INTERNATIONAL EDITION

AUGUST 9, 1984

A CAHNERS PUBLICATION

EDN

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Use power-buffer ICs to drive difficult loads

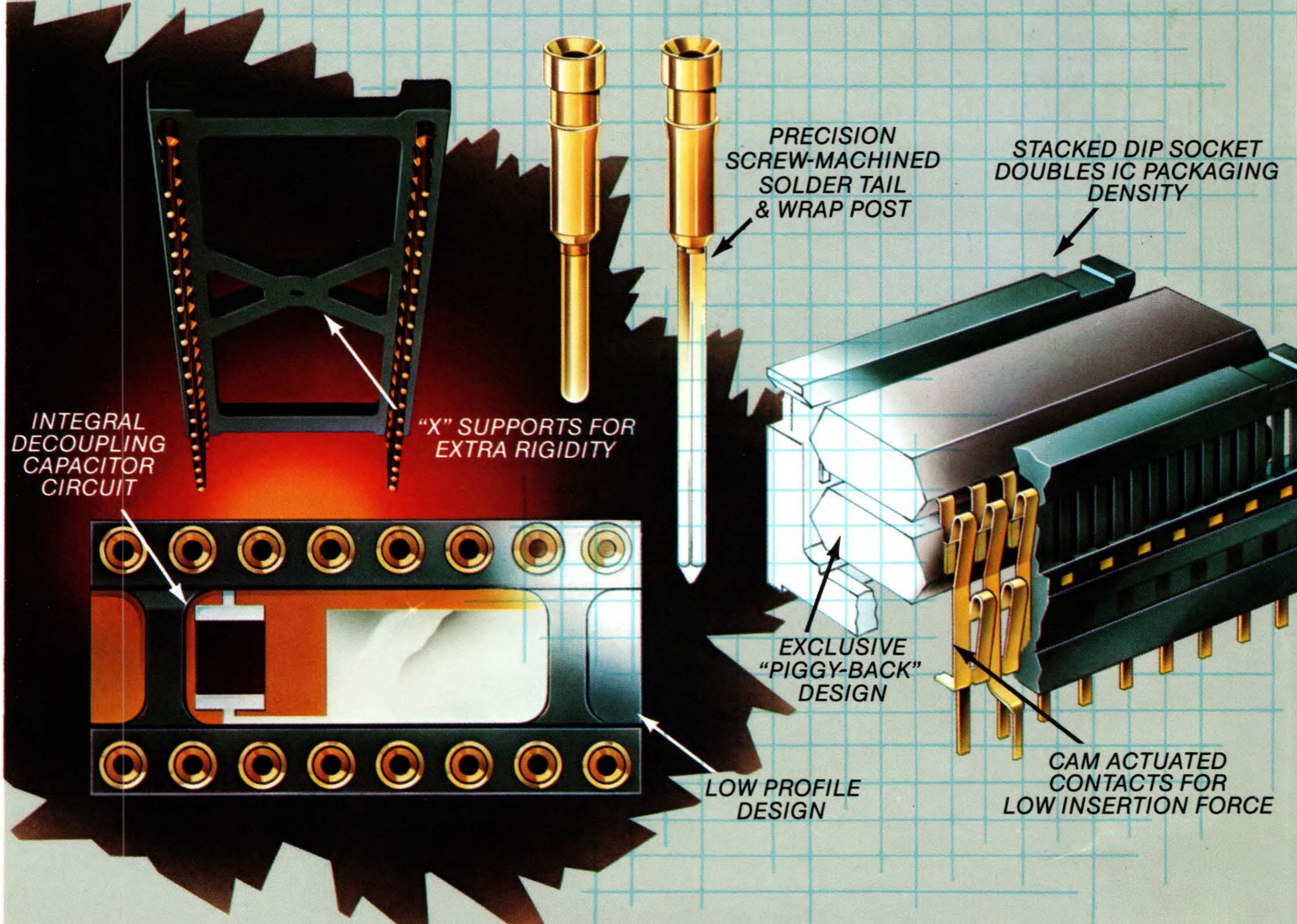
Analyze the application before selecting DMMs

Semiannual Technical Article Database Index

16-bit μP emulators

New industrial-interconnect designs keep harsh environments at bay

High density socketing from Ansley Electronics: put your latest technology into ours.



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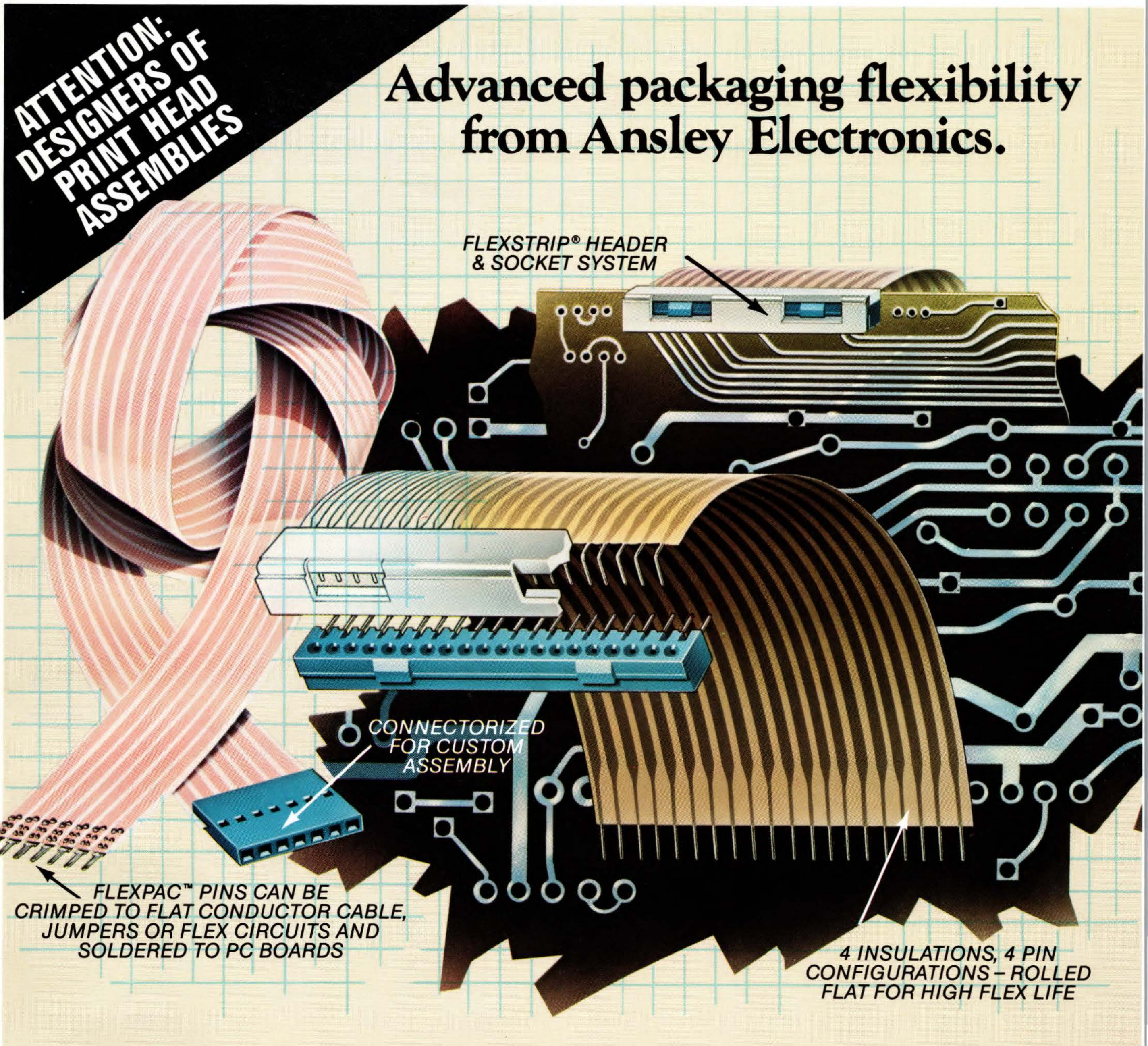

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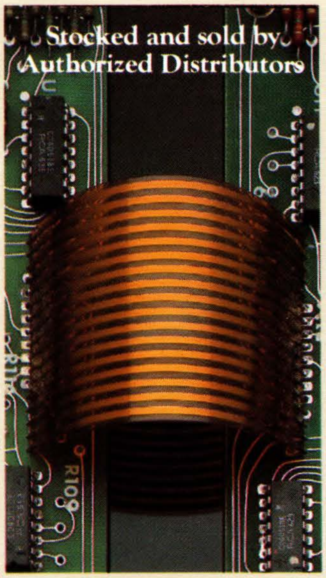

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Circle 8 for information

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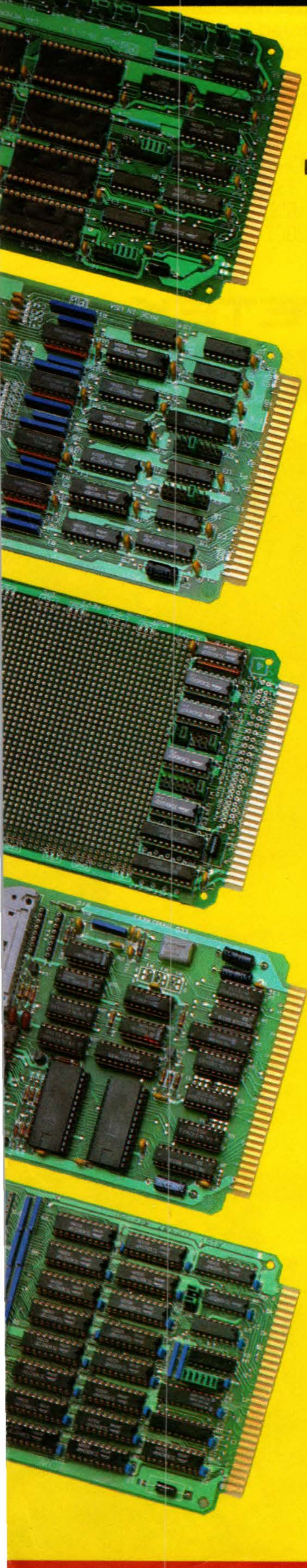

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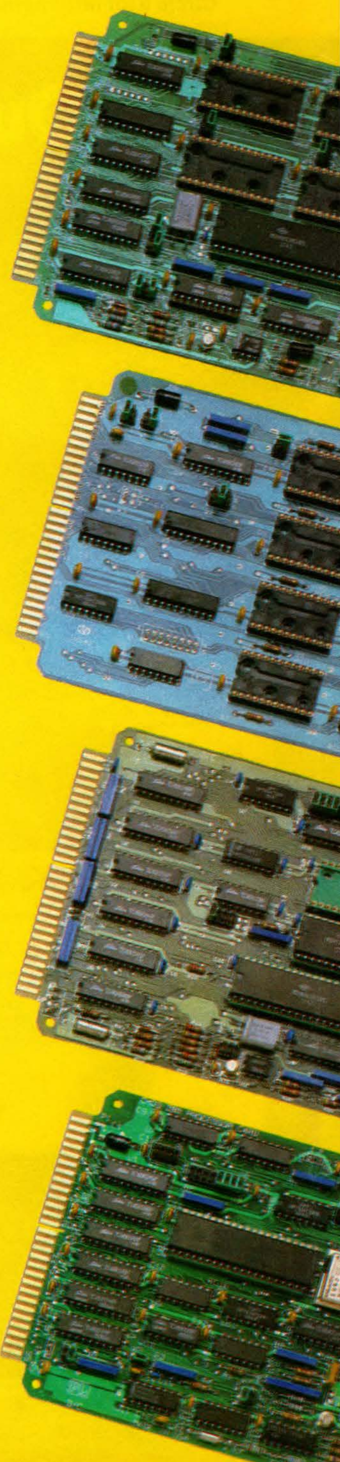

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CIRCLE NO 9

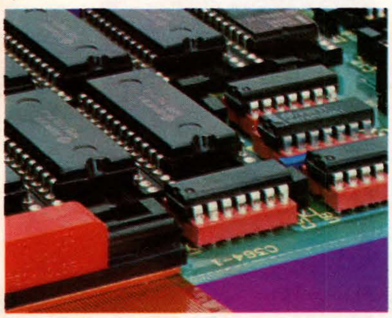
S T D B U S

EDN

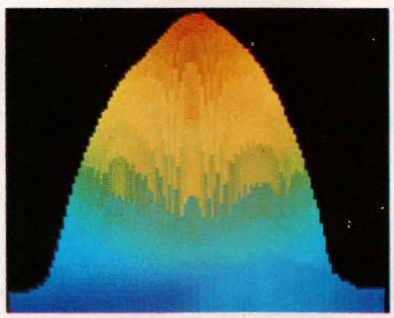
AUGUST 9, 1984 • VOLUME 29, NUMBER 16 • ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

DESIGN FEATURES

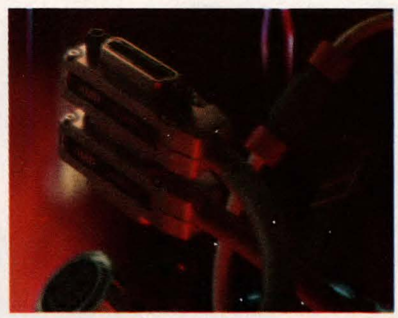
TECHNOLOGY UPDATE



Surface-mount-device technology *might be innovative, but implementation still lags the actual interest in this area. Nevertheless, new component adaptations improve the technology's prospects (pg 79).*



EDN's Semiannual Technical Article Database Index *lists articles appearing in EDN and four other major electronics publications between November 1, 1983 and April 30, 1984 (pg 223).*



On the cover: *Oil, water, humidity and heat are common elements that can affect industrial equipment. New interconnect devices keep these elements at bay. See pg 128. (Photo courtesy AMP Inc)*

Continued on page 7

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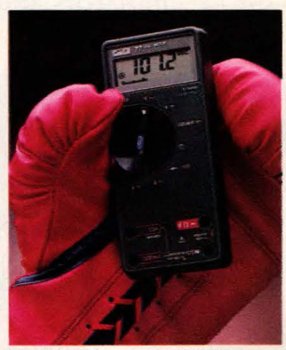

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EDN AUGUST 9, 1984

Continued from page 5

TECHNOLOGY UPDATE: NEW PRODUCTS

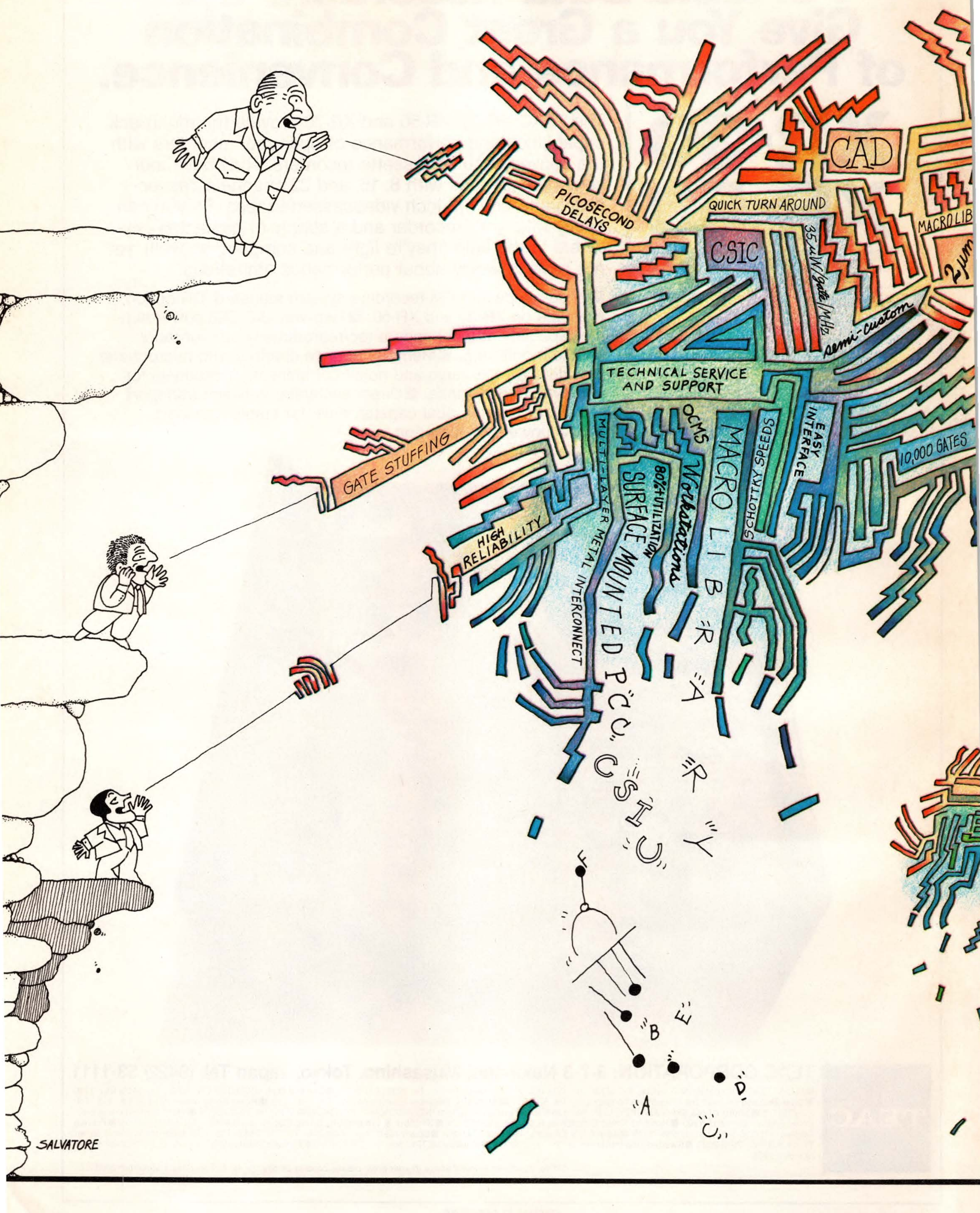
DESIGN IDEAS

NEW PRODUCTS

EEs rank US competitive stance, job satisfaction as top concerns.

Engineers will increase use of EEPROMs, NVRAMs . . . Optical-recording market to reach $5.7B by 1990 . . . Artificial intelligence attracts business users.

DEPARTMENTS



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QUICK TURN AROUND
MACROLIB
CSIC
35 µW/gate/MHz
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TECHNICAL SERVICE AND SUPPORT
GATE STUFFING
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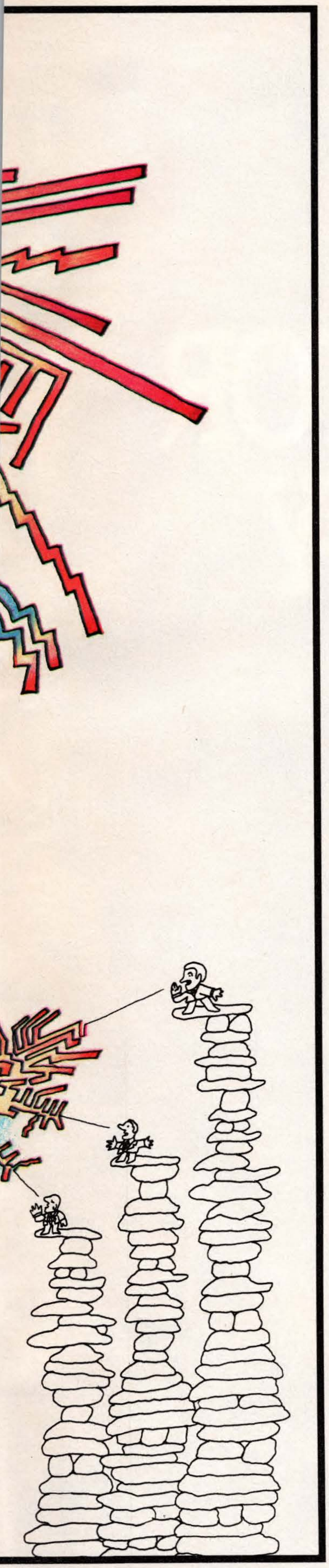

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CIRCLE NO 11

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CIRCLE NO 12

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

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Advanced program tracking and data capture.

Flexibility is the key.

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

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An analyzer that speaks your language.

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

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Clear, concise pattern definitions.

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

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

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

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

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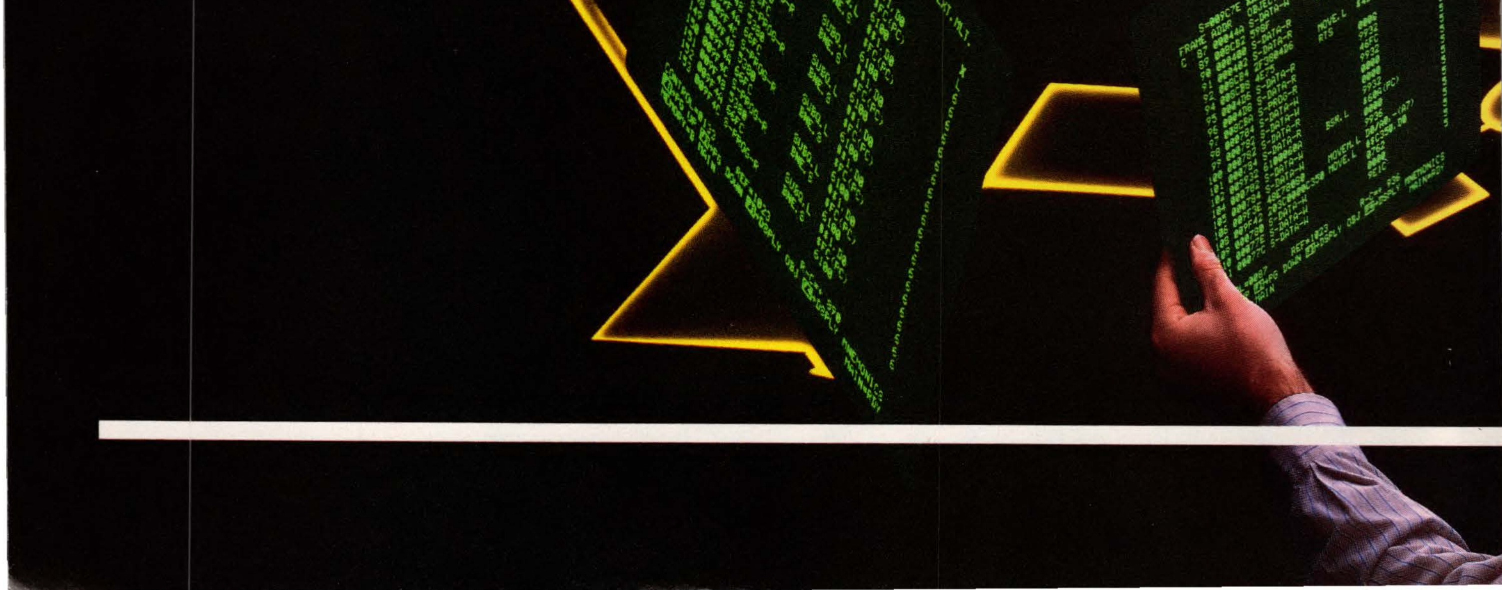

You won't get caught in a loop.
By using the K105-D's loop counter, you can follow a sequence of events for a specific number of iterations. Then stop at will.

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

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

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

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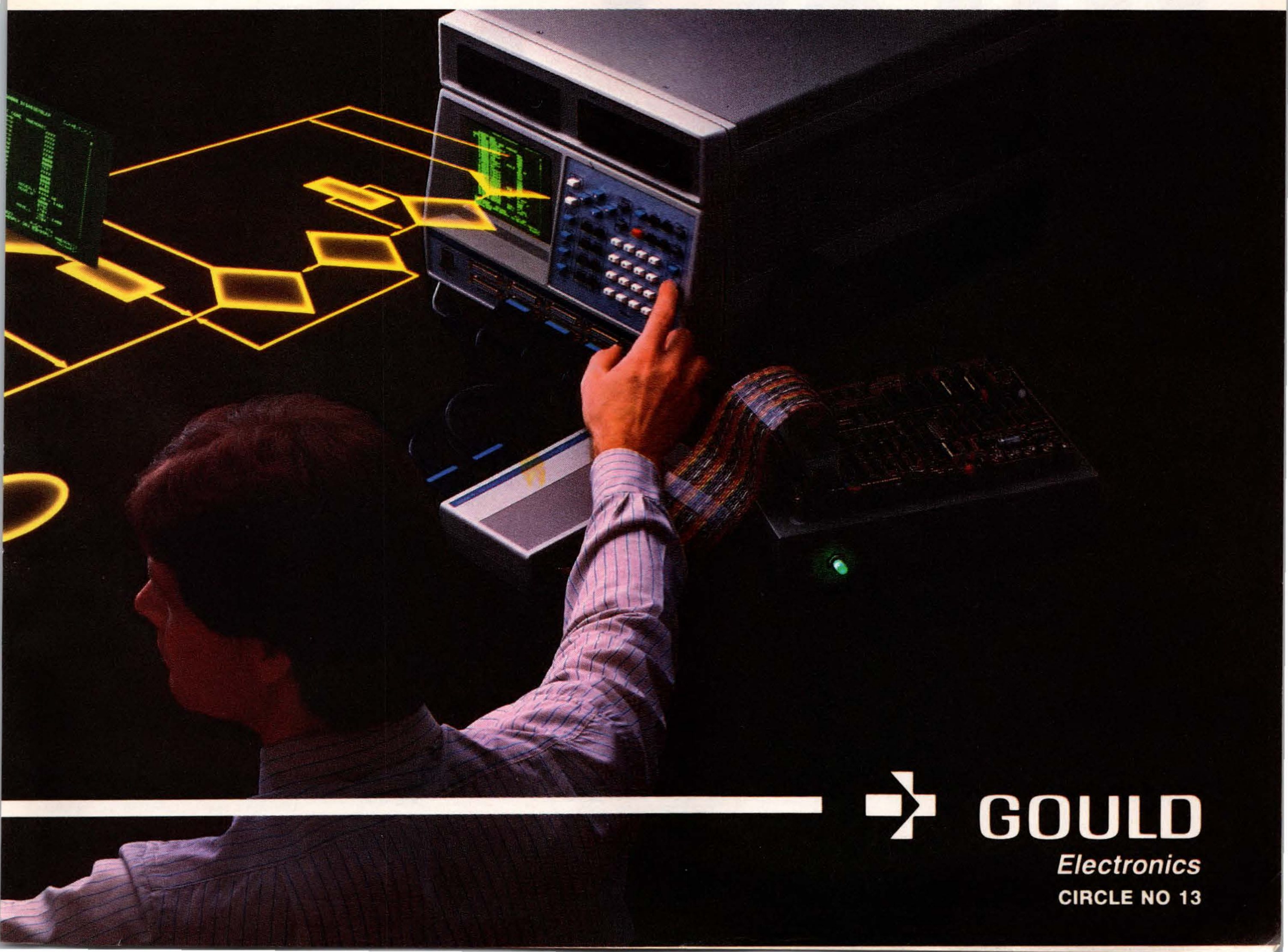
The K105-D gives you two levels of HELP at the touch of a button. First, step-by-step operating instructions that appear along the bottom of the analyzer screen. Second, a menu that allows you to select more detailed "help" should you need it.



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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 (1-4)
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CIRCLE NO 14

C74 REV. E

NEWS BREAKS

Edited by Joan Morrow

LINEAR CAD SYSTEM RUNS ON IBM PC

Micro Linear Corp's (San Jose, CA) Linear CAD I combines graphics and simulation on an IBM PC to let you design linear and linear/digital LSI. The software includes an expandable library of 30 macro cells that accelerate the design of linear circuits for the firm's bipolar-fixed and bipolar-linear arrays. The package performs schematic capture, generates a net list and executes a SPICE simulator. It costs $7900 and interfaces to the Cybernet, a network of timesharing computers that simulates circuits requiring more than 140 transistors.—Ed Teja

HIGHLIGHTS FROM NCC/84

At NCC in Las Vegas last month, Morrow Inc (San Leandro, CA) introduced a UNIX-based (System V) computer that supports four to eight users. The system's hardware is optimized for UNIX. A 3-port DMA architecture allows the I/O controller and disk controllers to talk directly to main memory. The 10-MHz MC68000 CPU can also talk to 80188-based slave processors running MS-DOS, expanding the user base. Each slave processor comes with 128k or 512k bytes of dual-port RAM. Prices start at less than $9000 ($5500 in OEM qty).

The emphasis on local-area networking at NCC prompted 3M's Interactive Systems Business Communication Products Div (St Paul, MN, (612) 736-2701) to tip its hand, showing a prototype for one type of networking. The company plans to produce a network interface for token-passing broadband LANs that will comply with IEEE 802.4, thus becoming the first announced competitor for Concord Data Systems (Waltham, MA, (617) 890-1394), whose hardware provided the physical network link at the show's LAN demonstration sponsored by General Motors. 3M's new LAN/II link will let a network operate at 10M bps, twice its current speed, and will use a true frequency translation technique as called for in the IEEE specification. It will not only implement Layers 1 and 2 (physical and data links) of the Open Systems Interconnect model, but Layer 3 (network management) and part of Layer 4 (transport protocol) as well. Samples of the unit will be available late this year, with production quantities coming early in 1985.

3M is also negotiating with manufacturers of disk drives and media to use the company's stretched-surface-recording technology for inexpensive, high-capacity storage. Prototype 5¼-in. disks, in which a flexible magnetic film covers a hard plastic disk, have achieved reliable capacities of 5M bytes per side. Removable disks, which 3M sees as an ideal application for the technology, could eventually store as much as 37M bytes, according to the company, without resorting to either perpendicular recording or thin-film media. 3M claims that error rates for the prototype disks are roughly the same as for hard disks and that shock resistance is twice as high. Minor modifications to standard Winchester drives are required to use the new disks.—Ed Teja, Richard Comerford, Gary Legg

VIDEOTEXT FINDS NEW LIFE AS COMMERCIAL TOOL

A colossal flop in the consumer field, Videotext (a character-based mix of text and graphics of approximate video-game quality) might make gains in the commercial sector if VideoLog's (Norwalk, CT) plans for an on-line catalog service materialize. Using the NAPLPS (North American Presentation Level Protocol Syntax), the firm has coded the DATA Series component data books. It expects to have the product lines of major electronics vendors encoded soon. A user of the service can obtain the electronic catalogs via a timesharing service and display them on an IBM PC or a dedicated Videotext terminal. The firm claims it can have new-product information on line 24 hours after receiving it, which is far shorter than the time required for preparing and distributing printed specs.—Charles H Small

SCHEMATIC-CAPTURE SOFTWARE RUNS ON WORKSTATIONS, MICROS

The CADroid schematic-capture software package from Lucasfilm Ltd (San Rafael, CA) runs on low-cost CAE workstations from Sun Microsystems and is making the migration to workstations from other vendors. But first, CADroid will migrate to Apple Computer's Lisa. Written in C, CADroid runs under UNIX. It comes with a library of more than 1000 TTL, ECL, MOS and linear gate representations and costs $6000 in single-unit quantities, with OEM prices of approximately $2000 (10). An automatic component-placement algorithm will be available in the 3rd qtr.—Ed Teja

LATEST IN CAE SHOWN AT DESIGN AUTOMATION CONFERENCE

The Design Automation Conference in Albuquerque, NM at the end of June was a showcase for the latest trends and products in the CAE industry. Personal workstations were a significant attraction, led by Daisy's (Sunnyvale, CA) IBM-PC-based Personal Logician, the Lucasfilm (San Rafael, CA) CADroid on a Sun workstation and the Valid (Mt View, CA) SCALDsystem IV. These workstations bring schematic capture, net-list generation and a port for simulation to your desk. Other vendors, including CAE Systems (Sunnyvale, CA), Mentor Graphics (Beaverton, OR), Calma (Santa Clara, CA) and VIA Systems (North Billerica, MA), demonstrated suites of integrated software packages supporting the range of design activity. The packages facilitate integration of the database and tools onto common systems for easier management and design automation.

During the conference, the CAE industry revealed two distinct trends: Some manufacturers offered specialized tools addressing specific design problems, while others have developed systems supporting design environments.

Increasing sophistication of the products and players in the CAE market also suggested future bearings. Some booths exemplified the movement toward joint ventures and cooperation. Several software firms were showing products in the Digital Equipment Corp (Maynard, MA) display, while the Omnicad/AT&T (Fishers, NY) and Metheus/Computervision (Hillsboro, OR) agreements resulted in shared, coordinated exhibits and products. Other booths contained unreleased products, such as Metalogic's (Cambridge, MA) silicon compiler, based on the MIT MacPitt's compiler, which generates IC layout data from a functional description. New simulation products were shown by Prime (Natick, MA), Simon (San Jose, CA), Zycad (St Paul, MN) and Silvar-Lisco (Menlo Park, CA), demonstrating higher speeds and friendlier interfaces. —David Smith

PROCESS-CONTROL COMPUTER SPEAKS ENGLISH

The IC800 STD Bus computer from MK Hannsen Co (Seattle, WA) is specifically tailored to meet the needs of process control. It comes in a heavy-gauge steel enclosure and accepts English commands for standard industrial processes, such as monitoring pressure, temperature, flow, composition or other variables.

The fully programmable system comes with an extensive library of modular process-control software. Each software package incorporates communications software that lets you use the unit as part of a distributed control network.—Ed Teja

DISK/TAPE CONTROLLER INCORPORATES DATA ENCRYPTION

The DC-6 disk/tape controller from Sigen Corp (Santa Clara, CA) connects a wide range of Winchester disk drives and a QIC-II-compatible cartridge tape drive to an IBM PC. To meet the growing need for data security, the controller furnishes data encryption/decryption using the National Bureau of Standards' Data Encryption method. This technique has been approved by the American Banking Association for electronic funds transfer. The standard

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DC-6 hard-disk controller costs $395. With data encryption (Model DC-6IE), it costs $495. With tape backup and encryption (Model DC-6Q), it costs $567.—Ed Teja

DIGITAL SCOPE OCCUPIES HALF-HEIGHT DISK-DRIVE SLOT

Although the Commodore SX-64 doesn't have expansion slots and the IBM PC might not have enough for your application, Lindgren Associates (Brattleboro, VT, (802) 257-1800) gets around the problem by replacing a full-sized 5¼-in. disk drive with a half-height drive and its half-height digital-scope module. For $3800 (the Commodore version includes the computer, and the IBM PC version includes an interface board), you receive a 4-channel, 8-MHz sampling scope.

The drive uses charge-coupled devices to store 4092 analog samples, and the unit achieves accuracies to 0.01%. With software, you select input ranges (50 mV to 10V), time base from 8 kHz to 8 MHz, trigger level (128 steps, input-level dependent) and trigger channel. The unit's A/D converter features 12-bit resolution, ½-LSB accuracy and a 14-μsec conversion time. Operating software allows you to add or subtract two waveforms and display the result, compare two forms and store setups on disk.—Paul G Schreier

USER GUIDE ON DISKETTE TEACHES PROGRAMMABLE LOGIC

Bob Osann, president of Assisted Technology Inc, has assembled an interactive tutorial that teaches programmable logic. The menu-driven program lets you choose the area and technical level you want to review. It runs on the IBM PC or a compatible system. Write to the firm on your letterhead at Suite 150, 2381 Zanker Rd, San Jose, CA 95131.—Ed Teja

COMPREHENSIVE CAE SYSTEM SUITS ELECTRONIC ENGINEERING

Racal-Redac's (Westford, MA) Computer Integrated Electronic Engineering or CIEE system supports schematic entry and simulation as well as the design needs of pc-board, hybrid, gate-array, standard-cell and full-custom technologies. It provides outputs for manufacturing equipment, including NC drills and profilers, pattern generators, automatic component insertion and automatic test equipment. Racal-Redac's V Series workstations, utilizing DEC VAXs, provide pc-board-design capability. The A Series workstations, based on Apollo computers, are used for engineering and silicon design, while IBM PCs provide engineering and data capture. A relational database permits management procedures and authorization levels, allowing job files to be transferred from workstation to workstation as well as to other systems. The facilities for the IBM PC should be available next month; those for the Apollo workstations should be available in October. Complete CIEE system software is scheduled for release in the 2nd qtr of 1985.—David Smith

3.5-IN. WINCHESTER DRIVE PACKS 20M BYTES

Microcomputer Memories Inc (Van Nuys, CA, (818) 782-2222) introduced last week a 3½-in. Winchester disk drive that stores 20M bytes of formatted data. The newest and highest capacity member of the firm's family of Winchester drives, Model M125 furnishes an average access time of 85 msec and an ST-506/412 interface. Priced at less than $600 (OEM qty), the drive fits in the same footprint as a 3½-in. floppy drive.—Ed Teja

STREAMING TAPE DRIVE FURNISHES SCSI INTERFACE

Model 540S streaming ¼-in. cartridge tape drive from Cipher Data Products Inc (San Diego, CA, (619) 578-9100) talks directly to the Small Computer System Interface (SCSI). The drive has sufficient intelligence to take over may system functions, such as running its own diagnostics and performing drive-to-tape or tape-to-drive copying operations. Production quantities will be available this month.—Ed Teja

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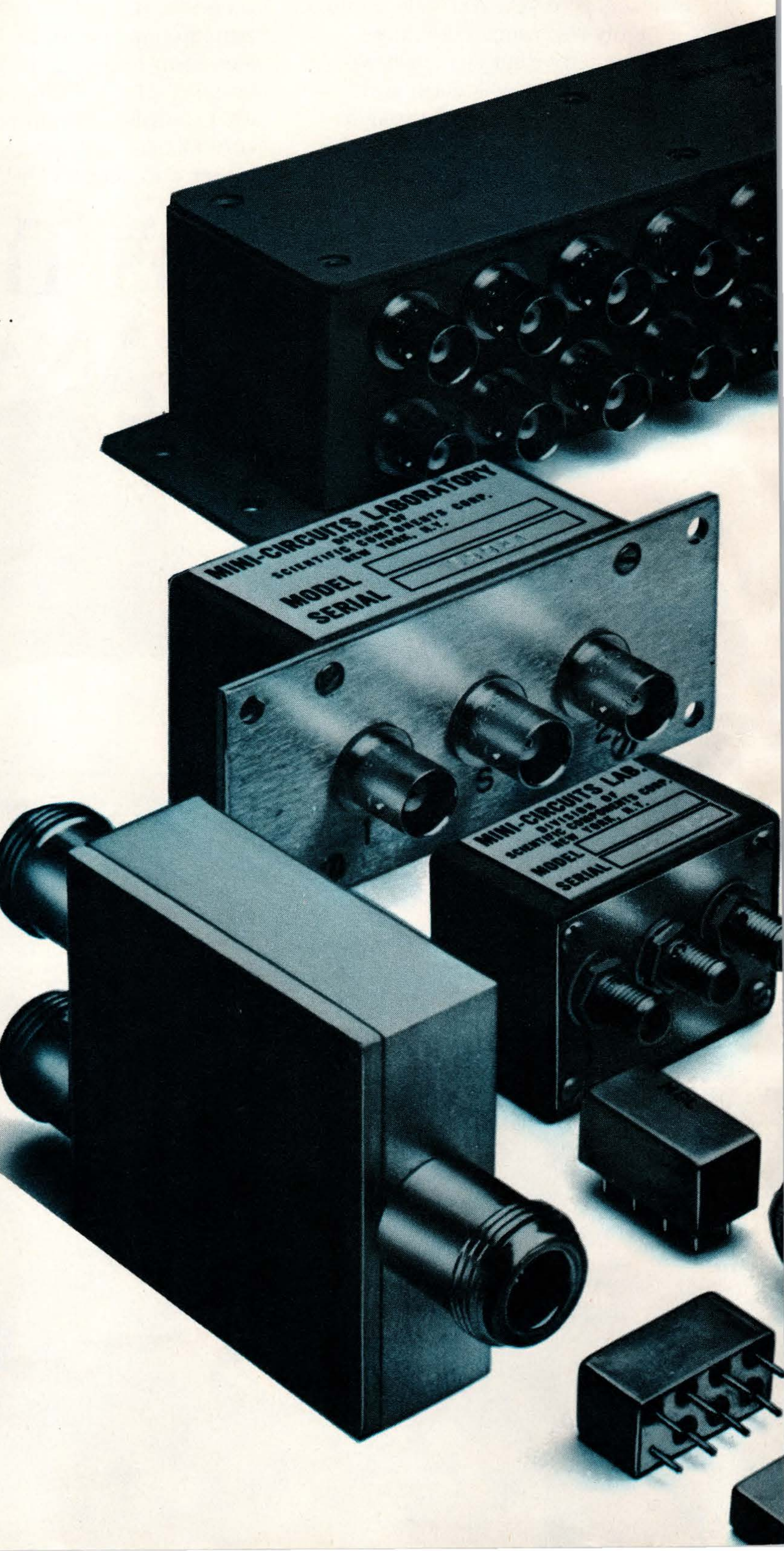

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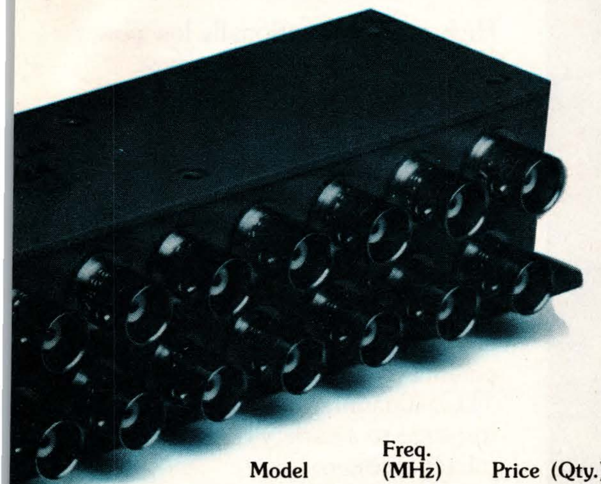
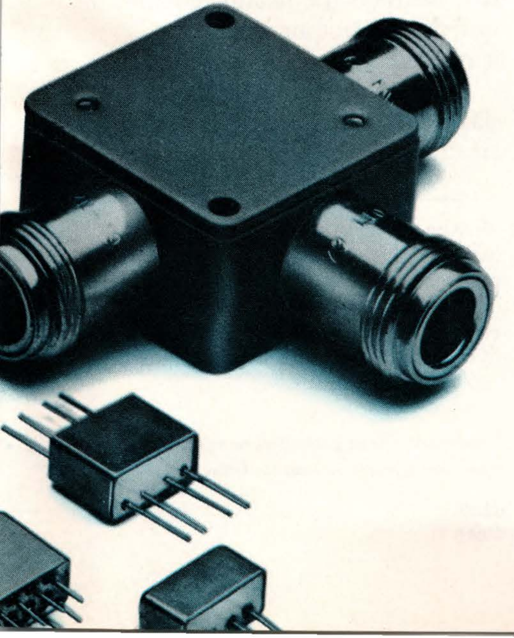


Model	Freq. (MHz)	Price	(Qty.)
2 WAY-90°			
PSCQ-2-1.5	1.4-1.7	12.95	(5-49)
PSCQ-2-3.4	3.0-3.8	16.95	(5-49)
PSCQ-2-6.4	5.8-7.0	12.95	(5-49)
PSCQ-2-7.5	7.0-8.0	12.95	(5-49)
PSCQ-2-10.5	9.0-11.0	12.95	(5-49)
PSCQ-2-13	12-14	12.95	(5-49)
PSCQ-2-14	12-16	16.95	(5-49)
PSCQ-2-21.4	20-23	12.95	(5-49)
PSCQ-2-50	25-50	19.95	(5-49)
PSCQ-2-70	40-70	19.95	(5-49)
PSCQ-2-90	55-90	19.95	(5-49)
PSCQ-2-120	80-120	19.95	(5-49)
PSCQ-2-180	120-180	19.95	(5-49)
PSCQ-2-250	150-250	19.95	(5-49)
PSCQ-2-400	250-400	19.95	(5-49)
PSCQ-2-450	350-450	19.95	(5-49)
ZAPDQ-2	1000-2000	59.95	(1-9)
ZAPDQ-4	2000-4200	59.95	(1-9)
ZMSCQ-2-50	25-50	49.95	(4-24)
ZMSCQ-2-90	55-90	49.95	(4-24)
ZMSCQ-2-180	120-180	49.95	(4-24)
ZSCQ-2-50	25-50	39.95	(4-24)
ZSCQ-2-90	55-90	39.95	(4-24)
ZSCQ-2-180	120-180	39.95	(4-24)
2 WAY-180°			
PSCJ-2-1	1-200	19.95	(5-49)
PSCJ-2-2	0.01-20	29.95	(5-49)
ZFSCJ-2-1	1-500	49.95	(4-24)
ZFSCJ-2-3	5-300	39.95	(4-24)
ZMSCJ-2-1	1-200	47.95	(4-24)
ZMSCJ-2-2	0.01-20	57.95	(4-24)
ZSCJ-2-1	1-200	37.95	(4-24)
ZSCJ-2-2	0.01-20	47.95	(4-24)



Model	Freq. (MHz)	Price	(Qty.)
2 WAY-0°			
LPS-109	10-500	15.95	(5-24)
PSC-2-1	0.1-400	9.95	(6-49)
PSC-2-1W	1-650	14.95	(6-49)
PSC-2-2	0.002-60	19.95	(6-49)
PSC-2-4	10-1000	19.95	(6-49)
■ PSC-2375	55-85	19.95	(6-24)
■ PSC-2-1-75	0.25-300	11.95	(6-49)
MSC-2-1	0.1-450	16.95	(5-24)
MSC-2-1W	2-650	17.95	(5-24)
TSC-2-1	1-400	13.95	(5-24)
ZFSC-2-1	5-500	31.95	(4-24)
■ ZFSC-2-1-75	0.25-300	32.95	(4-24)
ZFSC-2-1W	1-750	35.95	(4-24)
ZFSC-2-2	10-1000	39.95	(4-24)
ZFSC-2-4	0.2-1000	44.95	(4-24)
ZFSC-2-5	10-1500	49.95	(4-24)
ZFSC-2-6	0.002-60	36.95	(4-24)
■ ZFSC-2-6-75	0.004-60	38.95	(4-24)
ZMSC-2-1	0.1-400	37.95	(4-24)
ZMSC-2-1W	1-650	42.95	(4-24)
ZMSC-2-2	0.002-60	47.95	(4-24)
ZSC-2-1	0.1-400	27.95	(4-24)
ZSC-2-1W	1-650	32.95	(4-24)
ZSC-2-2	0.002-60	37.95	(4-24)
ZSC-2-4	10-1000	37.95	(4-24)
■ ZSC-2375	55-85	37.95	(4-24)
■ ZSC-2-1-75	0.25-300	29.95	(4-24)
	GHz		
ZAPD-1	0.5-1.0	39.95	(1-9)
ZAPD-2	1.0-2.0	39.95	(1-9)
ZAPD-4	2.0-4.2	39.95	(1-9)
ZAPD-21	0.5-2.0	49.95	(1-9)
3 WAY-0°			
PSC-3-1	1-200	19.95	(5-49)
PSC-3-1W	5-500	29.95	(5-49)
PSC-3-2	0.01-30	29.95	(5-49)
■ PSC-3-1-75	1-200	20.95	(5-49)
■ PSC-3-1-75-2	10-300	22.95	(5-49)
PSC-3-13	1-200	24.95	(5-49)
ZFSC-3-1	1-500	39.95	(4-24)
ZFSC-3-1W	2-750	41.95	(4-24)
ZFSC-3-13	1-200	39.95	(4-24)
ZMSC-3-1	1-200	47.95	(4-24)
ZMSC-3-2	0.01-30	57.95	(4-24)
ZSC-3-1	1-200	37.95	(4-24)
ZSC-3-2	0.01-30	47.95	(4-24)
■ ZSC-3-1-75	1-200	38.95	(4-24)
■ ZSC-3-2-75	0.02-20	48.95	(4-24)
	GHz		
ZA3PD-1	0.5-1.0	79.95	(1-9)
ZA3PD-1.5	0.75-1.5	79.95	(1-9)
ZA3PD-2	1-2	79.95	(1-9)
ZA3PD-4	2-4.2	79.95	(1-9)

■ Denotes 75 ohm models

Performance over the entire frequency range is approximately less than 1 dB insertion loss, greater than 20 dB isolation, less than 0.5 dB amplitude unbalance and less than 3 degree phase unbalance.

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CIRCLE NO 17

Model	Freq. (MHz)	Price	(Qty.)
4 WAY-0°			
PSC-4-1	0.1-200	28.95	(6-49)
■ PSC-4-1-75	1-200	24.95	(6-49)
PSC-4-3	0.25-250	23.95	(6-49)
PSC-4-6	0.01-40	29.95	(6-49)
PSC-4A-4	10-1000	49.95	(6-49)
ZFSC-4-1	1-1000	89.95	(1-4)
ZFSC-4-1W	10-500	74.95	(1-4)
ZFSC-4-3	10-300	69.95	(1-4)
■ ZFSC-4375	50-90	89.95	(1-4)
ZFSC-4-2-75-1	200-800	74.95	(1-4)
ZMSC-4-1	0.1-200	56.95	(4-24)
ZMSC-4-2	0.002-20	69.95	(4-24)
ZMSC-4-3	0.25-250	53.95	(4-24)
ZSC-4-1	0.1-200	46.95	(4-24)
■ ZSC-4-1-75	1-200	46.95	(4-24)
ZSC-4-2	0.002-20	69.95	(4-24)
ZSC-4-3	0.25-250	43.95	(4-24)
	GHz		
ZA4PD-2	1-2	79.95	(1-9)
ZA4PD-4	2-4.2	79.95	(1-9)
ZB4PD-42	1.7-4.2	99.95	(1-9)
ZB4PD-4	3.7-4.2	89.95	(1-9)
5 WAY-0°			
PSC-5-1	1-300	59.95	(1-5)
■ PSC-5-1-75	1-300	59.95	(1-5)
6 WAY-0°			
PSC-6-1	1-175	68.95	(1-5)
■ PSC-6-1-75	1-300	78.95	(1-5)
ZFSC-6-1	1-175	89.95	(1-4)
■ ZFSC-6-1-75	1-200	89.95	(1-4)
8 WAY-0°			
PSC-8-1	0.5-175	68.95	(1-5)
■ PSC-8-1-75	0.5-175	69.95	(1-5)
PSC-8-6	0.01-10	79.95	(1-5)
PSC-8A-4	5-500	89.95	(1-4)
■ PSC-8A4-75	1-300	79.95	(1-4)
ZFSC-8-1	0.5-175	89.95	(1-4)
■ ZFSC-8-1-75	0.5-175	90.95	(1-4)
■ ZFSC-84-75	1-300	119.95	(1-4)
■ ZFSC-8375	50-90	119.95	(1-4)
ZFSC-8-4	5-700	129.95	(1-4)
ZFSC-8-43	30-1000	139.95	(1-4)
ZFSC-8-6	0.01-10	109.95	(1-4)
	GHz		
ZB8PD-2	1-2	149.00	(1-9)
ZB8PD-4	2-4.2	149.00	(1-9)
12 WAY-0°			
	MHz		
ZFSC-12-1	1-200	174.95	(1-4)
ZFSC-12-11	10-300	174.95	(1-4)
16 WAY-0°			
ZFSC-16-1	0.5-125	174.95	(1-4)
ZFSC-16-3	1-30	174.95	(1-4)
■ ZFSC-16-675	0.01-25	189.95	(1-4)
ZFSC-16-12	0.1-200	189.95	(1-4)
24 WAY-0°			
ZFSC-24-1	0.2-100	264.95	(1-4)
ZFSC-24-11	1-200	274.95	(1-4)
ZFSC-24-6	0.025-50	274.95	(1-4)
48 WAY-0°			
ZFSC-48-1	10-300	595.00	(1-4)
■ ZFSC-48-1-75	10-300	595.00	(1-4)

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You only have to remember TI. And two new LinCMOS families: The 28-pin TLC532A family with parallel output, and the 20-pin TLC540 family with serial output for interface to a variety of popular microprocessors.

One-chip data-acquisition system

Both families provide an entire data-acquisition system, from analog multiplexer to digital data bus, on one chip. You treat the IC as a simple plug-in component, replacing a board of parts.

Eliminating external components also reduces total system costs. And the chip itself is less costly than many metal-gate CMOS ICs having only an A-D converter function.

One potential application for the new LinCMOS peripherals is environmental control. An array of these A-D peripherals could sense room temperatures throughout a building and feed them to a microprocessor that instructs the heating/cooling system to direct air where it is needed.

Result: Energy bills could be slashed by a simpler, more cost-effective system.

◀ **Moving energy costs down** by moving air around—that's how TI's new LinCMOS A-D peripherals could work in a large building. These ICs could take multiple readings of each room's temperature for a microprocessor that quickly determines where warmer or cooler air is needed.

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Photo taken at Plaza of the Americas, Dallas, Texas.

control system with TI's new microprocessor-controlled A-D ICs.

DATA-ACQUISITION EVOLUTION

	1979-83	1981-85	1983-1990s
Technology: Process: Circuit:	 Metal-gate CMOS Resistor ladder	 Metal-gate CMOS Switched capacitor	 Si-gate LinCMOS Switched capacitor
Converter: Part types:	 ADC0808, 0809N	 TL520, 521, 522N	 TLC532A, 533A
Size: Components:	8,000 mil² 256 resistors 511 switches	1,700 mil² 9 capacitors 26 switches	500 mil² 9 capacitors 26 switches
Features: Bar size: Speed: Error: Inputs:	 29,000 mil² 10k samples/sec. ±0.75 LSB 8 analog	 21,000 mil² 14k samples/sec. ±0.75 LSB 8 analog	 15,000 mil² 67k samples/sec. ±0.5 LSB 11 analog*

*Includes six multipurpose inputs.

Major speed improvements, more inputs, smaller size—the evolution to LinCMOS products from metal-gate technology reflects big performance boosts and operational advantages, creating a bright linear future.

Up to 71,000 samples per second

Dramatic speeds are available—as fast as 71,000 samples per second. With power requirements as low as 6.0 mW.

This allows noise canceling and precise control of blower motors or heating elements. While virtually eliminating bulky power supplies.

Exceptional stability over a wide temperature range

Both the TLC532A family and the TLC540 family offer excellent temperature-range stability—total output error is within ±0.5 least significant bit (LSB) over a wide temperature range—from −40° to 85°C.

Military versions, also available, are stable within ±0.5 LSB over a −55° to 125°C temperature range.

Handle up to 11 inputs

Each LinCMOS A-D peripheral family allows a processor to monitor up to 11 analog signals. Six signals can be digital, if preferred, allowing keyboard or switch-position sensing.

These devices feature a built-in sample-and-hold circuit (software-controlled on the TLC540) that holds a "snapshot" of the input signals to reduce the effects of noise and random spikes.

Immediate availability

All of these LinCMOS A-D peripherals are TTL, MOS, and CMOS compatible. And all are available now. With performance that will change the way you look at linear.

Environmental control is only one possibility. These LinCMOS peripherals offer many opportunities in test equipment, automotive instrumentation, industrial controls, robotics, toys, home computers, signal processing, and other applications.

For more information on TI's a/d converters, op amps, and the LinCMOS process that creates them, call your authorized TI distributor or nearest TI sales office. Or write Texas Instruments Incorporated, Dept. SLA043ED, P.O. Box 809066, Dallas, Texas 75240.

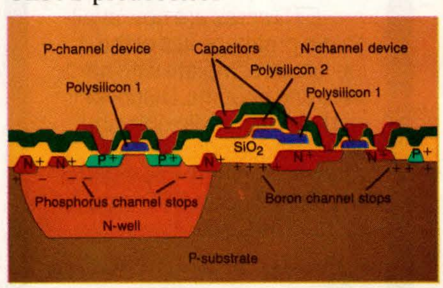
TI is first with silicon-gate CMOS for linear.

The key to a successful combination of CMOS and bipolar capabilities: Phosphorus doping of the silicon gates that effectively halts and binds sodium ions—the main cause of threshold voltage shifts in MOS-based technologies.

For enhanced carrier mobility, NMOS transistors are placed in a p-type substrate and the PMOS transistors in an n-well. This increases carrier mobility of the NMOS transistors to about 3.7 times that of the PMOS transistors, enhancing speed.

The LinCMOS process also provides a gate-to-drain capacitance about one-seventh that of metal-gate CMOS. This performance stems from gate formation, which is accomplished in the same step that forms the transistor source and drain. The source, gate, and drain are all self-aligned, boosting speed and enhancing the bandwidth even further.

And the final result: A built-in speed advantage that greatly enhances AC performance and makes possible the 20X speed improvement of the TLC532A over its pin-compatible metal-gate TL532 predecessor.



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CIRCLE NO 18

SIGNALS & NOISE

UNIX omissions

Dear Editor:
I would like to commend your editorial staff on its fine article about UNIX (EDN, May 17, 1984, pg 102). It presented the information effectively, and I particularly liked the comparison table.

I'd like to call your attention to one omission to which I was particularly sensitive. As product manager for Hewlett-Packard's UNIX-based systems, I'd like to point out the fact that HP has two UNIX-based systems.

The HP 9000 Series 500 is a full 32-bit superminicomputer for engineering work. It's available as a workstation with high-performance graphics and as a multiuser system for software development and scientific computation. It's being enhanced with more memory and a new operating-system release to support as many as 32 users. We're also offering CAD packages, including ANSYS, ANVIL and GRAFTEK. System prices start at about $50,000.

The HP 9000 Series 200 is a 68000-based supermicrocomputer that serves as a lower end to the 9000 family. It's appealing to OEMs and other resellers because of its starting price of about $25,000.

Sincerely,
Doug Hartman
UNIX Systems Product Manager
Hewlett-Packard Co
Cupertino, CA

"I SEE THEY'RE STILL WORKING ON THE WORTHINGHAM JOB!"

Dear Editor:
CIE Systems (2515 McCabe Way, Irvine, CA 92713, (714) 660-1800), a manufacturer of computers based on a UNIX-like operating system called Regulus, was omitted from the Special Report on UNIX.

Regulus is a multiuser, timesharing operating system for the CIES 680 family of business computers. It's compatible with UNIX and offers multiple users the ability to execute multiple tasks while requiring less memory than UNIX. Signals are queued to support real-time tasking with 32 system-defined events and 32 user-defined events. Because these events are priority driven, Regulus ensures rapid response to real-time events.

Sincerely,
Ned Madden
Account Manager
The Cox & Burch Advertising Co
Newport Beach, CA

Emulator clarification

Dear Editor:
We would like to correct a misunderstanding about the HP 64264S 8051 emulator. In the article describing Emulogic's 8051 emulation support (EDN, June 14, pg 102), you state: "Because bond-out chips still aren't available, Emulogic, like HP, employs the external-memory version of the 8051-8031." This is not true for the Hewlett-Packard 8051 emulator.

SIGNALS & NOISE

To circumvent the lack of bond-out chips, our engineers designed and implemented a custom chip to serve in lieu of a bond-out chip. With the custom chip, the HP 64264S 8051 emulator supports emulation of the 8051 microcomputer at full speed (12 MHz) without wait states. The HP 64264S emulator nonintrusively captures system activity and accesses program memory, internal and external data memory, accumulator and special-function registers, and I/O ports 0, 1, 2, and 3.

In short, the HP 64264S 8051 emulator provides full emulation of the 8051, 8031 and 8751 chips, as you reported in the article introducing Hewlett-Packard's emulator (EDN, May 31, pg 82).

Sincerely,
Mark Tolliver
Product Marketing Manager
Logic Systems Div
Hewlett-Packard Co
Colorado Springs, CO

Editor's response

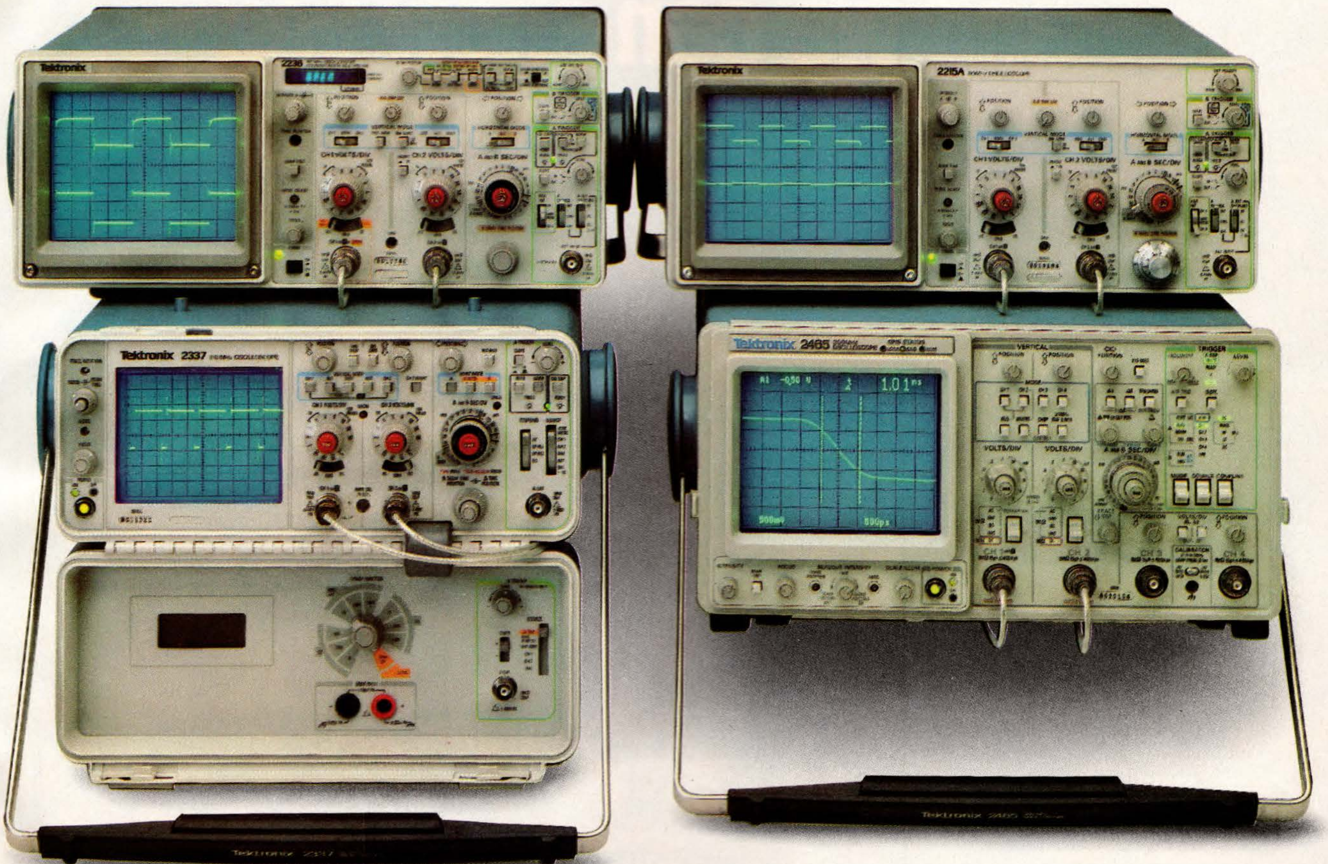
We regret lumping HP's 8051 emulator with Emulogic's 8051 emulator; the sentence quoted should, of course, read "...Emulogic, *unlike* HP,..." We also must point out that HP did not reveal the internal workings of its 8051 emulator's pod when it announced the 64264S. The difficulty with emulating the 8051 is well known, and we think our readers would have liked to have known how HP did it.

Sincerely,
Charles H Small
Associate Editor

Correction

Sierra Scientific Corp is listed incorrectly as a manufacturer of color monitors in the May 31 Special Report on that topic (pg 123). The company is not a maker of color monitors. Also, the correct address of the company is 2598 Bayshore Frontage Rd, Mt View, CA 94043.

High performance portable scopes. One name says it all!



A world standard in performance plus value: the Tek 2000 family of portable scopes. Each one has different characteristics but they have plenty in common: quality that's unmistakably Tektronix. In our 30 years of oscilloscope leadership, no other scopes have recorded such immediate popular appeal.

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 performance for the money.

There's a full family of scopes to fit demanding portable needs. At 60 MHz, choose the 2213A or dual time base 2215A. At 100 MHz, the 2235 or 2236 with its bright fluorescent readout and integrated counter/timer/DMM. For field service environments, the ultra-durable, 100 MHz 2335, 2336 or 2337, built to be rugged and reliable beyond all previous standards.

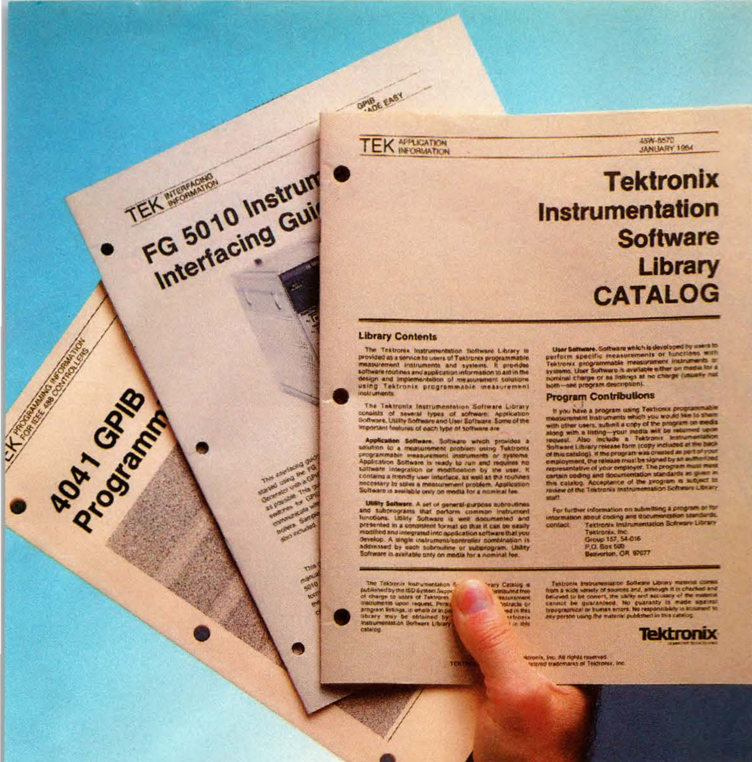
Finally, there are the 150 MHz 2445 and 300 MHz 2465: the leading edge in portable scope performance. Now you can specify either with built-in GPIB interface for automated measurements and a powerful TV option for precise video measurements.

Contact the Tektronix office or sales representative nearest you for complete details. Each scope is backed by a 3-year warranty, excellent documentation, training programs, plus applications and service support worldwide. All part of the high standard of excellence to expect when you work with Tektronix, the world's largest and most respected scope manufacturer.

Tektronix®
COMMITTED TO EXCELLENCE

TEK INSTRUMENTS AND SYSTEMS

Your know-how. Our systems. Tell us your needs and we can show you a thing or two.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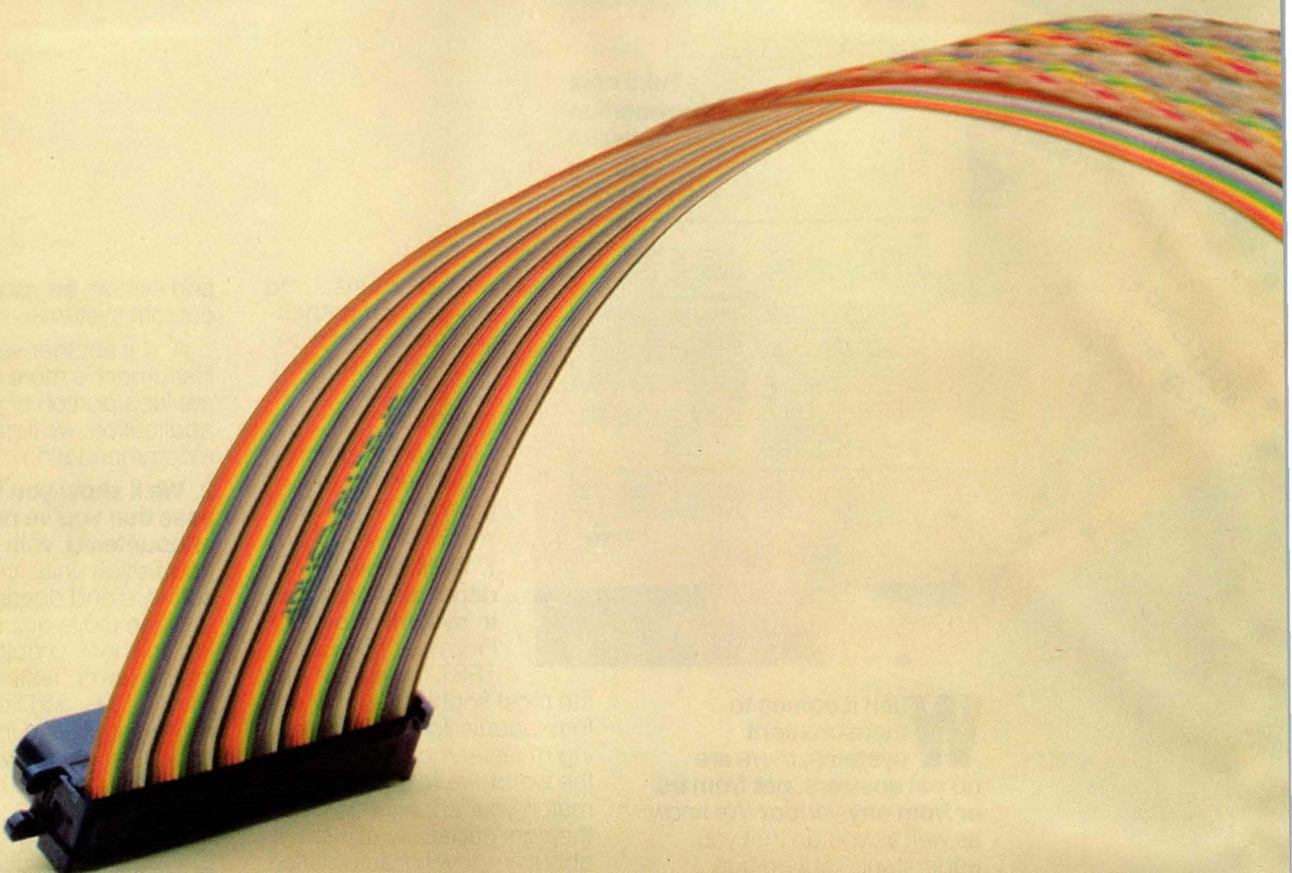


There's no end to it.

Stop searching. Nobody offers you a greater potful of planar interconnect solutions than Amphenol Products, the new connector company.

Our expertise in the design, development and production of Spectra-Strip® planar cable, IDC connectors and complete interconnect systems, makes it easy for us to make planar assembly easy for you.

You can get the quality products and service you need. Fast. We make more varieties of planar cable for special applications than anyone else. Anywhere. Of course, we've got a wide range of IDC connectors to match.

From computers, to communications equipment, to instrumentation, Spectra-Strip cable and connectors are your cost-effective, no-hassle interconnection solution.

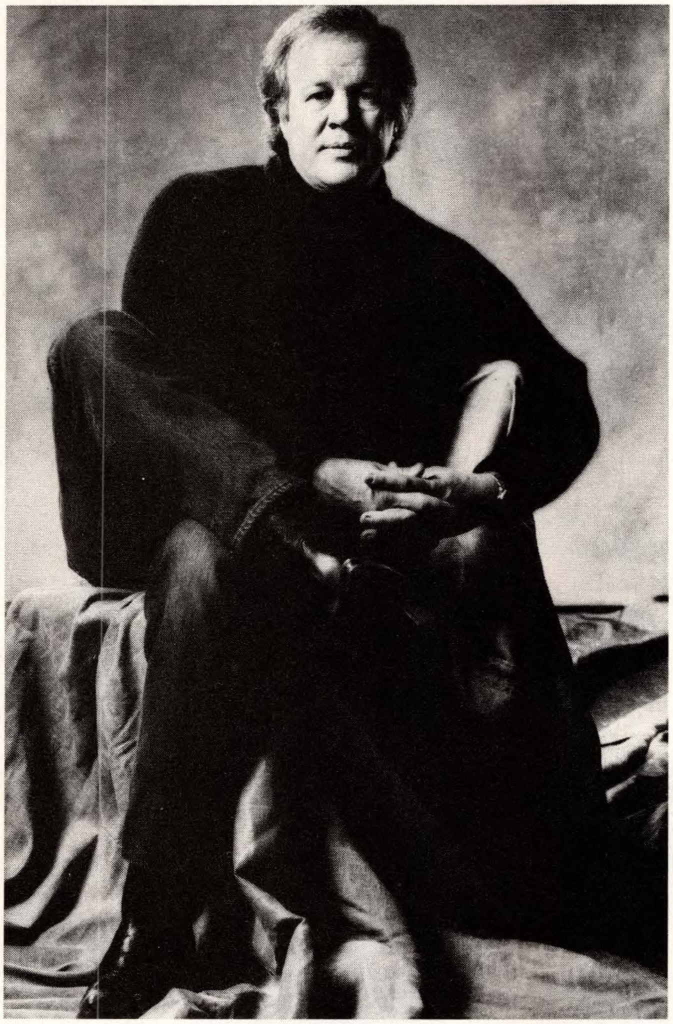
Get our quote on complete assemblies. We can give you a uniquely engineered planar system that will lower your total installed cost.

In planar products, there's no end to what we can do for you. And we're easy to find today. For more information, technical and application data, prices and delivery, contact your nearest Amphenol Products sales office.

ALLIED Amphenol Products


SPECTRA-STRIP

"IN 2001, WE REACHED THE STARS. NOW, WE CAN PRACTICALLY TOUCH THEM."



DOUGLAS TRUMBULL
Director. Creator of Oscar Winning Special Effects. Three-Time Oscar Nominee. Film Making Innovator.

The year was 1968.

But for the audience, the year was 2001. And they were not in a movie theater, they were in deep space — propelled by the stunning special effects of Douglas Trumbull.

The incredible realism of "2001. A Space Odyssey" opened new possibilities in film making — which Trumbull explored in "Silent Running," "Close Encounters," "Star Trek," "Blade Runner," and "Brainstorm."

But ultimately, it launched Trumbull on an odyssey that may completely revolutionize films.

"Films try to recreate or record reality. The more life-like a film is, the more exciting it will be. Right now, I'm trying to create the most life-like films ever."

Trumbull has developed a new way to shoot and project film that goes beyond 3-D. In "New Magic," his first effort, the images are so sharp and life-like the screen seems non-existent.

"The difference is astonishing. Yet, all we did was utilize the full potential of the technology. It's that simple."

Trumbull is, perhaps, being too modest. At Hewlett-Packard, we know it takes exceptional skill and commitment to transform mere potential to full reality. That's what sets Hewlett-Packard apart, just as it sets Douglas Trumbull apart.

Like Trumbull, we've found that the superior results justify the effort. And the clear superiority of the HP-41CX Advanced Programmable Calculator is a perfect example.

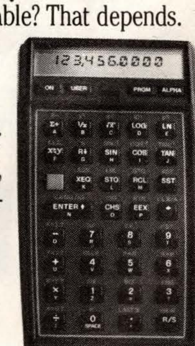
Compare functionality. The HP-41CX offers 223 built-in functions. But that's just the beginning. You'll have over 2,500 different software programs to choose from.

Compare programmability. The HP-41CX gives you 2.2K bytes of main memory — again, just the beginning. It expands to 6.4K bytes. And the RPN logic of the HP-41CX gives you maximum use of memory through its ability to eliminate scores of extraneous keystrokes.

More functionality. Superior programmability. In short, the power to solve more kinds of technical problems more simply than any other calculator.

The HP-41CX.

Do you need a calculator this capable? That depends. Do you want to merely reach for the stars, or actually touch them?



For the HP dealer nearest you, call (800) FOR-HPPC.

HEWLETT PACKARD

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NATIONAL ANTHEM®

Technology News From National Semiconductor 52

microCMOS Brings New Lower Cost Solutions For Board Level Systems

Higher speed, lower power, more applications

Recently, design engineers have learned to rely on National's CIMBUS™ board family for low power, high speed CMOS reliability. Performance superior to NMOS – at NMOS prices.

With the expansion of its microCMOS product line, National is now offering customers an even greater choice of high-quality, cost-effective CIM™ (CMOS Industrial Microcomputer) boards.

True reliability

The low power consumption of CIMBUS components results in low power dissipation. This makes the boards ideally suited for sealed enclosure – allowing them to operate trouble-free even in unforgiving environments.

Further, low power dissipation, along with a choice of two temperature ranges – plus improved noise immunity & vibration resistance – guarantee a true high-reliability product.

Smaller size = smaller cost

Each board in the CIMBUS microCMOS line uses the single-wide Eurocard form factor – 100mm x 160mm. Overall system size is greatly reduced with a corresponding drop in system cost.

Near-limitless applications

Strengthened with microCMOS, CIM boards offer an incomparable application potential. With over 60 available products (many second-sourced) to choose from, design engineers will find a board to fit almost every application need – portable computing, medical instrumentation, pipeline monitoring, robotics, communications & alarm systems, and more. And National's complete CIMBUS software support package ensures a perfect match wherever the boards go.

Lower total-system cost

The company's extensive CIMBUS line offers systems engineers additional and immediate board-level solutions that significantly aid in reducing total system costs.

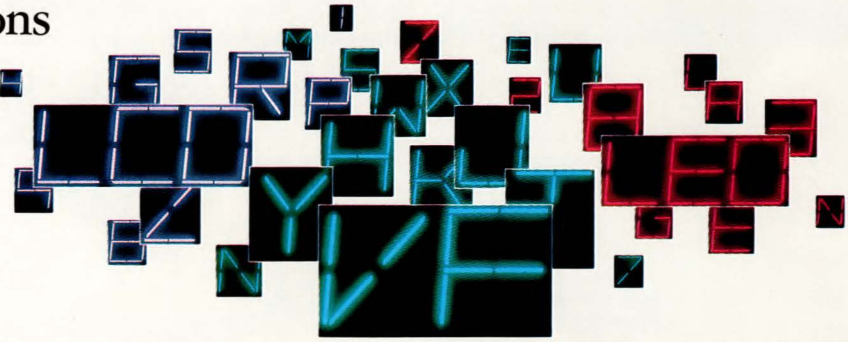
Blue-ribbon performance, expanded applications, lower end-system costs – these features explain National's continuing lead in CMOS board-level technology.

*For more information on the CIMBUS line, check box **L4** in the back page coupon.*

Inside News

National Semiconductor

Versatile New Additions To the 'First Family' Of Display Drivers



For all display technologies – LED, LCD and VF

National's broadbase family of popular display drivers now strengthens its leadership position by adding its newest VF and LCD drivers – the MM58241/8, MM58341/8 and the MM58538/9, MM58540/8 respectively.

Unrivaled compatibility

Each driver in this comprehensive 22-member family offers function-similar features – a simple serial data-input channel, a 31- to 35-bit shift register, latches, and buffer/drivers for direct interface to respective LED, LCD or VF displays. This compatibility provides users with true design flexibility in selecting display technology.

VF products: direct microprocessor interface plus full features

High-voltage MM58241/8 (up to 60V) and MM58341/8 (up to 35V) VF drivers furnish a direct, simple interface from microprocessor to display. In addition, they offer on-chip pull-down resistors, direct serial data and clock interface, on-chip brightness and blanking control, and data-out for easy cascading. Each is ideal for driving multiplexed VF displays such as 5 x 7 dot-matrix character arrays.

Equally important, the new VF drivers fit a wide scope of customer applications, from sophisticated instrumentation to automotive dashboard readouts and word-processor text displays.

With industry-first metal gate CMOS and full software compatibility, National's VF display drivers become instant favorites with both hardware and software engineers.

Unique flexibility in multiplexed 32/34-bit LCD drivers

Socket-equivalent to the HLCD0538 series, National's innovative MM58538 family provides full TTL compatibility plus alphanumeric, dot-matrix, and bar graph display capabilities.

Advanced features like these bring engineers of microprocessor-based systems the true flexibility necessary to maintain their competitive edge.

Traditional quality and performance

The new VF and LCD driver family members are carrying on an all-important National tradition of high-performance, first-quality drivers offered at a reasonable cost – for all popular display technologies.

*Check box **R5** on the back page of this Anthem to receive National's display driver family brochure.*

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 ouput 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 offering 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.

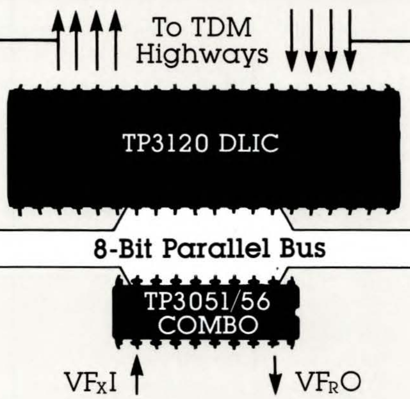
Design entry via workstations

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.*

COMBO and DLIC Enhance Digital Line Card Performance With Parallel Data Bus



Increased capacity–up to 32 lines

National's TP3051 codec/filter COMBO™ and TP3120 digital line interface controller (DLIC) share a unique parallel data bus which allows–for the first time at reasonable cost–32 subscriber lines on a single line card.

Increased speed–just one time slot switching delay

The high-speed data bus interface combines with the DLIC's non-blocking first-level time and space switching to produce faster switching speeds than those offered by any conventional time slot interchanger (TSI). As fast as one time slot delay.

This new approach significantly improves the call efficiency of the total system.

Decentralization, modularity mean more flexibility–now and for the future

As in any parallel bus structure, as opposed to serial, the straightforward addition of new peripherals can be accomplished without the need for interface logic and significant software control.

The result is a simple pathway for upward migration towards full digital loops, voice-data terminals and ISDN.

HDLC security

The DLIC provides a secure pathway for control data to the main system processor. The use of High-Level Data Logic Control guarantees the security of control information flowing between line cards and the supervising processor. Again, the need for additional or redundant hardware/software is eliminated.

And because the control messages are integrated into the PCM bit stream, line card modules can be remotely located via any standard digital line system–further expanding the DLIC's modular capabilities.

National's parallel COMBO is available in μ law (TP3051) or A LAW (TP3056). The DLIC is available with 8-bit parallel I/O and four full duplex serial TDM highways (TP3120)–or 10-bit parallel I/O and two full duplex serial TDM highways (TP3110).

Low-cost telecommunication solutions

With broad-range applications in the telecommunications field (PBX & central office switching, voice-data terminals, digital telephones and more), the new parallel interface chips provide design engineers with a viable means of packing more lines per line card while increasing system speed and reducing overall system complexity and cost.

*Check box **N1** on the back page of this Anthem for more information on the TP3110/20 and TP3051/56 circuits.*

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

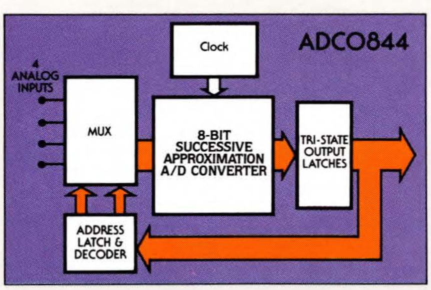
μP compatible too

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 μs (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 compete details, check box **J0** in the coupon on back page.*

Series 32000™–the industry standard for 32-bit microprocessors.

The Fourth Dimension–Time to Market

In today's fast paced, high technology marketplace, time equals money. You need product and National responds.

National provides the best and most complete 32-bit microprocessor family of CPUs, slave processors, systems peripherals, development tools and software... ***today!***

When you thoroughly evaluate and compare the other options it will become clear that the Series 32000 is the undisputed choice.

Full 32-bit architecture

In a world of over-stretched band-aided microprocessor architectures, National sets the record straight–the Series 32000 is the world's first commercially available 32-bit microprocessor that was designed as a 32-bit. National has taken a systems solution approach to give you what you need: An innovative microprocessor family that you can count on for your performance needs now.

32-bit–An advanced 32-bit architecture is the basis of the Series 32000. This same 32-bit architecture is implemented in all Series 32000 CPUs. These CPUs also offer downward compatibility in 16- and 8-bit external data bus versions.

Fast Floating Point Support–National's NS32081 is the only viable Floating Point Unit to support your system's floating point operation needs.

Powerful MMU Supports Demand Paged Virtual Memory–The NS32082 is the industry's only Memory Management Unit that supports demand paged virtual memory. This industry-first gives you fast on-chip address translation. It also offers advanced operating systems support, making it an ideal choice for a UNIX environment.

UNIX experts say Series 32000 is best

GENIX™ is a fully Bell licensed implementation of the Berkeley 4.1 bsd UNIX™ that experts state is the best UNIX port.

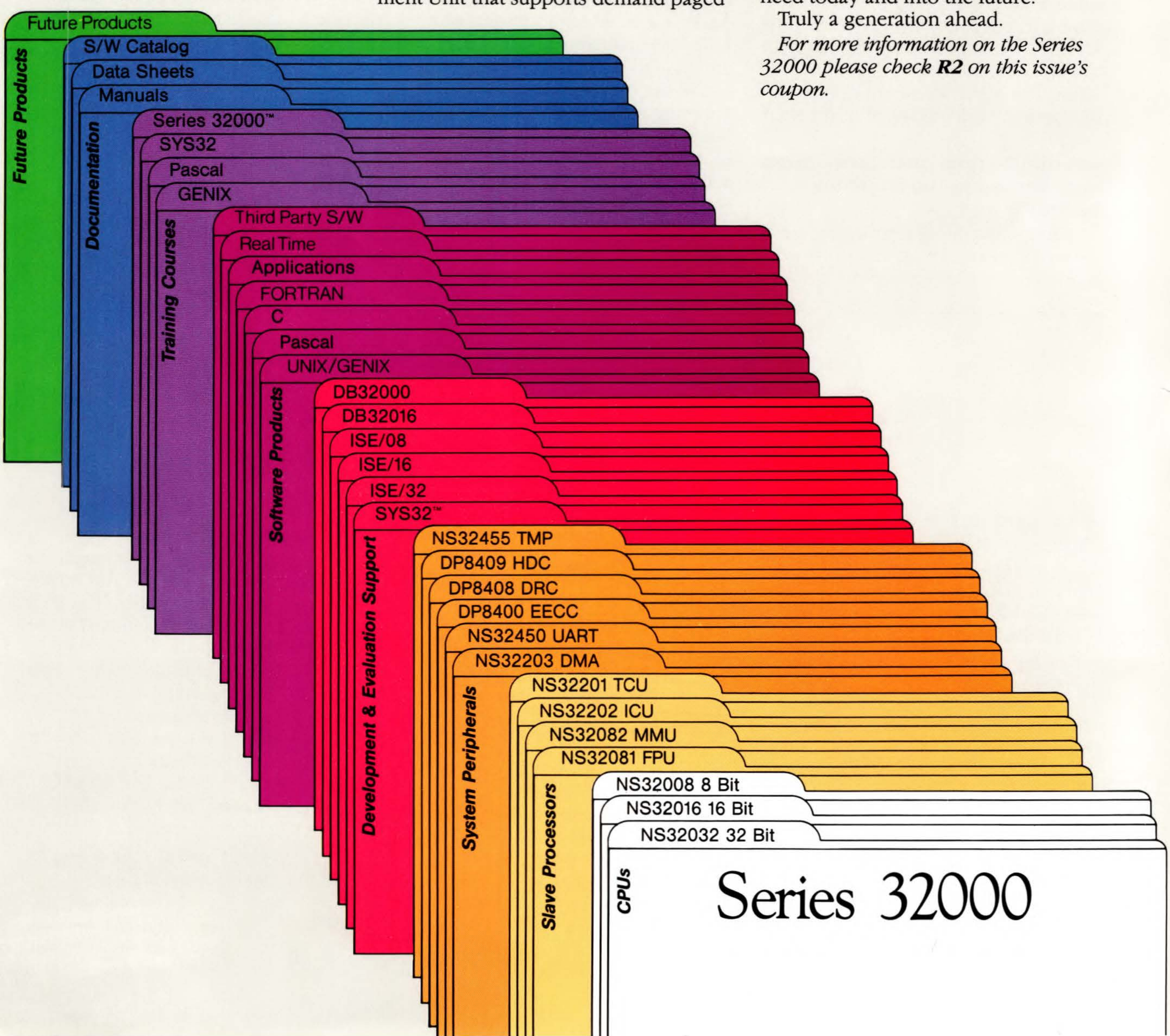
Your only safe 32-bit solution

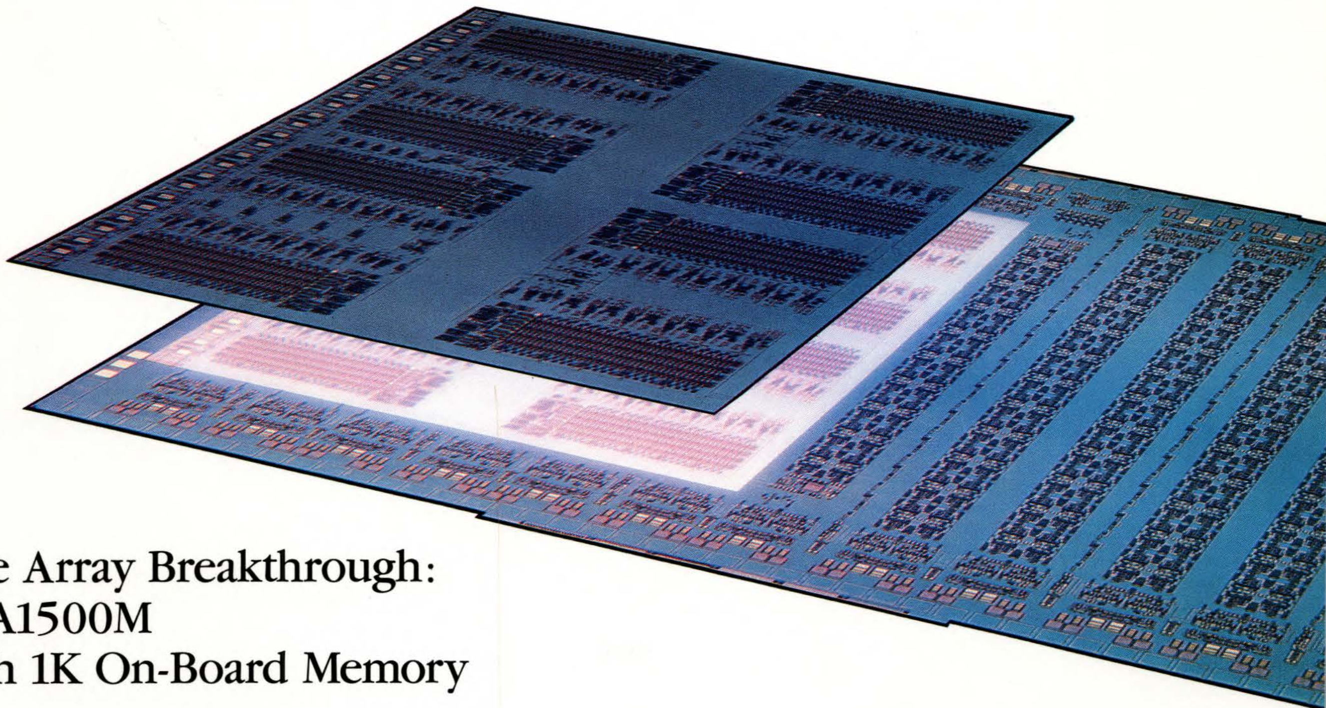
National is the only manufacturer with a complete 32-bit microprocessor family. National offers a proven 32-bit architecture that is available now and is alternately sourced by major manufacturers.

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

Truly a generation ahead.

*For more information on the Series 32000 please check **R2** on this issue's coupon.*





Gate Array Breakthrough: MCA1500M With 1K On-Board Memory

With the introduction of the new MCA1500M, National makes a quantum leap in bipolar gate array technology. Now, for the first time, systems designers have available a single LSI chip offering *both logic and memory.*

The revolutionary MCA1500M is the newest addition to the Macrocell array family and combines 1464 equivalent logic gates with an on-chip memory of 1280 bits of user-configurable RAM.

Pace setting memory

On-chip memory coupled with a unique architecture explain the MCA1500M's exceptional ability to increase system performance with ECL speeds. The new chip furnishes 110 total logic cells, 64 major and 46 output. On-board memory is arranged in eight functional 32 x 5 memory blocks providing 1280 total bits.

The chip features 10 basic memory macros, which offer a wide choice of customized memory configurations. And, as a fixed part of on-chip RAM, the MCA1500M provides a memory test circuit giving the designer access to each memory block. This added test capability is completely independent of user-selected memory configurations and the logic portions of the array.

Performance redefined: twice the speed of other arrays

A 5 nanosecond memory access time with .3ns gate delays makes the MCA1500M twice as fast as all other arrays being sold. The high performance of this speedier chip provides systems engineers with a strong, competitive edge.

Employing the OXISS II™ oxide-isolated walled-base, non-walled-emitter process, National has produced this ingenious 300 picosecond IC in 3-layer metal. And the logic function of the new chip utilizes the same macro library as National's MCA25000ECL, so designers can work on two designs using one source. No additional library is required.

ECL/TTL: mix or match

MCA1500M provides engineers with I/Os for both ECL or TTL interfaces – or any combination of the two.

The chip carries on-board translators for both logics, permitting systems to talk, and receive, interactively in both worlds. In this way, designers can take advantage of the best of each technology. On-chip translators also bring a substantial savings in board real estate.

Full CAD support

MCA1500M is supported by a totally automated full-feature CAD system that includes a time-domain logic simulation capability plus fault grading-testability analysis. Equally important, the CAD system allows for verification of actual design performance versus expectations.

Other advanced features

Power dissipation is typically 5 watts with an ambient temperature range from 0° to 70°C and a maximum operating junction temperature of 130°C. The MCA1500M's on-board memory incorporates voltage compensated ECL, V_{EE} at $-4.5V$, $\pm.3V$. The chip interfaces with ECL 10K/10KH or ECL 100K with each ECL output able to drive 50 ohm loads. For optimized performance, the MCA1500M comes in a 149-pin grid array package.

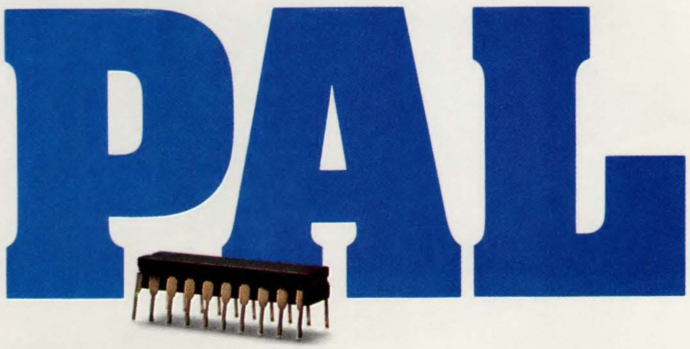
National leading the way

With wide applications in the data processing field (mainframes, superminis, workstations, test equipment and more), the innovative MCA1500M is a sure bet for becoming an industry standard.

Ultra-high speed, 1K on-board memory, mixed or matched ECL-TTL I/Os – these are the features that bring National its earned leadership – and the systems engineer an unrivaled bipolar array.

*For more information, check box **M0** in this Anthem's coupon.*

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.*

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 nonvolatile 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.*

15 New High Performers Join National's microCMOS COPS™ Family

When it comes to high performance, low cost, innovative microcontrollers, National enjoys a well-earned lead on the competition.

That lead now widens as the company adds 15 new single-chip devices to its microCMOS COPS family.

Low-cost static operation

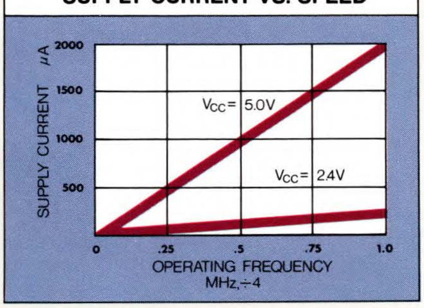
Both new and established family members feature fully static operation, a 4-μs instruction time, and operating voltages down to 2.4V.

And no one but National offers these high performance microcontroller features at such reasonable cost.

Systems-on-a-chip

National's unique systems-on-a-chip construction provides customers with a powerful design advantage. Each microCMOS COPS chip packs everything necessary for implementing dedicated control functions on-board – timing, internal logic, ROM, RAM, and I/O.

SUPPLY CURRENT VS. SPEED



New low power applications

With true, power consumption programming, COPS customized microcontrollers fit a diverse range of low power applications.

A dual software selectable clock option allows easy switching between high and low frequency oscillators. And since microCMOS COPS devices are truly static, a halt mode feature enables the oscillator to be turned off for minimal power consumption of 24μW.

Power consumption can also be reduced with an optional on-board idle on timer function.

CMOS COPS MICROCONTROLLERS			
PKG	ROM SIZE		
	0.5K	1.0K	2.0K
28	—	COP424C	COP444C
24	COP410C	COP425C	COP445C
20	COP411C	COP426C	—

Straightforward design-in

All 15 new microcontrollers are built for easy design-in via the ROMless COP404C and National's MOLE™ development system.

*For more information, check box **K2** in this Anthem's coupon.*

National Enters Personal Communications Market With Space-Saving Demodulator

LM3361A problem-solver

National's recent entry into the radio communication parts market promises high-quality problem-solving help for personal communication-device engineers.

Easier design-in

The LM3361A low-voltage/narrow band FM demodulation system lets engineers conserve board space and significantly lower parts count. Design-in is simplified and assembly costs are sharply reduced.

Low-power operation

Operating at low-supply voltage (less than 2V), the LM3361A permits finished products to run on 2-cell rather than 3-cell battery power. As a result, products can be made smaller and at lower cost.

Other key LM3361A features include highly sensitive −3dB limiting at 2.0μV, an on-board op-amp & squelch circuit for reduced external circuitry, and lower nominal current drain for extended battery life.

Broad communications uses

In addition to its primary use in the new FCC approved 10 channel cordless telephones, the new demodulation IC is design-effective in a variety of communication products – cellular radio subscriber units, scanners & marine receivers, beepless pagers, and amateur radio FM transceivers.

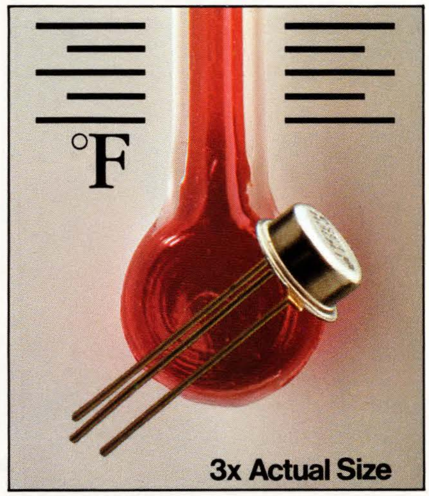
*For more information on the LM3361A, check box **R4** on this Anthem's back page.*

Precision Fahrenheit Scaling With LM34 Temperature Sensor

National's new LM34 series of temperature sensors makes low-cost, high-accuracy Fahrenheit scaling a reality at last.

In the past, Fahrenheit scaling involved subtracting a 2.5538-volt constant from standard Kelvin-calibrated devices.

This scheme required an ultra-stable reference, a couple of trimpots and a tedious calibration procedure.



Fast, precision °F measuring

With the new sensors, calibration is executed at the wafer level. All external calibration and trimming are eliminated. Quick, effortless, and precise °F scaling is the result.

Low self-heating

The LM34 family offers design and process control engineers exceptional accuracies of ±.5°F at room temperature and ±1.5°F between −50 and +300°F. Even the lower-cost versions are rated for the wide range of +32 to 212°F. Non-linearity of the output is typically less than ±0.3°F over a 350°F span.

Additionally, a low current drain of 70μA means low self-heating (less than 0.2°F in still air).

Wide-scope application

Complementing National's LM35 Centigrade family, the LM34 Fahrenheit sensors have extensive applications – from solar energy systems, laboratory ovens, and process temperature control, to home appliances and heating & cooling equipment. Added application flexibility is provided by metal can and TO-92 plastic packaging options.

*For more information, check box **R3** in this Anthem's coupon.*

QUALITY **National Semiconductor**

Quality & reliability is a matter of policy

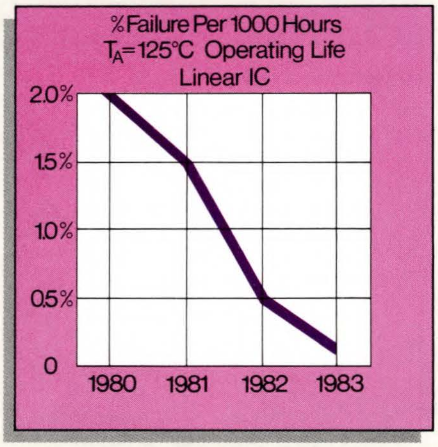
National's *Fast Reaction Program:* A Reliability Program That Works

The company's "all-business" commitment to product quality has made National the premier manufacturer of high-performance electronic components. To National, however, component reliability (how *long* a product works) is just as important as how *well* it works.

A component of superior reliability is expected to function optimally with repeated, long-term use.

At National, this long-term performance is assured through the company's *Fast Reaction Program*–a proven approach based on tightly structured teamwork.

The program involves far more than just inspecting and testing finished products. It is a *continuous* quality & reliability sequence in which trouble-spots are detected early–with immediate feedback to production management. Individuals responsible for the particular problem area take corrective action at the *source* to solve the problem permanently.



Reliability statistics confirm the program's success. Example: National's linear IC failure rate has dropped from 2.0% to just 0.15% in only four program years. That's a 92.5% cut in failure rate under highly accelerated conditions. The 1000 hour test is equivalent to 20 years of operation under normal usage.

The company continues to strive toward its goal of zero defects and 100% product reliability. National's innovative Fast Reaction Program (coupled with advanced statistical control checks, new corrosion prevention techniques, and automated manufacturing lines) is rapidly closing in on that goal.

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CALENDAR

International Conference on Luminescence (ILC '84), University of Wisconsin, Madison, WI. Optical Society of America, 1816 Jefferson Pl NW, Washington, DC 20036. (202) 223-8130. August 13 to 17.

Basic IC Technology, Sunnyvale, CA. Pat Fruscello, ICE, 15022 N 75th St, Scottsdale, AZ 85260. (602) 998-9780. August 21.

International Conference on Parallel Processing, Shanty Creek Lodge, Bellaire, MI. Dr Feng, (614) 422-1408. August 21 to 24.

Basic IC Technology, Minneapolis, MN. Pat Fruscello, ICE, 15022 N 75th St, Scottsdale, AZ 85260. (602) 998-9780. August 28.

National Software Show/West, Anaheim, CA. Raging Bear Prod, 21 Tamal Vista Dr, Suite 175, Cortemadera, CA 94925. September 5 to 7.

International Conference on Optical Fiber Sensors, Stuttgart, Germany. Optical Society of America, 1816 Jefferson Pl NW, Washington, DC 20036. (202) 223-8130. September 6 to 7.

Electronics and Aerospace Systems Conference (EASCON '84), Shoreham Hotel, Washington, DC. Dr James Babcock, IRT Corp, 6800 Poplar Pl, McLean, VA 22101. (703) 893-2111. September 10 to 12.

Midcon '84, Dallas, TX. Jerry Fossler, ECI, 8110 Airport Blvd, Los Angeles, CA 90045. (213) 772-2965. September 11 to 13.

Mini/Micro, Dallas, TX. Jerry Fossler, ECI, 8110 Airport Blvd, Los Angeles, CA 90045. (213) 772-2965. September 11 to 13.

Software Expo-West, McCormick Place, Chicago, IL. John Dobbertin, (312) 299-3131. September 12 to 14.

CALENDAR

Compcon/Fall '84, Hyatt Regency Crystal City, Arlington, VA. Compcon Fall '84, Box 639, Silver Spring, MD 20901. (301) 589-8142. September 16 to 20.

Semicon/East '84, Boston, MA. Mary Beth Kern, Semiconductor and Equipment Materials Institute, 625 Ellis St, Suite 212, Mt View, CA 94043. (415) 964-5111. September 18 to 20.

Basic IC Technology, Framingham, MA. Pat Fruscello, ICE, 15022 N 75th St, Scottsdale, AZ 85260. (602) 998-9780. September 18.

Semiconductor International, National Exhibition Centre, Birmingham, England. CEG, Dept "M," Box 3833, Stamford, CT 06905. (203) 964-0000. September 25 to 27.

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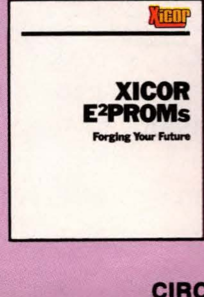

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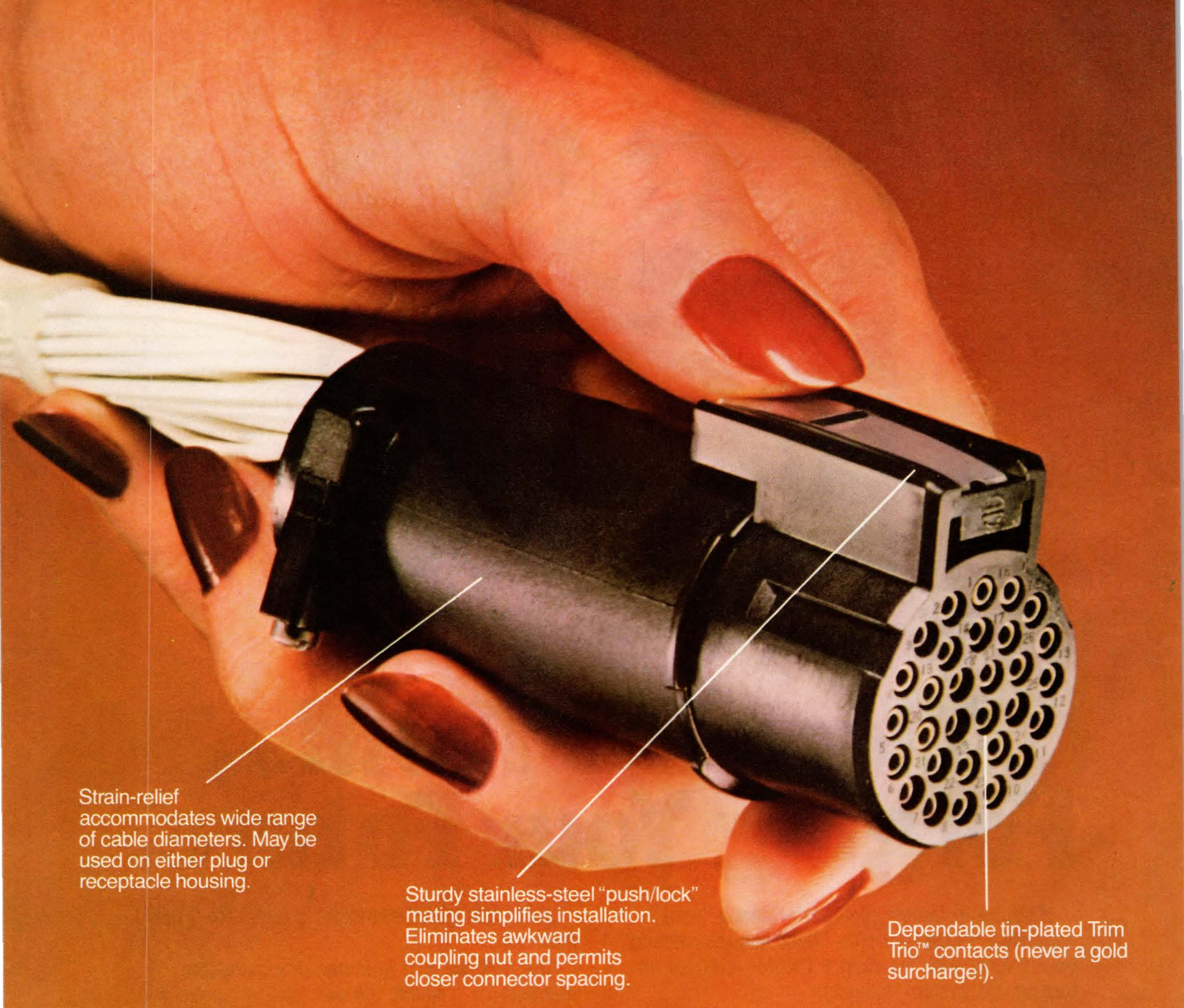

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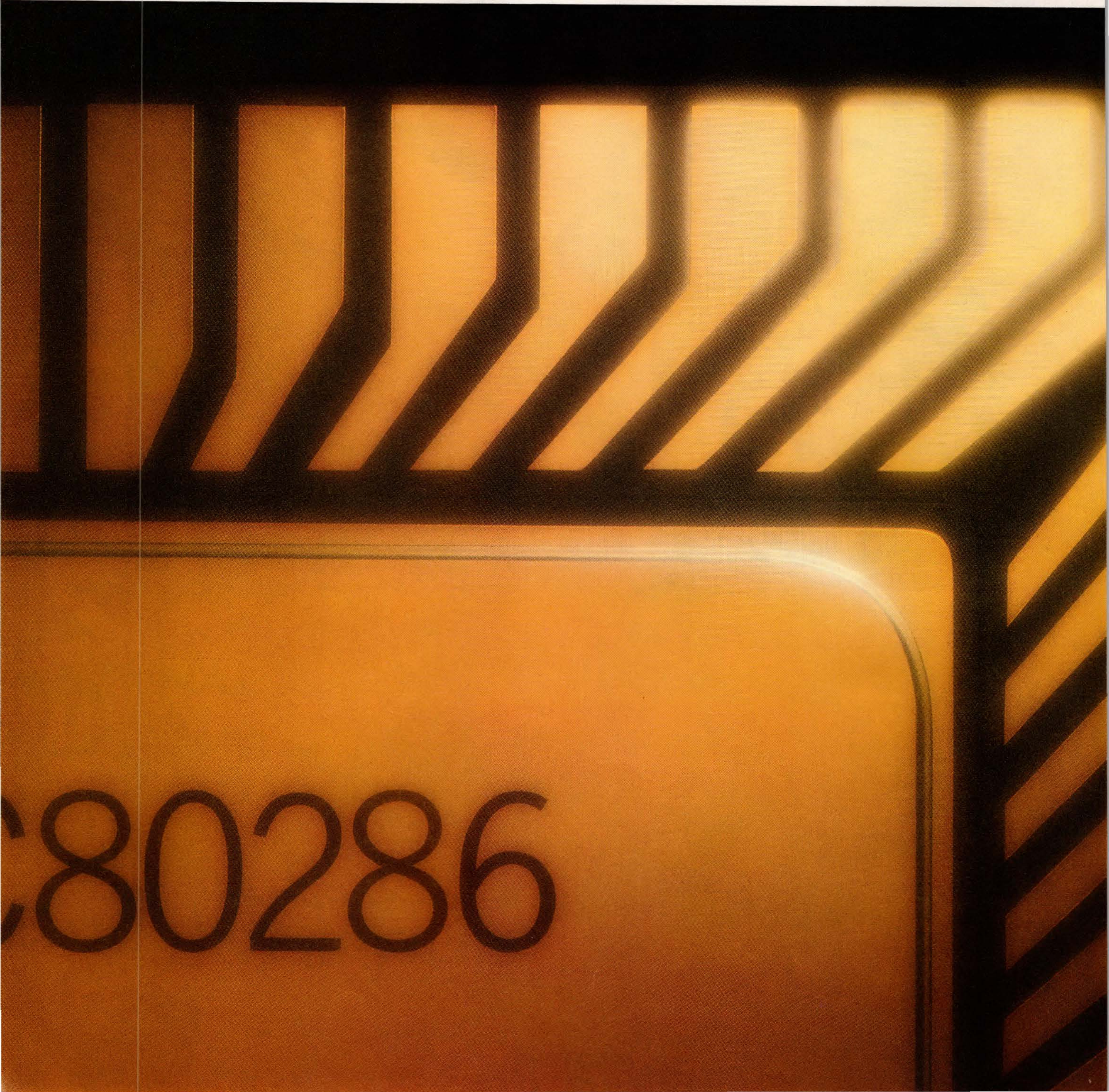
CIRCLE NO 28

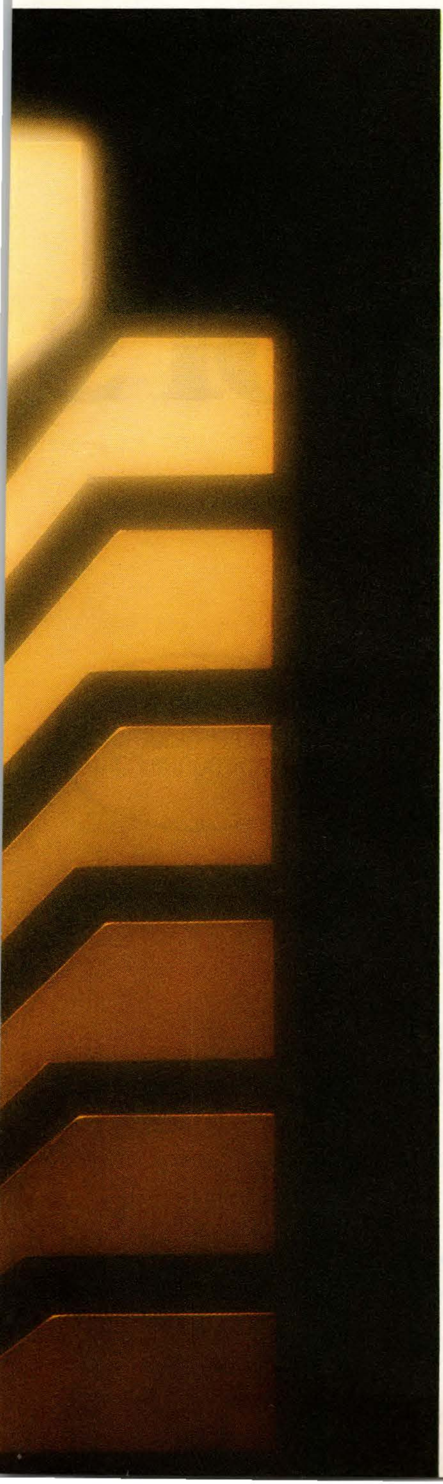
MICROSOFT STRIKES GOLD.



This is what paydirt looks like when it's turned into silicon.

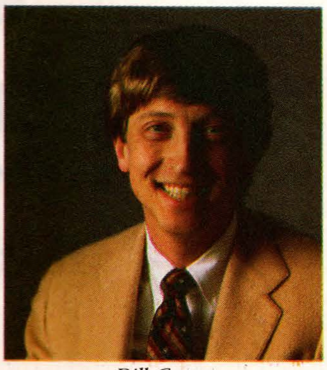
Intel's iAPX 80286 microprocessor.

Together, Microsoft and Intel used this gem to create another: the XENIX* 286 Operating System. The most powerful implementation of UNIX* on the market today for any microprocessor. And the most reliable, functional, commercial enhancement of the UNIX operating system ever created.



The XENIX 286 Operating System includes UNIX enhancements available from both AT&T™ and U.C. Berkeley. But Microsoft has also added loads of other commercial enhancements to make your life richer, in more ways than one. For instance, there are record and file locks, semaphores to help manage multiuser/multitasking data, and automatic disk recovery for better reliability.

Which makes XENIX 286 an ideal Operating System for applications software development. Over one hundred and fifty customized business software packages have been developed for XENIX, making it one of the most useable multiuser Operating Systems available today.



Bill Gates,
Chairman of Microsoft Corp.

For Microsoft, the unique advantages of Intel's 80286 microprocessor were most appealing. As Bill Gates, chairman of Microsoft, said, "On-chip memory management and protection offered by the 286 ensures code compatability and makes it easy to port XENIX between different OEM systems."

In addition, its ability to run in fast 8086 mode makes the 286 the only processor that can support both XENIX 286 and MS-DOS without additional hardware. "With this ability, users get the best of both worlds in one piece of hardware," said Gates.

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				DC-1000	1000-1500	DC-1000	1000-1500
—AT—3	3	±0.2dB	DC-1500	0.6dB	1.0dB	1.3:1	1.5:1
—AT—6	6	±0.3dB	DC-1500	0.6dB	0.8dB	1.3:1	1.5:1
—AT—10	10	±0.3dB	DC-1500	0.6dB	0.8dB	1.3:1	1.5:1
—AT—20	20	±0.3dB	DC-1500	0.6dB	0.8dB	1.3:1	1.5:1

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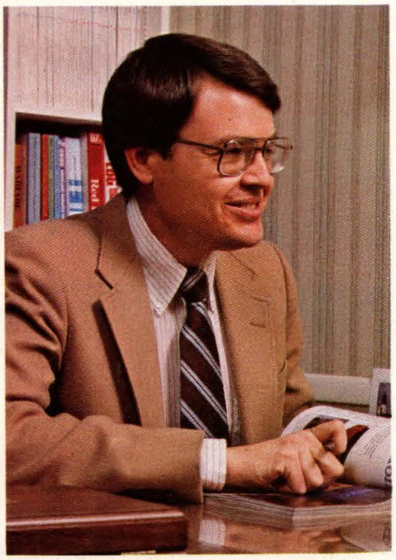
CIRCLE NO 30

C91 Rev. A

EDITORIAL



Only *real* products, please

Consider this all-too-common scenario: An electronics manufacturer announces a new device, claiming immediate (or at least imminent) availability. The trade press writes about the device, relying on the information provided. But when engineers attempt to buy the part, they find it isn't available. Worse, when they try to buy it two months—and sometimes two years—later, it still isn't available.

Unfortunately, and despite the best efforts of the trade press, situations such as this do occasionally arise; what's presented as a product is actually only a plan. And although we at EDN are conscientious and thorough in our efforts to write only about *real* products, even we've been burned more often than we'd like to admit. But we *will* admit it when it occurs, because you—our readers—need reliable, factual information. So companies take note: If we find out you've misrepresented the availability of a product, we'll set the record straight—in print.

From our readers we ask assistance in carrying out our policy. If EDN has presented inaccurate product-availability information, let us know. If we can validate your claims, we'll print a correction in our Signals and Noise section. We're currently investigating one possible misrepresentation of a product's availability, but in this case, as in all such cases, we will allow the suspect company to respond before we go to print. So although it wouldn't be proper to mention the company's name now, we will publish a correction later if the situation warrants it.

We realize, of course, that most high-technology companies are honest in their dealings with the press. In fact, it's partly because of this honesty that we feel compelled to take our stand. It simply isn't fair that honest companies lose sales to unscrupulous companies that string customers along with delays and empty promises. Maybe Leo Durocher was right about nice guys finishing last, but in the case of electronics suppliers, we'll do whatever we can to prove him wrong.

Gary Legg

Gary Legg
Editor

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

MEMORIES.

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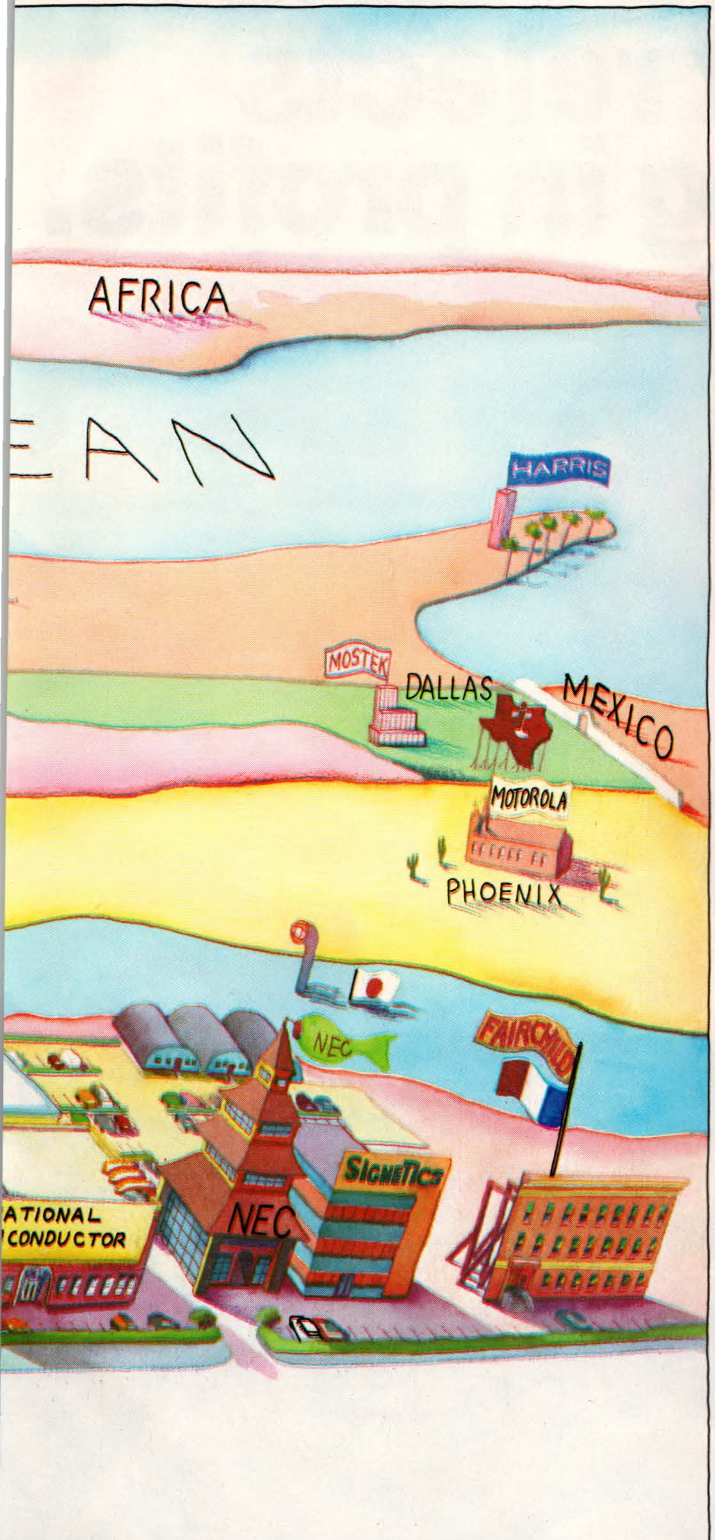
A WORLD PERSPECTIVE.



