line printer and an analog digitized recorder in a single compact module. Choose one to four channels of high quality real time waveform recording with all of these features:

- Fully interactive high speed raster graphics, waveform recording and alphanumerics for maximum flexibility and expansion.
- Programmable interface meets all your hard copy demands while minimizing the burden on your host processor.
- Interlaced waveforms and alphanumerics on every channel for direct annotation or labeling.

- High-speed multiple tab-over control in raster graphics for maximum throughput at high chart speeds.
- Compact, efficient module design for simple mechanical interface.
- Resident software and interface controls for today's and tomorrow's hardcopy needs.

The Supertrak family of printer/plotter/recorders from Gulton advances the display capability of your medical or industrial instrumentation. Find out more about the Supertrak module that best meets your needs. Write GRAPHIC INSTRUMENTS DIVISION, Gulton Industries, Inc., East Greenwich, RI 02818, or call (800) 343-7929.

CIRCLE NO 36



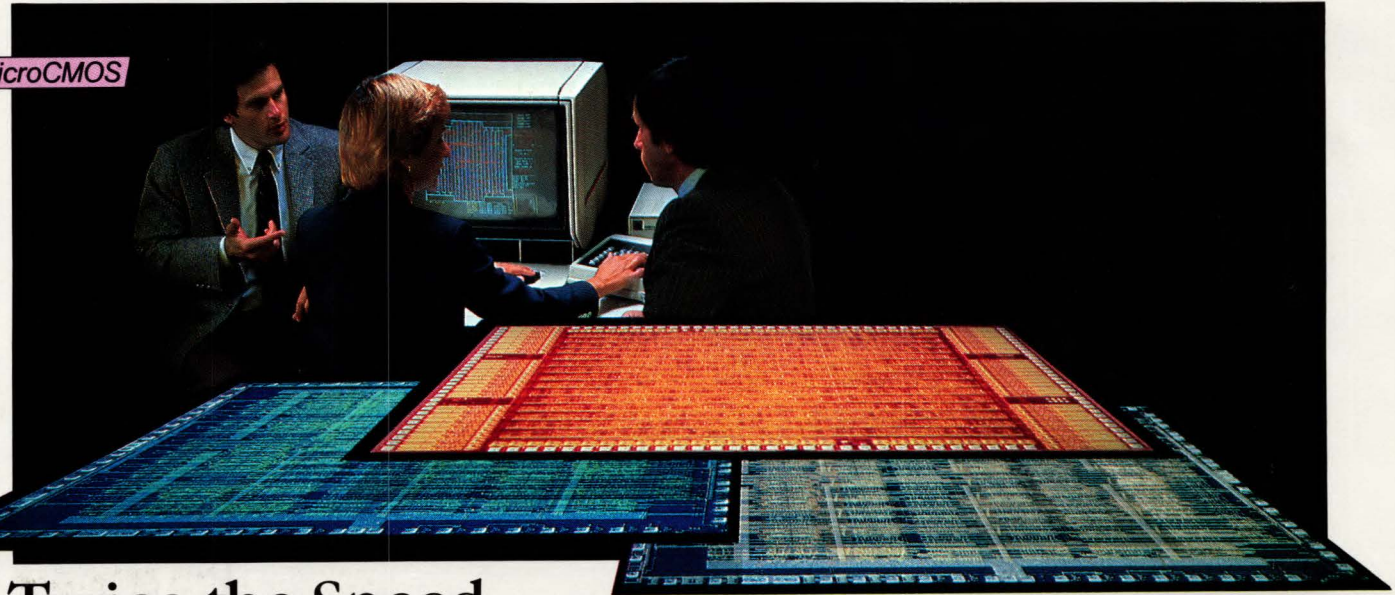
gulton®
 PLOTTING THE FUTURE
 OF GRAPHIC RECORDING

NATIONAL ANTHEM[®]

Technology News From National Semiconductor

51

microCMOS



Twice the Speed From 2-Micron, 1ns microCMOS Gate Arrays

National continues to advance state-of-the-art CMOS gate array technology with its 2-micron (actual drawn geometry) SCX-series microCMOS family. These super-high-performance CMOS gate arrays have a typical internal gate delay of 1ns, and output drive capability of 6ma each.

2-micron performance with 3-micron economics

National's CMOS gate arrays have been production-proven over a wide range of densities from 1200 to 6000 gates. Consequently, these 2-micron devices are offered at prices comparable to their 3-micron counterparts while operating at roughly twice the speed.

Complete development support

National provides the latest in customer training, design automation tools and technical support to help streamline your design process.

For example, a complete range of hardware macros lets you choose the functions needed to implement the desired logic. And an extensive selection of "software macros" from National's software libraries enables you to design large 7400 Series logic functions.

These hardware and software macros are supported by National's fully integrated design automation system offer-

ing user-friendly design verification and 100% auto-place-and-route capabilities.

The TLC™ approach - Gate Array development made easy

From identification of a gate array need through successful implementation of the circuit, National's Training, Layout and Consulting group (TLC) has the expertise and the commitment to work closely with you to ensure a smooth, cost-effective development process.

The TLC commitment includes circuit evaluation, training, logic capture, design verification and validation, place-and-route, implementation, and prototype delivery - the entire range of technical resources necessary to produce advanced designs with built-in integrity and economy.

Design entry via workstations

In keeping with National's dedication to full technical support, workstation design-entry for gate array development is now available through Daisy and Mentor.

National offers the production-proven 2-micron CMOS gate arrays combined with workstation support, expert service, and a comprehensive set of design automation tools. Expect nothing less from the gate array technology leader.

For more information check box M0 on this month's coupon.

Inside News

CMOS

microCMOS Offers New Dimension to VLSI. Over 350 Products Detailed in New CMOS Databook.

Single-Chip microCMOS Modems. Versatile, No-External-Circuitry Converter. Easy Interface with Microprocessor-Compatible Real-Time Clock.

NS32032

First true 32-bit microprocessor.

New Products

TMP Family Opens New Terminal Applications. Small PALs Match 25ns Medium PAL Performance.

PLAN. PAL Software for Easier Programming. 5V-Only E²PROM Offers Fast Read Access.

Ultimate Performance Budgeting.

1.2V to 15 V Range Covered by Single 10 Amp Regulator.

Quality

Q/R Policy: Communication is Key.



**National
Semiconductor**

microCMOS: High-performance for the VLSI Era

microCMOS

National meets your needs as a system designer today for speed, analog and digital circuitry on the same chip, a wide operating temperature range, high noise immunity, and reliability with microCMOS.

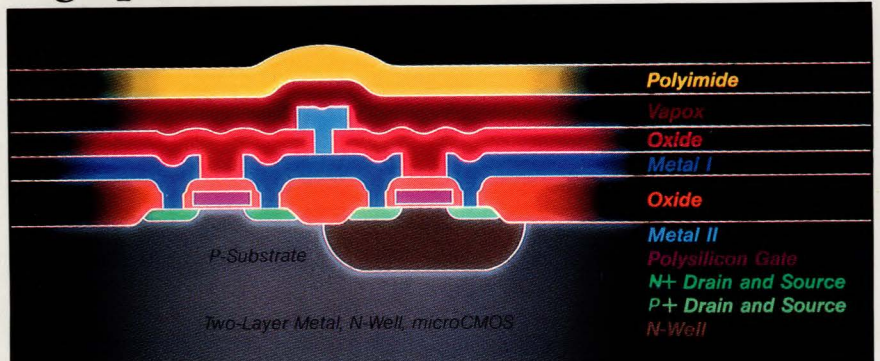
microCMOS is National's array of small geometry, silicon gate, oxide isolated CMOS processes used to manufacture a broad line of more than 250 high-performance integrated circuits.

With low power consumption, microCMOS combines NMOS speed and bipolar ruggedness to begin a new era in VLSI design.

Getting the speed

To increase speed, National uses self-aligning gates and oxide isolation to reduce internal capacitances. Plus, shortened channel lengths and reduced feature sizes throughout the circuit.

National gave speed yet another boost by developing microCMOS in N-well technology. Where extra-high performance is required, multiple-layer, metal interconnect systems extend our speed even further.



Beating the heat

Because microCMOS circuits require only about 5% of the power needed by a comparable NMOS circuit, heat dissipation is much less—allowing many more functions on the same chip.

Unmatched reliability

Proprietary processing enhancements make microCMOS latch-up proof and highly immune to ESD. Low DC current flow decreases metal migration and lower junction temperatures reduce heat dissipation—both of which increase reliability.

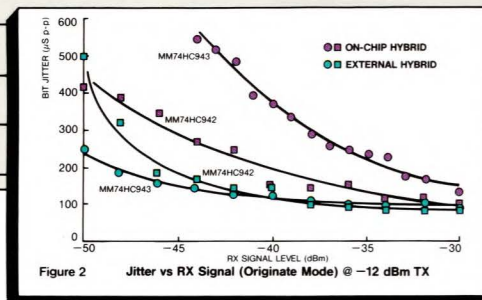
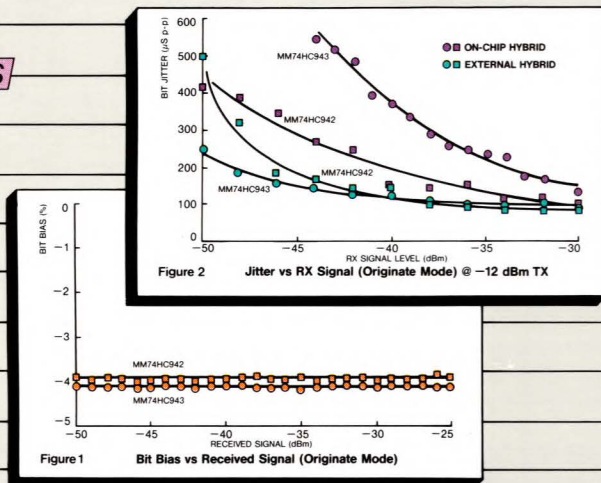
Analog-digital combinations, broad temperature ranges, high noise immunity

The availability of both P and N transistors allows analog and digital circuitry on the same chip. And low power microCMOS chips operate over a wide temperature range. In addition, the large separation between logic voltage levels means high immunity to electrical interference.

Whatever your application, National's more than 250 microCMOS products will help meet your system needs.

For more information, check box **M5** on this month's coupon.

microCMOS



reduced, making significant cost savings possible.

The new modems also incorporate modulator, demodulator and all necessary filtering functions—further reducing required board space.

By simplifying the design and lowering the cost of 300-baud interfaces, the MM74HC942/943 become the practical choice for generating and decoding Bell 103 frequencies.

Lowest bit error rate

When data is modulated by one modem and demodulated by another, two distorting phenomena can occur—bit bias and bit jitter.

Figure 1 illustrates how using National modems results in bit bias typically less than 4 percent. Figure 2 shows the exceptionally low bit jitter of the MM74HC942/943 with on-chip internal hybrid.

When lower-still bit jitter is needed, a simple external hybrid does the job at a small additional cost.

The small size and lower CMOS power requirements allow the MM74HC942/943 to be built directly into computers and terminals, eliminating cumbersome separate units.

For more information, check box **K8** on the coupon in this issue of the *Antem*.

New Single-Chip microCMOS 300-Baud Modems

Now available in high-volume production, National's MM74HC942/943 are advanced 0-300 baud microCMOS modems that facilitate data communications between two computers over telephone lines and other narrow bandwidth channels.

The MM74HC943 features a single +5V power supply, while the MM74HC942 further enhances dynamic

range by utilizing a dual $\pm 5V$ supply.

The MM74HC942 dissipates 120mW maximum; the MM74HC943 dissipates 60mW. Both offer a unique power-down mode that can further reduce dissipation to 2.5mW and 1.25mW respectively.

Fewer parts save board space, system costs

National's MM74HC942/943 are the world's first single-chip Bell 103 compatible modems.

Because line driver and hybrid functions are included internally, the number of required parts is substantially

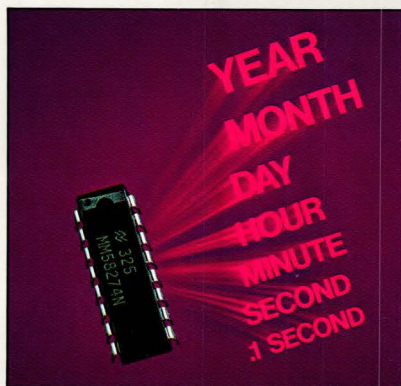


Easy Interfacing and Microprocessor-Compatibility from Real-Time, Clock/Calendar

Accurate time-keeping from tenths of seconds through years

Offering simplified interfacing to microprocessor buses, MM58274 is the latest addition to National's family of low power CMOS clock and calendar devices; which include the MM58167A and MM58174A.

PIN-compatible with the MM58174A, the MM58274 provides extended time-keeping up to units and tens of years plus a variety of added features.



High accuracy at low power

An on-chip 32,768-Hz crystal-controlled oscillator maintains accurate time-keeping with only 10 μ A at 2.2V—allowing low-power standby battery operation and long battery life. Other features include:

- Programmability for 12- or 24-hour operation.
- Interrupts with single or repeat modes for delay times of 0.1, 0.5, 1.0, 5.0, 10, 30 or 60 seconds.
- Easy bus access for both address and data.
- Buffered crystal frequency output for easy oscillator tuning.
- Testable "Data Changed" flag for easy, error-free time reading.

Compact, versatile, economical

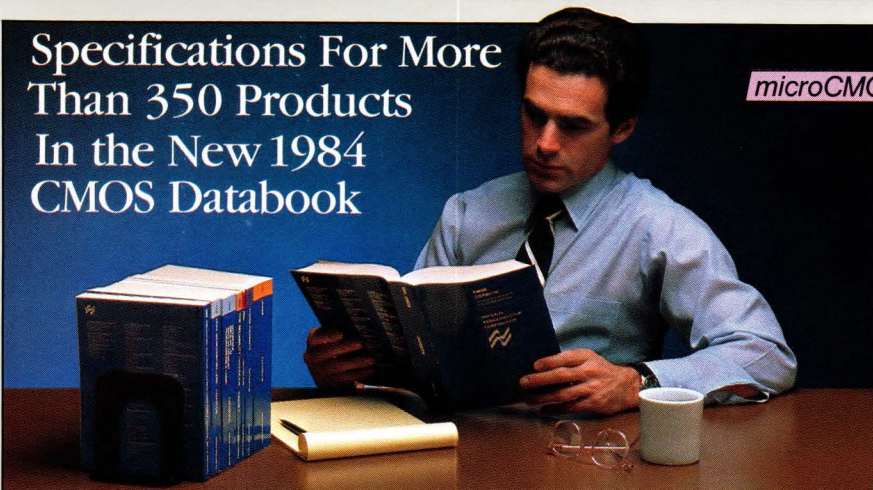
The MM58274 is fully TTL compatible and interfaces without wait states to most microprocessors.

Packaged in a small, 16-pin DIP package, the low-cost MM58274 marks another advance in low-power real-time clock devices for broad applications in bus-oriented microprocessor systems.

For more information, check box **L9** on the coupon in this issue of *Anthem*.

Specifications For More Than 350 Products In the New 1984 CMOS Databook

microCMOS



National Semiconductor Corporation's new CMOS Databook supplies the industry's most comprehensive collection of high-performance CMOS and microCMOS product specifications available today.

This massive reference contains technical information and detailed product specifications on more than 350 products. You'll find yourself referring again and again to this important addition to your technical library.

Our early commitment to microCMOS technology made possible the development of a broad spectrum of advanced devices that will simplify your designs and ensure low-power state-of-the-art systems.

microCMOS technology, National's array of small geometry, silicon gate, oxide-isolated processes was used to build many of the high-performance products described in this 1,500 page databook. Highlights include specifications of the 54/74HC High Speed microCMOS Logic Family, A/D and D/A Converters, CMOS Industrial Microcomputer Boards (CIM™), Telecommunication Devices and much more.

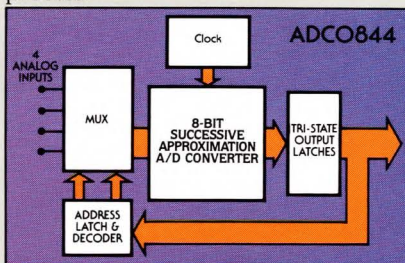
microCMOS accounts for nearly half of National's current research and development effort, and this technological commitment will increase through the 80's.

To order your data book today, refer to this month's coupon.

The Efficient ADC0844 Converter: All You Need Between Incoming Analog Signals and Your Data Bus

μ P compatible too

National's ADC0844 8-bit A/D converter offers a versatile 4-channel analog-input multiplexer complete with built-in address logic and an internal clock. In most cases, no external circuitry is needed for the digitizing process.



Total unadjusted error (including offset, full-scale, linearity and multiplexer errors) is $\pm 1/2$ LSB and ± 1 LSB.

The advanced device is fully compatible with most microprocessors, and operates from a single 5V power supply. Power consumption is a mere 10mW.

Designed to operate from the control bus of the NSC800, the converter incorporates TRI-STATE® output latches that directly drive the data bus. As a result, the unit can be configured as a memory location—or as an I/O device to the microprocessor. No interface logic is needed.

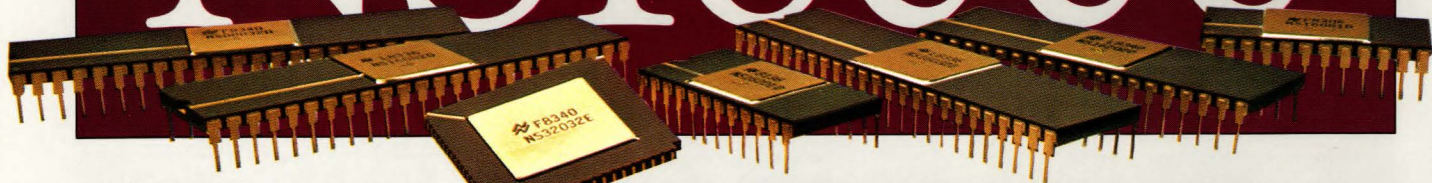
The ADC0844 operates ratiometrically or with 5V_{DC} voltage reference, 0V to 5V input range with single 5V power supply, and delivers a rapid conversion time of just 40 μ s (max.)—all in a 0.3" standard width 20-pin DIP!

The 4-channel multiplexer of the ADC0844 can easily be software-configured for single-ended or differential operating modes—or any combination of the two.

For these reasons, the versatile ADC0844 converter is your high-efficiency design choice.

For complete details, check box **J0** in the coupon on back page.

NS16000



NS32032

With the recent introduction of NS32032, National's NS16000 microprocessor family has become the foundation for the next generation of high performance, low cost computers.

The new microprocessor is the first to feature:

- Full 32-bit architecture
- Full 32-bit internal implementation
- Full 32-bit data bus to memory

Any software developed for the 32-bit NS32032 will run just as well on the 16-bit NS16032 or the 8-bit NS08032, and vice-versa. It will also run on future 32-bit CPU versions.

Downward/upward compatibility

The absolute *downward-upward* compatibility of the NS16000 CPU family is in sharp contrast to the *upward-only* compatibility of other microprocessor families. Their 16-bit processors will become obsolete when 32-bit processors join their product lines.

The fact that National's NS08032 and NS16032 CPUs (with their 8-bit and 16-bit data buses) share identical 32-bit architecture and 32-bit implementation with the NS32032, means it is now possible to develop 8- and 16-bit systems with all the benefits of 32-bit software performance.

The same software can now be implemented on all systems within a product family – an enormous benefit to programmers and systems designers. **NS32032 is supported by available peripherals**

The NS16000 family already includes all these peripherals: the NS16201 Timing Control Unit, the NS16202 Interrupt Control Unit, the NS16081 Floating Point Unit, and the NS16082 Memory Management Unit – all in full production now.

National's 32-Bit Microprocessor Joins the Impressive NS16000 Family

Mainframe software on microprocessor-based systems. Another industry 'first'

The billions of bytes of existing mainframe software can now be easily ported to run on NS16000-based systems.

This achievement is an industry 'first', made possible by NS16000's architectural support for high level language programming, its full high-speed floating point arithmetic capability, its integral support for Demand Paged Virtual Memory, and the NS32032's 32-bit data bus to memory.

Microprocessor speeds from 1 MIPS to 10 MIPS

Future 32-bit CPU versions from National will also be compatible, ranging from the 1 MIPS NS32032 today to 10 MIPS by 1988. The migration path

for product enhancement will be clear, and the initial software investment of National customers will be preserved.

Fully implemented 32-bit architecture, without exception or restriction

The value of elegant implementation is easily illustrated. Except for NS32032, every microprocessor available today takes eight to 20 internal steps to execute the equation: $A = A \cdot X + A_i$, an expression evaluation commonly used in technical and scientific applications.

The NS32032 takes four.

To better understand the significance of this milestone in computer technology, order your free copy of NS16000: The Specifics of 32-bit Architecture. Check box L6 in this Anthem's coupon.

Now compiled in one book for fast easy reference

The Elegant NS16000 Microprocessor Family

All hardware, software and development-tool data sheets

More than 500 pages in all! Includes specs, instruction sets and architectural descriptions of the three CPU families: (NS08032, NS16032 and NS32032); plus memory management, floating point, and 10 peripherals.

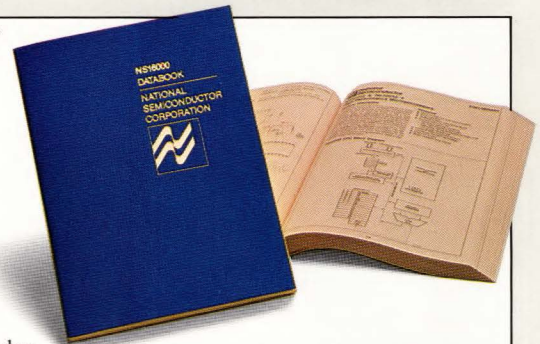
Also featured is information on the supporting development tools and software – the SYS16™, ISE16™, DB16000, cross software, and GENIX™ operating system.

GENIX, a version of Berkeley 4.1 bsd UNIX™ tailored for the NS16000 family,

supports Demand Paged Virtual Memory and optimizes the 16000 architectural elegance. GENIX runs on SYS16 and is available in source code form for OEM adaptation to NS16000-based systems.

Don't miss this important industry publication – an information bonanza at the reduced price of only \$5.00 each.

To order, check box L5 on this Anthem's coupon and return with your remittance. Multiple-copy orders welcome!





New, Simpler, 20-Pin Small PALs Match 25ns Medium PAL Performance and Cost Less

For over a year, designers of high performance digital systems have taken advantage of the 25ns Medium PAL Family to replace LS Logic devices in their systems. Now, the same performance advantage is available in the 20-Pin Small Family—a less complex, less costly family—from National Semiconductor.

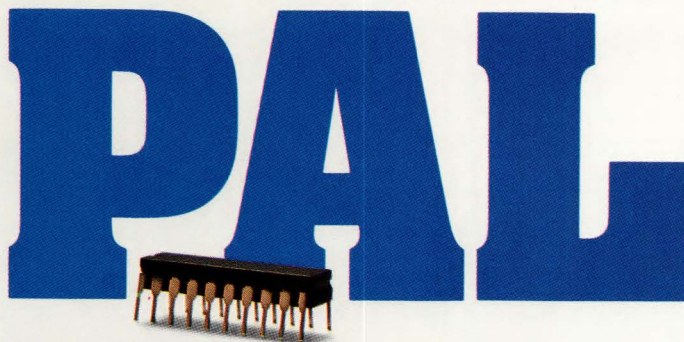
Address decoding, multiplexing, arbitration, and high-speed random gating are typical applications which can be made faster by replacing low power Schottky SSI gates with National's new high-speed PAL® devices.

Integration improves system development

Designing with National's new PAL family enables you to reduce your chip count, typically by 4:1 to achieve significant space and cost savings. Improved system reliability from fewer components are added benefits.

Design flexibility and simplicity through instant customization

Beyond the obvious advantage of flexibility obtained from the ability to program chips to perform specific functions, PAL technology simplifies the



design process. Simplification is primarily due to the automated design capability offered by PLAN™—National's new design software.

In addition, complex interconnections that previously required time-consuming PC layout are now processed in silicon where they can be easily modified during prototype checkout or production.

More design and product benefits

Additional design benefits of National's PAL family include variable input/output

ratio, skinny DIP packages for more compact designs, and titanium-tungsten fuses for greater reliability.

Moving you ahead

Higher speeds and the many other benefits of PAL technology help make your designs as advanced as they can be.

For shortening your product's design-to-market cycle, there's nothing faster and more efficient in programmable logic circuits than National's new PAL devices.

For more information, check box P6 on the Anthem coupon.

PLAN™ Makes PAL Programming Easier Than Ever

PLAN (Programmable Logic Analysis by National) is a set of interactive design and development tools specifically created for systems designers using PAL (Programmable Array Logic) devices.

These tools take the errors and confusion out of determining PAL requirements; they automatically select the correct PAL, saving valuable time spent in search and evaluation.

PLAN's primary programs, 'PLUS', 'PROG' and 'SERV' guide designers all the way from initial Boolean entry, through device selection and documentation, to the programming of the devices on DATA I/O and other programmers.

Efficient, versatile

Interfacing with virtually all popular PAL programmers, and using notations like those of the familiar PALASM®, PLAN accepts Boolean equations and provides on-going message to the user regarding PAL requirements for the

equations. And PLAN's comprehensive messaging includes error alerts, device selection guidance and prompts.

Next, PLAN *automatically* selects the proper PAL—and the pin assignments—and creates a permanent file on disk representing the defined logic element.

Easy to use

PLAN offers design engineers a more friendly method of operation. Displaying equations, for example, is as easy as entering 'STATUS' and providing an affirmative response to PLAN's subsequent question.

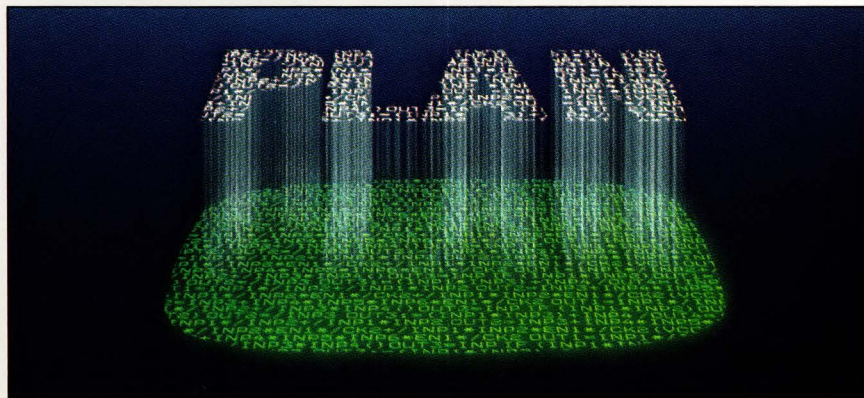
If, after automatic PAL selection, the user has reason to believe that a

different PAL would serve better, PLAN can be instructed to evaluate any PAL of the user's choice for implementing the set of equations at hand.

Designed to work with a broad range of personal computers, PLAN is supplied on 8-inch single-side, single-density disks formatted for operation under CP/M-80® and on 5-1/4-inch single-side, double density floppy disks for operation under MS-DOS®.

PLAN. One more powerful tool from National for the system designer.

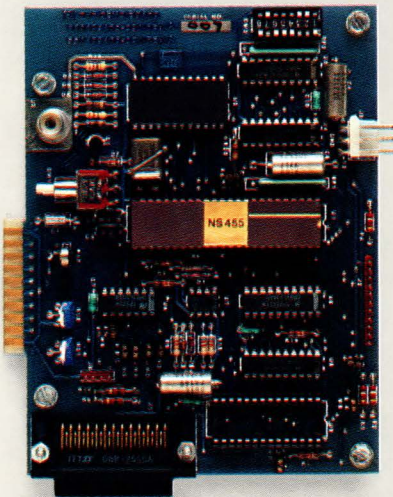
For complete information, check Box K7 in the coupon on back page.



NEW PRODUCTS

CRTs Are No Longer Limited To Traditional Terminal Applications

If your application could benefit from a CRT data display but you don't have the space, there is now a device that gives you full CRT functions on a smaller board.



The small size of the NS455 Series TMP Evaluation Board allows many new CRT applications.

National's amazing new NS455-Series Terminal Management Processor (TMP) family provides the functions of an 8-bit microprocessor, CRT controller, ROM, DMA controller, character generator, UART and BAUD rate generator in one 48-pin package. The integration provided by the TMP offers board area savings, improved reliability and faster design cycles.

See how small a complete system can be

The NS455 evaluation board typifies the type of minimum CRT data terminal system possible with a pre-programmed TMP. With the addition of a video monitor, ASCII-encoded keyboard, and power supply, a complete data terminal is structured. In addition, you may write your own program, which the NS455 can execute by using external program memory (up to 8K offboard).

Features of the TMP evaluation board include:

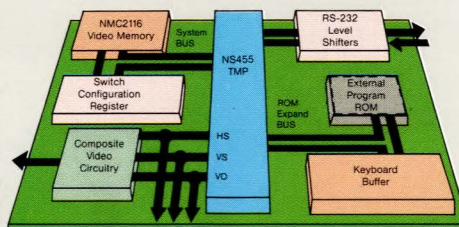
- Internal masked ROM or external EPROM program execution
- 80 column x 25 row display
- 5 x 7 characters with 2 level descenders
- 12 MHz video bandwidth

- BALL or composite video output
- 50/60 Hz operation
- RS-232C Serial Interface with Full Duplex 110-19.2K BAUD
- Status line display
- 24 escape sequences
- 15 control sequences

Familiar instruction set makes programming easy

Feel comfortable right away with the chip's familiar, but enhanced, 8048 instruction set. The system operates with two, bidirectional buses—a 16-bit system bus providing up to 64K by 16 bits of video RAM addressing, and a 13-bit ROM expansion bus offering up to 8K of addressing, all off-chip, or 2K on and 6K off-chip.

National offers a complete selection of boards and devices for your system design. Eliminate software design efforts by continuing to use the NS455 evaluation board or the pre-programmed NS455 found on it. Or develop your own program with the NS405 ROMless device. And for higher volume quantities, the program can be masked into the NS456.



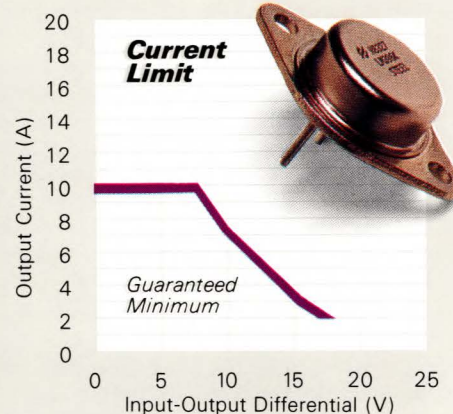
New MOLE™ Development System makes TMP design-in and program development easy

The MOLE (Microcontroller On-Line Emulator), National's low-cost development system, brings dedicated support to the TMP chip with the MOLE Brain board, Personality board and software package.

The high-speed processing and storage capabilities of your host computer and MOLE software provide the ability to program, edit and cross-assemble the TMP program. The results are then downloaded over an RS-232C link to the MOLE boards where real-time in-circuit-emulation and program debugging take place in a free-standing, workstation mode. The result is rapid program development capability using your familiar host computer system. MOLE also supports other members of National's microcontroller family.

For more information, check Box M6 on the response coupon on the back page.

A Single, 10 Amp Voltage Regulator Meets Output Specs From 1.25V to 15V



This is the voltage regulator for all your 10 amp designs. With National's LM396 there's no need to design-in several lower current regulators for one voltage application requiring output from 1.25V to 15V. The LM396 is easy to use and continuously adjustable.

The LM396 Adjustable Voltage Regulator enhances system performance, reduces the system part count requirement, and increases reliability beyond any regulator currently available.

Consistency and protection in worst cases and conditions

The LM396 ensures 10 amp output current under worst-case conditions. Running at power levels up to 70 watts, the output voltage will remain as set. The LM396 is immune to blowout from overloads, shorts, or accidental disconnection of the adjustment pin.

Easily designed-in

Because only two external resistors are used to set output voltage, the LM396 is very easy to use.

The LM396 features on-chip trimming of reference voltage to $\pm 0.8\%$.

These regulators come in a TO-3 package with oversized (0.060") leads to provide best possible load regulation. Operating junction temperature range for the LM396 is 0°C to $+125^{\circ}\text{C}$. The LM196 is specified for a -55°C to $+150^{\circ}\text{C}$ junction temperature range.

Additionally, the regulator receives 100% thermal limit burn-in at no extra charge.

For more information, check box P9 on the Anthem coupon.

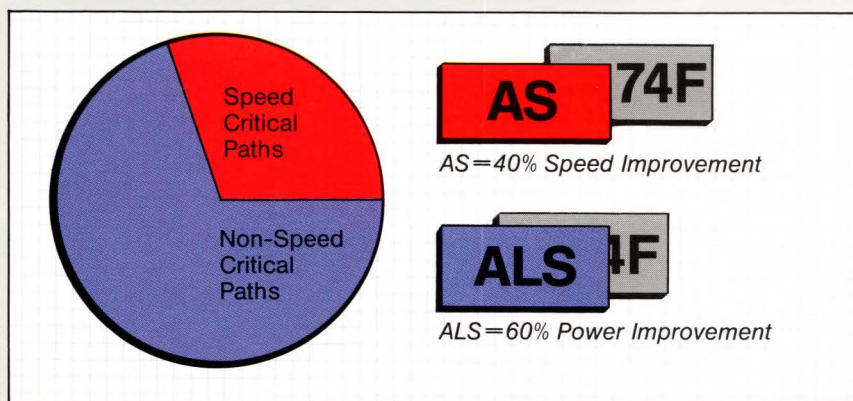
Achieve Ultimate Performance Budgeting with National's AS/ALS

The ideal design solution offers the ultimate performance in both "Speed-Critical" and "Non Speed-Critical" paths. Logic products within a typical system design are divided 30% on "Speed-Critical Paths" and 70% on "Non Speed-Critical Paths." These functions can be optimized using National's Advanced Schottky products, and system performance increased.

The primary benefit of Advanced Schottky (AS) is speed; a significant improvement over 74F. Advanced Low Power Schottky (ALS), while offering twice the speed of LS, excels in low power requirements. Similarly, ALS offers significant performance benefits over 74F.

Compatibility and breadth

National offers a full SSI, MSI and LSI family. AS/ALS have the same pinouts and functions of existing LS and S devices. This broad product family affords you the capability of fully



upgrading your existing product and represents the ideal design/performance solution for new designs.

Performance confidence

Because AC specifications are guaranteed over the full V_{CC} , when you design using AS/ALS, you can be confident of expected performance. The increased voltage tolerance of commercial AS/ALS products ($\pm 10\%$ supply voltage compared to the $\pm 5\%$ of 74LS, 74S and 74F) allows the use of less expensive power supplies, and can frequently eliminate special test requirements. While LS and S are only guaranteed at 25°C , AS and ALS are guaranteed across the full military or commercial temperature range.

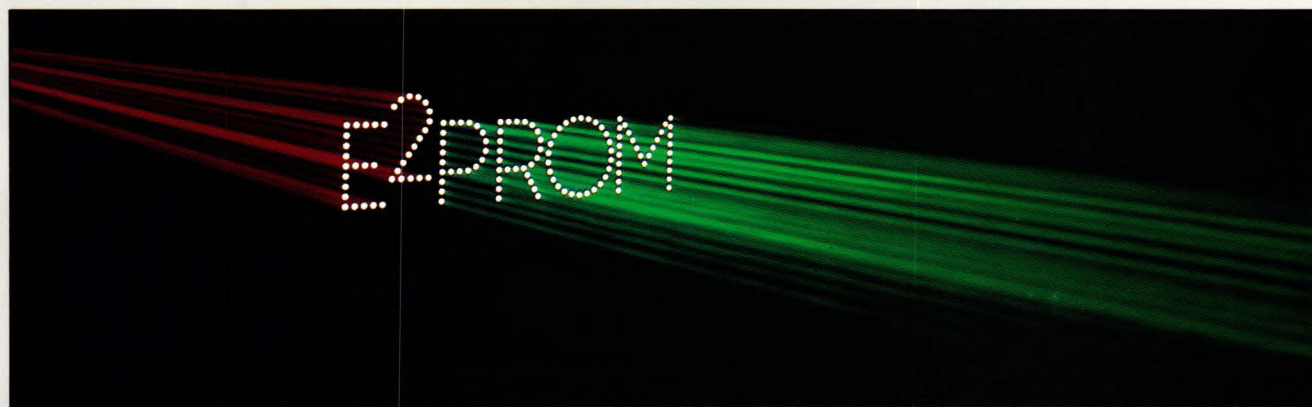
Improved capability

PNP inputs reduce high and low level input current. This significantly improves AS/ALS fanout. Increased drive capability of AS/ALS outputs improves speed consistency as propagation delays are less susceptible to load capacitance-related variations.

Assured alternate source

National and TI entered an alternate sourcing agreement in 1981. Through joint product selection, coordination of specifications and design mask exchanges, you can be assured of two sources with products that will react the same way in all applications.

For more information, check box **M1** on the Anthem coupon.



Fast Read Access From National's Leading 5V-Only E²PROM

National's high-performance NMC9817 complements its full line of E²PROMs. Very fast read access times – typically 200 ns, make these E²PROMs very compatible with high-performance microprocessor applications.

Versatile applications

The NMC9817 is ideal for non-volatile memory requirements in applications requiring storage of user-defined functions, calibration constants, configuration parameters, and accumulated totals.

Added features

On-chip V_{PP} generation during ERASE/WRITE allows 5V-only operation in all modes while on-board address, and data latches completely eliminate the requirement for external circuitry. The CPU is free during ERASE/WRITE operations.

Other time and cost-saving features include an automatic ERASE before WRITE and complete self-timing, a

ready/busy signal on pin 1 to notify the microprocessor when the programming cycle is complete, plus a two-line control architecture, which eliminates bus contention in a system environment.

These features promote application efficiency and ease of design.

For more information, check box **P7** on the coupon on the last page of this Anthem.



Quality/Reliability is a matter of policy

Successful Communication Ensures Products That Work

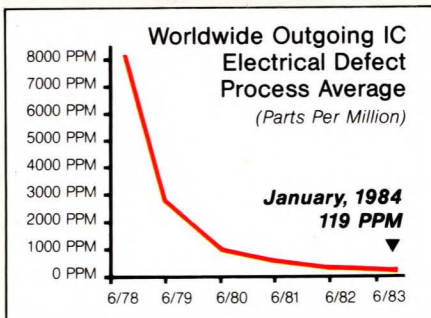
In 1978, National's overall electrical IC rejections averaged 8,000 parts per million. Today, that number is an industry-leading low of 119 parts per million—an outstanding decrease that mirrors a very strong corporate dedication to a goal.

Zero defects and unsurpassed reliability are National's goals. These goals are being accomplished through close cooperation with both customers and vendors.

Communication is the key

Every National employee, from incoming materials—to design—through shipment of product, assumes a responsibility for insuring the highest standards of quality and reliability. This level of teamwork promotes communication.

Careful communication of details on a project produces better results—every time. Details must be discussed, clarified,



and communicated before a project is properly initiated.

Attention to details combined with systems provide results

National's improved results were made possible by several company-wide systems such as the Long-Term Audit Program, High-Temperature Bias testing,

Statistical Quality Control, and ESD protection. These, along with other systems and procedures assure the very best in quality and reliability each day, and in the long run.

National, through its long-term and corporate goals, will continue toward zero defects and continued improvement in reliability—in design, throughout manufacturing, and into the customer application.

And although the quality and reliability of National's products are already second to none, the commitment to improve will continue—to the noticeable advantage of every National customer.

If you want to know more about what National is doing about quality and reliability, check box P8 on the coupon below. You'll receive, free of charge, the REL Scanner, National's bi-monthly publication devoted to quality and reliability.

News From Your National Library

- J0 ☐ ADC0844 Datasheet
- K7 ☐ PLAN Flyer
- K8 ☐ MM74HC942/943 Datasheets
- L6 ☐ NS32032 Datasheet
- L9 ☐ MM58274 Datasheet
- M0 ☐ Gate Array Brochure
- M1 ☐ AS/ALS Performance Budgeting Brochure
- M5 ☐ microCMOS Brochure
- M6 ☐ TMP Information
- P6 ☐ PAL Series 20B Datasheet
- P7 ☐ NMC9817 Datasheet
- P8 ☐ Reliability Information/REL Scanner
- P9 ☐ LM196/396 Datasheet
- J5 ☐ 1983 Interface, Bipolar LSI, Bipolar Memory, Programmable Logic Databook \$12.00*
- L5 ☐ 1983 NS16000 Databook (\$5.00 if used before October, 1984. Coupon or facsimile thereof must accompany order. Regular price \$7.00.)
- M7 ☐ 1984 CMOS Databook \$12.00*
- P0 ☐ 1984 Linear Supplement \$7.00*
- P1 ☐ 1984 Data Acquisition Databook \$12.00*



National Semiconductor

For desired information, mail coupon to:

National Semiconductor Corporation
P. O. Box 70818
Sunnyvale, CA 94086

*Enclose check or money order based upon appropriate currency. U.S. residents may use VISA or MasterCard (all information must be supplied). Make checks payable to NS Publications. All prices shown are U.S. prices only. California residents add applicable state and local sales tax. Allow 4-6 weeks for delivery. This coupon expires on December 31, 1984.

Name _____

Title _____

Phone _____

Company _____

Address _____

City _____

State _____

Zip _____

☐ M/C ☐ VISA # _____

Expires _____

Signature _____

Acct. Address _____

NA 51

EDN



MOTOROLA

22 WEEKS
\$3.05, 250-999



STOCK-TO-8-WEEKS
\$2.25, 100-UP

100 days and dollars off IRFs. Cut delivery, costs, with TMOS™ powerFETs.

Right from the start, you're quoted stock-to-eight-week delivery when you specify Motorola

IRF powerFETs.

We provide 124 individual IRF types with performance, specs, characteristics and packaging

identical to the hard-to-gets.

All the popular families are represented: IRF100 — IRF200 — IRF300 — IRF400 — IRF500 — IRF600 — IRF700 — and IRF800 series from 1 to 40 A, 50 to 500 V. Visually, they're Motorola-trademarked. Electrically, they're one-and-the-same as the scarce types.

All deliverable in less than half the time and hassle in stocking and inventory. A unique Motorola advantage.

What's more, ASP of our completely comparable, TMOS IRF family is 33% lower than ASP of the other IRF lineup... and that's in 100-999 quantities, not 250-up, with some individual TMOS types priced at 50% less than those in short supply.

REPLACE THIS:	WITH THIS:
IRF TO-220 ASP \$ 4.02	TMOS IRF TO-220 ASP \$3.03
IRF TO-3 ASP \$12.09	TMOS IRF TO-3 ASP \$8.18

Calculations based on latest available IR prices.

Twice the voltage with TMOS.

TMOS technology yields 1,000 V—twice more than most. Which means you can raise series-resonant power supply operating frequencies to higher-than-you-

thought-possible levels. Or direct-drive TMOS powerFETs from control ICs, such as the MC34060 or TL494, without buffers to control supplies up to 100W.

Switching losses are lower, less heat sinking's required, drive is simpler, component size and weight shrunk.

We source 44 TMOS units from 550 V to 1 KV in TO-218, TO-220 and metal TO-204 (TO-3).

Forever-and-a-day excellence.

TMOS provides outstanding, MIL-level quality that can improve performance and reliability of your commercial/industrial design. Documented, 100 ppm AOQ levels are improving to the degree we project 50 ppm within the next twelve months. We continue to lead the industry with Vendor Certification Programs that guarantee specific levels of quality which reduce or eliminate incoming inspection. MIL-acceptance and an elaborate factory monitoring system ensure you get only the best quality. In half the time and better.

One-on-one design-in help.

In person or on the phone, anywhere in the US or Canada, get an engineer-to-engineer update on the latest semiconductor products and technologies.

1-800-521-6274

Call toll-free any weekday, 8 a.m. to 4:30 p.m., MST. Or, we'll have a local field application engineer drop by. And get you to market faster. Write for our new TMOS Selector/Cross Reference/Reliability Data.

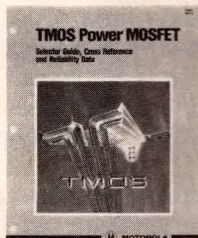
Motorola
Semiconductor
Products, Inc., P.O.
Box 20912,
Phoenix, AZ 85036.

We're
on your
design-in
team.



MOTOROLA

To: Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, AZ 85036
Please send me more information on TMOS!™ 240EDN061385



Name _____

Title _____

Company _____

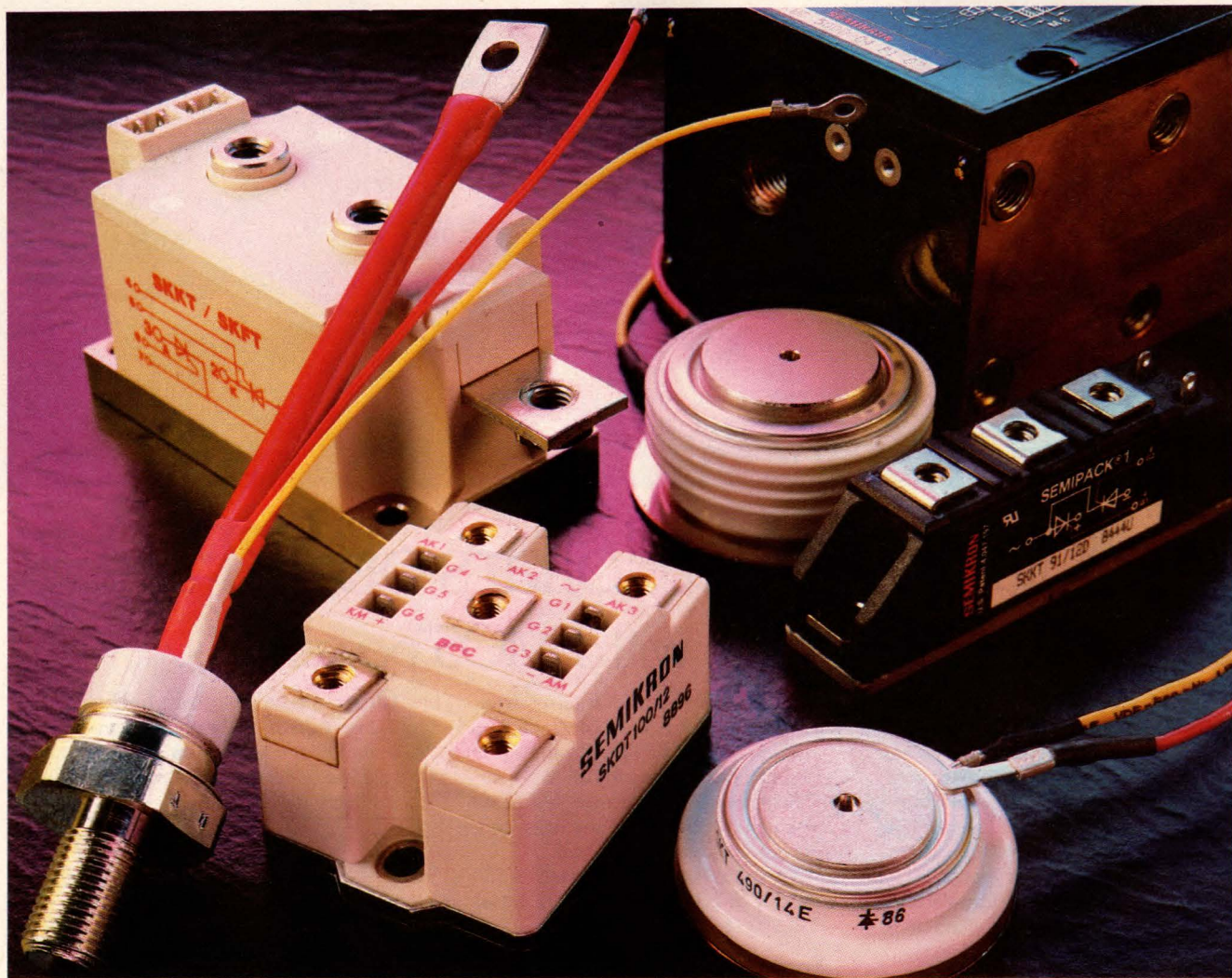
Address _____

City _____ State _____ Zip _____

Call me () _____

SEMIKRON

innovation + service



IN POWER SEMIS, THE SOLUTION IS SEMIKRON.

Innovation + service. At Semikron, we've made these ideals our total commitment.

Right from the start, Semikron was an innovator in power semiconductors. The Semipack 1® isolated thyristor/diode module, originated by Semikron, has become a world standard for the power semiconductor industry. It was followed by the Semipack 2, Semipack 3, and other modules with greatly increased current handling capacities—as high as 7000 A. And now, Semistack® thyristor and diode assemblies.

We look for solutions. Designs that reduce the size and cost of the package—or the assembly. Designs that offer more power, greater efficiency—and improved heat dissipation. Cost effective solutions to *your* problems.

Throughout the design process, reliability is a paramount consideration. And its importance continues with stringent quality control throughout the production process.

Call us. Our engineers are ready to help. No one else has the depth of technical experience. At Semikron, serving you well is the bottom line.

CIRCLE NO 37

TECHNOLOGY UPDATE

Gate-turn-off thyristors spec new current/voltage highs

Peter Harold, *European Editor*

Gate-turn-off (GTO) thyristors are replacing silicon controlled rectifiers (SCRs) as solid-state switches in high-frequency power-conversion equipment. GTO thyristors are now available with voltage ratings as high as 4.5 kV. By eliminating the need for the bulky and expensive LC networks required to commutate equivalent SCRs, the devices allow reductions in size, weight, and manufacturing cost. Be aware, however, that their more complex gate waveforms increase drive-circuit complexity.

The production of high-power GTO thyristors owes much to techniques originally developed for VLSI-device fabrication. The gate/cathode structure of a GTO thyristor must be highly interdigitated in order to minimize switching times, ensure adequate turn-off gain in the device, and control avalanche breakdown during the turn-off period.

Fabricating this structure necessitates the use of fine-line lithography to produce patterns clean enough to avoid field-strength breakdown, and the use of such techniques as neutron-transmutation doping to adequately control silicon resistivities and thereby ensure current sharing among the multiple cathodes.

The availability of these techniques has increased the number of manufacturers prepared to produce GTO thyristors. Current product offerings range from TO-220-encapsulated devices capable of switching a few amps, to giant hockey-puck GTO thyristors that can repeatedly switch 2500A at voltages as high as 4.5 kV.



Generating all the necessary gate waveforms, International Rectifier's driver modules enable you to control 81- and 84-RDT stud-mounting GTO thyristors and 160PFT pressure-pack GTO thyristors with a single logic level.

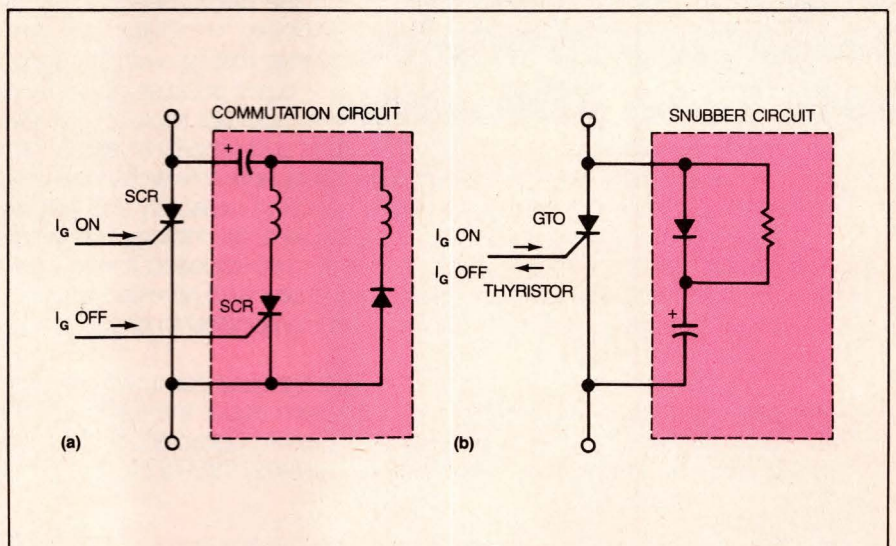
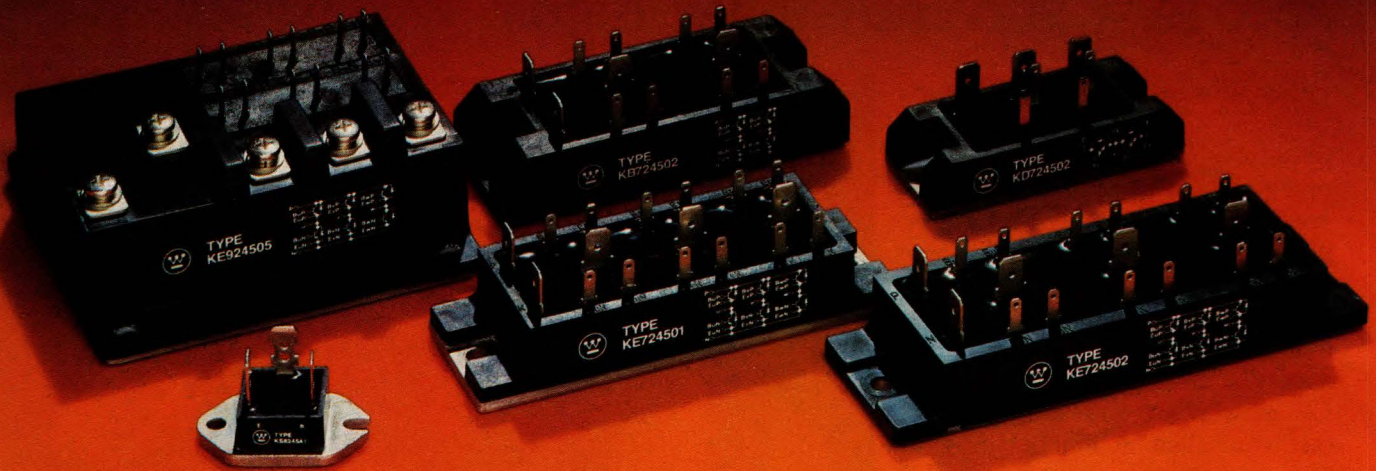


Fig 1—The snubber components required by the GTO thyristor in circuit **b** are far less bulky and expensive than the SCR's commutation components in circuit **a**.

New additions to the Darlington line.



Because more and more users are taking advantage of the cost-saving features of isolated modular packaging, we've expanded our line of Darlington power transistor modules even further. We've added eight ratings in six different package configurations, increasing your design options over a range of 10 to 300 amps.

The additions answer the growing needs of ac and dc servomotor control manufacturers, and include a complete SIX/PAC transistor inverter module for HVAC applications.

Manufactured to the famous Westinghouse quality standards that mean lifetime reliability, the new modules are a 15-amp, 450-volt single; a 20-amp dual; a 20-amp, 450-volt quad (single-phase bridge); and 10-amp, 15-amp, 20-amp, 30-amp, and 50-amp, 450-volt SIX/PACs (three-phase bridge).

Now Westinghouse offers a full line of Darlington Modules from 10 to 300 amps.

The complete Westinghouse Darlington line offers users unusual design flexibility, reliability, and the cost savings that go with simplified circuitry. Because power transistor modules replace discrete elements, they save space and assembly costs and simplify inventory control.

Every module in the Darlington line offers large forward and reverse bias safe operating area for greater power handling capability and fast switching. And every one is reliable because of planar technology and glass passivation. Transistor and diode junctions are not exposed to the elements. Transistors are triple-diffused planar processed with no exposed junctions. Diodes are glass passivated chips or planar processed to provide increased parameter stability.

Nowhere else can you get the Westinghouse commitment to power semiconductors and lifetime reliability. Learn about the full Westinghouse Darlington line by writing Westinghouse Electric Corporation, Semiconductor Division, Youngwood, PA 15697. Or call (412) 925-7272.

Westinghouse Power Semiconductors

LIFETIME RELIABILITY

You can be sure... if it's Westinghouse



Taking a look at the lower end of voltage and current ratings, GTO thyristors switching less than 400A and having forward-voltage capabilities below 1 kV encounter fierce competition from the new generation of bipolar power transistors. In comparison with GTO thyristors, bipolar transistors have simpler base-drive requirements and lower on-state saturation voltage, and they allow you to operate at frequencies above the GTO thyristors' 1- to 2-kHz limit.

Nevertheless, if your application involves high peak-to-average current ratios, eg, those encountered in pulse-width-modulated (PWM) inverters or under fault conditions, GTO thyristors probably still fare better than bipolar transistors. Because the self-regenerative switching action of the GTO thyristor forces it further into saturation as the anode current increases, the device does (for a given average current) carry and switch higher peak currents than a bipolar transistor.

High- and medium-power GTO thyristors (Tables 1 and 2) frequently replace SCRs in such appli-



This 50-mm GTO thyristor wafer from Marconi Electronic Devices Ltd shows the highly interdigitated gate/cathode structure of a gate-turn-off thyristor.

cations as dc-to-dc chopper converters, uninterruptible power supplies, and 3-phase, variable-speed, ac-motor-drive inverters. Because a GTO thyristor turns off through the extraction of a current pulse from its gate electrode, the device eliminates the need for the large inductive and capacitive components necessary to reduce artificially an SCR's anode current to zero and, by so doing, commute it to the off state (Fig 1).

Electromagnetic and acoustic noise, associated with high-current

switching in the commutation circuit, is also lower for a GTO thyristor. A typical device is capable of breaking a current two to three times its rms load current. Although you require larger snubber circuits to adequately control the GTO thyristor's anode dV/dt (occurring immediately after turn-off) and more complex gate-drive circuitry, the added cost of these circuits is exceeded by the savings in cost, size, and weight achieved by eliminating commutation components.

Consider gate-drive circuitry

Fig 2 illustrates the typical gate-control waveforms required to turn a GTO thyristor on and off. Turning on a GTO thyristor is much the same as turning on an SCR, ie, by applying a positive current pulse to the gate electrode. However, unlike the case of the SCR, the GTO thyristor's rate of rise of gate current (dI_G/dt) is critical to ensure a fast turn-on time and good dynamic current sharing in the multiple cathodes.

Unless you're certain that anode current will be maintained at a sufficiently high level, you must continuously supply a small level of gate current (back-porch current) during the GTO thyristor's on period. Without this sustained gate current, an unpredicted fall in anode current could cause some cathodes to unlatch into the off state—imposing an excessive current density on those cathodes that remain latched—when the anode current rises again.

Because of their interdigitated cathode structure, GTO thyristors exhibit rapid turn-on times of 5 to 10 μsec typ. The devices can therefore sustain a high rate of rise of anode current: A rate as high as $600\text{A}/\mu\text{sec}$ is permissible for some devices.

Turning off a GTO thyristor is more difficult. Turn-off gain in high-current devices is usually around 5, so to break a load current of 2500A requires that you extract a 500A current pulse from the gate. In ad-

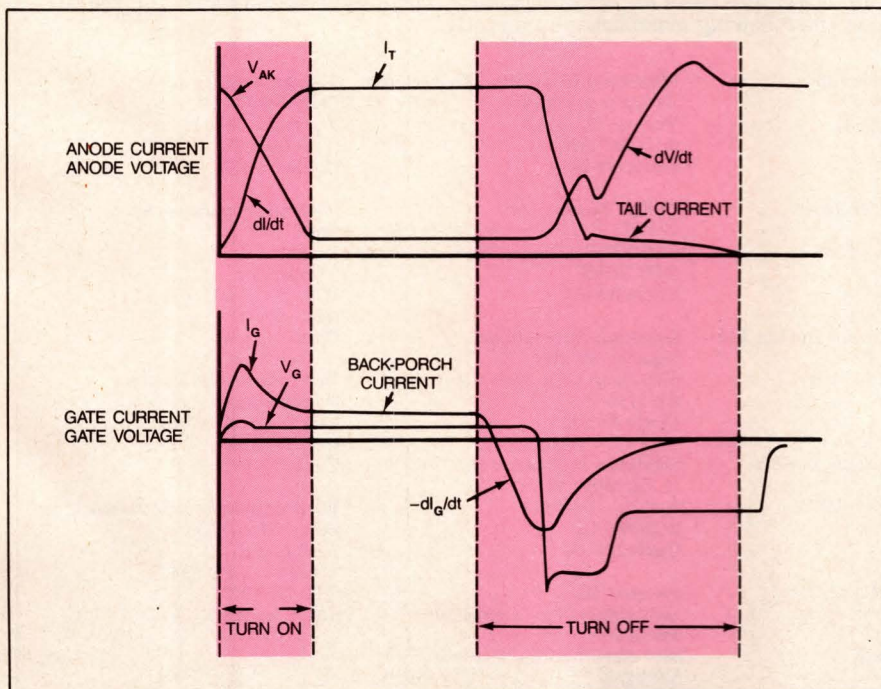


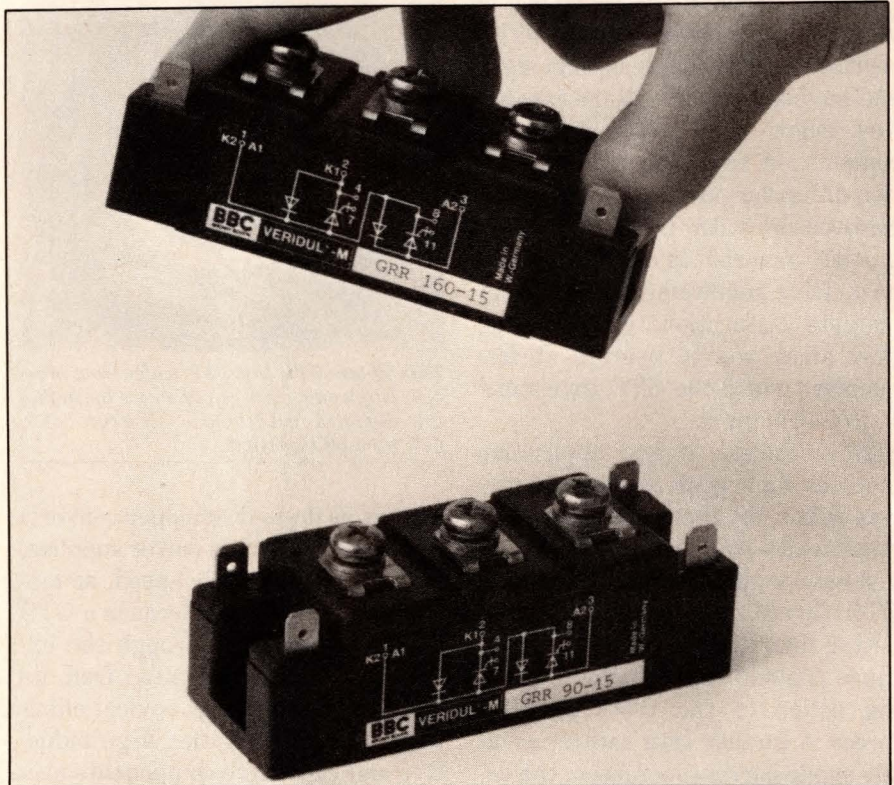
Fig 2—Defining gate-drive waveforms for a GTO thyristor requires a thorough understanding of device and load parameters in order to minimize switching losses.

TECHNOLOGY UPDATE

dition, you must control the rate of rise of gate current (usually by controlling the gate circuit's inductance) to optimize turn-off time and power losses in the GTO thyristor.

However, for those who don't wish to become involved in the complexities of gate-drive circuitry, several companies offer gate-drive modules for their GTO thyristors. Typical of these are International Rectifiers' GK2-A and -B modules, which drive the firm's 81/84-RDT and 160PFT GTO thyristors, respectively. The modules reduce GTO-thyristor on-off control to a 12V logic level, provide 2.5-kV optical isolation between the control input and the GTO thyristor, and require only a +5 and -15V dc power supply with reference to the GTO thyristor's cathode.

A possible disadvantage of using a manufacturer's drive module, though, is that you might not be able to optimize the gate drive to suit particular load conditions. For



Typical of GTO-thyristor modules, the GRR-90 and soon-to-be-released GRR-160 from BBC Brown Boveri are easy to mount; moreover, they provide electrical isolation from the heat-sink assembly.

For more information . . .

For more information on the gate-turn-off thyristors described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

AEG-Telefunken AG
Box 2160
4788 Warstein-Belecke, West Germany
(02902) 763-0
Circle No 680

AEG-Telefunken Corp
Rte 22, Orr Dr
Somerville, NJ 08876
(201) 722-9800
Circle No 681

Brown Boveri & Cie
Box 1180
6840 Lampertheim, West Germany
(06206) 503-483
Circle No 682

Brown Boveri Corp
1460 Livingston Ave
North Brunswick, NJ 08902
(201) 932-6000
Circle No 683

Hitachi Ltd
6 Kanda-Surugadai 4-chome
Chiyoda-ku
Tokyo 101, Japan
(03) 258-1111
Circle No 684

Hitachi America Ltd
2210 O'Toole Ave
San Jose, CA 95131
(408) 942-1500
Circle No 685

International Rectifier
233 Kansas St
El Segundo, CA 90245
(213) 772-2000
Circle No 686

Marconi Electronic Devices Ltd
Carholme Rd
Lincoln LN1 1SG, UK
(0522) 29992
Circle No 687

Marconi Electronic Devices
160 Smith St
Farmingdale, NY 11735
(516) 293-8686
Circle No 688

Mitsubishi Electric Corp
2-3 Marunouchi 2-chome
Chiyoda-ku
Tokyo 100, Japan
(03) 218-3473
Circle No 689

Mitsubishi Electronics America Inc
200 Unicorn Park Dr
Woburn, MA 01801
(617) 938-1220
Circle No 690

Philips Elcoma Div
Box 523
5600 AM Eindhoven, The Netherlands
(040) 757005
Circle No 691

Semikron International
Sigmund Str 200
Hudson, NH 03051
(0911) 6559-1
Circle No 692

Semikron International
11 Executive Dr
Hudson, NH 03051
(603) 883-8102
Circle No 693

Siemens AG
Zentralstelle fuer Information
Box 103
8000 Munich 1, West Germany
(089) 2340
Circle No 694

Toshiba America Inc
2441 Michelle Dr
Tustin, CA 92680
(714) 730-5000
Circle No 695

Westcode Semiconductors
Box 57
Langley Rd
Chippenham
Wilts SN15 1JL, UK
(0249) 654141
Circle No 696

Westcode Semiconductors
0-02 Fair Lawn Ave
Fair Lawn, NJ 07410
(201) 791-3020
Circle No 697

Westinghouse Semiconductor Corp
Semiconductor Div
Armbrust Rd
Youngwood, PA 15697
(412) 925-7272
Circle No 698

PRODUCING... *Matrix Express*

Register

cent Tech

ENCE / TECHNOLOGY

Zero Discovers Cure To Delivery Dilemmas!

(DETAILS BELOW)

**Assured 10-Day Shipment* On
Standard Matrix IV Cabinets
At A Price You've Been Used To
Paying For 10-Week Promises!**

If you're experiencing the pain and suffering of placing an order for the cabinet you need tomorrow, then agonizing for up to three months waiting for it to finally arrive, wait no more. Call for Matrix Express!

If you've gone into acute "sticker shock" after asking the price for *rush* shipment of that same cabinet, treat it as a learning experience and a bad dream. Simply call for Matrix Express!

If you've had to compromise your engineering integrity on a "slightly less than perfect" cabinet solution only because you could get it on time — even if it was ridiculously overpriced — don't make the same mistake again. Call for Matrix Express!

**Get Up To 5 Cabinets
in Just Two Weeks*
For Only \$593.25 Each!**

We offer you the most popular sizes of quality Matrix IV cabinets or shipment within two weeks* from Zero factories on either coast, at *absolutely no premium price*.

They're available in a standard 60" depth, with your choice of 66", 63" or 70" EIA standard panel heights.

Every Matrix IV cabinet features all-welded steel construction, a textured finish with a black frame accenting beige panels and floor, adjustable leveling feet, and your choice of either a flush or pagoda style top. Complete your order with a variety of basic



accessory items; Zero will ship up to five cabinets to your door within 10 working days. Sorry, no modifications can be included on Matrix Express cabinets.

**Isn't It Time You
Got A Little Relief?
Call Zero For The Cure!**

There's a cabinet expert waiting to hear from you. He can help you pick the Matrix Express

cabinet that's right for you with fast, fast delivery. It's a sure cure for what ails you, so call today!

(413) 267-5561 • (818) 846-4191



ZERO-EAST DIVISION
288 Main Street, Monson, MA 01057

ZERO-WEST DIVISION
777 Front Street, Burbank, CA 91503

*Basic 56" Model. Maximum quantity, five units. Shipped within 10 working days.

Circle #2, Call me, I'm interested

Circle #3, Send literature only

TECHNOLOGY UPDATE

example, consider a particular situation in which you activate a single-shot, artificially high gate-current pulse to turn off a fault load current.

After the bulk of a GTO thyristor's anode current turns off, a low-level tail of anode current continues to flow for a period of time, as a result of charge storage in the GTO thyristor's n-base regions. Alternative measures taken to minimize the duration of this tail current—and hence to minimize the total turn-off time—resulted in the manufacture

of two types of GTO thyristors.

If you dope the n-base region with a heavy metal (eg, gold), a technique that provides recombination centers for trapped charge, you end up with a symmetric GTO thyristor capable of blocking approximately equal forward and reverse voltages. The alternative method—providing a recombination circuit by shorting out the n-base region to the anode-emitter metallization—results in an asymmetric GTO thyristor.

This asymmetric GTO thyristor

has severely limited reverse-voltage blocking capability: typically below 20V. You therefore need to provide some form of protection unless you can guarantee that this blocking-voltage value is never exceeded. The advantage of the anode-emitter shorting method is that it lowers the device's on-state voltage, and hence the on-state power loss, by 10 to 15%.

For switching currents as high as 200A, many manufacturers offer GTO-thyristor modules, which in-

TABLE 1—HIGH-POWER GTO THYRISTORS (HOCKEY-PUCK PRESSURE PACKAGES)

MANUFACTURER	TYPE NUMBER	REPETITIVE PEAK OFF-STATE VOLTAGE	RMS ON-STATE CURRENT	REPETITIVE PEAK CONTROLLABLE ON-STATE CURRENT	SURGE (NON REPETITIVE) ON-STATE CURRENT
		V_{DRM} (V)	I_T (RMS) (A)	I_{TCM} OR I_{TGO} (A)	I_{TSM} (A)
HITACHI	GFP600B12	1200	220	600	4500
	GFP600C16	1600	270	600	6000
	GFP1000B25	2500	400	1000	7000
	GFP2000B25	2500	800	2000	—
INTERNATIONAL RECTIFIER	150PFT-200,-250	2000,2500	235	800	2100
	160PFT-100,-120	1000,1200	250	600	2600
	160PFT-140,-160	1400,1600	250	600	2100
	160PFT-100A,-120A	1000,1200	250	700	2600
	320PJT-200,-250	2000,2500	450	1500	—
	350PJT	1000-1600	550	1200	4700
MARCONI ELECTRONIC DEVICES	DG224SE	1200	120	300	2000
	DG304SE	1200	250	600	4000
	DG386SL	2500	400	1000	7000
	DG506SD	2500	600	1400	12000
	DG508SD	4500	500	1800	10000
	DG758SU	4500	800	2500	16000
MITSUBISHI ELECTRIC	FG450BL	800-1600	200	450	2500
	FG600AL	800-1600	270	600	5000
	FG600AH	2000,2500	270	600	5000
	FG600C	2000,2500	270	600	5000
	FG1000A	2000,2500	450	1000	7000
	FG1000AL	800-1600	450	1000	7000
	FG1000AH	2000,2500	450	1000	7000
	FG1800AH	2000,2500	860	1800	11000
	FG2000AV	4500	700	2000	7000
TOSHIBA	SG600R21	1300	400	600	—
	SG800R21	1300	400	800	—
	SG1000R22	1300	250	1000	—
	SG600EX21	2500	400	600	—
	SG800EX21	2500	400	800	—
	SG1200EX21	2500	700	1200	—
	SG1400EX21	2500	700	1400	—
	SG2000EX21	2500	1000	2000	—
	SG400EX22	1300-2500	150	400	—
	SG500GXH22	3300,4500	200	500	—
	SG700EX22	1300-2500	200	700	—
	SG800GXH22	3300,4500	300	800	—
	SG1000EX23	1300-2500	400	1000	—
	SG2000EX22	1300-2500	800	2000	—
	SG2500GXH22	3300,4500	800	2500	—
	SG2700EX22	1300-2500	1000	2700	—
WESTINGHOUSE	GSO11245	1200	200	450	2500
	GSO11260	1200	270	600	5000

*POR—PRICE ON REQUEST

TECHNOLOGY UPDATE

corporate two series-connected GTO thyristors or a combination of a GTO thyristor and power diodes, in configurations suitable for direct use in bridge circuits. **Table 3** highlights the diversity of circuit configurations available.

These modules typically offer 2.5-kV isolation between the internal GTO-thyristor pellets and their base plate, and they allow you to easily mount several devices on one heat-sink assembly.

This ease of mounting, however,

is not a feature of higher-current GTO thyristors. With the exception of some flat-base devices from Toshiba, GTO thyristors capable of switching over 400A are packaged in hockey-puck pressure packages whose faceplates form the anode and cathode electrodes. Not only do you have to ensure even contact between these faceplates and the connection/heat-sink assemblies, but you must also clamp the GTO thyristor between the two assemblies with a specified force while

maintaining anode-to-cathode isolation.

The GTO thyristor market is now seeing increased competition from European vendors. AEG-Telefunken, BBC Brown Boveri, Marconi Electronic Devices, and Philips are offering varied products (see **Tables 1, 2, and 3**). In late 1985 and 1986, moreover, you'll see other companies entering the field.

Siemens, which estimates a 15% annual growth rate in the market for GTO thyristors and fast thyris-

Text continues on pg 70

	CRITICAL RATE OF RISE OF ON-STATE CURRENT	CRITICAL RATE OF RISE OF OFF-STATE VOLTAGE	REPETITIVE PEAK REVERSE VOLTAGE	ON-STATE VOLTAGE	REPETITIVE PEAK OFF-STATE CURRENT	GATE-CONTROLLED TURN-OFF TIME	PRICE
	di/dt (A/μSEC)	dV/dt (V/μSEC)	V _{RRM} (V)	V _{TM} AT I _{TM} (V) (A)	I _{DRM} (mA)	t _{GO} (MAX) μSEC	
	100 200 260 —	600 TYP 600 TYP 600 TYP —	— — — —	2.0 450 2.5 600 2.5 1000 2.5 —	50 50 50 —	7 15 30 35 TYP	POR* POR* POR* POR*
	500 600 600 600 — 600	1000 1000 1000 1000 — 1000	2000,2500 1000,1200 1400,1600 1000,1200 2000,2500 1000-1600	3.2 471 2.7 503 3.15 503 2.7 503 2.8 900 3.42 1100	80 50 50 50 — 80	15 8 8 8 15 15	\$1425 ALL PRICES \$400 ARE FOR A POR* 1200 OR POR* 2000V V _{RRM} \$2275 (1 to 9) \$963
	500 500 250 250 250 250	500 500 500 500 500 500	16 16 16 16 16 16	2.5 300 2.5 600 2.5 1000 2.5 1400 3.0 1800 3.0 2500	25 50 50 100 100 200	10 TYP 10 TYP 20 25 TYP 100 TYP 50 TYP	~\$130 (1000) ~\$290 (1000) ~\$730 (100) ~\$1900 (10) POR* POR*
	200 200 200 200 200 200 200 300 300	500 500 500 500 500 500 500 500 1000	15 15 15 500 500 15 15 15 15	2.5 450 2.2 600 2.5 600 3.2 600 3.5 1000 2.2 1000 2.5 1000 3.0 1800 3.5 2000	60 80 80 80 100 100 100 120 150	15 15 20 20 20 15 20 30 30	~\$250 ~\$300 POR* POR* POR* ~\$550 ~\$600 ~\$1500 POR*
	100 100 200 100 100 250 250 — 200 200 150 200 250 300 300 300	350 350 350 350 350 350 350 — 400 500 400 500 400 500 500 500	650 650 100 1250 1250 500 500 — 15 15 15 15 15 15 15	2.0 600 2.0 800 2.8 1000 2.3 600 2.3 800 2.5 1200 2.62 1400 2.5 — 2.5 400 3.5 500 2.7 700 3.5 800 2.5 1000 2.8 2000 3.5 2500 3.0 2700	50 50 50 50 50 100 100 — 10 40 10 40 20 50 150 60	18 18 15 18 18 22 25 25 16 15 16 15 18 23 25 25	por* por* por* por* por* por* por* por* por* por* por* por* por* por* por* por*
	200 200	500 500	15 15	2.5 450 2.2 600	60 80	15 15	\$200 (250) \$275 (25)

TECHNOLOGY UPDATE

**TABLE 2—MEDIUM-POWER GTO THYRISTORS
(STUD-MOUNTED AND FLAT-BASE PACKAGES)**

MANUFACTURER	TYPE NUMBER	REPETITIVE PEAK OFF-STATE VOLTAGE	RMS ON-STATE CURRENT	REPETITIVE PEAK CONTROLLABLE ON-STATE CURRENT	SURGE (NONREPETITIVE) ON-STATE CURRENT
		V_{DRM} (V)	I_T (RMS) (A)	I_{TCM} OR I_{TGQ} (A)	I_{TSM} (A)
AEG-TELEFUNKEN	G20A	1200	10	20	44
	G50A	1200	22	50	125
	G90A	1200	40	90	270
	G200A	1200	—	200	330
HITACHI	GFT20B12	1200	7	20	65
	GFT50B12	1200	18	50	180
	GFF90B12	1200	30	90	400
	GFF200E12	1200	70	200	500
	GFF300E12	1200	100	300	700
INTERNATIONAL RECTIFIER	81RDT-100M,-120M	1000,1200	125	350	1550
PHILIPS	BT157-1300,-1500	1300,1500	3.2 AVG	12	20
	BTV59-600,-850,-1000	600-1000	15 AVG	50	100
	BTV60-850,-1000,-1200	850-1200	25 AVG	120	150
TOSHIBA	SG300EX11	1300-2500	120	300	2640
	SG400EX11	1300-2500	150	400	3300
	SG700EX11	1300-2500	200	700	4400
	SG800EX11	1300-2500	300	800	6600

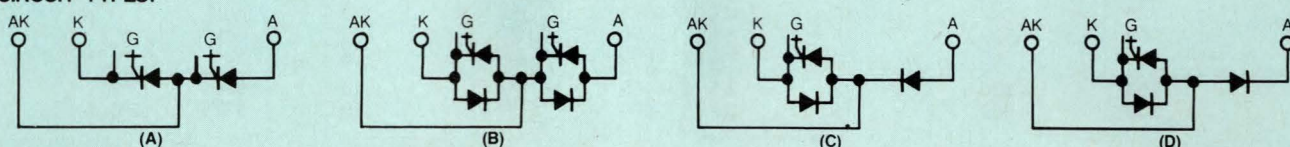
*POR—PRICE ON REQUEST

TABLE 3—GTO-THYRISTOR MODULES

MANUFACTURER	TYPE NUMBER	CIRCUIT TYPE	REPETITIVE PEAK OFF-STATE VOLTAGE	RMS ON-STATE CURRENT	REPETITIVE PEAK CONTROLLABLE ON-STATE CURRENT
			V_{DRM} (V)	I_T (RMS) (A)	I_{TCM} OR I_{TGQ} (A)
AEG-TELEFUNKEN	GG50,GD50,DG50 SERIES	A,B,C,D,E,F	1200	22	50
	GG90,GD90,DG90 SERIES	A,B,C,D,E,F	1200	40	90
	GG150,GD150,DG150 SERIES	A,B,C,E	1200	60	150
BBC BROWN BOVERI	GRR90	B	800-1500	48	90
MARCONI ELECTRONIC DEVICES	MGT100D-120	B	1200	31	100
	MGT150D-120	B	1200	50	150
MITSUBISHI	GM100DY	B	800-1200	31	100
	GM200DY	B	800-1200	70	200
TOSHIBA	S6418	B	1200,1300	30	50
	S6419	B	1200,1300	50	100
	S6420	G	1200,1300	90	200
WESTINGHOUSE	GDM-11210,-21210	A,B	1200	31	100
	GDM-11220,-21220	A,B	1200	70	200

**POR—PRICE ON REQUEST * TYPES WITHOUT ANTIPARALLEL DIODES.

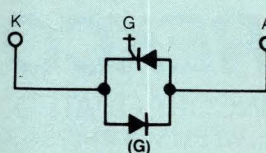
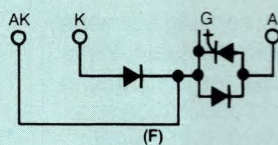
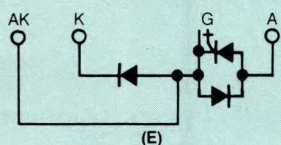
CIRCUIT TYPES:



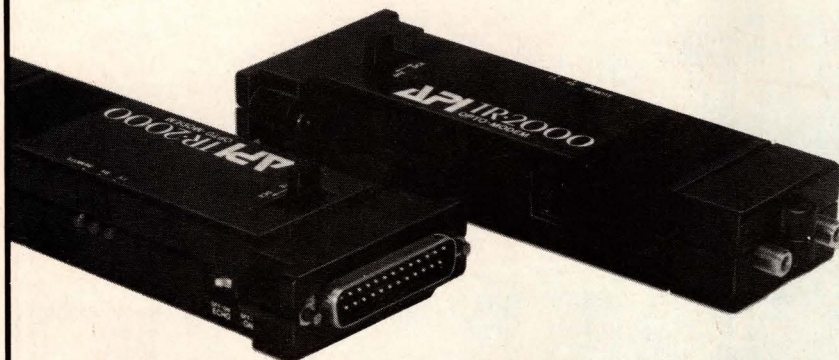
TECHNOLOGY UPDATE

CRITICAL RATE OF RISE OF ON-STATE CURRENT	CRITICAL RATE OF RISE OF OFF-STATE VOLTAGE	REPETITIVE PEAK REVERSE VOLTAGE	ON-STATE VOLTAGE	REPETITIVE PEAK OFF-STATE CURRENT	GATE-CONTROLLED TURN-OFF TIME	PRICE
di/dt (A/ μ SEC)	dV/dt (V/ μ SEC)	V_{RRM} (V)	V_{TM} AT I_{TM} (V) (A)	I_{DRM} (mA)	t_{GQ} (MAX) μ SEC	
150	1000	13	3.35 20	3	6	POR*
200	1000	13	3.45 50	5	6	POR*
200	1000	13	3.1 90	8	6	POR*
200	1000	13	4.1 200	—	6.5	POR*
150	1000	—	3.0 20	1	6	\$5.40 (1000)
200	1000	—	3.1 50	1	6	\$14.50
200	1000	—	2.8 90	1	6	\$28.00
200	1000	—	3.8 200	1	6	\$64.00
200	1000	—	2.8 300	1	8	\$99.00
400	600	1000, 1200	2.84 251	30	8	\$290 (1 to 9)
—	1500	—	<3.4 2.5	—	<0.7	POR*
—	1000	—	<2.0 10	—	<0.85	POR*
—	1000	—	<2.2 20	—	<1.3	POR*
200	600	15	2.4 300	10	16	POR*
200	600	15	2.4 400	10	16	POR*
200	600	15	2.4 700	10	16	POR*
200	600	15	2.4 800	10	16	POR*

SURGE (NONREPETITIVE) ON-STATE CURRENT	CRITICAL RATE OF RISE OF ON-STATE CURRENT	CRITICAL RATE OF RISE OF OFF-STATE VOLTAGE	REPETITIVE PEAK REVERSE VOLTAGE	ON-STATE VOLTAGE	GATE-CONTROLLED TURN-OFF TIME	PRICE (1000)
I_{TSM} (A)	di/dt (A/ μ SEC)	dV/dt (V/ μ SEC)	V_{RRM} (V)	V_{TM} AT I_{TM} (V) (A)	t_{GQ} (MAX) μ SEC	
125	200	1000	13*	3.45 50	6	CIRCUIT A ~\$35, B ~\$40, D ~\$35
270	200	1000	13*	3.1 90	6	CIRCUIT A ~\$65, B ~\$75, D ~\$60
440	200	1000	13*	3.1 150	6	CIRCUIT B ~\$140
450	500	1000	—	— —	5.1	POR** (AVAILABLE 4TH QTR '85)
400	200	1000	—	3.6 100	8	~ \$150
400	250	1000	—	3.5 150	7	~ \$200
400	200	1000	—	4.5 100	8	~ \$80
500	200	1000	—	4.3 200	10	~ \$145
550	200	1000	—	2.0 50	8	V_{DRM} 1200 ~\$61, 1300 ~\$67
880	200	1000	—	2.2 100	8	V_{DRM} 1200 ~\$98, 1300 ~\$109
1540	50	300	—	2.2 200	8	V_{DRM} 1200 ~\$136, 1300 ~\$151
400	200	1000	15*	3.6 200	8	CIRCUIT B ~\$75
500	200	1000	15*	3.8 200	10	CIRCUIT B ~\$150



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

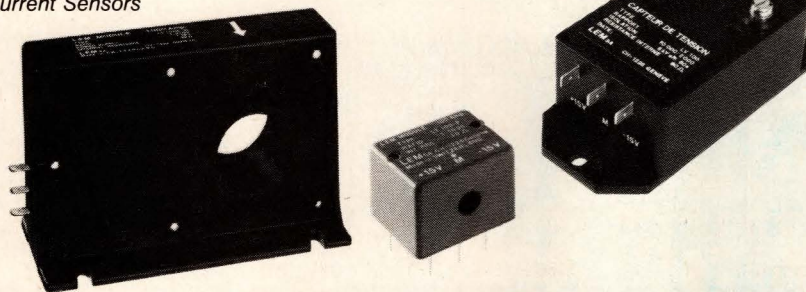


American Photonics Inc.
71 Commerce Drive, Brookfield Center, CT 06805
(203) 775-8950/8955 TELEX: 821353

CIRCLE NO 39

LEM SA*

Non-Contact DC & AC
Current Sensors



Measure current to $\pm 0.2\%$ accuracy!

LEM current sensors are precision, self-contained sensors utilizing the latest electronic technology and quality fabrication. Current sensing in the range of milliamps to 100KA is offered in printed circuit and panel mount packages, in standard and high temperature versions.

Measured sensitivity, accuracy and stability range from $\pm 0.2\%$ to $\pm 1\%$ of nominal current, including .25ma offset current, thermal deviation of

$< 0.5 \times 10^{-4} \times I_n / ^\circ\text{C}$, and linearity of better than 0.1% of I_n .

Response time is better than one microsecond and frequency range of the standard units covers DC to 100KHz. Standard isolation ranges to 6KV, with up to 50KV available. Data on mean-time-to-failure, shock and vibration available for most models.

REKCO
INCORPORATED

Voltage sensing versions are also available. Write or call for our catalog and application help.

P.O. Box 162 • New Berlin, WI 53151 • 414/784-3430 • TWX 910-262-3005

*Manufactured by Liaisons Electroniques Mecaniques, SA, Switzerland.

CIRCLE NO 40

TECHNOLOGY

tors, will introduce a 2500V, 1700A GTO thyristor in late 1985. Its target specs include 1000V/ μsec critical dV/dt, 150A/ μsec critical dI/dt, and a gate-turn-off gain of about 5 to 7. The company plans to follow this with 4500V GTO thyristors, beginning with current ratings of 3000A and working downwards to 200A devices.

Expect the addition of 160 and 400A power modules to BBC Brown Boveri's 90A version, and watch for power modules and pressure packs from another West German company, Semikron, which expects to enter the market in 1986 with devices rated between 100 and 250A. In the UK, 1986 should also see the first GTO-thyristor products from Westcode Semiconductors.

Although GTO thyristors are replacing SCRs in all but the highest power applications, in a few years they may themselves face replacement by another device currently under development. The static-induction thyristor (SIT), also known as the field-controlled thyristor, promises straightforward voltage control of its gate, low on-state voltage, and operation at very high frequencies.

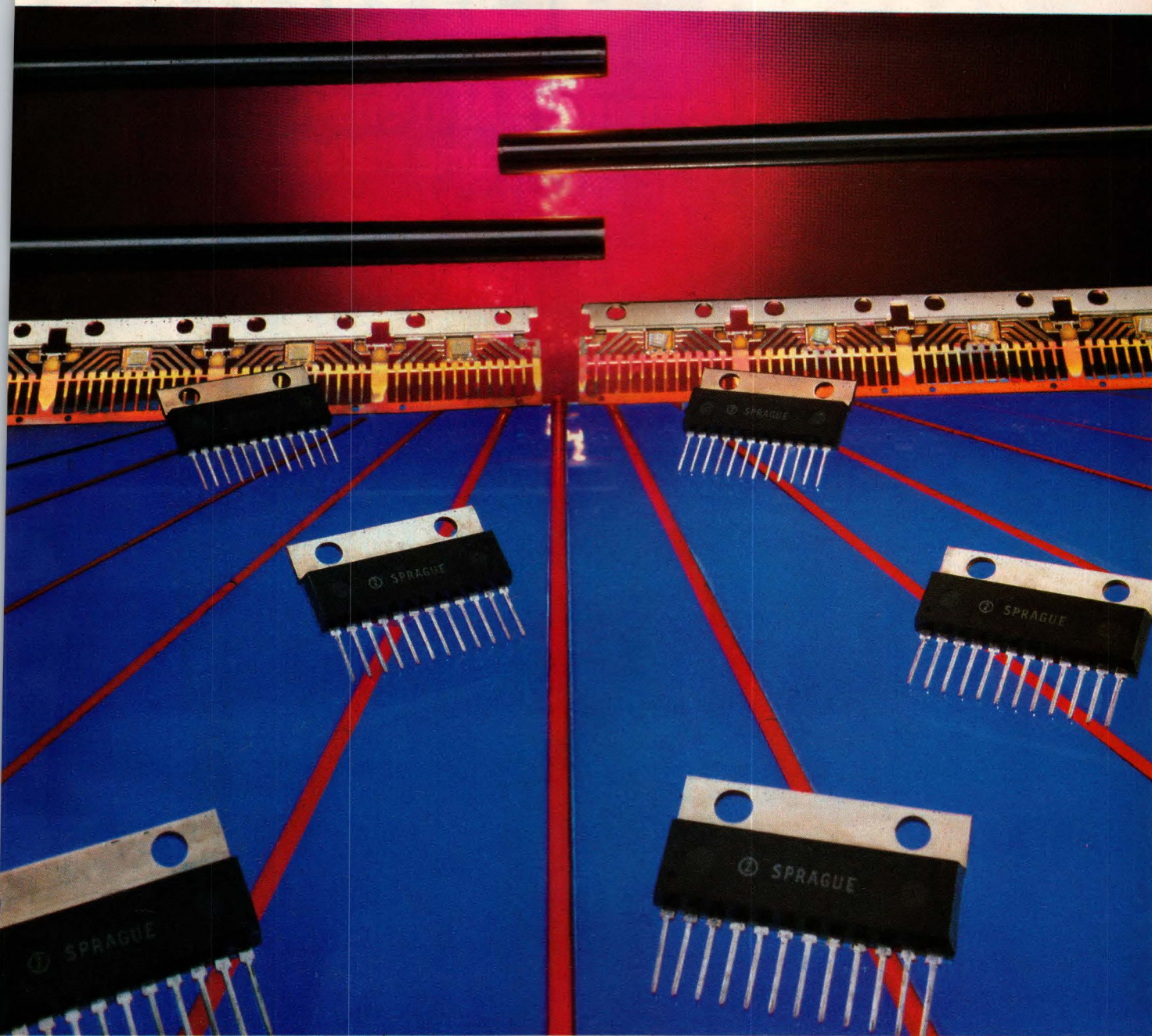
The SIT requires the processing of a large wafer area with very fine horizontal geometries and deep vertical-diffusion zones, and so fabrication techniques are not yet available to make the device commercially procurable. Dr Paul Taylor, head of power-device design at Marconi Electronic Devices Ltd, believes that SITs will eventually match the voltage capabilities and probably exceed the current capabilities of current GTO thyristors, yet operate at switching frequencies as high as 100 kHz. In his estimation, though, commercial devices could be at least five years away.

EDN

Article Interest Quotient
(Circle One)

High 500 Medium 501 Low 502

POWER HANDLERS.



4SS-3134R1

SPRAGUE DARLINGTONS SWITCH UP TO 1280W.

Sprague UDN-2878W and UDN-2879W Quad High-Current Darlington Switches provide a new level in power control capability. They serve as interface between low-level logic and high-power peripheral loads such as solenoids, motors, and incandescent displays.

Capable of handling loads up to 320 W per channel, they are provided in 12-pin single in-line power tab packages. The inputs are compatible with most TTL, DTL, LS TTL, and 5 V CMOS logic. The UDN-2878W has an output voltage rating to 50 V (35 V sustaining) while the UDN-2879W has an 80 V (50 V sustaining) rating. Volume pricing (50k) is just over \$2. Write for Engineering Bulletin 29305.10 to Technical Literature Service, Sprague Electric Co., a Penn Central unit, 491 Marshall Street, North Adams, Mass. 01247. For applications assistance, call Mark Heisig at 617/853-5000.



SPRAGUE
THE MARK OF RELIABILITY

CIRCLE NO 41

Total Compatibility

Why 2 Out Of 3 Computers And Business Machines
Are Made With General Electric Plastics



LEXAN® resin/sheet/film/foam **NORYL®** sheet/foam/resin **VALOX®** resin/film/foam
ULTEM® resin/sheet/film/foam **XENOY®** resin/sheet/film



and ® Registered Trademarks of General Electric Company.

lity

Vision Resources Reality

The concept of compatibility takes on a whole new definition when industry leaders team with the Strategic Supplier in engineering plastics to accelerate innovation. GE Plastics' universal workstation concept is an exciting example where vision in design and function driven by advanced materials and resources make the office-of-the-future today's reality.

Materials Compatibility

The unmatched choice of high-tech GE resins and grades—many developed specifically for C&BE applications—creates multiple opportunities for increased functionality and advanced design. The result: stronger, tougher, heat resistant, flame retardant components that meet UL requirements without sacrifices in performance or economy.

System Compatibility

GE Plastics' systems approach to application development provides integrated solutions to cost/performance challenges. For enclosures, bases, keyboards, internals, graphics, membrane switches and media, advanced technology and intensive support from GE Plastics enhance your total program for optimum results.

Strategic Compatibility

With GE Plastics, you capitalize on years of C&BE experience and the translation of innovative ideas from GE technical and R&D centers worldwide. GE Plastics is the Strategic Supplier. An active partner in industry advances, matching its development efforts to your own, GE Plastics contributes technology, facilities and people to expand your resources. No other materials company can offer so much.

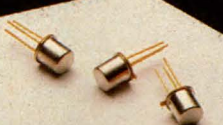
Discover the real meaning of compatibility. Team up with GE Plastics, the Strategic Supplier, from the very start.

For detailed information on GE Plastics' Office-Of-The-Future module, call toll free (800) 845-0600.

GE PLASTICS
THE STRATEGIC SUPPLIER



CIRCLE NO 42



TO-52 HEXFETs...
tiny, hermetically sealed case
for hi-rel military and aerospace
applications.



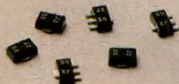
Commercial power hybrids
for 3Ø subfractional hp
dc brushless motor
control applications.



Hi-rel HEXFETs... Quad 14-pin
ceramic side-braze DIP
hermetically sealed for high
reliability applications.



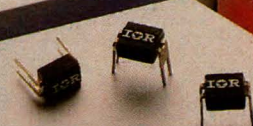
TO-66 HEXFETs... for a smaller, more
compact version of the industry
standard TO-3 package.



SOT-89 HEXFETs...
a highly reliable power FE
in one of the world's sma
surface mountable
cases.



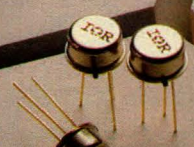
TO-61 HEXFETs in an industry
standard stud package with
electrically isolated chip.



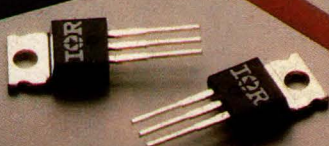
Cost effective HEXDIPs
in 4-Pin Dual In-Line Package
for end-stackable, automatic
insertion efficiencies.



TO-3 HEXFETs... in the industry's
ever-popular workhorse package;
also Mil-qualified to
JANTXV level.



TO-39 HEXFETs...
Mil versions to JANTXV level.
Reliable, hermetically sealed,
cost effective.



TO-220 HEXFETs...
The Number 1 power MOSFET
around the world! Unbeatable
quality, performance,
reliability.

When all else fails ...look to a HEXFET.®

HEXFET is a Reg. TM of International Rectifier.

Then you'll know why quality pays
for itself.

HEXFETs offer the longest
operating life in power FETs. Test
results show they've reached
performance levels unmatched by
any other semiconductor device.
Defects run less than 100ppm —
making ours the most desirable

power MOSFETs in the world.

Learn why HEXFETs deliver more
value and performance to real world
applications. Send for "The
HEXFET Report" on company
letterhead. It's free.

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

Technology driven

CIRCLE NO 43

TECHNOLOGY UPDATE

Multiple-access fiber-optic couplers enhance data-link performance

Tom Ormond, *Senior Editor*

Multiport fiber-optic couplers (devices with three or more access points) can add flexibility and sophistication to your fiber-optic system and network designs: They allow for bidirectional transmissions; let you tap, split, and combine transmissions; and permit you to multiplex signals.

Fiber-optic couplers, once mere laboratory curiosities, are now available off the shelf. They're affordable, too, considering the system enhancements they provide. Naturally, because no one coupler can provide all the aforementioned

capabilities, vendors offer couplers in a wide range of configurations and coupling technologies (see **box**, "The technology of fiber-optic couplers").

Interfacing multiple locations

AMP, for example, offers six splitters/combiners—three squid types and three unitized types. Squid models come in 1×2-, 1×3-, and 1×7-port versions. Fiber-cable legs are individually terminated on one end of the assemblies; fibers on the other end are clustered into a bundle that's terminated with a single Optimate simplex connector.

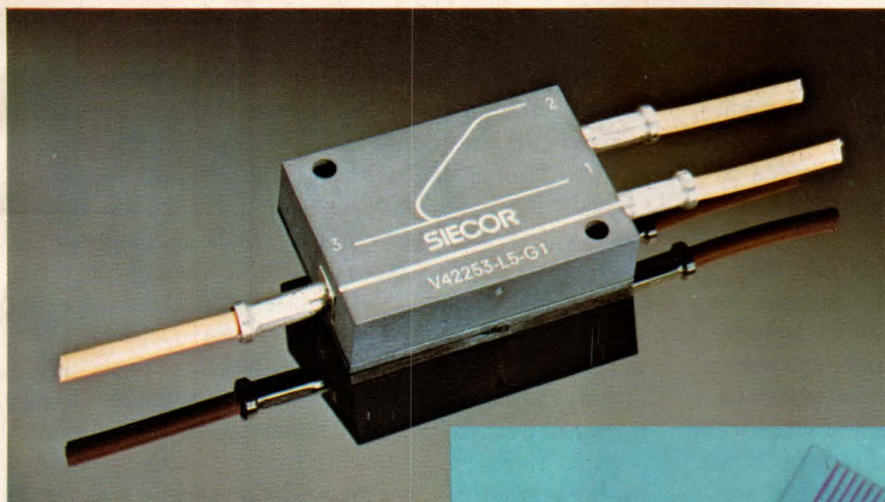
AMP's unitized devices are avail-

able in 1×7- (140- μ m fiber), 1×7- (250- μ m fiber), and 7×1×7-port star configurations. The devices are housed in a thermoplastic material that's fitted with metal Optimate simplex connectors.

Insertion loss for these splitters/combiners depends on your particular interface. When you design them into a system employing a 400- to 500- μ m source and a detector with a 400- μ m active window, the devices can transmit over distances of as great as 1 km and operate over -20 to +60°C.

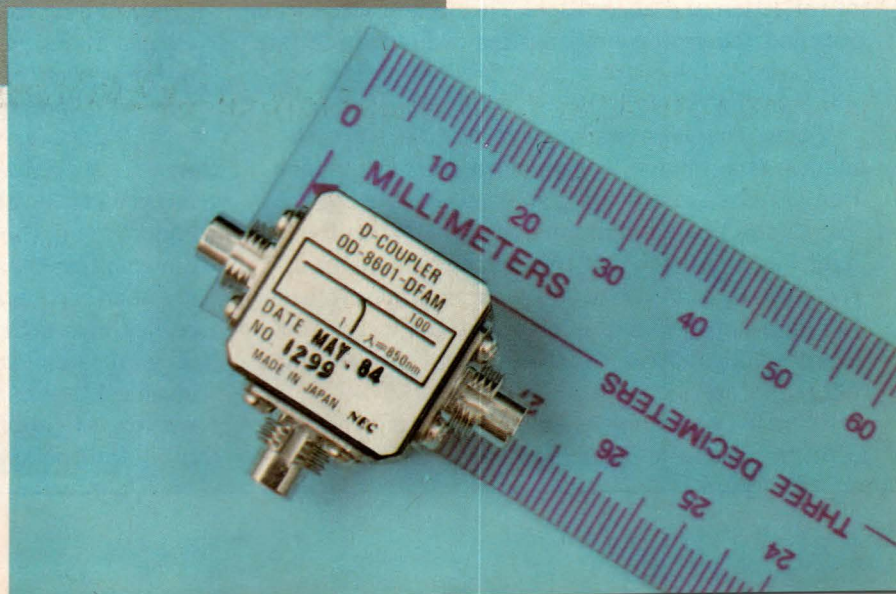
NEC offers similar splitters/combiners: The OD-8601 optical directional coupler has three ports; the OD-8602 has four. Both devices offer three splitting ratios—1:1 (K), 10:1 (L), and 100:1 (M). Standard versions of both devices work with either 50- μ m-core, graded-index fiber or 80- μ m-core, step-index fiber.

Both couplers accommodate transmission in the short (850 nm) or long (1300 nm) wavelength regions. Maximum insertion loss specs at 2 dB (1.5 dB typ). Minimum isolation measures 15, 20, and 30 dB



Performing multiplexing and demultiplexing, the wavelength-division couplers from SIECOR feature insertion loss of less than 1 dB and are available in pigtail or connector versions.

Available in 3- or 4-port designs, the directional couplers from NEC Electronics offer splitting ratios of 1:1, 10:1, and 100:1. They are compatible with both step- and graded-index fibers and are housed in a 20×16×20-mm package.



for K, L, and M versions, respectively. Splitting-ratio accuracy specs at ± 1 , ± 2 , and ± 3 dB.

Couplers are also available for single-mode fiber. Canstar provides its SM line of couplers in any configuration ranging to four input and four output ports. Designed for test equipment, telemetry, sensor, and telecommunication applications, the couplers can operate at 850 or 1300 nm, depending on the model.

Three of the Canstar models have splitting ratios of 1:1 (SM3C), 1:1

(SM4C), and 4:1 (SMS4 $\times$ 4). Maximum insertion loss specs at 1, 1, and 1.5 dB, respectively, and directivity is greater than 45 dB for all models. Maximum thermal, polarization, and wavelength coefficients are 0.002 dB/ $^{\circ}$ C, ± 0.1 dB/360 $^{\circ}$, and 0.03 dB/nm, respectively.

The 850-nm fibers have a 0.1 numerical aperture (NA), a 4.5- μ m core, and a 770-nm cutoff wavelength. The 1300-nm fibers have a 0.1 NA, a 10- μ m core, and a 1250-nm cutoff wavelength. The couplers

are supplied with fiber pigtailed and operate over -50 to $+70^{\circ}$ C.

