A CAHNERS PUBLICATION

OCTOBER 29, 1987

EDN®

Techniques tame noise in high-speed CMOS designs

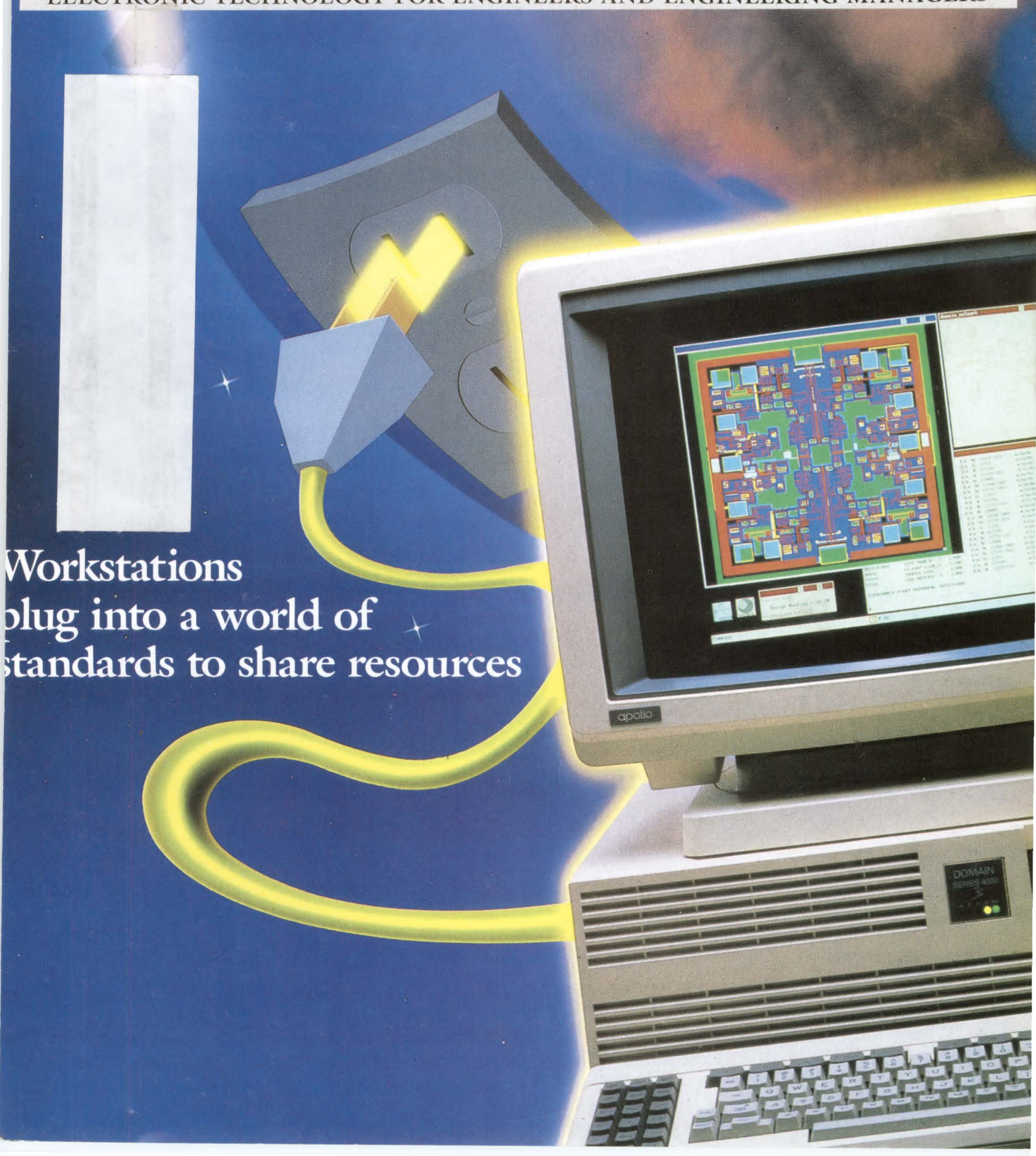
VME Bus system replaces a 68000 with an 80386

Voice-synthesis digital ICs

Wescon/87 preview

Salon des Composants

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



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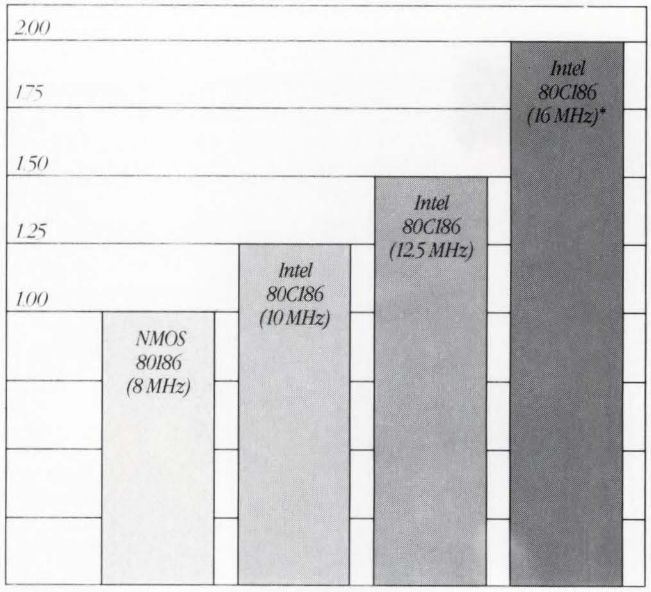

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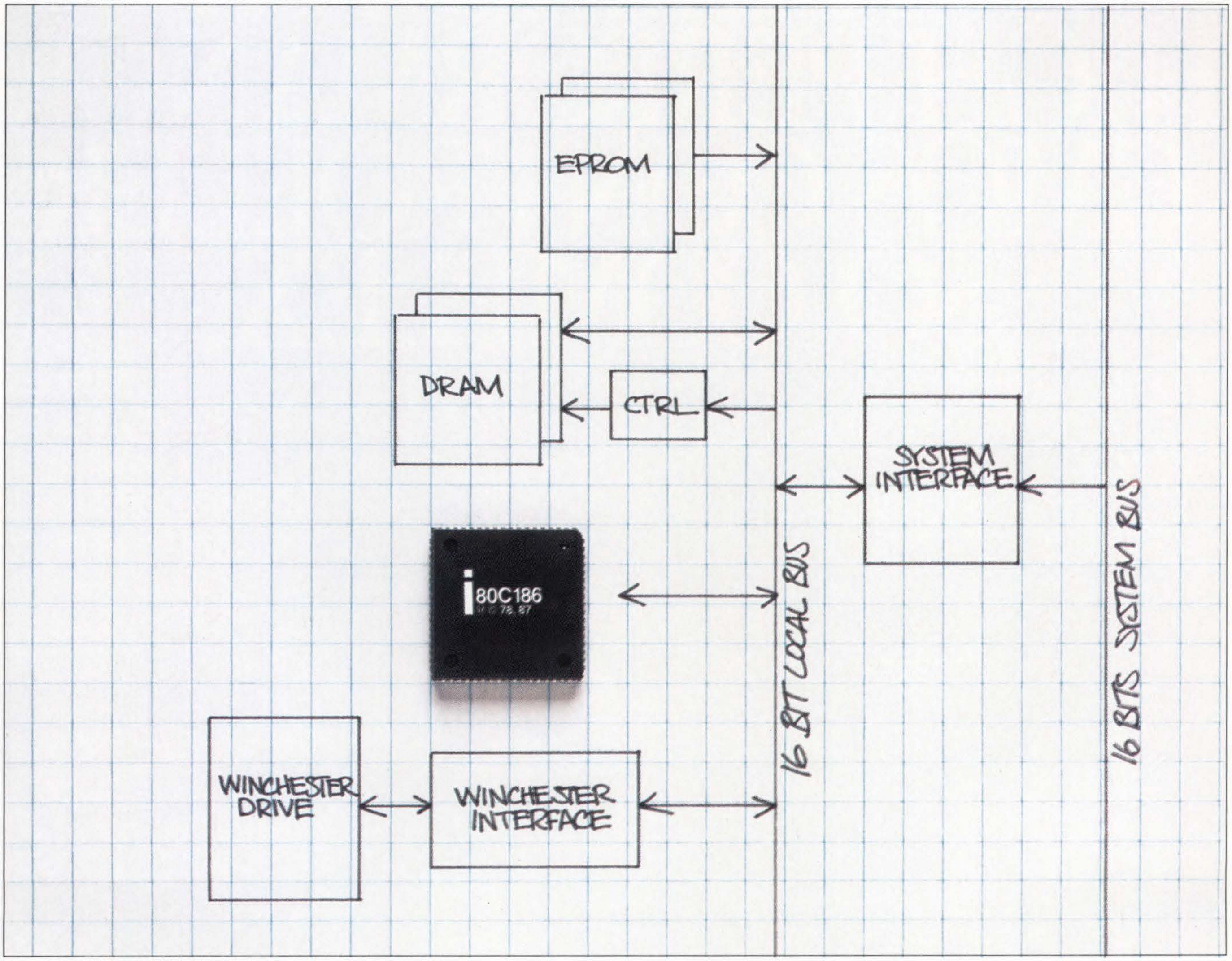

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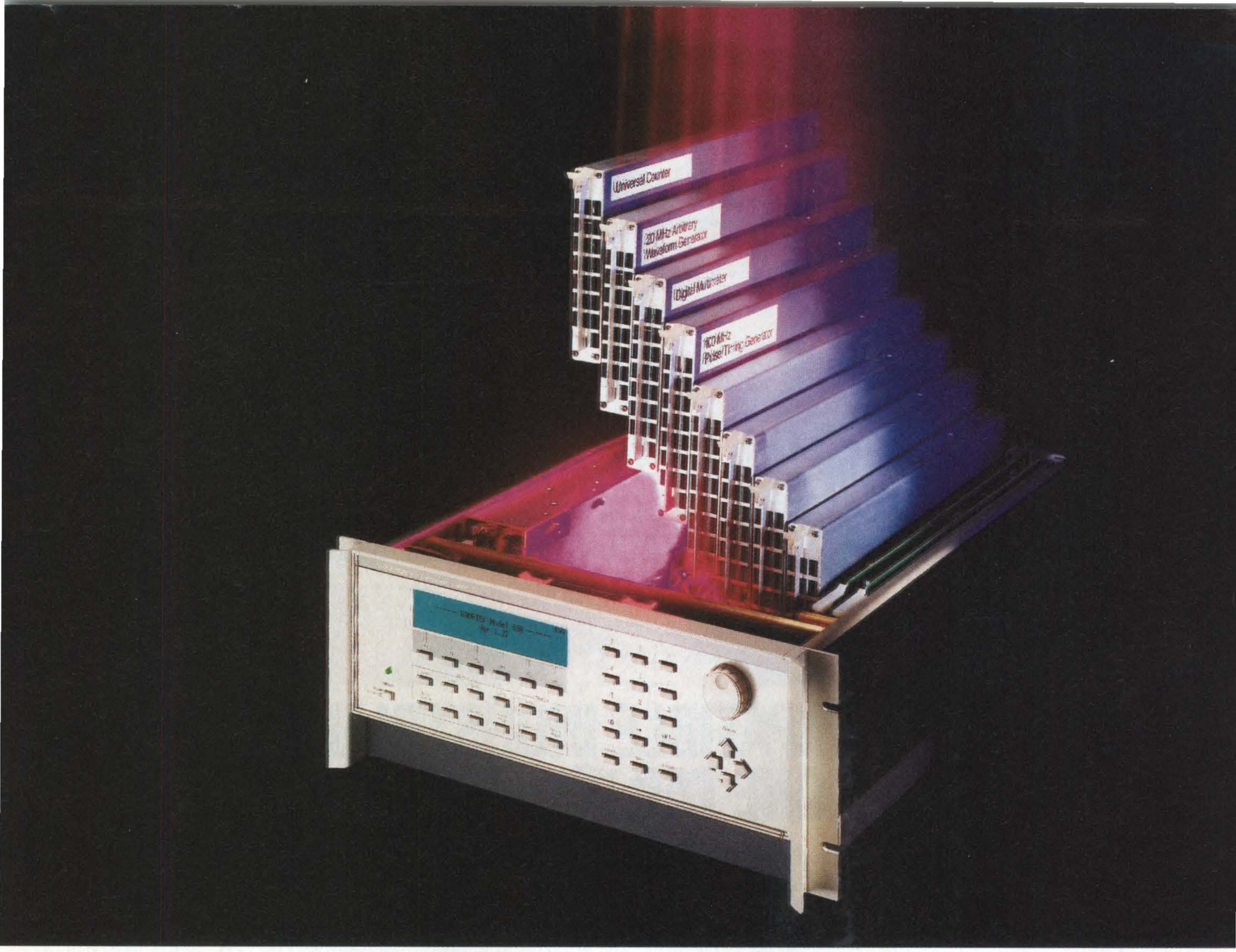
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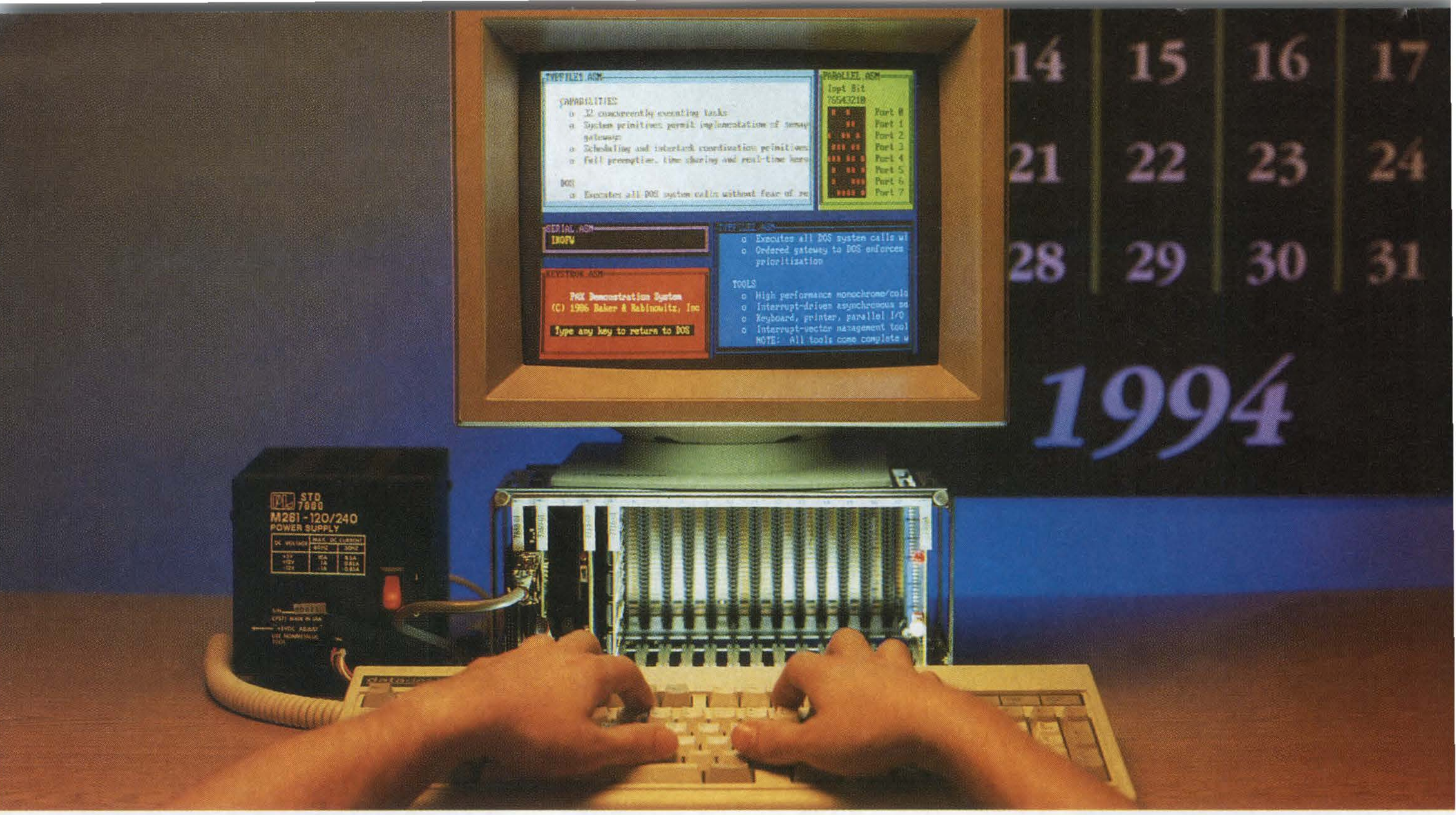

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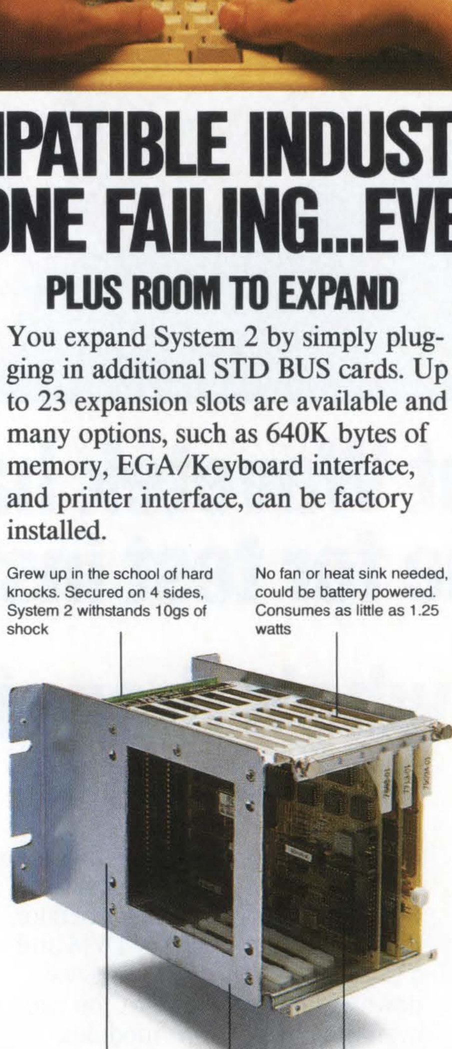

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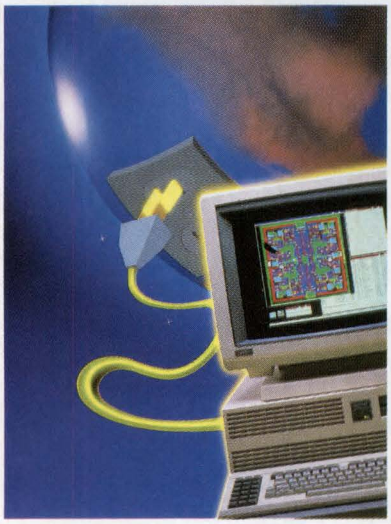
PL055

INDUSTRIAL COMPUTERS PRO-LOG IN CONTROL QUALITY

EDN

Volume 32, Number 22 October 29, 1987

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



On the cover: *Because of the acceptance of three popular standards, your workstation can now hook up with the vast resources of other workstations on a network. See pg 168. (Photo courtesy Apollo Computer Inc)*

DESIGN FEATURES

Continued on page 7

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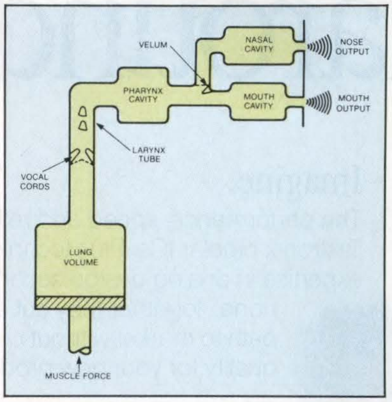
EDN

October 29, 1987



***The key to one voice-synthesis method**—parametric synthesis—is a model of the human speech production mechanism (pg 63).*

TECHNOLOGY UPDATE

PRODUCT UPDATE

DESIGN IDEAS

Continued on page 9

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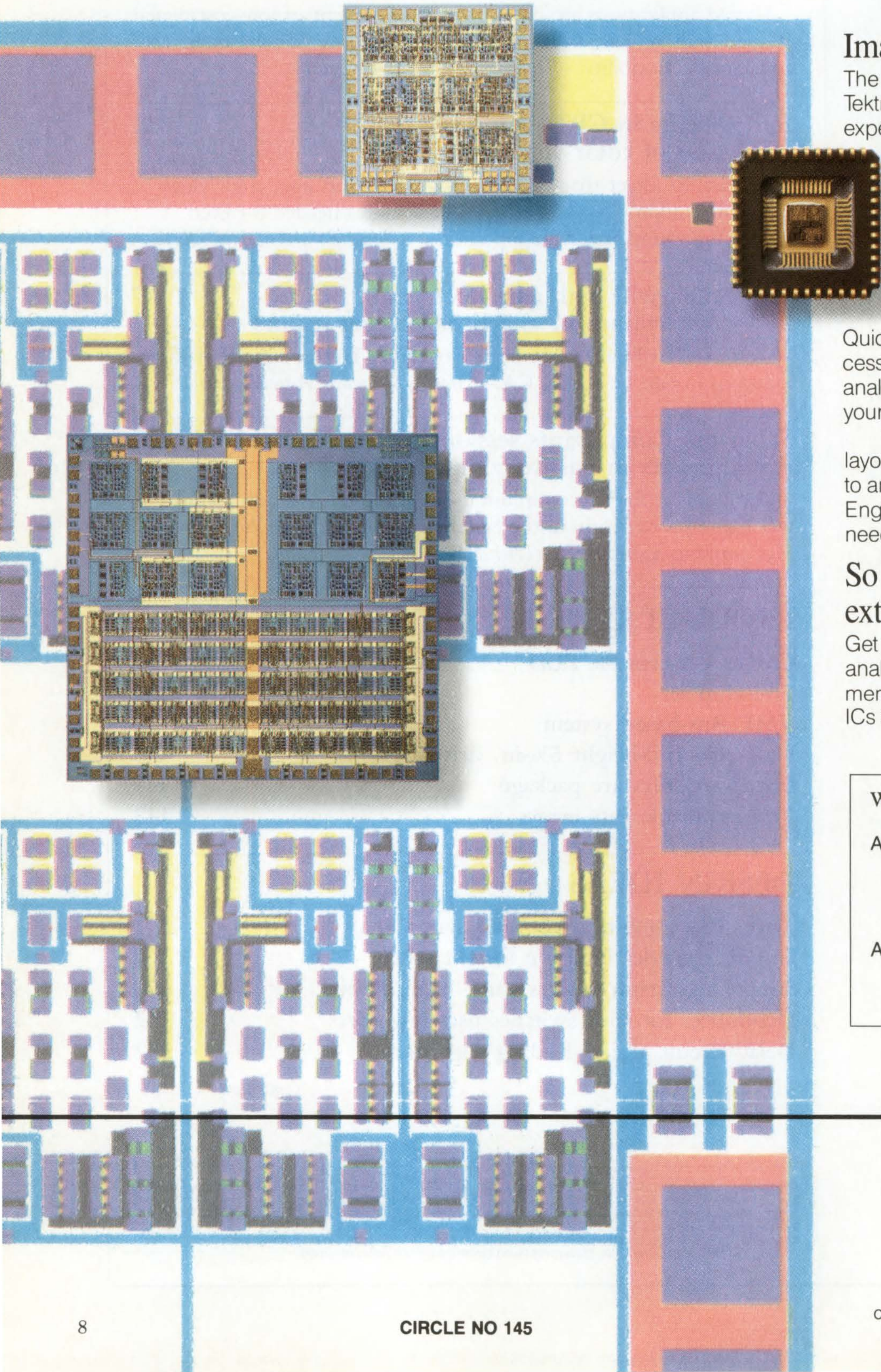

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CIRCLE NO 145

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EDN

October 29, 1987

EDITORIAL 57

Instead of banning digital audio tape (DAT) recorders, Congress should let the market forces determine the systems' future.

NEW PRODUCTS

PROFESSIONAL ISSUES 351

Attending graduate school via videotape.—*Deborah Asbrand, Associate Editor*

LOOKING AHEAD 371

Short boom in store for packet-switching industry. . .''Interoperability'' is watchword in data sharing.

DEPARTMENTS

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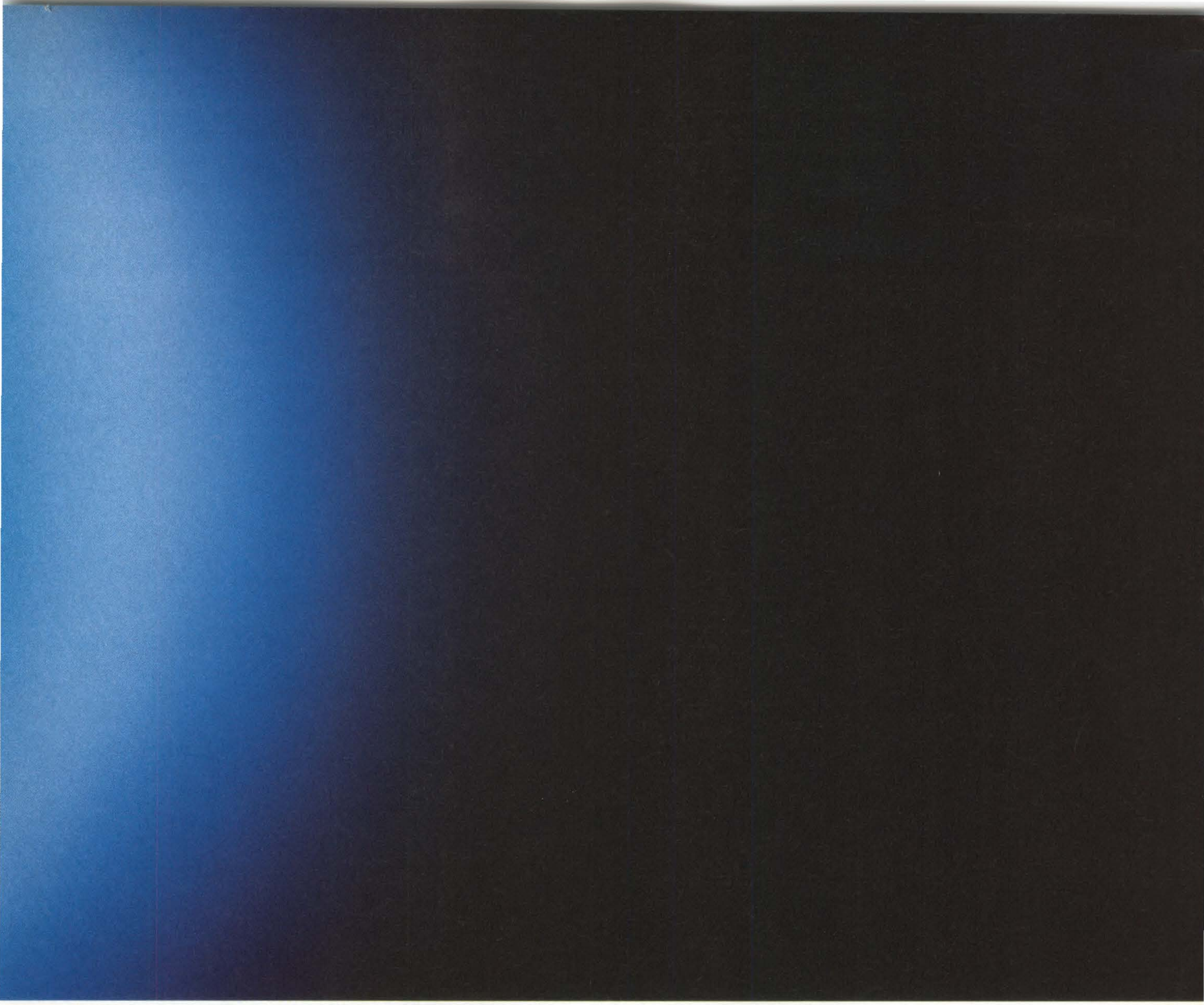

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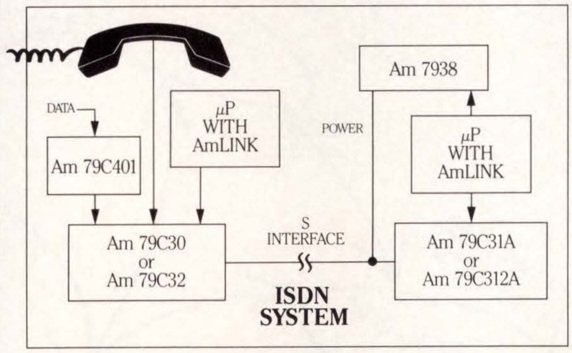

The set is so highly integrated, you won't need extra chips for things like dialing and ringing.

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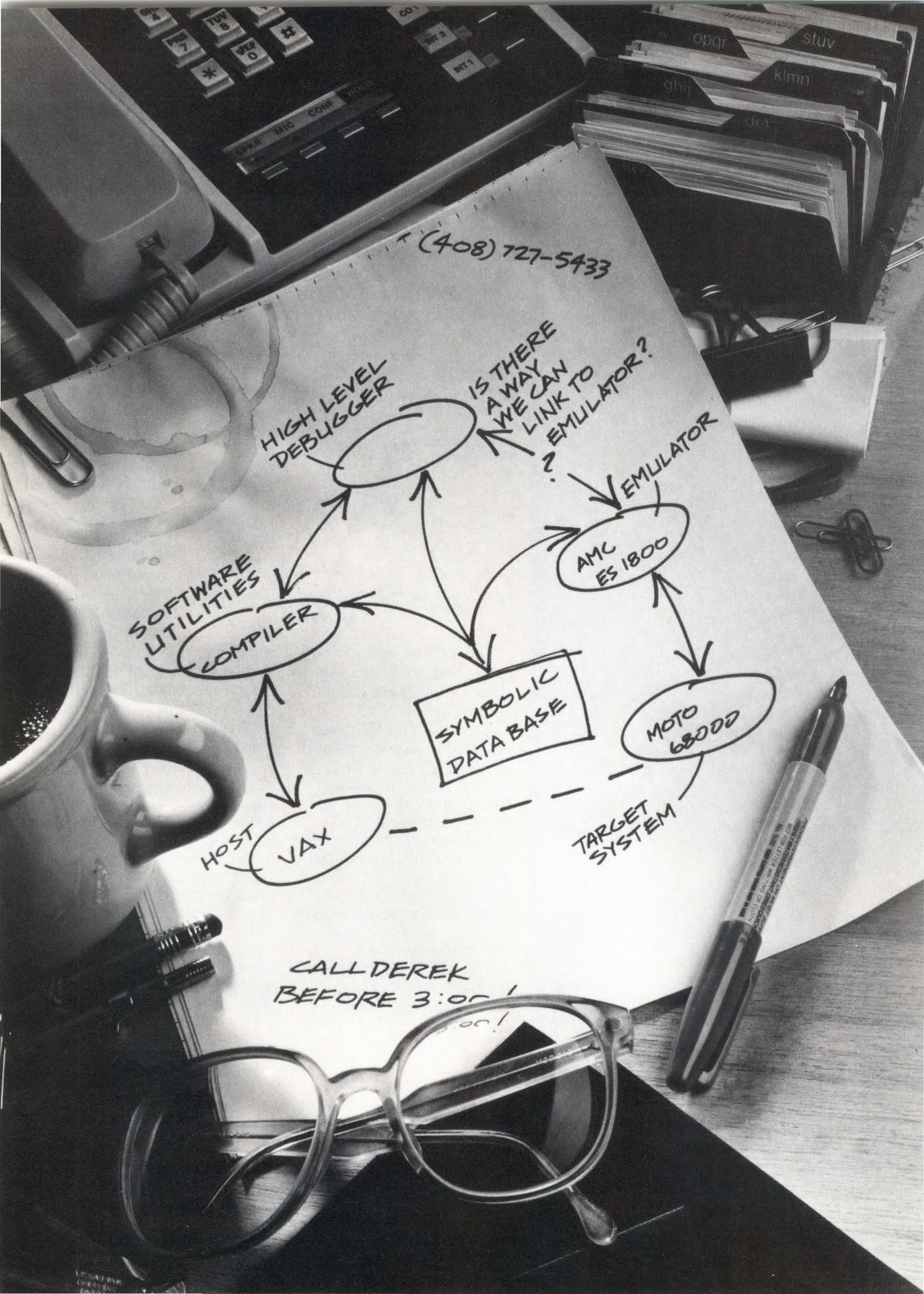
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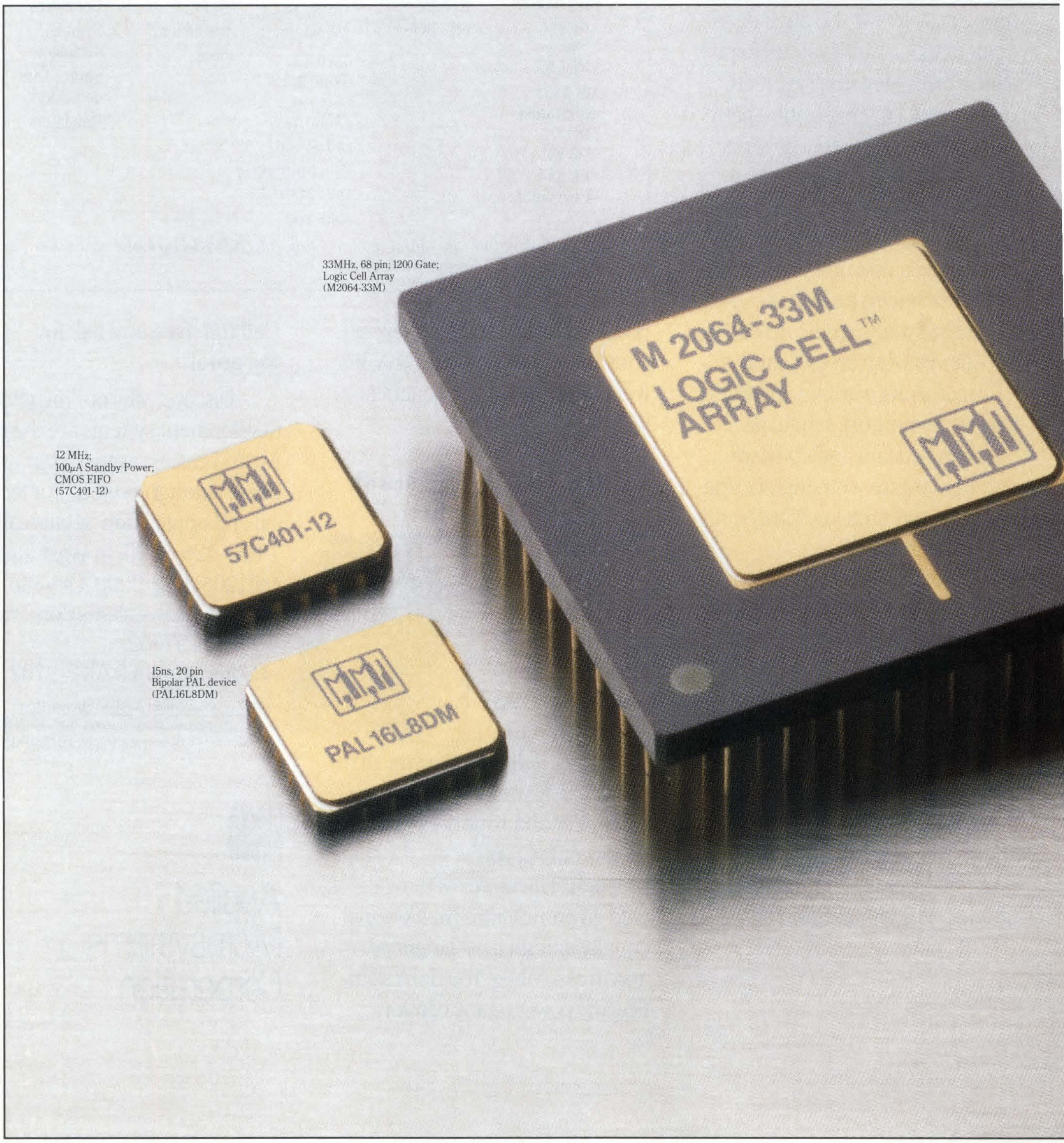
How to outwit the enemy.



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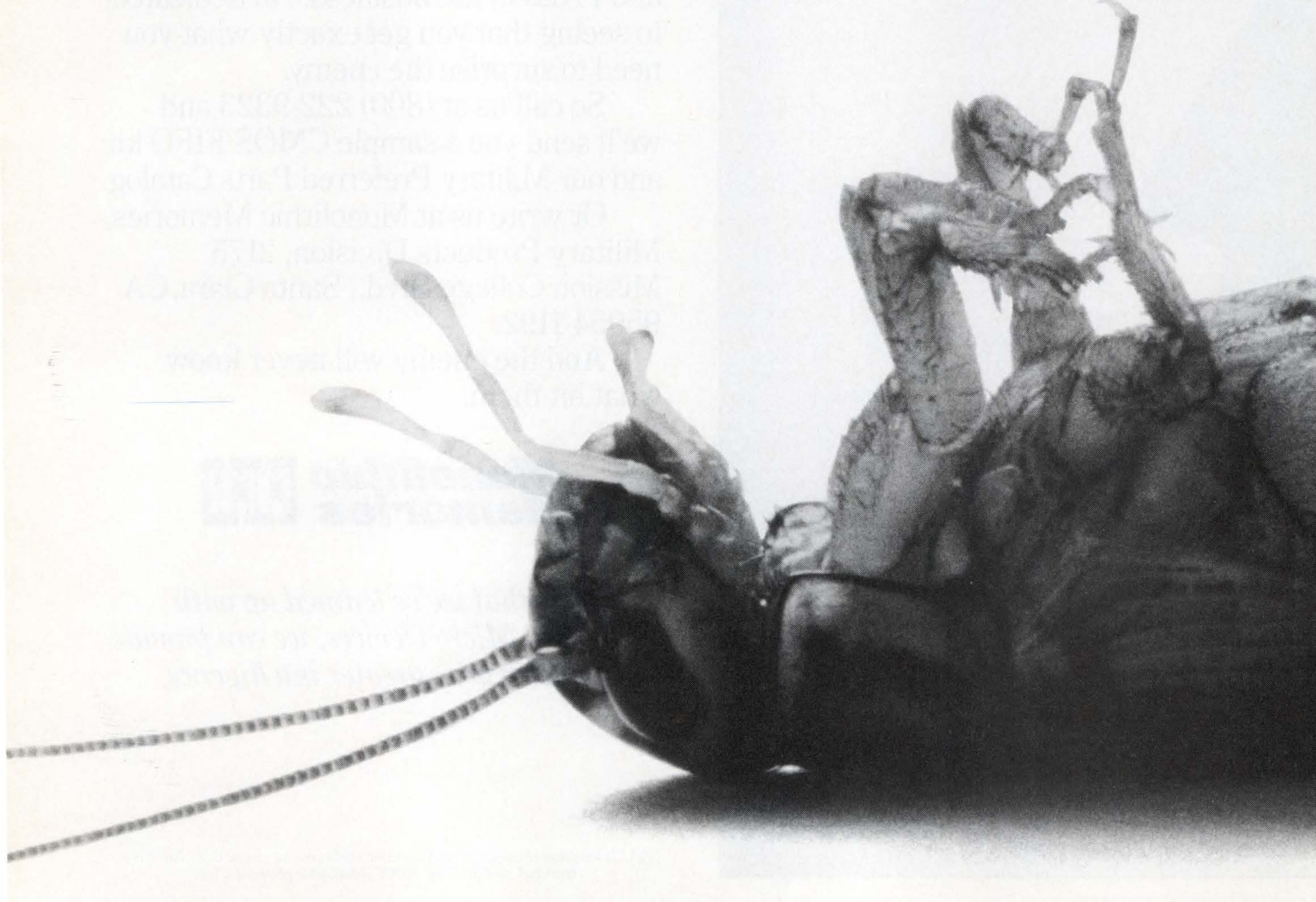

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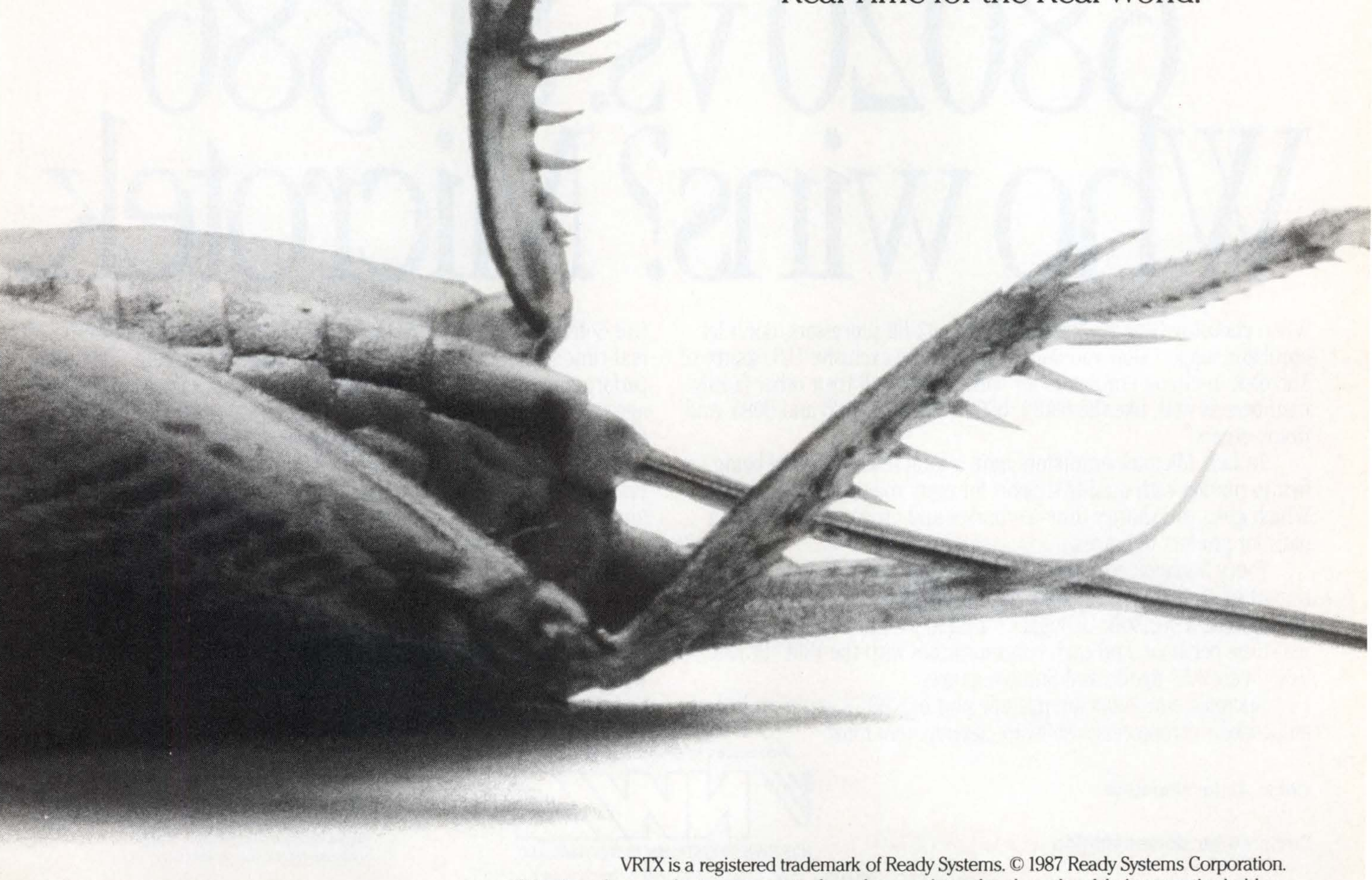

CIRCLE NO 137

NEWS BREAKS

EDITED BY JOAN MORROW

HIGH-SPEED CMOS 8-BIT μC INCLUDES AN ON-CHIP A/D CONVERTER

Motorola (Austin, TX) has upgraded the MC68HC05C4 with the introduction of the MC68HC05B6 μC, which adds an 8-channel A/D converter, two pulse-length-modulation (PLM) systems, 1792 additional bytes of ROM, and eight more bidirectional I/O lines. It also features a serial communications interface (SCI) with separate baud-rate selection for transmitter and receiver, a software-selectable Slow Mode, and a software-programmable external interrupt. This new μC costs $4.90 (OEM qty) and comes with 176 bytes of RAM, 5952 bytes of ROM, and 256 bytes of byte-erasable EEPROM. If you need more EEPROM, you can order an MC68HC805B6, which provides 6k bytes of EEPROM (and no ROM). Or you can select an MC68HC05B4 with 4k bytes of ROM. The MC68HC05B4 sells for $4 (OEM qty), and the MC68HC805B6 is available for $49.50 in limited quantities. For $500 you can order evaluation modules of the MC68HC05B6 for development support.—J D Mosley

COMMUNICATION SYSTEM PROVIDES SPEED AND FLEXIBILITY

Although you have many choices when looking for high-speed digital communication systems, the systems are incompatible, causing you to either buy from one vendor or develop your own hardware. The BPS/128 from Telestream Corp (Mountain View, CA, (415) 968-7977) provides a solution to this problem by giving you a programmable system that can operate on data streams in real time. Parallel-processing elements based on the AMD 29116 allow you to execute up to 160 MIPS on a data stream of 1.28G bps. You can use the BPS/128 on network applications such as protocol and format converters, multiplexers, cross-connect systems, and ISDN gateways. The company offers the BPS/128 with open architecture, allowing you to add your own proprietary hardware. System prices range from $15,000 to $50,000.—Doug Conner

FLOATING-POINT PACKAGE FOR 68HC11 AVAILABLE AT NO COST

With just a telephone call to Motorola Inc's (Phoenix, AZ) computerized bulletin-board system (phone (512) 440-3733), you can obtain the source code for a floating-point arithmetic software package that runs on the company's 68HC11 μC. The package takes slightly more than 2k bytes of code space plus 10 bytes of the μC's page-zero RAM. It performs addition, subtraction, multiplication, division, sine, cosine, and tangent operations. The software package also contains routines that perform conversions between floating-point and ASCII or floating-point and integer numeric representations. Floating-point numbers are represented in a proprietary format composed of a 1-byte exponent, a 3-byte mantissa, and one additional byte for the sign. All routines in the software package place temporary variables on the stack, allowing re-entrant programming.—Steven H Leibson

SURFACE-MOUNT-ASSEMBLY SERVICE MEETS MILITARY STANDARDS

It's hard to find an assembly house with fully automated assembly equipment for commercial surface-mount board designs; your problem is compounded if you're designing for the military environment. SMTEK (Chatsworth, CA, (818) 718-0380) can assemble a board to MIL-Q-9858. The company also offers its own design of a MIL-STD-1750A VHSIC-based computer board, which can be configured for your application; a representative price is $7000.—Margery S Conner

POWER CONVERTER SYSTEM BUILDS LOW-COST, ISOLATED OUTPUTS

By using one power IC to drive multiple output channels, Burr-Brown's (Tucson, AZ) PWS740 distributed, multichannel, isolated dc/dc converter system allows you to incorporate multiple dc output channels into your design with 1500V-ac isolation between channels. Three components comprise the system: the PWS740-1 oscillator/driver, which powers as many as eight channels and operates at 400 kHz; the plastic-encapsulated, trifilar-wound PWS740-2 isolation transformer; and the PWS740-3 high-speed bridge rectifier, which is packaged in an 8-pin DIP. These components cost $12.75, $2.50, and $1.25 (100), respectively. You use one PWS740-2 and one PWS740-3 per output channel. Each output channel can supply as much as 30 mA delivered at the voltage supplied to the PWS740-1's input within a range of 7 to 20V dc.—Steven H Leibson

PC-BOARD LAYOUT PROGRAM ACCOMMODATES 400 ICs, 30 LAYERS

Boasting a component library of more than 2000 TTL, CMOS, and µP components, the Schema-PCB design program from Omation Inc (Richardson, TX, (214) 231-5167 or (800) 553-9119) runs on IBM PC and compatible computers and works in conjunction with the manufacturer's Schema II schematic editor. Using Schema-PCB, you can design boards as large as 32×32 in. with as many as 30 layers.

The program offers 1-mil resolution on placement and tracking, autoplacement, air-gap and connectivity design-rule checking, autorouting with four separate accuracy algorithms, and schematic input and back annotation. You can define track width, pad size and shape, and enter engineering changes at the schematic level. Schema-PCB costs $975; it costs $1500 for both Schema-PCB and Schema II.—J D Mosley

GRAPHICS BOARD FOR MACINTOSH GIVES 1024×768-PIXEL RESOLUTION

If you use Apple's Macintosh II personal computer as an engineering tool, you can enhance its graphics capability with the $2795 ColorBoard 1/104 from RasterOps Corp (Cupertino, CA, (408) 446-4090). It increases the computer's screen resolution to 1024×768 pixels. Based on the company's proprietary ASICs, the single-slot board communicates with the Mac II's 68000 processor over the 32-bit NuBus.—Margery S Conner

ASIC LIBRARY GAINS 6805 CORE CPU

Through its alliance with Motorola Inc, NCR Microelectronics (Fort Collins, CO, (303) 226-9550) has added a 6805 core CPU to its 2-µm VS2000 supercell library (see EDN, September 3, pg 69). The 68C05 library supercell contains just the ALU portion of the 6805 µC, operates at clock speeds to 8 MHz, and executes all of that processor's instructions, including the 8×8-bit unsigned multiply instruction found in only some of the 6805 family of µCs. The CPU features a 16-bit address bus (up from the discrete part's 13 bits) and four uncommitted interrupt lines. Three of these interrupt lines became uncommitted when the discrete µC's timer and communications ports were stripped away to create the CPU core. NRE charges for an ASIC including the 6805 core start at $69,500.—Steven H Leibson

INDUSTRIAL PC BUS BOARDS INTEGRATE MULTIPLE FUNCTIONS

The MacroCard (MC) Series of PC/AT- and 80386-compatible multifunction boards for industrial applications is now available from Texas Microsystems (Houston, TX, (713) 933-1029). The MC-01 board has a SCSI hard-disk-drive controller; you can choose as much as 256k bytes of battery-backed RAM or 512k bytes of EPROM. The MC-02 lets you add as much as 512k bytes of nonvolatile RAM or 1M byte of EPROM. Both boards come with one parallel and one serial communications port, CGA/EGA/Hercules-compatible video outputs, and a floppy-disk controller. Each board plugs into a single PC/AT expansion slot, and pricing starts at $650 (100).—J D Mosley

Flash A/D conversion as easy as

1,2,3,4,5

TRW LSI Products makes it easy to select the high-speed A/D converter that best fits your needs. Our growing family of flash converters offers hybrid and monolithic solutions for your 8- and 9-bit applications.

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TDC1048	Monolithic	8-bits	20MSPS
THC1068	Hybrid	8-bits	25MSPS
TDC1049	Monolithic	9-bits	30MSPS
THC1069	Hybrid	9-bits	30MSPS
TDC1020	Monolithic	10-bits	20MSPS

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LSI Products Division

CIRCLE NO 111

PREVIEW OF SALON DES COMPOSANTS EXHIBITION

Our primary coverage of the Salon des Composants exhibition, which will be held in Paris, France (November 16 to 20), begins on pg 109 in this issue. Some products that will be exhibited at the event, but which arrived too late to include in our primary coverage, are described below.

BiMOS PROCESS PRODUCES SINGLE-CHIP TELEPHONE ICs

By using a BiMOS process to mix analog and digital functions on a single chip, Mietec (Oudenaarde, Belgium, TLX 85739) has developed ICs for use at both ends of telephone lines. Incorporating a DTMF or pulse repertory dialer that supports on-hook dialing, speech circuits that provide 4-wire/2-wire conversion and background noise reduction, plus line impedance matching and load/gain regulation circuitry, the MTC2083 single-chip telephone IC interfaces telephone sets to PSTN or PABX networks. Its speech circuit incorporates an additional receive amplifier that you can use either to drive a loudspeaker or to increase the receiver gain in phones made for people who are hard of hearing. At the PABX or central-office end of the line, the MTC6042 provides a single-chip solution to many of the BORSHT functions of the subscriber line interface. These functions include a high- or low-ohmic-value battery feed, overpower, and 2-wire/4-wire conversion circuitry, and supervisory functions that monitor hookswitch status, ring-trip, and ground-wire conditions. It also has a driver for relay-operated or electronic ringing-signal injection circuitry. In volume, the MTC2083 and MTC6042 are priced at around £1.55 and £3, respectively. The devices will be shown in Hall 3, alley 35, stand 98.

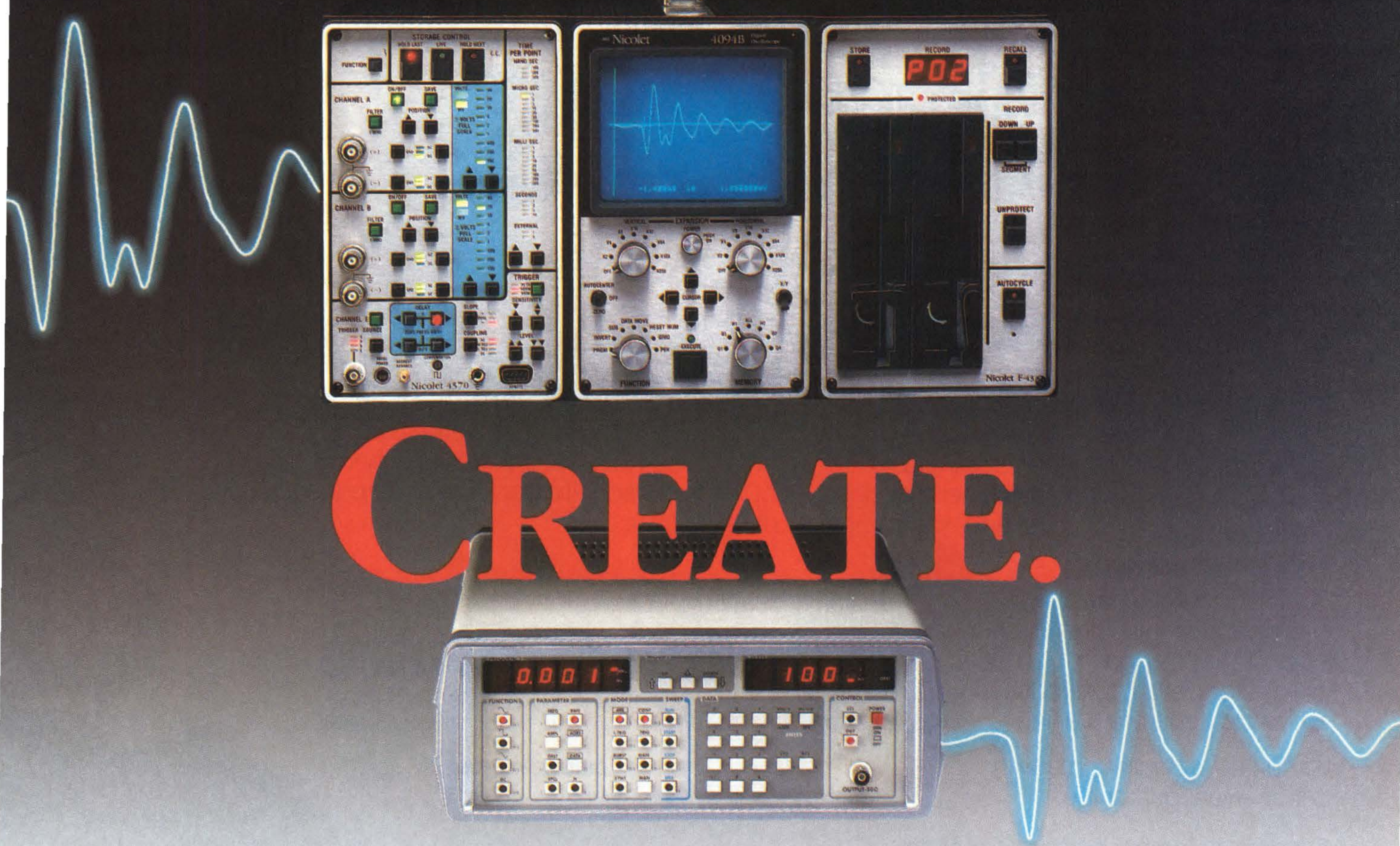
VOICE-CHANNEL SCRAMBLERS INTERFACE TO μP SYSTEMS

You can internally switch the transmit and receive audio pathways in Consumer Microcircuits Ltd's (Witham, UK, TLX 99382; in the US, Mx.Com Inc, Winston-Salem, NC, (919) 7445050) FX-214, -224, and -234 variable split-band voice-scrambler ICs; you can then use them in half-duplex communications systems. Because the scramblers work by splitting the voice band into high- and low-frequency sections and frequency-inverting each section, the ICs also have an on-chip highpass filter to prevent interference from the subaudio frequencies used in continuous-tone-controlled squelch systems (CTCSS). You can program the devices to operate with any one of 32 different split-point/inversion-carrier frequency combinations, allowing you to implement fixed- or rolling-code scramblers. To control operation of the scrambler, the FX214 has a serial interface, the FX224 has a parallel interface, and the FX234 has both parallel and serial interfacing capability. The ICs cost approximately £9 (1000) each; you can see them in Hall 3, alley 34, stand 127.

DEVELOPMENT SYSTEM SUPPORTS THE 68HC11 MICROCOMPUTER

Ashling Microsystems Ltd's (Limerick, Ireland, TLX 70357) CT68HC11 PC-based development system supports software development for the Motorola MC68HC11 8-bit microcomputer. It provides real-time emulation of all three of the microcomputer's operating modes; an integral 70-bit-wide logic state analyzer allows you to trace activity on the microcomputer's address bus, data bus, control lines, and I/O ports. You can set as many as 64k read- and 64k write-address breakpoints, plus elapsed-time and external-signal breakpoints. An integral PROM programmer programs the on-chip EEPROM and configuration register of the 68HC11, and standard or paged EPROMs. The system, which typically costs between $5000 and $6000, includes a full-screen editor, a relocatable macroassembler, and software utilities that interface it with third-party C compilers. Ashling Microsystems will be at Hall 2, alley 21, stand 21.—Peter Harold

CAPTURE.



CREATE.

Stimulate experiments with real-time analog waveforms reproduced from your actual captured data!

Connected via the GPIB interface, the Nicolet Model 4094 digital oscilloscope teamed up with the Nicolet Model 42 arbitrary function generator provides instantaneous waveform storage and generation.

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or 608/273-5008

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Nicolet Digital Oscilloscopes

Incoming signals digitized by Nicolet's high accuracy 12-bit, 10 MHz digitizers or high speed 8-bit digitizers allow you to see things you've never seen before. Zoom expansion to X256 allows you to see the details in waveforms composed of up to 16k points. Cursor readout of measurement values, continuously variable pretrigger positioning, and built-in disk drives all contribute to Nicolet's tradition of measurement power and ease of use.

Nicolet Programmable Function Generators

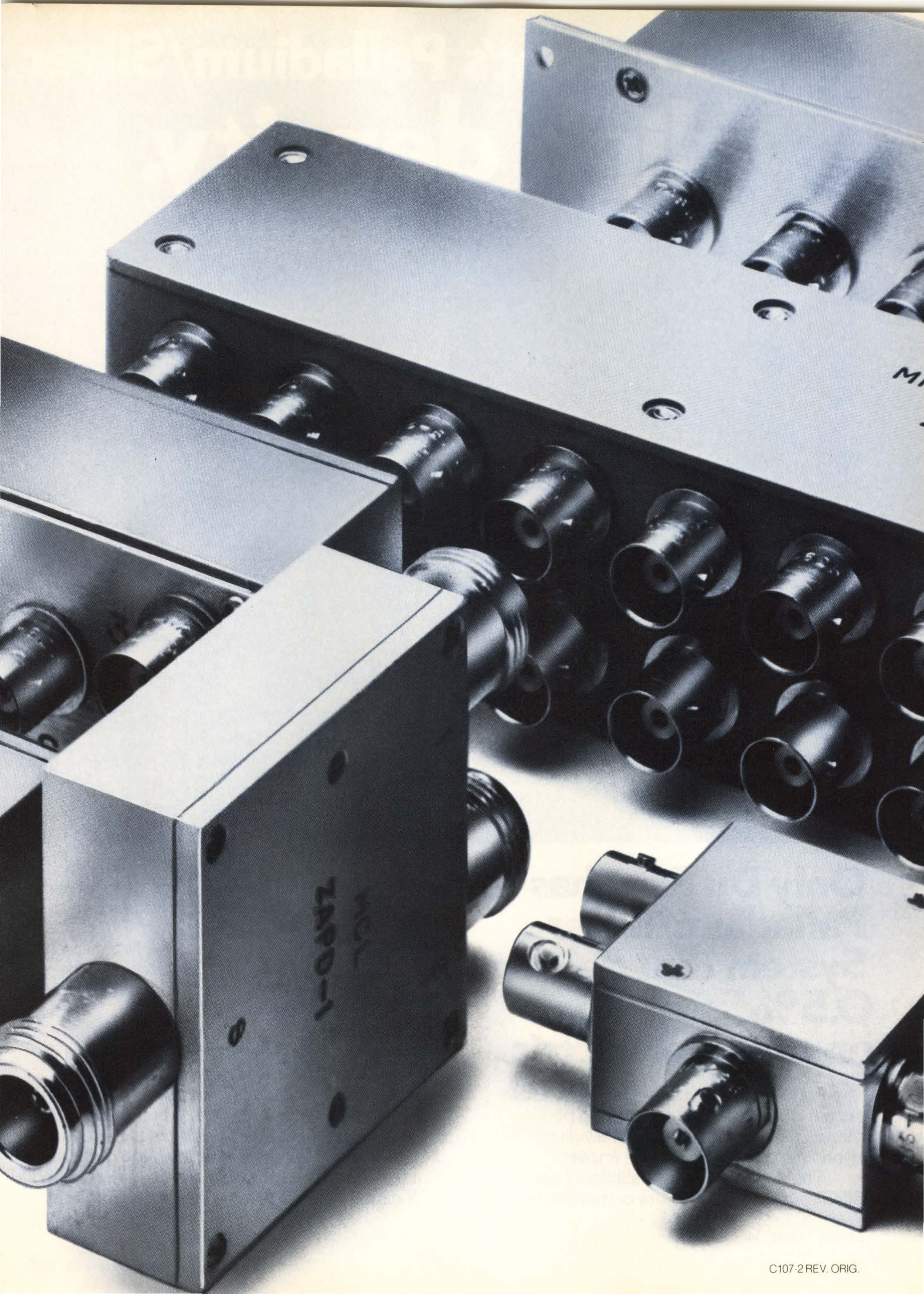
NEW!

Outgoing signals are accurately generated from the 12-bit by 2k arbitrary waveform memory in the Model 42. Real-time duplication of the captured signal can be produced at speeds up to 1 μSec per data point.

Continuous, triggered, gated, and burst output modes are possible. A unique feature, arbitrary sweep, allows you to accurately program the output frequency. Standard waveforms (sine, triangle, square, sawtooth, pulse), 10 mV_{p-p} to $20V_{p-p}$ amplitudes, are all available at speeds up to 4 MHz.

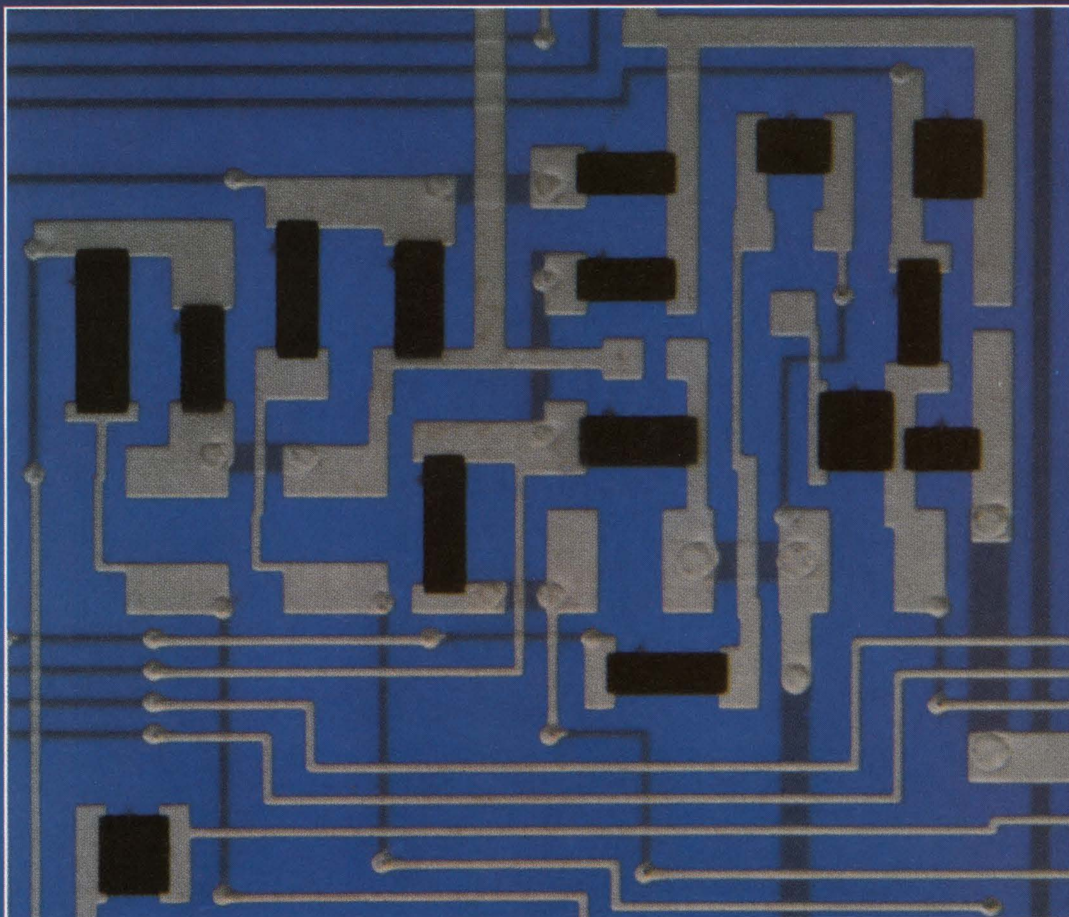
Nicolet
"Instruments of Discovery"

CIRCLE NO 110



C107-2 REV. ORIG.

Du Pont's Palladium/Silver High density.



Only Du Pont has a Palladium/Silver System that delivers 0.5%* stability on top of dielectric.

If you want to free up valuable real estate but are concerned about sacrificing performance, Du Pont's coordinated Palladium/Silver Hybrid Materials System is the answer.

The designed-in compatibility of our BIROX® 1900 Series resistor compositions, 6134 and 6125 Palladium/Silver Conductors and 5704 Dielectric, delivers total system performance, lot after lot, run after run, without "mix and match" problems.

The BIROX 1900 Series thick film resistor compositions are the key. Consistent resistor performance with average end-of-life stabilities of 0.5% or better is just the beginning.

Fireable in a fast 30-minute profile, the resistors make laser trimming over the system dielectric as simple as laser trimming over alumina. Tight, reproducible post-trim distributions with TCRs of 0 ± 100 ppm/°C are a real advantage. And because these resistors are screened onto the 5704 Dielectric surface, you can build up in the Z dimension as well as out in the X and Y directions. This means denser circuits and

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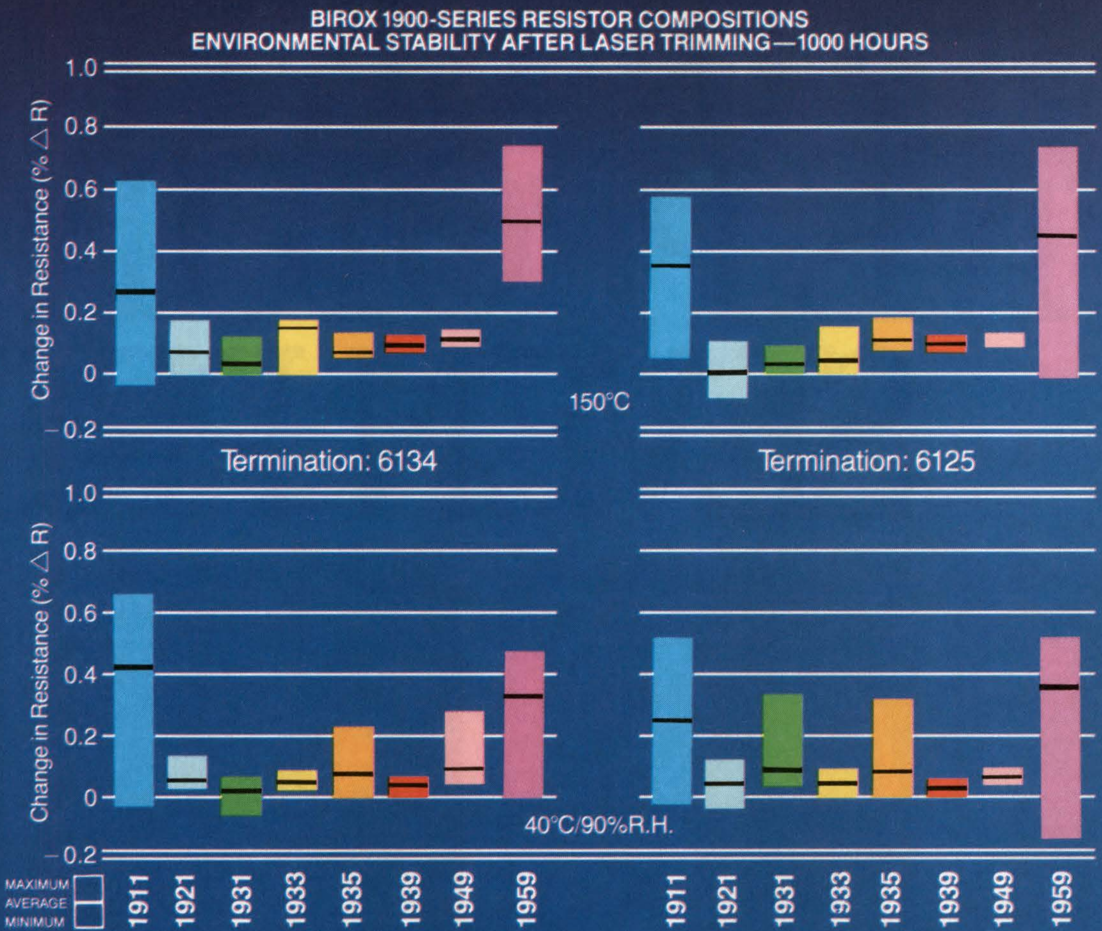
Multilayer System.
High confidence.



greater design freedom.

As for conductor performance, Du Pont's 6134 and 6125 Palladium/Silver Conductors resolve better than 10-mil lines to maximize circuit density while excellent solder wetting and aged adhesion assure high-yield assembly and dependable component attachment.

Du Pont's 5704 Dielectric completes the system. Circuit performance benefits from its low K (9–10). And with the TCE matched to alumina, substrate bowing is minimized even through multiple firings. 5704 prints at 6 in/sec for high productivity and resolves 8- to 10-mil vias for increased density.

The combination of superior product performance and Du Pont's commitment to manufacturing quality delivers a Palladium/Silver Hybrid Materials System with high density and high confidence.

To learn how Du Pont's Palladium/Silver Hybrid Materials System can solve your packaging problems, call 1 800 441-7543. Or write: Du Pont Company, Electronic Materials Division, Room X50533, Wilmington, Delaware 19801.

*Typical average stability after 1,000 hours on a trimmed 40 mil × 40 mil resistor.

DU PONT
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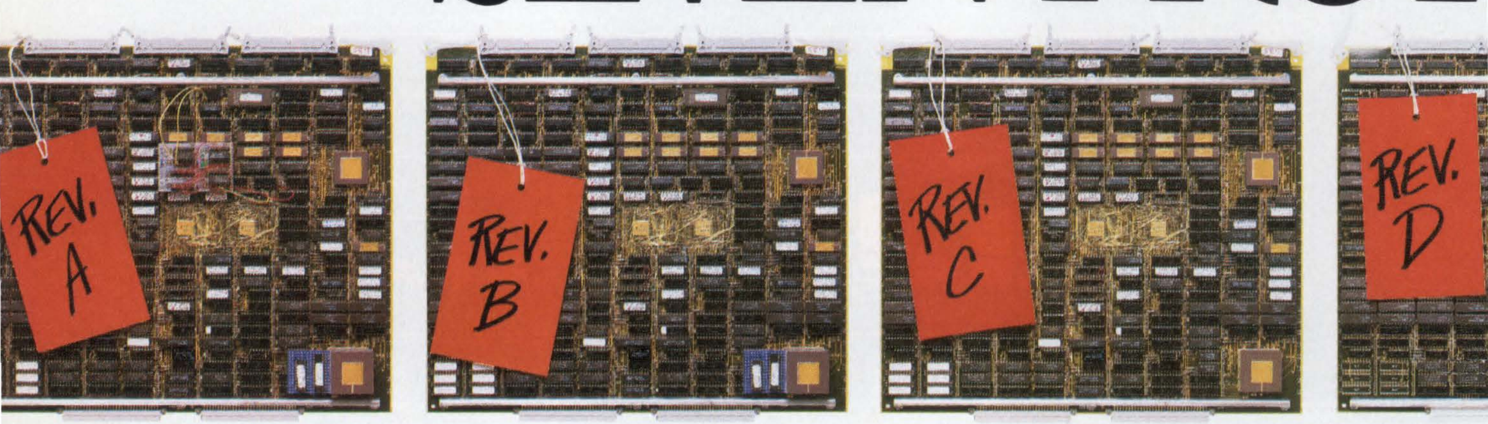
ONE PROTOTYPE
THREE PRO
FIVE PROTOTYP
SEVEN PROT



Teradyne's new CAE tools help you get to market faster by

Designing VLSI circuit boards that work the first time isn't child's play. You can't do it without fast, accurate feedback on design and test quality.

Now count on Teradyne to help. With our new family of CAE products, you'll uncover flaws before they're cast in hardware. So you'll be able to jump from initial design directly to final prototype. And from design to manufacturing test.

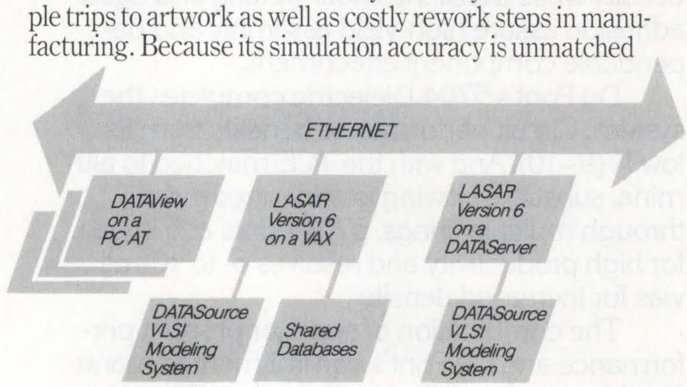
Start with a firm design foundation.

The process starts with DATAView our new design entry system. Running it on a standard AT-class PC, you can control the whole design process right at your desk. From schematic entry and waveform analysis on the PC to simulation and fault simulation on more powerful networked computers. All with the same mouse-and-menus, multiple-window interface.

You move from schematic capture to simulation effortlessly. DATAView's links with our LASAR Version 6 simulation system save hours of model compilation time. Incremental compiling lets you revise a design and resimulate in minutes.

Make your design work together before it comes together.

LASAR Version 6 is the only sure way to avoid multiple trips to artwork as well as costly rework steps in manufacturing. Because its simulation accuracy is unmatched



Teradyne networks advanced CAE tools for convenience *and* performance.

TWO PROTOTYPE,
TYPE FOUR
SIX PROTOTYPE,
TYPE, MORE.

giving you a working prototype the first time.

for analyzing PC board designs prior to prototyping. For instance, LASAR takes full device timing specifications into account for true worst-case timing analysis. And it eliminates shared timing ambiguity in reconverging signals. Both of which mean LASAR finds real design errors reliably.

Finally, you can use LASAR fault simulation. It will uncover testability problems and untested circuit functions before it's too late.

Simulation without trial and tribulation.

LASAR also takes care of the board modeling problem. It includes models of over 4000 devices. And the most popular gate array libraries.

For new VLSI parts, our DATASource hardware modeling system uses actual devices instead of software models. A single system supports multiple users and concurrent fault simulation. With extraordinarily fast response.

LASAR and DATASource work with any VAX. For simulations up to 25 times faster, you can use our new parallel/multiprocessing host, DATAServer. It will give you quick results, with full LASAR precision.

Teradyne makes it easy.

If you want to avoid multiple prototypes and get to market faster with better products, Teradyne's new CAE system is the way. Why not call Daryl Layzer at (617) 482-2700, ext. 2808 for more information. Or write Teradyne, 321 Harrison Avenue, Boston, MA 02118.

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CIRCLE NO 132

SIGNALS & NOISE

Poor business practice is biggest US export obstacle

In his editorial entitled "Loosen export restrictions" (EDN, June 25, pg 59), Jon Titus stated that US export regulations are the main obstacle to US export.

The regulations are a barrier for sure, but there are some much bigger problems with shopping in the US. Here are a few examples from the point of view of a Swiss electronics company:

1. When I buy 1000 RAMs in the US, I get (with luck) 990 good parts. When I buy 1000 RAMs in Japan or Europe, I get 1000 good parts. Companies in Japan and Europe have a zero-reject, zero-defect philosophy.

2. US salesmen don't speak any language other than English. Can they do sales promotion in English in Switzerland or France? Further, they don't know how non-US customs works, nor are they informed about shipping. They send me a 1-kg package by air freight collect, although prepaid air parcel is six times cheaper and much faster, and it passes customs control without paperwork for the customer.

"I WOULDN'T BE CONCERNED, FRANK. THE ROBOT WON'T GET FAR."

3. It takes US companies weeks—not days—to respond to a telex or fax request. Using the phone is sometimes not possible because of the 6- to 11-hour time difference (I leave the office when they start working). Even bigger companies have no telex or fax capability.

4. It takes a US bank four to eight weeks to validate a non-US banker's check. In Europe, the same procedure takes one to two working days.

5. US companies almost never confirm orders in a reasonable amount of time, and they take a few days or even a few weeks to answer a quotation request. Why isn't the procedure instant? Is the Pentagon the only US organization that has a computer?

6. Ordering goods and equipment in metric units creates confusion in US sales offices. Why does a US company send me an aircraft altimeter calibrated in inches mercury

SMT STANDARDS.

4SW-6127R2

SPRAGUE TANTALUMS SET SURFACE MOUNT STANDARDS.

Sprague Type 195D and 293D solid tantalum chips meet the brand new EIA size and packaging standards for surface mount capacitors. These miniature components fill your surface mount needs with economy, reliability and high performance. Conformal-coated Type 195D TANTAMOUNT® capacitors meet EIA specifications for Extended Capacitance Range devices. These units feature gold or solder plated terminals and the highest capacitance in the smallest packages available in the industry. Rugged, fully molded Type 293D TANTAMOUNT® capacitors conform to EIA specifications Standard Capacitance Range devices. These "machine-friendly" tantalum chips are compatible with all automatic placement equipment. Both types are supplied taped and reeled per EIA 481A. Standard ratings: 0.10 to 100μF, 4 to 50 WVDC. *Sprague Electric Company, Lexington, MA.* For "Quick Guide To Tantalum Chip Capacitors", ASP-642, write to Marketing Communications, Sprague Electric Company, P.O. Box 9102, Mansfield, MA 02048-9102. For applications assistance, call our Customer Service Center at Concord, NH at 603/224-1961.

CIRCLE NO 131

SPRAGUE
THE MARK OF RELIABILITY

when I ordered it in hectopascals?

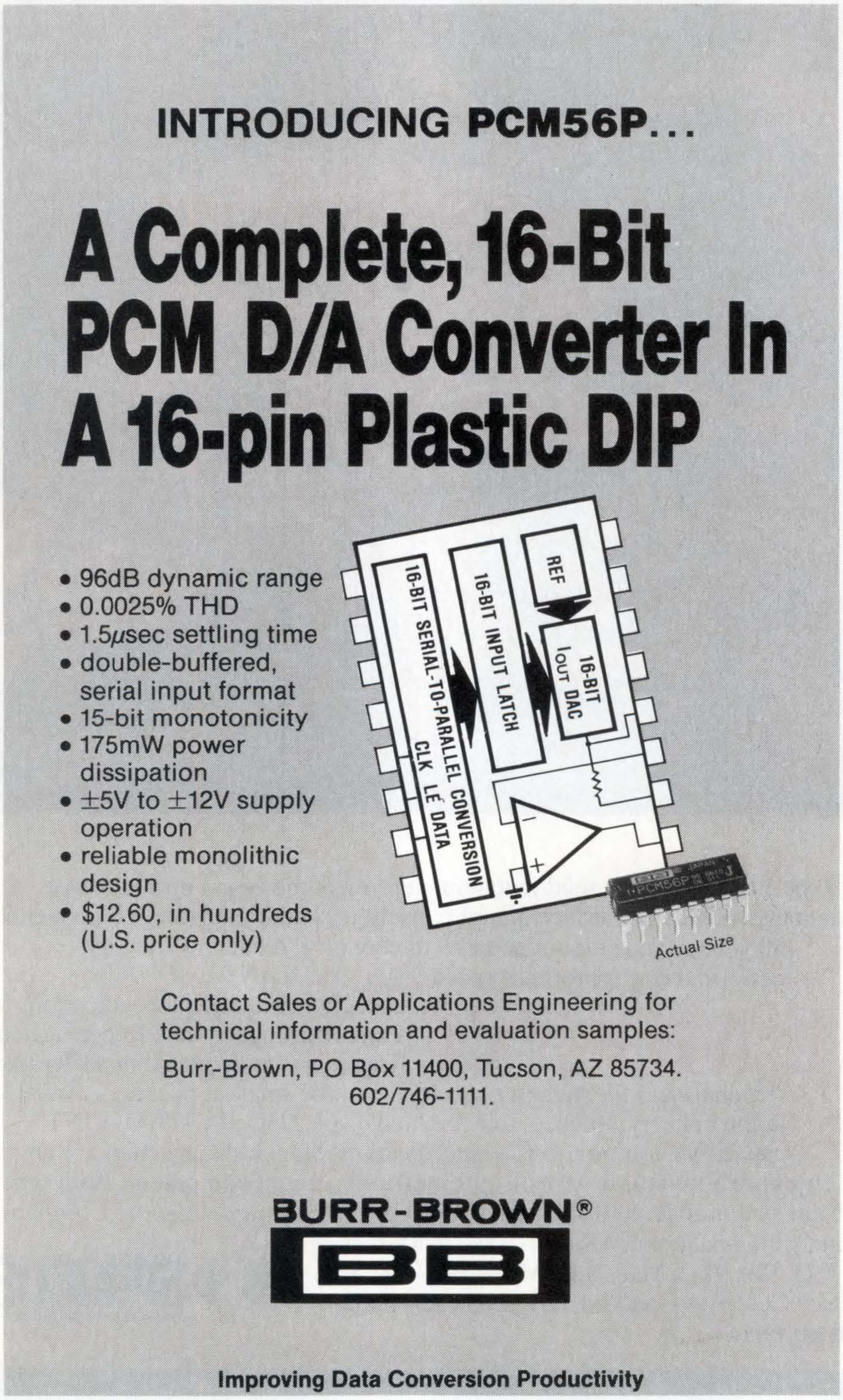
7. Export works quite well from such historical trade centers as New York and Boston, but as soon as you go a few miles from the coast, things get worse. Some companies have no export experience.

I buy in the States, but only if I have to. It's difficult to deal with the average US company, not mainly because of export licenses, as Jon Titus states, but because of the above-mentioned communication, education, and service problems.

We in Europe, and others too, would have considerable problems in the world markets if the US had the same power in export that it has in its inland market.

Perhaps Mr Titus could entitle his next export article "Loosen export potential."

Chris Moser
Mostec Inc
Liestal, Switzerland



Company doesn't require minimum orders

The May 28 issue of EDN contained an excellent technology update by Chris Everett ("Smaller, cheaper silicon pressure sensors are starting to appear on vendors' shelves," pg 83). Chris is knowledgeable in the field and the update was an excellent review of the area.

The piece did contain an error, however—it indicated that NovaSensor would not accept orders for quantities smaller than 10,000 pieces. This is incorrect. The statement apparently comes from a product release on our silicon sensor die-level product. For these die-level sensors, our minimum is indeed 10,000 pieces, although occasionally we have taken smaller orders.

However, NovaSensor has a full line of sensors and microstructures. None of these other products has a minimum requirement.

Joseph R Mallon Jr
NovaSensor
Fremont, CA

Product notes

Please note these changes to the Hardware and Interconnect section of EDN's July 9 Product Showcase. First, the LSI Microseries Model 13/23K optical encoder (from Litton/Itek Encoder) described on pg 222 and 224 costs $1650, *not* $16.50. Second, the Recortec rack enclosure described on pg 222 as the KBD-100 is actually called the RME-100.

WRITE IN

Send you letters to the Signals and Noise Editor, 275 Washington St, Newton, MA 02158. We welcome all comments, pro or con. All letters must be signed, but we will withhold your name upon request. We reserve the right to edit letters for space and clarity.

TEXAS INSTRUMENTS REPORTS ON

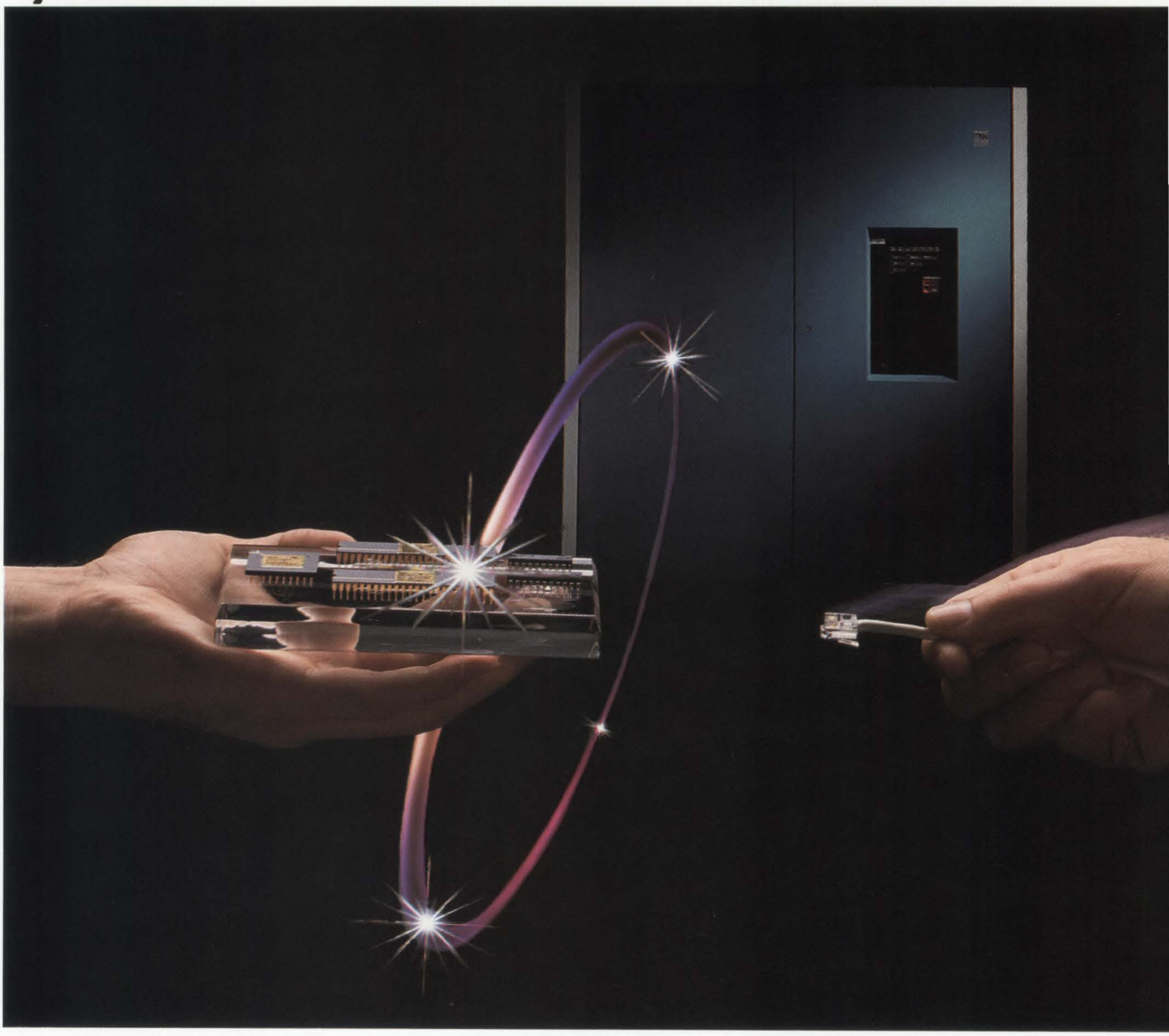
NETWORKING

IN THE ERA OF

MegaChip□ TECHNOLOGIES

Networking in the Era of MegaChip Technologies:

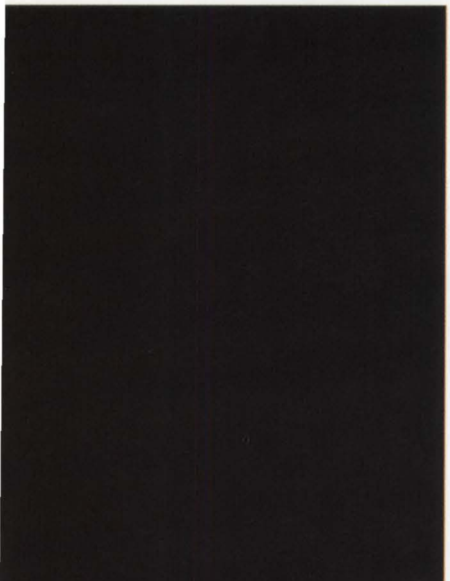
When connecting to the
you need to connect with



Only the TMS380 Chip Set from Texas Instruments is tested and verified with IBM. That frees you to concentrate on the important business of making your products market winners.

Industry observers agree: The IBM® Token-Ring Network is capturing a lion's share of the LAN (local-area network) market. As stated by IBM in their October 15, 1985, product announcement, the IBM Token-Ring Network is "an 'open' network architecture for accommodation of non-IBM and IBM attaching devices . . . with semiconductor components available

IBM Token-Ring, Texas Instruments first.



from Texas Instruments." All you need to capitalize on the growing demand for products that will operate on the ring is to design with TI's TMS380 Chip Set.

"We use TI's TMS380 Chip Set and TI's implementation of IEEE 802.2 LLC protocols to ensure IBM compatibility at media-access and software levels." That is Howard S. Charney, senior vice president of 3Com Corporation, stating the chief reason for turning to TI first when designing-in token ring connectivity. You know your TMS380-based product will be 100% compatible with IBM and industry standards.

As a result, you avoid any problems of validation, verification, or long development time. You gain time to add product enhancements that can mean a competitive edge in the marketplace.

Martin Sinnott, director, Dayton Development Center of the NCR Corporation, sums up the advantage this way: "We offer the very highest level of interoperability with the IBM Token-Ring Network via TI's TMS380 Chip Set and our own software."

An integrated solution for "open" systems

TI's TMS380 Chip Set begins with a 40-million-bits-per-second DMA interface. This provides efficient connection to high-speed microprocessors such as Intel's 80X86 and Motorola's 680X0 families and open-system buses like IBM's Micro Channel™ and Apple's NuBus™.

Having built-in software jointly copyrighted by IBM and TI, the TMS380 provides all IEEE 802.5 media-access control processing, including on-board network-management services *(see box).* In addition, the TMS380 provides capability for message-buffer expansion and higher layer protocols, such as IBM-compatible IEEE 802.2 Logical Link Control (LLC), available from TI.

The TMS380 completes your connection to the IBM Token-Ring with physical-layer interface circuits that provide clocking, data reception and transmission, and ring-insertion control.

Opening the way to internetworking the TMS380 facilitates the design of token ring bridge and gateway products.

Good news about cost

Another reason to choose the TMS380 is that the cost of connectivity is coming down. The chip set is available now at a suggested resale price under $100.00 (quantity 100).

The TMS380 reflects the influence of TI's MegaChip™ Technologies. These are the skills and disciplines acquired through ongoing development of high-density circuits which generate advances in semiconductor design, processing, manufacturing, and service.

These technologies are having an effect on other LAN standards. For example, TI has developed the SN75061/62 single-channel drivers/receivers that can easily be configured for use with StarLAN IEEE 802.3 1BASE5 networks. These new devices perform data transmission/reception and minimize transmission-line noise. The SN75061 is ideally suited to 1BASE5 stations; the lower-power, lower-cost SN75062, to hubs.

For more information on the broad TMS380 support, turn the page.

Reliable network management

"We have designed our ProNET®-4 product using the industry-standard TI TMS380 Chip Set. In addition to normal data-communications functions, the chip set provides power-up self-test as well as network-management frames for automatic error detection, parameter services, and reconfigurations. The net effect is reliable, manageable network operation."

Howard Salwen,
Chairman and Founder, Proteon, Inc.

Comprehensive support from TI speeds TMS380 design-in.

To help you with everything from token ring adapter-card prototyping through communications-protocol development and systems integration, TI makes available the comprehensive TMS380 Development Products Family.

Design-in Accelerator Kit includes hardware and debug software for completing a prototype token ring adapter: Three sample TMS380 chip sets, engineering debug software with User's Guide, and an interconnect schematic.

PC Adapter Card helps you develop software and analyze traffic on the IBM Token-Ring Network. It works in both the PC Family and PC AT compatibles and incorporates TI's new IEEE 802.2 LLC. The card comes with demonstration software as well as protocol-analysis software to help develop your communications protocol.

Test Wiring Concentrator (TWC) provides the mechanism for any station to be inserted on the ring and adds LEDs that indicate ring insertion.

TMS380 LLC EvaluationKit provides the hardware, software, and documentation required to evaluate the IBM-compatible IEEE 802.2 LLC software on your designs.

ASIC-LAN Tool Kit enables the fast development of highly integrated, differentiated, and compact adapters. The kit contains ASIC software macro building blocks and completed design examples. These support Adapter Memory Expansion and PC Bus Interface. The kit not only helps save board space, but also several months of system and hardware design.

TMS380 Bridge Design Kit contains one TMS38021 Bridging Protocol Handler, one set of Bridge Options Adapter Software, and a TMS38021 Bridge Application Report to help you develop bridge or gateway products.

Token Ring Seminars are conducted on request at TI Regional Technology Centers or at your site. A two-day workshop includes an introduction to the TMS380 Chip Set and hands-on experience in the lab. A one-day TMS380 Advanced Topics Workshop provides an understanding of the extended LLC interface on the TMS380 and provides insight into bridge applications.

For more information on TI's TMS380 Chip Set, call TI's hot-line number, **(713) 274-2380.** Or complete and return the coupon today to Texas Instruments Incorporated, P.O. Box 809066, Dallas, Texas 75380-9066.

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Dallas, Texas 75380-9066

YES, please send me information on TI's networking products and services.