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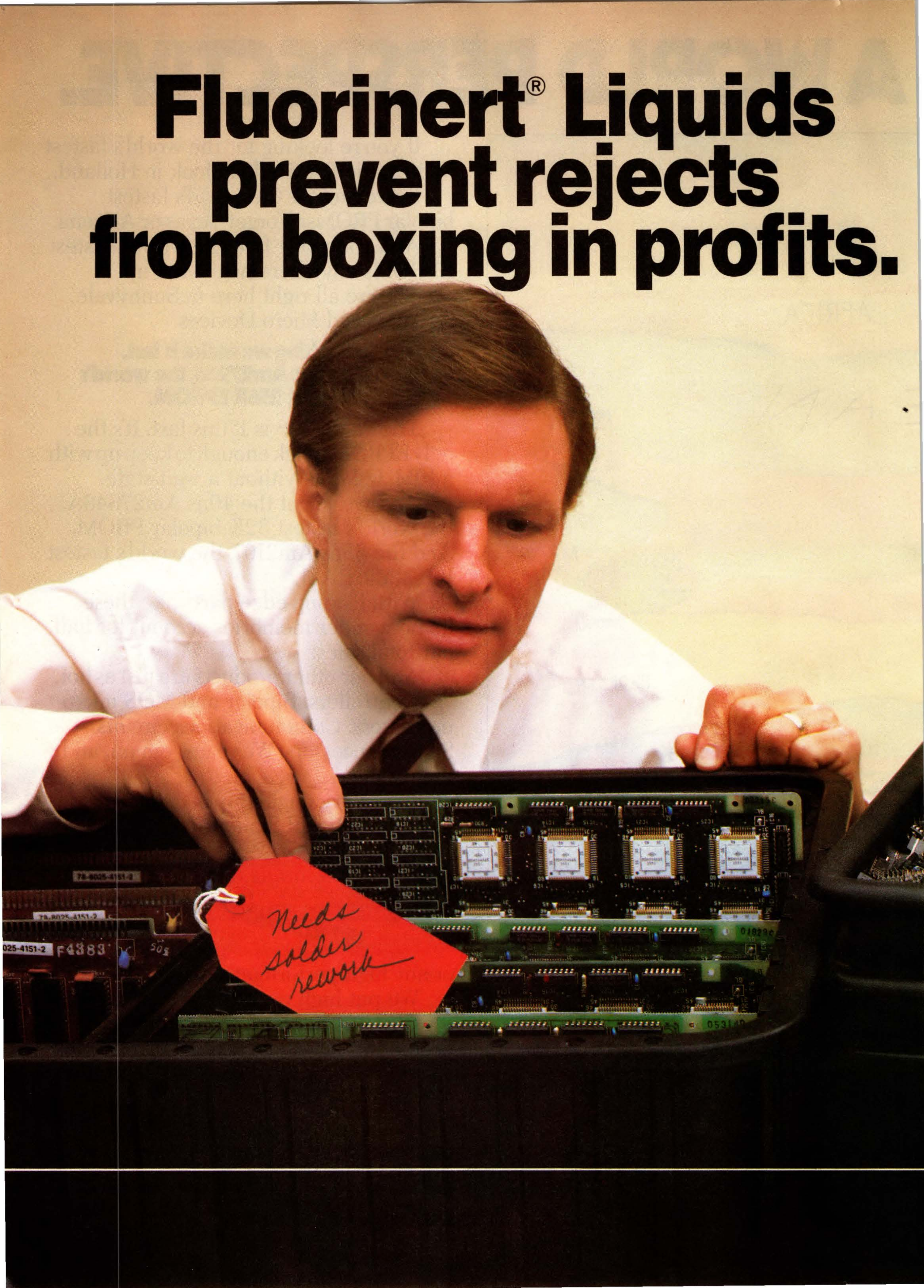
CIRCLE NO 31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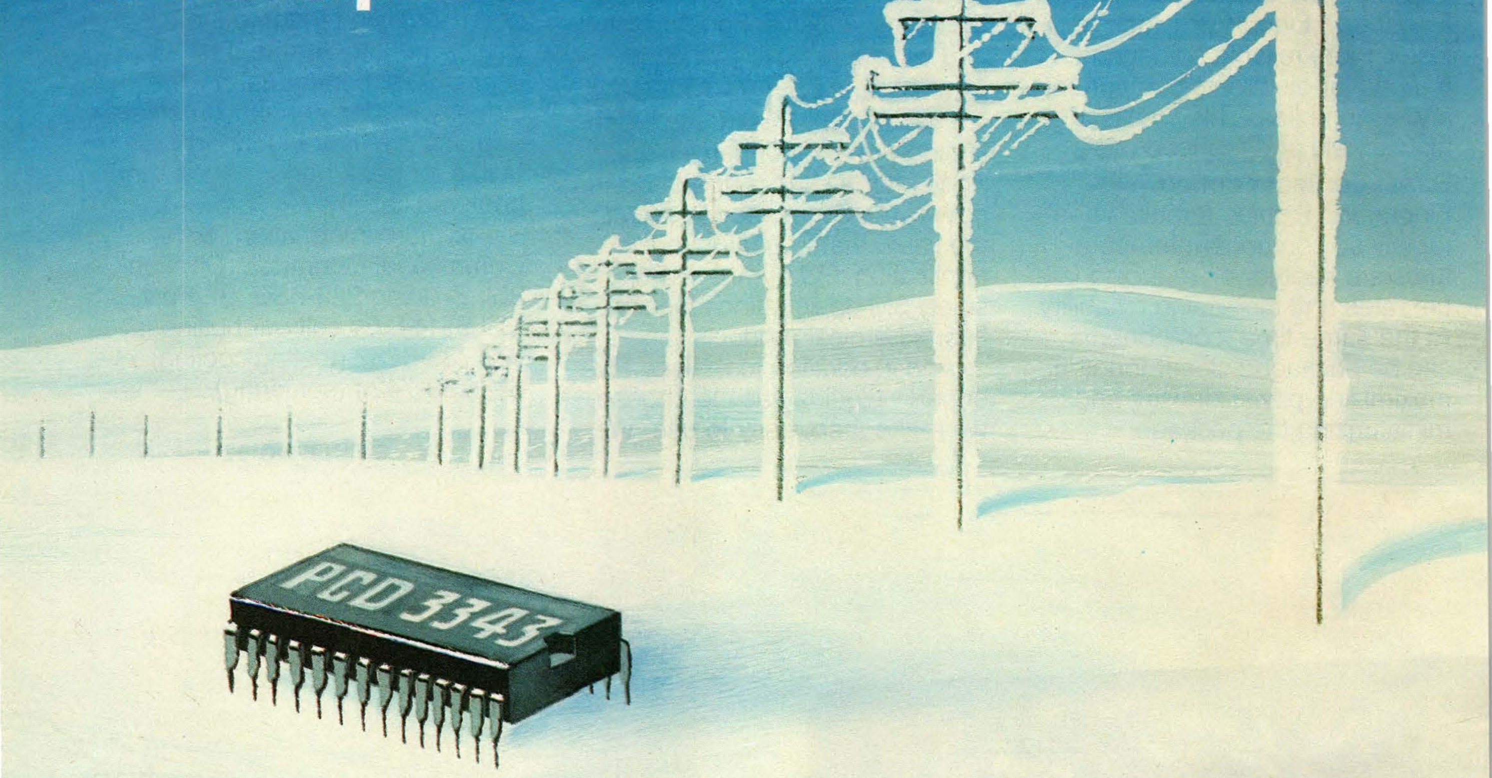
Low-power CMOS chips keep their cool in electronic feature phones



With our low threshold, high-density CMOS chips, modern feature phones can be line-powered – just like their less intelligent predecessors. And these chips benefit the designer, too! Thanks to our modular approach you can offer your customers a range of subscriber facilities, all from one basic design.

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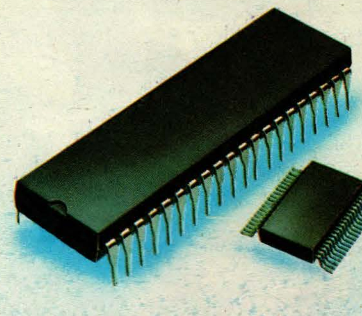
We've CMOS chips for DTMF dialling (with on-chip filter and voltage reference source), LCD drivers (and display), tone ringer, etc. And with our serial I²C Bus you only clip-in what you need.

For data and samples please contact: Philips Electronic Components and Materials Division, 5600 MD Eindhoven, The Netherlands.



Philips also put the PCD3343 and other ICs in space-saving SO mini packages. Comparison shown here is between 40-pin DIL and 40-pin SO.

Making the Most of CMOS

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Electronic components and materials

CIRCLE NO 226

Powerful 5½-digit DMMs abound, but intended use dictates choice

Maury Wright, *Western Editor*

If you're in need of a 5½-digit bench DMM, there are plenty of high-performance instruments available in the $500 to $2000 range. Selecting a meter from the current generation of 5½-digit units, though, might prove to be a difficult task. Even instruments within the same price range offer different capabilities.

If you can pinpoint your intended application, you'll significantly lighten the burden of choosing the optimum DMM. In most instances, selection hinges on three essential and distinct areas:

- Performance features, such as ranges, accuracies, speeds and mathematical functions or data logging
- Price of the DMM, options and accessories
- Operator preferences or ease-of-use features, including location of controls, control-sequence simplicity and display readability.

A basic dc-volts accuracy of 0.005% *and the ability to take 100 4½-digit readings per second are features made possible by the recirculating-remainder A/D converter used in Fluke's Model 8840A DMM.*

One way to assess a DMM's capabilities is to analyze available equipment data sheets. Data sheets alone, however, often don't tell the whole story. In many cases, direct hands-on experience with the instruments or specific questions directed at knowledgeable company officials, or a combination of the two, constitutes a better way to evaluate each meter's strengths and weaknesses. But before you conduct a hands-on analysis or a direct inquiry of manufacturers, take a close look at available DMMs with the important selection criteria in mind (see nearby **table**).

Model 8840A from Fluke is a meter with strong points in each of the three categories. It excels in measurement performance, speed and accuracy. The instrument boasts a basic 1-year dc-volts accuracy of 50 ppm or 0.005%+3 digits. It takes 4½-digit readings at a speed of 100 measurements/sec.

DMM contains custom A/D IC

The 8840A's performance is outstanding for an instrument costing less than $1000. It's made possible through the use of a controlling μP and a fully custom CMOS IC, which is designed and manufactured by Fluke's microcircuits group. The IC consists of an A/D converter with on-board timing, control and switching circuitry. The A/D converter uses a recirculating-remainder technique, as opposed to the dual-slope integrating scheme prevalent in most meters (see **reference**).

The recirculating-remainder technique involves comparing the input voltage with a voltage reference. A D/A converter controls a variable reference and adjusts its output so that it approaches the meter's input voltage. The difference between the two values is amplified and stored in a track/hold (T/H) circuit while the μP stores the known reference value. The amplified remainder stored in the T/H circuit is then presented as an input to the meter, and the whole procedure is repeated. The μP updates the stored result during each cycle.

The accuracy of this A/D technique depends on the stability of the voltage reference and the precision of the resistor networks used for voltage scaling. The 8840A's reference amplifier contains a zener with temperature compensation provided by a transistor. The transistor replaces the diode traditionally used for compensation and provides a gain stage. The gain helps overcome noise, drift and thermal voltaic problems normally associated with zener references.

If one of your primary concerns is

pricing, the 8840A's $695 base figure is certainly impressive. Adding all the options, including an IEEE-488 interface, raises the price tag to $995. Accessories such as probes, cases and a rack-mounting kit are also available.

This meter also sports some impressive ease-of-use features. Unlike other 5½-digit DMMs listed in the **table,** the 8840A has a vacuum-fluorescent display. This display technology provides advantages in terms of legibility, viewing angle and readability in different levels of ambient light.

Each button on the control panel is associated with a single function, ensuring easy manipulation of the instrument. All measurement capabilities are easy to access and invoke; one touch sets the function and one touch sets the range. This does, however, limit the number of functions (other than measurements) that the instrument can incorporate.

The 8840A's autoranging capability—a feature many users normally find too slow on most DMMs—provides a pleasant surprise in terms of speed. The 8840A has three speeds, with the slowest being the most accurate. For instance, measuring resistance ranging from an open circuit down to the lowest level (200Ω) requires 900 msec and delivers 5½-digit resolution. Higher speed measurement reduces the ranging time to 250 msec but yields only 4½-digit resolution.

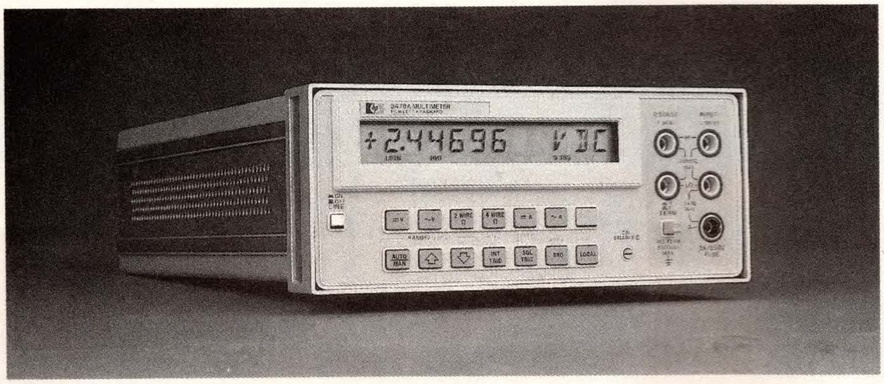
In contrast with the 8840A, Keithley's Model 197 provides less speed and accuracy but more measurement functions for the base price. The $595 standard unit includes all functions and some mathematical and data-logging capabilities. In fact, the only options are a battery pack, an IEEE-488 interface and an analog output.

The $595 base price for the 5½-digit Model 197 *from Keithley includes 5-function measurement capabilities and a 100-measurement storage buffer.*

The basic 1-year dc-volts accuracy of 0.013%+2 digits fulfills many application requirements. The instrument provides this accuracy by using a constant-frequency charge-balance single-slope A/D converter. The charge-balance stage contains an integrator that periodically approaches a reference voltage in a linear fashion; each time the integrator voltage equals the reference voltage, the latter is subtracted from the input voltage. When the input voltage is low enough and no longer causes the ramp to reach the reference voltage, this residual voltage is measured with a single-slope technique to complete integration.

Mathematical functions include storage of minimum/maximum input-voltage values and relative measurement capabilities. Model 197's data-logging function permits storage of 100 readings. The meter can transmit the stored data via the IEEE-488 bus or an analog output. The meter's IEEE-488 interface supports normal talker modes, but as a listener, the meter won't permit bus control of function switching. Ranges are programmable.

If you require system-DMM capabilities, Keithley's Model 195 might suit your needs. It provides many of the features found on the 197. For the $995 base price, you obtain full IEEE-488 control, 100-nV sensitivity and a measurement-speed increase to 76 3½-digit readings per second.



With an MTBF of 50,000 hrs, *Model 3478A from Hewlett-Packard employs the multislope A/D technique and comes standard with the IEEE-488 interface.*

DMM and choice of computing

Solartron gives the user a choice by offering two meters with identical measurement capabilities. One includes math functions and data-logging features. Model 7150 ($995) and Model 7151 ($1600) come as standard units with no options offered. RS-232C and full IEEE-488 interfaces are included in both.

The meters employ a pulse-width A/D-conversion technique to provide a basic 1-year dc-volts accuracy of 0.008%+3 digits. The pulse-

Text continued on pg 62

DIGITAL-MULTIMETER SPECIFICATIONS

MANUFACTURER/ MODEL NUMBER	GENERAL INFORMATION						DC VOLTAGE							
	BASE PRICE	STANDARD FEATURES	OPTIONAL FEATURES/PRICE	DISPLAY TYPE	A/D-CONVERTER TYPE	MAX READINGS/SEC AT N DIGITS	RANGES	MAX RANGE	MAX SENSITIVITY	1-YR ACCURACY % INPUT + DIGITS	OVERLOAD PROTECTION	RANGES	MAX RANGE	MAX SENSITIVITY
DATA PRECISION 2590	$799	VDC, VAA, IDC, IAC, R	N/A	LED	DUAL SLOPE	N/S	5	1200V	1 µV	0.007% +2	1200V	5	800V	1 µV
DATA PRECISION 2590R	$849	VDC, VAC, IDC, IAC, R	N/A	LED	DUAL SLOPE	N/S	5	1200V	1 µV	0.007% +2	1200V	5	800V	1 µV
DATA PRECISION 3500	$1195	VDC, VAA, R, DC/DC	AC/AC/$1040	GLOW-TUBE	DUAL SLOPE	N/S	5	1000V	1 µV	0.007% +1 (6 MO)	1000V	5	700V	1 µV
DATA PRECISION 3600	$795	VDC, DC/DC, AC/DC	R/$120, VAA/$145, VAC/$325 (AC COUPLED), VAC/$200 (DC COUPLED), GPIB/$200, BCD/$100	LED	DUAL SLOPE	N/S	5	1200V	1 µV	0.008% +2	1200V	5	800V	1 µV
FLUKE 8840A	$695	VDC, R, IDC, RI, CA	VAC AND IAC/$150 GPIB/$150	VF	RECIRCULATING REMAINDER	100 AT 4½	5	1000V	1 µV	0.005% +3	1000V	5	700V	1 µV
HEWLETT-PACKARD 3478A	$1315	R, VDC, VAC, IDC, IAC, CA, GPIB, RI	N/A	LCD	MULTI-SLOPE	71 AT 3½	5	300V	100 nV	0.019% +2	303V	4	300V	1 µV
HEWLETT-PACKARD 3468A/B	$695	R, VDC, VAC, IDC, IAC, HPIL, CA	BAT/$125	LCD	MULTI-SLOPE	32 AT 3½	4	300V	1 µV	0.018% +2	301V	4	300V	1 µV
KEITHLEY 195	$995	R, VDC, TEM, GPIB, L, M, RI, CA	VAC, IAC, IDC/$295	LED	CHARGE BALANCE	76 AT 3½	6	1000V	100 nV	0.02% +8	1000V	5	700V	1 µV
KEITHLEY 197	$595	R, VDC, VAC, IDC, IAC, M, L, CA	LGPIB/$225, AO/$300, BAT/$99	LCD	CHARGE BALANCE	3 AT 5½	5	1000V	1 µV	0.013% +2	1000V	5	750V	1 µV
RACAL-DANA 5001	$950	R, VDC, VAC, IDC, IAC, M, CA	LGPIB/$295	LED	CHARGE BALANCE	4 AT 5½	5	1000V	1 µV	0.01% +6	N/S	4	750V	20 µV
SOLARTRON 7150	$995	R, VDC, VAC, IDC, IAC, GPIB, RI, CA	N/A	LCD	PULSE WIDTH	25 AT 3½	5	1000V	100 nV	0.002% +5 (2 YRS)	1.2 kV PEAK	4	750V	10 µV
SOLARTRON 7151	$1600	R, VDC, VAC, IDC, IAC, M, CA, L, GPIB, AO, RS, TEM, RI	N/A	LCD	PULSE WIDTH	25 AT 3½	5	1000V	100 nV	0.008% +3	1.2 kV PEAK	5	750V	1 µV

KEY: R — RESISTANCE
VDC — DC VOLTAGE
VAC — TRUE RMS AC VOLTAGE
VAA — AVERAGED AC VOLTAGE
IDC — DC CURRENT
IAC — AC CURRENT
M — MATHEMATICS
L — DATA LOGGING
BCD — BCD REMOTE INTERFACE
GPIB — IEEE-488 INTERFACE
LGPIB — LIMITED IEEE-488
AO — ANALOG OUTPUT

AC VOLTAGE		RESISTANCE					DC CURRENT				AC CURRENT				INPUT/INTERFERENCE		
1-YR ACCURACY % INPUT + DIGITS	MAXIMUM FREQUENCY	RANGES	MAX RANGE	MAX SENSITIVITY	1-YR ACCURACY % INPUT + DIGITS	OVERLOAD PROTECTION	RANGES	MAX RANGE	MAX SENSITIVITY	1-YR ACCURACY % INPUT + DIGITS	RANGES	MAX RANGE	MAX SENSITIVITY	1-YR ACCURACY % INPUT + DIGITS	IMPEDANCE	NORMAL-MODE REJECTION	COMMON-MODE REJECTION
0.05% + 20	100 kHz	6	20 MΩ	1 mΩ	0.007% +2	500V RMS	5	2A	1 nA	0.1% +10	4	2A	10 nA	0.3% +40	1000 MΩ (<20V) 10 MΩ (>20V)	>80 dB AT 50/60 Hz	>160 dB (DC) >120 dB AT 50/60 Hz
0.4% + 300	100 kHz	6	20 MΩ	1 mΩ	0.007% +2	500V RMS	5	2A	1 nA	0.1% +10	4	2A	10 nA	0.75% + 300	1000 MΩ (<20V) 10 MΩ (>20V)	>80 dB AT 50/60 Hz	>160 dB (DC) >120 dB AT 50/60 Hz
0.05% +0.02% FS	100 kHz	6	10 MΩ	1 mΩ	0.007% +0.001% FS +1 (6 MO)	115V RMS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1000 MΩ (<10V) 10 MΩ (>10V)	>80 dB AT 50/60 Hz	>160 dB (DC) >120 dB AT 50/60 Hz 400V MAX
0.15% + 50	100 kHz	6	20 MΩ	1 mΩ	0.007% +2	250V RMS	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1000 MΩ (<20V) 10 MΩ (>20V)	>80 dB AT 50/60 Hz	>160 dB (DC) >120 dB AT 50/60 Hz 500V MAX
0.16% + 100	100 kHz	6	20 MΩ	1 mΩ	0.013% +3	300V RMS	1	2A	10 μA	.05% +4	1	2A	10 μA	0.4% + 200	10000 MΩ (<20V) 10 MΩ (>20V)	>98 dB AT 60 Hz ±0.1% MAX 20V OR 2X FS	>140 dB (DC) >140 dB AT 60 Hz ±0.1% 1000V MAX
0.26% + 102	300 kHz	7	30 MΩ	100 μΩ	0.016% +2	350V PEAK	2	3A	1 μA	0.17% +6	2	3A	1 μA	1.50% + 163	10000 MΩ (<3V) 10 MΩ (>3V)	>80 dB AT 50/60 Hz ±0.1%	>140 dB (DC) >150 dB AT 50/60 Hz ±0.1%
0.26% + 102	300 kHz	6	30 MΩ	1 mΩ	0.016% +2	350V PEAK	1	3A	10 μA	0.17% +6	2	3A	1 μA	1.8% + 163	10000 MΩ (<3V) 10 MΩ (>3V)	>80 dB AT 50/60 Hz ±0.1%	>140 dB (DC) >150 dB AT 50/60 Hz ±0.1%
0.3% + 200	250 kHz	7	20 MΩ	1 mΩ	0.022% +5	360V PEAK	6	2A	100 pA	0.09% +10	5	2A	1 nA	0.6% + 250	1000 MΩ (<2V) 10 MΩ (>2V)	>80 dB AT 50/60 Hz ±0.15%	>120 dB (DC) >120 dB AT 50/60 Hz ±0.15% 500V MAX
0.35% + 130	300 kHz	7	200 MΩ	1 mΩ	0.26% +2	450V PEAK	6	10A	1 nA	0.1% +10	6	10A	1 nA	0.8% + 130	1000 MΩ (<2V) 10 MΩ (>2V)	>80 dB AT 50/60 Hz ±0.15%	>120 dB (DC) >120 dB AT 50/60 Hz ±0.15% 500V MAX
0.5% + 150	20 kHz	6	20 MΩ	2 mΩ	0.004% +0.5	375V PEAK	4	2A	100 nA	0.2% +2	4	2A	100 nA	0.7% + 15	1000 MΩ (<2V) 10 MΩ (>2V)	>60 dB AT 50/60 Hz	>140 dB (DC) >120 dB AT 50/60 Hz
0.16% + 70	300 kHz	4	20 MΩ	10 mΩ	0.03% +5 (2 YRS)	240V RMS	1	2A	1 μA	0.05% +5 (2 YRS)	1	2A	10 μA	0.2% + 100 (2 YRS)	10 MΩ	>60 dB AT 50/60 Hz ±0.1%	>140 dB (DC) >120 dB AT 50/60 Hz ±0.1% 500V MAX
0.05% + 20	500 kHz	5	20 MΩ	1 mΩ	0.02% +3	240V RMS	1	2A	1 μA	0.04% +3	1	2A	10 μA	0.2% +20	10 MΩ	>60 dB AT 50/60 Hz ±0.1%	>140 dB (DC) >120 dB AT 50/60 Hz ±0.1% 500V MAX

RS — RS-232 INTERFACE
BAT — BATTERY OPERATION
DC/DC — DC/DC RATIO
AC/DC — AC/DC RATIO
AC/AC — AC/AC RATIO
TEM — TEMPERATURE
HP-IL — SERIAL INTERFACE
RI — REAR INPUT
N/S — NOT SPECIFIED
N/A — NOT APPLICABLE
FS — FULL SCALE
CA — ADVANCED CALIBRATION
VF — VACUUM FLUORESCENT

width technique essentially consists of a voltage-to-frequency conversion. The frequency is then counted to obtain results. This technique doesn't require an integrator stage, and so the measuring process is faster and continuous operation is possible. These A/D systems also allow a 6½-digit reading that's a walking average of the last 10 measurements.

Unlike Fluke, Solartron uses no custom ICs in its meter. This is partly due to the market at which each company aims its product. Fluke sells a majority of its products domestically. Solartron manufactures its meters in the United Kingdom and depends on exports for most of its sales. With such a large foreign business, Solartron feels it's safer to use standard, readily available components.

The 7150's front panel contains 12 single-function buttons, making it simple to operate. The 7151 has five additional buttons and uses all buttons for multiple functions. Both meters employ an LCD. The display can show alphanumeric messages in addition to measurement results.

As a data logger, the 7151 stores 500 readings, which can be sent to the IEEE-488 bus, RS-232C port or an analog output. In scope mode, the meter scans the last 100 readings, providing continuous analog output for an oscilloscope. A zoom feature allows you to review a portion of the stored data. A nonvolatile real-time clock enables measurements to be made in real or elapsed time.

Firmware contains eight mathematical programs. A "scale" feature allows display of a measurement that's multiplied by a user-specified constant. The "offset" feature is similar to scale, but it adds a user-specified constant to the measurement. The "stats" program provides five types of statistical data, and "percent deviation" gives error information relative to user-specified nominal values. Four types of ratios and four types of maximum/minimum storage are available. Go/no-go or low/high checking provides visual results as well as the equivalent TTL output of these conditions.

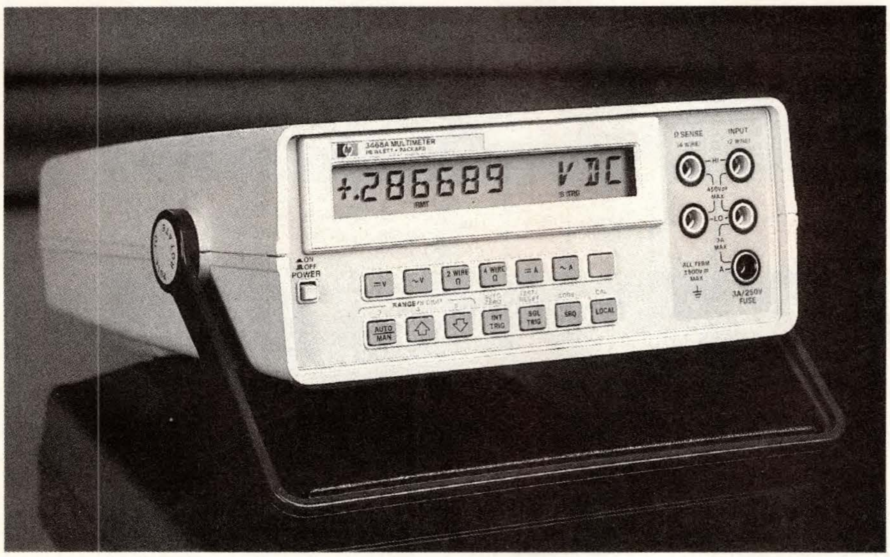
TTL I/O triggers action

TTL inputs and outputs like those found on Solartron's DMMs—used to trigger measurements or report completed measurements—are fairly common in meters. Hewlett-Packard originally introduced this feature, and the two 5½-digit DMMs it currently markets include them. Model 3468A/B provides an HP-IL interface and sells for $695. The IEEE-488-compatible 3478A costs $1315 and has more ranges and increased speed.

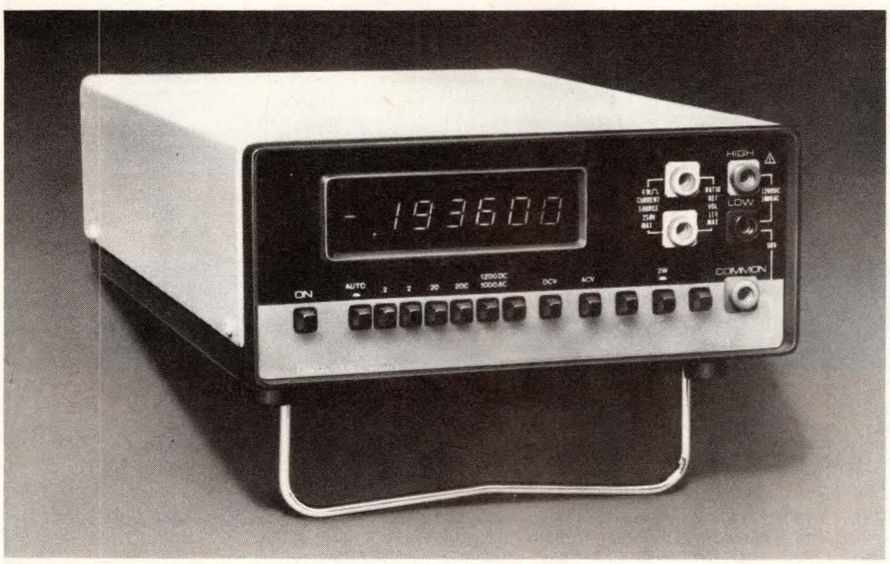
The 3468A/B boasts a basic 1-year dc-volts accuracy of 0.018%+2 digits, compared with 0.019%+2 digits for the 3478A. Hewlett-Packard uses a variation of the dual-slope integrator, called multislope, for the A/D-conversion process. Both meters carry an MTBF spec of 50,000 hrs.

Meter aids troubleshooting

An MTBF spec is not given by most manufacturers, but mainte-



The HP-IL interface and choice of packaging *combine in the 5-function Model 3468A/B from Hewlett-Packard.*

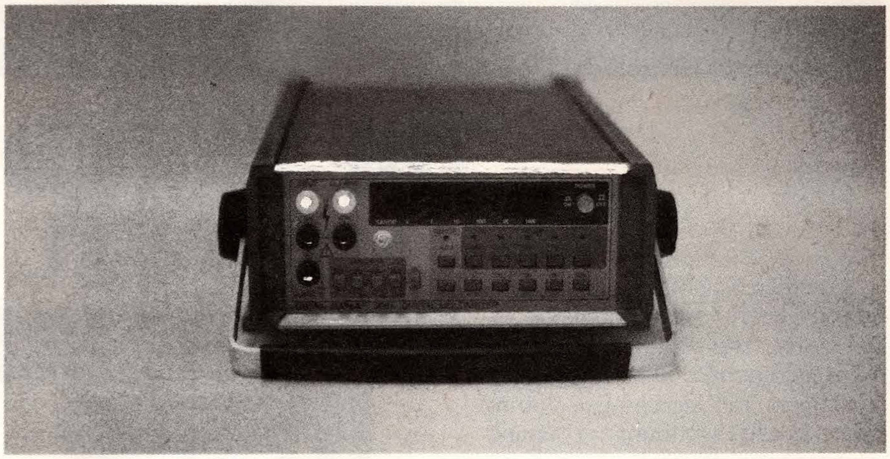


Optional modular plug-ins providing dc/dc and ac/dc ratios *and ac conversion allow users of Data Precision's Model 3600 to start with a $795 base price and add capabilities as required.*

nance certainly is a point to consider when choosing a meter. With the Model 5001, Racal-Dana has made troubleshooting a feature of the meter. Resident firmware working with a signature-analysis troubleshooting adapter allows the user to locate defective components. The adapter also includes a written troubleshooting guide.

The 5001 sells for $950, which includes all measurement capabilities. Mathematical functions include minimum/maximum, percent-deviation and null capabilities. A charge-balance A/D converter provides a basic 1-year dc-volts accuracy of 0.01%+6 digits. A talker-only IEEE-488 interface option costs $295.

IEEE-488 or BCD interfaces are offered for the $795 Model 3600 from Data Precision. Basic 1-year dc-volts accuracy is 0.007%+2 digits, as it is for the company's entire DMM line. The 3600 marks a bit of a departure from the rest of the industry, because only dc voltage and 3-wire dc/dc and ac/dc ratios are standard. A resistance option costs $120, and the ac-coupled true-rms option sells for $325. This meter is targeted for users who want a low entry price but who might also wish to expand the meter's capabilities in the future.



Troubleshooting aids implemented in firmware *provide users of the Racal-Dana Model 5001 with the ability to maintain the meter in house.*

Another Data Precision instrument, the 2590/2590R ($799 and $849 for the respective versions), takes the opposite approach by offering no options. Five functions are included on the unit, which incorporates a dual-slope A/D device. The 2590 employs an averaging ac converter, and the 2590R uses a true-rms device. No remote-interface capability is provided.

Data Precision also markets an older product, the $1195 Model 3500, which uses a BCD interface. More important, for $2235 the meter can be ordered with an ac/ac-ratio function. The 3500 and its sister products differ in another way from the rest of the industry: There's no autocalibration mode. Data Precision feels that it's not required if the meter is sufficiently accurate.

Defining calibration

Automatic calibration, digital calibration and software calibration are all buzz words currently used by the test and measurement industry. Meter manufacturers use the words frequently, yet they may or may not mean the same thing.

The Keithley 197, for example, has a dual-mode calibration system. With power applied, any user can temporarily calibrate the meter. When power is removed, however, the meter reverts to its prior precalibrated state. Permanent calibration requires removing the top lid and changing a jumper plug. This provides security from unauthorized personnel trying to calibrate the instrument incorrectly.

In either case the actual calibration procedure is identical. The operator holds two buttons simultaneously to enter the cal mode. Next, a series of standards is presented by the operator. Each time a standard is applied, the operator pushes an Up or Down button on the meter to adjust the reading. The operator then pushes a button to store the calibration factor in nonvolatile RAM for permanent calibration or regular RAM for temporary calibration.

Eight firmware mathematical routines and an alphanumeric display *allow the Model 7151 from Solartron to function automatically without a controller.*


At $2435, Arium's Logic Analyzer now supports 16-bit µP options
Now the Arium ML4100B logic analyzer gives you even *more*, with two new options: 16-bit microprocessor disassembly capability, and nonvolatile memory — including power-off storage of reference data and eight setups.
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CIRCLE NO 35

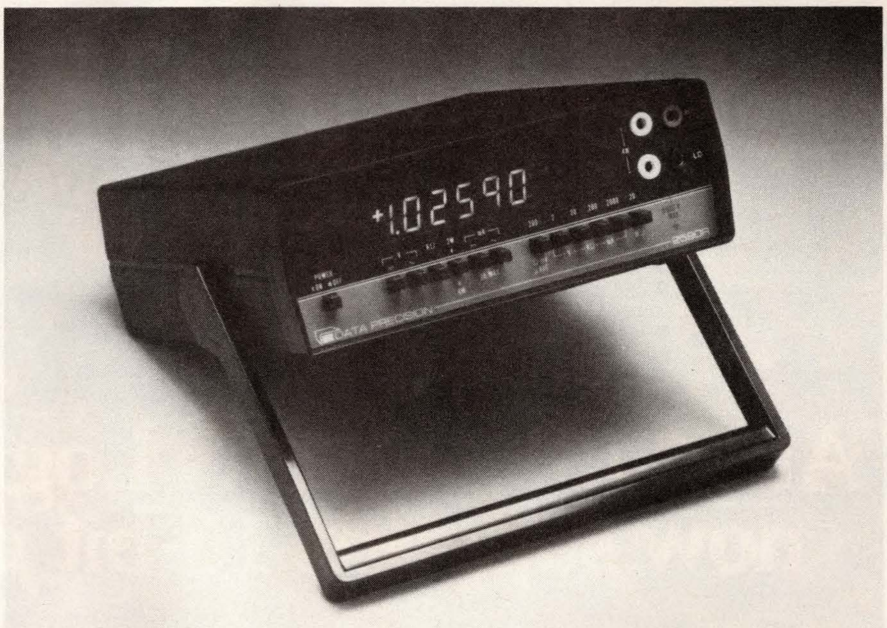
The Racal-Dana Model 5001 calibrates in a similar manner. There is, however, no temporary-calibration capability. Also, calibration is enabled with a tool stuck in a hole in the front panel. The hole can be covered with a cal sticker for security. The calibration procedure for each of these meters must proceed without the aid of a controller.

Autocalibrate with the GPIB

Solartron, on the other hand, requires the use of a controller for its Models 7150 and 7151. The operator places a special plug into the back of the meter to enable calibration. The controller then proceeds to command the meter through each function and range via the IEEE-488 bus. At each setting, the controller must obtain the value being applied by the standard. The controller then sends the value to the meter, and the meter derives a calibration factor.

This method has an advantage because if your standard is only accurate at 1.9999V dc, as opposed to 2.0000V dc, you can still calibrate the meter. The requirement for a controller might be a problem, though, and ideally the standards must also be bus compatible.

Hewlett-Packard solves this problem on its Model 3478 by allowing calibration manually or via the bus. In either case, the meter must be commanded through each function and range. A switch within the case enables calibration. The problem of not having a standard capable of every voltage is also addressed by this meter.



Choice of averaging or true-rms ac conversion *is included with five functions in the base price for Model 2590 from Data Precision.*

On each function and range the operator presents a short to the meter. Next, either a full-scale signal or another more common calibration signal is applied. For example, on the 3V dc range, either a 1 or 3V signal is applied. The meter then senses the correct value and stores the calibration factor.

Meter controls calibration

The calibration procedure for Model 8840A from Fluke follows a similar path. The primary difference is that the meter itself controls the calibration sequence. Whether it's performing manually or via a controller, the instrument provides prompts for each step of the process. The operator or controller simply complies with the meter's request and signals it to continue. This technique relieves the operator from following a written procedure.

EDN

Reference

Nicholson, B, "Novel A/D converters, built-in facilities extend DMM accuracies and capabilities," *EDN,* April 5, 1984, pg 85.

For more information . . .

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

Data Precision Corp
Electronics Ave
Danvers, MA 01923
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Circle No 745

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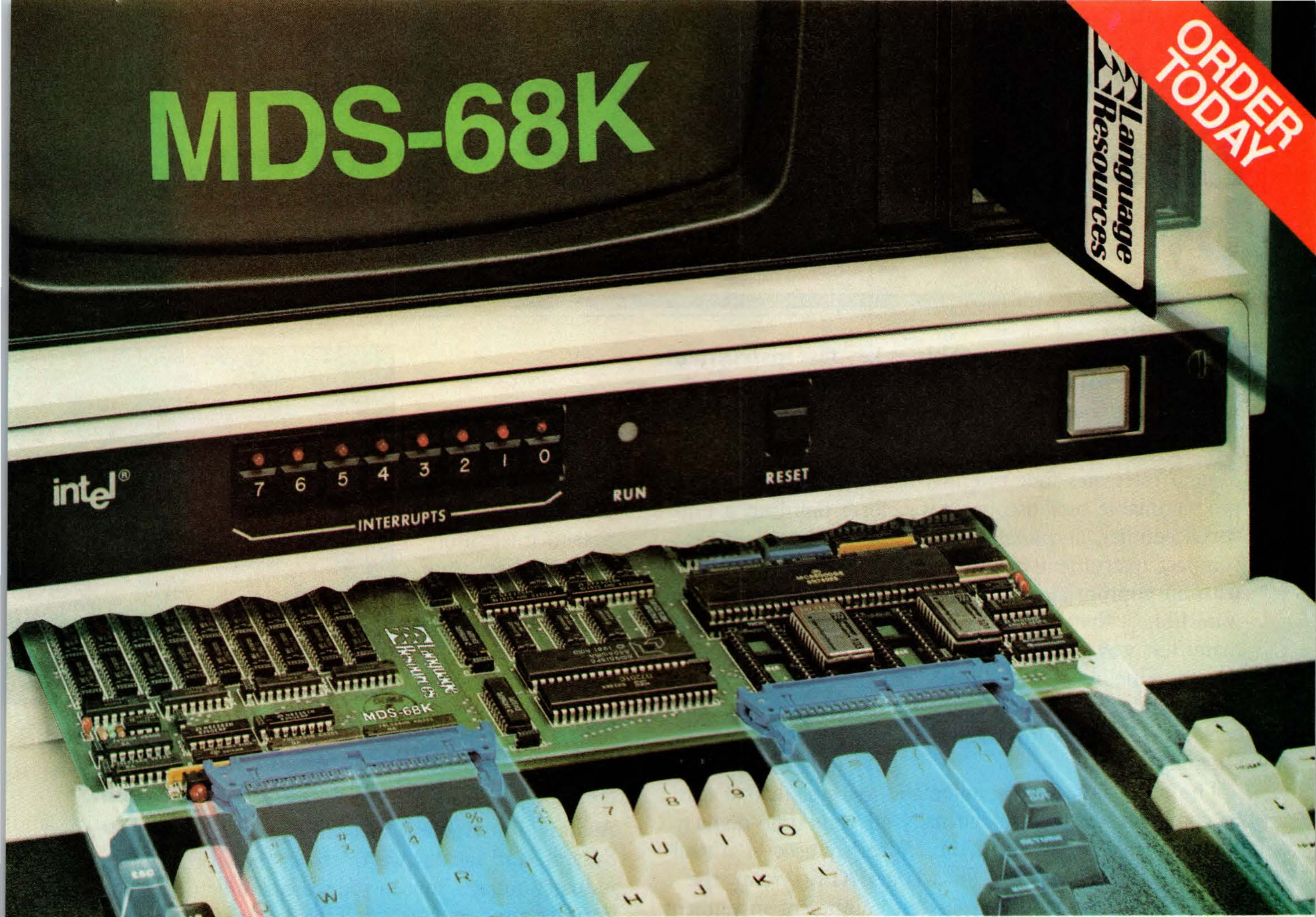

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The HP 1980 System combines key test instruments with powerful computers, flexible software, and comprehensive support for a total test solution.

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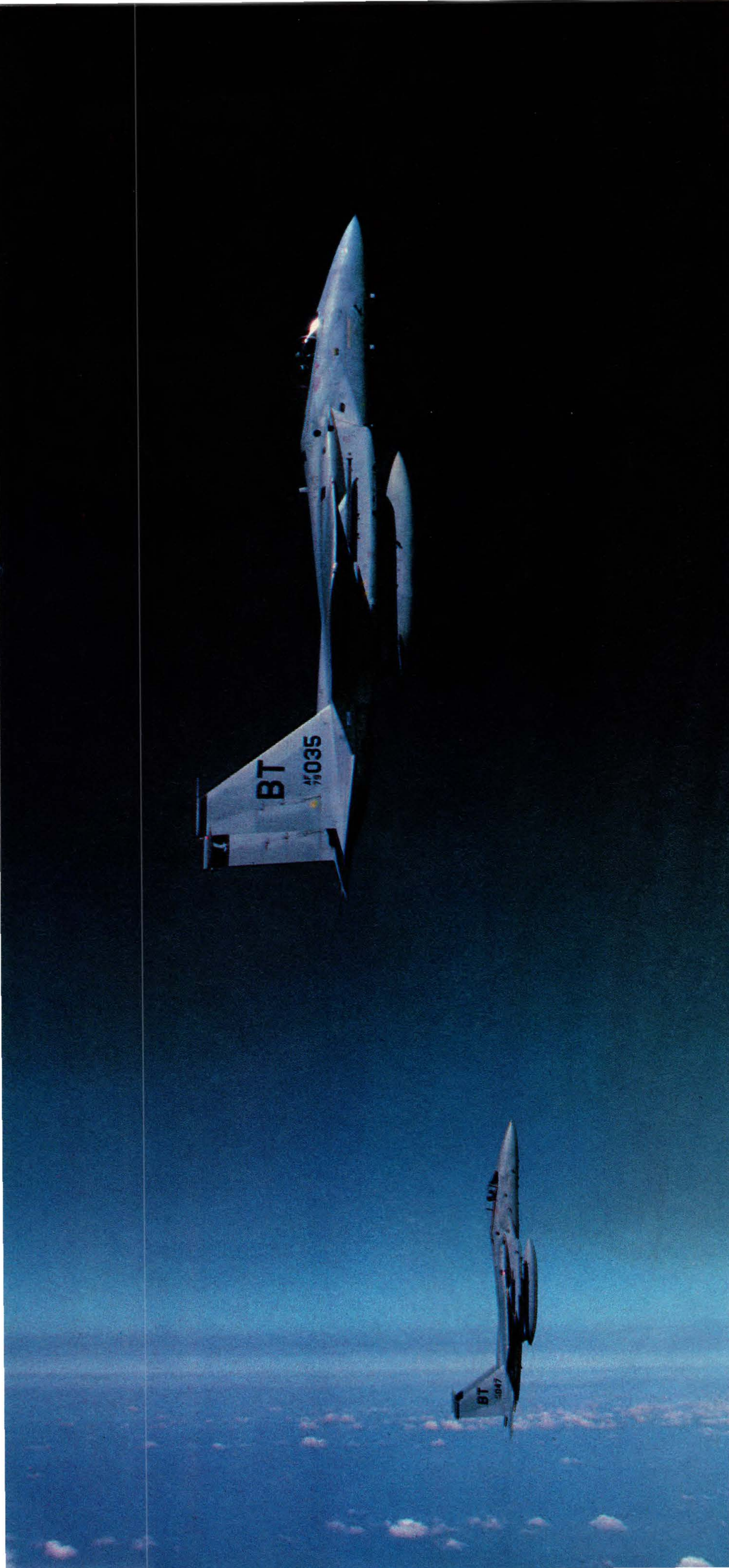
The HP 1980 System saves test time and assures high product quality through consistent waveform comparison and characterization.

Automate production measurements with the HP 1980 System, and tackle two of the biggest problems facing industry today...how to reduce manufacturing costs and improve product quality. This system can significantly reduce test time and increase production throughput. And it can virtually eliminate errors associated with operator interaction, interpretation, and fatigue.

For example, in waveform comparison measurements, the HP 1980 can quickly compare a waveform under test with a stored limit waveform and provide a pass/fail indication within seconds. It eliminates the problems of waveform positioning, parallax, and judgement so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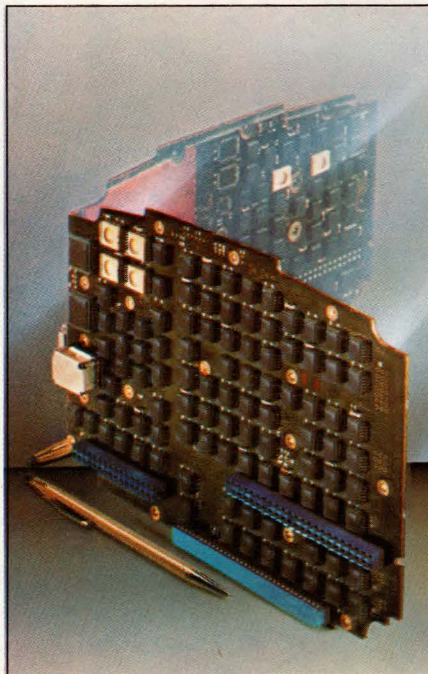


Instruments and Collins Avionics dense circuit reliability soar.

board caused the solder joints attaching the components to the board to break.

TI's solution: A composite metal core of low-TCE Invar that is clad on both sides with copper. Thin, polyimide-glass, multilayer boards were bonded to each side of the metal, to provide the circuitry function.

With a TCE match between the board and the chip carriers, the PC boards easily passed the exacting thermal cycling tests.

And the metal core in the board dramatically improved thermal conductivity and overall rigidity.

Solves thermal mismatch problems

As Collins Avionics discovered, the advantage of using chip carriers to achieve high-density, high-performance circuitry also imposes stringent demands for increased thermal management, structural integrity, as well as TCE compatibility—demands met by Texas Instruments copper-clad Invar.

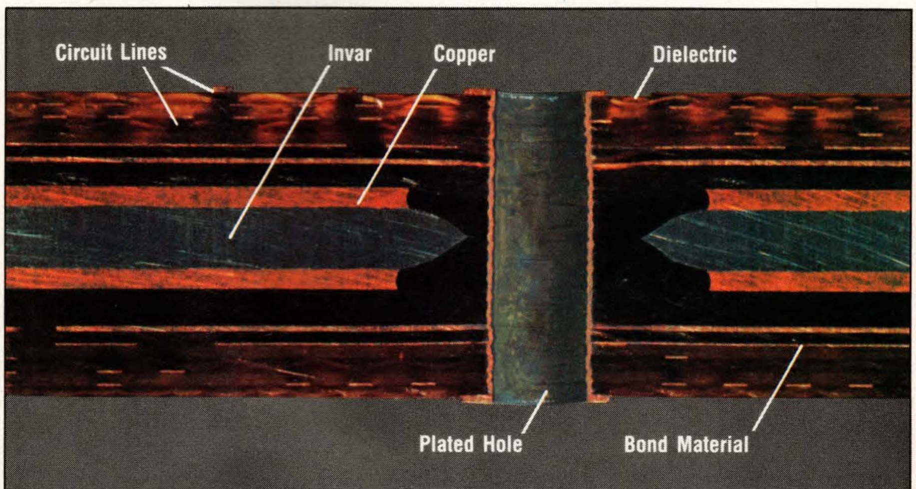
By combining TCE compatibility with high lateral thermal conductivity. And mechanical rigidity.

All at lower cost than alternate approaches. ■

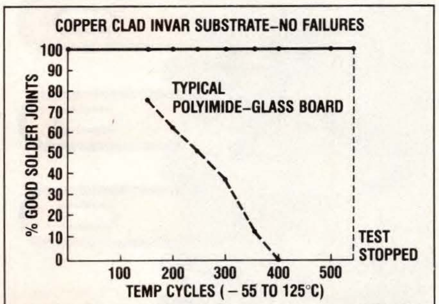
The solution is a trilayer metal.

TI's process involves roll bonding copper foil to Invar—a 36% nickel/64% iron alloy. The bonding to each side of the Invar is accomplished by the same process used to make thermostat metal and coins. No adhesives or brazing alloys are required to achieve a permanent bond.

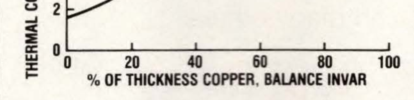
By varying the ratios of the high thermal conductivity copper to the ultra-low TCE Invar, the TCE of the clad metal can be tailored to match that of silicon, alumina, or beryllia.



Effective thermal management is achieved with a copper-clad Invar core that acts as a support for circuitry in the PC board. Heat dissipation characteristics of the copper are excellent, and the Invar contributes rigidity and strength.



After 540 thermal cycles from −55° to 125°C failed to break chip carrier solder joints, Collins Avionics halted tests of PC board used in F-15 communications system. Reliability goals had been surpassed by a wide margin.



Matching the TCE of the metal core of a PC board to chip carrier ceramic is accomplished by bonding the correct ratio of copper to Invar.

This material is available in thicknesses from 5 to 62 mils (.13 to 1.57 mm). You can get it in widths up to 24 inches (610 mm).

Copper-clad Invar is being developed for many other applications: From ground and power planes in multilayer boards, to heat sinks and covers for multichip ceramic modules, and more.

A clad remedy to packaging challenges

TI's innovative clad metal solutions can solve your circuitry packaging problems—with a variety of materials.

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In fact, TI—the world's leading clad metals manufacturer—can help you develop a clad metal solution to many electronic materials problems.

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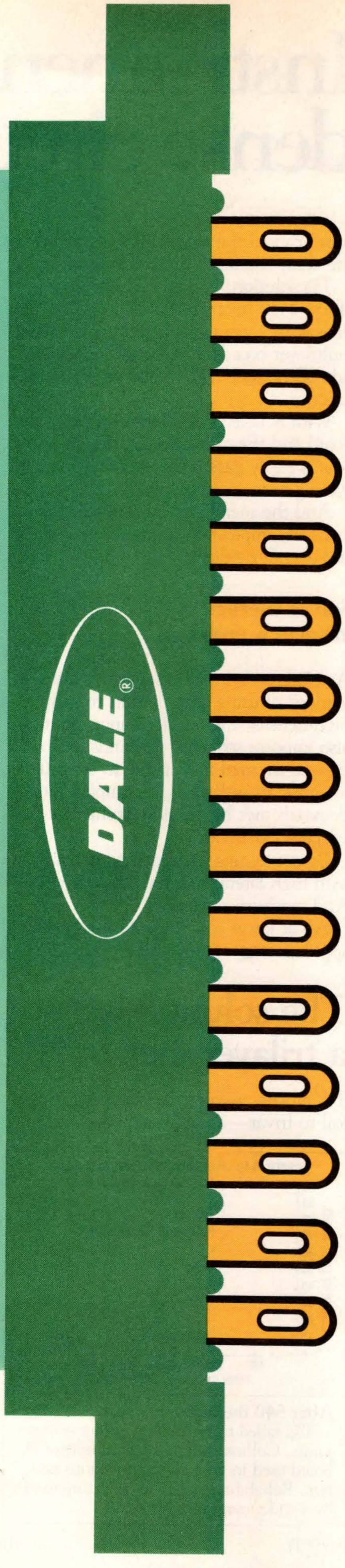
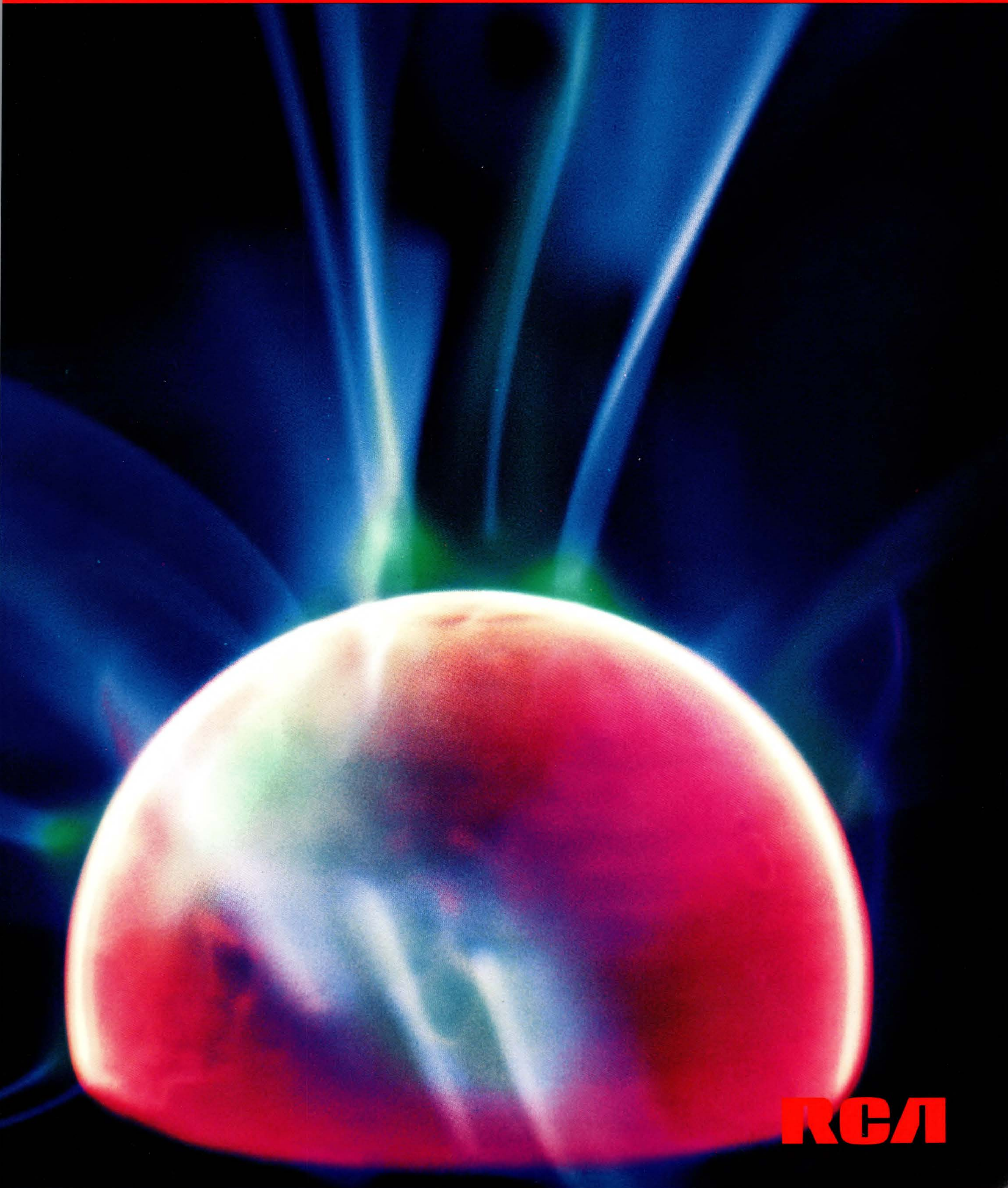


How to solve the problems of the ever-changing analog world.



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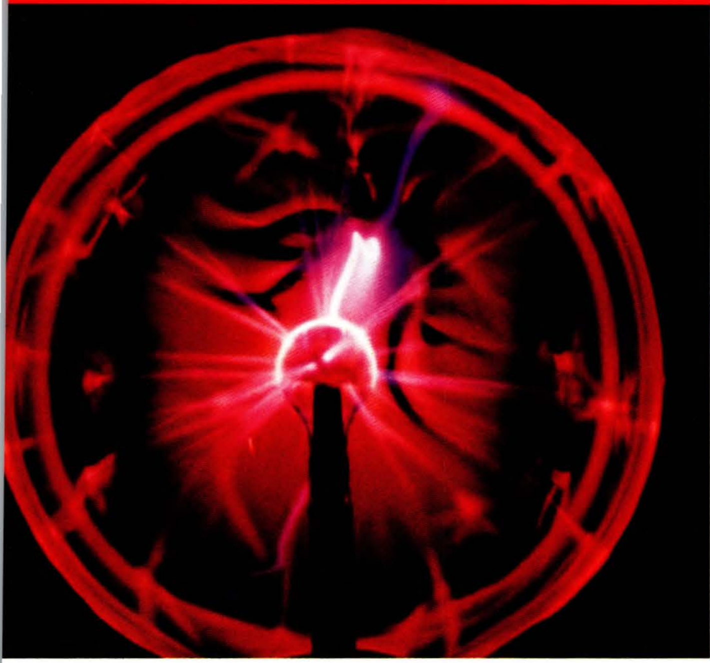

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CA301A	CA258	CA3015	CA3060
CA307	CA358	CA3029	CA3078
CA741	CA747	CA3030	CA3080
CA748	CA1458	CA3037	CA3440
CA3166	CA1558	CA3038	CA6078A
CA3193	CA2904	CA3100	**Dual Unit**
CA3420	**Quad Unit**	CA3130	CA3280
CA3493	CA084	CA3140	
CA6741	CA124	CA3160	
	CA224	**Dual Unit**	
	CA324	CA3240	
	CA3401	CA3260	
	CA3410		

Differential Amplifiers

Differential Amplifiers
CA3000
CA3001
CA3005
CA3006
CA3026
CA3028
CA3040
CA3049
CA3050
CA3051
CA3053
CA3054
CA3102

Arrays

Amplifier	Transistor	
CA3026	CA1724	CA3086
CA3048	CA1725	CA3096
CA3049	CA3018	CA3097
CA3052	CA3045	CA3118
CA3054	CA3046	CA3127
CA3060	CA3050	CA3138
CA3102	CA3051	CA3146
Diode	CA3081	CA3183
CA3019	CA3082	CA3227
CA3039	CA3083	CA3246
CA3141	CA3600	

Power Control Circuits

Voltage Regulators	Solenoid and Motor Drivers
CA723	CA3169
CA1524	CA3219
CA2524	**Automotive Ignition Switches**
CA3085	CA3165
CA3524	**Universal Controller**
Zero-Voltage Switches	CA3228
CA3058	
CA3059	
CA3079	
Programmable Schmitt Triggers	
CA3098	
CA3099	

Data Conversion

A/D Converters	
CA3162	
CA3300	
41051	
Display Drivers	
CA3161	CA3081
CA3168	CA3082
CA3207	CD22104/A
CA3208	CD22105/A

Special Function Circuits

Single-Chip Detector Alarm Systems	Automotive Circuits	Broadband (Video) Amplifiers
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Prescalers	CA3160	CA082
CA3179	CA3161	CA084
CA3199	CA3165	CA3001
CA3232E	CA3168	CA3002
	CA3169	CA3020
	CA3207	CA3040
	CA3208	CA3100
	CA3219	CA3130
	CA3228	CA3140
	CA3260	CA3160
	CA3290	CA3240
		CA3260

Voltage Comparators

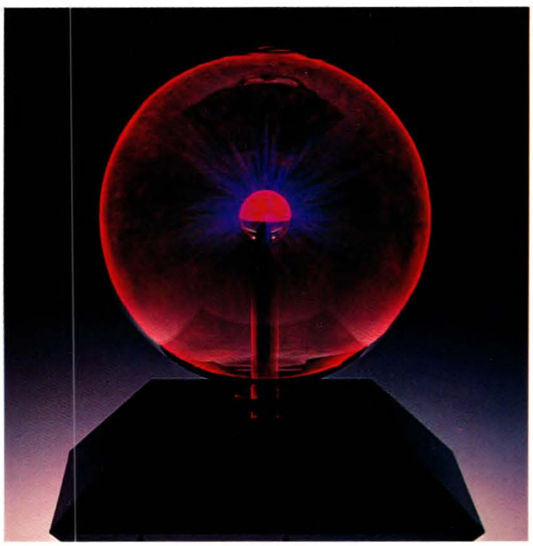
Single Unit	Dual Unit	Quad Unit
CA311	CA3290	CA139
CA3098		CA239
CA3099		CA339

Video Systems

AFT	Horizontal Vertical Systems	PIX IF
CA3139	CA1391	CA3068
Chroma Systems	CA1394	CA3136
CA3151	CA3154	**Sound IF**
CA3194	CA3159	CA1191
CA3201	CA3190	CA3065
CA3217	CA3202	CA3134
CA3234	CA3210	**Tuning**
Luminance Processors	CA3223	CA3238
CA3135	CA3236	CA3163
CA3143		CA3166
CA3156		CA3168
		CA3237

Communications Circuits

CA2111A	CD22302
CA2136A	CD22303
CA3014	CD22100
CA3088	CD22101
CA3089	CD22102
CA3123	CD22301
CA3189	CD22103A
CA3209	CD22859
CA3195	



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RCA

Photos by Pete Turner, NYC; StarSculpture™ Visual Technologies Corp, New Canaan, CT.

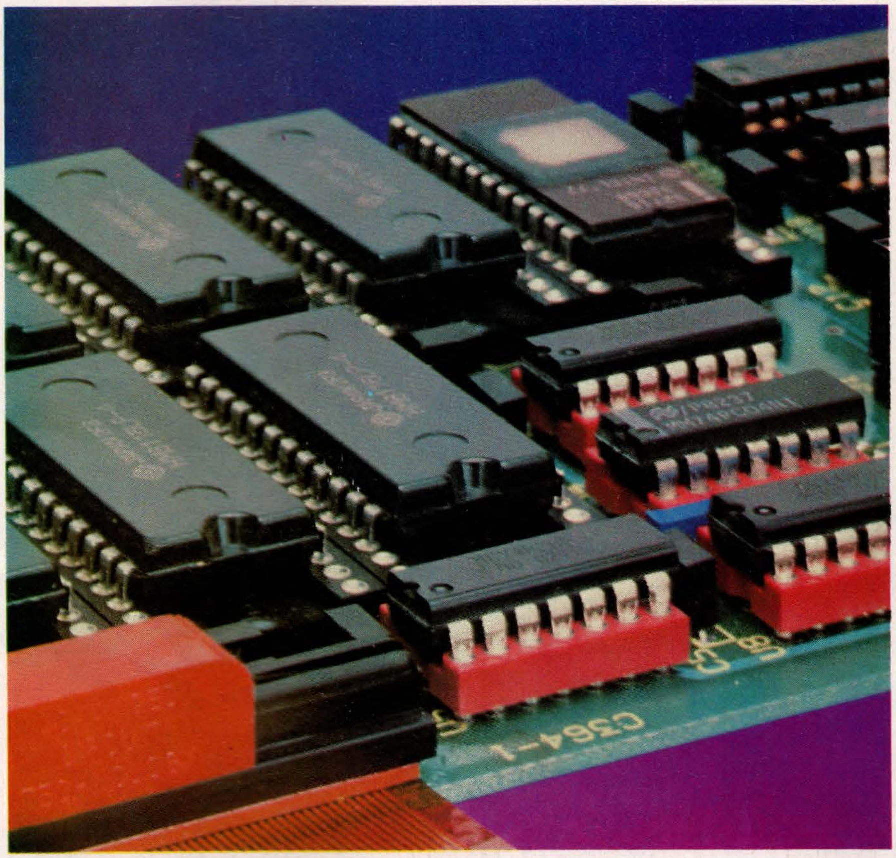
Ever-widening list of component types improves outlook for SMD technology

Tom Ormond, *Senior Editor*

Thus far, interest in surface-mount-device (SMD) technology has outstripped its implementation. Nevertheless, innovative SMDs, ranging from data converters to delay lines, are steadily improving the technology's prospects.

To date, a lack of such components has ranked high on the list of factors contributing to SMD technology's limited use. Although chip resistors, capacitors and inductors are available from many sources, more exotic surface-mount devices have been hard to find, often forcing users to mix SMDs with conventional leaded-component technologies. Moreover, many designers have shied away from the technology because they're not familiar with the details of its use.

With the appearance of a host of devices—data converters, crystal oscillators, reed relays, delay lines, thermistors, resistor networks, transformers and connectors—the technology is becoming increasingly attractive. One firm even offers help to those designers considering the technology (see **box**, "Easing the transition"). A look at some recently introduced products illustrates the flexibility that SMD technology can afford.



Offering twice the contact density *of conventional insulation-displacement connectors, Advanced Circuit Technology's SNAP connectors mate flat flexible circuitry to pc boards.*

Data converters to the surface

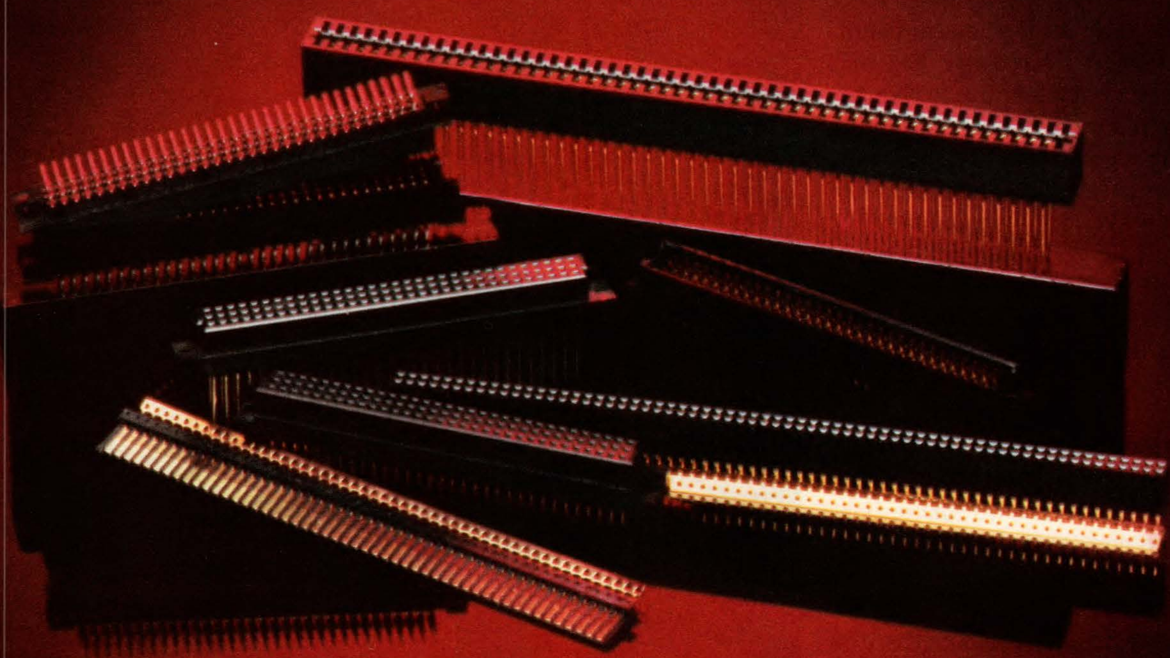
First, consider data converters. The MN3660 from Micro Networks is a 12-bit, 7-μsec D/A converter, complete with an output amplifier and a low-drift, compensated zener reference. It comes with an internal, high-speed (40-nsec setup time and 0-nsec hold time) data register that facilitates μP interfacing. Monotonicity and 12-bit linearity are guaranteed over the device's operating ranges (which include −55 to +125°C), and 100% screening to MIL-STD-883B is optional.

The MN3660 ($109 to $174) features 0 to 10, ±5 and ±10V user-selectable output ranges. Unadjusted full-scale accuracy errors are guaranteed to be less than ±0.1% at room temperature and less than ±0.3% over all specified operating ranges. The accuracy spec over temperature encompasses all unipolar-offset, bipolar-offset and gain-drift effects, and all linearity, monotonicity and accuracy specs are 100% tested at room temperature and at temperature extremes.

The converter specs a 10-μsec max settling time to within ±½ LSB in response to a 20V step. It consumes less than 760 mW when operating from ±15 and +5V.

Micro Networks also offers a line of surface-mountable A/D converters. MN5610 Series devices are high-speed (13 μsec), 12-bit successive-approximation units that can operate with a 1-MHz clock. Offering parallel and serial data outputs, the devices come in hermetically sealed ceramic packages with 24 pads on 100-mil centers. No missing codes and 12-bit linearity (±½ LSB maximum error) are guaranteed over the entire specified operating range (including −55 to +125°C).

These A/D converters ($155 to $225) feature input-voltage ranges of 0 to 10, 0 to −10, ±5 or ±10V. For each range, you can specify models complete with internal ref-



erences, or versions that use an external reference for improved accuracy.

The MN5610 operates without external gain- and offset-adjustment potentiometers. Active laser trimming of the device's thin-film resistor networks provides high initial accuracies and stable performance over temperature. Zero error, for example, is guaranteed to be better than ±0.025% FS reading at 25°C and better than ±0.05% FS reading over the entire operating range. The converters operate from ±15 and 5V supplies and consume 915 mW max.

Other active SMDs include oscillators. Housed in standard 24-pin ceramic leadless chip carriers, Statek Corp's surface-mountable crystal oscillators consist of a CMOS-compatible hybrid circuit and a miniature quartz crystal. Spanning frequency ranges of 10 kHz to 2 MHz (Model SQXO-2-SM) and 1 Hz to 10 kHz (Model DQXO-3-SM), the devices are compatible with conventional vapor-phase solder-reflow and wave-solder processing techniques and offer small size (0.4 ×0.4×0.085 in.), high shock resistance and good long-term stability.

Low power consumption is a key feature of these oscillators. Because conventional low-frequency quartz crystals are large, most low-frequency clock oscillators use smaller high-frequency crystals and internal dividers to produce a low-frequency output. However, because power consumption in a CMOS oscillator is directly proportional to the crystal's resonant frequency, these oscillators consume large amounts of power.

Marking a departure from this technique, SQXO ($50 in quantities of 100) and DQXO oscillators use microminiature crystals that resonate at the desired oscillator frequency, resulting in significantly less power consumption. For example, SQXO devices draw 2 mA at 2 MHz (operating with a 4 to 6V supply) and only 0.2 mA at 10 kHz.

The oscillators come in two grades, offering ±0.01% and ±0.03% tolerances, and a choice of operating ranges: −40 to +85°C and −55 to +125°C. Temperature coefficient specs at −0.035 ppm/°C, and frequency temperature stability equals ±0.02% from −40 to +85°C. Depending on output frequency, shock resistance (for 1 msec) ranges from 750 to 1000g, and vibration resistance (from 10 to 2000 Hz) equals 10g.

Relays are joining converters and oscillators in SMD configurations. For example, there are the 0.75×0.24×0.15-in. 9100 Series reed relays from Coto Corp, which offer substantial circuit-board real-estate economies. Aimed primarily at component ATE applications, the relays are compatible with automatic component-placement equipment and can withstand the high temperatures of vapor-phase and reflow-soldering techniques.

The $2.50 (10,000) relays are manufactured on a lead frame and feature a molded construction. They have 5V/150Ω coils and feature high-stability sputtered-ruthenium reed-switch contacts. The contacts can carry 1.5A and switch 200V or 0.5A at 10W max. Lifetime at rated load specs at 5×10^6 operations. Relay design features a straight-through microstrip ground plane that achieves a 93Ω characteristic

Easing the transition

Many reasons have been advanced to explain why surface-mount-device (SMD) technology has been slow to gain widespread acceptance in the US. One prime factor concerns circuit layout; prospective users are not totally familiar with what's involved in designing pc boards, and consequently they don't realize the advantages afforded by the new components. If this is what's been stopping you from jumping on the SMD bandwagon, Cermetek Microelectronics may well have the solution to your problem.

The company's Designer's Kit ($25, refundable with the first order) leads engineers and board-layout personnel through the process of designing custom hybrids using a combination of thick-film-substrate and surface-mount technologies. Starting with a proven schematic diagram or an already existing pc board containing a variety of conventional components, the designer can reduce his circuit size by a factor of five. The kit offers step-by-step instructions on how to lay out an SMD circuit, specifies the necessary design rules, and provides a design example that guides the designer through the complete process.

The package consists of a 20-page instruction manual, a laminated design grid (four times the size of the design space), self-stick icons of typical surface-mount components (small-outline ICs and transistors, diodes, ceramic chip capacitors, and chip inductors and resistors) and 10 vellum overlays for indicating component-to-component interconnections. Once you complete the layout, you simply return the grid to Cermetek for a estimate (available within seven working days) on prototype- and production-quantity pricing.

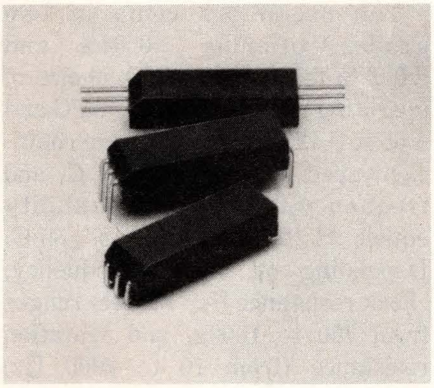
The finished ceramic SMD module can be located on a pc board that incorporates other components, such as large electrolytic capacitors, switches and connectors, to satisfy the overall circuit design. For added circuit security, Cermetek can provide a special black dielectric polymer or overglaze mask over the entire ceramic substrate. This mask permanently hides all of the layout, making it almost impossible for anyone to perform reverse engineering and copy the finished product.

impedance. Contact-to-coil capacitance measures less than 1 pF.

The devices feature J-type leads to compensate for thermal coefficient-of-expansion variations. The relays also come with axial leads for in-circuit strip-line mounting.

The converters, oscillators and relays discussed so far illustrate only some of the recent innovations in SMD technology. Other offerings include active and passive delay lines, hybrid- and chip-style thermistors, standard and custom resistor networks, signal transformers and connectors.

Technitrol Inc, for example, offers two lines of active delay modules designed for use with TTL, Schottky TTL and low-power Schottky TTL. Each incorporates an LS hex inverter, provides five tap lines, and offers total delays from 20 to 200 nsec. The modules can satisfy many timing applications with a minimum of interface requirements.

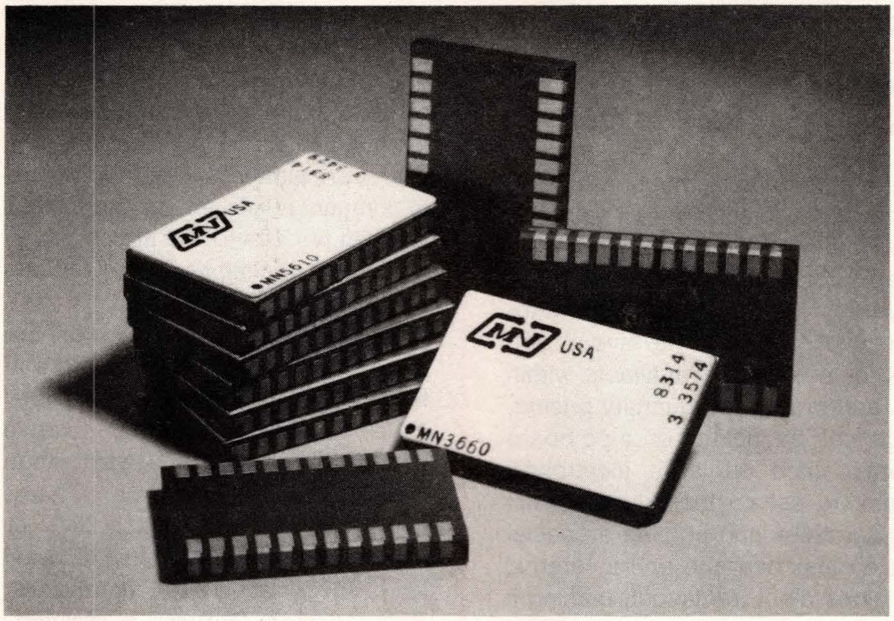


Aimed primarily at ATE applications, *Series 9100 reed relays from Coto Corp come in three mounting styles and switch 10W loads for more than 5×10^6 operations.*

You can cascade the delay modules to obtain any delay combination without degrading output rise time, which equals 2 to 5 nsec max for all taps. The delay-to-rise-time ratio is approximately 50:1 and improves when cascading modules. Output rise times of each module are independent of input rise times ranging to 50 nsec.

Each module can handle input pulse widths as low as 40% of the total delay time (with less than 2.5-nsec input rise times). They operate from 0 to 70°C and require a 5V supply. Fanout specs equal 20 and 10 for logic One and logic Zero states, respectively. Encapsulated by transfer molding, the modules are pin compatible with 54/74 Series TTL/SSI 14-lead flat packs or SO-14 packages.

The company also offers two families of passive delay lines. Designed for use with TTL, the BF (0.5 in.^{2}) and CF (0.75 in.^{2}) Series delay lines offer total delays of 10 to 100 nsec and 10 to 200 nsec, respectively, with taps at every 10% point. Operation spans the −55 to +125°C temperature range, and the units can be mounted in standard chip-carrier sockets or directly on substrates using reflow-soldering techniques.



Surface-mountable A/D and D/A converters *from Micro Networks come in leadless packages with a maximum height of 0.183 in. Outside dimensions measure 0.81×1.315 in. max, and each unit's 24 bonding pads are located on 100-mil centers.*

Standard characteristic impedance equals 100Ω, ±10% (versions with 50 and 200Ω impedances are also available). The delay lines feature a 2-nsec max input rise time and accommodate minimum input pulse widths equal to three times the output rise time (2.2 to 20 nsec for BF devices and 2.2 to 40 nsec for CF units).

Delay tolerance equals ±1 nsec. Temperature coefficient specs at 100 ppm/°C, and distortion measures ±10%.

Solving temperature problems

With its two styles of SMD thermistors, Dale Electronics offers designers a choice of termination configurations and performance levels for temperature-measurement applications. Both devices are NTC (negative temperature coefficient) devices constructed of high-density sintered-oxide ceramic.

Type H (hybrid) units have silver wrap-around terminations on each end for solder or conductive-epoxy mounting. Resistance values at 25°C (R_{25}) range from 5 kΩ to 1 MΩ, and standard tolerances spec at ±5 and ±10%. Although size varies with resistance, measurements are approximately 0.1×0.05 in.

Dale's Type W (chip) styles have silver terminations on top and bottom surfaces. You can mount the bottom surface directly to a substrate bonding pad using conductive epoxy or reflow soldering and terminate the top surface via a wire bond to complete the circuit connection. R_{25} values range from 50Ω to 1 MΩ, and standard tolerances are, again, ±5 and ±10%. Thermistor sizes range from 0.2 to 0.3 in.^{2}, depending on the R_{25} value.

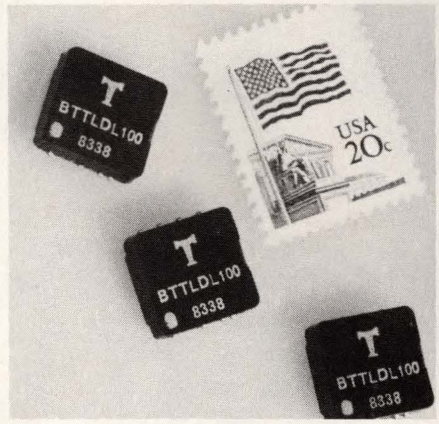
If, instead of measuring temperature, you want your circuit to perform consistently through all temperature variations, you should consider SMD resistor networks that minimize temperature sensitivity. Available in both standard and custom configurations, the Econo-Chip and Versa-Chip resistor networks from Electro-Films Inc suit applications requiring precise ratio matching, close temperature tracking and tight absolute tolerances, and they offer significant cost savings in applications not requiring hermetic sealing.

Available in 16- to 64-terminal configurations, the resistor networks feature resistance values from 20Ω to 250 kΩ, low temperature coefficients (25 ppm typ, 50 ppm max), and absolute-resistance and resistance-ratio accuracies to 0.01%. Temperature tracking specs at 2 ppm/°C, and worst-case absolute-resistance and resistance-ratio stability is better than ±0.05%/1000 hrs at 125°C.

Econo-Chips ($6 (1000) for 0.1% tolerance) are mounted with the same technology used in hermetic chip carriers. The Econo-Chip package consists of a resistor network on a ceramic substrate, soldered face down to a tooled outer ring. The circuitry is covered with an epoxy preform, and the contact ring is soldered at standard bonding-pad locations. In addition, for hybrid-circuit applications, capacitors or semiconductor chips, or both, can be attached to the network prior to securing with epoxy.

Versa-Chips ($4 (1000) for 0.1% tolerance) are mounted on a tooled frame and soldered face up to the pc board. The flexible lead frame is designed to compensate for the difference in temperature coefficients of expansion between the pc board and the chip. Versa-Chips are also available without the epoxy coating to allow for laser trimming by the end user.

Other SMD offerings include transformers. The units in the WCT Series of leadless transformers from West-Cap, for instance, are primarily intended for use in low-power signal applications. Useful for filtering, pulse-network and delay-line services, they come with center-tapped primaries and secondaries. The devices offer a choice of winding configurations and use pot, toroid, bobbin, E or I cores. The transformers can be supplied with turns ratios of 1:1, 2:1, 3:1, 4:1, 5:1 and 10:1.



Satisfying many timing applications *with minimum interfacing, these active delay lines from Technitrol suit use with TTL, Schottky TTL and low-power Schottky TTL.*

The 0.51×0.51×0.175-in. C11-LHA from Technitrol is a 3-winding interface transformer designed to interface transmitter/encoder and receiver/decoder chips to a transmission line. Providing an easy means of interfacing a coaxial cable or twisted shielded pair to a communications network, it isolates the transmission line from the user's equipment and furnishes high common-mode rejection.

The transformer accommodates bit rates to 3.5 MHz and rejects any dc component in the data. Completely encapsulated by transfer molding, it operates from 0 to 70°C. Pertinent electrical specs include a 1:1:1 turns ratio, 750-μH mutual inductance, 0.7-μH leakage inductance, 1.8Ω winding resistance, 26-pF interwinding capacitance and 4-pF effective distributed capacitance.

Finally, consider connectors suited to SMD applications. Designed to terminate flat flexible circuitry to pc boards, Advanced Circuit Technology's SNAP (sustained necessary applied pressure) surface-mount connectors save valuable pc-board real estate by offering more than twice the density—40 contacts per linear in. standard—of conventional insulation-displace-

For more information . . .

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

Advanced Circuit Technology
Box 547X
Nashua, NH 03060
(603) 880-6000
Circle No 726

Berg Electronics
30 Hunter Lane
Camp Hill, PA 17011
(717) 975-2000
Circle No 727

Cermetek Microelectronics Inc
1308 Borregas Ave
Sunnyvale, CA 94089
(408) 734-8150
Circle No 728

Coto Corp
55 Dupont Dr
Providence, RI 02907
(401) 943-2686
Circle No 729

Dale Electronics Inc
Western Thermistor Div
2300 Riverside Blvd
Norfolk, NB 68701
(402) 371-0080
Circle No 730

Electro-Films Inc
111 Gilbane St
Warwick, RI 02886
(401) 738-9150
Circle No 731

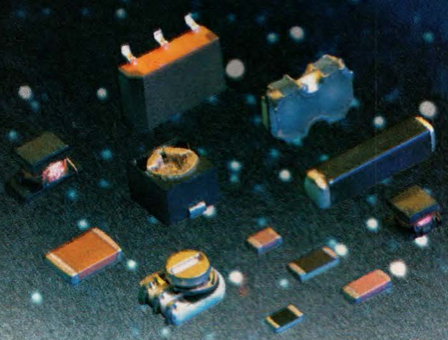
Elfab Corp
Box 810555
Dallas, TX 75381
(214) 233-0753
Circle No 732

Micro Networks
324 Clark St
Worcester, MA 01606
(617) 852-5400
Circle No 733

Statek Corp
512 N Main St
Orange, CA 92668
(714) 639-6810
Circle No 734

Technitrol Inc
1952 E Allegheny Ave
Philadelphia, PA 19134
(215) 426-9105
Circle No 735

West-Cap Arizona
1501 First St
San Fernando, CA 91341
(213) 365-9411
Circle No 736



ment connectors. They feature a mounted profile of less than 0.5 in. and require no mating half.

Available in 2-, 3-, 4-, 5- and 6-in. sizes (approximately $1 (50,000) for a 40-position unit) the connectors have a self-locating design that permits placement virtually anywhere on the pc board. No soldering is required; two guide posts mate with holes located on the board, and when the connector is closed, a spring clamp holds the connector firmly in place. The connectors provide reliable gas-tight connections for more than 250 insertions.

Elfab's Box-Pac connectors are edge-mounted types (mounted coplanar to the pc board). They can be soldered directly to tin lead pads utilizing inexpensive reflow-soldering equipment supplied by the manufacturer. You can also employ vapor-phase techniques, if you're so equipped, by applying spring tension to the position and holding the connectors in place prior to soldering. Compatible with pick-and-place assembly techniques, the connectors can mount on standard boards or ceramic substrates. They suit use with flexible circuits.

Box-Pac connectors ($0.025 to $0.045/line) mate with 0.025-in.^{2} pins. They are available in 2-row versions (0.1×0.1-in. center lines) in 2- to 70-position configurations (4 to 140 pins).

Berg Electronics also offers an extensive line of pc-board connectors. Single-row versions come in sizes ranging from 3 to 52 positions; double-row designs have 3 to 65 positions. Both versions offer a choice of 15- or 30-μin. gold plating.

The connector contacts are designed to float in the housing, allowing the legs to center themselves on the pads. This action compensates for board warping or other irregularities. **EDN**

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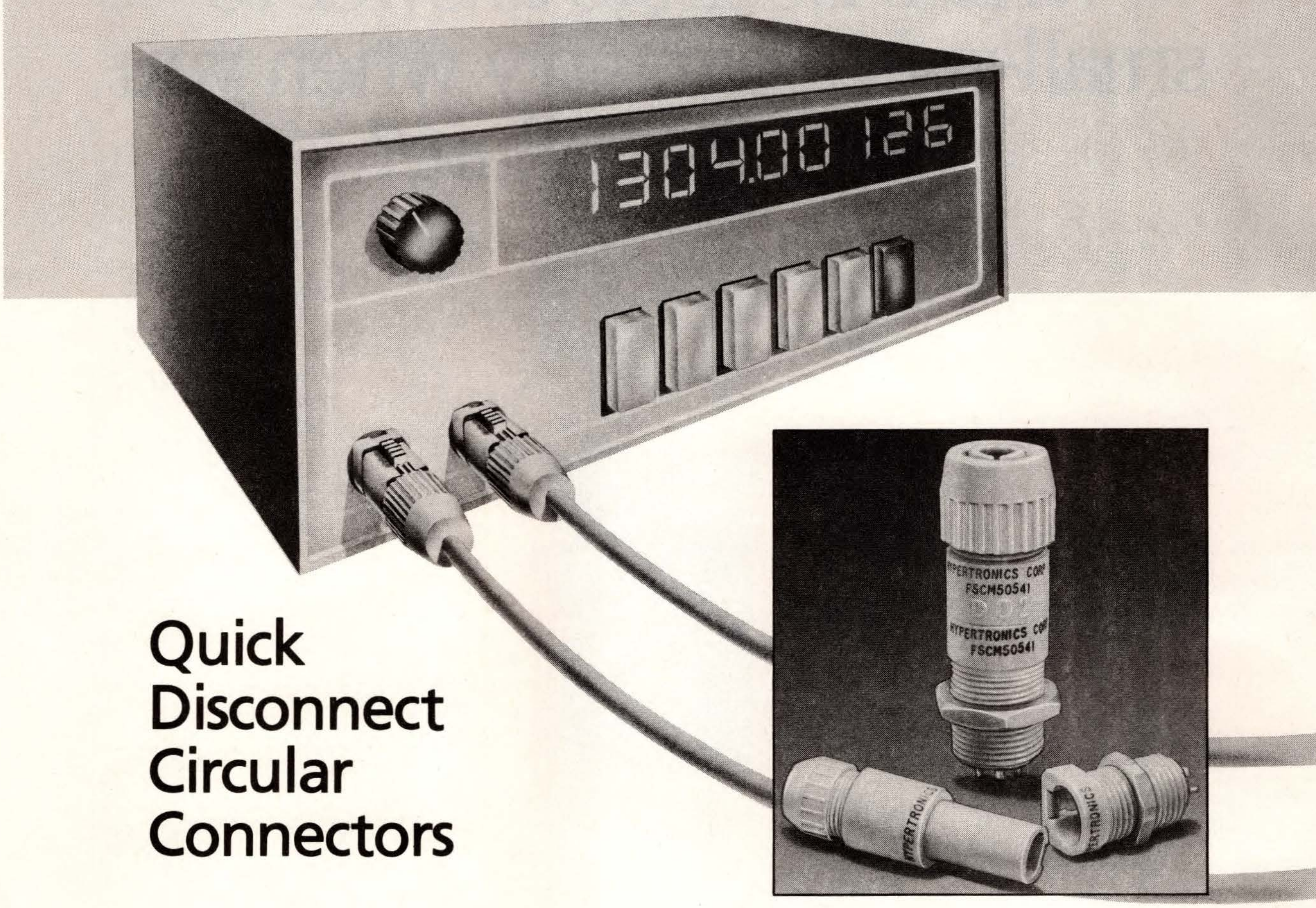

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The D Series circular connector combines the cost benefit of an injection molded polycarbonate or polysulfone housing with the performance of military grade high performance contacts...minimizing material costs, field service calls and equipment down time.

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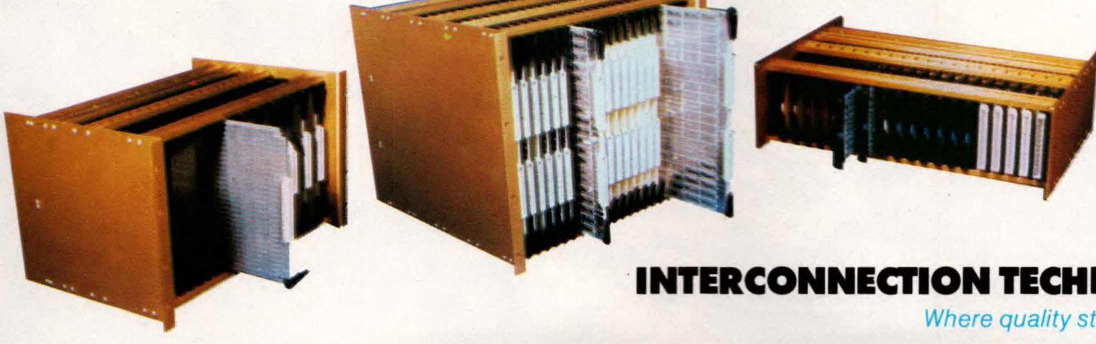

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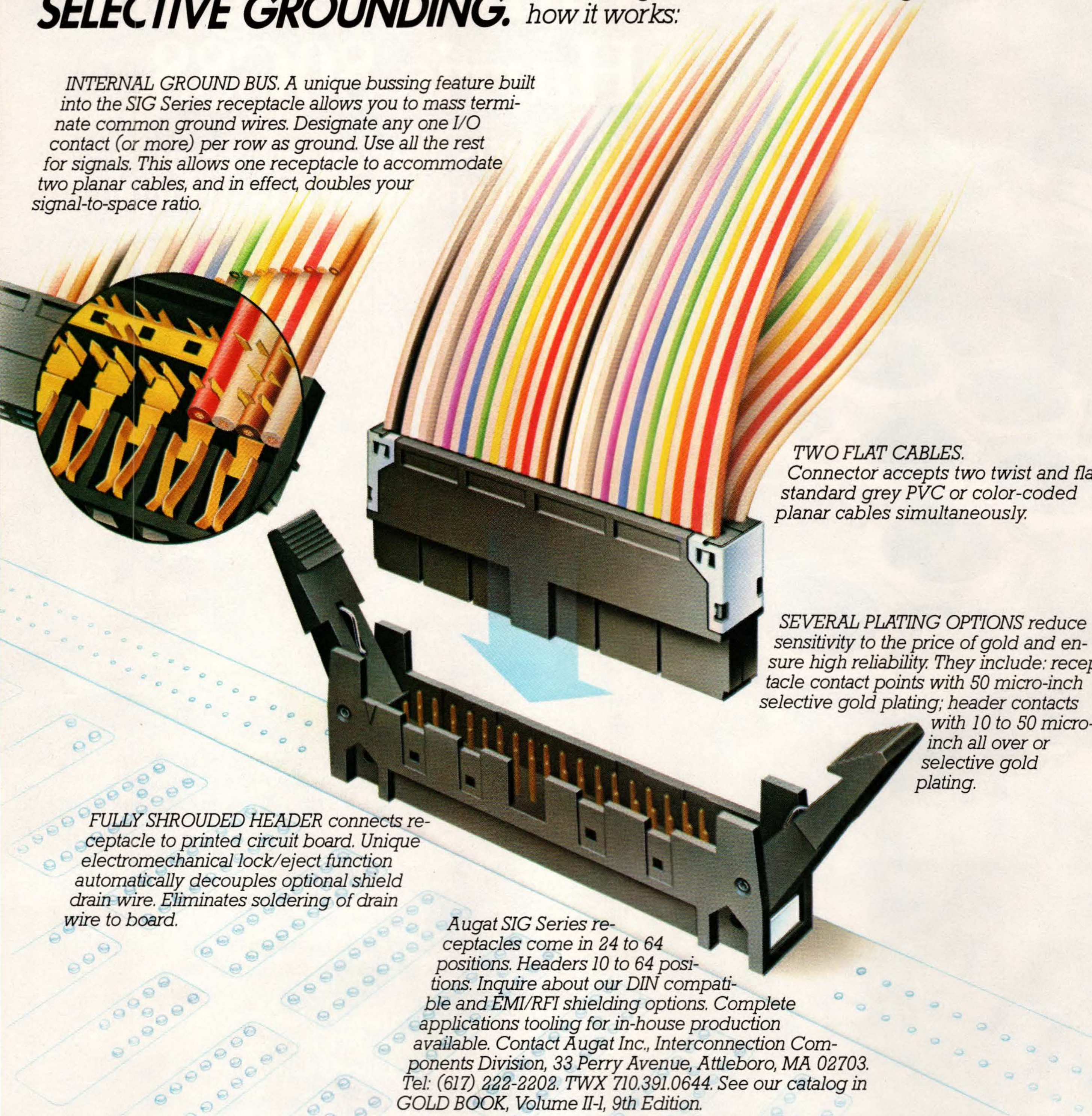

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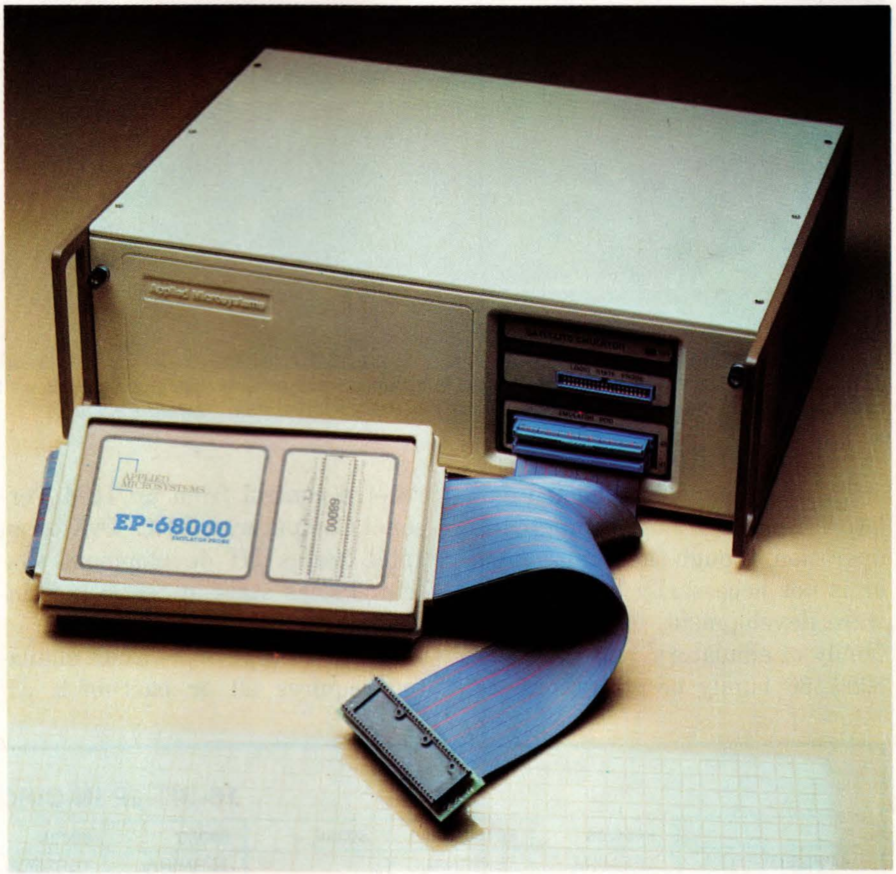
New 16-bit μP emulators add features, but performance quirks limit usefulness

Chris Everett, *Western Editor*



Stand-alone in-circuit emulators *like this one from Applied Microsystems assist in hardware/software debugging without tying up expensive software-development tools.*

New in-circuit emulators for 16-bit μP systems—in which long and increasingly sophisticated software programs combine with increasingly complex hardware—are more capable than their 8-bit counterparts. But selecting the right emulator for your needs requires more than just comparing some data sheets and observing a few product demonstrations. Not only must you compare features, you must also beware of emulator quirks—performance characteristics that, in some cases, can hinder your hardware/software integration efforts.

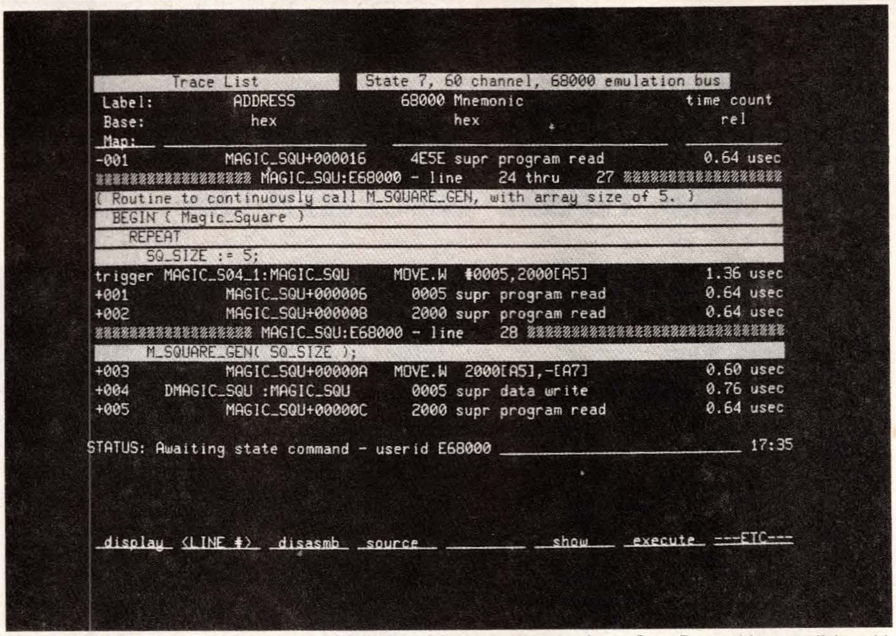
Many features of the latest emulators are impressive; you obtain much more than just the ability to emulate μP operation and display register and memory contents. The new emulators assist in symbolic debugging, and they even emulate coprocessor chips and other system chips, as well as the system μP. Their performance quirks, however, aren't usually highlighted—and often aren't even mentioned—on data sheets. Consequently, with emulator prices ranging from approximately $4000 to well beyond $40,000, choosing an emulator requires great care.

Ease of use varies

Before looking at specific performance characteristics, you should consider the three categories of in-circuit emulators that are available: the stand-alone, the computer-hosted, and the development-system-dependent emulators. Any one type will probably work for you, but with varying degrees of success and ease. As you move from stand-alone to hosted to system-dependent emulators, you'll find that capabilities and ease of use often increase, and the integration of other debugging tools with the emulator is more complete. Needless to say, prices increase as well.

The stand-alone emulator, as you would expect, can operate independently of the host computer or the μP development system that's used to develop the μP software. After you download the target-system software into the stand-alone emulator via (normally) an RS-232C link, you can detach the emulator and use a CRT terminal to control the emulator's operation. The stand-alone emulator offers the benefit of freeing a host computer or a μP development system for additional software development while hardware/software integration is proceeding with the emulator.

As noted, prices for stand-alone emulators tend to be lower than those for computer-hosted emulators or emulators tied to particular μP development systems. ES Series stand-alone emulators from Applied Microsystems start at $9350, plus the cost of a CRT terminal. The Microtek Lab Mice-II emulators start at $3995; you add a terminal and a power supply.



Tracing instruction execution in high-level languages *such as C or Pascal is possible with in-circuit emulators and the HP 64000 μP development system from Hewlett-Packard.*

The more expensive hosted emulators require a host computer for operation, though the same computer is not necessarily used for software development. The Microcosm family of emulators, supporting the 8086/186 family of processors, can receive control from an IBM Personal Computer, a DEC VAX or an Intel Series III development system. Prices start at $6290 (not including the cost of the host).

The third type of in-circuit emulator requires all or part of a μP development system for operation. Use of Tektronix emulators, for example, requires the company's $11,000 Model 8540 integration unit. Use of Hewlett-Packard emulators requires the firm's $11,130 development station. Similarly, Emulogic and Intel emulators require a total development-system workstation.

With an emulator controlled by a μP development system, you obtain the benefit of complete interfaces between different development tools. For example, a symbolic debugger that's optimized to operate with an emulator uses a system compiler's symbol-table output. And because suppliers of μP development systems optimize system integration/debug tools to work with each other, you normally need to learn only a single, common command language.

With Intel's development system, you receive additional optimization; not only are the emulators optimized for the system, but some μPs are as well. Intel has designed special 80186 and 80286 configurations

16-BIT μP IN-CIRCUIT EMULATORS

	8086/88	80186/188	80286	68000	68008	68010	Z8001	Z8002
APPLIED MICROSYSTEMS	TERMINAL	TERMINAL		TERMINAL	TERMINAL	TERMINAL	TERMINAL	TERMINAL
EMULOGIC	DEDICATED	DEDICATED		DEDICATED		DEDICATED	DEDCIATED	DEDICATED
HEWLETT-PACKARD	DEDICATED	DEDICATED				DEDICATED		
INTEL	DEDICATED	DEDICATED	DEDICATED					
KONTRON	HOST, DEDICATED	HOST, DEDICATED		HOST, DEDICATED	HOST, DEDICATED	HOST, DEDICATED	HOST, DEDICATED	HOST, DEDICATED
MICROCOSM	HOST	HOST						
MICROTEK	TERMINAL	TERMINAL (80186 ONLY)		TERMINAL	TERMINAL	TERMINAL		
MOTOROLA				DEDICATED	DEDICATED	DEDICATED		
NATIONAL SEMICONDUCTOR								
TEKTRONIX	DEDICATED	DEDICATED (80186 ONLY)		DEDICATED	DEDICATED	DEDICATED	DEDICATED	DEDICATED
ZAX	TERMINAL			TERMINAL	TERMINAL	TERMINAL		
ZILOG							TERMINAL, DEDICATED	TERMINAL, DEDICATED

NOTES:

TERMINAL — AFTER THE TARGET SYSTEM SOFTWARE HAS BEEN LOADED INTO THE IN-CIRCUIT EMULATOR, THE EMULATOR CAN OPERATE IN A STAND-ALONE MODE BY USING A CRT TERMINAL AS A CONTROLLER. SOME STAND-ALONE EMULATORS CAN ALSO USE HOST COMPUTERS AS CONTROLLERS.

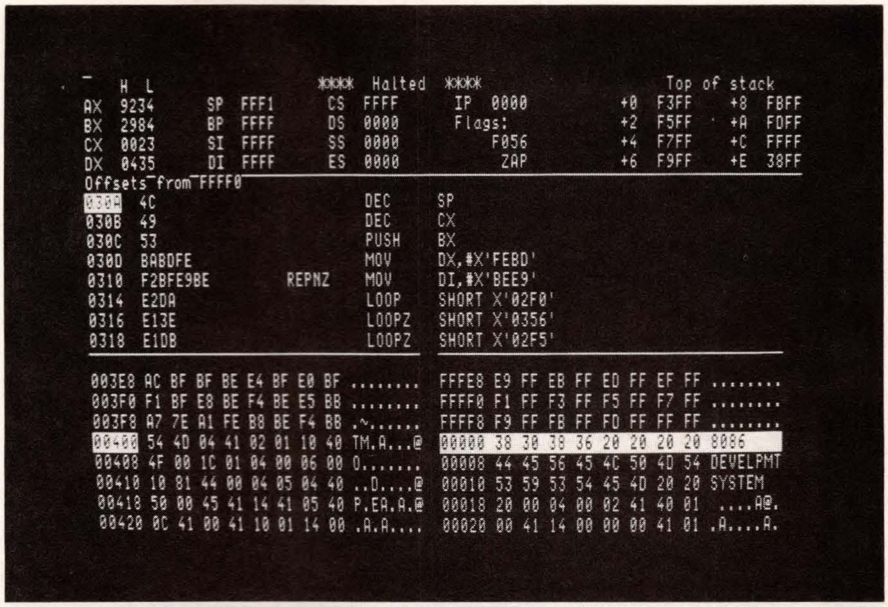
HOST — THE IN-CIRCUIT EMULATOR REQUIRES A HOST COMPUTER TO OPERATE. DEPENDING ON THE EMULATOR MANUFACTURER, THE HOST CAN RANGE FROM A PERSONAL COMPUTER TO A DEC VAX SYSTEM.

DEDICATED — THE IN-CIRCUIT EMULATOR REQUIRES THE MANUFACTURER'S μP-DEVELOPMENT SYSTEM TO CONTROL ITS OPERATION.

("bondout" chips) that have more than the usual number of output pins and thus can provide additional information on many internal processor functions. According to Intel, these special chips eliminate the need to obtain the same information via simulation or other time-consuming techniques. Without them, the company states, emulators might not be able to operate at the µPs' maximum speeds. The chips reside in Intel's emulators and aren't available separately.

Debugging solutions vary

In many design applications, such advanced capability might not be required. For example, if your application is primarily a hardware-debugging process, or if you're using a proven software package or conducting a relatively modest software-development effort, stand-alone or hosted emulators might be adequate. Applied Microsystems offers the widest range of stand-alone 16-bit emulators, including products for the Z8003 and Z8004 µPs. The only other supplier of emulators for these processors is Zilog.



A processor-status window and four additional display windows *can show program flow in machine language, assembly language or a waveform diagram on Kontron KSE emulators. You can independently direct each window to display an absolute or symbolic address or to track a µP register.*

The ES-1800 mainframe from Applied Microsystems can accept as much as 512k bytes of emulation memory, and memory-map segments can be as small as 2k bytes. The provided trace-control logic is quite extensive, permitting tracing of selected data for display in hex-formatted machine language or in assembly language. It shows only those instructions (and instruction addresses) that are actually executed. For products in the 8086/186 and 68000 families, a limited-capability symbolic-debugging option is available.

Microtek Lab's stand-alone Mice emulators are the price leaders. The entry price for the 68000 and the 8086/88 families is $3995, although you must add a terminal and +5V and ±12V dc power. Only 23 commands are in the Mice instruction set, but they provide sufficient power to emulate, set, and execute breakpoints and display results. By adding a Multi-Mice controller for $2495, you can control as many as four Mice emulators and perform multiprocessor emulation. If you need more than four emulators, you can cascade controllers.

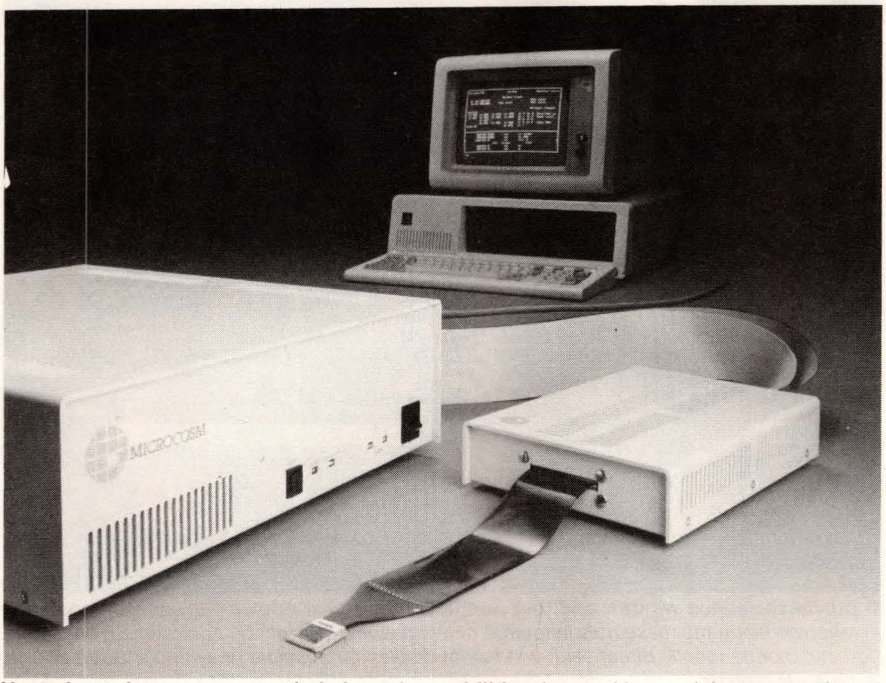
With the Zax stand-alone emulators, which sell for $7995, you get 128k bytes of emulation memory (expandable to 256k bytes) and an exceptionally deep 4k-byte trace memory. The ICD-178/8086-88 emulator can also emulate the 8086/87 or 8088/87 coprocessor pairs.

As noted, you need a host computer to operate a hosted emulator, although it's not necessarily the same computer used to develop your software. With the additional capabilities of the host, however, you gain advantages. For example, the Microcosm emulator takes advantage of an IBM Personal Computer's graphics to provide an easy-to-learn and easy-to-use human interface. The interface combines a high-level-language command line with a menu.

Matched tools debug software

If your project is software intensive, you might prefer an emulator that's coupled to a dedicated µP development system. The in-circuit emulator itself won't necessarily be better, but the closer tie-in with other parts of the development system provides advantages. For example, because the entire develop-

Z8003	Z8004	16032
TERMINAL	TERMINAL	
		HOST, DEDICATED
TERMINAL, DEDICATED	TERMINAL, DEDICATED	



Hosted emulators can use their hosts' capabilities *in graphics and fast computing to provide easy-to-use human interfaces and debug tools. Microcosm's user interface utilizes command-line and menu-driven formats to accommodate novices and advanced users.*

ment system comes from one manufacturer, you don't need to learn different operating systems or different human interfaces. In addition, there aren't hardware and software incompatibilities between the emulator and other development-system tools.

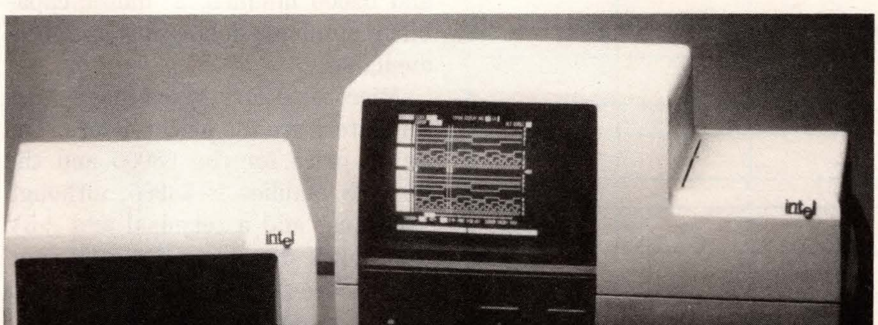
Intel's integrated instrumentation and in-circuit emulation system (I^2ICE) combines an emulator, a timing-logic analyzer and a high-level-language symbolic debugger in one package. Because the software debugger and the in-circuit emulator are from the same source, 80% of the two tools' procedural commands are identical.

The coupling of a debugger with the rest of a system also allows more complex symbolic debugging than would otherwise be possible. Although many stand-alone and hosted emulators have some symbolic-debug capability, many of them—particularly the stand-alone emulators—can assign names only to memory-address locations or to unchanging numeric values. Also, to supply a symbol table to the emulator, you might actually have to generate it manually at the terminal keyboard.

In an emulator such as Intel's Series IV with the I^2ICE package, however, the generated symbol table and associated debug program track not only unchanging or static symbols but dynamic variables as well. The program can also keep track of each symbol's type—for example, whether it's an address label, a data byte or word, an array, a real number, or a Pascal record. With such languages as C and Pascal, in which program modules move in and out of memory, the Intel debugger can also recognize active symbols and remember the symbols' locations and values.

The close association of an emulator with other software-development tools also allows you to see a section of executed code not only in hex-formatted machine language but also in the assembly-language mnemonics or in the high-level-language source-code statements from which the executable code resulted. For example, Emulogic's new SLICE (Source Language In-Circuit Emulator) symbolic-debugging system lets you choose whether to control an emulation process at the assembly-language level or the source-code level. It allows you to set and execute breakpoints. Alternatively, you can step through source or assembly code one instruction at a time. You can quickly switch between assembly language and a high-level language such as C or Pascal by typing in a command.

Another reason for selecting an emulator that's tied to a µP development system is the use of multiple µPs in an application, particularly if close coordination of the different emulators' activities is necessary. The Intel Series IV development



In a dedicated µP development system, *in-circuit emulation, logic-timing analysis and high-level-language software debugging occur via a common user interface. This system is Intel's Series IV with its integrated instrumentation and in-circuit emulator (I^2ICE).*

system, for example, can control as many as four in-circuit emulators at one time from a single workstation. Previously, debugging multiprocessor systems required several engineers at individual stations.

Kontron's KDS development system also handles four emulation units, and it supplies another degree of freedom: The processors needn't all be from a single manufacturer. The system can, for example, emulate a 68000-based system that uses a Z80 for I/O processing.

And speaking of I/O processing, complete μP development systems can offer a debugging advantage in systems that do intensive I/O processing and for which the actual I/O hardware hasn't yet been developed. With an emulator on a system like Hewlett-Packard's HP 64000 workstation, you can simulate I/O with system resources such as disk files, a printer, display and keyboard, and RS-232C ports.

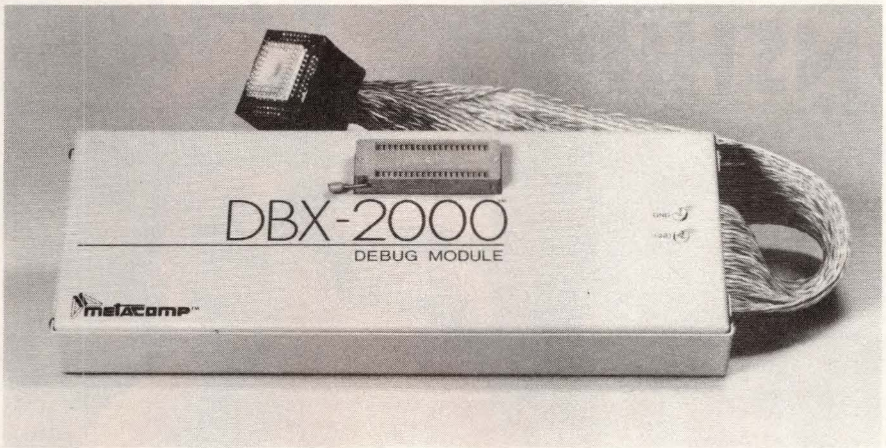
Specs aren't complete

After determining the type of emulator you plan to use, you should be ready to examine specs. Unfortunately, this can be a difficult job; the different in-circuit-emulator manufacturers haven't agreed on a common terminology. You'll also find that some of the basic specifications needed to make a product comparison simply aren't available on the data sheets.

One of the greatest difficulties connected with emulator data sheets is interpreting different manufacturers' definitions and specifications of capabilities associated with breakpoints (starting and stopping the emulation process) and with trace data (starting and stopping the collection of logic-state data from a μP bus). Not only do data-sheet terms and definitions vary among manufacturers, but breakpoint and trace-control logic are conceptually different in each manufacturer's product. Consequently, you'll find that making side-by-side data-sheet comparisons is difficult, if not impossible. The end result is that it's difficult to determine whether a particular emulator meets your needs.

To complicate matters further, the previously mentioned performance quirks in some emulators might or might not hinder your μP development effort. A quirk (as opposed to a bug) is a well-defined, designed-in characteristic that causes an emulator's performance to deviate from what you desire, or from what you might expect after investigating competitive emulators. Usually, a quirk is a result of an engineering tradeoff made during an emulator's design phase in order to gain some advantage.