Employing fused-fiber technology, TS Series transmissive star couplers from Phalo evenly split or combine energy between the input and output ports for optical data collection or distribution. They are available with 0.5m-long cabled or buffered graded- or step-index fiber leads (50- or 100- μ m core). Input and output port count can be as high as 32 $\times$ 32; standard couplers are available in 8 $\times$ 8-, 16 $\times$ 16-, and

The technology of fiber-optic couplers

Taps, splitters, and combiners are the simplest forms of single-wavelength fiber-optic couplers. A tap (or T-type coupler) is a 3-port device that divides a transmitted optical signal into two channels. Taps typically remove only a small portion of the main signal; you'd use them mainly in applications requiring feedback control of the optical power, or in applications in which you want to provide a signal-monitoring capability.

Splitters take an optical signal and divide it into several channels; combiners are simply splitters configured in the opposite direction. Unlike taps, splitters divide the signal equally among the output fibers. Typically, you'd use splitters in data-link applications in which a significant portion of the main transmitted signal must be channeled to peripheral devices.

In T-type couplers, the tap ratio defines the fraction of light energy that's coupled at each access point in a link. Tap ratio is a critical system variable in a data bus. Another critical variable is excess loss, the energy lost in the coupler because of reflection and absorption. The sum of the excess loss and the power-splitting loss (a function of the tap ratio) is the coupler insertion loss at each terminal in the network.

T-type couplers employ several different techniques. One kind of T coupler contains a combination of lenses and a beam splitter. As the light leaves one fiber, a lens collimates it. When the light hits the beam splitter, the beam splitter directs the light to other lenses, which then refocus the light onto the appropriate output fibers. You can use this approach with step- and graded-index fibers.

Some T-type couplers employ a mixing-rod concept, in which the incoming fiber is fastened to one

end of a thick glass rod, and the output fibers are attached to the other end of the rod. As light enters the rod, it bounces around randomly and then exits to the output fibers. You can use this technique only with step-index fibers.

A third type of T coupler employs identical fibers and fuses them into a biconical taper. You can also use this biconical-taper-based coupler to fabricate power combiners and duplex couplers by fusing two or more fibers of different diameters.

Because of insertion-loss buildup, T couplers aren't practical for use in systems with many access points. Instead, you can use star couplers—devices that have M number of ports on one side and N number of ports on the other side. To qualify as a star coupler, N must be greater than two; M can be between one and N. Stock couplers typically have values for N of 4, 8, 16, 32, and 64.

Star couplers come in two varieties: transmissive and reflective. The transmissive star coupler's input ports are essentially isolated from each other; the reflective star's ports are coupled. Both types of star couplers are composed of input fibers, output fibers, and a mixing region, which is usually either a glass rod, a reflecting mirror and lens, or a fused, tapered zone.

Multiport transmissive star couplers that use a fused, tapered zone for a mixing region are manufactured by cutting the desired number of fibers and twisting them together into a hexagonal bundle or other densely packed formation. The fibers are then put under tension and placed over a controlled heat source. As the fibers soften, the claddings fuse and the tension pulls the fibers into biconical tapers with a central fused section. By varying the applied tension, the flame temperature, and the applied torsion, the manufacturer can

TECHNOLOGY UPDATE

20×20-port designs.

The TS Series couplers feature maximum insertion loss ranging from 2 to 3 dB. Maximum port-to-port throughput factor is -11 to -15.5 dB, and typical directivity measures >-40 dB. Operating range spans -50 to +85°C.

For multiplexing and demultiplexing in local-area networks, for 2-way video/data links on a single fiber, and in long-haul data transmission links, you can use Gould's 2×2-port single-mode, wavelength-



Employing fused-fiber technology, Gould's 2-channel wavelength-division-multiplexing (WDM) couplers operate with 1300- and 1550-nm wavelengths. They feature an excess loss of <0.5 dB and a wavelength isolation of -16 dB min.

closely control the diameter, shape, and length of the fused section.

Whatever the fabrication technique, the reflective star coupler is generally more versatile than the transmissive star: Even after the reflective star has been constructed, you can select or vary its relative number of input and output ports. In the transmissive star, the number of input and output ports is fixed during the initial design and fabrication.

Despite its versatility, the reflective star is usually less efficient than the transmissive star, because a portion of the light fed into the reflective star is injected back into the input fibers. A transmissive star is twice as efficient as a reflective star that has the same number of input and output ports.

Because reflective and transmissive star couplers have their own particular advantages and disadvantages, your network topology is the most important factor that you must consider when choosing a star coupler for your application.

Boosting your system performance

If you're designing fiber-optic data links, you'll find wavelength-division-multiplexing (WDM) couplers very useful. Such couplers can, for example, increase the effective bandwidth of your system. They allow you to develop 2-way communications over a single fiber, and, because they allow your system to operate at the longer wavelengths, they provide a simple means of upgrading an existing system.

Manufacturers use several different technologies to make WDM couplers. One method, the fiber-fusion technique, lends itself well to wavelength-division multiplexing—it's a simple matter to fuse

fibers optimized for a wide range of wavelengths. Two other methods employ miniature optical components: the graded-index (Grin) lens, and the spherical retroreflecting mirror.

In the Grin-lens coupler, light from the transmitting fiber strikes a dividing or combining element (a beam splitter or dichroic mirror) and then strikes the Grin lens. The Grin lens refocuses the collimated light onto another fiber or fibers. Because the beam has been collimated, the dichroic mirrors can handle the closely spaced optical wavelengths.

The Grin-lens coupler is harder to make than are other optical components; it doesn't lend itself to large-scale automatic manufacturing techniques. To focus a Grin lens, the manufacturer must perform active alignment of the fibers. When light exits the transmitting fiber, the manufacturer monitors the receiving fiber for coupled power. The manufacturer positions the receiving fiber for peak power and then fastens the fibers in place.

Unlike the Grin-lens coupler, the retro-reflecting-mirror coupler design relies on the fact that light exiting from the center of curvature of a spherical mirror is reflected perfectly back onto itself. The mirror has no geometric aberrations and no chromatic aberrations.

A typical dual-wavelength, retroreflective coupler has two spherical surfaces—one with a dichroic mirror coating and the other with a metallized mirror coating. The dichroic coating transmits the source output, and the second mirror reflects the source output to the link fiber. The dichroic mirror then reflects the link fiber's output to the detector port's fiber.

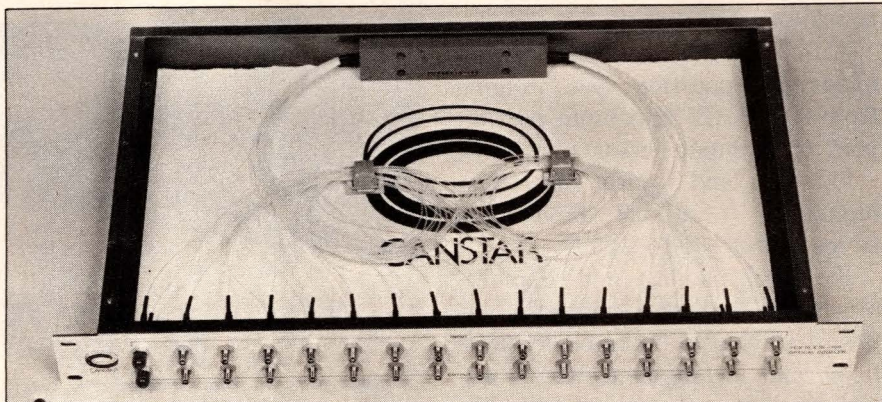
TECHNOLOGY UPDATE

dependent couplers. The devices are fabricated with fusion technology and come in very small packages (4×0.4 cm).

These WDM (wavelength-division-multiplexing) couplers operate with 1300- and 1550-nm wavelengths. Maximum excess loss is 0.5 dB, and wavelength isolation is -16 dB min. Maximum thermal and polarization coefficients spec at ±1.5% and ±1%, respectively. The units are supplied with 1m-long fiber pig-tails, and they operate over -55 to +125°C.

American Photonics, Kaptron, and Siecor all offer WDM couplers that utilize optical-component technology. The WC4200 Series couplers from American Photonics use Grin (graded-index) lens techniques. Available for multiplexing (M suffix) and demultiplexing (D suffix), the devices are designed for 2-channel WDM transmission and can be used in either unidirectional or bidirectional systems.

The WC4200 Series includes devices whose operating wavelengths range from 780 to 1600 nm. You can select models that pair short or long wavelengths or models that offer a combination of short and long wavelengths. Typical port-to-port insertion-loss figures range from 1.5 to 2 dB max, and minimum port-to-port



Completely enclosed for maximum protection, Canstar's star couplers come in transmissive and reflective designs. Compatible with stand-alone or rack-mounting operation, they are available with port counts ranging to 64×64, and can operate with both step- and graded-index fiber.

optical isolation measures from 18 to 50 dB. The couplers employ 50-μm-core fiber with a 0.2 NA, are housed in a package measuring 13×13×63 mm, and operate over -50 to +65°C.

Kaptron also takes a dedicated-service approach, offering devices specifically designed for multiplexing (WDM-01) and demultiplexing (WDM-02) tasks. The devices are housed in a package (7/16×2 1/2 in.) that lends itself to pc-board mounting. Both devices are dual-channel couplers; different models are available for operation at the following wavelengths: 820/1300, 1200/1300, and 1300/1520 nm.

The WDM-01 and WDM-02 both

employ mirrors with low-loss dichroic coatings; the mirrors let you multiplex (WDM-01) and demultiplex (WDM-02) wavelengths that are separated by as little as 7%. The couplers use high-quality reflective optics, which improves imaging (less aberration) and increases immunity to radiation-induced loss. Insertion loss measures 1.5 dB max, and crosstalk doesn't exceed -30 dB. The devices operate over -40 to +50°C.

Siecor's WDM coupler serves as an optical multiplexer and demultiplexer. Available with pigtails (500 mm long) or with SMA or DIN connectors, the coupler operates with two optical channels and has one signal in each of the following wavelength windows: λ_1 =1150 to 1600 nm, and λ_2 =800 to 900 nm.

The WDM coupler is available with two types of fiber: 50-μm-core fiber with a 0.2 NA, and 100-μm-core fiber with a 0.29 NA. The device is fabricated with interference-filter technology, which results in insertion loss of <1 dB for pigtail versions and <2.5 dB for connector versions. With or without the connectors, the couplers' crosstalk is at least -20 dB, and the operating temperature spans -10 to +55°C.

EDN

For more information . . .

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

American Photonics Inc
71 Commerce Dr
Brookfield Center, CT 06805
(203) 775-8950
Circle No 718

AMP Inc
Eisenhower Blvd
Harrisburg, PA 17105
(717) 564-0100
Circle No 719

Canstar Communications
1240 Ellesmere Rd
Scarborough, Ontario
Canada M1P 2X4
(416) 293-9722
Circle No 720

Gould Inc
Defense Electronics Div
6711 Baymeadow Dr
Glen Burnie, MD 21061
(301) 760-3100
Circle No 721

Kaptron Inc
3460 W Bayshore
Palo Alto, CA 94303
(415) 499-8008
Circle No 722

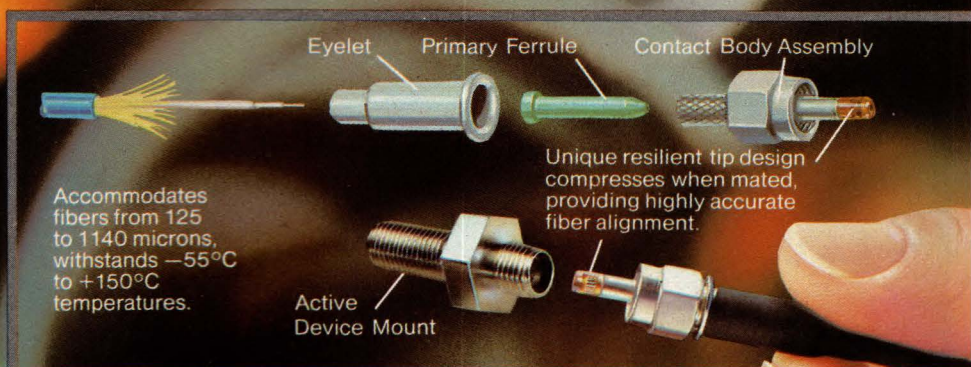
NEC Electronics Inc
401 Ellis St
Mountain View, CA 94043
(415) 960-6065
Circle No 723

Phalo/OSD
900 Holt Ave
Manchester, NH 03103
(603) 669-4347
Circle No 724

Siecor Corp
489 Siecor Park
Hickory, NC 28603
(704) 327-5000
Circle No 725

Article Interest Quotient
(Circle One)

High 503 Medium 504 Low 505



SIMPLE AND ACCURATE.

**The FSMA
fiber optic connector
with a nose for
superior performance.**

The nose is the news in our newest fiber optic idea.

The precision resilient tip on our FSMA OPTIMATE connector minimizes tolerance problems, accurately centering the fiber during mating without special procedures, without extra parts. And the internal-ferrule construction provides two-point support and axial alignment to within 0.1 degree for remarkably low insertion loss.

Need a rugged package? Corrosion resistant metal construction provides high strength. Simplified bonding minimizes fiber stress in extreme temperatures. And the overall design meets proposed NATO and IEC standards for FSMA type fiber optic connectors.

The result is everything you're looking for in a light connection. The FSMA connector that's simple. Precise. And available right now.

For more information, call the AMP OPTIMATE Desk at (717) 780-4400. AMP Incorporated, Harrisburg, PA 17105.

AMP Interconnecting ideas



Korean porcelain water-dropper in the form of a mythical beast covered in a blue-green celadon glaze. Yi Dynasty.

SAMSUNG THE STATE OF THE ART

The art of Korea:
Celadon ceramics

The art of Samsung:
The 1 Megabit DRAM

In the fifteenth century, the skill, patience and commitment of a Korean artist produced this celadon figure. ■
At Samsung today, that same skill, patience and commitment is perfecting the one megabit DRAM for delivery by 1986. ■
But you don't have to wait until then to enjoy the art of Samsung. Our current semiconductor collection includes memories, micros, linears and discretes, as well as the smallest, lowest power 64K DRAM in the industry. ■

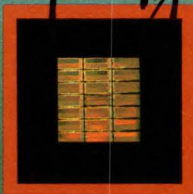
The Samsung reign is starting. Get to know our semiconductor dynasty now. ■
For the Samsung Semiconductor source nearest you, call Marketing Communications at (800) 423-8624, (in CA, (408) 980-1630). And don't forget to ask for the first in our Korean art poster series.

SAMSUNG MEMORY PRODUCTS

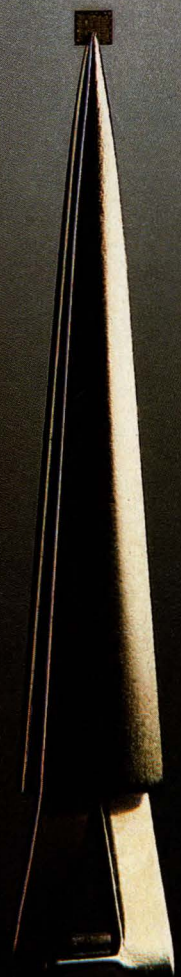
MEMORY PRODUCT	NOW	LATER IN '85	1986
DRAMS	64K/256K	64K/256K (120ns, plastic)	1 MEGABIT
SRAMS		64K	256K
EEPROMS	16K		64K
EPROMS			512K

SEMICONDUCTOR

dynasty



AFTER 15 YEARS,
CALMA IS MAKING IT BIG.



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.

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.

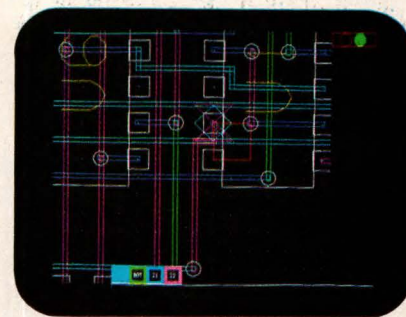
BIGGER AND BIGGER HELP.

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

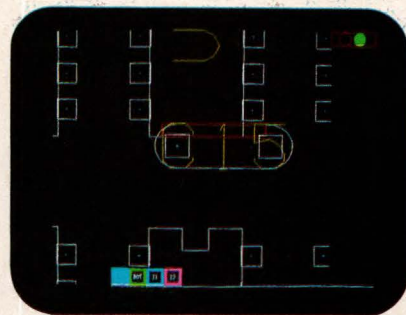
But it doesn't stop there. When brought into Calma's full TEGAS™ tation environ-

All over the world.

We offer a variety of service plans, hardware and software



Error lockout and dynamic checking.



Red rectangle shows clearance violation.

support, education programs—even a hotline.

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.

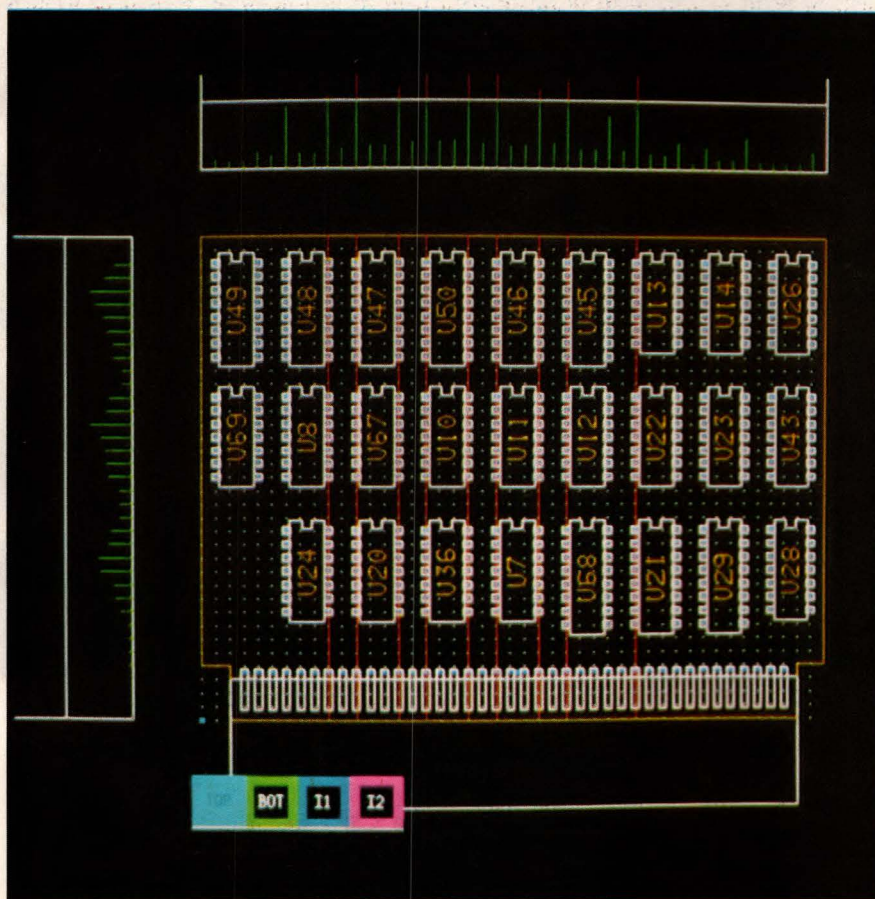
Calma's been here for 15 years—an institution in this mercurial business.

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 GE-CALMA for specifics.



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.

ment, 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— MAY BE THE BIGGEST HELP.

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

In 60 places, for that matter.



...to the right place
at the right time,
regardless of
operating environment.



Belden can assure your fiber optic system delivers.

You already know some of the reasons people choose optical fiber over copper:

- higher data rates over longer distances without repeaters or equalizers
- EMI/RFI noise immunity
- reduced cable size and weight for easier installation

Now, make certain you get exactly what you bargain for when you design your next optical fiber system...no more or less.

Belden can protect your performance.

Many system designers assume the job is over once the bandwidth and attenuation requirements are determined.

Yet factors other than modal dispersion and attenuation will quickly limit your system's efficiency and performance over time.

Operating temperatures, for example, can greatly change signal-to-noise ratios.

Impact, crush, and even elongation dur-

ing installation cause microbending which results in increased attenuation.

That's why Belden cables are available with such a wide range of cable jackets and strength members to optimize your installation requirements: direct burial, field deployable, aerial, all-dielectric, plenum or duct.

We know the trade-offs between tight or loose buffered cables because we make both, in fiber core diameters ranging from 50 to 600 microns.

Nobody has more field experience.

We've helped develop optical fiber cables that have been pulled through crowded ducts beneath Houston, buried beneath Alaskan tundra to hookup satellite antennas, deployed for radar links in the Sahara, and installed on transmission towers rising 1500 feet above California hills.

Our simplex and duplex Belden Bit-Lite™ cables for short-haul computer intercon-

nects, equipment control, CAD/CAM and process control applications benefit from years of Belden experience with coaxial cable counterparts.

So for answers to your fiber optic cable installation needs you won't find a more experienced source. One that will help get your signal to the right place at the right time.

Write for our Belden Application Digest or call your local distributor now. For quick assistance, call our fiber optic cable specialist at 800-323-0864. Belden, Fiber Optics, 2000 S. Batavia Avenue, Geneva, Illinois 60134. Phone: 312-232-8900.



BELDEN

IBM PC-compatible single-board controller runs tape, floppy, and Winchester drives

The Universal Mass Storage Controller promises to relieve the expansion-slot constraints of the IBM PC and compatible devices. The single-board, single-slot controller, compatible with the IBM PC and PC/AT, includes interfaces for tape drives as well as floppy- and Winchester-disk drives. The board sports improved data-transfer rates over competitive products, thus increasing its value in Unix-like environments.

The unit's tape interface meets the Quarter Inch Committee's QIC-36 specification; this spec requires virtually no intelligence on the part of the tape drive, so you can use a low-cost model. The board also provides an SA-450-compatible floppy-disk interface that can handle four drives.

The unit's Winchester controller, however, provides the most significant performance improvements. Although most IBM PC controllers use a Modified Frequency Modula-

tion (MFM) encoding scheme for hard disks, the Universal Controller offers MFM capabilities or the firm's proprietary Run Length Limited (RLL) encoding. An IBM PC-compatible hard disk can function with either scheme, but the RLL method provides such advantages as increased capacity and improved data-transfer rate.

For example, a typical hard disk that can hold 60M bytes of MFM-encoded data will actually store 92M bytes when it's formatted with RLL encoding. The capacity increase requires no change to the disk drive. In addition, the board increases the normal 5M-bps data-transfer rate to 7.5M bps. These performance enhancements are due in part to the board's ability to use one-to-one interleaving on the disk drive.

A CMOS chip set provides most of the controller board's capabilities. The DC1001 controller chip includes a data serializer/deserializer, encoding/decoding logic, error-checking

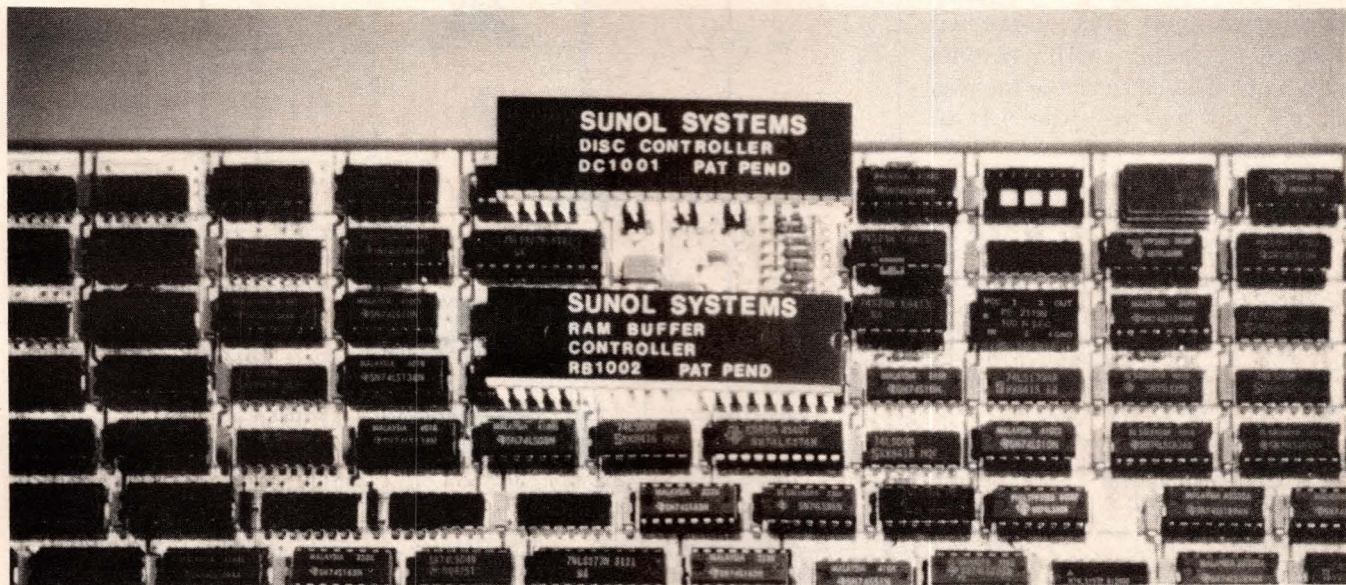
and -correcting logic, and interface/glue logic. In addition, the chip contains registers to store parameters for each of the peripherals.

The controller chip ties to the second chip in the set, an RB1002 RAM buffer, through one of the buffer's three DMA channels. The RAM buffer also includes a host interface port and a dynamic-RAM controller. The chip set supports data-transfer rates to 15M bps.

In addition to the chip set, the Universal Mass Storage Controller includes an onboard μ P and 16k to 64k bytes of RAM. The board also allows transparent communication between the tape and disk drives. The firm plans deliveries in June and expects the board to sell for \$595.—**Maury Wright**

Sunol Systems, 1187 Quarry Lane, Pleasanton, CA 94566. Phone (415) 484-3322.

Circle No 726



The 7.5M-bps data-transfer rate and increased Winchester capacity—the result of RLL encoding—allow the Universal Mass Storage Controller to increase IBM PC and PC/AT system performance using only one expansion slot.

Thick-film data-acquisition hybrid IC combines T/H amp, programmable-gain stages

Model AD365, a complete hybrid data-acquisition front end for A/D converters, provides wide dynamic range for the processing of analog signals. It incorporates a programmable-gain amplifier (PGA) and a track/hold (T/H) amplifier on a ceramic substrate. The PGA chip, the manufacturer's AD625, offers gains of 1, 10, 100, and 500; you program the gains with a 2-bit digital word. In addition, the hybrid incorporates the manufacturer's AD7502 CMOS multiplexer for switching the gains of the PGA.

The PGA's gain inaccuracy is 0.05% max for gains from 1 to 100 and 0.1% max for a gain of 500. Nonlinearity limits are one-tenth the gain-inaccuracy figures. Gain-drift figures for the cited gain ranges are 5 and 10 ppm/°C, respectively. Input offset voltage is 200 μ V max; offset drift is 2 μ V/°C max.

The PGA has a fully differential, instrumentation-style input stage and a guard terminal that lets you, for example, bootstrap the capacitance of an input cable. Input impedance is typically 1 G Ω in parallel with 5 pF. The noise at the input is 0.2 μ V p-p typ over the 0.1- to 10-Hz range.

The PGA's output settles within a 0.01% error band in 10 μ sec max for gains of 1 and 10 and in 15 and 50 μ sec max for gains of 100 and 500, respectively. Small-signal bandwidth, for the four gain values in ascending order, is typically 800, 400, 150, and 40 kHz.

The internal T/H amplifier uses the manufacturer's AD585 chip. The T/H amplifier contains a 100-pF hold capacitor—this value, in conjunction with the amplifier's input bias, yields a 1V/sec max droop spec, a figure that doubles every

10°C. The amplifier specs an open-loop gain of 100,000 min and 0.01% max nonlinearity: The latter figure makes the T/H amplifier suitable for 12-bit applications.

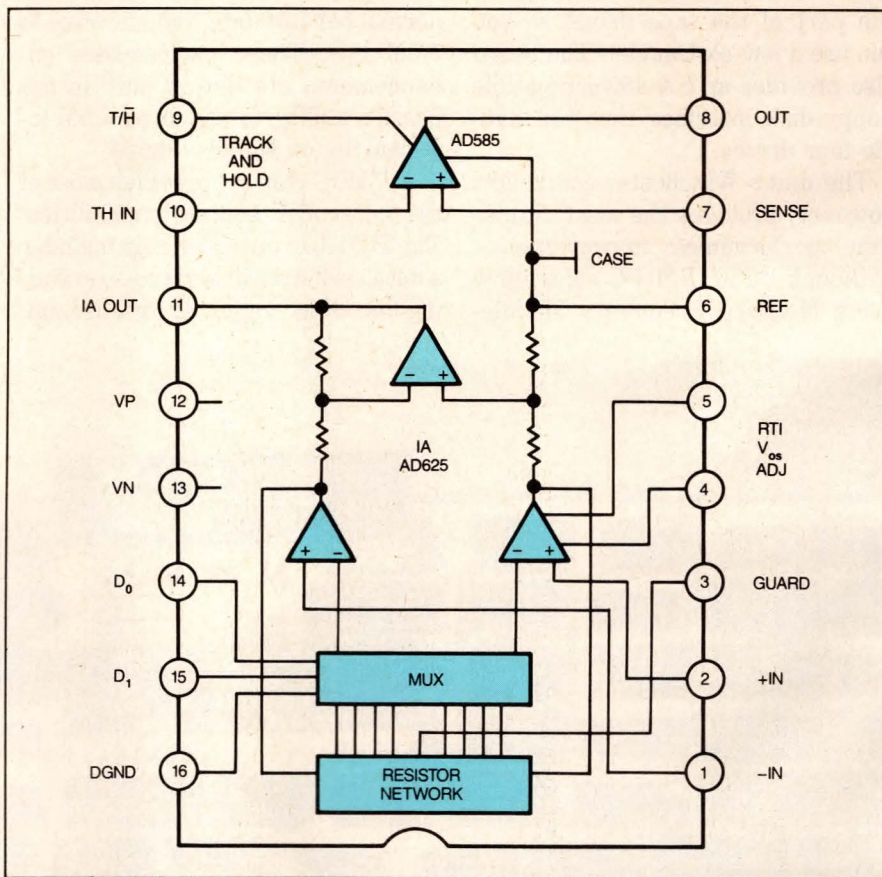
The 0.5-nsec typ aperture uncertainty (or jitter) allows sampling of signals with frequencies as high as 77.7 kHz (for $\frac{1}{2}$ -LSB max error) in 12-bit systems. The data sheet gives diagrams for two 12-bit A/D-conversion systems—one uses an AD578 A/D converter and yields 117.6-kHz throughput; the other uses an AD574 converter for 26.3-kHz throughput. According to Nyquist's

theorem, of course, the frequency of the sampled signal is limited to half these throughput figures.

The AD365 is housed in a 16-pin, metal single-width DIP. The hybrid dissipates 550 mW max and operates over -25 to +85°C. Its gain-selection and T/H digital inputs are TTL and CMOS compatible. The circuit operates from 4.75 to 17V and -11 to -17V supplies. \$61.95 (100).—**Bill Travis**

Analog Devices Inc., Box 280, Norwood, MA 02062. Phone (617) 329-4700.

Circle No 730



A complete front end for a data-acquisition system, Model AD365 from Analog Devices incorporates the company's monolithic programmable-gain amplifier and track/hold amplifier in a thick-film hybrid circuit. All the hybrid's accuracy and nonlinearity specs render the device suitable for use in 12-bit analog-input systems.



Introducing the World's First MIL-C-28876 Fiber Optic Connector.

Now, mil spec reliability in a rugged, sea-going, multi-channel fiber optic connector. Developed to meet stringent Navy requirements, these connectors incorporate all the qualities you'd expect and the Navy demands in a ship-board fiber optic connector.

- Environmental sealing, corrosion resistance, fluid immersion protection
- Mechanical shock/vibration resistance
- Maximum cable range accommodation/cable strain relief

- Hughes exclusive, field-proven contact alignment system yielding repeatable low insertion losses

For more information about our new mil spec fiber optic connector, or any of our other first-with-the-military multi-channel types, phone Tom Cobb at 714-660-6710. In England, call Hugh McNally at 932-47262.

HUGHES
AIRCRAFT COMPANY

CONNECTING DEVICES DIVISION
Industrial Electronics Group

Low-power RS-232C and -423 line-driver IC operates from wide power-supply range

An RS-232C and -423 quad line driver (**Fig 1a**) works from power supplies ranging from ± 5 to ± 15 V, vs the ± 9 to ± 15 V required by the earlier, industry-standard 1488 driver. Moreover, the LT1032 consumes 1-mA max supply current vs the 1488's 34 mA max.

The device features both current and thermal limiting on the outputs for protection against externally applied voltages as high as ± 30 V. The outputs have low saturation drops: 0.3V max in the high state and 0.9V max in the low state (with 2-mA output) vs the 1488's drops of approximately 3V. **Fig 1b** shows a typical device's saturation drops vs output current.

An on-off control allows you to

shut off the IC completely—when off, the device consumes no supply current. The LT1032 also includes a strobe pin that you can use to force all outputs low, independently of the IC's input conditions or the on-off terminal's state. The strobe line needs 3V min at 2 mA to perform its role.

Another useful control pin is the response terminal. It allows you to vary the device's nominal 15V/ μ sec slew rate by $\pm 50\%$. To use the response trim, you inject current into the response terminal—50 μ A increases the slew rate by 50%; -50 μ A reduces it by the same amount.

The LT1032's TTL-compatible inputs source 2 μ A typ to the IC's driver in the high state, 10 μ A typ

in the low state. By contrast, a 1488 sources 1.6 mA max in the low state. Like the 1488, the LT1032 sinks or sources at least 10 mA at its outputs. The outputs assume a high-impedance (open) state when the device is off or powered down.

Packaged in a 14-pin plastic or ceramic DIP, the LT1032 is available in commercial (0 to 70°C) or military (-55 to +125°C) versions. The commercial LT1032CN costs \$2.95 (100); the MIL-STD-883C LT1032MJ, \$10.95. —**Bill Travis**

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 942-0810.

Circle No 731

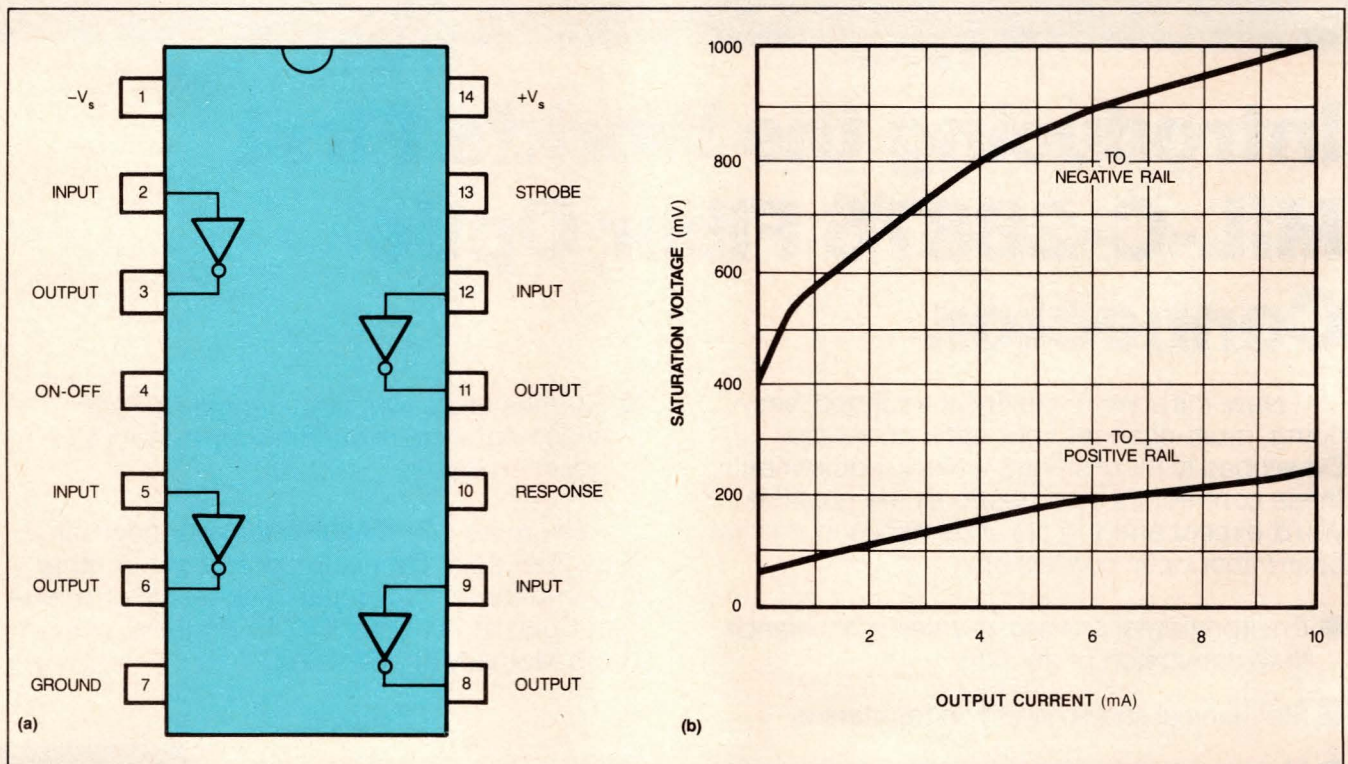
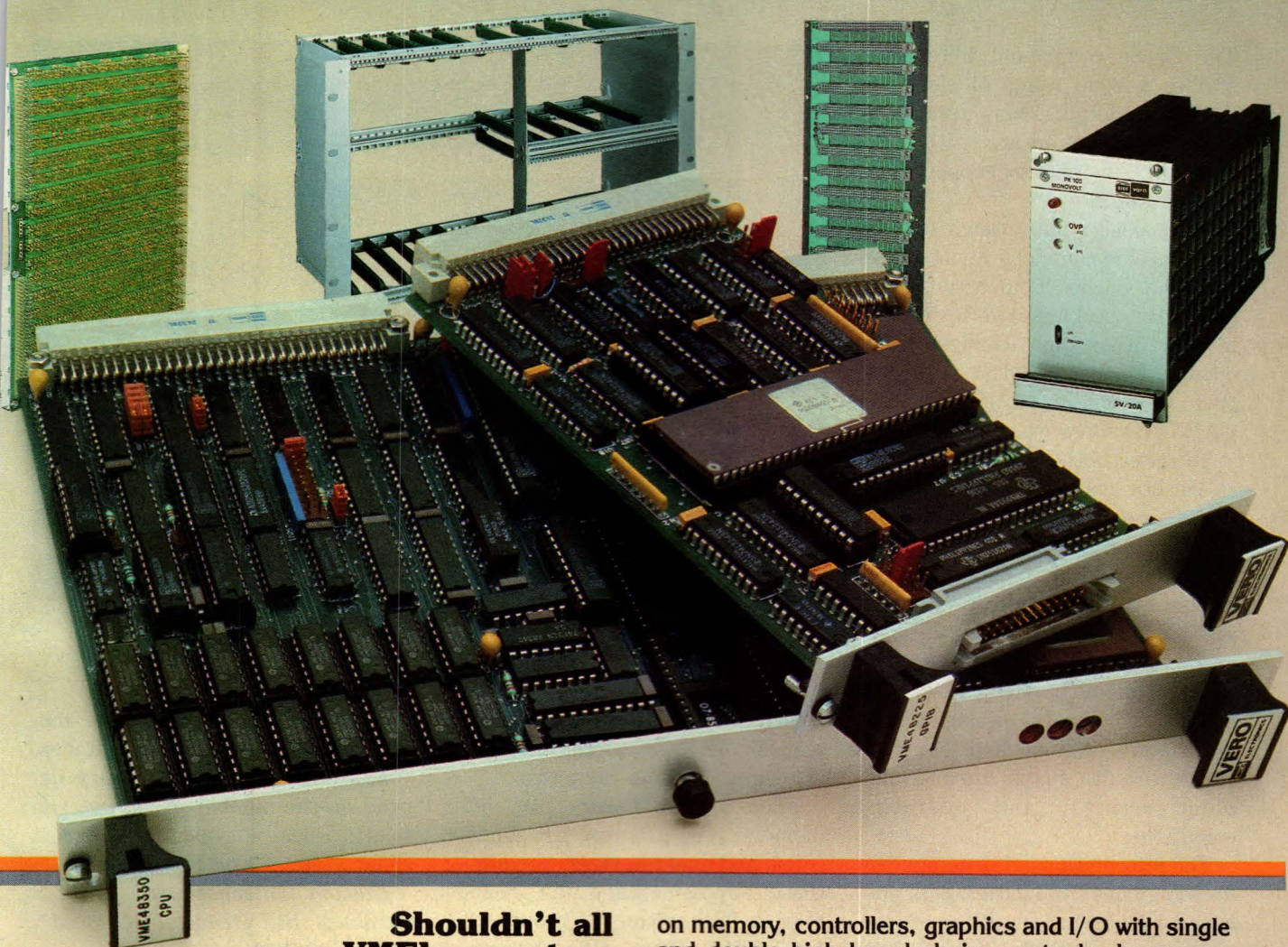


Fig 1—Low saturation drops allow a wide supply range for Linear Technology Corp's LT1032 RS-232C and -423 line driver (**a**). For example, at 2-mA output current, the saturation drops are approximately 700 and 100 mV (**b**), referred to the negative and positive rails, respectively.

VME

means Vero Module Europe
the new definition of the
total approach to VMEbus
from BICC-Vero



Shouldn't all your VMEbus system come from one supplier?

Before you get on a VMEbus, check its destination. You may be on a shuttle: back and forth to your distributor, looking for all the active boards, backplanes, card-frames, power supplies, prototype boards, wiring systems and enclosures that other VME suppliers just don't offer. Or, you can choose VERO MODULE EUROPE, our totally integrated VMEbus system that takes you where you want to go in style, ease and comfort!

VERO has all the VMEbus 68000 SBC's... plus the total VME hardware support you need!

Fast 68000 Single Board Computers with 512 K of dual ported memory are just the start of your trip. Add

on memory, controllers, graphics and I/O with single and double high board choices put wheels on your ideas. And, our CP/M and OS-9 software smooths out the bumpy road to your exciting new design. But, that's not all. VERO MODULE EUROPE speeds you to your destination with all the VMEbus hardware, power sources, connection, cages and enclosures you need. You save time... see results sooner... get into production faster.

Call VERO today and say "VME."

You'll quickly see that VERO MODULE EUROPE is the total VMEbus system to get on now. Call (203) 372-0038, or write for information.



BICC-VERO ELECTRONICS, INC.

40 Lindeman Drive, Trumbull, CT 06611

Tel: (203) 372-0038 Fax: (203) 372-6224

Twx: (510) 227-8890

Library file of devices for CAD systems describes logical and physical specs

The Cache component library describes a wide range of electronic devices in detail. These description files can communicate with CAE and CAD systems to support electronic design.

Many design-automation systems don't include complete device libraries. The Cache component library solves this problem by offering files in the Electronic Device Interchange Format (EDIF), a format that is becoming a standard for CAE/CAD software.

To serve both logical- and physical-design needs, the library supports schematic capture and mask layout. Logic files contain at most two hierarchical levels. Physical representations of chips give shapes and pin layouts.

A typical device file requires 7k bytes of memory. Each device file comprises a pin I/O listing, a logic description, timing and electrical characteristics, maximum and minimum ratings, and operating conditions.

The information in the component library comes from data sheets published by various suppliers of electronic parts. When these suppliers issue changes to their data sheets, the developers of the device library will release updates within 60 days.

The device library contains schematic device representations, logic diagrams, outline drawings, and parametric data for 5000 standard ICs. The initial version of the device library furnishes software models of 1800 TTL ICs from data sheets supplied by Texas Instruments (Dallas, TX), National Semiconductor (Santa Clara, CA), and Signetics (Sunnyvale, CA). In addition to TTL devices, the library includes 300 CMOS ICs, from National Semi-

conductor and Texas Instruments, and 200 ECL ICs, from Motorola (Phoenix, AZ) and Signetics.

Files in this library also offer memory ICs, μ Ps and μ P support chips, and linear devices. Vendors of these supplementary ICs include Mostek (Carrollton, TX), Motorola, Intel (Santa Clara, CA), Advanced Micro Devices (Sunnyvale, CA), RCA (Somerville, NJ), and National Semiconductor.

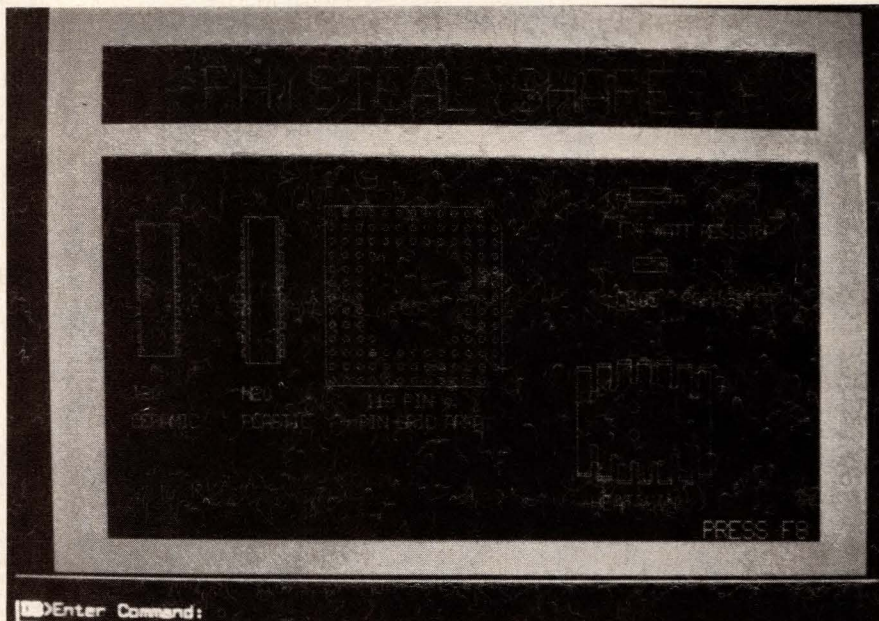
Besides ICs, the library files include discrete and power semiconductors, optoelectronic devices, resistors, and capacitors. Some of the sources of these devices are RCA, Texas Instruments, Motorola, Hewlett-Packard, General Instrument (Palo Alto, CA), Allen-Bradley (Milwaukee, WI), and Sprague (North Adams, MA). Because pc boards generally contain mechanical parts as well as electrical components, the Cache library also offers

files describing a number of mechanical elements, such as switches.

Prices for the Cache library depend on the number of devices you select. Files of typical length cost about \$3000.—**Eva Freeman**

Inacom International, 4380 S Syracuse St, Denver, CO 80237. Phone (303) 694-4200.

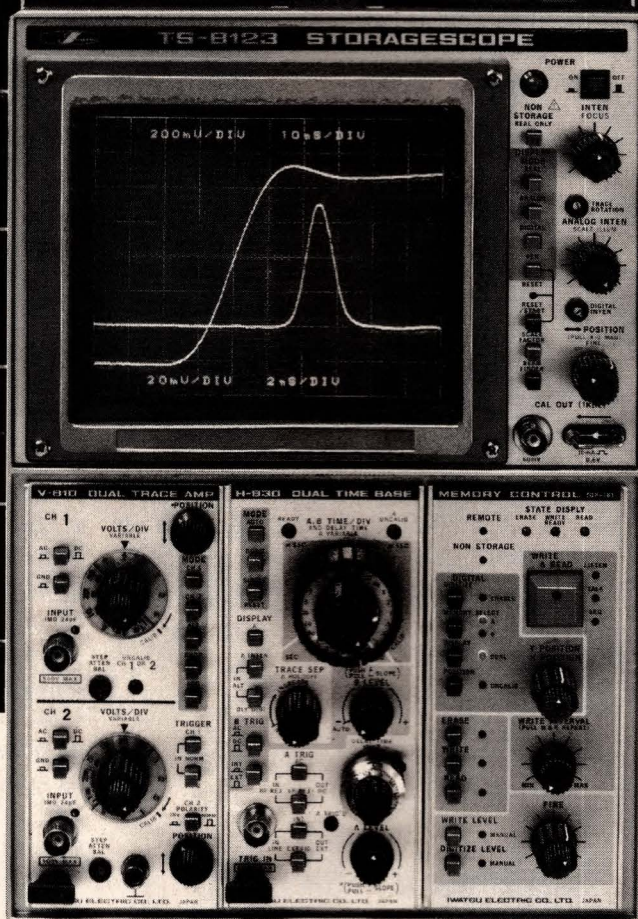
Circle No 729



Physical shapes supplied by the Cache component library include all standard IC packages, passive elements, and mechanical parts.

FREEZE THE MOMENT, AT A WRITING SPEED OF 3,000 cm/ μ s

The TS-8123 100MHz Storage Oscilloscope incorporates seven major innovations



1. Storage at extremely high writing speed up to 3,000 cm/ μ s is possible by simple operation.
2. Digitizing the stored waveform is easy with a maximum clock speed equivalent to 25 GHz/word.
3. GP-IB interface for the digital processing of transient phenomena.
4. High resistance of the CRT surface to burn-out and shocks is obtained as the scan converter tube uses a single-crystal sapphire substrate.
5. The best write condition is set automatically with the sweep time base setting; no complicated setting is needed for optimum waveform storage at any high or low sweep speed.
6. A pen recorder output is provided so that hard copies of waveforms are available.
7. Waveform comparison is easy: Waveforms can be stored and later used for comparison with a digitized or real-time waveform. Unlike other storage oscilloscopes, real-time waveforms can be observed without erasing stored waveforms.



IWATSU INSTRUMENTS INC.
430 COMMERCE BOULEVARD, CARLSTADT, NJ 07072 PHONE: (201) 935-5220, TWX: 710-989-0255

■ In Canada: ATELCO, 3400 Pharmacy Avenue, Unit 1, Scarborough, Ontario, M1W 3J8, Phone (416) 497-2208, TWX 610-492-0122

Laser probing system for VLSI designs captures logic states at 20-MHz speeds

The Dataprobe 2010 logic analyzer probes CMOS VLSI chips to verify designs and analyze failures. As the system positions a 1.8- μm laser spot over the surface of an IC, the logic analyzer captures logic-state diagrams at clock speeds as high as 20 MHz.

The logic analyzer, which uses the solar-cell effect, measures the digital state of an active element inside an IC. The system analyzes these logic states by irradiating a transistor with a 2- μW laser spot and monitoring the photoelectric response of the transistor. The detector can detect photocurrents in the submicro-ampere range.

If, for example, in a CMOS cir-

cuit, a p-type transistor is in the low state, the laser doesn't produce any current. On the other hand, if the p-type transistor is high, the detector measures a finite photocurrent. Conversely, an n-type transistor generates a photocurrent only when it is at a logical low.

Because only a beam of light interacts with the device under test, this logic-analysis scheme is completely nondestructive. You don't even need to remove passivation layers. Stray magnetic fields probably won't affect measurements, according to the vendor.

The VLSI logic analyzer uses an IBM PC/XT for its main processor. The system can operate either in a

stand-alone configuration or as a satellite of a CAE or CAD host. The interface to design-automation workstations enables the logic analyzer to verify previously simulated signals.

A pipeline processor accelerates measurements. The overall test time per logic node specs at approximately 320 msec, assuming a 1024-state timing diagram, a stage movement of 100 μm , and a test clock frequency of 10 MHz. Thus, the average test rate is greater than 3 nodes/sec.

A laser-interferometric X-Y stage under computer control positions the probing beam to an accuracy of 1.0 μm . Because of the accuracy of the stage, the logic analyzer can evaluate devices having design rules as small as 2 μm .

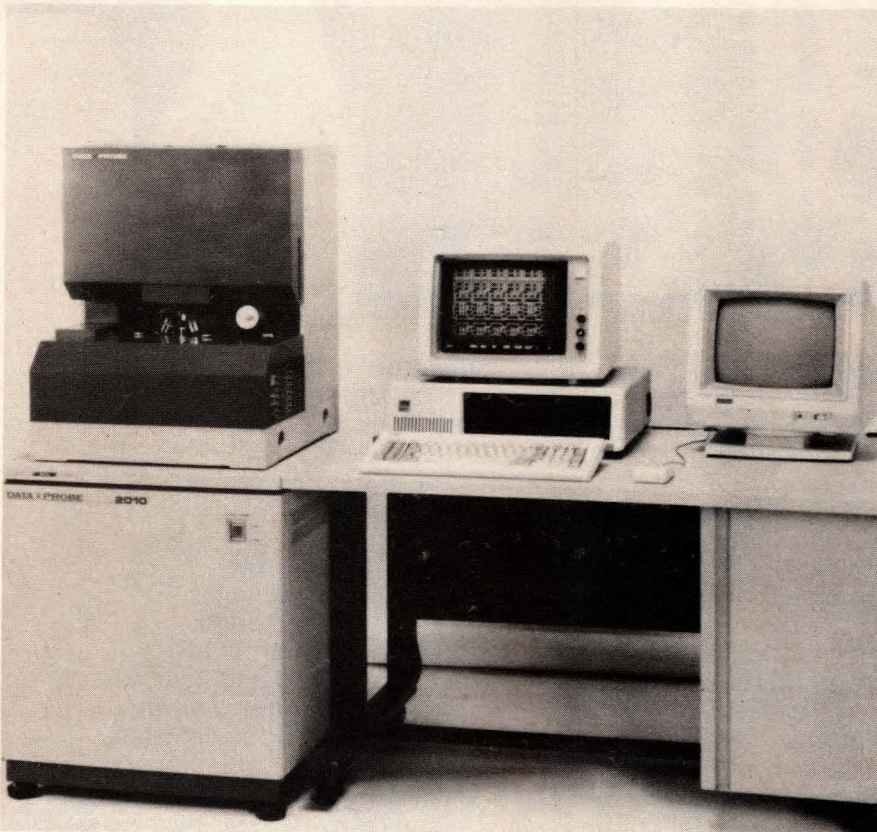
In addition, the system can test devices having as many as 128 pins. The logic analyzer can handle DIP, flat-pack, pin-grid, and leadless-chip-carrier packages. The system offers 256 analysis channels, each of which may detail from 32 to 1024 states.

The personal computer displays 16 channels at a time. You can scroll displays up or down through all channels, and you can rearrange the order of the channels.

The logic analyzer's internal clock can synthesize frequencies from 200 kHz to 40 MHz, in increments of 100 kHz. If you supply a TTL-compatible external clock, you can operate the system from dc to 20 MHz. \$140,000.—*Eva Freeman*

Mitsui & Co (USA), Semiconductor Systems, 10050 N Wolfe Rd, Building SW2, Cupertino, CA 95014. Phone (408) 725-8797.

Circle No 728



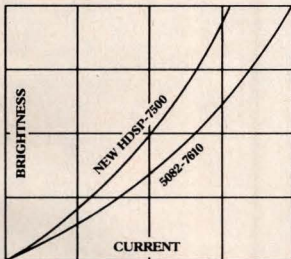
By taking advantage of the solar-cell effect, the Dataprobe 2010 probes logic states of transistors in CMOS ICs without destroying the ICs.

SURPRISE!

Add color to your bright ideas with HP's smaller 0.3" LED displays.

A smaller, brighter LED display.

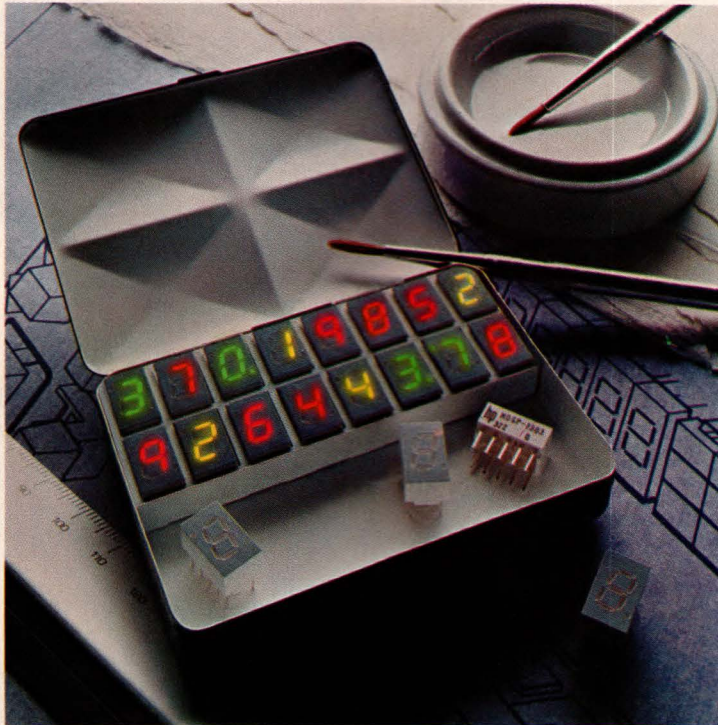
One of the newest and brightest enhancements in LED technology is now available from Hewlett-Packard. Our new family of 0.3-inch displays can offer design engineers more flexibility than before. Offering smaller package size and increased brightness, this series of seven-segment displays provides some



attractive solutions where space is at a premium. They have an eye-pleasing mitered character font that comes in four distinctive colors—red (HDSP-73xx), high efficiency red (HDSP-75xx), yellow (HDSP-74xx), or green (HDSP-78xx). And every one is pin-for-pin compatible with Fairchild's FND 350/360 series.

Now you can do more, with less. Measuring just 0.3 by 0.5-inches each

(7.6 by 12.7mm), ten of our high-performance displays can fit into a space of only three inches (76.2mm). You can power each display with 25 percent less forward-drive current and still see the same brightness as with our original family of 0.3-inch displays. This means excellent viewability at distances of up to ten feet. What's more,



our new displays let you see brightness increases of up to 50 percent at drive currents of just 5 to 10mA. Ideal for high-ambient light applications.

A free sample is yours for the asking.

For a free sample and data sheet on HP's newest family of 0.3-inch displays, circle the reader response number, or complete and mail the coupon. For pricing and delivery contact your local HP distributor. In the U.S., contact Hall-Mark, Hamilton/Avnet or Schweber. In Canada, call Hamilton/Avnet or Zentronics Ltd.

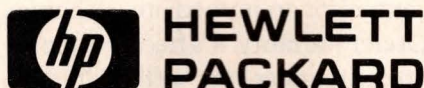
☐ I'd like a sample of your new 0.3" LED Displays.

Name _____
Company _____
Address _____
City _____
State _____ Zip _____

In the U.S. mail coupon to: Hewlett-Packard Company, 1820 Embarcadero Rd., Palo Alto, CA 94303. In Europe: Hewlett-Packard, Nederland BV, Central Mailing Department, P.O. Box 529, 1180 AM Amstelveen, The Netherlands. EDN

6/13/85

HP: The right choices for easy-to-read displays.





Every TI calculator comes with one extra number.

1-800-TI-CARES

When you buy a Texas Instruments calculator you don't just buy a calculator, you buy Texas Instruments' commitment to quality.

It's a commitment backed by a fully developed service network that includes the above toll-free number you can call from anyplace in the United States.

If you have any applications,

operations, or service questions, call us Monday thru Friday between 9:00 am and 4:00 pm CST, and we'll be glad to help.

If your calculator needs repairing, we'll direct you to one of our 46 conveniently located service centers for an immediate exchange. Under warranty, it's free. If there's no center near you, we'll do it all by mail.

Of course, there's just one catch. It has to be a Texas Instruments calculator. But then, if you're as smart as we think you are, why wouldn't it be?

TEXAS 
INSTRUMENTS

Creating useful products
and services for you.

Drawing digitizer and editor interface with electronic data storage and CAD systems

Model 3000, a drawing-digitizing system, provides an automated link between engineering drawings produced by hand, electronic data-storage systems (which often store drawings in raster form), and CAD systems (which generally use a vector format to store drawings).

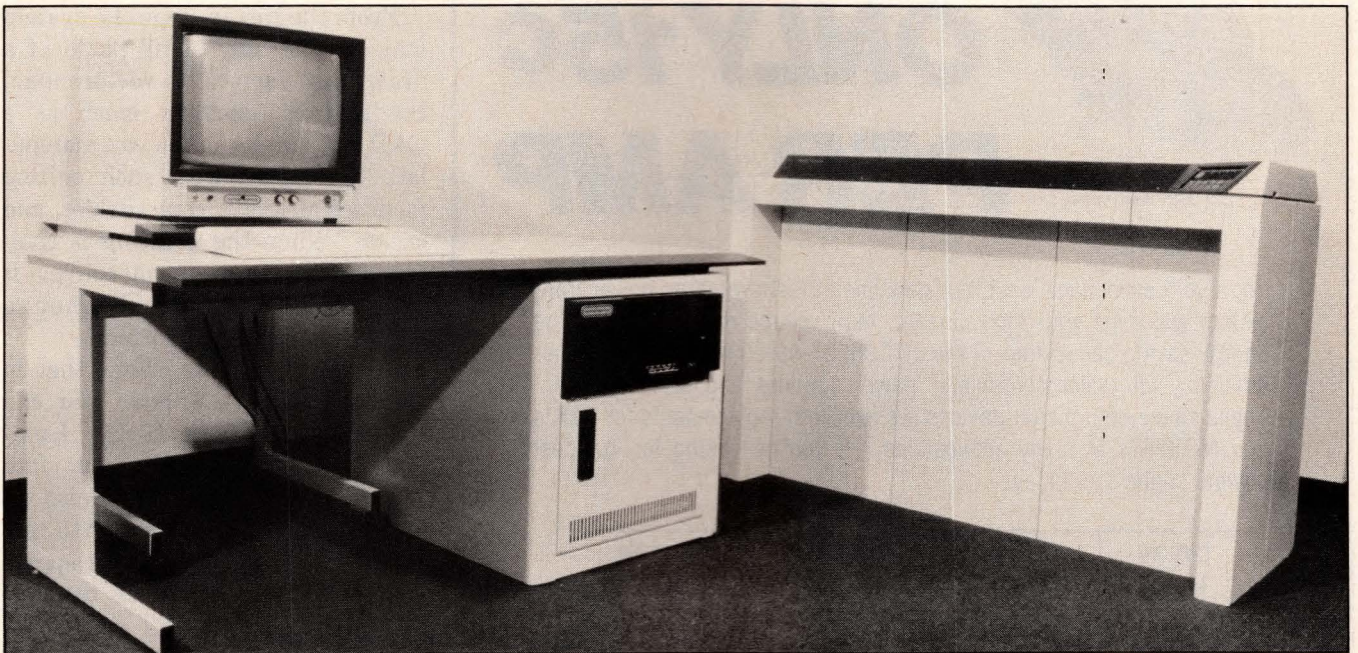
The drawing-digitizer system

looks like a CAD/CAE workstation and includes computer, 19-in. CRT, and mouse. In addition, the system includes a free-standing document scanner connected via a parallel interface. A Versatec-type electrostatic-plotter interface provides hard-copy output capabilities.

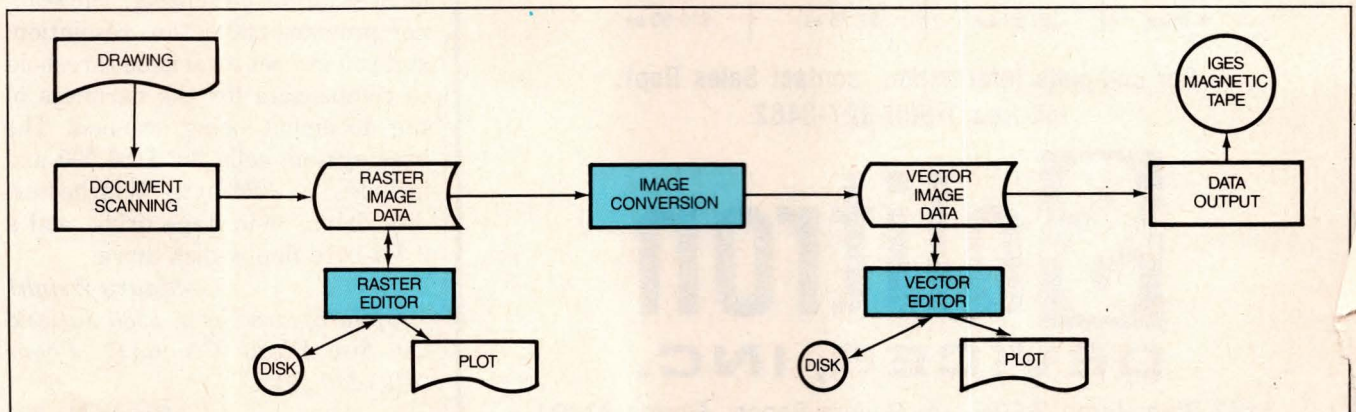
Model 3000 scans an E-size draw-

ing in approximately 90 sec. The system retains the raster image of the document in a dedicated 10M-byte section of RAM. Once the document is stored in memory, the system's software tools become active.

Via the system's raster editor, you can manipulate stored data to clean up a drawing. For example,



Able to capture, edit, convert, and store drawings, the Model 3000 drawing-digitizing system bridges the gap between various engineering automation tools.



Raster edit, image conversion, and vector edit make up the primary functional blocks of Model 3000's scheme of operation.

LOW COST POWER FROM SOLITRON



TO-3 (60 Mill Pins)

ONLY 15¢ PER AMP

For a very economical cost, our new line of fast switching power transistors will meet your high current, high voltage requirements. The energy saving capabilities of the SDT 96307-08-09 will result in higher efficiency for motor controllers, power supplies and servo drivers. These single chip planar devices are excellent replacements for SCR's and MOSFETs in many applications. If you're looking for low cost power, contact us today!

TYPE NO.	SDT 96307	SDT 96308	SDT 96309
I_C max	70A	50A	40A
V_{CEO}	80V	100V	200V
V_{EBO}	10V	10V	10V
$V_{CE(sat)}$ max	1.25V @ 50A, 5A	2.0 @ 40A, 4A	2.0V @ 30A, 3A
h_{FE} min	10 @ 50A, 5V	10 @ 40A, 5V	10 @ 30A, 10V
f_t min	10 MHz	10 MHz	10 MHz
K Price	\$8.50 ea.	\$7.75 ea.	\$10.50 ea.

For complete information, contact Sales Dept.
toll-free 1-800-327-8462.

Solitron

DEVICES, INC.

1177 Blue Heron Boulevard, Riviera Beach, Florida 33404
Tel: (305) 848-4311 • TWX: (510) 952-7610

UPDATE

the system includes a speckle-removing feature. To use this feature, you define the size of the speckle you want deleted. The system then searches the image and removes all spots that size and smaller.

During the raster-edit stage, you can also clean up lines or portions of the drawing that run together. Although the system automatically recognizes Leroy, typewriter, and neatly printed text, you may have to use the editor to identify portions of carelessly hand-lettered text. In addition, you can view any part of the image or send it to the plotter at any time before, during, or after the raster-edit stage.

From the raster stage the system may convert any or all parts of a drawing to vectors. In vector mode, the system functions much as a CAD system does. You can manipulate the image with such editing facilities as move, copy, delete, and create. When the drawing is complete, the system lets you convert it into Initial Graphics Exchange Specification (IGES) format.

The manufacturer claims that in 45 minutes to one hour you can transform a typical D-size, hand-drawn engineering diagram into IGES format. The system also allows conversion from vector to raster form. Regardless of the operation performed, the CRT displays the progress. The CRT also monitors the image as the initial scan occurs.

Model 3000 uses charge-coupled devices for image sensing. The scanner provides 200-dot/in. resolution, and you can set a variable threshold to compensate for the darkness of the document being scanned. The base system sells for \$180,000 and includes a 30M-byte Winchester-disk drive, 1/2-in. tape drive, and a 2.7M-byte floppy-disk drive.

—Maury Wright

Optiguaphics Corp, 4380 Jutland Dr, San Diego, CA 92117. Phone (619) 270-4942.

Circle No 727

Silicon Foundry For Sale.

86

\$2500

Notice the small blue box in the photo at right. Open it and you enter the new age of logic design. Because inside that box is a technology so revolutionary, it's like having a desktop silicon foundry.

Consider this. You design your logic circuit. Draw your schematic. Load it into your IBM PC (or compatible). Let the PC do all the work that results in a JEDEC object code. Then program a chip. Right there at your desk.

No suffering to learn a new technology. No waiting for mainframe time. No hassling with an outside vendor. No scratching your head while your marketing window slams shut.

You get a working prototype. A CHMOS* device that can be evaluated. Changed. Experimented with.

A custom circuit that can be mass-produced like a standard product.

The technology is called Erasable Programmable Logic. The desktop foundry is called the PLDS2. The devices are called EPLDs. The important thing is to call us. Right now.

Because what used to take months and months now takes minutes. And what used to cost thousands and thousands now costs a mere pittance.

\$2500 to be exact. That's what the development system costs. You supply the PC. The desktop. And a MasterCard or Visa number if you'd like to see your foundry on your desk this week. Of course, if you'd like to know all the nitty gritty first, just call us for brochures on the PLDS2 development system and our growing family of CHMOS EPLDs. But do hurry. Because in the design game, whoever finishes first wins.

Call (408) 984-2800.

ALTERA

3525 Monroe Street
Santa Clara, CA 95051

The \$2500 PLDS2 includes a PC board that snaps into your IBM PC or PC-compatible, our A+PLUS software, complete documentation, an EPLD programming box, two EP300 erasable programmable logic devices and the snappy blue box pictured above. PC-CAPS and DASH-2 schematic capture packages are available optionally. IBM PC not included.

Complete.



A+PLUS is a registered trademark of Altera Corporation. IBM is a registered trademark of International Business Machines Corporation. PC-CAPS is a trademark of P-CAD. DASH-2 is a trademark of FutureNet.

* CHMOS is a patented process and registered trademark of Intel.

Distributed in U.S. by Alliance, Pioneer, Schweber, Wyle and in Canada by Future.
© 1985 Altera Corporation.

When The Call Soph

68000

V20 V30

80188

80186

8088

8087

8086

8085

Z80



Chips Are Down on Systems.

The chips are finally down on your design. And the project's deadline is drawing near. Now you need the broad-based support only Sophia Systems can provide.

Our expanding line of portable in-circuit emulators and microprocessor development systems supports the widest range of 8 and 16-bit microprocessors available today.

UNIVERSAL 8-BIT DEVELOPMENT SYSTEM/EMULATOR FOR CMOS AND SINGLE-CHIP MICROCOMPUTERS.

The Sophia SA1000 is a combined software development system and real-time in-circuit emulator. It supports a broad line of CMOS and single-chip microcomputers, including Motorola's 6800 family, Hitachi's 6301, Intel's 8048/49/50, Zilog's CMOS Z80C and even NEC's μ PD7810/11 and many more. All the development tools, from macro-assemblers and linkers to integrated real-time ICE[™] probe and PROM programmer, are standard.

PORTABLE 16-BIT IN-CIRCUIT EMULATORS FOR STANDALONE DEBUGGING AND TEST.

Sophia's SA700 portable in-circuit emulators let you develop in the lab or troubleshoot in the field. Full support is available for Intel's 8086/88 and 186 family, Motorola's 68000, and NEC's new V20/V30 series of CMOS microprocessors.

Emulator features include a fully integrated CRT, 8" floppy disk drive, ASCII keyboard, PROM programmer, and ICE probe. You can even use floppy disks from Intel's Series II and III directly in the emulator. The SA700 lets you debug and handle hardware/software integration without a host or add-on peripherals.

When combined with an MDS[™] or through our serial link to a VAX[®] or IBM[®] PC, you get all the capabilities of a fully integrated 16-bit development solution.

The 8-bit SA700 systems for Z80[™] and 8085 are complete, portable development systems, and come with a relocatable assembler, linker and emulator.

A WORLDWIDE REPUTATION FOR RELIABILITY.

Sophia's 16-bit in-circuit emulators and 8-bit development systems are field-proven, with over 5,000 installed worldwide since 1982.

CALL TODAY FOR A DEMONSTRATION.

When the chips are down, count on Sophia to get your designs to market faster. Easier. And at less cost.

See the SA1000 and SA700 in action for yourself.

To arrange a hands-on demonstration or for more information, call today.

**CALL TOLL-FREE 1-800-824-9294
(IN CALIFORNIA, 1-800-824-6706)**



Sophia systems[™]

**MICROPROCESSOR DEVELOPMENT
SYSTEMS & IN-CIRCUIT EMULATORS**

Japan: SOPHIA SYSTEMS CO., LTD, NS Bldg., 2-4-1, Nishishinjuku, Shinjuku-ku, Tokyo 160, Tel: 03-348-7000.

West Germany: SPECIAL ELECTRONIK KG, Kruzbreite 14, 3062, Buckeburg, West Germany, Tel: 07961/4047, TLX: 17796110.

U.S. Corporate Headquarters: SOPHIA COMPUTER SYSTEMS, INC., 3337 Kifer Road, Santa Clara, CA 95051.

U.S. Regional Offices: 22 Executive Park-Suite 280, Irvine, CA 92715, Tel: (714) 261-8688; Glenpointe Centre East, 300 Frank W. Burr Blvd., Teaneck, NJ 07666, Tel: (201) 836-5959.

© 1985 Sophia Computer Systems, Inc. Sophia Systems is a trademark of Sophia Computer Systems, Inc.

LEADTIME INDEX

Percent of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Last months average (weeks)	Average (weeks)
TRANSFORMERS								
Toroidal	0	29	29	35	0	7	10.7	10.4
Pot-Core	0	29	43	14	7	7	10.3	13.7
Laminate (power)	0	29	42	29	0	0	8.6	9.4
CONNECTORS								
Military panel	0	43	14	29	7	7	10.6	13.6
Flat/Cable	0	52	32	16	0	0	6.2	7.4
Multi-pin circular	0	19	13	43	25	0	15.0	13.0
PC	5	28	45	12	5	5	8.9	6.8
RF/Coaxial	7	39	39	15	0	0	6.3	7.8
Socket	6	55	33	6	0	0	4.7	5.8
Terminal blocks	16	28	39	17	0	0	6.4	8.9
Edge card	0	33	53	14	0	0	7.1	6.4
Subminiature	0	14	57	29	0	0	9.5	7.3
Rack & panel	0	22	45	33	0	0	9.3	11.1
Power	0	42	29	29	0	0	7.8	10.3
PRINTED CIRCUIT BOARDS								
Single sided	0	45	45	10	0	0	6.1	6.4
Double sided	0	29	61	10	0	0	7.1	7.1
Multi-layer	0	32	47	21	0	0	7.8	8.8
Prototype	5	90	5	0	0	0	2.2	3.5
RESISTORS								
Carbon film	39	36	18	7	0	0	3.3	4.7
Carbon composition	25	40	20	5	10	0	5.8	6.7
Metal film	18	41	18	23	0	0	5.9	6.6
Metal oxide	15	31	46	8	0	0	5.6	6.7
Wirewound	10	20	60	10	0	0	6.8	8.7
Potentiometers	6	42	29	23	0	0	6.8	8.2
Networks	9	32	41	18	0	0	6.8	8.6
FUSES								
	19	42	27	12	0	0	4.9	4.4
SWITCHES								
Pushbutton	13	26	48	13	0	0	6.4	8.1
Rotary	13	19	43	25	0	0	7.8	10.0
Rocker	6	38	44	12	0	0	6.2	4.8
Thumbwheel	0	20	60	10	10	0	9.4	10.6
Snap action	17	50	25	8	0	0	4.3	7.9
Momentary	0	50	25	25	0	0	7.0	7.3
Dual-in-line	17	33	33	17	0	0	6.0	5.7
WIRE AND CABLE								
Coaxial	21	58	21	0	0	0	2.8	4.1
Flat ribbon	21	50	29	0	0	0	3.3	3.6
Multiconductor	18	41	41	0	0	0	4.1	6.1
Hookup	45	35	20	0	0	0	2.3	3.1
Wirewrap	55	27	18	0	0	0	2.0	3.9
Power cords	16	56	20	8	0	0	4.0	5.8
Other	0	75	25	0	0	0	3.5	6.0
POWER SUPPLIES								
Switcher	0	21	29	36	7	7	12.5	14.8
Linear	0	42	25	25	8	0	8.9	12.0
CIRCUIT BREAKERS								
	0	16	58	26	0	0	9.1	11.0
HEAT SINKS								
	5	42	32	21	0	0	6.8	10.8

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Last months average (weeks)	Average (weeks)
RELAYS								
General purpose	16	20	52	12	0	0	6.5	8.2
PC board	0	24	41	35	0	0	9.4	10.4
Dry reed	0	50	50	0	0	0	5.0	10.6
Mercury	0	25	75	0	0	0	6.5	9.2
Solid state	0	33	25	33	9	0	10.3	10.3
DISCRETE SEMICONDUCTORS								
Diode	15	42	30	12	0	0	5.2	6.9
Zener	15	40	37	7	0	0	4.9	7.4
Thyristor	0	54	31	15	0	0	6.0	9.1
Small signal transistor	6	39	39	16	0	0	6.5	8.6
FET, MOS	0	33	27	27	13	0	10.5	10.4
FET, bipolar	0	29	43	14	14	0	9.9	11.2
INTEGRATED CIRCUITS, DIGITAL								
CMOS	4	30	22	37	7	0	10.1	10.1
TTL	14	27	23	36	0	0	8.1	8.9
LS	15	30	25	25	5	0	7.9	8.7
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	0	9	36	46	9	0	12.8	11.0
OP amplifier	0	23	46	27	4	0	9.5	10.5
Voltage regulator	0	30	39	26	5	0	9.2	10.7
MEMORY CIRCUITS								
RAM 16K	17	33	33	17	0	0	6.0	9.9
RAM 64K	6	38	31	19	6	0	7.8	8.4
RAM 256K	11	0	67	11	0	11	10.5	9.1
ROM/PROM	0	30	40	10	20	0	10.6	9.5
EPROM	7	33	40	13	7	0	7.8	7.9
EEPROM	0	29	29	28	14	0	11.0	8.3
DISPLAYS								
Panel meters	0	23	54	23	0	0	8.5	9.5
Fluorescent	25	0	0	75	0	0	12.0	14.6
Incandescent	50	0	10	50	0	0	8.0	7.2
LED	5	21	32	42	0	0	9.7	9.2
Liquid crystal	0	0	29	71	0	0	13.7	7.8
MICROPROCESSOR ICs								
8-bit	0	20	33	40	7	0	11.3	9.9
16-bit	11	11	34	33	11	0	11.1	10.9
FUNCTION PACKAGES								
Amplifier	0	17	66	17	0	0	8.4	11.5
Converter, analog to digital	0	33	50	17	0	0	7.4	9.5
Converter, digital to analog	0	43	43	14	0	0	6.5	13.1
LINE FILTERS								
	0	9	73	18	0	0	8.9	9.5
CAPACITORS								
Ceramic	24	28	40	8	0	0	5.0	5.3
Ceramic monolithic	10	25	35	30	0	0	8.1	7.4
Ceramic disc	16	36	32	16	0	0	5.8	8.3
Film	0	25	50	25	0	0	8.5	6.8
Electrolytic	7	29	39	25	0	0	7.7	8.3
Tantalum	11	11	48	26	4	0	9.3	10.3
INDUCTORS								
	5	16	53	26	0	0	8.7	7.9

Source: Purchasing magazine's electronic business survey

SIEMENS

Controlling standard industrial motors

SIPMOS* puts feel into speed regulation

Highly precise driving control used to be the reserve of commutator motors and elaborate dc drives.

Now you can implement open-loop and closed-loop control systems with SIPMOS® power transistors that offer you solutions with enhanced economics:

Sensitive speed-regulated asynchronous motors

no longer need be wishful thinking. The advantages for drive applications of all kinds and on all scales are quite obvious:

- no more elaborate dc converters
- an extensive range of inexpensive, standard industrial motors
- motors without commutators live longer.

All in all another impressive example of innovative solutions optimally implemented with SIPMOS components.

You can obtain more information about SIPMOS components by writing to Siemens AG, Infoservice/B 8425, Postfach 156, D-8510 Fürth, West Germany and simply quoting »SIPMOS«.

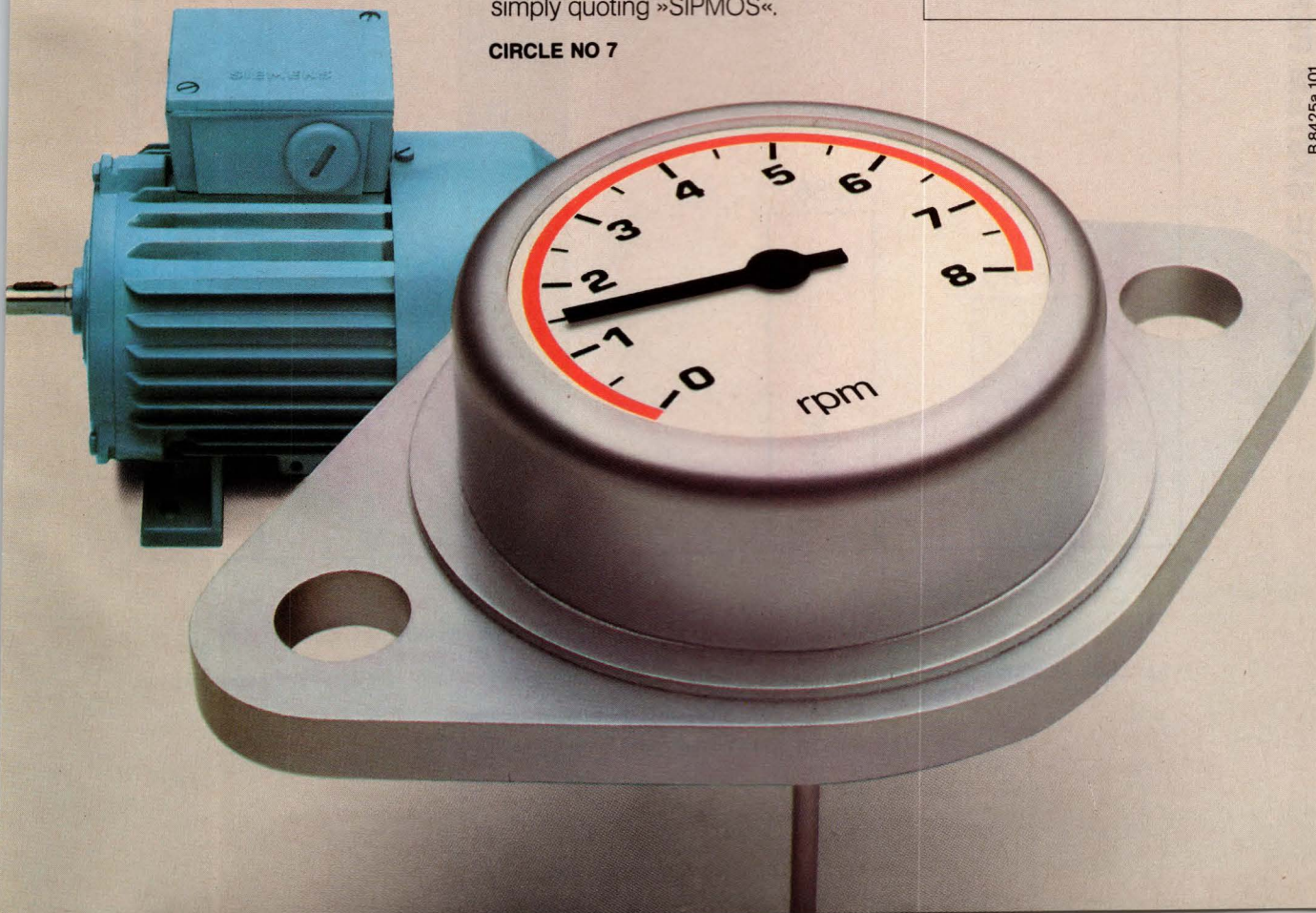
CIRCLE NO 7

*SIPMOS – Siemens Power MOS

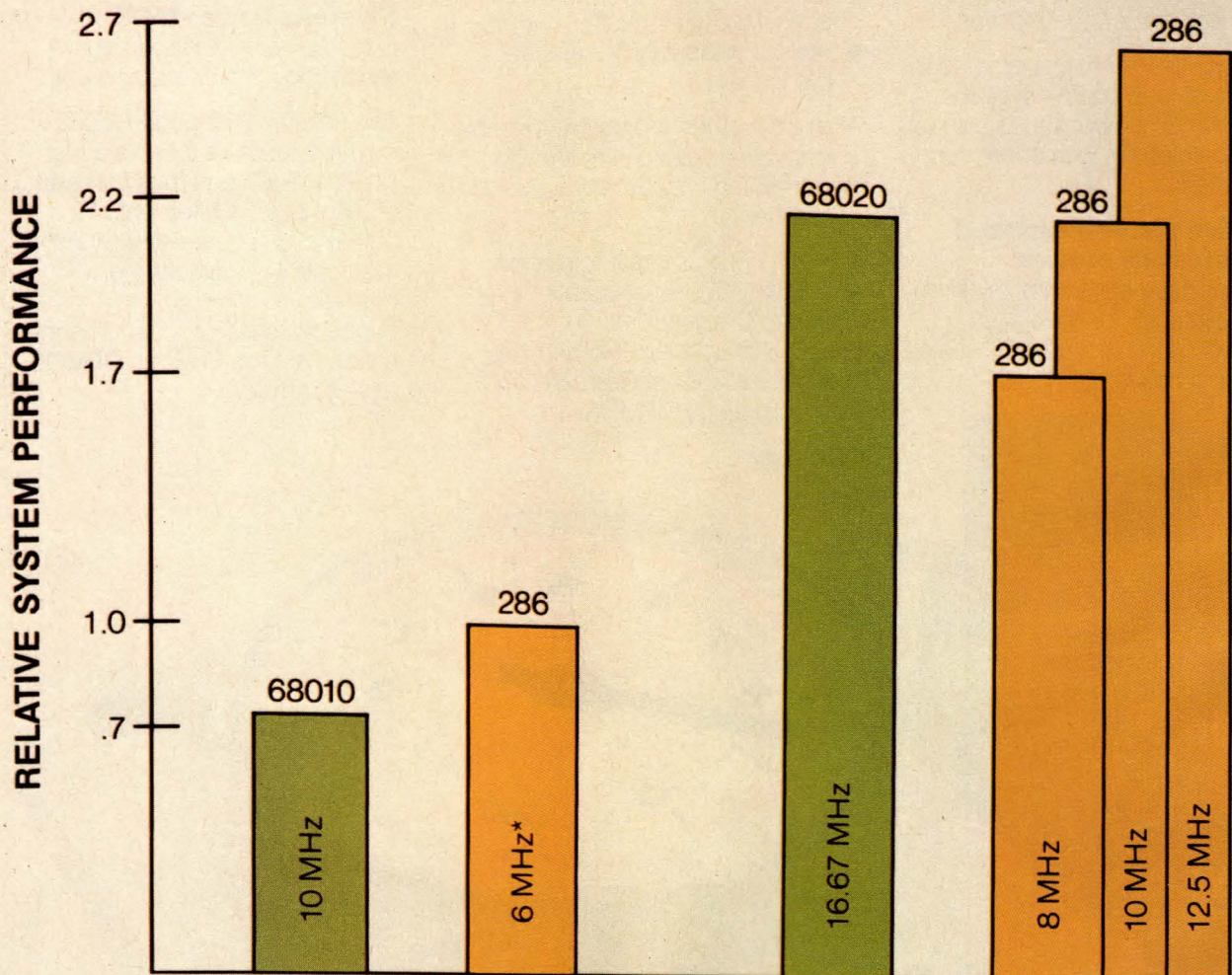
is the power-semiconductor technology that sets standards.

The newly developed FREDFET power transistors include a fast reverse diode and thus fulfil one of the major requirements for uncomplicated free-wheeling in the control of asynchronous motors.

Especially suitable for such applications are the BUZ 2...SIPMOS device families.



WE JUST BLEW THE UNIX PERFORMANCE DEBATE TO BITS.



*1 wait state. All others at 0 wait states.

Performance Number Sources:
68010 (10 MHz)—BYTE
286 (6 MHz, 8 MHz, 10 MHz)—Yates Ventures, Inc.

Benchmark Program Source: BYTE

We know that the question of system performance is important to you.

That's why it's important to benchmark where it counts — at the system level.

Our 286 microprocessor was compared with the 68010 and 68020. All in a Unix environment.

The results may surprise you.

First, performance benchmarks of the 68010 running

in both a Sun Workstation 2/120 and a Masscomp System were compared with Intel's 6 MHz 286 in the IBM PC AT and Intel's 286/310 Supermicro.

In overall system performance, the 6 MHz 286 outperformed the 10 MHz 68010.

And it did this while running at 60% of the clock rate of the 68010.

And that's not all.

When you take the claimed performance of the 16.67 MHz 68020, and compare it with benchmark data of higher speed 286 versions, the results are equally surprising. Our 286 provides the highest system level performance. Again.

The reason for these unexpected results is innovative architecture.

The 286 achieves superior performance, in part, through pipelining. Four on-chip parallel pipelined units, including the MMU, allow the 286 to do more work per clock than any competitive CPU.

Pipelining extends to the address and data buses as well. Because of its efficient bus architecture, the 286 is the only microprocessor to execute a memory transfer cycle in 2 clocks. Providing higher data transfer throughput.

Unix performance is also optimized by the unique operating system features of the 286 architecture. Multi-tasking, for example, is made quicker and easier. Everybody else does task switching in software. We do it in hardware up to 10 times faster. Our 286 can switch tasks in a mere 13.5 μ s, speeding

up system performance.

But the microprocessor is only one part of the performance story.

For even greater system performance, Intel's specially designed coprocessors turbocharge your system. Our 80287 effectively boosts 286 number-crunching capability. Our 82258 Advanced DMA Coprocessor provides high-performance I/O. And our 82586/82588 LAN Coprocessors give you effective data communications management.

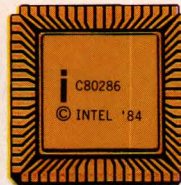
ARCHITECTURAL PERFORMANCE ENHANCERS

	iAPX 286	68020
PIPELINING		
Register memory moves	Avg. Clock/Inst. 5	Avg. Clock/Inst. 7.9
Arithmetic and logic instructions	4.75	7.5
Conditional jumps	7	6.5
ON CHIP MMU	YES	NO
TASK SWITCH	13.5 μ s	Up to 10X slower (Software dependent)
EFFICIENT BUS		
Memory to memory move	6MB/SEC	5.2 MB/SEC
COPROCESSOR SUPPORT (in volume production)	Numerics-80287 I/O-82258 LAN-82586 Graphics-82730	DMA-68450

So there you have it. The 286. Absolutely the most powerful microprocessor architecture in the world. With all the turbo-charging coprocessors you need.

And as your system requirements grow, all of this migrates directly to our next generation 386 for even greater system-level performance.

For detailed 286 benchmarks and more information on Intel's high-performance microprocessors, call toll free (800) 538-1876. Or write Intel Corporation, Lit. Dept. W-213, 3065 Bowers Avenue, Santa Clara, CA 95051.



intel®



Development systems for 32-bit μ Ps

With the introduction of 32-bit μ Ps, a microprocessor development system will no longer be limited to a single-user host coupled to an in-circuit emulator. Now such tools can range from software development systems made from board-level products to high-speed bit-slice hardware-development equipment.

Charles H Small, Associate Editor

Developing a product that incorporates a 32-bit μ P is a completely new ballgame, whether you're moving down from superminicomputers or moving up from 8- and 16-bit systems. What distinguishes a 32-bit- μ P project from all other μ P development projects is the target system's increased complexity (of both hardware and software), cost, and power.

These aspects affect the two groups of developers differently. For the developer whose previous experience is with 8- or 16-bit μ Ps, the 32-bit projects will entail vastly more complicated hardware and software. These developers will now confront challenges previously reserved for mainframe-computer developers. In

Developing products that incorporate 32-bit μ Ps should prove to be an out-of-this-world experience that differs significantly from projects based on either superminis or 16-bit μ Ps. However, a variety of tools, ranging from emulators to board-level target hardware, can help you bring the task down to earth. (Photo courtesy Motorola)

many cases they will for the first time have to deal with cache memory, memory management, multiuser/multitasking software, and multiprocessor architectures. The wide buses and high clock speeds of 32-bit μ Ps will strain the capabilities of the hardware-based development tools this group is used to.

Supermini users move on

Those who have developed large software systems on superminis and want to take advantage of lower-cost 32-bit- μ P systems will find themselves working in unfamiliar territory as well. Particularly, they will be able to develop software on the target system itself, because that target system is so powerful. Typically, these developers have to share the supermini resource fairly with a multitude of users in other departments.



Combining a ROM emulator, a logic-state analyzer, a pattern generator, and a hard-disk-based computer, the Step Engineering Step 27 can work with the fastest 32-bit μ Ps.



The NCR32 32-bit μ P is a microprogrammed processor and, hence, mandates a development tool like the Hilevel DS370 ROM emulator and logic analyzer rather than an in-circuit emulator. However, because of their high speed and flexibility, ROM emulators also suit nonmicroprogrammed μ Ps like the 68020 and 32032.

A 32-bit- μ P software-development system assembled from available board-level products, as National Semiconductor's VR32 is, can serve as both a powerful software-development environment and as a software-integration environment that closely mimics that target system.



No one user may monopolize the supermini's facilities or damage other users' programs. Consequently, the supervisory software on a supermini must strictly protect and isolate the hardware from the users. Indeed, this practical necessity that programmers keep their hands off the native machine has been raised to an article of faith among computer scientists. They maintain that high-level-language programmers should never have to deal with the real nature or peculiarities of the computer they're working with.

Inexpensive, plentiful 32-bit- μ P systems will revolutionize the way this group interacts with target systems. Unlike previous inexpensive computers based on 8- or 16-bit μ Ps, 32-bit- μ P systems have the execution speed and addressing range to handle the most sophisticated software tools, and they still have plenty of room left over for the application code. Because 32-bit- μ P systems won't be expensive, each programmer—or small team of programmers—can have exclusive use of one machine. Consequently, programmers can do their development on the target system rather than on a superminicomputer. You can even get a software-development/software-execution vehicle composed of board-

level products for about the same cost as a single terminal on a DEC VAX.

What's more, because each programmer has his own computer, the requirement for protecting the computer from multiple users goes away. Therefore, the 32-bit- μ P programmer can delve deeply into the workings of his hardware and software by connecting such hardware-based development tools as emulators and logic analyzers, which were previously used only by 8- or 16-bit- μ P programmers. If these hardware-based tools have access to information from the compiler and know how the operating system works, they can provide real-time tracing and trapping, in terms of high-level constructs, of the execution of even the most complex software.

High-level-language programmers developing software on superminicomputers have had no such intimate control over the target system. The best they had to work with was so-called symbolic debuggers that, in essence, transformed their host-system CRT into the controller of a monitor ROM on the target system's CPU board. This monitor ROM gave the programmers rudimentary debugging facilities. With the monitor,

Mainframe-like aspects of 32-bit- μ P projects will strain the ability of conventional instrumentation to keep up.

they could set software breakpoints, perform single-stepping, and examine and change memory and processor registers. The developers couldn't, however, handle interrupts, measure execution times with high resolution, trace and trap on dynamically defined data constructs, or do sequential triggering on complex series of events. Such advanced debugging is possible only with hardware-based debugging tools.

Emulator choices limited

The hardware-based debugging tool most familiar to the developers of 8- and 16- μ Ps is the in-circuit emulator. Currently, your choices for in-circuit emulators for 32-bit systems are as limited as your choices for 32-bit μ Ps. Right now, only Motorola and National have in-circuit emulators for their respective 68020 and 32032 32-bit μ Ps. Prospective 32-bit- μ P vendors like Intel and Zilog have 32-bit emulators in the works but won't announce the development tools until they have chips ready as well. With the exception of Microtek, third-party makers of universal development systems, like Tektronix, Hewlett-Packard, and Philips, think that it's much too early in the 32-bit μ Ps' lives to begin supporting the chips.

The makers of universal development systems supposedly learned from their experience with 16-bit- μ P development systems that the first wave of users of a new class of μ P doesn't need in-circuit emulators. Initially, these companies see the 32-bit μ Ps going into software-intensive workstations. They envision that, though each workstation maker will sell large numbers of workstations, there will not be many such makers. Furthermore, developers of such systems have scant need for real-time tools. Beyond merely getting their target systems to function, these developers will be perfectly satisfied with conventional software-based debugging. By the development-system makers' reckoning, therefore, two or more years will have to pass before there are enough embedded-processor designs (employing 32-bit μ Ps) to make it worthwhile to produce third-party emulators. The R&D commitment would simply be too great at this point.

The specs for Motorola's 68020 emulator pod for its HDS-400 emulator station illustrate just how difficult designing real-time debugging tools for 32-bit μ Ps is. If you plug a 16.67-MHz 68020 into the pod, it can run with no wait states at 8.0 MHz. If you run the processor at its full clock speed, you pick up one wait state with each memory access.

The pod can address any contiguous 16M-byte sector

within the 68020's 4G-byte address space. The HDS-400 provides as much as 256k bytes of emulation memory, which you can map in 4k-byte increments over the target system's memory. According to the company, the pod supports cache-memory operation. Either the target system can control its own cache, or you can use a command from the development system.

The HDS-400 emulator also has a state analyzer that runs in parallel with its emulator. The analyzer has 75 pins committed to the μ P, plus four uncommitted



Because of the multichip architecture of the 32032, National's ICE32 emulator has a cable for the μ P, the memory-management unit, and the clock chip.

inputs with which you can monitor additional nodes in the target system. The state analyzer can keep up with 5-MHz bus transactions in real time; at 20 MHz, the analyzer must insert a 1-cycle wait state.

The development system has two kinds of breakpoints; emulator breakpoints and analyzer breakpoints. The emulator breakpoints include 16 (in four address ranges) that are defined by the state of the μ P, one cross-triggered breakpoint initiated by the analyzer, an autonomous timer breakpoint, and an erroneous-write breakpoint caused by writing to a section of memory designated as ROM. Motorola states that its emulator isn't fooled into breaking on instructions that are pre-fetched but not executed; its emulator breaks prior to an instruction's execution, and only on instructions that would actually have been executed.

Sophisticated triggering a must

Given that most 68020 programs will be complex, sophisticated triggering of the analyzer's capture cir-

cuitry is imperative. As an example of a hardware tool that can provide more power than software debuggers, the HDS-400's optional state analyzer can halt the target system's execution after it sees a preprogrammed sequence of events. This ability to follow a complicated sequence of software events contrasts with the emulator's basic ability to halt on any one of 16 events. The analyzer can monitor a program's execution through a predefined series of as many as seven events. Each event is a state defined across the analyzer's 79 input lines.

Halting the target system is only one capability of the analyzer. It can also selectively capture data as it steps through its trigger sequence. If you set up the analyzer to recognize the entry and exit points of a particular routine, the analyzer can then measure the routine's execution time—with a resolution of one cycle, of course. You can also define 16 address ranges for a software-performance histogram.

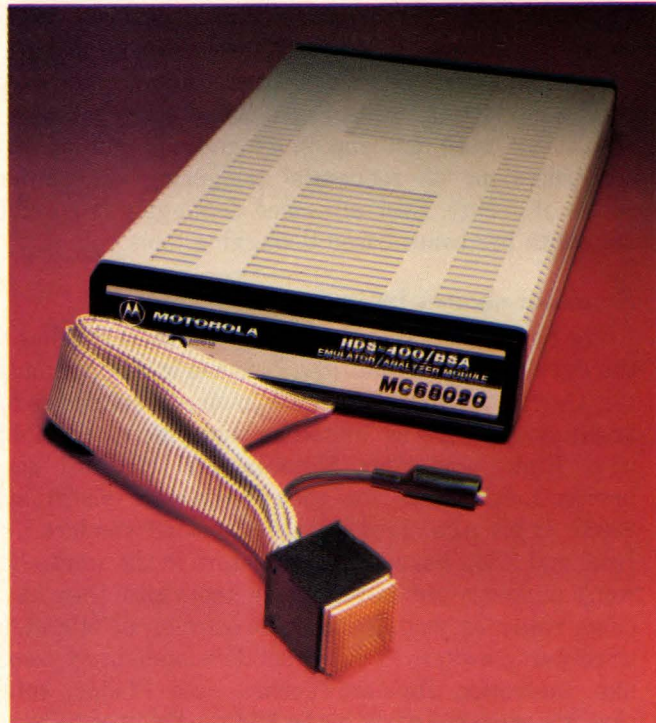
A simple feature is the analyzer's ability to record activity *outside* a given range as well as inside it. This capability allows you to find out not only where your program goes but where it doesn't go as well. Analyses of the run-time behavior of large programs reveal two things: the expected overuse of certain modules (candidates for being rewritten in assembly code for greater speed), and the unexpected (ie, modules that never get called at all). The latter are candidates for elimination, or perhaps they're symptoms of poor execution of a top-down design.

National's \$12,900 ICE32 emulates the 32032 32-bit μ P at 6 MHz (later versions will run at the chip's top speed of 10 MHz). The emulator has 128k bytes of emulation memory (not expandable). The emulator looks different from most emulators. Instead of having a single cable with a DIP header for connection to the target system, the ICE32 has three cables; one cable terminates in a dummy leadless chip carrier (LCC), and the other two have more conventional DIP headers.

Hydra-headed emulator

The ICE32 needs three connections to the target system because of the 32000 Series architecture. The 32000 Series has separate CPU and memory-management chips. So that the emulator can meet timing requirements, it contains the CPU, memory-management, and clock-control chips in its pod—hence the three connections to the target system.

With the ICE32, you can set three event breakpoints on either instructions or address fetches. Alternatively,



Sporting an elaborate plug that mates to a 68020 32-bit μ P's pin-grid-array socket, Motorola's HDS-400 emulates the μ P at 8.0 MHz with no wait states.

you can use the three events to break on a range of addresses. The emulator also has a 12-bit counter with which you can count different kinds of processor cycles—memory, instruction, or clock—or breakpoints that delay the halting of the software under test. In addition, you can set a 24-bit counter to time the execution of specific software modules.

The emulator also has a 255-state trace memory. In its program-counter mode, it stores 255 nonsequential program-counter values and keeps a count of cycles occurring between stored events. In memory-bus mode, it captures 255 sequential states of the μ P, including address, data, and status values.

Alone among third-party emulator makers, Microtek Labs is bringing out emulators for the 68020 and Intel's 80286 this year. By press time, the company should have introduced a 16-MHz 68020 emulator. The unit will have 256k bytes of emulation memory and cost less than \$10,000.

Embedded μ Ps strain emulators

Even though these available in-circuit emulators don't run at a 32-bit μ P's top speeds, some beta-site users are already designing-in the 68020 as a high-

Powerful, inexpensive 32-bit- μ P target systems will challenge the fundamental tenets of software engineering.

speed, embedded processor. At first glance, a 32-bit μ P might seem like overkill as an embedded processor. The term "embedded processor" often refers to an 8-bit single-chip μ P that controls, say, a microwave oven or performs a simple task like protocol conversion in a multiprocessor computer. Such is not the case for the 68020's embedded applications. The embedded-processor designs it's being considered for are applications that would otherwise require a bit-slice processor.

The 68020 is fast, handles wide words, does bit manipulation and barrel shifting of those long words, and can perform a 64×32 -bit unsigned divide in 5 μ sec. Although it's not as fast as a bit-slice processor and can't be microcoded for optimizing specific tasks, the 68020 takes up far less room and consumes far less power. Furthermore, the hardware design and debugging time is shortened for an integrated 68020 vs the multitude of chips that compose a bit-slice design.

Using a 68020 or another 32-bit μ P in designs that previously could have been done only with bit-slice processors mandates the use of some sort of real-time debugging tool. ROM emulation is the standard technique employed in bit-slice-processor development, but it's presently not very common for μ P development. However, many of the most difficult aspects of bit-slice development are similar to those of 32-bit μ P development. Specifically, such tasks include the measurement and characterization of the performance of high-speed processors, wide data and address buses, and custom configurations of target systems. Therefore, those who have used only in-circuit emulators for their 8- and 16-bit designs should take a fresh look at bit-slice development tools for their 32-bit μ P development projects.