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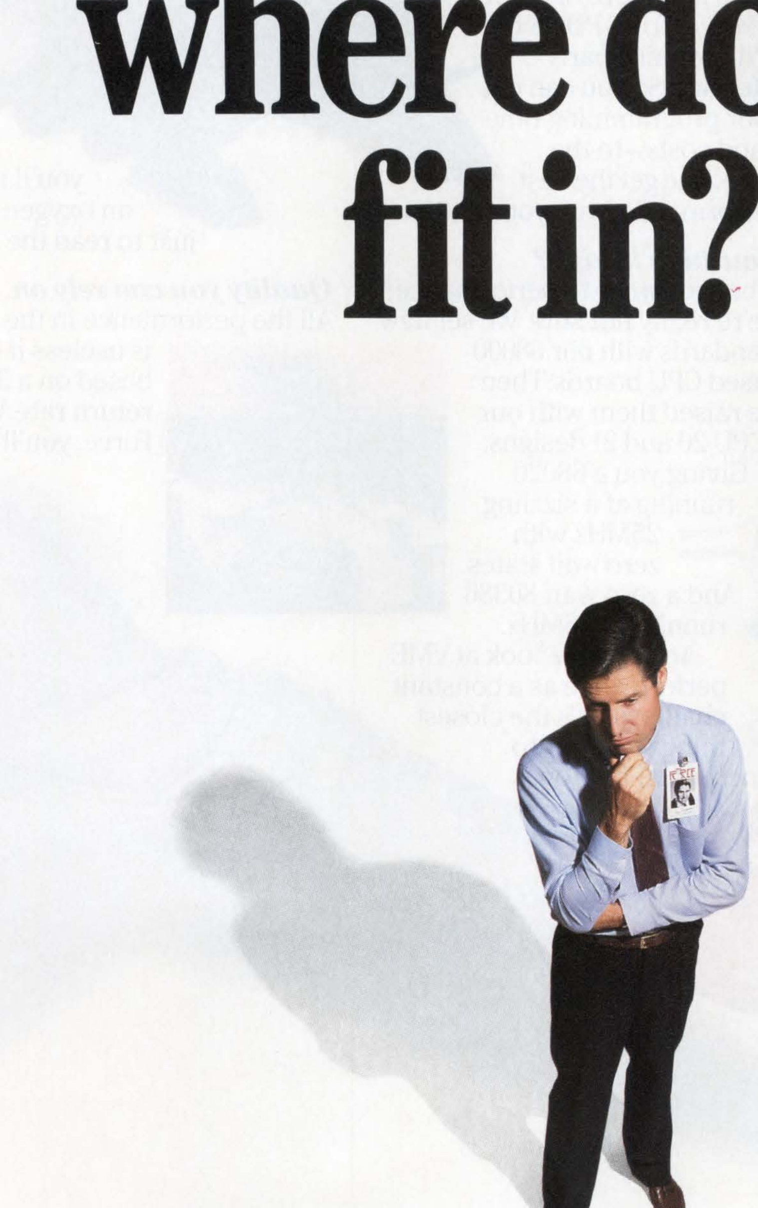
27-4512

TEXAS INSTRUMENTS

CIRCLE NO 149 for general purpose op amp information **CIRCLE NO 188** for low offset op amp information

In the grand design of VME, where do we fit in?



performance that lasts. Because our standards are based on NATO guidelines. And our Q/A policies are merciless. Every board is 100% in-circuit tested. Then 100% functional tested. And, as if that's not enough, they're put through 100% dynamic burn-in. No wonder our return rate is less than 0.9%. And dropping fast.

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Fed up with the 30-day promise and 90-day wait? Get your boards from Force and you'll have them in your racks in 30 days. Period. Nobody gives you better on-time delivery. Period.

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CALENDAR

Designing Signal Processors with DSP and Bit-Slice Chips (short course), Washington, DC. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. November 3 to 6.

Hands-On Microprocessor Software, Hardware, and Interfacing (short course), Los Angeles, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. November 3 to 6.

Troubleshooting Microprocessor-Based Equipment and Digital Devices, Atlanta, GA. Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032. (800) 247-5239; in KS, (913) 898-4695. November 10 to 13.

Advanced SMT Design Techniques (short course), San Jose, CA. Surface Mount Technology Plus, 1786 Technology Dr, San Jose, CA 95110. (408) 943-0196. November 16 to 17.

Designing Signal Processors with DSP and Bit-Slice Chips (short course), Anaheim, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. November 17 to 20.

Troubleshooting Microprocessor-Based Equipment and Digital Devices, Norfolk, VA. Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032. (800) 247-5239; in KS, (913) 898-4695. November 17 to 20.

9th Interservice/Industry Training Systems Conference, Washington, DC. Ralph Nelson, ADPA, Rosslyn Center, Suite 900, 1700 N Moore St, Arlington, VA 22209. (703) 522-1820. November 30 to December 2.

Hands-On Graphics Programming Using GKS/VDI Tools, Washington, DC. Integrated Computer Systems, Box 3614, Culver City, CA

CALENDAR

90231. (800) 421-8166; in CA, (213) 417-8888. December 1 to 4.

Troubleshooting Microprocessor-Based Equipment and Digital Devices, Oklahoma City, OK. Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032. (800) 247-5239; in KS, (913) 898-4695. December 1 to 4.

IEEE International Electron Device Meeting (IEDM), Washington, DC. Courtesy Associates, 655 15th St NW, Suite 300, Washington, DC 20005. (202) 347-5900. December 6 to 9.

Lasers '87, Lake Tahoe, NV. Society for Optical and Quantum Electronics, Box 245, McLean, VA 22101. (703) 642-5835. December 7 to 11.

Hands-On Graphics Programming Using GKS/VDI Tools, Los Angeles, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. December 8 to 11.

Microcomputer Graphics Conference, New York, NY. Expoconsul International, 3 Independence Way, Princeton, NJ 08540. (609) 987-9400. December 16 to 18.

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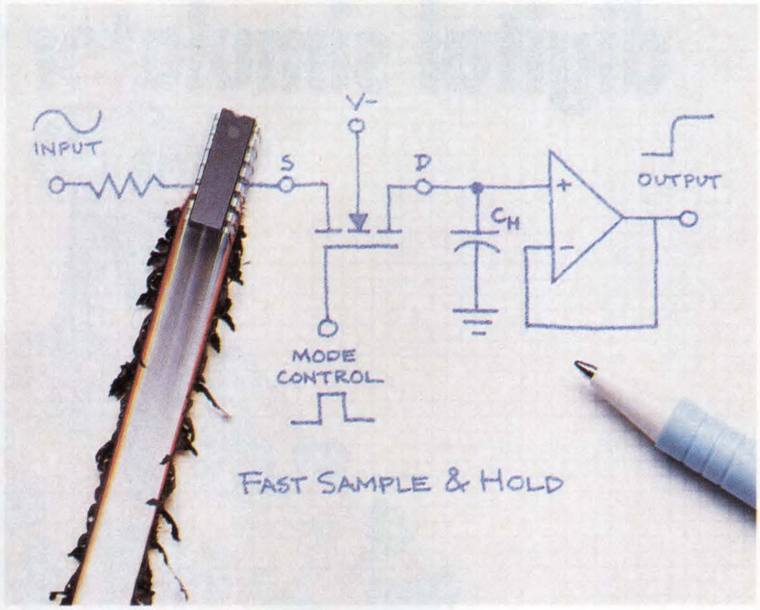

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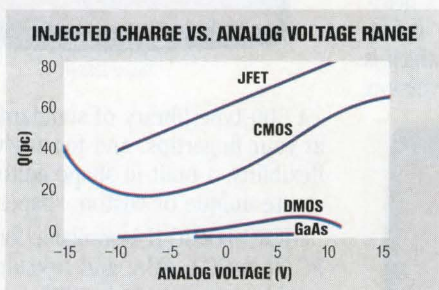

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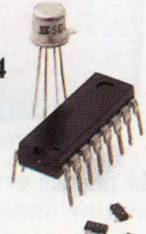

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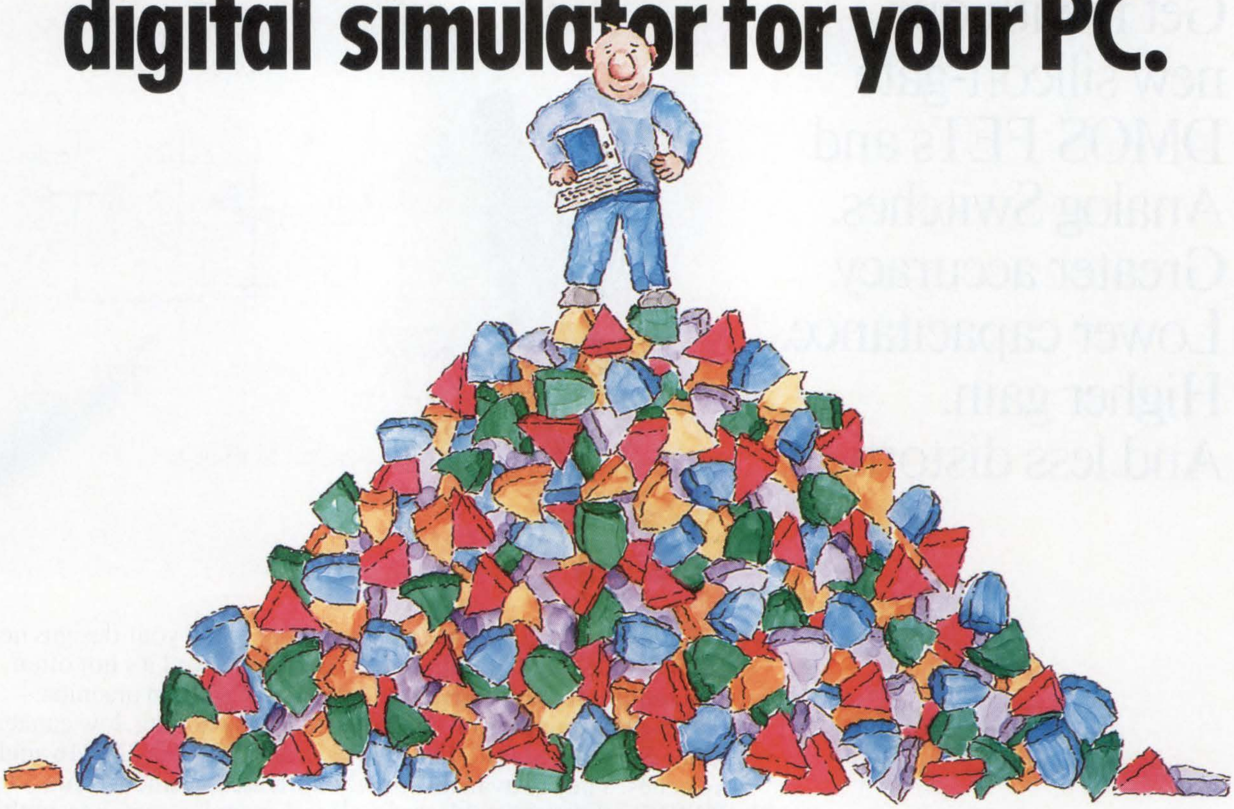

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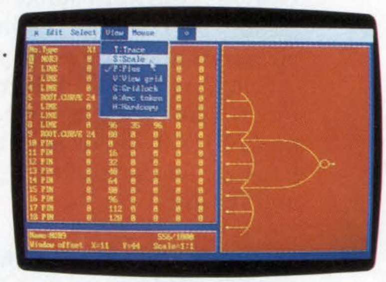

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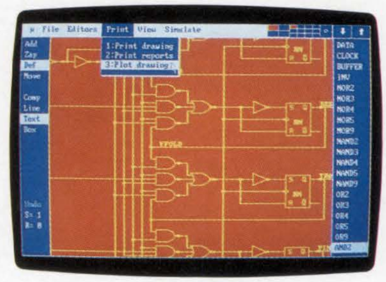

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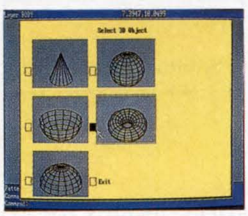
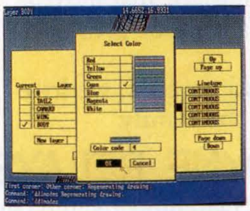


Icon menus.

When you wish to select 3-D objects, text fonts, or hatch patterns, for example, you can pick them from an icon menu that appears on the screen. You can do the same thing with objects you create on your own. Icon menus make it easier and faster to choose the option you want.



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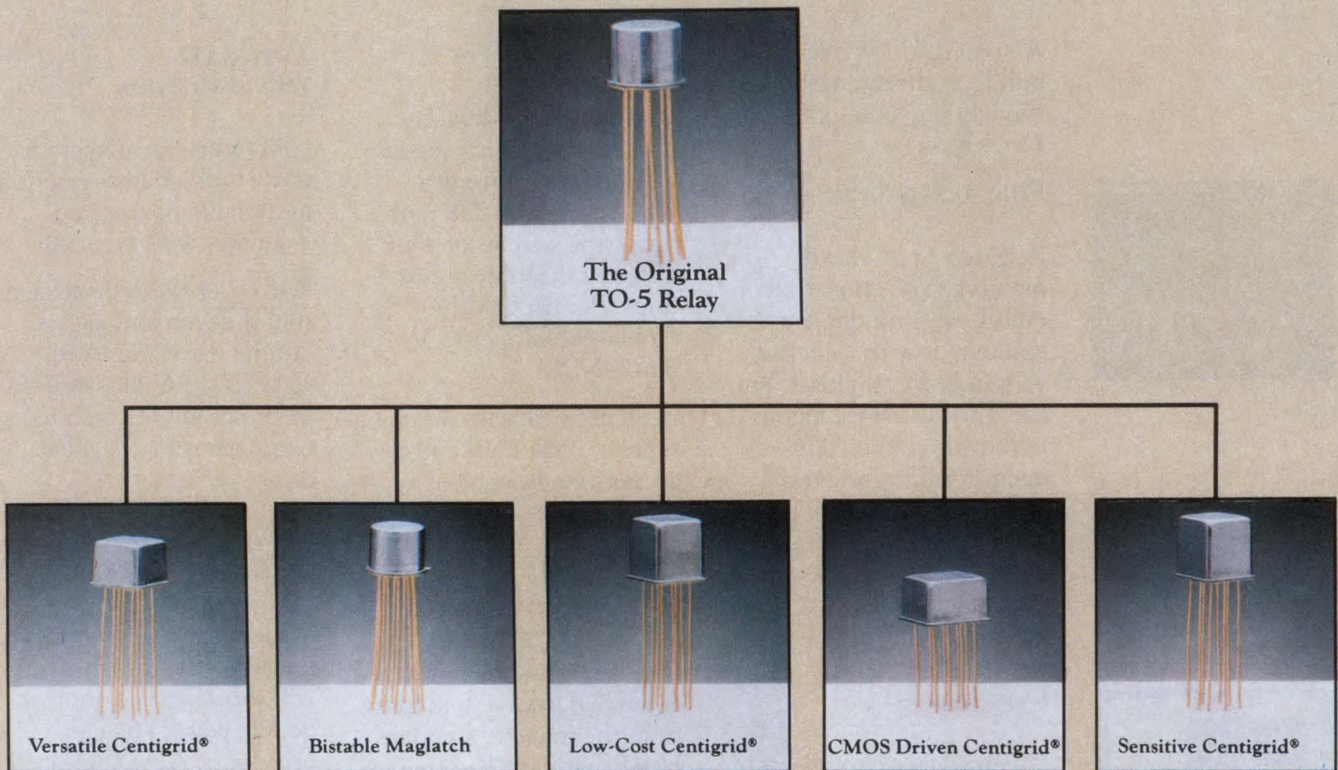

We designed the original TO-5 relay over 20 years ago. But that was just the beginning. Since those first days, we nudged it into fathering a family of adaptations and extensions along the way.

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PUBLISHED BY **ILC DATA DEVICE CORPORATION** OCTOBER 1987

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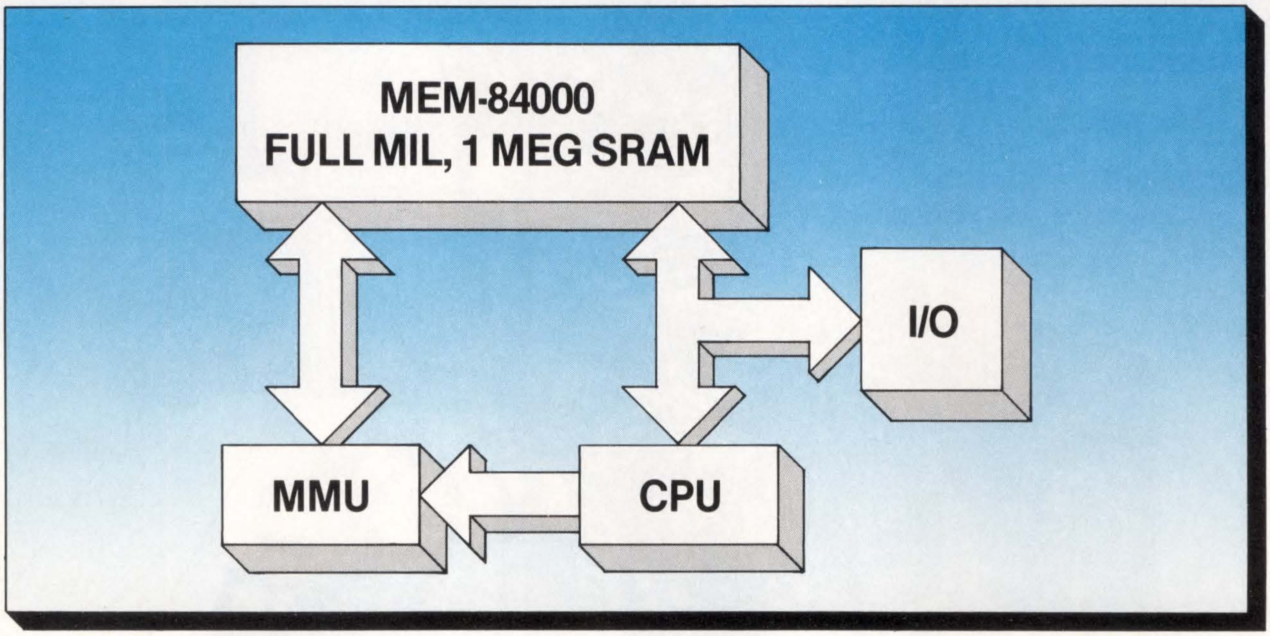

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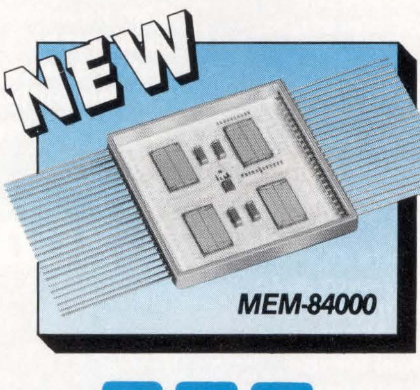

With its small size, high performance, wide operating temperature range and screening to MIL-STD-883, the MEM-84000 1 megabit memory hybrid is well-suited for use in the most demanding military applications.

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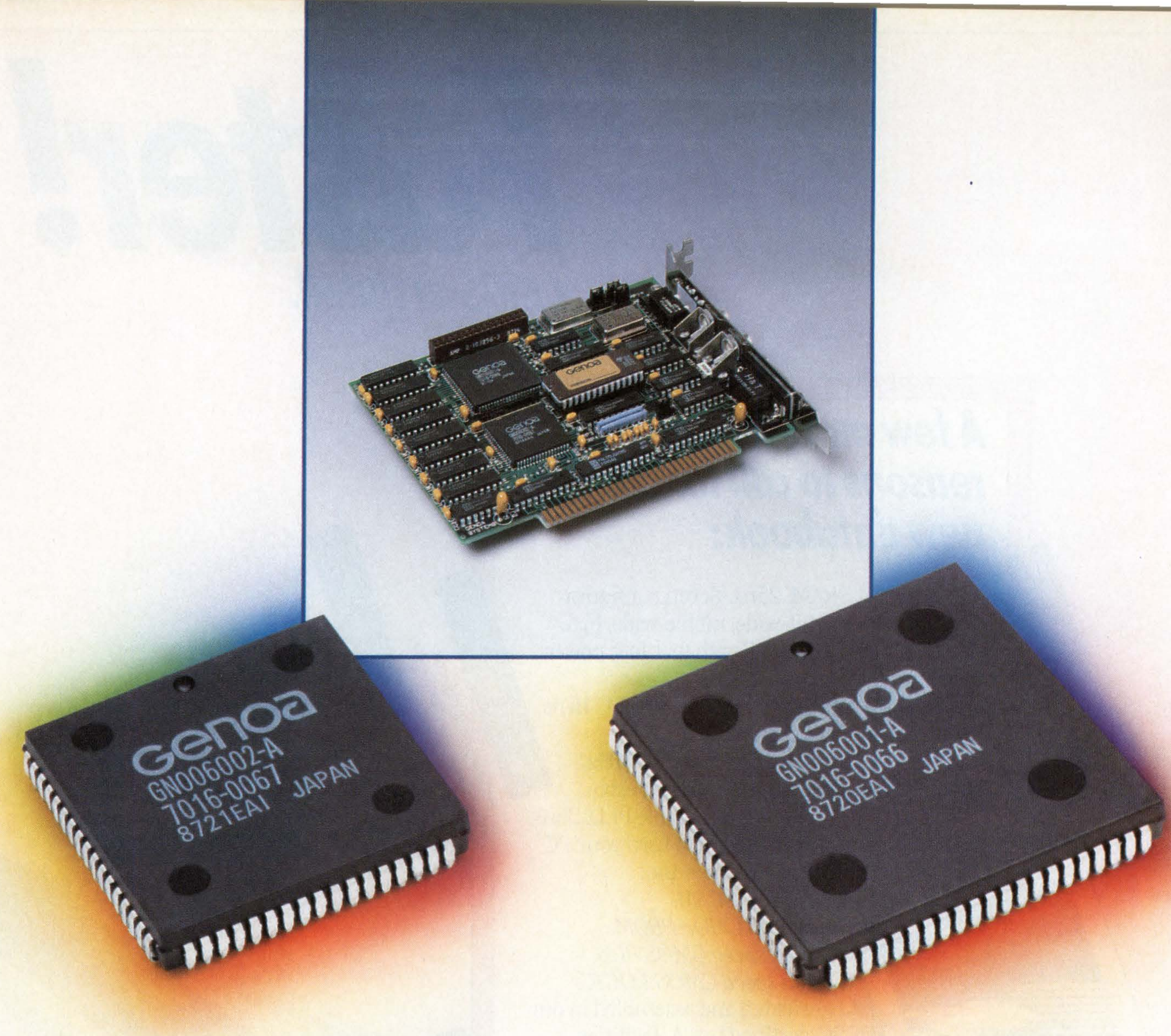

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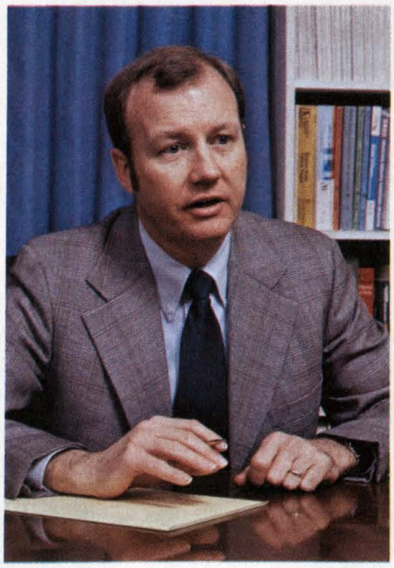
EDITORIAL

DAT's the way it is



***Washington, DC, October 1, 1990**—The House Subcommittee on Commerce, Consumer Protection, and Competitiveness voted today to ban digital backup cassette tapes and floppy disks. "By adding such devices to the 1987 Digital Audio Recorder Act, the committee has taken an important step toward preserving intellectual-property rights," stated a committee spokesman. "People are abusing these devices, copying and distributing computer programs at will. Programmers deserve protection," he added.*

Although the scene above is fanciful, such action isn't out of line with Congress's current mood. In fact, Congress may act soon—if it hasn't already—to ban digital audio tape (DAT) recorders. Supporters of the 1987 Digital Audio Recorder Act argue that such a measure is necessary to prevent unauthorized copying of compact-disk (CD) recordings. Under the terms of the pending bill, DAT recorders couldn't be sold during the next year unless they included a copy-prevention circuit that would make it impossible to accurately reproduce CD-quality sound on a DAT.

It's difficult to ban or restrict technology. When audio cassettes became available, there were similar arguments about illegal copying of long-playing records. Likewise, when VCRs became readily available, there were futile attempts to regulate the industry. Luckily, reason and the consumer prevailed. Support for prohibitions waned as movie and record companies saw new markets for their products. These days, few people go to the trouble of recording music when it's available on an inexpensive tape.

Just suppose that someone had proposed a ban on floppy disks in the early 70s. Proponents of such a ban could have argued that floppy disks would let people quickly copy and bootleg programs that were previously available on large rolls of punched paper tape or on punched cards. But because there was no mass market for such media and no powerful computer companies or lobbyists were involved, technology carried the day. In fact, the availability of inexpensive disks helped spawn the personal-computer industry.

Rather than banning DAT recorders, the congressional committee should concentrate on commerce, consumer protection, and competitiveness. Technology will take care of itself in the marketplace. Who knows? The DAT technology, too, might spawn a new industry.

Jon Titus

Jon Titus
Editor

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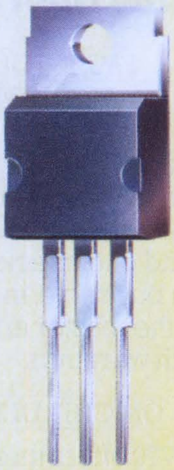
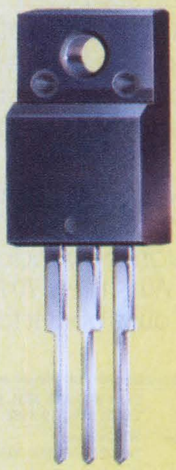


BLACK

Ultra fast switching and reliability for less than a quarter! No wonder our MTP3055A Power MOSFET in TO-220 is such a bright idea—even in basic black. But if you want to see real high-tech chic, take a look below at the Power MOSFET package that's getting everyone's attention.



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MTP3055AP. Black on black (That's right no metal on the back)! Only four cents more and worth every penny. Because this SGS-developed package—the break-through ISOWATT220™—is "FULLY ISOLATED" to 2000V DC (guaranteed) with thermal performance equal to non-isolated technology. Mounts directly to a heatsink with no insulating washers, bushings, etc. needed. Actually cuts parts and assembly costs, while improving equipment quality and reliability. No wonder SGS is the brighter power.

PACKAGE	TYPE	V_{DSS}	$R_{DS\,(ON)}$	I_D	P_D
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*Parts have identical electrical characteristics. I_D and P_D for the MTP3055A (TO-220) need to be derated by the designer depending on isolation used. For the ISOWATT220, this derating is already included.

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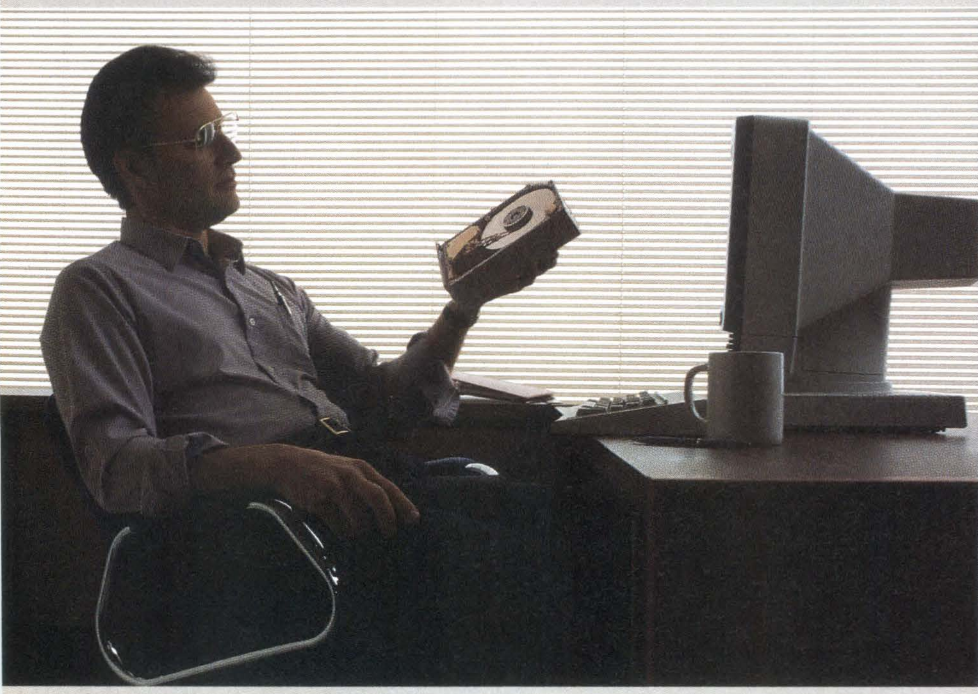

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kHz, resulting in a 96k-bps rate. ADPCM reduces the amount of data by quantizing and encoding the differential between adjacent samples. Adaptive changes to the quantization width depend on the amount of the differential. When the differential is large, the quantization width increases. When the differential is small, the quantization is reduced.

The MSM6258 speech processor from Oki Semiconductor contains a speech-analysis stage in which PCM data is compressed to 3- or 4-bit ADPCM data. The chip's compressed ADPCM mode makes further data reduction possible, at the expense of quality. Compressed ADPCM eliminates intervals of silence that exceed a certain time length, and it eliminates redundancies in, for example, the waveforms that represent vowels. The bit rate in the compressed ADPCM mode can be reduced by as much as one-third of the ADPCM bit rate, depending on the characteristics of the speech.

The MSM6258 contains an 8-bit A/D converter, which samples analog speech at a 4.0-, 5.3-, or 8.0-kHz rate when the on-chip clock uses 4.096-MHz crystal. The chip also has a provision to accept PCM encoded data from an external 8- to 12-bit A/D converter. Using a 12-bit ADC and selecting a 4-bit ADPCM yields 16k-, 21.2k-, and 32k-bps data rates at the 4.0-, 5.3-, and 8.0-kHz respective sampling rates. Lower bit rates are possible using the compressed ADPCM mode and 3-bit quantization.

The chip can obtain ADPCM-encoded data from as much as 1M bits of external dynamic RAM or from as much as 256k bits of external static RAM. The chip contains an internal dynamic-RAM controller with refresh circuitry. Playback is also possible from EPROMs. On playback, PCM data is reconstructed using an on-chip DAC with 10-bit quantization level.

The chip comes in two versions: one for stand-alone operation (over the −40 to +85°C temperature range) and one (which operates from −30 to +70°C) for interfacing with an 8-bit μP. Four plastic-package options include a 40-pin DIP, 44- and 60-lead flat packages, and a 68-lead chip carrier. Each chip requires a 5V supply with current draw of 4 mA max. In standby mode, the chip draws 10 μA when used with static RAMs. Each chip costs $12.90 (1000).

Oki also produces two digital ICs, the MSM6308 and the MSM6309, that combine speech-synthesis and -analysis capability. For analysis, they contain on-chip amplifiers and lowpass filters, which permit direct connection to a microphone. Each chip contains a built-in 8-bit A/D converter and an 8-bit DAC as well as a speaker-driving amplifier. They both use the ADPCM algorithm for speech analysis and synthesis, with selectable sampling frequencies of 4 and 8 kHz. The MSM6308 stores speech data in 256k bits of external dynamic RAM, and the MSM6309 uses 256k bits of external static RAM. The MSM6808 comes in a 44-pin plastic flat package; the MS6809 comes in a 60-pin plastic flat package. Both devices require a 5V supply and operate from −40 to +85°C. Each chip costs $5.50 (1000).

Toshiba America also features waveform coding as a method of voice synthesis. The company has several digital ICs that use an Adaptive Delta Modulation algorithm for code compression. The algorithm is a variant of ADPCM.

Parametric synthesis

Parametric synthesis is a method of speech synthesis that can achieve a higher degree of data compression than does waveform encoding, but the higher compression does result in a somewhat lower quality. Nevertheless, the quality is more than adequate for many applications, and Texas Instruments, a parametric-synthesis proponent, offers a tape recording that allows you to judge for yourself the effects of various levels of compression.

The key to parametric synthesis is a model of the human speech production mechanism **(Fig 1a)**. The vocal tract is excited when the air from the lungs is forced through the vocal chords (two small flaps at the base of the larynx). When voiced sounds such as "A" or "E" are produced, the vocal chords vibrate to modulate the air from the lungs,

For more information...

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

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Signetics Corp
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Silicon Systems
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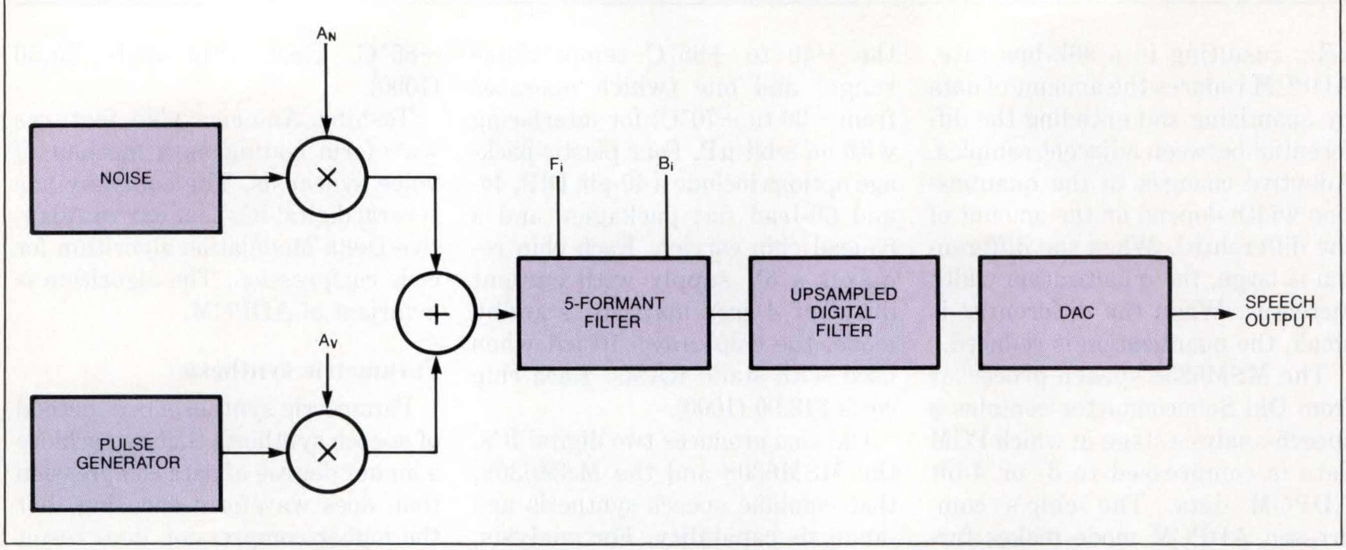

Fig 2—An electronic speech model *requires the combination of amplitude-modulated noise and pulse sources that excite a filter that simulates five formants.*

thus producing pulses of air that are nearly periodic. The period determines the pitch of the sound produced. Besides the voiced sounds, unvoiced—or noise—sounds, such as "S," are required to generate speech. Unvoiced sounds are produced when turbulent air passes through the open vocal tract.

Situated above the vocal chords are the pharynx and the oral and nasal cavities, all of which shape the spectrum of the sound. The vocal tract can be thought of as an acoustic tube that's nearly closed at the vocal-chord end and open at the other. The frequency response of such a tube with constant diameter is characterized by a number of resonances known as formants (**Fig 1b**).

In parametric synthesis, an analysis system extracts parameters from recorded speech and stores them in ROM. A synthesis chip then uses that data to electronically and dynamically model the vocal tract.

One such chip is the Signetics PCF8200, a 24-pin CMOS device that operates from −40 to +85°C. The $15 chip operates from one 5V supply with a typical current draw of 10 mA; it can be switched to a standby mode, in which it draws 200 μA typ. The synthesizer is divided into three sections: a μC interface and control section; a formant synthesizer; and an output stage.

Fig 2 shows a simplified electronic model of the human speech production mechanism that's used by the PCF8200. Here, a periodic source and a noise source, respectively, represent the voiced and unvoiced sounds. The outputs of these sources are amplitude-modulated, combined, and fed to the formant filter, which mimics the vocal tract.

To create the parameter data needed to make the PCF8200 speech synthesizer talk, a recording of the speech to be synthesized must be analyzed using a $5500 Signetics OM8210 speech-development system. This system is a hardware input/output adapter box for either the Hewlett-Packard 9816S or the IBM PC/XT computers. All software for analyzing, coding, and editing speech resides on a floppy disk. The system features a graphic display of the speech parameters, allowing synthesized speech segments or single frames to be pronounced and checked for quality during interactive editing.

Although Signetics performs speech analysis for high-volume customers, it recommends that most speech development be done by outside speech-coding services. One of these services, Voice-Tech, accepts a vocabulary list or a list of complete sentences; the company develops the synthesized speech code files and stores them in EPROMs. Cost for this service is nominally $70 for new words and $50 for canned words.

The analysis process divides recorded speech into intervals called frames and then determines for each frame a set of parameters that describes the speech. In the synthesis step, the PCF8200 synthesizer chip accesses the EPROM-resident frame parameters via a μP that uses the I²C serial bus or an 8-bit parallel bus. Standard frame durations of 8.8, 10.4, 12.8, or 17.6 msec are software selectable.

The PCF8200's on-chip 8-step linear interpolator smoothes the transition from one set of parameters to the next. A frame whose parameters can be approximated by interpolation between parameters of adjacent frames need not be encoded, thereby saving memory.

To model the formants, the PCF8200 uses a vocal formant synthesis algorithm that's a variation of a linear-predictive-coding technique. The excitation signal is filtered with a 5-formant filter for male speech and a 4-formant filter for female speech. The formant filter is a cascade of second-order sections. The control parameters, formant frequencies, and bandwidths are updated eight times per speech

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frame by linear interpolation.

The formant-filter output is eight-times oversampled (or upsampled) to reduce quantization noise, and it's applied to a digital lowpass filter, whose output is then scaled up or down for optimum positioning for an on-chip 11-bit DAC. The digital filter reduces the requirement for external filtering before application of the synthesis chip's output to an amplifier and speaker.

Linear predictive coding

Texas Instruments also manufactures speech devices that perform parametric synthesis. The TI parts use a pitch-excited linear-predictive-coding (LPC) technique. The TSP5220C uses an LPC-10 (linear-predictive coding with a tenth-order filter) voice-synthesis function. It's a 28-pin device that operates from 0 to 70°C and requires −5V and 5V power supplies, from which it draws 10 mA and 3 mA, respectively.

The chip's microcontroller interface consists of an 8-bit bidirectional bus with read, write, interrupt, and ready control signals. Data is written into a command register or a 128-bit FIFO register. A data register and a status register send data to the host µP. For added flexibility, the TSP5220C's 4-bit address bus provides a direct interface to the external TSP6100 Series vocabulary ROM. Synthesized-speech data outputs are provided in an analog and a digital format. An on-chip 8-bit DAC, which operates at 8 kHz, provides the analog output. The chip operates at data rates from 1000 to 1700 bps. An external lowpass filter, amplifier, and speaker are required to produce sound. The chip sells for $9.20 (100).

The TSP50C41/42/40A chips from TI also implement an LPC-10 speech-synthesis algorithm, but they each have an internal processor that can access speech data from an internal or an external ROM; they therefore suit high-volume applications. The µP is an 8-bit processor with 8k bytes of ROM. The housekeeping code required for speech synthesis and interface to a host µP is typically 1k to 2k bytes, leaving 6k to 7k bytes of internal ROM for speech data. The chips have an 8- and a 4-bit µP interface.

Speech data rates vary from 800 to 2000 bps, depending on quality. During speech synthesis, data is retrieved, decoded, and sent to the on-chip LPC-10 lattice filter. The input to the lattice filter is an excitation source that uses data stored in an on-chip excitation ROM to furnish either periodic (for voiced sounds) or pseudorandom (for unvoiced sounds). Pitch is stored in a dedicated register that accesses the excitation ROM. Interpolation of data between frames is accomplished by a ROM-resident speech algorithm.

The lattice-filter output is sent to an on-chip DAC. The chips operate from 0 to 70°C and require one 5V supply. The TSP50C41 comes in a 28-pin package and features a 128-bit RAM, a 150-mW drive capability into a 50Ω speaker, and two 8-bit I/O ports. The TSP50C42 has the same features with two additional 8-bit I/O ports in a 40-pin package. The TSP50C40A is a 28-pin device with reduced features. Prices for the chips start at $5 (OEM qty).

TI provides a speech-development service (called SDS), for which it charges $100/word to store speech parameters in EPROM for use with the TSP220C. Because the TSP50C41/42/40A requires an internal ROM to be programmed, speech development is only available for minimum orders of 10,000 units/year. TI has indicated that a personal-computer version of SDS will be available in early 1988.

TI is also finding uses for the TMS320C17 digital-signal-processing (DSP) chip in parametric speech science. The parametric devices thus far discussed require non real-time speech analyses by minicomputer systems. A block diagram of a speech system that can perform parametric speech synthesis as well as real-time speech analysis and speaker verification is shown in **Fig 3.** It consists of a host µP, a DSP chip, a codec (TCM29C18), and a speech-data ROM. The codec consists of an input antialiasing filter and a nonlinear (µ-Law or A-Law) A/D converter, which allows speech to be sent to the DSP chip and to a DAC and filter for speech output.

Several speech algorithms have been developed to run on the TMS320C17/codec hardware. These algorithms include ADPCM coding, LPC synthesis, speech recognition, and dual-tone multiple frequency (DTMF) encoding and decoding for telecommunications. The TMS320C17 and the TCM29C18 cost less than $10 (OEM qty), and

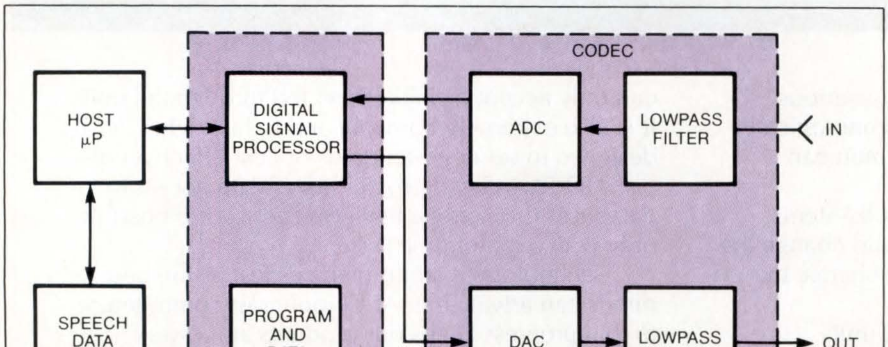
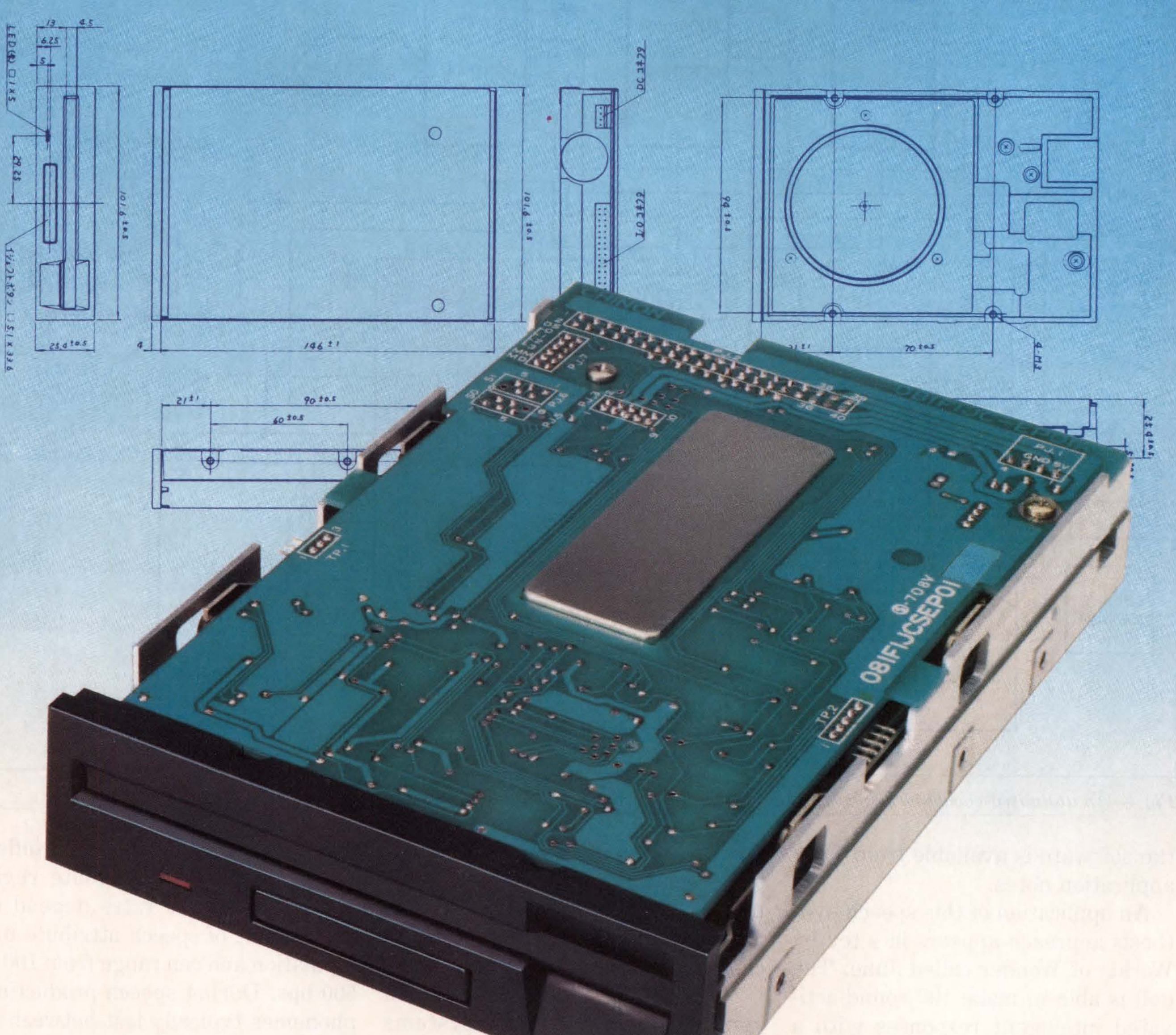


Fig 3—A real-time speech-synthesis I/O system *using a DSP IC and a codec eliminates the need for voice-parameter analysis by computer.*



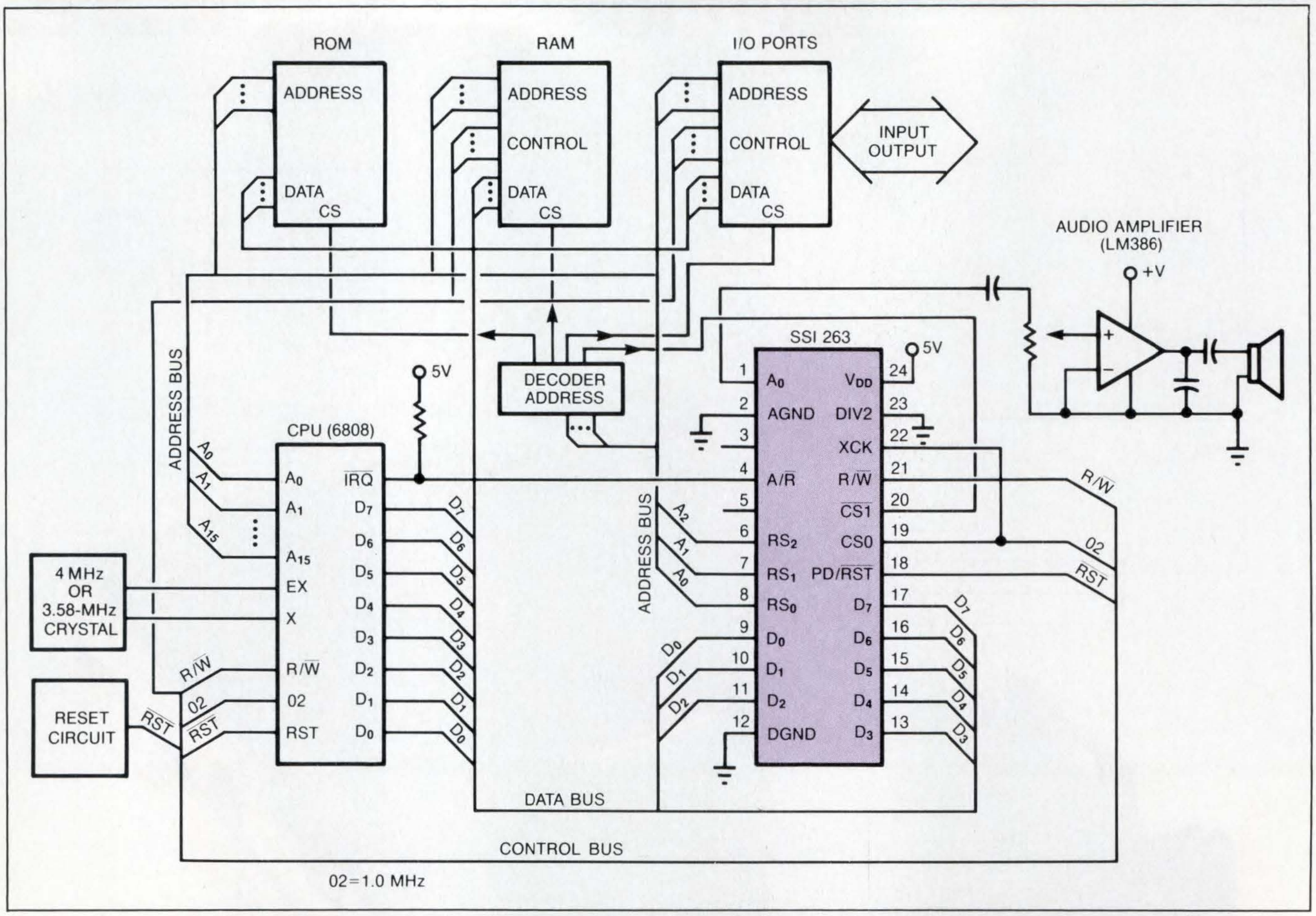


*Fig 4—**An unlimited-vocabulary** speech system is possible when an IC containing phoneme synthesis is combined with a μP.*

the software is available from TI in application notes.

An application of this speech-synthesis approach appears in a toy by Worlds of Wonder called Julie. The doll is able to make 100 sound-activated intelligent responses with a 64k-word resident memory. Through a conversation training process, it can store as much as three minutes of synthesized speech.

Synthesis by rule

The previously discussed speech-synthesis methods require priming by a human voice to obtain speech data. However, every language contains a number of basic speech sounds (phonemes) that represent the building blocks of speech. English, for example, contains 50 or so distinct sounds. Speech synthesis by rule is accomplished by storing these basic units in memory and combining them in a proper sequence to develop speech. Although this technique produces a more primitive quality of speech, it has the advantage of an unlimited vocabulary.

The SSI 263A phoneme speech synthesizer from Silicon Systems stores 64 phonemes or allophones (an allophone is one of two or more variants of the same phoneme) in ROM. Speech is produced when successive phonemes are accessed and sent to a model of the human vocal tract. The vocal tract is modeled in the chip by five cascaded programmable filter sections using switched-capacitor filters. Either a glottal (pitch) or a pseudorandom noise source is used to excite the vocal tract model, depending on whether a voiced or nonvoiced phoneme is selected; **Fig 4** shows a typical μP-controlled implementation.

Attributes such as speech rate, pitch, amplitude, vocal-tract filter frequencies, phoneme articulation rate, phoneme duration, and inflection are stored in attribute registers. Speech data rates depend on the amount of speech attribute manipulation and can range from 100 to 500 bps. During speech production, phonemes typically last between 25 and 100 msec. The 24-pin CMOS chip operates over −40 to +85°C and draws 20 mA max from a 5V supply. The chip sells for $18.90 (100).

General Instrument also manufactures speech-synthesis products that will perform speech synthesis by rule. The $2 (OEM qty) SPO264 is a 28-pin device with an internal 64k-byte (8k×8-bit) ROM that can be programmed to support LPC synthesis and formant synthesis as well as allophone synthesis. **EDN**

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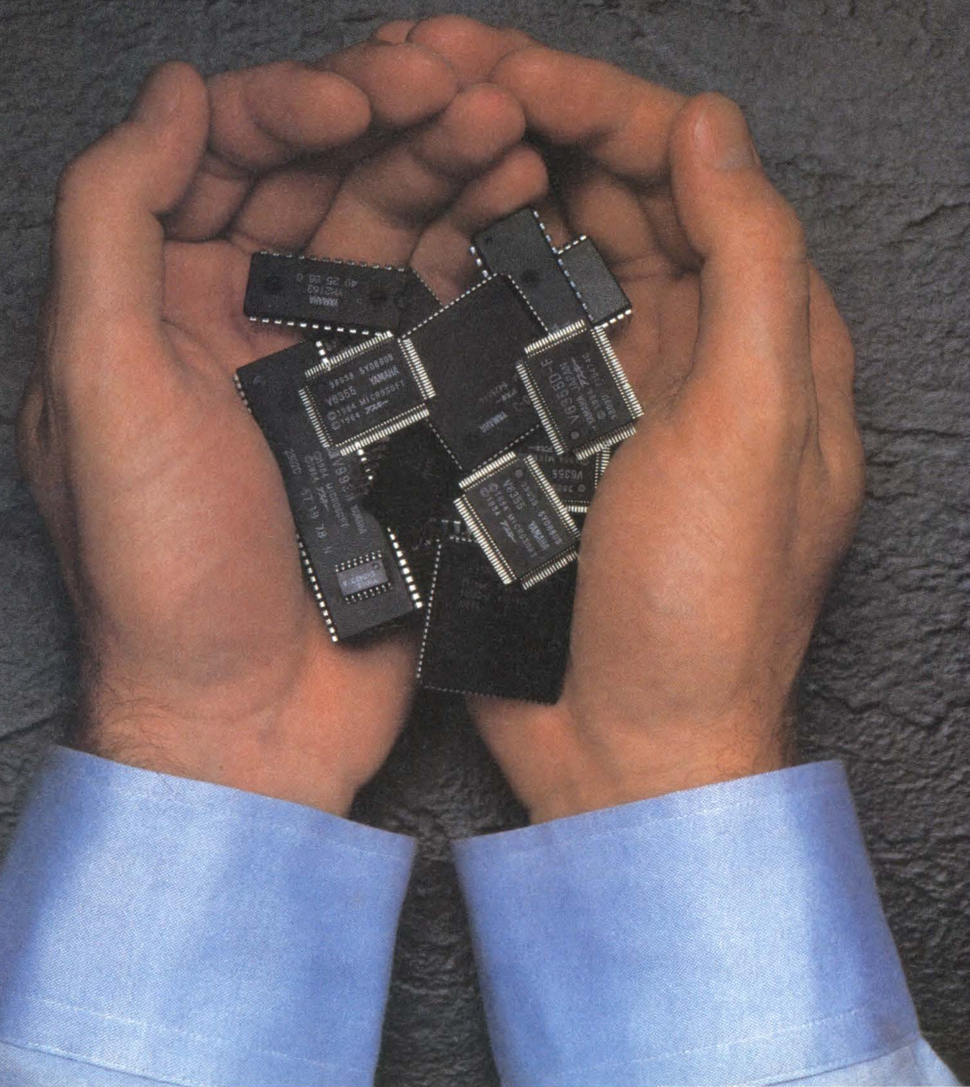

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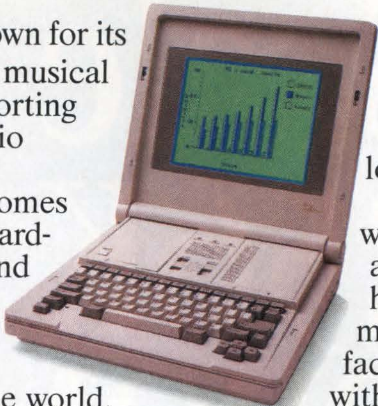

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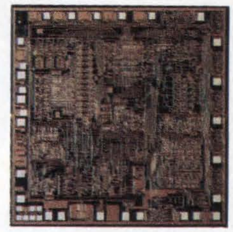

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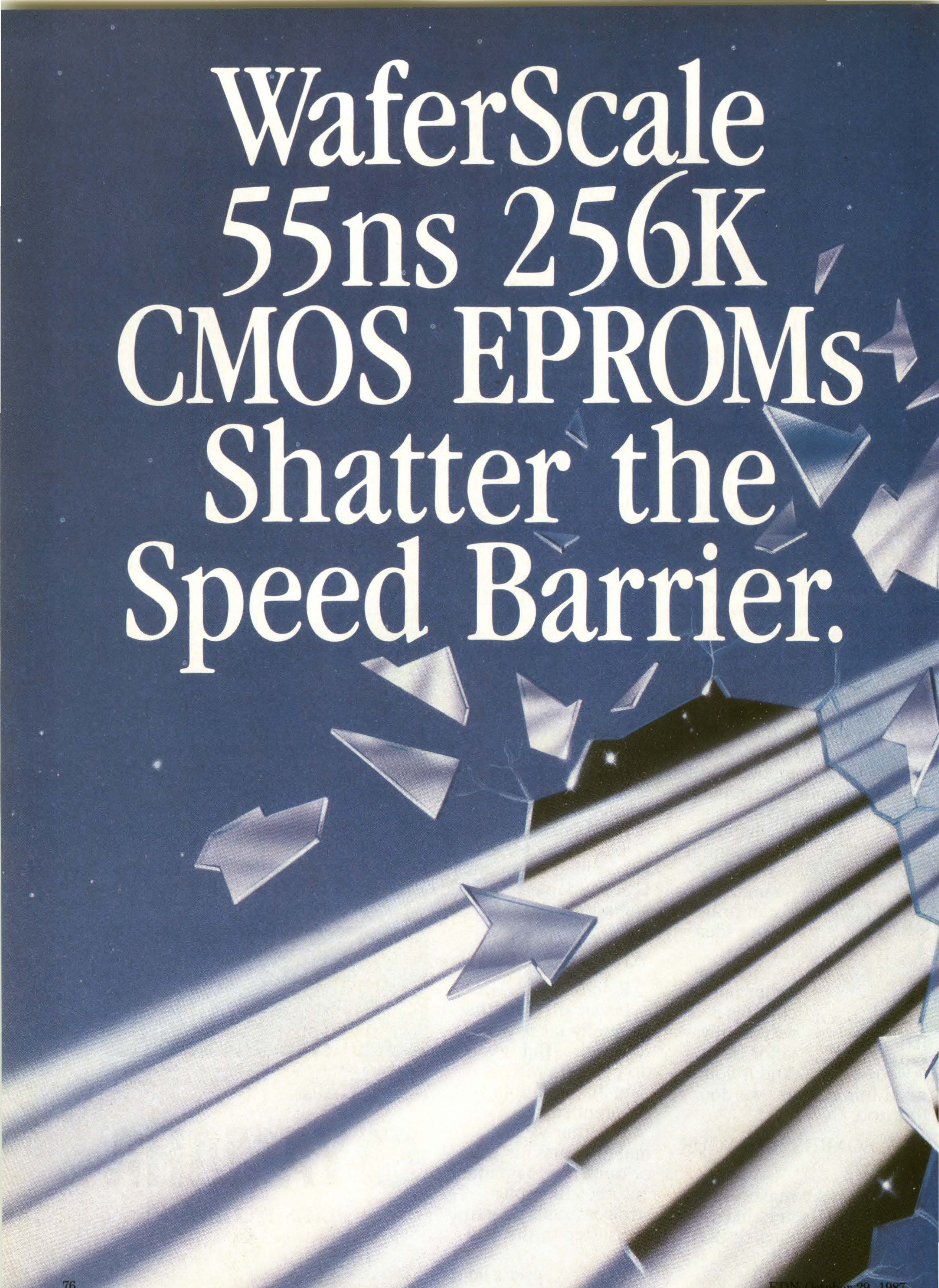
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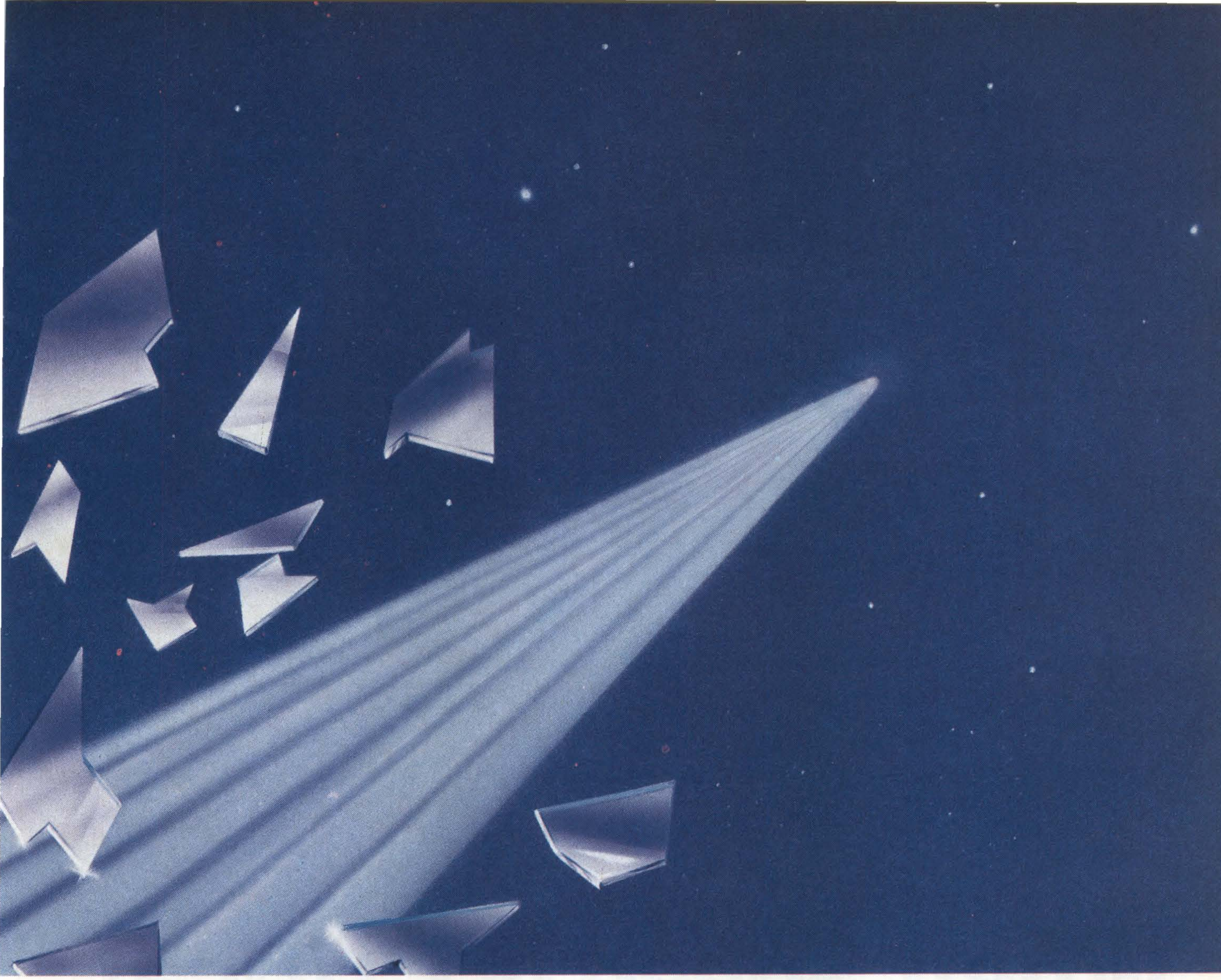

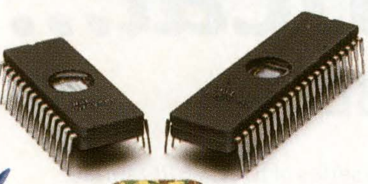

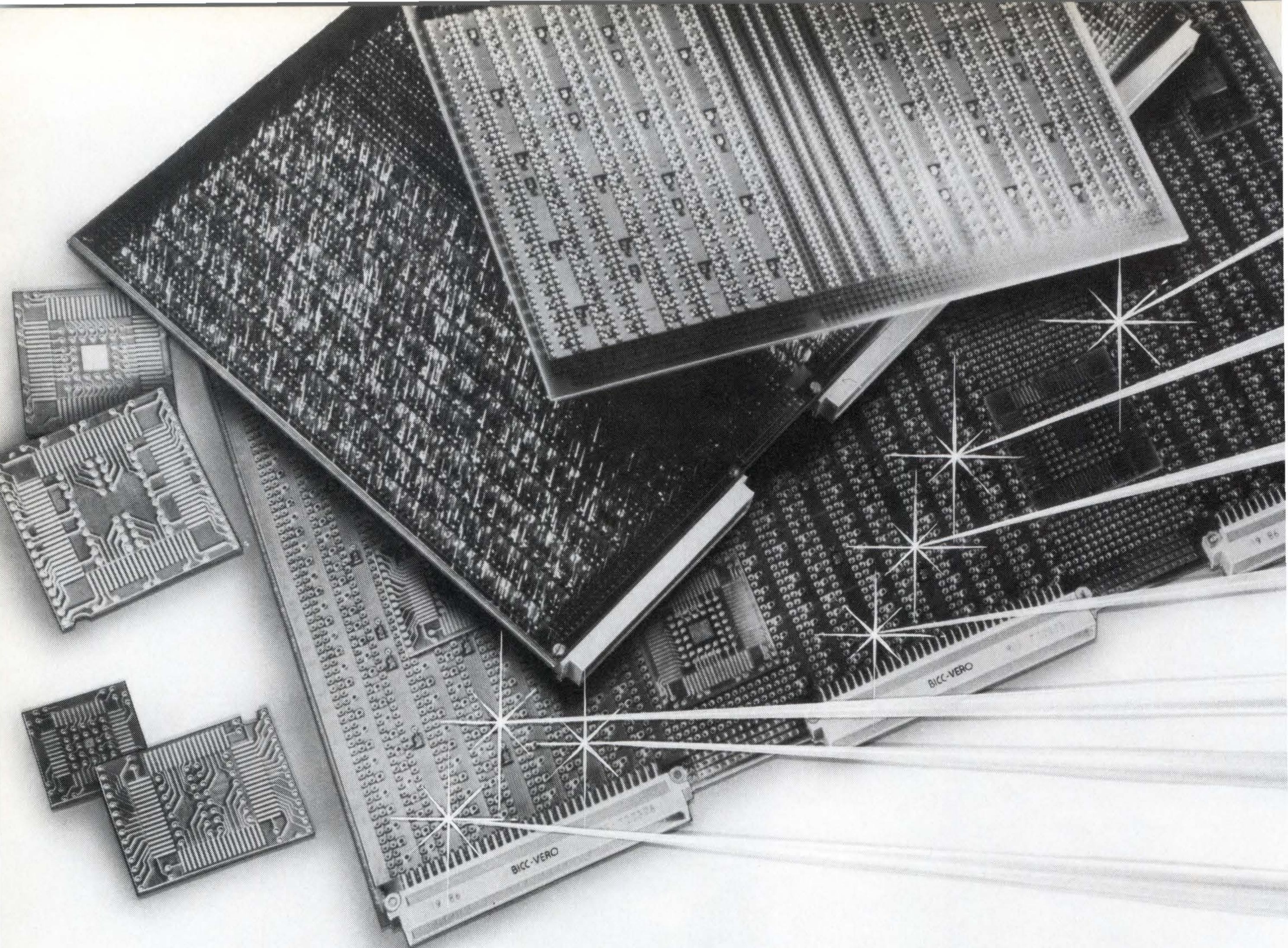
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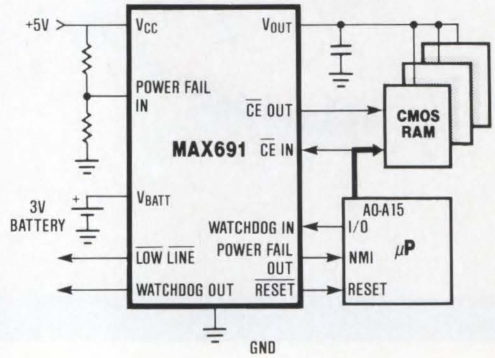

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CIRCLE NO 124

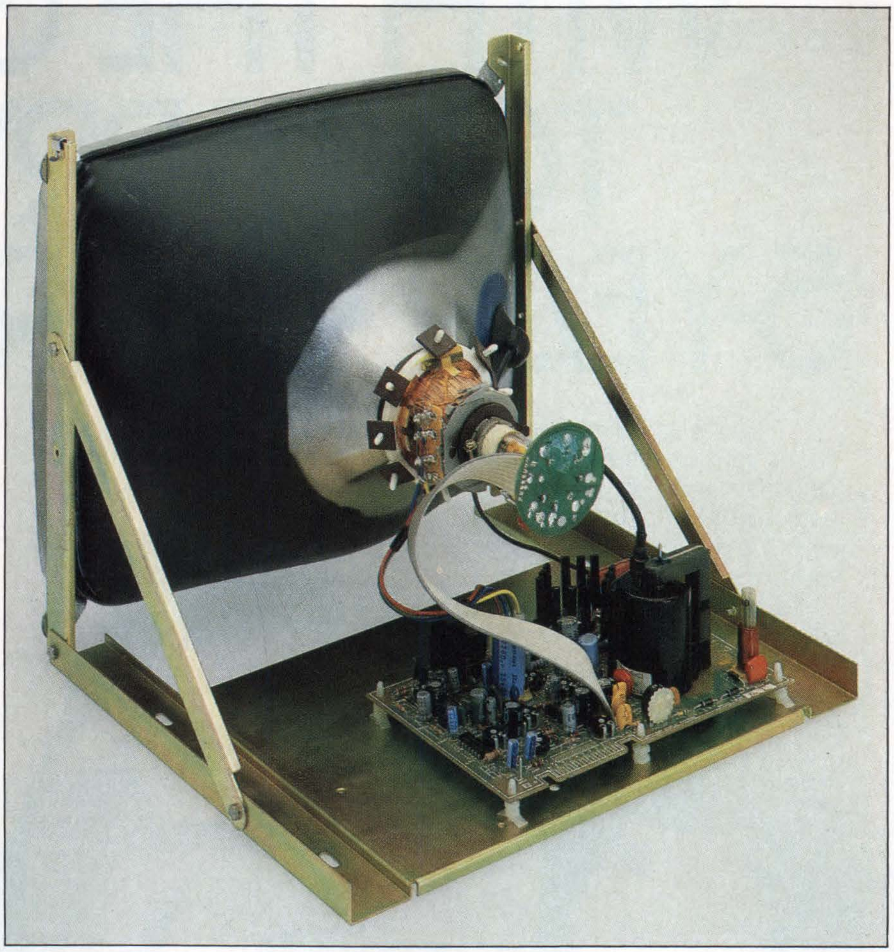
Refinements in CRT design boost resolution of color video monitors

Chris Terry, *Associate Editor*

It's easy to forget that as recently as a few years ago, color video monitors couldn't produce the finely detailed images needed for even moderately complex CAE applications. Both monochrome and color monitors of the early 1980s offered fairly low resolutions—350×250 to 640×250 pixels—so the images they produced were often fuzzy.

Today, however, you can find color monitors that provide resolutions from 640×480 to 2048×2048 pixels. These monitors are suitable for use in electronics-design workstations as well as in mechanical- and structural-engineering workstations and systems that provide fast animation, such as training simulators.

Furthermore, these monitors are not prohibitively expensive—an important factor, because the monitor represents one of the biggest system-component investments you'll make when you're putting together a graphics system. The latest color monitors now cost between $3000 and $10,000.



Available as a kit, mounted on a chassis, or enclosed in a cabinet, *the 300DMX from Computron provides 1040×1040-pixel resolution on a 9-, 12-, or 14-in. screen.*

New developments

The high resolutions of these color monitors result from a number of developments in monitor design. The amount of detail that a color monitor can display is governed by the resolution the tube is capable of and the accuracy of its color registration. The total number of colors in your palette and the number of colors that you can display simultaneously are both functions of the way the graphics display-generator board stores the screen position and color attributes of each pixel. The display-generator board supplies vertical and horizontal synchronization signals to the monitor together with the RGB components of the video signal.

Although a resolution of 640×350 pixels is adequate for many applications, most CAE applications—particularly those that involve mechanical drawings—demand much better definition. High-resolution monitors generally display at least 1024×1024 pixels (that figure is, incidentally, the resolution specified by the proposed European high-definition television standard).

The number of pixels that a screen can accommodate largely depends on the size of the spot that the lensing system of the tube can produce—the smaller the spot, the more pixels the screen will accommodate horizontally and vertically.

Recent refinements in the technology of electrostatic lens systems have allowed monitor designers to bring the minimum spot size down to 0.26 mm; however, the difficulties and cost of fabricating tubes that have such a small spot size make them uneconomical. A few vendors (such as Computron, Philips, and Mitsubishi) offer tubes with

a spot size of 0.28 mm, but the majority of vendors offer monitors with a 0.31-mm size. The 0.31-mm spot size provides a resolution as high as 1024×1024 pixels on 17-in. or larger screens and 2048×2048 pixels on 20-in. or larger screens, and allows the vendors to keep the monitors' prices under $3000.

The lens refinements that have allowed the decrease in spot size also entail a reduction of the lens aperture size with respect to the beam size, so they pose some problems in maintaining brightness, especially in color tubes, in which beams from three electron guns (for red, blue, and green) must all pass through the same lens system. To increase the brightness, the manufacturer must pass a larger beam current through the lens to produce stronger excitation of the phosphor. If the beam current increases beyond a certain limit, however, it starts to heat the lens system, thereby causing defocusing or distortion. The safe limit is somewhat dependent on aperture size, so that reducing the spot size may also entail a smaller light output from the screen. The most recent color tubes have better light output than their predecessors do, but they still don't achieve as much light output as do monochrome tubes.

Also critical for high resolution and good color registration is the color tube's shadow mask. The smaller the holes in the shadow mask, the higher the resolution. However, the difficulty and cost of fabricating a shadow mask increase as the size of the holes decreases.

Different types for varied uses

When you evaluate a monitor for use in your system, you need to know whether it has a fixed or flexible scanning rate. If you're selecting a color monitor for incorporation in an integrated CAE workstation, for example, you'll need the monitor to provide a fixed resolution, so it will operate optimally with your system's particular display-generator board. If you're selecting a monitor for use with a microcomputer system that can accept a Color Graphics Adapter (CGA), Enhanced Graphics Adapter (EGA), Professional Graphics Adapter (PGA), or Video Graphics Array (VGA) display board, you'll want the monitor to be able to adjust to different resolutions.

***Its flexible scan rate** makes the XC-3710C color monitor compatible with the CGA, EGA, and PGA display generators. The 37-in. monitor, from Mitsubishi, offers a resolution of 640×480 pixels.*

Among the recent offerings of fixed-resolution monitors is Computron's 300DMX, which has a fixed scan rate of 64 kHz and a resolution of 1024×1024 pixels; this monitor is available as a kit (tube and electronics unmounted), mounted on a chassis, or enclosed in a cabinet. You can also order it with a 9-, 12-, or 14-in. tube. Prices start at $186 (in OEM quantities) for the kit configuration.

If you want even higher resolution, consider Mitsubishi's $3790 HG-6905BK color monitor. This 20-in., stand-alone unit tracks horizontal scanning frequencies of 40 to 70 kHz and vertical scanning frequencies of 50 to 75 Hz, and it provides a resolution of 1280×1024 pixels. You can switch the input between 90 to 132V ac and 198 to 264V ac for use anywhere in the world, and the high-voltage stabilizer maintains picture size and brightness when the picture switches from low to high illumination or vice versa.

Some monitor vendors provide both fixed- and variable-resolution types in similar configurations. Conrac, for example, offers its 19-in. Model 7350 for $2995; the monitor automatically tracks the display board's horizontal scanning frequency from 15.75 to 37 kHz, providing resolutions as high as 1024×1024 pixels. The 19-in. Model 7351 provides a fixed scan rate of 64 kHz for a single 1280×1024-pixel display format; it costs $3495.

If you need a really large screen—37 in., for example—consider the Mitsubishi XC-3710C. The monitor tracks horizontal scanning frequencies from 15 to 31.5 kHz and vertical scanning frequencies from 40 to 75

For more information . . .

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

Computron Display Systems
3100 New York Dr
Pasadena, CA 91107
(818) 791-5600
Circle No 717

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Torrance, CA 90502
(213) 515-3993
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Philips International BV
5600 MD Eindhoven
The Netherlands
(040) 79 11 11
TLX 35000
Circle No 720

Hz, and it provides resolutions as high as 640×480 pixels. It operates with CGA, EGA, and PGA display boards, and it accepts standard NTSC video signals from VCRs and laser-disk equipment. Its price depends on the options you order, but even the most complex configuration costs less than $10,000.

The M37 Series color tubes from Philips International provide a spot size of 0.29 mm and resolution of 800×600 pixels at a modulation depth of −9 dB; you can obtain even greater resolution if you decrease the modulation depth. These 14-in. tubes are also distinguished by an internal magnetic shield that provides excellent immunity against stray magnetic fields. You can choose from a variety of yoke assemblies that operate with horizontal scan rates of 16 kHz to as much as 64 kHz. The M37 Series color tubes start at $125.

Another critical item in a high-quality color monitor is the power supply. High-resolution monitors may consume as much as 200W, much of which is dissipated in the monitor's deflection yoke, so the yoke design is an important factor in the monitor's reliability. The regulation of the high-voltage supply is also critical; a poorly regulated supply will cause raster size and light output to change when the picture suddenly switches from a few bright lines to full illumination, or vice versa. In extreme cases, the focus may also suffer.

To find out how good the monitor's high-voltage regulation is, you can either check the data sheet for black-level stability specs, or you can perform a simple test: You call up a page containing some scattered text characters and switch the page from normal video to reverse video. When you switch to reverse video, the characters should remain sharp and clean; any blurring of characters is a sign of poor high-voltage regulation.

Finally, you should check to see that the switching power supply is shielded, because any radiation from the power supply can introduce noise that degrades the picture. Units that provide fixed-frequency scanning should also allow you to tune the power supply to synchronize the switching frequency with the scanning frequency; this procedure eliminates beat frequencies that could interfere with the picture. **EDN**

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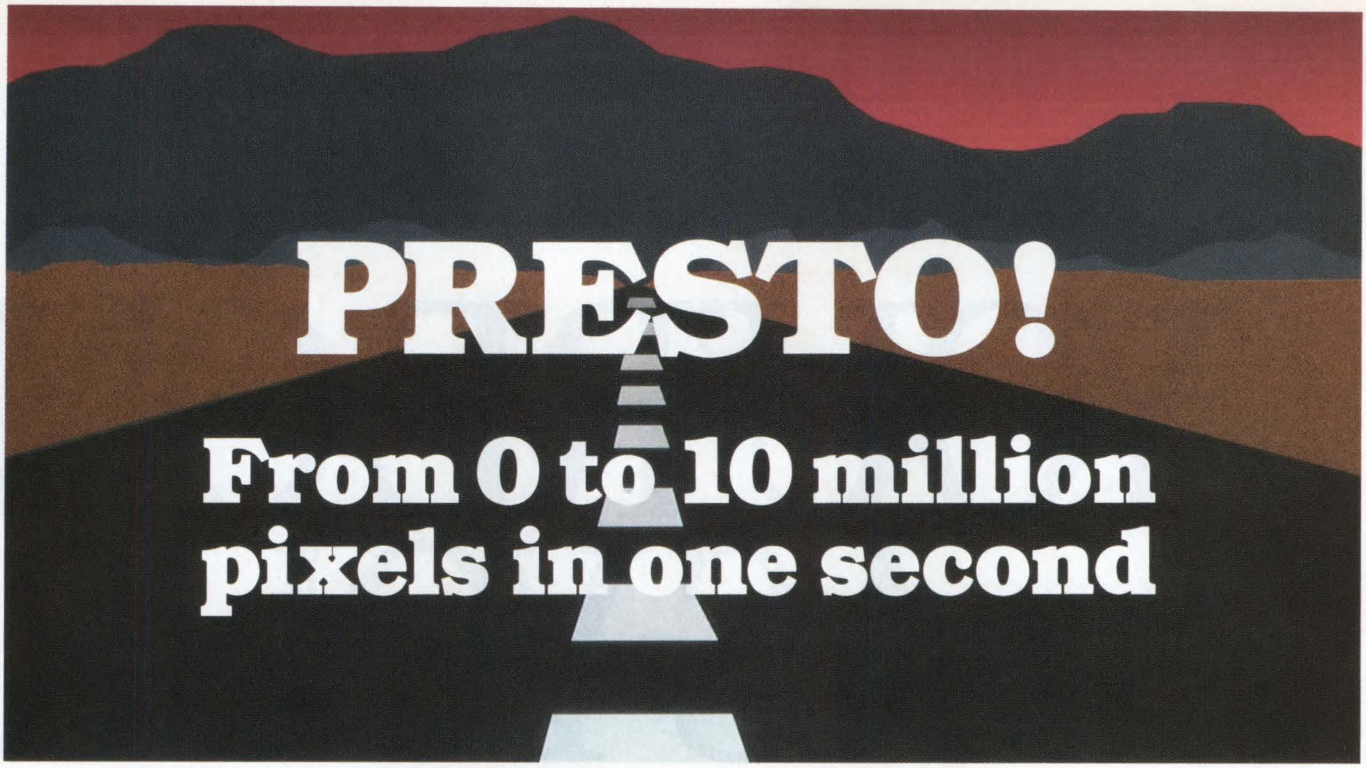

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SEPTEMBER

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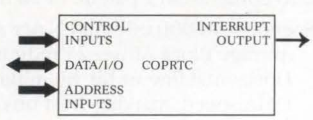

The COPRTC Real-time Clock peripheral has a direct interface to the COP800. It's 32 KHz crystal oscillator allows independent operation while the controller core cell is in a low-power halt state. The interrupt timer can "wake up" the controller at user-programmable intervals. This peripheral keeps time with tenth-second resolution and includes an automatic leap year calculation. Of course, it is also fully compatible with all the digital and analog cells in our Triple Technology™ 2 micron CMOS cell library.

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Key Features:

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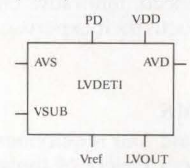
Negative going trip point, Vtr−	3.7			Volts
Positive going trip point, Vtr+			4.5	Volts
Hysteresis (Vtr+)−(Vtr−)	200			mV



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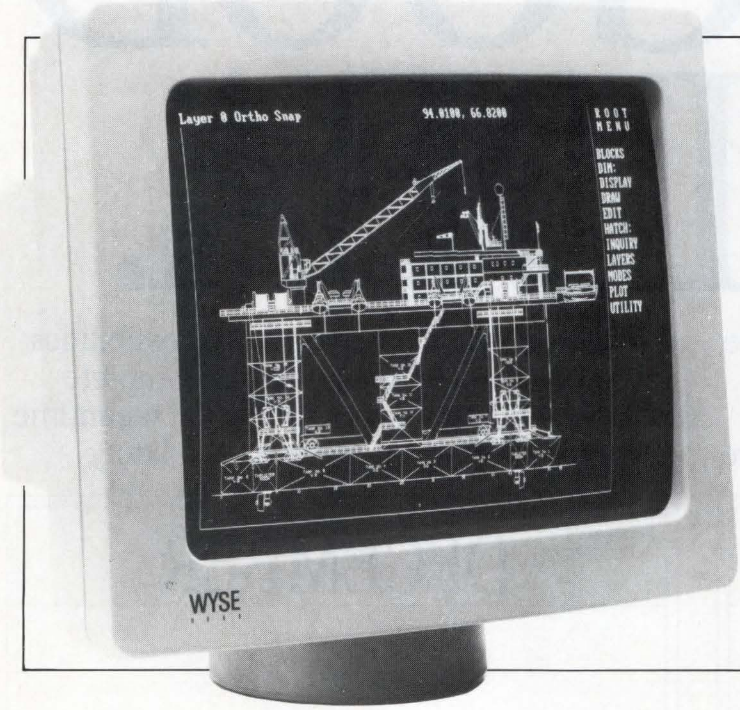

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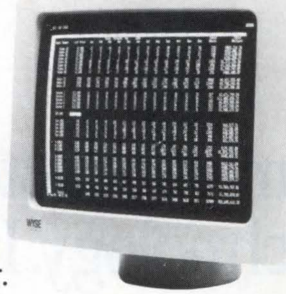

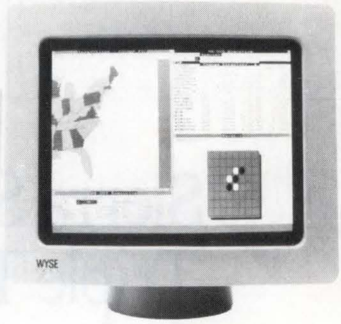

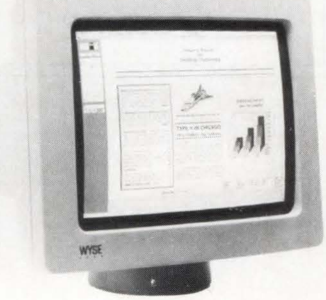

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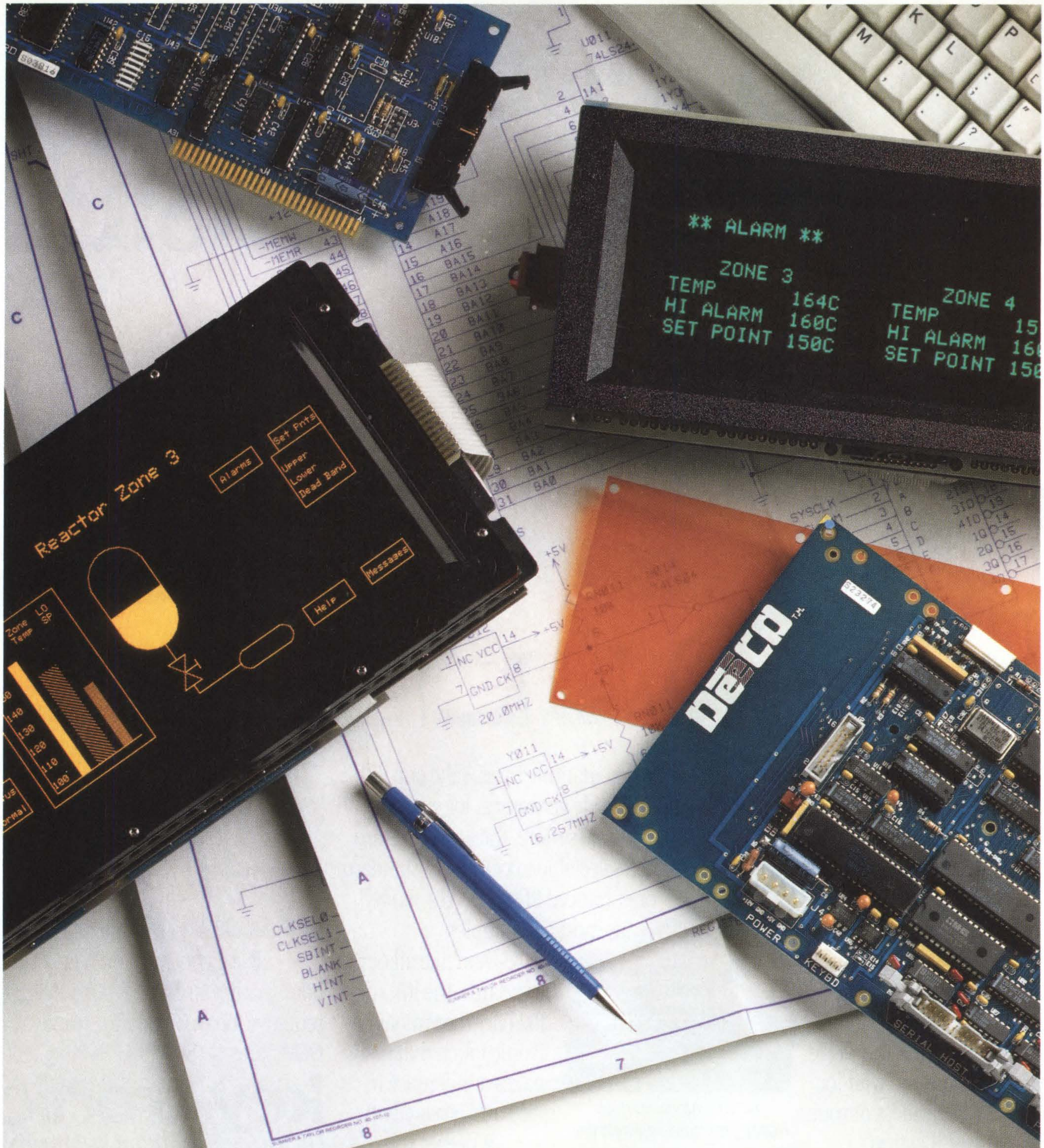

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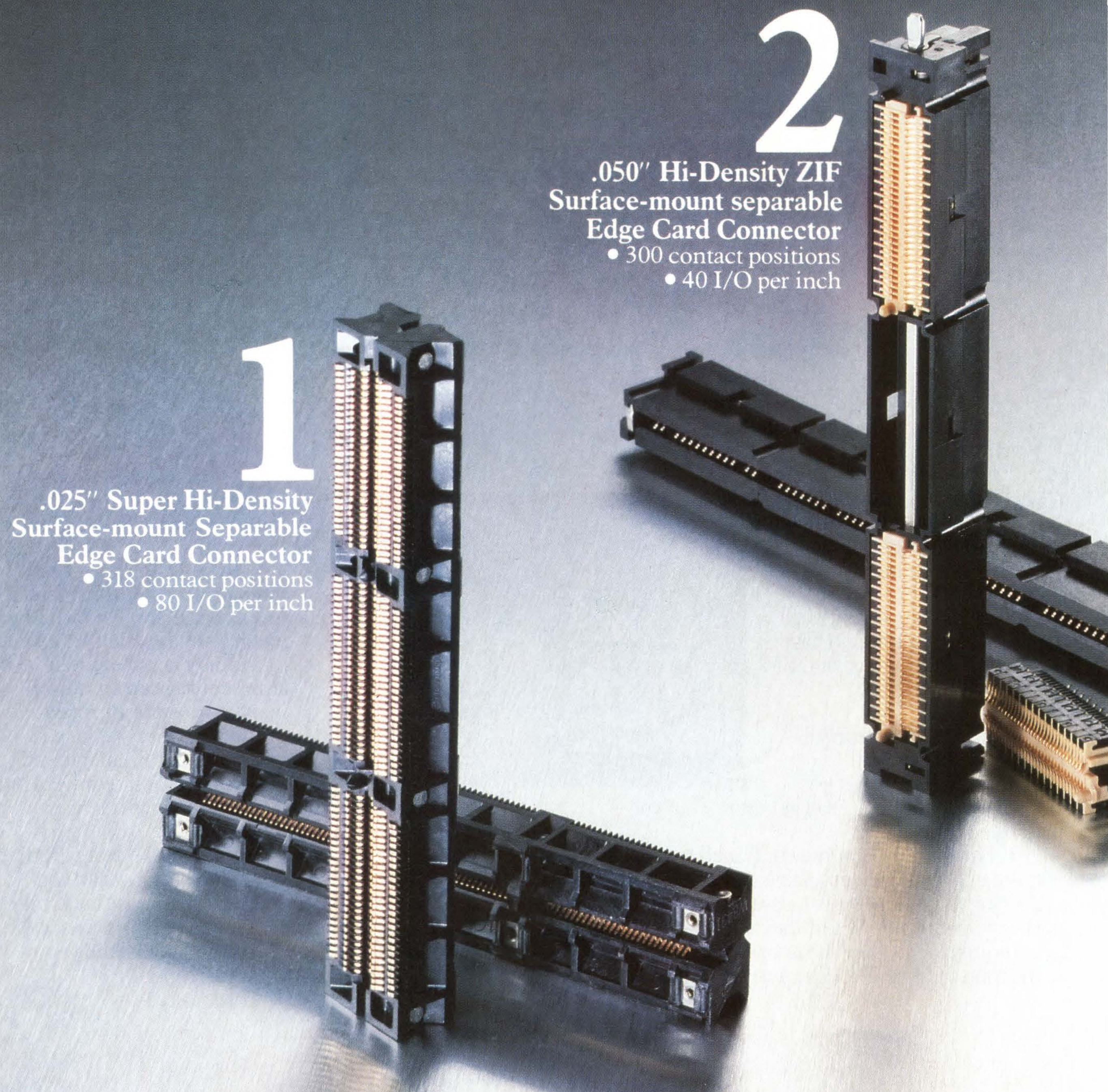

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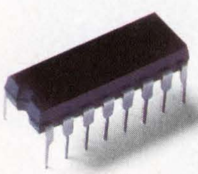

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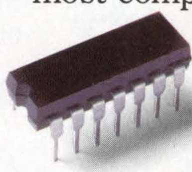

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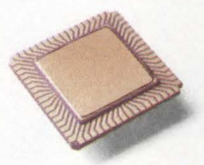

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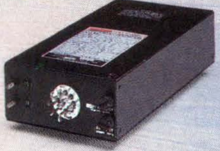
CIRCLE NO 73

Sometimes, keeping a low profile pays off.

The survival of today's combat helicopter depends on keeping a low profile. Abbott's BC100 triple output, switching DC-DC converter helps the Lynx helicopter achieve this low profile.



The BC100's low 1.875″ profile allowed 100 watts to fit into a tight space requirement. At the same time, the Lynx helicopter was able to take advantage of the economy and reliability that come from using a standard product, the BC100.

Because the BC100 meets the requirements of MIL-STD-810C, and MIL-S-901C, the Lynx program's decision to go with Abbott's BC100 will also pay off in extra survivability. Plus the BC100 features low ripple/noise and EMI within the limits of MIL-STD-461B.

For other applications that call for small yet powerful converters, Abbott offers both 100 and 200 watt models. Each available in single and triple configurations. And all with a wide array of options available.

For more information and a copy of our 1988 Military Power Supply Product Guide, call or write today.

Abbott Transistor Laboratories, Inc. Power Supply Division, 2721 S. La Cienega Blvd., Los Angeles, CA 90034 (213) 936-8185. Eastern Office: (201) 461-4411, Southwest Office: (214) 437-0697, London Office: 0737-82-3273.

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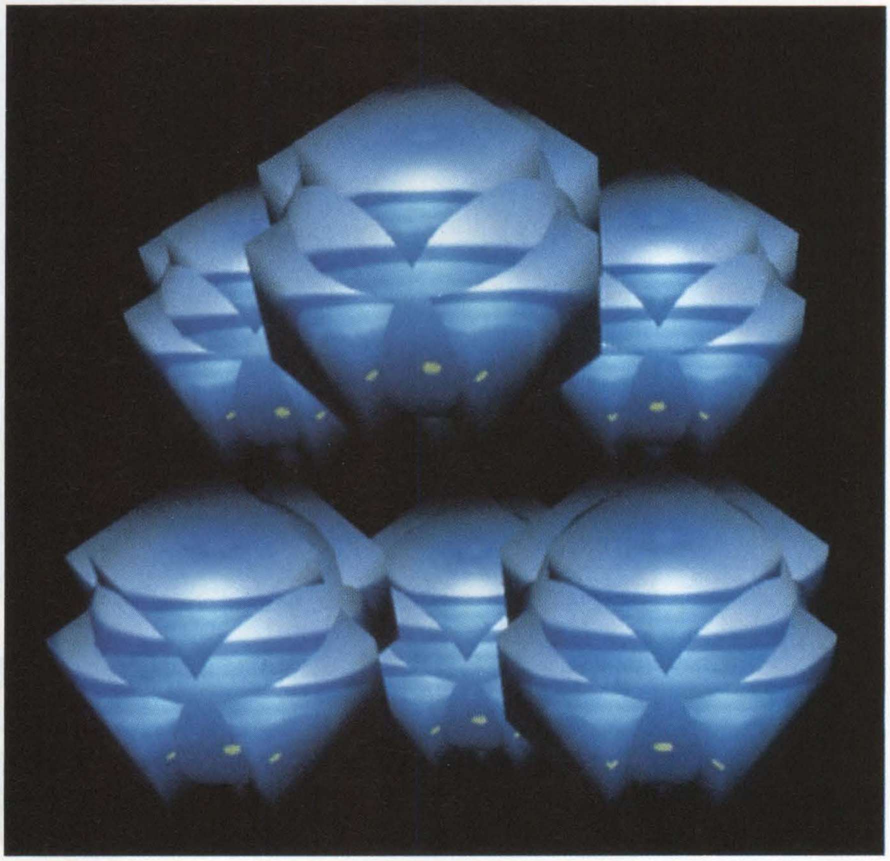
CIRCLE NO 102

Wescon/87 will highlight electronics in the entertainment and broadcasting sectors

Charles H Small,
Associate Editor



The theme of Wescon/87 is *"Electronics in Entertainment and Broadcast." The Electronic Theatre will emphasize that theme with a session on "Computer graphics animation," which will present animated examples. (Photo courtesy BTS Broadcast Television Systems Inc)*

Wescon/87, with the theme of "Electronics in Entertainment and Broadcast," will take place from November 17 through 19 at three locations in San Francisco, CA: Moscone Center, Civic Auditorium, and Brooks Hall. Wescon officials expect 50,000 attendees, 1800 booths, and 800 exhibitors.

The show's sessions will explore new methods of applying technology with current tools. They will also present nontechnical issues, such as the benefits of ASIC design centers and how to protect new technology from competitors—and yourself.

Virtually all sessions will be held in the Moscone Convention Center, and you will incur no additional charges when attending the professional programs. Professional-program speakers this year include 30 company presidents or vice presidents, 27 technical vice presidents, 47 marketing managers, and 29 engineers. The speakers represent 125 different companies from 20 states and three foreign nations.