Consider the following quirk. In trace operations, you would normally expect an emulator to use not only collected addresses but also collected data to generate disassembled instructions for display and analysis. But at least one analyzer (from Microcosm), uses only the addresses collected in the trace memory and then retrieves data from μP memory for disassembly. If the data happens to be altered after the addresses are recorded in the trace



Emulating an 80186 with an 8086 *is possible with Metacomp's DBX-2000 emulator and debug module. The module includes PALs for emulating 80186 chip-select logic; memory-chip and peripheral-I/O-chip select/decode logic for independent wait-state generation; an i8254 programmable interval timer; an i8259A programmable interrupt controller; and space for 8k bytes of emulation memory.*

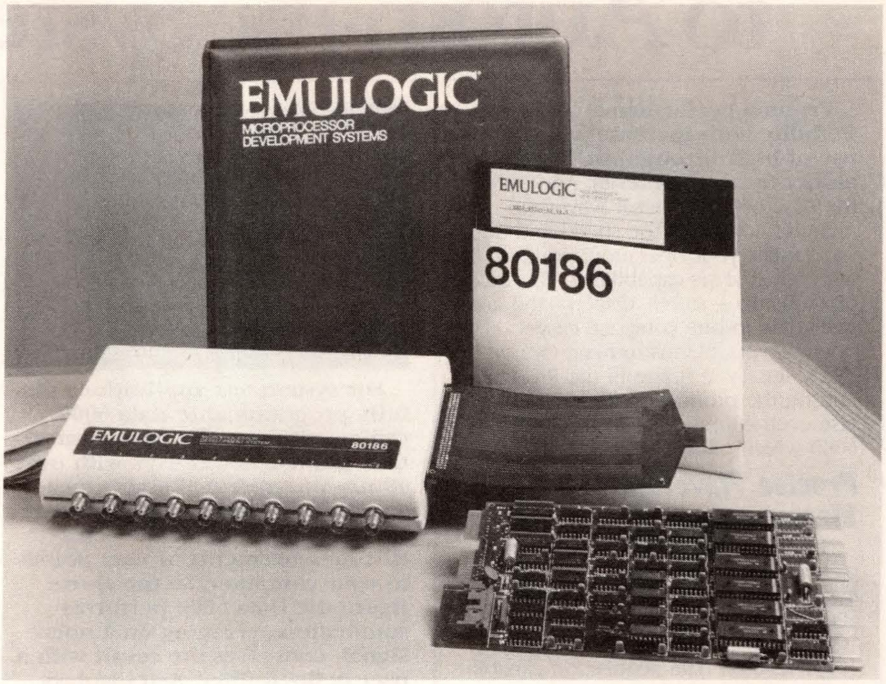
Stand-alone and hosted in-circuit emulators *combine with personal computers to form low-cost μP development systems. This stand-alone hosted system is from Zax.*

memory and before the emulator fetches data for disassembly, then the disassembled instructions reflect the new data (or instructions) in memory, not the data (or instructions) actually encountered by the emulator.

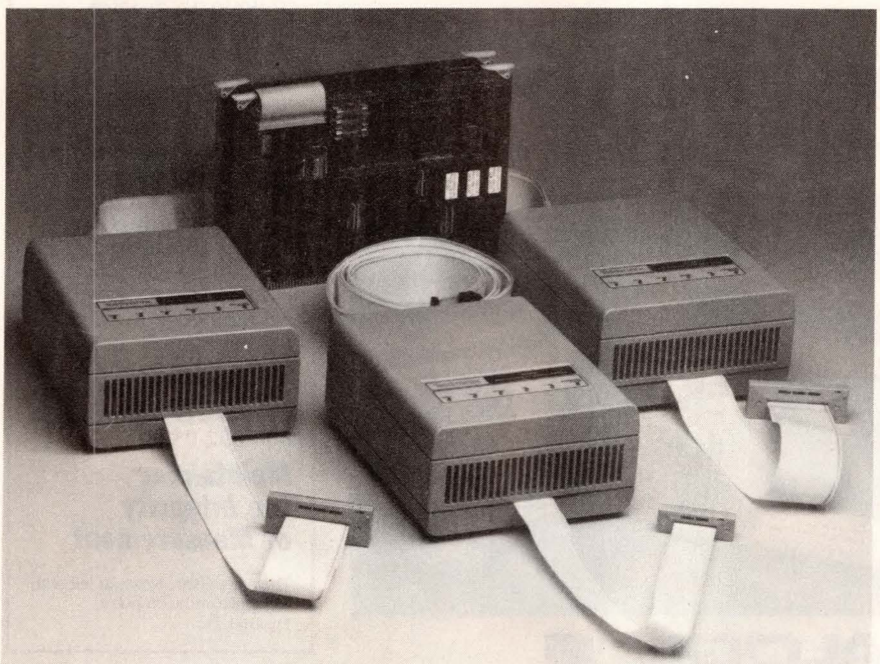
Kontron's emulator manifests another quirk. It can run full-speed emulation when operating with less than 16k bytes of emulation memory, but it will insert one or two wait states (depending on the memory map used) when you use more than 16k bytes of memory. Depending on your application, this might or might not be a problem.

Not all emulators handle interrupt lines the way you would expect, either. Some of them use a μP's nonmaskable (highest priority) interrupt line for breaking or stopping emulation and for entering the emulator's monitor program to capture μP register values. With HP's 8086 emulator, for example, the nonmaskable interrupt line is never available to the system under emulation (although it is available with the company's 80186 emulator).

With some other emulators, the interrupt line isn't available during the time the monitor program is running. Interrupts aren't necessarily lost, however; with some some μPs (eg, the 68000), the interrupts remain pending in the system and are serviced after the interrupt line once again becomes available to the target system. The performance cost in such cases is the additional waiting time, a cost that may not be acceptable in your application.



A queue-management board from Emulogic *allows you to track prefetch instruction-queue operation in 8086/186 or 16032 μP families. With the board installed in a host, you can set Emulogic's emulators to break emulation on fetch or execute conditions and to label instructions in the trace that were fetched but not executed.*



Switching from 68000 to 68010 emulation *requires only a control-probe change with the 68XXX emulator from Tektronix.*

You should also be aware that an emulator can usurp some of a target system's memory space to house the monitor program during emulation. For instance, HP's 8086 emulator uses 1k byte of memory, although with the 1M-byte and larger memories available with 16-bit processors, this isn't likely to be a concern.

Real time and transparent

Many of the personality quirks exhibited by different emulators are related to two terms used extensively on the different manufacturers' data sheets: "transparency" and "real-time emulation." These terms, of course, correspond to emulation's two goals: the replacement of a system's μP by an emulator without the system's being aware of the change (transparency) and operation of the system at its intended clock speed (real time). Depending on your application needs, certain

For more information . . .

For more information on the 16-bit in-circuit emulators described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

Applied Microsystems Corp
5020 148th Ave
Box C-1002
Redmond, WA 98052
(206) 882-2000
Circle No 711

Emulogic Inc
Three Technology Way
Norwood, MA 02062
(617) 329-1031
Circle No 712

Hewlett-Packard Co
1820 Embarcadero Rd
Palo Alto, CA 94303
Phone local sales office
Circle No 713

Intel Corp
Literature Dept
3065 Bowers Ave
Santa Clara, CA 95051
(408) 987-8080
Circle No 714

Kontron Electronics Inc
630 Price Ave
Redwood City, CA 94063
(415) 361-1012
Circle No 715

Metacomp Inc
9466 Black Mountain Rd
San Diego, CA 92126
(619) 578-9840
Circle No 716

Microcosm Inc
14355 SW Allen
Beaverton, OR 97005
(503) 626-6100
Circle No 717

Microtek Lab Inc
17221 S Western Ave
Gardena, CA 90247
(213) 538-5369
Circle No 718

Motorola Inc
Microsystems Div
2900 S Diablo Way
Tempe, AZ 85282
(602) 438-3000
Circle No 719

National Semiconductor
2900 Semiconductor Dr
Santa Clara, CA 95051
(408) 721-5644
Circle No 720

Tektronix Inc
Box 1700
Beaverton, OR 97077
(800) 547-1512;
in OR, (800) 452-1877
Circle No 721

Zax Corp
2572 White Rd
Irvine, CA 92714
(714) 474-1170
Circle No 722

Zilog Inc
1315 Dell Ave
Campbell, CA 95008
(408) 370-8000
Circle No 519

transparency and real-time issues might be of vital concern to you and are thus worth pursuing with the different manufacturers during your emulator-selection process.

Fortunately, the definition of real-time emulation is fairly consistent from manufacturer to manufacturer. An emulator is generally regarded as "real time" if it can operate at the rated speed of the μP without inserting wait states during memory execution or I/O operations. Most manufacturers specify a real-time-emulation speed on their data sheets, and some also specify how fast the emulator will operate without the guarantee of no wait states.

You should, however, check to see that real-time emulation doesn't require any unusual limitations on an emulator's use. Make sure, for example, that real-time emulation doesn't limit emulation memory to an unacceptably small amount. Be aware, also, that although some emulators don't insert wait states when emulation occurs in the target system's or the emulator's memory, they *can* insert wait states upon switching between the memories.

The transparency issue is much more complicated than that of real-time emulation. Few, if any, emulators are totally transparent to a target system, despite claims to the contrary. The problems in deciding whether or not a particular emulator is transparent arise from the different definitions that manufacturers use. Fortunately, you can analyze transparency by breaking it down into three parts: functional transparency, resource transparency and electrical transparency.

Functional transparency asks two questions: Can the emulator execute all of a μP's instructions, and will it interfere with the operation of other system components such as coprocessors? As an aside, if you plan to run a coprocessor system like the 8086/87 combination, check to see

how the emulator will handle, collect and display the coprocessor's bus activity.

Under resource transparency, you should determine whether all µP functions, such as interrupts, are available full time or part time to the target system. Also, find out if all of the target system's memory is available to the target system, or if a portion of it must be turned over to the emulator for storing the monitor program.

Electrical transparency is the least documented, yet potentially the most critical, transparency issue faced, especially with 10-MHz and faster µPs. Signal-edge speeds and system loading are the most vital concerns, but others exist. For example, one concern with the 8086/186 µP family is whether a crystal on the target system's board can serve as the emulator clock without replacement by a TTL driver.

In short, data sheets for most in-circuit emulators detail neither their products' quirks nor their transparency criteria. It's up to you to make these determinations, by asking questions and getting product demonstrations on your target system. **EDN**

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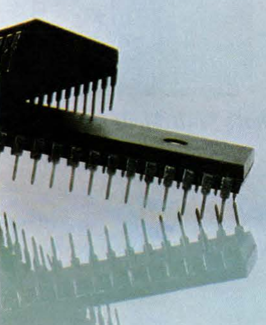
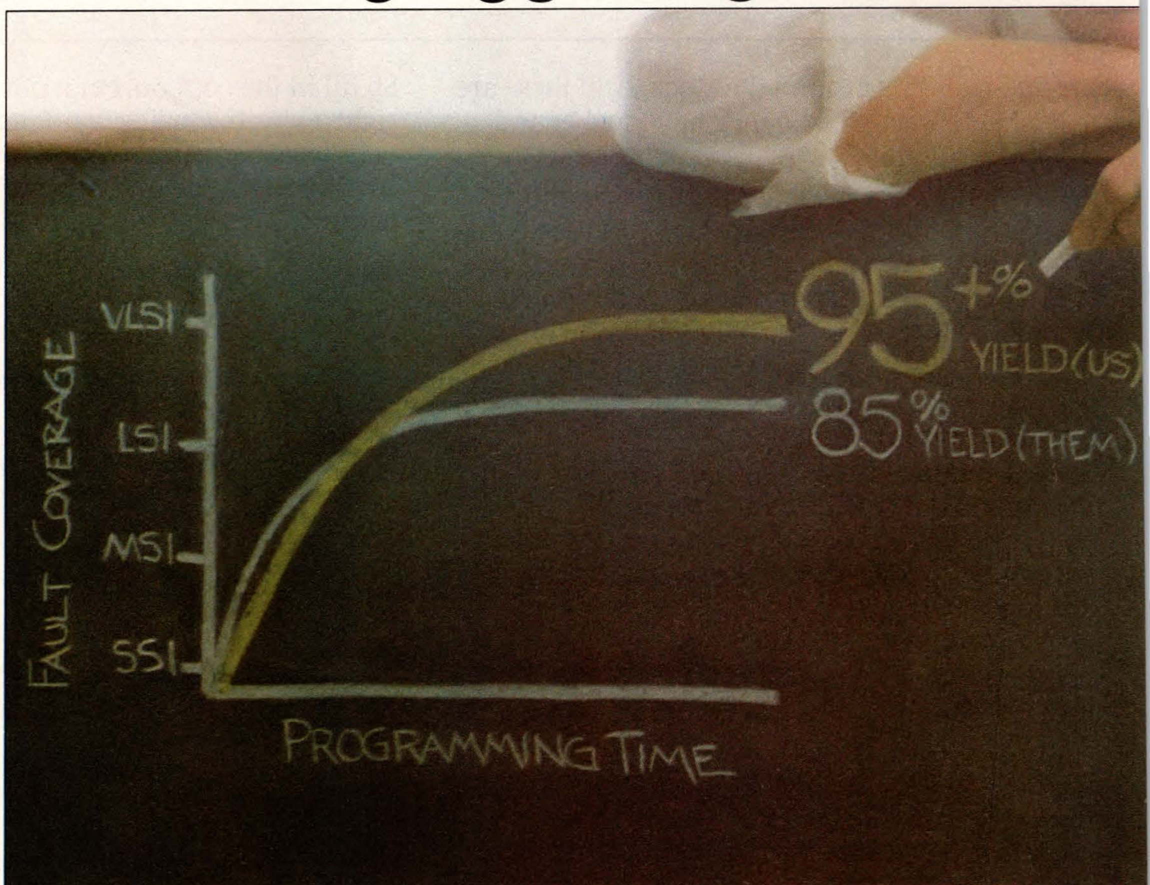
4. The entry coupon (or facsimile) must be filled out completely and legibly.
5. Only one entry per person.
6. All entries must be postmarked no later than 8/31/84.
7. The winner will be announced on 9/28/84.
8. Shipment of 8051s to the winner will be 10 weeks after verification of the winner's ROM code in accordance with Signetics' standard verification procedure.
9. Signetics distributors, brokers, reps and Signetics/Philips employees are not eligible to win.
10. All entries will remain the property of Signetics.
11. Contest offer not valid where prohibited by law.



VLSI from Signetics

a subsidiary of U.S. Philips Corporation

The L200 Board Test System. For when the going gets tough.



Consider the L200 Board Test System by Teradyne. Combining both in-circuit and functional testing capabilities, it's absolutely the best system available to tackle today's complex designs.

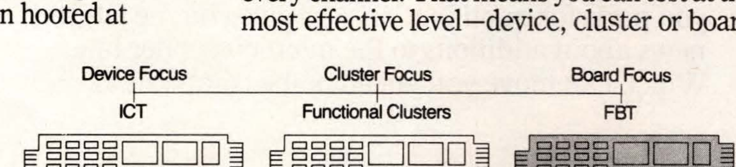
We call this unique integration MultiMode™ testing. It's a Teradyne invention already working on over 100 machines turning out sophisticated electronics. Our competition hooted at first. Now they're scrambling to catch up. Why?

Because the L200 delivers yields of some 95% plus at system test on modern VLSI boards. On average, that's a full 10% higher than any of our competitors. Nobody does it better. Here's how it works.

The Three P's of MultiMode.

Partitioning. Patterns. Performance. This is what you need to get good yields. With MultiMode testing, the L200 gives you all three.

Partitioning. The L200 gives you precision functional test capability with overdrive on every channel. That means you can test at the most effective level—device, cluster or board.



Program and diagnose at the most efficient level. That's MultiMode testing.

Multicolor liquid-crystal displays feature thin 20-mm profile

Using a low-cost electrodeposition process (vs photolithography techniques), Series FT1616 multicolor LCD modules provide 160×64-pixel resolution. Each pixel comprises a red, green and blue element; the dot matrix features resolution of 480×64 color elements. The LCDs have a maximum depth of 20 mm and consume approximately 2W.

Activating any or all of the red, green and blue dots allows 8-color displays of red, green, blue, yellow, purple, cyan, white and black. Current FT1616 models have a 4.16×1.66-in. display area; the manufacturer plans to introduce desktop-computer-size displays in 1985. In an intermediate step, Models FT2416 and FB2416 will be available in the third quarter of 1984 and will feature eight and four colors, respectively, and 240×64-pixel resolution.

Currently, the family includes Model FT1616 Types I and II. The first provides roughly twice the contrast of the second; its screen is divided into upper and lower sections, entailing somewhat more complicated drive electronics (**Fig 1**). Although the LCDs consume only 150 and 200 mW, respectively, the modules include a cold-cathode-tube backlight that draws 1.5 to 2.5W.

Fig 2 illustrates the use of multicolor LCDs in a typical system. The module can display characters, graphics or a combination of both. Under control of the microprocessor, the system reads and writes controller data and instructions as well as the refresh-memory character data. The difference between this system and a monochrome system lies in the color-bit selector, where monochrome signals are converted to eight different colors.

Note that the company's pocket-size color television doesn't use the LCD technology described here—an LCD's response time (several hundred milliseconds) is much too slow for TV applications. Module size of the FT1616 family is 6.69×3.94×0.79 in. $446 and $346 (1000) for Type I and II modules, respectively.—***Bill Travis***

Seiko Instruments USA Inc, 2990 W Lomita Blvd, Torrance, CA 90505. Phone (213) 530-8777.

Circle No 738

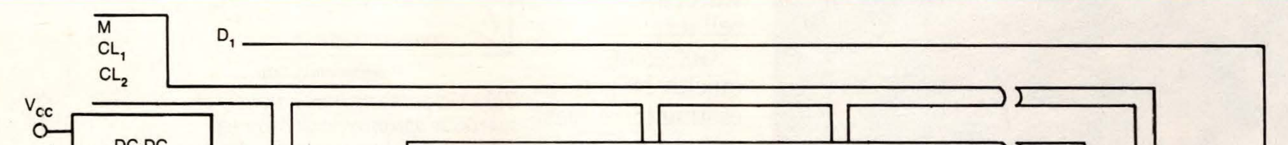


Fig 1—Requiring different drive circuitry, *Types I and II are constructed with upper and lower sections and with a single section, respectively. Type I needs two data-drive lines* **(a)**; *Type II has lower contrast but requires only one data line* **(b)**.

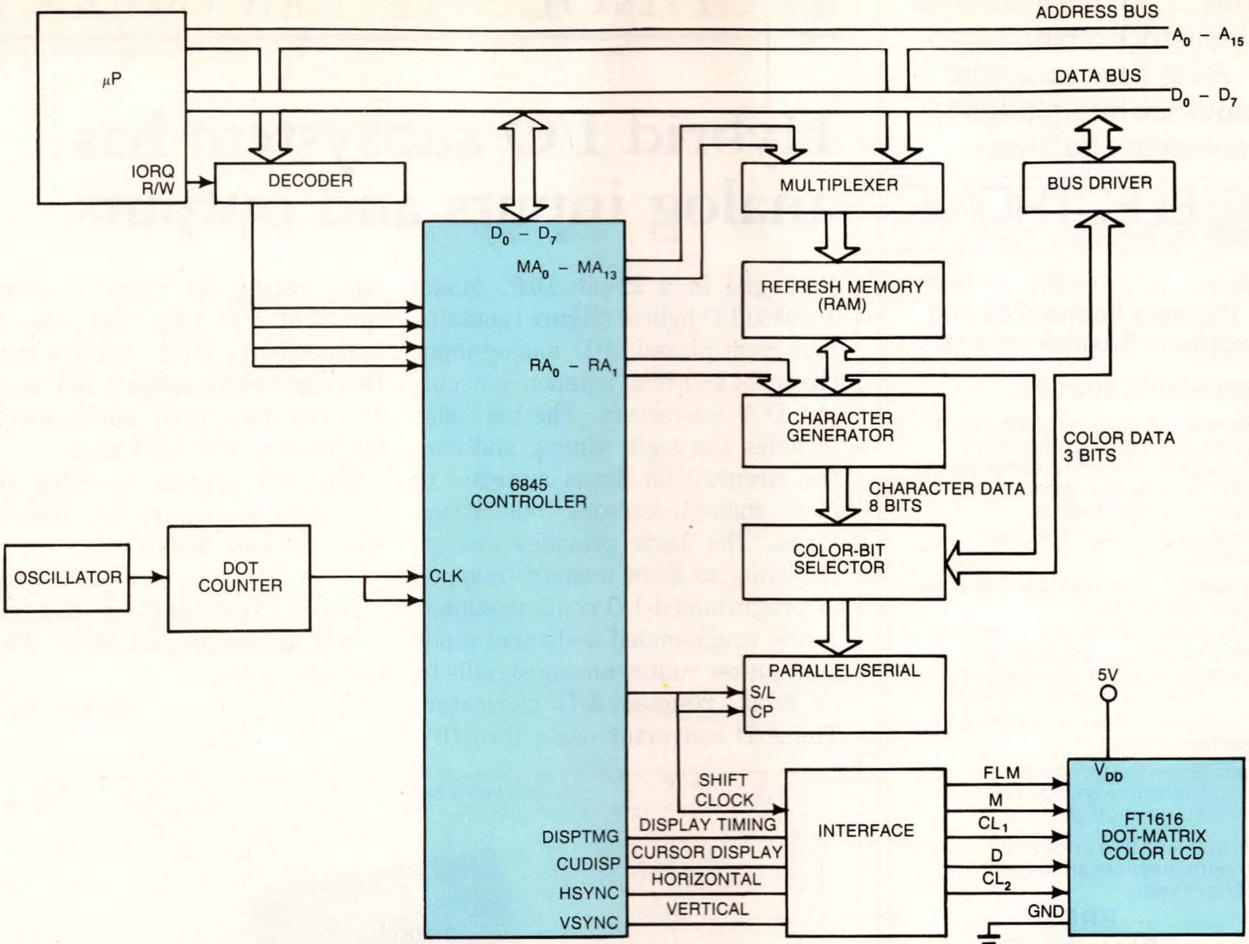
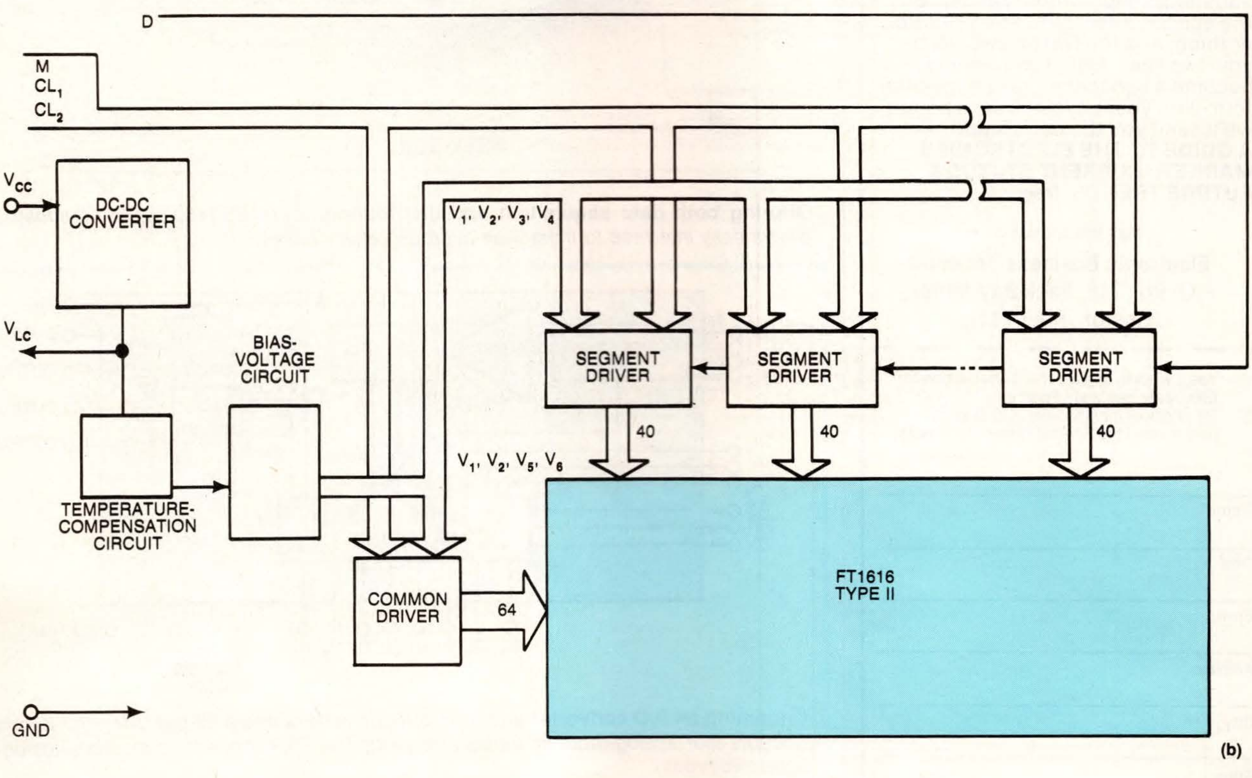


Fig 2—Similar to CRT-drive systems, *FT1616 displays use the familiar refresh memory, a 6845 CRT-controller IC and a character ROM to generate characters or graphics.*



Hybrid I/O subsystem has analog inputs and outputs

Packaged in a 28-pin DIP, Model HS9460 I/O hybrid (**figure**) contains four multiplexed A/D analog-input channels and four independent output D/A converters. The part also includes the logic, timing and control circuitry for direct interface to most microprocessors' bus structures. The logic provides enough flexibility to allow memory-mapped or programmed-I/O configurations.

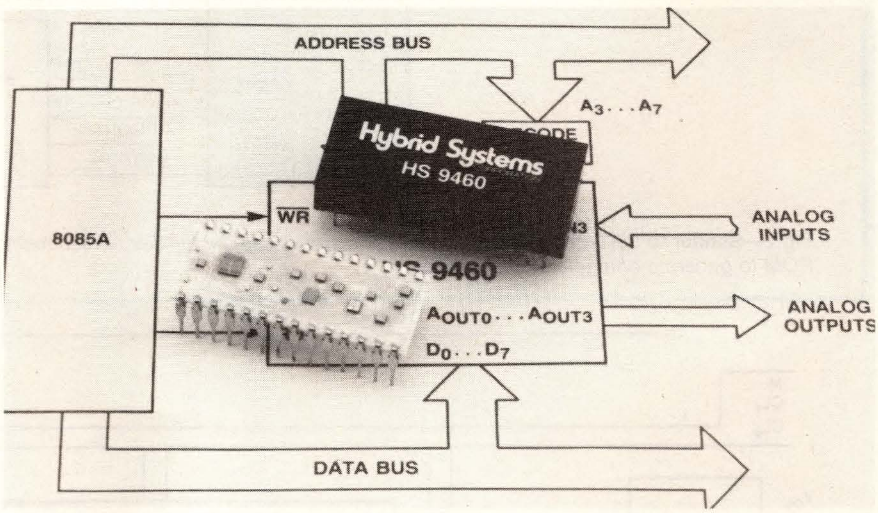
The single-ended 4-channel input multiplexer routes analog signals to an 8-bit, 20-μsec A/D converter. The A/D converter has a 0 to 10V input range; its linearity error is spec'd at ±¾ LSB max. The four independent 8-bit voltage-output D/A converters settle a 10V step in 25 μsec max; their nonlinearity is specified at ±½ LSB max.

The I/O system operates from ±15 and 5V supplies and dissipates 800 mW max. $89 (100).

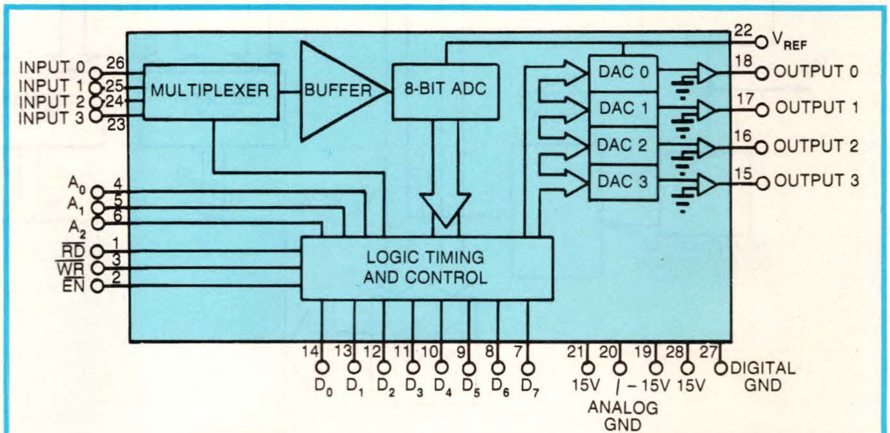
—Bill Travis

Hybrid Systems Corp, 22 Linnell Circle, Billerica, MA 01821. Phone (617) 667-8700.

Circle No 740

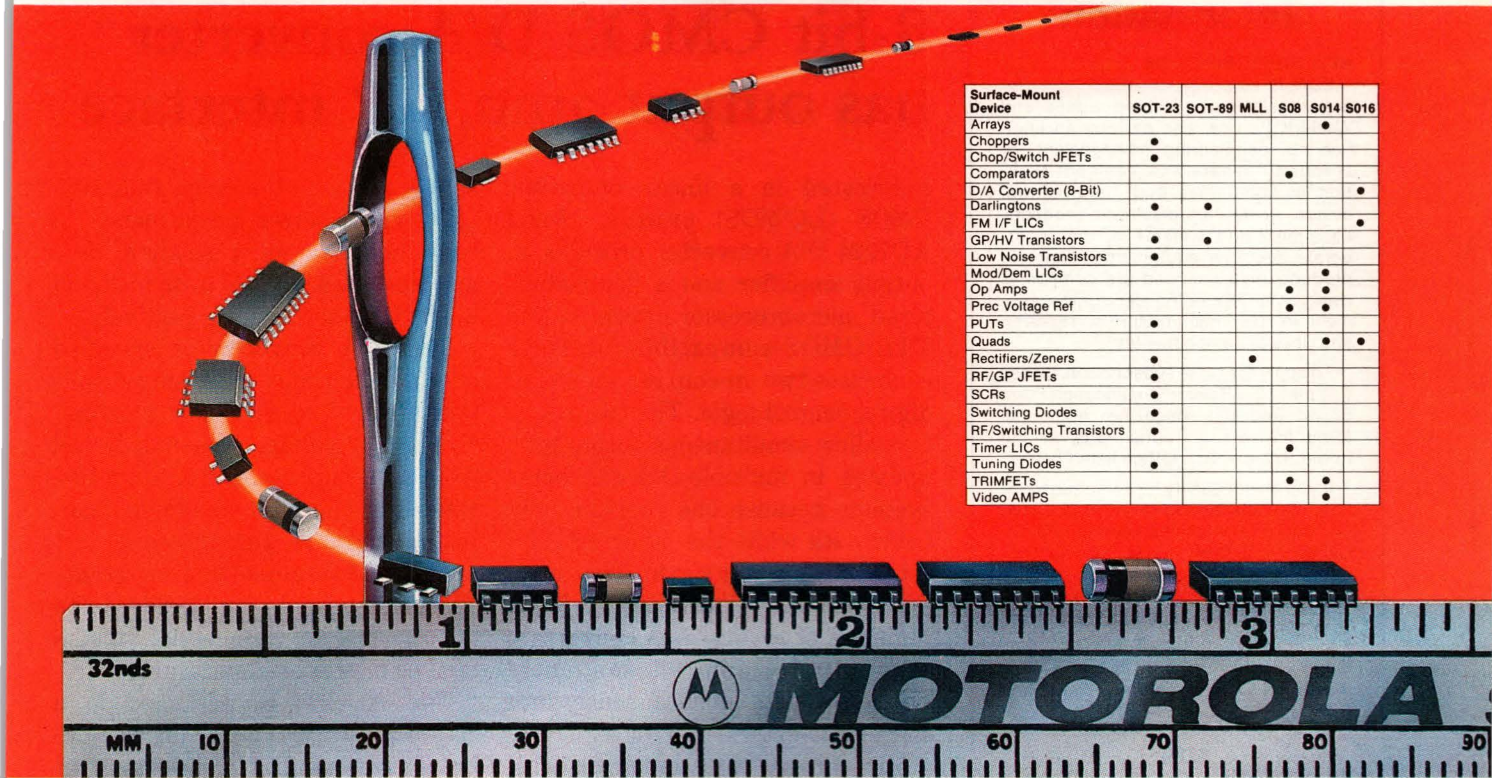


Offering both data acquisition and distribution, *Model HS9460 hybrid I/O subsystem allows easy interface to most 8-bit microprocessor buses.*



Cramming an A/D converter and four D/A converters into a 28-pin DIP, *this hybrid accepts four analog-input channels and yields four D/A-converter-controlled analog-output voltages.*

More squeeze per square inch. Motorola surface mount.



Surface-Mount Device	SOT-23	SOT-89	MLL	S08	S014	S016
Arrays					•	
Choppers	•					
Chop/Switch JFETs	•					
Comparators				•		
D/A Converter (8-Bit)						•
Darlingtons	•	•				
FM I/F LICs						•
GP/HV Transistors	•	•				
Low Noise Transistors	•					
Mod/Dem LICs					•	
Op Amps				•	•	
Prec Voltage Ref				•	•	
PUTs	•					
Quads					•	•
Rectifiers/Zeners	•		•			
RF/GP JFETs	•					
SCRs	•					
Switching Diodes	•					
RF/Switching Transistors	•					
Timer LICs				•		
Tuning Diodes	•					
TRIMFETs				•	•	
Video AMPS					•	

Motorola surface-mount technology slashes system size and weight to one-tenth or less of what's acceptable now. Packages aren't much bigger than the chips they contain. Layers are cut in half, costs plunged 75% or more, higher frequencies optimized through short, uniform trace lengths.

You can mass-place them at up to 200K/hour.

We already offer the broadest line of easy, automatable, testable, surface-mount semiconductors--over 800--with more coming.

Pick and place in a fraction of discrete space.

Choose from most-popular switching transistors, Darlingtons, HV and low-noise types, RF, JFETs, tuning diodes, thyristors, rectifiers and PINs, plus numerous other discrete functions. All are SOT-23 packaged, with many in SOT-89 and MLL outlines for application flexibility. All SOT-23s are ready for placement; no lead forming is required. SOT-23/SOT-89 packaging is laser-marked. And, we'll encapsulate almost any discrete in a SOT package, depending on die compatibility and requirements. Low-profile, too.

MLL. Most economical of all.

Think of a DO-35 or DO-41 without leads and you've got the MLL (Motorola leadless) package...optimized for very high-volume, very low-cost application. Whereas SOT-23s are ideal for transistors, reliable MLL packaging is perfect for our full line of 0.5 to 1 W zeners and rectifiers in an extensive voltage range because of minimized space, ease of placement and second-to-none economy.

SOIC. Space-saving linear alternative.

Get standard linear DIP performance in tiny SOICs from Motorola and give yourself a 2.5:1 delta in board space savings.

Our lineup includes op amps, comparators, voltage regulators, TRIMFETs™, DACs, arrays and timers.

All current and future linear ICs are potential candidates for S08, SO14 or SO16 packaging as long as chip size and power dissipation are within viable parameters.

SOICs pass the same assembly procedures as DIPs and offer identical performance at both 0° to 70°C and -40° to 85°C ranges. Device reliability is inherent because industry studies show it to be so...and because it's Motorola. A 20-times improvement in quality over manually-inserted units not only enhances reliability but saves rework and returns.

Automate it with tape and reel.

T1 or T2 options in industry-accepted 8 mm and 12 mm tape and reel format, 3,000 devices per reel, enable immediate placement of most discretes on automatic or semi-automatic lines. All can be wave or reflow soldered.

Write for our new Surface-Mount brochure BR127REVI. Motorola Semiconductor Products, Inc., Box 20912, Phoenix, AZ 85036.

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MOTOROLA INC.

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

Please send me information on Surface-Mount.

187EDN080984

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8-bit CMOS D/A converter has output amp, μP interface

Fabricated in a linear-compatible CMOS (LC^{2}MOS) process, Model AD7224 D/A converter provides an output amplifier and a double-buffered microprocessor interface. The TTL/CMOS-compatible interface comprises two on-chip registers and digital control logic. The two registers allow simultaneous output-gain updates in multiple-D/A-converter systems because one register only holds data while the other actually sets the converter's gain. That way, a μP can load data into the input registers of several D/A converters sequentially and subsequently strobe the data simultaneously into all the converters' control registers.

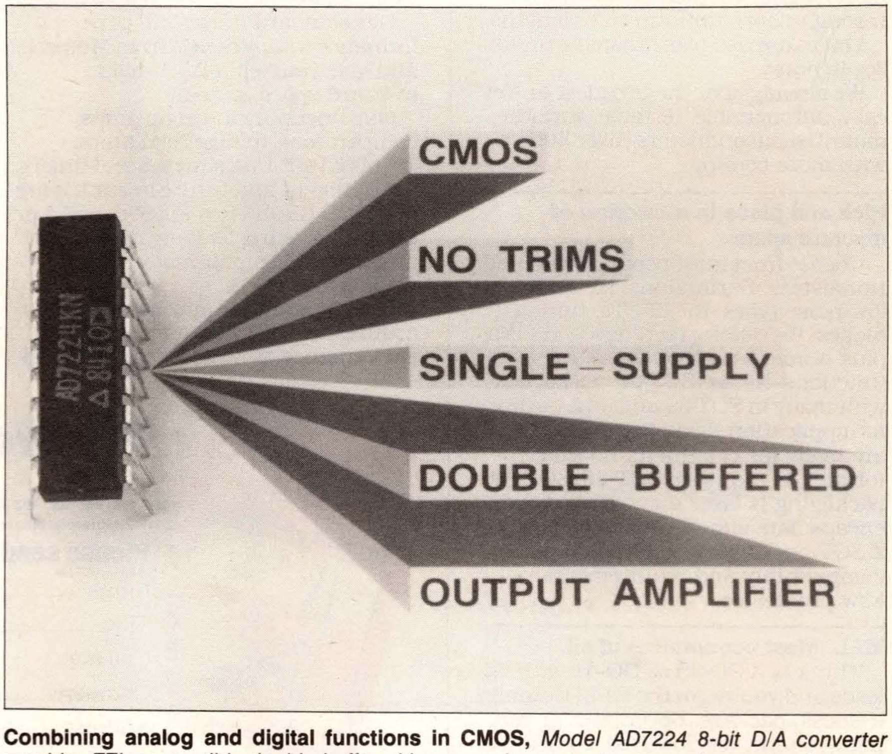
You can use the converter with either single or dual supplies. The specified supply voltage in single-supply operation is 15V; in dual-supply applications, the D/A converter uses an 11.4 to 16.5V positive supply and a −5V supply. Dual supplies yield better performance in both negative-going settling time and slew rate: 7 vs 20 μsec max and 2.5 vs 2V/μsec min, respectively.

The D/A converter is specified over a wide range of reference voltages: from 2 to 4V below the positive supply voltage. When operated from dual supplies and a fixed 10V reference, the total maximum unadjusted error is guaranteed at ±1 and ±2 LSB, depending on grade. The firm guarantees all grades to be monotonic over commercial, industrial or military temperatures.

The AD7224 is packaged in a 20-pin plastic DIP, Cerdip or side-brazed ceramic DIP. Prices start at $4.95 (100).—***Bill Travis***

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

Circle No 737



Combining analog and digital functions in CMOS, *Model AD7224 8-bit D/A converter provides TTL-compatible double-buffered inputs and an output op amp. It operates from one or two supplies.*

Bench DMM doubles as system instrument

Although at $595 the Keithley Model 197 is one of the lowest priced, sensitive 5½-digit bench DMMs available (and, in fact, sells for less than some 4½-digit units), its performance rivals systems DMMs costing twice as much. The instrument carries a sensitive label because it measures down to 1 μV, 1 nA and 1 mΩ, with a 1-year dc-volts accuracy spec of ±0.015% of reading ±2 counts.

The 5-function, true-rms instrument looks like a bench DMM with its tilt-bail handle and LCD readout. But along with typical bench-DMM features like a diode-test setting, battery backup option ($99) and a 10A range, come such systems-DMM functions as a 100-reading data logger, a fully programmable IEEE-488 interface ($225 option) and program-controlled calibration.

The meter doesn't have all the built-in data-analysis programs of some systems DMMs, but it performs both relative (to a programmable or captured offset voltage) and decibel measurements. It also captures and holds a minimal or maximal reading. At three readings/sec, Model 197 won't replace high-priced systems DMMs that can make thousands of readings per second (at reduced accuracy), but its reading rate is about the same as most sensitive bench DMMs. In contrast, most low-cost systems DMMs make 30 to 100 readings/sec. The instrument works either in autoranging or manual-ranging modes.

Also holding true to Model 197's bench orientation is its lack of rear-panel inputs. The unit performs 4-wire resistance measurements via front-panel jacks and accepts an external trigger—with the press of a front-panel button.

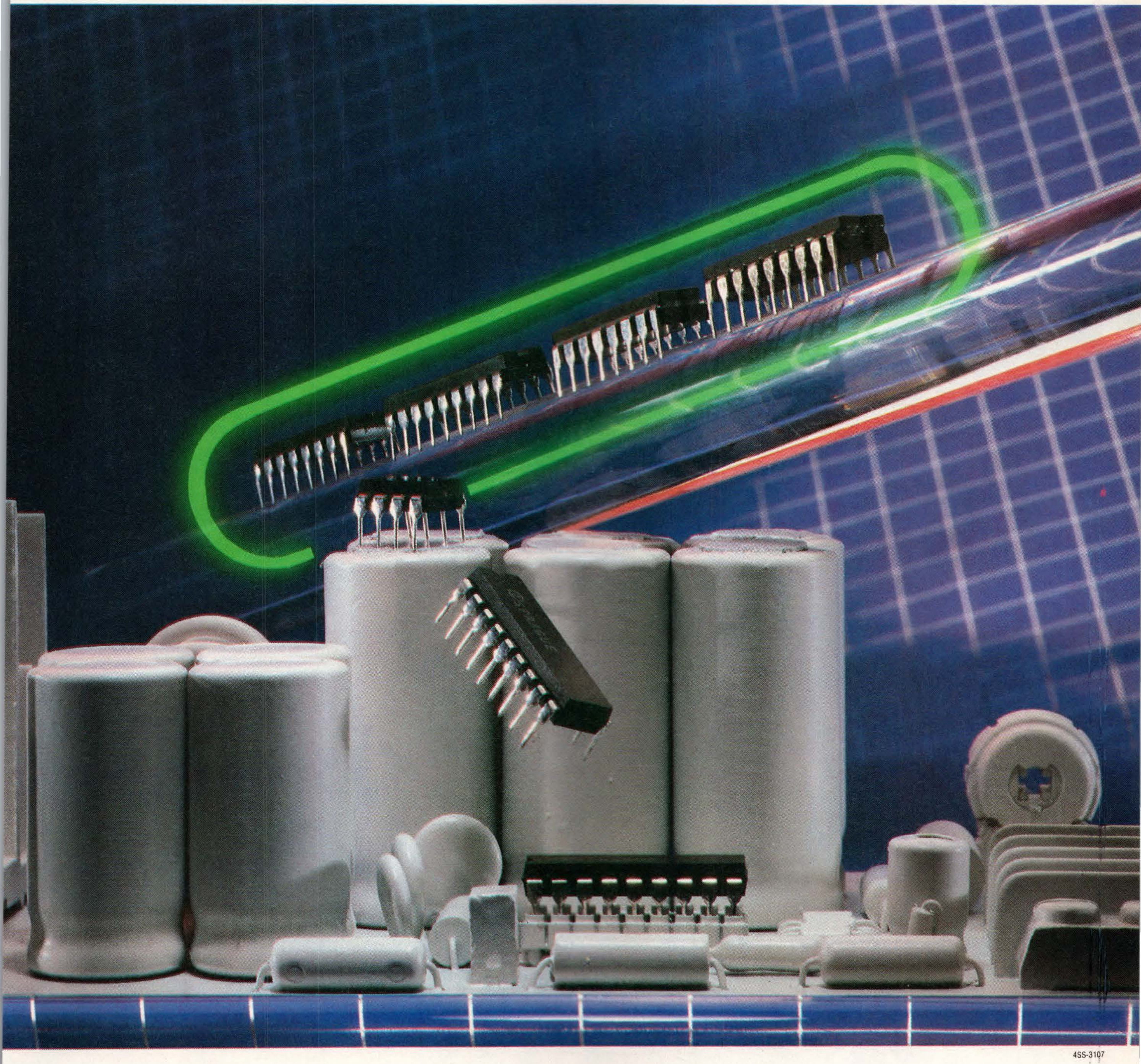
—Charles H Small

Keithley Instruments Inc, 28775 Aurora Rd, Cleveland, OH 44139. Phone (216) 248-0400. TLX 985469.

Circle No 723

Priced similar to a 4½-digit bench DMM, *the $595 5½-digit Model 197 from Keithley boasts high sensitivity (1 μV, 1 mΩ, 1 nA) and low-cost systems-DMM features like datalogging, autocalibration and a programmable IEEE-488 interface.*

COST-EFFECTIVE.



4SS-3107

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Make it a rule to use Sprague Series 8126, 8160 and 8161 control circuits in your switched-mode power supplies. For the same reason you use other Sprague components. These SMPS devices are reliable and available at reasonable cost. Choose the one that fits your needs. For detailed technical data on these high-performance SMPS ICs, write for Engineering Bulletin Group 27466 to Technical Literature Service, Sprague Electric Company, 491 Marshall Street, North Adams, Mass. 01247. For application assistance, call Ron Lutz at 617/853-5000.

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CIRCLE NO 65

Tomorrow's one-step connectors.

Integral EMI/RFI shielding. Easy I/O.

From AMP, right now.

Our newest idea in I/O comes in a one-piece assembly, already shielded, all ready to go.

One crimp operation terminates flat shielded cable. And applies strain relief at two points. And attaches the cable shield to the connector shield. One operaton.

And our new SDL connector is as hard-working as it is good-looking. Selective gold plating gives it a high cycle life, with easy insertion, secure retention, simple release.

Sensible? You bet: the shielding you need, in an economical connector with unbeatably economical one-step application.

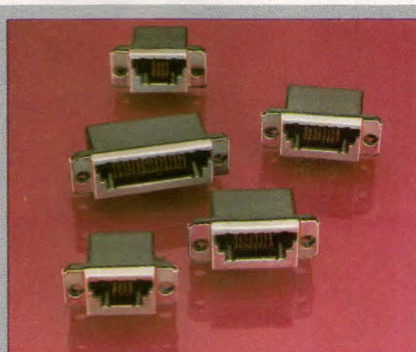
Cost effective? No question about it: it's from AMP.

For more information, contact the
AMP SDL Connector Desk, (717) 780-4400.
AMP Incorporated, Harrisburg, PA 17105.

CIRCLE NUMBER 253

AMP means productivity.

Shielded Data Link connectors available in 4, 8, 16, 24 contact configurations. Insulation-displacing design provides redundant contact on each conductor. Built-in polarization/keying system.

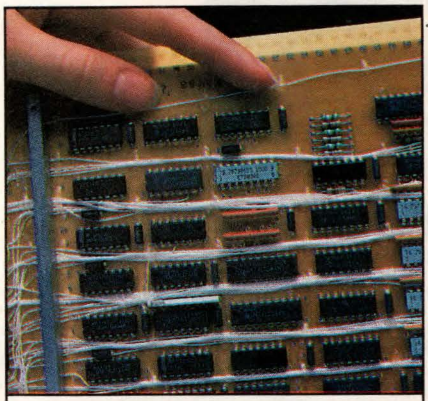


Top or side entry pcb receptacles, for complete design flexibility.

Round shielded cable terminates in just two steps–one for the conductors, one for the shield.

A Texas Control

Months ahead of the market, Control Data is delivering the DDC (Director-to-Device Controller) interface on its 33800 Disk Storage Subsystem. It's an extremely compact, high-speed, large-capacity unit. Most important, it is the only available mass-storage subsystem plug compatible with the new-generation IBM DDC. What helps give Control Data this competitive edge? The SN75174 line driver from Texas Instruments.



Only TI's SN75174 line driver could provide the drive capability vital to Control Data's new 33800 disk storage subsystem featuring DDC interface.

No choice but TI

Only TI's SN75174 could provide sufficient differential current drive through Control Data's special compensation circuit to deliver proper signals in the DDC interface cable.

And Control Data will be able to stay current with future market developments because of the minimum active-high drive (40 mA) capability of the '174.

Forty-two '174s are used in a fully configured 33800 disk storage subsystem.

TI's SN75126 and SN75127 are also used in the new storage subsystem. These circuits meet the IBM 360/370 specifi-

◀ **Leading the market,** Control Data is shipping the first non-IBM storage subsystem that's plug compatible with the IBM Director-to-Device Controller interface. Use of TI's new SN75174 line driver not only made the Control Data design feasible but also minimized design time, component count, board size, and power requirements.

27-4812

Instruments line driver drives Data to market faster.

cation, providing fault protection and power up/power down protection, as well as enable and fault flags.

Performance as specified

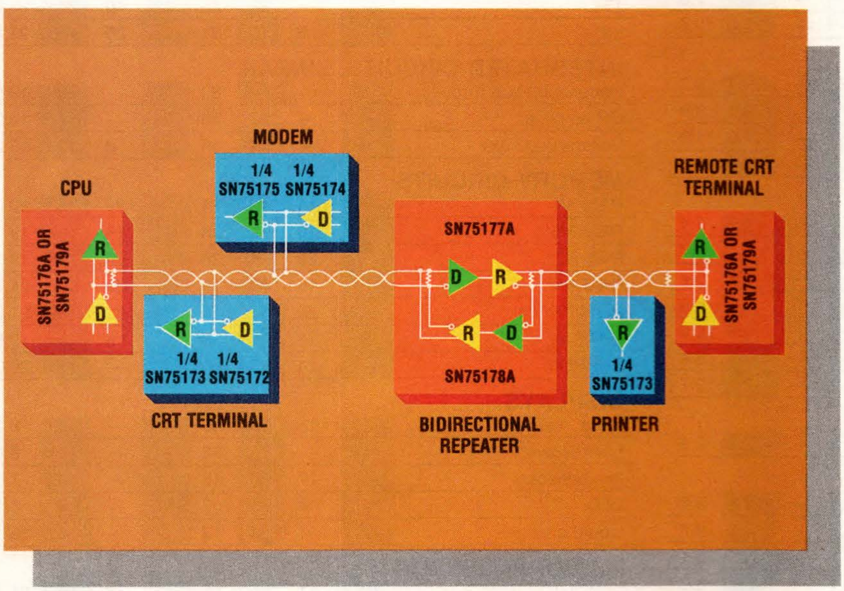
Control Data engineers learned about the '174 early on. Moving quickly, they evaluated and designed it in, counting on it to perform to very exacting specifications. It did . . . perfectly.

The alternative? Greater costs

Control Data engineers estimate that a discrete-component alternative would have resulted in at least a 15% increase in board area to accommodate the necessary additional components.

As it turned out, the SN75174 driver contributed important system savings to the design, improved reliability, helped Control Data get to market faster. ■

Get on the party line faster with eight new line circuits from Texas Instruments.



Hooking 32 driver-receiver pairs on a single bus to achieve party-line communication is possible with TI's full family of line circuits.

Now, eight new line drivers, receivers, and transceivers from Texas Instruments allow you to implement party-line applications on a single bus efficiently.

SN75176A Half-duplex Transceiver

This new circuit wraps the capability to send or receive data over a single twisted pair in a compact, 8-pin package. It saves board space and cuts component cost.

SN75179A Full-duplex Transceiver

Also available in a space-saving, 8-pin package, the SN75179A can send and receive data simultaneously, and requires two twisted pairs.

SN75177A/SN75178A Bus Repeaters

These two differential ICs are identical except for complementary enable inputs.

The SN75177A is active high and the SN75178A is active low. This allows you to pair the two back-to-back for improved bidirectional communication when extending cable distance.

SN75172/SN75174 Quad Drivers, SN75173/SN75175 Quad Receivers

The two quad drivers operate from a single +5 V supply, yet maintain a high-impedance output over a common-mode range from −7 V to +12 V with power on or off. Without sacrificing speed. Both drivers have maximum delay times of 50 ns, rise and fall times of less than 80 ns. They allow data rates up to four megabaud.

The major difference between the two drivers is the enable scheme. And this increases design flexibility. All four drivers in the SN75172 are enabled at once, whereas they are enabled in pairs in the SN75174.

The two quad receivers are similar to existing RS-422 devices but have higher input impedance and extended common-mode range, from ±7 V to ± 12 V. Sensitivity is ±200 mV over −12 V to +12 V common-mode range.

All other standards covered, too

In addition to offering these new devices that meet RS-422 and other party-line applications, TI offers the industry-standard ICs you need to meet the EIA RS-485, RS-232-C, and RS-423 standards, as well as IEEE 488.

In fact, with its wide selection of general-purpose line circuits, TI fields the industry's broadest line of line circuits. Results: Component compatibility, design flexibility, and immediate availability.

For details on TI's broad family of line circuits, write Texas Instruments Incorporated, Dept. SLL053ED, P.O. Box 809066, Dallas, Texas 75240.

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CIRCLE NO 201

LEADTIME INDEX

Percent of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last months average (weeks)
TRANSFORMERS								
Toroidal	—	29	29	42	—	—	9.6	12.6
Pot-Core	20	20	20	20	20	—	10.4	14.6
Laminate (power)	12	25	38	25	—	—	7.5	11.8
CONNECTORS								
Military panel	—	—	29	71	—	—	13.7	17.3
Flat/Cable	9	36	37	18	—	—	6.6	8.2
Multi-pin circular	14	43	—	29	14	—	9.1	15.1
PC	22	45	22	11	—	—	4.4	7.4
RF/Coxial	—	38	62	—	—	—	5.7	12.3
Socket	9	46	27	18	—	—	6.0	6.4
Terminal blocks	23	15	38	8	15	—	9.0	6.7
Edge card	25	12	63	—	—	—	5.3	7.4
Subminiature	57	29	—	14	—	—	2.8	10.6
Rack & panel	—	50	33	17	—	—	6.4	7.6
Power	—	50	50	—	—	—	5.0	10.4
PRINTED CIRCUIT BOARDS								
Single sided	—	24	52	12	12	—	9.7	8.7
Double sided	—	20	60	13	7	—	9.1	9.9
Multi-layer	—	—	43	43	14	—	14.0	13.9
Prototype	10	70	10	—	10	—	4.8	4.8
RESISTORS								
Carbon film	29	29	29	13	—	—	4.9	5.4
Carbon composition	13	31	43	13	—	—	6.1	5.7
Metal film	21	26	32	21	—	—	6.4	5.7
Metal oxide	40	20	30	—	—	10	5.9	6.0
Wirewound	15	8	46	31	—	—	8.8	10.0
Potentiometers	6	44	6	33	11	—	9.5	9.4
Networks	7	33	27	33	—	—	8.1	10.7
FUSES	47	32	16	5	—	—	2.7	2.9
SWITCHES								
Pushbutton	24	38	38	—	—	—	3.8	5.8
Rotary	23	11	33	33	—	—	8.1	9.7
Rocker	40	20	20	20	—	—	5.2	6.1
Thumbwheel	—	29	42	29	—	—	8.6	6.0
Snap action	—	50	33	17	—	—	6.4	7.2
Momentary	25	38	12	25	—	—	5.7	5.3
Dual-in-line	—	83	17	—	—	—	3.0	8.4
WIRE AND CABLE								
Coaxial	34	25	25	8	8	—	5.9	5.3
Flat ribbon	29	50	21	—	—	—	2.7	4.9
Multiconductor	19	36	36	9	—	—	5.0	4.8
Hookup	32	47	16	5	—	—	3.0	2.3
Wirewrap	50	30	20	—	—	—	2.2	2.5
Power cords	22	39	22	17	—	—	5.3	4.4
Other	—	100	—	—	—	—	2.0	8.5
POWER SUPPLIES	—	31	39	15	15	—	10.0	10.8
CIRCUIT BREAKERS	13	27	27	20	13	—	9.3	8.5
HEAT SINKS	50	13	13	18	6	—	5.7	7.3

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last months average (weeks)
RELAYS								
General purpose	18	29	29	24	—	—	6.7	8.4
PC board	10	30	30	30	—	—	7.8	13.3
Dry reed	—	50	50	—	—	—	5.0	10.6
Mercury	—	33	34	33	—	—	8.7	11.2
Solid state	—	12	25	63	—	—	12.3	10.7
DISCRETE SEMICONDUCTORS								
Diode	17	26	31	13	9	4	8.7	10.5
Rectifier	6	24	35	29	—	6	9.8	12.2
Thyristor	9	18	37	27	9	—	10.0	11.5
FET	—	27	13	47	13	—	12.5	12.9
Zeners	15	15	25	40	5	—	10.0	9.8
INTEGRATED CIRCUITS, DIGITAL								
CMOS	5	10	15	35	20	15	16.9	22.2
TTL	—	—	20	28	12	40	21.6	23.8
LS	—	6	13	31	25	25	20.4	22.2
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	—	—	—	80	20	—	18.0	19.9
OP amplifier	—	—	23	46	31	—	17.3	14.5
Voltage regulator	6	—	41	35	12	6	13.9	15.2
MEMORY CIRCUITS								
RAM 4K	—	14	43	14	—	29	15.0	20.3
RAM 16K	9	18	9	28	18	18	15.8	19.1
RAM 32K	—	29	14	28	—	29	15.2	19.1
RAM 64K	10	10	30	10	10	30	16.1	21.7
ROM/PROM	—	22	11	11	34	22	18.7	21.0
EPROM	8	23	8	30	23	8	14.4	19.5
EEPROM	—	24	13	50	13	—	13.0	20.1
DISPLAYS								
Panel meters	—	18	36	46	—	—	10.6	8.3
Fluorescent	—	—	75	25	—	—	10.0	8.8
Incandescent	—	17	66	17	—	—	8.3	7.6
LED	14	14	51	7	14	—	9.1	8.1
Liquid crystal	17	—	66	17	—	—	8.0	13.1
MICROPROCESSOR ICs	11	11	11	11	11	45	19.7	21.7
FUNCTION PACKAGES								
Amplifier	—	—	50	50	—	—	12.0	12.5
Converter, analog to digital	—	17	33	50	—	—	11.0	13.5
Converter, digital to analog	—	—	75	25	—	—	10.0	10.9
LINE FILTERS	29	—	57	14	—	—	7.0	7.9
CAPACITORS								
Ceramic	19	38	14	29	—	—	6.5	8.6
Ceramic monolithic	14	36	21	29	—	—	7.0	12.2
Ceramic disc	15	46	31	8	—	—	4.7	8.1
Film	7	36	21	36	—	—	8.2	8.7
Electrolytic	12	29	35	24	—	—	7.2	10.7
Tantalum	6	28	32	28	6	—	9.2	10.7
INDUCTORS	11	11	78	—	—	—	6.5	10.6

Source: *Purchasing* magazine's electronic business survey

SIEMENS

Reference: Optocouplers

"Quadrupeds" win 3-2 on space

With its four pins the new Siemens SFH 610 optocoupler is quite unlike any of its predecessors in a DIP-6 case. And its smallness gives it an enormous

space advantage: now you can fit three couplers where there used to be room for only two.

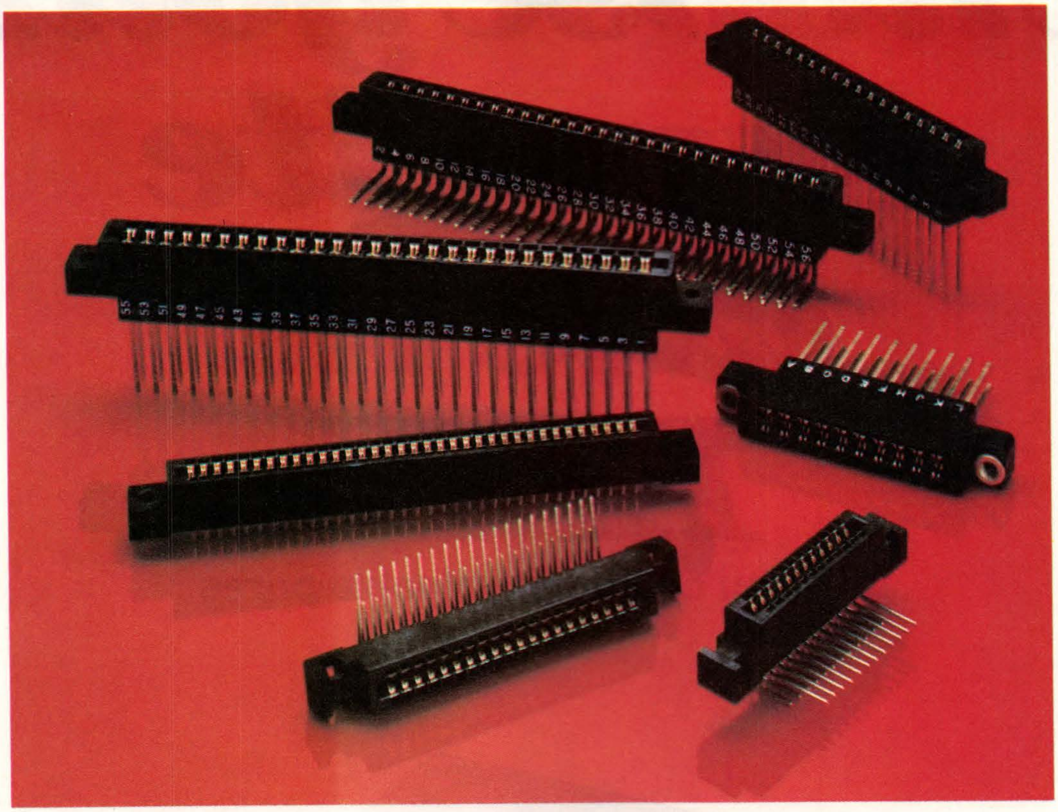
Thus you get the packing density of multiple couplers, but without any of their so hard to avoid problems with non-uniform current transfer ratio.

A big bonus in return for a small sacrifice: we've done away with two inessential pins (can you remember ever wiring the base pin?). Otherwise the new four-pin models offer the same proven technology as the SFH 600 family:

- high current transfer ratio in four versions from 40 to 320 %, with specified values at $I_F = 1$ mA (important for all CMOS applications)
- isolation test voltage 2.8 kVdc
- long useful life (half life of 200,000 h)
- stable electrical data through TRIOS® (transparent ion screen)
- 100 % burn-in (at $I_F = 50$ mA/60 °C/24 h)

Get to know the "Quadrupeds", write to Siemens AG, Infoservice/B 8404, Postfach 156, D-8510 Fürth, mentioning "SFH 610 optocouplers".

B 8404.101 a



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You could win valuable prizes

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1. Select the 10 ads in the August 9 issue of EDN that you think your fellow readers will choose as being the most helpful, informative, and attractive.
2. List your selections on the entry card provided.
3. Mail by September 20, 1984.

CONTEST RULES

1. List your Top selections on the entry card provided. Be sure to indicate the name of the advertiser (company or organization) and the Information Retrieval Service number for each advertisement selected. Do NOT use page number. (Ads placed by Cahners Publishing Company EDN or other Cahners' publications cannot be considered in this contest.)

2. No more than one entry may be submitted by any one individual. Entry blank must be filled in completely, or it will not be considered.

3. To qualify, you must be engaged in electronic design engineering, supervising or managing design engineering or setting standards for design components and materials.

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

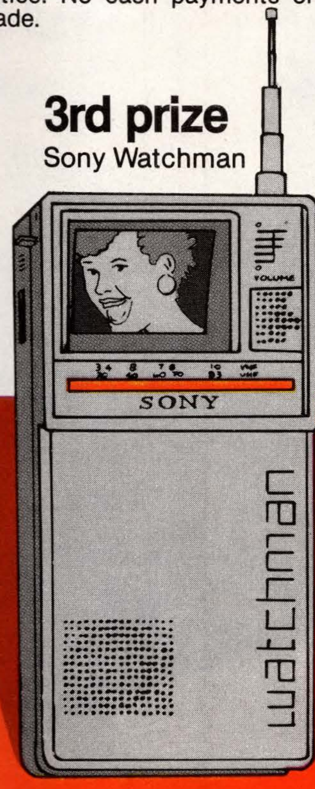
5. Entries that most closely match the rank will be declared winners.

6. Entry cards must be postmarked before September 20, 1984.

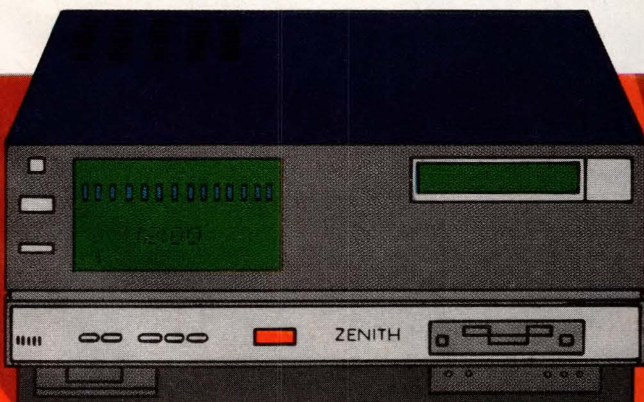
7. In case of a tie, the earlier postmark will determine the winner. Decisions of the contest judges will be final.

8. In the event that a prize is not available, publisher may substitute an alternative prize of equal value without prior notice: No cash payments or other substitutes will be made.

3rd prize
Sony Watchman



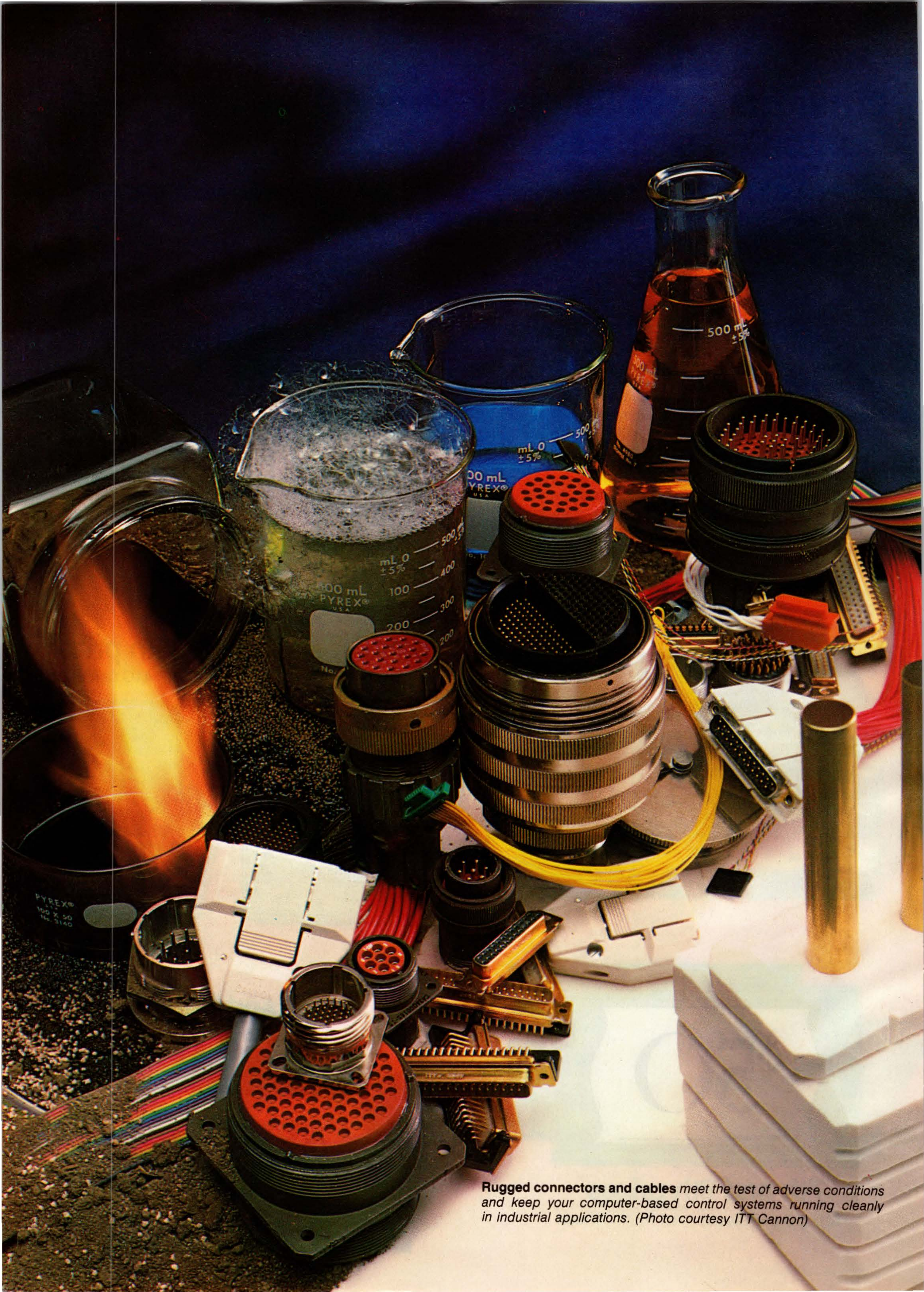
2nd prize
Radio Shack Model 10 VCR



4th prize
H-P 41C calculator

7th and 8th prizes
$50 gift certificate from Radio Shack

9th and 10th prizes
$25 gift certificate from Radio Shack



Rugged connectors and cables *meet the test of adverse conditions and keep your computer-based control systems running cleanly in industrial applications. (Photo courtesy ITT Cannon)*

Industrial Interconnect Devices

If you're designing a computer-based digital motion-control system for an industrial application, you'll have to select carefully the connectors and cables. Otherwise, the adverse industrial environment can render your system inoperable.

Jim McDermott, *Special Features Editor*

The use of computer-driven digital motion-control and robotic systems in industrial applications is on the rise. If you're responsible for developing such equipment, designing the actual system might only be half the problem. Unlike most computer-based systems, those intended for industrial-control applications must contend with adverse physical environments. These environments include such fault-producing elements as

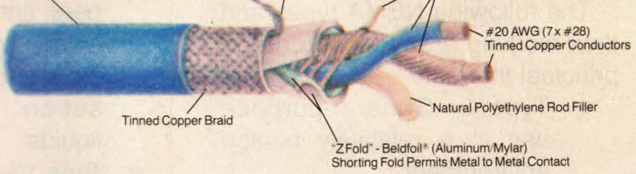
- moisture
- oils
- machine-tool cutting fluids
- harsh chemicals
- shock and vibration
- elevated temperatures
- high ambient electrical noise.

As a consequence, though your system might operate properly in the electrically and physically clean environment of your production floor or engineering lab, it might not function properly when installed at its destination. What's more, the problems that arise might not only be environmental. In fact, a number of experienced designers, who are responsible for carrying motion-control systems from in-house design to field installation, point out other pitfalls.

For example, from the system-design end, compliance problems can result from unfamiliarity with specific kinds of standards established by the National Electrical Code (NEC), the National Electrical Manufacturers Association (NEMA), the Underwriters Laboratories (UL), the National Fire Protection Association (NFPA) and other associations governing industrial installations. Also, user-related problems might exist. Factory installations are often made by plant electricians who have a minimum of tools and who, in many cases, are unfamiliar with the care and handling of electronic equipment. For this reason, it's mandatory that the system designer make sure that every necessary procedure and precaution is documented plainly for proper installation.

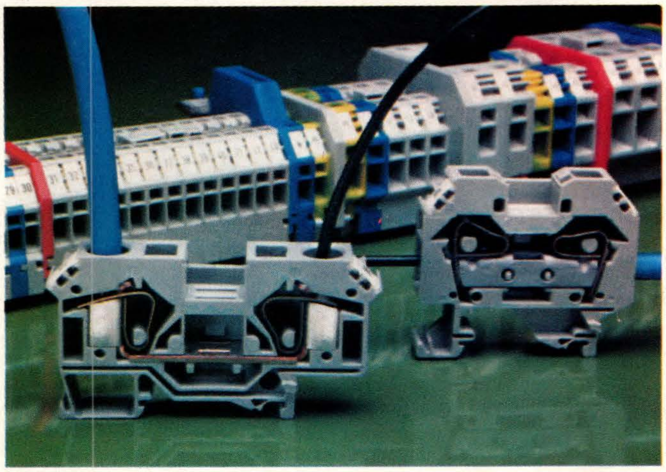
Assuming you avoid these installation pitfalls, there remains the problem of ensuring that the equipment operates in less-than-ideal conditions. Fortunately, component manufacturers are developing products specifically designed to protect against adverse environments. Such products include special kinds of enclosures, connectors, wires, cables and fiber-optic systems.

Controlling EMI in an industrial environment is

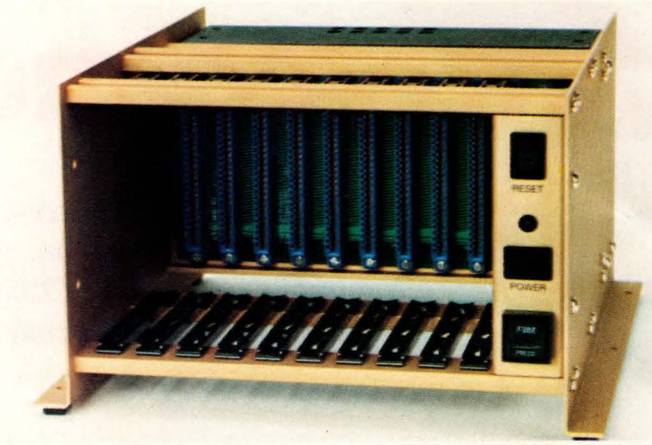


The construction of a 75Ω control cable, *such as the Belden 9463, is tailored for maximum EMI protection.*

perhaps the prime concern you'll face when designing systems. When selecting enclosures, cables, filters and connectors for their resistance to undesirable physical elements, you'll also have to consider the components' EMI-shielding effectiveness. Electromagnetic compatibility is necessary if the digital control system is to operate in a noisy electrical environment without being interfered with by neighboring equipment and other ambient-noise sources. Conversely, the newly installed equipment must not interfere with other equipment in the area. Fortunately, by observing the rules of good shielding, grounding, filtering and wiring, you protect your equipment and the equipment surrounding it in one fell swoop.



For limited working space, *the Wago cage-clamp connectors are terminated by pushing the stripped wire end into a stainless-steel clamp assembly. They pass stringent vibration and corrosion tests.*



Designed with Tite-Grip card guides *to secure the cards against the shock and vibration in an industrial environment, the VersaLogic G10X is a 10-slot STD Bus card cage. A low-noise mother board has individually shielded signal lines.*

Enclosures for industrial applications

There are a number of standards and specifications that apply to enclosures that house electronic equipment. The dominant US-industry enclosure standards for control equipment are those of the National Electrical Manufacturers Association (NEMA) and the Underwriters Laboratories (UL).

These standards specify the construction requirements of the enclosures as well as performance tests the enclosure must pass. Most NEMA standards pertain to indoor equipment, and you should note that these enclosures do not protect against condensation or corrosion that originates inside them.

The following NEMA types and their working environments are of principal interest:

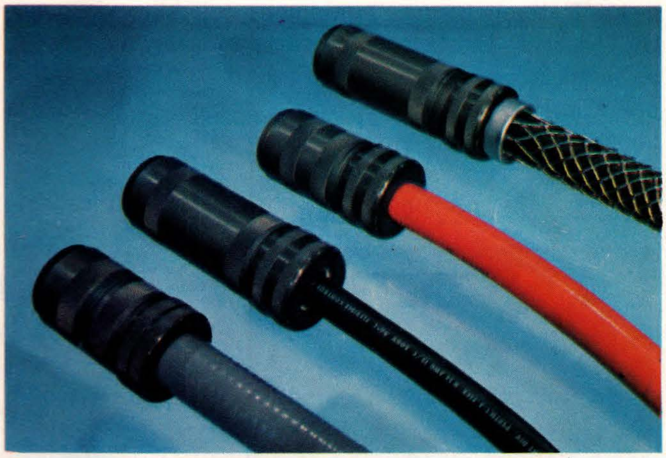
- Type 1—General-purpose use in a relatively benign environment
- Type 3—Dust-tight, rain-tight and sleet resistant for outdoor use. Protects against windblown dust, water and sleet
- Type 3R—Completely rainproof
- Type 4—Watertight and dust-tight to protect against direct splashing and high external condensation (outdoors also)
- Type 4X—Weather-tight, dust-tight and corrosion resistant (outdoors also)
- Type 9—Sealed to prevent the entry of explosive amounts of hazardous dusts
- Type 12—Dust-tight and drip-tight to protect the enclosed equipment against fibers, lint, dust, dirt and light splashing, seepage, dripping and external condensation of noncorrosive liquids
- Type 13—Oil-tight and dust-tight, primarily for housing pilot devices such as push-buttons and selector switches to protect against lint and dust, seepage, external condensation and sprays of water, oil or coolant.

For detailed descriptions and requirements of the NEMA housings, see NEMA Standards Publication No ICS 6-1978, *Enclosures for Industrial Controls and Systems,* and No 250-1979, *Enclosures for Electrical Equipment (1000 Volts Maximum).*

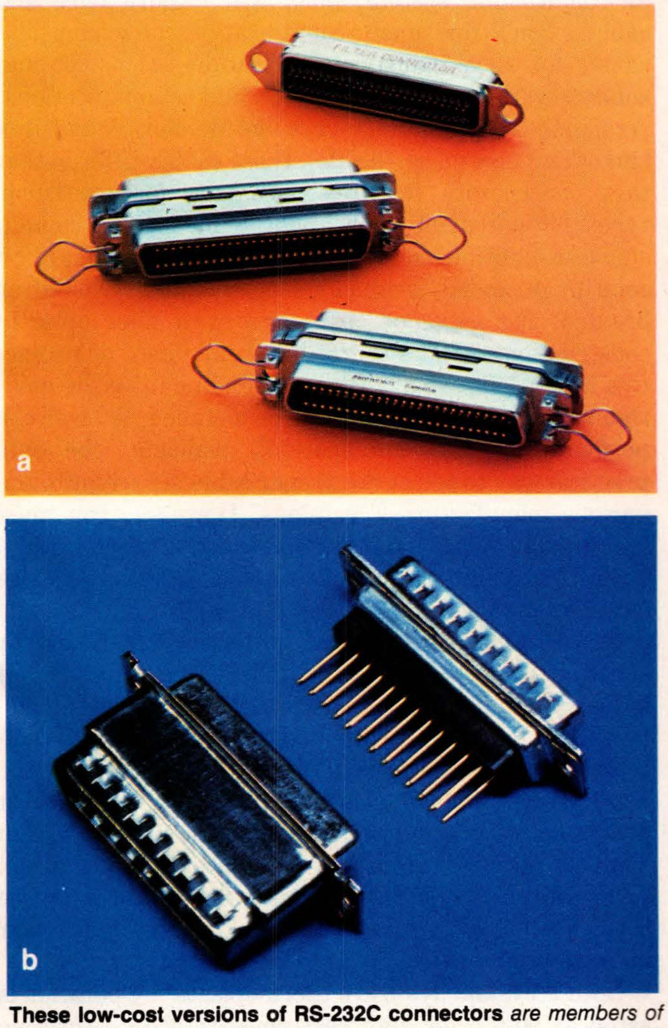
If your company sells equipment in Canada, you need to be familiar with the Canadian Standards Association (CSA). For overseas standards, refer to the British BSI standard BS 5490:1977 or the International Electrotechnical Commission standard IEC 529:1976, which are identical. (The names and addresses of the standards organizations mentioned throughout this report are listed in the **box,** "Hazardous locations defined.")

Selecting an enclosure for sensitive μC control electronics and the power stages driving the servo or stepper motors involves two considerations: protection against the environment and against EMI. Toward this end, there are several types of NEMA enclosures. A Type 1 enclosure is intended only to protect personnel from contact with the hazardous equipment, but eight other types protect the equipment from moisture, water, dust, oils and corrosive ambients. Still other types permit operation of equipment in hazardous ambients containing flammable or explosive vapors, gases, fibers or dust. (Protective features of the various types are described in the **box,** "Enclosures for industrial applications," and you can obtain further details by contacting such suppliers as Hoffman Engineering and Square D and the agencies listed as standards sources.)

The proper packaging of motion-control μC electronics and the power drivers and supplies can be highly effective in minimizing the effect of noise pickup, according to Fred Graham, president of Amtek, a supplier of motion-control systems ranging from machine tools to rolling mills. In tracking down faulty installations, Graham has found situations in which pulse-width-modulator servo-motor amplifiers are placed alongside the computer control system in the same NEMA enclosure. The typical pulse-width amplifier has base square-wave outputs between 5 kHz and 20 kHz and is a high-power EMI generator. Amtek's solution to the problem involves placing the control electronics and motor power drivers either in separate subsystem enclosures, mounting them some distance apart in the main NEMA cabinet, or in separate NEMA enclosures completely. To further guard against noise, Amtek uses a 12V power source for its circuitry.



A modular, sealed connector system *for harsh conditions can be configured with a small number of basic parts, like those in Industrial Interface's Spirit family of connectors.*



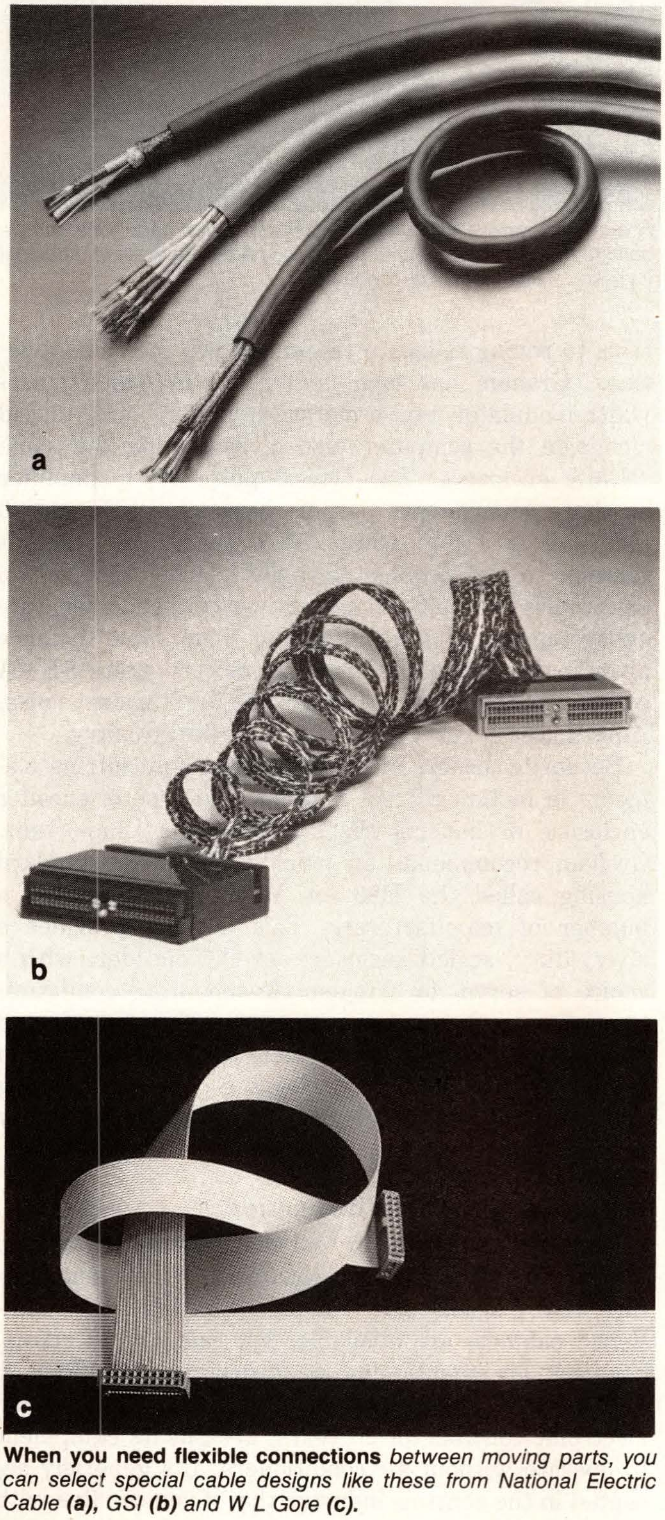
These low-cost versions of RS-232C connectors *are members of Amphenol's 57 Series* ***(a).*** *Programmable filtering is available with Cannon's transverse monolithic filter connectors* ***(b).***

Because encoders are key accuracy-determining elements in motion control systems, the type of encoder enclosure or housing that's used is very important. Graham recommends an industry de facto standard housing called the H25 (or M25), available from a number of manufacturers. This housing provides a heavy-duty, sealed enclosure for the encoder, with a choice of servo- or flange-style mounting configurations. It also has a heavy-duty (0.375 in.) shaft and bearings that can withstand as much as 30 or 40 lbs of side-loading without distorting the shaft or affecting transmission. As a result, it can tolerate minor misalignment.

Use air conditioners with caution

Housing equipment in sealed enclosures entails an increase in operating temperatures. Where temperature rise exceeds safe equipment ratings, air-conditioned cabinets are available. For many applications, however, air conditioning is not desirable. Giddings & Lewis (G&L) Electronics, manufacturers of industrial electronic controls for 26 years, designs its equipment to operate without air conditioners. It's generally accepted in the controls industry that if you can live with a 120°F temperature, equipment reliability is good. G&L designs its enclosed circuitry to operate at 160°F, although it's conservatively rated at 120°F. The actual operating temperature within the equipment package is about 135°F, which leaves a 25° margin.

G&L eschews the use of air conditioners for several reasons. First, air conditioners are relatively unreliable when compared with solid-state circuitry. Second, during operation they cause the cabinet temperature to oscillate over a range of approximately 5°F through the course of the day. The circuits in this environment are continually contracting and expanding. After a few years, the circuits become fatigued and break down. Without an air conditioner, there is normally a 1-day temperature cycle, warming up during working hours and cooling off during the night.



When you need flexible connections *between moving parts, you can select special cable designs like these from National Electric Cable* **(a)**, *GSI* **(b)** *and W L Gore* **(c)**.

A third adverse factor becomes evident when you note what happens as an air conditioner cools the temperature below ambient levels: Condensation forms within the equipment. If the equipment cools one day, dries the next, and condenses the next, this cycle ultimately oxidizes the connector and other contacts in the equipment. To operate equipment where oils or hydraulic or cutting fluids are nearby, G&L recommends a drip-proof NEMA-12 enclosure.

Industrial cables and wiring

Though not all industrial applications call for an air-conditioning system, most will require wire and cables. You'll find many configurations of wiring and cables for such industrial applications as power and control systems, instrumentation and communications. Available from manufacturers like Belden, Brand-Rex and others (see nearby **table**), these cables differ in that they incorporate features necessary for particular types of industrial application. Some cables contain single or multiple conductors, with wire that might be solid or stranded, unshielded or shielded, twisted or braided, flat cable or coax, and even fiber optic in construction. What's more, different kinds of protective insulations are available, depending upon the environment into which they are to be installed. With all the permutations and combinations available, the only practical way to select the proper cable is to refer to the various manufacturers' catalogs. However, you must understand some basic guidelines when selecting a cable that claims the ability to survive in an adverse environment.

For example, the type of protective insulation, or sheath, is a principal factor. There are a number of industry-standard materials, including polyvinyl chloride (PVC), nylon, cross-linked polyethylene, irradiated PVC, Teflon FEP and Tefzel ETFE. PVC is the least costly, but it generally provides the poorest protection against harsh ambients. Manufacturers can combine the PVC sheath with an outer jacket of nylon to provide added abrasion protection; in cases where the cable may be moving, the nylon reduces cable wear because of its low coefficient of friction.

Both PVC and nylon are thermoplastics. Operation is rated at 90°C. For high resistance to the destructive effects of solvents or chemicals, two other thermoplas-

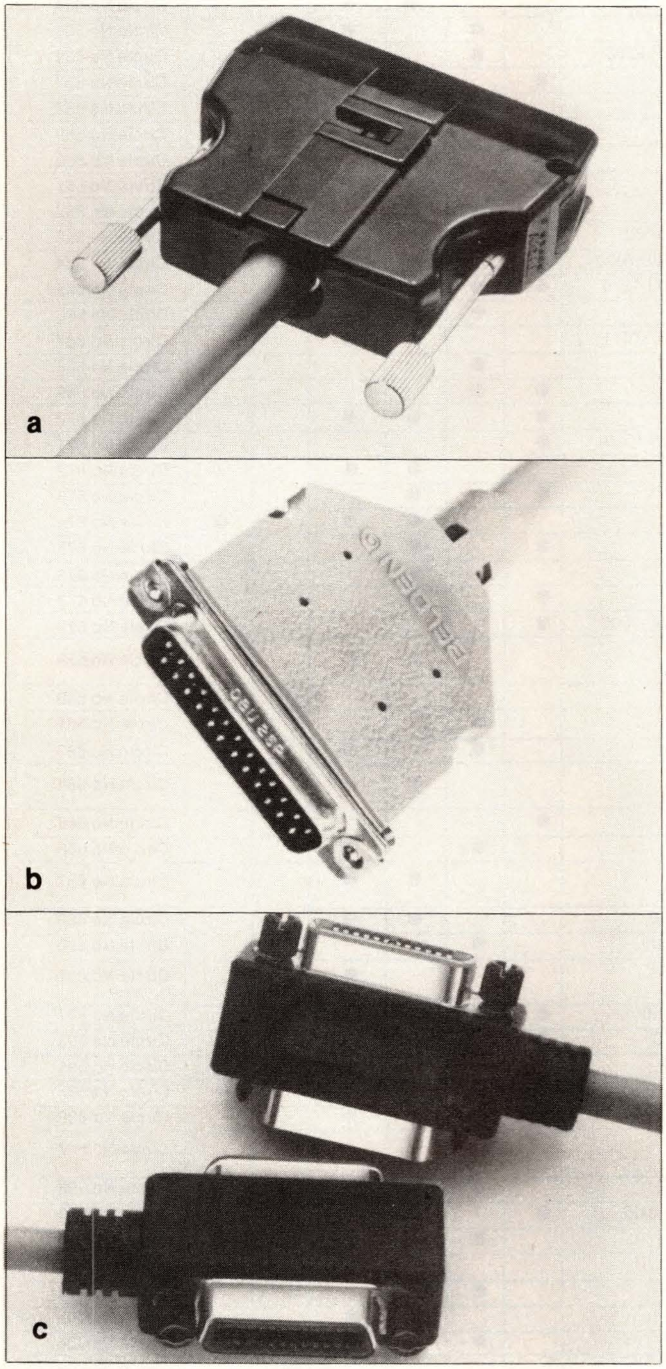
Manufacturers of interconnect components for digital motion-control and other industrial applications

For more information on products and systems like those described in this article, circle the appropriate numbers on the Information Retrieval Service card or contact the following manufacturers directly.

	INDUSTRIAL INTERCONNECT COMPONENTS AND HARDWARE						
	ELECTRICAL		FIBER OPTICS				
	WIRE AND CABLE	CONNECTORS	CABLE	COMPONENTS AND SYSTEMS	ENCLOSURES	HARDWARE	READER SERVICE NUMBER
Adirondack Wire & Cable, New Britain Ave, Farmington, CT 06302, (203) 677-2657	●						Circle No 651
Alpha Wire Corp, Box 711, Elizabeth, NJ 07207, (201) 925-8000	●						Circle No 652
AMP Inc, Box 3608, Harrisburg, PA 17105, (717) 564-0100		●		●			Circle No 653
American Photonics Inc, 71 Commerce Dr, Brookfield Center, CT 06805, (203) 775-8950			●	●			Circle No 654
Amphenol Products, 2122 York Rd, Oak Brook, IL 60521, (312) 986-2322		●		●			Circle No 655
Augat Interconnection Products, 33 Perry Ave, Attleboro, MA 02703, (617) 222-2202		●					Circle No 656
Belden Corp, Box 1980, Richmond, IN 47374, (317) 983-5200	●						Circle No 657
Berg Electronics, 30 Hunter Lane, Camp Hill, PA 17001, (717) 975-2457		●					Circle No 658
Brand-Rex Co, Box 498, Willimantic, CT 06226, (203) 423-7771	●		●				Circle No 659
Breeze-Illinois, Main & Agard Sts, Wyoming, IL 61491, (309) 695-2511	●		●				Circle No 660
Brim Electronics, Box 336, Fair Lawn, NJ 07410, (201) 796-2886	●						Circle No 661
Burndy Corp, Richards Ave, Norwalk, CT 06852, (203) 838-4444		●					Circle No 662
Cable Systems & Assembly Co, 210 Broadway, Everett, MA 02149, (617) 389-7080	●						Circle No 663
Columbia Electronic Cables, 249 Roosevelt Ave, Pawtucket, RI 06862, (401) 728-7000	●						Circle No 664
Computer Cable & Products, 147 Gazza Blvd, Farmingdale, NY 11735, (516) 293-1610	●	●	●				Circle No 665
Cornell Dubilier Electronics, 150 Ave L, Newark, NJ 07105, (201) 256-2000		●					Circle No 666
Cuda Fiber Optic Products, 6000 Powers Ave, Jacksonville, FL 32217, (904) 737-7611			●	●			Circle No 667
CW Industries, 130 James Way, Southampton, PA 18996, (215) 355-7080		●					Circle No 668
Daburn Electronics & Cable, 70 Oak St, Norwood, NJ 07648, (201) 768-5400	●	●					Circle No 669
Dolan Jenner Industries, Box 1020, Woburn, MA 01801, (617) 935-7444	●		●	●			Circle No 670
Dearborn Wire & Cable Co, 9299 Evenhouse Ave, Rosemont, IL 60018, (312) 696-1000	●						Circle No 671
EOTec Corp, 200 Frontage St, W Haven, CT 06516, (203) 934-7961			●	●			Circle No 672
Electro Weave, 38 Harlow St, Worcester, MA 01605, (617) 752-8932	●		●				Circle No 673
Fiber Optic Products, 1213 N Main St, Blacksburg, VA 24060, (703) 552-3001			●	●		●	Circle No 674
GSI Corp, 1917 Greenspring Dr, Timonium, MD 21093, (301) 252-1768	●		●				Circle No 675
Galileo Electro-Optics, Galileo Pk, Sturbridge, MA 01518, (617) 347-9191			●				Circle No 676
Galite, 2 Tower Dr, Wallingford, CT 06492, (203) 265-7162	●		●				Circle No 677
General Electric Wire & Cable, 1285 Boston Ave, Bridgeport, CT 06602, (203) 382-2000	●						Circle No 678
Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303, (Phone local sales office)			●	●			Circle No 679
Hoffman Engineering, 9th & Tyler, Anoka, MN 55303, (612) 421-2240					●		Circle No 680
Hypertronics Corp, 16 Brent Dr, Hudson, MA 01749, (617) 568-0451		●					Circle No 681
ITT Cannon, Box 8040, Fountain Valley, CA 92708, (714) 964-7400		●		●			Circle No 683
ITT Electro-Optical Products, 7635 Plantation Rd, Roanoke, VA 24019, (703) 563-0371			●	●			Circle No 684
ITT Suprenant Div, 172 Sterling St, Clinton, MA 01510, (617) 365-6331	●						Circle No 685
Industrial Interfaces Inc, 300 Elgin Ave, Elgin, IL 60120, (312) 965-0010		●					Circle No 686
Lightwave Communications Inc, 650 Danbury Rd, Ridgefield, CT 06877, (203) 438-3591			●	●			Circle No 687
Math Associates, 6 Manhasset Ave, Port Washington, NY 11050, (516) 334-6800			●	●			Circle No 688
Methode Electronics Inc, 7447 W Wilson Ave, Chicago, IL 60656, (312) 867-9600		●					Circle No 690
Motorola Semiconductor Products, 5005 E McDowell Road, Phoenix, AZ 85008, (602) 244-9600				●			Circle No 691
National Electric Cable, 16566 SW 72nd Ave, Portland, OR 97223, (503) 620-9400	●	●	●				Circle No 692
Omega Wire & Cable, 1500 Gehman Rd, Harleysville, PA 19438, (215) 247-7820	●		●				Circle No 693
Optical Fiber Technologies, Box 148, Nutting Lake, MA 01865, (617) 663-6629				●			Circle No 694
Panduit Corp, 17301 Ridgeland Ave, Tinley Park, IL 60477, (312) 532-1800		●				●	Circle No 695
Phalo OSD, 65 Moreland Rd, Simi Valley, CA 93603, (805) 522-3333			●	●			Circle No 696
Philadelphia Insulated Wire Co, 333 New Albany Rd, Moorestown, NJ 08507, (609) 235-6700	●						Circle No 697
Phoenix Contact, 1900 Greenwood St, Harrisburg, PA 17104, (717) 232-0500		●					Circle No 698
Pirelli Cable Corp, Special Cable Div, Box 50, Wallingford, CT 06492, (203) 265-7126	●		●				Circle No 699
Pyle-National, 1334 N Kostner Ave, Chicago, IL 60651, (312) 342-6300		●					Circle No 700
SI Tech, Box 609, Geneva, IL 60134, (312) 232-8460			●	●			Circle No 701
Samtec, Box 1147, New Albany, IN 47150, (812) 994-6733		●					Circle No 702
Seicor Corp, 489 Seicor Pk, Hickory, NC 28603, (704) 328-2171			●	●			Circle No 703
TRW Connector Div, 5725 E River Rd, Chicago, IL 60631, (312) 693-7730		●		●			Circle No 704
Square D Co, Executive Plaza, Palatine, IL 60067, (312) 397-2600					●		Circle No 705
Versatile Logic Systems, 87070 Dukhobar Rd, Eugene, OR 97402, (505) 485-8575						●	Circle No 706
WL Gore & Associates Inc, 1505 N Fourth St, Flagstaff, AZ 26002, (602) 526-1290	●						Circle No 707
Warner Electric, 449 Gardner St, South Beloit, IL 61080, (815) 389-3771				●		●	Circle No 708
Wago Corp, 6657 N Sidney Pl, Milwaukee, WI 53209, (414) 352-1035		●					Circle No 709
Woven Electronics, Box 189, Mauldin, SC 29662, (803) 963-5131	●						Circle No 710

tics, Teflon and Tefzel, are superior. They are rated at 200 and 150°C, respectively. The cost of these materials is relatively high, though.

Two thermosetting materials, irradiated PVC and cross-linked polyethylene, provide added protection, but at a higher cost. The irradiated PVC has better mechanical properties than the regular PVC, including higher softening temperatures under a solder iron. The polyethylene provides high moisture resistance and is flexible at low temperatures. Neoprene and Hypalon are frequently used for jacketing materials in cases where optimum protective characteristics are required.



RS-232C D connectors are available in several forms. *Typical styles include seamless die-cast metal shells that suppress EMI, such as TRW's Super Shielded D connector system* ***(a)****, a shielded and molded cable assembly from Belden* ***(b)****, and a version from Cable Systems & Assembly that incorporates special grounding features* ***(c)****.*

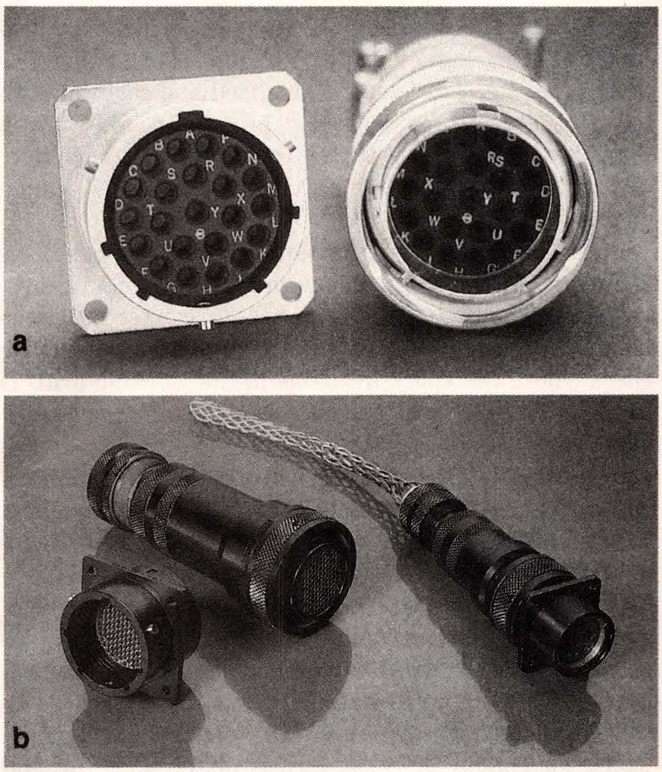
Special requirements yield new products

To satisfy many of the special requirements for interconnection systems in industrial applications, manufacturers of electrical and fiber-optic cables and connectors are tailoring special products to these uses. For example, Belden has a 78Ω twinaxial cable for transmitting digital control signals from one factory location to another. The Belden 9463 cable is constructed as a shielded, twisted pair. For maximum protection against external and radiated noise, two shields are used. The inner shield is an aluminum Mylar with a special overlapping, shorting Z section. Over this is a 57%-tinned braid with stranded, tinned copper wire for shield termination. The conductors are insulated with polyethylene for low capacitance and attenuation and high signal rise-time characteristics. The twisted conductors reduce external noise pickup and minimize cross-talk from adjacent wiring. The outer jacket is PVC, which passes UL's VW-1 flame test.

A new line of high-temperature cables for plant installation is available from Pirelli Cable Corp's Special Cable Division. Both the conductor insulation and cable jacket are Tefzel, which is rated at 150°C in 300 and 500V cables. These cables meet or exceed UL, NEC, NEMA and MIL-C-17 requirements. The thinner Tefzel insulation and jacket result in a substantially smaller cable for the same conductor and voltage rating.

For those cases in which connections must be made to independently moving points, as in machine tools and other factory equipment, specially designed round and flat cables are available. For example, Brand-Rex has a VN-Flex thermoplastic flexible control cable that is covered with nylon for maximum gas, oil and chemical

For flat, shielded cable, *special jaws on the back of the CW Industries connector grip the cable jacket.*



Where moisture, oils or other fluids are present, *sealed connectors like these from Burndy **(a)** and Pyle National **(b)** are mandatory.*

resistance. Rated at 105°C in dry locations, it is CSA and UL approved. The cables are assembled with six to 58 stranded 18-gauge conductors in a single jacketed assembly, six to 30 conductors of 14-gauge wire, six to 24 12-gauge conductors, and six to 20 10-gauge conductors. For flexible connections between moving elements of robotics equipment, ITT Suprenant and National Electrical Cable manufacture specialty cables and interconnections.

For combining flatness and flexibility, W L Gore produces an IDC-terminated ribbon cable with tough Teflon insulation for the conductors. Spec'd for 100 million continuous flex cycles for a 30-gauge conductor cable, the GFX-617 cable is supplied with six to 34 conductors of 26-, 28- or 30-gauge wire. Temperature ratings vary with the copper-conductor plating, ranging from −65 to +200°C with silver plating, −65 to +260°C with nickel plating, and −55 to +105°C with unplated conductors.

A different approach to flexible cables is adopted by GSI Corp with its woven-cable line. With this approach, GSI says that one of the limitations of laminated ribbon cables—delamination—is eliminated. Furthermore, electrical conductors and fiber-optic cables can be woven into the same cable assembly. For high strength, Kevlar is woven into the cable. A variety of shielding and jacket options are available. Woven Electronics also produces a line of specialty flat cables for flexible industrial applications.

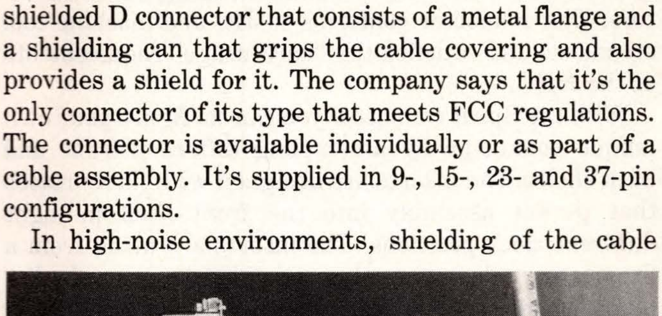
Yet another approach to flexible interconnection is taken by Adirondack Wire & Cable, Cable Systems and Assembly, and National Electric Cable. They all produce totally shielded, coiled-cord retractile molded cable assemblies. You have a choice of connectors, insulation and jackets.

For standard straight lengths of cable, Belden produces an RS-232C shielded, molded cable assembly with the connector completely shielded by copper tape. Tin-plated connector shells are used with grounding detects for positive connection. The connectors are molded onto 5-, 10-, 25-, 50- and 75-ft lengths of 25-conductor cable. The cable has a Duofoil aluminum-polyester laminate shield with a stranded 22-gauge tinned copper drain wire. Twenty-five pin connectors are standard, but you can get nine, 15, 25, 37 and 50 positions on special order.

The new TRW Super Shielded D-connector line employs a continuous 360° 1-piece seamless die-cast metal shell for its basic shield. The shell is contained within an external plastic hood assembly. The solid metal shell reduces EMI/RFI leakage, which occurs with split shells. The connectors are available in 25-contact plug or socket styles. These units also feature solderless insulation-displacement contacts for rapid field assembly. The price is less than $5 (500).

If you need flat, shielded cable, CW Industries has a shielded D connector that consists of a metal flange and a shielding can that grips the cable covering and also provides a shield for it. The company says that it's the only connector of its type that meets FCC regulations. The connector is available individually or as part of a cable assembly. It's supplied in 9-, 15-, 23- and 37-pin configurations.

In high-noise environments, shielding of the cable



Shielded and filtered connectors *from AMP suit use in several types of connector systems.*

and connectors might not be sufficient to prevent EMI from affecting the control system. In such environments, you can choose from a wide variety of filter connectors that are available from several sources, including AMP, Amphenol and Berg. Amphenol, for example, has a new low-cost filtered version of its standard 57 Series connector. Filtered adapters can be used in input-output cabinet interfaces and cable assemblies. Retrofitting the 57 Series connector with the adapters allows you to meet EMI/RFI restrictions without costly modifications. The 50-contact male-to-female adapter costs less than $0.30 in OEM quantities.

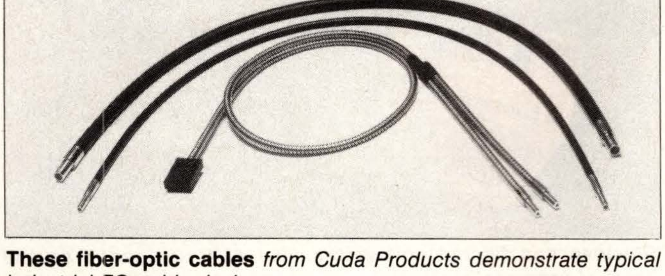
Connectors defeat adverse environments

For equipment that works in an environment of moisture, oil, dirt and high vibration, there are connectors that resist one or more of these influences. For example, Pyle-National has a new E-Line Series of circular connectors, which feature down-sized, heavy-duty aluminum shells that accept a variety of removable and interchangeable inserts to accommodate 11 to 128 contacts. Wire-gauge sizes range from 12 to 26. A wide-track bayonet coupling ensures positive locking.

One of the most original tough-environment designs to appear recently is the Spirit modular-component sealed connector system. Produced by Industrial Interfaces, the connector system, which borrows features of MIL-standard connectors, is available in three shell sizes that accommodate 16-, 18- and 20-gauge conductors. The connector conforms to JIC and machine-tool standards and satisfies the "hard usage" requirements of the NEC.

With the Spirit connector you can configure your own unique connector by assembling different front and back shells. The inserts are designed with flat surfaces that permit assembly into the front shell in eight different clock positions. The inserts are made from a proprietary elastomer that provides sealing. A diaphragm over each terminal core remains unbroken until the terminal pin is inserted. As a result, the insert maintains seal integrity without the use of dummy contacts in spare locations.

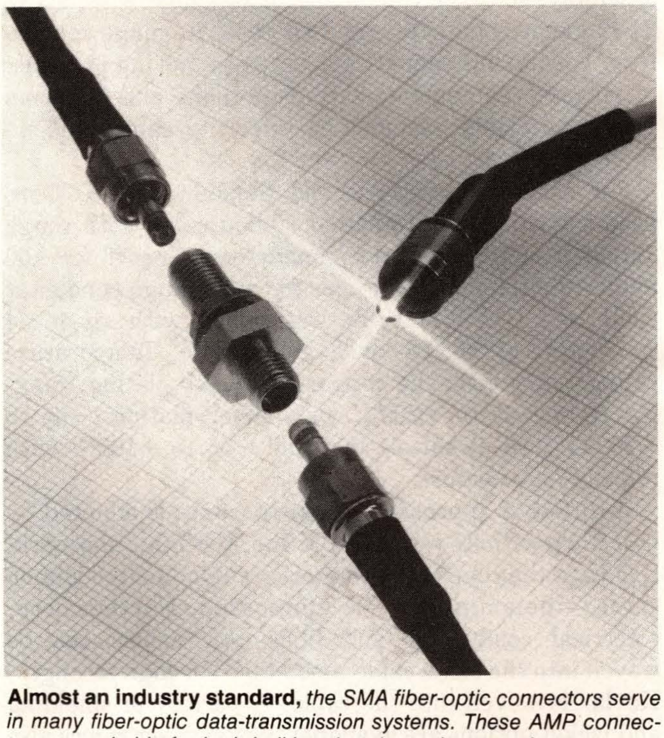
Tightening the back shell pressurizes the insert, creating a peripheral seal to the outer shell. Unlike MIL connectors, the Spirit line has back-shell configurations for all common industrial-interface requirements. All back shells fit any of the front shells. The aluminum-shell hardware is anodized and covered with a Teflon coating for corrosion protection and built-in thread lubrication. The three basic inserts accept five, 19 and 37 crimped terminals that take 16- to 20-gauge conductors.



These fiber-optic cables *from Cuda Products demonstrate typical industrial FO-cable designs.*

To solve some of the unusual connection problems attending motion-control equipment and robotic systems, some different approaches to connectors have been developed. For robotic systems, especially in cases where the space available in the working arms is limited, Wago Corp offers what is called a "cage clamp" type of termination. The unusual connector design accepts and clamps the bare ends of wires directly. This design uses a stainless-steel spring assembly to clamp the end of the conductor, thus eliminating screw terminals. It's approved for both solid and stranded wire by the UL, CSA, VDE and US Coast Guard marine-standards agency, as well as Lloyd's Register of Shipping. This last standard requires a simultaneous vibration and temperature-cycling test, as well as a salt-spray test for 500 hrs. The copper bar against which the conductor is clamped is plated with tin, and with the stainless-steel spring clamp it offers high resistance to gaseous-chemical and liquid corrosion.

A low-insertion-force but high-vibration-resistant connector is available from Hypertronics. In this connector's design, the contact pins are inserted into hyperboloid wire sleeves that stretch and wrap themselves around the pin. The low mass and inertia of



Almost an industry standard, *the SMA fiber-optic connectors serve in many fiber-optic data-transmission systems. These AMP connectors are suitable for both bulkhead and exterior mounting.*

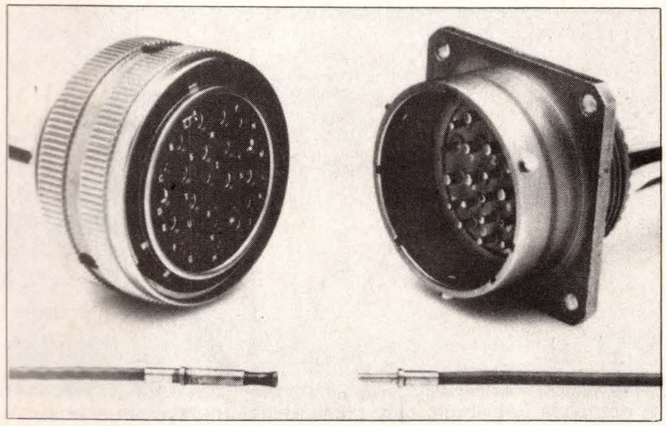
the wires relative to their resilience enables them to follow pin movements without loss of contact. Vibration tests show no discontinuity, even during a period as short as 8 nsec at 50g rms.

For terminating multiple conductors in a cabinet or on a pc board, Phoenix Contact has a series of terminal blocks. For example, with the Phoenix FLK block you can terminate 12-gauge wires and 0.05-in. flat-ribbon cables in the same block. The blocks are available with 20 and 26 positions.

Proper system connections minimize EMI

A system of interconnecting cables between controls and controlled equipment can, if installed improperly, be both a receiver and a source of EMI. In general, shielded conductors are preferred to unshielded ones, and a balanced-line transmission is better than a single-ended unit. Although many shielded cables a constructed with a separate ground wire, the best practice involves grounding the cable completely around its shield periphery as it leaves or enters enclosures. In cases where noise generated on the power line from external machinery, solenoids, motors, welders and relays is excessive, you should use an isolation transformer. Using connectors that incorporate lowpass filters is a good way to remove conducted high-frequency noise from the control-signal lines.

Perhaps the best technique for ensuring EMI-free transmission is to use a fiber-optic system. Industry experts agree that the use of fiber-optic systems in industrial applications is increasing and will ultimately supplant many electrical cable systems now in use.



Useful in adding fiber-optic-link capability *to conventional circuitry, Cannon's new fiber-optic contacts are interchangeable with size-16 pin and socket electrical contacts in the MIL-C-38999 Series and other connectors.*

The particular types of cables you use for industrial installation depend on interface standards—RS-232C, RS-449, IEEE-488, etc. According to AMP, RS-232C is a slow-speed, short-range serial interface limited to 20k bps over a 15m maximum length. However, the spec allows longer cables, provided you keep the load capacitance below 2500 pF. The slow speed of the RS-232C interface makes it fairly quiet in spite of the relatively

Hazardous locations defined

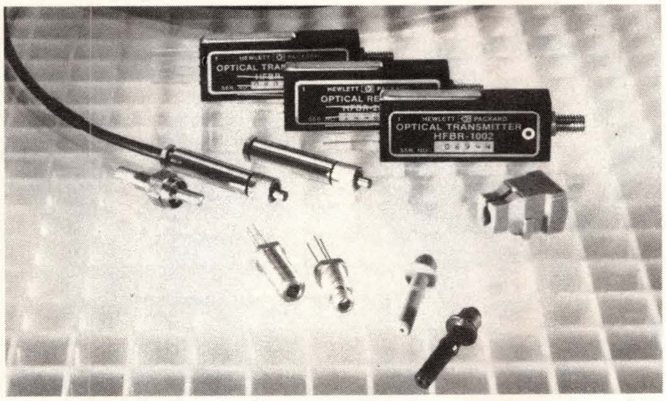
The various kinds of hazardous locations, which range from those in which flammable gases or vapors are present to those in which combustible or explosive dust is suspended in the air, are defined by the National Electrical Code (NEC) publications. You can obtain these publications from the American National Standards Institute (ANSI). They are ANSI/NFPA 70-1978 National Electrical Code; ANSI/UL 698, industrial control equipment for use in hazardous locations; ANSI/UL 877, outlet boxes and fittings for use in hazardous locations; and ANSI/UL 894, switches for use in hazardous locations.

Publications with "/UL" suffixes are also available from the Underwriters Laboratories. You can obtain those with a "/NFPA" suffix from the National Fire Protection Association. This organization has a recommended standard, NFPA 79, which is an electrical standard for metalworking machine tools and plastics machinery (1980).

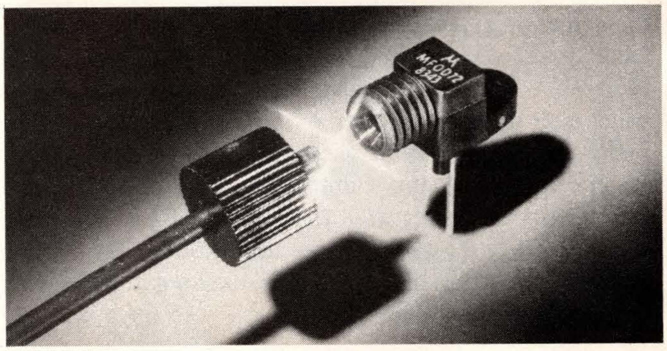
For more information, contact the following organizations:

- American National Standards Institute, 1430 Broadway, New York, NY 10018, (212) 354-3300.
- British Standards Institution, 2 Park St, London W1A 2BS, UK.
- IEC/EIA, 2001 Eye St NW, Washington, DC 20006, (202) 457-4966.
- IEEE, 345 E 47th St, New York, NY 10017, (212) 705-7900.
- National Electrical Manufacturers Association, 2101 L St NW, Washington, DC 20037, (202) 457-8400.
- National Fire Protection Association, Batterymarch, Quincy, MA 02169, (617) 770-3000.
- National Machine Tool Builders Association, 7901 Westpark Dr, McLean, VA 22102, (804) 893-2900.
- Underwriters Laboratories Inc, 128 Walt Whitman Rd, Melville, NY 11745, (516) 271-6200; 333 Pfingsten Rd, Northbrook, IL 60062, (312) 272-8800; 1655 Scott Blvd, Santa Clara, CA 95050, (408) 985-2400.

Consider the outer insulation when choosing ruggedized cables



A complete fiber-optic data-communications system *is possible using Hewlett-Packard's active and passive components.*



A GaAs emitter and four detector types *are packaged by Motorola in a standardized plastic receptacle that has a mounting flange and the male portion of a fiber-optic connector. A plastic fiber-optic cable mates with the receptacle.*

high ±15V signal levels allowed. The RS-449 standard allows serial operation to 2M bps over a distance of 1200m, a situation which usually requires shielding. Meanwhile, the characteristics of RS-449 are further defined by RS-423A for the unbalanced mode of transmission and by RS-423A for the balanced mode. The latter is recommended because it allows higher transmission rates over longer distances with better EMI control.

These three standards leave to the user the choice of the specific type of cable, unshielded or shielded connectors and the number of terminal contacts. AMP, for example, offers RS-232C- and RS-449-compatible Amplimite connectors in all-plastic, metal-shell, shielded or filtered versions. The choices of cable terminations include crimp contacts, solder contacts or insulation-displacement contacts.

The IEEE-488 standard defines a general-purpose parallel-interface bus, including the 24-conductor cable specs. It calls for an overall braid shield for the cable. The purpose of this outer shield is to protect the signals from outside interference and to prevent energy radiation. The standard also specifies the connector type, but it doesn't specify a method for connecting the outer cable shield to ground through the connector, which is a problem you must solve.

Fiber optics gains industrial ground

Fiber-optic cables' total immunity to EMI/RFI problems has industrial-equipment designers actively pursuing their use. Large bandwidths, relatively low transmission losses, small cable sizes, light weight and electrical isolation make the systems more attractive.

In response to demand, fiber-optic cables are being supplied by an increasing number of vendors, including many of the established wire-cable companies. Several fiber-optic producers are specializing in industrial products. For example, Cuda Products supplies 30-ft-long fiber-optic cables that are unaffected by water, gasoline, oil and common organic acids. They are used, for example, in NEMA-type enclosures for Warner Electric's μP-compatible Photoscanner lines. Industrial grades of Cuda's fiber-optic cable include a PVC/Monocoil flame-retardant, spring-steel cable coated with PVC. This crush-resistant design operates over a temperature range of −50 to +225°F. An even more rugged design is Cuda's stainless-steel Stripwound cable, which has a heavy interlocking maximum-strength jacket and an operating temperature of −50 to +525°F. Standard fiber-bundle diameters range from 0.045 to 0.50 in. They are supplied with stainless steel, aluminum or brass end fittings.

Phalo/OSD offers industrial-grade fiber-optic cables (A043, A093 Series) with bundles of four to six and seven to nine fibers in cable diameters of 5.5 and 6.5 mm, respectively. The fibers surround a central steel member and are cushioned within polyurethane jackets by aramid fibers.

Coupling the optical energy into and out of the fibers is accomplished by using any of several proven types of connectors developed by manufacturers like ITT Cannon and AMP. (For a comprehensive look at fiber-optic components and systems, see AMP's book, *Designer's Guide to Fiber Optics.*) AMP's Optimate SMA-style connectors accept a wide variety of cable configurations. They are designed to conform to proposed NATO and IEC standards for military and instrument applications. They are compatible with existing SMA-style devices and provide a means of interfacing single fibers as small as 125 μm and bundled fibers as large as 1.14 mm. An internal ferrule ensures axial alignment of fibers to within 0.1°.

A corrosion-resistant metal body and coupling nut provide EMI shielding for sensitive electro-optic receiver circuitry. For cable-to-cable connections, a bulkhead mounting adapter is available. There are also several mounts that accept active devices, including those in TO-18 and TO-46 housings as well as the single-position, resilient-ferrule types.