It's a fact of physics that emulating a processor with a cycle time of less than 100 nsec is difficult. Bit-slice processors have always run at such speeds, and most semiconductor makers state that they will eventually have 32-bit μ Ps that will be almost as fast. If you try to remove such a processor from its socket and make it run in a pod at the end of a 12- to 18-in. cable, signal delays down the cable may violate the target system's timing requirements. Furthermore, a major purpose of putting the emulation μ P in the pod is to let the emulator switch the emulation μ P's I/O and memory lines back and forth from the target system's memory to the emulator's emulation memory. Recognizing when to switch the processor's lines and effecting the change in time is very difficult at the high speeds of 32-bit μ Ps.

Like 32-bit μ Ps, bit-slice processors have wide buses—quite a bit wider than 32 bits, in fact. It's very common for a bit-slice processor's microcode word (the bit-slice equivalent of an op code) to be 128 bits wide. Some designs exceed 256 or even 512 bits. In addition, a bit-slice design doesn't have a predetermined configuration for the processor.

ROM is key to target system

Because of these characteristics, designers of bit-slice development systems have chosen to gain control of the target system, not by emulating the processor, but by emulating the processor's ROM. This approach has some advantages and some disadvantages when compared with in-circuit emulation. The first advantage is that ROM emulation is easy to do; you can obtain a ROM emulator that has a 10-nsec cycle time (measured at the target-system interface). This speed is far faster than the 8-MHz max clock rate (with no wait states) of Motorola's 68020 in-circuit emulator.

Also, with ROM emulation, the emulator doesn't have to switch the processor's lines back and forth between target-system and emulation memory; the processor is connected to emulation memory all the time. Furthermore, although no two μ Ps are at all alike, all ROMs look pretty much the same. Therefore, you can use a ROM emulator for a wider variety of projects than a processor-specific in-circuit emulator can handle.

Second-hand μ P information

The major disadvantage of ROM emulation is that the emulator does not see activity within the processor. The emulator must infer such activity based on external information. Therefore, to capture the state of the processor, a ROM emulator must recognize an event, halt the processor somehow, and obtain a dump of the processor's state. You can't do this in real time.

Note, however, that 32-bit μ Ps have built-in debugging modes that allow you, for example, to single-step them and easily dump their registers. Earlier 8- and 16-bit μ Ps had no such special control modes. Therefore, 8- and 16-bit in-circuit emulators employed special-purpose hardware in the pod—or even special bond-out versions of the μ Ps—to effect such debugging functions. With a ROM emulator, you can easily access the 32-bit μ P's built-in debugging facilities from an idle loop inserted into the target system's program in emulation memory.

ROM emulators employ two basic schemes to gain



Currently, the only noncaptive in-circuit emulator for 32-bit μ Ps comes from Microtek Labs. The company's units emulate the 68020.

control of the processor. One is to replace an instruction in the program under test with a Jump instruction to a diagnostic routine (idle loop) or with a Halt instruction. Alternatively, if the emulator has an optional logic analyzer installed, the analyzer's trace and trap circuitry can toggle an emulator-output line that gates the target system's clock on or off.

Now that Advanced Micro Devices (the originators of the bit-slice processor) has bowed out of the bit-slice development-system business, only two vendors remain: Hilevel Technology and Step Engineering. Both companies are convinced that their equipment suits 32-bit development.

ROM emulator choices limited, too

In fact, Hilevel Technology has been supplying development systems for NCR's 32-bit μ P, the NCR32. In the case of the NCR32, designers have little choice except to use a bit-slice development tool; the NCR32 is microcoded. In practice, NCR32 developers haven't restricted the use of Hilevel Technology's Emulyzer (emulator plus logic analyzer) to just the chip's microcode ROM; the developers emulate their target system's ROM with the instrument as well. They do so because, although you should theoretically get the microcode (which executes op codes) running correctly before you begin assembling or compiling programs into op codes, in practice it's often not until you begin running higher-level code that you find errors in the microcode. When emulators take the place of both the microcode ROM and the target system's ROM, fixing errors and trying out the repairs becomes much easier than when the microcode is burned into ROMs.

Hilevel acknowledges that the NCR32's external microcode ROM is an exception to the current run of 32-bit μ Ps. Neither the 68020, the 32032, the 80286, nor the Z80000 has external microcode ROMs. Neverthe-



Because the instruments are designed for emulating ROMs in 8- and 16-bit systems, you would need a pair of Orion's \$2395 UDLs to work with 32-bit μ Ps.

less, the company thinks that the latter phases of NCR32 development demonstrates that ROM emulation can compete with in-circuit emulation in both performance and price. For example, to handle a 68020, you'd need at least a 32-bit $\times$ 64k-word ROM emulator. Such a system would cost \$14,000. An 80-bit $\times$ 4k-word state logic analyzer would add \$12,500. Adding a \$2200 timing analyzer (with 15-nsec resolution) would provide not only timing analysis but also a time stamp with which the instrument can calculate software-performance histograms. (Hilevel also thinks that ROM emulation especially suits developing embedded-processor designs.)

Hilevel Technology also supplies emulator-control software that runs on either the IBM PC or a DEC VAX. The control software does expected chores like downloading programs to the emulator's emulation memory and sending commands to the emulator and logic analyzer, and it accesses the symbol tables of common compilers. That way, you can program the emulator to trace and trap on symbolic names rather than raw hex addresses, data, and condition codes.

Emulator includes computer

At \$35,000, Step Engineering's top-of-the-line Step 27 costs more than a Hilevel Technology Emulyzer with roughly equivalent emulation and logic-analysis capabilities. The Step 27 costs more because it's a 68000-based Multibus computer as well as a ROM emulator. The unit includes 512k bytes of computer memory, a

ROM emulators gain control of the system under test by simulating the system's ROM rather than the microprocessor.

10M-byte hard disk, a floppy disk, four serial ports, a Multibus expansion port, and a Centronics printer port. You must supply a CRT terminal. The system runs under the CPM-86K operating system and comes with a 68000 C compiler and a 68000 assembler. (The company also has less expensive models featuring either less powerful computers or just the emulator and no computer at all.)

The Step 27 can emulate ROMs (at their sockets) at 40 MHz, recognize events and control the target system's clock at 20 MHz, and do pattern generation at 35 MHz. It's highly modular and accepts a wide range of ROM-emulation and logic-analysis boards. For a unit that suits 68020 development, a \$35,000 Step 27's instrumentation comprises a 32-bit $\times$ 16k-word ROM emulator and a 54-bit $\times$ 16k-word state analyzer. The state analyzer features 16 levels of sequential triggering, and each level has five 54-bit-wide word recognizers active simultaneously. The price also includes cabling. At extra cost, you can obtain pattern-generator boards. Step offers either a simple sequential pattern generator or one having rudimentary algorithmic pattern generation.

At press time, neither Hilevel nor Step had processor-specific software for setting up the analyzers or decompiling captured data. Such software is easily within the capabilities of both machines' bit-slice software and will probably be on the market soon.

Not all ROM emulators on the market were designed for bit-slice applications. For example, at \$2395, Orion Instruments' 8k-byte UDL ROM emulator is by far the least expensive ROM emulator available. The UDL is not a bit-slice development tool; it was designed for 8- and 16-bit μ P development and, in its present form, can migrate to 32-bit μ Ps with some reservations. The system expands to 32k, 64k, or 128k bytes of 195-nsec response-time memory. The 128k-byte expansion adds \$1395 to the basic price. The emulator's memory appears to the target system as either an 8- or 16-bit-wide ROM. According to the company, the UDL is fast enough to keep up with 20-MHz processors.

The emulator's primary window into the target system is the target system's ROM socket. The emulator also requires approximately 10 additional inputs (depending on the μ P type) to characterize completely the target system's activity. The emulator has a built-in state analyzer. The analyzer features a 4-step sequential trigger, counters, and selective tracing.

The UDL can halt a target-system program's execution in a way that points out the value of combining a

state analyzer with emulated ROM. You can, for example, program the unit to jump to an endless loop when the analyzer recognizes an event. This capability provides a "soft" halt—ie, one that stops the execution of program under test and still leaves the processor running. (This concept is familiar to high-level-software developers who use system monitors for debugging.) In some cases, you may want to keep some aspect of the target system alive even though the program's been halted. In-circuit emulators generally interrupt and halt the target system's processor, which may cause you problems depending on just what the target system is supposed to be doing.

Because the UDL ROM emulator was designed for 8- and 16-bit applications, you would therefore have to parallel two emulators for 32-bit applications. Though each emulator can trace and trap on the 16-bit activity it sees, the pair of emulators has only a single output line. To coordinate two emulators, you would have to make one unit's output line into an input for the other. The success of this scheme depends heavily on the bit patterns in a given 32-bit μ P's op codes.

The company supplies control programs—written in Forth—that run on most common personal computers. Because Forth is an extensible language and because Orion has not hidden the Forth kernel from users, you can extend the control programs with your own programs—if you can program in Forth. The company presently has no software specific to 32-bit μ Ps.

In contrast to the time-critical applications for embedded processors, many applications for 32-bit μ Ps will have few or no time-critical aspects. The critical time for many of these projects will be the time it takes to get a product to market. For these projects, it can make more sense to adopt a development system comprising board-level products than to try—at least initially—to design your own boards from scratch. That way, you can get to work almost immediately and try out your code incrementally as you write it directly on the target system. Developing software on the target system offers a distinct advantage over writing volumes of code on a mainframe and later integrating that code all at once on a target system.

Motorola's initial 32-bit offering comprising board-level products is the Benchmark 20. For \$16,500 you get a 6-slot Versabus backplane (recently upgraded from a 4-slot backplane), a CPU board, and a memory board. The backplane includes a removable front panel and two fans; you provide the power supply. You can also obtain the CPU board and memory board separately.

A state analyzer that has access to the compiler's tables of module and data-construct addresses can trace and trap on high-level software.

The \$6855 VM04 CPU board carries the 68020 32-bit μ P. The board's clock rate is a fixed 16.67 MHz. The board also has a 32-bit $\times$ 4k-word cache memory, memory-management hardware, serial I/O, and a debugging-routine monitor in ROM. Because Motorola's memory-management chip isn't available, the company in the meantime is shipping a small, hybrid board that plugs into the memory-management unit's socket.

The \$4200 VM13 RAM board stores 1M byte (in the form of 64k-byte RAMs) or 4M bytes (in the form of 256k-byte RAMs). To speed memory fetches, the RAM board communicates with the CPU board over a high-speed cable rather than over the Versabus.

The company's latest board-level product is the VME130 CPU board for the VME Bus. Because VME boards aren't as big as Versabus boards, the VME130 doesn't have all the facilities of the VM04. Like the VM04, the VME130 CPU board accepts the hybrid-circuit substitute for the memory-management chip. The CPU board has two 28-pin sockets for 16k bytes of static RAM. Also like the VM04, the VM130 accepts a debugging-routine monitor in ROM.

Motorola doesn't have a packaged VME system, but this shouldn't prove much of a problem, thanks to the large number of vendors offering VME Bus products. Motorola doesn't supply any software beyond the monitor ROM for its CPU boards. If you want to do software development with these boards, you'll have to install an operating system yourself.

National's prepackaged system comprising board-level products is the \$14,500 VR32. The VR32 is a Multibus I computer that includes 500k bytes of main memory, a 40M-byte hard disk, a 1M-byte floppy disk, two serial ports (one for a CRT, the other for controlling an in-circuit emulator), and a Centronics printer port.

The VR32's CPU board is a modified version of the company's \$1895 DB30216 CPU board. This board uses the 16-bit 32016, not the 32-bit 32032. National states that the two chips are code compatible. If you buy the board alone, it comes with a ROM—called the TDS, for Tiny Development System—that has an assembler, linker, and debugging routines for setting breakpoints and single-stepping. Because the TDS code is in the public domain, you can ship it with your product as a testing aid.

Unlike Motorola's system, which has no high-level software installed, the VR32 comes with Genix—National's version of Unix. The Genix system includes an editor, an assembler, a C compiler, and a pair of

The trouble with logic analyzers

All the major logic-analyzer firms have modular logic analyzers that, when stuffed with optional boards, have enough channels and qualifiers to trace and trap on the activity of 32-bit μ Ps.

That's the good news.

The bad news is that a fully configured logic analyzer will cost well over \$20,000. Worse yet, only Intech's logic analyzers come with processor-specific hardware and software for 32-bit μ Ps. With all other brands of analyzer, you'll have to set up the analyzer's event recognizers and label display screens yourself so that they match the μ P. Furthermore, you'll have to configure the target-system interface yourself.

What's more, you'll have to write all the post-capture data-analysis software yourself, because—again except for Intech—logic-analyzer makers supply no disassemblers for 32-bit μ Ps.

symbolic debuggers. Each symbolic debugger has its own monitor ROM for your target system. A Pascal compiler costs an extra \$6000.

Because the VR32 runs the same software, employs the same chip set, and controls the same in-circuit emulators as the company's more expensive SYS32 development host (\$31,450), you might wonder whether National is competing with itself. The group that designed National's μ Ps simultaneously designed the SYS32, but the VR32 is based on more recent products from National's board-product division. The SYS32 employs a proprietary, high-speed backplane and can support as many as eight users. The bandwidth of the Multibus limits the VR32 to a single user, even though the software and processor are easily capable of handling several. The company expects that later versions of the 32000-based Multibus CPU boards will have more local memory and will therefore be able to handle more users.

Silicon software stands ready

If you choose to do your development on a system, like Motorola's Benchmark 20, that doesn't come with an operating system, you should consider adding one. Going beyond simple, ROM-based monitors, an operating system in onboard ROM (silicon software, or "siliware") can turn the target system into a development system. Although you could download the operat-

ing system into the packaged target system's RAM each time you switch it on, having the operating system in ROM has two advantages: Programming becomes faster because you don't have to wait for the operating system to load beforehand, and the development system is more robust because the system's operation doesn't depend on reliable operation of the program-communication software and hardware. (Such operating systems must have a slightly different structure than operating systems that reside in RAM and are thus examples of what's called "ROMable" code.)

Luckily, makers of software-development systems for 32-bit μ Ps show none of the reluctance of hardware makers to jump into the market. Predefined operating systems that you can put in a ROM on your target system range from a skeletal set of real-time operating-system calls like Hunter & Ready's VRTX to a full-blown development environment like Forth Inc's 32-bit Polyforth. In fact, you'll soon be able to obtain stripped-down, ROMable versions of elaborate operating systems like Whitesmiths's Idris (a Unix version with real-time extensions).

Perhaps the best reason for adopting a predefined operating system for your target system (to be distinguished from the completely separate issue of choosing a standard operating system for your host development system) is that you can avoid the system programmer's syndrome, which is manifest in the following scenario: A programming team has nine months in which to complete a job and 128k words of program memory to use. Eight months later, the team has written a 124k-word operating system and no application programs whatsoever. A predefined operating system allows your programmers to concentrate on applications.

Skeletal operating system

The least-elaborate ROMable operating system for the 68020 is Hunter & Ready's VRTX. The system costs \$5275 for a 5-copy R&D starter set. The price includes a 1-year warranty, documentation, and one year of maintenance. The price drops to \$70 per copy in lots of 100. The company claims that its system requires almost no customizing to make it fit a target system. Tailoring VRTX to your target system involves writing one page of assembly code.

VRTX is a collection of short routines that your programs can call. The routines perform both real-time and nonreal-time functions. For example, your multitasking program can jump to routines that handle real-time interrupts. The interrupt handlers can use

other calls to post messages for tasks to read, suspend or reactivate tasks, or even change a task's priority. The tasks themselves can use VRTX to send messages to each other. The company also has supplementary systems for nonreal-time tasks like file management.

The kind of multitasking that VRTX enables is very familiar to process-control software engineers and shouldn't be confused with virtual-environment multitasking familiar to high-level-language programmers. That kind of multitasking allows a programmer, for example, to edit a file in foreground mode while compiling or printing out a file in background mode. In this type of environment, each task is a program that operates independently, the programmer cares little about the time that the programs consume, and the tasks do little communicating beyond piping the output of one program to the input of another.

The VRTX system provides only calls for executing applications. There's no development support. To develop programs that use VRTX, the company staunchly supports host-based development. Modifying a host's C compiler so that it invokes VRTX system calls is easy. You can get the necessary hooks for C compilers from the following companies: Hewlett-Packard, Tektronix, Alycyon, Whitesmiths, Greenhills, Intermetrics, Lattice, and Mark Williams.

VRTX isn't presently available for the National 32032. National does have a real-time executive, called Exec. It comes as a 4k-byte module of preassembled code that you can link with your programs. The module provides timer (1-msec resolution), task-scheduling, memory-allocating, and intertask-communication system calls that your programs can use. The company is working on integrating these calls into its C and Pascal compilers.

Industrial Programming's MTOS is similar to VRTX in philosophy—it provides a common skeletal operating system—but it furnishes a richer suite of intertask-communication and -control facilities. The company presently has the 68000 version of MTOS running on the 68020 and plans soon to amend MTOS so that it will work with the special features of the 68020.

Tasks running under MTOS can communicate via bit patterns in global memory (called "event flags" by the company), common memory (called "memory pools"), mailboxes, and semaphores. In addition to allocating memory constructs dynamically, you can also create tasks as the program runs. Under VRTX, you must define all tasks in advance. Furthermore, MTOS can handle as many as 16 μ Ps at once. That way, your

Prepackaged board-level systems save development time if they match the architecture of your eventual target system.

multitasking program can have 16 tasks active at once, with each task dynamically assigned to a processor as needed.

Like Hunter & Ready, Industrial Programming believes in host-based development. Toward this end, one MTOS utility will accept a standard Unix output file (a.out file). This utility makes it easy to download a program from a Unix host to your target system.

MTOS also has links to such software-development tools as debuggers and monitors, as well as high-level languages and file systems. A representative version of MTOS is the \$12,000 package for the 68000-based Omnibyte single-board computer. If you don't need all the source documentation, you can obtain MTOS's object code alone burned into a PROM for the same single-board computer for \$1500 (additional PROM sets are \$350).

Monitor-sized development system

VRTX, MTOS, and National's executive are the underlying skeleton of an operating system. The 32-bit Polyforth package has all the elements of a complete software-development environment. The precompiled Polyforth kernel for 32-bit μ Ps presently occupies 16k words of ROM. In this 16k words, Polyforth has an editor, an assembler, a high-level language, and a multitasking operating system. By comparison, Motorola's 020bug debug monitor comes in a 32k-word EPROM set, and Hunter & Ready's VRTX (with extension) occupies 18k bytes of ROM. What's more, Polyforth's facilities are not separate programs that must be read in and activated one at a time, as with conventional software-development systems. Instead, all these facilities are on line at all times.

You can develop Forth programs on a host or on your target system. All high-level Polyforth I/O calls are vectored to assembly-language routines, so that code written on one computer will run on another. In addition, during the initial stages of a development project, you can use this facility to simulate inputs and outputs to hardware under development by redirecting the vectors to software-simulation routines. When a prototype of the hardware is available, you need rewrite only the assembly-language handlers. Forth Inc provides an ancillary product called the Target Compiler that takes care of the differences between a host computer and the target system, such as I/O port addresses and RAM/ROM boundaries.

The chief strength of Forth is the speed with which you can write and try out code. Because Forth is

interpreted, the compilation of your program is not a complicated translation process. The Forth compiler only needs to find the addresses of the Forth modules (or Forth "words") that you're invoking and put them in an executable list. However, unlike other interpreted languages, such as Basic, you're not limited to the functions that come with the language. You can easily add both your own words and even words that define other words (like DIM in Basic and Fortran). And if you are doing development on your target system, you can take advantage of the fact that Forth makes no attempt to protect the target system from your mistakes; all the resources of the target system are directly available. What's more, Forth wastes no time performing frills (unless you add them) like range checking, type checking, or memory-bounds checking.

Not all projects are successful

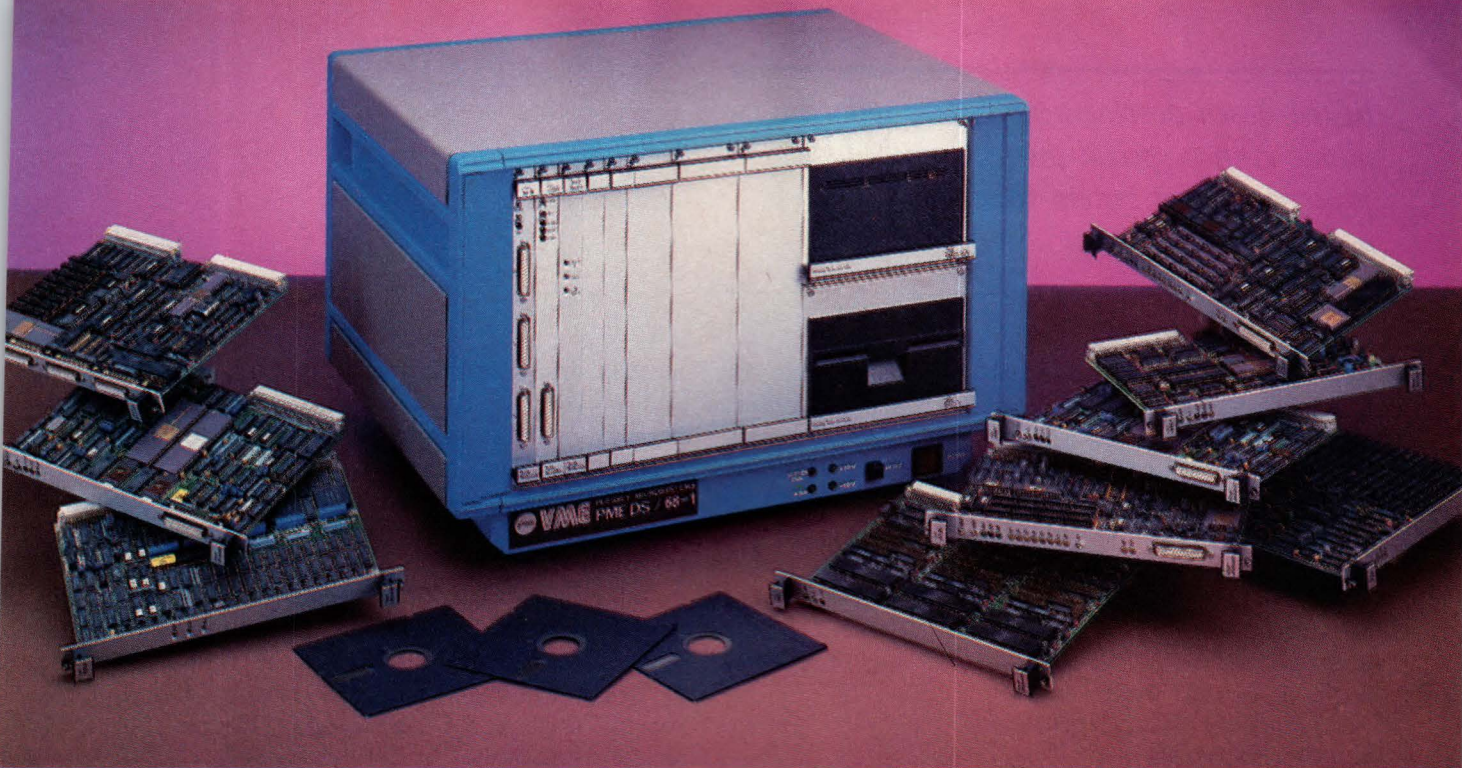
The chief disadvantage of programming in Forth is that it necessitates a different style of programming than that suitable to other high-level languages. Good Forth programming style demands top-down, hierarchical partitioning of a problem into Forth words that have only one function. Because the Forth interpreter has no intelligence and cannot deduce anything about the meaning of a word from its context, your extensions—like the kernel that comes with Forth—must be unequivocal. When Forth gurus mandate that each Forth word do only one thing, they mean what they say in the strictest terms.

This programming style is completely foreign to most high-level-language programmers. For example, the typical Unix programmer defines "one thing" much more loosely. "The essence of a Unix shell command is this: It does one thing, and multiple options let the user modify the characteristics of the basic operation to customize the command" (Ref 1).

High-level-language programmers aren't the only ones who have trouble with Forth. Assembly-language programmers who fail with Forth often do so because they try to use the Forth kernel as an assembly language. These programmers attempt to write a straight-line sequence of code and don't employ Forth's inherent structured-programming nature.

Minimal system costs less

The strict minimalism of Forth may or may not pay off in terms of quickly written programs that run fast and don't take up much memory—despite what Forth proponents claim. There's no doubt that the minimalism



The Fastest Route to Your Next VMEbus System Is Our VMEbus System:

The PME DS/68-1 VME Development System from Plessey.

The fastest, most efficient way to reach a great VMEbus system is with a great VMEbus development system. The Plessey DS/68-1. It's a high-performance development system that combines a CPU, memory board, disk controller, backplanes, and Winchester and floppy drive, all in one centrally-powered, fan-cooled chassis.

A CPU with Plenty of Power.

Our 68000-based PME 68-1B CPU board is built with 128 Kbyte DRAM, 16 Kbyte EPROM and 16 Kbyte user EPROM space, along with a monitor, PIO channel, programmable timer, real-time clock, battery back-up, and three RS232C SIO channels. Or choose any of our other CPU boards, with up to 512 Kbyte DRAM and plenty of special features.

Fast Memory for Tough Applications.

Our PME 512EP board features 512 Kbyte of high-performance DRAM, byte parity, 8/16/32-bit data, 24-bit address, 150nS write and 270nS read access speeds. An optional daughterboard boosts your memory up to 1 Mbyte. More optional memory is available, up to 4 Mbyte DRAM per slot, parity or EDC.

Intelligent Disk Storage for Fast Changes.

The PME SASI-1 disk controller works on a 4-channel programmable DMA controller, local diagnostic RS232C channel and interface for Winchester, floppy and tape drives. An FD-1 1 Mbyte floppy drive provides maximum storage on a

compact 5¼" package. Use it with the standard WD-40 40 Mbyte Winchester for fluent data storage and retrieval. Want more? Add an SIO board or even a multidrive interface/controller.

Excellent Connections in a Cool Chassis.

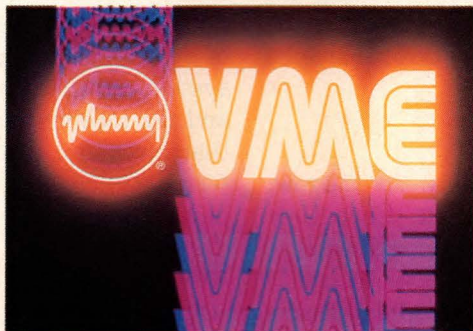
Each backplane features gold-plated Fast-ON power connectors, full termination networks at both backplane ends, and full control of daisy chain signal jumping. The chassis keeps cool with an internal fan and protected power supply built right into the body.

More Plessey VME.

Hardware is just the surface of the Plessey VME story. We also give you firmware, software and many other development aids, including the finest technical support in the business.

And our entire VME line supports VERSAdos* and many other operating systems, including COHERENT*, pSOS** and PDOS**. Get a running start on your VMEbus system today. Call or write Plessey Microsystems for complete details.

*TM Motorola. **TM Mark Williams Company.
TM Software Components Group. *TM Eyring Research.



PLESSEY

Plessey and the Plessey symbol are registered trademarks of The Plessey Company plc.

CIRCLE NO 57

England
Water Lane
Towcester
Northants
NN12 7JN
(0327) 50312

France
BP 74
7-9 rue Denis Papin
78194 Trappes Cedex
(3) 0514952

Germany
Bahnhofstraße 38
D-6090 Russelsheim
(0 61 42) 6 80 04

United States
One Blue Hill Plaza
Pearl River
NY 10965
(914) 735-4661

For additional information, clip and mail to Plessey Microsystems Ltd., Water Lane, Towcester, Northants, UK NN12 7JN

Name _____
Company _____
Address _____
Phone _____
Title _____
Postcode _____

ROM-based development-system software allows even a special-purpose, embedded-processor target system to serve as a development system.

pays off in terms of low initial costs. Forth Inc, for example, sells a full multitasking system with editor, assembler, and target compiler for \$3200—a price that's an order of magnitude less than that of real-time Unix systems. And unlike that of any other software system, Forth Inc's price includes a copy of all the source code. Having the source code proves useful when you're debugging programs with instrumentation, because you know not only the addresses of your program constructs but also the addresses of routines in the operating system.

Unix needs work

Unix is all the rage as a software-development environment. As an *execution* environment, it's sadly lacking in the facilities needed to survive in the real world. Unix lacks—among other things—security, sequential files, and real-time processing. Unix operating systems with real-time extensions attempt to remedy these shortcomings so that you can employ Unix as both a development and execution vehicle.

For example, both Whitesmiths's Idris (based on Unix version 6) and Alcyon's Regulus (based on Unix System V in the latest release) have a prioritized, real-time scheduler appended to the native Unix scheduler. The companies are currently implementing the necessary modifications to tailor the systems to the 68020 32-bit μ P. These versions should be available by the second or third quarter of this year.

Real time for real world

The native Unix scheduler suits only the narrow, idealized world of program development. Each Unix user has the same priority and is assigned a fixed slice of the processor's time on a round-robin basis. A task is interrupted, whether it's finished or not, when its time slice elapses. The scheduler is deemed successful if it responds to an interrupt within a human's threshold of perception ($\frac{1}{30}$ sec). The real-time extensions to Unix allow a high-priority task to respond directly to an interrupt instead of letting a largely autonomous I/O system herd the tasks' messages in and out of a pool of buffers. The real-time task can monopolize the processor until it finishes its job. As conditions change, the real-time scheduler can reorder tasks' priorities.

Furthermore, because regular Unix users are individuals working on their own files, there's little need for intertask (interuser) communication beyond electronic mail or piping the output of one task into the input of another task. In contrast, the real-time extensions have

mechanisms for fast, intimate, intertask communication and control. As a consequence, these real-time operating systems suit engineering applications far better than do plain Unix operating systems.

Alcyon charges \$42,000 for a license for 600 copies of Regulus. The fee includes one year's maintenance. If you want the source code so that you can trace and trap on operating-system activity or customize the operating system, you'll have to pay an additional \$22,000 for it. In a surprising turnaround, rather like Volkswagen of Brazil exporting cars to Germany, the company reports that AT&T has licensed Regulus for some smaller computers.

Scheduler consumes overhead

As for performance, the Regulus real-time scheduler does, of course, add overhead. Performance figures aren't available for the 68020, but a system call takes a minimum of 60 μ sec on a 10-MHz 68000.

Whitesmiths's pricing for its Idris operating system isn't as clear cut as Alcyon's. A representative price is the \$15,000 single-copy fee for Idris on the Omnibyte 68000-based workstation. Whitesmiths also details a performance benchmark obtained from the Omnibyte system. The company set up a pair of independent tasks that communicated on a 38.4k-baud loop-back serial line. Each character transmission involved a sequence of events: The transmitting task requested a transmit system call that invoked a transmit-interrupt handler, and the receiving task requested a receive system call that invoked a receive-interrupt handler. Idris transferred 240 cps and simultaneously processed 50 timer-task interrupts per second.

Unix versions are large

In addition to dealing with the slow response time of most nonreal-time versions of Unix, you'll have to contend with their alarming size. For example, the IBM PC implementation of a small-system Unix variant (Venix) consumes 192k bytes of RAM for the kernel, and on-line utilities consume an additional 3.5M bytes of disk storage for library routines. Versions of Unix for superminis are even larger and can consume 500k bytes of RAM and 16M bytes of disk space.

The fact that most Unix versions have a large code size and low performance is easily understood when you remember that they were written in a high-level language: C. However Uniflex—a *Unix-like* operating system—from Technical Systems Consultants is written in 68000 Series assembly language. Consequently,

Put your blue box out to pasture.

Genesis Has Better Choices for Superior 8086 Designs.

Genesis development tools turn your IBM PC or compatible computer into the most flexible, comprehensive development system made for 8086-family designs. Genesis offers the widest choice of proven languages, superior debugging tools, and even in-circuit emulators. It all starts with ACCESS, the superior Genesis operating environment that allows Intel's 8086 development software to run under MS-DOS. And not only do we sell ACCESS and all the Intel languages for 8086 and 80186 designs — we also offer an ACCESS system for 8-bit designs as well.

Genesis Is Faster.

You get performance as well as flexibility with Genesis. For example, in our tests the ASM 86 assembler running under ACCESS on an IBM PC AT runs 4.7 times as fast as the assembler on a hard-disk based Series III and an incredible eleven times faster than a

floppy-disk based Intel system. The ASM 86 assembler we tested under ACCESS even ran 1.53 times faster than a VAX 11/782 running competing cross-software.

Genesis Is Easier to Use.

Of course, Genesis offers more than speed of execution. The GeneScope family of symbolic debuggers and in-circuit emulators share the most powerful and easiest to use human interface available today. GeneScope offers high-level macro facilities, an on-line symbolic assembler, alphanumeric and graphic support, and many more features that make Genesis tools a better solution than other systems.

Genesis Costs Less.

With Genesis you get all the flexibility of a personal computer and all the power of expensive dedicated development systems. You can get your products to market faster, at a fraction of the cost.

Is there really any reason to keep using obsolete, expensive equipment — when you can have Genesis instead? ***Quit chewing your cud — give us a call and find out how Genesis tools can make your life easier.***



Genesis Has a Better Solution.



Genesis™
Microsystems

Genesis Microsystems Corporation
196 Castro Street
Mountain View, California 94041
Phone: (415) 964-9001
Telex: 4998093 GENMS UI

CIRCLE NO 58



Adopting a predefined operating system for your target system will allow your programming team to concentrate on applications.

Uniflex takes up 68k bytes of RAM and 1.7M bytes of disk space. The company asserts that Uniflex runs much faster than other Unix or Unix-like systems.

Uniflex costs \$550, including a C compiler and C library. Basic, Fortran, Pascal, assemblers, and various other utilities are extra. The company plans to field a ROMable version of Uniflex within a year, but at this time it has no plans to append real-time extensions to Uniflex.

You can obtain Uniflex installed on a 68020-based multiuser system from Gimix. A base version of the GMX 68020 costs \$13,680.20 and comes with 512k bytes of RAM (expandable to 1M byte), three intelligent serial ports, a 1M-byte floppy disk, and a 19M-byte hard disk.

Consider common operating system

An examination of the costs for these software-development systems reveals two reasons why having a common operating system on the host development computer and the target system makes sense: First,

you could easily spend far more than these operating systems cost in writing and maintaining your own operating system (to find out just how much more, translate Regulus's \$42,000 into programmer man-months at your company's rate). Second, with the same operating system on the host and target systems, programmers should have no problems when moving a program from the host to the target.

Whether you buy a standard operating system for your target system or write your own, software-development systems for your host will be plentiful from both third-party vendors and the μ P vendors. For example, Boston Systems Office plans to introduce cross assemblers, cross compilers, and symbolic-debugging programs for the 68020 during the third and fourth quarters of this year. Systems & Software Inc will extend its Softprobe/87 (a software simulation of Intel processors) to the 80286 by the fourth quarter of this year. Softprobe/87 runs on DEC VAXs under either VMS or Unix (System III, System V, or Berkeley 4.2).

Compensating for a lack of third-party support,

Manufacturers of 32-bit- μ P development tools

For more information on 32-bit- μ P development tools, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

Alcyon Corp

8716 Production Ave
San Diego, CA 92121
(619) 578-0860
Circle No 699

Boston Systems Office

469 Moody St
Waltham, MA 02154
(617) 894-7800
Circle No 700

Forth Inc

2309 Pacific Coast Hwy
Hermosa Beach, CA 90254
(213) 372-8493
Circle No 701

Gimix Inc

1337 W 37th Place
Chicago, IL 60809
(312) 927-5510
TWX 910-221-4055
Circle No 702

Hilevel Technology Inc

Irvine Technology Center
18902 Bardeen Way
Irvine, CA 92715
(714) 752-5215
Circle No 703

Hunter & Ready Inc

445 Sherman Ave
Palo Alto, CA 94306
(415) 326-2950
Circle No 704

Industrial Programming Inc

100 Jericho Quadrangle
Jericho, NY 11753
(516) 938-6600
Circle No 705

Intech Inc

282 Brokaw Rd
Santa Clara, CA 95050
(408) 727-0500
Circle No 706

JMI Software Consultants

904 Sheble Lane
Box 481
Spring House, PA 19477
(215) 628-0840
Circle No 707

Microtek Inc

9514 Chesapeake Dr
San Diego, CA 92123
(619) 569-0900
Circle No 708

Motorola Microsystems Operations

2900 S Diabolo Way
Tempe, AZ 85282
(602) 438-3522
Circle No 709

National Semiconductor Corp

2900 Semiconductor Dr
Santa Clara, CA 95051
(408) 721-4964
Circle No 710

Orion Instruments Inc

702 Marshall St, Suite 614
Redwood City, CA 94064
(415) 361-8883
Circle No 711

Softtrade International

11 Suzane Lane
Pleasantville, NY 10570
(914) 796-7334
Circle No 712

Solutionware Corp

1283 Mt View-Aviso Rd
Sunnyvale, CA 94089
(408) 745-7818
Circle No 713

Step Engineering

Box 61166
Sunnyvale, CA 94088
(408) 733-7837
Circle No 714

Systems & Software Inc

3303 Harbor Blvd, Suite C-11
Costa Mesa, CA 92626
(714) 241-8650
Circle No 715

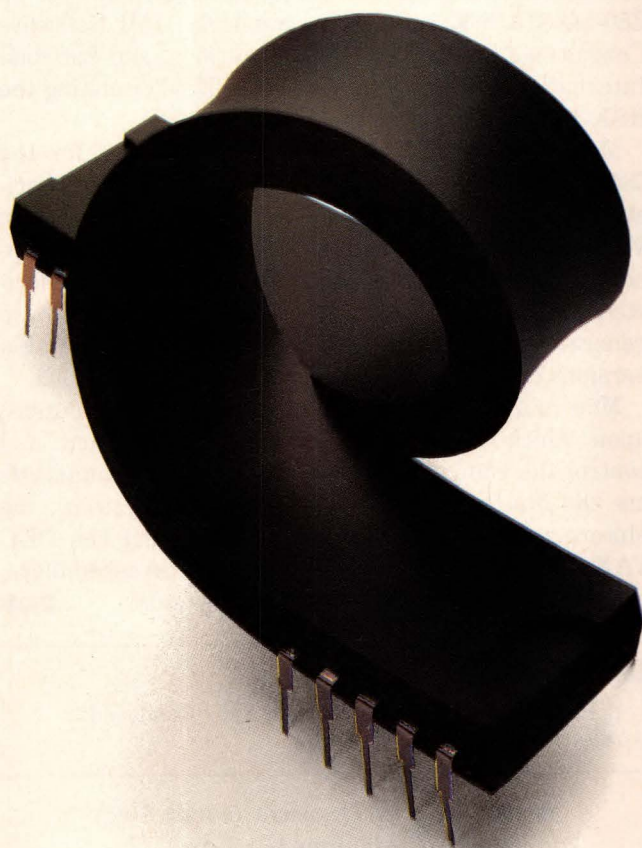
Technical Systems Consultants Inc

111 Providence Rd
Chapel Hill, NC 27514
(919) 493-1451
TWX 510-920-0540
Circle No 716

Whitesmiths Ltd

97 Lowell Rd
Concord, MA 01742
(617) 369-8499
Circle No 717

DON'T LET SPEED SLOW YOU DOWN.



The Mostek BiPort FIFO takes your processor out of the loop.

Until now, buffering two devices with different data rates meant one of two things. Either extra hardware design effort. Or software loops to slow your processor down while it's waiting for a peripheral or a coprocessor to be available.

But now there's a better way. The BiPort™ FIFO from Mostek. You can do away with the need for extra hardware design and software loops, and let your processor operate at its optimal performance level.

Our MK4501 is a 12.5 MHz CMOS device with access times as fast as 65 ns. It can handle asynchronous and simultaneous reads and writes from each respective port. And its 512 x 9 architecture is fully expandable by word width or depth. It even has a retransmit capability.

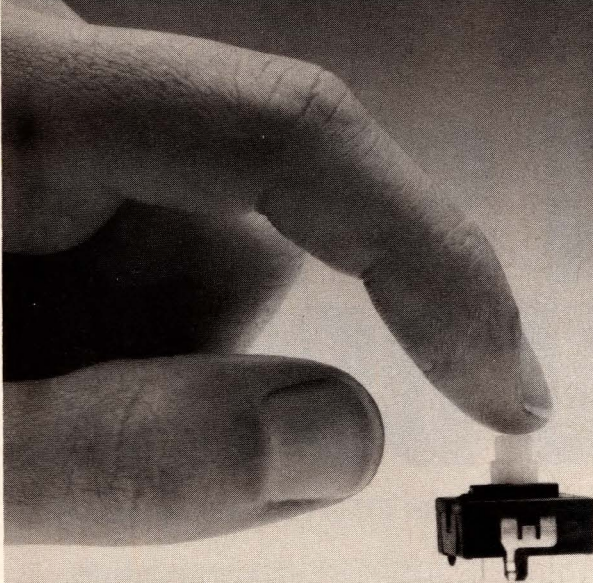
There's nothing quite like it. Except our MK4511. The MK4511 is similar, but has the added advantage of being a true dual-port RAM that's randomly-accessible for bi-directional applications.

So put a speedy end to your interface problems. Call or write Mostek for more details. Mostek Corp., 1215 W. Crosby Road, MS1051, Carrollton, Texas 75006, 214/466-7479. In Europe, (32) 02/762.18.80. In Japan, 03/496-4221. In the Far East (Hong Kong), 5.681.157-9.

BiPort is a trademark of Mostek Corp.



FEEL FREE.



Get a free sample of the American Switch

Are you ready to trade your Seoul supplier for some Yankee ingenuity? Switch to Grimes.

Grimes' low-profile, low-cost keyboard switches are used by one of the most popular personal computer manufacturers. And for good reasons: they're proven reliable at over 10 million cycles; stamped spiral springs control tolerances better than coiled springs; a built-in jumper eliminates the need for jumper wires and double sided circuit boards; and the unique bottom bearing reduces binding.

Grimes' switches cost less because their high-volume automated production reduces assembly costs. And American-made means immediate delivery, immediate credit and no overseas freight charges.

To get your free sample of Grimes' switches with and without tactile feel, call **1-714-671-3931** or circle the reader service number.

Feel for yourself why Grimes' high-quality low-profile keyboard switches will make you want to sell your Seoul.

GRIMES
THE AMERICAN SWITCH

115 S. Arroyo Circle Brea, CA 92621

Dealer Rep. inquiries invited. Several territories available.

National is offering a wide range of software products. Genix, the firm's version of Unix, costs \$30,000 for a source license for custom installations and \$10,000 for a version that will run on DEC VAXs under either VMS or Berkeley 4.2 operating systems. Genix includes a C compiler, cross assembler, linker, library routines, programmer utilities, emulator-control routines, and two kinds of symbolic debuggers. You can obtain a Pascal compiler for an additional \$6000.

For host computers other than the VAX, National depends on other vendors. Solutionware has National's development software in versions that will run on Z80-based CP/M computers. Similarly, JMI Software Consultants handles an IBM PC version, and Softrade International works with the DEC PDP-11 running the RSX-11 operating system.

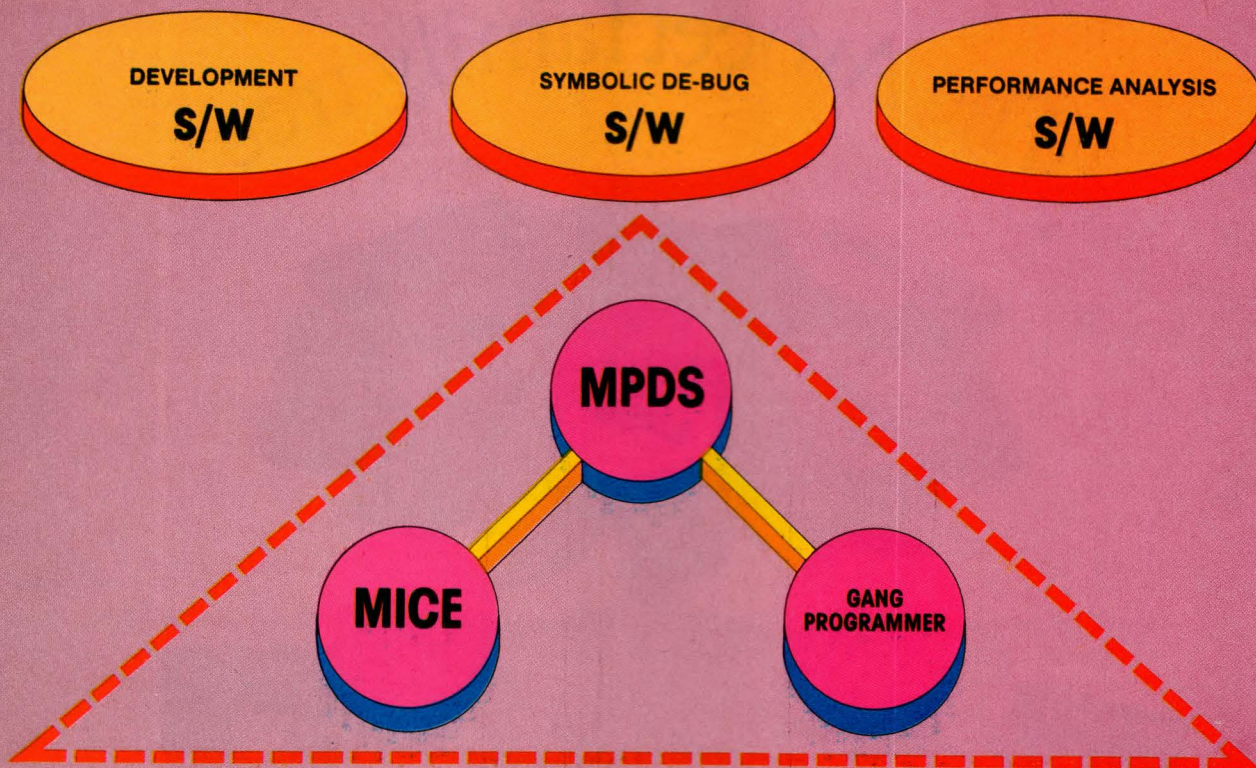
Motorola currently has only an assembler for the 68020. The assembler runs under the company's proprietary Versados operating system or under its System V/68 (a derivative of Unix). The macroassembler supports not only the 68020 CPU chip but also the associated floating-point processor. The assembler will also generate code for the 68000 and 68010. Executable versions cost \$600, and the source code costs \$5000.

Motorola provides links to three different computers, upon which you can do software development and control the company's emulator. The three computers are the Motorola VME/10 (a single-user system), the Motorola Exormacs (a 4-user system), and the DEC VAX. For each computer, the company has assemblers, compilers, and emulation-control programs. **EDN**

Reference

1. Brouwer, Peter, "Developing a Unix Command," *Attage*, March/April, 1985, pg 53.

Article Interest Quotient (Circle One)
High 470 Medium 471 Low 472



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 micro-computer, 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/debug 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

The Avocet family tree



Avocet turns an ordinary PC into an extraordinary development system.

And saves you \$20,000 in the process.

Now, there's a way to see all your best microprocessor designs take root, easily and effectively. Avocet cross-assemblers, simulators,

to use. We provide you with everything you need to develop microprocessor software, from data entry through assembly, debugging and final EPROMs.

lets you control emulation and download code from your terminal or PC. Priced from \$498.

AVPROM programmer works with any PC.

The AVPROM programs over 37 different devices, including EPROMS through 27512, CMOS and E² PROMS, and MPU/EPROM combos, using fast "adaptive" algorithms. Intelligent, self-contained units work with any personal computer, using Avocet's GDX driver software...from \$429. Gang programmers from \$979.

To find out more about Avocet software development tools and accessories, call us toll-free:

1-800-448-8500

(In the U.S. except Alaska and Hawaii.)

VISA and Mastercard accepted. All popular disc formats now available—please specify. Prices do not include shipping and handling—call for exact quotes. OEM INQUIRIES INVITED. Avocet Systems Inc., P.O. Box 490 N, Rockport, Maine 04856, (207) 236-9055. Telex: 467210 AVOCET CI.

AVOCET SYSTEMS INC.™

PO Box 490 - EDN

THE AVOCET CROSS-ASSEMBLER FAMILY.

Avocet Cross-assembler	Target Micro-processor	CP/M*-80	CP/M-86 IBM PC, MSDOS**
XASM04	6804	\$250.00	\$250.00
XASM05	6805	200.00	250.00
XASM09	6809	200.00	250.00
XASM18	1802/1805	200.00	250.00
XASM48	8048/8041	200.00	250.00
XASM51	8051	200.00	250.00
XASM65	6502/65C02	200.00	250.00
XASM68	6800/01,6301	200.00	250.00
XASM75	NEC 7500	500.00	500.00
XASM85	8085	250.00	250.00
XASM400	COP400	300.00	300.00
XASMF8	F8/3870	300.00	300.00
XASMZ8	Z8	200.00	250.00
XASMZ80	Z80	250.00	250.00
NEW!			
XASM6811	68HC11	250.00	250.00
NEW!			
XASM180	HD64180	250.00	250.00
XMAC682	68200	595.00	595.00
XMAC68K	68000/68010	595.00	595.00

*Trademark of Digital Research
**Trademark of Microsoft

emulators and EPROM programmers turn your personal computer into a sophisticated development system. No more searching for the ever inaccessible mainframe. Or, wondering how to pay for a \$20,000 dedicated development system. Avocet products save time and money, and provide the most flexible development system available.

Avocet allows you to develop software for practically any microprocessor without switching development systems. And equally important, Avocet development tools are easy to install and easy

Now "debug" on your PC.

Avocet has realistic answers for users who want low cost



debugging capability.

Until now, engineers have been very much on their own in the

area of testing. But

now Avocet simulators

and emulators virtually eliminate the frustrating and often costly "crash and burn" method.

New AVSIM family of full screen simulators.

Avocet's new software simulator/debuggers let you test your code in a crashproof, interactive environment, without additional hardware. Your PC's screen becomes a "window" into the simulated target CPU. Extensive break point, I/O, and interrupt facilities make AVSIM a truly useful development tool. Price \$299.

New TRICE in-circuit emulator.

At last, an affordable in-circuit emulator! With the self-powered TRICE, you can examine target memory and register, set break points, single-step, trace and more; TRICE recognizes 34 different commands. Its serial interface

CIRCLE NO 62

**So
how many
years
would you
like to take
off?**

Before you waste any more time, you may want to read about this.

VRTX®. That being the real-time operating system packaged in silicon. From Hunter & Ready.

It's a versatile kernel, efficient I/O system and flexible file manager.

Or to put it another way, it's everything you'd want in a multi-tasking operating system.

But not in the usual all-or-nothing sense of the word.

Fact is, you can use as much — or as little — as you like. And yes, then take as many years off as you like.

A good place to start is the VRTX kernel. Because with it, you can subtract two years from a lengthy design cycle.

Think of it as task management, real-time clock support, dynamic memory allocation, basic I/O, interrupt handling and fast pinpoint timing — all rolled into a neat 4K of memory.

OK, sounds like a lot, but not quite two years? You're right. That doesn't just come from design time. But from what makes VRTX as reliable as a quartz watch.

100,000 manhours of debugging and testing. The stuff nights and weekends can be made of.

Still you'll be happy to know, for all VRTX takes off, there's not much to give up.

Unlike other operating systems, it doesn't lock you into one processor

for life. Or tie you to one type of I/O and file management forever. VRTX is compatible with all major processor families and all standard types of file management and I/O.

And with that choice, we're back to the count.

Meaning if you don't want to spend time on I/O, take off another two years. Since our IOX component works with VRTX to take care of all block, disk and character I/O.

And right along with that goes our FMX file manager. And another two years off. Besides which, FMX includes all the things you'd want in a hierarchical file system. Concurrent file access. Random and sequential access. And compatibility with standard file systems, including none other than PC-DOS.

We could go on. But it's now time for our final summation.

A total of six years if you want it all off (VRTX, IOX and FMX). Two or four years if you'd like a real-time head start.

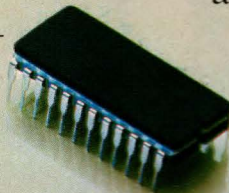
Or if you'd like to know more before you decide,

write Hunter & Ready, 445 Sherman Avenue, Palo Alto, CA 94306. Or call (415) 326-2950.

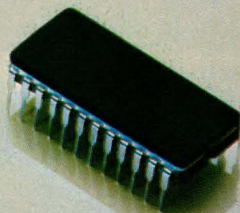
There should always be more than one way to buy time.

HUNTER ♦ READY

We've taken the hard part out of operating systems.



2 Years



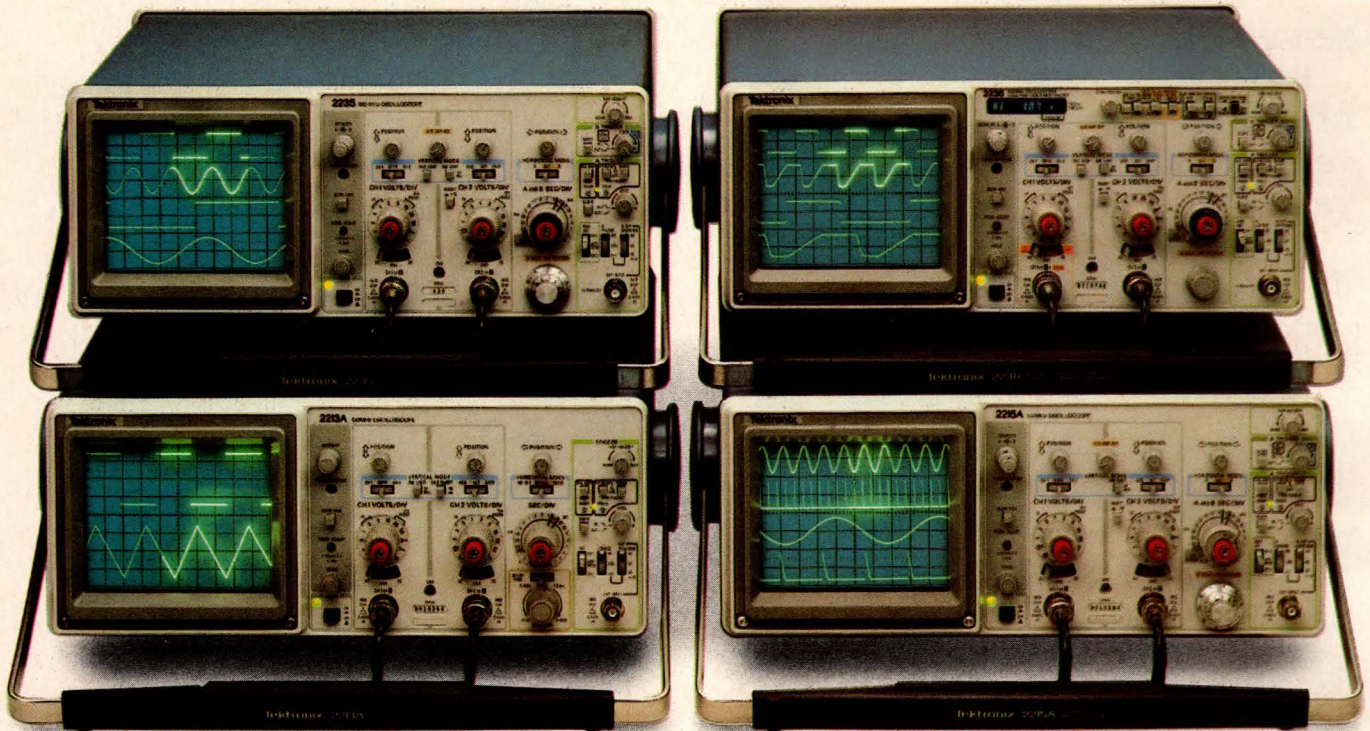
4 Years



6 Years



Don't settle for second best. Put Tek quality to work at 60 MHz and 100 MHz.



The Tektronix 2200 family sets a performance standard by which other portable oscilloscopes must be judged. Even compared to Tek's own previous industry standards, these scopes are easier to use, more portable, more precise. You get better measurements faster, more value for the money.

It's not surprising that in our 35 years of oscilloscope leadership no other scopes have recorded such immediate worldwide appeal.

The 2200 family features a radically simplified internal design

	2213A	2251A	2235	2236
Bandwidth	60 MHz	60 MHz	100 MHz	100 MHz
No. of Channels	2	2	2 + Trigger View	2 + Trigger View
Alternate Sweep	—	Yes	Yes	Yes
Vert/Trig—B/W Limit	Yes—10 MHz	Yes—10 MHz	Yes—20 MHz	Yes—20 MHz
Single Sweep	Yes	Yes	Yes	Yes
Accuracy: Vert/Horz	3%	3%	2%	2%
Delay Jitter	1:10,000	1:20,000	1:20,000	1:10,000
Triggering Sensitivity	0.3 div at 5 MHz	0.3 div at 5 MHz	0.3 div at 10 MHz	0.35 div at 10 MHz
Input R-C	1M Ω —20pf	1M Ω —20pf	1M Ω —20pf	1M Ω —22pf
Variable Holdoff	10:1	10:1	10:1	10:1
Integrated Counter/Timer/Multimeter	No	No	No	Yes

that improves reliability as it keeps costs low. Yet there is no compromise with Tek quality. Sensitivity, accuracy and triggering are excellent. Capabilities are extensive, yet easy to use.

At 60 MHz, choose the 2213A or dual time base 2251A. At 100 MHz, the 2235, or 2236 with its bright fluorescent readout and integrated counter/timer/DMM. Each scope is backed by a 3-year war-

ranty, excellent documentation and worldwide service support.

There is no substitute for Tek quality, anywhere. Contact the Tektronix office or sales representative nearest you.

Follow design rules for optimum use of fast comparator IC

To fully exploit a high-speed comparator IC's capabilities, you must understand both the IC's innate attributes and the influences of the circuit environment surrounding the device. This article, first in a 3-part series, explores these attributes and influences, and provides guidelines for optimizing high-speed circuit performance.

Jim Williams, *Linear Technology Corp*

A recent high-speed comparator, the LT1016, offers complementary, TTL-compatible outputs and 10-nsec response time. The outputs directly drive all TTL families, including high-speed AS and Fairchild Advanced Schottky TTL (Fast) parts. The TTL outputs make the device easy to use in linear-circuit applications, where ECL output levels are often inconvenient. This article, first of a 3-part series, covers application and measurement techniques and discusses a number of problems associated with the high-speed circuitry the LT1016 would normally inhabit. The other two articles

will provide a variety of circuit applications that exploit the device's capabilities.

The LT1016 is relatively easy to use; it's less prone to oscillation and other vagaries than some other comparators (see box, "A fast TTL comparator"). Unfortunately, the laws of physics dictate that you properly prepare the circuit *environment* in which the device works. The performance limits of high-speed circuitry often stem from layout considerations or from such parasitic effects as stray capacitance and ground impedance. Some of these considerations also exist in digital systems, in which you're perfectly comfortable describing bit patterns and memory-access times, for example, in terms of nanoseconds.

The LT1016 is, of course, useful in the mentioned fast digital systems; Fig 1 gives an idea of just how fast the device is. The simple test circuit allows you to see that the comparator's response (trace B) to the pulse generator's output (trace A) is faster than that of a TTL inverter (trace C). In fact, the inverter's output never attains a TTL zero level. Linear circuits that operate with this order of speed make many designers justifiably wary. Nanosecond-domain linear circuits are widely associated with oscillations, mysterious shifts in circuit characteristics, unintended modes of operation, and outright failure to function.

Among other common problems of such high-speed

To use a high-speed comparator effectively, you must understand not only the IC itself, but also the influences and vagaries of the circuit environment surrounding the device.

linear circuits are differing measurement results when you use various pieces of test equipment, the inability to make measurement connections to the circuit without inducing spurious responses, and dissimilar operation between two supposedly identical circuits. When a circuit's design and the components used in it are sound, you can usually trace all the cited problems to an improper circuit environment. To provide a proper

environment, you must study the causes of the mentioned difficulties.

The most common high-speed-circuit problem is improper power-supply bypassing. Bypassing is necessary to maintain low supply impedance. Inductance and dc resistance in supply wires and pc-board traces can easily attain unacceptable levels. These parasitics allow the supply line to fluctuate in response to changes in the

Text continues on pg 134

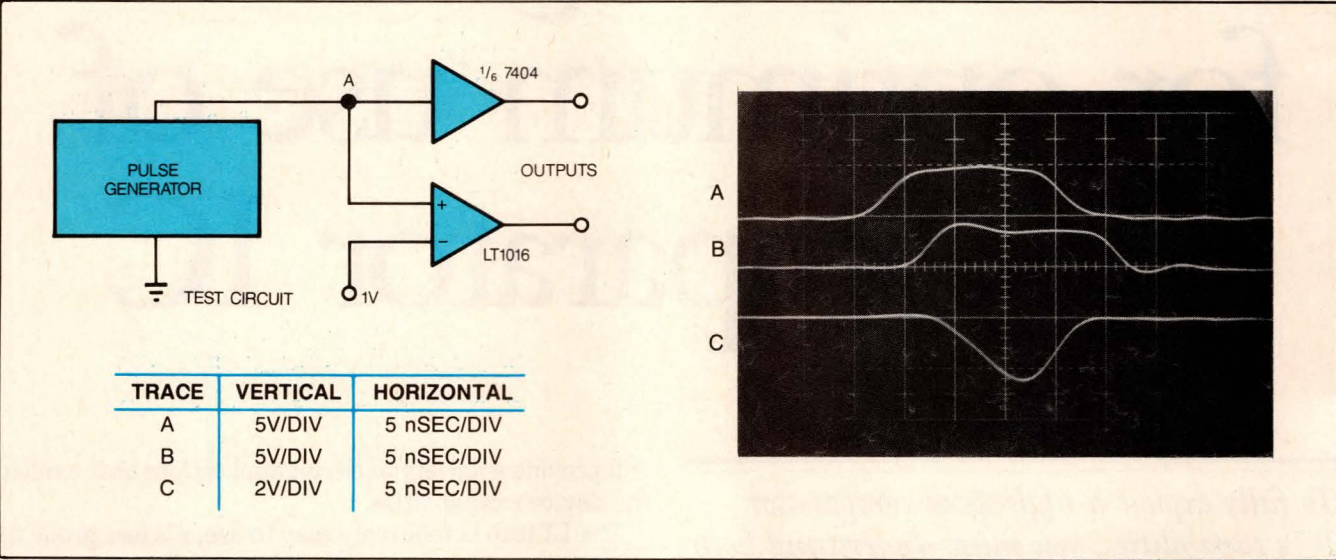


Fig 1—Faster than a TTL inverter, the LT1016 switches (trace B) in less than 10 nsec after application of an input pulse (trace A). The TTL circuit's output (trace C) never attains 0V.

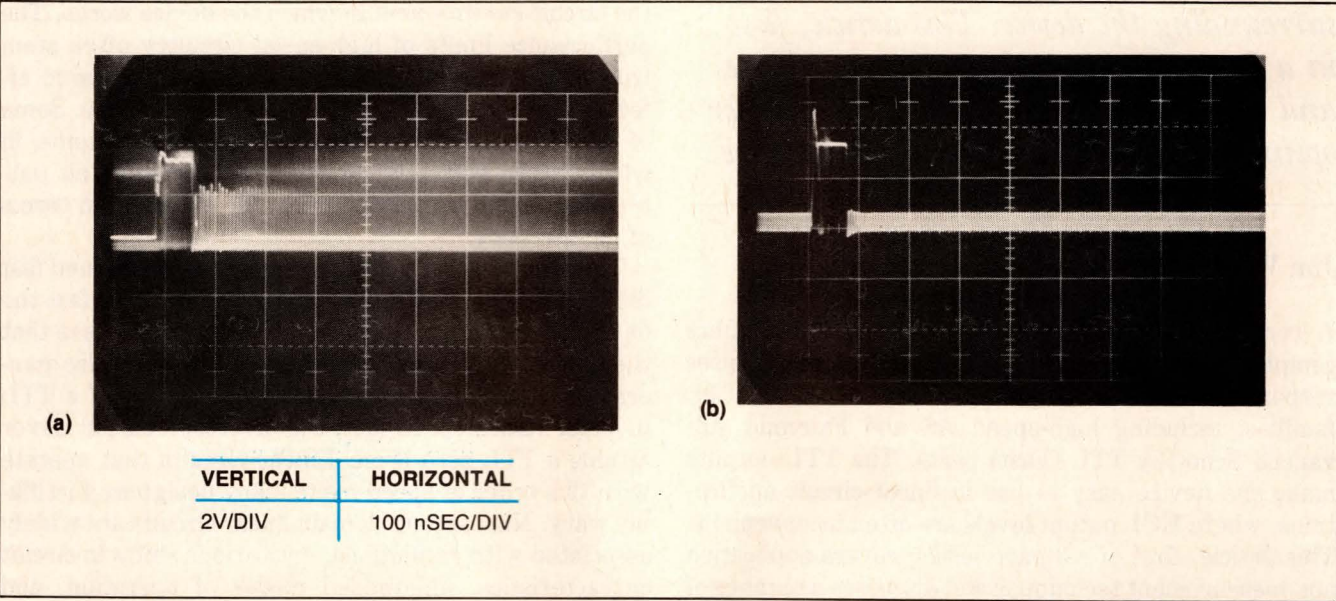


Fig 2—Proper bypassing is important, as shown by these scope photographs. The unbypassed case appears in a; b shows the result of inefficient bypassing (capacitors either too distant from the LT1016 or excessively lossy).

A fast TTL comparator

The LT1016 is a fast (10-nsec typ propagation delay) comparator that provides a direct interface to TTL logic while operating from either one 5V supply or dual $\pm 5V$ supplies. The IC offers matched complementary outputs and a latch pin for input-data retention at the outputs.

The LT1016's output stage provides active drive in both directions for high-speed drive into TTL logic or passive loads, yet does not exhibit the large current spikes usually found in totem-pole output stages. This attribute eliminates the need for a minimum slew-rate spec for the input signal, a spec that typ-

TABLE1—LT1016A KEY SPECIFICATIONS

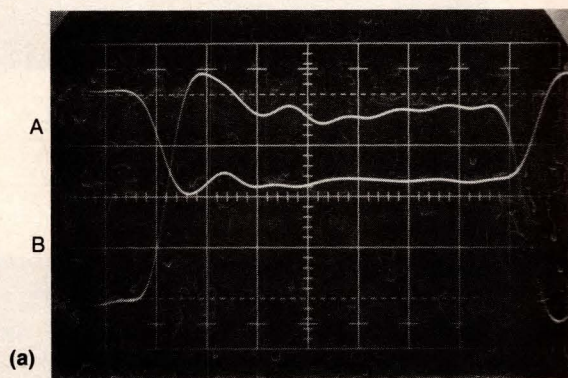
PARAMETER	SPEC
INPUT OFFSET VOLTAGE	1.5 mV MAX
OFFSET-VOLTAGE DRIFT	10 $\mu V/^{\circ}C$ MAX
INPUT BIAS CURRENT	10 μA MAX
INPUT-VOLTAGE RANGE	$V_{CC} - 1V$ $V_{EE} + 1.25V$
COMMON-MODE REJECTION	80 dB MIN
VOLTAGE GAIN	2000 MIN
PROPAGATION DELAY (5-mV OVERDRIVE)	12 nSEC MAX
V_{CC} CURRENT	35 mA MAX
V_{EE} CURRENT	5 mA MAX

ically encumbers other very fast comparators.

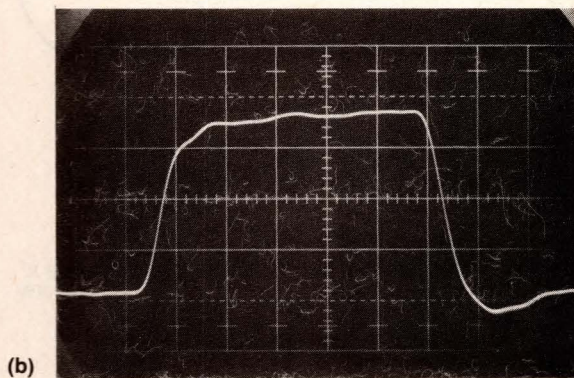
Another factor that makes the LT1016 easier to use than other

high-speed comparators is the fact that its outputs are stable when the device operates in its linear region, regardless of how slowly the input signal changes. This trait eliminates the problem of output chatter in the presence of slow-moving or dc-input signals.

Finally, the LT1016's quiescent negative-supply current is typically 2.5 mA—approximately 10 times lower than that of other very fast, bipolar comparators. This feature allows you to drive the negative-supply pin from any negative supply by using a simple resistive divider.



VERTICAL	HORIZONTAL
2V/DIV	10 nSEC/DIV



VERTICAL	HORIZONTAL
1V/DIV	50 nSEC/DIV

Fig 3—Proper selection and use of probes is all important. In a, a miscompensated probe yields a grossly exaggerated output (8V vs the true 5V); in b, an overcompensated (or insufficiently fast) probe delivers an unduly slow output to the oscilloscope.

Choose bypass-capacitor types and values with care

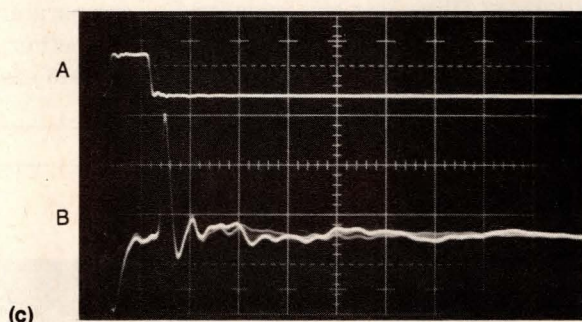
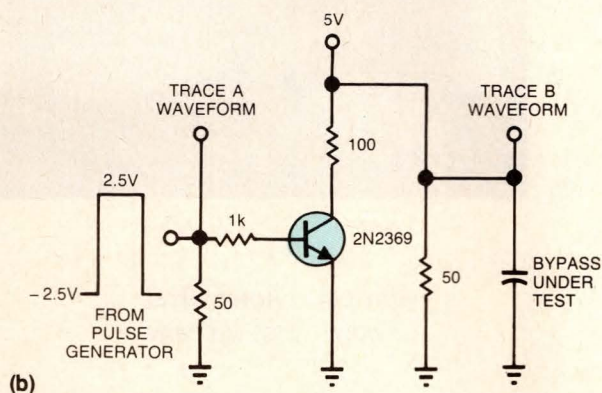
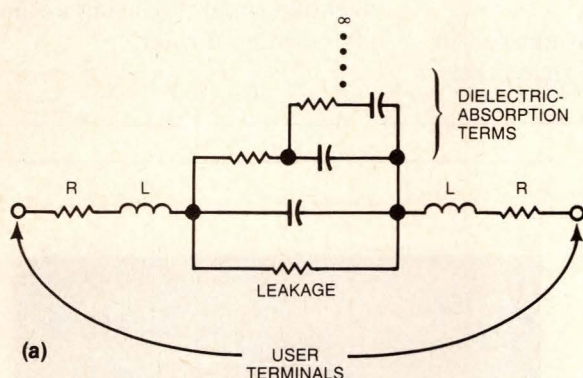
Bypass capacitors serve to maintain low power-supply impedance at the point of load. Because of parasitic resistance and inductance in supply lines, the supply impedance can often be very high. As frequency rises, the inductive parasitic becomes particularly troublesome. Even if these parasitic terms did not exist, or if you use local regulation, bypassing is still necessary because no power supply or regulator has zero output impedance at, say, 100 MHz.

The type of bypass capacitor to use is a function of the application, frequency domain of the circuit, cost, board space, and many other considerations. However, you can make some useful generalizations. All capacitors' equivalent circuits contain parasitic terms, some of which appear in **Fig Aa**.

In bypass applications, leakage and dielectric absorption are secondary terms, but series inductance and resistance are not. These last two terms limit the

capacitor's ability to damp transients and to maintain low supply impedance. Bypass capacitors must often have large values so they can absorb long transients. In these cases, it's necessary to use electrolytic types, which exhibit high-value series inductance and resistance.

Different types of electrolytics—both polar and nonpolar—have markedly different characteristics, and the type (or types) to use is sometimes a subject of debate. In choosing a bypass ca-



TRACE	VERTICAL	HORIZONTAL
A	5V/DIV	100 nSEC/DIV
B	1V/DIV	100 nSEC/DIV

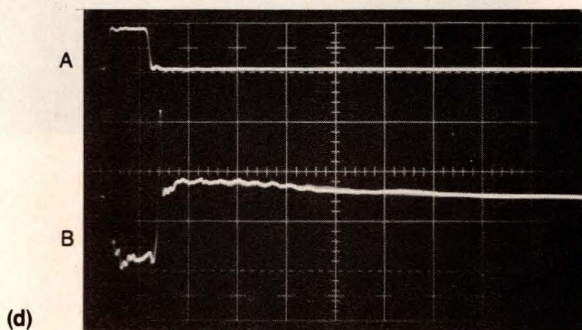


Fig A—Understand the all-important bypass capacitors when you're designing high-speed circuitry. The diagram in **a** is the equivalent circuit of a capacitor. The important parasitics for bypassing are series inductance and resistance. The circuit in **b** allows you to test bypass capacitors. The scope photographs show the response with the various bypass combinations described.

capacitor, the test circuit in **b** and the accompanying scope photos can perhaps be useful. The photos show the response of five bypassing methods to the transient generated by the test circuit.

The photo in **c** shows an unby-passed line, whose voltage sags and ripples badly at high amplitudes. In **d**, a 10- μ F aluminum electrolytic cuts the disturbance considerably, but the potential for trouble still exists.

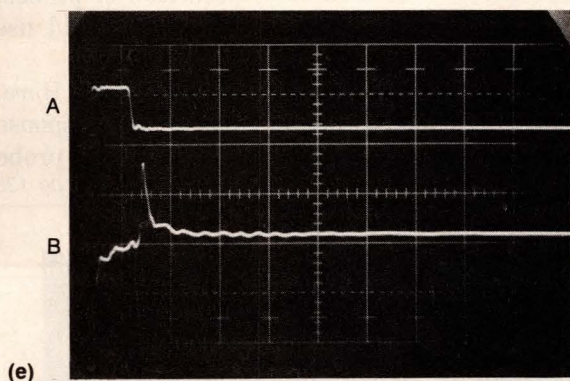
A 10- μ F tantalum unit (**e**) offers cleaner response; a 10- μ F

aluminum combined with a 0.01- μ F ceramic type (**f**) is even better. Combining electrolytics with other capacitor types (usually ceramic) is a popular way to obtain good response, but beware of picking the wrong duo.

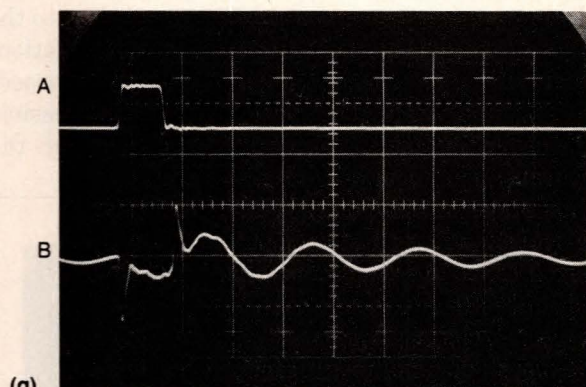
Choosing the right pair is not an easy task. Circuit characteristics (including line inductance and the nature of the signals you're dealing with) and the capacitors' parasitic terms both play a role. The photo in **g**, for example, shows the results of

using a parallel combination of a 10- μ F aluminum electrolytic and a 0.1- μ F ceramic capacitor in the test circuit. Note the resonant, ringing response.

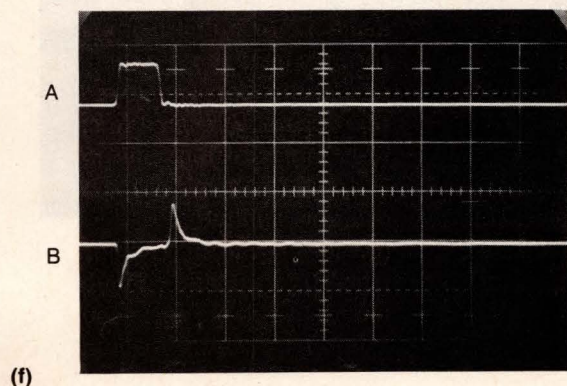
The preceding example shows that you must tailor bypass capacitors and capacitor combinations to your particular system. And this tailoring is more an empirical task than an analytical one. In other words, experiment with various bypass components in your system until you achieve the best results.



(e)



(g)



(f)

TRACE	VERTICAL	HORIZONTAL
A	5V/DIV	100 nSEC/DIV
B	0.1V/DIV	100 nSEC/DIV

A high-speed IC needs a rock-stable and impedance-free supply to do its job properly. Therefore, supply bypassing is not only beneficial, but crucial.

internal characteristics of the devices connected to it. This fluctuation almost always causes unruly operation.

What's more, several devices connected to an unbypassed supply can effectively communicate through the finite supply impedances, thereby provoking erratic operating modes. Bypass capacitors, by providing local reservoirs of energy at the device level, represent a simple way to eliminate this communication. The bypass capacitor acts like an electrical flywheel that keeps supply impedances low at high frequencies. The choice of capacitor type for bypassing is a critical issue, so weigh your decision carefully (see **box**, "Choose bypass-capacitor types and values with care").

Fig 2a shows the response of an unbypassed LT1016 to a pulse input. The power supply that the comparator sees at its terminals has high impedance at high frequencies. This impedance forms a voltage divider with the LT1016, allowing the supply voltage to move in response to changes in the comparator's internal conditions. The supply instability causes local feedback, and oscillation occurs. Although the LT1016 responds to the input pulse, its output is a blur of 100-MHz oscillation.

In **Fig 2b**, the comparator's supplies are bypassed, but it still oscillates. This oscillation has two possible causes: The bypass units are either too far from the

LT1016, or they're lossy capacitors. These examples suggest two rules: *Use capacitors with good high-frequency characteristics, and mount them as closely as possible to the LT1016.* Even an inch of wire between the capacitor and the comparator can cause problems.

Perhaps number two in the list of circuit-environment problems is the use of improper—or the improper use of—oscilloscope probes. In **Fig 3a**, the comparator is properly bypassed, but a new problem arises. The photo shows both outputs of the comparator. Trace A appears normal, but trace B shows an excursion of almost 8V—quite a feat for a device running from one 5V supply. This anomaly is commonly reported in high-speed circuits, and it can be very confusing.

The anomaly arises from a grossly miscompensated or improperly selected oscilloscope probe. This example prompts another rule of thumb in working with high-speed circuitry: *Use probes that match your oscilloscope's input characteristics, and compensate the probes properly.* (For a further discussion of probes, see **box**, "Oscilloscopes and probes: Choose and use wisely.")

Fig 3b shows another probe-induced problem. Here, the amplitude seems correct, but the 10-nsec-response LT1016 exhibits 50-nsec edges. In this case, the probe

Text continues on pg 138

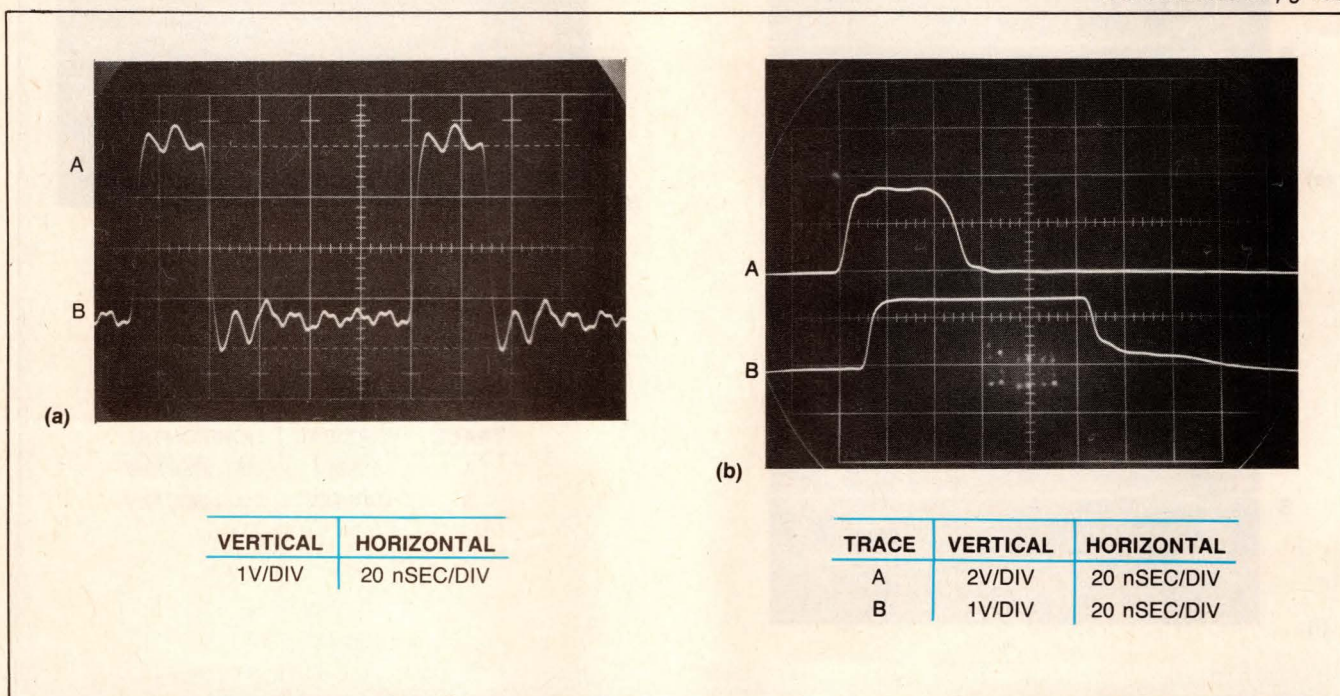


Fig 4—More probing-caused problems afflict these waveforms. In **a**, the probe's too-long ground lead causes ringing and distortion; in **b**, a badly overdriven FET probe delivers false information to the oscilloscope.

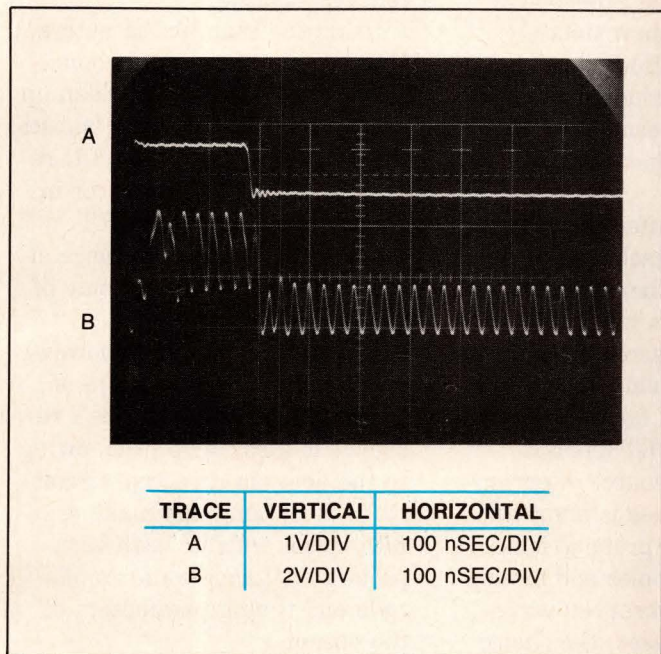


Fig 5—Improper grounding of high-speed ICs can lead to disaster. Trace B is the output of an LT1016 whose ground lead is 1 in. in length. The comparator oscillates at approximately 40 MHz. To avoid such problems, keep the IC's ground lead to less than ¼ in. in length.

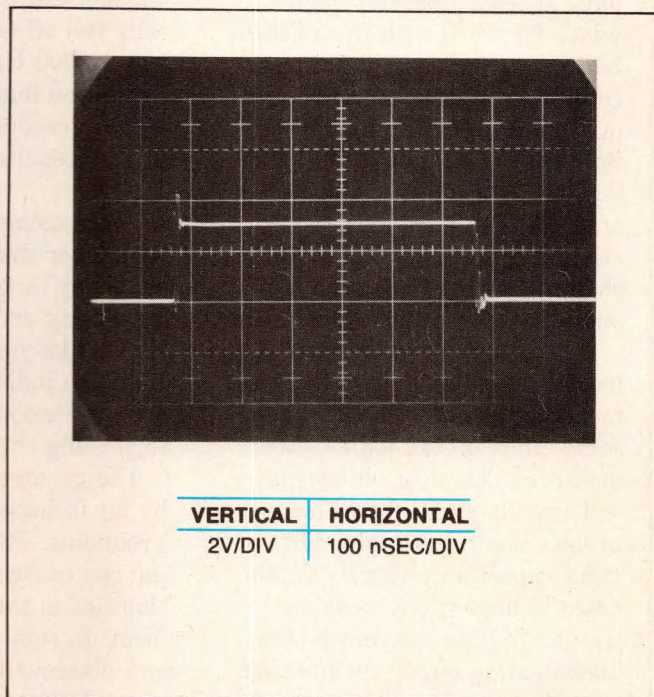


Fig 6—Failure to use a ground plane provokes the chattering edges on this waveform. A ground plane in this example would have reduced inductance sufficiently to eliminate the chatter.

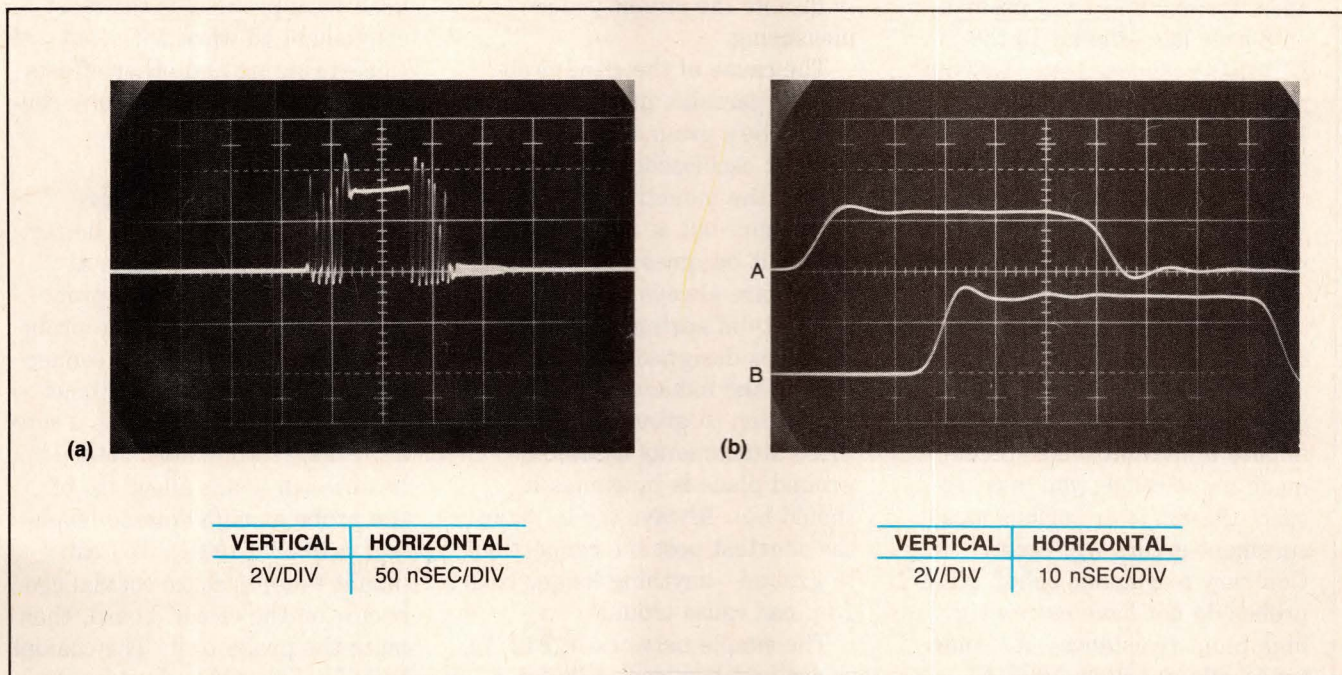


Fig 7—Stray capacitance from output to input causes the singing on the edges of the waveform in a. A lower source impedance at the comparator's input and some attention to input and output lead routing would cure this condition. More stray-capacitance-induced woes are evident in b, where the culprit is the stray capacitance to ground at the comparator's input.

Oscilloscopes and probes: Choose and use wisely

In high-speed-design work, the choice of an oscilloscope-probe combination is the most important decision you must make. Ideally, the oscilloscope should have at least 150-MHz bandwidth for work with the LT1016, but slower instruments are acceptable if you have a good understanding of their limitations. Be aware of your scope's behavior with respect to input impedance, noise, overdrive recovery, sweep nonlinearity, triggering, channel-to-channel feedthrough, and other characteristics.

Probes are the most overlooked cause of oscilloscope mis-measurement. All probes have some effect on the points they measure. The most obvious effect usually stems from the probe's input resistance, but input capacitance usually dominates in high-speed measurements. You can lose much time investigating circuit events that actually stem from improperly selected or applied probes.

An 8-pF probe observing a point with 1-k Ω source impedance, for example, will produce an 8-nsec lag—similar to the LT1016's response time. Low-impedance probes (with 50 Ω to 1-k Ω resistance) usually have input capacitance of 1 or 2 pF; these probes are a good choice if you can tolerate the low resistance.

FET probes maintain high input resistance and keep capacitance at the 1-pF level, but have substantially more delay than passive probes. FET probes also impose limitations on common-mode input range; you must respect the limits or serious measurement errors will occur. Contrary to popular belief, FET probes do not have *extremely* high input resistance—for some types, it's as low as 100 k Ω .

The passive, transformer-based types of current probes

are fast and they introduce less delay than the versions based on the Hall effect. The Hall-effect types, however, respond at dc and low frequencies, while the transformer-based probes typically roll off at approximately 100 to 1000 Hz. Both types have saturation limitations which, when exceeded, cause odd CRT-display results that can be confusing.

When using different probes, remember that each has a different delay time; therefore, apparent timing errors will occur on the oscilloscope screen. Know what the individual probe delays are, and account for them in interpreting the CRT display.

The greatest source of error by far in probe use is improper grounding. Poor probe grounding can cause ripples and discontinuities in the observed waveform. In some cases, the choice and placement of a probe's ground connection can affect waveforms on another channel. In the worst case, connecting a probe's ground wire can virtually disable the circuit you're measuring.

The cause of the cited problems is parasitic inductance in the probe's ground connection. In most oscilloscope measurements, the inductive effect is not a problem, but at nanosecond speeds it becomes critical. Fast probes are always supplied with a variety of spring clips and accessories designed to aid in minimizing the inductance of the connection to ground. Most of these attachments assume a ground plane is in use (as it should be). Always try to make the shortest possible connection to ground—anything longer than 1 in. can cause trouble.

The simple network in **Fig Aa** shows just how easy it is for poorly chosen or improperly used probes to cause bad re-

sults. A 9-pF input-capacitance probe with a 4-in. ground strap monitors the output, seen in **b**, trace B. Although the input (trace A) is clean, the output contains ringing.

Using the same probe with a ¼-in. spring-tip ground-connection accessory seems to clean up everything (**c**). However, substituting a 1-pF FET probe (**d**) reveals a 50% amplitude error in **b**'s measurement. The FET probe's low input capacitance allows a more accurate display of the circuit's action.

The FET probe does, however, contribute its own form of error. Note that the probe's response is tardy by 5 nsec, owing to the delay in its active circuitry. Hence, you must make separate measurements with each probe to determine the amplitude and timing parameters of the output.

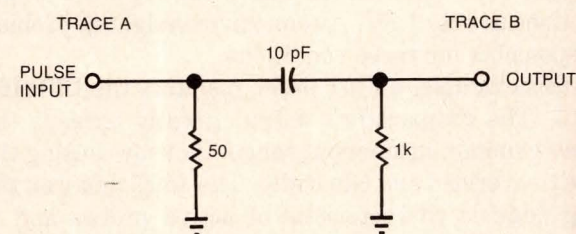
In **e**, probes A, B, E, and F are standard types equipped with various forms of low-impedance grounding attachments. The conventional ground lead used with probe G is the most convenient to work with, but causes ringing and other effects at high frequencies, thereby rendering the probe virtually useless.

Probe H has a very short ground lead. This lead is better, but can still cause trouble at high speeds. C is a FET probe. The active circuitry in the probe and a very short ground connector ensure low parasitic capacitance and inductance. D is a separate FET-probe attenuator head. Such heads allow use of the probe at high voltage levels (eg, ± 10 or ± 100 V). You can mount the miniature coaxial connector on the circuit board, then mate the probe to it. The coaxial technique provides the lowest possible parasitic inductance; therefore, it's recommended.

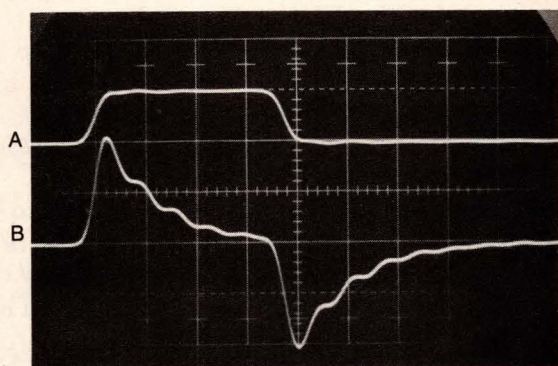
Probe I is a current probe; it usually doesn't require a ground connection. However, at high speeds, the ground connection might result in a cleaner CRT presentation. Because no current flows in the ground lead of these probes, a long strap is usually permissible.

A final form of probe is the human finger (J). Probing the circuit with a finger can accentuate desired or undesired effects, thereby giving clues to circuit behavior. You can use a finger, for example, to introduce stray capacitance into a suspect circuit node while observing results on

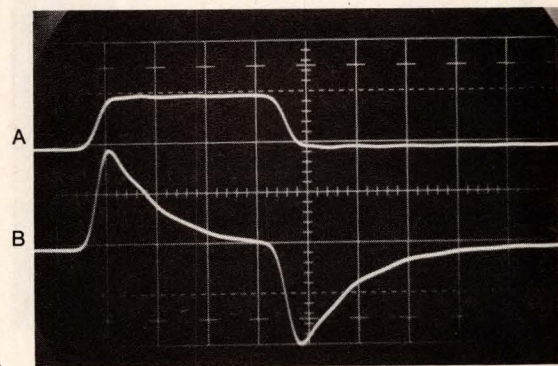
a CRT. You can use two fingers, lightly moistened, to provide an experimental resistance path. Some high-speed-circuit engineers are particularly adept at these techniques, and can estimate the simulated capacitive and resistive effects with surprising accuracy.



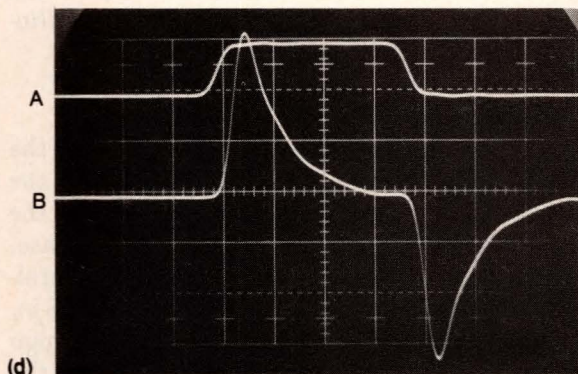
(a)



(b)



(c)



(d)

TRACE	VERTICAL	HORIZONTAL
A	5V/DIV	10 nSEC/DIV
B	1V/DIV	10 nSEC/DIV

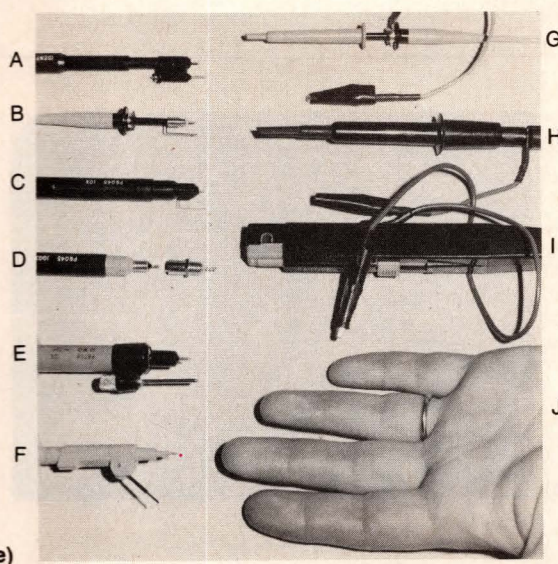


Fig A—Choosing, and correctly using, appropriate probes is crucial in working with high-speed circuitry. The test network in **a** serves as an evaluation vehicle for various probes. In **b**, the probe's long ground lead causes ringing. A shorter ground strap (**c**) cleans up the ringing, but the FET probe's low input capacitance shows in **d** that the previous probe's high capacitance led to amplitude errors. Various types of probes and ground attachments are shown in **e**.

A prevalent cause of measurement problems, the improper choice or use of scope probes can lead to misleading or false results when testing high-speed circuitry.

used is too heavily compensated or too slow for the oscilloscope. Never use, for example, 1X (un-attenuated) probes. Their bandwidth is 10 to 20 MHz or less, and their capacitive loading is high. The rules: *Check probe bandwidth to ensure that it's adequate for the measurement. Equally important, use an oscilloscope with adequate bandwidth.*

Additional probe problems

Limited bandwidth and capacitive loading are not the only sources of probe-induced woes. In **Fig 4a**, the probes are properly selected and compensated, but the LT1016's output rings and distorts badly. In this case, the probe's ground lead is too long. For general-purpose work, most probes use ground leads about 6 in. long. At low frequencies, this length is fine—at high frequencies, however, the long ground lead takes the form of an inductor, and the illustrated ringing occurs.

High-performance probes are always supplied with some short ground straps to deal with the problem. Some come with very short spring clips that mate directly with the probe tip to facilitate a low-impedance ground connection. For high-speed work, the ground connection to the probe should not exceed 2 in. in length. *Keep the probe's ground connection as short as possible.*

A final probe-induced problem causes the aberrations of **Fig 4b**. The problems in trace B are delays and insufficient amplitude. A small delay on the leading edge is followed by a long delay before the falling edge begins. In addition, a lengthy, tailing response stretches to 70 nsec before finally settling. The amplitude rises to only 1.5V. A common oversight in probing is responsible for these conditions.

In this example, a FET probe monitors the LT1016's output. The comparator's output greatly exceeds the probe's common-mode input range, thereby causing the probe to overload and clip badly. The small delay on the rising edge is characteristic of active probes and is legitimate. During the time the LT1016's output is high, the probe is driven deeply into saturation. When the output drops, the probe's recovery is lengthy and uneven, causing the delay and long tail.

Thus, some final probe-related rules: *Know your FET probe. Take account of the delay of its active circuitry. Avoid saturation effects arising from common-mode input limitations (typically $\pm 1V$). Use 10X and 100X attenuator heads when required.*

Fully as important as—and closely related to—the bypassing issue, proper grounding is crucial in any high-frequency application of the LT1016 (or any other high-speed IC). **Fig 5**, for example, shows the LT1016's

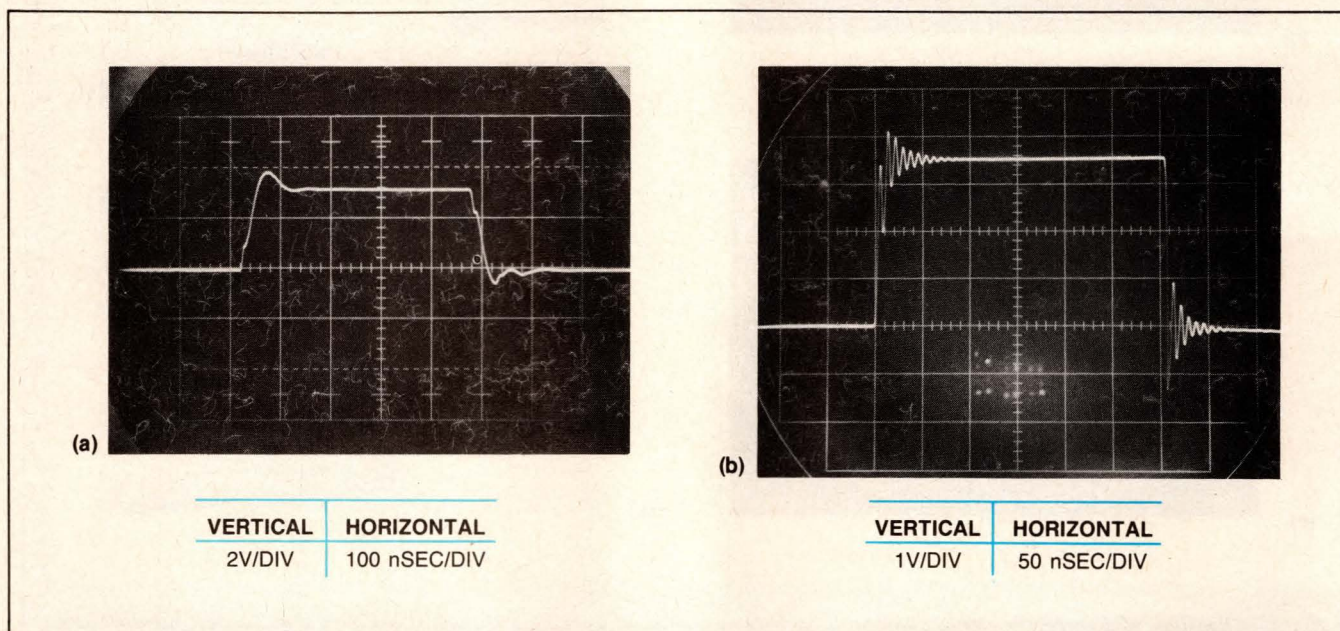


Fig 8—Beware of output-loading problems in using the LT1016. In **a**, a large capacitive load causes distortion and slow response on the output's edges. For heavy capacitive loads, use a buffer. In **b**, the LT1016 faces a load that resembles an unterminated transmission line. The solution is to terminate the line with a resistor, or to shorten the output-lead length.

output (trace B) oscillating at approximately 40 MHz as it responds to an input (trace A). Note that the input signal shows traces of the oscillation. The problem in this example is improper grounding of the comparator. In this case, the LT1016's ground-terminal connection is 1 in. long.