Keynote speaker

Charles S Steinberg, CEO of Ampex Corp, will deliver the keynote address at a special luncheon to be held at noon in the Cabernet Room of the Meridien Hotel. Tickets for the luncheon cost $25. Steinberg, known as "Mr Olympics" for his behind-the-scenes attention to the technology that has given audiences front-seat viewing of the Games since 1964, will tell an engaging story of entertainment technology—past, present, and future.

In addition to free exhibits and technical sessions, Wescon will have business conferences on subjects such as the state of the entertainment-electronics business, commercialization of superconductivity, improving the bottom line, just-in-time theories, investing in electronics, and doing business in the Pacific rim.

A special exhibit will feature the latest hardware that creates the sights and sounds of today's world. Among the products on display will be a 1-in. videotape recorder and the ADO (Ampex Digital Optics) special-effects device from Ampex Corp (Redwood City, CA). You can also experience the Emulator II—a computer-based digital musical synthesizer from E-Mu Systems (Scotts Valley, CA). The exhibit will showcase video-digitizing equipment and a mobile broadcast van.

In addition to static displays, you will be able to see videotapes of avionics, engineering-design, and graphics-modeling systems from Robert Bosch Corp and Evans and Sutherland—both of Salt Lake City, UT. The special exhibit, located in the Civic Auditorium, will be open during regular show hours at no charge.

The show will feature a free Elec-

tronic Theater, which will be located in the Civic Auditorium. The Electronic Theater will present a session exploring applications of leading-edge technologies each morning at 9:30. For example, on Tuesday, a show entitled, "Television and special event communications—the concept and how it can help you," will detail how intercommunications systems can communicate simultaneously in network fashion. This session's organizer, Robert Turkow of Clear-Comm Intercom Systems, gathered first-hand experience coordinating communications for the 1984 Summer Olympics and the 1986 Fourth of July Liberty Weekend.

Animated graphics

Wednesday, the Electronic Theater opens its doors with a session on "Computer graphics animation." The session, organized by Allen Jensen of BTS Inc, starts with a historical perspective of computer graphics animation and ends with a discussion of the current state of the industry. The show will present animated examples.

Thursday begins with a session on "Digital signal processing for television broadcast," organized by Fraser Morrison of Ampex Corp. The session will present a description of some of the processing operations necessary to generate and manipulate television signals.

Each afternoon, from 2:30 to 4:30, the Electronic Theatre will present selections from the "1986 ACM/SIG-

WESCON/87 TECHNICAL-SESSION PROGRAM

		BALLROOM F	BALLROOM G	BALLROOM H	MERIDIEN HOTEL (SAUTERNES BALLROOM I, II, III)
TUESDAY, NOVEMBER 17	9:00 AM TO 11:00 AM	(1) MICROCONTROLLERS MAKE THE 8- TO 16-BIT TRANSITION	(2) SOFTWARE VALIDATION AND VERIFICATION	(3) DEBUGGING AND INTEGRATION OF EMBEDDED SYSTEMS: CURRENT ISSUES	
	12:30 PM TO 2:30 PM	(4) THE 32-BIT RISC VS CISC CONTROVERSY	(5) NEW CAD TOOLS INTEGRATE PLDs, GATE ARRAYS, AND STANDARD CELLS	(6) MODERN METHODS IN DIGITAL SIGNAL PROCESSING	
	3:00 PM TO 5:00 PM	(7) NEW WAVE OF HIGH-PERFORMANCE VLSI PERIPHERAL CHIPS	(8) PC BASED CAD—COMPUTER-AIDED DESIGN OR COMPUTER-AIDED DISASTER? A USER'S PERSPECTIVE	(9) HIGH-VOLUME MICROWAVE APPLICATIONS	
WEDNESDAY, NOVEMBER 18	9:00 AM TO 11:00 AM	(10) PLDs. . . ARE THEY A DESIGN STEPPING STONE OR DO THEY OFFER LONG-TERM DESIGN AND MANUFACTURING SOLUTIONS?	(11) PHOTOVOLTAIC TECHNOLOGY AND SYSTEMS FOR THE 1990s	(12) ADVANCES IN BUS INTERFACE	(13) ELECTRONICS BUSINESS IN CANADA
	12:30 PM TO 2:30 PM	(14) QUICK-TURN ASICs; AN ELIXIR FOR SHORT PRODUCT LIFE CYCLES	(15) MICROPROCESSOR TECHNOLOGY AND APPLICATIONS FOR POWER SYSTEMS; DATA ACQUISITION AND CONTROL	(16) A FACTORY-FLOOR PERSPECTIVE OF COMPETITIVE BUS STRUCTURES	(17) NEW TECHNOLOGY—PROTECTING IT AND PROTECTING YOURSELF FROM IT
	3:00 PM TO 5:00 PM	(18) APPLICATION-SPECIFIC PLDs—A NEW THRUST	(19) PERSONAL-COMPUTER-BASED DATA ACQUISITION AND CONTROL	(20) SERVICES, ISSUES, AND TECHNOLOGY IN THE REALIZATION OF INTEGRATED SERVICES DIGITAL NETWORK (ISDN)	(21) BENEFITS OF ASIC DESIGN CENTERS
THURSDAY, NOVEMBER 19	9:00 AM TO 11:00 AM	(22) PROGRAMMING MICROCONTROLLERS —NEW SOFTWARE ENVIRONMENTS	(23) THERMAL CONSIDERATIONS IN SURFACE-MOUNT TECHNOLOGY	(24) SILICON SENSOR AND MICROSTRUCTURE TECHNOLOGY	
	12:30 PM TO 2:30 PM	(25) CMOS CORE PROCESSORS—THE KEY TO HIGH-PERFORMANCE ASIC	(26) POWER CONVERSION	(27) REAL-TIME MULTIPROCESSING TECHNOLOGIES	
	3:00 PM TO 5:00 PM	(28) HIGH INTEGRATION TECHNOLOGY FOR PERSONAL-COMPUTER DESIGN	(29) FLAT-PANEL TECHNOLOGY—"THE MEMBRANE ALTERNATIVE"	(30) LOW-POWER GaAs GATE ARRAYS—ALTERNATIVE TO HIGH-POWER ECL ARRAYS IN HIGH-SPEED SYSTEM DESIGN	

NOTE: ALL SESSIONS WILL BE HELD IN THE MOSCONE CONVENTION CENTER UNLESS OTHERWISE NOTED.

Transportation and parking at Wescon

As anyone who's been to San Francisco knows, the parking situation there is horrendous. Therefore, Wescon officials recommend that you park at Candlestick Park if you're driving in. It costs \$3, and you must be on your way out by 6:45 pm. If you take the BART (Bay Area Rapid Transit), get off at the Civic Center stop for (naturally) the Civic Auditorium and Brooks Hall. Get off at the Powell Street stop for the Moscone Center. If you travel by bus, take the 21 Hayes or 19 Polk for Brooks Hall and Civic Auditorium; take 15 Kearney or 30 Stockton for Moscone Center. The bus costs \$0.75, and the drivers *do not* make change.

GRAPH convention video review" organized by Stephen Keith, ACM/SIGGRAPH local-groups coordinator. The show will feature outstanding examples of computer graphics. The Electronic Theatre will also show selected short subjects during lunch.

Technical sessions

The program of technical sessions will cover a multitude of interesting hardware and software topics.

Tuesday, November 17, will see three sessions on high-performance VLSI, three sessions on software-applications tools, and three sessions exploring system solutions.

For example, **Session 3** on Tuesday will cover debugging of integrated systems. **Session 4** will add more sound and fury to the controversy between 32-bit RISC and CISC computer instruction-set schemas. **Session 2** will delve into the ill-defined problem of software verification. And **Session 8** has the intriguing title of "PC-based CAD—computer-aided design or computer-aided disaster? A user's perspective." Those familiar with the generally small-production-volume microwave market might be curious about **Session 9**, "High-volume microwave applications."

Wednesday's agenda will include multiple sessions on programmable logic devices (PLDs), three on power systems, and three on data-acquisition and control, as well as sessions on bus interfaces, metastability, and ISDN. Programmable logic devices will get coverage in **Session 10**, which will pose the question: Are PLDs just a stepping stone to ASICs or a long-term solution in their own right? **Session 18** will cover a subject dear to the hearts of chip vendors who are tired of offering look-alike, general-purpose PLDs: application-specific PLDs. PC-based data-acquisition systems are catching the eye of engineers now that the systems are finally achieving a level of performance that professional engineers can use. Check them out at **Session 19**, "Personal computer based data acquisition and control."

Thursday's visitors to Wescon will find three sessions on new-generation single-chip μPs as well as discussions on SMT, flat-panel switches, silicon sensors, real-time programming, and GaAs devices. For example, **Session 22** will cover programming single-chip μPs and discuss new software environments; **Session 27** will highlight real-time programming for multiple CPUs.

EDN

Article Interest Quotient
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High 503 Medium 504 Low 505

"THEY SAID NO ONE COULD PUT IT ALL ON ONE CHIP."

Introducing the SSI K224 With Everything You Want in a 2400 BPS Modem— With DSP on Chip.

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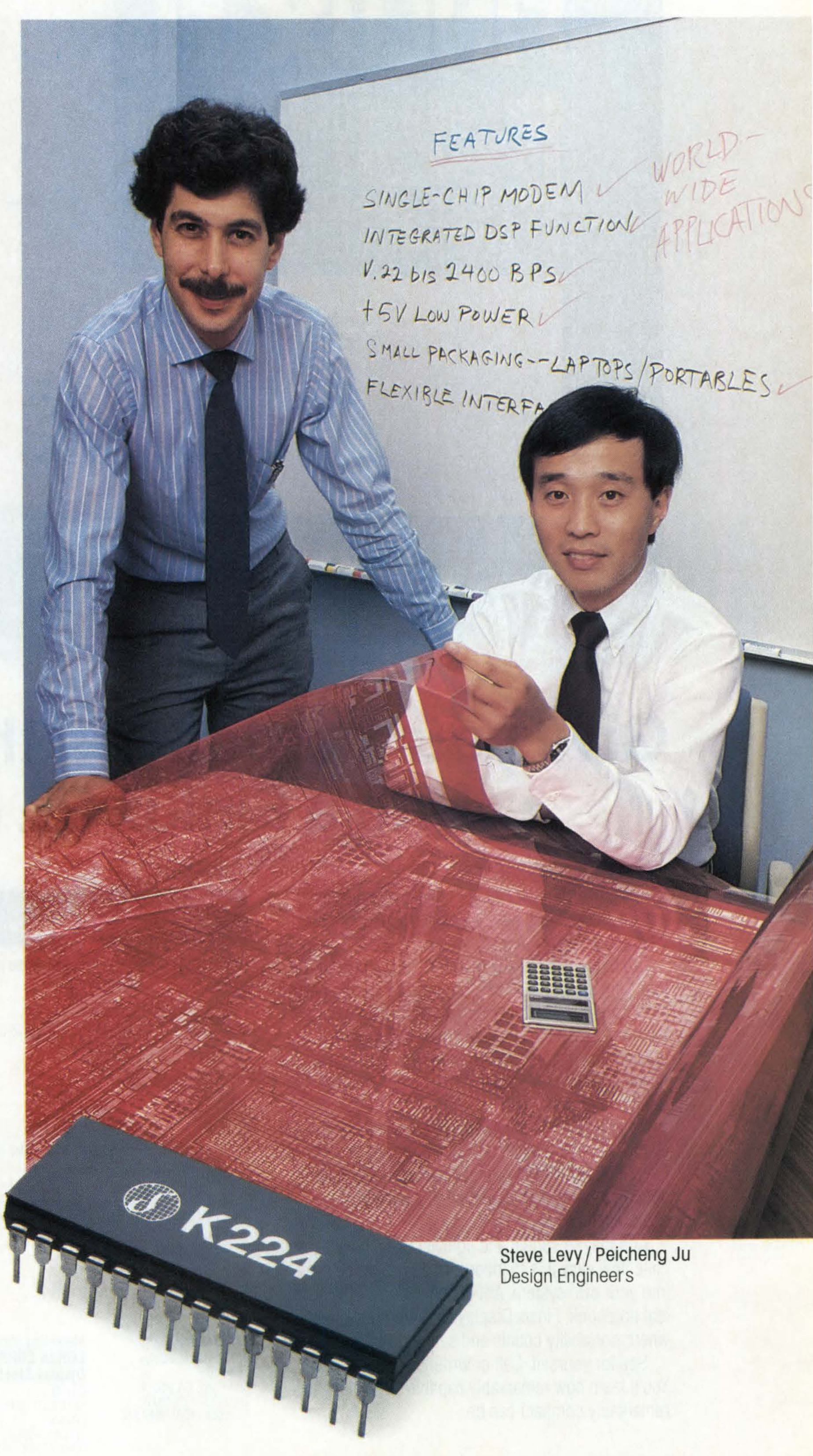
For more information on the SSI K224, or the complete K-Series family of compatible modem IC's, contact: **Silicon Systems**, 14351 Myford Road, Tustin, California 92680.



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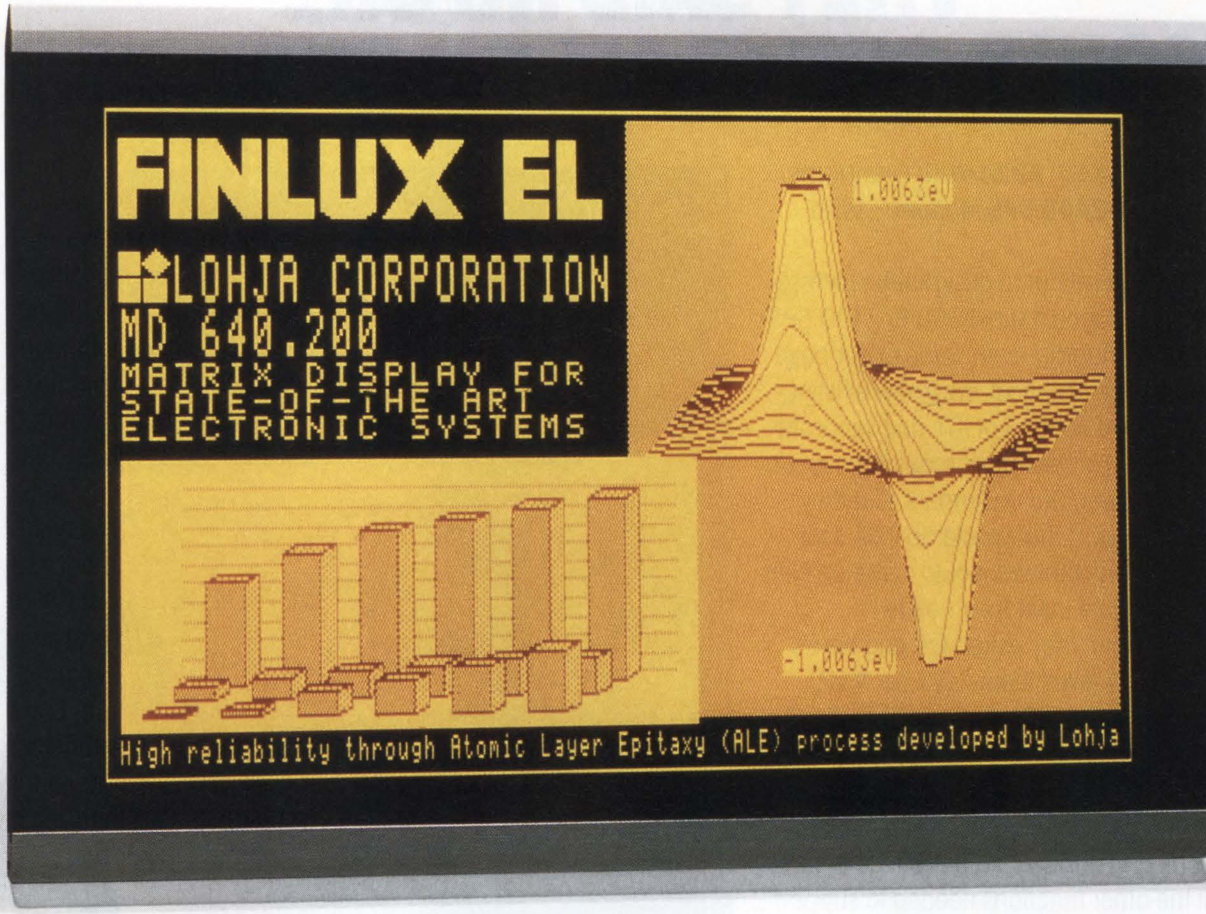

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	Input Voltages	Matrix Configuration	Display Area	Size	Weight
MD640.200-12	+5V/+12V	640 × 200 pixels	4.8 × 7.68 in.	6.24 in. (158.5 mm) H	13.4 oz. (375 g)
-10	+5V/+15V		(122 × 195 mm)	9 in. (228.5 mm) W	
				0.72 in. (18.3 mm) D	
MD512.256-33	+5V/+15V	512 × 256 pixels	3.85 × 7.69 in.	5.67 in. (144 mm) H	23 oz. (650 g)
-34	+5V/+12V		(195.2 × 97.7 mm)	10.2 in (260 mm) W	
-35	+5V/+12V		1.04 in. (26.5 mm) D		
-39	+5V/+12V**				
-37	+5V/+15V**				
-38	+5V/+24V**				
MD640.400-50	+5V/+12V***	640 × 400 pixels	4.8 × 7.68 in.	6.24 in. (158.5 mm) H	13.4 oz. (375 g)
			(122 × 195 mm)	9 in. (228.5 mm) W	
				0.72 in. (18.3 mm) D	

*Process developed by Lohja Corporation, Finland. **With integrated power supply and low power drivers. ***Available fourth quarter 1987.

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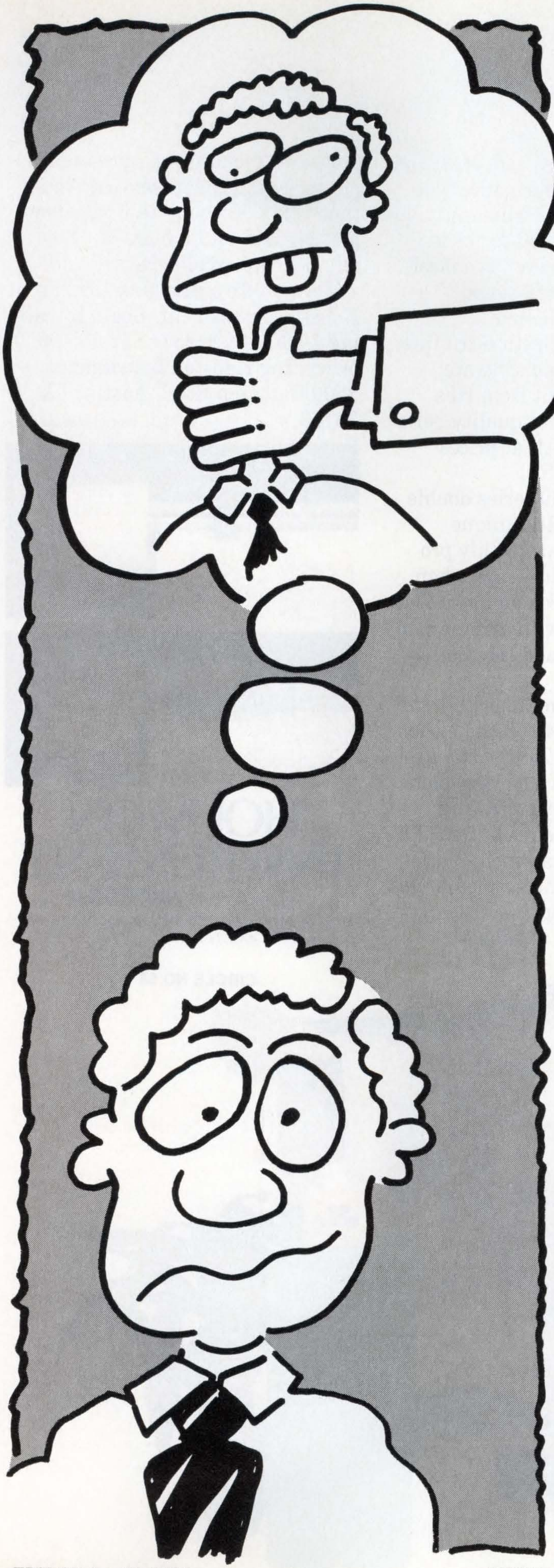
CIRCLE NO 100

See us at WESCON, Booth 5143



 CIRCLE NO 99

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FROM HOUSTON INSTRUMENT

Prepare to be impressed. Meet the new line of high-performance plotters from Houston Instrument.™ HI's sleek new DMP-60 series is designed to impress even the most demanding CAD professional.

Discover unprecedented flexibility—blended with ultra-fine resolution, speed, and software compatibility. Benefit from HI's rigorous standards for quality, reliability, and service. All at prices starting from $4,695.*

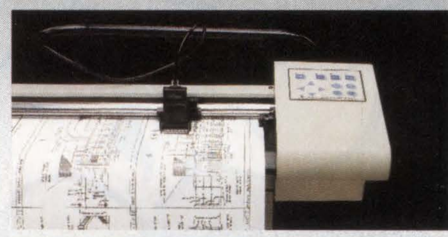
Watch the DMP-60 series double as a scanner with HI's unique SCAN-CAD™ option. Quickly produce multicolored drawings when you use the Multi-Pen adaptor. Plot several originals—without tying up your PC when you add HI's buffer expansion board.

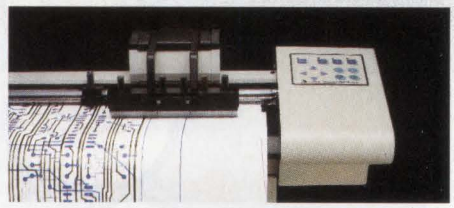
Select media as small as 8½″×11″ or as large as 36″×48″. Load either DM/PL™ or HP-GL 758X-compatible software. Then watch as your plotter quickly produces a drawing polished to a precise resolution of 5 ten-thousandths of an inch. Smile when you see smoothly formed circles, curves, and lettering.

Explore HI's host of support programs including an overnight plotter-replacement service. And then relax, knowing that HI's new plotters rest on 27 years of engineering excellence.

Move up. To a fine, new line. From Houston Instrument. Begin by calling 1-800-444-3425 or 512-835-0900 or writing Houston Instrument, 8500 Cameron Road, Austin, TX 78753.

**U.S. suggested retail price.*





HOUSTON INSTRUMENT

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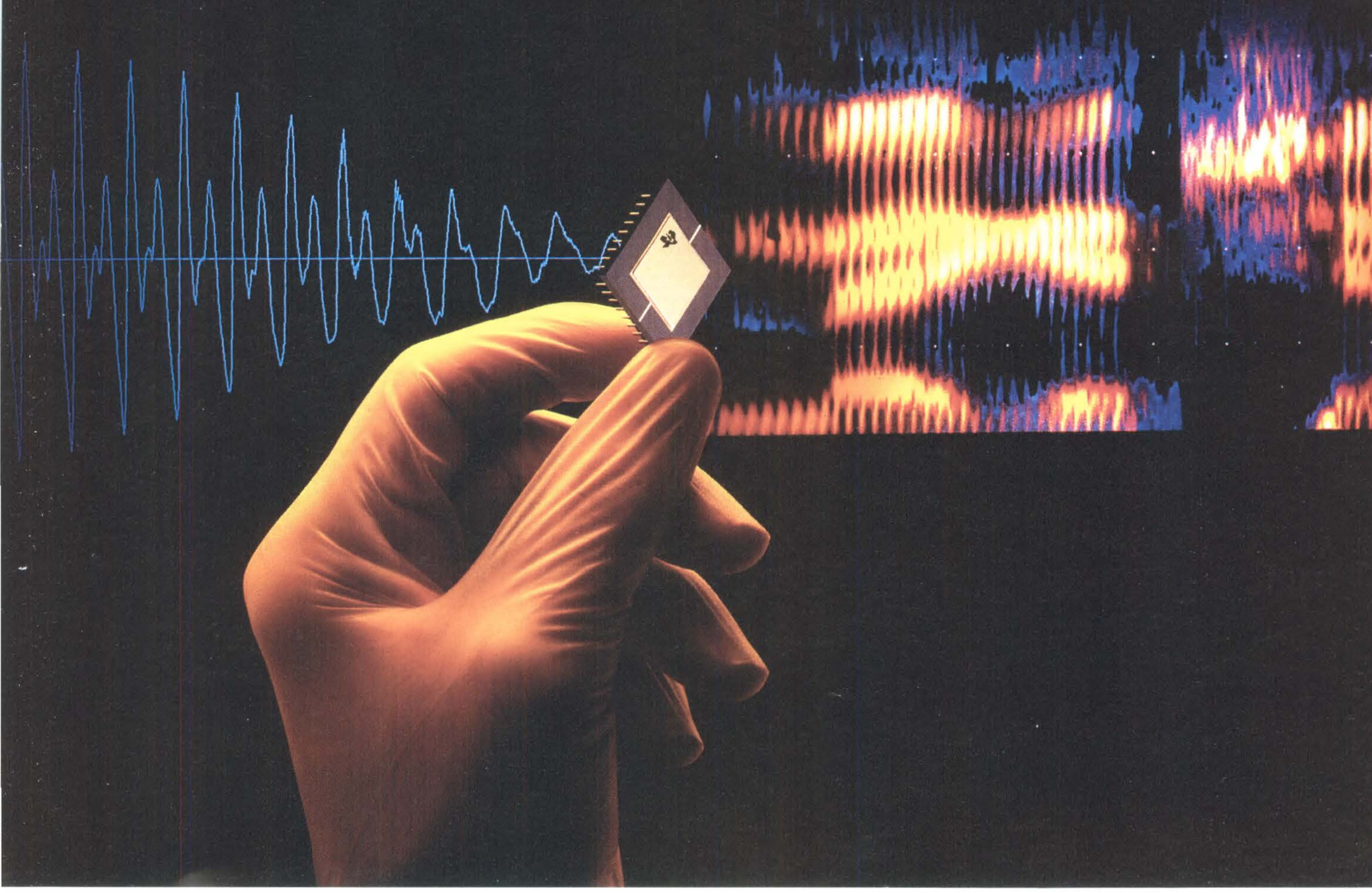
CIRCLE NO 98

TEXAS INSTRUMENTS REPORTS ON DSP

IN THE ERA OF MegaChip TECHNOLOGIES



DSP in the Era of MegaChip Technologies:

Digital signal processors are turning up winners

TI's TMS320 DSPs add high performance at costs low enough to open new worlds of applications — from a high-performance Formula 1 car suspension to an intelligent doll and everything in between.

The results are in. You can add more performance at lower cost desig ing with the standard in digital signal processors (DSPs), TI's TMS320 fami There are now even more reasons tha ever to get the advantages of TI DSP performance in applications wherever realtime number crunching is essenti

from Texas Instruments
in all sorts of places.

hese advantages can make a differ-
nce in applications as wide ranging as
odems, disk servo controllers, sona-
uoys, and voice multiplexers to
pectrum analyzers and graphics
orkstations.

Getting started in DSP design is
sier with Texas Instruments training

and support. But once you see what the TMS320 family can do, you'll want the features TI DSP can give your designs.

"Handling performance is up there next to speed in Formula 1 racing. TI's TMS320 gives us a real advantage — enough to win a Grand Prix." **Peter G. Wright, Technical Director, Lotus Engineering**

Lotus designed the active suspension in their Camel-Lotus-Honda Formula 1 car to approach the theoretical maximum-control point which gives the best balance between handling and performance. At racing speeds, each wheel is positioned by the TMS320-controlled hydraulics. A single TMS320 chip measures wheel forces and displacements and reads data from a body-mounted inertial platform. Then, in real time, the chip computes wheel position and controls actuators that adjust the suspension components to precise settings.

The TMS320 can also handle closed-loop engine control and more responsive braking systems, as well as many other automotive applications.

"The TMS320 helps us with one of our toughest tasks — designing toys with exciting features at prices that will sell." **Dave Small, VP Engineering, Worlds of Wonder, Inc.**

Worlds of Wonder is a pioneer in developing interactive toys and now has an innovative new doll named Julie™ Using a single TMS320 chip, Julie's designers are able to give her voice-recognition ability, coupled with synthesized speech and coordinated facial movement.

The TMS320 design expands the applications for affordable consumer products like solid-state answering machines, cellular phones, improved hearing aids, and animated electronic games.

TI's MegaChip Technologies

Our emphasis on volume manufacturing of high-density CMOS circuits is the catalyst for ongoing advances in how we design, process, and manufacture semiconductors and in how we serve our customers. These are our MegaChip™ Technologies. They are the means by which we can help you and your company get to market faster with better, more competitive products.

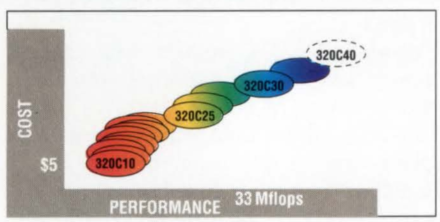
Winning designs come from a family of winners

There are 15 compatible members in the TMS320 family *(see the road map below)*, featuring two new DSPs with on-chip EPROM, the TMS320E15 and the TMS320E17. For applications requiring off-chip memory, there is the new CMOS EPROM, the TMS27C292, with 35-ns speed.

New interface alternatives include the low-cost CMOS TCM29C18/19 Combo Codecs with A/D, D/A, and filters all on a single chip.

The high-performance TLC32040 Analog Interface Circuit has 14-bit A/D and D/A and programmable filters.

For higher performance in digital signal processing, you can use building-block products like TI's microcodable ACT88XX 32-bit processor family.



From $5 to 33 Mflops: With three generations covering 15 products, the TMS320 family offers software compatibility to protect your development investment and provide a smooth path to future applications.

For more information on support for the TMS320 family, please turn the page.

Salon des Composants sessions will emphasize developments in passive components

Peter Harold, *European Editor*

Components for telecommunications, automotive systems, and industrial automation—three of Europe's fastest growing electronic-component markets—will figure prominently in the 28th Salon International des Composants Électroniques exhibition in Paris, France. The exhibition will take place November 16 through 20 at the North Paris exhibition grounds at Villepinte. With more than 1500 exhibitors occupying four halls at the site, the show will give you the opportunity to view the latest components in all fields of electronics. You'll also be able to listen to international panel discussions on quality-assurance programs and on the state of the semiconductor industry.

Despite its French name, the exhibition isn't mainly a French affair —752 of the 1261 manufacturers registered by September 1 were from countries other than France. In addition, 260 French distributors will be at the exhibition to display products from other non-French manufacturers. The show is divided into two sections: one dedicated to electronic components and subassemblies, and the other intended for electronic-test and -measurement and ATE equipment. Components, however, will continue to dominate the exhibition.

The international panel discussions, which are becoming a regular feature of the exhibition, will take place on Tuesday, November 17, and will be divided into a morning and an afternoon session. At the morning session, participants will discuss ways that the US and Western Europe can respond to the threat of Japanese dominance in the semiconductor industry. If you're an industry analyst, you'll want to attend this discussion. You'll have the opportunity to question the experts on whether collaboration agreements or mergers—such as the recent merger between Thomson Semiconductors (France) and SGS (Italy)—will be effective in helping the European semiconductor industry survive against both US and Japanese competition.

The afternoon session will focus on the cost and value of the quality-assurance programs, such as zero-defect policies, that some semiconductor manufacturers are currently offering. It will also examine the relative merits of ship-to-stock or just-in-time delivery programs. The participants will debate whether these policies and programs reflect users' real requirements, or whether they're merely a marketing ploy by the semiconductor manufacturers to capture greater market share.

A program of technical sessions will also accompany the exhibition this year: The Second International Conference on Passive Components will run from November 18 to 20. The conference will focus on advancements in technology that help passive components keep pace with semiconductor devices. The sessions will also deal with the passive aspects of active-device manufacture —for example, die mounting and packaging, soldering, and protection techniques.

A paper by an invited speaker will open each of the main conference sessions. The sessions will cover VLSI packaging and interconnection techniques, capacitors, connectors, resistive and protective devices, and optical components and human/system interfaces. In parallel with these main sessions will be sessions on magnetic materials and resistive devices, capacitors, and transducers. In total, three opening reviews, five papers from invited speakers, and 65 submitted papers will be presented over the 3 days.

Be sure to leave yourself plenty of time to walk the floors of the exhibition, however. Depending on the breadth of your interest in electronic components, it could easily take you two or three days to explore every manufacturer's offerings. Once you've satisfied your immediate information requirements, you may want to spend some time at the large semiconductor manufacturers' stands to see how today's technology will affect the automobiles and telecommunication systems of tomorrow. And at the end of the day, when you're footsore from tramping the exhibition floors, remember that the Paris nightlife is only 20 minutes away by Métro. **EDN**

For more information . . .

For more information on the Salon International des Composants Électroniques exhibition and the associated conference program, contact the following organizers directly.

SDSA
20 rue Hamelin
75116 Paris, France
Phone (1) 45051317
TLX 630400

Tables Rondes 1987
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Article Interest Quotient
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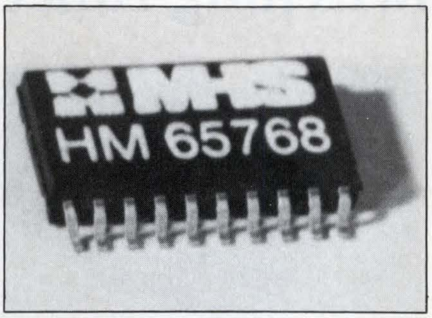
CMOS static-RAM families add high-performance and low-cost parts

Additions to the Comet family of high-speed 16k-bit CMOS static RAMs include the HM65767F, HM65768F, and HM65728H, all of which have faster access times than those of previous Comet family devices. The 16k×1-bit HM65767F and 4k×4-bit HM65768F have access times of 20 nsec, and the 2k×8-bit HM65728H has an access time of 25 nsec. The RAMs are available in versions that operate over the commercial and military temperature ranges, and they come in plastic or ceramic DIPs, small-outline surface-mount packages, or leadless chip carriers. Volume pricing for commercial-temperature-range devices in plastic DIPs and small-outline packages ranges from $2.50 to $7, depending on access time and organization.



The vendor has also added members to its HM65641 line of 8k×8-bit CMOS static RAMs. The additions include both high-performance and low-cost parts. The HM65641B has a 70-nsec access time. Its standby current is 50 μA, and its data-retention current, at a 2V supply voltage, is 20 μA. The company believes this part to be the lowest-power 8k×8-bit device on the market. The HM65641C is a low-cost version of the HM65641. It has an 85-nsec access time, a standby current of 500 μA, and a data-retention current (at 2V) of 200 μA. Both devices are available in versions that operate over the military and industrial temperature ranges, and both come in either 28-pin ceramic DIPs or 32-contact leadless chip carriers. Prices for military-temperature-range devices in ceramic DIPs range from $46 to $280, depending on access time, standby current, and quantity.

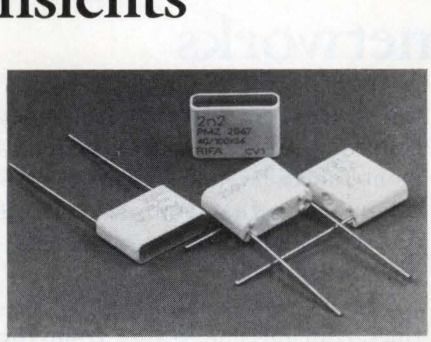
Matra-Harris Semiconducteurs, Centre de Guyancourt, 38 Blvd Paul Cézanne, BP 309, 78054 Saint-Quentin-Yvelines Cedex, France. Phone 1-30607000. TLX 697317. Hall 3, alley 36, stand 19.

Circle No 708

RFI-suppression capacitors handle 8-kV transients

Employing a self-healing paper dielectric that can withstand a dV/dt as high as 2000V/μsec, the PMZ2067 Series RFI-suppression Y capacitors can handle voltage transients as high as 8 kV. They are suitable for use in applications that require long component lifetimes and experience high-voltage transients. For protection against fire in the event of component failure, the capacitors are housed in a self-extinguishing epoxy resin encapsulation that meets the requirements of UL 94V-0.

These multilayer metallized-paper capacitors are available with capacitance values ranging from 0.001 to 0.022 μF, and they have a nominal capacitance tolerance of



±20%. They have a voltage rating of 250V ac at 50 Hz, and their operating temperature range is −40 to +100°C. Their recommended dc-operating-voltage limit is 1000V dc. At 1 kHz, the capacitors spec a dissipation factor of 1.3%. Their insulation resistance, measured at 23°C after 60 sec at 500V dc, is ≥1200 MΩ.

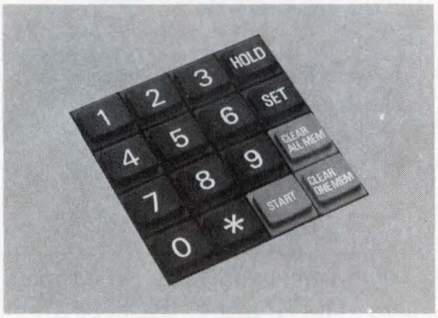
Each capacitor is tested to withstand a dc voltage of 2.7 kV, and each is subjected to a pulse test using a 10-kV peak, 1.2/50-μsec full wave, according to IEC-60. The capacitors' electrical and mechanical properties make them suitable for use in IEC-40/100/56 climatic category environments. The capacitors come in four case sizes ranging from 13×5.5×13.5 mm to 18×8.5×17 mm. The smallest case size has leads that are 10 mm apart; leads for all other case sizes are 15 mm apart. Around 6 Swedish krona (10,000).

Rifa AB, Box 945, 39129 Kalmar, Sweden. Phone (0480) 15660. TLX 43062. Hall 2, alley 24, stand 70.

Circle No 713

Gold-contact pc-board switches provide several switching functions

Models 15.502 and 15.552 are gold-contact versions of the company's momentary and alternate-action silver-contact switches. These low-profile, pc-board-mounting modular switches are suitable for low-voltage and dry-circuit switching, or for applications in which they might be subjected to corrosive environments. Each switch has a contact configuration that allows you to implement a variety of switching functions—including two changeover contacts, two normally open or normally closed contacts, two normally open and two normally closed contacts, or polarity-reversal contacts —simply by altering the pc-board tracking.



The switches' initial contact resistance is 35 mΩ. The switch contacts have a maximum switched current rating of 250 mA, and a maximum voltage rating of 120V. When they are not switching, they can carry a current of 0.5A. Their ac and dc power ratings are 9 and 6W, respectively. Their contact bounce is <5 msec. The switches have an operating pressure of around 2 newtons, and the key travel is 1.8 mm. The momentary-action version of the switch has a lifetime of 1,500,000 switching cycles; the alternate-action version has a lifetime of 500,000 cycles. The switches' operating temperature range is −25 to +75°C.

They have a 12.6-mm square footprint and presoldered leads that fit into pc-board holes on a 0.1-in. matrix. The switches accept a variety of keycaps and bezels, including the company's new Model 16.700 concave keytops. The gold-contact switches cost less than $1.50 (1000).

Mec, Industriparken 23, 2750 Ballerup, Denmark. Phone 02-973366. TLX 9125649. Hall 4, alley 43, stand 97.

Circle No 714

Single-chip token-bus modem supports MAP networks

The SAB82511 baseband modem provides layer-1 functions of the OSI communications model for IEEE-802.4 token-bus networks. It is therefore suitable for use in MAP (manufacturing automation protocol) networks. An associated token-bus controller, the SAB82510, will provide layer-2 functions; it's scheduled for introduction before the end of this year.

Using phase-coherent FSK modulation, the modem transmits data at a rate of 5M or 10M bps. It also includes a digital demodulator to decode received data. The modem chip generates the receive and transmit clocks from a 20-MHz crystal or from an external frequency source, provides station-management functions, and has an electrical interface that you can connect directly to a network-medium coupling transformer.

The modem recognizes five distinct transmission states from the media-access control (layer-2) functions of the token-bus controller: silence, nondata, pad-idle, data one, and data zero. It modulates the transmit carrier signal accordingly. It also supports such station-management functions as a loop-back mode for use in fault diagnosis. In addition, the modem incorporates a watchdog timer to prevent the modem from locking up the network by going into continuous-transmit (jabber) mode.

The SAB82511 is packaged in a 44-pin plastic leaded chip carrier and operates over 0 to 70 °C. It uses one 5V supply and draws a maximum supply current of 290 mA. All inputs and outputs that interface the modem to the token-bus controller are TTL-compatible. Approximately $50 (1000).

Siemens AG, Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025. Hall 4, alley 43, stand 8.

Circle No 711

Electroluminescent display provides graphics and 25-line×80-column text

The Finlux MD640.400 flat-panel electroluminescent display has a screen resolution of 640×400 pixels, allowing you to display high-resolution graphics or 25 lines of text at 80 characters/line. The display comes with a display-driver board and power supply and requires only TTL-level video data, video clock, and horizontal and vertical synch-pulse inputs. It's designed to scan at a refresh rate of 60 Hz.

Comprising a matrix of 0.22-mm square pixels on a 0.3-mm pitch (which is equivalent to 83 pixels/in.), the display produces a flicker-free yellow image with a viewing angle of greater than 140°. The pixel luminance is typically 90 cd/m². The display area is 122 mm high and 195 mm wide, and the whole display assembly, including the drive-electronics board, measures 158.5 mm high, 228.6 mm wide, and only 18.3 mm deep.

A dc/dc converter, which you can use remotely or mount on the back of the assembly, is supplied with the unit; it's connected to the display via a ribbon cable. The converter requires dc inputs of 12 or 15V and 5V, and the display typically consumes 16W. It operates over 0 to 55°C.

Prototypes of the display are available now; production shipments are scheduled to start during the first quarter of 1988. The initial sample price for the MD640.400 is DM 2710, or $1650.

Lohja Corp, Electronic Display Div, Box 46, 02201 Espoo, Finland. Phone 042001. TLX 125023.

Circle No 709

Finlux Inc, 20395 Pacifica Dr, Suite 109, Cupertino, 95014. Phone (408) 795-1972. Hall 4, alley 45, stand 126.

Circle No 710

ECL gate arrays let you make tradeoffs between speed and power

When you design with the SH100E family of ECL gate arrays, you can select the logic gates to operate at one of three speed/power levels. For designs that require some parts of the logic to run faster than other parts, you can mix these three speed/power levels on a single device, provided that you don't exceed the maximum power-dissipation level of the PGA package.

The standard speed level for a logic gate provides you with a typical gate delay of 130 psec, a delay per unit load of 30 psec, and a delay per millimeter of routing metal of 150 psec. This speed level results in an average power dissipation per gate of 1 mW for a −3.3V supply voltage and 1.5 mW for a −4.5V supply voltage.

Selecting the low-power mode increases the typical gate delay, the delay per unit load, and the delay per millimeter of metal to 220, 60, and 300 psec, respectively, but reduces the average power dissipation per gate to 0.5 mW for a −3.3V supply and 0.75 mW for a −4.5V supply.

Selecting the high-speed mode leaves typical gate delays at 130 psec, but reduces the delay per unit load and the delay per millimeter of metal to 15 and 75 psec, respectively. However, it increases the average power dissipation per gate on −3.3 and −4.5V supplies to 2 and 3 mW, respectively.

The initial offering is a 2500-gate array, but during 1988 the company plans to extend the family to include arrays with gate counts of between 1000 and 10,000. The array's I/O pins are 10K/100K ECL compatible, and on all the arrays except the 10,000-gate version, you can optionally configure the I/O pins to be LSTTL compatible.

A library of ECL and current-mode-logic functions for the product is already available, and the vendor will accept designs for implementation in silicon during the second quarter of 1988. For the 2500-gate array, the company predicts that nonrecurring layout and prototyping charges will be less than DM 100,000, and the per-piece cost will be less than DM 500 (1000).

Siemens AG, Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025. Hall 4, alley 43, stand 8.

Circle No 716

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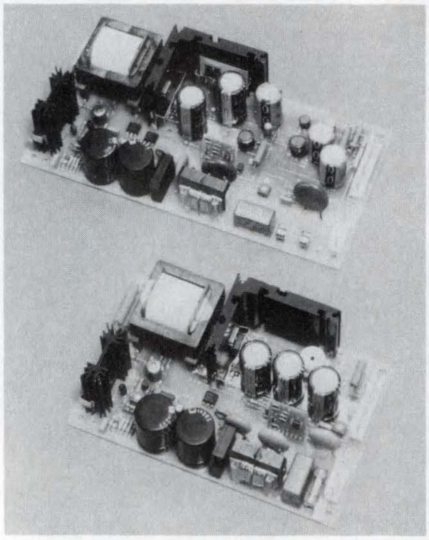
Convection-cooled 40 and 60W switch-mode power supplies fit on single Eurocards

The 190 Series 40W and 60W frameless switch-mode power supplies employ 150-kHz self-oscillating flyback-converter technology and achieve an MTBF of 40,000 hours. The 40W range comprises single-output versions with a 5V/6A, 12V/2.5A, or 24V/1.25A output; dual-output versions with a 5V/4A main output and a 12V/2A auxiliary output or with ±12V/1.25A outputs; and triple-output versions with a 5V/5A main output and 12V/2A and −12V/0.5A auxiliary outputs, or with a 5V/4A main output and either ±12V/0.8A or ±15V/0.5A auxiliary outputs.



The 60W range comprises single-output versions with a 5V/12A, 12V/5A, or 24V/2.5A output; dual-output versions with a 5V/8A main output plus a 12V/3A auxiliary output or with ±12V/2.5A outputs; and triple-output versions with a 5V/8A main output and auxiliary outputs of 12V/3A and −12V/1A, or with a 5V/8A main output and ±12V/1A auxiliary outputs.

All the main outputs are fully regulated: The line regulation for ±10% line input variations is ±0.2%; the zero- to full-load regulation is ±2%. You can reduce the load regulation to ±0.5% by using the remote-sensing terminals provided on single-output versions of the power supplies. All the main outputs have potentiometer adjustment.

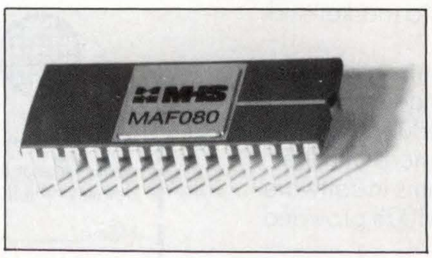
The auxiliary outputs have a line regulation of ±0.5% and a half- to full-load regulation of ±5%. All the outputs have short-circuit protection, and the 5V outputs have overvoltage protection. All the power supplies operate from 90 to 140V (or 180 to 264V), 47- to 63-Hz ac line supplies. The power supplies operate over 0 to 70°C but require linear derating to 50% between 50 and 70°C. $80 to $120.

Philips, Industrial and Electro-acoustic Systems Div, 5600 MD Eindhoven, Netherlands. Phone (040) 788620. TLX 35000. Hall 1, alley 17, stand 70.

Circle No 712

Low-cost CMOS gate arrays achieve gate delays as low as 1 nsec

The MAF Series gate arrays are fabricated in 1.2-μm silicon-gate CMOS technology; they achieve typical gate delays of 1 nsec, so they're suitable for use as low-power replacements for bipolar PLDs. Gate complexities range from 250 to 1200 gates. When it's operating from a single 5V supply at a clock speed of 10 MHz, the 1000-gate array typically dissipates 250 mW.



Because the MAF arrays are architecturally the same as the company's MA Series gate arrays, you can use the same design tools and libraries that the vendor supplies for the MA Series. The vendor also offers software that allows you to develop designs on a range of computers and workstations, including the IBM PC, Daisy workstations, and VAX computers.

Packaging options for the arrays include DIPs, surface-mount packages, and pin-grid arrays. The packages can have as few as eight pins or as many as 68. A gate array in a 40-pin plastic DIP costs $2.30 to $4.30 (100), depending on the number of gates.

Matra-Harris Semiconducteurs, Centre de Guyancourt, 38 Blvd Paul Cézanne, BP 309, 78054 Saint-Quentin-Yvelines Cedex, France. Phone 1-30607000. TLX 697317. Hall 3, alley 36, stand 19.

Circle No 715

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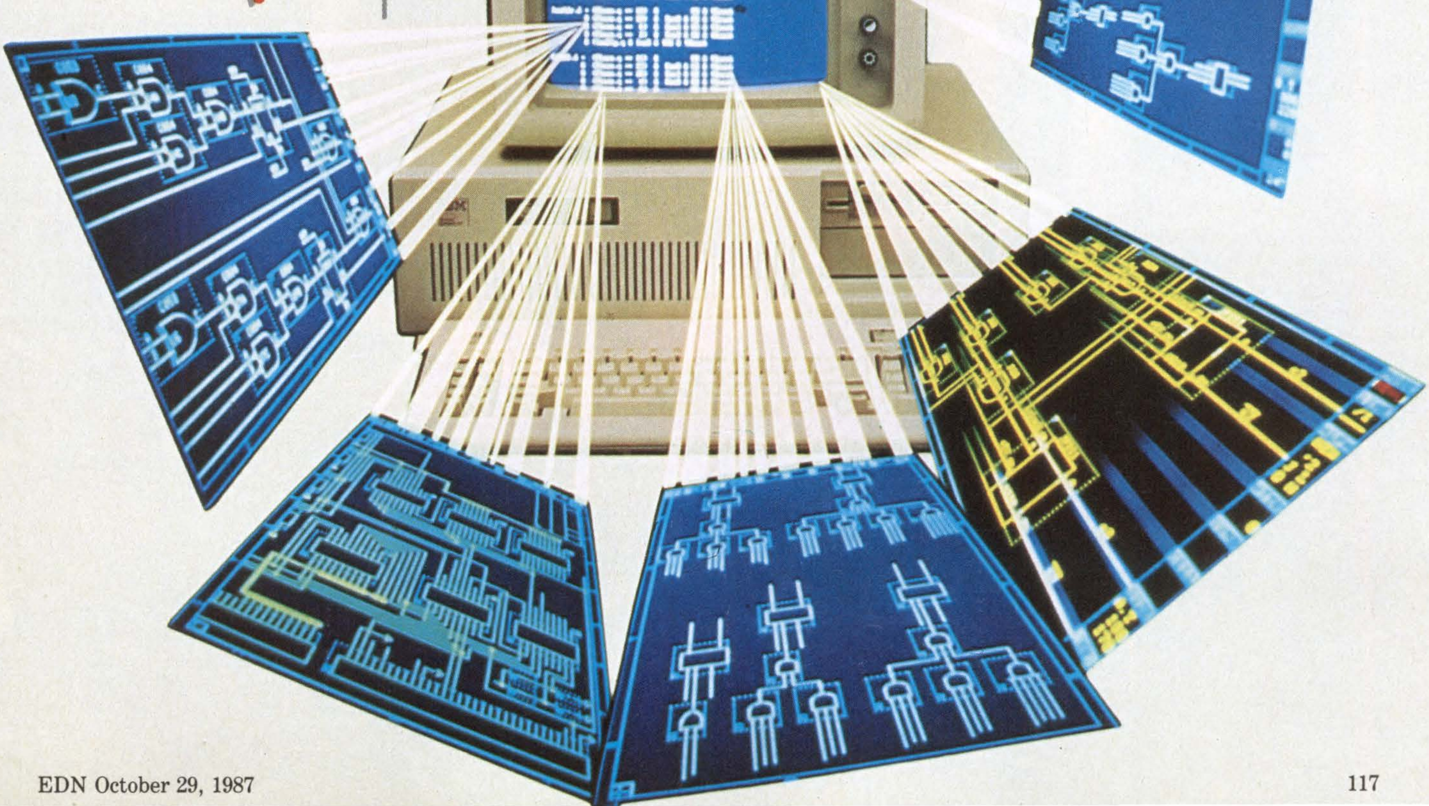

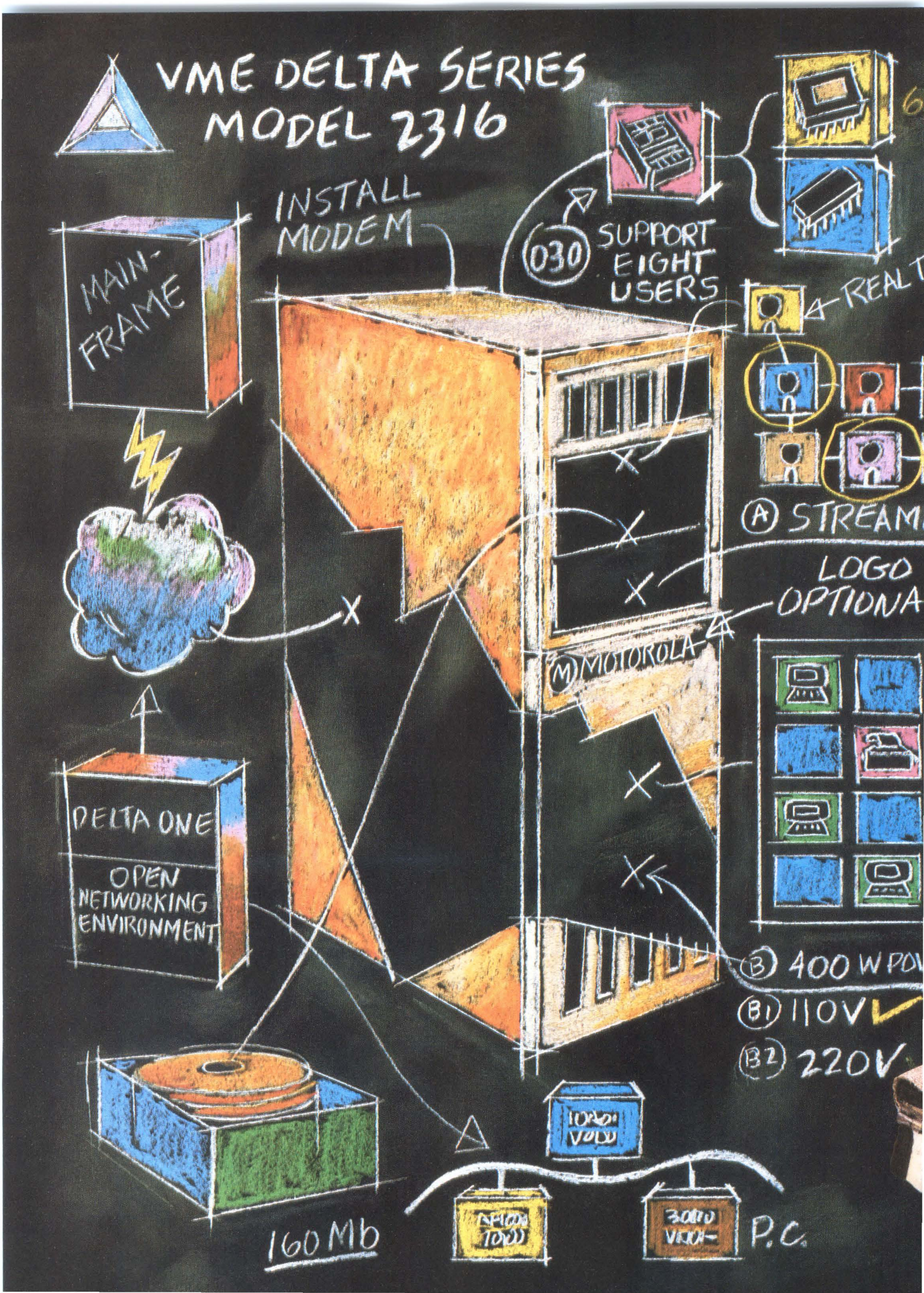

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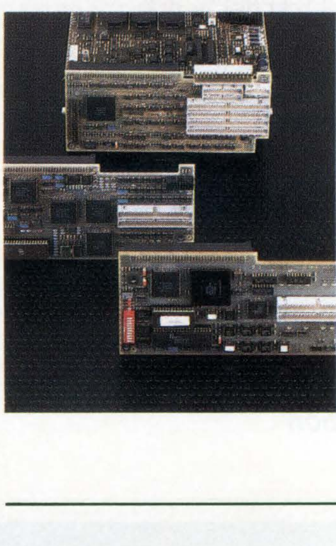

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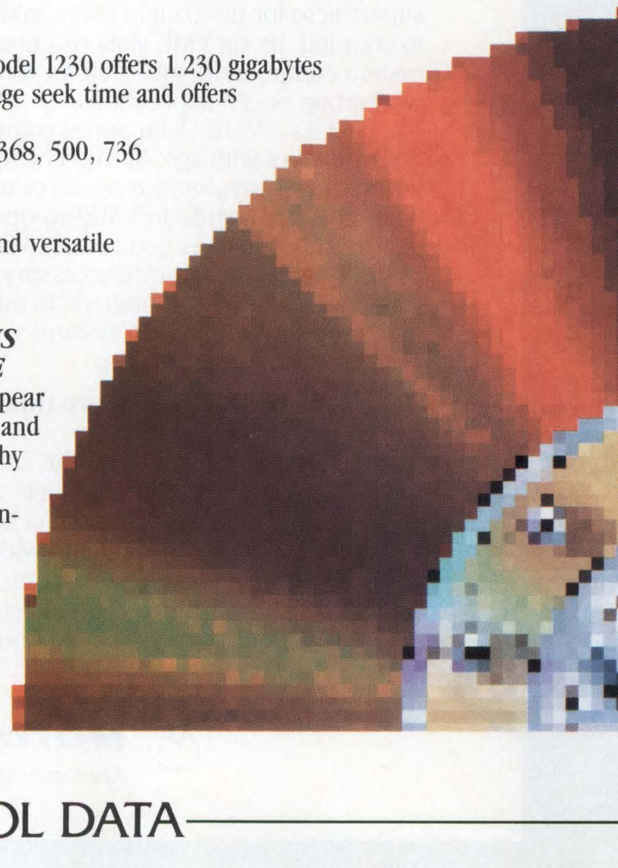
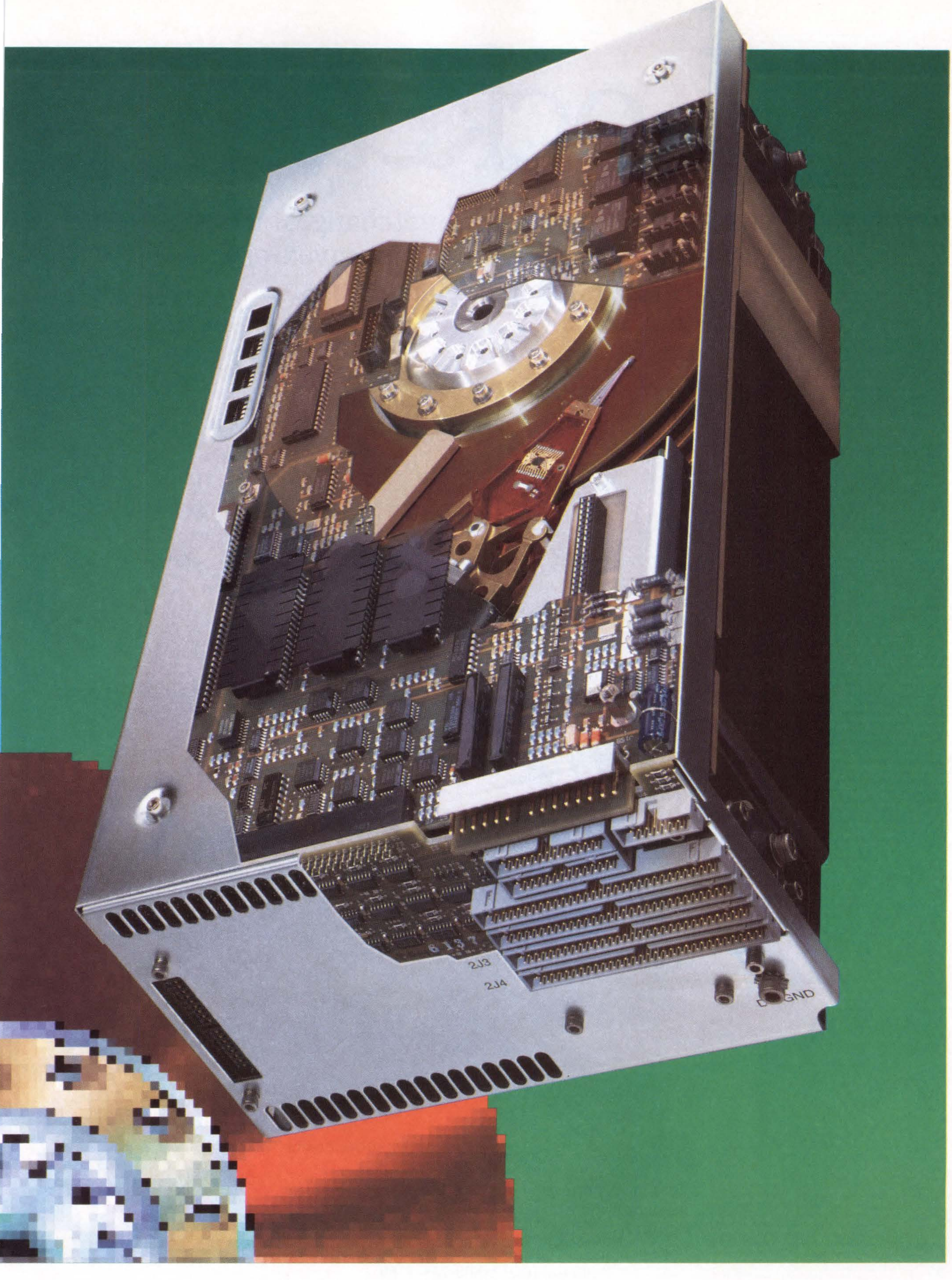


CONTROL DATA



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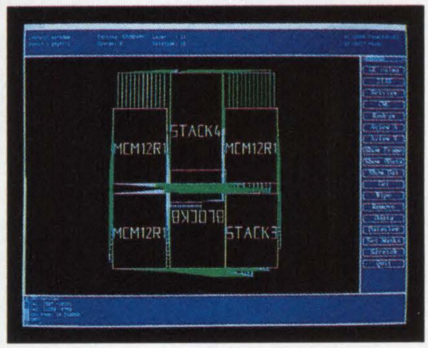

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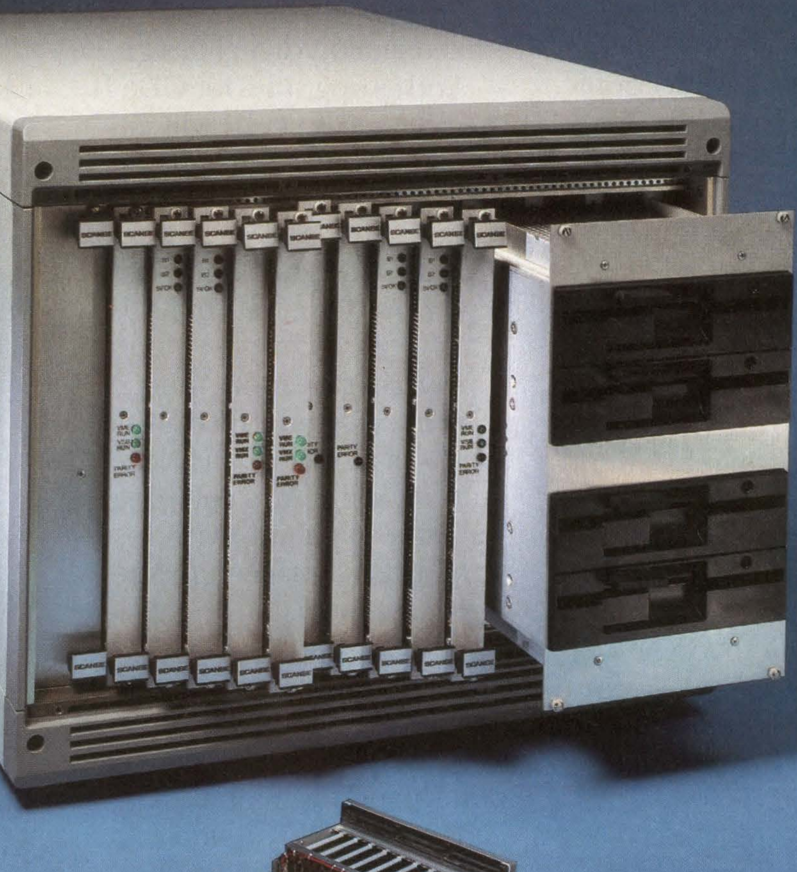

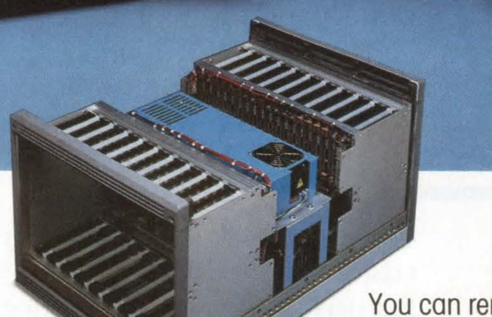

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Registered I/O and enhanced controls make EPLD suitable for µP designs

The 5AC312 is a CMOS, UV-erasable programmable logic device (EPLD) with enhancements to the standard PLD architecture that make it especially suitable for µP applications. The 24-pin PLD runs at 40 MHz with no feedback (25-nsec t_{PD} typ) and consumes 150 µA of standby current. (The programmable, low standby current comes at the price of an additional 10-nsec delay.)

The device has programmable outputs and programmable inputs. The 5AC312's 12 programmable output macrocells are similar in function to those of the industry-standard 22V10 PLD. As **Fig 1** shows, you can program the device's output macrocells to act as D, T, or JK registered outputs; combinational outputs; buried state registers; or inputs. An XOR gate in the signal path allows you to program the output's polarity. Note that because the macrocell has two feedback paths into its AND/OR array, you can use it as an input and a buried state register simultaneously.

More unusual are the device's programmable inputs (**Fig 2**). You can program each of the eight inputs individually to work as a register, a latch, or a conventional flow-through input. You can clock the latches and registers either with an external pin or from a product term (P term). If you choose the P term for control, the external-control pin can function as an asynchronous input to the AND/OR array. The ability to clock both inputs and outputs separately suits µP applications that employ multiphase clocks.

Further, for µPs with multiple qualifiers, the device has two product terms (instead of the usual single term) for each of its output-macrocell, secondary control signals: output enable, preset, clear, and clock.

Internally, the PLD's AND/OR array has a unique architecture that can permit a higher degree of P-term utilization than is possible with conventional PLDs. Conventional PLDs have a fixed number of AND gates associated with each output's OR gate. The 5AC312 has eight AND gates (or P terms) feeding each output's OR gate (**Fig 1**); the eight AND gates are divided into two groups of four.

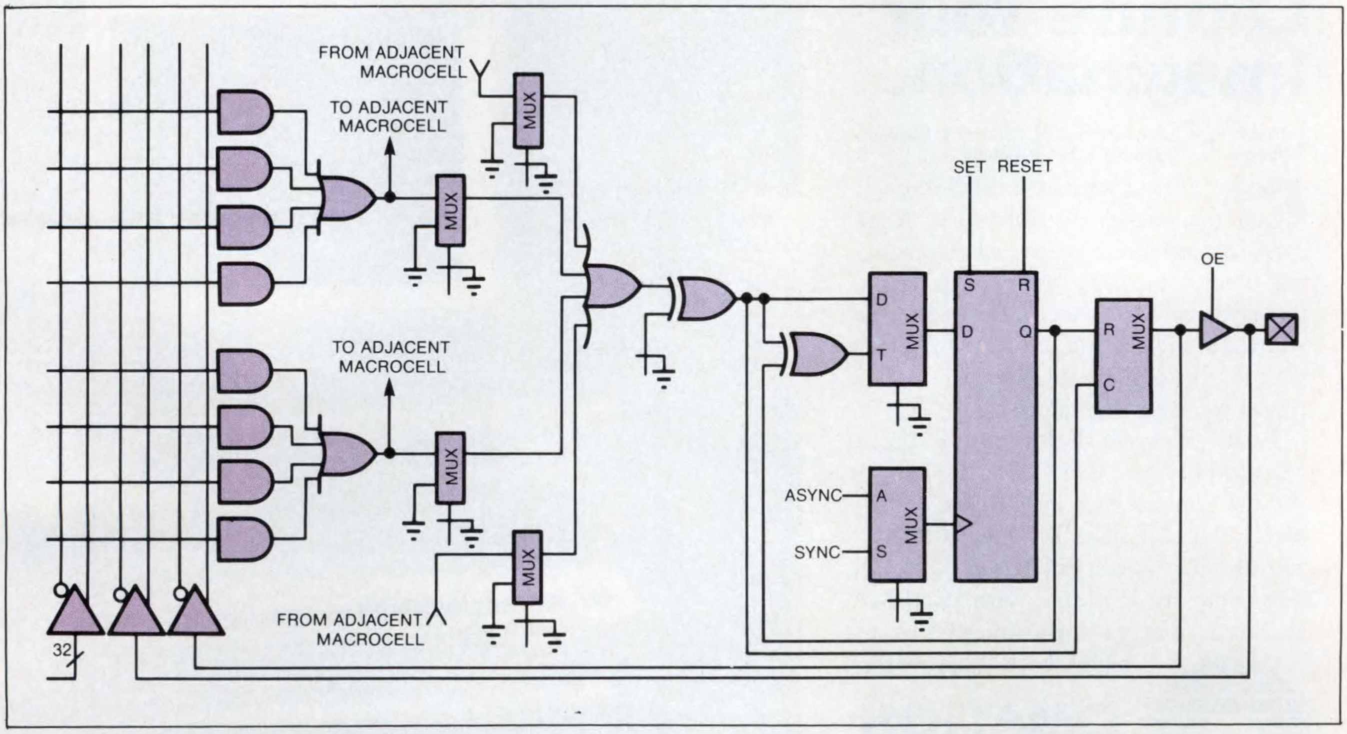


*Fig 1—**You can program the 5AC312's 12 output macrocells** to act as D, T, or JK registered outputs; combinational outputs; buried state registers; or inputs. The XOR gate in the signal path sets the output's polarity. Note also that you can assign P terms in groups of four (via multiplexers) to either the macrocell or an adjacent macrocell. Not shown in this figure are the two P terms (instead of the usual single P term) that drive the output macrocell's secondary control lines.*

Each group of four first drives its own 4-input OR gate. The outputs of the two OR gates go to a pair of multiplexers. The multiplexers, in turn, feed either their own output macrocell or an adjacent macrocell. Thus, you can assign four, eight, 12, or 16 P terms to a given output macrocell.

The architectural complexity of the 5AC312 taxes the capabilities of PLD software. Currently, only the vendor's iPLDS II version 1.5 software supports the device. The vendor claims that because its UV-erasable CMOS technology is more reliable than bipolar fuse-link technology, and because it programs, tests, and erases each device before shipping, you do not need to perform any testing on devices after you program them at your facility. This purportedly high, no-test AQL (acceptable quality level) stands in sharp contrast to bipolar devices, which require burn-in and testing after programming to achieve a high AQL.

The 5AC312 will be available in sample quantities this quarter; production quantities will be available in the first quarter of 1988. Windowed devices cost $21.50 (100), and production quantities of nonwindowed, one-time-programmable (OTP) devices will be $10; iPLDS II version 1.5 costs $3450.

—*Charles H Small*

Intel Corp, Literature Dept W-388, 3065 Bowers Ave, Santa Clara, CA 95052. Phone local office.

Circle No 722

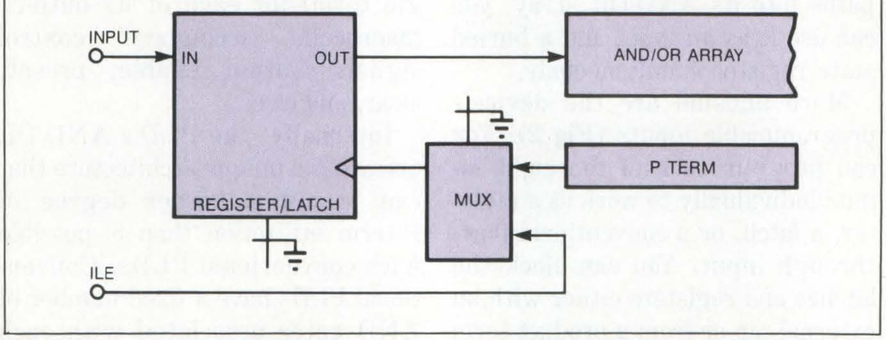


Fig 2—The UV-erasable device's eight inputs *are also programmable. The inputs can function as latched, registered, or standard inputs. You can clock the latched or registered inputs either with an external pin or from a P term.*

CIRCLE NO 96

Five-chip set eases design of 100M-bps, fiber-optic local-area networks

The Supernet 5-chip set is compatible with ANSI X3T9.5, which is also known as the Fiber Distributed Data Interface (FDDI) standard. FDDI allows as many as 500 network nodes to transfer data at 100M bps. The distance between nodes can be 2 km, and the total fiber length can be as great as 100 km.

FDDI is organized as a dual ring of optical fiber—a primary ring and a secondary ring. The rings consist of a series of point-to-point connections between neighboring nodes. If a station or a link fails, the secondary ring can act as a backup ring.

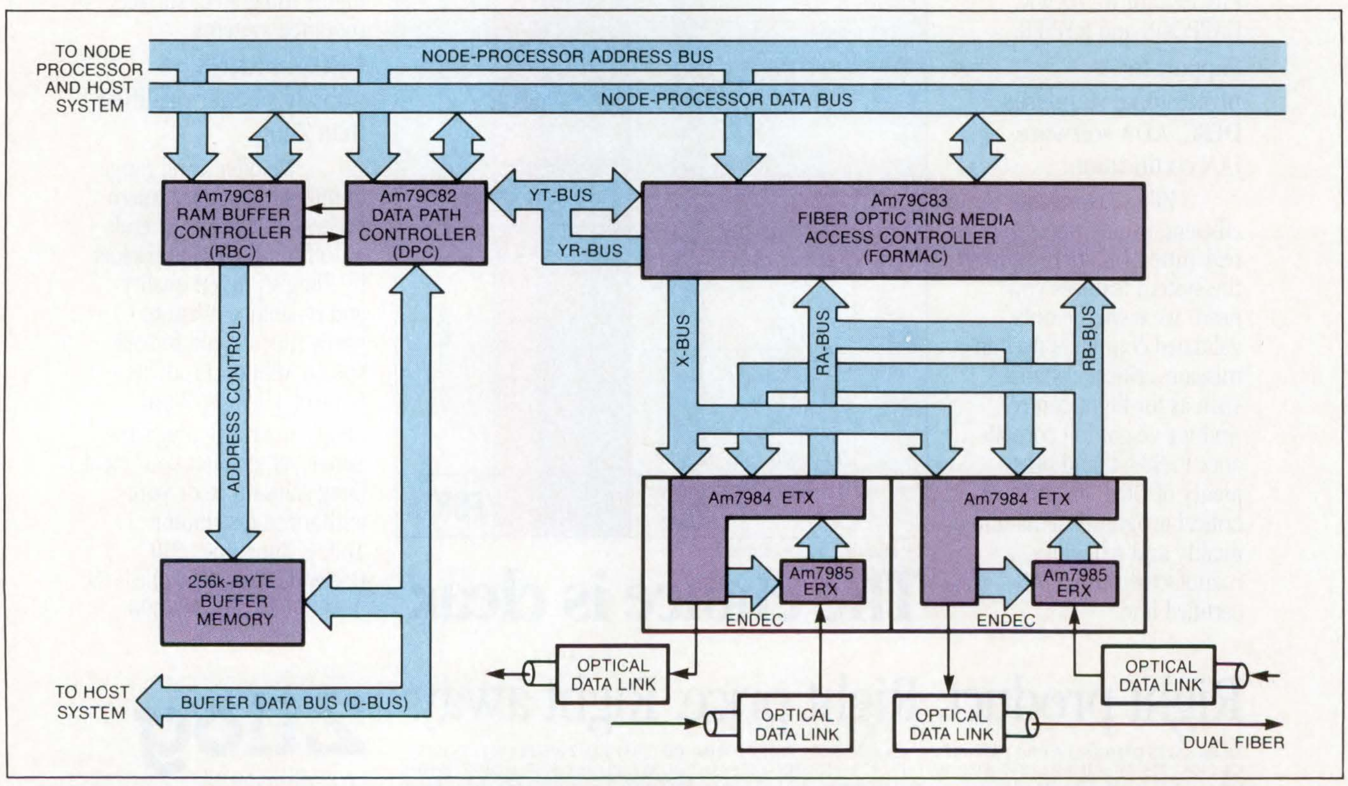
FDDI uses a timed token-ring protocol. The ring's maximum token-rotation time is decided in a bidding process that takes place at initialization. The bidding process allows the station that requires the fastest time between token arrivals to dictate the token-rotation time for the ring; the process also guarantees each node access to the network.

The Supernet chip set acts as the interface between a host computer that transfers data in parallel and the network, which transfers data serially. The set consists of the Am7985 Endec Receiver (ERX), the Am79C83 Fiber Optic Ring Media Access Controller (Formac), the Am79C82 Data Path Controller (DPC), the Am79C81 RAM Buffer Controller (RBC), and the Am7984 Endec Transmitter (ETX).

The chip set receives data from the network via the optical data link (**Fig 1**). The ERX passes the reconstructed 8-bit byte to the Formac. The Formac strips away the packet-format information and sends the pure data to the DPC. The primary function of the DPC is to convert data in received packets from byte-wide to 32-bit-word formats, and to convert data in transmitted packets from 32-bit-word to byte-wide formats.

The received 32-bit data is then stored in the buffer memory by the RBC. The data is finally sent to the host processor on a 32-bit bus. The chip expects that the host processor is 32 bits wide; if it's not, you can use external logic to interface the chip set to other bus widths.

When the host processor transmits data to the network via the chip set, the data flows in the oppo-



***A 5-chip set** called Supernet acts as the interface between a host computer that transfers data in parallel and an FDDI network, which transfers data serially.*

site direction—the ETX sends the data to the optical data link.

The Formac performs the Media Access Control (MAC) layer protocol for the FDDI standard. The Formac determines when a node can have access to the network and implements the logic required for token handling, address recognition, and CRC (cyclical redundancy checking).

The RBC generates addresses to the buffer memory for received and transmitted packets. The RBC also arbitrates requests for access to the buffer memory that come from the DPC, the node processor, and the host processor.

The node processor oversees the operation of the chip set. Its main function is to initialize the five chips and respond to various system-level and packet-level interrupts. The node processor and the host processor can be one and the same. In a large system, a powerful and independent node processor can be used to offload various network-specific chores.

The vendor plans to offer an implementation of its Station Management software-development package for the Supernet chip set. Station Management is a network-management package that controls the operation of the physical and data-link components. The development package will be available in the first quarter of 1988. Samples of the 5-chip set are available now. A limited number of production parts are also available; they sell for $625 (100). The chip set will be in full production in the first quarter of 1988.—***David Shear***

Advanced Micro Devices, 901 Thompson Pl, Sunnyvale, CA 94088. Phone (408) 732-2400. TLX 346306.

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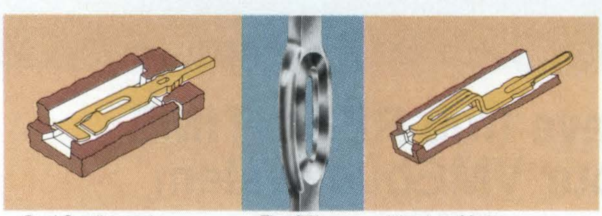

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CIRCLE NO 120

VME Bus-based system uses the 32200 μP, runs Unix System V release 3.1

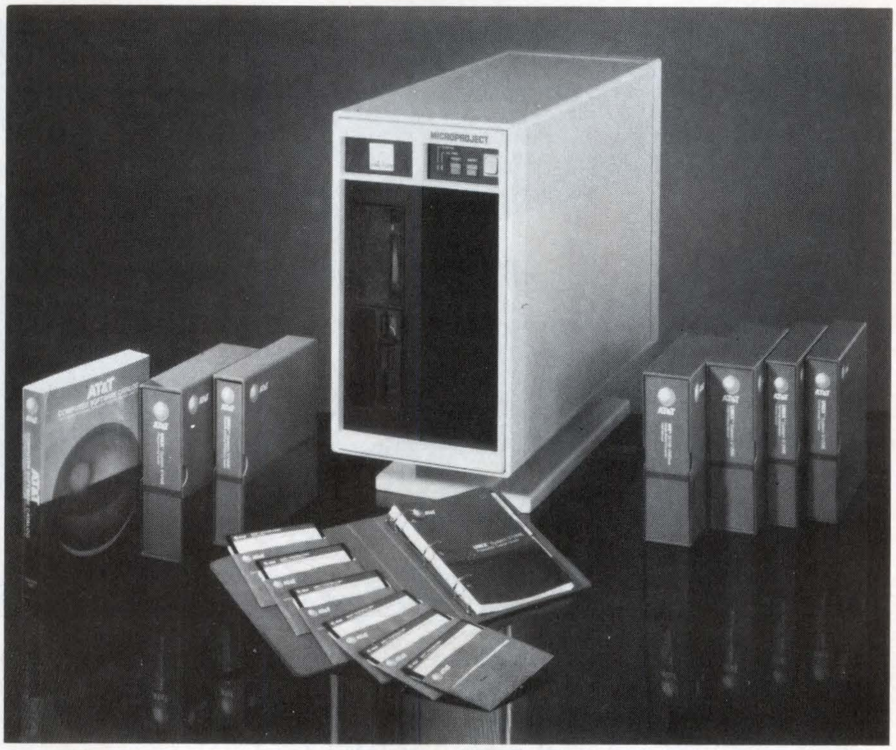
The Unicorn C multiuser/multitasking computer system runs Unix System V release 3.1. The VME Bus-based system incorporates the AT&T WE 32200 μP and support chips. You can buy configurations of the system that support as many as 200 users and a variety of peripheral configurations. In addition, the Unix implementation provides software hooks that let you easily add device drivers without modifying the Unix source code.

Unix System V release 3.1 includes several features not found in earlier versions of the operating system. For example, the new release allows systems on a network to share files and executable libraries. In addition, release 3.1 includes a streams-communication interface.

The CPU chip set used by the system includes a 30-MHz WE 32200 μP, a WE 32201 MMU/cache, a WE 32104 32-bit DMA controller, and a WE 32106 math coprocessor. The DMA/cache chip allows the μP to access local dynamic RAM with zero wait states. When you boot the system, the system software loads frequently used portions of the Unix kernel into the local memory, thereby speeding execution of the operating system.

A host adapter provides an intelligent SCSI (Small Computer System Interface) bus that handles input and output independently of the system bus. The SCSI bus can connect to disk and tape drives, as well as to other peripherals.

You can buy system configurations with hard-disk drives ranging in capacity from 40M to 780M bytes. You can also choose from cartridge or 9-track open-reel tape drives. The system includes an Ethernet interface.



***The VME Bus-based** Unicorn C computer system runs Unix System V release 3.1, which includes such enhancements as network file sharing and executable libraries.*

Because the system uses the AT&T chip set and runs Unix System V, it can execute any code developed for AT&T's 3B computer family, which runs more than 1000 software packages for engineering and business applications. In addition, any updates that AT&T makes to Unix will be immediately available for the Unicorn C.

You can also specify the system with 68000-family VME Bus boards that act as a front end for real-time control applications. The company offers several real-time operating systems—including Software Components Group's pSOS, Industrial Programming's MTOS, and Ready Systems' VRTX—to control the VME Bus boards. You can also add interface modules, such as an IEEE-488 interface, to the boards.

The Unicorn C is available in versions having 5-, 12-, and 21-slot VME Bus backplanes. The cost of the system ranges from $15,000 for an 8-user, 85M-byte configuration to $40,000 for a 380M-byte version that supports 64 users.

—Maury Wright

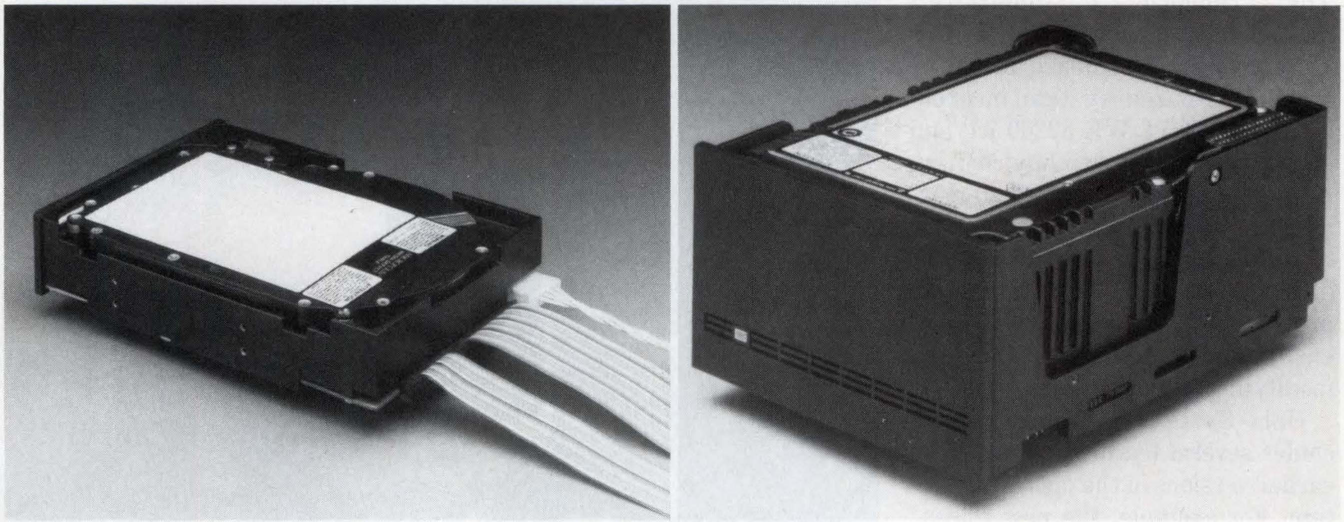
Microproject Corp, 4676 Admiralty Way, Suite 610, Marina del Rey, CA 90292. Phone (213) 306-8000. TLX 556443.

Circle No 725

Microproject BV, Claus Sluterweg 125, 2012 WS Haarlem, The Netherlands. Phone 23-292084. TLX 71189.

Circle No 726

Half- and full-height 5¼-in. drives store 180M and 765M bytes, respectively



Respective data densities as high as 22M and 44M bits/in.² allow the half-height 1600-family drives (left) to store as much as 180M bytes and the full-height 1500-family drives (right) to store as much as 765M bytes. You can choose SCSI or ESDI interfaces for both drive sizes.

The half-height 1600 family and the full-height 1500 family of 5¼-in. Winchester disk drives offer storage capacities of 180M and 765M bytes, respectively. Both drive families offer ESDI (Enhanced Small Device Interface) and embedded-SCSI (Small Computer System Interface) models. Furthermore, both families feature a straight-arm, 1-piece rotary voice-coil actuator that gives the drives typical seek times of 16 msec.

The 1650/1670 (ESDI/SCSI) half-height drives employ four platters to achieve the 180M-byte unformatted capacity. The drives store data on seven of the disk surfaces; the remaining surface is dedicated to servo-control functions. Because each drive uses 2,7 RLL encoding, is partitioned into 1249 cylinders, and writes 20,832 bytes/track, it has a data density of 22M bits/in².

Eight platters fit within the full-height package of the Model 1560/1580 (ESDI/SCSI) drives. The drives store data on 15 disk surfaces and use one surface for servo control. Each drive is partitioned into 1632 cylinders and writes 31,248 bytes/track, so it has a data density of 44M bits/in².

The 1650/1670 drives' read channels operate at 10 MHz, and the 1650 also performs 10M-bps transfers to an ESDI controller. The 765M-byte 1560 ESDI drive can transfer ESDI data at 15M bps. In fact, both the 1560 and the 1580 drives have read channels that operate at 15 MHz.

Both the 1670 and the 1580 share the same embedded-SCSI controller design. The controller implements the CCS (Common Command Set), and it's compatible with all the vendor's SCSI implementations. The controller board includes a 60k-byte buffer, and it can perform read-ahead caching operations. It decodes SCSI commands from a host in less than 750 μsec.

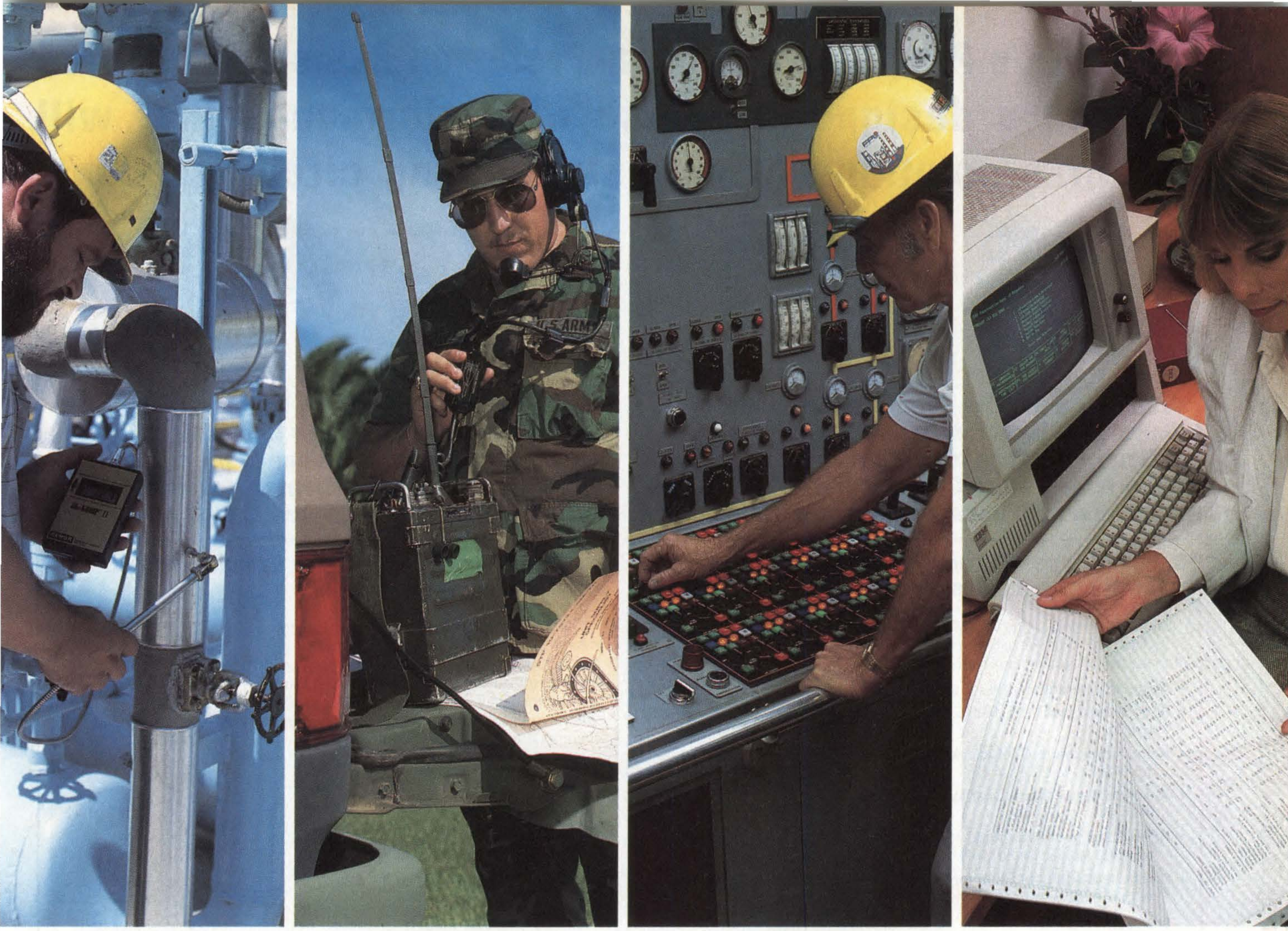
Although the drives' read-channel electronics can't operate at such speeds, the controller can transfer data at the specified SCSI rates of 1.5M bytes/sec asynchronously and 4M bytes/sec synchronously. The vendor claims the controller has been tested at higher speeds in the lab.

The vendor specifies an MTBF of 35,000 hours for the 1600 family and 30,000 hours for the 1500 family. Samples of both product families are available now; production quantities will be available in the second quarter of 1988. The Model 1600 drives cost less than $4.50/megabyte (2500); the Model 1500 versions are less than $3/megabyte (2500).

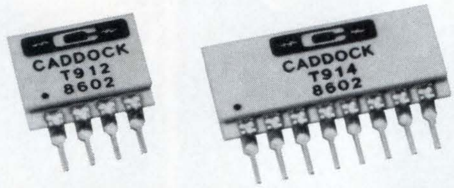
—Maury Wright

Micropolis Corp, 21123 Nordhoff St, Chatsworth, CA 91311. Phone (818) 709-3306. TLX 651486.

Circle No 724



CADDOCK's Precision and Ultra-Precision Resistor Networks provide a designer's choice of performance that will optimize solutions in precision analog circuit designs.

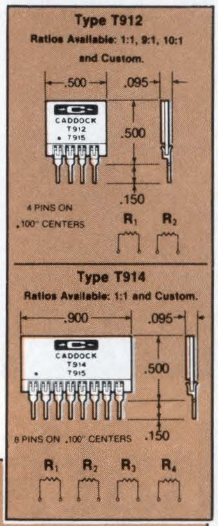


Precision and Ultra-Precision Resistor 'Pairs' and 'Quads' deliver a selection of Ratio Tolerance to as tight as ±0.01% and Ratio Temperature Coefficient to 2 PPM/°C combined with exceptional long-term stability.

Standard Type T912 and T914 Precision and Ultra-Precision Resistor Networks.

Standard models of the Type T912/T914 Precision and Ultra-Precision Resistor Networks combine all of these performance characteristics:

- **Absolute Tolerance:** 0.1% for all resistors.
- **Ratio Tolerances:** 0.1%, 0.05%, 0.02% and 0.01%
- **Ratio Temperature Coefficients:** from 10 PPM/°C to 2 PPM/°C.
- **Absolute Temperature Coefficient:** 25 PPM/°C from 0°C to +70°C.
- **Ratio Stability of Resistance at Full Load for 2000 Hours:** within 0.01%.
- **Shelf Life Stability of Ratio for Six Months:** within 0.005%.



The standard part number below provides a selection of over 500 in-production models of Type T912/T914 precision and ultra-precision 'pairs' and 'quads':

T912 - A 10K - 010 - 10

Model Number: T912

Ratio Code Letter:

A - T912 with $R_2 = 10R_1$ (Example: 1K - 10K)
B - T912 with $R_2 = 9R_1$ (Example: 1K - 9K)
No Letter - T912 with $R_2 = R_1$
No Letter - T914 with $R_1 = R_2 = R_3 = R_4$

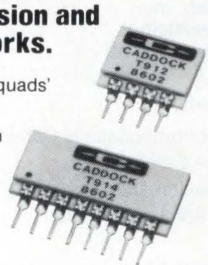
Standard Resistance Values (R_1):

1K	10K	40K	200K	500K
2K	20K	50K	250K	1 Meg.
5K	25K	100K	400K	

Ratio Tolerance:
-100 = 0.1% -020 = 0.02%
-050 = 0.05% -010 = 0.01%

Ratio Temperature Track: (0°C to +70°C)
-10 = 10PPM/°C -05 = 5PPM/°C
-02 = 2PPM/°C

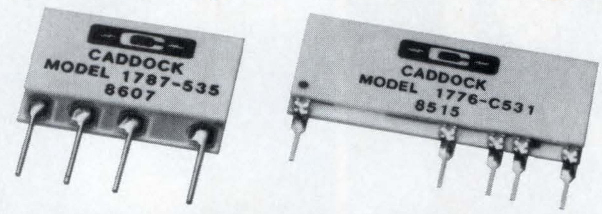
Custom Type T912 and T914 Precision and Ultra-Precision Resistor Networks.



Custom models of these precision 'pairs' and 'quads' can include these special performance features:

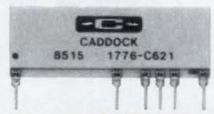
- **Resistance Values:** from 1K to 2 Megohms with maximum ratios of 250-to-1.
- **Absolute TC:** as low as 15 PPM/°C.
- **Ratio TC:** as low as 2 PPM/°C.

- **For Type T912/T914 data, circle Number 201.**

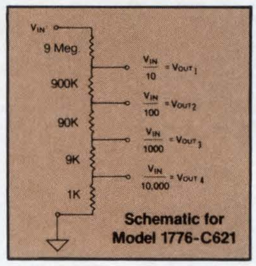


Precision Decade Resistor Voltage Dividers and Current Shunt Resistor Networks deliver many optimum combinations of precision and temperature coefficient performance for high accuracy range-switching circuitry.

Standard Type 1776 Precision Decade Resistor Voltage Divider Networks.



