A CAHNERS PUBLICATION

JUNE 8, 1989

EDN®

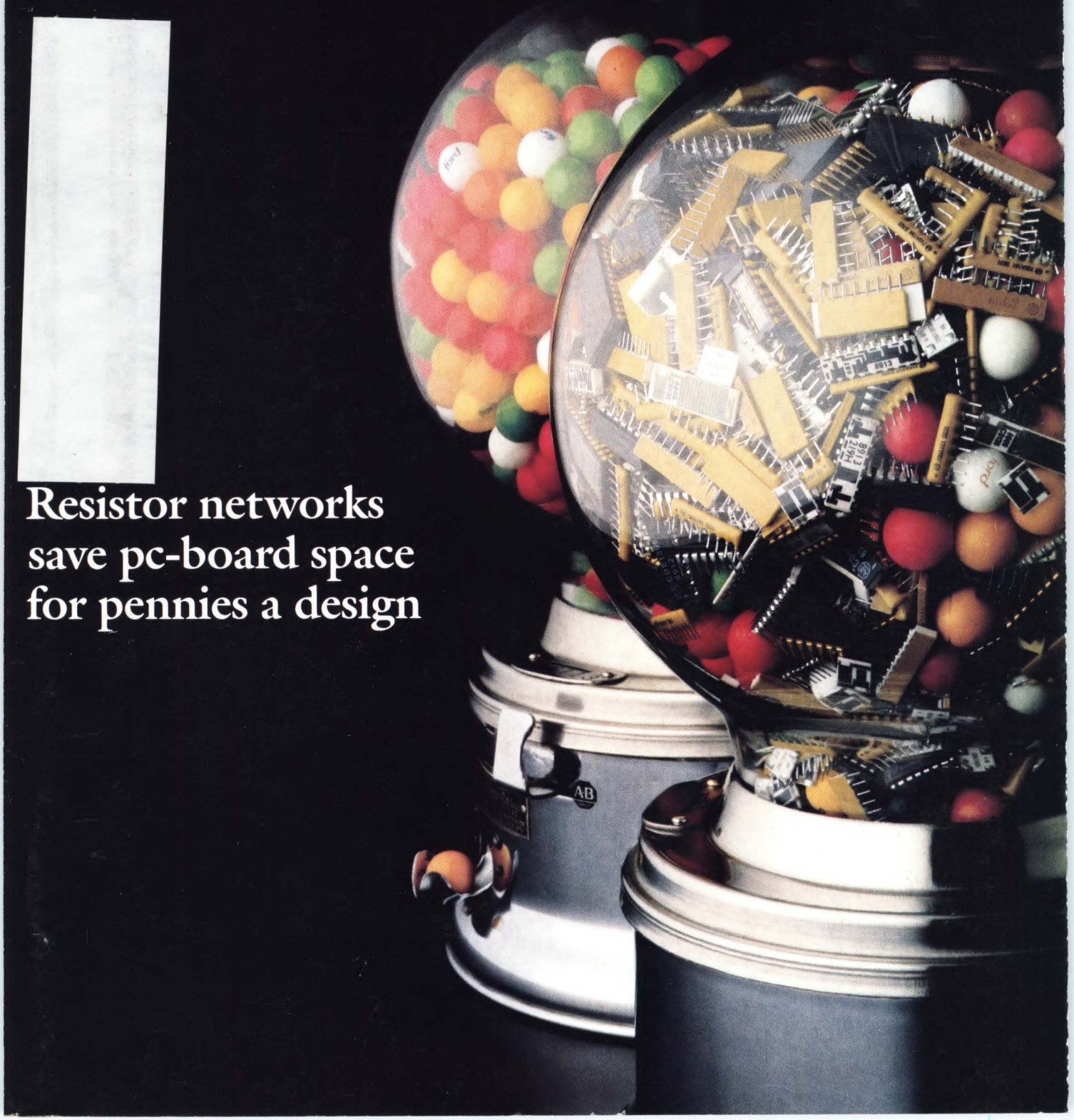
EDN's twelfth annual μP Support-Chip Directory

Micro Channel interface ICs

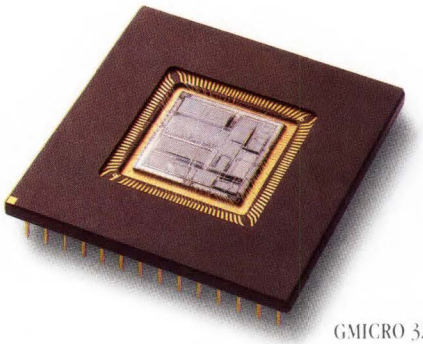
Universal cross-assemblers handle all μP traffic

Special-purpose ICs link multiple processors

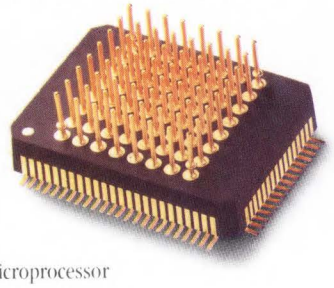
ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

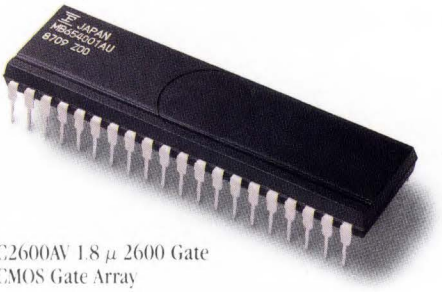


Resistor networks save pc-board space for pennies a design



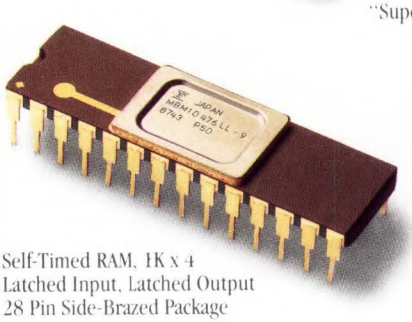
MB86220 DSP Emulation Processor
for Engineering Development





C2600AV 1.8 μ 2600 Gate
CMOS Gate Array

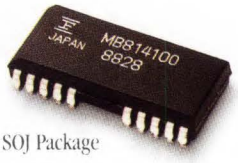
GMICRO 32-bit Microprocessor
"Super CISC"



Self-Timed RAM, 1K x 4
Latched Input, Latched Output
28 Pin Side-Brazed Package

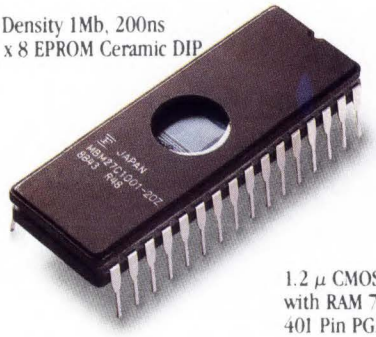
24-bit Floating-Point General Purpose DSP
1.2 μ CMOS 80 Pin Flat Package

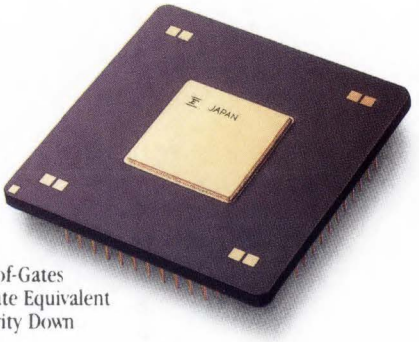
1.5 μ 12K Gate
CMOS Gate Array
with 152 I/O



4Mb DRAM
300 MIL Wide, SOJ Package

High Density 1Mb, 200ns
128K x 8 EPROM Ceramic DIP





Ultra High Speed ECL
2-Input, D-Flip-flop
(3.0 GHz typical)

1.2 μ CMOS Sea-of-Gates
with RAM 75K Gate Equivalent
401 Pin PGA, Cavity Down

On top of that, our microcomputer products let you choose from 4-bit microcontrollers, 8-bit to 32-bit microprocessors and SCSI controllers.

And our wide range of telecommunications products includes digital signal processors, prescalers and phase-locked loop devices.

All of which means that no matter what your needs, you've got the family behind you.

To find out more, call 1-800/742-7616. Just tell us you'd like to meet the family.

FUJITSU

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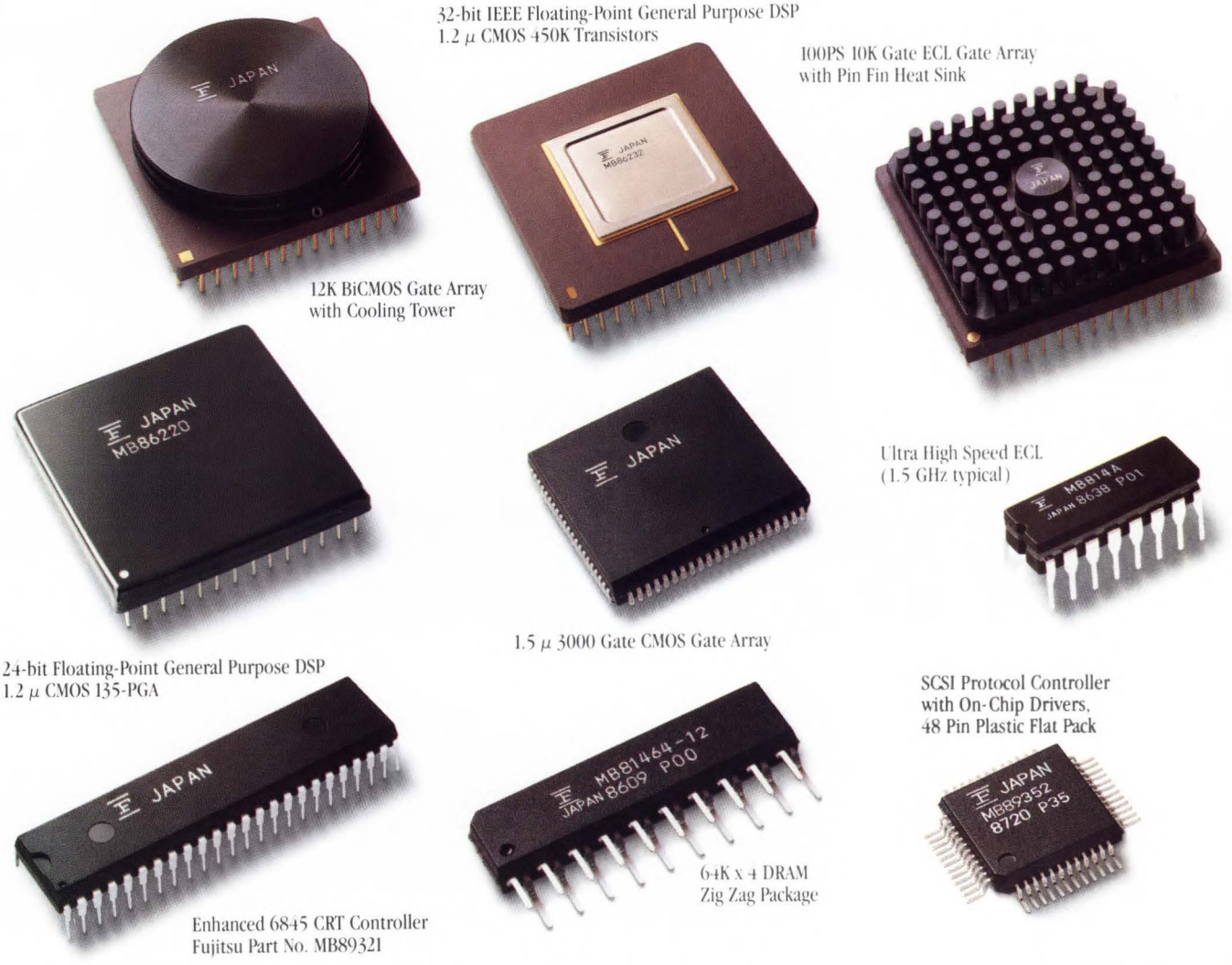
Every step of the way.SM



Getting ahead is always easier when you have the support of your family.

Which is precisely why the Fujitsu Microelectronics family of ASIC and standard memory products gives you all the support you need every step of the way.

Our wide selection of memory and logic products, for example, is among the most complete in the industry. Which means you can choose from every product in the book. Including static and high-speed ECL RAMs, ROMs, PROMs and EEPROMs, ultra high-speed ECL RAMs, SRAMs and DRAMs.

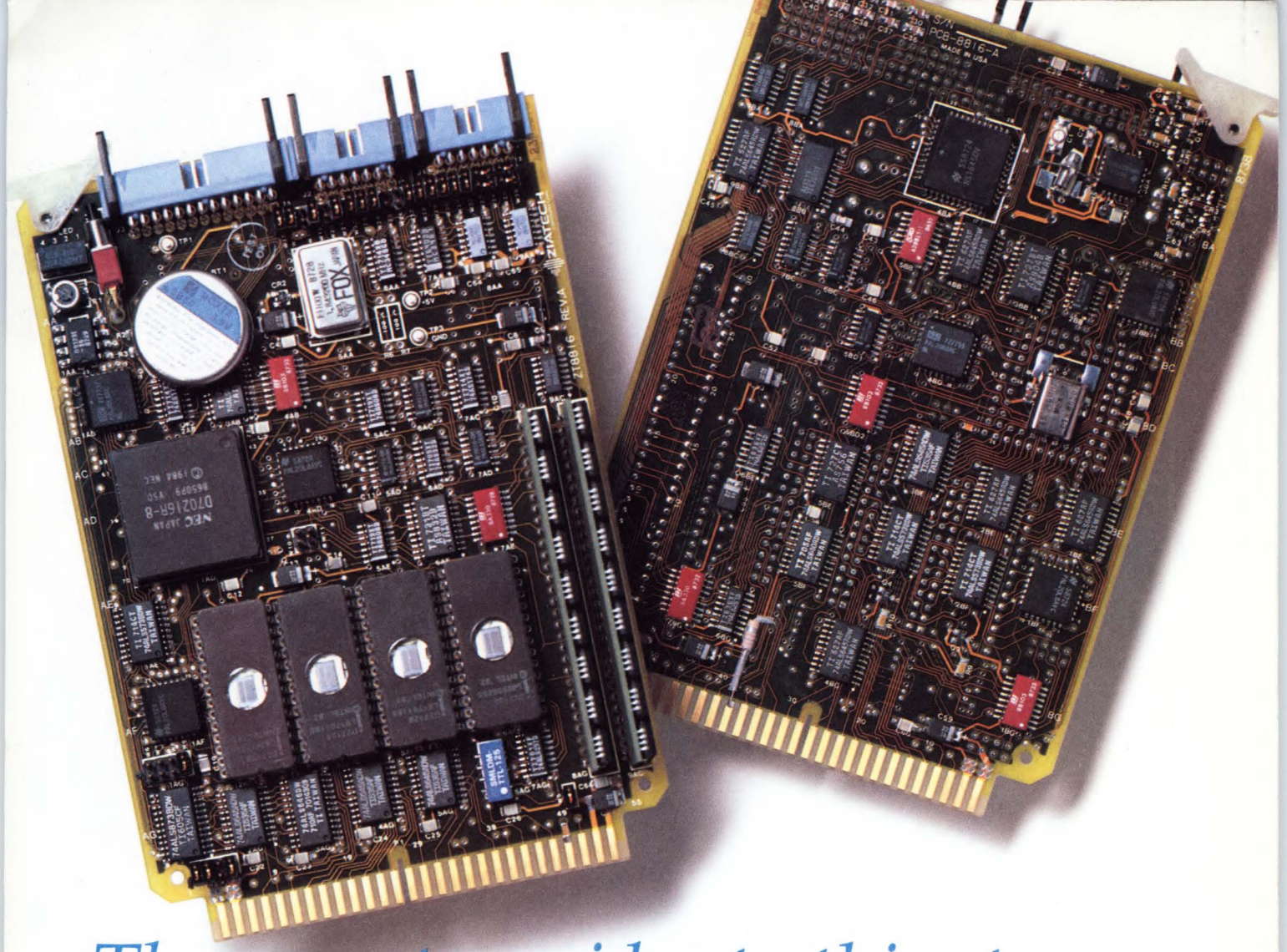
When it comes to ASICs, we've got everything you need to develop your own. Like powerful workstation software tools.

A broad ASIC product offering in bipolar, CMOS and BiCMOS technologies.

And products that include high-speed ECL and BiCMOS arrays. CMOS sea-of-gates devices with over 100,000 gates. As well as standard cell capability to support up to 60,000 gates.

Meet the Family.

CIRCLE NO 142



There are two sides to this story...

Side One:

Highly integrated 16-bit industrial computer

Ziatech's NEC V50-based single board computer, the ZT 8816, packages the features of several STD boards into a unique, dual-sided surface-mount design. The ZT 8816 tackles demanding industrial applications with a 16-bit data bus, an 832K on-board memory capacity, a real-time battery-backed clock, AC/DC power-fail protection, DMA controller, an interrupt controller, two serial channels, and three counter-timers.

Side Two:

IBM AT-compatible industrial computer

The ZT 8816 is more than just the most advanced STD Bus computer hardware on the market today. It is designed to operate PC DOS or ROM-based user programs such as the VRTX multitasking kernel. Development tools are available to provide a large range of target system software architectures. STD DOS V50 on the ZT 8816 delivers IBM AT performance and compatibility with optional networking, EGA video, disk and bubble memory subsystems, multiprocessing, and a device driver library. Ziatech's exclusive Virtual System Console supports easy development through a host PC by transparent resource sharing.

For the rest of the story...

Free Technical Brochure

Call today for the ZT 8816 Technical Data Sheet and the 24-page STD DOS Technical Brochure. With more information on what the ZT 8816 can do for your industrial application, you may start seeing the Ziatech side of the story.

(805) 541-0488

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ZIATECH CORPORATION

3433 Roberto Court
San Luis Obispo, California 93401 USA
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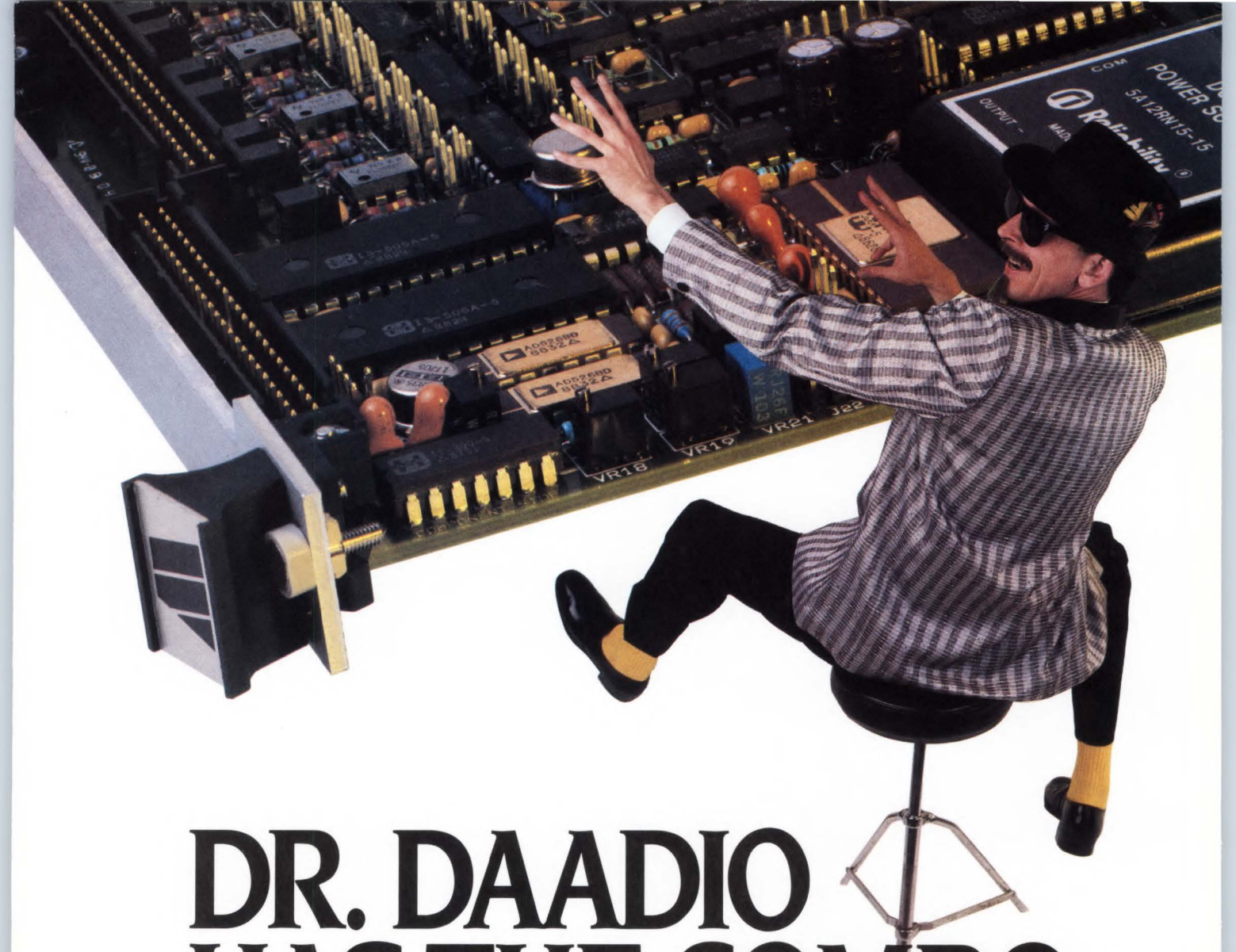


DR. DAADIO HAS THE COMBO

to cure your data acquisition blues!

D/A, A/D and PIO requirements in the same VMEbus application mean three separate boards, right? Not any more! The MD-DAADIO from MATRIX Corporation gives you everything you need in one combination board—and saves you space and money!

125 KHz A/D Rate!
The MD-DAADIO knocks your socks off with a unique pipelined A/D conversion method and ten software selectable gains. Also, the MD-DAADIO features external triggering for synchronous applications.

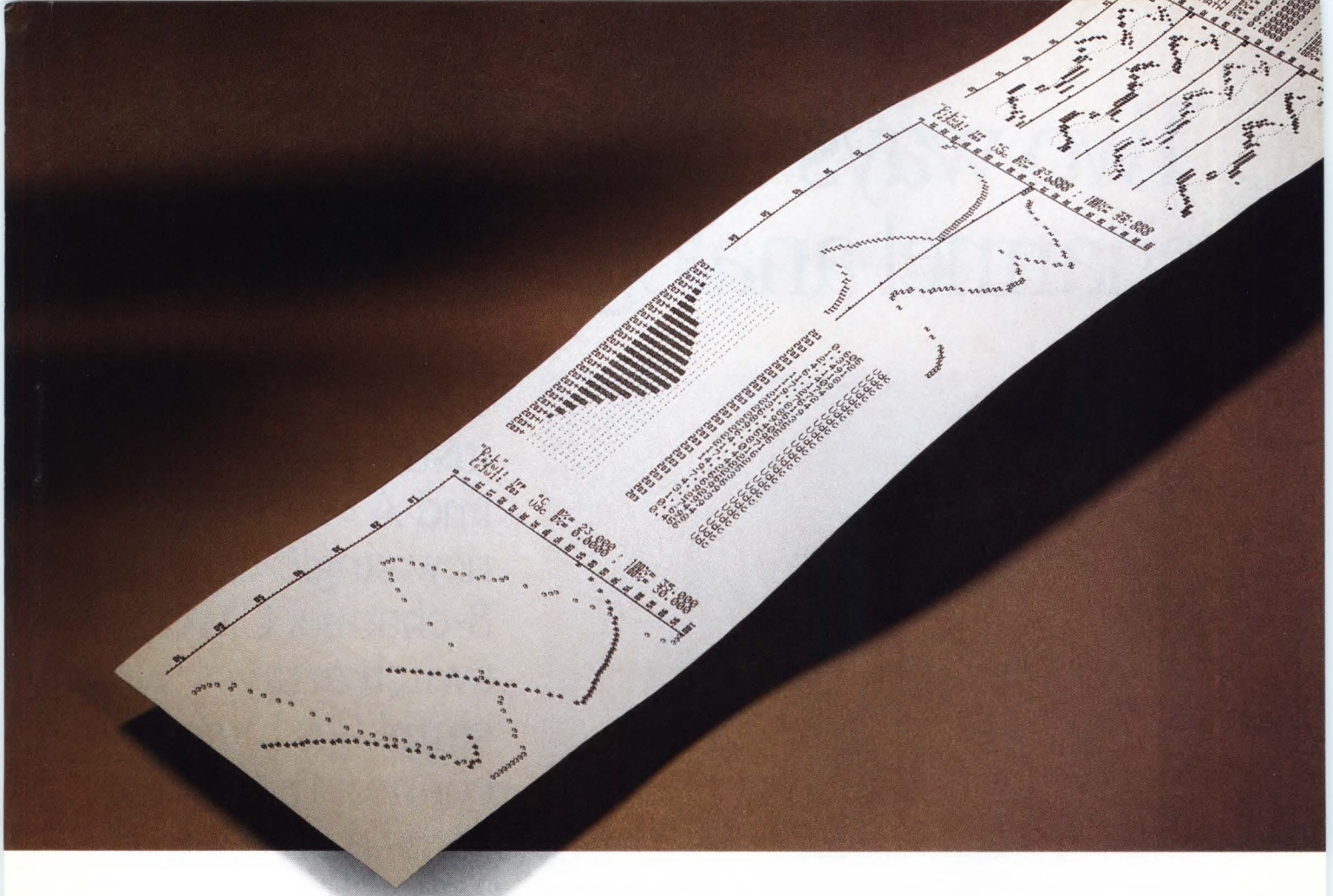
12-Bit, 8-channel D/A.
The MD-DAADIO gives you analog output any way you want it—you decide the voltage range and the mode. The MD-DAADIO even has current output capability and external scaling.

48 Lines Parallel I/O.
The MD-DAADIO offers six, eight-bit ports, each software configurable for data directionality. In addition, the first port is capable of interrupting the VMEbus on change-of-state or byte recognition.

The Combination Cure.
Why risk the health of your VME data acquisition solution? The MD- DAADIO gives you everything you need in one combination board and gives it to you at less cost.

Call now...and ask for the Doctor!

MATRIX CORPORATION
1203 New Hope Road
Raleigh, NC 27610
Phone: (919) 833-2000
FAX: (919) 833-2550



A plot to get you to buy our Data Logger.

As if you didn't have enough reasons already.

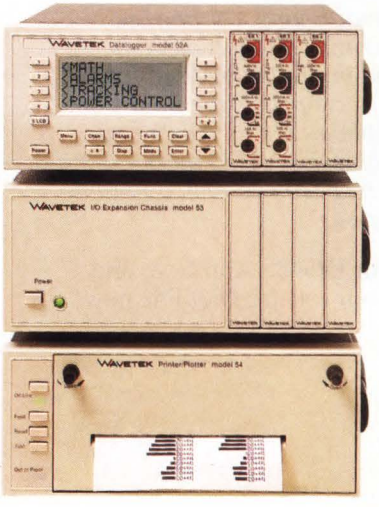
Our Series 50 Data Logger is a fraction the size of most other data loggers. Considerably less expensive. Completely portable.

And now, as you can see, Series 50 not only gathers data, it explains it.

You can plot from one to sixteen variables at a time. Divide the width of the page into one, two or four segments, with multiple variables in each.

If conditions change, Series 50 can be programmed to change the plot with them. For instance, it can switch to higher resolution and time-stamp data with messages during alarm conditions. And it does all this on its own, no computer needed. (On the other hand, it can also be controlled by a computer via IEEE-488 or RS-232.)

Series 50 will plot bar graphs next to numerical data. Create min/max plots. Or generate x-y graphs from stored data.



Speaking of stored data, Series 50 can keep up to 100,000 readings in memory. Which is a good thing, because with four independent A/D converters and up to 260 channel scanning capacity, you could be gathering plenty of data.

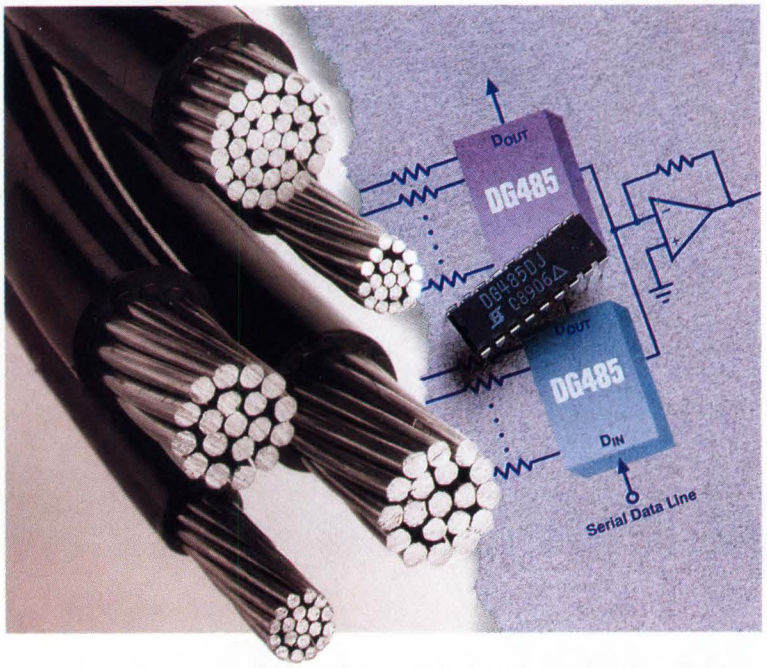
Data such as temperatures (6 thermocouple types and RTD's), AC/DC volts and current, resistance, frequency, time period, pulse width and more.

If our plot is working, you'd probably like to know more about the Series 50 Data Logger. Just phone (619) 279-2200. We'll be expecting your call.

Circle 103 for Literature
Circle 104 for Demonstration

WAVETEK®

Two ways to control multi-channel analog signals.



The wire saver for instrumentation and ATE. Siliconix' new single-chip 8-channel CMOS switch array simplifies inter-connect through serial data control.

Reduce the size and weight of any digitally-controlled analog system. Cut manufacturing and maintenance costs. And improve system reliability.

Now it's easy. The industry's first switch array, the Siliconix DG485, allows any combination of eight channels to output. And controls them with a serial interface that replaces most of your wiring.

A single chip—an expandable solution. You can daisy-chain DG485s to harness all the analog inputs your system requires.

DG485 KEY PARAMETERS	
Precise	$r_{DS(ON)} < 85\,\Omega$
Fast	$t_{(ON)} < 200$ ns
Efficient	$P_D < 105\,\mu W$
Reliable	ESD protected ± 4000 V
Versatile	Any combo of 8 SPST to Output

The versatile DG485 is ideal for gain ranging, signal conditioning, routing and mixing, channel selection and multiplexing functions in microprocessor-controlled applications such as instrumentation, ATE, audio, aerospace and telecommunications.

Imagine the possibilities! Ask for your DG485 App Note and Design Kit including free sample. Call our toll-free hot line now! **1-800-554-5565, Ext. 945.**

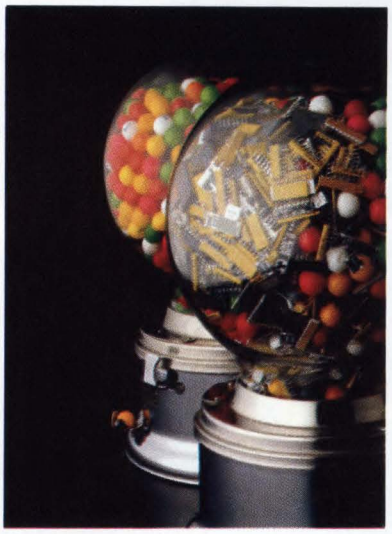
Siliconix
incorporated

2201 Laurelwood Road, Santa Clara, CA 95054

EDN Magazine Edition

Volume 34, Number 12 June 8, 1989

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



On the cover: *The wide assortment of off-the-shelf and semicustom resistor networks lets you find a high-performance device to enhance almost any design. See pg 124. (Photo courtesy Allen Bradley Co)*

SPECIAL REPORT

DESIGN FEATURES

Continued on page 7

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VBPA ABP

FLUKE

PHILIPS

Other meters show half the picture

The new Fluke 45 has dual display versatility.

With 2 multifunction displays and 16 different measurement capabilities, the new Fluke 45 does virtually everything you want a meter to do. And for a surprisingly affordable price.

Get everything you've ever wanted.
Dual displays. 16 functions. Even the security of an optional two-year warranty extension for only $35. For all the information on the new Fluke 45, contact your local distributor. Or call toll-free **1-800-44-FLUKE, ext. 33.**

The 5-digit, 100,000 count dual displays give you more information in less time — and with less effort. For example, measure the VDC output of a power supply while measuring the VAC ripple. Or check the amplitude and frequency of an AC signal. From a single test connection!

And the Fluke 45 is designed to make complex measurements easier, with standard features like a 1 MHz frequency counter, Min Max, limits testing (Hi/Lo/Pass), Touch Hold® and Relative modes. There are 21 different reference impedances for dB measurements; in the 2 Ω to 16 Ω ranges, audio power can be automatically displayed in watts.

Accuracy to get the job done right.
The Fluke 45 is a true-rms meter, with 0.02% basic dc voltage accuracy and 100,000 count resolution on both displays. Basic dc current accuracy is 0.05%, making the 45 ideal for servicing 4-20 mA current loops. Closed-case calibration simplifies the calibration process and increases uptime.

Even an RS-232 interface is standard.
Connecting the Fluke 45 to PCs, RS-232 printers and modems is as easy as attaching the cable. An IEEE-488.2 interface and rechargeable batteries are available as options.

FLUKE 45 DUAL DISPLAY MULTIMETER

$595*	Compare and Relative functions
Dual Display	Min Max and Touch Hold® functions
True-rms voltage and current, including ac+dc	Optional PC software for RS-232 applications
0.02% basic dc voltage accuracy	Optional IEEE-488.2 interface, battery pack
0.05% basic dc current accuracy	One year warranty
1 MHz frequency counter	Optional two year warranty extension $35*
RS-232 interface standard	
dB, with 21 reference impedances, and audio power calculations.	

*Suggested U.S. List Price

John Fluke Mfg. Co., Inc. P.O. Box C9090 M/S 250C Everett, WA 98206
U.S.: 206-356-5400 Canada: 416-890-7600 Other Countries: 206-356-5500

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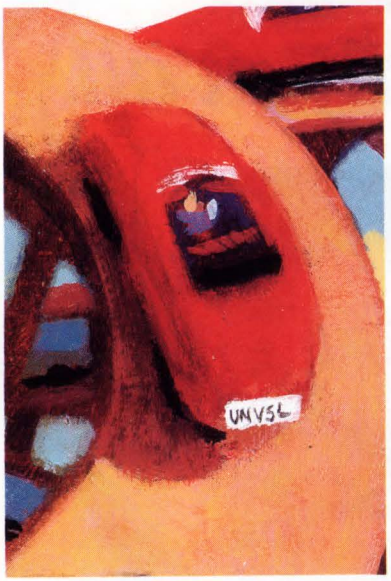


***Universal cross assemblers** allow you to drive different μPs on different projects without the additional cost of new software development tools (pg 89).*

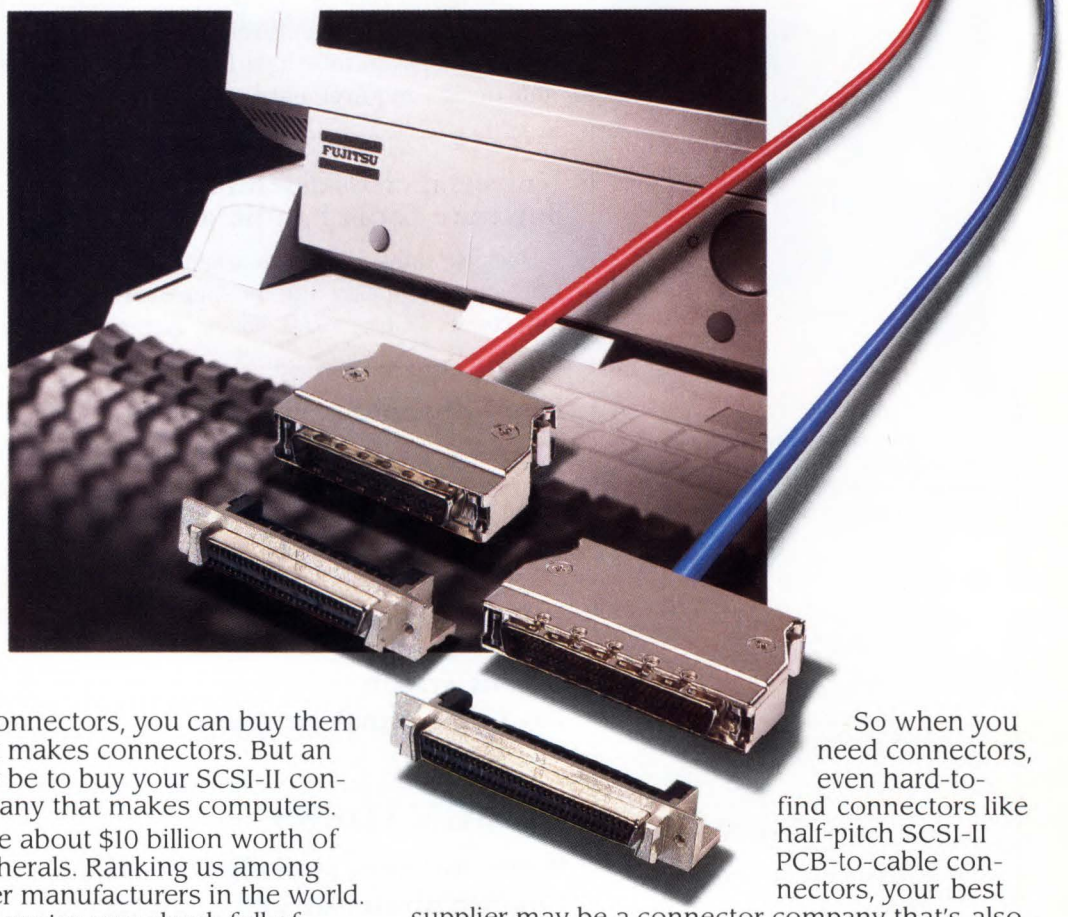
TECHNOLOGY UPDATES

PRODUCT UPDATES

DESIGN IDEAS

Continued on page 9

Why your best choice for SCSI-II connectors may not be a connector company at all.



If you need SCSI-II connectors, you can buy them from a company that makes connectors. But an even better idea may be to buy your SCSI-II connectors from a company that makes computers.

Last year we made about $10 billion worth of computers and peripherals. Ranking us among the top four computer manufacturers in the world. And every Fujitsu computer was chock full of Fujitsu connectors.

Our reputation for quality and reliability depends on the reliability of every single component. Including connectors.

So we've learned to make components of uncompromising quality. And we've learned that the best way to make them economical for our own systems is to supply them at reasonable prices to companies like yours as well.

Today, components – along with computers and communications – are an important part of our $16 billion annual sales.

So when you need connectors, even hard-to-find connectors like half-pitch SCSI-II PCB-to-cable connectors, your best supplier may be a connector company that's also something more.

Please call Fujitsu Component of America at **408-562-1000**.

FCN-230 Series Connectors

Item	Specifications
Operating Temperature	−55°C to +105°C
Current Rating	1 ADC
Voltage Rating	240VAC
Contact Resistance	30mΩ max. at 6VDC, 0.1A
Insulation Resistance	1000MΩ min. at 500VDC
Dielectric Strength	750VAC for 1 minute
No. of Contact	50, 68

FUJITSU COMPONENT OF AMERICA, INC.:
3330 Scott Blvd., Santa Clara, California 95054-3197 Phone: 408-562-1000 Telex: 910-338-0190 Fax: 408-727-0355
FUJITSU LIMITED (Electronic Components International Sales Support Div.):
Furukawa Sogo Bldg., 6-1, Marunouchi 2-chome, Chiyoda-ku, Tokyo 100, Japan Phone: National (03) 216-3211
International (Int'l Prefix) 81-3-216-3211 Telex: 2224361 Fax: (03) 215-1961

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Continued from page 7

EDITORIAL 65

To stay alive, Electro needs a shot of vitality. Here are some recommendations.

NEW PRODUCTS

LOOKING AHEAD 284

Systems-integration market to hit $6.4 billion in 1993 . . . First-quarter US factory electronics sales total $63.8B.

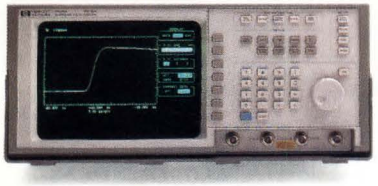
DEPARTMENTS

FLUKE

Compare our DSOs and you'll find a

PM 3365
Fluke

2230
Tek®



54501A
HP®

Features	PM 3365 FLUKE	2230 TEK®	54501A HP®
Analog & Digital	Yes	Yes	Digital Only
Analog Bandwidth	100 MHz	100 MHz	Not Available
Digital Bandwidth For Repetitive Signals	100 MHz on all channels	100 MHz on all channels	100 MHz on all channels
Maximum Single Shot Frequency*	10 MHz on 1 or 2 channels	1 MHz on 2 channels 2 MHz on 1 channel	1 MHz on 1 or 2 channels
Sampling Rate	100 Ms/s on 1 or 2 channels	10 Ms/s on 2 channels 20 Ms/s on 1 channel	10 Ms/s on 1 or 2 channels
Autoset	Yes	Beamfinder only	Yes
Cursors	Smarter	Smart	Smart
Probefactor	Automatic (+ readout)	Automatic	Manual
IEEE-488/ RS232C	Both, with full control	Both, with data only	HP-IB only, with full control
Warranty	3 year	3 year	3 year

*10 points per period.

Not only is the PM 3365 from Fluke easier to learn and use, it's also incredibly accurate, thanks to the fastest sampling rate in its class.

Not long ago, Fluke was first in helping you make the jump from analog to digital multimeters. Now we're helping you make the leap from analog to digital oscilloscopes, too, with easy to use full-performance DSOs at prices equally easy to handle.

To begin with, our DSOs are more than just full digital scopes. They're also full analog scopes. At the push of a button, you're free to switch from analog to digital and back whenever you want.

In either mode, operation is intuitive. A single "AUTOSET" button lets you find your signal and fully set up your scope automatically, without hunting or pecking. Plus, an easy-on-the-eyes LCD window keeps all your settings in clear view at all times without wasting your valuable CRT real estate.

Our cursors are smarter, too, so you can do more of the measurements and computations you want from a DSO quicker and easier.

Of course a big reason you'll want a DSO in the first place is to capture a wider variety of signals. Not just repetitive signals, but single shot and low repetition rate waveforms also.

To do the job, you need ample bandwidth. But to do the job well, you need the high resolution only fast sampling rates can provide.

Which is exactly why our PM 3365 samples a signal up to ten times faster than the competition, even with both channels in use.

When it comes to the full DSO performance you need, no one makes it easier to handle than Fluke.

PHILIPS

PHILIPS

to TEK® and HP® handy difference.

Buy any Fluke medium frequency DSO before Oct.1 and get a free Fluke 77 DMM.

Getting a handle on digital scopes has never been easier than with Fluke's family of DSOs, including the PM 3335, PM 3350, and PM 3365. Each offers superior performance, intuitive operation, and full product support.

Priced from a low of $2,495 to just $4,990, our family of DSOs gives you high speed digitizing plus full analog capabilities for the lowest prices ever offered in this class.

And if you order any medium frequency DSO from Fluke before October 1, 1989, you'll also get your hands on a free Fluke 77 handheld 3½ digit multimeter, complete with Touch Hold® and multipurpose holster.*

Discover how easy it can be to make the transition from analog to digital. Send for our free video, "DSOs with a Difference," and see how easy and powerful a DSO can be. Order yours today.

*Offer good only in North America.

Digital performance from Fluke begins at $2,495! For unbeatable value, ask about the PM 3335 and PM 3350.

For your **FREE** video and product literature call **800-44-FLUKE ext. 77** or mail this coupon today.

Name_____

Title_____

Company_____

Address_____

City_____ State_____ Zip_____

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John Fluke Mfg., Inc., P.O. Box C9090, M/S 250C, Everett, WA 98206. U.S. (206) 356-5400. Canada (416) 890-7600. Other countries: (206) 356-5500. Ad no. 0492-P3350. Tek® & HP® are registered trademarks of Tektronix, Inc., and Hewlett-Packard, Inc.

CIRCLE NO 72

You didn't get into this

business to come in second.

The only self-respecting place to be is first.

And AMD can help you stay there with the World Network,™ system level solutions in networking and communications.

Everything from silicon to software to responsive support.

The World Network offers solutions that work together. Right out of the box. From the company that sells more communications devices than anyone.*

AMD has the world's most complete family of ISDN hardware and software. And two fiber optic products: The first and only FDDI solution around; and our breathtaking TAXI™ for very high speed point-to-point communications.

We have conventional communications solutions on line, too: SLIC/SLAC™ for switching equipment, and complete hardware and software for Ethernet. All designed to get you to market first.

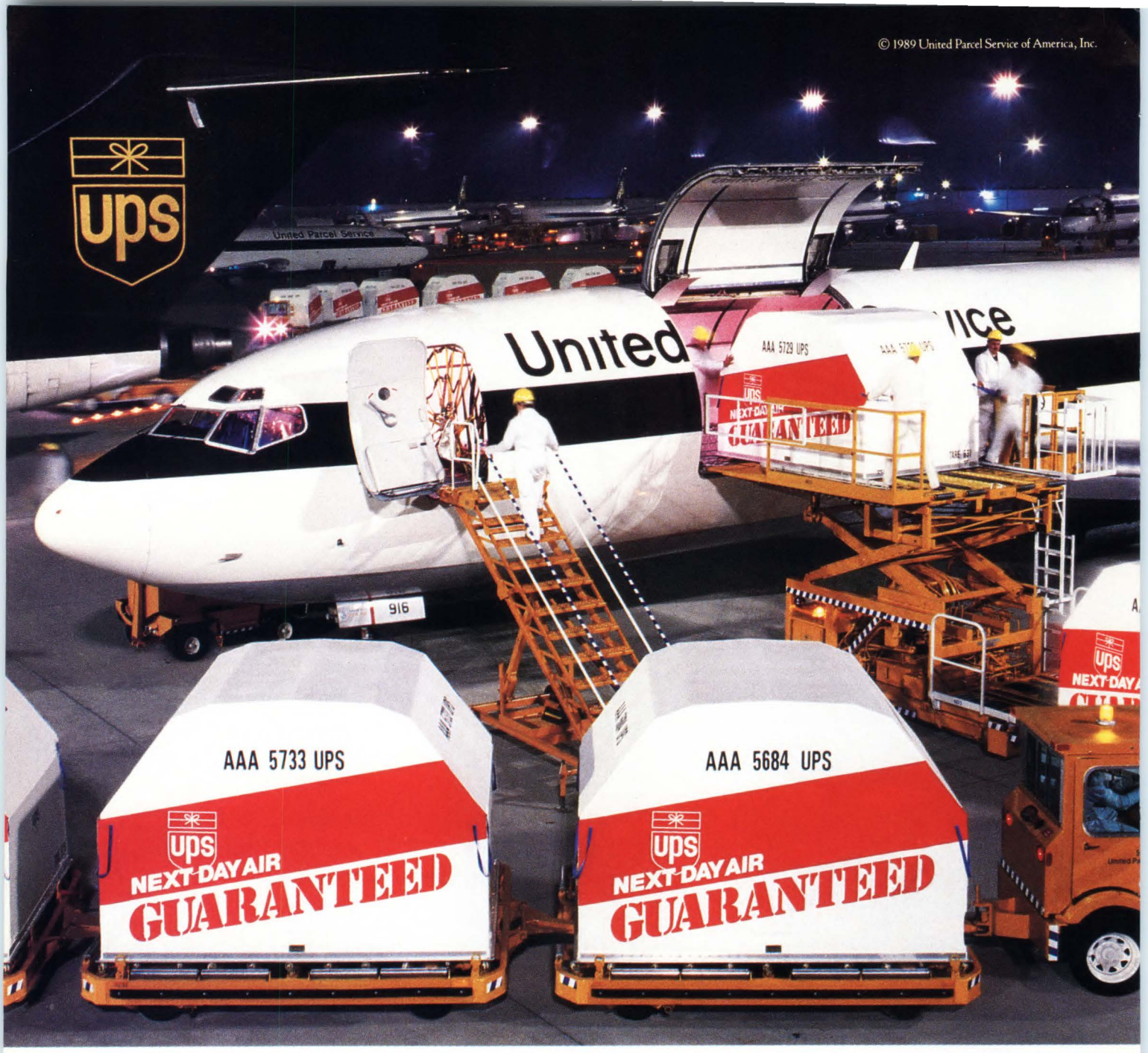
Because, no matter where you stand, the only way to look at second place is from over your shoulder.

Advanced Micro Devices

901 Thompson Place, P.O. Box 3453, Sunnyvale, CA 94088.
For more information about the World Network, call (800) 222-9323.

*According to a Dataquest Report, October 1988 for the year 1987. Stated in dollars.

CIRCLE NO 68



Here's something that will help everyone sleep better. Except our competition.

At UPS, we have something that will help assure you a restful night's sleep when it comes to overnight delivery.

It's guaranteed UPS Next Day Air.*

For some time UPS has been the only company fast and reliable enough to deliver overnight to every single address coast to coast. And we guarantee it, or you don't pay for it.

What's more, we'll even guarantee delivery in the morning to the vast majority of people across the country.

And because of our efficiency, we're still able to do all of this for up to half what other companies charge.

All of which is guaranteed to give our competition a restless night's sleep.

And you a comfortable one.

ups®

We run the tightest ship in the shipping business.

*See our current Next Day Air Service Explanation and Air Service Guide for complete guarantee details.

NEWS BREAKS

EDITED BY JOANNE DE OLIVEIRA

SOFTWARE PERFORMS MIXED ANALOG-DIGITAL IC SIMULATION

Sierra Semiconductor (Milpitas, CA, (408) 263-9300) is now offering open-architecture software that accommodates mixed analog-digital cell-based IC designs. The Montage software uses behavioral models for both the analog and the digital cells to achieve interactive simulation speeds; it's adaptable to other vendor's cell libraries. The software currently runs on Sun workstations and is scheduled to be released for Apollo workstations by the third quarter of 1989. The software costs $29,500 and includes schematic capture, a simulator, and Sierra's 1.5-μm CMOS cell library.—Richard A Quinnell

DSP CHIP HAS 32-BIT ALU TO PREVENT OVERFLOW

Another digital signal-processing (DSP) chip from Texas Instruments (Dallas, TX, (800) 232-3200, ext 700) will be available in sample quantities by the end of 1989. The TMS320C50 chip extends the company's line of fixed-point math DSP devices from today's TMS320C20 family. Although the device provides a 16-bit data bus and 16-bit internal memory, the arithmetic and logic unit (ALU) operates on 32-bit values. The 16 added bits let you perform many math operations without fear of overflow or loss of precision. The multiply-and-accumulate time for the chip's ALU is 35 nsec.

During an interrupt-processing sequence, each internal register saves its contents in a shadow register. Saving the registers automatically lets the CPU switch to the interrupt task quickly without resorting to performing many stack-push and stack-pop operations. The CMOS chip also offers 2k words of internal mask-programmed ROM and 8k words of internal static RAM, as well as serial and parallel I/O lines. Users can change the RAM's configuration so that it can hold program instructions or data. Because the chip operates at speeds from dc to 57 MHz, wait states are necessary when the chip controls slower I/O devices. Users program the wait-state configuration by means of software commands.—Jon Titus

500-MHz-BANDWIDTH DSO COSTS LESS THAN ANALOG SCOPE

Hewlett-Packard Co (Colorado Springs, CO, (800) 752-0900) has rolled out a four-channel random-equivalent-time-sampling DSO with a 500-MHz bandwidth and a price tag of $4950. That price is lower by $900 than the price of the leading analog scope, which offers closely comparable performance. According to Tom Saponas, Hewlett-Packard's marketing manager for the product, the 54503A is the first high-performance DSO priced lower than closely comparable analog instruments. The unit physically resembles the vendor's 54501A, a 100-MHz-bandwidth unit introduced last year, and another new product, the 54502A. The $6450 54502A has two channels and a 400-MHz repetitive-signal bandwidth. Unlike the 54503A, the 54502A offers a single-shot mode that can acquire 400M samples/sec with a 100-MHz bandwidth. Saponas points out that in analog scopes you can normally achieve single-shot capability like the 54502A's only by photographing a CRT that has a high writing rate.—Dan Strassberg

IN-CIRCUIT EMULATOR FOR TMS370 HAS ONBOARD PROGRAMMER

For $2995, you can buy an in-circuit emulator for TI's TMS370 microcontrollers that will also let you program both the data EEPROM and the program EEPROM of

your target device. Dubbed the MR370 Development Kit from Macrochip Research Inc (Carrollton, TX, (214) 242-0450), this 7×7.5-in. emulator lets you perform real-time emulation and debugging at clock speeds reaching 20 MHz with no wait states. The unit contains 16k bytes of emulation overlay memory and a 68-pin PLCC emulation plug on 8 in. of woven cable. A pop-out socket eliminates any need to use specialized chip-extraction tools to remove the TMS370 from the emulator. The MR370's software includes a TMS370 macro assembler, editor, and communications software. You can program as many as four software breakpoints and perform software tracing, including examining, editing, disassembly, and single-stepping through program memory. Drawing all of its power requirements from the target TMS370's socket, the MR370 can operate with any host that has an RS-232C port; however, it comes with software for IBM PC-compatible or Macintosh computers. Options for the MR370 include 28-pin DIP and PLCC adapters for $250.—J D Mosley

MIX HARDWARE, STIR, GET FAST MIXED-LEVEL SIMULATION

You can use a hardware simulator to speed your gate- and switch-level simulation while allowing your workstation to process behavioral models more efficiently. The 2800 and 2900 Simulation Systems from Ikos Systems (Sunnyvale, CA, (408) 245-1900) couples behavioral simulation on Apollo DN3000 and DN4000 workstations or Sun 3 and Sun 4 workstations with hardware-based lower-level simulation on Ikos tools. To achieve higher workstation performance, Ikos implements the control for the behavioral simulator in hardware that resides with the company's hardware simulator. The control provides such functions as time-queue management and event filtering. The behavioral-simulation software uses C++, so you can translate a behavioral-language description for execution on the 2800/2900 system. The simulation systems will be available in the fourth quarter of 1989 at a starting price of $95,000.—Michael C Markowitz

CONFERENCE ADDRESSES TESTING SCSI DRIVES

The Disk/Test 89 conference will focus on the testing of disk drives that host embedded SCSI (Small Computer Systems Interface) controllers. The SCSI controller blocks access to the signals traditionally used to test disk drives; the conference will describe new tools and techniques for testing SCSI drives. The conference will take place July 13 and 14, 1989, at the Hilton Hotel in Sunnyvale, CA. Call (408) 947-6348 for registration information.—Maury Wright

DIGITAL AUDIO IC PROVIDES 16-BIT STEREO A/D CONVERSION

Providing delta-sigma conversion across 25-kHz bandwidths for digital audio applications, the CS5326 from Crystal Semiconductor (Austin, TX, (800) 888-5016) is a 16-bit A/D convertor (ADC) in a 28-pin DIP; it sells for $48 (1000). The chip contains dual ADCs, digital antialiasing filters, digital decimation, sample-and-hold circuits, and a voltage reference. Harmonic distortion is less than 0.0015%, dynamic range exceeds 94 dB, and the signal-to-noise-plus-distortion ratio exceeds 92 dB over the 10- to 22-kHz bandwidth. The CS5326 has a 30- to 50-kHz sampling range and contains a serial interface.—J D Mosley

TMC2310 Runs 1024-Point FFT in 0.5ms

Here's the FFT runner you need to win the race. It's the TMC2310 — the first single-chip FFT controller to be this fast and simple to use.

Imagine all of these capabilities on one chip: Arithmetic functions, FFT coefficients ("twiddle factors"), even built-in address generation. That's why the TMC2310 runs forward or inverse transformations, or multiple equal-length FFTs totalling 1024 points, in just 0.5ms. Or a complex radix-2 butterfly in only 100ns. The TMC2310 executes other functions just as quickly, including FIR filtering and vector operations. Even data windowing is included without impact on either performance or price.

Better still, no development system is required. The TMC2310 jumps into action with just two 13-bit control words. It's so simple. No complex, bit-slice, microcode-intensive building blocks. No chip sets to contend with either.

You can qualify for a FREE sample. Just tell us about your application and we'll send you a TMC2310 to run in your system. You can build a complete spectrum analyzer with the TMC2310, our new 12-bit ADC (THC1200 Series), our TDC1012 DAC and external data and window memories. Be a winner. Try the TMC2310. Available now in 88-pin plastic pin grid array (PPGA) from TRW LSI Products or your nearest Hall-Mark or Hamilton/Avnet location.

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NEWS BREAKS

SCSI-BASED WORM DRIVE STORES 1.28G BYTES

Information Storage Inc (Colorado Springs, CO, (719) 579-0460) plans to widen the market for its 6-month-old, 1.28G-byte 525GB WORM (write-once, read-many) optical disk drive by replacing the proprietary ESDI-based port with an integral SCSI port. Many existing WORM drives from various vendors have proprietary interfaces; as a result, they can be used only in systems for which the drive vendor offers an appropriate host-interface card. In general, that situation has restricted WORM drives to systems that employ the IBM PC bus. The SCSI-based 525GB-SCSI drive can plug into systems that incorporate the SCSI peripheral bus, and the company is currently developing drivers for a variety of operating systems to support the drive. The 525GB-SCSI drives cost $2756 (100). You can obtain a development system, including the drive, a single-sided (640M-byte) disk cartridge, a SCSI card, and the WORM-TOS Plus operating-system software for $6488.—Steven H Leibson

LAN LABORATORY IS PROVING GROUND FOR ETHERNET PRODUCTS

When application notes and telephone support won't suffice, engineers designing products based on National Semiconductor Corp's Ethernet products can take advantage of the company's LAN laboratory (Santa Clara, CA, (408) 721-7942) to test new designs, search for interoperability problems in new equipment, or perform stress testing on immature network components. The lab contains several personal computers, including PCs from Apple and IBM, and allows network communication over coaxial, twisted-pair, and fiber-optic cables. In addition, you can reach out from the lab to the company's corporate computer network to boost the number of nodes on the network and to test communications with the company's engineering workstations. National Semiconductor also plans to use this LAN lab to work on developing network standards, such as the IEEE's 10BaseT proposal for a 10M-bps Ethernet network that employs twisted-pair wiring.—Steven H Leibson

ISDN CHIP SET MEETS ANSI STANDARDS

AT&T Microelectronics ((800) 553-2447) is now offering sample quantities of a 2-chip set for implementing the 2-wire 2B1Q U-interface ANSI standard. The chips allow you to create a full-duplex ISDN communications link over a telephone line designed for analog signals. The link would allow, for example, a single phone line to handle both voice and data simultaneously without the use of a modem. The chip set costs $95 in sample quantities and will be in production by the fourth quarter of 1989.—Richard A Quinnell

FREE SOFTWARE CREATES PLD FUSE MAPS

Plan, version 3.14, is a free software package available from National Semiconductor (Santa Clara, CA, (408) 721-5341) that includes a PLD assembler, a PLD-to-GAL (generic array logic) fuse-map converter, and a disassembler. The Plan assembler translates a PLD's source-code description (based on Boolean equations) into a file containing a JEDEC fuse map. The PLD-to-GAL converter transforms a JEDEC PLD fuse map into a GAL map. The disassembler accepts PLD or GAL map files and produces a Plan source-code file. Plan runs on IBM PCs and compatible computers, is supplied on a 5¼-in. floppy disk, and supports all of the company's programmable-logic devices, including TTL and ECL PLDs and GALs.—Steven H Leibson

EVERYBODY'S TALKING ABOUT THE FUTURE OF EDA.

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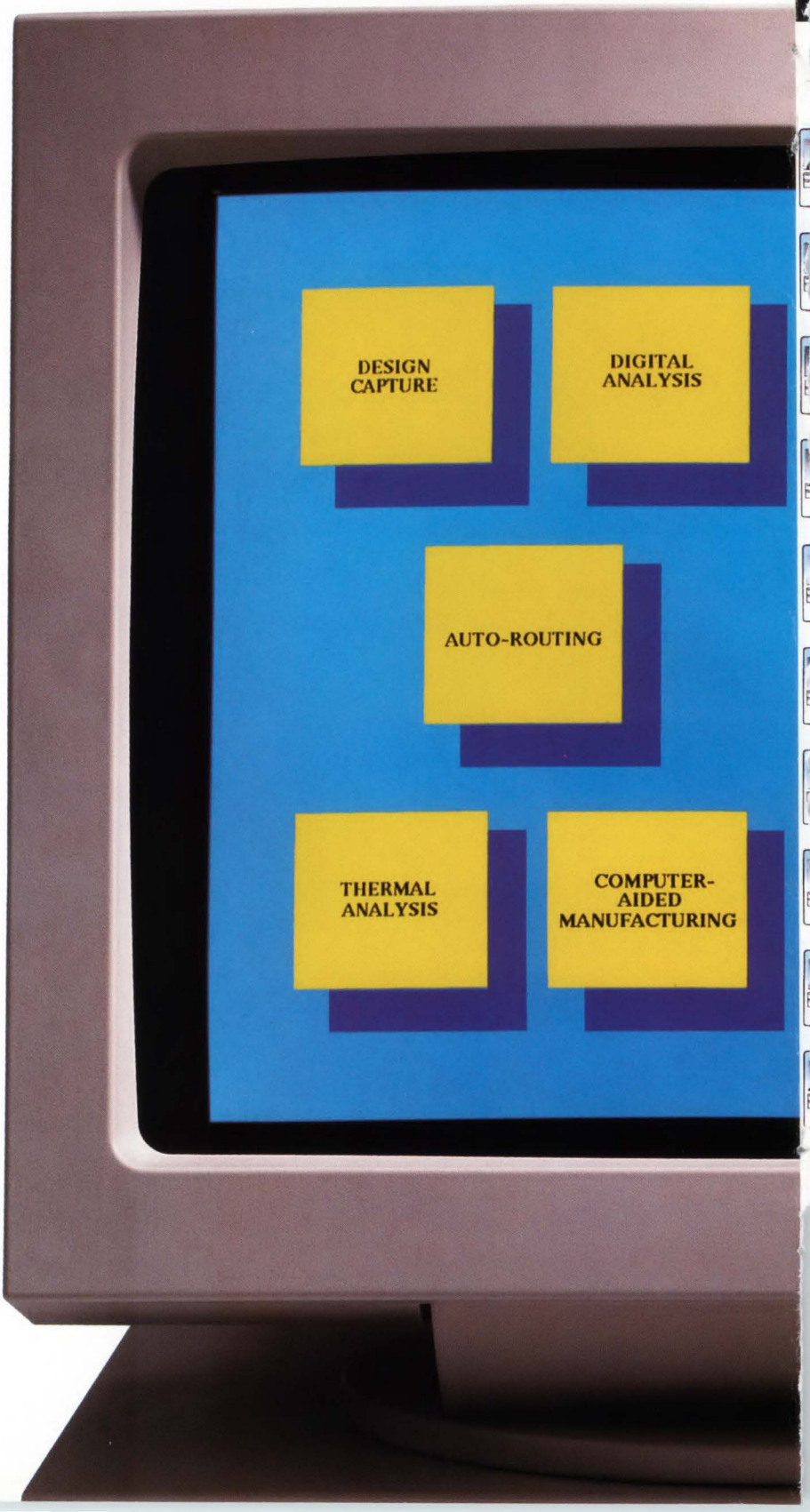

Talk is fine.
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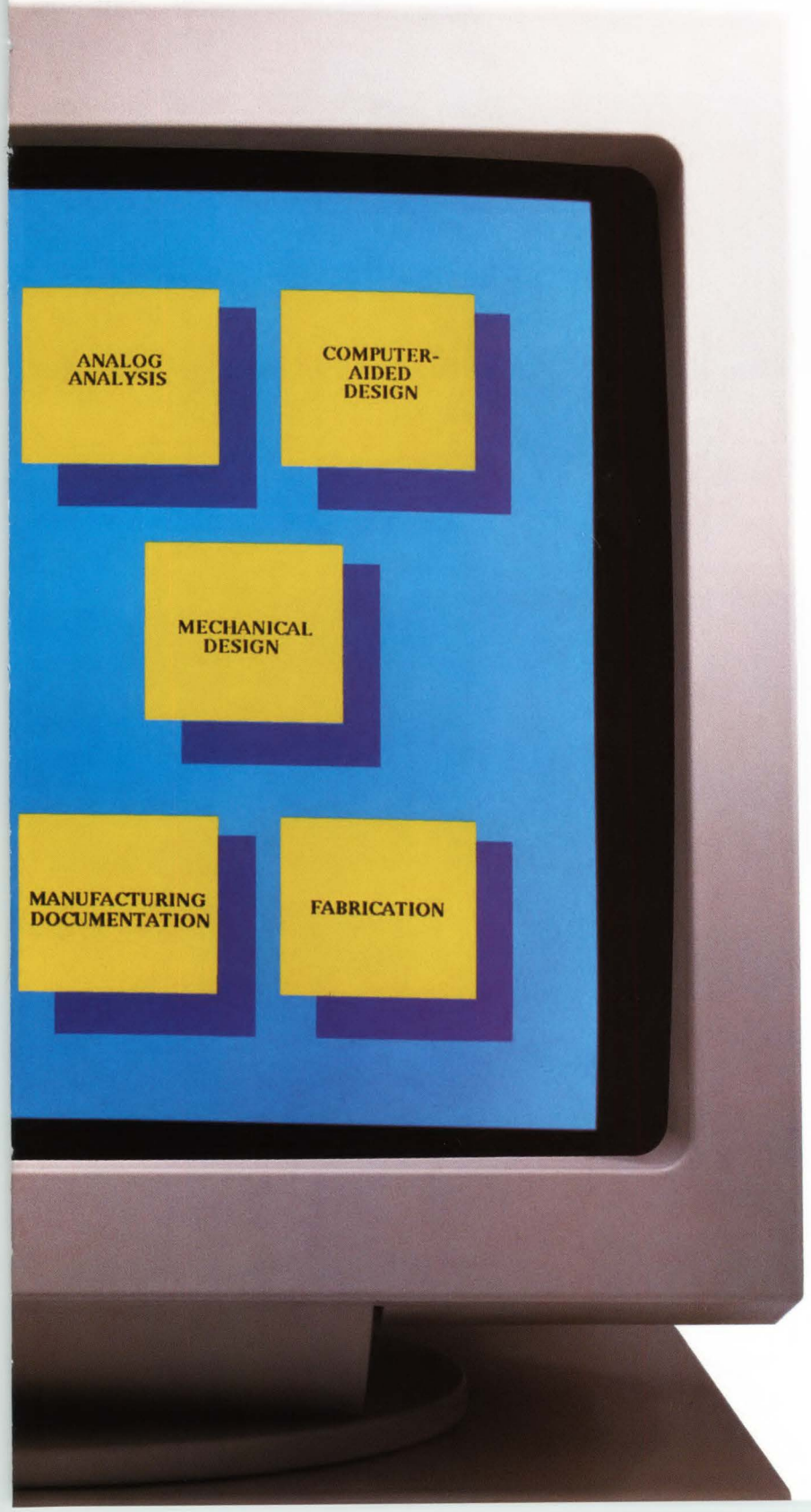

the next generation of EDA. And making it what it should have been all along. A complete set of the industry's richest, most powerful design tools. The best graphic interface. Open systems and industry standards. And the most comprehensive support in the industry.