A series of AMP's Optimate DNP (dry, nonpolish) connectors includes a product line that enables you to configure both single- and dual-channel cables as well as the interface to emitters and detectors. Cannon makes the FOMC Series of multiple-channel connectors for 2-, 4- and 8-channel layouts. Originally designed for military systems, and immune to hydraulic fluid, oil, gasoline, ethylene glycol, dirt and dust, the series is finding application in industrial plants. These connectors are totally sealed and are available in plug-to-plug or plug-to-receptacle forms. The receptacles mount on control enclosures. The connectors are designed for cables using graded-index fibers, such as those from ITT's EOPD Division.

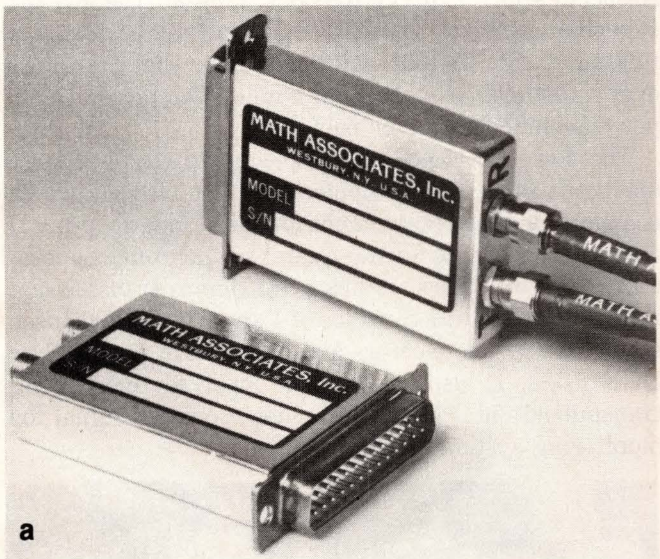
Innovative lines of connectors that allow you to adopt fiber-optic capabilities without radical equipment changes include Cannon's KJA and KJL Series units, based on MIL-C-38999 versions, and the PV/CV Series based on MIL-C-83723 devices. The MIL connectors are modified with an insert that accepts size-16 fiber-optic contacts. The advantage here is that you can replace an electrical contact with a fiber-optic contact without altering the connector. Consequently, you have both electrical and fiber-optic signals in the same connector. You use the same contact-insertion and -retraction tools as you would for the standard MIL connectors.

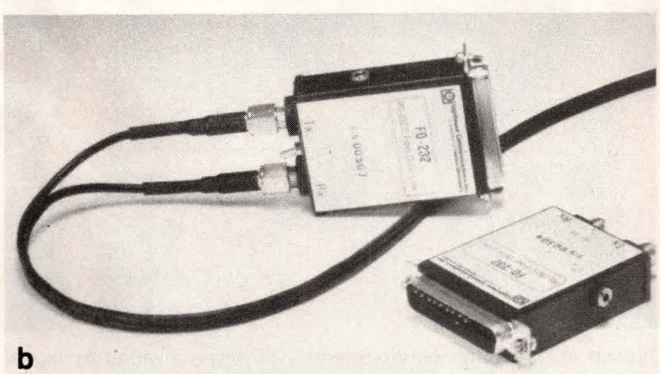
Aimed at harsh automated-factory environments employing fiber optics is a new ultraprecision single-channel connector with lapped ceramic ferrules, available from Optical Fiber Technologies. This SC ceramic series directly intermates with Amphenol 906-style connectors. The body of these SC connectors, unlike others, is made of stainless steel and nickel-plated brass. The lapped ferrules are 99.99% aluminum oxide for maximum thermal and chemical stability. Three versions are available. The 200 SC is designed for use with a 50- or 100-µm multimode fiber. The 200 SCM is a field-installable connector for single-mode, 125-µm fibers. The 100 SC unit is a low-loss version of the 200 SC for 50-µm fibers only. Respective prices for the 200 SC, 200 SCM and 100 SC connectors in OEM quantities of 501 to 2000 are $11.95, $80 and $39.50.

System components are available

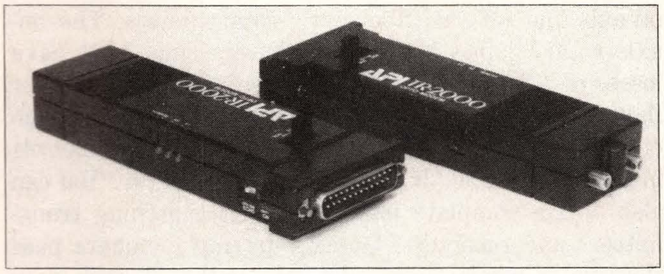
If you're adapting your system to fiber optics, many components and subsystems are available off the shelf. Hewlett-Packard has transmitter/receiver pairs that are suitable for transmission rates from 1M to 5M baud and cables from 0.1 to 25m (with connectors) in its Snap-In Link family. These units use a 1-mm-diameter fiber, plastic Snap-In connectors and a TTL-compatible output.

Motorola recently announced a GaAs emitter and four detectors that can be combined as a matched system when used with a 1-mm plastic cable core (DuPont OE1040 or Eska SH4001). The system's MFOE71 IR diode has an electrical bandwidth of 20 MHz at an 820-nm optical output, which matches the fiber characteristics and transmits over a distance of 10 to 40m, depending upon the detector employed. To simplify system assembly, all components are permanently installed in a plastic receptacle that includes both the connector and the mounting flange. To connect the components to the cable, you insert the fiber into the connector opening until it sits against the lens and then tighten the lock nut over the receptacle. The detectors include a very-high-gain photodarlington



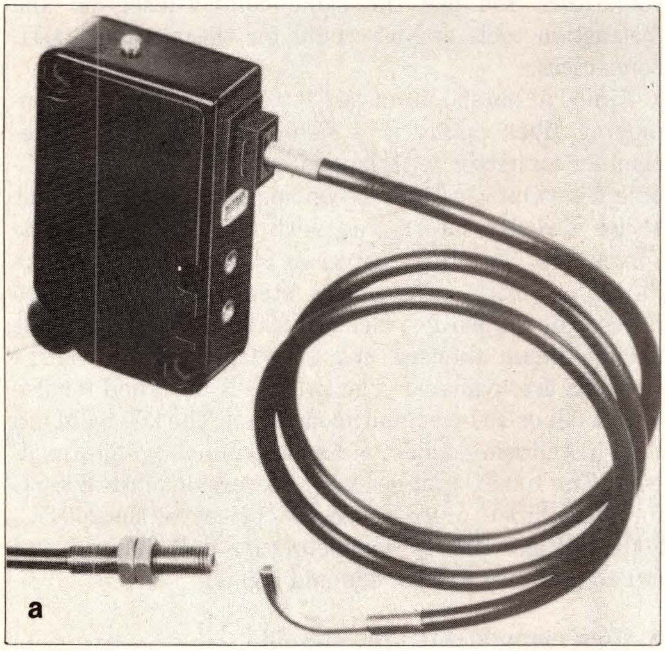


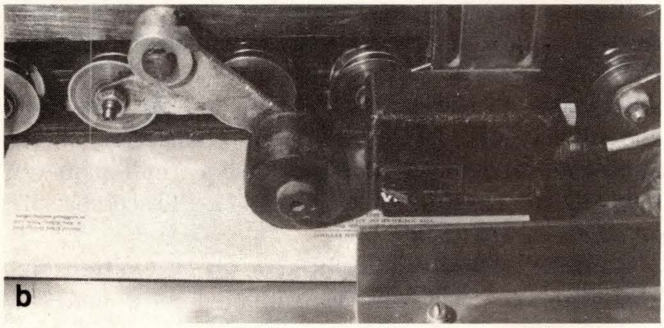
The availability of fiber-optic hardware *compatible with RS-232C is growing. Transmitter/receiver pairs for full-duplex operation are available from Math Associates* **(a)** *and Lightwave Communications* **(b)**.



The lowest price RS-232C optical modem *is the $99 American Photonics TR2000. Suitable for full-duplex operation, it can transmit data over distances to 1 km.*

Innovative, flexible cabling suits moving-element equipment





A solid-state fiber-optic mark scanner, *Warner Electric's MCS-638* ***(a),*** *is packaged in an aluminum die-cast enclosure that is rated to NEMA 1, 3, 4, 12 and 13. The scanner here is used in a bindery and senses 3600 magazine jackets per hour* ***(b).***

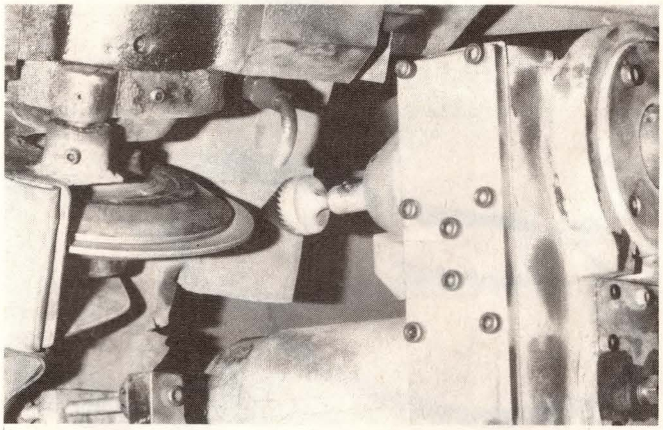
(MFOD73), a very fast PIN photodiode (MFOD71) and a low-cost phototransistor (MFOD72). A Schmitt-trigger photodetector will also be available. Principal advantages of the Motorola system are high performance, simple assembly and a substantially reduced price compared with previously available components offering similar performance.

For transferring digital data between two rotating mechanical elements, Fiber Optics Products offers both on-axis and off-axis fiber-optic rotary joints. The on-axis rotary joints are fiber-optic slip rings that have losses of less than 3 dB. They are supplied as barrel- or flange-mounted components with 1m fibers on each end. The joints are 2 and 2.16 in. long and have barrels measuring 1.12, 0.75 and 0.68 in. in diameter. You can also obtain complete links, including matching transmitters and receivers. On-axis driving members pass through a rotary joint, but you can still pass data through the joint using the Fiber Optic Products' off-axis device. It's supplied as a complete package with a 2-channel digital transmitter/receiver combination. The optical connectors are SMA style. The inside diameter of the joint is 3.995 in., while the outside is 7.680 in. It's 2.05 in. thick.

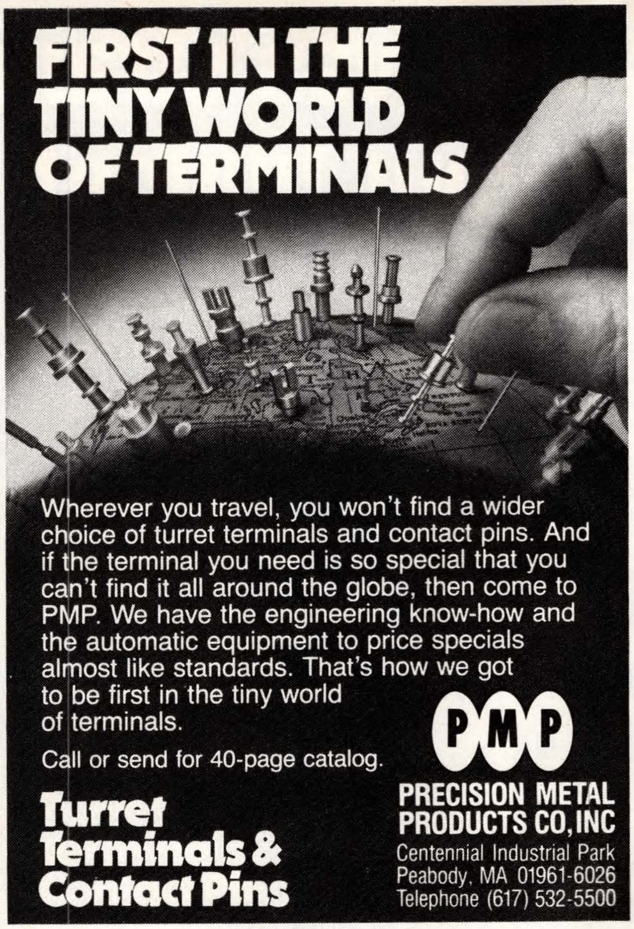
Meanwhile, a number of fiber-optic links with RS-232C interfaces are also available. S I Tech, which recently acquired Belden's fiber-optics product line, is producing the Model 2000 Optical Bit-Driver line, a system that comes with an RS-232C interface plus input and output transmission connections. These units are available as asynchronous or synchronous, simplex or full-duplex optical systems for 56k-bps operation over distances of 2, 4, 6 or 10 km. For the full-duplex model, two AMP Optimate connectors interface with fiber-optic duplex cable.

Another RS-232C-compatible unit is the FO-232S fiber-optic modem from Lightwave Communications. Transmitting in synchronous or asynchronous half- or full-duplex mode, the unit has a maximum speed of 19.2k bps. Typical transmission distances with a 3-dB operating margin are 425m for a 50-μm core and 2000m with a core twice that size. The price is $475. Math Associates has a direct RS-232C plug-in, the RS-232 Fiberlink system. The 2-module package contains a full-duplex, dc to 100k-bps transceiver that transmits over a distance of more than a mile. The price is $349 per transmitter/receiver pair.

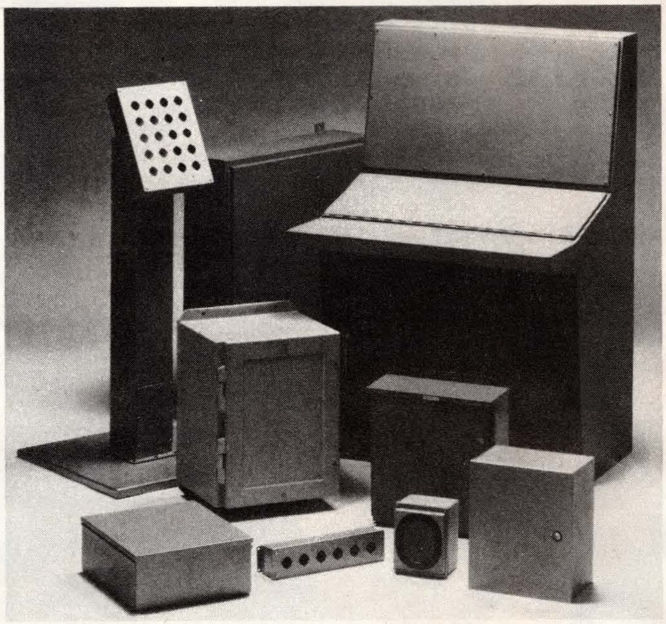
The lowest priced RS-232C-compatible fiber-optic modem is American Photonics' new $99 TR2000, which is a plug-for-plug replacement for the standard 25-pin D connector. Suitable for full-duplex asynchronous operation over two fibers, it has a maximum transmission rate of 150k bps at a distance of 1 km. The TR2000 uses standard SMA connectors and operates in the DTE or DCE mode. It also has an echo mode for monitoring transmitted data. It also provides a control signal for monitoring system operation.



Typical of the rough environments *now being invaded by digital motion-control equipment is this special grinding machine by Atrax Research and Development. Here, a Compumotor electronically controlled microstepping motor replaces the hydraulic drive of earlier designs.*



New connector materials defeat adverse environments



A variety of NEMA enclosures *is representative of the many types of enclosures available. These from Hoffman Engineering include NEMA Types 1, 3R, 4X, 12 and 13.*

For those situations in which you need to control a number of data channels, an RS-232C-compatible asynchronous/synchronous time-division multiplexer with a built-in modem, the OMX-1900 from Phalo/OSD, can handle either eight or 16 full-duplex channels. In the asynchronous mode, each channel is transparent to the data rate, which extends to 19.2k bps. In an internally clocked mode, each channel can be independently programmed for data rates of 1200, 2400, 4800, 9600 and 19.2k bps. The fiber connectors are standard SMAs. A triple-channel mode configures the multiplexer to pass 24 bits (OMX-1908) or 48 bits (OMX-1916). This allows the user to define the configuration of the multiplexer. Possible configurations are passing data for three dumb-terminal asynchronous channels through each multiplexer channel, or passing data, an external clock and a handshaking line through each channel. **EDN**

Acknowledgments

We wish to thank the following manufacturers of motion-control equipment for the helpful information used in the preparation of this article: Amtek (Seattle, WA), McDonnell Douglas/SAFI Engineering (Grand Rapids, MI), Compumotor (Petaluma, CA), Finell Systems (San Jose, CA), G&L Electronics (Fond du Lac, WI) and Warner Electric Brake and Clutch (South Beloit, IL).

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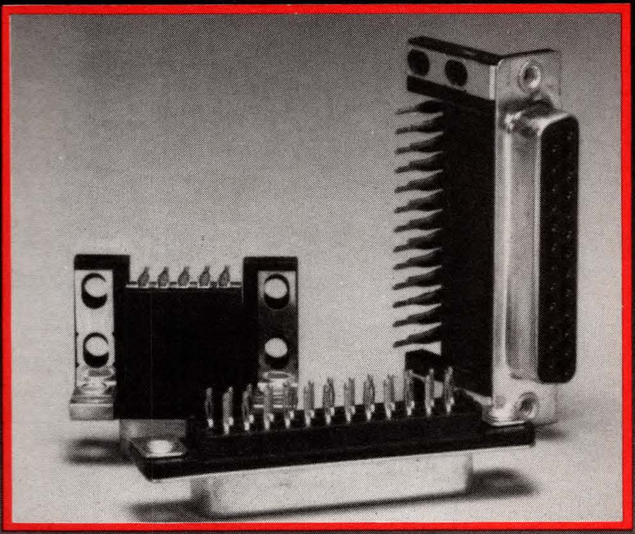

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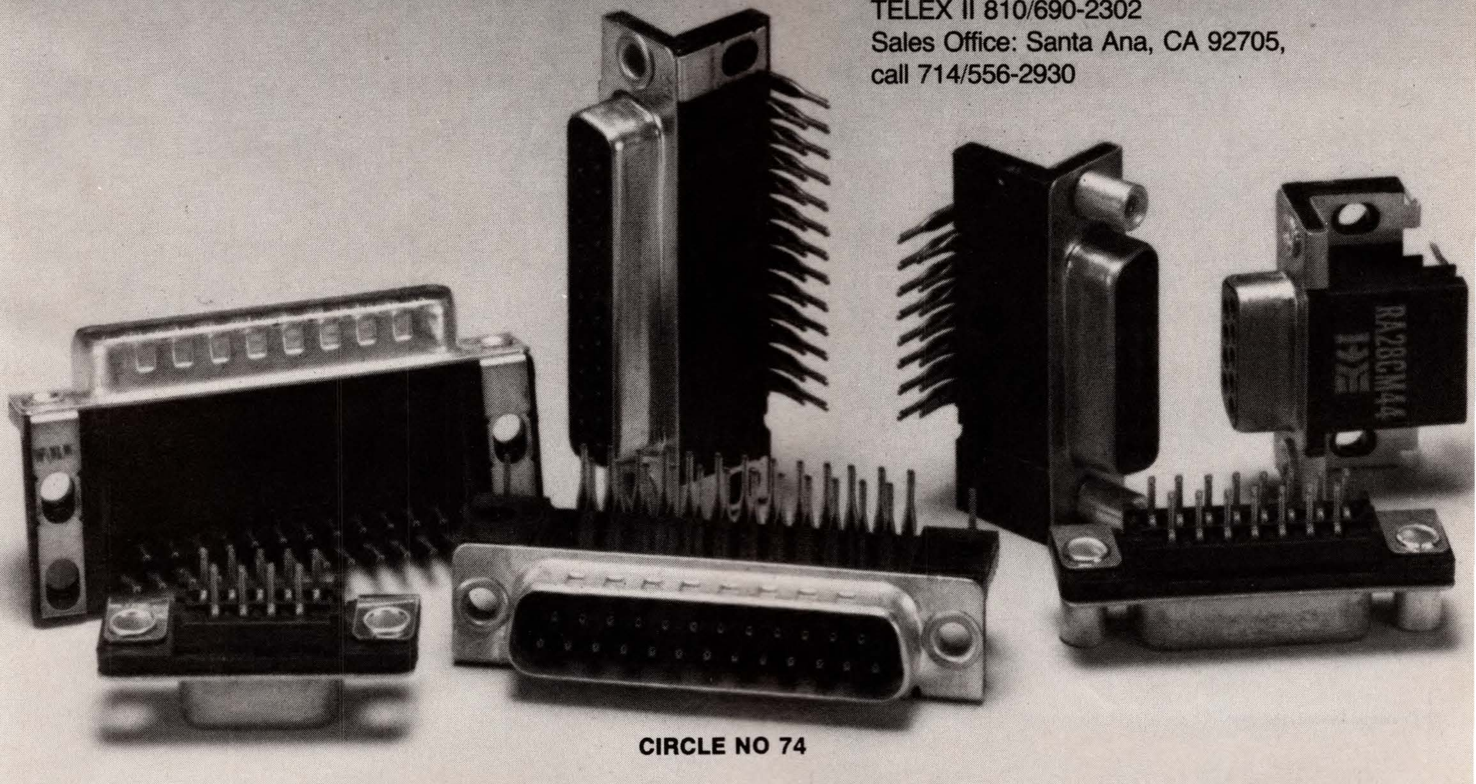

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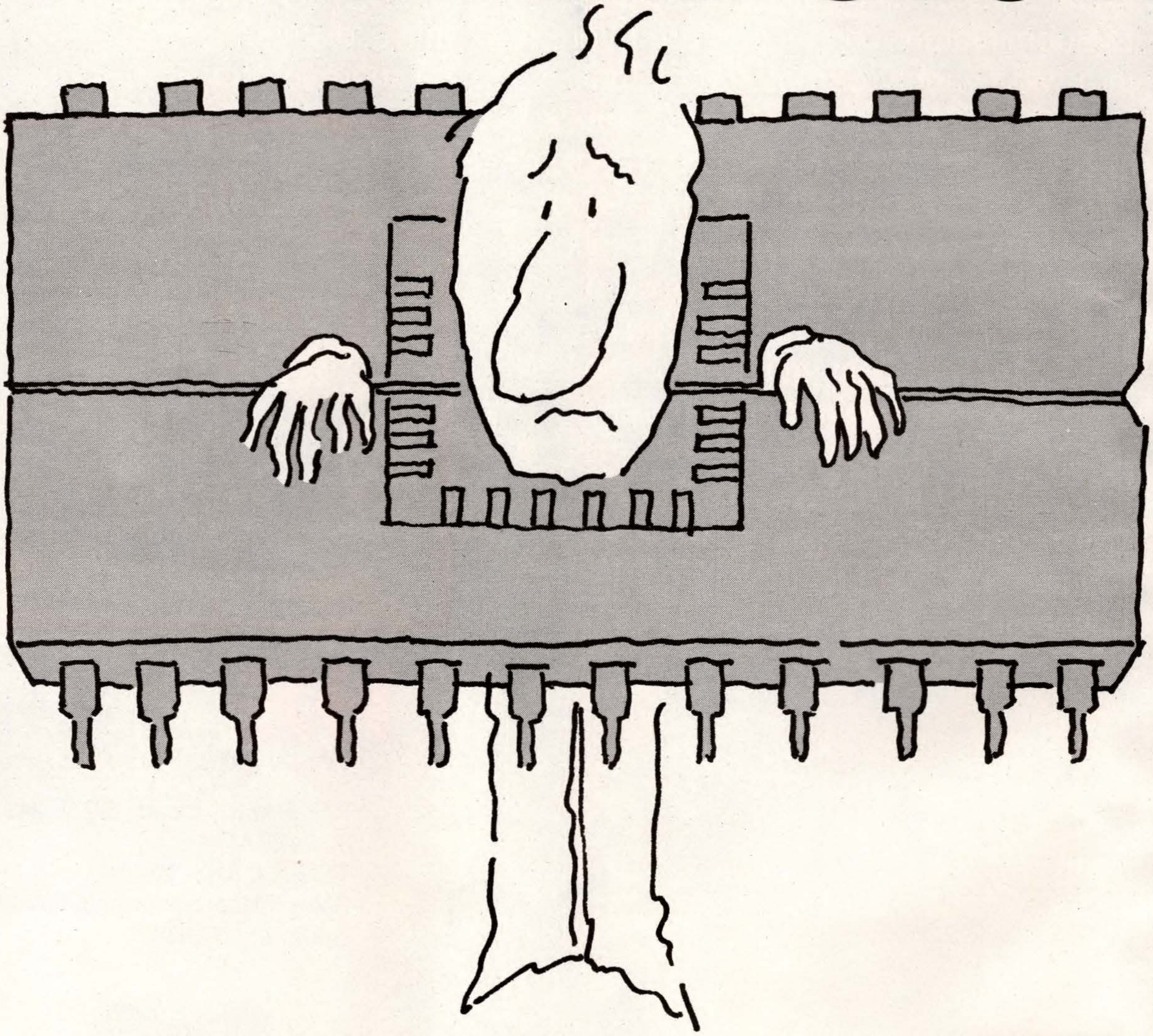

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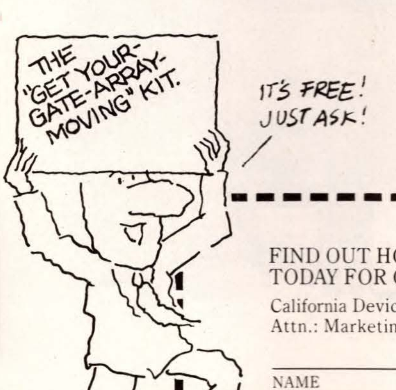

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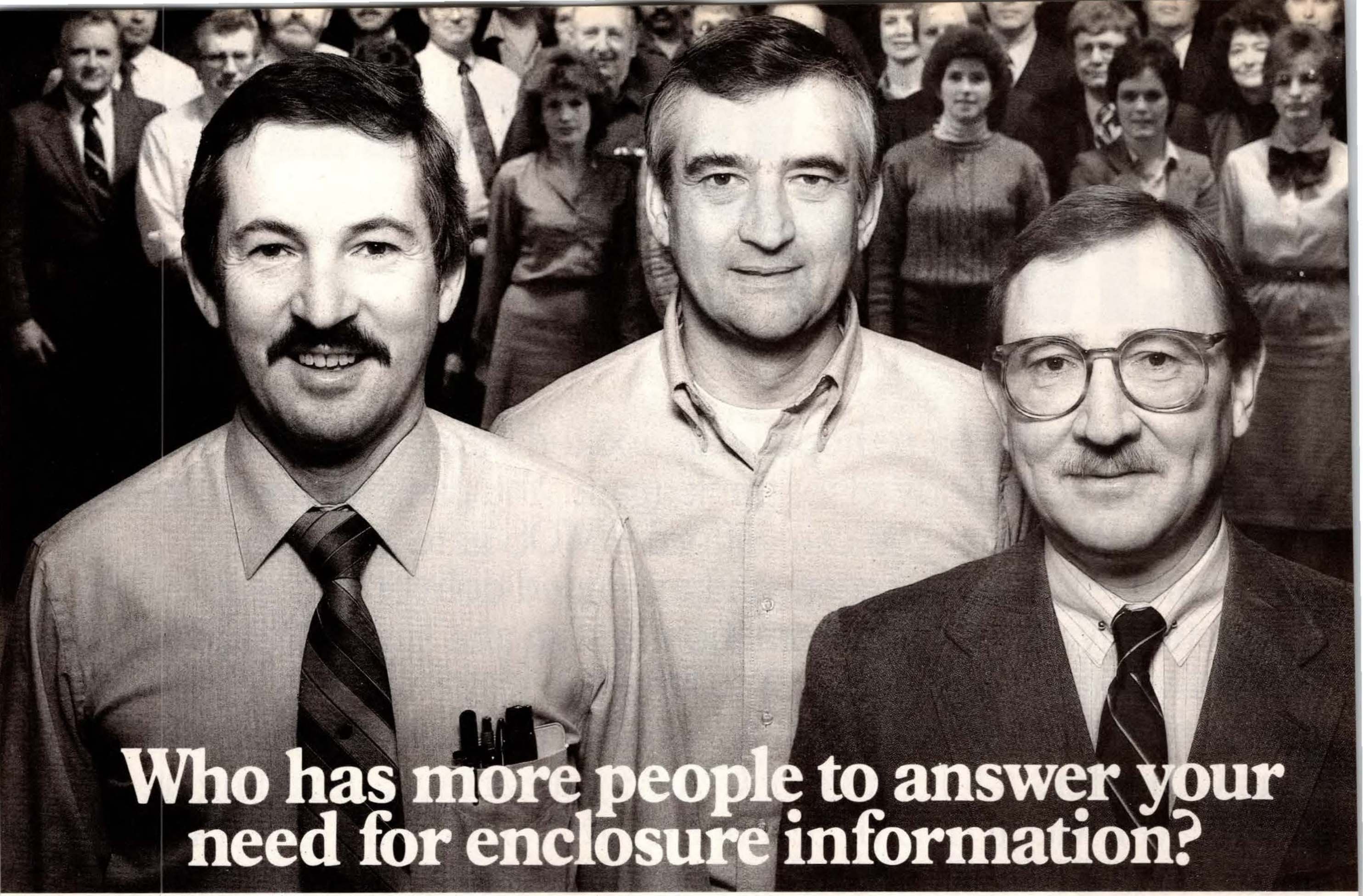

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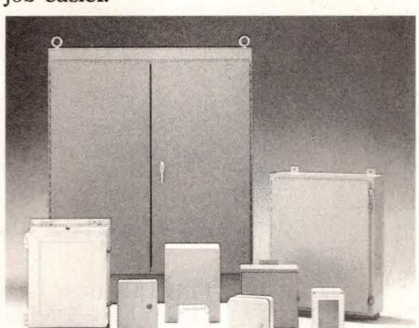

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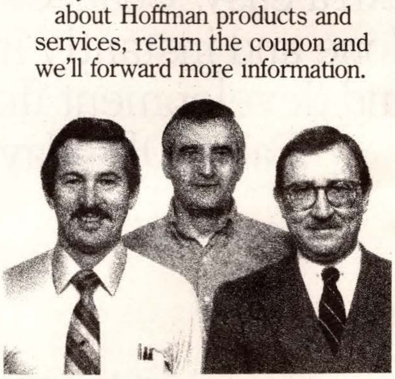

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CIRCLE NO 76

Monolithic power-buffer IC drives difficult loads

A high-speed monolithic buffer amplifier simplifies the driving of analog signals into nonlinear or reactive loads. Moreover, the IC's self-protection features cover a variety of possible output fault conditions.

Jim Williams, *Linear Technology Corp*

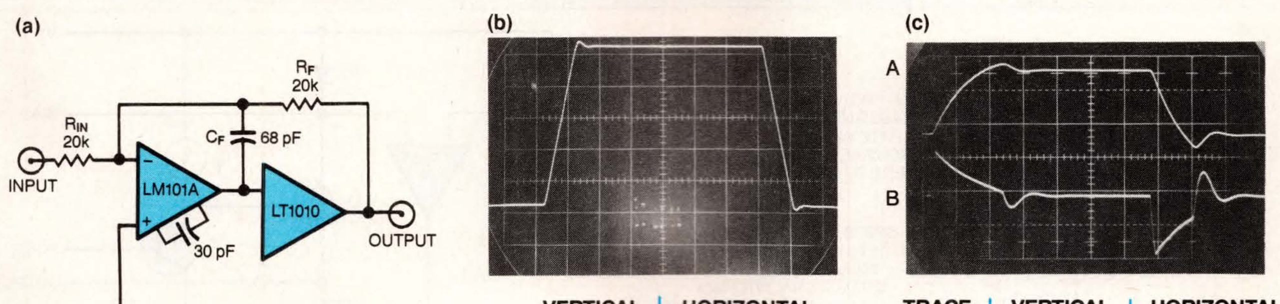
A frequent system requirement involves driving analog signals into nonlinear or reactive loads. Some examples of such difficult loads are cables, transformers, motors and sample/hold circuits. Although several power-buffer ICs are available, there are none optimized for driving problem loads.

The Model LT1010 power-buffer IC, on the other hand, can isolate and drive almost any reactive load. What's more, the device includes current-limiting and thermal-overload protection, guarding the IC against fault conditions. The combination of high speed, output protection and reactive-load-driving capability (see **box,** "Physiology of the LT1010") make the device useful in a variety of practical situations.

Fig 1a shows the LT1010 inserted in an operational amplifier's feedback loop. At low frequencies, the buffer is effectively within the feedback loop; its offset voltage and gain error are negligible. At higher frequencies, however, feedback occurs through C_F. Therefore, the phase shift resulting from load capacitance acting in combination with the buffer's output resistance doesn't produce loop instability.

Fig 1b illustrates circuit performance when the LT1010 drives a 50Ω, 0.33-μF load. Even if you increase the load to a brutal 2 μF, the circuit is still stable, as borne out by trace A in **(c).** Trace B, however, shows that the large capacitance requires substantial current from the buffer. Note also that you can obtain improved damping by adjusting the R_FC_F time constant. Though this circuit is quite useful, its speed is limited by that of the op amp.

There are ways to overcome the op-amp limitation while maintaining good dc characteristics. In **Fig 2a,** the LT1010 combines with a wideband gain stage (Q_1

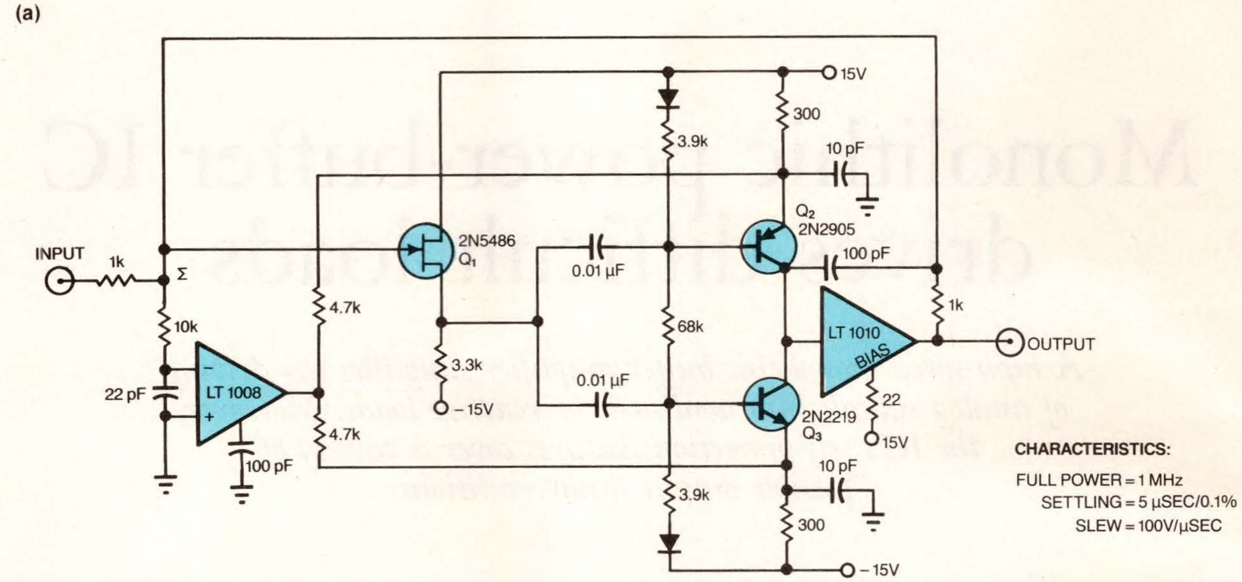


VERTICAL	HORIZONTAL
2V/DIV	20 μSEC/DIV

TRACE	VERTICAL	HORIZONTAL
A	5V/DIV	50 μSEC/DIV
B	200 mA/DIV	50 μSEC/DIV

Fig 1—Inserted in a feedback loop, *the LT1010 effectively isolates an operational amplifier from highly capacitive loads. The photos show the circuit's response with a 0.33-μF* **(b)** *and a 2-μF* **(c)** *load.*

Amplifier scoffs at reactive loads



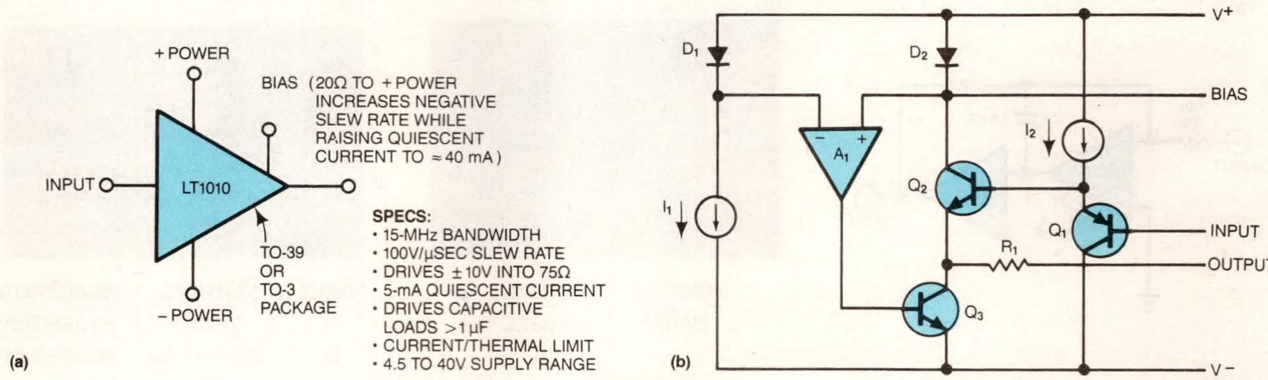
Physiology of the LT1010

Bob Widlar, *Linear Technology Corp*

The schematic diagram in the **figure** shows the basic elements of the LT1010 buffer's design. The op amp drives the output sink transistor Q_3 so that the output follower's collector current never drops below the quiescent current (determined by the area ratio of D_1 and D_2). As a result, the high-frequency response is essentially that of a simple follower, even when Q_3 is supplying the load current. The internal feedback loop is isolated from the effects of capacitive loading in the output lead.

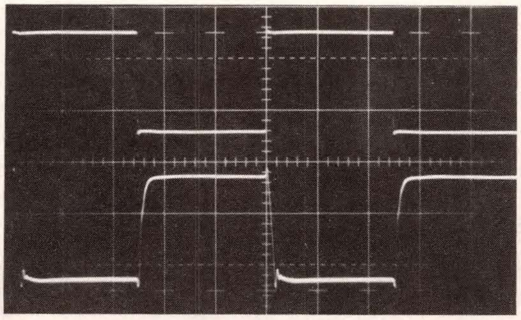
The scheme is not perfect; the rate of rise for sinking current is noticeably lower than that for sourcing current. You can mitigate this difference by connecting a resistor from the bias terminal to V^+, thereby raising quiescent current. One of the design's features is that the output resistance is largely independent of the follower's quiescent current or the output load current. Also, the output can swing to the negative rail, a particularly useful feature for single-supply operation.

As far as stability is concerned, the buffer is no more sensitive to supply bypassing than slower op amps. The 0.01-µF ceramic capacitors usually recommended for op amps are adequate for low-frequency work. As always, it's prudent to keep capacitor leads short and to use a ground plane, especially when operating at high frequencies.



Featuring a bias pin to optimize negative slewing, *the LT1010 offers high speed and the capability to drive highly reactive loads. The device is available in a TO-39 package or the heftier TO-3 package.*

(b)



TRACE	VERTICAL	HORIZONTAL
A	10V/DIV	1 μSEC/DIV
B	10V/DIV	1 μSEC/DIV

Fig 2—Faster than monolithic-op-amp configurations, *this discrete circuit offers good dc and high-speed characteristics. The configuration, a low-distortion, unity-gain inverting amplifier, is similar in concept to* ***Fig 1****'s circuit.*

through Q_3) to form a fast inverting configuration. The LT1010 dc-stabilizes the gain stage by biasing Q_2 and Q_3 emitters to force a 0V dc potential at the circuit's summing junction.

The frequency rolloffs of the fast stage and the op amp are the optimum values to provide smooth overall circuit response. A higher speed is possible because the circuit's dc-stabilization path is in parallel with the buffer. Even when this circuit drives a heavy 600Ω/2500-pF load, as **Fig 2b** illustrates, the output (trace B) faithfully follows the input (trace A).

Amplifier drives video lines

In many cases, dc stability is unimportant in applications requiring ac gain. **Fig 3a** shows how to combine the LT1010's load-handling capability with a fast discrete gain stage. Q_1 and Q_2 form a differential stage that drives the buffer IC in single-ended fashion. The capacitively terminated feedback divider establishes unity dc gain for the circuit while allowing ac gains as high as 10.

Inadequate supply bypassing can compromise the buffer's slew rate. With output current slewing much faster than 100 mA/μsec, the use of 10-μF solid-tantalum capacitors is a good practice, although in some applications bypassing from the positive to the negative supply will suffice.

When used in conjunction with an op amp and heavy resistive or capacitive loads, the buffer can couple into supply leads that are common to the op amp, thereby causing stability problems with the overall loop. The 10-μF tantalum capacitors can usually provide adequate bypassing in these situations. Another solution is to use smaller capacitors in conjunction with series decoupling resistors. Finally, note that some op amps have much better high-frequency rejection for one supply than for the other, so bypassing requirements are less stringent for this supply.

In many applications, the LT1010 requires heat-sinking. Thermal resistance from junction to still air is 150°C/W for the TO-39 package, 60°C/W for the TO-3 package. Circulating air, use of a heat sink or mounting of the TO-3 package to a pc board reduces thermal resistance. In dc circuits, it's easy to compute the buffer's dissipation. On the other hand, in ac circuits the signal waveshape and the nature of the load determine dissipation. For example, with reactive loads, peak dissipation can be several times the average value. It's particularly important to determine dissipation when driving large-load capacitances.

The LT1010 has both instantaneous current limiting and thermal-overload protection. The device doesn't use foldback limiting, and so allows the buffer to drive complex loads without limiting. Because of this feature, it's capable of dissipating power in excess of its continuous ratings.

Usually the thermal-overload protection limits the dissipation and prevents damage. However, with voltages higher than 30V across the conducting output transistor, the thermal limiting isn't fast enough to ensure protection. As long as the load current is limited to 150 mA, however, the thermal protection is effective with voltages to 40V across the conducting output transistor.

When driving capacitive loads, the LT1010 prefers to be driven from a low source impedance at high frequencies. Some low-power op amps are marginal in this respect. You might need to take some care to avoid oscillations, especially at low temperatures. Bypassing the buffer's input with 200 pF min solves the problem. Raising the IC's operating current is also effective, but this is only feasible with the TO-3-packaged version.

Bob Widlar is a design engineer for the Milpitas, CA-based company. For more information on the LT1010, **Circle No 725.**

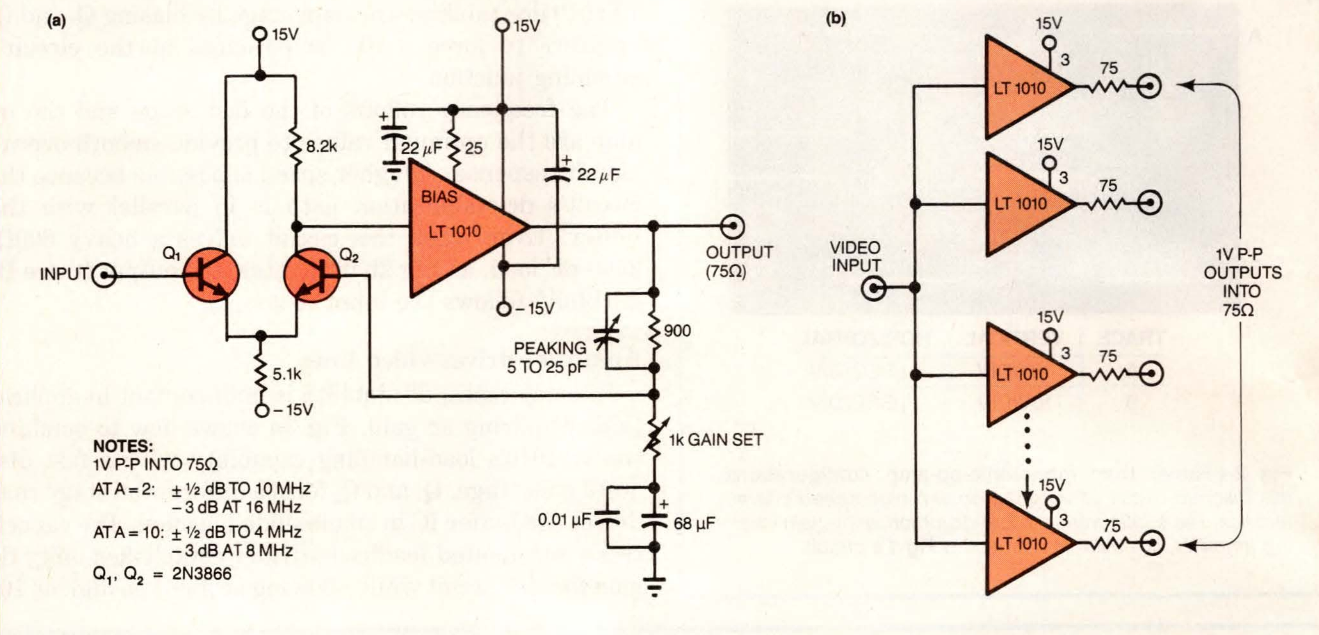


Fig 3—Suitable for video applications, *these circuits provide standard 1V p-p composite-video signals into 75Ω lines. The circuit in* **(a)** *provides variable gain. The one in* **(b)** *allows you to drive multiple video lines.*

Using a 20Ω bias resistor, the circuit delivers 1V p-p into a typical 75Ω video load. For applications sensitive to National Television Systems Committee (NTSC) requirements, reducing the bias resistor's value aids performance. For a gain of 2, the response is flat within ±0.5 dB to 10 MHz; the −3-dB point occurs at 16 MHz. At a gain of 10, the gain is flat within ±0.5 dB to 4 MHz; the −3-dB point is at 8 MHz. For best performance, optimize the peaking adjustment under loaded-output conditions.

Fig 3b shows a video-distribution amplifier. In this example, the resistors in series with the outputs serve to reduce reflections from unterminated lines. If you know the lines' characteristics, you can tailor the resistor values accordingly. The 3Ω bias resistors provide a minor boost characteristic that helps the circuit meet NTSC gain-phase requirements. Into a 75Ω load, each 1V p-p output response is flat within ±0.15 dB to 6 MHz.

Buffer suits track/hold circuits

A track/hold (T/H) amplifier—a good example of difficult driving conditions—requires high capacitive-load-driving capability to achieve fast acquisition times.

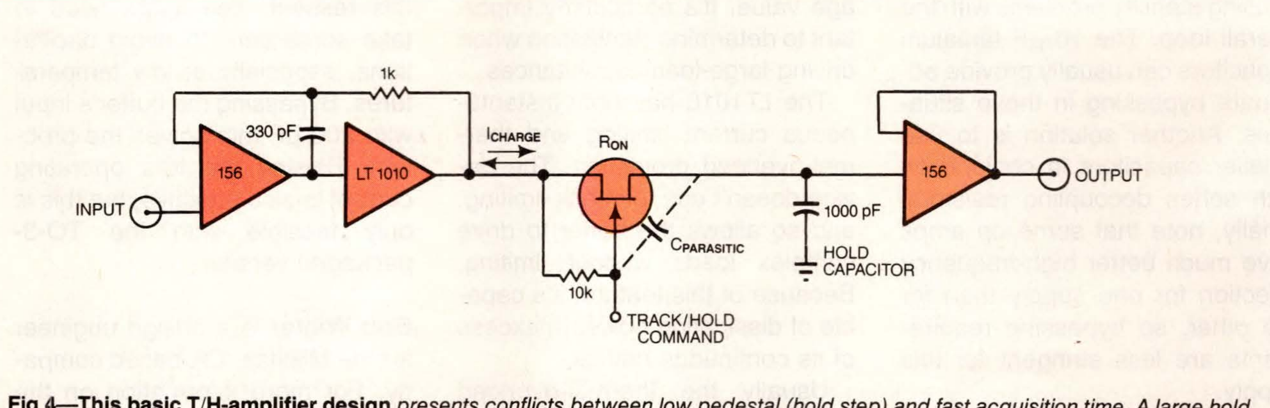


Fig 4—This basic T/H-amplifier design *presents conflicts between low pedestal (hold step) and fast acquisition time. A large hold capacitor reduces the former problem but increases the latter. The circuit also needs a fast level shifter to drive the FET's gate from TTL signals.*

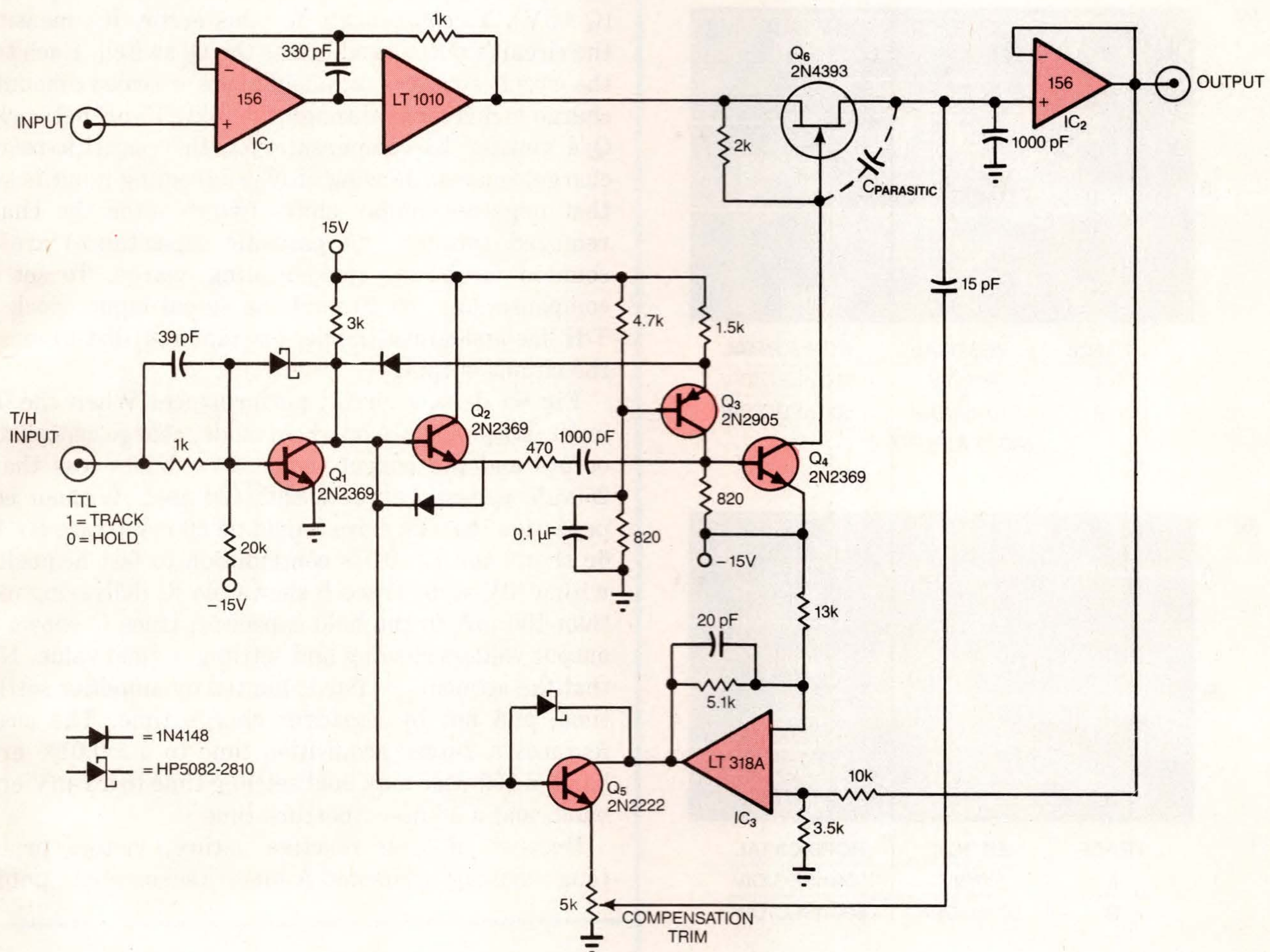


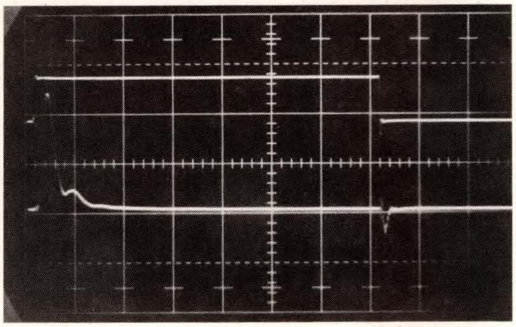
Fig 5—This fast, accurate T/H amplifier *uses discrete transistor circuitry to provide both low pedestal and fast acquisition time. It also features a very fast TTL-to-FET level shifter. The scheme uses a compensation technique to reduce parasitic-induced pedestal.*

Moreover, you must consider other tradeoffs in developing a good design. The conceptual circuit in **Fig 4** illustrates some of the issues involved. Fast acquisition requires high charging currents and dynamic stability. To have a reasonable droop rate, the hold capacitor must be appropriately large. If it's too large, however, the On resistance of the FET switch will affect the acquisition time.

If you use FETs with low On resistance, the parasitic gate-source capacitance becomes significant, and a substantial amount of charge is removed from the hold capacitor when the gate switches off. This charge removal causes the stored voltage to change abruptly when the circuit switches into hold mode. This phenomenon, called "hold step" or "pedestal," limits the T/H amp's accuracy. You can reduce the effect by increasing the hold capacitor's value, but then (again) acquisition time suffers. Finally, because a TTL-compatible input is often desirable, the FET requires a level shifter. This level shifter must provide adequate pinchoff voltage over the entire range of circuit inputs. It must also be fast. Delays result in aperture errors and thereby introduce dynamic sampling inaccuracy.

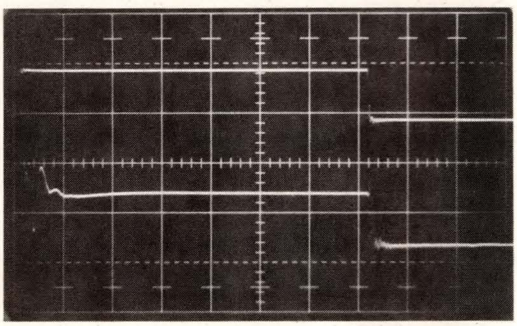
Fig 5 shows a LT1010-based circuit that manifests fast, precise T/H performance. Q_1 through Q_4 form a high-speed TTL-compatible level shifter. The total delay, from the TTL input's switching into hold mode to Q_6's turn-off, is 16 nsec. Baker-clamped Q_1 biases Q_3's emitter to switch level shifter Q_4. Q_2 drives a heavy feed-forward network, speeding Q_4's switching. This stage minimizes aperture errors while providing the necessary level shifting for Q_6's gate. Q_5 and IC_3 compensate for the pedestal error that results from Q_6's parasitic gate-source capacitance.

(a)



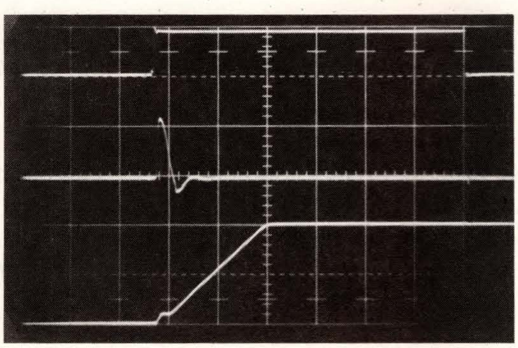
TRACE	VERTICAL	HORIZONTAL
A	5V/DIV	500 nSEC/DIV
B	10 mV/DIV (AC COUPLED)	500 nSEC/DIV

(b)



TRACE	VERTICAL	HORIZONTAL
A	5V/DIV	500 nSEC/DIV
B	50 mV/DIV	500 nSEC/DIV

(c)



TRACE	VERTICAL	HORIZONTAL
A	5V/DIV	500 nSEC/DIV
B	100 mA/DIV	500 nSEC/DIV
C	5V/DIV	500 nSEC/DIV

Fig 6—Performance of Fig 5's T/H circuit *is evident in these scope photos. The hold step (pedestal) is seen with* ***(a)*** *and without* ***(b)*** *compensation. The LT1010's heavy current contribution to fast acquisition time is seen in* ***(c).***

The amount of charge removed from the hold capacitor by the parasitic capacitance is signal dependent (Q=CV). To compensate for this error, IC_3 measures the circuit's output and biases the Q_5 switch. Each time the circuit switches into hold mode, a scaled amount of charge is delivered through the 5-kΩ/15-pF network in Q_5's emitter to compensate for the parasitic-related charge removal. Biasing of IC_3's inverting input is such that negative supply shifts (which alter the charge removed through the parasitic capacitance) are accounted for in the compensating charge. To set the compensation, you ground the signal input, clock the T/H line and adjust the pot for minimum disturbance at the circuit output.

Fig 6a depicts circuit performance. When the T/H input (trace A) goes into hold mode, charge cancellation occurs and the output (trace B) exhibits less than a 250-μV pedestal error within 100 nsec. Without compensation **(b),** the error would be 50 mV (trace B). **Fig 6c** shows the LT1010's contribution to fast acquisition with a 10V step. Trace B shows the IC delivering more than 100 mA to the hold capacitor; trace C shows the output voltage slewing and settling to final value. Note that the acquisition time is limited by amplifier settling time, and not by capacitor charge time. The circuit features a 2-μsec acquisition time to a ±0.01% error band, a 100-nsec max hold settling time to a 1-mV error band, and a 16-nsec aperture time.

Because of their reactive nature, motors present tough driving problems. A motor/tachometer combina-

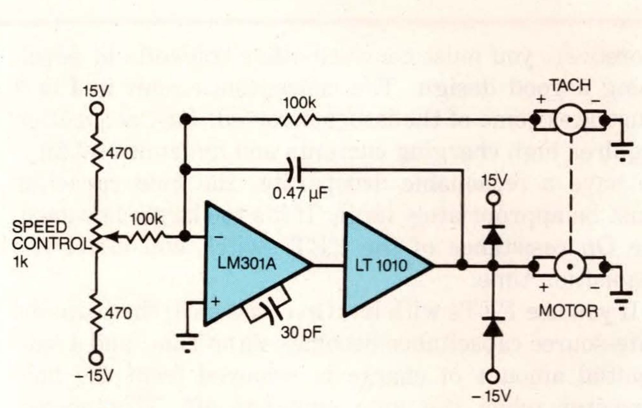


Fig 7—This simple motor-tachometer circuit *takes advantage of the LT1010's ability to drive heavy reactive loads. The circuit allows speed control in both directions, thanks to the tachometer's bipolar output.*

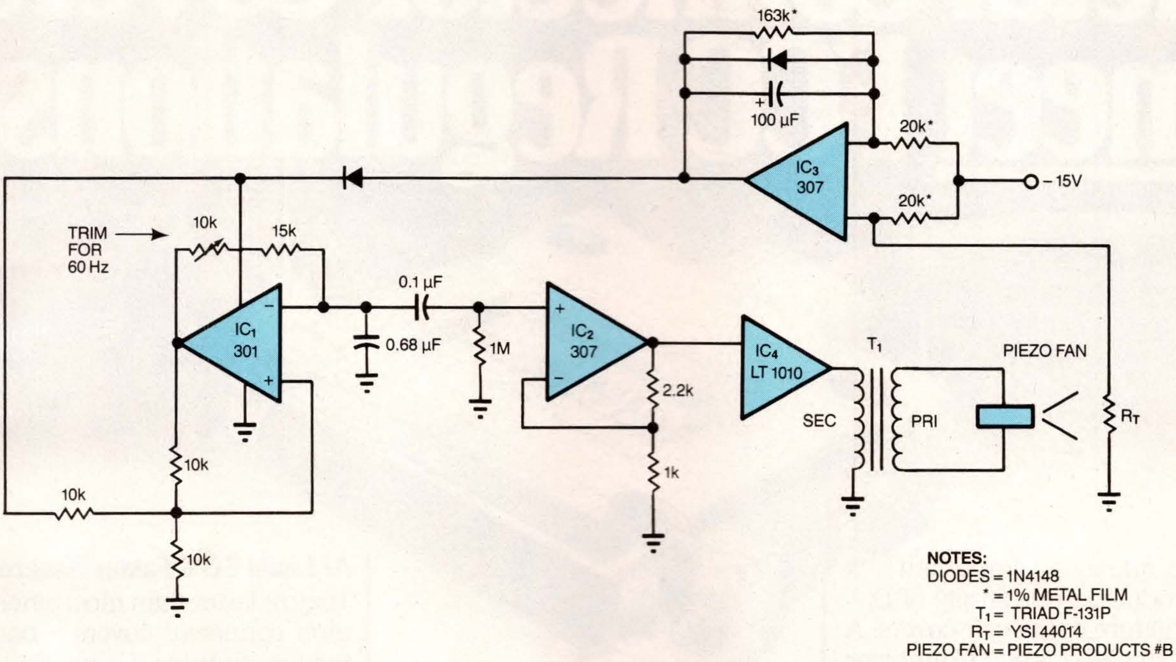


Fig 8—An instrumentation temperature controller is easy to build *with new electrostatic fans. The thermistor in the fan's exhaust stream is the temperature-sensing element. The circuit features a long time constant, to reduce audible and annoying hunting. The LT1010 easily handles the highly reactive transformer/piezo-fan load.*

tion (**Fig 7**) exemplifies such a problem. The tachometer signal feeds back for comparison with a reference current; the 301A amplifier closes a control loop. The 0.47-µF capacitor provides compensation for stability. Because the tachometer has a bipolar output, the speed is controllable in both directions with clean transitions through zero. The LT1010's thermal protection is particularly useful in this application, preventing IC destruction in the event of mechanical overload or malfunction.

The circuit shown in **Fig 8** controls a fan motor's speed in order to regulate instrument temperature. The fan in this example is a new electrostatic type that requires high-voltage drive. Upon power-up, the thermistor (located in the fan's exhaust stream) has a high value. This unbalances the IC_3-amplifier-driven bridge, IC_1 receives no power, and the fan doesn't run.

As the instrument enclosure warms up, the thermistor value decreases until IC_3 begins to oscillate. IC_2 provides isolation and gain, and IC_4 drives the transformer to generate high voltage for the fan. In this fashion, the loop acts to maintain a stable instrument temperature by controlling the fan's exhaust rate. The 100-µF capacitor across the error amplifier's pins is typical of such configurations. Fast time constants produce audible and annoying "hunting" in the servo. The optimum values for the time constant and stage gain depend on the thermal and airflow characteristics of the enclosure being controlled. EDN

Author's biography

Jim Williams, staff scientist at Linear Technology Corp (Milpitas, CA), specializes in analog-circuit and -instrumentation design. He has served in related capacities at National Semiconductor Corp, Arthur D Little Inc and the Instrumentation Development Lab at the Massachusetts Institute of Technology. A former student of psychology at Wayne State University, Jim enjoys tennis, art and collecting antique scientific instruments.

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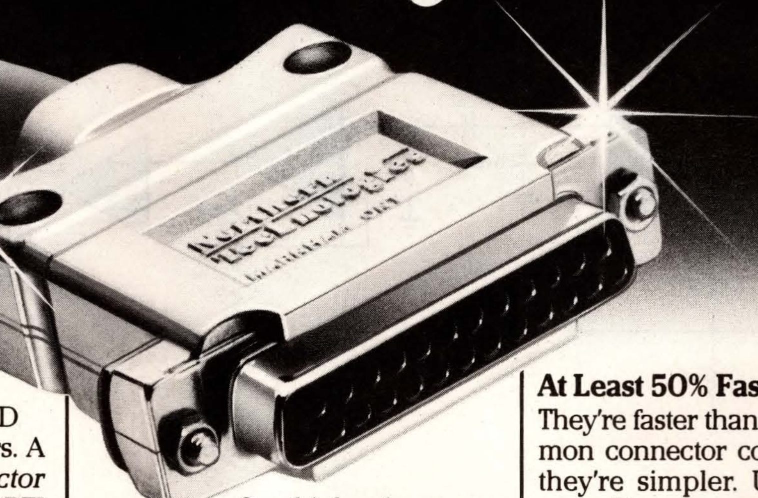

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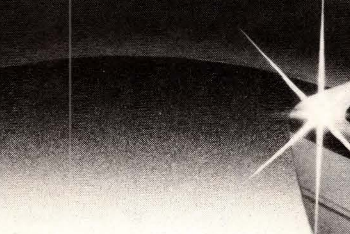

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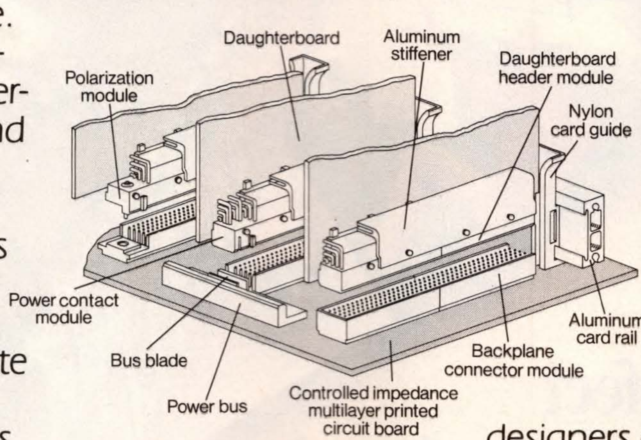

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Modem-circuit techniques simplify instrumentation designs

A commutating modem circuit, whether an IC or pc-board version, can serve as a building block for many measurement-system functions, reducing noise and ensuring the integrity of transmitted data.

Walt Jung, *Consultant, and*
Moshe Gerstenhaber, *Analog Devices Inc*

Although used extensively in communications, amplitude modulation/demodulation can also serve industrial-control instrumentation systems. In such applications, a commutating modulation/demodulation circuit is an extremely versatile building block that can perform several functions—such as amplification and clock generation—in addition to helping assure the integrity of measurement-data transmission. This article describes the operation and application of that type of modem in a variety of instrumentation situations.

Modulating and demodulating the output of an instrumentation system's sensors, a process often referred to as balanced mod/demod, provides a host of advantages:

- Ease of filtering
- Inherent noise discrimination
- Good linearity over a wide dynamic range
- Transmission of phase as well as amplitude information
- Relaxation of intermediate-stage amplification requirements.

Fig 1's representation of a typical control-instrumentation system helps demonstrate how to use a modem to realize these advantages. Transducers typically used in such control systems—such as linear and rotary variable differential transformers (LVDTs or RVDTs), ac bridges and photochoppers—measure occurrences that are usually static or slowly varying. This measurement

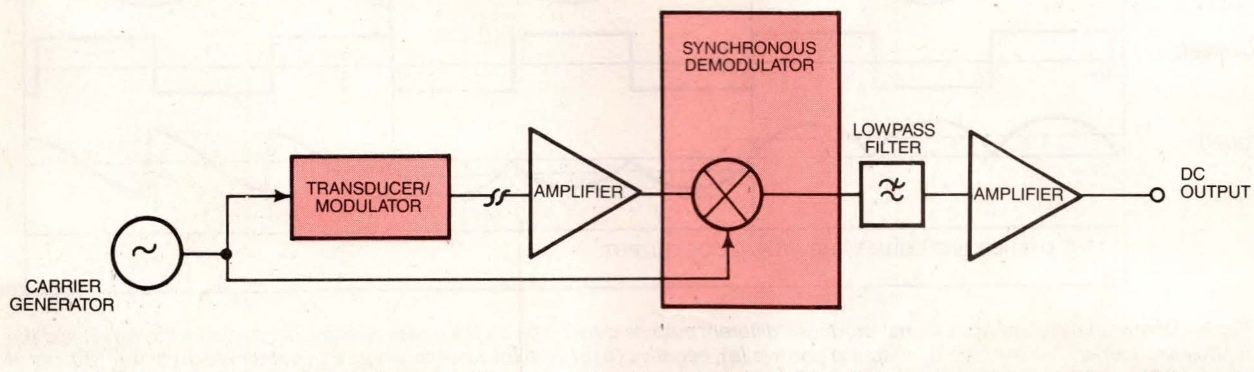


Fig 1—A typical instrumentation system *can include a synchronous demodulator that removes the carrier signal from a transducer's modulated output. Using balanced modulation/demodulation removes system offset, drift and noise too.*

data can be imposed on a carrier signal by modulation; modulation capability may be inherent to the transducer, as is the case with an LVDT, or require use of an external modulator, as with some types of photochoppers.

The modulated signal is then typically transmitted to a central controller that extracts raw measurement data from the signal. If the carrier's frequency is well above the measured parameter's rate of change (typically, a carrier frequency of about 1 kHz gives sufficient carrier/data separation), simple post-demodulation filtering rejects all noise and dc errors but leaves the original signal intact.

The balanced modulation/demodulation scheme inherently rejects frequency disturbances—such as 1/f components, drift and power-line noise—that are either asynchronous to or in quadrature with the demodulating carrier. Thus, the combination of balanced modulation/demodulation and filtering eliminates many of the chief causes of measurement errors.

Consider, though, that the additional modulation/demodulation circuitry could introduce new sources of error. One type of modulation/demodulation circuit, the commutating modem, minimizes the sensitivity of the measurement signal to variations in the amplitude and waveform of the demodulating carrier signal, thus minimizing the effects of demodulation on measurement results.

To understand how a commutating modem minimizes noise sensitivity, consider two ac signals: a modem input that you wish to demodulate and a carrier signal that you can use to do the demodulating. When the carrier is positive, the commutating modem multiplies the input by +K (a scaling constant that you choose), and when the carrier is negative, by −K. Because the carrier's transitions between positive and negative states control the modulation process, the carrier's waveform and amplitude do not affect the output.

Fig 2 graphically shows the commutating modem's multiplication process. If the input and the carrier signal are in phase, the commutating modem's output is a positive, full-wave-rectified version of the input. When the input and the carrier are 180° out of phase, the output is a negative, full-wave-rectified version of the input. In either case, the average value of the output is proportional to the amplitude of input signal. But for an input signal in quadrature with the carrier, the output is a zero average value. In other words, the averaged output is proportional to the input amplitude as well as the phase difference between the input and the carrier.

Because modulation and demodulation are reciprocal processes, the **Fig 2** waveforms can also apply to a modulation scheme in which the input and output are reversed. That is, when the signal labeled output is mixed with the carrier at the modulator, that device creates the waveforms marked input.

This reciprocity is a powerful advantage of balanced modulation/demodulation because it allows you to use a common circuit for both modulation and demodulation. And most hardware implementations of the balanced modulation/demodulation circuit function are designed to be used either way.

Fig 3 shows a commutating balanced modulation/demodulation circuit that you can build with standard components. This circuit, commonly used in data acquisition and signal processing, is called an absolute-value circuit, a precision rectifier or a sign-programmable amplifier, depending on its specific use.

The **Fig 3** circuit is optimized for the commutating

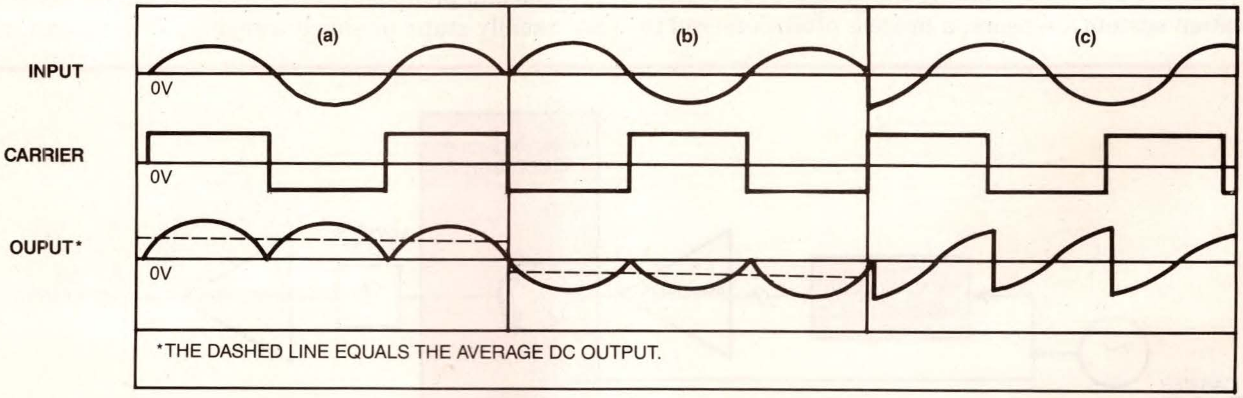


Fig 2—Demodulating an input signal *produces different outputs depending on the phase relationship between the signal and the modulating carrier. The average dc output is positive* ***(a)****, negative* ***(b)*** *or zero* ***(c)*** *when the input and carrier are in phase, 180° out of phase or 90 or 270° out of phase, respectively. For simplicity, the input is shown as a sine wave of the same frequency as the carrier, but a carrier whose frequency is an odd multiple of the signal frequency produces similar average-dc results.*

A commutating modem IC

The AD630 includes all the circuit blocks needed to implement balanced modulation and demodulation with high precision in a single IC. Shown functionally in the **figure**, it contains two uncommitted op-amp input stages, A and B. Depending on the state of the input to the IC's integral comparator, either stage A or B is connected to the chip's integrating output stage. When pin 10 is high relative to pin 9, input stage A is active; when the reverse is true, input stage B is active.

The chip's comparator is an internally latched stage with a specified switching window of ±1.5 mV (max), a window that includes not only comparator offset but a hysteresis of about 0.2 mV as well. The hysteresis is built in to make switching clean and unambiguous, even with slowly varying or noisy signals.

When switched, the AD630 can slew as fast as 45V/μsec between the output limits. In response to a 20V step, the output typically settles to within 0.01% of the final value in 3 μsec.

Inputs to stages A and B can be connected into conventional op-amp feedback loops, either with external components or internal resistors. On-chip resistors are ratio-trimmed for precise gains of ±1, ±2, ±3 and ±4 and are easily configured by appropriate pin strapping. Other gains are possible with external resistors.

The advantage of the internal resistors lies not only in their convenience, but also in their precision. Gain error is 0.05% (max) for B and K grade devices and 0.5% for other grades. These resistors also feature a 2-ppm/°C tracking specification. Resistors for bias-current compensation are also available at the A+ and B+ inputs for optional use in attaining the highest dc accuracy.

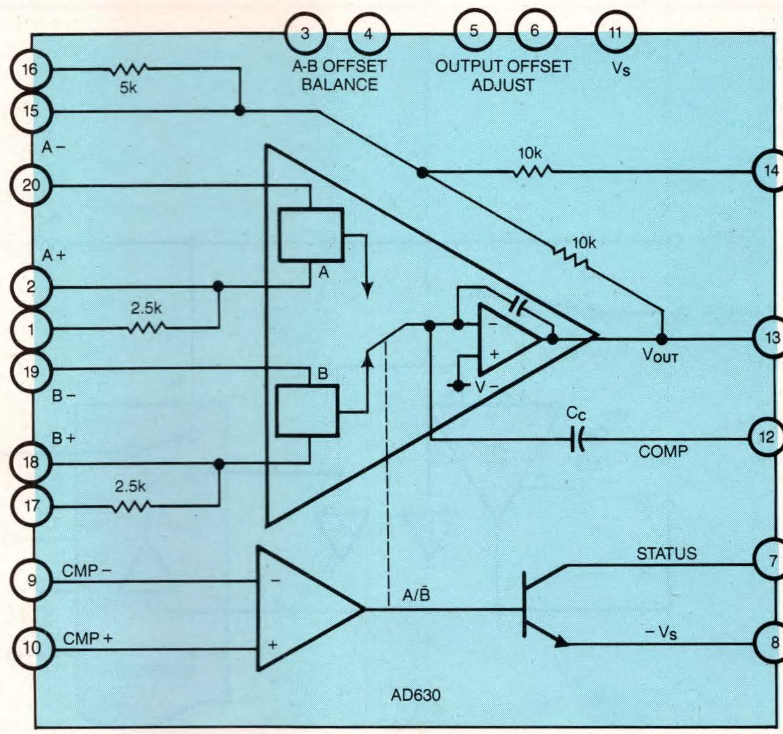
With its on-chip resistors, the AD630 can achieve submillivolt dc offsets and 0.1% or better dc accuracy without user trimming or gain-setting resistors. The dynamic specifications are such that the device is generally useful for modem uses to 100 kHz, and it is useful with high precision through the range of common instrumentation carrier frequencies—well above the limits of 0.5V/μsec-slew-rate devices.

All AD630 family devices come in plastic or ceramic 20-pin DIPs and operate from standard ±15V supplies, with conventional ±10V input/output ranges.

Many details of the AD630's design prove advantageous in various applications. For example, you can use the open collector output from the comparator (pin 7) as a logic status indicator. This status output can be used with an external pullup resistor to a positive voltage and can sink load current to $-V_S$ in the 0 state.

Another useful feature is that you can optimize device frequency compensation by strapping pin 12 to 13. Doing so reduces device bandwidth and phase at unity gain to its lowest value and reduces slew rate to 35V/μsec. With this pin open, the device speed is at its 45V/μsec maximum.

Two optional dc-offset trim connections use a pair of 10-kΩ trimmers: one between pins 5 and 6 and the other between pins 3 and 4. The wipers of both trimmers are tied to $-V_S$ (pin 8). The offset trimmer between pins 3 and 4 is first adjusted for a minimum-level square-wave output with a switching signal applied to the comparator and 0V dc input. The offset trimmer at pins 5 and 6 is then used to adjust the output offset to zero, with the comparator state fixed. These offset trims need only be used in the most demanding applications because of the low level of pretrimmed offset.



Uncommitted op-amp inputs A and B *allow the AD630 to operate as a commutating modem. An integral comparator selects between the two stages depending on the relative input levels at pins 9 and 10.*

The commutating modem is useful in many applications

function and minimizes errors from both the dc and ac sources. The carrier input controls output polarity with switch SW_1 set as shown, and the circuit functions as a modulation/demodulation circuit that exhibits the **Fig 2** waveforms. It might also be correctly referred to as a sign-bit amplifier, generally used in A/D or D/A conversion. In conversion applications, the carrier input would be called the sign-bit input.

When comparator stage A_3 is driven by the input signal rather than the carrier, the circuit is an absolute-value (or precision rectifier) circuit. Regardless of which signal does the driving, the output polarity can be changed by reversing the input of comparator A_3.

Although furnishing good performance, this circuit needs three separate active devices, a matched pair of precision resistors, board space, and design and debug time to build it. Furthermore, you have to optimize the amplifier for low noise, low offset and low drift and fast slew rate—not a trivial design problem. Integrating these components with an eye toward such performance objectives would be a logical improvement **(Ref 1)**, and a chip that does just that is discussed in the accompanying **box** ("A commutating-modem IC"). This chip is used for simplicity in the examples that follow, but the discrete circuit of **Fig 3** could also be used.

Fig 4a shows a general-purpose modulation/demodulation circuit using the AD630. It is basically a switched-gain circuit with an absolute gain of 2; the V_{REF} input to the comparator determines the output polarity. Like the **Fig 3** circuit, this circuit can be used as a modulator or demodulator, a sign-bit amplifier, an absolute-value (precision rectifier) circuit or a phase detector applied to the device.

To understand the circuit operation, think of the AD630 as having three separate internal functions: a comparator stage and an output stage and two switched-input stages, only one of which is on at a time, depending on comparator state. The active input stage in conjunction with the output stage forms a single composite op amp, so you can regard the AD630 as an op amp that has two configurations depending on the comparator input.

For example, with input stage **A** on, the overall circuit is equivalent to that of **Fig 4b**. The circuit has a noninverting gain of 2 when V_{REF} is greater than V_{OV}, or in general, when the AD630's pin 10 has a higher input than its pin 9. Conversely, when input stage **B** is on, the overall circuit is equivalent to the circuit of **Fig 4c**. This circuit has an inverting gain of 2 when V_{REF} is less than V_{OV}, or in general, when pin 10 is lower than pin 9.

In this circuit, the feedback loop that sets the gain at 2 is defined using the chip's internal resistors that are

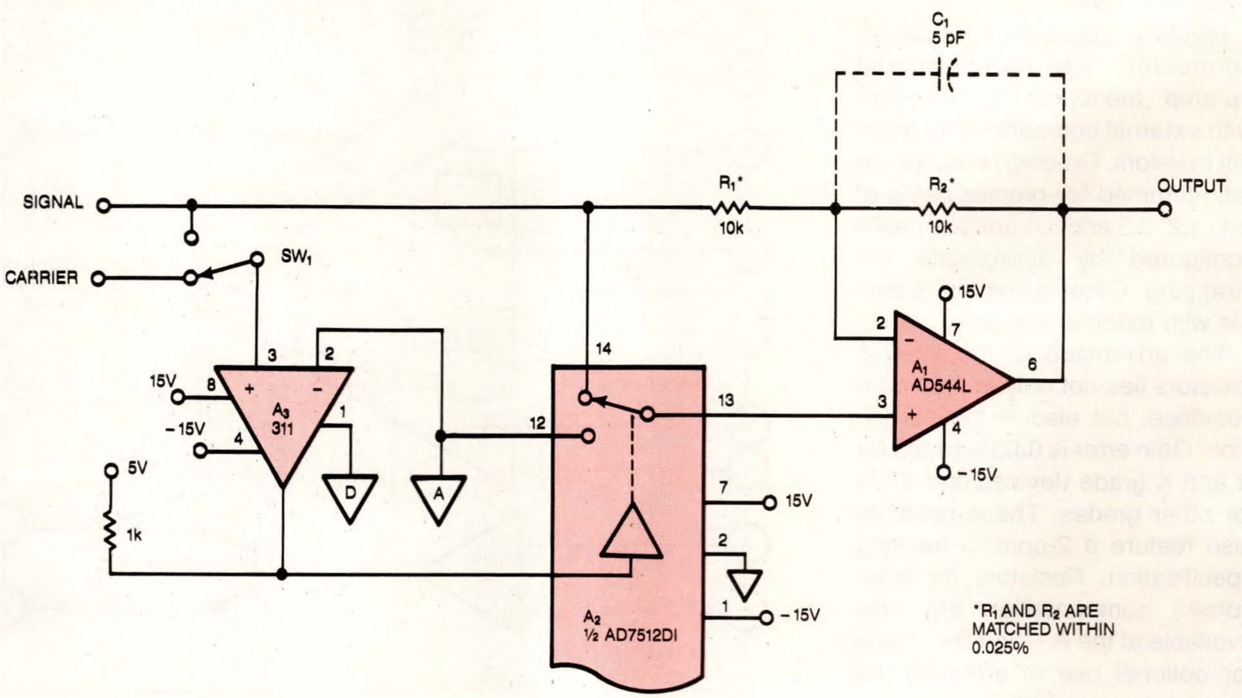


Fig 3—Known by a variety of names, *the basic commutating modulator/demodulator circuit is called a sign-bit amplifier when comparator A_3's carrier input, selected with switch SW_1 in the position shown, is a sign-bit signal. When the signal serves as A_3's input, the circuit is called an absolute-value or precision-rectifier circuit.*

connected to the circuit's pins 13, 14, 15 and 16. Including a variety of internal precision resistors with pin-accessible taps lets you use jumpers to simply select the gain state desired. If you should decide to use your own external feedback components, the sign and the gain magnitude might be different. Regardless of the feedback-loop approach you choose, the active state of inputs A and B **(Fig 4b** and **Fig 4c)** remain generally true.

In many applications, the A and B inputs are often interconnected, as A− and B− are in **Fig 4a**. This presents no output problem because the deselected input is switched off and presents no extra loading to the summing point.

However, the circuit presents different loads at its signal input depending on the input to the comparator. Note that the inverting configuration B in **Fig 4c** presents a load equal to R_{IN}, or 5 kΩ, when this input is selected, and the noninverting stage **(Fig 4b)** presents an input impedance intrinsically higher. Thus, the external input source faces a load that varies dynamically. To maintain the highest precision, you may have to add an input buffer to compensate for this dynamic loading.

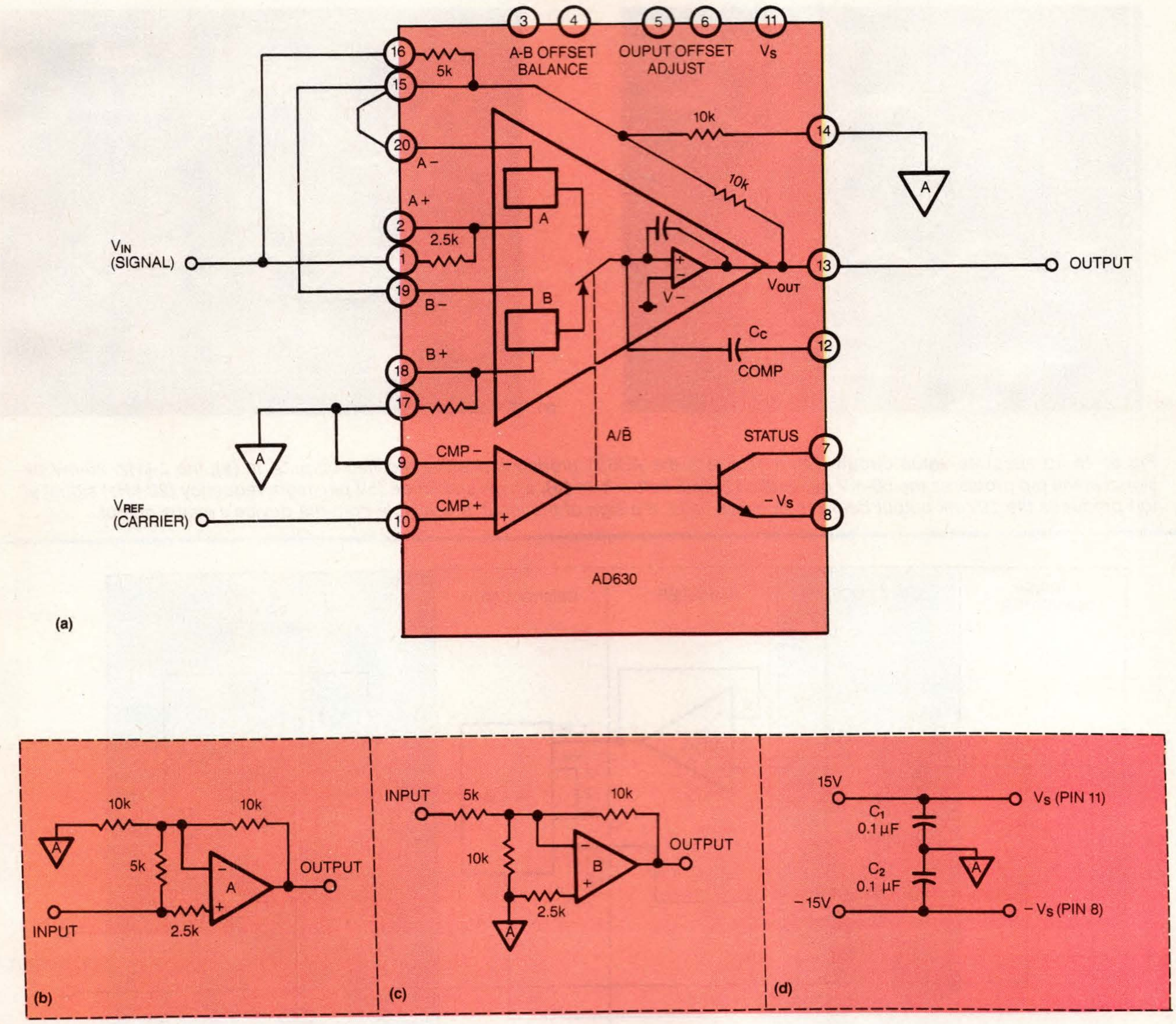


Fig 4—A building block IC *like the AD630 can be turned into a balanced modulator/demodulator* **(a)** *similar to that in* **Fig 3.** *Using the chip's precision resistors to set the gain (to a value of 2 with the configuration shown here) eliminates the need for trimming in most applications. The equivalent circuits seen when looking into the AD630's input when channel A or B is active are shown in* **(b)** *and* **(c)**, *respectively, and the supply-conditioning circuitry for the chip appears in* **(d)**.

LVDTs' inherent modulation requires a precise carrier

For absolute-value applications, the AD630 has distinct advantages over the traditional op-amp approach. Even when implemented with high-performance amplifiers, traditional absolute-value circuits have classic problems: With high-frequency inputs of low amplitude, for example, the op amp must slew for high percentages of the time to accommodate the diode thresholds. As a result, the output waveform can be severely distorted. The balanced-modulator approach alleviates this problem simply by changing the sign of the forward signal path in synchronism with the zero crossings, with no diode thresholds to overcome. Using the **Fig 4** configuration as a gain-of-2 absolute-value circuit produces **Fig 5**'s results.

Such balanced modulation/demodulation techniques are highly useful with a variety of common transducers. What's more, a number of transducer types lend themselves to this approach because they perform the modulation of an ac carrier as an integral part of their transducing function. Examples of such transducers are those that fall in the LVDT and ac-bridge categories. Other types, such as some photochoppers, don't furnish modulation and require further interfacing to modulate their outputs. The **Fig 3** and **Fig 4** circuits can be built

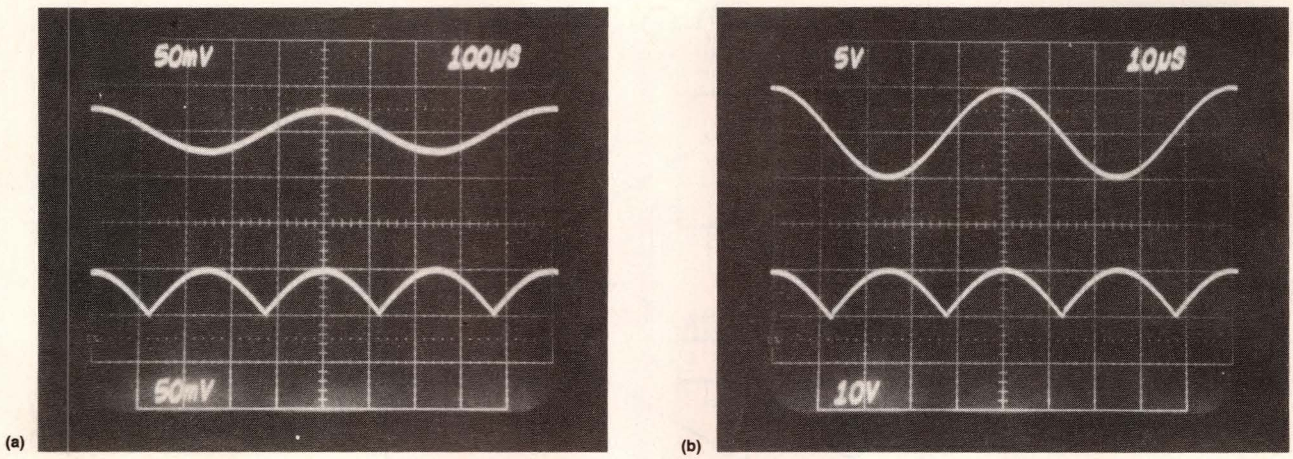


Fig 5—In an absolute-value circuit *with a gain of 2, the AD630 produces positive rectified outputs. In* ***(a),*** *the 2-kHz, 25-mV pk signal at the top produces the 50-mV pk rectified output below it. In* ***(b),*** *a high-amplitude (5V pk), high-frequency (20-kHz) signal at top produces the 10V pk output below it. In either case, the sign of the input is available from the device's status output.*

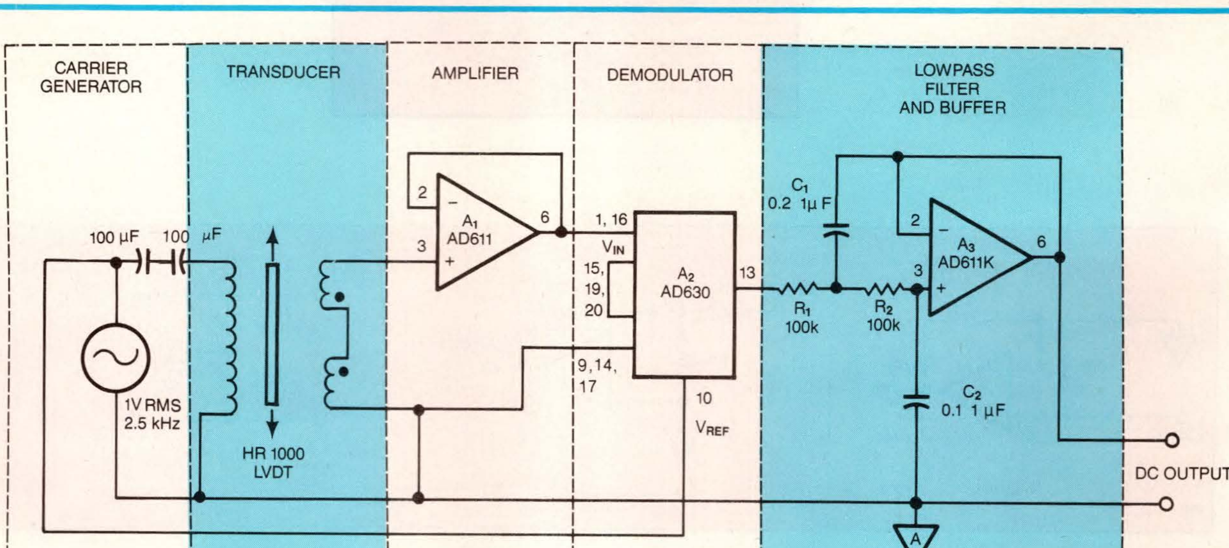


Fig 6—A linear variable differential transformer *whose measurement signal rides on a 1V rms, 2.5-kHz carrier can work with a commutating modulation/demodulation circuit such as the one shown in* ***Fig 4.*** *The lowpass filter at right, with a 10-Hz corner frequency, removes any high-frequency noise.*

into or added to the sensor/transducer to provide this modulation.

Among the transducers that have integral modulating capability, the LVDT measures linear displacement, and a related type, the RVDT, measures rotary displacement (**Ref 3**). Although the mechanical construction of these two types of transducers differs, they share many electrical similarities. Therefore, similar electrical considerations apply to the application of either type of device.

A transducer of either type is really a specialized transformer. The transformer is connected with two secondary windings in series opposition and exhibits a minimum electrical output at the LVDT's mechanical null point. The core motion, controlled by the object whose displacement is to be measured, varies the mutual inductance between the primary and the two secondaries. This variation produces a variable-phase and -amplitude ac output that is linearly proportional to the core displacement. A balanced demodulator can transform this variable ac output into a bipolar dc output that, when referred to the LVDT reference, or null, position, indicates the displacement.

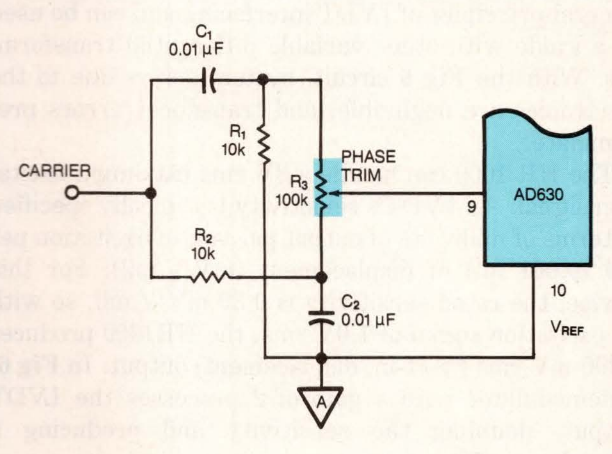


Fig 7—To trim a carrier signal *so that it's in phase with the input signal, you can use this lead-lag network. With the transducer at its maximum value, adjust resistor R_3 to maximize the circuit's average dc output.*

The LVDT's physical advantages lie in the virtues of a low core mass, an essentially frictionless, no-hysteresis action, infinite resolution, and long mechanical life. Electrical advantages are the low sensitivity to external fields and the high common-mode isolation that a transformer inherently affords. The main disadvantage is the relatively high cost, which tends to be proportional to core length and accuracy. LVDTs come in a wide variety of mechanical and electrical configurations, with different nonlinearity and sensitivity specifications (**Ref 3**).

Fig 6 shows a representative application using a general-purpose LVDT, a Schaevitz Engineering (Pennsauken, NJ) Model HR 1000, whose core can travel distances of ±1 in. and whose output is linear to

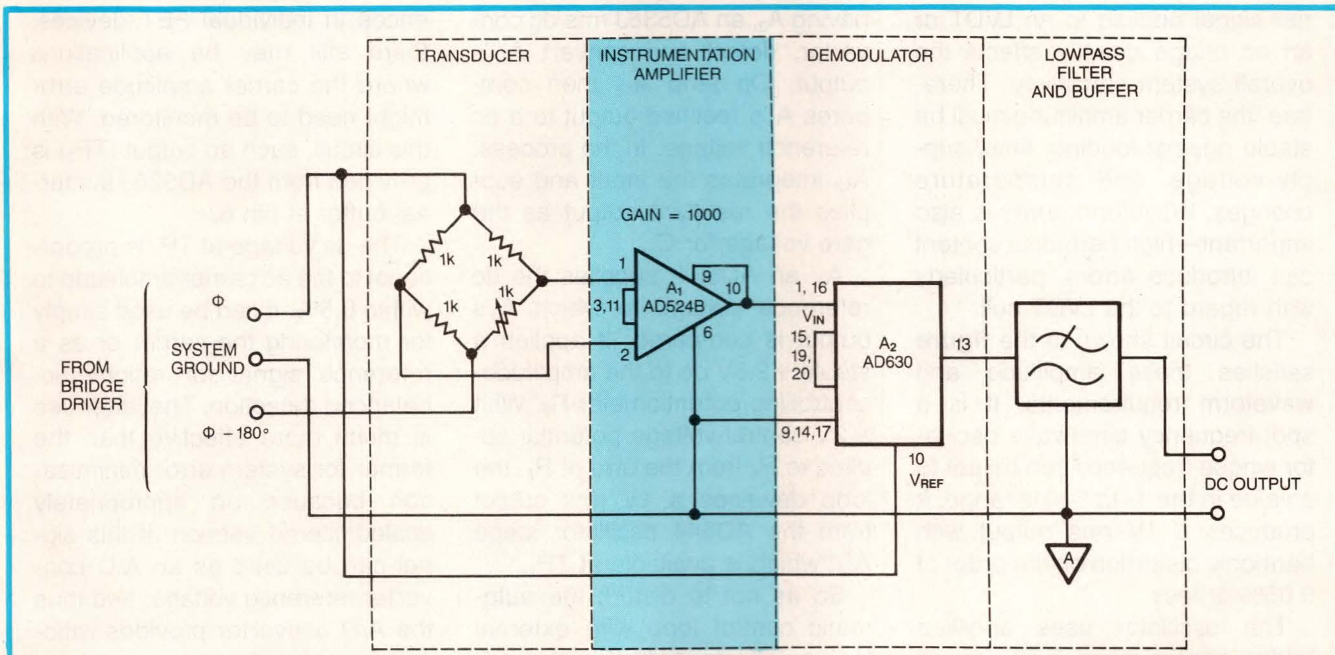


Fig 8—To measure changes in a bridge's variable arm, *this circuit uses a demodulator and filter similar to those in* ***Fig 6.*** *The bridge circuit's low-voltage output, however, requires use of a high-gain instrumentation amplifier, and the circuit requires a special bridge driver such as the one shown in* ***Fig 9.***

Carrier phase trimming may be needed for accuracy

within 0.25% FS. This circuit demonstrates some of the general principles of LVDT interfacing and can be used as a guide with other variable differential transformers. With the **Fig 6** circuit, system errors due to the electronics are negligible, and transducer errors predominate.

The HR 1000 can handle a 3V rms maximum excitation signal. An LVDT's sensitivity is typically specified in terms of millivolts of output per volt of excitation per mil (0.001 in.) of displacement (mV/V/mil). For this device, the rated sensitivity is 0.39 mV/V/mil, so with an excitation signal of 1.0V rms, the HR1000 produces a 390-mV rms FS (1-in. displacement) output. In **Fig 6**, a demodulator with a gain of 2 processes the LVDT output, doubling the sensitivity and producing a 780-mV rms FS output.

A Sallen-and-Key two-pole active filter with unity gain filters the demodulator output and buffers it to a low impedance. This circuit, using A_3 and the associated passive components, employs a maximally flat Butterworth alignment for minimum passband-amplitude errors. This filter's corner frequency is approximately 10 Hz, and the filter yields more than 8 dB of ripple attenuation for carriers as low as 1 kHz. Although this application is fairly straightforward, it serves to point out certain general rules you should know to use LVDTs effectively.

For maximum sensitivity and a minimum of susceptibility to carrier-frequency changes, the LVDT should see a high-impedance load. In **Fig 6**, a follower-connected FET-input op amp that acts as a buffer provides this load. The op amp also provides the balanced demodulator with a low source impedance that makes the circuit insensitive to dynamic load changes.

A stable oscillator

The performance of the carrier oscillator is critical to high-accuracy balanced modem signal processing. Although absolute accuracy and long-term frequency stability are not highly critical, amplitude stability and waveform purity are.

Amplitude stability is critical because the voltage level of the carrier signal applied to an LVDT or an ac bridge directly affects the overall system sensitivity. Therefore, the carrier amplitude must be stable against loading, time, supply-voltage and temperature changes. Waveform purity is also important—high harmonic content can introduce errors, particularly with regard to the LVDT null.

The circuit shown in the **figure** satisfies these amplitude and waveform requirements. It is a spot-frequency sine-wave oscillator whose frequency can be set to a value in the 1- to 5-kHz range. It produces a 1V rms output with harmonic distortion on the order of 0.05% or less.

The oscillator uses a Wien bridge configuration built around FET-input op amp A_{1A}. The Wien network consists of frequency-determining components R_1-C_1 and R_2-C_2. An oscillator frequency of 1 or 2.5 kHz can be selected by the choice of the timing components indicated in the **figure**.

Although the Wien bridge can provide a pure sine wave, automatic gain control (AGC) is required to regulate the output amplitude. AGC is provided by first having A_3, an AD536J rms/dc converter, detect and convert A_{1A}'s output. Op amp A_{1B} then compares A_3's rectified output to a dc reference voltage. In the process, A_{1B} integrates the input and supplies the resultant output as the gate voltage for Q_1.

A_4, an AD584, supplies the dc reference voltage to which A_3's output is compared. It applies a stable +2.5V dc to the amplitude-controlling potentiometer R_8. With a 2V control-voltage potential applied to R_6 from the arm of R_8, the loop develops a 1V rms output from the AD644 oscillator stage A_{1A}, which is available at TP_1.

So as not to disturb the automatic control loop with external loading effects, A_2 buffers the output. This design also lets you adjust the gain of the buffer stage to accommodate different output levels while the oscillator stage itself operates at a fixed low level for best stability and lowest distortion. This oscillator can operate with supply voltages ranging from ±5V to ±15V, but best performance occurs at ±15V.

Although the inherent stability of the AGC system nulls the differences in individual FET devices, there still may be applications where the carrier amplitude error might need to be monitored. With this circuit, such an output (TP_2) is provided from the AD536J's internal buffer at pin 6.

The dc voltage at TP_2 is proportional to the ac carrier amplitude to within 0.5%. It can be used simply for monitoring the carrier or as a reference signal for ratiometric-balanced detection. The latter use is much more effective than the former for system error minimization because an appropriately scaled/filtered version of this signal can be used as an A/D converter reference voltage, and thus the A/D converter provides ratiometric conversion.

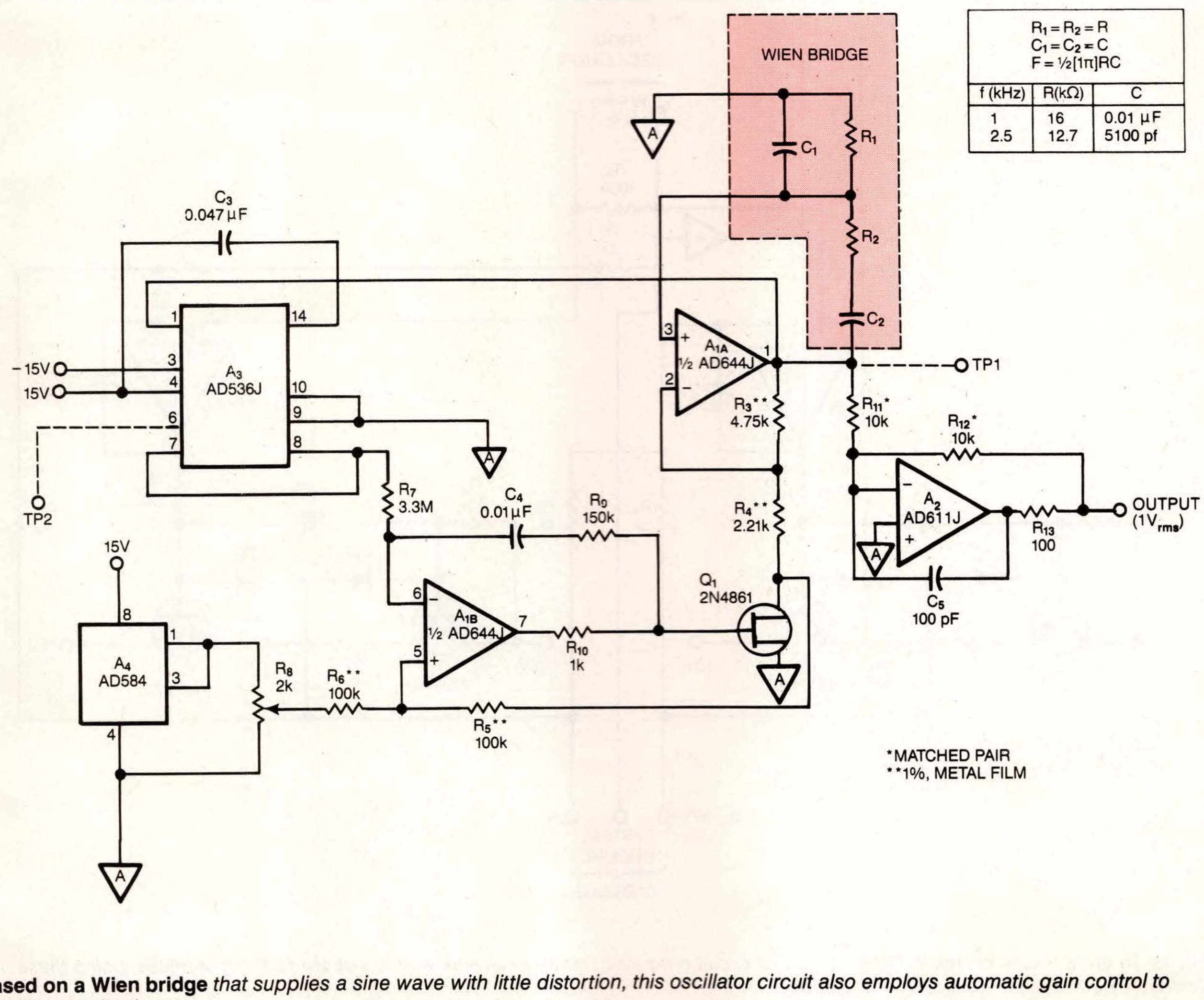
This op amp can also serve to introduce gain scaling. If you opt for gain scaling here, low temperature-coefficient resistors with ratios that track closely yield the best gain stability. Although amplifier drift and offset at this point is not critical, gain stability is because it directly influences overall sensitivity.

Depending on the specific transducer used, a phase-trim network might be needed in the referenece channel. The **Fig 7** combination lead-lag network provides a carrier reference phase trim for minimum dc output at null, and if used it should be connected between the carrier generator and the AD630 as indicated. The circuit should employ stable components, which suggest a high-resolution multiturn trimmer for R_3, and, for the other components, fixed-value capacitors and resistors with low temperature coefficients. Metal-film resistors and polystyrene capacitors offer this performance.

As previously noted, the carrier excitation voltage applied to the LVDT directly influences the overall system sensitivity. Therefore, the carrier generator should provide a stable, low-distortion sine wave (see **box,** "A stable oscillator") and should be ac coupled with the LVDT, as **Fig 6** shows, to eliminate any possible primary dc in the transducer; any dc voltage here could result in nonlinearity or catastrophic faults.

Use balanced modems with ac bridges

The oscillator requirements also apply to another widely used class of transducers: bridge-type sources. For bridge transducers that can accommodate ac excitation as well as dc, balanced demodulation of the amplified ac output suppresses a host of problems, including the drift and noise of the (usually) necessary preamplification.



Based on a Wien bridge *that supplies a sine wave with little distortion, this oscillator circuit also employs automatic gain control to stabilize amplitude.*

AC bridge transducers work best with balanced inputs

Fig 8 illustrates an ac signal-conditioning system using a 1-kΩ/leg bridge, driven by a balanced 20V p-p, 1-kHz signal. An AD524B instrumentation amplifier (**Ref** 4) serves as a 1000× gain block (A_1), which is followed by a balanced demodulator with a gain of ±2 and by the 10-Hz lowpass filter used with the LVDT. Phase trim, if needed, is performed using **Fig** 7's network.

Driving the bridge with balanced signals maximizes bridge sensitivity—enabling the system to resolve bridge unbalances of 1 ppm or less—and minimizes unbalance problems caused by stray capacitance. It also minimizes the common-mode voltage presented to the bridge preamp, thus enhancing input dynamic range. Remember that those preamp common-mode errors in quadrature with the carrier are nulled in the balanced demodulation process.

Fig 9 shows a push-pull circuit that provides balanced drive signals for the bridge. This driver develops two 10V p-p waveforms 180° out of phase when fed a 1V rms input from an oscillator. Because ac bridge excitation, like that of LDVTs, should be stable for best overall sensitivity, the **Fig 6** circuit's oscillator, described in the nearby **box**, should prove suitable for this application. The ratiometric option for the oscillator can be equally useful with bridge transducers.

The oscillator's output is fed to two halves of a dual op amp, with each half buffered by a 75-mA bipolar output stage. Although shown in **Fig** 8 as driving a 1-kΩ/leg bridge (a load not directly suitable for typical IC op-amp loading), this buffer can drive even lower impedance bridges, down to 300Ω/leg. Note that the feedback resistors (R_1 through R_4) for the two driver amplifiers should be stable types with low temperature coefficients that track. This type of temperature-coefficient performance can best be realized using a single resistor-array device.

In addition to balanced modulation/demodulation op-

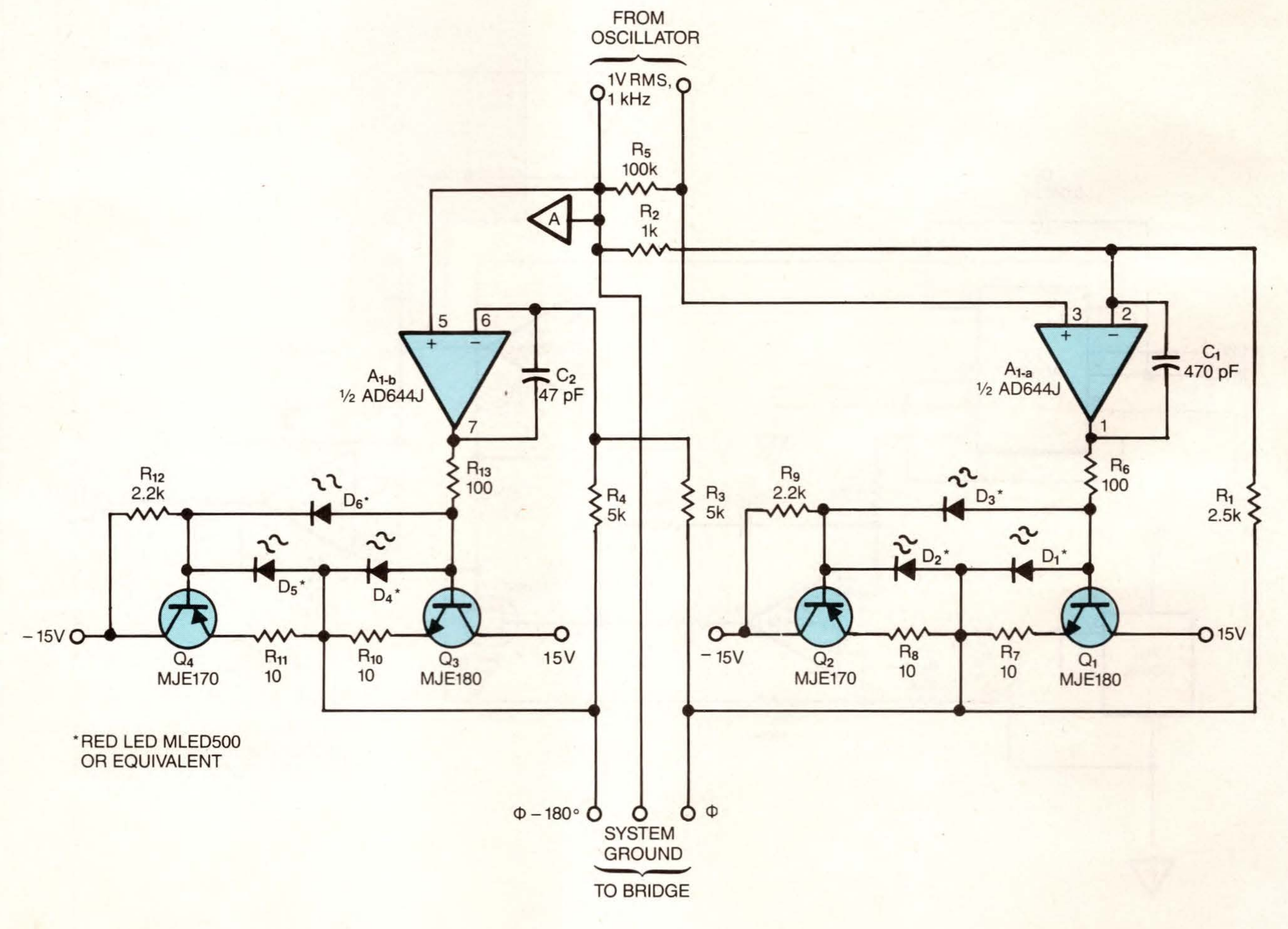


Fig 9—To drive the ac bridge *in* **Fig 8,** *this driver circuit produces two 5V peak sine waves that are 180° out of phase. Using these balanced signals maximizes system sensitivity.*

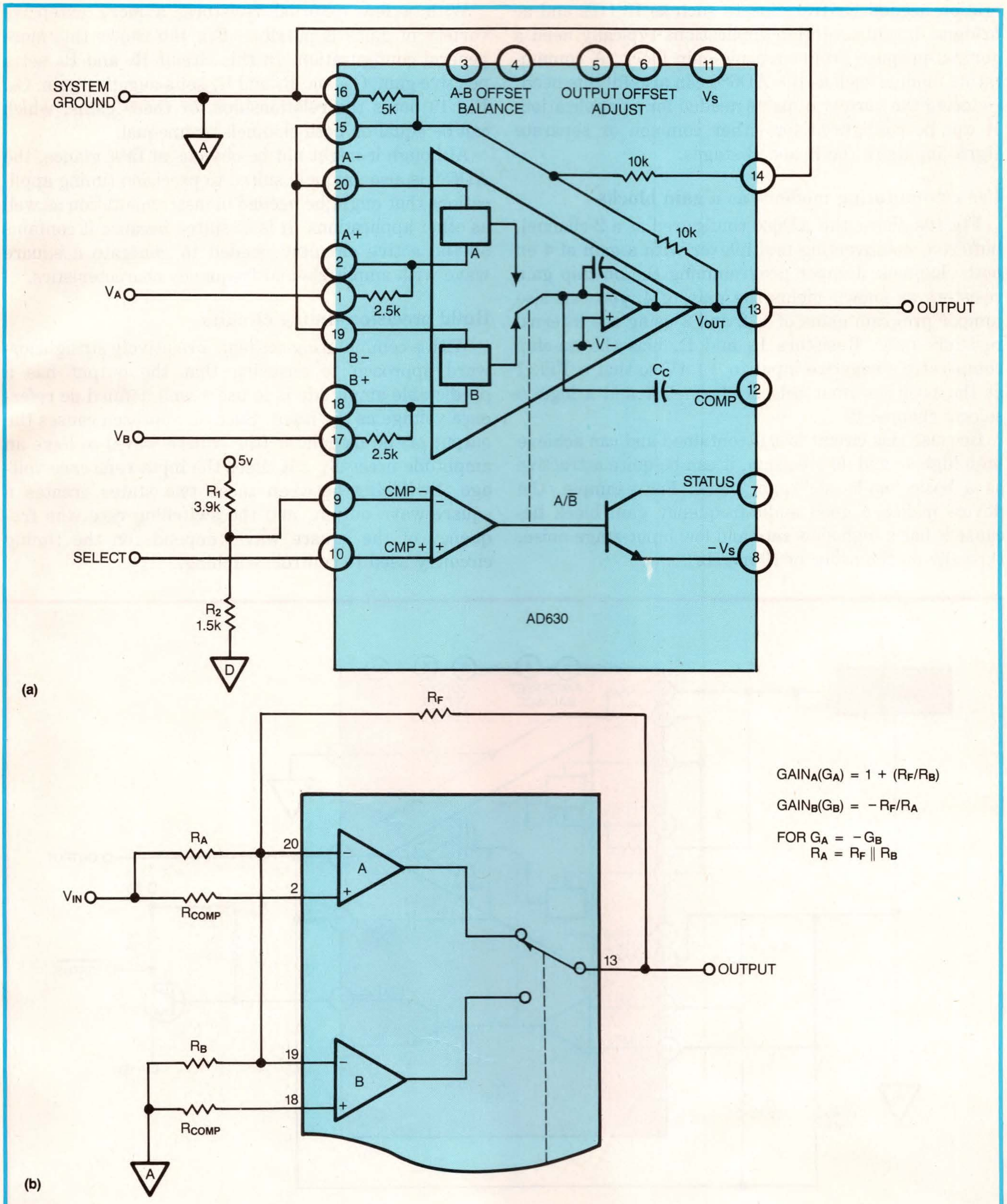


Fig 10—A dual-channel gain block *can be built using the AD630's internal resistors* ***(a)*** *or with external resistors* ***(b)*** *for a greater range of gains. In either case, you can select the desired port with a TTL-level input by adding the R_1-R_2 network* ***(a)*** *to the negative input of the chip's comparator.*

eration needed for transducers such as LVDTs and ac bridges, instrumentation applications typically need a general-purpose programmable-gain block. A commutating modem such as the AD630 can also fill this need, reducing the variety of parts needed for an application. It can be configured for either common or separate signal inputs to the A and B stages.

Use commutating modems as a gain blocks

Fig 10a shows the AD630 configured as a 2-channel, buffered, noninverting multiplexer with a gain of 4 on both channels. Jumper programming the on-chip gain resistors as shown yields the gain of 4; you can also jumper program gains of 1, 2 and 3 using the internal resistors only. Resistors R_1 and R_2 bias the on-chip comparator's negative input to +1.4V so that a TTL 1 at the positive input selects channel A and a logic 0 selects channel B.

Because this circuit is self-contained and can achieve both high ac and dc precision, it can be quite attractive as a basic "no-hassle" gain block. For example, the device makes a good audio-frequency gain block because it has a high slew rate and low input-stage noise, typically on the order of 10 nV/Hz$^{1/2}$.

With a few external resistors, a more extensive variety of gains is possible. **Fig 10b** shows this more general configuration. In this circuit R_F and R_B set a positive gain, G_A, and R_F and R_A set a negative gain, G_B. **Fig 10** notes the relationships for these gains, which can be equal on both channels or unequal.

Although it might not be obvious at first glance, the AD630 is also uniquely suited to precision timing applications that might be needed in instrumentation as well as other applications. It is so suited because it contains all the active circuitry needed to generate a square wave with amplitude and frequency characteristics.

Build precision timing circuits

With a commutating modem, a relatively straightforward approach to ensuring that the output has a predictable amplitude is to use a well-defined dc reference voltage as the input. Such an approach causes the output of the modulator (the square wave) to have an amplitude precisely ±K times the input reference voltage. Switching between these two states creates a square-wave output, and the switching rate (the frequency of the square wave) depends on the timing circuitry used to control switching.