The Type 1776 Precision Decade Resistor Voltage Dividers provide a family of networks that includes 3, 4 and 5-decade voltage dividers with ratios from 10:1 to 10,000:1. Standard performance includes a wide range of specifications in particular combinations that meet the most often requested requirements.



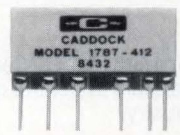
Schematic for Model 1776-C621

- **Absolute Tolerances:** from 0.25% to 0.1%.
- **Ratio Tolerances:** 0.25%, 0.1% or 0.05%.
- **Absolute TC:** from 50 PPM/°C to 25 PPM/°C.
- **Ratio TC:** from 50 PPM/°C to 5 PPM/°C.
- **Voltage Coefficient:** As low as 0.02 PPM/Volt.

With 36 standard models to choose from, each circuit designer can specify the exact levels of performance required by each application.

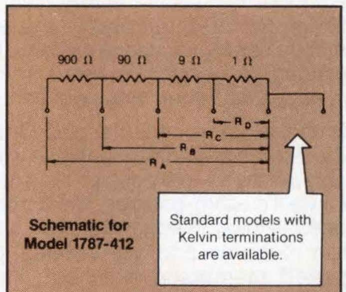
- **For Type 1776 data, circle Number 202.**

Standard Type 1787 Precision Current Shunt Resistor Networks.



The Type 1787 Current Shunt Resistor Networks achieve the combination of performance requirements necessary to meet the demands of precision current measurement circuits, including laboratory and bench-type instrumentation:

- **Resistance Values:** 1 ohm, 10 ohms, 100 ohms and 1000 ohms.
- **Absolute Tolerances:** 0.25%, 0.1% or 0.05%.
- **Absolute TCs:** 100 PPM/°C, 80 PPM/°C or 50 PPM/°C.



Schematic for Model 1787-412

There are now 12 standard models of the Type 1787 Current Shunt Resistor Networks available for 3 and 4-decade applications, and prototype quantities of many models are normally available from factory stock.

- **For Type 1787 data, circle Number 203.**

Caddock's new 28-page General Catalog describes over 200 models of both standard and custom precision and ultra-precision resistors and resistor networks. For your personal copy, call or write our main offices at -

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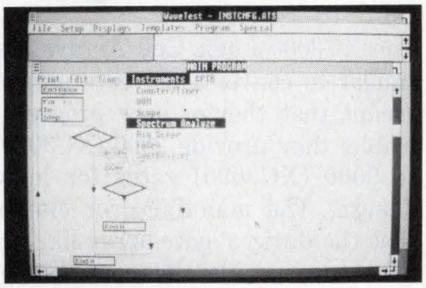
CIRCLE NO 71

Card and software make PC/AT an instrument controller

Combined with software, the Wavetest IEEE-488 interface card can turn an IBM PC/AT or compatible computer into an instrument controller. Although this hardware/software instrument-controller package isn't the first one available for the PC/AT, it's particularly easy to use because of its instrument library and menus. You don't need to be an expert in IEEE-488 communications to use this software, you just have to be sure that each instrument has a unique address; the instrument library takes care of the communication.

When using Wavetest, you develop a program from menus in flowchart form. The vendor implements the menus by using Microsoft's Windows program, which is part of the package. In a typical program, you'd select the instruments you want to use; initialize them; step through a set of parameters, taking data at each step; perform some mathematical reduction of the data; and display the data in tabular form.

If you've selected instruments from the library (which contains more than 100 instruments), the menus will guide you through the initialization selections. The menus act as check lists that let you make sure that all parameters are set as you desire. For example, when you want to step through a set of parameters, you first select an instrument. A menu appears to show the parameters that you can vary on that particular instrument. You select the parameter to be varied, the value to start with, and either the step size and final value or the final value and number of steps. You measure a value in a similar fashion —you first select the instrument and then select the function you want to measure.



The menu selections and flowchart format *provided by the Wavetest software minimize the time you need to program an instrument for test.*

You can display results directly in tabular form or set up a data-reduction program by using a Basic language block. Wavetest allows you to write any or all of a test program in Basic; however, you'd probably need this function only for data reduction.

You can also select interactive windows that give you direct control of an instrument without executing a program. This feature lets you vary instrument settings during program development and debugging.

The package also allows you to add an operator window to a program; the window prompts you for the necessary input selections before the program runs. Although you could use a PC/XT or compatible machine to run the programs, you need a PC/AT during program development to allow Microsoft Windows to operate at an acceptable speed.

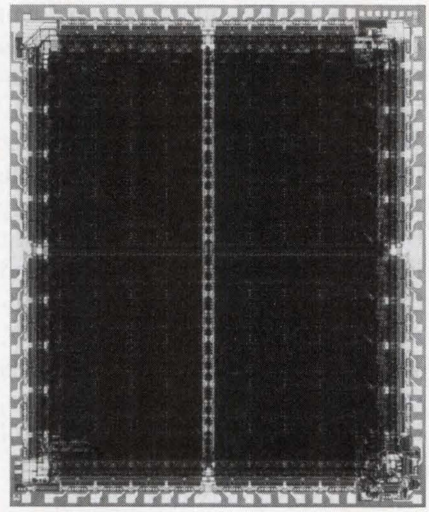
If you need to use an instrument that isn't included in the library, you can add the instrument by means of the package's library-generation program. Wavetest costs $3500.

— Doug Conner

Wavetek San Diego Inc, 9045 Balboa Ave, San Diego, CA 92123. Phone (619) 565-9234. TLX 5212996. **Circle No 727**

Programmable gate arrays have 9000-gate capacity

The XC3000 Logic Cell Arrays are similar to conventional gate arrays except that they're user programmable; they provide 2000 (XC3020) to 9000 (XC3090) gates for logic design. The manufacturer claims that the devices' gate-array-like architecture—unlike the more restrictive AND/OR plane architecture that most programmable logic devices (PLDs) use—lets you achieve the same level of gate utilization that you can achieve with conventional gate arrays. The parts' 1.2-μm, double-layer-metal CMOS process provides a 30-MHz clock rate, which is a level of circuit performance equivalent to that of most CMOS gate arrays. The company projects that by next year its 1.0-μm process will bring the clock rate to 40 MHz and gate count to 12,000.



***The XC3020 user-programmable gate array employs 1.2-μm, double-layer-metal CMOS technology** to provide you with 2000 gate equivalents. The part features the same level of utilization typical of conventional gate arrays. In contrast, PLDs based on an AND/OR plane architecture generally can't match the utilization levels of gate arrays.*

Design support for the XC3000 Series comes in the form of schematic-entry packages: FutureNet's Dash and Schema II currently support the arrays. Packages from Daisy, Mentor, Valid, Cadnetix, Personal CAD Systems, Case, Viewlogic, and OrCAD will support the series by the end of the year. Because the arrays are user programmable, they require no NRE charge, no test-tape development, and no revision charges.

The top-of-the-line XC3090 part offers 640 user-definable logic functions and 928 flip-flops—the equivalent of 9000 2-input NAND gates. The XC3020 provides 128 functions, 256 flip-flops, and 2000 gates.

In addition to the top and bottom of the line, you have several other Logic Cell Arrays to choose from. The XC3030 offers 3000 gates, 200 functions, and 360 flip-flops. The XC3042 provides 288 functions, 480 flip-flops, and 4200 gates. Finally, the XC3064 offers 448 functions, 688 flip-flops, and 6400 gates.

Samples of the XC3020 are available now; samples of the XC3090 will be available in December. High-volume prices start at $20 per device for the XC3020.

—***Jim Wiegand***

Xilinx Inc, 2069 Hamilton Ave, San Jose, CA 95125. Phone (408) 559-7778. TWX 510-600-8750.

Circle No 721

HP's new logic analyzer family gives you more of what you want in logic analyzers. For less.

So now measurements are easier to make. And high-quality HP logic analyzers are easier to buy!

You get the performance that best suits you: from 32 to 400 channels of 100 MHz transitional timing/25 MHz state, and up to 80 channels of 1 GHz timing analysis.

Our new family also offers you easy operation, powerful triggering, a CAE link, an oscilloscope, pattern generation, portability, built-in mass storage, simple probing, optional 3-year protection, and much more.

The small secret behind the big value.

To give you more for your money, HP developed a Logic-Analyzer-on-a-Chip containing a complete state analyzer, timing analyzer, and acquisition memory. This proprietary HP IC makes exceptional value possible...80 channels of 100 MHz transitional timing for only $7,800*.

You can assign state or timing in 16-channel increments. Get fully independent state, timing, state/timing, or state/state setups. Even time-correlate measurements on complex multiprocessor systems.

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We've made our controls even easier than before, without sacrificing performance.

You can make timing or state measurements using just three menus, so you never get lost. Triggering setups, from the simple to the complex, are a snap. And autoscale gives you one-button setup for timing analysis.

You even get a color touch-screen and knob, or optional mouse with the new HP 16500A. Color lets you quickly distinguish between menu choices, measurements, and results...and find glitches more easily.

Probing made easy.

HP's new passive probes are lightweight and flexible...specially designed to grip easily and securely to your device under test. Plus, our preprocessors give you quick setups with most popular 8, 16, and 32-bit μPs, including the Motorola 68020 and Intel 80386. And if you've already invested in HP preprocessors, we offer you an easy upgrade path.

HP 1651A: full-featured logic analyzer for only $3,900.*

With 32 channels of 100 MHz transitional timing for just $3,900*, the HP 1651A gives the hardware engineer a highly economical, yet powerful debugging tool.

It's a full-featured logic analyzer with no compromises in state and timing capabilities (25 MHz state/100 MHz transitional timing on all channels), memory depth, triggering, or I/O features. It supports most popular 8-bit μPs with full inverse assembly. Plus it's compact, weighs just 22 lbs., and has an optional carrying case for easy transport.

HP 1650A: the new standard in general-purpose logic analysis for just $7,800.*

The HP 1650A features time-correlated state/state or timing/state operation on 80 channels. Plus eight sequence levels to meet your toughest triggering tasks. Yet it's priced below $8,000!

You get 25 MHz state/100 MHz transitional timing on all 80 channels, and preprocessor support for 8, 16, and 32-bit μPs. And, the

More value.

HP 1650A is portable, lightweight, and small enough to fit comfortably on a crowded workbench. It's also programmable, has a built-in disc drive for storing measurements, and provides hardcopy documentation.

through your choice of performance modules. You can have up to 400 channels of 25 MHz state/100 MHz transitional timing. 8 channels of full-featured, simultaneous scope analysis. 80 channels of 1 GHz timing. Or 204 channels of 50 Mbit/sec stimulus.

Just $12,400* buys you a

Now, bring real-world measurements into the CAE environment.

The HP 16500A is part of HP DesignCenter...a product development environment that unites engineers from IC design/verification to PCB design and test. By linking the HP 16500A with HP CAE, you can compare measurement results and simulated data on your workstation, and use measurement results as your simulator patterns.

HP 16500A: modular system solution, priced your way.

The HP 16500A is modular, with the flexibility to meet your debug, characterization, or pass/fail test application needs today and tomorrow. You get a combination of state, timing, oscilloscope, and stimulus-response capabilities

basic configuration with 80 channels of 25 MHz state/100 MHz transitional timing.

You can trigger one module with another. Time-correlate measurements between modules...400 Ms/sec scope and 1 GHz timing, for example. Even view state, timing, and analog on the same screen! Fully programmable, the HP 16500A eliminates the need for separate data storage and printer control. HP-IB and RS-232 are standard.

Mail the card today!

For more information, fill out and mail the postage-paid reply card today. Call us direct at **1-800-752-0900.** Or contact your local HP sales office listed in the telephone directory white pages. Ask for the electronic instruments department.

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Excellent reliability, service, and support.

When you purchase a logic analyzer from HP, you get high reliability. The support you need to be productive with your instrument quickly. And a worldwide sales and service network to ensure your continuing satisfaction for years to come.

we never stop asking "What if..."

HP 1651A $3,900 *

The HP 1651A is a general-purpose, low-cost 32 channel logic analyzer with many features normally found on more expensive analyzers.

- 100 MHz transitional timing on all 32 channels.
- 25 MHz state on all channels.
- Support for most popular 8-bit μPs.
- Fully programmable, with built-in disc drive and hardcopy output.
- Portable and compact — weighs just 22 lbs.
- Optional 3-year protection.

HP 1650A $7,800 *

The HP 1650A is a general-purpose logic analyzer with a range of features to satisfy many requirements in design and test.

- 100 MHz transitional timing/25 MHz state on all 80 channels.
- Support for most popular 8, 16, and 32-bit μPs.
- Configurable as 2 totally independent analyzers.
- Fully programmable, with built-in disc drive and hardcopy output.
- Eight sequence levels with storage qualification, pattern and range recognizers.
- Glitch capture on all channels.
- Optional 3-year protection.

HP 16500A

The HP 16500A is a modular, configurable system solution that can meet a wide variety of logic analysis, oscilloscope, and stimulus-response measurement requirements.

- Configurable through your choice of performance modules:
  - 25 MHz state/100 MHz transitional timing (80 channels per module) $5,200 *
  - 400 Ms/sec 100 MHz bandwidth digitizing oscilloscope (2 channels per module) $5,500 *
  - 1 GHz timing (16 channel master) $7,800 *
  - 50 Mbits/sec pattern generation (12/48 channels per module) $3,700/$4,000 *
  - Mainframe $7,200 *
- Color touchscreen and knob, with optional mouse.
- Intermodule triggering.
- Two built-in disc drives.
- Fully programmable, with RS-232 and HP-IB interfaces.
- Optional 3-year protection.

* U.S. list price.

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E115620
5954-2660

CIRCLE NO 143

HP's integrated CAE/CAD

The HP DesignCenter offers integrated CAE/CAD software tools that accelerate the design process from idea to test. These tools, which run on the HP 9000 Series 300 technical workstations, improve productivity and communication throughout the product development process. So engineers can design faster and get products to market quickly.

Analog and digital design on one system

Both digital *and* analog designers can use the same HP design capture system, helping you to maximize return from your CAE/CAD investment. The system offers a number of features that help speed design, including a consistent environment of component libraries and schematics; hierarchical design entry; integrated documentation; on-line electrical rule checking; automatic component selection; and links between external design tools and design capture.

Faster microprocessor software development

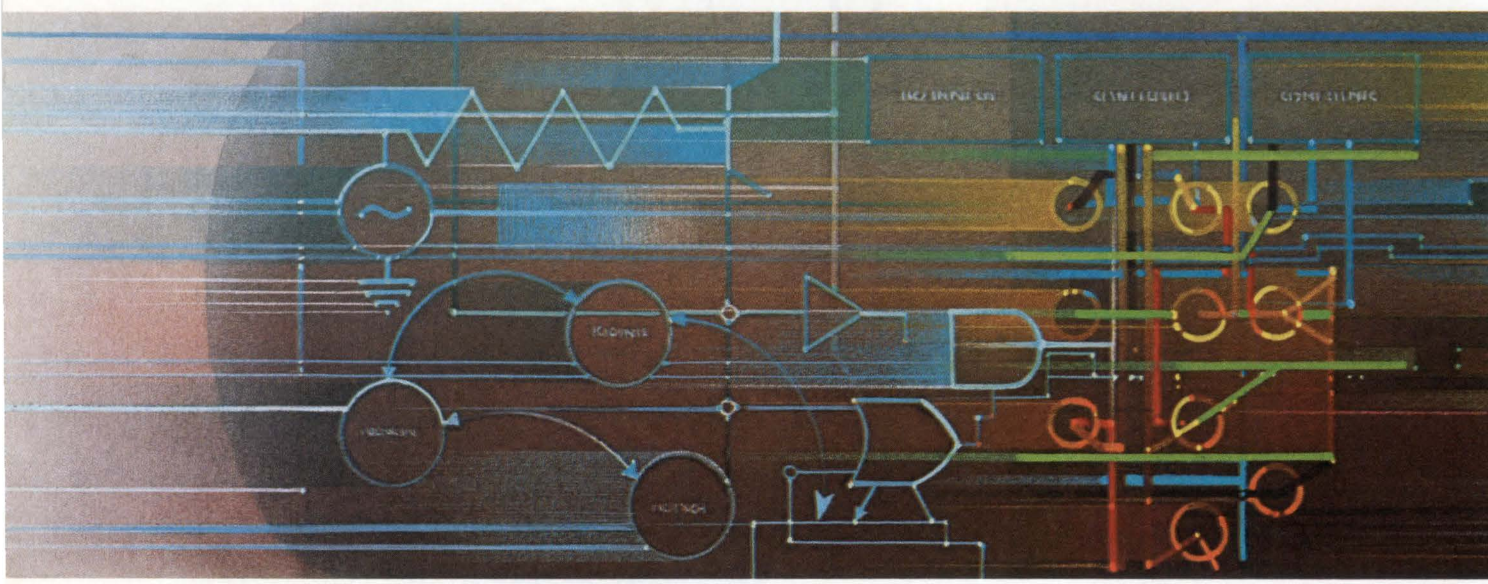
You get HP computer-aided software engineering. And some of the most advanced hardware and software integration tools available, including real-time emulation for over 40 processors. These tools let engineers tap the power of HP's microprocessor development environment to speed product development.

There's even a link to design capture from microprocessor system development so engineers can transfer programs directly to simulation, reducing both simulation setup time and the possibility of manual-entry errors.

Advanced PCB design tools for a head start in manufacturing

HP's automated printed circuit design system helps

Accelerate your product from idea to design and



Go from engineering design ▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷

turn engineering ideas into finished printed-circuit boards quickly. And gives you the assurance that boards will match the approved design from engineering and be practical to manufacture.

You get a link from schematic capture to PCB design for highest design integrity, and system features that optimize designs for your actual manufacturing environment. The result is reduced manufacturing costs, higher yield, and improved reliability.

You can also transfer netlist and part information from PCB design to HP's board test system, ending manual-entry hassles and errors.

HP DesignCenter: our commitment to CAE/CAD

HP's CAE/CAD tools are part of HP DesignCenter . . . a powerful product development environment that unites the activities of electronic, mechanical, and software engineers through integrated systems, software, and support.

For all the facts, call your local HP sales office listed in the telephone directory white pages. Or call 1-800-447-3282 (in Colorado call 590-5540 collect) for free literature on our CAE/CAD solutions.

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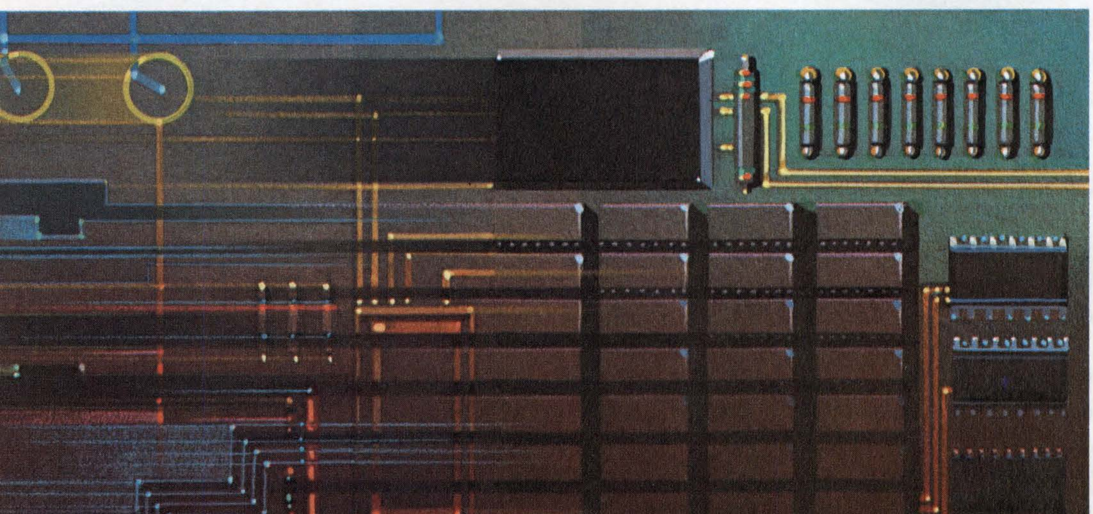
development test.

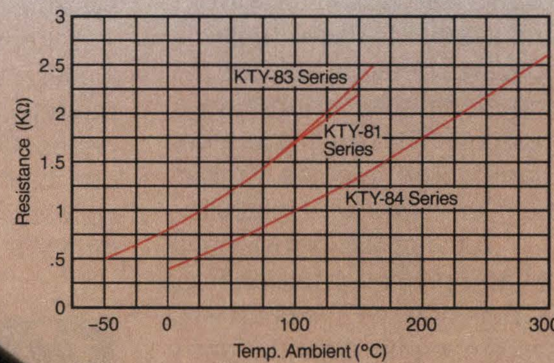


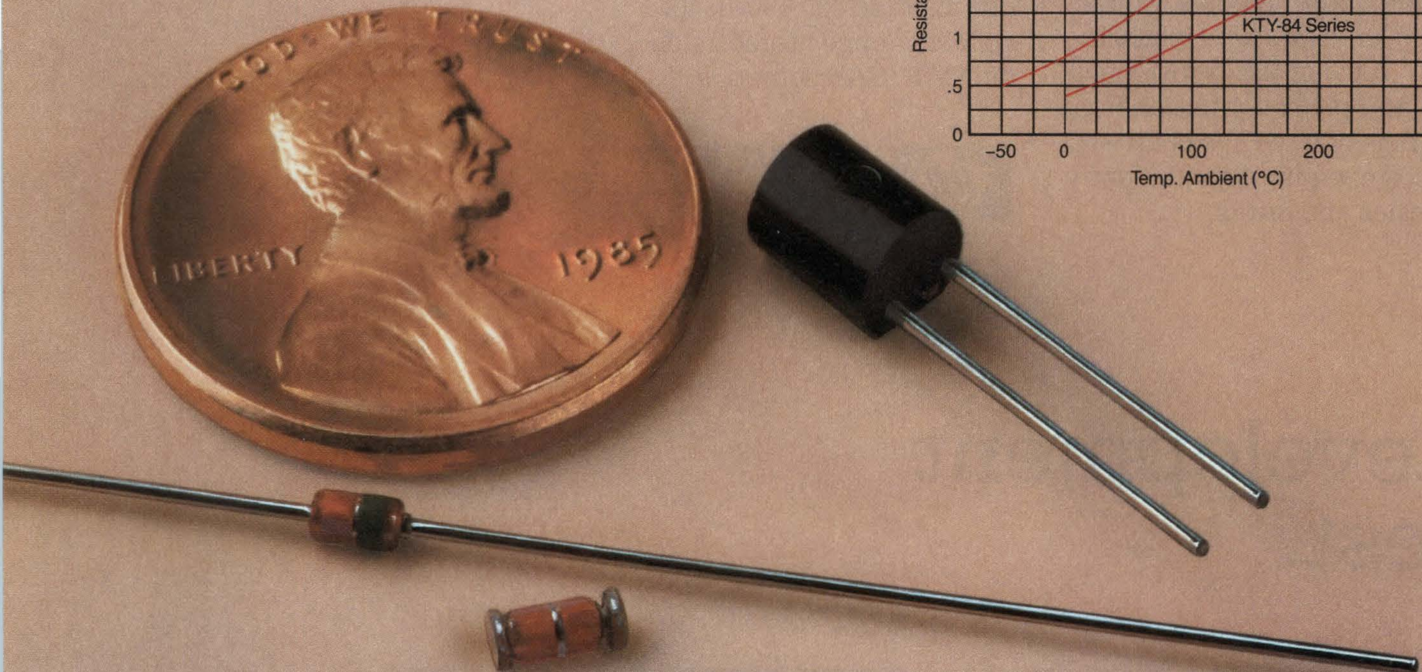
▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷▷ to finished product faster

DS15611A

CIRCLE NO 142

Philips KTY sensors. For sensing a wider range of temperatures, for pennies.





Philips KTY silicon temperature sensors are not only attractively priced, they also monitor a wider range of temperatures than any other sensor.

Three models monitor temperature ranges from -55°C to +150°C; -55°C to +175°C; and 0°C to 300°C.

Wide operating range and excellent reproduceability are direct results of proven silicon planar technology.

By utilizing the nearly linear temperature-dependent resistivity of silicon, Philips KTY sensors can detect and respond to temperature changes in the broad ranges mentioned, with response times as fast as one second.

Exceptional accuracy of Philips KTY sensors results from a positive temperature coefficient (PTC) of 0.7 percent per degree Centigrade. They are available off the shelf in tolerances of ±1%, ±2%, and ±5%.

Because KTY sensors are small, are not polarity dependent, and need no special interfacing, they are ideal for applications involving solid-state circuitry. Configurations: plastic-encapsulated, axial lead glass bead, and surface-mounted device.

And remember, whatever the model, whatever the package, we're talking pennies.

To find out how Philips KTY sensors can fit into your measurement and control designs, call or write Amperex Electronic Corporation, A North American Philips Company, George Washington Highway, Smithfield, RI 02917. Phone (401) 232-0500; TWX 710-381-8808. In Canada contact Philips Electronics Ltd, ELCOMA Division.

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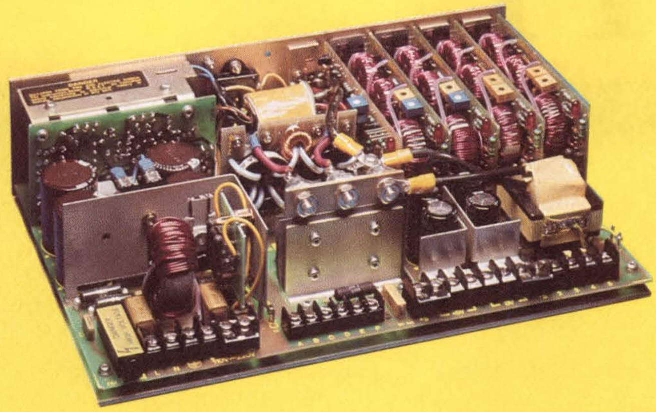
The latest Advance



New Powerflex 350-watt 5-output switching power supply

Go ahead. Design your microprocessor based equipment any way you want, and don't worry about the power supply. Whatever voltages you require, from 2V to 50V in either polarity, the Powerflex 350 switching power supply can provide them.

Because it's modular, we can easily configure the P350 for up to five outputs in standard or special voltages. And if your design changes, you can easily change outputs without changing your physical dimensions.

Just 2.9″ x 7.5″ x 11.8″, this high efficiency (75% at full load) 350-watt power supply takes both 110V and 220V inputs. Overvoltage and overcurrent protection on outputs is standard, along with margin testing (4.750V — 5.250V) on the main +5V 50A output. An optional signals board provides TTL compatibility.

The magnetic amplifier and soft switching technique assure high reliability and enable regulated auxiliary outputs to function without any minimum load on the main +5V output. Filtering is to VDE 0871, Curve A. The P350 is UL listed, CSA certified and meets other VDE, EC and FCC requirements.

Compare the calculated MTBF of over 52,000 hours with other power supplies in its class. There's no compromise on quality when you build around the P350 from Advance.

Contact your Advance Power Supplies representative for complete data on the P350 and other open and closed frame units from 25 to 1000 watts. Or call 1-216-349-0755 for more information.

Advance Power Supplies
32111 Aurora Road
Solon, OH 44139

ADVANCE POWER SUPPLIES

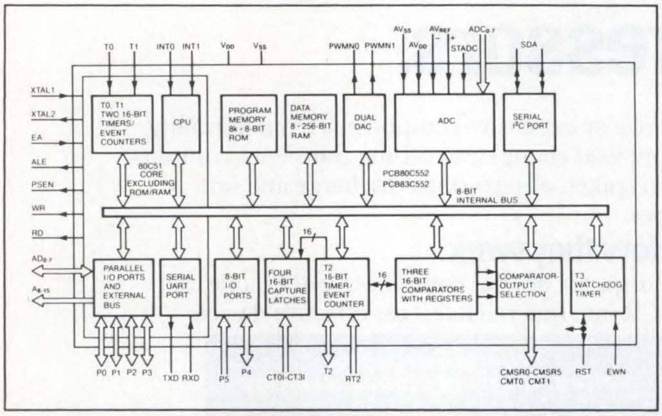
CIRCLE NO 140

703-001-1

Suppress those

READERS' CHOICE

Of all the new products covered in EDN's **August 20, 1987**, issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, or refer to the indicated pages in our **August 20, 1987**, issue.



▲ CMOS MICROCONTROLLER

The PCB83C552 single-chip CMOS microcontroller offers numerous analog and digital I/O facilities that make it suitable for use in a wide variety of applications, such as medical, instrumentation, and industrial-control equipment (pg 93).

Philips.
Circle No 601
Signetics.
Circle No 602

DSP DESIGN TOOL

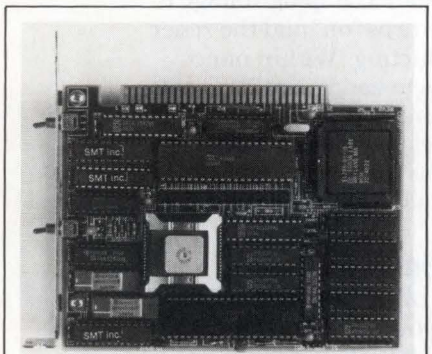
DSPlay is a software package that runs on an IBM PC or compatible computer that's equipped with at least 256k bytes of RAM and a CGA or equivalent color-graphics board (pg 308).

Burr-Brown Corp.
Circle No 607

▲ PLD PROGRAMMER

The Sailor-PAL is a universal PLD programmer that requires no personality adapters. It handles 20-, 24-, and 28-pin devices (pg 306).

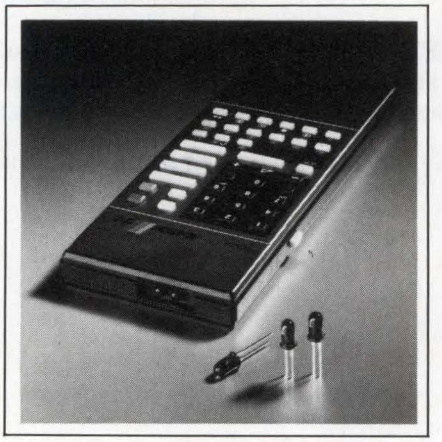
Advin Systems Inc.
Circle No 606



▲ IBM PC/XT ACCELERATOR

The XT-286 Speed Card is a half-slot add-in board for the IBM PC/XT. It has an 80286 μP that runs at 10 MHz and a cache memory that has zero wait states (pg 294).

SMT Inc.
Circle No 605



◄ INFRARED LEDs

The CQW-58A, -89A, and -89B infrared LEDs feature a switching speed of 30 nsec and allow you to increase the data rate between remote equipment and control handsets (pg 266).

Philips.
Circle No 603
Amperex Electronic Corp.
Circle No 604

LEADTIME INDEX

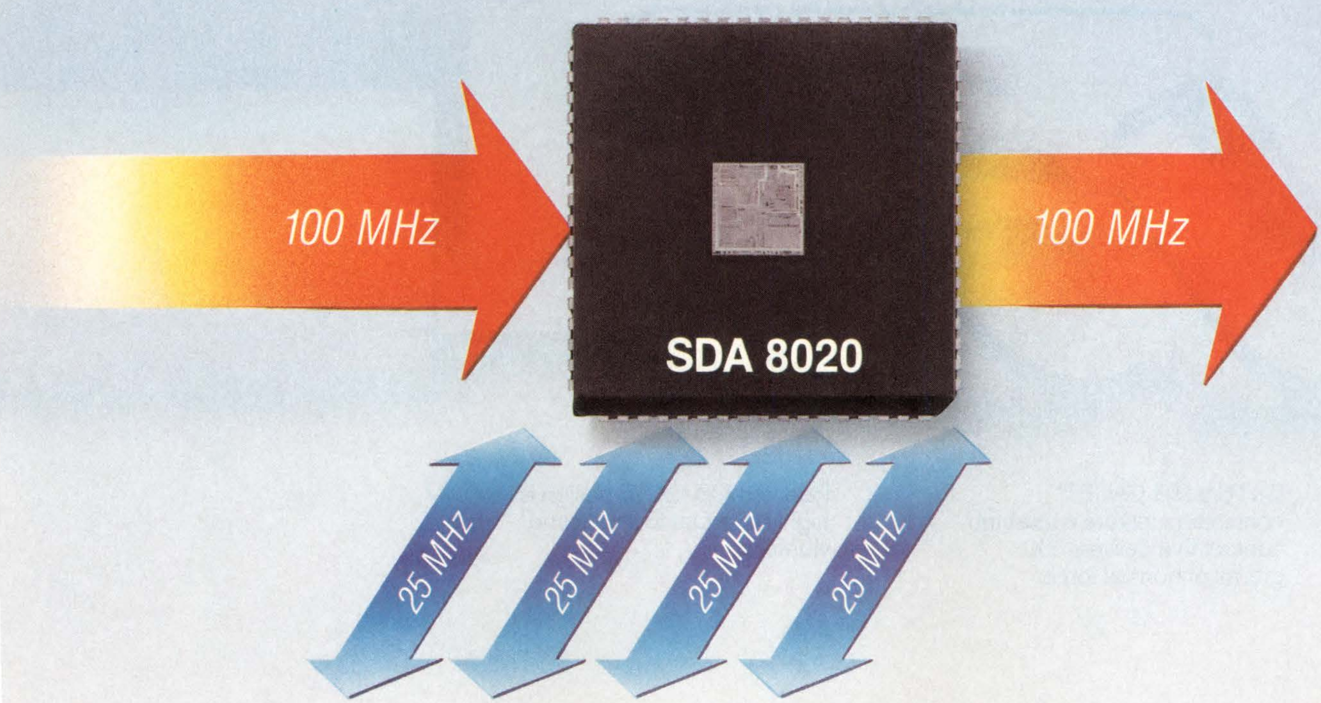
Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
TRANSFORMERS								
Toroidal	0	25	50	25	0	0	8.6	5.9
Pot-Core	8	15	46	23	8	0	9.7	7.7
Laminate (power)	0	40	27	27	6	0	9.2	6.7
CONNECTORS								
Military panel	0	0	75	25	0	0	9.9	5.3
Flat/Cable	27	27	40	6	0	0	5.0	4.3
Multi-pin circular	0	29	71	0	0	0	6.6	7.9
PC	0	44	56	0	0	0	5.8	5.6
RF/Coaxial	17	33	42	8	0	0	5.6	6.6
Socket	37	26	32	5	0	0	4.1	5.2
Terminal blocks	19	43	38	0	0	0	4.3	5.7
Edge card	19	19	43	19	0	0	7.0	5.8
D-Subminiature	20	20	47	13	0	0	6.4	6.3
Rack & panel	7	8	69	8	8	0	8.9	7.7
Power	9	46	36	9	0	0	5.7	6.9
PRINTED CIRCUIT BOARDS								
Single-sided	5	54	36	5	0	0	5.3	4.9
Double-sided	3	35	48	14	0	0	7.0	5.2
Multi-layer	0	12	63	25	0	0	9.3	8.1
Prototype	5	70	25	0	0	0	4.1	3.8
RESISTORS								
Carbon film	38	31	28	3	0	0	3.7	3.1
Carbon composition	38	33	29	0	0	0	3.3	3.2
Metal film	36	29	32	5	0	0	4.1	3.5
Metal oxide	18	29	41	12	0	0	6.0	2.8
Wirewound	14	24	48	9	5	0	7.2	6.6
Potentiometers	27	27	46	0	0	0	4.5	6.9
Networks	19	31	31	19	0	0	6.3	5.1
FUSES	35	35	20	10	0	0	4.2	2.6
SWITCHES								
Pushbutton	26	21	32	21	0	0	6.4	5.6
Rotary	15	35	35	15	0	0	6.2	6.7
Rocker	18	29	35	18	0	0	6.4	5.0
Thumbwheel	0	25	42	33	0	0	9.3	6.4
Snap action	15	31	31	23	0	0	7.0	5.5
Momentary	23	15	39	23	0	0	7.1	5.8
Dual in-line	30	20	20	30	0	0	6.9	5.9
WIRE AND CABLE								
Coaxial	33	20	47	0	0	0	4.3	2.8
Flat ribbon	33	22	34	11	0	0	5.1	4.1
Multiconductor	15	23	54	8	0	0	6.2	3.8
Hookup	48	28	24	0	0	0	2.8	1.6
Wire wrap	50	33	17	0	0	0	2.3	5.0
Power cords	36	18	27	14	5	0	6.0	4.4
POWER SUPPLIES								
Switcher	20	33	27	20	0	0	6.2	7.4
Linear	10	40	30	20	0	0	6.7	8.2
CIRCUIT BREAKERS	16	47	21	16	0	0	5.6	7.5
HEAT SINKS	11	56	28	5	0	0	4.8	4.8
RELAYS								
General purpose	32	37	21	10	0	0	4.4	6.1
PC board	10	37	21	32	0	0	7.7	7.4

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
RELAYS								
Dry reed	0	50	17	33	0	0	8.0	7.9
Mercury	17	33	17	33	0	0	7.5	7.6
Solid state	8	50	17	17	8	0	7.5	6.0
DISCRETE SEMICONDUCTORS								
Diode	39	29	21	7	0	4	4.8	8.0
Zener	37	26	21	11	5	0	5.4	7.4
Thyristor	8	25	42	25	0	0	8.0	6.6
Small signal transistor	9	37	27	27	0	0	7.5	5.5
MOSFET	15	23	31	31	0	0	7.9	6.2
Power, bipolar	20	20	20	40	0	0	8.4	5.4
INTEGRATED CIRCUITS, DIGITAL								
Advanced CMOS	8	17	50	25	0	0	8.4	11.7
CMOS	26	21	32	21	0	0	6.4	8.9
TTL	27	27	26	20	0	0	6.0	6.5
LS	44	6	25	25	0	0	6.1	6.6
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	11	11	56	22	0	0	8.2	6.3
OP amplifier	14	21	36	29	0	0	7.9	7.9
Voltage regulator	21	26	42	11	0	0	5.8	6.8
MEMORY CIRCUITS								
RAM 16k	20	20	30	30	0	0	7.7	7.9
RAM 64k	23	15	39	23	0	0	7.1	8.3
RAM 256k	37	0	27	27	9	0	8.7	7.8
RAM 1M-bit	17	17	33	17	16	0	10.0	8.8
ROM/PROM	30	0	50	20	0	0	7.1	9.0
EPROM 64k	21	14	36	29	0	0	7.7	9.4
EPROM 256k	17	8	42	33	0	0	8.8	8.8
EPROM 1M-bit	13	12	50	25	0	0	8.3	13.9
EEPROM 16k	10	20	40	30	0	0	8.5	12.3
EEPROM 64k	10	30	30	30	0	0	8.0	13.0
DISPLAYS								
Panel meters	7	29	21	36	7	0	9.9	6.6
Fluorescent	0	0	40	60	0	0	12.5	10.1
Incandescent	14	29	14	43	0	0	8.6	7.6
LED	30	15	20	35	0	0	7.5	6.0
Liquid crystal	0	27	33	40	0	0	9.7	9.9
MICROPROCESSOR ICs								
8-bit	14	33	33	20	0	0	6.8	8.9
16-bit	13	13	47	27	0	0	8.3	8.1
32-bit	0	9	36	46	9	0	12.5	8.5
FUNCTION PACKAGES								
Amplifier	0	22	45	33	0	0	9.4	7.5
Converter, analog to digital	0	20	50	30	0	0	9.3	8.3
Converter, digital to analog	0	25	50	25	0	0	8.6	8.3
LINE FILTERS	20	0	60	20	0	0	7.9	7.9
CAPACITORS								
Ceramic monolithic	28	32	32	8	0	0	4.8	5.9
Ceramic disc	38	19	33	10	0	0	4.7	6.0
Film	38	19	31	12	0	0	5.0	7.3
Aluminum electrolytic	18	41	27	14	0	0	5.5	8.2
Tantalum	35	15	35	15	0	0	5.6	7.3
INDUCTORS	21	22	43	14	0	0	6.3	5.8

Source: *Electronics Purchasing* magazine's survey of buyers

SIEMENS



Now, Data Acquisition is a One-Chip Proposition.

Siemens Data Acquisition Shift Register lets you read and write at 100 MHz using CMOS memory!

Forget about those costly, complicated, multi-chip designs for 100 MHz applications. Because Siemens SDA 8020 Data Acquisition Shift Register makes them obsolete. It's a fully integrated, one-chip solution that captures your 100 MHz signal and re-routes it into four parallel 25 MHz channels...and vice-versa! What's more, you get all this versatility in a compact 1" square 68 pin PLCC design that saves development cost and real estate...while chopping power consumption from an average of 12 watts to a miserly 1.5 watts.

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- Cascading to achieve large cache memory and/or lower TTL clock rates
- Choice of 1:4 Demux or 4:1 Mux capability
- External control signals that are TTL compatible
- Does it all for only $70.00 per 100 units

Stop playing board games with your 100 MHz data acquisition designs...and see for yourself why Siemens SDA 8020 (DASR) is the best solution. It's one proposition you'll appreciate.

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Or write: Siemens Components, Inc., Consumer Marketing Department, 2191 Laurelwood Rd., Santa Clara, CA 95054

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 CG/2000-419A WLM 645

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Simulating and testing large, multi-technology systems utilizing ASIC's always involved lots of guesswork. And a little magic.

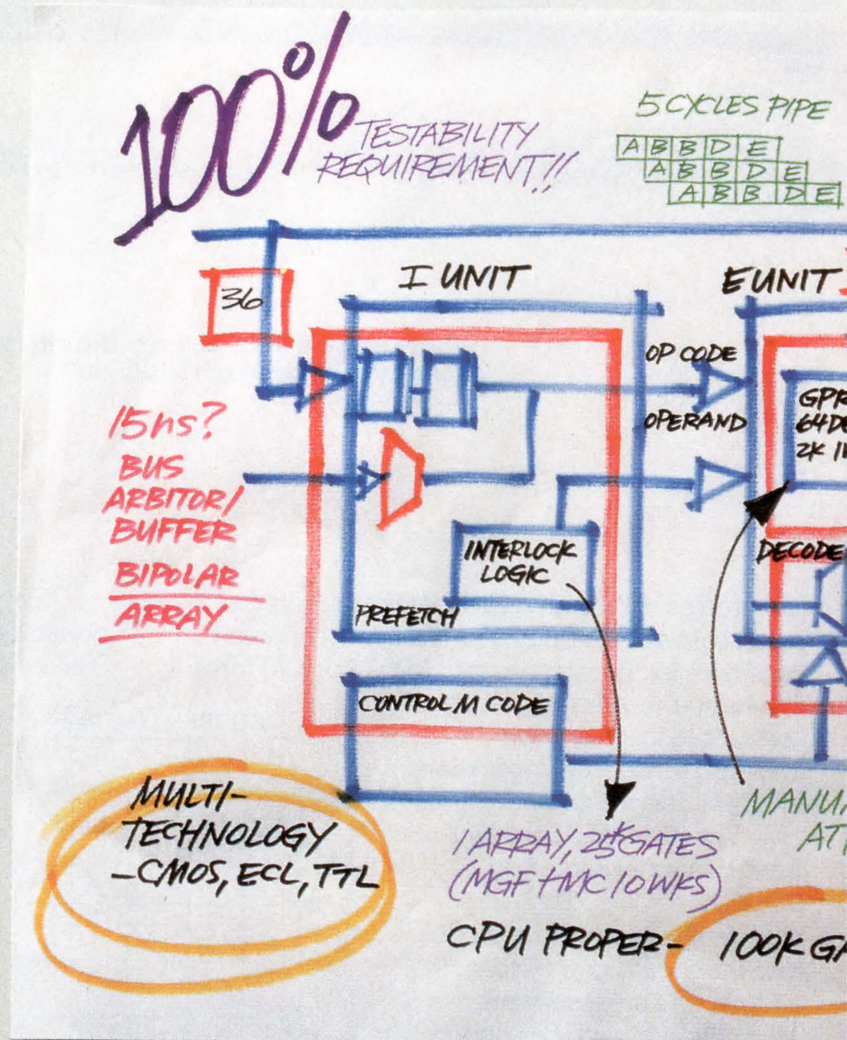
No more.

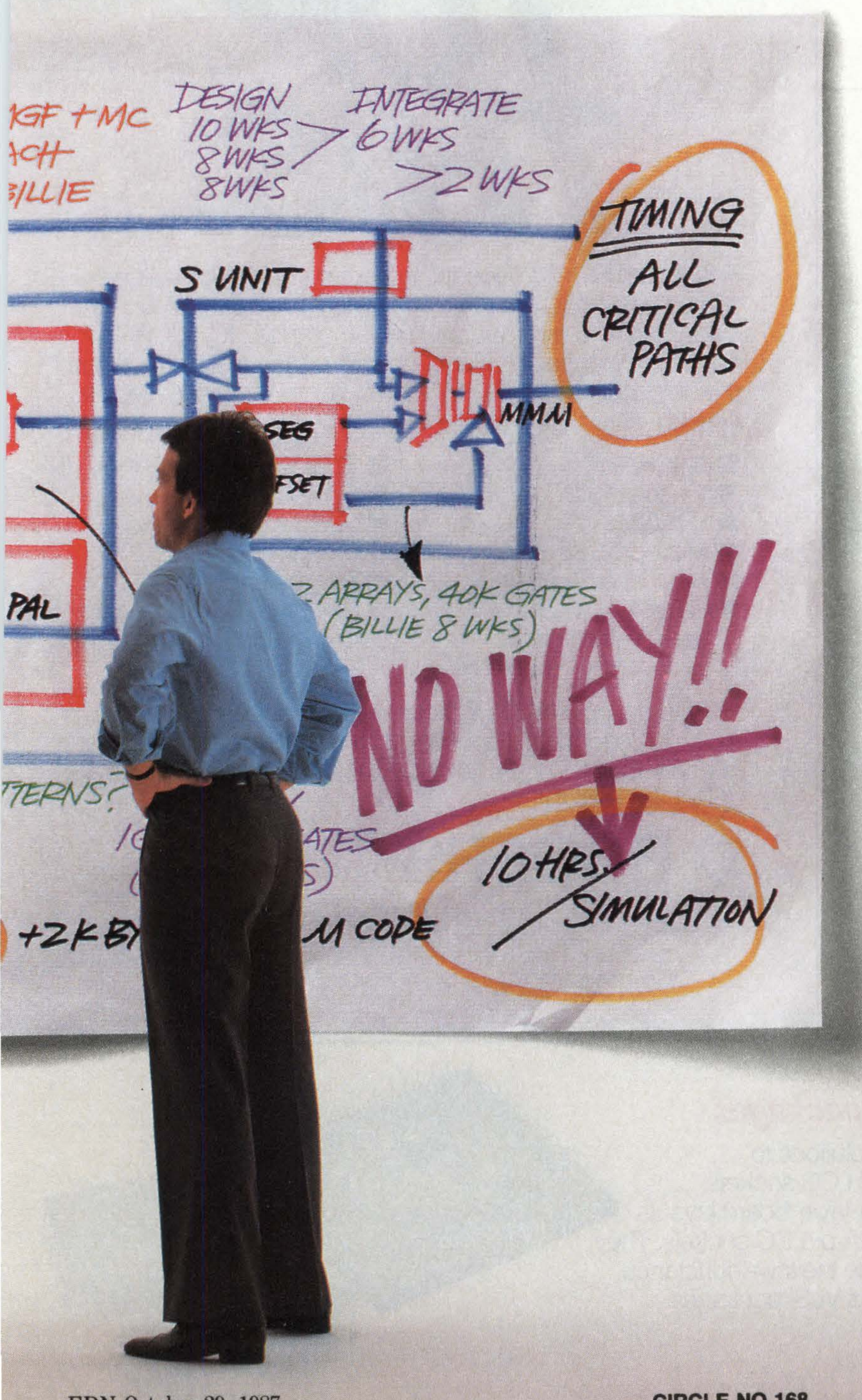
Now there's the AIDA Design System.

A comprehensive set of software design tools for capture, simulation and automatic generation of test patterns for systems of 5000 to 1 million gates. At all levels—chip, board, system.

Faster and more cost effective than ever before. Giving each designer 20 to 30 simulation turns a day. At one-tenth the cost of hardware accelerators.

The AIDA tool set is so powerful, it lets you do complete and automatic timing analysis of your design to identify all critical paths. And simulate its operation by running actual application programs and diagnostic software.





Even better, it guarantees 100% test coverage for scannable designs by automatically generating all possible test vectors.

Installation and training are easy, too. Because the AIDA Design System runs on industry-standard workstations. And we have translators that let you use your existing databases with the AIDA design tools.

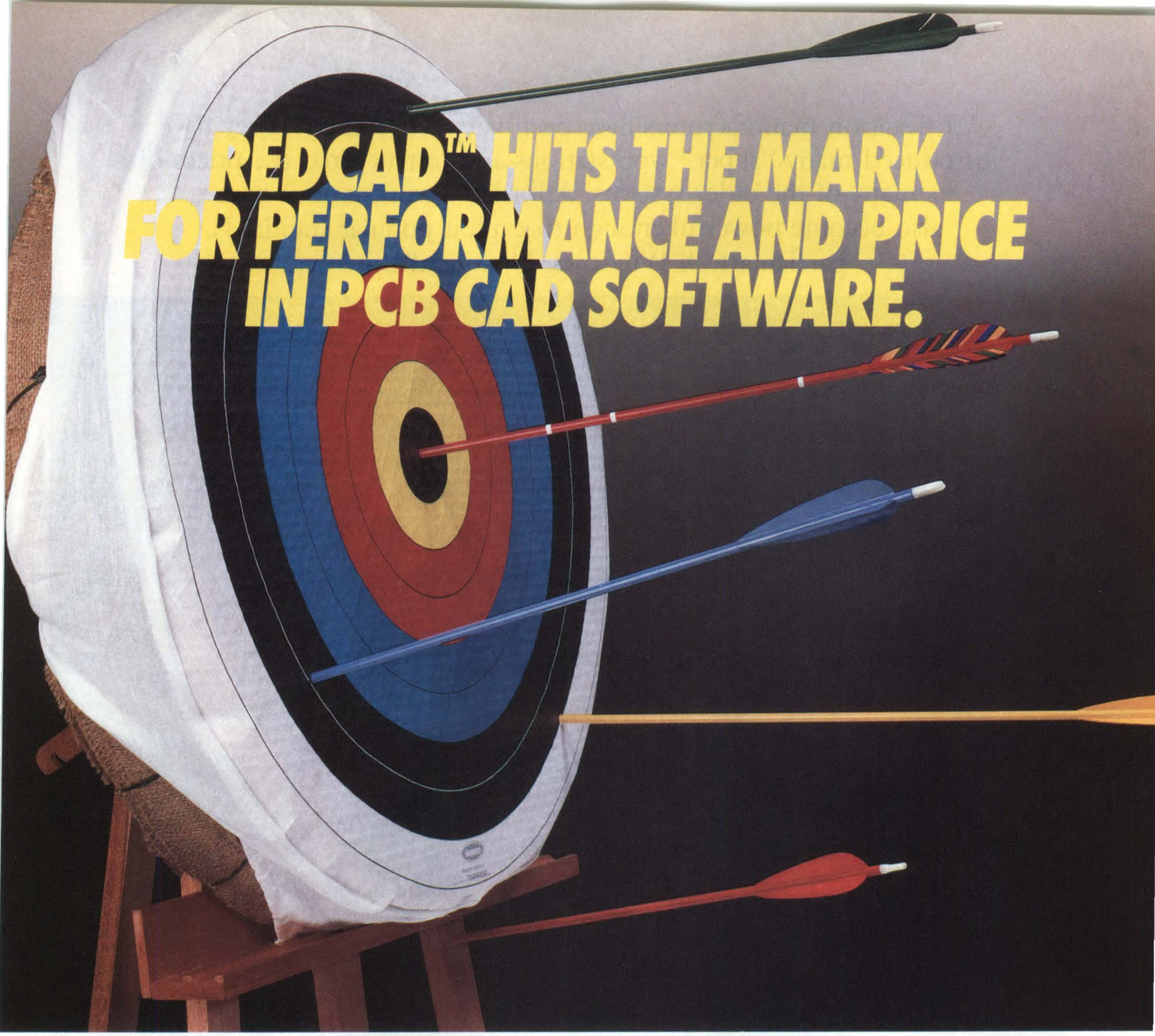
Skeptical? Call 408-980-5200 now to get a video tape* of what our customers are saying.

And see how we're helping them get systems off the wall and into production. Fast.

For more information, contact AIDA Corporation, 5155 Old Ironsides Drive, Santa Clara, CA 95054, 408-980-5200.

AIDA

*We reserve the right to qualify recipients.



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RACAL

Workstation manufacturers have been very active lately: They have introduced many "super" workstations and restructured the prices of many of the older systems. Affordable workstations have also become powerful enough to exploit popular standards, particularly X Windows, Unix, and Ethernet.

***By embracing relevant standards, today's workstations** are breaking down the wall that has prevented different computer networks from interacting and accessing each other's resources. (Photography by R G Muna; design by Morduk A Sayad; photo courtesy Sun Microsystems Inc)*

KEEPING AMERICA COMPETITIVE

Workstations

Special Report

David Shear, *Regional Editor*

Various workstation standards have existed for many years, but their acceptance has been hampered for two reasons. It takes time for workable standards to evolve and become accepted, and standard implementations are usually slower than nonstandard approaches. Workstation users often speak in favor of standards, but they also want the highest performance. Typically, to get the greatest level of performance, you had to bypass layers of software standards and interact directly with the hardware.

At long last, workable standards have evolved, and powerful, affordable workstations are available that embrace those standards (see **Table 1** on pg 172). In today's workstation market, the de facto operating-system standard is Unix. (Berkeley 4.X seems to be merging with AT&T's System V, resulting in one hybrid Unix standard.) The networking-system window manager is X Windows (version 11); almost all of the new workstations support some form or another of X Windows. The local-area network is Ethernet. Because the acceptance of these three standards is gaining momentum, you can now sit at your workstation and access any of the multitudinous resources of the other workstations on the network; indeed, your computer actually becomes a single network of shared resources.

You can imagine the incredible performance and flexibility that this combination of standards and workstations has to offer the average engineer. For example, using X Windows you can use your workstation to run a program from another computer, interacting with the program as if it were running on your machine (see **box,** "X Windows offers workable windowing environment"). Many windows can be open simultaneously, all running different programs and each running on any machine in the system—even if the machines are from different vendors.

***One of the new RISC-based workstations,** the HP Model 825SRX, operates at a 12.5-MHz clock rate and offers twice the performance of the company's 68020-based Model 350.*

Although imaginative, this scenario depicts a real-life situation. You can actually achieve this type of workstation performance now. Currently not much software is available to take advantage of *all* of these standards but, because it is so easy to port software to the X Windows environment, many application packages will soon be on the market. As a user (and potential customer), you can hurry this process by adopting these standards—by choosing a workstation that runs Unix, interfaces to Ethernet, and uses X Windows.

You'll find that evaluating the performance of these new workstations is a less-than-straightforward task. As far as a vendor is concerned, the easiest way to cite performance is by using MIPS (million instructions per second), but this number actually tells you, the user, very little. In fact, the acronym might as well stand for "meaningless indication of performance." If you look at how many instructions a machine can execute in one second without determining what that instruction is doing, you'll end up with a misrepresented number. For example, if a RISC (reduced instruction set computer) machine has a 16-MHz clock and each instruction executes in one cycle, should you classify it as a 16-MIPS machine? And, how do RISC MIPS compare to CISC (complex instruction set computer) MIPS?

The two problems with standards is the length of time it takes for a workable standard to evolve and the user's perception of reduced performance.

A small portion of your desk *is all you need for Digital Equipment Corp's VAXstation 2000.*

In an attempt to deal with this nebulousness, many vendors use what they call VAX MIPS. They begin with the premise that a VAX 11/780 is a 1-MIPS computer; then, they run a series of benchmarks and compare the results with what the VAX 11/780 is capable of doing. These results vary, depending on the benchmark being used. The most popular benchmarks are Whetstone, Dhrystone, and Linpack.

The Whetstone benchmarks are Fortran programs derived from an analysis of 1000 programs in an attempt to represent an average program instruction mix. The programs include floating-point and integer calculations, transcendental functions, array manipulation, and conditional jump statements. The Dhrystone benchmark simulates a high-level C programming environment and contains 100 statements with 53% assignments, 32% control statements, and 15% function calls. The Linpack benchmark solves a dense system of linear equations to provide a measure of floating-point performance.

Benchmarks can confuse the issue, too

To help you comprehend how confusing and arbitrary this practice of computing MIPS actually can be, consider a couple of examples provided by the manufacturers. The Sun 4/260 can do 19,000 Dhrystones/sec, whereas the VAX 11/780 can do 1428, and thus the Sun machine executes 13.3 times as many Dhrystones/sec as the VAX. Running the single-precision Linpack benchmark, however, the Sun 4/260 is only 6.4 times as fast as the VAX. Sun rates the workstation as a 10-MIPS machine.

Another example is Hewlett-Packard's Model 825SRX. This machine executes about nine times as many Dhrystones/sec as does the VAX 11/780. Running the single-precision Linpack benchmark, the 825SRX is less than three times as fast as the VAX 11/780. Hewlett-Packard classifies the 825SRX as an 8-MIPS workstation.

The Dhrystone, Whetstone, and Linpack benchmarks measure raw CPU power. They don't measure the overall efficiency of a system. Often these benchmarks can fit within the system's cache memory, and therefore only a very small portion of the system's peformance is measured, because the benchmarks are executing from the cache memory and don't have to access the main memory. The raw CPU speed of a computer doesn't tell you what the I/O bandwidth and system performance will be. You can usually assume that a 10-MIPS workstation will run your application faster than will a 1-MIPS machine, but you can't determine just how much faster.

The best way to evaluate a system's performance is to run your actual application. Normally you can't run your application as your benchmark, but check with your vendor. You might be pleasantly surprised. The next best thing is to look at all of the available benchmarks and decide the relative importance of each with your application in mind. Base your performance estimate on an aggregate of all of the benchmarks.

RISC-based workstations are here

Despite the lack of a single, reliable measure of workstation performance, the hardware available to take advantage of Unix, X Windows, and Ethernet has undoubtedly taken a quantum leap in terms of performance. This giant step is due in large part to the RISC architecture. In the past six months, Sun, Hewlett-Packard, and Silicon Graphics have introduced affordable RISC-based workstations.

The new Sun 4 Series of superworkstations is based on a 32-bit RISC μP called Sparc (Scalable Processor Architecture). To meet the corporate goal of doubling performance every year, Sun decided to develop its own μP; the vendor rates the performance of the Sun 4/260 at about 2½ times that of the 25-MHz, 68020-based Sun 2/260.

The Sun 4 family is source-code compatible with Sun's existing family of 68020-based products. Porting

X Windows offers workable windowing environment

Window managers have been available on many workstations for some time now. These windows allow you to access multiple applications simultaneously from several overlapping text and graphics windows. You can manipulate these windows in various ways: moving, sizing, overlapping, hiding, and iconizing.

Window managers are powerful tools but until recently have suffered from some serious problems. For one thing, there have been too many different window systems. As a user, you had many different controls to remember. Also, the windows were very machine and application dependent; even after you became comfortable with one application's windowing system, you still had another set of controls to learn for a different application. Another drawback was the impossibility of effectively accessing a network from within the windowing environment.

Ideally all manufacturers would use a common window manager and then all applications would look similar. Also, if this same window manager allowed networking, you could run applications on any machine on the network just as if they were running on your machine.

The problems are solved

X Windows, which was developed at MIT, provides high-performance, high-level, device-independent graphics. All of the major workstation manufacturers have embraced it. Most have built software-development tool kits to facilitate its use, thus greatly simplifying the creation of sophisticated user interfaces.

With X Windows, even if workstations are from different vendors, programs can run on one workstation and be displayed on another. Computation-intensive applications can run on a minicomputer or mainframe computer without ever requiring that you change the user interface.

Another major advantage that X Windows offers is device independence **(Fig A)**. In the past, it was always necessary to alter each software package to take advantage of a new display. With the X Windows architecture, a server does all the display manipulation. The server receives requests from all the application programs using the display and carries them out. Thus, entire networks of workstations with different display hardware can utilize the same executable application code. As new displays are added, the only requirement is a new server that understands X Windows.

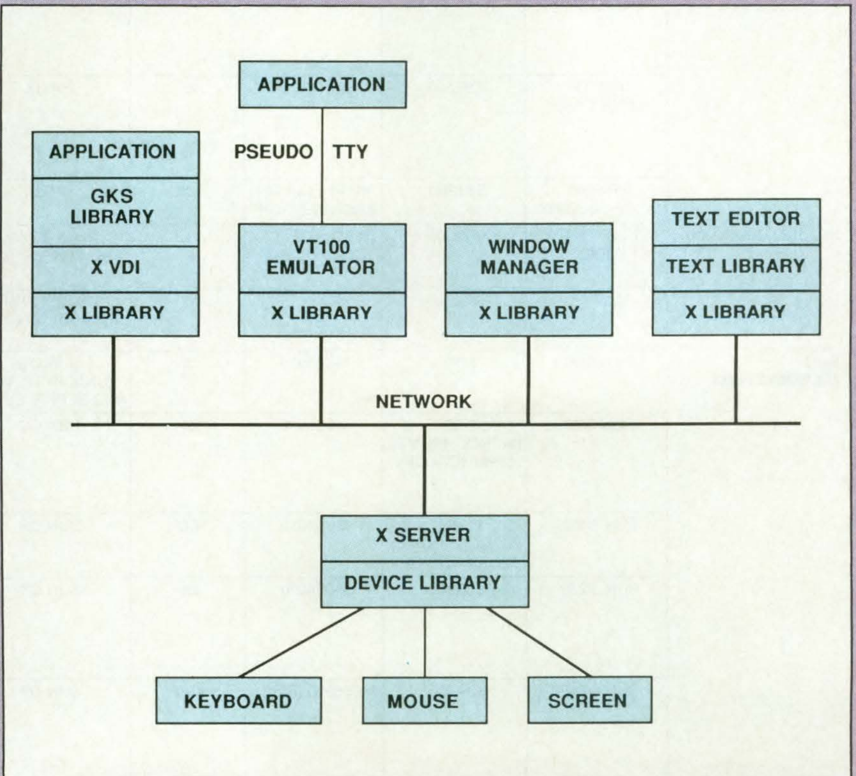


Fig A—X Windows is hardware independent. *A server takes care of all the display-manipulation requests from the various application programs, so different workstations can use the same executable application code.*

TABLE 1—WORKSTATIONS

COMPANY	PRODUCT	BASE PRICE	CPU	CLOCK FREQUENCY (MHz)	OPERATING SYSTEM	MEMORY (MIN/MAX) (BYTES)	GRAPHICS	
							MONITOR	RESOLUTION (PIXELS)
APOLLO COMPUTER	DOMAIN SERIES 3000	$4990	MC68020	12	UNIX SYSTEM V AND BERKELEY 4.2 AND AEGIS	2M/8M	15-IN. MONOCHROME 19-IN. MONOCHROME 15- OR 19-IN. COLOR	1024×800 1280×1024 1024×800
	DOMAIN SERIES 4000	$13,900	MC68020	25	UNIX SYSTEM V AND BERKELEY 4.2 AND AEGIS	4M/32M	19-IN. MONOCHROME 15- OR 19-IN. COLOR	1280×1024 1024×800
	DN5XX TURBO WORKSTATIONS	$46,900	MC68020	20	UNIX SYSTEM V AND BERKELEY 4.2 AND AEGIS	8M/32M	19-IN. COLOR	1280×1024
APPLE COMPUTER	MACINTOSH II	$4796	MC68020	15.7	MACINTOSH OS A/UX (UNIX SYSTEM V AND BERKELEY 4.2)	1M/8M	12-IN. MONOCHROME 13-IN. COLOR	640×480 640×480
DIGITAL EQUIPMENT CORP	VAXSTATION 2000	$4600	MICROVAX II	40	ULTRIX (UNIX) OR VMS	4M/6M	15- OR 19-IN. GRAY SCALE 15- OR 19-IN. MONOCHROME 15- OR 19-IN. COLOR	1024×864 1024×864 1024×864
	VAXSTATION II	$26,000	MICROVAX II	40	ULTRIX (UNIX) OR VMS	2M/16M	19-IN. MONOCHROME	1024×864
	VAXSTATION II/GPX	$19,900	MICROVAX II	40	ULTRIX (UNIX) OR VMS	3M/16M	19-IN. GRAY SCALE 19-IN. COLOR	1024×864 1024×864
	VAXSTATION 3200	$19,900	CMOS CPU (VAX BASED)	22	ULTRIX (UNIX) OR VMS	8M/16M	19-IN. GRAY SCALE 19-IN. COLOR	1024×864 1024×864
	VAXSTATION 3500	$50,400	CMOS CPU (VAX BASED)	22	ULTRIX (UNIX) OR VMS	16M/32M	19-IN. GRAY SCALE 19-IN. COLOR	1024×864 1024×864
HEWLETT-PACKARD	HP 9000 MODEL 318M	$4990	MC68020	16.67	HP-UX	4M/4M	17-IN. MONOCHROME	1028×768
	HP 9000 MODEL 330	$12,950	MC68020	16.67	HP-UX	4M/8M	19-IN. MONOCHROME 16- OR 19-IN. COLOR	1280×1024 1280×1024
	HP 9000 MODEL 350	$25,100	MC68020	25	HP-UX	4M/48M	19-IN. MONOCHROME 16- OR 19-IN. COLOR	1280×1024 1280×1024
	HP 9000 MODEL 825SRX	$69,500	HP PRECISION ARCHITECTURE	12.5	HP-UX	8M/48M	19-IN. COLOR	1280×1024
SILICON GRAPHICS	IRIS 4D/60 TURBO	$64,900	RISC μP (MIPS COMPUTERS)	12.5	UNIX SYSTEM V AND BERKELEY 4.3	4M/12M	19-IN. COLOR	1280×1024
	IRIS 3130	$59,900	MC68020	16	UNIX SYSTEM V AND BERKELEY 4.3	8M/16M	19-IN. COLOR	1024×768
SUN MICROSYSTEMS	SUN 3/50	$4995	MC68020	15	SUN OS (UNIX SYSTEM V AND BERKELEY 4.2)	4M/4M	19-IN. MONOCHROME	1152×900
	SUN 3/60	$7900 (MONOCHROME) $9900 (COLOR)	MC68020	20	SUN OS	4M/24M	19-IN. GRAY SCALE 19-IN. HIGH-RESOLUTION MONOCHROME 19-IN. MONOCHROME 16- OR 19-IN. COLOR	1152×900 1600×1280 1152×900 1152×900
	SUN 3/160	$19,900 (MONOCHROME) $27,900 (COLOR)	MC68020	16.67	SUN OS	4M/16M	19-IN. MONOCHROME 19-IN. GRAY SCALE 19-IN. COLOR	1152×900 1152×900 1152×900
	SUN 3/260	$28,900	MC68020	25	SUN OS	8M/32M	19-IN. MONOCHROME 19-IN. HIGH-RESOLUTION MONOCHROME 19-IN. GRAY SCALE 19-IN. COLOR	1152×900 1600×1280 1152×900 1152×900
	SUN 4/260	$39,900	MB86900 (RISC)	16.67	SUN OS	8M/128M	19-IN. MONOCHROME 19-IN. HIGH-RESOLUTION MONOCHROME 19-IN. GRAY SCALE 19-IN. COLOR	1152×900 1600×1280 1152×900 1152×900

COLOR/ PALETTE	FLOATING-POINT PROCESSOR	STORAGE (BYTES) FLOPPY DISK	HARD DISK	TAPE	LOCAL-AREA NETWORK
16/4096 OR 256/16.7M	MC68881	5¼ IN. 1.2M	72M-348M	60M	APOLLO TOKEN RING OR ETHERNET
256/16.7M	MC68881	5¼ IN. 1.2M	155M-348M	60M	APOLLO TOKEN RING OR ETHERNET
256/16.7M OR 1.3M/16.7M	MC68881 OPTIONAL FPX		155M-696M	60M	APOLLO TOKEN RING OR ETHERNET
	MC68881	3½ IN. 800k	20M-80M		APPLETALK, ETHERNET
16/16.7M	78132 (PROPRIETARY)	5¼ IN. 1.2M	44M-159M	95M	ETHERNET
	78132 (PROPRIETARY)	DUAL 5¼ IN. 400k	71M-159M	95M	ETHERNET
16 OR 256/16.7M	78132 (PROPRIETARY)	DUAL 5¼ IN. 400k	71M-159M	95M	ETHERNET
256/16.7M	CMOS FLOATING-POINT UNIT		71M-318M	95M	ETHERNET
256/16.7M	CMOS FLOATING-POINT UNIT		280M-560M	296M	ETHERNET
	MC68881	3½ IN. 270k-630k 5¼ IN. 270k	101M-571M	15M-140M	ETHERNET
256/16.7M	MC68881 OPTIONAL FLOATING-POINT ACCELERATOR	3½ IN. 270k-630k 5¼ IN. 270k	101M-571M	15M-140M	ETHERNET
256/16.7M	MC68881 OPTIONAL FLOATING-POINT ACCELERATOR	3½ IN. 270k-630k 5¼ IN. 270k	10M-571M	15M-140M	ETHERNET
16/16.7M	HP PROPRIETARY		132M-571M	15M-140M	ETHERNET
4096/16.7M OR 16.7M/16.7M	PROPRIETARY		170M-340M	60M	ETHERNET
4096/16.7M OR 16.7M/16.7M	WEITEK 1064		170M	60M	ETHERNET
			71M-141M	60M	ETHERNET, GM-MAP
256/16.7M	MC68881		71M-282M	60M	ETHERNET, GM-MAP
256/16.7M	MC68881		141M-1.2G	60M	ETHERNET, GM-MAP
256/16.7M	MC68881		280M-2.3G	60M	ETHERNET
256/16.7M	WEITEK 1164/1165		280M-2.3G	60M	ETHERNET

A RISC-based *Sun 4/260 from Sun Microsystems uses a proprietary μP to more than double the performance level of the 68020-based 2/260.*

code from the Sun 2 and Sun 3 families requires only the recompilation of programs. This level of compatibility also allows all systems to use the same software and be combined in network installations. If you already have a Sun 3, you can upgrade to a Sun 4 by swapping CPU boards. Both machines use a triple-height, quad-depth Eurocard board. Two of the three bus connectors provide internal communications between boards; the third is a VME bus for I/O access.

Hewlett-Packard has three new advanced computer systems that employ a RISC architecture. Model 825SRX is the family's workstation and is the first workstation based on HP's Precision Architecture. The company claims that the 12.5-MHz 825SRX's performance is twice that of the 25-MHz, 68020-based Model 350. Model 825SRX uses the HP-UX operating system, which adheres to AT&T's Unix System V. The workstation is object-code compatible with all Series 800 products and is source-code compatible with all Series 300 products.

The Iris 4D/60 Turbo workstation from Silicon Graphics is the third RISC-based machine to be introduced recently. The machine uses a 32-bit RISC μP from MIPS Computers (Sunnyvale, CA), a floating-point accelerator, and a 10-MHz geometry engine for high-speed graphics.

Non-RISC workstations still have a place

Don't be misled into believing that RISC-based workstations are making non-RISC machines obsolete: They

The hardware that the standards will work on is more powerful and offers greater performance.

Offering three display options*—a 15-in. color, a 19-in. color, or a 19-in. monochrome monitor—the Apollo Computer Domain Series 4000 workstation is based on a Motorola 68020 running at 25 MHz.*

are alive and well. The Domain Series 4000 Personal Super Workstation from Apollo Computers uses the MC68020 CPU and the MC68881 floating-point coprocessor, both running at 25 MHz. The system memory uses 1M-bit surface-mount dynamic RAMs for a maximum of 32M bytes of main memory, and the system supports as much as 1G bytes of virtual-memory space.

The Series 4000 has an IBM PC/AT-compatible peripheral bus. The CPU runs with zero wait states on an independent 32-bit bus that is fully synchronized with the PC/AT-compatible bus, which holds the system's mass storage, network, and graphics controllers. The 32-bit CPU bus provides a full 32-bit data path between the CPU, cache memory, floating-point coprocessor, and system memory.

The Macintosh II from Apple Computers *is a 68020-based computer with an open architecture that has six-32-bit Nubus slots for expansion.*

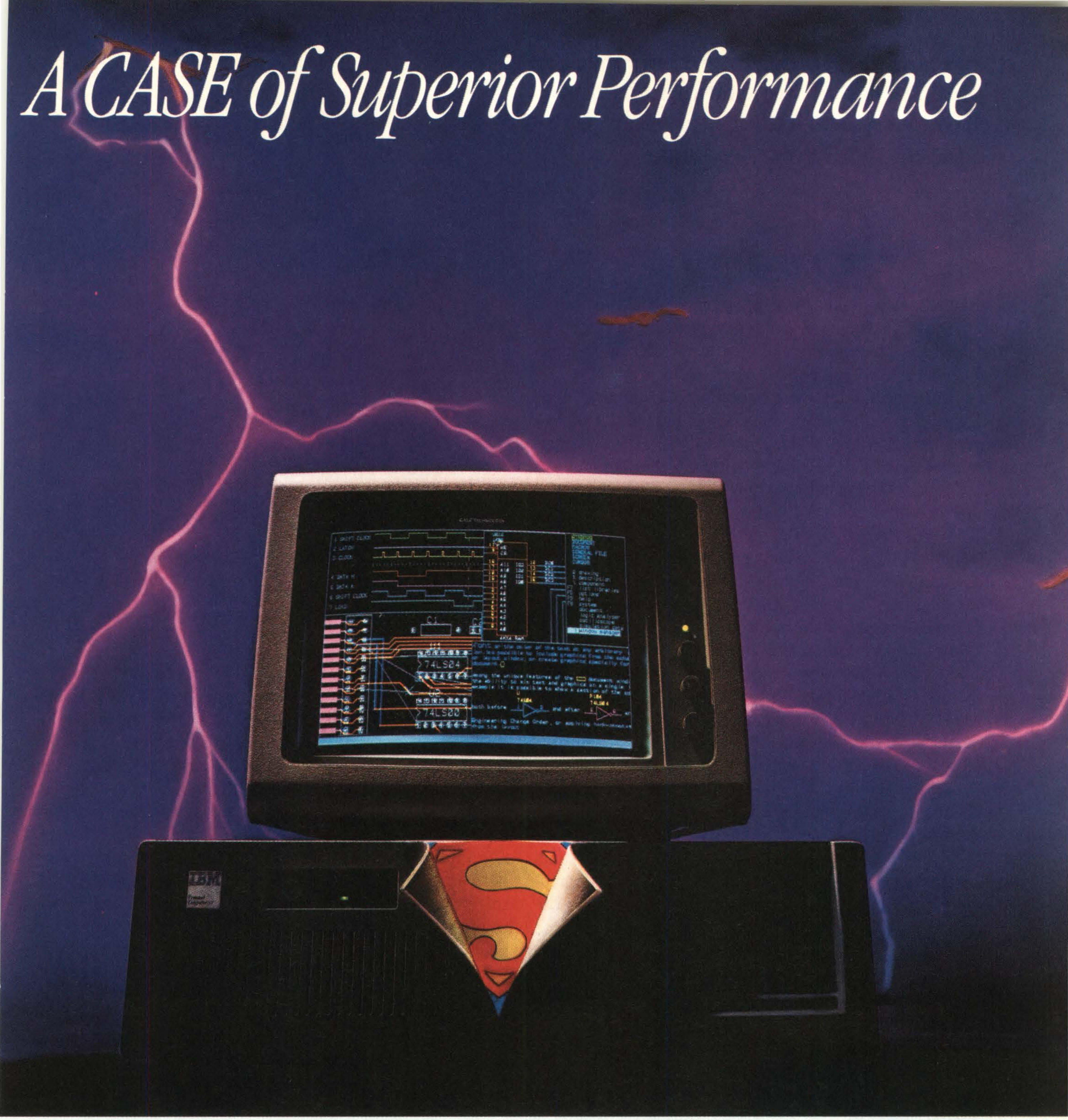
You can either purchase a diskless node, or you can specify a 5¼-in., 1.2M-byte floppy-disk drive; a 60M-byte cartridge tape drive; and either a 155M- or 348M-byte hard-disk drive. You also have a choice of a 19-in., 1280×1024-pixel monochrome display or a 15- or 19-in. color display with a resolution of 1024×800 pixels. The local-area network can be either Ethernet or Apollo's Token Ring.

The Series 3000, which also has an IBM PC/AT-compatible peripheral bus, has gone down in price by as much as 50%, thanks to enhancements in the manufacturing process. A monochrome diskless node has a base price of $4990. The price of a Series 3000 with a 19-in. monochrome monitor, 4M bytes of memory, a 72M-byte hard-disk drive, and a floppy-disk drive is now less than $10,000.

Open architecture means low-cost expansion

Open architecture is a big plus with the Apollo line. Because of the low-cost PC/AT bus, you can use peripheral boards from the inexpensive PC domain to expand the system. You also have the option of plugging in an 80286-based board and running MS-DOS applications.

The newly announced Sun 3/60 workstation uses a 20-MHz MC68020 μP with a 20-MHz MC68881 coprocessor. The Sun 3/260 uses the same processors but operates at a 25-MHz clock frequency. Like Apollo's



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Non-RISC-based workstations are alive and well; in fact, manufacturers are introducing many new products.

Domain Series, some existing members of the Sun 3 family have also seen a significant decrease in price. At the low end, for example, is the Sun 3/50, a diskless node with a base price of $4995.

Digital Equipment Corp manufactures several non-RISC workstations. The VAXstation 3200 and 3500 are recent introductions. Both are based on a proprietary, 32-bit, VAX-based μP made with CMOS technology. The vendor claims that this new CMOS chip set results in performance 2.6 to 4.2 times greater than that of DEC's VAXstation II/GPX. A 1-year on-site warranty is included in the purchase price. The VAXstation 2000, 3200, and 3500 are all software compatible with the other members of the VAXstation family.

The VAXstation 2000 is an entry-level workstation. The lowest-cost version is a monochrome diskless node that sells for $4600. The same system with a 42M-byte Winchester disk drive and a 1.2M-byte floppy-disk drive costs $7650. Designed as a desktop system, the VAXstation 2000 contains a single-board computer with a MicroVAX II μP, a floating-point unit, system memory, disk controllers, a video controller, a mouse, a keyboard, a printer, and serial communication lines. It also has a separate Ethernet controller.

Don't overlook the possibilities of using your personal computer as a low-end workstation. The Apple Macintosh II is a 15.7-MHz 68020-based machine and is the

This under-$10,000 color workstation *from Sun Microsystems uses a 20-MHz 68020 μP. The Sun 3/60 offers a choice of five different monitors and has as much as 24M bytes of memory.*

first Macintosh with an open architecture. Six 32-bit Nubus expansion slots support a 10M-byte/sec data-transfer rate. Apple is planning to have Unix available for the Macintosh II in the form of A/UX. A/UX is a full implementation of AT&T Unix System V and includes features from Berkeley's 4.2. The Appletalk network is built into the Macintosh, but an Ethernet interface is available so you can access other machines on your network. The computer's open architecture and massive third-party support provide you with the flexibility to select a configuration that meets your needs.

It's too soon to tell where the IBM PS/2 family will fit in the workstation market. But it's easy to predict that these machines, like the Macintosh systems, will make major inroads into the low-end market.

Regardless of what the future holds, the advantages of having a workstation hooked up to a network of systems all working together and using X Windows can't be overstated. RISC-based workstations have a very easy migration path to higher performance, and gradual improvements in performance will continue. When making your purchasing decisions, insist on a workstation compatible with X Windows, Unix, and Ethernet. Finally, be careful when you evaluate a vendor's estimate of workstation performance and keep your application in mind. **EDN**

Manufacturers of workstations

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

Apollo Computer Inc
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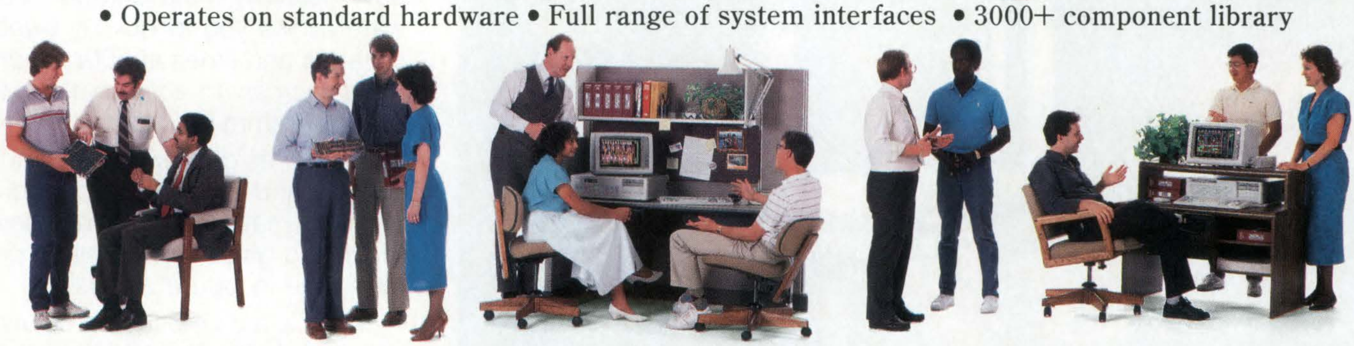

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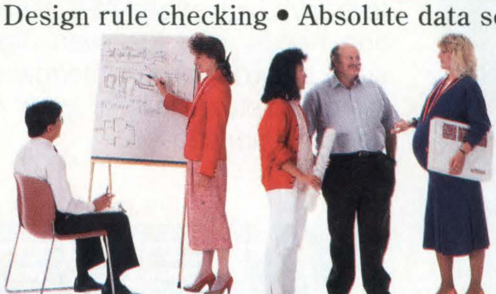

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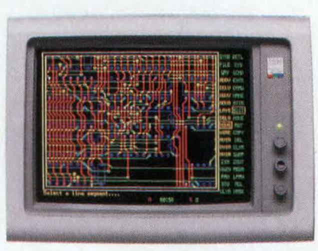

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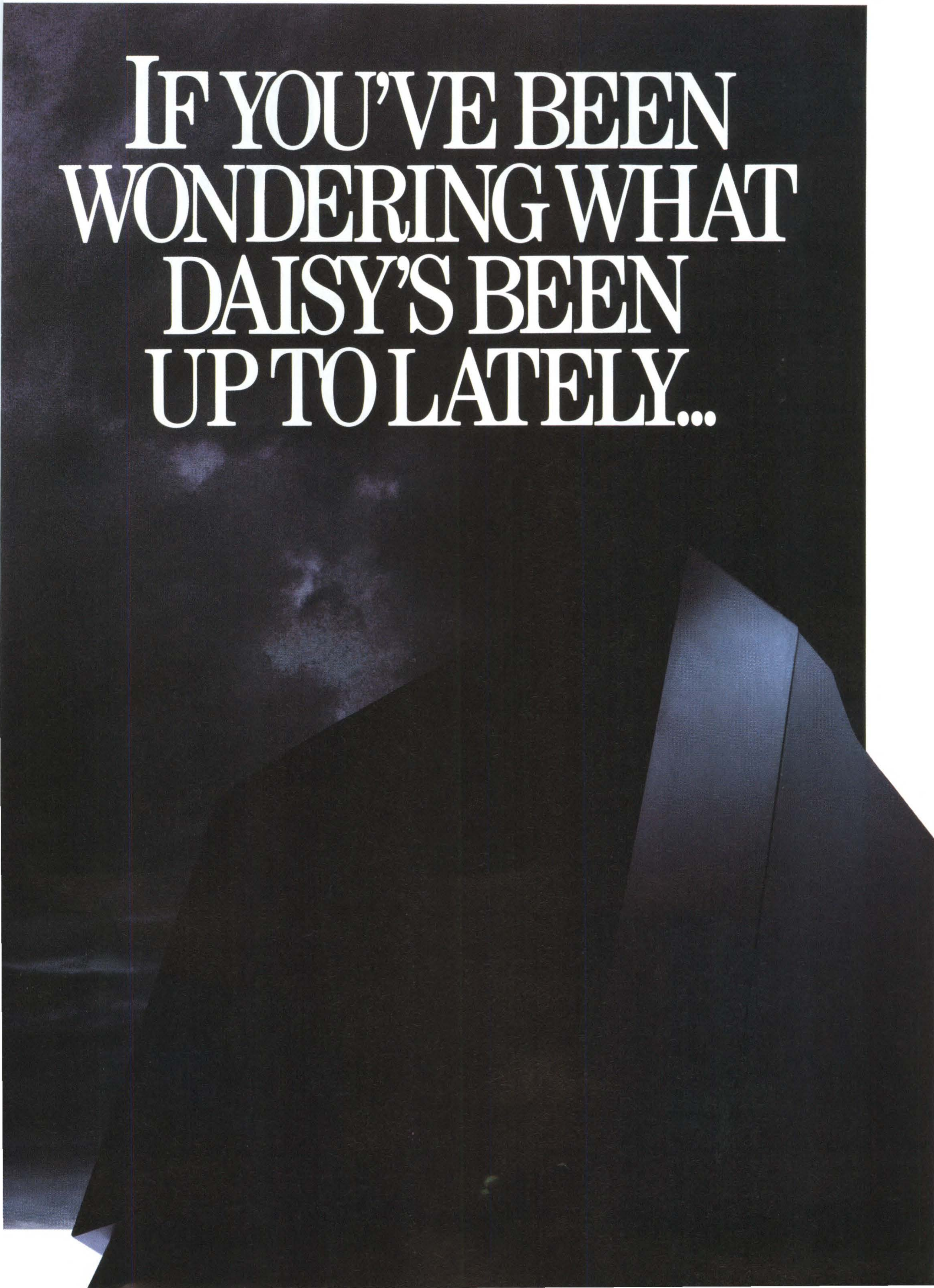
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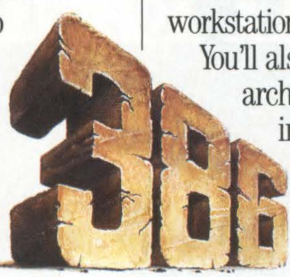

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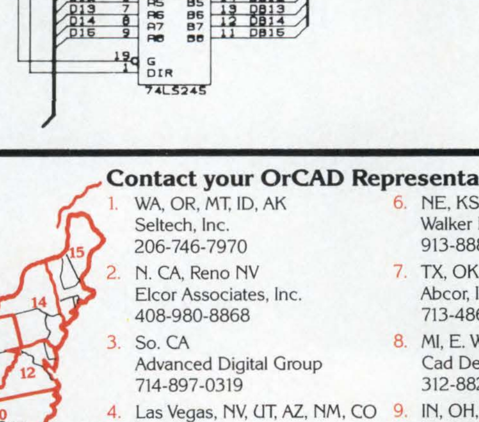

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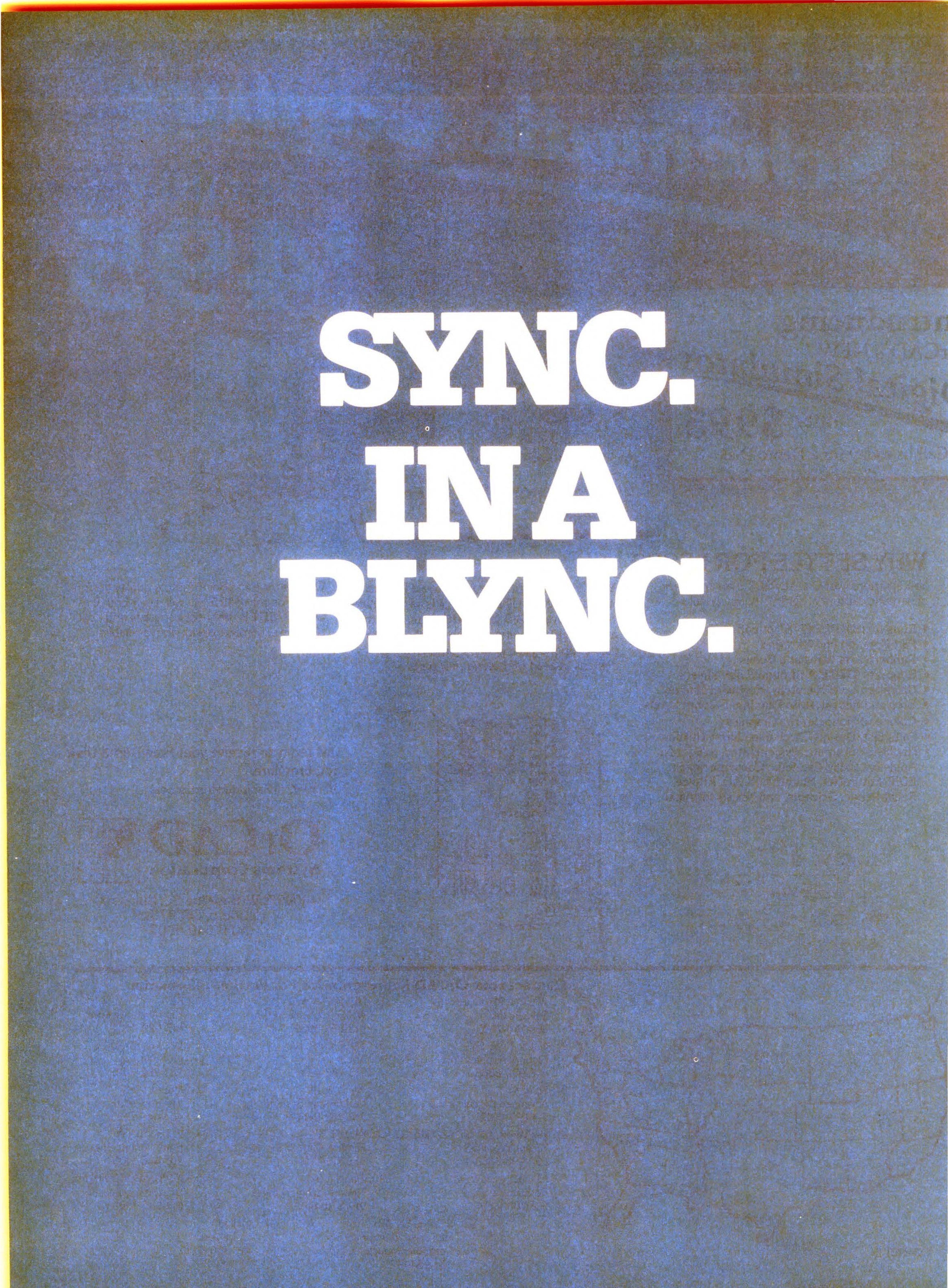
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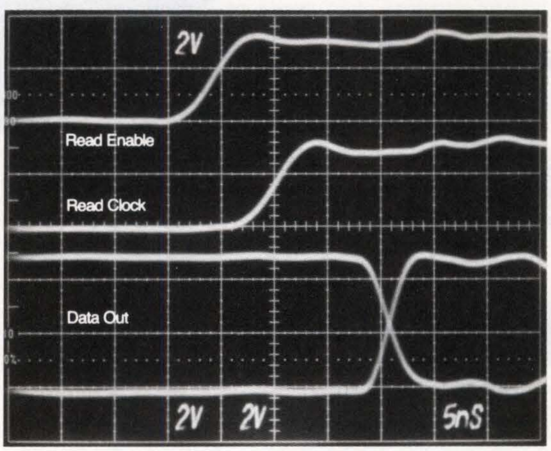
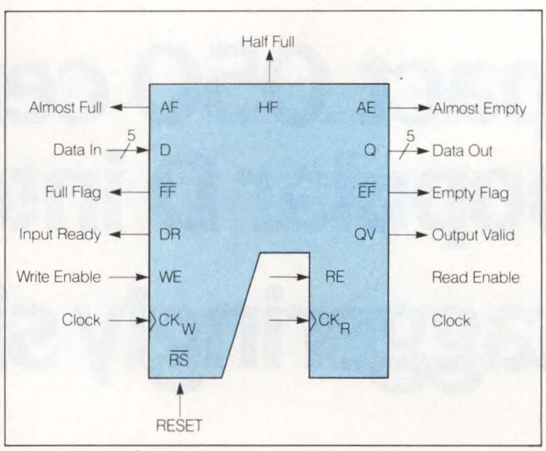


Actual MK4505 BIPORT FIFO Scope Trace Photograph



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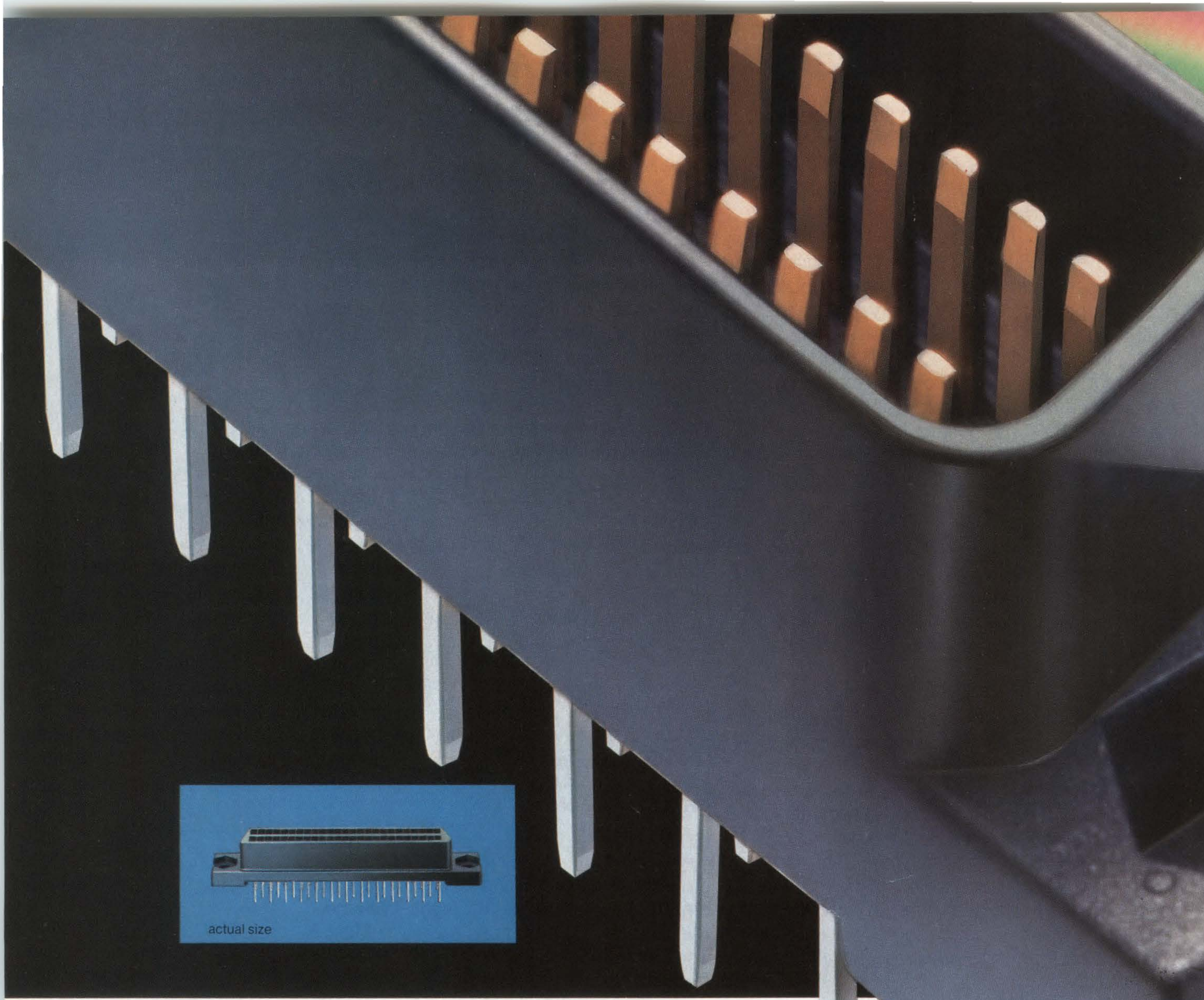

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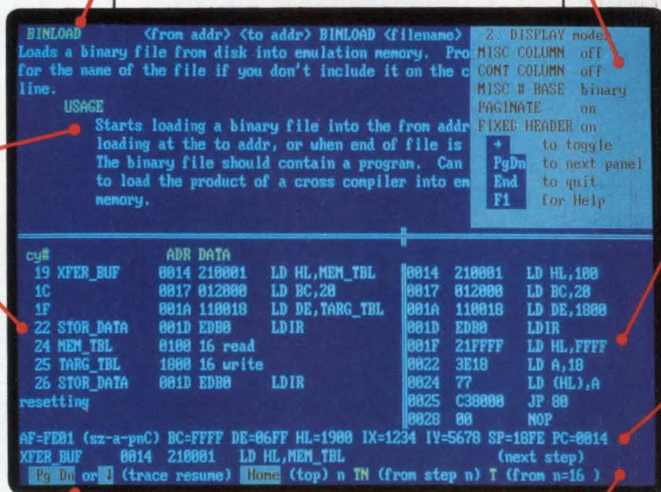

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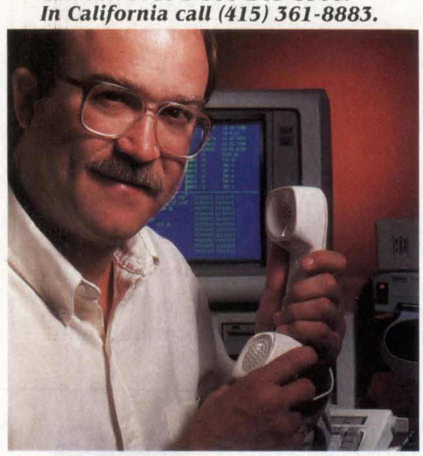

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VME Bus applications can benefit from 80386-based designs

Traditionally, designing for the VME Bus automatically meant a design based on a 68000 μP. But without too much trouble you can use an 80386 as a VME Bus CPU.