The ground lead of the LT1016 must be as short as

possible, and it must be connected directly to a low-impedance ground point. Any substantial impedance in the comparator's ground path will generate effects like those shown in Fig 5. The source of the malady is related to the necessity for bypassing the power supplies. The inductance created by a long device ground lead permits mixing of ground currents, thereby caus-

Text continues on pg 142

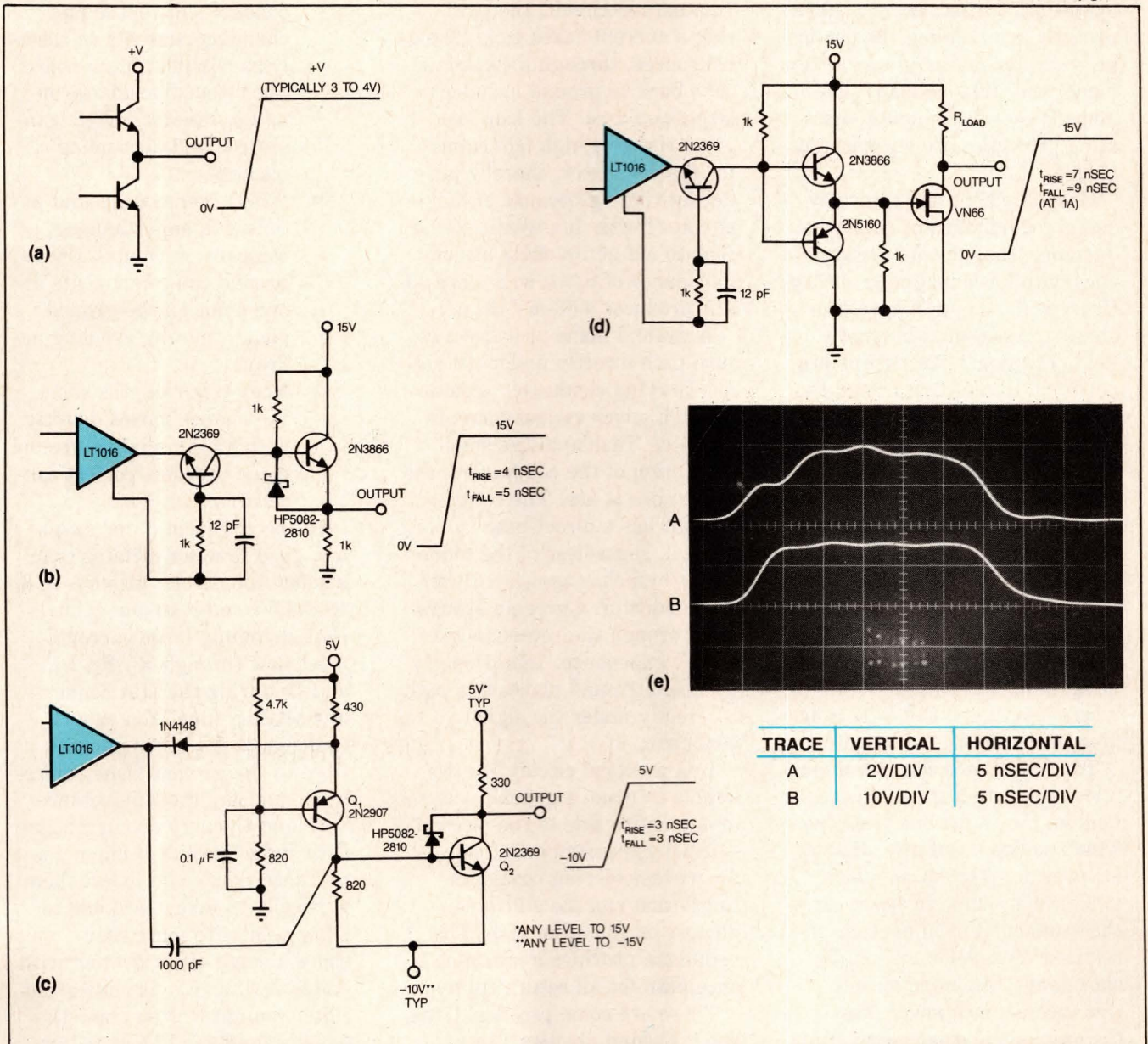


Fig 9—Level shifting is not a trivial task. These level-shifting circuits take advantage of the LT1016's sink-source output (a) to provide shifting with very small delays. The shifters suit various applications. The circuit in b, for example, provides a 15V unipolar output. The configuration in c allows you to vary the levels; e shows waveforms for this circuit. The setup in d provides a 15V, 1A output.

Understand the rules for ground planes

The term "ground plane" crops up frequently in discussions of high-frequency circuit layout, most often as a mystical and ill-defined cure for spurious circuit operation. In fact, there is little mystery surrounding the usefulness and operation of a ground plane, and—like so many phenomena—its fundamental operating principles are surprisingly simple.

Ground planes are primarily useful for minimizing circuit inductance; they do so in accordance with basic magnetic theory. Current flowing in a wire produces an associated magnetic field. The field's strength is proportional to the current and the distance from the conductor.

You can thus visualize a current-carrying wire (**Fig Aa**) surrounded by magnetic-field lines. The unbounded field diminishes with distance from the wire. A wire's inductance is defined as the energy stored in the field set up by the wire's current. Computing the inductance requires integrating the field over the wire's length and the total radial area of the field.

The inductance calculation implies integrating the magnetic field on the radial line from the wire's radius to infinity. However, consider **Fig Ab**, in which two parallel wires in space carry the same current in opposite directions. The fields essentially cancel, and the inductance in this case is much lower than in the case of the single wire. You can make this inductance arbitrarily small by reducing the dis-

tance between the two wires.

The reduction of inductance between current-carrying conductors is the underlying operating principle of ground planes. In a normal circuit, the path that a current takes from its signal source, through a conductor, then back to ground includes a large loop area. The loop area gives rise to a high inductance for the conductor, thereby producing ringing because of tank-circuit effects. It's worth noting that 10 nH at 100 MHz has an impedance of 6.3Ω , so a mere 10 mA produces a 63-mV drop.

A ground plane provides a return path directly under the signal-carrying conductor, a path through which return currents can flow. Thanks to the small separation of the conductors, the inductance is low. The return current has a direct path to ground, regardless of the number of branches associated with the conductor. Currents always flow through the return path of lowest impedance. In a properly designed ground plane, this path is directly under the signal conductor.

In a practical circuit, it's desirable to make a ground plane of one entire side of the pc card—usually the component side, for wave-soldering considerations—and run the signal conductors on the other side. This technique provides a low-impedance path for all return currents.

There are some practical hints about ground planes.

- On the component side of the board, devote as much

area as possible to a ground plane (especially under traces that operate at high frequencies).

- Mount components that conduct substantial fast-changing currents as close as possible to the board. Such items include termination resistors, ICs, transistors, and decoupling capacitors.
- Where common ground potential is important (eg, at comparator inputs), try to ground the components at one point on the ground plane, thereby avoiding ac drops.
- Keep trace lengths short. Inductance varies directly with length, and no ground plane provides perfect cancellation.

In the circuit in **c**, for example, good practice dictates that, insofar as possible, grounds 2, 3, 4, and 5 connect to one point. Fast-changing, large currents must flow through R_1 , R_2 , D_1 , and D_2 during the D/A converter's settling time. You should thus mount these components close to the ground plane, thereby minimizing their inductance.

R_3 and C_1 carry no current, so their inductance is of minor importance. You could insert them vertically to save space and to allow point 4 to more easily share a single-point ground with points 2, 3, and 5. In critical circuits, you must often trade the beneficial effects of lowered inductance for the loss of a single-point ground.

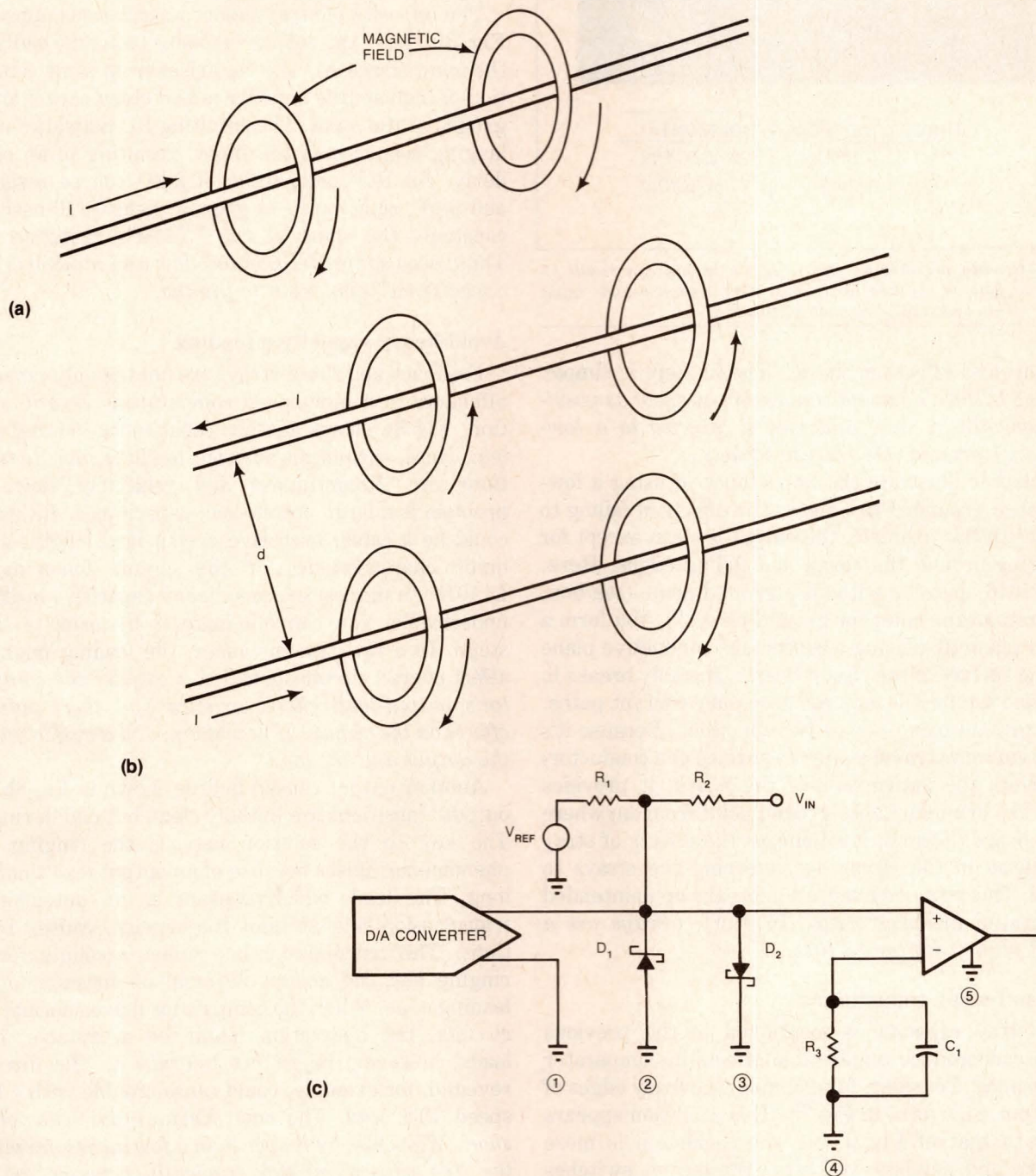


Fig A—Not a convenience, but a necessity: Ground planes are essential in high-speed circuitry. They minimize inductance by cancelling the magnetic fields generated by currents in conductors. The diagrams in **a** and **b** show the fields and cancellation thereof. In the circuit example in **c**, it's important to provide a single-point ground for the components carrying fast-switching currents.

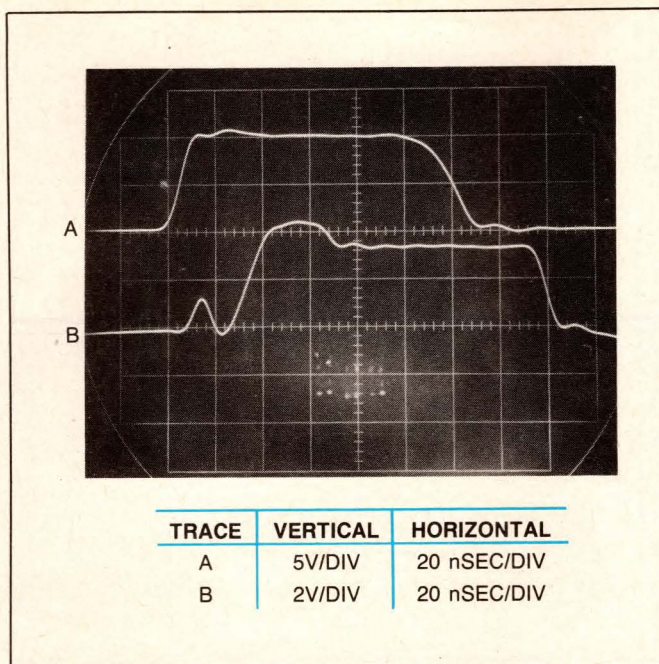


Fig 10—Grossly overdriving the LT1016's inputs can result in output aberrations, as seen in trace B. Keep common-mode input voltages within spec-sheet limits at all times.

ing undesired effects in the IC. The fix here is simple: *Keep the LT1016's ground connection as short as possible (typically 1/4 in.), and run it directly to a low-impedance ground. Do not use sockets.*

To further illustrate the importance of using a low-impedance ground, **Fig 6** shows the effects of failing to use one. In this example, the output is clean except for chattering around the rising and falling edges. Here, the LT1016 operates without a ground plane (see **box**, "Understand the rules for ground planes"). You form a ground plane by placing a continuous conductive plane over the surface of the circuit board. The only breaks in this plane are for the circuits' necessary current paths.

The ground plane serves two functions. Because it's flat (ac currents travel along the surface of a conductor) and covers the entire area of the board, it provides access to a low-inductance ground point from anywhere on the board. Second, it minimizes the effects of stray capacitance in the circuit by referring the strays to ground. This stray neutralization breaks up unintended and harmful feedback paths. In short, *always use a ground plane with the LT1016.*

Effects of stray capacitance

The stray capacitance mentioned in the previous section can produce undesirable effects in comparator performance. Consider, for example, the fuzzy edges of the output waveform in **Fig 7a**. This condition appears similar to that of **Fig 6**, but the oscillation is more stubborn and persists well after the output switches low. The cause is stray capacitance from the comparator's outputs to its inputs. A 3-k Ω input-source impedance and 3-pF stray-capacitance feedback allowed this oscillation. The solution for this condition is not difficult: *Keep source impedances as low as possible (pref-*

As the operating speed of circuits increases, proper grounding becomes more important. It's crucial to minimize series inductance and resistance.

erably ≤ 1 k Ω). Route output and input pins and components away from each other.

The opposite of stray-induced oscillations appears in **Fig 7b**. Here, the output response (trace B) badly lags the input (trace A). The lag arises from some combination of high source impedance and stray capacitance to ground at the input. The resulting RC network forces a lagging response at the input, resulting in an output delay. An RC combination of 2-k Ω source resistance and 5-pF capacitance to ground yields a 10-nsec time constant—the same as the LT1016's response time. Thus, *keep source impedances low and minimize stray capacitance from input to ground.*

Avoid heavy capacitive loading

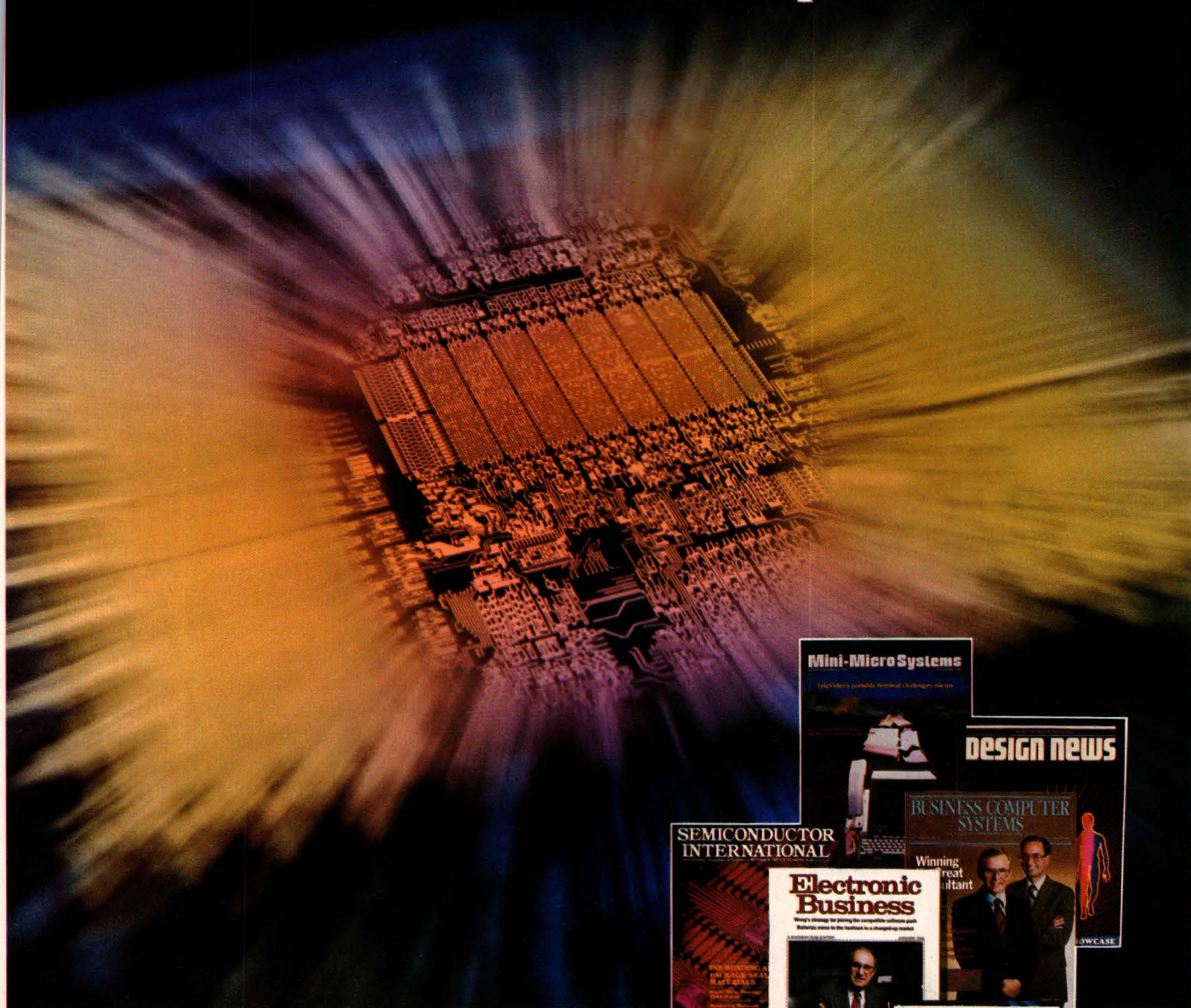
Feedback and shunt strays are not the only capacitive offenders in a high-speed comparator's erratic operation. **Fig 8a** shows another capacitance-induced problem. Here, the output does not oscillate, but its transitions are discontinuous and relatively slow. The problem is a large output-load capacitance. Its genesis could be a cable, excessive output-lead length, or the input characteristics of the circuit following the LT1016. In most situations, heavy capacitive loading is undesirable; you can eliminate it by using a buffer stage. In a few circumstances, the loading might not affect overall circuit operation. *Consider the comparator's output-load characteristics and their potential effects on the circuit. If necessary, add a buffer between the output and the load.*

Another output-caused fault is shown in **Fig 8b**. The output transitions are initially clean but end in ringing. The key to the solution here is the ringing. The phenomenon arises because of an output lead that's too long. The lead, which appears as an unterminated transmission line at high frequencies, causes reflections. The transmission-line effect accounts for the ringing and the abrupt reversal of direction on the leading edge. When the comparator drives normal TTL circuits, the aberration might be acceptable; other loads, however, might not tolerate it. The direction reversal, for example, could cause trouble with a high-speed TTL load. The rule: *Keep output lead lengths short. When they're longer than a few inches, terminate the line with a resistor (typically between 200 and 500 Ω).*

Another aspect of the LT1016's TTL outputs is that you must sometimes shift the levels of the output-voltage swing. In LT1016-based circuits, this task is not trivial; it's necessary to maintain very low delays in the

Cahners Means Business

In Electronics & Computers



The electronics and computer market has doubled in size since 1978. And it will double again by 1987. It takes a lot of circulation to reach all of the important buying influences in this very complex, fast-growing market. Cahners publishes eight magazines in the electronics and computer fields. These magazines have a combined circulation of over 650,000. Each magazine serves a well-defined, important segment of the electronics and computer market, and is recognized as a prime source of information on the technology and products in its field. Last year we sent out over 3.4 million sales leads from our readers to advertisers in our electronics and computer magazines. Cahners means business. That's why we're the first choice of American business in magazines for electronics and computers.

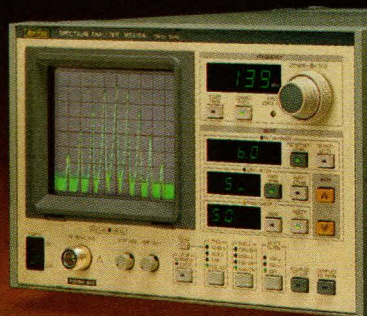
Cahners Publishing

33 Specialized Business Magazines for Building & Construction, Electronics & Computers, Foodservice, Manufacturing, and Health Care.

EDN June 13, 1985



Photo: Varian Associates, Inc.



MS610A



MS710A

Two of Anritsu's Best Ideas To Cut Testing Time

MS710A Spectrum Analyzer
For fewer errors, an internal tracking pre-selector keeps distortion down. And peak signal search and half-screen shift let you locate the desired signal spike sooner.

The MS710A covers the entire spectrum from 100kHz to 23GHz, so there's no need to overload your bench with instruments.

And it's ergonomically designed for no eyestrain and fewer headaches in operation. Push-buttons handle signal averaging for noisy or low-amplitude signals. And digital storage keeps the display flicker free.

MS610A Spectrum Analyzer
The MS610A automatically sets all measurement conditions at optimum values — you just set frequency, reference level, and frequency span. And that saves you time *and* cuts errors in measurement. Two keys, COUPLED TO REF, and COUPLED TO SPAN, set all measurement parameters, so fewer dial operations are required.

And like the MS710A, it's smaller and more portable than ever. So you get full console performance in a personal, portable tester.

The test of the best is still the name Anritsu. Contact Anritsu today for more information.

Anritsu

ANRITSU ELECTRIC CO., LTD. 10-27, Minamiazabu 5 chome, Minato-ku, Tokyo 106, Japan Phone: (03) 446-1111/Telex: 0-242-2353 **ANRITSU ELETRÔNICA S.A.** Av. Passos, 91-Sobrelôjas 204/205-Centro, 20.051-Rio de Janeiro-RJ, Brasil Phone: 221-6086, 224-9448 Telex: 2131704 ANBR **ANRITSU AMERICA, INC.** 128 Bauer Drive, Oakland, NJ 07436, U.S.A. Phone: 201 337-1111 Telex: 642-141 ANRITSU OKLD **ANRITSU EUROPE LIMITED** Thistle Road, Windmill Trading Estate, Luton, Beds, LU1 3XJ, U.K. Phone: (STD0582)418853 Telex: 826750 ANRSEU G **ANRITSU ELEKTRONIK GmbH** Uhlrandstrasse 9, 4000 Düsseldorf 1, F.R. Germany Phone: (0211) 682424 Telex: 8584904

Beware of such stray-reactance problems as feedback or shunt capacitance and series inductance. Such unwanted circuit terms can cause ringing, oscillation, or worse.

level-shifting stage to obtain optimum performance. When you design level shifters, keep in mind that the comparator's output stage is a sink-source pair (**Fig 9a**) with a reasonable ability to drive capacitance (eg, feed-forward capacitors).

Fig 9b shows a noninverting voltage-gain stage with a 15V output. When the LT1016 switches, the 2N2369's base-emitter voltage reverses, causing the transistor to switch very rapidly. The 2N3866 emitter follower affords a low-impedance output; the Schottky diode aids the circuit's current-sinking capability. **Fig 9c** shows a very versatile stage. It offers a bipolar swing whose levels you can program by varying the output transistor's supplies.

The 3-nsec stage is ideal for driving FET-switch gates. Q_1 , a gated current source, switches the Baker-clamped output transistor, Q_2 . The heavy feed-forward capacitor from the LT1016 is the key to low delays; it

provides Q₂'s base with nearly ideal drive. This capacitor loads the LT1016's output (**Fig 9e**, trace A), but Q₂'s switching is clean (trace B) and exhibits 3-nsec delay in its rising and falling edges.

The circuit in **Fig 9d** is similar to that in **Fig 9b**, except that a sink transistor replaces the Schottky diode. The two emitter followers drive a power MOSFET that switches 1A at 15V. Most of the 7- to 9-nsec delay in this stage occurs in the MOSFET and the 2N2369. *When designing level shifters, remember to use transistors with high switching speeds and high f_T s.* To obtain results like the ones in these examples, you'll need switching times in the 2-nsec range and f_T s approaching 1 GHz.

A final example of environment-induced maladies is shown in **Fig 10**. These waveforms are reminiscent of the input-RC-induced delay of **Fig 7b**. The output waveform initially responds to the input's leading edge,

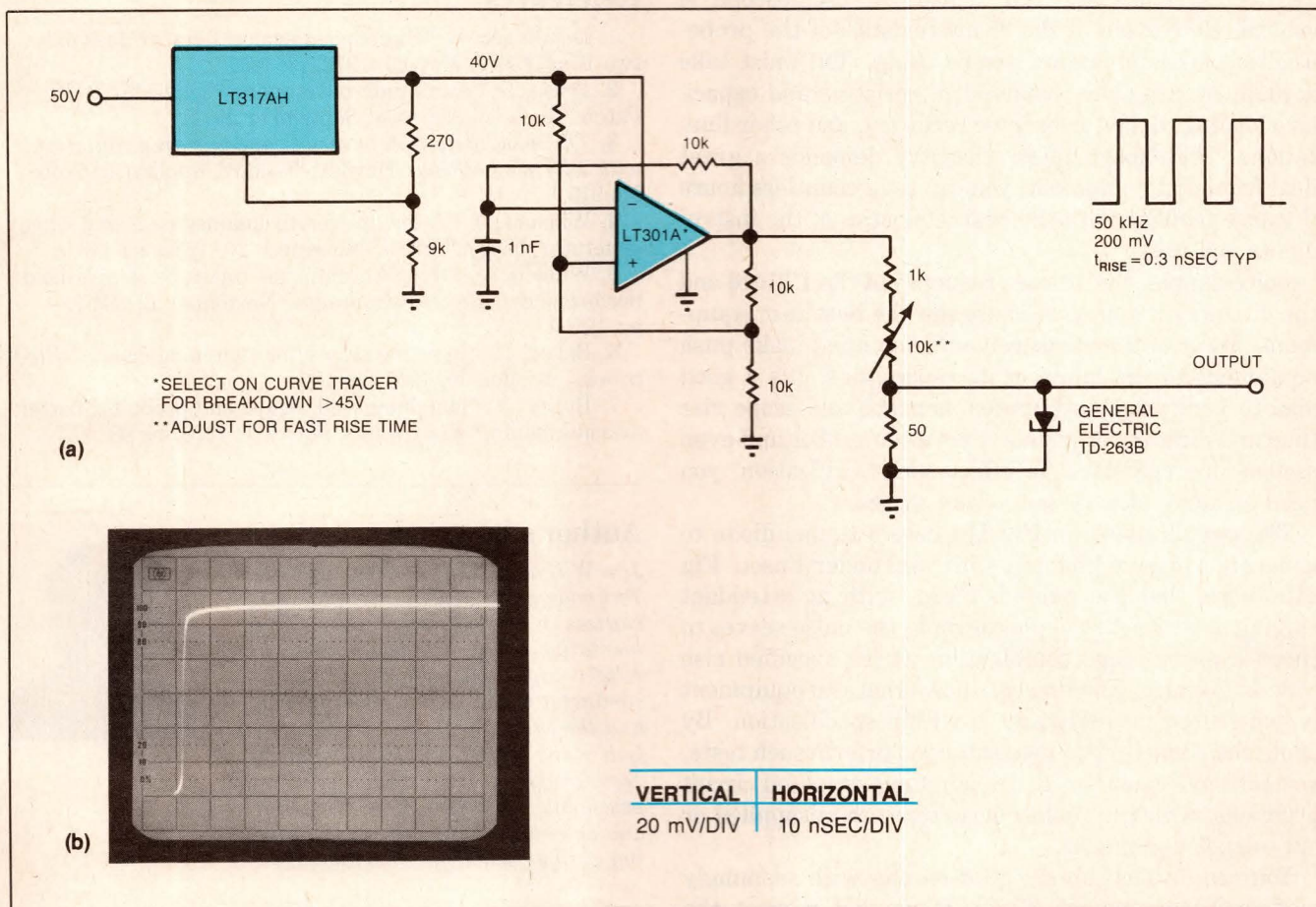


Fig 11—Be sure of your input pulses when measuring the response of your equipment. The circuit in **a** uses a tunnel diode to generate very clean pulses with rise times much lower than 1 nsec (**b**).

Respect a high-speed comparator's data sheet with regard to such parameters as common-mode input range and capacitive-load ability.

but then returns to zero before switching high again. When it does switch high, it slews slowly. Other odd characteristics include pronounced overshoot and pulse-top aberration. The fall time is also slow, and it's well delayed from the input. This behavior is certainly unusual for a TTL output.

All of these TTL-output anomalies are caused by the input pulse. Its 10V amplitude is well outside the 5V-powered LT1016's common-mode input range. Internal input clamps prevent such a pulse from damaging the comparator, but an overdrive of this magnitude invariably results in poor response. *Keep input signals within the LT1016's common-mode input range at all times.*

Verify equipment response

Although some of the examples described earlier dealt with probe-caused problems, oscilloscopes, too, can be troublesome. Your choice of oscilloscope is crucial. Be certain of the characteristics of the probe-oscilloscope combination you're using. You must take account of rise time, bandwidth, resistive and capacitive loading, delay, overdrive recovery, and other limitations. High-speed linear circuitry demands a great deal from test equipment; you can save countless hours if you're familiar with the characteristics of the instruments you use.

For example, the 10-nsec response of the LT1016 and the circuitry it's used in challenge the best test equipment. Many of the measurements you must make push equipment to the limits of its capabilities. It's a good idea to verify such attributes as probe and scope rise time and differences in delays between probes and even oscilloscope channels. To effect such verification, you need a source of very fast, clean pulses.

The circuit shown in Fig 11a uses a tunnel diode to generate a pulse with a rise time well under 1 nsec. Fig 11b shows that the pulse is clean, with no attendant ringing or noise. In the photograph, the pulse serves to check a probe-scope combination whose specified rise time is 1.4 nsec. The display shows that the equipment is being used properly and is within specification. By using the tunnel-diode generator to perform such tests, you can save countless hours pursuing supposed circuit problems, which in reality arise through misapplied or out-of-spec equipment.

You can, in fact, obtain good results with seemingly inadequate equipment if you know and respect the equipment's limitations. All the applications to appear in the two follow-on articles involve rise times and

delays that correspond to frequencies that are greater than 100 or 200 MHz, but 90% of the development work was accomplished with a 50-MHz oscilloscope. Familiarity with equipment and thoughtful measurement techniques permit useful measurements that are seemingly beyond instrument capabilities.

A 50-MHz oscilloscope, for example, cannot track a 5-nsec rise-time pulse, but it can measure a 2-nsec delay between two such events. Using such techniques, you can often deduce the desired information. There are situations, though, where no amount of cleverness will work, and you must use the right equipment (eg, a faster oscilloscope). In general, *use equipment you trust and measurement techniques you understand. Keep asking questions and don't be satisfied until everything on the oscilloscope makes sense.* **EDN**

References

1. Dendinger, S, "High-speed analog sampler uses only two ICs," *EDN*, May 20, 1977, pg 128.
2. Pease, R, "Amplitude-to-frequency converter," US Patent No 3,746,968, filed September 1972.
3. *Threshold detection of visible and infrared radiation with PIN photodiodes*, Hewlett-Packard Application Note No 915.
4. Williams, J, "A few proven techniques ease sine-wave-generator design," *EDN*, November 20, 1980, pg 143.
5. Williams, J, "Simple techniques fine-tune sample-and-hold performance," *Electronic Design*, November 12, 1981, pg 235.
6. Baker, R, "Boosting transistor switching speed," *Electronics*, Volume 30, 1957, pg 190.
7. Bunze, V, "Matching oscilloscope and probe for better measurements," *Electronics*, March 1, 1973, pg 88.

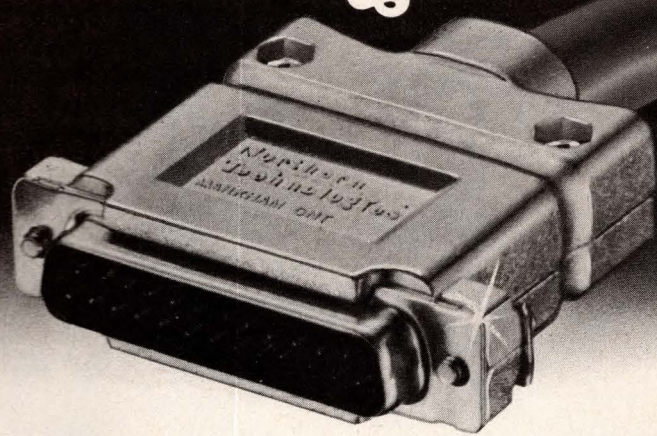
Author's biography

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 473 Medium 474 Low 475

Northern Technologies. The most trusted name in FCC Shielding



Metalized Plastic and Metal

When it comes to far exceeding the requirements of FCC regulation 20780, major OEM's specify Northern Technologies first, for the new standard in both metal and metalized plastic connector covers. Available in 9, 15, 25, 37 and 50 position.

Higher Performance

Both the metal and metalized plastic connector covers utilize the same proprietary Nortech™ Shielding System. The performance secret is in the unique Nortech™ compression inserts which seal the cable so tightly so as to virtually eliminate EMI/RFI emissions. The result is the higher performance by Northern Technologies Inc. as illustrated in an independent test on shielding effectiveness.

Aggressive Pricing

High volume automated production facilities give Northern Technologies the pricing edge in the industry worldwide.

Reduced Inventory

Every connector cover comes with a complete set of compression inserts that accommodate a wide range of cable diameters. Custom inserts are also available for your special applications. This one-size-fits-all concept was engineered to simplify inventories and minimize stocking requirements.



Industry Compatibility

Northern Technologies connector covers are compatible with all major manufacturers D-subminiature connectors. And they can accommodate a wide variety of braided or foil shielded cables.

Size	Cable Diam. Range	Part Number	
		Metal	Metalized Plastic
9	(.190-.350)	C88000218	C88201000
15	(.190-.350)	C88000207	C88211000
25	(.190-.460)	C88000203	C88221000
37	(.300-.680)	C88000206	C88231000
50	(.300-.680)	C88000208	C88241000

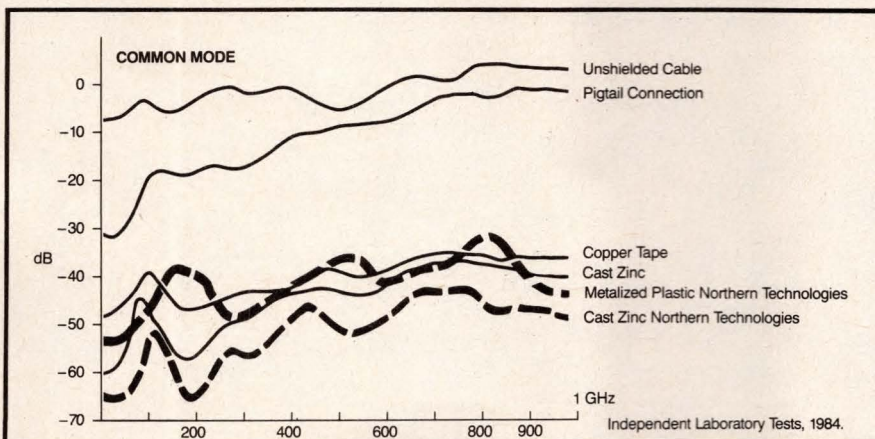
Custom Logos

Your custom logo can be applied upon request, unlabelled product is available from stock for immediate shipment.

Plastic Too!

For fast, easy-to-assemble, plastic D-subminiature connector covers that can accommodate many cable diameters. Ask about Northern Technologies complete line of plastic covers.

Call today for free samples and information on the industry's highest performance connector covers.



• Concord, MA (617) 371-0915 • San José, CA (408) 275-6170 • Canada (416) 475-9123

Copyright ©1984, 1985 Northern Technologies Ltd. The Nortech™ System is a trademark of Northern Technologies Ltd. *The compression insert(s), covers, insert system, and multiple compression inserts on a tree are proprietary to and copyright of Northern Technologies Ltd. Canadian Patent #1181504, U.S. patents pending. Northern Technologies Ltd. is a wholly-owned manufacturing subsidiary of Lanpar Technologies Inc. Specifications subject to change without notice.

LANPAR

Service for Life. Guaranteed.™
CIRCLE NO 75

**VOICE PRINT
REQUIRED**



AN INVITATION TO EXPLOIT JAPAN'S MOST CAREFULLY GUARDED TECHNOLOGICAL SECRETS.

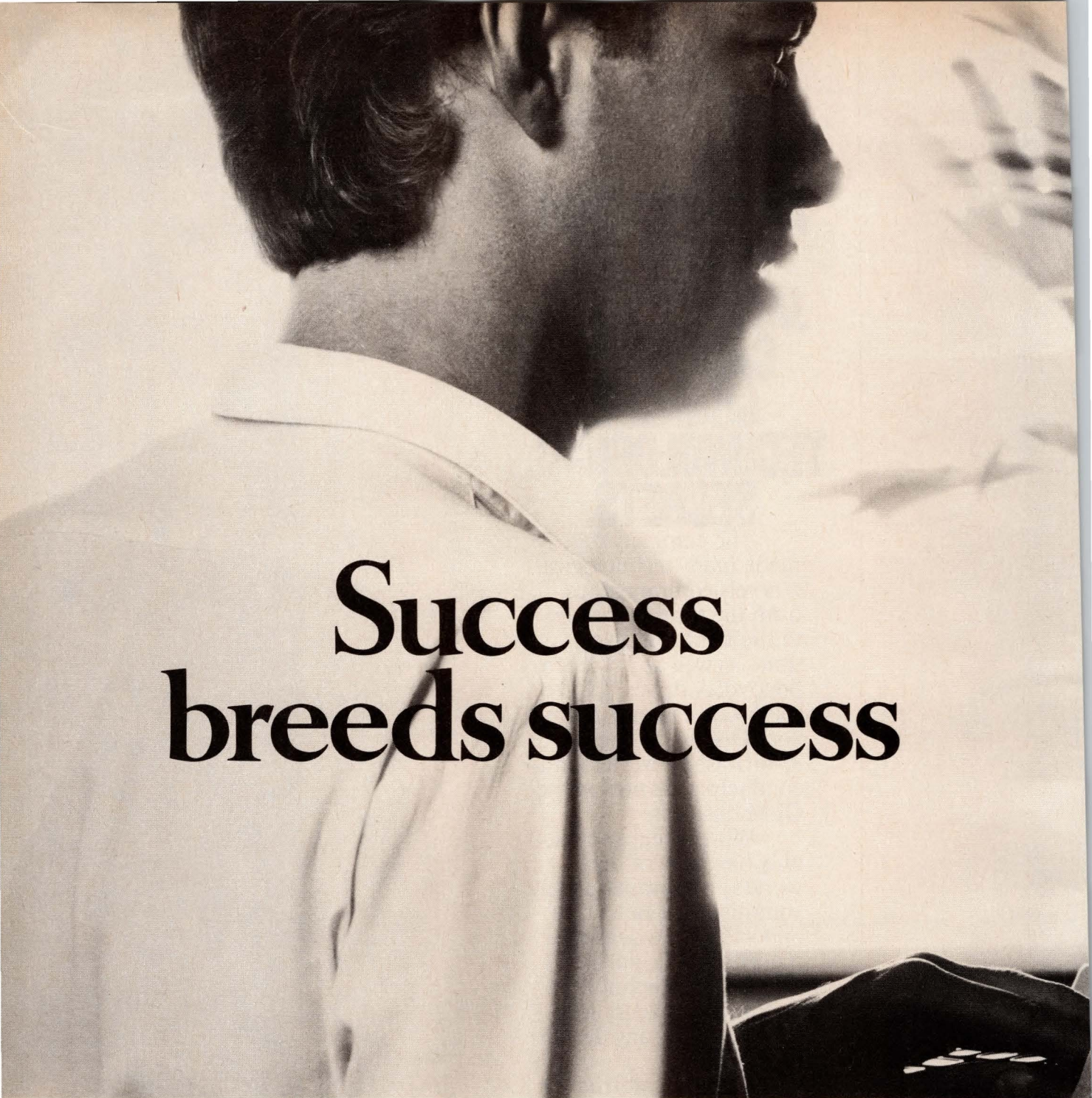
The company that made many technological marvels commonplace, from the transistor radio to the Trinitron® television—as well as 3.5" micro floppydisk drives, CCD solid state cameras, Compact Disc ROM's, and 10-bit flash converter semiconductors—is now in the OEM business.

Which means you not only have one of the world's great brain trusts at your disposal. But a rare opportunity to develop a most profitable partnership with a company ready, willing and able to help solve virtually any design problem.

For more information on how to exploit Japan's most sought-after technological resource, write to Mr. Kevin Finn, Sony Component Products Division, 15 Essex Road, Paramus, New Jersey 07652.

© 1985 Sony Corporation of America. Trinitron and Sony are registered trademarks of Sony Corp.

SONY
Component Products Division



Success breeds success

It seems that every IC company in the world offers a semi-custom service.

So why choose Plessey?

Well, as a major supplier of semi-custom ICs, we can offer a track record of success and experience few others can match. In every area of application, including telecoms, robotics, business computers and data processing, we've consistently achieved a high first-time success rate. In fact, the chances of you not getting it right first time with Plessey are exceptionally low.

How do we do it?

In a word, accessibility. We offer a range of options that gives you maximum access to our semi-custom programs from day one.

A simple low-cost terminal is all you need to key into one of our software suites: proven interactive simulation programs for you to run in your own time, on your own premises. And of course you can call in on our Design Rooms any time you need help or product testing.

But, if you prefer to use our facilities, we have Design Rooms at

At a glance Plessey semi-custom

- Choice of cell-based or gate array techniques.
- High first-time success rate.
- Comprehensive low-cost software support for interactive simulation.
- Full bureau service.
- Total manufacturing capability.
- More performance from a given chip.



our UK headquarters in Swindon, in
Munich and in Irvine, California.

This includes access to
the best test unit in the
business, the Teradyne J941.
(At a cost of nearly \$1 million
it should be.)

Our semi-custom
routine means that we'll
supply you with an end result
that's testable, workable and
manufacturable, in just a few
working weeks.

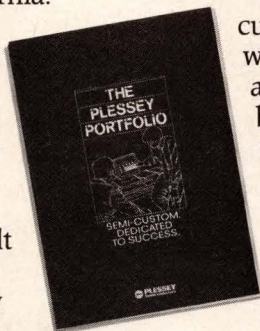
With all the options to choose
from we'll never force you into a

non-optimum solution.

So, whichever semi-
custom option you choose,
whether cell-based or gate
array, the end product will
be every bit as advanced as
the design techniques.

If you feel the semi-
custom service you're
using now is only giving
you half the story, send
for the Plessey Semi-
Custom Portfolio.

If you're ready for success so
young, that is.



Plessey Semiconductors Limited,
Cheney Manor, Swindon, Wiltshire,
United Kingdom SN2 2QW.
Telephone: Swindon (0793) 36251.
Telex: 449637.

USA Irvine, Calif. (714) 951 5212.

Benelux Brussels (02) 733 9730.

France Les Ulis (6) 446 23 45.

Italy Milan (02) 345 20 81.

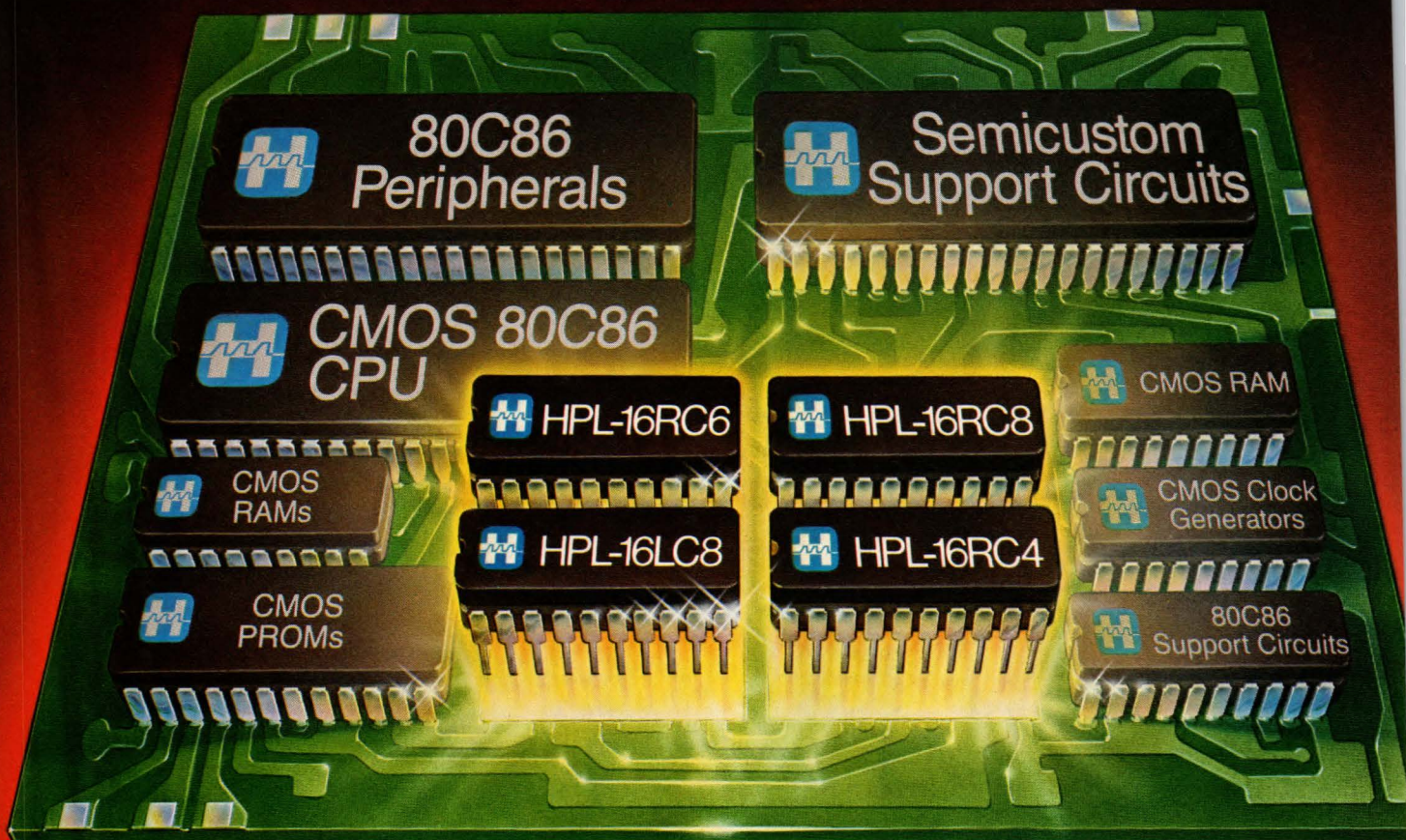
West Germany Munich (089) 23 62-0.

 **PLESSEY**
In a word, success

PLESSEY and the Plessey symbol are Registered Trade Marks of The Plessey Company plc.

CIRCLE NO 68

HARRIS PROGRAMMABLE LOGIC



We've solved the total CMOS system puzzle with a perfect-fitting family of CMOS HPLs™.

Now Harris gives you low-power programmable logic to tie your CMOS system together.

New CMOS HPLs from Harris move your designs to a higher level of integration by replacing multiple SSI/MSI devices with a single logic circuit with on-chip test circuitry.

These static CMOS HPLs are pinout and function-compatible with bipolar HPL/PALs™ yet draw only 5% of the power.

Their cooler operation allows you to shrink board size by eliminating fans and vents, and reducing power supply requirements.

And all HPL products feature VOCAL™ (patent pending) — exclusive Verification of On-Chip Array Logic — that gives you complete AC/DC and functional testing of blank devices. This can eliminate the need for exhaustive post-programming vector testing.

They're the logical first choice in harsh environment applications, in portable battery-operated systems, in all your low-power/sealed-enclosure applications.

Why wait to complete your total CMOS system designs. CMOS HPLs are available now to give your system the perfect fit.

Harris CMOS HPLs

Part Number	Pin Configuration	Supply Current (mA)	Product Highlights
HPL-16LC8	Replaces 16L8, 16P8, 10L8, 10H8	5 mA/MHz	• CMOS/TTL Compatible
HPL-16RC4*	Replaces 16R4, 16RP4	5 mA/MHz	• Programmable Output Polarity
HPL-16RC6*	Replaces 16R6, 16RP6	5 mA/MHz	• 5 mA Output Drive (IOH, IOL)
HPL-16RC8*	Replaces 16R8, 16RP8	5 mA/MHz	

*Available Q1 1985.

Harris CMOS HPLs are supported by H.E.L.P.™ — Harris Enhanced Language for Programmable Logic — the first easy-to-use programmable logic support software.



For full details, contact: Harris Systems Ltd., European Semiconductor Operations, Eskdale Road, Winnersh Workingham, Berkshire RG11 5TR, England.

Harris Semiconductor: Analog - Bipolar Digital
CMOS Digital - Gallium Arsenide - Semicustom - Custom

H.E.L.P., HPL and VOCAL are trademarks of Harris Corporation
PAL is a registered trademark of Monolithic Memories, Inc.



For your information, our name is Harris.

CIRCLE NO 69

Input vectors drive simulation of logic-array designs

To evaluate logic-array designs correctly, logic simulators require accurate input vectors. You must generate the appropriate vectors to verify your logic's functionality and to determine dynamic operation, performance margins, and critical timing constraints like setup and hold times.

Michael Franz, Applied Micro Circuits Corp

In logic-array design, the input signals are as important to determining the behavior of the circuit as the logic diagram is. These input signals, when used as simulation vectors and test vectors during the design phase, serve as a design specification and as a means of verifying and testing a design. Consequently, they must be as correct as the logic design before you can be confident that your physical implementation operates as intended.

This article is the first of a 2-part series for designers who are beginning to use logic simulators and automatic test equipment (ATE) for the design and testing of logic arrays. This installment discusses logic-array requirements for input vectors to logic simulators, requirements that are similar to those for pc-board-level designs. Part 2 (scheduled for EDN's June 27 issue) will

examine issues of logic-array testing and the generation of correct test vectors, using functional simulation vectors as a starting vector set.

Simulation vectors allow you to establish the functional and timing integrity of a design. They drive a circuit through all intended logic functions, at or above the specified clock or data rate, to verify that it's functionally and dynamically in agreement with the designer's intentions. The primary tool for functional and timing verification is the logic simulator, a program that runs on an engineering workstation or mainframe computer.

In contrast, test vectors are used to verify that a chip is free of defects. The dynamic stimulation of a circuit by a tester is subject to constraints that don't affect a logic simulator. Testers have a limited test frequency that's slower than the operating speeds of many systems and chips. Also, inputs to the circuit being tested inevitably experience skew that can be attributed to pin-electronic drift and differences in the signal paths to the device under test. Finally, completeness of test vectors is important, because the primary objective for the design of test vectors is high fault coverage rather than functional verification.

Simulator needs net list for vectors

To examine the performance of a logic design, the logic simulator first needs a description of the design and then a set of input signals, collectively called input vectors, that describe how the environment outside the

To evaluate a circuit's function, a logic simulator needs both a circuit description and a set of input signals emulating the circuit's environment.

design stimulates the logic. On the simulator's computer, you generate the description of the design, called a net list, using building blocks that the simulator can interpret. The blocks are either simple logic units (such as 2-input NOR gates), which are directly understood by the simulator, or hierarchical constructs thereof, which are stored in software libraries. For logic arrays, these building blocks are called macros, and the hierarchical constructions are called structural models because they describe the internal structure of a particular circuit function.

Advanced logic simulators also accept functional macro models, for which a detailed knowledge of the constituent parts of building blocks is no longer required. The macro model characterizes the macro as a black box with functional and timing relationships between its inputs and outputs. This functional description is also referred to as a behavioral model.

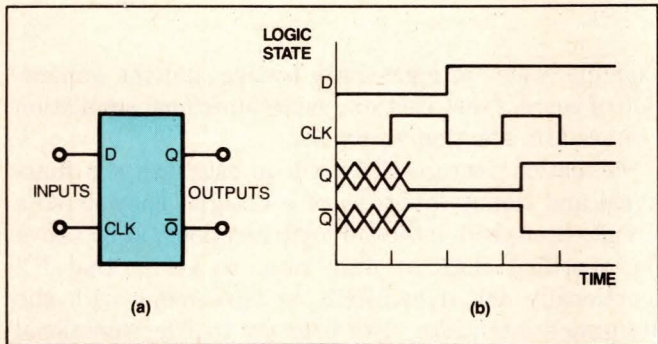


Fig 1—The waveform format for simulation vectors is familiar to most designers; it resembles the visual display of a logic analyzer. For this D flip-flop (a), the simulation vectors (b) toggle the outputs to high and low states.

You define the second input to the simulator, a description of the input stimuli that exercise the circuit, using signal states. The choice of states available to express inputs depends on the particular simulator. These states are an abstraction of the actual electrical quantities that represent logical states in the circuit. The most common set contains zero and one as logic states, X as the unknown state, and Z as the high-impedance state. Two other states, U (up transition) and D (down transition), are useful in timing simulations.

Moreover, states may have associated levels of strength, such as forcing, resistive, and high impedance. Strengths reflect the different driving capabilities of actual devices in physical circuits; for example, passive pull-up transistors on a bus structure have a resistive strength.

The simulator determines the behavior of the circuit

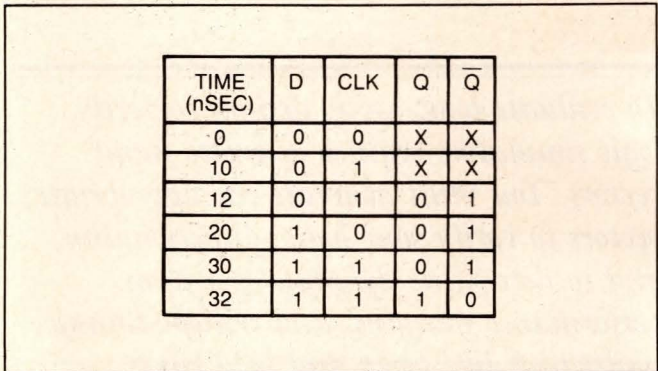
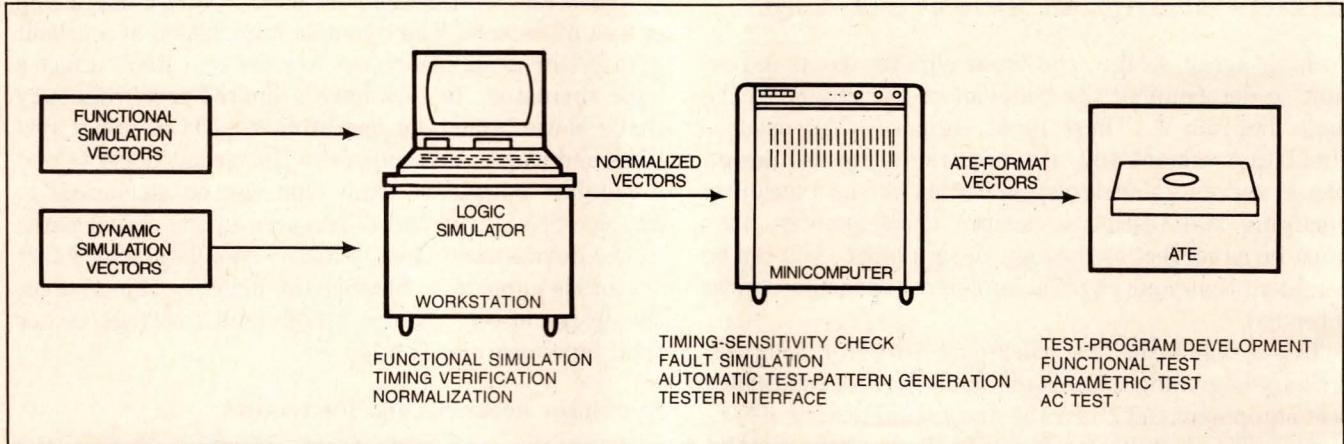


Fig 2—A tabular format for simulation vectors is more compact than the waveform representation. This table shows the vectors for the flip-flop in Fig 1.



The process of vector development begins on an engineering workstation, where you enter the functional and dynamic vector sets according to the verification needed for your logic design. You must normalize the vectors before checking timing sensitivity and simulating faults on a minicomputer or mainframe. A tester interface writes the vectors in a format compatible with ATE, and you download the vectors to the ATE for inclusion in the test program.

described in the net list by applying the input stimuli, called simulation vectors, to the inputs of macros. Based on the states and strengths of the input vectors, the macro models then assign the appropriate signals to their own outputs. In this way the simulator propagates the effect of the input vectors through the circuit to the primary outputs of the net list. Signal delays internal to the macros, as well as between the macros, can be incorporated and manipulated for worst-case simulation. You can observe any node in the circuit during the

simulation, facilitating the tracing of errors.

To write the vectors so that the simulator will understand them, you must adopt a particular format. Simulation vectors are commonly expressed in one of two formats. **Fig 1** shows a typical waveform format for a set of simulation vectors that might be used to exercise a D flip-flop. D and CLK are inputs to the flip-flop, and Q and $\bar{Q}$ are expected output values. This format resembles that of a logic analyzer and is thus easily interpreted by designers. It's good design prac-

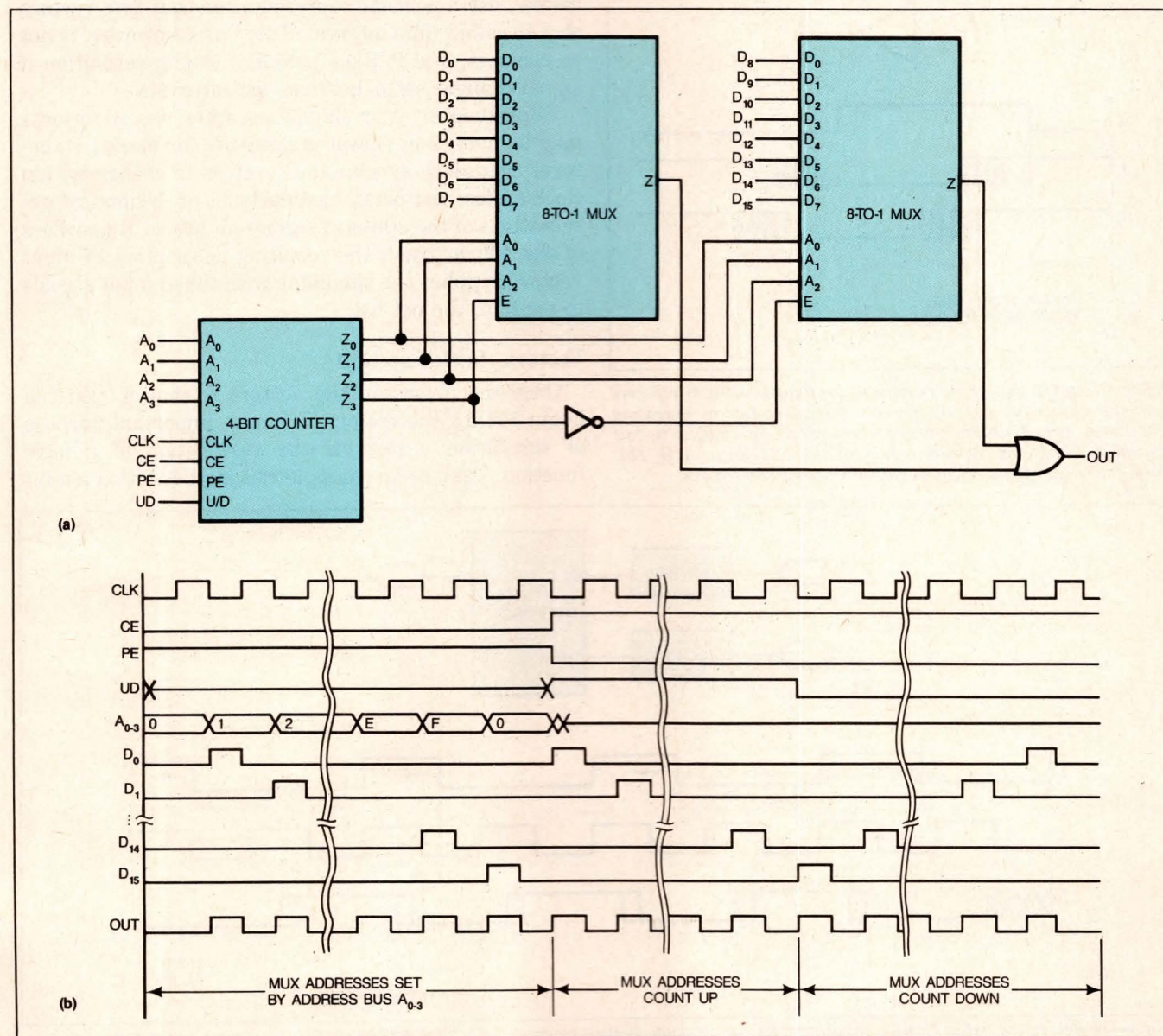


Fig 3—A circuit example (a) illustrates how a verbal description forms the basis for simulation vectors (b). The counter selects one of the data lines D₀₋₁₅ either by latching in the address at A₀₋₃ or by counting up or down.

Signal strengths allow a simulator to model the varying driving capabilities of different types of devices, such as passive pull-up transistors.

tice to develop expectation values for outputs during the vector-design process and then compare these values with simulated outputs.

The waveform format lends itself well to detailed timing development. It's not very compact, however. For a typical design, many waveforms would be required to describe a complete set of simulation vectors. A denser format is the listing of vectors in tabular form, shown in Fig 2 for the same flip-flop.

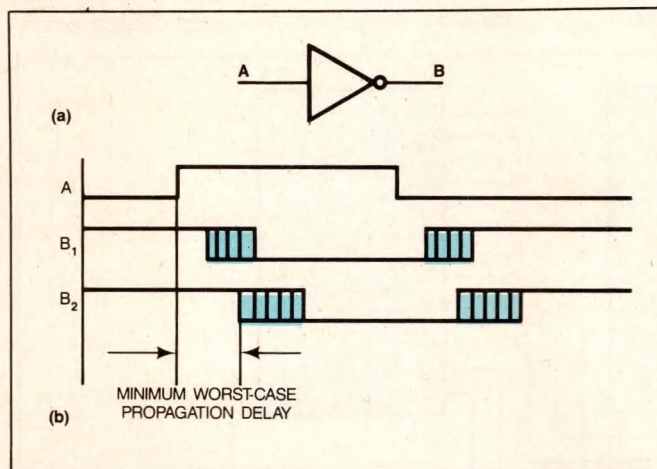


Fig 4—Circuit delays cause regions of ambiguity in the waveforms from the simulator. For an inverter (a) under typical operating conditions, circuit delays cause the transition of node B to fall anywhere within the shaded region in the waveform of B₁ (b). Worst-case operating conditions shift the ambiguity regions.

This format is called the print-on-change format: You add a line for a simulation vector only if one or more signals change. The left column of the table contains the time axis, and the columns under the signal names contain the logic states of the signal names. This tabular description is the most accurate and compact representation of signal timing in vector format, and it's available on most simulators.

One drawback to the print-on-change format is that it distorts the linearity of the time axis. Some designers instead use a periodic representation that lists vectors at a specified time interval. This form, however, is not as compact, and it loses potential timing resolution if signal changes occur between list intervals.

Depending on your simulator, other vector formats may be available: repeat statements for clocks; structures that allow synchronous vectors to change within clock cycles; and octal, hexadecimal, or decimal representations of the states of signals on buses. Regardless of the format used, the resulting description of input vectors supplies the simulator with timed input signals to apply to the net list.

Vectors check function

Once the format of the vectors is chosen, you can begin writing the vectors. The most important purpose of simulation vectors is the verification of a logic function. Take as an example of a logic function a 4-bit

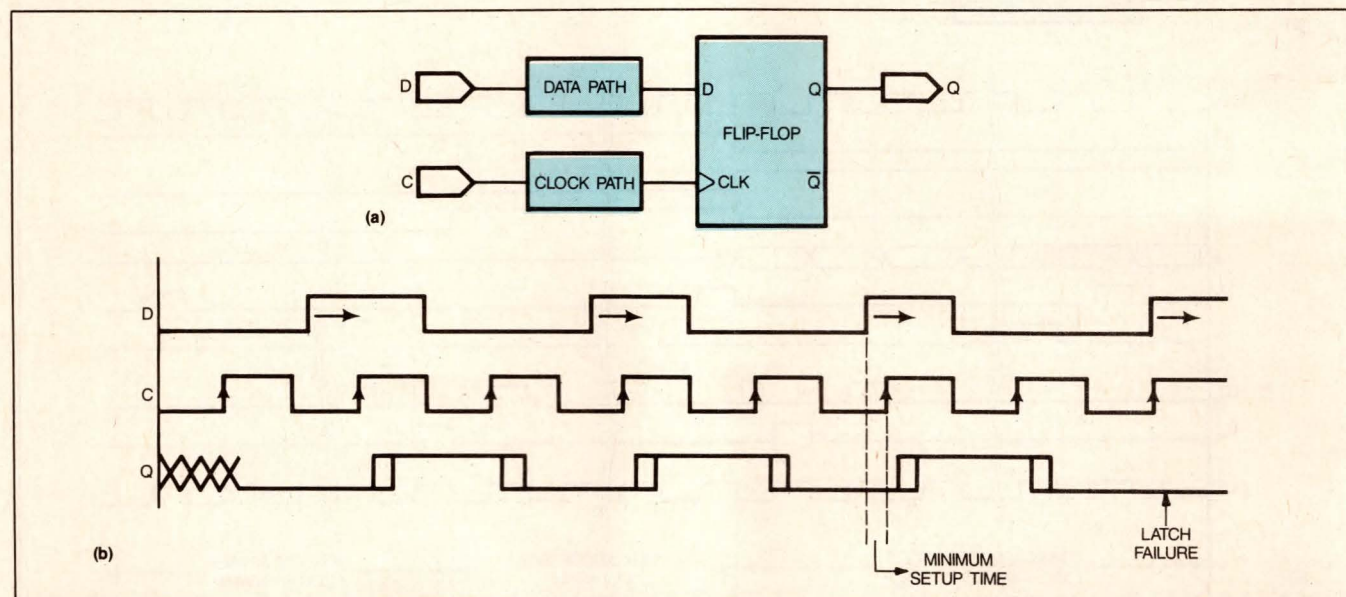


Fig 5—To determine setup timing requirements for internal storage elements, you first determine data and clock paths from primary inputs to those elements (a). Then you iteratively clock the data into the elements; each iteration reduces the amount of time between the data transition and the clock transition. The period between the edges for the last successful storage of data is the minimum setup time (b).

up/down counter that must select the data path of a 16-bit multiplexer, as depicted in Fig 3a.

A verbal description of the circuit's operation forms the basis for the simulation vectors. The outputs of the counter address one of the input data lines (D_0 to D_{15}); the inputs to the counter determine the counter's outputs. For Count Enable $CE=0$ and Parallel Enable $PE=1$, the address inputs at A_{0-3} appear at Z_{0-3} on the rising edge of the clock. When $CE=1$ and $PE=0$, each rising of the clock signal increments ($UD=1$) or decrements ($UD=0$) the value on the Z_{0-3} bus.

Fig 3b shows the associated waveforms for the functional simulation vectors. During the first 16 clock cycles, the mux addresses are set directly by the address bus, A_{0-3} . Then the counter is clocked up and down, selecting each of the addresses in order. A pulse at every addressed data channel verifies that the counter has selected the right channel. At this phase of stimulus development, the timing between inputs should be generous to simplify functional verification. Furthermore, the expected output value does not reflect the propagation delays of the circuit.

Once you're satisfied with your design and your vectors, you enter them into the simulator and start the simulation. You would find that the output in this example doesn't switch at all. You rerun the simulation to display the multiplexer outputs, which do not toggle, and then resimulate again to find that the counter outputs are correct. However, these iterative simulation steps have revealed the bug in the design: The inverter on the Z_3 line is connected to the wrong multiplexer.

This example demonstrates an important rule of thumb for debugging a logic design through simulation. Design errors tend to creep in at design interfaces and during changes in operation mode. Inside a logic array, design interfaces are located between macros that express a particular logic function. In this example, a design interface appears at the division of the 16-bit multiplexer into two 8-bit multiplexers. Consequently, functional vectors should specifically verify behavior at design interfaces. Of course, the regular function should be tested first, but then it pays to determine what happens if a counter turns over, or if the 16-bit multiplexer switches from direct addressing to counted addressing, etc.

Once you establish that your design is functionally correct, you can verify that it satisfies dynamic requirements—system speed, setup times, hold times, and propagation delays. Many logic simulators can verify

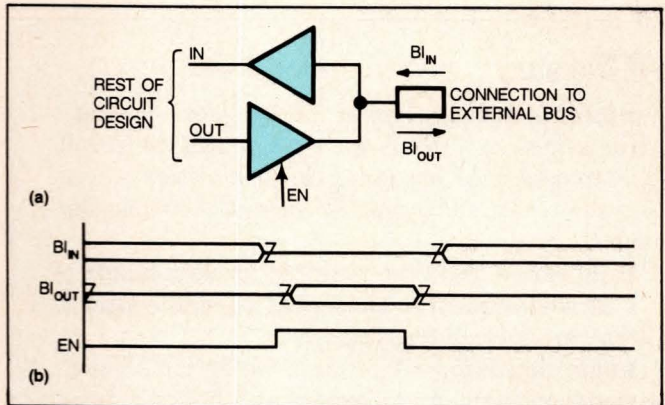


Fig 6—You can avoid bus contention by switching EN at the appropriate interval to prevent the external signal bus and the output buffer from driving the I/O node at the same time. Also include extra time margin to allow for propagation delay.

timing constraints by including delay calculations in the simulation. These simulators can flag violations of the macro's setup, hold, and pulse-width times. They can also simulate transition ambiguity, which is the window of uncertainty between the minimum and maximum delays of a signal path. These logic simulators consider the signal as unknown during the transition period.

Simulator can show delay effects

Fig 4 shows how a simulator can exhibit the effects of circuit delays in a signal path—in this case that of an inverter. For typical operating conditions, output B_1 shows minimum and maximum delay times and the window of switching ambiguity in between. Output B_2 is the same response under worst-case conditions. The difference between the two signals is a consequence of differing operating conditions.

This approach to timing verification takes advantage of the so called "on-chip tracking" effect. The underlying principle of on-chip tracking is that all propagation delays of logic paths on the same chip are affected similarly by the external operating conditions. The dominant influences are temperature and supply voltage. Typically an increase in operating temperature and a decrease in supply voltage (within the specified operating limits) increase propagation delays. Conversely, a decrease in operating temperature and an increase in supply voltage decrease propagation delays. Consequently, under worst-case operating conditions of high temperature and low supply voltage, all paths are going to be slow.

In order to cover all operating conditions, use all three selectable delay ranges: minimum, typical, and

Although waveform formats are easier for most designers to understand, tabular formats are more compact for describing simulation-vector sets.

Glossary

Bus contention—Two or more devices driving the same bus at the same time, which can result in an undefined bus state. In such a state, there is a potential for large I/O currents and considerable signal noise.

Hold time—The time required for data inputs of a clocked sequential element to be stable after a triggering clock transition.

Logic simulator—A program accepting a logic model and simulation vectors as inputs for the purpose of predicting the logic behavior of the model.

Macro—The logic building block on logic arrays. Individual macros are as complex as SSI, MSI, and sometimes LSI components.

Setup time—The time required for data inputs of a clocked sequential element to be stable before a triggering clock transition.

Simulation vectors—A set of timed input stimuli used by a logic simulator to approximate the input signals to a logic model. The simulator uses these vectors to simulate the functional and dynamic behavior of the model.

Test vectors—A set of input stimuli and expectation values that automatic test equipment uses to verify the operation of a circuit.

Timing verifier—A logic simulator that is capable of verifying a logic model's setup and hold times. It can also simulate min-max delay ambiguity.

maximum. The ranges are determined by the operating condition, and the magnitude of each range models the delay variation caused by on-chip processing fluctuations and nonuniform power distribution across the chip. If you verify your design's operation at extreme operating conditions, you gain a high level of confidence in all operating conditions between the extremes.

Generate typical and worst-case delays

You can run a timing-verification simulation for the 16-bit multiplexer described earlier to obtain the propagation delays of the data paths. This simulation can use the existing functional vectors and both typical and worst-case delay values for the design's components. The resulting output vectors show delays for both nominal or worst-case operation, and they also have

ambiguity regions associated with every transition.

Next you can determine the setup and hold times for your design's storage elements. To understand the concept of setup- and hold-time verification more clearly, consider the example shown in **Fig 5**. You can analyze signal paths that have setup- and hold-time requirements by reducing them to a clocked macro (eg, a flip-flop, latch, counters, etc) and a data and clock path.

Mathematically, the setup time measured at the output of the design for given operating conditions is

$$t_{\text{setup,ex}} = t_{\text{setup,ff}} + \max(t_{\text{data}}) - \min(t_{\text{clock}}),$$

and the hold time is

$$t_{\text{hold,ex}} = t_{\text{hold,ff}} + \max(t_{\text{clock}}) - \min(t_{\text{data}}),$$

where $t_{\text{setup,ex}}$ ($t_{\text{hold,ex}}$) is the setup (hold) time, seen at the chip's input pins; $t_{\text{setup,ff}}$ ($t_{\text{hold,ff}}$) is the setup (hold) time of the internal flip-flop; and t_{data} (t_{clock}) is the delay of the data (clock) path from the data-input pin to the internal data (clock) input of the flip-flop. You may need to analyze high and low transitions separately if delay data for the circuit elements is dependent on the direction of signal transitions.

You should determine setup time and hold time separately to avoid confusing the effects of each on the other. To find the setup time with the logic simulator, you run iterative simulations while reducing the time between the edge of the data input and the triggering edge of the clock. You must remember to reset the flip-flop after every attempt to set it.

The simulator initially latches the data properly and then flags a setup violation when the signal edge reaches the minimum setup time of the macro. Eventually, when the data changes state too close to the clock edge, the macro doesn't store the correct value of the data. The last successful storage of data in the macro determines the external setup time for the particular state transition of the data. You must repeat this procedure for the other transition if data propagation delays and internal setup times differ for up and down data transitions.

A similar vector sequence verifies hold times, except that the data edge now moves in on the clocking edge from the right. The last successful clocking-in of data determines the minimum hold time. To isolate and attribute the violation unambiguously when it occurs, it's good practice to write separate simulation vector sets for setup- and hold-time verification. Also, you

The ZZZ . . . ZL30 [ZL32]
Logic Programmer
A development tool
A High—Speed Production system for PALs* and IFLs



The ZL30 [ZL32] will give you the best of all worlds. A multi—functional, totally sophisticated tool designed with your needs firmly in mind **and already acknowledged as the “industry standard”**.

Now you can have flexibility and speed in one high—speed production/development system.

The ZL30 in conjunction with CUPL* software, plus a PC makes the most powerful workstation for PALs* and IFLs. In fact the **ZL30 is such a powerful combination that cloned lookalikes are inevitable. Don't be fobbed**

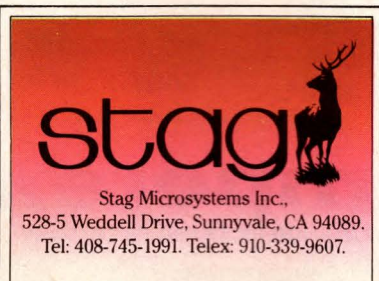
off with pale imitations.

Remember, there's only one Stag and there's certainly only one ZL30.

- Complete Stand—alone.
- Will program most 20, 24 and 28 pin PAL*, EPLD and IFL.
- Includes Altera 40 pin EPLD. ■ RS232C, IEEE—488 Interfaces, plus parallel handler interface. ■ Durable, function, Edit keyboard.

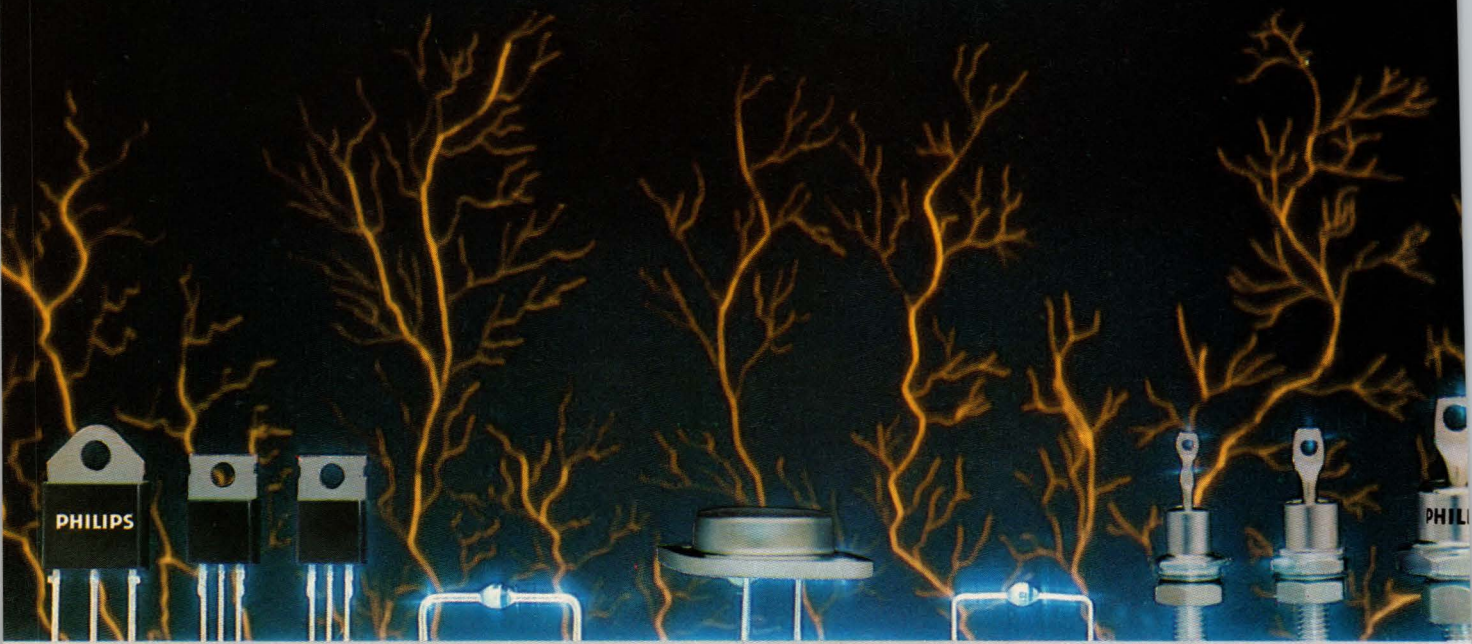
- Green Alphanumeric Display
- Comprehensive Device Library
- Remote Control Option as standard. ■ Carries out customer vector tests, product performance checks as well as a continuity check on the sockets. ■ Ultra high speed — to a degree that would make other manufacturers envious.
- An extremely low cost.

Start Buzzing — Call Stag today.



*CUPL — Assisted Technology.
 *PAL — Monolithic Memories Inc.

The answer to all your rectifier needs.



Philips ultra-fast recovery rectifiers from Amperex.

Get high quality levels and the widest range for SMPS applications available.

Others offer ultra-fast epitaxial and schottky rectifiers, but Amperex offers you a range of products to cover all your switching needs. Get Philips epitaxial fast recovery and schottky rectifiers with average current ratings from 1A to 80A and voltage range from 50 to 1000 volts.

Philips epitaxial and schottky rectifiers from Amperex have the lowest PPM in the industry, due, in part, to direct communications with end users. The result – a process of constant improvement and refinement that assures you of the best possible performance and reliability.

Features of these high-performance Philips rectifiers include:

- Fast, soft recovery time – for use in high-speed switching circuits.
- Small reverse-recovery current and low stored charge – reduces collector current peaking, transistor turn-on losses and ringing.
- Triple-glass passivated chips – for long-term stability.
- Single-chip dual rectifiers for perfect matching.

Call or write us today for the answer to all your switching rectifier needs. Ask for a free copy of the Philips Power Semiconductor Brochure and a list of available application notes.

Amperex[®]

A NORTH AMERICAN PHILIPS COMPANY

Amperex Electronic Corp., George Washington Highway, Smithfield, RI 02917 • Telephone: (401) 232-0500 • TWX: 710-381-8808

CIRCLE NO 73

When you use the simulator for debugging, examine the behavior of your circuit at the design interfaces and operation-mode changes.

should specify ample clock periods to allow the circuit to settle between triggering edges.

In real circuits this procedure often requires many additional vectors, which establish other primary inputs to set up the data path (and sometimes the clock path). In a simulator, however, the Q output of the flip-flop can always be displayed, even if it isn't a primary output, so the measurements are easier to observe.

After you verify functional correctness and certain critical parameters like setup and hold times, you may want to simulate your logic at full system speed under worst-case operating conditions. A common dynamic simulation runs your logic at actual system speed or above while setting the macro delays to worst-case operating conditions. This simulation determines whether the part will perform in its intended application, and running your logic at frequencies higher than the intended ones establishes what margin your circuit exhibits with respect to clock frequency.

You shouldn't use vectors designed for dynamic simulation for functional testing of the physical circuit. The vectors produce failure under specific simulation conditions, so the occurrence of failure is an indicator of dynamic performance. If the vectors are used on ATE, they will most likely cause unpredictable failures because of the added constraints of the tester.

Finally, bidirectional inputs and outputs require some special attention in timing to avoid bus contention. The rule is, if the bus is armed, disarm the output, and if the output is armed, disarm the bus. For example, a bidirectional I/O buffer consists of an input buffer, which transmits any signal on the I/O pin to the interior of the array, and a 3-state output buffer (Fig 6). Also, the I/O pin typically connects to a bus signal that's external to the circuit.

Coordinate signals to avoid contention

To avoid bus contention, you must coordinate the bus-interface input signal (BI_{IN}), coming from the bus, and BI_{OUT} , from the output buffer. You switch the output buffer into high-impedance state (Z) using the output-buffer enable signal (EN), which is an input signal in most cases. Using your input vectors, you set EN to a specific value to disarm the output buffer. The buffer must generate a high-impedance signal whenever the bus is driving the pad. Similarly, when the output buffer needs to drive the I/O pad, you must ensure that the external bus signal is in the high-impedance state.

As one signal goes into a high-impedance state so the

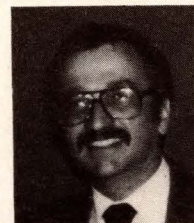
other can drive the bus, some timing margin is required. EN should become active when or after the bus is released. It should disable the output so that the high-impedance state is in effect before the bus is armed. You must include propagation delay through the output buffer and the circuitry driving the enable line. Luckily, most logic simulators will produce some warning in case of bus contention.

Once you've generated the vectors for functional and timing verification of your circuit and run your simulations, you can begin preparing these vectors for testing the physical implementation of your logic design. The second article in this series will examine the restrictions that ATE places on the development of test vectors, in particular vectors for verification of logic-array prototypes.

EDN

Author's biography

Michael Franz is in charge of advanced development at Applied Micro Circuits Corp (San Diego, CA). He performs research and development in the areas of testability, logic simulation, fault grading, and modeling. He holds a Diplom Ingenieur from the Technical University in Munich, West Germany. He also received MS and PhD degrees in engineering from the University of Wisconsin in Madison. He enjoys sailing and playing the piano in his spare time.



Article Interest Quotient (Circle One)
High 476 Medium 477 Low 478

Upgrade your product for less than 1¢

Replace the 1N4004 rectifier with Varo-Symbol 100% Glass Passivated devices.

Get better stability, quality and performance.

All at a cost of less than 1¢ more than you're paying now for our 1N4004 part (based on one-million units or more).

The new series of Varo-Symbol standard and fast switching axial-lead rectifiers are manufactured and tested to Varo's specs.

For standard applications, the GPP Series, to replace the 1N004 Series.

For Fast Switching, the RGPP Series, to replace the 1N4933 Series.

Both series have a molded plastic case using UL-94V-0 Flame Retardant Epoxy; terminals solderable to Mil-Std 202, Method 208.

Both series have excellent operating specs, with 100% glass passivated junctions; low forward voltage; high current, surge capabilities; low leakage current.

Standard Glass Passivated Rectifiers, GPP10 Series (to replace 1N4004 Series).

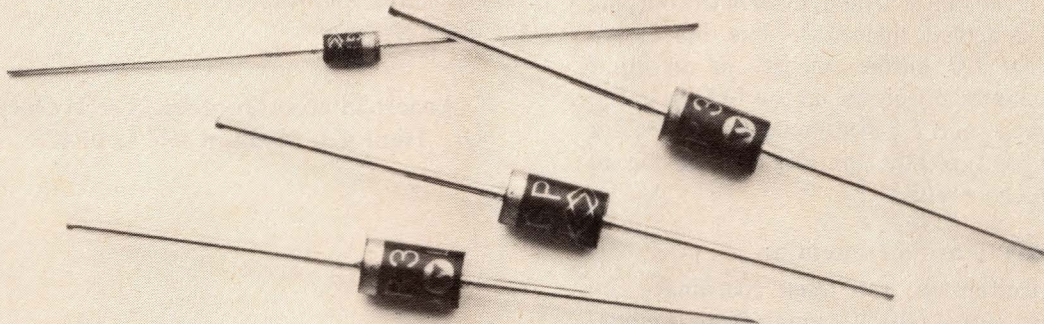
GPP10, 50 to 1000 v: 1 amp
GPP30, 50 to 1000 v: 3 amp
GPP60, 50 to 1000 v: 6 amp

Fast Switching Glass Passivated Rectifiers, RGPP10 Series (to replace 1N4933 Series).

RGPP10, 50 to 1000 v: 1 amp
RGPP30, 50 to 1000 v: 3 amp
RGPP60, 50 to 1000 v: 6 amp



© 1985 Varo Semiconductor/5975



Varo-Symbol axial lead rectifiers are manufactured and tested to specifications set by Varo. For product data or samples, call

(214) 487-4300 Varo Semiconductor Box 469013 Garland, Texas 75046-9013

Design a simple dual-UART-based network

With a dual UART and some simple circuitry, you can easily design an inexpensive network. Each network station has identical interface hardware and software; you can expand the network's function to cover binary-file transfer and electronic mail.

Mike Lowndes, *Motorola Ltd*

You can use a dual UART and some simple circuitry to design a network in which the computers on the network have continuous access to any of the peripherals. Such access is possible because the network provides local buffering at the printer-driver network nodes; this local buffering also allows for fast file transfer and effective print-spooling. The network uses a true multi-master arbitrating configuration that has identical network-interface hardware and software for every station. Furthermore, you can expand the network's function to cover binary-file transfer and electronic mail without modifying the network itself.

Designing the network

You configure the network as a bus consisting of continuous conductors that are terminated at each end of the bus. You can connect network nodes along the bus wherever you require. The MC68681 dual UART's

multidrop mode of operation (see **box**, "A look at the MC68681 dual UART") is optimized for terminal-cluster interfacing (**Fig 1**), but by adding circuitry you can develop a low-level network for ASCII-file transfer. Software enhancements can provide control data that facilitates file transfer from computers to print buffers. Further software enhancements can even provide binary-file transfer and electronic-mail functions. You can make a limited number of branches on the network to suit your installation requirements, but all the stations see exactly the same signals on the network (**Fig 2**). Each station has a unique network address that is switch selectable at the station.

The network's electrical-signal levels conform for the most part to both RS-422 and RS-232C standards, but the design includes modifications that enable half-duplex communications between any two stations on the network. The data path consists of a differentially driven twisted-pair cable. A line-terminating resistor at the end of the cable forces the data path to a logical one, a line-idle condition. A station can drive the line actively only when transmitting a logical zero. In other words, the stations are disjunctively connected (that is, connected via a wire-OR). Because it uses serial receivers/drivers (the MC3486 and 3487), the system will operate correctly even when some network stations are inoperative.

In this system, an extra differential signal pair acts as a network-free control signal; this method enables you to dispense with intermessage gaps. The scheme also allows the network's message protocol to contain significant line-idle periods during a message transmis-

Without modifying the network itself, you can expand its function to include binary-file transfer and electronic mail.

A look at the MC68681 dual UART

The Motorola MC68681 dual UART consists of two independent UART sections that are capable of operating as fast as 1M bps. The sections can operate in the multidrop mode, in which the bit in a serial character frame that would normally be a parity bit is instead designated Address/Data for logical states one and zero; thus, a disabled receiver channel in multidrop mode can accept address characters.

Typically, the CPU would compare such an address character with its own network address and, if the two matched, the CPU would enable the receiver channel for reception of data characters. By using the

multidrop mode, however, you can configure the dual UART to interrupt its host CPU when it receives such a character. You can also trigger a host interrupt by selecting from a variety of other dual-UART conditions, such as level transitions on an input pin or a counter-timer time-out. All the interrupts use the same IRQ pin, and an on-board vector register provides the host CPU with a vector number during 68000 bus-interrupt-acknowledge cycles (Fig A).

The MC68681's 16-bit counter-timer and the handshake protocol work together to avoid tying up your network's serial data path. The chip also offers general-purpose pins (six for input and

eight for output), some of which you can software-configure to operate as modem lines, flow-control lines, and external-clock inputs for the UART sections. Each receiver in each of these sections also provides a 3-byte FIFO buffer for incoming characters, a feature that's particularly useful in high-speed communications schemes controlled by the host CPU.

The dual UART also has an onboard crystal oscillator that, when connected to a 3.6864-MHz crystal, will provide a range of software-selectable standard rates; it will act as the chip's clock signal, which generates the DTACK signal on an asynchronous 68000 interface.

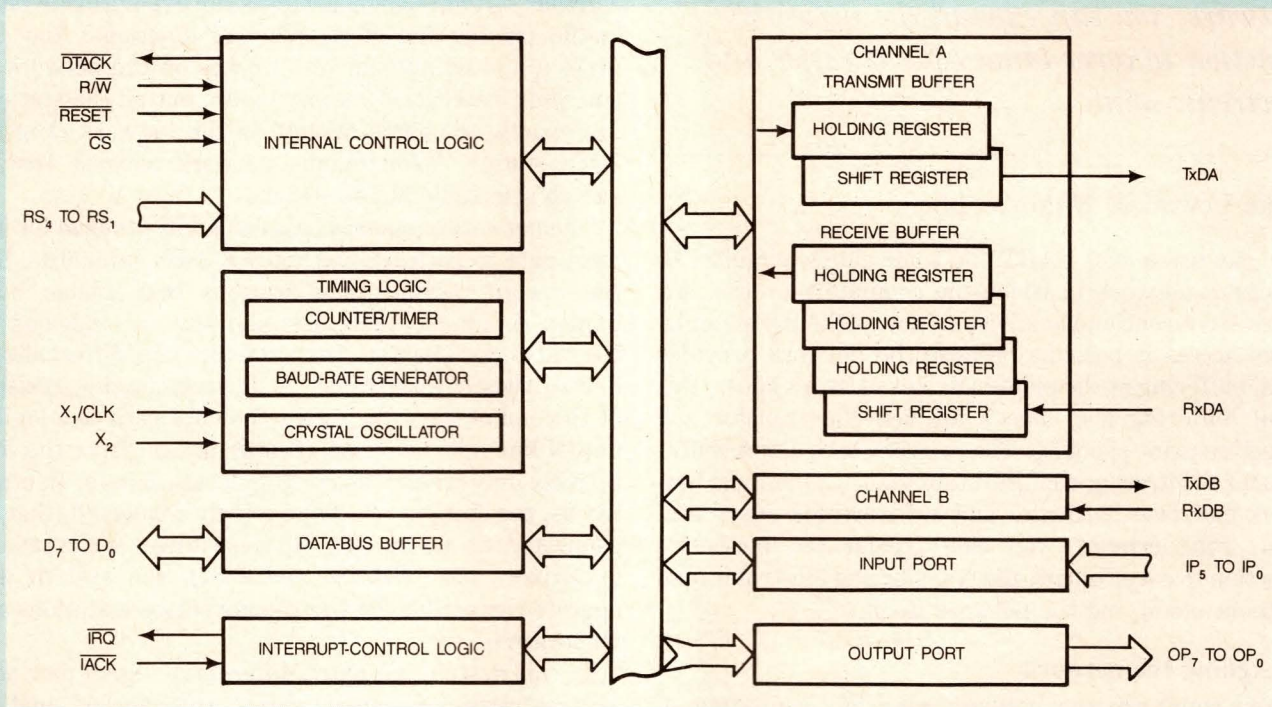


Fig A—The MC68681's independent UART sections, 3-byte FIFO buffering, and ability to operate in multidrop mode provide the basis for a number of high-speed network configurations.

sion, a useful feature if a printer driver node must spend time searching for free buffer space. The extra line drivers and receivers needed for the control signal are already available in the receiver/driver chips.

LAN uses a simple arbitration scheme

The network interface hardware illustrated in Fig 3 provides a serial interface with communication arbitration. The network-free control line (Free) at input pin IP_2 of the dual UART remains high when the network is not in use. To transmit, a station pulses its Claim line at output OP_0 of the dual UART. If the network is still free on the leading edge of this pulse, the flip-flop will set, and the Own line at input IP_0 will let the station know that it controls the network. The station can then

proceed with its transmission; when the transmission is finished, the station pulses the Release line to free the network. If the station's attempt to claim control of the bus is unsuccessful, it must try again.

This arbitration scheme is not sufficient to guarantee a station the exclusive use of the network, because propagation delays between two distant network stations mean that there is a finite temporal window during which simultaneous network claims can occur. Consequently, the first three control bytes transmitted by a station are verified by local readback at the transmitting station and by remote echo from the network destination. A mismatch or a time-out in waiting for the remote echo aborts the transmission. The content of the first three control bytes ensures that

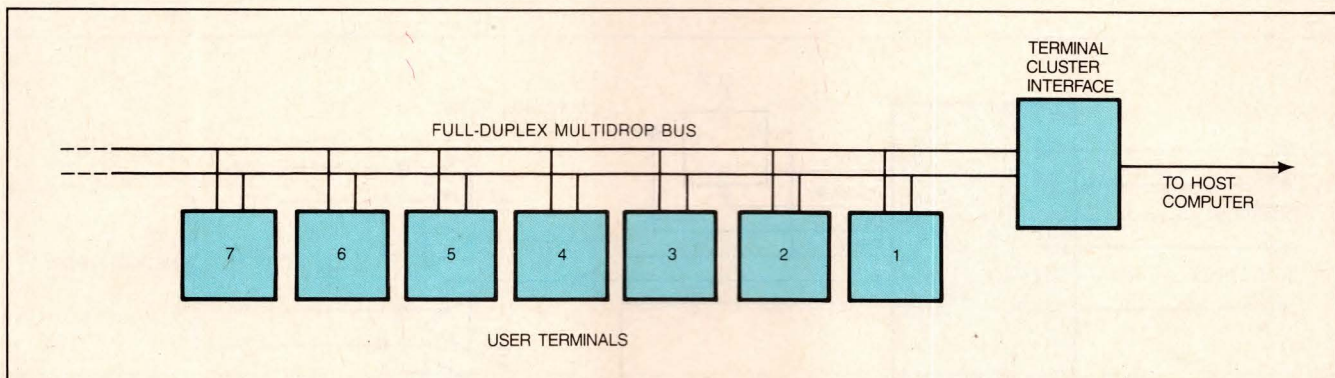


Fig 1—This terminal-cluster configuration, which uses the MC68681's multidrop mode of operation, is based on a bus that consists of continuous conductors. The conductors are terminated at each end of the bus; you can connect terminal nodes along the bus wherever you require.

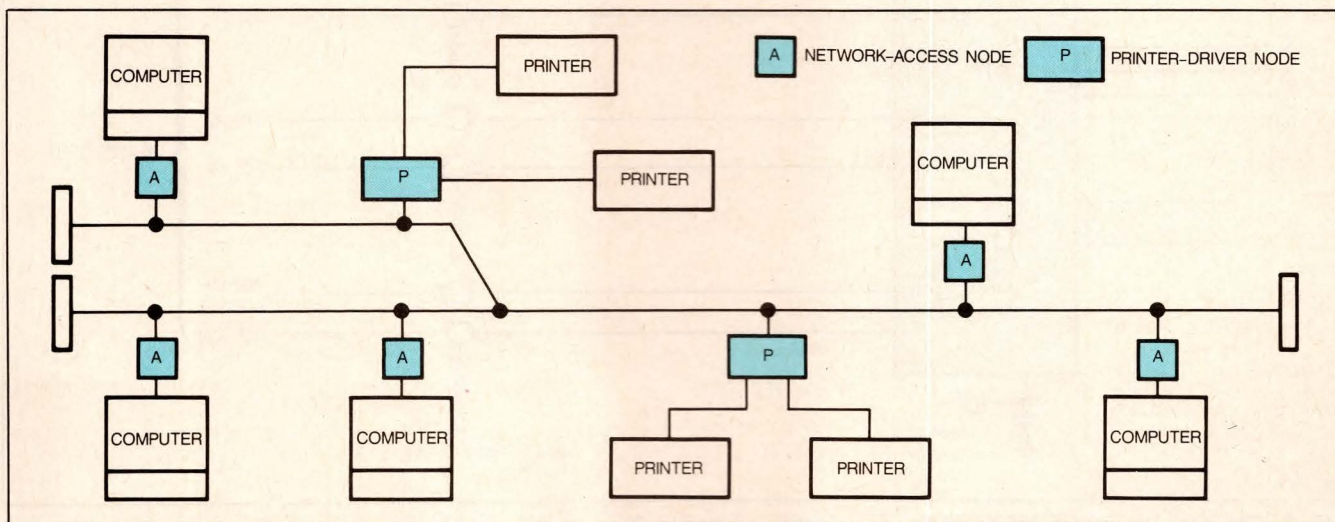


Fig 2—This dual-UART network's local-area topology allows all the stations on the network to see exactly the same signals and to have unique, switch-selectable network addresses.

You can make a limited number of branches on the network to suit your installation requirements, but all the stations see exactly the same signals.

it's virtually impossible for an undetected collision to occur; one or both of the simultaneous network claimants will back off and try again later.

Protocol also provides control

In addition to providing a means for detecting network collisions, the message protocol must also provide the control features necessary for successful transfer of data between stations. **Fig 4** illustrates the general form of a transmission packet, showing the state of the control signal, the transmitting station's data-line-drive signal, and the receiving station's data-line-drive signal. The first byte the station transmits after it successfully claims the network is the network-destination address, which is a multidrop-mode address byte that alerts the destination station.

As long as that destination station is present and active, it must echo the address within a predefined time-out period. If the echo occurs and the local and remote readbacks match the transmitted address, the transmitter sends its own address (the second transmitted byte) to the destination station, which includes the address in the transmission station's download-file copy. Note that this data and any remaining data in the transmission frame are transmitted as multidrop-mode data bytes, and are therefore ignored by everything but the destination station's dual UART. The third byte the transmitter sends is a byte count that is locally and remotely read back to specify the number of bytes in the message part of the frame.

The message data is transmitted as a continuous burst without any verification by readback, so the

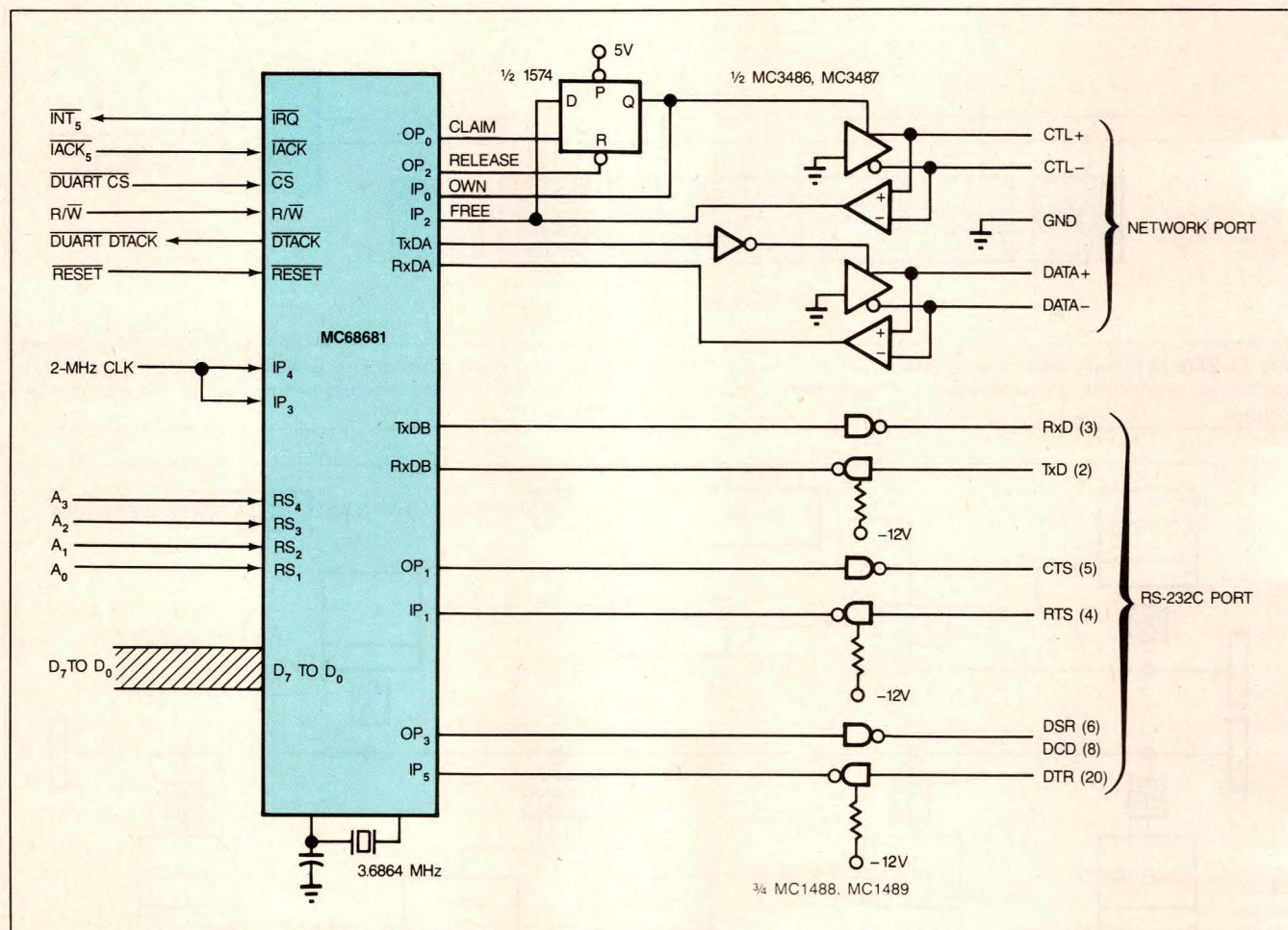


Fig 3—This network serial interface offers communication arbitration. To transmit, a station pulses its Claim line at output OP₀ of the dual UART. If the network is free on the leading edge of this pulse, the flip-flop will set, and the Own line at input IP₀ will let the station know that it controls the network.

transmission takes place at maximum network speed for most of the frame. To obtain data security and network availability, you can employ one of two schemes, both of which use a combination of message and hardware protocols. In the first scheme, the dual UART's receiver at the destination station enters a block-error mode, in which the station accumulates error bits for each character. Then, after receiving the entire message, the station checks the dual UART's status bits to determine whether any character errors have occurred.

In the second scheme, the transmitting station software-generates a block-check character (BCC) during message transmission. At the end of the message, the transmitting station sends the BCC to the destination station. Any errors in the message-data transmission create an incorrect BCC, which causes the destination station to ignore the message; the transmitting station will attempt the transmission again.

125k-bps data rate suits a small LAN

Assuming that each CPU in your network can communicate directly with its communication node's dual UART, the maximum speed at which this network can operate with a locally generated $\times 16$ serial clock is 125k bps. At 125k bps, transmission for each character—which comprises one start bit, one stop bit, one address/data bit, and eight data bits—takes 88 μ sec. Theoretically, if you were to transmit an 11,000-character print file in one burst, it would take just under 1 sec to download the file to a printer-driver node's buffer area. In practice, however, the file must be split into frames; in this case, each frame contains 125 data bytes. Because of the message-protocol and network-claiming-

mechanism overhead, the network needs about 1.2 sec to download the file.

Limiting the volume of data transferred per frame to 125 data bytes reduces system latency; that is, it enables other network nodes to use the network without having to wait for a transmitting station to transfer a whole file. Besides, if an error occurs during transmission, the originating station needs to retransmit only the part of the file that is in error.