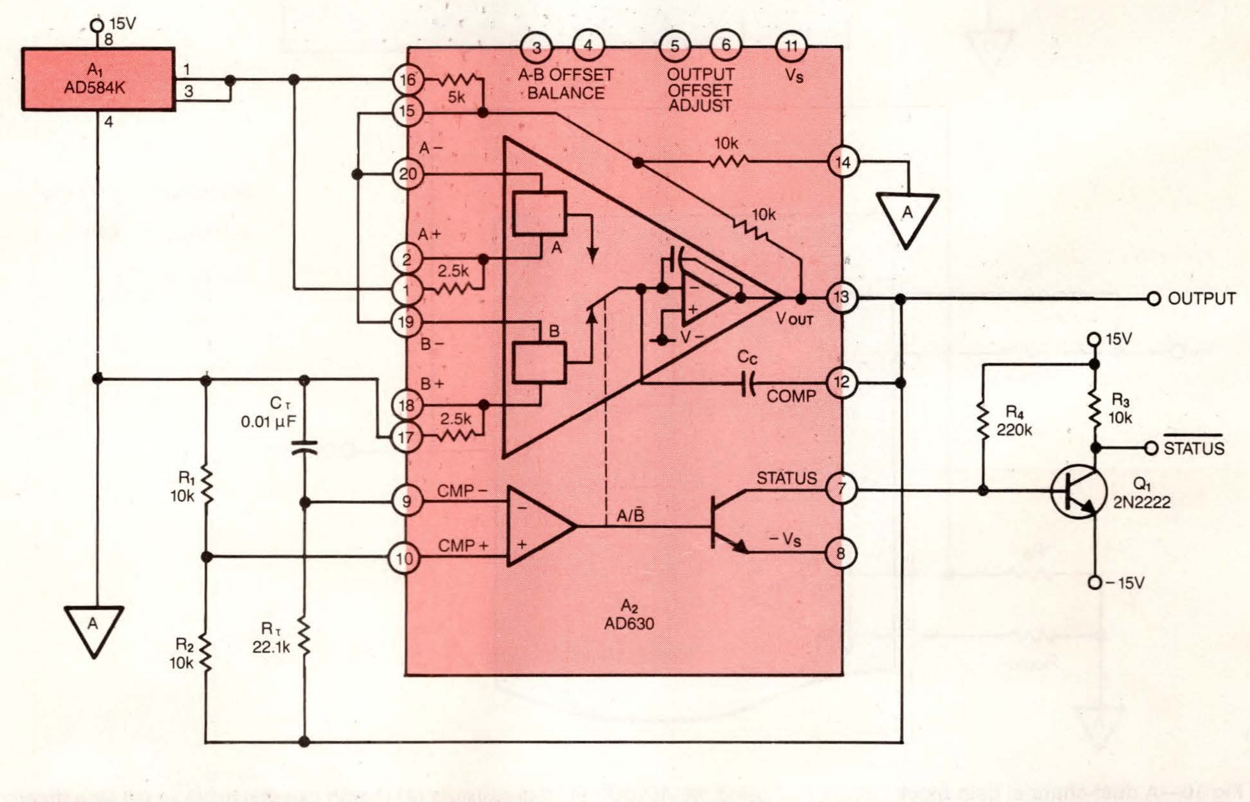


Fig 11—To produce a square wave *with a precise, 10V p-p amplitude, the AD630 switches the polarity of the AD584K's precision 2.5V dc output and multiplies it by a gain of 2. The square wave's frequency is set by C_T and R_T; in this case, it's about 2 kHz.*

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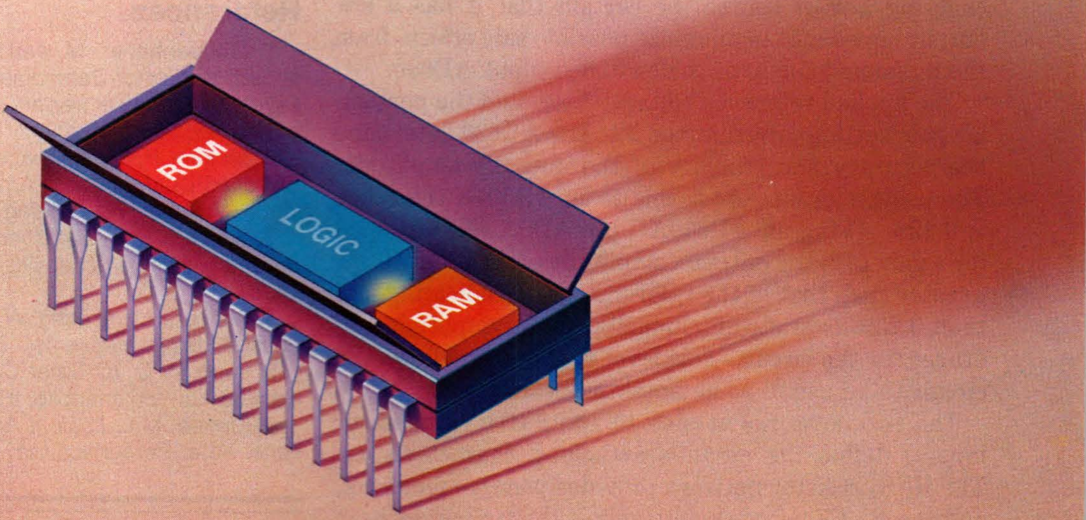

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Precise timing generation is also a commutating modem's forte

In **Fig 11**, the AD630 is hooked up as a switched-gain amplifier, with an absolute gain, K, of 2 set as in **Fig 4**. With the gain set at 2, the peak output is 2 times V_{REF}, and the peak-to-peak output equals $4V_{REF}$. An AD584 precision reference-voltage source furnishes V_{REF}; connecting its pin 1 to pin 3 straps it for a +2.5V dc level, yielding the 5V pk, or 10V p-p, circuit output. In choosing a V_{REF} source, be certain that it has a low output impedance to minimize possible side effects from the dynamic loading of the switched-input AD630.

The applied reference voltage, V_{REF}, and the particular gain setting programmed into the AD630 determine the accuracy and stability of the output's amplitude. The basic tolerance applicable to an AD584K reference is 0.12%. Using an AD630AD (or AD630JN) strapped for a gain of 2, the output's amplitude error is only 0.1% greater than that of the reference used, indicating less than 0.25% overall (untrimmed) output-amplitude tolerance for the circuit. This level of precision allows the circuit to be useful as an amplitude calibrator.

The two networks at pins 10 and 9 (the comparator inputs) define the circuit's switching characteristics. The R_1-R_2 resistor network provides positive feedback, and the R_T-C_T network determines the timing delay in switching between states. The timing expression for the circuit is:

$$f=1/(2.2R_TC_T).$$

As with all such RC-time-constant oscillators, the predictability and stability of this circuit are only as good as those of the components used, particularly those in the external timing networks. Both the R_1-R_2 and the R_T-C_T networks should have low temperature-coefficient components; metal-film resistors should be used for R_1, R_2, and R_T, and C_T should be a low-dielectric-absorption polystyrene or polypropylene film capacitor **(Ref 5)**.

Using the components shown, the frequency of the output square wave is approximately 2 kHz. The circuit operates with the best predictability and accuracy below 10 kHz, but it can be used with minor degradation to frequencies as high as 100 kHz.

A virtue of the timing scheme used in this circuit is that a comparison is done between a fraction of the output voltage and an exponential timing ramp derived from it. This basic scheme, popularized by the ubiquitous 555 timer **(Ref 5)**, provides high immunity to changes in output frequency with changes in output amplitude. The practical advantage of this scheme is that the reference voltage can be programmed for different amplitudes, and the AD630 can be strapped for different gains without disturbing the nominal operating frequency.

Although the main square-wave output from the AD630 provides ±5V in this circuit, the status output of the AD630's comparator is also available. This output, buffered by a discrete npn transistor as shown, provides an inverted status signal, which swings from +15 to −15V and can be interfaced easily to logic stages.

EDN

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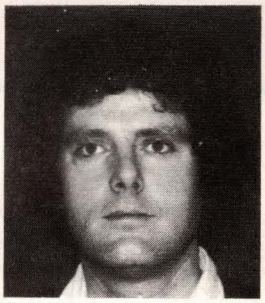
Authors' biographies



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Walt Jung, a technical consultant, is a prolific author. A member of the IEEE and a fellow of the Audio Engineering Society, he has published eight books on IC applications. Walt lists music and audio as his leisure interests.

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74F3037	—Quad 2-input NAND 30 Ohm transmission line driver
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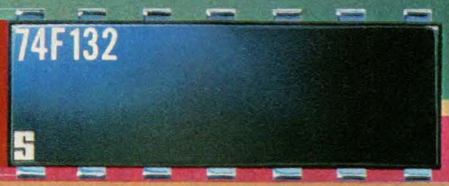

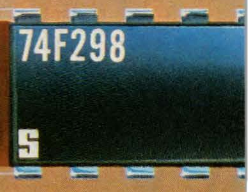

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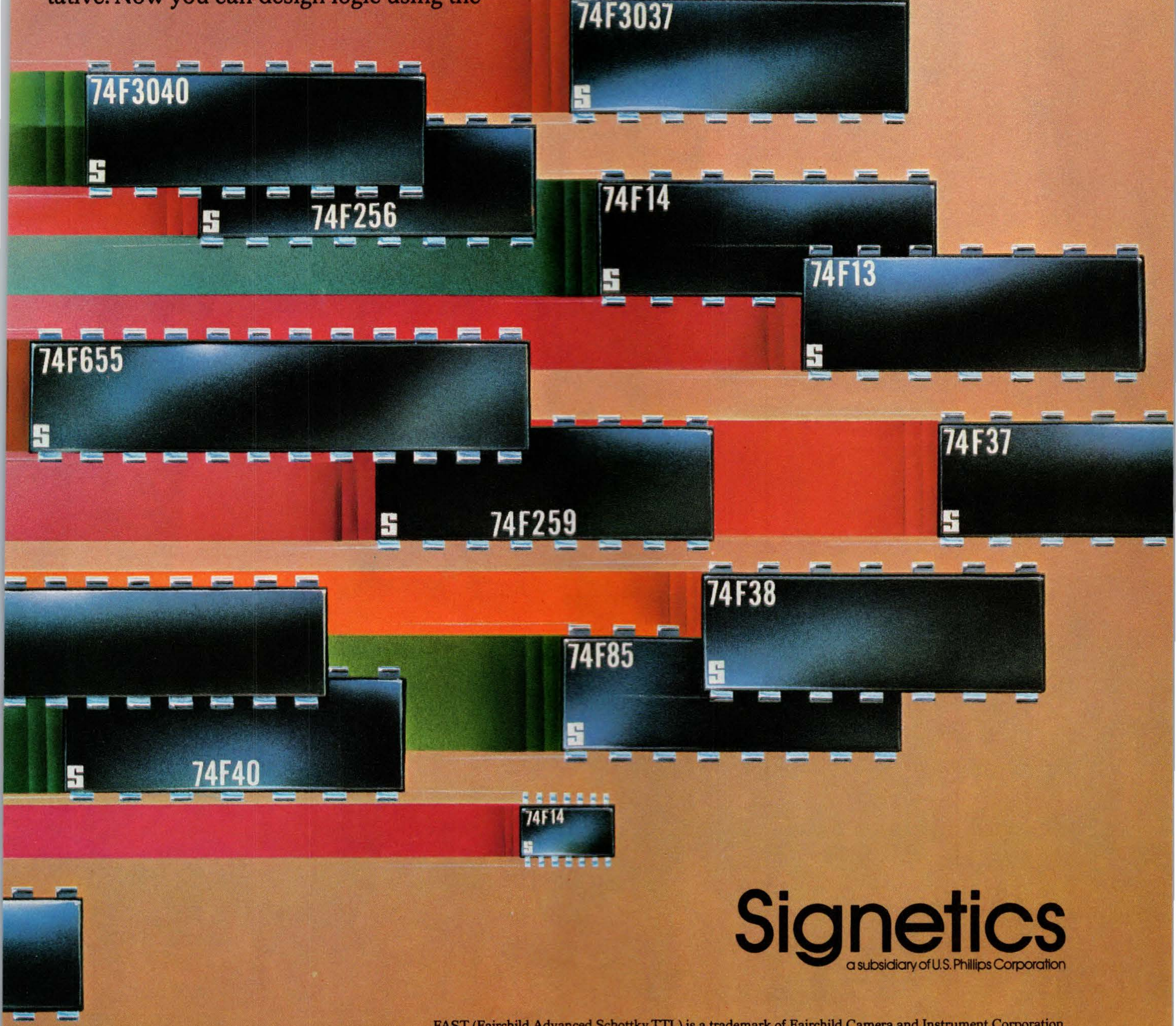

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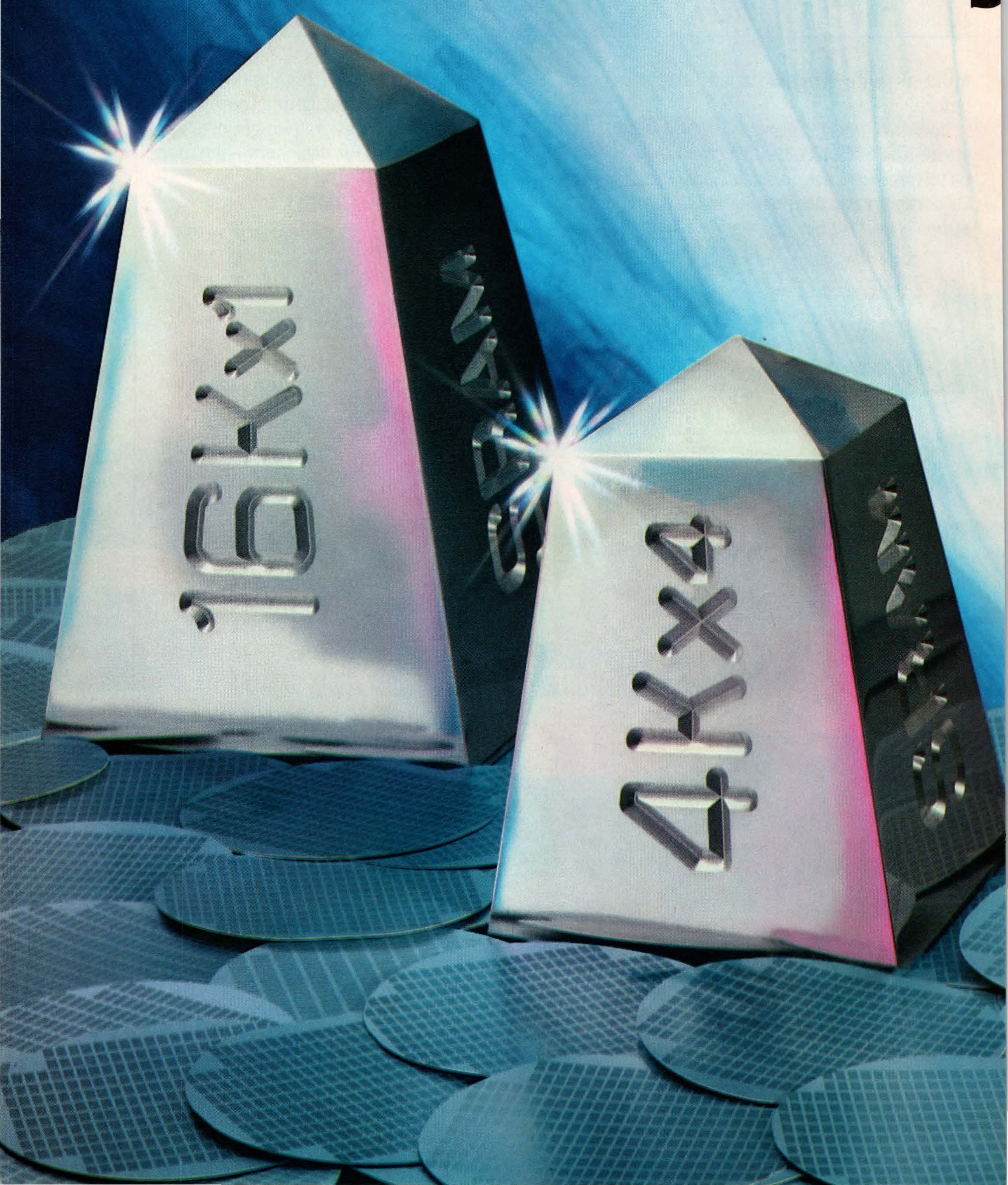

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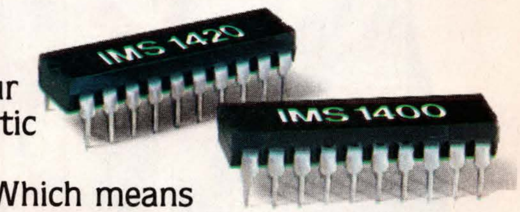

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	55	660	110	IMS1400-55
	70	495	83	IMS1400-70L
	100	495	83	IMS1400-10L
4Kx4	45	605	165	IMS1420-45
	55	605	165	IMS1420-55
	70	495	83	IMS1420-70L
	100	495	83	IMS1420-10L

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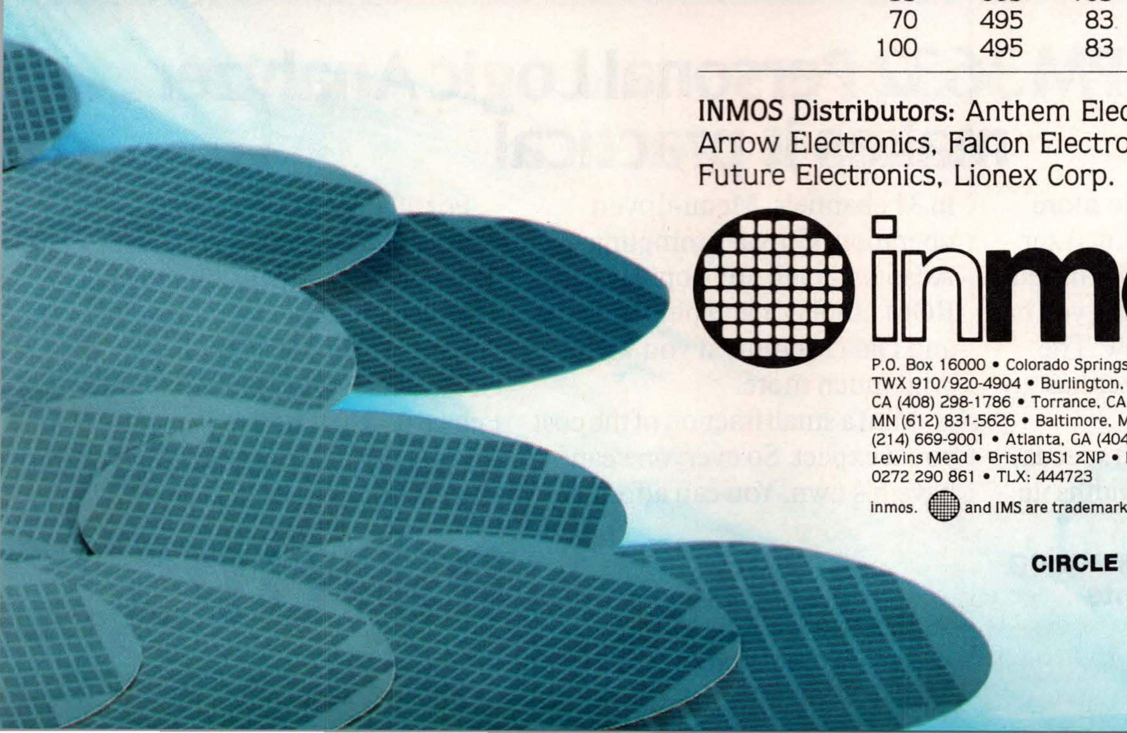

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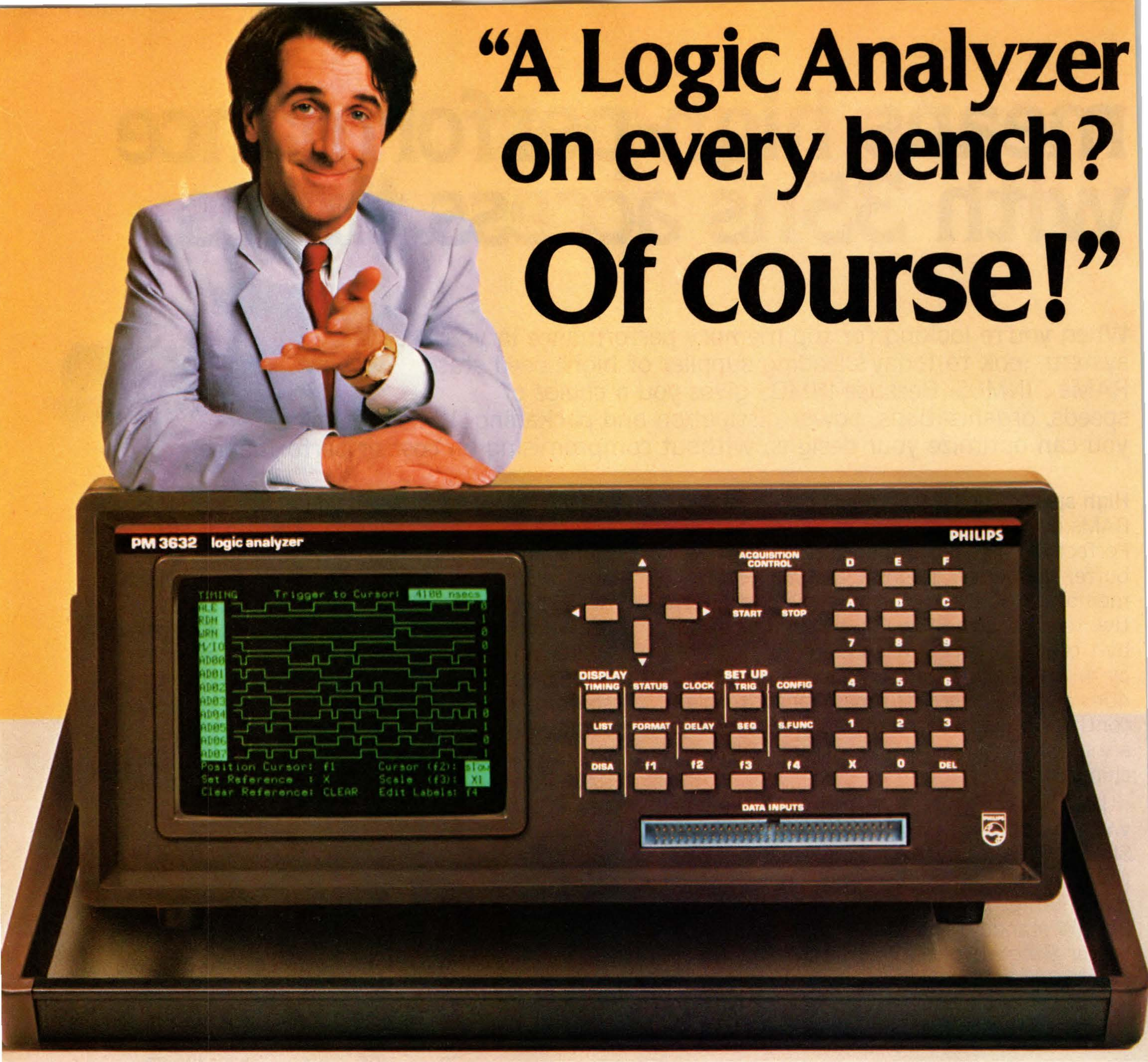

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CIRCLE NO 227

Buck-type switching regulator furnishes multiple outputs

For applications requiring auxiliary supply voltages in addition to a high-power primary output, you can employ a buck converter's switching action to derive regulated and isolated secondary channels.

Mike Jachowski, *National Semiconductor*

When faced with deriving isolated secondary voltages from a buck-type switching regulator, you needn't rely on separate dc/dc converters and their attendant expense and real-estate consumption. Instead, you can employ a buck-type converter's switching action to derive one or more isolated secondary outputs directly in bipolar or single-polarity configurations.

Each such supplemental output requires a rectifying diode and filter capacitor but no magnetic cores other than the primary channel's. In a typical configuration, the components required to add ±12V and −5V outputs to a 5V buck-type supply would occupy less than 1 in.^{2} of pc-board space.

Switchers illustrate operating theory

A review of switcher theory demonstrates how such secondary outputs can be obtained. In normal buck-converter operation, an output inductor (L_P) with N_P turns stored steady-state magnetic energy approximately equal to $\frac{1}{2}L_P I_O^2$, where I_O is the primary dc output current. A secondary inductor (L_S), wound with N_S turns on the same magnetic core as L_P, can tap this stored energy to generate auxiliary output voltages **(Fig 1)**. The magnetically coupled inductors form a high-frequency transformer, so that the ac voltage that the buck converter's switching action creates across L_P also appears across L_S, multiplied by the turns ratio N_S/N_P.

Note that during the On time (t_{ON}) of **Fig 1**'s switch Q_1, the voltage across L_P is

$$|V_P| = V_I - V_Q - V_O,$$

where V_Q is the switch transistor's saturation voltage, and V_O is the buck converter's output voltage.

During the transistor's Off time (t_{OFF}), the catch diode D_1 conducts, and the voltage across L_P is

$$|V_P| = V_O + V_{FP},$$

where V_{FP} is the forward voltage drop across D

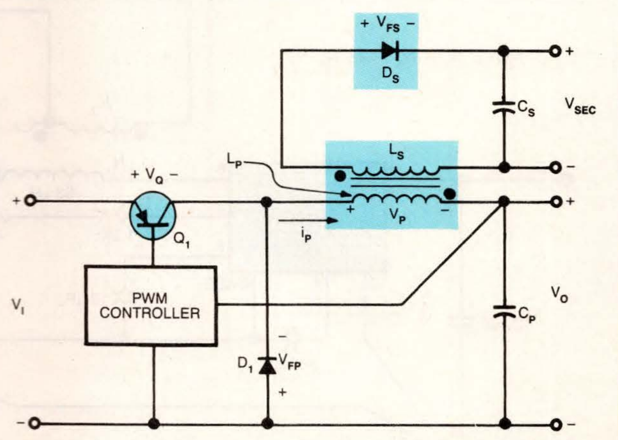


Fig 1—A secondary inductor *magnetically coupled to a buck-type converter's primary circuit can derive isolated auxiliary output voltages. The secondary rectifier D_S is oriented so that it conducts only when switch Q_1 is Off.*

Magnetic coupling transfers energy to secondary outputs

Because V_{FP} is relatively constant, and because the buck controller regulates V_O, the voltage across L_P remains constant during t_{OFF}. Orienting the secondary rectifier (D_S) so that it conducts only during t_{OFF} causes **Fig 1**'s filter capacitor (C_S) to charge to a steady-state voltage equaling

$$|V_{sec}| = \left(\frac{N_S}{N_P}\right)(V_O + V_{FP}) - V_{FS},$$

where V_{FS} is the forward-voltage drop across D_S. With good magnetic coupling, these voltage relationships hold true for a range of secondary loading conditions.

To regulate the steady-state voltage V_O, **Fig 1**'s pulse-width-modulated (PWM) controller regulates Q_1's duty cycle at approximately V_O/V_I, thus fixing the inductors' voltage waveforms. Consequently, secondary loading is reflected in the primary inductor as a distorted current waveform.

During t_{ON}, D_S is reversed biased, and no current flows through the secondary inductor. Current builds in L_P at the rate

$$\frac{di_P}{dt} = \frac{V_I - V_Q - V_O}{L_P},$$

where i_P is the primary-inductor current.

At the transition from t_{ON} to t_{OFF}, current begins to flow in L_S, and there's a step decrease in i_P, as **Fig 2** shows. The following equation, which describes the continuous magnetic energy in the inductor at the moment of transition, predicts this step decrease:

$$\left(\frac{1}{2}L_P i_P^2\right)\bigg|_{t=0^-} = \frac{1}{2}\left(L_S i_S^2 + L_P i_P^2 + 2k\sqrt{L_S L_P}\, i_S i_P\right)\bigg|_{t=0^+},$$

where i_S is the secondary inductor current and k is a

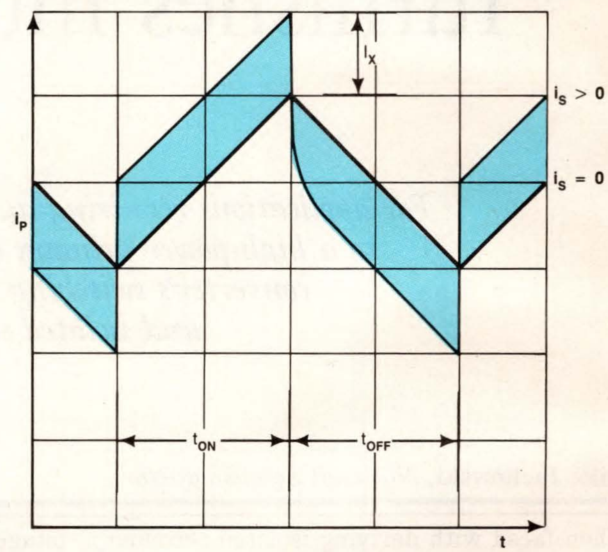


Fig 2—Secondary loading results in a step change *in primary-inductor current i_P when **Fig 1's** Q_1 switches. Here, i_P is shown for secondary current i_S both equal to zero and greater than zero; the deviation in i_P when i_S is greater than zero is labeled I_X.*

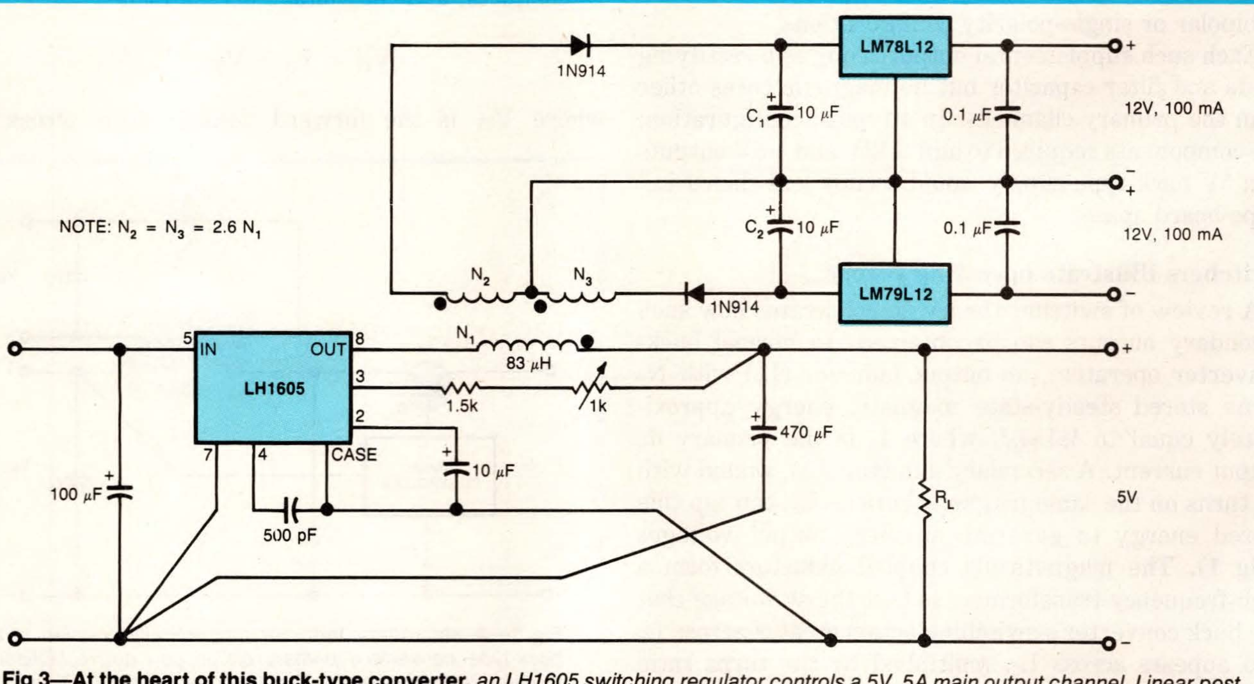


Fig 3—At the heart of this buck-type converter, *an LH1605 switching regulator controls a 5V, 5A main output channel. Linear post regulators hold the derived secondary outputs to ±12V at 100 mA.*

constant. Similarly, a step increase occurs in i_P at the transition from t_{OFF} to t_{ON}.

To offset the lower i_P during t_{OFF}, the PWM controller increases the average energy stored in the magnetic core to increase i_P during t_{ON}, thus maintaining a constant average i_P equal to I_O. (The increase in i_P caused by the secondary loading is labeled I_X in **Fig 2.**) The following equations predict the increase in i_P:

$$P_S = (V_I - V_Q)(I_X)\left(\frac{t_{ON}}{t_{ON} + t_{OFF}}\right)$$

and

$$I_X = P_S\left[(V_I - V_Q)\left(\frac{t_{ON}}{t_{ON} + t_{OFF}}\right)\right]^{-1},$$

where P_S is the secondary output power.

Any one of several factors can limit the available secondary power for stable regulator operation. The addition of secondary loading, for example, must not increase the peak switch current beyond the switch transistor's capabilities, and the magnetic core must be capable of sustaining the greater flux required for the secondary output without saturating. Moreover, primary-channel performance requirements might indirectly limit permissible secondary power; increasing the secondary load increases the primary output ripple voltage, because the primary filter capacitor (C_P in **Fig 1**) must integrate an increased ripple current. Secondary loading must therefore be sufficiently limited to maintain primary ripple within tolerable levels.

As long as switch-transistor current, magnetic-core flux and primary output ripple remain within acceptable limits, however, secondary power can increase until it equals the primary power. At that point, i_P during t_{ON} is twice what it would be with no secondary loading, and as a consequence i_P must be zero during t_{OFF}. This implies that the buck converter operates in a discontinuous mode, in which (during t_{OFF}) conduction through D_1 ceases and the voltage across L_P becomes unclamped. Additional output loading would result in output voltage oscillations with potentially disastrous results.

As long as these power restrictions are observed, achieving good secondary regulation depends primarily on employing a low-resistance secondary winding and good magnetic coupling between the primary and secondary inductors. Poor coupling or high-resistance windings cause the secondary output voltage to drop as secondary current increases.

Other factors, however, also influence secondary regulation. Increases in V_{FS} at higher currents, for example, cause additional decreases in V_{SEC}. Furthermore, higher secondary current results in lower primary current during t_{OFF}, decreasing V_{FP} and creating an even lower V_{SEC}.

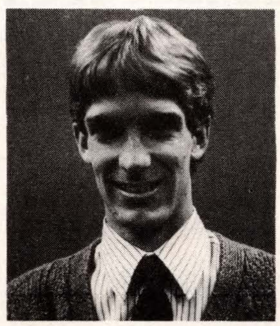
Conversely, with no secondary loading, D_S and C_S act as a peak-holding network, raising V_{SEC} to the value of the switching transients and therefore exacerbating no-load to full-load output-voltage variations. (Adding an RC snubber across the secondary load or requiring a minimum secondary load, or both, can suppress such increases in V_{SEC}.) Nevertheless, such secondary outputs can achieve better than ±10% regulation over a wide range of secondary loads.

Fig 3 shows specific component values for a circuit that derives a bipolar secondary output from a buck-type regulator. In this circuit, an LH1605 serves as the heart of a converter capable of delivering 5V at 5A. LM78L12 and LM79L12 linear regulators on the secondary outputs provide ±12V at 100 mA each.

To derive the secondary voltages, two secondary inductors are wound on the primary inductor's core with approximately a 2.6:1 secondary-to-primary turns ratio. This configuration develops 16 to 19V across the secondary inductors during t_{OFF}, depending on the current through the LH1605's internal catch diode.

Although **Fig 3** shows two 1N914 diodes rectifying the secondary outputs, any fast-recovery diode rated to the maximum output current and capable of withstanding a peak-reverse voltage to 100V (at V_I=30V) could be substituted. Because the LH1605 is set to operate at 50 kHz, and because the current levels are low, small tantalum or aluminum electrolytic 10-μF capacitors are adequate to filter the inputs to the two linear regulators, which provide current limiting at ~200 mA.

Finally, 0.1-μF ceramic disk capacitors added to the secondary outputs attenuate any remaining high-frequency switching transients. The secondary outputs can provide 100 mA each, with a minimum of 1A flowing in the primary output. **EDN**



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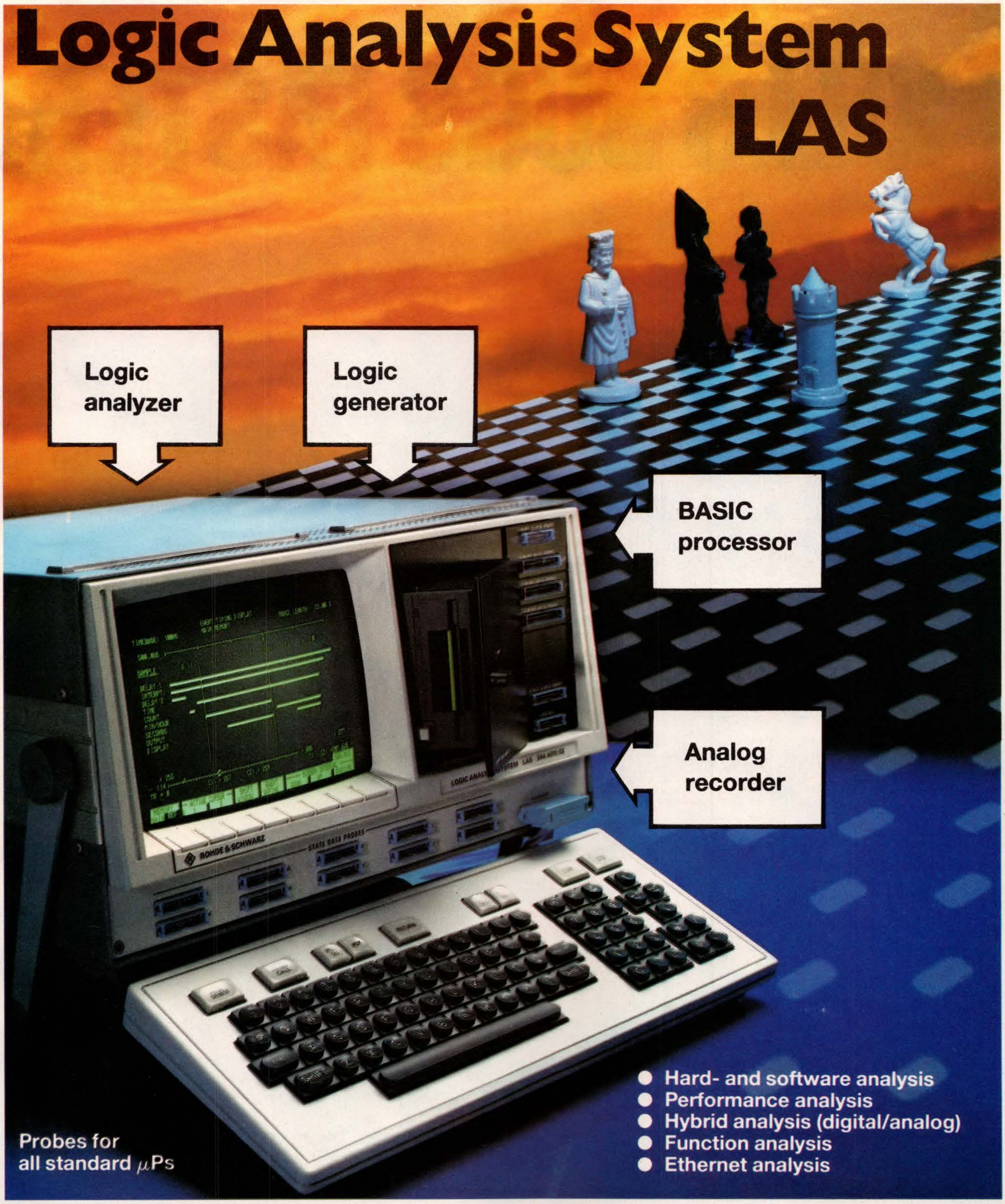

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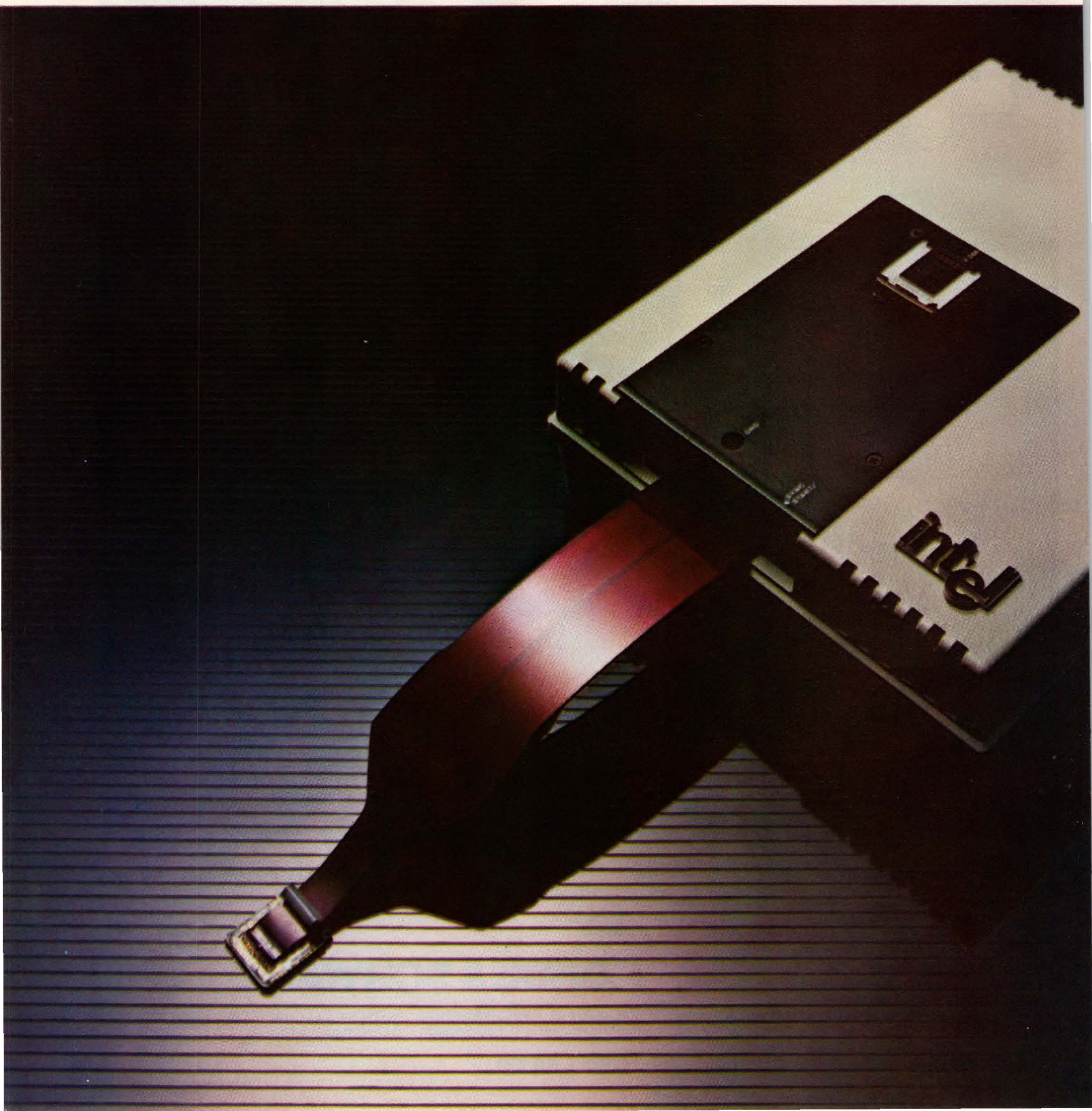

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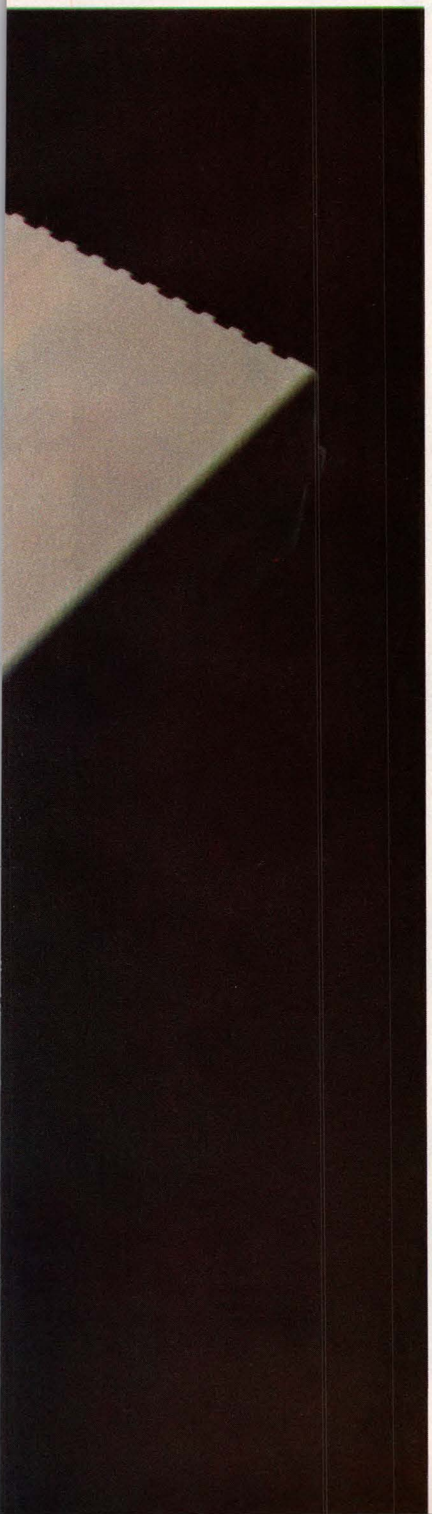

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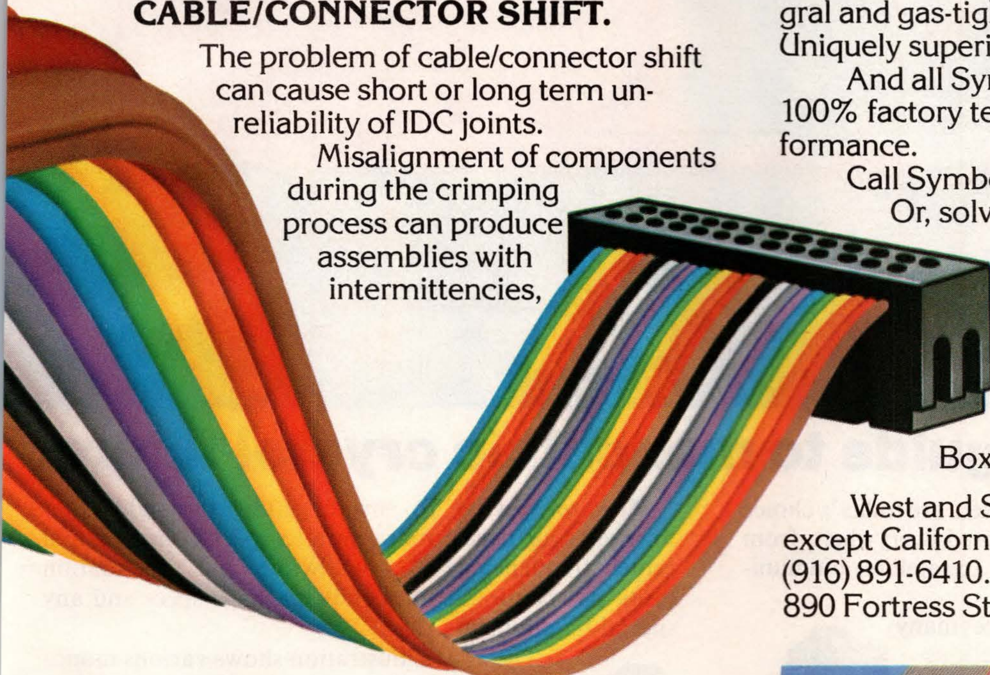

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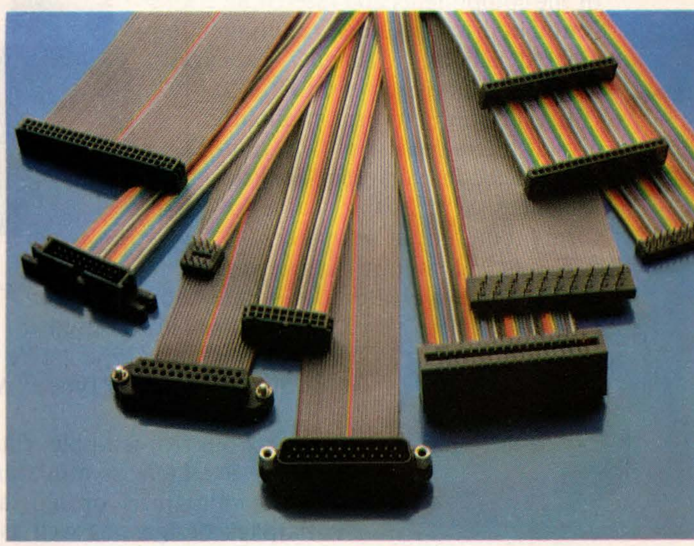

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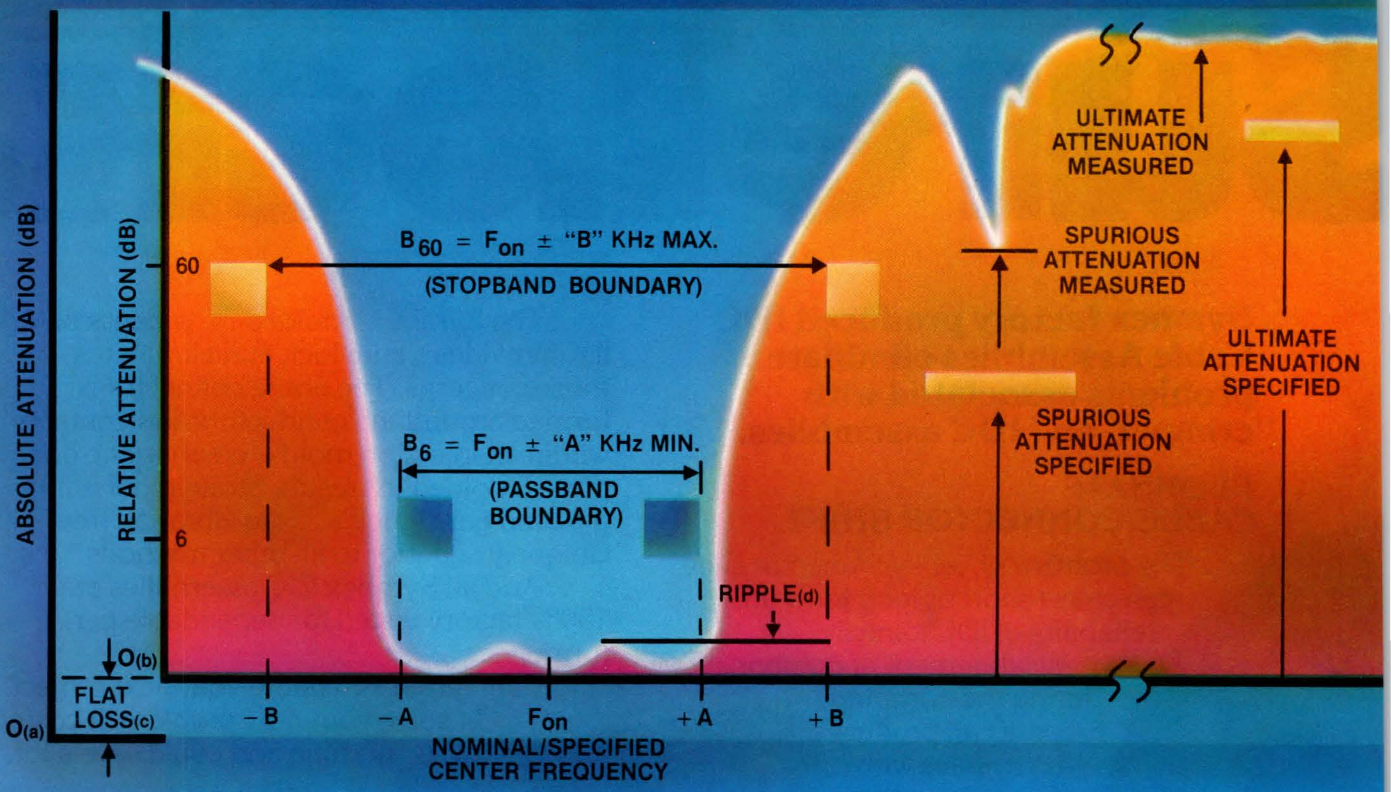

(a) ABSOLUTE ATTENUATION REFERENCE: SIGNAL LEVEL WITH SOURCE MATCHED TO LOAD.
(b) RELATIVE ATTENUATION REFERENCE: MINIMUM VALUE OF LOSS IN PASSBAND OR PEAK OF TRANSMISSION
(c) FLAT LOSS: POWER OUT AT PEAK OF TRANSMISSION DIVIDED BY POWER AVAILABLE
(d) MEASURED FROM PEAK TO VALLEY

A designer's guide to monolithic crystal filters.

Description. Monolithic crystal filters are today's choice for crystal filter applications — used everywhere from mobile radios to medical monitors to satellite communications equipment.

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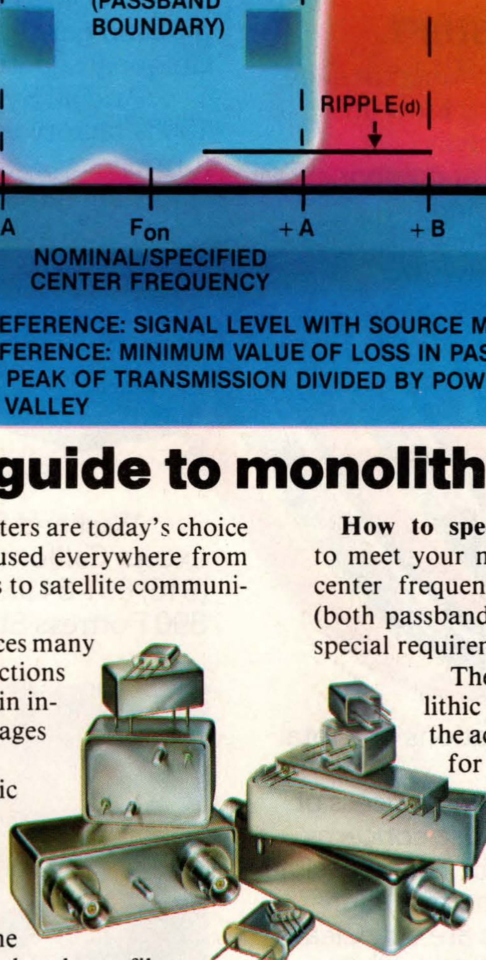

In their simplest form, monolithic crystal filters consist of two, thin-film electrode pairs deposited on the faces of a quartz wafer to form input/output resonators.

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CIRCLE NO 93

Consider using the S-100 bus to host your 16-bit μP

Although originally designed to support 8-bit 8080 μP systems, the S-100 bus also allows you to perform 16-bit transfers. An example based on the 16-bit (32-bit internal) NS32 μP illustrates the techniques involved.

Richard Kalish *and* **David Plomgren,** *CompuPro*

Thanks to the IEEE-696 standard, the S-100 bus, originally designed to support 8-bit μPs, now handles 16-bit data transfers among conforming memory, I/O and CPU boards. Building 16-bit S-100-compatible boards, however, presents some design problems. The boards must coordinate 8- and 16-bit data transfers, accommodate wait states and generate the appropriate status signals for the bus. An example incorporating the 16-bit NS32016 μP illustrates the design techniques involved.

The IEEE-696 standard defines two status signals that help coordinate 16-bit data transfers. Pin 58 of the 100-pin bus is the Sixteen Request status line, sXTRQ*, which is active when Low. (An initial lowercase s in a signal's symbolic representation indicates that the signal is a status line, and the trailing asterisk indicates that the signal is Low when active.) The CPU board, as bus master, asserts sXTRQ* when requesting that a 16-bit data transfer occur during the current bus cycle. (An inactive sXTRQ* line requests an 8-bit transfer.) Devices capable of performing 16-bit operations respond to an active sXTRQ* line by sending a Sixteen Acknowledge signal (SIXTN*) to the master when addressed.

In conventional 8-bit operations, the S-100 bus uses two unidirectional 8-line bus segments: Data In (DI) for sending data to the CPU, and Data Out (DO) for transferring data out of the CPU. The IEEE standard, however, allows these two bus segments to handle 16-bit data as well. When the CPU board receives the SIXTN* signal, it gangs the DI and DO buses to form a single bidirectional data path.

Fig 1 shows the four ICs required for both 16- and 8-bit transfers between the NS32016 μP and the S-100 bus. For a 16-bit transfer, whether it's a read or write operation, the low (even) byte travels through 74LS245 buffer IC_2, which interfaces the μP's data pins AD_0 through AD_7 with the DO bus lines. Simultaneously, the high (odd) byte passes through a second 74LS245 buffer (IC-1), which interfaces pins AD_8 through AD_{15} on the μP side with the DI lines on the bus side.

During the first clock cycle (T_1) for 16-bit transfers with no wait states **(Fig 2)**, the NS32016 μP asserts address and status strobes. Its Ready (RDY) line remains High. Once the address lines are demultiplexed from the address data bus (AD_0 through AD_{15}), these lines remain stable until the end of the fourth clock cycle (T_4). Consequently, the status lines remain valid throughout the third cycle (T_3), at the end of which the strobe goes Low.

On the S-100 bus, the μP asserts addresses and status lines early in T_1, and those lines remain valid through T_4. During the second clock cycle (T_2), the pSYNC line goes High, indicating the beginning of a new bus cycle. During T_3, the μP asserts a memory read or write strobe. When performing a 16-bit read operation, for example, the NS32016 reads the word on the falling edge of its read strobe. The S-100 RDY line remains High throughout the transfer cycle.

Byte swapping mates 8- and 16-bit boards

Not all data transfers in this type of S-100 system need be 16 bits wide, however, and the ability to mix and match 8- and 16-bit memory and peripheral boards

IEEE-696 standard supports 8- and 16-bit data transfers

in the same system is one advantage of the IEEE-696 standard. Through *byte swapping* operations, which can be performed by an on-board finite-state machine (making them transparent to the μP), you can transfer 16-bit data between a 16-bit CPU board and an 8-bit memory board one byte at a time. You can economically construct the finite-state machine using a PAL.

In such a system, if a slave (eg, a memory board) can't perform 16-bit operations, it doesn't acknowledge the sXTRQ* request. When the CPU board doesn't receive the SIXTN* acknowledgment within a specified time period, that board assumes that the memory board has a byte-wide data path. The CPU board then performs two memory fetches or writes, requiring two bus cycles in place of the one cycle required by a 16-bit transfer.

In a read operation, the low byte enters via the DI

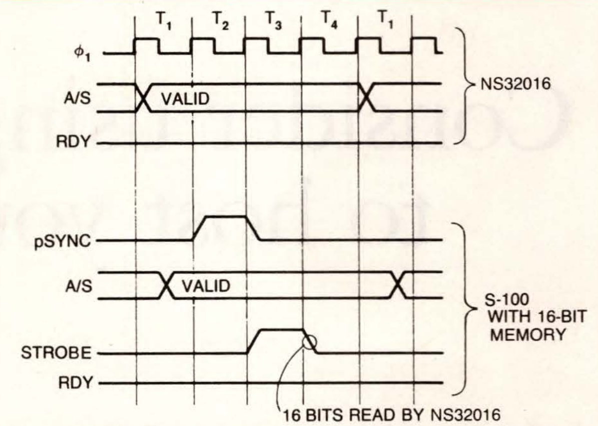


Fig 2—In 16-bit transfers with no wait states, *an S-100 bus board's 16-bit μP asserts address and status strobes (A/S) during T_1. Assertion of pSYNC indicates a new bus cycle. The memory strobe occurs during T_3, and the μP reads the stored word on that strobe's falling edge.*

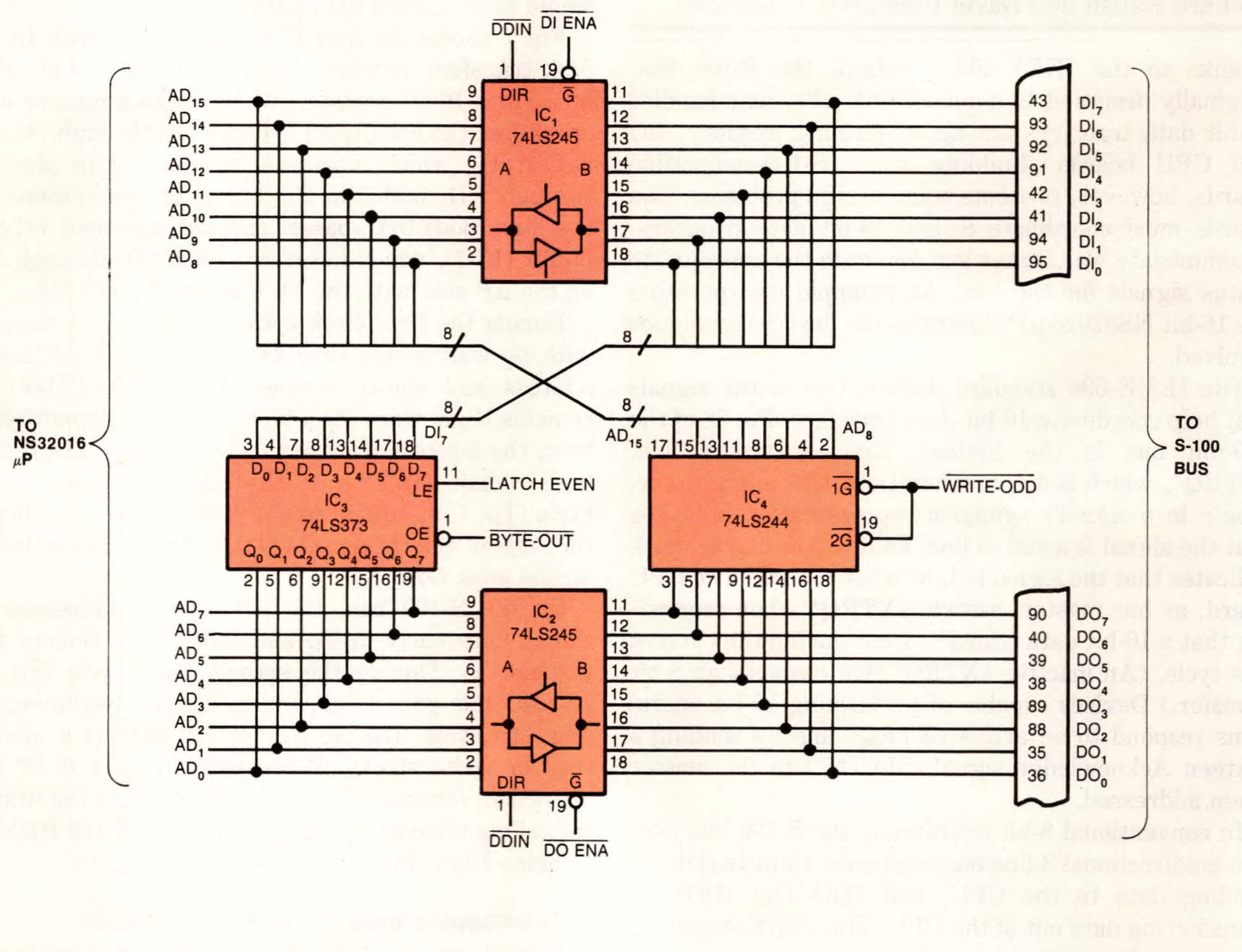


Fig 1—Four ICs provide the circuitry required *to interface a 16-bit μP such as the NS32016 with the S-100 (IEEE-696) bus.*

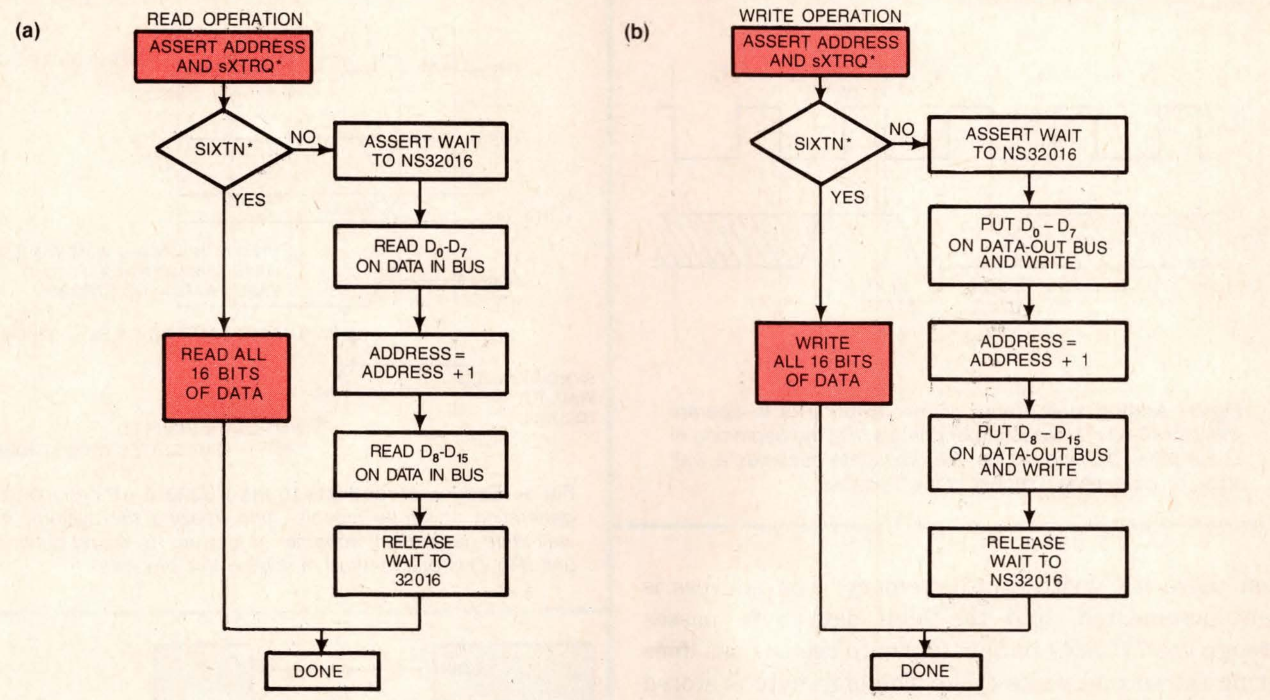


Fig 3—Read (a) and write (b) operations *for a 16-bit processor on the S-100 bus begin with the presentation of an address and assertion of the sXTRQ* line. A 16-bit-wide memory board would respond by asserting SIXTN*, allowing a single 16-bit transfer. An 8-bit memory board wouldn't assert SIXTN*, signaling its requirement for two single-byte data transfers.*

bus and is latched by the 74LS373 device (IC_3 in **Fig 1**) onto the μP's lines AD_0 through AD_7. The state machine then increments the address and fetches the high byte from the next memory location. The high byte passes through IC_1 to AD_8 through AD_{15}, and both bytes are simultaneously valid on the μP's data lines.

For a write operation, the low data byte passes through IC_2 from the μP to the DO lines of the bus, and

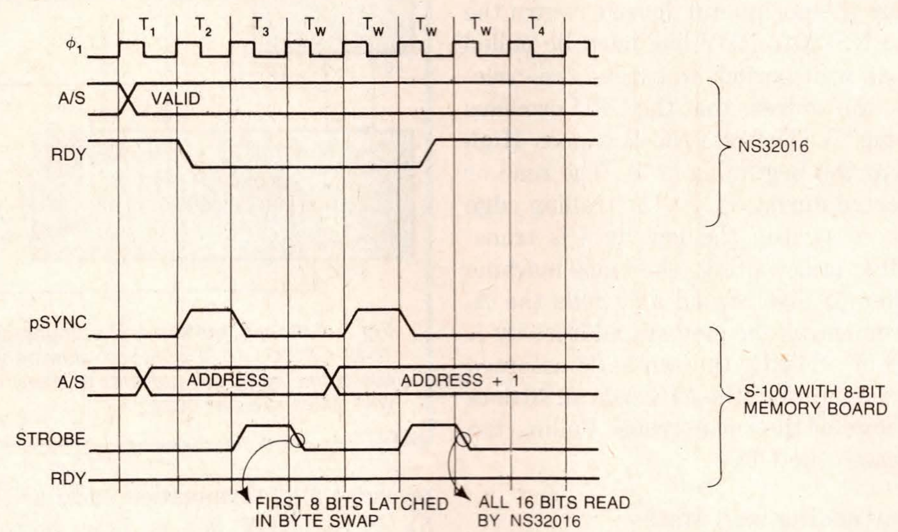


Fig 4—To perform the byte swapping necessary *for reading 16-bit data in two byte-wide segments, the μP's RDY line goes Low to halt the μP. On the first falling edge of the strobe, the low byte is latched, after which the address is incremented. Finally, on the second falling edge of the strobe, the μP reads the 16-bit data.*

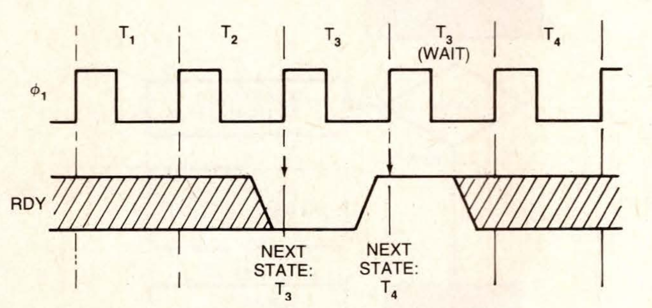


Fig 5—Adding wait states allows 16-bit µPs *to operate with slow 8-bit memories or peripherals. If at the beginning of T_3 the µP's RDY line is Low, the next state becomes a wait state, or essentially a repeat of the T_3 cycle.*

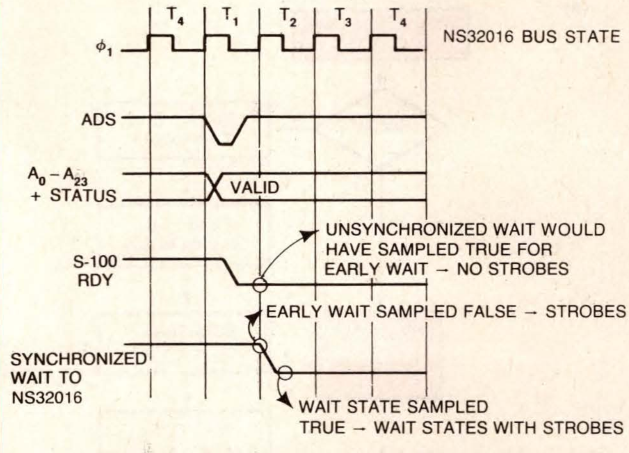


Fig 6—Early wait requests to the NS32016 µP *can inhibit generation of strobe signals, thus freezing the system. A wait-state-generation scheme employing a timing-control unit* ***(Fig 7)*** *is one method of solving this problem.*

from there it's written into memory. The address is then incremented, and the high data byte passes through the 74LS244 buffer (IC_4) onto the DO bus lines during the second write cycle. The high byte is stored in the memory location above that of the previous byte. The flow charts in **Fig 3** illustrate the byte-level read and write cycles.

Timing is key when swapping bytes

Timing for byte-swapping operations is as important as the data paths. **Fig 4** shows the timing for a system with no S-100 wait states (ie, the bus Ready line is always High). The T_W cycles—wait states for the µP—enable a 16-bit word to be handled as two 8-bit transfers. Early in T_1, the µP asserts an address and the status signals. When the peripheral doesn't return the SIXTN* signal, the NS32016 RDY line must be pulled Low during T_2 to add wait periods to extend the cycle.

On the S-100 bus, the address that the CPU provides becomes valid during T_1. The pSYNC line goes High during T_2 and falls at the beginning of T_3. The read or write strobe is asserted during T_3. At the trailing edge of the strobe (read or write), the low byte is transferred. With the CPU still waiting, the state machine duplicates the earlier pSYNC signal and pulls the A_0 line High, thus incrementing the memory address by 1. On the falling edge of pSYNC, the strobe is asserted again. During a read operation, the µP reads all 16 data bits on the falling edge of the read strobe. Pulling the RDY line High releases the CPU.

Extend bus cycle by adding wait states

In the event of slow memory response or 8-bit transfers to a 16-bit CPU, the µP lengthens the bus cycle by adding wait states (additional T_3 cycles). If the RDY line at the rising edge of T_3 is High, the µP provides a T_4 termination cycle as the next state **(Fig 5)**. If the RDY line is Low, however, the NS32016 issues a wait cycle as the next state. Such wait cycles continue until the µP encounters a High RDY line.

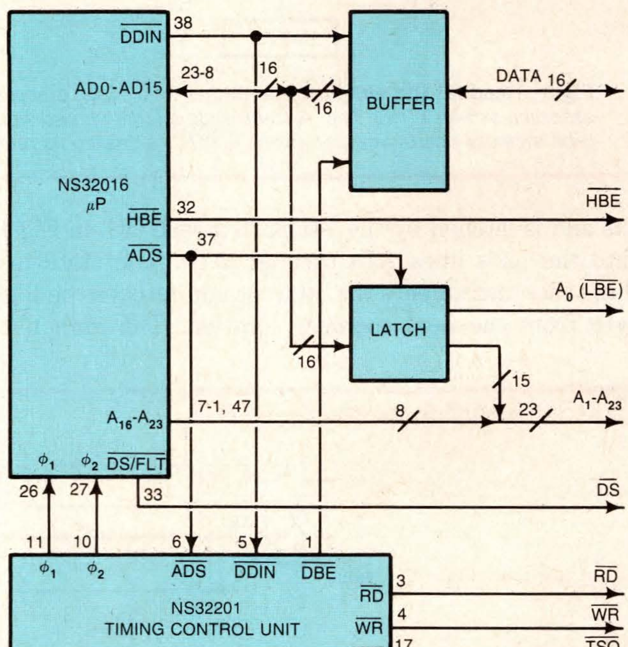


Fig 7—Latches, buffers and a timing-control unit *allow a 16-bit CPU board to work with slow peripheral boards. The use of the timing unit provides as many as 15 programmed wait states in a bus cycle.*

A problem can occur: The NS32016 allows an early wait state during T_2, and if the µP receives a wait

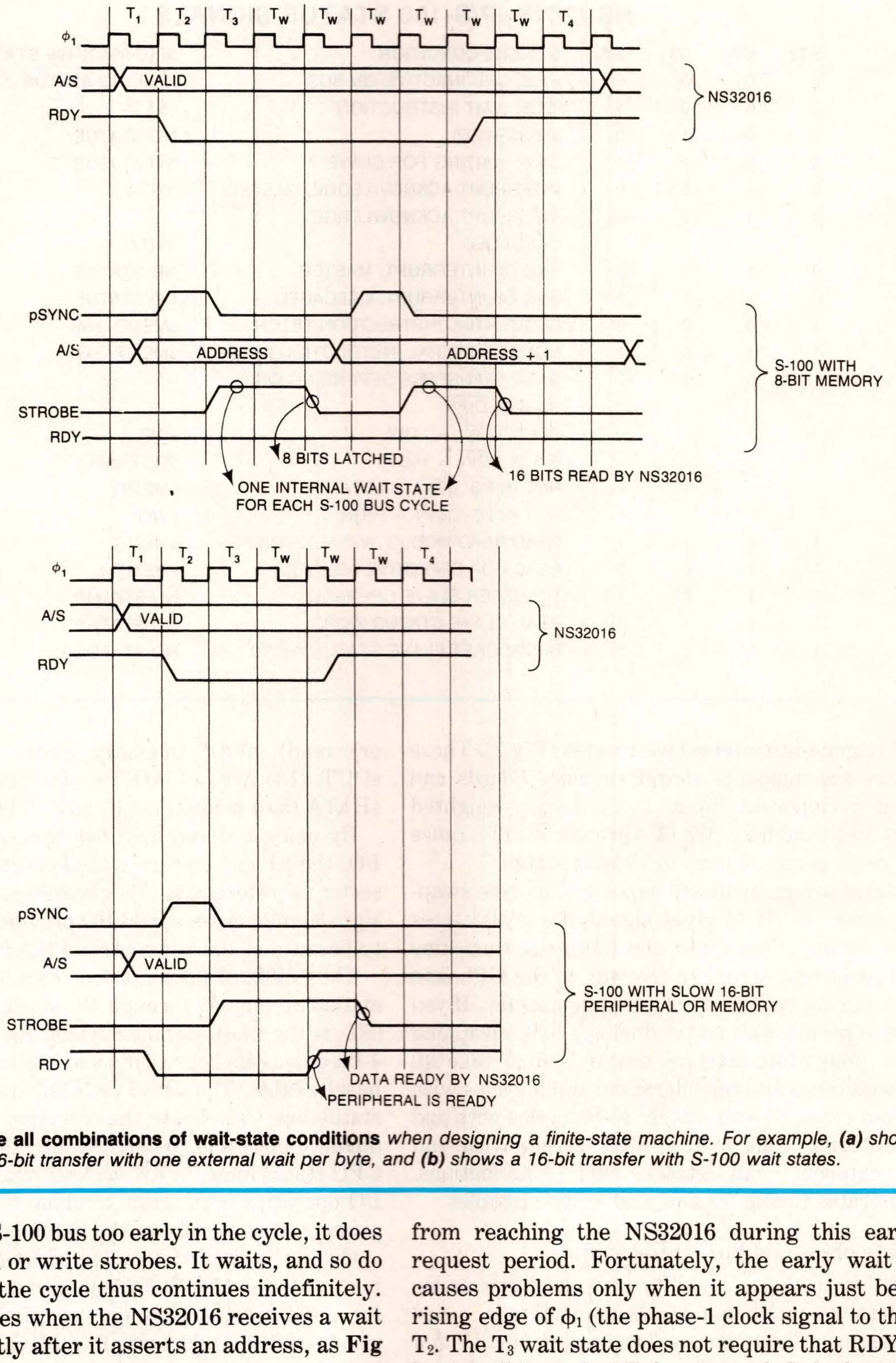


Fig 8—Anticipate all combinations of wait-state conditions *when designing a finite-state machine. For example,* **(a)** *shows a byte-serialized, 16-bit transfer with one external wait per byte, and* **(b)** *shows a 16-bit transfer with S-100 wait states.*

request from the S-100 bus too early in the cycle, it does not assert its read or write strobes. It waits, and so do the slave boards; the cycle thus continues indefinitely. This situation arises when the NS32016 receives a wait request very shortly after it asserts an address, as **Fig 6** shows.

Such a situation can easily occur, because a peripheral on the S-100 bus can assert a Low level (requesting a wait state) on the RDY pin at any time. You therefore need to provide logic circuitry to prohibit the signal from reaching the NS32016 during this early wait-request period. Fortunately, the early wait request causes problems only when it appears just before the rising edge of ϕ_1 (the phase-1 clock signal to the μP) at T_2. The T_3 wait state does not require that RDY become Low until just after T_2 has started. It is therefore only necessary to disallow early requests for wait states prior to the rising edge of ϕ_1 during T_2.

One method of overcoming this problem involves using signals from a timing control unit (TCU) like the

NS32016 μP/S-100 STATUS SIGNALS

ST_3	ST_2	ST_1	ST_0	NS32016 CONDITION	IEEE-696/S-100 STATUS
0	0	0	0	IDLE: CPU INACTIVE ON BUS	IDLE: NO STATUS
0	0	0	1	IDLE: WAIT INSTRUCTION	sHLTA
0	0	1	0	(RESERVED)	NO STATUS
0	0	1	1	IDLE: WAITING FOR SLAVE	NO STATUS
0	1	0	0	INTERRUPT ACKNOWLEDGE, MASTER	sINTA
0	1	0	1	INTERRUPT ACKNOWLEDGE, CASCADED	sINTA
0	1	1	0	END OF INTERRUPT, MASTER	NO STATUS
0	1	1	1	END OF INTERRUPT, CASCADED	NO STATUS
1	0	0	0	SEQUENTIAL INSTRUCTION FETCH	sMEMR, sM1
1	0	0	1	NONSEQUENTIAL INSTRUCTION FETCH	sMEMR, sM1
1	0	1	0	DATA TRANSFERS DEPENDING ON I/O AND $\overline{DDIN}$:	
				IN I/O, $\overline{DDIN}$ = LOW	sINP
				IN I/O, $\overline{DDIN}$ = HIGH	sOUT, sWO*
				NOT IN I/O, $\overline{DDIN}$ = LOW	sMEMR
				NOT IN I/O, $\overline{DDIN}$ = HIGH	sWO*
1	0	1	1	READ READ-MODIFY-WRITE TRANSFER	sMEMR
1	1	0	0	READ FOR EFFECTIVE ADDRESS	sMEMR
1	1	0	1	TRANSFER SLAVE OPERAND	NO STATUS
1	1	1	0	READ SLAVE STATUS WORD	NO STATUS
1	1	1	1	BROADCAST SLAVE STATUS WORD	NO STATUS

NS32201 to generate internal wait states (**Fig 7**). These wait states accommodate slower memory boards and other slow peripherals. Inputs to the binary-weighted TCU pins 18 through 21 ($\overline{WAIT_1}$ through $\overline{WAIT_8}$) cause that device to generate zero to 15 wait states.

Wait states are particularly important in byte swapping. Because the TCU gives signals for wait states only once during a bus cycle, the finite-state machine must intercept that signal on the way to the CPU and produce it during both parts of the data transfer. If you do intend to permit wait states during a byte-swapping operation, your state-machine design should take all possible wait cases into consideration: 16-bit cycles with and without external wait states, 16-bit cycles with and without internal wait states, 8-bit cycles with and without external wait states, and combinations. **Fig 8** illustrates timing for two wait-state examples.

Coordinate chip- and bus-status signals

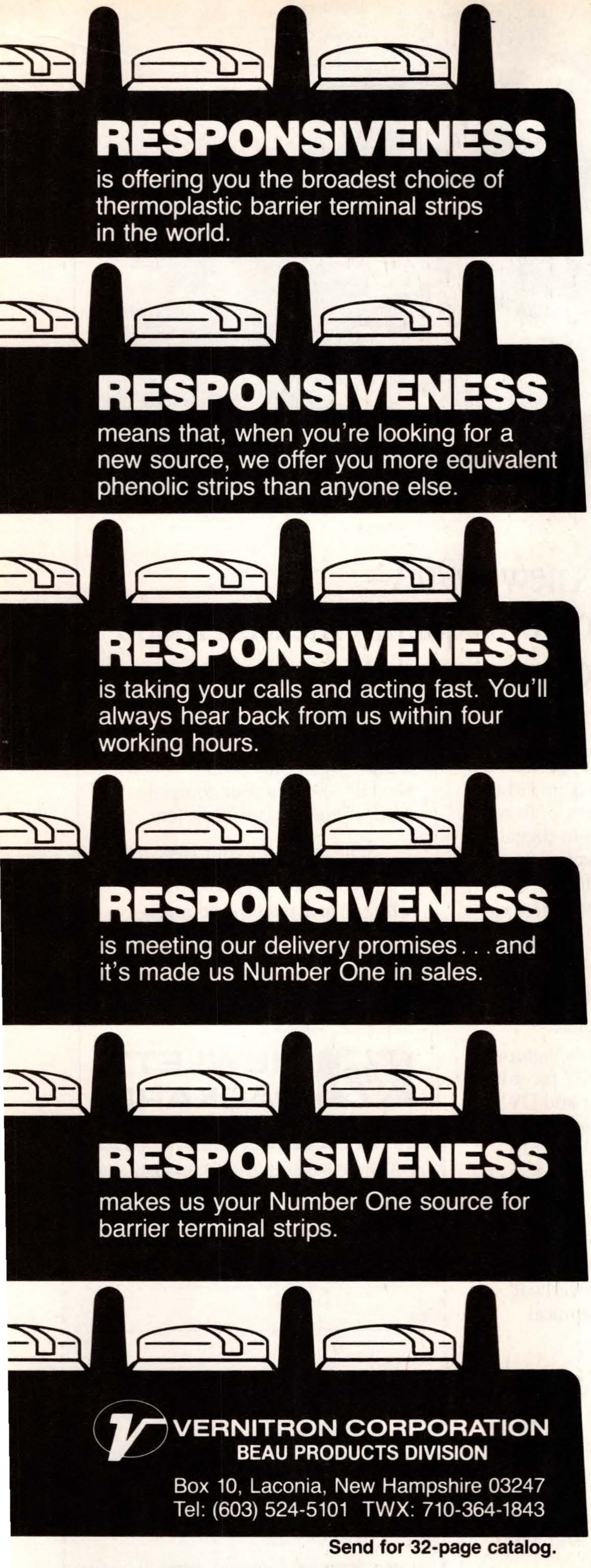
In addition to the availability of wait states under various data-bus width and processor conditions, board design must coordinate status signals from the μP and the bus. Because the S-100 bus was originally designed for the 8080 μP, its status signals tend to reflect the idiosyncrasies of that 8-bit processor. The eight S-100 status signals are sM1 (which indicates that the master is fetching an instruction from the bus), sMEMR (memory read), sWO* (memory write), sINP (I/O read), sOUT (I/O write), sINTA (interrupt acknowledge), sHLTA (halt acknowledge) and sXTRQ*.

By using a designated 64k-byte memory sector for I/O, the μP can discern an I/O operation any time that sector is referenced. In generating S-100 I/O status signals, memory-mapped I/O provides greater flexibility because of the symmetry of the NS32016.

The NS32016 presents four bits of bus-status information on pins 40 through 43, labeled ST_3 through ST_0 (ST_3 is the most significant bit). Each of the resulting 4-bit quantities represents a status code, as given in the nearby **table.** The μP's $\overline{DDIN}$ line (pin 38) also acts as a status line to indicate the direction of a data transfer during a bus cycle. When it's Low, the CPU reads data. CPU status lines, $\overline{DDIN}$ and information on whether an I/O operation is in effect combine to assert the appropriate status signals on the S-100 bus.

Originally limited to a 64k address space, the S-100 bus under the IEEE-696 standard uses 24 address lines for a 16M-byte addressing range. Because the NS32016 also uses 24-bit addresses to achieve the same addressing range, the transfer of addresses from chip to bus is simple. As **Fig 7** shows, however, some buffers and latches are necessary for demultiplexing addresses and data.

You can gain additional address space by adding an



Adding wait states to μP cycles aids slow or 8-bit transfers

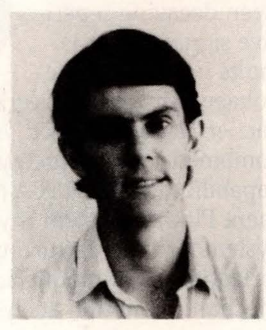
NS32082 memory-management unit (MMU) to an S-100 bus board, thereby allowing implementation of demand-paged virtual memory. Employing such a system in a multiuser environment would give each user access to a separate 16M-byte virtual address space for computing tasks.

You can use one of the undefined pins on the S-100 bus as a 25th MMU address bit (A_{24}). This undefined pin effectively doubles the memory accessible to the CPU. Usually, this MMU signal is used to trap back and forth between different memory sections.

Finally, consider the many scientific and business applications of a 16-bit CPU board used in conjunction with the S-100 bus. CompuPro, for example, offers an S-100 CPU board that combines the NS32016 μP and NS32201 TCU with an NS32202 interrupt-control unit and an optional NS32082 MMU or MS32081 floating-point unit or both. Illustrating the capabilities of S-100 systems, the CompuPro board has been integrated into a multiuser computer that runs the UNIX System V operating system, a C compiler and C application programs. **EDN**

Authors' biographies

Richard Kalish, director of hardware development at CompuPro (Hayward, CA), manages the hardware department and does hardware design. He joined CompuPro five years ago after serving in the US Air Force and subsequently working for Intel Corp. Richard has a BSEE degree from the University of California at Berkeley and is a member of the IEEE. His hobbies include photography and woodworking.



David Plomgren, a design engineer at CompuPro (Hayward, CA), is currently involved in CPU and networking design. He came to CompuPro directly from the University of California at Berkeley where he received a BSEE degree in June 1983. David is a member of the IEEE and enjoys waterskiing in his spare time.

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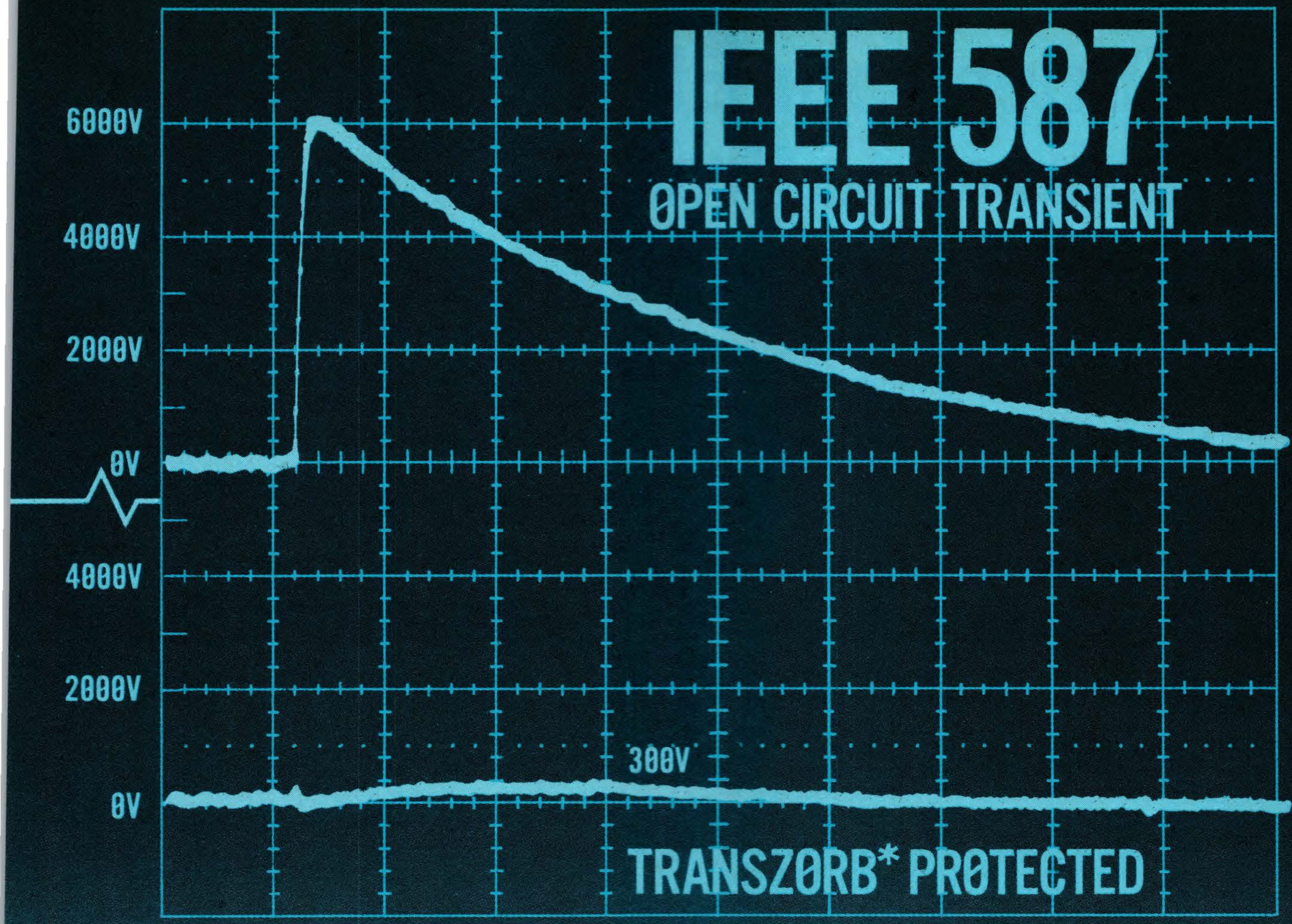
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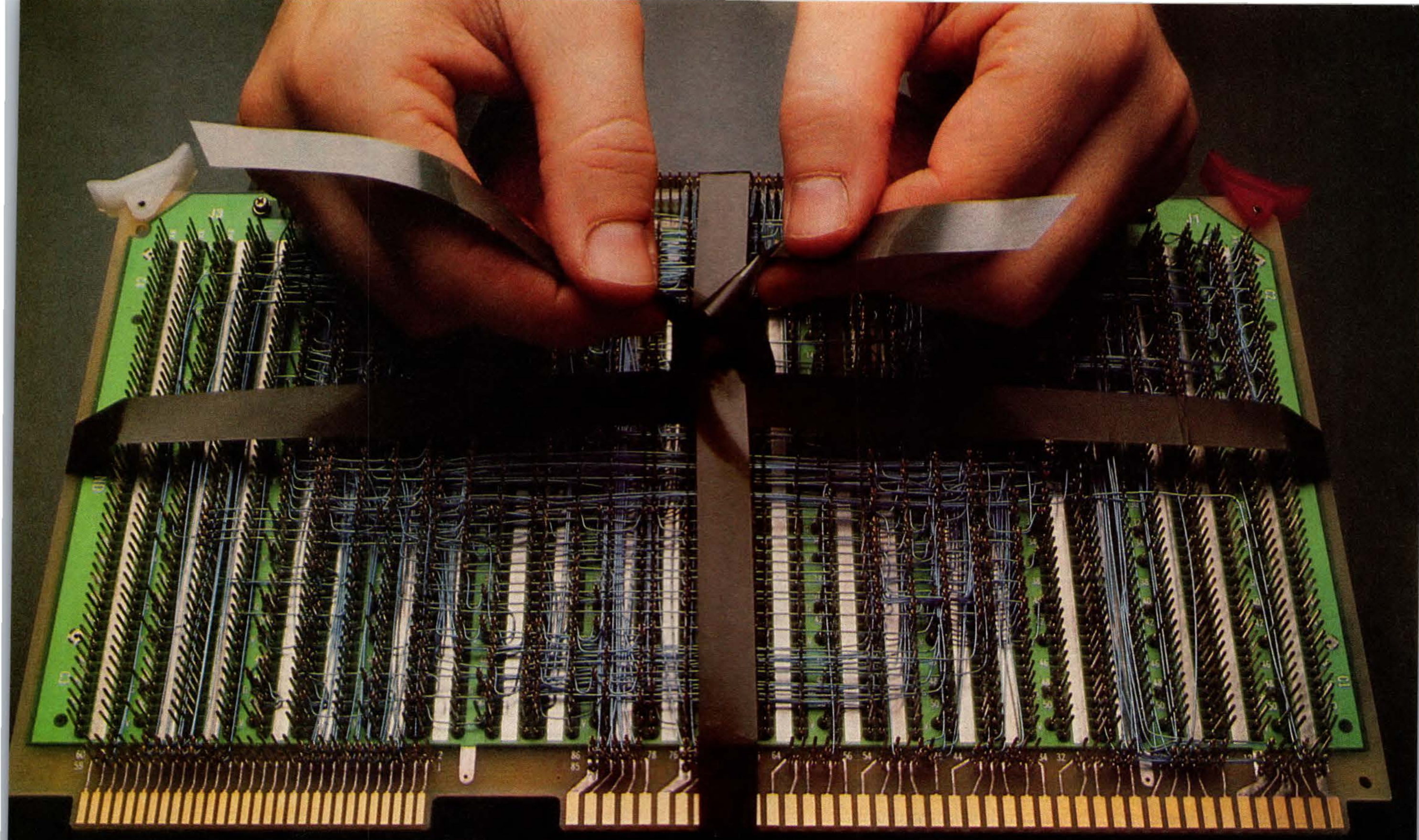

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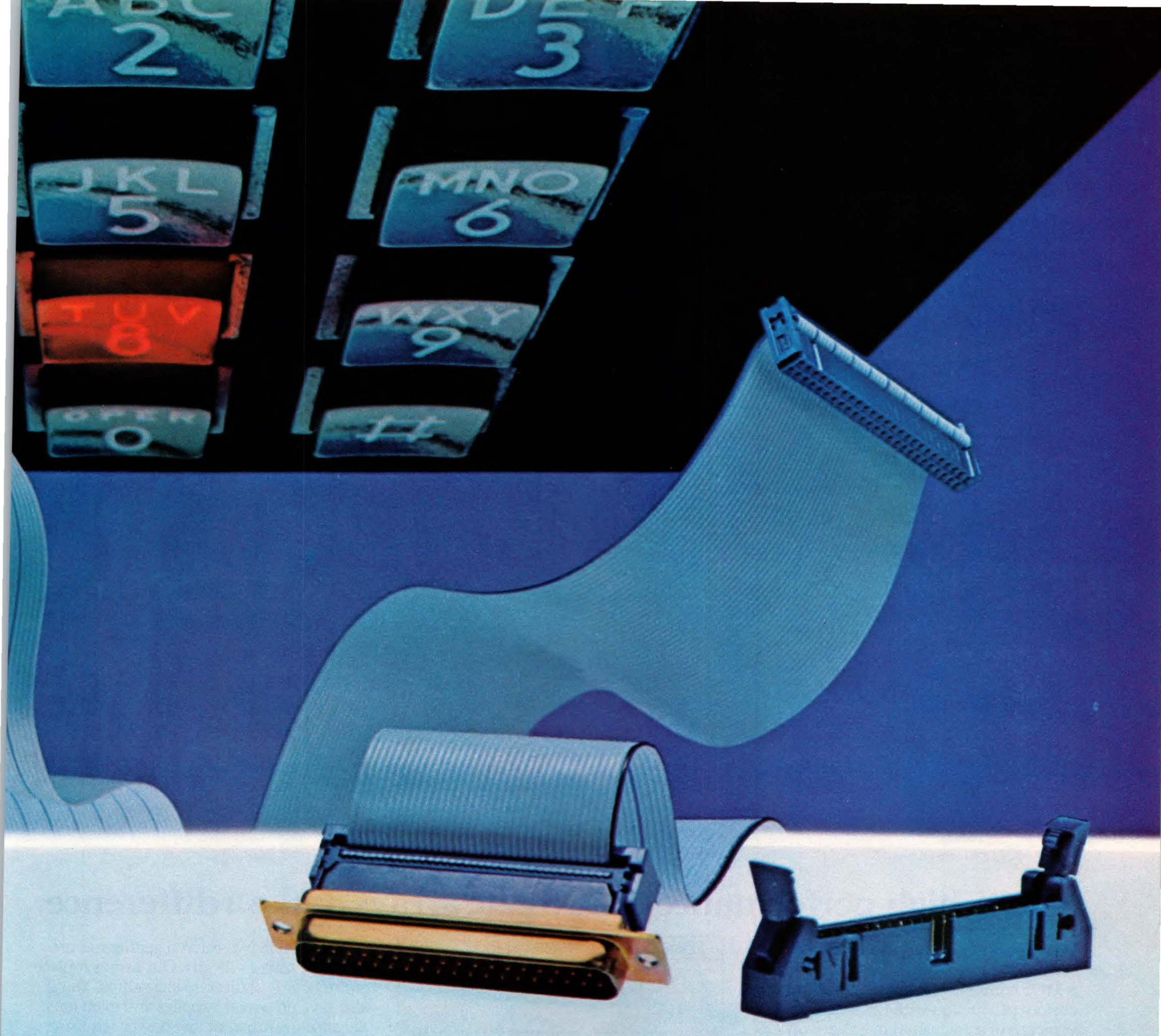

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CIRCLE NO 99

Thorough ESD testing prevents digital-device field failures

Frequently neglected in the rush to market a product, electrostatic discharge can destroy a product line after it's shipped. Problems not seen in the lab can suddenly occur in the field when humidity drops to 20%.

Glen Dash, *Dash, Straus and Goodhue Inc*

As recently as the late 1970s, little was known about the effects of electrostatic discharge (ESD) on digital equipment. However, in the last few years, researchers have found that ESD causes a substantial portion of field failures. Symptoms of ESD problems vary, from loss of data to destruction of the equipment itself.

You can detect and rectify ESD problems early in the design cycle if you follow the procedures outlined in this article. Though much has been written on how to handle individual ICs to avoid ESD damage, this article describes how to test an entire *assembled* system and what to do about problems when you find them.

Modeling the human-ESD event

The human-ESD model is very simple (see **box,** "Body capacitance causes sparks"), and building an ESD simulator would seem to be a trivial task. In practice, however, serious problems with simple ESD simulators cause wide variations in test results. In one study, for example, an ESD simulator with a fast rise time caused computer failure when set to only 4 kV. An ESD simulator with a slower rise time caused no failures even when set to 25 kV.

It follows that the rise time of an ESD simulator is a most important spec, with lead inductance limiting the simulator's rise time. Lead inductance results not only from the lead length between the discharge capacitor in the ESD simulator and the device under test, but also from the length of the supply's return to earth ground **(Fig 1).** Because wires have an inductance of approximately 500 nH/ft and the total lead length can be on the

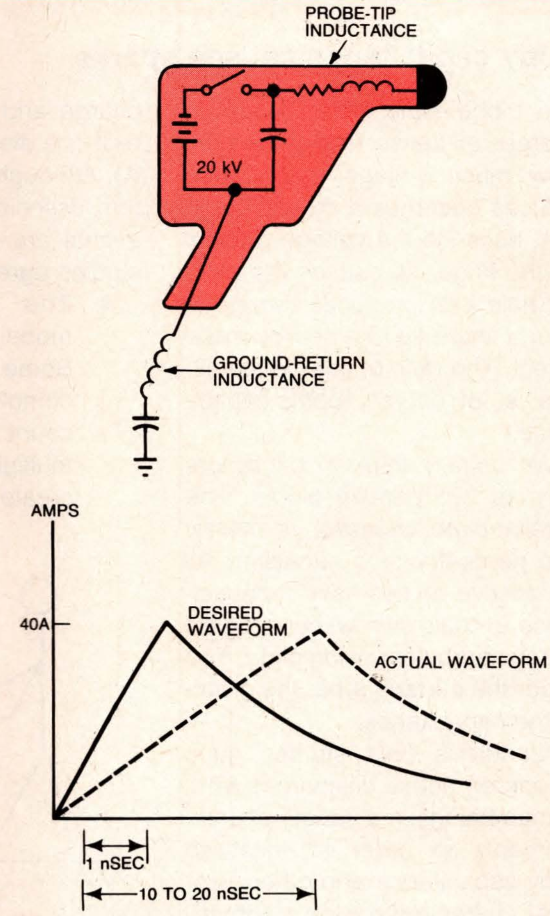


Fig 1—Stray inductance can severely impair the performance *of an ESD simulator, slowing rise time as a consequence. This inductance results from ground-return length or the length of the probe.*

order of tens of feet, rise time is slowed considerably.

In order to understand how lead length affects the rise time, you must understand "earth ground," as it's commonly termed. Although you usually think of capacitors as two parallel planes, a conductive sphere in free space is a capacitor as well, with a capacitance of approximately 1.1 pF/cm of radius. The earth is a very large, conductive sphere with an enormous capacitance. No matter how much charge we place on the earth or current we pass through it, its voltage relative to the rest of the universe doesn't change very much. Because of this effect, we call the earth a "ground." It's a capacitor too big to charge.

Controlling rise time

When you charge the ESD simulator's capacitor to 20 kV, the potential across it remains until a spark is drawn. Current then begins to flow up through the inductive ground-return lead. The total instantaneous current is a function of the circuit's impedance.

The rise time can be highly unpredictable because it depends on the unit's line cord and the building's wiring. Furthermore, at high frequencies, the ground return's impedance is complex, and the waveform produced tends to ring severely.

Grounding the ESD simulator to the case of the device under test is one possible way to shorten the ground-return path and shorten rise time. In this way, return currents flow directly through a shortened return path (**Fig 2**). Unfortunately, this setup can be unreliable. In a natural discharge, a human acts as a capacitor, discharging accumulated charge into a digital device. This device's potential relative to earth ground then rises, and the amount of the voltage rise depends on its physical size, eg, its capacitance. Eventually, this voltage bleeds off through the ground return.

If you use an ESD simulator with its ground-return path attached to the chassis, you cause a current flow that's completely different from a real human-ESD event. Instead of returning through the natural

Body capacitance causes sparks

The triboelectric effect builds up charges on the surface of the skin. How much voltage that charge induces becomes a crucial question, because the voltage present on the finger tip causes the electric field that produces the spark from a finger tip to a nearby metal object. The ratio of charge to voltage is, of course, body capacitance.

We usually think of capacitors only as two parallel plates. The parallel-plate capacitor is merely one geometry of a capacitor. All conductive bodies have a capacitance of their own without regard to any nearby opposing plate. The larger the surface area, the greater the capacitance.

Numerous field studies have measured actual discharges from human beings in a variety of environments in order to establish body capacitance and other electrical characteristics of a human-ESD event. Typically, these studies measure the potential built up on the person prior to the discharge and the short-circuit current of a discharge to ground **(Fig A)**. Although some of the parameters associated with human-ESD events are still controversial, the studies agree on the following:

- The basic human-ESD model is a simple RC circuit. Some propose using more complicated models to account for the occasional multiple discharges and to create a faster rise time. To date, however, only the simple RC configuration is widely accepted. The IEC and the Department of Defense have both opted for the RC approach (through MIL-M-38510).
- The most violent discharges occur when a person holds a metal object. The object enhances the electric field, causing discharge of a higher current. Most human-

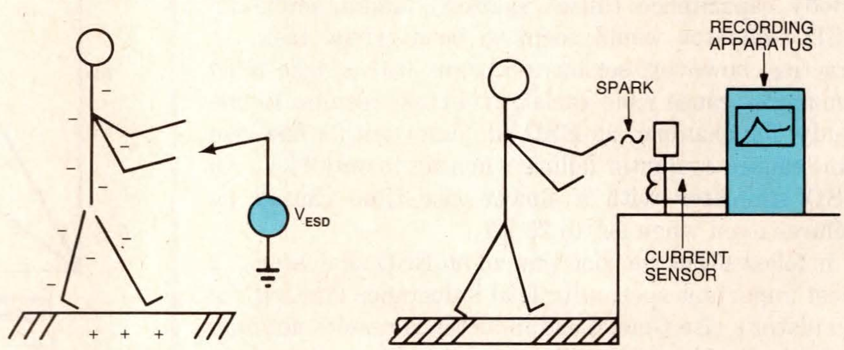


Fig A—By first measuring the open-circuit voltage *on a human's finger tip and then recording the current as the charge is discharged, you can model a human-ESD event.*

ground-return path, the current returns through a shortened path to the simulator, causing different and unpredictable effects. Rather, you should connect the ground-return lead on the ESD simulator to an earth ground, such as a large ground plane on the floor of the test site, which is in turn connected to the ac third-wire ground return.

Getting a good ground

When you set up your test site, then, you shouldn't have to worry about the temperature or the humidity. A well-designed ESD simulator should supply the proper potential, regardless of the humidity. Your primary concern is rise time. Consequently, your test site must have a good reference ground available (**Fig 3**). Because the potential difference between the probe's tip and earth ground causes the electrostatic discharge, you need a ground that won't vary in voltage when a discharge occurs. A voltage variation would reduce the instantaneous current flowing from the probe's tip through the device under test.

Creating a good reference ground poses problems. The third-wire return won't work by itself, because it's inductive and you have no way of knowing how much inductance there is between the test site and earth ground via the lab's ac wiring. You must therefore create a local earth ground. You can do this with a large ground plane.

On the floor of your test lab, you want a ground plane whose potential won't change much during discharge. Like a metal sphere, a metal plate has a free-space capacitance of approximately 30 pF/ft^2. Therefore, a 20×20-ft ground plane has a free-space capacitance of apprroximately 12,000 pF.

The average ESD simulator's discharge capacitor is approximately 150 pF. Therefore, even if the ESD simulator discharged directly to a ground plane of this size, the ground plane's voltage will rise only slightly.

Once you've established the ground plane, you must arrange the facilities to simulate as closely as possible

---

ESD models therefore assume the worst case of a person holding a pointed metal object. The IEC has even adopted a standard for what the probe tip of an ESD simulator should look like.

- Different ESD events result when a human being pushes a large metal object, such as a cart or a chair, against a digital device. Although some authorities propose separate networks to model this event, others consider it to be such a rare event compared with the normal human-ESD discharge that it can be ignored.
- In nature, both positive and negative polarities can build up on human skin. However, there is no clear evidence that testing with either positive or negative voltage produces different effects. Therefore, most simulators and standards such as the IEC standard specify only positive simulator voltages.
- **Fig B** describes the worst-case waveform observed in nature. The rise time can be as fast as 1 nsec, and the current peak as high as 40A. Fall time is on the order of 100 nsec.

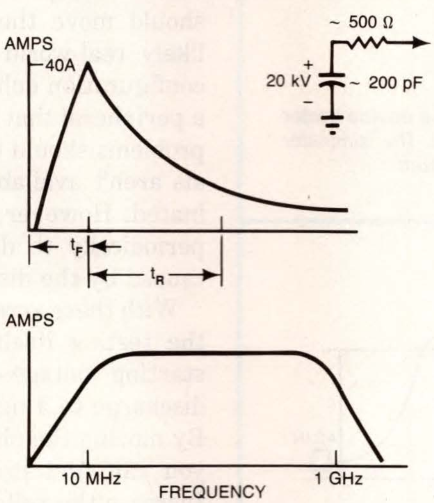


Fig B—The graphs depict a worst-case short-circuit human-ESD event. *The peak current is 40A, minimum rise time is 1 nsec, and maximum fall time is 100 nsec.*

CDI (Boxborough, MA), ETS (Glenside, PA) and Keytech (Boston, MA) make acceptable ESD simulators.

The human-ESD model

You can derive the value of body capacitance (C) and series resistance (R) with simple calculations from the current waveform in **Fig B.** The peak current is 40A. Dividing the voltage that produced the waveform by that current yields the minimum series resistance:

$$20\text{ kV}/40\text{A}=500\Omega.$$

The maximum fall time, from **Fig B,** is approximately 100 nsec. The time constant RC then yields a value for body capacitance C:

$$RC=10^{-7}$$

$$C=\sim 200\text{ pF}.$$

Using similar calculations, the IEC standard specs 150 pF of body capacitance and a 150Ω surge resistance. Many commercial designs in the US use 150 pF and 500Ω.

the kind of environment you'll encounter in the field. In practice, floor-standing units can be in contact with the metal floor, or they can stand on an insulated surface. Because of this, you should test floor-standing devices in two ways: first, sitting directly on the ground plane, and second, insulated from the ground plane with a spacer **(Fig 4)**.

Similarly, desktop units can sit on a metal or an insulated table. Because many of the components of an ESD that cause failure are radiated electric fields, nearby metal objects, like the surface of a metal table, can change test results by altering the incident field on the device under test. Therefore, use both configurations **(Fig 5)**. It's important to ground the metal desk to the ground plane to prevent buildup of potentially harmful charges on the surface of the desk.

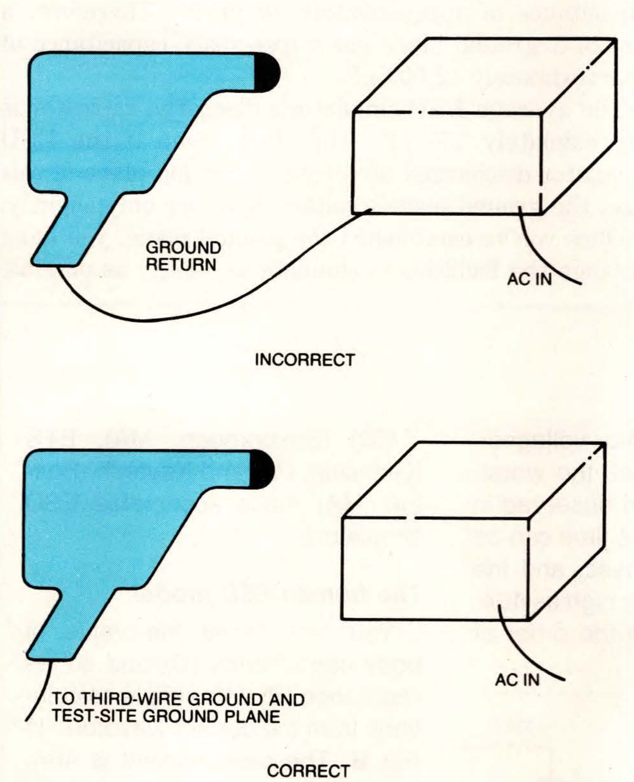


Fig 2—Grounding the ESD simulator to the device under test *produces an unnatural current path. The simulator should have its own independent ground return.*

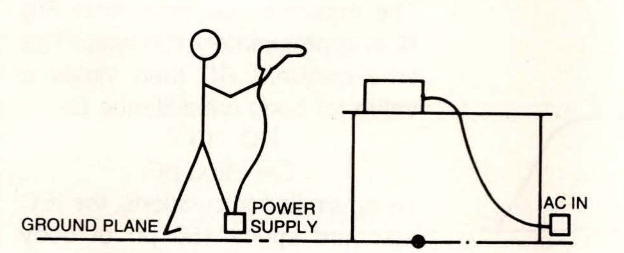


Fig 3—A ground plane on the test site's floor *supplies a local earth ground. The plane has a free-space capacitance of 30 pF/ft². If large enough, a direct discharge to the ground plane will raise its potential only slightly.*

A third feature of the site is simply a small metal plate, which you can move around the device under test. This allows you to simulate discharge to a nearby object, as opposed to the device under test itself. In cases of severe ESD susceptibility, even discharges to a nearby metal object will crash the equipment. Discharging to this "radiating plane" first can help you observe an ESD problem without directly discharging to the unit and possibly damaging it.

You must consider two other features of your test setup before testing. First, the software exercising the equipment under test should interrogate all the devices on the computer's bus, including I/O ports and most memory locations. This interrogation allows ESD problems associated with a particular port or memory location to appear during testing. Any output device should display the results of the interrogations to show state changes that can be inadvertently ignored by a simpler test program. Second, because radiated emissions cause many disruptive ESD effects, you should attach cables to at least one of each kind of port into the device under test.

Cables act as antennas

These cables act as antennas, picking up the radiated emissions and passing them down the cable, where they can be interpreted as true data. During testing, you should move the cables and arrange them in every likely real-world configuration to see if a particular configuration enhances the likelihood of error. Ideally, a peripheral that has been previously checked for ESD problems should terminate each cable. If the peripherals aren't available, you can leave the cables unterminated. However, the I/O lines should then be strobed periodically to detect the presence of spurious data caused by the discharge.

With these arrangements in place, you can proceed to the testing itself. Set the ESD simulator to a low starting voltage—5 kV, for example. Make the first discharge to a nearby object, like the radiating plane. By moving the plane around the equipment under test, you can find problems with poorly designed units. Increase the voltage in 5-kV steps to 20 kV, and make approximately 20 discharges at each voltage level during this initial phase of the test.

If discharges to the radiating plane reveal no ESD problems, you can begin discharging to the device itself to determine at what point the equipment under test is most susceptible and what arrangement of I/O cables and peripherals results in the most system upset. You should probe every point that's likely to be touched by the end user, starting with a low (5 kV) voltage. Pay special attention to keyboards and the connector's shells, because these components are touched frequently. During this phase of the testing, move the cabling and peripherals around to find the positions that cause the most errors.

Once the preliminary scan determines the location of greatest sensitivity and worst-case cable and peripheral placement, you can make a more detailed examination of these spots. Begin by discharging to each of these sensitive locations at least 50 times at a low voltage. Increase the voltage in 5-kV steps to 20 kV and record system errors. If the 50-discharge test produces fewer than the acceptable number of errors, move on to other points on the equipment under test and repeat the examination. All in all, a good ESD test takes approximately 2 to 4 hrs to complete.

ESD criteria

But what are the criteria for acceptable ESD performance? Before making that determination, you must understand that system faults occur in three basic forms:

- Transient system upsets that don't permanently alter the system's operation. These include snow or rolling displays on a CRT or momentary slowdown of a printer.
- Soft errors, which are more serious. These come in two forms. An operator can correct some with a keyboard entry. Others can't be corrected, and the operator can't undo the damage without reinitializing the computer.

You can choose your own criteria for how many transient, soft and hard errors you will allow. However, the standard listed in the nearby **table** is one accepted by many companies. The standard tolerates no transient, soft or hard errors at 5 kV. From 5 to 10 kV, the standard accepts 50% transient errors and 5% correctable soft errors but no noncorrectable soft errors or hard errors. At 10 to 15 kV, there are no specs for transient errors. The standard limits correctable soft errors to 15% and noncorrectable soft errors to 5%. Still, no hard errors are tolerated. From 15 to 20 kV, there are no specs for transient or soft errors. Tests in this range are for hard errors only.

A word of caution: Normally, the energy stored in the capacitor of an ESD simulator isn't high enough to hurt anyone seriously. However, it can cause a discomforting shock and surprise the unwary. To avoid this shock, ground the equipment under test. Metal objects that receive discharge must have a third-wire safety ground.

Curing ESD susceptibility

The cure for radiated interference is most easy to understand if you consider discharge to a nearby metal object and not to the device under test **(Fig 6).** This

ALLOWABLE ERRORS

TEST VOLTAGE	TRANSIENT ERRORS	SOFT ERRORS: CORRECTABLE	SOFT ERRORS: NON-CORRECTABLE	HARD ERRORS
5 kV	0%	0%	0%	0%
10 kV	50%	5%	0%	0%
15 kV	100%	15%	5%	0%
20 kV	100%	100%	100%	0%

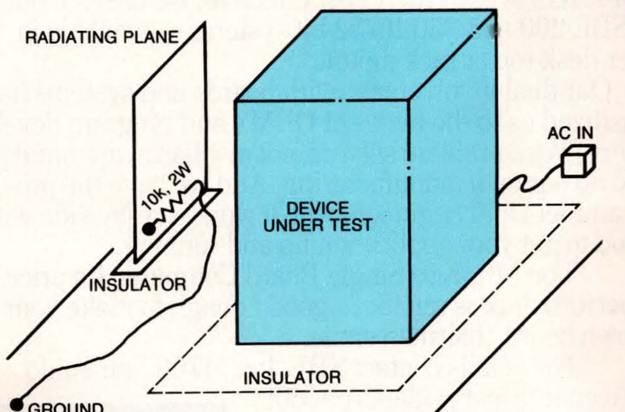


Fig 4—For floor-standing units, *run tests with the device under test both in contact with the metal plane and standing on a 0.5-in.-thick plastic insulator.*

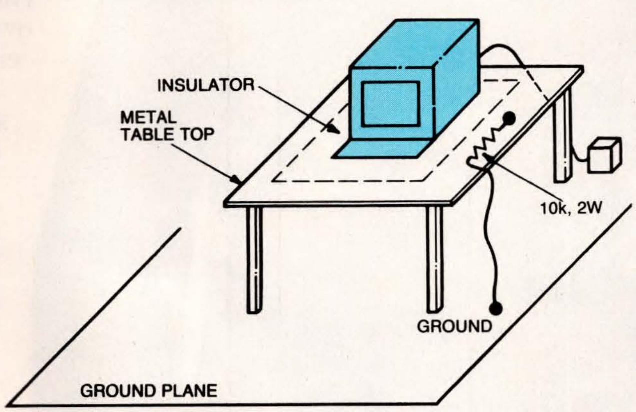


Fig 5—Test table-top units *as you would floor-standing units: with and without an insulating spacer. Be sure to use a metal table top grounded through a 10-kΩ resistor.*

creates an electric field that couples to the device under test. If shielding is inadequate, cables or traces on the pc board act as antennas and pick up the emissions. Because interface cables are the longest antennas attached to a device under test, they act as very good sources for picking up these emissions.

The cures for this interference are straightforward. Shielding—enclosing the entire pc board in a metal shell—can reduce the effect of these radiated emissions on the components. Similarly, you can shield an I/O cable, provided that the cable has a properly designed boot (a 360° metal shell as opposed to a pigtail) connected directly to a metal chassis. As an alternative, you can bypass I/O ports with a small capacitor (on the order of 470 pF). This bypass capacitor, however, must be connected to a good ground—the chassis ground, not the signal ground. In severe cases, a pi filter replaces bypass caps.

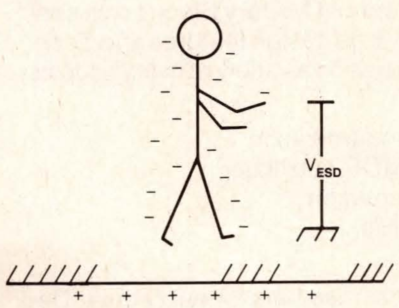
Discharges to the shield of the device under test can also cause radiated emissions. If the shield is a 6-sided, completely sealed metal box, no amount of current passing through the shield will cause radiated interference inside the box. However, discontinuities in the shield, such as cracks, apertures and seams, cause RF voltages to build up on the shield. This RF voltage causes electric fields inside the shield. In a sense, the shield now acts as a radiatintg plane and can excite the I/O cables and internal wiring. Furthermore, bypass caps might be ineffective if the shield doesn't have good integrity. If currents in the shield build up significant RF potentials, these potentials can couple into the system through the bypass caps.