For designers, DAZIX EDA will be a shot of adrenaline to their productivity. For product managers, it'll be the catalyst that drives design and manufacturing. And for your company, it'll provide the competitive edge to carve out a larger market share.

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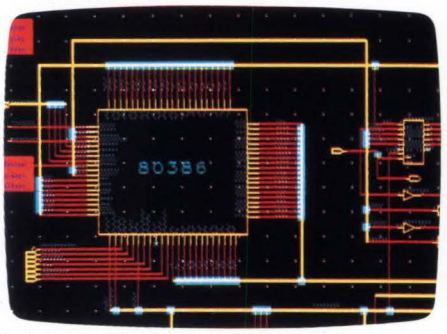
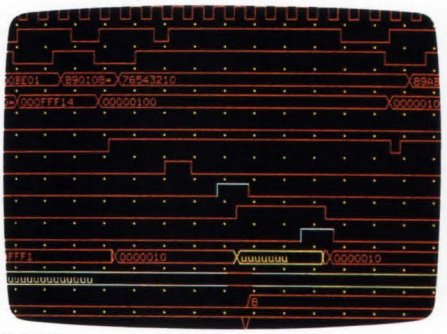
Design Capture



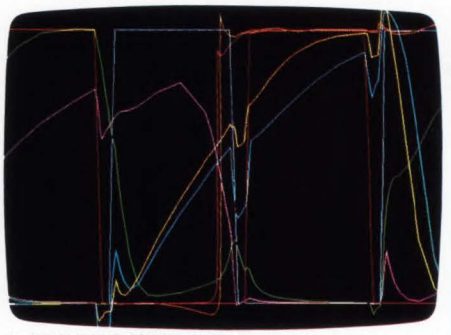
Industry standard design capture packages are available for Sun® products and the IBM® PC AT.® Integrated design analysis tools help assure a successful design. DAZIX ACE schematic editor is tightly coupled with simulation and PCB design tools to improve your design productivity.

Digital Analysis



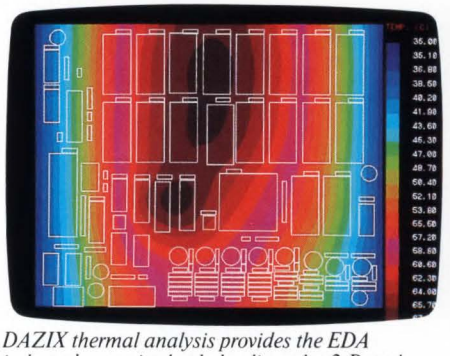
DAZIX mixed-level digital design environment supports over 170 ASIC design kits, and over 4500 popular standard components. Comprehensive VHDL design capabilities satisfy IEEE standards and DOD requirements. DAZIX logic, fault and worst-case timing simulations ensure your design's performance.

Analog Analysis



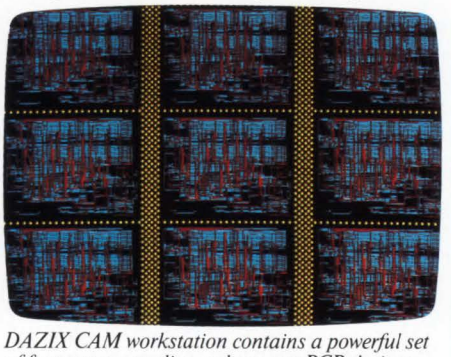
DAZIX DSPICE/PACSIM and Saber Analysis engine share the VLAB interface and draw from a common library. Over 1800 components are currently available in our Analog Library, including special purpose devices such as transformers and pulse width modulators.

Thermal Analysis



DAZIX thermal analysis provides the EDA industry's most in-depth, leading edge 2-D and 3-D thermal analysis solutions.

Computer-Aided Manufacturing



DAZIX CAM workstation contains a powerful set of features to panelize and prepare PCB designs for all manufacturing processes—photo tooling, fabrication, assembly and test to meet diverse data requirements.

We now have the richest set of EDA tools ever assembled in one place. Bar none.

Instead of the usual mind-numbing reiterations, you create, simulate, debug and manufacture uncompromised by design bottlenecks. So your designs move from concept to customer with extraordinary speed and control.

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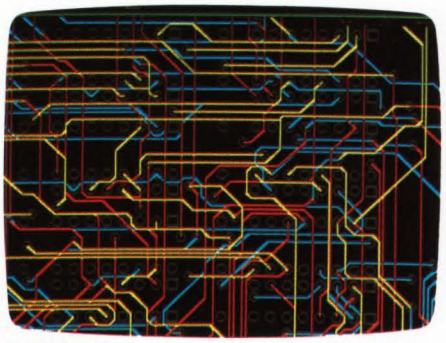
We provide Digital and Analog Analysis tools with remote compilation and analysis capability. Including our innovative Saber Simulator for board and system-level design, DSPICE/PACSIM for ASIC and discrete designs, our proprietary VLAB interface and our well-stocked Analog Component Library.

To test your ideas, we have the industry's most popular physical modeler. It lets you plug in different parts to create "what

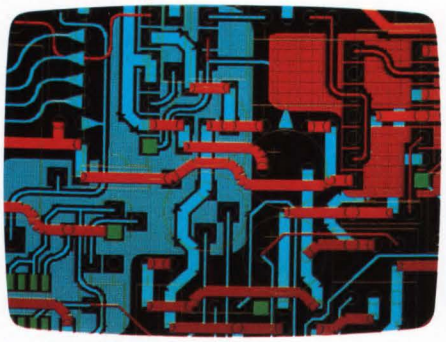
COMPLETE SET OF POWERFUL TOOLS.

Computer-Aided Design



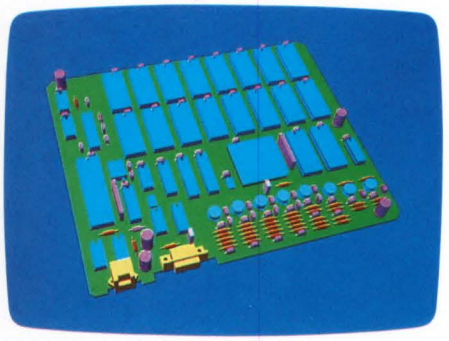
DAZIX CAD tools meet the most complex PCB design requirements, including boards with over 1000 EIC. DAZIX CAD workstations accommodate a wide variety of boards, from two-sided surface mount designs, to those that combine surface mount, pin grid arrays and standard DIP packaging.

Auto-Routing



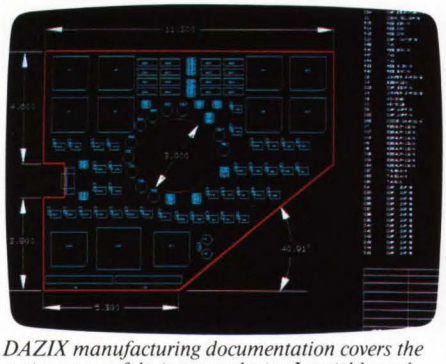
Routing on DAZIX workstations may be accomplished interactively, automatically or with a combination of the two. Routing may also be performed over the network on the DAZIX Route Engine 3,™ which performs true multilayer routing to 100% completion.

Mechanical Design



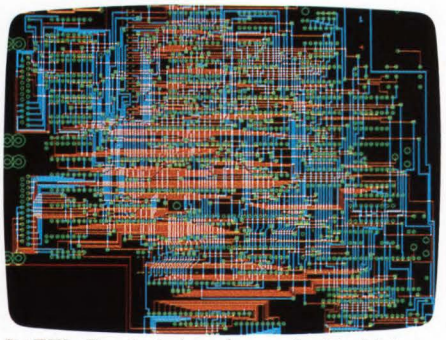
The DAZIX MCAE interface provides access to the best available 3rd party 3-D mechanical CAE software. This allows electrical packaging, thermal and vibration analysis to be performed at both board and system level.

Manufacturing Documentation



DAZIX manufacturing documentation covers the entire range of design complexity. It quickly and easily handles process flow through complex feature sets for DOD documentation requirements.

Fabrication



DAZIX offers the industry's most flexible fabrication workstation tools. Tools that quickly and easily handle your most complex panels and difficult PCB designs.

if" scenarios in seconds. So you can modify and perfect your design on-the-fly.

And for complex sequential ASIC designs, there's Automatic Test Program Generation, for the most complete fault coverage. When it's time to put it all together, you hit the boards running with the industry's best 100% Automatic Routing tools. Featuring accelerated graphics, comprehensive SMT and ECL tools and "design for manufacture." Your assurance that your boards can be easily built at the lowest possible cost.

To physically package everything into a system with maximum efficiency, we interface with leading-edge Mechanical Design tools. And to make sure your designs don't lose their cool, we have sophisticated Thermal Analysis.

And when you're finished, DAZIX EDA translates it all over to manufacturing, without losing a bit. So what you get off the assembly line is exactly what you had in mind.

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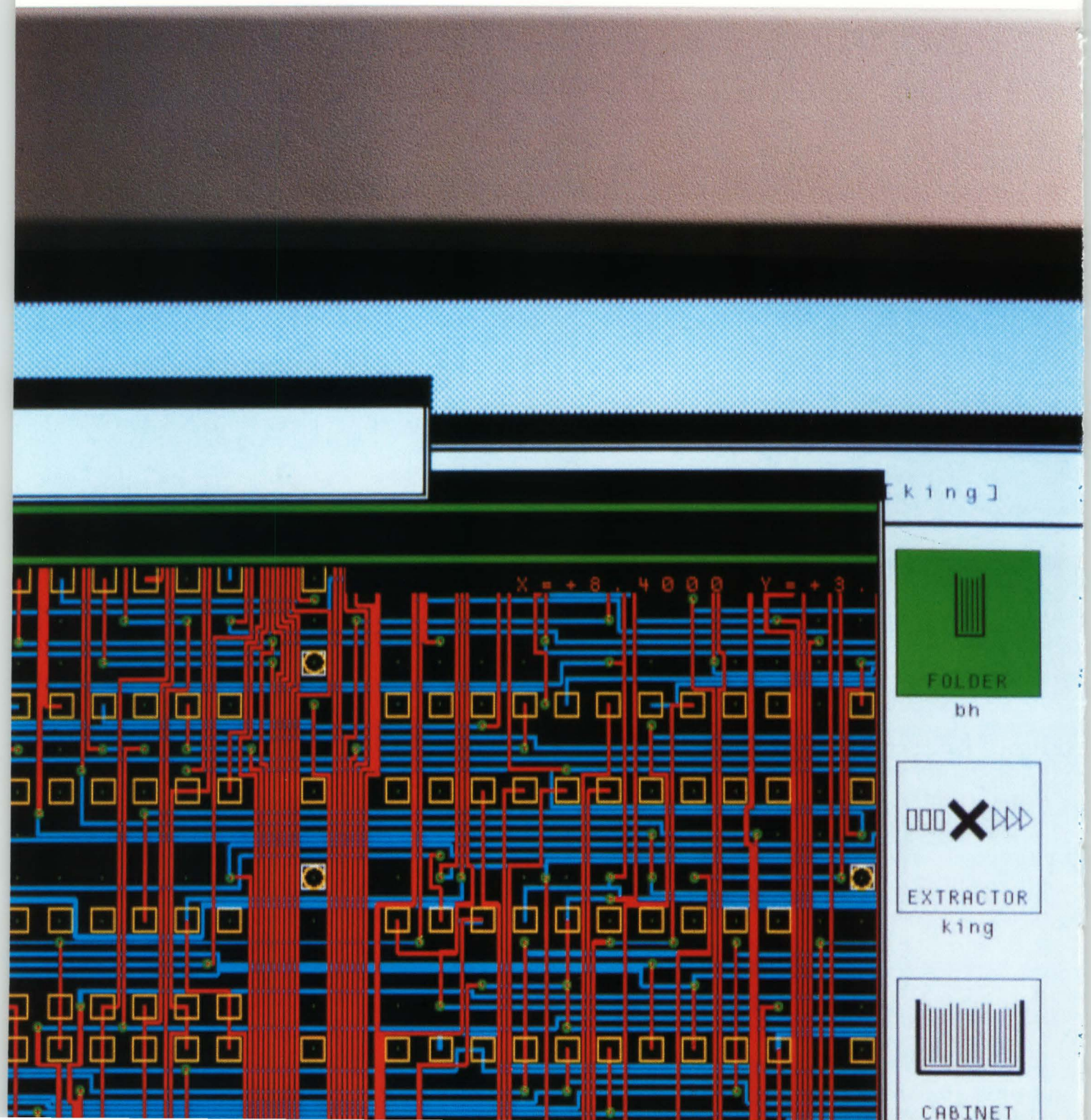

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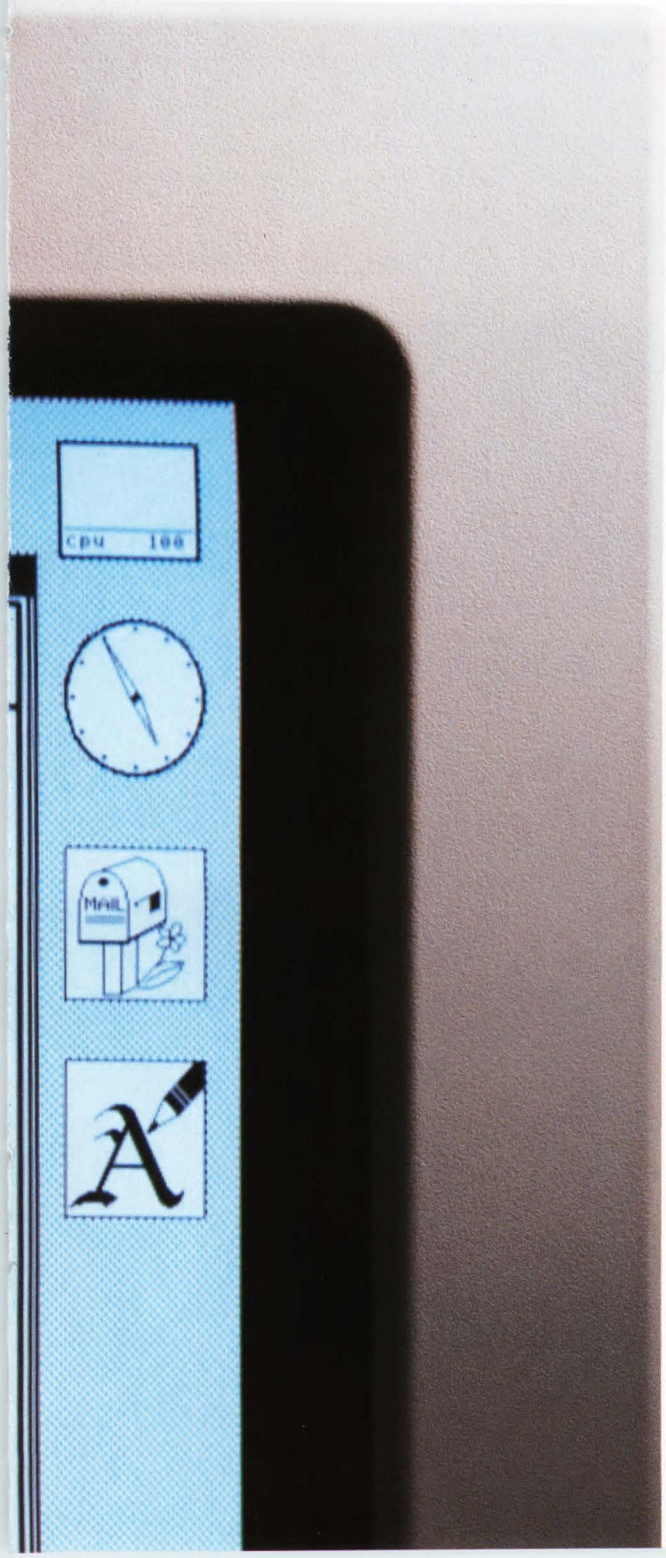

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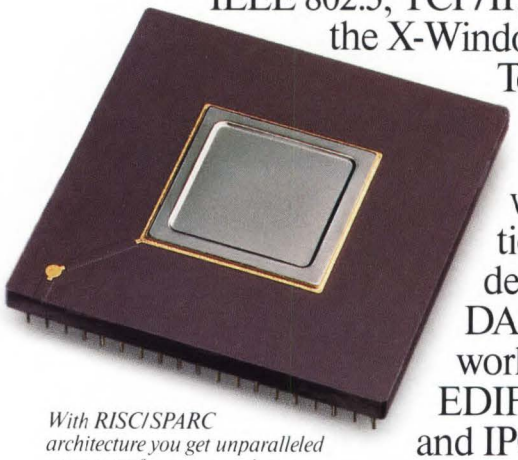

With RISC/SPARC architecture you get unparalleled system performance and easy migration to the next generation of processing power.

To guarantee an open database, with protection of your design data, DAZIX EDA works with EDIF, IGES and IPC data exchange standards. So nothing gets lost in porting your design from tool to tool.

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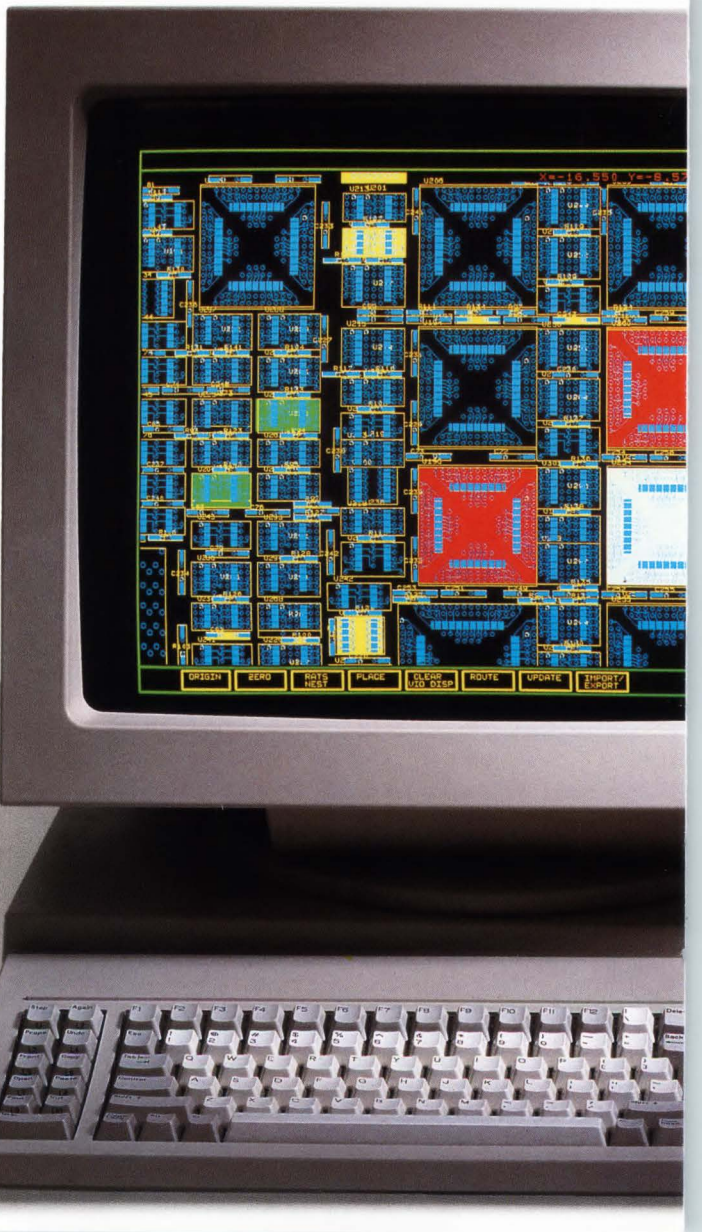

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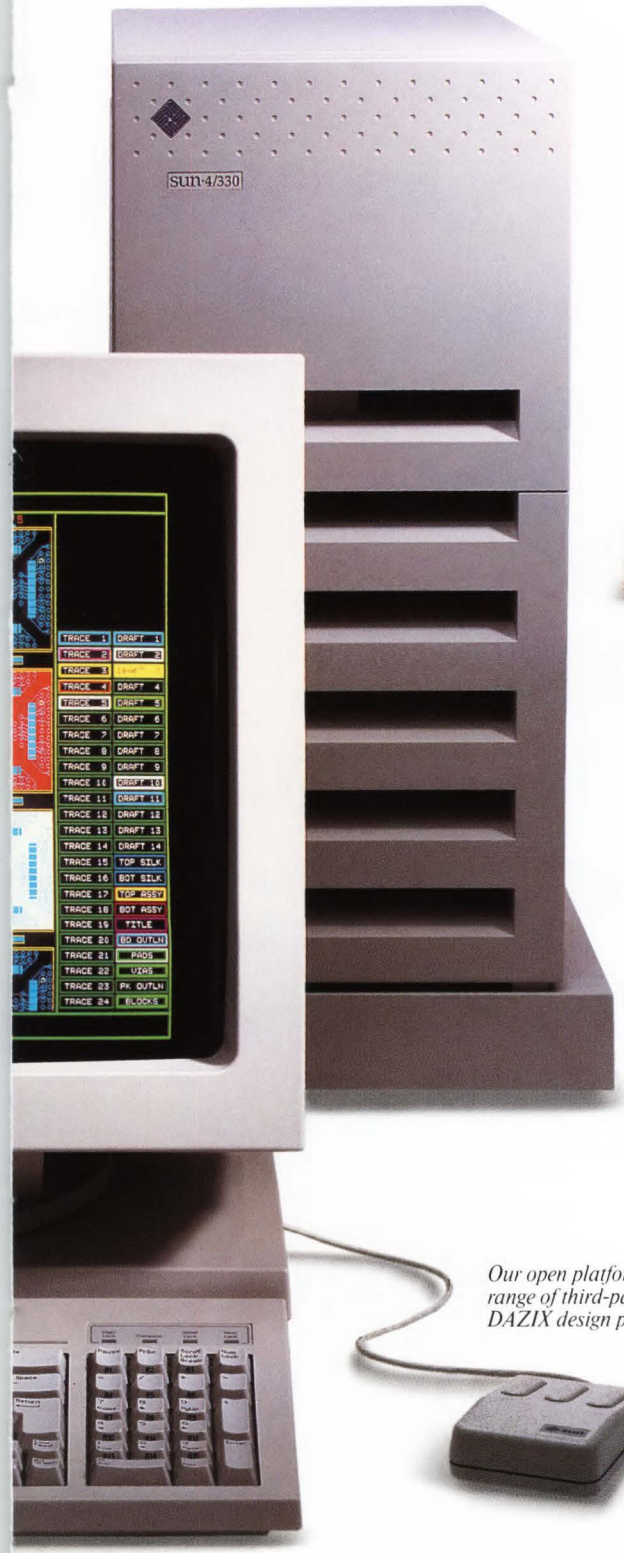

partition projects among your designers. And still have everybody work together, sharing the same libraries and hardware.

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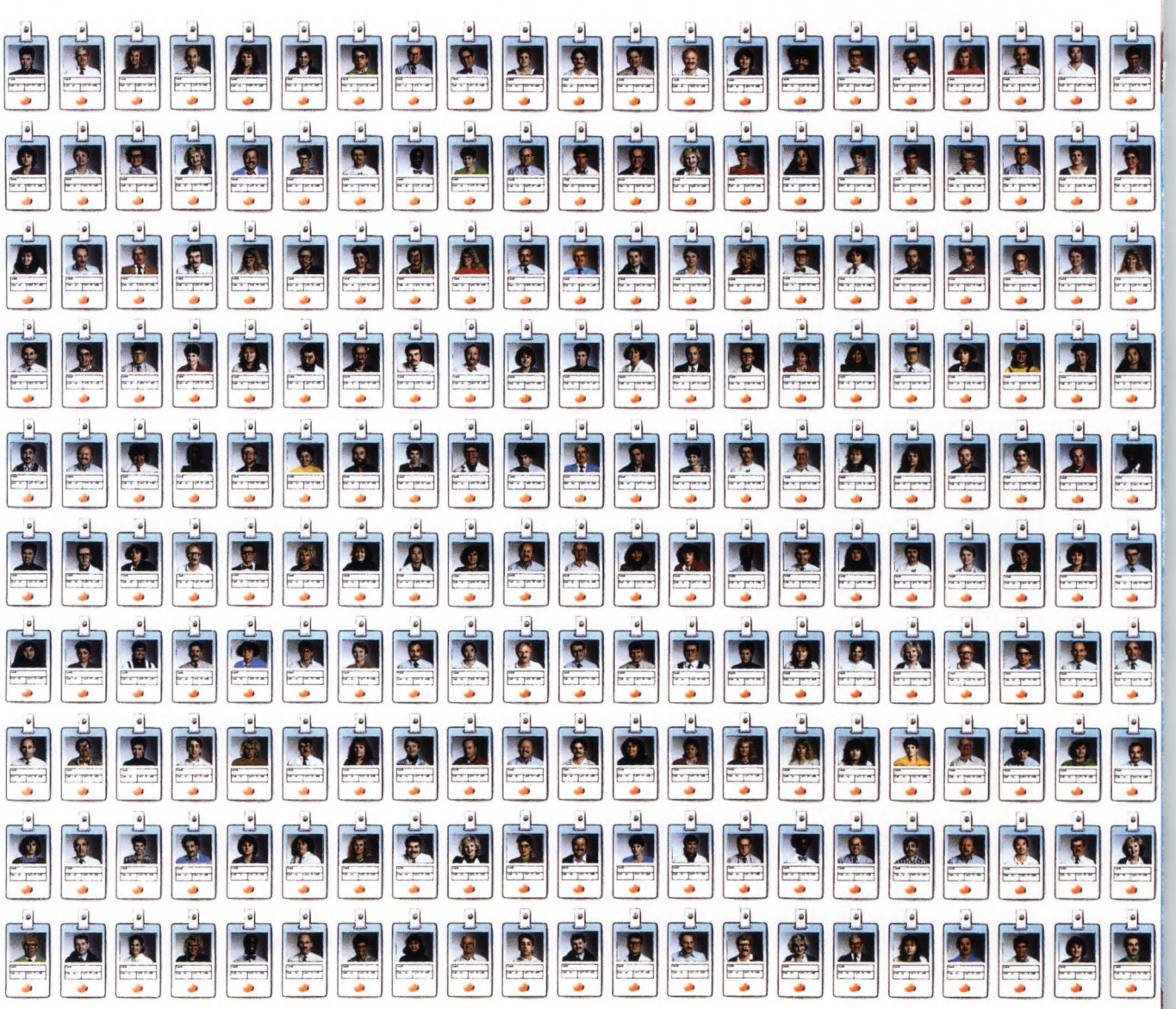

Some of our best design tools are the experience and talent of the industry's largest R&D staff. All 435 of them. All focused on EDA. And our sales and support staff in 44 offices in 17 countries worldwide.

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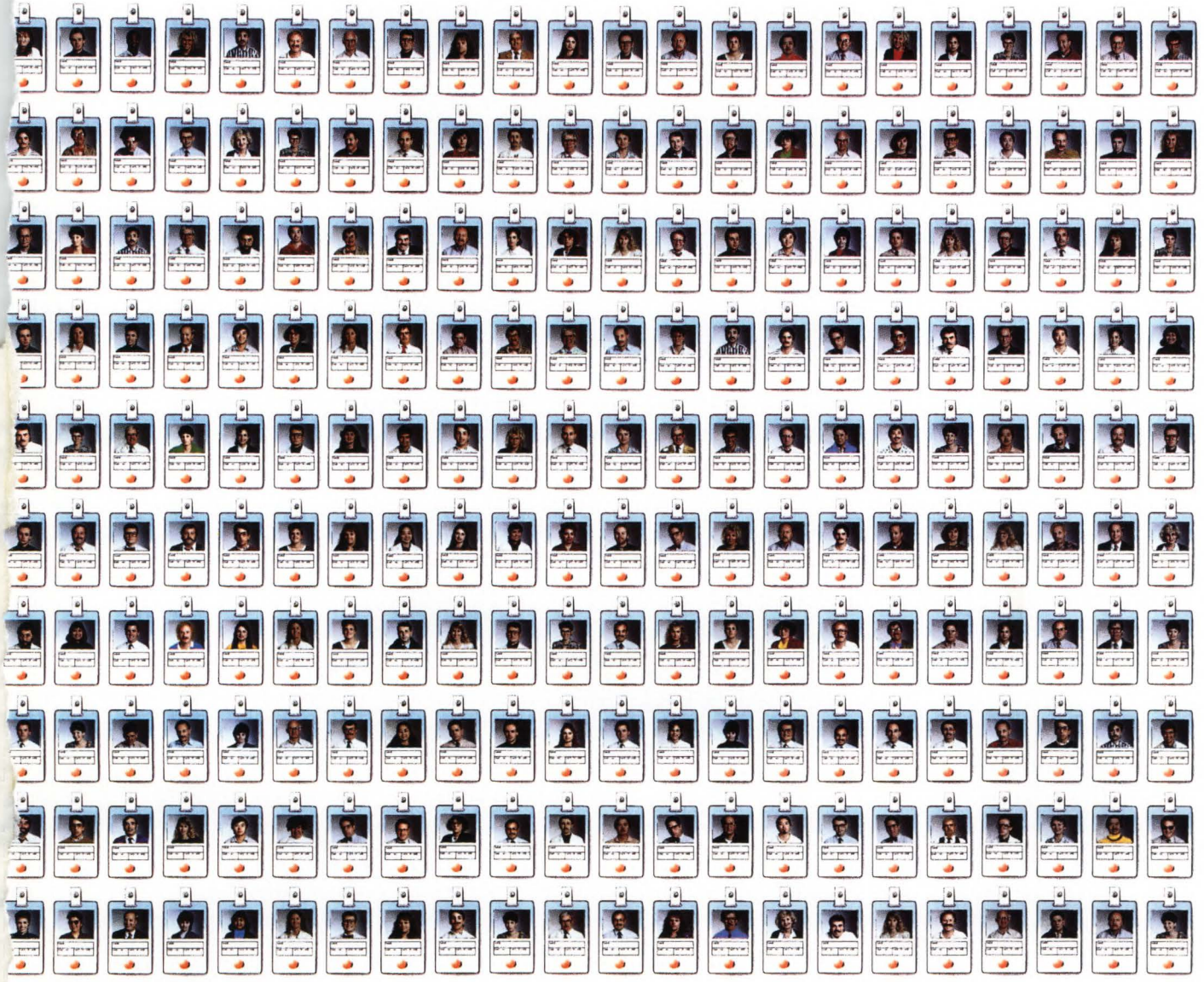

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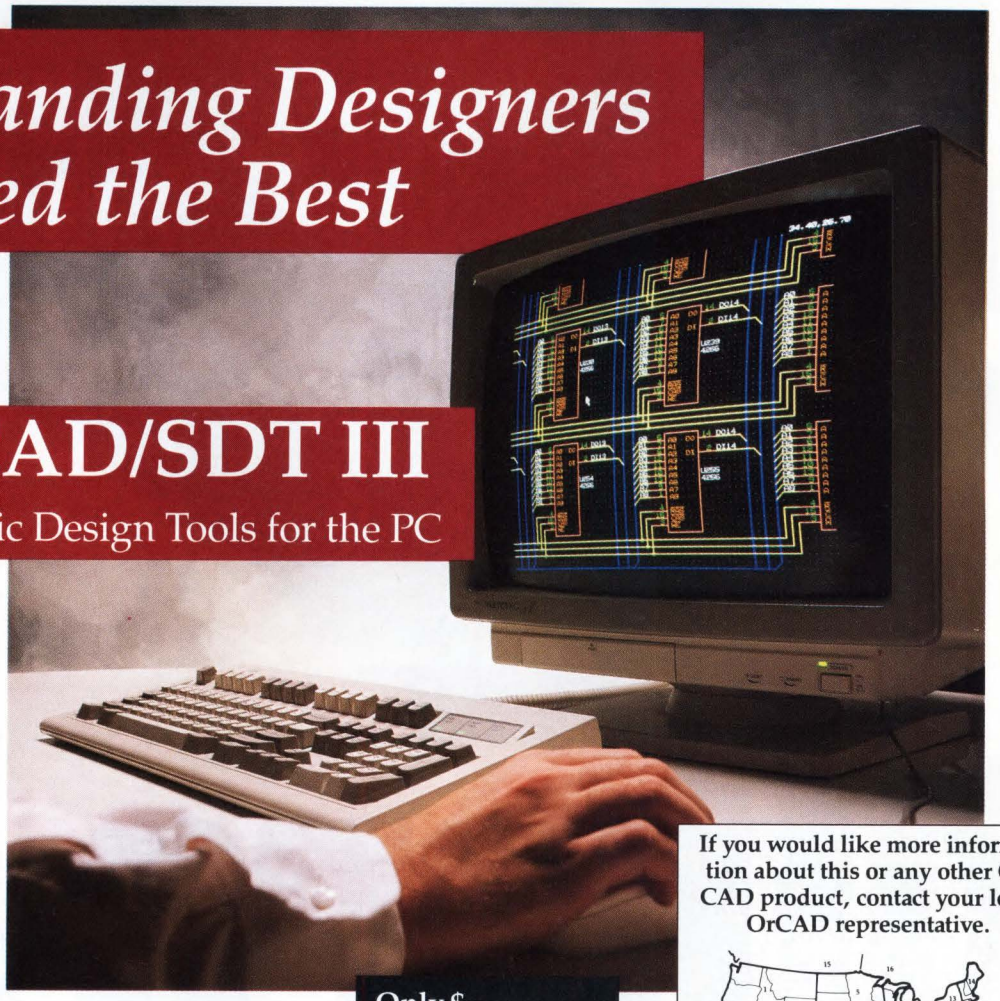

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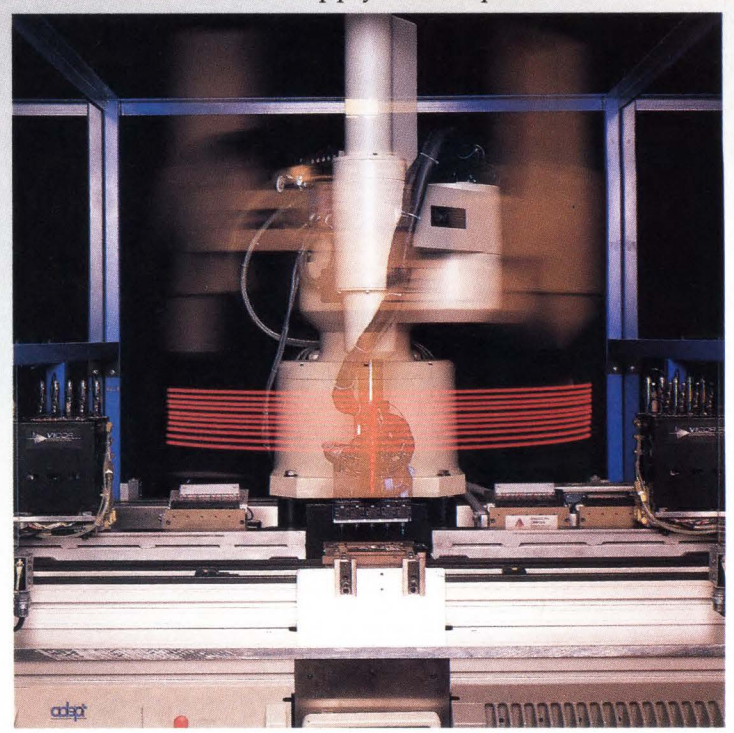

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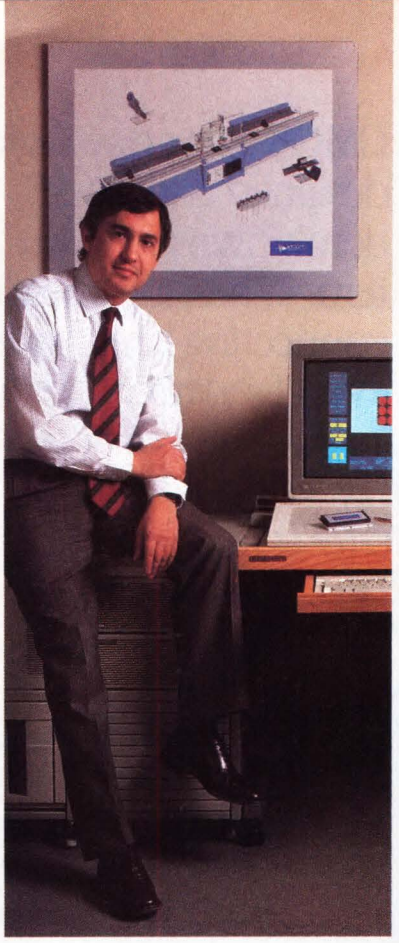

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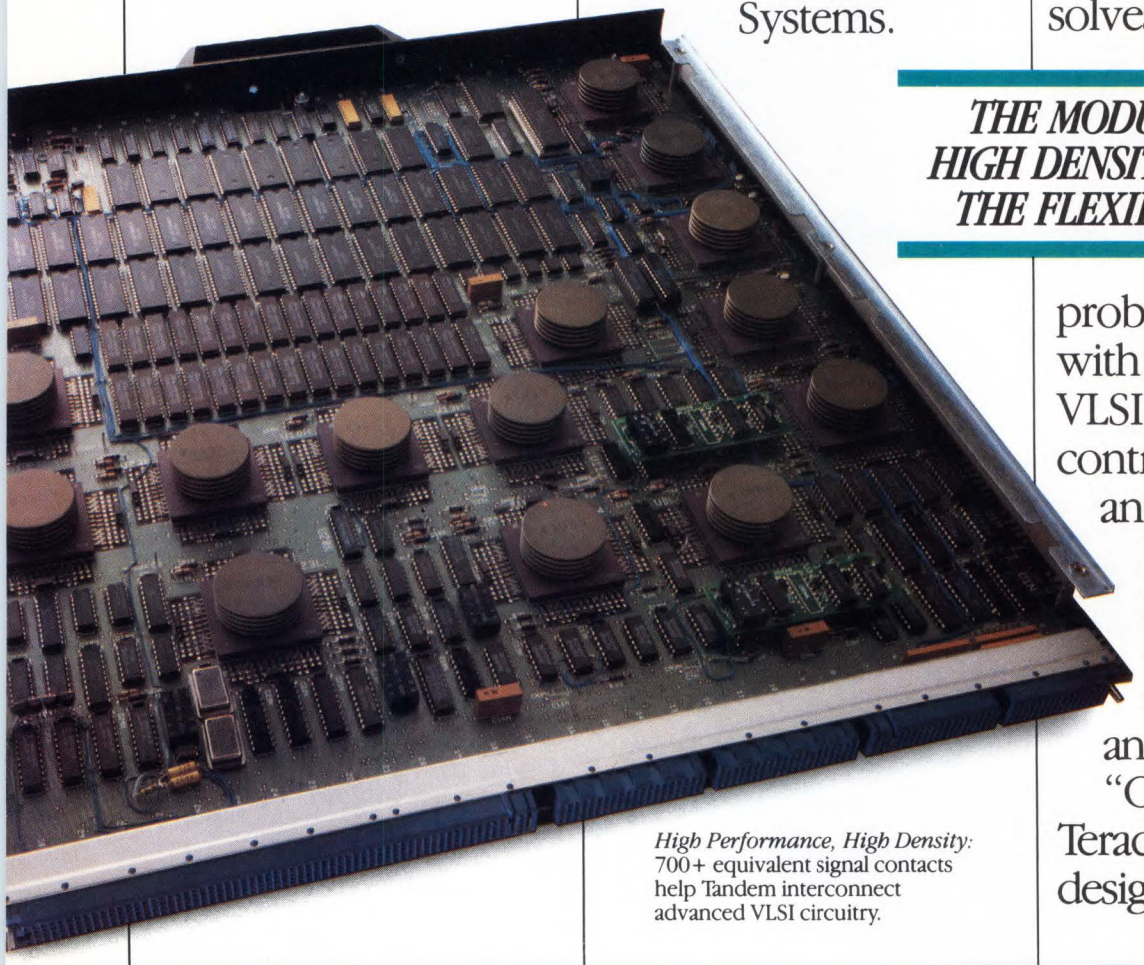
THE MODULAR DESIGN OF HIGH DENSITY PLUS PROVIDES THE FLEXIBILITY WE NEED.

"On top of all that, Teradyne's modular design provides the



High Performance, High Density: 700+ equivalent signal contacts help Tandem interconnect advanced VLSI circuitry.

TANDEM CONNECTS

flexibility we need to tailor our backplanes to each application."

Now, nearly 1,000 backplane systems later, is Tandem still completely sold on Teradyne's High Density Plus? "We made the right choice with Teradyne. And we look forward to working with Teradyne to meet future interconnection requirements."

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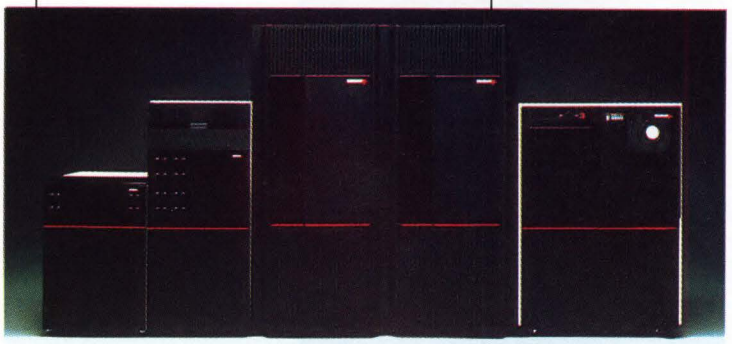

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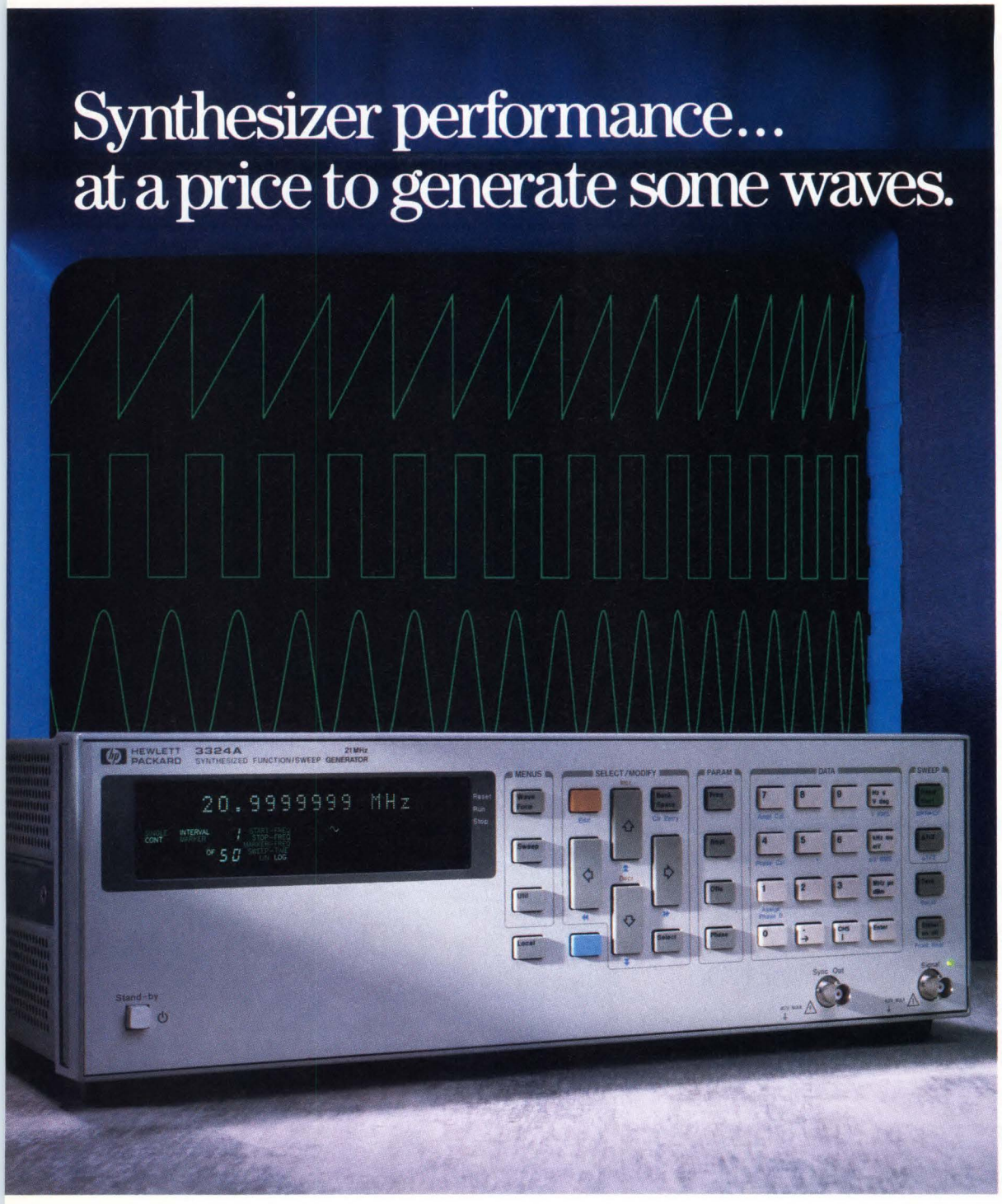

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*U.S.A. list price.

HEWLETT PACKARD

Foreign-born EEs are an important US resource

Jon Titus's editorial "Send alien graduates home" (EDN, October 27, 1988, pg 57) displays his lack of knowledge regarding foreign graduates and developing countries. It seems he hit upon the idea of the editorial while holidaying on some Caribbean island and wrote the article without any further investigation or study. Let me mention that the majority of graduate students coming to this country are from Asia, from countries like China, India, Taiwan, Korea, and Hong Kong. All these countries have advanced institutes for areas of engineering such as civil engineering, agricultural engineering, and food technology. So students who like to study in these fields do not come to the US.

Furthermore, energy engineering is a very new and advanced field, and is as equally relevant to the US as it is to the developing nations. And I have seen neither solar heaters in Florida nor windmills in Chicago.

The pool of foreign engineers and professors serves as an immensely important resource to US industry and universities. For your information, lots of computer science and EE departments would have closed for lack of faculty if it had not been for foreign-born engineers and scientists.

Let us realize that as the greatest debtor nation in the world, the US no longer enjoys the luxury of giving gratis advice to foreigners on how to serve their nations. Let it take the benefit of foreign talent if that serves both parties.

Sandip Chattopadhya
Principal Engineer
Wang Laboratories
Lowell, MA

Criticisms of IEEE were unfair

I would like to register strong disagreement with David A Meyer's letter of November 10, 1988 (EDN, pg 30), as well as other IEEE criticisms. These criticisms seem to indicate that some engineers are afraid of the competition that foreign engineers pose. I view this competition as a positive situation, one in which I am forced to be a better engineer and one in which my company and my country will benefit by receiving the best-engineered products.

I attended an engineering college of high caliber whose undergraduate population consisted of a high percentage of foreign students. These students were smart and hard-working. Their presence in the classroom greatly increased the competition and resulted in everyone's being pushed harder. I am for-

ever grateful for this situation, as it made me a better engineer.

A plan that proposes (as David A Meyer's does) to train foreign engineers at a lower level than domestic engineers cannot be taken seriously. It would be another form of protectionism, a policy that simply makes this country weaker and less competitive. Given a competitive situation, there are two possible responses: limit the competition or be better than the competition. Being better than the competition involves continuing education, innovation, and drive. Limiting the competition involves crying and complacency.

Finally, I have some thoughts on the subject of the "unreadable IEEE publications." I believe that statement to be an unfair criticism. The IEEE serves both the academic and the commercial communities. Many of the publications are clearly academically oriented (universities do benefit commercial entities). However, many of the publications—*Computer*, *Micro*, and *Spectrum*, to name a few—are very readable for anyone with an undergraduate engineering education. I do read these as well as some journals and use the information to the advantage of myself and my company. *Popular Electronics* is a nice hobby magazine, but it can be used only so much in the engineering profession.

I encourage all engineers and engineering students to join and contribute to the IEEE. I believe it to be a very worthwhile organization.

Rich Simons
Project Engineer
Tridelta Industries
Mentor, OH

Additions

Although Charles H Small attempted to include all the sources and alternate sources of programmable logic devices in the manufacturers list accompanying his November 10, 1988, Special Report on that subject (EDN, pg 142), a few manufacturers slipped by. One such was Cypress Semiconductor, which manufactures CMOS PLDs. Cypress was mentioned in the article, but was accidentally omitted from the manufacturers list. You can reach the company at 3901 First St, San Jose, CA 95134; (408) 943-2600.

Another omission was SGS-Thomson Microelectronics, which acts as an alternate source for Lattice Semiconductor's Generic Array Logic (GAL) devices. You can contact the company at 1000 E Bell Rd, Phoenix, AZ 85022; (602) 867-6100. FAX 602-867-6102.

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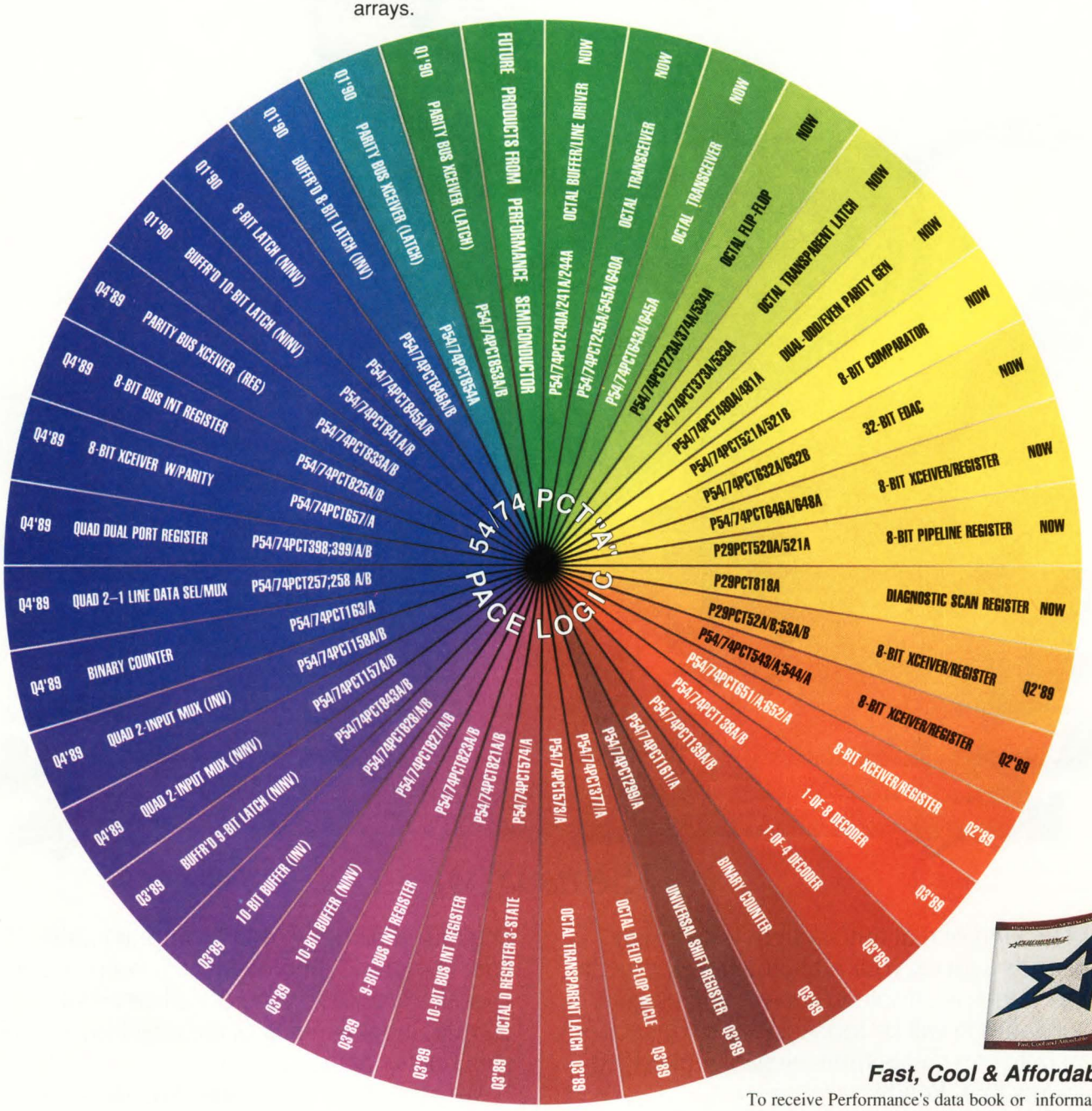

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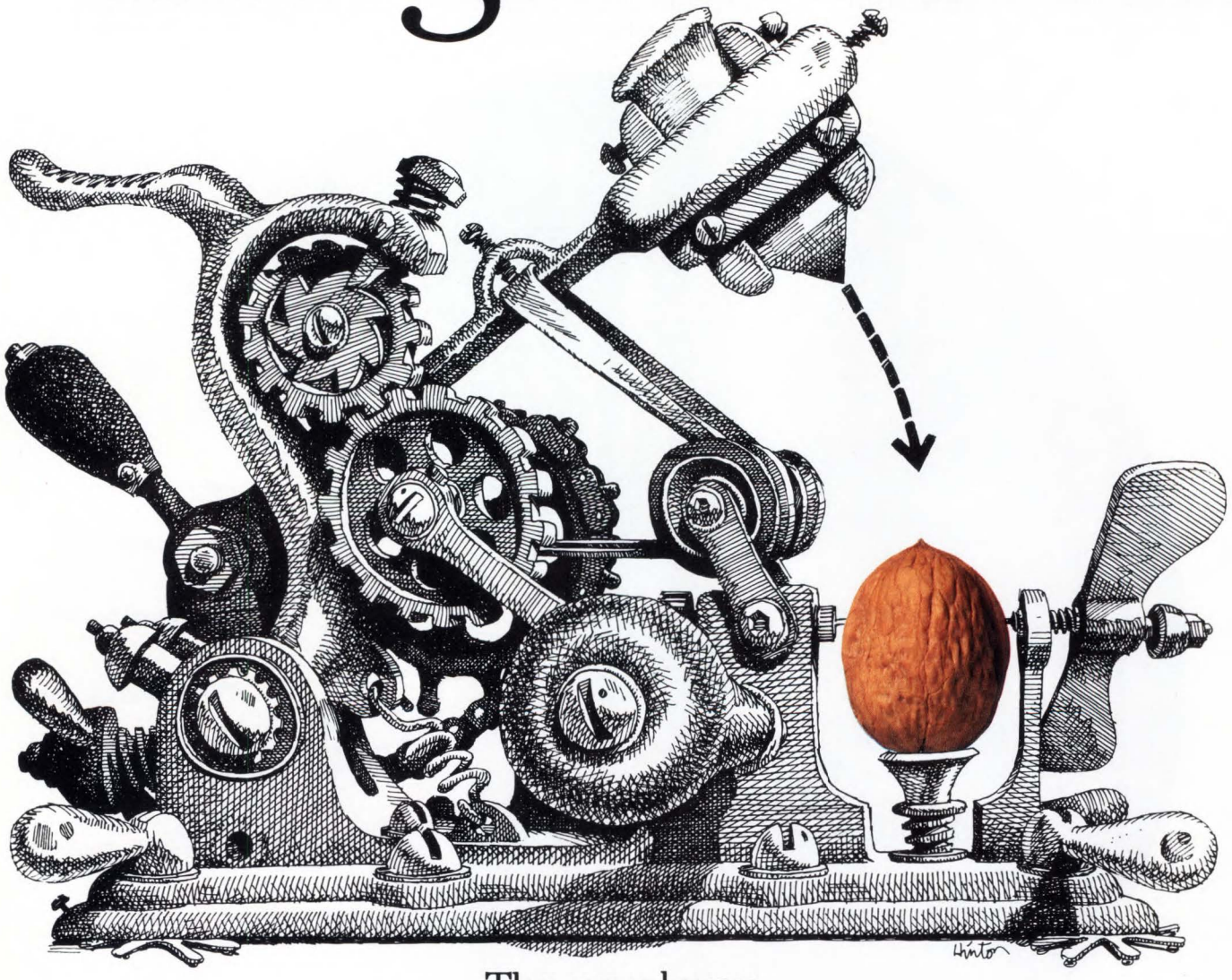

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We start at the same place you do—with your requirements. And we don't care what you're building, which embedded microprocessor you use, or whether you're working in complex

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So why go nuts with your next real-time project? Call us, toll free, at (800) 228-1249.

That way you'll have a fair crack at getting the kind of real-time system you really want.

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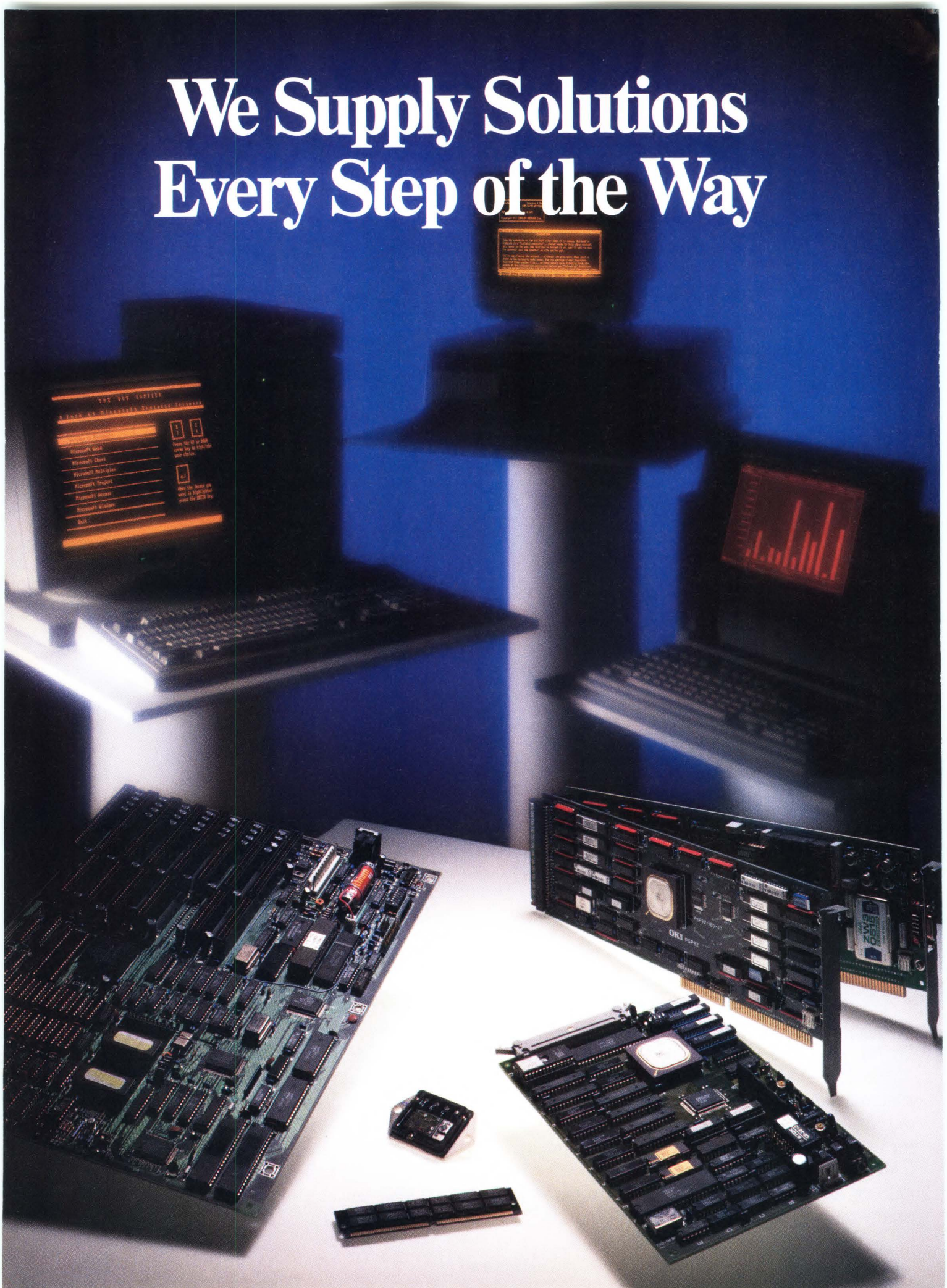

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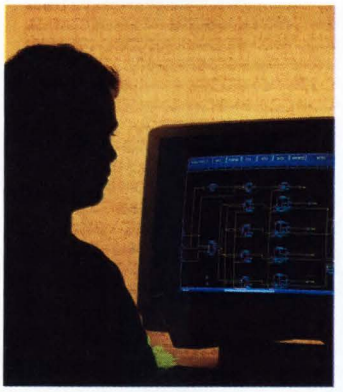

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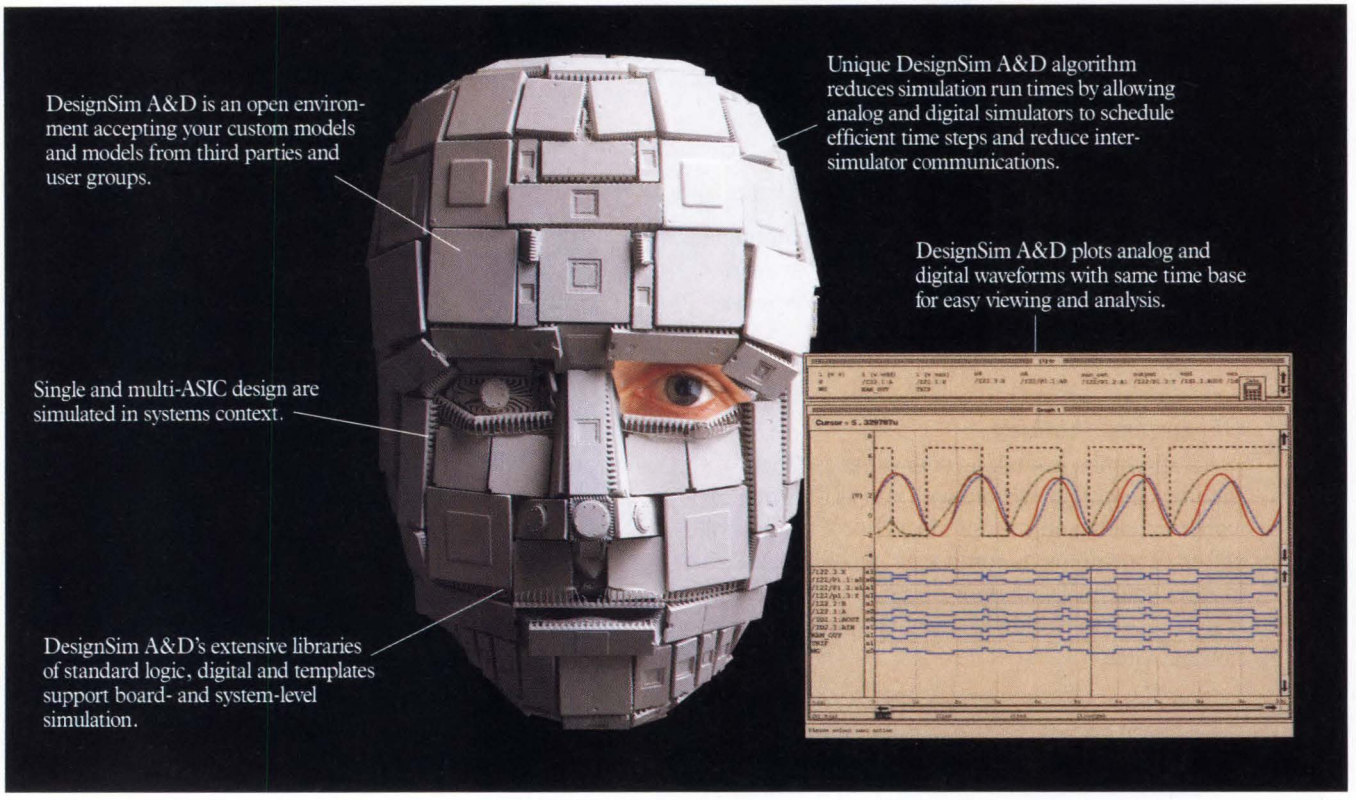

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Your product design is brilliant. Inspired. A masterwork.