Furthermore, these limited-volume frames ease buffer management at printer-driver nodes. Assuming that five computers are downloading 11,000-character print files at the same time, the average downloading time from each computer would be six seconds. In comparison, it takes approximately two minutes to download each file to a locally connected line printer.

Incidentally, the MC68681 can support 1M-bps operation; in such a case, you'd have to make sure that one station would always be available on the network as a serial-clock master. However, because Fig 3's network works best for a maximum of 10 simultaneous users, the 125k-bps data rate is adequate, and a serial-clock signal on the network isn't needed.

Accessing the LAN

Although a computer that could communicate directly with the dual UART could obtain a download time of 1.2 sec, most computers can't download a file that fast, because they have only 9600-baud serial ports for common external communication.

Downloading an 11,000-character print file through 9600-baud ports takes at least 14 seconds. Because other stations are on this network, the 14-sec file transfer time will increase. However, the transfer time

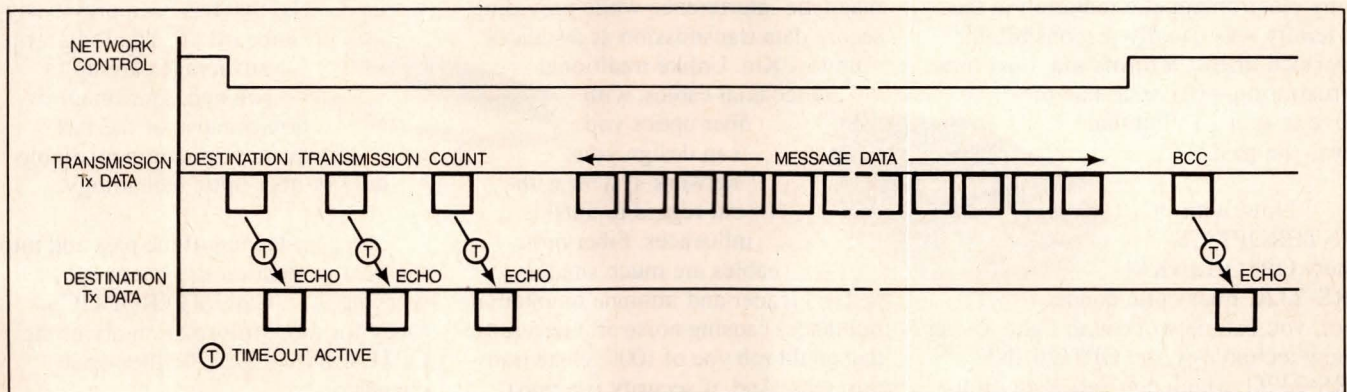
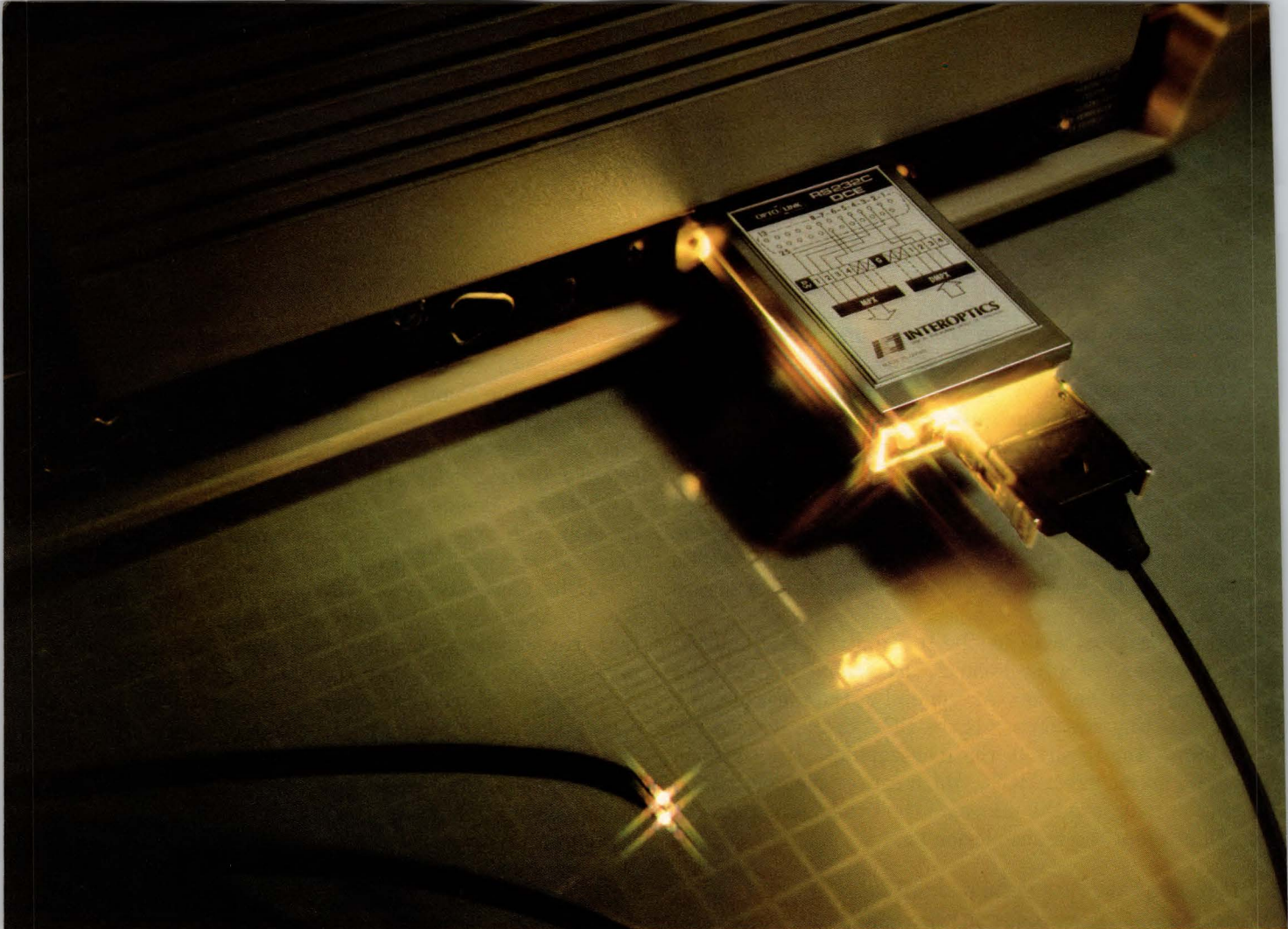


Fig 4—During the network-control pulse, the transmitting station sends out a control signal, a data-line drive signal for the destination station, and a data-line drive signal for itself. If the destination station is present and active, it echoes the source station's address byte within a predefined time-out period.



Network with Light!

In the past, computer networking could only be done using bulky coaxial cables office to office, terminal to terminal, and terminal to peripheral. And, as we all have learned, clean data was not always the rule. Power surges, radiating machine interference or any electromagnetic radiation in the vicinity was usually responsible for garbled or lost information. Lost time, frustration—we've all had to live with it . . . but that was the past.

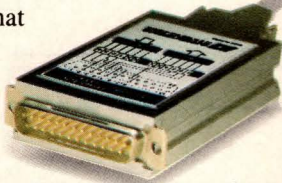
Now, with INTEROPTICS new OPTO/LINK™ RS-232C fiber optic connector, you can network with light. Using new technology, the OPTO/LINK RS-232C, which converts data infor-

mation into optical energy, provides bi-directional, high speed data communication between computers and peripherals while maintaining electrical isolation between them. The OPTO-LINK RS-232C eliminates surge noises, ground loops and electromagnetic interference while providing secure data transmission at distances up to 1 Km. Unlike traditional coaxial cables, with fiber optics you can design your network system without regard to outside influences. Fiber optic cables are much smaller, faster, cleaner and immune to external influences causing noise or interference that could rob you of 100% clean transmissions. And, if security is a must,

only fiber optic cables can assure you of a secure data line for sending or receiving confidential data.

This new and revolutionary, next generation transmission medium offers growth potential in Local Area Networks (LANs) that has been previously unheard of. The long term advantages are up to you and your imagination because of the full frequency spectrum available only in fiber optic technology.

So . . . step out of the past and into the next generation in system networking. . . . Call INTEROPTICS today for more information about the OPTO/LINK RS-232C fiber optic connector.



*OPTO/LINK is a trademark of INTEROPTICS

INTEROPTICS
ONE OF THE PURDY GROUP OF COMPANIES

770 AIRPORT BLVD. • BURLINGAME, CA 94010 • (415) 347-7727 • TWX 910-375-2012

CIRCLE NO 74

The content of the first three control bytes ensures that it's virtually impossible for an undetected collision to occur.

won't increase by more than a factor of 1.2, even when as many as five stations are performing the same downloading operation simultaneously via the 9600-baud ports. If all 10 computers were to download files simultaneously, though, each computer's download time would increase by a factor of 2, raising the file-transfer time for your 11,000-character file to 30 seconds.

After you've constructed your local-area network, you must program the dual UARTs, which appear to the programmer as sets of byte-wide registers. Some of these registers configure the operational modes, some read operating status, and others interrupt control. Generally, you must program four registers to configure a channel of the dual UART for operation in any mode; these registers select parity/error modes and character length, channel mode and stop-bit length, transmitter/receiver clock sources and rates, and channel enable/disable.

Once you set up these registers, the channel status becomes available in the channel-status register (SR). The CPU loads the transmission data into the transmit buffer (TB), and the receiver buffer (RB) accesses the first character of received data that's available in the channel's FIFO buffer. The set of registers is duplicated; the duplicate and the original are completely independent of each other, so no operation on one channel can affect the other channel.

The dual UART's counter-timer starts and stops as it reads register locations. You can preset the values in the counter-timer by writing data into its two registers, and the counter-timer can read the instantaneous value of each byte on the fly. You can also program the counter-timer clock source and mode in the auxiliary control register (ACR). In addition, you can configure the counter-timer to control the general-purpose output pin OP₂ by programming the output-port-configuration register (OPCR).

The OPCR lets you use the output pins for bit-oriented output (the default), channel flow-control signals (CTS), and clock outputs. You can configure the general-purpose input pins to act as flow-control signals (RTS inputs) and channel clock inputs or as bit-oriented inputs with associated change-of-state detectors. You can also monitor both input level and change of state, and, optionally, you can generate interrupts.

All interrupt sources in the dual UART share a common interrupt-request pin (IRQ). A vector register in the dual UART presents one vector number to the CPU during an interrupt-acknowledge cycle, when the

dual UART's IACK line is asserted. You must use an interrupt status register (ISR) to establish the source of an interrupt within the dual UART. Note that the interrupt mask register (IMR) selectively enables or disables interrupt sources without affecting the status of the ISR.

In Fig 3's network, channel A is the network port, which takes transmit and receive clocks from IP₂ and IP₄. The OP₀, OP₂, IP₀, and IP₂ UART pins provide bit I/O so that the station can claim the network. At reset, the channel A UART goes into multidrop mode, in which the UART's receiver is disabled. Channel B uses the IP₁ and OP₁ pins for automatic-flow-control signals RTS and CTS on the RS-232C serial port; IP₅ and OP₃ provide the additional control signals DSR and DTR.

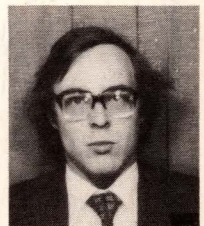
As you can see from Fig 4, the counter-timer simply acts as a timer that has an internal clock source and no output. The counter-timer's time-out status appears in the ISR; the timer doesn't act as a CPU interrupt. The initialization routine that configures the dual UART after system reset consists of 14 byte-move instructions to the dual UART's registers.

Operating the dual UART is a simple matter. The command register (CR) associated with each UART channel provides the means of enabling, disabling, and resetting receiver and transmitter sections. The CR also lets you change the channel mode, because it gives you access to both of the mode registers associated with the channel.

EDN

Author's biography

Mike Lowndes is currently employed at Insight Terminals Ltd (Wooton, Bedford, UK), where he is an engineering manager. When he wrote this article, he was a senior systems engineer for the semiconductor products sector of Motorola Ltd (Aylesbury, Buckinghamshire, UK). Mike holds a BSc in Electronics from the University of Manchester Institute of Science and Technology and is an associate member of the Institution of Electrical Engineers. His interests include church bellringing in the English style, cello playing, black-and-white photography, and drinking English beer.



Article Interest Quotient (Circle One)
High 479 Medium 480 Low 481

We know your TIME IS MONEY

and we'll save you both, with **BUYING STRATEGY FORECAST**, the twice-monthly newsletter for purchasing managers. The editors of **BUYING STRATEGY FORECAST**, together with **PURCHASING Magazine** and **Cahners Economics**, will bring you the short-term price and supply forecasts, analysis, advice, and long-term outlooks you need to plan and buy smart.

TRY US...

with a **FREE**, six-week, three-issue complimentary review.

You'll have the information you need, when you need it, at your fingertips.

BUYING STRATEGY FORECAST will tell you what's happening... what it means... and what to do about it, when—to ensure you make the right buying decisions at the right time.

Specially organized in a "rapid report" format, **BUYING STRATEGY FORECAST's** major departments give you specific developments, analyzed and interpreted in brisk, no-nonsense advisories... concise management "briefings" you can use immediately. Look for:

DATELINE — Business trends that require your attention, that should be figured into your buying decisions now...

PRICELINE — Where prices are headed, and why, plus what you should do about the coming changes...

SUPPLYLINE — Exclusive, proprietary, leadtime data with what-this-means-to-you interpretation...

BUSINESSLINE — Overview of the latest available data on business activity trends and complete 90- to 180-day forecasts for all major purchasing activities...

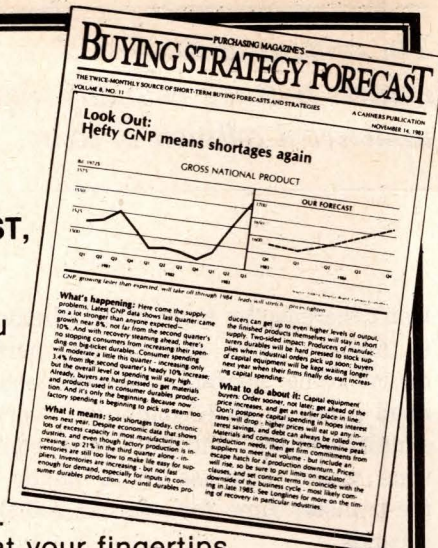
COMMODITY & PRODUCTLINE — A focus on where the action is, with analysis of key developments in specific industrial product and commodity markets...

LONGLINES — A running, long-term forecast for the economy at large with analysis of how predicted short-term shifts will impact the long-term forecast...

Just fill out the coupon below. We'll send you the next three issues of **BUYING STRATEGY FORECAST** at no cost or obligation. At the end of your complimentary review, you can choose to subscribe for a year at the low rate of just \$180, or do nothing at all and the three issues will still be yours to keep, free.

As a bonus for trying **BUYING STRATEGY FORECAST**, we'll also send you the new Report, **HOW INDUSTRY BUYS**, a look at the purchasing practices of four of the nation's top procurement operations—a \$25 value—yours, free.

Mail this coupon today to: **BUYING STRATEGY FORECAST**, P.O. Box 716, Back Bay Annex, Boston, MA 02117



☐ **YES!** Please send me, at no cost or obligation, the next 3 issues of **BUYING STRATEGY FORECAST**. I will also receive a **FREE** copy of the Special, In-depth Report, **HOW INDUSTRY BUYS**—a \$25 value!—as a bonus. After receipt, I may either continue as a subscriber by paying the low rate of just \$180, or do nothing at all—the three issues and the Report will be mine to keep—free.

NAME

TITLE

COMPANY

ADDRESS

CITY

STATE

ZIP

EDN 6/13/85

KEPCO POWER SUPPLIES

WORLD POWER™ OEM SWITCHING MODULES
 DOMESTIC OEM SWITCHING MODULES
 POWER MANAGERS™ FOR LABORATORIES & SYSTEMS
 OEM LINEAR & FERRORESONANT MODULES
 IEEE 488 COMPATIBLE PROGRAMMERS



KEPCO
 THE POWER SUPPLIER™

SWITCHING MODULES

All Kepco/TDK switchers run cool because all use specially designed magnetics with TDK's own H7C1 ferrite materials. Components are mounted firmly and reliably by TDK's automatic component insertion machines. Built-in filters reduce conducted EMI.

EFX: 50-, 100-, 150-, and 210-Watt high-quality, low cost open frame switchers, with four outputs which offer a variety of popular Volt/Ampere combinations. UL recognized, CSA certified, built-in EMI filter for FCC Class A requirements.

Output #1: all +5V; outputs #2 and #3: either $\pm 12V$ or $\pm 15V$; output #4: either +24V or -5V. Optional enclosures available.

EMR: Triple-output 22-, 42-, and 54-Watt, and quadruple-output 53- and 80-Watt, fully enclosed and shielded power supplies. High quality and low price are due in part to computer-aided design, and to use of proprietary hybrid microcircuits which greatly reduce parts population. UL recognized, CSA certified, built-in EMI filter for FCC Class B requirements.

On all models, output #1 is +5V, output #2 is +12V, and output #3 is -12V; on the two models with a fourth output, it is +24V.

ERX: World Power™ single-output 30-, 60-, and 120-Watt open frame power supplies meeting highest international safety and EMI standards. Two custom hybrid microcircuits reduce parts population, increase reliability. All sizes available with a 5V, 12V, 15V, or 24V well stabilized, adjustable output, protected by a current limiter and over-voltage protector. UL recognized, CSA certified. SELV per IEC 380 and VDE 0806. Built-in EMI filter for FCC Class B requirements.

MRM: Multi-output 40-120 Watts, flyback and forward converters in PC card (frameless) and L-chassis style, designed to meet the logic, display, serial output, and disk drive needs of CRT terminals, microcomputers and video games. All units are UL recognized and CSA certified. "KV" models are TÜV certified SELV per IEC 380 and VDE 0806. Built-in filter for FCC Class B requirements.

MP/CMP: Single-output (MP) and dual-output (CMP) 10-Watt extra compact, high efficiency switching power supplies. d-c output range of MP: 5V to 15V and 2A to 0.8A. d-c output range of CMP: output #1, +12V to +15V and 0.4A to 0.5A; output #2, -5 to -12V and 0.4A to 0.5A.

RMT/RXT/RMK/RMX/RBX: Compact, highly efficient, fully enclosed and shielded a-c to d-c or d-c to d-c switching power supplies offering stabilized outputs, overvoltage and overcurrent protection, and remote on-off. On most models, output voltages are adjustable +10% to -30%.

Series RMT (30 and 70 Watts), and RXT (150 Watts) all provide three outputs, including a basic 5V logic output which is rated at 6.0Amps in the 30 Watt models, 10 Amps in the 70 Watt models, and 20 Amps in the 150 Watt models.

Series RMK, RMX and RBX provide one output. Models are available with outputs with 2V, 5V, 9V, 12V, 15V, 24V, and 28V d-c, and a wide range of current ratings. (30Watts-600Watt(s)) offering adjustable overvoltage and overcurrent protection and remote on-off. UL recognized; CSA certified.

RMD/RDT: Isolated, fully enclosed and shielded 30-, 50-, 70-, 125-, and 225-Watt d-c to d-c converters offering adjustable over-voltage and overcurrent protection, and remote on-off. In Series RMD, output voltages are adjustable +10% to -30%; in Series RDT, $\pm 10\%$ at all outputs. Standard inputs for Series RMD are 12V, 24V, 48V, and 110V; for Series RDT, 24V and 48V.

Series RMD provides one output and 5V, 9V, 12V, and 48V outputs are offered for all except the 110V models. For the 110V models, 15V and 24V outputs are offered.

Series RDT provides three outputs: a +5V principal output, a second output which can be either +12V or +15V, and a third which can be -12V or -15V. UL recognized, CSA certified.



POWER SUPPLIES FOR LABORATORY BENCH AND TEST SYSTEMS

Kepco Power Managers are linear (series pass) stabilized power supplies optimized for precise and rapid control of voltage and current. They can be programmed by nearly any analog signal in any rating, and can be controlled digitally using a suitable Kepco interface, including Kepco's GPIB interface. Unipolar models for single quadrant operation, bipolar models for 4-quadrant operation.

ATE: Voltage/current stabilizer with automatic cross-over, and separate voltmeter and ammeter for continuous output monitoring. Can be controlled either directly through front panel 10-turn rheostats, or remotely by analog or digital signals. Digital control is by Kepco's SN or TLD digital programmers. User selectable slow or fast mode of operation — slow for delivering constant voltage, fast for constant current or responding to fast control inputs. Bandwidth in fast mode up to 53 kHz. 50-, 100-, 250-, 500-, 1000-Watt models available, including the new high-voltage 250-Watt Model ATE 325-0.8M which uses power FETs as the series pass element.

APH: High voltage (0-500V, 0-1000V, and 0-2000V) voltage/current stabilizer with automatic crossover. Separate voltmeter and ammeter. Direct front panel or remote control. Digital control of 500V and 1000V models through Kepco SN digital programmer. All models: 20 Watts.

KEPCO: THE POWER SUPPLIER™

Kepco offers a broad choice of products for stabilizing and controlling d-c power, based on three power supply technologies.

LINEAR POWER SUPPLIES

employ a dissipative bank of power transistors or vacuum tubes, the "series pass element," which are installed between a rectified-filtered source of "raw d-c" and the output. Feedback from the output, and control signals, modify the conductance of the series pass element, stabilizing and/or modifying the output. Kepco linear power supplies, except for two series offered to the OEM, are intended for use on the laboratory bench, or in automatic test systems.

The advantages of Kepco linear supplies are:

- They offer high gain for "tight regulation" and high accuracy control, including the ability to interface with the IEEE bus.

- They function with negligible radiated or conducted EMI.

- They provide such facilities as current stabilization and operational amplifier-like control.

Their disadvantages are that they are less efficient than switching and ferroresonant power supplies with similar power ratings, and much larger and heavier than switchers.

FERRORESONANT POWER SUPPLIES'

stabilizing principle is based upon the saturation of a portion of a transformer's iron by use of a resonating capacitor, so that the output becomes a square waveform of a constant amplitude related to the magnetic structure.

The advantages of Kepco ferroresonant power supplies are:

- They are extremely simple, rugged, and reliable, and are thus suitable for heavy duty industrial service.

- They are very efficient (65-70%).

- They offer considerable isolation from mains noise and are virtually indifferent to any outside interference.

- With respect to their power, stability, and reliability, they are quite low-priced.

Their disadvantages are that they are rather large and heavy, and their output is fixed and cannot be adjusted (except by taps).

SWITCHING POWER SUPPLIES

are based upon the conversion of an a-c input into d-c, and chopping the d-c with high frequency square pulses. The pulses are re-rectified, to produce the d-c output. Modifying the width of the pulses allows a measure of control over the voltage.

The advantages of Kepco switching power supplies are:

- They are the smallest and lightest of the three types of power supplies, because transformers operating at high frequencies can be much smaller and lighter than transformers operating at 50/60 Hz.

- They are the most efficient (65-85%).

- They can function with a wide choice of source voltages, including d-c.

- They store sufficient energy to bridge short power outages.

A basic disadvantage of most switching power supplies is that they require shielding and filtering to control EMI generated by the switching process. Most Kepco switchers have such filters built in, and the covers which are standard on some, and optionally available for most others, provide substantial shielding.

BHK: High voltage (0-500V, 0-1000V, and 0-2000V) voltage/current stabilizer with automatic crossover. User selectable slow or fast programming mode of operation. Separate voltmeter and ammeter. Direct front panel or remote control. Digital control of 500V and 1000V models through Kepco SN digital programmer. All models 200 Watts.

BOP: Bipolar operational power supplies. Operate in all four quadrants — positive or negative source, positive or negative sink — bounded by four independently adjustable, programmable limits. Full, programmable control over both voltage and current, with mode selector. Separate channels are activated for each mode. Bandwidths up to 4.5 kHz. Can be controlled either directly through front panel 10-turn bipolar controls, or remotely. Digital control through optional internal plug-in interface, or Kepco SN or TLD digital programmer*. 100-, 200-, and 400-Watt models available.

*Available fourth quarter, 1985

BOP-HV: High voltage ($\pm 500V$ and $\pm 1000V$) bipolar operational power supplies. Four quadrant operation, with independently adjustable, programmable limits. Full, programmable control over both voltage and current (from -100% to +100% of their range), with mode selector. Separate voltage and current channels. Direct front panel or remote control. Digital control through Kepco SN digital programmer. Both models 80 Watts.

CC/PCX-MAT: Plug-in, 1/6 rack width stabilizers for current (Series CC) and voltage (Series PCX-MAT). Output controlled from front panel multi-turn controls or by remote analog or digital control. Digital control through Kepco SN digital programmers. Six PCX-MAT models, outputs 7V to 100V d-c. All 14 to 20 Watts.

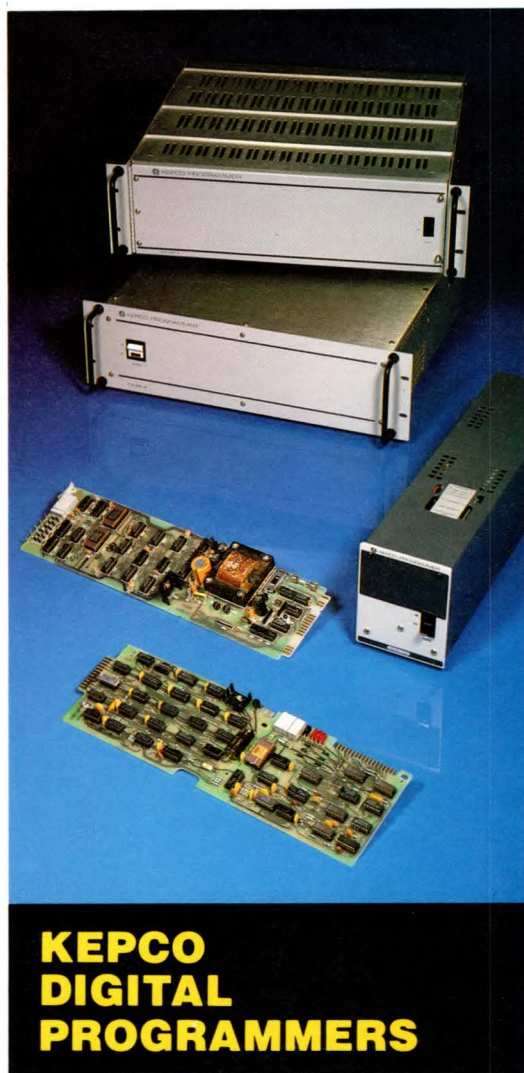
JQE: Systems-type voltage stabilizers with rectangular current limiting. Direct front-panel or remote control. Digital control of voltage through Kepco SN digital programmers. 31 models, 100, 250, 500, 1000 Watts, 0-6V to 0-150V d-c output.

MPS 620M: Triple output 70-Watt bench supply intended for the IC/ μP experimenter. Has one 0 to 6V / 0 to 5A d-c output with current limiting and overvoltage protection, continuously adjustable with a 10-turn front panel control, for digital circuits; and two tracked outputs: 0 to +20V and 0 to -20V, each rated at 0-1A, which can be used in series for 40V.

NTC: Low power (2-Watt) shunt stabilized operational inverting amplifier, intended principally as an interface between an active programming signal and a higher powered, operationally programmable power supply, to allow for control with the power supply's negative output terminal common, or grounded.

OPS IXB/OPS X: High voltage (0-500V, 0-1000V, 0-2000V, 0-3500V, and 0-5000V) voltage/current stabilizers. When used with a resistive load, they are fast-programmable. Can be controlled through their entire rated range by a 0-1mA control current, either externally generated or derived from a built-in uncommitted amplifier connected to the input summing terminal. The 500V and 1000V models can be digitally controlled through Kepco SN digital programmer.

PRR: 1000-Watt fixed output rack mounted or systems ferroresonant voltage stabilizers. Low-cost, reliable. Efficiency 70-80%. Superb line isolation. Low ripple, no spikes. Inherent current limiting and overvoltage protection. Four models: 12V/0-77A, 24V/0-42A, 28V/0-36A, 48V/0-22A d-c outputs.



KEPCO DIGITAL PROGRAMMERS

Translate digital signals into analog voltage outputs that Kepco programmable power supplies understand and respond to. Output is an analog signal ± 10 Volts, which drives Kepco's programmable power supplies as scaling amplifiers. Some models (Series SN) offer 10:1 ranging. Digital input and analog output are optically isolated.

TLD 488-16: Interactive programmer: commands, and reacts to as many as 16 Kepco ATE and/or BOP* power supplies at once. Communicates with system controller in CIIL (a subset of ATLAS Programming Language), through IEEE 488 bus.

*BOP card available fourth quarter, 1985

BIT-488: Programming card designed to be built into Kepco BOP power supplies (optional), or subsequently field-installed. For use with IEEE 488 bus. BIT 500: Same, but for use with data buses using bit-parallel data transfer.

SN 488: Stand-alone single or dual channel programmer, for use with IEEE 488 bus.

SN 500: Same, but for use with data buses using bit-parallel data transfer.

SNR 488: Card-cage digital programming system. Can accommodate up to 8 dual channel program cards. For use with IEEE 488 bus.



KEPCO MODULAR POWER SUPPLIES FOR THE ELECTRONIC OEM

LINEAR PROGRAMMABLE MODULES

PAT: 20-Watt fully programmable voltage or current stabilizers. Digital control with Kepco SN digital programmers. Six models available, d-c output range 0-7V to 0-100V, 0-2A to 0-0.2A.

PTR: 50-Watt fully programmable voltage/current stabilizers with automatic crossover. Digital control with Kepco SN digital programmers. Six models available, d-c output range 0-7 to 0-100V, 0-5.5A to 0-0.6A.

FERRORESONANT MODULES

PRM: 50 to 450 Watt voltage stabilizers. Low-cost, reliable. Efficiency 65-75%. Superb line isolation. Low ripple, no spikes. Inherent current limiting and overvoltage protection. UL recognized (UL 114 & 478).

PRM 280 Series: 7 models — 8.5V/0-30A to 120V/0-2.4A d-c outputs

PRM 180 Series: 4 models — 12V/0-15A to 120V/0-1.5A d-c outputs

PRM 120 Series: 3 models — 12V/0-10A to 120V/0-1A d-c outputs

PRM 300 Series: (two outputs) 4 models — 12V/0-12A to 60V/2.5A d-c outputs

PRM 450 Series: 4 models — 12V/0-35A to 48V/0-10A d-c outputs

PRM 60 Series: (multiple taps) 8 models — 5V/10A to 240V/0.25A d-c outputs

Data subject to change without notice
© 1985 KEPCO, INC. Litho in U.S.A.



KEPCO®
THE POWER SUPPLIER™



MTBF values aid in predicting component failures

The concepts of reliability, failure rate, and mean time between component failures are frequently misunderstood and misused. Although related, each represents a different aspect of a component's projected operating life; together, they can help you predict how many components in a lot will fail over time.

Mark Forbes, Qualogy Inc

Although the concept of mean time between failure (MTBF) is frequently mistaken for such concepts as failure rate and reliability, MTBF is simply a statement about the *average* component in a lot; it says little, if anything, about individual components. Instead, MTBF describes what you can expect from the component lot as a whole. Unlike failure rate and reliability, and even operating life and service life (which generally connote component-replacement time), MTBF is a statistical tool, one that you can use, for example, to help compare similar products.

But besides using MTBF figures to compare products, you can use MTBF data to help predict the number of products in a lot that will fail in a given time. Such predictions are useful in making warranty estimations, ordering spare stock, or predicting the load on a factory repair depot.

Although reference books define MTBF in different ways, one common thread is, of course, that only repairable devices can have an MTBF. One of the better MTBF definitions, and the one used here, is from the *IEEE Handbook*: "MTBF is the product of the number of items and their operating time, divided by the total number of failures." The inverse of MTBF is failure rate, which is generally expressed as a percentage of a number of items per unit time (for example, 5% per year). Finally, reliability is an exponential relationship between a device's MTBF and a specifically targeted period of failure-free operation. In using these three different but related values to predict component failures, you'll find that the greater the number of repair intervals, the higher the percentage of components that fail.

MTBF and failure analysis

In applying MTBF values to manufactured devices, including solid-state electronic components, you must first consider some of the life-cycle characteristics of these devices. The manufacturing process yields a large percentage of failures caused by component weaknesses that show up in the first few hours of operation. These failures (infant mortalities) result from the stress applied to a device during its initial operation—the burn-in period. Once you eliminate the weak devices, those that remain exhibit the long-life characteristics that you expect from solid-state devices.

However, once solid-state components begin to wear out, the failure rate increases dramatically (**Fig 1**). When using an MTBF value, you must recognize that the value applies to the constant failure rate during the

MTBF is a statement about the average component in a lot; it says little about individual components.

normal life of the component. Accordingly, MTBF is a statistical tool that applies only to the time between the end of burn-in and the beginning of wear-out.

One common misconception about MTBF is that a given device should operate for roughly one MTBF period before failing. As Fig 2 shows, however, 63.2% of the units produced will experience at least one failure

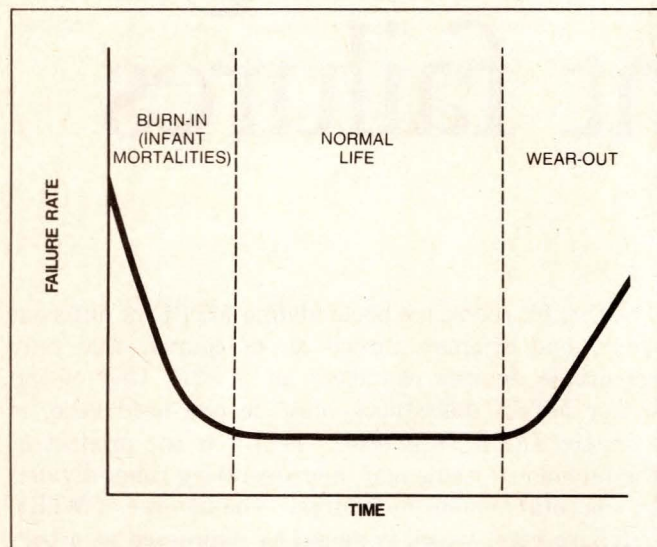


Fig 1—For the average solid-state electronic component, the highest mortality rates occur during the burn-in and wear-out periods. MTBF is a statistical tool that describes typical component behavior during the normal-life period.

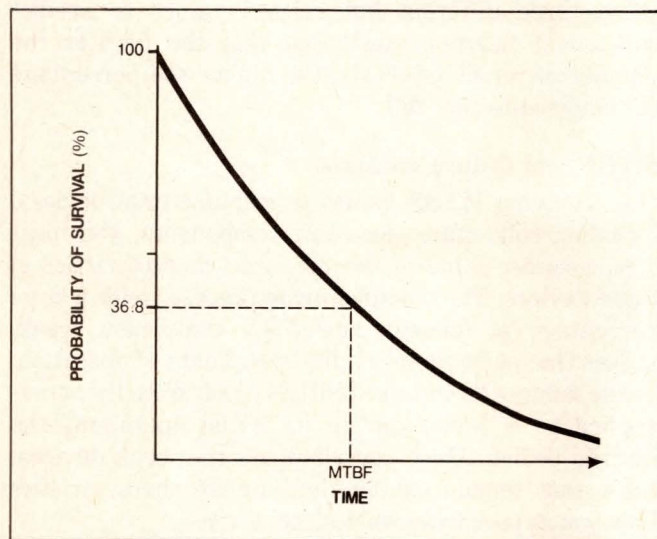


Fig 2—The probability of component survival over time is an exponential distribution. The probability that a component will survive one MTBF period is 36.8%; the probability of failure is 63.2%.

in one MTBF period; thus, only 36.8% will operate through the entire MTBF period without failure. More important, of the 63.2% that fail, some will fail more than once. Furthermore, when enough devices are produced, some will fail almost immediately regardless of the length of the MTBF. Referring to Fig 2, you can estimate that a device with an MTBF of 30 years, if produced in large quantities, yields about 0.3% failures in the first month of operation. However, this curve also indicates that about 3.6% of the units will operate for the next 100 years.

Reliability and probability of survival

Besides failure rate, MTBF is sometimes confused with reliability. Reliability (R) is an exponential relationship between a device's MTBF and a specifically targeted period of failure-free operation: R is the chance that a device will survive to the specified target date. For example, when R is 0.95 for a 5-year period, either a given device has a 95% chance of operating for five years without failure, or 95% of such devices will operate for at least five years without failure. Both interpretations are valid.

In the reliability relationship $R = e^{-(t/m)}$, t is the target period of time and m is MTBF. To avoid misinterpretation of MTBF values, consider the following comments:

- MTBF is the mean time between successive failures of a component. The term "successive failures" implies that you can repair the unit.
- MTBF is different from operating life, service life, or other indices that generally connote re-

TABLE 1—REPAIRS VS FAILURES

REPAIR INTERVALS	TOTAL FAILURES
1	0.63212
2	0.7924698
3	0.834367
4	0.8535459
5	0.8645299
6	0.8716436
7	0.8766254
8	0.8803084
9	0.8831418
10	0.8853889
50	0.9010728
100	0.9029732
250	0.9041076
500	0.9044856
1000	0.9046728
5000	0.9048276

placement time. Operating life, for example, is the more pertinent measure for a component that operates continuously.

- When the failure rate is constant, the probability of a component operating without failure for a time equal to or greater than the MTBF is only 36.8%; not 50%, as many designers believe.

Furthermore, an increase in MTBF doesn't yield a proportional increase in reliability. The probability of component survival increases slowly as MTBF grows. For example, if t equals one year, the MTBFs (in years) required for various R values are as follows:

MTBF	R
5	0.82
10	0.90
20	0.95
100	0.99

Thus, to increase the reliability factor by four percentage points, you must increase MTBF by a factor of 5, from 20 to 100 years. In comparison, doubling the MTBF from five to 10 years yields an 8-percentage-point increase in reliability. Although many designers use MTBF in making reliability decisions, R itself—the probability of survival for a specified time—is actually a more appropriate index for such decisions.

Although R indicates that 63.2% of the components produced at a given time will fail in one MTBF period, some of the units included in the 63.2% figure will fail more than once. To simply use 63.2% as a prediction for component failure results in a significant underestimation. Note the distinction—63.2% of the units produced will fail, but you can expect a higher percentage of failures as you repair the failed units. The calculations to determine this higher probability of failure are based on the premises that all failures are repairable and that the distribution of failures remains exponential: ie, $R = e^{-(t/m)}$.

As defined by the exponential distribution, the probability of surviving one MTBF period is $R = e^{-1}$, or 36.8%. Again, Fig 2 illustrates this distribution, and 63.2% is the probability of failure. However, once a part is repaired and placed back in service, a new MTBF period begins. During the new MTBF period, failures will occur, and some of these failures will occur before the first MTBF period expires; in other words, some parts will fail more than once during the original MTBF period.

For example, assume that you purchase a large

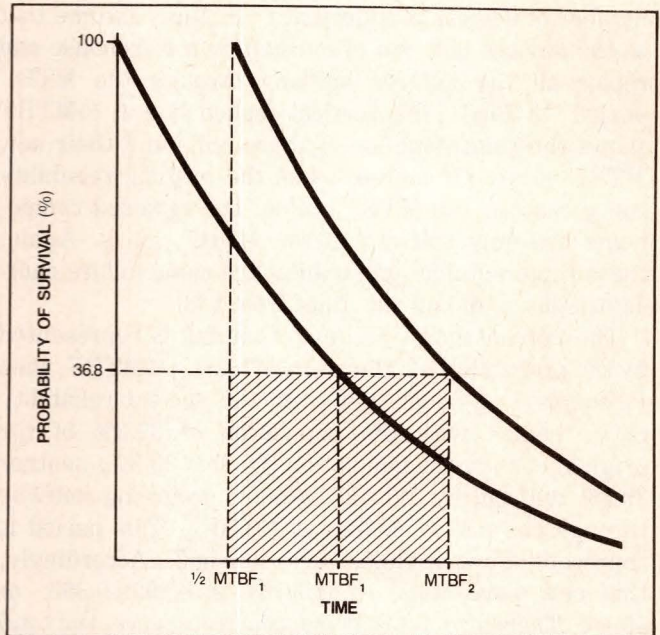


Fig 3—When you repair failed components at a period that is one-half the duration of $MTBF_1$, and then place those components back into service, a new MTBF period begins. During the new period (shaded area), which lasts until $MTBF_2$, failures will occur; some of these failures will occur before the $MTBF_1$ period expires.

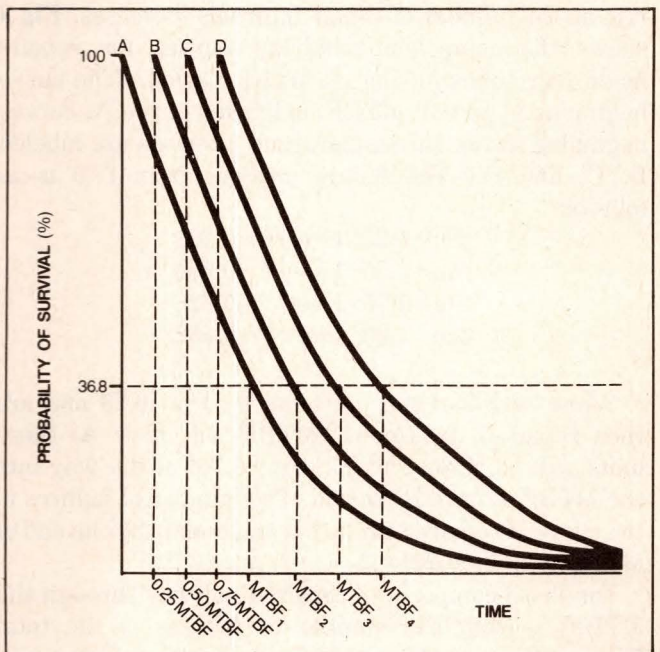


Fig 4—By decreasing the intervals between component-repair periods, you increase the total probability of failure (P_f). Assuming four equally spaced repair intervals, the P_f by MTBF is 63.2%+11.7%+6.8%+3.0%, or 84.7% of the number of units produced.

One common misconception about MTBF is that a device should operate for roughly one MTBF period before failing.

number of devices produced at $t=0$. Now, assume that as the devices fail, you place them in a warehouse and repair all the failures halfway through the MTBF period. In Fig 3, the vertical dashed line at $\frac{1}{2}$ MTBF shows the reintroduction of these units and their new MTBF curve. Of course, when the original reliability curve reaches the $MTBF_1$ value, the repaired components are only halfway to the $MTBF_2$ mark. Again, these repaired units will exhibit the same failure characteristics as did all the units from $t=0$.

The percentage of products that fail is represented by the probability of failure, P_f . When $t = \frac{1}{2}$ MTBF, then P_f equals $1 - e^{-0.5}$, or 0.393. So the second reliability curve begins with the population of 39.3% of the original component population. Of this 39.3%, another 39.3% will fail by $MTBF_1$, a point occurring halfway through the period ending at $MTBF_2$. (This period is represented by the shaded area in Fig 3.) Accordingly, this new percentage of failures is 0.393×0.393 , or 15.4%. Therefore, for only one repair instance, the total percentage of failures is $0.632 + 0.154$, or 78.6%—a figure significantly greater than the 63.2% failure probability for components that aren't repaired and reused during the original MTBF period.

Furthermore, the probability of failure continues to rise as the number of repair intervals increases. Fig 4 shows the component-reliability curves for repairs made four times during an MTBF period. (The curve beginning at $t=0$ of $MTBF_1$ is labeled curve A; curves beginning at the subsequent time intervals are labeled B, C, and D.) The failure analysis from $t=0$ is as follows:

$$t/m=0.25: 1 - e^{-0.25} = 0.221$$

$$t/m=0.50: 1 - e^{-0.50} = 0.393$$

$$t/m=0.75: 1 - e^{-0.75} = 0.528$$

$$t/m=1.00: 1 - e^{-1.00} = 0.632$$

When 22.1% of the units fail by $t/m=0.25$ and are then repaired, by $t/m=1$ ($MTBF_1$ on curve A) these units will be three-fourths ($t/m=0.75$) of the way into the $MTBF_2$ (curve B) period. The number of failures in the curve-B repaired group of components by the end of $MTBF_1$ will be $0.221 \times (1 - e^{-0.75})$, or 11.7%.

For those components repaired halfway through the $MTBF_1$ period, the number of failures is the total failures from $t=0$ to $MTBF_3$, less the failures just accounted for in the first quarter: $0.393 - 0.221 = 0.172$. Of this 17.2%, the number of repaired units that will fail by $MTBF_1$ is $0.172 \times (1 - e^{-0.5})$, or 6.8%. Accordingly, the number of failures by $MTBF_4$ is

$0.528 - 0.393 = 0.135$. And the number of these repaired units to fail by $MTBF_1$ is $0.172 \times (1 - e^{-0.25})$, or 3.0%.

Probability of failure rises

Thus, the total probability of failure, including the multiple failures and assuming four equally spaced repair intervals, is $63.2\% + 11.7\% + 6.8\% + 3.0\%$, or 84.7%. Note that the 84.7% figure refers to the original number of units on hand at $t=0$, not to the number of the units produced and repaired.

The general form of the equation for ρ equally spaced repair intervals is:

$$P_f = (1 - e^{-1}) +$$

$$\sum_{n=1}^{\rho} \left[\left(1 - e^{-\frac{n}{\rho}} \right) - \left(1 - e^{-\left(\frac{n-1}{\rho} \right)} \right) \right] \left(1 - e^{-\left(1 - \frac{n}{\rho} \right)} \right), \quad (1)$$

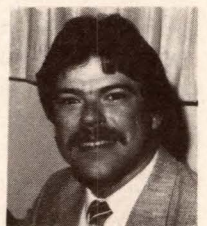
where n is the fraction t/m , and ρ is the number of repair intervals, including the one at $MTBF_1$. So, for the Fig 3 example, ρ equals 2; for the Fig 4 example, ρ equals 4, and so on.

To determine the convergence of Eq 1, calculate the limit as ρ approaches infinity. This limit was approximated with a program written in Basic, the results of which are shown in Table 1. For a realistic number of repair intervals, the equation converges to roughly 0.9, or 90%, and not to 63.2% (as indicated by the probability of failure with no repair intervals).

EDN

Author's biography

Mark Forbes is a product manager at Qualogy Inc in San Jose, CA, where he is involved in product marketing and the development of application notes. Mark obtained his BSEE degree from Bradley University and holds one patent. He enjoys skiing, photography, amateur radio, and sports officiating.



Article Interest Quotient (Circle One)
High 482 Medium 483 Low 484

COMPLETE DISASSEMBLY SUPPORT FOR YOUR MICROS —AND OVER 30 OTHERS.

From the logic analysis leader: The most comprehensive picture of microprocessor activity—on the most comprehensive of all logic analyzers: the Digital Analysis System.

The DAS is optimized to track your micro's internal states, including MC68000-type pipelined processors. Three disassembly display formats let you zoom in for the desired level of detail. With DMA cycle masking, you select only what you want to see. Result: the most accurate and precise microprocessor support.

The versatile DAS integrates and displays both hardware and software disassembly.

SEQ	68010 SOFTWARE
651	AA5662 BRA AA567C (U)
662	AA5664 ? TRAPA (ABAI) (U)
663	AA567C 15FA (FETCH/PL)
665	0053FC 567C (WRITE) (S)
666	0053F8 0000 (WRITE) (S)
667	0053FA 000A (WRITE) (S)
668	000010 0035 (READ) (S)
669	000012 5682 (READ) (S)
664	AA567E ? ORI.B #43.D0 (U)
670	555682 MOVE.B #9E.(AS) (S)
672	555686 NOP (S)
673	002001 —9E (WRITE.L) (S)
674	555688 NOP (S)
676	0053F6 5688 (WRITE) (S)
675	55568A ? MOVE.B #43.(AS) (S)
677	IPL=7 —9E (INT ACK)

You can also disassemble your own custom and support processors.

Solve other logic analysis problems with this unsurpassed array of tools. Capture data with the world's fastest

high-speed acquisition modules. Simultaneously stimulate and analyze complex systems with over 100 pattern generation and acquisition channels, for more accurate measurements. Harness the power of a VAX™ or IBM™

PC to the DAS, to test VLSI prototypes.

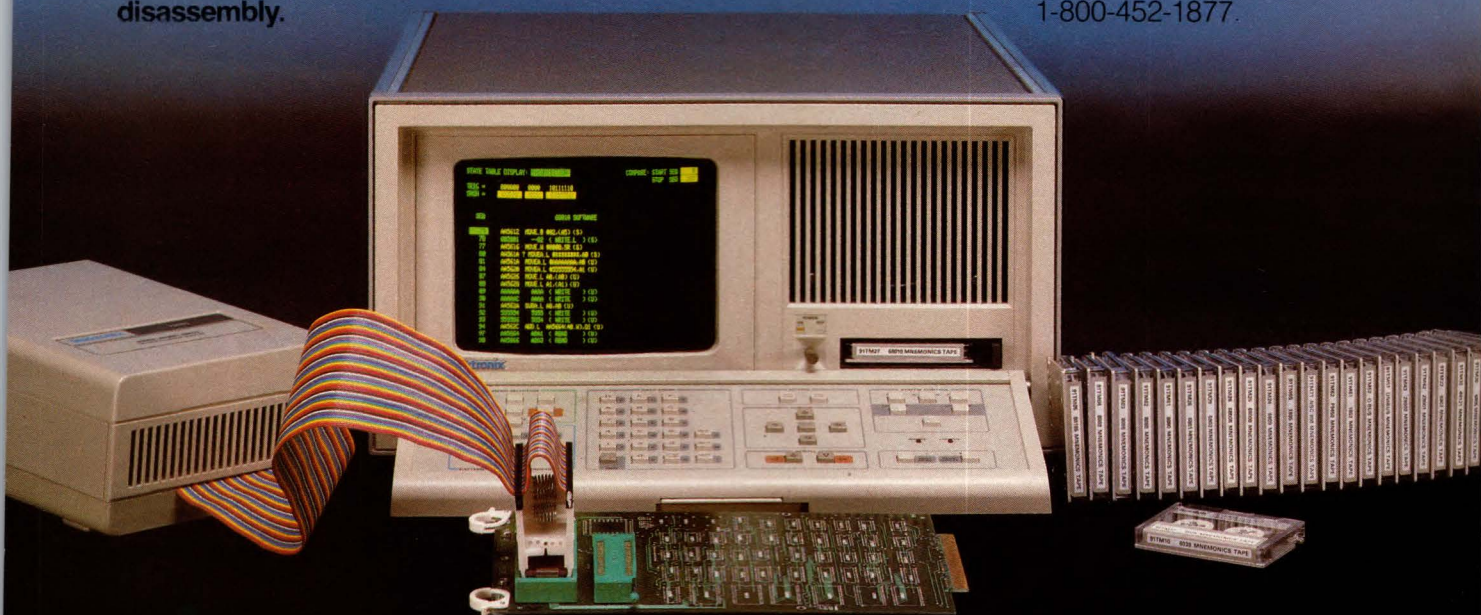
The DAS is as easy to use as your tasks are complex.

The exclusive color display highlights discrepancies for faster evaluation. A menu-driven keyboard plus detailed documentation start you off fast.

Call today for the facts:

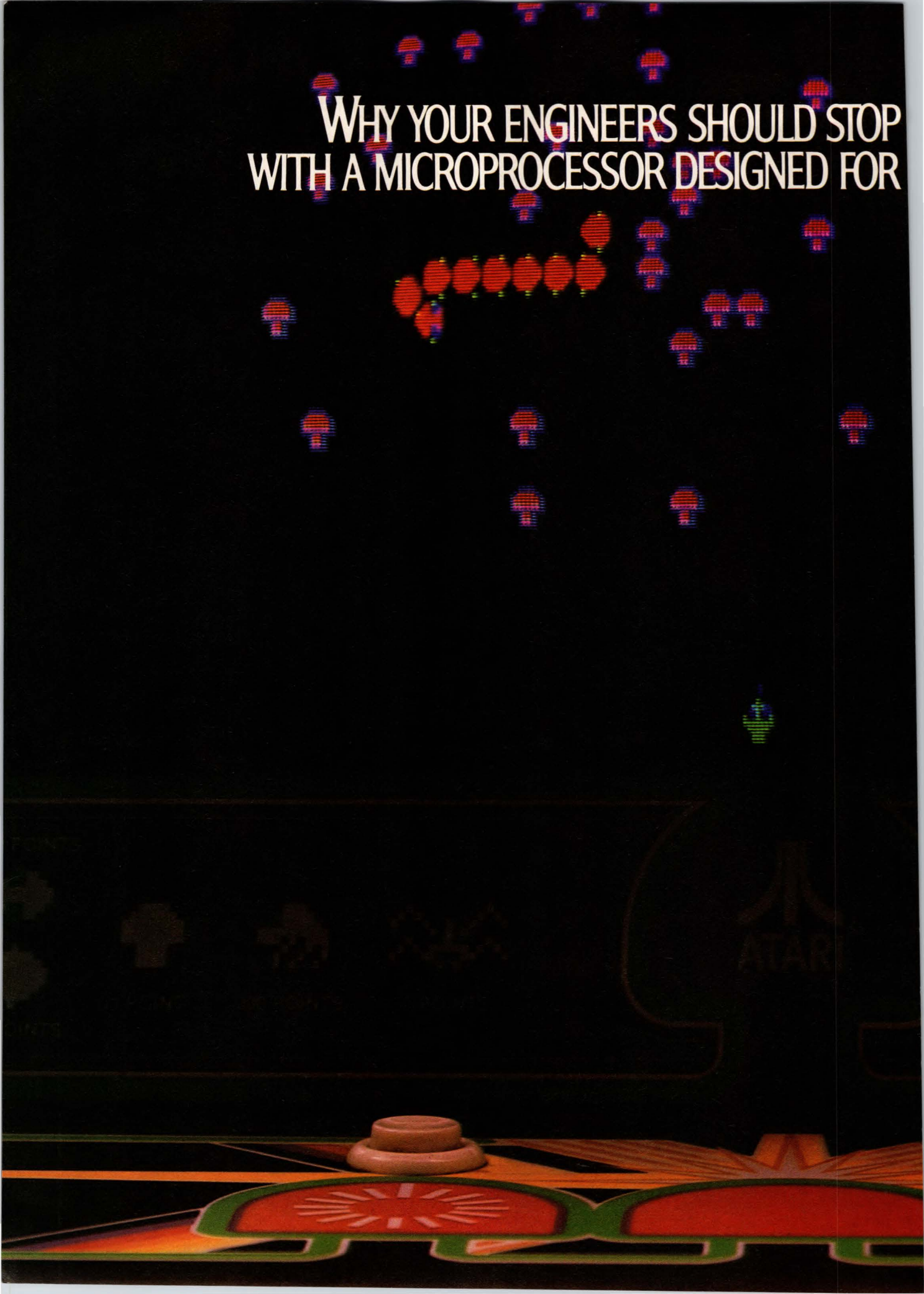
1-800-547-1212. In Oregon:
1-800-452-1877.

ONLY ON THE TEK DAS 9100



Tektronix
COMMITTED TO EXCELLENCE

WHY YOUR ENGINEERS SHOULD STOP
WITH A MICROPROCESSOR DESIGNED FOR



DEBUGGING PROGRAMS ZAPPING CENTIPEDES.

Just because your product uses a microprocessor doesn't mean your software development team should.

Because now there's a far more powerful, faster, and less expensive way to develop software for microprocessors.

A VAX-based system from Digital.

Using a VAX™ computer, Digital software products, and development tools from companies like Tektronix and Boston Systems Office, your engineers can develop software for over 40 different microprocessors.

All from one extremely powerful, fast, and easy-to-use VAX computer system.

Just consider.

The complex and powerful software for the VAX computer was developed on—what else? A VAX computer. And now you can put that same power to work with sophisticated microprocessor software development tools.

Tools like high-level language compilers. Relocatable macro assemblers. Language-directed editors with automatic syntax checking. Symbolic program debuggers. And even revision control systems to keep track of what happened to your code weeks ago. Or what should happen to it tomorrow.

What's more, the price per station of a VAX-based system is lower than that of most microprocessor-based development systems.

So why keep using a microprocessor on a job that calls for a real computer?

To find out more about VAX-based microprocessor software development systems, call 1-800-DIGITAL, Extension 121.

And find out how much easier your job can be if you use the right tools.



Digital, the Digital logo, and VAX are trademarks of Digital Equipment Corporation.

© Digital Equipment Corporation, 1985.

Centipede™ video game used courtesy of Atari Games.

Centipede is a registered trademark of Atari Games. © 1981, Atari Games.

CIRCLE NO 78

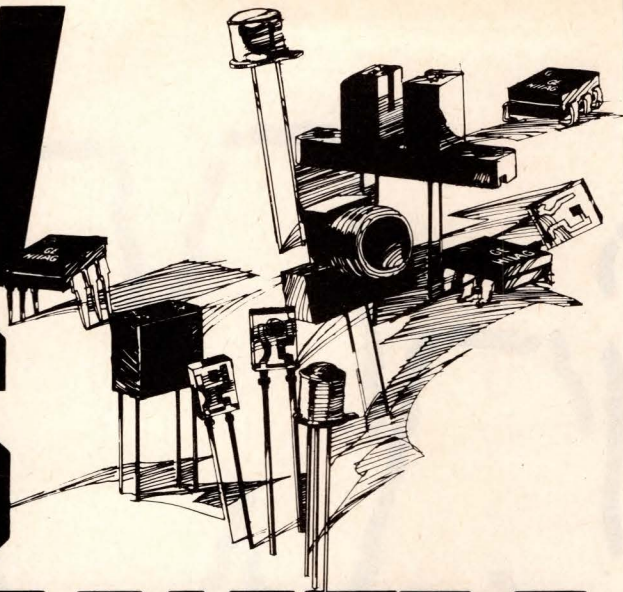
To EDN readers, for consistently voting
EDN your favorite electronics
publication.





From the staff of EDN

12 NEW OPTOS ON THE WAY.



Watch the boxes and watch your design options multiply.

All the opto devices you need from General Electric – isolators, interrupters, emitters & detectors, fiber optic components.

Quality you can count on – industry's highest emitter output, lowest CTR degradation rate, most efficient couplers.

And new products with the flexibility you need for industrial, computer, and telecommunications applications.

We make it easy for you to go with GE – the strongest application engineering support and more stocking distributor outlets than anyone.

GE stands for Great Engineering.

Call us or write us:
GE Semiconductor,
Electronics Park, Bldg. 7, MD-49,
Syracuse, NY 13221.

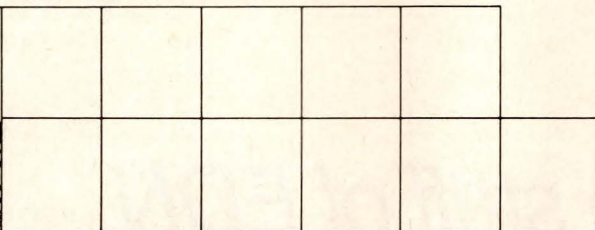
800-626-2001 EXT. 425

or call your local GE distributor

Watch here for our next announcement.

H11AG optoisolator.

Operates at 1/3rd or less current than garden variety CMOS compatible couplers. Features high CTR, low degradation. Needs very little input current.



A registered trademark of General Electric Company.
222-41



Understand probe resistance to ensure accurate measurements

When you choose a probe for an oscilloscope measurement, consider the effects of the probe's resistance on your circuit. By selecting the right probe for your circuit, you can avoid measurement errors.

William Escovitz, *Hewlett-Packard Co*

When you use a scope probe to test a circuit, the probe becomes part of that circuit and affects its performance. Thus, you must be sure to choose the proper probe for a particular oscilloscope measurement. Otherwise, the scope probe could have a profound influence on the measurement results. For example, if you attempt to measure a high-resistance circuit node with a scope probe of insufficient resistance, any or all of the following problems may occur:

- The dc values at some circuit nodes may change significantly, even though the circuit under observation still works.
- Significant changes may occur in the output waveform.
- The circuit may not work.

To see how probe loading can cause such effects on a circuit, consider the wideband amplifier in **Fig 1**. The circuit includes an op amp and a high-frequency hybrid.

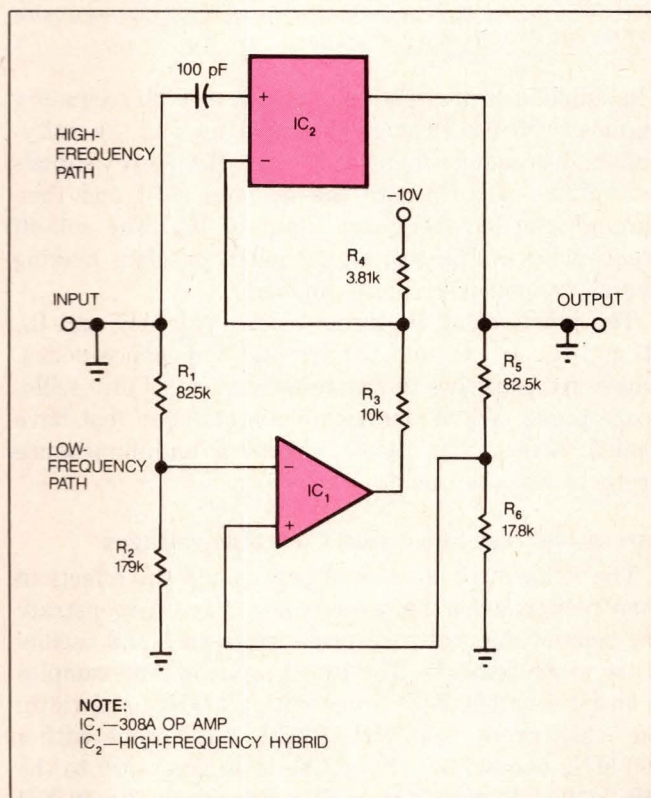


Fig 1—You can see the effects of probe loading by probing different nodes in the wideband amplifier contained in the input pod of an HP 54003A scope probe. The circuit has nodes whose impedance can be as high as 150 k Ω . If you take measurements with probes of insufficient resistance, you might change the characteristics of the circuit.

A probe's resistance can load your circuit to the point where it will not operate.

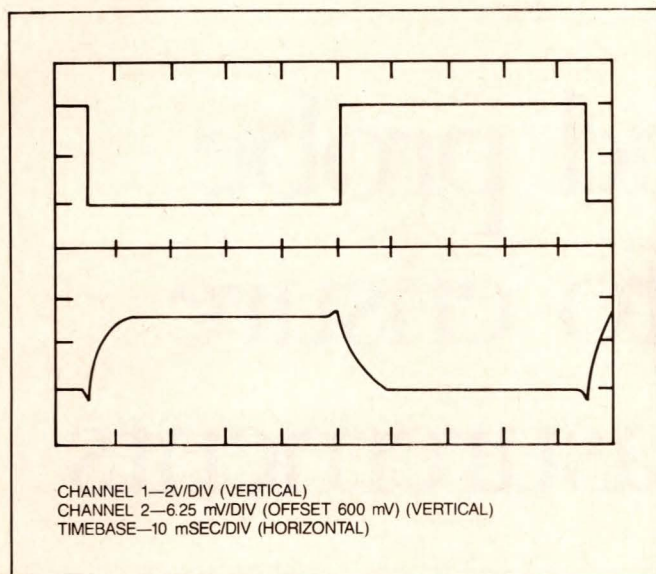


Fig 2—When you apply an 11-Hz square wave to the amplifier in Fig 1, you get the traces shown here. The top trace is the amplifier output. The bottom trace is at the low-frequency input of IC₂ (the junction of R₃ and R₄). Correct output waveforms do not guarantee that the circuit is operating properly.

The amplifier's dual-path circuit passes high-frequency signals (>20 Hz) through the capacitor and the unity-gain high-frequency hybrid, IC₂. Low-frequency signals (<1 MHz) pass through the op amp (IC₁) and then through the low-frequency input of IC₂. The roll-off frequencies of the two signal paths overlap, making overall frequency response uniform.

The junctions of the three resistor pairs (R₁ and R₂, R₃ and R₄, and R₅ and R₆) are high-impedance nodes, which are sensitive to the resistive load of an oscilloscope probe. When you test op-amp circuits that have similar nodes, you should choose a high-impedance probe to test the circuit.

Low probe resistance shifts internal voltages

The following examples of probes and the effects of their resistance on the test circuit in Fig 1 demonstrate the relationship between probe resistance and oscilloscope measurements. The 10-k Ω probe in the examples is an HP 54001A, 2-pF probe with a 1-GHz bandwidth; the 1-M Ω probe is an HP 54003A, 8-pF probe with a 300-MHz bandwidth (this probe is an accessory to the HP 54100A/D digitizing oscilloscope); and the 10-M Ω probe is an HP 10014A, 10-pF probe with a 300-MHz bandwidth.

When you use the 1-M Ω probe to monitor the junction of R₃ and R₄ (a node with a 3-k Ω impedance), the

normal dc output of IC₁ is 0V and the low-frequency input of IC₂ is -7.5V. As you would expect, channel 2's waveform is a bandwidth-limited square wave (Fig 2).

If you use the 10-k Ω probe to take the same measurement, the output waveform is still correct. However, the dc output of the operational amplifier is -7.5V instead of 0V; -7.5V is close to the minimum voltage

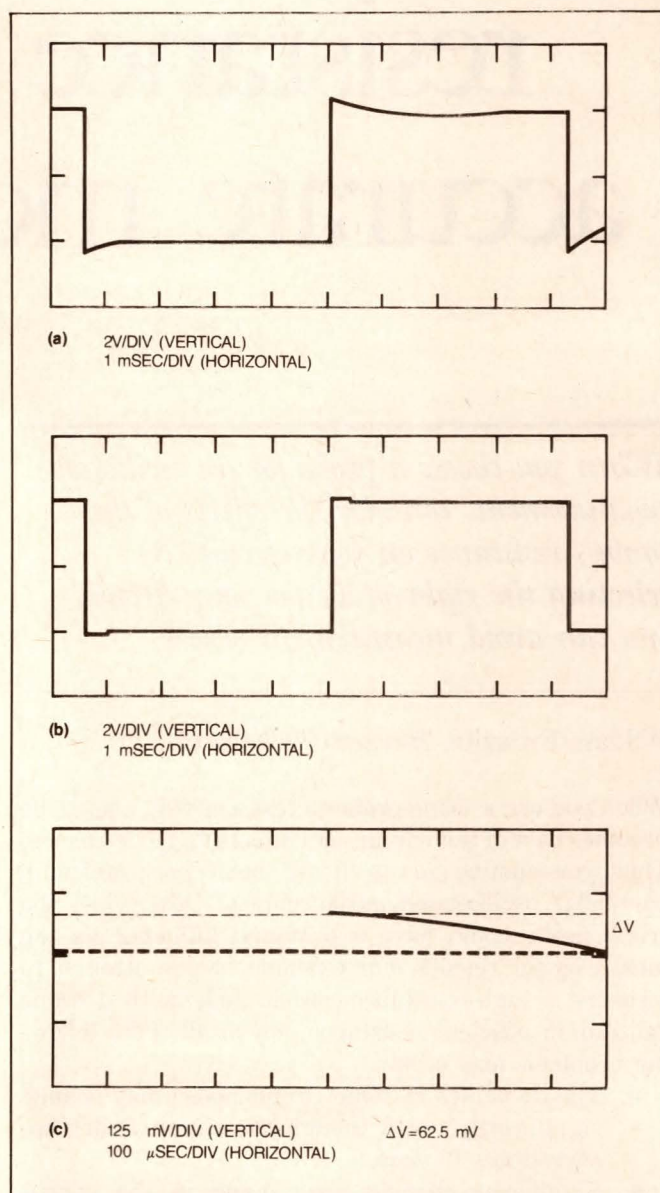


Fig 3—Resistive loading of the 1-M Ω probe causes a gain mismatch between IC₁ and IC₂ that results in the droop (a). Taking the same measurement with a 10-M Ω probe reduces the error caused by the probe to 1.5% (b). Expanding the scale quantitatively shows the reduction in the measurement error. The droop (ΔV) is 62.5 mV, or approximately 1.5% of the 4V p-p value of the waveform (c).

IC₁ can provide and far from the design voltage of 0V dc. Thus, using a probe whose resistance is too low significantly upsets the circuit's internal voltages, even though the circuit still works.

You might be tempted to conclude that the measured -7.5V is the valid operating level and that your design voltage of 0V was a design error or a circuit malfunction. In this case, however, the probe caused the shift in the dc levels. So, if your measured values vary greatly from your design values, be sure to check your probe's impedance.

Insufficient probe impedance shifts gain

Besides changing the dc levels, probe loading can make circuits inoperative. In Fig 1, the node impedance of IC₁'s noninverting input is approximately 15 kΩ. If you use the 10-kΩ probe to take a measurement at the noninverting input, you will double the low-frequency gain of the circuit. Attaching the probe from IC₁'s noninverting input to ground reduces R₆ from 17.8 to 6.4 kΩ. When you insert the reduced value of R₆ into the equation

$$\frac{R_2(R_5 + R_6)}{(R_1 + R_2)R_6} = 1, \quad (1)$$

you see that the circuit's low-frequency gain increases from 1 to 2.5. The circuit cannot operate with that much gain, so it latches up.

Reduce errors by changing probes

You can reduce measurement errors by using a probe that has higher impedance. In the test circuit in Fig 1, the impedance of the inverting input of the op amp is approximately 150 kΩ. If you probe the inverting input with the 1-MΩ probe you can see that the circuit's output is changed (Fig 3a), because the shunt resistance of the probe has reduced the low-frequency gain. When you use the 1-MΩ probe to look at the inverting input, the probe's 1-MΩ resistance reduces R₂'s value to 152 kΩ. Insert R₂'s new value in Eq 1; you'll see that the low-frequency gain is now 0.87. The low-frequency gain of 0.87 and the high-frequency gain of 1 causes the drooping response that you see in Fig 3a.

If you reduce probe loading at the inverting input by using a 10-MΩ probe to take the measurement, the gain mismatch caused by the probe will be 1.5%, which will show up in Fig 3b as a slight break in the square wave.

Using the high-resistance 10-MΩ probe essentially eliminates the effects of probe loading at the inverting input.

By magnifying the waveform, you can measure the reduction in the measurement error quantitatively. Fig 3c shows the circuit's output magnified from 2 V/div to 125 mV/div (the sweep speed has been increased to 100 μsec/div). Two voltage markers, one at the peak value and one at the long-term value of the square wave, measure the wave's droop. The change in voltage indicated by ΔV is 62.5 mV, or approximately 1.5% of the waveform's 4V p-p value.

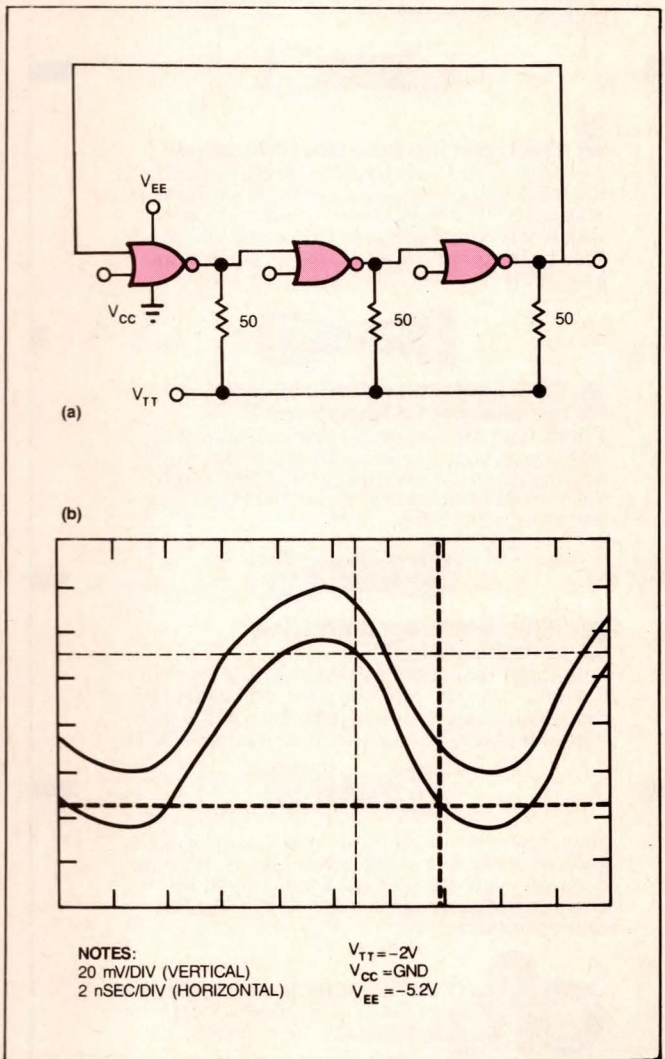


Fig 4—An ECL NOR-gate ring oscillator (a) is a high-frequency circuit that is relatively insensitive to a probe's tip capacitance. The scope traces (b) show that you can probe this ECL circuit with a 500Ω, 0.7-pF probe (top trace) or a 1-MΩ, 8-pF probe (bottom trace). The markers show a 90 to 10% fall time of 3.15 nsec.

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.

You can use a high-resistance probe to take measurements of circuits that have frequencies as high as 300 MHz, as long as the probe's tip capacitance doesn't load the source impedance. When you use the 1-M Ω probe, for example, make sure that the source resistance is <70 Ω at 300 MHz.

To examine the effects of probe capacitance on high-speed circuits, consider the ring oscillator in Fig 4a. The circuit includes three 10K ECL NOR gates. ECL outputs have very low impedance and are relatively insensitive to the 1-M Ω probe's 8-pF load capacitance.

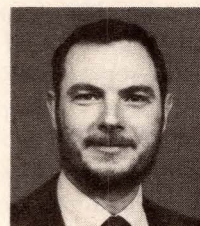
When you probe the oscillator circuit with the 1-M Ω probe and a 500 Ω , 10 $\times$ resistive-divider probe, you get the waveforms shown in Fig 4b. The output waveforms of the two probes are essentially the same.

Manufacturer's specifications for 20 to 80% rise and fall times for 10K ECL devices are typically on the order of 2 nsec. The traces in Fig 4b show that the rise and fall times for the probes are 2.2 and 2.04 nsec, respectively. When 0.7- and 8-pF probes were used in the oscillator circuit, the oscillator period was 12.93 and 12.99 nsec, respectively. Although the 1-M Ω , 8-pF probe is intended for low current loading at low frequencies, when it was used to probe a high-speed ECL circuit, it produced the same timing measurements as the 0.7-pF probe did.

Finally, remember that you can usually represent a scope probe as a resistor in parallel with a capacitor. Redrawing the schematic of your circuit with the probe's resistance and capacitance added, and analyzing the circuit's behavior, will help you choose the proper probe for measuring your circuit. **EDN**

Author's biography

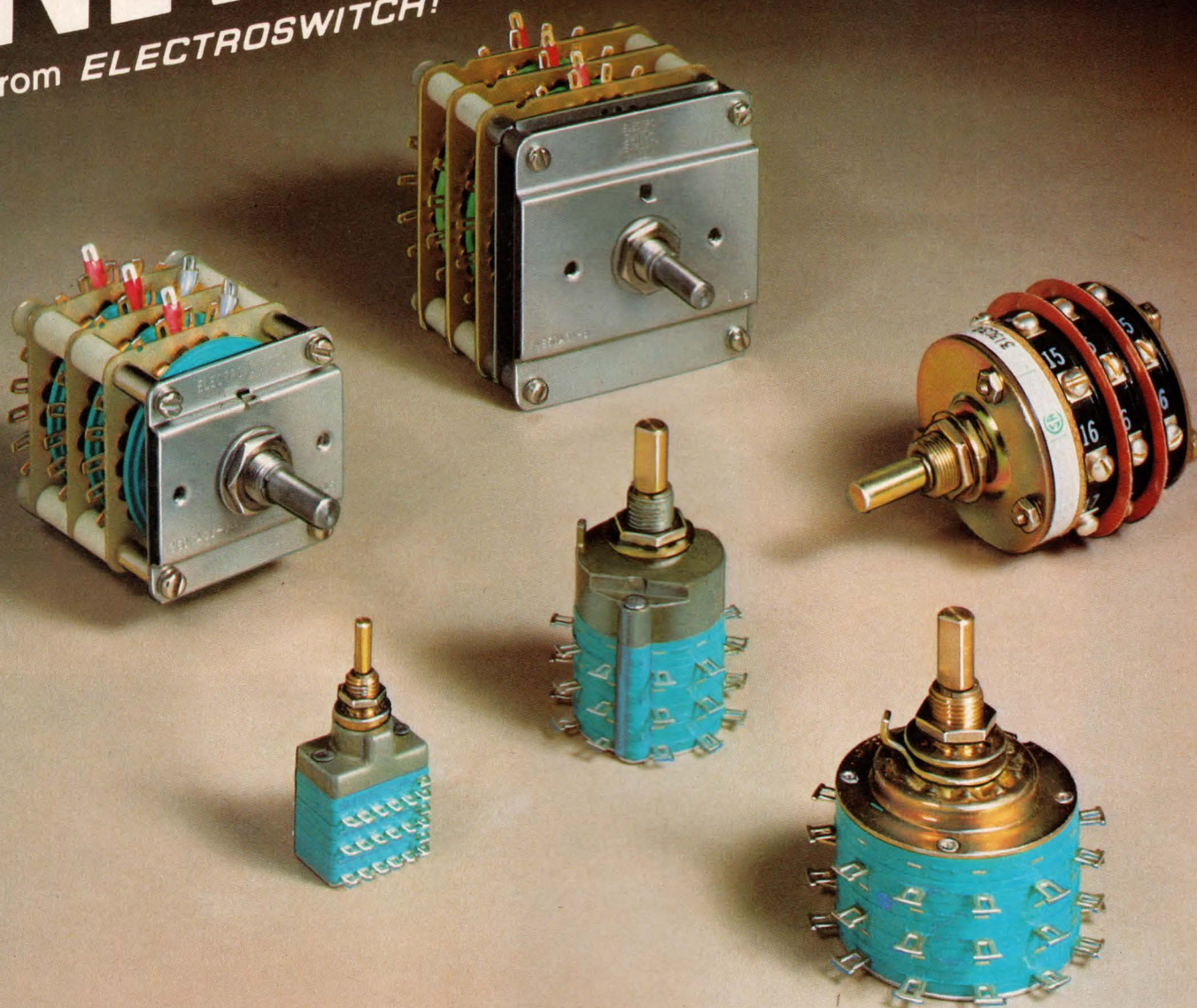
Bill Escovitz is an engineer at Hewlett-Packard Co (Colorado Springs, CO), where he designs oscilloscopes. He was previously employed by the University of Chicago. Bill holds a BA in physics from Dartmouth and MS and PhD degrees in physics from the University of Chicago. He is a member of the American Physical Society and the IEEE.



Article Interest Quotient (Circle One)
High 485 Medium 486 Low 487

NEW

from *ELECTROSWITCH!*



A Full Range of **ELECTRONIC ROTARY SWITCHES** from low-level to power applications.

Interrupt Ratings: from .10 to 10 amps • Continuous Ratings: from 6 to 25 amps
Up to 48 Positions

Applications include: Communications Systems ... Computers & Peripherals ... Test Equipment
... Power Supplies ... Medical Electronics ... Industrial Controls ... etc.

AVAILABLE WITH: Special Contacting (encoded, shorting/non-shorting, etc.); Special Terminals (PC mounts, solder & quick-connect); Dual Concentric Shafts; Key-operated; Spring-return; Field Adjustable Stops; etc.

Ask for the **NEW** Catalog RES-1



ELECTROSWITCH

ELECTRO SWITCH CORP.

Weymouth, Massachusetts 02188

Telephone: 617/335/5200 • TWX: 710/388/0377



VMEBus Support



UNIFIVE: the UNIX* System Five port on Philips VMEbus/68000 hardware

UNIX System Five, latest and generally regarded as the most advanced member of the UNIX family, incorporates many new and powerful features. 512 or 1024 block size with fsba (file system block analyzer), improved interprocess communication (shared memory, semaphores, messages), improved standard libraries, and a speed enhancement of about 20%, as well as a line printer spooler.

UNIFIVE, Philips UNIX for VMEbus/68000 hardware, is not only

fully compatible with UNIX System Five but also incorporates the Berkeley enhancements BSD 4.2.

UNIFIVE running on Philips VMEbus/68000 modules provides a

powerful UNIX environment. Naturally, a full range of application packages and languages is available!

* UNIX is a registered trademark of A.T. & T. TECHNOLOGIES

For more information contact:

Philips Industrial
Data Processing,
Building TQIII-2,
5600 MD Eindhoven,
The Netherlands,
Telex: 35 000 PHTC (NL)
Or:
c/o Signetics Corporation,
811 East Arques Avenue,
SUNNYVALE Ca. 94086,
800-227-1817 ext. 951 D,
USA

Belgium
02-5256646 · (Mr. Ph. Donnini)
France
01-8301111 · (Mr. A. Perrot)
Italy
039-3635207 · (Mr. E. Conti)
Netherlands
040-788325 · (Mr. N. Blonk)

Nordic(S)
8-7821091 · (Mr. J. Hedberg)
Portugal
01-683121 · (Mr. J. Calado)
Spain
01-4043200 · (Mr. E. Delgado)
Switzerland
01-4882407 · (Mr. T. Kälin)

UK
01-5806633 · (Mr. J. Langman)
West-Germany
0561-501348 · (Mr. D. Krostewitz)
USA and Canada
408-991 3544 · (Mr. B. Celebi)

DESIGN IDEAS

EDITED BY KEN MARRIN

Circuit provides temperature compensation

Joe Lutz

Peninsula Engineering, Redwood, CA

The circuit shown in Fig 1 provides temperature compensation for a microwave amplifier circuit's gain and gives three degrees of freedom over the amplifier's operating temperature range (-40 to $+60^{\circ}\text{C}$). To provide compensation, the circuit sends a control signal to a pin diode that's in series with the amplifier's main signal path. As the current through the pin diode decreases, the diode provides more attenuation. As the current increases, the diode provides less attenuation.

Fig 2 shows the relationship between diode current and operating temperature. At room temperature, IC_{1b} and R_{10} supply a constant current of 0.16 mA to the diode. This current remains constant until the temperature falls to -10°C . At -10°C , IC_{1b} slowly begins to shut off. Finally, at -30°C , IC_{1b} supplies no current. At this temperature, the only current that the diode

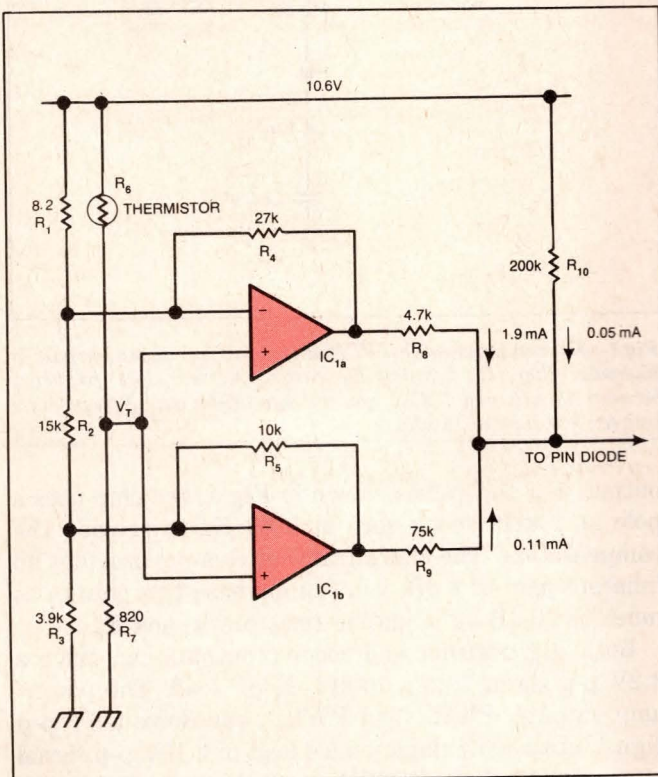


Fig 1—This circuit provides temperature compensation for a microwave amplifier circuit's gain. With the components shown, the circuit provides three degrees of freedom over -40 to $+60^{\circ}\text{C}$.

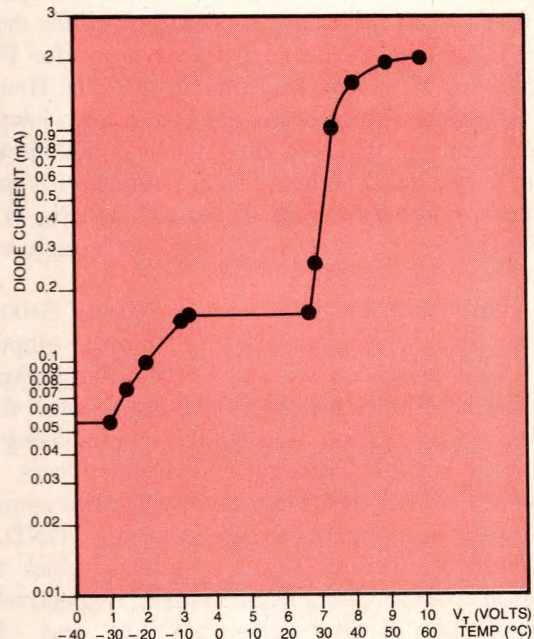


Fig 2—This graph shows the relationship between the system's operating temperature and the pin-diode current supplied by the compensation circuit in Fig 1. The control current that the compensation circuit supplies acts as a control signal to the pin diode, whose attenuation is proportional to the control current.

receives is the 0.05 mA provided by R_{10} . R_5 's value determines the temperature range over which this transition occurs.

For temperatures as high as 40°C , R_{10} and IC_{1b} provide a constant 0.16 mA . Above 40°C , however, IC_{1a} 's current output rises dramatically. At 55°C , IC_{1a} saturates, and the pin diode provides its maximum attenuation.

To modify the response shown in Fig 2 for different applications, you can adjust either the feedback resistors (R_4 and R_5) or the reference voltage divider (determined by resistors R_1 , R_2 , and R_3). To give the circuit additional degrees of freedom, you can add more op amps.

EDN

To Vote For This Design, Circle No 745

PCM filter offers lowpass, bandpass options

David J Donovan
Harris Corp, Melbourne, FL

The Harris HC-5512, 5512A, and 5512C pulse-code-modulated (PCM) filters are switched-capacitor monolithic circuits that were originally designed for PCM codec filtering in systems that sample at 8 kHz. However, by taking advantage of the devices' receive lowpass filter and transmit highpass filter, you can build a wide range of lowpass and highpass filter circuits with cutoff frequencies ranging from 200 Hz to 10 kHz (Fig 1). To program the filter's cutoff frequency, you simply vary the device's input clock frequency.

The chip's transmit side uses a 200- to 3400-Hz bandpass filter, which comprises a fifth-order elliptical lowpass filter cascaded with a fourth-order highpass filter. The receive side uses a 3400-Hz lowpass filter with $\sin X/X$ correction. Second-order antialiasing filters precede both the transmit and receive filters.

To specify a 3-dB cutoff frequency, you first connect the chip's CLK_0 input (pin 14) to either V_{CC} , GND, or V_{BB} . (These connections result in internal clock frequencies of 2.048, 1.544, and 1.536 MHz, respectively.) V_{CC} 's and V_{BB} 's nominal values are +5V and -5V, respectively. You then set the filter's cutoff frequency by applying an external clock signal to pin 12, whose frequency lies between 300 kHz and 5 MHz (the device won't work at frequencies out of this range).

For a 300-kHz external clock frequency, the lowpass filter will have a cutoff frequency of 1 kHz, and the bandpass filter will have a lowpass cutoff frequency of 200 Hz and a highpass cutoff frequency of 1 kHz. At 5 MHz, the lowpass filter will have a cutoff frequency of 10 kHz, and the bandpass filter will have a lowpass cutoff frequency of 5800 Hz and a highpass cutoff frequency of 9 kHz.

Between 300 kHz and 5 MHz, the cutoff frequencies for both the lowpass and bandpass filters will vary nearly linearly with the programming frequency, with some compression occurring at either end of the programming frequency's spectrum. The bandpass filter's bandwidth will remain constant at 3200 Hz, except for some compression at the lower end of the programming spectrum. The least amount of compression will occur for the highest internal clock frequencies (ie, when pin 14 is connected to V_{CC}).

At 3300 Hz, the chip's receive filter provides an inherent gain. You can compensate for this gain by providing pole-zero compensation at the receive filter's

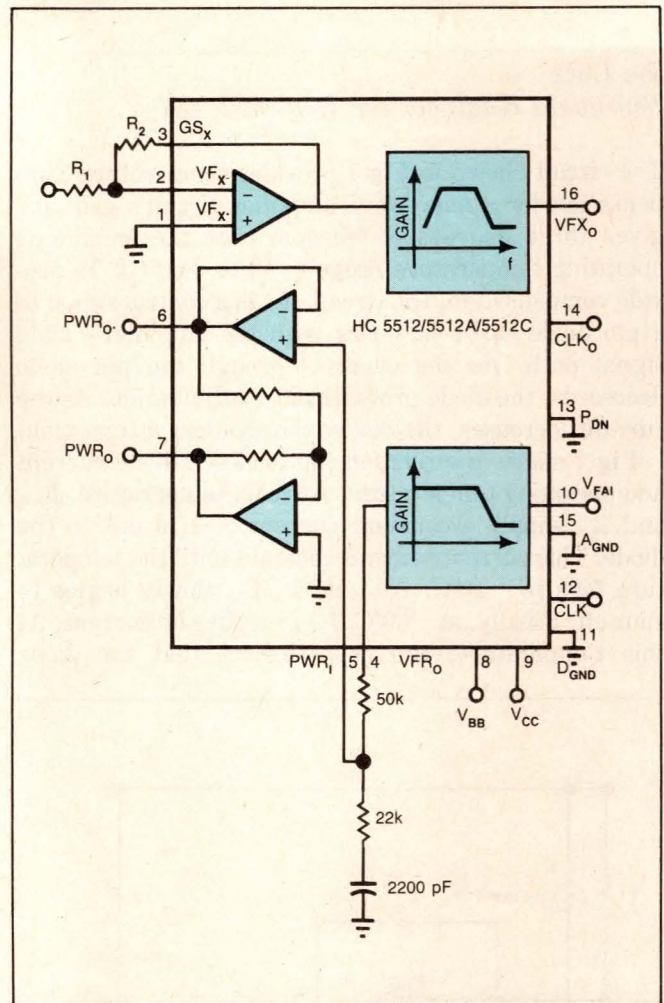


Fig 1—You can program this PCM filter to act as either a lowpass or highpass filter. By varying the chip's external clock frequency between 300 kHz and 5 MHz, you can select filter cut-off frequencies between 200 Hz and 10 kHz.

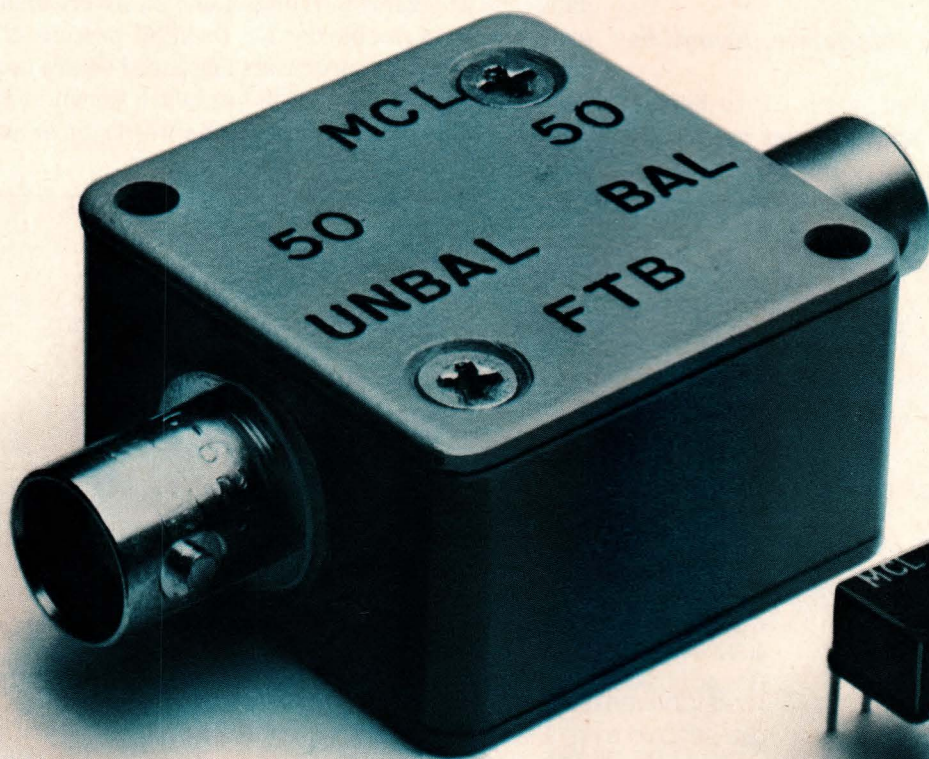
output. For the values shown in Fig 1, the chip uses a pole at 1 kHz and a zero at 3300 Hz to provide the compensation. The chip's transmit channel provides an inherent gain of 3 dB; you can increase this gain to as much as 20 dB by adjusting resistors R_1 and R_2 .

Both the transmit and receive outputs can drive a 3.2V p-p signal into a 10-k Ω , 25-pF load. The power-amp outputs, PWR_0^+ and PWR_0^- , can drive a 5V p-p signal into a 300 Ω single-ended load or a 10V p-p signal into a 600 Ω balanced load.

EDN

To Vote For This Design, Circle No 743

RF transformers



3 KHz-800 MHz
over 50 off-the-shelf models
from \$295

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



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

C71 Rev. Orig.

CIRCLE NO 84

Program provides gray/binary conversion

Dan G Sporea
Central Institute of Physics, Magurele, Romania

In position-encoder systems that use a μ P to handle data processing, the position encoder uses gray code and the μ P uses binary code to process the position

data. The programs in **Tables 1** and **2** convert binary to gray and gray to binary for the Z80 processor. The algorithms that the programs are based on are derived from the parallel-conversion hardware shown in **Fig 1**. The programs operate first on the word's most significant byte.

TABLE 1—BINARY TO GRAY CODE CONVERSION PROGRAM

3000	78		LD A,B	THE MOST SIGNIFICANT BYTE OF THE NUMBER TO BE CONVERTED
3001	08		EX AF,AF'	IS STORED.
3002	CB28		SRA B	THE MOST SIGNIFICANT BYTE IS SHIFTED RIGHT.
3004	08		EX AF,AF'	CONVERT THE LEAST SIGNIFICANT BIT OF THE NUMBER TO BE CONVERTED. STORE THE MOST SIGNIFICANT BYTE IN THE CARRY FLAG OF THE STATUS REGISTER F'.
3005	A8		XOR B	PART OF THE MOST SIGNIFICANT BYTE OF THE RESULT IS COMPUTED, EXCEPT FOR ITS MOST SIGNIFICANT BIT.
3006	CB78		BIT 7,B	THE MOST SIGNIFICANT BIT OF THE RESULT IS OBTAINED.
3008	47		LD B,A	LOAD THE RESULT'S MOST SIGNIFICANT BYTE IN REGISTER B.
3009	2007		JRNZ CNV 1	
300B	08	CNV 2	EX AF, AF'	THE CARRY FLAG CONTAINS THE LEAST SIGNIFICANT BIT OF THE MOST SIGNIFICANT BYTE OF THE NUMBER TO BE CONVERTED.
300C	79		LD A,C	THE ACCUMULATOR IS LOADED WITH THE SECOND BYTE OF THE NUMBER TO BE CONVERTED.
300D	CB19		RR C	THE SECOND BYTE'S MOST SIGNIFICANT BIT IS ROTATED. THE LEAST SIGNIFICANT BIT OF THE MOST SIGNIFICANT BYTE OF THE NUMBER TO BE CONVERTED IS INPUT FROM THE CARRY FLAG.
300F	A9		XOR C	THE LEAST SIGNIFICANT BYTE OF THE RESULT OF THE NUMBER TO BE CONVERTED IS COMPUTED.
3010	AF		LD C,A	STORE RESULT IN REGISTER C.
3011	C9		RET	RESULT IS STORED IN REGISTERS B AND C.
3012	CBF8	CNV1	SET 7,B	CORRECT THE RESULT'S MOST SIGNIFICANT BIT.
3014	18F5		JR CNV 2	

TABLE 2—GRAY CODE TO BINARY CONVERSION PROGRAM

3100	2610		LD H,10 H	LOAD THE LOOP COUNTER.
3102	7A		LD A,D	THE MOST SIGNIFICANT BYTE OF THE NUMBER TO BE CONVERTED IS LOADED IN THE ACCUMULATOR.
3103	CB07	CNV	RLC A	THE CARRY FLAG RECEIVES THE CURRENT BIT OF THE RESULT.
3105	CB11		RL C	THE CURRENT BIT OF THE RESULT IS SHIFTED IN RESULT REGISTERS B AND C, WITH THE MOST SIGNIFICANT BYTE STORED IN REGISTER B.
3107	CB10		RL B	
3109	CB0F		RRC A	THE MOST SIGNIFICANT BIT IN THE ACCUMULATOR IS RESTORED.
310B	CB23		SLA E	THE NUMBER TO BE CONVERTED IS ROTATED.
310D	CB12		RL D	
310F	AA		XOR D	THE CURRENT BIT OF THE RESULT IS COMPUTED.
3110	25		DEC H	DECREMENT LOOP COUNTER.
3111	20F0		JRNZ CNV	COMPUTE ALL BITS OF THE RESULT. STORE RESULT IN REGISTERS B AND C.
3113	C9		RET	

THRIFTY & VERSATILE.



4SC-5105

SPRAGUE MODULAR POWER SUPPLIES FOR DISPLAYS.

Sprague Series 200Z Modular Power Supplies meet a wide variety of needs at low cost. They're compact—measure but 2" x 2.5" x 0.9". They offer economical dc-to-dc conversion for high voltage displays (planar gas-discharge, electroluminescent, and vacuum-fluorescent), liquid crystal displays, CMOS-based systems, and many other applications requiring nonstandard voltage levels. The versatility provided by both open-frame and encapsulated modular construction is further enhanced by options that include over-voltage protection, output-shutdown and output-voltage adjustment. Input voltages: 5 to 48 VDC. Single or dual output voltages: 12 VDC to 400 VDC. Delivery from stock or up to 4 weeks ARO. For applications assistance and prices, contact our Customer Service Center at 209/732-4585. For technical information, write for Brochure VS-111A to Technical Literature Service, Sprague Electric Co., a Penn Central unit, 491 Marshall St., North Adams, Mass. 01247.



CIRCLE NO 146

WAVETEK Digital Signal Analyzer model 5830B

MAIN **CURSORS**

VIEWING

SET UP

ON **RESET** **AUTO** **ARMING MODE** **SINGLE** **THRESHOLD** **EXT TRIG INPUT** **OUTPUT** **ATTENUATOR** **START**

DESIGN IDEAS

The program in **Table 1** converts binary code to gray code and is based on the hardware shown in **Fig 1a**. The program stores both the binary number that you're converting and the resulting gray number in registers B and C.

The program in **Table 2** converts gray code to binary code and is based on the hardware shown in **Fig 1b**. The program stores the gray number that you're converting in registers D and E. It stores the resulting binary number in registers B and C.

Both programs avoid time- and memory-consuming memory-addressing instructions by relying exclusively on the Z80's internal registers. The program also improves execution speed by taking advantage of the Z80's rotation and bit-manipulation instructions. **EDN**

To Vote For This Design, Circle No 742

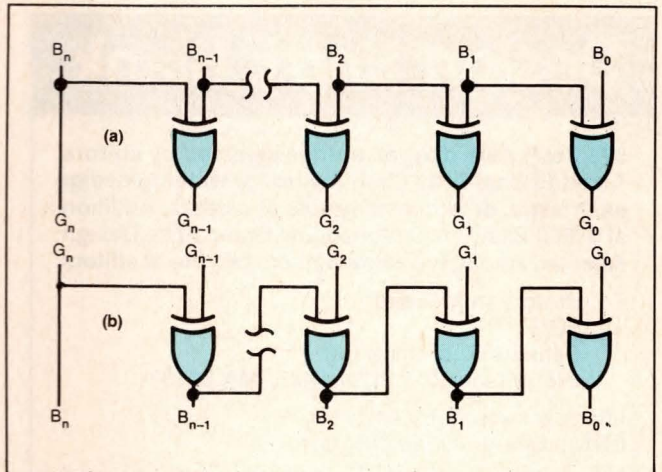


Fig 1—These binary-to-gray (a) and gray-to-binary (b) parallel-conversion devices serve as hardware models for the programs shown in Tables 1 and 2.

Vary frequency without changing duty cycle

Gordon Rogers
Bradenton, FL

In some pulse-generator applications, you may want to vary a pulse's frequency without changing its duty cycle. **Fig 1** shows you how to do this with a dual monostable multivibrator and a dual-gate MOSFET. R_1 and C_1 determine the pulse's frequency. R_2 determines the duty cycle. The sawtooth waveform at IC_{1A}'s pin 2 drives the FET, which in turn produces a sawtooth waveform with an adjustable dc component. R_2 's setting determines how much of the FET's output waveform triggers IC_{1B}. IC_{1A}'s Q_1 output resets IC_{1B}, which is

configured as a bistable multivibrator.

Output Q_2 of IC_{1B} goes high when the FET triggers pin 12 and goes low when IC_{1B} sends a reset pulse to pin 13. Because the trigger level applied to pin 12 is independent of frequency, the duty cycle is also independent of frequency. With the circuit values shown, you can vary the frequency between 8 and 50 Hz and the duty cycle between 3 and 97%. The frequency decreases by about 10% for duty cycles of 10 and 90%.

EDN

To Vote For This Design, Circle No 738

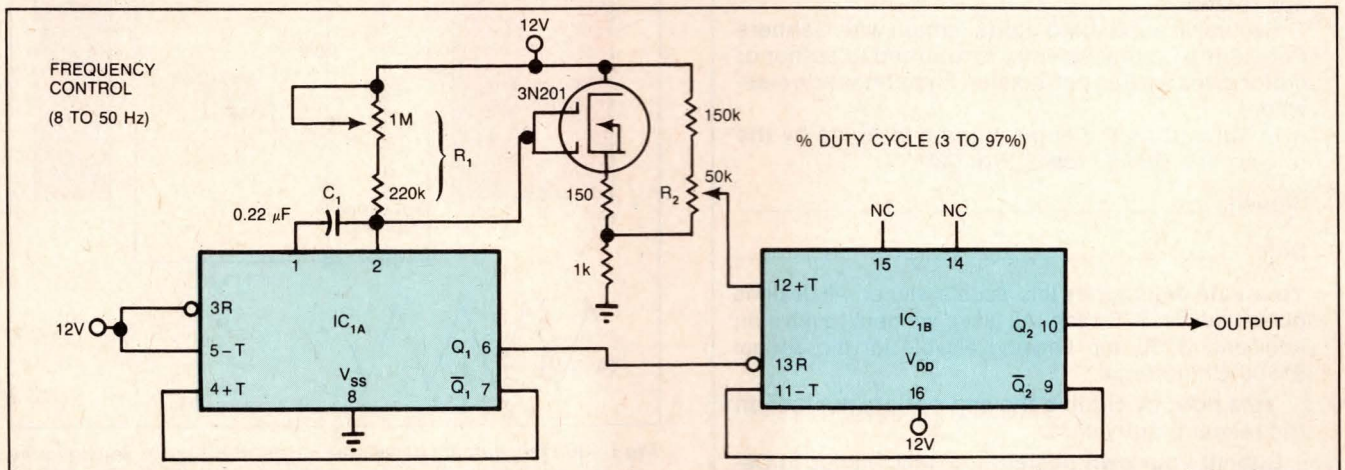


Fig 1—This circuit allows you to modify a pulse's frequency while keeping its duty cycle constant. By adjusting R_2 , you can select duty cycles from 3 to 97%.