Electrostatic theory explains sparks

In order to understand the cause of a spark, it helps to understand a little electrostatic theory. Conductive bodies—including human beings—acquire a charge by way of the triboelectric effect **(figure).** Two dissimilar materials, like the wool in a rug and the rubber in the soles of shoes, can exchange electrons, causing a person to build up a significant charge. These two materials, rubber and wool, have different affinities for electrons. Wool likes to give up its electrons, and rubber likes to absorb an excess of electrons. Because of this, when you rub the two together, the wool acquires a positive charge and the rubber a negative charge. Through induction or conduction, the negative charge on the sole of the shoes passes through to the body.

Depending on the materials involved and the rate at which they're rubbed together, two different insulating materials will tend to build up charge at different rates. The triboelectric series listed in the **table** ranks materials according to their affinity for absorbing charge. Among the materials that have the greatest affinity for electrons are polyester and teflon. Those that shed electrons most easily include nylon and human hair.

Once the charge begins to build up on a human being as a consequence of the triboelectric effect, a second effect begins to occur: Humidity in the air can bleed off the charge that resides in the surface of the skin. This is why dry environments tend to exhibit more electrostatic-discharge effects. The rate of charge buildup on a human being is the same, but the charge that's acquired bleeds off so quickly in a humid environment that there's no ESD problem.



Movement can produce a charge buildup, *creating a potential V_{ESD} for an electrostatic discharge (ESD).*

THE TRIBOELECTRIC SERIES

POSITIVE +	AIR
	HUMAN HANDS
	ASBESTOS
	RABBIT FUR
	GLASS
	MICA
	HUMAN HAIR
	NYLON
	WOOL
	FUR
	LEAD
	SILK
	ALUMINUM
	PAPER
	COTTON
	STEEL
	WOOD
	AMBER
	SEALING WAX
	HARD RUBBER
	NICKEL, COPPER
	BRASS, SILVER
	GOLD, PLATINUM
	SULFUR
	ACETATE RAYON
	POLYESTER
	CELLULOID
	ORLON
	POLYURETHANE
	POLYETHYLENE
	POLYPROPYLENE
	PVC (VINYL)
	KEL P
NEGATIVE −	SILICON
	TEFLON

Peripheral arrangement influences test results

There are two approaches to solving radiated interference caused by exciting a device's shield. The first approach is simply to make the overall shield as complete as possible. Making the shield a nearly seamless 6-sided box reduces or eliminates internal fields. Furthermore, a continuous metal shield will not have RF voltages dropped across it; bypass caps will thus be effective.

For cosmetic reasons, it might not be possible to make a metal housing with enough electrical integrity to eliminate ESD problems. In this case, try the second approach. Use a second internal shield over the pc board. Ground bypass caps to the second shield and connect the second shield to the first shield where electrical power enters the unit. In this way, although the first outside shield acts as a radiating plane producing fields in its interior, the second shield does not have RF currents flowing through it. It therefore provides the additional shielding necessary for suppression. Often, a ground plane under the pc board or a multilayer board with a buried ground plane can achieve a similar effect.

Conducted interference occurs when the spark jumps onto the pc board and discharges through traces and components. Usually, the cure for conducted interference is insulating areas of the pc board with plastic or a nonconductive compound to prevent the spark from jumping onto the pc board itself. Grounding exposed metal parts to the third-wire ground return can also help prevent potentials from building up on these exposed parts. These potentials can cause an arc between these parts and the pc board.

Finally, the role of properly designed software in eliminating ESD problems should not be overlooked. Error-recovery software can often help avoid annoying soft errors. Also, the design of I/O ports can limit ESD susceptibility. Ports must not capture the leading edge of input waveforms; these ports will be quite susceptible to accepting spurious signals when an ESD event occurs. Rather, a strobe should latch the data. This makes coincidence between the strobe and the ESD event necessary to latch spurious data. EDN

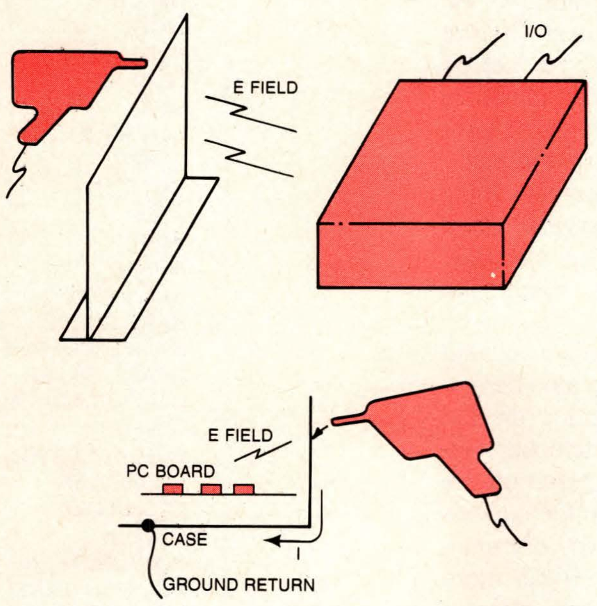
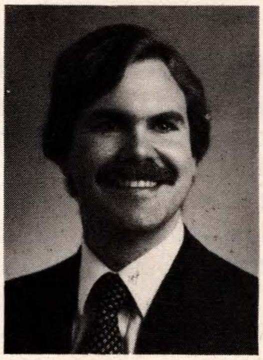


Fig 6—Radiated interference can result *from discharges to nearby metal objects or to the device under test itself. Currents flowing through the metal create RF voltages and E fields, which can be picked up by wires acting as antennas and interpreted as valid signals.*

Author's biography



Glen Dash is president of Dash, Straus and Goodhue Inc (Boxborough, MA), an EMI testing and consulting firm. In addition to holding four EMI-related patents, he earned BSEE and MBA degrees from MIT and a law degree from Harvard. Glen is a member of the American and Massachusetts Bar Associations and lists softball and collecting antique radios and phonographs as outside interests.

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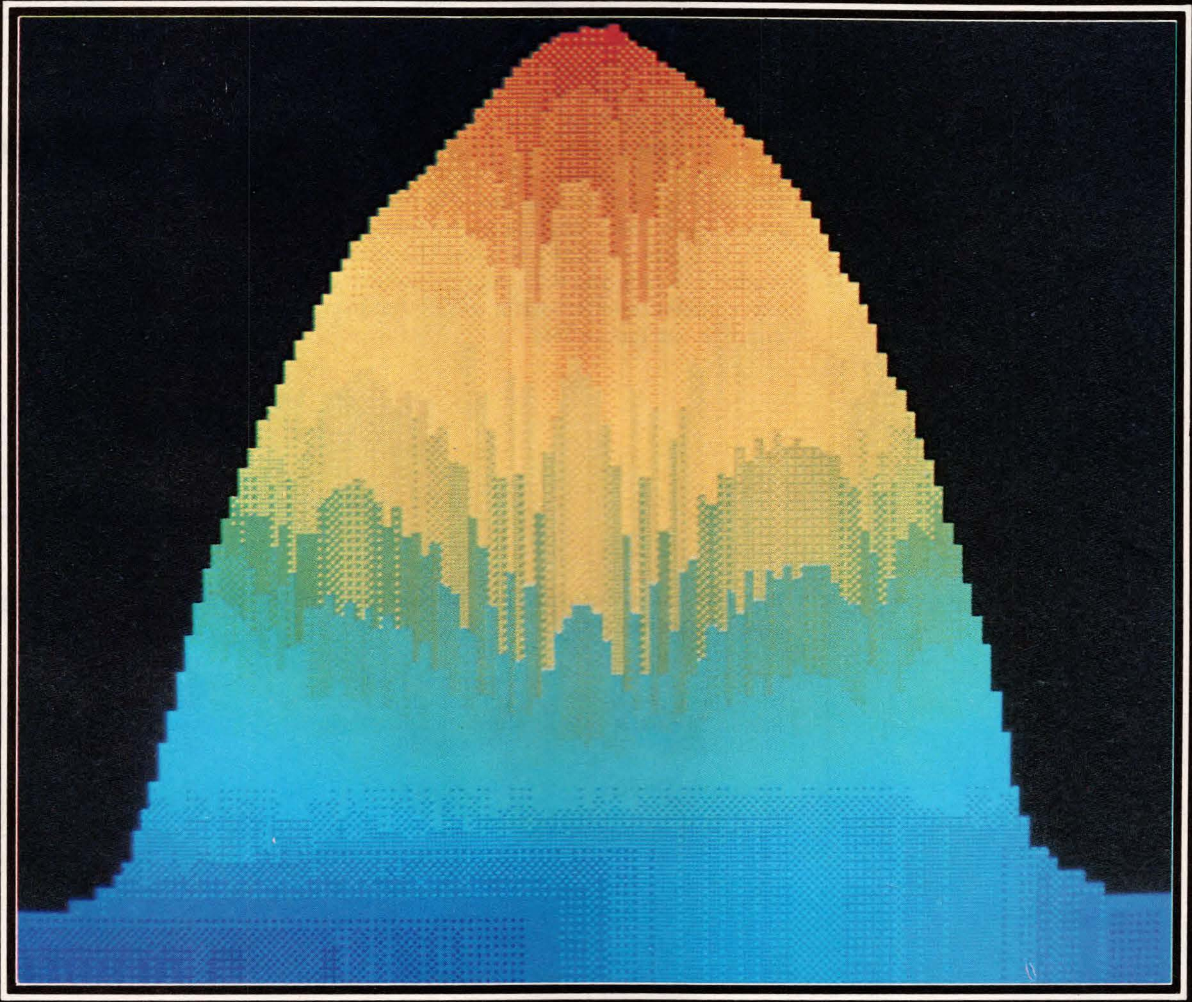

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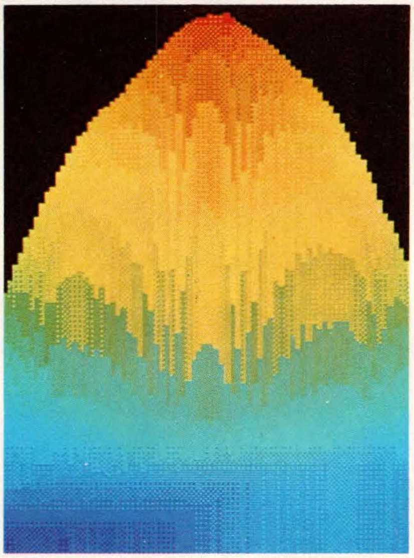

Dear Readers:

I'd like to thank all of you who responded to our Technical Article Database Survey in the January 12, 1984 issue of EDN.

This version of the database index is a direct result of that survey, where the highest vote on the question of frequency of publication was 44.5% for two times a year. Therefore, the database index will be published in January and August each year, covering the 6-month periods May 1 to October 31 and November 1 to April 30, respectively.

Many of you also suggested that we make the index available on magnetic media. Unfortunately, we've not yet been able to find an economically efficient way of doing that with all the different systems available. We haven't given up, though.

In order to make the index easy to use, we have listed many articles under two, or sometimes three, categories, because they may cover multiple topics. For example, an article describing how to integrate a memory into a microcomputer system would be listed under Memories and under Microcomputers in the keyword index.

Your first step in searching for an article should be to see if your topic is listed in the keyword index. If it isn't, try a related but less specific topic. Then go to the appropriate page in the database and scan article titles, which are listed alphabetically within each keyword category. Information provided in each listing includes article title, author, company, magazine name, issue date, starting page number and article length.

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75-MHz, 6-bit flash A/D converter specs full MIL-temperature range. *Travis, Bill, Associate Editor, EDN, 02/23/84, pg 79, 1 pg.*
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30-MHz functional tester offers 16k per channel memory. *Nicholson, Barrie, European Editor, EDN, 01/12/84, pg 96, 1 pg.*
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Low-cost programmable sources expand ATE pin-count capabilities. *Gantt, Philip R, Magnetic Peripherals, Anding, Martin, Magnetic Peripherals, EDN, 02/09/84, pg 220, 5 pgs.*
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Program yields active-filter R, C values. *Wolfe, Kenneth, EDN, 02/09/84, pg 232, 2 pgs.*

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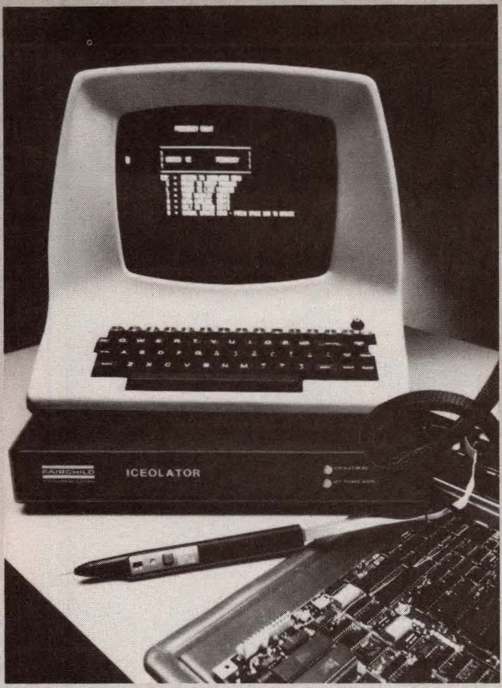

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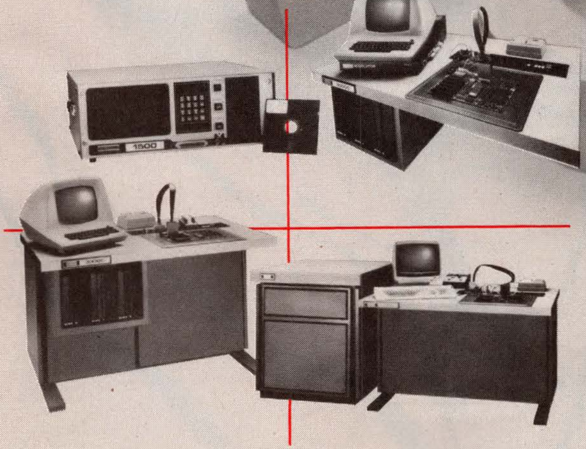

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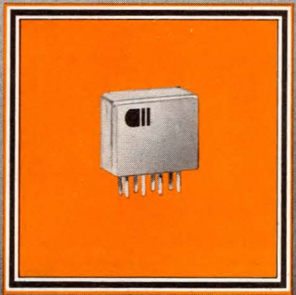

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ISSCC 1984 papers and panel discussions stress semicustom-I/C developments. *Travis, Bill, Associate Editor, EDN, 02/09/84, pg 93, 3.33 pgs.*
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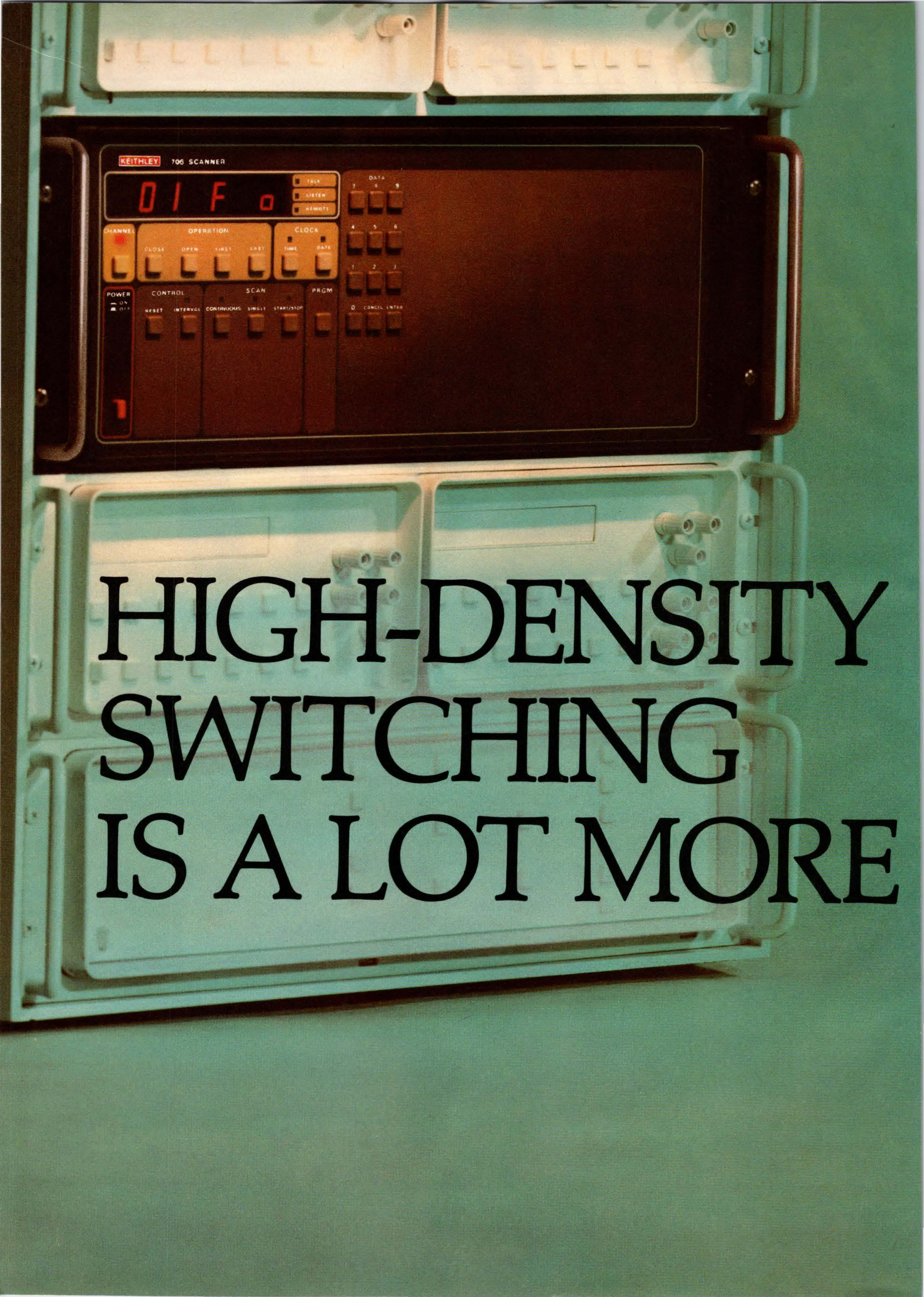
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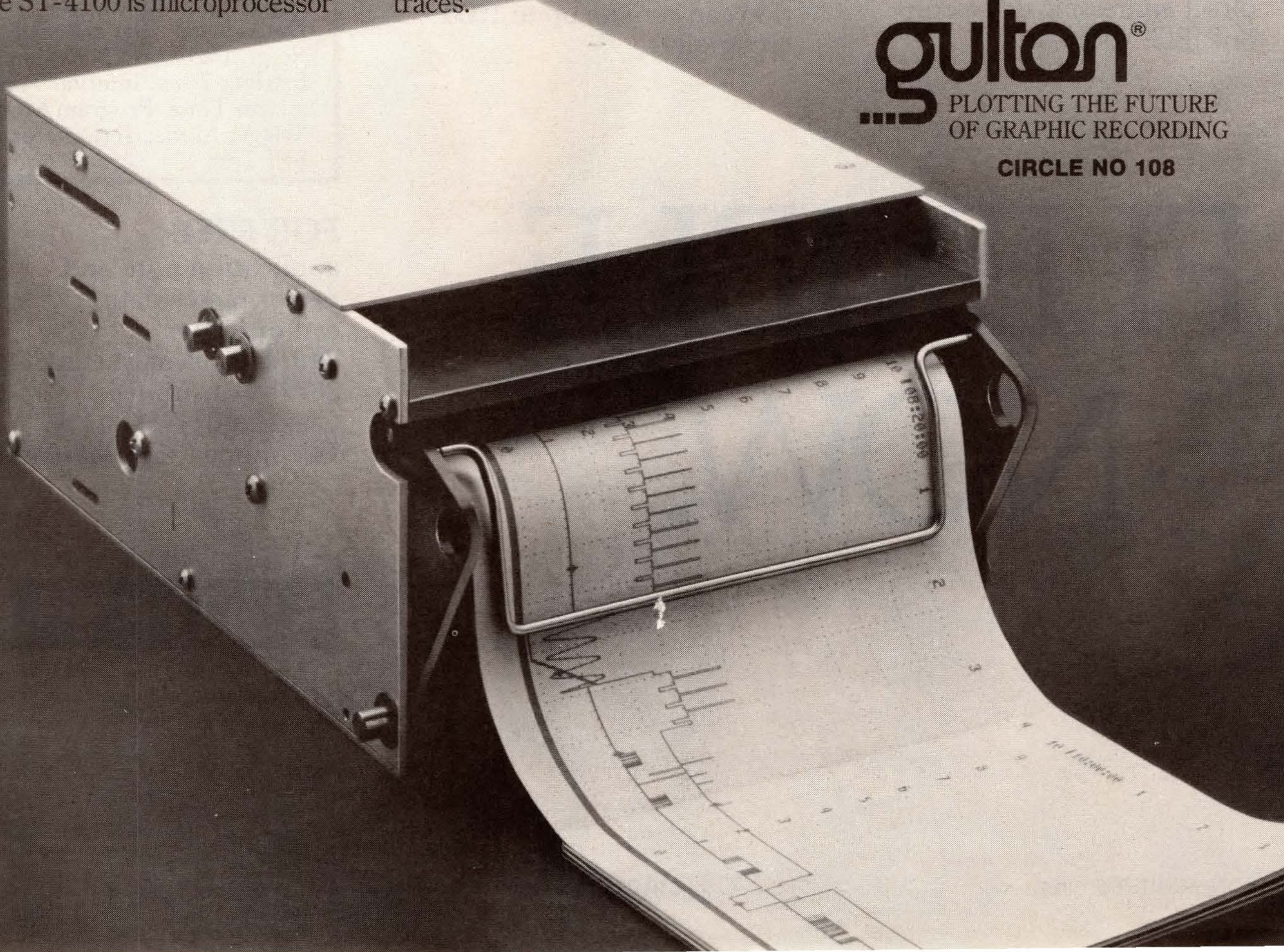

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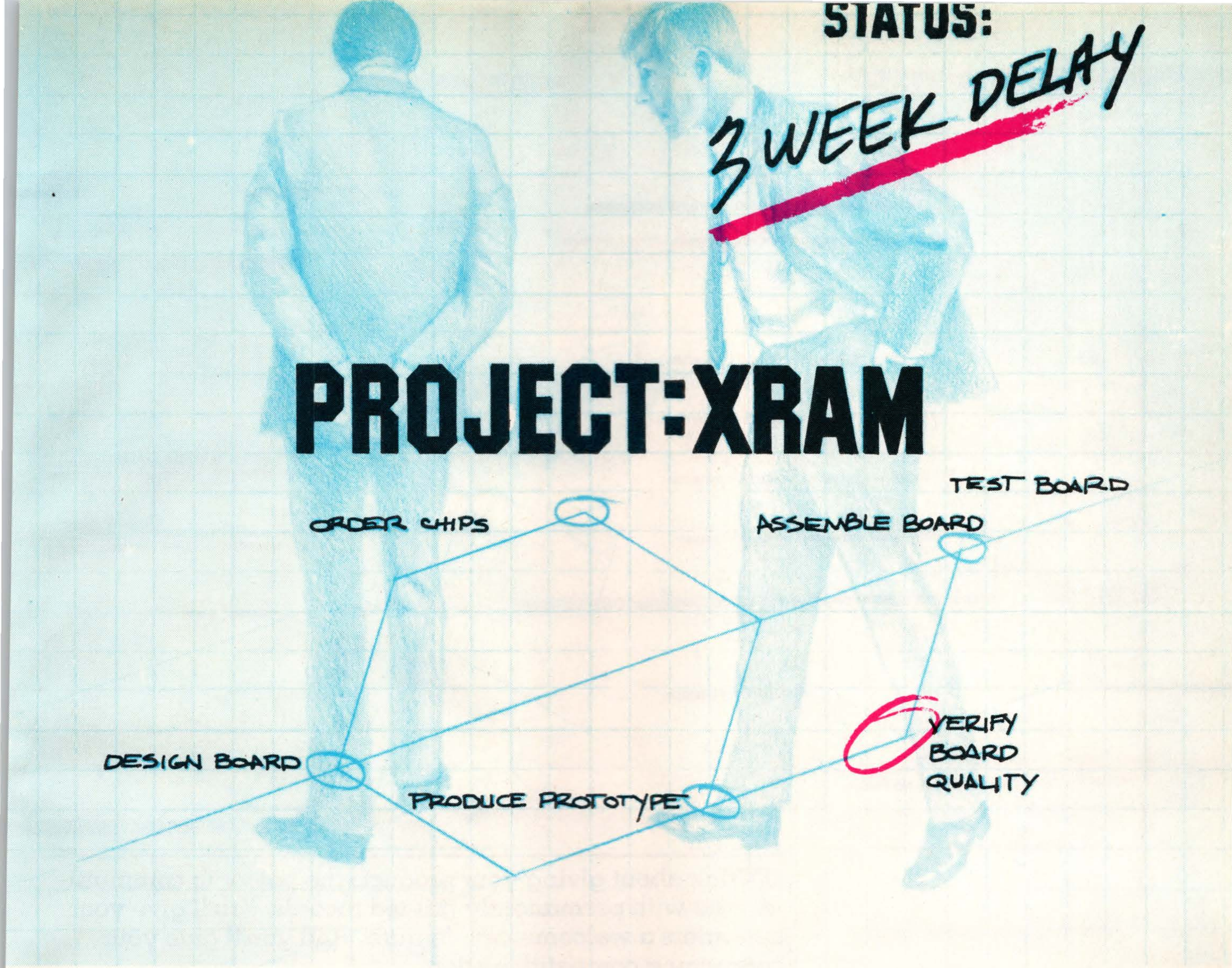

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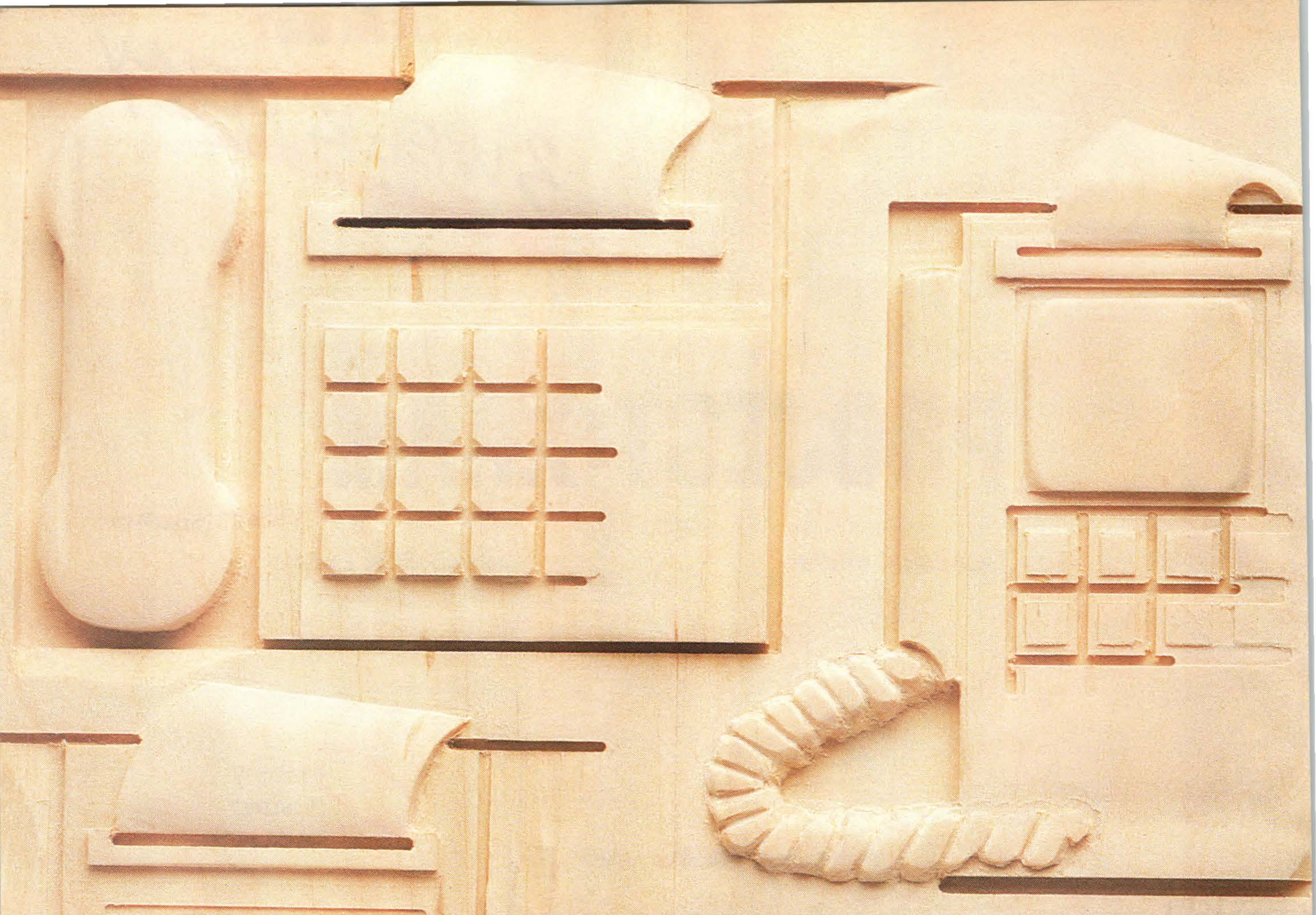

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Printing Direction	Left to right						Character: Bi-directional logic seek Graphics: Uni-directional logic seek	
Number of Columns	13	16	20	24	32	40	42	40
Character Size (WXD) (mm)	2.4 x 1.4	2.4 x 1.1	2.4 x 1.5	2.4 x 1.3	2.4 x 1.4	2.4 x 1.1	2.4 x 1.6	2.47 x 1.88
Character Construction	7 x 5 dot matrix						7 x 5 dots	9 x 7 dots
Printer Supply Voltage (v)	DC 5.0 ± 1						DC 5.0 ± 0.5V	
Printing Speed (lines/sec) Bi-directional			—		—		Approx. 0.5	Approx. 0.4
Uni-directional	Approx. 1.5		Approx. 0.8		Approx. 0.6		Approx. 1.0	Approx. 0.8
Dimensions (WXDXH) (mm)	48 x 31 x 13.8		70 x 34 x 14.4		91.5 x 35.5 x 20		153 x 44.5 x 20	
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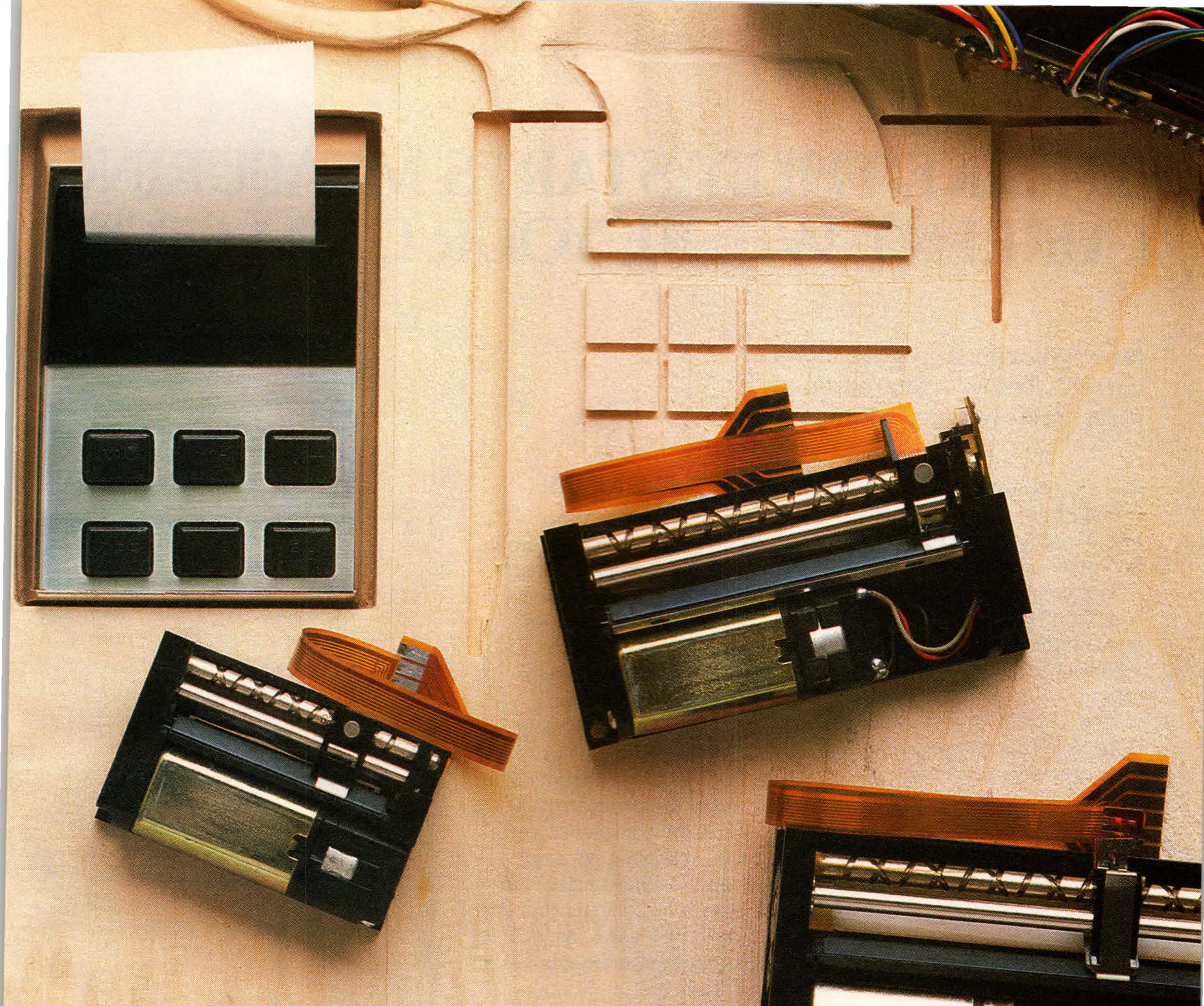

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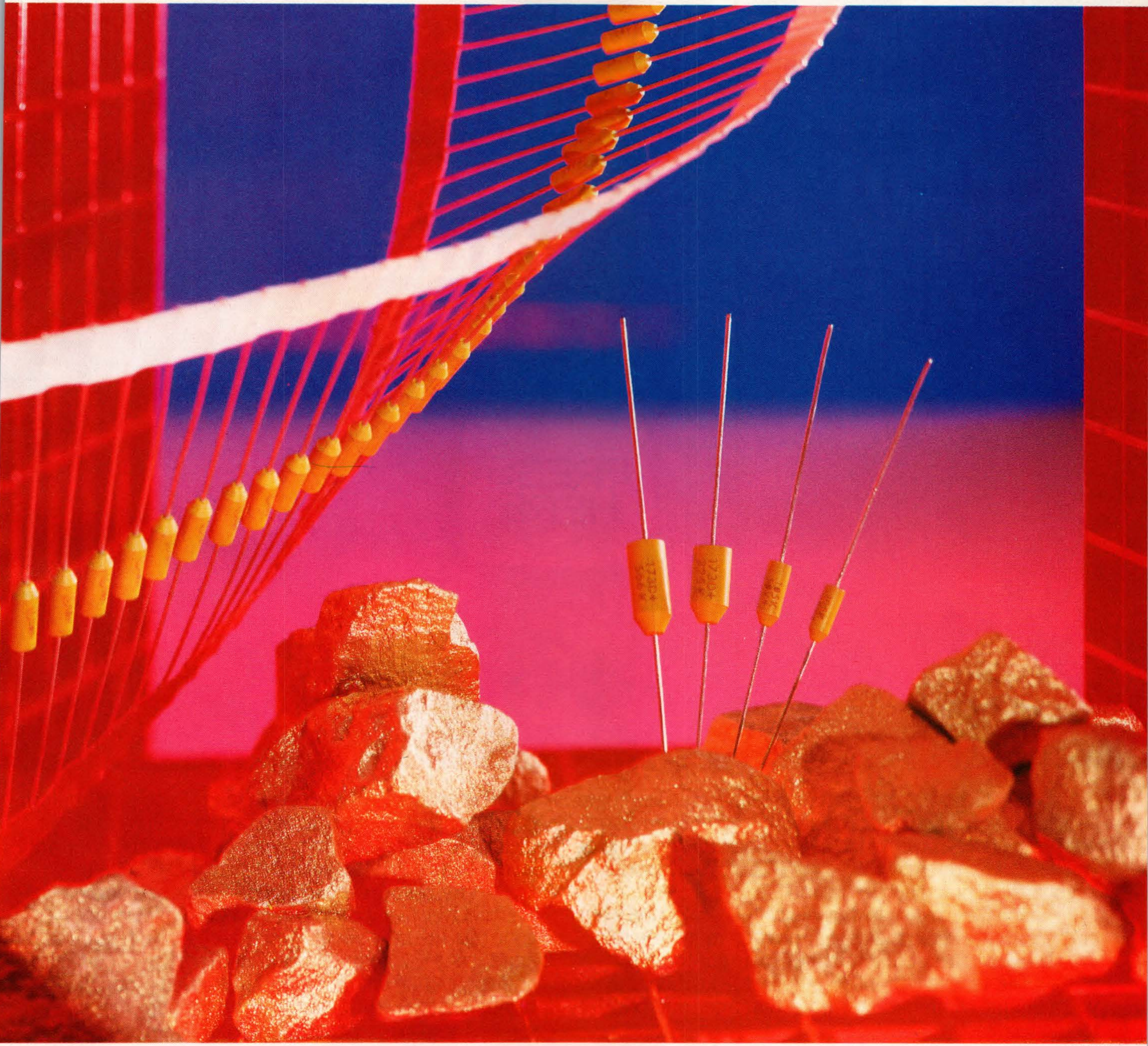

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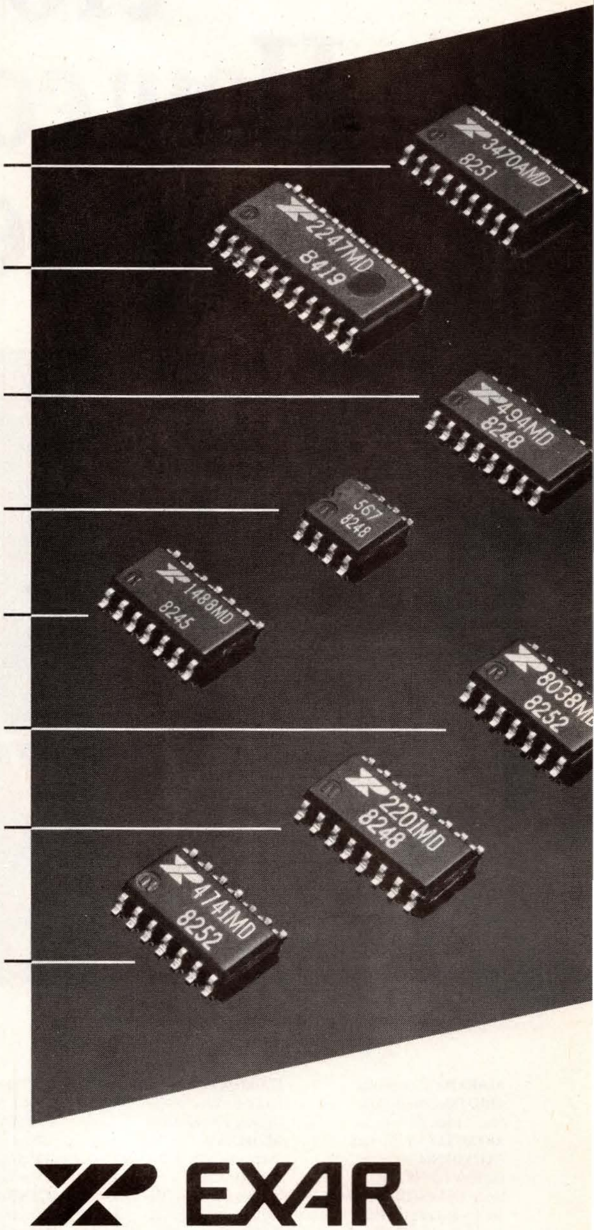

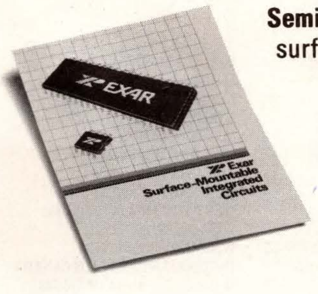

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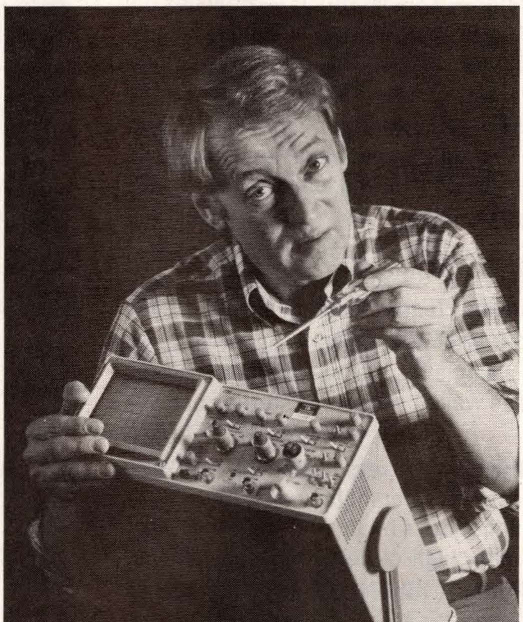

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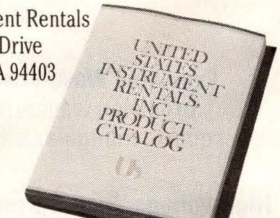

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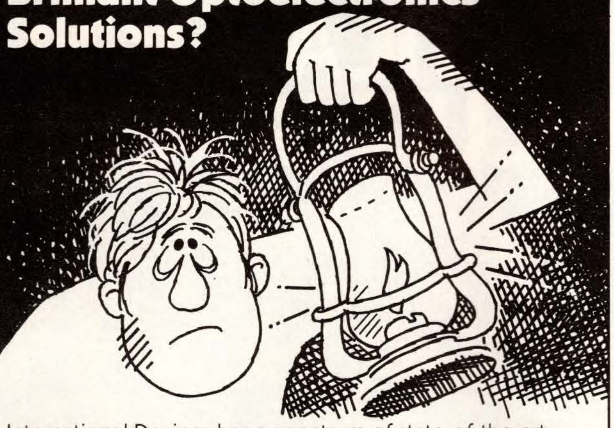

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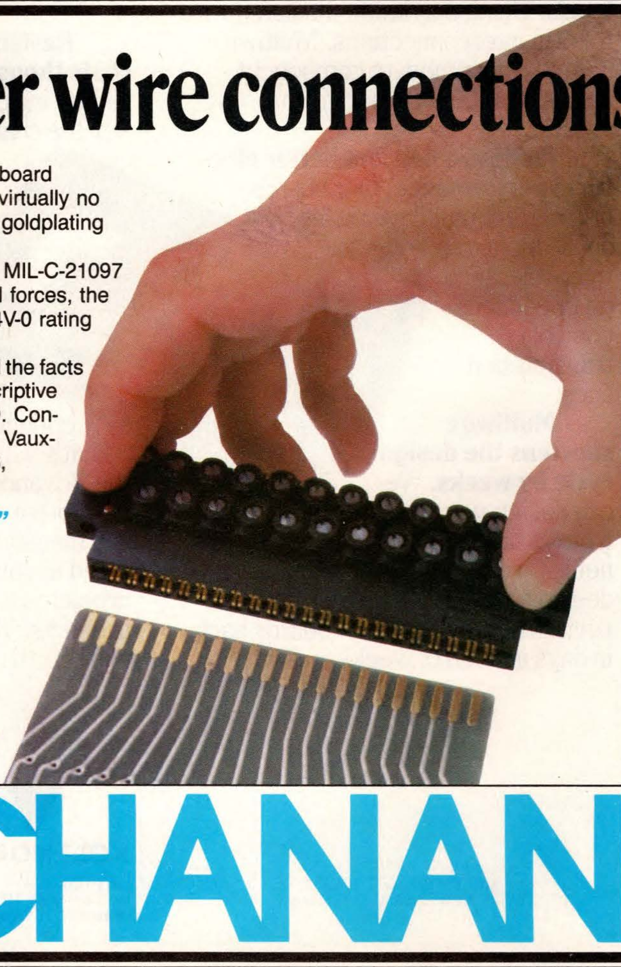

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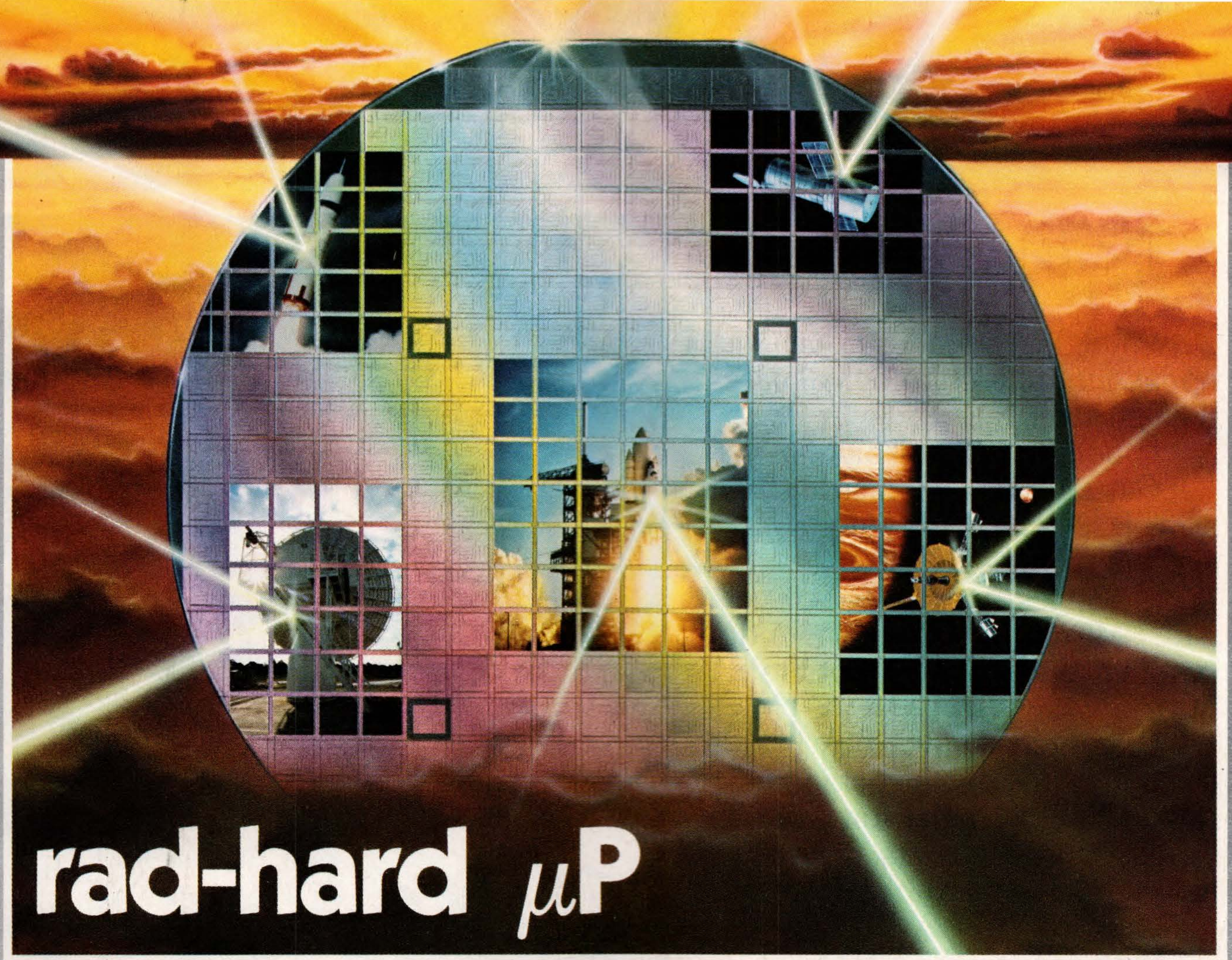

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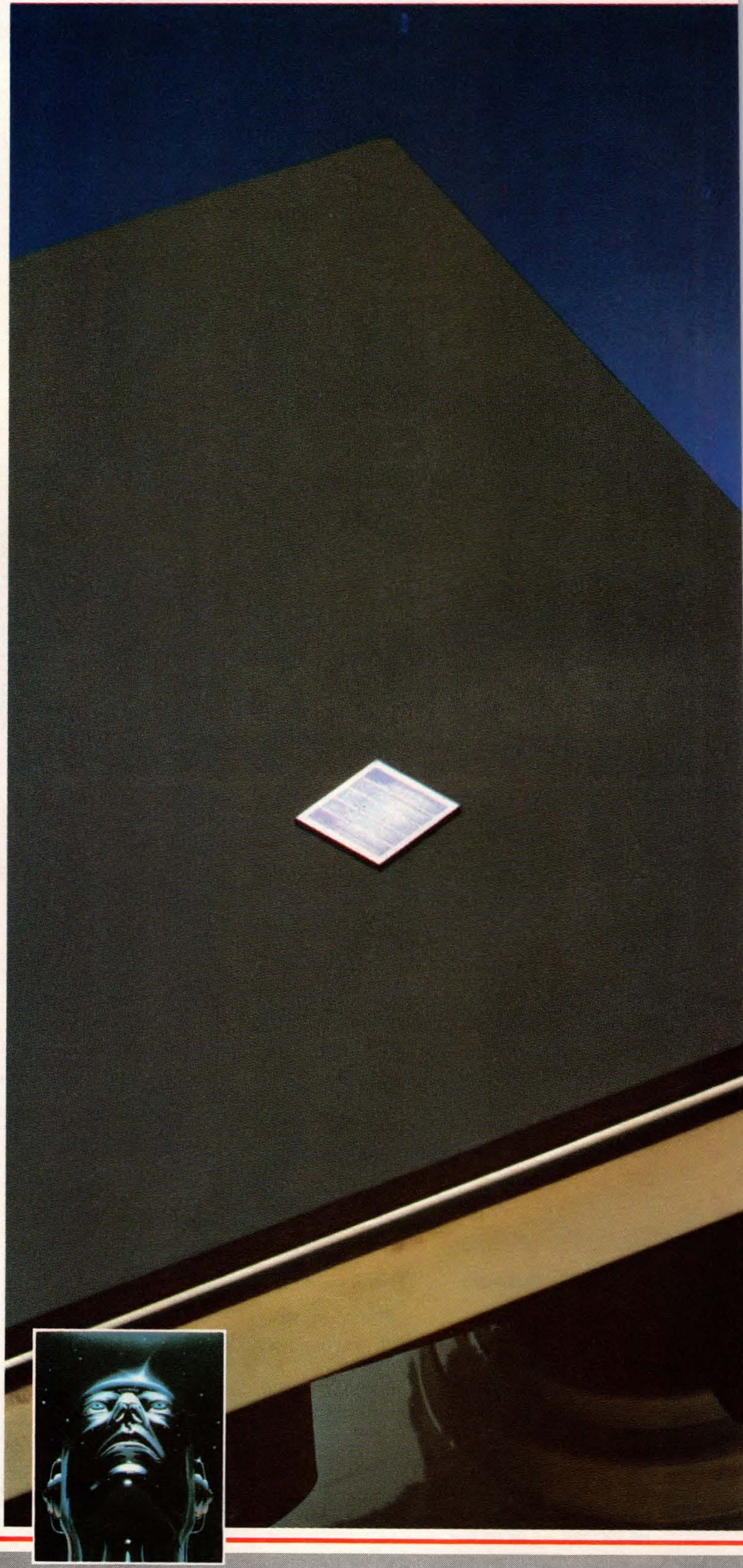

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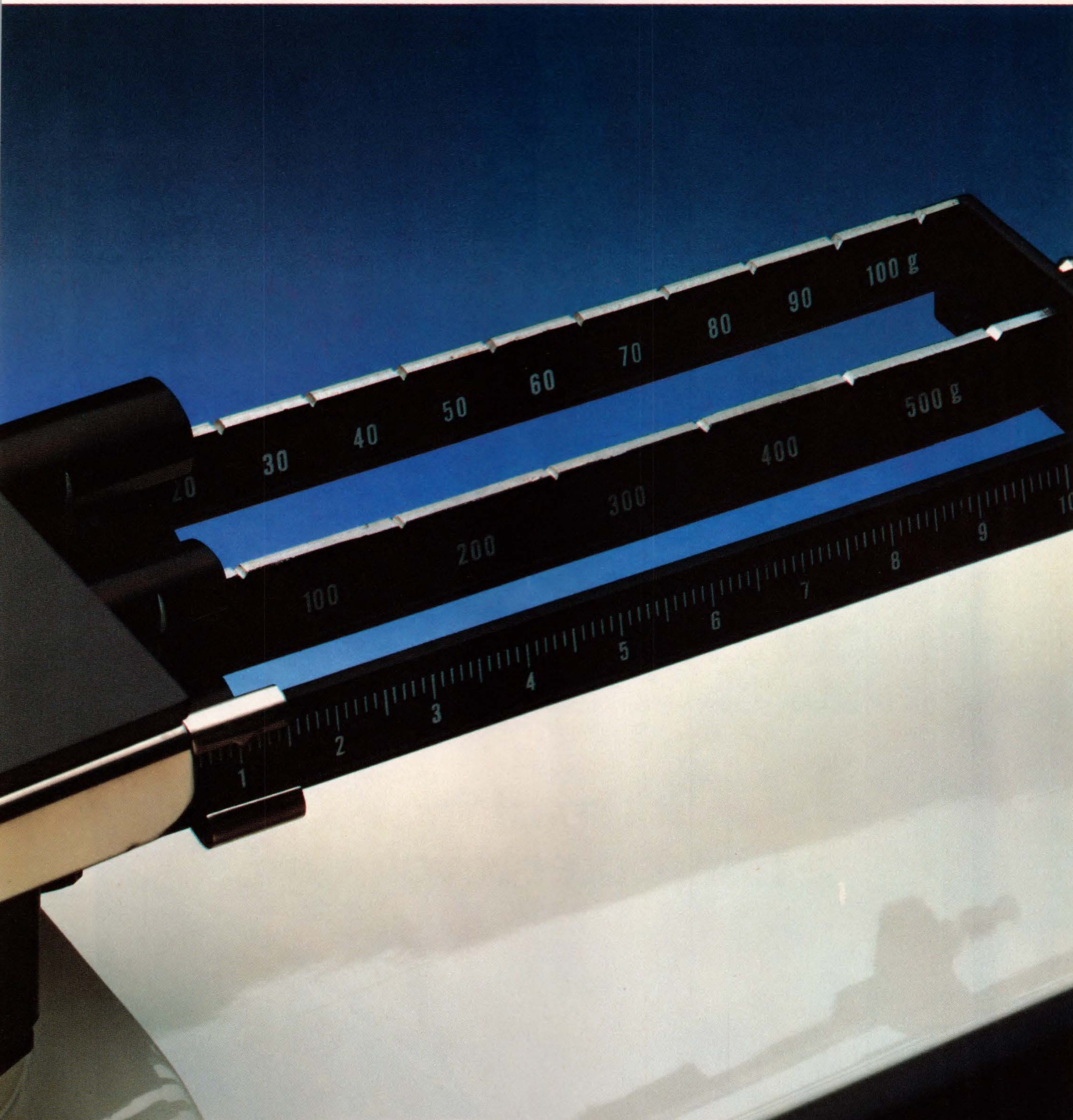

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Voice-output chip stands alone or interfaces to external memory

A speech-synthesizer chip's on-board ROM allows it to provide limited-duration speech or melody output. To satisfy more demanding applications, you can interface the chip to a μP and external memory.

Iftikhar Saeed *and* **Makoto Suzuki**,
Mitsubishi Electronics America Inc

Using the CMOS M50800 single-chip speech synthesizer and a handful of external components, you can design simple low-power voice-output systems suited to battery operation. The chip includes on-board ROM that allows it to produce speech segments as long as 15 to 18 sec, or musical-tone sequences over a 3-octave range lasting as long as 60 sec. Using its internal ROM, the chip can respond to keypad- or μP-generated inputs. In addition, it can interface with external ROM or RAM

VOICE FRAME

PARAMETER	AMPLITUDE	REPEAT	PITCH	K PARAMETERS									
				K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}
CODE BITS	5	1	6	6	6	4	4	4	4	4	3	3	3

53 BITS TOTAL

UNVOICE FRAME

PARAMETER	AMPLITUDE	REPEAT	PITCH	K PARAMETERS									
				K_1	K_2	K_3	K_4	K_5	K_6	K_7	K_8	K_9	K_{10}
CODE BITS	5	1	6	6	6	4	4	4	4	4	3	3	3

53 BITS TOTAL

REPEAT FRAME

PARAMETER	AMPLITUDE	REPEAT	PITCH
CODE BITS	5	1	6

12 BITS TOTAL

SILENCE FRAME

PARAMETER	AMPLITUDE
BIT SEQUENCE	00000

5 BITS TOTAL

MELODY MODE FRAME

PARAMETER	AMPLITUDE
BIT SEQUENCE	00001

5 BITS TOTAL

STOP CODE FRAME

PARAMETER	AMPLITUDE
BIT SEQUENCE	11111

5 BITS TOTAL

Fig 1—A speech-synthesis system *employing the M80500 chip stores data in 53-bit, 12-bit or 5-bit formats corresponding to six types of frames. Depending on oscillator rate and frame-length-programming inputs, a frame represents 7.5, 10, 15 or 20 msec of speech.*

and a μP for additional speech-storage capacity. (See **box**, "A smart single-chip CMOS speech synthesizer.")

Before you can store the speech data in a synthesizer chip's internal or external memory, though, you must digitize the speech waveform, extracting the essential speech parameters and encoding them in a way that uses as little memory as possible.

One method of accomplishing the speech-analysis and -synthesis tasks involves modeling the human vocal tract as a source of two excitations: the periodic excitation originating from the human vocal cords, and the nonperiodic excitation created when air forced from the lungs does not pass through the vocal cords. In each case, air from these sources passes through a series of sound modifiers (the glottis, mouth cavity and tongue) to produce speech. The periodic excitation generates the voiced sounds such as those of the letters a, e, i, o and u. The nonperiodic excitation generates the unvoiced sounds, such as those accompanying pronunciation of the letters h, f and s.

The M50800 synthesizer simulates such a vocal-tract model by employing a multistage, 10-coefficient digital lattice filter. The chip must therefore store the filter's coefficients (K_1 through K_{10}) as well as amplitude and pitch information.

To determine these parameters, you can use Mitsubishi's Melvas 83, a voice-analysis system that uses a partial-autocorrelation (PARCOR) technique to analyze human speech, animal voices and sound effects from recorded tapes or microphone outputs. It samples speech at 8- or 10-kHz rates. For each sample period, called a frame, the speech-analysis software extracts 12 speech parameters required by the M50800: amplitude, pitch and 10 filter coefficients. The software processes these parameters, performs an amplitude compensation and packs each parameter into a bit stream corresponding to a decoding table stored in a 328×10-bit ROM on the M50800 synthesizer chip.

Note that the frame duration must be sufficiently short that the parameters of the input waveform don't change significantly within one frame period. Speech-parameter encoding normally takes place at a 7.5- to

A smart single-chip CMOS speech synthesizer

Employing 3-μm n-well CMOS technology, the M50800 draws only 10 μA at 5.5V in standby and 2 mA in normal mode. This low current drain, coupled with the chip's 2.4 to 5.5V operating range, suits the device to battery-powered applications.

The 28-pin M50800 contains a 32k-bit ROM, a 7-bit D/A converter and speaker drive circuitry **(figure).** It requires a 4.8-MHz oscillator input and generates a 200-kHz clock output. To allow synchronization with μPs operating at slower rates, the synthesizer can work with oscillator inputs as low as 3.8 MHz, although degraded speech quality results.

The chip manipulates speech data in blocks corresponding to frames—periods sufficiently short that speech parameters can be assumed to remain relatively constant during them. The chip's FR_0 and FR_1 pins allow programming of frame duration: High/High, Low/High, Low/Low and High/Low inputs on FR_0/FR_1 yield, respectively, 20-, 15-, 10- and 7.5-msec frame lengths.

The synthesizer can store on chip sufficient data to produce 15-sec speech segments when operating with a 3.8-MHz oscillator and a 20-msec frame length. The speech segment length reduces to 6 sec when a 4.8-MHz clock and 10-msec frame length are used. The device can interface to external memory for extended speech-data storage.

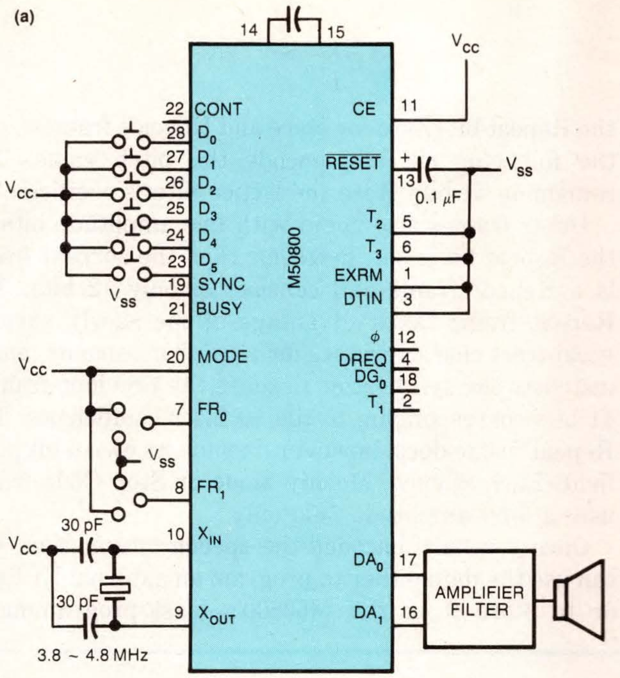
When operating with its internal ROM, the chip requires 5-bit binary-address inputs (on its D_0 through D_5 pins) to begin synthesis. Those inputs can be controlled by a keyboard or a μC. In its μC mode, the synthesizer requires assertion of its Sync input to begin reading data on its pins D_0 through D_5.

When interfaced with external memory, the chip requires a serial data input on its Data In (DTIN) line in response to data-request pulses from its Data Request (DREQ) line. Its serial bit rate depends on frame length and oscillator frequency, equaling 2120 bps for a 3.8-MHz oscillator input and 20-msec frame length, and 5300 bps for a 4.8-MHz oscillator input and 10-msec frame length. The chip's Busy line goes High when speech synthesis is in progress; it cannot accept new input data until the Busy line goes Low.

To begin operation, the chip's $\overline{\text{Reset}}$ pin must be pulled Low for at least 5 msec after the supply voltage reaches 90% of its steady-state value. The chip also includes a Chip Enable (CE) input that, when set Low, places the M50800 in a standby mode, turning its internal supply voltage off. In standby, the Busy line goes High, and the chip draws only 10 μA. However, when the power supply or CE input is switched On for the next speech output, you must, if using the μC mode, delay the Sync input for 400 μsec min after the Busy output goes Low.

For more information on the M50800, **Circle No 527.**

(a)



(b)

TIMING REQUIREMENTS

SYMBOL	PARAMETER	MIN	MAX	UNIT
t_C	KEY DEBOUNCE PROTECTION TIME	5		msec
t_{DH}	DATA HOLD TIME	30		msec
t_B	BUSY OUTPUT DELAY	5		msec
t_O	SPEECH OUTPUT DELAY	70		msec

f_{OSC} = 4.8 MHz

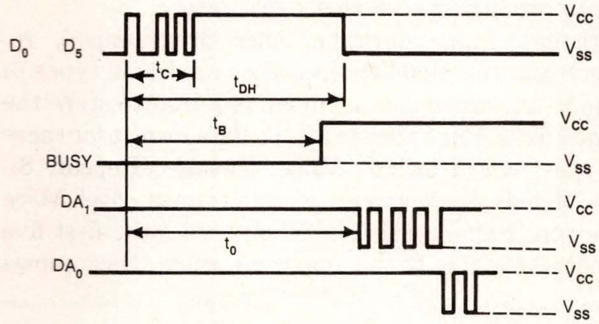
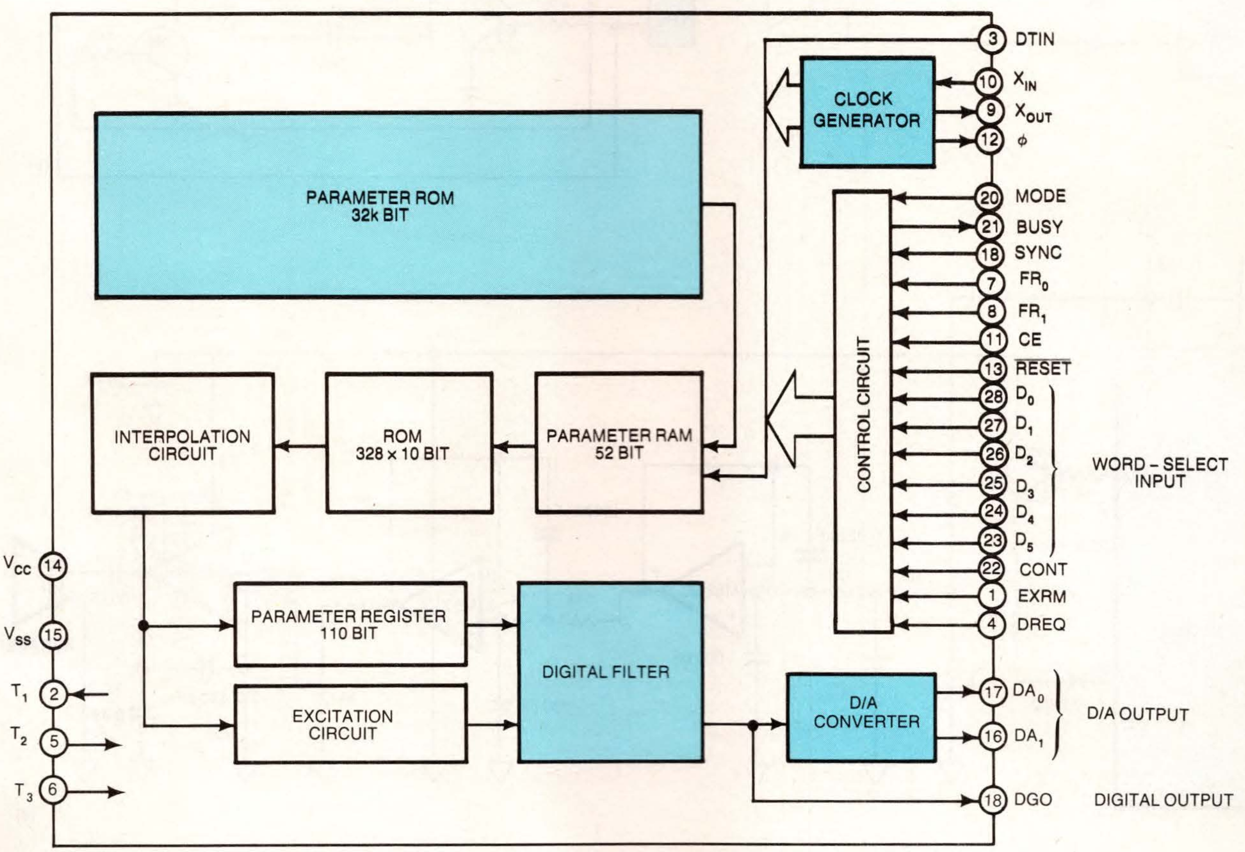


Fig 2—In the key-input mode, *the M50800, along with a 4.8-MHz ceramic resonator, speaker and a few switches, forms a complete speech-output system.*



With on-board ROM as well as a digital filter, *D/A converter and clock generator, the single-chip M50800 can function as a stand-alone speech-output circuit, or it can interface with external memory and a μP.*

A digital filter emulates the vocal tract

20-msec/frame rate. Using the M50800's FR_0 and FR_1 inputs, you can program that chip's decoding frame rate to control speech speed. For example, assuming a 10-msec encoding frame length, you can program a 15-msec decoding frame length to reduce speech speed by 50%. Or, maintaining the same encoding frame length, you can set the decoding frame length to 7.5 msec to produce speech that's 25% faster.

Although frame duration, once programmed, remains fixed, the M50800 recognizes six frame types to minimize the amount of memory required to store the encoded data. **Fig 1** illustrates the data format for these six types, which include Voice, Unvoice, Repeat, Silence, Melody Mode and Stop Code frames. Each Voice or Unvoice frame consists of 53 bits, with the first five bits corresponding to the amplitude value. Next comes the Repeat bit (Zero for Voice and Unvoice frames), and the following six bits encode the pitch value. The remaining 41 bits store the lattice filter's coefficients.

Other frames also begin with five amplitude bits. If the Repeat bit is set, however, then the current frame is a Repeat frame and consists of only 12 bits. The Repeat frame takes advantage of the slowly varying vocal-tract characteristics for continuant sounds, and it instructs the synthesizer to reuse the previous frame's 41 bits corresponding to the 10 filter coefficients. The Repeat frame does, however, include its own 6-bit pitch field. Each Silence, Melody Mode or Stop Code frame uses a 5-bit amplitude field only.

Once you have encoded the speech information, you can use the data either to program an external EPROM or to store it in the M50800's mask-programmable

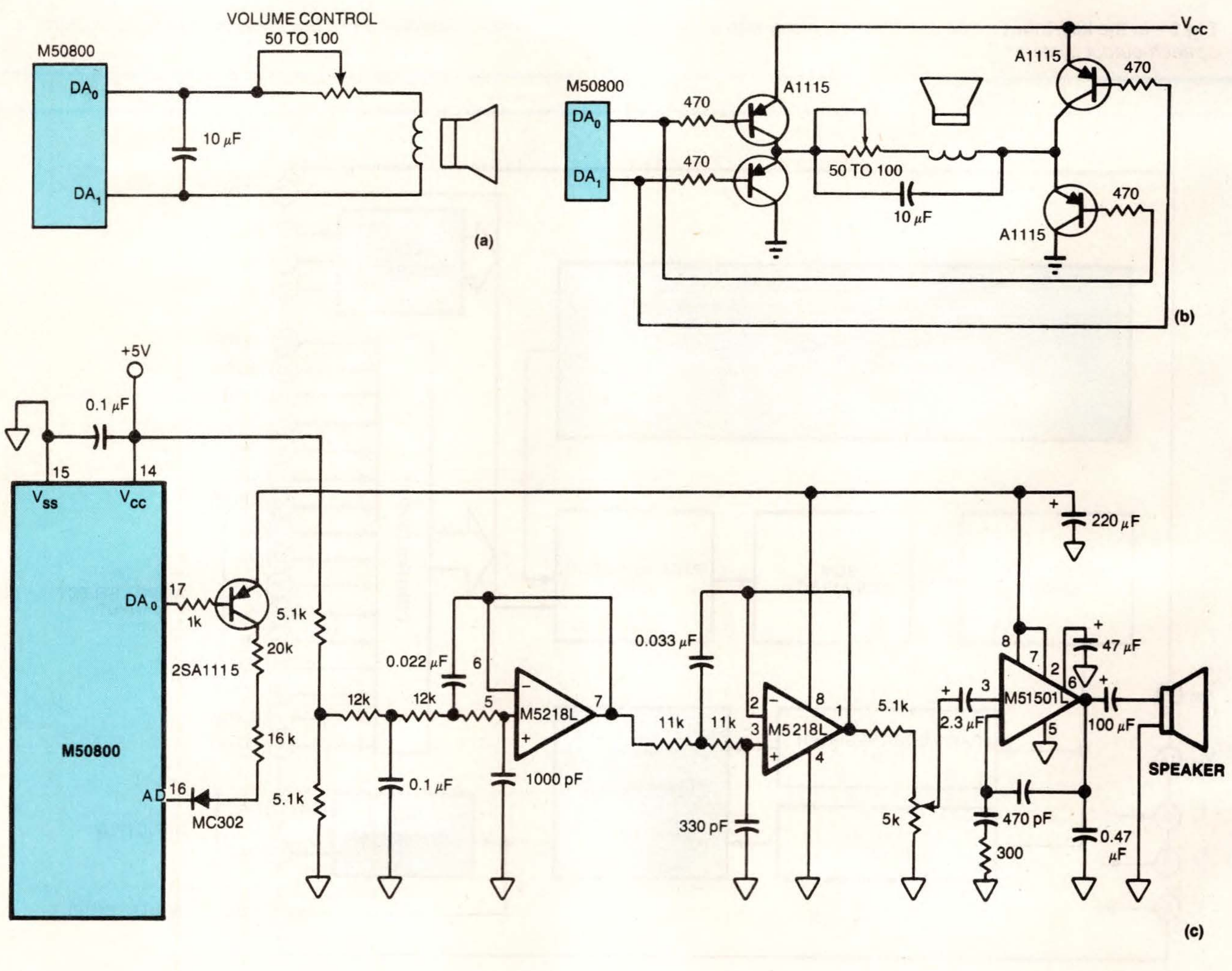


Fig 3—Although it can directly drive a speaker (a), *you can also connect the M50800 to an external amplifier* ***(b).*** *To minimize output noise, you can use an active-filter configuration* ***(c).***

ROM. You can configure the chip for internal or external memory with its EXRM input. During speech synthesis, the encoded frame data from the speech-parameter ROM is transferred to a 52-bit-parameter RAM, which provides temporary storage for the encoded speech parameters. (The Repeat bit is used only as a decision control and is not stored in the parameter RAM.) The encoded data is decoded to 10-bit data by the 328×10-bit ROM-based lookup table.

In the next step of the synthesis process, an interpolation circuit linearly interpolates this decoded data at 2.5-msec intervals to smooth any rapid changes in the control parameters. This action protects the voice spectrum from distortion.

Then, the interpolation-circuit output goes to the parameter register and the excitation circuit. The parameter register is a temporary register that holds the interpolated data corresponding to the amplitude and the K_1 through K_{10} parameters. The register is 110 bits wide, and it uses 10 bits to store amplitude data and 100 (10×10) bits to store the coefficients of K_1 through K_{10}. The pitch-data output from the interpolation circuit drives the excitation circuit, which generates periodic impulses for the voiced sounds, and pseudorandom white noise for the unvoiced sounds. The digital lattice filter, a 14-bit, 10-step matrix filter sampling at 8 to 10 kHz, emulates the glottal (sound source), vocal-tract and lip-radiation effects to reconstruct the speech.

Designing the complete system

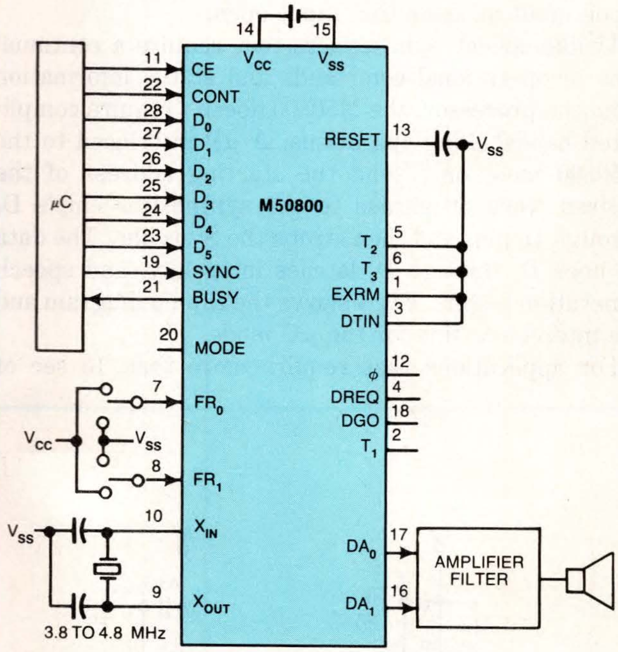
Depending on the duration of speech and the type of control that you need, you can use the chip alone or with external memory and a μP. The M50800 can operate in key-input, μC and external-memory modes.

In the key-input, or stand-alone, mode **(Fig 2)**, you need to add only a 4.8-MHz ceramic resonator, a speaker and a few switches to synthesize 64-word vocabularies. To establish this mode, connect the chip's Mode input to V_{CC}. You can apply the starting address of any one of the 64 words using the switches connected to the word-selection inputs (D_0 through D_5). When any of these pins is set High, speech synthesis begins.

Speech output appears on the DA_0 and DA_1 pins and can directly drive a speaker. **Figs 3a** and **3b** show two speaker drive circuits, one with direct drive and one using an amplifier.

To minimize output harmonic distortion, you can connect a lowpass active-filter and amplifier circuit to the DA_0 and DA_1 pins; **Fig 3c**'s circuit, a 5-pole Chebyshev filter with a 4-kHz cutoff frequency, proves adequate for such applications. The output amplifier can deliver 200 mW, and the filter section provides more than 50 dB of attenuation at 10 kHz.

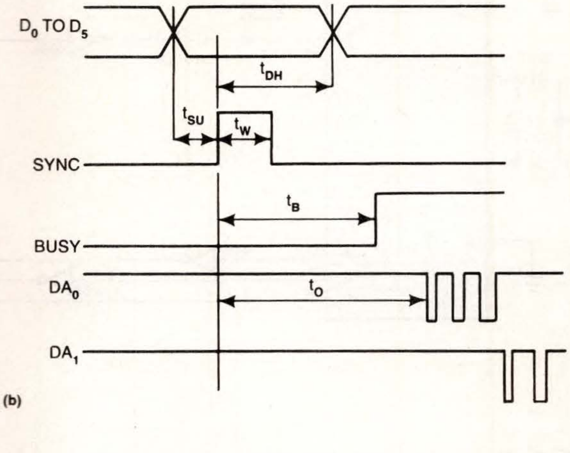
You can replace the switches in **Fig 2**'s circuit with a



(a)

SYMBOL	PARAMETER	MIN	MAX	UNIT
t_{SU}	DATA SETUP TIME	0		μSEC
t_{DH}	DATA HOLD TIME	25		μSEC
t_W	SYNC PULSE WIDTH	15		μSEC
t_B	BUSY OUTPUT DELAY	10	25	μSEC
t_O	SPEECH OUTPUT DELAY*	50		mSEC

*DEPENDS ON SPEECH DATA



(b)

Fig 4—You can replace Fig 2's switches *with a μP by selecting the M50800's μC mode. To configure the chip for that mode, let its Mode pin float.*

Stand-alone operation requires a speaker and ceramic resonator

μP or microcontroller by using the M50800's μC mode. To implement this mode, tie a pull-down resistor to the Mode input or leave that input open.

Unlike speech synthesizers that require a continual flow of operational commands and status information from the processor, the M50800 doesn't require complicated handshaking operations. A μP interfaced to the M50800 must only send the starting address of the desired word or phrase to the synthesizer chip's D_0 through D_5 pins and then strobe the Sync line. The data on lines D_0 through D_5 latches internally, and speech generation begins. **Fig 4** shows the timing diagram and the interconnection for the μC mode.

For applications that require more than 15 sec of speech, you can disable the M50800's internal ROM and interface the chip to external EPROMs, ROMs or RAMs. The upper limit on the external memory's size depends only on the addressing capability of the external μP. To select the external-memory mode **(Fig 5)**, tie the M50800's EXRM input High.

Fig 5's circuit employs an external M5L2732K EPROM and M5M80C49 microcontroller. The latter is a single-chip μC with 2k×8 on-chip ROM and 128×8-bit RAM. The circuit provides a total speech time of 20 sec and can store six phrases.

The M5M80C49 keeps the M50800 speech synthesizer disabled until any one of the six phrases is selected via switches SW_1 to SW_6. Once a switch is depressed, the

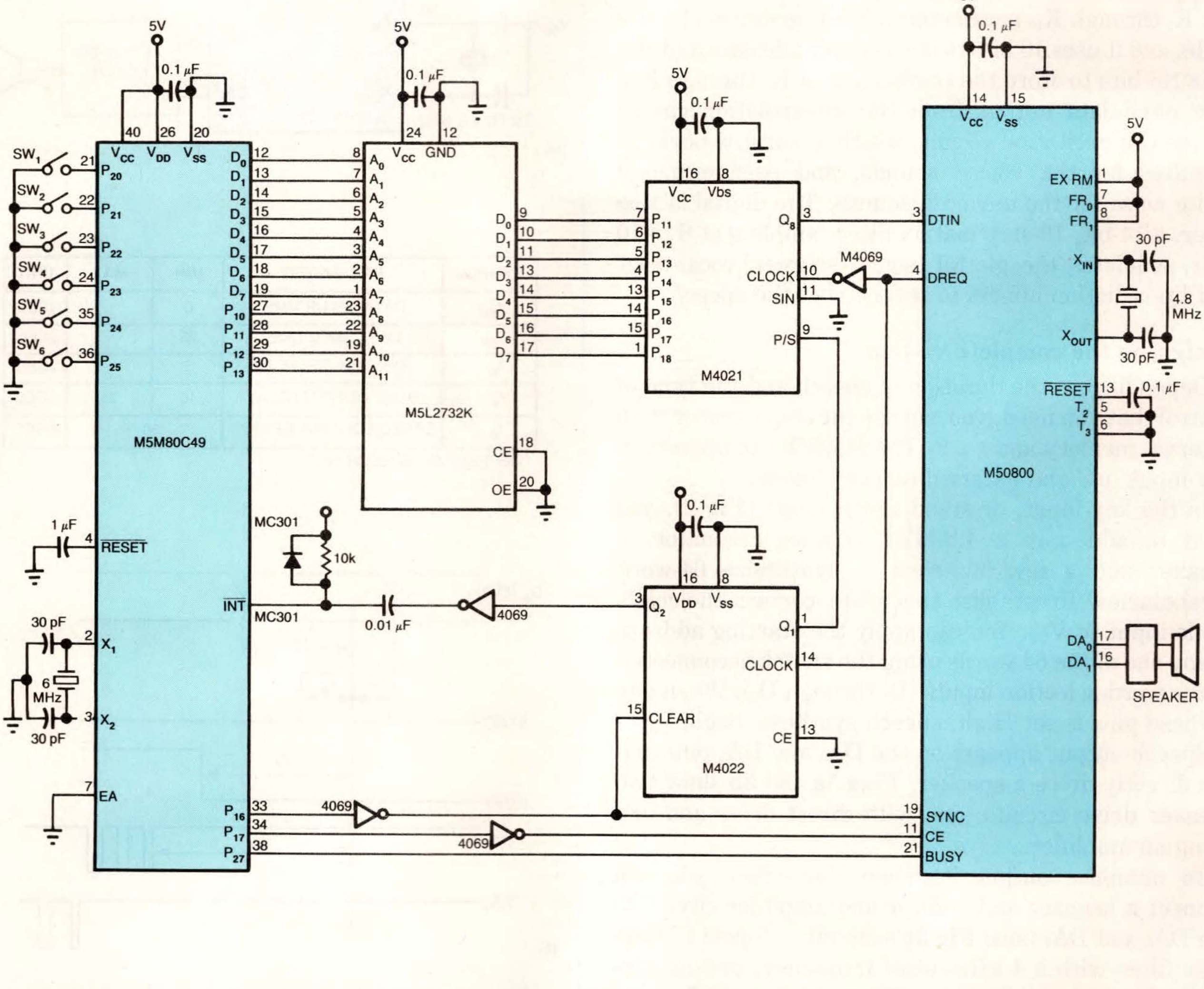


Fig 5—For applications that require more storage *than the M50800's on-chip ROM provides, you can add external memory. The circuit shown here provides 20 sec of speech output. The amount of memory such a circuit can accommodate is limited only by the addressing range of the accompanying μP.*

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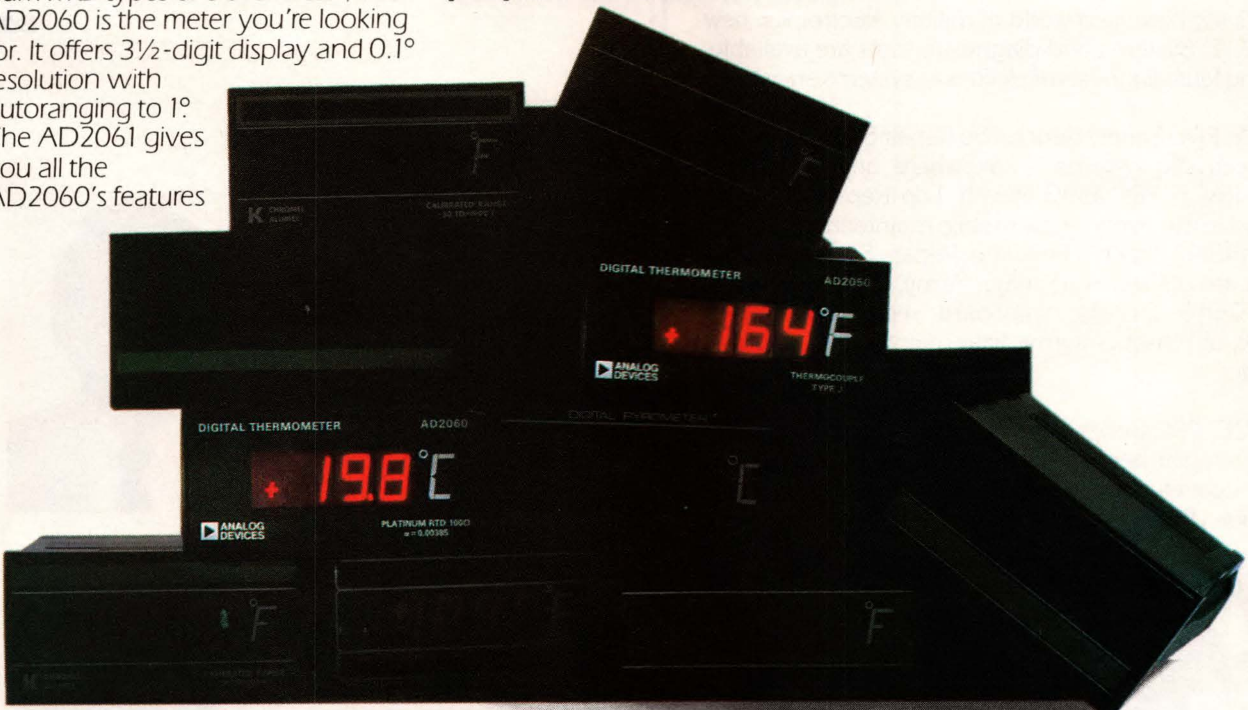

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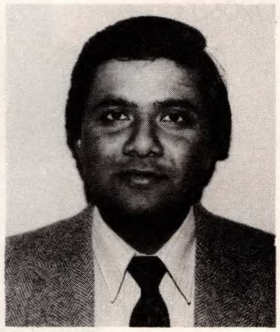
CIRCLE NO 128

External storage allows extended speech-output duration

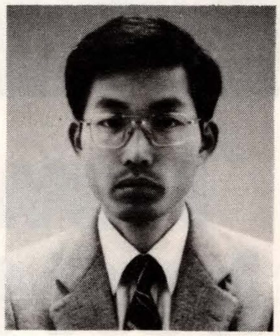
controller locates the starting address of speech data and sends it to data-bus pins D_0 through D_7 and to I/O ports P_{10} through P_{13}. Next, the controller enables the synthesizer's CE pin and strobes the Sync line.

After the Busy line goes Low, the M50800 accepts external speech data on its Data In (DTIN) input. As **Fig 5** shows, shift register M4021 receives the 8-bit speech data from the M5L2732K EPROM. Then, in response to synchronization pulses sent by the M50800 over its Data Request (DREQ) line, the shift register sends the speech-data bits serially to the M50800's DTIN input. After an 8-bit data transfer, octal counter M4022 sends an interrupt to the controller. During the interrupt service routine, the EPROM's address is incremented and sent to the data bus and I/O ports. The data transfer continues until M50800 recognizes the data corresponding to a Stop Code frame. The synthesizer then turns off the DREQ pulses, sets the Busy output High and begins the speech-generation process. **EDN**

Authors' biographies



Iftikhar Saeed is applications engineering manager at Mitsubishi Electronics America (Sunnyvale, CA), where he is involved in applications and marketing for μPs, microcontrollers and speech ICs. Iftikhar holds a BSEE from the University of Peshawar in Pakistan and an MSEE from the University of Tennessee, Knoxville. His hobbies include hiking, personal computing and reading.



Makoto Suzuki is a design engineer at Mitsubishi Electric Corp (Itami City, Japan), where he has been employed for four years. He is currently responsible for the design of speech synthesizers for the company's MOS IC department. Makoto holds a BSEE from Shizuoka University and enjoys tennis and computer games.

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DESIGN IDEAS

Edited by Don Powers

Single switch provides dual function

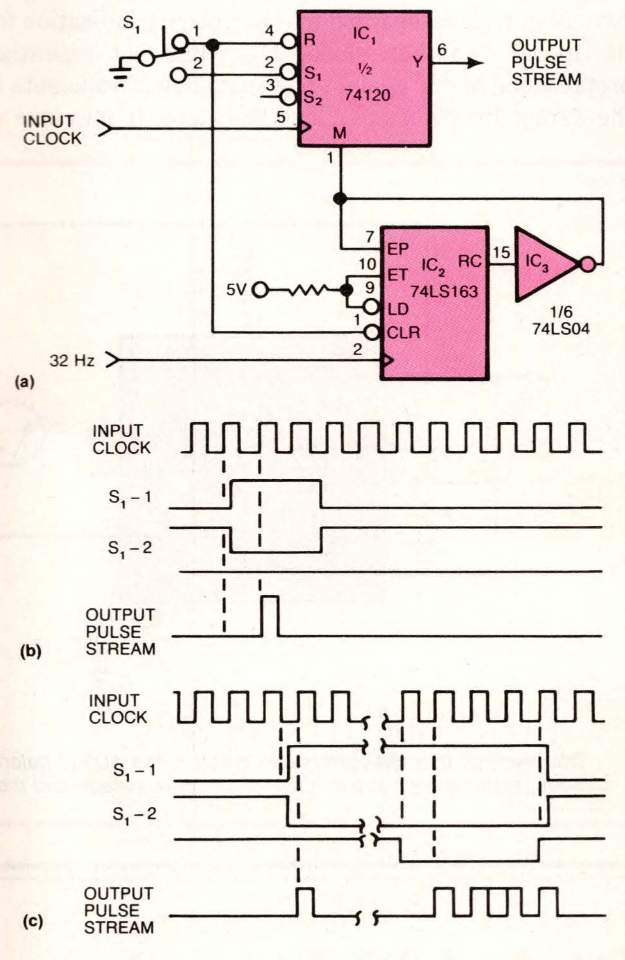
Steve Lubs
Department of Defense, Washington, DC

In electronic equipment where panel space is at a premium, it is sometimes necessary to design controls that perform multiple functions. An example of such a control is a pushbutton-based circuit **(a)** that generates either a single pulse or a pulse train.

When S_1 is switched to position 2, the falling edge of the S1 input to IC_1 triggers that IC's output. This allows a single cycle of Input Clock to gate through to pin 6 **(b)**. Only one pulse goes to the output because IC_1's mode control input (M) is High. IC_1, a 74120, can handle an input frequency range of 0.1 Hz to 30 MHz for a wide pulse-width range, and has an output sinking capacity of 48 mA. After this output pulse is generated, you must reset IC_1 (S_1 returned to position 1) before it can be triggered again.

However, if the switch is held in position 2 long enough for IC_2 to cycle through 16 counts, IC_2's RC output goes High, disabling the counter and applying a low level to IC_1's M input. IC_1 now passes the Input Clock, beginning with the next complete counting cycle, until the R input is again Low **(c)**. On the next rising edge of the clock after clear goes Low, IC_2 is cleared, ready to begin another counting cycle. A 32-Hz clock into IC_2 develops a ½-sec delay between the single clock and the beginning of the pulse train; change the delay by adjusting the clock rate of IC_2. **EDN**

To Vote For This Design, Circle No 744



Using a pushbutton and a few ICs (a), *you can generate either a single-pulse output* **(b)** *or a single pulse followed by a pulse train* **(c)** *whose duration is a function of how long you depress the switch.*

IC simplifies autopolarity-meter design

Steve Kirby
Analog Devices Ltd, E Molesly, Surrey, England

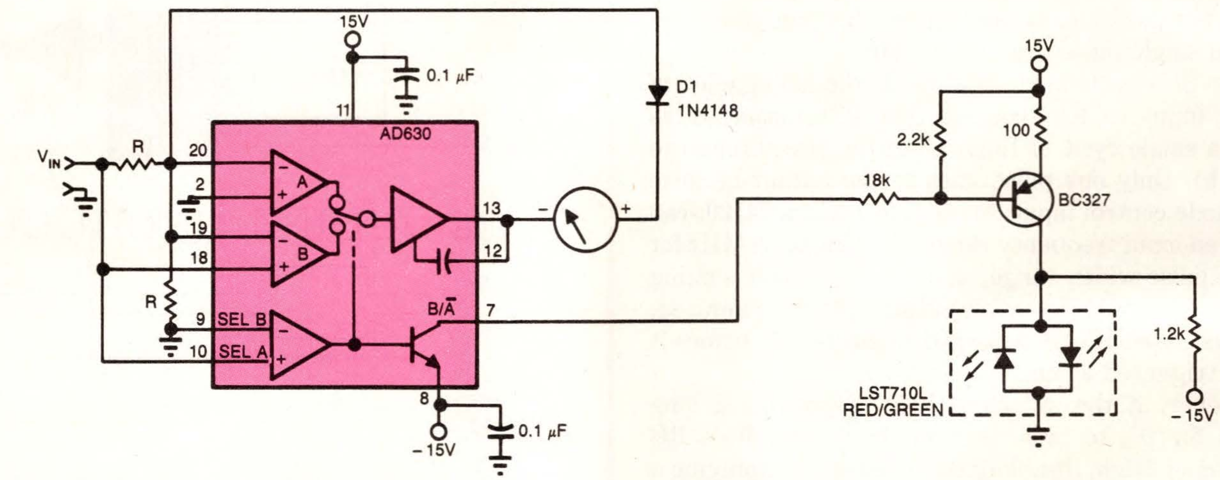
This simple absolute-value, or autopolarity, moving-coil meter **(figure)** uses only one IC and a handful of other components. The IC is an AD630 balanced modulator/demodulator used in an absolute-value voltage-to-current conversion mode.

When input V_{IN} is positive, the comparator selects op-amp input stage A. This drives the meter from a standard V-to-I conversion circuit. When V_{IN} goes negative, however, the comparator switches the input over to stage B. Now the output drives the meter until the drop across gain-setting resistor R to ground equals V_{IN}. ($I_{METER} \times R = V_{IN}$.) For example, use an R of 1k with a 1-mA meter for a full-scale input of 1V. The "unused" resistor R in each mode has no effect, being connected across a virtual ground.

A bicolor LED driven by the comparator's output-switching translator provides the polarity indication for the meter. Another diode, D_1, while not essential, protects the meter against power up/down transients in the wrong direction and allows the meter to measure ac signals, providing the movement's inductance is suitably low.

Because the input offset voltage of both input stages is laser trimmed to better than 100 μV, you can use the circuit to meter ac (as well as dc) voltages down to tens of millivolt levels. The scale factor is $I_{max}(\text{meter}) = V_{IN}/R$; you should use 1% or better resistors for both Rs. **EDN**

To Vote For This Design, Circle No 741



The heart of this absolute-value meter *is the AD630 balanced modulator/demodulator. In its absolute-value voltage-to-current mode, meter current is a function of the input voltage and the input resistor, R.*

Digital PLL synchronizes clocks simply

Allen Lui
General DataComm, Danbury, CT

In many data-communication systems, a phase-locked loop (PLL) synchronizes the internal system clock with an external clock signal. You can use this synchronized system clock signal to generate a frequency N times the input clock rate for processing received data. A digital PLL circuit suitable for this a purpose (**figure**) consists of two 7474 ICs and a divide-by-N counter comprising three 4-bit 74169 ICs. (You could replace IC_4 and IC_5 with an 8-bit 74393 or 74AS869).

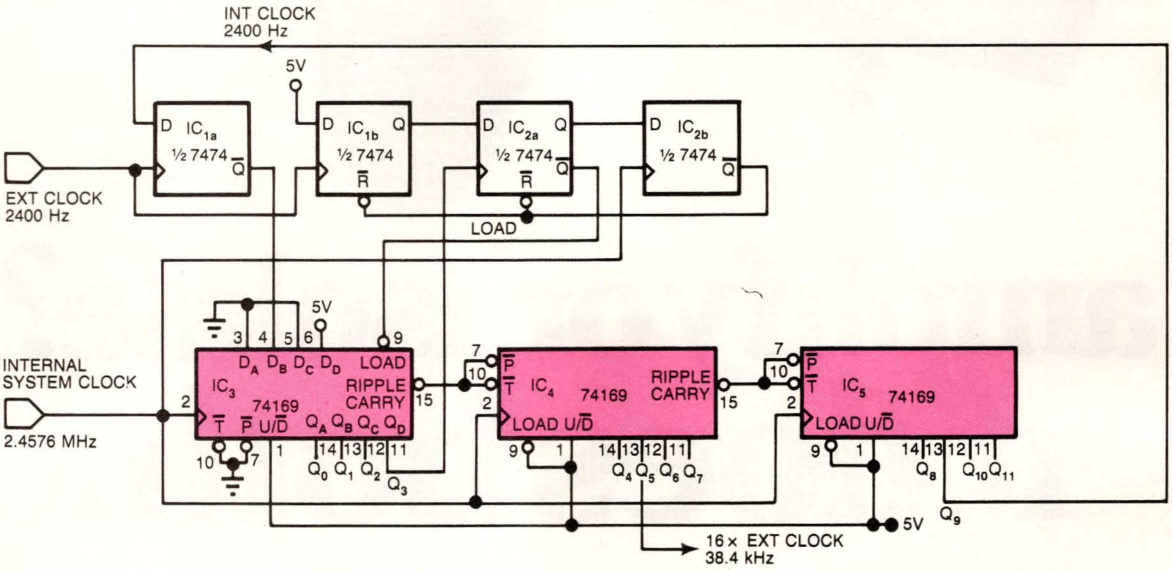
The circuit is self-initializing, with IC_{1a} functioning as a phase detector. On the positive-going edge of the external clock, IC_{1a}'s $\overline{Q}$ output goes Low if the external clock signal lags behind the internal clock signal; otherwise it goes High. This output drives input D_B of counter IC_3. At the same time, IC_{1b}, which functions as the positive-edge set latch, sets its Q output High. IC_{2a} and IC_{2b} feed counter IC_3 when pin 11 of IC_3 (Q_3) goes High.

When Q_3 goes High, the Load signal goes Low, loading data 1010 ($D_D D_C D_B D_A$) into IC_3. As a result, the counter advances one extra state from 1000 to 1010. If the external clock leads the internal clock, the counter is held in state 1000 for one extra clock period. In doing so, the counter chain runs faster or slower than the normal clock speed by one state (407 nsec) per external

clock cycle in order to compensate for the differential between the speeds of the external and internal clock.

Assume a maximum speed variation between the external and internal clock signals of 0.01% (as recommended by the Industrial Data Communication Equipment Standard). The digital PLL shown in the **figure** gives a capture range of 2397.42 to 2402.11 Hz, a locking time of 208 μsec (512 internal clock cycles) for 180° out of phase, and 0.35° phase jitter. The calculation is based on the external clock operating at 2400 Hz, +0.01%, and the internal clock at 2400 Hz, −0.01%. **EDN**

To Vote For This Design, Circle No 724



This digital-PLL circuitry *provides a clock, in synchronization with an external clock, and a frequency 16 times that of the external clock. Synchronization of the counter—three 74169 ICs—is accomplished by holding or advancing the state of IC_3.*

FIFO eases ADC-to-UART interface

Wes Freeman
Teledyne Semiconductor, Mt View, CA

Integrating A/D converters with multiplexed BCD outputs is popular for instrumentation and panel-meter applications because of the relative ease of interfacing to LCD and LED displays. However, complications arise if you want to send data to a remote computer or other device because the A/D converter generates data faster than a typical serial data link can transmit it. The circuit in the **figure** can interface an A/D converter to a serial data link at any rate through use of a first-in, first-out (FIFO) register. By using commonly available CMOS parts, both cost and power consumption are kept at a minimum.

Because the A/D converter's output is BCD data, a 4-bit-wide FIFO is appropriate. You can shift data into the FIFO at one rate and shift it out at another. A data-ready flag indicates the FIFO contains valid data. Interfacing the FIFO to a universal asynchronous receiver/transmitter (UART) isn't straightforward because the handshake signals occur out of the proper sequence. You can simplify the task, however by using four of the A/D converter's digit-select outputs as a multiphase clock.

The A/D-converter-to-UART data transfer begins when, at the end of the conversion cycle, IC_1's $\overline{STB}$ output pulses low five times. These $\overline{STB}$ pulses occur in

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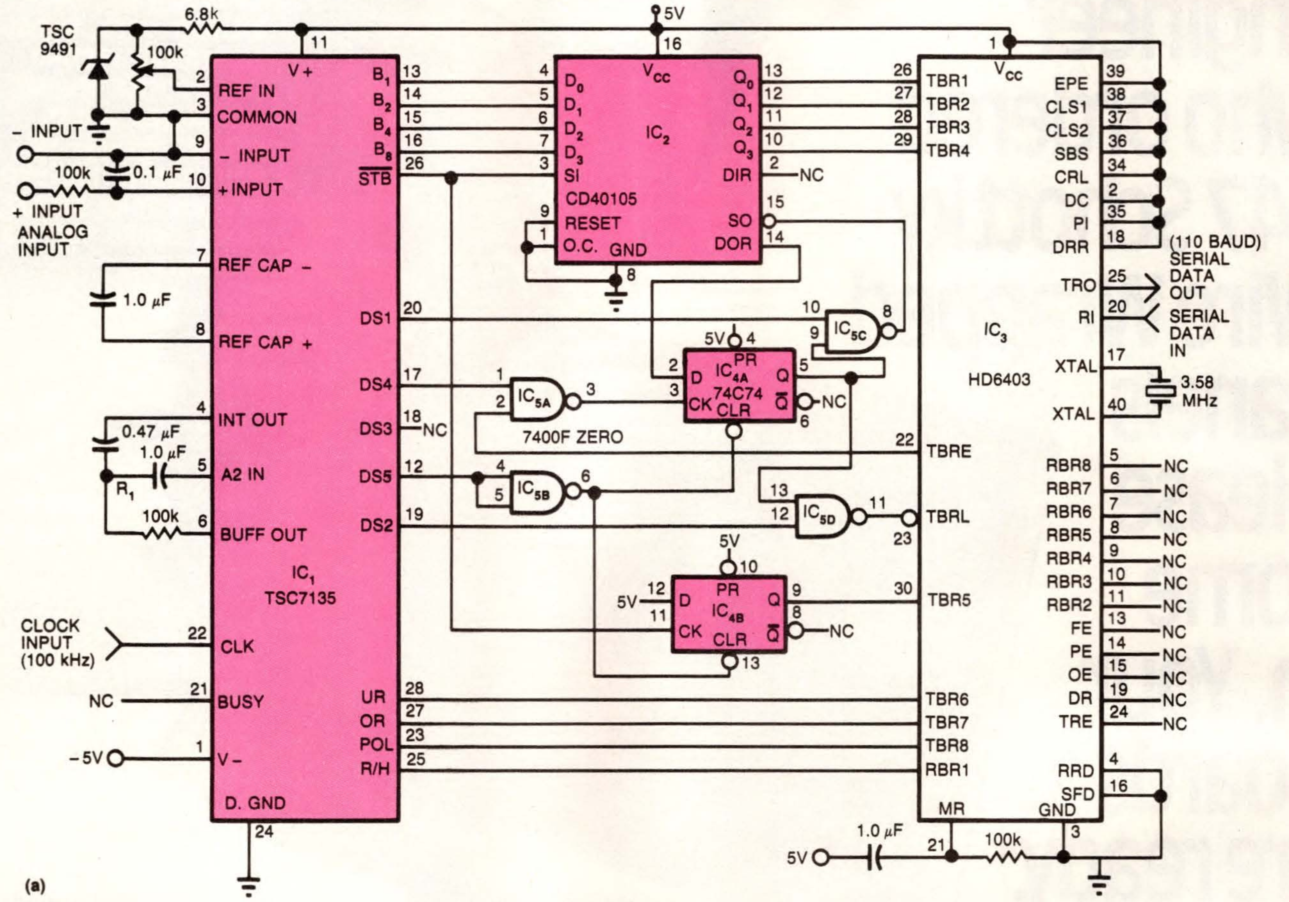
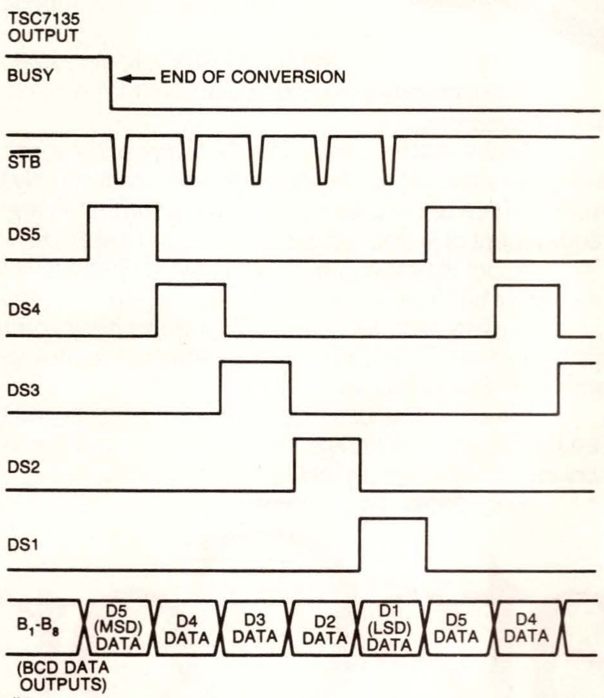


(a)



(b)

A/D converter IC_1 (a) *loads five BCD digits into the FIFO, IC_2, in 8 msec for transmission over a slow serial data link. Transfer timing, including the $\overline{STB}$ pulse that shifts the data into the FIFO, is shown in* **(b)**. *The digit-select outputs then act as a multiphase clock to load the UART, IC_4, for transmission at 10 cps.*

the middle of each of the first five digit-select outputs (**b**). The $\overline{STB}$ pulses latch the five BCD nibbles into IC_2. Two microseconds after the first $\overline{STB}$ pulse, IC_2's Data Output Ready (DOR) goes High, and valid data is present at IC_2's Q_1-Q_3 outputs.

Assuming IC_3 is ready to accept data, its Transmit Buffer Register Empty (TBRE) output is High. Then IC_{4A} sets on the falling edge of DS4, and DS2 pulses IC_3's Transmit Buffer Register Load (TBRL) input to start serial transmission. DS1's going High pulses IC_2's Shift Out (SO) input, shifting the next BCD nibble to the outputs. Finally, IC_{4A} is reset by DS5 and the transfer cycle begins again.

If IC_3 isn't ready to receive data, TBRE remains Low. Because of this IC_{4A} is not set, and the gate controlling TBRE isn't enabled. Again IC_{4A} isn't set and transmission ends. Synchronization of received data is made easier by identifying the first transmitted byte. Each $\overline{STB}$ sets IC_{4B} and each DS5 resets it. On the first digit, select scan cycle after a conversion. IC_{4B} is set when DS2 strobes TBLR; it is reset during succeeding characters. If receiving software finds RBR5 High, then that character is the DS5 (most significant) digit. The next four characters received will be DS4 through DS1, respectively.

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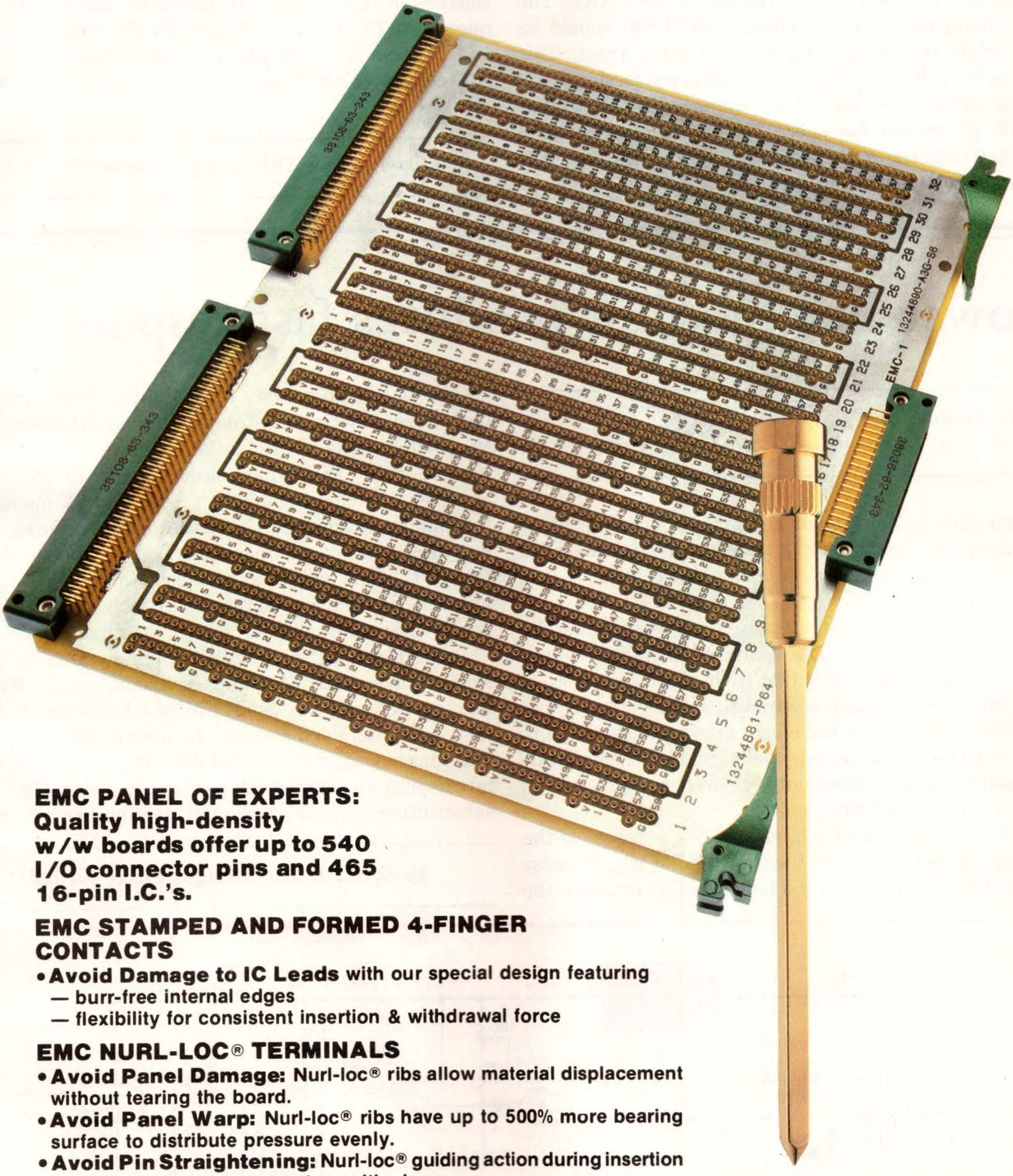

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The A/D converter can provide either conversions on command or continuous conversions. For convert-on-command (**a**), send two characters to the UART. The first character's least significant bit (LSB) should be set, while the second character's LSB is reset. This pulses IC_1's R/H input and initiates a conversion.

For continuous conversions, connect IC_1's R/H input to 5V. Be careful, however, that the serial data rate is greater than the A/D converter's conversion rate. For example, a teleprinter operating at 110 baud receives 10 cps. Because the converter sends five characters per conversion, IC_1's conversion rate must be less than two conversions per second. In this case, use a clock frequency of 75 kHz for optimum 60-Hz noise rejection, and increase R_1 to 133 kΩ to prevent saturation of the A/D converter's integrator. **EDN**

To Vote For This Design, Circle No 743

Power-line monitor produces fast response

Dave Nelson
Los Alamos National Lab, Los Alamos, NM

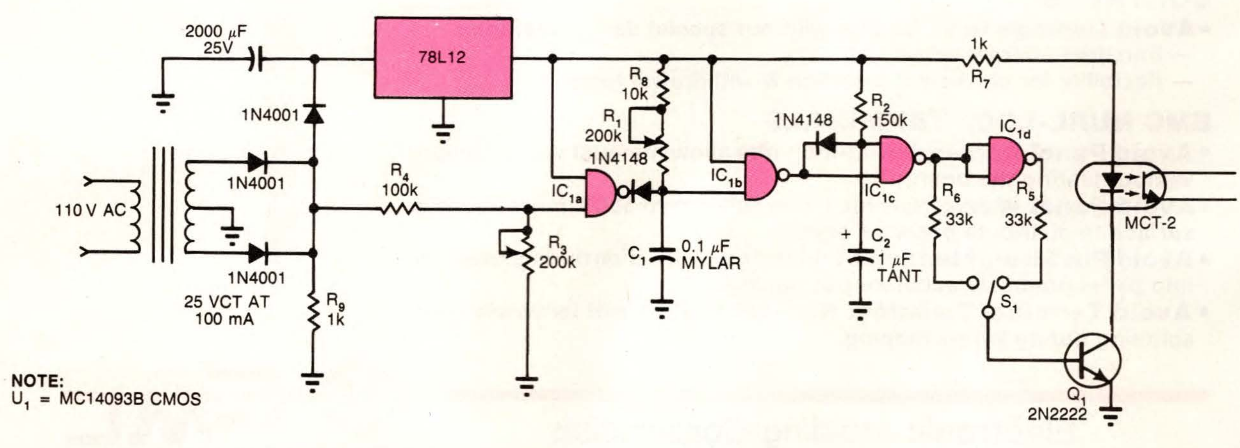
If you have to notify your equipment quickly of an ac power failure, use the circuit shown in the **figure.** It can respond in as little as one-half a cycle following an outage.

In practice, IC_{1a} creates a pulse train by squaring the rectified ac waveform. The setting of R_3 creates a pulse train at the output of IC_{1a} that is On for at least 50% of the duty cycle. R_3 also assures that the gate triggers near the peak of the waveform making it sensitive to any reduction in amplitude and signal loss. Amplitude sensitivity means brownouts, as well as total loss of signal, can trigger the monitor.

When the output of IC_{1a} is Low, C_1 is reset. If the voltage across C_1 rises to the threshold of IC_{1b} (because of the lack of a pulse for too long a period of time), the output of IC_{1b} goes Low, resetting C_2. This turns the optical isolator On or Off depending on the position of the switch. (The optical isolator allows the circuit to operate from 12V while interfacing with 5V logic; however, the circuit could be rescaled to 5V operation to eliminate this device.) With the switch as shown, IC_{1d} provides normally On operation. If the outage is short, the R_2/C_2 time constant creates a minimum 0.1-sec pulse. R_1 determines the response time, which can be as low as one-half a cycle for critical installations.