There's just one hitch.

Your design overwhelms the capabilities of your simulator.

It can't handle your mixed-signal analog-digital circuits even at the ASIC chip level.

Not simultaneously. Not accurately. Not with feedback.

And at the system level? With multiple ASICs? No way.

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And because DesignSim A&D is fully featured, one system provides many types of analysis such as fault-grading and frequency analysis.

DesignSim A&D is just one benefit of working with NCR's Knowledge-based Engineering Environment (KE²).

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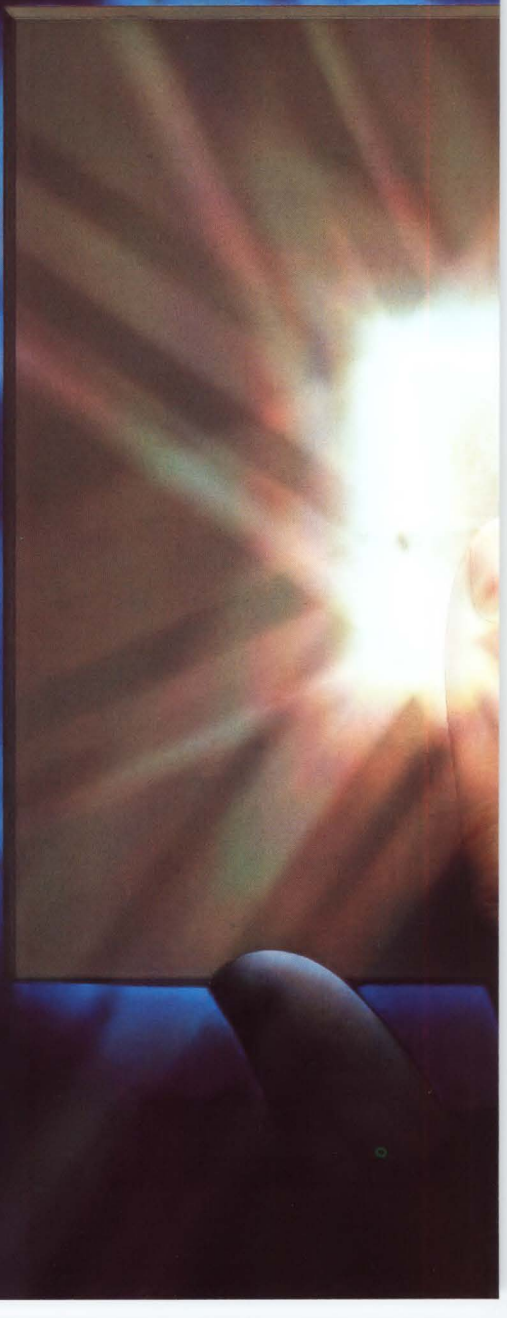
Creating value

It's time you really going connector



Seems like everyone in this business is asking the same question. "What's happening to the connector industry?"

Mergers. Acquisitions. Product withdrawals. Plant closings.

After reviewing the evidence of this difficult period for the industry, Du Pont Electronics felt it was time to ask some serious questions.

About our position and how we can better serve the electronics marketplace. About the way we do business. About where we need to go as a company. And how we want to get there.

The answers have led to some dramatic changes that will make us a stronger supplier and technology partner in the connector industry.

Among other things, we've streamlined our worldwide operations. Retrained our people. Invested heavily in new manufacturing technology. And continued to vigorously pursue R&D.

The result is that we're more global. More realistic. More flexible. And, we believe, more responsive in our approach to the industry.

In short, Du Pont is poised to help lead this industry as a permanent, competitive player.

We believe that what our customers want most is a new energy, a new commitment. And Du Pont Electronics intends to provide precisely that.

That's why, in virtually every area of our business, we're turning up the power.

knew what's on in the business.

R!

There's a new force driving Du Pont Electronics today. It can be summed up very simply: Being responsive.

Being responsive to your needs.

Being responsive to the needs of our people. By providing them with the tools—and the authority—to promote effective, efficient business relationships.

Finally, and perhaps most important, being responsive to this industry's constant need for technological improvement. Which means really listening to the demands of the marketplace. And then acting quickly.

Du Pont would like to hear what you think about these changes. Talk to us. We want to succeed and grow in the connector market. And we're committed to doing everything possible to make it happen.

It's a challenging goal, but one well worth reaching for.

And that's why we're turning up the power.

Du Pont Electronics

Share the power of our resources.

DU PONT

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Behind the merger mania in the connector industry.
Forecast Calls For Drop In Connector Growth.
Profit Squeeze In Connector Business.
Distributors Report Weak First Quarter.

VE'RE TURNING

PEOPLE.

Because the worldwide marketplace is changing, we're changing the way we do business. In fundamental ways, beginning with our people.

Our first goal was to get our people closer to their customers, so that everyone at Du Pont could better understand the people we're serving.

With that first step came some powerful insights. And solutions.

Du Pont employees have the power to solve problems *now*, instead of wading through a sea of red tape. Our people don't have to "check with the company." They *are* the company.

We're increasing our technical support staff with more experienced engineers. So we can quickly design more new products that address real customer needs.

And we've changed our sales operation.

Today, our unique team of direct sales people, manufacturers' reps, distributors and application engineers work in concert to solve problems—from technical solutions to improving delivery.

PRODUCTS.

Our aim is to broaden our overall product offering. And in doing so, meet customer demand for interconnect and packaging solutions that yield higher density and faster data rates.

To achieve that, we're developing smaller, more cost-effective products that work with increasing chip capabilities, and allow denser packaging—all in keeping with customer needs.

We're also making customized cable assemblies to meet specific industry requirements.

We intend to develop and produce the best connectors, terminals, assemblies and subsystems in the electronics marketplace. A better, broader product mix—which includes more reliable, more competitively-priced, and higher quality connectors for our customers—is going to help us do it.

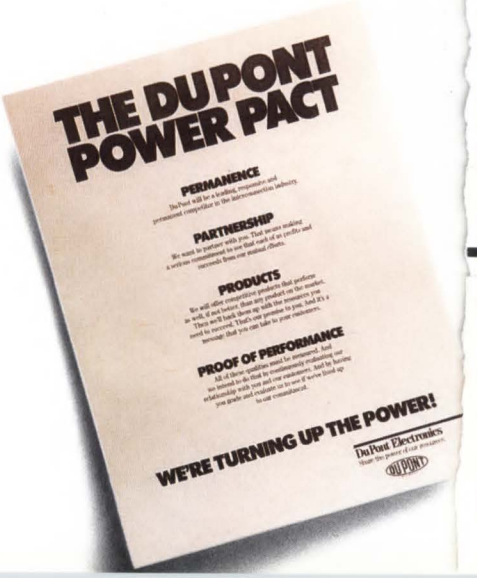
COMMITMENT.

Du Pont is here to stay in the interconnection and packaging business. That's a fact. And we're backing it up with demonstrable proof.

We're committed financially, with hundreds of millions of dollars for capital expansion and continuous improvements over the next five years.

We have 16 state-of-the-art facilities—13 manufacturing sites and 3 Technology Development Centers—located throughout the world to better serve emerging global markets. As well as new regional electronics centers in Boston, Research Triangle Park and Santa Clara.

We're also committed to extensive research and development—$50 million this year for the connector business alone—to meet specific customer needs for faster, smaller and more versatile connector products.



UP THE POWE

MANUFACTURING.

We've designed flexible manufacturing processes that allow us to respond faster to changing customer and market demands. Right now, for example, we're delivering smaller, specialized orders more quickly on a Just-In-Time basis to satisfy the needs of our customer partnerships.

We've made substantial investments in robotics systems as well. Our plants have been renovated with new automation systems to meet increasing customer demands for quick response and state-of-the-art products.

We've also installed modern CAD/CAE/CAM equipment at our sites around the world.

Then there's ICONSIM. This proprietary computer program, designed by Du Pont, allows designers to predict the performance of interconnects and assemblies through real-time simulation, which produces faster, more reliable interconnect designs.

DELIVERY.

Even the best connectors and terminals are worthless if you don't have them when and where you need them.

So Du Pont set out to improve this critical area of our business from the ground up.

We're managing our supply chain better, to make sure we can fill your order as needed.

Our Just-In-Time delivery programs are running smoothly. And our program to meet shipping dates as promised is right on target.

We're also upgrading our order-entry system. By year end several of our customers will be "on line" with Electronic Data Interface so that their orders reach the plant with the touch of a button. And that's going to mean more accurate, on-time deliveries.

We also have a centralized 800 number for all Interconnect and Packaging orders (1-800-237-2374).

QUALITY.

No one is more committed to Total Quality Management than Du Pont Electronics.

A unifying philosophy for achieving business excellence, TQM is a state of mind that results in continuous, measurable improvement in everything we do. And requires each of us to create and nurture the highest level of personal and organizational quality in our work.

The goal is to satisfy completely market and customer needs by providing value for ourselves and our customers. As well as promoting an environment that rewards individual initiative and teamwork.

We believe that if we're going to supply you with top quality connectors it has to show in everything we do—from handling a shipment to answering the phone.

Very simply, TQM is one more tool that allows us to satisfy your full range of requirements, from new designs to on-time delivery and defect-free products.

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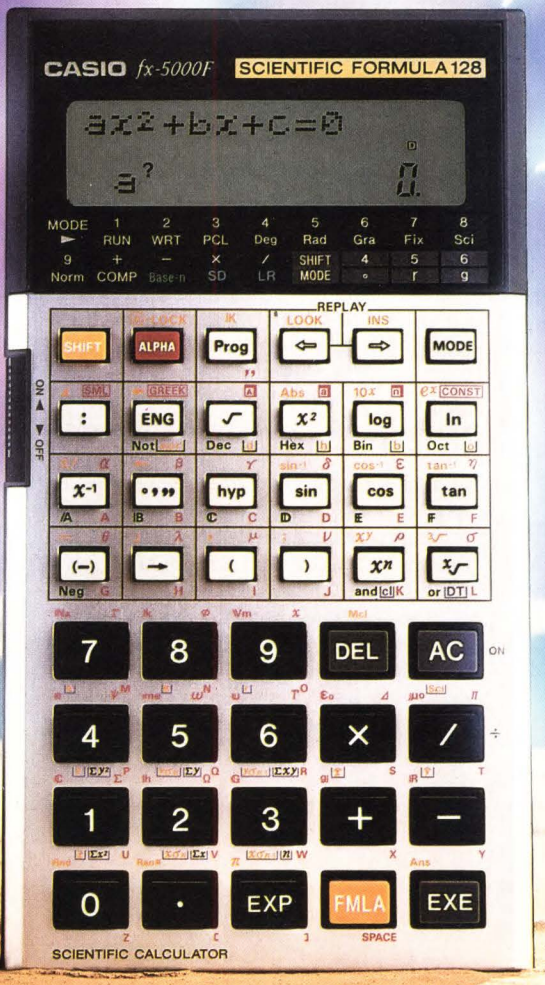

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The Casio FX-5000F Formula Calculator. To save you the time and trouble of looking up or memorizing many of the most important mathematical and scientific formulas, we put 128 of them in our FX-5000F Formula Calculator. And you can call them up in a flash.

The formulas are numbered and cover the fields of *math, statistics, physics, electronics* and *mechanics.* Plus you can input 12 of your own. Just key-in the appropriate number and the formula you need appears instantly. The alpha numeric display with 10 digit mantissa plus 2 digit exponent is easy to read and scrolls to over 70 characters. Its two-line display shows both the formula and the answer simultaneously.

And it doesn't stop there. Once you've recalled the formula, the calculator prompts you to input the values of the variables and automatically calculates the result.

The FX-5000F's 675 steps of program memory allow you to create some pretty sizeable programs and store them until needed. While an instant replay feature lets you review and edit formulas at the touch of a button.

Adding to its usefulness are an additional 160 powerful scientific functions, for a combined total of 288 functions and formulas.

Get your hands on a Casio FX-5000F and flash through a few formulas. You'll find it very illuminating.

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NEW PRODUCTS—NICOLET'S 400 SERIES

New Digital Oscilloscope is Best in Memory

Nicolet introduces a new standard of measurement

Nicolet, the company that first introduced digital oscilloscope technology in 1972, continues to break new ground. With the introduction of their new 400 Series digital oscilloscope, they have sent a clear message that they intend to lead the industry into the 1990s.

Ground-breaking innovations

The new Nicolet scope not only offers the option of an unprecedented 256K word memory per channel, but also gives you the capability of cascading together four channels for memory as long as a megasample.

This jump in memory greatly increases the digital oscilloscope's ability to record transient events over very long periods of time. For example, a seismic test could gather 1000 samples/sec for over four minutes. With up to one million data points, the Nicolet scope gives long time traces with intervals as short as five nanoseconds.

The increased memory of the 400 also gives you a great advantage over an ordinary DSO when taking short sweeps, such as when you only need 1K or 2K data points. The 400 Series saves more than 100 2K waveforms which can easily and immediately be reviewed and compared.

And there are other advantages in having vastly increased memory in a scope. The Nicolet 400's memory is complemented by its standard 32-bit CPU giving you waveform processing 10 to 100 times faster than you would get interfacing with a PC.

Transportable MS-DOS for automated testing

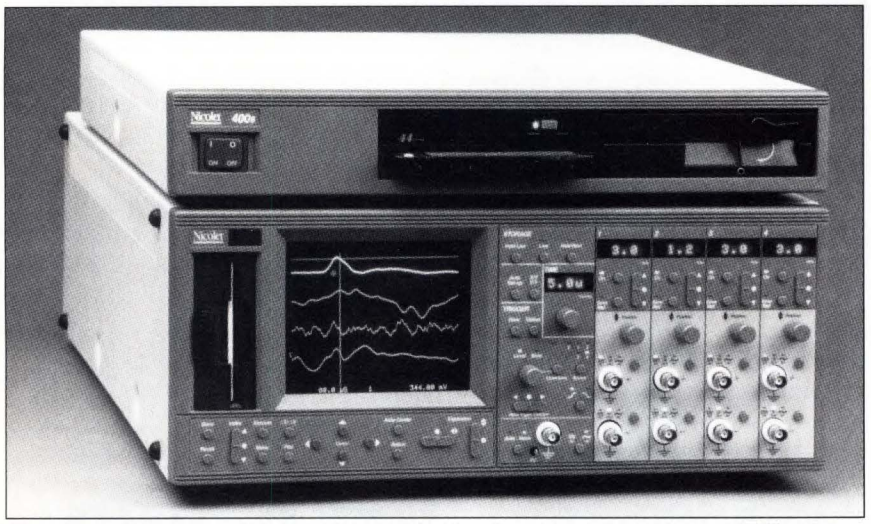
Another industry–leading feature Nicolet has brought to market with the 400 Series is a 44 megabyte, *removable* hard disk. While the best of the rest of the industry is equipped with floppys, Nicolet now offers an option which lets you store massive amounts of test data for instant retrieval.

This 44 megabyte hard drive lets a user recall test data, along with parameters and settings, ten times faster than previously possible. It allows you to duplicate the parameters of literally thousands of previous tests.

The 44 megabyte hard drive, as well as the 400 Series' built-in floppy drive, are ideal for automated testing. Using MS-DOS format, the disks allow analysis and archiving not only on the 400, but also on any PC.

Several other new advances introduced with the Nicolet 400 Series make this oscilloscope ideal for specialized testing and give it markedly improved calculation speed. For full details you'll need to read the product brochure.

Call Nicolet Test Instruments (800) 356-3090



The Nicolet 400 Series digital oscilloscope family offers 2 to 4 channel upgradability, 8 and 12 bit resolution at up to 200 MegaSamples/Second digitizing rates.

CALENDAR

Troubleshooting Microprocessor-Based Equipment and Digital Devices (seminar), Portland, OR. Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032. (913) 898-4695. June 13 to 16.

ATE & Instrumentation Conference East, Boston, MA. MG Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126; in MA, (617) 232-3976. June 19 to 22.

COMPASS '89 Conference, Gaithersburg, MD. Nettie Quartana, 2100 Washington Blvd, Arlington, VA 22204. (703) 486-3500. June 20 to 22.

Introduction to X.25 (short course), College Park, MD. University of Maryland University College Center for Professional Development, University Blvd at Adelphi Rd, College Park, MD 20742. (301) 985-7122. June 20 to 22.

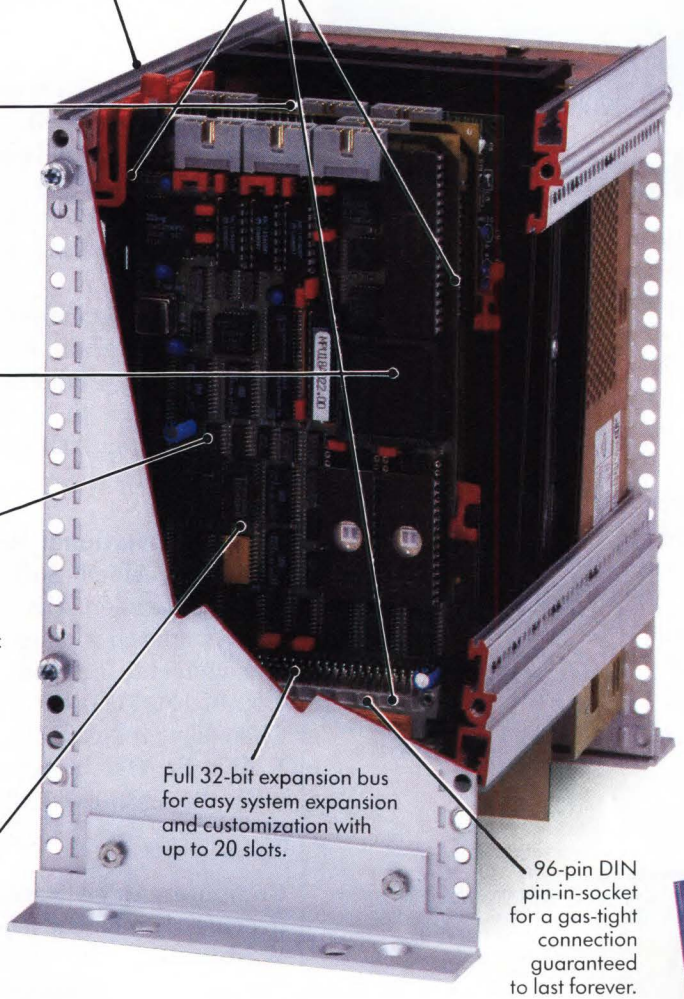
VHDL and Modeling in the DoD Procurement Process (seminar), Washington, DC. Paul Hunter, Program Chair, NRL, Code 5305, Washington, DC 20375. (202) 767-3264. June 21 to 23.

Fiber Optics in Local Communications (seminar), New York, NY. Raycom Systems Inc, 6395 Gunpark Dr, Boulder, CO 80301. (800) 288-1620. June 22.

26th Design Automation Conference, Las Vegas, NV. MP Associates, 26th Design Automation Conference, 7490 Clubhouse Rd, Suite #120, Boulder, CO 80301. (303) 530-4333. June 25 to 29.

Knowledge Engineering Today's Marketplace, The Annual Conference of the International Association of Knowledge Engineers, College Park, MD. Fred Whiting, IAKE Conference, Georgetown

At Last, a *Truly* Industrial PC AT System for the OEM



Unprecedented selection of inexpensive I/O functions, from the simplest parallel and serial I/O, to high performance networking, X.25, motor control and imaging.

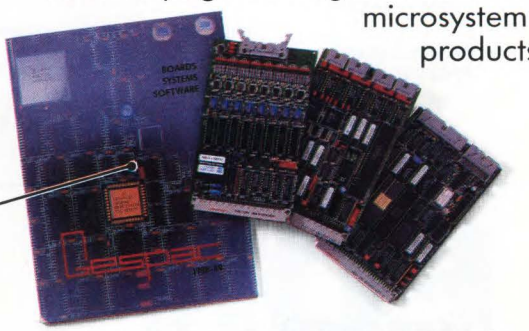
Introducing the first PC AT system originally designed to be embedded into your machinery or instrumentation.

With the GESPAC AT system, "ruggedized PC" no longer describes a desk top PC in a stronger black box. Rather it is an architecture made to last by design, with such features as small and robust board format, and ultra-reliable pin-in-socket DIN connector.

What's more, the GESPAC System is built for performance with Intel's original 80286 processor and 80287 Arithmetic Unit — In fact this system is the most compact implementation of the 286 in the market today.

The powerful G-64 bus interface lets you customize your AT system with any of the 200-plus system components available from GESPAC, to match virtually any system requirement.

Take advantage of GESPAC's 10 years of experience in serving the OEM marketplace. Call today to receive your free data sheet and our new 116 page catalog of board level microsystem products.



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Fax. 94 06 30 56

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CH-1228 Geneva
Tel. (022) 713 400
Fax. (022) 713 834

CIRCLE NO 96

CALENDAR

Box 25461, Washington, DC 20007. (301) 231-7826. June 26 to 28.

OS/2: A Comprehensive Hands-On Introduction (short course), Ottawa, Ontario, Canada. John Valenti, Integrated Computer Systems, 5800 Hannum Ave, Culver City, CA 90231. (800) 421-8166; in Canada, (800) 267-7014. June 27 to 30.

National Conference of Standards Laboratories (NCSL '89) Workshop and Symposium, Denver, CO. Ken Armstrong, NCSL, 1800 30th St, Suite 305B, Boulder, CO 80301. (303) 440-3339. July 9 to 13.

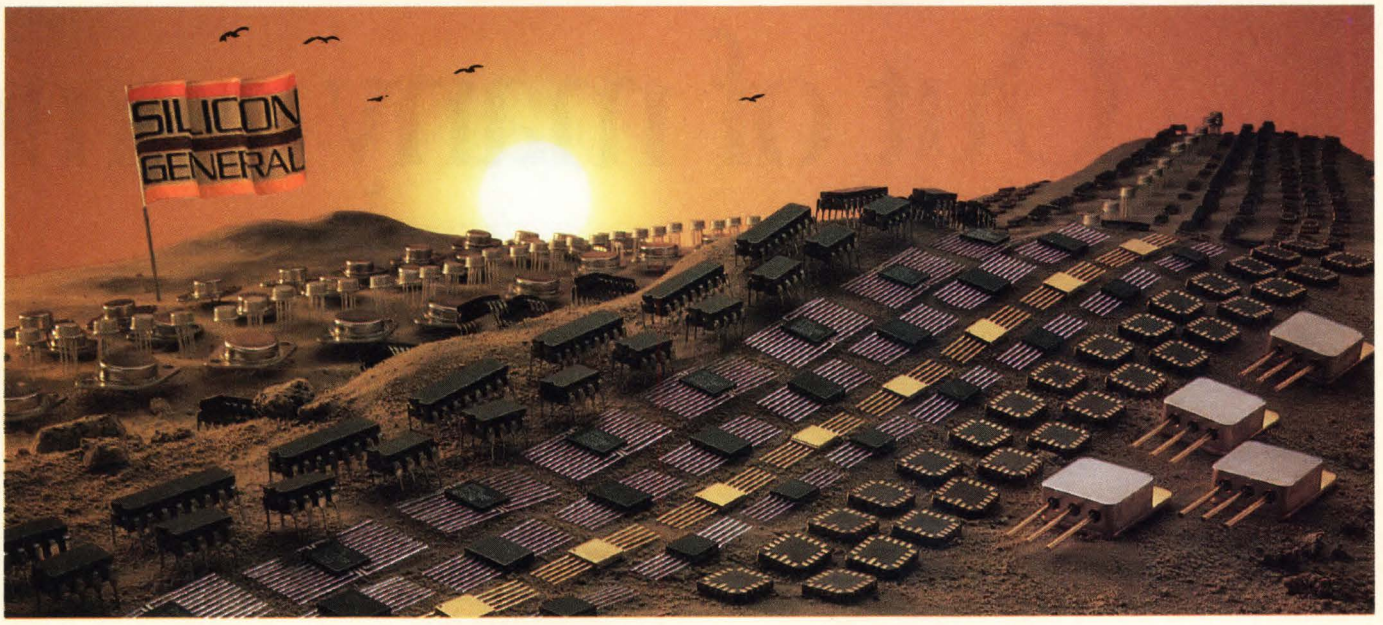
Quality Management Conference, Denver, CO. Pam Frye, Quality Management Conference, ACEC, 1015 Fifteenth St NW, Washington, DC 20005. (202) 347-7474. July 12 to 14.

Third International Workshop on Computer-Aided Software Engineering, London, UK. John O Jenkins, Imperial College, School of Management, London, SW7 2PG, UK. 01 589 5111, ext 7112. Elliot J Chikofsky, Index Technology Corp, 1 Main St, Cambridge, MA 02142. (617) 494-8200, ext 1989. July 17 to 21.

Computer-Aided Software Engineering, Hands-On (short course), Washington, DC. John Valenti, Integrated Computer Systems, 5800 Hannum Ave, Culver City, CA 90231. (800) 421-8166; in Canada, (800) 267-7014. July 18 to 21.

Supercomputers, Hypercubes and High Performance Architectures (short course), Boston, MA. John Valenti, Integrated Computer Systems, 5800 Hannum Ave, Culver City, CA 90231. (800) 421-8166; in Canada, (800) 267-7014. July 25 to 28.

Who leads the ranks in military ICs? The General does.



The General has mobilized the greatest army of Hi Reliability ICs ever. There are troops of leadless chip carriers, flat packs, power packages, cerdips, side brazed, standard metal cans, and our newest recruit, the hermetic TO-220. It's an army of pulse width modulators, supervisory circuits, power supply ICs, regulators, FET drivers, memory drivers, diode arrays, and transistor arrays.

The introduction of the Hermetic TO-220 is another example of the General's commitment to the demanding requirements of the military marketplace.

Other examples include: • Radiation hardened devices • Military hybrids • Flat packs/LCCs • New JAN quals • Aggressive deliveries.

You'll like the General's allies too: • Mil-M-38510 • Mil-S-19500 • Mil Std 883 Class B, Class S • Mil/DESC Drawing • SCD.

Call Silicon General for our new short form catalog and an updated JAN QPL listing (including 7800, 7900 series regulators in process). Please address Silicon General, 11861 Western Ave., Garden Grove, CA 92641. Phone (714) 898-8121, TWX (910) 596-1804, FAX (714) 893-2570.

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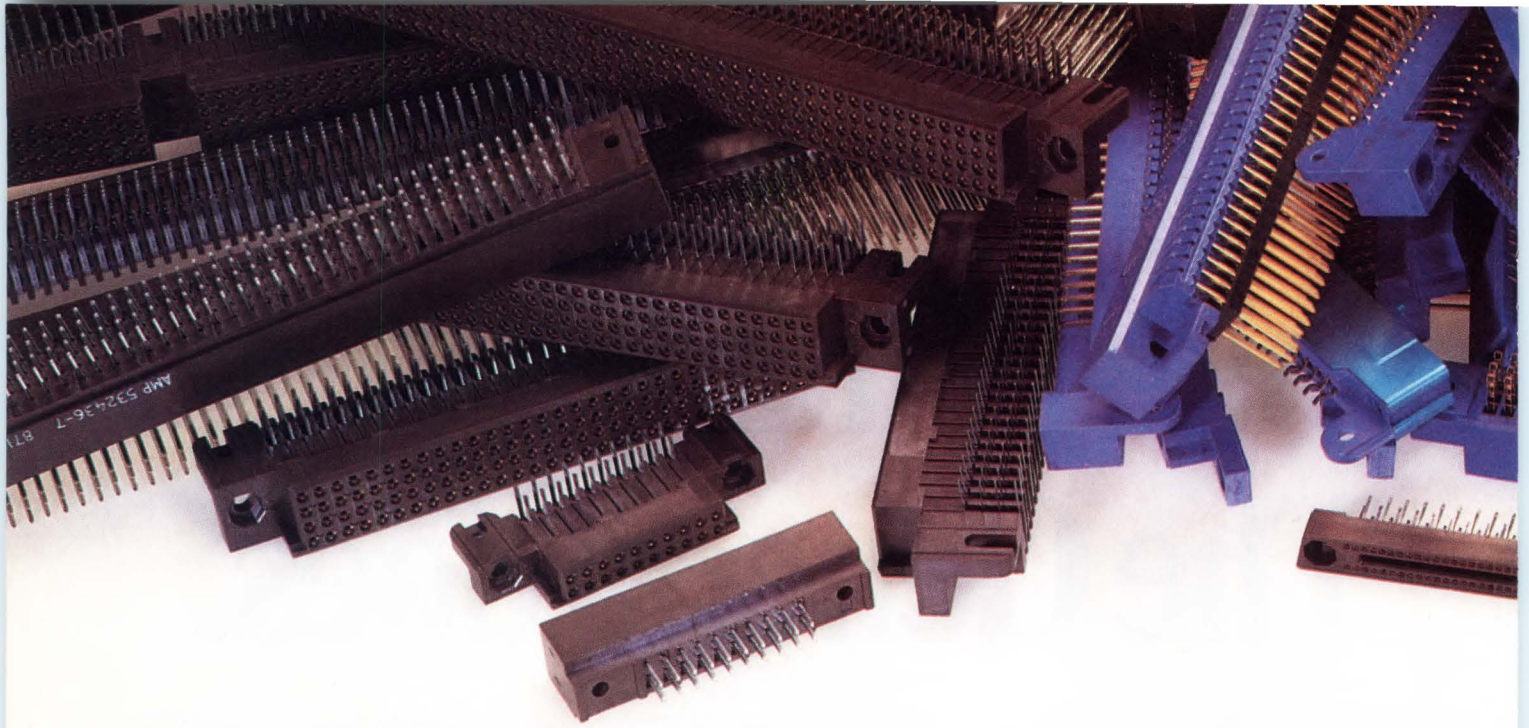


Out of many come

It takes a lot to keep our two-piece connector customers happy. Reliability. Quality. Availability.

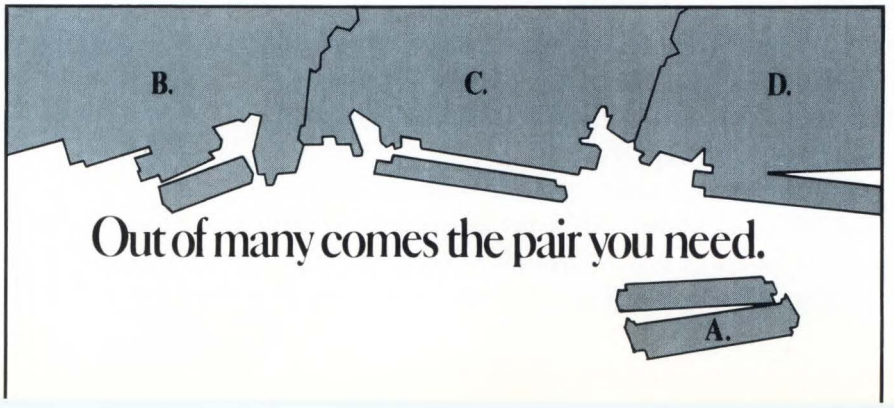
And enormous selection.

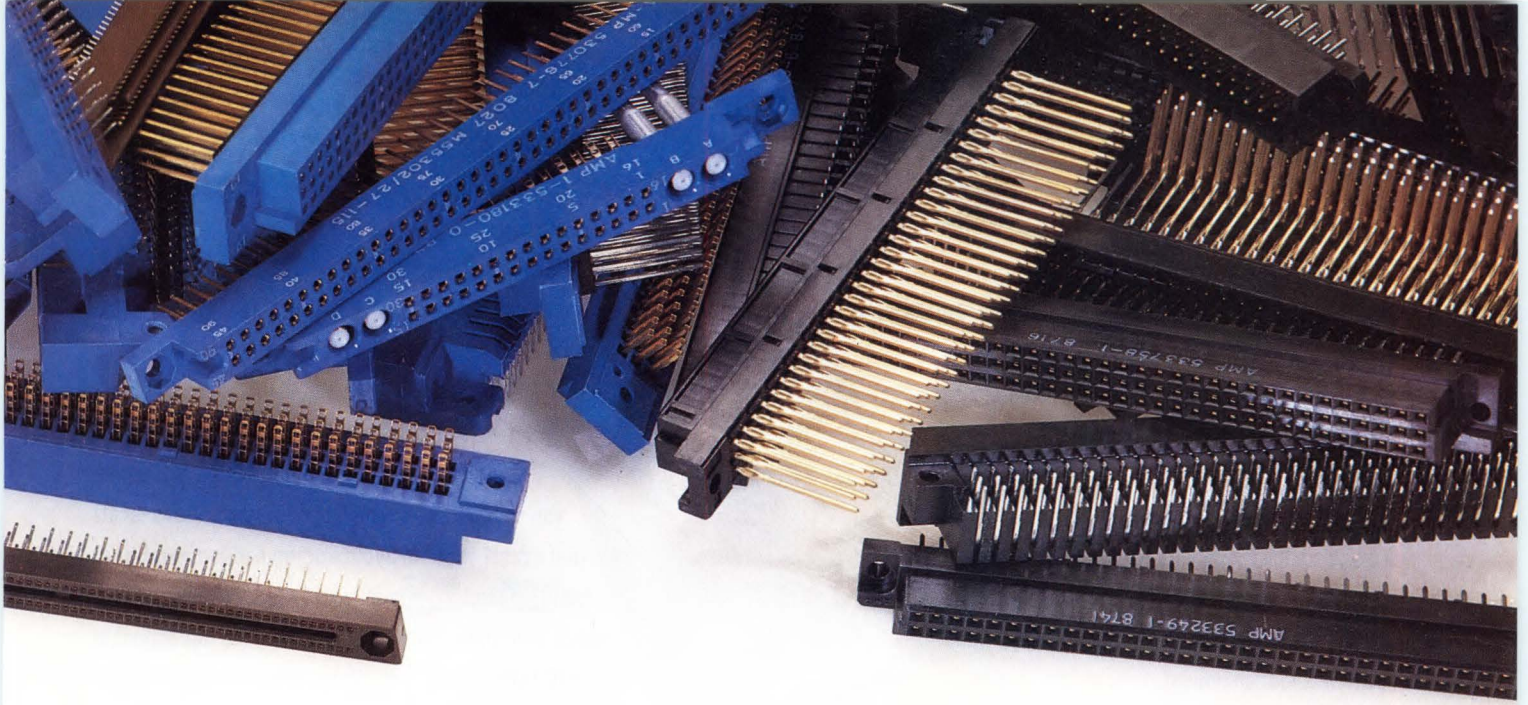
We're confident we've got one for you, too.

A. Example. Our AMPMODU two-piece connectors, 12-200 positions, 2 row and 30-300 positions, 3 row, in horizontal and right-angle versions. Our worldly (and world-famous) post and receptacle design—dual cantilever beams, anti-overstress, post-stop. Clean, elegant, reliable.

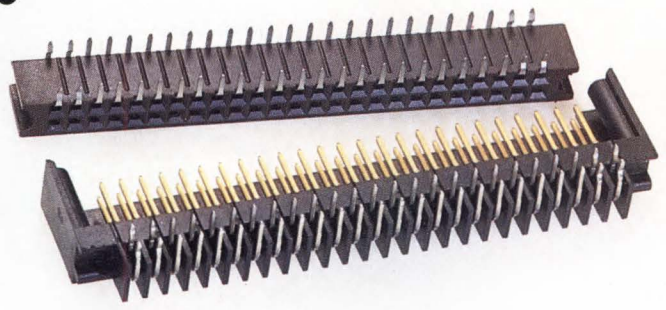
B. Or our high-pin-count contender, the AMP-HDI connector group. Available to 684 positions on a 0.100″ grid, with four-way contact on every pin. Power and miniature coax contacts available, too. All in all, hard-working state of the art.

C. Or our Box Contact group. Same contact design as AMP-HDI—





s the pair you need.



very forgiving of pin angle during mating. Very reliable. And available on 0.100″, 0.075″, and 0.050″ CLs, with microminiature coax. MIL-C-55302s available as well.

D. And Eurocards, compatible with DIN 41612 types, available in 1/2s, reverses, expanded 2 and 3 row specials to 150 positions. Made worldwide by AMP, available nearby.

All these choices come with options, of course—special platings, ACTION-PIN press-fit contacts, and more. All in the name of having exactly the one you need.

For information on AMPMODU Two-Piece Connectors or others in our lineup, call the AMP Information Center, 1-800-522-6752. For characterized backplane assemblies, contact AMP Packaging Systems Inc., P.O. Box 9400, Austin, Texas 78766, (512) 244-5100, or your AMP Sales Engineer. AMP Incorporated, Harrisburg, PA 17105-3608.

AMP Interconnecting ideas

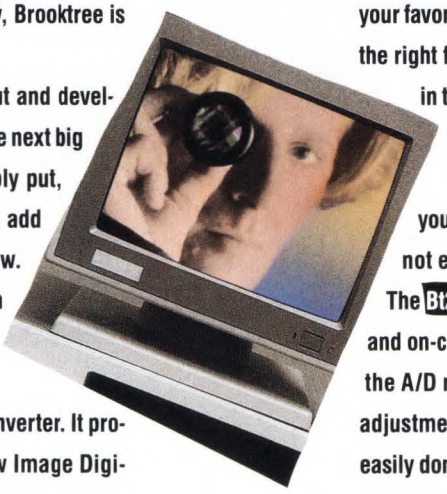
We've captured the key to image capture technology in three highly-integrated new devices.

Take a look.

Ready! Focus! Fire!

We did. And we nailed the target. Now, Brooktree is What's Hot in Image Digitizing.

We turned our D/A expertise inside out and developed the A/D front end that just might fuel the next big wave in PC and workstation demand. Simply put, we make it easy, economical and smart to add image capture capability to your system. Now.

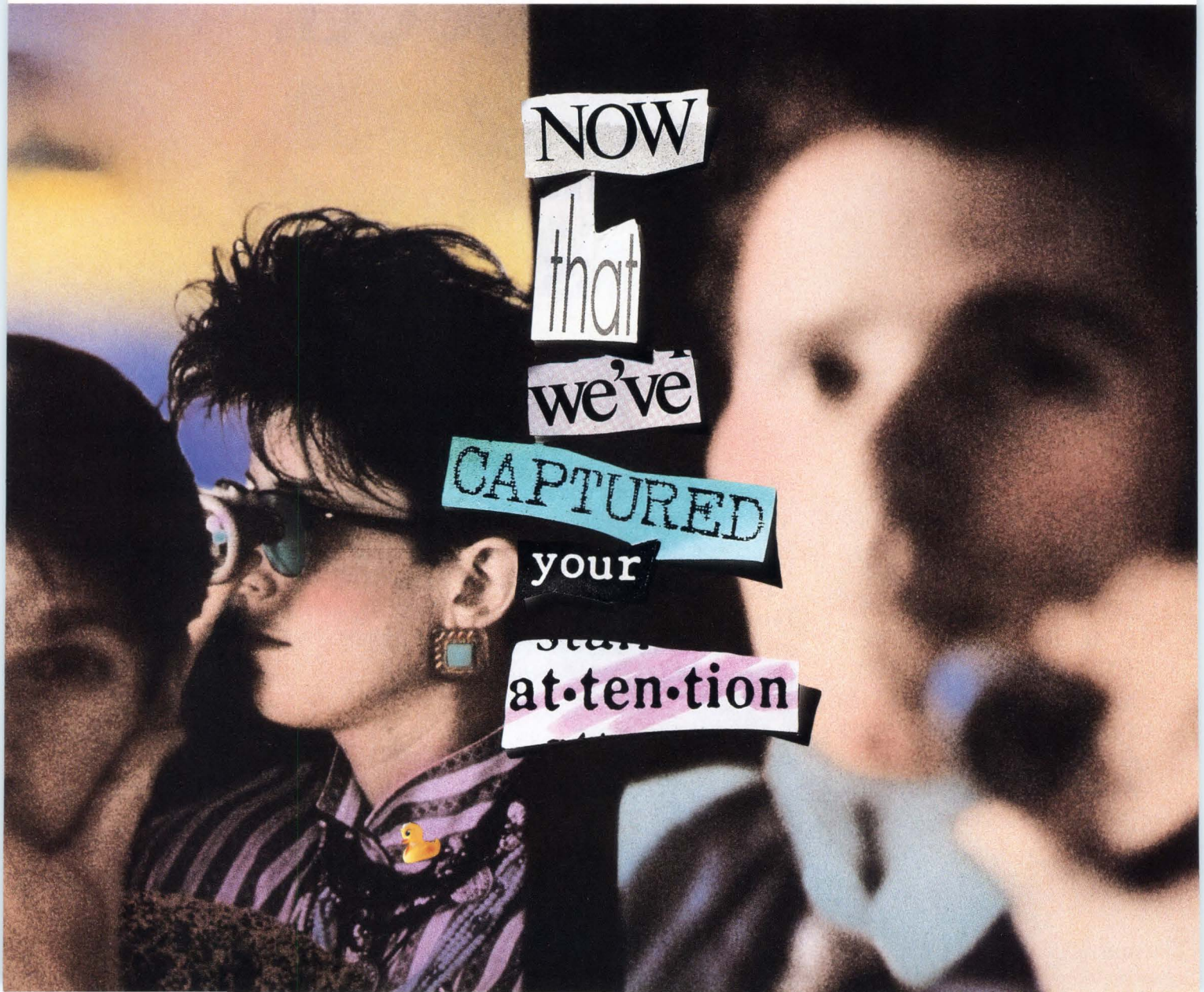


Our focus on imaging has created a team of highly integrated devices, here today, awaiting your command.

Start with our Bt208 flash 8-bit A/D converter. It provides the base technology for our two new Image Digitizers—the Bt251 single-channel device for gray scale applications and the Bt253 triple-channel device for color applications.

Flexible architectures are the key. Take filtering—your favorite subject, right? We make it easy for you to use the right filter for your application, and place it anywhere in the signal path. Use multiple filters or a single filter—it's up to you.

At the back end, the programmable DACs give you complete control over your image. Video levels not exact? Want to avoid adding a video amplifier? The Bt251 and Bt253 digitize 0.7v to 1.2v video signals, and on-chip DACs allows adjustment of the top/bottom of the A/D reference ladder. So contrast enhancement or adjustment for different or nonstandard video levels are easily done under MPU control.

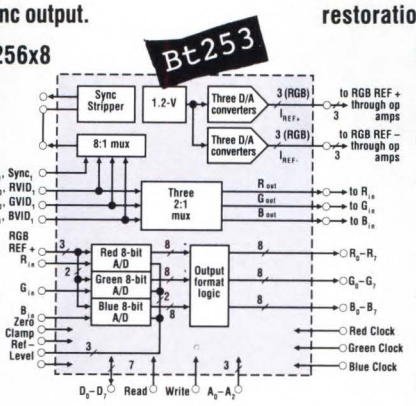


The **Bt251** is the monolithic CMOS single-channel, 8-bit device with the features you need. Four input video sources. Sync detection with TTL compatible sync output. DC restoration. Programmable gain/offset. 256x8 lookup table RAM for gamma correction removal, contrast enhancement or thresholding and a standard MPU interface. All in a 44-pin PLCC.

The **Bt253** is its color companion. It's a monolithic CMOS triple channel 8-bit device that digitizes three channels of video signals, generating up to 24 bits of color pixel information.

Use the Bt253 for 24, 15 or 8-bit color applications. It provides for extensive MPU control and supports two video sources. All in an 84-pin PLCC.

Couple the **Bt253** with our **Bt473** True Color RAMDAC to capture and display 8-bits each of RGB.



Like we said, highly integrated.

Feeling especially creative? Our 8-bit **Bt208** is ideal for unique designs. Tailored for video, it also supports DC restoration, on-chip reference, and digitizes 0.7v to 1.2v video signals.

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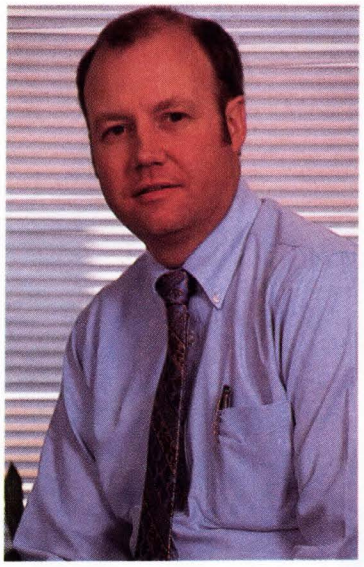
EDITORIAL

Revive Electro



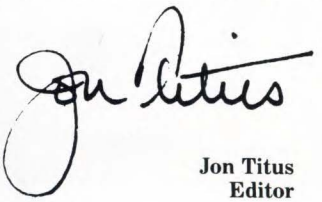
This April, the light attendance at Electro was shocking. Only about half of the expected 46,000 attendees showed up. This scanty turnout may have been a combination of holding the show in New York City's Jacob Javits convention center—an out-of-the-way location—and the dismal local economy for engineers. Whatever the cause, Electro needs a dose of vitality, or this meeting will pass into oblivion. Here are some suggestions:

- Emphasize the sales nature of the show. In the past, selling wasn't permitted on the show floor. Now it is, and more companies should use the meeting as an opportunity to meet with customers who are ready to buy. If Electro becomes simply a show-and-tell gathering where attendees view products, it will die.
- Although Electro has a smaller contingent of representatives standing in for principal companies than, say Wescon, more companies should send key people to help man the booths. Most representatives do a fine job, but often, customers and prospects want to talk with key people in sales and engineering. Also, having a company person on hand shows a commitment to the show, the representative, and the customers.
- Emphasize useful material in the technical sessions. Too often what sounds like an interesting talk degenerates to a product introduction or an "aren't-we-great" talk about a company's astounding and unique technologies. Many speakers pat themselves and their companies on the back instead of giving attendees information they can use to do their jobs better. Among the causes for the demise of the National Computer Conference, for example, was the switch from useful, helpful talks to promotional pitches and new-product introductions.
- If the local engineering situation is bleak, set up a job-information exchange program. Also, companies that have openings should be encouraged to make attendees aware of the job opportunities. The professional program should also include more professional and job-related topics of practical value.
- Set up displays within product classifications. If I want to visit with power-supply companies, I shouldn't have to walk back and forth across the entire exhibit area. Eight or nine major product classifications should take care of everyone.
- Reaffirm that Electro isn't a *trade* show. Once and for all, let's kill the idea that engineering is a trade. Electro, Wescon, and other meetings are professional gatherings that provide an opportunity for professionals to meet, exchange ideas, and learn about new technologies, techniques, and products.

Electro can regain its luster as the premier gathering time and place for electronics- and electrical-engineering professionals, for the companies they do business with, and for the companies they work for. But, the show's organizers can't do the job alone. They need your support, and they need it now. You must be willing to invest time and money to help revitalize this event. If Electro gets smaller or disappears, the entire electronics industry will suffer. It's time for action, and all of us must act now.

Jesse H Neal
Editorial Achievement Awards
1987, 1981 (2), 1978 (2),
1977, 1976, 1975

American Society of
Business Press Editors Award
1988, 1983, 1981



Jon Titus
Editor

Bred for the Job

Hitachi's New H8/532 One-time-programmable 8-bit Microcontroller

Handles the Toughest Real-time Control Tasks with Ease

The Clydesdale. Superior strength and stamina, yet easy to work with. Created by man and nature to excel in a specific role. . . tackling heavy-duty work.

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This 8-bit microcontroller harnesses the power of a 10MHz CPU with a 16-bit internal architecture. It muscles its way through complex math problems with a 200ns minimum instruction cycle time, 2.3μs 16 x 16-bit register multiplies, and 2.6μs 32/16-bit register divides. In addition, the H8/532 supports "C", making it easier for you to put its power to work.

The H8/532 ZTAT™ (Zero Turn-Around Time) microcontroller features an unprecedented amount of one-time user-programmable EPROM. . . 32 Kbytes. The ZTAT microcontroller gets you to market fast. The very day you finish development. No waiting for mask ROM parts. You get unbeatable flexibility—change code instantly without creating an inventory of obsolete devices. The ZTAT feature also saves you money by eliminating mask charges and minimum order quantities. For high volume, you can go to a mask ROM version of the H8/532 for the lowest high-volume unit cost.

The H8/532 contains a wagonload of on-chip peripherals; including 1 Kbyte RAM, 8-channel 10-bit A/D, 8 timers, a serial communications interface, 65 I/O pins, and a data transfer controller—all tightly packed in a small, surface-mount plastic package. This combination of high integration and large memory makes the H8/532 a true single-chip solution.

Now you have the right device for challenging office automation, automotive, industrial, and telecommunications applications. Applications requiring heavy-duty math, I/O, or timing control. The H8/532 provides the horsepower for a broader range of applications than you thought a single 8-bit microcontroller could ever manage.

Development with the H8/532 is easy, with our full stable of development tools running on IBM PC* or VAX* computers: a "C" compiler, a cross-assembler, a simulator/debugger, an in-circuit emulator, ZTAT programming socket adapters, and a low-cost evaluation board. The H8/532 has a familiar architecture, and its instruction set is similar to industry standards.

With the H8/532, you can harness a whole team of Hitachi devices to work together in your application: memories, peripheral devices, logic, LCD drivers, opto and analog ICs.

The H8/532 is the first in a long line of new H8 workhorses. Each created for a different cost/performance objective. All H8 devices have the bloodlines common to all Hitachi products—quality and reliability. For more information on the hard-working H8/532, contact your local Hitachi Sales Representative or Distributor Sales Office today.

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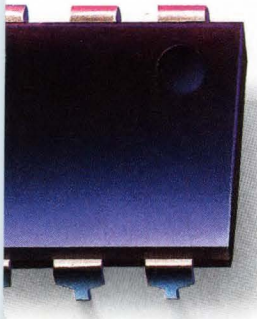

Fact is. Four times the speed at 1/6 the power.

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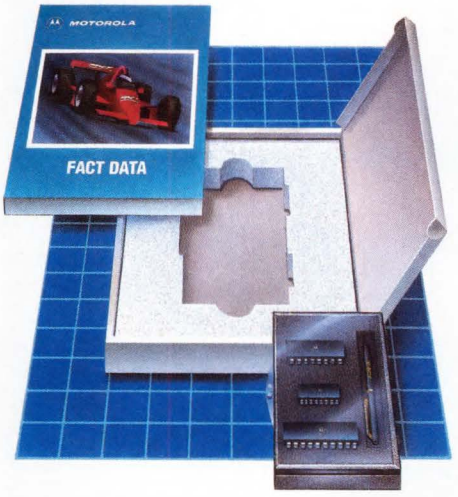
What's more, FACT boasts highest-of-all DC sink or source output drive at 24 mA, providing wide logic fanout and allowing it to drive a 50 Ω transmission line at commercial temperature ranges without external buffering. That's a first for CMOS logic.

And, you can also use FACT logic to drive highly capacitive nodes and bus structures.

Fact is. A limited number of FACT sample kits are available through Motorola sales offices and distributors.



Fact is. FACT logic clamps noise, kicks latch-up and kills ESD.

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As for latch-up, Motorola FACT logic typically handles currents as high as 300 mA on its output.

And, 2 KV min. electrostatic discharge (ESD) immunity means unnecessary device handling procedures can be significantly reduced with FACT.

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Final Fact. Design-in help is available.

If you want direct assistance for design-in of FACT or other Motorola logic families, call 1-800-521-6274 toll-free any weekday, 8:00 a.m. to 4:30 p.m., MST, from anywhere in the US or Canada. For the FACT Selector Guide, send the coupon or write to Motorola Semiconductor Products, Inc., P.O. Box 20912, Phoenix, AZ 85036.

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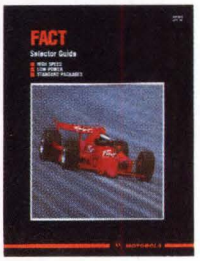

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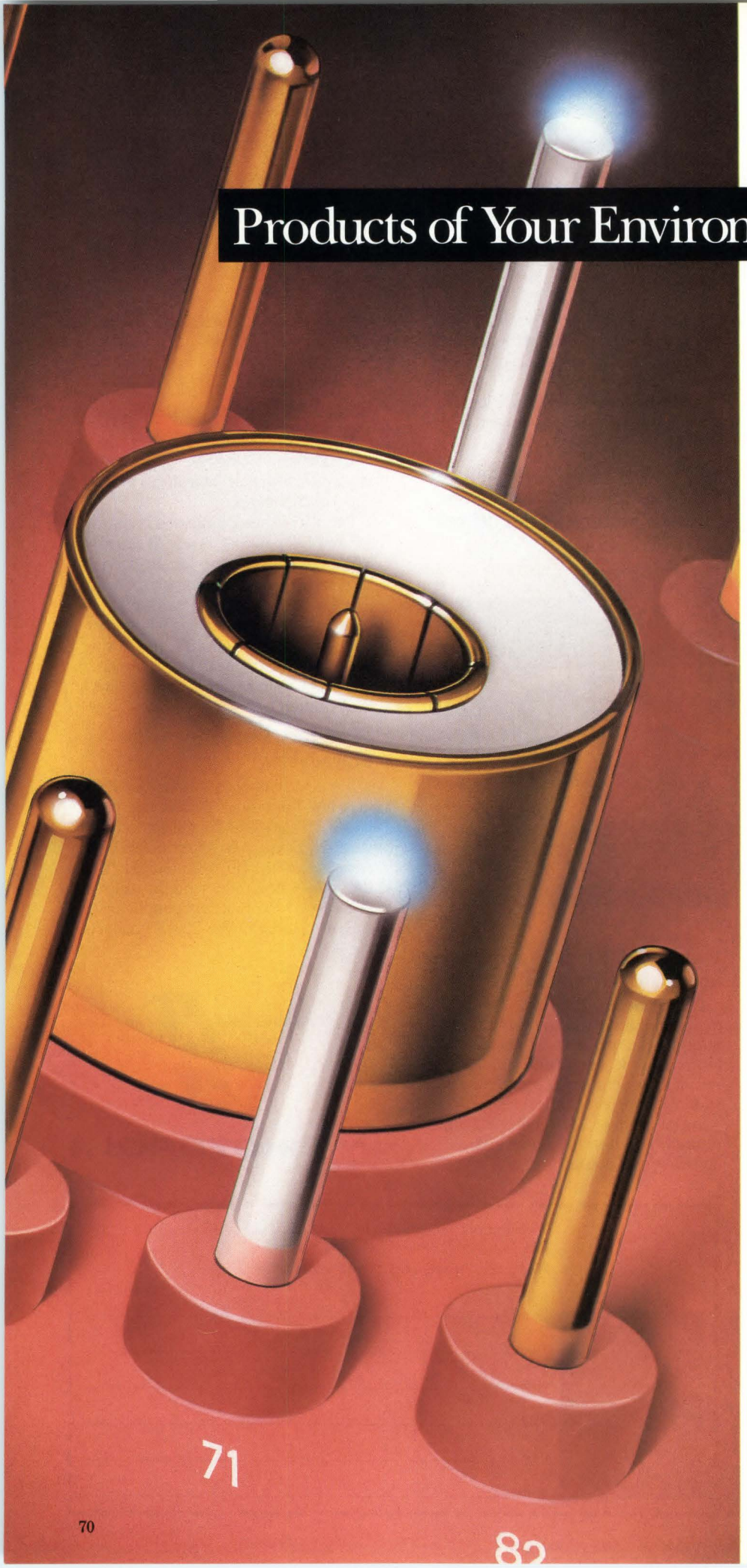

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CIRCLE NO 105

MICRO CHANNEL INTERFACE ICs

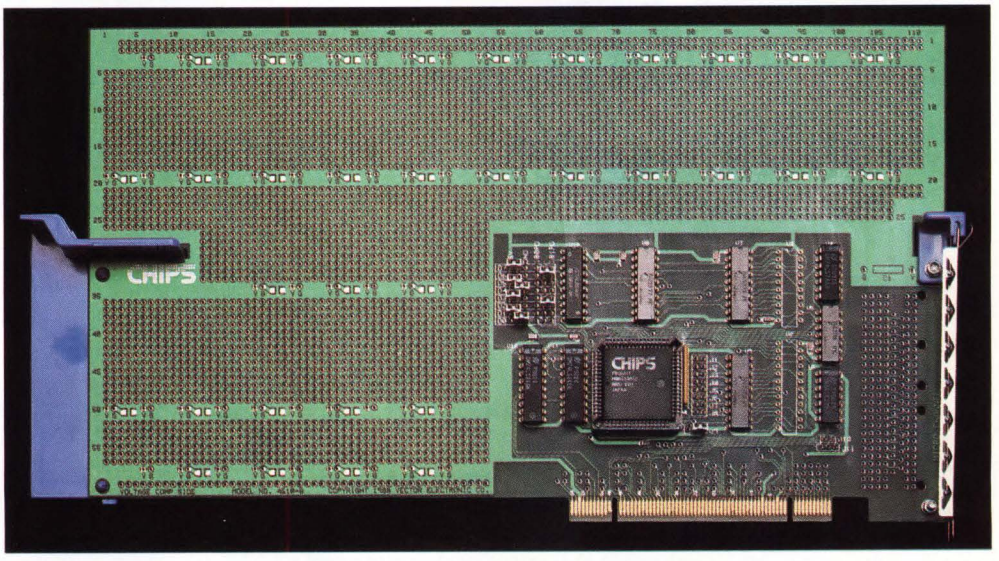
Board's functions determine IC choice

To make the most of the space, power, and money available for your Micro Channel add-in board design, choose an interface IC that closely matches your board design's requirements.

Margery Conner,
Regional Editor

When you're designing a plug-in board for the IBM PS/2, you'll find a variety of adapter ICs available to implement the IBM Micro Channel interface. You can choose a chip that implements almost every conceivable interface function, for example, or one that supports the barest minimum of functions and requires you to add extra logic. Which chip you choose can make a big difference in the board space, power, and money your design will consume. Although it may be tempting to choose the IC that has the greatest number of features packed into the smallest space, that device isn't necessarily the best choice for your design. Instead, you should choose an interface IC whose capabilities closely match your design requirements.

Note from the outset that, for a Micro Channel adapter board, one option you realistically don't have is that of designing the interface in discrete logic. For one thing, the Micro Channel specification requires that adapter boards take up less space and run on less power than did adapter boards for the Micro Channel's predecessor, the IBM PC/AT bus. The spec reduces board size by 43% and limits the available power to only 1.6A at 5V dc. Added to the power and size constraints is the fact that the Micro Channel is much more complex than the PC/AT bus. For example, the Micro Channel relies on programmable-option-select (POS) registers rather than hardware switch settings for determining such options as the adapter ID, memory and I/O addresses, and arbitration level. Further, it supports three different



To aid you in developing a Micro Channel *adapter-board design, Vector Electronics (Sylmar, CA) offers the PS/2 Active Interface Prototyping development board for the 82C611/12 interface chip. (The board costs $350.)*

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types of bus cycles. An interface IC, therefore, is clearly imperative.

To select the best interface chip for your design, consider the functions your board will have to perform. If you're designing a straightforward I/O adapter with no DMA requirements, you'll want a chip that implements minimal functions. You'll have no need for an interface chip that contains all possible POS registers and multiple DMA channels. If, on the other hand, your board design will require access to all POS registers as well as DMA capability, you must either use a full-featured interface chip, or use a chip with fewer features and pay the power and size penalty of adding features in the form of discrete logic. Given the wide variation in adapter-IC capabilities, it's unlikely that any one interface chip will emerge as a cure-all for all bus-interface design problems in the industry.

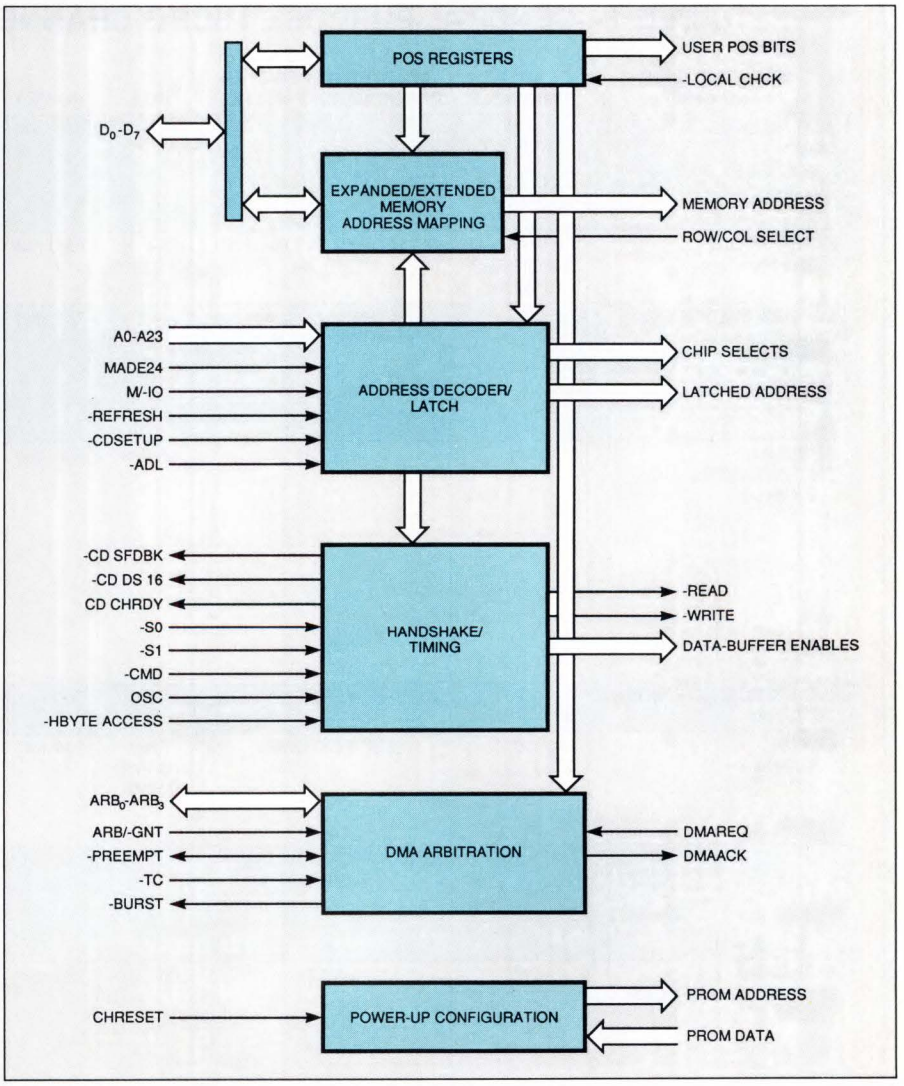
Micro Channel interface ICs fall into two main categories. The first group contains ICs that incorporate as many features as possible, such as Capital Equipment's 88C01, Standard Microsystems' MCI-94C18, and the DT7920 from Data Translation. In the other category are ICs with minimal features, such as Chips and Technologies' 82C611/612, Altera's EPB2001/2002, ACC's 5810-BIO, PLX's MCA 1200, and NCR's 86C01. **Table 1** lists the available general-purpose Micro Channel adapter ICs. ICs that serve as interfaces for specific board types, such as modem boards, SCSI-bus boards, and Ethernet boards, are available from NCR, Chips and Technologies, and Western Digital.