Design Entry Blank

\$75 Cash Award for all entries selected by editors. An additional **\$100 Cash Award** for winning design each issue, determined by vote of readers. Additional **\$1500 Cash Award** for annual Grand Prize Design, selected among biweekly winners by vote of editors.

To: Design Ideas Editor
EDN
Cahners Publishing Co
275 Washington St, Newton, MA 02158

I hereby submit my entry for
EDN's Design Ideas program.

Name _____

Title _____ Phone _____

Company _____

Division (if any) _____

Street _____

City _____ State _____ Zip _____

Design Title _____

Home Address _____

Social Security No _____

Entry blank must accompany all entries. Design entered must be submitted exclusively to EDN, must be original with author(s), must not have been previously published (limited-distribution house organs excepted), and must have been constructed and tested.

Exclusive publishing rights remain with Cahners Publishing Co unless entry is returned to author or editor gives written permission for publication elsewhere.

In submitting my entry, I agree to abide by the rules of the Design Ideas Program.

Signed _____

Date _____

Your vote determines this issue's winner. All designs published win \$75 cash. All issue winners receive an additional \$100 and become eligible for the annual \$1500 Grand Prize.

Vote now, by circling the appropriate number on the reader inquiry card.

Submit your own design, too. Mail entries to Design Ideas Editor, EDN, 275 Washington St, Newton, MA 02158.

Circuit measures capacitor's resistance

Fred Brown

Consulting Engineer, Lake San Marcos, CA

To test large numbers of capacitors in production runs, use the circuit in **Fig 1a**, which lets you use an oscilloscope to determine a capacitor's series resistance at a glance. You drive the circuit with a square wave. If the capacitor has no series resistance, the oscilloscope will display a perfect sawtooth wave. If the capacitor has series resistance, however, the oscilloscope will display a sawtooth wave with a square wave superimposed on it (**Fig 1b**). The larger the superimposed square wave, the greater the series resistance.

To obtain a quick approximation of the capacitor's series resistance, look at the ratio of e_r to e_c . For $RC \gg T$, $e_c = ET \div RC$, where T is the square wave's period and e_c is the voltage across the capacitor. The ratio of e_r to e_c equals the ratio of the capacitor's series resistance to $T \div C$. For nonpolarized capacitors, you can omit the dc polarizing voltage.

EDN

To Vote For This Design, Circle No 744

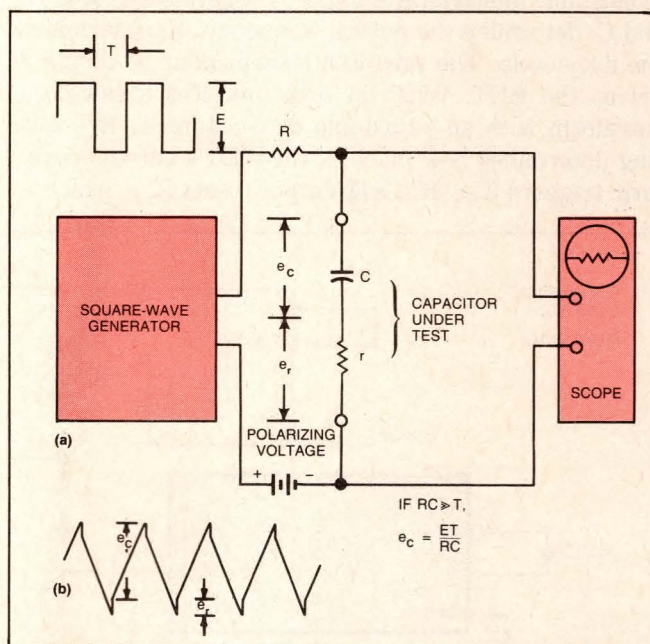


Fig 1—You can quickly determine a capacitor's series resistance by using the circuit in **a**. By looking at the relative magnitudes of e_r and e_c (**b**), you can decide whether the capacitor's resistance lies within acceptable limits.

Why are you still using LSTTL?

Now you can drop in RCA High-Speed CMOS and get four times greater reliability.

When you switch from LSTTL to RCA HCT QMOS, you get four times greater reliability, at no extra cost.

You also get all the other CMOS advantages, including low power consumption, low chip operating temperature, high noise immunity and wide temperature operating range.

You already know how to use it.

HCT parts are as fast as LSTTL. And they're direct drop-in replacements for virtually all applications, so you already know how to use them. You can even mix HCT and LSTTL parts in the same design.

We have extensive technical data which will give you all the information you need to use and test HCT parts.

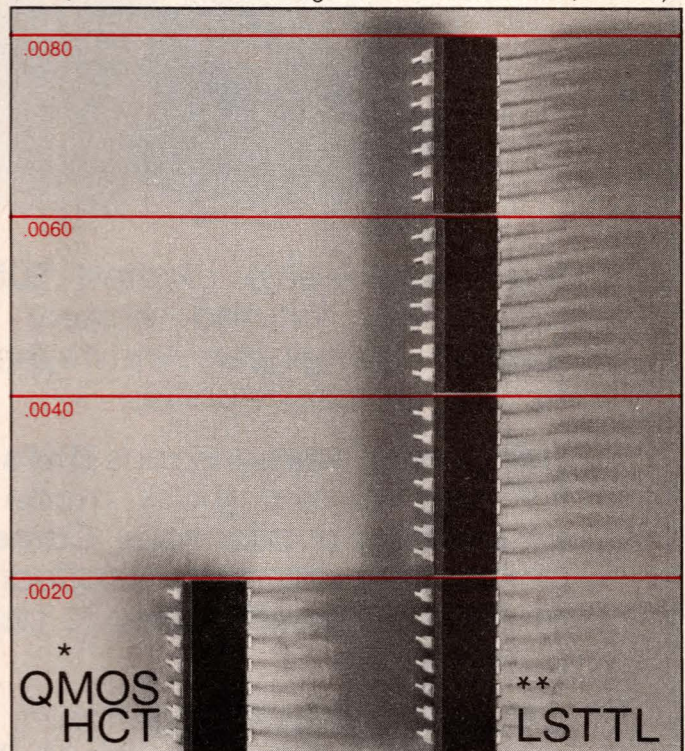
There will be one big difference when you start using HCT: you'll have a lot fewer equipment failures in the field. And if you want to improve your product even more, you can reduce the power supply or add battery back-up capability with only slight re-design.

If you're worried about getting the exact part you need, don't. Because RCA has the widest range of HCT devices in the industry, including many in High-Rel versions. And we offer an extensive line of QMOS HC, too.

Contact your local RCA sales office or stocking distributor. Or write: RCA Solid State, Box 2900, Somerville, NJ 08876.

Rate of failure

(in % per 1,000 hours of testing at 60% confidence level, at 85° C).



* Based on accelerated-life testing of 6,000 plastic-packaged devices using 1.0 eV activation energy.

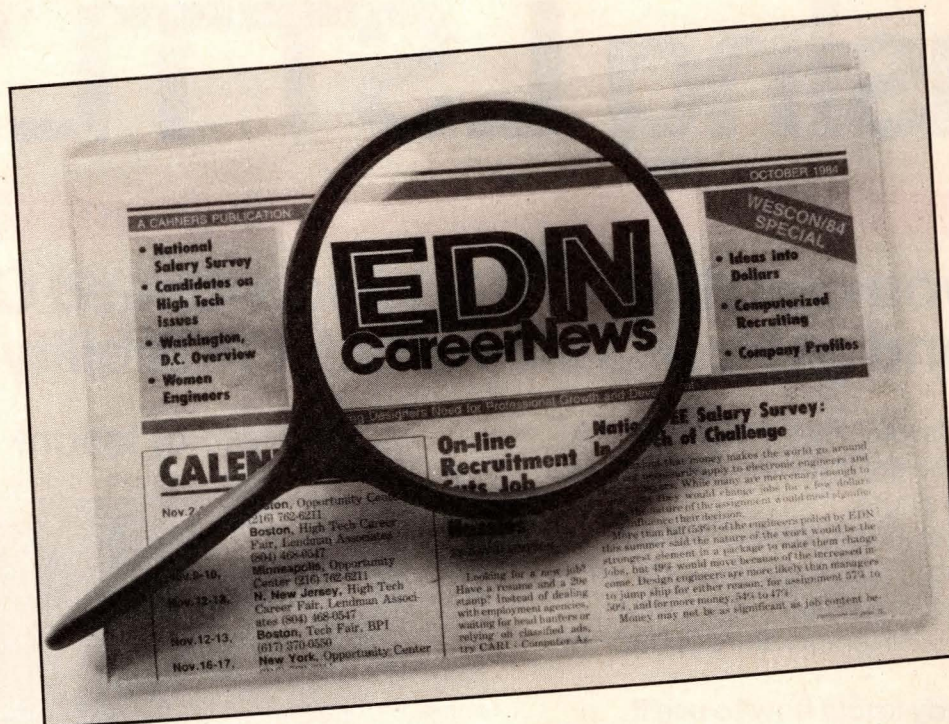
** Based on "Microcircuit Devices Reliability - Digital Failure Rate Data," RADC Publication MDR-17, Summer 1981, using 1.0 eV activation energy.

Your Mega-partner in CMOS.

CIRCLE NO 88

RCA

WE THINK YOUR CAREER NEEDS SOME CLOSE ATTENTION.



That's why we've created **EDN Career News**. It's the one publication focused entirely on the career concerns of electronics engineers. And it's the added source you need to find new career opportunities.

EDN Career News expands **EDN's** career coverage with the same first-rate editorial that's made **EDN** first among electronics engineering publications. **Career News** looks at the legal and government-related issues affecting the electronics industry. And at personal growth issues to help you reach your professional potential.

Join the 300,000 electronics engineers and engineering managers who pay attention to **EDN Career News** each month. It will make a difference in your career.

EDN CareerNews

Everything Designers Need for Professional Growth and Development

Roberta Renard, National Sales Manager
475 Park Avenue South, New York, N.Y. 10016 (212) 576-8045

Cahners Publishing Company

- Publishers of 32 specialized business magazines in Building & Construction
- Electronics & Computers • Foodservice • Manufacturing • Medical/Health Care

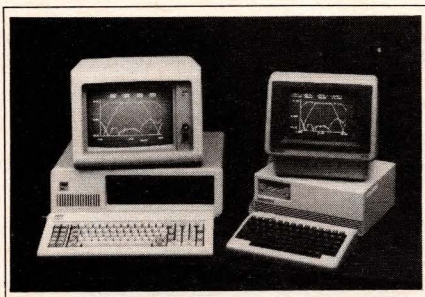
NEW PRODUCTS: COMPUTER-AIDED ENGINEERING

LAYOUT VERIFIER

Vecheck (verification and electrical check package), a version of ECAD's Dracula II software, runs on its vendor's Tegastation and GDSII CAD systems. The package lets you compare a net list of a logical design from a Tegastation with a GDSII physical layout to ensure logical, electrical, and geometric consistency. You can also extract electrical parameters from the mask-level layout to increase the accuracy of simulations and to back-annotate schematics using Tegastation's interactive graphics editor for schematic capture. The software system includes an electrical-rule checker that checks for violations that are either independent of or dependent on process technology. The network-consistency package compares layouts against circuit schematics. From \$41,000.

Calma Co., 501 Sycamore Dr., Milpitas, CA 95035. Phone (408) 434-4000.

Circle No 350



MICROWAVE/RF CAE

Version 1.3 of the Touchstone microwave/RF CAE program provides noise-figure analysis for as many as four stages of noise measurement and optimization. Analyses include shunt and series feedback, device parasitics, and ohmic losses in amplifier matching and feedback components. Version 1.3 also provides Monte Carlo yield predictions, including random variations of element values and wave-scattering data. The program reads this wave-scattering data into the HP 8510 network analyzer. The HP 8510 interacts with this CAE package,

over the IEEE-488 bus, on either an IBM PC (or PC compatible) with 640k bytes of RAM, or an HP 2000 Series computer with 1.25M bytes of RAM. The microwave/RF program calculates generalized scattering parameters based on frequency-dependent source and load impedances. In addition, the program features elements such as bipolar transistors, broadside-coupled lines in striplines, and a rectangular-waveguide terminator. Other capabilities include voltage-gain analysis for 2-port networks with 50 Ω or non-50 Ω source and load terminations, as well as exponential frequency sweeps for creating a common ratio between frequencies. \$7500.

Eesof Inc., 31194 LaBaya Dr., Suite 205, Westlake Village, CA 91362. Phone (818) 991-7530. TLX 384809.

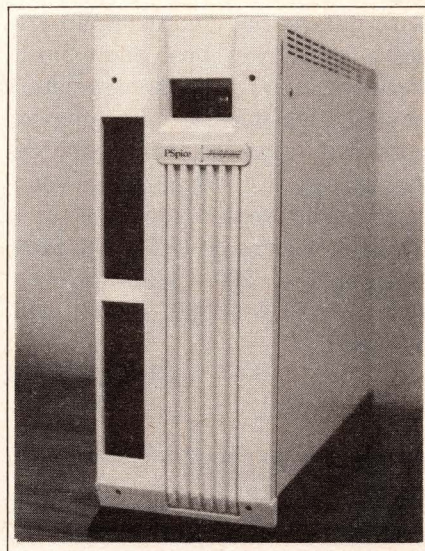
Circle No 351

3-D PERSPECTIVE

An added feature in VersaCAD Advanced software provides 3-D perspectives that you can rotate, edit, and use in other plots generated by the program. The software offers three drawing options: wire frame, which shows all the lines in the construction; backplane, which removes the back sides with a keystroke; and hidden line, which deletes backplane lines after calculating those that would be hidden from view. This CAD system includes 10 built-in primitives (arcs, French curves, and polygons); point-and-place symbol libraries; autodimensioning; proportional and unproportional scaling; and 250 overlay levels. Inquire and calculate functions evaluate area and perimeter totals, centers of gravity, cross-section areas, and moments of inertia. IGES compatibility is standard. \$1995.

T&W Systems Inc., 7372 Prince Dr., Suite 106, Huntington Beach, CA 92647. Phone (714) 847-9960.

Circle No 452



SPICE ACCELERATOR

PSpice Turbine accelerates the company's PSpice circuit-simulation program, permitting it to run on an IBM PC as fast as Spice runs on an unloaded VAX 11/780 running VMS with floating-point hardware. The device comes in a stand-alone chassis approximately the size of the PC chassis. It interfaces with a PC via a card that plugs into one of the short slots in a PC's backplane and a shielded ribbon cable that connects the card to the accelerator. Because the Fortran source code for the simulation program is included, users can write their own electrical-device equations. The accelerator can handle circuits containing as many as 200 transistors and routinely performs self-diagnostics during power-up. \$19,500.

Microsim Corp., 14101 Yorba St., Tustin, CA 92680. Phone (714) 731-8091.

Circle No 352

PRESENTATION PLOTS

Tutsim, a simulation program for modeling continuous systems on a μ C, can produce presentation-quality plots. The program generates pen-plotter output that labels the X and Y axes of curves and titles and dates each plot. Hard copy and CRT images can include these annotations. You can also simulate systems if you can define their processes

with differential equations. To create a model, you must enter block, structural, and variable parameters in single-line format. The program optimizes systems that are described by time-dependent equations or differential equations. It is available for use on IBM μ Cs. \$495.

Applied i, 200 California Ave, Palo Alto, CA 94306. Phone (415) 325-4800.

Circle No 353

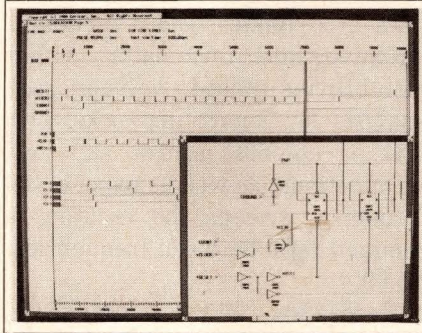
COLOR OPTION

This high-resolution color option is available for the CT1000 CAE design system. The software package supports the IBM enhanced color monitor and display adapter for the IBM PC, PC/XT, and PC/AT, providing 650 $\times$ 350-pixel resolution in 16 colors. You can define foreground and background colors, line widths, character fonts, and text placement. Based on a personal computer, the

CT1000 CAE design system supports the hierarchical Scald logic and timing verifier. CT1000 with color option, \$3750.

Case Technology Inc, 633 Menlo Ave, Menlo Park, CA 94025. Phone (415) 322-4057.

Circle No 354



IC DESIGN

The CDA 5000 CAE software package is available for Data General's Distributed System workstations as

well as for HP workstations. You can choose from two software packages: a schematic entry editor, which includes component libraries, and an event-driven logic and timing simulator. Schematic editor, \$19,900; simulator, \$15,000.

Cerikor Inc, 716 E 4500 South, Salt Lake City, UT 84107. Phone (801) 264-8600.

Circle No 355

SCHEMATIC CAPTURE

When used with Designer III workstations, CAEPac II draws schematic diagrams. It features a schematic definition file (SDF), a schematic definition file compiler (SDFC), a schematic capture editor, and a net-list formatter. You can edit the SDF by using any text editor running under the Unix operating system and by defining all the schematic symbols and functional parameters. The schematic capture

This new solid state industrial timer lets you field-select from 4 operating modes and 8 timing ranges.

The Agastat SCF Multi-Mode Timer

This versatile timer lets you choose from any of four operating modes — on-delay, off-delay, interval, or latching interval — with the twist of a screwdriver. The same simple move sets your choice of eight timing ranges from .1 second to ten hours, with a handy knob to adjust the timing within each range. All without wiring changes or disassembly. And you get the high repeat accuracy, outstanding transient protection, and reliable performance you've come to expect from AGASTAT — all at a price that's less than you might expect.

Consider what these unique features could mean in reducing your setup costs and inventory requirements.



And this portable digital calibrator makes time-setting faster and more accurate than ever before.

No more tedious trial-and-error adjustments. Or expensive, delicate thumbwheel switches for precise settings. Get 4-digit accuracy instantly. Just plug the calibrator probe into an energized timer, match its range, and set desired delay, up to ten hours. Get an instant readout — no waiting for timer to complete its cycle . . . dramatically reducing setup time. Just one calibrator is all you need to set all your SCF timers with digital accuracy . . . at analog prices.

426



AMERACE CORPORATION

AMERACE CORPORATION
1065 FLORAL AVENUE, UNION
NEW JERSEY 07083
(201) 289-8200

AGASTAT®

COMPUTER-AIDED ENGINEERING

editor operates in conjunction with the user-defined SDF to create a schematic diagram; it can automatically update an edited database. The net-list formatter offers the flexibility of C within a Unix environment. \$12,000.

Caeco, 2558 Mountain Industrial Blvd, Tucker, GA 30084. Phone (404) 493-7000. TWX 810-766-8099.

Circle No 356

ate as a stand-alone unit or as a node in a distributed-network environment for team engineering. It uses DEC's VMS Release 4 and DEC-shell. The package features schematic capture, logic simulation, circuit simulation, timing verification, and interfaces to other design tools. The VAX 8600 specs 4.2 times the speed of the 11/780, which, in turn,

affects the speed of the CAE package. Prices depend on applications: \$22,000 to \$50,000 for VAXstation package; from \$124,000 for the VAX 8600 tool. Shipments to begin in July.

CAE Systems Inc, 1333 Bordeaux Dr, Sunnyvale, CA 94089. Phone (408) 745-1440.

Circle No 358



TTL LIBRARY

This TTL parts library is available for Dash-Cadat, a logic simulator that runs on the IBM PC/XT or PC/AT. The library of primitives includes MOS and CMOS transistors and transmission gates; buffers and inverters; binary and BCD counters; encoders and decoders; 3-state drivers; and JK- and D-type flip flops and latches. The library also includes registers, transceivers, adders, ALUs, comparators, parity checkers, ROM, and RAM. Dash-Cadat requires that you add a 1M-byte 32016 processor board to the IBM PC. Dash-Cadat 40 is identical to Dash-Cadat, except that it replaces the 10M-byte Winchester disk drive on the PC/XT with a 40M-byte drive. Cadat-TTL library, \$1800.

Futurenet Corp, 6709 Independence Ave, Canoga Park, CA 91303. Phone (818) 700-0691. TWX 910-494-2681.

Circle No 357

VAX-BASED CAE

The CAE 2000 design-automation package runs on DEC's VAXstation I and VAX 8600. When running on a VAXstation, the software can oper-

**UNIX™ System V
Interactive Streamer
Ethernet™
Multiuser
Unify™**

MINI BOX

Minibox—Heurikon's new multi-user, multitasking workstation—puts the power of the MC 68000/68010 microprocessor (8 or 10 Mhz) and the flexibility of UNIX all in 1.5 square feet of desk space. Designed with the OEM in mind, Minibox gives you these features and capabilities you've been searching for: Electronic mail • Interprocess communications (IPC) • Fully integrated streaming tape drive, up to 280 MB of Winchester storage • 1 MB floppy drive • UNIX System V or III • Ethernet (TCP/IP) for fast expansion and networking • Floating Point Processor • CPM Shell for CP/M-to-UNIX link • Hotline customer support.

UNIX is a trademark of Bell Telephone. Unify is a trademark of Unify. Ethernet is a trademark of Xerox Corp. Minibox is a trademark of Heurikon Corp.

HEURIKON
3201 Latham Drive Madison, WI 53713
Wisconsin 608 271 8700 Telex 469532

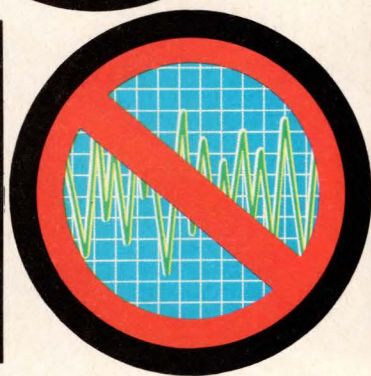
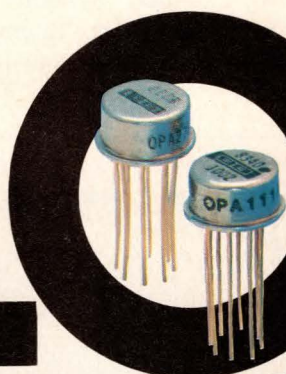
© 1984

1-800-356-9602

CIRCLE NO 91

the best FET and Bipolar

LOW NOISE



amplifiers you can buy.

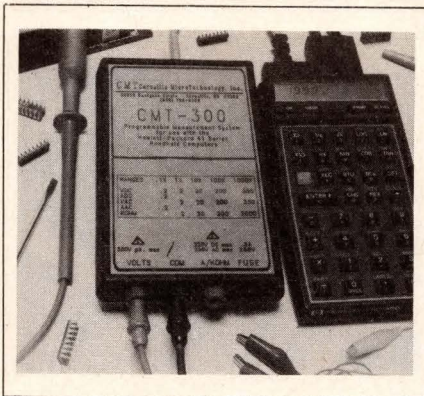
All parameters, including noise, 100% tested and guaranteed.

MODEL	NOISE (10kHz, max)	V _{os} (max)	DRIFT (max)	I _B (max)
OPA111BM	8nV/ $\sqrt{\text{Hz}}$	$\pm 250\mu\text{V}$	$\pm 1\mu\text{V}/^\circ\text{C}$	$\pm 1\text{pA}$
OPA27AJ	3.8nV/ $\sqrt{\text{Hz}}$	$\pm 25\mu\text{V}$	$\pm 0.6\mu\text{V}/^\circ\text{C}$	$\pm 40\text{nA}$



Putting Technology To Work For You

NEW PRODUCTS: COMPUTERS & PERIPHERALS



MEASUREMENT SYSTEM

The CMT-300 is a portable, programmable measurement system that you can customize to operate with various transducers so it can measure temperature, moisture, light intensity, rpm, pH, and other physical conditions. For signal-analysis and data-reduction applications, you can connect the CMT-300 to an HP-41 handheld computer. The CMT-300 uses dual-slope integration to provide $3\frac{1}{2}$ -digit resolution in measuring dc and true-rms ac voltages, dc and true-rms current, and resistance. Programs in the CMT-300 allow you to use the device as a data logger, digital multimeter, and data-analysis tool. The product includes a keyboard overlay for the HP-41 and test leads. Optional accessories include the CMT-200, which can control external devices. CMT-300, \$350; CMT-341CX (includes HP-41CX), \$595.

Corvallis Microtechnology Inc., 33815 Eastgate Circle, Corvallis, OR 97333. Phone (503) 752-5456.

Circle No 359

FAULT TOLERANCE

Mimic Master provides redundant processing on one of its manufacturer's local-area networks to ensure continuous network operation in the event of the failure of a hard disk or master computer. Using software that emulates a fault-tolerant mode, the device duplicates, in real time, all data written to the network's master. When it detects the absence of the master computer, it acts as the network's primary computer,

thereby allowing maintenance personnel to locate and repair failed system components while the network continues to operate fully. It can support a network of as many as 63 stand-alone personal computers, running any combination of CP/M-80, CP/M-86, MS-DOS, or PC-DOS. Additional hard-disk storage and streaming-tape backup systems are available. From \$7950.

Digital Microsystems Inc., 1755 Embarcadero, Oakland, CA 94606. Phone (415) 532-3686.

Circle No 360



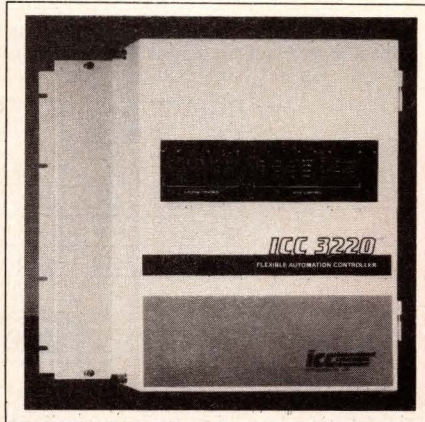
BROADBAND GATEWAY

This gateway server, the GS/6, lets you interconnect multiple Ethernet networks over CATV-based broadband networks. It facilitates the routing of data communication among as many as 255 Ethernet LANs over one 6-MHz broadband channel. By using a CSMA device, the server achieves signaling rates as fast as 2M bps. The server is suitable for organizations with multiple buildings. According to the manufacturer, this hybrid allows users to take advantage of Ethernet's high speed, low cost, and simple installation and maintenance. The server uses a mid- or high-split single-cable system (which fits on the spare channels of most installed cable) and such standard CATV-based broadband components as frequency translators. An Ethernet controller card and a 68000-based CPU card execute the XNS protocols. An HDLC controller card provides CSMA and address recognition for the data stream being fed into the server's FSK-based RF modem. Network traffic is filtered

so that a message is sent only to the address for which it is intended. \$10,500; annual license fee for routing software, \$150. Delivery, 60 days ARO.

Bridge Communications Inc., 1345 Shorebird Way, Mountain View, CA 94043. Phone (415) 969-4400. TLX 176544.

Circle No 361

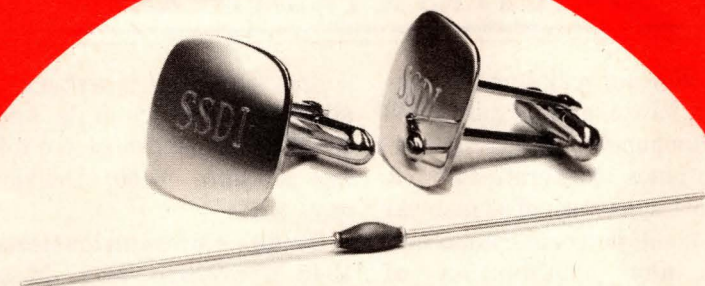


AUTOMATION CONTROL

The ICC 3220 automation controller features software packages for robotic control, machine control, and automated work cells; it can interface with CAD/CAM systems, factory computers, and factory networks. According to the manufacturer, the controller combines the power of an industrial computer, the flexibility of a programmable logic controller, and as many as eight axes of closed-loop brushless servo control. Because the controller offers direct numerical processing, users can select the parameters for either dc or brushless servos. The processing system uses 16-bit μ Ps with real-time adaptive algorithms rather than the usual analog and digital hardware. By using this software approach to automation control, the device does not require analog signal-processing components such as Hall-Effect sensors, tachometers, and optical encoders. \$8600 to \$24,000.

International Cybernetics Corp., 105 Delta Dr, Pittsburg, PA 15238. Phone (412) 963-1444.

Circle No 362



NEW! VOIDLESS GLASS HIGH VOLTAGE HERMETICALLY SEALED RECTIFIERS. ULTRA-FAST, FAST, STANDARD.

Hermetic, voidless glass package. Solid silver leads. +175°C operating. Metallurgically bonded. Military/industrial quality. Screening to TX, TXV, or Space level available. Applications: CRT displays, HV multipliers, HV power supplies. For free samples and pricing, call: (213) 921-9660. TWX 910-583-4807.

DEVICE TYPE	MAXIMUM REVERSE RECOVERY TIME T_{RR}	PEAK INVERSE VOLTAGE PIV	AVERAGE CURRENT $I_O @ 55^\circ C$	MAXIMUM REVERSE CURRENT $I_R @ PIV @ 25^\circ C$
SERIES	(NSEC)	(VOLTS)	(mA)	(μA)
SHM-UF	60	1500-10,000	250-100	1.0
SHM-F	150	1500-10,000	250-100	1.0
SHM	5000	1500-10,000	250-100	1.0



Solid State Devices, Inc., 14830 Valley View Ave., La Mirada, CA 90638

CIRCLE NO 93



Augat's turnkey prototype service, QWIKTURN, provides ONE-WEEK turnaround on panels and wiring from a clean database. Just select your panel from our stock or yours and submit your netlist and placement data in electronic form. CAD or CAE WORKSTATION database is acceptable either VIA MODEM or on mag tape or floppy disc.

For other input formats, or additional services such as twisted pair, installation of solder clips and capacitors, engineering changes, etc., there will be a slightly longer turnaround.

Now on our shelf:

VME Bus
Multibus I and II
IBM PC
Plus other Augat standard panels

Call For Details:

Central (713) 495-3100

West (408) 249-8801

East (617) 222-2202



Write for AUGAT "Wiring Services Brochure"

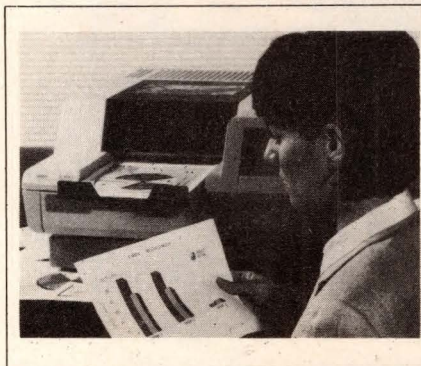
OUR GUARANTEE: ONE-WEEK
DELIVERY OR YOU PAY NO PREMIUM!



Multibus and IBM PC are registered trademarks of INTEL Corp. and International Business Machines Corp. respectively.

CIRCLE NO 145

COMPUTERS & PERIPHERALS



GRAPHICS PRINTER

Combining color printing and graphics processing in one machine, the LCP01 printer contains the company's J-11 μP and page-buffer memory, which relieve the host computer of the graphics-processing operation. This ink-jet printer produces an image on either $8\frac{1}{2} \times 11$ -in. or A4 ($8\frac{1}{4} \times 11\frac{1}{4}$ -in.) paper in approximately 2 min. Resolution is 154 dots/in. both horizontally and vertically. Connected via a standard serial-line interface, the printer feeds, processes, and stacks as many as 100 sheets of paper or 50 transparencies automatically. The printer creates images in eight highly saturated colors and as many as 216 shades. Operating noise is <58 dBA. The office-size printer includes self-test diagnostics. \$14,595.

Digital Equipment Corp., 146 Main St., Maynard, MA 01754. Phone (800) 344-4825.

Circle No 363



BUSINESS SYSTEM

This version of the DECmate II business computer, the Omnimate, is a 3-user system in its standard configuration. It provides each user with access to WPS8, COS310, or OS/8 operating systems in a multi-

tasking environment. The computer features an HD-6120 μ P with 128k words of memory (expandable to 256k words), six serial ports, SCSI interface, BCD arithmetic, real-time clock and calendar, two 5¼-in. floppy-disk drives (1M byte each), and one 5¼-in. Winchester disk drive (40M bytes). The system also includes a VT220 word-processing terminal and a 180-cps draft-quality printer. Options include 10 serial ports that accommodate seven devices. \$9450.

Computer Extension Systems Inc., 17511 El Camino Real, Houston, TX 77058. Phone (713) 488-8830. TLX 774279.

Circle No 364

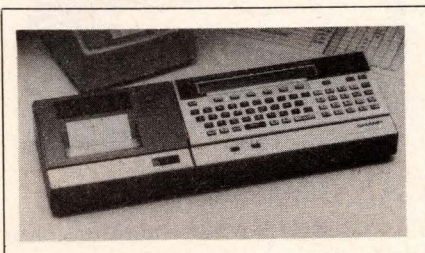


CHART COMPUTER

The Instant SPC with an updated variable chart program is a Sharp PC-1500A with additional preprogramming for plotting and printing in four colors. The device computes control limits; plots $\bar{X}/R$ charts; draws histograms; and calculates standard deviations, capability ratios, capability index, and the number of standard deviations from the average. The computer also calculates percentages over spec, prints additional copies, draws normal distribution curves, and plots as many as 60 averages or ranges. Four 1.5V AA batteries, ac adapter, cassette-recorder adapter cables, three rolls of printer paper, eight replacement pens, program and computer instruction manuals, and a case are included. \$995.

Elco Industries Inc., Rockford Div, Box 7009, Rockford, IL 61125. Phone (815) 397-5151. TWX 910-631-3420.

Circle No 365

VIDEO PRINTER

This video photography system includes the Model 1600 video printer and the Model 250 video digitizer board, which performs frame grabbing via software. The 1600 produces television-quality color prints on plain paper without liquid chemicals or paper toners. With this system, you can access a video frame

from an IBM PC or a PC-compatible system and combine computer-generated graphics with captured video images. The 250 can capture a simple picture from a video signal in 1/60 sec. Offering a resolution of 256 pixels $\times$ 256 lines with four bits per color, the digitizer board captures red, green, and blue signals simultaneously; if you use a monochrome

Schaffner EMC filters...we make them better, so we can make this offer.

Buy a competitor's EMC filter and you may find some of those you test before installation not functioning up to spec. Sure they'll be replaced, but can you afford the delay? The resulting variations of attenuation can cause problems you don't need.

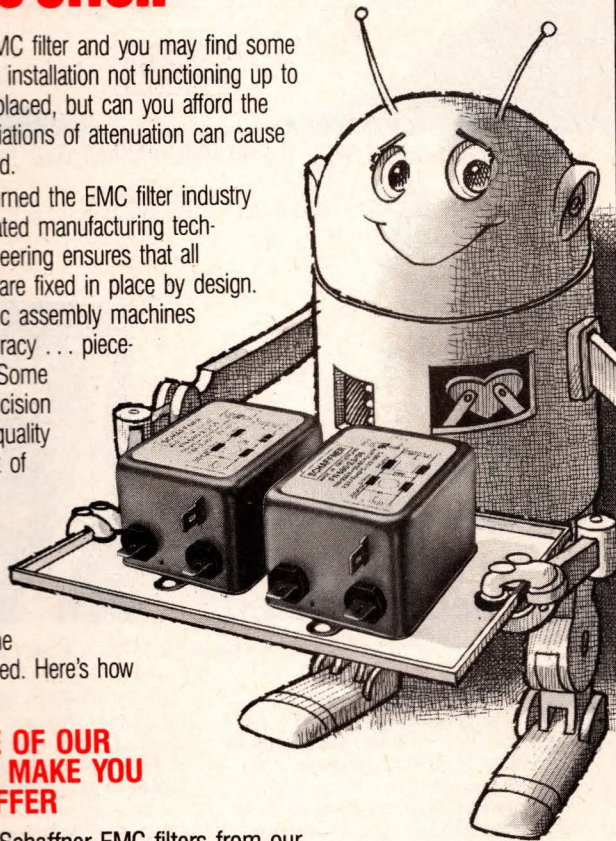
At Schaffner, we've turned the EMC filter industry around with our automated manufacturing techniques. Advanced engineering ensures that all components and leads are fixed in place by design. What's more, our robotic assembly machines adhere to pinpoint accuracy... piece-after-piece, after piece. Some call this attention to precision fanatical... we call it quality... and it's at the heart of every filter we make.

Schaffner EMC filters meet international safety agency standards, are competitively priced, delivered on time and perform as promised. Here's how we prove it.

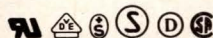
WE'RE SO SURE OF OUR QUALITY, WE'LL MAKE YOU THIS 2 FOR 1 OFFER

Order at least 1,000 Schaffner EMC filters from our wide selection, and for any one found to be defective, we'll send you two in return.* We're not trying to make a deal... just make a point. Schaffner EMC filters are better by design. We promise... and we deliver.

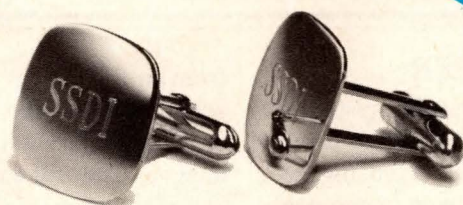
*Contact Schaffner for details and disclaimer. Offer may be withdrawn at any time.



SCHAFFNER



• RFI Suppression Filters • EMC Test Equipment • Test and Application Services
USA: Schaffner EMC, Inc., 825 Lehigh Ave., Union NJ 07083/(201) 851-0644
Switzerland: Schaffner Elektronik AG, CH-4708 Luterbach, Switzerland/Telefon 065 4231 31



NEW! SUB-MINIATURE HIGH VOLTAGE EPOXY CASE RECTIFIERS. ULTRA-FAST, FAST, STANDARD.

High density packaging. Solid silver leads. +150°C operating. Metallurgically bonded junctions. Industrial/military quality. Screening to TX or TXV available.

Applications: CRT displays, HV multipliers, HV power supplies.

For free samples and pricing, call: (213) 921-9660. TWX 910-583-4807.

DEVICE TYPE	MAXIMUM REVERSE RECOVERY TIME T _{RR}	PEAK INVERSE VOLTAGE PIV	AVERAGE CURRENT I _O @ 55°C	MAXIMUM REVERSE CURRENT I _R @ PIV @ 25°C
SERIES	(NSEC)	(VOLTS)	(mA)	(uA)
SHB-UF	60	1500-10,000	80-25	0.1
SHB-F	150	1500-10,000	80-25	0.1
SHB	5000	1500-10,000	80-25	0.1



Solid State Devices, Inc., 14830 Valley View Ave., La Mirada, CA 90638

CIRCLE NO 95

"Our NHS partnership saved a dying Oakland neighborhood."

—CAL HATCH, Chairman & CEO, The Clorox Company

In 1975, there were 250 vacant or abandoned homes in Oakland's Elmhurst area. The neighborhood was dying. Then Neighborhood Housing Services, a non-profit partnership of residents, businessmen and local government was formed to help residents rehabilitate their homes. Now, 80% of the neighborhood's blighting influences have been eliminated. For every \$1 donated to the Oakland NHS for local operating support, \$39 has been reinvested in the neighborhood



by residents, financial institutions and city government NHS is succeeding in 136 cities. It needs the help of business leaders like us to continue its good work."

You can help. Call toll-free (800) 344-6472, or write Neighborhood Housing Services of America, 1951 Webster Street, Oakland, CA 94612.



Local partnership: key to neighborhood renewal



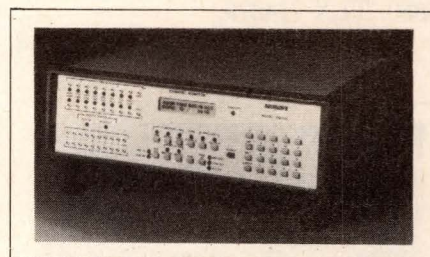
A Public Service of This Publication & The Advertising Council

COMPUTERS & PERIPHERALS

monitor, you can write to all three color planes simultaneously. The printer features an 8×10-in. editing area. A thermal printing head and color dye sheets provide hard-copy reproductions with over 4000 hues. Using a menu, you can adjust color contrast levels, choose positive or negative prints, and format copy. Color printer with Centronics-compatible interface, \$6500; digitizer board, \$1100.

Biflyx, 2522 Dupont Dr, Irvine, CA 92715. Phone (714) 476-3153.

Circle No 366



CHANNEL MONITOR

The Model DW300 monitors the IBM 370 and 4341 and equivalent compatible computer channels. This portable diagnostic machine provides multilevel triggering to pinpoint problems in situations where different makes and/or models of computer equipment are used. Connected to the IBM channel via bus and tag cables, the monitor features a library of such standard channel protocols as start I/O and interface disconnect. Using the hexadecimal keypad, you can program the monitor's line states to zero, one, or don't care. The unit captures as much as 8k bytes of data to aid in diagnostics and features a 40-character LCD plus controls for voltage and skew settings. The monitor records 8192 channel events for all 34 lines (tag, bus, and parity) at rates to 16 MHz. Triggers are based on any combination of line states or external events plus standard IBM sequences. LEDs indicate parity errors and the state of each tag line while the LCD shows the contents of the data bus in hex. Also displayed are the cur-

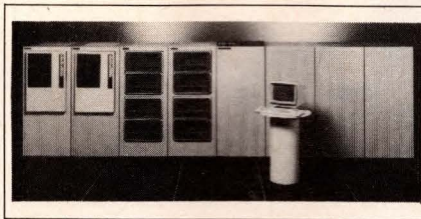
rent buffer location and a time stamp for each data point. An optional RS-232C card for operating an external printer, terminal, or modem is available. \$9450; RS-232C card, \$395.

Dataware Development Inc., 4204 Sorrento Valley Blvd, San Diego, CA 92121. Phone (619) 453-7660. TWX 910-335-2066.

Circle No 367

SUPERMINICOMPUTER

The 3260MPS is a tightly coupled superminicomputer that can contain a combination of as many as nine auxiliary processing units (APUs) and I/O processors in addition to its CPU. The system is asymmetric so each processor performs a primary function, and each has equal access to memory for data sharing and programs. The computer offers transparent parallel processing under OS/32, the company's Series



3200 operating system. Performance ranges from 1.2 MIPS in a configuration consisting of the CPU with one I/O processor to 7.2 MIPS in a fully expanded 9-APU system. Floating-point processors are standard in all processing units except the I/O processors. The task-scheduling microcode, in conjunction with cache memory for each processor, minimizes software overhead and reduces bus contention. The global memory bus specs a 64M-byte/sec bandwidth. Four versions are available including Model 3262-01, which provides a 2M-byte (2-bank) memory, an I/O processor with bus switches, and two DMA channels; and Model 3262-10, which features a

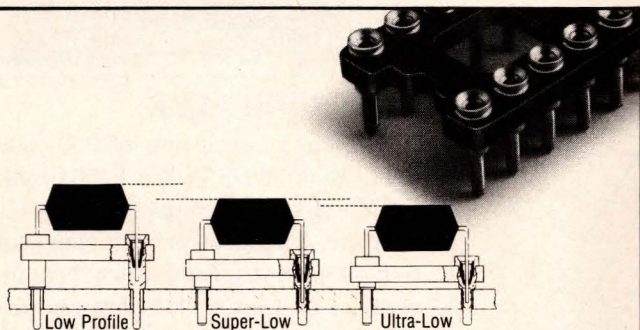
4M-byte (4-bank) memory, an APU, and four DMA channels. The computers are packaged in two 56-in. cabinets with power supplies and ac distribution panels. You can add APUs, I/O processors, memory and banks, DMA channels, I/O chassis and controllers, peripheral devices, and cabinets as needed. From \$185,000.

Perkin-Elmer Corp., Data Systems Group, 2 Crescent Pl, Oceanport, NJ 07757. Phone (201) 530-5900.

Circle No 368

3-SPEED MODEM

The CDS224 is a single-card, rack-mountable, 3-speed modem for asynchronous operation at 300 bps and asynchronous or synchronous operation at 1200 and 2400 bps. Suitable for the needs of a central communications facility, it features speed-sensing and autoanswer ca-



3 Heights

Now choose DIP sockets in .165, .120 or .095 inch heights above board.

- Accommodate IC leads as short as .100%.
- Four-finger contacts for highest reliability.
- Tapered entry for easier insertion. • 100% anti-wicking of solder. • Screw-matching housings.
- Insulation in molded polyester, .062 glass epoxy, or Peel-A-Way™ in Mylar® or Kapton®.

Call or write for new 32 page catalog #5.



ADVANCED INTERCONNECTIONS

5 Division St., Warwick, RI 02818 • (401) 885-0485
TWX 710 3820400

©Dupont Chemical

CIRCLE NO 96

Cut Glare...Add Contrast To Flat Panel Displays With Chromafilter®



Chromafilter is a high-resolution, contrast-enhancing, glare-reducing, abrasion-resistant polycarbonate or acrylic window material for all types of displays: LED, LCD, VFD, CRT, plasma, or electroluminescent. Available in sheets or fully fabricated, screen printed, and ready to use, in clear, neutral gray, or a wide variety of standard colors. Whatever the display, count on Chromafilter!



PANELGRAPHIC CORPORATION

10 Henderson Drive, West Caldwell, New Jersey 07006
Phone (800) 222-0618 • In N.J. (800) 222-0617
TWX: 710-734-4367

CIRCLE NO 97

NEW! 2 AMPERE HIGH CURRENT HIGH VOLTAGE EPOXY RECTIFIERS. ULTRA-FAST, FAST, STANDARD.

Ratings to 2 Amps. Solid silver leads. + 150°C operating. Metallurgically bonded junctions. Industrial/military quality. Screening to TX or TXV level available. Applications: Lasers, HV power supplies, Radar Applications, HV multipliers. For free samples and pricing, call (213) 921-9660. TWX 910-583-4809.

DEVICE TYPE	MAXIMUM REVERSE RECOVERY TIME TRR	PEAK INVERSE VOLTAGE PIV	AVERAGE CURRENT I _O @ 55°C	MAXIMUM REVERSE CURRENT I _R @ PIV @ 25°C
SERIES	(NSEC)	(VOLTS)	(mA)	(uA)
SHE-UF	60	1500-10,000	1000-400	1.0
SHE-F	150	1500-10,000	1500-500	1.0
SHE	5000	1500-10,000	2000-600	1.0



Solid State Devices, Inc., 14830 Valley View Ave., La Mirada, CA 90638

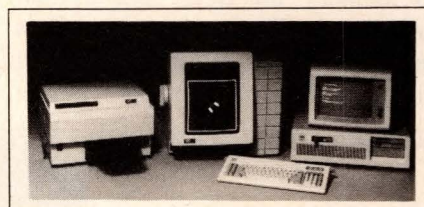
CIRCLE NO 98

COMPUTERS & PERIPHERALS

pabilities that automatically adjust the unit to the speed of each incoming call. Thus all users can access the central site using the same phone line and any modem. This feature in the 1200- and 2400-bps modes compensates for line interference and allows maximum data throughput even on marginal lines, according to the manufacturer. Optional autodial allows automatic dialing to remote sites. Integral diagnostics include digital self-test, analog self-test, and an internal-pattern generator and checker. From \$855.

Concord Data Systems Inc., 303 Bear Hill Rd, Waltham, MA 02154. Phone (617) 890-1394. TLX 951793.

Circle No 369



LASER PRINTER

Providing a resolution of 300×300 dots, Model CDS 2300's 1.28M-byte RAM stores a bit map of an 8½×11-in. page. The laser printer connects to most personal computers through a serial or Centronics port and offers four print formats: Diablo-630 emulation, Tektronix-4014 emulation, ANSI X3.64, and full bit-map image mode. For this last mode, the company offers a letter-quality type font in 10-pt normal, bold, or italics. You can space characters singly, proportionally, or independently on the page. The printer's controller uses an 8-MHz 80186 μ P and contains 1.28M bytes of bit-map RAM, 128k bytes of system RAM, and 128k bytes of system ROM. The system prints at a rate of 8 pgs/min. \$5695.

Corporate Data Sciences Inc., 2560 Mission College Blvd, Suite 102, Santa Clara, CA 95054. Phone (408) 980-9747. TLX 757453.

Circle No 370

SUPER POWER!

High reliability ELCOM® brushless DC servo motors are ideally suited to continuous process applications as well as demanding motion control functions in automated equipment. Optional, integrally mounted optical encoders facilitate use with latest digital control

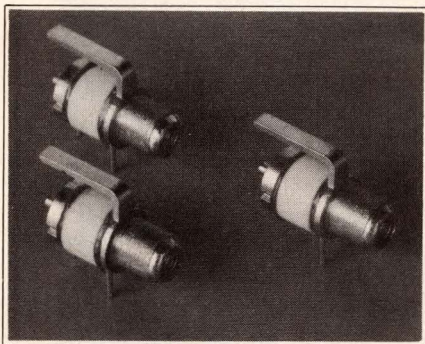
systems. Now available in 3 frame sizes and multiple lengths up to 50mm square x 100.4mm long; Continuous duty outputs to 47 oz.-in. at 7,200 rpm (1/3 hp). For complete information on how ELCOM® brushless motors can improve your design, call PITTMAN at (215) 256-6601.

PITTMAN®
HARLEYSVILLE, PA 19438-0003 USA
A DIVISION OF PENN ENGINEERING & MANUFACTURING CORP

CIRCLE NO 99

© 1984 Pittman 22-c

NEW PRODUCTS: COMPONENTS & PACKAGING



TRIM CAPACITORS

The C-Line 14-turn air-dielectric trimming capacitors have high Q and high resolution. Specifications include a Q at 100 MHz of 1000 min, a capacity range of 2 to 7 pF, and a resolution of 0.4 pF/turn. The units measure 0.305×0.697 in., with three mounting styles available. \$0.85 (1000). Delivery, 6 to 8 wks ARO.

Murata Erie North America Inc., 1148 Franklin Rd SE, Marietta, GA 30067. Phone (404) 688-4181.

Circle No 371

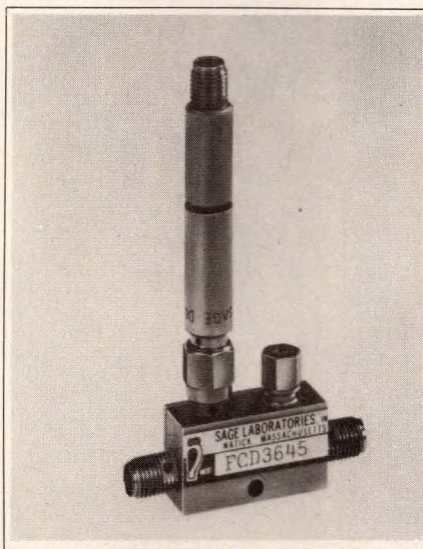
SIGNALING COMPONENTS

The 3501 multifrequency generator and the 3101 multifrequency receiver are signaling components for telecommunications. The generator, which meets Bell MF and CCITT specifications, contains a CMOS digital-frequency synthesizer, a D/A converter, and filtering circuitry. A 2.976-MHz crystal generates 18 frequencies for multifrequency interoffice signaling. In each signaling format, six frequencies provide 15 tone combinations. Starting sine waves at 0° phase permit control of harmonic content. Suitable for use with the US RI or European CCITT No 5 signaling formats, the receiver detects pulses, transfers the digital information to control equipment, and establishes connections through the switches. A 2.976-MHz external crystal determines the frequencies and the timing for detection. The unit consists of six internal band-pass filters and limiters as well as a monolithic decoder. Six data outputs indicate the individual tones

received; the seventh indicates a valid 2-of-6 code; and the eighth warns that an improper tone combination has been received. Generator, \$46; receiver, \$214.50 (500). Delivery, 4 to 6 wks ARO for prototypes.

Tektronix Inc., Box 500, Beaverton, OR 97077. Phone (503) 627-4220.

Circle No 372



COUPLER/DETECTOR

Model FCD3645, an X-K band coupler/detector, operates over 7.5 to 17 GHz. Input VSWR is 1.5:1 max, 1.2:1 typ. The device specs an insertion loss of <1 dB. Video output voltage, with 100 mA bias and 0 dBm RF input power, is 5 mV min, 25 mV typ. \$600. Delivery, 60 to 90 days ARO.

Sage Laboratories Inc., 3 Huron Dr, Natick, MA 01760. Phone (617) 653-0844.

Circle No 373

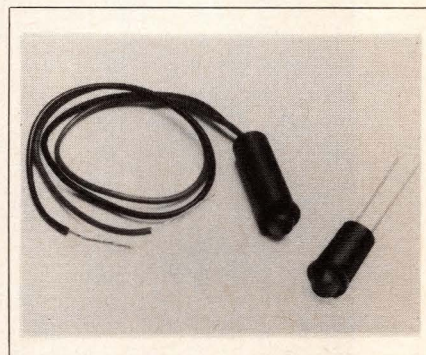
ISOLATION AMPLIFIER

The AD295 hybrid isolation amplifier combines $\pm 2500V$ isolation with maximum nonlinearity of $\pm 0.012\%$. Two internal transformers provide 3-port isolation among the input, output, and power-supply ports. Isolated power for signal-conditioning circuitry is rated at $\pm 15V$ dc at 5 mA, thus eliminating the need for

an external dc/dc converter. You can configure the input amplifier as a buffer, inverter, subtractor, or differential amplifier. And you can program the gain from 1 to 1000 V/V at the input or output stages (or both). Input noise equals 2 μV p-p, and common-mode rejection is 106 dB. The isolation amplifier is available in three grades, offering different tolerances of nonlinearity, offset voltage drift, and input offset drift. Key specifications include $\pm 1.5\%$ gain accuracy typ, ± 60 ppm/°C gain drift, ± 18 mV output offset voltage, and ± 3 mV maximum input offset voltage. \$78.75 to \$101.25 (100).

Analog Devices Inc., Box 280, Norwood, MA 02062. Phone (617) 329-4700.

Circle No 374



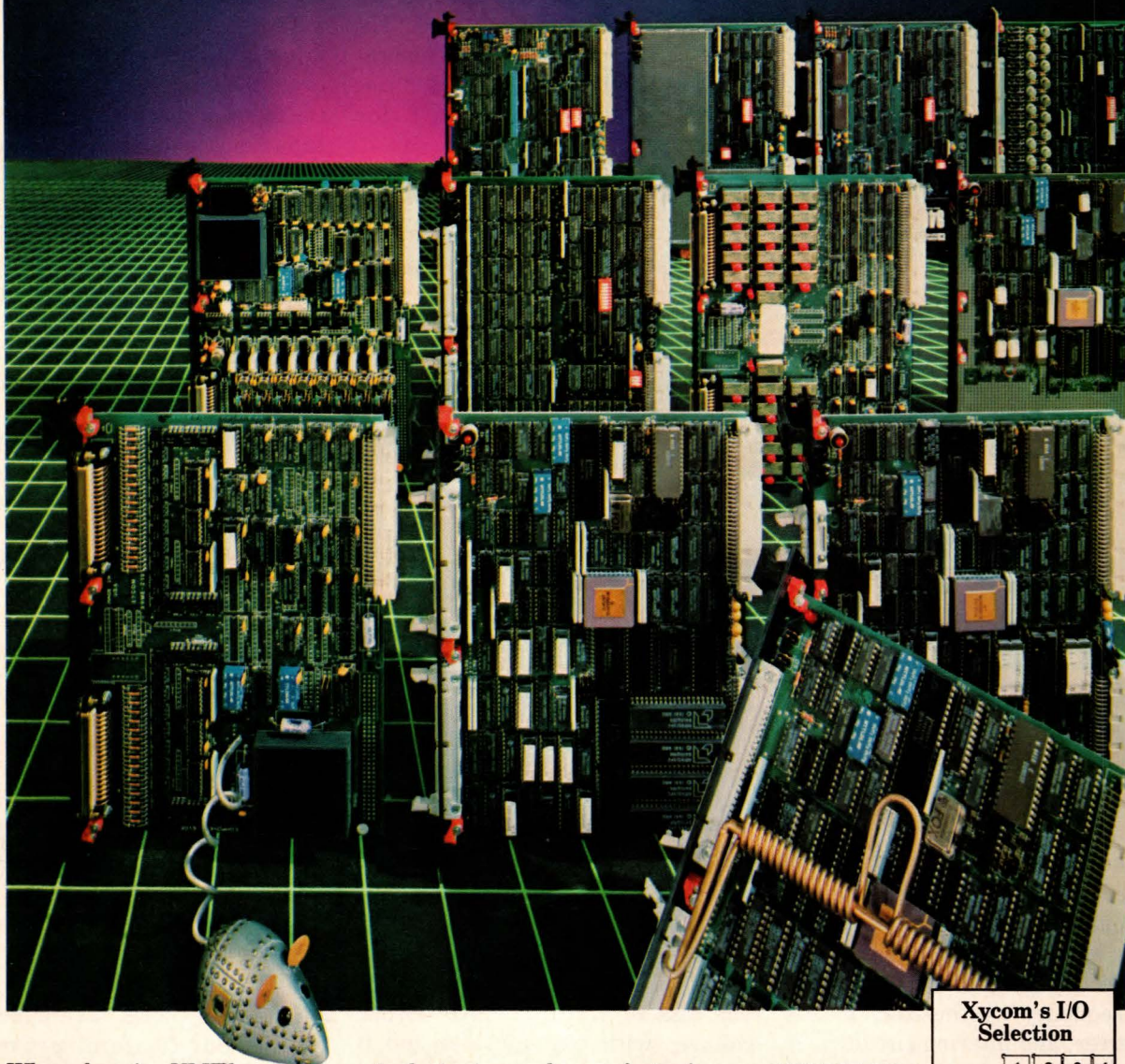
LEDs

P407 Series LEDs have a medium-profile lens (0.15-in. protrusion above the panel surface) and come in three colors (red, amber, and green). Choices for mounting include snap-in mounting (in a ¼-in. panel cutout) with fixed leads and snap-in mounting with 6-in. flying leads. The LEDs can be specified with a built-in resistor for operation ranging from 2.4 to 24V dc. They can also be driven by an ac source below 15V. For ac operation above 15V, you'll need an external rectifier. \$0.35 (1000). Delivery, stock to 5 wks ARO.

Data Display Products, 301 Coral Circle, El Segundo, CA 90245. Phone (800) 421-6815; in CA, (213) 640-0442.

Circle No 375

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.

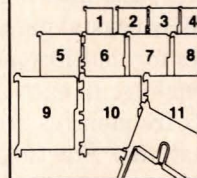


xycom®

Look closer. We deliver added value.



Xycom's I/O Selection

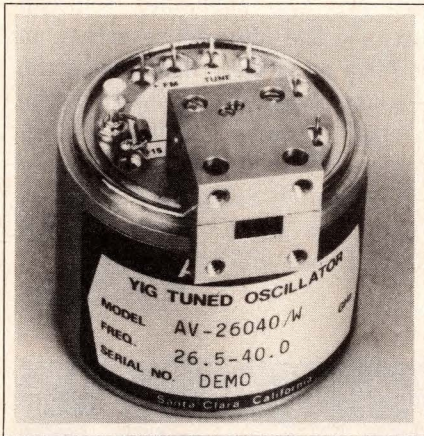


- 1) XVME 010 System Resource
- 2) XVME 085 VMEbus Prototyping
- 3) XVME 560 64/32 Channel Analog Input
- 4) XVME 220 32 Channel Isolated Digital Output
- 5) XVME 530 8 Channel Isolated Analog Output
- 6) XVME 240 64 Channel Digital TTL I/O
- 7) XVME 260 32 Channel Relay Output
- 8) XVME 080 Intelligent 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
 • Houston (713) 530-9200 • Philadelphia (215) 536-0810 • San Francisco (415) 573-0404

CIRCLE NO 100

EDN June 13, 1985



OSCILLATOR

The AV-26040/W is a 26.5- to 40-GHz YIG-tuned, GaAs FET transistor oscillator with WR28 waveguide output. It features a minimum output power of 10 dBm with a maximum ± 3 -dB variation over the entire tuning range and a frequency-vs-tuning current linearity of $\pm 0.1\%$. The oscillator draws 150 mA from an unregulated 15V-dc supply. A 12-bit TTL-compatible driver or a 0 to 10V analog driver is optional. The unit combines a GaAs FET fundamental oscillator with two stages of single-ended GaAs FET amplification, followed by a balanced-amplifier output stage. \$3650. Delivery, 3 months ARO.

Avantek Inc., 3175 Bowers Ave, Santa Clara, CA 95051. Phone (408) 496-6710.

Circle No 376

TACHOMETER

The Tach-Pak 3 tachometer accepts magnetic speed sensor, sinewave, and TTL signals at frequencies from 0.0625 to 30,000 Hz and converts those signals to a meter output of 0 to 1 mA dc or an analog output of 0 to 20 or 4 to 20 mA dc. The unit also operates 5A spdt relays at four preset speed trip-points. Response time is 50 msec at frequencies above 100 Hz. The relay trip-points are field programmable via pushbutton switches. \$600.

Airpax Corp., Box 868, Cheshire, CT. Phone (305) 587-1100.

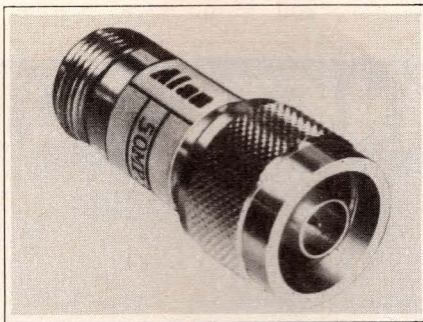
Circle No 377

SWITCHES

These wiping-contact and butt-contact pushbutton switches are available with a snap-in bezel that mounts from the front of a panel. The switches come in spst, spdt, and dpdt configurations, and they include such features as maintained action and overtravel. You can mate the switches with either a square or a rectangular bezel, which offers a choice of one or two snap-fit LED holes for applications requiring indicator lights. The square model inserts in a $\frac{3}{4}$ -in.² hole, and the rectangular model fits in a $\frac{3}{4} \times 1$ -in. hole. Six different colored button caps are available. \$2.51 to \$6.90 (100).

Grayhill Inc., 561 Hillgrove Ave, LaGrange, IL 60525. Phone (312) 354-1040.

Circle No 378



18-GHz ATTENUATOR

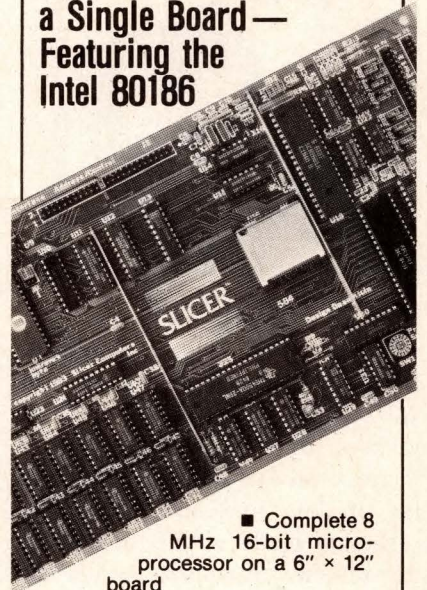
Model 50MP(1-40)-N is a fixed attenuator with a frequency range of dc to 18 GHz. It has an attenuation range of 1 to 40 dB in 1-dB steps. VSWR is 1.15:1 at dc to 4 GHz, 1.20:1 at 4 to 8 GHz, 1.25:1 at 8 to 12 GHz, and 1.35:1 at 12 to 18 GHz. The attenuator has a 50 Ω impedance and a type N connector per MIL-C-39012. Accuracy is rated at ± 0.3 dB from 1 to 6 dB, ± 0.5 dB from 7 to 20 dB, and ± 0.75 dB from 21 to 40 dB. Average power consumption is 2W and the operating range is -55 to $+125^\circ\text{C}$. From \$90.

Alan Industries Inc., Box 1203, Columbus, IN 47202. Phone (812) 372-8869.

Circle No 379

THE SLICER

Real 16 Bit Power on a Single Board—
Featuring the Intel 80186



■ Complete 8 MHz 16-bit microprocessor on a 6" x 12" board

- 256K RAM, plus up to 64K EPROM
- SASI port for hard disk controller
- Two full function RS232C serial ports with individually programmed transmission rates—50 to 38.4K baud
- Software compatibility with the 8086 and 8088
- 8K of EPROM contains drivers for peripherals, commands for hardware checkout and software testing
- Software supports most types and sizes of disk drives
- Source for monitor included on disk
- Bios supports Zebec 1410 and Western Digital WD 1002 SHD controller for hard disks
- Modifications available for specific applications

Fully assembled and tested only \$995. Also available in kit form.

Operating systems are CP/M 86 by Digital Research, Inc. (\$85), and MS DOS by Microsoft Corporation (\$175).

Prices subject to change without notice.

Also available:

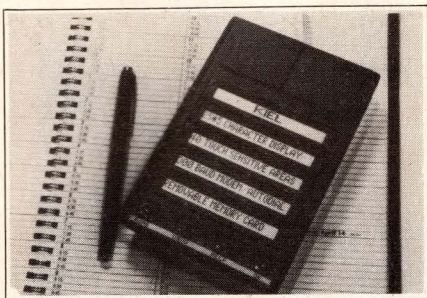
THE SLICER SYSTEM EXPANSION BOARD for expanded memory, additional ports, and real time clock.

The SLICER PC EXPANSION BOARD gives your Slicer high performance video capability.



Slicer Computers Inc.
2543 Marshal St. N.E.
Minneapolis, MN 55418
612/788-9481
Telex: 501357 SLICER UD

COMPONENTS & PACKAGING



TOUCH TERMINAL

The Touch Pad I is a handheld touch-screen terminal capable of displaying 25 characters/line. Each line has 15 touch-sensitive areas. The terminal can display one to five lines of data and operates in an interactive mode with a host computer or smart terminal. An optional 48k bytes of RAM is available for off-line data acquisition. A memory program card, which is specific to the application, contains all the screens that you want to display. To change programs, you insert new memory program cards. You devel-

op the programs on a μ C with the manufacturer's program generator. The unit measures 6.3 $\times$ 4.1 $\times$ 0.8 in. <\$250 (OEM qty).

Kiel Corp., Box 6430, Nashua, NH 03063. Phone (603) 881-8666.

Circle No 380

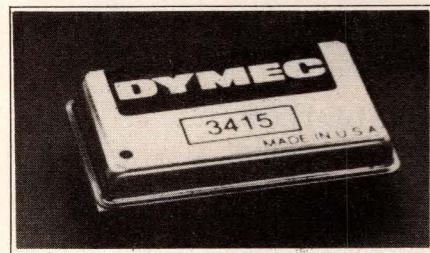
TOUCH SCREEN

The Microtouch screen offers touch resolution of 256 $\times$ 256 points. According to its manufacturer, the glass overlay sensor allows transmission of as much as 85% of the display's light. The sensor also conforms to the CRT surface, eliminating parallax problems. The controller transmits touch data over an RS-232C serial line to the host computer. It digitizes 50 points/sec in the stream mode or 1 point/touch in the point mode. You can program different data formats and store calibration values in onboard nonvolatile memory. The screen comes in 12-, 13-, and 19-in. sizes; custom

sizes are also available. You can purchase the Microtouch screen in kit form or already installed in the company's line of Point-1 monochrome or color monitors. 13-in. version, <\$500 (OEM qty).

Microtouch Systems Inc., 400 W Cummings Park, Woburn, MA 01801. Phone (617) 935-0080.

Circle No 381

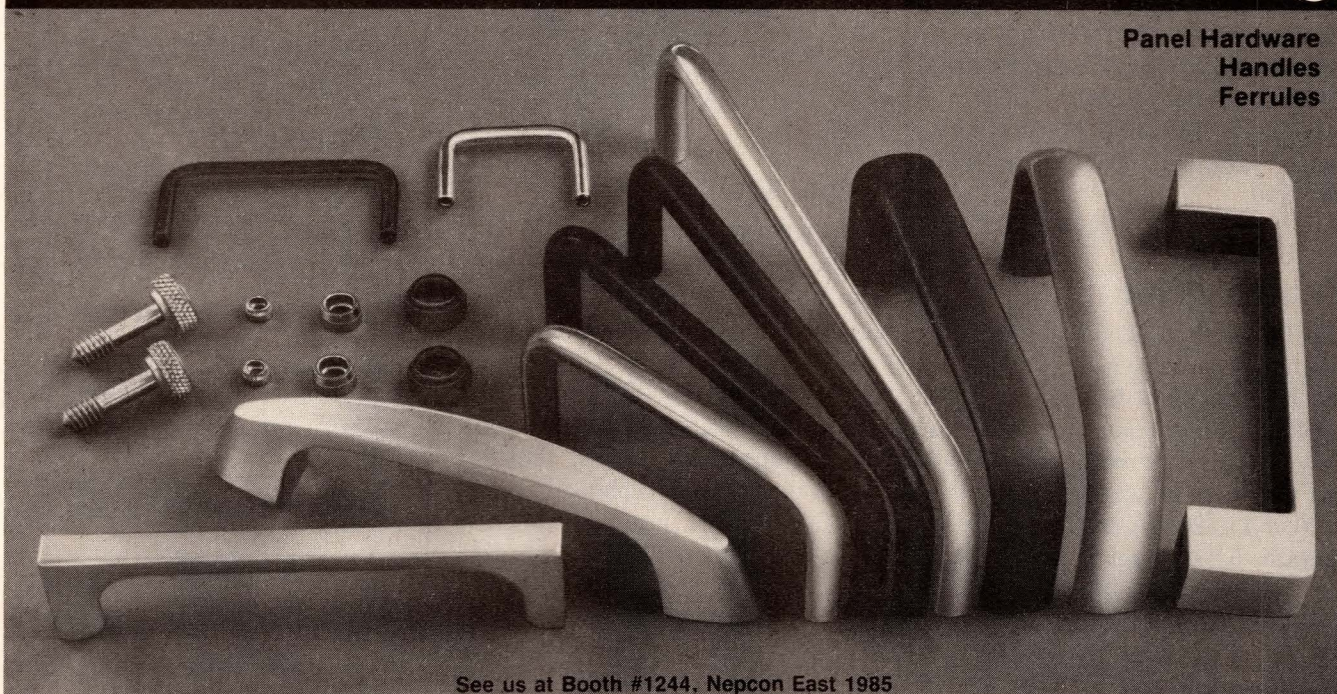


S/H AMPLIFIER

Combining 200-nsec acquisition time with 150-nsec sample-to-hold settling time, the Model 3415 sample-and-hold amplifier offers $\pm 0.005\%$ FSR linearity. Offset is

WE SHIP PRODUCTS...NOT PROMISES™

Panel Hardware
Handles
Ferrules



See us at Booth #1244, Nepcon East 1985

KEYSTONE PRODUCTS ARE AVAILABLE FROM YOUR LOCAL DISTRIBUTOR.
Send For Complete Electronic Component Catalog.



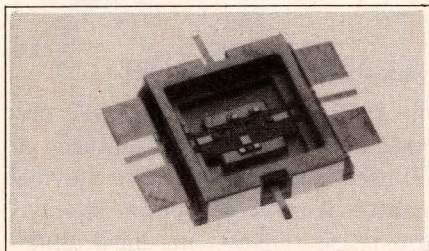
KEYSTONE ELECTRONICS CORP
49 Bleecker Street, New York, NY 10012 • Tel: (212) 475-4600 TLX: 35-3700 • Call Toll Free: (800) 221-5510

COMPONENTS & PACKAGING

± 5 mV, with drift held to ± 50 $\mu\text{V}/^\circ\text{C}$ max. Other specifications include 1-mV pedestal, 90-dB min feedthrough, and 50-mA output at $\pm 10\text{V}$. The amplifier requires $\pm 15\text{V}$ typ and dissipates 720 mW typ, 875 mW max. Operating range is -25 to $+85^\circ\text{C}$. The unit comes in a 24-pin hermetic package and is a pin-compatible replacement for the SHC803CM. \$163 (100).

Dymec, 8 Lowell Ave, Winchester, MA 01890. Phone (800) 225-1151; in MA, (617) 729-7870.

Circle No 382



GAIN MODULES

The G-PAC gain and power modules are broadband gain-package amplifiers that perform over the 2- to 8-GHz frequency band and measure $0.52 \times 0.52 \times 0.11$ in. The 2-stage gain model offers a gain of 12 dB min and gain flatness of ± 0.75 dB max. It delivers 11-dBm output power at the 1-dB compression point. The power-block module specs a gain of 8.5 dB min and a gain flatness of ± 0.75 dB max. Power output is 19 dBm at the 1-dB compression point. Gain response changes less than ± 0.6 dB from -54 to $+85^\circ\text{C}$. Input and output VSWRs are less than 2:1; noise figure is less than 5.5 dB at 25°C . Both devices require an 8V supply. \$300.

Gould Inc, Microwave Products Div, 2580 Junction Ave, San Jose, CA 95134. Phone (408) 943-9055. TWX 910-338-0180.

Circle No 383

ATTENUATORS

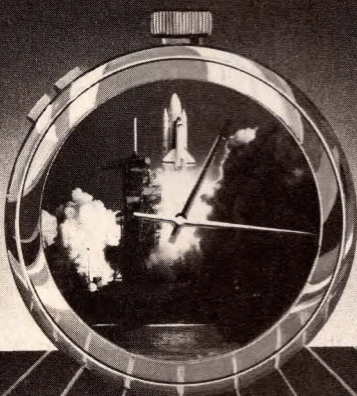
Model 54 dc to 40-GHz fixed coaxial attenuator is available in values of 3, 6, 10, 20, 30, and 40 dB. SWR is

1.35 from dc to 26.5 GHz and 1.60 from 26.5 to 40 GHz for all units. The attenuator suits use in telecommunications systems, EW, radar, and other K and Ka band applications. Each attenuator is 1.75 in. long and measures 0.25 in. in diameter. The unit's 1W power rating (200W peak) over an operating range of -55 to $+125^\circ\text{C}$ is derated

linearly to 0.1W at 125°C . Each unit employs the manufacturer's WPM-4 connectors, which mate with SMA per MIL-C39012. \$295. Delivery, 90 days ARO.

Weinschel Engineering, 1 Weinschel Lane, Gaithersburg, MD 20877. Phone (800) 638-2048; in MD (301) 948-3434.

Circle No 384



CUSTOM Mil Performance POWER SUPPLIES

*There is a way to
beat long lead
times...
and eliminate
NRE charges!*

Arnold's unique line of miniaturized, high reliability power supplies lets you order tailor-made units from off-the-shelf sub-modules. Lead times are reduced to weeks and NRE charges are totally eliminated. Most importantly, you get performance and reliability that's been proven in thousands of demanding government/military applications.

There are hundreds of possible configurations...from 1 to 8 DC outputs (up to 400 watts) with either AC or DC inputs. And, our high density (5.33 watts/cubic inch) encapsulated packages are 50% to 75% smaller than other switching power supplies.



Send for our "Design-Your-Own" High Reliability Power Supply Catalog today. Better yet, call us toll free 1-800-421-8181 (in California 213/390-3537) and ask for it!

ARNOLD **MAGNETICS**

ARNOLD MAGNETICS CORPORATION
11520 W. Jefferson Blvd., Culver City, CA 90230
(213) 390-3537 • (213) 390-8837 • TWX 910-343-6486

CIRCLE NO 103

NEW PRODUCTS: ICs & SEMICONDUCTORS

NEW SWITCHMODE III HIGH VOLTAGE TRANSISTORS IN TO-218

DEVICE	CURRENT RATING	$V_{CE(sat)}$	V_{CEV}
MJH16002-4	5	450	850
MJH16004-8	8	450	850
MJH16010-12	15	450	850
MJH16002A	5	500	1000
MJH16008A	8	500	1000
MJH16015A	15	500	1000
MJH16024-25	5	800	1500
MJH16028-30	8	800	1500
MJH16018	15	800	1500



1500V TRANSISTORS

The MJH16000 family of transistors for high-voltage switching and high-resolution CRT-deflection circuits includes units rated at 5, 8, and 15A, with V_{CE0} of 450 and V_{CEV} of 850V or V_{CE0} of 500 and V_{CEV} of 1000. Other units are rated at 5, 8, and 10A, with V_{CE0} of 800 and V_{CEV} of 1500. Inductive fall times range from 50 to 80 nsec, crossover times are from 70 to 120 nsec, and inductive storage times range from 500 to 800 nsec. The 450V models suit use in line-operated bridge and push-pull applications; the 500 or 800V versions suit line-operated, single-transistor flyback and converter applications. All devices come in TO-218 plastic packages. From \$1.58 (100). Delivery, stock to 12 wks ARO.

Motorola Semiconductor Products Inc., Box 20912, Phoenix, AZ 85036. Phone (602) 244-4912.

Circle No 385

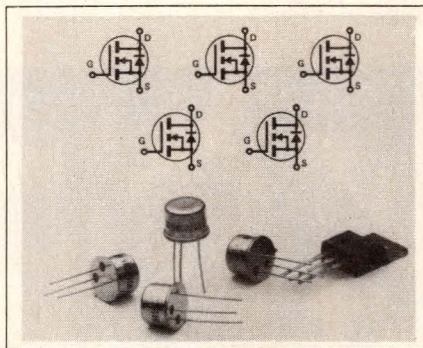
D FLIP-FLOP

The CD54/74HC273 and -HCT273 contain eight D flip-flops with common clear and clock lines. The HC versions suit use in high-speed CMOS-logic designs; the HCT models are speed, function, and pin compatible with LS TTL devices but dissipate less power than those units do. Propagation delay from the D input to the Q output is 13 nsec with the output driving a 15-pF capacitive load at 5V. Maximum clock frequency is 50 MHz typ. The -54-Series devices are supplied in 20-lead ceramic hermetic packages and operate over -55 to $+125^{\circ}\text{C}$. The -74-Series devices are housed in 20-lead plastic packages and operate

from -40 to $+85^{\circ}\text{C}$. The HC types run from supply voltages of 2 to 6V, while HCT types operate from 4.5 to 5.5V. 74HC/HCT273, \$1.70 (100).

RCA, Solid State Div, Rte 202, Somerville, NJ 08876. Phone (800) 526-2177.

INQUIRE DIRECT



MOS DEVICES

Suitable for applications that require low threshold voltage and compatibility with CMOS logic levels, VNC-, VND-, and VNE010 devices feature breakdown voltages of 60, 80, and 100V, respectively; turn-on threshold of 2V max; drain current of 4A; and on-resistance of 0.5Ω . All devices in the series feature a guaranteed threshold voltage of 3.6V max, high input impedances, low drive requirements, and a square safe-operating-area curve. They come in either TO-220 plastic or TO-39 packages. \$2.95 to \$4.02 (100).

Siliconix Inc., 2201 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 988-8000.

Circle No 387

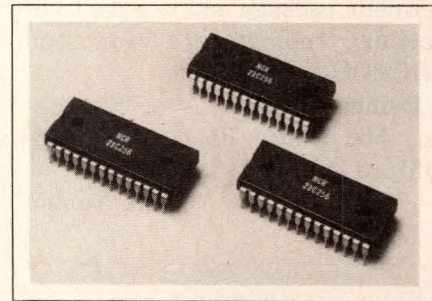
GRAPHICS IC

The enhanced 82720 graphics-display controller operates at 5 MHz and draws into a bit-map display at 800 nsec/pixel, a rate twice as fast as that of the company's original version of NEC's 7220 IC. The controller relieves the host μP of bit-map loading and refresh tasks. It also supports mixed graphics and alphanumeric displays; draws characters, points, lines, arcs, and rectangles; and permits zoom, pan, and

windowing via a 4M-pixel display memory. Less than \$40 (100).

Intel Corp., Literature Dept W-209, 3065 Bowers Ave, Santa Clara, CA 95051. Phone (408) 987-7602.

Circle No 388



256k-BIT CMOS ROM

The 23C256 CMOS static ROM, organized as $32\text{k} \times 8$ bits, features a 150-nsec access time. The device operates from one 5V power supply. In operating mode, current drain is 40 mA; in standby mode, the drain falls to 100 μA . A fully TTL-compatible device, the ROM suits use in portable and personal computers, telephone systems, robotics, and test equipment and comes in a 28-pin DIP with industry-standard JEDEC pinout. \$6.50 (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 389

AUDIO D/A CONVERTER

The PCM53 Series of 16-bit monolithic audio D/A converters includes an internal zener reference, a resistor ladder network, high-speed current switches, and (on voltage-output models) a fast, low-noise op amp. The JP and KP models come in current (-I) or voltage (-V) output versions, and all provide 16-bit resolution, 96-dB dynamic range, and 16-bit monotonicity typ. Total bipolar drift and bipolar zero drift are ± 25 ppm/ $^{\circ}\text{C}$ of full-scale range (FSR) and ± 4 ppm/ $^{\circ}\text{C}$ of FSR, respectively. Typical settling time for



THE INCREDIBLE SHRINKING CORDLESS.

DURACELL® high-energy density batteries can improve your cordless design (...providing you call us in early).

Is the mighty chip enabling you to miniaturize your portable designs further or to go cordless for the first time? Yes?... Then you should be aware that Duracell battery technology is keeping pace with the chip. And if you call Duracell in early, before your design is locked in, we can apply that new technology in reducing the size and weight of your product even more, while improving performance and usage cycle. We can determine the optimum battery for you and help design the cavity and the circuitry. Duracell, manufacturer of the **World's Number One Premium Battery**, offers you primary cells and batteries in a full range of capacities, sizes and shapes, in all key systems. We also give you the most complete design and applications assistance you can get: ■ a new 90,000 square foot research and development center; ■ several separate engineering facilities; ■ product engineering specialists; ■ field engineering specialists throughout the country; ■ and all the resources of a subsidiary of a FORTUNE 50 Company... plus international availability under the DURACELL® brand. But to take full advantage of Duracell's resources and advanced technology, call us in early on your cordless design.

DURACELL INC.
OEM Technical Sales & Mktg.
Berkshire Industrial Park
Bethel, CT 06801

...call toll-free
1-800-431-2656
(In CT, call 203-796-4000)

☐ Please send information on Duracell battery technology.

☐ Please have an Engineer call me.

EDN 61385

My application is _____

Name _____ Title _____

Company _____

Address _____

City _____ State _____ Zip _____

Telephone (____) _____



DURACELL

ZINC AIR • LITHIUM • ALKALINE • MERCURY • SILVER

CIRCLE NO 104

ICs & SEMICONDUCTORS

the voltage-output units is 3 μ sec; the current-output models offer 350-nsec settling time. Operating temperature is -25 to $+85^{\circ}\text{C}$. The devices are compatible with industry specification EIAJ STC-007. JP-I and JP-V, \$17; KP-I and KP-V, \$19 (100).

Burr-Brown Corp., Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TWX 910-952-1111.

Circle No 390

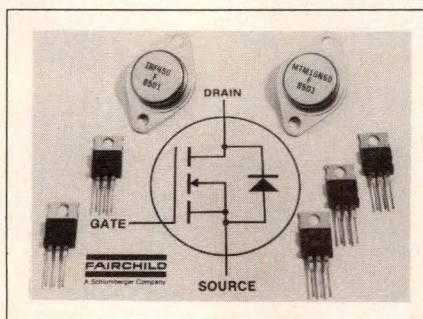
SPEAKERPHONE IC

The MC34018 incorporates the amplifier, attenuators, and control functions necessary to produce a speakerphone system. A peak-limiting AGC circuit inhibits speaker-amplifier clipping when the speaker is overdriven. The chip is powered by the phone line; onboard regulators provide voltage for the internal and external circuitry. A chip-select pin allows you to power down the

device. The circuit requires an external 2-to-4-wire converter and comes in a 28-pin DIP or a 28-pin surface-mount package. \$2.50 (10,000).

Motorola Semiconductor Products Inc., Box 20912, Phoenix, AZ 85036. Phone (602) 897-3838.

Circle No 391



POWER MOSFETs

Implementing a proprietary design and manufacturing process, these six series of power MOSFETs spec ranges of 350 to 500V and 4.5 to

15A. Within this series, the IRF330-333 and MTM/MTP5N35 are 400 and 350V, 5.5A devices that dissipate 75W at 25°C and feature delay times of 30 and 55 nsec, respectively. Maximum on-resistance specs are 1 and 1.5Ω , respectively. The high-end IRF450-453 and MTM15N45 are 500 and 450V, 15A MOSFETs. Power dissipation at 25°C is 150W for the IRF450-453 and 250W for the MTM15N45, and respective turn on/off delay times are 35 and 150 nsec. Resistance specs are 0.4 and 0.5Ω max. The MOSFETs are available either in TO-220 plastic packages, with an operating range of -55 to $+150^{\circ}\text{C}$, or in TO-3 metal packages, for operation spanning -55 to $+175^{\circ}\text{C}$. \$2 to \$37.90 (100).

Fairchild Camera and Instrument Corp., Power Systems Div, 4300 Redwood Hwy, San Rafael, CA 94903. Phone (415) 499-4406.

Circle No 392



VLSI Tester

Ideal for Incoming Inspection

The **STM 4000** is a fully integrated digital function tester. Available at PC prices. **Perfect for incoming inspection** of digital ICs. Lets you automate inspection and reject bad ICs. Test MICROS, EPROMs, RAMs, ROMs, PALs, PLAs, PLDs, UARTs, 7400s, printed circuit boards, and custom/semicustom VLSI parts. Performs pass/fail tests, as well as detailed failure analysis.

Easy to use. No special skills required. **Powerful menu driven software eliminates programming.** The STM 4000 can directly drive your autoprobe/autofeed stations with no additional equipment required.

Complete 7400 test library, vector generators, and adapters are available. Price for 64 channels and software to meet all of your basic needs is \$4895.

Available now from **CADIC Inc.**, Beaverton, Oregon. 1 (800) 824-1617 or (503) 626-7902.

CIRCLE NO 105

NEW FROM

ovenaire

LOW PROFILE
PCB MOUNT 10MHz

TCXO

ONLY 1.2 CU. IN.
VOLUME

1.50 IN. SQUARE BY
0.53 IN HEIGHT



Features a low aging crystal with excellent ambient stability and logic output. Also features built-in voltage regulator and a piston trimmer to correct for long term crystal aging. Several options on temperature range and stability.

FAST PROTOTYPE DELIVERY
FOR DETAILS CALL ANDY BELL 804-977-8050

OVENAIRE-AUDIO-CARPENTER

706 Forrest St. Charlottesville Va. 22901
804-977-8050 TWX510-587-5461

CIRCLE NO 106

MULTIPLEXER

The S1520 CMOS data-acquisition system combines an 8-channel multiplexer, a sample-and-hold function, an 8-bit A/D converter, and μ P control logic on one chip. The device offers conversion times as low as 70 μ sec plus a 14-kHz throughput rate. Linearity error equals ± 0.5 LSB max. Digital inputs and outputs have latchable 3-state buffering. The converter operates from one 5V supply and is housed in a plastic or ceramic 28-pin DIP, providing temperature ratings of -40 to $+85^{\circ}\text{C}$. \$7.50 to \$8.63 (100).

Siliconix Inc, 2201 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 988-8000.

Circle No 393

SWITCHING DIODE

The PIN RF switching diode type DPJ 0350-034 operates with a resistance of 0.6Ω at a forward current of 3 mA. Typical capacitance is 1 pF at zero bias; it drops to 0.8 pF at 3V reverse bias. Minority-carrier lifetime is 50 nsec. The manufacturer guarantees a 35V reverse breakdown. The diode comes in an axial-lead DO-34 glass package; the company provides optional taped and reeled devices for quantities exceeding 10,000. \$0.36 (100).

SDI Inc, 11 Executive Park Dr, North Billerica, MA 01862. Phone (617) 667-7700.

Circle No 394

KM3703D feedback pulse generator—are now available in plastic packages. The -3701D generates interpolation pulses for two axes of movement, according to instructions from a host CPU. With the addition of the -3702D comparator, the -3701D can control dc servo motors. The -3703D monitors the direction of rotation of servo motors, as

sensed by an encoder, and transmits the information to the -3702D. A prototyping kit for 2-axis numerical control contains one -3701D, two -3702Ds, two -3703Ds, and documentation. \$155.

Toko America Inc, 5520 W Touhy Ave, Skokie, IL 60077. Phone (312) 677-3640. TLX 230724372.

Circle No 395

THE BEAUTY OF A ROGERS INTERFACE IS MORE THAN SKIN DEEP.

We admit our MEKTRON® micromotion keyboard assemblies look good from the outside. We use a wide range of striking visual effects such as deadfronts, backlighting and embossing.

But the real beauty of our keyboards lies below the surface, in the total design capabilities we put behind them. Our engineering staff helps you choose the most economical and practical way of arranging switch functions. We select the proper dielectrics, conductors, adhesives and rigidizers and, if you need it, we'll

assemble your complete data entry system incorporating LED's, LCD's and IC's. We can even show you how a membrane keyboard assembly can be an easier, cost-effective alternative to full travel technology. We won't deny that it helps to have a pretty face in this business. But at Rogers, we think true beauty is reflected from the inside out.



ROGERS

Rogers Corporation, Keyboard Division
Box 700, Chandler, AZ 85224 602 963-4584

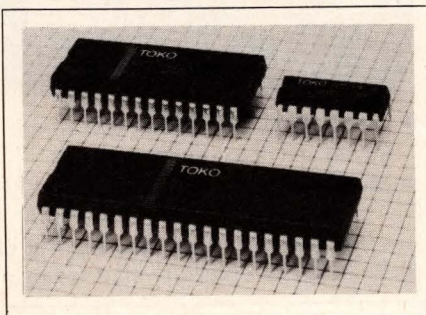
Graphic layer designed with your switching and display, in any color, size or background.

Strength and flexibility requirements are met through the use of various rigidizing materials.

Contact layer precision screened for specified conductivity and proper switching to ensure product reliability.

Standard industry terminations may be used.

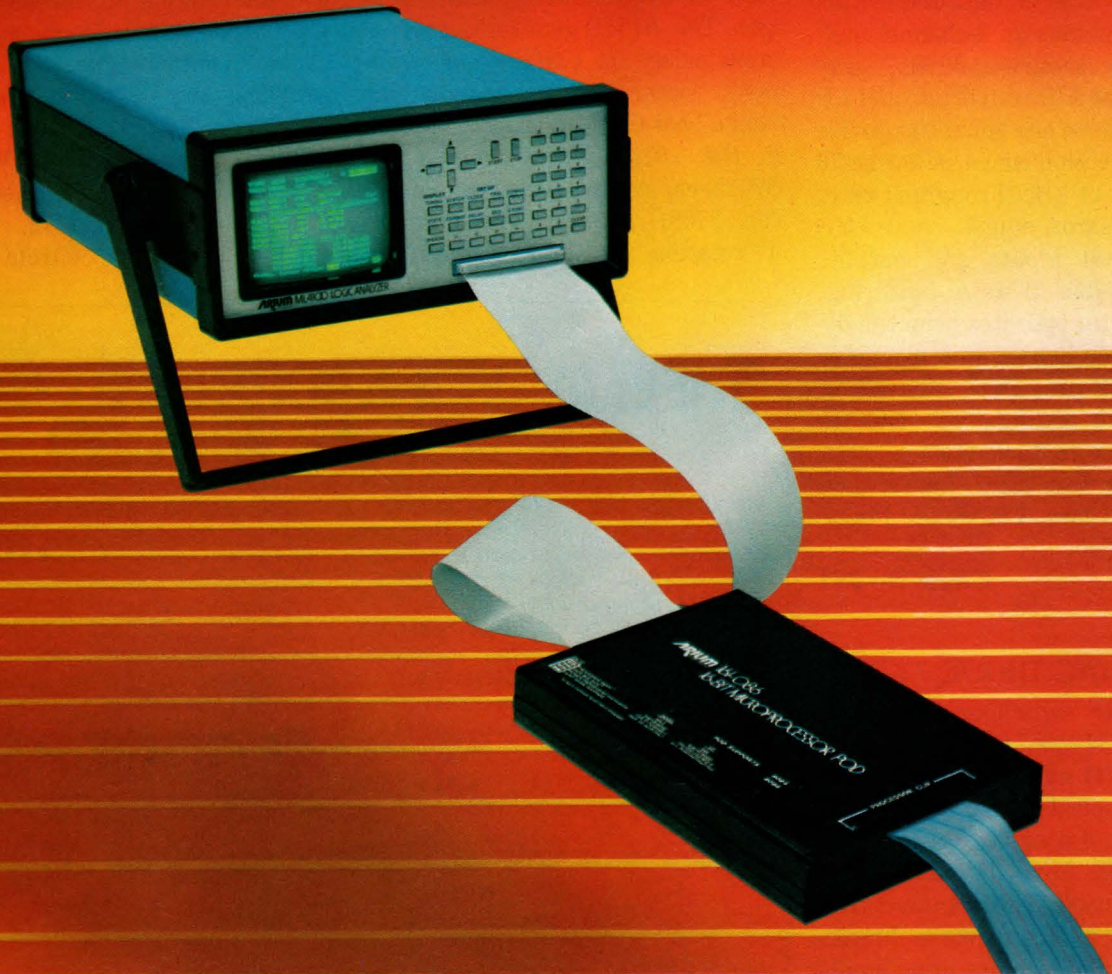
Total design capability means LCD's, LED's, and other IC components can be assembled on circuit layer.



CONTROL ICs

Three CMOS LSI chips—the KM3701D function generator, KM3702D comparator, and

"Best performance in a 16-bit supporting role..." The Arium ML4100B Logic Analyzer.



At only \$2,675, Arium's full-featured ML4100B Logic Analyzer delivers more performance per dollar than any other logic analyzer:

- Disassembler support for Motorola 68000 and 68010, and Intel 8086 and 8088 microprocessors. (Optional)
- Immediate reconfiguration from front panel to 4, 8, 16, or 32 channels, and up to 100-MHz bandwidths.
- FILTERED mode removes all non-executed prefetched cycles in the pod hardware.
- JUMP mode suppresses all but program control transfers and produces disassembled "map" of code location in actual execution.
- STATE display shows data as it occurs on address and data busses.
- DISASSEMBLY display shows reverse-assembled code mnemonics and labelled exceptions processing as they are actually executed by the processor (including data cycles **unscrambled** and put back

with their corresponding instructions).

STATE	PC	DISASSEMBLY	68000T	S/U
-0010	000402	MOVE #2000, SR		S
-0015	000406	NOP		S
-0014	000408	MOVEA.L #00040400, A1		S
-0011	00040E	MOVEA.L #00000200, A0		S
-0006		EXTERNAL INTERRUPT EXCEPTION		
	PC: 0403FC<00000414	SR: 0403FA<2000		
	INTERRUPT LEVEL 01	VECTOR #17		
	VECTOR: 0001D8>05000500			
TRIG	000500	MOVEA.L #00040200, A0		S
00003	000506	MOVEA.L #00040300, A1		S
00006	00050C	RTE		S
	SR: 0403FA<2000	PC: 0403FC>00000414		
00011	000414	ADD0.B #0, D0		S
00012	000416	ADD0.B #0, D1		S
f1=Pos. Cursor f2=Spd: slow f3=Cycles: on				

- TRANSPARENT mode with state, timing and disassembly formats.
- Multilevel combinational triggering.

STATE	ADDR	DISASSEMBLY	X: 00B6T*0007
-0023	02B3B	INT #10	
-0020		SOFTWARE INTERRUPT TYPE 10	
	CS: 00040>3FE0 (IP)	CS: 00042>0000 (CS)	
	SS: 207FD<FC96 (F)	SS: 207FB<0000 (CS)	
	SS: 207F9<2B3D (IP)		
-0014	03FE0	IRET	
	SS: 207F9>2B3D (IP)	SS: 207FB>0000 (CS)	
	SS: 207FD>FC96 (F)		
-0004	02B3D	STI	
-0003	02B3E	NOP	
TRIG		EXTERNAL INTERRUPT TYPE FF	
	CS: 003FC>3FE0 (IP)	CS: 003FE>0000 (CS)	
	SS: 207FD>FE96 (F)	SS: 207FB<0000 (CS)	
	SS: 207F9<2B3F (IP)		
f1=Pos. Cursor f2=Spd: slow f3=Cycles: on			

The Arium ML4100B: The star in state-of-the-art logic analysis. Call or write today for complete information.

ARIUM CORPORATION
1931 Wright Circle, Anaheim, CA 92806-6052
(714) 978-9531, Telex: 754903, ARIUM UD

ARIUM
CORPORATION

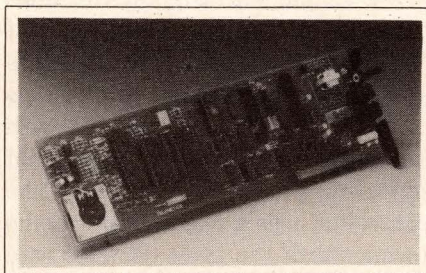
NEW PRODUCTS: COMPUTER-SYSTEM SUBASSEMBLIES

GRAPHICS CPU

By using two 16-bit CPUs, the Mega Machine lets you generate and animate 3-dimensional objects that won't show hidden surfaces. The real-time computer system operates with an IBM PC, PC/XT, PC/AT, or compatible computer, and the display system provides a 1024×768 pixel image area. You can display as many as 4096 colors on a color monitor screen simultaneously. Options include a digitizing frame buffer that captures and manipulates video images and a programmable audio synthesizer with six voices. The computer system contains an IEEE floating-point math processor, and the system's memory sizes range from 1M bytes to as much as 16M bytes. The manufacturer supplies Lumena graphics software and a diagnostic program with the system. From \$12,000.

Lazerus Productions, 2821 Ninth St., Berkeley, CA 94710. Phone (415) 845-1237.

Circle No 396



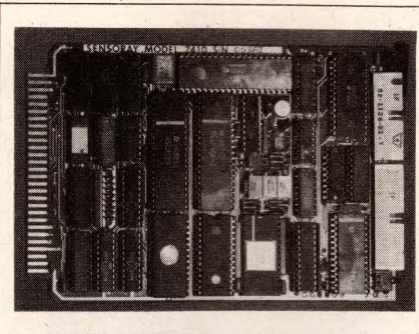
1200-BPS MODEM

The Expressdata 12i 1200-bps modem features adaptive equalization so that it adjusts automatically to varying telephone-line conditions. According to the company, this feature assures error-free and consistent performance over public telephone lines. The single-card modem plugs into the IBM PC and μ Cs having PC-compatible hardware. The asynchronous, full- or half-duplex device features autoanswer and autodial. The company's Relay software, which supports PC-to-PC and PC-to-mainframe communication, provides password and

encryption security and emulates 3270 terminals. The modem operates with most widely used communications packages. It meets Bell 212A and 103 standards and operates at 110/300 and 1200 baud. A call-monitoring feature detects busy, dial, and ringback signals automatically. \$495.

Telenetics Corp, 895 E Yorba Linda Blvd, Placentia, CA 92670. Phone (714) 524-5770.

Circle No 397

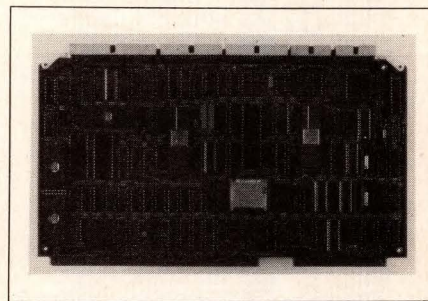


A/D CARD

The 7410 Series of STD Bus, data-acquisition processors suits use in process control, ATE, and laboratory systems. The interfaces combine a CMOS processor, a 12-bit A/D converter, serial and parallel communications ports, counter/timers, and 40k bytes of memory. Eight models are available; each comes with EPROM firmware for configuration as a dedicated interface. Thus you can construct multiprocessing and stand-alone systems from the basic 7410. The EPROMs provide a high-level command set that reduces software design time. The Z80-type code-compatible processors allow master/slave operation, DMA transfers, and vectored interrupts. STD Bus communication can also occur via two I/O ports. The 50- μ sec A/D converter includes a 16-channel multiplexer and sample/hold circuit. Multiple 7411T terminations can expand A/D channel capacity to 256. \$600.

Sensoray, 1445 Koll Circle, Bldg 112J, San Jose, CA 95112. Phone (408) 998-7271.

Circle No 398

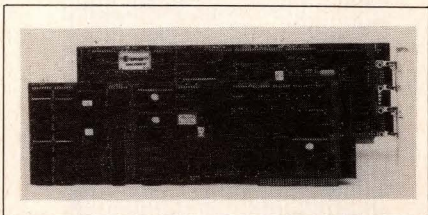


MULTIBUS BOARDS

The iSBC 214 and iSBC 226 multi-function single-board computers control peripheral storage devices in Multibus-based systems. The -214 provides standard interfaces to Winchester disk drives, floppy-disk drives, or streaming-tape drives. It controls as many as two 5¼-in. Winchester disk drives compatible with the ST506/412 standard, as many as four 5¼-in. floppy-disk drives (SA450/460 compatible), and as many as four ¼-in. streaming-tape drives (QIC-02 compatible). The board supports 20- or 24-bit addressing. The -226 board supports the enhanced version of the SMD interface. Intended for the control of high-performance, high-capacity hard disks, the board controls as many as two drives, compatible with the SMD interface, at rates to 1.9M bytes/sec. Both boards offer onboard diagnostics and error-correcting circuitry. The iSBC 214 and iSBC 266 cost \$1450 and \$2700, respectively.

Intel Corp, Literature Dept W-184, 3065 Bowers Ave, Santa Clara, CA 95051. Phone (503) 640-7147.

Circle No 399



PC GRAPHICS

The M-16 and M-256 plug-in graphics controllers and the CD-1 RGB monitor are compatible with the IBM PC/XT, PC/AT, and the PC

FIBER OPTIC COUPLERS

WORLD LEADER IN

CIRCLE NO 109

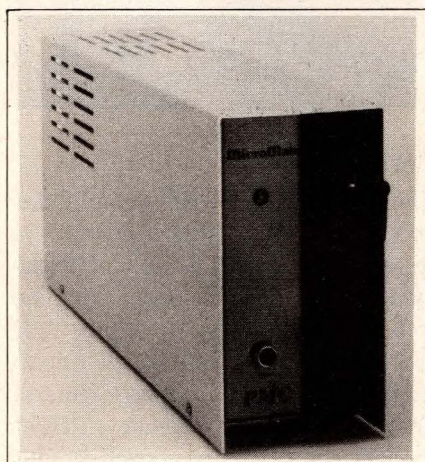
**CANSTAR
COMMUNICATIONS**
1240 Elmhurst Road,
Scarborough,
Ontario, Canada M1P 2K4
Tel: (416) 293-9722

COMPUTER-SYSTEM SUBASSEMBLIES

expansion board. The M-16 and M-256 controller cards can draw images at 1M pixels/sec and provide a choice of 16 and 256 colors, respectively, from palettes of 4096. They each have a 68000 CPU on board and a proprietary CMOS graphics controller chip. The CD-1 60-Hz, noninterlaced RGB display offers 640×480-pixel resolution. These three products are compatible with the IBM color-graphics adapter and support VDI and Halo graphics standards. Controllers, \$2250 to \$2850; display, \$1025.

Verticom Inc., 545 Weddell Dr, Sunnyvale, CA 94089. Phone (408) 747-1222.

Circle No 400



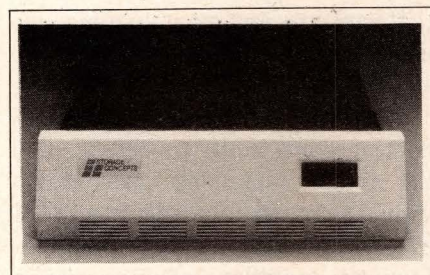
SINGLE-BOARD CPU

The Micromate computer is available as a single board for OEMs and systems integrators to incorporate in system designs. Designated Model PC-101, it has two serial ports, one parallel printer port, one floppy-disk interface for a maximum of four drives, and one high-speed parallel I/O bus with seven address lines for customized control interfaces. A 10M-byte hard-disk drive is available. The CPU interfaces to any standard ASCII terminal through one of its RS-232C serial ports. These ports are software programmable to independent baud rates from 50 to 19.2k. The OP/SYS software package option includes CP/M 3.0, PMC and CP/M utilities, and documentation. The Micro-

mate's BIOS source code, CP/M programmer's utilities, and bundled applications software is unbundled from the hardware for purchase as a package with the board, if desired. Model PC-101, \$495; software package, \$185.