Steph Rutel and X Kim Rubin, *Force Computers*

Although the first processors designed into VME Bus applications belonged to the 68000 family, there aren't any insurmountable signal or timing restrictions that limit the bus to only these types of processors. The 80386, for example, a 32-bit virtual-memory μP capable of processing 3 to 5 MIPS, can also provide the basis for a VME Bus design. Moreover, the 80386 can execute object code for the 8086 family, which adds to its allure. The device's on-chip resources also allow the chip to intermix operating systems (such as Unix and MS-DOS), which allows you to run application packages as tasks under Unix (see **box**, "Putting the 80386 aboard the VME Bus.")

Multiple bus masters offer advantages

The VME Bus is a high-speed bus that allows you to implement a system that supports data-transfer rates as high as 40M bytes/sec. It also supports multiple bus masters so that you can mix 80386- and 68020-based cards in the same system and take advantage of each of their strengths. For those instances when you want to include more than one master in your VME Bus system, you'll have to include circuitry that will arbitrate between bus masters. Either a round-robin arbitration scheme or a prioritized approach is effective.

Take a close look at the VME Bus standard before considering the 80386 in a VME Bus design. Two standard 96-pin DIN edge connectors, P1 and P2, provide the backplane bus interface. P1 contains all the control lines as well as the lower 24 address and 16 data lines. The middle row of P2 contains the remaining address and data lines, and the two outer rows contain 64 unassigned pins, which system designers can use to define their own functions (see **box**, "VME Bus and 80386 signals are compatible"). The VME Bus's electrical interface requires that the bus drivers' rated drive current is 64 mA for the address- and data-strobe lines as well as for the system-clock and the bus-clear signals. Most of the other lines (including the address and data lines) require only 48-mA drivers.

The critical timing of some onboard signals requires that you include a clock on your board that operates at a much higher frequency than the processor's clock. For instance, you might use a 64-MHz clock as your timebase, which you can then divide by 2 to obtain the 32-MHz signal that the CPU requires. Additional clock phases are distributed on the board so that each drives about the same number of loads, and the signals are about equal in trace length. The combination of limited

Although the first processors to be designed into VME Bus applications were 68000s, the VME Bus isn't confined to just those processors.

trace lengths and equal loading minimizes clock skew. The availability of precision clock signals such as these is crucial to the design of control logic. You can use these master clock signals to synchronize, through gating or latching, all of the control signals **(Fig 1)**. This way you restrict the accumulated clock skew to the variation in propagation delay within a chip.

The 80386 accommodates the VME Bus's asynchronous timing via its ready line; the line indicates when outgoing data on the bus is available and valid. The VME Bus's data-acknowledge signal controls the 80386's ready line, thus eliminating the need for any complex clock schemes to synchronize data transfers. This fact isn't surprising, because the 80386's bus is a clocked asynchronous bus that's very similar to that of the 68000 family. The 16-MHz clock that the 80386 requires is identical to the clock required by the VME Bus backplane.

The 80386's remaining signals connect to the VME Bus in a straightforward manner. The data bus is a bidirectional, nonmultiplexed, 32-bit bus. You can buffer it using two 74ALS646-1 dual octal registers, which then connect directly to the VME Bus. (The ALS octal registers provide the required fast switching speed without the noise-inducing edges that some other logic chips have.) You need to generate four control signals (data direction, bus write, latch address, and write mode) for the data bus and four signals for the address bus (latch address, memory address direction, prelongword, and pre-A01).

You can buffer the unidirectional address bus by using high-current 74ACT374 octal drivers, which latch the address directly from the CPU's bus and connect

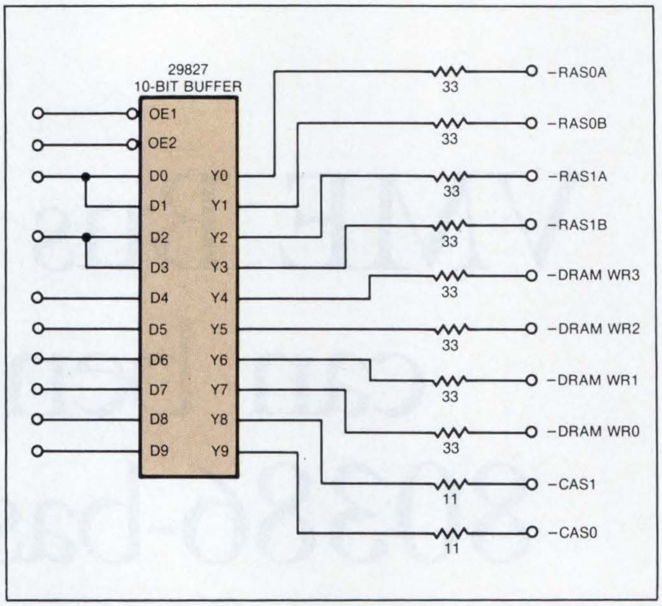


Fig 1—By running all your memory control signals *through the same buffer, you minimize the signals' skew. The termination resistors shown here also minimize reflections on the signal lines.*

directly to the board connector. The reason for using latches, rather than buffers, is simple: Very often the system will operate in a pipelined mode for bus accesses and therefore will have to hold the address until the bus is released.

The bus's 32-bit address space is common to both the VME Bus and the 80386, and the VME Bus's A16 address mode supports the 80386's I/O space. The VME Bus supports multiple address spaces, which are controlled by the six address modifier lines. The address space selected depends on whether the access is for I/O,

Putting the 80386 aboard the VME Bus

Force Computers developed a debug monitor for its CPU-386 80386-based VME Bus computer using the company's 68000/020 code as a basis for the development of the 80386 software. Because the 80386 can internally emulate the 8086, it directly executes code already written for the 8086 processor. The only exception to this internal emulation is the initialization and startup utility, which is specific to the 80386. Programs written in native code for the 8086 will run on the 80386, and software written in higher-level languages may be recompiled for the 80386.

The single-board CPU-386 includes three serial ports, two general-purpose RS-232C ports, two 16-bit counter/timers, and three 8-bit counter/timers. All these functions are included in just two chips: the 68901 multifunction peripheral chip from Thomson-Mostek and the 68562 dual universal serial-communications controller-timer chip from Signetics. Front-panel DIP switches set the EPROM type and speed, and these switches also determine the board's bootup mode.

memory, code, or data, and whether it's a user or supervisory type of access.

A caveat of which you should be aware involves "byte ordering." The 80386 uses a different numbering convention than does the MC68000 family. The 68000 processors' bytes are numbered from left to right (high order to low order) within a long word (32-bit word); the 80386's bytes are numbered from right to left (low order to high order). If you use only one type of processor in a system, the numbering scheme will be inconsequential, but if you develop a system with both types, you must exercise some caution and make sure that you translate low-order to high-order bytes between the processors.

Some VME Bus cycles can take an indeterminately long time to run. In such cases control circuits are necessary to ensure that onboard dynamic RAM cycles don't start while a VME Bus cycle is in progress and that the RAM is refreshed before data is lost. An inhibit signal to the RAM decoder prevents interference between memory cycles and VME Bus cycles. While the RAM decoder is inhibited, another decoder provides VME Bus decoding in parallel with the RAM decoding; the subsequent VME Bus cycle is set up while the RAM cycle is being completed.

The 80386 has a 4G-byte address space. You can load a board with 2M bytes of interleaved, 100-nsec dynamic RAM and yet still obtain zero-wait-state performance (**Fig 2**). Interleaving divides the memory into two banks and permits one bank to finish its cycle while the other bank is being accessed. If you use look-ahead logic for the interleaved access, the memory can handle data-transfer rates of 32M bytes/sec. To achieve such high rates, the look-ahead feature must examine the current state of the system and decide which of several combinatorial paths to follow next. By selecting the combinatorial path in advance, the timing section only encounters the delay caused by the combinatorial logic.

Another technique you can use to accelerate memory accesses is transparent memory refresh—a technique that eliminates interference between the processor and the refresh function. Your refresh circuitry must access the dynamic RAM only when the RAM is idle, when the processor isn't trying to read from or write to memory. You can use a few programmable logic chips to generate the necessary refresh logic. It's a good idea to buffer all the RAS (row address strobe) and CAS (column address strobe) signals with the same chip to minimize the skew between those signals. You should also use termination resistors on these signal lines; the signals will be distributed to many chips on your board, and the termination resistors will eliminate signal-quality problems such as reflections.

You can base your RAM-control logic on a state-

VME Bus and 80386 signals are compatible

Using the 80386 in a system originally designed for the 68000 requires only a minimal amount of head scratching as far as control signals are concerned: Buses are buses, after all. Many of the control signals that the 68000 Series uses have equivalents on the 80386, or you can reconfigure 80386 signals using glue logic to generate the appropriate equivalent.

The 80386 comes in a 132-lead pin-grid array package. If you eliminate the 21 V_{CC} pins, the 20 ground pins, and the eight unconnected pins, you have 83 signal pins. The data bus uses 32 pins, and Intel's expansion of the lower two address bits into byte-enable lines produces a total of 34 address lines. Subtracting the data and address pins' total from 83 leaves 17 control and status signals to deal with.

Like most μPs, many of those 17 pins have standard functions —for example, single-phase clock, reset input, nonmaskable interrupt, and general interrupt. Hold and hold-acknowledge signals on the 80386 provide the necessary handshaking for you to get the processor on and off the bus. The signals that are specific to the memory interface are the read/write and address-strobe lines and the memory/IO lines. Another line, data/code, indicates whether the processor is pulling an instruction or data word from the bus.

One more control signal, "bus size 16," tells the processor that it should use a 16-bit, rather than a 32-bit, data bus. The busy output permits the processor to indicate to the rest of the system that it can't respond to a bus access.

The VME Bus supports multiple bus masters, so that you can mix 80386- and 68020-based cards in the same system.

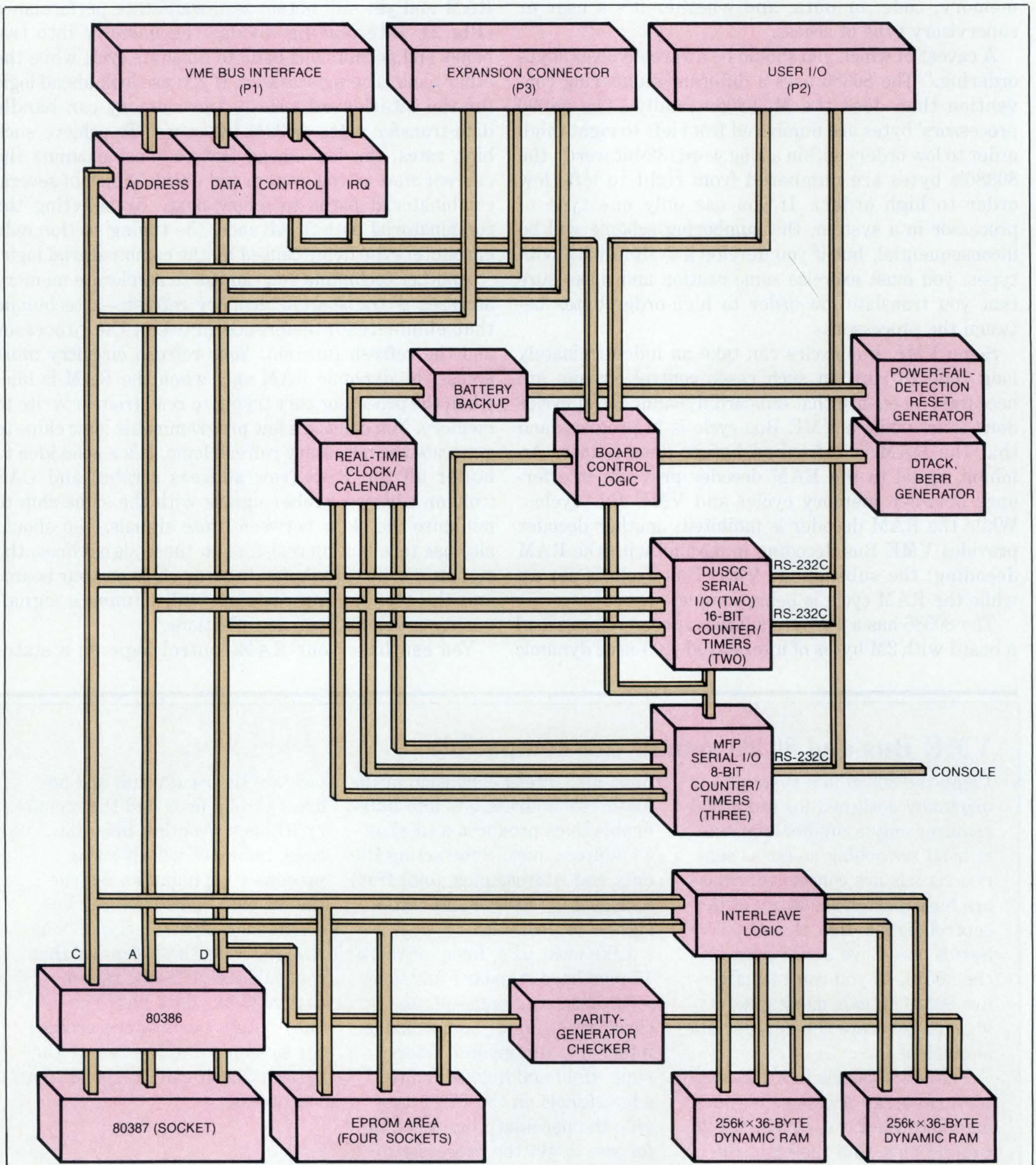


Fig 2—This diagram of an 80386-based VME Bus board's architecture *illustrates, among other things, the interleaved RAM that provides zero-wait-state operation.*

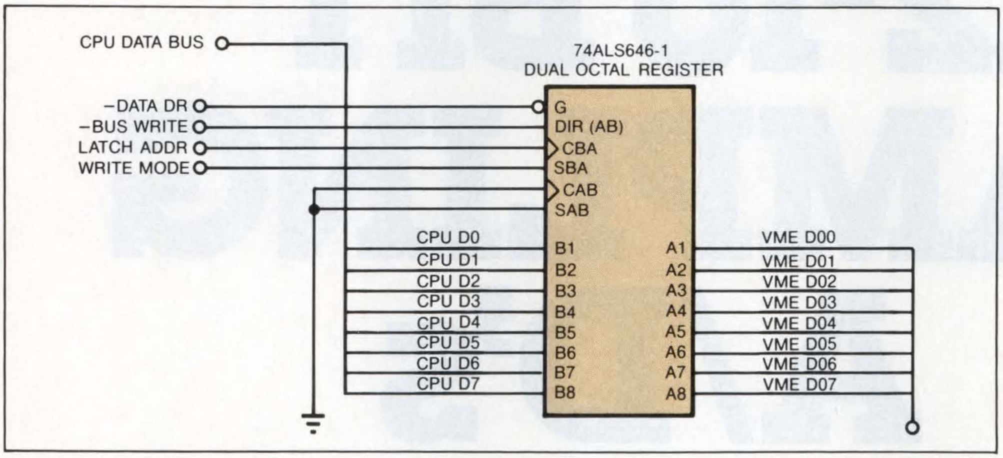


Fig 3—Using an octal register *for all the VME Bus address and data lines allows you to pipeline data acquisition.*

machine sequencer. The basic machine consists of nine states, though there are additional substates. One of the nine states is an idle state; four others control each bank of RAM; and four more control the refresh operation. Of the four states that control each bank of RAM, each state corresponds to a single cycle of the 16-MHz clock. The first two states represent the access, and the next two states represent the recovery states, which guarantee that the minimum cycle time requirement for the chips in each bank isn't violated. If the memory banks are accessed alternately, which happens for consecutive accesses, then only the first two states are needed because another access starts in the other bank while the previously accessed bank finishes its cycle. Although four states are available to control the refresh operations, two more idle states must be injected if the refresh logic requests a high-priority refresh.

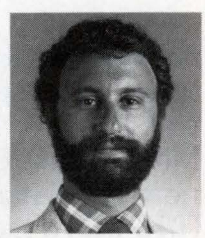
You might think, from the above description, that only those instruction streams that consist entirely of consecutive instructions will run without wait states. However, because the 80386 can't process changes to its execution flow as fast as it processes consecutive instruction fetching (due to its on-chip 16-byte prefetch queue), it must pause when it encounters a jump instruction and generate a new address (the queue is flushed and refilled with information pointed to by the new starting address). This pause gives the memory banks a chance to complete the current cycle, which allows the processor to jump to either bank without a wait state. The processor's pause isn't considered a wait state because it is internal to the μP; this design uses the pause opportunistically to refresh the memory.

Using pipelining techniques, you can accelerate the execution of bus operations **(Fig 3)**; that is, as a data transfer is being completed, you begin broadcasting the next address. The VME Bus allows you to assert the address lines with as little as a 2-clock-cycle delay from the previous address cycle.

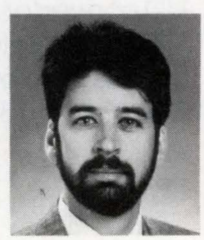
You can accomplish pipelining in two ways. The address for the next cycle can be placed on the VME Bus immediately following the assertion of the DTACK signal, overlapping the end of one bus cycle and the beginning of another. You can also use look-ahead logic to allow the board to retain control of the bus in those instances when the next CPU cycle is also going to require control of the VME Bus; this method eliminates the bus request/grant operation's overhead. **EDN**

Authors' biographies

Steph Rutel is manager of product marketing at Force Computers in Los Gatos, CA. He received his BSEE from Arizona State University and previously worked as a consultant. Steph enjoys the outdoors and particularly likes to hike and fish.



X Kim Rubin is Force Computers' director of engineering. He received his BSEE/CS from the University of California at Berkeley. He belongs to the IEEE and holds several patents.



Article Interest Quotient (Circle One)
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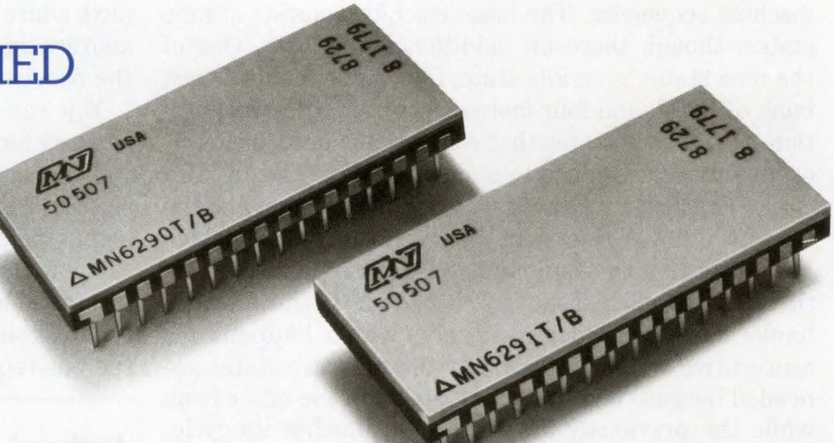
FFT-TESTED 12-16 BIT SAMPLING A/D's

MIL-STD-1772 CERTIFIED

MN6000 Series



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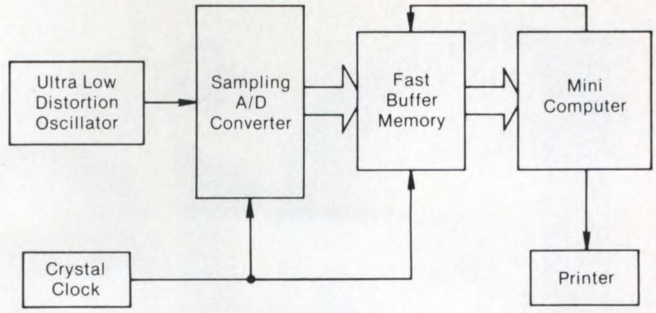
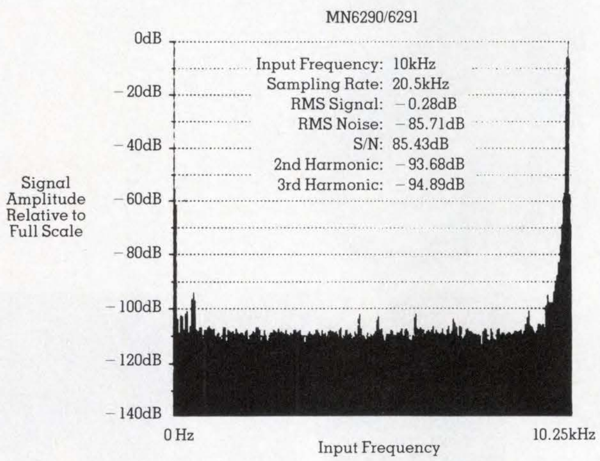
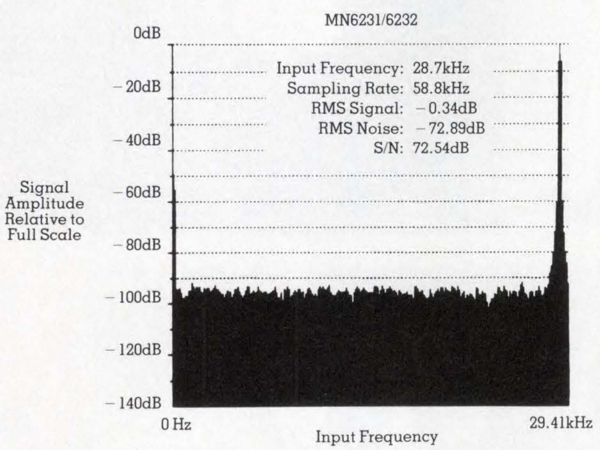


Frequency-Domain Testing of A/D Converters





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MN6228	20V	33kHz	16.5kHz	70dB	−80dB
MN6231	10V	50kHz	25kHz	70dB	−80dB
MN6232	20V	50kHz	·25kHz	70dB	−80dB
16-Bit Resolution					
MN6290	10V	20kHz	10kHz	84dB	−88dB
MN6291	20V	20kHz	10kHz	84dB	−88dB

1. Input bandwidth for which SNR and harmonic specs are guaranteed when sampling at the minimum guaranteed rate.
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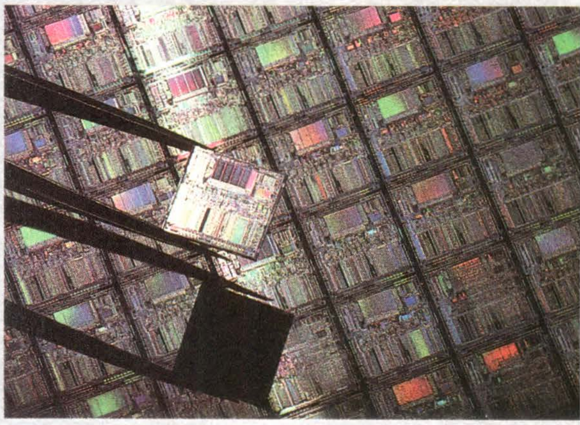

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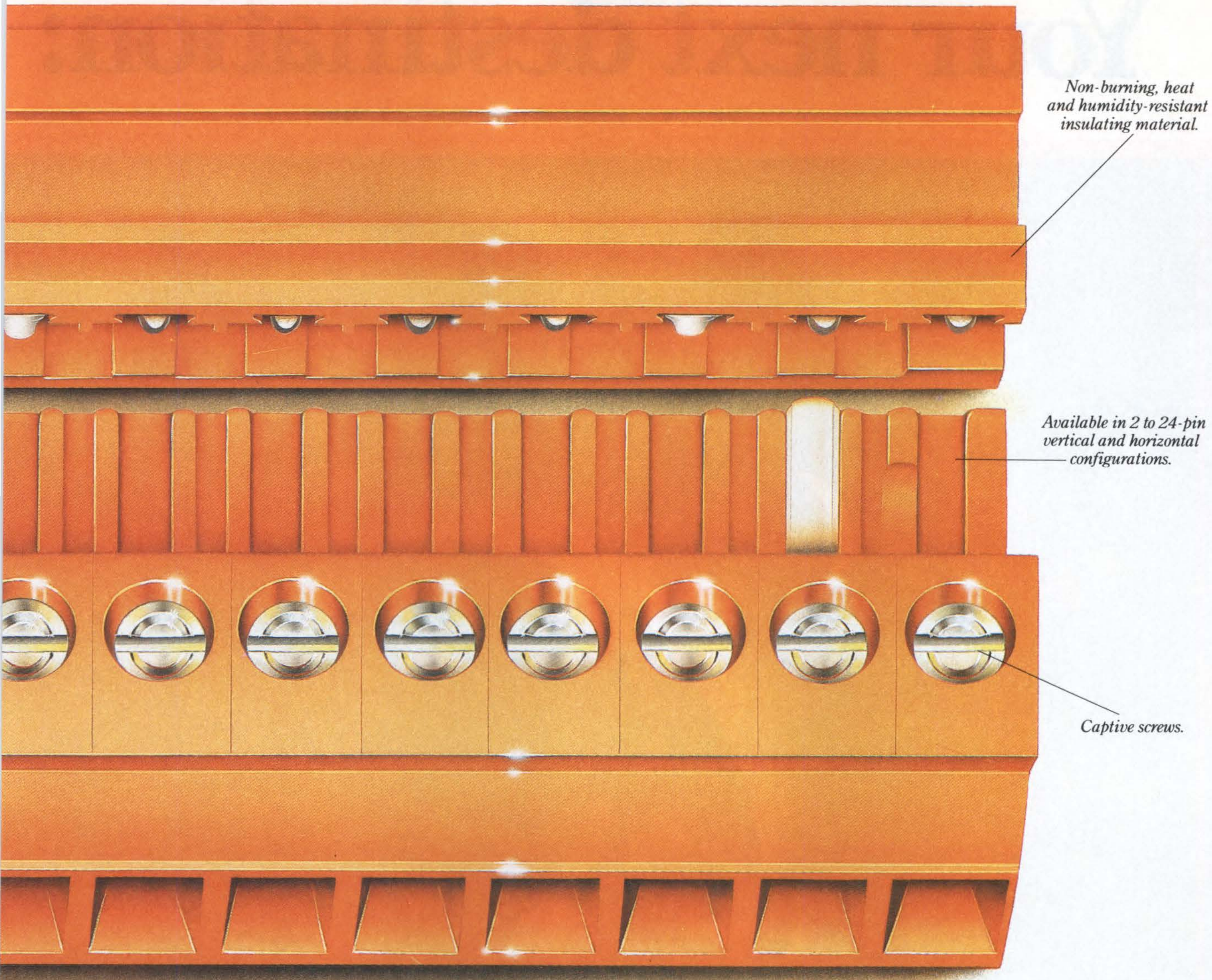

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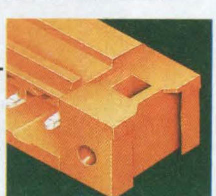

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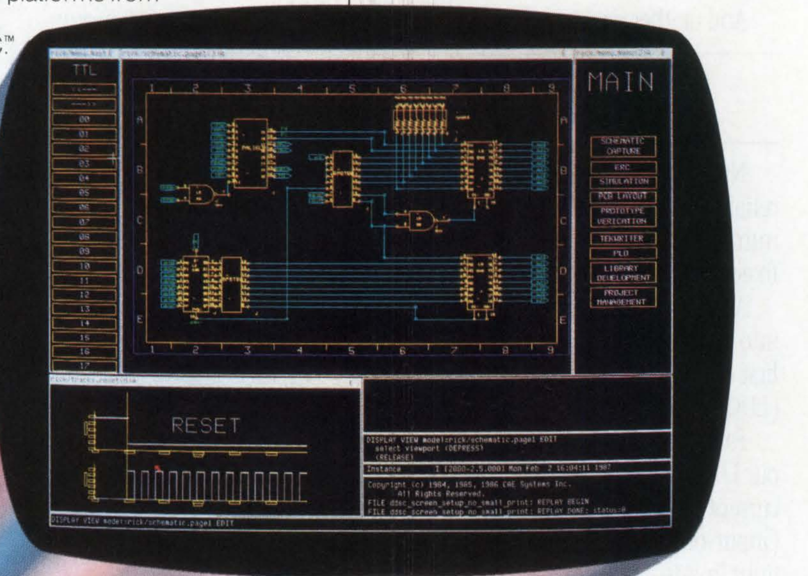

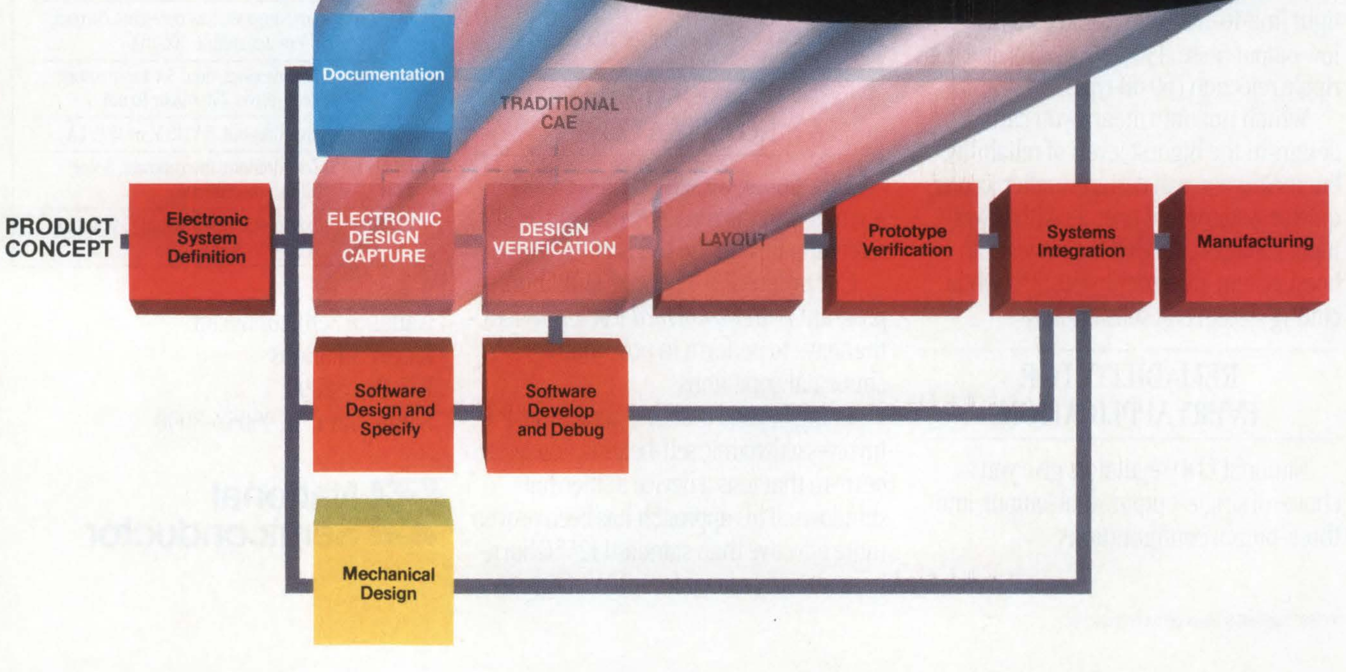

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FET op amps convert photodiode outputs to usable signals

Because FET op amps have low input currents, circuit designers almost universally employ them to monitor the outputs of most photodetectors. Your choice of an amplifier and circuit connection for use with a photodetector depends on the linearity, offset, noise, and bandwidth specs your application requires.

Jerald Graeme, *Burr-Brown Corp*

Instruments that gather data remotely, without contact with the measured object—such as CAT scanners, star-tracking instruments, and electron microscopes—depend on light for linking the received signals with signal processing. Photodetectors act as the bridge between a basic physical indicator and the subsequent electronic processing of the received signals.

Photodetectors use photodiodes, as well as FET op amps and other circuitry, to convert light energy to electrical energy. The accurate conversion of the photodiodes' output to a linear electrical signal is a contest between speed and resolution, and noise is a basic limiting factor in this contest. Central to the contest is the current-to-voltage converter, which seems simple but exhibits surprising constraints, such as noise amplification and difficulty in maintaining dc stability. You can optimize the performance of the current-to-voltage converter, and thus facilitate accurate signal conversion, by choosing the right op amp for your application and by using one of a number of circuit configurations.

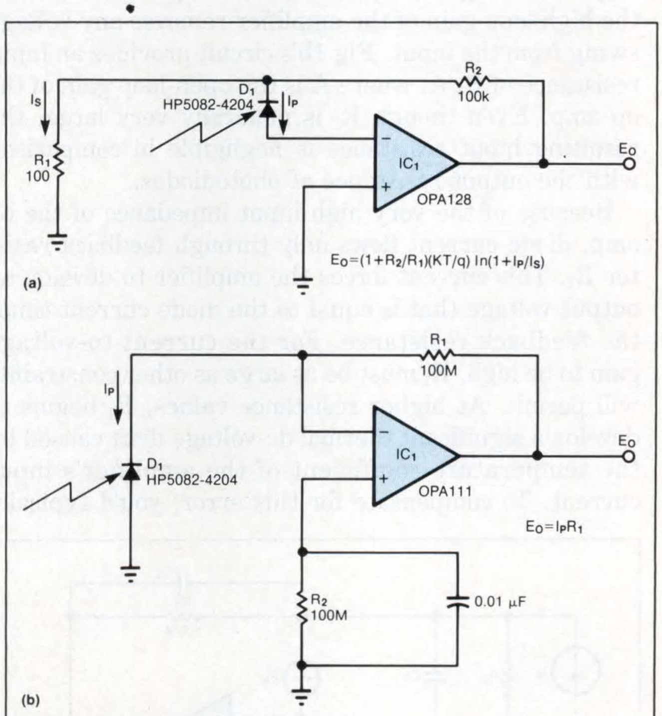

***Fig 1—You can monitor the output of a photodiode** as a voltage **(a)** or as a current **(b)**. Although the first technique is a common one, it has a drawback: The voltage mode is nonlinear.*

The light energy transmitted to a photodiode produces an output that you can measure as either a voltage or a current. When you measure the output as a voltage, you must monitor the diode from a high impedance that does not draw a significant amount of signal current. The circuit shown in **Fig 1a** provides such a condition; the photodiode is in series with the input of an op amp where (ideally) zero current flows. The op amp's feedback, set by R_1 and R_2, determines the

The accurate conversion of photodiode output to a linear electrical signal is a contest between speed and resolution, and noise is a basic limiting factor.

amplification of the diode voltage as though this voltage were an offset voltage of the amplifier. Although this technique is common, it has a drawback: The voltage mode is nonlinear. Because the diode's sensitivity varies with its voltage, its response has a logarithmic relationship to the light energy it receives.

To obtain a constant voltage for a fixed sensitivity, you should use the current-mode approach, in which the diode's response is linearly related to the incident light energy. A diode-current monitor must have zero input impedance to be able to respond with no voltage across the diode. You can obtain zero impedance by using a configuration like the one shown in **Fig 1b**. The op amp's virtual ground provides zero impedance because the high loop gain of the amplifier removes any voltage swing from the input. **Fig 1b**'s circuit provides an input resistance of R_1/A, where A is the open-loop gain of the op amp. Even though R_1 is generally very large, the resulting input resistance is negligible in comparison with the output resistance of photodiodes.

Because of the very high input impedance of the op amp, diode current flows only through feedback resistor R_1. This current forces the amplifier to develop an output voltage that is equal to the diode current times the feedback resistance. For the current-to-voltage gain to be high, R_1 must be as large as other constraints will permit. At higher resistance values, R_1 begins to develop a significant thermal dc-voltage drift caused by the temperature coefficient of the amplifier's input current. To compensate for this error, you'd typically connect a resistor of equal value (R_2) in series with the op amp's noninverting input, and then capacitively bypass this resistor to remove most of its noise. The mismatches between the amplifier's input currents and between the two resistors determines the remaining dc error.

A drawback of this error-correction method is that it creates a voltage drop across the diode, which results in diode leakage current. Photodiodes typically have a large junction area (which gives them high sensitivity); the leakage current is proportional to the diode area. This leakage current can become much larger than the op amp's input currents and can override the correction achieved by R_2.

Watch out for parasitic capacitance

Although a diode voltage of zero can eliminate leakage current as an error source, the zero diode voltage inhibits your control of another effect of large diode area—large parasitic capacitance, which can often cause severe amplification of noise. To reduce this capacitance, you can impress a large reverse-bias voltage on the diode, but doing so greatly complicates dc stability and makes the current noise from the photodiode an additional error factor. In sum, a large diode area may actually degrade the diode's overall accuracy, so you should try to obtain higher photosensitivity in photodiodes through optical means, such as using a package with an integral molded lens.

The value of the feedback resistor in a current-to-

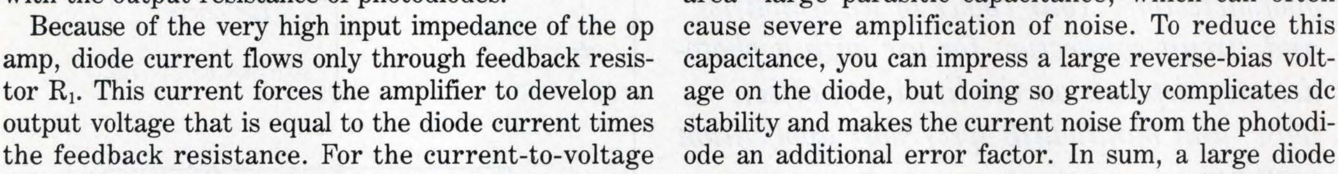

***Fig 2—Diode capacitance in the feedback path** of the basic current-to-voltage converter **(a)** allows the op amp to provide gain and bandwidth **(b)** that's not available to the signal.*

The value of the feedback resistor in a current-to-voltage converter largely determines the circuit's gain, bandwidth, and noise.

voltage converter largely determines the noise and bandwidth as well as the gain. Resistor noise has a spectral density of $\sqrt{4KTR}$, and it appears directly at the output of the converter without amplification (**Ref 1**). Increasing the size of the resistor raises the output noise by $\sqrt{4KTR}$, but also increases the output signal in direct proportion to the increase in resistance. As a result, the signal-to-noise ratio tends to increase by the square root of the resistance.

Besides the diode's capacitance, a high value of feedback resistance can also influence the noise output of the op amp to a surprising degree. The amplifier-noise sources shown in **Fig 2a** include the input noise current (I_N) and the input noise voltage (E_N). The noise current flows through the feedback resistor and experiences the same gain as the signal current does. The noise current is the shot noise of the input bias current, I_B, and it has a noise density of $\sqrt{2QI_B}$ (**Ref 1**). If you choose an op amp having input currents in the picoamp range, this noise component will be negligible for practical values of feedback resistance.

The input noise voltage is another matter. At first glance, it might seem that the amplifier, with low gain, would transfer this noise voltage to the output. The gain is indeed kept small at dc (gain$=1+R_I/R_D$) by the large diode resistance (R_D); however, at higher frequencies, the capacitance of the diode (C_D) alters the feedback, adding a significant amount of gain to E_N.

Because both the capacitance and the feedback resistance are usually large, the feedback effect can begin at fairly low frequencies. **Fig 2b** illustrates this effect by showing an op-amp gain curve plotted with the reciprocal of the feedback factor, or the "noise gain." The gain curve first experiences a zero response to C_D and then begins a rise that is terminated because of a second parasitic capacitance. Stray capacitance (C_S) shunts the feedback resistor, resulting in a response pole that levels the gain at $1+C_D/C_S$. For large-area diodes, C_D can be hundreds of picofarads and can cause the noise gain to peak at a high level. The gain continues to higher frequencies until the op amp's bandwidth limit rolls it off. As the feedback resistance increases, the pole and zero of this gain-peaking phenomenon move together to lower frequencies, encompassing a greater spectrum at high gain.

The first signs of this gain-peaking phenomenon will be familiar to anyone who has used high-resistance op-amp feedback in more general circuits. High output-to-input resistance in circuits containing op amps results in overshoot, response peaking, poor settling, and sometimes even oscillation—all because of the resistance interaction with the amplifier's input capacitance. Together, the resistance and capacitance form another pole in the feedback loop, resulting in the classic differentiator feedback response.

As the dashed line in **Fig 2b** shows, in more general op-amp cases, the associated feedback-factor reciprocal intercepts the amplifier's open-loop magnitude response with a 12-dB/octave rate of closure, which corresponds to a feedback phase shift that approaches (or is equal to) 180°. The common cure for this condition is to have some capacitance across the feedback resistor. For the very high resistances commonly used in current-to-voltage converters, the stray capacitance automatically takes care of this need. Such capacitance degenerates the added feedback pole to control phase shift in the feedback loop.

All frequency responses are not equal

To understand the noise performance of current-to-voltage converters, you must note that the signal current and the noise voltage encounter entirely different frequency responses. The current-to-voltage gain remains flat with frequency until the stray capacitance rolls off the feedback impedance, as shown in **Fig 2b**. The gain received by the amplifier's noise voltage, shown on the same graph, extends well beyond that roll-off and is high in that extended region. The greater part of the op amp's bandwidth often serves only to amplify the noise error, not to amplify the signal. This characteristic is typically the dominant source of noise for higher feedback-resistance values.

Fig 3 illustrates the relative effects of the major noise sources of a current-to-voltage converter. These curves show the output noise for **Fig 1b**'s basic current-to-voltage converter and the effects of the noise gain represented in **Fig 2b**. The curves in **Fig 3** plot the total output noise as a function of feedback resistance for three different cases. Each curve is the rms sum of the components produced by the feedback resistor and an op amp. Each of the three examples uses a different FET op amp.

Each op amp is optimized for a different performance characteristic useful in photodiode applications. Although all three types are low-noise designs and have low input currents, the OPA111/OPA2111 offers the lowest noise—6 nV/$\sqrt{\text{Hz}}$—and the OPA128 has the lowest input current—0.075 pA. The OPA404 design has a 6.4-MHz bandwidth. For the graph, the noise caused by the op amp was found by integrating the

The value of the feedback resistor in a current-to-voltage converter largely determines the circuit's gain, bandwidth, and noise.

amplifier's noise-density spectral response over the noise-gain response (**Ref 2**). The dashed line shows the noise caused by the resistor alone for the OPA111/OPA2111. This resistor's noise curve is different for the other op amps, because each amp has a different bandwidth that rolls off the noise caused by the resistor.

Different factors control the noise curves for different ranges of feedback resistance. At low values of resistance, the noise curves are essentially flat; the op amp's voltage noise is the dominant contributor. That dominance prevents any initial increases in resistance from having much effect, except in the case of the OPA111/OPA2111, with its very low voltage noise. In this low-resistance region, noise gain peaking is not a factor, and the output noise remains small. Between 10 kΩ and 1 MΩ, resistor noise dominates, and the curves track that error source (as the dashed line in **Fig 3** shows) for the OPA111/OPA2111. Here, the curves demonstrate the square-root relationship with the resistance; they differ only because of amplifier bandwidths.

At still higher resistance values, noise gain peaking takes effect, returning the op-amp noise to dominance and boosting the curves higher. This effect is first demonstrated by the increased slope of the OPA404

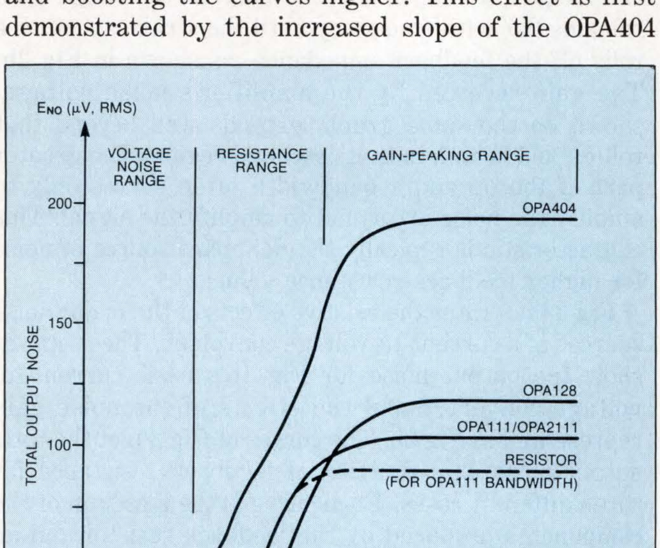

Fig 3—As the feedback resistance of a current-to-voltage converter increases, *the dominant noise source changes from the op amp to the resistor and back to the op amp under gain-peaking conditions.*

curve, which rises into the gain-peaking range, then levels off.

At even higher resistances, resistor noise would return the curves to rising slopes, except that stray capacitance rolls off the resistor bandwidth. In this upper region, any increase in resistance is accompanied by a matching reduction in resistor-noise bandwidth, so the total resistor noise becomes a constant. Diode- and stray-capacitance variables alter the onset point of gain-peaking errors, but the characteristic shape of the output noise curves remains the same. Each curve displays ranges that are dominated by op-amp noise, resistor noise, or gain-peaking effects.

Comparing the response curves

A comparison of the curves shows that the OPA111/OPA2111 provides the lowest noise in two of the characteristic ranges. The OPA128 has a lower noise curve in the middle range as a result of its lower bandwidth. Where the OPA128 excels is in low dc error, which results from its very low (0.075-pA) input currents. The third op amp, the OPA404, produces higher total output noise, but this noise is also largely a bandwidth phenomenon. The 6.4-MHz response of the OPA404 amplifies noise over a much greater frequency range. Although the noise curve for the OPA404 amplifier is consistently higher than that of the OPA128, the OPA404 actually has lower noise density. However, the OPA404's 6.4-MHz bandwidth (six times that of the OPA128) is available with circuit feedback resistances as high as 50 kΩ, and that bandwidth is still best for resistances as high as 150 kΩ.

Only a 5-dimensional graph could display the output noise, resistance, dc error, diode area, and signal bandwidth that you must consider when you design current-to-voltage converters. You need to evaluate the requirements of each specific application separately. To optimize a given design for a single factor (such as gain, for example) you must anticipate the various effects of increasing the feedback resistance at each step. When you choose the size of the diode area, for example, you must consider the related capacitance and its effect on the output noise and the overall circuit sensitivity.

As mentioned, gain-peaking effects are the primary cause of noise problems in circuits that have high values of feedback resistance. To limit gain-peaking effects, or to eliminate the gain rise entirely, you can add capacitance across the feedback resistor to bypass its effect. Note, however, that for some values of R_1, the capacitance value required can be very small. Because the unpredictable stray capacitance is therefore relatively significant, you'll probably want to tune the circuit to adjust the total capacitance.

Taken together, these requirements pose a challenge that you can best resolve by using a capacitor tee network (**Fig 4a**). The tee network can provide tuning capacitance in the subpicofarad range with little effect by stray capacitance. The tee uses a capacitive divider formed by C_2 and C_3 to attenuate the signal applied to C_1 at the circuit input. C_1, which has only a fraction of the output signal, supplies far less shunting current to the input node than it would as a direct-feedback capacitor. Controlling the attenuation ratio is tunable capacitor C_3, the largest of the capacitors (its capacitance value is more readily available in tunable form). Because C_3 is grounded, it has a shielding effect that reduces the influence of the stray capacitance during tuning.

Another way to achieve a practical feedback-resistor bypass is to use a resistor tee to replace the high-value feedback resistor (**Fig 4b**). In this circuit, resistor elements of a lower value replace the single feedback resistor, but they also introduce greater low-frequency noise. The attenuator operates in much the same way as the capacitor tee does: R_2 and R_3 attenuate the signal to R_1 so that the latter appears to the input node as a much larger resistor. A similar opportunity for the dc-error-compensation resistor R_4 does not exist. Any dc error caused by the amplifier's input current is the same whether you use a resistor tee or a capacitor tee, so you need to use the large-valued compensation resistor in either case.

The resistor tee somewhat reduces the stray capacitance across the feedback path because of the extra physical spacing of the three feedback elements. Also, stray capacitance across each individual element has much less effect because the elements' resistances are low. Other stray capacitances from the op amp's output to its input aren't affected by the resistor tee, however.

You can intentionally bypass R_2 with the appropriate capacitor values. Bypassing the moderate resistance of R_2 removes the feedback attenuation at higher frequencies, leaving the net feedback resistance at the value of R_1. This operation differs from true feedback bypassing in that the impedance levels off rather than continues to fall with frequency, but the dramatic drop in equivalent resistance serves the circuit requirement. Another benefit offered by the resistor tee is more accurate dc-error compensation. The low resistor values of the resistor tee allow you to tune the resistance. Resistance tuning

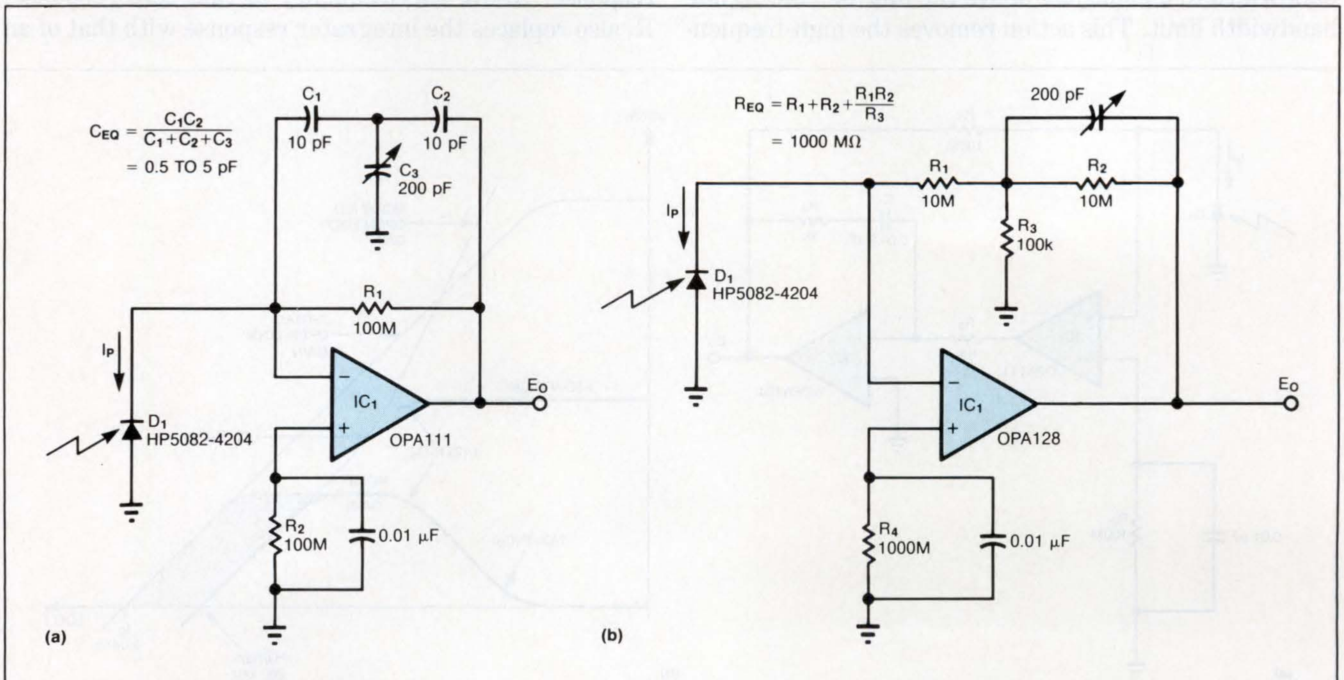

***Fig 4—To remove amplifier gain peaking** by means of a small capacitive bypass of the large feedback resistance, you can use a capacitor tee **(a)**, or you can bypass one element of a feedback resistor tee **(b)**.*

Adding voltage gain to a current-to-voltage converter will increase the circuit's bandwidth faster than it increases noise.

is most useful for very high resistance values, at which wide resistor tolerances degrade the dc-error compensation.

Although the tee-element bypass reduces high-frequency noise, it also increases the noise at lower frequencies. Below the frequency of the bypass, the noise gain increases because of the tee network's feedback attenuation. The net result is the amplification of the noise and offset voltages of the op amp, as well as the noise of resistor R_1, by a factor of $1+(R_2/R_3)$. The resistor's smaller value counters this factor, so the noise increases only by the square root of the new noise gain. Most important, however, is the fact that the bypass capacitor removes high-frequency gain by eliminating the greatest portion of the previous noise bandwidth. In the absence of other means to remove the high frequencies, the bypassed resistor tee provides lower total output noise for the higher ranges of feedback resistance.

Adding feedback capacitance is an effective means of reducing noise gain, but it also decreases signal bandwidth by the same factor. The bandwidth is already low for high values of feedback resistance, and the end result can be a response of 1 kHz or less. A better solution to the noise problem is to limit amplifier bandwidth to a point just above the unavoidable signal-bandwidth limit. This action removes the high-frequency gain that only amplifies the noise. Op amps with a provision for external phase compensation offer this option, but those available lack the low input currents and low voltage noise needed for photodiode monitoring.

Composite amplifiers provide a solution

The solution to this problem is to use a composite amplifier **(Fig 5)** comprising two op amps: One provides for low input currents and low voltage noise; the other provides phase-compensation control. Note that to retain a single phase inversion with two amplifiers in series, you must reverse (in comparison with single op-amp configurations) the inverting and noninverting inputs of IC_1, as **Fig 5** shows. In the composite structure, internal feedback controls the frequency response of the gain added by IC_2. At dc, the feedback is blocked by C_1 and the overall open-loop gain is the product of the two amplifiers (225 dB for the amplifiers shown). This gain is rolled off by the open-loop pole of IC_1 and by the integrator response established for IC_2 by C_1 and R_3. Because this is a 2-pole roll-off, to establish frequency stability the circuit must reduce the roll-off before intercepting the noise-gain curve.

Resistor R_4 reduces this roll-off by introducing a zero response. Above the frequency of that zero response, R_4 also replaces the integrator response with that of an

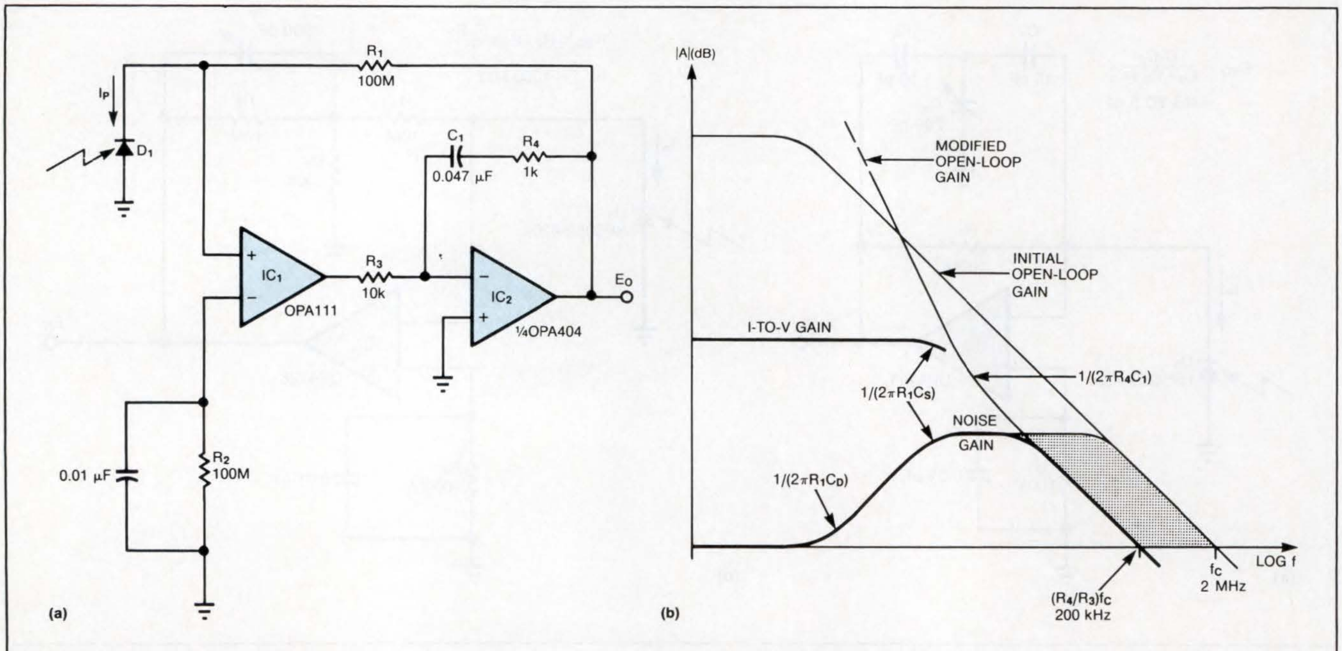

Fig 5—Noise reduction occurs *in a composite amplifier* ***(a)*** *that restricts noise bandwidth* ***(b)*** *without reducing the signal's bandwidth.*

inverting amplifier that has a gain of $-R_4/R_3$. Making this gain less than unity drops the net-gain curve below that of a single amplifier at high frequencies. Graphically, the noise-gain response of **Fig 5b** moves back in frequency as though the op-amp bandwidth had been reduced.

Eliminated is the shaded area of noise gain, which may not appear to be large because of the logarithmic frequency scale, but which actually encompasses a wide frequency range of associated noise reduction. Moving the unity-gain crossover of the noise gain from 2 MHz to 200 kHz, as shown, lowers the output noise of IC_1 by about a factor of three.

The same output-noise drop in a feedback-bypassing configuration, such as **Fig 4b's** circuit, would lower the signal bandwidth by a factor of 10. **Fig 5a's** circuit, however, has no effect on signal bandwidth, and the high gain of IC_1 eliminates any noise or offset effects by IC_2. Because of the exceptionally low noise of the OPA111 input amplifier, this improvement reduces noise to the fundamental limitation imposed by the feedback resistor. This condition is retained for all practical values of feedback resistance. For the second amplifier, the wideband OPA404 continues its attenuating amplifier action well beyond the unity-gain crossover of IC_1. This attenuating action avoids a second gain peak that could cause oscillation. The signal bandwidth of the current-to-voltage conversion is essentially unaffected because there's no influence on R_1.

The technique used in **Fig 5** is most useful with low-level signals that are very sensitive to noise. In higher-level applications, the circuit can encounter a voltage-swing limitation caused by the maximum output-voltage limit of IC_1 and its attenuation by IC_2. If the output of IC_1 has a peak swing of 12V, and IC_2 has a gain of $-1/10$ as shown, the final output is limited to a 1.2V peak swing. For lower-level signals this peak swing is acceptable, because the maximum practical level of feedback resistance already limits the output swing.

Bandwidth and noise are related

The output noise of a current-to-voltage converter increases in proportion to the square root of the system bandwidth simply because of the broader noise spectrum. The optimum S/N ratio occurs at very high gain, but high-gain current-to-voltage converters have bandwidth limitations far below the roll-off of the op amp. To the signal current, the amplifier feedback factor is unity, a condition that would normally make available the full unity-gain bandwidth of the amplifier. However, the high values of feedback resistance used to produce the desired gain are shunted by stray capacitances that greatly reduce the potential bandwidth. Just 0.5 pF of stray capacitance around a 100-MΩ feedback resistor will pull the signal bandwidth's unity-gain crossover from the megahertz range to 3.2 kHz.

To minimize the shunting effect, you should use low-capacitance resistors and take precautions during circuit assembly. For example, by mounting the feedback resistor on standoffs, you can reduce the resistor's capacitive coupling with the printed-circuit board. It's also a good idea to insulate the standoffs with Teflon to reduce leakage currents. To avoid introducing noise from the microphonic effects of mechanical stress or vibration, you should make the mounting as rigid as possible.

There's an ultimate limit to the effectiveness of the measures you take to minimize the shunting effects, because capacitive coupling through the air around the resistor body always remains. Increasing the bandwidth beyond that imposed by such residual limits requires lower feedback resistance and accompanying lower converter gain. One of several options available to restore the gain is shown in **Fig 6a**: You simply add a second amplifier with voltage gain to the current-to-voltage converter in order to retain the net input-to-output transimpedance ($R_T=A_VR_1$). The usual high-value resistance is reduced by a factor equal to the voltage gain of the second amplifier, which increases the bandwidth by as much as the same factor.

Although this scheme is an obvious alternative, the second amplifier's overall effect on bandwidth and noise is not so immediate. The response limitation of the second amplifier bounds the upper end of the bandwidth increase. The bandwidth of the 2-op-amp circuit, which has a net transimpedance of 100 MΩ, is plotted in **Fig 6b** as a function of the voltage gain in the overall conversion. The bandwidth initially increases linearly with voltage gain as the reduction in R_1 diminishes the roll-off effect of stray capacitance. However, the added demands of the voltage gain on IC_2 eventually make that amplifier's bandwidth the controlling factor.

For a given set of conditions, you can find an optimum gain (A_V) that produces the peak bandwidths shown for the three sample amplifiers. The peak occurs when the amplifier's closed-loop bandwidth and the stray-limited bandwidth of R_1 coincide. Variables affecting this peak are the net transimpedance, R_T, and the second op amp's unity-gain bandwidth, f_C. The relationship of the

Because of its very high resistance, a current-to-voltage converter is sensitive to noise coupling from electrostatic, magnetic, and radio-frequency sources.

controlling factors at the optimum bandwidth point is shown in the expression that defines the choice of R_1:

$$R_1=\sqrt{R_T/2\Pi C_S f_C}.$$

Extending the bandwidth

You can extend the bandwidth of **Fig 6a's** circuit to 100 kHz (from the original 3 kHz) by using the wideband OPA404 for the second amplifier. This wideband op amp offers the best frequency response of the three **(Fig 6b)** and, although its total output noise is greater, that output noise is largely caused by the greater available bandwidth. If you require even greater bandwidth, you can choose either a faster op amp (which typically has poorer noise performance) or a lower transimpedance. With its unity feedback factor, IC_1 encounters lower demands on bandwidth, so **Fig 6a** uses a low-noise OPA111 FET amplifier.

The price you pay for improved bandwidth through voltage gain is increased output noise. Although the lower value of R_1 reduces its noise density, the increase in bandwidth counteracts that effect for a net zero change in resistor noise. The second amplifier amplifies the resistor noise, causing an increase in output noise proportional to the voltage gain. The noise from the op amps themselves adds to the amplified resistor noise; **Fig 6b** shows the net result. The noise curves are continuations of the ones presented in **Fig 3**, except that in **Fig 6b** the transition begins at 100 MΩ.

In the lower gain range, from one to 10, the noise is largely a result of the op amps and their gain peaking, but those effects give way to resistor noise dominance before the end of this range. Stray capacitance controls the signal bandwidth in this range, and the plotted bandwidth shows a linear increase with gain as a result of the corresponding decrease in resistance. When the gain is between 10 and 100, the bandwidth begins to drop because of the limitations imposed by IC_2. Coincident with this drop in gain is a flattening of the output noise curve. Roll-off of the amplifier's bandwidth and the simultaneous resistance drop nullify the effect of any increasing voltage gain, leaving output noise constant. In the voltage-gain range from 100 to 1000, these trends continue; they degrade the circuit's optimum performance because the bandwidth gets narrower while the noise remains constant.

Although the noise degrades with the voltage gain's replacement of resistance, the circuit's overall performance improves. The improvement in bandwidth more than offsets the drop in signal-to-noise ratio.

As already mentioned, the simple current-to-voltage converter exhibits a problem: It has a greater bandwidth for the amplifier voltage noise than it does for the signal current. The circuit in **Fig 6a** removes this discrepancy; as the voltage gain increases, IC_2 begins to filter out the higher frequencies. You can find evidence of this filtering in the noise curves of **Fig 6b,** which increase more gradually than do the bandwidth curves, until they reach the optimum bandwidth point. At this optimum point, noise bandwidth and signal bandwidth are equal. In effect, IC_2 also serves as the output active filter discussed earlier. Each of the curves in **Fig 6b** is

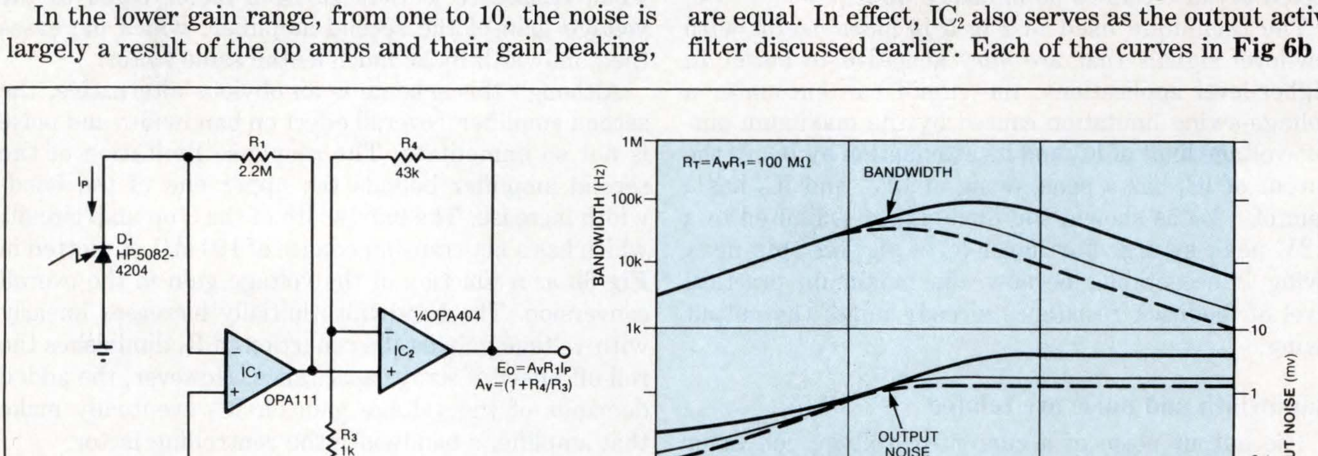

Fig 6—For greater bandwidth and the same net transimpedance *as those of the circuit in* ***Fig 5a,*** *this circuit* ***(a)*** *adds voltage gain; its bandwidth* ***(b)*** *increases faster than the noise does.*

drawn for a 100-MΩ transimpedance and for the amplifiers and photodiode specified.

For some of the more common photodiode applications, a significant drawback of the **Fig 6** circuit is that it requires two op amps per photodetector. This requirement can pose a real problem in large photodetector arrays, which often employ hundreds of detectors. You can compromise, as long as you're willing to accept some noise and bandwidth degradation, by using one op amp to provide the same transimpedance, and you don't need the very large resistors. A single op amp can perform the current-to-voltage conversion and can also provide the subsequent voltage gain.

The traditional way to accomplish this task would be to design a circuit like **Fig 7a's**, which uses R_2 for the conversion and R_3/R_4 to set the voltage gain. Current from D_1 flows in R_2, resulting in a signal voltage at the input of the noninverting amplifier. However, that signal voltage is also across the photodiode, and this condition produces a nonlinear response.

Alternatively, you can use the configuration in **Fig 7b**, in which the diode is connected directly between the op-amp inputs, maintaining a zero diode voltage. Current from the photodiode still flows in R_2 and develops the same signal voltage. Diode current also flows into the feedback network, but has little effect because of the low resistance values. For the resistor values shown, the circuit exhibits a transimpedance of 100 MΩ, just as the 2-op-amp example does, but its bandwidth has improved less.

At 20 kHz, the bandwidth increases by a factor of seven rather than by a factor equal to the voltage gain, as in **Fig 6a**. A new bandwidth limitation accounts for the difference; it occurs because of the new placement of the high-value resistance. That resistor is now shunted by the op amp's common-mode input capacitance instead of just by the smaller stray capacitance. To maximize bandwidth, you make this new shunting effect coincide with the amplifier roll-off by your choice of R_2 and the amplifier voltage gain. A second benefit of this choice is that the resistor noise beyond the signal bandwidth experiences a 2-pole roll-off.

As expected, the final output noise from the resistor increases over that of the basic circuit by the square root of the voltage gain. A small noise component that's normally caused by the op amp's gain peaking is no longer present. However, **Fig 7b** includes a new noise source caused by the diode capacitance (which is modeled in **Fig 8a**). The amplifier voltage noise, E_N, is impressed directly across the diode capacitance, developing a noise current that flows in R_2. This noise current creates a noise voltage that is a multiple of E_N at the input of the noninverting amplifier. The capacitive feedback network of C_D and C_{ICM} produces a noise gain that peaks at $1+(C_D/C_{ICM})$; this noise gain exists in addition to the normal voltage gain of the noninverting amplifier.

The effects of the new noise source on the frequency response are plotted in **Fig 8b**; again, they produce a high-frequency peak in the noise gain. This peak occurs at a much higher frequency than does the peak of the basic current-to-voltage converter (because the conversion resistance in **Fig 8a's** circuit is lower), and it's truncated earlier by the op amp's roll-off. For the low-capacitance diode used in both circuit examples, the new peaking encompasses only a small area in the

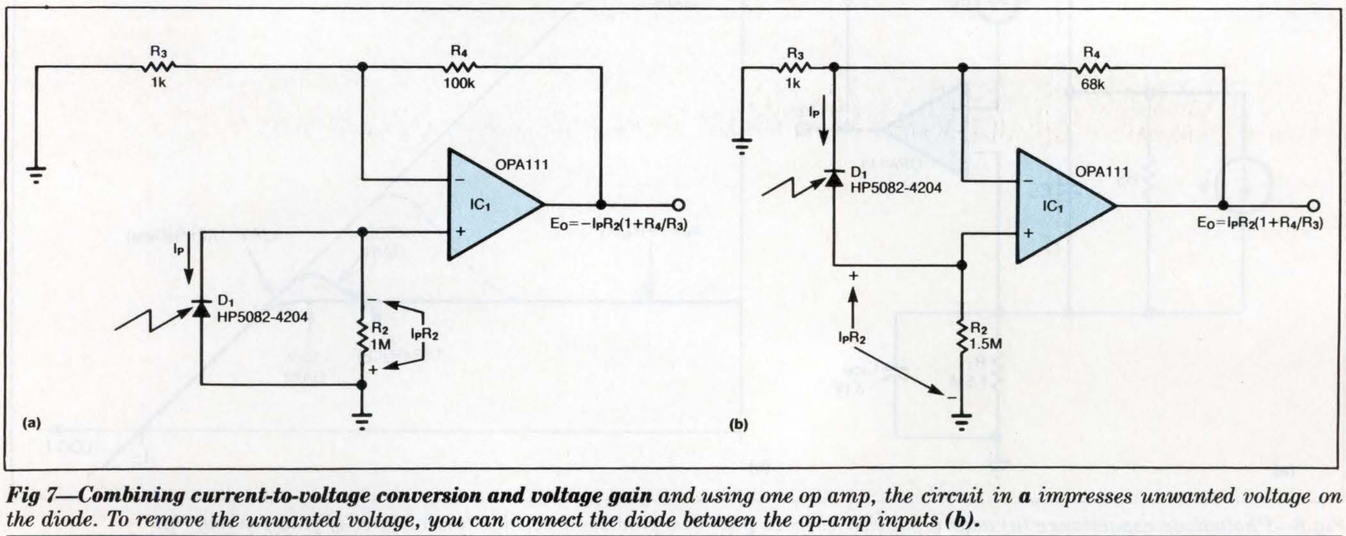

*Fig 7—**Combining current-to-voltage conversion and voltage gain** and using one op amp, the circuit in **a** impresses unwanted voltage on the diode. To remove the unwanted voltage, you can connect the diode between the op-amp inputs **(b)**.*

Magnetic coupling of noise is harder to eliminate than the electrostatic type is, but an op amp's differential input helps to reduce its effect.

response plot, corresponding to less noise effect. Larger diodes don't escape the effect, as **Fig 8b** shows; the dashed line corresponds to the noise gain for a capacitance of about 200 pF. Even here, the spectrum covered by the peaking is not the high end of the op amp's bandwidth as it was in the basic circuit. Hence, op-amp noise is not the overriding source of noise.

External noise can cause interference

Once the diminishing returns limit the reduction of noise caused by the circuit itself, you must consider external noise sources. With its very high resistance, a current-to-voltage converter is extremely sensitive to noise coupling from electrostatic, magnetic, and radio-frequency sources. Unless you pay careful attention to shielding, grounding, and the physical location of components, those sources could become the dominant noise contributors (**Ref** 3). In each case, the most important step to take is to physically separate the noise source from the sensitive circuitry.

You must take other measures as well, however. Electrostatic coupling, such as from the power line, supplies noise signals through the mutual capacitances that exist between any two objects. Voltage differences between the objects are impressed on those capacitances, and any voltage variation couples a noise current from one to the other. To avoid that error signal, you should use electrostatic shielding to intercept the coupled current and shunt it to ground. In this case, the ground must be earth ground, because earth ground is the common reference for the separate objects.

Note, however, that such shields create parasitic capacitances between the components shielded; you must return the shields to the signal common to avoid such coupling. In this way, you make sure that any shield-carried capacitive currents from the output of a current-to-voltage converter are shunted to ground, so they do not present a bandwidth restriction to the feedback resistor. Even so, the shield produces a capacitance from the converter input to ground, possibly adding to the gain peaking and to its effect on the total output noise.

Because electrostatic noise is most often of power-line frequency and is common to all points, the CMR of an op amp tends to eliminate it. At the line frequency, op-amp CMR is very high. However, current-to-voltage converters don't take advantage of an op amp's CMR capabilities, because these circuits have a single-ended rather than a differential input configuration. But you can alter this configuration to obtain improved noise rejection and less dc error. An op amp's CMR is not a total replacement for shielding, because electrostatic coupling doesn't generate perfect common-mode signals at the amplifier's inputs. As a second defense, CMR capability is most useful in removing the residual coupling that passes through shield imperfections.

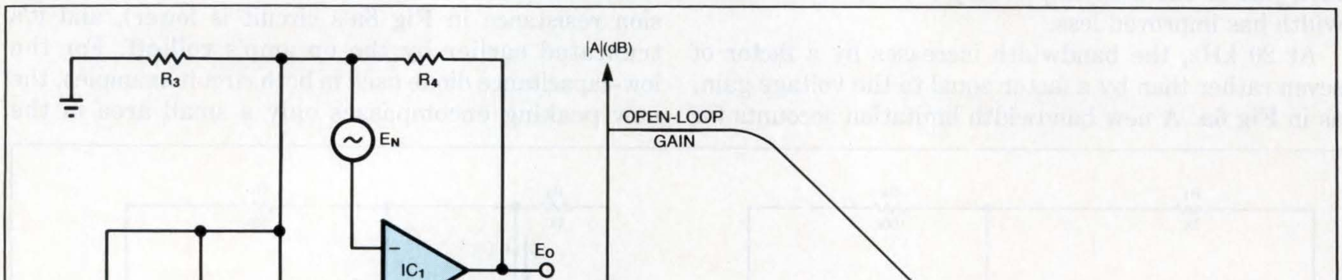

Fig 8—Photodiode capacitance (a) adds a positive feedback path that provides a new but lesser source of gain peaking (b).

You can measure the light energy transmitted to a photodiode as a voltage output or as a current output, but the current output is far more linear.

The differential input capability of an op amp fits exactly with the signal from a photodiode. Because the diode signal is a current, it is available at both terminals of that sensor, and it can drive both amplifier inputs as shown in **Fig 9a**. In that circuit, the diode current is no longer returned directly to common, but drives the amplifier's noninverting input in that path. This setup creates a second signal voltage that doubles the circuit gain when $R_2=R_1$. For a given gain, the resistor value is typically only half the normal value required for a similar reduction in error sensitivity to amplifier input currents. Because the diode is connected directly across the inputs of the op amp, there is essentially no dc voltage across the diode, and the diode leakage current is minimized.

This setup also improves the common-mode rejection of coupled noise. **Fig 9b** models the electrostatic coupling and the parasitic capacitances of this current-to-voltage converter. Because the signal you'd normally get from the photodiode is zero in this example, you can observe only the electrostatic-coupling effects. The electrostatic noise source (E_E) couples error currents (I_E) through mutual capacitances (C_M) to the circuit's two inputs. It might seem that the coupling effects to the two points would be different, because feedback gives the R_1 input node a virtual zero impedance, and the other node is a high impedance. Actually, the noise coupling occurs when voltage signals applied to the mutual capacitances generate currents through those capacitances. Because of the amplifier feedback, both input nodes have the same voltage, and both receive the same level of noise current (I_E). These equal currents develop canceling noise-voltage effects (E_{NE}) on the two circuit resistors, resulting in a zero output signal.

Matching conditions involving the mutual capacitances, the resistors, and the parasitic capacitances shunting them determine the accuracy of the error cancellation. You can best ensure the matching of mutual capacitances by placing the resistors in a position equidistant from any significant noise source that's not effectively blocked by a shield. The equal resistance values will ensure the accurate cancellation of error signals until the circuit reaches operating frequencies at which capacitive shunting imbalances the net impedances. Only about 0.5 pF of stray capacitance shunts R_1, but the much larger common-mode input capacitance of the op amp is across R_2. For the 3 pF of the OPA111 and the 50-MΩ resistance shown, a pole occurs at about 1 kHz, leaving the impedances of interest unbalanced. This shunting by C_{ICM} also imposes a signal-bandwidth limitation at a lower frequency than usual. The bandwidth of R_2 rolls off earlier than does R_1's, creating a response with two gain plateaus separated by a factor of two.

This capacitive shunting has little effect, however, on the most common electrostatic coupling at the power-line frequency. To better reject higher frequencies, you can add capacitance around R_1 to restore impedance

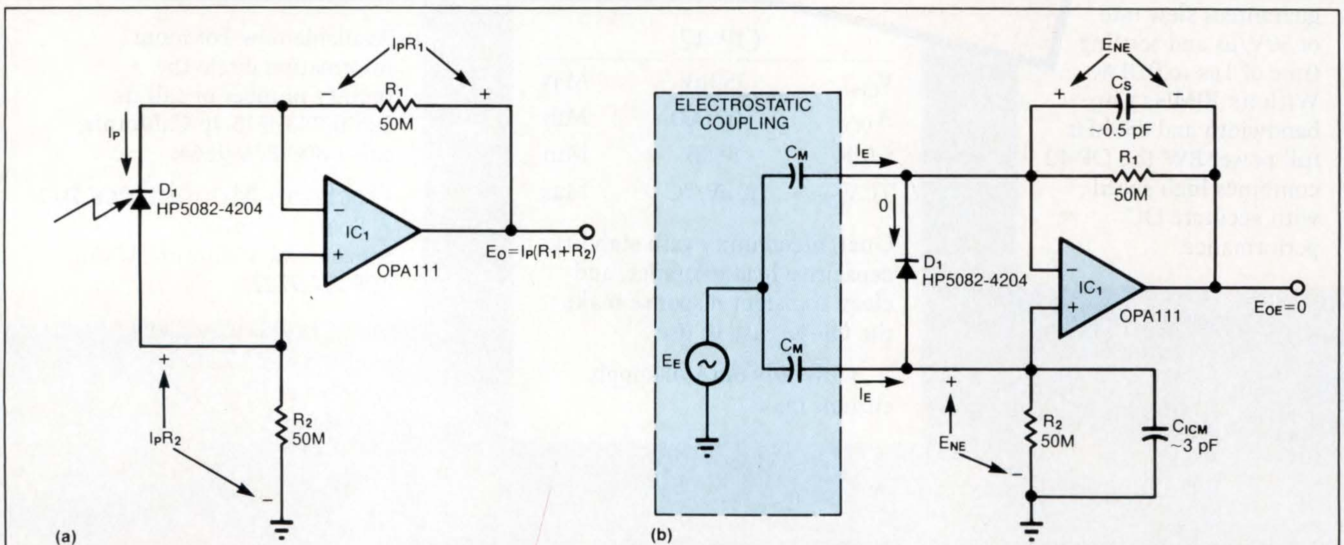

***Fig 9—Exploiting the CMR capabilities** of the op amp, the photodiode **(a)** drives the differential inputs, thus providing rejection of electrostatic coupling **(b)**.*

You can best match mutual capacitances by placing the resistors equidistant from any unshielded noise source.

matching, or you can avoid signal swing on the common-mode input capacitance. The latter option offers a more accurate solution and avoids the bandwidth limitation of C_{ICM} by using a second differential connection.

Photodiode connection determines performance

Fig 10 shows a photodiode connected between the inputs of two current-to-voltage converters whose outputs drive an INA105 difference amplifier. Again, the diode current flows in two equal resistances that will receive equal electrostatic noise coupling. The diode current creates a differential output on the resistances, but the noise coupling generates a common-mode signal. These two signals are separated when they're supplied to the INA105: The diode signal is passed to the output, and the noise is rejected.

This new differential-input circuit retains the lower-value individual resistances and a zero diode voltage. The zero diode voltage is a result of the grounded noninverting inputs of both current-to-voltage converters. These connections also avoid signal swing on the common-mode input capacitances, improving bandwidth in electrostatic suppression and signal gain. Note that the noninverting inputs are not connected through high resistances for input-current error correction. Such a connection is not necessary because the input currents of IC_1 and IC_2 produce matching voltages at the amplifiers' outputs. These voltages are a common-mode signal to the input of the INA105, so they, too, are rejected.

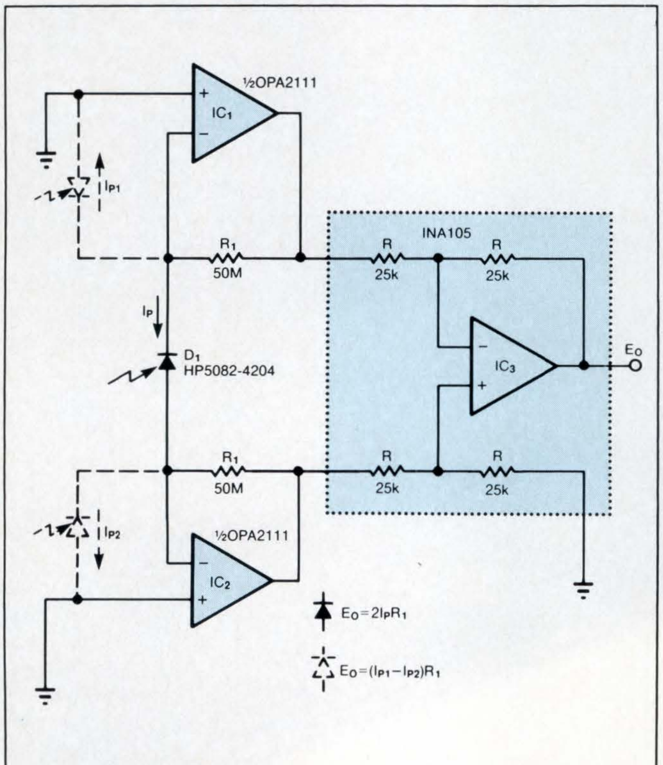

Fig 10—By using two current-to-voltage converters, *you can obtain differential inputs with wideband-CMR and -gain characteristics, because the common-mode input capacitances of IC_1 and IC_2 are virtually connected to ground.*

The differential structure of **Fig 10** also provides for the difference monitoring of two photodiodes. Instead of D_1, you connect two diodes (in the dashed lines) separately to the inputs of the current-to-voltage converters. The diodes' currents produce independent voltages at the outputs of IC_1 and IC_2. The difference amplifier processes these voltages to remove any common-mode portion. What remains is an output that's proportional to the difference between the two input photocurrents; this output is a measure of relative light intensity. (A relative-light-intensity measure is the type of signal used in position sensing or optical-tracking control to direct the feedback correction.)

Magnetic coupling of noise can be more difficult to eliminate than electrostatic coupling, but **Fig 10's** differential input connections reduce magnetic-coupling effects as well. In this circuit, magnetic coupling occurs through mutual inductances; to control it you must keep the sensitive loop area at a minimum, provide shielding, and separate the source and receiver as far as possible.

The electrostatic shield doesn't remove the effects of magnetic coupling, however, so the first step is to control the source itself **(Ref 3)**. You can internally shield any power transformers that can't be placed at a distance, thus essentially terminating their magnetic fields at the transformer boundaries. To deal with any remaining magnetic coupling, you must adjust physical and circuit configurations. For example, high-value resistors used in photodiode monitoring are sensitive to magnetic coupling, so you must keep connections short between these resistors and the high-impedance op-amp inputs.

To allow the op amp to provide maximum noise rejection, you should make any remaining coupling effects appear as common-mode signals by adjusting the loop size and performing distance matching. In the circuits in **Figs 9** and **10**, the high resistance is divided into two equal elements that are each physically mounted with the same orientation and spacing relative to the magnetic coupling sources. Noise coupled to the two resistors then causes equal signals that have canceling effects at the circuit output.

Op amps are not as effective against the third class of

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noise coupling—radio frequency interference (RFI)—so shielding and filtering are the best defenses. Sources of RFI (such as digital circuitry) may be close to the photodiode monitor. Because of the high frequencies involved, op amps have little gain or CMR capability remaining to reject such signals. Because of this same amplifier limitation and the basic bandwidth restriction of the voltage-to-current converter, the desired signals will not be in the radio-frequency range, so you can use filters in front of the op amp to largely remove the unwanted signal. Filtering that follows the op amp is less effective, because the op amp can act like an RF detector, separating a lower-frequency envelope from a carrier **(Ref 4)**. You can further reduce RFI by using an RF shield and a ground-plane layer in your pc board. **EDN**

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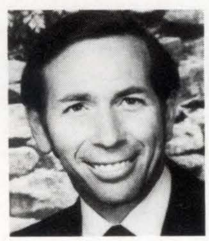
Author's biography



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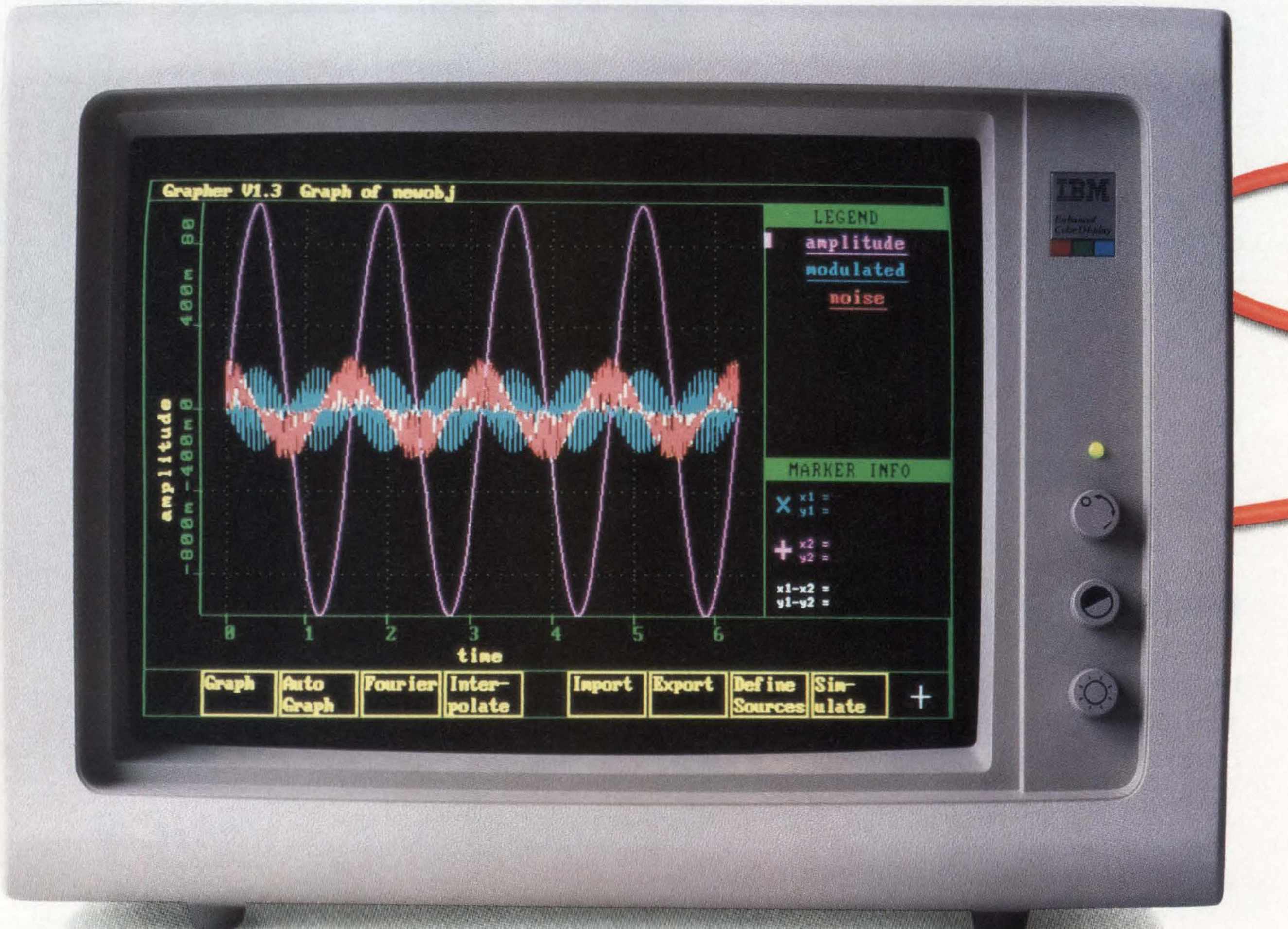

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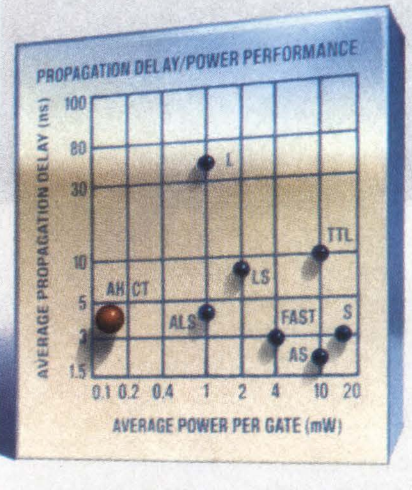

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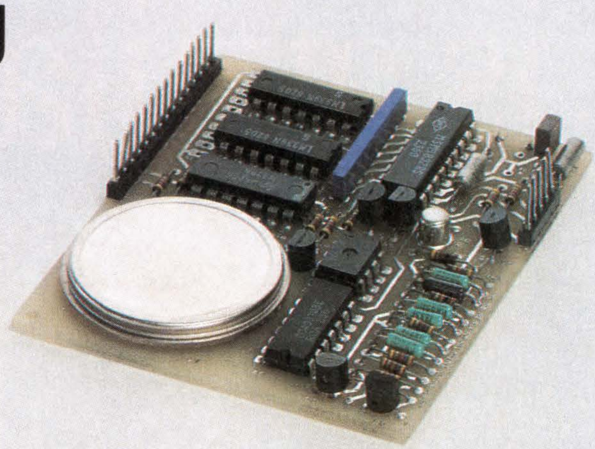

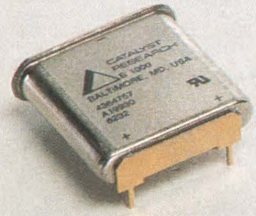

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Good design methods quiet high-speed CMOS noise problems

No doubt about it: Today's high-speed CMOS logic can generate a significant amount of noise. This problem is not insurmountable, however. Circuit design techniques that are prudent but not unusual will readily tame troublesome noise.

Tim Tripp and Bill Hall,
Fairchild Semiconductor Corp

Today's high-speed CMOS logic is creating a big controversy over the issue of ground-bounce noise and the problems it creates in digital system design. Using some constructive design techniques can minimize the effects of ground-bounce noise. Minimize is a key word here, because designers do not have total control over the problem—chip manufacturers have to provide some help, too.

Edge rates of today's advanced high-speed CMOS logic families are much faster than those for HC/HCT CMOS logic and the popular low-power Schottky TTL (LSTTL) and advanced low-power Schottky TTL (ALSTTL) bipolar logic. These faster edge rates generate noise effects that are more pronounced than in older, slower logic technologies. Hurried solutions, such as increasing package size and changing traditional power and ground pinouts, will do little to ease the task of designing advanced CMOS into high-performance systems. What you need are intelligent technology tradeoffs that balance the need for device speed against system noise constraints.

Although CMOS was originally introduced to satisfy low-speed, low-power applications, today's devices have the switching speed and drive capability necessary to accommodate high-performance system needs. Not surprisingly, higher noise levels go hand in hand with gains in performance. With its rail-to-rail voltage swings (which equate to greater dV/dt), advanced CMOS generates more noise than does LSTTL, which has both slower edge rates and smaller voltage swings.

Some noise effects are inconsequential because they fall within the switching time of the devices. But you must neutralize others by using careful design and layout techniques. Your effort will be worthwhile, however. Advanced CMOS operates at clock rates exceeding 100 MHz and consumes about the same static power as first-generation CMOS devices. And with its higher output capability, today's high-speed CMOS families, such as Fairchild's Fact devices, can directly drive transmission lines.

Logic designers and chip manufacturers share responsibility for minimizing CMOS device noise and the system noise it spawns. Logic designers can reduce capacitive loading on signal lines and provide optimum power and ground planes. For their part, chip manufacturers must strike a balance between how fast a logic

Faster edge rates in high-speed CMOS generate noise effects that are more pronounced than noise in older, slower logic technologies.

device switches and how much noise it generates. The faster the slew rate, the greater the noise generated at the device output. By slightly reducing edge rates, a chip maker need not change the device packaging or pinouts to reduce noise levels.

Minimizing ground bounce benefits other noise effects that limit system performance. These effects include overshoot, undershoot, and propagation-delay degradation. The problems with ground-bounce effect all begin at the output stage of a gate.

Modeling the bounce

The schematic in **Fig 1** shows the output stage of a CMOS gate driving a capacitive load. The gate's package connections and leads have a certain amount of inherent inductance. When the gate switches from a high to a low state, current stored in the load capacitance flows to ground through the lower N-channel output transistor and the package inductance.

As the formulas in **Fig 1** show, the load capacitor's discharge current I is a function of the load value and the output transition. As this current flows through the package inductance L_P, it creates a voltage V_{GB}, better known as ground bounce.

The equations in **Fig 1** seem to simplify the ground-bounce phenomenon, but secondary and tertiary effects make it difficult for chip manufacturers to develop a practical ground-bounce model. At first glance, it seems that reducing L_P will decrease V_{GB} proportionally. Unfortunately, reducing L_P increases the rate of current flow and thereby minimizes the decrease in V_{GB}.