In evaluating interface chips for your adapter-board design, you'll need to concern yourself with four main features of the Micro Channel bus: POS registers, DMA, memory and I/O addressing, and interrupt processing. What distinguishes one Micro Channel interface chip from another is which of these features the chip supports and how it implements them.

POS registers identify board

The Micro Channel's POS registers eliminate the need for hardware switches on board by acting as modifiable registers that set I/O and memory addresses and other board parameters. The most notable of these registers are 0100_{HEX} and 0101_{HEX}, which contain the adapter ID number, a unique number that IBM assigns to each board product. The adapter ID must be present at start-up, so it must be fixed in hardware. The chips' method of implementing the ID varies: Chips and Technologies requires the ID to be hard-wired in an external latch, Altera places the PROM on chip, and the remaining vendors supply control lines for an off-chip PROM.

The control lines consist of a



Because it's likely that no adapter board *will use all the features of the Micro Channel, the 88C01 loads configuration data at power-up from an external PROM. The configuration data selects the subset of Micro Channel signals that the interface chip will implement. For example, chips used on adapters that don't need to address expanded/extended memory can configure those pins as address pins A_0 through A_9, saving an external latch.*

Micro Channel interface ICs

PROM-enable pin that goes high during the power-on reset. It's important to know what PROMs the chips work with to know how much space and power the PROMs will use. For example, Capital's 88C01 works with a 1k-bit PROM such as the 16-pin 74S287, requiring about 0.26 in^2 and 100 mW. The DT7920 requires a 20-pin PROM that takes up about 0.32 in^2 and uses 125 mW.

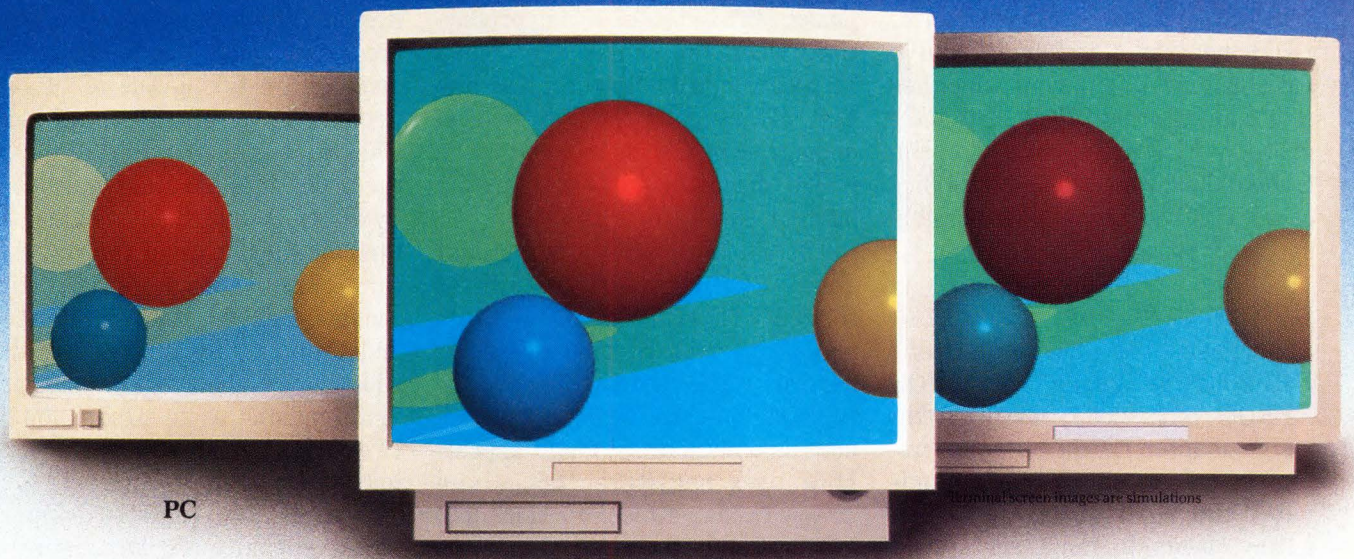
Note that the two POS registers take up only two bytes in the PROM. The 88C01 uses the remaining PROM space to store configuration information for the interface chip. Capital assumes that any one adapter will require only a subset of all possible Micro Channel signals. At power-up, the 88C01 reads configuration information and the adapter ID from the PROM. The configuration information tells the chip whether expanded or extended memory is used, whether or not the DMA is used, and also determines pinout choices. For example, if DMA is not used, the pins can be redefined as POS bits and memory address bits. In this way, the chip can support all Micro Channel functions with only 84 pins.

At first glance, Chips and Technologies' hard-wired method may look like the most restrictive, because it lacks the flexibility of a programmable POS adapter ID register, but that's not necessarily the case. Once you know the board ID,

TABLE 1—GENERAL-PURPOSE MICRO CHANNEL INTERFACE CHIPS

MANUFACTURER AND CHIP	DMA CHANNELS	ADAPTER ID-REGISTER PROGRAMMING METHOD	SIZE	POWER	PRICE	FEATURES
ACC MICROELECTRONICS CORP ACC 5810	1	LATCH	60-PIN	150 mW	$7 (1000)	ON-CHIP POS REGISTER 0104_{HEX} IS MEMORY-RELOCATOR REGISTER (REQUIRED BY MEMORY ADAPTERS ONLY)
ALTERA CORP EPB2001	1 (OPTIONAL, REQUIRES EPB2002)	ID STORED IN ON-CHIP EPROM	84-PIN (EPB2002: 28-PIN)	1000 mW	$12 (10,000) (EPB2002: $5)	
CAPITAL EQUIPMENT CORP 88C01	1	EXTERNAL, 16-PIN, 1k-BIT PROM	84-PIN	500 mW	$27.50 (1000)	EXPANDED/EXTENDED MEMORY ADDRESSING; DIRECTLY DRIVES 1M-BIT DYNAMIC RAMS; SUPPORTS 8-, 16-, AND 32-BIT-WIDE MEMORY
CHIPS AND TECHNOLOGIES INC 82C611/612	0/1	LATCH	68-PIN	500 mW	$8/$12	GENERATES AT-LIKE I/O AND MEMORY READ/WRITE SIGNALS; POS REGISTERS 0100H-0104H ARE ON CHIP; READ/WRITE STROBES FOR ADDING REGISTERS 0105H-107H EXTERNALLY (FOR NON-MEMORY ADAPTERS, REGISTER 0104_{HEX} CAN BE EXTERNAL AND USER-DEFINED)
DATA TRANSLATION INC DT7920	2	EXTERNAL 20-PIN PROM	84-PIN	500 mW	$31 (1000)	
EDSUN EL2010	0	SEE FEATURES	TWO 84-PIN CHIPS	200 mW	$35 (1000)	SUPPORTS MEMORY ADAPTERS ONLY; CHIP SET AVAILABLE WITH ONE OF FIVE IBM-ASSIGNED ADAPTER IDs
PLX MCA 1200	1	NO POS-REGISTER SUPPORT	24-PIN	400 mW	$23 (1000)	CHIP ONLY SERVES AS BUS CONTROLLER AND LOCAL ARBITER (BASED ON MANUFACTURER'S PLX 448 BUS INTERFACE PLD)
STANDARD MICROSYSTEMS CORP MCI94C18	2	LATCH	68-PIN	125 mW	$8.85 (1000)	BUS-REQUEST AND ACKNOWLEDGE SIGNALS CONTROL LOCAL BUS FOR LOCAL MEMORY; INTERRUPT CONTROLLER; INITIATE DMA TRANSFERS VIA HARDWARE OR SOFTWARE; DMA ERROR TIMEOUT PREVENTS BUS HANGUPS

Tomorrow's Color Graphics—Today



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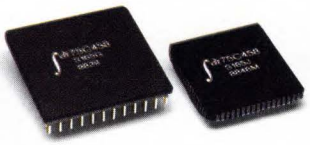

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chances are you won't need to change it. Besides, hard-wiring the ID POS registers is less expensive, requiring just a buffer IC and a gate, instead of requiring you either to use an external PROM or to integrate a PROM on chip. So, the tradeoff boils down to the flexibility of a PROM vs the cost and possible space advantage of hard-wiring.

ID registers on chip

Because the 84-pin Altera EPB2001 is based on CMOS EPROM technology, its programmable adapter ID registers are implemented on chip, which eliminates the need for external circuitry. Keep in mind that you'll need a nonstandard EPROM programmer to program the chip. In addition, the fact that the registers are erasable, although beneficial during the evaluation and design phase, isn't as useful during production, when the chip will probably be programmed only once. The biggest advantage of the two bytes of onboard EPROM is the savings in board circuitry—it eliminates a latch or an off-chip EPROM.

There's more for you to consider about POS-register capabilities than the ID registers. The Altera and Chips and Technologies chips have six rather than all eight of the registers on chip. That's not as heinous an omission as it might appear. IBM uses registers 106_{HEX} and 107_{HEX} to map a memory block into any portion of the physical memory space. The only adapter boards that require these two registers are add-in memory boards. If your add-in board is one of these, you'll need to choose a chip with all eight registers. Otherwise, the two registers are extraneous. Most interface IC vendors are taking one of two approaches with the registers: They're either not implementing them on chip, the course followed by Chips and Technologies and Altera, or they're using the registers for their own configuration schemes, as do Data Translation and Capital. (Note, however, that Chips and Technologies does provide read and write strobes for the two registers, should you wish to implement them off chip.)

Besides POS-register support, DMA capability is a key feature of the chips. The EPB2001 has no DMA support; you must add the 28-pin EPB2022 to gain this feature.

The 82C611 also lacks DMA capability. The 82C612 is similar to the 611, except that it adds arbitration and DMA support. The 88C01 has one DMA channel; the DT7920 and Standard Microsystem's MCI94C18 both support two DMA channels.

Multiple DMA channels can be an advantage if you need to perform multiple, long DMA transfers. The Micro Channel limits DMA transfers to 64k words per transfer. After the DMA controller has transferred the 64k words to or from the memory buffer, it stops and waits for a command to initiate the next transfer. This delay can take hundreds of microseconds. If the adapter has two DMA channels, it can switch to the second channel after the first has emptied its 64k-word buffer. During the second channel's transfer, the software resets the first channel for the next transfer.

DMA and bus arbitration

The DT7920 and the 94C18 differ in the amount of independence there is between the two DMA channels. The two channels on the 94C18 share a fairness bit; each channel on the DT7920 has its own. The fairness bit is part of the arbitration scheme for access to a DMA transfer. (Every adapter that is either a bus master or uses DMA must have bus arbitration logic.) In order to decide the importance of an independent fairness bit in your adapter interface, it's necessary to understand the Micro Channel's arbitration scheme.

Arbitration logic determines whether the value on the arbitration bus is a higher level (that is, a lower value) than the adapter's level. The fairness bit 4 of PS register 105_{HEX}, when cleared, prevents an adapter that has been pre-empted from requesting the bus again until all other adapters have had use of the bus. Thus, all adapters can have access to the bus at least once before being pre-empted by a higher-priority adapter.

The Micro Channel specification allows a bus master to set the fairness bit low, so the asserting adapter can ignore the fairness algorithm. The current implementation of the specification, however, requires that the bit be enabled. The only adapters that will need access to the fairness bit will be those that may be bus masters. So, unless

you're designing a bus master, it's not important to have an independent fairness bit.

The chips with only one DMA channel, such as the 88C01, have more space to support features such as chip select. The 82C612 has 10 multifunction pins that you can program for one of three modes. In these modes you have access to address comparators, or read and write strobes for the chip's internal POS registers, or some combination of the two. However, you'll still need to gate together the address-comparator outputs with the Card Enable signal to derive the I/O selects for the adapter; the 88C01 fully supports multiple chip selects on chip.

Programmable bus cycles

In addition to implementing the POS registers and DMA and arbitration support, the Micro Channel's timing requirements are more complex than the PC/AT's. There are three types of access cycles on the Micro Channel: the default cycle at 200 nsec, the synchronous extended cycle at 300 nsec, and the asynchronous extended cycle, which can be as much as 3 μsec. Adapters that have a straightforward interface on the PC/AT's synchronous bus can have complex timing to support on the asynchronous Micro Channel. For example, I/O devices, which are inherently slow, use the variable cycles. In addition, most I/O chips require the extended cycle for read access or write set-up times. They may also need delayed or extended read/write control signals.

To support these three timing options, the 88C01 uses the same PROM that contains the adapter ID registers to store the timing variables. The chip can drive the CD CHRDY signal low to add wait states for slow devices. The 82C612 can also handle different cycle timing, but you must add circuitry that can tell the chip when a board function requires an extended cycle.

Like the timing considerations, interrupt relocation is another significant difference between the PC/AT and Micro Channel buses. The chips provide differing levels of interrupt relocation. The Altera, Capital, Standard, and Data Translation chips all provide circuitry to translate as many as five interrupt levels down to the one supported by the bus. The Chips and Technologies 82C612 and the PLX MCA 1200 chip don't support interrupt relocation; however, this missing feature is not as serious a problem as it would be for PC/AT-bus systems, because the Micro Channel uses active-low interrupt signals and supports active-low interrupt sharing.

Translating Micro Channel signals into more familiar, easier-to-use signals is an important function of Micro Channel interface ICs. The PC/AT bus uses decoded processor-control lines for memory read and writes (MEMR, MEMW, SMEMR, SMEMW) and I/O reads and writes (IOR, IOW). The Micro Channel provides only the processor-control lines S0, S1, and M/IO and does not decode them as memory and I/O enables. This scheme allows for greater control over timing margins, because the processor-control lines are valid earlier in the cycle than the decoded lines. To ease the transition for PC/AT-bus designers, both the 82C611/12 and the 88C01 provide the familiar memory and I/O read and write strobes.

Roll your own adapter

After examining all these available off-the-shelf interface chips, you may still find that your adapter's interface requirements

For more information . . .

For more information on the Micro Channel interface chips discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

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UPDATE

Micro Channel interface ICs

don't find a good match in any of them. If your production volume is high enough, and you are confident that your adapter's specifications are firmly fixed, consider designing your own interface IC. At one end of the custom spectrum are the semicustom chips available from foundries such as LSI Logic (Milpitas, CA). At the other end of the spectrum are PLDs and EPLDs. Intel (Santa Clara, CA), for example, has developed a Micro Channel interface based on its 5AC324 EPLD. You can implement a very minimal interface in just one 40-pin 5AC324. Keep in mind that because the chip is programmable, you can burn the adapter ID number into the chip and eliminate the need for an external latch or PROM, saving even more space over that used by one of the more elaborate ready-made chips. A 30-nsec version of the chip costs $24 (1000) and uses about 50 mA. EDN

References

1. Slater, Michael, "VLSI solutions for Micro Channel interfacing," *Professional Program Session Record III*, Wescon/88, Anaheim, CA.

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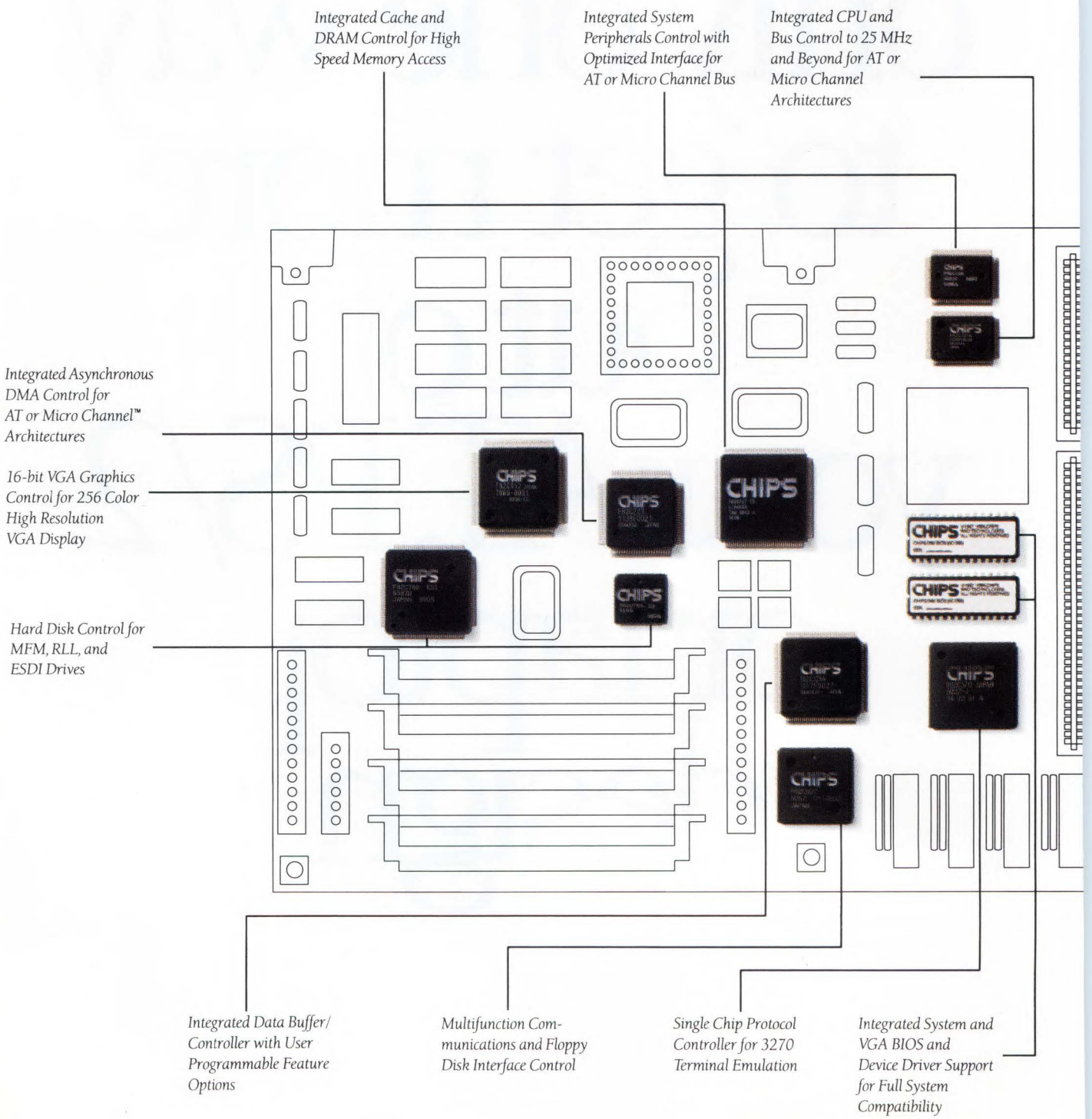
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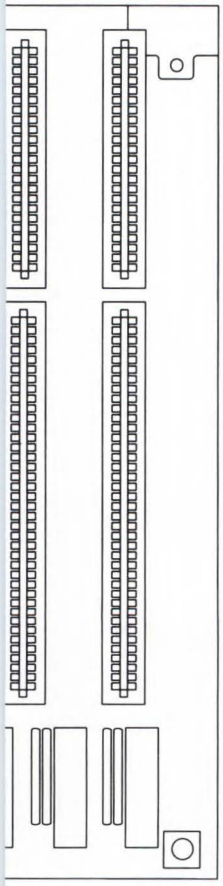

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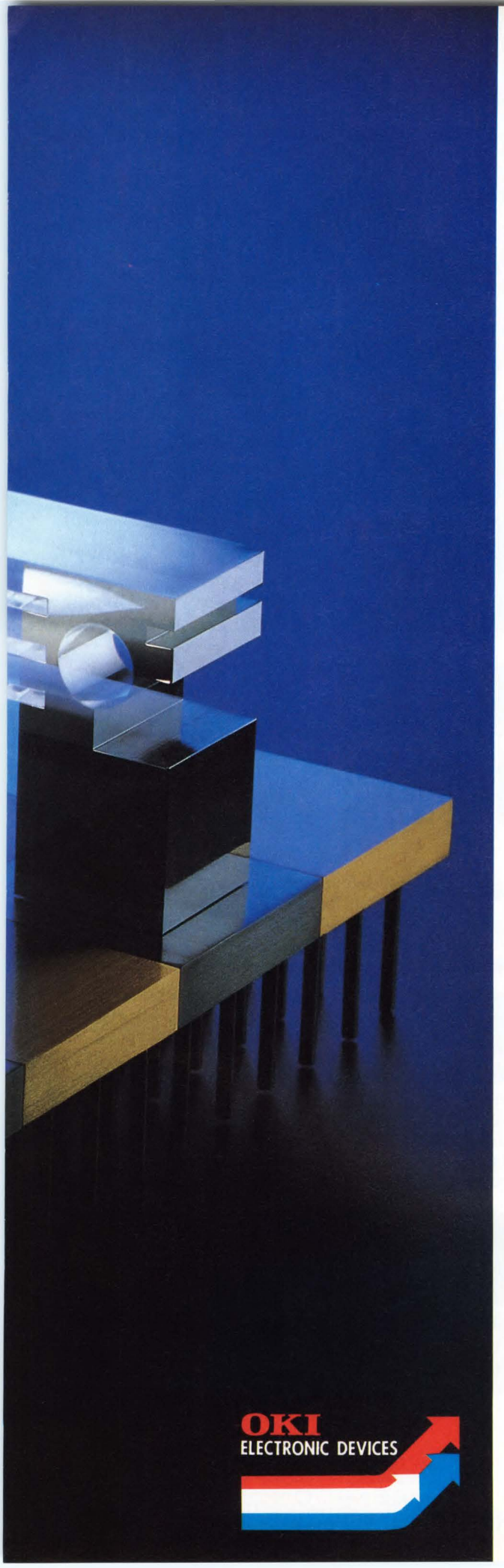

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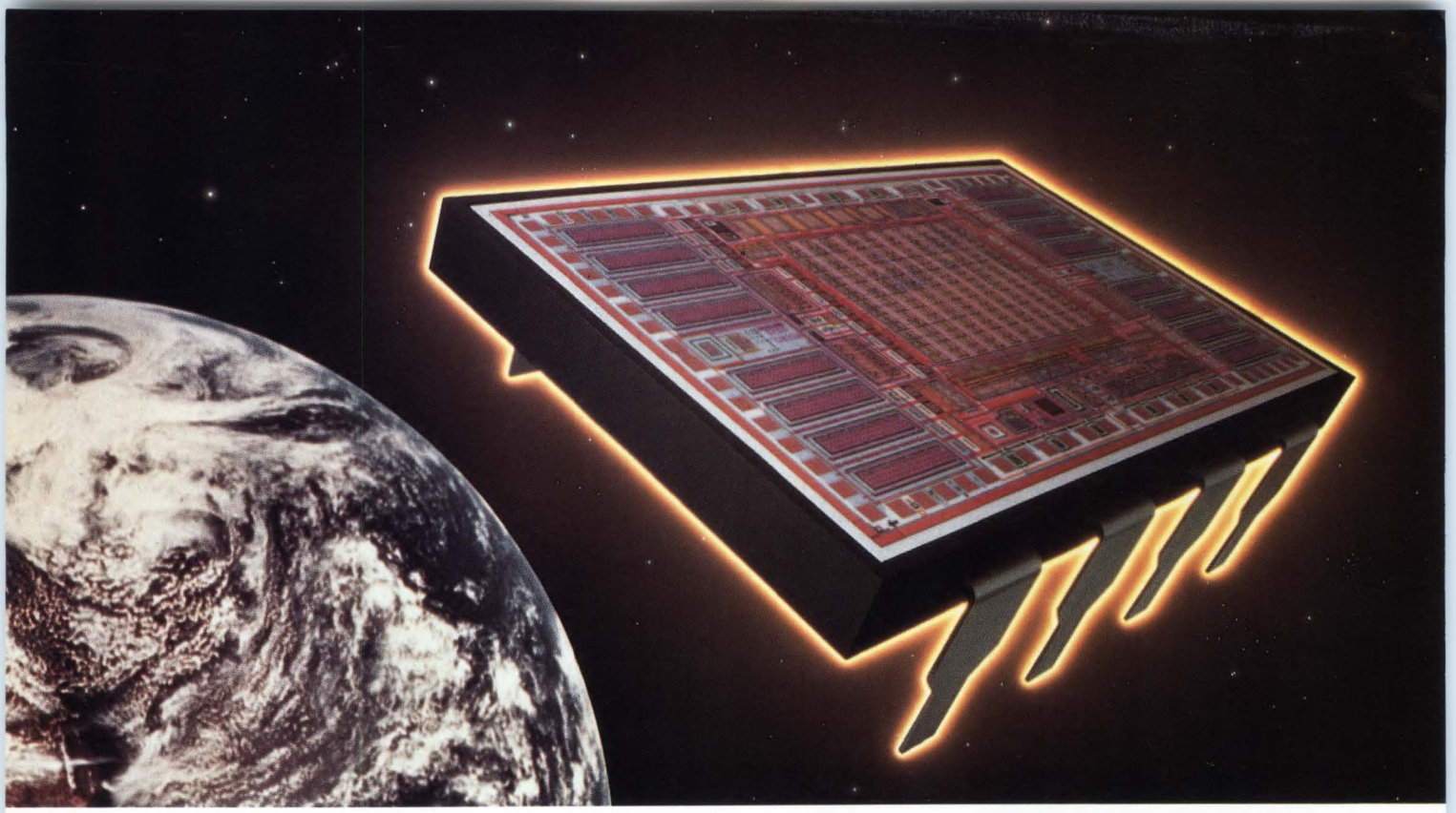

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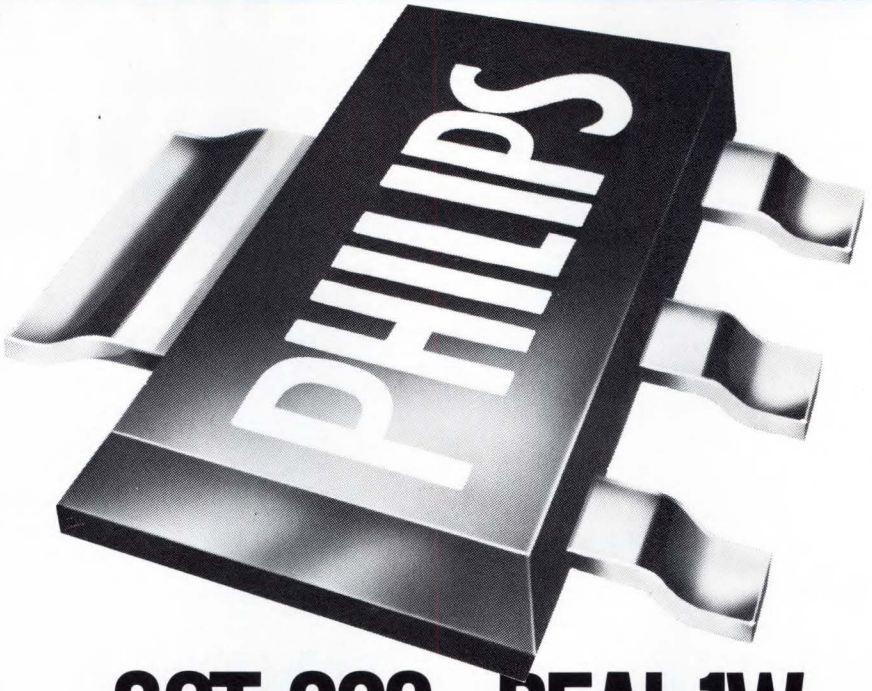

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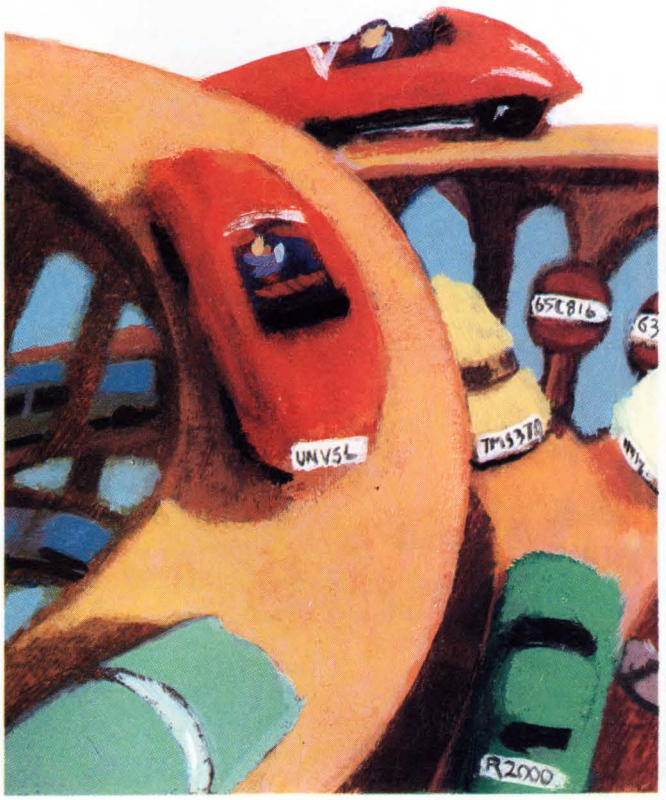
Steven H Leibson,
Regional Editor

If you routinely work with several types of processors, you're no doubt disenchanted with buying a new assembler for each of your designs. Furthermore, the added cost of yet another assembler may tilt the economic scales against using the "perfect" μP for a project, obliging you to choose an older or less efficient device because you already own the software-development tools for that processor. Universal cross-assemblers can help you solve these dilemmas permanently.

Although universal (also called retargetable) cross-assemblers don't provide exact compliance with a μP's assembly language, they can translate assembly-language source code into machine code for a wide variety of processors. They also let you quickly develop subsets of standard processor instruction sets. You might use this capability, for example, to write code for an ASIC processor core you optimized (shrunk) by removing the hardware that executes unnecessary instructions.

You can also use a universal cross-assembler to define one processor's instruction set using another processor's mnemonics. With this feature, you can convert a program written for one processor into another's machine code rather painlessly.

Despite the multiple benefits of universal cross assemblers, vendors that provide assemblers for standard μPs and μCs generally don't sell universal cross-assemblers. Instead, they offer a range of separate assemblers closely tailored to an individual processor or processor family. For example, Boston Systems Office (Waltham, MA) offers a wide variety of tailored assemblers. It even sells more than one assembler for the Motorola 6800 μP family because the instruction sets differ slightly between the 6800 and Hitachi's compatible 6300 μP series. Several other third-party vendors of assemblers for standard processors, including Enertec Inc (Lansdale, PA), Introl Corp (Milwaukee, WI), and



KEVIN HAWKES

Universal cross-assemblers

Lear Com Co (Lakewood, CO), offer assemblers suited to specific processors.

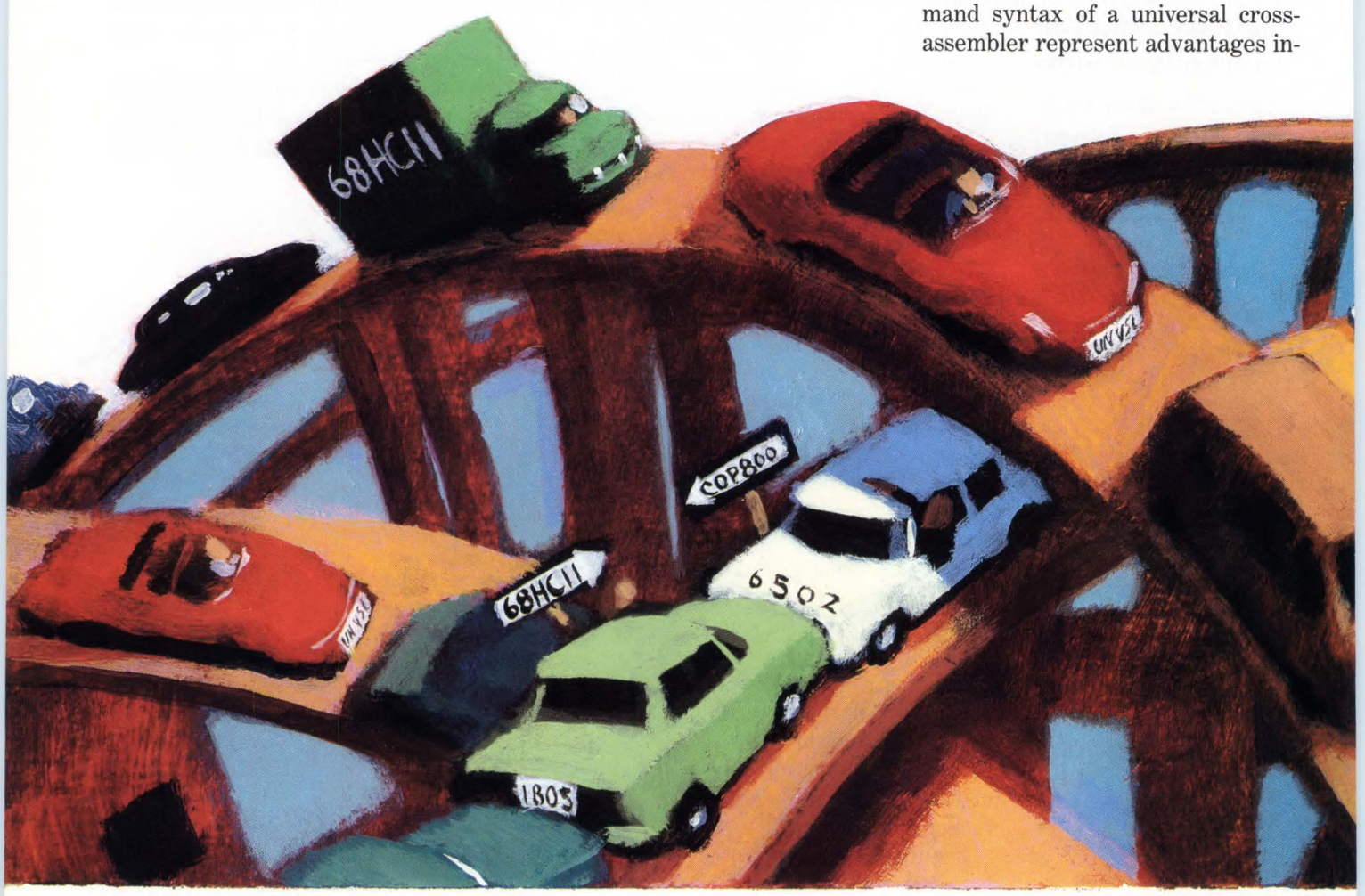
Most assembler vendors don't feature universal assemblers because they believe that they can't make an assembler that recognizes *any* assembly-language statement. Assembler directives (pseudo ops) and numbering schemes (such as writing the hexadecimal equivalent of 56 as 56H or $56) present the major stumbling blocks in developing a truly universal cross-assembler. The assembly language for Intel's 80X86 μP family, for example, includes a huge number of assembler directives and pseudo ops. Most of these assembler directives are specific to Intel's μPs; you won't find many analogous pseudo ops in assemblers from other vendors, unless the assemblers are specifically designed to accept Intel's assembly code.

Designing an assembler that conforms with just the instruction-set syntax, however, doesn't seem to present much of a problem. In fact, assembler vendors often use universal assembler generators to perform the majority of work in creating tailored assemblers. They can then make minor adjustments and fine tune the assemblers by hand.

You may interpret this practice as a blatant attempt to improve sales by keeping the cost-effective technology in house. However, vendors of tailored assemblers cite the same reason for withholding universal products: Many customers want assemblers that exactly conform to the μP or μC vendor's assembly-language syntax. In some cases, this strict compliance is warranted.

Assemblers that comply with the semiconductor vendor's original assembly language let you reuse code that you or your company previously wrote using original-equipment assemblers. In addition, tailored assemblers let you easily assemble source-code routines that you obtain from other sources. You may also need this strict compliance to assemble source code generated by a high-level-language compiler.

Some engineers, however, don't need to preserve existing assembly-language source code, and many of these same engineers write assembly-language programs for a large number of μPs and μCs. For these people, the single set of assembler directives and the standard command syntax of a universal cross-assembler represent advantages in-



stead of liabilities. If you don't need the exact compliance of a tailored assembler, if you routinely work with several different processors, and if you don't have a budget to buy software tools at whim, then you too can benefit from using a universal cross-assembler.

Similar needs and considerations prompted three engineers to develop several of the universal cross assemblers that are now available **(Table 1)**. Although they initially wrote these programs for their own use, these people later offered the programs to other engineers and eventually introduced their programs and software-development packages to the commercial market.

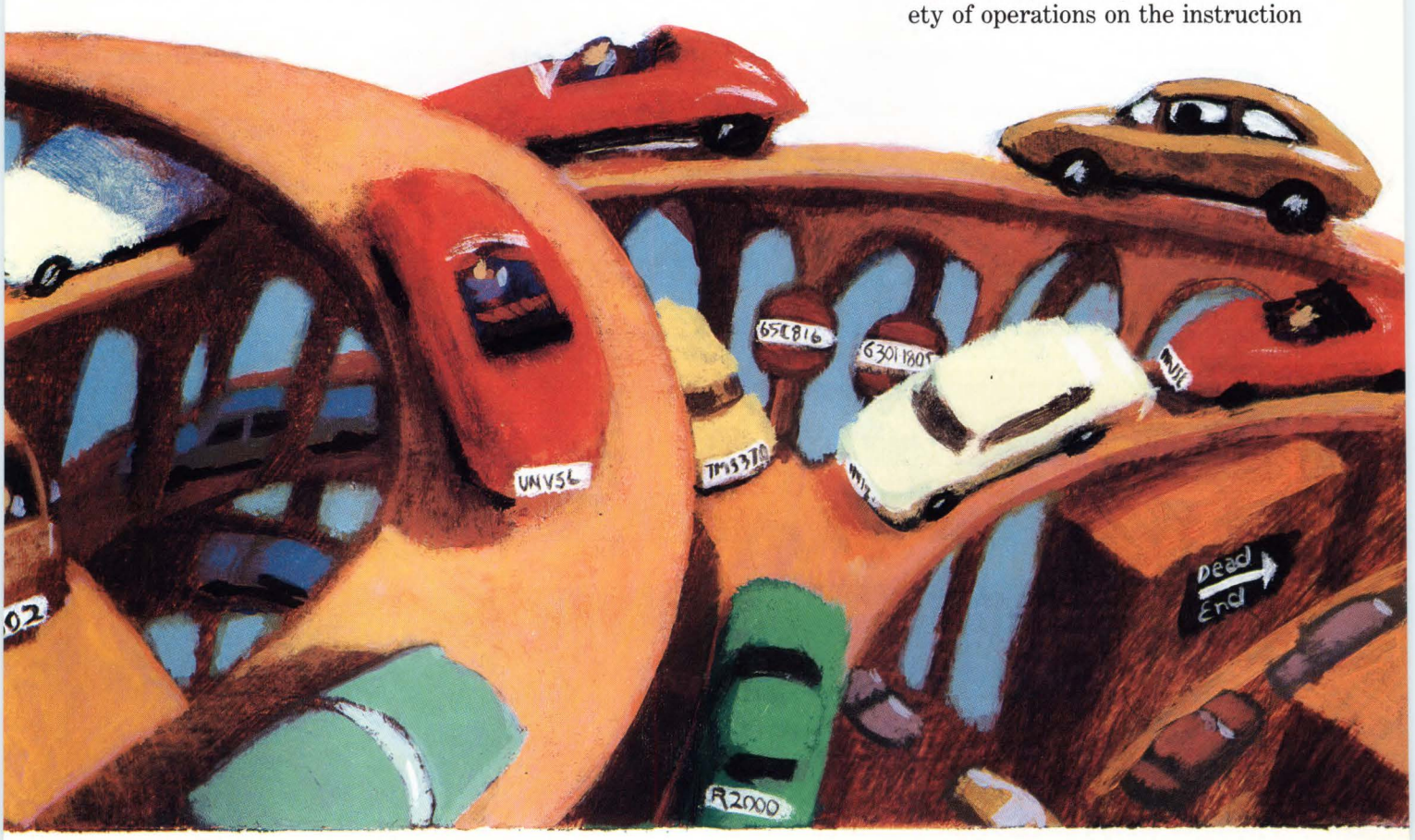
In 1985, for example, Thomas Anderson developed TASM (table-driven assembler) because he tired of hand assembling μP programs for products he designed to aid blind people. Anderson's designs incorporate Texas Instruments' speech chips, giving voice to instruments such as a glucometer (which measures blood-sugar levels), a dietary scale, a tachometer, and a skin caliper. After testing his universal assembler in commercial waters, Anderson decided to market TASM as shareware through his company, Speech Technology.

Because it's a shareware product, you can obtain TASM at a low cost. PC-SIG (Sunnyvale, CA) provides a copy for $6 on its disk #643, or you can download the program from the Library Bulletin Board System (Seattle, WA). You can also find TASM on many information services, such as Compuserve, but those sources may not have the latest version of the assembler.

You can also obtain a registered copy of TASM directly from Speech Technology. Anderson requests a $30 registration fee for the package. Registered users receive the latest version of the assembler and are entitled to support.

Speech Technology supplies TASM with several instruction-set definitions **(Table 2)**. You can also write instruction-set definitions for TASM by creating an instruction-set table with a text editor. In fact, one of the tables included in TASM version 2.7 is an instruction-set table. It accommodates the Zilog Z80 μP and was created by Carl A Wall, one of TASM's users.

Each line of a TASM instruction-set table consists of six fields. The first five fields in the table define the instruction mnemonic, the instruction arguments (if any), the 1-byte op code that is represented by the mnemonic, the size of the instruction (in bytes), and the "MODOP" field, which performs a variety of operations on the instruction



Universal cross-assemblers

and argument bytes such as swapping bytes or merging. The op code's 1-byte size confines the assembler to 8-bit processors.

The sixth field in the table defines an instruction's class. TASM lets you define classes (sets) of instructions and designate which class the program should use when you assemble a file. You can use this feature to define an improved processor's extended instruction set. The TASM table for the 6502 μP, for example, defines extra instructions for Rockwell's R65C00 and R65C02 microprocessors.

For reasons resembling Anderson's, Jonathan Griffitts wrote a universal cross-assembler called CASM to help him with his consulting work. Griffitts has been using his assembler since early 1987 to assemble code for the many different μPs and μCs. He now markets CASM through his company, AnyWare Engineering.

CASM can assemble code for 8-, 16-, and 32-bit processors and includes instruction-set definitions for many μPs and μCs. If you want to create an instruction-set definition for a processor not supported by AnyWare, you must create a text file containing that definition, written in AnyWare's proprietary instruction-set definition language. You must then compile your definition using the package's DEFCOMP compiler, which produces a control file for the assembler.

CASM can accommodate some fairly complex processor instruction sets because it uses a definition language that includes C-like constructions such as subroutines, loops, and user-defined data types, instead of simple instruction-set definition tables. The instruction-set definition for NEC's 7720 DSP μC, which AnyWare supplies in the CASM package, illustrates the flexibility of this definition language. This unusual DSP μC features a 23-bit instruction word and a 13-bit-wide ROM for storing constants that can be difficult or impossible to describe within the structured environment of a table.

A third engineer, Peter Aske, also developed a universal cross-assembler to simplify his own work. While working as an engineer in Nova Scotia, he found that he needed development software to write code for several different

TABLE 1—REPRESENTATIVE UNIVERSAL CROSS-ASSEMBLERS

MANUFACTURER	ANYWARE ENGINEERING	MACROCHIP RESEARCH	SPEECH TECHNOLOGY	STAG	UNIVERSAL CROSS-ASSEMBLERS	
PRODUCT	CASM	DEVELOPMENT ENVIRONMENT	TASM	VSDS	CROSS-16	CROSS-32
PRICE	$195	$299	(NOTE 1)	$998 (NOTE 3)	$99.95	$199
HOST COMPUTER	IBM PC	ATARI ST, AMIGA, IBM PC, MACINTOSH	(NOTE 2)	IBM PC	IBM PC	IBM PC
MAXIMUM ADDRESS SIZE (BITS)	32	24	16	32	24	24
EDITOR	NO	YES	NO	YES	NO	NO
COMMUNICATIONS UTILITY	NO	YES	NO	YES	NO	NO
MAKE UTILITY	NO	NO	NO	YES	NO	NO
LINKER	YES	NO	NO	YES	NO	NO
LOADER	NO	NO	NO	YES	NO	NO
DEBUGGER	NO	NO	NO	YES	NO	NO
DISASSEMBLER	NO	NO	NO	YES	NO	NO
MACROS	YES	YES	YES	YES	NO	YES
CONDITIONAL ASSEMBLY	YES	YES	YES	YES	YES	YES
DEFINITION FORMAT	LANGUAGE	TABLE	TABLE	TABLE	TABLE	TABLE
OUTPUT FORMATS SUPPORTED	INTEL HEX, BINARY, HUMAN-READABLE BINARY	INTEL HEX, MOTOROLA HEX, BINARY	INTEL HEX, MOS TECHNOLOGY HEX, BINARY	INTEL HEX, BINARY, S-RECORDS, EXTENDED S-RECORDS, TI 9900/ 7000, ASCII SPACE HEX	INTEL HEX, MOTOR-OLA HEX	INTEL HEX, MOTOR-OLA HEX, BINARY

NOTES:
1. TASM IS A SHAREWARE PRODUCT WITH A $30 REGISTRATION FEE.
2. TASM IS SUPPLIED AS AN MS-DOS EXECUTABLE FILE. REGISTERED USERS RECEIVE C SOURCE CODE SO YOU CAN COMPILE TASM ON ANY COMPUTER.
3. VSDS IS ALSO AVAILABLE WITH AN EPROM EMULATOR FOR $1695.

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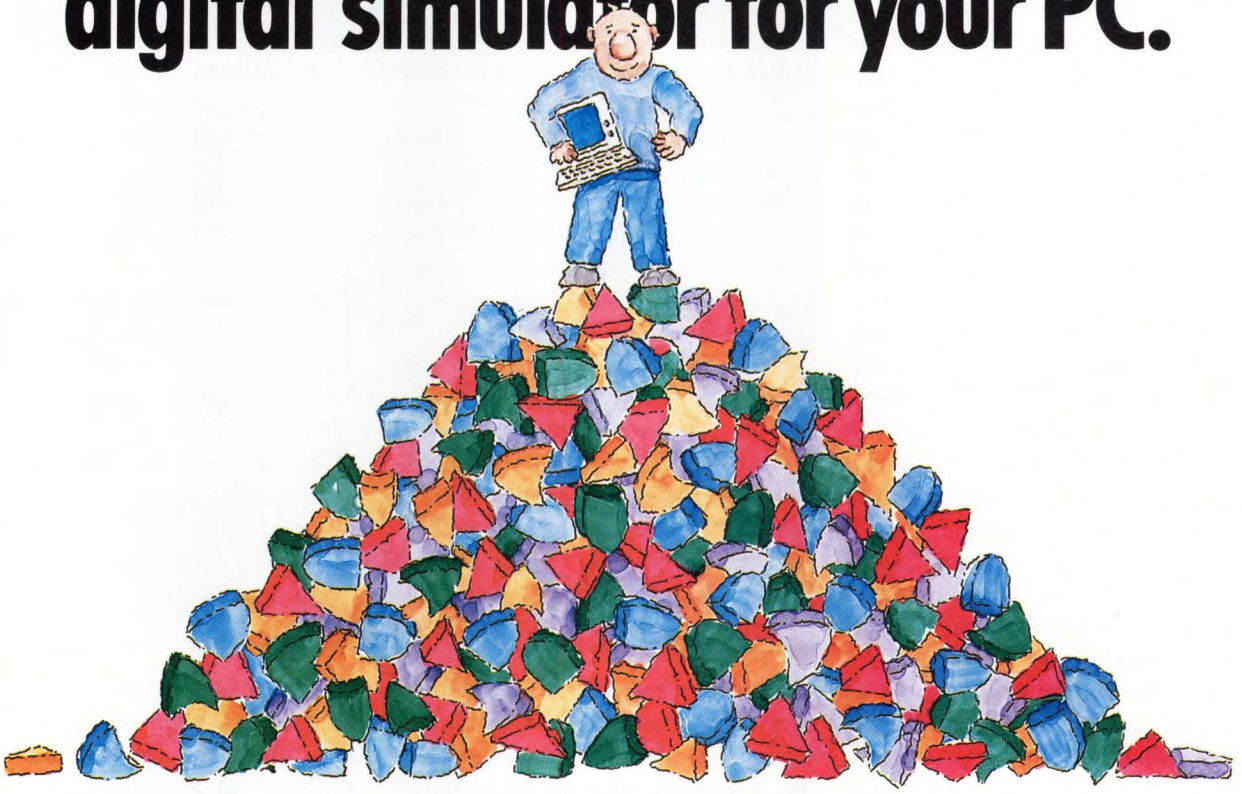

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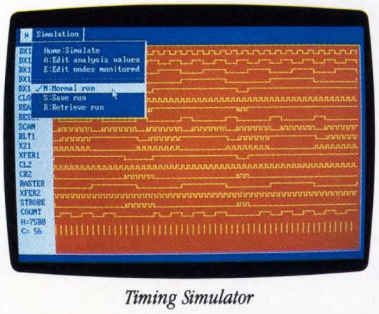

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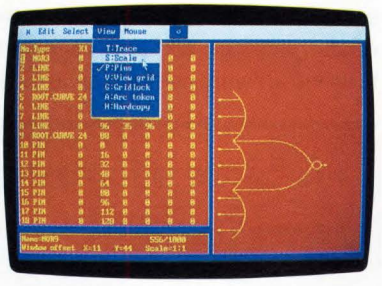

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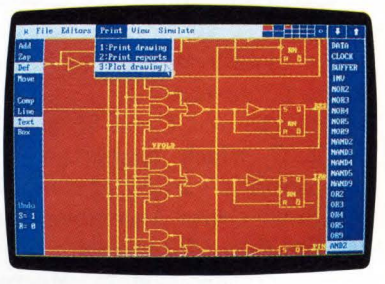

Schematic Editor

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CIRCLE NO 132

μPs. In addition to the cost of buying a new assembler for each of his designs, Canadian import duties and an unfavorable monetary-exchange rate made purchasing commercial assemblers from US vendors unattractive. As a result, Aske produced a universal cross-assembler using Borland International's Turbo Pascal compiler. On a friend's recommendation, he transformed Cross-8 into a commercial product.

Cross-8 became the first cross-assembler marketed by Aske's company, Universal Cross-Assemblers. Because the program was written in Turbo Pascal, versions of Cross-8 were available for Digital Research's CP/M and Microsoft Corp's MS-DOS operating systems. Cross-8 is now obsolete and has been succeeded by two more powerful products: Cross-16 and Cross-32. As their names imply, these products assemble code for 16- and 32-bit processors as well as for processors with smaller instruction-word sizes. Both assemblers employ a multipart instruction-set table to define the processor instructions. The instruction-set tables are stored in text files, so you can use a text editor to modify an existing table or create a new one.

Cross-16 and Cross-32 are written in C, which makes them portable across a variety of computers. Universal Cross Assemblers offers its assemblers for use with the MS-DOS operating system. Macrochip Research, however, licensed the source code for Universal Cross Assemblers' Cross-32 and offers the assembler as part of a universal code-development package called the Macrochip Development Environment. The vendor markets this package for use on several computers that run different operating systems.

The Macrochip Development Environment includes a universal cross-assembler, a text editor for creating source code, and a communications program for transferring assembled object code to your target hardware through an in-circuit emulator. The various components of the package are tied together by a menu-driven user interface. Macrochip Research also sells in-circuit emulators for various μPs and μCs and offers the Development Environment as a support tool for its emulators.

Like Macrochip Research, Stag Microsystems offers a universal

Meta-assemblers are universal

If you've worked with microprogrammable processors, you're probably familiar with meta-assemblers, which let you create assemblers for processors built from microprogrammable components. You can also use a meta-assembler to perform the same functions as a universal cross-assembler.

Although they are sold mainly for assembling code for special-purpose processors and proprietary architectures, meta-assemblers also let you easily assemble code for commercial μPs and μCs. If you wish to use a meta-assembler for this purpose, though, you must create an instruction-set definition for your processor; meta-assembler vendors don't provide definitions for standard processor instruction sets. In addition, because they're targeted at the relatively small microprogrammable-processor market, meta-assemblers cost several thousand dollars. Meta-assemblers are available from several companies, including Hilevel Technology Inc (Irvine, CA), Microtec Research (Santa Clara, CA), Quantitative Technology Corp (Beaverton, OR), and Step Engineering (Sunnyvale, CA).

For more information . . .

For more information on the universal cross-assemblers discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

AnyWare Engineering
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(303) 442-0556
Circle No 733

Macrochip Research Inc
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Suite 204
Carrollton, TX 75006
(214) 242-0450
FAX 214-245-1005
Circle No 734

Speech Technology Inc
837 Front Street S
Issaquah, WA 98027
(206) 392-8150
Circle No 735

Stag Microsystems Inc
1600 Wyatt Dr
Santa Clara, CA 95054
(408) 988-1118
FAX 408-988-1232
Circle No 736

Universal Cross-Assemblers
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CIRCLE NO 131

Universal cross-assemblers

cross assembler as part of a comprehensive software package—the Stag VSDS (versatile software-development system) package. Stag's universal cross-assembler is an ideal companion for its EPROM emulator. You can use the general-purpose emulator hardware to develop code for systems built around any processor, as long as your target system has an EPROM socket.

In addition to its universal cross-assembler, the VSDS package incorporates several other programs, including a text editor, a linker, a universal disassembler, a "make" facility, an instruction-table generator, and a communications utility that transfers code to the EPROM emulator. Stag also offers the SDS package, which includes the software from the VSDS package without the EPROM emulator. Even if you don't buy Stag's emulator, you still need a slot in your computer that accommodates the EPROM emulator's interface card because it also serves as a software antipiracy device.

Like linkers used with tailored assemblers, the VSDS linker binds object modules together, resolves address references between these modules, and emits an absolute object file. Of the universal cross-assemblers listed in **Table 1**, only the products from Stag and AnyWare Engineering include linkers. The remaining products generate absolute object code directly from the assembler. If you're writing large programs or have more than one programmer working on your project, you may find that the combination of an assembler and a linker lets you break your assembly-language program into manageable chunks.

You can achieve a similar effect with "include" directives, which tells the assembler to merge text stored in separate source files during the assembly. All the assemblers listed in **Table 1** have the "include" capability. Even if you use these statements, you must reassemble your entire program after modifying any piece of it. Reassembling an entire program takes more time than assembling just one source-code module and relinking the program. As a result, assemblers that generate relocatable code are often more efficient for building large programs than are absolute assemblers.

The VSDS package's "make" facility automatically helps you avoid reassembling all your source-code modules each time you alter a program. After you specify your program's modules in a text file called the "makefile," the "make" facility reassembles only the program source files that have a later date and time stamp than their corresponding object files. The "make" facility won't reassemble any files that you haven't edited since the program was last assembled.

You should also note the package's universal debugger, which lets you set breakpoints, read and alter register contents, and examine and modify information stored

TABLE 2—μP INSTRUCTION SETS SUPPLIED WITH UNIVERSAL CROSS-ASSEMBLERS

μP INSTRUCTION SET	MANUFACTURER AND MODEL					
	ANYWARE ENGINEERING, CASM	MACROCHIP RESEARCH, DEVELOPMENT ENVIRONMENT	SPEECH TECHNOLOGY, TASM	STAG, VSDS	UNIVERSAL CROSS-ASSEMBLERS	
					CROSS-16	CROSS-32
1802		•		•	•	•
1805				•		
R2000	•					
TMS320		•	•	•		•
TMS370		•		•		•
3870/F8				•	•	
COP400		•		•		•
COP440				•		
COP800		•				•
HMCS400				•		
SMC4050				•		
6301				•		
64180		•		•	•	•
65C00/21			•			
65C02		•	•	•		•
65CE02		•				
6502	•	•	•	•	•	
65C812				•		
65C816		•		•		•
6800				•		
6801		•		•	•	•
6802				•		
6803				•		
6804				•		
6805	•	•	•	•	•	•
6809		•		•	•	•
68HC11	•	•		•	•	•
68000		•		•	•	•
68010				•		

μP INSTRUCTION SET	MANUFACTURER AND MODEL					
	ANYWARE ENGINEERING, CASM	MACROCHIP RESEARCH, DEVELOPMENT ENVIRONMENT	SPEECH TECHNOLOGY, TASM	STAG, VSDS	UNIVERSAL CROSS-ASSEMBLERS	
					CROSS-16	CROSS-32
TMS7000				•		
μPD7500A				•		
μPD7500B				•		
μPD7800				•		
μPD7806				•		
77P20	•			•		
8021			•			
8022			•			
8031				•		
8035			•	•		
8039			•	•		
8041	•		•			
8048	•	•	•	•	•	•
8049			•			
8051	•	•	•	•	•	•
8080			•	•		
8085	•		•	•	•	•
8086/8				•	•	
8096	•	•			•	•
80186/8		•		•		•
80196		•				
80286				•		
TMS94110				•		
TMS9900				•		
TMS9995				•		
Z8		•		•	•	•
SUPER8		•				•
Z80	•	•	•	•	•	•

in your target system's RAM. The debugger resides in a personal computer running the VSDS package and works with any processor and instruction set by reading the same instruction-set tables created for the VSDS assembler and disassembler. To make the universal debugger work with your target system, you must write a small amount of monitor code that runs in your target system and interacts with the debugger in the PC.

The monitor software communicates with the PC running the debugger over an RS-232C link. You need to dedicate a serial port in your target system for this purpose, at least during the debugging process. Stag provides a prototype version of the monitor code, written in the assembly language for Motorola's 6800 μP. You can use this code as a model when writing your own code. The monitor software you write must be able to transmit and receive information via the serial port and must respond to commands generated by the debugger in the PC. Monitor routines typically require about 200 to 300 bytes of code.

Whichever universal product you choose to incorporate in your designs, you needn't limit it to the general purpose of assembling code for your μP. You can also use these software-development tools to simplify related design tasks. For example, you can use a universal cross-assembler to standardize programs with one assembly-language style or one instruction set for every processor you use. This feat is simple to perform with closely related processors, such as the Zilog Z80 and Intel 8085 μPs. If you like the Zilog Z80 μP's code syntax and argument structure (move source to destination) better than Intel's syntax for the 8085 μP (load destination from source), for example, you can extend Zilog's format to the Intel processor with the aid of a universal cross-assembler. Similarly, if you prefer Intel's syntax, you can extend it to Zilog's processors. You can also use a universal cross-assembler to create one assembly-language syntax for several unrelated processors.

Further, you may want to use a particular μP or μC, but discover that an assembler isn't yet available for that processor either because the device is too new or because the expected market for the processor is too small to catch the tailored-assembler vendors' attention. Or, you may dislike the processor's original-equipment assembler. In either case, you can create the program you need if you add a universal cross-assembler to your software-development tool kit. EDN

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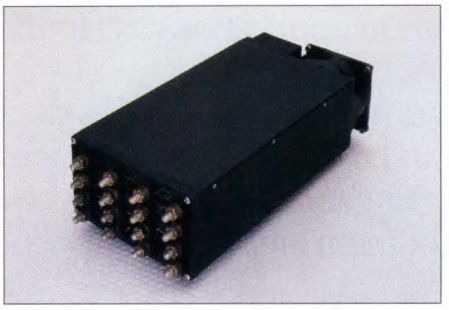

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SP1-1803	12 @ 100				
SP1-1804	15 @ 80				
SP1-1805	24 @ 50				
SP1-1806	28 @ 42				
SP1-1807	48 @ 25				
Dual Output					
SP2-1801	2 @ 120	5 @ 120			
SP2-1802	5 @ 120	5 @ 120			
SP2-1803	5 @ 120	12 @ 66			
SP2-1804	12 @ 66	12 @ 66			
SP2-1805	15 @ 53	15 @ 53			
Triple Output					
SP3-1801	5 @ 180	12 @ 16	12 @ 16		
SP3-1802	5 @ 150	12 @ 33	12 @ 16		
SP3-1803	5 @ 180	15 @ 13	15 @ 13		
SP3-1804	5 @ 150	15 @ 26	15 @ 13		
Quad Output					
SP4-1801	5 @ 150	12 @ 16	12 @ 16	5 @ 30	
SP4-1802	5 @ 150	15 @ 13	15 @ 13	5 @ 30	
SP4-1803	5 @ 150	12 @ 16	12 @ 16	24 @ 8	
SP4-1804	5 @ 150	15 @ 13	15 @ 13	24 @ 8	
Five Output					
SP5-1801	5 @ 120	12 @ 16	12 @ 16	5 @ 30	24 @ 8
SP5-1802	5 @ 120	15 @ 13	15 @ 13	5 @ 30	24 @ 8

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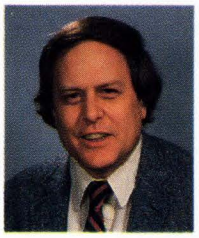
CIRCLE NO 138

IC philosophies vie for glue-logic role



A welter of complex, special-purpose ICs wants to glue your multiprocessor system together.

Charles H Small,
Associate Editor

At the leading edge of computer design, engineers are tackling computationally intensive problems that require them to parallel high-speed, high-powered processors. The glue logic necessary to control and coordinate multiple processors and other digitial subsystems in superminicomputers, array processors, digital signal processors, and high-end workstations must operate at the very limits of semiconductor technology.

Although random-logic makers have dramatically increased the speed of their products (**Ref 1**), the high clock speeds of the latest processors, ALUs, and DMA and DSP chips may mean that glue-logic functions cannot tolerate the pc-board path delays inherent when you use multiple IC packages. Consequently, engineers will be forced to employ special-purpose glue-logic ICs that have all the necessary glue-logic functions integrated into a single package.

Arguably, a modern automobile or a high-speed laser printer with a dozen or more μPs *is* a multiprocessor system. But such systems present few demands to glue-logic components and hence put little strain on system engineers.

The processors in automobiles and printers are mostly single-chip μPs that are dedicated to a specific, usually hardware-related, task. These processors operate more or less independently. They have little communication with their system's controlling processor other than simple commands, a few bytes of data, and error messages.

The glue logic for high-performance systems, on the other hand, must orchestrate digital subsystems that generate and consume complex instructions, formulate intricate replies to queries, and pass large quantities of data. Glue logic for such systems must often reconfigure the system's data and control pathways dynamically, from cycle to cycle, as the physical embodiment of a step of an algorithm.

As is well known, you can realize any logical function or algorithm in either hardware or software. Multiprocessor glue logic can have a full range of effects on your system's software, from none at all to substantial. Hardware designers can add glue logic to a multiprocessor system that can speed up the execution of some software tasks without having any effect on the software. Or the glue logic might require that software engineers write special-purpose code to operate it. In some cases, the glue logic can dictate and dominate the entire structure of the software.

> There are no rules of thumb to tell you when your software has run out of gas and you must push some of your system's computing and coordinating burden onto hardware.

An intermediate case is special-purpose glue-logic software that gets written only once and buried in your system's operating system.

How much of your system's proc-

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PLX TECHNOLOGY

CIRCLE NO 126

Multiprocessor glue logic

essing burden you offload onto hardware and which hardware you choose can significantly affect not only your system's execution speed but also the amount of special software you must write. Unfortunately, no rules of thumb exist to tell you when your software has run out of gas and you must push some of your system's computing and coordinating burden onto hardware.

Not all multiprocessor glue-logic ICs will affect your system's software. Cypress Semiconductor's $719.94 CY7C605 cache-controller/memory-management unit is an example of a multiprocessor system glue-logic chip that will have no effect on the way you write your software.

The device automatically performs an absolutely necessary, but somewhat arcane, function in multiprocessor systems that use cache memory. With a single processor, a cache-memory scheme lets you use just a small amount of fast static RAM for your processor's immediate computational needs. Less-expensive, slower dynamic RAM does the bulk of on-line storage.

You purchase this economy and faster operation at the expense of considerable overhead headaches. Your system's memory controller must ensure that the cache memory's contents and the portion of the main memory that the cache memory temporarily duplicates correspond. That is, if the processor writes a new datum to the cache memory, sooner or later, the corresponding datum in the main memory must be updated.