Personal Micro Computers Inc., 275 Santa Ana Ct, Sunnyvale, CA 94086. Phone (408) 737-8441. TWX 910-379-5022.

Circle No 401



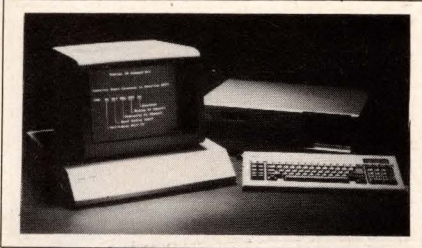
DISK SUBSYSTEM

Consisting of a controller and parallel transfer disk, the Concept 21 disk subsystem operates at transfer rates as fast as 9.3M bytes/sec to support real-time image-processing and communications applications. It's available with adapters for Multibus, Q Bus, Unibus, Versabus, and VME Bus computers. The disk subsystem can command five channels of disk I/O from one drive, with each channel operating at a 1.86M bytes/sec peak transfer rate. The controller uses a formatting scheme to maximize the peak transfer rate to 9.3M bytes/sec for the five channels with a storage capacity of 474M bytes on each of as many as four disks. The user provides the software to access the subsystem's command sets via a host adapter port. With the diagnostics command set, you can initialize the drive and controller at system start-up or when an error occurs. Using the maintenance command set, you can format the disk to account for bad sectors and bad cylinders before beginning a read or write operation. \$17,700.

Storage Concepts Inc., 3198-G Airport Loop Dr, Costa Mesa, CA 92626. Phone (714) 557-1862.

Circle No 402

COMPUTER-SYSTEM SUBASSEMBLIES



SINGLE-BOARD μ C

The Scadar Series 10 self-contained μ C system can be installed close to a process-measurement area, thus minimizing sensor and signal wiring. Analog-input modules interface directly to low-level sensors or high-level signals (from 4 to 20 mA and 1 to 5V dc). Two-wire transmitter power is included. All communications, I/O scans, and routine functions are controlled by the 16-bit 8088 CPU and internal firmware. Complete with memory, power supply, and I/O, the unit interfaces with IBM PCs and Intel 310/A and HP-3000 systems and DEC LSI-11, PDP-11, and VAX computers via

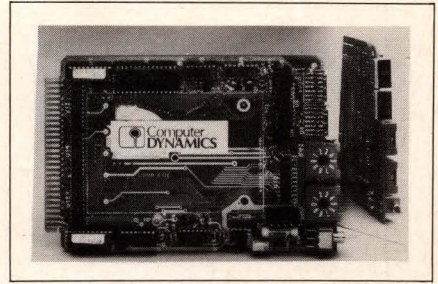
RS-232C and TTY current loop ports. ASCII characters are used as the command/response protocol to or from the Series 10. Available plug-in modules include an analog-input module and an analog I/O module—each accepts eight differential inputs over a ± 10 V dc range. Scadar Series 10, \$2500; I/O modules from \$475.

Burr-Brown Corp., Data Acquisition and Control Systems Div, Box 11400, Tucson, AZ 85734. Phone (602) 747-0711.

Circle No 403

STD BUS BOARD

The Combo is an STD Bus-compatible board that lets you choose any combination of these options: a battery-backed real-time clock/calendar that has a start/stop command for time adjustment and software interrupts; a 25W card-mounted power supply providing 5V at 4A



and ± 12 V at 0.2A; a power-fail interrupt with an adjustable brown-out level and missing-pulse detector for every half line cycle; 2k or 8k bytes of battery-backed RAM; and dual 7-segment LEDs and thumb-wheel switches for an operator interface. Substituting a parallel I/O for the operator interface, you get eight parallel latched outputs, eight parallel buffered inputs, and a strobe on a 34-pin header. From \$125.

Computer Dynamics Inc., 105 S Main St, Greer, SC 29651. Phone (803) 877-7471.

Circle No 404

IMMEDIATE PRODUCT RELEASE WITH ZZF, VDE, UL, FCC

The PLI Alternative:

PLI product certification to ship and sell internationally now; ZZF, VDE, UL, etc., later. The PLI label recognized internationally.

Services:

PLI electrical product safety/RFI/EMI/telecommunications testing and certification provides manufacturers with one product design to meet all agency criteria.

PLI safety/RFI/EMI seminars at product factory include review of product design, follow-up service inspection, and implementation of quality control systems.

The PLI Solution:

ZZF: ZZF license obtained in two weeks using only PLI follow-up service procedures and data.

VDE: PLI experience and pretesting ensures certification in six months.

UL: PLI expertise allows certification in six weeks.

FCC: Recognized thirty meter open field test site provides certification in two weeks. Includes Part 15, Subpart J, Classes A and B.

International product certification by PLI allows immediate product entry in 22 European and Pacific markets.

Stop product certification delays and struggles; contact PLI and free design engineers to design.

PLI: Your one-stop laboratory for fast, accurate product certification with no hassles.

800-635-3050
208-342-1000

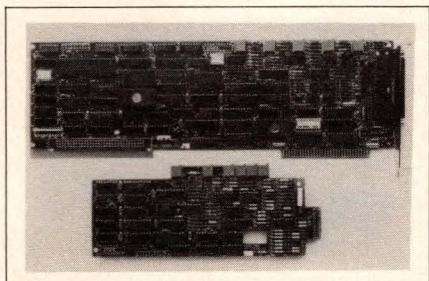


PULVER LABORATORIES INC.

415 SOUTH 8TH STREET BOISE, IDAHO 83702-7106 USA
POST OFFICE BOX 5 BOISE, IDAHO 83707-0005 USA



COMPUTER-SYSTEM SUBASSEMBLIES



POWER CONTROLLER

The PPC100 interfaces an IBM PC to fixed-output power supplies and makes them programmable. Four isolated output channels allow you to configure as many as four programmable supplies in a system. Each output channel features 8-bit programming resolution and an optically isolated logic on/off control. An additional output for controlling ac system power with a solid-state relay is available. An onboard μ P allows you to create arbitrary waveforms to simulate ripple, noise, and voltage transients on the supply's outputs. An optional readback mod-

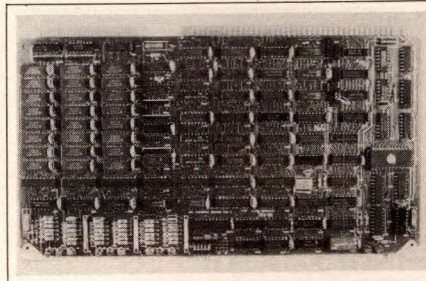
ule monitors voltage and current at each output and includes programmable overvoltage and overcurrent shutdown limits. An 8-bit A/D converter samples all eight readings every 160 μ sec. \$1260; readback option, \$590.

Carlton Industries Inc., 22661 Lambert St, Unit 207, El Toro, CA 92630. Phone (714) 770-7846.

Circle No 405

GRAPHICS BOARD

Multibus computer systems can use the RG-12C RGB color graphics board to display 512x240 pixels in any of eight colors on an RGB color monitor. The board provides both graphic and alphanumeric displays. Because the circuitry divides the onboard memory into four video display pages, you can store as many as four screen images at a time. The manufacturer claims that displays scroll smoothly. When you use the



board with a black-and-white monitor, you have a choice of eight shades of gray, or you can use three separate black-and-white display planes to drive three monitors. In addition, you can create one image from these three display planes. You control the board with a set of simple I/O commands. The board provides both a composite and a TTL video signal; it operates with either a 50- or 60-Hz synchronous frequency. \$695.

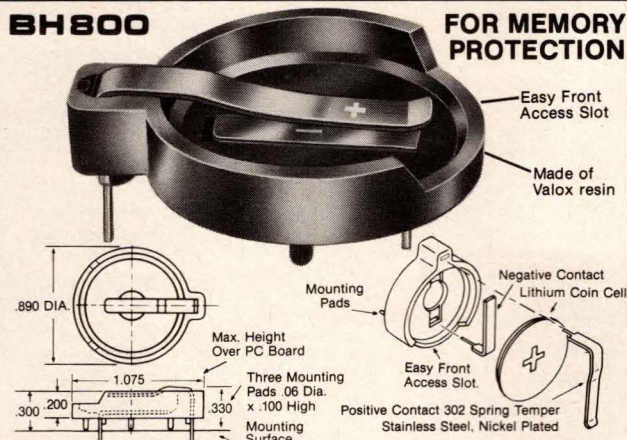
Raster Graphics Inc., Box 5157, Bend, OR 97708. Phone (503) 388-2584.

Circle No 406

NEW LITHIUM BATTERY HOLDER for 20mm coin cells

BH800

FOR MEMORY PROTECTION



Now you can permanently solder MPD's new coin battery holder right on your PC board. Lithium coin cells for reliable memory back-up systems clip right in...

- Model BH800 fits all 3-volt coin-type cells 20mm x 3.2mm
- Unique molded in beveled edge assures proper polarity
- Cell cannot make contact if upside down
- Easy insertion and removal of cells
- Low profile for high density packaging

Patent 4,487,820

For details of complete line call or write. Custom holders available.



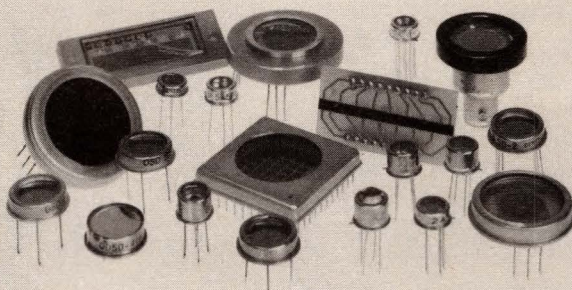
® VALOX is a Registered Trademark of the General Electric Company

Memory Protection Devices Inc.

320 Broad Hollow Road, Farmingdale, N.Y. 11735 • (516) 454-0340

ELECTRO-OPTIC COMPONENTS

Affordable High Reliability... From Stock or Custom Engineered To Your Exacting Requirement



Centronic has built its international reputation on a combination of engineering expertise, cost effectiveness and reliability. From custom applications to off the shelf **silicon photodiodes**, our commitment to excellence is reflected in everything we do.

Call Us For Engineering Assistance or Confirmation...
(201) 233-7200

"Engineering Makes The Difference"

CENTRONIC, INC.
1101 Bristol Road
Mountainside, N.J. 07092

CENTRONIC

THE COMPLIANCE REPORT—FCC/VDE/ESD

FCC special task force goes to work and seizes over 2,700 pieces of electronic equipment, mostly those regulated under Part 15 of its FCC Rules, in a sweep coordinated with the U.S. Customs Office. In addition to the equipment seizure, one man was arrested and arraigned before the U.S. Magistrate in the Eastern District Court of New York. If convicted, he will face up to five years of imprisonment.

A new special branch of the Commission announced that it had found a number of *cordless telephone* manufacturers to be out of compliance with Part 15, and sanctioned many in that industry, as well. (Part 15 prescribes mandatory emissions compliance for such devices as industrial and personal computers, peripherals, radios and televisions.) The newly organized branch dedicates its entire activities to spotting violators in the field and responding to complaints from competitors that others in their industry are not in compliance. According to sources close to the Commission, a special target will be those devices "verified" by the manufacturer as complying.

The East Coast's largest independent consulting firm, Dash, Straus & Goodhue, announced a new program to ease the chore of FCC compliance with either Part 15 or Part 68. Under the program, manufacturers can call in for a "guaranteed rate/guaranteed date" plan for having their equipment tested for compliance. And if the equipment does not comply, engineers at DS&G have a lengthy track record of quickly saving failing units with inexpensive fixes. DS&G's stamp of verification has been recognized by government authorities around the world.

If an application must be made with regulatory authorities, DS&G's in-house legal staff, which includes telecommunications attorneys, will prepare all the paperwork. Should the FCC call, DS&G will be there to give the Commission answers to any questions they may have concerning the product's compliance. The same program is now applicable to meeting the more stringent European mandatory EMI regulations.

VDE regulations reissued. Under West Germany's "Hfrg" Law, all devices which produce any radio noise between 10 KHz and 3000 GHz must have a permit to be sold in West Germany. Sanctions for failure to comply, which can be triggered by a competitor's complaint, include fines, seizures, recalls and injunctions. But under a new *revision of the law*, certain select, properly equipped U.S. test facilities can issue that permit. (Formerly, VDE engineers had to do the testing themselves for permits to be issued.) Facilities such as Dash, Straus & Goodhue, recognized by certain German-based authorities, have already begun issuing the rights to use the new general permits.

Said one Fortune 500 company executive, "This has eased the burden of selling in Europe tremendously." Compliance with West German law implies *de facto* compliance with the laws of most Western European nations.

Citizens' action group ask for sanctions against telephone interconnect makers. A Washington-based citizens' action group has filed with the Federal Trade Commission and the Federal Communications Commission against several cordless telephone, modem and telephone answering machine manufacturers, alleging they have falsely advertised their equipment as having FCC approvals which the devices did not have. The complaints are currently pending before the Commission.

Lamented one industry executive, "The regulations are so complicated; we intended to comply, but we have difficulty keeping track of all the changes." Complaints have also been filed with the State of California, which has separate regulations over telephone interconnect equipment.

An information clearing house has been set up by Dash, Straus & Goodhue to provide the information on VDE, FCC Part 15 and Part 68 rule changes. Persons needing information on the latest changes in these complicated regulations can contact the company at 617-263-2662.

Part 68 test workstations have never been previously available in the market, according to Compliance Design Incorporated of Boxborough, MA (617-264-4668). Rather, manufacturers and test houses have had to jury-rig the necessary facilities. Now, in one compact workstation, all the equipment is available from a single source. The workstation has been filed with the Federal Communications Commission and, according to the company, will soon be filed with Canada's Department of Communication, as well.

ANSI's open area test site committee continues its work, and according to sources close to the Committee, the group, which is setting standards for how EMI test sites would be constructed, is reaching a consensus position that will soon be voted on by ANSI. This influential document will feature the use of a "Standard Site Method," ideal curves for both broadband and dipole antennas, and a "Reference Antenna Method" based on the nearly lossless antenna known as the Roberts Antenna,TM developed by Willmar Roberts while he was Assistant Director of the FCC's lab in Laurel, Maryland. The Roberts Antenna is currently available from Compliance Design Incorporated of Boxborough, MA.

DASH, STRAUS & GOODHUE, INC.
593 Massachusetts Avenue
Boxborough, MA 01719
617-263-2662

For information on DASH, STRAUS & GOODHUE, INC.
circle number 85

For information on Compliance Design Incorporated
circle number 196

An 8031 Emulator that works with your IBM PC® with 16,000 hardware breakpoints for under \$1,500!

Impossible, you say?

Not for MetaLink.™

Now the design tool needed by all design engineers — but affordable by few — is within reach of everybody's pocketbook. Really. And \$1,500 is not a misprint.

Our MetaICE-31™ in-circuit-emulator for the widely used 8031 single chip micro-computer with your host IBM PC® provides complete real time, transparent emulation up to the maximum 12MHz operating frequency of the chip. With a powerful, flexible breakpoint mechanism including 16,000 hardware breakpoints.

MetaLink has emulators for the 8032 and 8344, too. But we don't want to stretch our credibility. If you can't believe what you read, maybe you'll believe what you hear. Call toll free 1-800-METAICE and talk to the engineers who designed them. They'll make a believer out of you.



MetaLink™
Corporation

33 W. Boxelder Place, Suite 110
Chandler, AZ 85224
(602) 926-0797 Telex: 4998050 MTLNK

IBM PC® is a registered trademark of International Business Machines Corporation

NEW PRODUCTS: INSTRUMENTATION & POWER SOURCES



LOAD MODULE

The D410 power-supply test instrument provides four individually programmable, isolated load channels with ratings as high as 50V at 10A. Each of the 0 to 10A, 2 to 50V loads can operate either manually or automatically with the manufacturer's test modules. In the manual mode, each channel has a constant-current range of 0 to 10A, $\pm 0.5\%$, and a slew rate of $1A/\mu\text{sec}$. In the automatic mode, accuracy is $\pm 0.5\%$ with 12-bit resolution, stable to within 0.1% over a temperature range of 15 to 35°C. The 4-load cabinet is 16.5 in. wide, 8.75 in. high, and 10.375 in. deep. It weighs 15 lbs. \$2500.

Datapower Inc., Dept QTS, 3328 W First St, Santa Ana, CA 92703. Phone (714) 775-2000.

Circle No 407

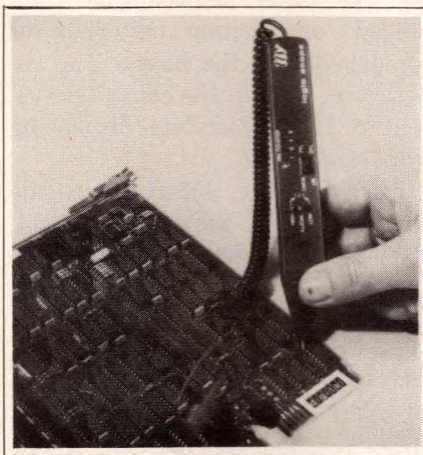
TEST SYSTEM

The PC1000 test and measurement system, which runs on an IBM PC, PC/XT, PC/AT, or bus, consists of as many as seven instruments in an expansion chassis. You can connect two chassis to the PC, thus yielding 14 instruments. The system features menu- or command-driven software. A semiautomatic mode allows you to run test sequences recalled from the PC's disk. The instrument modules include a $4\frac{1}{2}$ -digit autoranging multimeter, a 10- to 200-Hz low-distortion oscillator, a 0.01-Hz to 11-MHz function generator, a programmable 3-output power supply, a 125-MHz counter/timer, a 16-channel multiplexer pod, and an IEEE-488 interface.

Chassis \$1280, modules \$350 to \$950.

Vistar Corp., 13740 McCormick Dr, Tampa, FL 33624. Phone (800) 237-8812; in FL, (813) 855-6611. TLX 522434.

Circle No 408



LOGIC PROBE

The Logicscope handheld logic probe measures 10-nsec pulses at frequencies as fast as 45 MHz. Because the probe has eight LEDs with 3-color coding, it can indicate as many as 13 logic stages. For example, one LED clearly differentiates pulse trains from interference spikes. A binary counter with memory distinguishes between a pulse train and single pulses and indicates the results on four LEDs. Input capacitance is ≤ 2 pF, and the unit tolerates an overload of as much as 300V ac for five minutes. Test tips are replaceable. The company offers a 6-month warranty. \$85.

TEX Inc., Box 276, Martinsville, NJ 08836. Phone (201) 560-0588.

Circle No 409

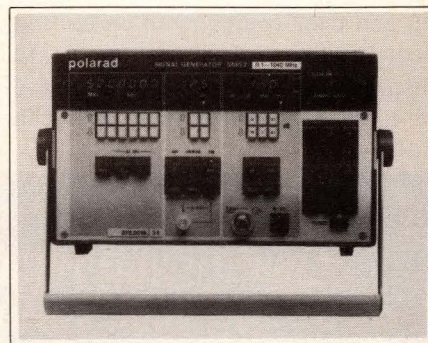
OSCILLOSCOPE

Model 9400 dual 125-MHz digital oscilloscope combines a 100M-sample/sec acquisition rate with 8-bit A/D converters and two 32k-word acquisition memories. It has an interleaved sampling rate of 12.5G samples/sec. You can control front-panel settings, display organization, and waveform processing with an

RS-232C port or an IEEE-488 interface. A 5x7-in. display shows internal status, measurement results, and software menus. A built-in plotter driver allows a hardcopy of the display. Capabilities include pretriggering and posttriggering, sequence and roll modes as well as standard triggering modes. The cursor allows you to measure voltage, time, and frequency of input and processed waveforms. You can store and recall as many as eight control settings manually or under external control. \$14,900.

LeCroy Research Systems Corp., 700 S Main St, Spring Valley, NY 10977. Phone (914) 425-2000. TWX 710-577-2832.

Circle No 410

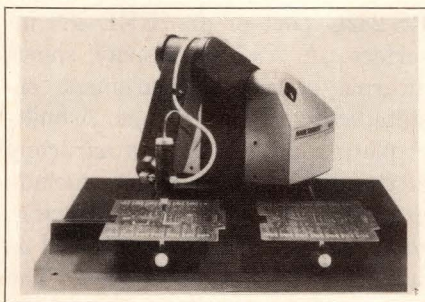


SIGNAL GENERATORS

Model SMS2 offers RF measurements within the range of 100 kHz to 520 MHz; option B2 extends the range to 1040 MHz. The generator has a 100-Hz frequency resolution. On AM/FM, the same features obtain a resolution of 0.05% (or 0.05 kHz). Spurious deviation is 3 Hz (CCITT weighting) or 15 Hz (30 Hz to 20 kHz). Phase noise is typically less than -125 dBc/Hz at a 20-kHz distance from the carrier and -145 dBc/Hz at 1 MHz. You can select channel-step sizes. Settling time is <40 msec. The built-in memory permits storage and recall of 40 settings for frequency, modulation, and output-signal level. \$7750.

Polarad Electronics Inc., 5 Delaware Dr, Lake Success, NY 11042. Phone (516) 328-1100.

Circle No 411



ROBOTIC DISPENSER

With the Alpha II robotic dispensing system, users can automate such electronic pc-board manufacturing tasks as solder masking and masking prior to conformal coating, as well as the dispensing of such materials as thermal grease, silicones, RTV, solder paste, adhesives, lubricants, and potting compounds. You program the robot arm with a joystick. The arm can move up and over components on stuffed boards and can tilt its needle to dispense material around the base of components. The robot also can

dispense materials onto large parts and assemblies that may require dispensing envelopes as large as 24×48×18 in. Featuring 5-axis movement, the robotic arm's controls include a mechanical gripper and two additional outputs for controlling conveyors, rotary index tables, or other devices that load, unload, or position materials or components on the board. The robotic arm without the computer system, \$21,825; complete dispensing system, \$24,950.

Microbot Inc., 453-H Ravendale Dr, Mountain View, CA 94043. Phone (415) 968-8911. TLX 4992310.

Circle No 412

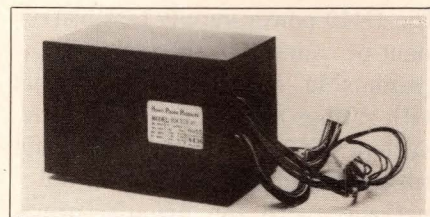
MULTICOUNTER

The WD-757 universal counter measures frequencies, periods, totals, ratios, and time intervals. It furnishes ±0.003% accuracy and ±0.002% stability. The unit also fea-

tures three signal inputs and a switchable attenuator to reduce signals to 1/10 of their original value. A 10-MHz switchable lowpass filter passes or rejects signals below 10 MHz. \$479.

VIZ Test Equipment, 335 E Price St, Philadelphia, PA 19144. Phone (215) 844-2626. TWX 710-670-2626.

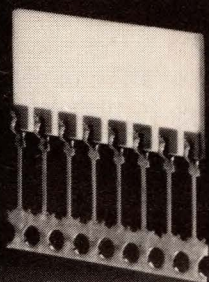
Circle No 413



PC POWER SUPPLY

Model HSC 130-40 is a 130W, 4-output power supply compatible with the IBM PC/XT. Typical ratings (fan-cooled) are 5V at 10A, 12V at 4.2A, -5V at 0.3A, and -12V at

**Quality and reliability
made Die-Tech's lead frames
the standard in the industry.**



Die-Tech's lead frames offer you superior quality, flexibility and savings in lead frame costs. A wide variety of lead frames including both SIPS and DIPS are available.

Increase your productivity. Die-Tech makes the most advanced fully automated equipment for high speed production to attach lead frames to substrates.

Find out why Die-Tech's lead frames are the standard in the industry. Write or call: Die-Tech, Inc., R.D. #1, Sipe Road, Box 518A, York Haven, PA 17370, (717) 938-6771

die-tech

Engineered productivity.

CIRCLE NO 114

DID YOU KNOW

EDN publishes two Technical Article Databases per year that list the feature articles published in the preceding 12 months in five of the leading electronic engineering publications.

EDN



A BATTERY SHOULD BE DESIGNED TO MATCH YOUR SPECIFICATIONS. NOT VICE VERSA.

Has this ever happened to you?

Your specs and their battery complement each other about as well as the proverbial square peg in a round hole.

And oddly enough, when that happens, you're the one that gets sent back to the drawing board. Not them.

After laboring months, or even years on specifications, you're forced to compromise for want of a power system.

Well, that won't happen if you bring your project to Saft first. We're a leading manufacturer of all types of high technology electro-chemical energy systems: Nicad®, Lithium, Gelyte, and Lead Acid just to name a few.

In fact, we're the ultimate power source. Unlike many of our competitors we give you choices. Not excuses, or whatever happens to be on the shelf.

Add to those choices our expertise and innovative design capabilities, and you'll discover we can solve many of your energy problems.

You'll find Saft batteries virtually everywhere: in computers, aviation, military, medical, home appliances, and even in aerospace.

Ours is the original equipment battery on the Boeing 757 and 767 jumbo jets, the most advanced aircraft in the sky today.

You'll find a Saft battery safeguarding the electronic memory in portable drug pumps, the latest medical breakthrough in the control of diabetes.

We're even considered a pioneer in rechargeable batteries used in video cassette recorders, stereos, photoflash equipment and mobile transceivers. Batteries that can be recharged up to 1,000 times.

If your project requires a high technology electro-chemical energy system, talk to a specialist at Saft first.

We'll give you a battery that's custom fit to your specifications. Not ours.

For more information, contact SAFT America Inc., 711 Industrial Blvd., Valdosta, GA 31601 or call (912) 247-2331.



SAFT

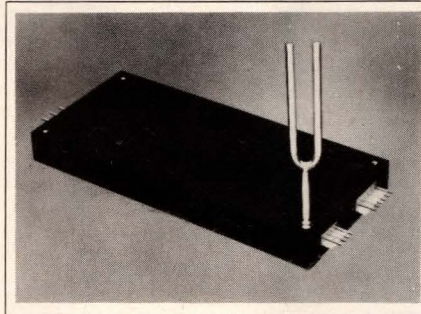
MORE POWER TO YOU.

CIRCLE NO 116

0.25A. Overload is set at 165W. The unit has two EMI line filters, is UL listed, and meets VDE 0806. Two ac receptacles are available for external peripherals. \$177.50.

Hughes Power Products Inc., 709 N Memorial Parkway, Station F, Huntsville, AL 35801. Phone (205) 534-0078.

Circle No 414



SMALL SWITCHER

The P100 Model, also identified as the Falcon, is one of a series of off-line switchers that incorporates a design that provides a power density of 5W/in³ within a 0.8-in.-high package. According to the manufacturer, this power density represents a threefold improvement over conventional open-frame supplies. The switcher is rated to 100W with outputs of 5, 12, -12, and -5V. Input is 110/220V. All heat-dissipating elements are thermally linked to a common baseplate to facilitate cooling by air flow, heat sinking, or normal convection. The device features 2% regulation, soft-start, autosequencing, short-circuit protection, and RFI filtering. \$126 (1000). Delivery, 10 to 12 wks ARO.

Theta-J Corp., 8 Corporate Pl, 107 Audubon Rd, Wakefield, MA 01880. Phone (617) 246-4000.

Circle No 415

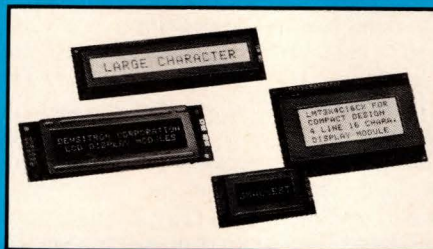
DENSITRON has the LCD module you need!

CHAR. FORMAT	5x7 CHAR. SIZE (mm)	CHAR. FORMAT	5x7 CHAR. SIZE (mm)	GRAPHIC TYPE
1x8	4.55	2x24	8.44	32x120
1x16	5.50	2x40	4.55	64x120
1x16	5.73	2x40	12.71	64x240
1x16	7.95	2x80	3.31	64x320
1x16	12.71	3x40	3.52	64x480
1x20	3.80	4x16	4.15	128x128
1x20	12.71	4x20	5.55	128x256
1x24	5.50	4x20	12.71	128x480
1x24	12.71	4x40	4.85	200x640
1x40	5.50	4x40	12.71	
1x40	12.71	4x80	4.15	
1x80	3.31	8x20	3.66	
2x8	3.80	8x40	3.66	
2x16	4.55	8x80	3.45	
2x16	8.44	16x20	3.09	
2x20	4.85	16x40	3.31	
2x20	8.44	16x80	3.31	
2x20	12.71	25x80	3.10	
2x24	4.55	25x80	5.35	

■ **NEW LIGHTED DOT VERSION WITH DARK BACKGROUND (LOOKS LIKE VFD)**

■ NEW .5" CHAR. TYPES

- INTEGRAL E-L BACKLIGHTING
- OPERATING TEMP.: -20° to +70°C
- STORAGE TEMP.: -40° to +90°C
- WIDE VIEWING ANGLE-TOP OR BOTTOM
- BUILT-IN CMOS CONTROLLER (RAM/ROM)
- Take advantage of our engineering support and comprehensive application note documentation.



DATA-LINE MONITOR

The battery-powered, handheld Network Probe (Model 6620A) diagnoses problems in computer systems, data-communications networks, and peripherals. It incorporates the functions of a data-line monitor; a protocol analyzer; a programmable emulator; a bit/block error-rate tester; a digital meter that measures volts, ohms, and decibels; a speaker monitor; an RS-232C breakout status display; and a continuity tester. \$3495.

Network Communications Corp., 9600 W 76th St, Minneapolis, MN 55344. Phone (612) 944-8559.

Circle No 416

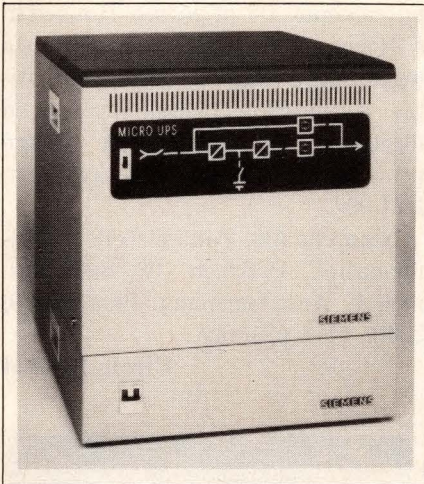


DENSITRON CORP.

America [CA]: (213) 618-9647

Europe [UK]: (0732) 455522

NEW PRODUCTS: INTERNATIONAL



UPSs

The Micro Series of uninterruptible power supplies includes units with power ratings of 0.5, 1.0, and 2.5 kVA. Controlled by a single on/off circuit breaker, the units feature automatic start-up and load connection after switch-on, and a mimic-diagram LED display to indicate the system status. A static bypass switch allows you to keep equipment on line while carrying out maintenance on the UPS. The units provide dc battery-charging current at 48V and therefore are compatible with standard telephone and telecommunications battery packs. Optional sealed lead-acid battery packs, which provide standby power for periods of 10 to 120 min, are available for mounting beneath the main unit. RF interference meets the requirements of BS800, and acoustic noise is below 50 dBA. From £1735.

Siemens Ltd, Windmill Rd, Sunbury-on-Thames, Middlesex TW16 7HS, UK. Phone (09327) 85691. TLX 8951091.

Circle No 417

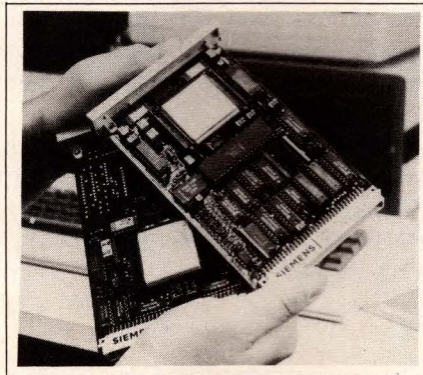
LINE FILTERS

The SUP-BR-E Series of pc-board-mountable line filters features current ratings of 2, 4, or 6A and meets UL, CSA, and VDE standards. RX732 filters, which are available in 1, 2, or 4A versions and have resin-sealed cases, also meet ASE re-

quirements. The filters operate over -25 to +85°C. Approximately £2.50 (1000). Delivery, 6 to 8 wks ARO.

Roxburgh Suppressors Ltd, Haywood Way, Ivyhouse Lane, Hastings, East Sussex TN35 4PL, UK. Phone (0424) 442160. TLX 957104.

Circle No 418



BUBBLE MEMORY

The PMS-S85B bubble-memory card for PMS μ C systems is expandable from 256k bytes to 1M byte of nonvolatile storage. Running under the CP/M-85 operating system, the memory is formatted to resemble a floppy disk. A 256k-byte version has 32 tracks, each with 64 sectors of 128 bytes/sector; expansion to 1M byte increases the number of tracks to 128. DM 8000.

Siemens AG, Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025.

Circle No 419

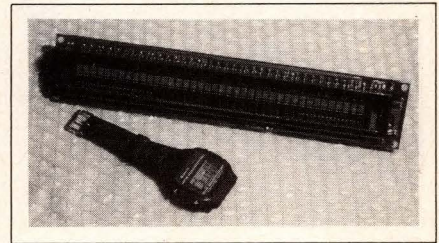
SPEECH PROCESSOR

Using the BA1701 variable-speech-control IC, you can maintain the intelligibility of recorded speech while replaying the recording as fast as 2.5 times the normal speed. Targeted at audio-cassette, dictation, and video-tape-recording equipment, the IC incorporates a PLL motor-speed controller to synchronize operation of the speech processor with the tape speed. The device also includes a unity-gain

buffer-amplifier, which typically introduces 0.2% THD. Supplied in a 14-pin DIP, the device operates from a 4 to 14V supply and requires 11-mA typ supply current. Approximately DM 10 (2000).

R-Ohm Electronics GmbH, Muhl-enstrasse 70, 4052 Korschenbroich 1, West Germany. Phone (02161) 61010. TLX 852330.

Circle No 420



DOT-MATRIX DISPLAY

Featuring 40 5-mm-high, 5×7-dot-matrix characters, the PVS35-05-40 vacuum-fluorescent display module has an onboard μ P to handle display multiplexing and interfacing. Its character generator produces a 96-character ASCII set, but you can download the module with 128 additional user-definable characters. You can program the display's brightness to one of eight levels; color filters can modify the color from blue/green to between orange/red and blue. The unit requires one 5V supply. Communication with the host system is via a serial or parallel TTL-level interface. £98.47 (100).

Pulseview Ltd, Unit 1 & 2, Suffolk Way, Drayton Rd, Abingdon, Oxfordshire OX14 5JY, UK. Phone (0235) 34909. TLX 83428.

Circle No 421

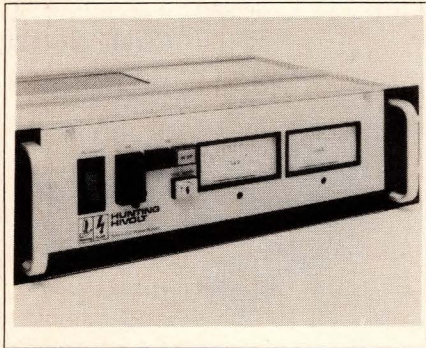
FORTH COMPUTER

The Forth Microcard runs with an RS-232C terminal and requires a development ROM for language development. In addition, this card has an autostart feature that lets you use it as the CPU in a computer system. The card runs an R65F12 μ P with an on-chip Forth kernel and includes two 28-pin, byte-wide

RAM/EPROM sockets. The processor's 40 I/O pins come on ribbon cable connectors. £119.

Essex Electronics Centre, University of Essex, Wivenhoe Park, Colchester CO4 3SQ, UK. Phone (0206) 865089. TLX 98440.

Circle No 422



POWER SUPPLIES

Utilizing switch-mode power-MOSFET techniques, the Series 250 high-voltage dc power supplies are able to deliver 250W. Various

models offer nominal outputs of 10, 16, 25, 30, 40, and 50 kV. They operate from a line input of 216 to 264V, 48 to 62 Hz, and have a line regulation ($\pm 10\%$ line change) of $\pm 0.02\%$ of nominal output. Zero to full-load output regulation is 0.05% of nominal output. The units are suitable for rack (19-in.) or bench mounting, and they operate over a range of 0 to 50°C, with an output TC of less than 200 ppm/°C. The supplies meet IEC348 Class 1 safety requirements and cost between \$1300 and \$2000.

Hunting Hivolt Ltd, Riverbank Works, Old Shoreham Rd, Shoreham-by-Sea, West Sussex BN4 5FL, UK. Phone (07917) 4511. TLX 87466.

Circle No 423

A/D CONVERTER

The SDA8010 IC performs an 8-bit A/D conversion in 10 nsec and dissi-

pates about 1W of power. Housed in a 24-pin ceramic DIP, the unit has a logic output that is ECL compatible. Applications include high-speed digitizing instrumentation, image processing, and medical systems. DM 994.

Siemens AG, Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025.

Circle No 424



SOLID-STATE RELAYS

Type A-BP and A-BM solid state, pc-board-mountable relays switch ac loads of 3A rms (60A single-cycle peak) at voltages between 24 and



New intelligent panel printers

- 16-24 column, \$435 single unit.
- μ P based. Plain paper. Dot matrix impact. Exclusive word wrap.
- Select double high/double wide (or both) printing.
- Inputs: RS-232-C/20mA, Centronics, or parallel BCD.
- Graphics and keypad data entry available.
- Optional 2K buffer, clock.
- Meets FCC RFI/EMI specs.

Request Bulletin 6600A.

513-254-6251

Digitec Corporation
918 Woodley Road, P.O. Box 458
Dayton, Ohio 45401-0458
Telex: 6874219-W.U.I.

Digitec

CIRCLE NO 118

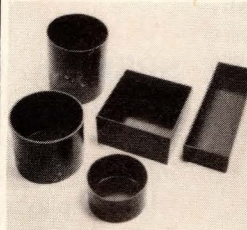


RYTON[®] ENCAPSULATING SHELLS

From The World's Largest Supplier

PLASMETEX INDUSTRIES, INC.

**Send Your Print Today
For A Prompt Quote**



- IN-HOUSE TOOLING
- FAST TURN AROUND
- HIGH VOLUME PRODUCTION
- CHOICE OF RYTON[®] OR DAP
- MEETS UL94-VO Specs

PLASMETEX INDUSTRIES INC.

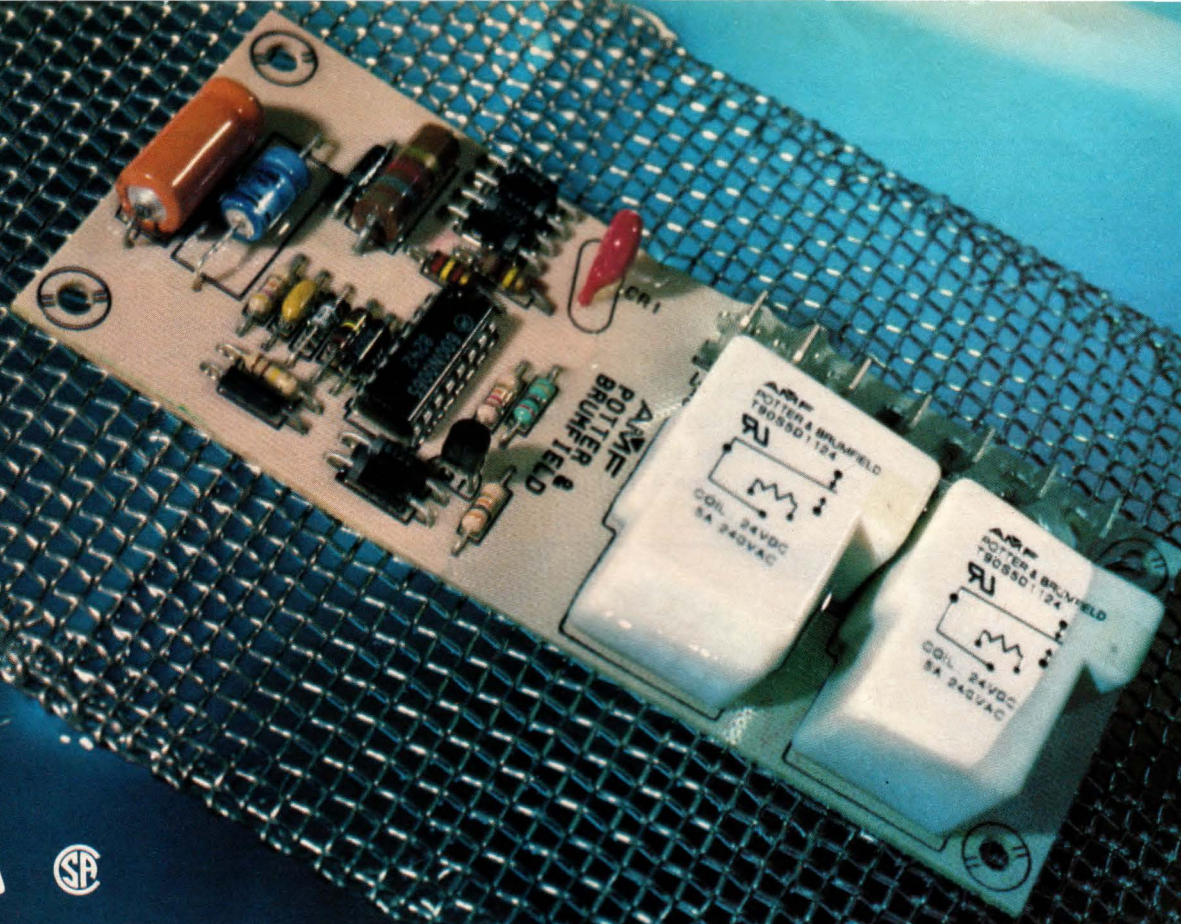
1425 Linda Vista Dr. San Marcos, CA 92069

619-744-8300 * TWX 910-322-1751

Injection, Compression & Transfer Molding

CIRCLE NO 119

EDN June 13, 1985



P&B's T90 relay available for immediate delivery from stock!!!

OEM orders to 100,000 pieces filled in four weeks.

Low cost...

Now you can design low cost power switching into your products with Potter & Brumfield's T90 relay.

Switches .5—30A...

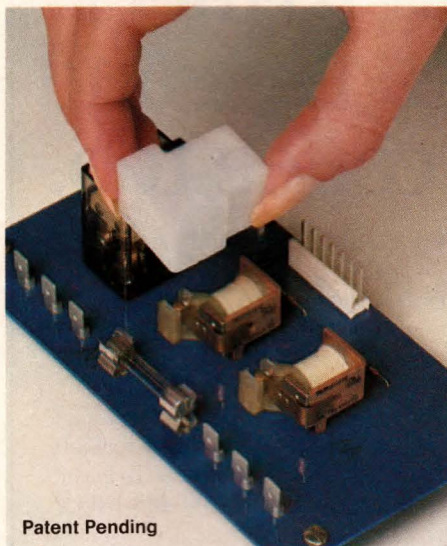
Its small size and low coil power requirement (less than 1W) make the T90 the ideal printed circuit board mounted interface between your solid state devices and power loads.

Open or sealed...

The T90 is available as an open-style relay, with an optional, snap-on dust cover or sealed to withstand immersion cleaning.

Meets your design needs...

The T90 series offers the combination of features you've demanded for new generations of appliances, load management controls, business machines, HVAC equipment and similar applications.



Patent Pending

Consistent quality...

Our totally automated production under tight process control assures you of consistent, high quality relays, minimizing your needs for incoming inspection.

CIRCLE NO 120

Find out more...

For more details on the T90, call our toll free number for the name of your authorized Potter & Brumfield distributor or your local P&B sales representative: 800/223-1416.

Potter & Brumfield Division AMF Incorporated, 200 Richland Creek Drive, Princeton, Indiana 47671.

Regional Sales: Oak Brook, IL, 312/887-0811; Braintree, MA, 617/848-6550; San Juan Capistrano, CA 714/493-4503; Norcross, GA, 404/449-4601.

International Sales: Guelph, Ontario, 519/822-1576, TELEX: 0695-6522; Bristol, England, (0272)716301; Yokohama, Japan, (045) 812-1418; Hong Kong, TELEX: 39555; Singapore, TELEX: RS34686; Chatswood, N.S.W. Australia, (02) 411-5222.

AMF

Potter & Brumfield

280V rms. They feature zero-voltage switching and require a minimum current of 5 mA to remain on. The devices have a maximum voltage of 1.6V rms when they are on and can withstand a minimum of 600V peak, with less than 1 mA of leakage current, when you switch them off. At switch off, their critical rate of change in voltage is 100V/

μsec. The relay's dc input control has a switching threshold between 1 and 3V and a switching delay of 10 msec maximum. The input is optically isolated with the output, which gives the relays 2.5 kV rms input/output isolation. The A-BP relay occupies 38×35.5 mm of board area and has an above-board height of 9.5 mm; type A-BM occupies 11×40 mm

of board area and specs an above-board height of 22.5 mm. Models for chassis mounting are also available with load current ratings of 10, 25, and 45A rms. A-BP, £3.45 (100); A-BM, £3.53 (100); versions for chassis mounting, £7.25 to £12.07 (100).

Allen-Bradley Electronics, Ennia House, High St, Edenbridge, Kent TN8 5LY, UK. Phone (0732) 866566. TLX 957293.

Circle No 425



How to meet your deadline and have your coffee too.

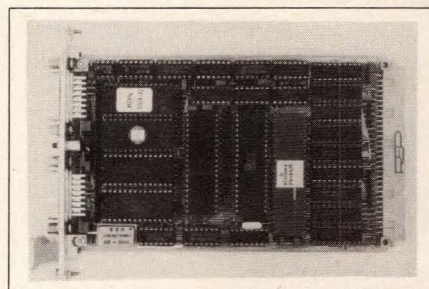
Find a converter, your boss says. Oh no you think, this could take hours or days with the design parameters he's specified. More precious time down the tubes. That's the way it is. *Unless* you have PARAMETRIX™ from INACOM International. Our Computer Aided Access helps you find integrated circuits by parameters in seconds. Frequently updated, PARAMETRIX provides a current source of comprehensive component information. And it's the only computerized parametric retrieval package that resides on your workstation. So you can concentrate on your real job ... *Designing*. And perhaps even have time to enjoy your coffee. To learn more about PARAMETRIX, the design time saver, call 1-800-443-INFO, 303/694-4200 (In Colorado) or drop us a line.

INACOM
International

INACOM International
4380 South Syracuse Street
Denver, Colorado 80237

COMPUTER AIDED ACCESS™
We go right to the source.

CIRCLE NO 121



CPU CARD

Containing a 68008 μP with speeds as fast as 16 MHz, the MPM68008 CPU card allows you to run 68000 code on 8-bit Euro-Bus systems or on the VME Bus. The board includes four 28-pin, byte-wide sockets. Three of the sockets accept either RAM or EPROM; the fourth one accepts only EPROM. The sockets accommodate devices with memories as large as 32k bytes. Using a PLA, you can program memory maps in the board's 1M-byte address range. The board also includes a 16-line parallel port with four control lines; two 16-bit programmable timers; and a serial I/O channel that you can configure for RS-232C, RS-422, HDLC, or SDLC protocols (any of which can be either asynchronous or synchronous) or for a fiber-optic link. \$330 (100).

PEP Elektronik Systeme GmbH, Am Klosterwald 4, 8950 Kaufbeuren, West Germany. Phone (08341) 8974. TLX 541233.

Circle No 426

PEP Modular Computers Inc., 600 N Bell Ave, Pittsburgh, PA 15106. Phone (412) 279-6661.

Circle No 451

Noise Solution.



Tokin EMC Products

Around the world, Tokin EMC products are solving a wide variety of EMI/EMC problems, backed by a long background of pioneering research and testing in this field.

That's why Tokin EMC products, besides meeting the EMC standards of the FCC and VDE, comply with the safety standards of the UL, CSA, TÜV, and VDE.

And why some of the world's most prestigious electronics companies turn to Tokin EMI/EMC filters and coils to achieve compliance with exceedingly strict standards.

So no matter what the problem or the product, Tokin's wide range of EMC products offers the noise solution you need.

Tohoku Metal Industries, Ltd.

Head Office: Hazama Bldg., 5-8, Nishicho, Kita-kyo, Minato-ku, Tokyo 107, Japan
Tel.: Tokyo (03) 402-6166; Telex: 02425695 TOKIN J; Cable Address: TOHOKUMETAL TOKYO

Tokin America Inc.

2251 Fortune Drive, San Jose, California 95131 U.S.A. Tel.: 408-946-4887

You can reach our agents by phone:

London (01) 837 2701; Paris (1) 534 7535; Milan (0331) 67 8058; Munich (089) 59 4621; Seoul (02) 777 5767;
Taipei (02) 731 1425; Hong Kong (3) 31 5769; Singapore 747 8668; Sydney (2) 922 7566

Tokin

Cahners Means Business

In Electronics & Computers



The electronics and computer market has doubled in size since 1978. And it will double again by 1987. It takes a lot of circulation to reach all of the important buying influences in this very complex, fast-growing market. Cahners publishes eight magazines in the electronics and computer fields. These magazines have a combined circulation of over 650,000. Each magazine serves a well-defined, important segment of the electronics and computer market, and is recognized as a prime source of information on the technology and products in its field. Last year we sent out over 3.4 million sales leads from our readers to advertisers in our electronics and computer magazines. Cahners means business. That's why we're the first choice of American business in magazines for electronics and computers.

Cahners Publishing

33 Specialized Business Magazines for Building & Construction, Electronics & Computers, Foodservice, Manufacturing, and Health Care.



NEW PRODUCTS: SOFTWARE

WORD PROCESSOR

A replacement for the copy-protected V 5.2, the unprotected Zardax V 6.0 permits user backup and program installation on most hard-disk drives running under DOS 3.3. The word processor features mail merge, a glossary of frequently used phrases, on-screen preview of printer output, printer spooling, and a cut-and-paste function. According to the company, its Utilities V 2.0 allows you to configure the program for use with various printer interface cards and with more than 50 different printers, including ink-jet and laser types. \$210; update for registered owners of Version 5.2, \$50.

Action-Research Northwest, 11442 Marine View Dr SW, Seattle, WA 98146. Phone (206) 241-1645.

Circle No 427

PC/AT FORTH

Polyforth II, a multitasking, multi-user operating system, has been adapted for use on the IBM PC/AT. (This software-development system is available for the IBM PC and PC/XT as well.) Features include fixed-point fractional math, disk partitioning, kernel reconfiguring, tone generator control, inter-segment memory-access operations, and a graphics package for the standard IBM PC color adapter board. The graphics package features line drawing with texturing, color selection, vector math, vectored drawing functions, and aspect ratio selection. It also contains X-Y graphing routines and a documentation program. You can choose from several levels. Level 3 includes the operating system, Forth turnkey compiler, assembler, editor, math library, database-support system, utilities, graphics, and source code for everything but the nucleus. Level 4 includes all of the above features plus complete system source code and the company's Target compiler, which is capable of generating ROMable applications or recom-

piling the operating system itself. Level 3, \$600; Level 4, \$3200.

Forth Inc, 2309 Pacific Coast Hwy, Hermosa Beach, CA 90254. Phone (213) 372-8493.

Circle No 428



TERMINAL EMULATOR

Tektronix terminal emulation, VT100 terminal emulation, and four error-correcting, file-transfer protocols are combined in the VTERM/4010 package. On an IBM PC, PC/XT, PC/AT, or PC-compatible system, the emulator runs host software written for a Tektronix 4010, including Tell-a-graph, Sasgraph, and Plot-10. It also features printer and plotter support, throughput to 9600 baud, disk capture of graphics and text, support for Microsoft's mouse, setup screens, on-line help, and automatic dialing. The software emulates a 132-column display with horizontal scrolling. The file-transfer system includes Kermit; to use Kermit, you must obtain host software available from Columbia University. \$249.

Coefficient Systems Corp, 611 Broadway, New York, NY 10012. Phone (212) 777-6707.

Circle No 429

UNIX COPROCESSOR

The Opus516 personal mainframe is a Unix/coprocessor subsystem designed to transform an IBM PC into a 32-bit Unix workstation. The subsystem consists of a 32-bit coprocessor and a complete port of Unix System V (release 2.0) for the IBM PC and plug-compatible computers.

You negotiate transfers between Unix and DOS via a keyboard command. Based on an NS32016 CPU, the subsystem includes the 32082 MMU and 32081 floating-point unit. Onboard memory is expandable to 2M bytes. Included with Unix System V and its utilities are C and Fortran-77 compilers, an assembler, and a debugger. A 1M-byte configuration, including a single-user object-code license, costs \$3140 (OEM qty); multiuser licensing is available as an option.

Opus Systems, 960 San Antonio Rd, Suite 120, Los Altos, CA 94022. Phone (415) 941-7201.

Circle No 430

LIBRARIES

The 8096 FPAC/DPAC floating-point libraries are sets of subroutines used to process floating-point numbers in the proposed IEEE single- and double-precision formats. The libraries come in optimized source assembly language. The 8096 PFAC/DPAC library performs basic single-precision operations at approximately 12k floating-point operations/sec on an 8096 with a 12-MHz crystal. Double-precision operations run at about 5k floating-point operations/sec. The FPAC/DPAC 8096 library performs basic arithmetic, trigonometric, and exponentiation functions, and data-conversion and floating-point-utility procedures. Maximum code space for the single-precision routines is <3300 bytes; the combined single- and double-precision routines require 8100 bytes max of code space. Routines for double-precision basic operations comprise 1800 bytes, while single-precision operations constitute approximately 1M bytes of code. Single-precision 8096 FPAC, \$750; double-precision 8096 DPAC, including 8096 FPAC, \$1250.

United States Software Corp, 5470 NW Innisbrook Pl, Portland, OR 97229. Phone (503) 645-5043. TLX 4993875.

Circle No 431

ADA PROCESSOR

The GDADL processor is written in C and runs on VAX/VMS and VAX/Unix, Gould/UTX, and the HP-9000 Series 500 systems. With the processor, you can describe your concept of a design using structured English and still take advantage of the full set of Ada features. Specifying your system first in structured English lets you understand your design before you implement it in your target code. You can keep the design and the implementation-language source code in the same file for processing by both the source-language compiler and the Ada processor. By analyzing the structured English code and any Ada declarations you have made, the processor produces reports that reflect the design during any stage of development. The processor also generates a design description that highlights the control structures inherent in the design as well as any

module invocations and abnormal exits that are expressed in design code. \$7500; demonstration version, \$100.

Computer Systems Design, 3627 Padua Ave, Claremont, CA 91711. Phone (714) 625-6147.

Circle No 432

CP/M COMMUNICATIONS

Uniform, version 3.0, allows CP/M μ C users to read and write to data diskettes directly from different CP/M μ Cs. In addition, users can use it to initialize or reformat program or data diskettes for those machines. The program's enhancements include expanded user prompts and compatibility with more than 80 μ Cs—more than twice as many as permitted by the previous version. The utility permits transfer of files between CP/M and PC-DOS, MS-DOS, and many TRS-DOS files. It also allows easy file

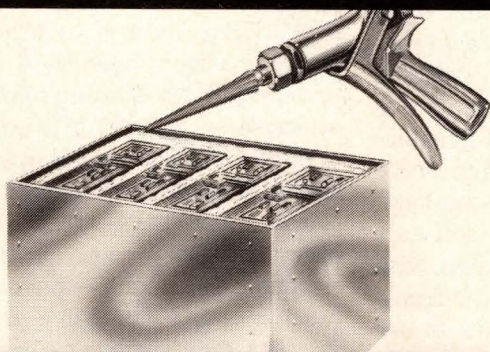
transfer of obsolete format CP/M diskettes to a format compatible with newer CP/M or MS-DOS machines. With the program, you can move any data file, including ASCII text, binary data, or program code, between CP/M and PC-DOS, MS-DOS, and compatible operating systems. \$69.95.

Micro Solutions Inc, 125 S Fourth St, DeKalb, IL 60115. Phone (815) 756-3411.

Circle No 433

REAL-TIME SOFTWARE

RTime is a software package for the company's Lambda family of Lisp machines that enables almost any Lisp program or expert system to perform real-time tasks, such as distributed process control. By implementing this program, the MC68010 coprocessor of the Lisp-based computer monitors and screens incoming information in real time. The



Thermally conductive silicone and epoxy encapsulants for critical electrical applications.

ECCOSIL® 4952 STYCAST® 2850FT

- High thermal conductivity
- Electrical insulation properties
- Resistant to chemicals, solvents
- Good heat transfer qualities

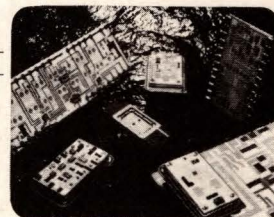
Call 1-800-TECHWAY for free product information

Emerson & Cuming, Inc.
Polymer & Electronic Materials
869 Washington Street
Canton, MA 02021

A GRACE Co
EMERSON & CUMING

Where there's a way.

We're
with you
through **thick & thin.**



thick film capabilities

Solder Reflow
Semiconductor Dice
Chip Capacitors
Ultrasonic Wire Bonding
Static Free Handling
Precision Trimming
Active Circuit Trimming
Epoxy Die Attach
Eutectic Die Attach
50 PPM/°C Resistors
30 PPM/°C Tracking
1/2 Ohm to 300 Meg-Ohms
>500 Volt Dielectric
Multilayer Interconnect

In-house circuit design capabilities ... DC-to-Light!

FOR ADDITIONAL INFORMATION ...

CALL TOLL-FREE: 800/628-3263

(NOTE: IN MASSACHUSETTS CALL COLLECT 617/686-6620)

thin film capabilities

Substrates:
(010" to .080" Thick and 4.2" Square)
Alumina (99 + % std)
Beryllia, Silicon, Quartz, Glass
Conductors:
TiW/Au
Cr/Au
Cr/Cu/Au
Au to specification

Resistors:
TaN = 40 - 100 ohms/square
TCR = ± 100 ppm ± 20 ppm
Tol = $\pm 10\%$ as deposited
 $\pm .05\%$ trimmed
Stability = .05%/1000 hrs @ 150°C max
TCR Tracking = 10 ppm/°C
Power
Dissipation = 150 watts/in²

Etching:
.001" lines typical with .0005" possible.
(Definition is substrate-surface dependent).
Alignment to .0001"

hybrid circuits

Networks: Precision R2R, ladders, etc.
Microwave ICs
YIG and SAW devices
Discrete Resistors
Chip Carriers and motherboards
High Frequency Amplifiers
Note: Combined thick/thin film capabilities may result in cost-effective solutions. Please inquire.

MATEC MICROELECTRONICS

530 TURNPIKE STREET ■ NORTH ANDOVER, MASS. 01845 ■ 617/686-6620
OTHER MATEC, INC. SUBSIDIARIES: Bergen Cable Technologies, Inc., Lodi, NJ
Valpey-Fisher, Frequency Control & Ultrasound Divisions, Hopkinton, MA
Matec Instruments, Inc., Warwick, RI ■ Alloy Surfaces, Inc., Wilmington, DE

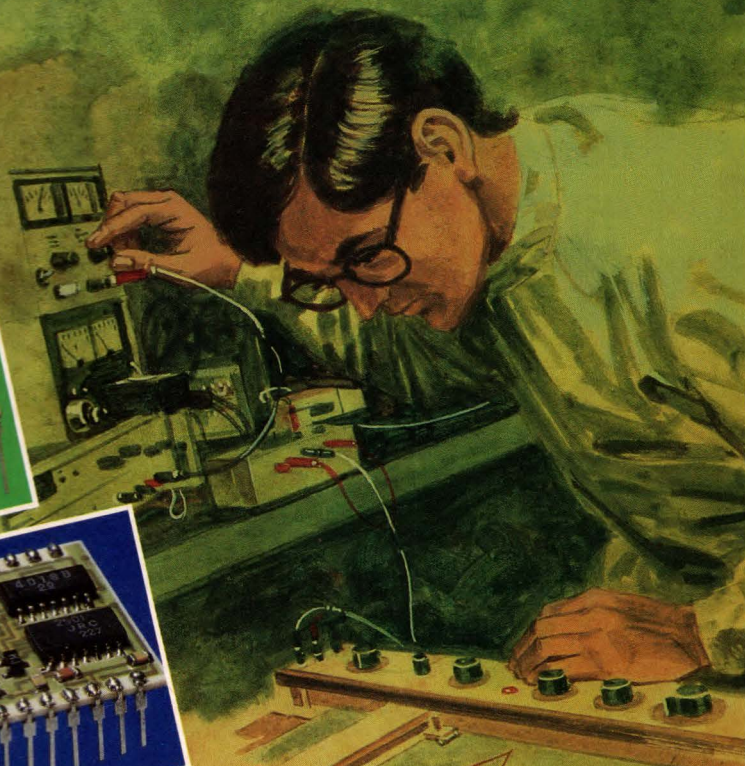
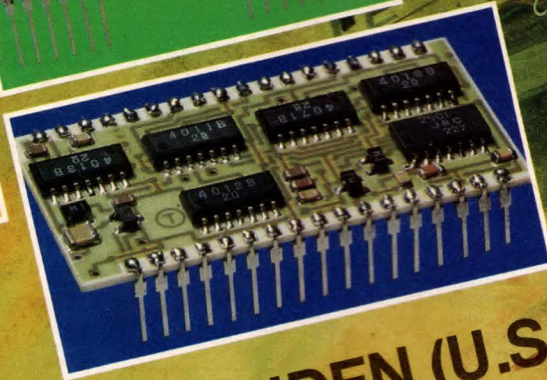
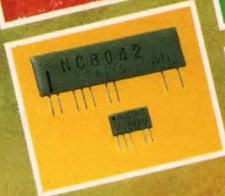
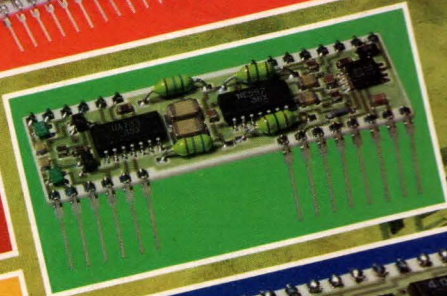
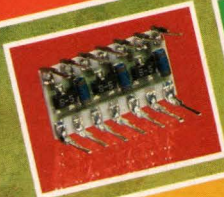
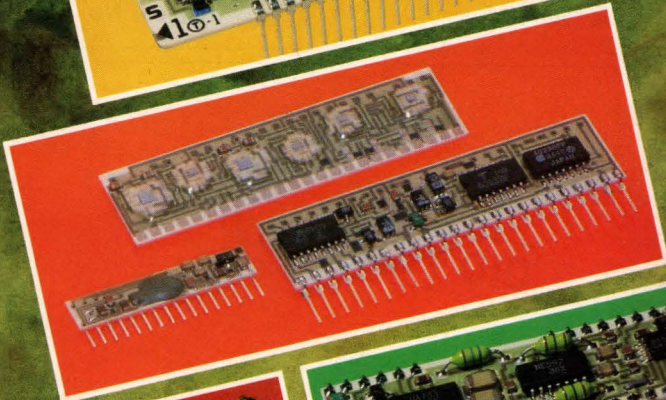
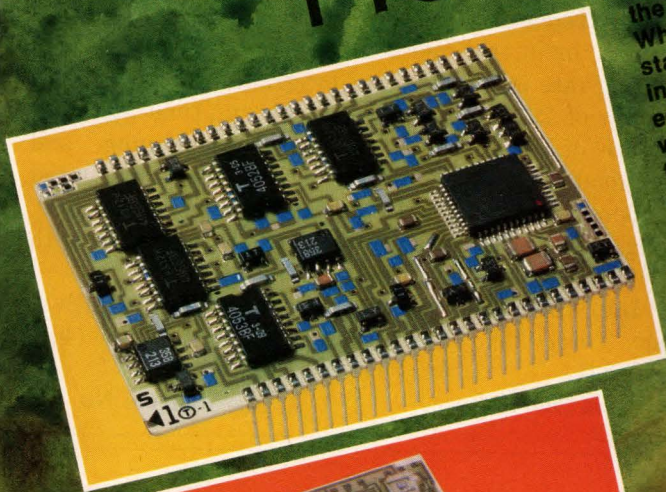
TELEX: 325987

CIRCLE NO 124

Hybrid Reliability Begins Here

Whether you're producing...computers...computer peripherals...telecommunications...medical equipment...terminals...office machines...or NC machine tools...Taiyo Yuden hybrid circuits are your best investment in reliability. **Why?** The reason is simple. In thick film hybrids, design, manufacturing and rigid testing is critical. Taiyo Yuden - **with almost 50 years in electronics** - is the international leader in hybrid circuit assembly. Whatever your requirements, our U.S.-based engineering staff will work with you to transform your hybrid design into a working product incorporating the latest in leading-edge technology, with the same high quality delivered the world over. And like the rest of our electronic components, they're available at very competitive prices. To find out more about Taiyo Yuden hybrids, write or call today:

TAIYO YUDEN (U.S.A.) INC.
714 West Algonquin Road
Arlington Heights, IL 60005
Tel: 1-312-364-6104
Telex: 910-687-0378 TAIYO U.S.A. ARHT



TAIYO YUDEN (U.S.A.) INC.
714 West Algonquin Road • Arlington Heights, IL 60005
Tel.: 1-312-364-6104 • Telex: 910-687-0378 TAIYO U.S.A. ARHT

package is written in C code. It operates in parallel with the Lisp processor and communicates with it via Streams (a Lisp-based serial interface) or by maintaining data values in arrays within shared memory. The software handles data acquisition, calculations, process-related algorithms, and low-level inferences or alerts. The Lisp processor can dynamically program this software either to monitor expected events or to focus on special areas of the process. \$20,000/license.

Lisp Machine Inc., 6033 W Century Blvd, Los Angeles, CA 90045. Phone (213) 642-1116. TLX 664608.

Circle No 434

VOICE MAIL

Soundtools allows developers to write voice-communications applications for an IBM PC. The package consists of a voice-communications card that fits in a half slot of an IBM

PC or PC compatible and a software program with documentation that includes the programming codes for developing applications. The following function calls are available: record a file, play a file, receive a Touchtone digit, and generate a Touchtone digit. The functions include fast forward, reverse, Touchtone abort, keyboard abort, and silence deletion. You can use the program with several languages, including C, assembly, and MS Basic A and Pascal. The software requires PC-DOS/MS-DOS 2.0, 2.1, or later versions. Speech sampling rate is 7 kHz; a compression ratio of 2:1 is achieved through the use of adaptive delta-pulse-code modulation. This ratio allows for approximately 1 hr of voice recording on a 10M-byte disk. \$449.

Digital Pathways Inc., 1060 E Meadow Circle, Palo Alto, CA 94303. Phone (415) 493-5544.

Circle No 435

SCREEN MANAGEMENT

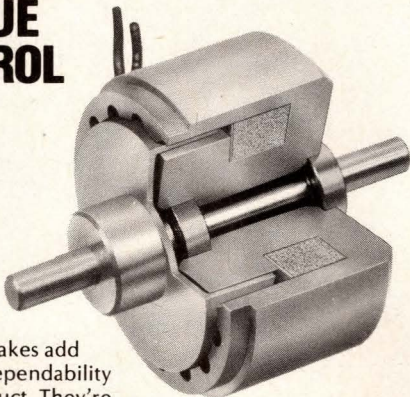
The XMenu/E information-display-management facility uses Rexx/Exec2 and other programming languages to create and display full-screen menus on display terminals. It supports all of the features of the 3270 family, as well as the 3180 and 3290, for creating menus as large as 256 rows×256 columns. Program function keys define 3270 fields with full control of attributes, including color and extended highlighting. You can assign alphanumeric names to fields for referencing by program. A Rexx/Exec interface allows run-time attribute changes, cursor positioning, and field-validity checking. \$1000, initial license fee and source code; \$2000, annual license fee thereafter with updated source code.

Kolinar Corp., 3064 Scott Blvd, Santa Clara, CA 95054. Phone (408) 980-9411. TLX 4998530.

Circle No 436

lowest cost, longest life

HYSTERESIS OEM TORQUE CONTROL



Hysteresis brakes add value and dependability to your product. They're smooth, clean, quiet. They're repeatable, precisely controllable, environmentally stable. They're virtually service-free over a long life, because their power absorption is frictionless. And now their cost is lower than ever. Our free handbook tells why you'll find them the unbeatable torque-control components, and describes OEM applications. Request it today.

see our catalog in
THOMCAT
or call us toll-free at
800-828-7844
(except New York State)



MAGTROL, INC.

70 GARDENVILLE PARKWAY WEST
BUFFALO, NEW YORK 14224 716-668-5555

DID YOU KNOW

In February 1985, EDN sponsored the first Automated Design and Engineering for Electronics Conference and Exposition; the second ADEE conference will be in Boston in October.

EDN



Heat sinks, accessories inventoried

This updated catalog contains 92 pages on the manufacturer's heat sinks and related accessories. Text, graphs, and dimensional drawings present information on stamped, extruded, clip-on, and slide-on heat sinks. New products described include a low-cost heat sink that provides bidirectional cooling for LCCs, a clip-on heat sink for 12-pin SIPs, and slide-on heat sinks for 8-pin DIPs. Five pages of the 3-hole-punched catalog are devoted to new extruded heat sinks. Request *Catalog 1100*.

Aavid Engineering Inc., Box 400, Laconia, NH 03247.

Circle No 437

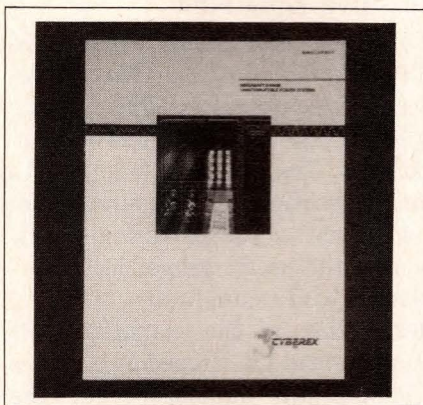
Interfacing a terminal with MIL-STD-1553 network

A 6-pg application note, *Designing a Remote Terminal to Talk with a MIL-STD-1553 Network*, discusses the interface that the BUS-65112 Superhybrid remote terminal provides to link a 1553B bus and the user's subsystem. The subsystem's interface comprises a 3-state, 16-bit parallel data bus, 12 address lines, DMA control lines, and status inputs and outputs. The brochure describes the remote terminal's design in detail as well as its built-in test and external clocking features. In

addition, the subsystem interface, error flags, and illegalizing mode codes are presented. Four figures and a table illustrate major points. A separate box defines the five functional blocks that constitute an MIL-STD-1553 LAN. Finally, five of the company's 1553 data bus products are illustrated and described.

ILC Data Device Corp., Marketing Dept, 105 Wilbur Pl, Bohemia, NY 11716.

Circle No 438



Primer explains UPSs

This 4-color brochure, designated Bulletin U-01302-3, explains how an uninterruptible power system can provide protection for a computer installation. It also describes the features for multimodule and single-module installations based on 350- and 426-kVA building blocks. The 12-pg primer details the firm's megawatt range of uninterruptible power systems, including descriptions of computer/overload fault protection, brownout protection, diagnostics, and space and cooling requirements. Figures and photos supplement the text.

Cyberex Inc., 7171 Industrial Park Blvd, Mentor, OH 44060.

Circle No 439

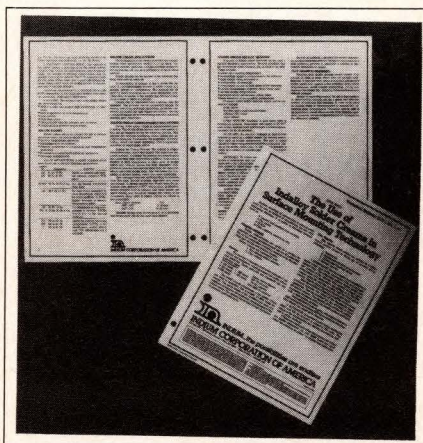
Compilation of switching regulator ICs

This data book contains 75 pages of summary technical information on the vendor's switching-regulator-IC products. Each entry includes prod-

uct features, applications information, absolute maximum ratings, system descriptions, and ordering information. In addition, the catalog reviews the fundamentals of pulse-width-modulated regulator circuits and presents several design and applications articles.

Exar Corp., Box 375, Sunnyvale, CA 94088.

Circle No 440



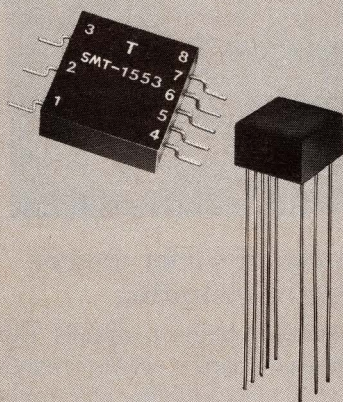
Learn use of solder creams for surface mounting

This technical bulletin details the use of the company's solder creams as a method of assembling electronic circuits with increasing densities. The data sheet describes how solder creams are formulated, what applications require which type of flux vehicle, characteristics of the available alloy compositions, and how the creams can be applied (screen printing, stenciling, or syringe). It also explains the curing process, which reduces spattering or solder balling, reflow methods, and flux removal. The bulletin suggests alloy combinations to satisfy surface-mounting applications found in printed flexible circuits and thick-film hybrid circuits. Other topics discussed include attaching chip components to the bottoms of pc boards prior to wave soldering and the use of alloys that help compensate for high TCE differences.

Indium Corp., Box 269, Utica, NY 13503.

Circle No 441

Mil-Std 1553 data bus couplers, interface transformers, absolutely to spec.



Just paying the price for 1553-rated components doesn't guarantee their ability to perform.

Test and compare. Technitrol 1553 data bus couplers and interface transformers comply with *all* Mil-Std 1553 requirements—not some, not most, not almost.

At Technitrol, you won't come away thinking you've bought what you haven't.

Investigate our prices and large selection, including flat-pack and surface-mount 1553 interface transformers.

Commercial models, too.

Technitrol, Inc.

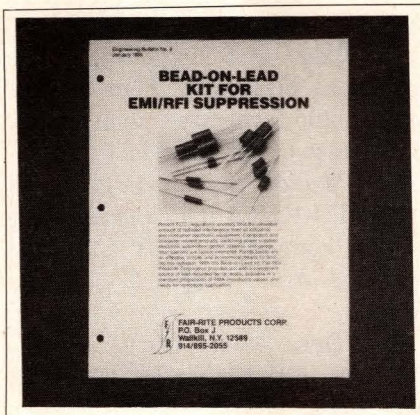
1952 E. Allegheny Avenue
Philadelphia, PA 19134 USA
(215) 426-9105 • Telex 834245

active and passive delay lines
• pulse transformers • Manchester encoder/decoders • data bus couplers
• pulse-width regulators • high-voltage, Scott T, and ferroresonant transformers

8152

CIRCLE NO 128

LITERATURE

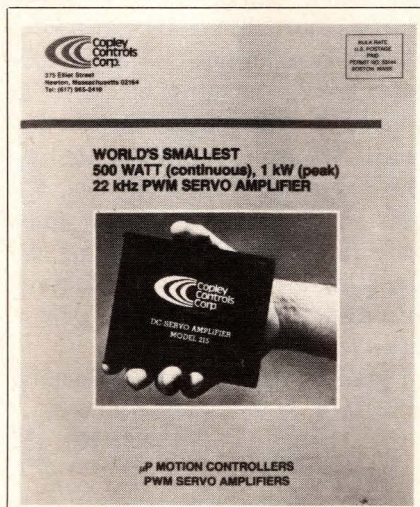


Use ferrites to solve EMI/RFI

This 4-pg data sheet (designated *Engineering Bulletin No 9*) describes a solution for reducing EMI/RFI through the use of ferrite components. The brochure begins with an explanation of the source of interference, continues with a discussion of the useful properties of ferrites, and concludes with a description of the manufacturer's bead-on-lead kit. Impedance values and physical dimensions for the beads in the kit are included. Seven figures supplement the text.

Fair-Rite Products Corp, Box J,
Wallkill, NY 12589.

Circle No 442



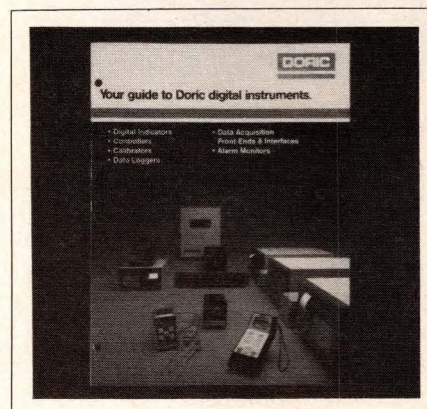
Specs for servo amps, digital controllers

This 2-color brochure details the manufacturer's line of servo amplifiers and digital controllers. Electrical and mechanical specifications are

presented for the 450 Series, which is an STD Bus-compatible servo I/O subsystem; Models 220 and 230, which are high-power, pulse-width modulation (PWM) dc amplifiers; and a small, modular series of PWM servo amplifiers. The catalog also presents product features, functional diagrams, drawings of outline dimensions, and ordering guides.

Copley Controls Corp, 375 Elliot
St, Newton, MA 02164.

Circle No 443



Catalog depicts digital instruments

This catalog covers the manufacturer's line of digital indicators, controllers, calibration instruments, data loggers, data-acquisition front ends and interfaces, and alarm monitors. Specification tables provide information on input types, packaging, power requirements, and measurement ranges. The 20-pg brochure also highlights product applications. It comes 3-hole punched for loose-leaf filing.

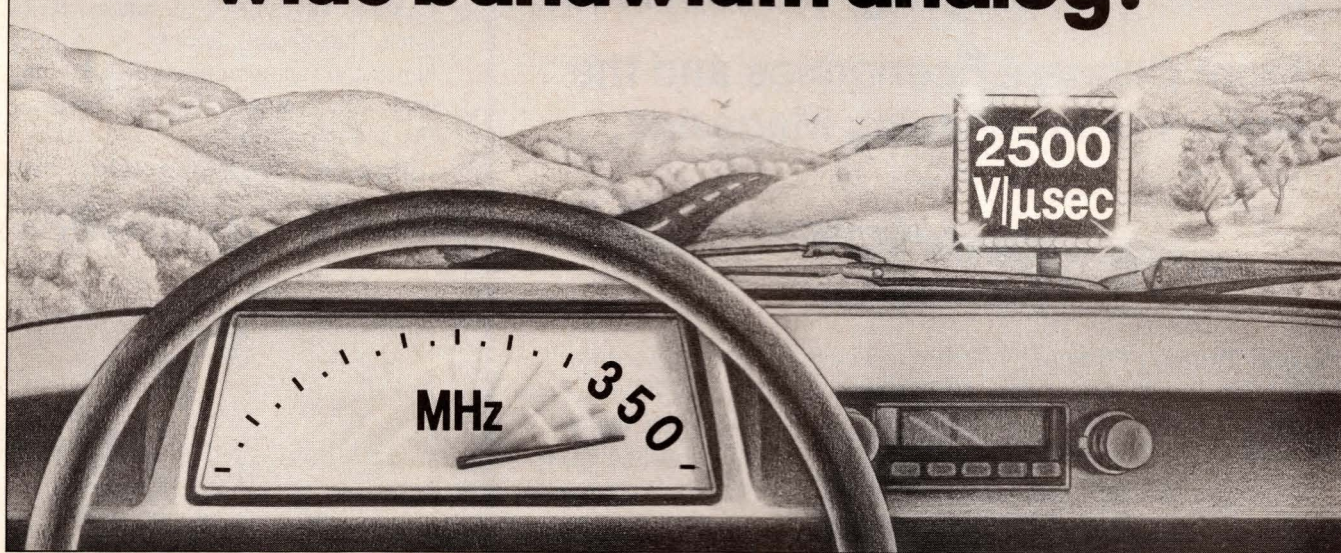
Doric Scientific Div, Rosemount
Inc, 3883 Ruffin Rd, San Diego, CA
92123.

Circle No 444

Bibliography targets computer books

The 18th *Annual Bibliography of Computer-Oriented Books* lists more than 300 new publications. Although all introductory-type books published prior to 1982 have been deleted, the bibliography still contains over 1250 books from 155 pub-

Designing high speed, wide bandwidth analog?



Compare the New 350 MHz EL2004 buffer/amplifier to whatever you're using now.



Pin for pin compatible with the LH0033. But, it'll knock the pins off an 0033. In fact, the EL2004 gives you 1.6 X the slew rate and 3.5 X the bandwidth of the 0033. It's a 350 MHz, 2500 V/μsec Buffer/Line Driver that's ideal for coax cable drivers, high speed video buffers, buffers for fast DAC's and A/D converters, sample and holds, impedance transformers... you name it. If high speed and wide bandwidth are your parameters, the EL2004 is your part.

Are we mad at the 0033? Nope. We make 'em. Along with a lot of other high-performance analog IC's: Wide bandwidth, high slew rate op amps; high speed buffers; high current output op amps. And more. As a matter of fact, we're totally dedicated to the analog world. With superior quality industrial and MIL STD-883 Rev. C products.

Compare for yourself. If bandwidth and slew rate are critical in your application, here are a few comparisons:

Device	Bandwidth	Slew Rate
LH0033	100 MHz	1500 V/μsec
3553	300 MHz	2000 V/μsec
HOS-100	125 MHz	1500 V/μsec
EL2004	350 MHz	2500 V/μsec

(If better D.C. performance than the LH0033 is your hot button, check out our new EL2005)

Availability? Off-the-shelf. From our stocking distributors listed below. But you won't have to buy your first EL2004. We'll give it to you. Free. Along with a detailed data sheet.

A free EL2004. It's as close as your telephone. Just call us: **TOLL FREE 1-800-821-7429.** We'll have your EL2004 on the way. With élan.

EL2004 • EL2005 • EL2007 • eLH0002 • eLH0021 • eLH0032 • eLH0033 • eLH0041 • eLH0101

Elantec Stocking Distributors. Worldwide.

AL HUNTSVILLE HAMMOND ELECTRONICS
AZ PHOENIX WYLE
CA IRVINE WYLE
CA LOS ANGELES WYLE
CA SACRAMENTO WYLE
CA SAN DIEGO WYLE
CA SANTA CLARA WYLE
CO DENVER WYLE
CT NEW HAVEN MILGRAY ELECTRONICS
FL FT. LAUDERDALE HAMMOND ELECTRONICS
FL ORLANDO HAMMOND ELECTRONICS
GA ATLANTA MILGRAY ELECTRONICS
GA ATLANTA HAMMOND ELECTRONICS
IL CHICAGO RM ELECTRONICS
MD BALTIMORE MILGRAY ELECTRONICS
MA BOSTON GERBER ELECTRONICS
MI DETROIT REPRON

MN MINNEAPOLIS
MO KANSAS CITY
NJ CHERRYHILL
NY FARMINGDALE
NY FARMINGDALE
NY FISHKILL
NY ROCHESTER
NC GREENSBORO
OH CLEVELAND
OH COLUMBUS
OR PORTLAND
SC GREENVILLE
TN KNOXVILLE
TX AUSTIN
TX DALLAS
UT SALT LAKE CITY
WA SEATTLE
WI MILWAUKEE

A.C.T. MILGRAY ELECTRONICS
MILGRAY ELECTRONICS
MILGRAY ELECTRONICS
NU HORIZONS ELECTRONICS
INTERCEPT ELECTRONICS
MILGRAY ELECTRONICS
HAMMOND ELECTRONICS
MILGRAY ELECTRONICS
REPRON
WYLE
HAMMOND ELECTRONICS
HAMMOND ELECTRONICS
WYLE
WYLE
WYLE
WYLE
RM ELECTRONICS

MINORITY DISTRIBUTOR—INTERCEPT: EASTERN AND MIDWEST STATES
FRANCE TEKELEC-AIRTRONIC 1-534-75-35
ISRAEL VECTRONICS LTD. 0525-56070
ITALY MURATA ERIE 02-607-37-86
JAPAN INTERNIX, INC. 81-336-91101
SWEDEN SVENSK TELEIMPORT AB 08-890265
SWITZERLAND LASER- & ELECTRONIC EQUIPMENT 01-55-33-30
TAIWAN GALAXY FAR EAST 02-781-18957
W. GERMANY BITRONIC 089-496-00105

élan

Analog answers to real-world problems
Elantec, Inc., 1996 Tarob Court, Milpitas, California 95035
Tel: (408) 945-1323 TWX: 910-997-0649

Now...for every purchasing executive who must make strategic buying decisions

From Cahners Economics and the editors of Purchasing Magazine.

BUYING STRATEGY FORECAST
For Purchasing Managers



Buying Strategy Forecast is an entirely new source of the steady flow of price and supply forecasts, market reports, and buying tips you need to develop sound buying strategies in the weeks and months ahead.

As a subscriber to this insider's information service, you will be given advice, ideas and strategies that you can use at once to cut costs and 'buy smart.' With **Buying Strategy Forecast** on your side you'll be alert to changing conditions, and ideally positioned to make the most of every new development.

Buying Strategy Forecast will forecast lead times... report and predict supply and price trends... provide the solid information and reliable analyses you need to reduce purchasing costs and uncertainty... actually give you an 'edge' on other buyers.

Start to benefit from this remarkable information source right now.

Return this coupon. We'll send you the latest issue of **Buying Strategy Forecast** by return mail. More important, you'll receive every one of the next twelve issues at a special charter subscriber rate of just \$9.75 a month, payable annually. Act now, and you'll also receive a free copy of the new guide, 10 TIPS FOR BETTER BUYING STRATEGIES.

Mail this coupon to:

Buying Strategy Forecast

Cahners Building
275 Washington St.
Newton, MA 02158



EDN 6/13/85

Please send me the latest issue of **BUYING STRATEGY FORECAST** and enter my one year trial subscription at the charter rate of just \$9.75 per month, payable annually.

☐ Bill later

☐ Payment enclosed

NAME _____ TITLE _____

FIRM _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

ACT NOW and receive a free copy of 10 TIPS FOR BETTER BUYING STRATEGIES.

Guarantee: If you are not completely satisfied you can receive a pro rata refund at any time.

LITERATURE

lishers. Books are separated into 86 categories and are cataloged according to type (reference, textbook, handbook) and style of presentation (programmed instruction, case study, narrative). \$4 (\$6 if an invoice is required.)

Computing Newsletter, Box 7345, Colorado Springs, CO 80933.
INQUIRE DIRECT



Data sheet depicts circuit breakers

This 4-pg data sheet describes the manufacturer's NEJ, NEJH, and HEJ molded-case circuit breakers. The brochure details the circuit breakers' constructions, thermal magnetic trip, and terminals and how they operate. In addition, available accessories and modifications for the products are included. Dimensional drawings, selection charts, and time-current curves supplement the text. The data sheet is 3-hole punched.

Federal Pacific Electric, Marketing Information Center, Box 99457, Cleveland, OH 44199.

Circle No 445

Tome tabulates data on CMOS logic families

This 408-pg manual examines the company's ZX54/74AHCT advanced high-speed CMOS logic and ZX54/74HCTLS high-speed CMOS logic families. In addition to 120 data sheets, the compendium con-

tains information on parameter measurements, enhancement programs, reliability, ordering information, and package dimensions. The book is free from authorized sales representatives, but costs \$5 if you order it directly from the company.

Zytrex Corp., 750 E Arques Ave, Sunnyvale, CA 94086.

INQUIRE DIRECT



Manual describes high-speed wire-wrapping

This manual, designated No S-3368, presents information on discrete wiring of high-speed logic. The book contains the Unilayer II test report, data sheet reprints of the company's ECL design panels, a flyer on Futurenet, a designer's guide, and a profile of the company's Interconnection Systems Division.

Augat Inc., Literature Dept, 40 Perry Ave, Attleboro, MA 02703.

Circle No 446

Bulletin covers solid-state timers

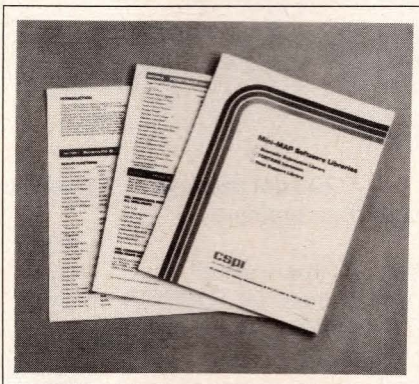
"Bulletin MM/MR-1" contains technical specifications, installation techniques, and application suggestions on two of the manufacturer's solid-state timers, which are designed to reduce setup costs and inventory requirements. The 6-pg brochure covers the SSF and SCF Series of multimode, multirange



timers. Charts, tables, and diagrams supplement the text. The bulletin is 3-hole punched for loose-leaf filing.

Amerace Corp., Newburgh Rd, Hackettstown, NJ 07840.

Circle No 447



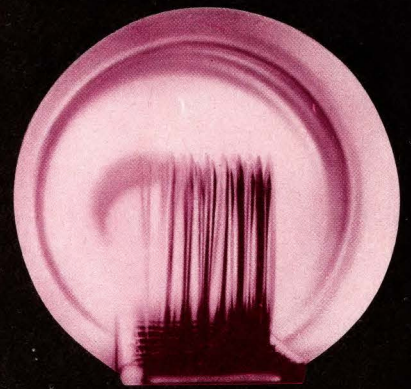
Array-processor software routines compiled

This 8-pg booklet chronicles a company's array-processor software routines. It lists, in tabular form, the functions, mnemonics, and timings for the scientific subroutine library, Fortran intrinsics, and the host-support library. The brochure catalogs approximately 400 programs, including algorithms for signal processing, matrix arithmetic, vector operations, scalar operations, image processing, and Eispack functions.

CSPI, 40 Linnell Circle, Billerica, MA 01821.

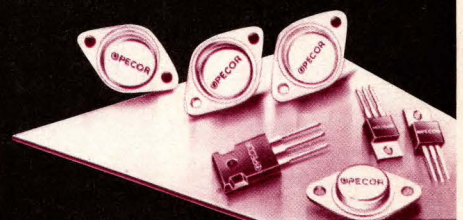
Circle No 448

PECOR



THE POWER TEAM YOU CAN COUNT ON

You can meet the tough demands of competition by processing in Taiwan. PECOR's plant has complete facilities for producing power transistors in TO-3, TO-220, and TO-3P (TO-218) packages for power supplies, TVs, monitors, car regulators and ignitions, printers, or other applications. Experienced engineers work under rigorous QC to give you best results at unbeatable prices. In the second half of the year PECOR will add new regulator ICs, Schottky diodes, and microwave transistors to its top-quality line for you.



PRESIDENT ENTERPRISE CORP.

International Sales Headquarters: 11th & 12th Fl., No. 560, Sec. 4, Chung Hsiao E. Rd., Taipei, 105, Taiwan, R.O.C. Tel: (02) 700-2866

Telex: 12200 PECORTPE

Hong Kong Office:

Tel: 3-850020, 3-850029

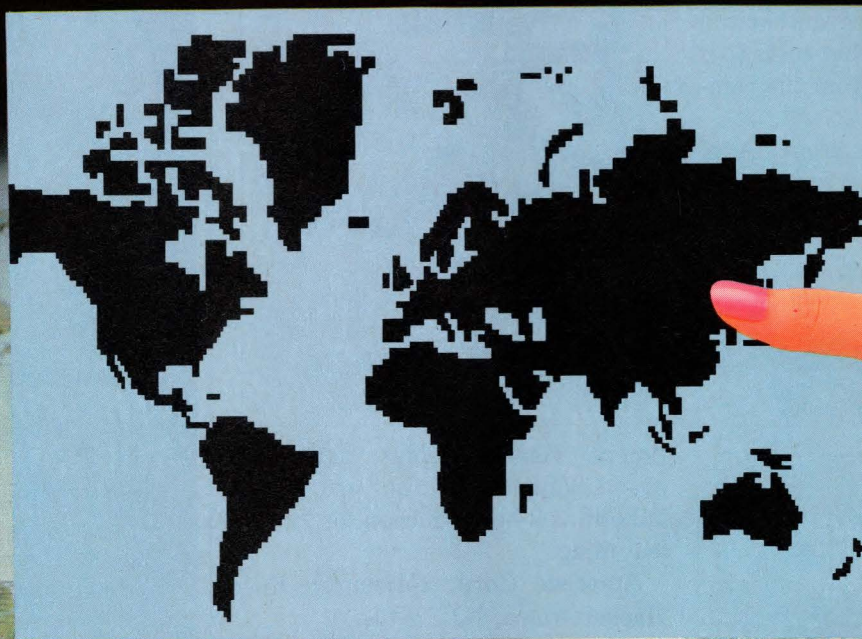
Telex: 50514 PECOR HK

U.S.A. Office:

Tel: (408) 748-0900 Telex: 176400 PECOR SNTA

There's Room in One LCD Module for the Entire Globe.

—It Displays 2,000 Characters on a Large Screen—



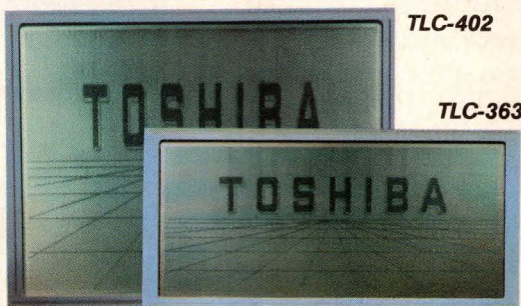
Simulated picture

New LCD modules from TOSHIBA give you 640×200 dot displays plus your choice of display area: virtually the size of an ordinary magazine or half that size.

The large display area puts a lot of information on view — either module can give you an array of 80 characters $\times$ 25 lines. Yet TOSHIBA technology cuts bulk and power consumption to the bone. These slim LCD modules are battery-powered and they are compatible with current CRT displays without changing software.

All these features add up to portability. Versatility. Usability. These LCD modules are ideal as displays for portable word processors, personal computers, POS terminals and other display terminals.

Ask us. TOSHIBA is there when it comes to the technology you need in LCD components.



Specifications

	TLC-402	TLC-363
Display		
Number of Characters	80×25 (2,000 characters)	80×25 (2,000 characters)
Dot Format	8×8 , alpha-numeric	8×8 , alpha-numeric
Overall Dimensions (W $\times$ H $\times$ D)	$274.8 \times 240.6 \times 15.0$ mm	$275.0 \times 126.0 \times 15.0$ mm
Maximum Ratings		
Storage Temperature	$-20 - 70^\circ\text{C}$	$-20 - 70^\circ\text{C}$
Operating Temperature	$0 - 50^\circ\text{C}$	$0 - 50^\circ\text{C}$
Supply Voltage	V DD 7 V	7 V
Voltage	V DD-V EE 18 V	18 V
Input Voltage	$0 \leq V_{IN} \leq V_{DD}$	$V_{SS} \leq V_{IN} \leq V_{DD}$
Recommended Operating Conditions		
Supply Voltage	V DD 5 ± 0.25 V	5 ± 0.25 V
Voltage	V EE -13 V Max.	-13 V Max.
Input Voltage	High 4.0 V Min.	4.0 V Min.
Low	0.5 V Max.	0.5 V Max.
Typical Characteristics (25°C)		
Response Time	Turn ON 300 ms	300 ms
Turn OFF	300 ms	300 ms
Contrast Ratio	5	5
Viewing Angle	$15 - 35$ degrees	$15 - 35$ degrees

Design and specifications are subject to change without notice.

TOSHIBA

Toshiba America, Inc.: Electronic Components Business Sector, 2692 Dow Avenue, Tustin, CA 92680, U.S.A. Tel: (714) 832-6300

Toshiba Europa (I.E.) GmbH: Electronic Components Div., Hammer Landstrasse 115, 4040 Neuss 1, F.R. Germany Tel: (02101) 1580

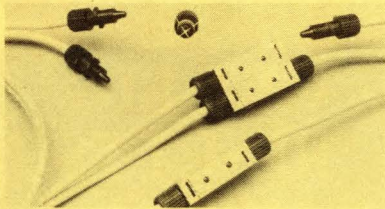
Toshiba (UK) Ltd.: Electronic Components Div., Toshiba House, Frimley Road, Frimley, Camberley, Surrey GU 165JJ, England Tel: 0276 62222

Toshiba Electronics Scandinavia AB: Vasagatan 3, 6th Floor, S-111 20 Stockholm, Sweden Tel: 08-14 56 00

EDN PRODUCT MART

This advertising is for new and current products.

Please circle Reader Service number
for additional information from manufacturers.



NEW "LITE-LINK" MINIATURE FIBER OPTIC CONNECTOR

- Easy In-the-Field Installation
- Exclusive Quick-Disconnect

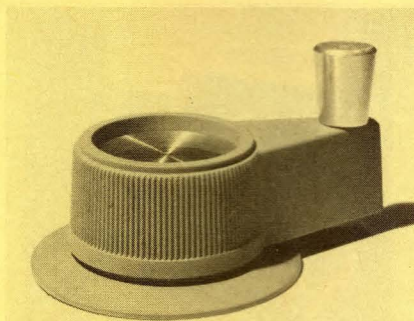
Series 808 provides a space-saving glass fiber optical connector for applications ranging from optical data links to LAN (Local Area Network) interface. It is field installable. Features bayonet type, twist lock for quick-disconnect. Has integral bushing and spring loading to assure proper fiber end-spacing and alignment.

Connector will terminate 50/125 or 100/140 micron multimode, glass fiber optic cable. Available in both single and duplex line configurations for cable-to-cable, cable-to-PCB and cable-to-wall mount interconnects. Application Kits are offered.

METHODE ELECTRONICS, INC.

7447 W. Wilson Ave., Chicago, IL 60656
(312) 867-9600 Outside IL: 1-800-323-6858

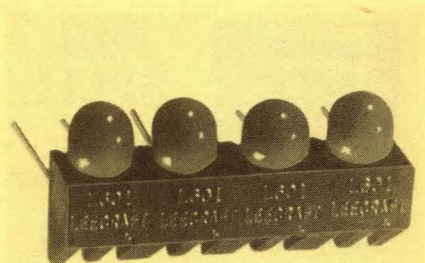
CIRCLE NO 150



CONTROL KNOBS

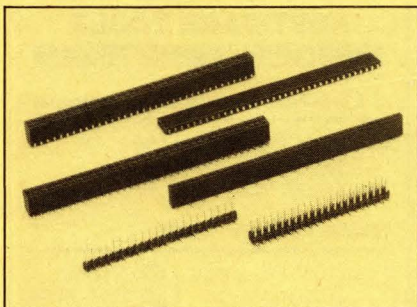
A full line of both plastic and aluminum control knobs is manufactured by Radial Controls. All knobs are of the set screw type and are available in a wide variety of sizes and shapes. Standard shapes include round, skirted, bar, spinner and concentric. Plastic knobs are supplied in four standard colors. A catalog is available from **Radial Controls**, 2555 E. 55th Place, Indianapolis, IN 46220.

CIRCLE NO 151



LED-QUAD ARRAY is used for panel lighting to display more than one function. Has housing cutouts that permit soldering resistors to PC boards. Supplied in all LED colors. 1.8 to 3 VDC voltages. LED position is .500" from adjacent slot. Total array length is 2.00". Other status LEDs for PC boards, discrete and packaged units and specials, also available. FREE LED guide. **LEECRAFT MFG. Co.**, 21-36 44th Road, L.I.C., NY (718) 392-8800.

CIRCLE NO 152



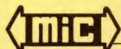
NEW SURFACE MOUNT STRIPS

New .025" square post and receptacle socket and terminal strips are molded with Du Pont Rynite PET polyester for surface mounting applications where vapor phase or IR soldering will be employed. Both sockets and terminals are available in single and double row designs and in straight and right angle pin configurations. Gold, tin and selective plating are available. **Samtec, Inc.**, P.O. Box 1147, New Albany, IN 47150. Phone: 812/944-6733.

CIRCLE NO 153

RUN INTEL development software ON YOUR PC \$190

MICRUN86 is an operating system interface that will allow you to run Intel's 16 bit software. All you need is an IBM PC or compatible, running MS-DOS Ver 2, and you will be able to run ALTER, ASM86, PLM86, etc.



MICRO INTERFACES CORPORATION

6824 NW 169th St., Hialeah, Florida 33015
(305) 822-9900

Dealer inquiries welcomed.

MICRUN is a registered trademark of Micro Interfaces Corp.

ALTER, ASM86, PLM86 and Intel are registered trademarks of Intel Corp.

IBM and PC are registered trademarks of International Business Machines Corp.

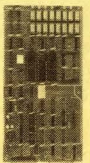
MSDOS is a registered trademark of Microsoft Corp.

CIRCLE NO 154

Micromate CP/M 3.0 COMPUTER



System or
Board Level
to suit your
application



- Use with RS 232C terminals
- Thousands delivered — in use
- 128KB RAM and autoboot ROM
- Interfaces four 400 KB disks
- 10-20MB hard drive add-on
- Abundant software available
- Excellent price/performance

Personal Micro Computers, Inc.

PMC

275 Santa Ana Court
Sunnyvale, CA 94086
Phone 408-737-8444

CIRCLE NO 155

Endicott

MECC



For Keyboard Clickers

For FREE Brochure Call or Write...

MECC

Endicott Coil Co. Inc.

24 Charlotte Street • P.O. Box 67 • Binghamton, NY 13905
607-797-1263

CIRCLE NO 156

Quelo™ 68000 Software Development Tools

68000/68010 Assembler Package

Assembler, linker, object librarian and extensive indexed typeset manuals.

Conforms to Motorola structured assembler, publication M68KASM[4], Macros, cross reference and superb load map, 31 character symbols.

Optimized for CP/M-80, -86, -68K, MS-DOS, PC-DOS... \$595
Portable Source written in "C" \$1495

Complete 68000 Development Package for MS-DOS

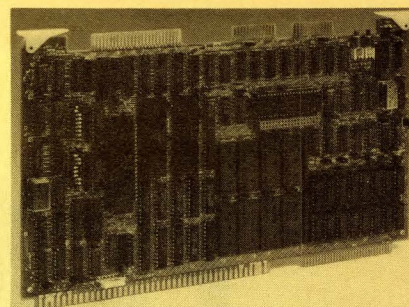
Lattice 68000 "C" Compiler and
Quelo 68000 Assembler Package \$1095

68200 Assembler Package

Assembler and linker for Mostek MK68200.
Optimized for CP/M-80, MS-DOS, PC-DOS \$ 595

For more information contact **Quelo Inc.**
2484 33rd W. Suite #173
Seattle, WA 98199
Phone (206) 285-2528
telex II (TWX) 9103338171
COD, Visa, MasterCard
CP/M, TM DRI. MS-DOS TM Microsoft. PC-DOS TM IBM.

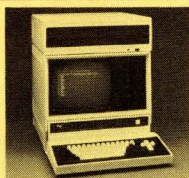
CIRCLE NO 157



CP/M-8000™ MULTIBUS™ SYSTEM

The CP/M-8000 operating system is now available for our 10 MHz Z8000™ Single Board Computer. This high-performance system has all the familiar CP/M commands. File compatibility with CP/M-80 and CP/M-86 makes it easy to transport files to CP/M-8000. A 'C' compiler and MACRO assembler are included. Call for further information. CP/M™ Digital Research, Multibus™ Intel, Z8000™ Zilog. **SINGLE BOARD SOLUTIONS**, 7669 Rainbow Drive, Cupertino, CA 95014. (408) 253-0181.

CIRCLE NO 158



FOR SALE!

Like new
Intel Series III
286FD Development
System

\$11,900.00

50% LESS than
Intel list!

FULL 120 DAY WARRANTY — Includes DX225 Microcomputer Development System and an MDX-720 Dual Double Density Flexible Disk Subsystem with an iMDX-556 Resident Processor Card. System software will be Intel's most current revision level. Ask about **FREE MEMORY** with every 286 purchased. Subject to prior sale. Phone (800) 225-1008, in Mass. (617) 938-0900, or (800) 227-8409, in Calif. (818) 887-4000.

GENSTAR

REI Sales Company

6307 De Soto Avenue, Suite J
Woodland Hills, CA 91367

CIRCLE NO 159



smARTWORK® Circuit-Board-Artwork Software. For only \$895, **smARTWORK®** lets the design engineer create and revise printed-circuit-board artwork on the IBM Personal Computer. Forget the tedium of taping it yourself or waiting for a technician, draftsman, or the CAD department to get to your projects. With **smARTWORK®** you keep complete control over your circuit-board artwork from start to finish. Call or write to **Wintek Corporation**, 1801 South Street, Lafayette, IN 47904-2993. (317) 742-8428.