Some manufacturers have designed appropriate out-

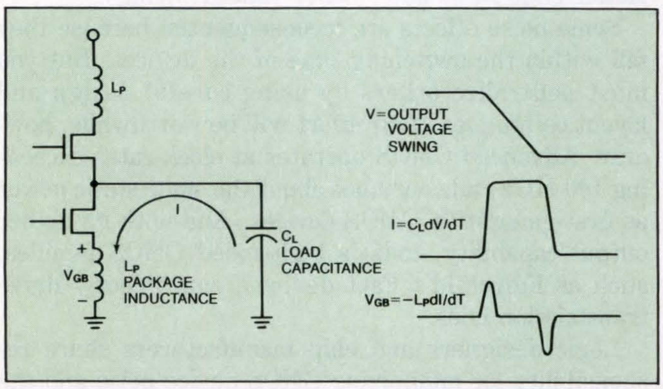

Fig 1—Ground-bounce-related noise in high-speed CMOS logic *results from current flow through package and wiring inductances. The devices fast edge rates, rail-to-rail voltage swings, and high output-current capability combine to maximize the ground-bounce problem.*

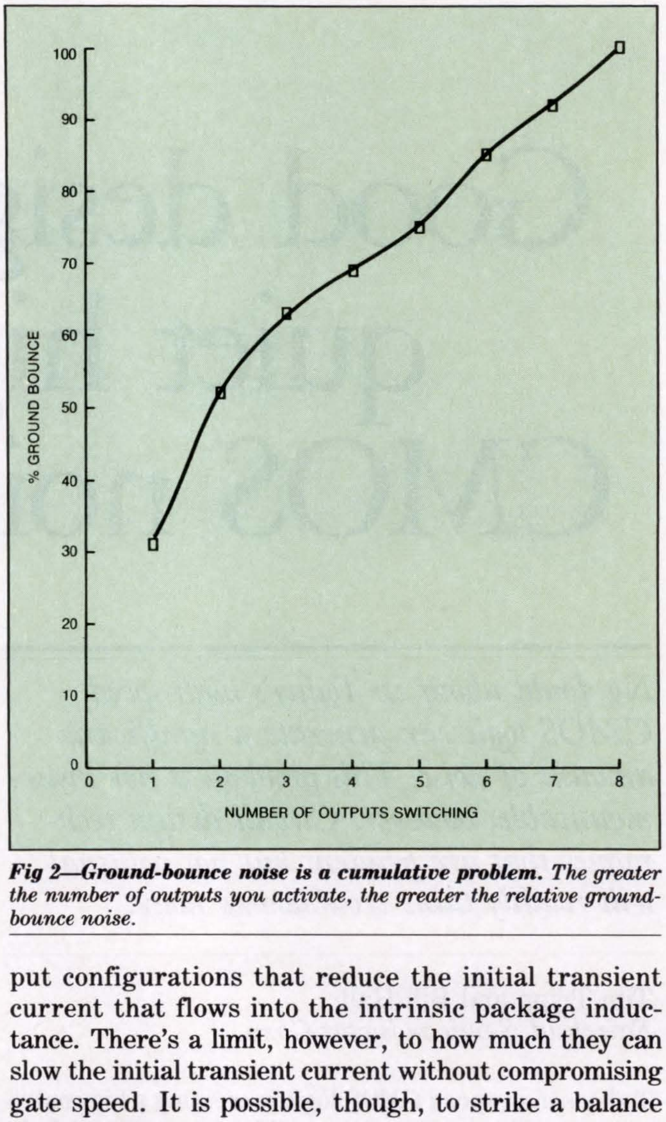

Fig 2—Ground-bounce noise is a cumulative problem. *The greater the number of outputs you activate, the greater the relative ground-bounce noise.*

put configurations that reduce the initial transient current that flows into the intrinsic package inductance. There's a limit, however, to how much they can slow the initial transient current without compromising gate speed. It is possible, though, to strike a balance that provides a controlled output that's sufficiently fast to provide high performance and still slow enough to reduce bounce voltage.

The key point to note is that the chip manufacturer is responsible for reducing system noise effects—particularly ground bounce that stems from fast voltage transitions on switching signals. This responsibility does not eliminate the system designer's responsibility, however. Proper design and layout techniques will further reduce ground bounce.

Fig 1 models ground bounce for a single-output device. Devices with multiple outputs have nodes where the output transistors physically connect to the common package inductance. With multiple-output switching, there is a cumulative current flow through the common package inductance, which proportionally increases ground bounce.

The curve in **Fig 2** shows the relative increase in ground-bounce noise as a function of the number of outputs being switched. Curve development assumes that a single switched output generates 30% of the maximum ground-bounce voltage. As the curve shows, three switched outputs generate 60% of the maximum voltage—twice as much noise as a single output. And seven outputs generate 90% of the voltage—three times as much noise as a single output.

Propagation delay is one parameter that suffers from excessive ground-bounce created when switching multiple outputs. As **Fig 1** illustrates, the greater the voltage drop across the package inductance (V_{GB}), the lower the voltage drop across the gate's output transistor. The lower voltage level reduces the rate of current discharge from the load capacitors, which slows down edge rate and degrades propagation delay. The effect is most pronounced, for example, when all the outputs of an octal bus-driver IC switch simultaneously.

The scope waveforms in **Fig 3** illustrate the degradation of delay parameters under multiple-switching conditions. The curves on the left represent the clock input of an octal D-type flip-flop; the curves on the right illustrate the performance for varying numbers of switched outputs. The propagation delay from the input to the first output is about 6.5 nsec. As each additional output line activates, however, the input-to-output delay begins to increase. The delay difference for one and two switched outputs, for example, is about 200 psec, and for three outputs, it's about 400 psec. In essence, delay increases about 200 psec for each additional output.

As shown, the additional delay is greater than 1 nsec with seven outputs activated. Obviously, such a timing delay or system skew can affect projected operation. Fortunately, some manufacturers specify typical guidelines for propagation delay degradation due to multiple-output switching.

Ground-line bounce is more of a problem

As **Fig 1** illustrates, bounce is present on both the ground and V_{CC} lines of the device. Typically, spikes on the ground line cause more problems because TTL has less noise margin in the low-voltage state (logic 0) than in the high-voltage (logic 1) state. However, either ground or V_{CC} bounce can couple onto an active signal and develop undershoot or overshoot. An undershoot can drive a nominal 0V below ground, and an overshoot can drive a high-level signal above V_{CC}. Although some specialty devices (such as dynamic RAMs) are sensitive to undershoot, most general-purpose logic provides input protection, such as clamp diodes, to guard against these anomalies.

Quiet output switching (QOS) is the ground-bounce offshoot that primarily concerns most system designers. QOS is ground bounce that couples onto a non-switching output through the package inductance. Typically, QOS levels are benchmarked using industry-standard test fixtures, which consistently provide good correlation when measuring multiple devices under varying test conditions. Test-fixture measurements at the worst-case output pin of an advanced CMOS octal device under worst-case conditions show that typical bounce-voltage values range from 1.8 to 2.4V. However, test-fixture results do not represent real-life system QOS levels.

Test fixtures have lumped-load 50-pF chip capacitors soldered directly to the output pin of the DUT (device

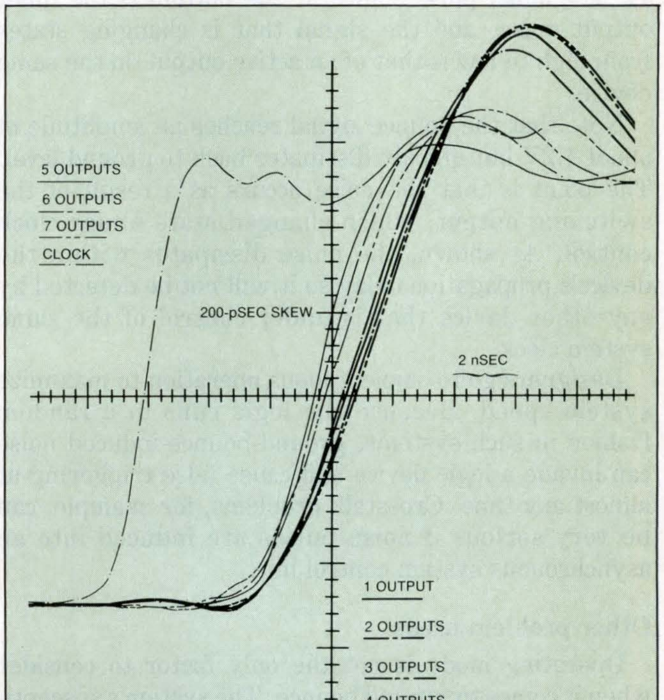

Fig 3—Propagation delays become skewed *in a high-speed octal driver as the number of activated outputs increases. A delay difference as high as 1 nsec can occur between switched output extremes, that is, one output switching and seven outputs switching. Such a delay difference can readily cause malfunctions in the system logic devices.*

Chip manufacturers are responsible for reducing system noise effects.

under test), while a real-life system has distributed loads along a transmission line. The additional transmission-line impedance reduces the initial transient current and thereby lowers the QOS levels. In addition, test-fixture outputs act like an LCR tank circuit and create an oscillation effect on the ground-bounce waveform. Using advanced CMOS octals in a typical system under worst-case conditions, QOS can range from 0.3 to 1.2V—well below what you'll observe in test fixtures.

Ground-bounce-related effects introduce spurious noise on signal lines that can erroneously trigger logic devices, so you must design to minimize such occurrences. To start, you must identify when a system is most likely to respond to noise effects. Generally, it occurs when a portion of the system operates asynchronously.

Under synchronous control, ground bounce occurs only when triggered by the clock, which makes the noise more predictable and easier to control. Moreover, noise spikes appear when they can do no damage (**Fig 4**). The small pulse shown at the bottom is the quiet output noise, and the signal that is changing states from high to low is that of an active output on the same device.

Note that the bounce signal reaches an amplitude of about 1.2V but quickly dissipates back to ground level. The point is that the noise occurs as a result of the switching output, which changed state under clock control. As shown, the noise dissipates within the device's propagation delay so it will not be detected by any other device that is under control of the same system clock.

Designers go to asynchronous operation to maximize system speed. Because the logic runs in a random fashion in such systems, ground-bounce-induced noise can invade a logic device and cause false triggering at almost any time. Crosstalk problems, for example, can be very serious if noise pulses are induced into an asynchronous system control line.

Other problem areas

Operating mode is not the only factor to consider when it comes to ground bounce. The system's susceptibility to ground bounce is also dependent on the thresholds of the logic (TTL or CMOS) used. CMOS thresholds provide better noise margins than do TTL thresholds; therefore, CMOS is less susceptible to false triggering from voltage-bounce effects. In addition, both CMOS and TTL inputs have a form of inherent noise rejection that's based on the amount of energy required to trigger the input (amplitude×duration). The input will either reject a relatively narrow noise pulse (ground bounce, crosstalk, etc) or respond to noise-pulse amplitudes that exceed the specified static-input thresholds.

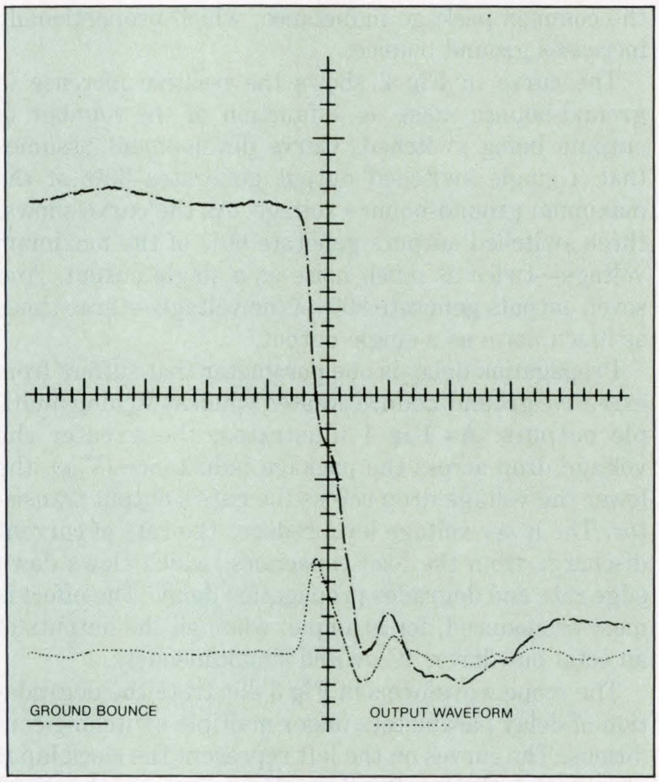

Fig 4—You can control the effects of ground bounce *by operating logic synchronously rather than asynchronously. If a ground-bounce-induced pulse occurs within the propagation delay of the switching device, it will not cause a system malfunction because switching activity will not take place until a few nanoseconds after the passage of the clock.*

Ground-bounce problems might seem formidable, but you can overcome them by following some simple guidelines for systems that contain both CMOS and TTL—the case in many systems today. First, try to avoid using TTL devices in any asynchronous portions of a mixed system. Second, if you use any high-speed CMOS octal bus drivers, be aware that ground-bounce noise increases significantly when all outputs switch simultaneously. Third, try to avoid using high-speed CMOS octal devices to drive asynchronous signals into TTL devices. If you must do so, however, you can follow some techniques that will minimize ground bounce.

When driving an asynchronous data line with an octal bus driver, use the output pin that is closest to the package ground pin. Compared to the pin closest to the V_{CC} pin, this technique will reduce noise by as much as

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Spikes on the ground line cause major problems because TTL has less of a noise margin in the low-voltage state.

50%. Driver output pins between ground and V_{CC} will generate increasing amounts of noise voltage. Therefore, always drive TTL devices with the lowest noise driver and use the noisier outputs to drive CMOS logic.

You can also reduce ground-bounce-noise problems by lowering the system's supply-voltage level. You might find this task difficult to perform, but the results are meaningful (**Fig 5**). This curve illustrates the relationship between supply voltage and relative ground-bounce noise for an octal buffer with seven of its outputs activated. The curve's slope shows that each 1V reduction in V_{CC} reduces ground bounce 18%. Advanced CMOS input thresholds are a linear function of V_{CC} (30% V_{CC}) so each 1V reduction in V_{CC} reduces the threshold by 14%. Given the 18 and 14% figures, it's obvious that reducing V_{CC} improves the noise margin.

Looking at the crosstalk problem

Most of the burden for quieting ground bounce falls on the device manufacturer; however, device manufacturers and circuit designers both have roles to play when it comes to reducing crosstalk problems. Crosstalk noise occurs when signals from one line capacitively couple into an adjacent line. Crosstalk is a function of both the slew rate of the signal and the capacitive coupling between the lines. Device manufacturers bear most of the responsibility for the slew rate, but designers can control the coupling by spacing signal lines properly.

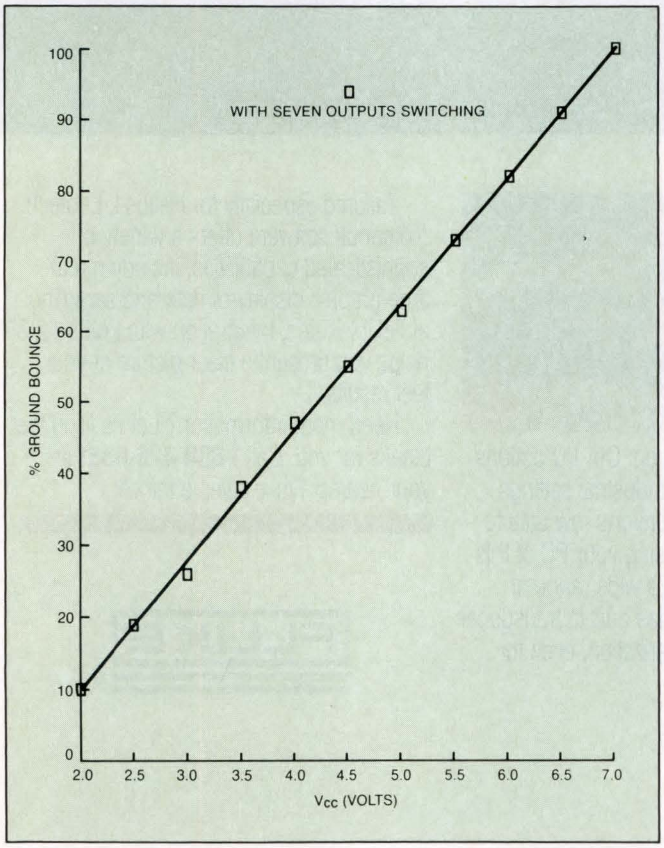

Fig 5—Ground-bounce noise varies directly with the power-supply voltages *used in the system. If you reduce supply voltage by just 1V, you'll reduce ground bounce by about 15 to 20%.*

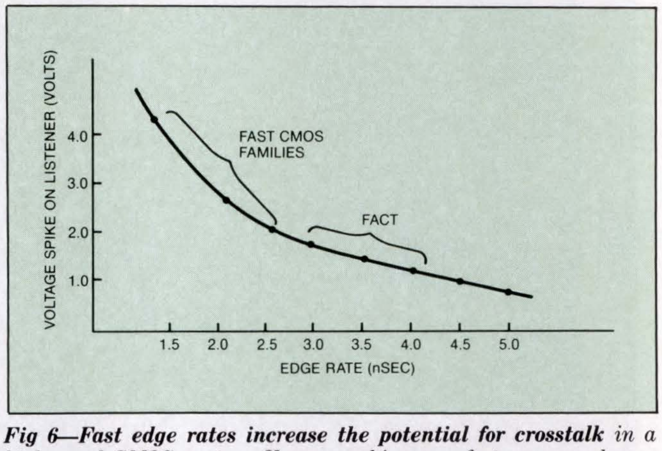

Fig 6—Fast edge rates increase the potential for crosstalk *in a high-speed CMOS system. However, chip manufacturers can lessen potential crosstalk problems by slightly decreasing edge rates, as shown by the figures for the Fact devices.*

Fig 6 illustrates the effect of a signal's edge rate on the noise generated at the input of a receiving device on a parallel line (noted as a listener on the vertical axis of the curve). First, note that edge rate directly influences voltage spike generation—the slower the edge rate, the lower the noise spike amplitude.

Fig 6 was generated from measurements on two 30-in. adjacent pc-board traces terminated with 50Ω impedances. The value of the voltage spike at various edge rates is a function of trace lengths, trace spacing, and termination impedances. Different trace lengths, spacings, and impedances will vary the spike amplitude, but the induced noise spike will always be a function of the signal's edge rate.

Crosstalk, like ground bounce, can be cumulative. If you run wires in a bundle instead of singly, you'll increase the probability of crosstalk problems. To minimize crosstalk, increase the spacing between sensitive lines, or use ground shielding.

Proper board layout is critical

You can take other prudent measures to minimize the effects of edge-related noise. In general, board layout is a key factor. In high-performance designs, separate

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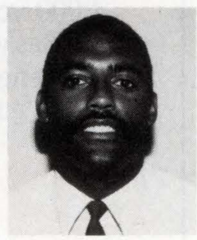
Authors' biographies



Tim Tripp is a product manager at Fairchild Semiconductor Corp's Digital Logic Div (Portland, ME). He directs advertising and all other publicity for the company's Fact family of high-speed CMOS devices; he also directs the design and operations for family growth and support. Tim has a BSEE degree from Notre Dame University. In his spare time, he is an avid sports enthusiast.

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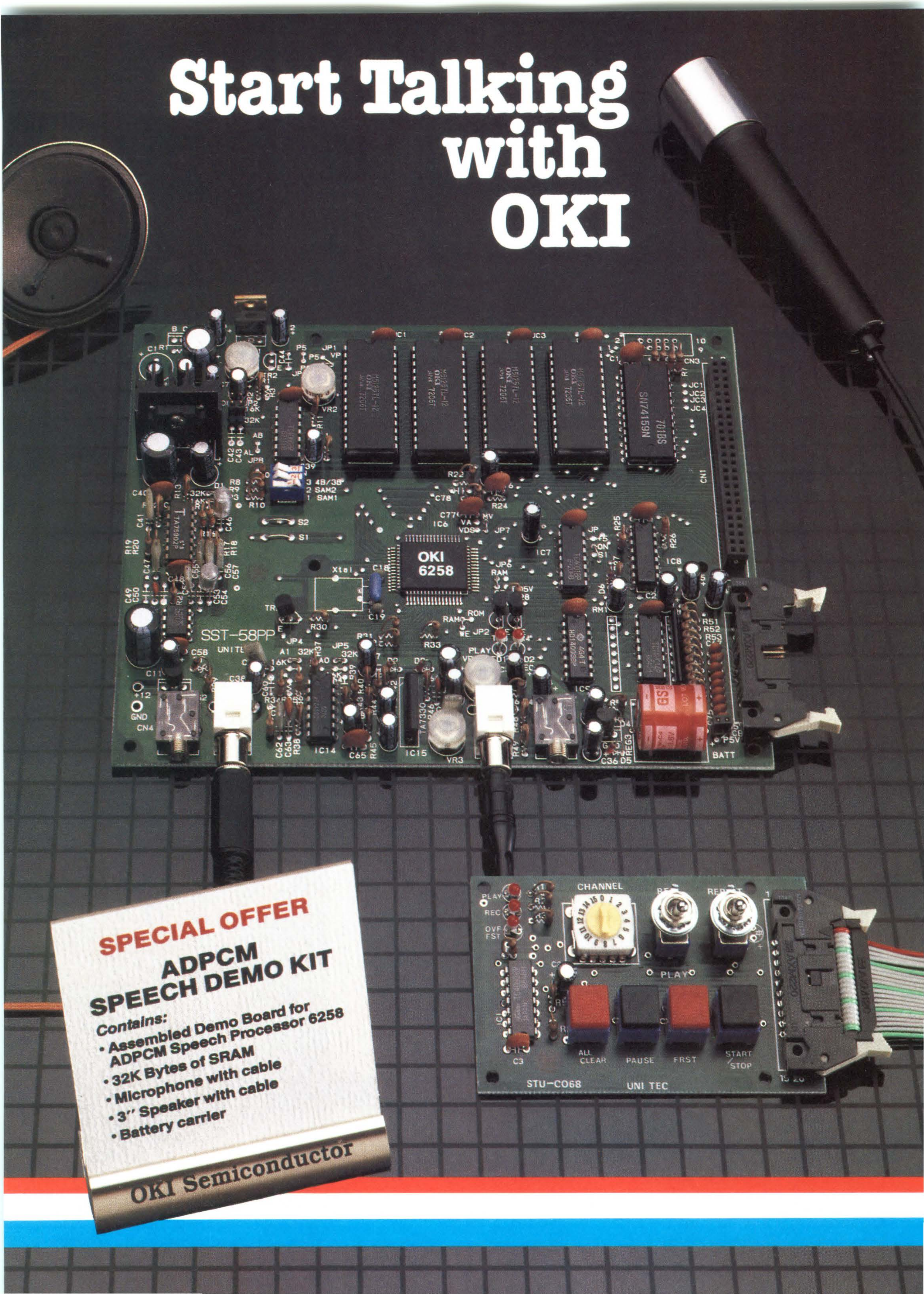
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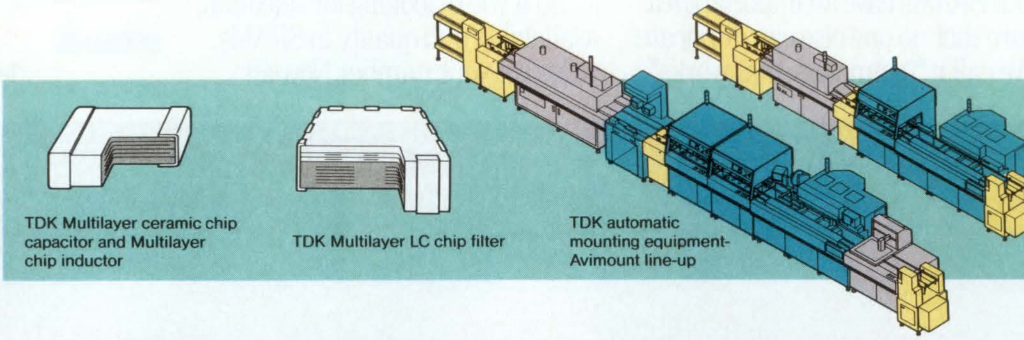

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William Rempfer

Introduction

For many signal processing applications a sample and hold function is required in a data acquisition system. It is often critical for the processing system to know the exact value of an analog input at an exact time. In DSP applications such as digital filters the usable bandwidth of the system is limited by the Nyquist frequency and the sample and hold bandwidth need only be, and is often intentionally limited to, one half the sampling rate. However, another area of application requires infrequently capturing instantaneous values of relatively fast signals, sometimes referred to as gated measurements. In the extreme case of pulse height measurements, only one sample point is required. Here, the sample and hold bandwidth should be as high as possible even though the sampling rate is very low.

The LTC1090 excels in both environments. This note shows how the LTC1090 sample and hold can be synchronized to an external event and gives two simple applications: an 8 channel data acquisition system with digital filtering, and the gated measurement of a 1MHz sine wave.

The LTC1090 Sample and Hold

The LTC1090 provides a sample and hold which is fast, accurate and can be synchronized to an external event. Although the sampling rate is limited (by the A/D conversion and data transfer rate) to about 30kHz, the signal bandwidth of the sample and hold exceeds 1MHz. The acquisition time is less than 1μs to 0.1% (1LSB). Accuracy is so good, in fact, that it is possible to include all the sample and hold's error contributions (offset, gain, hold step, droop rate, etc.) into the converter specification and still maintain overall system accuracy of ±0.05% (±0.5LSB) over temperature.

Sampling occurs on the falling edge of the last data transfer clock pulse as described in the LTC1090 data sheet. Figure 1 shows a typical application which includes circuitry to synchronize sampling to an external sample clock, f_S.

8-Channel Data Acquisition System with Digital Filter

The circuit of Figure 1 contains an LTC1090 providing multiplexing, sample and hold, A/D conversion and data transfer to the microcontroller (MCU). An MC68HC05C4 is used as the

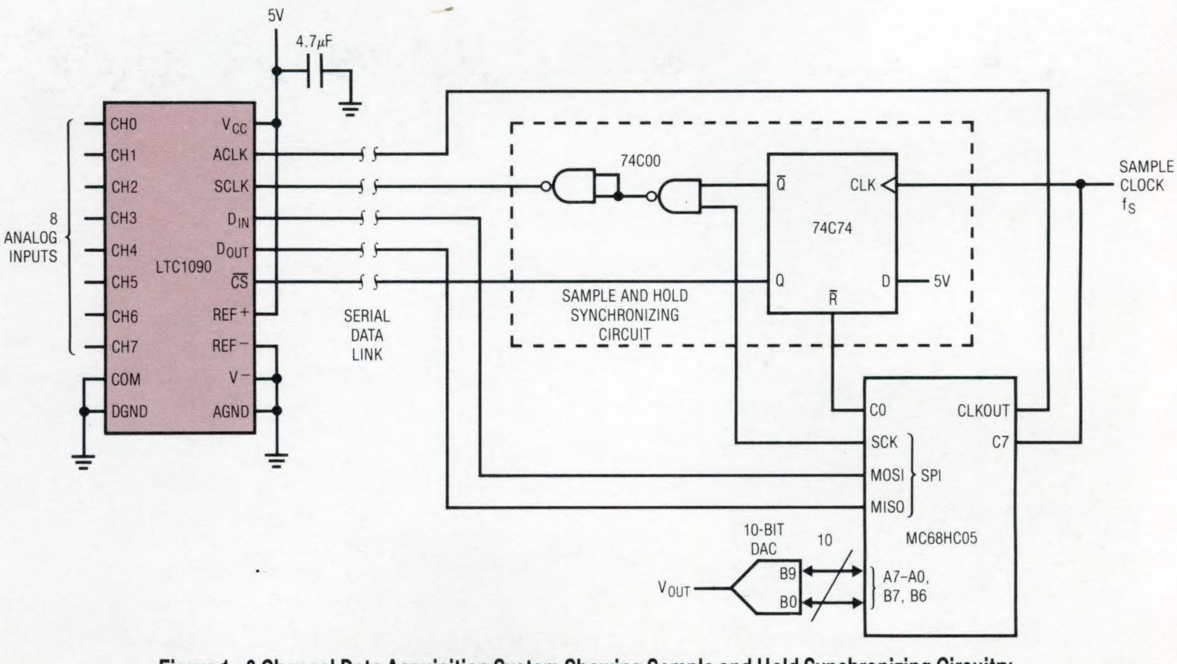

Figure 1. 8 Channel Data Acquisition System Showing Sample and Hold Synchronizing Circuitry

controller (much higher filter performance may be achieved with a dedicated DSP processor). The MCU communicates with the LTC1090 over the serial peripheral interface (SPI), performs the digital filtering algorithm and provides the filtered data on its output port. The DAC provides reconstruction of the filtered waveform for viewing on an oscilloscope or spectrum analyzer. The 74C74 and 74C00 synchronize the sampling of the LTC1090 to the externally applied sample clock, f_S.

In Figure 1, the MCU initiates a two byte serial data exchange with the LTC1090. This configures the LTC1090 for the next conversion, simultaneously reads back the previous conversion result and resets the 74C74. The LTC1090 will sample the analog input when the last shift clock (SCLK) pulse falls, so the MCU must end the data transfer by leaving the SCLK in a high state. This inhibits sampling of the selected analog input. When the sample clock, f_S, rises, it clocks the 74C74 which raises the $\overline{CS}$ and drops the SCLK. This falling SCLK causes the sample to be taken and starts the conversion. After the MCU senses the rising sample clock it waits for the conversion to be completed (44 ACLK cycles) and then initiates another data exchange, preparing the LTC1090 for the next sample. This cycle repeats.

4th Order Elliptic Filter

Using the circuit of Figure 1, a 4th order elliptic digital filter was implemented. 10 bit input and output data words and 14 bit coefficients were used with the same coefficients being used for each channel. A direct form II IIR filter was implemented according the following equations:

$$D(n) = [7203 \times D(n-1) - 19209 \times D(n-2) + 6324 \times D(n-3) - 4383 \times D(n-4)] \times 2^{-14} + X(n)$$

$$Y(n) = [3069 \times D(n) + 5505 \times D(n-1) + 7824 \times D(n-2) + 5504 \times D(n-3) + 3066 \times D(n-4)] \times 2^{-14}$$

where: $X(n)$ = filter input value
$Y(n)$ = filter output value
$D(n)$ = delay node value

The filter frequency response is shown in Figure 2. The cutoff frequency is 175Hz, one fourth the sample frequency of 700Hz. The cutoff frequency of the filter can be tuned by varying the frequency of the sample clock.

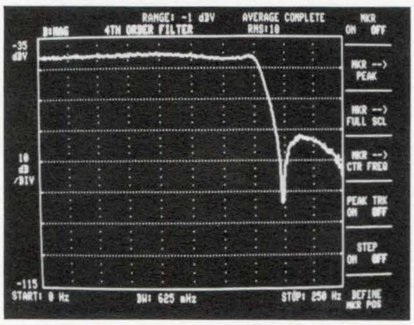

Figure 2. Spectrum of 4th Order Elliptic Digital Filter used in the Data Acquisition System, f_C = 175Hz

Because of 68HC05 speed and instruction set limitations, sample rate is limited by the MCU's ability to perform the DSP algorithm. Maximum sample rate was determined to be 700Hz for a single channel filter and 90Hz for eight channels. Using a high performance DSP would allow sample rates approaching the limit of 30kHz for one channel and 3.7kHz for all eight set by the LTC1090. Hopefully, this simple example will encourage the reader to pursue higher order, higher performance applications.

If large amplitude, unwanted AC signals are present on the inputs, a linear filter such as the LTC1062 can be used to remove them and prevent reduction in the dynamic range of the system.

Gated Measurements of Fast Signals

As an example of gated measurements, the circuit of Figure 1 was used with no filtering to repetitively sample a 5Vp-p 1MHz sine wave. The waveform was sampled at 15kHz (approximately one sample every 67 cycles of the 1MHz waveform). A 20ns pulse, triggered off the sample clock, was applied to the z-axis input of a storage scope to illuminate one dot on the CRT per sample. Samples were allowed to accumulate on the storage scope as shown in Figure 3. The upper waveform is the sampled input to the LTC1090 and the lower waveform is the sampled output of the DAC. (Remember that the waveforms are not real time: one dot was illuminated only every 67 cycles of the 1MHz sine wave.) With this technique the signal bandwidth of the LTC1090 sample and hold was determined to be 2MHz.

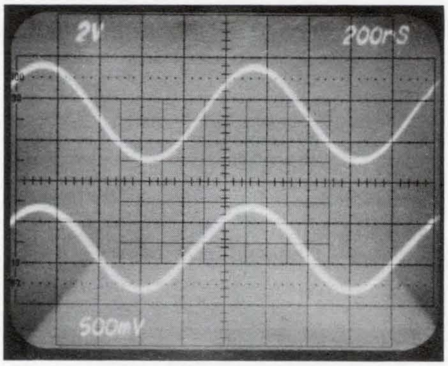

Figure 3. Input and Output Sample Points of a 1MHz Sine Wave Accumulated on a Storage Scope

Using the LTC1090 sample and hold, high speed circuits such as a 1MHz bandwidth AC to DC converter are possible. Because the acquisition time is less than 1μs it is also possible to make a gated measurement of the height of a pulse as narrow as 1μs to 0.1% accuracy.

For LTC1090 literature call **800-637-5545.** For help with an application call (408) 432-1900, Ext. 361.

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Three ICs combine video and sync signals

Wayne M Austin and D K Tidey
GE Semiconductor, Somerville, NJ

In **Fig 1,** high-speed CMOS inverters and analog switches combine a video signal with the sync and blanking signals produced by the CMOS sync generator IC_1. The result is a fully interlaced-scan, composite-video signal. The circuit works with a monochrome video signal or with the green component of an RGB video signal.

IC_1 offers I/O functions not required in this application. The connections shown enable the IC to accept an external clock signal, and an internal pullup resistor holds pin 20 high. The capacitor C_1 bypasses pin 10 and thereby prevents noise spikes from causing an inadvertent reset of the vertical input. You set the clock frequency to 32× the desired horizontal-sync frequency.

The hex inverter (IC_3) buffers the clock signal and inverts the analog-switch control signals as required. The switches add clamping, blanking, and sync signals to the video. A brief closure of switch IC_{2B} establishes the sync-pedestal amplitude by clamping the video signal at a level determined by the resistor divider R_3/R_4. Closing switch IC_{2C} sets the sync-tip level at V_{SS}, and closing IC_{2D} establishes the black-reference level ("Back Porch"), which you set by adjusting potentiometer R_6. **EDN**

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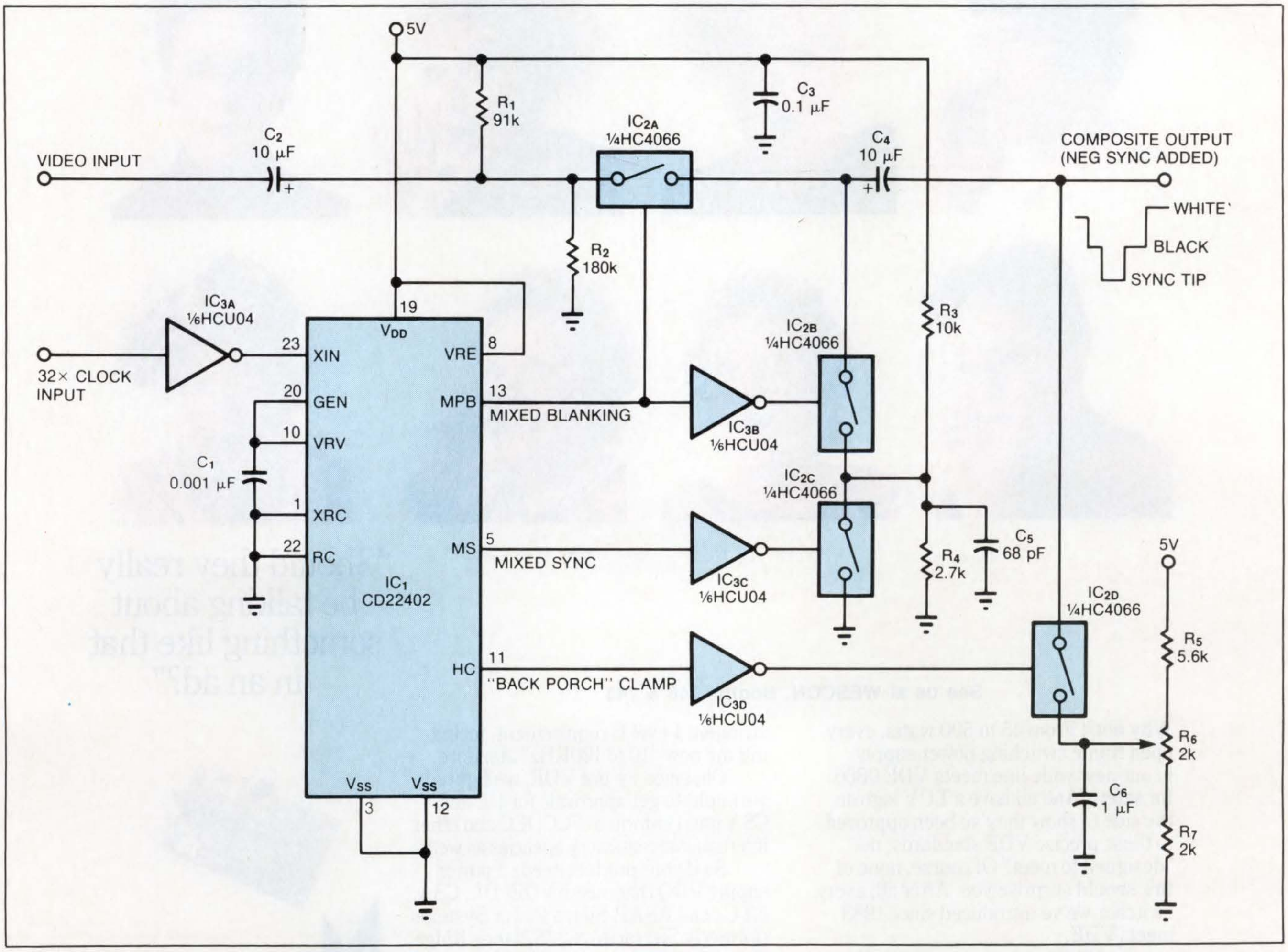

*Fig 1—**Timing signals generated within IC_1** enable this circuit to generate an interlaced-scan, composite-video signal by combining a video signal with vertical and horizontal sync and blanking pulses.*

Circuit provides interface for tilt sensor

Steve Momii
University of Washington, Seattle, WA

The **Fig 1** circuit performs level shifting and amplification of the voltage output of an electrolytic tilt sensor. (The sensor consists of a vial whose electrodes are in contact with a conductive liquid. Tilting the vial changes the resistance between the electrodes.)

IC_1 includes two pairs of spdt switches, optimized for switched-capacitor applications and suitable for use in precision dc functions such as instrumentation amplifiers. The chip has an internal 2-phase oscillator that drives the switches at approximately 185 kHz. In this application, the left-hand switches apply square-wave excitation to the tilt sensor. The right-hand switches transfer the resulting signal voltage (V_D) first to capacitor C_2, then to the output amplifier.

Resistor R_1 limits current through the sensor; high current shortens the sensor's life. Capacitor C_1 blocks the dc currents that would otherwise degrade the sensor by plating the electrodes. Op amp IC_2 is a CMOS type whose low bias current has little effect on the voltage across the hold capacitor (C_3).

Voltage V_B provides a reference for the output voltage and a means of calibrating the system offset—you simply have to adjust V_B for the desired V_{OUT} when the sensor is level. When V_B=2.5V, R_2=10 kΩ, and R_3=14 kΩ, the circuit provides a nominal 2.5V output. The resulting (nonlinear) output ranges from 0 to 5V in response to tilt inputs of ±30°. **EDN**

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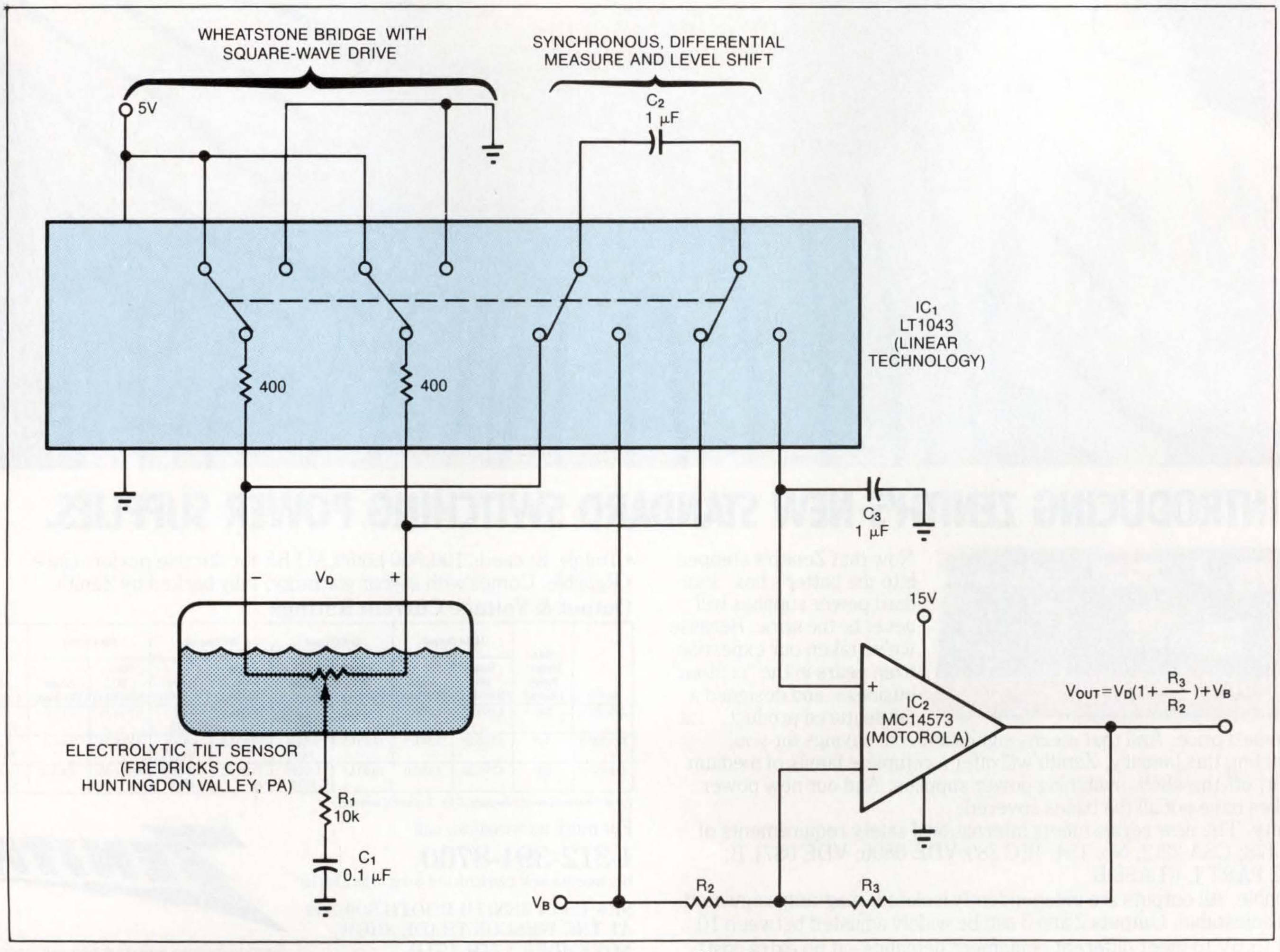

***Fig 1—This tilt-sensor interface** produces a 0 to 5V output in response to tilts of ±30°.*

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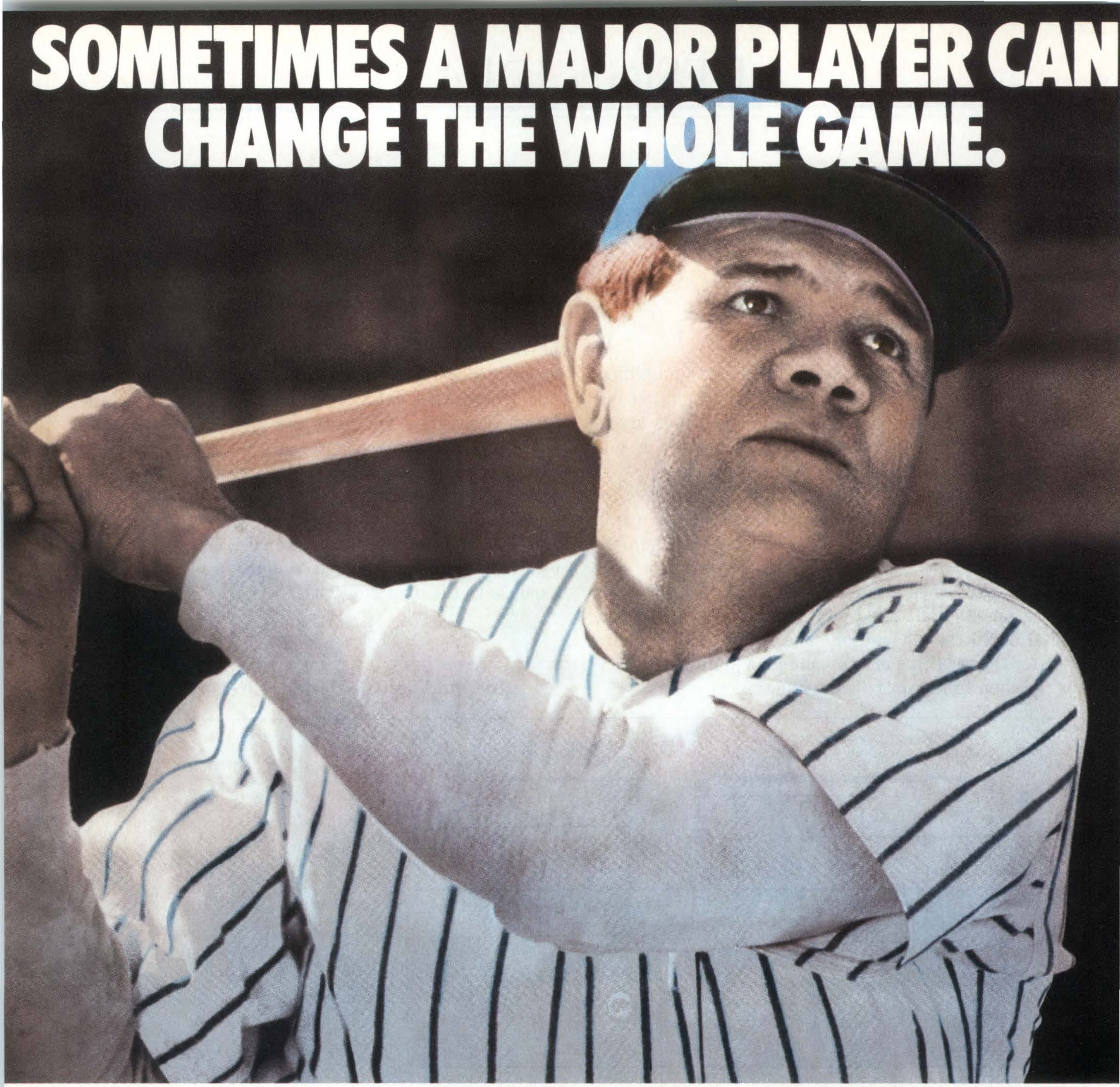

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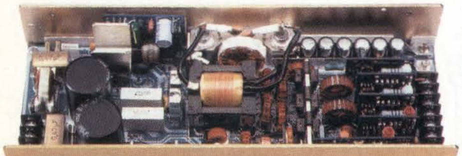

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Simple algorithm detects stuck memory bits

Vance Campbell
Novell Inc, Provo, UT

By performing logical AND and OR operations with appropriate bit masks, the simple algorithm of **Listing 1** detects the position of any bits in a memory array that are permanently stuck. Unlike other test methods such as checksums, the routine also tells you whether a bit is stuck in the high or low logic state. **Listing 1** is written in 68000 assembly language.

First you establish an all-zeros mask and an all-ones mask (of the same widths as the memory under test), and then you initialize the appropriate counters. During execution the algorithm takes each memory word in sequence, performs an OR operation with the all-zeros mask, stores the result in the all-zeros mask, performs an AND operation with the all-ones mask, and stores the result in that mask.

This procedure rapidly fills the zero mask with ones and the one mask with zeros. After program execution, you can assume that any 0 in the zero mask indicates a bit stuck in the low state, and any 1 in the one mask indicates a bit stuck in the high state. You can use the routine for the initial testing of ROMs or for testing RAMs (after first filling the RAM with a known pattern). **EDN**

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LISTING 1—MEMORY-TEST ALGORITHM

```
ROMBase      equ    $f68000        32K of ROM
ROMSize      equ    $3fff          16 K x 16

BitTest:
* Check for stuck bits

        clr.l   d4                    use d4 for zero mask
        move.l  #$ffff,d5             use d5 as ones mask
        move.l  #ROMBase,a0           use a0 as pointer
        move    #ROMSize,d0           use d0 as loop counter

StuckLoop:
        move    (a0)+,d3              d3 is the temporary register
        or      d3,d4                 logical or to zero mask
        and     d3,d5                 logical and to ones mask
        dbf     d0,StuckLoop          loop back until finished

* At this point, any bits still 0 in "zero mask" are stuck at 0, and any bits
* still set in "ones mask" are permanently stuck high. Report to user and exit.

        cmp     #$ffff,d4             any bits stuck low in "zeroes mask?"
        bne.s   StuckLow              if so, go process it

CheckForHighBits:
        tst     d5                    test for zero in "ones mask"
        bne.s   StuckHigh             if not zero, it's an error!

ExitBitTest:
        rts                           back to calling routine

StuckLow:
* User routine to output error message and/or bit mask.

        bra.s   ExitBitTest           exit through common exit point

StuckHigh:
* User supplied routine to handle bits being stuck high.

        bra.s   ExitBitTest           exit through common exit point
```

Debouncer for spdt switches uses few parts

Mounir Boukadoum
University of Quebec at Montreal, Montreal, Quebec, Canada

The debounce circuit of **Fig 1**, applicable to spdt switches, uses fewer components than that of an earlier Design Idea (EDN, March 18, 1987, pg 212). Like the earlier version, **Fig 1**'s circuit has two inverters in a bistable-latch configuration but, unlike its predecessor, it requires no other components.

After assuming a given binary state, the output becomes insensitive to contact bounces thanks to positive feedback around the inverter loop. You can set the circuit output normally high or normally low by connecting IC_{1A}'s input to the appropriate switch contact. **EDN**

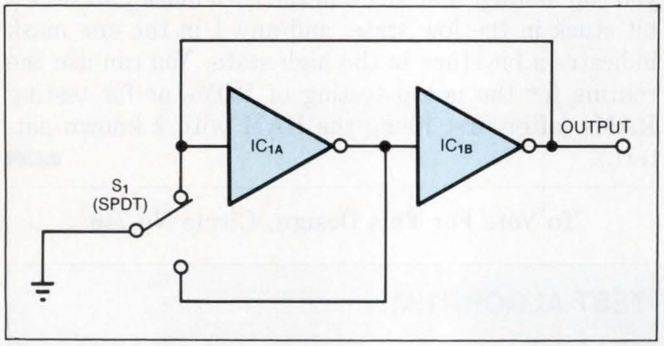

***Fig 1—The position of switch S_1** determines the output state of the bistable latch formed by inverters IC_{1A} and IC_{1B}; positive feedback makes the circuit insensitive to contact bounces.*

To Vote For This Design, Circle No 749

Delay circuit affects leading edge only

Harold J Weber
Effectrol Products Corp, Framingham, MA

The **Fig 1** circuit lets you delay the leading edge of a positive pulse while leaving the trailing edge almost unaffected. A positive input transition, inverted by IC_2, has no effect on IC_{1B}. However, when the positive transition reaches IC_{1A} (delayed by the adjustable network of R_1, R_2, and C_1), it toggles both NOR gates, initiating the output pulse. When the input returns low,

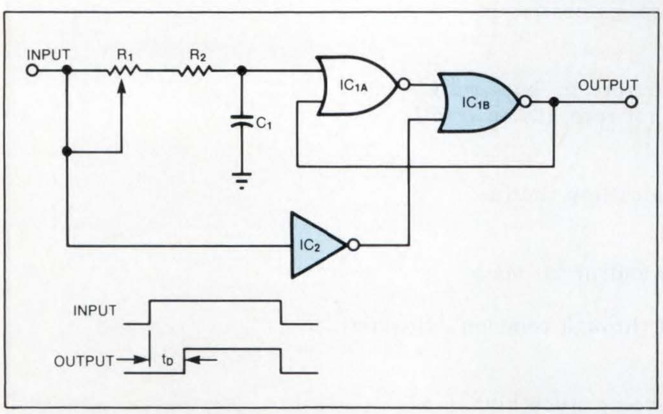

***Fig 1—This circuit delays the leading edge** of an input pulse according to the setting of R_1 as shown. The trailing-edge delay equals the propagation delay through IC_2 and IC_{1B}.*

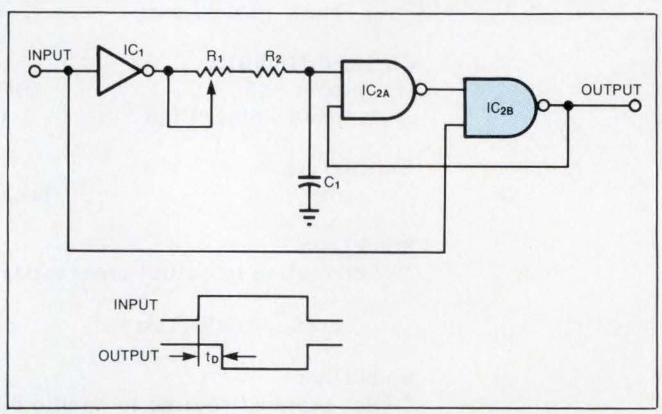

***Fig 2—This circuit delays the leading edge** of an inverted pulse and buffers the input signal. The trailing edge is delayed only by the propagation through one gate (IC_{2B}).*

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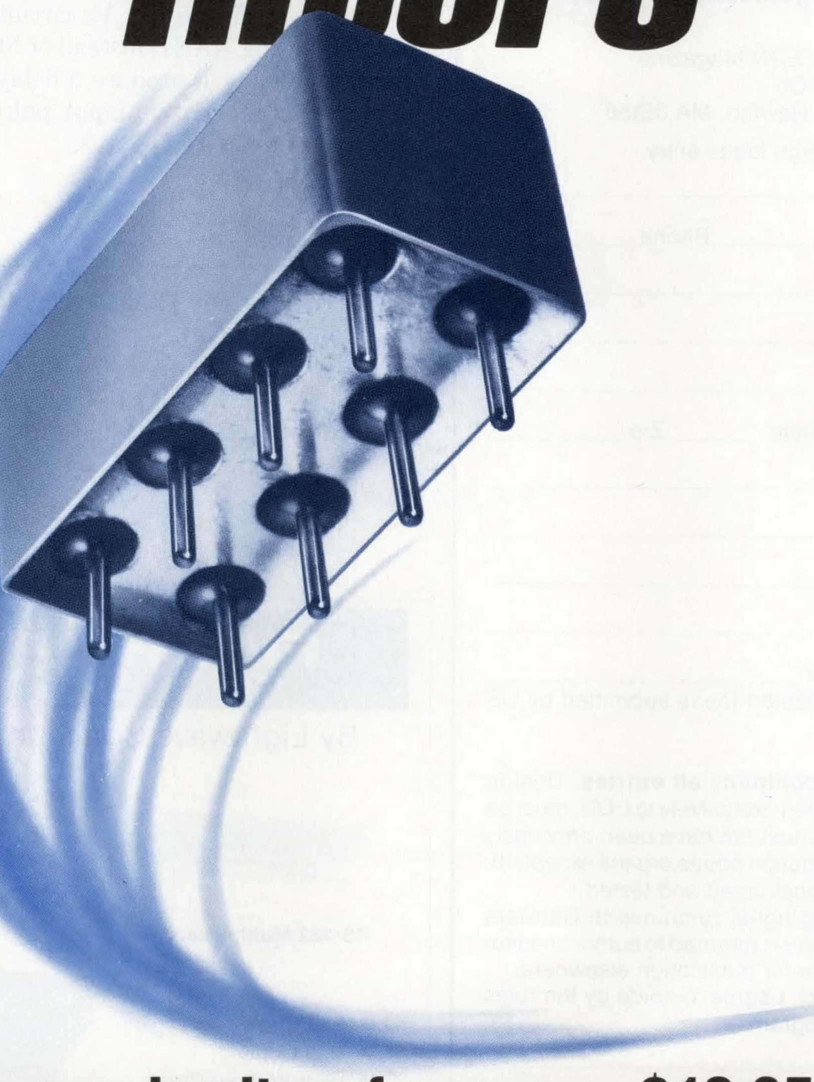

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IC_{1B} follows suit, delayed only by the propagation through itself and IC_2.

The **Fig 2** circuit produces an inverted output pulse. Inverter IC_1 serves as a buffer for the signal source—an advantage when driving a low-impedance (short-delay) network. Moreover, only the propagation delay of IC_{2B} separates the output's trailing edge from that of the input.

You can configure **Fig 1**'s circuit to handle negative pulses by using NAND instead of NOR gates. Similarly, **Fig 2**'s circuit will produce a delayed positive pulse in response to a negative input pulse, if you substitute NOR gates for NAND gates. **EDN**

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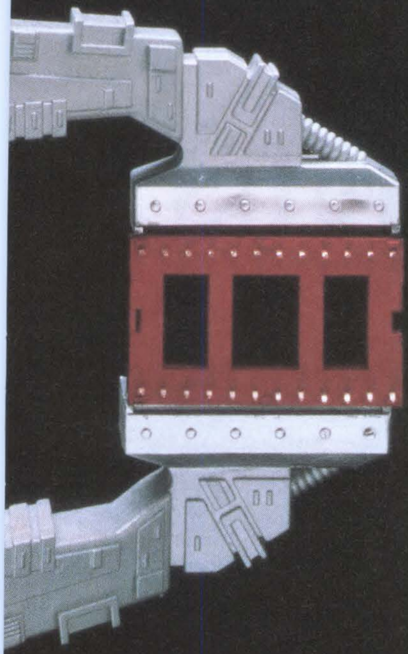

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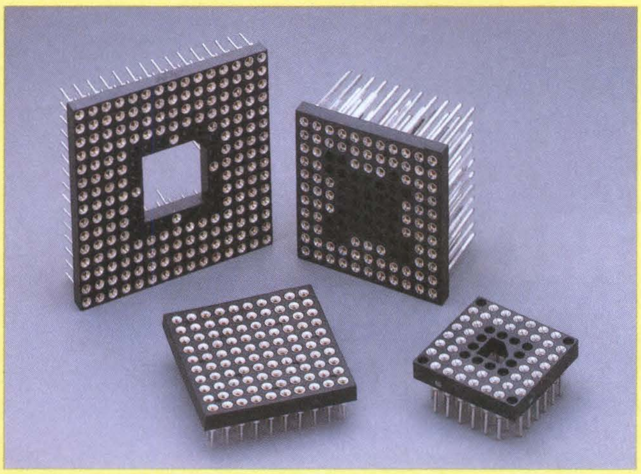

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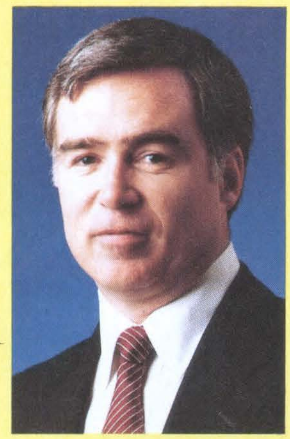

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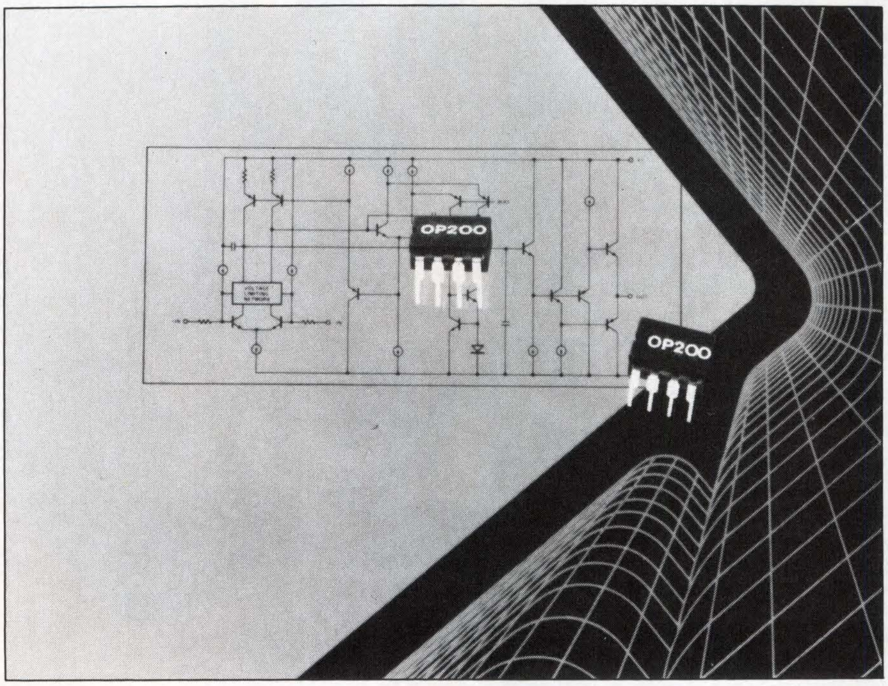

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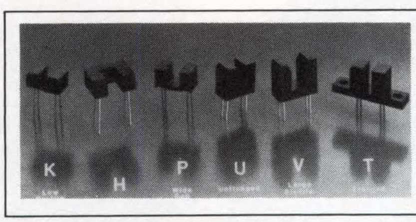

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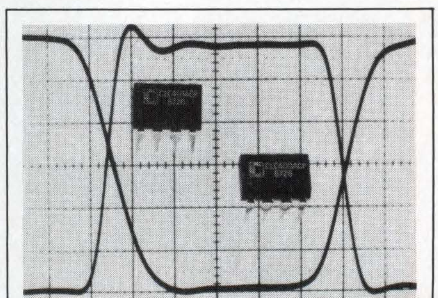
Employing a complementary bipolar process, the CLC400 is a high-speed, fast-settling op amp for low-gain applications (gains of ±1 to 8). Its sister chip, the CLC401, is for applications requiring a gain of 7 or greater. With an 8-nsec settling time to 0.05% and the ability to drive capacitive loads, the CLC400 is suitable as a flash A/D driver. The 200-MHz bandwidth and 2.2-nsec



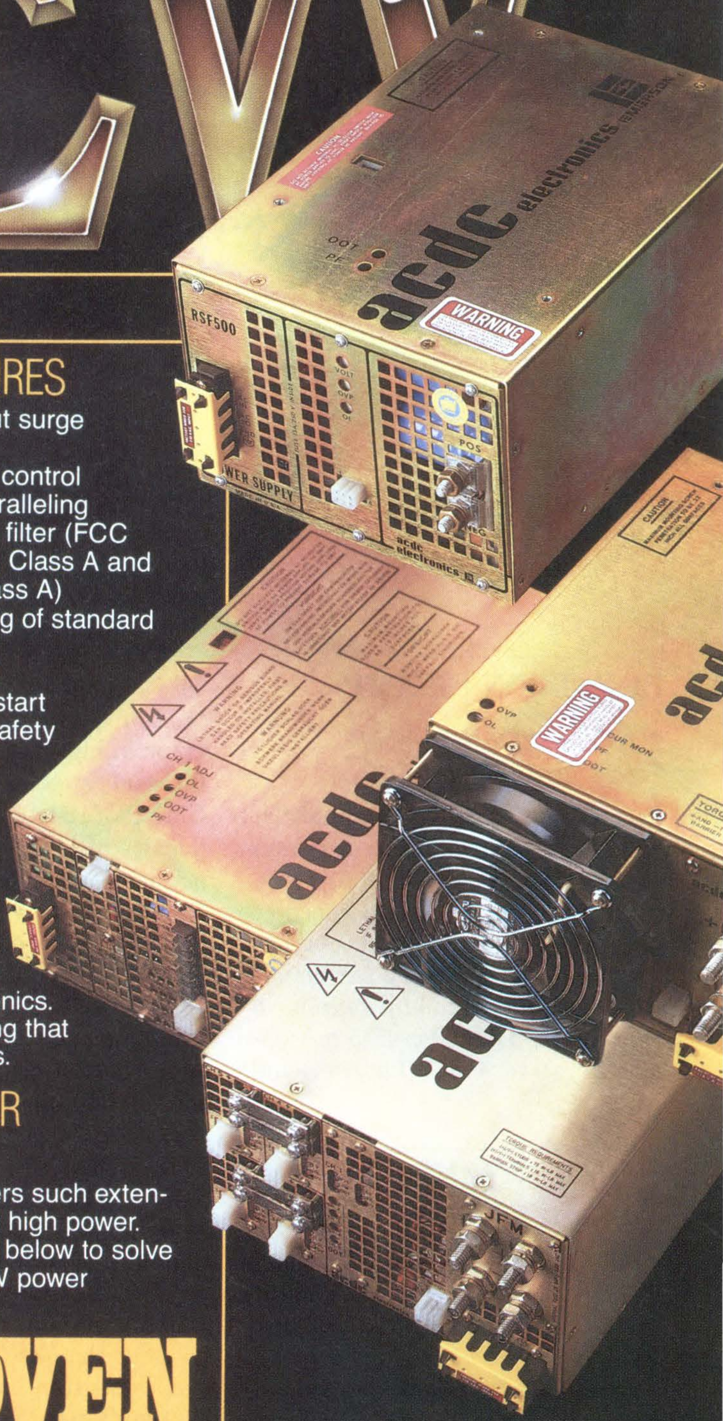
rise/fall times ensure good signal fidelity when amplifying high-speed pulses. The CLC401 has a bandwidth of 150 MHz and a settling time of 10 nsec to 0.1%. Both devices have a 50-mA output current rating. Applications include instrumentation, radar/electronic warfare, communications, computers and peripherals, and electronic imaging. Either type in an 8-pin plastic DIP, \$15.50 (100). Delivery, 60 to 90 days.

Comlinear Corp, Box 20600, Fort Collins, CO 80525. Phone (303) 226-0500. TLX 450881.

Circle No 353

NEW

500 to 1600 WATT POWER SUPPLIES



NEW 1600W MULTI

The industry's SMALLEST 1600W Multi output package. ACDC's JFM Series features unlimited flexibility of output voltage & current combinations.

Any combination you choose will be delivered in 2 weeks.

NEW 1000W & 800W MULTI's

Don't compromise on output voltage. ACDC's REV 1000/800W Series has the output combination your design requires.

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High performance, competitive pricing and 2 week delivery have made this the most popular "slot" supply in the industry.

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1600		■
1500	■	NEW
1000	■	■
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NEW FEATURES

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- Single wire paralleling
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- Largest offering of standard options
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NOT NEW

Building quality, reliable power supplies that meet specifications, is not new at ACDC Electronics. We've been doing that for over 30 years.

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1600w 1500w 1000w 800w 750w 500w 400w 300w 220w 175w 135w 70w 40w 15w

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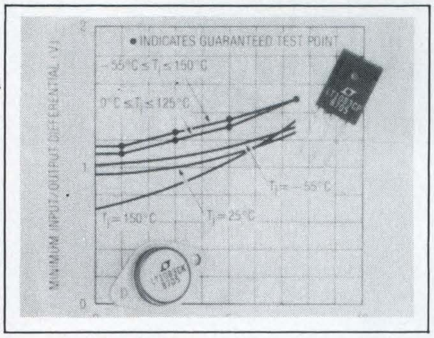
CIRCLE NO 246



7.5A REGULATOR

- *Low dropout of 1.5V max*
- *On-chip trimming adjusts reference voltage to 1%*

The LT1083 7.5A adjustable (positive) voltage regulator features a low dropout voltage of 1.5V at maximum-rated output current and is pin compatible with existing 3-terminal regulators. Intended for power regulation within tight enclosures, it can reduce heat-sink and cooling-fan requirements. On-chip trimming adjusts the reference voltage to 1%, and current limiting is trimmed to minimize the stress on the regulator and power-source circuitry under overload conditions. Unlike in pnp regulators, quiescent current flows into the load to increase efficiency. The input-to-output differential is 35V. Typical applications include high-efficiency linear regulators, post regulators for switching power supplies, constant-current regulators, and battery chargers. In TO-247 plastic package, $7.70 (100). Delivery, 30 to 60 days ARO.

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035. Phone (800) 637-5545; in CA, (408) 432-1900.

Circle No 354

NAND-GATE DRIVER

- *Has 60V, 1.5A operation*
- *Draws 8 mA from a 5V supply*

The UDN-2540B is a quad NAND-gate power-driver IC. With outputs disabled and loads disconnected, the device draws 8 mA from a 5V supply or 33 mA from a 15V supply. Each of the independent outputs can withstand 60V in the off state and sink 1.5A in the on state (the maximum-recommended continuous load current is 1.25A, however). You can connect outputs in parallel to obtain higher load current. The device's integral transient-suppression diodes and its minimum 35V output-sustaining voltage suit inductive-load applications. The device is housed in a 16-pin DIP equipped with contact tabs for a heat sink. At 25°C, the package can dissipate 2.7W in free air or 4.5W with a heat sink. $0.97 (1000).

Sprague Electric Co, Box 9102, Mansfield, MA 02048. Phone (617) 853-5000.

Circle No 355

IWATSU ADDS TWO NEW DIGITAL STORAGE OSCILLOSCOPES

The new 60 MHz DS-6612 and 40 MHz DS-6411 both have large-capacity 16 K word memory, digital persistence display, GO/NO GO judgements, direct hardcopy output to a plotter, plus dual A/D converter operating at 20 MS/s (DS-6612) and at 10 MS/s (DS-6411). These two new models feature the best price/performance in the industry.

	NEW DS-6411	NEW DS-6612	DS-6121A
Max. Sampling Rate	10 M S/s	20 M S/s	40 M S/s
Equivalent Time Sampling BW	None	60 MHz	100 MHz
Analog Bandwidth	40 MHz	60 MHz	100 MHz
Capture Memory Length	1 or 16 k/CH	1 or 16 k/CH	2 k/CH
Glitch Capture	200 ns	100 ns	50 ns*
Vertical Resolution	8 bit	8 bit	8 bit
CRT Readout/Cursors	YES	YES	YES
GP-IB/RS-232C (options)	YES ($500)	YES ($500)	YES ($750)
3-year Warranty (U.S.A. & Canada)	YES	YES	YES
Price (U.S.A. only)	$2,570	$3,795	$5,475

*Also available: Model DS-6121 (without Glitch/Envelope mode) $ 4,975

DS-6411/6612

Both models feature easy-to-learn, easy-to-use Menu-Driven operations, pre/post-triggering capabilities, averaging and much more.

U.S.A. & Canada

IWATSU INSTRUMENTS INC.

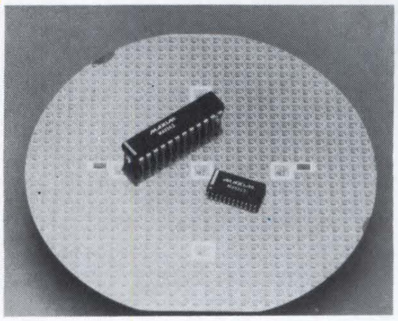
430 Commerce Boulevard, Carlstadt, NJ 07072 TEL: (201) 935-5220 FAX: (201) 935-2075

Japan & Other Countries

IWATSU ELECTRIC CO., LTD.

TOKYO, JAPAN

CIRCLE NO 247



12-BIT CMOS ADC

- *Has 3-μsec max conversion time*
- *High-speed digital interface*

The Max162 fast, 12-bit successive-approximation ADC features a 3-μsec max conversion time when operating with a 4-MHz external clock. Included on-chip are a zener reference, 3-state output drivers, μP interface circuitry, and internal or external clock options. It operates from 5V and −15 or −12V supplies and provides an analog input range from 0 to 5V. The high-speed digital interface and 3-state outputs allow the Max162 to operate with most widely used μPs. Applications include high-speed data acquisition, ATE, process control, and digital signal processing. It's available in three temperature ranges. $46 to $165 (100).

Maxim Integrated Products, 510 N Pastoria Ave, Sunnyvale, CA 94086. Phone (408) 737-7600.

Circle No 356

SOUND CONTROLLER

- *Controls volume, balance, bass, and treble in stereo systems*
- *Suitable for audio systems, car radios, and TV receivers*

Using dc input-control signals the CA3259 can control the volume, balance, bass, and treble outputs in a stereo sound system via inexpensive potentiometers or a programmable remote-control system. Each channel contains a preamp and amplifiers for treble, bass, and volume/balance. The bass and treble responses are controlled by external capacitors. The volume range is 75 dB, the tone control range is 14 dB, and the typical distortion is 0.1%. The channel separation is a minimum of 45 dB. $2.75 (500).

GE/RCA Solid State, Rte 202, Somerville, NJ 08876. Phone (201) 685-6713.

INQUIRE DIRECT

D/A CONVERTER

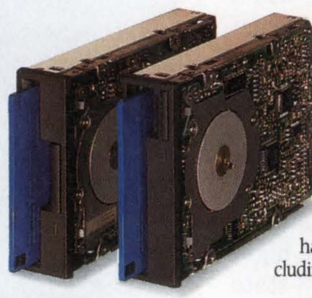
- *Provides 12-bit resolution*
- *Specifies a 35-nsec settling time*

The AD568 is a 12-bit, monolithic D/A converter that settles to within ±0.025% of full scale in typically 35 nsec. The current-output device (10.24 mA full scale) is suitable for use in waveform generation, video

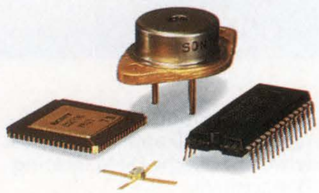
If this is what comes to mind when you think Sony,

Think again.

CD ROMs. From the company that pioneered optical memory technology come CD ROMs in built-in and stand-alone models. Also look for a half-height model coming soon.



Disk drives. We're the industry leader in 3.5-inch Micro Floppydisk drives and have over 18 versions available. Including an all-new 2-megabyte drive.



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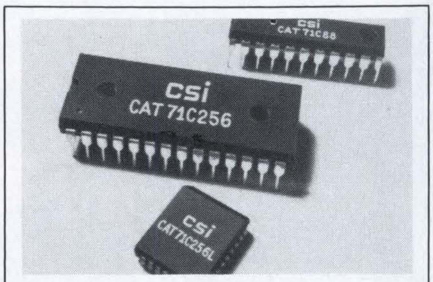
WA Bellevue (206) 455-3460
Spokane (509) 924-4410
WI Waukesha (414) 542-5352

graphics, and as a component in high-speed successive-approximation A/D converters. The part is the first offering to employ the vendor's proprietary complementary-bipolar process, which combines high-speed npn and pnp transistors on the same chip. The converter has a buried-zener voltage reference and a user-variable input-logic threshold; onboard resistors provide output-voltage ranges of 0 to 1.024V and ±0.512V. The device comes in a 0.3-in.-wide, 24-pin ceramic DIP, requires ±13.5 to ±15V supplies, and dissipates 525 mW. From $35 (100).

Analog Devices, Literature Ctr, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 935-5565.

Circle No 358



CMOS STATIC RAMs

- *Organized as 256k bits*
- *Low-power version has 100-μA standby current*

The 32k×8-bit CAT71C256 and CAT71C256L CMOS static RAMs have an 85-nsec access time, which, according to the manufacturer, is the highest speed available in a 256k-bit static RAM. Standby currents are 1 mA for the CAT71C256 and 100 μA for the low-power CAT71C256L. Each device is available in either a 28-pin DIP or a 32-pin PLCC, operates from a 5V supply, and features TTL-compatible inputs and outputs. CAT71C256, $18.25; CAT71C256L, $20.62; CAT71C88, $8.55 (100).

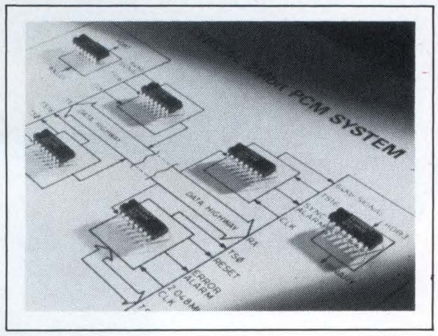
Catalyst Semiconductor Inc, 4051 Burton Dr, Santa Clara, CA 95054. Phone (408) 980-9144.

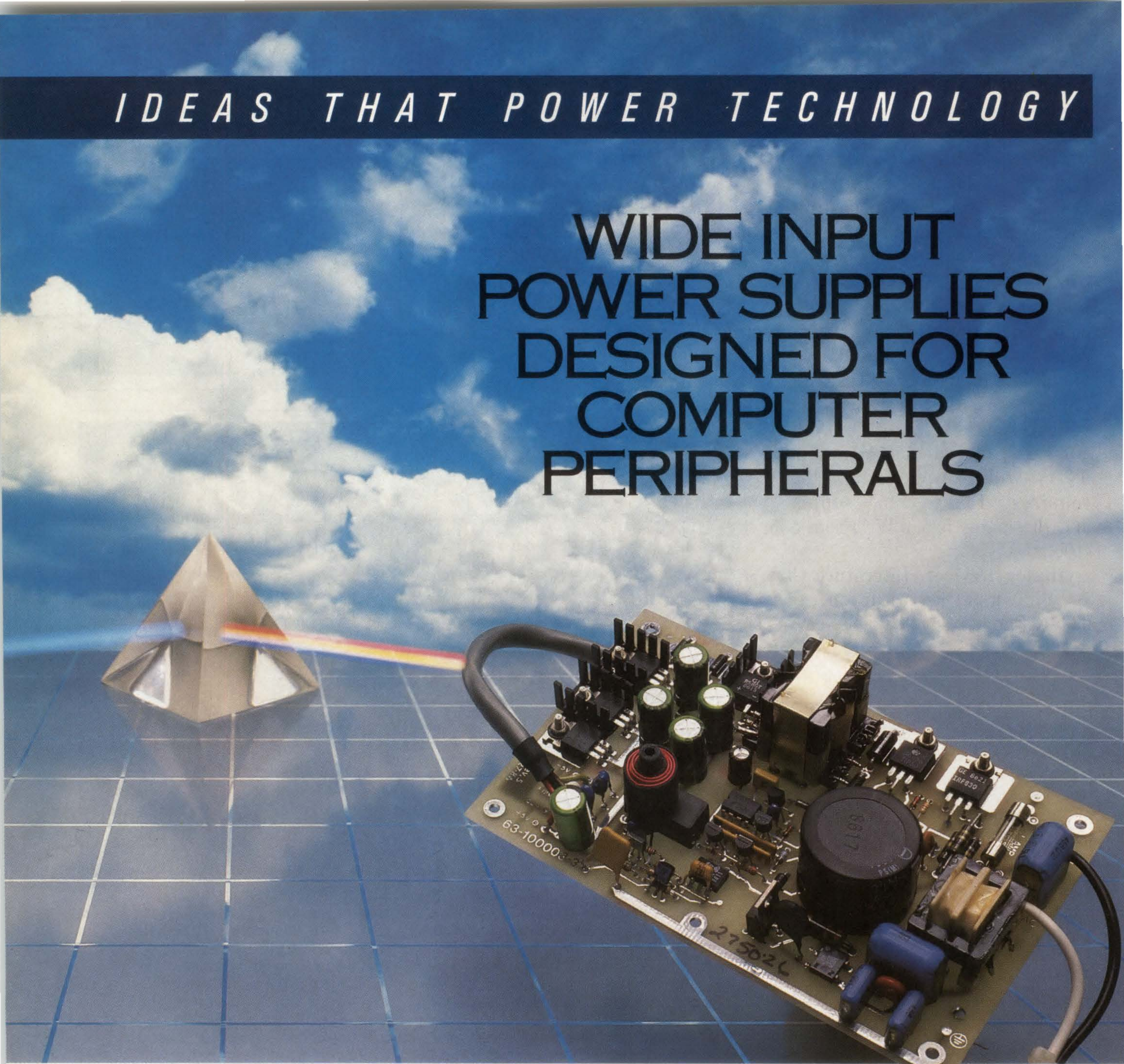
Circle No 359

CHIP SET

- *Provides signaling and error detection for PCM links*
- *Pin and function compatible with MJ1440 Series devices*

The ZN1440 chip-set series, consisting of four ICs, performs all the common signaling and error-detecting functions required in a 2.048M-





CONVERTER CONCEPTS' CP 22 OPERATES LOW POWER COMPUTER PERIPHERALS ANYWHERE IN THE WORLD WITHOUT POWER SUPPLY MODIFICATION

The CP 22 is a low profile power supply designed for low power computer peripheral applications.

It adapts to WIDE input variations of 90 to 250 VAC. That means it operates on any voltage anywhere in the world WITHOUT SWITCHES, JUMPERS, TAPS OR OTHER MODIFICATIONS.

The high efficiency CP 22 is UL recognized, and TUV approved. Plus, it features over voltage limit protection and quad output design.

Too good to believe? Well, believe it. The low profile CP 22 is but one of our many powerful ideas that work.

To find out more, contact the Converter Concepts' representative nearest you. Or call us directly. That's the best idea yet.

CONVERTER CONCEPTS INC

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(608) 429-2144 • TWX: 910-280-2630
Toll-Free 800/253-5227

CIRCLE NO 250

bps, 30-channel PCM transmission link. All the devices conform to the appropriate CCITT recommendations. The ZN1440E simultaneously and asynchronously encodes and decodes data in the link's HDB3 format and detects any coding errors. At the link's transmission end, the ZN1444E generates a synchronizing word and injects it into the PCM data highway during time-slot 0 of alternate transmission frames. At the receiving end of the link, the ZN1445E detects the frame synchronization word and synchronizes the receiver. It also flags synchronization errors. The ZN1446E operates at either end of the link, transmitting or receiving signaling information during each frame's time-slot 16. It accepts information in either binary or AMI format. The chips are available in either ceramic or plastic 16-pin DIPs and are pin and function compatible with corresponding MJ1440 Series devices. ZN1440E and ZN1445E, each $6.20; ZN1444E, $10.18; ZN1446E, $7.38 (1000).

Ferranti Electronics Ltd, Fields New Rd, Chadderton, Oldham OL9 8NP, UK. Phone (061) 624 0515. TLX 668038.

Circle No 360

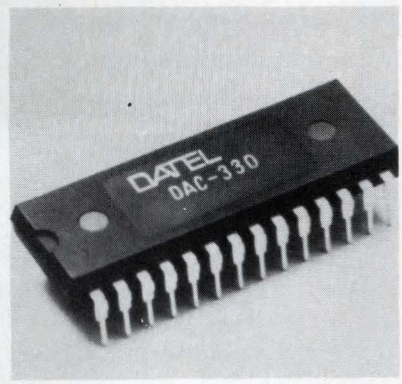
Ferranti Electric Inc, 87 Modular Ave, Commack, NY 11725. Phone (516) 543-0200. TLX 6852104.

Circle No 361

10-BIT VIDEO DAC

- *160-MHz conversion rate*
- *14-MHz multiplying bandwidth*

Designed for ultrafast applications such as graphics displays and high-speed signal processing, the DAC-330 is a monolithic 10-bit, 100-MHz, multiplying D/A converter with a 14-MHz multiplying bandwidth capability. It operates from a −5V power supply and dissipates a maximum of 1.48W. Its digital inputs are ECL compatible, and you can invert the proportional relationship between input data and output voltage. The output voltage range is 0 to −1.0V, with a settling time of 4.7 nsec. The operating temperature range is −20 to +75°C. It comes in a 28-pin plastic DIP. $112.



Datel, 11 Cabot Blvd, Mansfield, MA 02048. Phone (617) 339-9341. TWX 710-346-1953. TLX 951340.

Circle No 362

FIFO MEMORIES

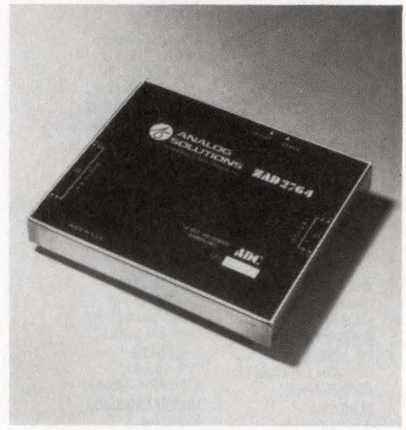
- *Offer 64-word×4- or 5-bit organizations*
- *Operate over 10 to 45 MHz*

Four CMOS FIFO memories are available. The IDT72401 and IDT72403 (identical to the IDT72401 except it has an extra output-enable function) come in a 64-word×4-bit organization, and the IDT72402 and IDT72404 (also with the extra output-enable function) come in a 64-word×5-bit configuration. All are asynchronous devices, available in 10-, 15-, 25-, 35-, and 45-MHz versions. A RAM-based architecture provides a 25-nsec fall-through time (compared with 1 μsec or more for bipolar devices). The typical power dissipation is 200 mW, or less than ⅕ that of bipolar types. The chips provide both asynchronous and simultaneous shift-in/shift-out operations. You can cascade the chips to achieve greater word depth or bit width. From $15 (100).

Integrated Device Technology Inc, Box 58015, Santa Clara, CA 95052. Phone (408) 727-6116. TWX 910-338-2070.

Circle No 363

INTEGRATED CIRCUITS



SAMPLING CONVERTER

- *Combines sample/hold and A/D converter*
- *Has max 500k-sample/sec throughput*

The ZAD2764 sampling A/D converter combines a sample/hold amplifier with a 2-pass, digitally corrected, subranging A/D converter with 14-bit resolution. Intended for applications in instrumentation, ATE, and medical-imaging systems, the device has a maximum throughput rate of 500k samples/sec. Its A/D-conversion time is 0.9 μsec. Its package measures 3.8×4.5×0.55 in. $496 (100). Delivery, four to six weeks ARO.

Analog Solutions, 85 W Tasman Dr, San Jose, CA 95134. Phone (408) 433-1900.

Circle No 364

HIGH-SPEED μP

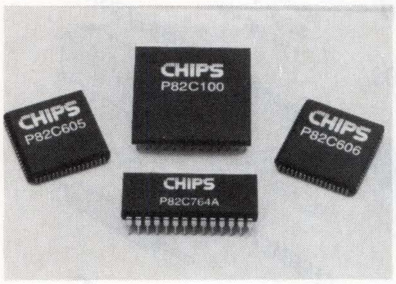
- *Operates at 16 MHz*
- *Compatible with lower-speed versions*

The 80286-16 is a 16-MHz version of the 80286 μP, which boosts system performance nearly to the level of 80386-based systems. The 80286-16, a continuation of the manufacturer's line of 8-, 10-, and 12.5-MHz 80286 μPs, provides a 28% speed increase over the 12.5-MHz version. The device is compatible with the lower-speed versions. The manufacturer claims that the 80286-16's bench-

mark performance (with currently available software designed for 16-bit bus architectures) is equivalent to the performance of systems based on the 80386. $150 (100).

Advanced Micro Devices Inc, Box 3453, Sunnyvale, CA 94088. Phone (408) 732-2400.

Circle No 365



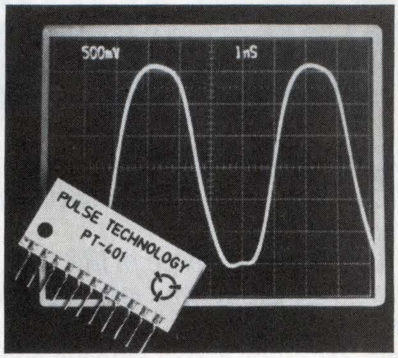
PS/2 CHIP SET

- *Compatible with IBM PS/2 Model 30 and PC/XT*
- *Supports 8088/V20 and 8086/V30 microprocessors*

The 82C100 system-control chip supports 8088/V20 and 8086/V30 microprocessors at speeds to 10 MHz and is targeted for high-performance IBM PS/2 Model 30s, PC/XTs, and compatible computers. It includes a memory controller that supports the Lotus-Intel-Microsoft expanded memory specification and offers power-management features for laptop systems to help reduce battery consumption. The 82C101 chip supports 8088 and V20 8-bit processors. It's aimed at lower-cost PC/XT-compatible computers and terminals and does not include power-management features. The three companion chips are the 82C606 Chipspak and the 82C605 Chipsport—both multifunction peripheral controllers and the 82C764A floppy-disk data separator. 82C100, $51.30; 82C101, $41.10; 82C606, $23.40; 82C605, $17.60; 82C764A, $7.80 (100).

Chips and Technologies Inc, 521 Cottonwood Drive, Milpitas, CA 95035. Phone (408) 434-0600.

Circle No 366



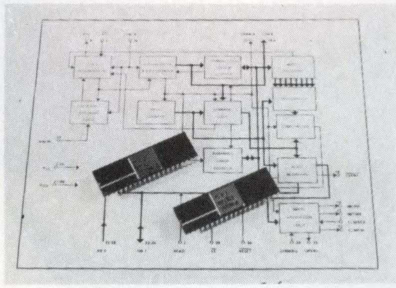
PIN-DRIVER IC

- *Output frequency is 200 MHz*
- *Output levels span −5 to 10V*

Intended for applications in digital ATE and semiconductor-device testing, the hybrid PT-401 pin driver comes in an 11-pin SIP (single in-line package). The device provides level translation for ECL, TTL, and CMOS signals and generates output levels from −5 to 10V. Its output signal can have 1.35-nsec rise and fall times and a frequency as high as 200 MHz. Its output impedance in the drive mode is 50Ω. The driver also has a 3-state mode in which the output exhibits the high impedance required for I/O applications. From $208. Delivery, eight weeks ARO.

Pulse Instruments Co, 1234 Francisco St, Torrance, CA 90502. Phone (213) 515-5330.

Circle No 367



TELETEXT CHIP

- *Handles all world-standard Teletext packets*
- *Supports electronic fine-tuning of Teletext receivers*

The MV1812 Teletext data-acquisition chip is suited for use in dedi-

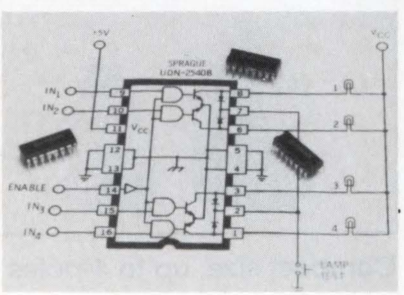
cated receivers for Teletext applications. It interfaces to an 8-bit µP bus. The chip receives all world-standard Teletext packets and has special features that simplify the design of receivers that use Datacast and pseudopage transmission techniques. On-chip registers allow you to select any one of 16,777,216 Teletext pages, and a data-purity counter allows electronic fine-tuning of the Teletext receiver for optimal reception. In a full-field Teletext system, the device acquires data at a rate exceeding 600k bytes/sec. The CMOS device consumes less than 10 mA from a 5V supply. It is enclosed in a 40-pin DIP. £9.50 (1000).

Plessey Semiconductors Ltd, Cheney Manor, Swindon, Wiltshire SN2 2QW, UK. Phone (0793) 36251. TLX 449637.

Circle No 368

Plessey Semiconductors, 9 Parker, Irvine, CA 92718. Phone (714) 472-0303.

Circle No 369



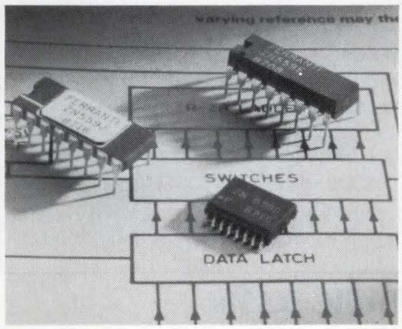
QUAD POWER DRIVER

- *60V/1.5A output capability with integral suppression diodes*
- *TTL, CMOS, PMOS, NMOS compatible*

Combining NAND logic gates and high-current bipolar outputs, the UDN-2540B power and relay driver provides an interface between low-level signal-processing circuits and power loads to 350W. In the On state, each of the four independent outputs can sink as much as 1.5A. In the Off state, the drivers can withstand at least 60V. Internal clamp diodes and a minimum 35V sustaining voltage allow the use of these drivers with many inductive loads. Applications include relay and solenoid drivers and dc stepping-motor drivers. $0.97 (1000). Delivery, eight to 12 weeks ARO.

Sprague Electric Co, Box 9102, Mansfield, MA 02048. Phone (617) 853-5000.

Circle No 370



D/A CONVERTER

- *Has on-chip data latches*
- *Is monotonic over the full operating temperature range*

The ZN559 is a µP-compatible 8-bit D/A converter with an on-chip 2.5V bandgap reference. After a full-scale output change, the output settles to 0.5 LSB typically within 1.25 µsec. The typical settling time for a 1-LSB output change is 800 nsec. Maximum linearity error is ±1 LSB, and maximum differential nonlinearity is ±0.75 LSB, with monotonicity guaranteed over the full operating temperature range. The maximum zero offset is 6 mV, and full-scale output is typically 2.55V (2.54V minimum; 2.56V maximum) with a full-scale output temperature coefficient of 2 ppm/°C typ. On-chip latches with TTL/CMOS-compatible inputs allow you to load 8-bit parallel data into the device under the control of a latch-enable input. The ZN559 operates from one 5V supply and typically consumes 20 mA of supply current. It's available in a 16-pin DIP that operates over the commercial or military temperature range, or you can order it in a SO-16 surface-mount package that operates over the commercial temperature range. $2.98 (100) for commercial-temperature-range devices.

Ferranti Electronics Ltd, Fields New Rd, Chadderton, Oldham OL9 8NP, UK. Phone 061-624 0515. TLX 668038.

Circle No 371

Ferranti Electric Inc, 87 Modular Ave, Commack, NY 11725. Phone (516) 543-0200. TLX 6852104.

Circle No 372

PLL SYNTHESIZER

- *Operates in single- or dual-modulus modes*
- *Includes a voltage doubler for greater output dynamic range*

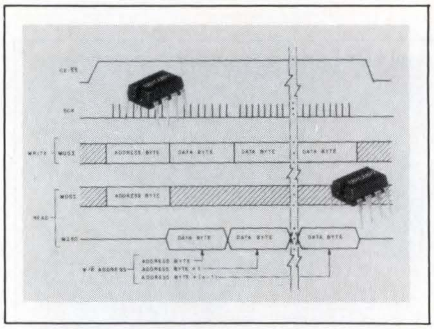
The TBB200 CMOS PLL frequency synthesizer is targeted for use in radio communications equipment—for example, 900-MHz cellular radios. The synthesizer incorporates two programmable dividers—one with a division ratio of between 1 and 127, and the other with a division ratio of between 3 and 4095—to divide down the VCO-frequency input. It also includes a reference-frequency divider with a division ratio of between 3 and 65,535. The two independent dividers for the VCO frequency and a single-line output that you can use to control the division ratio of an external prescaler allow you to operate the synthesizer in a dual-modulus mode. In single-modulus mode, the maximum frequency for the VCO-frequency input is 70 MHz; in dual-modulus mode, the figure is 30 MHz. The maximum frequency for the reference input is 30 MHz. The on-chip phase detector incorporates a voltage doubler to extend the dynamic range of its output, but you can disable the voltage doubler if required by omitting one external capacitor. The TBB200 operates from a 5V supply and comes in a 14-pin plastic DIP or a SO-14 surface-mount package. $3 (1000).

Siemens AG, Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025.

Circle No 373

Siemens Components Inc, 2191 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 980-4500.

Circle No 374



STATIC RAMs

- *128-word×8-bit and 256-word×8-bit versions*
- *Standby current is 1 μA typ*

The CDP68HC68R1 (128-word×8-bit) and CDP68HC68R2 (256-word×8-bit) are CMOS, serial static RAMs that have separate data-input and 3-state-output pins. Each device is suitable for use in serial peripheral interface (SPI) systems based on the CDP6805, CDP68HC04, CDP1804A, or 80C51 microcomputer families. In such systems, the microcomputer generates a clock signal only during address and data transfers. Both chips operate from voltages spanning 3 to 5.5V; they will retain data when the supply voltage is as low as 2V. The typical standby current is 1 μA. The devices come in 8-pin DIPs. CDP68HC68R1E, $1.38; CDP68-HC68R2E, $1.85 (1000).

GE Solid State, Rte 202, Somerville, NJ 08876. Phone (201) 685-6771.

INQUIRE DIRECT

Reducing your product costs could be as simple as pushing the right buttons.

How can a little thing like a MICRO SWITCH pushbutton lower the cost of making your product? Dozens of ways.

We can add, subtract, or redesign our standard pushbutton features to eliminate manufacturing steps. Reduce inventory requirements. Or lower component costs.

Sometimes it's as simple as leaving out features like audible feedback or UL listing when they're not needed.

Or it can get as involved as supplying a finished subassembly with custom-molded buttons, legended faceplate, keylock, PC board, and LEDs.

When it comes to saving you money without sacrificing product performance, we can be very flexible.