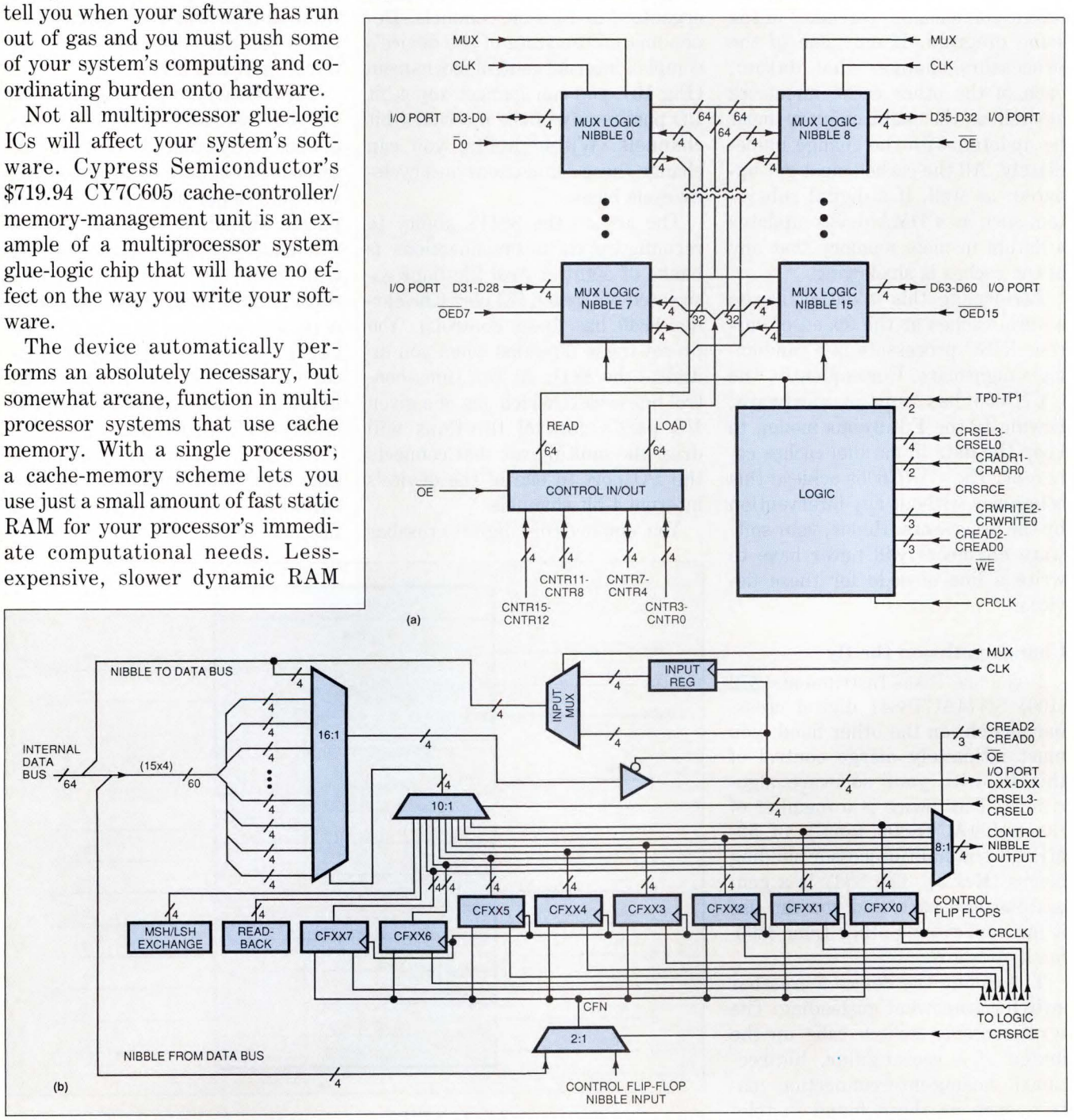

Fig 1—This digital-crossbar switch, *Texas Instruments' SN74ACT8841, has 16 4-bit I/O ports* ***(a)****. The control flip-flops and multiplexers associated with each port* ***(b)*** *let you dynamically connect any 4-bit I/O port to any 4-bit channel of the device's internal 64-bit bus.*

Multiprocessor glue logic

Now consider parallel processing with multiple processors, each having its own cache. Conceivably, two or more processors could have copies of the same main-memory datum in their cache memories—especially if the processors are executing different portions, or "threads," of the same program. If only one of the processors changes that datum, each of the other cache memories as well as the main memory must be updated with the change immediately. All the caches must get updated, as well, if a digital subsystem such as a DMA device updates a datum in main memory that any of the caches is shadowing.

Performing this updating across several caches at the speed of current RISC processors is a random-logic nightmare. Consequently, the CY7C605 has built-in hardware, hewing to the Futurebus model, to keep the data in parallel caches coherent. The CY7C605s achieve this coherency without any intervention by the processors. Hence, your software engineers will never have to write a line of code for these devices.

Change paths on the fly

If you use Texas Instruments' $72 (100) SN74ACT8841 digital crossbar switch, on the other hand, you must intimately merge control of this IC with your software algorithms. The device is a member of the SN74ACT8800 family of 50-MHz, 32-bit multiprocessor building blocks (**Ref 2**). The 8841 is a general-purpose part, and you can use it for applications other than 8800-family designs.

TI's calling the device a crossbar switch is somewhat misleading. The term crossbar switch calls up the image of a rectangular, bidirectional, analog-interconnection matrix, such as those found in telephone exchanges. The 8841 performs a similar function to interconnect numerous bus-oriented digital subsystems, but it has significantly different properties than an analog crossbar switch.

This device has 16 external 4-bit I/O ports and a 64-bit internal bus (**Fig 1**). The internal 64-bit bus is organized in 16 4-bit channels. Depending on the state of the device's complex internal control mechanism (**Fig 1b**), you can connect any 4-bit I/O port to any of the internal 4-bit channels. Within limits, you can change these connections on a cycle-by-cycle basis.

The key to the 8841's ability to reconfigure its interconnections is banks of eight control flip-flops associated with each I/O port (the earlier 8840 has fewer controls). You preset these flip-flops when you initialize the 8841. At run time, control lines select which one of a given I/O port's control flip-flops will drive the multiplexer that connects the I/O port to one of the device's internal 4-bit channels.

You employ this digital crossbar switch to dynamically interconnect the digital subsystems in your design, such as processors, multiplier/accumulators, floating-point processors, memories, and bus interfaces. This method of dynamically interconnecting computing, communication, and storage elements contrasts sharply with that of conventional hard-wired buses.

The 8841 will have a major impact on your software because the sequence of dynamically changing interconnection paths that it executes will be a major portion of the computing algorithm your software is realizing. An FFT (fast Fourier transform), for example, involves considerable algorithmic swapping of data among various parallel processing elements. An array processor's interconnection scheme thus, in effect, executes part of the processor's FFT algorithm.

FIFOs are another example of glue logic that mimics a common software construct—the first-in, first-out queue. Designers employ

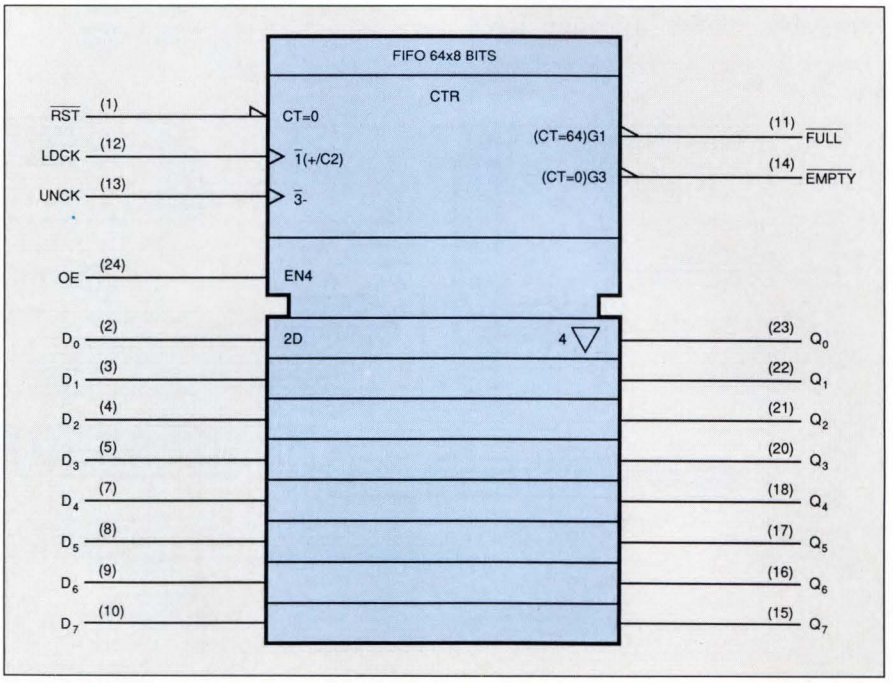

Fig 2—This diagram of a 64×8-bit FIFO, *the SN74ALS2232, illustrates that Texas Instruments, alone among US semiconductor firms, has adopted the IEC standard for digital circuit symbols.*

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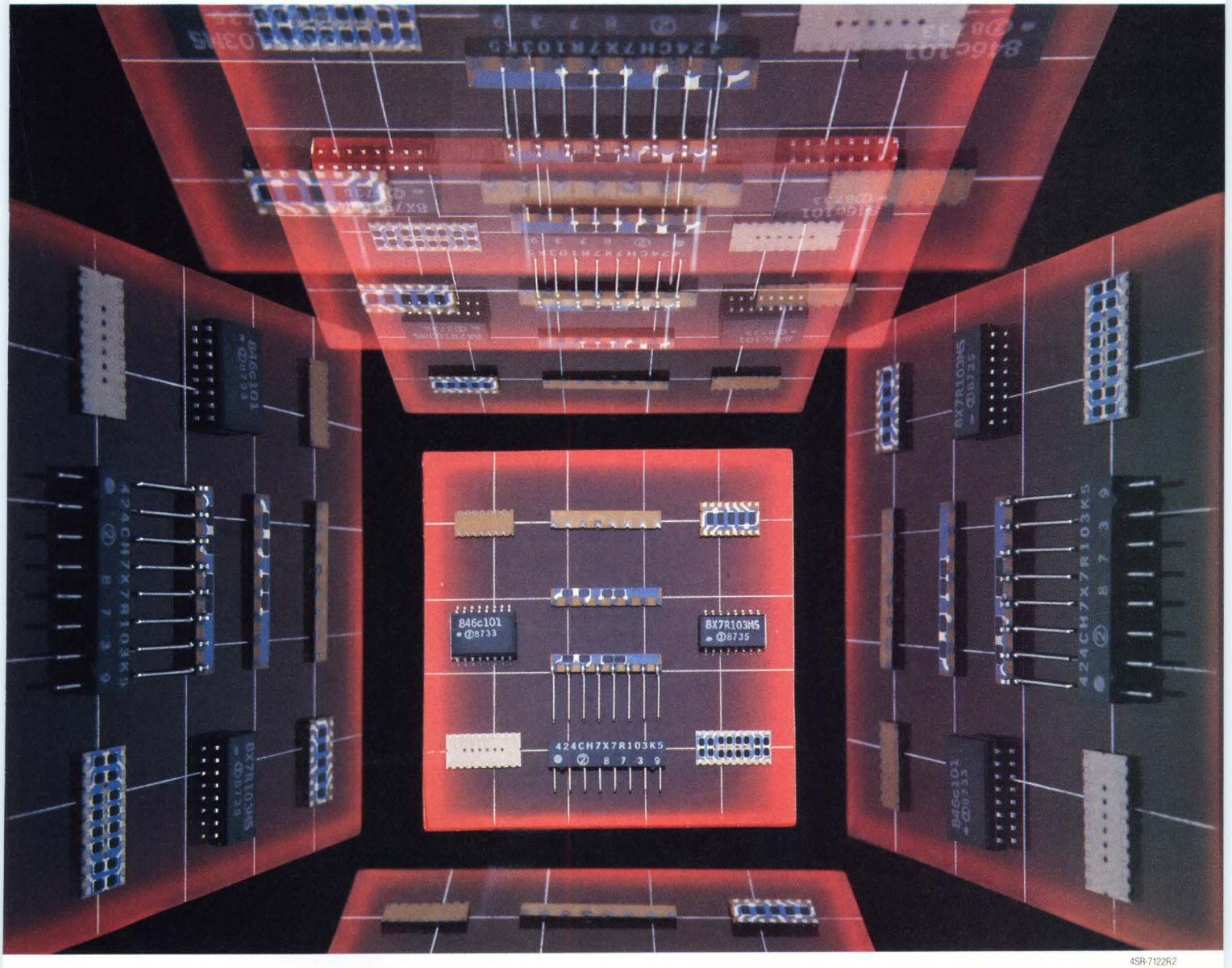

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CIRCLE NO 133

Multiprocessor glue logic

FIFOs for two basic reasons: to provide asynchronous communication between two processes or to virtually double the bandwidth of data passing. Consequently, FIFOs come in a variety of depths (memory capacities), speeds, and control schemes.

Texas Instruments' ALS2232 and ALS2233, both $14.56 (1000), are examples of devices that you would use as "accordion buffers" between two asynchronous processes (**Fig 2**). The devices are only 64 words deep and support data-transfer rates as high as 40 MHz.

These small, fast FIFOs prove handy in situations, for example, where a master processor sends simple commands to a slave I/O processor. When the slave processor completes its execution of the command, its reply to the master processor consists of either a pointer, a few bytes of data, or a simple error message. The ALS2232 stores 8-bit words; the AL2233 stores 9-bit words for those commonly encountered applications where you need to pass an 8-bit byte plus a qualifing bit.

Because these devices have a simple control interface, your software can treat them much as it does I/O ports. For example, you can use the FIFOs' two control lines that signal that the FIFO is full or empty as you would the control lines from an I/O port that signal that the port is busy or has no data available. Thus, you can bury any custom software the FIFOs require at the lowest, least-visible operating-system layer along with other device handlers.

Several companies produce much deeper FIFOs and multiple-port memories (**Ref 3**). You would use these deeper FIFOs to pass large files between processes—as opposed to the simple commands, error messages, or few bytes of data you would pass with a small FIFO. One software/hardware tradeoff you could make is to choose between using a small FIFO to pass pointers to data buffers or to use a large FIFO or dual-port memory to pass the data itself.

Among multiple-port memories, dual-port memories have been on the market for some time. These chips allow two subsystems simultaneous access to a single memory bank, providing that they both do not try to write to the same location at once. Absent write collisions, such a memory obviously doubles the data-transfer speed of a single-port memory that must be alternately shared between two processes.

Two recent developments in multiple-port memories expand their utility. First, Integrated Device Technology has two 4-port memories: the 1k-byte, $233.77 (100) IDT7050 and the 2k-byte, $327.31 (100) IDT7052 (**Fig 3**). These static RAMs are fast: Civilian versions have 25-nsec access times.

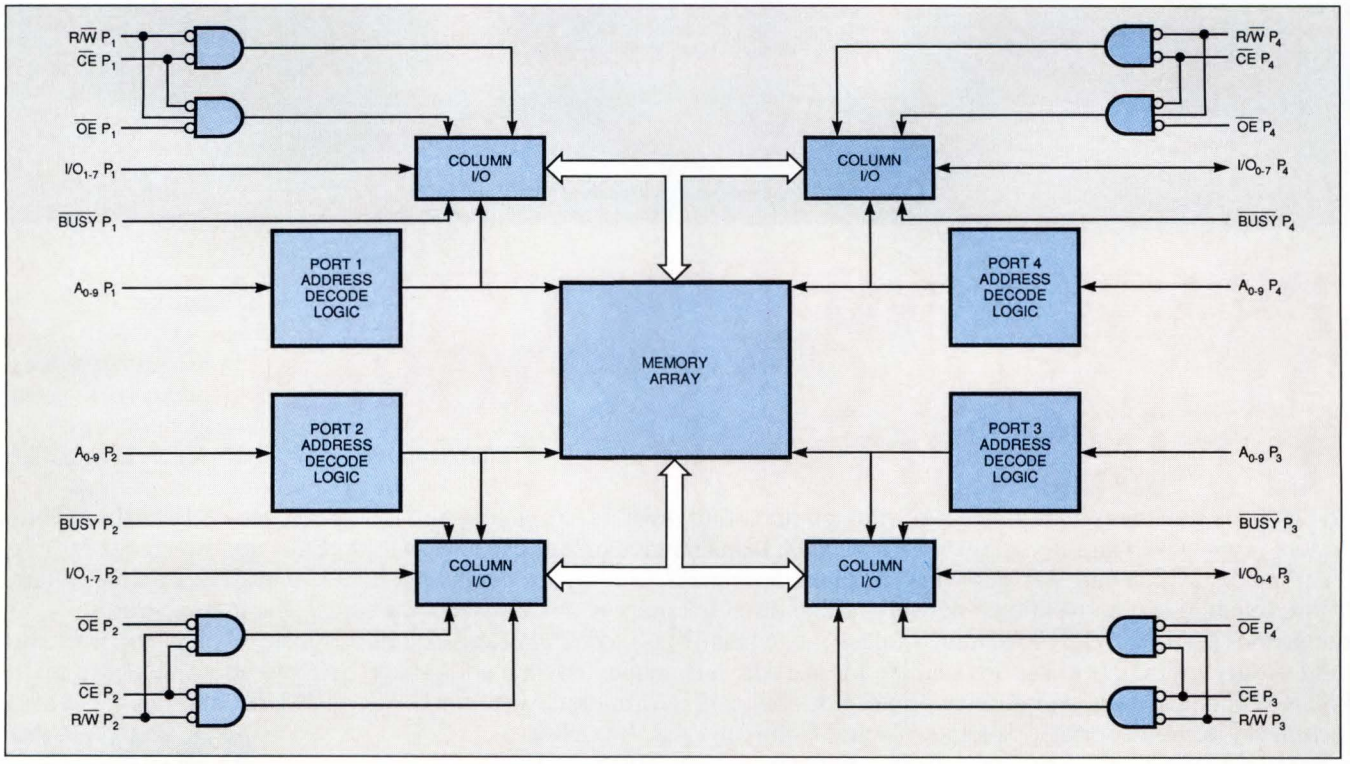

***Fig 3—Four digital subsystems** can access the common memory array of Integrated Device Technology's IDT7050/52 simultaneously.*

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TECHNOLOGY UPDATE

Multiprocessor glue logic

The devices have four sets of I/O and control lines. Four digital subsystems can access virtually all memory locations simultaneously. With these chips, multiprocessor systems can share data at several times the rate they could if they had to contend, one at a time, for a shared-memory message-passing space. And unlike some other IDT dual-port RAMs, which have a built-in hardware semaphore to help avoid read/write collisions, the 4-port RAMs leave it up to you to keep the four digital subsystems from trying to access the same locations at the same time.

Also termed a 4-port memory, but in fact a vastly different device from the IDT parts, is Dallas Semiconductor's DA2015. The company sells the device as part of a 4-port local-area network (LAN) for IBM PCs. It costs $100 with two port adaptors and software.

The DA2015 forms the heart of the LAN and is a good example of what is usually thought of as a software construct being realized in hardware: The device is a hardware mailbox that can serve four patrons. The chip is indeed a 4-port RAM, but the ports are *serial* ports. (The DA2015 comes in an 18-pin package—IDT's 4-port RAM comes in a pin-grid-array package.) Internally, the device has four RAM banks of 8 bytes each. Each port can read and write to its own bank and read the three other ports' banks. One byte in each bank serves as a flag register.

In operation, subsystems can post messages in their port's RAM bank and receive messages posted by other subsystems in their banks. Each subsystem can access the device simultaneously with the other subsystems. Although the device does make a nifty, 9600-baud LAN, it could also serve as a hardware replacement for software mailboxes in multiprocessor systems. EDN

References

1. Small, Charles H, "Programmable Logic Devices," *EDN*, November 10, 1988, pg 142.
2. Swager, Anne Watson, "Cross-point-switch ICs enter digital domain," *EDN*, February 16, 1989, pg 75.
3. Pryce, Dave, "Dual-port RAMs: Specialized memories ease communications," *EDN*, April 13, 1989, pg 83.

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For more information . . .

For more information on the glue-logic products discussed in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

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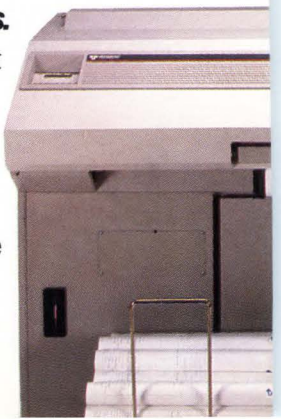

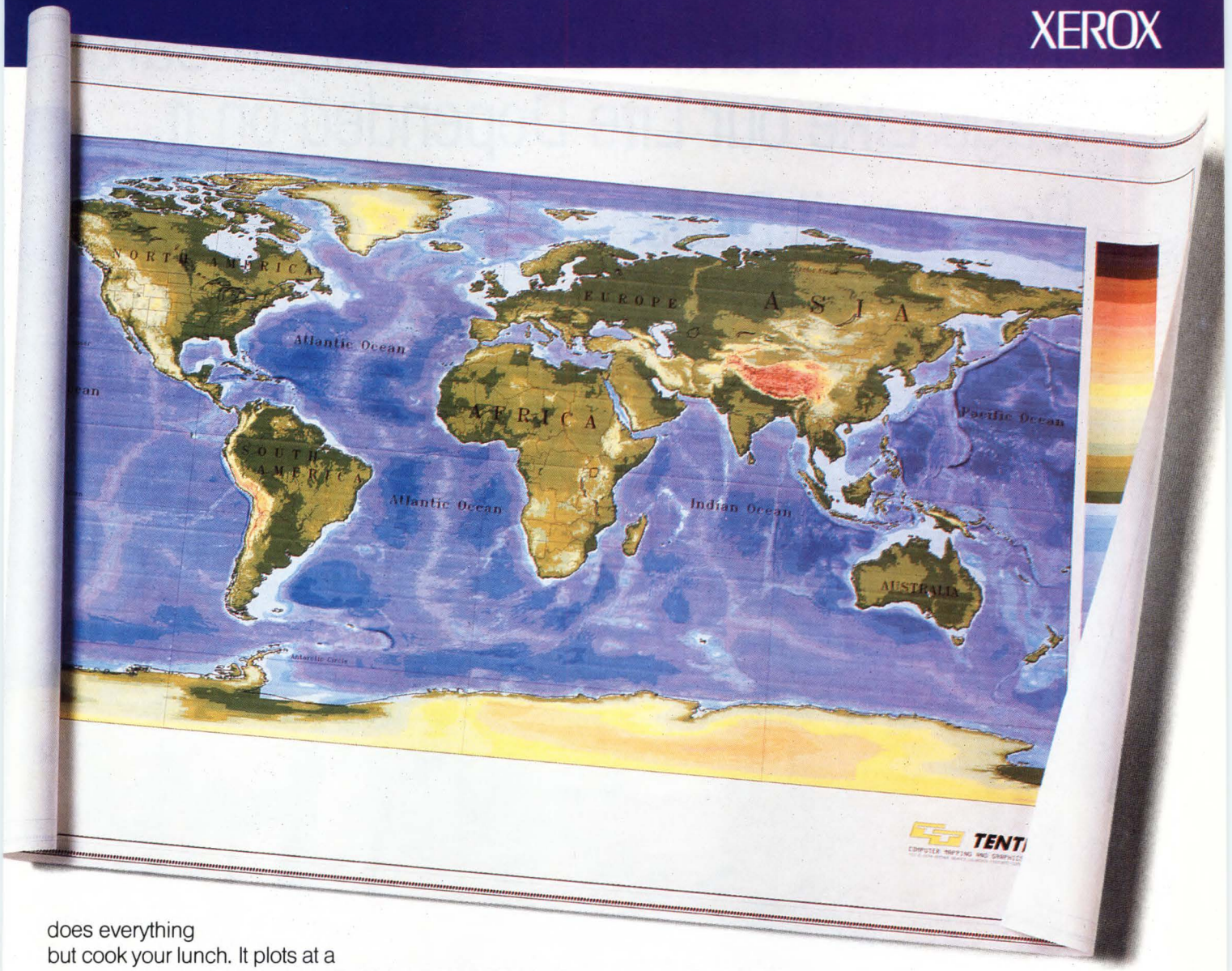

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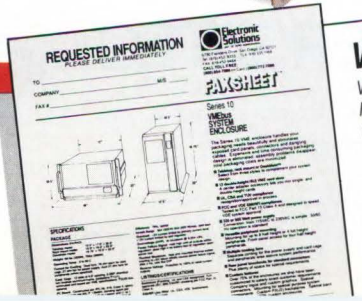

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CIRCLE NO 93

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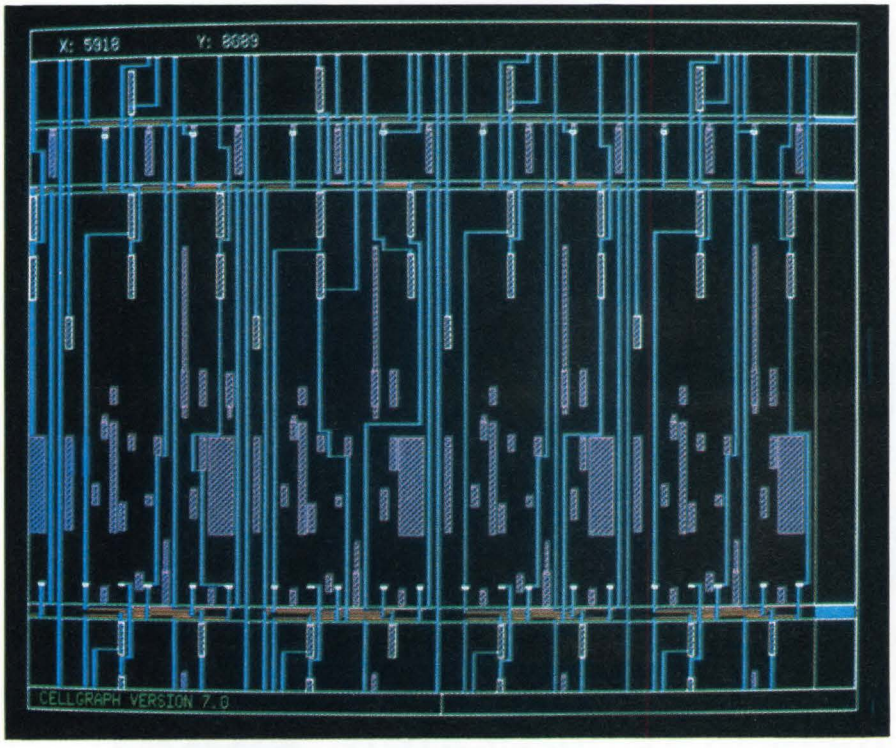
Circle No 739



This example of automatic over-the-cell routing *shows how Cell Station/Blocks navigates via the blue lines around blockages (the purple cross-hatched blocks) to connect to the internal pins (the white-bordered blocks) within the block.*

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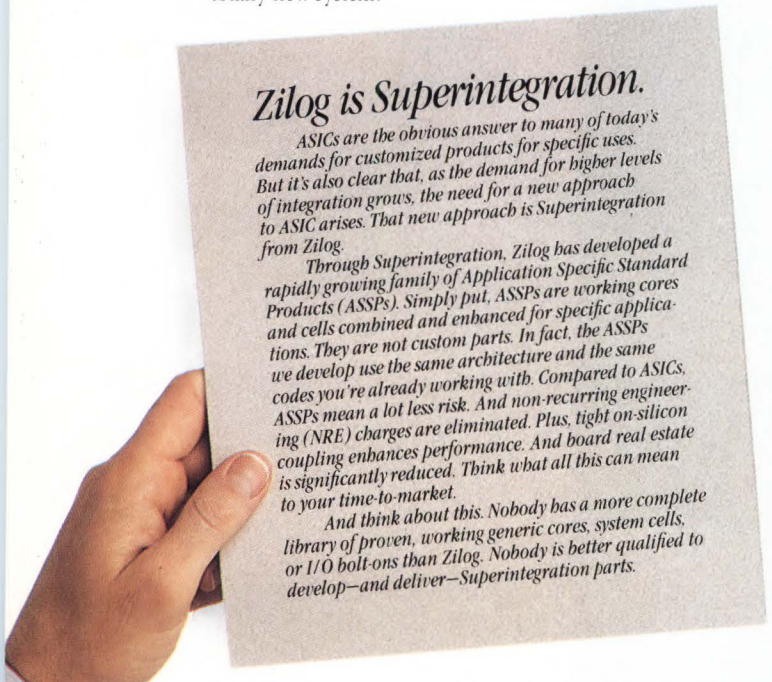

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CIRCLE NO 139

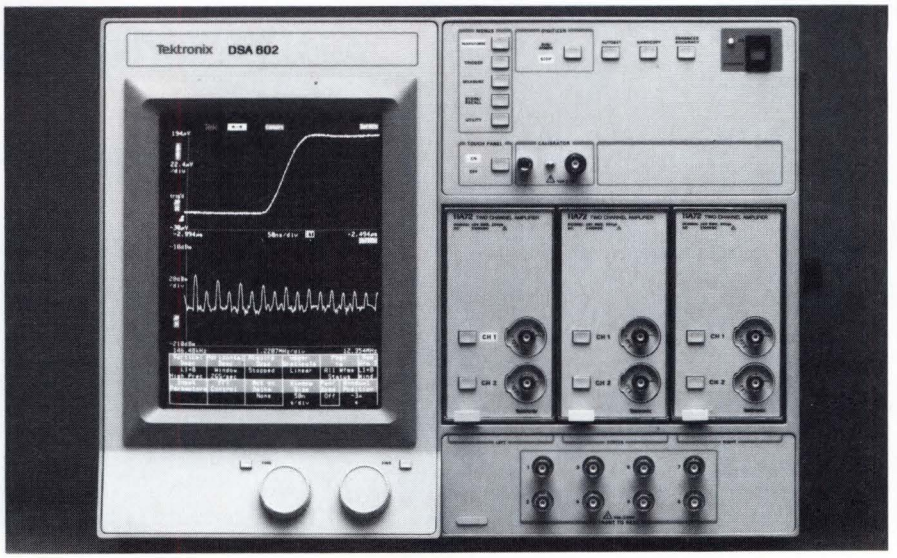
Analyzer combines real-time DSP with 1-GHz-bandwidth, 2G-sample/sec DSO

The DSA 601 and 602 digitizing signal analyzers, which combine a DSP capability with a digital storage oscilloscope, have extremely impressive specifications made possible by the use of several proprietary technologies. The DSA 602 can take 2G samples/sec in real time, and the bandwidth is 1 GHz—but the instruments' scope performance is just the beginning of the story.

By adding DSP (digital signal processing), implemented with a proprietary CMOS RISC processor, the vendor has created instruments that perform floating-point operations almost two orders of magnitude faster than its previously highest performing scopes. Moreover, DSA Series units perform several functions that the earlier products could not perform; for example, they calculate FFTs so rapidly that they can present simultaneous displays of waveforms and their spectra, and update them "live" approximately 20 times every second.

The units' proprietary flash ADCs can make 500M 8-bit conversions/sec. (Real-time signal averaging can extend the dynamic range to 14 bits.) The converters and the accompanying track and hold amplifiers are based on a semiconductor fabrication technology called "LBT" ("little bitty transistor"). The DSA 602 contains four flash converters that operate independently, in pairs, or in an interleaved manner in which they collectively acquire a sample every 500 psec. The DSA 601 has two converters.

Among the features made possible by signal processing is the ability to "dejitter" waveforms. The instruments automatically time-shift newly acquired data sets to provide the best fit with a stored reference waveform. The result is a jitter-free display. Another feature is called "act on delta", an extension of the "save on delta" feature of some of the vendor's other scopes. With act on delta, when a specified number of points in a waveform display fall outside of the boundaries defined by a template, the instrument can save the waveform in its nonvolatile memory, repeat the display, sound a chime, transmit the waveform over the IEEE-488 bus, or print out a copy of the waveform.



Three μPs plus a proprietary DSP chip *endow DSA 600 Series digitizing signal analyzers with real-time signal-processing capabilities. The units reduce the massive amounts of data they capture and present them on a color display in a form you can interpret.*

The instruments provide very deep waveform storage. Each waveform can comprise as many as 32k samples. All units contain nonvolatile storage for 258,560 samples. As an option, you can add storage for more than 450k additional samples.

Like the vendor's 11400 Series DSOs, these instruments have uncluttered front panels. Onscreen menus and a touch-sensitive screen simplify control. Unlike the vendor's earlier units, however, screen displays appear in color to simplify distinguishing waveforms from each other. Furthermore, you can annotate the displays—one menu selection causes an image of a "Qwerty" keyboard to appear on the touch-sensitive screen. When the keyboard appears, you can type alphanumeric labels on it.

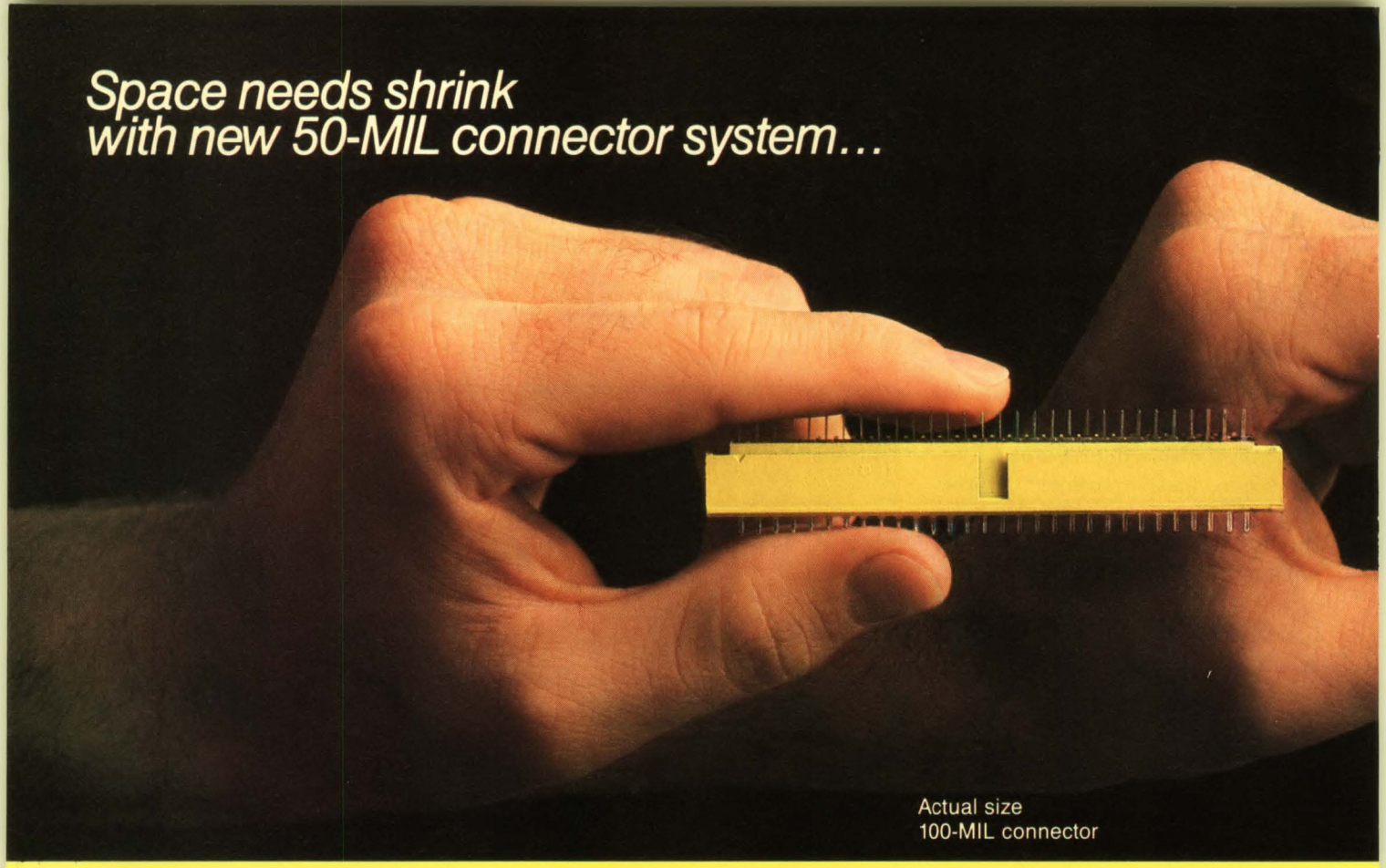
You can connect many types of printers and plotters to obtain hard-copy output. The units support color hard-copy devices and include a Centronics parallel port in addition to IEEE-488 and RS-232C ports.

Both DSA instruments accommodate three plug-in units. The vendors's 11400 Series of DSOs utilizes the same plug-ins. The 2-channel DSA 601 mainframe lists for $21,025 without plug-ins or options, and the 4-channel DSA 602 starts at $27,125.—***Dan Strassberg***

Tektronix Inc, Box 500, Beaverton, OR 97077. Phone (800) 835-9433.

Circle No 738

Space needs shrink with new 50-MIL connector system...

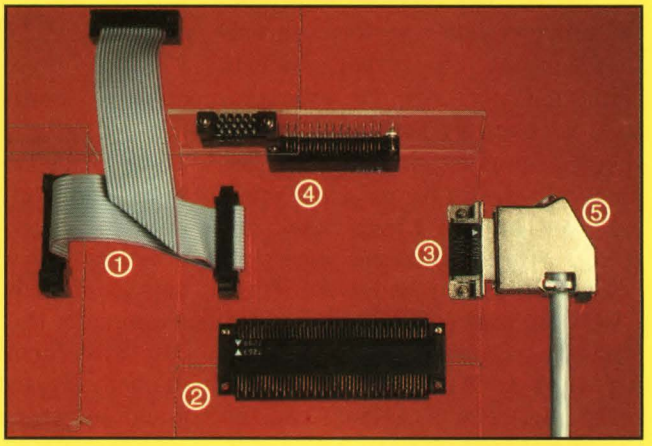


Actual size
100-MIL connector

The new Robinson Nugent PAK-50™ interconnect system replaces existing 100-MIL spacing with 50-MIL spacing, doubling your PC board connector density. You can now reduce the cost of your systems with smaller PC boards without decreasing I/O— or add more I/O without increasing board size.

RN PAK-50™ incorporates a dynamic contact interface, the male and the female contacts simultaneously deflect. This dynamic movement facilitates a high density/high pin count interconnect system with low insertion/ withdrawal forces, low contact resistance, high normal forces, and high wear resistance.

Investigate this cost saving, high reliability interconnect system today. The RN PAK-50™ system includes 2-piece PCB connectors, IDC flat cable connectors, and laminated or discrete wire I/O connectors—all in micro-miniaturized 50-MIL configurations.



This is the complete RN-PAK-50™ Interconnect System:

1. 2-pc. IDC cable connectors—50-MIL cable assures compatibility between .050″ and 100″ center technology.
2. 2-pc. horizontally mated connectors.
3. Right angle board mount I/O connector.
4. 2-pc. vertically mated connectors.
5. Discrete or laminated wire I/O connector with EMI shielded back shell.

CIRCLE NO 78

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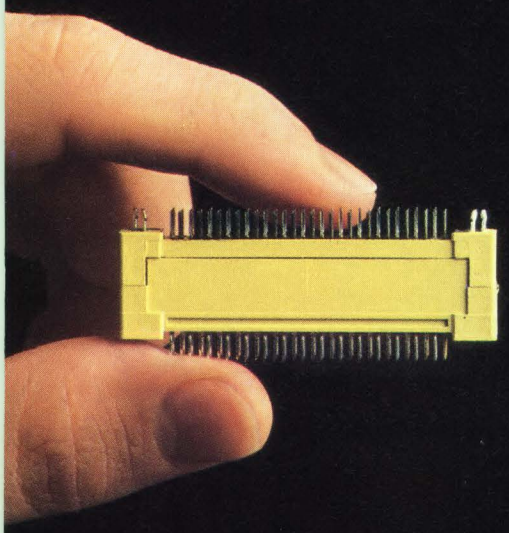
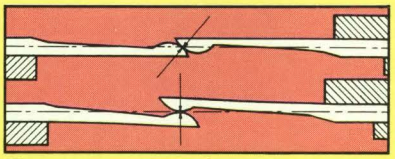


The RN "Partners in Quality" Team delivers new PAK-50™ connector system that shrinks needed board space by 50%!

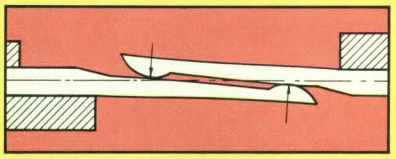
Actual size
PAK-50™ connector

THE RN PAK-50™ redundant ribbon contact is the key to the high reliability of the PAK-50™ interconnect system, providing a low 20 gram insertion force with high 100 gram minimum normal forces. As the RN PAK-50™ connectors are mated, the two straight beam contacts mate in the axial direction of the contacts. Both contact surfaces move together when mated so contact surfaces work together, not against each other. Because contacts are shrouded, they are protected from misalignment and pin damage is minimized.

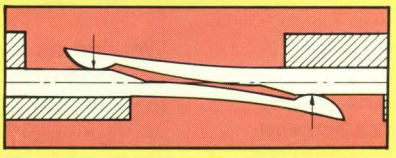
Write today for specifications and test data on the new RN-PAK-50™ micro-miniaturized connector system.



First stage mating—Smoothly curved tips of each contact meet and slide over each other's surface.



Second stage mating—Each curved contact tip wipes against the smooth tapered beam of the other contact.



Third stage mating—Finally the mating point of each tip reaches the trunk of the other contact.

CIRCLE NO 79

"The RN 'P/Q TEAM' concept brings all of our design, engineering and production skills to bear on *your* unique socket/connector problems. We work closely with your people to create solutions that are delivered on-time and defect-free. *You have my personal guarantee on it.*"

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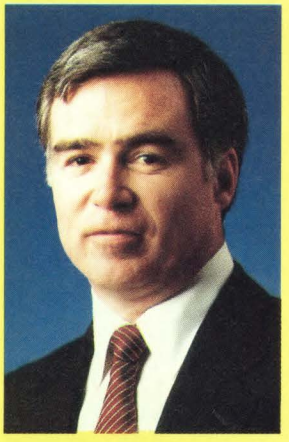
President/CEO



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CIRCLE NO 80

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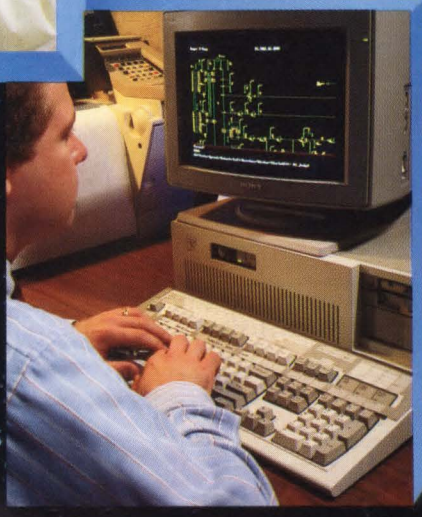

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CIRCLE NO 123

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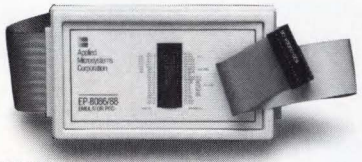

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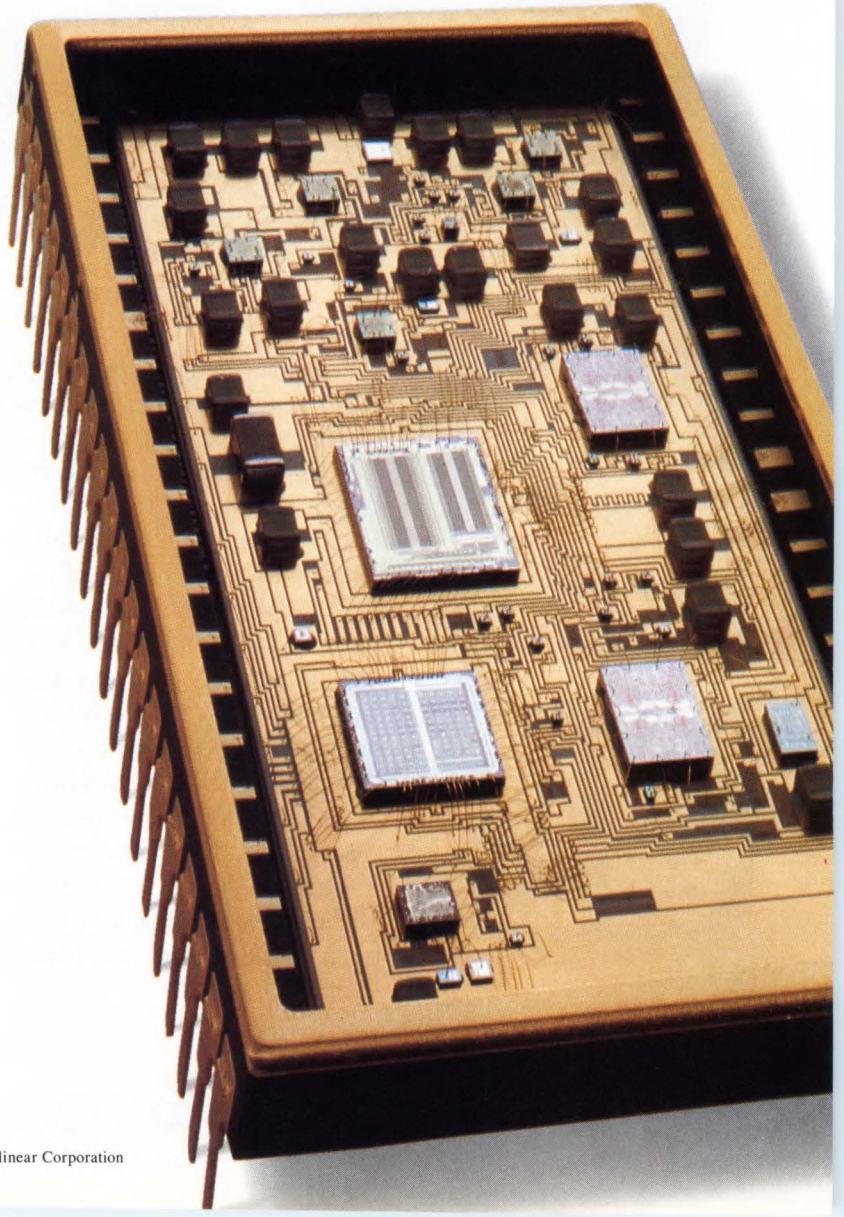

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CIRCLE NO 70

The newest resistor networks, which feature SIP-, DIP-, and surface-mount-style packages, soar into today's critical-performance applications. (Photo courtesy Bourns Inc)

Resistor networks

Thanks to recent developments in the resistor-network market, the newest networks not only maximize pc-board space, but also offer improved reliability and flexibility. You can choose from a host of devices that feature different performance specs, package styles, and manufacturing techniques.

Tom Ormond, *Senior Editor*

Compared with discrete devices, resistor networks offer more inherent advantages in regard to reliability and board-fabrication considerations. Resistor networks minimize thermal-management problems, reduce pc-board space requirements, and make the design process easier. Many recent developments in the resistor-network market, including changes in packaging and manufacturing techniques, further enhance the devices' efficiency and simplify your design tasks. Because manufacturers offer such a wide selection of off-the-shelf and semicustom resistor networks that reflect these improvements, you can find a high-performance device to enhance almost any design.

Although network manufacturers were initially hesitant to deviate from the typical SIP- and DIP-style through-hole designs, more and more vendors now offer surface-mount networks. Manufacturers have also concentrated on improving film-deposition processes, such as metallization chemistry and film stability. As a result, surface-mount networks fabricated with thin-film technology are now available. Although thick-film networks continue to dominate the market (mainly because they're less expensive than thin-film devices), designers now have the option of selecting the type of device that best suits their applications. Thick-film networks, for example, satisfy the demands of digital-

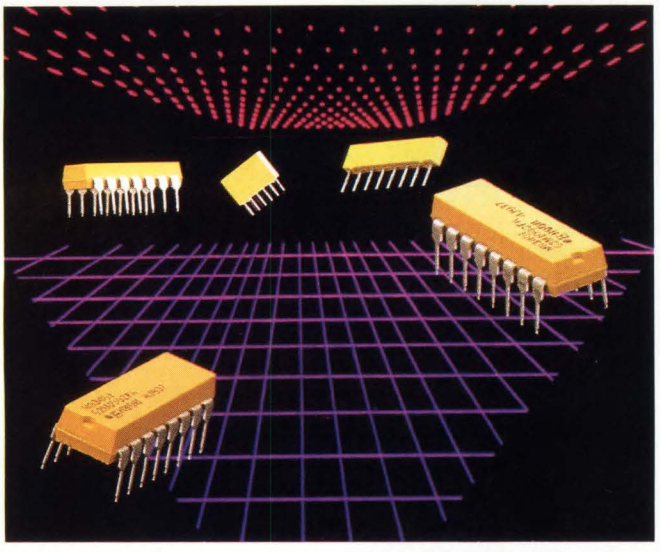
Resistor networks save considerable pc-board space and minimize thermal-management problems.

circuit applications, and thin-film devices provide the high precision needed for analog circuitry.

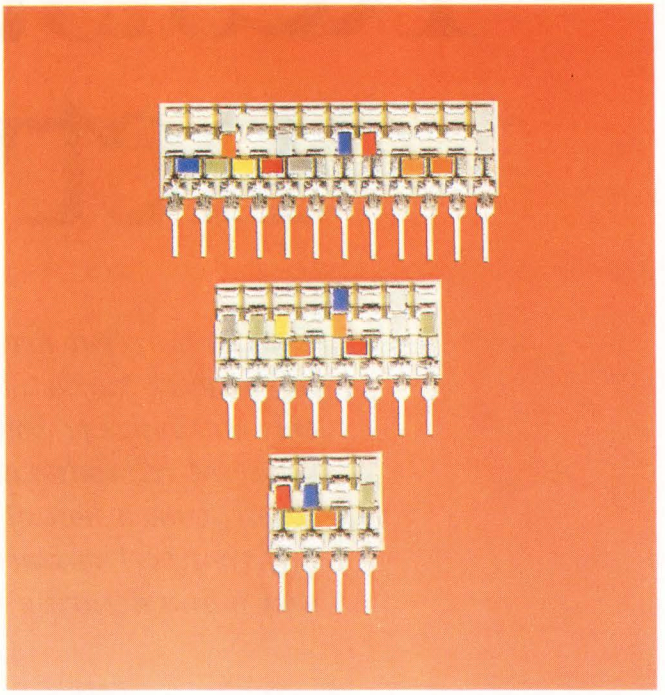
Thick-film technology typically yields networks that have resistor tolerances in the 1 to 2% range, temperature coefficients (TCs) of 100 ppm/°C, and power-dissipation specs to 125 mW. With such capabilities, these networks can satisfy the needs of computer, peripheral, and telecommunications applications. Sprague, Dale, CTS, and Bourns are a few vendors that provide thick-film, surface-mount resistor networks.

Sprague offers a varied line of surface-mount, thick-film resistor networks. The 14-pin 834 and the 16-pin 836C SOM models are 0.22-in. wide; the 16-pin 826C and the 20-pin 820C SOL versions measure 0.295-in. wide. All four models, which come in SOIC packages, are available in multiple-isolated-resistor; Thevenin-terminator; translator-network (TTL-to-ECL and CMOS-to-ECL); R/2R-ladder; and pullup-, pull-down-, and interface-bused configurations.

The networks' resistance values range from 22Ω to 1 MΩ with tolerances of ±2% or ±1Ω, whichever is greater. Each device features a ±200 ppm/°C TC and a ±50 ppm/°C tracking TC (for like-valued resistors). At 70°C, the 0.22-in. isolated-resistor types have per-resistor power ratings of 160W, and the pullup/pull-down and Thevenin-terminator circuits have per-resistor power ratings of 80 mW; the respective figures for the 0.295-in. units are 200 mW and 100 mW. The 14- and 16-pin SOM packages have power-dissipation ratings of 0.52 and 0.6W, respectively; the 16- and 20-pin SOL versions dissipate 1.5 and 1.9W. All the networks in the series accommodate 50V and operate over −55 to +125°C.



Available in both DIPs and SIPs, *the Model M83401 thick-film networks from Bourns feature resistor tolerances of 1% and meet the requirements of the MIL-R-83401 standard.*



To satisfy prototype, pilot-run, *or emergency requirements, International Manufacturing Services can supply SIP-type, thick-film networks in less than two weeks. The networks' resistance values range from 10Ω to 25 MΩ with tolerances as low as 1%.*

The networks' epoxy-resin packages carry a 94V-0 UL flammability rating. Each package features 10^9Ω insulation resistance and a 200V-rms dielectric-withstanding voltage. Available on 24-mm embossed tape, the networks cost $0.40 to $0.50 (10,000).

Choose from a variety of configurations

Dale also offers a line of surface-mount, thick-film networks. The units feature molded-epoxy, SOIC packages and are available in bused-resistor (SOMC-01), isolated-resistor (-03), and resistor-pair (-05) configurations.

The SOMC networks feature resistance values ranging from 10Ω to 1 MΩ with tolerances of 1, 2, and 5%. The units feature ±100-ppm/°C absolute TCs and 50-ppm/°C tracking TCs. At 25°C, the SMOC-01 and -02 styles both feature power ratings of 1.625 and 1.875W for the 14- and 16-pin packages, respectively; the 14- and 16-pin SMOC-03 versions dissipate 1.75 and 2W.

Each network features a maximum operating voltage of 50V dc and operates over −55 to +125°C.

The SOMC-01 networks are available with either 13 or 15 resistors, each connected between a common lead (pin 14 or 16) and a dedicated pin. The SOMC-03 versions are available with either seven or eight isolated resistors, and the SOMC-05, TTL dual-line terminators feature either 12 or 14 resistor pairs. Each pair is connected between ground and a common line, and each resistor junction connects to an input pin. A 14-pin, SMOC-01 network with a 2% resistor tolerance sells for $0.57 (1000).

CTS Corp offers two families of surface-mount, thick-film networks with solid ceramic bodies. Housed in a 0.154-in.-wide package, the Series 766 devices are the smallest surface-mount networks available. The Series 767 networks come in 0.220-in.-wide packages that you can interchange with several insert-molded devices available from the company's competitors.

The standard resistance values for both families range from 22Ω to 1 MΩ with standard tolerances of ±2%. The networks are also available with resistance tolerances of 0.5% or 5Ω, whichever is greater. Their TCs are ±100 ppm/°C for resistance values above 100Ω and ±200 ppm/°C for values below 100Ω. Each unit accommodates 50V and operates over −55 to +125°C.

Both the Series 766 and 767 networks are available in 14- and 16-pin packages and in bused-, isolated-, and Thevenin-terminator-resistor configurations. At 25°C, the power ratings for the Series 766 packages are 1.6 (14-pin version) and 1.8W (16-pin version). The Series 767 units' respective power ratings are 2 and 2.3W.

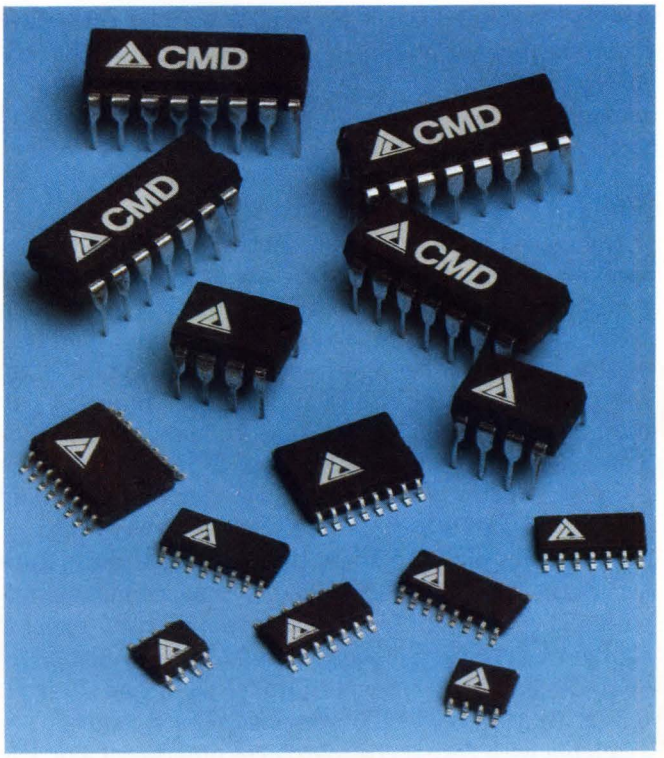
The networks' solid ceramic construction gives manufacturers the maximum surface area to apply thick-film circuitry and lets them thermally isolate the units without using a molded coating. The packaging also alleviates thermal mismatch problems that often develop when networks undergo vapor-phase or IR solder-reflow procedures. The Series 766 networks cost $0.68, and the 767 models cost $0.61 (1000).

Take your pick of packages

Although surface-mount components are becoming more popular among circuit designers, many vendors still offer traditional package styles. Bourns, for example, features a line of thick-film networks that meet the MIL-R-83401 requirements. Providing 1% resistor tolerances, the Model 83401 networks are available in molded DIPs and SIPs. The DIP units come in both isolated- and bused-resistor configurations and in 14-(Model 83401-01) and 16-pin (-02) housings. The SIP versions are also available in isolated- and bused-resistor configurations and in 6-, 8-, and 10-pin low-profile (Models 83401-07, -08, and -09) and high-profile styles (Models 83401-04, -05, and -06).

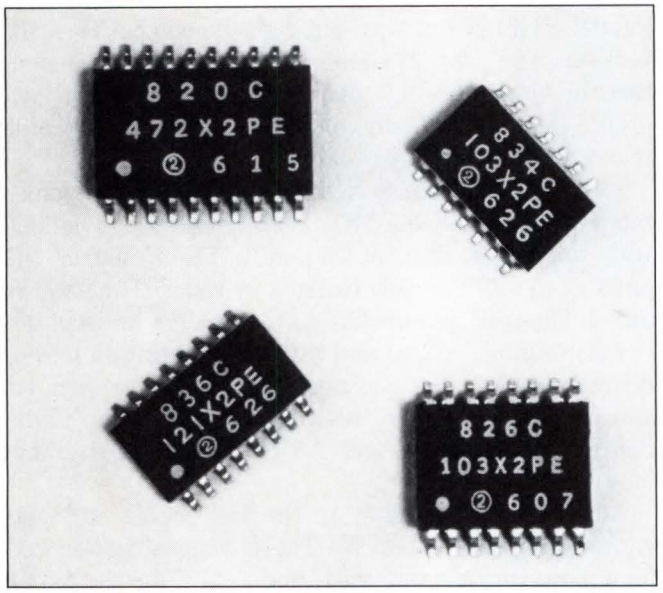
All models in this series feature resistance values ranging from 51Ω to 1 MΩ. Each network is available with tolerances of 2 or 5% and a TC of 300 or 500 ppm/°C. At 70°C, each resistor in the DIP networks has a 200-mW power-dissipation rating in isolated-resistor configurations and a 100-mW rating in bused-resistor styles. The packages' power ratings are 1.4 and 1.6W for 14- and 16-pin isolated-resistor units, respectively, and 1.3 and 1.5 for the 14- and 16-pin bused-resistor versions.

At 70°C, each resistor in the low-profile SIP networks dissipates 120 mW. The packages' power ratings, however, are 0.6, 0.84, and 1.08W for the 6-, 8-, and 10-pin bused-resistor units and 0.36, 0.48, and 0.6W for the 6-, 8-, and 10-pin isolated-resistor models. All the high-profile SIP networks have a 200-mW per-resistor power rating; the packages' dissipation values



With tolerances as low as ±0.1%, *PRN Series networks from California Micro Devices feature resistance values ranging from 100Ω to 500 kΩ. Housed in surface-mountable SOIC packages, these networks operate over a −55 to +150°C range.*

Although through-hole devices continue to dominate the market, many vendors are now offering surface-mount resistor networks.



Designed for surface-mount applications, *Sprague's 800C family of thick-film networks features resistance values ranging from 22Ω to 1 MΩ. Each unit has an accuracy of ±2%.*

are 1, 1.4, and 1.8W for the 6-, 8-, and 10-pin bused-resistor units and 0.6, 0.8, and 1W for the respective isolated-resistor models. The 83401 networks are housed in epoxy packages that feature a 94V-0 UL flammability rating. Their prices start at $1.00 and vary with each package style (1000).

Thin-film units offer high precision

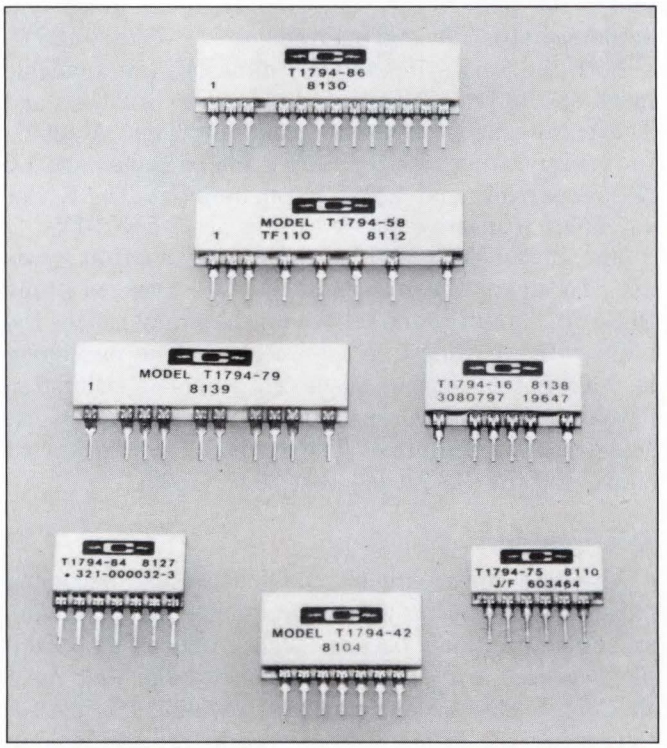
Compared with thick-film networks, thin-film devices have tighter tolerances (0.1% or better) and have parameters that are more stable over time. Beckman, RCD, and California Micro Devices offer thin-film networks that meet the high-precision needs typically associated with analog-circuit applications. You must pay more money for this performance, though, and sacrifice some degree of power dissipation: Thin-film networks dissipate about ⅓ less than thick-film resistors and about ¾ less than comparable thick-film networks.

Beckman's high-precision, thin-film networks feature accuracies to 0.1%. This series of surface-mount networks is available in both isolated- and bused-resistor configurations and includes 8-lead, 0.15-in.-wide (Model 664); 16-lead, 0.15-in.-wide (Model 668); and 16-lead, 0.3-in.-wide (Model 688) versions. The networks are available with resistance tolerances of either 0.5 or 1%.

Models 664 and 668 have standard resistance values ranging from 1 to 100 kΩ; the Model 688 versions feature either 50- or 100-kΩ of resistance. All the networks provide ±25-ppm/°C TCs and ±5-ppm/°C tracking TCs. Each device has a 100V maximum operating voltage, a 10^9Ω minimum insulation resistance, and a −65 to +125°C operating range. At 70°C, these networks have a 100-mW per-resistor power-dissipation rating. The packages' power-dissipation ratings are 0.4W for the Model 664, 0.5W for the Model 668, and 0.7W for the Model 688. Packaged in antistatic tubes, the networks cost $1.42 (1000).

RCD's resistor networks, which comprise the SMN 25 Series, are high-density, thin-film networks. They come in 14-, 16-, 20-, 24-, and 44-pin SOIC packages that feature compliant gull-wing leads on a 0.025-in. pitch. These networks can accommodate as many as 32 resistors in each ⅛-in.^{2} package.

The SMN 25 Series networks, which are available in bused- and isolated-resistor configurations, feature resistance values from 50Ω to 10 kΩ, resistor tolerances to ±0.5%, and TCs to 25 ppm/°C. At 25°C, the networks' per-resistor power ratings are 62.5 mW for the budded-resistor configurations and 31.25 mW for the isolated-resistor designs. The packages range in size from 0.2 (14-pin packages) to 0.575 in. wide (44-pin units). Each network costs from $4 to $6, depending



You can independently select TC *and tolerance specifications for each resistor in the T1794 networks from Caddock.*

on the number of resistors in the package and the unit's degree of accuracy.

The PRN Series thin-film networks from California Micro Devices are available in 8-, 14-, and 16-pin narrow-body packages and in 14-, 16-, and 20-pin wide-body SOIC packages. The networks come in isolated- and bused-resistor configurations, both of which feature low TCs and good stability.