You can set up the circuit applying a 0 to 12V dc square wave at 120 Hz (twice the line frequency) from a function generator across R_3. Adjust R_1 for the desired response time, 8.3 msec min. Be aware, however, that different manufacturers build differing amounts of hysteresis into the 14093B IC; performance changes if you substitute one manufacturer's IC for another. **EDN**

To Vote For This Design, Circle No 742



Careful setting of R_1 and R_3 *enables this circuit to respond to power-line failure in as little as 8.3 msec.*

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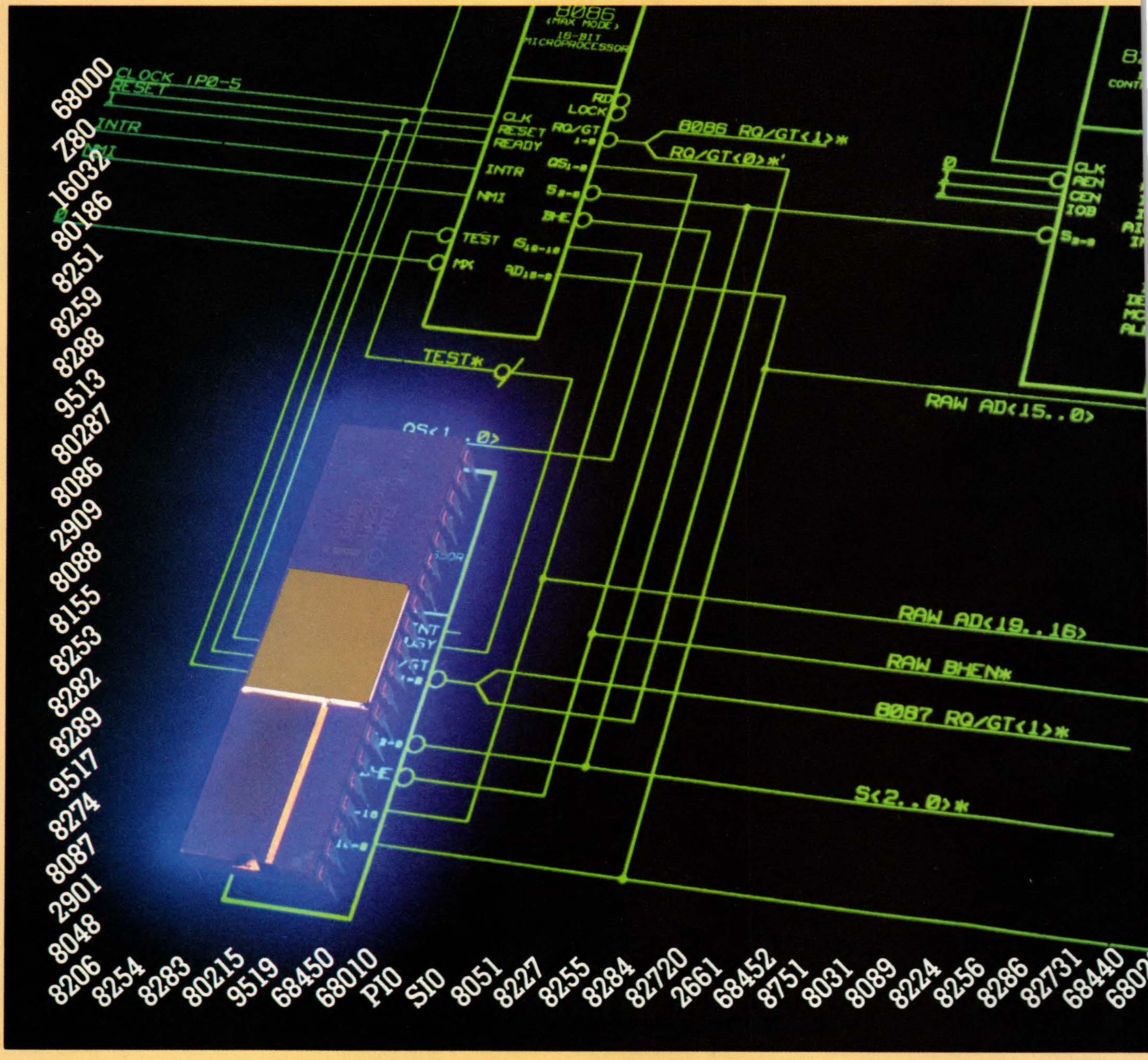

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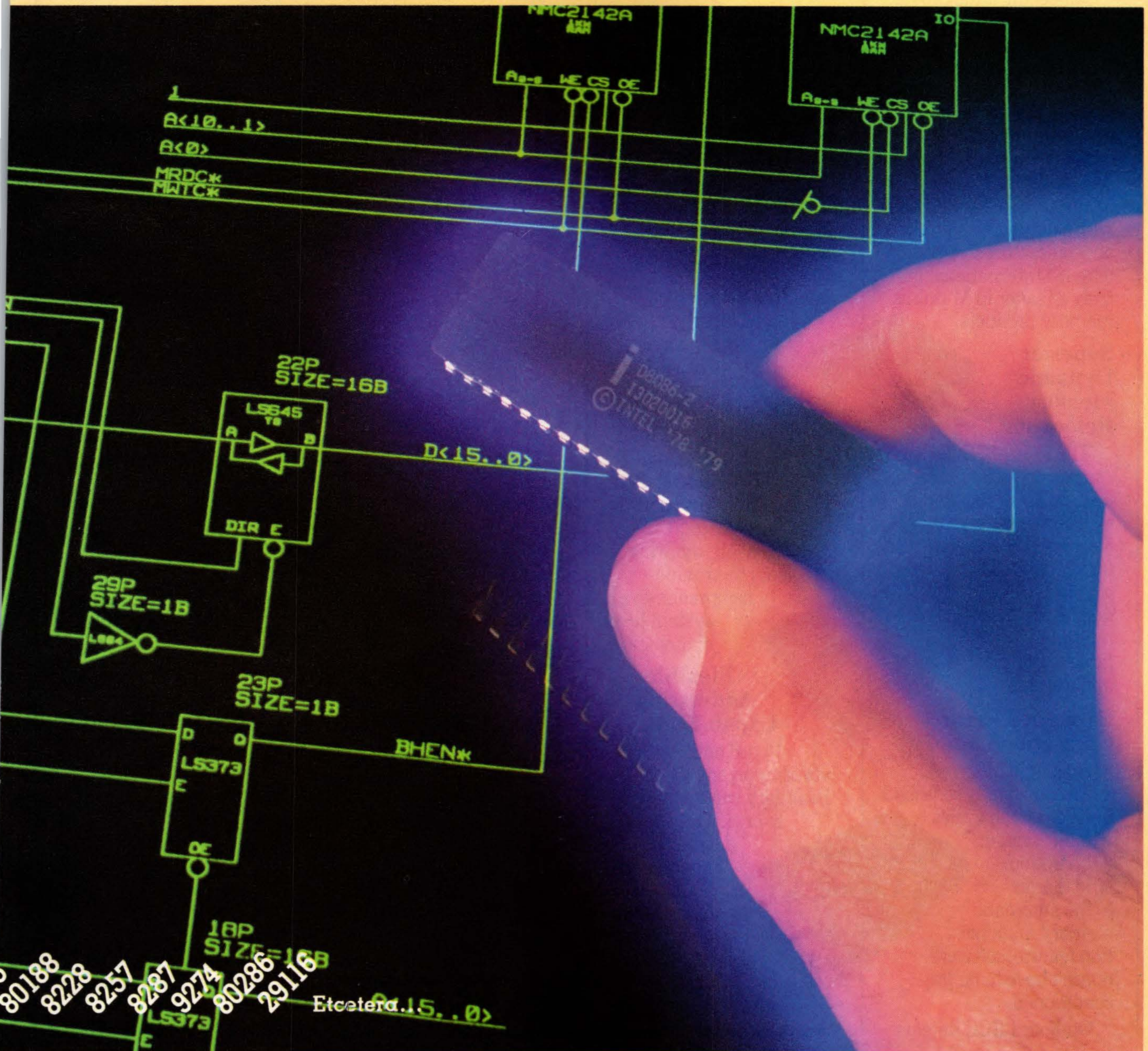

CIRCLE NO 137

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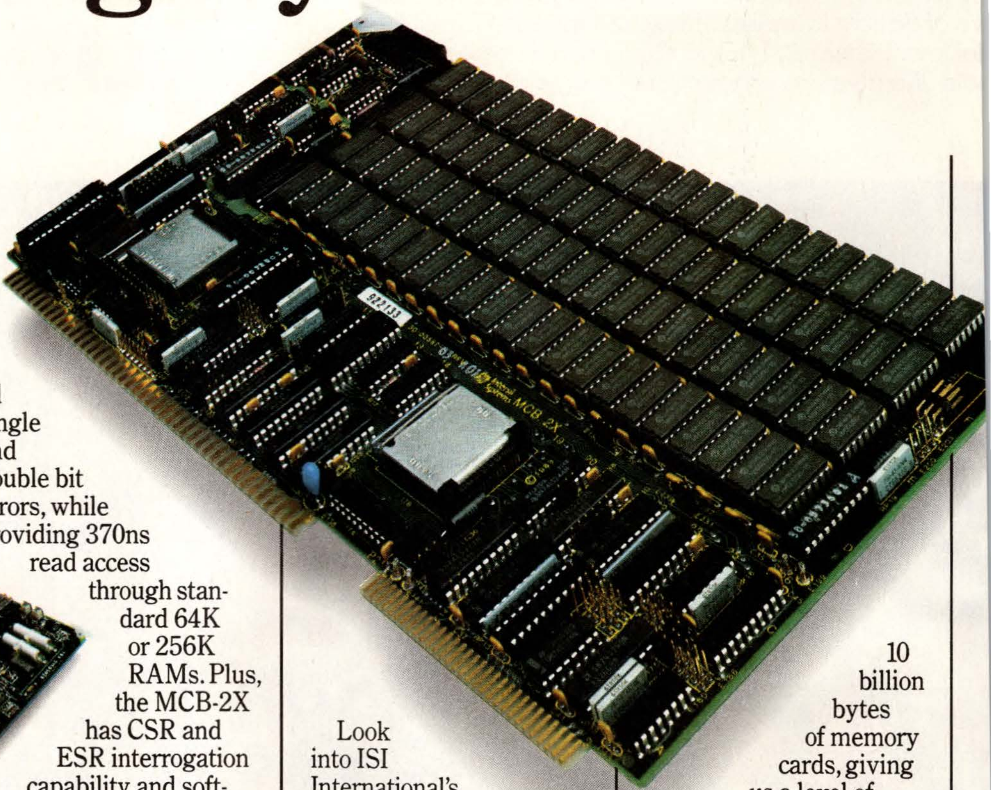

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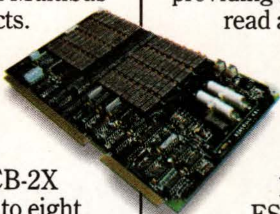

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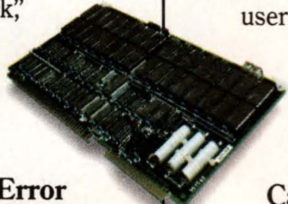

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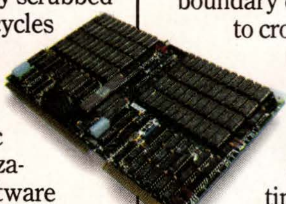

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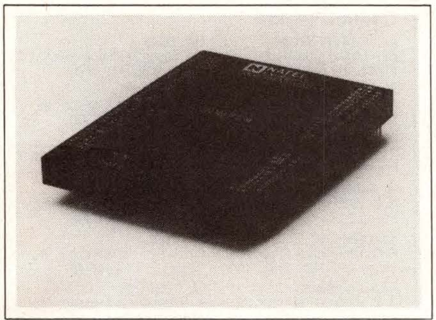
CIRCLE NO 138

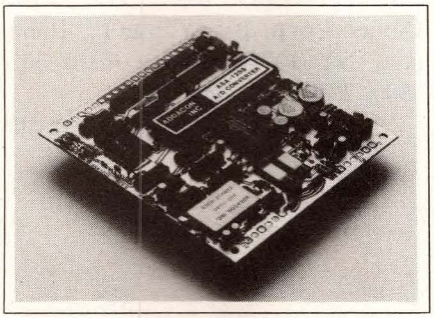


BCD-TO-BINARY CONVERTER. The SDB724 converts BCD angles (7 digits/359.9999°) into 24 binary bits, selectable in three bytes via 3-state outputs, and has 0.00001° accuracy. Its output drives five TTL loads. The most significant bit is 180°. Applications include code conversion, format conversion to IEEE-488-based instrumentation and interfacing between switches and digital-to-resolver converters. The converter measures 3×4×0.4 in. and weighs 6 oz. $295. **Natel Engineering Co Inc,** 4550 Runway St, Simi Valley, CA 93063. Phone (805) 581-3950. TWX 910-494-1959.

Circle No 301

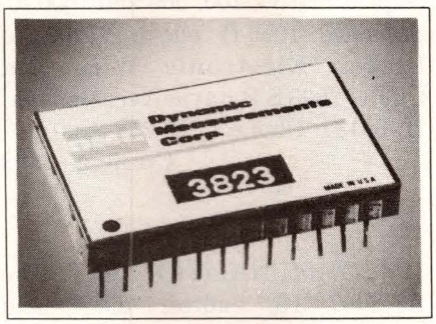
RELAY CARD. Model 4303 provides eight to 16 solid-state relay outputs for the STD Bus system. With strappable addressing and internal data latches, it provides the STD system with power output switching capabilities and optocoupled isolation through the relay module. Standard units have eight dc relays with load capacities of 4 to 60V dc and 3A max. On-board mounted suppression diodes for inductive load use are provided with optional mounting to permit relay switching on either side of the load. Options include as many as eight additional dc relays and ability to configure the card for ac relays. $300. **Technology 80 Inc,** 658 Mendelssohn Ave N, Minneapolis, MN 55427. Phone (612) 542-9545.

Circle No 302



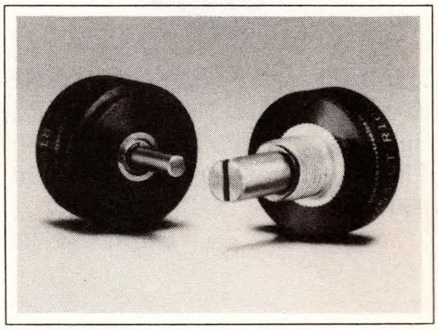
A/D CONVERTERS. These A/D converters digitize video signals at high speeds and accuracy. Model ASA-1205 operates to 12-bit resolution and at rates to 5 MHz. Model ASA-1020 operates to 10-bit accuracy and at rates to 20 MHz. The units are compatible with LS TTL and ECL, respectively. Each features single-board construction and on-board gain and offset-adjustment potentiometers. ASA-1205, $2895; ASA-1020, $2795. **Addacon Inc,** 3708 Alliance Dr, Greensboro, NC 27407. Phone (919) 852-6200.

Circle No 303



V/F CONVERTERS. Available in three output frequency ranges, these differential-input V/F converters provide 0 to 10V dc and 0 to −10V dc analog input ranges. Outputs are from dc to 2, 5 or 10 MHz full scale, linear within ±0.01% of full scale and ±0.01% of input voltage. Over −25 to +85°C, gain TC is 25 ppm/°C maximum, and offset TC is 10 μV/°C. An extended operating range (−55 to +125°C) is available. In 24-pin DIPs, $67 to $119 (100). **Dynamic Measurements Corp,** 8 Lowell Ave, Winchester, MA 01890. Phone (800) 225-1151.

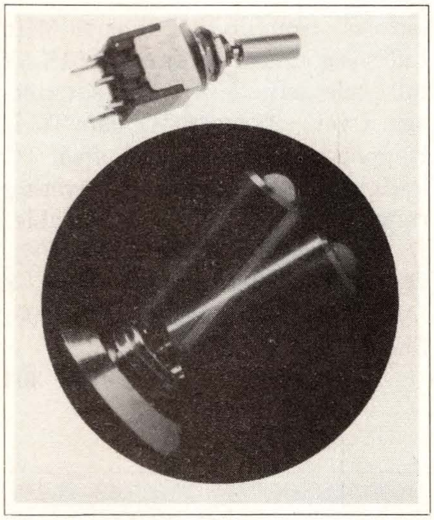
Circle No 304



POTENTIOMETERS. The servo-mount Model 5251 and bushing-mount Model 5253 2⅞-in., single-turn potentiometers are made from conductive plastic and feature infinite resolution and smooth output. Standard resistance range is 1 to 50 kΩ with an extended range of 500Ω to 100 kΩ. Tolerance specs at 120%, and linearity equals ±1% for the 5251 and ±2% for the 5253. Best practical linearity is ±0.25%. Model 5253, $4.95 (250). **Duncan Electronics,** 2865 Fairview Rd, Costa Mesa, CA 92626. Phone (714) 545-8261. TWX 910-595-1128.

Circle No 305

TOGGLE SWITCH. This bicolor toggle switch features a dual LED lamp which illuminates the toggle tip and changes color depending on the position of the switch. Color combinations of red/green, red/yellow, and green/yellow are available in spdt switches as On-None-On and On-Off-On versions. Both switches feature solder lug terminals and are rated at 6A/125V ac, 3A/250V ac



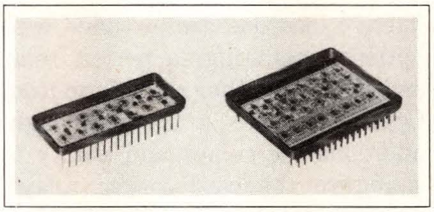
and 4A/30V dc. $3.98 (100). **NKK Switches,** 14415 N Scottsdale Rd, Suite 600, Scottsdale, AZ 85260. Phone (602) 991-0942. TWX 910-950-1167.

Circle No 306

TRANSDUCER AMPLIFIER. The Model 980 amplifier features high input impedance (greater than 20 MΩ, 0 to 10 Hz; greater than 10 GΩ, 3 Hz to 250 kHz) and combines high current output capability with pin-programmable gains of 1, 2, 5 and 10. It can drive 50 and 75Ω systems with less than 0.1% distortion to 20 kHz and operates over −55 to +125°C. Quiescent supply current is typically 10 mA. $32 (25). **Mel Tec,** 411 Providence Hwy, Westwood, MA 02090. Phone (617) 329-1508.

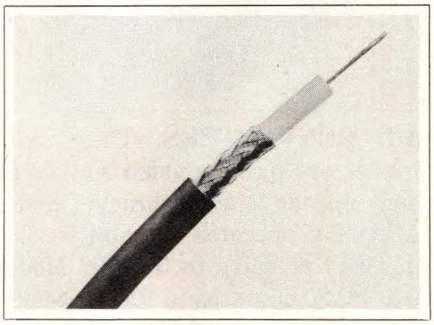
Circle No 307

PROTOCOL HYBRIDS. BUS-66101 and -66102 generate the protocol, timing and control functions required by a dual redundant MIL-STD-1553 remote terminal unit (RTU). They produce control signals for a dual-port memory as the system interface and for dual encoders/decoders as the 1553 interface. The hybrids resolve contention between the two signals and multiplex them. BUS-66101 is a 36-pin hermetic hybrid and measures



1.9×0.8×0.2 in.; the -66102 measures 1.8×1.6×0.2 in. and is a 68-pin hybrid. Both operate over −55 to +125°C, require a 5V dc supply and are available screened to MIL-STD-883B. $427. **ILC Data Device Corp,** 105 Wilbur Pl, Bohemia, NY 11716. Phone (516) 567-5600. TWX 510-228-7324.

Circle No 308



COAXIAL CABLE. The Model 9659 75Ω coaxial computer cable has a flame-retardant black PVC jacket that passes the UL VW-1 vertical wire flame test. This RG-59/U-type cable has a 22 AWG bare copper stranded center conductor and is more flexible than conventional cables of this type. A bare copper shield provides 95% coverage. Capacitance is 17.3 pF/ft. Standard lengths are 50, 100, 500 and 1000 ft. Standard 1000-ft put-up, $199.35. **Belden Electronic Wire and Cable,** 2000 S Batavia Ave, Geneva, IL 60134. Phone (312) 232-8900.

Circle No 309

IR COMMUNICATION SET. The SFH407 IR emitter diode and SFH202 PIN photo-detector diode are for fiber-optic cable communications. The GaAs SFH407 emits IR light at about 900-nm peak wavelength and couples 120 μW into a

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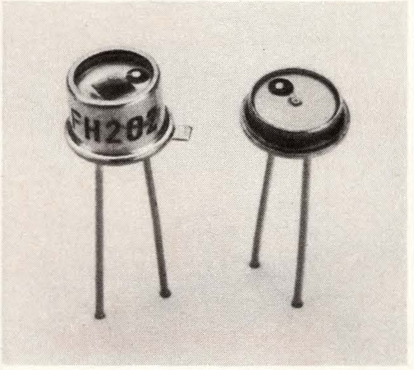
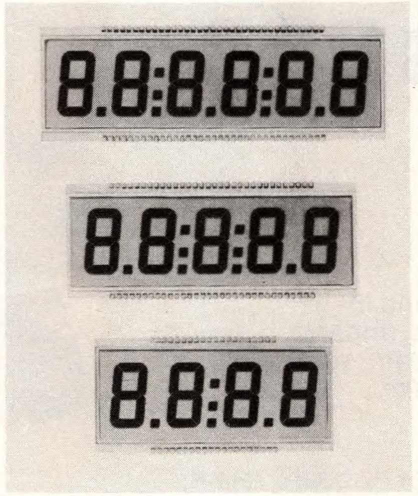
Ideal for high density printed circuit board mounting requirements. From less than 0.045 cubic inch. Both sealed and unsealed types.

CIRCLE NO 139



multimode stepped-index fiber with core diameters between 50 and 200 μm. It produces 4.7-mW max radiant power; switching time is 40 to 50 nsec at 100 mA. The Si SFH202 receives these signals with a 0.55-mA/mW response. SFH407, $6.80; SFH202, $3.95 (10,000). **Siemens Components Corp,** Optoelectronics Div, 19000 Homestead Rd, Cupertino, CA 95014. Phone (201) 321-4842.

Circle No 310

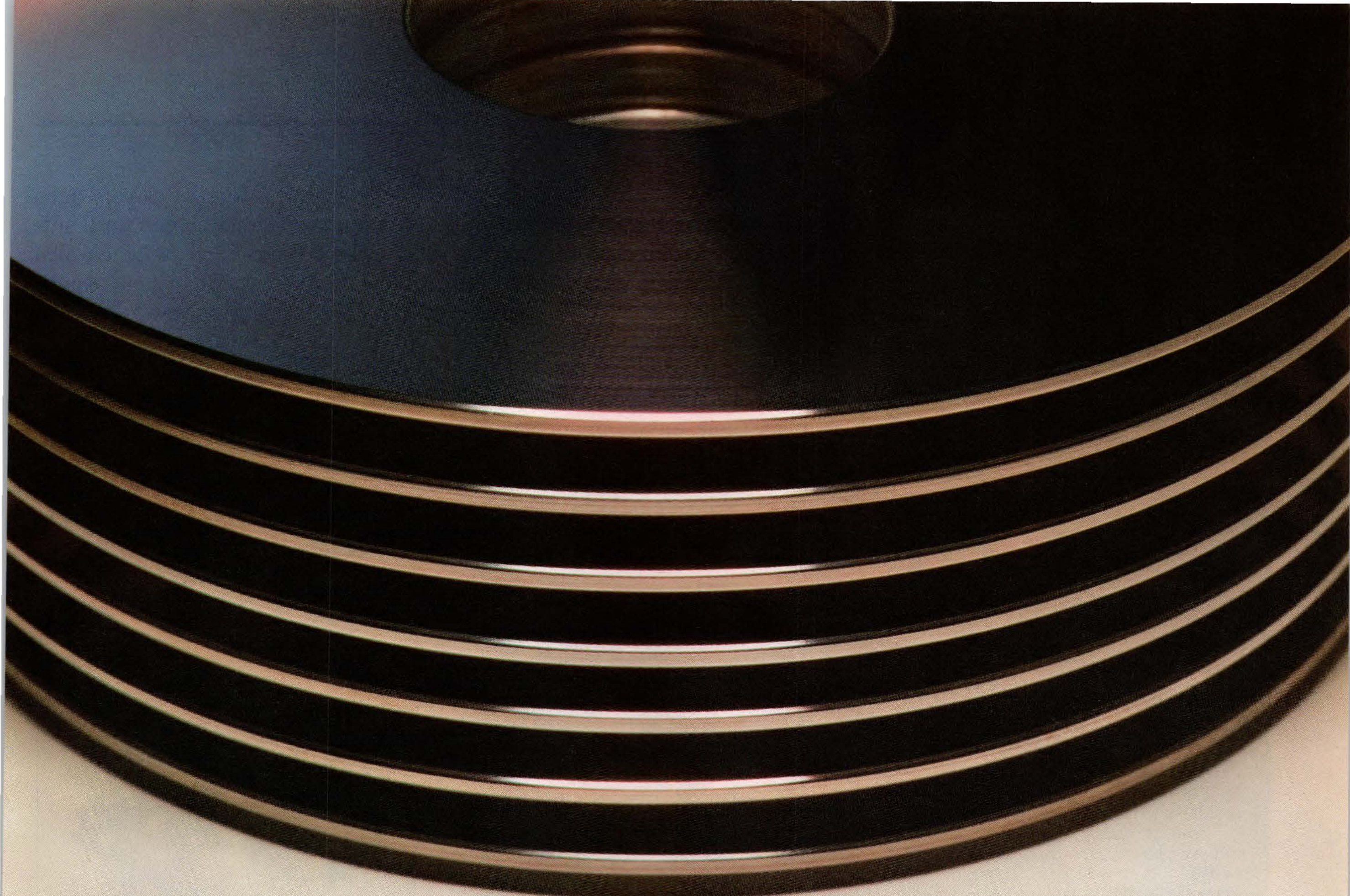


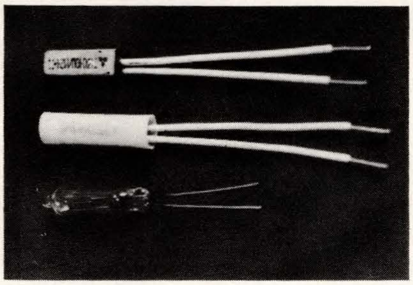
LCD. Three LCDs furnish 25.4-mm-high digits. Each 25.4×13.2-mm digit has seven 3.3-mm-wide segments. Minimum operating voltage is 3V, and operating range spans −10 to +60°C. SP-540 displays four digits, three decimal points and a colon and measures 94×46 mm with a 89×33-mm viewing area. SP-541 displays five digits, four decimal points and two colons and measures 114.3×46 mm with a 109×33-mm viewing area. SP-542 displays six digits, five decimal points and two colons and measures 136×46 mm with a 131×33-mm viewing area. They feature standard reflective viewing modes; optional transflective and transmissive modes are available. SP-540, $9; SP-541, $11.20; and SP-542, $12.90 (100) for elastomeric displays. Pin versions cost $9.60, $12.20 and $14 (100), respectively. **Seiko Instruments USA Inc,** 2990 W Lomita Blvd, Torrance, CA 90505. Phone (213) 530-8777.

Circle No 311

PROTECTION SWITCHES. The Thermal Protectors family consists of three basic switch types: glass case (33×7.5 mm), metal case

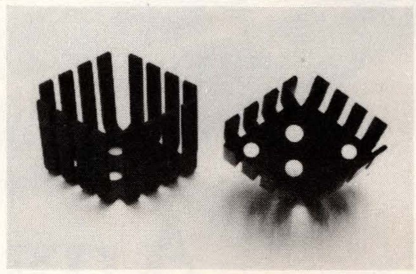
CIRCLE NO 140





(33×5×7 mm) and resin case (21×3.6×7.6 mm). Models are available with trip temperatures ranging from 70 to 160°C for glass-cased units and 80 to 140°C for metal- and resin-cased models. Trip temperatures vary in 5°C increments. The switches open an electrical circuit as soon as their environment reaches the set trip temperature; once tripped, they remain open until sufficiently cooled. The switches also guard against overcurrent conditions by snapping open whenever a current flowing through them exceeds a predetermined value that heats the switching element above its trip point. From $0.30 in production qty. Minimum order is 3000 for glass- and metal-cased models, 6000 for resin-cased models. **Panasonic,** 1 Panasonic Way, Secaucus, NJ 07094. Phone (201) 392-4651.

Circle No 312



HEAT SINK. Providing efficient cooling for TO-3 and TO-66 transistors while conserving board space, Model M1622 measures 1.4×1.88 in. Fin heights of 0.5, 0.75, 1 and 1.25 in. are available. Tests indicate that while dissipating 4W of power, the device experiences a temperature rise of 22 to 40°C above ambient, depending on fin height. The standard model is made from black anodized aluminum. $0.50 (10,000). **Tran-Tec Corp,** Box 1044, Columbus, NB 68601. Phone (402) 564-2748.

Circle No 313

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At Microbar, we're working today on the Multibus™ single-board computer (SBC) you'll need tomorrow. We specialize in developing SBCs that put OEMs and system integrators in front of the competitive pack—in technology, in time-to-market, and in cost. Doing that means maintaining a clear focus on the future and anticipating your needs—maybe even before you do.

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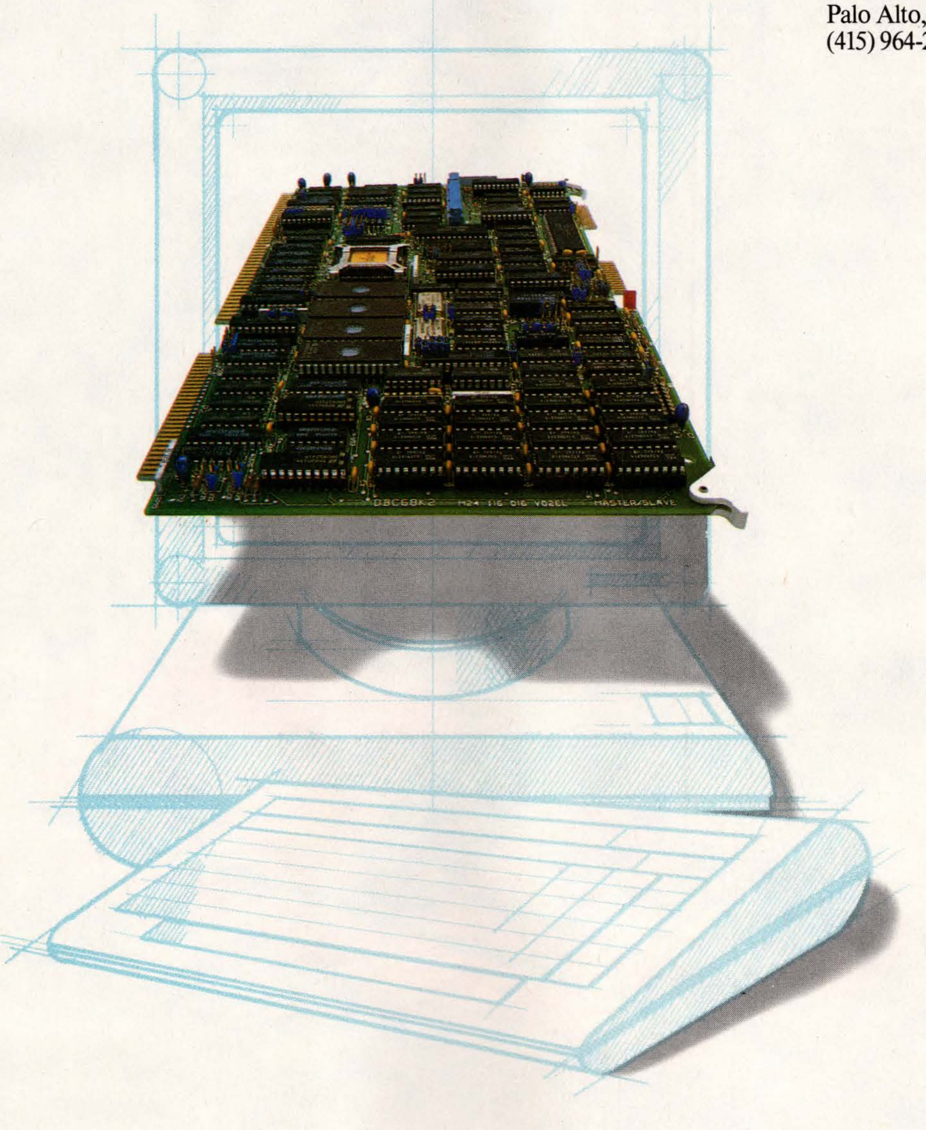
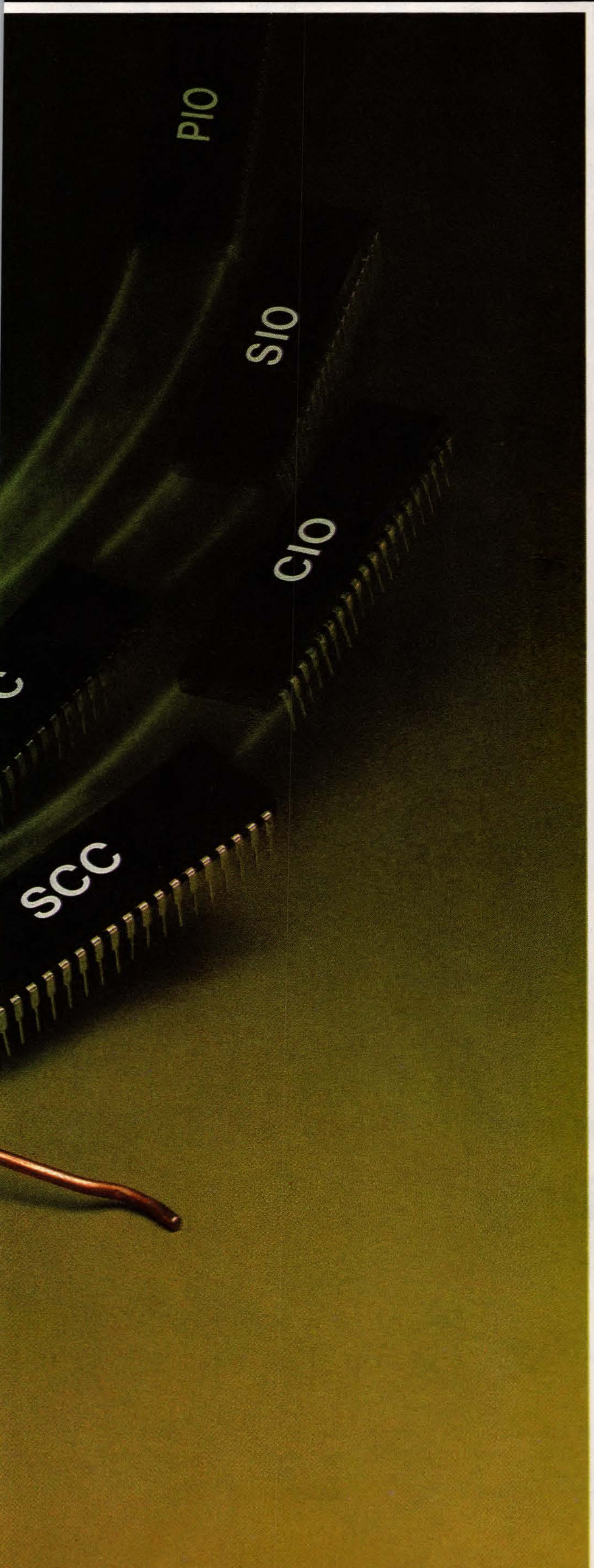


Zilog's high-speed Z80B CPU's and Peripherals.



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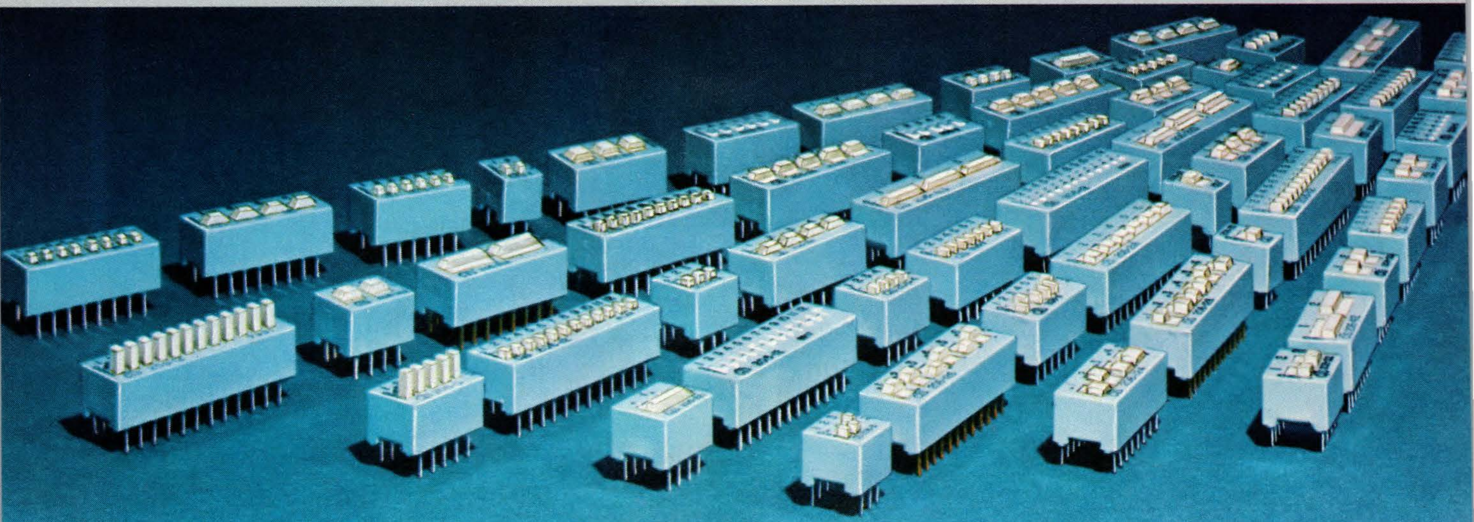

1. Better Quality that's built-in, not just "inspected in." Using Statistical Controlled Charting, CTS constantly monitors production processes and piece part tolerances to make sure finished switches are up to specifications—all the time.

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CIRCLE NO 2

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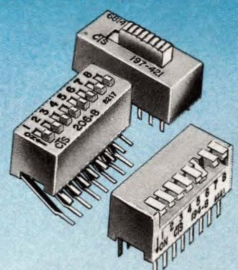

NEW side actuated switches, right angle switches and 4PDT circuitry. Plus low profile or extended actuator styles; SPST, SPDT, DPST, DPDT or 4PST circuitry; MIL approved versions; special markings, top/side; from 2 to 12 switch sections. All very competitively priced with off-the-shelf availability from CTS Distributors or early delivery from the factory.

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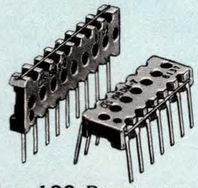

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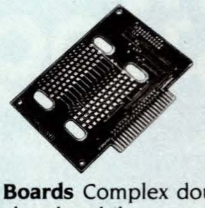

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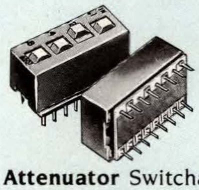

DIP Attenuator Switchable attenuator in standard DIP package.
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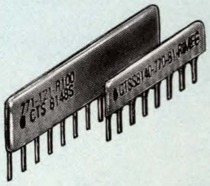
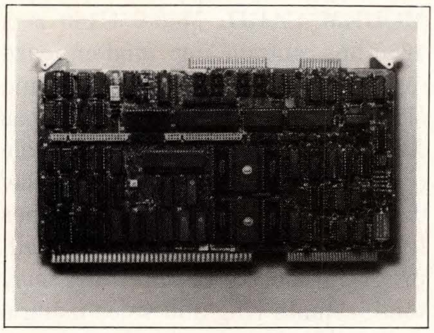
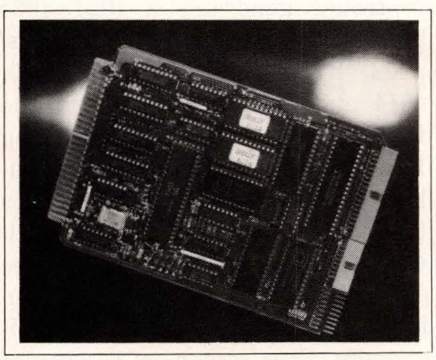


Series 770 New conformal coated SIP networks. Phone: (219) 589-8220
CIRCLE NO 197



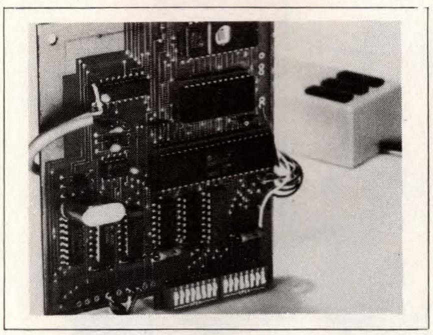
CMOS CPU BOARD. Featuring a 5-MHz CPU, the Model CBC 86/C05 Multibus-compatible single-board computer is hardware and software compatible with Intel's iSBC 86/05. Also included are 24 parallel I/O lines, three counter/timers, an RS-232C serial port and two iSBX-compatible bus interfaces. Power consumption is 200 mA max at 5V dc. Six 28-pin JEDEC sockets on the CPU board allow on-board expansion to 48k of RAM and ROM; a CMX 1600 expansion board lets you expand to 80k. An on-board lithium battery provides more than 2.5 yrs of data retention; sensing logic ensures data integrity during momentary and long-term power outages. 16k-byte RAM version, $1395. **Diversified Technology Inc,** Box 748, Ridgeland, MS 39157. Phone (601) 856-4121.

Circle No 368



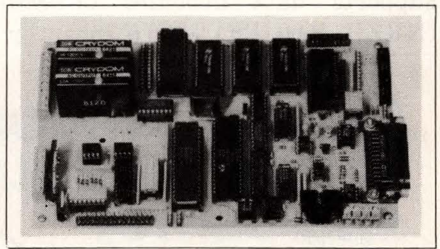
SINGLE - BOARD COMPUTER. STD Bus-compatible, Z80A-based Model MP6102 provides byte-wide memory in EPROM with 8k-bytes capacity. It provides three channels of user-definable counter/timer functions using one channel as a software-programmable time base for the computer's serial RS-232C I/O port. The port is programmable to 9600 bauds and lets you choose from a variety of protocols. An AM9519 universal interrupt controller provides management and priority resolution for eight maskable interrupt inputs. An I8255A peripheral interface provides 24 bits of multiple-mode I/O. The computer's fuse-link PROMs let you change DMA control or memory-timing-cycle definition. It operates in single or multiprocessor (master/slave mode) environments and requires no additional I/O, counter/timer or interrupt-controller cards. 2.5-MHz version, $570. **Burr-Brown,** Data Acquisition and Control Systems Div, Box 11400, Tucson, AZ 85734. Phone (602) 747-0711.

Circle No 369



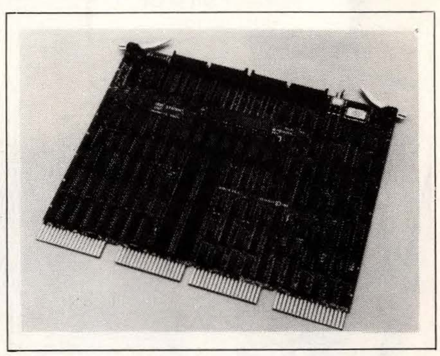
MOUSE CONTROLLER. Allowing you to use a digital mouse as a component, Model R/A-100 series interface is furnished as a fully or partially stuffed pc board. It's composed of a μC with firmware in PROM and can be housed in the user's terminal using a mouse as an external connection or mounted externally and connected to an RS-232C interface. You can profile the device from the terminal or the host and program displacement data to be sent to either. Both on-demand and on-motion transmission modes are profilable; you can turn transmission on or off under program control. Data format simulates cursor position signals or cursor key commands. You can program data buttons with three user-definable characters. System resolution is 200 points/in. (1-in. motion) with motion bounded to the limits of the screen. Hardware options include 16-baud rates and eight serial frame formats. $75 to $175. **Random Access Inc,** 246 Highland Rd, Pittsburgh, PA 15235. Phone (412) 247-7472.

Circle No 370



SINGLE - BOARD COMPUTER. Based on the Rockwell R65F single-chip μC, the Proatrol single-board computer replaces multiboard systems in real-time applications. The 5×8-in. computer contains a FORTH operating system in internal ROM and includes on-board I/O with RS-232C and 20-mA serial interfaces, plug-in sockets for I/O modules and an A/D converter. Also included are half-bridge power drivers, optically isolated inputs, level and speed adjustments, DIP-switch inputs, open outputs, in-circuit EEPROM programming, 5V regulator and sockets for as much as 14k bytes of memory and bus expansion. $495. **PROA Corp,** 4019 Edith NE, Albuquerque, NM 87107. Phone (505) 344-2106.

Circle No 371



TAPE CONTROLLER. Model TS11/TSV05 is a Q Bus-compatible tape controller/coupler that controls tape drives with embedded formatters. Configurable from the operator console, the controller self-tests on start-up and handles as many as eight 9-track tape drives from a quad board. Different operating modes and Q Bus address selection can be configured via operator console input to nonvolatile static RAM as units are changed or added. It supports data densities of 800 (NRZI), 1600 (PE), 3200 (Cipher) or 6250 cpi (GCR). Tape-drive combinations from 25 to 125 ips can be connected; you can use drives with different speeds or recording formats. A 16k-byte buffer between the controller and the tape drive ensures continuous tape streaming. **MDB Systems Inc,** Box 5508, Orange, CA 92267. Phone (714) 998-6900. TWX 910-593-1339.

Circle No 372

MODEM CARD. Model C100 is a 1200-bps autodialing modem card for the IBM PC, XT, portable and slot-compatible machines. It has full-duplex AT&T 212-compatible operation, tone sensing and voice/data control. The modem consumes less than 1W and features call-progress sensing of dial tone, busy tone, remote ring and voice using a switchable 20-pole filter. It senses when the telephone handset is lifted and can switch between voice and data operation on the same telephone call. The card measures 12.4×4.2×0.575 in. and uses one slot. $445. **Prentice Corp,** Box 3544, Sunnyvale, CA 94088. Phone (408) 734-9810.

Circle No 373

GRAPHICS CONTROLLER. The Model GC-20 graphics controller is for use with high-resolution monitors on DEC LSI-11 minicomputers. It consists of two standard DEC quad boards, the GI-20 graphics interface board and the RM-20 refresh memory board. The refresh memory board contains four 7200 VLSI graphics controllers, each driving a 1024×1024 plane. With one 7220 per plane, you can modify entire pixels rather than single bits with a single memory update. The controller generates a 1024×1024 interlaced image with four bits/pixel. It emulates Tektronix 4010, 4014 and 4065 terminals and the DEC VT-100 terminal; using REGIS protocol support, it emulates VT-125 and VT-240 graphics terminals. Sixteen colors from a palette of 4096 are displayed simultaneously. Zoom is two to 16 times; pan is smooth vertically and coarse horizontally. Four screens of 64 lines of 80 characters each, blink and underline and four standard RS-232C ports are also available. $5900. Delivery, 60 days ARO. **Dataram Corp,** Princeton Rd, Cranbury, NJ 08512. Phone (609) 799-0071. TWX 510-685-2542.

Circle No 374

WORK FAST. BUT WORK SMART.

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And since few changes were made to upgrade the V100 family to the V185, we'll be able to get up the high volume production ramp faster.

Speaking of fast . . . the V185 also has a 30msec average access time (including settling) and a microprocessor interface that starts head arm movement at the first seek pulse.

Every VERTEX drive is backed by the best Winchester engineering and manufacturing team in the business. So get your system and sub-system plans going now. Call us at (408) 942-0606. Or write VERTEX, 2150 Bering Drive, San Jose, CA 95131.

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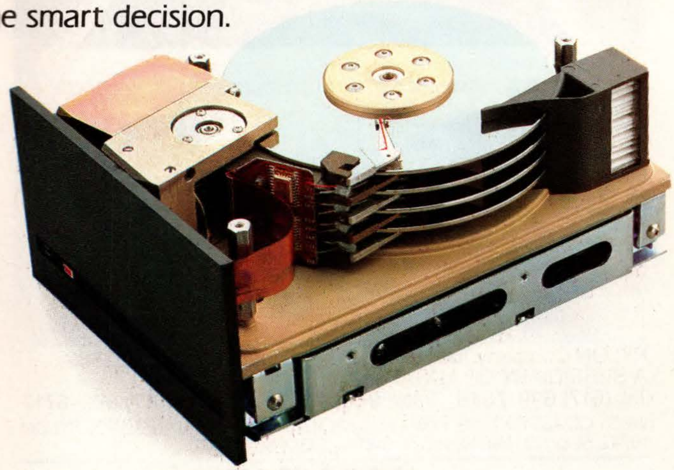

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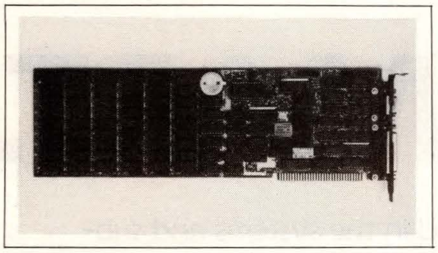
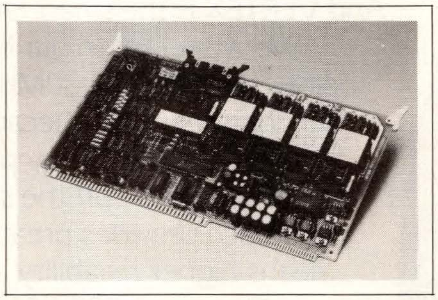


MULTIFUNCTION CARD. Ideamax 384 is a plug-in card for the IBM PC and XT that provides 64k to 348k of parity-checked dynamic RAM. It requires one PC slot, and its options include serial or parallel interface, a clock/calendar with a removable battery and a game port. Standard features include RAM floppy-disk emulation software, print-spooler software, real-time clock software, parallel-printer selection and diagnostic software. The floppy software emulates a floppy disk in RAM. The parallel-printer selection software provides switching among parallel printers. Print-spooler software runs printer operations in the background so the user can continue working. The card allows cabling of both serial and parallel interfaces from the back of the board. $320 for 64k of memory and one option; $795 for four options and 384k of memory. **IDE Associates,** 7 Oak Park Dr, Bedford, MA 01730. Phone (617) 275-4430. TLX 948245.

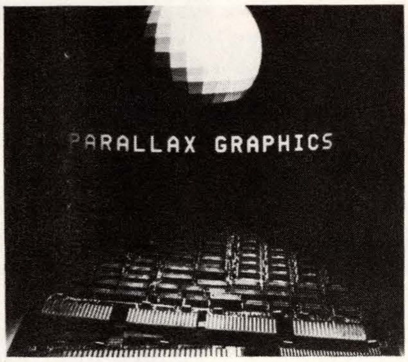
Circle No 375



4M-BIT MEMORY CARDS. Four Multibus-compatible memory cards feature capacities of 128k, 256k, 384k and 512k bytes. Using expansion ports, you can raise memory capacity to 4M bytes. Each card features a 5V dc power source, an 8- or 16-bit data bus, a built-in DMA controller, error correction, and the ability to connect to 1M-bit bubble cassettes. The company claims that access times are four times faster than competitive bubbles and 10 times faster than floppy disks. The cards' nonvolatile memory generates without a seed bubble. The cards operate as memory-mapped I/O and require only a 64-byte memory space. The base address can be set in units of 64 bytes. $944 to $2060. **Fujitsu Components Inc,** 918 Sherwood Dr, Lake Bluff, IL 60044. Phone (312) 295-2610.

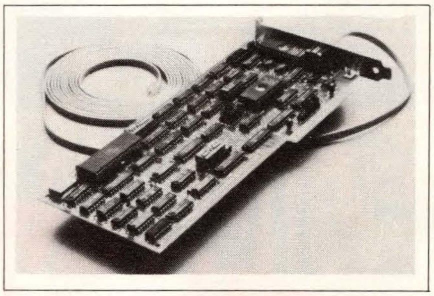
Circle No 376

GRAPHICS CONTROLLERS. Parallax 600 board-level graphics controllers feature a bit-slice drawing processor with 12M-pixels/sec drawing speed. The controllers are available for Multibus and Q Bus.



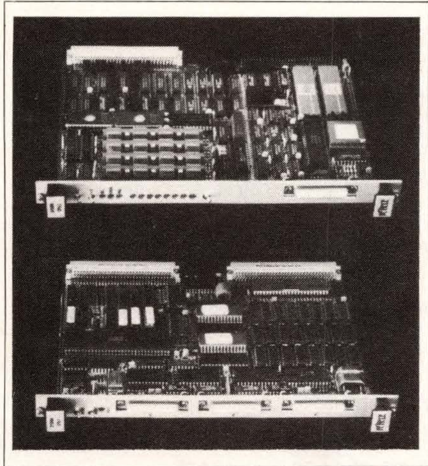
Users of the 4-bits/pixel model can choose 16 colors from a palette of 4096; the 8-bits/pixel version lets users choose 256 colors from 16M. The instruction set contains single-instruction polygon, box, circle and vector drawing commands as well as solid fill, outline, stipple, cut and paste and opaque/transparent modes. The double-buffered controllers feature dual-ported video memory, RS170 video compatibility with gen-lock, two frame buffers, zoom, smooth pan and scroll. They display 640×480 pixels out of a 512×1024-pixel memory with 4-bit planes; 8-bit planes are also available. Dejag, dithering, interactive drag and paint functions are also standard. **Parallax Graphics Inc,** 1095 E Duane Ave, Suite 215, Sunnyvale, CA 94086. Phone (408) 720-1600.

Circle No 377



LAN. AST-PCnet is a shared resource system that incorporates twisted-pair technology and print spooling. Its total network capacity is 160 workstations and 2500 ft of cable. The distributed bus system runs on the IBM PC, XT and PCjr and requires PC-DOS (2.0 or 2.1), one floppy-disk drive, 128k bytes of memory and an expansion slot for its controller card. It links two to 32 PCs on a 500-ft trunk cable length without repeater stations. Controller cards with an optional on-board repeater support an additional four 500-ft cable spans. The package uses standard PC-DOS commands to access remote drives and printers, shares resources like printers and communication lines and allows remote processing of keyboard commands. It also accesses as many as 16 floppy, hard, or RAM disk volumes from a user PC, transmits data at 800k bps, uses a CSMA/CA protocol and allows electronic mail and multiuser software. Starter kit, $1090. Individual mode, $495. **AST Research,** 2121 Alton Ave, Irvine, CA 92714. Phone (714) 863-1333.

Circle No 378



SINGLE-BOARD μC. Based on the 68000 μP and the VME Bus, the CPU-1B and CPU-2 are available with an 8- or 10-MHz processor unit and options of 128k or 512k bytes of local dynamic RAM. The -1B board provides three RS-232C I/O ports (110 to 38.4k baud) and one parallel, 68320-based I/O port. It features a 24-bit programmable timer, an on-board, real-time clock with battery, and sockets for 128k bytes of EPROM or 16k bytes of static RAM. The CPU-2 can be supplied with the 68000 or 68010. You can select dynamic-RAM configurations of 128k, 156k or 512k bytes or 1M byte. All high-speed memory banks have two ports with jumper-selectable base address and address-modifier decoding, allowing asynchronous access from the local on-board bus and the global VME Bus. On-board operating firmware in both units facilitates uploading and downloading of program transfers with S-record format. CPU-1B, $907; CPU-2, $1432 (100). **Force Computers Inc**, 2041 Mission College Blvd, Santa Clara, CA 95054. Phone (408) 988-8686. TLX 172465.

Circle No 379

SINGLE-BOARD μC. The Quark/300 is a 256k, CP/M-compatible computer that incorporates Winchester, floppy and video controllers onto one board. Based on the 6-MHz Z80B μP, the μC uses five PALs and a gate array to implement all memory, disk, display and I/O functions on a 3.9×7.5-in. Eurocard. Its CP/M software package includes BIOS, disk and terminal drivers, utilities, source code and a menu-driven installation program that permits you to configure device drivers and disk formats. Standard features include an ST506 Winchester controller that accommodates four drives, single- and double-density 5¼- or 8-in. floppy interfaces, full-duplex and simplex RS-232C serial ports, a parallel printer port and 22 general-purpose I/O lines. Access to the CPU's address, data and control buses is provided for special-purpose peripherals. $495 to $895. **Megatel Computer Corp Inc**, 150 Turbine Dr, Weston, Ontario M9L 2S2, Canada. Phone (416) 745-7214. TLX 06527453.

Circle No 380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Technical data ☐ Demonstration ☐ of 7151

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MODEM. Model 224 is a μP-based, 2400-bps modem for asynchronous or synchronous operation over the public switched telephone network. The unit features autoanswer capability, automatic adaptive equalization and diagnostics. The modem communicates with other Bell 212-compatible units in a fallback 1200-bps mode and complies with the CCITT recommendation for a V.22 bis data modem communicating at 2400 bps. The unit automatically detects whether the calling modem is a 212-compatible modem and adapts its speed and modulation scheme accordingly. $995. **Motorola Inc,** Information Systems Group, 5000 Bradford Dr, Huntsville, AL 35805. Phone (205) 837-8100. TWX 810-726-2100.

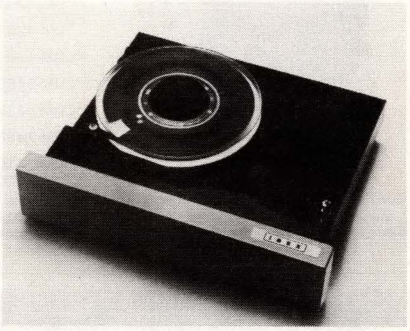
Circle No 314

FAULT-TOLERANT MINI. The fault-tolerant Parallel 300 minicomputer runs UNIX and uses Multibus. Users need no training or tools to restore the system to operation; components can be removed and replaced quickly. The system has duplicate MC68010 virtual-memory μPs, disk drives, disk controllers and power supplies. It deals with power fluctuations and failures with duplicate power modules and integrated batteries. Either module can power the unit alone. The entire memory system runs on the internal batteries, which are charged by external power. The computer runs on batteries with automatic shutdown at 15 min. An optional battery pack maintains memory for an additional 90 min. When external power resumes, the computer continues from where it left off. Options include more memory, disks, local-area networking, communications and software. $74,900. **Parallel Computers,** 3004 Mission St, Santa Cruz, CA 95060. Phone (408) 429-1338.

Circle No 315

GRAPHICS STATIONS. The GW/8000 and GW/10000 graphics workstations are based on the Eclipse MV/8000 and MV/10000, respectively, and include two monitors: a 19-in. color display with 1280×1024-pixel resolution, and the Dasher D460 alphanumeric monitor. Each system also includes the GDC/1000 graphics controller, the GKS level 2B programmer's graphics interface and the AOS/VS operating system. The GD/1000 graphic-display subsystem contains all of the packaged graphics hardware except the CPU, adding a workstation to an existing GW system. The workstation communicates with the host system at 2M bytes/sec. AOS/VS GKS Level 2B, an ANSI/ISO-compliant programmer's interface for graphics applications, provides workstation-independent segment storage and metafiles. The former allows you to combine graphics primitives and manipulate them as a unit. The latter allows filing and storage of graphic images on the system disk. GW/10000, $277,900; GW/8000, $160,500; GD/1000, $36,000; AOS/VS GKS Level 2B, $1600. **Data General,** Technical Products Div, 4400 Computer Dr, Westborough, MA 01580. Phone (617) 336-8911.

Circle No 316



STREAMING TAPE DRIVE. The PCT-1000 is an intelligent, 9-track streaming tape drive, which is compatible with IBM formats and provides 138M bytes of backup data storage. Two μPs and a real-time operating system control tape motion. The drive handles multiple formats, including 800-cpi NRZI, IBM and ANSI; 1600-cpi Perkin Elmer, IBM and ANSI; and dual-density 3200/1600 cpi. The drive is compatible with the Cipher/Pertec interface and has manual threading. The drawer-mount unit weighs 36 lbs, measures 19×5¼ in. and handles standard 7-, 8½- and 10½-in. reels. Vertical and horizontal configurations are available. Prices vary according to the number of formats specified. Basic PCT-1000 1600-cpi drive, $2256 (100). **Ibex Computer Corp,** 20741 Marilla St, Chatsworth, CA 91311. Phone (818) 709-8100.

Circle No 317

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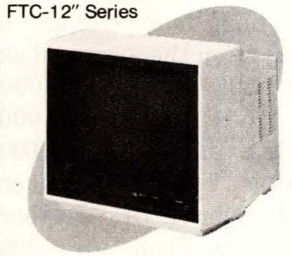
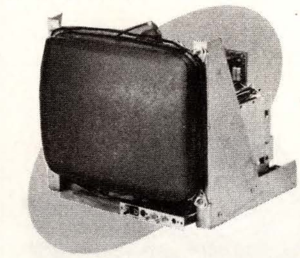


FTC Series (Housed in lightweight, impact-resistant Cabinet)

Versions / CRT Size	RGB Version	NTSC Version	PAL Version	NTSC & RGB Version	PAL&RGB Version	IBM PC Compatible only
12" (CRT Pitch)	FTC-1201-R* (0.47mm Stripe)	FTC-1200-N (0.64mm Stripe)	FTC-1200-P (0.64mm Stripe)	FTC-1201-NR (0.47mm Stripe)	FTC-1201-PR (0.47mm Stripe)	FTC-1203-H* (0.38mm Dot trio)
	FTC-1203-R* (0.38mm Dot trio)	FTC-1201-N (0.47mm Stripe)	FTC-1201-P (0.47mm Dot trio)			FTC-1208-H (0.28mm Dot trio)
	FTC-1208-R* (0.28mm Dot trio)					
14" (CRT Pitch)	FTC-1423H-R (0.42mm Stripe)	FTC-1410H-N (0.52mm Stripe)	FTC-1410H-P (0.52mm Stripe)	FTC-1410H-NR (0.52mm Stripe)	FTC-1410H-PR (0.52mm Stripe)	FTC-1435-H (0.39mm Dot trio)
	FTC-1435H-R (0.39mm Dot trio)	FTC-1416-N (0.64mm Stripe)	FTC-1416-P (0.64mm Stripe)			FTC-1455-H (0.31mm Dot trio)
	FTC-1455H-R (0.31mm Dot trio)					

Application/NTSC·PAL (Commodore·Apple II, IIe), RGM (IBM PC·Apple II, IIe, III·RGB TTL & Analog)
*FTC-1201-R, 1208-R: Applying for FCC Standard (Class B). *through Interface-Module
*FTC-1203-R: Acquired FCC Standard (Class B). FTC-1203-R, 1203-H: Non-Glare

CDM-14" Series



CDM Series (Unit for OEM)

Model	CRT Size	CRT Pitch
CDM-1208	12"	0.28mm Dot trio
CDM-1203	12"	0.38mm Dot trio
CDM-1201	12"	0.47mm Stripe
CDM-1455H-R	14"	0.31mm Dot trio
CDM-1435H-R	14"	0.39mm Dot trio
CDM-1423H-R	14"	0.42mm Stripe
CDM-1410H-R	14"	0.52mm Stripe

- Green/Orange CRT Displays are also available. (Included IBM Compatible.) CRT size: 9" or 12". Horizontal frequency: 15.75-64kHz. [15.75kHz version: acquired FCC Standard (Class B).]
- Conform to UL Standard.
- Special made products: Select Horizontal Frequency within 31-40kHz (Color), 24-64kHz (Monochrome). Models display providing with more than 640x400-dot-resolution are also available.
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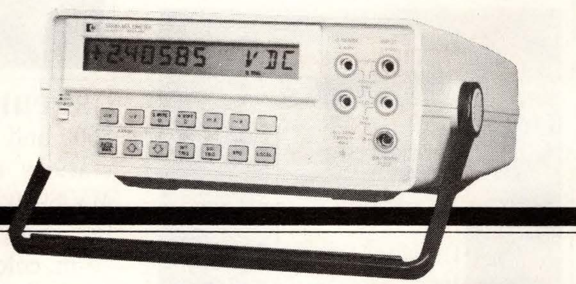

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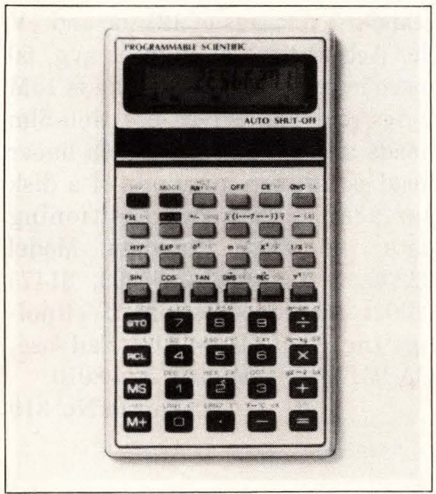
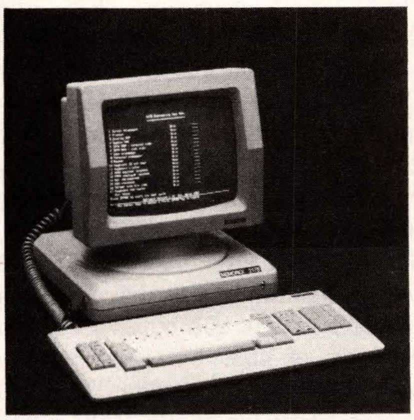


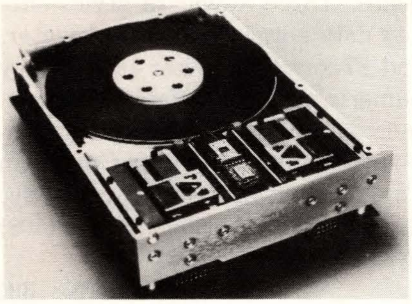
CALCULATOR. The CI-560 is a scientific and statistical calculator featuring seven operating modes: decimal, hex, octal, single and dual variable statistics, and two learn (program store) modes. It provides 45-step programming, 70 preprogrammed functions, seven levels of parentheses, seven permanent-storage memories (including one independent-user memory), a 10-digit LCD and automatic shutoff. **Calculated Industries,** 2010 N Tustin Ave, Suite B, Orange, CA 92665. Phone (800) 854-8075; in CA, (714) 921-1800.

Circle No 318



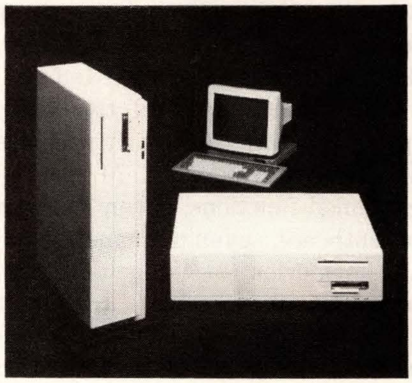
TERMINAL. Model 2178 is a monochrome terminal that contains three separate modules: the display, the keyboard and the logic module (containing display logic and power supply). You can easily swap modules for diagnosis and maintenance. A plug-compatible replacement for the IBM 3178, the terminal connects to 3276 and 3274 cluster controllers and is SNA/SDLC-compatible with 370, 303X, 308X, 43XX and 8100 systems. The 12-in.-diagonal, green-phosphor CRT displays 24 lines×80 characters, has 20° tilt and 90° swivel, and can stand apart from the logic module as well as the keyboard. Three keyboard styles—75-key data entry, 87-key typewriter, and 87-key typewriter plus 10-key numeric pad—are offered. The system supports 10 European languages. $1485. **Memorex Corp,** San Tomas at Central Expressway, Santa Clara, CA 95052. Phone (408) 987-3072.

Circle No 391



DISK DRIVES. Model 96202 5¼-in. half-height Winchester disk drive has a 103M-byte capacity, while Model 96204 has a 61.8M-byte capacity. The drives use a plated medium to achieve 960 tpi and 20,880 bytes per track. Each model is available in two formats: an entire disk drive or just the head-disk assembly. The units operate from standard voltages of 12V dc and 5V dc. Access time is 30 msec avg, 50 msec max. The transfer rate is 10M bytes/sec. The drives use thin-film heads and a voice-coil-driven linear head positioner. One side of a disk surface holds servo-positioning data; the other, the data. Model 96202, $1150, Model 96203, $1475 (1000). **Advanced Storage Technology Inc,** 6580 Via Del Oro, San Jose, CA 95119. Phone (408) 224-8010.

Circle No 319



MULTIUSER SUPER μC. The RAIR SuperMicro combines the iAPX 286 and 287 μPs with as much as 2M bytes of high-speed memory and 100M bytes of hard-disk memory. The μC supports 16 users and runs the Concurrent DOS and UNIX System V operating systems. The execution rate is greater than 1M instructions/sec, and floating-point multiply time is less than 24 μsec. An internal high-speed peripheral bus conforms to SCSI. The machine has one or two 50M-byte, 5¼-in. Winchester disks backed up by a streaming tape drive with a transfer rate of 90k bytes/sec and a capacity of 45M bytes/sec with a standard tape cartridge. The μC has capacity for 16 RS-232C ports and an IEEE-488 bus. It can be equipped with an Ethernet interface. $15,000. **RAIR Microcomputer Corp,** 4101 Burton Dr, Santa Clara, CA 95050. Phone (408) 988-1790.

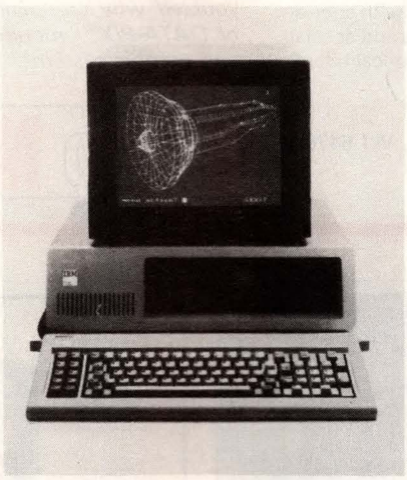
Circle No 320

GRAPHICS WORKSTATION. Colorware System 23, available in three models, has local processing with resolutions of 1024×768, 768×575 or 512×512 pixels on a 19-in. screen. Each model simultaneously displays 256 colors from a palette of 16.7M. The units have read/write masking of eight independent video planes for developing color overlays. The systems include an LSI-11/23 16-bit processor with 512k bytes of memory and optional expansion to 4M bytes as well as four serial ports, two RS-232C ports and one 50-pin parallel DMA port. The units accommodate Q Bus peripheral modules. They have eight disk configurations with capacities from 10M to 40M bytes. A fully-expanded system has two 5¼-in., 20M-byte Winchester drives with two 8-in., 1M-byte slimline floppy-disk drives. <$30,000. **Advanced Electronics Design Inc,** 440 Potrero Ave, Sunnyvale, CA 94086. Phone (408) 733-3555.

Circle No 392

32-BIT WORKSTATION. The 32S workstation executes as many as 8M instructions/sec and 1.5M Whetstone operations/sec. Placed under a desk or arranged as a stand-alone unit, it features 4-stage pipelined architecture. Its virtual memory provides 4G bytes of addressable code and data, 1M to 4M bytes of memory, demand-paged virtual memory with 4k-byte pages and a 375-nsec memory cycle time. The machine's languages are FORTRAN 77, C, Pascal and the manufacturer's Mainsail. Its operating system, ROS 3.1, is UNIX System V and bsd 4.2 derived. The basic configuration includes 1M byte of memory, a 78M-byte Winchester drive and a 1M-byte floppy-disk drive. Its interfaces include two RS-232C, one printer/plotter and one line printer ports. The system includes an Ethernet environment. Options are a 1024×800-pixel raster graphics terminal with monochrome display or a 19-in. color monitor with 1024×768-pixel resolution. Basic configuration, $36,400. Delivery, 90 days ARO. **Ridge Computers,** 2451 Mission College Blvd, Santa Clara, CA 95054. Phone (408) 986-8500. TLX 176956.

Circle No 393



CAD SOFTWARE. This software incorporates the IBM PC/XT computers and optional 2- or 3-D spatial digitizers with a high-resolution color-CRT display and digital plotter/printer. The menu-driven program uses macros to implement graphics functions: image digitizing and drafting, interactive editing, coordinate transformation, zoom/rotate/scale/plot and coloring/highlighting. An optional, high-resolution charge-coupled-device image camera and digitizing adapter together scan and process graphic images, drawings and photographs for both image/text data entry and display and integration using the the CAD system. From $4900. **Computer Systems,** 26401 Harper Ave, St Clair, MI 48081. Phone (313) 779-8700.

Circle No 403

WORKSTATION. Saber Station executes 1.2M instructions/sec using the NS32032 μP. It provides demand-paged memory and uses Berkeley UNIX. Software includes C, Pascal, FORTRAN 77, LAN support, programmers' workbench, virtual disk interface, window manager and graphics package. The package includes Siggraph Core 2-D and 3-D and GKS 2-D. The software works via window manager or under customer-developed application software. The graphics package gives you access to the 2M-pixel display at the pixel level. The graphics processor employs a 32-bit, 20M-byte/sec op-code/data bus structure. An image processor does vector-to-raster conversions and bit alignment for the 1664×1248-pixel image memory. The system allows expansion to 24 image planes and a color palette of 16M colors. The image processor produces a display every 5.5 nsec. <$40,000. **Saber Technology Corp,** 2381 Bering Dr, San Jose, CA 95131. Phone (408) 945-9600.

Circle No 394

VAX-BASED WORKSTATION. The Phoenix workstation simultaneously displays logical and physical designs on a split screen. The manufacturer's software includes schematic capture, logic and circuit simulation, waveform analysis, physical design, layout verification and fractioning. This package also runs on DEC's μVAX and VAX 11/725. You can purchase the workstation in graphics-display-only configuration which a VAX supports. The basic system is a μVAX I computer with a Tektronix 4109 color-graphics terminal (16-color display from a palette of 4096) and 640×480-pixel resolution. One-terminal system, $44,900. Delivery, 90 days ARO. **Phoenix Data Systems Inc,** 2700 Augustine Dr, Suite 200, Santa Clara, CA 95054. Phone (518) 459-6202.

Circle No 395

WORKSTATION SOFTWARE. Hilo-2 software now runs on the Apollo-based CAE 2000 workstation. This logic-design simulation software is used for IC design, pc-board design, structural and functional modelling, timing analysis, fault simulation and test validation. **CAE Systems,** 1333 Bordeaux Dr, Sunnyvale, CA 94089. Phone (408) 745-1440.

Circle No 396

CAE WORKSTATION. CDS 3000 systems have software for schematic capture, drafting, space planning and facilities management, technical publications and manufacturing-information distribution. It supports FORTRAN 77, C and Pascal as well as debuggers, linkers, loaders and other utilities. It has an optional set of tools for personal management, including report generation, spreadsheets, word processing, database management utilities and an interactive data-query language. Using the CDS 9000 shared resource manager and Ethernet software, the workstation can be clustered in multiple-user networks, linked with central peripherals, disk and tape drives, and additional graphics and storage. Features are a 68010 CPU, 2M bytes of memory, UNIX, a Multibus chassis and a 900×1152-pixel graphics unit. From $35,000. **Computervision,** 100 Crosby Dr, Bedford, MA 01730. Phone (617) 275-1800.

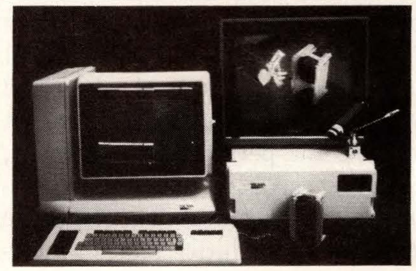
Circle No 397

IC-DESIGN SOFTWARE. Users of the Logician V CAE workstation can now buy 3- and 5-μm gate-array and PaCMOS standard-cell libraries on floppy disks to design semicustom ICs. Five libraries are available. PA50000 Series devices use 3-μm double-level metal Si-gate CMOS technology. You get six designs with complexities from 880 to 6000 gates. V_{CC} ranges from 3 to 7V dc. The PA4000 Series is also a 3-μm Si-gate process with a typical 2.5-nsec delay time. These V_{CC}s also range from 3 to 7V dc. You get four arrays with 650 to 1200 gates. The PA20000 is a 5-μm Si-gate process with 4-nsec typ gate delays. You get five arrays operating from 3 to 12V dc with 250- to 1000-gate complexities. The PaCMOS I and II standard-cell libraries use building-block circuits. They are 3- and 5-μm Si-gate processes that handle as many as 3000 and 5000 gates, respectively. Both libraries contain a logic-simulator package in which the designer uses the standard cells together with the analysis, debugging and verification software tools of the Logician V workstation. Annual license fee per library, $300. **RCA,** Rte 202, Somerville, NJ 08876. Phone (800) 526-2177.

INQUIRE DIRECT

CAE WORKSTATION. The EAS/300 workstation is integrated with the manufacturer's EAS/770 system and PCX software for pc-board design. Based on the IBM PC, the workstation links with EAS/770 workstations over Ethernet or connects via an RS-232C interface. The applications software includes PC-CAPS, a schematic-capture program, and PC-NODES, which extracts net lists and connective information from the PC-CAPS database. PC-LOGS software is available for logic simulation. The company's software includes terminal-emulator and file-transfer packages for the interface between the EAS/300 and the EAS/700. Typical hardware includes 640k bytes of RAM, hard disk, color monitor, mouse, serial interface and network controller. The system includes IBM-DOS 2.1. From $12,000. **Engineering Automation Systems Inc,** 936 Silas Deane Hwy, Wethersfield, CT 06036. Phone (203) 529-3200.

Circle No 399



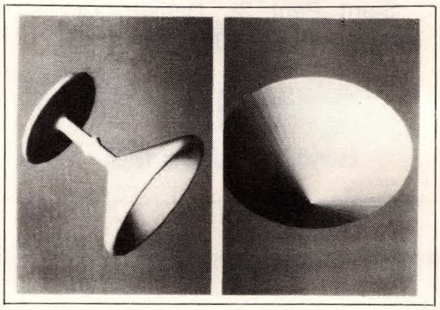
WORKSTATIONS FOR ROBOTS. Visicam is a CAE workstation for generating 3-D vision programs for inspection and robotics applications. The typical workstation includes a 32-bit desktop mainframe with 1024×800-pixel bit-mapped graphics, 70M-byte disk drive, vision processor, charge-coupled-device camera, color monitor and 3-D programming software. The software, once developed on the Visicam workstation, runs on a Silma 9000 computer. The computer stands alone for visual inspection tasks or connects to a robot controller. Robocam is for on- or off-line programming of industrial robots and simulating robots and their work cells. It uses Rise, an arm-independent language for programming robots. You describe layouts for a robot work cell using Silmodel, a 3-D modeling system. You use Robocam to write and debug robot-control programs and then download them to the robot. When Visicam and Robocam are combined in a system, 3-D models of parts in Rise simulations generate the appropriate recognition

routines in Visicam to locate and recognize parts. Visicam, from \$80,500; Robocam, from \$61,100; combined system, \$107,500. **Silma Inc,** 1800 Embarcadero, Palo Alto, CA 94303. Phone (415) 493-0145.

Circle No 400

CAE SOFTWARE. Five CDS 3000 workstation applications packages simplify engineering, design and manufacturing. Drafting/3000 has both English and metric dimensioning, protractor emulation and construction lines. It supports ANSI, ISO, DIN and JIS standards. Schematic Capture/3000 produces schematics and logic diagrams, permits on-line design-rules checking and has a library of schematic symbols. Spaceplan/3000 analyzes organizational relationships, optimizes stacking, and generates block layouts with alternative choices. Tech Pubs/3000 produces print-shop quality documents with merged text and graphics and includes pagination, text editing and formatting. Factoryvision/3000 allows distribution of text, graphics and numerical-control information. It organizes and maintains project information like drawings, plans, text and engineering data. Drafting/3000, \$12,000. Schematic Capture/3000, \$12,000. Spaceplan/3000, \$25,000. Tech Pubs/3000, \$4500. Factoryvision/3000, \$3500. **Computervision,** 100 Crosby Dr, Bedford, MA 01730. Phone (617) 275-1800.

Circle No 401



COMPUTER GRAPHICS. Merlin 9200 computer graphics system combines advanced graphic capabilities with local database and task processing. The multiprocessor system includes hardware implementation of solids-rendering functions including a real-time shading process with constant, Gouraud or Phong algorithms and a variable light source. Other system features are Z-buffer hidden-surface removal; hardware perspective with programmable focal point and range; X-, Y- and Z-axis clipping; pattern-to-surface adherence and 3-D entity detection. The system has internal and external networking facilities: an internal LAN for high-speed data transfer between processors and Ethernet for intra-system and intra-computer communications. <\$35,000. **Megatek Corp,** 9605 Scranton Rd, San Diego, CA 92121. Phone (619) 455-5590.

Circle No 402

Dry film caps eliminate fluids that can leak, give the TRW-35 and TRW-61 capacitors higher current capability, higher ESR, and special high current terminations.

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CIRCLE NO 168

TOSHIBA 2
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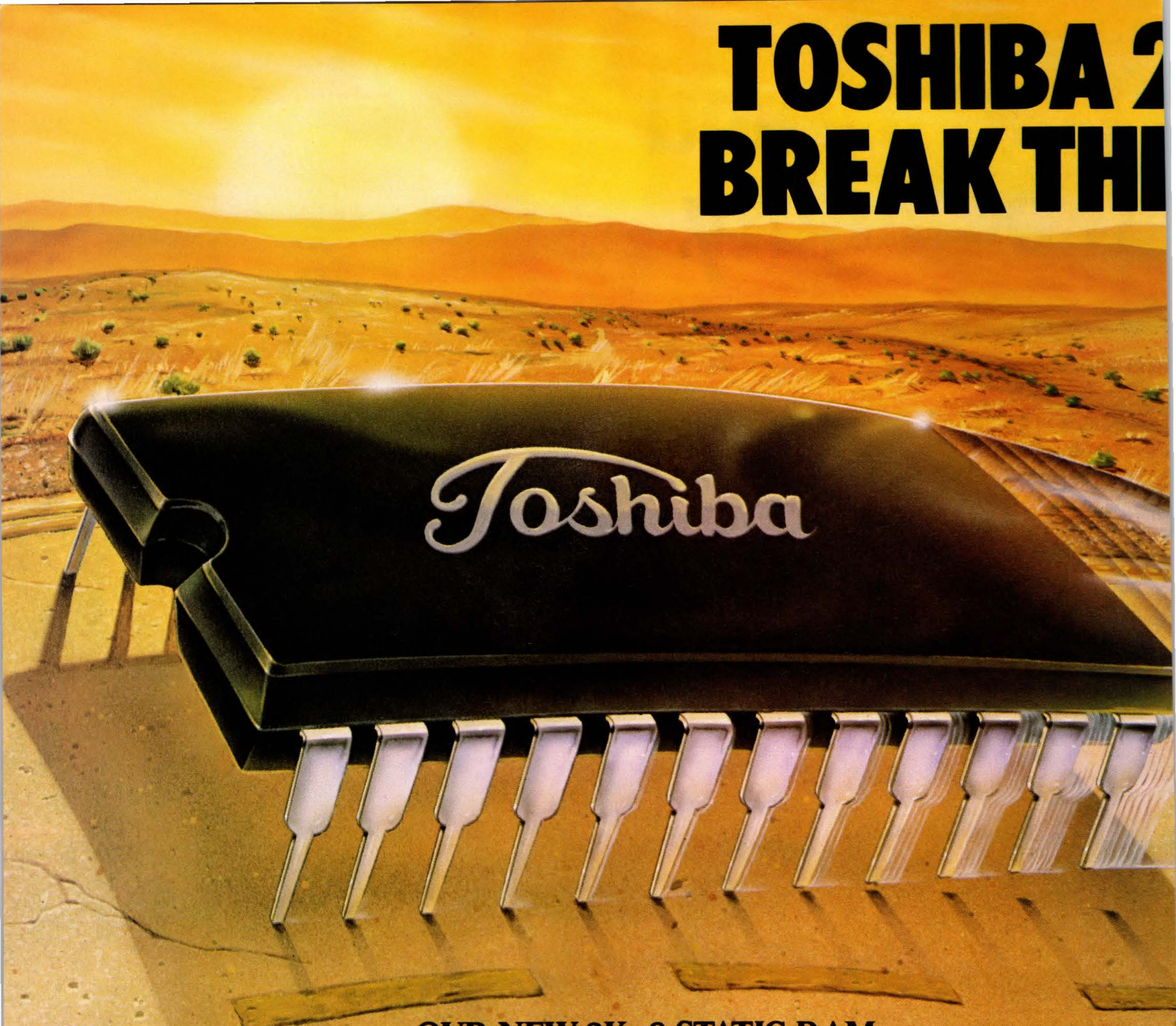

OUR NEW 2Kx8 STATIC RAM IS TWICE AS FAST AS ANY OTHER BYTE-WIDE. HITTING SPEEDS TO 45ns.

Toshiba has the world's fastest 2K x 8 Static RAM. With speeds as fast as 45ns and other byte-wide units with power consumption as low as 1μA, your range of design options just got twice as wide as before.

Our new TMM2018D provides both high-speed and low-power features with an access time of 45ns. This, along with high density, explains why they're rapidly displacing bipolar devices.

All our high-speed *NMOS* and *CMOS* 2K x 8's are designed for maximum compatibility with microprocessor bus structures.

In fact, ours were the first 16K CMOS RAMs on the market. We designed them for a maximum 1μA standby current.

Operating from a single 5V power supply, our byte-wide RAMs are available in a 24-pin package, DIP (.300″ or .600″), flat pack and a variety of other configurations.

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2016AP-10	NMOS	100ns	65mA	7mA
2016AP-12	NMOS	120ns	65mA	7mA
2016AP-15	NMOS	150ns	65mA	7mA
*2015AP-90	NMOS	90ns	80mA	7mA
*2015AP-10	NMOS	100ns	65mA	7mA
*2015AP-12	NMOS	120ns	65mA	7mA
*2015AP-15	NMOS	150ns	65mA	7mA
*2018D-45	NMOS	45ns	120mA	20mA
*2018D-55	NMOS	55ns	120mA	20mA
**5516AP	CMOS	250ns	55mA	30μA
**5516AP-2	CMOS	200ns	55mA	30μA
**5516APL	CMOS	250ns	55mA	1μA
**5516APL-2	CMOS	200ns	55mA	1μA
**5517AP	CMOS	250ns	55mA	30μA
**5517AP-2	CMOS	200ns	55mA	30μA
**5517APL	CMOS	250ns	55mA	1μA
**5517APL-2	CMOS	200ns	55mA	1μA
5517BP-20	CMOS	200ns	25mA	30μA
5517BPL-20	CMOS	200ns	25mA	1μA
5518BP-20	CMOS	200ns	25mA	30μA
5518BPL-20	CMOS	200ns	25mA	1μA

*.300" wide dual in line package.
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ANDREWS

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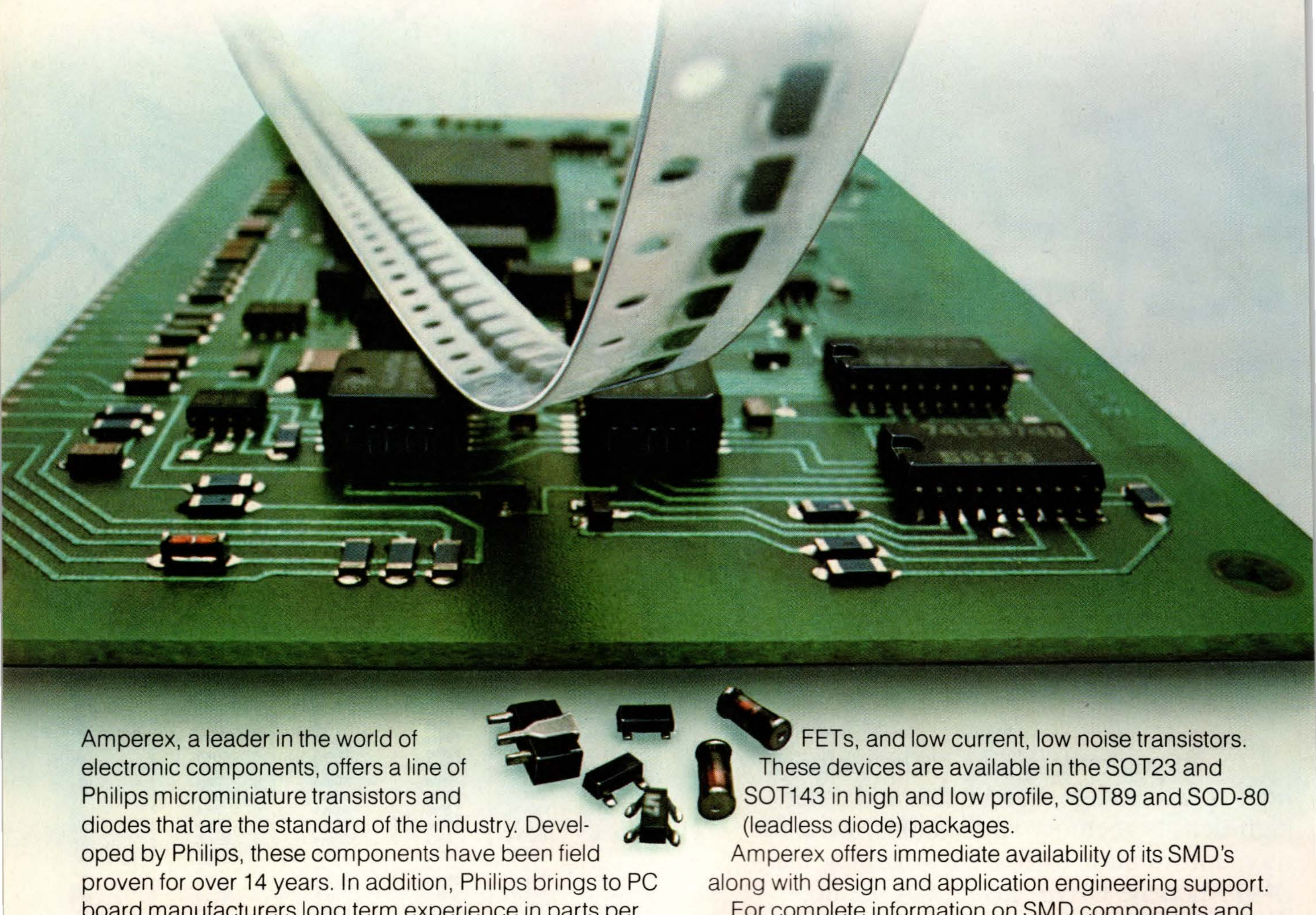

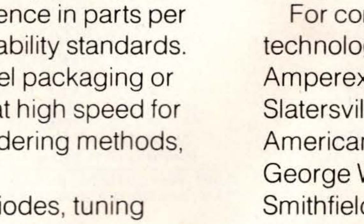

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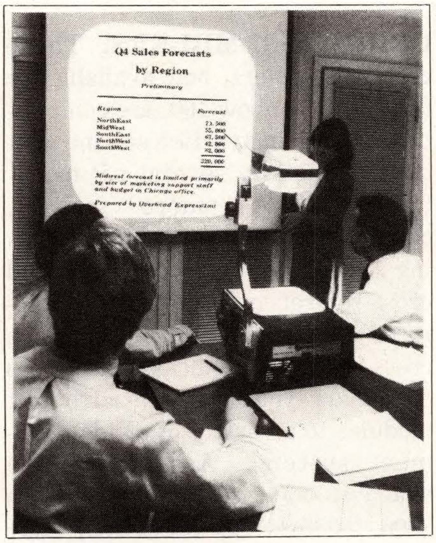
CIRCLE NO 170

Amperex

IBM PC COMPATIBILITY. According to the manufacturer, ROM BIOS software for the OEM market has been developed under strict controls to avoid copyright infringement, and it's insured against infringement suits. The software is part of a package that renders an OEM's µC compatible with the IBM Personal Computer. It includes a version of the MS-DOS operating system, utilities and a BASICA-like implementation of the GWBASIC language. The manufacturer installs the package on the OEM's machine and provides custom hardware and software services to allow hardware-incompatible machines to become compatible. Unlimited-use licensing, $290,000. **Phoenix Software Associates Ltd,** 1420 Providence Hwy, Suite 260, Norwood, MA 02062. Phone (617) 769-7020. TWX 710-345-0199.

Circle No 355

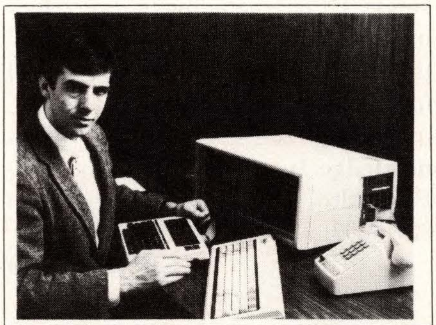


GRAPHICS. The Overhead Express presentation-graphics package produces overhead transparencies and foils and operates on an IBM PC, XT or compatible system running PC-DOS 1.1, 2.0 or 2.1. The package includes the Modern, Script, Popular, and Classic typefaces, in roman and italic fonts and in five point sizes. Also included are international characters in most typefaces and sizes. In order to add graphics emphasis to a presentation, the package features such symbols as arrows, stars, brackets, legal symbols and check marks, each in two sizes. The package has 12 fill-in-the-blanks templates: a title page, a bulleted list, a comparison chart, a table and a budget. The results are printed on a dot-matrix printer and copied onto overhead acetate transparencies using most copiers. The program resides on two disks and requires 192k of RAM. Eleven printers, including the Epson MX and FX, HP ink-jet, C Itoh, Okidata and IBM graphics printers, are supported. $195. **Business & Professional Software Inc,** 143 Binney St, Cambridge, MA 02142. (617) 491-3377.

Circle No 356

PC C TOOLS. The cView package is a forms- and window-management tool for C software developers. It allows the construction of user interfaces and, without changing the underlying code, the modification of forms. The package requires an IBM PC or compatible system, 192k bytes of memory and a monochrome monitor. You can use it with the Computer Innovations, Microsoft or Lattice C compilers. The programmer can create a form larger than the screen size. Input fields are defined as they are placed on the screen. Type specification of the input fields provides automatic testing and rejection of incorrect user entries. The software defines as many as six overlapped or disjointed windows per screen but only keeps one active at a time. The package contains on-line help functions, all run-time libraries required to interface to applications programs, a manual, utilities for file management and file reading, and an editor to create and modify forms. $245. **Compucraft Corp,** 42101 Mound Rd, Sterling Heights, MI 48078. Phone (313) 731-2780.

Circle No 357

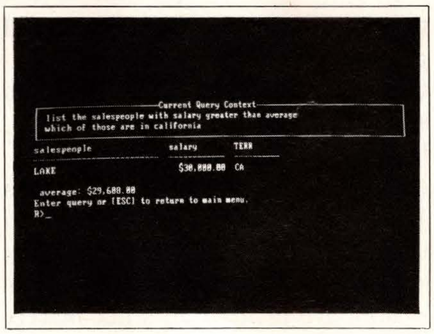


FILE TRANSFER. The Disk+ program turns the TRS-80 Model 100 and any of several other systems into an instant disk system. The program comes on diskette and cassette for loading into the Model 100. Both are needed initially, but only the disk is needed after loading. The software works on the TRS-80 Models II, III and IV and most other Radio Shack computers; the IBM PC and MS-DOS-based computers (Compaq, Corona, etc); the Apple II, IIe and II+; the Olivetti ETV 300, M 20 and M 24; and some CP/M systems. The program uses the main-menu concept. Files are transferred at the highest feasible baud rate for the computer, most at 19.2k baud. The program can also work through the Model 100's built-in modem. It needs 4.5k bytes of memory once loaded, and an additional 4.5k bytes to run. $69.95 for cassette, disk and manual. **Portable Computer Support Group,** 11035 Harry Hines Blvd, No 207, Dallas, TX 75229. Phone (214) 351-0564.

Circle No 358

KNOWLEDGE TOOL. M.1 is a software tool used to design, build and run stand-alone knowledge systems that solve problems normally requiring human intelligence. The system runs on the IBM PC and features an English-like knowledge-representation language, interactive knowledge-base debugging, explanations of reasoning, certainty factors in decision making and manipulation of variables. $12,500 for single CPU, including 4-day training course and maintenance. Additional CPU licenses, \$2500. \$5000 for additional course participants, including CPU license. **Teknowledge Inc,** 525 University Ave, Palo Alto, CA 94301. Phone (415) 327-6600.

Circle No 359



μC SOFTWARE. Clout, a natural-language software interface, runs on the manufacturer's R:base relational database software. The software has a dictionary of 200 words and allows you to add your own vocabulary. Once installed, the software reads the attributes in the existing database and adds them to the dictionary. The program defines unfamiliar words via a question-and-answer dialog with the user. It searches through the database to retrieve records based on adjectives or qualifying terms, and it inquires into five different files from the 40 files available concurrently in R:base. The package accompanies the R:base Series of single and multiuser systems, which operate on PC-DOS, MS-DOS, CTOS, BTOS and UNIX. \$195. **Microrim Inc,** 1750 112th Ave NE, Bellevue, WA 98004. Phone (206) 453-6017.

Circle No 360

CROSS ASSEMBLERS. These cross assemblers, now available for the DEC Rainbow 100, are compatible with the instruction set and syntax specified by several μP manufacturers. A macro facility, conditional-assembly options, linking loader, list control operators and cross-reference listing are incorporated into each assembler. Each cross assembler includes utilities that allow you to download object modules to a variety of μP development systems. Assemblers are available for several μPs: Intel's 8096, 8086/80186, 8080/8085, 8051 and 8048; Motorola's 68000, 6809, 6800/6801 and 6805; Zilog's Z8002 and Z80; the 6500 families; and μPs from Hitachi, TI and others. The assemblers require 128k bytes of RAM and run MS-DOS. \$600 to \$1800 for CPU licenses. **Microtec Research Inc,** 505 West Olive, No 325, Sunnyvale, CA 94086. Phone (408) 733-2919.

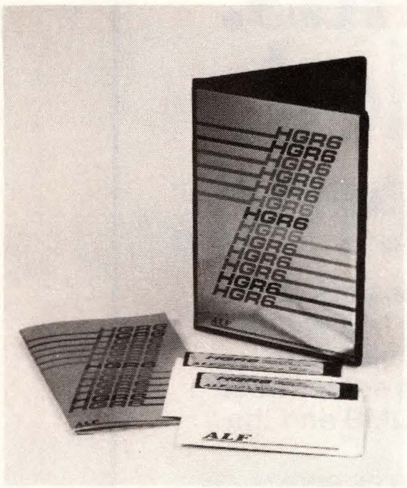
Circle No 361

COMMUNICATIONS. The 3101 communications program provides the Professional or Portable Professional computers with IBM 3101 terminal characteristics while retaining the usefulness of a standalone computer. It attaches to IBM and IBM-compatible mainframes via direct cabling or through a telephone line via a modem. The software supports a character mode that accesses and retrieves information from databases, and it provides timesharing services that support the 3101 character protocol. A block mode accesses applications running on a remote computer. The system requires a synchronous/asynchronous communications board or a TI internal modem, along with a floppy disk, 128k bytes of RAM and MS-DOS 1.1 or 2.1. Diskette and user documentation, $140. **Texas Instruments,** Data Systems Group, Box 402430, H-710, Dallas, TX 75240. Phone (800) 527-3500.

Circle No 362

COMMUNICATIONS. The Multiple Access Facility with Remote Host Option (MAF/RHO) for the manufacturer's 3600 communications-processor system allows SNA and BSC 3270 terminals in an IBM SNA or pre-SNA network to access IBM and non-IBM hosts. In an IBM network, these terminals can access applications within any IBM or non-IBM host capable of supporting link-attached BSC 3271 or 3274 cluster controllers. In addition, the terminals have access to a gateway between IBM hosts located in separate networks. Compatible with earlier MAF releases, the package provides polling and addressing of terminals for the host, error-recovery and control functions, and alternate routing for the remote nodes. Initial license, $3218; continuing license, $585/mo or $6435/yr. **NCR Comten Inc,** 2700 Snelling Ave N, St Paul, MN 55113. Phone (612) 638-7777.

Circle No 363



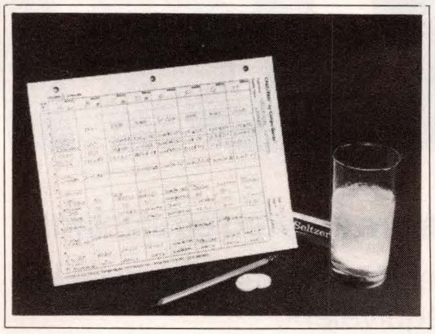
GRAPHICS. The HGR6 Double-Res graphics package for Apple IIe personal computers, featuring an extended 80-column card, is now ProDOS compatible and includes DOS 3.3 and ProDOS disks. The package adds several features to Applesoft. New statements, such as HGR3 through HGR6, work like the older HGR and HGR2 statements, but with 16 high-resolution colors and 560×192-dot resolution. You can change existing programs to use the new colors and higher resolution, or you can use the features in new programs. Customers who have the old version can return it to the vendor for replacement at no charge. $49.95. **ALF Products Inc,** 1315-F Nelson St, Denver, CO 80215. Phone (303) 234-0871.

Circle No 364

DATABASE. The filePro 16 database-software package is for use with the IBM PC/XT (or an IBM PC with a hard disk), the Tandy 2000 and other MS-DOS-based μCs. Its default selections let the user define fields; the software then arranges those fields on the screen or report. The menu-driven system uses plain-English guides to take the user through each step in setting up database files. The program allows automatic data transfer between files. High-level math operations include conditional processing. The system maintains as many as 16 million records per file, 999 fields per record and 4608 characters per record. It can transfer information to Multiplan and Wordstar programs. The system requires 256k bytes of internal memory and a hard-disk drive. It's also available for the Tandy 2000 on floppy disks. $495. **The Small Computer Co Inc,** 230 West 41st St, Suite 1200, New York, NY 10036. Phone (212) 398-9290.

Circle No 365

FORM. Calc/Pad allows you to put your spreadsheet template thoughts on paper and work out Calc structures away from a terminal. The 20-row×8-column form offers room



for penciling in text, values or formulas. It's printed on both sides and consists of 50 sheets per 8½×11-in. cardboard-backed pad. The form is printed on erasable green paper and is punched for 3-ring binders. $4.75/pad. **Compu-Quote,** 6914 Berquist Ave, Canoga Park, CA 91307. Phone (818) 348-3662.

Circle No 366

GRAPHICS. Template Version 4.0 is a 3-D computer-independent, device-intelligent graphics and data-display subroutine library that supports graphics devices on 32-bit and larger computer systems. It provides routines to create, display, modify and save graphics information. This version includes 24 new user-callable routines. An Escape interface enables users to access those device-dependent features not supported by Template. The upgraded package also offers user-defined segment clip boundaries, allows enhanced device-independent display surface definition and provides logical file-name support for user files and extended post-processing capability. Superminicomputer package, $6000; minicomputer package, $25,000; mainframe package, $32,000. **Megatek Corp,** 9605 Scranton Rd, San Diego, CA 92121. Phone (619) 455-5590.

Circle No 367

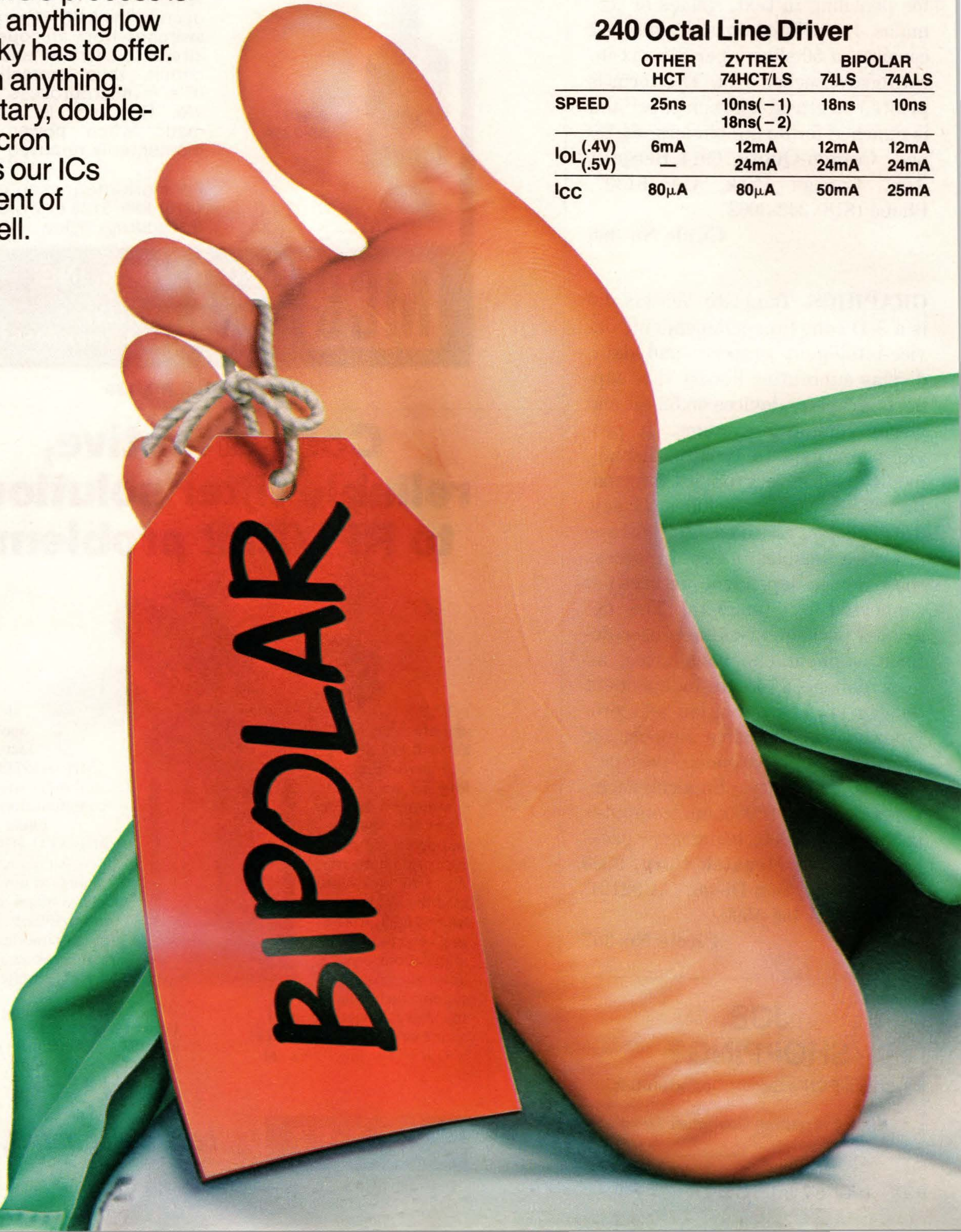
BIPOLAR BI

Bipolar is on its way to that big computer in the sky.

And it's all because of Zytrex.

Our new CMOS process is just as fast as anything low power Schottky has to offer. And we mean anything.

Our proprietary, double-metal, two micron process gives our ICs the drive current of LS/TTL, as well.



All our parts are created equivalent.

Our parts aren't just compatible with LS/TTL. They're equivalent.

240 Octal Line Driver

	OTHER HCT	ZYTREX 74HCT/LS	BIPOLAR 74LS	74ALS
SPEED	25ns	10ns(−1) 18ns(−2)	18ns	10ns
I_{OL}(.4V)	6mA	12mA	12mA	12mA
I_{OL}(.5V)	—	24mA	24mA	24mA
I_{CC}	80μA	80μA	50mA	25mA

It's easy to see why our new CRT series is an improvement down the line.

Improvements that give our HD-100 Series the good-looking features you expect from a quality CRT. You get sharper, cleaner lines and characters, plus improved focus and stability—even in the corners. And you can display over one million pixels on 15- or 17-inch screens, vertically or horizontally. In your choice of standard video or inverted displays, with line rates from 26 to 36 kHz. In effect, you can have enhanced visibility any way you want it, no matter whether your customers are processing words or graphics.

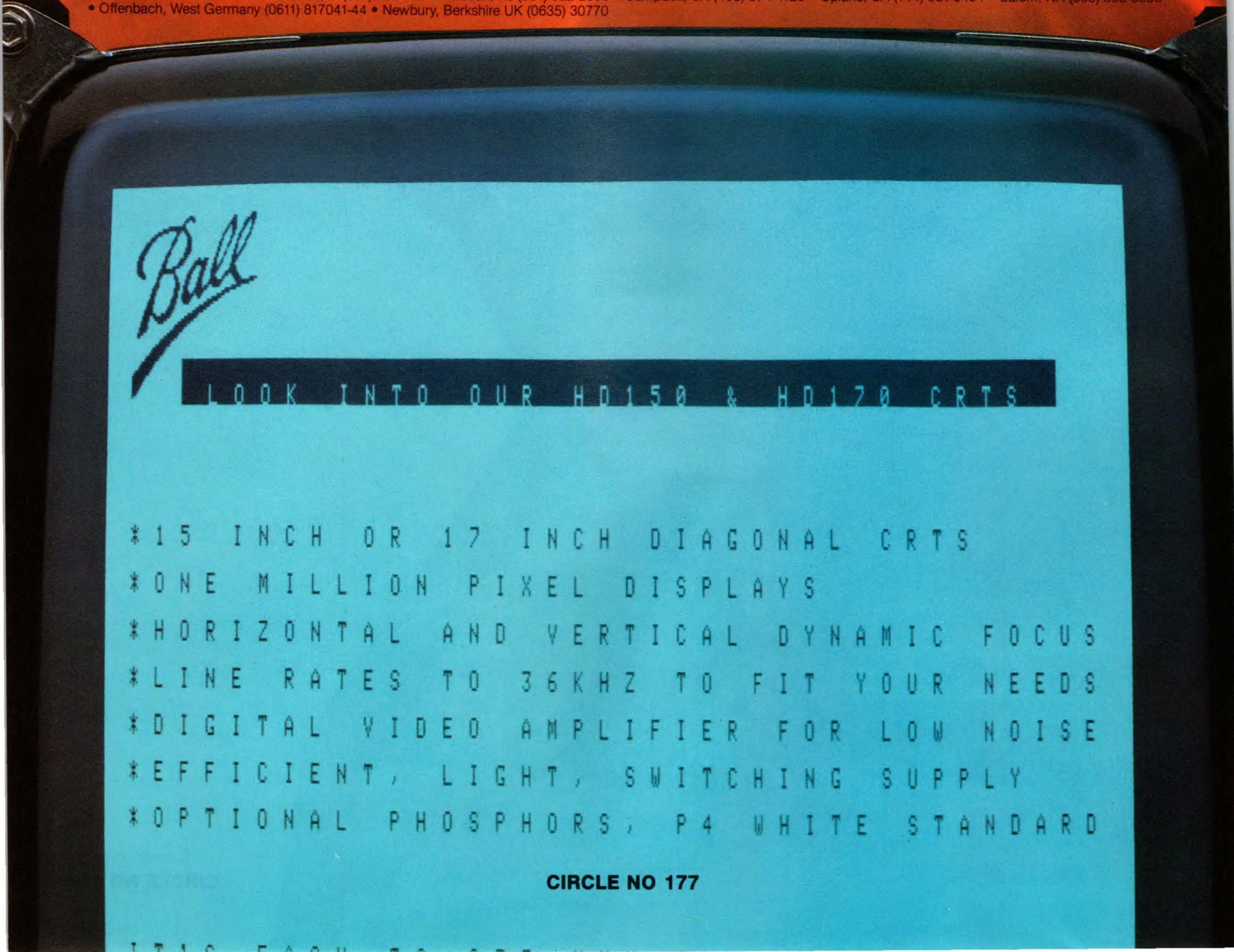
Our CRT line includes a number of other significant improvements. The HD-100 Series displays are 33% lighter than our previous HD Series. That adds up to easier handling, integrating and lower freight costs.

We also built in an efficient switch mode power supply that reduces power consumption for your customers while enabling a stable display over a wide voltage input range. In addition, our new HD-100 Series features an advanced CRT/yoke combination for better focusing. All our improvements are packaged neatly in a compact chassis design that offers convection cooling and makes service a breeze, and naturally, our CRTs are UL-478 approved and CSA certified.

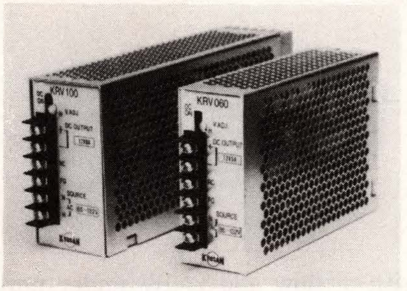
All these enhancements put the focus on quality inside and out. High quality manufactured with great efficiency to give you a new, low price that's an improvement in itself. Call your nearest Ball sales office and ask to see our new HD-100 Series. The CRTs designed to give you a clear advantage with every line.

Ball Electronic Systems Division
P.O. Box 64376 • St. Paul, MN 55164
Bright ideas for better visibility.

General Sales Offices: Downers Grove, IL (312) 960-4434 • Ocean, NJ (201) 922-2800 • Campbell, CA (408) 374-4120 • Upland, CA (714) 981-9404 • Salem, NH (603) 893-3050 • Offenbach, West Germany (0611) 817041-44 • Newbury, Berkshire UK (0635) 30770

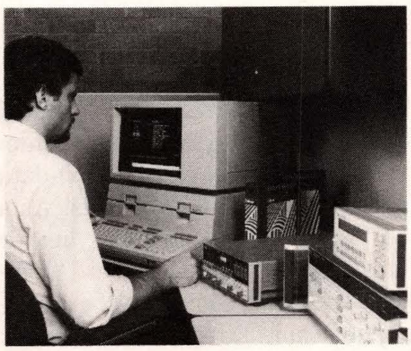


CIRCLE NO 177



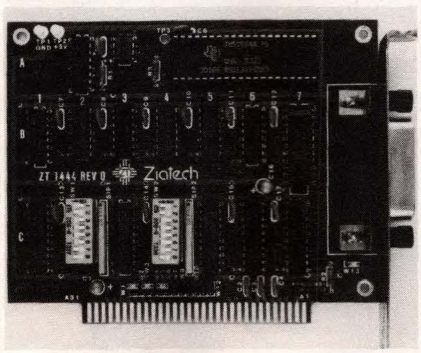
SWITCHERS. Sixty- and 100W KRV Series power supplies feature 100-kHz switching speeds instead of the usual 20 kHz. The faster switching speed results in smaller size. Models are available in 5, 12, 15 and 24V dc versions. All have overvoltage protection. 60W, $129; 100W, $176 (1-9). **KEC Electronics,** 20817 Western Ave, Torrance. CA 90501. Phone (213) 320-3902.

Circle No 334



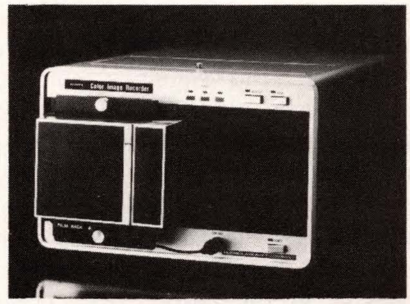
IEEE-488 DEVELOPMENT. Unitest software eliminates the need to understand HP BASIC protocol and syntax required in programming HP IEEE-488 instruments. It works with HP Series 200 computers. On-screen prompts guide the user through the executive program and define the configuration, develop the control program, build data files, define the instrument setups and prepare the run. The firm claims that the software reduces by as much as 75% the time necessary to develop and debug a measurement-intensive program. The basic HP hardware configuration for a development station includes an HP Series 200 computer with serial number PROM, an 80-column CRT, 750k to 1000k bytes of RAM (500k bytes more than OS requirements), a dual floppy or Winchester disk and HP BASIC with Extension 2.0. $3000. Specific instrument packages from $750. Demonstration package, $249. **Production Automation,** 3160 De la Cruz Blvd, Santa Clara, CA 95050. Phone (408) 980-9880.

Circle No 335



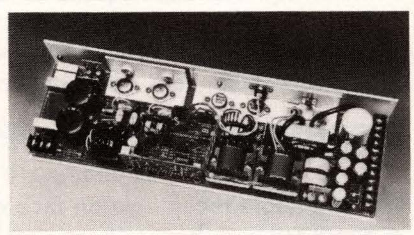
IEEE-488 INTERFACE. ZT 1444 is a short-slot card featuring 450k-byte/sec throughput speeds, an EMI-protected backplate that accepts stackable GPIB connectors directly and software drivers callable from BASIC, compiled BASIC, Pascal, C, FORTRAN, and assembly language. The BASIC software package includes an interactive verification program that lets the user exercise the GPIB without having to write code. A time-out ability ensures the system won't hang up if a device fails to respond. The card supports the ability to "pass control," which lets more than one computer control the same devices without physical recabling. This allows multiple computers to share devices on common GPIB cabling for backup. The card is 5¼ in. long and fits into any IBM PC-compatible I/O slot, including the short slots behind the disk in the XT. $375. Software driver packages, $45 to $55. **Ziatech Corp,** 3433 Roberto Ct, San Luis Obispo, CA 93401. Phone (805) 541-0488. TLX 4992316.

Circle No 336



COLOR-CRT CAMERAS. Models CIR 100 and CIR 200 interface directly with a color display. Each contains a high-resolution, flat-face CRT, primary color filters and controls for exposure and color. They record on 35-mm or instant film. Adjustable exposure and brightness controls ensure color balance. RGB additive-color exposure provides accurate color shading, chromaticity and level. The CIR 100 accepts standard input of 525-line, 60-Hz video with 2:1 interlace. The CIR 200 is a high-resolution version used with 525-line noninterlace or 1023-line, 60-Hz video with 2:1 interlace. Less than $7000. Delivery, 60 days ARO. **Hughes Image and Display Products,** 6155 El Camino Real, Carlsbad, CA 92008. Phone (619) 438-9191.

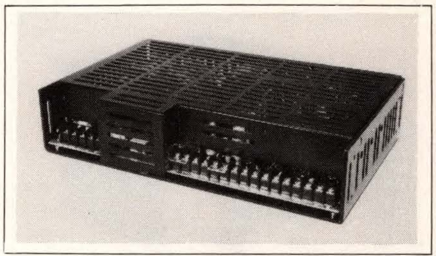
Circle No 337



400W SWITCHERS. DP-400 Series open-frame power supplies deliver 400W at 80% efficiency with as many as five regulated voltage/current output combinations. Five supplies have a fixed 5V dc at 50A output with four other V/I combinations, and the sixth has custom-configured outputs. Conforming to VDE 0806 and IEC 380, the power supplies provide separate primary and secondary connectors. The units' thermal switches shut down the system if the heat sinks' temperatures exceed 100°C as well as thermistor limiting and soft-start limiting. Input ranges from 90 to 130V ac or 180 to 260V ac (47 to 63 Hz, single phase) are strap-selectable by the user. With moving air, the supply operates at full output from 0 to 50°C with 50% derating of current output at 50°C. External heat sink or fan is required for full output. Less than $400. **Datapower Inc,** 3328 W 1st St, Santa Ana, CA 92703. Phone (714) 775-2000.

Circle No 338

300W SWITCHER. The 5 - output Model 3519 switcher provides 300W



with airflow and 250W under normal convection cooling. It has 5V dc at 40A, 24V dc at 6A, 5V dc to 15V dc at 3A and two 12 to 15V dc at 6A outputs. Housed in a 2.56 × 7.5 × 11.81 -in. package, all outputs are regulated, switching, user-adjustable and floating. The supply meets UL 478, CSA 22.2, VDE 0804 and 0806, IEC 380 with SELV circuitry and has British Telecom approval to GT2 and GT26. $410. **Qualidyne Systems Inc,** 2256 Main St, Chula Vista, CA 92011. Phone (619) 429-7440.

Circle No 339

PARALLEL INTERFACE. Model 4833 parallel interface connects devices with parallel or BCD I/O-data formats to the IEEE-488 bus. As a bus Talker, it accepts BCD, hex or binary data from a parallel-I/O instrument and converts it to the proper format for transmission over the IEEE-488 bus to the bus controller. As a bus Listener, the interface accepts bus data sent to it from the bus controller and converts the data into parallel words for control of the user's parallel-I/O instrument. At power turn-on or when reset, the interface initializes its parallel data lines—52 lines in the single-channel version, 104 lines in the dual-channel version—according to factory-set tables stored in internal EPROM. These can be overridden by commands from the 488 bus. Single-channel version, $850; dual-channel version, $1050. **ICS Electronics Corp,** 2185 Old Oakland Rd, San Jose, CA 95131. Phone (408) 263-4844.

Circle No 340

BOB WIDLAR WANTS YOU TO DRIVE FAST SAFELY.

One of the world's foremost linear IC designers introduces a fully protected new unity gain power buffer with a 100V/μsec slew rate.

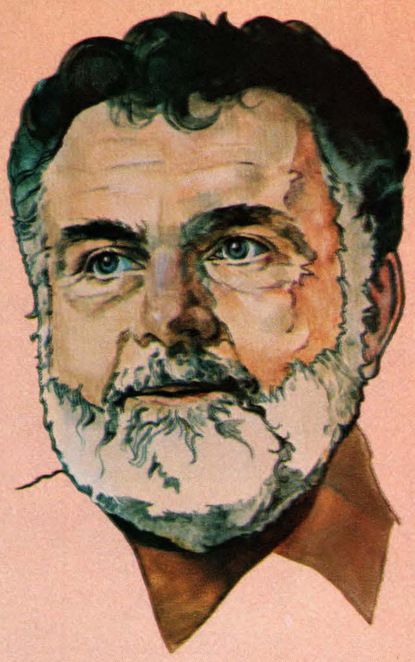
Bob Widlar doesn't normally like to play it safe. In the past years, he's spent his time in daring pursuit of breaking with tradition. Bob is credited with inventing the first industry standard monolithic operational amplifier, voltage comparator, and three-terminal voltage regulator.

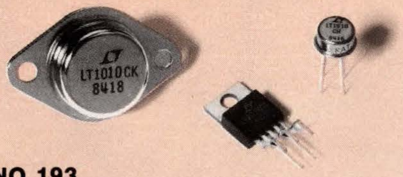
But now Bob wants to play it safe. However, not in the traditional sense. He simply wants you to be able to drive fast safely. That's why he's created his new LT1010. Bob's sensational new offering is a low-cost, high-speed, high-current, easy-to-use unity gain power buffer. The new LT1010 is capable of boosting op amp output from about ±5 milliamps to ±150 milliamps without blowing up.

Some of the new Widlar-inspired LT1010's more impressive features include:

- 20 MHz bandwidth and 100 volt/μsec slew rate
- 4.5v to 40v supply range
- Drives complex impedance loads, such as:
  1 μf capacitors
  cables
  motors
  sample and hold
- Plug-in replacement for LH0002 (at about half the price)
- Both current and thermal overload protected

The new Widlar LT1010 is safe, simple, fast, fully protected, economical on power, and stable with any load. And all LT1010's offer super reliability (each device goes through 100% thermal limit burn-in screening before it ships out). Now you can drive the whole world with absolute safety. Available now from your local Linear Technology distributor. For added information, call or write today.





CIRCLE NO 193

☐ I'd like to be kept current on Linear's products.
☐ Send technical and applications information on your new LT1010.