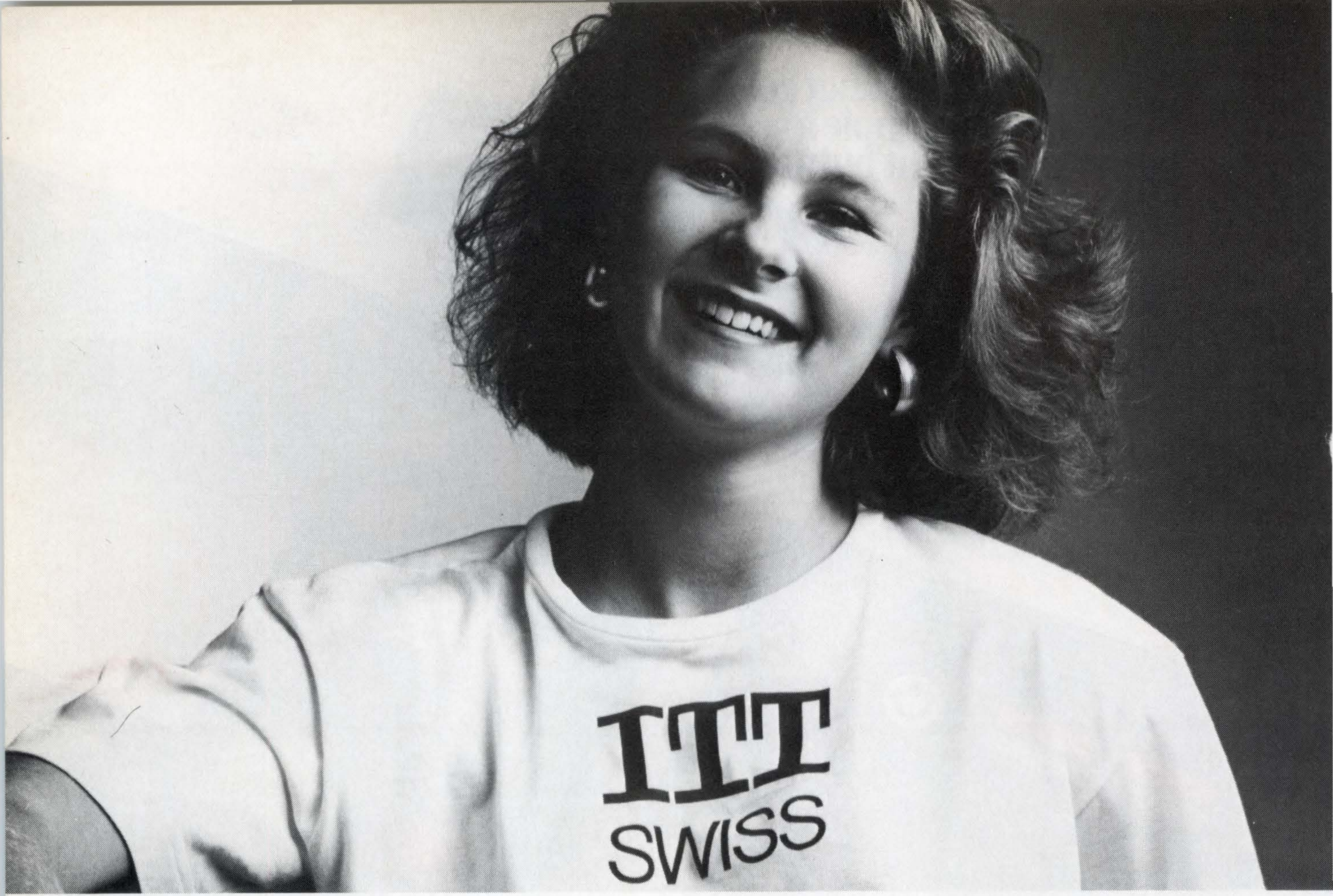
To learn more about how we can work with you to reduce total costs, or improve product performance or appearance, ask for our new brochure. Call us at 815-235-6600, ext. 610. Or write MICRO SWITCH, Freeport, IL 61032.

Together, we can find the answers.

MICRO SWITCH
a Honeywell Division

Stop by and Visit us at Booth #1951 during Electro, NY

CIRCLE NO 253


ITT
SWISS

CIRCLE NO 254

OPTICAL MODULES

- *Designed for high-speed digital applications*
- *Possess 1.3-μm operating wavelength*

These fiber-optic transmitter and receiver modules operate at 1.3 μm and are designed for high-speed digital applications. The 1218-Type transmitter operates at data rates to 1G bps and incorporates an InGaAsP laser, a thermoelectric cooler, a monitoring photodiode, modulation circuitry, and feedback controls. It operates on 5V and is housed in a 14-pin hermetic SIP (single in-line package). The 1306AA linear receiver can accommodate 1.7G-bps data rates. It employs an avalanche-photodiode detector and a GaAs IC preamplifier with adjustable transimpedance. The preamp's typical −32-dBm sensitivity can be achieved at 3×10^{-11} bit-error rates. 1218-Type, $2500 to $4500; 1306AA, $2850 (100).

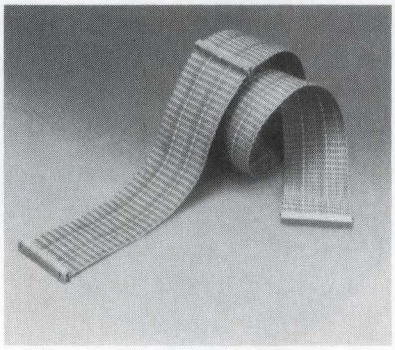
AT&T Components and Electronic Systems, Dept 50AL203130, 555 Union Blvd, Allentown, PA 18103. Phone (800) 372-2447.

Circle No 394

FLAT CABLE

- *Eliminates the flat spots usually provided for termination*
- *Available with 16 to 64 conductors*

Space-Mizer IDC-compatible woven-design cables eliminate the flat spots customarily provided for termination. The conductors feature 50-mil spacings, so you can terminate the cables at any point. The cables come on standard bulk reels, and you can order them in increments of 100 ft (300 ft max) and with 16, 20, 26, 34, 40, 50, 60, or 64 color-coded and individually insulated conductors. The cables meet



the requirements of UL Style 20503; CSA (Canadian Standards Association) approval is pending. $74.36 for a 100-ft 26-conductor cable.

Woven Electronics, Box 667850, Charlotte, NC 28266. Phone (803) 963-5131.

Circle No 395

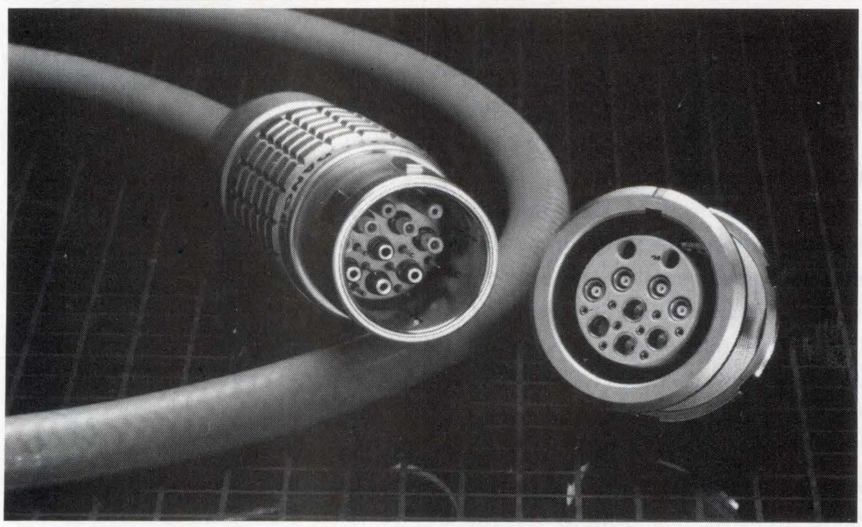
RELAY

- *100,000-cycle lifetime*
- *1500V ac dielectric strength*

Available in 1A, 1B, 1C and 1CW configurations, the Oar relay has a 30A switching capability and a dielectric strength of 1500V ac between coil and contacts. Designed for pc-board mounting, the relay has a control-voltage range of 5 to 24V dc. Its shock resistance measures 10g min. The relay has a 100,000-cycle electrical lifetime, and the operating range spans −55 to +85°C. $1.09 (1000). Delivery, eight to 12 weeks ARO.

Original Electric Mfg Co Inc, 123B Lincoln Blvd, Middlesex, NJ 08846. Phone (201) 271-5770.

Circle No 396



CONNECTORS

- *Combine fluidic or pneumatic contacts and signal contacts*
- *Guaranteed for 5000 mating cycles*

Designed for industrial ink-jet printer applications, these mixed-contact connectors combine in a single housing four 50Ω coaxial contacts, two 5-kV contacts, eight signal contacts, and four fluidic or pneumatic contacts. The devices are guaranteed to last 5000 mating cycles min. They accept cables to 1 in. in diameter and have a 180-lb cable-retention spec. They feature a quick-connect or -disconnect self-latching system. $266.24 per pair (500 pairs).

Lemo USA Inc, Box 11488, Santa Rosa, CA 95406. Phone (707) 578-8811. TLX 340933.

Circle No 397

Continued on pg 282

THE ANSWER IS IN TEK DIGITAL STORAGE:

$2995 $3995 $4995

Now! The new 60 MHz Tek 2221 joins the world's best-selling family of digital storage oscilloscopes. All featuring 20 MS/s *digitizing* along with familiar, full-bandwidth analog operation. It's the best of both worlds in an easy-to-use portable.

Discover the potential. With digital storage you can freeze waveforms. Capture events invisible to nonstorage scopes. Find signals buried in noise. And build a library of reference waveforms.

Digital storage display accuracy enhances your confidence in measurements. And all you have to do is push a button for *real-time* display analysis.

Compare the 2230, 2221 and 2220 to each other—and all others. The new 2221 offers such advanced features as CRT readout and measurement cursors. For even more performance and flexibility, there's the 100 MHz, dual time base 2230 with optional battery-backed memory for saving up to 26 waveform sets. And if it's economy you want, choose the 60 MHz 2220 with many of the same features at an even lower cost.

Features	2230	NEW! 2221	2220
Analog/Digital Storage BW	100 MHz	60 MHz	60 MHz
Maximum Sampling Speed	20 MS/s	20 MS/s	20 MS/s
Record Length	4K/1K (selectable)	4K	4K
Peak Detect	100 ns	100 ns	100 ns
Save Reference Memory	One, 4K Three, 1K	One, 4K	One, 4K
Vertical Resolution	8 bits 10 bits (AVG mode) 12 bits (AVG mode over the bus)	8 bits 10 bits (AVG mode)	8 bits
CRT Readout/Cursors	Yes	Yes	No
GPIB/RS-232-C Options	Yes ($750)	Yes ($500)	Yes ($500)
Battery-Backed Memory (save 26 waveform sets)	Yes (inc with GPIB/ RS-232-C)	No	No
Price	$4995	$3995	$2995

With each scope you can capture events as narrow as 100 ns at any sweep speed thanks to Tek's proprietary peak detect mode. View events prior to or following a trigger event with pre/post trigger. Store waveforms into 4K records. Automate measurements with optional GPIB and RS-232-C interfaces. And output direct to a printer or plotter.

Tek software is available to help you make the most of the 2230, 2221 and 2220 in system configurations.

Call Tek for a free video brochure or to place an order.

Ask about free digital storage application notes and educational materials. Orders include complete documentation, manuals and 3-year warranty on labor, parts and CRT.

Call Tek direct:

1-800-426-2200

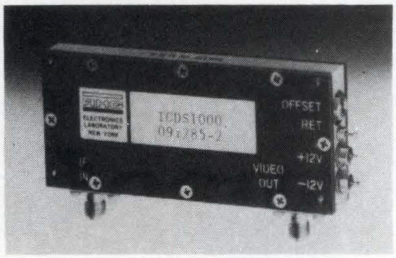
for free video brochure for orders/assistance.

VISA MasterCard

Tektronix

COMMITTED TO EXCELLENCE

CIRCLE NO 189



IF LIMITER

- *Features 5-nsec rise time*
- *500-MHz bandwidth*

The Model ICDS1000 IF limiter/discriminator operates at 1000 MHz with a p-p bandwidth of 500 MHz and a linear bandwidth of 300 MHz min. Specially designed video amplifiers provide a 5-nsec rise time. The unit is rated for an input level of 0 dBm, but it is usable to −10 dBm. The video output measures 10 mV/MHz min. Designed for MIL-E-5400 and MIL-E-16400 environments, the ICDS1000 operates over a −54 to +71°C range. The frequency accuracy is 10% over the full operating range and better than 5% at 25°C. Standard models operate from ±12V supplies, but units that operate from 15V are available. $1995. Delivery, 90 days ARO.

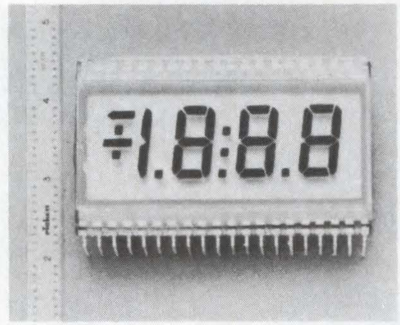
RHG Electronics Laboratory Inc, 161 E Industry Ct, Deer Park, NY 11729. Phone (516) 242-1100.

Circle No 398

DISPLAY

- *Features 1-in. characters*
- *Readable from 20 ft*

The LCD 5618 is a direct-drive, 40-pin, 3½-digit display with a character height of 1 in. The 7-segment unit has a viewing distance of 20 ft and is offered in two versions. The economy model has a −10 to +60°C operating range; the high-performance version operates over −40 to +84°C. Options include reflective or transflective polarizers and a choice



of fixed dual-in-line pins or elastomeric-type terminations. The liquid-crystal material is environmentally tested for stability, and the package is epoxy sealed to ensure an operating life of more than 5 years. Standard economy model with reflective polarizers and fixed-pin terminations, $17.10 (100). Delivery, stock to six weeks ARO.

IEE Inc, Component Products Div, 7740 Lemona Ave, Van Nuys, CA 91409. Phone (818) 787-0311. TLX 4720556.

Circle No 399

(ADVERTISEMENT)

Anti-Static Keylock Switches For All Ratings To 4 Amps @ 120 V.A.C.

Oak anti-static keylock switches protect sensitive electronic circuitry from inadvertent static discharges of up to 20 KV. They can be used for operating voltages from dry circuits to 4 amps at 120 V.A.C. These switches also provide equipment security from unauthorized users. Market applications include CRT terminals, point-of-sale terminals, credit verifications systems, bank teller systems and security systems.

Only 2-1/2 inches long, the Oak anti-static keylock switch will fit a .760 diameter x .635 double flatted cutout. Oak anti-static keylock switches are UL and CSA listed and are available in a wide range of key options.

Contact: Oak Switch Systems Inc.
P.O. Box 517
Crystal Lake, IL 60014
Phone: 815/459-5000

CIRCLE NO 190

Low-Profile, Full Travel Membrane Based Keyboards

Oak's Low-Profile FTM uses an optomized keymodule that provides improved consistency, better feel and lower cost per keystroke position. DIN compatible, Oak FTM keyboards are designed for high speed data entry systems that require long life and operator comfort.

The patented switch design has a profile of just 19.9 mm (0.785 inches). Operating (finger) forces of the keystroke are available from .9 to 6 ounces. The keyswitch features only four parts providing extremely high reliability – in excess of 50 million cycles.

Contact: Oak Switch Systems Inc.
P.O. Box 517
Crystal Lake, IL 60014
Phone: 815/459-5000

CIRCLE NO 191

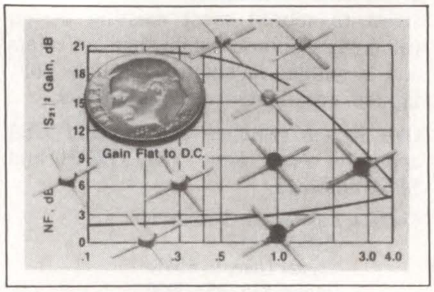
Off-The-Shelf Rocker Switches To Fit Your Design Parameters

Oak rocker switches are available in an assortment of designs, colors, sizes and styles to retrofit most existing design parameters. Choose from 6 standard colors and 9 profiles in single or double pole, lighted, non-lighted, or LED varieties.

Oak rocker switches are UL and CSA approved. Most have VDE, BEAB and SECV approval.

Contact: Oak Switch Systems Inc.
P.O. Box 517
Crystal Lake, IL 60014
Phone: 815/459-5000

CIRCLE NO 192



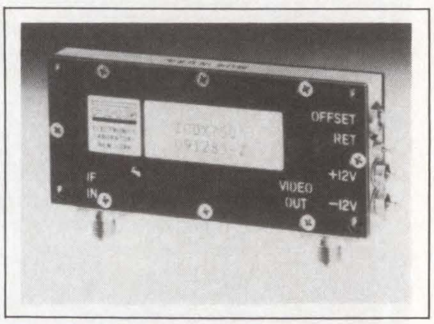
AMPLIFIERS

- *Operate on 5V supplies*
- *Have gains to 19 dB typ*

Offering a dc to 4-GHz frequency range, these general-purpose monolithic microwave IC amplifiers are cascadable 50Ω gain blocks that can operate with power supply voltages as low as 5V. At 0.5 GHz, the MSA-0635 and MSA-0670 typically feature a 19-dB gain and a 2.8-dB noise figure. The MSA-0685 features an 18.5-dB gain and a 3-dB noise figure. The MSA-0635 is housed in a glass-sealed microstrip ceramic package. The MSA-0670 is in a 70-mil hermetically sealed metal ceramic package and the MSA-0685 comes in an 85-mil plastic package. MSA-0635, $5.40; MSA-0670, $18.90; MSA-0685, $2.30 (100).

Avantek Inc, 3175 Bowers Ave, Santa Clara, CA 95054. Phone (408) 970-2659.

Circle No 400



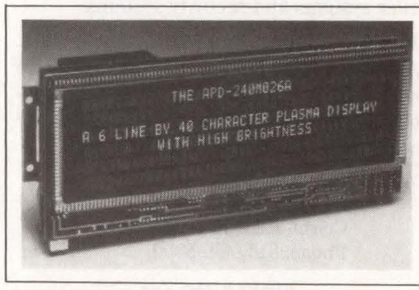
IF LIMITER

- *Operates at 750 MHz*
- *Rated for 0-dBm input level*

The ICDX750 IF limiter discriminator operates at 750 MHz and has a peak-to-peak bandwidth of 450 MHz. Its linear bandwidth equals 250 MHz min. The unit has a 20-nsec rise time and is rated for a 0-dBm input level, but it's usable down to −10 dBm. The ICDX employs a delay line for demodulation coupled with a constant-phase limiter/driver for minimum degradation of pulsed waveforms. It is designed for MIL-E-5400 and MIL-E-16400 environments and has a −54 to +71°C operating range. The standard model operates at ±12V; a unit is available for 15V operation at no extra charge. $1535. Delivery, 90 days ARO.

RHG Electronics Laboratory Inc, 161 E Industry Ct, Deer Park, NY 11729. Phone (516) 242-1100. TWX 510-227-6083.

Circle No 401



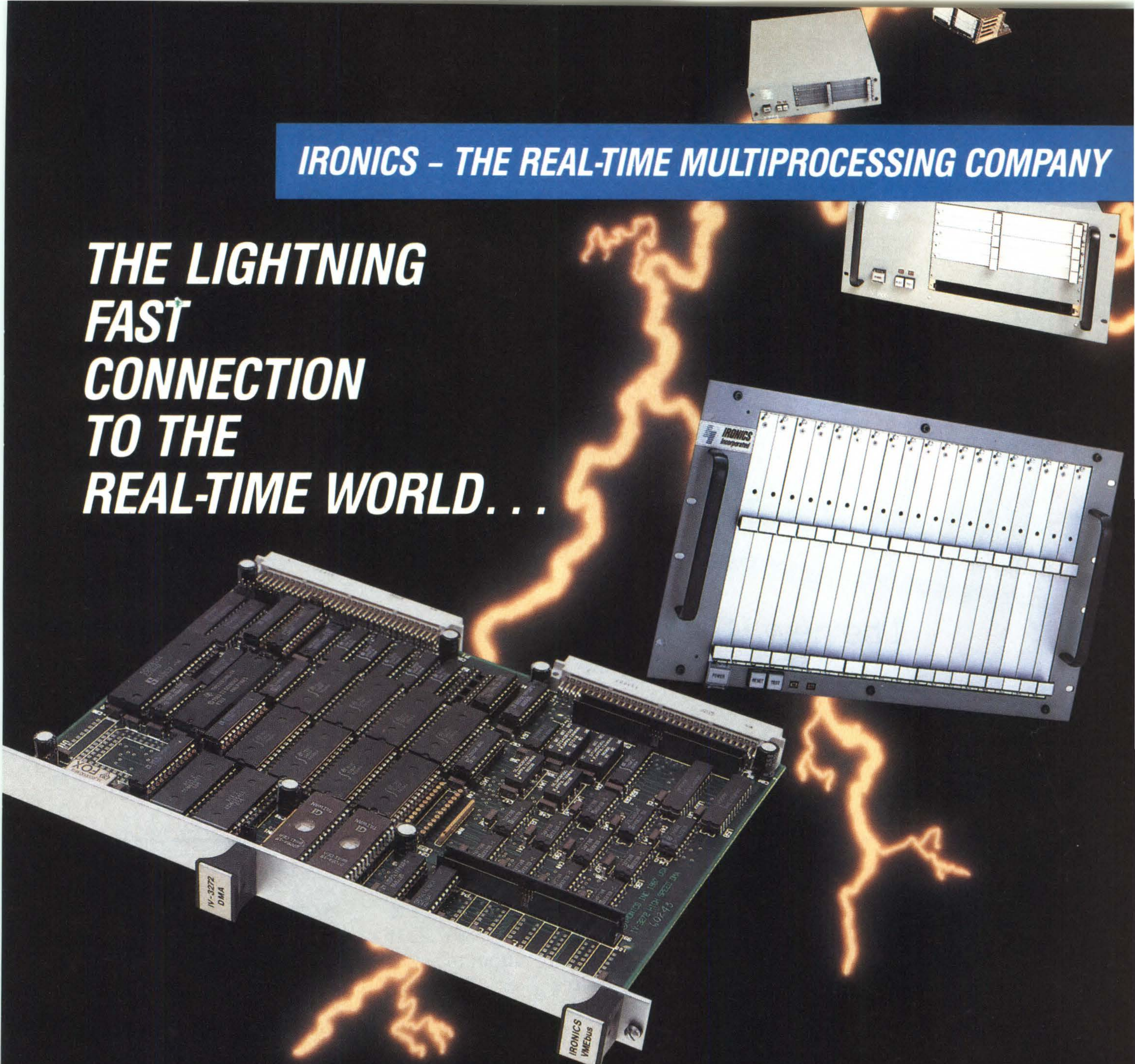
PLASMA DISPLAY

- *Includes drive electronics*
- *Interfaces with CRT controller*

The APD-240MO26A 240-character dot-matrix plasma panel display comes with drive electronics. It displays six lines of 40 characters and provides information in a row-by-row scanning mode that begins at the top. Each of the 5×7 dot-matrix characters has a height of 0.26 in., and the panel's viewing area measures 2.26×8.33 in. The unit specs a 100-fL brightness level and a 150° viewing angle, and you can easily interface it with CRT controllers. You can also order a model with a controller board that has parallel and RS-232C ASCII inputs. $480 (100). Delivery, six to eight weeks ARO.

Dale Electronics Inc, 2064 12th Ave, Columbus, NE 68601. Phone (402) 564-3131.

Circle No 402


IRONICS – THE REAL-TIME MULTIPROCESSING COMPANY
THE LIGHTNING FAST CONNECTION TO THE REAL-TIME WORLD. . .
IV-3272 DMA
IRONICS VMEbus

COMPONENTS & POWER SUPPLIES

AUTORANGING DPM

- *Features ±0.01% accuracy*
- *Supports RS-232C or RS-422 interfaces*

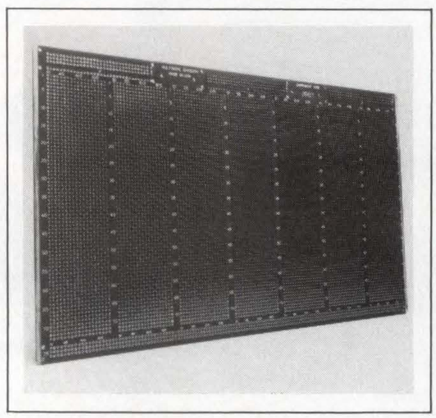
The DP-950 μP-controlled 4½-digit device can operate in either the autoranging mode or as a fixed-input digital panel meter (DPM). It has input ranges of ±2, ±20, ±200, and ±1000V dc, and it features over- or underrange indication and RS-232C or RS-422 serial support. Its accuracy equals ±0.01%±1 count, and its overvoltage protection measures 1200V min. The DPM operates on either 115 or 230V ac. It provides 5 and −5V output to power external circuitry. Its red LED display has 0.56-in.-high characters. You can select continuous-data-streaming or return-on-request modes, and make power and signal connections through a 30-pin edge connector or an optional termination block. $375.

Acculex, 440 Myles Standish Blvd, Taunton, MA 02780. Phone (617) 880-3660. TLX 240713.

Circle No 403

PROTOTYPE BOARDS

- *100% electrically tested*
- *Single-slot mountable*

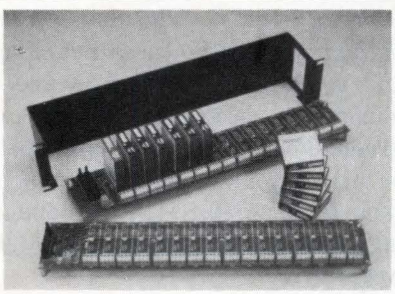


Protoboard Series prototype boards offer designers an alternative to wire-wrappable panels. Each board has been 100% electrically tested on a bed-of-nails tester and features a 0.1-in. hole pattern that accommodates different package types. Single-slot mountable, the boards maximize utilization of card rack space. The series includes four Mupac-compatible boards and one Multibus-compatible board. $485 to $1700.

Multiwire/East, 250 Miller Pl, Hicksville, NY 11801. Phone (516) 933-8300.

Circle No 404

COMPONENTS & POWER SUPPLIES



SIGNAL CONDITIONERS

- *Feature 1500V isolation*
- *±0.05% accuracy*

The MB Series hard-potted signal-conditioning modules accept raw analog input and provide a 0 to 5V or ±5V output. The modules feature 1500V transformer-based isolation and accept thermocouple, RTD, current, low- or high-level voltage, and wide bandwidth (to 10 kHz) inputs. They have ±0.05% accuracy. You can plug as many as 16 modules into either the MB-01 or MB-02 mounting backplane. All modules are the same size and have the same pin connections. Modules, $150; MB-01, $250; MB-02, $260.

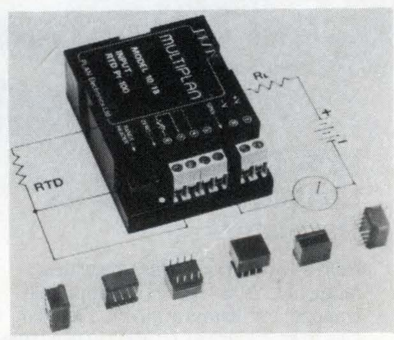
MetraByte Corp, 440 Myles Standish Blvd, Taunton, MA 02780. Phone (617) 880-3000. TLX 503989.

Circle No 405

4- to 20-mA TRANSMITTER

- *Versions available for a range of sensor types*
- *Feature programmable input sensitivities*

This range of sensor transmitters has an output of 4 to 20 mA and features small plug-in header modules that adapt the transmitters for a range of input sensitivities. The line includes a standard model for each type of sensor, including models for platinum resistance thermometers, thermocouples, dc voltage or current sources, and potentiometric transducers. By changing the header module in each transmitter, you can alter the input range of each type of transmitter. Transmitters are supplied with one header module, but you can change the module for a different type if required. They are supplied with a universal mounting kit that also adapts to DIN-rail mounting systems. Approximately £100 (100).



TC Ltd, Box 130, Uxbridge UB8 2YS, UK. Phone (0895) 52222. TLX 264820.

Circle No 406

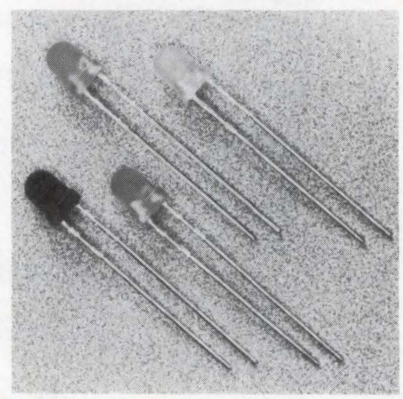
RELAYS

- *Eliminate arcing at contact points*
- *Have contact rating of 30A at 50V dc*

These high-current relays eliminate contact-point arcing and thus extend their expected life to 1 million operations min. They also meet the vibration and shock specifications of MIL-R-6106, characteristic C. The contacts possess a 30A at 50V dc rating for resistive loads and a 17A at 50V dc rating for motor loads. The coil's pickup sensitivity equals 500 mW. The relays meet EMI MIL-STD-461B.REO2 for RFI. They are available in 1 Form A configurations. $290 (100). Delivery, 22 weeks ARO.

Electronic Specialty Corp, Box 3501, Vancouver, WA 98668. Phone (206) 574-5000.

Circle No 407



LED LAMPS

- *Have 10-mcd luminous intensity*
- *Come in four colors*

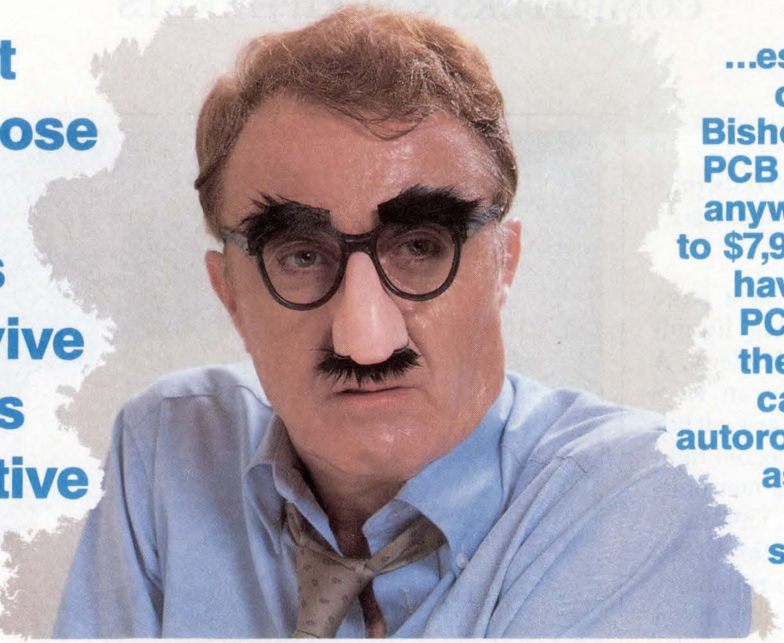
SLR-40 Series T-1¾ LEDs have a 50° viewing angle and a luminous intensity of 3.6 mcd min and 10 mcd typ. Forward current is 2V typ at 10 mA, and reverse current equals 10 μA at V_R=3V. They operate over −55 to +100°C. The devices are packaged for brightness matching, and you can order them in one of four colors—orange, red, yellow, or green. They come in an ammo pack or on a customer-specified taping on reel. $0.15 to $0.25 (1000), depending on color. Delivery, stock to eight weeks ARO.

Rohm Corp, Box 19515, Irvine, CA 92718. Phone (714) 855-2131. TWX 910-595-1721.

Circle No 408

He Just Spent $175,000 NEEDLESSLY On A Competitive PCB CAD Software System

You Can't Make Those Kinds of Mistakes and Survive in Today's Competitive World...



...especially when he could have owned Bishop's PATHFINDER™ PCB CAD system from anywhere from $1,995 to $7,990. And he would have had, on an IBM PC-based computer, the same schematic capture, layout and autorouting capabilities as the "mainframe-based" software system he bought.

If you've been designing printed circuit boards or doing hand tape-ups during the last 22 years, then you know Bishop Graphics as the world leader in printed circuit design and engineering products. An interesting thing happens when you are effectively the only company selling PCB design products in over 72 countries in the world. You see, there is absolutely no company anywhere in the world that has the existing customer base that Bishop has. As a result, just about every CAD company or author has approached Bishop to either privately label *their* CAD package or distribute it for them.

Now why is that important to you, the engineer, designer or drafter? Simple! We've waited a long time to decide *which* CAD package we wanted to put our name on. We've looked at the advantages and disadvantages of the packages that have been brought to us and we've looked very hard at where the industry is going. The more we looked and compared, the more we realized that PATHFINDER was *the* way to go.

WHAT MAKES PATHFINDER DIFFERENT?

We know that the majority of the serious designers would like a fully integrated CAD system with an autorouter that can lay down as many as three traces between a DIP if they want. The problem is not a heck of a lot of people can afford to spend $80,000 to $200,000 for a CAD package. **It didn't take us long to realize that PATHFINDER's AutoRouter had the power and performance of the most expense mainframe-based PCB CAD systems.** Nothing that we had evaluated, or that was brought to us (including most of the brand names that you know), could compare with the overall ability of PATHFINDER.

We've sold PCB design products to you for over 20 years and there's one thing that we know for certain...you're not interested in sales hype or fluff. **The problem that we're faced with, is how to convince you that it is foolish to spend $1,000 on a "make do" CAD system and just as foolish to spend $15,000, $20,000, or even $80,000 on a medium to high-end CAD system when you can get the performance of a $90,000 plus CAD system *at PATHFINDER's prices.***

LET'S TALK FACTS AND SPECIFICATIONS

PATHFINDER works in conjunction with, and uses the industry standard for 2D drafting... AutoCAD.™ You get a complete PCB and electro-mechanical 2D CAE workstation. You have full schematic drawing and capture, layout plus 32-bit autorouting. Not only can you create your own netlists, partslists, etc. but you can take an ASCII formatted list or document from another CAD system and format it so that PATHFINDER will read it. You've also got full IGES and Gerber I/O capability. PATHFINDER even allows you to "preview" your photoplot *before* sending it out to be plotted. You have generation of silkscreen and solder mask layers, drill drawings, assembly drawings, fabrication drawings, fast "on-the-fly" parts creation, 3D views, color or monochrome at any resolution, hardware pan and zoom, the use of a TTL, discrete and connector part library, stretching the layout, the latest concept of "what you see is what you get" (WYSIWYG), ratsnesting, drag and rubber-banding, semi-automatic heat sinks, keepout areas, top and bottom views for SMT with 3D views, and on and on.

MAINFRAME PERFORMANCE AUTOROUTING

The power and speed of a true 32-bit autorouter is what PATHFINDER's AutoRouter is all about. We supply you, along with the AutoRouting software, a parallel processor card that allows you to autoroute using 32-bit integer manipulations. We don't play any games when we talk about true 45° routing. You get it with PATHFINDER. None of this 90° routing and then go back and chamfer the corners to make it look like a 45° route was actually done. We know, and you know, that buys you absolutely no additional "real estate" on the board.

PATHFINDER also provides you with *real time Display While Routing.* What good does it do to come back *after* the autorouting has taken place only to discover that you wish you would have stopped it 5 minutes into the routing design to make a manual edit? Also, you'll be able to autoroute down to 6¼ mil trace widths...3 traces between a DIP pad.

Another thing we discovered is that even mediocre autorouters can achieve 100% completion rates if the parameters are sloppy enough. The real test of autorouting is not just speed, not just percent completion, but most importantly the *quality of design.* **You'll achieve the same kind of performance and completion rates that you would achieve on mainframe-based autorouters with PATHFINDER.** You can autoroute up to 16 layers. You have total access to the strategy parameters given you in the AutoRouter including rip-up and re-route when needed.

FREE TECHNICAL HOT-LINE SUPPORT

Whether you're doing analog, digital or SMT work, PATHFINDER allows you the ability to get the job done. It's easy to use and comes with a thorough, complete technical manual and tutorial. It is a fully integrated, intuitive CAD system expressed in terms that the PCB engineer, designer or drafter can appreciate. Bishop will provide free technical hot-line support during your first year of use.

NO-RISK GUARANTEE

We are so thoroughly convinced that PATHFINDER will become the de facto standard in the industry that we'll let you use it for 30 days and if it doesn't meet our published specifications, we'll refund your money with no questions asked. We suggest that you take a minute now to call our toll-free number, 800-222-5808,* to get any of your questions answered that haven't, and can't, be answered in an ad. If you'd like to drop us a line, certainly do so, and mark your envelope "PATHFINDER."

**In Alaska, California, and Hawaii call (818) 991-2600.*

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Schematic Capture & Layout	"Standard" AutoRouter
$1,995.00 (order #40000)	$2,995.00 (order #40020)

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Westlake Village, CA 91359
Phone (818) 991-2600
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CIRCLE NO 194

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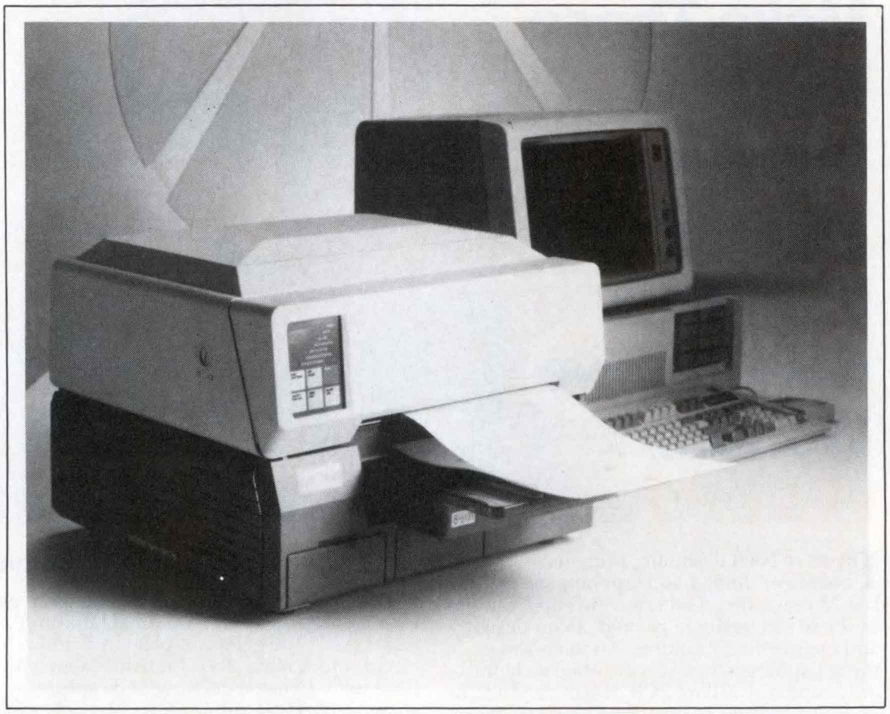
See us at WESCON, Booths 2638-2640, Moscony Center

PAGE PRINTER

- *Has a resolution of 300 dots/in.*
- *Drum set and 5000-pg toner set are separate units*

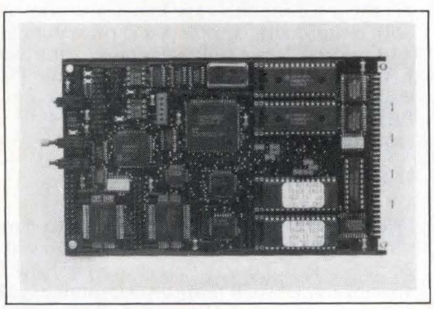
The CrystalPrint VIII is a page printer that incorporates liquid-crystal shutter (LCS) technology. A light source shines onto an LCS array whose elements are either opened or closed. The selected light passage is sent through a nonrotating lens onto the drum. This technique yields a print resolution of 300 dots/in. and provides the reliability of nonmoving parts. The drum set and the 5000-pg toner set are also separate units, allowing individual replacement. The unit features full emulation of HP's LaserJet Plus and is compatible with Microsoft's Windows and Aldus's PC Pagemaker. It also has three ROM-resident and cartridge-based type fonts from Bitstream; downloadable fonts, including HP's compatible fonts; 1.5M bytes of RAM for bit-mapped



graphics on DIN A4, DIN B5, letter- and legal-size paper; and optional Epson, Diablo, HPGL (HP graphics language), and IBM ProPrinter command and font emulations. $2495.

Data Technology Corp, 2551 Walsh Ave, Santa Clara, CA 95051. Phone (408) 727-8899. TLX 4745044.

Circle No 376



CPU CARD

- *Runs a 10-MHz 68008 μP*
- *Has monitor/debugger and real-time operating system support*

The 10681-MCU is a single-Eurocard CPU card for the 8-bit Eurobus-E backplane bus, also known as the Intelligent I/O Channel (IIOC-bus) sub bus for VME Bus systems. The board has a 10-MHz 68008 μP and five byte-wide memory sockets into which you can install as much as 4M bytes of local EPROM or static RAM. The board has front-panel LEDs and pushbuttons to monitor and control CPU operation. Software support for the board includes the company's Testbug68k monitor/debugger and Microware's OS-9/68000-Professional multiuser, multitasking, real-time operating system. DM 790.

EKF - Elektronik - Messtechnik GmbH, Weidekampstrasse 1a, 4700 Hamm 1, West Germany. Phone (02381) 12630. TLX 828621.

Circle No 377

VIDEO PRINTER

- *Provides B/W prints in 9 sec*
- *Has 640×490-dot resolution with a 32-level gray scale*

The UP-811 is a thermal-transfer B/W video printer for medical, security, and instrumentation applications that require real-time prints. It can generate prints in 9 seconds wherever real-time video-based systems are in use. It provides 640×490-dot resolution with a 32-level gray scale. The unit produces 3.8×2.9-in. prints. In addition to a brightness and contrast control, it features a monitor mode that controls the video monitor's brightness and contrast, allowing you to match the monitor image with the printed

Plug-in power for VME!

Here's a fully featured 400-watt, triple-output power system that's configured for *direct connection* to the motherboard in your VME bus system. It's a standard MOSFET switcher that includes all the features you've come to expect from NCR Power Systems.

Switching frequency is 80 kHz, and the unit has protection against overvoltage, overcurrent, and input surges. It meets the stringent safety and EMI requirements established by UL, CSA and TUV (VDE). Packaging complies with the Eurocard standards defined in DIN-41494 and IEC-297 for plug-in attachment to the motherboard. Precise (±0.4%) line and load regulation and 75% efficiency make the unit ideal for data communications and processing applications.

Standard units can be modified by NCR for precise conformance to customer requirements.

For detailed specifications and price quotation, contact NCR Power Systems, 3200 Lake Emma Road, Lake Mary, FL 32746; Telephone 800/327-7612 or in Florida, call 305/323-9250.

SEE US AT WESCON: BOOTHS 150 & 152

NCR

image. The printer is UL-544 approved and FCC Class B certified. It is also available in a CCIR (International Radio Consultative Committee) and a NTSC version. $1100.

Sony Corp of America, Component Products Div, 10833 Valley View St, Cypress, CA 90630. Phone (714) 229-4181.

Circle No 378

32-BIT μP

- *Runs on the Unix 386*
- *Operates with IBM PC, PC/XT, and PC/AT*

The Ivy 386 Series' Model 40 is a 32-bit μC for stand-alone or multiuser applications. Its operating system, the PC-MOS/386, can run single-user IBM programs such as Lotus and Wordstar. As many as 24 of the company's graphics workstations can access multiuser versions of Supercalc 4, Word Perfect, dBase III, and Focus. The μC can also run the Unix 386 operating system for 32-bit Unix programs. IBM PC, PC/XT, PC/AT, and compatible boards can operate the computer. Standard features include an 80386 μP, running at 16 MHz or 20 MHz; a 40M-byte hard-disk drive; a 1.2M-byte floppy-disk drive; 2M bytes of RAM on a mother board containing one 32-bit slot, five 16-bit slots, two 8-bit slots, and an 80387 socket; and a 220W power supply. $2995. Optional devices: high-resolution monochrome monitor, $255; EGA color monitor, $695; 40M-byte streamer tape drive, $495.

Ivy Microcomputers Corp, 15 Ararat St, Worcester, MA 01606. Phone (617) 853-6914. TLX 928446.

Circle No 379

ACQUISITION BOARD

- *Mac II board possesses eight differential analog inputs*
- *Has 12-bit resolution with six software-selectable ranges*

The ACM2-12-8A is a data-acquisition board for the Macintosh II. It has a 12-bit A/D converter with six software-selectable voltage ranges: ±25 mV, 50 mV, ±250 mV, 500 mV, ±5V, and 10V; an autorange feature automatically selects the best range. Its inputs are protected to 50V continuously and 150V momentarily. The board includes thermocouple cold-junction compensation and linearization for 10 thermocouple types: E, J, K, T, B, R, S, C, D, and G. The board is capable of transferring data to memory at a 10,000-sample/sec rate. Two optional analog outputs have 12-bit resolution. The outputs are protected from shorts to ground or power supplies. The board also has eight digital I/O lines that are individually selectable as inputs or outputs. The analog inputs and outputs are self-calibrated and use an onboard reference that is guaranteed for two years. $1190.

Strawberry Tree Computers Inc, 150 N Wolfe Rd, Sunnyvale, CA 94086. Phone (408) 736-3083. TWX 610-317-2834.

Circle No 380

INTRODUCING FUJITSU'S
NEW 8" DISK DRIVE.

Our best performance numbers yet.

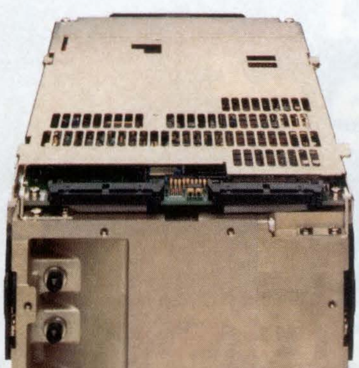
Our new 8" Winchester offers an improved access time of 16ms. 690MB of storage. And 35,000 hours MTBF.

Three of the best numbers in the business. That's quality. That's reliability. That's the performance you should demand. And we're delivering production quantities.

Model	M2322K	M2333P	M2333K	M2344K
Capacity	168 MB	337 MB	337 MB	690 MB
Access Time	20 ms	20 ms	20 ms	16 ms
Transfer Rate	1.229 MB/s	2.46 MB/s	2.46 MB/s	2.46 MB/s
Interface	SMD	IPI-2	HSMD/SCSI	HSMD/SCSI

It's SCSI compatible, too. Because our Intelligent Disk Controller provides single-ended or differential drivers and Common Command Set support for easy integration.

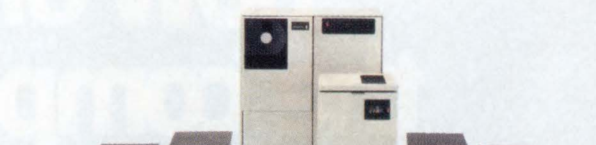
What's more, our new 8" disk drive has a dual-supported spindle that improves thermal off-track performance. And greatly increases shock tolerance.



So call for more information. On this or any of our famous family of data storage products, including Winchester, tape, optical and flexible drives. 408-432-1300.

Or write Fujitsu America, Computer Products Group, 3055 Orchard Drive, San Jose, CA 95134-2017.

You'll find we have all the right numbers.



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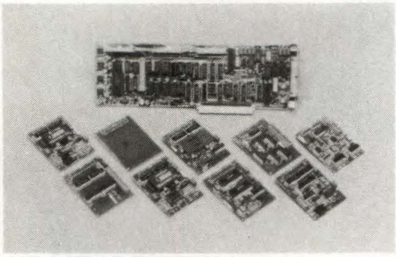


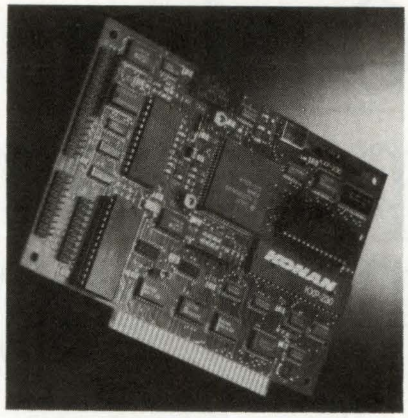
DATA ACQUISITION

- *10-board set for Macintosh II*
- *Analog input acquisition of 883,000 samples/sec*

The MacADIOS (Macintosh A/D input/output system) II is a 10-board set that provides an interface for analog and digital signals to the Macintosh II. It consists of the MacADIOS II card, which occupies one expansion slot, and nine daughter boards, which attach to the first card. The MacADIOS II can sample 12-bit data through one channel at a 142,000 sample/sec rate. The conversion time is 5 μsec with ±0.02% accuracy. A software-programmable instrumentation amplifier has three gain settings: ×1, ×10, ×100. An AM9513A counter/timer chip lets five 16-bit counters handle frequency and pulse-width measurements and event counting. The optional nine daughter boards provide increased performance features such as analog input acquisition at 833,000 samples/sec; high-resolution (16-bit) analog input or output at 50,000 samples/sec; analog multiplexing with 32 single-ended or 16 differential input channels; digital input or output with 16-bit parallel ports; and software-controlled antialiasing filters. Each MacADIOS data-acquisition board can hold as many as three daughter boards. MacADIOS II card, $1290; daughter boards, $65 to $1425.

GW Instruments Inc, Box 2145, Cambridge, MA 02141. Phone (617) 625-4096.

Circle No 381



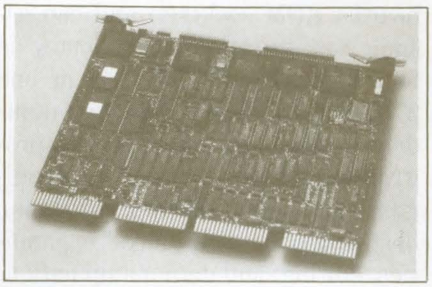
HARD-DISK CONTROLLER

- *Compresses files of repetitive data by as much as 800%*
- *Supports as much as 302M bytes of hard-disk storage*

The Model KXP-230 hard-disk expander increases the drive capacity of the IBM PC, PC/XT, PC/AT, Tandy 1000/3000, and compatible computers. The hard-disk controller uses data-compression and file-compaction techniques that compress files of repetitive data by as much as 800%. It can be used with any ST-506/412 compatible hard disk and supports as much as 320M bytes of storage. Data is stored on the disk in modified frequency modulation (MFM) format. The controller features a disk cache to decrease access time; error correction; and fragmentation control, which allows files to be placed in the next available contiguous location. During installation a software program separates the hard disk into an MS-DOS partition and a compacted user-data partition called EDISK (expanded disk). A 20M-byte hard disk has 1M bytes of bootable DOS and as much as 38M bytes of Edisk. Versions for IBM PC, PC/XT, and Tandy 1000, $249; IBM PC/AT version, $299.

Konan Corp, 4720 S Ash Ave, Tempe, AZ 85282. Phone (602) 345-1300. FAX (602) 345-2829.

Circle No 382



OPTICAL-DISK KIT

- *Reduces time needed to connect optical disk to MicroVAX II*
- *Single-board controller provides SCSI port*

This optical development kit helps to reduce the time it takes to connect an optical disk to a MicroVAX II μC. It includes an SMS 0109 Q bus single-board optical disk controller; an 800M-byte 5¼-in. optical disk; Optical System Software for the VMS operating system; and cables. The disk controller provides a SCSI port that connects the optical disk to the computer. It has a proprietary chip set that provides simultaneous access to multiple devices. The controller also supports two ESDI or two ST412 fixed Winchester disk drives. The optical disk is the Maxtor RXT-800S 5¼-in. drive. It is a write-once-read-many (WORM) device that provides 800M bytes of storage on a double-sided removable media. The drive has an embedded SCSI controller that communicates with the single-board controller and provides error detection and correction. The software implements a file structure similar to DEC's ODS-2 file structure, a utility to manage the optical disk, and a set of routines accessible by application programs. Kit, $10,000; single-board controller, $1150 (OEM qty).

Scientific Micro Systems Inc, 339 N Bernardo Ave, Mountain View, CA 94043. Phone (415) 964-5700.

Circle No 383

VME BUS SBC

- *Features a 68020 CPU and a 6881 FPU*
- *Uses a 16-MIPS RISC μC for DMA*

The VME32QX is a single-board workstation for the VME Bus. It features a 68020 μP, running at 16 MHz or 20 MHz; a 68881 floating-point unit (FPU); a 68551 paged memory-management unit (PMMU); as many as 4M bytes of onboard RAM; and a 16-MIPS DMA controller that uses RISC technology. The DMA controller has full access to onboard and VME memory and can transfer data at 80M bytes/sec. Its hardware allows detection of a peripheral interrupt, rescheduling, and task switching in 100 nsec. The DMA controller handles the low-level protocols used in Ethernet, X.25, and SCSI interfaces and controls access to a battery-backed clock, nonvolatile memory, and a keyboard or a mouse. £3995.

Torch Computers Ltd, Abberley House, Great Shelford, Cambridge CB2 5LQ UK. Phone (0223) 841000. TLX 818841.

Circle No 384

DEVELOPMENT MODULE

- *Firmware for 8-bit μP boards*
- *High-speed RAM is cabled directly to ROM*

The pdm/8 is a development module that develops firmware for any 8-bit μP-based board. Its high-speed RAM is cabled directly into the board's ROM socket(s) and can assume configurations for as many as four 27(C)64, two 27(C)128, or one 27(C)256 EPROMS. Eleven menu-driven modes include EPROM programming (with standard, intelligent, and quick-pulse algorithms); host upload and download capabilities; editing; and data manipulation. The development module uses memory substitution instead of μP emulation. You can combine the module with any μC with terminal-emulation software and cross-assembler software so that your design μP can enter assembly-language code, create an object file, and debug. This special-function computer is mounted on a pc board and housed in an attache case with storage pockets for diskettes and papers. It can be custom ordered for use with breadboards, terminals, PCs, and printers. $995.

Advanced Software Machine Systems, Box 31131, Sarasota, FL 33582. Phone (813) 351-4188.

Circle No 385

GRAPHICS CARD

- *Based around 63484 advanced CRT controller*
- *Color look-up table is available*

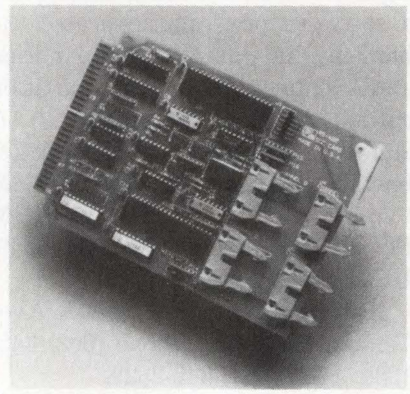
The VGPM is a single-Eurocard VME Bus board using an 8-MHz 63484 advanced CRT controller chip and 1M byte of graphics memory to provide graphics displays with 1280×1024-pixel resolution. You can reconfigure the board to provide other screen resolutions. The standard version displays 16 fixed colors, but you can add a color look-up table to display 16 colors from a palette of 4096 colors. The board supports interlaced displays at a pixel frequency of 32 MHz or noninterlaced displays at a pixel frequency of 64 MHz. A front-panel, 9-pin subminiature D connector provides TTL-level video outputs. Miniature BNC connectors provide a front-panel analog RS-343A RGB output on the model with the color look-up table. From $999 to $1499 (OEM qty).

Pep Modular Computers GmbH, Am Klosterwald 4, 8950 Kaufbeuren, West Germany. Phone (08341) 8974. TLX 541233.

Circle No 386

Pep Modular Computers Inc, 600 N Bell Ave, Pittsburgh, PA 15106. Phone (800) 228-1737; in PA, (800) 255-1737. TLX 825098.

Circle No 456



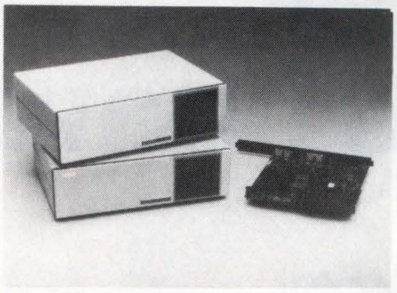
COMMUNICATIONS CARD

- *Full-duplex RS-422A/485 channels for the STD Bus*
- *Baud rates to 1.2M synchronous, 76.8 asynchronous*

The 7315 is a serial communications card for the STD Bus. It provides four independent RS-422A/485 serial channels. One version of the card supports 8088 CPU-based systems, and the other supports Z80- or 8085-based systems. As many as 32 STD Bus systems can be linked using the multidrop RS-485 interface combined with programmable recognition. The card offers synchronous and asynchronous protocols and features baud rates as high as 1.2M baud synchronous and 76.8 baud asynchronous. The card can generate prioritized vectored interrupts from external or on-card sources. You can design communications diagnostics using a local-loopback mode. $250.

Pro-Log Corp, 2560 Garden Rd, Monterey, CA 93940. Phone (800) 538-09570; in CA, (408) 372-4593.

Circle No 387



VOICE/DATA MUX

- *Digitizes as many as four voice signals*
- *Voice and digital data becomes a 56k-bps digital link*

The Oneliner multiplexes multiple synchronous and asynchronous data channels and as many as four 9.6k-bps voice channels over a single digital data link. It has two full-duplex voice digitizing cards. Each card converts two analog voice signals into a 9.6k-bps digital stream. This stream is then multiplexed with data from digital channels to provide a 56k-bps digital link for transmission over satellite, fiber, microwave, or T1 circuits. Internal echo cancelers are included for operation in PBX applications. The voice-performance specifications include a 1×10^{-3} bit error rate; a 180-msec processing delay; 35-dB min echo suppression; and 1-sec max echo-suppression training. From $4635.

Micom Systems Inc, 4100 Los Angeles Ave, Simi Valley, CA 93063. Phone (805) 583-8600. TWX 910-494-4910. TLX 687497.

Circle No 388

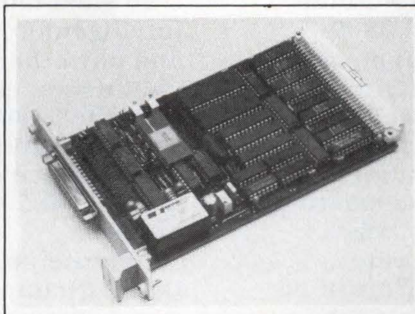
PC ADD-IN

- *Interfaces an IBM-PC family to bridge transducers*
- *Includes outputs to energize the transducers*

The PCLVDT6 is a 6-channel signal conditioning and 12-bit A/D converter board for the IBM-PC, -PC/XT, -PC/AT, or compatible computers that allows you to interface the computer to linear variable differential transformer (LVDT) and resistive transducers. A single card can connect to a mix of half- and full-bridge transducers, with each of the six input channels jumper-selectable to have a single-ended or a differential input. You can software program each channel for ac or dc coupling, and you can software program the input amplifier to have a gain between ×1 and ×128. A synchronous demodulator is provided for ac inputs. Two additional input channels are provided so that you can calibrate the board's gain and offset errors. The A/D converter has 12-bit resolution, an accuracy of ±1 LSB, and a conversion time of 120 μsec. The board also provides transducer drive outputs. These outputs comprise a 5V/60 mA rms sinewave output that you can jumper select to frequencies of 410 or 700 Hz, or 1, 5, 7, or 14.3 kHz; plus 6V/60 mA and ±8V/80 mA regulated, and ±12V/100 mA unregulated dc outputs. The board is supplied with support software that runs under the PC-DOS and MS-DOS operating systems. £495.

NMI Electronics Ltd, 26 The Heathlands, Wombourne, Wolverhampton WV5 8HF, UK. Phone (0902) 895185.

Circle No 389



A/D BOARD

- *Provides 8- or 16-channel, 12-bit ADC on VME Bus*
- *Accepts piggyback signal conditioning modules*

You can configure the VADI single Eurocard VME Bus A/D converter board to have 16 single-ended, or 8 differential input channels. The board digitizes to 12-bit resolution

Designing a better communications board was easy...

once we saw the light.

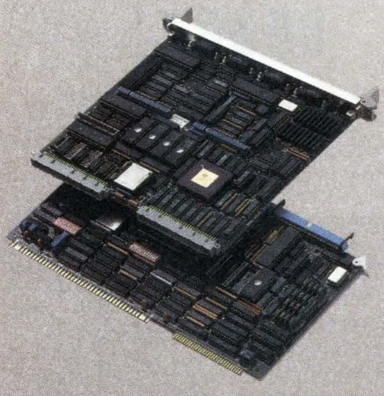
Why is it that good ideas always seem so simple . . . after they're implemented?

Like multiple wattages in one bulb.

Or multiple communications protocols on one board.

After all, you don't just use one protocol, so why buy a controller board that offers only one? With Central Data's Intelligent Communications Controllers using our Communications Monitor Firmware, you've got a built-in three-way connection.

Utilizing an 80186 processor and optional on-board Communications Monitor Firmware, our Models CD21/3518 (Multibus* I) and CD22/3800 (Multibus II) provide the flexibility to handle asynchronous, X.25, and SNA communications protocols co-existing on a single board under firmware control. (SNA will be available on CD22/3800 in 1988.)



That's flexibility.

You can even write your own protocols. On-board memory includes 512K of parity protected dynamic RAM and up to 256K of EPROM, and communications protocols downloaded to the board run under control of the Communications Monitor Firmware. That augments the effective power of your system, since the communications controller takes over most of the host processor's communications tasks.

We won't leave you in the dark.

To shed more light on Central Data's Intelligent Communications Controllers, and our other products for Multibus and VME users, call our Product Manager Jeff Tieri. He'll talk specs and prices, and send you a brochure with full product and performance details. Reach him, toll-free, at 1-800-482-0315 (217-359-8010 in Illinois).

Or write us, Central Data, 1602 Newton Drive, Champaign, IL 61821-1098.

Central Data

*Multibus is a trademark of Intel Corporation

CIRCLE NO 207

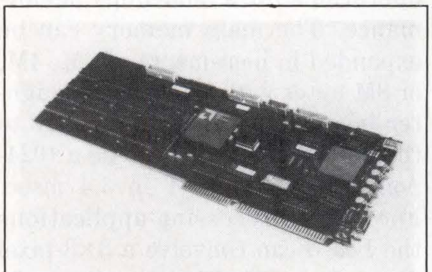
and has a conversion time of 8 μsec. It provides 5, 10, ±5, and ±10V input ranges and has a programmable gain amplifier that you can software program to a gain of ×1, ×10, ×100, or ×1000. The inputs are overvoltage protected to ±20V. Digitized readings are automatically transferred into a 2k-byte FIFO buffer, and you can generate software-programmable VME Bus interrupts to indicate available readings in the buffer. You can add optional piggyback signal-conditioning modules to provide ±30V input protection, and a separate single-ended or a separate differential input amplifier for each input channel, or 16 ±10 mA current inputs. The board is also compatible with Analog Devices' 3B and 5B series of signal conditioning modules. Around $900.

Pep Modular Computers GmbH, Am Klosterwald 4, 8950 Kaufbeuren, West Germany. Phone (08341) 81001. TLX 541233.

Circle No 390

Pep Modular Computers Inc, 600 North Bell Ave, Pittsburgh, PA 15106. Phone (412) 279-6661. TLX 825098.

Circle No 391



GRAPHICS BOARD

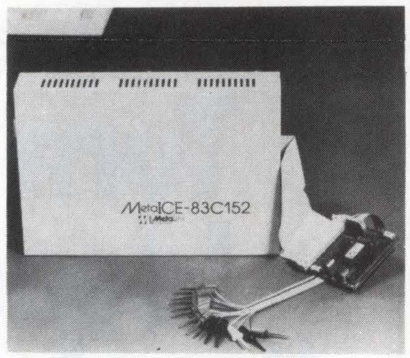
- *Uses the AMD 95C60 data-flow manager*
- *Raises IBM PC/AT graphics to workstation performance*

The 7000CB is a graphics controller card for the IBM PC/AT for high-end workstation performance. It contains one or two AMD 95C60 Quad Pixel Dataflow Managers (QPDM) as graphic engines. This engine allows data for each pixel plane (with a resolution of 1280×1280 pixels) to be accessed in parallel. The unit can thus maintain the same draw times no matter how many planes are addressed. Typical draw times are 100,000 vectors/sec and bit-block transfers occur at the rate of 18.2 million pixels/sec. The board has 1280×1024- or 1024×780-pixels displayable resolution. The standard color palette allows 16 colors out of 4096. A color palette option is available, which attains 256 out of 16.7 million colors. It utilizes a Brooktree DAC (BT458/451) and an invisible pixel memory to 4M bytes of RAM, which can store lists and data for recurring polygons. The board can be configured as

EGA- or VGA-compatible (video-graphics array) to run Lotus 1-2-3. From $2995. Delivery, eight weeks ARO.

Kontron Electronics Inc, 630 Clyde Ave, Mountain View, CA 94039. Phone (800) 227-8834.

Circle No 392



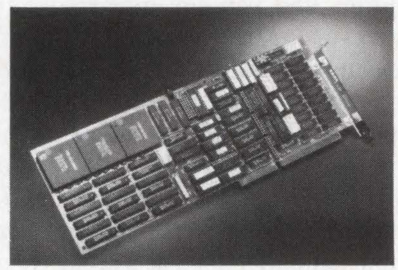
EMULATOR

- *Emulates the 83C152 and 80C152*
- *Runs on IBM PC/XTs and PC/ATs with 640k bytes of RAM*

The MetaICE-83C152 is an in-circuit emulator for the Intel 83C152 and 80C152 single-chip microcontrollers. It can perform real-time and transparent emulation at 12-MHz rates on the IBM PC, PC/XT, PC/AT, and compatibles. The unit requires 640k bytes of RAM, two floppy-disk drives, and an RS-232C interface. It supports all modes of the 83C152: single-line assembly and disassembly; 4k×32-bit real-time traces; 128k hardware breakpoints on as many as 16 triggerable events, including PC addresses and read or write operations to a direct byte or direct bit; and conditional and logic statements. You can also download executable code to 64k bytes of program overlay and download external data to 64k bytes of external data-overlay memory. Using an adapter card, the device can also emulate 8051, 8031, 8751, 8053, and 8753 microcontrollers. It costs $3995, including a probe card, an emulation base, a company application system, and an ASM51 macro cross-assembler.

MetaLink Corp, Box 1329, Chandler, AZ 85224. Phone (800) 638-2423; in AZ, (602) 926-0797. TLX 4998050.

Circle No 393



COPROCESSOR BOARD

- *Cache, integer processor, and FPU deliver 20M flops*
- *Runs on IBM PC/AT and Apollo Series 3000/4000*

The MC3200AT is a single-board coprocessor that can accelerate computation-intensive vector and scalar operations on the IBM PC/AT and the Apollo Series 3000/4000 workstations. The 2M-byte main memory combined with a cache, an integer processor, and a floating-point unit (FPU) provides 32-bit floating-point operations for a 20M-flops performance. The main memory can be expanded in increments of 2M, 4M, or 8M bytes with an optional daughter board that connects directly to the board. The board can do a 1024-point (complex) FFT in 3.4 msec. For image-processing applications the board can convolve a 3×3-pixel filter on a 512×512-pixel image in 255 msec. For modeling and simulation, it can multiply a 100×100-dot matrix in 125 msec. The board draws 15W of power fully configured. With 2M-byte dynamic RAM, $8000; with ½M-byte dynamic RAM, $6500.

Mercury Computer Systems Inc, Wannalancit Technology Center, 600 Suffolk St, Lowell, MA 01854. Phone (617) 458-3100. TLX 311515.

Circle No 457


SL/L SERIES—small to medium size metal stand-alone enclosures
TRACEWELL enclosures inc.
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CIRCLE NO 209
CH SERIES—chassis type, 19 inch rack mounted enclosures
TRACEWELL enclosures inc.
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TEST & MEASUREMENT INSTRUMENTS

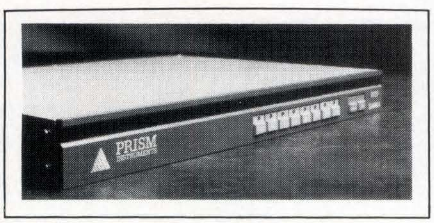
VIDEO GENERATOR

- *Tests MDA, EGA, PGA, and multisynchronous monitors*
- *Has connectors matching all compatible displays*

The Montest-AD8 video generator uses an 8-MHz dot clock to generate four test patterns—full raster, color bars, cross hatch, and windows—at any of eight user-selectable scan frequencies from 15.75 to 31.5 kHz. It tests MDA (Monochrome Display Adapter), EGA (Enhanced Graphics Adapter), PGA (Professional Graphics Adapter), and multisynchronous monitors. The output appears simultaneously on three connectors—BNC, 9-pin D analog, and 9-pin D digital—and has connectors matching all compatible displays. Sync is available on a separate BNC; composite sync is switch selectable. The unit is battery powered, but you can operate it from the ac line using a plug-in transformer supplied with it. $875.

Network Technologies Inc, 19145 Elizabeth St, Aurora, OH 44202. Phone (800) 742-8324; in OH, (216) 543-1646.

Circle No 409



IEEE-488 CONTROLLER

- *Controls as many as 28 IEEE-488 instruments*
- *Executes programs contained in EPROMs*

Targeted for use in repetitive testing applications—for example, in component test systems, burn-in racks, or environmental chambers—the Gamma IEEE-488 slave controller can control as many as 28 instruments on its two IEEE-488 ports, using preprogrammed sequences stored in internal RAM or in EPROMs. You can execute any one of eight program sequences by pressing the unit's front panel pushbuttons. Program sequences are either downloaded into the controller's internal RAM via its RS-232C interface or installed by plugging in EPROMs. £595.

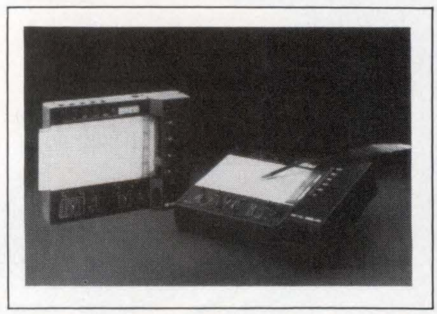
Prism Instruments Ltd, Burrel Rd, Industrial Estate, St Ives, Huntingdon, Cambridge PE17 4NF, UK. Phone (0480) 62225. TLX 32303.

Circle No 410

RECORDERS/DMMs

- *Power from ac line, 12V dc, or internal battery*
- *Measure and record ac, dc voltage, current*

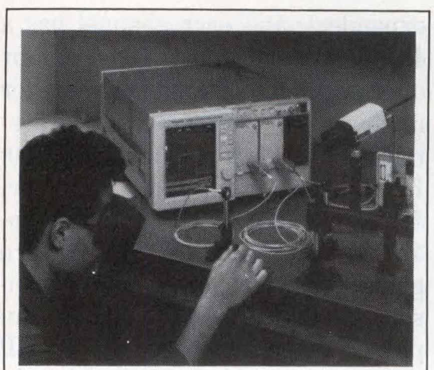
The SE110 and SE111 recorders provide both analog chart recording and digital readout of the measured value. The SE110 handles full-scale readings from 1 mV to 500V in 18 ranges and offers variable scaling and as much as two times full-scale zero suppression. The SE111 sacrifices the zero suppression and some



sensitivity but adds 12 ac-voltage, ac-, and dc-current ranges; full scale can be as low as 150 mV ac or dc or 600 μA ac or dc, and as high as 750V ac or dc or 6A ac or dc. The units accommodate roll charts and individual paper sheets; they also include an internal battery charger. The printed codes indicate range, chart speed, and battery status. You can remotely raise and lower the pen and control all chart-drive functions. SE110, $995; SE111, $1095.

BBC-Metrawatt/Goerz, 2150 W 6th Ave, Broomfield, CO 80020. Phone (800) 821-6327; in CO, (303) 469-5231. TLX 4970869.

Circle No 411



OPTICAL PROBES

- *Convert optical signals to drive scope*
- *Handle 700-MHz modulation*

The P6701 and P6702 converters perform optical/electrical power conversion in a package the size of a probe-compensation box and provide a scope with waveforms for acquisition, display, measurement, and analysis. The P6701 responds to light wavelengths from 450 to 1050 nm; the P6702 response is from 1000 to 1700 nm. The P6701 and P6702 handle modulations as high as 700 and 500 MHz, respectively. The vendor's scopes supply all the power needed by the converters. By using the companion P6751 spatial-input head, a tunable, bench-mountable lens system, you can convert laser beams to scope inputs. P6701, \$1800; P6702, \$1995; P6751, \$295.

Tektronix Inc, Marketing Communications Dept, Box 1700, Beaverton, OR 97075. Phone (800) 547-1512; in OR, (800) 542-1877.

Circle No 412

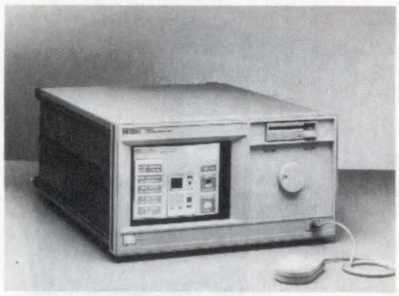
COMB GENERATOR

- *Covers 1 to 40 GHz*
- *Has 1-GHz frequency spacing between comb outputs*

The Model 1040A comb-frequency generator operates from 1 to 40 GHz in three bands: 1 to 18 GHz, 8 to 26.5 GHz, and 26.5 to 40 GHz. The output power for the three bands is −5 to +15 dBm, −25 to −5 dBm, and −35 to −25 dBm, respectively. The standard frequency spacing between comb outputs is 1.0 GHz; 100- and 500-MHz spacings are available. The unit is ac powered, measures 5×9×7.6 in., and is transportable. $7900 (small quantities).

ST Research Corp, 8419 Terminal Rd, Newington, VA 22122. Phone (703) 550-7000. TWX 710-832-9818.

Circle No 413



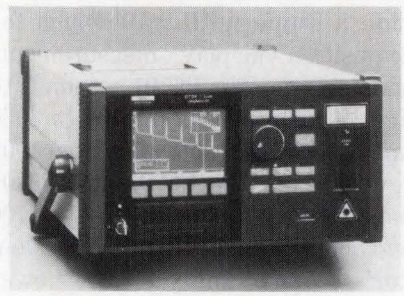
LOGIC SYSTEM

- *Comprises analyzer, scope, and generator*
- *Software links system to CAE workstations*

The modular and user-configurable HP 16500A logic-analysis system comprises a 100-MHz timing logic analyzer, a 25-MHz state logic analyzer, a dual-channel 400M-sample/sec digitizing scope, a 50M-bps pattern generator, and a 1-GHz timing analyzer. The system's mainframe accepts as many as five pc boards. The various functions are provided by modules that comprise different numbers of boards. All of the instrument pc boards can cross trigger. The system's front panel features a 9-in. color, touch-sensitive CRT, which displays a menu-oriented control system. The unit also has two disk drives for measurement setups and data storage. Each single-board, state/timing logic-analyzer module provides 80 channels. The single-board digital analyzer has two 4k-sample memories. The single-board, 1-GHz timing analyzer has 16 channels. The scope and analyzers require special probes. The pattern generator provides 12 channels (48 channels with the optional expander), and each channel has a 4k-bit pattern depth. The vendor offers communications software for linking to its proprietary CAE system. HP 16500A mainframe, $7200; HP 16510A timing/state analyzer, $5200; HP 16515A 1-GHz timing analyzer, $7800; HP 16520A pattern generator, $3700; 48-channel expansion, $4000; HP 16530A 400M-sample/sec scope timebase, $1500; HP 16531A scope, $4000; CAE link software, $2000. Delivery, one to three months ARO.

Hewlett-Packard Co, Inquiries Manager, 1820 Embarcadero Rd, Palo Alto, CA 94303. Call local office.

Circle No 414

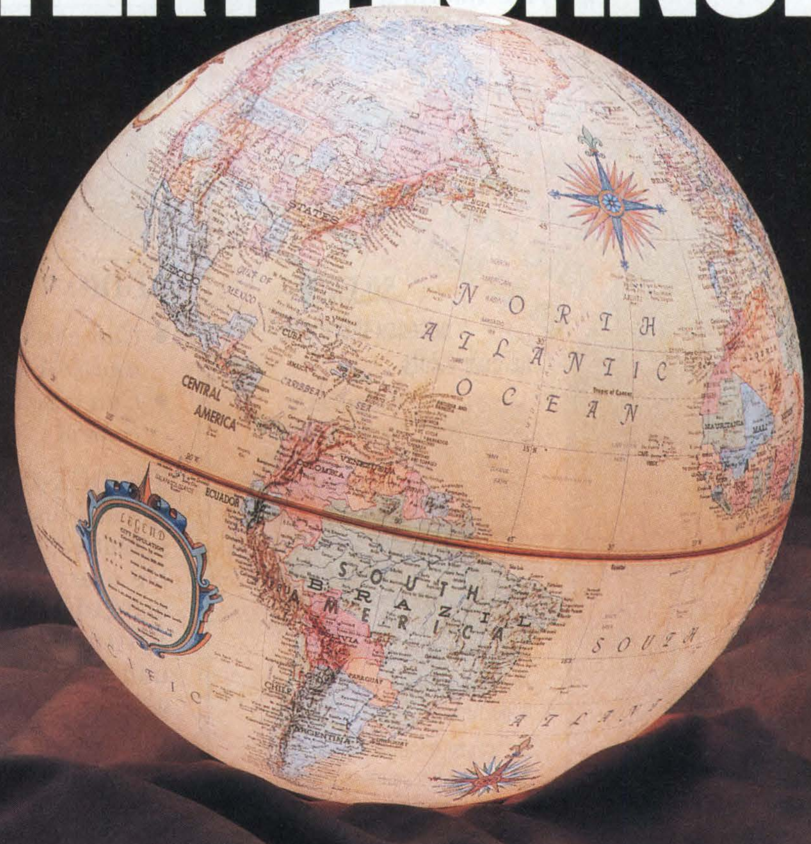


FIBER TESTERS

- *Simplify testing of fiber-optic cables*
- *Include models to test multimode or monomode fibers*

Models 7721, 7723, and 7725 optical time-domain reflectometers allow you to make bandwidth and attenuation measurements for the installation and maintainance, production test, or length measurement of fiber-optic cables. The instruments use menu and automatic setups to achieve repeatable measurements of bandwidth, cable losses, and splice losses, and to locate breaks in the fiber. The CRT trace of the cable's characteristic is fully annotated with the losses. Initial cable profiles, optionally stored on a magnetic tape cassette, can be recalled for comparison purposes. An integral printer provides hard-copy results. A manual operating mode allows

THE NEW POWER IN RECHARGEABLE BATTERY TECHNOLOGY.



Gates Energy Products has purchased GE's Battery Business Department, making us the world's largest source of sealed rechargeable batteries.

What does this mean to you?

That Gates is dedicated to providing you with the best rechargeable batteries in the world.

Gates now has the technology and resources to offer the largest selection of rechargeable batteries including nickel cadmium, nickel hydrogen and sealed lead batteries–from .065Ah to 300Ah.

Leading the technological advancements at Gates is our new GEMAX™ Series of nickel cadmium cells. These cells are providing more run time and maximizing power delivery in all product applications by incorporating higher capacities and lower internal resistance.

As a result of GEMAX technology, Gates now offers the world's highest capacity, production-volume Sub C cell at 1.4Ah (1-hour rate). And more advancements are on the way.

Our commitment to supply batteries tailored to your specific applications is yet another aspect of our determination to make sure that Gates batteries are superior.

No other rechargeable battery company in the world is taking such dramatic steps to perfect and expand their rechargeable battery products as the new Gates. It's time you discovered the difference.

For more information worldwide, contact one of the Gates Regional Sales Offices listed below.

Gates Energy Products

WESTERN U.S.
4063 Birch St. #130
Newport Beach, CA 92660
(714) 852-9033

CENTRAL U.S.
2860 S. River Rd.
Suite 401
Des Plaines, IL 60018
(312) 827-9130

EASTERN U.S.
1 Prestige Dr.
Meriden, CT 06450
(203) 238-6840

SOUTHERN U.S.
1835 Savoy Dr.
Suite 200
Atlanta, GA 30341
(404) 458-8755

PACIFIC AND ASIAN
3706 A, Shun Tak Centre
200 Connaught Rd. Central
Hong Kong
011-852-5-403073

EUROPE
Units 12/13
Loomer Rd. Industrial Estate
Chesterton
Newcastle-under-Lyme
Staffs. ST5 7LB, Great Britain
011-44-782-566525

CIRCLE NO 217

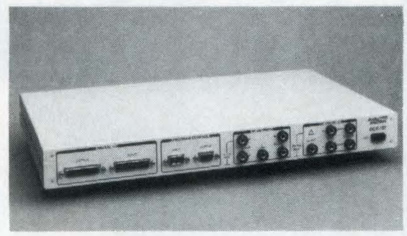
more advanced users to make additional measurements and to zoom in on areas of special interest. Models 7721, 7723, and 7725 are designed for 850-nm multimode, 1300-nm multimode, and 1300-nm monomode cables, respectively. In the 7721, a special fiber connector accepts several cable sizes and reduces the dead zone in the fiber to zero. The instruments for use with multimode fibers feature a backscatter single-way dynamic range (SWDR) of >25 dB; and the monomode instrument specs a backscatter SWDR of >24 dB. All the instruments have IEEE-488 and RS-232C interfaces and operate from ac line or 10 to 16V dc supplies. £12,000 to £16,500.

Enertec Instruments, 5 rue Daguerre, 42030 St Etienne Cedex 2, France. Phone 77252264. TLX 300796.

Circle No 415

Solartron Instruments, 2 Westchester Plaza, Elmsford, NY 10523. Phone (914) 592-9168. TLX 145487.

Circle No 416



AUDIO TESTER

- *Can check 16- and 18-bit A/D and D/A audio gear*
- *Can execute tests under IBM PC control*

The DCX-127 module adds dc-voltage and resistance measurement capabilities, two dc outputs controllable over ±10V (20-μV resolution), and 21-bit digital I/O to the vendor's System One audio-test system. The unit incorporates an autoranging 4½-digit DVM. With this module, the system can automatically test audio equipment power supplies and can also check amplifier-offset voltage, loudspeakers, voltage-controlled amplifiers, and 16- or 18-bit A/D and D/A converters. $2150.

Audio Precision, Box 2209, Beaverton, OR 97075. Phone (503) 627-0832; in OR, (800) 231-7350. TLX 283957.

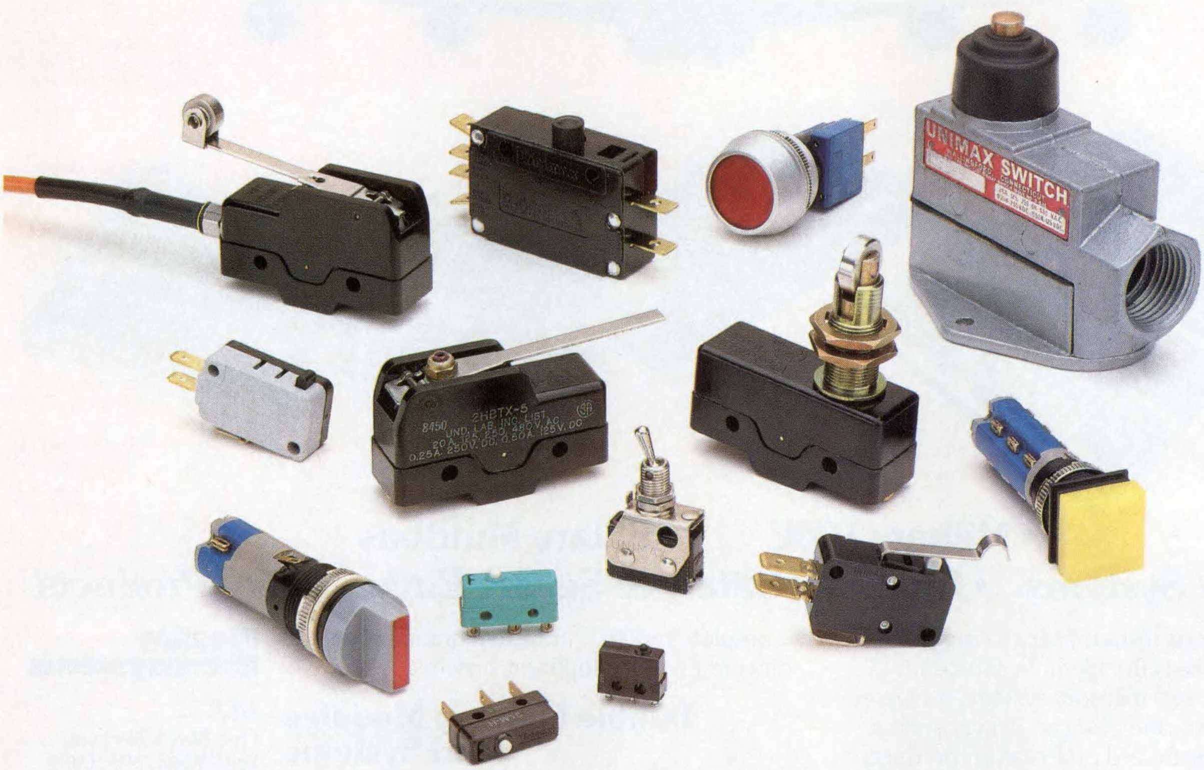
Circle No 417

VIDEO GENERATOR

- *Superimposes time/date information on a video image*
- *Has programmable character size and display formats*

The TDG-1 video time/date generator superimposes time or date information onto a video picture signal. You can move the time/date display around the screen area and select

Timing is everything.



When you are looking for delivery, quality, and performance for your snap-acting, or lighted pushbutton switch applications timing is everything. Backed by a nationwide network of technical sales representatives and full-service distributors—C&K/Unimax provides a full range of solutions to your switching requirements from custom engineering support through value-added capabilities. All available when you need them!

Our broad line of snap-action switches offers multiple options in actuators, terminal styles, and operating forces with current ratings ranging from low-level to 25A in both electrical and fiber optic packages.

The Lighted Pushbutton Switch line includes a wide range of time-saving features, and attractive options including pre-wirable slide-on contact blocks, oil-tight models, interlock switches, and matching indicators.

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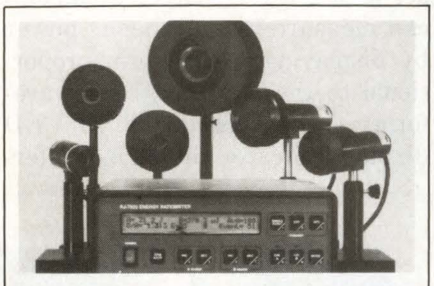
CIRCLE NO 218

various character sizes and formats for the time/date display. You set the display to be either black or white, with or without a contrasting background, to ensure readability on all types of images. The instrument has battery backup for its real-time clock/calendar and its display format data. A switchable internal synch facility allows the instrument to operate as a stand-alone unit if required. The TDG-1 measures 280×50×254 mm (11×2×10 in.) and operates from 110/240V ac line supplies or a 12V dc supply. £450.

Wallington Instrument Co, Kimberley Pl, Purley, Surrey CR2 2BX, UK. Phone 01-668 4315.

Circle No 418



LASER-ENERGY METERS

- *Measure power of pulsed lasers*
- *Handle energy levels of 10^{12}J min*

The Rj-7600 Series laser-energy meters measure the output of pulsed-laser sources with energy levels of 10^{12}J min at pulse-repetition rates to 40 pps. The instruments can calculate the minimum, maximum, and standard deviations of sets of 10 or 100 pulses, and each can accommodate one of eight interchangeable pyroelectric, silicon, or thermopile probes. An IEEE-488 interface is optional. The dual-channel version of the instrument takes ratiometric measurements. Single-channel model, $3475; dual-channel model, $3850; 488 option, $550; probes, from $975 to $1500.

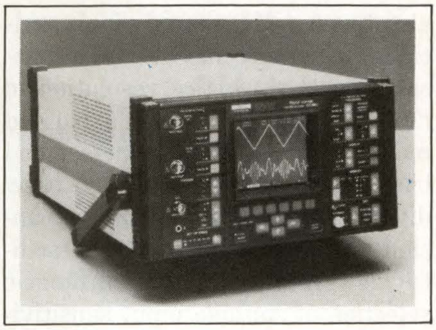
Laser Precision Corp, 1231 Hart St, Utica, NY 13502. Phone (315) 797-4449. TLX 646803.

Circle No 419

STORAGE SCOPE

- *Has a bandwidth of 100 MHz for repetitive signals*
- *Includes window triggering for glitch capture*

By random sampling at 40 MHz, the 5602 2-channel digital storage oscilloscope achieves a bandwidth for repetitive waveforms of 100 MHz. It



also has a 4-MHz-bandwidth real-time oscilloscope mode. The oscilloscope has 8-bit vertical resolution on its 10 mV/div (2 mV/div in expanded mode) to 5V/div input ranges, and has timebase ranges from 50 nsec/div (5 nsec/div with timebase expansion) to 20 sec/div. An autoset facility is provided for automatic selection of suitable input sensitivity and timebase ranges. You can display pretrigger traces on any timebase setting. The instrument can store as many as four pairs of traces (channel A and channel B) using 1k byte of trace memory per channel. Alternatively, you can reconfigure the trace memories to store one pair of traces at 4k bytes/channel or one trace at 8k bytes/channel. You can also store the corresponding instrument set-up with the traces. Trace annotation is provided on the CRT. On-screen measuring functions include absolute and relative voltage values, time from trigger point, time interval, frequency, and rise and fall times. Processing functions include averaging, smoothing, summing, multiplication, and trace expansion. The 5602 has both RS-232C and IEEE-488 interfaces for control and up/down loading of trace information. The oscilloscope also has analog and digital plotter outputs. Fr fr 64,000.

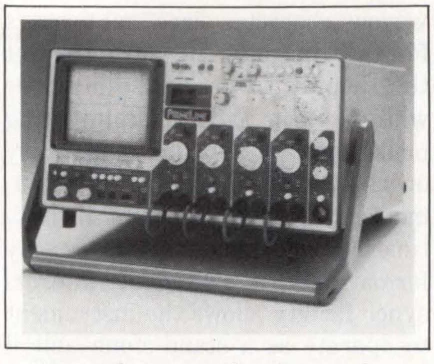
Enertec Instruments, 5 rue Daguerre, 42030 St Etienne Cedex 2, France. Phone 77252264. TLX 300796.

Circle No 420

POWER-LINE DISPLAY

- *Fully isolated inputs protected to 1 kV*
- *LEDs read out phase with 1° accuracy*

The 881 Powerscope II displays waveforms obtained from ac power



systems, but can also be used as a general-purpose triggered scope. Four 25-MHz-bandwidth differential channels are isolated from each other and from the chassis and provide sensitivity from 20 mV/div to 200V/div. A fifth 50-MHz-bandwidth trigger-view channel is single ended. Any of the five channels can act as a trigger source. Channel 3 can measure instantaneous power by displaying a waveform proportional to the product of the waveforms on channels 1 and 2. An LED display indicates the phase difference between any two channels or between any channel and the ac line with an accuracy of 1° from 25 Hz to 2 kHz. $4995.

Primeline, Box 670, San Fernando, CA 91341. Phone (800) 525-5554; in CA, (818) 764-5400. TLX 4943094.

Circle No 421

DIGITAL TESTER

- *Provides 336 inputs and 336 outputs*
- *Offers 20-MHz data rate*

The DSR10 high-performance digital word generation and recording device functionally tests µP boards, emulates system buses, and tests digital components and custom circuits. A Compaq DeskPro-386 personal computer performs computations, provides control, and supports the Microsoft Windows programming environment. During setup, you generate system-command sequences using a Windows-based pattern editor; you then merge them into TestBasic programs. You can loop a pattern indefinitely, or your program can specify the number of loops—as many as 64k—to be burst. Inputs and outputs can be backed by 16k-bit-deep, full-width, full-speed memory. You can place vectors with 10-nsec resolution. Three pod families provide compatibility with TTL, 5V HCMOS (high-speed CMOS), and ECL. An ASIC/PLD test fixture is also offered. System with one timing generator, two memory modules, three pods, and a blank test-head, $36,625; ASIC/PLD fixture, $995. Delivery, 60 days ARO.

Summation Inc, 11335 NE 122nd Way, Kirkland, WA 98034. Phone (206) 823-8688. TLX 152219.

Circle No 422

RECORDERS

- *Plot traces of as many as 24 input channels*
- *Scan channels at 0.1, 0.2, or 0.5 readings/sec*

A 4- to 24-channel pen recorder comes in two versions: the HR-1100 panel/rackmount recorder and the HR-2100 flatbed recorder. The units have four pens of different colors that can plot continuous traces of as many as 24 input signals. The re-

VF Technology... The Bright Decision

Futaba, a world leading manufacturer of vacuum fluorescent displays, offers a wide assortment of *display tubes* in many sizes and formats. Also, Futaba offers *display modules* with all the electronics required to refresh the display and easily interface with the host system.

GRAPHIC DISPLAY

Both front glass phosphor, which provides maximum viewing angle and uniform surface appearance, and conventional back glass phosphor, with optimum brightness and software dimming capabilities, are available. All Futaba graphics modules offer complete drive electronics, bit mapped control with a DC/DC converter. All active components are surface mounted onto a single board.

DOT MATRIX MODULES

Utilizing Futaba's dot matrix displays, a completely intelligent line of "dot modules" is available. Each includes all drive, power supply and microprocessor components surface mounted onto a single board. Surface mounted technology results in higher reliability and allows for a smaller overall package and lower cost. All dot modules require only a 5V DC power source and can accept parallel or 8 possible serial baud rates.

GRAPHIC DISPLAYS/MODULES

Futaba Display	Futaba Module	Pixels (Row X Char.)	Brightness (FT-L)	Module Dimensions (in.)
GP1005B	GP1005B03	128X64	400	7.28X3.35X1.77
GP1006B	GP1006B04	256X64	200	9.84X3.35X1.77
GP1009B	GP1009B03	240X64	200	6.2X2.76X1.57
GP1010B	GP1010B01	176X16	200	7.32X2.16X1.70
GP1002C	GP1002C02	320X240	100*	7.10X6.30X1.60
GP1004B	GP1004B03	640X400	30	9.65X7.28X1.85

*Different Versions Available

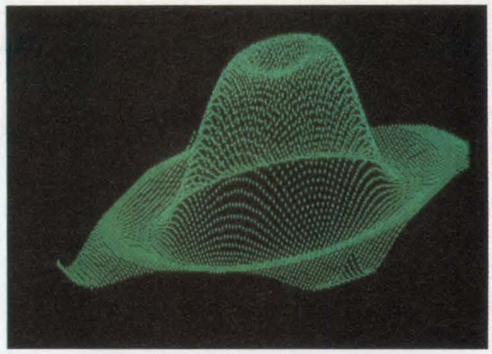
DOT MATRIX DISPLAYS/MODULES

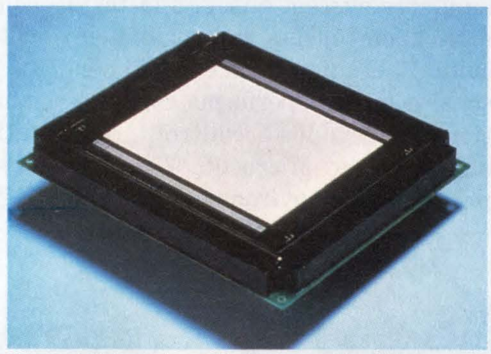
Futaba Display	Futaba Module	Char. X Row	Dot Format	Char. Ht. (in.)	Module Dimensions (in.)
20SD01Z	M20SD01	20X1	5X7	0.200	6.3X1.97X.75
20SD42Z	M20SD42	20X1	5X12	0.344	7.1X2.16X.88
40SD02Z	M40SD02	40X1	5X7	0.200	9.45X2.16X.88
40SD42Z	M40SD42	40X1	5X12	0.344	9.45X2.16X.88
202SD03Z	M202SD03	20X2	5X7	0.200	6.7X2.56X.90
402SD04Z	M402SD04	40X2	5X7	0.200	10.43X2.56X.90
MANY OTHER DISPLAYS	NEW MODULES AVAILABLE SOON				

FUTABA
Corporation of America
Electronic Components Division

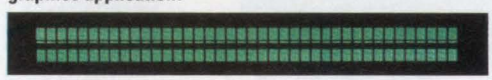
711 E. State Parkway
Schaumburg, IL 60173

Telephone: (312) 884-1612
or (312) 884-1444

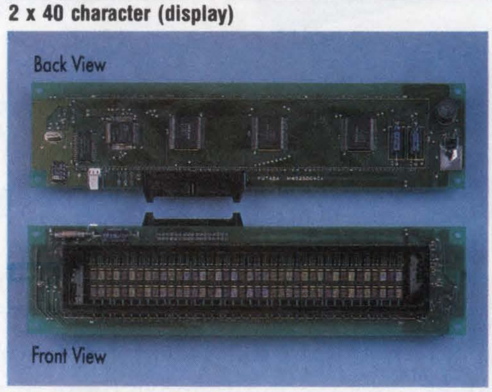




Compact, flat panel graphic displays and modules present clean, sharp images, whether for text or full graphics application.

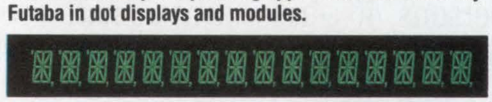


2 x 40 character (display)



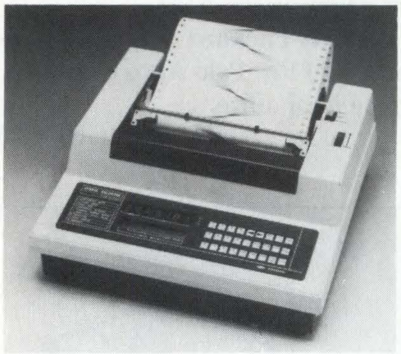
2 x 40 character (module)

Pattern flexibility and pleasing appearance are offered by Futaba in dot displays and modules.