The devices provide standard resistance values of 100Ω to 500 kΩ with resistance tolerances of ±0.1, ±0.2, ±0.5, ±1, and ±5%. Although their standard

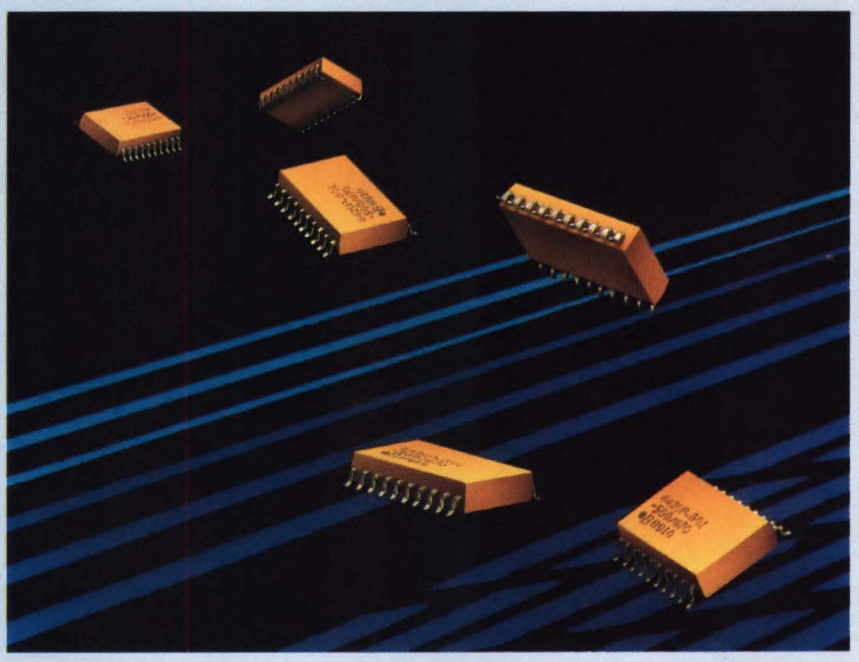
Text continued

RC networks provide reliability in small packages

As size becomes an increasingly important factor in circuit designs, the surface-mount revolution gains impetus. Surface-mount resistor networks play a vital role in this trend because they save considerable pc-board space. Vendors such as Bourns, Dale, and Sprague offer integrated RC networks that meet your high-performance needs and coincide with today's space-saving goals.

The Series 601 networks from Bourns illustrate the capabilities of RC filter networks. These surface-mount networks, which are smaller than comparable inductor-type filters, come in 20-pin, 0.295-in.-wide packages with either gull-wing or J-type leads. Featuring a T-configuration of 16 series resistors and 8 shunt capacitors bused to a common ground, the networks can suppress high-frequency EMI/RFI noise for as many as eight separate power or signal lines. All the networks feature 50Ω resistors combined with 50-, 100-, 200-, or 400-pF capacitors. The resistors have tolerances of ±2%, and the capacitors have tolerances of ±20%. The networks can accommodate 50V and operate over a −55 to +125°C range. Prices for the RC networks start at $0.95 (1000).

Bourns offers two families of ECL terminator networks. The Series 801 units are designed for 10K logic-family applications. Available in either molded or conformally coated SIPs, the 801 RC networks can terminate 6 lines. You can select resistance values that match their transmission-line characteristic impedance values of 50, 68, 75, and 100Ω. Single capacitors are available with values of 39 pF to 0.039 μF and with tolerances of ±20%. Prices for the Series 801 units start at $1.50 (1000).



Available in 20-pin, 0.295-in.-wide packages *with either gull-wing or J-type leads, the Series 601 surface-mount RC filter networks from Bourns terminate as many as eight lines.*

The Series 802 RC terminator networks are designed for 100K logic-family applications. Housed in a 10-pin, conformally coated SIP, these networks can terminate as many as 6 lines. Their resistance values range from 10Ω to 10 MΩ. The two bypass capacitors have values ranging from 100 to 39,000 pF with tolerances of ±20%. The terminator networks have an operating range of −55 to +125°C. Their prices start at $1.60 (1000).

Manufacturers of resistor networks

For more information on resistor networks such as those described in this article, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

Allen Bradley Co
Electronic Components Div
Box 14309
Greensboro, NC 27415
(919) 621-9010
Circle No 602

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North Hollywood, CA 91605
(818) 765-8300
Circle No 603

American Micro-Tronix Inc
85 Flagship Dr
North Andover, MA 01845
(508) 686-1882
Circle No 604

Ametek
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Anaheim, CA 92806
(714) 630-0081
Circle No 605

Augat Alcoswitch
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North Andover, MA 01845
(508) 685-4371
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4141 Palm St
Fullerton, CA 92635
(714) 447-2700
FAX 714-447-2500
Circle No 607

Bourns Inc
Resistive Components Group
1200 Columbia Ave
Riverside, CA 92507
(714) 781-5500
TWX 910-332-1252
Circle No 608

Bradford Electronics Inc
550 High St
Bradford, PA 16701
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FAX 814-362-5635
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Brel International Components
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Sarasota, FL
(813) 355-9791
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TWX 910-332-6108
Circle No 611

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Milpitas, CA 95035
(408) 263-3214
TWX 910-338-2304
Circle No 612

Circuit Technology Inc
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Farmingdale, NY 11735
(516) 293-8686
Circle No 613

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HP/A-1-7
Corning, NY 14831
(607) 974-4102
Circle No 614

CTS Corp
Resistor Network Div
406 Parr Rd
Berne, IN 46711
(219) 589-3111
FAX 219-589-3243
Circle No 615

Dale Electronics
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El Paso, TX 79926
(915) 592-3253
Circle No 616

Doran Manufacturing Co
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Cincinnati, OH 45225
(513) 681-5424
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Warwick, RI 02886
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Cherry Hill, NJ 08034
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Richardson, TX 75081
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Circle No 621

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Olathe, KS 66062
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Circle No 622

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International Components Corp
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FAX 401-683-5571
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Boone, NC 28607
(704) 264-8861
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IRC Inc
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Boone, NC 28607
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MTS Microelectronics Inc
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RCD Components Inc
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Manchester, NH 03103
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FAX 603-669-5455
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Rohm Corp
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Irvine, CA 92718
(714) 855-2131
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Sfernice Inc
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Solitron Devices Inc
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If accuracy and stability are the key requirements of your application, thin-film networks are appropriate.

resistance-ratio tolerances are ±1%, the networks are also available with ±0.1, ±0.2, and ±0.5% tolerances. The PRN Series networks offer absolute TCs of ±25, ±50, and ±100 ppm/°C, and they are available with ratio TCs of ±2, ±5, and ±10 ppm/°C (±10 ppm/°C is standard).

Housed in molded-epoxy packages, the networks operate over −55 to +150°C. At 70°C, their per-resistor power ratings are 100 mW for the isolated-resistor configurations and 50 mW for the bused-resistor designs. The PRN Series networks cost from $0.85 to $1.95 (1000).

If you can't find a resistor network that suits your particular application, you can use a semicustom device. Many network manufacturers will tailor a network's specifications to your needs and let you evaluate a prototype design, without the expense and long lead time typically associated with custom devices.

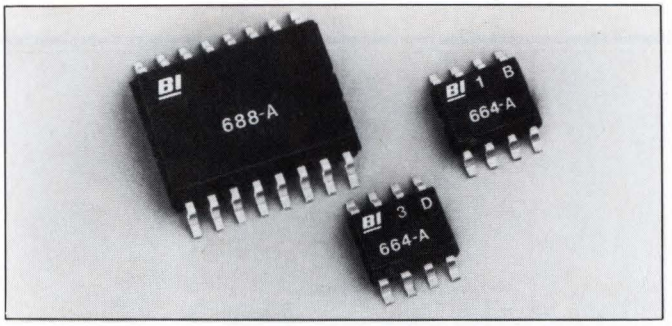
Constructed with Caddock's Tetrinex films, the Type 1794 precision SIP-type networks, for example, give you the flexibility to independently select the network's absolute TC, ratio TC, absolute tolerance, and ratio tolerance. You can select resistance values ranging from 500Ω to as high as 50 MΩ. From 0 to 70°C, their absolute and ratio tolerances are available in seven grades, ranging from ±1 to ±0.025%. Absolute and ratio TC values of 50, 25, and 15 ppm/°C are also available.

The semicustom networks come in 0.1-in.-wide packages. Their heights and pin locations vary, depending on the number of resistors you choose to incorporate in the network. A 9-pin semicustom network that features eight resistors (ranging in value from 1 to 100 kΩ), a ±0.1% tolerance, and a 25-ppm/°C absolute TC costs $1.90 (10,000).

Allen-Bradley also offers an extensive line of semicustom, thin-film networks in a variety of surface-mount packages. They are available in SOIC packages with gull- or J-type leads on either 0.15- or 0.30-in. spacing. Alternatively, you can package the networks in 20- or 28-lead PLCCs (plastic leaded chip carrier). All the networks are available in bused- and isolated-resistor configurations.

Featuring 0.15-in. pin spacing, the Series 150 units are available in 8-, 14-, and 16-lead SOIC packages. The isolated resistors range in value from 1 to 50 kΩ and offer per-resistor power ratings of 25 to 50 μW.

The Series 300 devices are available in 16-, 18- and 20-pin SOIC packages. The resistors range in value from 100Ω to 500 kΩ for the isolated-resistor configurations and from 1 to 200 kΩ for the bused-resistor designs. The resistors' power ratings range from 25 to 75 mW.



Featuring accuracies to 0.1%, *Beckman's thin-film networks include isolated- and bused-resistor configurations in 8-lead, 0.15-in.-wide (Model 664); 16-lead, 0.15-in.-wide (Model 668); and 16-lead, 0.3-in.-wide (Model 688) packages.*

The PLCC-type networks offer resistance values of 0.5 to 50 kΩ and 1 to 200 kΩ for the isolated- and bused-resistor configurations, respectively. Their per-resistor power ratings range from 25 to 75 mW.

The vendor's semicustom networks feature absolute resistance tolerances as low as 0.05% and ratio tolerances as low as 0.015%. Their absolute TCs range from ±10 to ±25 ppm/°C, and their ratio TCs are as low as ±5 ppm/°C. The resistors can accommodate 100V and operate over −55 to +125°C. The packages are compatible with automatic-placement equipment and meet the MIL-R-83401 environmental requirements. The prices of these networks range from $1.50 to $8 (1000).

International Manufacturing Services supplies prototype quantities of semicustom, thick-film networks in less than two weeks. The units feature as many as 30 resistors attached to a ceramic substrate by means of solder-reflow techniques. The devices' resistor values range from 10Ω to 25 MΩ with tolerances of ±1, ±2, or ±5%.

The networks are available in SIPs that feature from two to 12 pins. When mounted, the three available package styles feature heights of 0.195, 0.295, and 0.345 in. At 25°C, each resistor has a 175-mW power rating in free air. The networks are fabricated to customer specifications for a maximum cost of $200. This price includes design procedures, assembly, and approximately 50 parts. EDN

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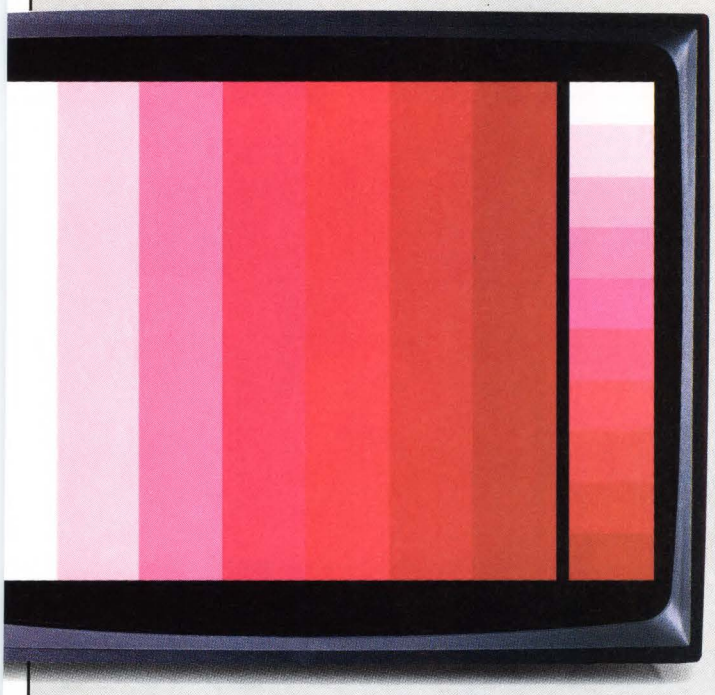

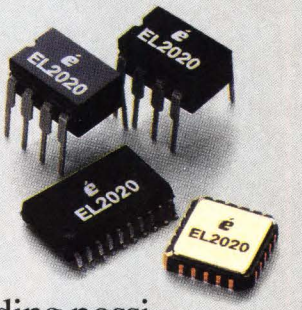

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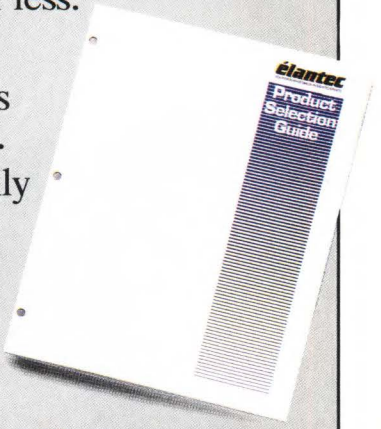

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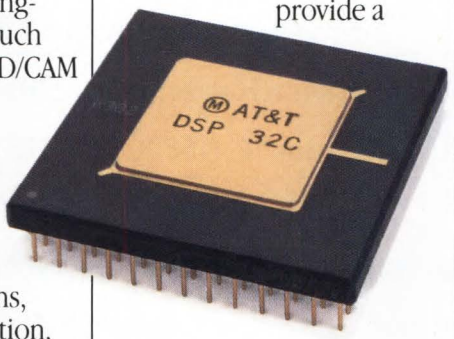

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Image created at R/Greenberg Associates on Pixel Machines' PXM 900 Series graphics workstation, using AT&T's first generation floating point DSPs.

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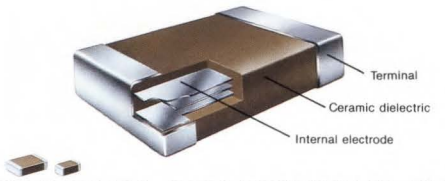
Multilayer Ceramic Chip Capacitor

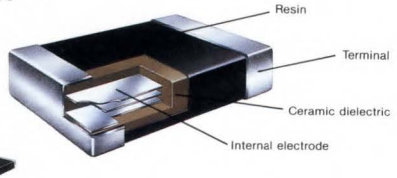
This line of capacitors offers a wide range of capacitances, temperature characteristics, and sizes, with terminals designed for excellent solderability. As a leading manufacturer of ceramic capacitors, TDK remains committed to bringing you the highest possible product reliability and stability at all times.



C1608 (CC0603) C: 0.5 ~ 22,000pF
C2012 (CC0805) C: 0.5 ~ 100,000pF
C3216 (CC1206) C: 0.5 ~ 220,000pF
C3225 (CC1210) C: 750 ~ 470,000pF
C4532 (CC1812) C: 2,400pF ~ 1μF
C5650 (CC2220) C: 5,100pF ~ 1.5μF

Large-Capacitance Multilayer Ceramic Chip Capacitor

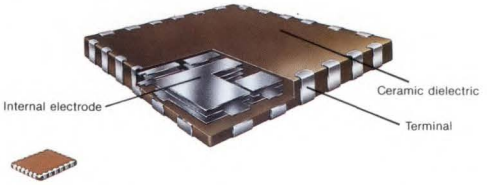
Large-capacitance multilayer ceramic chip capacitor covers the capacitance range normally associated with electrolytics. It features a non-polarized construction and a long life. This large-value capacitor is seeing widespread use in switch-mode power supplies.



HC8050 C: 1 ~ 6.8μF
HC1063 C: 1.5 ~ 10μF
HC1280 C: 2.2 ~ 22μF
HC1612 C: 4.7 ~ 47μF
TC: +20, −30% (−25 ~ 0 +25 ~ +85°C)

Multilayer Ceramic Chip Capacitor Network

Through advanced multilayer and integration processes, TDK can incorporate a network of 12 ceramic capacitors into a single chip, with your choice of capacitances and interconnection topologies. In addition, these networks are made of high-performance insulating materials, allowing other chips to be mounted directly onto the surface. This provides compatibility with the new generation of hybrid chip designs.



MCN7575
TC; C0H, 1 ~ 100pF (12 capacitors) Class II, 100 ~ 470,000pF
; SL, 10 ~ 1,000pF (TC: −1,000, +350ppm/°C) (12 capacitors)

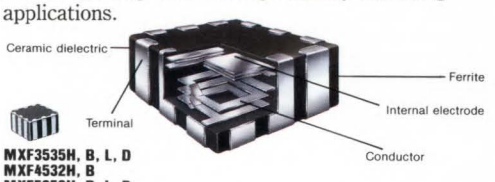
Multilayer Chip Inductor

TDK created the world's first inductor without windings by using alternating layers of ferrite paste and conductive silver paste. The unique properties of TDK ferrite give a monolithic closed magnetic circuit with excellent shielding properties, for suitability in high-density configurations. A whole series of multilayer chip inductors are available, starting with the smallest 2012 series. They measure only 2.0 × 1.25 × 0.6 to 1.25mm (.079 × .049 × .024 to .049 inches).

MLF2010 L: 0.047 ~ 33μH
MLF3216 L: 0.047 ~ 33μH
MLF3225 L: 39 ~ 220μH

Multilayer Chip LC Filter

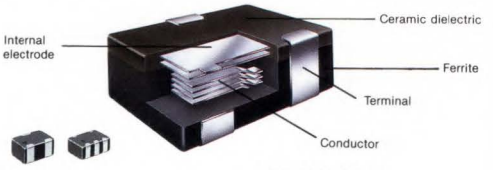
TDK's multilayer technology and simultaneous sintering of magnetic materials and ceramic dielectric materials have created this advanced chip LC filter. An inductor, transformer, and capacitor are layered and integrated into a single monolithic chip measuring only 5 × 5 × 2.8mm (.197 × .197 × .110 inches). This closed magnetic circuit eliminates cross talk and makes this chip ideal for high-density mounting applications.



MXF3535H, B, L, D
MXF4532H, B
MXF5050H, B, L, D
HPF, BPF, LPF, Delay Line

Multilayer Chip LC Trap
Multilayer Chip IF Transformer

This Multilayer Chip LC Trap and Multilayer Chip IFT feature new chip construction obtained by the simultaneous sintering of different materials, such as ferrite and conductive and ceramic dielectric. Both house closed monolithic magnetic circuits which eliminate cross talk. Their compact size is ideal for high density mounting.



MXT4532
MXT5050
F: $f_0 \pm 3\%$
F range: 700kHz ~ 10MHz

MIA4532 F: 455kHz
MIF4532 F: 10.7MHz

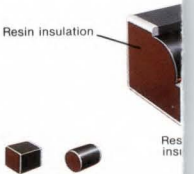
Multilayer Ch

This innovative ch
windings, thanks to
materials, conducti
technology. The tr
monolithic design,

MTT4532 L: 10 ~ 200μH

Micro Chip In

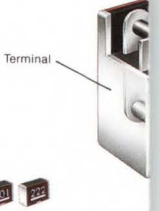
This chip inductor
miniature size with
Its proprietary clos
insures full magne
ideal for high-densit
low DC resistance



ACL3225S
ACL3225R
L: 0.01 ~ 1,000μH

Micro Chip E

This Micro Chip E
combination of ferrit
chip capacitor. Eac
25dB in the 4.5 to
its compact ferrite
excellent magnetic
In addition, becaus
ACF Series, is only
matches IC pin pit
high density
mounting.



ACF453218
Attenuation: 25dB min.
F range: 4.5 ~ 650MHz

TDK TOTAL SURFACE MOUNT TECHNOLOGY

In Surface Mount Technology, It's What's Beneath The Surface That Counts

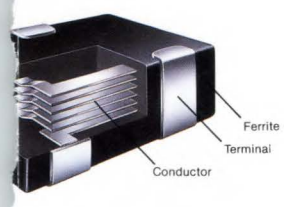
TDK puts you at the leading edge of today's most important surface mount technology developments—from a full range of multilayer SMDs to complete automatic mounting systems. Waiting inside is your introduction to TDK's Total Surface Mount Technology.

TDK®

nd Mounting Systems Apply Leadi

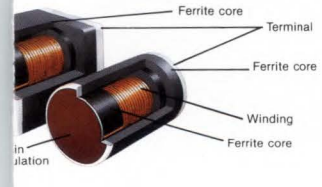
ip Transformer

ip transformer has absolutely no
TDK advancements in magnetic
ve materials, and multilayer
ansformer features a completely
with inherent magnetic shielding.



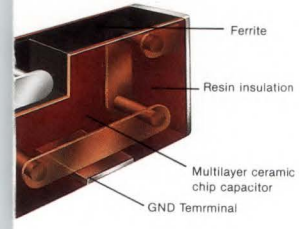
ductor (Wound Micro Chip Inductor)

was developed to combine
high inductance up to 1000μH.
ed magnetic circuit structure
ic shielding, making this chip
mounting applications. It features
and achieves a high Q factor.



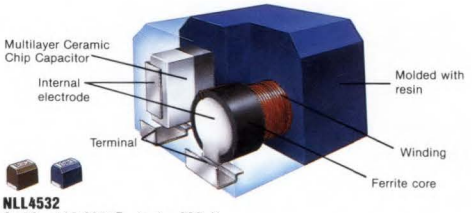
MI Filter

MI Filter, ACF Series, is a
e chip bead and multilayer ceramic
h has an attenuation of over
650MHz frequency range and
construction accounts for its
shielding characteristics.
e the Micro Chip EMI Filter,
1.8mm (.07 inch) thick, it
ch for



Leadless EMI Filter (Wound Chip EMI Filter)

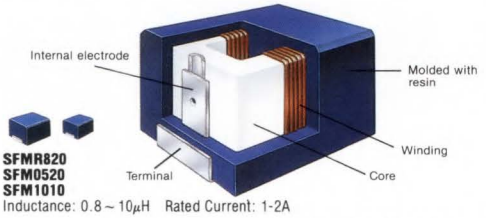
The rendering of the EMI filter into a chip format has been considered essential for the creation of the smallest and lightest electronic products. TDK was one of the first to do it. Our leadless EMI filter is effective against EMI in signal lines, and has been designed for good solderability, thermal resistance, moisture resistance, and mechanical strength.



NLL4532
C: 33 ~ 100,000pF L: 1 ~ 220μH

Leadless Line Choke SF Coil
(Wound Chip Line Choke)

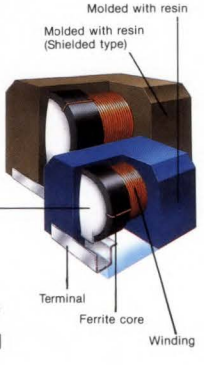
By employing advanced winding technology, TDK has developed magnetic material with excellent absorption of thyristor switching noise. Molded in resin, they are ideal for eliminating EMI in power supply lines for digital circuits.



SFMR820
SFM0520
SFM1010
Inductance: 0.8 ~ 10μH Rated Current: 1-2A

Leadless Inductor/Power-Line Leadless Inductor (Wound Chip Inductor)

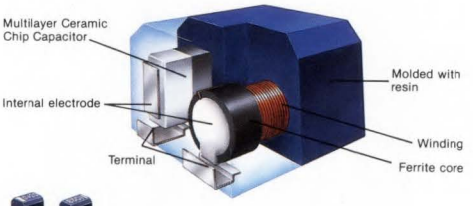
TDK's advanced winding technology together with compact ferrite cores with highly precise performance characteristics are what make TDK Leadless Inductor unique. Power-Line Leadless Inductor is ideal for EMI suppression in power lines with 60 ~ 1800mA current rating. Both feature metal terminals and come molded in resin for maximum reliability.



NL322522 L: 0.01 (450) ~ 220μH (50mA)
NL453232 L: 1.0 (450) ~ 1,000μH (30mA)
NL565050 L: 1,200 (75) ~ 10,000μH (25mA)
NLF453232 L: 1.0 (150) ~ 1,000μH (15mA)
[Shielded Inductor]
NLC322522 L: 1.0 (850) ~ 330μH (60mA)
NLC453232 L: 1.0 (1050) ~ 220μH (120mA)
NLC565050 L: 1.0 (1,800) ~ 1,000μH (85mA)

Leadless LC Trap (Wound Chip LC Trap)

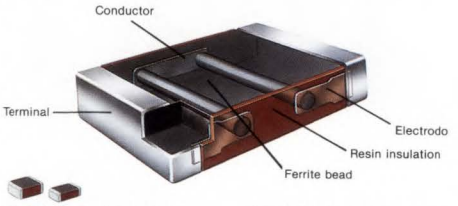
TDK's LC trap is a composite consisting of a miniature coil and a multilayer ceramic chip capacitor. A new proprietary structural design affords highly accurate dimensional control, making this chip well suited for fully automated mounting systems. Metal terminals insure excellent solderability.



NLT4532
F range: 630kHz ~ 13MHz
Tolerance: ±2% Attenuation: 20dB min.

Ferrite Chip EMI Suppressor

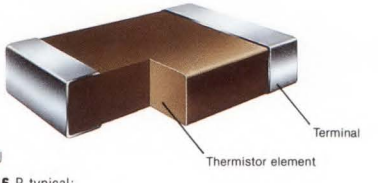
This chip EMI suppressor features proprietary new materials and incorporates the latest advances in chip technology. The device effectively eliminates EMI and prevents parasitic oscillation. A TDK proprietary structural design insures high impedance per volume, and coverage over a wide frequency range.



CB201209 Zo: 7, 10, 11Ω
CB321611 Zo: 19, 26, 31Ω
CB322513 Zo: 31, 52, 60Ω
CB453215 Zo: 70, 120, 125Ω

NTC Chip Thermistor

The Negative Temperature Coefficient chip thermistor is a temperature compensation device. Although in chip form, it has the same basic performance characteristics as conventional lead-type NTC thermistors. The NTC chip thermistor can also be utilized to make a temperature compensation circuit on a PC board. Nominal resistance and temperature characteristic tolerances have been reduced to extremely low levels.



NTC CS3216 R typical:
1.0 ~ 150kΩ at 25°C
Temp. Range: −25 ~ +85°C

You Unsurpassed Technology

With the pressures to make products smaller, thinner and more reliable, you need a versatile SMT partner...that's TDK. Our Total SMT includes the development of new materials, advanced multilayer SMDs, and sophisticated mounting systems. No one else gives you this level of expertise and support.

New Materials Development For A Solid SMD Foundation

The basis for all SMD product development is R&D in new materials and control, on the microscopic level, of individual crystals. TDK is one of the few firms having experience at the atomic level with these ultra-micron structures. Our expertise encompasses magnetic materials, ceramic dielectric materials, resistive materials and conductive materials. Raw materials are also the basis for total quality control—insuring you that quality is designed in from the start and not added on later.

Advanced Multilayer Chip Devices For Performance, Reliability, and Added Value

TDK's advanced techniques in circuit design and multilayer and composite structures have opened the door to functional modules: single SMD chips containing complete circuit blocks. They handle more efficiently than super-miniaturized discrete components, and are ideal for the high density, high value-added circuit engineering of today and tomorrow. TDK has developed proprietary techniques for fine thick film printing, using many layers of magnetic pastes, ceramic dielectric pastes, and conductive pastes. Our multilayering processes create as many as 90 alternating layers in a single structure.

Simultaneous sintering technology of different materials gives us total control over material behavior for highly predictable results. TDK was the first to succeed in simultaneous sintering of ferrite below 1,000°C (1832°F)—a temperature formerly considered impossible—and apply it to multilayer SMDs with silver conductors. With these techniques, TDK overcame problems such as cracking, peeling, and distortion with mutual diffusion between layers—difficulties previously encountered in simultaneous sintering of different materials.

TDK composite multilayer chip components made with this method feature closed magnetic circuits for excellent magnetic shielding. The low flux leakage avoids crosstalk with other components, permitting extremely high mounting densities.

TDK multilayer SMD chips integrate complete circuit modules, greatly reducing the number of parts and solder connections, simplifying handling, and significantly improving reliability. This means you can create more compact designs with fewer parts, and achieve higher reliability and greater added value.

Sophisticated Mounting Systems For Automation Flexibility

There's no company more qualified to develop surface mounting equipment than TDK...a company with unparalleled experience in surface mount technology. Our AVIMOUNT® series is the third part of our Total SMT commitment, providing you with a complete line-up of automatic mounters, satellite computers, and ancillary equipment for mounting chip components and flat package ICs.

Their most outstanding feature is "Sequencing." This fixes the chip supply system with a programmable pick-and-place machine to select the right parts at the right time. In addition, systems using high-resolution vision cameras detect and correct skewed positions, bent leads, planarity, and the fiducial marks on the PC boards, for high mounting speed and precision.

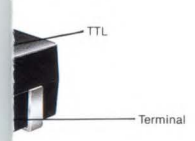
To achieve the greatest automation flexibility, the AVIC-7800EX satellite computer can control a complete, multi-machine, in-line plant.

TDK's commitment to SMT is as integrated as it is comprehensive: from advanced raw materials to revolutionary multilayer components, to complete turnkey mounting systems. For this most important of today's technologies, make TDK your most important partner.

TDK®

Performance.

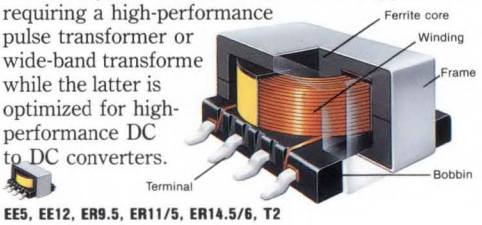
ay Line is of a
e and incorporate
of original TDK
comprised of a chip
chip capactior.
iable compact unit.



ultilayer ceramic chip capacitor

SM Transformer/Inductor

TDK's highly miniaturized transformer/inductor is designed for today's high-density surface mount applications. The component features two distinct cores: one high-permeability ferrite core, and one low-loss ferrite core with high saturation magnetic flux density. The former is well-suited for applications requiring a high-performance pulse transformer or wide-band transforme while the latter is optimized for high-performance DC to DC converters.

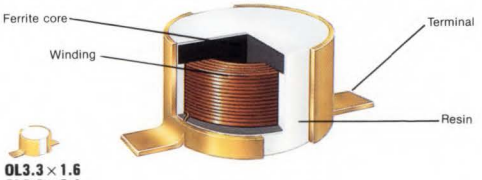


EE5, EE12, ER9.5, ER11/5, ER14.5/6, T2

SM Step-up Inductor

(For Unimorph Piezoelectric Buzzer)

This miniature step-up inductor features high inductance, and works with the unimorph piezo-electric buzzer circuit to produce high sound pressure levels. The inductor is compatible with fully automatic mounting systems.

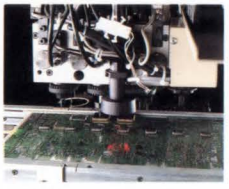


OL3.3 × 1.6
OL3.3 × 2.1

nt CX-4A

CX-4240
IC Mounter with Vision Cameras

a special-purpose mounting
igh mounting precision.
vision cameras detects and
leads and planarity, and
. Any problems are quickly
cision and accuracy. The
Cs, and can accommodate
PLCCs, and LCCs. The
g of three ICs in a single operation, with speeds as
nt.

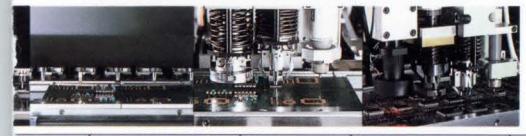


ntable ent types	Speed per component	PC Board dimensions mm (inches)	Unit dimensions mm (inches)
ypes	2.5 sec.	Max. 457L × 356W (17.99L × 14.02W) Min. 90L × 60W (3.54L × 2.36W)	1600L × 1100W × 1650H (62.99L × 43.31W × 64.96H)

nt CX-5

CX-5230NS, CX-5230F, CX-5030D,
CX-5030DD, CX-5030DV/DDV
Automatic Chip Component Mounter

ic mounter is available in three head types —
you the right head for a particular production run.
nodate a large number of different chip components,
nked to one of TDK's core machines, the CX-5 will



ntable nent types	Number of pins	Speed per component	PC Board dimensions mm (inches)	Unit dimensions mm (inches)
types	10	0.65 sec.	Max. 457L × 356W (17.99L × 14.02W) Min. 90L × 60W (3.54L × 2.36W)	1180L × 1160W × 1573H (46.46L × 45.67W × 61.93H)
types	5	1.1 sec.		
types	2	1.2 sec.		
types	2 (with dispenser)	1.2 sec.		
types	2 (with vision camera)	3.3 sec.		

NEW

avimount CX-6

CX-6160
Automatic Chip Component Mounter
An independent flexible manufacturing system, the Avimount CX-6160 has 160 feeder stations which can handle a range of components from micro to odd-shaped chips.

AVIC-7800EX

Satellite Computer System

The AVIC-7800EX satellite computer system can control up to eight AVIMOUNT machines. When you put an AVIC-7800EX in your production line, you get equal load capacities since program instructions are dispensed in a well-balanced manner.

FUNCTIONS
1) DNC communications 2) Achievement and schedule management 3) Sequential manufacturing line management 4) Machine control 5) NC Program management 6) Automatic program generation for respective machines 7) Program compiling and editing for respective machines 8) Communication with the host computer in TDK standard format

ng Edge Technology For Advanced

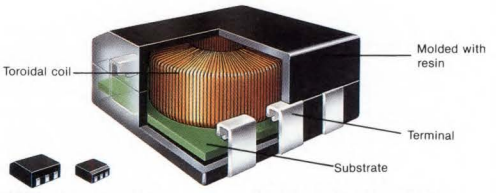
Ceramic Chip Filter • 10.7MHz

Compact TDK 10.7MHz Ceramic Chip Filter for FM tuners is perfect for automatic mounting (6.4×3.3×1.2mm—.25×.13×.05 inch). Its original capsulated metal terminals allow for excellent solderability and prevent silver migration.

CEF1070
F: 10.7±0.03 ~ ±0.12MHz

SM Pulse Transformer

This surface mount pulse transformer achieves miniaturization through advanced winding technology and a small, high performance toroidal ferrite core. Its high level of reliability makes it ideal for signal transmission applications.

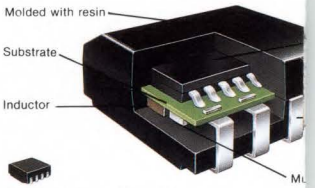


CPT6×6 L: 10 ~ 100μH
Winding ratio N1:N2; 1:1

CPT10×10 L: 100 ~ 1,000μH
Winding ratio N1:N2:N3; 1:1:1

SM Active Delay Line

This Surface Mount Active Del
5 output lumped constant natur
Fast TTL elements. A product
design, each active delay line is
inductor and multilayer ceramic
Together they form a highly rel



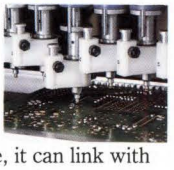
SAD Delay Time: 20 ~ 250nsec.

Systematization - TDK Automated Mounting Technology

avimount RX-4A

RX-4260
Automatic Chip Component Mounter

The AVIMOUNT RX-4260 high-speed mounting system is ideally suited to factory automation requirements. It features a rotary disk head—an industry first. In addition, the RX-4260 has a sequential supply system for easy batch changeover and for communication with the system's host computer. And, since the RX-4260 is a core machine, it can link with other types of machines for increased component mounting capacity. For example, an RX-4260 linked to a CX-5030 mounter can handle up to 90 different types of components.



Model	Component supply	Mountable component types	Speed per component	PC Board dimensions mm (inches)	Unit dimensions mm (inches)
RX-4260	8, 12mm taping	60 types	0.29 sec.	Max. 330L×250W (12.99L×9.84W) Min. 90L×60W (3.54L×2.36W)	2460L×2200W×1548H (96.85L×86.61W×60.94H)

avimoun

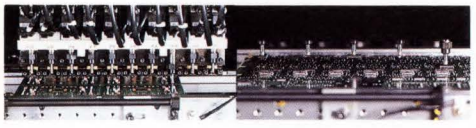
TDK's AVIMOUNT CX-4240 is
system designed for extremely l
A system with two high-resolutio
corrects skewed positions, bent
fiducial marks on the PC boards
corrected, for high levels of pre
CX-4240 handles flat package I
up to 40 types of SOPs, QFPS,
3-pin design enables the mountin
fast as 2.5 seconds per compone

Model	Component supply	Mou compon
CX-4240	16 ~ 56mm taping, stick, tray	40

avimount CX-1

CX-1020, CX-1010
Automatic Chip Component Mounter

The AVIMOUNT CX-1020 is a multi-pin mounter with two 10-pin heads. This allows it to mount up to 20 different chip components in a single operation while providing mounting speeds as fast as 0.32 seconds per component. You can achieve even greater productivity by adding optional equipment to match your production operations precisely.

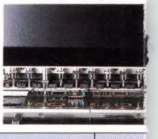


The AVIMOUNT CX-1010 multi-pin mounter features twin 5-pin heads to mount as many as 10 different chip components in a single operation. Its 10-pin specification enables it to accommodate many different component sizes, assuring positive mounting of SOPs, QFPs, PLCCs, LCCs, and other odd-shaped IC components. The CX-1010 can handle a wide range of chip components—whether operating on its own, or linked to RX-4260 or CX-1020 mounters.

Model	Component supply	Mountable component types	Speed per component	PC Board dimensions mm (inches)	Unit dimensions mm (inches)
CX-1020	8, 12mm taping	20 types	0.32 sec.	Max. 300L×250W (12.99L×9.84W) Min. 90L×60W (3.54L×2.36W)	1430L×1210W×1550H (56.30L×47.64W×61.02H)
CX-1010	16 ~ 32mm taping	10 types	0.54 sec.		

avimou

The AVIMOUNT CX-5 automat
2-pin, 5-pin, and 10-pin—to give
Compact and designed to accom
it offers maximum flexibility. Li
upgrade your production line's capabilities.



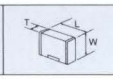
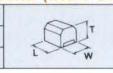
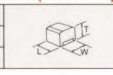
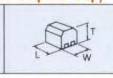
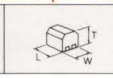
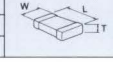
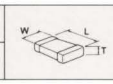
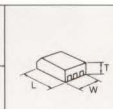
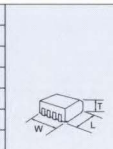
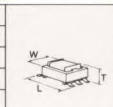
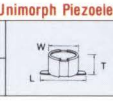
Model	Component supply	Mo compo
CX-5230NS	8, 12mm taping	30
CX-5230F	16 ~ 32mm taping, stick	15
CX-5030D	8 ~ 32mm taping, stick	30
CX-5030DD	8 ~ 32mm taping, stick	30
CX-5030DV/DDV	8 ~ 32mm taping, stick, tray	30

TDK SMDs at a glance

Product name

Type	Shape	Dimensions (mm) [inches] L	W	T
Multilayer Ceramic Chip Capacitor				
C1608 (CC0603)	(EIA Style)	1.6 [.063]	0.8 [.031]	0.9 [.035] max.
C2012 (CC0805)		2.0 [.079]	1.25 [.049]	0.6 [.024]
				0.85 [.033]
				1.25 [.049]
C3216 (CC1206)		3.2 [.126]	1.6 [.063]	0.6 [.024]
				0.85 [.033]
				1.1 [.043]
C3225 (CC1210)		3.2 [.126]	2.5 [.098]	1.9 [.075] max.
C4532 (CC1812)		4.5 [.177]	3.2 [.126]	1.9 [.075] max.
C5650 (CC2220)		5.6 [.220]	5.0 [.197]	1.9 [.075] max.
Large-Capacitance Multilayer Ceramic Chip Capacitor				
HC8050		8.0 [.315]	5.0 [.197]	6.0 [.236]
HC1063		10.0 [.394]	6.3 [.248]	6.0 [.236]
HC1280		12.5 [.492]	8.0 [.315]	6.0 [.236]
HC1612		16.0 [.630]	12.5 [.492]	6.0 [.236]
Mulitlayer Ceramic Chip Capacitor Network				
MCN7575		7.5 [.295]	7.5 [.295]	0.9 [.035]
Multilayer Chip Inductor				
MLF2012		2.0 [.079]	1.25 [.049]	0.85 [.033]
		2.0 [.079]	1.25 [.049]	1.25 [.049]
MLF3216		3.2 [.126]	1.6 [.063]	0.6 [.024]
		3.2 [.126]	1.6 [.063]	1.1 [.043]
MLF3225		3.2 [.126]	2.5 [.098]	1.1 [.043]
		3.2 [.126]	2.5 [.098]	2.5 [.098]
Multilayer Chip LC Filter				
MXF3535L	LPF	3.5 [.138]	3.5 [.138]	2.3 [.091]
		3.5 [.138]	3.5 [.138]	2.8 [.110]
MXF5050L		5.0 [.197]	5.0 [.197]	2.3 [.091]
		5.0 [.197]	5.0 [.197]	2.8 [.110]
MXF3535B	BPF	3.5 [.138]	3.5 [.138]	2.3 [.091]
		3.5 [.138]	3.5 [.138]	2.8 [.110]
MXF5050B		5.0 [.197]	5.0 [.197]	2.3 [.091]
		5.0 [.197]	5.0 [.197]	2.8 [.110]
MXF3535H	HPF	3.5 [.138]	3.5 [.138]	2.3 [.091]
		3.5 [.138]	3.5 [.138]	2.8 [.110]
MXF5050H		5.0 [.197]	5.0 [.197]	2.3 [.091]
MXF3535D	Delay Line	3.5 [.138]	3.5 [.138]	2.3 [.091]
		3.5 [.138]	3.5 [.138]	2.8 [.110]
MXF5050D		5.0 [.197]	5.0 [.197]	2.3 [.091]
		5.0 [.197]	5.0 [.197]	2.8 [.110]
MXF4532B	BPF (FM)	4.5 [.177]	3.2 [.126]	2.2 [.087]
MXF4532H	HPF (TV)	4.5 [.177]	3.2 [.126]	1.6 [.063]
Multilayer Chip LC Trap				
MXT4532		4.5 [.177]	3.2 [.126]	2.2 [.087]
		4.5 [.177]	3.2 [.126]	2.8 [.110]
		4.5 [.177]	3.2 [.126]	3.0 [.118]
MXT5050		5.0 [.197]	5.0 [.197]	2.3 [.091]
Multilayer Chip IF Transformer				
MIA4532 (AM radio)		4.5 [.177]	3.2 [.126]	2.8 [.110]
MIF4532 (FM radio)		4.5 [.177]	3.2 [.126]	2.2 [.087]
Multilayer Chip Transformer				
MTT4532		4.5 [.177]	3.2 [.126]	2.8 [.110] max.
MTT5050		5.0 [.197]	5.0 [.197]	2.3 [.091] max.
Micro Chip Inductor (Wound Micro Chip Inductor)				
ACL3225S		3.2 [.126]	2.5 [.098]	2.5 [.098]
ACL3225R		3.2 [.126]	φ2.5 [.098]	—

Product name

Type	Shape	Dimensions (mm) [inches] L	W	T
Micro Chip EMI Filter				
ACF453218		4.5 [.177]	3.2 [.090]	1.8 [.071]
Leadless Inductor (Wound Chip Inductor)				
NL322522		3.2 [.126]	2.5 [.098]	2.2 [.087]
NL453232		4.5 [.177]	3.2 [.126]	3.2 [.126]
NL565050		5.6 [.220]	5.0 [.197]	5.0 [.197]
NLF453232		4.5 [.177]	3.2 [.126]	3.2 [.126]
Power-Line Leadless Inductor (Wound Chip Inductor)				
NLC322522		3.2 [.126]	2.5 [.098]	2.2 [.087]
NLC453232		4.5 [.177]	3.2 [.126]	3.2 [.126]
NLC565050		5.6 [.220]	5.0 [.197]	5.0 [.197]
Leadless Line Choke SF Coil (Wound Chip Line Choke)				
SFMR820		8.5 [.335]	7.5 [.295]	6.0 [.236]
SFM0520				
SFM1010				
Leadless LC Trap (Wound Chip LC Trap)				
NLT4532		4.5 [.177]	3.2 [.126]	3.2 [.126]
Leadless EMI Filter (Wound Chip EMI Filter)				
NLL4532		4.5 [.177]	3.2 [.126]	3.2 [.126]
Ferrite Chip EMI Suppressor				
CB201209		2.0 [.079]	1.25 [.049]	0.9 [.035]
CB321611		3.2 [.126]	1.6 [.063]	1.1 [.043]
CB322513		3.2 [.126]	2.5 [.098]	1.3 [.051]
CB453215		4.5 [.177]	3.2 [.126]	1.5 [.059]
NTC Chip Thermistor				
NTCCS2012		2.0 [.079]	1.25 [.049]	0.9 [.035] max.
NTCCS3216		3.2 [.126]	1.6 [.063]	1.3 [.051] max.
Ceramic Chip Filter•10.7MHz				
CEF1070MA		6.4 [.252]	3.3 [.130]	1.2 [.047]
CEF1070NA				
CEF1070MS				
SM Pulse Transformer				
CPT6×6		6.9 [.271]	6.5 [.255]	4.6 [.181]
CPT10×10		10.8 [.425]	10.5 [413]	5.2 [.205]
SM Active Delay Line				
SAD020		12.6 [.496]	11.6 [.457]	4.7 [.185]
SAD025				
SAD050				
SAD060				
SAD075				
SAD100				
SAD125				
SAD150				
SAD200				
SAD250				
SM Transformer/Inductor				
EE5		8.2 [.323] max.	6.5 [.256] max.	5.2 [.205] max.
EE12/5/6		14.0 [.551] max.	12.8 [.504] max.	6.5 [.256] max.
ER9.5/5		12.5 [.492] max.	10.7 [.421] max.	5.7 [.224] max.
ER11/5		13.0 [.512] max.	12.0 [.472] max.	6.3 [.248] max.
ER14.5/6		17.2 [.677] max.	15.5 [.610] max.	7.2 [.283] max.
T2		8.0 [.315] max.	5.5 [.217] max.	2.5 [.098] max.
SM Step-up Inductor (Unimorph Piezoelectric Buzzer)				
OL3.3×1.6		5.4 [.213]	3.3 [.130]	1.6 [0.63]
OL3.3×2.1		5.4 [.213]	3.3 [.130]	2.1 [.083]

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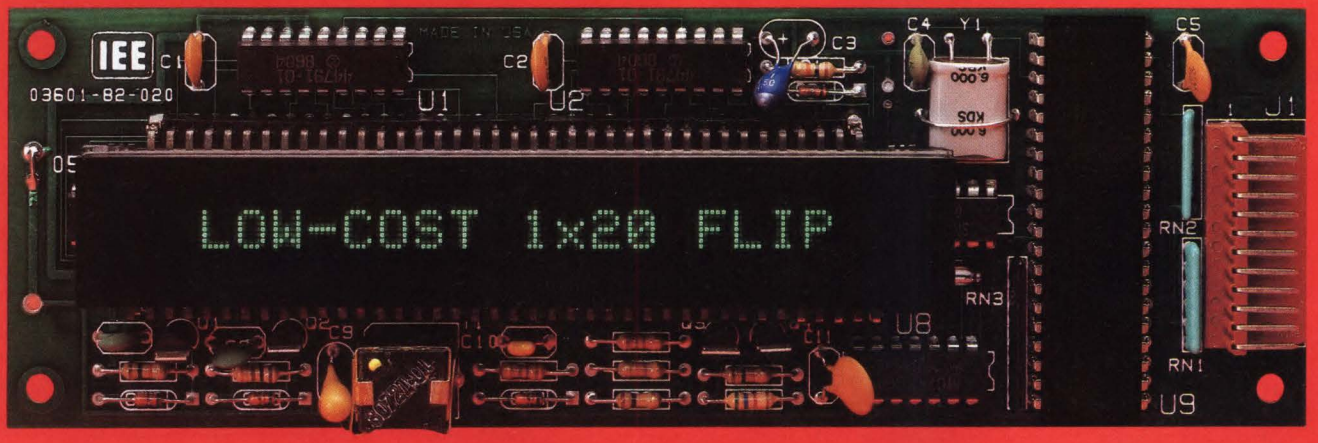

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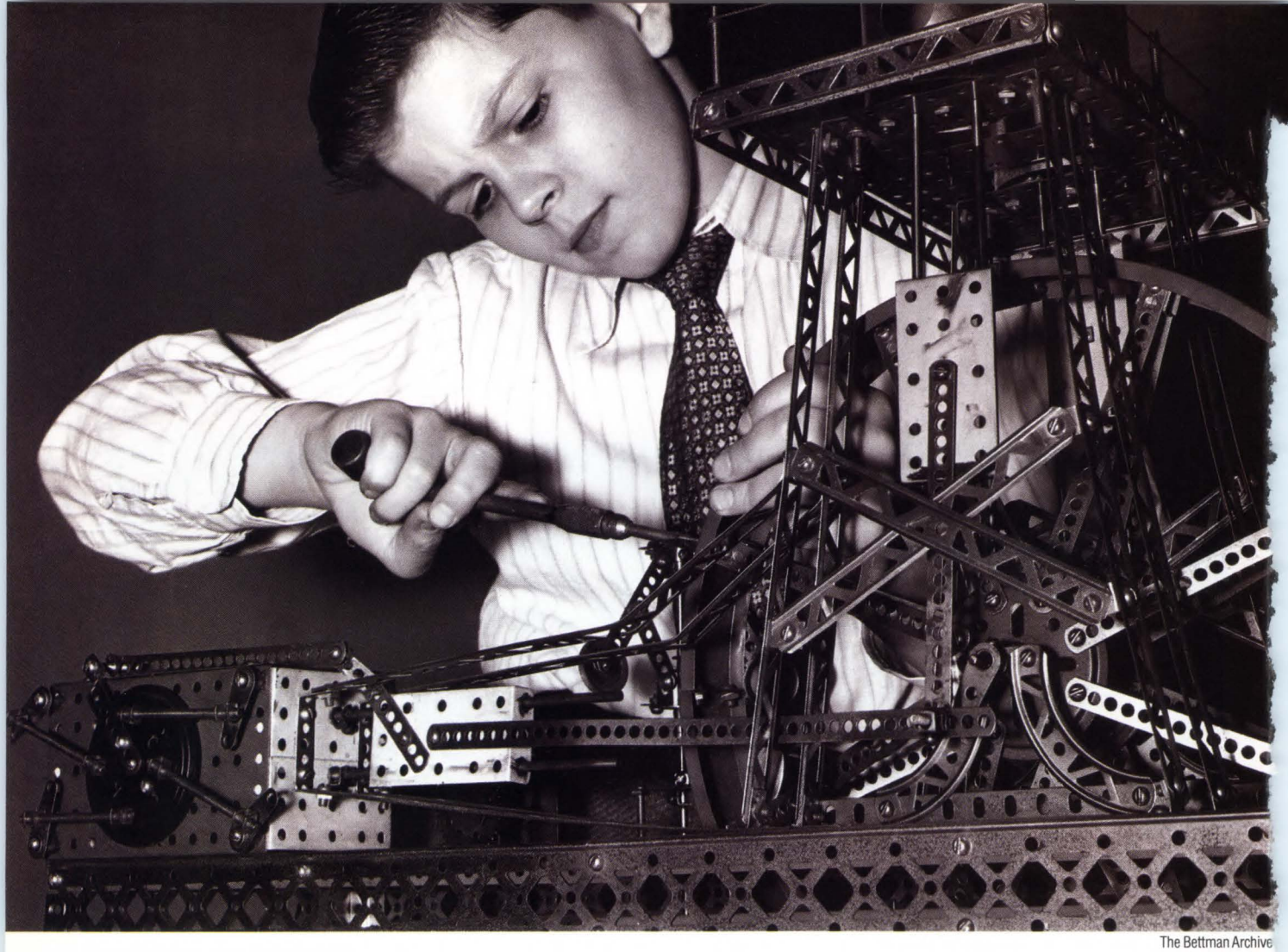

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Simple techniques provide compensation for capacitive loads

With the use of two simple formulas that relate to basic feedback techniques, you can eliminate the guesswork in capacitive load compensation and obtain optimal performance on the first try.

Sergio Franco, *San Francisco State University*

Capacitive loads have a notorious tendency to destabilize negative-feedback circuits because of the pole formed by the load capacitance, C_L, and the output impedance, R_o, of the error amplifier. Because this pole is located within the feedback loop, its phase lag erodes the phase margin of the system, thus leading to potential instability. You can also look at this potential instability from an alternative viewpoint: Because the open-loop gain rolls-off with frequency, the load capacitance is affected by the op amp's closed-loop output impedance, which increases with frequency and behaves inductively. Unless you provide adequate damping, resonance may occur at the circuit's output and excessive peaking and ringing may result.

Fig 1 shows a popular cure for this instability problem. This circuit uses a small series resistance, R_C, to decouple the error-amplifier output from the load capacitance, and a small feedback-capacitance, C_C, to provide a high-frequency bypass from the output back to the input. The phase lead introduced by C_C compensates for the phase lag due to C_L, thus restoring stability. As a rule of thumb, R_C is usually made equal to R_o, and the value of C_C is selected empirically—typically in the range of 10 to 100 pF.

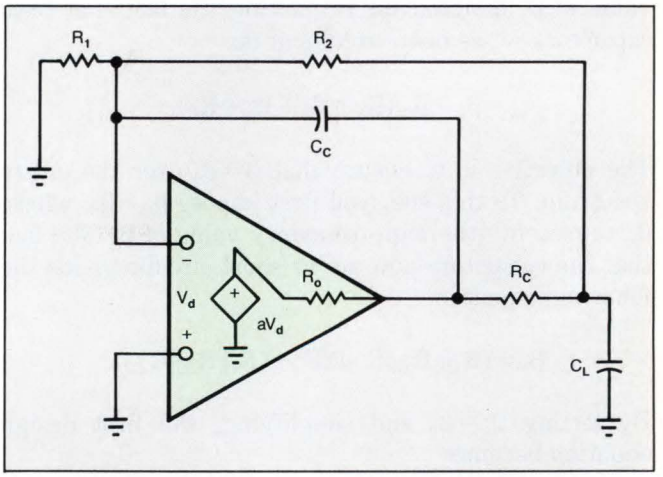

***Fig 1—This capacitively coupled, resistive-feedback circuit** uses compensation network R_CC_C to achieve stability.*

Though usually effective in achieving stability, empirical values do not necessarily guarantee optimum results (**Ref 1**). For a detailed analysis, it is necessary to examine the feedback factor, β, which together with the open-loop gain of the error amplifier plays a key role in the stability of the circuit. Redrawing **Fig 1**'s

The load capacitance is affected by the op amp's closed-loop output impedance, which increases with frequency and behaves inductively.

feedback network yields the equivalent circuit shown in **Fig 2**. Using this circuit, you can find the feedback factor by applying a test voltage, V_x; determining the resulting inverting-input voltage, V_n; and then taking the ratio: $\beta \approx V_n/V_x$.

The equivalent circuit of **Fig 2** is easily recognizable as a bridged-T network of the type frequently used in audio graphic equalizers (**Ref 2**). Its distinguishing features are a flat response at the low and high ends of the frequency spectrum with a midband bump or dip that is dependent on the relative magnitudes of its components. By selecting R_C and C_C so that β is flat over the entire frequency spectrum, you can achieve neutral compensation—a condition where the phase contribution from the feedback network is zero. In other words, as far as the feedback signal is concerned, the feedback network behaves as if it were purely resistive. This behavior is similar to that obtained in the compensation of an oscilloscope probe.

To achieve neutral compensation, start with the dc value of β, denoted β_0. Exploiting the fact that both capacitors act as open circuits at dc:

$$\beta_0 = R_1/(R_1 + R_2 + R_o + R_C).$$

The objective is to ensure that $\beta = \beta_0$ over the entire spectrum. To this end, you first impose $\beta_\infty = \beta_0$, where β_∞ represents the high-frequency value of β. The fact that the capacitors now act as short circuits yields the following equation:

$$\beta_\infty = (R_1 \| R_2 \| R_C)/(R_o + (R_1 \| R_2 \| R_C)).$$

By letting $\beta_\infty = \beta_0$ and simplifying, the first design equation becomes

$$R_C = R_o \cdot R_1/R_2.$$

Next, impose the absence of any midband bumps or dips. With the resistances in fixed ratios, these characteristics are controlled by the capacitances. Let f_L be the frequency at which the reactance of C_L equals the resistance represented by the remainder of the circuit. Assuming negligible loading by C_C, R_1, and R_2:

$$f_L = 1/(2\pi(R_o + R_C)C_L).$$

Likewise, let f_H be the frequency at which the reactance of C_C equals the resistance represented by the remainder of the network. Assuming C_L is essentially a short circuit at this frequency and that $(R_1 \| R_2) \gg (R_o \| R_C)$:

$$f_H = 1/(2\pi(R_1 \| R_2)C_C).$$

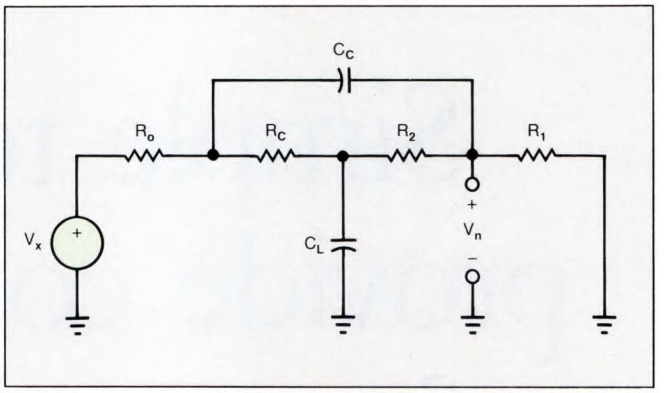

***Fig 2—You can use this equivalent bridged-T test circuit** to determine the feedback factor, β.*

The objective is to position f_H relative to f_L, so that β comes out flat. A laborious analysis, confirmed by SPICE simulation, indicates that flatness is achieved when the ratio f_H/f_L is made equal to the ratio R_o/R_C. Substituting the above expressions for f_H and f_L and using the first design equation yields the second design equation:

$$C_C = (1 + (R_1/R_2))^2 C_L(R_o/R_2).$$

As an example, suppose you configure an op amp having an R_o of 100Ω as a gain-of-ten, noninverting amplifier. Further suppose that $R_1 = 20$ kΩ, $R_2 = 180$ kΩ, and that the amplifier drives a 0.05-μF load. The previous equations indicate that to achieve neutral compensation you must use the following values for R_C and C_C: $R_C = (20/180)100 = 11.1\Omega$ and $C_C = (1 + 20/180)^2(0.1/180)(0.05)(10^{-6}) = 34.29$ pF.

The curves of **Fig 3**, obtained via SPICE, confirm that neutral compensation (curve 1) yields optimum performance. Making C_C smaller than needed (curve 2) yields a magnitude response with a dip and a phase response with a pole-zero characteristic. The resulting closed-loop transient response (**Fig 4**) exhibits undesirable ringing. Conversely, too large a value of C_C (curve 3) yields a magnitude response with a rise and a zero-pole phase, thus unnecessarily slowing down the closed-loop responses. Shown for comparison is curve 4, which corresponds to component values based on the rule-of-thumb method.

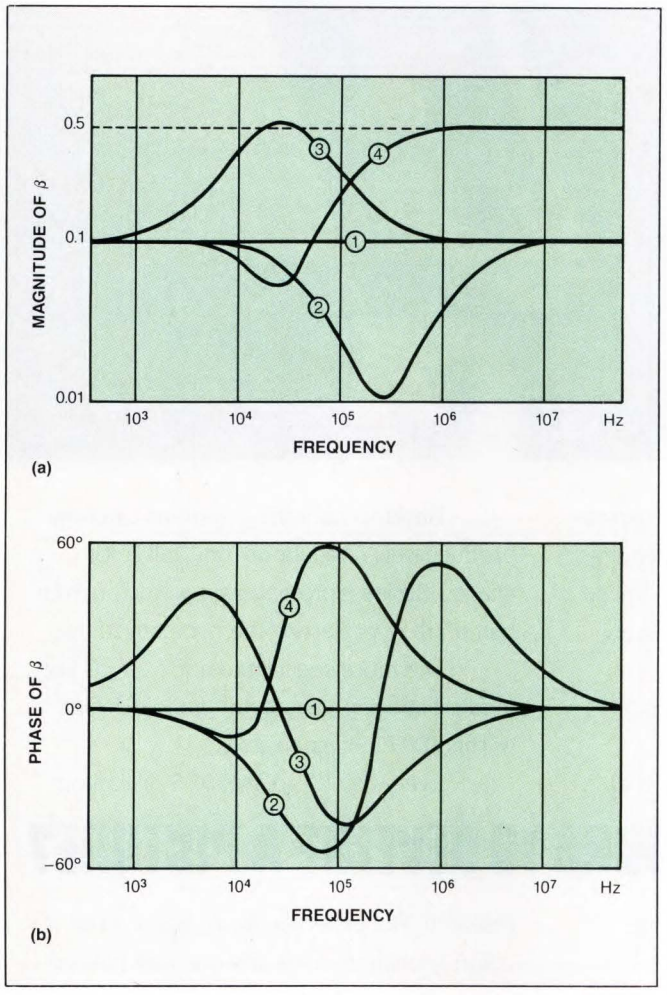

Fig 3—These curves show plots of magnitude (a) and phase (b) *for different values of R_C and C_C. Curve 1: $R_C = 11.1\Omega$, $C_C = 34.3$ pF. Curve 2: $R_C = 11.1\Omega$, $C_C = 3.4$ pF. Curve 3: $R_C = 11.1\Omega$, $C_C = 340$ pF. Curve 4: $R_C = R_o = 100\Omega$, $C_C = 34.3$ pF.*

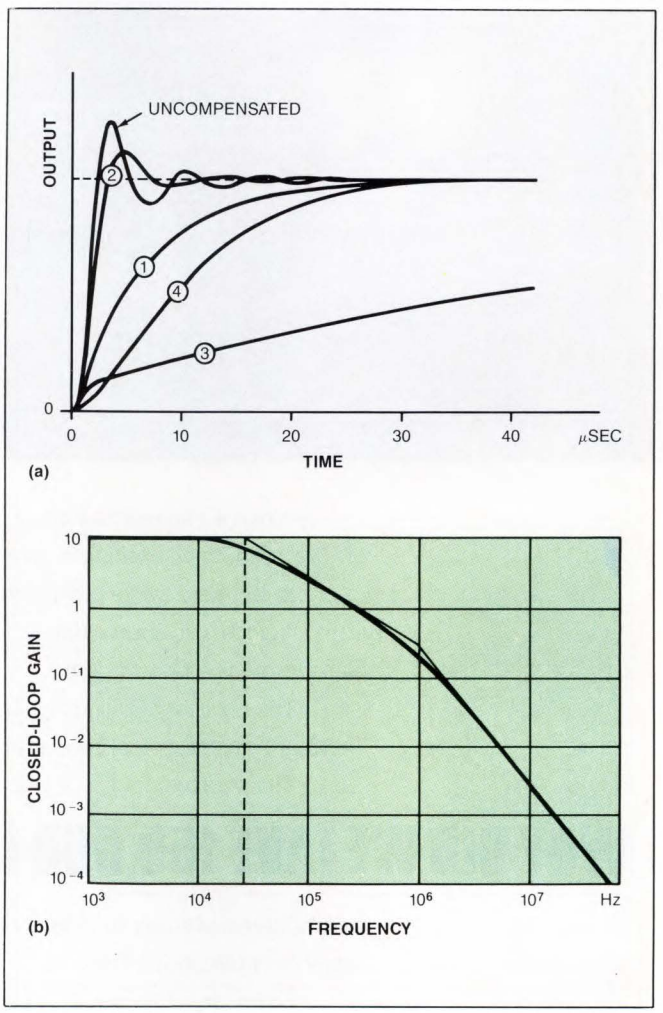

Fig 4—These curves show the closed-loop transient response (a) and frequency response (b) *for the case of a 10-MHz op amp having a constant gain-bandwidth product.*

The pole formed by C_C with R_2 establishes the small-signal bandwidth of **Fig 4**'s closed-loop response. In the example, this pole is located at $1/(2\pi R_2 C_C) = 26$ kHz. The frequency at which the loop gain becomes unity provides an additional pole. This pole is located at (10 MHz)/10 = 1 MHz. Thus, the closed-loop gain rolls off at −20 dB/decade between 26 kHz and 1 MHz and at −40 dB/decade thereafter. EDN

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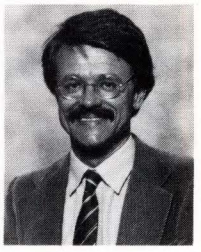
1. Precision Monolithics Inc, *1988 Analog Applications Seminar.*
2. Franco, S, *Design with Operational Amplifiers and Analog Integrated Circuits*, McGraw-Hill, New York, NY, 1988.

Author's biography



Sergio Franco is a professor of electrical engineering at San Francisco State University, where he teaches courses in microelectronics. Sergio, who is also an industry consultant, has a BS in physics from the University of Rome, Italy; an MS in physics from Clark University, Worcester, MA; and a PhD in computer science from the University of Illinois, Urbana, IL. In his free time, he enjoys classical music, gardening, and mountain hiking.

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You can simplify stability analysis of digital-control loops

Standard methods for providing frequency compensation for a μP-controlled feedback system involve complicated conversion calculations. But if you use phasor techniques, you can establish a common ground on which you can combine analog and digital signals without converting at all.

George Ellis, *Kollmorgen Corp*

All feedback-control systems used in high-performance applications require frequency compensation to stabilize the feedback loop. This compensation allows you to modify the system's gain and phase characteristics for specific applications. A number of well-known compensation methods are available, but they assume that the feedback system consists of only analog functions or digital functions. Yet many of today's control systems mix analog and digital functions, making stability computations difficult. By using phasor expressions for complex quantities however, you can treat digital and analog functions on a common ground.