Name ______________________
Company ______________________
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LINEAR TECHNOLOGY CORPORATION • 1630 McCarthy Blvd.
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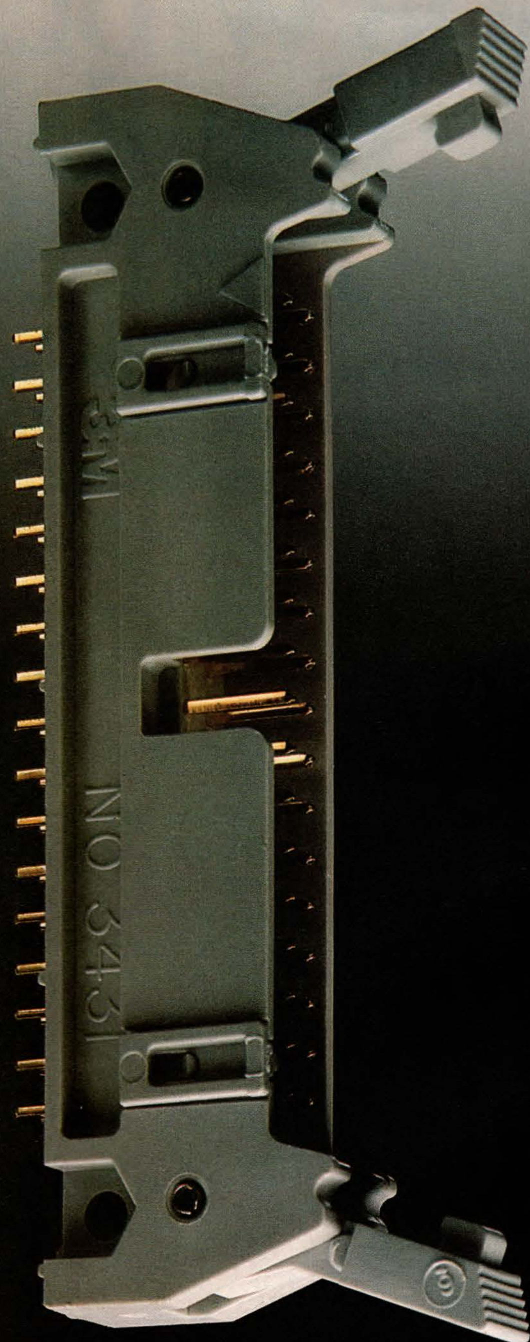

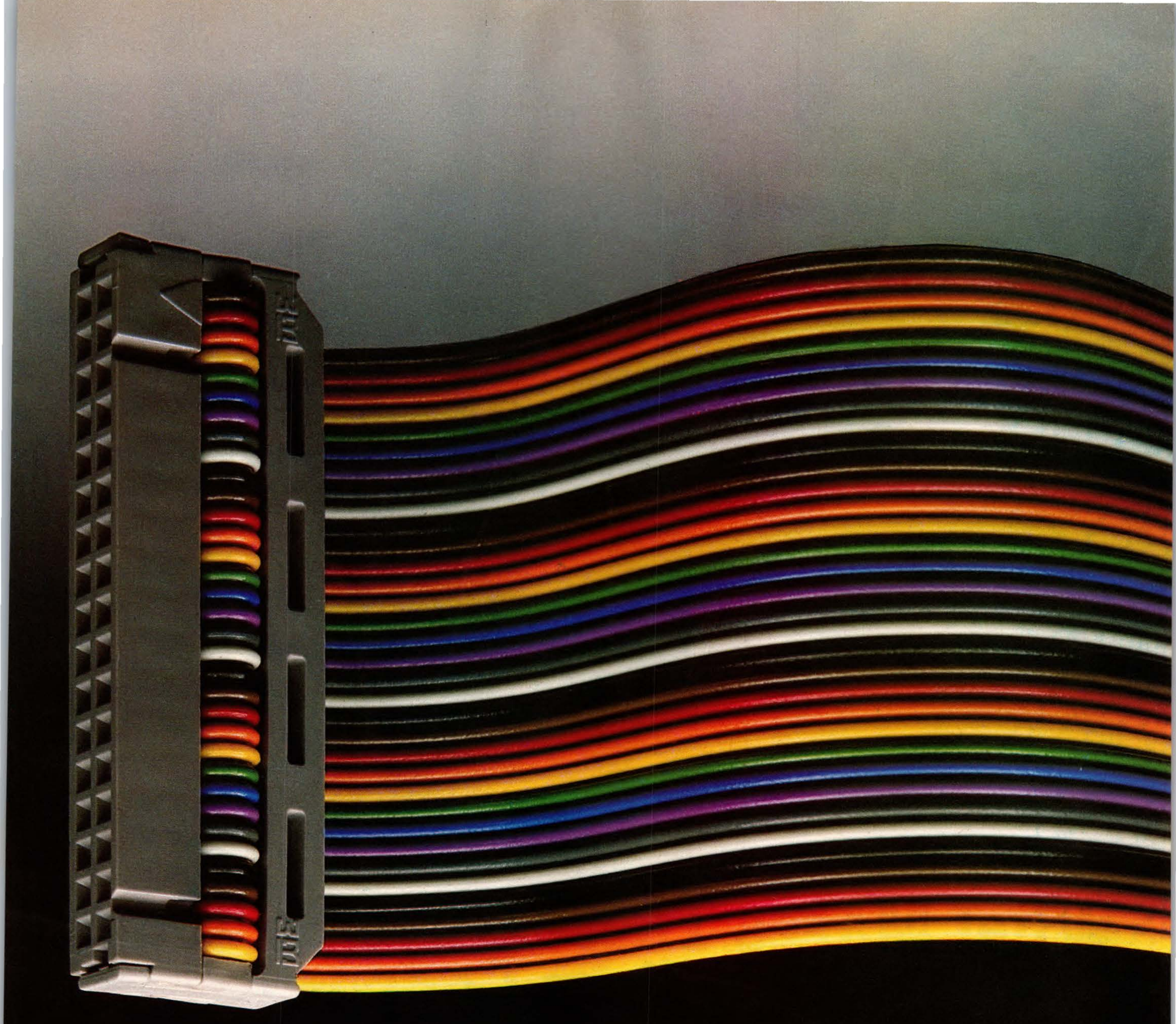

What Makes These Guys So Tough? Beryllium Copper.

Meet CLINCHER,™ CHAMP,® and BLUE MACS® connectors, and LITTLE CAESAR®* They're among the most rugged, most reliable components in their respective lines. And there's a whole gang of others that are just as tough.

What sets them apart from the crowd? It's the use of beryllium copper alloys for the critical terminal and socket parts.

These parts are expected to perform in the most rugged in-out types of application . . . or in systems which must be fail-safe. In these critical designs, beryllium copper has some important advantages over other materials:

Age hardened beryllium copper offers the highest strength of any commercially available copper based alloy. In addition, age hardened spring contacts have excellent resistance to "stress relaxation."

Beryllium copper packs the best one-two combination of any copper-based alloy — good formability and high strength. So it's possible to scale down your package without sacrificing performance. And excellent thermal conductivity gives beryllium copper the ability to dissipate heat in the contact area, thus minimizing temperature rises.

If you want top performance in connectors and other electronic components, come to the source for beryllium copper alloys: Brush Wellman Inc. Literature available on request.

BRUSH WELLMAN

ENGINEERED MATERIALS

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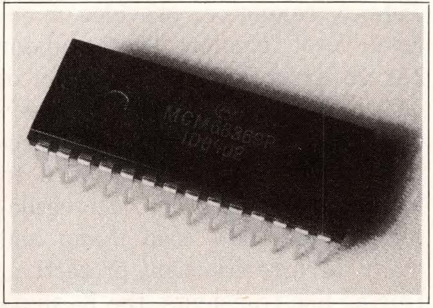
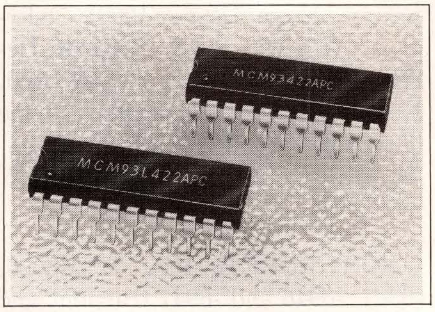
CIRCLE NO 180

TM Trademark of the DuPont Company. ®Registered trademarks of AMP Inc., and T&B/Ansley Corporation, respectively. ®*Registered trademark for ITT Cannon rear release contact retention assemblies.



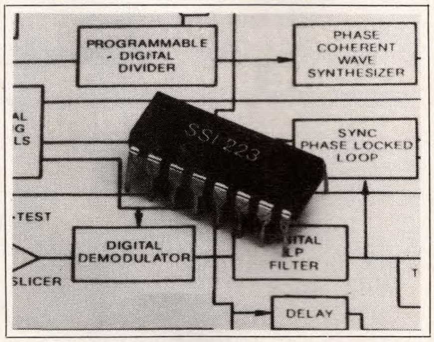
64k ROM. MCM68369 is a mask-programmable, byte-oriented MOS ROM. Organized as 8k×8 bits, it is TTL compatible. The chip contains current-surge protection circuitry that maintains it in an internal deselect mode until V_{CC} approaches 2.5V dc, at which time the chip is internally selected. The user defines the active level of the chip selects and the memory contents. The chip is available in MCM68369P20, -P25 and -P30 versions. Maximum access times from address are 200, 250 and 300 nsec, and maximum access times from chip select are 80, 100 and 120 nsec for the -20P, -25P and -30P, respectively. The chip operates on a 5V dc supply and requires no clocking on chip selects. $3.35 (2000). Mask charge, $1000. **Motorola Inc,** Memory Products Div, 3501 Ed Bluestein Blvd, Austin, TX 78721. Phone (512) 928-6659.

Circle No 321



UPGRADED RAMs. Faster "A" versions replace the MCM93422 and -93L422 1024-bit (organized as 256×4 bit) RAMs. Dubbed the MCM93422A and MCM93L422A, these RAMs have maximum address access times of 35 and 45 nsec compared with their predecessors' 45 and 60 nsec, respectively. All four memories provide 3-state outputs to drive bus-organized systems and capacitive loads. The chips are TTL compatible and come in JEDEC standard 22-pin, 400-mil-wide plastic or ceramic packages. MCM93422A and -93L422A, $9.50 in plastic, $10.76 in ceramic. Delivery, stock to 6 wks ARO. **Motorola Semiconductor Products Inc,** Box 20912, Phoenix, AZ 85036. Phone (602) 962-2516.

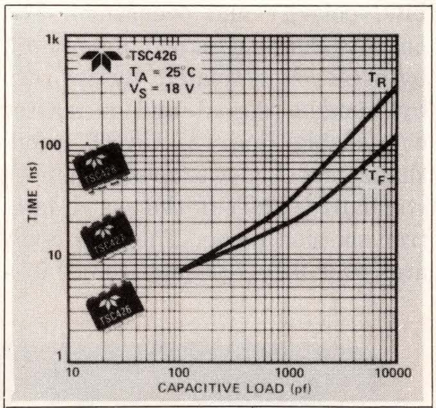
Circle No 322



CMOS MODEM IC. Model SSI 223 transmits and receives serial and parallel binary data over telephone lines using frequency shift keying. It provides the filtering, modulation and demodulation to implement a serial, asynchronous data-communication channel. It employs CCITT V.23 signaling frequencies and operates at 1200 baud. The circuit simultaneously transmits and receives and can be used for half duplex over a single line or full duplex over a two-line system. $10 (OEM qty). **Silicon Systems,** 14351 Myford Rd, Tustin, CA 92680. Phone (714) 731-7110.

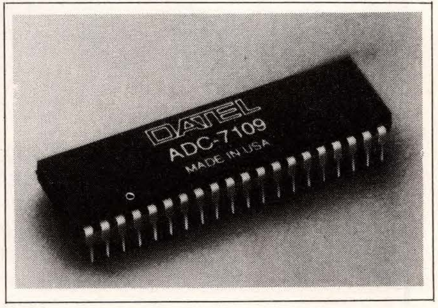
Circle No 323

MOSFET-DRIVER ICs. TSC426, -427 and -428 dual-power MOSFET-driver ICs translate a CMOS/TTL input signal to an output signal within 25 mV of ground or the supply rail. The ICs operate on 4.5 to 18V dc. TSC426 contains two inverting drivers, TSC427 contains



two noninverting drivers, and TSC428 has one inverting and one noninverting driver. The drivers swing a 1000-pF load 18V in 30 nsec. Their output impedance is 6Ω with 1.5A peak output current. Input current of 1 μA permits interfacing to such switch-mode power-supply controller ICs as the TL494, SG1524 and SG1526. The CMOS drivers typically draw 5-mA quiescent current (C_L=1000 pF). Eight-pin plastic and hermetic DIPs are available. TSC426, from $1.45; TSC427, from $1.60; TSC428, from $1.65 (100). **Teledyne Semiconductor,** 1300 Terra Bella Ave, Mt View, CA 94043. Phone (415) 968-9241.

Circle No 324

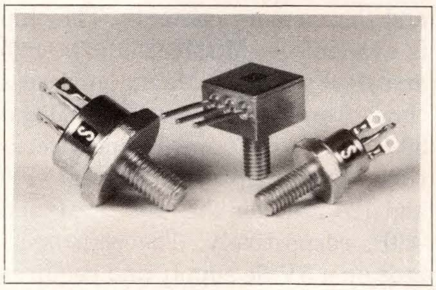


12-BIT A/D CONVERTER. The ADC7109 integrating A/D converter interfaces with 8- and 16-bit μPs. It includes a buffer amplifier, integrator, comparator, 12-bit binary counter and 3-state outputs for data-bus interfacing. In the byte-organized parallel mode, the converter interfaces with such μPs as the 6800, 8080 and 8048. Fourteen data outputs provide 12 magnitude bits, polarity and overrange. The outputs can be grouped in two 8-bit bytes, each activated by its own byte-enable signal and a master chip-enable line. A UART handshake mode allows operation with standard UARTs in the serial data-transmission mode. The chip operates over 0 to 70°C and comes in a 40-pin plastic DIP. $11.20 (100). **Datel,** 11 Cabot Blvd, Mansfield, MA 02048. Phone (617) 339-9341. TLX 951340.

Circle No 325

VOLTAGE REGULATOR. The LM2925, a low-dropout, monolithic 750-mA regulator, provides a delayed reset function. The regulator has an error flag for detection of output faults. The regulator operates with input-to-output differentials as low as 0.6V dc at 0.5A. In automotive applications, the regulator provides 60V load dump and −50V reverse-transient protection. During line transients, the IC shuts down to protect the internal circuit and the load. The regulator comes in a plastic, 5-pin TO-220 package. $1.70 (100). **National Semiconductor Corp,** 2900 Semiconductor Dr, Santa Clara, CA 95051. Phone (408) 721-5000. TWX 910-339-9240.

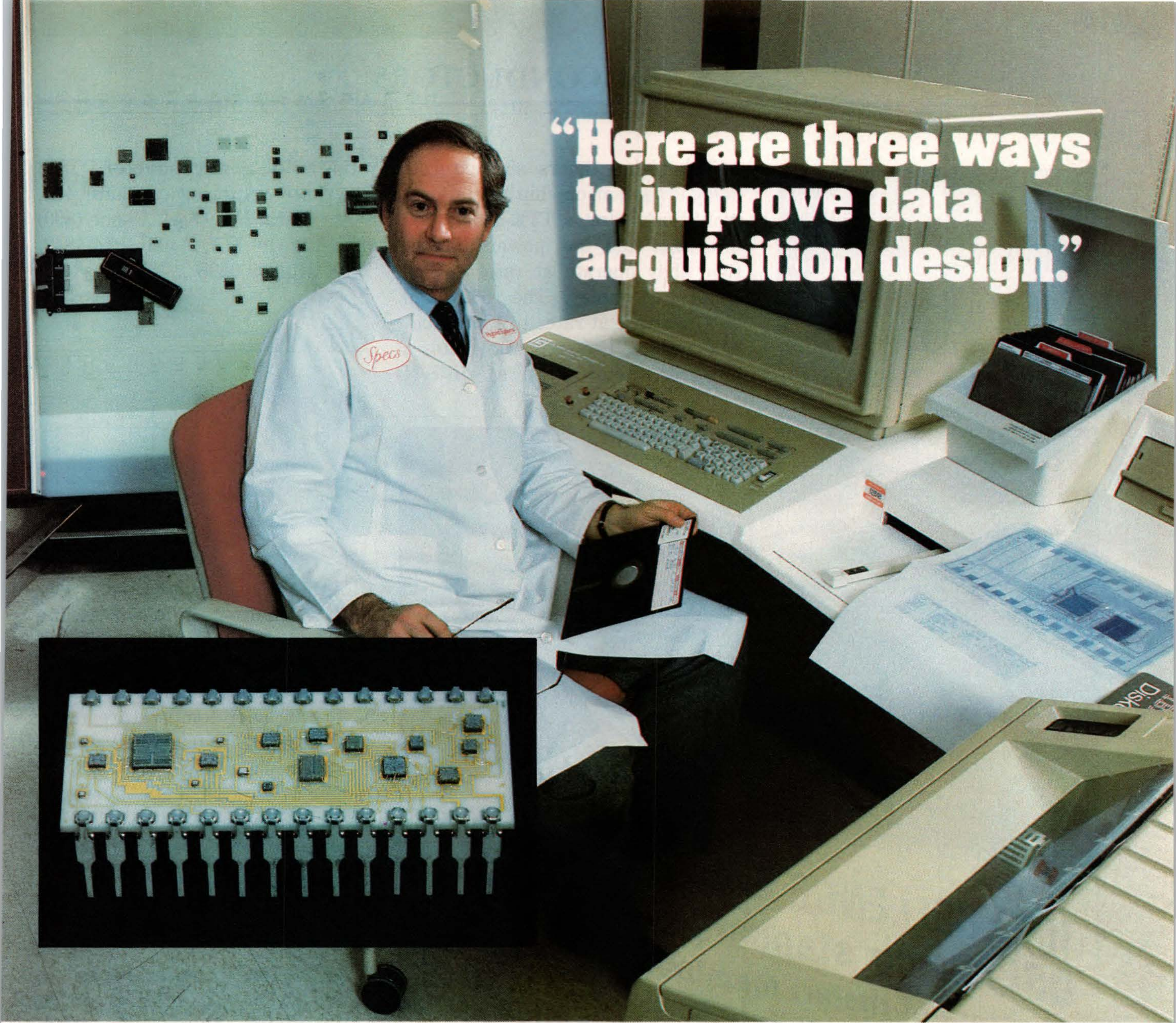
Circle No 326



POWER MOSFETs. Switchmos fast-switching power MOSFETs meet MIL standards and feature V_{DS}s to 400V and I_{D}s to 8A. They employ isolated packaging in TO-61/I, TO-111/I and TO-228AA cases. The manufacturer claims the isolated packaging reduces size and weight. From $12.85 (1000). Delivery, 6 to 8 wks ARO. **Solitron Devices Inc,** 1177 Blue Heron Blvd, Riviera Beach, FL 33404. Phone (305) 848-4311. TWX 510-952-7610.

Circle No 327

CMOS MODEM ICs. MSM6926, -6927, -6946 and -6947 transmit and receive serial and parallel binary data over the switched telephone network using FSK. The MSM6926 is compatible with CCITT V.21, -6927 with CCITT V.23, -6946 with Bell 103 and -6947 with Bell 202. Models -6926 and -6946 have originate and answer modes, selectable



"With a complete family of 8 to 12 bit data acquisition components."

"I'm Bob 'Specs' Spector of Hybrid Systems. We've engineered our innovative family of hybrid data acquisition systems (DAS) to combine several discrete components into a single package, with a *single* specification.

"You no longer have to wrestle with different specifications from competing vendors. Hybrid Systems' components eliminate the risk of interfacing mismatched solutions. The result is *total system accuracy.*

"Here are three DAS's that will save you time and help you produce a better final design.

"The HS9410 is a complete 8 channel, 12 bit DAS with MUX, sample-and-hold amplifier and 12 bit ADC. Throughput rates of 22 khz are achieved, and tri-state outputs allow direct 150ns interface to 8 or 16 bit microprocessors.

"And the HS362, a 16 channel multiplexer with precision sample-and-hold that serves as a complete front end for 12 bit DAS's. The HS362 is flexible enough to be user configured to accept either 8 differential inputs or 16 single ended inputs. It features 7 μsec acquisition time to .01%, hold mode settling time of 600ns, and 10ns aperture uncertainty.

"Our new HS9460 is the industry's first complete hybrid I/O subsystem. Incorporating the functionality of up to 15 individual components, the HS9460 contains four analog input channels, CMOS 8 bit ADC, complete μP interface, and 4 channels of 8 bit DAC output. Advanced thin-film and LSI technology help package all this functionality in a single 28 pin dual in line package.

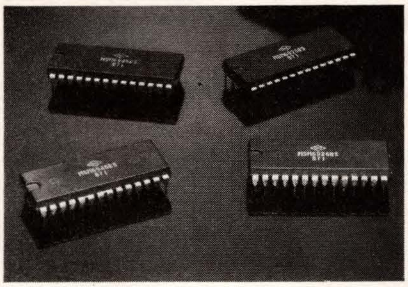
"Because we design and manufacture components strictly for use in data acquisition design, we're experts at making them accurate, reliable, and easy to use. If you'd like to know how Hybrid Systems can help you with special design problems, just call. And ask for 'Specs'."

Hybrid Systems Corporation,
22 Linnell Circle, Billerica, MA 01821.
(617) 667-8700.

Hybrid Systems CORPORATION

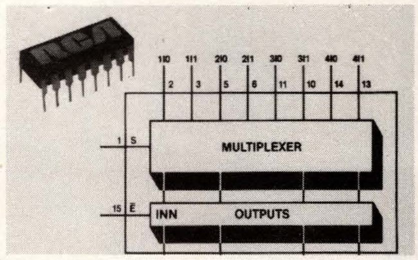
Precision Data Converters, Hybrid Data Acquisition Systems, and Thin-Film Products.

CIRCLE NO 185



built-in delay timers and external delay timers, an on-chip crystal-controlled oscillator, a TTL-compatible interface, and low power dissipation; they operate at rates to 300 baud, full duplex. The -6927 and -6947 operate at rates to 1200 baud, half duplex. The company claims a bit-error rate of 10^{-6} at a 7-dB S/N ratio. **Oki Semiconductor,** 1333 Lawrence Expressway, Suite 401, Santa Clara, CA 95051. Phone (800) 984-4842; in CA, (408) 984-4842. TWX 910-338-0508.

Circle No 328



QUAD MULTIPLEXERS. Two CMOS quad 2-input inverting muxes have the same speed and functions as their bipolar equivalents, but they consume less power, have a broader temperature range (−40 to +85°C vs 0 to 70°C) and are drop-in replacements. CD74HC158 is used in all-CMOS systems; CD74HCT158 is used in LS TTL systems. HC-type devices operate over a supply-voltage range of 2 to 6V dc, and HCT types are specified for a 4.5 to 5.5V dc supply. Both versions have 4-mA source and sink output drives. They're housed in 16-pin DIPs. CD74HC158, \$0.74; CD74HCT158, \$0.81 (100). **RCA,** Rte 202, Somerville, NJ 08876. Phone (800) 526-2177.

Circle No 329

QUAD DRIVER. DS3668 has the high current and breakdown-voltage capability of the DS3658 family as well as current sensing and individual output shutdown capability for fault protection. The current-sensing circuit on each output senses a short circuit and shuts down only that output, allowing the remaining channels to operate. If an input line is broken or open, the driver enters the high-impedance state and prevents invalid signals from appearing at the outputs. Each of the four outputs sinks 600 mA and provides 70V output break-

UNFORGETTABLE

At last, random access memory that won't let you down. Introducing Mostek's MK48Z02. We call it ZEROPOWER™ RAM. You'll call it unforgettable.

Because that's exactly what this new non-volatile RAM does. It keeps its memory. Thanks to the integration of advanced CMOS technology, ZEROPOWER RAM has an on-board, long-lived lithium energy source. That means ZEROPOWER RAM does not forget, even if the power goes down. ZEROPOWER RAM can keep on remembering for over 10 years without power, drawing less than one nanoamp at room temperature in the power-down mode. Plus it can be reprogrammed quickly and efficiently, as often as you want, without the wear-out mechanisms associated with E^2PROMs.

Also, this amazing new RAM can be read to and written from like the static RAM it is. Data access is 150 nanoseconds with an active power consumption of 330 milliwatts. And the MK48Z02 can replace existing 2K x 8 static RAMs, directly conforming to the popular bytewide 24-pin DIP package. No other components are needed.

So when you are looking for memory power that lasts, remember Mostek's MK48Z02 ZEROPOWER RAM. It's the unforgettable memory.

For more information, contact Mostek, 1215 W. Crosby Road, MS2205, Carrollton, TX 75006, (214) 466-6000. In Europe, (32) 02/762.18.80. In Japan, 03/496-4221. In the Far East (Hong Kong), 5-681157.

UNITED TECHNOLOGIES MOSTEK

CIRCLE NO 206

How we created an MDS that looks like a million, performs like 100 grand and costs under $20,000.

Introducing Emulogic's ECL-3200 universal development system.

It wasn't simple. And it took a lot more than seven days.

But when you start with the world's most advanced emulator, you're already way ahead. The ECL-3211 universal emulator gave our new MDS a repertoire of features you can't find in any comparable system. Like full-speed, no-wait-state emulation. Eight real-time, multi-function breakpoints for every chip. Real-time trace decode. And full-speed, full-range memory mapping with single-word resolution.

And then DEC™ made our job a little easier, too. We built their powerful new desktop computer–the Professional 300–right into the system. With RT11XM,™ 11/23 with MMU, 22-bit addressing, 512KB memory, 800KB dual diskette and optional 5 or 10MB Winchesters.

We didn't skimp on looks, either. We wrapped the ECL-3200 in a clean, compact package that, frankly, we call beautiful. But you tell us what you think.

You might conclude that, with all we've put on the inside, the price tag on the outside would be just as impressive. Not so! We brought the ECL-3200 in for 25% less than expected. So now you can buy a full-function development system for under $20,000–25% less than you'd expect. Including an 8-bit emulation package for the Z80,® 6502, 6809 or another popular chip. And you can also use it with all 16-bit emulation packages and our new high-level software development tools like C and Pascal cross-compilers and our just-introduced SLICE™ Symbolic Debugger.

So you see, creating our miracle MDS wasn't all that difficult. But we don't recommend anyone else try.

For detailed information, call 800-435-5001 or 617-329-1031 in Massachusetts. Or write Emulogic,® Three Technology Way, Norwood, MA 02062.

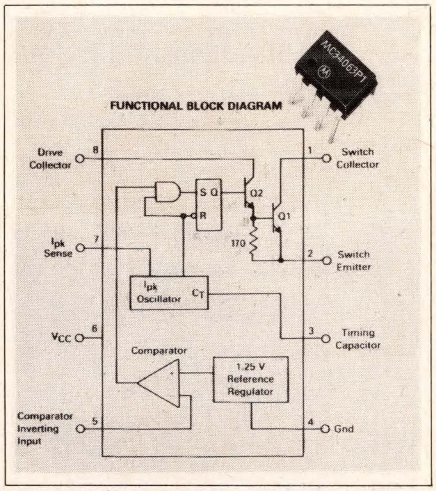
EMULOGIC®
MICROPROCESSOR
DEVELOPMENT SYSTEMS

European Distributors: Austria: Walter Rekirsch, (43 222) 235555; Denmark: Instrutek, (45 5) 611100; France: YREL, (33 3) 9568142; Sweden: Aktiv Elektronik AB, (46 8) 7390045; Switzerland: Instrumatic AG, (41 1) 7241410; United Kingdom: MSS, (44 494) 41661; West Germany: Instrumatic Electronic GmbH, (49 89) 852063.

CIRCLE NO 189

down voltage. $5.40 (100). **National Semiconductor Corp**, 2900 Semiconductor Dr, Santa Clara, CA 95051. Phone (408) 721-5000. TWX 910-339-9240.

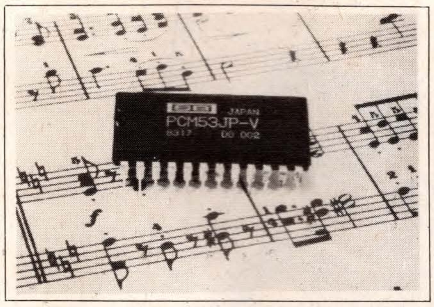
Circle No 330



DC/DC CONVERTER. The MC34063 dc/dc converter IC operates over a range of 2.5 to 40V dc and requires only 2.4-mA quiescent current. It contains a temperature-compensated reference and oscillator and furnishes cycle-by-cycle current limiting and feedback sensing for voltage regulation. An on-chip 1.5A, 40V output switch transistor provides enough drive to perform switching-regulator functions without external components. The IC operates to 100 kHz, and its output is adjustable from 0 to 40V with a simple inductor. The chip is specified over commercial and military temperature ranges and is available in an 8-pin ceramic or plastic DIP. From $1.85 (100). Delivery, stock to 12 wks ARO. **Motorola Semiconductor Products Inc**, Box 20912, Phoenix, AZ 85036. Phone (602) 962-2516.

Circle No 331

16-BIT D/A CONVERTER. Intended for audio applications, PCM53JP-V provides 16-bit resolution and typically 16-bit

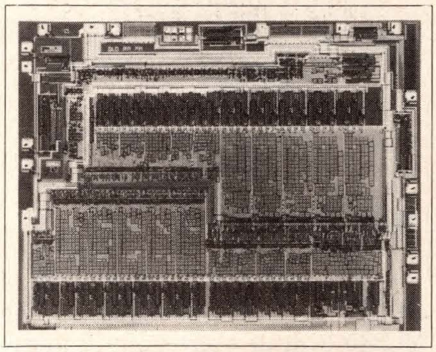


monotonicity. THD is 0.002% typ at full-scale (16 bits) input and 0.02% typ THD at −20-dB input. Differential-linearity error is typically 0.001% FS reading at the bipolar zero point. Dynamic range is 96 dB, and typical settling time is 3 μsec. Housed in a 24-pin plastic package, the IC is spec, performance and pin

CIRCLE NO 190

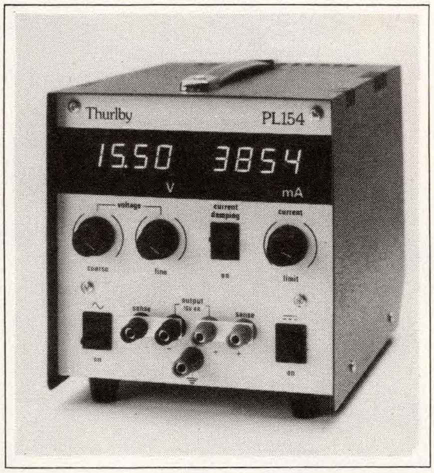
compatible with its ceramic-packaged version. According to the manufacturer, its high conversion speed allows using a single D/A converter for both left and right channels in a stereo system. This speed also minimizes phase delays in dual-channel applications. $19 (100). **Burr-Brown,** Data Div, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111.

Circle No 332



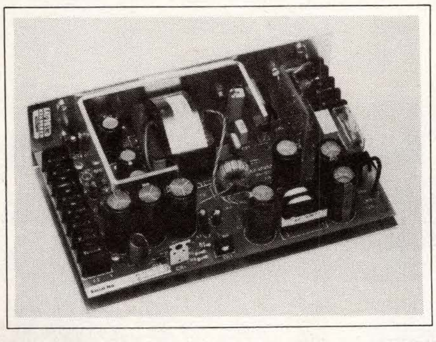
FILTER IC. The CMOS Model S35212 modem filter with on-chip equalizers implements the filtering and line-equalizing functions required in Bell 212A- and CCITT V.22-compatible modems. On-chip originate/answer mode-selection logic eliminates the need for external circuitry. Two uncommitted op amps can provide antialiasing, smoothing and gain-control functions. The continuous lowpass filter for smoothing can be switched between a call-progress tone-detection mode and a normal data-transmission mode. Call-progress mode allows for timing techniques that, when combined with a detector circuit, can create a more intelligent modem for communication of phone-call status to a terminal or computer. You can operate the IC from multiple clock frequencies of 153.6 kHz and 1.228 and 2.304 MHz. It operates from a ±4 to ±6V supply, dissipating 75 mW typ. $16 (100). **American Microsystems Inc,** 3800 Homestead Rd, Santa Clara, CA 95051. Phone (408) 246-0330.

Circle No 333



BENCH POWER SUPPLY. The 60W PL154 benchtop power supply provides 4A over its 0 to 15V range. It incorporates a switchable current-limit delay that makes peak currents as high as 7A available to circuits with fluctuating loads. Twin digital meters provide a display of voltage and current to a resolution of 10 mV and 1 mA, and the unit operates in both constant-voltage and -current modes. Remote-sense terminals allow precision at high currents, and a separate dc switch enables voltage- and current-level setting before connecting a load. £145. **Thurlby Electronics Ltd,** New Rd, St Ives, Huntingdon, Cambs PE17 4BG, UK. Phone (0480) 63570. TLX 32475.

Circle No 341

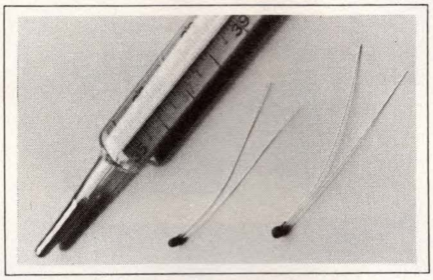


50W SWITCHER. The 50W EP6003 multioutput switching power supply has five output rails: 5V at 6A max and ±12V, +24V and −5V all at 1A max. Line and load regulation is better than 0.1% and 1% for the 6A and 1A outputs, respectively. The open-frame module meets a 4-kV ac insulation test and other requirements of IEC 380, UL 478, TG 2 and 26, and BS3861. £54 (100). **Powerline International Ltd,** 5 Nimrod Way, Elgar Rd, Reading RG2 OEB, UK. Phone (0734) 868567. TLX 847073.

Circle No 342

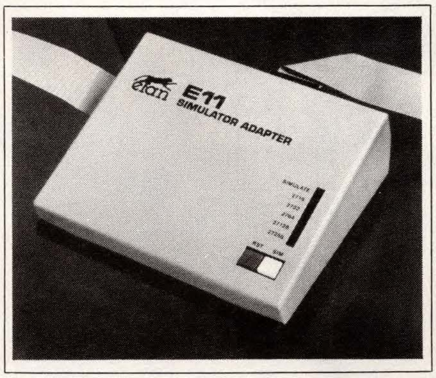
EUROCARDS. These two single Eurocard modules include a 12-bit analog input and provide optoisolated I/O functions for the system bus of its manufacturer's Tiny Basic Computer. The analog card has 16 inputs with resistor scaling and a single- or dual-channel 12-bit output. The optoisolator board provides 12 inputs and 12 outputs isolated to withstand as much as 1500V. Each output contains a power FET capable of switching 800 mA at 5 to 60V. The inputs accept voltages from 2.6 to 40V. Output circuits have LED indicators. Approximately £160 each. **Essex Electronics Centre,** University of Essex, Colchester CO4 3SQ, UK. Phone (0206) 865089.

Circle No 343



NTC THERMISTOR. The M841 negative - temperature - coefficient thermistor furnishes 0.1°C accuracy (which corresponds to a resistance tolerance of ±0.4%) over a 30 to 50°C temperature range. It comes with 20-mm silver-plated leads and operates from −40 to +100°C. Rated resistance values are either 3 or 5 kΩ. An epoxy-coated version, the M861, is available for operation to 125°C; that version has 25-mm nickel leads with Teflon insulation and a measuring accuracy of ±1 degree. Rated resistance is 30 kΩ. **Siemens AG,** Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025.

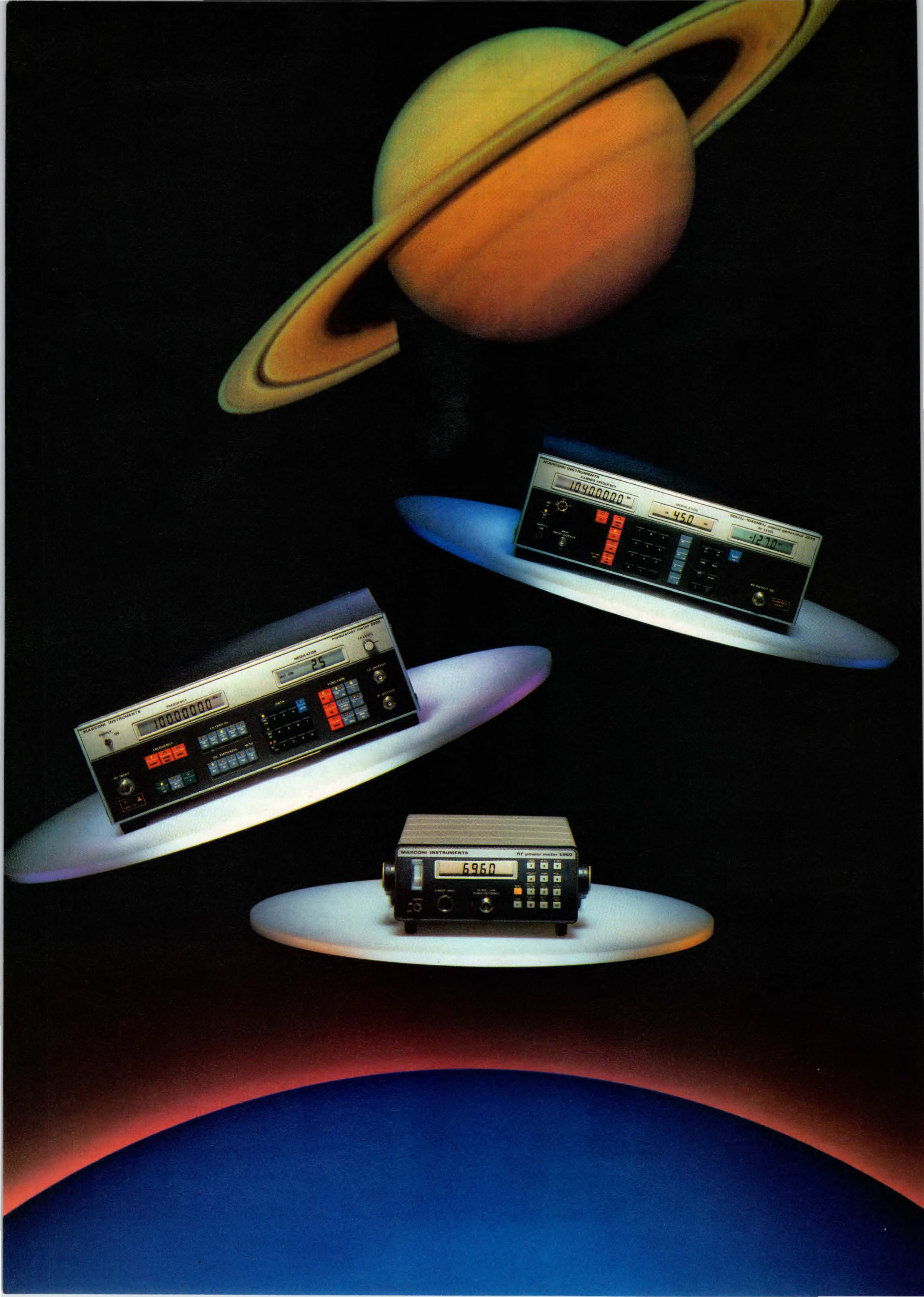
Circle No 344



EPROM SIMULATOR. The E11 simulates JEDEC 24-pin EPROMs to a 256k-bit density. You can make program changes and check them more quickly with this simulator than you can by blowing EPROMs; data is edited in the main programmer and transferred via ribbon cable to the simulator's static RAM. A second cable connects to the target socket with a flying lead to the μP control signal. Access time is typically 175 nsec. The simulator draws power either from the target system or the main programmer; consumption is typically 10 mA standby, 45 mA active. Battery backup is provided for the simulator's RAM. £495 for 16k version, £795 for 32k model. **Elan Digital Systems Ltd,** 16 Kelvin Way, Crawley, W Sussex RH10 2TS, UK. Phone (0293) 510448. TLX 877314.

Circle No 345

CIRCULAR CONNECTOR. The Series 28 circular connector provides 50 size-22 3A contacts. Contacts are tin plated and supplied on a carrier strip; standard resistance is 5 mΩ. The subminiature housing


MARCONI INSTRUMENTS
RF power meter 6960

Value

Stock Marconi signal generators to precisely locate NASA deep space probe.

Throughout the world, Marconi signal generators, modulation meters, and microwave power meters prove their on-going value every day.

For instance, the position of NASA's Voyager space probe must be determined exactly on a frequent schedule. To do so, California's Jet Propulsion Laboratory needed a frequency source with ultra-stable phase performance. Normally expensive custom instrumentation would be purchased. JPL found the extraordinary stability they needed in a standard Marconi signal generator. So at a great saving to the taxpayer and no expense to the accuracy of the program, JPL bought 40 units of our Model 2018 microprocessor-based signal generators to help them carry out the mission.

That's what we call value. That's what you should call it, too. Value is accurate, reliable, rapid measurements at lowest cost. Here are other instances of value in Marconi instrumentation.

The Easiest, Most Flexible Signal Generator You'll Ever Use.

For rapid production testing our Model 2019 microprocessor-controlled signal generator can't be matched. An operator can set it up in seconds, because it stores 10 complete test settings and 40 frequencies in non-volatile memory. Touching a few buttons recalls any stored setting.

Range is 80kHz to 1040 MHz. Features both AM and FM modulation and a full GPIB interface. All this at a price of only $7700.* That's what we call value.

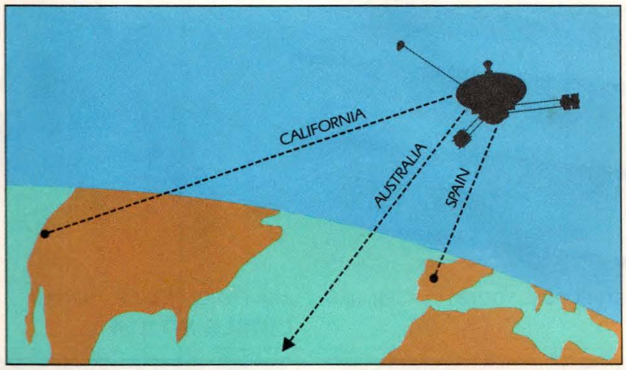
Most Accurate Modulation Meter.

Our Model 2305 has an accuracy of 0.5%, twice that of prominent competitive instruments. To recalibrate it you just push a front-panel button.

It's really five instruments in one. Use it to make conventional measurements such as FM or PM deviation and AM depth. Make RF frequency and power measurements. A low cost option lets you make distortion/SINAD measurements to CCITT and CCIR requirements. Works to 2 GHz.

The 2305 is fast. The operator just connects the signal. The microprocessor-controlled meter tunes itself in about half a second and displays a measurement.

Price is $7500. Isn't all that performance for so little what you would call value, too?



Tracking stations in California, Spain and Australia will fix the position of space probes by Very Long Baseline Interferometry. The phase of the space probe signal is compared with the phase of extra-galactic radio sources. A frequency standard with ultra-stable phase is essential.

The Microwave Power Meter With Total Automation.

Simply connect the signal source to the Sensor Input. Our microprocessor-controlled Model 6960 does the rest. Automatic calibration, zero, and ranging. To top it off, you get automatic sensor linearity correction. Fully automatic operation, complete GPIB control, plus 25 millisecond sensors will boost your test line productivity to a new high.

Range is 10 MHz to 20 GHz. Input signal power −30 dBm to +20 dBm. Meter accuracy is ±0.5 percent.

The whole system, GPIB and 50 dB probe goes for a reasonable $3615. That's what we mean by value.

World Class Instrumentation By A World Class Company.

For more information contact Marconi Instruments, 100 Stonehurst Court, Northvale, NJ 07647. Phone (201) 767-7250. In the western United States phone (714) 895-7182. Outside North America, address Marconi Instruments, Longacres, St. Albans, Herts., England AL4 OJN. Phone 44 (727) 59292. Telex 23350.

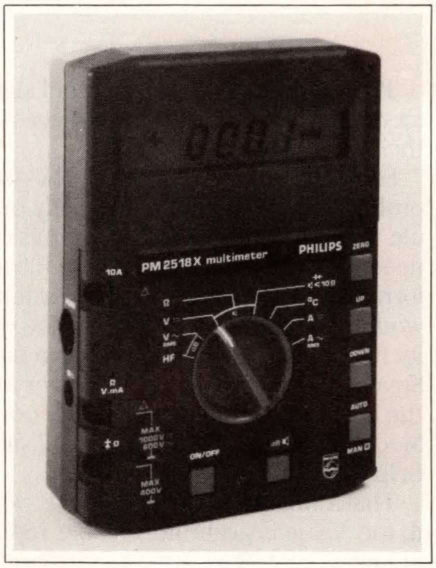
*Domestic U.S. Prices Only.

marconi instruments

CIRCLE NO 235

is made from glass-reinforced plastic with a plastic coupling unit of less than a 25-mm diameter. Insulation resistance is 5000 MΩ min at 5 kV ac. Working voltage is 250V ac, and temperature range is −40 to +85°C. **Plessey Connectors Ltd,** Box 30, Kingsthorpe, Northants NN2 6NA, UK. Phone (0604) 712000. TLX 31576.

Circle No 346

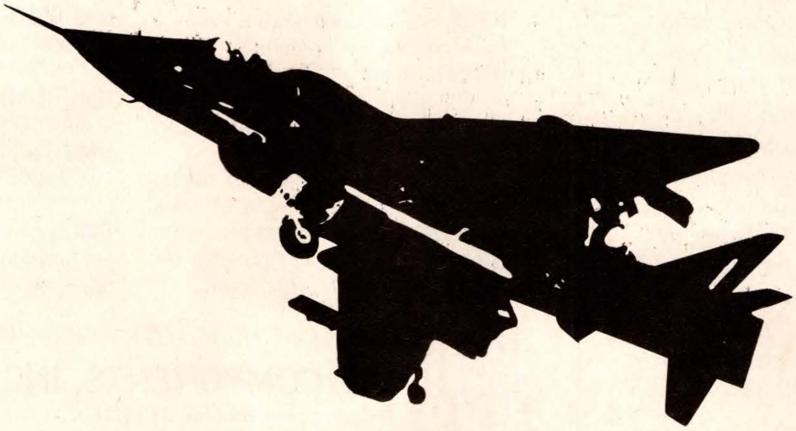


DMM. The Model 2518X digital multimeter's 4-digit LCD is back-lit for easy reading. The handheld meter provides a basic accuracy of 0.1%, dc voltage and current ranges, true-rms ac voltage and current measurement, and resistance functions. In addition, decibel, diode-voltage drop, audible continuity and temperature-measurement facilities are provided. A zero-set feature permits direct reading of tolerances and variations on all ranges. **Philips S & I Div,** TQ III-4, Eindhoven, The Netherlands. Phone (040) 788620. TLX 35000.

Circle No 347

TUNER IC. The SP 5000 frequency synthesizer device, in conjunction with a varactor tuner, provides a complete phase-locked-loop tuning system for TV and cable applica-

GET YOUR CAREER OFF THE GROUND —



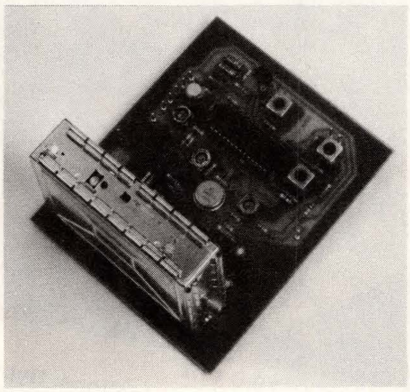
Be sure to read EDN's career opportunities section in the upcoming August 23 Military Issue!

Companies advertising are:

McDonnell Douglas
General Dynamics
Boeing
Honeywell
FMC
and more!

tions. An on-chip 1-GHz prescaler, a multimodulus divider/storage register, a crystal-oscillator divider chain and phase-comparator control circuits minimize external circuitry requirements. The device runs off a 5V supply, drawing 50 mA typ, and features a PLL circuit capable of selecting frequencies from 30 to 1024 MHz in 62.5-kHz steps. **Plessey Semiconductors Ltd,** Cheney Manor, Swindon, Wilts SN2 2QW, UK. Phone (0793) 36251. TLX 449637.

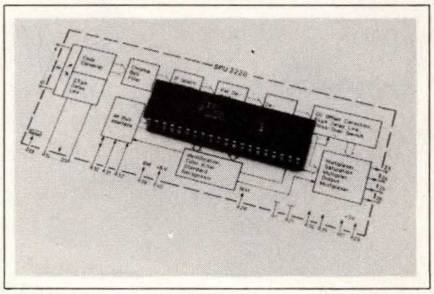
Circle No 348



TV-RECEIVER IC. The TDA4503 incorporates the small-signal functions of a B&W TV receiver, except for the tuner, and exhibits no noticeable crosstalk between vision and sound. The only additional circuits necessary to build a set are horizontal- and vertical-deflection output stages and video/sound outputs. The device can also be used with an external sandcastle-pulse (a video-input synchronizing pulse) generator and color decoder to form a 2-chip small-signal section for a color TV. In addition to the usual circuits, the device has a coincidence detector for sound muting, phase and AGC detectors, a gate-pulse generator and a sound limiter with feedback. **NV Philips Gloeilampenfabrieken,** Elcoma Div, Box 523, 5600 AM, Eindhoven, The Netherlands. Phone (040) 757005. TLX 51573.

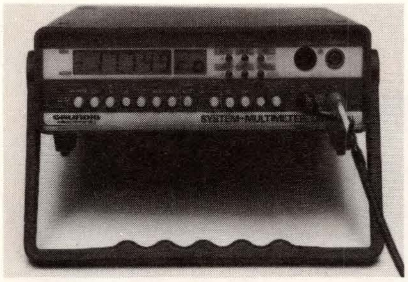
Circle No 349

SECAM PROCESSOR. The SPU2220 chroma processor works to the SECAM (the French color-television system) standard. It interfaces directly to the digital-signal-processing Digit 2000 IC family for TV-receiver design. It's housed in a 40-pin plastic DIP and processes chroma signals in combination with



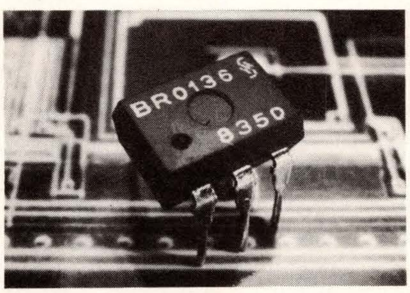
he VPU2200 video processor, vhich handles the luminance infor- nation simultaneously. Automatic ;ECAM identification logic is provided. $4 (OEM qty). **ITT Inter- netall GmbH,** Box 840, 6800 Frei- burg, West Germany. Phone (0761) 5170. TLX 0772715.

Circle No 350



SYSTEMS DMM. The DM50 benchtop multimeter has a count of +54,000 digits. Basic dc-voltage accuracy is 0.02%, and the unit can measure true rms ac voltage (0.1% accuracy), resistance and current. It comes with built-in computing power for such tasks as calculating and displaying decibels, limit-testing results and percent deviation. 2450 DM. Optional IEEE-488 interface, 500 DM. **Grundig Electronic AG,** Wuerzburger Str 150, Fuerth/Bay, West Germany. Phone (0911) 73301. TLX 623435.

Circle No 351



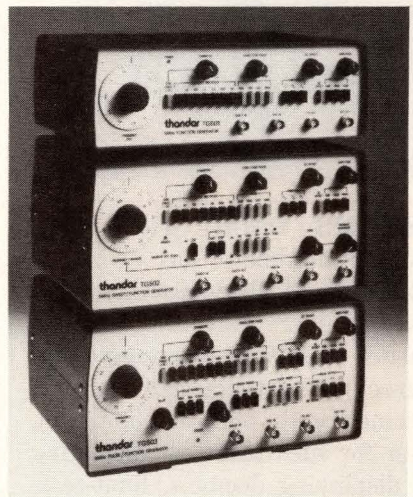
OPTO AC SWITCH. The BRT12 6-pin IC contains a light-triggered ac switch capable of linking logic to 220V mains. Input sensitivity is lower than 2 mA, and reverse voltage is greater than 600V. Input/output isolation is tested to 7 kV. The required trigger-pulse current is 2 or 5 mA. Effective current is rated at 300 mA (3A surge). Power dissipation is 500 mW; dv/dt is more than 5 kV/μsec at 100°C/400V. **Siemens AG,** Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025.

Circle No 352

ALKALINE BATTERY. The MN123 alkaline battery provides 4.4 Ahr of charge from a leak-resistant package measuring approximately

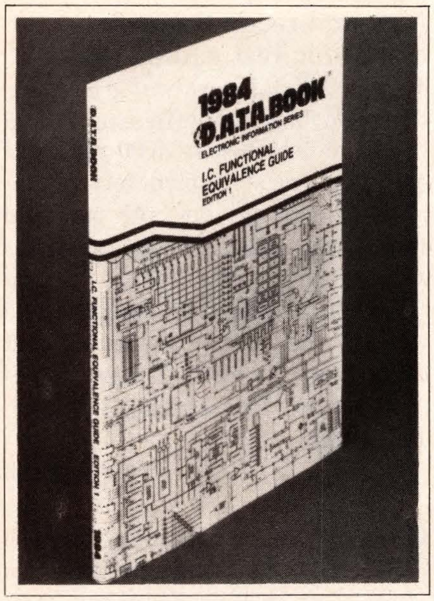
6×6×2 cm. The edges of the case are rounded, and it weighs 154g. It provides a 100-hr life into 75Ω down to 2.4V at 20°C. Recommended load range is from 2.2Ω to 10 kΩ. IEC designation is 3LR12. **Duracell,** Church House, Lowfield Heath, Crawley, W Sussex RH11 0PQ, UK. Phone (0293) 517527. TLX 877393.

Circle No 353



FUNCTION GENERATORS. TG500 Series benchtop function generators provide sine, square, triangle, ramp, pulse and haversine waveforms from a 50Ω, 20V (variable) output. The instruments work to 5 MHz. The TG501 provides free-run, triggered or gated modes, variable start/stop phase and a 19:1 symmetry range. Frequency range is from 0.005 Hz to 5 MHz with a 100:1 sweep capability. TG502 adds 1000:1 (linear) or 10,000:1 (log) sweep cabability. The more sophisticated TG503 includes normal-, double- (10-MHz capability) or delayed-pulse modes with pulse widths variable from 50 nsec to 50 msec. The main output can be normal or complement. £295 to £495. **Thandar Electronics Ltd,** London Rd, St Ives, Huntingdon, Cambs PE17 4HJ, UK. Phone (0480) 64646. TLX 32250.

Circle No 354



Reference book groups ICs by pin-for-pin equivalence

The *IC Functional Equivalence Guide* contains 23,792 different IC type numbers grouped in families organized by pin-for-pin functional equivalence. It lists primary specifications for each device and groups devices with the same technical and electrical characteristics. Included are flip flops, gates, counters, adders, shift registers, interfaces, RAMs, ROMs, level converters, buffers, drivers and muxes. **D A T A Inc,** Box 26875, San Diego, CA 92126.

Circle No 381

Newsletter covers personal engineering

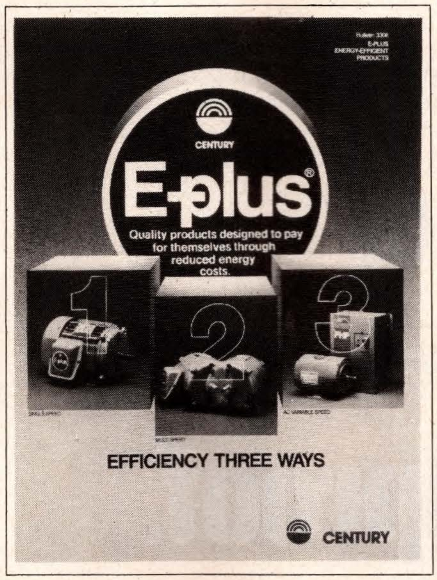
Personal Engineering & Instrumentation News is a monthly newsletter that provides industry news and applications stories as well as a vehicle where users can exchange tips and comments on the latest products and design techniques. It is the official newsletter of PECUS (the Personal Engineering Computer Users' Society). The subscription fee includes membership in that organization. $25/yr. **Personal Engineering Communications,** Back Bay Annex, Box 983, Boston, MA 02117.

Circle No 382

Computer graphics supplies

This catalog describes tapes and accessories, disk packs, magnetic storage cabinets and cleaning supplies as well as a selection of Versatec electronic media. The catalog/guide explains dimensional and performance data, features and benefits, characteristics and care and handling information. **CAD CAM Inc,** 2844 E River Rd, Dayton, OH 45439.

Circle No 383



Select energy-efficient motors and speed controls

Bulletin 3308, an 8-pg brochure, gives readers an in-depth look at the company's E-plus system of energy motors and variable speed drives. The brochure includes insert sheets describing product performance, ratings, tables and dimensions. **Century Electric Inc,** 1831 Chestnut St, St Louis, MO 63166.

Circle No 384

Data sheet examines multiport register file

The 4-pg LRF08 data sheet features a functional diagram of the chip as well as a pinout configuration chart, timing diagram, package drawings, and chart outlining electrical performance. It also includes information on the chip's five independently addressable ports and internally latched control bits. **Logic Devices Inc,** 628 E Evelyn Ave, Sunnyvale, CA 94086.

Circle No 385

Plastic parts for OEM and general-purpose use

The 32-pg Catalog Number 34 describes plastic parts, including instrument cases and covers; control, ball and clamping knobs; and handles and appliance parts. Dimensions and mounting information are included. **Harry Davies Molding Co,** 4920 W Bloomingdale Ave, Chicago, IL 60639.

Circle No 386

Custom and semicustom power-supply assemblies

This brochure describes more than 65 custom and semicustom programmable power-supply assemblies available off the shelf. It gives specifications, schematics and illustrations of typical 19-in. rack and vertical cabinet assemblies. **Sorensen Co,** 676 Island Pond Rd, Manchester, NH 03103.

Circle No 387

LITERATURE

New and reconditioned electronic test equipment

The *1984 Full Line Catalog* contains descriptions, specifications and prices for more than 4000 pieces of new and reconditioned test equipment. Items are for both sale and rent. Organized by manufacturer and category, the 250-pg catalog describes a variety of equipment as well as the company's repair and calibration services. **Tucker Electronics Co,** Box 461060, Garland, TX 75046.

Circle No 388

Catalog contains more than 3500 hardware components

More than 3500 standardized components are described in text, dimensional drawings and photographs in this 60-pg, 2-color catalog (No 888). Standoffs and spacers, terminals, clips, jack screws, wire-wrap terminals, carrier boards, battery holders, transistor sockets and terminal boards are among the products listed. **Keystone Electronics Corp,** 49 Bleecker St, New York, NY 10012.

Circle No 389

Flat cable connectors

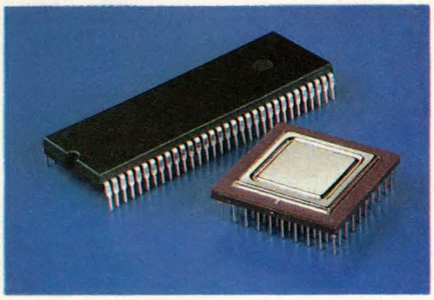
A new 16-pg catalog covers the firm's headers, block headers, mini-headers, socket connectors, mini-socket connectors, receptacle connectors, pc-board transition connectors, DIP connectors, mini-DIP connectors and card-edge connectors. **Fujitsu Components,** 918 Sherwood Dr, Lake Bluff, IL 60044.

Circle No 390

Wires and cables

Bulletin IC-'84 describes cables for instrumentation, control and thermocouple extensions. The 12-pg, 4-color bulletin includes details on proprietary insulations and jackets; protective coverings and sheaths and has cable selector charts. **Okonite Co,** Box 340, Ramsey, NJ 07446.

Circle No 404



What we offer are semi-custom LSIs with basic structures that are custom finished to match your logic circuits.

They can be ready soon after you order at an economical cost.

These are the high-speed, 2.5n sec., TC15G Series Gate Arrays and the ultrahigh-speed, 1.5n sec., TC17G Series Gate Arrays.

That's why Toshiba's world-leading CMOS and VLSI technology is appreciated around the world.

What's more, we have a wide line ranging from 880 to 10,000 gates. That means we have an LSI to meet any requirement.

Behind these LSIs is our superior CAD (Computer-Aided Design) system that supports designing these Gate Arrays.

Ask us. We will respond quickly and effectively to your requirements.

Toshiba CMOS Gate Array Series

Series		High-speed Gate Array Series	Ultrahigh-speed Gate Array Series
Number of gates	880	TC15G008P (70)	TC17G008P (64)
	1,400	TC15G014P (88)	TC17G014P (82)
	2,200	TC15G022P (110)	TC17G022P (102)
	3,200	TC15G032P (134)	TC17G032P (124)
	4,200	TC15G042P (152)	TC17G042P (146)
	6,000	TC15G060P (176)	TC17G060P (182)
	8,000	–	TC17G080P (218)
	10,000	–	TC17G100P (228)

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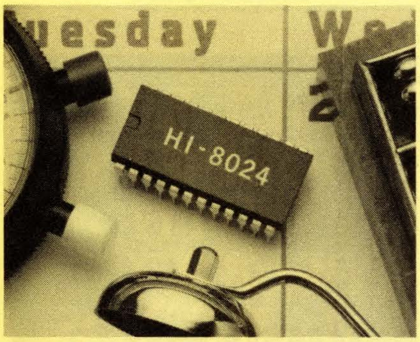
Toshiba Europa (I.E.) GmbH: Electronic Components Div.: Hammer Landstrasse 115, 4040 Neuss 1, F.R. Germany Tel. (02101) 1580
Toshiba (UK) Ltd.: Electronic Components Div.: Toshiba House, Frimley Road, Frimley, Camberley, Surrey GU 165JJ, England Tel. 0276 62222
Toshiba Electronics Scandinavia AB: Banérgatan 21-23, S-115 22 Stockholm, Sweden Tel. 08-616265

CIRCLE NO 209

EDN PRODUCT MART

This advertising is for new and current products.

Please circle Reader Service number for additional information from manufacturers.



HI-8024 μP REAL TIME CLOCK WITH INDEPENDENT COUNTER/TIMER

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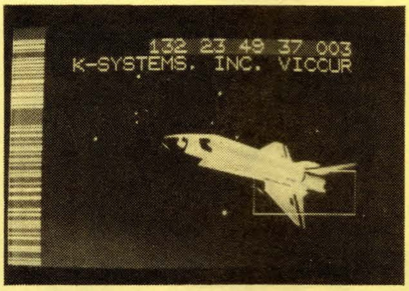
CIRCLE NO 270

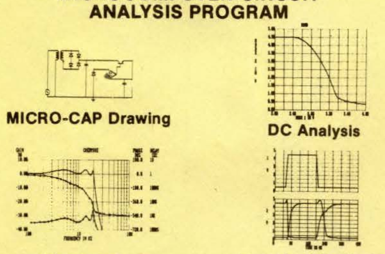


VIDEO INSERTER WITH TITLING, GRAPHICS, AND TIMING

VICCUR inserts time code, titling, and graphics; initializes battery-backup clock from IRIG-B timing; and generates a cursor. Optional 8 analog inputs and binary video insertion. RS-170(A)/NTSC/PAL. $1500. **K-Systems, Inc.**, 3902 Lilac, Las Cruces, N.M. 88005, (505)526-3209, 800-525-5797.

CIRCLE NO 271

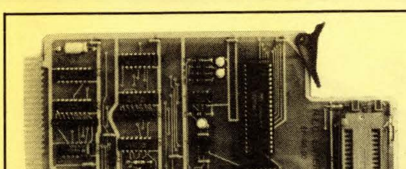
MICROCOMPUTER CIRCUIT ANALYSIS PROGRAM



MICRO-CAP Drawing — DC Analysis — AC Analysis — Transient Analysis

Tired of trial & error circuit design? Analyze and debug your designs before you build them. With **MICRO-CAP** you simply sketch your circuit on the **CRT** screen using built-in keyboard-driven graphics routines, then run an **AC, DC** or **Transient Analysis**. Your circuit may consist of **RESISTORS, CAPACITORS, INDUCTORS, DIODES, SWITCHES, BATTERIES, SINEWAVE PULSE OR USER-DEFINED SOURCES, BIPOLAR OR MOS TRANSISTORS, OPAMPS, OR TRANSFORMERS. MICRO-CAP** is a full non-linear simulator and can analyze virtually any network containing up to 60 nodes. Includes a user-controlled library for modelling complex components. The product is available for **APPLE II** (64k) and **IBM PC** (192k + color graphic adapter card) systems and requires two drives. The price is $475. An Evaluation Kit, identical to the main product but limited to 5 node simulations, is available for $50 and may be credited towards the purchase of **MICRO-CAP**. Write or call for brochure. **SPECTRUM SOFTWARE DEPT E, 1021 S. WOLFE RD #130., SUNNYVALE CA 94086. (408) 738-4387**

CIRCLE NO 272



STD EPROM PROGRAMMER CARD

The most versatile STD EPROM Programmer card available. Programs all popular 2K, 4K or 8K EPROMS with our easy to use menu driven software. Single quantity price $159.95. Other STD products include

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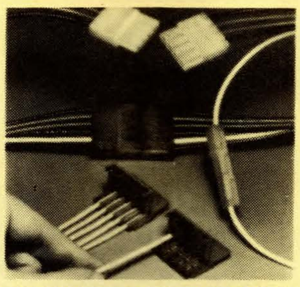

NEW 12 AMP, 1 THROUGH 6 CIRCUITS "JAGUAR" POWER CONNECTORS

Series 2300 general purpose, wire to wire connector utilizing insulation displacement termination in a hermaphroditic housing. One housing configuration fulfills both the male and female interconnection. New design saves cost of wire stripping, crimping and stuffing contacts. Reduces handling & inventory. Accommodates #16 through #22 AWG wire. Unique multi-circuit disconnect on .250 centers.

METHODE ELECTRONICS, INC.

INTERCONNECT PRODUCTS DIVISION
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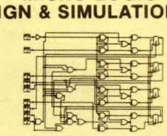
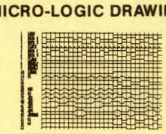
CIRCLE NO 274

MICRO-LOGIC LOGIC DESIGN & SIMULATION SOFTWARE



MICRO-LOGIC DRAWING



MICRO-LOGIC TIMING SIMULATION

MICRO-LOGIC is an interactive drawing & simulation system. You simply sketch your logic diagram right on the **CRT** screen using built-in keyboard-driven graphics routines. The program then generates the netlist required for the timing simulation automatically. **MICRO-LOGIC** can handle networks as large as 1750 5-input gates. It includes editors for **Networks** and **MACROS**, Data Channel patterns, clock waveforms and Gate Libraries. Gate attributes include truth table, name, delay and clocking convention. The product is available for **APPLE II** (64k) and **IBM PC** (192k + color graphics adapter card) systems and requires two drives. The price is $450. An Evaluation Kit, identical to the main product but limited to 25 gate simulations, is available for $50 and may be credited towards the purchase of **MICRO-LOGIC**. Write or call for brochure. **SPECTRUM SOFTWARE DEPT E, 1021 S. WOLFE RD #130., SUNNYVALE CA 94086. (408) 738-4387**

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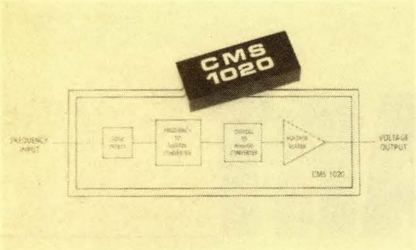

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8048

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*Trademarks SIM48 (LSC), IBM-PC (IBM), CP/M-80 (DR), MS-DOS (Microsoft)

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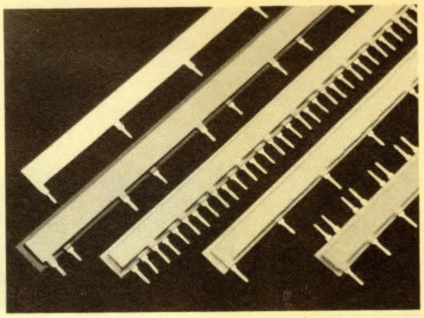

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Rogers MINI/BUS® PCB bus bars let you create higher density boards without the added design time and expense of multilayer. Because they eliminate on-board power and ground traces. And save valuable real estate for maximizing ICs and signal interconnections. All at about half the cost of 4-layer PCBs. Call (602) 830-3370. Or write: **Rogers Corporation**, 5750 East McKellips Road, Mesa, AZ 85205.

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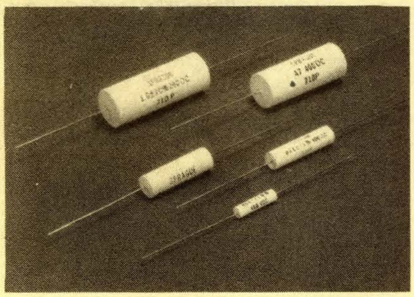

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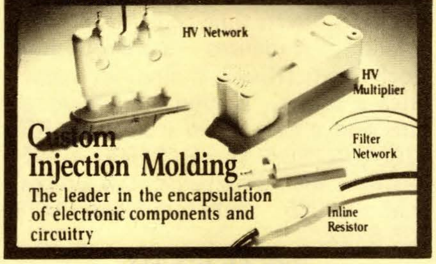

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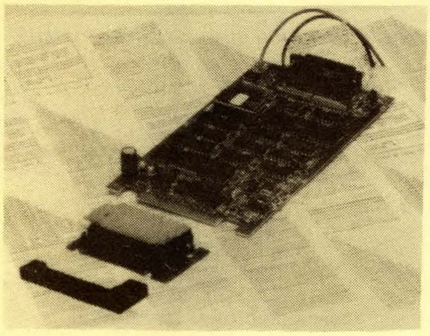

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$225.00 OEM Qty

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Printer Sales (617) 894-8700.

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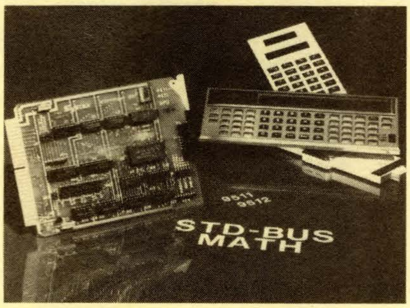

STD-BUS MATH BOARD

Floating-point math board for the STD-BUS features 32-bit trigonometric and logarithmic functions (4411) and 64-bit precision (4412). All boards have a crystal-controlled clock, anticipated wait request, and controlled reset logic. An on-board regulator allows operation from +12 or +15v. From $395, stock to two weeks. **SYSTEK**, 1023 N. Kellogg St., Kennewick, WA 99336, (509) 735-1200.

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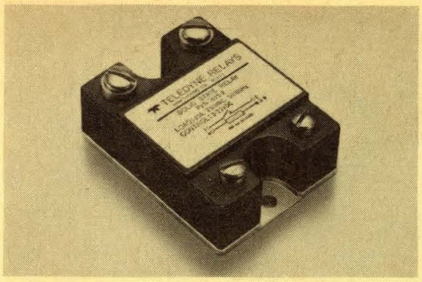

RELIABLE 0.1 AQL SOLID STATE RELAY

Teledyne's 615 features AC load ratings to 40 amps @250VRMS, optical isolation to 3750 VRMS, logic compatible input, and zero voltage turn-on. Constant current input from 3 to 32VDC. Built-in snubber for high noise immunity. Incorporates custom IC's to reduce component count. Conditioning screen prior to shipping yields highly reliable 0.1 AQL SSR. UL recognized (file #E55197); CSA approved. 615V meets VDE and IEC standards. From $10.75 ea in production quantities. **Teledyne Solid State Product,** 12525 Daphne Ave., Hawthorne, Cal. 90250 (213)777-0077

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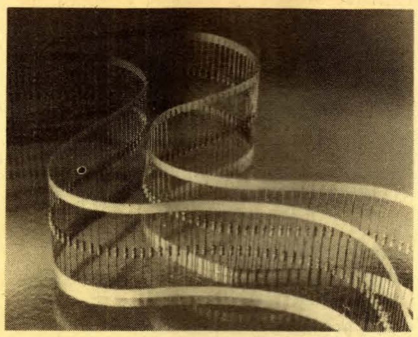

Miniature, axial lead ceramic capacitors for automatic insertion into pc boards. Replace monolithics and ceramic discs in some applications. More reliable than ceramic discs. Values from .47 pF to 100,000 pF. Voltages of 16, 25 and 50 WVdc. Temperature coefficients from NPO (COG) to Y5T. Measures .276" long × .110" dia., max. Packaged on tape and reel. **Zamco Electronics**, division of Laube Corporation, 6400 Variel Ave., Woodland Hills, CA 91367.

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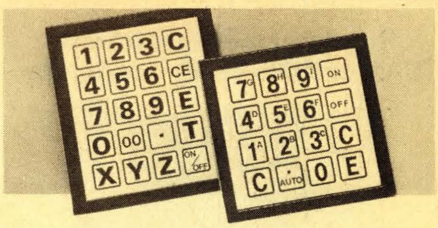

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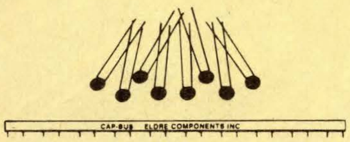
ELIMINATE DECOUPLING CAPACITORS



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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.

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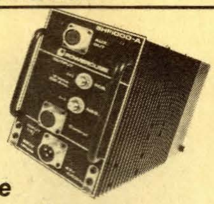

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For MS-DOS, CP/M
Price $175

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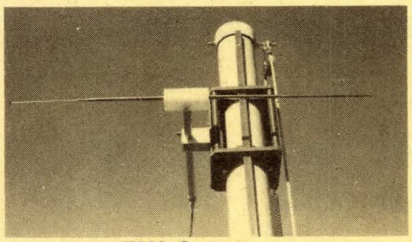

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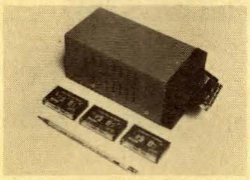

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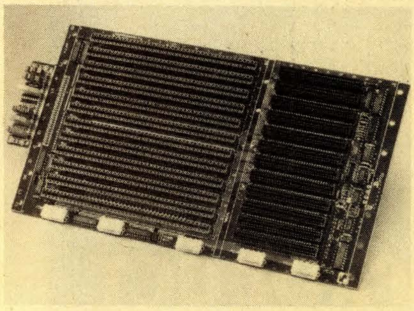

Combination backplane/monitor/power harness provides quality design. Grounded, terminated, 24-bit addressing, bussed p2. Unique 4-layer backplane is integrated unit with 32 system-monitor LEDs, ten voltage monitor LEDs providing system diagnostics, visual warning of improper performance. Signals, CPU readable, display bus master, pending interrupts, control strobes, incorrect voltage/temperature, more. **PACIFIC MICROCOMPUTERS, INC.**, 160 Chesterfield Drive, Cardiff, CA 92007, 619/436-8649.

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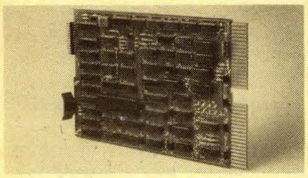

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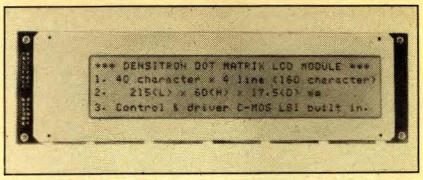

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Information Device Division
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Phone: (213) 618-9647
FAX: G2/G3: 213-618-1658 Telex II: 910-349-6200

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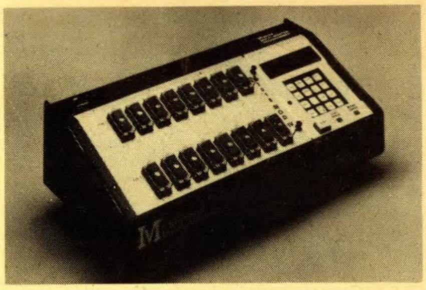

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The IM3016 programs up to 16 different masters in one cycle. Suitable for engineering applications with large EPROM sets and RS232 computer interfacing. The IM3016 provides dependable, high-throughput operation for production environments using electronically isolated sockets, one-key control, and fast programming algorithms. Software selection for all common EPROMs including 2764, 2764A, 27128, 27128A, and 27256.

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11554 C Avenue, Auburn, California 95603
For immediate action call: 916-885-7262

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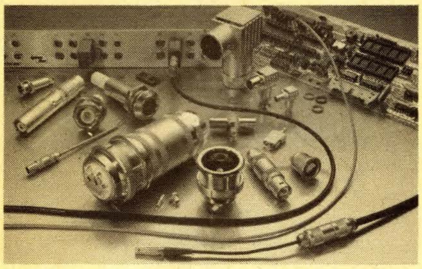

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The Lemo S Series features a wide variety of precision-machined cylindrical connectors with several capabilities: subminiatures, coaxial, triaxial, PC board mount, multipin to 106 contacts, robotic, thermocouple, high voltage, mixed high voltage, coaxial and multipin configurations, audio video, and custom designed. Quick connect-disconnect system, positive locking mechanism, available in aluminum or stainless steel.

Lemo U.S.A., Inc., P.O. Box 11006, Santa Rosa, CA, 707/578-8811

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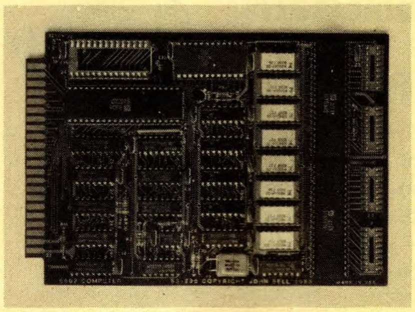
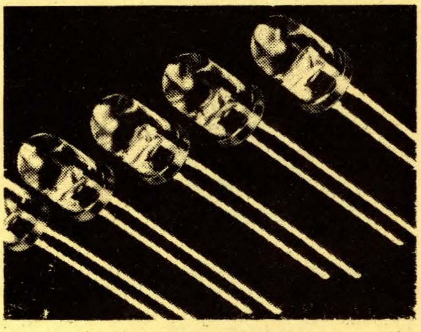


6502 64K COMPUTER-CONTROLLER

The model 83-230 single board computer has 55K of dynamic RAM, up to 8K of EPROM, four parallel ports, 1 serial RS232 port, and four timers. This 4.5″ × 6.5″ computer uses the 44 pin AIM bus. This computer was designed to be used as an industrial controller. A 2716 monitor EPROM is available for $19.95. Bare board for $49.95 or assembled and tested for $299.95.

John Bell Engineering, Inc.
1014 Center Street, San Carlos, CA. 94070
(415) 592-8411

CIRCLE NO 298



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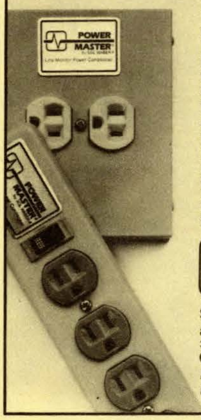

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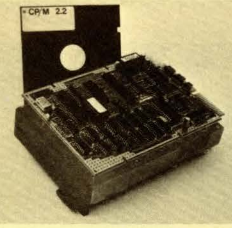

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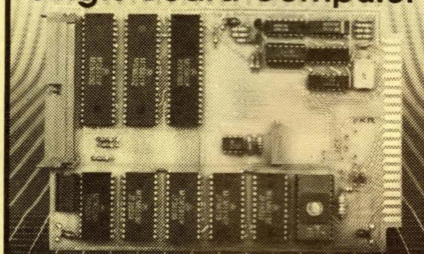

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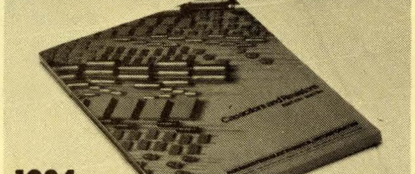

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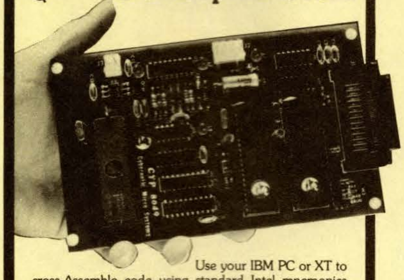

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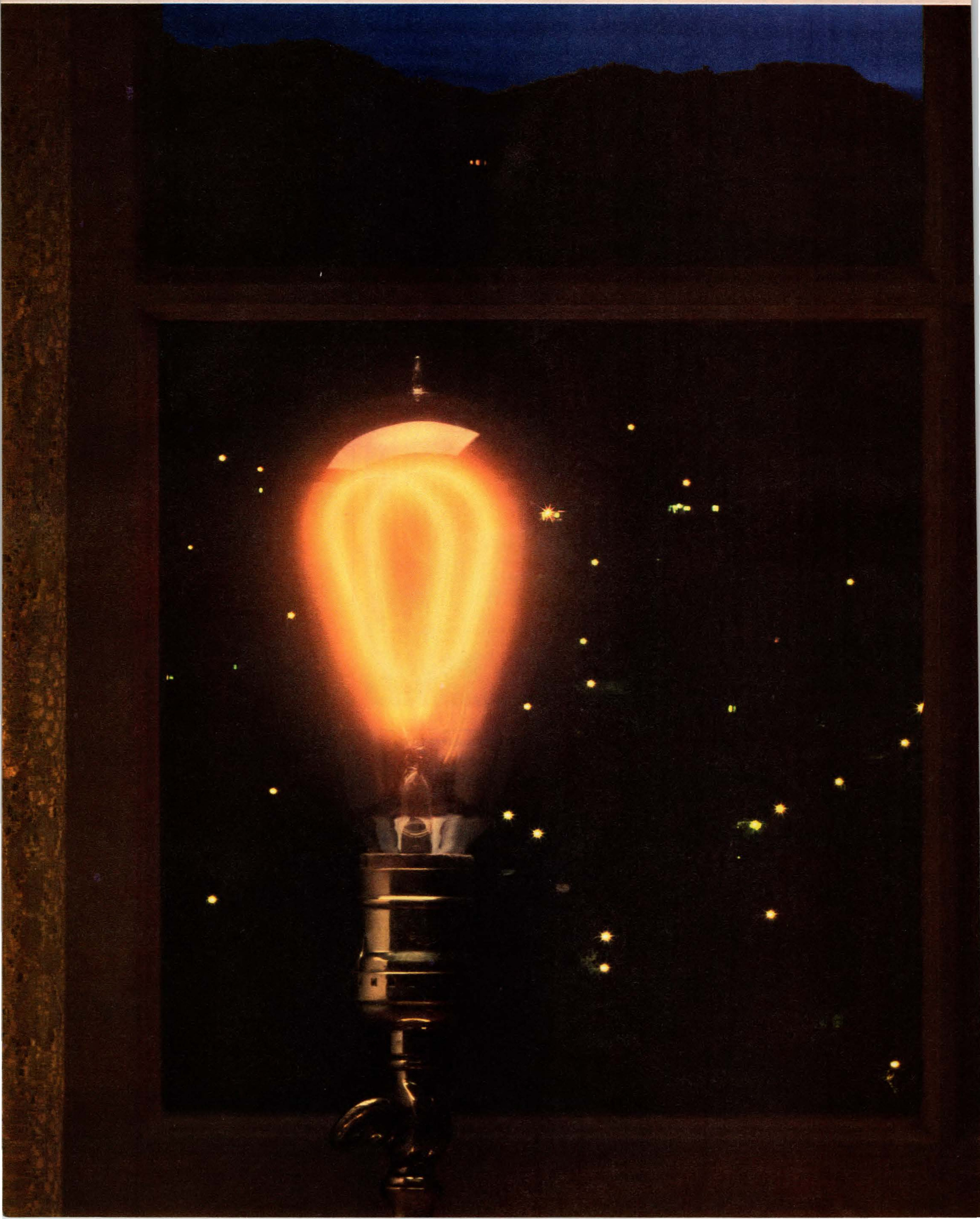

Religiously studying the power of CP/M

Soul of CP/M, *by Mitchell Waite and Robert Lafore. 391 pgs; $18.95; Howard W Sams & Co Inc, Indianapolis, IN, 1983.*

CP/M Bible, *by Mitchell Waite and John Angermeyer. 429 pgs; $19.95; Howard W Sams & Co Inc, Indianapolis, IN, 1983.*

This pair of books constitutes an excellent basic library for the study and use of CP/M-80. Though the books are written for those seeking a deeper understanding of CP/M, both provide references for the casual user to system commands and language use within the CP/M environment.

Soul of CP/M instructs. From this book you can learn both CP/M-80 system calls and, to a slightly lesser extent, 8080-μP assembly language. As the name implies, the book takes you from the use of basic system calls (routines that enable the operating system to perform the most rudimentary functions) to the hidden portion, or soul, of CP/M: the Basic Input/Output System (BIOS). At this level the user learns to modify CP/M to interface with different peripherals. Though you may never need to reach this level of understanding, the knowledge can provide you with greater insight into the workings of the operating system.

CP/M Bible is a reference work, and one of the best for that particular operating system. It answers the users' questions concerning commands. After an introductory chapter that defines the book's purpose and format, each of the next 19 chapters deals with the execution of a different Digital Research-supplied CP/M command. The final chapter provides an overview of CP/M Plus and its utilities. (CP/M Plus, or 3.0, is the latest, and a considerably different, version of CP/M.) The book contains 100 pages of appendices covering a range of subjects, from optional .COM files and available compatible languages

BOOKS

to comprehensive command summaries.

The only shortcoming in the *CP/M Bible* is its failure to include clarification of all commands. (The reader should remember that not all versions of CP/M-80 provide common utilities not covered in the reference; some are supplied for a specific set of hardware by the manufacturer.) Unfortunately, the number of machines running CP/M-80 makes such an extension of *CP/M Bible* nearly impossible.

Both books are well written and possess a design quality that is often lacking in this type of book (except in books from this publisher). One attractive and effective visual technique that enhances instruction in both books is the use of blue screening to highlight important segments. In *Soul of CP/M*, light-blue boxes provide explanations of important instructions, directives, etc. In *CP/M Bible*, screen presentations illustrating user interfaces are printed in blue. It is a pleasure to see that those designing books on programming (as well as a number of manual designers) are learning to take this multicolor approach.

— Don Powers

NEXT TIME

EDN's August 23 issue will be special in more ways than one. It's our annual Military Electronics special issue. There will be design features and Technology Update articles on a variety of military topics including:

- Component standardization
- A modulator CMOS correlator
- Military documentation
- Rad-hardened ICs
- Military hybrids

. . . and much more. Also look for our regular Design Ideas and Professional Issues departments. You can't afford to miss this issue!

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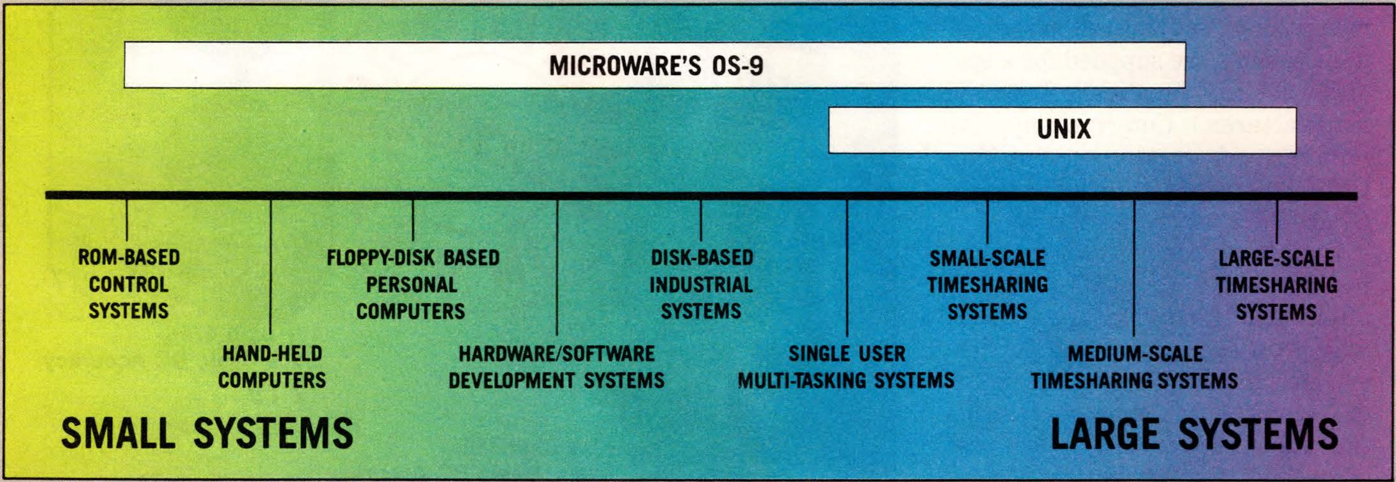

Is complicated software and expensive hardware keeping you back from Unix? Look into OS-9, the operating system from Microware that gives 68000 systems a Unix-style environment with much less overhead and complexity.

OS-9 is versatile, inexpensive, and delivers outstanding performance on any size system. The OS-9 executive is much smaller and far more efficient than Unix because it's written in fast, compact assembly language, making it ideal for critical real-time applications. OS-9 can run on a broad range of 8 to 32 bit systems based on the 68000 or 6809 family MPUs from ROM-based industrial controllers up to large multiuser systems.

OS-9'S OUTSTANDING C COMPILER IS YOUR BRIDGE TO UNIX

Microware's C compiler technology is another OS-9 advantage. The compiler produces extremely fast, compact, and ROMable code. You can easily develop and port system or application software back and forth to standard Unix systems. Cross-compiler versions for VAX and PDP-11 make coordinated Unix/OS-9 software development a pleasure.

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Once an underground classic, OS-9 is now a solid hit. Since 1980 OS-9 has been ported to over a hundred 6809 and 68000 systems under license to some of the biggest names in the business. OS-9 has been imbedded in numerous consumer, industrial, and OEM products, and is supported by many independent software suppliers.

Key OS-9 Features At A Glance

- Compact (16K) ROMable executive written in assembly language
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CIRCLE NO 214

Written and edited by Shelley Mumford

EEs rank US competitive stance, job satisfaction as top concerns

Electrical engineers overwhelmingly rank the US's competitive position in world markets as their primary social concern, according to a recent survey of approximately 2000 IEEE members conducted by Louis Harris and Associates. The survey, sponsored by the IEEE and the National Science Foundation, was conducted to determine what EEs' perceptions are of their training, profession, social responsibilities and coworkers.

Substantiating their worries about the erosion of US technological leadership, EEs show serious concern for US productivity. Indeed, more than seven of 10 engineers surveyed believe that US productivity is only fair (60%) or poor (12%).

The majority of engineers (81%) who see a weakening in US productivity blame labor unions for the decline. Many also blame major corporations (49%), the work force (48%) and Congress (45%). Focusing more closely on their own companies' productivity, EEs are critical of their coworkers in terms of how many hours they put in and how effective and creative they are, the survey reports. Management also faces severe criticism. Nearly one-third of the respondents believe that managers of engineers deserve the principal blame for productivity's not being better than it is.

The survey observes that low productivity might be the result of job dissatisfaction among engineers. In confirmation, responses indicate that one in four EEs expresses unhappiness with the job (although almost three-fourths of those surveyed are satisfied with their current position). What's more, 27% indicate that their careers have fallen short of what they had originally hoped for. The survey, therefore, concludes that "if achieving overwhelming employee satisfaction is a goal driving management, increased productivity should be the result. When individual company productivity increases, US productivity should follow close at its heels."

Electrical engineers recommend three ways in which management can begin enhancing productivity. These include:

- More and better information from management about decisions that affect engineers
- More engineer participation in decisions that affect them
- A greater chance for recognition and promotion.

In addition, engineers feel that increased job satisfaction can be achieved through the following measures (echoing the above concerns):

- More creative opportunities
- A good working relationship with a supervisor
- Increased growth potential
- A good working relationship with peers.

More specifically, engineers of all ages recommend increased responsibilities in development and design in order to increase job satisfaction (**Fig 1**). Design is particularly appealing to EEs in computer-hardware and -software areas and least interesting to those in power- and energy-related fields. Research is also a popular area, with its greatest supporters in the computer-software field. Teaching, on the other hand, holds little attraction for those surveyed, and government service ranks last in the list of the most desirable tasks.

It's interesting to note that the number of dissatisfied workers is

MOST DESIRABLE JOB FUNCTIONS FOR EEs

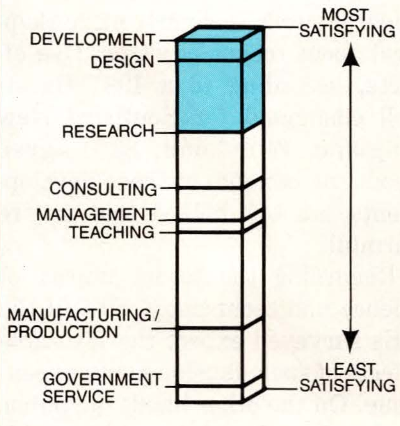

Fig 1—Development and design *rank as the two most desired job functions of EEs today.*

considerably higher in the engineering field than in the medical and legal professions (**Fig 2**). In a recent American Bar Association survey, only 11% of the responding lawyers were moderately to totally unhappy—half the percentage of EEs who reported job dissatisfaction. Similarly, the American Medical Association's most recent statistics on job satisfaction reveal that very few doctors (5%) indicated unhappiness with their jobs—one-fifth the number recorded among EEs.

EEs hopeful about technology

On a more positive note, electrical engineers show optimism in a variety of areas throughout the profession as a whole. They feel that things have improved in the last 10 years in

- The preparation of engineers at the undergraduate and graduate levels
- The quality of electrical engineering

- The design of new high-technology products
- The caliber of engineers who are managers
- The extent to which high-technology businesses are investing in new equipment and facilities.

In addition, 89% of the EEs feel that the impact of science and technology has done more good than harm in the past. In comparison, the general public is slightly more skeptical about technology's positive effects, according to a 1983 Harris poll conducted for Southern New England Telephone; 83% agree about the benefits of these developments, but 14% believe that they're harmful.

Regarding the future impact of science and technology, 80% of the EEs surveyed expect the favorable effects of such developments to continue. On the other hand, the public is significantly less positive, with only 68% believing that more good than harm would result from such technological developments.

Improving the quality of life

EEs identify seven existing scientific and technological developments that will improve the quality of life.

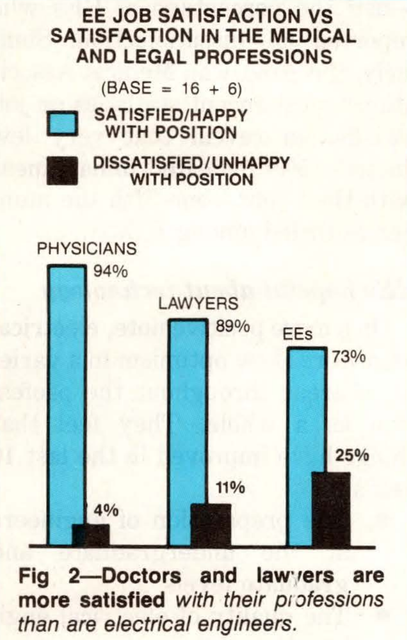

Fig 2—Doctors and lawyers are more satisfied *with their professions than are electrical engineers.*

TECHNOLOGICAL DEVELOPMENTS THAT IMPROVE THE QUALITY OF LIFE

EE RANKING (IN DESCENDING ORDER OF PERCENTAGE)	GENERAL PUBLIC RANKING (IN DESCENDING ORDER OF PERCENTAGE)
ROBOTS AND AUTOMATION	HAND HELD ELECTRONIC CALCULATOR
LASER BEAM	LASER BEAM
HAND HELD ELECTRONIC CALCULATOR	GENETIC ENGINEERING
GENETIC ENGINEERING	PERMANENT SPACE STATIONS
NUCLEAR POWER	ROBOTS AND AUTOMATION
PERMANENT SPACE STATIONS	NUCLEAR POWER

Fig 3—EEs rank robots and automation *and the laser beam as the technological developments most likely to improve the quality of life. The general public, on the other hand, rates the handheld calculator as the most important technological contribution to an improved lifestyle.*

These include (in descending order by percentage of responses):

- Satellite communications
- The personal computer
- The handheld calculator
- Robots and automation
- The laser beam
- Microwave technology
- Next-generation computers.

Responses from the public concerning positive developments, on the other hand, differ considerably from the EEs' responses. Where engineers are more hopeful about robots and automation and somewhat more optimistic about nuclear power (**Fig 3**), the general public feels more positive about handheld calculators and the laser beam.

Regarding those areas that might have a negative impact on society, EEs list nuclear weapons (73%), video games (50%) and missile guidance systems (46%) as being harmful to the quality of life. Those who conducted the survey note their surprise at the strong negative reaction of engineers to video games—a recreational activity spawned from high technology. They account for this view by noting that "perhaps video games, being computer-based but serving only recreational purposes, are seen as detracting from, rather than contributing to, an appreciation of the overall importance of electrotechnology."

Electrical engineers believe that, on the whole, their profession has changed very little in the past 10 years. More than one-third of those surveyed say that the quality of electrical engineering has improved since 1974, while a similar number feels that it's stayed the same. A little less than one-half of those surveyed (43%) think EEs work the same number of hours they did a decade ago.

EEs tend to be negative, however, with respect to the amount of pride they have in their work today. A substantial one-third of those surveyed say that they have *less* pride in their jobs than they did 10 years ago. Likewise, EEs see the profession suffering in the amount of loyalty shown today by EEs to their employers. More than half of the respondents (61%) find EEs *less* loyal at this time than they were in 1974. One in four engineers sees the same degree of loyalty these days, and about 4% think EEs are more loyal now than they were a decade ago. Additionally, more than one-third (39%) consider EEs' motivation to work to be less strong than it was 10 years ago. **EDN**

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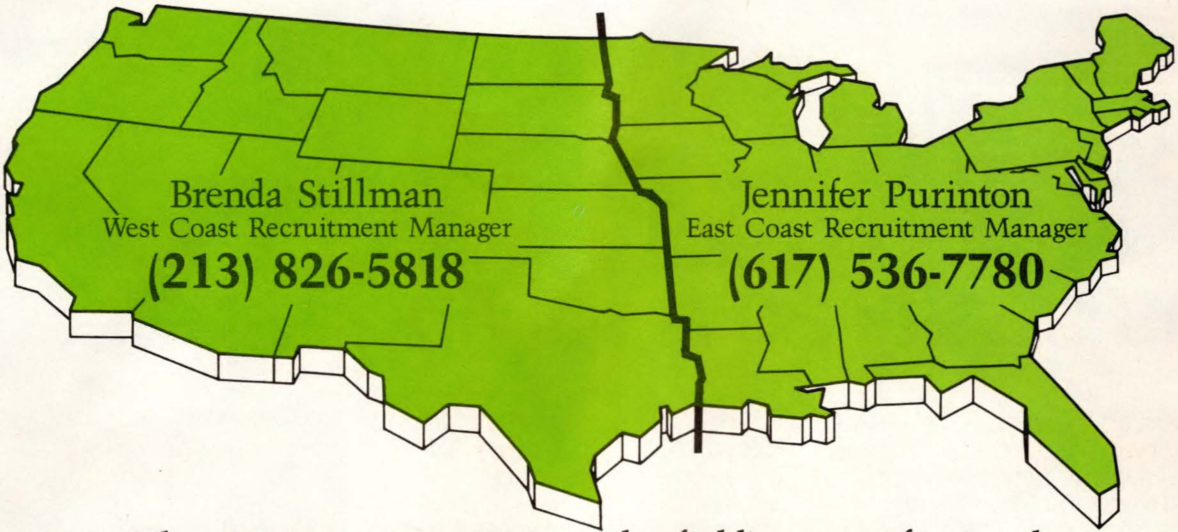

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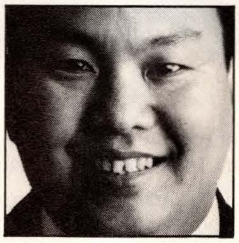

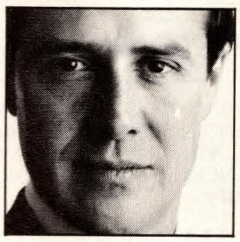

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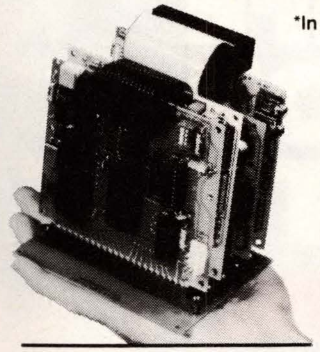

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LOOKING AHEAD

Edited by George Stubbs

Engineers increase use of EEPROMs, NVRAMs

Engineers currently making limited use of EEPROMs and nonvolatile RAMs will significantly increase their use of such memory circuits in the near future, according to an EEPROM benchmark study conducted by EDN. The study polled the opinions of EDN readers, many of whom specify and use EEPROM and nonvolatile-RAM circuits sporting a wide variety of system densities and organizations.

Approximately one-third (32.9%) of the respondents have a design in production that uses EEPROMs. More than half (52.5%) anticipate incorporation of EEPROMs in circuit designs within the next six months to two years. Approximately 19% of the respondents are currently using nonvolatile RAMs, but within the next two years, 40.8% plan to develop new designs that require quantity purchases of the nonvolatile memories.

Readers indicated that second sourcing, 250-nsec access times and low power consumption were the most important features attracting them to EEPROMs. Required system densities span 256×8 to 1M×8, with 64k×8, 16k×8 and 8k×8 attracting 29.1, 34.6 and 35.8% of the respondents, respectively. Nonvolatile-RAM users plan to employ a variety of system densities, from 256 bits to 64k bits. The 16k-bit densities were more popular than the rest, garnering a 14.5% response when readers were asked which densities they plan to use.

PLANNED PRODUCT TYPES FOR EEPROMs AND NONVOLATILE RAMs

	% OF USERS*
INDUSTRIAL-CONTROL SYSTEMS	22.3
TEST AND MEASUREMENT EQUIPMENT	20.1
COMMUNICATIONS EQUIPMENT	16.2
MICROCOMPUTERS	16.2
AIRCRAFT, MISSILES, SPACE AND GROUND-SUPPORT EQUIPMENT	12.8
COMPUTER PERIPHERALS	11.2
NAVIGATION/GUIDANCE EQUIPMENT	10.1
MEDICAL ELECTRONICS	6.1
OTHER	19.0

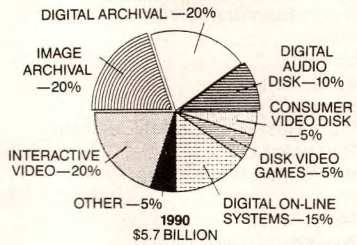
*TOTAL EXCEEDS 100% DUE TO MULTIPLE RESPONSES

EEPROMs and nonvolatile RAMs will find their way into a wide variety of products. The most popular are industrial-control systems, test and measurement equipment, communications equipment and microcomputers. The principal uses of EEPROMs in such equipment will be configuration storage, program storage and user-defined functions.

Optical-recording market to reach $5.7B by 1990

The market for optical-recording technology, today at approximately $1.5 billion, will reach $5.7 billion by 1990, according to Strategic Inc, a market-research firm based in San Jose, CA. Strategic reports that the advantages of high-density optical recording and fast access of image and digital data will have a significant impact on conventional recording technology.

WORLD MARKET FOR OPTICAL-RECORDING TECHNOLOGY



(SOURCE: STRATEGIC INC)

Current applications of optical-storage technology are limited to adaptations of existing uses, such as digital audio, entertainment video and archival storage. Future applications, however, are touted as limited only by the imagination.

The field's most successful companies, says Strategic, won't be those that attempt to replace magnetic technology, but rather those that envision new applications, such as interactive video and CAD/CAM. The well-established technology of magnetic data storage should hold its ground against the optical-storage techniques.

Artificial intelligence attracts business users

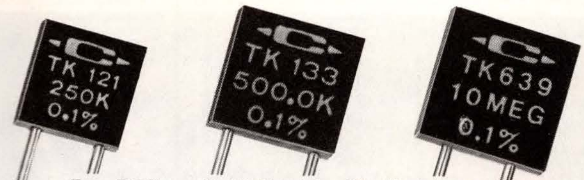
Though the commercial introduction of artificial intelligence (AI) is only as recent as 1983, the US market for AI systems by 1990 could reach $11 billion. So says Karl M Wiig, chief architect and director of the AI program at Arthur D Little Inc, a consulting and research firm based in Cambridge, MA.

Business management's increasing awareness of AI's value stems from the successful use of knowledge-based systems, or "expert" systems, as they are also known, in solving problems in a broad range of fields, from banking to medical diagnosis and oil exploration. These systems represent, store and manipulate the knowledge of human experts in a given field of study. The systems are called upon to apply such knowledge to a given situation and evaluate courses of action.

Wiig believes that AI could account for as much as 4.5% of the projected $267 billion in 1990 computer-industry revenues. Contributing to the growth are the decreasing cost of computer hardware, improvements in workstation technology, the emergence of software packages accommodating the needs of the "uninitiated," and in-house AI development programs.

There are, however, barriers to rapid growth. It takes a long time to develop and implement an AI system; knowledge representation and manipulation is a science still in its infancy. Also, the $10,000 to $20,000 capital investment required to provide an AI workstation for each "knowledge worker" may be prohibitive. One thing business managers are discovering is that these workers require highly integrated workstation environments. The costs involved may compel them to settle for interim solutions.

Radial-Lead Precision Film Resistors from Caddock combine high values and tight tolerances with a choice of two high-power densities or three low TCs.



Type MK Radial-Lead Precision Power Film Resistors

MK 132 and MK 632
10 ohms to 100 Megohms

MK 120 and MK 620
30 ohms to 40 Megohms

Type TK Temp-Stable Precision Film Resistors

TK 121 and TK 621
1 Kohm to 2 Megohms

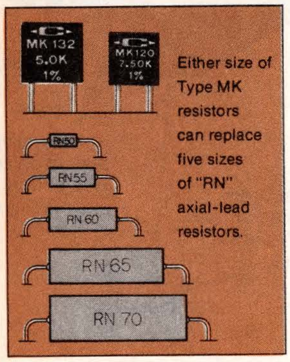
TK 133 and TK 633
1 Kohm to 10 Megohms

TK 139 and TK 639
1 Kohm to 10 Megohms

Type MK Radial-Lead Precision Power Film Resistors utilize Caddock's Micronox® resistance films to achieve high power density and an extended range of resistance values:

Available in two rectangular radial-lead packages that include values as high as 100 Megohms, these high-density film resistors permit electronic circuit designers to optimize packaging and PC board layouts with resistors that meet all these specifications:

	MK 120	MK 620	MK 132	MK 632
• Resistance Range	30 ohms to 2 Megohms	2.1 Megohms to 40 Megohms	10 ohms to 5 Megohms	5.1 Megohms to 100 Megohms
• Resistance Tolerance	±1.0% is standard, to ±0.1% on special order, depending on value and model.			
• Wattage	0.5 Watt	——	0.75 Watt	——
• Voltage	200 V	200 V	400 V	400 V
• Temperature Coefficient	50 PPM/°C	80 PPM/°C	50 PPM/°C	80 PPM/°C
	Temp Range: -15°C to +105°C, ref. +25°C.			
• Package Size	.250" square, .100" thick		.300" square, .100" thick	



These full-size photos comparing the Type MK resistors to "RN" style axial-lead resistors show that the largest Type MK, which is rated at 3/4 watt, requires less board space than the 1/20 watt "RN 50".

And within their voltage ratings, both sizes of Type MK resistors can replace five sizes of "RN" resistors, including the 1/2 watt "RN 70" which requires 10 times the board space of the MK 132 !

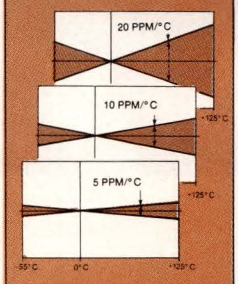
This combination of higher power rating and smaller size can also lower procurement costs by replacing many sizes of axial-lead resistors with Type MK resistors that have a 'standard' size and mounting dimensions.

Type TK Temp-Stable Precision Film Resistors with Caddock's Tetrinox® resistance films combine a choice of TCs of 5, 10 or 20 PPM/°C, a wide resistance range and tight tolerances.

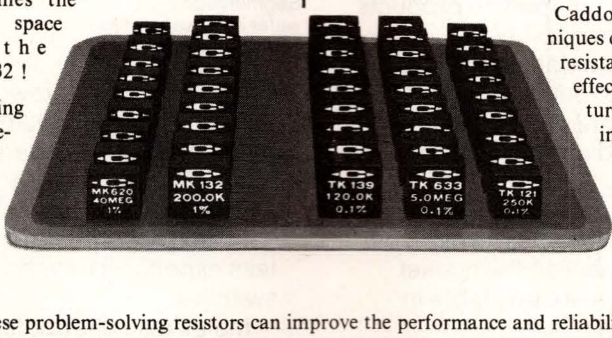
Type TK Temp-Stable Precision Film Resistors provide a combination of performance advantages that are unique in a miniature resistive component:

- **Three Standard Temperature Coefficients:** 5 PPM/°C, 10 PPM/°C or 20 PPM/°C over the temperature range from -55°C to +125°C. (+105°C max. for values above 500 Kohms or 1.5 Megohms, depending upon model.)
- **Resistance Range:** 1 Kohm to 10 Megohms.
- **Precision Tolerances:** ±1.0% is standard, and tolerances as close as ±0.05% are available on special order.
- **Load Life Stability:** 0.05% maximum ΔR after 2000 hours at full power at +125°C. (0.2% max. for values above 500 Kohms or 1.5 Megohms, depending upon model.)
- **Two Power Ratings:** .2 watt and .3 watt.

Each model of Type TK resistors has three TC options:



The Model TK 121, TK 133 and TK 139 precision film resistors have demonstrated performance which meets the requirements of Mil-R-55182/9 for thermal shock, moisture resistance, shock and vibration, dielectric withstanding voltage and low temperature operation.



Caddock's high-thru-put manufacturing techniques combined with our advanced Tetrinox® resistance film technology provide this cost-effective way to match the needs of temperature stable circuitry. For price and delivery information on both production and evaluation quantities, contact Caddock's main offices in Riverside, California.

Discover how easily these problem-solving resistors can improve the performance and reliability of your equipment, too. For your copy of the latest edition of the Caddock 24 page General Catalog, and specific technical data on any of the more than 150 models of the 13 standard types of Caddock High Performance Film Resistors and Precision Resistor Networks, just call or write to –

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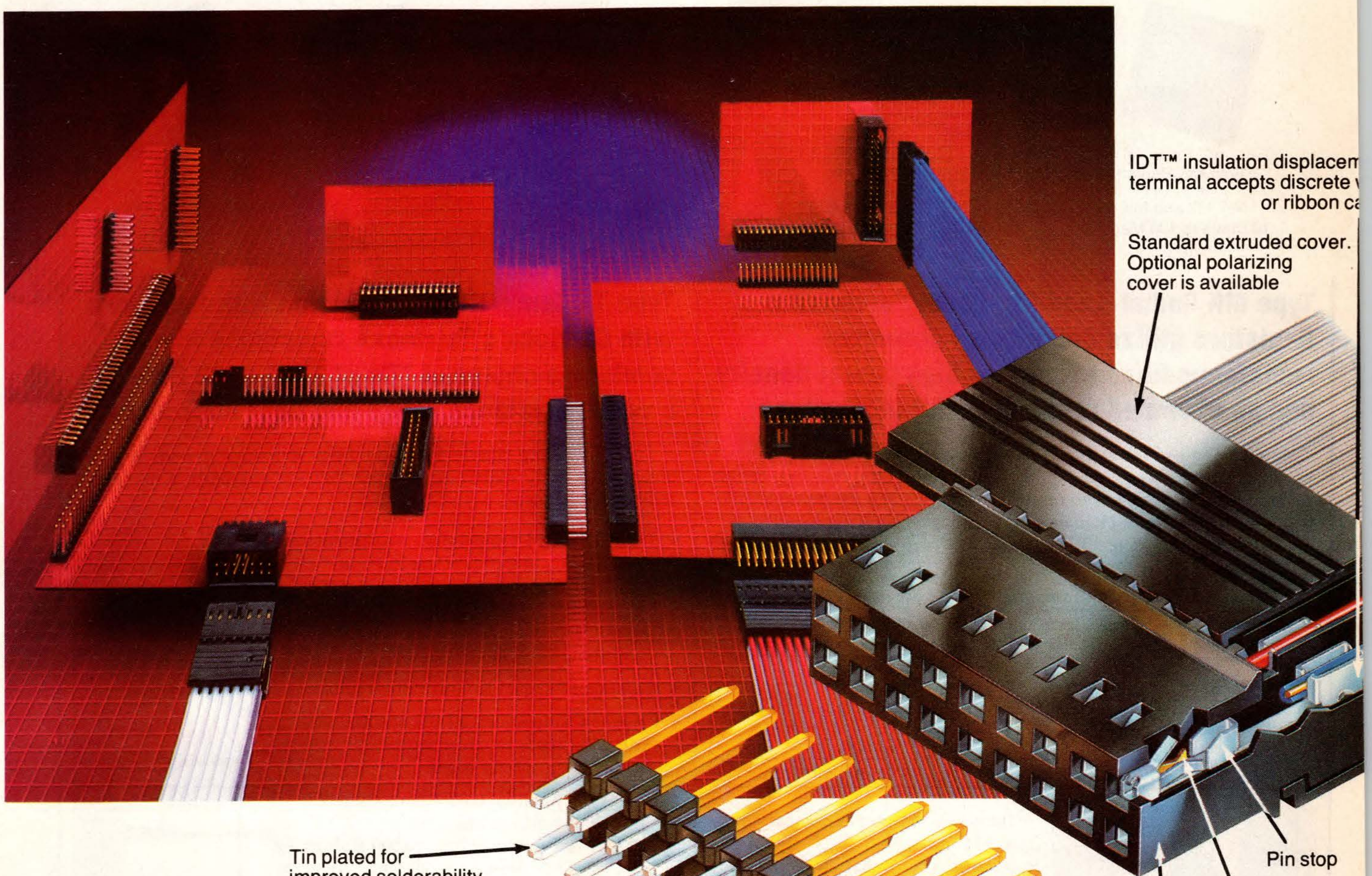

C-Grid is the most advanced high density interconnection system Molex has ever designed for board-to-board, wire-to-board and wire-to-wire applications. It features selective plating, for the highest performance at the lowest cost, and offers you a wide variety of companion products for convenient design flexibility and reliability.

The C-Grid system achieves its high density capability by using .025″ (0,64mm) square pins for the male connector parts, set in a .100″ x .100″ (2,54 x 2,54mm) matrix. The pins can either be placed directly in the board or used in volume with wafer bodies.

To load loose pins into the PC board, Molex offers a patented single- or Multi-Pinsetter® capable of up to 156,000 insertions per hour—the fastest on the market.

Shrouded and unshrouded headers are available in straight and right-angle wafer bodies.

The #8676 dual-row, insulation displacement connectors are stackable, end-to-end, and feature IDT™ terminals with mass termination application tooling available to help you achieve greater cost savings in your assembly operations.

Molex closed-or open-end shunts make it easier and less expensive to retrofit board circuitry by avoiding DIP switches.

Molex also offers a female connector (7990-series) to be soldered to one board and mated with the .025″ (0,64mm) pins on another. Its features include low mating force, ease of insertion and improved solderability.

For more information on our C-Grid interconnection system, contact the Molex office nearest you.

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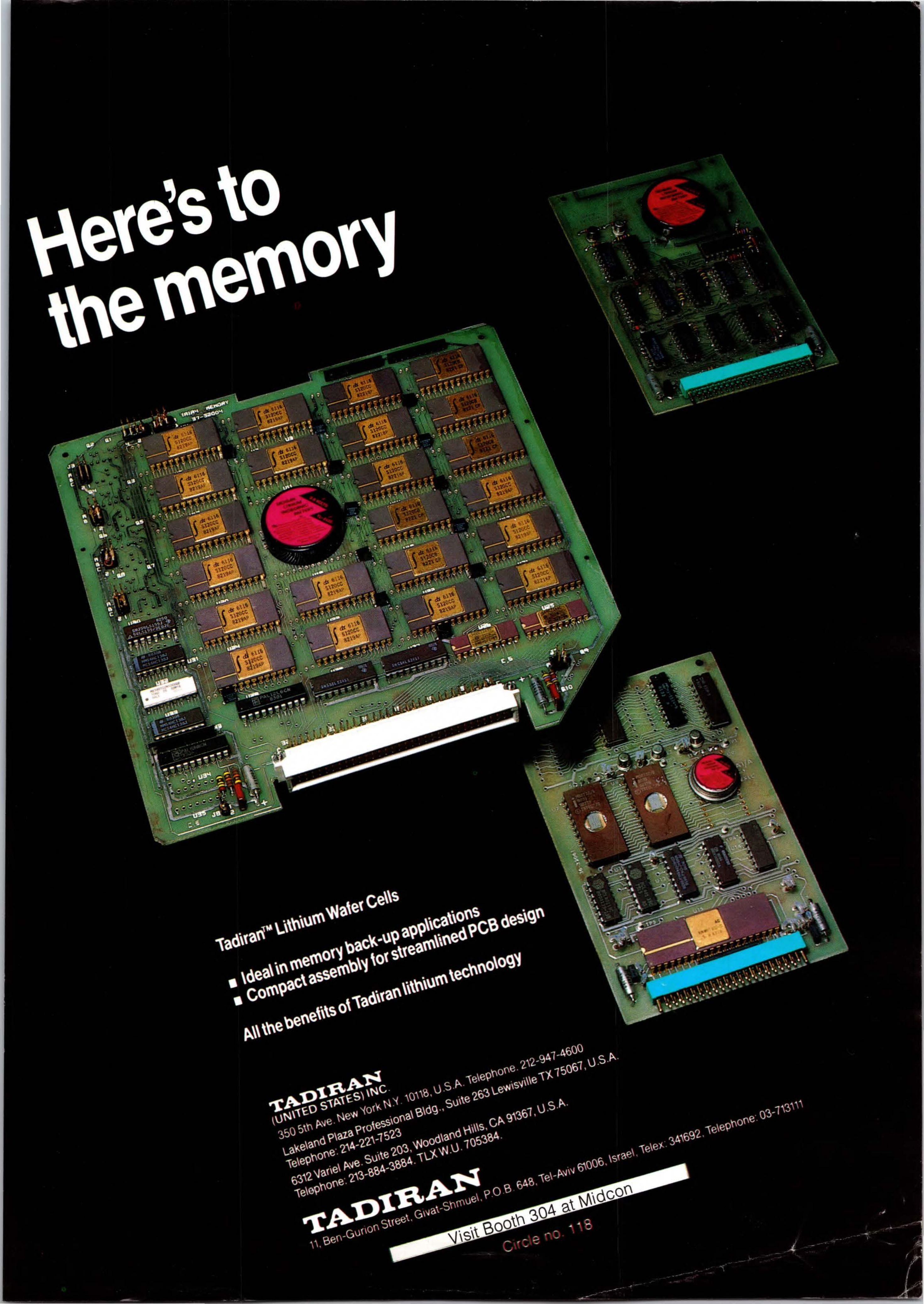
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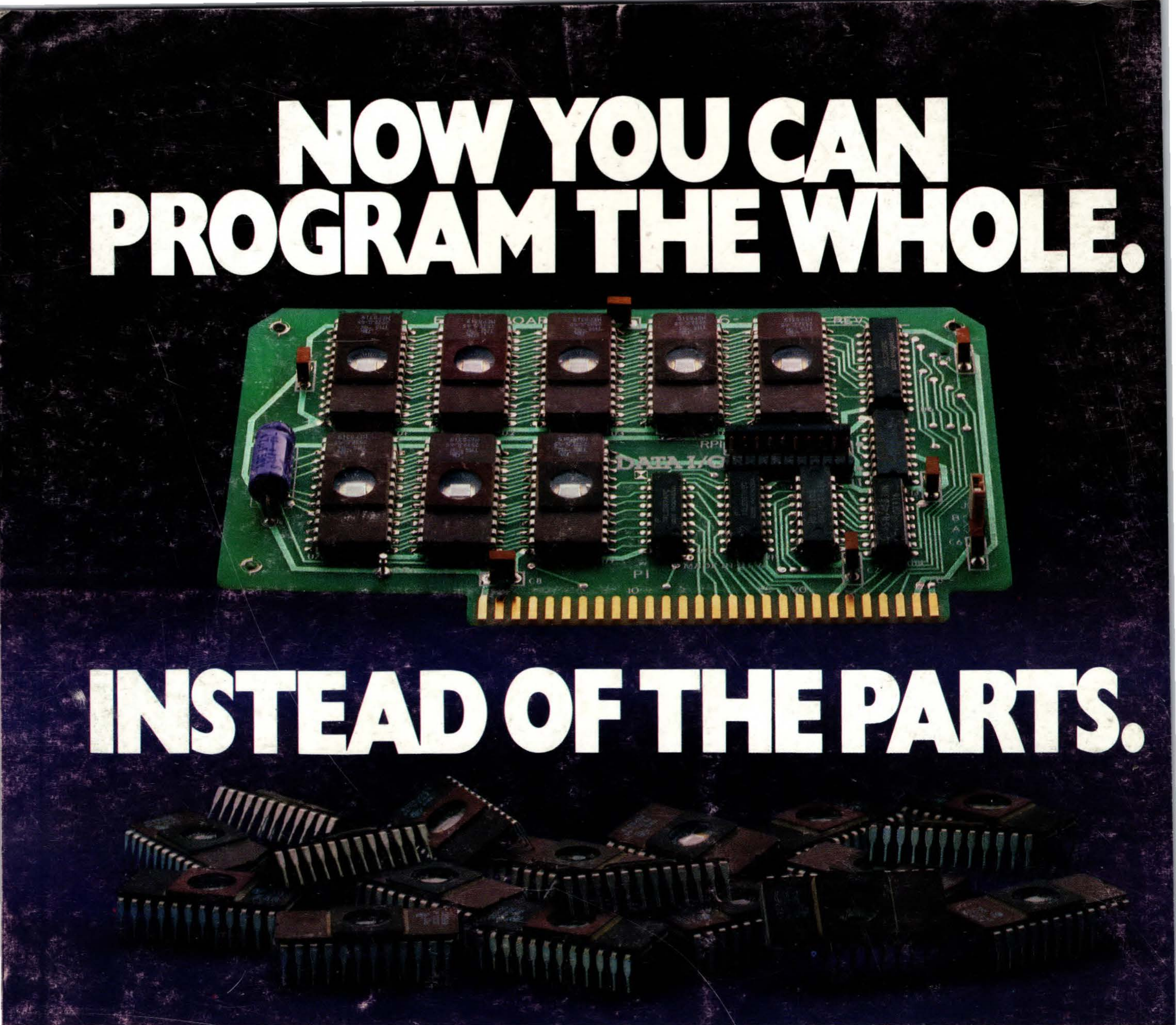

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Cost-efficiency is a major bonus with the 156A. It handles up to eight identical boards at a time, each with up to 96 installed 27128s—or over 1.5M bytes per board. A 64-board software option will also be available.

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