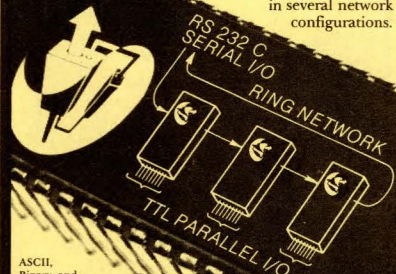
CIRCLE NO 160

GET BIG RESULTS WITH PRODUCT MART ADS

REACH OVER 137,000
READERS —
ALL SPECIFIERS
OF ELECTRONIC
COMPONENTS, SYSTEMS
AND EQUIPMENT!

CY232 NETWORK CONTROLLER AND PARALLEL-SERIAL INTERFACE

will connect any RS232 CRT or computer to any 8-bit parallel TTL I/O port and works with one port or up to 255 parallel ports in several network configurations.



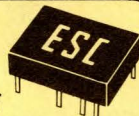
ASCII, Binary, and ASCII-hex modes of operation for maximum flexibility
\$75 ea. (\$30/100)
Prototyping board available.

Cybernetic Micro Systems
P.O. Box 3000, San Gregorio, CA 94074
(415) 726-3000 Telex: 171-135 att: Cybernetic

CIRCLE NO 161

ESC DELAY LINES

DELAY MODULE,
VERY LOW PROFILE



Series 9T

Features maximum height of only .165 inches. Available for total delays of 25 to 200 nsec with 5 output taps (9T Series) or untapped (9G Series.) Operating temperature is -55°C to +125°C. Also available as 9TCM and 9GCM commercial version for 0°C to +70°C operation and at low cost.

ESC ELECTRONICS CORPORATION

534C BERGEN BOULEVARD
PALISADES PARK, N.J. 07650
PHONE: (201) 947-0400 • TWX 710-991-9780
TOLL FREE 800-631-0853 (EXCEPT N.J.)

CIRCLE NO 162

CROSS-DEVELOPMENT SOFTWARE TOOLS

C COMPILERS (with ROM support)

host	IBM/PC, target	6809
	PDP-11,	6809

MACRO ASSEMBLERS

host	IBM/PC, target	6801, 6805
	PDP-11,	68HC11, 6809,
	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 163



WRITE IT — RUN IT — ROM IT

An 8088 based single board computer that is so simple to use, you will be developing applications programs the first day!

- Choice of 8K Basic or FORTH in ROM
- 8 channel, 8 bit A/D converter
- Two 8 bit input ports
- Two 8 bit output ports
- Time of day
- Onboard EPROM programmer
- RS-232 terminal and parallel printer port
- 7 current sinking outputs rated at 500 mA, 50 VDC
- Up to 32K of user memory

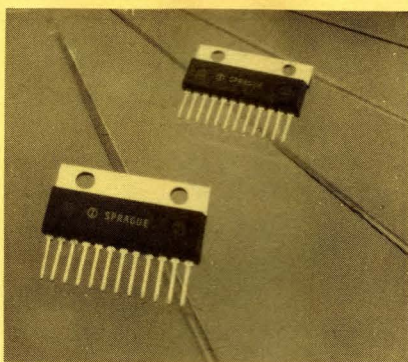
• Units start at \$279

• Power supplies also available

OEMs, let us quote on your customized hardware and applications programming requirements.

Vesta Technology, Inc., 7100 W. 44th Avenue, Suite 101, Wheatridge, CO 80033, (303)-422-8088.

CIRCLE NO 164



DARLINGTON ICs SWITCH UP TO 1280 W.

Sprague UDN-2878W and UDN-2879W Quad High-Current Darlington Switches serve as interface between low-level logic and high-power peripheral loads such as solenoids, motors, and incandescent displays. Handle loads up to 320 W per channel. Inputs compatible with most TTL, DTL, LS TTL, and 5 V CMOS logic. Volume pricing (50K) is just over \$2. Write for Bulletin 29305.10.

SPRAGUE ELECTRIC CO., 491 Marshall St., North Adams, Mass., 01247 (413)664-4411

CIRCLE NO 165

ABSOLUTE LINEAR ENCODERS

- BINARY
- GRAY
- BCD



Digital outputs in Binary, BCD or Gray Code (directly computer compatible) requires no signal conditioning or buffering amplifiers. Available stroke lengths 1, 2, 4, 8, 12, 24, 36 and 48 inches.

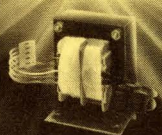
The VERNITECH Linear Encoder is pre-aligned and extremely rugged, suitable for industrial environments. Accuracies to .003 inches can be achieved.

Call or write VERNITECH, 300 Marcus Blvd., Deer Park, New York 11729 • 516-586-5100 • TWX 510-227-6079.

CIRCLE NO 166

Endicott

MECC



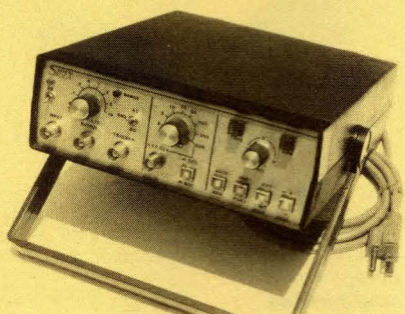
For Transformers
For FREE Brochure Call or Write...

MECC

Endicott Coil Co. Inc.

24 Charlotte Street • P.O. Box 67 • Binghamton, NY 13905
607-797-1263

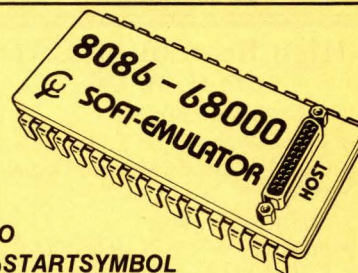
CIRCLE NO 167



NEED A STORAGE SCOPE?

The Model 601 Scope Memory converts your analog oscilloscope into a digital storage scope or a data recorder. Stores analog and digital signals. Features a 1.4 MHz sample rate, 2K memory, pre and post trigger capabilities. An economical way to acquire the benefits of a storage scope. For more information contact Sibex Inc., 2340 State Rd. 580, Suite 241, Clearwater, FL 33515, 813-797-9589.

CIRCLE NO 168



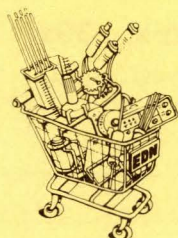
GO

%STARTSYMBOL
TO %BREAKSYMBOL

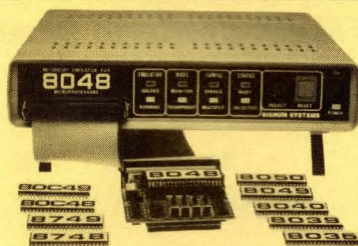
MICRO-CRAFT ANNOUNCES SYMBOLIC DEBUGGING with portable Soft-Emulators for 16 Bit CPU'S. Position independent, PROM resident 8086/68000 debugging executives for development and test (3.9K Code). No linking required, table driven I/O interface. PGM-execution: go, call, trace, 11 breakpoints. Line disassembly. Find string. Substitute, display, move, compare: I/O ports memory, registers. Load & save memory to/from host (MS-DOS, X-modem). Features: register and arithmetic on numeric input, **SYMBOLIC COMMAND INTERPRETER** on host (MS-DOS). (408) 338-4958 MICRO-CRAFT, PO Box 124, Boulder Creek, CA 95006.

CIRCLE NO 169

BE REMEMBERED...



Enhance your visibility
to EDN's 137,000
EOEM circulation with
a Product Mart Ad



8048 IN-CIRCUIT EMULATOR

E232-48 emulates Intel compatible 8048,

8049, 8050 microcomputers and their

ROMless and CMOS versions. It features:

- Real time emulation up to 11 Mhz.
- Hardware Breakpoints.
- RS-232 interface to host system.
- In-line Assembler and Disassembler.
- Complete debugging facilities.
- Software Drivers for IBM PC, CP/M-80, and CPM/86 included at no extra cost.

E232-48.....\$1795.00
Cross Assembler (8048 & others) From99.50

SIGNUM SYSTEMS

726 Santa Monica Blvd.
Santa Monica, CA 90401 (213) 451-5382

CIRCLE NO 170

FULLY AUTOMATED CONVERSION OF SCHEMATICS INTO PROCESSOR OBJECT CODE

8051 * LOGIC COMPILER * 8048
LOGIC SIMULATOR * DEMO DISK
6804 * PRUS PROCESSOR * 6805

Aldec compiler converts logic schematics and logic equations directly into object code for popular microprocessors. Add-on software simulator verifies schematic/circuit performance. A 48-pin flat-pack PRUS processor using standard EPROMs replaces over 20K gates and flip-flops. Logic compiler and simulator demo disk (\$38), compiler (\$1980), processor module (\$870) and simulator (\$985) run on IBM-PC and compatibles. Availability is from stock to 8 weeks.

ALDEC

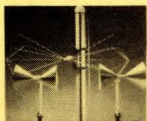
- Automated Logic Design Co. -

3525 Old Conejo Rd., #111

Newbury Park, CA 91320

Tel. (805) 499-5887

CIRCLE NO 171



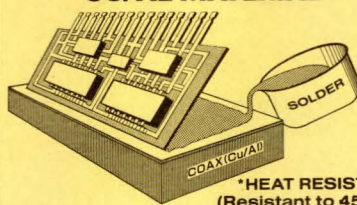
The Best Test Sites.

Accuracy, simplicity, and ease-of-operation characterize the best FCC/VDE/EMI test sites. For yours, choose our Roberts™ A-100 dipole antennas; the industry standard—identical to those used by the FCC at its sites. Or select our B-1000 line of accurate, portable biconicals ranging from 30 MHz–1000 MHz, with antenna factors traceable to national standards. And our motorized masts are perfect for any antenna set.

Compliance Design Inc.
593 Massachusetts Avenue
Boxborough, MA 01719
(617) 264-4668

CIRCLE NO 172

COAX ELECTROPLATED CU/AL MATERIAL



- * LIGHT WEIGHT (1/3 the weight of copper)
- * EASY SOLDERING

— Applications —
Heat sink and lead frames for:
• Hybrid ICs • Diodes
• Power transistors • Power Modules
Other available materials • Ni/Cu/Al • Solder/Cu/Al

Manufactured by:
★ **DAINICHI-NIPPON CABLES, LTD.**
New Kokusai Bldg. 4-1, Marunouchi 3-chome, Chiyoda-ku, Tokyo 100, Japan
Telex: 222-3146 DNCBL-J

For further information, contact:
★ **Mitsubishi International Corp.**
North Ferrous Metal Div. 520 Madison Ave., New York, NY 10022
Tel: (212) 605-2159

Agent and Distributor inquiries welcome

CIRCLE NO 173

ELIMINATE DECOUPLING CAPACITORS



CAP-BUS® CAPACITOR/BUS BAR

Eliminate the decoupling capacitors and the power and ground traces from your PCB for more reliability. CAP-BUS® has a distributed capacitance of .05 micro-farads per lin. in., at 50 VDC with low inductance and low impedance. The capacitor and the bus bar have been joined together for CAP-BUS®; a more efficient capacitive decoupled power distribution system, increasing IC density on a two sided board.

ELDRE COMPONENTS, INC. 1500 Jefferson Rd.
Rochester, NY 14623
(716) 244-2570

CIRCLE NO 174

High Resolution CAD on IBM PC

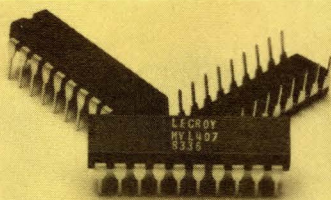
- 1024x768 or 640x400 Color Graphics
- Graphics Editor Electronic Design
- PCB & IC Design
- Schematic Capture
- Interfaces to SPICE, SCICARDS, GDS II, Gerber
- 9-State Logic Simulator for PC and VAX

DEALER OR REPRESENTATIVE
INQUIRIES INVITED



**Chancellor
Computer
Corporation**
1101 San Antonio Road
Mountain View, CA 94043
800/222-2660

CIRCLE NO 175



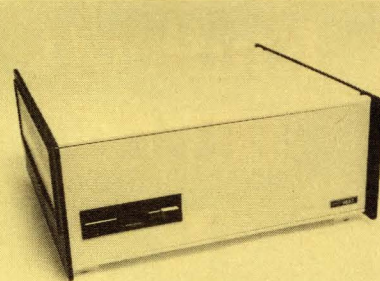
400 MHz Voltage Comparator

LeCroy MVL407 voltage comparator provides 2.5 nsec propagation delay for ultra high speed operation. Its quad packaging provides excellent interchannel matching for critical applications.

- Quad Packaging
- Input Matching: ± 1.25 mV
- Propagation Delay Matching: ± 125 psec
- Power Dissipation: 105 mW/channel
- ECL Outputs
- Packaging: 20 Pin DIP
- Price: \$18.00/4 Channels, Single Quantity (U.S.A.)

Circle Reader Response Card for complete technical data.
Write for complete data and free sample, describing general application. Attention: Dr. Peter Martin, Sales Manager.
LeCroy Research Systems Corp.
700 South Main St. Spring Valley, New York 10977 U.S.A.

CIRCLE NO 176



MULTIUSER EXORbus™ SYSTEMS

- 9687 Table Top, 14 Card Positions
- 9688 Rack Mountable, 8 Card Positions
- 20 To 50 Megabyte Winchester Drives
- One Megabyte Mini Diskette Drive
- 128K To One Megabyte Of RAM
- Up To Ten Serial Ports
- Utilizes OS-9 Level 2

For catalog, pricing and quantity discount information contact: **CREATIVE MICRO SYSTEMS**,
3822 Cerritos Ave., Los Alamitos, CA 90720,
213/493-2484.

CIRCLE NO 177

Fill out this form to advertise in Product Mart.

ISSUE(S) REQUESTED _____

RATE:	1x	4x	7x	13x	19x	26x	39x	52x
(Please circle)	\$670	650	630	570	550	540	530	515

Company _____

Address _____

City _____ State _____ Zip _____

Telephone _____

Signature _____

AD ENCLOSED ☐

AD TO FOLLOW ☐

Mail to: EDN / 221 Columbus Avenue / Boston, MA 02116

EDN PRODUCT MART appears in every issue — 30x a year!

**ADVERTISE
IN
PRODUCT
MART
AT
LOW COST**



HI QUALITY CAPACITORS

Computer Grade Electrolytics
5mm pcm Capacitors, High Current
Long Life Electrolytics
Single Ended Electrolytics
Silver Dipped Mica, Motor Start,
Motor Run
Polypropylene - Metallised & Film/Foil
Polyester - Metallised & Film/Foil

Polycarbonate - Metallised & Film/Foil
Polystyrene - Metallised & Film/Foil
Pulse (High DV/DT)
Suppressors, Snubbers, Switched Mode
Power Supply Capacitors
Voltage Multipliers
X & Y Capacitors "UL PENDING"

Stacked Film Capacitors

QUALITY, RELIABILITY & SERVICE
4-6 Week Leadtimes, Samples Available
Technical Support

L.C.R. COMPONENTS

Woodfield Works
Tredegar, Gwent
So. Wales, U.K.
Telex 497201 1crtgrg
Telephone 495253131

IN THE U.S.A. CONTACT:

M.A.E.C., INC.
3410 Post Road
Warwick, R.I. 02886
401-737-9010
Telex: 6814105

CIRCLE NO 178

**DISTRIBUTE
YOUR
LITERATURE
AND
CATALOGUES
THROUGH
THIS SPACE
FOR ONLY**

\$670

**8051
8048**

SIMULATORS - CROSS ASSEMBLERS - PROGRAMMERS - SIM51 and SIM48 Software Simulators run on IBM-PC, CP/M-80, MS-DOS. Designed for validation & debugging application software. Simulation includes all on chip functions plus expansion chips. \$250, one year **FREE** updates. Formats: PC-DOS 2.x DSSD, CP/M-80 8" SSSD, many 5 1/4" formats. Cross Assemblers and EPROM pgmrs also available. **Logical Systems Corp.** 6184 Teall Station, Syr., NY 13217 (315) 457-9416.

Logical Systems

CIRCLE NO 183

IBM AT 3Mb COMBO CARD WITH LIFETIME WARRANTY*



The AT Multifunction Card that can give you up to 3Mb of added memory plus added I/O features.

Expandable from 128K to 3Mb. Add memory as you need it. • IBM AT Compatible • Parallel Port • Serial Port • Spooler • Supports IBM VDISK • User Upgradable • Parity Checking Standard • Split Memory Addressing.

Complete with 128K RAM, Serial and Parallel Port \$449
AT RAM Expansion Card (OK) \$129
Additional RAM available at our low prices. **OTHER ADD ONS** 384K RAM/ Clock, 512K RAM Card, Spoolers, RAM Cards for PPCs and more.

Apparat, Inc.
ADD ON AND ON AND ON AND ON AND ON

4401 So. Tamarac Parkway / Denver, CO 80237 / 303/741-1778

ORDERING AND DEALER INFORMATION

800/525-7674

Stores in Denver & Chicago / *On all cards sold after June 1, 1984

CIRCLE NO 179

Endicott
MECC



For Solenoids

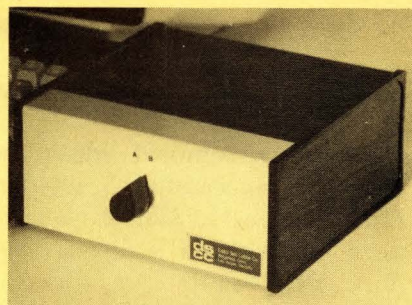
For FREE Brochure Call or Write...

MECC

Endicott Coil Co. Inc.

24 Charlotte Street • P.O. Box 67 • Binghamton, NY 13905
607-797-1263

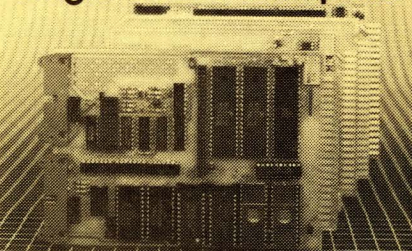
CIRCLE NO 181



SWITCH BOXES CAN ADD TO THE VERSATILITY OF YOUR HARDWARE. Data Set Cable provides ABC & ABCDE boxes in a wide variety with all kinds of connectors. Avoid need to change cables manually. Economical, too - ultra-compact ABC Single Coax box only \$55. In addition, Data Set has the biggest selection of interface cables, test equipment and other essentials to support your DP department. Send for catalog to **Data Set Cable Co.**, 722 Danbury Road, Ridgefield, CT 06877 - (203)438-9684 or Las Vegas - (702)382-6777.

CIRCLE NO 180

6809 Single Board Computer

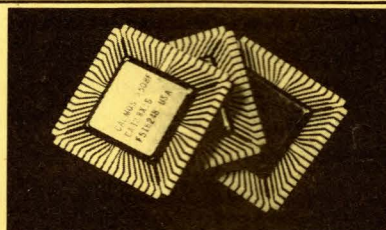


6809 MPU, 2 serial ports, 4 parallel ports, RAM, EPROM, real-time clock, watchdog timer, 44-pin 4.5" x 6.5" PCB

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 182



CMOS FIR Filter Data Memory and Control Unit

A powerful digital filter can now be implemented with only 4 I.C.'s. The CALMOS CA128X16 FIR Filter Data Memory and Control Unit (DMCU) operates at cycle rates in excess of 12.5 MHz and incorporates a 128 word by 16 bit high speed RAM, the address sequencers and the programmable Filter Control logic into one device. When configured as a full 128 point FIR Filter, the DMCU is capable of processing an input data stream at greater than 96K samples per second. Filter order lengths from 1 to 128 points are programmable via a seven bit control input.

Designed using low power CMOS the DMCU draws less than 250 mW at full speed and is now available in a 68 pin plastic or ceramic chip carrier. For further information, please contact Nick Deebale, Director of Sales, Calmos Systems Inc., 20 Edgewater St., Kanata, Ontario, CANADA K2L 1V8 Tel. (613) 836-1014 Telex 053-4501

CALMOS
Calmos Systems Inc.

CIRCLE NO 184



Get production performance in prototypes with QUIK/BUS® conductors.

Rogers QUIK/BUS conductors replace unwieldy wiring harnesses. Simply cut to length, snip off unwanted pins, seal the exposed ends. Fast-on or Bolt-on styles, 20 or 30 mils thick, offer versatility to fit any mounting need. Tie one or more custom-cut lengths together to make multi-layer bus bars. For full details, contact **Rogers Corporation**, 5750 East McKellips Road, Mesa, AZ 85205 - or call 602-830-3370.

CIRCLE NO 185

NEW BOOKS

Marketing Technical Ideas and Products Successfully! 400 pgs; IEEE members, \$29.40; nonmembers, \$48.95; IEEE Press, New York, NY, 1985.

Intended to introduce technical personnel to the marketing process, this anthology is geared to the special needs of marketing technical products and ideas. The volume contains selected articles and papers from American, Canadian, and European magazines and journals, ranging from the development of a marketing program to ways to evaluate its effectiveness.

The 67 papers are divided into five parts: Industrial Marketing: An Overview, The Marketing Program, Marketing Methods, Producing Marketable Copy, and Measuring Program Effectiveness. Topics covered include the marketing responsibilities of the engineer and scientist, advertising-sales productivity and how to measure it, and the needs of the customer and client during product development.

How to Write Papers and Reports About Computer Technology, by Charles H Sides. 162 pgs; \$21.95 (hardcover), \$14.95 (paperback); ISI Press, Philadelphia, PA, 1985.

This book is intended to assist computer professionals in writing effective proposals, documentation, specifications, reports, and papers. The guide focuses on such topics as writing a good user manual, defining your audience, writing proposals that work, and incorporating graphics into your writing. It also discusses which techniques work best for obtaining information during interviews.

Protecting Electronic Equipment from Electrostatic Discharge, by Edward A Lacy. 176 pgs; \$16.95 (hardcover), \$11.45 (paperback); TAB Books Inc, Blue Ridge Summit, PA, 1984.

This book describes precautions and solutions for minimizing ESD damage. It presents information on how to choose electrostatic test equipment, techniques for handling semiconductors, how to select the proper air ionizer, and techniques for protecting semiconductors during shipment and storage. The book also offers suggestions on how to use tools around semiconductors, what to consider when selecting grounded wrist straps and protective clothing, how to use humidity control effectively, techniques for building a static-free workstation, and methods for implementing ESD-control techniques in the field.

Flat-Panel Displays and CRTs, edited by Lawrence E Tannas Jr. 488 pgs; \$52.50; Van Nostrand Reinhold, New York, NY, 1984.

This anthology presents up-to-date coverage of flat-panel display technologies and their emerging relationship with CRTs. Contributing experts examine the display-system requirements, performance measures, and technical capabilities of both flat-panel displays and CRTs.

The book covers the theory of operation, device technology, materials, processes, and configurations for CRTs, electroluminescent displays, plasma displays, LEDs, and LCDs. The characterization of each type of display will help you select the appropriate technology for your application.

A User Guide to the UNIX System, 2nd edition, by Dr Rebecca Thomas and Jean Yates. 716 pgs; \$18.95; Osborne McGraw-Hill, Berkeley, CA; 1985.

Unlike the first edition, this book places greater emphasis on the concepts that underlie the Unix system and the character of the system as a whole. It isolates a core of information that everyone needs to know in order to use the Unix system effectively.

Divided into four parts, the book is useful as a reference as well as a source for more advanced study. Part 1 provides an overview of the Unix system and describes the programs' applications for business and science. Part 2 teaches you fundamental concepts and procedures as well as special features of the programs. Part 3 discusses 44 of the more useful command programs in detail, and part 4 provides additional information in seven appendices.

Gate Array and Standard Cell IC Vendor Directory, by Source III Inc. 385 pgs; \$195; Electronic Trend Publications, Cupertino, CA, 1984.

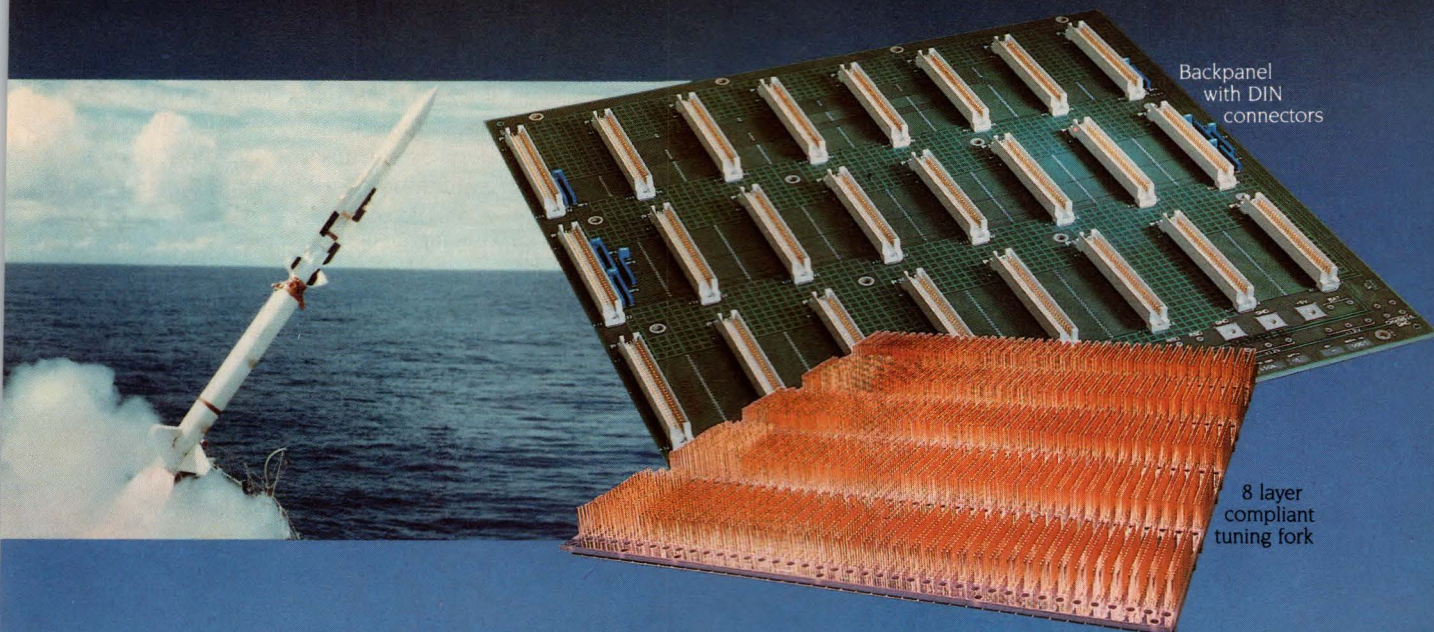
This guide provides the designer or procurer of semicustom ICs with the information necessary for selecting specific vendors and parts. In addition, it covers the technology and vendor-interfaces for gate-array and standard-cell manufacturers. Company profiles include the following data: corporate background, semicustom experience, development processes, production time, and CAD information.

Industrial Materials Science and Engineering, edited by Lawrence E Murr. 616 pgs; \$69.75; Marcel Dekker Inc, New York, NY; 1984.

This book gives an overview of current materials properties and behavior, provides a historical perspective, and discusses the emerging materials technologies. The compendium covers such topics as generic materials categories, including metals, semiconductors, ceramics, and polymers; the role of microstructure in new materials development; surface phenomena (eg, films, coatings, surface modification, wear, and degradation); and materials characterization tools. In addition, the book includes illustrations, references, and discussions of problems and solutions reinforcing materials science applications and engineering principles.

MIL-Q-9858A

Our competitors want it. Most can't get it.
CTS Fabri-Tek has it!



Backpanel
with DIN
connectors

8 layer
compliant
tuning fork

It's one of the military's most stringent quality control systems. MIL-Q-9858A is your assurance that CTS Fabri-Tek backplanes can handle your most demanding military interconnection requirements.

Whether you need a nonstandard, high reliability custom connector that meets tough military specs—or a standard connector to operate dependably for "at least 20 years"—CTS Fabri-Tek has the expertise to meet your requirements.

Example: CTS Fabri-Tek has 29 QPL

listings* under MIL-C-28859 for PC board backplanes to 26 layers. Our metal backplanes and headers are qualified under MIL-C-28754; bare board PC multilayers qualify to MIL-P-55110-D. Compare your present supplier with this kind of hi-rel military approval.

We've been delivering premium quality interconnection devices for military, aerospace, telecommunications and computer needs for over 20 years. From design through manufacture and testing, our custom connectors are cost competitive and available with minimum lead time.

And MIL-Q-9858A is just one guarantee of our high level of quality control in the manufacturing process.

*QPL numbers: 1-01 thru 1-07, 2-01, 2-04, 3-01 thru 3-14 and 4-01 thru 4-06.

WRITE TODAY for brochure describing these custom hi-rel connectors and backplanes at cost-effective prices. Contact:

CTS Fabri-Tek Connector, Inc.,
9210 Science Center Dr.,
New Hope, MN 55428.
Phone: (612) 533-3533.



CIRCLE NO. 131

CTS® MEANS RELIABILITY

CTS CORPORATION • ELKHART, INDIANA



Two-piece Military Connectors

MIL-C-55302/4 and
MIL-C-55302/6.
Phone: (612) 533-3533
CIRCLE NO. 132



92-pin PC Mount Connector

Low insertion force military connector.
Phone: (612) 533-3533
CIRCLE NO. 133



Military Box Connectors

BeCu contacts, overstress protection, DAP insulators.
Phone: (612) 533-3533
CIRCLE NO. 134



ISEM-B Military Connector

Hi-temp insulation withstands vapor phase soldering.
Phone: (612) 533-3533
CIRCLE NO. 135

PICOLOGIC™ ICs LET YOUR PRODUCTS CHALLENGE THE SPEED OF LIGHT!

The signal propagation speed in a transmission line trace on a typical printed circuit board is 1.5 centimeters per 100 picoseconds—also the distance between packages—or half the speed of light. With 100 picosecond gate delays, our PicoLogic family of GaAs ICs helps you create products and systems that run that fast.

Now, your products can enjoy all of the advantages of PicoLogic ICs—enhanced speed performance with a lower speed-power product, high speed surface mount packaging, and temperature and voltage compensation. With the versatility to adapt to a wide range of output impedance and pulldown supply options, PicoLogic ICs offer the built-in capability to translate from ECL levels to CMOS or TTL levels.

In application after application, where speed is of paramount importance, PicoLogic ICs ensure survival of the fastest. Consider...***In computers.*** Combining PicoLogic fanout buffers and comparators yields low skew

clock distribution circuitry to speed up your entire system. ***In instrumentation.*** Multi GHz signals can be handled. ***In fiber optics.*** Our precision D flip flop regenerates and retransmits more bits per second; more channels of communication per fiber. ***In microwave equipment.*** Ultra-high frequency dividers and counters broaden your use of phase-locked loop synthesizers. ***Act now...ensure survival of the fastest.*** Our PicoLogic family is available now. NOR gates, fanout buffers, flip flops, comparators/complementary drivers, dividers, counters, prescalers, even transistor and diode arrays. There's also an evaluation board to speed up your testing and evaluation of PicoLogic ICs.

Let your products challenge the speed of light. Call or write today.

GigaBit Logic, 1908 Oak Terrace Lane, Newbury Park, CA 91320. Telephone (800) GAAS-ICS(422-7427). In CA, (805) 499-0610. Telex 6711358.



THE NEXT GENERATION



PROFESSIONAL ISSUES

WRITTEN BY DEBORAH ASBRAND

NSF research centers open with high hopes for innovative technology, better-trained EEs

The National Science Foundation's funding of six engineering research centers at US universities has touched off new levels of enthusiasm in both the education and industry sectors, rekindling hopes for US advancements in research and development and consequently in the international market. The centers began operating on May 1 and are conducting research in robotics, telecommunications, systems engineering (including VLSI circuits, CAE, and artificial intelligence), intelligent manufacturing systems, composites manufacturing, and biotechnology process engineering.

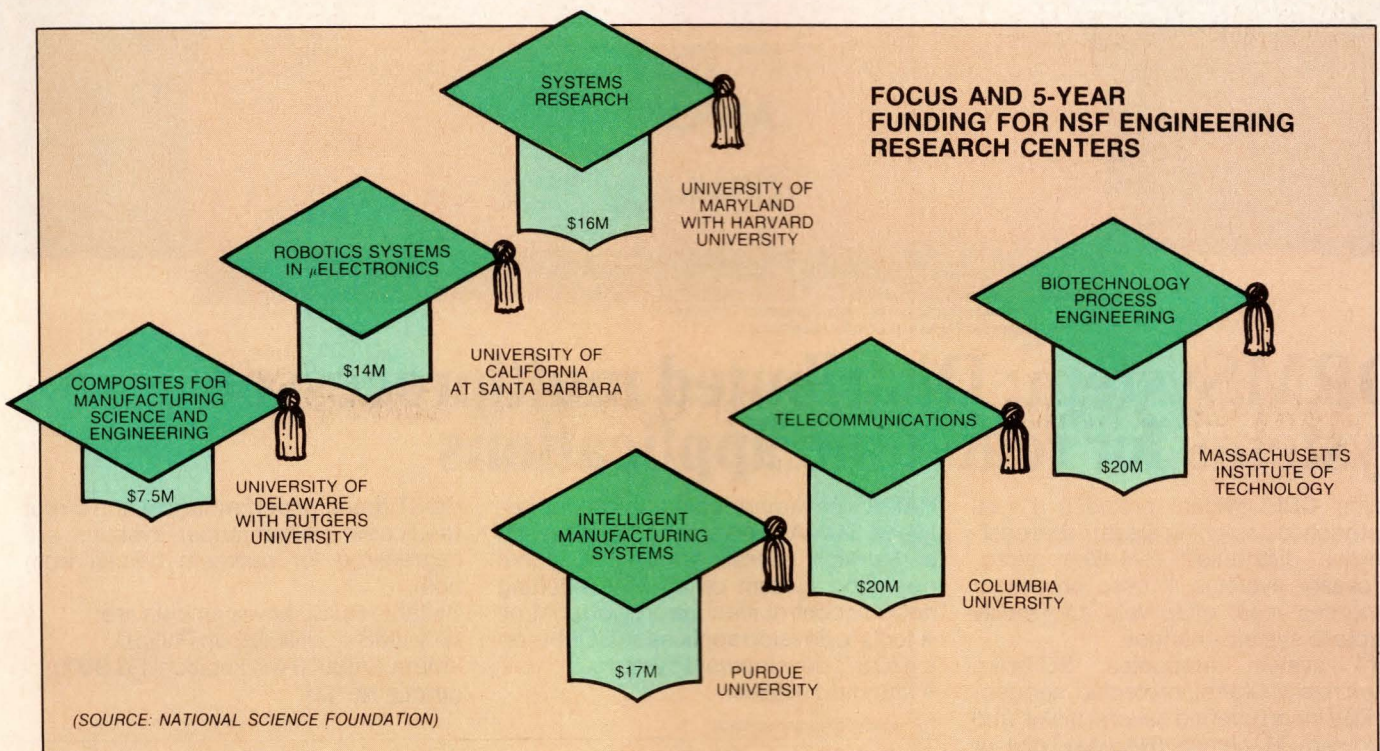
"The basic idea behind this new program is to help university researchers develop long-term, fundamental knowledge of engineering problems of significance to indus-

try, and to educate a new generation of students who can readily integrate ideas and techniques from a wide range of scientific and engineering disciplines," NSF director Erich Bloch said when the funding awards were announced in April. In addition, the centers provide a research component that has been noticeably lacking in undergraduate engineering education.

Institutions sharing the NSF's initial \$9.5 million in funding are the University of California at Santa Barbara (UCSB), Columbia University, University of Delaware, University of Maryland, Massachusetts Institute of Technology, and Purdue University. The University of Delaware will operate its center in conjunction with Rutgers University; the University of Maryland will op-

erate in collaboration with Harvard University. The research sites were selected from 142 submissions received by the NSF after it announced the program last year. They will receive a total of \$94.5 million in NSF funding over the next five years.

The research centers are the result of the NSF's recent reorganization of its Engineering Directorate (see EDN, May 2, pg 311). The NSF expects that the federal funding will begin a healthy collaboration between industry and education, with the private sector eventually taking on a more substantive role in financing the centers and participating in research. Susan Hackwood, director of the Center for Robotics Systems in Microelectronics at UCSB, says industry support for the center has



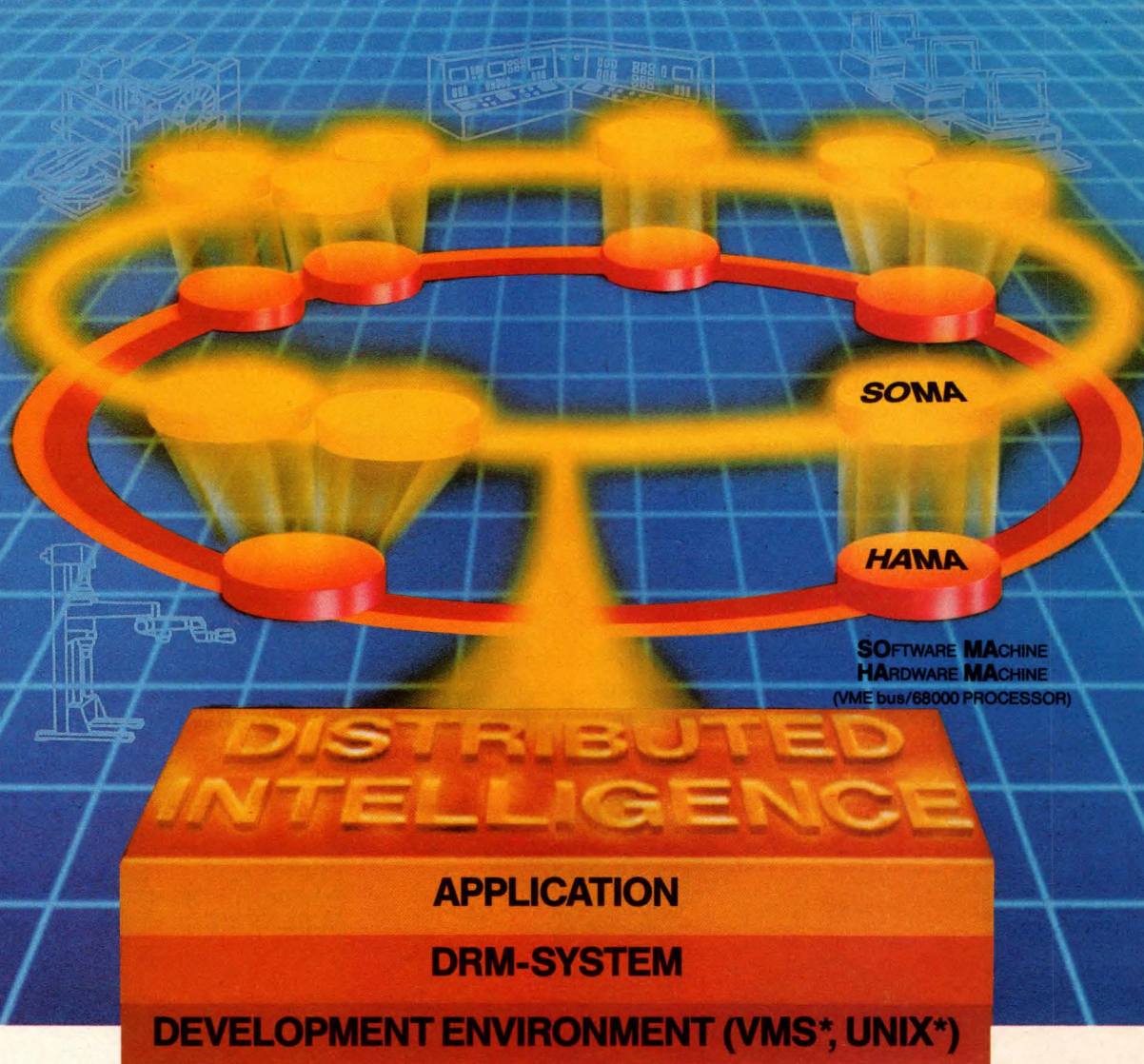
The National Science Foundation (NSF) chose these six engineering research centers for \$94.5 million in funding over the next five years. The NSF expects the funding to begin a healthy collaboration between industry and education.



Industrial
Automation

PHILIPS

DRMSYSTEM



DRMSystem: Distributed multiprocessor systems for real-time applications

Philips' DRM system provides a total approach to designing elegant and cost-effective distributed real-time micro-processor systems. It uses processor resources most effectively and easily adapts to system changes.

DRM system embodies Software Machines (SOMAs), protected, sequential files incorporating several tasks, and Hardware Machines (HAMAs), one or more processors with common memory. Application software is written as SOMAs that are mapped onto the HAMAs.

DRM system comprises:

★ a local operating system on each

HAMA, providing communication between SOMAs and a set of primitives in a real-time operating kernel; a global operating system on HAMAs needing network control, file control or job control.

★ tools to develop application SOMAs on a (HOST) development system.

★ standard utilities.

For more information contact:

Philips Industrial
Data Processing,
Building TQIII-2,
5600 MD Eindhoven,
The Netherlands,
Telex: 35 000 PHTC (NL)

Belgium
02-5256646 · (Mr. Ph. Donnini)
France
01-8301111 · (Mr. A. Perrot)
Italy
039-3635207 · (Mr. E. Conti)
Netherlands
040-788325 · (Mr. N. Blonk)

Nordic (S)
8-7821091 · (Mr. J. Hedberg)
Portugal
01-683121 · (Mr. J. Calado)
Spain
01-4043200 · (Mr. E. Delgado)
Switzerland
01-4882407 · (Mr. T. Kälin)

UK
01-5806633 · (Mr. J. Langman)
West-Germany
0561-501348 · (Mr. S. Krostewitz)

HOST (general performance) and target (dedicated performance) systems are segregated for optimum benefit from both.

Suitable HOST environments are: VAX-VMS or UNIFIVE on Philips' VMEbus/68000 workstation: PG 9000.

CIRCLE NO 137

PROFESSIONAL ISSUES

been enthusiastic from the start. Intel chairman Gordon Moore was impressed enough by the UCSB center's plans to voice his support during the site review the university underwent as a grant finalist. A wide base of support from industry was also evidenced at the University of Maryland, where a dozen industry representatives attended the NSF review.

At Columbia University, Mischa Schwartz, director of the NSF-funded Center for Telecommunications Research, is working to foster liaisons between the university and nearby companies, which are "some of the biggest telecommunications manufacturers, carriers, and users in the world," he says. The center's research will focus on developing integrated telecommunications networks capable of carrying such disparate types of traffic as data, voice, and video. He hopes to have telecommunications professionals lecture, conduct seminars, and work in

the center with faculty or students on projects one or two days each week. In the future, he hopes to work with Columbia's School of Law and School of International Affairs to incorporate the study of telecommunications law and regulatory policies into the center's curriculum.

But more than advancing research and development, the centers have restored the badly needed research component to undergraduate engineering education. A report issued in July 1983 by National Academy of Engineering president Robert White had cited sparse research opportunities as a glaring weakness in US undergraduate training of engineers. Most educators see the educational element of the research centers as the program's greatest strength.

"One of the problems universities have is that they have no in-house problems to work on," says William Dick, deputy director of the University of Delaware's Center for Com-

posites for Manufacturing Science and Engineering. "Students need problems to address. One of the benefits of working with industry is that [industry has] the problems we can train our students with, and that is both to the students' and industry's advantage."

"The university needs industry as much as, if not more than, industry needs the university," says UCSB's Hackwood. At that college, 150 to 200 undergraduates will use the center's facilities, including the center's 1400-sq-ft Class 100 clean room. Three undergraduate courses will have laboratories associated with the robotics center. Hackwood, a professor of electrical engineering, says students will be working to design and build robotics systems for microelectronic-device manufacturing. "What's unique about this center is the focus on systems work, which means building a whole working system, rather than just playing with one robot. It

NAE takes steps to boost US competitiveness

The National Academy of Engineering is another organization that has set its sights on using US technology to tackle the difficulties of competing in the international market. It established seven new programs to accomplish its goals of assessing the nation's technical needs, strengthening engineering education, and promoting national awareness of the importance of technical leadership. The new goals are part of the academy's Decade III Program Plan, a 10-year agenda that the NAE approved last year.

After a year of evaluation and planning, the NAE decided to step up its participation in the advancement of the US's technological leadership by establishing programs to study:

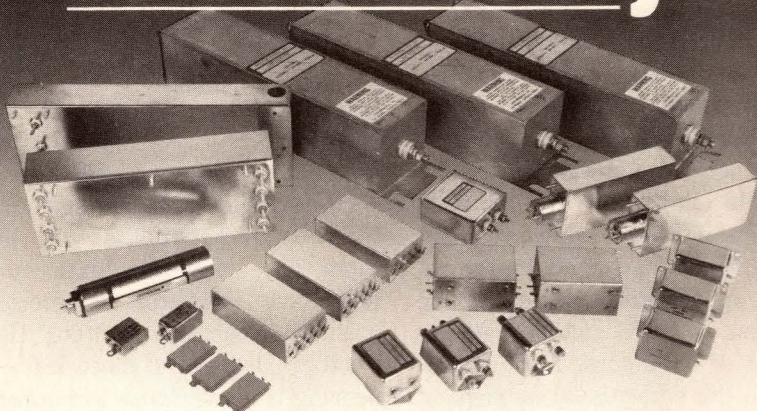
- Industrial issues
- Engineering education
- The status of technology and engineering research
- Technology and society
- Public awareness
- International issues
- Management support.

The Decade III Program Plan will be funded by

donations from the private sector; the NAE hopes to raise \$30 million for the program in the next few years. The organization plans to devote the most funds to the study of international issues, (including cooperative relationships with the Peoples' Republic of China), nuclear safeguards, and global technologies. Engineering education is earmarked as the second financial priority and will encompass future educational needs, the fundamental structure of engineering education, and the establishment of a database for engineering and technology studies.

The NAE is a private organization established in 1964 to study science and technology issues. It is the engineering counterpart to the National Academy of Sciences (NAS). More than 1200 engineers from industry, education, and research and development are honorary members of the NAE. The NAE, NAS, and the Institute of Medicine operate under the auspices of the National Research Council, which carries out more than 300 studies each year for a variety of sponsors from industry and government.

LMI makes RFI/EMI filter selection easy.



- **Lectroline® power line filters** meet MIL-F-15733 and interface with all UL and NEC approved equipment. UL-1283 approval pending.
- **Wall- and Floor-mounted Lectroline power line filter panels.**
- **Filters and power factor coils** available for standard 60 Hz and 400 Hz power systems.
- **Communication and control line filters.**
- **Lectroline signal line filter panels.**
- **Custom filters** to your specs to comply with MIL-STD-461/2/3, FCC, VDE and other regs.
- **Common mode filters.**

Reliability — an LMI advantage.

All Lectroline power line filters are supplied with internal bleeder discharge resistors per UL 478-1967 and NEC 460-4.

Oil leakage is virtually eliminated by hermetically

sealing both the oil-impregnated capacitors and the external case.

Other LMI advantages include ventilation screens in high-current Lectroline filters (to UL-1283), use of wiring wells to isolate input and output wiring, and internal filter wiring at 1000 circular mils per ampere, minimum. Assembly of all electrical wiring, terminal strips and cabling is performed with UL-approved devices.

For most RFI/EMI suppression applications.

LMI filters and filter panels are now widely used in shielded rooms and cabinets, ground support equipment, computer rooms, hospital diagnostic facilities, electrical and electronic equipment, and communication centers. Write or call the LMI Application Engineering Department for additional information.

Nationwide Representatives



LECTROMAGNETICS, INC., 6056 West Jefferson Blvd., Los Angeles, CA 90016
(213) 870-9383, Toll Free (800) 325-9814-U.S.A. • (800) 325-9815-CA

CIRCLE NO 138

DID YOU KNOW

EDN goes to electronic engineers
in 100 countries, not including the U.S.

EDN

ISSUES

means doing something useful with the robots," says Hackwood. Her goal is to see robotics become a "sound academic discipline," and she envisions the center in a few years developing robots for oceanographic and space applications.

Students at the University of Maryland's Center on Systems Research will study the implications and applications of CAE, VLSI circuits, and artificial intelligence on design methodologies. "Currently used methods and theories for the design of control and communications systems were really motivated and thought out on the basis of a different implementation," says the center's director, John Baras, a professor of electrical engineering. "Now the technology has changed drastically, but the corresponding design theories and methodologies have not. We are in an era where we can no longer afford to separate the design processes from the way we're going to implement the design." Baras says that students will participate in each of the center's projects and will also have the opportunity to attend seminars on various projects. He expects 50 undergraduate and 70 graduate students to participate in the center's activities.

Columbia University's Schwartz says students will play a big role in the school's telecommunications research, and he expects to have 200 undergraduates participating in research with 200 graduate students. Daniel Wang, director of MIT's Center on Biotechnology Process Engineering, is confident that the exposure to research provided by the centers to undergraduate students will contribute to "a new breed of professionals."

EDN

Section Interest Quotient
(Circle One)

High 518 Medium 519 Low 520

Order Your EDN Magazine Conference Proceedings Now!

If you design with linear integrated circuits or if you are planning to use gate arrays, semicustom, or custom integrated circuits, you will find these proceedings invaluable.

Practical Design With Linear Integrated Circuits Conference Proceedings

This proceedings presents the talks of engineers from Advanced Micro Devices, Harris, National Semiconductor, Precision Monolithics, RCA, Signetics, Siliconix, Texas Instruments and other leading linear integrated circuit manufacturers on the application of newly introduced devices. Products covered include the industry's fastest analog switches, an operational amplifier that also functions as a signal conditioner, the latest flash analog-to-digital converters, and state-of-the-art analog large-scale-integration.

Unique new circuits covered include monolithic active filters, fast and accurate sample/hold amplifiers, switching regulators, CMOS linear devices, analog multiplexers, FET-input operational amplifiers, drivers, interface circuits, and more.

Each talk in the proceedings was prepared to help engineers learn about the features and applications of new devices. The authors are applications engineers and are familiar with the problems commonly encountered in designing with integrated circuits. Each paper deals with application considerations and many include actual design examples.

Practical Design With Gate Arrays, Custom, and Semicustom ICs Conference Proceedings

This proceedings consists of 23 papers which were given at the 1982/1983 conference held by EDN Magazine to acquaint engineering designers with the rules and techniques for selecting and using the latest concepts in custom/semicustom technology. Virtually every important integrated circuit manufacturer contributed a talk including AMI, California Devices, Interdesign, National Semiconductor, Silicon Systems, Signetics, RCA and Synertek.

Topics presented include ways to go custom, how to get started, advantages of cell library systems, choosing parameters for a custom circuit, personalizing gate arrays, the role of computer aided design, testing gate arrays, linear custom products, and customer owned tooling.

Heavy emphasis is placed on design examples involving gate arrays. Newly developed products covered in the proceedings include the ACE series (advanced customized ECL) from Signetics, the R series of bipolar devices from Ferranti for systems with complexities to 10,000 gates, CMOS and CMOS/SOS gate arrays from RCA, ECL core arrays from Applied Micro Circuits Corp., and analog/digital gate arrays from Telmos. Also of interest are papers on linear arrays, logic simulation, software, and testing.

Proceedings can be purchased by European and other overseas readers at the same prices shown. Orders from European and other overseas readers should be accompanied by checks payable through New York banks or branches, in U.S. dollars. Use the coupon to order.

**Don't
delay.**

**Order
now.**

EDN Magazine Conferences
P.O. Box 1021
Melville, N.Y. 11747

Send the following proceedings:

- ☐ Linear IC Proceedings. 1982/1983. \$95.
- ☐ Gate Arrays, Custom, Semicustom Proceedings. 1982/1983. \$95
- ☐ Both of the above Proceedings. \$185.

Make check payable to EDN Conferences.

European/Overseas orders: Please make checks payable in U.S. currency through New York banks.

Mailing cost is included in prices shown.

Name _____

Title _____

Company _____

Street _____

City _____ State _____ Zip _____

Order Now!

**Get the latest
design information.**

CAREER OPPORTUNITIES

1985 Editorial Calendar and Planning Guide

Issue Date	Recruitment Deadline	EDN Editorial Emphasis	EDN CareerNews
July 25	July 2	Product Showcase — Volume II Computers & Peripherals Components Test & Measurement Instruments Products from Europe Literature on ICs, Semiconductors, Hardware & Interconnect Devices, Power Supplies/Sources, Software	
Aug. 8	July 16	Display Technology Technical Article Database Index Instrumentation	
Aug. 22	July 30	Military Electronics Special Issue High Speed ICs Power Supplies Software Semicustom ICs	Closing 8/20 Mailing 8/27
Sept. 5	Aug. 13	Power Semiconductors Computer Peripherals Components CAE Report	

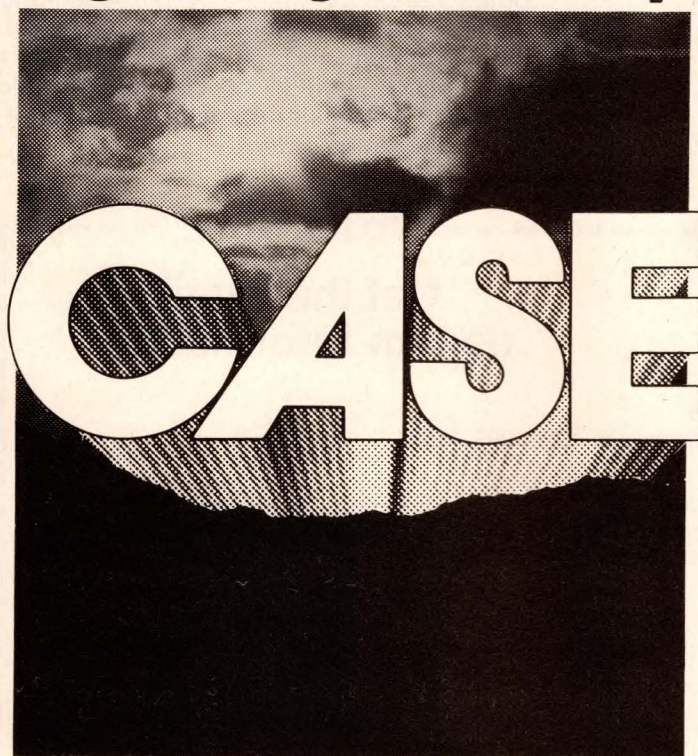
Call today for information.

East Coast Jennifer Purinton (212) 576-8049

West Coast Dan Brink (714) 851-9422

National Roberta Renard (212) 576-8048

The one word that spells engineering success for you



Unlimited professional challenges and unparalleled financial rewards for achievements await you at CASE — an international leader in data communications. Already Number One in Europe, CASE is stronger than ever in America, as we work to enhance our well-earned reputation as technical innovators. CASE engineers have the opportunity to work on the most sophisticated data communications projects. And, when our sales quotas are met, all CASE employees get bonuses. If our exciting professional environment and bonus system are what you've been seeking, consider these immediate opportunities in the following areas:

- LSI Design Engineering
- Modem Design Engineering
- Multiplexer Design Engineering
- Communications Architecture
- Software Engineering
- Component Engineering
- Advanced Manufacturing Engineering
- Field Engineering
- Production Engineering

We provide outstanding personal compensation and benefits. Our design centers in Silver Spring, Maryland and Clearwater, Florida offer challenging and fast paced environments. For more information, send your resume in strictest confidence to: John Jaeger, CASE COMMUNICATIONS, Inc., 2120 Industrial Parkway, Silver Spring, MD 20904. An Equal Opportunity Employer.

CASE
Future Proof
Data Communications

SHAPE YOUR OWN FUTURE.



General Dynamics Data Systems Division helps shape the future of many significant programs at its major locations in San Diego, California; Fort Worth, Texas; and Norwich, Connecticut; as well as at satellite locations including Detroit, Michigan, and Pomona, California.

We provide diverse support functions for such high-technology programs as the F-16 multimission fighter/attack aircraft, the M1 main battle tank, nuclear-powered submarines, and the entire family of cruise missiles. Throughout our division you'll find a variety of opportunities to apply your own scientific and

engineering expertise to create a more exciting future.

The Data Systems Division gives you the chance to join one of the most skilled teams in the industry today, and offers excellent salaries and benefits.

If you're interested in shaping your own future on our innovative support team, one of our opportunities listed below may be just right for you.

For immediate consideration, send your resume to the Vice President/General Manager, 12101 Woodcrest Executive Dr., Drawer 024, St. Louis, MO 63141.

PRODUCT SOFTWARE

- Bachelor's and/or Master's degree, and 3-8 years' experience.
- SKILLS: FORTRAN, JOVIAL, PASCAL, Ada, Assembly Languages, Applied Math, Data Bases, Real-Time Operating Systems, Documentation (MIL Standards).
- APPLICATIONS: Command & Control Software (Guidance, Navigation, C³I, Display Systems, Executive & System Support Software), Mission Planning, Data Handling & Communication, Automatic Test Equipment/Simulations, Image Processing, Estimation & Control Theory.
- Embedded Systems: Real-Time Software.

CAD/CAM

- Bachelor's and/or Master's degree, and 3-8 years' experience.
- SKILLS: FORTRAN, Ada, Assembly Languages, IBM, CDC & VAX Operating Systems, Computational Geometry, Information Modeling & Data Base Management Systems.
- APPLICATIONS: Turn-key Graphic Systems, Solid Modeling, Expert Systems, Robotics, CNC-DNC, Real-Time Process Control, Group Technology, Engineering Work Stations.
- CADAM, CATIA, Computervision, SCI CARDS, Model 204, Systems Engineering, Group Management.

ENGINEERING SYSTEMS

- Bachelor's and/or Master's degree, and 3-8 years' experience.
- SKILLS: Simulation Languages, FORTRAN, Ada, COBOL & IBM Assembler, Harris, VAX, IBM Operating Systems, TSO, SPE, DISPLA, RAMIS, Scientific Programming and Microcomputer experience.
- APPLICATIONS: Simulation, SLAM, Manufacturing, Operations Research, Image Processing, Graphics Application Development, Sneak Circuit Analysis, Program Marketing.

U.S. CITIZENSHIP REQUIRED
An Equal Opportunity Employer

GENERAL DYNAMICS
Data Systems Division

THE TELECOMMUNICATIONS REVOLUTION CONTINUES

East Meets West



At Hayes Microcomputer Products, Inc. our continued growth is reflected by the acquisition of SoftCom in San Francisco.

Our opportunities in either location provide an engineering environment free of constraints; one that encourages each individual to make valuable contributions— to see a project through from concept to completion. Take advantage of having a choice with Hayes—Atlanta or San Francisco...East meets West!

SoftCom, Inc., San Francisco

SENIOR DESIGN ENGINEERS

Requires experience with communications technology and design/development of microprocessor-based products. This senior position will require tangible proof of success in developing reliable and manufacturable products.

These positions require a BSEE; MS preferred and a minimum of 5 years related experience. Most important is a determined, tireless enthusiasm for the technological advancements with which we are involved.

Send confidential resume, including salary history and requirements, to: **SoftCom, Inc., A Hayes Company, 329 Bryant St., #3C, San Francisco, CA 94107.**

Hayes Microcomputer Products, Inc. Atlanta

RELIABILITY ENGINEERS

Will evaluate new product designs and perform reliability/testability of new products. Serves as part of design review teams in the functions of approval of reliability design and verification and approval of testability design and specifications. Requires a BS in Electronics Engineering, Computer

Science, Computer Engineering or other related discipline along with 4 years experience in applicable reliability engineering or testability design.

PRODUCT DEVELOPMENT ENGINEERS

Will be responsible for the implementation of designs produced by Design Engineering and insure that the product will be manufacturable, testable, well packaged, properly documented and cost effective. Assignments will involve developing requirements for circuit board layout, producibility evaluation, enclosure and packaging design for manufacturing and other tasks as required. Requires BSEE or equivalent experience with a minimum of 3 years experience in product engineering assignments.

DESIGN ENGINEERS

Will design hardware/firmware for microprocessor-based data communication and computer products. May serve as Project Leader on projects under development. Requires BS/MSEE or equivalent experience and a minimum of 5 years experience in microprocessor-based design. Experience in digital design including Digital Signal Processing, analog design, especially active filter design and data communications product design required. Background in Assembly language programming in a real-time data communications environment desirable.

TEST EQUIPMENT ENGINEERS

Responsible for planning, specifying and designing state-of-the-art ATE equipment and systems. Will function as liaison between R&D and manufacturing. Requires a BSEE and 5 years experience in electronic test equipment design.

Send confidential resume, including salary history and requirements, to: **Hayes Microcomputer Products, Inc., Dept. 81-185, PO Box 105203, Atlanta, GA 30348.** An Equal Opportunity Employer M/F.

Hayes®
Innovative products
for enterprising people

This is not an ad for the world's finest helicopter. It is an opportunity for the world's finest engineers.

At Bell, our engineers have proven that a challenging and advanced work environment encourages the most creative engineering thinking.

It's that kind of thinking which has involved Bell in projects like the V-22 Osprey program using tilt-rotor design, the advancement in redundant 'fly-by-light' and 'fly-by-wire' technology and many other progressive R&D programs. Bell currently employs engineers in 75 distinct disciplines, and we have many openings for experienced engineering professionals now.

Your chance to enhance your career potential begins today with a call to Bell Helicopter.

Help us make tomorrow unlike anything today.



Here's what we'd like: if you have appropriate degrees and three or more years experience in your specialty, our engineers are eager to meet you and detail the positions open in these areas now at Bell:

**AIRBORNE SOFTWARE
AUTOMATIC FLIGHT
CONTROLS
AVIONICS SYSTEMS
ELECTRICAL DESIGN
SUBSYSTEMS INTEGRATION
STANDARDS & CALIBRATION
ELECTRONIC TEST LAB
FLIGHT TEST ENGINEERING**

Here's what you'll like: the competitive salary ranges, superior benefit package, liberal vacation programs and sunny Texas location. But most of all, the hands-on responsibility and the opportunity to be involved with people who challenge themselves to the fullest: the best, creating the best. To learn more, call David McDavid at (817) 280-2377 today, or send your resume to him at Bell Helicopter, P.O. Box 482, Dept. EM-1, Fort Worth, TX 76101.

Bell Helicopter

an equal opportunity employer m/f/h/v

HUGHES

THE PEOPLE BEHIND MISSILE TECHNOLOGY

The people at Hughes Missile Systems in Tucson are designing the most sophisticated missile systems. Their dedication and talent have resulted in many new advancements and re-stated the Hughes commitment to excellence.

You can join these highly qualified engineering professionals and enjoy the unique lifestyle that Arizona has to offer. We currently seek engineers for challenging positions in the following areas:

- Test Equipment Design
- Electronic Circuit Design (Digital/Analog/Hybrid)
- RF/Microwave Design
- Optical Design
- Software Design
- Guidance Subsystem Design/Integration
- Missile Systems Test and Analysis
- Components and Materials
- Quality Assurance
- Reliability
- Environmental Test Design
- Hybrid Process Design

To qualify for these assignments you must have a BS or MS in Electrical Engineering, EET, Optics, Physics, Computer Science, Chemical Engineering, or Mechanical Engineering.

Hughes offers a competitive salary and a comprehensive benefits package that includes medical, dental, and vision-care coverage for you and your eligible dependents. We also provide our employees with a tax-deferred savings plan.

To reach our Professional Employment staff call toll-free to (800) 528-4927 or send your resume to: Hughes Missile Systems, Professional Employment, Dept. NDE-6, P.O. Box 11337, Tucson, AZ 85734. Proof of U.S. Citizenship Required. Equal Opportunity Employer.

HUGHES
AIRCRAFT COMPANY

MISSILE SYSTEMS/ TUCSON



CHALLENGING POSITIONS IN AIRCRAFT WEAPONS INTEGRATION

The Navy's major research, development, test and evaluation activity, located at the foot of the Sierra Nevada, has immediate openings for candidates with experience in one or more of the following areas:

- | | |
|--|--------------------------------------|
| • PROJECT MANAGEMENT | • TACTICAL EMBEDDED COMPUTING |
| • NAVIGATION SYSTEMS & ICNI | • SOFTWARE DEVELOPMENT & VALIDATION |
| • SYSTEMS DESIGN | • AVIONICS T&E |
| • DISPLAYS & CONTROLS | • DIGITAL DESIGN |
| • SYSTEMS ANALYSIS | • DATA ANALYSIS |
| • RADAR, LASER, EO-IR TARGETING SENSORS | • HUMAN FACTORS |
| • AUTOMATIC TARGET RECOGNITION | • INSTRUMENTATION |
| • SOFTWARE QA & CONFIGURATION MANAGEMENT | • INTEGRATED AVIONICS SYSTEMS |
| • AIRCRAFT FIRE CONTROL | • SYSTEM & SUBSYSTEM SIMULATION |
| • DIGITAL SYSTEMS ARCHITECTURE | • FLIGHT TRAINER SOFTWARE |
| | • PRODUCT ASSURANCE FOR ADPE HW & SW |

Applicants with a BS or advanced degrees in Engineering, Physics, Computer Science, Math or other appropriate disciplines are encouraged to apply.

SALARY TO \$47,000

An equal opportunity employer
U.S. citizenship required



NAVAL WEAPONS CENTER
ANN 092-31-85-1
CHINA LAKE, CA
93555-6001

EDN

#1 IN CIRCULATION

Over 129,000 engineers
and engineering managers

#1 IN READERSHIP

EDN wins more readership studies
than any other electronics magazine

#1 IN COST EFFECTIVENESS

EDN's cost per thousand is only \$30.00

#1 IN GROWTH

EDN is the fastest growing
electronics publication in the field

*Shape The Future
Share The Pride*

With The First Name In Telecommunications

Pioneering has been our business since 1891. Today, we're still leading the way toward shaping the future of modern telecommunications. Digitalized switching and transmission systems, advanced integrated circuits, new dimensions in fiber optics...all assimilated to shape the direction of tomorrow by the professionals at GTE.

DIGITAL CIRCUIT DESIGN ENGINEER

Candidate will be responsible for the design of digital circuits for high speed transmission equipment utilizing custom/semi-custom integrated circuits and off-the-shelf digital logic integrated circuits. A BSEE and 5 plus years experience is required, MSEE preferred.

R & D PACKAGING ENGINEER

Duties will involve design, evaluation and procurement of packaging materials and hardware to accommodate electro-optical devices for fiber optic transmission systems. At least 3 years semiconductor packaging experience, associated technical degree and thorough knowledge of semiconductor device packaging technology is required.

ELECTRICAL DESIGN ENGINEER

This position requires electrical design of DC high efficiency, precise regulation, multiple voltage and switching power supplies for fiber optic transmission systems. You will be working directly with mechanical designer and CAE/CAD tools to achieve highly manufacturable power supplies. A BSEE and 3 years directly related experience in the design effort on electronic power supplies is required. A background in analog and servo control circuits is preferred.

ELECTRICAL DESIGN ENGINEERS

Responsibilities include the design of digital electronic circuits for transmission system multiplexing in synchronous and asynchronous applications and the design of receiver and transmitter circuitry for electro-optical portions of fiber optic transmission systems. You will be using Computer Automated Engineering workstations to design custom/semi-custom integrated circuits. 1 plus years experience in digital and/or analog circuit design is required, preferably in custom/semi-custom integrated circuit design. A BSEE with communications option is necessary, MSEE with communications background preferred.

CAD PC BOARD DESIGNER

Applicant will perform printed circuit board and mechanical assembly design using Computer Automated Design techniques. You will also create material lists and documentation packages, prepare engineering change authorizations and create/modify detail drawings. An AA or a 2 year certificate from a Technical Vocation School or equivalent and a background in drafting, mechanical or electro-mechanical design and/or PC board design is required. Computer Automated Design system courses and/or 1 plus years experience is preferred.

We invite you to share the pride with GTE by becoming part of tomorrow's telecommunications task force today! Please send your resume with salary history: GTE Communication Systems, Human Resources, Dept. 7338, One Camino de Lenkurt, Albuquerque, NM 87123. We are an equal opportunity employer m/f/h/v.



**Communication
Systems**

Working Together To Be The Best

Dynamic Team Challenges

Your industrial or manufacturing experience can lead to greater challenges as part of our dynamic team. We're Allied/Bendix Aerospace, Electrodynamics Division, a leader in the development and manufacture of advanced power controls and electromechanical equipment for commercial and military aerospace and marine markets. Our steady growth has created the following positions:

Senior Project Engineer

Highly visible opportunity demanding 5-10 years solid planning, performing and supervision of non-routine research, design, development or manufacturing engineering assignments. Requires BS/MS/Ph.D or equivalent with excellent interpersonal skills to organize and motivate professional engineers and support personnel.

Design Engineer

Challenging assignment for individual with at least 4 years experience in both designing microprocessor-based hardware and writing applications software for microprocessors. Knowledge of assembly language and high-level language desired as well as microprocessor development systems experience. Requires BSEE minimum. Experience in applying microprocessors to control systems is highly desirable.

Senior Engineer

Responsibilities will include proposals, design approaches and projects. Requires BS/ME plus 5 years minimum experience in aircraft powered flight control servo-actuation and aircraft hydraulic system actuators and valves.

Senior Staff Engineer

Utilize your experience in computer systems management for an engineering environment. Requires BS/ME with at least 6 years experience in control systems analysis.

Senior Staff Engineer

Responsibilities will include making proposals, design approaches, projects, customer interface and travel. Requires BS/ME with at least 10 years experience in aircraft flight control servo-actuation and aircraft hydraulic system actuators and valves.

We offer an outstanding benefits and compensation package with annual stock option, company paid retirement, stock savings plan with tax deferred features, educational assistance, a comprehensive insurance program with a liberal paid vacation and holiday policy.

Interested candidates please forward your resume including salary history and requirements to:

Tammy Gabrinetti, Allied/Bendix Aerospace, Electrodynamics Division, 11600 Sherman Way, North Hollywood, CA 91605.

An Equal Opportunity Employer
U.S. Citizenship Required.



Allied Bendix Aerospace

Where are engineers designing PC compatibles that already meet future needs?

ZENITH BY THE LAKE

At Zenith Data Systems, we're designing some of the most upgradable, expandable, simply incredible personal computers available to meet the demands of both today and tomorrow. While nestled in one of the Southwestern Michigan's most beautiful lakeshore communities, we've established ourselves as one of the premier leaders in the PC compatible marketplace. Unprecedented growth has created career opportunities in the following area:

HARDWARE DESIGN ENGINEERS

Challenging Digital and Analog product design and development opportunities are available in personal computers, terminal systems and continuing engineering. A BSEE, MSEE or equivalent degree and a minimum of 2 years microcomputer, terminal or data communications system design using 16/32 bit technology experience are required.

Look to Zenith Data Systems, where our technology is meeting the future needs of customers — and of your career. For more information, call or send your resume to: Bill Flowers, 616/982-3504, Zenith Data Systems, Dept. EDN6, Hilltop Road, St. Joseph, MI 49085. Equal Opportunity Employer M/F/H/V. Principals only please.



**data
systems**

Corporation

A Wholly Owned Subsidiary of Zenith Electronics Corporation

*Unix is a trademark of AT&T Bell Laboratories

We have openings nationwide in power supplies, power conversion, magnetics, circuit design and packaging.

Search Northwest Assoc.
Ports O' Call - Swan Island
4505 N. Channel
Portland, Oregon 97217

Phone: (503) 285-6560
Keith Nyman or Doug Jansen
All Fees Employer Paid

ENGINEERS

Software, Hardware, Systems & QA
\$25 to \$75,000

We have more jobs than we can fill for BS, MS & PhD EE, ME, CS or Physics graduates with technical experience in the computer, communications, aerospace or electronics fields. Many U.S. locations. Interview, relocation and agency fee paid by client companies. Send resume & latest salary or call for confidential application...in PA (215) 735-4908; outside PA, 7 days/24 hours (800) 523-2906.



Arthur Krasnow, (USNA, MIT)
Electronics Department
Atomic Personnel, Inc.
Suite P4, 1518 Walnut
Philadelphia, PA 19102

Engineers Helping Engineers since 1959

Atlantic West International

—Executive Search & Selection—

Specialists in the Medical Device Industry

Nationwide opportunities in Design/Development, Test, QC, Mfg. & Production. Key openings in Electro Fiber Optics, Microprocessor Digital/Analog Design, Electronic Packaging.

For additional information call or write
Dick Valenti

25108 Marguerite Parkway
Suite B6
Mission Viejo, California 92692
(714) 855-1133
All Fees Employer Paid

NATIONAL OPENINGS

TECHNICAL WRITERS

COMMERCIAL:

SYSTEMS - Op/Sys, Language & program manuals (to 48K)
APPLICATIONS - App and "how to" manuals (to 35K)
HARDWARE - Installation and maintenance manuals (to 38K)

GOVERNMENT SYSTEMS:

MAINTENANCE/OPER - manuals and test procedures to Mil Spec (to 40K+)
LOGISTICS - ILS engineers (to 40K)
SOFTWARE - manuals to Mil Std (to 40K+)

Please call **Michael Dunn** (collect) at **609-424-8600**, or send resume to:



Judge Inc.
Suite G37 • 1930 E. Route 70
Cherry Hill, NJ 08003

All positions are direct career opportunities - all fees and interviewing expenses paid by client companies.

EDN Databank

Professional Profile

Announcing a new placement service for professional engineers!

To help you advance your career, Placement Services, Ltd. has formed the EDN Databank. What is the Databank? It is a computerized system of matching qualified candidates with positions that meet the applicant's professional needs and desires. What are the advantages of this new service?

- It's absolutely free. There are no fees or charges.

- The computer never forgets. When your type of job comes up, it remembers you're qualified.
- Service is nationwide. You'll be considered for openings across the U.S. by PSL and its affiliated offices.
- Your identity is protected. Your resume is carefully screened to be sure it will not be sent to your company or parent organization.

- Your background and career objectives will periodically be reviewed with you by a PSL professional placement person.

We hope you're happy in your current position. At the same time, chances are there is an ideal job you'd prefer if you knew about it.

That's why it makes sense for you to register with the EDN Databank. To do so, just mail the completed form below, along with a copy of your resume, to: Placement Services, Ltd., Inc.

IDENTITY

Name _____ Parent Company _____
Home Address: _____ Your division or subsidiary: _____
City _____ State: _____ Zip: _____ Location (City, State) _____
Home Phone (include area code): _____ Business Phone if O.K. to use: _____

PRESENT OR MOST RECENT EMPLOYER

EDUCATION

Degrees (List)

Major Field	GPA	Year Degree Earned	College or University
-------------	-----	--------------------	-----------------------

POSITION DESIRED

EXPERIENCE

Present or Most Recent Position	From:	To:	Title:
---------------------------------	-------	-----	--------

Duties and Accomplishments: _____ Industry of Current Employer: _____

Reason for Change: _____

PREVIOUS POSITION:

Job Title: _____
Employer: _____ From: _____ To: _____ City: _____ State: _____
Division: _____ Type of Industry: _____ Salary: _____
Duties and Accomplishments: _____

COMPENSATION/PERSONAL INFORMATION

Years Experience	Base Salary	Commission	Bonus	Total Compensation	Asking Compensation	Min. Compensation
Date Available	I Will Travel ☐ Light ☐ Moderate ☐ Heavy			☐ I own my home. How long? _____ ☐ I rent my home/apt. ☐		
☐ Employed ☐ Self-Employed ☐ Unemployed	☐ Married ☐ Single		Height _____ Weight _____			
Level of Security Clearance		☐ U.S. Citizen ☐ Non-U.S. Citizen		My identity may be released to: ☐ Any employer ☐ All but present employer		
☐ WILL RELOCATE ☐ WILL NOT RELOCATE		☐ OTHER _____				

EDN Databank

A DIVISION OF PLACEMENT SERVICES LTD., INC.

265 S. Main Street, Akron, OH 44308 216/762-0279

The recruiters at Tech FairTM are in need of professional help.

If you're an experienced engineer, computer or software professional, you're the help recruiters need. You see, each BPI TECH FAIR is full of recruiters from top local and national technical companies. And they have many openings to fill. So if you have experience, you're in high demand.

When BPI TECH FAIR is in your town, drop by. You'll get a chance to meet with many companies. Interview with them. Or simply learn about what other career opportunities are available to you.

BPI TECH FAIR is completely confidential. There's no registration. *And we're not an employment agency.* So there's no fee.

If you're an experienced engineer, computer or software professional be sure to attend BPI TECH FAIR. You could help your career. And give recruiters the professional help they need.

For a personal invitation to BPI TECH FAIR, simply send us your resumé indicating your home address and we'll add you to our mailing list.



*Attend BPI TECH FAIR.TM
Because you're the help they need.*

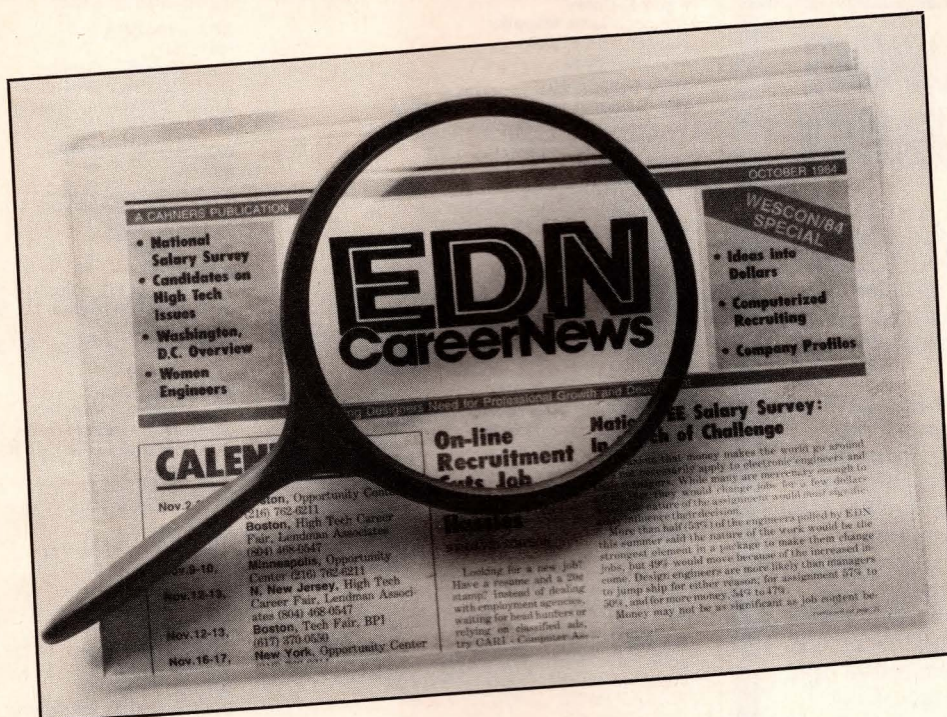
Nation's #1 rated career event.

TECH FAIRTM

BPI • 100 North Seventh Street • Dept. K • Minneapolis, MN 55403 • (612) 370-0550

1985 Schedule: Anaheim, Jan. 29-30 / Boston, Jan. 28-29, Apr. 22-23, July 29-30, Nov. 18-19 / Chicago, May 6-7, Oct. 14-15 / Dallas, Feb. 25-26, Aug. 5-6 / Denver, May 13-14, Sept. 9-10 / Detroit, June 17-18 / Long Island, Apr. 15-16, Aug. 12-13 / Los Angeles, Mar. 4-5, Oct. 21-22 / Minneapolis, Mar. 11-12, Sept. 30-Oct. 1 / Orlando, Apr. 1-2, Sept. 23-24 / Phoenix, Mar. 18-19, Aug. 19-20 / Raleigh, July 15-16 / San Jose, Jan. 14-15, Apr. 29-30, Aug. 26-27, Nov. 11-12 / Seattle, May 20-21 / St. Louis, Feb. 11-12 / Washington, D.C. Jan. 21-22, Mar. 25-26, June 5-6, Oct. 28-29.

WE THINK YOUR CAREER NEEDS SOME CLOSE ATTENTION.



That's why we've created **EDN Career News**. It's the one publication focused entirely on the career concerns of electronics engineers. And it's the added source you need to find new career opportunities.

EDN Career News expands **EDN's** career coverage with the same first-rate editorial that's made **EDN** first among electronics engineering publications. **Career News** looks at the legal and government-related issues affecting the electronics industry. And at personal growth issues to help you reach your professional potential.

Join the 300,000 electronics engineers and engineering managers who pay attention to **EDN Career News** each month. It will make a difference in your career.

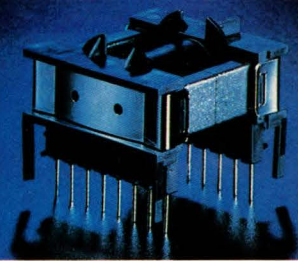
EDN CareerNews

Everything Designers Need for Professional Growth and Development

Roberta Renard, National Sales Manager
475 Park Avenue South, New York, N.Y. 10016 (212) 576-8045

Cahners Publishing Company

- Publishers of 32 specialized business magazines in Building & Construction
- Electronics & Computers • Foodservice • Manufacturing • Medical/Health Care



RESHAPING TECHNOLOGY.

From their very conception to their broad scope of applications, new ETD cores in 3C6A power material from Ferroxcube are a unique product for SMPS manufacturers the world over.

Designed in Europe to meet VDE specifications, these ETD cores operate from 20 kHz to 150 kHz with typical throughput powers of 100 W to 1200 W. They pack more performance into less space for use in forward converter transformers, and other SMPS designs where real estate is at a premium. Optimized for high-frequency operation, ETD cores are available in four sizes, gapped or ungapped. Gapped cores are supplied in a range of standard A_L values.

Ferroxcube ETD cores also feature bobbins and hardware specifically designed for automatic winding and ease-of-assembly. Their unique design lets you make optimum use of the latest manufacturing techniques. Plus, their round center leg minimizes core weight, reduces DC resistance and leakage inductance.

ETD cores are now available in prototype kits of the four sizes, complete with hardware and bobbins. Discover just how unique, flexible and worldly these cores are for yourself. For more information on purchasing an ETD product kit, call The Cube.



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 140

BUSINESS/CORPORATE STAFF

F Warren Dickson
Vice President/Publisher
Newton, MA 02158
(617) 964-3030

Peter D Coley
National Sales Manager
Newton, MA 02158
(617) 964-3030

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 Manager
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
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
Jim McErlean, Regional Manager
2041 Business Center Dr, Suite 109
Irvine, CA
(714) 851-9422

PORTLAND, OREGON 97221
Pat Dakin, Regional Manager
Walt Patstone, Regional Manager
1750 SW Skyline Blvd, Box 6
(503) 297-3382

UNITED KINGDOM, THE NETHERLANDS
Jan Dawson, Regional Manager
39A Bowling Green Lane
London EC1R/0BJ UK
1-278-8981
Telex: 261653

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

FAR EAST
Ed Schrader, Director of Sales
2041 Business Center Dr, Suite 109
Irvine, CA 92715
(714) 851-9422; Telex: 940573

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/
CAREER NEWS**
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

Dan Brink
Western Sales Representative
2041 Business Center Dr, Suite 109
Irvine, CA 92715
(714) 851-9422

Maria Cubas
Production Assistant
(212) 576-8045

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
Ed Christ, Group Manager
Eric Schmierer, Manager

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.

ADVERTISERS INDEX

Advanced Interconnections Corp.	211	Hughes Connecting Devices	87	Siemens	44-45, 103
Altera Corp.	97-99	Hunter and Ready	126-127	Signum Systems	251
Amerace Corp, Control Products Div	204	Inacom International	236	Single Board Solutions	250
American Photonics Inc	70	Intel Components	104-105	Slicer Computers	215
AMF Inc-Potter & Brumfield	235	International Rectifier	74	Solartron Instruments	8
Amperex Electronic Corp	160	Interoptics/Purdy	168	Solid State Devices Inc	208, 210, 212
AMP Inc	79	Intersil Inc	C2	Solitron	96
Anritsu Electric	144	Introl Corp	250	Sony Component Products	148-149
Apparat Inc	253	Iwatsu Instruments Inc	91	Sophia Systems	100-101
Arium Corp	222	John Fluke Manufacturing Co Inc	6, 143	Sprague Electric Co	71, 197, 251
Arnold Magnetics Corp	217	Kepco Inc	171-176	Stag Microsystems Inc	159
Augat Quicktwin	208	Keystone Electronics Corp	216	Taiyo Yuden (USA) Inc	241
Automated Logic Design Co	251	Lanpar Technologies	170	Tadiran Electronic Industries Inc	C3
Avocet Systems	124-125	LeCroy Research Systems Corp	252	Technitrol Inc	244
Belden Electronic Wire & Cable/Fiber Optics	84	Lectromagnetics Inc	260	Tektronix Inc	36-37, 128, 181
BICC-Vero Electronics Ltd	89	Leecraft Manufacturing Co Inc	249	Telesis	14-15
Boeing Electronics Co	35	Logical Systems Corp	253	Texas Instruments Inc	94
Bowmar/Harowe	251	Magtrol Inc	242	Tohoku Metal Industries Ltd	237
Burr-Brown Corp	206	Matec Microelectronics	240	Toshiba Corp	248
Cadic Inc	220	Matsushita Electric Trading Co Ltd**	11	TRW/LSI Products Div	21
Calmos Systems Inc	253	Memory Protection Devices Inc	226	Varo Semiconductor	162
Canstar Communications	224	MetaLink Corp	228	Vernitech	251
Centronic Inc	226	Method Electronics	249	Viewlogic	33
Chancellor Computer Corp	252	Microcraft	251	Wavetek San Diego Inc	3
Comlinear Corp	30	Micro Interfaces Corp	249	Wavetek Scientific	198
Compliance Design Inc	252	Microtek Lab	123	Welch Allyn Inc	42
Creative Microsystems	252	Mini-Circuits Laboratories	24, 25, 195, 276	Westinghouse Electric Corp	62
CTS Corp	255	Mostek Corp	121	Wintek Corp	250, 253
Cybernetic Micro Systems	250	Motorola Semiconductor Products Inc	28-29, 59	Xycom	214
Dainichi-Nippon Cables Ltd	252	Multiproduct International	274	Zero Corp	65
Daisy Systems Corp	38-39	National Semiconductor	12-13, 51-58		
Dash, Straus, and Goodhue	227	Nicolet Oscilloscope Div	23		
Data I/O	C4	North American Philips SMD Technology Inc	238		
Data Set Cable Co	253	Optical Fiber Technologies/ (OFTI)	190		
Densitron	232	Orion Instrument	34		
Die-Tech Inc	230	Ovenaire-Audio-Carpenter	220		
Digital Equipment Corp	182-183	Panelgraphic Corp	211		
Digitec	234	Personal Micro Computers Inc	249		
Duracell Inc	219	Philips Industrial	192		
Elantec	245	Philips Test & Measuring Instruments Inc	258		
Eldre Components Inc	252	Pittman Corp	212		
Electronic Synopsis	43	Plasmatek	234		
Electroswitch Corp	191	Plessey Microsystems	117		
Electrovac-MAEC	253	Plessey Semiconductor	150-151		
Emerson & Cuming	26-27, 240	Powercube Corp	41		
Endicott Research Group Inc	42	President	247		
Ensign-Bickford	46	Pro-Log Corp	4		
Epoxy Technology Inc	32	Pulver Laboratories Inc	225		
ESC Electronics Corp	250	Quelo	250		
Ferroxcube	272	Radial Controls	249		
GE Calma	82-83	RCA Solid State Div	201		
General Electric Plastics	72-73	Rekco	70		
General Electric Semiconductor	186	Rogers Corp	221, 253		
Genesis Micro Systems	119	Saft America Inc	231		
Genstar REI Sales Co	250	Samsung Semiconductor	80-81		
Gigabit Logic	256	Samtec Inc	249		
Grimes/Trackhouse	122	Schaffner EMC Inc	209		
Gulton Industries Inc	50	Semikron International Inc	60		
Harris Semiconductor	152	Sibex Inc	251		
Heurikon	205				
Hewlett-Packard Co	16-17, 40, 48-49, 93				
Hitachi America Ltd*	10-11				
Honeywell	18				

Recruitment Advertising

Atlantic West	268
Atomic Personnel	268
Bell Helicopter	265
BPI	269
Case Communications	262
General Dynamics	263
GTE Comm Systems	267
Hayes Microcomputer	264
Hughes Aircraft	266
Judge Inc	268
Naval Weapons Center	266
Search Northwest	268
Sperry Defense	266
Zenith Data Systems	268

*Advertiser in US edition

**Advertisers in International edition

This index is provided as an additional service. The publisher does not assume any liability for errors or omissions.

Super Powers

Remote power supplies for microprocessors

Wall Units

+ 5VDC @ 750 ma
± 12VDC @ 80 ma
(W512750/1)



MPI's remote new plug-in units let you take the power supply out of your product and put it practically anywhere. Insert it directly into a wall plug, or rest it on a table top, desk top, bench, or any flat surface.

Designed for use with modems, calculators, appliances, games and a variety of other electronic products, MPI wall and table top power supplies are super-performers; providing outstanding dependability, flexibility and economy. They free up valuable board space, reduce weight and eliminate hazardous voltages, power supply heat and the need for costly cooling devices.

All MPI wall and table top models are UL listed.

Get the MPI super powers working for you. Check these exclusive features and specifications and call us today for details.

- Multiple & single output
- Regulated low ripple
- UL and CSA listed
- Fully isolated outputs
- Comply with FCC EMI regs.
- High efficiency



Table Top Units

+ 5VDC @ 1.0 A
± 12VDC @ 310 ma
(T5121000/1)



Specifications:

Input:	120V ± 10% 50/60 Hz
Regulation:	+ 5V 5% overall
Regulation:	+ 15V or + 12V 5% overall
Regulation:	- 15V or - 12V 5% overall
Ripple:	50 MV P-P
Operating Temp:	0°C to + 40°C
Storage Temp:	- 55°C to 105°C
Operating Altitude:	15,000'

Multi Products International

218 Little Falls Rd., P.O. Box 238, Cedar Grove, NJ 07009
(201) 239-8183 • Telex 219289 • Cable: MUPRINUSA-CEDG

CIRCLE NO 141

LOOKING AHEAD

EDITED BY GEORGE STUBBS

Voice/data terminal sales to reach \$650M in '87

Terminals that integrate voice and data communications and data processing—equipment which until recently has been considered sophisticated playthings for executives—are about to achieve the level of popularity long predicted for them. The market for these terminals will grow from 1984's modest \$53 million to \$650 million in 1987, forecasts Market Intelligence Research Co (Palo Alto, CA).

This explosive sales growth will be the result of a change in customer base and the introduction of integrated voice/data microcomputers by such formidable companies as AT&T Information Systems and IBM. The most recent products have been designed for middle managers and other employees who must manipulate and move large amounts of information. These workers need local-processing capabilities and advanced telephone, data-query, and time-management features.

In terms of meeting these needs, integrated voice/data terminals mesh logically with several emerging trends in the datacomm and telecomm fields: Vendors of digital PBXs, electronic-mail packages, public and private databases, and videotex/teletext systems will strive to exploit the capabilities of the integrated terminals. Some of these companies may even offer voice/data terminals of their own. Additional players in this market, besides AT&T and IBM, will include other manufacturers of terminals, microcomputers, personal computers, and complete datacomm/telecomm systems.

According to Brian Jeffery, research director of the International Technology Group (Palo Alto, CA), the integrated voice/data terminal constitutes a useful enhancement to the existing personal-computer workplace. In fact, Market Intelli-

gence Research predicts that integrated microcomputers could compose as much as 10 to 12% of the personal-computer market by 1989.

Motion-control market to double in Europe by '89

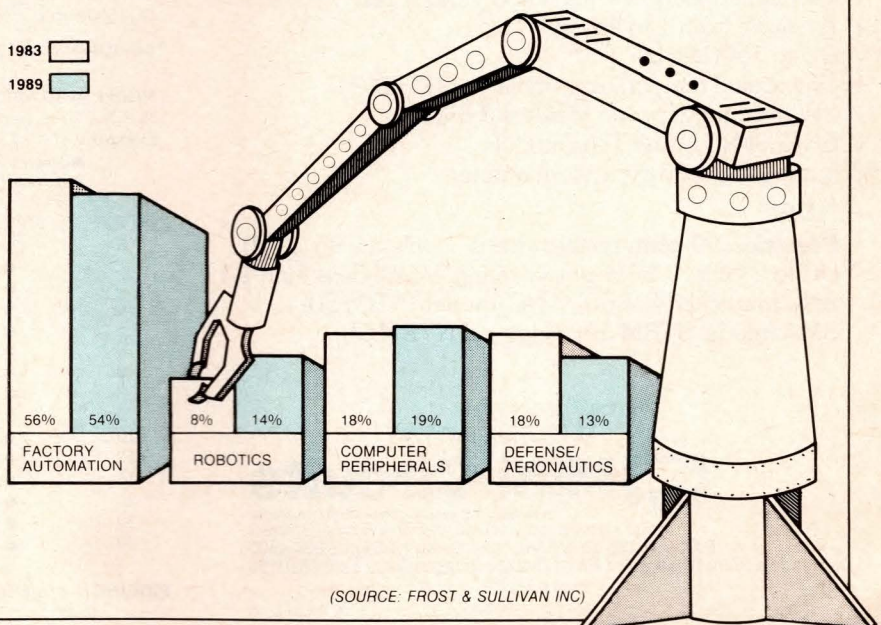
The small motors, drives, and control devices used in robots, disk drives, and other products that require rapid and precise movements for proper performance constitute a large and growing market. In Western Europe, the average annual growth rate for such products will be 15.5%, increasing from \$900 million in 1983 to \$2 billion in 1989, according to the market-research firm Frost & Sullivan Inc (New York, NY).

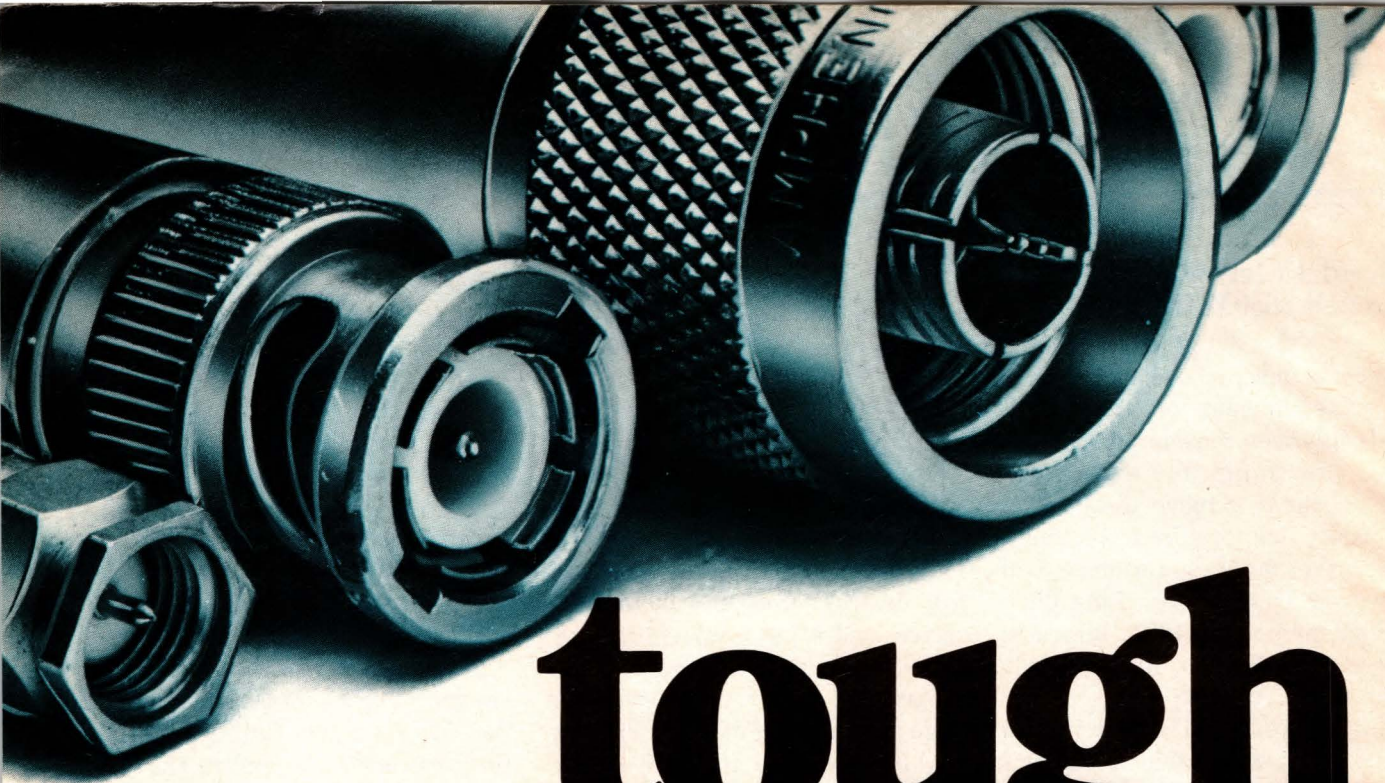
West German makers of the devices are expected to maintain their market dominance through 1989. Their 37% market share in 1983 will grow to 40% by 1989, Frost & Sullivan predicts. French vendors will collectively establish themselves as the number two makers of motion-control products.

Factory automation has been the driving force behind this market surge, and it will continue in that role through at least the next four years. Robotics is the fastest growing application area for the devices. The use of motion-control parts in computers and peripherals will hold steady throughout the 1983-89 period, while their use in defense/aeronautics applications will decline in comparison to these other areas.

Several technological advances are spurring the increasing automation of production facilities. Intel's Bitbus promises to ensure that the various parts and departments of the automated factory will be able to work with one another. Matsushita's (Japan) wound-type flat motor provides extremely accurate control in the start/stop and speed-control functions of machine tools, welding machines, card readers, line printers, data-recording devices, and other products. Last but not least, SGS-Ates (Italy) has developed a 2-chip motor-control system that might replace the handful of ICs and power transistors needed to drive a stepper motor from a μ P.

WESTERN EUROPE MARKET DISTRIBUTION OF MOTION-CONTROL DEVICES





tough attenuators

\$11⁹⁵
from (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)

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

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

C 92 REV. A

CIRCLE NO 142

ENSEMBLE



Tadiran Electronic Industries Inc.

350 5th Ave. New York N.Y. 10018 U.S.A. Telephone (212) 947-4600

Lakeland Plaza Professional Bldg. Suite 263 Lewisville. Tx 75067 U.S.A. Telephone (214) 221-7523

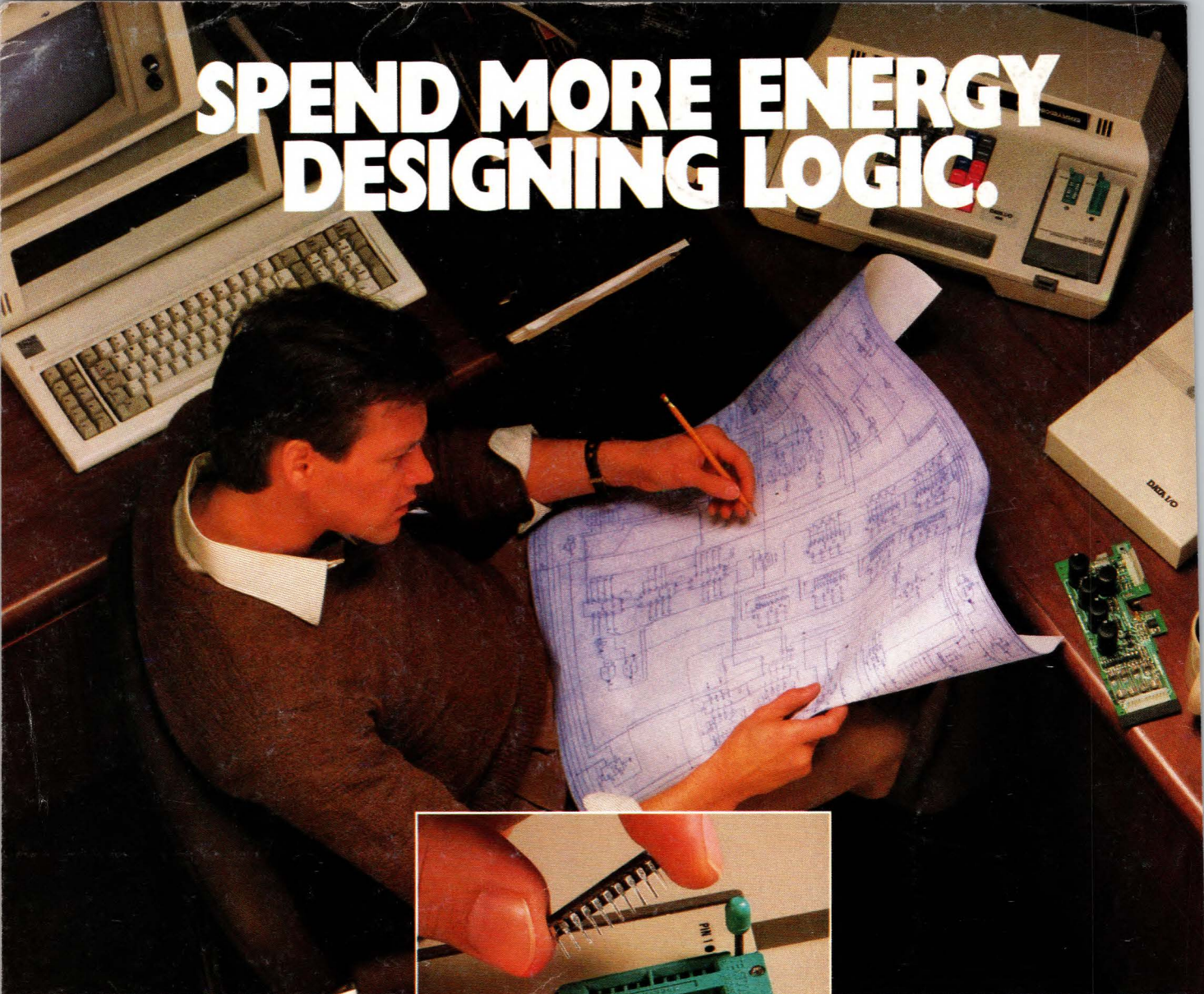
6312 Variel Ave. Suite 203 Woodland Hills, CA 91367 U.S.A. Telephone (213) 884-3884

TADIRAN LTD.

11, Ben Gurion Street, Givat-Shmuel P.O. Box 648, Tel Aviv 61006 Israel. Telephone (03) 713111. Telex 341692

CIRCLE NO 144

SPEND MORE ENERGY DESIGNING LOGIC.



AND LESS EFFORT PROGRAMMING PARTS.

The new 60A.

Data I/O's economical new 60A Logic Programmer is designed to do one thing only and do it very well: program logic.

Almost every programmable logic device is supported including PAL's and IFLs.

And it's user-upgradeable as new devices become available.

Logic pure and simple.

But what's really remarkable about the 60A is how easily it lets you program logic.

All you have to do is use the menu to select the kind of device you're programming, depress a single button to specify programming operation, and

press the start button. In less than a second your device is programmed. And selectable three-step functional testing ensures it is programmed correctly.

Add ABEL™ and design the way you think.

Taking advantage of programmable logic has never been easier, especially with ABEL, Data I/O's high-level design language.

Working with your computer, ABEL lets you express your designs in Boolean equations, truth tables, state diagrams or any combination... whatever works best.

**Call toll-free 1-800-426-1045
for a demo or details.**

To spend more energy designing logic and less effort programming devices, call Data I/O and ask about the 60A Logic Programmer. It's dedicated to one thing only: logic pure and simple. And like every Data I/O product, it's fully backed by our commitment to quality and our worldwide network of service representatives.



Data I/O® is a registered trademark of Data I/O Corporation, and PAL® of Monolithic Memories, Inc. ABEL™ is a trademark of Data I/O Corporation.

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.

CIRCLE NO 143

DATA I/O