Futaba also offers a complete catalog of alphanumeric, segmented displays.

Futaba supports its products with design engineering and system integration assistance. Call or write today.



corders handle straight dc voltages as well as seven thermocouple types and RTDs. The low-frequency recorders scan each input channel at 0.1, 0.2, or 0.5 readings/sec. You can also annotate the charts. A transient-capture option has a 20-kHz bandwidth and digitizes signals at 10-bit resolution into a 2k-sample memory. $4250.

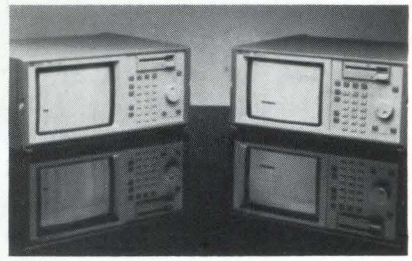
Primeline, Box 670, San Fernando, CA 91341. Phone (800) 525-5554; in CA, (818) 764-5400. TLX 4943094.

Circle No 423

LOGIC ANALYZERS

- *Have 25-MHz state or 100-MHz transitional timing*
- *Come in 80- and 32-channel models*

The 80-channel HP 1650A and the 32-channel HP 1651A logic analyzers both use pop-up menus for control, and each has a 3½-in. disk drive. You can split either analyzer into two independent sections to capture nonsynchronized activity. The first instrument can have either 25-MHz state timing or 100-MHz transitional timing on its 80 channels. It has five clock inputs and four qualifiers. Its trigger circuitry has eight word recognizers and one range recognizer; the trigger sequence is eight levels deep max. To help identify linkages in software, this analyzer can store two states prior to a trigger event. Each analyzer weighs 22 lbs. 1650A, $7800; HP 1651A, $3900.



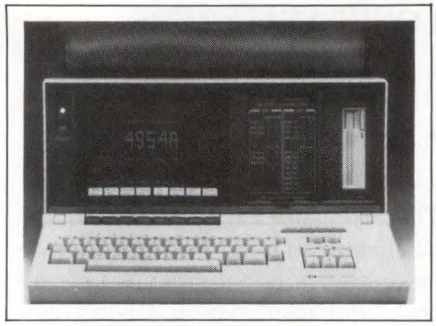
Hewlett-Packard Co, Inquiries Manager, 1820 Embarcadero Rd, Palo Alto, CA 94303. Call local office.

Circle No 424

PROTOCOL ANALYZER

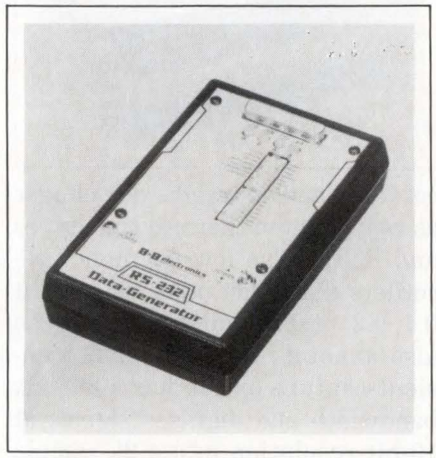
- *Supports common local- and wide-area protocols to 72k bps*
- *Has hard- and floppy-disk drives and GPIB port*

The HP 4954A protocol analyzer monitors, analyzes, and simulates network data traffic. It supports BSC, SNA/SDLC, HDLC, X.21, X.75, and DDCMP protocols and can act as an X.25 performance analyzer or as an SNA, X.21, or CCITT#7 development tool. It includes a 20M-byte hard-disk drive, 3½-in. floppy-disk drive, and GPIB port, and has standard test routines for common protocols so that you can check new designs for compliance to standards. $17,000. Delivery, eight weeks ARO.



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

Circle No 425



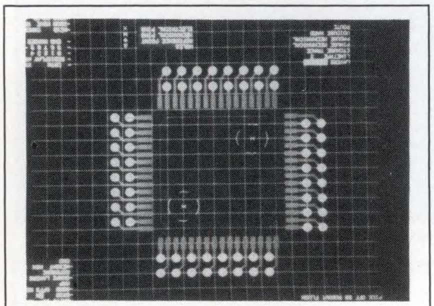
DATA GENERATOR

- *Generates ASCII data in user-selectable formats*
- *Powered from built-in battery or optional external supply*

The 232DG data generator provides serial ASCII data in several combinations of line length, baud rate, parity, number of stop bits, and word length. The output data flow can be controlled with the DTR (data terminal ready) or RTS (request to send) lines or by sending the X-on or X-off characters. You can use switches to control the sense of CTS (clear to send), DSR (data set ready), and CD (carrier detect) and to determine whether data comes out on TXD (transmitted data) and RXD (received data). By having the unit continuously output the letter "U", you make it generate a square wave at one-half the selected baud rate for a worst-case test. An internal 2716 EPROM generates the character set—all 96 printable ASCII characters. You can reprogram it to produce custom test patterns. $199.95; ac power supply, $14.95.

B & B Electronics Mfg Co, Box 1040, Ottawa, IL 61340. Phone (815) 434-0846.

Circle No 426



SHAPE LIBRARY

- *Lets you define, edit, and store custom shapes for SMDs*
- *Lets you mirror a shape for placement on back of board*

The Surface Intelligent Shapes (SIS) library for the Scicards CAE system lets you define, edit, and store an unlimited number of customized design geometries for surface-mount devices. When you create a new shape, you can include complete placement, routing, and assembly information; you can add etching instructions to the shape definition to facilitate the routing of complex body shapes. You can also set void areas for traces and vias. A menu system guides you through the levels of commands, prompts you to supply necessary data, and warns you of syntax errors. A graphics advisory tracks the shape-definition status and prioritizes commands during the creation of complex body shapes. You can define a shape by layers; the mapping protocol builds the shapes from the top down for standard pc boards and from the bottom up for hybrid designs. The Scicards system can place as many as 2500 components on each side of the substrate and can use the same SIS library definition for both sides by automatically inverting the original shape. The SIS Library is an enhancement of the Scicards CAE system and is included in the $25,000 price of a new system; if you already own the system, you can obtain the SIS Library at no extra charge.

Scientific Calculations Inc, Box H, Fishers, NY 14453. Phone (716) 924-9303.

Circle No 427

CODE-GENERATOR LINK

- *Connects Excelerator CASE tool to Telon code generator*
- *Provides Telon's specialized symbols*

XL/Interface Telon allows the screen and report designs that you generate with the vendor's Excelerator CASE tool to be passed to the Telon code generator from Pansophic Systems Inc (Oak Brook, IL). The Telon code generator, which runs on mainframes and IBM PCs and compatibles and which can generate Cobol or PL/1 code, is particularly suited to developing on-line information systems that incorporate multiple screens and reports. The vendor's link enhances Excelerator, allowing you to generate the specialized graphs and dictionary entities (circle flow graphs) that depict Telon applications and to translate files in Excelerator format to files in Telon format. Pansophic Systems' software lets you import the converted files into either the mainframe or the PC version of Telon for code generation. A corporate license for XL/Interface Telon, which permits its use throughout an organization, costs $9000.

Index Technology Corp, 1 Main St, Cambridge, MA 02142. Phone (617) 491-2100. TWX 910-380-7014.

Circle No 428

FORMAT CONVERTER

- *Transforms data from 5¼-in. to 3½-in. disk format*
- *Lets you transfer data from IBM PCs to PS/2 machines*

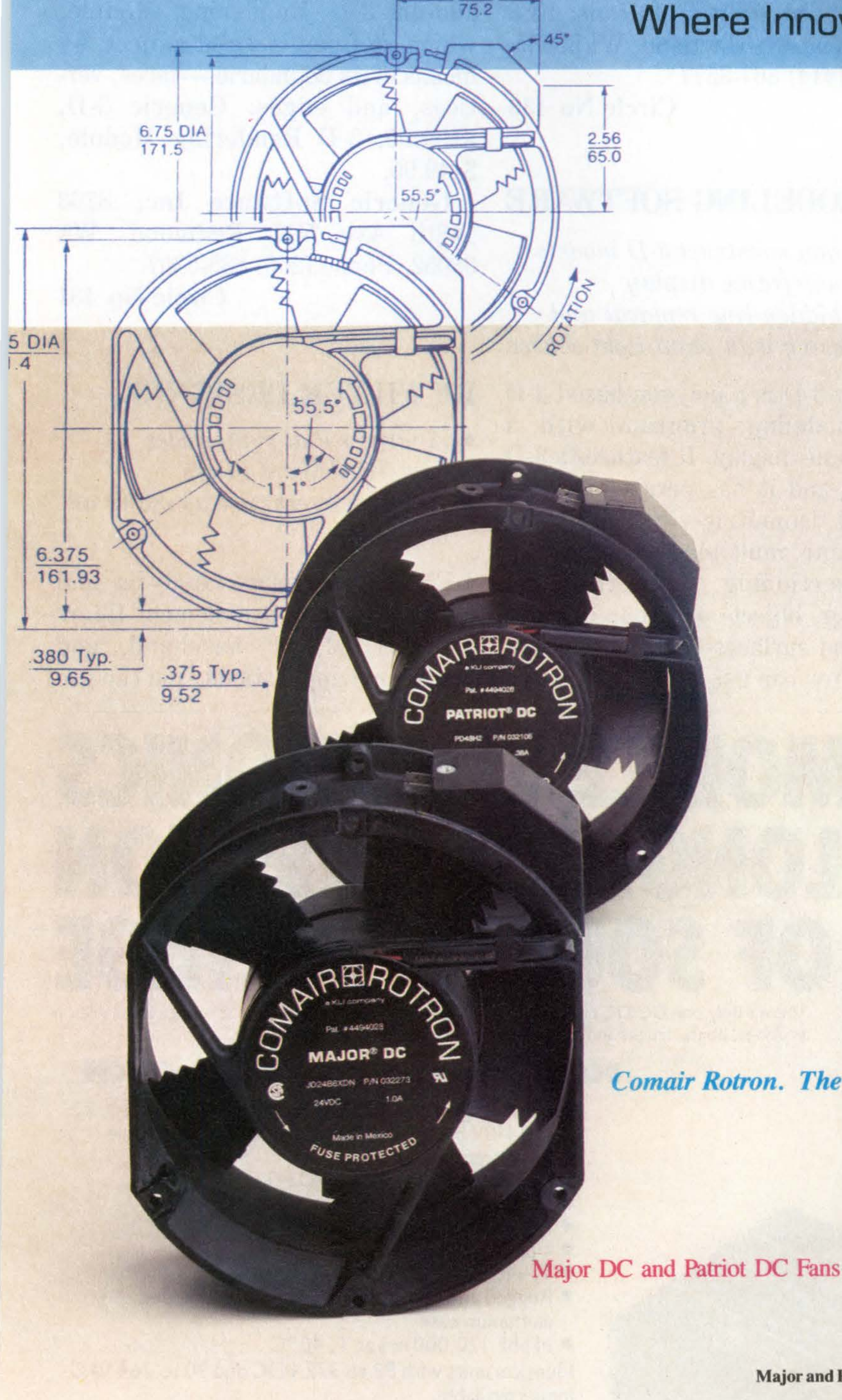
The Interchange package comprises software supplied on a 5¼-in. diskette, software supplied on a 3½-in. diskette, and a cable. The cable links the parallel ports of two IBM PC family or compatible computers, one of which uses the 5¼-in. format and the other of which uses the 3½-in. format. The software then provides high-speed data transfer in either direction. $39.95.

SMT Inc, 1145 Linda Vista Dr, San Marcos, CA 92069. Phone (800) 648-6262; in CA, (619) 744-3590.

Circle No 429

performance

Where Innovation Meets Reliability



Major DC and Patriot DC Fans

Comair Rotron's line of commercial air-movers are internationally respected because they do what they are designed to do . . . day in and day out.

Comair Rotron airmovers live up to your design expectations in everything from sophisticated mainframe computers to complex telecommunications systems.

Our engineering achievements are symbols for innovation and reliability. Nowhere is this professionalism more evident than in the popular high flow versatility of the Patriot and Major brushless DC tubeaxial fan. As the first domestic manufacturer of industrial six inch fans, Comair Rotron offers wide voltage input and performance ranges with Patriot DC and Major DC. In addition, Fan Performance Sensors (a Comair Rotron first) are available in both models . . . as are current limiting features.

Manufactured by Comair Rotron, the patented feather edge offers an acoustically quiet, ball bearing airmover able to satisfy your most demanding requirements.

Comair Rotron. The first name in forced convection cooling technology.

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CIRCLE NO 225

8051 DEVELOPMENT

- *Software development station provides CPU*
- *Offers 8051 assembler, disassembler, symbolic debugger*

The AMS 51 development station and target system permits you to develop software for the 8051 microcontroller family. The built-in RS-232C serial port operates at standard data rates from 300 to 9600 bps and lets you use any personal computer as a file server for source-code, Intel-Hex, or listing files. The resident 8051 assembler accepts standard Intel 8051 mnemonics and generates object code in Intel-Hex format. The hardware provides 22 bidirectional digital I/O lines and eight high-current output lines for control applications. An expansion bus lets you interface to external equipment. Debugging features allow you to set as many as five breakpoints and to execute a user program either as a stand-alone program or subroutine. Power consumption is 120 mA at 9V from a wall adapter. $1595.

Advanced Micro Solutions, 1033 S Imperial Dr, Hartland, WI 53029. Phone (414) 367-3577.

Circle No 430

3-D MODELING SOFTWARE

- *Lets you construct 3-D models in a wireframe display*
- *Has hidden-line removal and rendering with point light source*

Generic 3-D is a polygon-based 3-D solid-modeling program with a wireframe display. It features a 3-D cursor, and it has perspective, extrusion, isometric-view, construction-plane, multiple-window, automatic-sectioning, interference-checking, object- or group-duplication, and surfaces-of-revolution features. You can use the program as a stand-alone package, or you can transfer your models to Generic CADD and other of the vendor's products. Also available is the add-on 3-D Rendering Module, which defines a solid object by means of its boundaries—faces, vertices, and edges. Generic 3-D, $199.95; 3-D Rendering Module, $149.95.

Generic Software Inc, 8763 148th Ave NE, Redmond, WA 98052. Phone (206) 885-5307.

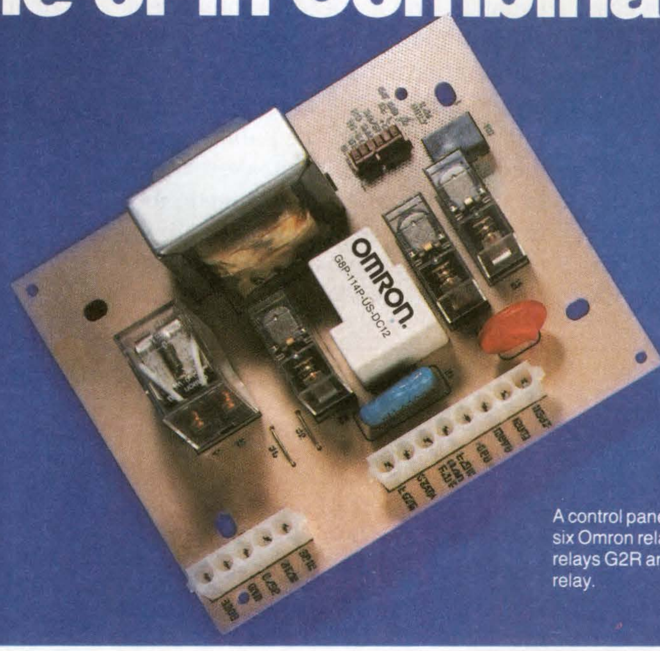
Circle No 431

RF FILTER DESIGNER

- *Analyzes and synthesizes lumped-element filters*
- *Lets you synthesize as many as 30 sections*

LEFLTR performs analysis and synthesis of lumped-element filters for AM/FM, IF baseband, and broadband applications. You can use

Omron Relays Respond-
Alone or in Combination



A control panel of a major appliance manufacturer shows six Omron relays—a general purpose LY2, power PCB relays G2R and G8P, as well as a G6E signal control relay.

Omron Has Your Relay

From industry standard general purpose relays to power PC board relays, Omron relays provide low power consumption, high speed operation and high reliability to meet your application needs. In addition to your standard relay requirements, Omron relays offer a wide variety of options, including LED indicators, push-to-test buttons, high switching capacity, and more.

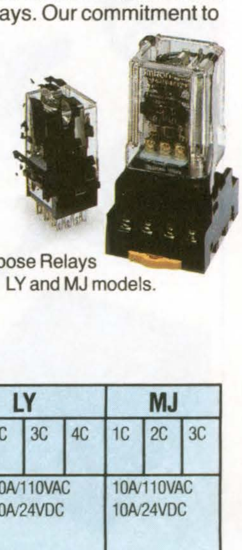
Designed To Meet Customer Needs

Because there are as many application requirements as there are design engineers, Omron backs up its extensive relay line with a commitment to product innovation. Many of our best-selling standard relays were initially developed to meet specific customer requirements in a wide variety of industry applications.

In Stock Where You Need Them

Count on your local Omron stocking distributor for assistance and off-the-shelf delivery of Omron switches and relays. Our commitment to customer service has forged one of the strongest distributor networks in the industry. But don't just take our word for it. Contact Omron for more information and a distributor list today.

1-800-62-OMRON



Omron General Purpose Relays include our MY, MK, LY and MJ models.

Shown here are key specifications for some of Omron's most popular power and general purpose relays.

Power Relays

Model	G2R		G4W		G4B	G5D		G8P		
Contact Form	1A, 1C	2A, 2C	1A	2A	1A, 1B, 1C	1X	2X	1A	1B	1C
Rated Load	10A, 250VAC/ 30VDC High Capacity Type 16A, 250VAC/ 30VDC	5A, 250VAC/ 30VDC	15A, 230VAC/ 24VDC	10A, 220VAC/ 24VDC	25A, 220VAC/ 24VDC	30A, 250VAC	20A, 250VAC	30A, 250VAC 20A, 28VDC	15A, 250VAC 10A, 28VDC	20A/ 10A*, 250VAC/ 28VDC
Terminal Types	PCB, QC, Solder		PCB, QC, Solder, QC and PCB		QC, QC and PCB (coil)	QC		PCB		
Coil Types	AC/DC		DC		AC/DC	AC/DC		DC		
Coil Power	AC: 0.9 VA DC: 0.53 W		0.8 W		AC: 1.3 VA DC: 1.2 W	AC: 3.0 VA DC: 1.9 W		0.9 W		
Approved Standards	UL, CSA, TUV, VDE, SEV, SEMKO		UL, CSA, VDE, SEV, SEMKO		UL, CSA	UL, CSA, VDE, TUV		UL, CSA		

General Purpose Relays

Model	MK			MY			LY				MJ		
Contact Form	1C	2C	3C	2C	3C	4C	1C	2C	3C	4C	1C	2C	3C
Rated Load	5A/220 VAC 3A/24 VDC		3A/ 220 VAC 2A/ 24 VDC	5A/220 VAC 5A/24 VDC		3A/ 220 VAC 3A/ 24 VDC	15A/ 110 VAC 15A/ 24 VDC	10A/110VAC 10A/24VDC			10A/110VAC 10A/24VDC		
	High Capacity Type 10A/230 VAC 10A/28 VDC			High Capacity Type 5A/240 VAC 5A/28 VDC									
Terminal Types	Octal Pin			PCB or Solder/ Plug-in			PCB or Solder/Plug-in				QC or Plug-in		
Coil Types	AC/DC			AC/DC			AC/DC				AC/DC		
Coil Power	2.1 VA 1.2 W			1.2 VA 0.9 W			1.2 VA 0.9 W		2.0 VA 1.4 W	2.5 VA 1.5 W	2.1 VA 1.2 W		2.5 VA 1.2 W
Approved Standards	UL, CSA, LR			UL, CSA, SEV, LR			UL, CSA, VDE, SEV, LR				UL, CSA		

*No/NC contacts

OMRON®

Responsive Innovation

OMRON ELECTRONICS, INC.
One East Commerce Drive
Schaumburg, IL 60173
TWX 910-291-0426

CIRCLE NO 226

the program to synthesize lowpass, highpass, bandpass, or bandstop filters with either Chebyshev or Butterworth response and with as many as 30 sections. You specify filter impedance, source impedance, load impedance, and other parameters; the program calculates input VSWR, time delay, insertion loss, through-path phase, and input impedance, and it specifies component values. You can analyze the performance of either the standard circuit or the dual of the standard circuit with respect to frequency. The menu-driven interface makes it easy to select the appropriate mode and to enter the required parameters; errors generate explicit messages that aid in recovery; and the program provides default values for most design calculations. The program runs on any IBM PC or compatible computer. $495.

Microwave Software Applications Inc, Box 1736, Norcross, GA 30091. Phone (404) 441-9193.

Circle No 432

CP/M WORD PROCESSOR

- *Provides programmable macros*
- *Has an "Undo" command*

WordStar, CP/M Edition, Release 4 provides more than 100 enhancements, including a new indexing system and improved versions of MailMerge and the Word Plus spelling checker. Other enhancements are a "Go to page" command, an "Undo" command, programmable macros, the ability to follow a drive/user-number path, and if your hardware permits, the capacity to employ definable function keys and to display boldface and underlining on screen. Operations speed has also been improved. You can use the new release with both floppy- and hard-disk systems and can configure it for output to laser printers. $295; updates, $89.

MicroPro International Corp, 33 San Pablo Ave, San Rafael, CA 94903. Phone (415) 499-1200. TWX 650-263-0157.

Circle No 433

AI SOFTWARE TOOL

- *Organizes and processes knowledge in four ways*
- *Runs on IBM PC/XT, PC/AT, and compatibles*

KnowledgePro is an artificial-intelligence software-development system that offers several ways of processing and organizing knowledge. You can create topics, which organize information as conceptual units with hierarchical structures. Each topic has a name, description, and contents, and each performs some action. Predefined topics act like built-in topics, and user-written

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Thanks to NMB Semiconductor, the future is suddenly now. With super-fast 256K Dynamic RAMS, having access times of just 60ns. Industry's first!

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How did NMBS suddenly become a world leader in this field? By putting together an entirely new type of IC manufacturing facility which Business Week calls "possibly the world's most sophisticated chip making plant." Imagine, Class 1 clean rooms, computer-controlled production lines and remote controlled robots.

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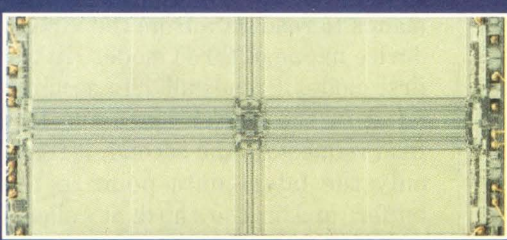
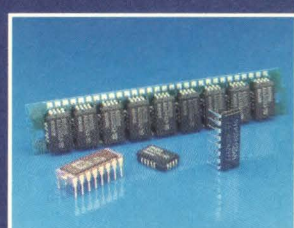
Phone or write for complete specs and application data today. Prove to yourself that, with FUTUREFAST™, your future is now.

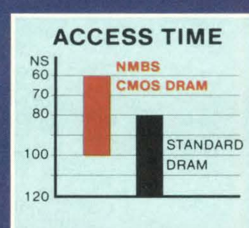


The Product: Die Size 52Kmil²



The Package

The Production



The Performance

NMB SEMICONDUCTOR CORPORATION

11621 Monarch Street • Garden Grove, California 92641
Telephone: (714) 897-6272 • FAX: (714) 891-0895 • TLX: 67-8486

CIRCLE NO 227

topics behave like system commands. You can use hypertext organization to highlight certain words or concepts in a screen of text; by pressing a function key, you can follow a highlighted thread, or train of thought, to other screens that also have highlighted words. When you design a system, you can cause highlighted words to actuate any set of instructions or area of the knowledge base. You can also use IF . . . THEN rules, which are the basis of current expert-system technology. The package's built-in list-processing facilities permit you to manipulate words or lists of words, change window colors, perform calculations, and access external files. The program requires a PC/XT, PC/AT, or compatible computer with at least 512k bytes of RAM. $495.

Knowledge Garden Inc, 473A Malden Bridge Rd, Nassau, NY 12123. Phone (518) 766-3000.

Circle No 434

REAL-TIME ANALYSIS

- *Lets analysis programs acquire real-time data*
- *Provides three modes for reading acquired data*

Labtech Notebook, which can gather real-time data in background mode while an application program runs in foreground mode, can now also communicate with foreground application programs through Labtech Real-Time Access. The access package creates a virtual data-acquisition and process-control device that emulates a standard file or I/O device. Thus, the foreground application can write a command stream that either modifies Labtech Notebook's acquisition and control parameters or sends data directly to an instrument. Likewise, the application program can use its own commands to read data from the virtual device in one of three modes. In the first mode, it reads all data accumulated in the buffer since the last read request; in the second, it reads only the latest data point in the buffer; and in the third, it collects and reads a new data point immediately. You can also set the read request to return with no data if none has been acquired since the last read request, or you can instruct it to wait until the acquisition module places new data in the buffer. The access package runs on any

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ALL AT COMPETITIVE PRICES... While others talk of meeting *DIN* performance levels, Panduit meets these requirements with an added plus—guaranteed gold thickness in the mating area for maximum reliability, with a *minimum* of 50 micro-inches for Level I, 15 (or 30) for Level II and 8 for Level III. Lets you choose the connector you need for your application.

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ELECTRONICS GROUP
Tinley Park, IL 60477-0981
In Canada: Panduit (Canada) Limited

CIRCLE NO 228

IBM PC, PC/XT, PC/AT, or compatible computer that has 384k bytes of RAM beyond the application program's memory requirements, and two 360k-byte floppy-disk drives (however, a hard disk will give better results). You also need PC-DOS version 3.1 or higher and Labtech Notebook version 3.0 or higher. $295.

Burr-Brown, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TLX 666491. TWX 910-952-1111.

Circle No 435

REAL-TIME KERNEL

- *Provides for fast response to interrupts*
- *Lets an 80386 perform multitasking in protected mode*

The iRMK is a 32-bit, real-time, multitasking operating-system kernel for use in 80386-based systems. The kernel and its applications operate in the 80386 protected mode, on a single privilege level, and in a memory space as large as 4G bytes. The kernel provides operating-system features and services such as task management, interrupt management, time management, device management, mailboxes and semaphores, and memory-pool management that provides both fixed- and variable-block allocation. Two optional modules allow applications to make full use of the Multibus II architecture: The first implements message passing by means of the Multibus II transport protocol, and the second gives access to the interconnect space. These modules let you distribute an application among several processors. The kernel size can vary from 8k bytes for a minimal system to 33k bytes for a system that uses all the optional modules. In embedded control applications, the kernel can reside in PROM or EPROM. The kernel's interrupt latency is 5.4 μsec min, 10 μsec avg, and 50 μsec max. Single-processor license, $1500.

Intel Corp, Box 58065, Santa Clara, CA 95052. Phone (800) 548-4725.

Circle No 436

MATH TOOL

- *Provides built-in simultaneous equation solver*
- *Lets you use LIM expanded memory protocol*

Version 2.0 of MathCAD is an upgrade of this interactive calculation software package for IBM PCs and compatibles. Among the new computational features are a built-in simultaneous equation solver and matrix capabilities, which include addition, multiplication, scalar multiplication, dot-product functions, and inversion, transposition, and determinant operations. The pro-

gram's more efficient RAM storage and other enhancements speed up most calculations by two to four times and yield faster scrolling and screen redrawing. In addition, the upgrade's ability to make use of the Lotus/Intel/Microsoft expanded-memory facilities allows you to build larger documents than before. The program's other new features include plot autoscaling; a configuration file that lets you set the defaults for plotting and hard-copy parameters; and support for more printers, plotters, and high-resolution monitors. $349.

MathSoft Inc, 1 Kendall Square, Cambridge, MA 02139. Phone (617) 577-1017.

Circle No 437

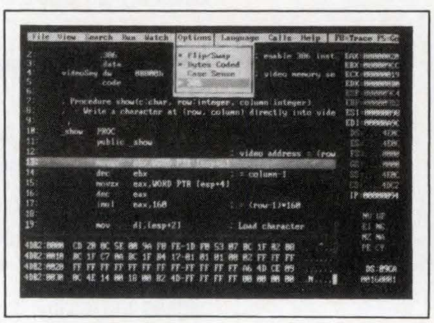
PARSER

- *Generates language translators in C or Pascal*
- *Automatically constructs syntax trees*

QParser+ is an enhanced version of a productivity tool for the development of computer languages and language translators such as compilers, assemblers, interpreters, and complex user interfaces. The program can construct a syntax checker, written in either C or Pascal, that is based solely on a set of syntax rules that define the language. It automatically places the verified input-language elements in a syntax tree; you can then easily write a recursive tree-walker that will walk through all the tree's leaves and generate code in the target language. A sample tree-walker comes with the program. The manual provides several sample translators (including a compiler, an assembler, an interactive calculator, and a simulator) that help you understand the principles of translation. PC-DOS version, $475; VAX site license, $2000.

QCAD Systems Inc, 1164 Hyde Ave, San Jose, CA 95129. Phone (408) 995-6884.

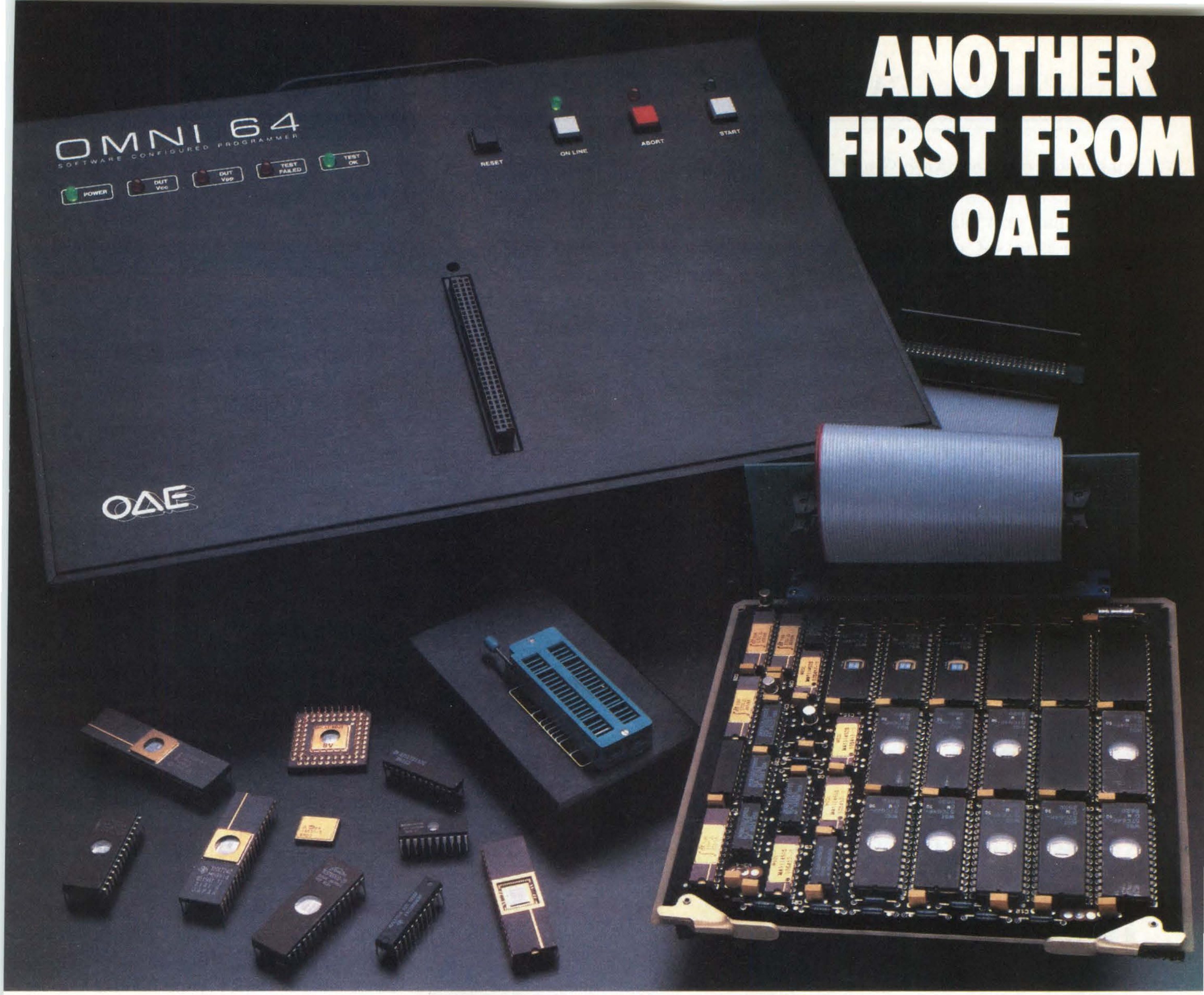
Circle No 438



80386 MACROASSEMBLER

- *Lets you program for the 80387 numeric coprocessor*
- *Has source-level debugger that provides multiple windows*

Macro Assembler version 5.0 has enhancements that allow you to program the 80386 μP and 80387 nu-



One OMNI can program *and test* everything from micro-power PLDs to fully populated PC boards.

The Ultimate Programmer. OAE has drawn upon 12 years of research and manufacturing experience to develop the ultimate software configured programmer.

The OMNI combines ***high-power, high-resolution,*** software configured pin drivers with a huge database of PROMs, EPROMs, EEPROMs, EAROMs, PLDs, microprocessors and ASICs (Application Specific ICs) to eliminate costly and outdated configuration modules and programming adapters.

The OMNI's patented pin drivers let you program and test more devices than any other system. The OMNI provides ***unlimited support*** from bipolar diode arrays to micro-power CMOS PLDs like the HPL-16LC8. And now you can program hybrid modules and complete PC boards with the OMNI 64.

Want to enter your own test and programming parameters? Just use the optional parametric editor to screen every device programmed to your own specifications.

- 100% Software Configured.
- Fast, high voltage, high current pin drivers can supply +-1.5A continuous to +-10A peak at each pin.
- Over 4,000 steps of voltage and current resolution and *sub*-nanosecond timing resolution.
- 100% laser trimmed for high speed and accuracy. No calibration is ever required.
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CIRCLE NO 221

meric coprocessor. According to the vendor, this version runs 25 to 40% faster than previous versions. It features a new set of segment directives that reduces the amount of time you have to spend on segment setup, and it has completely new documentation, which includes a mixed-language programming guide. DOS-interface macros make it easier to request operating-system services, and command-line options allow you to set "define" symbols and warning levels on the command line. The package includes a multiwindow source-level debugger, a library manager, an overlay linker that runs twice as fast as its predecessor, and other utilities that simplify assembly-language program development. In order to run the macroassembler, you'll need DOS 2.0 or higher and an IBM PC or compatible with at least 256k bytes of RAM and two double-sided floppy-disk drives or a hard disk. $150.

Microsoft Corp, Box 97107, Redmond, WA 98073. Phone (206) 882-8080. TLX 328945.

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Aptos Systems, 10 Victor Square, Suite 200, Scotts Valley, CA 95066. Phone (408) 438-2199. TLX 3710387.

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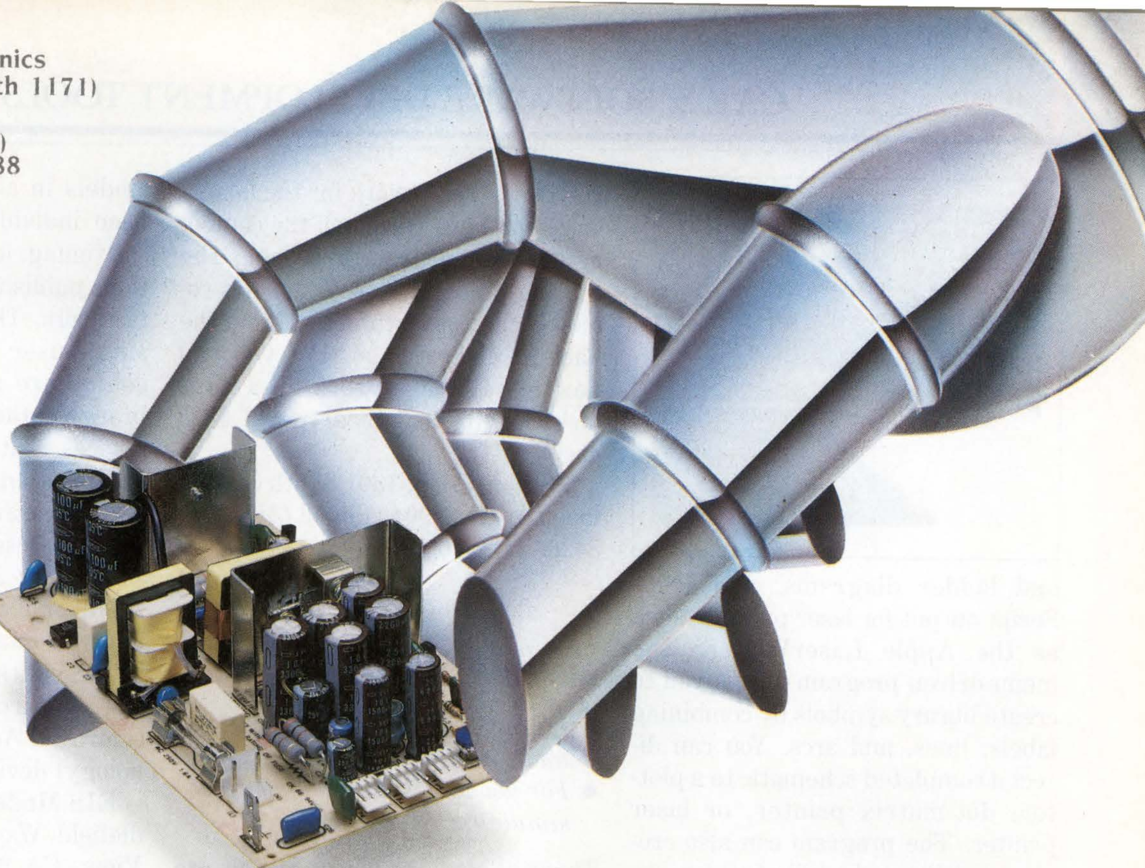

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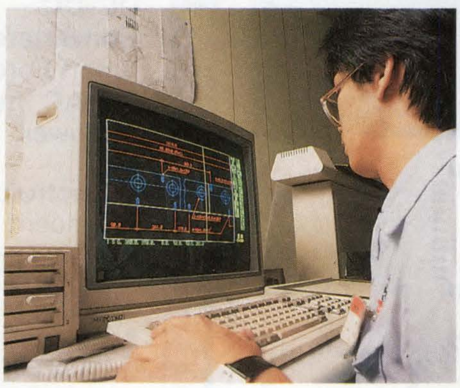

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and ladder diagrams, and PostScript output for laser printers such as the Apple LaserWriter. The menu-driven program allows you to create library symbols by combining labels, lines, and arcs. You can direct a completed schematic to a plotter, dot-matrix printer, or laser printer. The program can also create a net list and a bill of materials, and it provides cross-checking utilities. Smartwork is a pc-board design package that accepts net lists created by Hiwire and that helps you generate artwork for the board. Once you have placed all the components, the autorouter finishes the routing process. The vendor has removed the copy protection from the backup diskette, so that you can now install Smartwork on a hard disk. Hiwire and Smartwork, $895 each.

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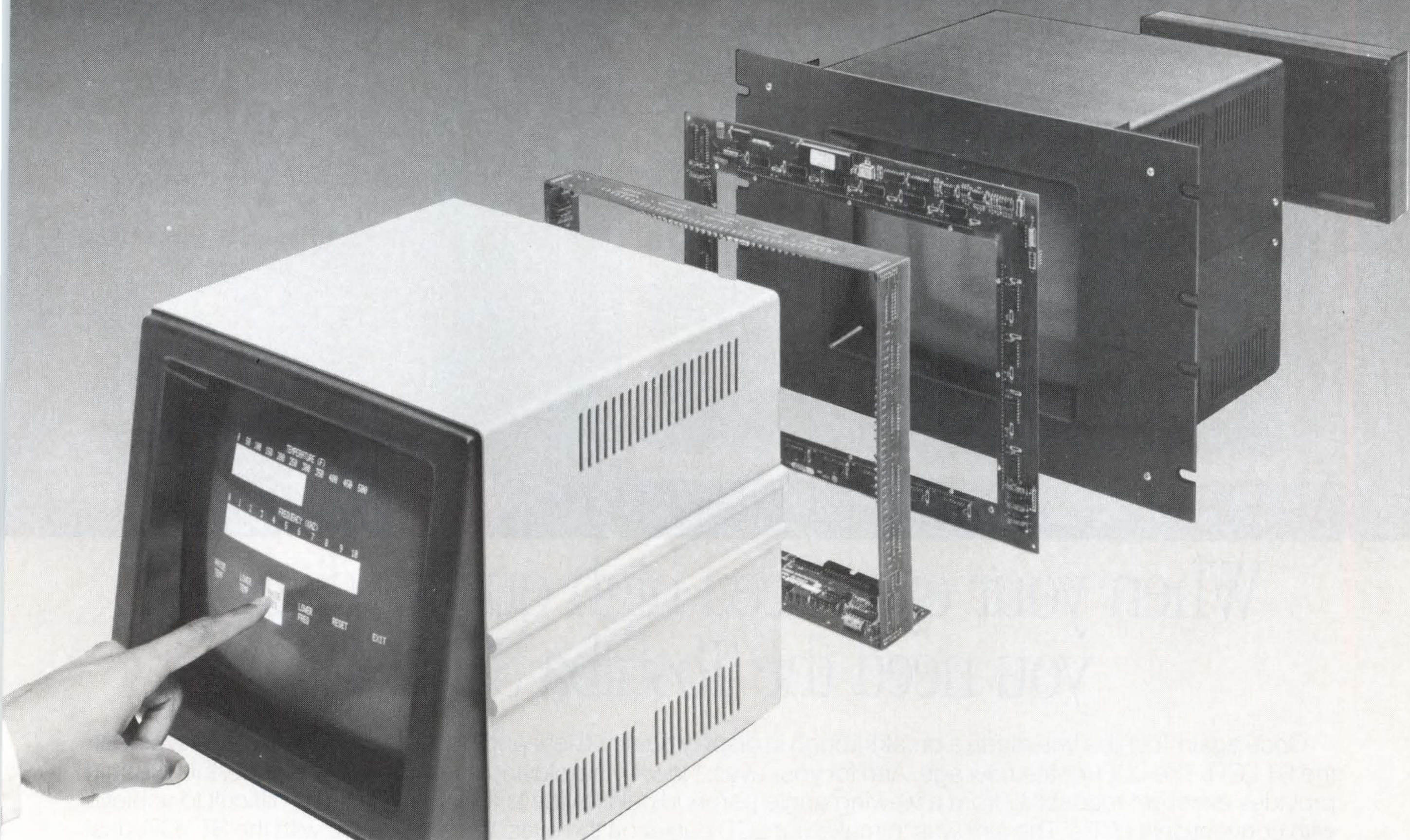

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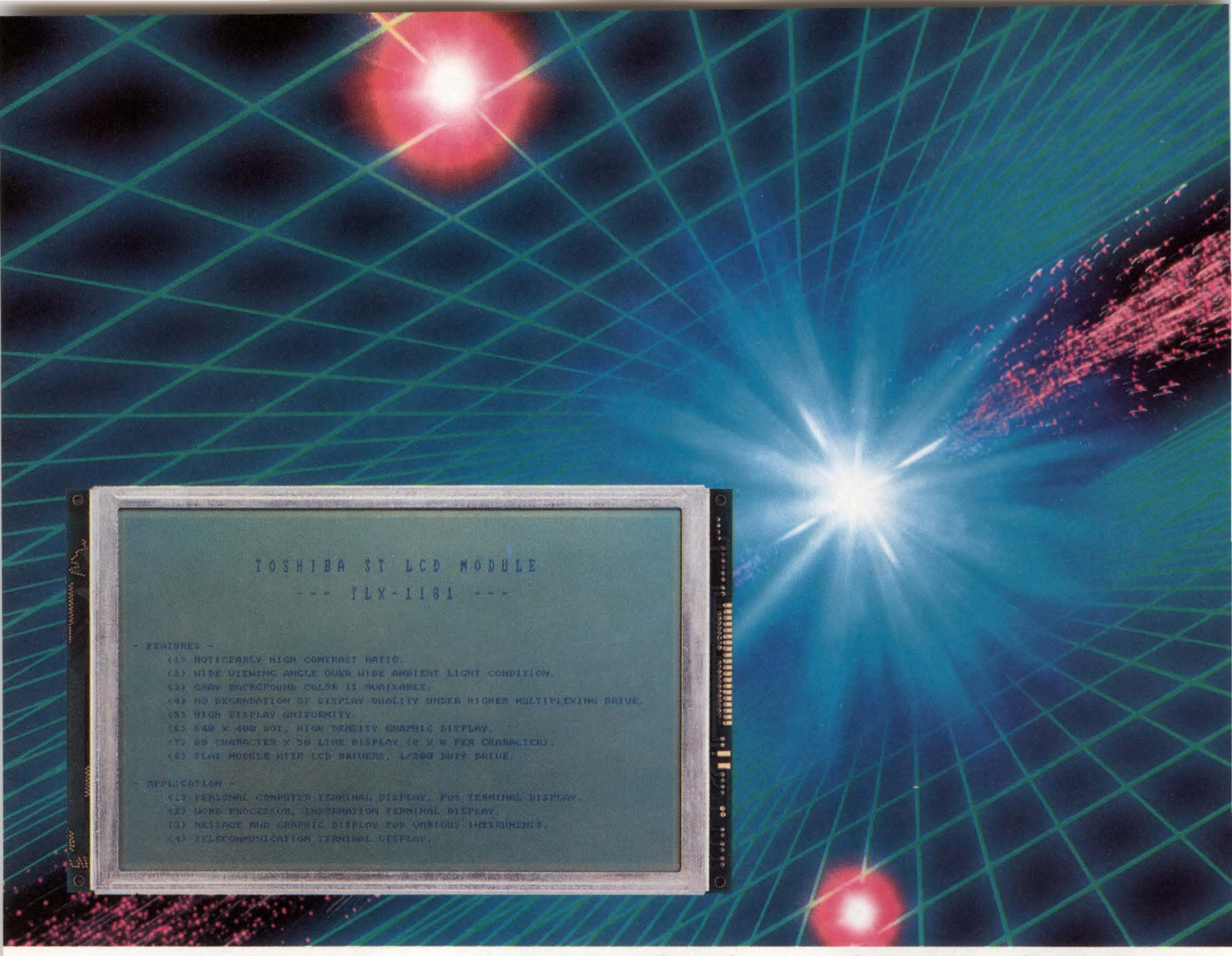

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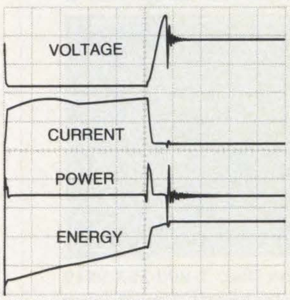

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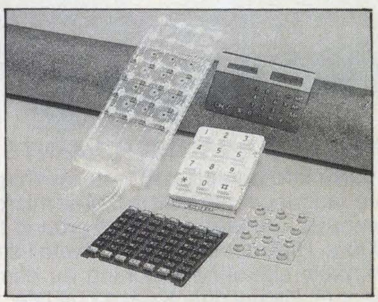

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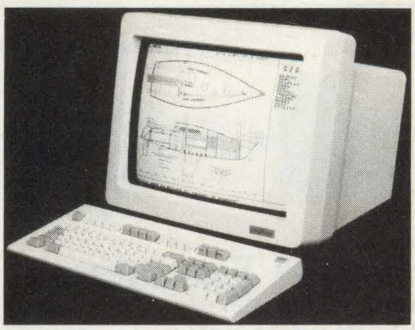

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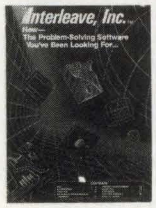

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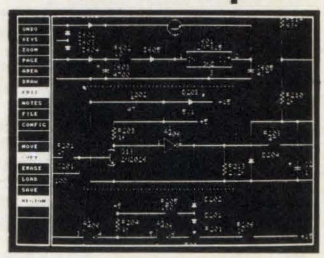

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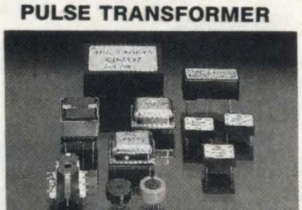

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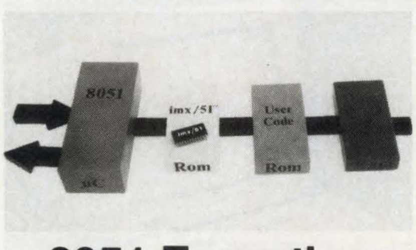

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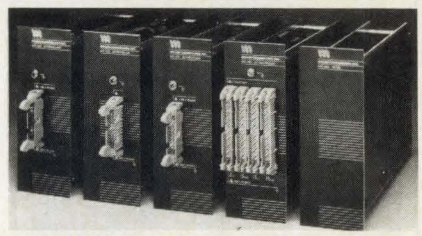

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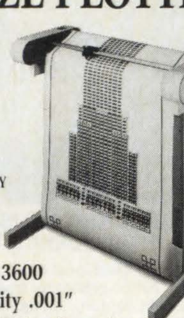

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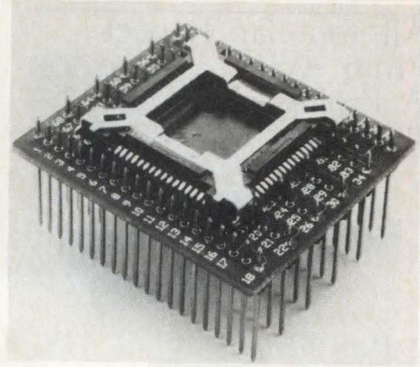

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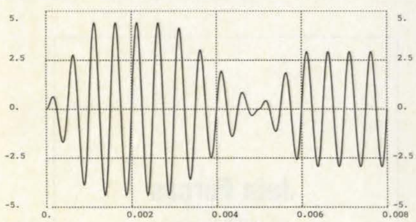

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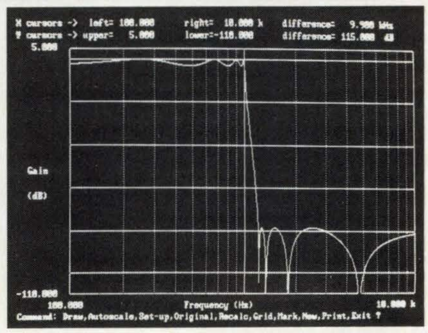

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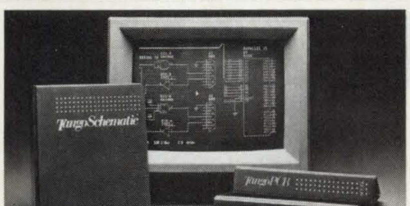

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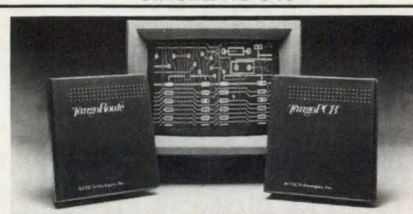

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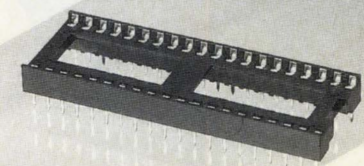

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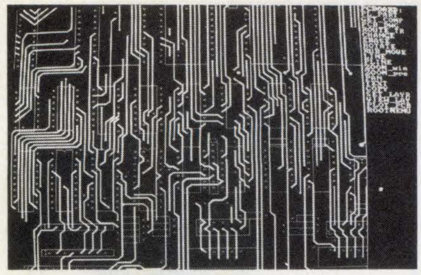

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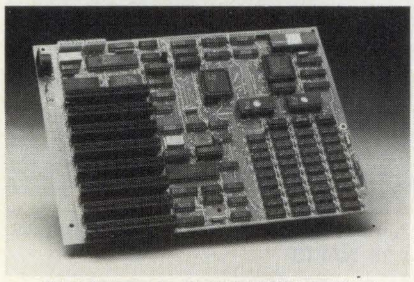

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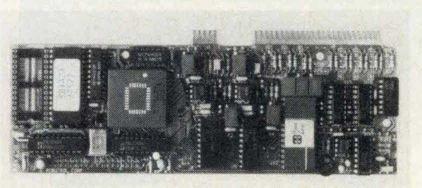

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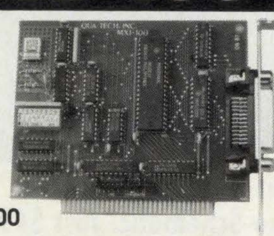

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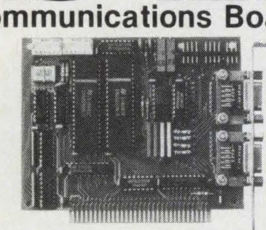

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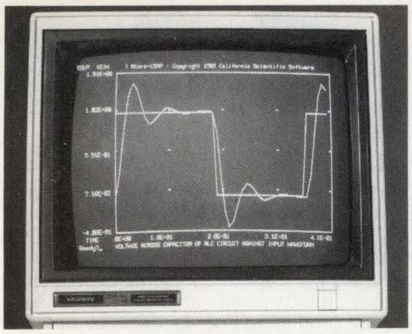

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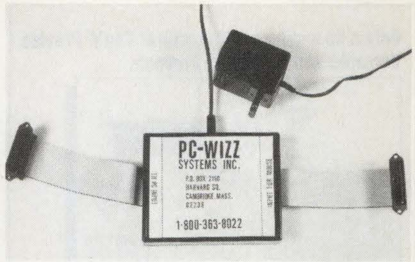

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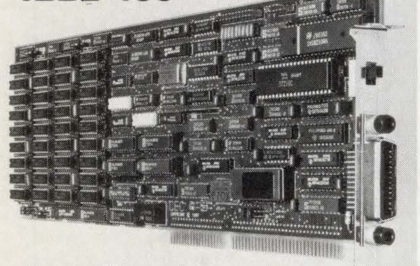

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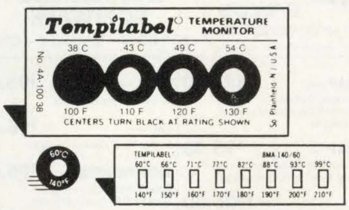

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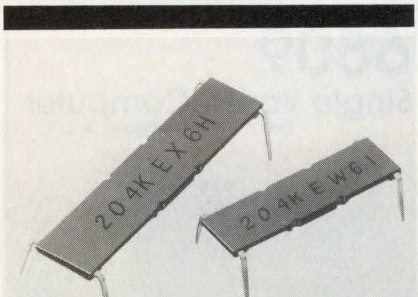

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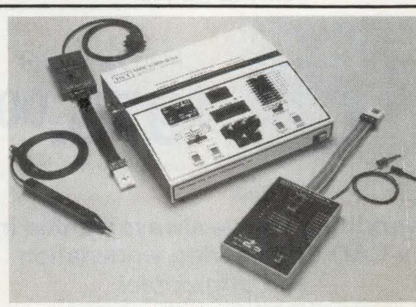

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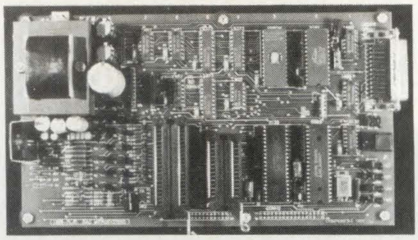

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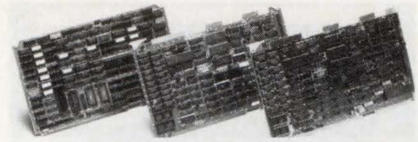

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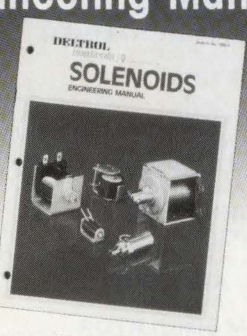

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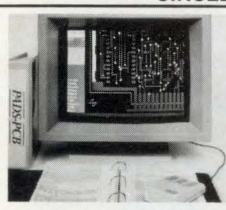

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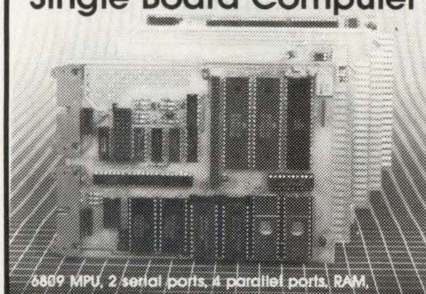

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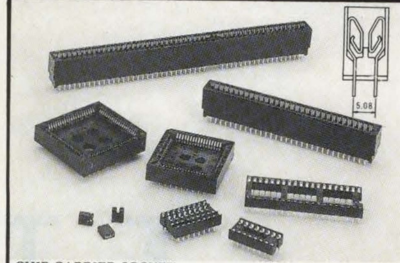

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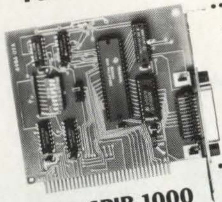

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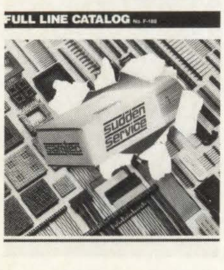

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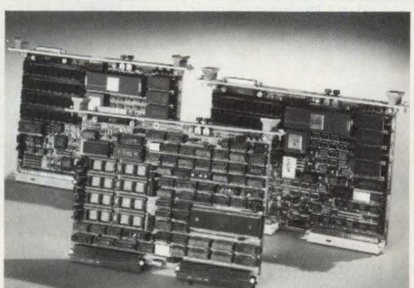

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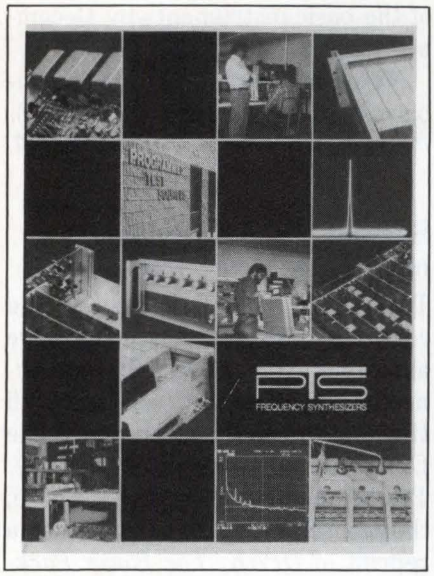


Frequency synthesizers described

This 20-pg, 4-color catalog provides general information about frequency synthesizers and outlines their characteristics. It lists specifications for the product line and provides illustrations of each device. The back of the catalog includes ordering information; data sheets for the company's newest models are also included.

Programmed Test Sources Inc, Box 517, Littleton, MA 01460.

Circle No 443

Reference offers solutions for measurement and control

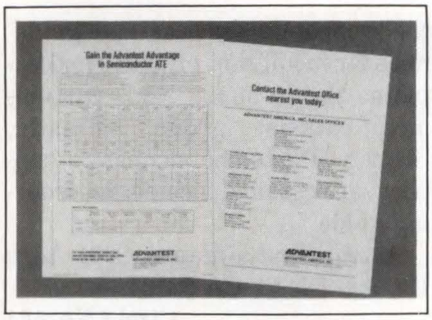
The first edition of *Applications Notebook: The Total Solution for Measurement & Control* is an 86-pg reference publication that's divided into four major sections. Section A provides reference tables with a Fahrenheit to Celsius temperature-conversion chart and mathematical and physical constants and formulas. Section B presents 1-pg application solutions to problems in temperature, flow, resistance, fluid level, and other process measurements; a system block diagram accompanies each application. Section C includes the company's services and guidelines for modifying products and explains the in-house R&D custom-modifications group. Finally, Section D lists the company's support services, and includes an ordering guide.

Action Instruments, 8601 Aero Dr, San Diego, CA 92123.

Circle No 444

Complete listing of semiconductor ATE

The *Advantest Semiconductor ATE System Selection Guide* summarizes the company's entire line of semiconductor automatic test equipment. It shows the compatibility of the company's test systems, as well as the wide range of systems that are available for testing VLSI, analog, memory, and mixed-signal semiconductor devices. Individual charts for each device's testing category allow you to make cross-refer-



ences to system test rates and model numbers.

Advantest America Inc, 300 Knightsbridge Parkway, Lincolnshire, IL 60069.

Circle No 445

Pamphlet on transceivers

The 6-pg brochure features MIL-STD-1553 single-channel transceivers in ±12, 5, ±15, and 5V versions. It discusses low-power dissipation, receiver-output logic options for encoder/decoder compatibility, third-order balanced-receiver input filtering, short-circuit protection of transmitter outputs, and a programmable transmitter thermal-shutdown option. Detailed specifications, schematics, outline drawings, and ordering instructions complete the write-up.

Stantel Components Inc, 636 Remington Rd, Schaumburg, IL 60173.

Circle No 446

Brochure highlights electronic products

This 4-color brochure (Publication No 5953-7040) presents information on 22 basic electronic measuring instruments that are grouped into four types: digital multimeters; counters; pulse and function generators; and power supplies. Included in the leaflet are brief product descriptions, specifications, and prices. A free HP-28C calculator is available with an order of any three of the basic instruments by December 15, 1987.

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

Circle No 447

Surface-mount versions of discrete devices discussed

This literature kit describes the company's discrete devices that are available in the DPAK surface-mount package. It combines all the technical literature on the DPAK products into one package. The kit includes the DPAK Update; the Surface Mount Selector Guide; a reprint of *DPAK, The Power Package For Surface Mount*; a tape-and-reel data sheet for surface-mount devices; and DPAK product data sheets.

Motorola Inc, Literature Distribution Center, Box 20924, Phoenix, AZ 85063.

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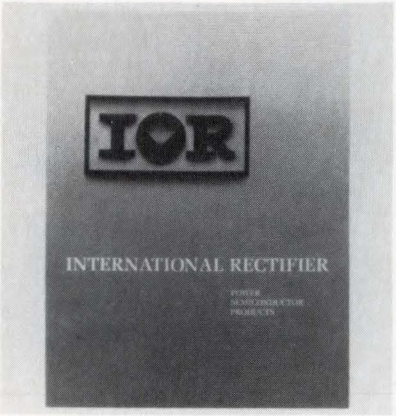


Catalog of power semiconductors

The 144-pg *Power Semiconductor Catalog* covers the company's range of products. It provides tables with key specifications for each product type, accompanied by drawings and dimensions for each package. The products covered include HexFET power MOSFETs; Schottky rectifiers; ultrafast recovery diodes; standard- and fast-recovery rectifiers; phase-control, inverter-type, and gate turn-off thyristors; power modules; military/government and custom products; and custom/standard assemblies, such as heat sinks and mounting hardware. Other sections include available literature, product cross-references, a JEDEC/alphanumeric index, and descriptions of quality/reliability programs.

International Rectifier, 233 Kansas St, El Segundo, CA 90245.

Circle No 449

Guide to software and services

The Directory of Micro Engineering Software/Services provides detailed information about engineering software and associated services. The book, divided into 27 sections, contains more than 700 microengineering packages and furnishes more than 250 company descriptions. The packages are grouped into sections by their engineering function, such as civil engineering, CAD, mechanical engineering, or structural/stress analysis. The book provides you with system requirements, pricing, and maintenance/support information. The company descriptions include market emphasis, types of services provided, sales volume, geographical area serviced, and principal contacts. The directory also includes a product index, which lists packages in alphabetical order; a vendor index that helps you determine which packages and services a vendor offers; and a service index that cross-refers the service vendors according to the type of service offered and the market area serviced. $239.

Decision Graphics Inc, 555 Sparkman Dr, Suite 652, Huntsville, AL 35816.

INQUIRE DIRECT

Listing of test and measurement instruments

This 64-pg catalog presents more than 1400 products from A W Sperry, Amprobe, B&K Precision, Check-It, Fluke, Simpson, TIF, and Yokogawa. Among the products listed are leak detectors, counters, generators, oscilloscopes, a variety of meters, and power supplies. The products described fill the requirements of HVAC (heating, ventilation, and air conditioning), refrigeration, automotive, electronic, electrical, and industrial users.

W W Grainger Inc, 1250 Busch Parkway, Buffalo Grove, IL 60015.

Circle No 451

Reference set details HCMOS programming

The M68HC11PM/AD, a Programming Reference Manual, is the basic software reference document for the MC68HC11 family of high-speed, CMOS single-chip μC devices. Besides general information, it presents descriptions of CPU register and addressing modes, instruction-set details, cycle-by-cycle CPU bus activity, and miscellaneous conversion tables. The MC68HC11-A8RG/AD, a pocket programming reference guide, includes sections on programming models, crystal-dependent timing, interrupts, memory and opcode maps, addressing modes, execution times, Hex/DEC conversions, and an ASCII chart.

Motorola Inc, Microprocessor Products Group, 6501 William Cannon Dr W, Austin, TX 78735.

Circle No 452

Document explains software system

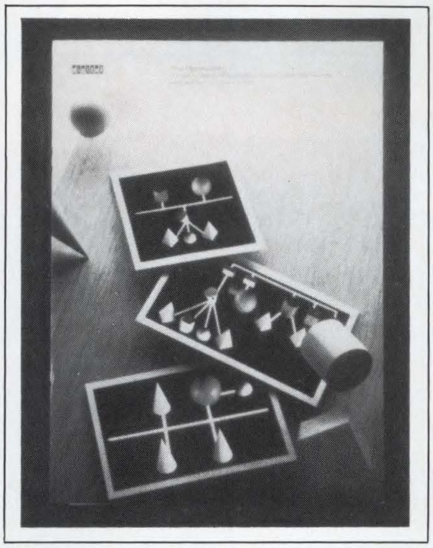
This 4-pg, 4-color brochure presents an overview of the company's Opera software system, a project-management risk-analysis program for the IBM PC, PC/XT, PC/AT, and compatibles. The publication sums up the package features, lists the hardware/software requirements, and contains drawings of sample screens.

Welcom Software Technology, 1325 S Diary Ashford, Suite 125, Houston, TX 77077.

Circle No 453

Literature package has app notes, product guide

This package of publications comprises four application notes, a VAXBI Third-Party Directory, and a product guide entitled, *New Opportunities*. The notes explain how the vendors products interact with other companies' products to make manufacturing tasks easier. The directory lists tool and service vendors and licensed option vendors.



Finally, the guide describes the company's microcomputer systems, local-area networks, and local-area VAX-cluster systems.

Digital Equipment Corp, Channels Marketing Group, 2 Mount Royal Ave, Marlborough, MA 01752.

Circle No 454

Networking system described in brochure

This CADDSnetwork pamphlet presents the networking capabilities of the CADDStation family of CAE/CAD/CAM workstations. It describes the data highway that allows access to computers from IBM and Digital Equipment Corp, as well as from the company. At the CADDStation level, networking is enhanced by windowing, which allows simultaneous access to Unix, IBM's VM, Digital Equipment's VMS, and the design data base.

Computervision, Dept 615, 100 Crosby Dr, Bedford, MA 01730.

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Attending graduate school via videotape

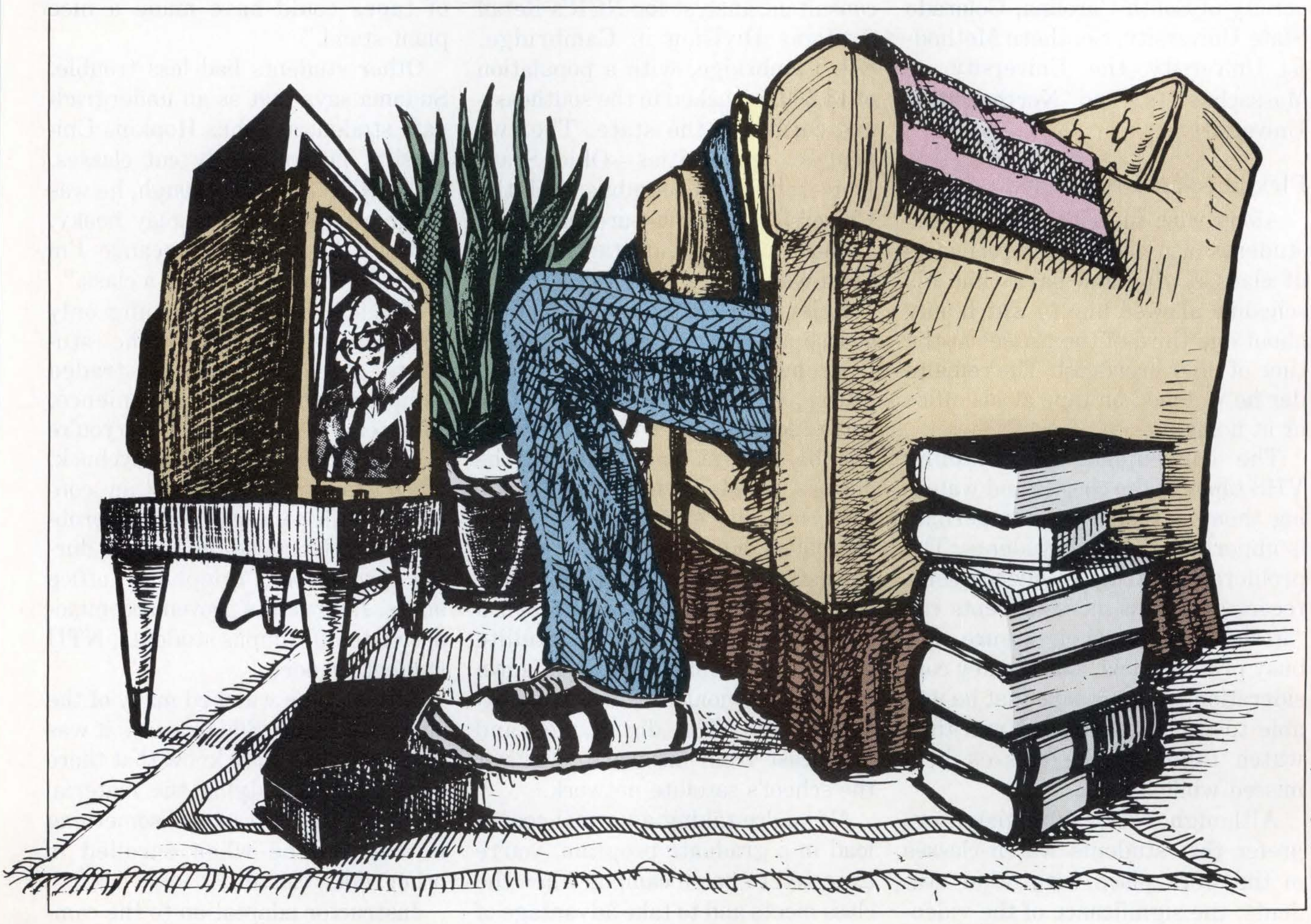
Deborah Asbrand, *Associate Editor*

National Technological University pushed video education a step forward in 1983 when it assembled the best video courses from 19 universities, packaged them into advanced-degree engineering curricula, and began beaming them via satellite to corporate work places. Video education was nothing new, but NTU's plan was: It would offer technical professionals a way to study and earn graduate degrees at some of the nation's most prestigious universities without ever having to leave the work place.

Now, four years later, NTU is producing its first graduates. Eight students have been graduated, and more will follow as the school's enrollment climbs. This academic year, NTU expects 2000 students to register for courses. In August, NTU was accredited by the North Central Association of Colleges and Schools.

With an average of nine to 11 NTU classes to their credit, graduates are well versed in the intricacies of study via videotape. NTU alumni say the school's compilation of courses from nearly two dozen universities lets students customize their educations. They also report that the option of watching classes on videotape allows them to adjust their "in-class" time to their schedules. But video teaching still has some bugs in it, including classrooms ill-suited to filming, camera-shy instructors who mumble or write on the board in letters too small to read, and slow distribution of course handouts and homework.

Ram Sudama was graduated from NTU in June, when he received a master's degree in computer science with a concentration in artificial intelligence. Sudama, a consultant en-


Denise St Germain

gineer for Digital Equipment Corp's Littleton, MA, distributed systems architecture and advanced development facility, considered graduate study for some time before finally taking the plunge, investigating local schools such as Boston University, the Massachusetts Institute of Technology, and the University of Massachusetts at Amherst.

To pass the time while he decided where to apply, Sudama enrolled in an NTU course in advanced data structures that was taught at the University of Minnesota. The course's content impressed him, and he decided to pursue a degree via NTU. "The selection of courses was much broader than at the other schools I was thinking of attending," he says. "In artificial intelligence, for example, they have 15 to 20 course offerings. Most universities . . . have two or three." Sudama took courses from the University of South Carolina, Colorado State University, Southern Methodist University, the University of Massachusetts, and Northeastern University.

Flexible class attendance

Along with the videotapes, NTU students also watch live broadcasts of classes. Sudama says that his schedule allowed him to watch only about one-third of the classes at the time of their broadcast. The remainder he watched on tape at his office or at home.

The convenience of obtaining VHS tapes of the classes and watching them as their schedule permits is important to NTU students. The proliferation of home videocassette recorders means more students can "attend class" at their leisure. For busy professionals, this is a key consideration. Sudama says that he was able to travel as planned and then watch tapes of the classes he'd missed while away.

Although NTU administrators prefer that students watch classes in the work place with other students, the significance of the videocassette option is not lost on them: They understand that work and family responsibilities often make it difficult for adults to attend classes presented at a particular time. "I don't think you could have a satellite network without VCRs," says NTU president Lionel Baldwin. "You're dealing with busy adults and their chance of being able to attend every class is nil."

The proliferation of videocassette recorders means more students can "attend class" in the comfort of their own homes.

For individuals employed in rural areas, such commute-less classes are ideal. Michael Reiss works as a consultant analyst for NCR's Retail Systems Division in Cambridge, OH. Cambridge, with a population of 13,500, is tucked in the southeastern corner of the state. The two nearest universities—Ohio State University in Columbus and the University of Akron—are more than 75 miles away. A videotaped curriculum was perfect for him.

Reiss watched all of his first course at his work site. But by the time he enrolled in his second course, he'd purchased a videocassette recorder and so began watching the tapes at home. Viewing the classes in his living room made studying more convenient, and thereafter he took two courses per semester. In November 1986, he became the first student to earn a master's degree via satellite courses. He donned a cap and gown for the ceremonies, which were attended by NTU dignitaries and broadcast from his work site over the school's satellite network.

"If you're taking a normal course load in a graduate program, you're expected to be on campus when the class meets and to take advantage of the lab hours when they're available," says Reiss, who earned a degree in computer engineering. "The best thing about [NTU's] program is that you're not tied to a schedule."

Videotaped classes also let a student study at his or her own pace. "If I didn't understand something that was said," remarks Sudama, "I could back it up and listen again. If I knew the material being covered, I could fast forward the tape."

The freedom that comes with attending classes at one's own convenience can cause trouble for some students. "The danger is it's really easy to let those tapes pile up," says Paul Melnychuck, a research scientist for Eastman Kodak in Rochester, NY. "I sometimes had to spend a whole Saturday catching up." Melnychuck, who graduated last June with an MSEE, won't reveal the number of classes by which he fell behind, but says that "the stack of tapes could have made a nice plant stand."

Other students had less trouble. Sudama says that as an undergraduate student at Johns Hopkins University, he frequently cut classes. As an NTU student, though, he was never even tempted to play hooky. "I don't know if it's because I'm older, but I never missed a class."

The solo style of learning only occasionally distracted the students. Most felt that they traded companionship for convenience. "You tend to be a loner when you're a video student," says Melnychuck. Most graduates say that they consulted with colleagues about problems, or telephoned the teacher during prescribed telephone office hours. Instructors proved accommodating to off-campus students, NTU students report.

Although he watched many of the classes at home, Sudama says it was important to him to know that there were others studying the material at the same time as he, something he had missed when enrolled in other video classes.

Instructor adaptation to the camera, however, was inconsistent. Some of the professors were consummate video lecturers and enhanced their classes with the use of transparencies and other video teaching tools. But other problems cropped up. "A few of the schools had lighting problems, or a professor wrote on the blackboard and then wound up blocking it," says Melnychuck, who withdrew from one class because of poor audio and video conditions. Sudama reports that occasionally professors made pertinent remarks after class and thus put the video students at a disadvantage.

New challenges for teachers

For their part, instructors admit that teaching off-camera students presents a challenge. Their lectures must be timed to end as scheduled; it's not possible to hold the class late if the professor hadn't covered all of the material he'd planned. Class materials and exams have to be prepared in advance to allow time for their mailing to off-camera students. Teaching on camera "is twice the amount of work," says Ronald Bonnell, a University of South Carolina professor who has taught video classes since 1970. "You have to be very organized. Most instructors won't wing it in a TV class. They're being taped for posterity, so they come prepared."

Interested in experiencing a video class from the students' end, Bonnell enrolled in one. "I wanted to see what it was like," he says. "I took 27 hours of class to get a feel for what students were going through. I actually liked it much better than I thought I would. I liked the idea that if I had 45 minutes free, I could sit down and watch it." Bonnell's research is evident in his teaching methods, says Sudama, who rated the instructor's course in expert systems as one of the best that he took.

Some professors, though, enter class unprepared to meet their off-camera students' needs, which has led various schools to train their faculty to use the camera to their best advantage. "We discovered they needed to know more about the new environment in which they were operating," remarks Dan Harrell, director of engineering extension at North Carolina State University. "We wanted the professors in our courses to look as professional as [possible]."

The solo style of learning only occasionally distracted the students. Most felt that they traded companionship for convenience.

After watching the filmed classes, the college made some changes in its procedures, says Harrell. For starters, it replaced the traditional blackboard with a white board. "It didn't make sense to use the blackboards," he says. "If you're always talking to the blackboard, the audio isn't good. And once you go through one erasure, the board becomes very cloudy looking." The school also installed special lighting, a microphone, an overhead camera that focuses on a desktop writing pad, and a light pen with which instructors can highlight slides.

Roll the cameras

The University of Maryland sets aside one evening at the beginning of each school year to introduce new faculty members to the equipment in its four video classrooms. The school annually broadcasts more than 100 courses, mostly in electrical engineering and computer science, and the classrooms are used more than 60 hours each week. "The biggest barrier we face in training these people is that they are terrified," says Susan Kromholz, assistant director of the university's instructional-TV system. "They don't like the way they look, and they're afraid their bald spot is going to show." Engineering professors, used to writing long equations that span an entire blackboard, must adapt their presentations. "And that takes work," says Kromholz.

Such work results in much better classes. Students say it's obvious which schools take the time to train instructors in video presentations. The quality of each professor's on-camera teaching skills is up to him and to his university; NTU's role is to facilitate the broadcast of the courses. But NTU polls its students on classroom conditions within the first two weeks of each semester so that it can take action should a course get off to a rocky start.

When polling began in the fall of 1986, 16% of the students rated course video and audio quality as unsatisfactory. Seventeen percent complained that they had not yet received the syllabus, and 40% reported that they were not receiving class handouts in a timely manner. By last spring, students' ratings of the classes had improved. Although 17% of the students still rated the picture quality as unsatisfactory, more deemed the audio quality satisfactory and found the turnaround time on mailed class materials acceptable.

In many ways, NTU students are more committed to academics than are their counterparts at traditional institutions of higher learning. They enjoy none of the amenities of the conventional student: NTU has no student organizations or activities, no library or cafeteria, no campus bookstore. Says Melnychuck: "If you want to be in a university and watch a football team on Saturdays, that's not NTU." **EDN**

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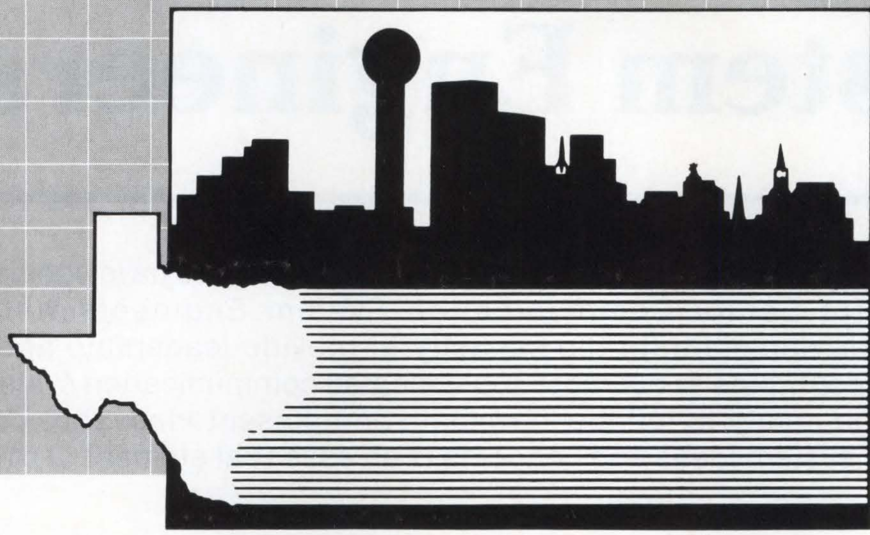

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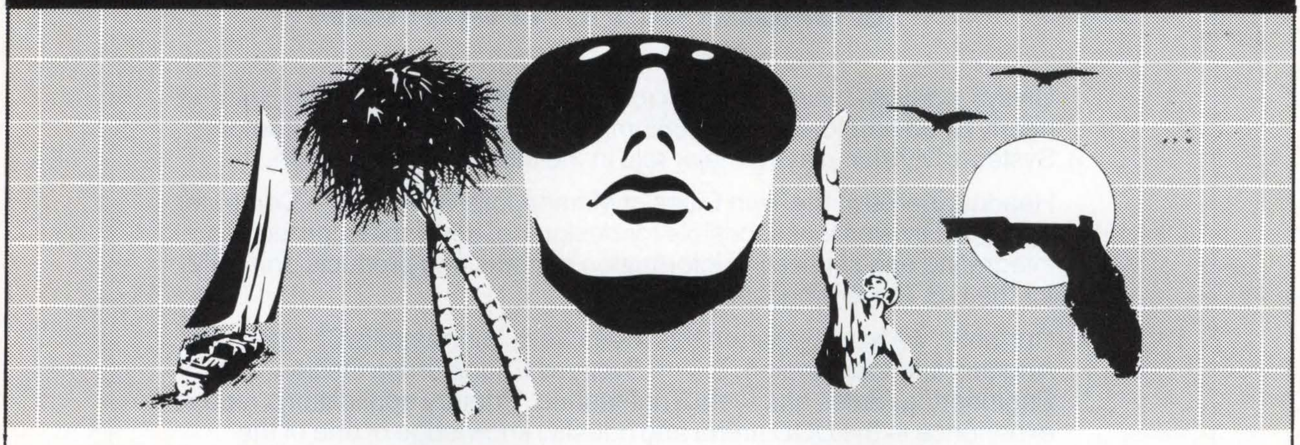

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Professional Profile

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Location (City, State) ______________________

Business Phone if O.K. to use: ______________________

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Degrees (List)	Major Field	GPA	Year Degree Earned	College or University

POSITION DESIRED

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EXPERIENCE

Present or Most Recent Position From: ______ To: ______ Title: ______________________

Duties and Accomplishments: ______________________ Industry of Current Employer: ______________________

Reason for Change: ______________________

PREVIOUS POSITION:

Job Title: ______________________

Employer: ______________ From: ______ To: ______ City: ______________ State: ________

Division: ______________ Type of Industry: ______________ Salary: ________

Duties and Accomplishments: ______________________

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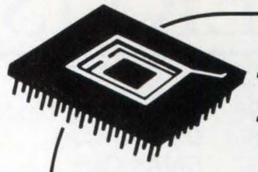

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Phil F. Walters
Marketing Director
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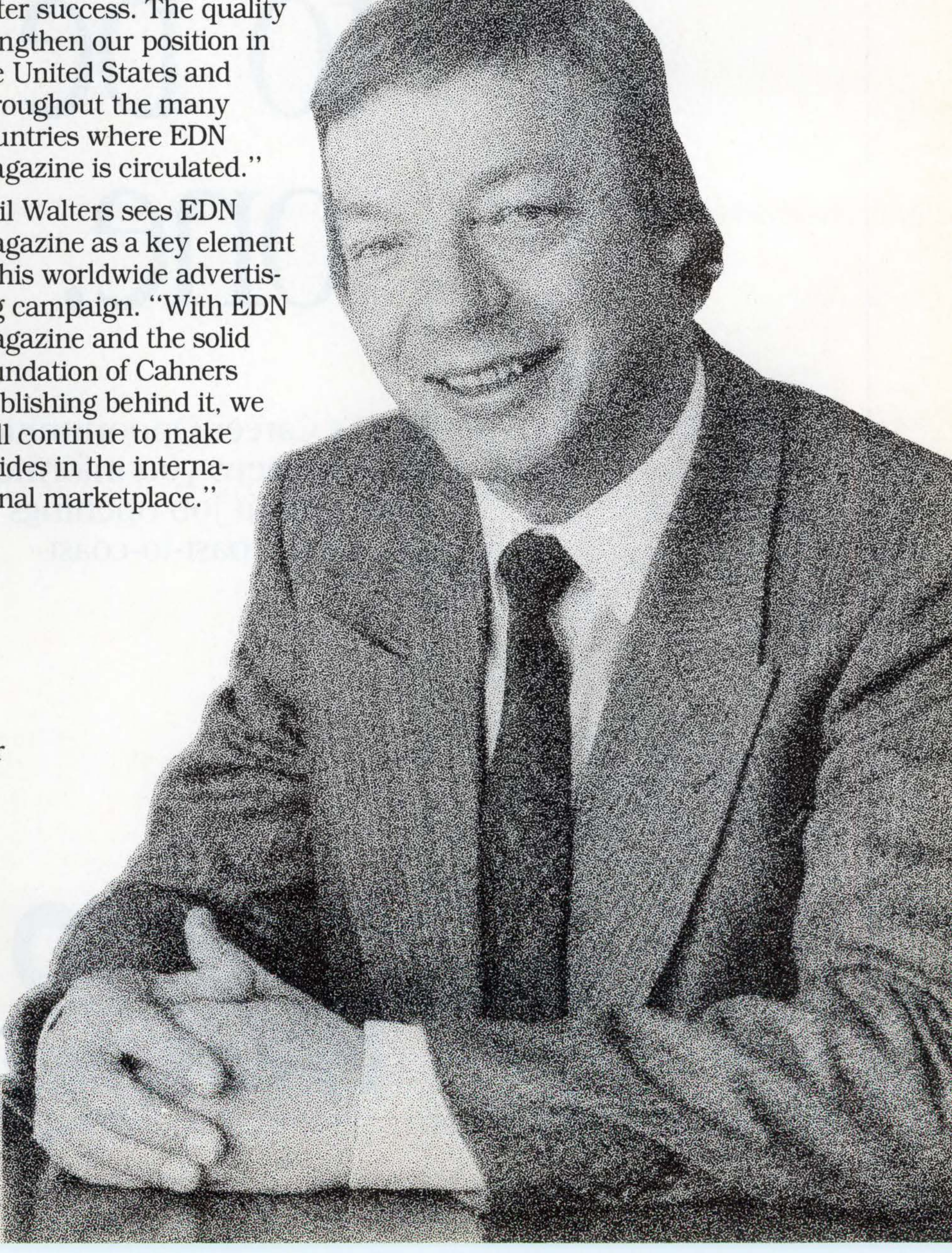
Phil Walters sees EDN magazine as a key element in his worldwide advertising campaign. “With EDN magazine and the solid foundation of Cahners Publishing behind it, we will continue to make strides in the international marketplace.”



Advertising in EDN magazine works for Hunting Hivolt. It can work for you.

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EDITED BY CYNTHIA B RETTIG

US PACKET-SWITCHING SERVICE REVENUE BY APPLICATION
($ MILLION)

	1987	1989	1991
TIMESHARING	$197	$205	$200
DATABASE ACCESS	150	300	455
SEMIPRIVATE ACCESS	180	297	400
ELECTRONIC MAIL	57	96	158
POS	9	30	90
EDI	7	30	94
INTERNATIONAL	50	110	185
LOCAL	NEGLIGIBLE	10	30
TOTAL	$650	$1078	$1612

(SOURCE: INTERNATIONAL RESOURCE DEVELOPMENT INC)

Short boom in store for packet-switching industry

The packet-switching services and systems market might experience substantial, imminent growth, predicts International Resource Development Inc (IRD). As a result of changes in US data communications, revenues for packet-switching enterprises could reach $1078 million by the end of 1989. However, the New Canaan, CT, market-research firm warns vendors that the market will peak by 1991 and thereafter face strong competition from new products, technologies, and price developments. By the end of the century, packet-switching commerce should recede to a lower but stable plateau, supported by military and specialized applications.

Packet-switching systems and services have just recently begun to enjoy sanction by IBM for use with its teleprocessing equipment here and in Canada, a development that allows packet networks to interface with a much greater array of products. The introduction of IBM's Systems Application Architecture (SAA) and its related products has given Systems Network Architecture (SNA) users a choice, IRD points out. SAA software permits mixed interconnection of products and thus provides a wider selection of lower-cost transmission techniques, including public packet-transmission services and private packet networks. Other actions by and new products from major telecommunications-equipment manufacturers have also simplified the operations of mixed-media data-communications networks.

Two developments will constitute the major threats to packet switching's market position within the next few years. Because of recent dramatic advances in fiber-optic technology, fiber-optic networks should proliferate, seriously challenging the price structures of basic long-distance transmission services by 1991. Furthermore, the movement of public telecommunications networks toward ISDNs (Integrated Services Digital Networks) seems to be threatening the cost advantages of packet switching. Although the effects of this trend on packet markets will depend on the tariffs for different services based on ISDNs, marked changes should occur in both European and US markets by 1992.

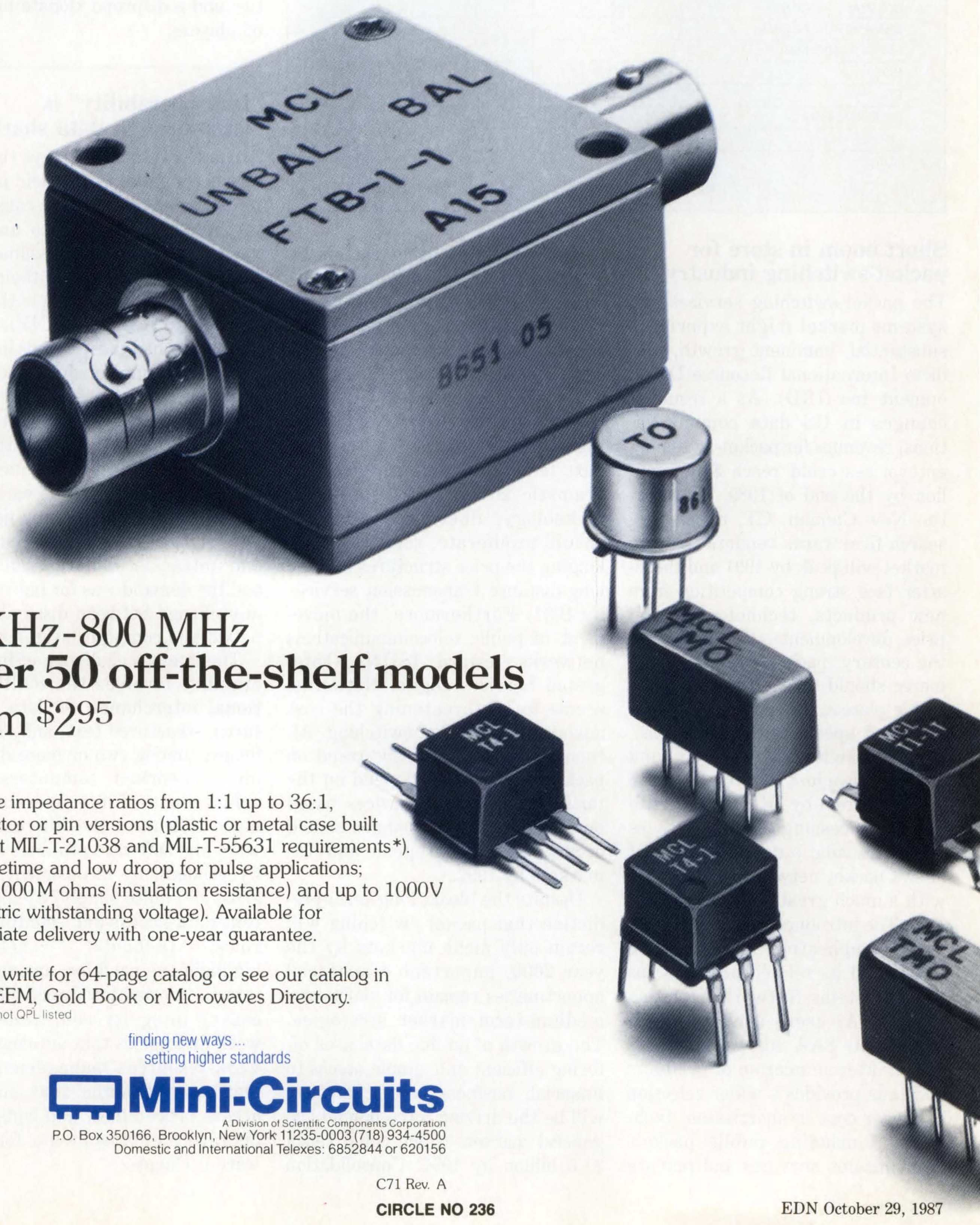
Despite the bleak, long-term prediction that packet switching will retain only niche markets by the year 2000, important commercial opportunities remain for short- and medium-term market strategies. The growth of on-line databases offering efficient and simple access to financial, business, and legal facts will be the driving force behind the general market, which could reach $1.6 billion by 1991. Consolidation and mergers seem both inevitable and expedient in the industry, which IRD characterizes as possessing clearly defined market possibilities and a disproportionate number of players.

"Interoperability" is watchword in data sharing

Advancements in the ways that different computers and their peripherals exchange data have caused interchange techniques to undergo various phases and to assume complicated names suited to their more difficult tasks. According to the Diebold Group (New York, NY), which has researched these trends in order to forecast further developments, *interoperability* presents the current challenge. The compatibility and portability sought in the 60s and 70s gave way to a quest for interconnectibility in the early 80s. During those years, the subjects of interchange were character streams and untranslated data structures, and the demand was for bidirectional exchange between dissimilar and networked computer systems.

The late-80s challenge of interoperability involves the multidirectional interchange of data structures, structured text, and encoded images among two or more dissimilar, networked computers. The achievement of interoperability is made difficult by the different hardware and software products offered by vendors, by inconsistent standards, and quite simply, by inconsistent data-access and -modification rules. Diebold's conclusions highlight the need for, among other things, information directories that convey integrity contraints, network directories that automate network-resources management, object-based designs that simplify access procedures, and consistent operating environments for software packages.

RF transformers



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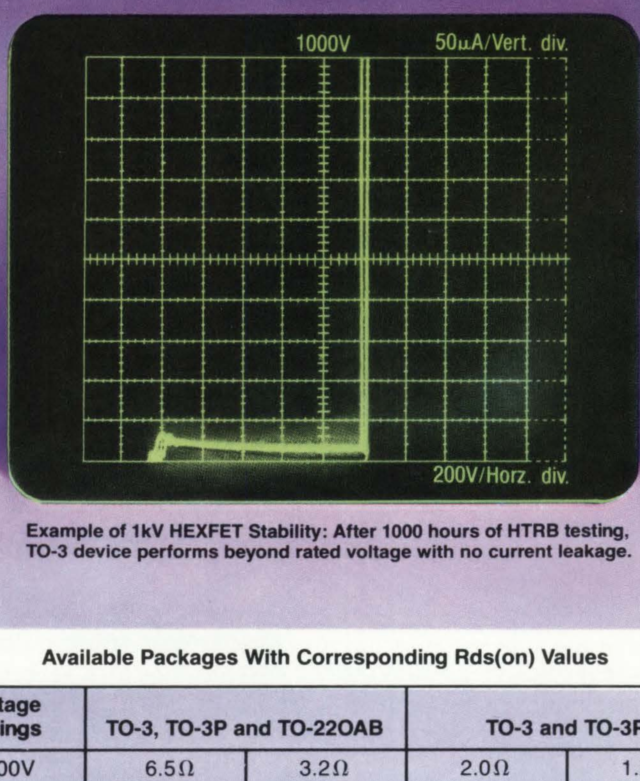

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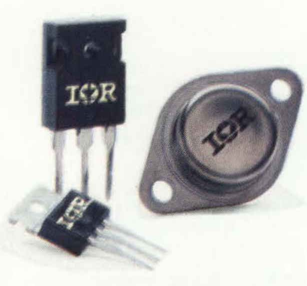

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