Of course it is possible to use the standard methods (Bode-plot and root-locus techniques, for instance) when a system contains both analog and digital sections—you can approximate the digital functions with analog functions. But these methods create inaccuracies. You can obtain a more precise representation of the transfer functions by using s and z parameters; however, a direct analysis of those parameters usually demands unwieldy conversions between the two domains. A frequency-compensation scheme based on the phasor representation for these parameters eliminates these conversion problems.

Analog and digital control systems differ in their response times to input disturbances. The output of an integrator in an analog system, for example, immediately responds to a step function, whereas a digital integrator only responds to discrete-time samples of the step function. A digital motor controller produces a sample at a given interval, which is defined as the sampling time (T). If a torque disturbance occurs between samples, the digital motor controller cannot react until the next sample. An analog controller, on the other hand, can respond immediately. Consequently, mathematical models for analog controllers use the Laplace transform operator, "s," which is suitable for continuous time analysis, while models for digital controllers use the z-transform operator for the analysis of discrete-time systems (see **box,** "Modeling in the s and z domains").

Before you can provide frequency compensation for a feedback system, you must create a mathematical model of the system. **Fig 1** shows the functional blocks of a digital control system. It consists of four sections: the digital controller; the D/A converter; the plant, which is the analog device to be controlled; and the A/D converter for feedback signals. For analog-motor

Most of today's control systems mix analog and digital functions, creating unwieldy calculations.

control, the plant includes the motor model and the transfer function of the motor-current driver. Because the plant functions are generally nonlinear, you must construct a linearized model of these function in order to analyze the system's stability.

It's hard to prioritize effects

One of the most difficult tasks in constructing a linearized model is deciding which effects to consider and which ones to ignore. Most motor-current drivers control a motor's speed via a pulse-width-modulated (PWM) voltage. The driver compares the feedback current from the motor with an input current command and then produces the corresponding error signal in a current-feedback loop. The amplified error signal determines the percentage of modulation of the motor drive voltage. Even though ripple and noise caused by PWM and variations in the motor-winding resistance and inductance introduce nonlinearities, you can easily model the motor controller with a single-pole low-pass filter. This simplification is possible because the bandwidth of the current-feedback loop is usually less than 10% the frequency response of the current-driver circuitry. The feedback loop essentially smooths out the nonlinearities.

The D/A converter generates the current command from the output of the digital controller. The mathematical model of the digital feedback control system contains a S/H function to account for the phase lag that sampling introduces. You can express the ideal S/H function as:

$$H_{S/H} = \frac{(z-1)}{Tz} \times \frac{1}{s},$$

where T is the sampling interval.

The A/D converter translates an analog voltage from the plant into a digital feedback signal, whose value is then subtracted from the loop's digital input command. A loop error signal results. The dimensions of the D/A converter are in V/bit and the dimensions of the A/D converter are in bits/V, so these quantities dimensionally cancel each other out when you calculate the loop gain.

Because you can express all the digital and analog sections of the control system as functions in either the s or z domain, you can also use phasors to express them. A phasor represents the gain (or attenuation) and phase shift of a function at a particular frequency. To calculate the combined phasor of two cascaded functions, you simply multiply the gains and add the phase shifts of the individual stages. The phasor technique lets you calculate the combined phasor of an s-domain function and a z-domain function in cascade without converting from one domain to the other.

The feedback system shown in **Fig 1** has an open-loop transfer function of:

$$G(s,z) = G_1(z) \times G_2 \times G_3(s,z) \times G_4(s) \times G_S.$$

You can express its closed-loop transfer function as:

$$G_C(s,z) = \frac{G(s,z)}{1 + G(s,z)}.$$

To ensure loop stability, the phasor for the open-loop transfer function must exhibit a phase shift of less than 180° at unity gain. The difference between the phase lag of the open loop and 180° at unity gain is

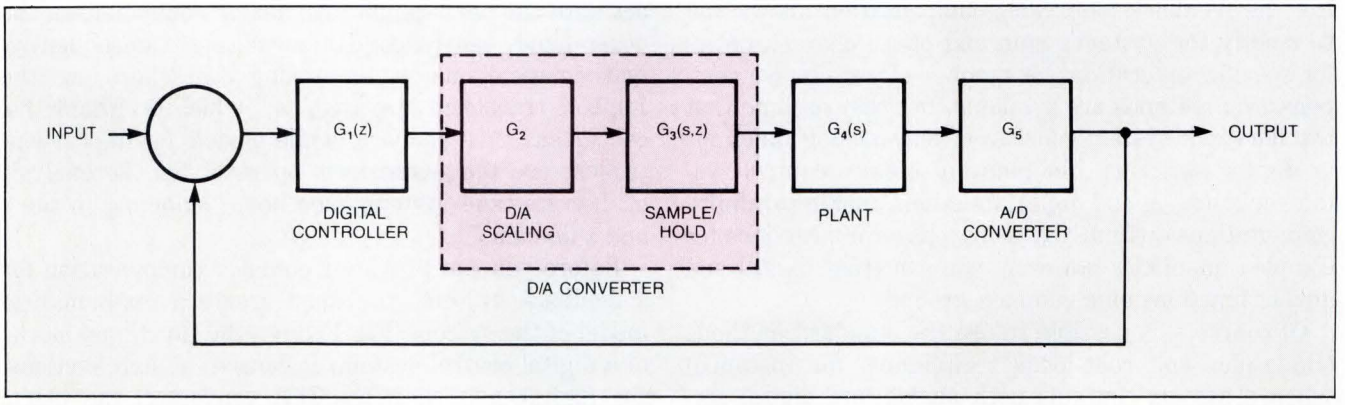

Fig 1—A typical digital feedback control system *consists of digital controller; a D/A converter; a plant, which contains the analog sections; and an A/D converter.*

called the phase margin (PM). The step-response of the feedback loop exhibits more overshoot and ringing as the phase margin decreases. If the phase margin is too large however, the loop reacts sluggishly. A phase margin between 30° and 60° is generally desirable. Frequency compensation lets you achieve a phase margin within that range.

The frequency at which the open loop has unity gain is known as the crossover frequency. The crossover frequency also provides a rule of thumb for determining

Modeling in the s and z domains

You can best construct mathematical models for analog and digital functions by using the s and z domains, respectively. The s parameters are well suited to models in continuous time, but they don't represent discrete-time functions adequately. The z parameters can handle the effects of time sampling and therefore are good for modeling digital controllers. In the z domain, z is defined as:

$$z = e^{sT},$$

where s is the Laplace operator, and T is the sample time of the controller.

Table A lists the transforms for a few functions calculated in the s and z domains.

You can use phasors to represent the steady-state response of a system for a particular input frequency. Essentially, a phasor is the polar-coordinate representation of a complex number. For example, if a transfer function has an input disturbance of 1V at a specific frequency, and its output is 0.7V with a 45° lag, the phasor for the transfer function would be $0.7 \lfloor -45°$. What's unique about phasors is that they are applicable to transfer functions in both the s and z domains.

To illustrate the use of phasors in both domains, consider the integrator function. In the s domain, the integrator function is 1/s. Evaluating the phasor for this function at a frequency of 10 Hz yields:

$$\frac{1}{s} = \frac{1}{j \times 2\pi f} = \frac{-j}{2\pi \times 10}$$
$$= 0.01592 \lfloor -90°.$$

The phasor represention for z is:

$$z = e^{j2\pi fT} = 1 \lfloor 57.3 \times 2\pi fT°$$
$$= 1 \lfloor 360 \times f \times T°.$$

The transfer function for an integrator in the z domain is $H(z) = Tz/(z-1)$. In order to evaluate its phasor, you must specify a sampling interval (T).

If, for example, you use a sampling frequency of 1 kHz, you obtain a timing interval of 0.001 sec. Therefore, for an input frequency of 10Hz, $z = 1 \lfloor 360° \times 10 \times 0.001° = 1 \lfloor 3.6°$. The phasor for the integrator is:

$$H_z = \frac{Tz}{z-1} = \frac{0.001 \times 1 \lfloor 3.6°}{1 \lfloor 3.6° - 1}$$
$$= \frac{0.001 \lfloor 3.6°}{0.06262 \lfloor 91.8°}$$
$$= 0.01592 \lfloor -88.2°.$$

Note that the phasor response for the integrator in the z domain differs from that of the s domain by 1.8°. This discrepancy becomes more pronounced when the input frequency approaches the sampling frequency.

TABLE A—TRANSFER FUNCTIONS IN s AND z

	s	z
INTEGRATOR	$\frac{1}{s}$	$\frac{Tz}{z-1}$
DIFFERENTIATOR	s	$\frac{z-1}{Tz}$
SUM	—	$\frac{z}{z-1}$
BACKWARD DIFFERENCE	—	$\frac{z-1}{z}$
REAL POLE	$\frac{2\pi f}{s+2\pi f}$	$\frac{z(1-e^{-T2\pi f})}{z-e^{-T2\pi f}}$
SAMPLE/HOLD	—	$\frac{1}{s} \times \frac{z-1}{Tz}$

NOTE:
f = FILTER CORNER FREQUENCY.

Analog and digital control systems exhibit different response times for input disturbances.

the 3-dB bandwidth for the closed-loop frequency response. The crossover frequency is approximately 125% of the closed-loop bandwidth when the loop has an adequate phase margin.

Establish a compensation procedure

Once you understand how to evaluate the phase margin by using phasors at the crossover frequency, you can establish a frequency-compensation procedure in four steps:

- **Step 1:** Select the desired closed-loop bandwidth (f_B). Use the rule of thumb to establish the crossover frequency (f_C) at $1.25 \times f_B$.
- **Step 2:** Evaluate the phasors for all of the fixed sections of the feedback loop at f_C. The fixed sections are the blocks without variable parameters for frequency compensation.
- **Step 3:** Calculate the combined phasors for the fixed sections by adding the individual phase shifts and multiplying the individual gains.
- **Step 4:** Adjust the frequency-compensation parameters so that the open-loop gain has unity gain at the crossover frequency, and the phase margin is suitable.

To illustrate the compensation procedure, consider the digital control of a motor inside a velocity loop. **Fig 2** depicts a mathematical model of a brushless servomotor operating in such a loop. The first step in the compensation procedure requires that you specify a closed-loop bandwidth. Typically, a high-performance servomotor requires a loop bandwidth of 40 Hz. Using this value, you set the crossover frequency at $f_C 1.25 \times 40\ \text{Hz} = 50\ \text{Hz}$.

In Step 2, you evaluate the phasors for each of the fixed sections at the crossover frequency. In order to calculate the z parameters, you must first establish the sampling interval, which is usually the μP. For this step, assume that the maximum sampling time is 0.00125 sec. Therefore,

$$s = 2\pi \times 50 \angle 90° = 314.2 \angle 90°$$

and

$$z = 1 \angle 360° \times 50 \times 0.00125° = 1 \angle 22.5°$$

(see **box,** "Modeling in the s and z domains").

Now you can start to calculate the phasors, beginning with the D/A converter, which contains a D/A scaling block and a S/H block. In this case, the feedback loop uses a 12-bit D/A converter to generate the current command. Because the converter provides a full-scale output voltage of 8V, its gain is 8/4096, or 0.001953 V/bit. The phasor for the D/A scaling block (G_2) is therefore $0.001953 \angle 0°$.

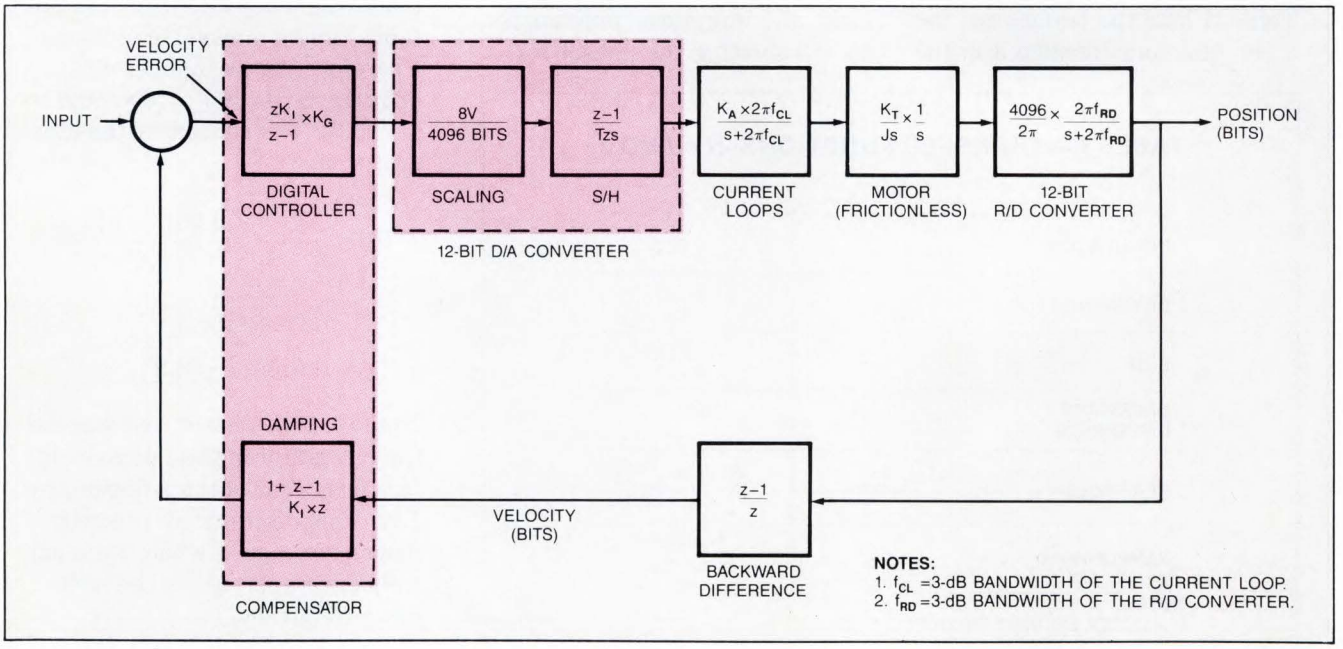

Fig 2—A high-performance digital feedback loop, such as a velocity loop *for a brushless servomotor, requires frequency compensation. The loop shown uses an integral-differential (ID) compensation scheme.*

The S/H block is a mathematical construct placed within the the D/A-converter block to account for the phase lag that the sampling process creates. Using the values for s and z at the crossover frequency, you can calculate that the phasor for the S/H block ($G_{s,z}$) is $(z\text{-}1)/(Tzs) = 0.9934 \angle -11.2°$.

The current loop is a model of the motor's current driver. Even with a 3-phase brushless servomotor, you can model the current loop as a low-pass filter because all 3 current drivers are identical, and they don't function concurrently. The gain (K_A) is the dc gain of the current loop measured in A/V. This design produces 70A (rms) of current drive when supplied with an 8V signal. If you set the 3-dB bandwidth of the current loop at 1000 Hz, the phasor for the current-loop block is:

$$\frac{70}{8} \times \frac{2\pi \times 1000}{s + 2\pi \times 1000} = 8.739 \angle -2.862°.$$

Motor block is frictionless

The model for the brushless servomotor assumes that the motor is frictionless. Because friction adds a damping term to the motor's transfer function, the assumption of no friction is the worst-case condition for stability analysis. Using a motor with a torque constant (K_T) of 0.3 ft-lb/A (rms) and a moment of inertia (J) of 0.0011 ft-lb-sec^2, you can calculate the phasor of the motor as $K_T/(J \times s^2) = 0.002763 \angle -180°$.

Next, calculate the phasor for the R/D block. A 12-bit R/D converter provides a feedback signal by converting the analog angular position of the motor to its digital equivalent. You calculate the dc gain of the converter as $4096/2\pi$ bits/rad. The bandwidth of the R/D converter is represented in the model by a single-pole low-pass filter with a 3-dB corner frequency of 800 Hz. The phasor representation for the R/D converter block is

$$\frac{4096}{2\pi} \times \frac{2\pi \times 800}{s + (2\pi \times 800)} = 650.6 \angle -3.576°.$$

Because the output of the R/D converter represents the motor-shaft position, the feedback loop must contain a block that converts angular position into angular velocity in order to create a velocity loop. The backward difference block performs this function by acting as a digital tachometer. The phasor for the backward difference block is $(z\text{-}1)/z = 0.3902 \angle 78.75°$.

TABLE 1—PHASOR TERMS FOR THE FIXED SECTIONS

BLOCK	GAIN	PHASE
D/A CONVERTER	0.001953	0.0°
SAMPLE/HOLD	0.9934	−11.2°
CURRENT LOOP	8.739	−2.9°
MOTOR	0.002763	−180.0°
FEEDBACK	650.6	−3.5°
DIFFERENCE	0.3902	78.7°
TOTAL FIXED	0.01189	−118.9°

In Step 3 of the compensation procedure, you calculate the combined phasors for the fixed sections. **Table 1** lists the gains and phase angles for the phasors of the individual fixed sections. The combined phasor is $0.01189 \angle -118.9°$.

The final step in the procedure involves adjusting the parameters available in the compensator block to obtain the desired phase margin. The compensator block uses an integral-differential (ID) compensation scheme. The digital controller block integrates the velocity error to provide a high dc gain, which establishes a small steady-state error signal. In addition, the compensator block contains a damping block that differentiates the velocity feedback signal. You can set the phase margin to the desired value by simply adjusting the K_I term in the damping block.

A phase margin of 40° is a good target to aim for. To obtain it, you have to adjust the gain and phase of the compensator block so that the loop phasor equals $1 \angle 140°$. A phasor of $84.1 \angle -21.1°$ for the compensator block produces the desired phase margin since:

$$0.01189 \angle -118.9° \times 84.1 \angle -21.1° = 1 \angle -140°.$$

The cascaded transfer function for the digital controller and the damping block is:

$$G_{COMP}(z) = \left(\frac{K_I \times z}{z - 1} + 1\right) \times K_G.$$

Because only K_I affects the phase angle of the compensator phasor (the phase angle is independent of K_G), you should adjust the value of K_I to achieve a phase angle of −21.1°. In that $z/(z\text{-}1) = 2.563 \angle -78.72°$ at the crossover frequency, the compensator transfer function is

$$G_{COMP}(z_C) = (K_I \times 2.563 \angle -78.72° \times 1) \times K_G,$$

where z_C is the value of z at the crossover frequency ($1 \angle 22.5°$). The compensator's phase term equals the inverse tangent of the imaginary part divided by the real part of $G_{COMP}(1 \angle 22.5°)$:

$$\text{REAL}[G_{COMP}(z_C)] = [K_I \times 2.563 \times \cos(-78.72°) + 1] \times K_G,$$

$$\text{IMAG}[G_{COMP}(z_C)] = [K_I \times 2.563 \times \sin(-78.72°)] \times K_G,$$

$$\text{PHASE}[G_{COMP}(z_C)] = \frac{K_I \times 2.563 \times \sin(-78.72°)}{K_I \times 2.563 \times \cos(-78.72°) + 1}$$

$$= 21.1°.$$

After calculating the trigonometry, you arrive at a value of 0.1654 for K_I that yields:

$$G_{COMP}(z_C) = K_G \times 1.160 \angle -21.1°.$$

Now you can set K_G to 72.5 to achieve the desired compensator gain of 84.1.

Phasor represention for the transfer functions eliminates the tedium involved in transferring between the s and z domains. Using this frequency compensation method, you can work easily with both analog and digital transfer functions. You can set the loop's gain, bandwidth, and phase margin, and analyze the loop's stability without domain conversions. In essence, it's a real time-saver. EDN

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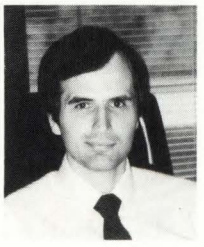
Author's biography



George Ellis is a design engineer for the Industrial Drives Div of Kollmorgen Corp in Radford, VA. He has been with Kollmorgen for 4 years; his duties include designing servomotor controllers. He holds a BSEE and MSEE degree from Virginia Tech and is a member of the Industrial Drives Committee for the IEEE Industrial Automation Society. In his spare time, George enjoys working with wood.

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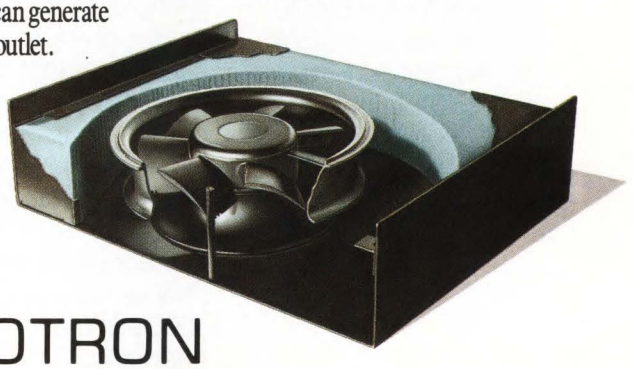

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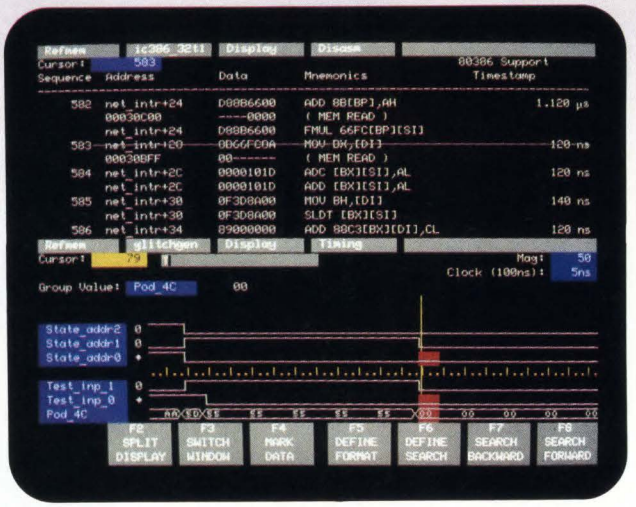

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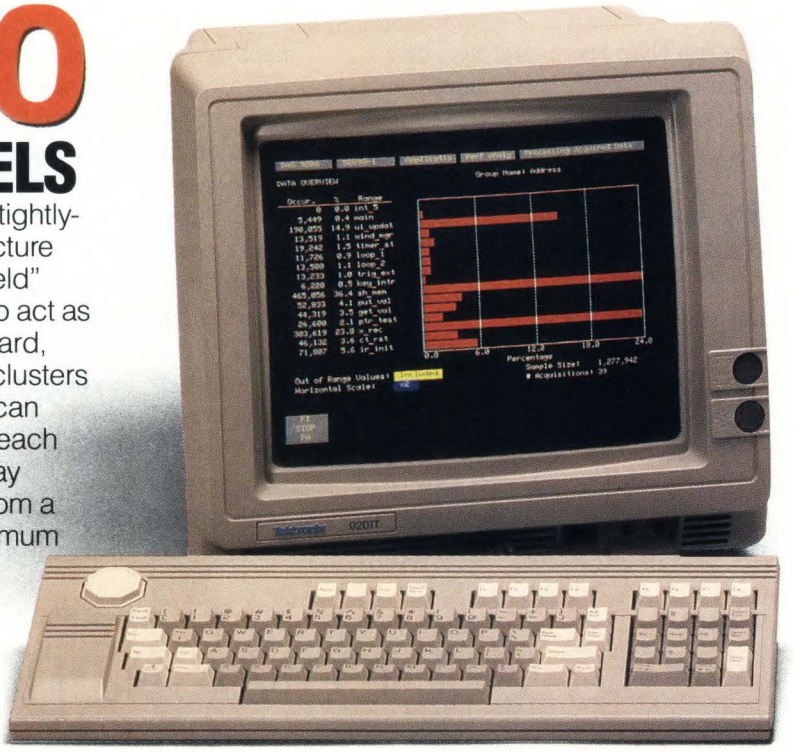

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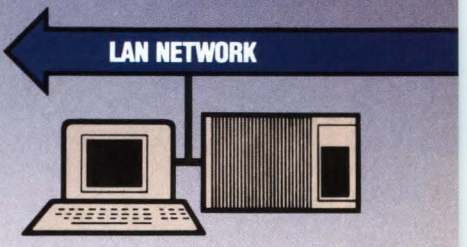

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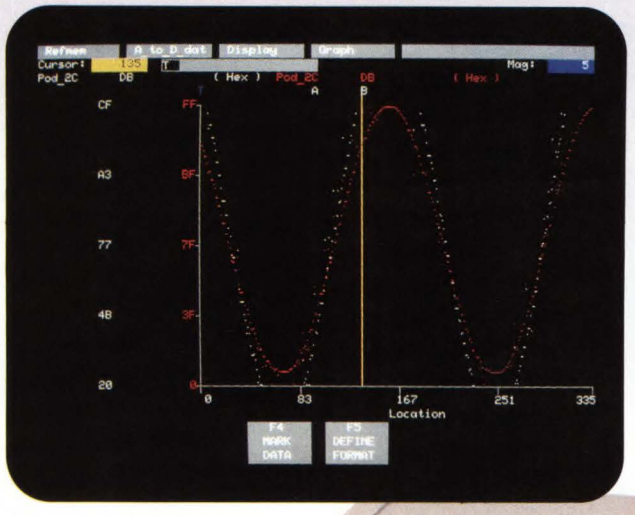

(Above) A/D data captured and displayed using Graph Format.
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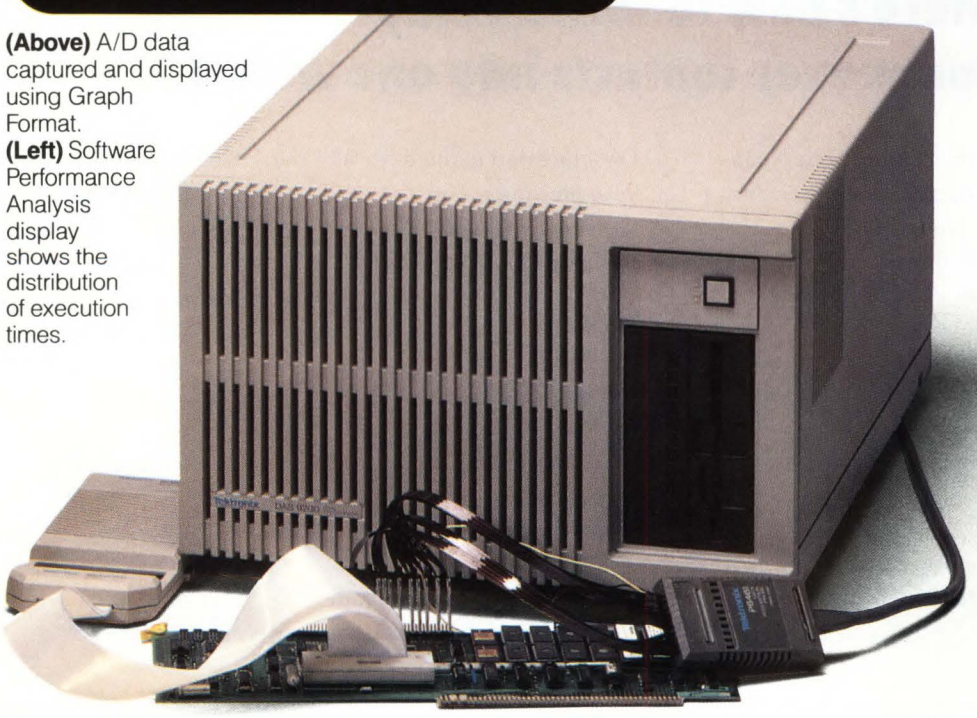

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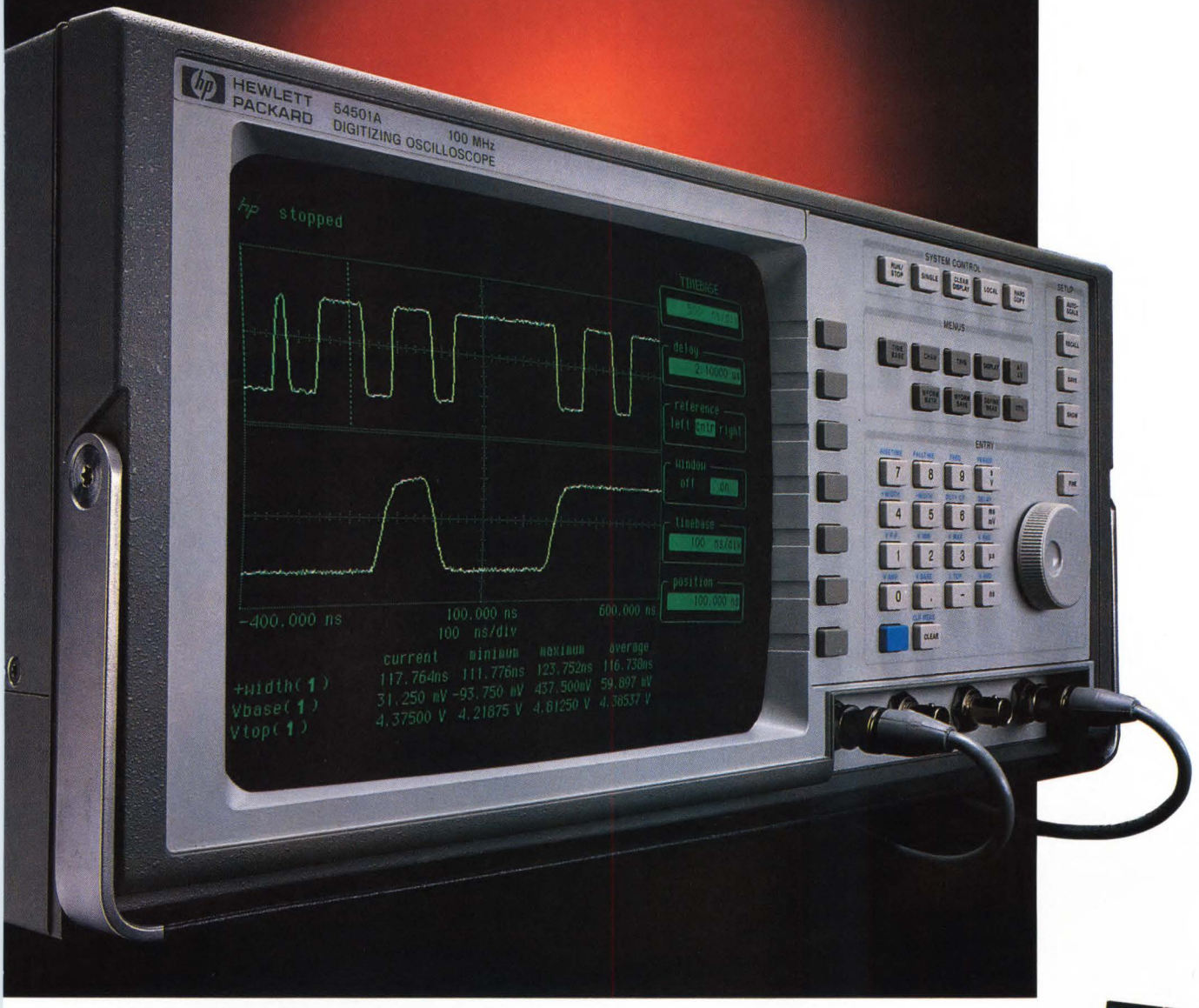

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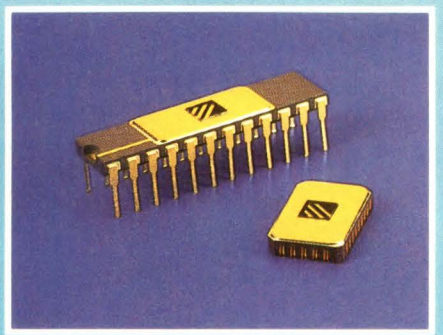

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Part 2

Tailor your code for limited memory space

When optimizing your μP/μC code, you can choose to favor either execution speed or code size, but not both. This article, part 2 of a 2-part series, offers techniques for reducing code size so that you can fit your programs into limited memory space. Part 1 discussed techniques for obtaining maximum execution speed from your code.

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For applications in which it's vital to make the best use of available memory, you'll want to optimize your code for size—even at the cost of some reduction in execution speed. Code size is usually most critical for programs that will reside in ROM. To optimize such code for size, you can use the instructions that have the fewest bytes, eliminate unnecessary branches, and use other byte-squeezing techniques instead of adhering to more conventional (and maintainable) structured-programming principles. These techniques will help you squeeze your code into a limited memory space.

Before you do anything else, you should familiarize yourself with all the details of the target processor's instruction set by obtaining the processor manufacturer's reference card. The card shows the complete instruction set, the number of execution cycles, and the number of bytes for each instruction. It's helpful to use a highlighter to mark the instructions that have the fewest bytes.

Use loops and subroutines to avoid repeating direct in-line code segments. If you want to initialize a block of memory, for example, use a loop. A loop uses far fewer bytes than the faster in-line code.

Subroutines provide a good way both to reduce code size and to maintain structured coding techniques. By scanning the program, you may be able to identify code segments that are so frequently used or have so many similarities that you can reduce them to a single subroutine. Remember, however, that the space you can save is a function of both the length of the subroutine (including the Return instruction) and the number of subroutine calls (each of which adds several bytes).

For example, if your Call instruction is 3 bytes long, you'd save space by converting a 12-byte macro, used twice, to a subroutine. The two macro expansions would occupy 24 bytes—the subroutine would occupy $(2\times3)=6$ bytes for the Call instructions, 12 bytes for the code, and 1 byte for the Return, for a total of $6+12+1=19$ bytes. If the macro expansion were only 4 bytes long, you'd save no space by converting it to a subroutine unless there were at least 20 calls to it (80 (that is, 4×20) vs $(3\times20)+4+1=65$), and you'd lose a lot of execution speed. Don't forget, too, that extensive nesting of subroutines may require additional stack space that will eat up part of what you save by eliminating in-line code.

Two other things to keep in mind when optimizing

You can exit from a subroutine by branching to the nearest Return instruction; this technique may allow you to use shorter branch insructions.

code inside subroutines are summarized by these axioms:

- All return-from-subroutine opcodes are created equal.
- All good subroutines start in the middle.

The first axiom means that you may be able to use shorter branch instructions by branching to the nearest RTS instruction rather than to the RTS that formally terminates the subroutine. For example, if an exit condition is detected at the beginning of a large subroutine, you could specify a short branch to the RTS of the preceding subroutine instead of making a long branch to the RTS at the end of the large subroutine. Some μPs (such as the Intel 8051 and 8085, Zilog Z80, and Hitachi HD64180) do even better—they provide conditional Return instructions as well as conditional branches. If your target μP has conditional Returns, you should use them to save time and space.

The second axiom means that you should examine all subroutines to see whether they would be more efficient if the entry point were in the middle. For example, a conditional branch instruction will branch to a location before the entry point, allowing you to eliminate an unconditional branch instruction. In fact, you should closely examine all unconditional branch instructions to see if you can eliminate any of them by rewriting the code. Such instructions do no work other than to control execution flow.

Null subroutines make compact delay loops

Sometimes you need to waste time in a program; for instance, if the system is not interrupt-driven, you may have to allow time for hardware responses, or for people to read messages on a CRT terminal. The usual method of wasting time is to introduce a loop that provides the required delay. For such loops, the optimum method is to include an instruction that does nothing and uses the smallest number of bytes and the largest number of execution cycles possible. The Multiply instruction meets the last two criteria, but fails to meet the first, so it's rarely used in wait loops. "No Operation" instructions (NOPs) are usually used in delay loops, because they meet the first and second criteria and are therefore an easy, safe choice. This method isn't the best, however, because to introduce delays of any magnitude, you'll need to use many NOPs inside the loop, or a large-count variable, or both. Both actions will increase the code size.

A more intelligent choice is to use a "Jump to Subroutine" (JSR) instruction that transfers control to a null subroutine—that is, a subroutine consisting solely of a Return from Subroutine (RTS) instruction. You can use any nearby RTS instruction for this purpose, following the principle that all return-from-subroutine opcodes (RTS) are created equal. In this case, the subroutine-linkage overhead is working for you instead of against you. For example, an MC6809 JSR instruction with extended addressing occupies 3 bytes and uses eight cycles. When you add the five cycles used by the RTS (the 1 byte comes free, because the RTS was already required for an existing subroutine), you find that the JSR instruction behaves like a 3-byte instruction that uses 13 cycles!

Optimizing code flow is another method of reducing code size. One approach is to rearrange the code to use smaller-size opcodes (conditional branches, calls to subroutines, and operand addressing modes, etc). You

LISTING 1A—BEFORE CASCADING SUBROUTINES

```
0100            JSR     SUBR3
0110            JSR     SUBR2
0120            JSR     SUBR1
0130            <code>

0200            JSR     SUBR3
0210            JSR     SUBR2
0220            JSR     SUBR1
0230            <code>


0300            JSR     SUBR3
0310            JSR     SUBR2
0320            JSR     SUBR1
0330            <code>


1000  SUBR1     EQU     *
1010            <code>

1090            RTS


2000  SUBR2     EQU     *
2010            <code>

2099            RTS


3000  SUBR3     EQU     *
3010            <code>

3099            RTS
```

may be able to save bytes by replacing extended- or absolute-addressing mode instructions with indexed addressing; however, you should make sure that the bytes saved by using shorter instructions aren't eaten up by the extra bytes needed to load the index register.

Another compaction technique is to look for repeating sequences of multiple subroutine calls immediately adjacent to each other. If you find such instances, you may be able to arrange for one or more subroutines to "cascade" into one another; that is, you remove the RTS instructions so that one subroutine falls into the next. This technique not only saves the RTS instructions, but also saves each of the subroutine-call instructions after the first one.

Listing 1a shows an example of cascading subroutines. Because there are multiple occasions when the same three subroutines are called sequentially (lines 100 through 120, 200 through 220, and 300 through 320), you can cascade these subroutines. That is, you can arrange them sequentially and remove the first two RTS instructions.

Listing 1b shows the rewritten code. Note that the calls to SUBR2 and SUBR1 have been removed (lines 110 through 120, 210 through 220, and 310 through 320) and that the three subroutines have been relocated, in calling order, to be contiguous (lines 1000 through 1290). The only remaining RTS instruction is the one for SUBR1 (line 1290), so calling SUBR3 is equivalent to calling all three subroutines. Because other code uses SUBR1 and SUBR2, these entry points must be preserved. But be careful: Before cascading subroutines in this manner, you should make sure that no other code needs to use SUBR3 alone, without also calling the other two subroutines.

LISTING 1B—AFTER CASCADING SUBROUTINES

```
0100            JSR     SUBR3
0230            <code>

0200            JSR     SUBR3
0230            <code>

0300            JSR     SUBR3
0330            <code>

1000  SUBR3     EQU     *
1010            <code>

1090  * Fall into SUBR2 to exit!

1100  SUBR2     EQU     *
1100            <code>

1190  * Fall into SUBR1 to exit!

1200  SUBR1     EQU     *
1210            <code>

1290            RTS
```

Try to eliminate redundant operations

A more obvious byte-reduction method is to eliminate all unnecessary instructions. Consider the M68000-family code shown in **Listing 2**. You'll see that the real function of line 100 is to clear the upper byte of the word value that is stored in line 140 (though, in fact, line 100 clears the lower byte as well). Once you recognize that function, you can change line 130 to an ANDI.W instruction, because it, too, clears the upper byte of the word and uses no more bytes or execution cycles than the ANDI.B. This change makes line 100 redundant, and you can eliminate it.

When the system must display a variety of text messages, and memory space is at a premium, you can save a few bytes by specifying the end-of-text (EOT) character as any byte that has the sign bit set (a negative value). Because half of the opcodes for any microprocessor will have the sign bit set, you can avoid using a separate EOT character by carefully placing the text message in front of a code segment (preferably a subroutine) that starts with a negative opcode. Of course,

LISTING 2—ELIMINATION OF UNNECESSARY CODE (M68000 FAMILY CODE)

```
0100          MOVEQ   #0,D0          ; Preclear D0.
0110          MOVE.B  BANKREG,D0     ; Read Bd. version
0120          LSR     #4,D0          ;  and right justify.
0130          ANDI.B  #$07,D0        ; Mask to LS 3 bits.
0140          MOVE.W  D0,HW_VERS     ; Save Bd. vers. (WORD).
```

LISTING 3—SKIP MACROS (MC6809 CODE)

```
0100  *  Macros to Skip Byte(s)
0110  *    SKIP1= TST instr. opcode ($0D) for "direct"
0120  *             mode addressing
0130  *    SKIP2= TST instr. opcode ($7D) for "extended"
0140  *             mode addressing
0150  *
0160  *   NOTE:  Destroys the N, Z, and V-bits of the
0170  *          condition code register (CC)!
0180  *
0190  SKIP1  MACRO
0200         FCB     $0D
0210         ENDM
0220  SKIP2  MACRO
0230         FCB     $7D
0240         ENDM


0300  SUBR1A LDB     #1
0310         SKIP1
0320  SUBR1B CLRB            ; CLRB = $5F
0330         STB     COUNT   ; Set up count= 1 or 0.


0400  SUBR2A LDA     #4
0410         SKIP2
0420  SUBR2B LDA     #8      ; LDA #8 = $86 $08
0430         STA     FLAG    ; Set up flag= 4 or 8.
```

to prevent problems when modifications are needed later or when the code is ported to another μP, you must carefully document this procedure with explicit comments.

Another code-size-reduction technique is to use a nondestructive instruction (such as TST) instead of a branch to skip over a 1- or 2-byte instruction. The TST (Test for Zero) instruction obtains a register or memory address from the one or two bytes following the opcode, and tests to see whether the contents of the location are zero. The TST instruction is considered nondestructive because it alters only the condition-code register.

Listing 3 shows an example of this "SKIP" technique for MC6809 code. Lines 100 through 180 are comments describing the SKIP1 macro (defined in lines 190 through 210) and the SKIP2 macro (defined in lines 220 through 240. Lines 300 through 330 and 400 through 430 are code segments showing how you might use the macros. Subroutine SUBR1 sets a byte value in the variable COUNT to 1 or 0, depending on which entry point you call. Likewise, SUBR2 sets a byte value in FLAG to 4 or 8, depending on which entry point you call.

If you call SUBR1A, you load 1 into the B register; an unconditional branch to line 330 that stores this value would require at least 2 bytes; instead, the SKIP1 macro inserts a TST instruction with direct-mode addressing, which interprets the 1-byte CLRB instruction in line 320 as the address to be tested. Executing the TST changes nothing except the flags in the condition register; the CLRB instruction is effectively skipped, and the next instruction executed is the STB in line 330, which sets COUNT to 1. If, on the other hand, you call SUBR1B, you execute the CLRB instruction, and the STB instruction sets COUNT to 0.

The code in lines 400 through 430 operates in almost the same way, except that the SKIP2 macro inserts a TST instruction with extended-mode addressing that effectively skips over the 2-byte LDA #8 instruction in line 420. In either case, you save 1 byte by using TST instead of BRA—not much, perhaps, but there'll be times when saving 1 byte can save your whole project.

Sometimes you can use the condition-code (status) register in unorthodox ways to reduce code size. One such method is to set up the condition-code (CC) register bits as temporary flags. For example, if you set the carry (C) bit as a flag, it can be preserved through several subsequent instructions (as long you choose them carefully so they don't affect the C bit). Then you can test the state of the C bit and act according to the state of the flag.

A second method is to select two CC register bits as flags and then use one of the conditional branch instructions to act on both flags at the same time. For example, the MC6800 "branch on lower or same" instruction (BLS) branches if the carry (C) bit or the zero (Z) bit is set. If the C bit and the Z bit are used as flags, then the BLS instruction could be used to determine whether the flags represented by the C bit or the Z bit are set. Once again, you must meticulously document any use of this method to prevent maintenance programmers from introducing errors at some later date.

LISTING 4—REGISTER LIMITATIONS (MC6800 CODE)

```
0100            LDX     #TO             ; Set X= dest. addr.
0110            LDB     #SIZE           ; Set B= # bytes to move.
0120            STS     SP_TEMP         ; Save stack pointer.
0130            LDS     #FROM-1         ; Set SP= source addr. -1.

0140   LOOP     PULA                    ; Get source data byte
0150            STA     0,X             ; and move to destination.
0160            INX                     ; Adv. dest. addr.
0170            DECB                    ; Count 1 more byte moved.
0180            BGT     LOOP            ; Continue 'til all are moved.

0190            LDS     #$FFFF+0-0      ; Restore SP.
0200   SP_TMP   EQU     *-2             ;   ***** INSTR. MODIFY ****
```

If you need to set or clear one of the CC register bits, examine the μP reference card carefully to see whether you really need a separate instruction to initialize the bit. If you examine the μP reference card carefully, you may find that you can set or clear the bit as a side effect of some other instruction that is needed anyway. For example, in addition to the dedicated C-bit opcodes (CLC, SEC), the MC6800 has other opcodes that clear (CLR, TST) and set (COM) the C bit. To reset the C bit, you could use a TST instruction instead of an LDA instruction, thus avoiding the need for a separate CLC instruction. Other instructions alter the C bit according to operand values. If the operand values can be guaranteed, the effect on the C bit will be known. For example, if you were to use the ADDA opcode, and could guarantee that the operands would be in the 0-$3F range, the C bit would always be reset at the end of the instruction.

Unassigned opcodes are dangerous

A word of caution regarding the use of "secret" instructions contained in unassigned opcodes: *don't*. Unassigned opcodes are those hex values for which the manufacturer has not designated an instruction—they are "holes" in the opcode map. Articles have been published that purport to reveal the secret instructions represented by the unassigned opcodes of various μPs. The truth of the matter is that the unassigned opcodes form the logical "don't care" states of the processor, and the manufacturer is free to change them without notice. If you are rash enough to use them in your code, your program may function correctly for years and then suddenly develop a bug when it's executed on a new batch of chips. So no matter how tempting unassigned opcodes may appear, don't use them. They will cause grief later.

Sometimes you must be inventive in order to overcome register restrictions in the target μP. For example, consider the MC6800 code shown in **Listing 4**, which copies SIZE number of bytes starting at location FROM, to the destination location TO. Because the MC6800 has only one 16-bit index register (X), this routine uses the stack pointer (SP) register as a second index register. This technique is feasible only if interrupts are disabled or if you've explicitly allocated sufficient free RAM immediately below the FROM address to allow proper stacking to occur during interrupts.

Lines 100 through 130 set up the registers for the copy loop composed of lines 140 through 180. Note that the code must execute in RAM, because instruction modification is used to restore the stack pointer in line 190. Line 130 makes the stack pointer point to the bottom (the lowest address) of the source block, which is now treated as though it were the stack. Line 140 increments the stack pointer to the next location, pulls the source byte from the new stack-pointer address, and loads it into the A accumulator. Using the stack pointer as a second index register saves many bytes, because it avoids loading and saving of the two index register values through the X register; what's more, the code executes more rapidly. Remember that the SP is set to the front of the FROM block (towards location 0), so interrupt stacking can still occur without destroying the data. This scheme obviously will not work if the FROM data is in ROM, but you could rewrite the code to push the data via the SP into RAM after reading it from ROM via the index register.

A seldom-used (but very effective) code-reduction technique is to take advantage of unused (don't-care) address bits; you can do this during the assembly of MC68008 code. Because the MC68008 MPU has only 20 (or 21) address bits, you can set the unused upper address bits, thus forcing the assembler to generate absolute short addressing modes when the most significant real address bits through A15 are also set. For example, changing CSBASE EQU $FFE00 to CSBASE EQU $FFFFFE00 will cause the assembler to generate a sign-extended 16-bit value ($FFE00) instead of an absolute 32-bit value ($000FFE00); thus, you'll save two bytes at each reference to CSBASE.

The techniques presented here will help you to compress your program into a limited memory space such as a PROM. But these techniques, sometimes called "byte squeezing," have some undesirable side effects. First and foremost, as you'll have seen from the examples, nearly all byte-squeezing procedures fall into the

category of "tricky coding." They work against structured-coding principles, and unless you are very careful, you can end up with spaghetti code. Because compaction techniques make the code difficult to read and understand, you must meticulously document each instance of your compaction procedures, not only in the form of lavish and explicit comments in the source code itself, but also in any reference manuals that describe the system. If you fail to provide these explanations, maintenance of your software will be impossible.

Byte squeezing can also be very time consuming, and time, as the proverb goes, is money. As each successive byte is squeezed out, it becomes harder and harder (that is, more time consuming and expensive) to squeeze out the next byte. Maintenance costs are higher for byte-squeezed programs, especially when you need to add code that exceeds the available unused space. Finally, no matter how well the comments are written, unless the same programmer who wrote the code is doing the maintenance, it's very difficult to learn the code well enough to be able to make corrections or enhancements without introducing other bugs or side effects. EDN

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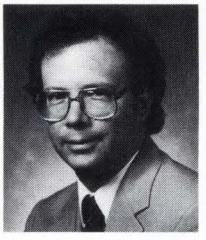

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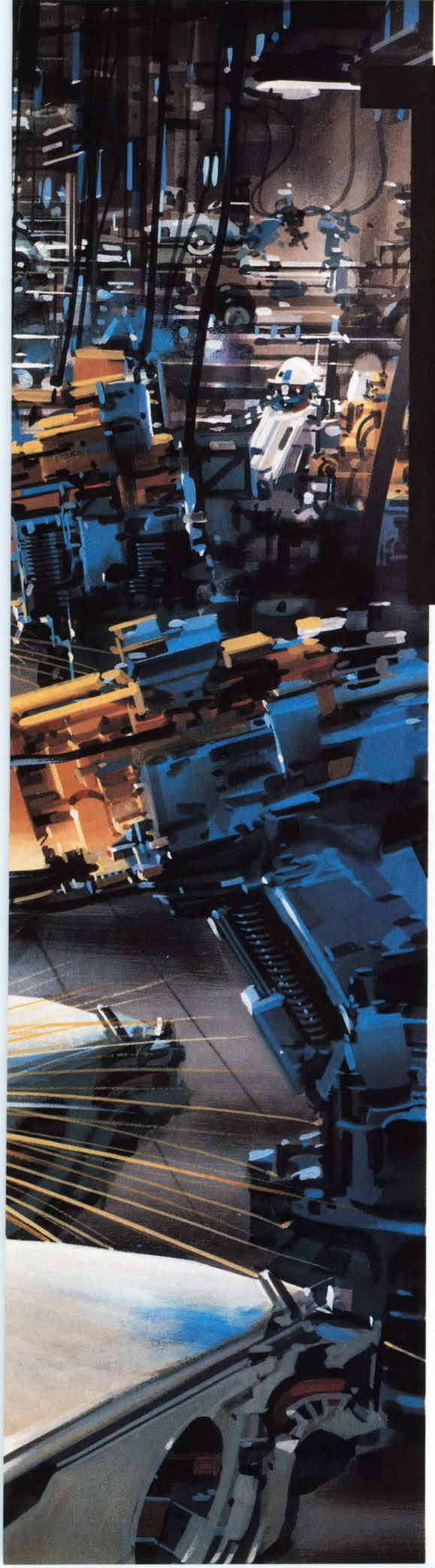

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EDN μP Support-Chip Directory

Support chips develop intelligence

Besides exhibiting a trend toward higher integration and better performance than their predecessors offered, the chips in this, EDN's twelfth annual μP Support-Chip Directory, also incorporate more intelligence. By making fewer demands on the CPU, these smart support chips can give you better system performance.

Michael C Markowitz,
Associate Editor

Microprocessor support chips are still around, and—prognostications about the rate of integration to the contrary—you'll probably have to use more than one of them in your μP-based designs. However, you may be in for a surprise when you start evaluating the choices available for your application. The support chips are getting smarter.

The incorporation of more intelligence in μP support chips is being driven largely by the vibrant IBM PC and compatibles market—end-users are continually demanding machines that perform more tasks more quickly. System performance hasn't reaped full advantage of these systems' higher clock speeds, because the host CPUs have had to perform too many of the peripheral tasks.

Lighten the CPU load

In an effort to alleviate the bottleneck created when a number of support chips need the processor to give them operating instructions, manufacturers are now producing support chips that are themselves programmable. These chips free the main processor to exercise faster control over the whole system. An appropriate analogy might be that of the large corporation whose decision-making power is centralized at corporate headquarters, and whose smaller, faster-to-respond rivals are beating it in the marketplace. A more efficient way for the large corporation to operate would be to decentralize its decision making by granting some decision-making power to each of its smaller subsidiaries. So it is with CPUs: They operate more efficiently by delegating important tasks to intelligent support chips.

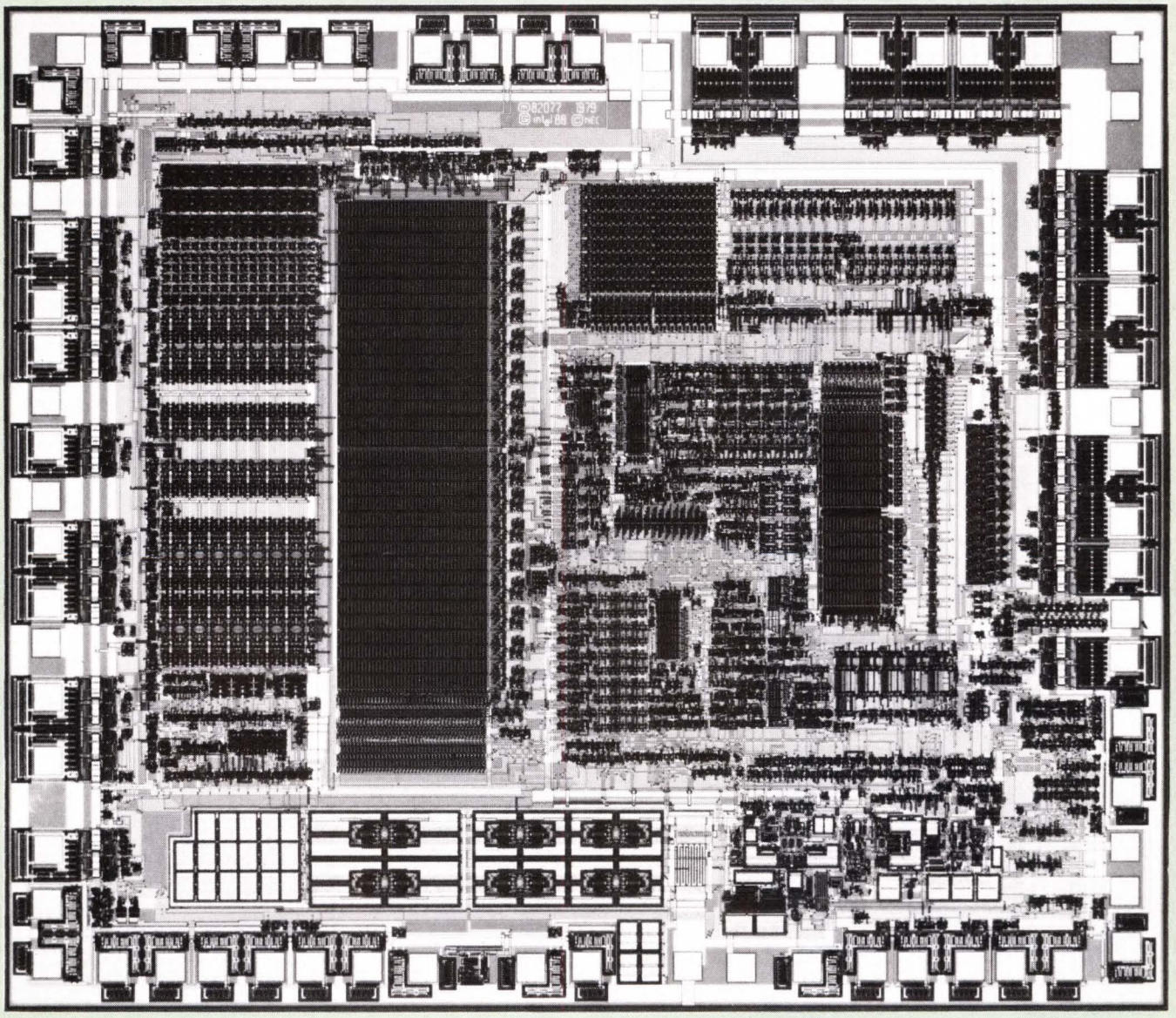
SCSI disk controllers, such as those listed in **Table 3A**, utilize intelligence in the form of storage controllers, buffer managers, and interface controllers to improve system throughput and reduce component count. A microprocessor can write device commands to a SCSI controller's command pipe without waiting for individual commands to execute. The SCSI sequencer state machine, resident on the SCSI controller, executes these commands.

Or consider the 84C10 DMA controller in **Table 1F.** In addition to performing the DMA function for the processor, the chip contains an Auto Restart control bit. Using this control bit, you can program the DMA controller to reload the starting address of either port at the end of a block transfer. This feature eliminates the CPU overhead for repetitive functions.

The ADSP-1410 word-slice address generator in **Table 1G** is another example of an intelligent support chip. The chip can generate a 16-bit memory address, modify the memory address, and

conditionally loop back to the top of a circular buffer, depending upon whether the address meets or exceeds a limit that you have preset. Without involving the main processor, therefore, you can implement circular buffers and modulo addressing.

The advantages of the intelligent peripherals are obvious—as you offload the μP's functions to the support chips, you either free the processor for other tasks or



This year's crop of μP support chips *incorporates more intelligence than last year's models. The Intel 82077 disk-controller IC is one such device.*

speed the execution of the job the μP was already doing, essentially by allowing parallel processing. But added smarts aren't the only thing you'll notice about this year's support chips.

When you look at **Table 3C**, which lists CRT and laser-printer controllers and graphics generators, you'll see that raster-display controllers represent the fastest growing segment of that market. You can use ICs such as the GP-340, the 32CG32, and the XL-8200 to drive dumb print engines. The expected high growth in the laser-printer market is driving a number of vendors to design chips for this sector **(Ref 1)**.

Another category in which strong end-user demand should fuel high growth is that of keyboard and non-CRT-display interfaces **(Table 3D)**. In particular, the growth in laptop computers and flat-panel displays, as well as the falling prices of LCDs, has created a strong demand for LCD drivers. The demand is causing some of the major chip vendors to shift their design efforts. LCD controllers that address these end-user demands are showing up both as discrete parts and as part of some of the chip sets in **Table 2**.

Integration isn't exactly a new word to semiconductor vendors. Indeed, engineers have come to expect the chips they buy to have twice as many features as the chips they bought last year, at half the price. The multifunction chips and chip sets in **Table 2** certainly justify that expectation. And the trend will most likely continue during the next year, when new chip sets for both the IBM Micro Channel and the Extended Industry Standard Architecture (EISA) will be introduced.

Unfortunately, the sheer volume of possible entries for **Table 2**, which is greater than that of any other table in this year's support-chip directory, necessitated the elimination of some very worthwhile listings. The continuing movement of 80X86-based machines into such applications as industrial instrumentation and control systems caused an explosion of candidates for **Table 2**.

Close the Patent Office

Although some users argue that the chip sets and multifunction ICs limit the system designer's flexibility, the μP-based end products contain more than just these ICs. These users claim that if everyone used the chip sets, there would be no way to differentiate products. This is the type of thinking that led to the apocryphal statement, allegedly spoken in 1844 by Henry Elsworth of the Patent Office, that "we might as well prepare to close the Patent Office; everything that

What did Henry say?

Henry Elsworth's actual comments came from his annual report. They have been widely misquoted. His actual words were: "The advancement of the arts, from year to year, taxes our credulity and seems to presage the arrival of that period when human improvement must end."

Manufacturers of μPs

For more information on μP support chips such as those included in this directory, circle the appropriate numbers on the Information Retrieval Service card or use EDN's Express Request service. When you contact any of the following manufacturers directly, please let them know you saw their products in EDN.

Abbreviations in parentheses after some companies conform to the ones used in this directory. Note that there is also a separate index that indicates which categories of chips each manufacturer makes.

Adaptec
691 S Milpitas Blvd
Milpitas, CA 95035
(408) 945-8600
FAX 408-262-2533
Circle No 653

Advanced Micro Devices (AMD)
901 Thompson Pl, Box 3453
Sunnyvale, CA 94088
(408) 732-2400
FAX 408-982-6162
TWX 910-339-9280
Circle No 654

Altera
3525 Monroe St
Santa Clara, CA 95051
(408) 984-2800
Circle No 655

Analog Devices
Box 9106
Norwood, MA 02062
(617) 329-4700
FAX 617-326-8703
TWX 710-394-6577
TLX 62896514
Circle No 656

Austek
2903 Bunker Hill Lane, Suite 201
Santa Clara, CA 95054
(408) 988-8556
FAX 408-988-0818
Circle No 657

California Micro Devices
2000 W 14th St
Tempe, AZ 85281
(602) 921-6000
FAX 602-921-6298
TLX 187202
Circle No 658

Calmos
20 Edgewater St
Kanata, Ontario, Canada K2L 1V8
(613) 836-1014
FAX 613-831-1742
TLX 0534501
Circle No 659

Capital Equipment Corp
99 S Bedford St
Burlington, MA 01803
(617) 273-1818
FAX 617-273-9057
Circle No 660

could be invented already has been" (see **box,** "What did Henry say?"). In the past, engineers have found ways to improve products' performance within whatever constraints the market sets, and they will continue to do so in the future. Witness the diversity of IBM PC-compatible computers, almost all of which perform within the boundaries of the IBM PC's specifications.

These chip sets are clearly the choice of the future, in spite of the popular arguments to the contrary. (After all, many pundits once claimed that the integrated op amp would never catch on because it was too restrictive.) At the expense of flexibility, the chip sets give you lower cost, less board space, and faster time to market—all critical factors in the success of your project.

When you look at the accompanying tables, you'll notice that an index of manufacturers and the chip functions they offer precedes each table. If none of the offerings listed in the tables suit your needs, you can consult these indexes and call the individual manufacturers directly. Also, keep in mind the ASIC alternative for higher volume or cost-insensitive applications: Many vendors offer libraries of support-chip functions that you can customize for your own purposes.

We need your help

Finally, we'd like to hear from you. Because EDN is *your* magazine, we want our directories to reflect your needs. The large base of existing devices and the tremendous volume of new products introduced each year requires us to make some difficult decisions in preparing both the EDN μP/μC Chip Directory and the EDN μP Support-Chip Directory. By circling the appropriate numbers on the Information Retrieval Service Card, dropping us a short note, or even giving us a quick call, you can let us know whether your directories should concentrate on *new* products such as the 80486 and 88000 μPs, *widely used* products such as the Z80 and 8086 μPs, or some *combination* of the two. EDN

If you think the directories should concentrate on:

New products	**Circle No 650**
Widely used products	**Circle No 651**
A combination of new products and widely used products	**Circle No 652**

References

1. Conner, M, "New ICs speed laser-printer control," *EDN*, November 24, 1988, pg 57.
2. Cushman, R H, "Support chips are in transition from discretes to ASICs," *EDN*, June 9, 1988, pg 139.

Article Interest Quotient (Circle One)
High 497 Medium 498 Low 499

Chips & Technologies (C&T)
3050 Zanker Rd
San Jose, CA 95134
(408) 434-0600
FAX 408-434-9315
TLX 272929
Circle No 661

Cirrus Logic Inc
1463 Centre Pointe Dr
Milpitas, CA 95035
(408) 945-8300
FAX 408-263-5682
TLX 171918
Circle No 662

Cybernetic Micro Systems
Box 3000
San Gregorio, CA 94074
(415) 726-3000
FAX 415-726-3003
TWX 910-350-5842
Circle No 663

Cypress Semiconductor
3901 N First St
San Jose, CA 95134
(408) 943-2600
FAX 408-943-2741
TWX 910-997-0753
TLX 821032
Circle No 664

Dallas Semiconductor
4350 Beltwood Parkway
Dallas, TX 75244
(214) 450-0400
FAX 214-450-0470
Circle No 665

ERSO
(Div of ITRI, Taiwan)
1590 Centre Pointe Dr
Milpitas, CA 95035
(408) 946-3015
FAX 408-946-3019
Circle No 666

Eyring Research
1455 W 820 North
Provo, UT 84601
(801) 375-2434
FAX 801-374-8339
TLX 882000
Circle No 667

Fujitsu Microelectronics Inc
3545 N First St
San Jose, CA 95134
(408) 922-9000
FAX 408-432-9044
Circle No 668

G-2 Inc (LSI Logic)
100 Homeland Ct
San Jose, CA 95112
(408) 452-8322
FAX 408-452-8455
Circle No 669

Gazelle Microcircuits
2300 Owen St
Santa Clara, CA 95054
(408) 982-0900
FAX 408-982-0222
Circle No 670

Gould Semiconductors (AMI)
13061 Montrose St
Saratoga, CA 95070
(408) 246-0330
Circle No 671

Harris Semiconductor
Box 883
Melbourne, FL 32901
(407) 729-5575
FAX 407-729-5691
Circle No 672

Manufacturers of μPs *(Continued)*

Hitachi America Ltd
2000 Sierra Point Parkway
Brisbane, CA 94005
(415) 589-8300
FAX 415-583-4207
TWX 910-338-2103
Circle No 673

Industrial Programming Inc (IPI)
100 Jericho Quadrangle
Jericho, NY 11753
(516) 938-6600
FAX 516-938-6609
TLX 429808
Circle No 674

Inmos
Box 16000
Colorado Springs, CO 80935
(719) 630-4000
FAX 719-630-4325
Circle No 675

Integrated Device Technology Inc (IDT)
3236 Scott Blvd
Santa Clara, CA 95054
(408) 727-6116
FAX 408-492-8674
TWX 910-338-2070
TLX 887766
Circle No 676

Intel Corp
1900 Prairie City Rd
Folsom, CA 95630
(800) 548-4725
FAX 916-351-5427
Circle No 677

International Rectifier (IR)
233 Kansas St
El Segundo, CA 90245
(213) 772-2000
FAX 213-772-9028
Circle No 678

IXYS
2355 Zanker Rd
San Jose, CA 95131
(408) 435-1900
FAX 408-435-0670
TLX 384928
Circle No 679

JMI Software Consultants Inc
Box 481
Spring House, PA 19477
(215) 628-0840
FAX 215-628-0353
TLX 467811
Circle No 680

Linear Technology Corp
1630 McCarthy Blvd
Milpitas, CA 95035
(800) 637-5545
FAX 408-434-0507
TLX 4993977
Circle No 681

Logic Devices Inc
628 E Evelyn Ave
Sunnyvale, CA 94086
(408) 720-8630
FAX 408-733-7690
TLX 172387
Circle No 682

LSI Logic Corp
1551 McCarthy Blvd
Milpitas, CA 95035
(408) 433-8000
FAX 408-433-7447
TLX 172153
Circle No 683

Maxim Integrated Products
120 San Gabriel Dr
Sunnyvale, CA 94086
(408) 737-7600
FAX 408-737-7194
Circle No 684

Microchip Technology Inc
2355 W Chandler Blvd
Chandler, AZ 85224
(602) 345-3287
Circle No 685

Micro Computer Control
Box 275
Hopewell, NJ 08525
(609) 466-1751
Circle No 686

Microware Systems
1900 NW 114th St
Des Moines, IA 50322
(515) 224-1929
FAX 515-224-1352
TWX 910-520-2535
Circle No 687

Mitsubishi Electronics America Inc
1050 Arques Ave
Sunnyvale, CA 94086
(408) 730-5900
Circle No 688

Motorola Microprocessor Products Group
6501 William Cannon Dr W
Austin, TX 78735
(512) 891-2990
FAX 512-891-2947
TLX 4999127
Circle No 689

National Semiconductor Corp
2900 Semiconductor Dr, Box 58090
Santa Clara, CA 95052
(408) 721-5000
FAX 408-730-0764
TWX 910-339-9240
Circle No 690

NCR Corp
2001 Danfield Ct
Fort Collins, CO 80525
(303) 226-9500
Circle No 691

NEC Electronics Inc (Corp Headquarters)
401 Ellis St
Mountain View, CA 94039
(415) 960-6000
TWX 910-379-6985
Circle No 692

Oki Semiconductor Inc
785 N Mary Ave
Sunnyvale, CA 94086
(408) 720-1900
FAX 408-720-1918
Circle No 693

Performance Semiconductor Corp
610 E Weddell Dr
Sunnyvale, CA 94089
(408) 734-9000
FAX 408-734-0258
TWX 650-271-5784
Circle No 694

Phoenix Technologies Ltd
320 Norwood Park S
Norwood, MA 02062
(617) 769-7020
Circle No 695

Ready Systems
470 Potrero Ave
Sunnyvale, CA 94086
(408) 736-2600
FAX 408-736-3400
Circle No 696

Rockwell International
Microelectronic Devices Div
4311 Jamboree Rd
Newport Beach, CA 92660
(714) 833-4700
Circle No 697

Samsung Semiconductor
3725 N 1st St
San Jose, CA 95134
(408) 434-5400
TLX 339544
Circle No 698

SGS-Thomson Microelectronics
1000 E Bell Rd
Phoenix, AZ 85022
(602) 867-6100
Circle No 699

Siemens Semiconductor
2191 Laurelwood Rd
Santa Clara, CA 95054
(408) 980-4500
FAX 408-980-4529
Circle No 706

Sierra Semiconductor
2075 N Capitol Ave
San Jose, CA 95132
(408) 263-9300
FAX 408-263-3337
Circle No 707

Signetics (Philips)
Box 3409
Sunnyvale, CA 94088
(408) 991-2000
FAX 408-991-3581
TWX 910-338-2104
TLX 172243
Circle No 708

Siliconix
2201 Laurelwood Rd
Santa Clara, CA 95051
(408) 988-8000
FAX 408-727-5414
TWX 910-338-0227
Circle No 709

Silicon Systems
14351 Myford Rd
Tustin, CA 92680
(714) 731-7110
FAX 714-669-8814
Circle No 710

Software Components Group
4655 Old Ironsides Dr, Suite 370
Santa Clara, CA 95054
(408) 727-0707
Circle No 711

Sprague Semiconductor Group
115 NE Cutoff
Worcester, MA 01615
(508) 853-5000
FAX 508-853-5049
TLX 221457
Circle No 712

Standard Microsystems Corp (SMC)
35 Marcus Blvd
Hauppauge, NY 11788
(516) 273-3100
FAX 516-273-3123
Circle No 713

Texas Instruments Inc (TI)
Box 655303
MS 8328
Dallas, TX 75265
(214) 997-5559
FAX 214-997-5403
TLX 73324
Circle No 714

Toshiba America Inc
9775 Toledo Way
Irvine, CA 92718
(714) 455-2000
Circle No 715

United Technologies
Microelectronics Center (UTMC)
1575 Garden of the Gods Rd
Colorado Springs, CO 80907
(800) 645-8862
FAX 719-594-8032
Circle No 716

Vadem
1885 Lundy Ave
Suite 201
San Jose, CA 95131
(408) 943-9301
FAX 408-943-9735
TLX 887591
Circle No 717

Via Technologies Inc
4160-B Technology Dr
Fremont, CA 94538
(415) 651-2796
FAX 415-659-9057
Circle No 718

VLSI Technology Inc
8375 S River Parkway
Tempe, AZ 85284
(602) 752-8574
FAX 602-752-6000
Circle No 719

Waferscale Integration Inc
47280 Kato Rd
Fremont, CA 94538
(415) 656-5400
Circle No 720

Weitek
1060 E Arques Ave
Sunnyvale, CA 94086
(408) 738-8400
FAX 408-739-4374
TWX 910-339-9545
Circle No 721

Western Digital (WD)
2455 McCabe Way
Irvine, CA 92714
(714) 474-2033
FAX 714-756-9247
Circle No 722

Xilinx
2069 Hamilton Ave
San Jose, CA 95125
(408) 559-7778
FAX 408-559-7114
TWX 510-600-8750
Circle No 723

Zilog Inc
210 Hacienda Ave
Campbell, CA 95008
(408) 370-8000
FAX 408-370-8027
Circle No 724

Zymos Corp
477 N Mathilda Ave
Sunnyvale, CA 94088
(408) 730-8800
Circle No 725

SUPPORT-CHIP MANUFACTURER/PRODUCT LISTING

THIS LISTING PROVIDES A GUIDE TO THE SUPPLIERS OF DEVICES MENTIONED IN THE DIRECTORY TABLES 1A THROUGH 4.

SUPPLIER	1A PARALLEL I/O PORTS	1B SERIAL I/O PORTS	1C TIMERS, EVENT COUNTERS, CLOCKS	1D NUMBER CRUNCHERS	1E INTERRUPT CONTROLLERS	1F DMA CONTROLLERS	1G MEMORY AND BUS CONTROLLERS	1H SYSTEM FIRMWARE	1I SYSTEM GLUE	2 COMBO CHIPS, CHIP SETS	3A DISK CONTROLLERS	3B SERIAL TAPE CONTROLLERS	3C CRT CONTROLLERS, GRAPHICS GENERATORS	3D KEYBOARD AND NON-CRT DISPLAY INTERFACES	3E POWER DRIVERS AND CONTROLLERS	4 μPs AND μP-LIKE CHIPS	ASIC CELLS?
ADAPTEK	●										●						YES
ALTERA									●								BY USER
AMD	●		●	●	●	●	●		●		●		●	●		●	YES
ANALOG DEVICES	●			●			●									●	N/A
AUSTEK							●										N/A
CALIFORNIA MICRO DEVICES (EX GTE)	●	●	●						●							●	YES
CALMOS	●	●	●	●	●	●	●		●						●	●	YES
CAPITAL EQUIP							●	●									—
CHIPS & TECHNOLOGIES	●							●		●			●				YES
CIRRUS LOGIC	●	●	●			●	●				●		●				YES
CYBERNETIC MICRO SYSTEMS	●	●	●				●							●	●	●	VIA FIRMWARE
CYPRESS SEMICONDUCTOR	●			●			●		●	●						●	—
DALLAS SEMICONDUCTOR	●	●	●		●		●		●								CLOSED LIBRARIES
ERSO								●		●							YES
EYRING								●									—
FUJITSU	●		●	●	●	●				●			●			●	YES
G-2 (LSI LOGIC)										●							—
GAZELLE MICROCIRCUITS									●								—
GOULD		●		●		●		●					●	●	●		—
HARRIS	●	●	●		●	●	●		●	●						●	YES
HITACHI							●			●			●			●	N/A
INDUSTRIAL PROGRAMMING								●									—
INMOS		●									●		●			●	—
INTEGRATED DEVICE TECHNOLOGY	●	●		●			●		●								YES
INTEL	●	●	●	●	●	●	●	●	●	●	●		●			●	YES
INTERNATIONAL RECTIFIER															●		—
IXYS	●	●													●		—
JMI SOFTWARE CONSULTANTS								●									—
LINEAR TECHNOLOGY		●													●		N/A
LOGIC DEVICES	●			●													—
LSI LOGIC		●	●	●	●	●	●		●				●			●	YES
MAXIM		●	●											●	●		N/A
MICRO COMPUTER CONTROL								●									—

SUPPORT-CHIP MANUFACTURER/PRODUCT LISTING

THIS LISTING PROVIDES A GUIDE TO THE SUPPLIERS OF DEVICES MENTIONED IN THE DIRECTORY TABLES 1A THROUGH 4.

SUPPLIER	1A PARALLEL I/O PORTS	1B SERIAL I/O PORTS	1C TIMERS, EVENT COUNTERS, CLOCKS	1D NUMBER CRUNCHERS	1E INTERRUPT CONTROLLERS	1F DMA CONTROLLERS	1G MEMORY AND BUS CONTROLLERS	1H SYSTEM FIRMWARE	1I SYSTEM GLUE	2 COMBO CHIPS, CHIP SETS	3A DISK CONTROLLERS	3B SERIAL TAPE CONTROLLERS	3C CRT CONTROLLERS, GRAPHICS GENERATORS	3D KEYBOARD AND NON-CRT DISPLAY INTERFACES	3E POWER DRIVERS AND CONTROLLERS	4 μPs AND μP-LIKE CHIPS	ASIC CELLS?
MICROCHIP TECHNOLOGY	●													●			YES
MICROWARE SYSTEMS								●									—
MITSUBISHI	●		●		●	●	●							●		●	N/A
MOTOROLA	●	●	●	●	●	●	●	●	●	●	●		●	●	●	●	YES
NATIONAL SEMICONDUCTOR (FAIRCHILD)	●	●	●	●	●		●				●		●	●		●	YES
NCR	●	●	●	●		●	●		●				●			●	YES
NEC	●	●	●	●	●	●			●		●	●	●	●		●	YES
OKI SEMICONDUCTOR	●	●	●	●	●	●	●		●	●					●	●	YES
PERFORMANCE SEMICONDUCTOR				●			●		●	●						●	YES
PHOENIX TECHNOLOGIES								●									—
READY SYSTEMS								●									—
ROCKWELL	●	●	●							●	●		●	●		●	N/A
SAMSUNG	●	●	●		●	●	●						●	●			—
SGS-THOMSON	●	●	●	●	●	●	●			●	●				●	●	YES
SIEMENS	●	●	●	●	●	●	●		●	●	●	●	●	●	●		N/A
SIERRA			●													●	YES
SIGNETICS		●				●	●		●		●		●			●	YES
SILICON SYSTEMS	●	●									●	●			●		YES
SILICONIX															●		YES
SOFTWARE COMPONENTS GROUP								●									—
SPRAGUE															●		N/A
STANDARD MICROSYSTEMS CORP	●	●					●				●	●	●	●			YES
TEXAS INSTRUMENTS	●	●	●	●	●		●		●				●		●	●	YES
TOSHIBA	●	●	●		●	●			●				●			●	YES
UTMC		●		●			●		●							●	YES
VADEM								●		●				●			—
VIA TECHNOLOGIES	●	●					●			●			●				—
VLSI TECHNOLOGY	●	●	●	●	●	●	●		●	●	●		●			●	YES
WAFERSCALE				●					●								YES
WEITEK				●									●				YES
WESTERN DIGITAL	●									●	●	●	●				N/A
XILINX									●								YES
ZILOG	●	●	●	●	●	●	●		●	●	●		●			●	YES
ZYMOS										●							YES

NOTES:
—=NOT APPLICABLE
N/A=INFORMATION NOT AVAILABLE

TABLE GROUP 1—SUBSYSTEM SUPPORT CHIPS

1A PARALLEL I/O PORTS

TYPICALLY HAVE AT LEAST TWO 8-BIT PORTS WITH LATCHES AND TWO HANDSHAKING LINES PER PORT FOR INTERFACING TO PERIPHERALS. IN SOME DEVICES, THE HOST μP CAN USE INTERNAL CONTROL REGISTERS TO SET UP BIT LINES AS INPUTS OR OUTPUTS. TREND TOWARD STANDARDIZATION; SCSI BUS IS ONE EXAMPLE. IBM'S MICRO CHANNEL, WHEN USED FOR ADDING FUNCTIONS, MIGHT ALSO BE CONSIDERED AN EXAMPLE.

μP BUS COMPATIBILITY	SUPPLIER	MODEL	SPEED	KEY SPECIFICATIONS					TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
				PORT 1	PORT 2	PORT 3	PORT 4	PORT 5			
NA	ANALOG DEVICES	ADSP-3128	20 MHz	16-BIT INPUT	16-BIT INPUT	16-BIT OUTPUT	16-BIT OUTPUT	16-BIT BIDIRECTIONAL	CMOS/144-PIN PGA	$145	5-PORT REGISTER FILE, 50-NSEC CYCLE TIME: 128x16 OR 64x32 SCRATCHPAD RAM, CROSSBAR SWITCH.
GENERAL	CALMOS TOSHIBA HARRIS INTEL	CA82C55A	5, 8, AND 10 MHz ZERO WAIT STATE	8-BIT I/O	8-BIT I/O	8-BIT I/O	—	—	CMOS 40-PIN DIP 44-PIN PLCC	$2.44	CMOS VERSION OF INDUSTRY-STANDARD 8255 WITH TTL I/O, 24 PROGRAMMABLE I/O PINS, AND BIDIRECTIONAL BUS.
8088 8086 80C286	HARRIS	82C55A	8 MHz	8-BIT PROGRAMMABLE I/O	8-BIT PROGRAMMABLE I/O	8-BIT PROGRAMMABLE I/O	—	—	CMOS 40-PIN PLCC	$3.67	HIGH DARLINGTON DRIVE OUTPUTS ON ALL PORTS. THREE OPERATING MODES.
GENERAL	LOGIC DEVICES, NCR, AMD, NATIONAL SEMI	5380/53C80	4M BPS	8+1 BITS	—	—	—	—	40-PIN DIP 44-LEAD PLCC 44-LEAD LCC	$5.65 (1000)	SCSI BUS PROTOCOL CONTROLLER, ON-BOARD DMA, ASYNCHRONOUS SCSI TRANSFERS. AVAILABLE IN MIL GRADE.
Z8000	ZILOG	Z8536C10	4, 6 MHz	8+2 HANDSHAKE	8+2 HANDSHAKE	4	—	—	40-PIN 40-PIN	$4.29	INCLUDES 3 16-BIT COUNTER/TIMERS.

1B SERIAL I/O PORTS

THESE DEVICES, WHICH WERE USUALLY ASYNCHRONOUS TELETYPE UARTs, NOW SERVICE AN INCREASING VARIETY OF COMPLEX ASYNCHRONOUS AND SYNCHRONOUS PROTOCOLS, RANGING FROM THOSE FOR SIMPLE 3-WIRE SYSTEMS TO THOSE FOR ELABORATE COMMERCIAL, INDUSTRIAL, AND MILITARY NETWORKS. (LANs AND TELECOMM NETWORKS COULD BE CONSIDERED AN EXTENSION OF THIS CATEGORY.)

μP BUS COMPATIBILITY	SUPPLIER	MODEL	SPEED	KEY SPECIFICATIONS				TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
				SDLC	HDLC	ADCCP	BISYNC			
8088 8086 80C286 GENERAL	HARRIS	82C50A	625K BPS	—	—	—	—	CMOS 40-PIN PLCC	$10.81	UART/BAUD-RATE GENERATOR WITH MODEM INTERFACE. IBM PC COMPATIBLE.
GENERAL	HARRIS	6409	1M BPS	—	—	—	YES	CMOS 20-PIN LCC	$8.94	MANCHESTER ENCODER/ DECODER. CONVERTER OR REPEATER MODE. DIGITAL PLL CLOCK RECOVERY. FREE FORMAT ON DATA-BIT PATH.
GENERAL	HARRIS	15530	1.25M BPS	—	—	—	YES	CMOS 28-PIN LCC	$47.12	MANCHESTER ENCODER/ DECODER. SUPPORTS MIL-STD-1553.
GENERAL	HARRIS	15531	2.5M BPS	—	—	—	YES	CMOS 40-PIN DIP	$65.96	MANCHESTER ENCODER/ DECODER. SUPPORTS MIL-STD-1553 WITH VARIABLE WORD LENGTH.
GENERAL	INMOS	C004-G205	20 MHz	—	—	—	—	CMOS 5V 84-LEAD PGA	$59	FULL 32 LINK CROSSBAR SWITCH AT BOTH 10M AND 20M BAUD.
28000	ZILOG	SCC 28530	8 AND 10 MHz	YES	YES	—	YES	CMOS 40-PIN 44-PIN QUAD FLAT PACK	$12.50	CMOS VERSION OF NMOS SCC.
GENERAL	ZILOG	USC 16C30	10 MHz	YES	YES	—	YES	CMOS 68-PIN PLCC	$105	HIGH-INTEGRATION, DUAL-CHANNEL 10M-BPS DATA RATE, GENERAL-PURPOSE, I/O PROTOCOL, 8 DATA-ENCODING FORMATS, 32-BYTE FIFO.
Z80/8080	SGS-THOMSON	Z8440 Z8441 Z8442	2 MHz	YES	YES	—	YES	NMOS 40-PIN DIP	$2.50	TWO INDEPENDENT FULL-DUPLEX CHANNELS.
GENERAL	SIGNETICS MOTOROLA	2652	2M BPS	YES	YES	YES	YES	NMOS 5V 40-PIN DIP 44-PIN PLCC	$6.55 $7.85	
	SIGNETICS	2698B	1M BPS	—	—	—	—	CMOS 5V 64-PIN DIP 84-PIN PLCC	$26.50 $27.75	OCTAL UART.
68000	SIGNETICS	68562	4M BPS	YES	YES	YES	YES	NMOS 5V 48-PIN DIP 52-PIN PLCC	$13.55 $15.70	DUAL MULTIPROTOCOL CONTROLLER.

— = NOT APPLICABLE
NA = NOT AVAILABLE
THE VOLUME OF AVAILABLE SUPPORT CHIPS PREVENTS INCLUSION OF ALL APPROPRIATE DEVICES IN THIS DIRECTORY. FOR MORE INFORMATION, REFER TO THE MANUFACTURER/PRODUCT LISTING AT THE BEGINNING OF THE DIRECTORY.

NEW! GOULD CLAS 4000

Configurable Logic Analysis System

Your interest in high performance GOULD products puts you in a select group of design engineers who have a need to know about advances in measurement technology. We are proud to announce a breakthrough in digital instrumentation, the **GOULD CLAS 4000**.

The CLAS 4000 provides outstanding measurement capability for examining high speed CISC, RISC, ASIC and general logic designs:

- 1 to 4 user configurable, independent logic analyzers
- 96 channel measurement module with 50/100/200 MHz data capture
- 16 channel measurement module with 1 GHz data capture
- User interface linkable measurement modules to 384 channels
- Full speed triggering with multilevel Trace Control™
- Time correlated data capture and display

The CLAS 4000 is fun to use:

- ICON directed, click-and-go mouse controlled interface
- Large, high resolution color display
- Intuitive operation with:
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  Graphic Clocking™
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Circle 48 for Literature
Circle 49 for Demonstration

1C TIMERS, EVENT COUNTERS, AND CLOCKS

TIMERS PROVIDE ONE OR MORE UP- OR DOWN-COUNTING REGISTERS THAT CAN BE PRESET VIA PROGRAM CONTROL BY μP. THEY THEN COUNT OUT CLOCK CYCLES AND FLAG μP BY INTERRUPT WHEN DONE. SOME COUNT PULSES (EVENTS) ON INPUT LINE. ALSO INCLUDED ARE OTHER TIMING FUNCTIONS, SUCH AS SYSTEM CLOCKS AND REAL-TIME CLOCKS.

μP BUS COMPATIBILITY	SUPPLIER	MODEL	SPEED	KEY SPECIFICATIONS				TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
				TIMER 1 (BITS)	TIMER 2 (BITS)	TIMER 3 (BITS)	TIMER 4 (BITS)			
INTEL μPs	CALMOS AMD OKI INTEL	82C54	8, 10 MHz ZERO WAIT STATE	16	16	16	16	CMOS 24-PIN DIP 28-PIN PLCC	$2.44	CMOS VERSION OF 8254 INDUSTRY STANDARD, FULLY STATIC OPERATION, 3 INDEPENDENT 16-BIT TIMERS AND 6 PROGRAMMABLE COUNTER MODES.
GENERAL	DALLAS SEMICONDUCTOR	DS1286	25 MHz	REAL-TIME CLOCK	WATCHDOG 16 BITS	ALARM	SQUARE-WAVE OUTPUT 1024 Hz	CMOS 5V 28-PIN	$13.75	
GENERAL	DALLAS SEMICONDUCTOR	DS1287	25 MHz	REAL-TIME CLOCK	SQUARE-WAVE OUTPUT 2 Hz TO 8.192 kHz	ALARM	—	CMOS 5V 24-PIN	$13.75	THE REAL-TIME CLOCK IS A DROP-IN REPLACEMENT FOR AN IBM PC/AT CLOCK/CALENDAR. IS NONVOLATILE AND REPLACES 16 COMPONENTS.
80C88 80C86 80C286	HARRIS	82C54	8 MHz	16	16	16	—	CMOS 24-PIN PLCC	$4.22	SIX PROGRAMMABLE COUNTER MODES, 10-μA STANDBY SUPPLY CURRENT.
Z80	TOSHIBA ZILOG SGS-THOMSON	Z80 CTC Z84C30	DC-4, 6, 8 MHz	8	8	8	8	CMOS 5V 40-PIN 44-PIN FLAT PACK	$2.50	CMOS VERSION OF NMOS Z8430. 1/10 OPERATING POWER AND LESS THAN 10 μA WHEN POWERED DOWN (CLOCK STOPPED).
Z8000	ZILOG	Z8536 C10	4, 6 MHz	16	16	16	—	40-PIN 44-PIN	$4.29	INCLUDES TWO 8-BIT AND ONE 4-BIT PARALLEL I/O PORTS.

1D NUMBER CRUNCHERS

PROVIDE HARDWIRED OR FIRMWARE IMPLEMENTATION OF DATA-MANIPULATION INSTRUCTIONS THAT ARE OTHERWISE DIFFICULT TO PROGRAM AND SLOW TO ACCOMPLISH WITH MAIN μP. INCLUDES INTEGER AND FLOATING-POINT MULTIPLICATION, TRIG FUNCTIONS, AND SPECIAL ALGORITHMS SUCH AS ENCRYPTION, ETC.

μP BUS COMPATIBILITY	SUPPLIER	MODEL	SPEED	KEY SPECIFICATIONS			TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
				MATH	TRIG	FL PT			
NA	ANALOG DEVICES	ADSP-1010A	13 MHz	×, +	NO	NO	CMOS 64-PIN DIP 68-PIN PGA, LCC	$18	16×16 MULTIPLICATION/ACCUMULATION AT RATES UP TO 13 MHz, 400-mW POWER DISSIPATION.
NA	ANALOG DEVICES	ADSP-1024A	10 MHz	×	NO	NO	CMOS 84-PIN PGA	$81	24×24 MULTIPLICATION AT RATES UP TO 10 MHz, 450-mW DISSIPATION.
NA	ANALOG DEVICES	ADSP-3201/ 3202	10 MHz	×, +, −, /	NO	YES	CMOS 144-PIN PGA	$97 PER DEVICE	32-BIT IEEE FLOATING-POINT CHIP SET. SINGLE-PRECISION MATH AT 10M FLOPS.
NA	ANALOG DEVICES	ADSP-3212/ 3222	20 MHz	×, +, −, / SQR ROOT	NO	YES	CMOS/144-PIN PGA	$350 PER DEVICE	32- AND 64-BIT IEEE FLOATING-POINT CHIP SET. 20M-FLOPS THROUGHPUT RATE.
80386	WEITEK	3167	20, 25, 33 MHz	×, ÷, +, −, ABS VAL, COMPARE	SUPPORTED BY RUN-TIME LIBRARY	YES	CMOS 5V 121-PIN PGA	$660 (20 MHz) $845 (25 MHz) $1230 (33 MHz)	SINGLE-CHIP VERSION OF EARLIER 1167. PLUGS INTO SUPERSET OF 80387 SOCKET. C, FORTRAN, PASCAL COMPILERS AVAILABLE. WITH 80386 DELIVERS 5.6M WHETSTONES AT 25 MHz.
R3000	INTEGRATED DEVICE TECHNOLOGY PERFORMANCE LSI LOGIC	R3010	16, 20, 25 MHz	SINGLE AND DOUBLE PRECISION	SUPPORTED	YES	CMOS 84-LEAD CERQUAD J BEND 84-PIN PGA	$346	FULL 64-BIT OPERATION FULL CONFORMANCE WITH IEEE 754-1985 FLOATING-POINT SPEC.
NA	NATIONAL	32381	15, 20, 25, 30 MHz	+, −, ×, ÷	SUPPORTED BY RUN TIME LIBRARY	YES	CMOS 5V 68-PIN PGA	$108	SUPPORTS IEEE 754-1985.
GENERAL 32 BIT (34020)	TI	34802	32, 40 MHz	+, −, ×, ÷ SQR ROOT	GRAPHICS INSTRUCTIONS	+, −, ×, ÷	CMOS 145-PIN PGA	$700 60 NSEC 32 MHz $900 50 NSEC	IEEE 754, MULTIPLIER, ALU, REGISTER FILE, SEQUENCER. SINGLE AND DOUBLE-PRECISION FLOATING POINT. 32 INTEGER/ LOGICAL OPERATIONS. COMPLEX INSTRUCTS TARGETED AT GRAPHICS MATH.
GENERAL	NEC	72185	8 MHz	—	—	—	CMOS 64-PIN SHRINK DIP 68-PIN PLCC	$50	PROGRAMMABLE INSTRUCTION ARCHITECTURE. CCITT GROUP 3/4 COMPRESSION/EXPANSION. 32k PIXELS LINE LENGTH. ONBOARD DMA CONTROLLER.
GENERAL	LOGIC DEVICES	10C23	50 MHz	—	—	—	CMOS 24-PIN DIP 24-PIN CERAMIC LCC	$25 (1000)	64×1 DIGITAL CORRELATOR FOR PATTERN MATCHING, IMAGE RECOGNITION, IMAGE RESTORATION.

— = NOT APPLICABLE
NA = NOT AVAILABLE
THE VOLUME OF AVAILABLE SUPPORT CHIPS PREVENTS INCLUSION OF ALL APPROPRIATE DEVICES IN THIS DIRECTORY. FOR MORE INFORMATION, REFER TO THE MANUFACTURER/PRODUCT LISTING AT THE BEGINNING OF THE DIRECTORY.

0 to 60 in 5 seconds

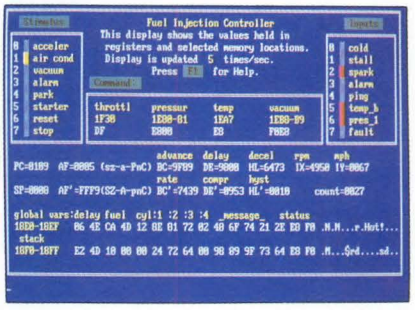
with new UniLab 8620 analyzer-emulator.

■ 64Kbytes from hard disk in 5 seconds. That's moving. But today you've got to be fast just to stay in the race for better microprocessor designs.

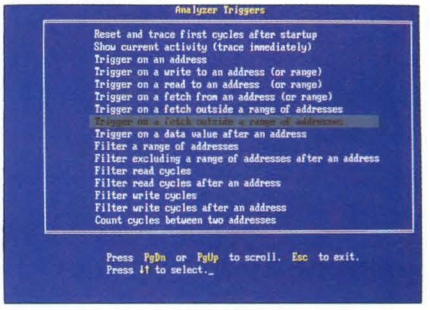
■ The secret is a new, high-speed parallel interface: the Orion bus. Which zips data between your PC/AT and the 8620 analyzer-emulator, breaking the RS-232 bottleneck.

■ The 8620 with O-bus gives you complete program diagnosis — and solutions — in real time. For more than 150 different microprocessors. Using **the same command set** environment.

■ A generous 2730 trace-cycle buffer with selective filtering lets you cut through the clutter and display just the traces you wish. And you get 1μsec resolution in program time measurement. Plus continuous InSight monitoring of your program's key functions as they are performed.



InSight Display. InSight blends analyzer-emulator techniques to give you continuous, real time monitoring of key processor functions. And still services user interrupts. It displays changing register contents, I/O lines, ports, user-defined memory windows. With your own labels.



Analyzer Triggers. Commonly used triggers can be selected quickly from a list of standard and user-defined triggers.

■ On top of that, you get UniLab's trademark ability to debug by symptom, not just by breakpoint and single step. And, to help you complete the job on time, on the spot, a stimulus generator and EPROM programmer are included.

■ Ease of use, another Orion trademark, is also built in. So you have all the familiar features and formats you're used to working with. It doesn't matter if your project is a single chip controller or complex 16-bit microprocessor, the 8620 is the top price/performance analyzer-emulator that does it all. At just $4380. With processor Personality Paks typically $550 each.

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Computer Integrated Instrumentation

1E INTERRUPT CONTROLLERS

EXPAND, PRIORITIZE, AND PROVIDE INTERRUPT VECTOR ADDRESSING FOR μPs. BECAUSE OF EMPHASIS ON FAST INTERRUPT RESPONSE, TREND HAS BEEN TO INCORPORATE THIS FUNCTION ON μP AND TO EXPAND IT ON THE CHIP SETS OF **TABLE 2.**

μP BUS COMPATIBILITY	SUPPLIER	MODEL	SPEED	KEY SPECIFICATIONS				TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
				PRIORITY LEVELS	EXPANDABLE	PROGRAMMABLE	INTERRUPT MASKING			
8080/85 8086/88	HARRIS OKI VLSI SIEMENS	82C59A	8, 10, 12.5 MHz μP CLOCK	8	YES TO 64 LEVELS	YES	YES	CMOS 5V 28-PIN PLCC	$3.70	OPERATES IN EITHER 8080/85 OR 8086/88 CALL MODE. THIS FUNCTION NOW ON HIGH-INTEGRATION CHIP SETS OF **TABLE 2.**
INTEL μP	CALMOS AMD INTEL	82C59A	8, 10 MHz	8	YES TO 64 LEVELS	YES	YES	CMOS 28-PIN DIP 28-PIN PLCC	$2.19	OPERATES IN 8080/85 OR 8088/86 CALL MODE.
8080/85 8086/88	NEC	71059	10 MHz	—	—	—	—	CMOS 5V 28-PIN PLCC	$3.10	OPERATES IN EITHER 8080/85 OR 8086/88 CALL MODE. THIS FUNCTION NOW ON HIGH-INTEGRATION CHIP SETS OF **TABLE 2.**
GENERAL	FUJITSU	92421	20 MHz	7	YES	YES	YES	CMOS 5V 68-PIN PLCC 64-PIN DIP	$39 $29.90	EDGE OR LEVEL TRIGGER MODE SELECTABLE. INTERRUPT GENERATOR OR HANDLER. CAN INTERRUPT POLL.
	NATIONAL	32202	10 MHz	16	YES TO 256 LEVELS	YES	YES	CMOS 5V 40-PIN DIP	$39.50	

1F DMA CONTROLLERS

TAKE OVER μP BUSES AND ACT AS SPECIAL-PURPOSE μPs TO CONTROL ADDRESS BUS AND MOVE BLOCKS OF DATA. FUNCTIONS AS COPROCESSOR. BECAUSE DMA IS OFTEN CRITICAL TO ANOTHER CHIP'S SYSTEM-LEVEL PERFORMANCE, TREND IS TO INCORPORATE DMA ON OTHER CHIPS. NOTE THAT HERE IS SITUATION WHERE IT IS IMPORTANT TO HAVE BUS WIDTHS MATCHED TO HOST μP IF MAXIMUM PERFORMANCE IS DESIRED.

μP BUS COMPATIBILITY	SUPPLIER	MODEL	SPEED	CHANNELS	MODES	TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
Z80 (8 BIT)	TOSHIBA ZILOG SGS THOMSON	Z84C10	DC TO 4, 6, 8 MHz	1	BYTE-AT-TIME, BURST, CONTINUOUS TRANSFER, SEARCH OR TRANSFER/SEARCH	CMOS 5V 40-PIN 44-PIN FLAT PACK	$5 $3	CMOS VERSION OF NMOS Z8410. SUPPORTS DAISY-CHAIN INTERRUPTS AND DMA REQUESTS. 2M BYTES/SEC.
8/16 BIT	CALMOS, AMD, TOSHIBA, OKI, NEC, INTEL	82C37A	5, 8, 10 MHz	4	SINGLE, BLOCK, OR DEMAND TRANSFER, CASCADE, MEMORY TO MEMORY	CMOS 40-PIN DIP 44-PIN PLCC	$3.66	CMOS VERSION OF 8237. FULLY STATIC OPERATION WITH AUTOINITIALIZE.
GENERAL 32 BIT	FUJITSU	92411	20 MHz	4	MULTIPLE BLOCK TRANSFER BY SEQUENTIAL DESCRIPTOR CHAIN TRANSFER	CMOS 5V 132-PIN PGA	$240 TO $360 (SAMPLES)	40M-BPS TRANSFER RATE. 32-BIT ADDRESS BUS. OPERAND SIZE: 1, 2, 4, 8 BYTES.
80C86/88 80C286	HARRIS	82C37A	5, 8, 12.5 MHz	4	SINGLE TRANSFER, BLOCK TRANSFER, DEMAND TRANSFER, CASCADE MODE, MEMORY TO MEMORY, BYTE/WORD	2-μm CMOS 40-PIN PLCC	$16.28	UP TO 6.25M-BPS TRANSFER RATE. 8/16-BIT MODE. LOW POWER OPERATION. EXPANDABLE TO ANY NUMBER OF CHANNELS.

1G MEMORY (INCLUDING VIRTUAL MEMORY AND CACHE) AND BUS CONTROLLERS (INCLUDING BACKPLANE)

THIS SECTION HAS BECOME A CATCHALL. ORIGINALLY JUST INCLUDED REFRESH EXCITATION FOR DYNAMIC MEMORIES BUT NOW INCLUDES BUS SUPPORT DEVICES FOR COMPLICATED BUSES LIKE VME AND MULTIBUS. CURRENT EMPHASIS IS ON NEEDS OF THE VERY LARGE AND HIGH-PERFORMANCE BUS SYSTEMS FOR 32-BIT μPs. SEE ALSO THE HIGH-INTEGRATION CHIP SETS IN **TABLE 2.**

μP BUS COMPATIBILITY	SUPPLIER	MODEL	SPEED	CHANNELS, ETC	MODES, ETC	TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
NA	ANALOG DEVICES	ADSP-1402	20 MHz	8 INTERNAL 2 EXTERNAL	64×16-BIT	CMOS 84-PIN PGA	$47	16-BIT PROGRAM SEQUENCER, SUPPORTS 20-MHz DATA-TRANSFER RATES.
NA	ANALOG DEVICES	ADSP-1410	11.1 MHz	NA	30 MODES, 16-BIT REGISTERS	CMOS 48-PIN DIP 52-PIN LCC	$37	16-BIT DATA ADDRESS GENERATOR, SINGLE-CYCLE LOOPING INSTRUCTIONS.
SPARC	CYPRESS	7C604	25, 33, 40 MHz	64-BIT MBUS 64k CACHE CONTROLLER	COPY-BACK AND WRITE-THROUGH MODES 32-BYTE READ BUFFER 32-BYTE WRITE BUFFER	243-PIN PGA 207-PIN QUAD FLAT PACK	$483 25 MHz $720 33 MHz	CACHE TAG, CONTROLLER, AND MMU.
GENERAL	NATIONAL	DP8420 DP8421 DP8422	0 TO 30 MHz	256k BIT 1M BIT 4M BIT	22-BIT PROGRAMMABLE REGISTERS	CMOS 5V 68- OR 84-PIN PCC	$12.50 $17.50 $24 25 MHz	PROGRAMMABLE DRAM CONTROLLER/DRIVER FOR 16-, 32-, AND 64-BIT WORDS, SUPPORTS DUAL PORTING.
UP TO 20 BITS	TI	SN74ACT4503	0 TO 10 MHz	4 BANKS OF 1M DRAMs	REFRESH, READ, AND WRITE	CMOS 5V 52-PIN DIP 68-PIN PLCC	$16.60	1M DRAM CONTROLLER.

— = NOT APPLICABLE
NA = NOT AVAILABLE
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20 Mbytes/Sec Advanced DMA For High Speed Engines

Don't let your system run out of gas! Keep your CPU running at top speed with fast Direct Memory Access.

PREMIUM GRADE

The Siemens Advanced DMA co-processor gives your system the kind of accelerated I/O performance it will always need at costs that are hard to beat.

Features	SAB 82257	SAB 82258A
Data Transfer Rate (Mbytes/sec)	8	20
Independent Channels	4	4
Multiplexer Channels	–	32
On-The-Fly Operation	NO	YES
Automatic Command and Data Chaining	NO	YES
Packages	PLCC	PLCC LCC PGA

The SAB 82258A is as fast as they come. It can transfer 32-bit data in single cycle mode at up to 20 Mbytes per second. All while switching between four independent data channels.

EXTRA MILEAGE

With a built-in multiplexer, any one of the four independent channels can control up to 32 separate I/O devices.

And the ADMA co-processor can free the main processor from routine tasks with exclusive operations like on-the-fly verify, compare, translate, and automatic command and data chaining.

FULL SERVICE PUMPS

The ADMA's adaptive bus interface makes it the ideal I/O fuel for any high end 8086/88, 80186/188 or 80286 system. It's a proven device for 32-bit 80386 and 68000/20/30 engines, too.

And an economy model, the SAB 82257, provides solid, fuel efficient performance for simpler 8/16-bit systems.

FILL UP TODAY

For more information and a free ADMA brochure, call: 408-980-4500, ext. 4347. Or fax: 408-980-4529. Or write: Siemens Components, Inc., Microprocessor/Peripheral Marketing Dept., 2191 Laurelwood Road, Santa Clara, CA 95054-1514.

Test driving any other DMA would be thoughtless.

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1G MEMORY (INCLUDING VIRTUAL MEMORY AND CACHE) AND BUS CONTROLLERS (INCLUDING BACKPLANE) *(continued)*

μP BUS COMPATIBILITY	SUPPLIER	MODEL	SPEED	CHANNELS, ETC	MODES, ETC	TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
GENERAL	TI	SN74ACT2155	22 AND 28 NSEC	2k×8	CACHE TAG CACHE DATA RAM 68030 BURST FILL	CMOS 5V 48-PIN DIP 44-PIN PLCC	$22.80	SUPPORTS MC68030 BURST FILL WITH NO ADDED WAIT STATES. CACHE-ONLY MEMORY-STORAGE CAPABILITY.
ALL	TI	SN74ACT2157	22 AND 25 NSEC	2k×16	CACHE TAG CACHE DATA RAM	CMOS 5V 48-PIN DIP 44-PIN PLCC	$36.00	TWO MATCH OUTPUTS FOR DIRECT INTERFACE TO MOTOROLA MC68030. CACHE-ONLY MEMORY STORAGE.
ALL	TI	SN74ACT2150	20 AND 30 NSEC	512×8	CACHE TAG CACHE DATA RAM	CMOS 5V 24-PIN DIP 28-PIN PLCC	$13.20	PARITY GENERATION, STORAGE AND CHECKING.
MICRO CHANNEL 16 OR 32 BIT	CAPITAL EQUIPMENT CORP	88C01	—	—	MICRO CHANNEL MEMORY, I/O, OR MULTIFUNCTION DECODING AND TIMING	CMOS 5V 84-PIN PLCC	$27.50	PROGRAMMABLE DECODING FOR EXTENDED AND EXPANDED MEMORY. MULTIPLE I/O AND ROM. DMA ARBITRATION. PROGRAMMABLE MEMORY AND I/O TIMING. USER CONFIGURABLE.

1H SYSTEM FIRMWARE

ROMABLE SOFTWARE OF INTEREST TO OEM DESIGNERS. INCLUDES OPERATING-SYSTEM KERNELS, I/O DEVICE DRIVERS (BIOS), REAL-TIME EXECUTIVES, POPULAR INTERPRETED-TYPE HIGH-LEVEL LANGUAGES, MATH SUBROUTINES, ETC. CONSIDERED PART OF DIRECTORY BECAUSE ARE USUALLY CLOSELY ASSOCIATED WITH SUPPORT CHIPS AND ARE OFTEN PURCHASED AS COMPONENTS (ROMs) BY DESIGNER.

μP BUS COMPATIBILITY	SUPPLIER	MODEL	SPEED	KEY SPECIFICATIONS			TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
				ROM FIRMWARE (BYTES)	RAM REQ (BYTES)	OTHER FEATURES			
80286 80386SX 80386	CHIPS AND TECHNOLOGIES	82C230 8220 8221 8223 8281 8283 8230 8231	VARIES WITH TARGET PROCESSOR	32k	VARIES	INCLUDES KEYBOARD-CONTROLLER CODE	BY CUSTOMER	$4.60 $2.55 $5.15 $6.25 $5.15 $6.25 $5.15 $5.15	INCLUDE BIOS MODIFICATION PROGRAMS TO LET YOU CONFIGURE CUSTOM VERSIONS.
Z80 8080/85 8086/88 80286/386 680X0 32000 LSI-11 WE32100 TMS34010 CLIPPER 64180 ETC SUN SPARC AMD 29000	JMI	C EXECUTIVE	17-μSEC CONTEXT SWITCH 25-MHz 68020	5k TO 7k ×8 ON 16 MHz 68020	—	PROVIDES INTERRUPT-DRIVEN DEVELOPMENT DRIVERS AND PRIORITIZED SCHEDULING, ETC. MOSTLY IN C LANGUAGE. OPTIONAL FILE SYSTEM	BY CUSTOMER	$70 (LIC)	ROMABLE SOFTWARE THAT PERMITS MULTIPLE C PROGRAMS TO RUN FROM MAIN MEMORY WITHOUT DISK. PORTABLE C LIBRARY HAS UNIX-LIKE ROUTINES FOR EMBEDDED APPLICATION. WHILE SPEED MAY SUFFER BECAUSE IN C RATHER THAN ASSEMBLY, IT IS EASILY TRANSFERRED TO NEW μPs.
680X0	MICROWARE	IND OS-9	VARIES WITH TARGET PROCESSOR	48k	16k	CUSTOMIZED BY OEM, OPTIONAL DISK, TAPE AND NETWORK I/O MODULES ARE AVAILABLE	BY CUSTOMER	$67.50 68000 $97.50 68020 $127.50 68030	REAL-TIME KERNEL WITH SUPPORT FOR INTER-PROCESS COMMUNICATION AND CONSOLE I/O. SOFTWARE IS DISTRIBUTED UNDER OEM LICENSE.
680X0 FAMILY 8086 FAMILY (INCLUDING 80386) Z80 Z8002 32000 29000 1750A	READY SYSTEMS	VRTX32 ARTX	VARIES WITH TARGET PROCESSOR	8k 12k	3k	MULTITASKING, PREEMPTIVE PRIORITY-BASED SCHEDULING. FIXED-COST SYSTEM CALLS. MINIMAL INTERRUPT DISABLE TIME. INCLUDES SEMAPHORES, FLAGS, QUEUES, AND MAILBOXES	BY CUSTOMER	$40k WITH VOLUME LICENSE, $3k–$4k FOR R&D LICENSE	REAL-TIME KERNEL WITH I/O, FILE MANAGEMENT, MULTIPROCESSOR NETWORKING, AND DEBUG SUPPORT. COMPILER AND CASE DEVELOPMENT TOOLS. HELP FOR ADA AND REAL-TIME LINK TO UNIX. ARTX ON 1750A 68k ONLY.
MICRO CHANNEL 16 OR 32 BIT	CAPITAL EQUIPMENT CORP	03000–10200	—	—	—	EXTENDED AND EXPANDED MEMORY CONFIGURATION	NMOS 5V 28-PIN DIP	$7.26 $4000 SOURCE CODE	PROVIDES INITIALIZATION AND CONFIGURATION FOR MICROCHANNEL MEMORY AND I/O UNDER DOS OR OS/2.
V-40 PC/XT	VADEM	VG1BIOS	TO 10 MHz	32k	VARIES	SET-UP MENU, CGA, EGA, ROM DISK	ROM, EPROM OR FLOPPY FOR OEM TO REPRODUCE	$2.5k/ INITIAL $9/COPY	BIOS FOR PC/XT SYSTEMS BASED ON NEC V-40 PROCESSOR AND VADEM VG-100A/200A OR VG-110/210 CHIP SETS. PROVIDES UNIQUE ROM DISK FEATURE FOR DISKLESS SYSTEM DESIGN. OEM ADAPTATION KIT AVAILABLE.

— = NOT APPLICABLE
NA = NOT AVAILABLE
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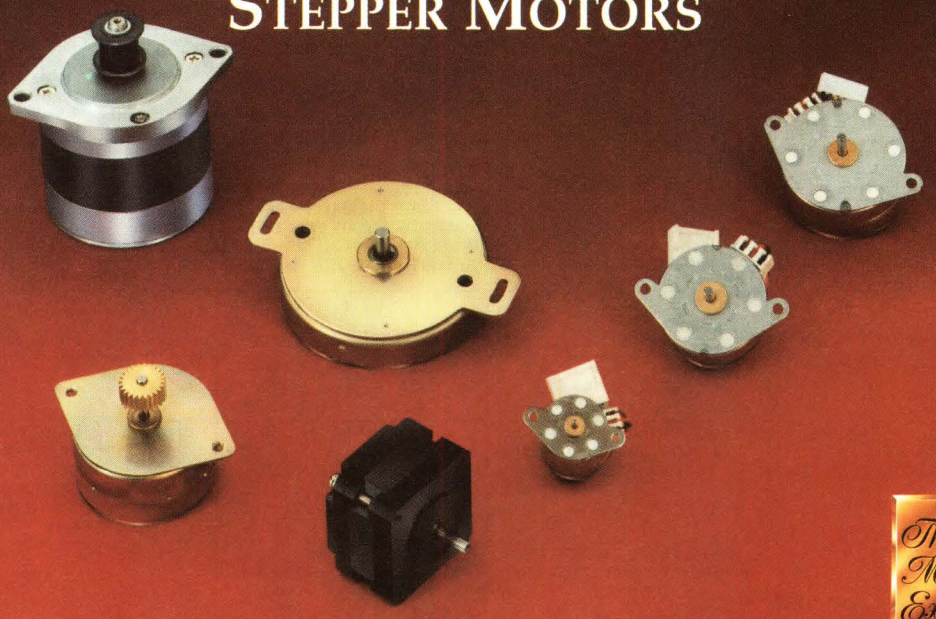
NOW FROM NMB TECHNOLOGIES

HIGH TORQUE

STEPPER MOTORS



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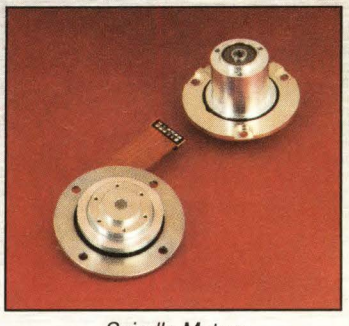
Now there are two families of NMBT precision stepper motors. Both offer top performance at low cost. And both are available from NMB Technologies

AstroSyn motors are known worldwide for smooth performance, quiet reliable operation, long life. They feature extremely accurate step angles and the widest available selection of sizes.

Now we've added the new AccuStep PM-series. They feature 30% higher torque than comparably sized motors. Or equal torque in smaller packages. And 15 to 20% cooler operation in either case. Automatic assembly and advanced stator designs make it possible.



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The newest addition to our family is a line of advanced spindle motors. Directed specifically to the hard disk drive market, they offer improved rotational accuracy in a smaller package.

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CIRCLE NO 41

1H SYSTEM FIRMWARE *(continued)*

μP BUS COMPATIBILITY	SUPPLIER	MODEL	SPEED	KEY SPECIFICATIONS			TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
				ROM FIRMWARE (BYTES)	RAM REQ (BYTES)	OTHER FEATURES			
80C186 PC/XT PS/2 H30	VADEM	VG5BIOS	UP TO 16 MHz	64k	VARIES	SET-UP MENU, CGA, EGA ROM DISK EMS 4.0	ROM, EPROM OR FLOPPY FOR OEM TO REPRODUCE	$2.5k/ INITIAL $9/COPY	BIOS FOR PC/XT AND PS/2 MODEL 30 SYSTEMS BASED ON INTEL 80C186 CPU AND VADEM VG-501/502 CHIP SET. PROVIDES UNIQUE ROM DISK FEATURE FOR DISKLESS SYSTEM DESIGN. OEM ADAPTATION KIT AVAILABLE.

1I SYSTEM GLUE

THESE BUS BUFFERS, DRIVERS, TRANSCEIVERS, ADDRESS, CONTROL LOGIC GATES, ETC, UNITE THE MAIN LSI PARTS OF A μP SYSTEM. LISTED IS A VERY SMALL, SOMEWHAT RANDOM, SAMPLING OF THE MANY THOUSANDS OF DEVICE TYPES AVAILABLE. FOR A MORE COMPLETE PICTURE, CONSULT STANDARD CATALOGS FOR BIPOLAR TTL, CMOS TTL, ECL LOGIC, ETC. KEEP IN MIND THAT MANY OF THESE PARTS ARE ALSO IN MOST SEMICUSTOM CELL LIBRARIES. LATEST TREND IS TO SAVE VALUABLE BOARD SPACE BY ABSORBING THESE IN HIGH-INTEGRATION CHIP SETS (SEE **TABLE GROUP 2**).

μP BUS COMPATIBILITY	SUPPLIER	MODEL	FUNCTIONS	SPEED	TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
GENERAL 8-BIT	CALMOS AMD INTEL	82C12	8-BIT I/O PORT, PARALLEL DATA REGISTER, AND BUFFER	DC TO 10 MHz	CMOS 24-PIN PLASTIC DIP	$3.25	
GENERAL	IDT PERFORMANCE LSI LOGIC	FCTXXX FCTXXXA FCTXXXB	BUFFERS/LINE DRIVERS, TRANSCEIVERS, REGISTERS, COUNTERS, LATCHES	—	CMOS 16-, 20- & 24-PIN PLASTIC DIP, CERDIP, LCC, PLCC, SOIC	$1.80– $16.50	HIGH-SPEED, HIGH-DRIVE, LOW-POWER, TTL-COMPATIBLE BUS INTERFACE AND MEMORY DRIVE PRODUCTS. FCTA AND FCTB ARE NECESSARY FOR RISC-BASED SYSTEMS.
GENERAL	TI	PAL16XX-7	HIGH-SPEED PLD. 8 DEDICATED INPUTS, 8 I/Os, AND 2 DEDICATED OUTPUTS	7.5-NSEC MAX PROP DELAY INPUT TO OUTPUT	BIPOLAR 5V 20-PIN DIP PLCC	$10	
GENERAL	NEC TI TOSHIBA	D42273 D42274	256k×4 PARALLEL-TO-SERIAL BUFFER	PARALLEL 100, 120 NSEC SERIAL 30, 40, NSEC	CMOS SMALL-OUTLINE J LEAD ZIGZAG IN-LINE PACKAGE	$40 (1000)	
GENERAL	NEC	D42101 D42102 D42532	910×8 SERIAL BUFFER 1135×8 SERIAL BUFFER 32k×8 SERIAL BUFFER	27, 49 NSEC 21, 40 NSEC 50 NSEC	CMOS DIP SMALL-OUTLINE PACKAGE	$5 (1000) $5.50 (1000) $28 (1000)	BUFFER SIZE CHOSEN FOR VIDEO APPLICATIONS.
GENERAL	XILINX AMD	2064 2018 3020 3030 3042 3064 3090	USER-PROGRAMMABLE 1200 GATES USER-PROGRAMMABLE 1800 GATES USER-PROGRAMMABLE 2000 GATES USER-PROGRAMMABLE 3000 GATES USER-PROGRAMMABLE 4200 GATES USER-PROGRAMMABLE 6400 GATES USER-PROGRAMMABLE 9000 GATES	100 MHz 100 MHz 100 MHz 100 MHz 100 MHz 100 MHz 100 MHz	CMOS	$10 TO $150 (1000)	CAN BE "SET-UP" BY HOST μP. WRITE PATTERNS INTO INTERNAL RAM THAT CONFIGURES LOGIC.
GENERAL	GAZELLE	2358	124 PRODUCT-TERM PLD WITH 6 BURIED REGISTERS	7.5 NSEC 10 NSEC	GaAs 20-PIN	$43 $35	

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NA = NOT AVAILABLE
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Up to 0.3 μF

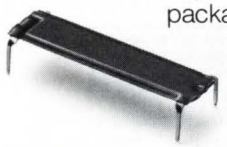
MICRO/Q 2000 capacitors have available capacitance levels from 0.01 μF to 0.3 μF. Reduce board level noise up to a factor of 10. And MICRO/Q 2000's molded construction seals out moisture and humidity.

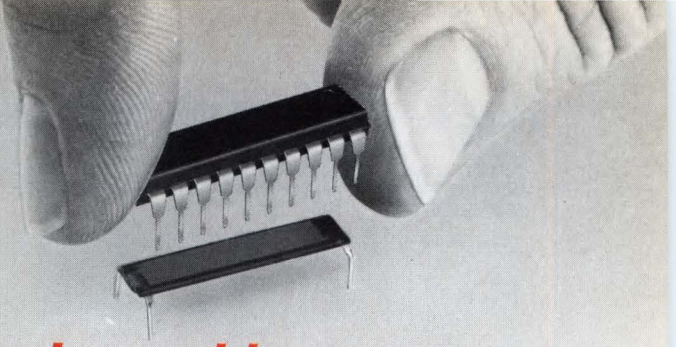
Improve existing board performance

MICRO/Q 1000 capacitors can be retrofitted to solve noise problems on existing boards. Because MICRO/Q 1000 caps share mounting holes with existing IC pins, no board redesign is required. Effective decoupling becomes a matter of adding one insertion step.

Simplify board layout and get a choice

MICRO/Q 1000 ceramic decoupling capacitors share board mounting holes with IC pins. You don't have to waste space on additional holes, as you do for standard caps. Simplifying board design opens up two very attractive options. Add more active devices with increased packaging density in the same space, or design the same package on a smaller board. Either way, you win with MICRO/Q 1000.





noise problems... space problems... EMI/RFI problems...

TOP THIS.

Rogers MICRO/Q® decoupling capacitors reduce voltage noise spikes in IC s, often by as much as a factor of ten. And since they're easily mounted *underneath* the IC, MICRO/Q capacitors conserve valuable board real estate, too. A range of configurations makes MICRO/Q flat capacitors especially effective at reducing noise on:

- 256 K RAMs
- Video RAMs
- EPROMs
- Static RAMs
- Microprocessors
- Bus drivers/buffers
- Other ICs where noise spikes create performance problems
- Boards that need EMI/RFI fix
- CAD/CAM/CAE
- Telecommunications
- Minicomputers
- Printers and copiers
- Single-board computers

Find out how MICRO/Q capacitors reduce noise and provide better board density. Get the full story and a free sample. Call a Rogers MICRO/Q Product Specialist today, at (602) 967-0624. Fax (602) 967-9385.

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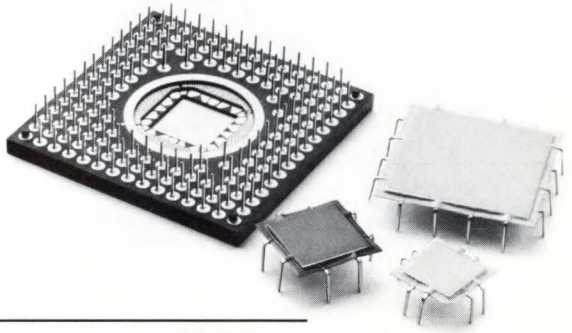
Design noise out of PGA and LCC packages

MICRO/Q 3000 capacitors provide effective solutions to noise problems with VLSI PGA packages and LCC sockets. Design effective decoupling on complex multi-layer board layouts by fitting MICRO/Q 3000 capacitors under PGA or LCC sockets. They occupy no additional board space and provide the low-inductance, high-frequency decoupling required by today's VLSI packages. Available in a range of pinout configurations.



For information on all of these Rogers products **CIRCLE NO 42**

TABLE 2—COMBINATION CHIPS AND CHIP SETS

THESE DEVICES COMBINE SEVERAL SUPPORT AND μC SYSTEM FUNCTIONS. IN THE PAST THEY WERE POPULAR BECAUSE THEY PERMITTED ECONOMICAL 2-CHIP SYSTEMS. NOW THE TREND IS TO COMBINE SUPPORT FUNCTIONS WITH μP ITSELF AND CREATE A SYSTEM ON A CHIP. MASS-PRODUCED PERSONAL COMPUTERS IS HAVING A PROFOUND EFFECT.

μP BUS COMPATIBILITY	SUPPLIER	MODEL	SPEED	PARALLEL I/O PORTS	SERIAL I/O PORTS	TIMERS, EVENT COUNTERS, CLOCKS	NUMBER CRUNCHERS	INTERRUPT CONTROLLERS	DMA CONTROLLERS	MEMORY	SYSTEM FIRMWARE	SYSTEM GLUE	PERIPHERAL CONTROLLERS	TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
80286 (PC/AT)	ERSO	83745 83746 83747	8, 10, 12 MHz	• •	•	• • •		•	• • •	• •		• • •		CMOS 5V 68-LEAD PLCC	$50 KIT ($110 BOARD) SAMPLES	HIGH-INTEGRATION CHIP SET FOR BUILDING PC/AT CLONES FROM TAIWAN FOUNDRY. ALSO 83748/9 FOR ADDRESS AND DATA.
80286	ERSO	83100 83101 83102 83103 83104	12, 16, 20 MHz			• •		•	•	• • •		• • • • •	•	CMOS 5V 84-PIN 100-PIN FLAT PACK	$170 KIT	PS/2 MODEL 60 CHIP SET.
Z80	ZILOG	8AC90	8, 10 MHz	•	•	•								CMOS 5V 84-LEAD PLCC 44-LEAD QUAD FLAT PACK	$9.64	INTEGRATES COUNTER/TIMER, SERIAL I/O AND PARALLEL I/O FOR Z80-BASED SYSTEMS.
Z180	ZILOG	Z80180	6, 8, 10 MHz		•	•		•	•	•		•	•	CMOS 8-BIT μP	$8.93	INTEGRATES I/O DEVICES. MMU ALLOWS 1M-BYTE ADDRESSING, DMA, UART & TIMER CHANNELS. INCLUDES GLUE FUNCTIONS: DYNAMIC RAM REFRESH, WAIT-STATE GENERATORS, CLOCK OSCILLATOR & INTERRUPT CONTROL.
Z280	ZILOG	Z80280	10 MHz		•	•		•	•	•		•	•	CMOS 16-BIT CPU	$28.57	CODE COMPATIBLE TO Z80. 8- AND 16-BIT BUS-WIDTH-SELECTABLE. MMU GIVES PROCESSOR ACCESS TO 16M-BYTE MEMORY. ALSO INCLUDES ON-CHIP INSTRUCTION AND CACHE MEMORY, 3-STAGE PIPELINE.
80386SX	CHIPS AND TECHNOLOGIES	CS8281	16, 20 MHz	•	•	•		•	•	•	•	•	•	CMOS 84-PIN PLCC	$85.55	4-CHIP 386SX. ASYNCHRONOUS ARCHITECTURE.
80386	CHIPS AND TECHNOLOGIES	280 281	20, 25, 35 MHz	• •	• •	• •		• •	• •	• •	• •	• •	• •	CMOS 5V 100-PIN PLASTIC FLAT PACK 160-PIN PLASTIC FLAT PACK 174-PIN PLASTIC FLAT PACK 84-PIN PLCC	$295.10 (1000) $333.90 (1000)	7 CHIP MCA MODEL 70 AND 80 INCLUDING GRAPHICS.
80286	CHIPS AND TECHNOLOGIES	250	10, 12, 16, 20 MHz	•	•	•		•	•	•	•	•	•	CMOS 5V 100-PIN PLASTIC FLAT PACK 84-PIN PLCC 144-PIN PLCC	$125 (1000)	IMPLEMENTS ALL LOGIC FOR PS/2 MODEL 50 COMPATIBLE PLUS GRAPHICS, COMMUNICATIONS, AND PERIPHERAL CONTROL.
80386	INTEL	82350	33 MHz			•	•	•	•	•		•		CMOS 132-LEAD SMT	$213	EISA CHIP SET INCLUDES BUS CONTROLLER FOR THE 386 AND HIGHER-PERFORMANCE CPUs, A BUS MASTER ADAPTER SUPPORTING I/O CAPABILITIES, AND AN EISA BUS BUFFER.
80386	INTEL	82311	16, 20, 25 MHz	•		•		•	•	•			•	CMOS SMT JEDEC PKGS	$171 16 MHz TO $311 25 MHz	MICRO-CHANNEL CHIP SET CONSISTS OF SEVEN COMPONENTS.
80376	INTEL	82370	16 MHz			•		•	•	•		•		CMOS 5V 100-PIN PLASTIC QUAD FLAT PACK 132-PIN PGA	$57 $77	MULTIFUNCTION SUPPORT PERIPHERAL. 8 CHANNELS, 32-BIT DMA (32-BIT EXTERNAL, 16-BIT INTERNAL).
80386SX	G-2	181 182 183 184 186 205	NA	•	•	•		•	•	•	•	•	•	CMOS AND BiCMOS 68-PIN PLCC 120-PIN QUAD FLAT PACK 160-PIN QUAD FLAT PACK	$222 1k	BIOS INCLUDED WITH CHIP SET.

— = NOT APPLICABLE
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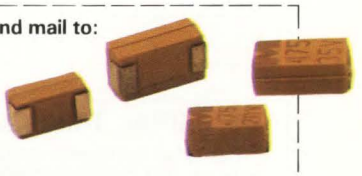

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TABLE 2—COMBINATION CHIPS AND CHIP SETS *(continued)*

μP BUS COMPAT-IBILITY	SUPPLIER	MODEL	SPEED	PARALLEL I/O PORTS	SERIAL I/O PORTS	TIMERS, EVENT COUNTERS, CLOCKS	NUMBER CRUNCHERS	INTERRUPT CONTROLLERS	DMA CONTROLLERS	MEMORY	SYSTEM FIRMWARE	SYSTEM GLUE	PERIPHERAL CONTROLLERS	TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
PC/XT PS/2 M30	VADEM	VG-501 VG-502	16 MHz					•	•	•		• •	•	CMOS, 84-PIN PLCC	$42 SET	COMPLETE PC/XT, PS/2 M30 SOLUTION FOR INTEL 80C186. REQUIRES CPU, 3 CHIPS, MEMORY. INCLUDES FULL EMS 4.0 SUPPORT TO 32M BYTES.
GENERAL	VADEM	VG-603	10 MHz	•	•	•				•		•	•	CMOS, 84-PIN PLCC	$21	GENERAL-PURPOSE PERIPHERAL FOR ALL PC AND PS/2 SYSTEMS. INCLUDES VALUABLE SYSTEM GLUE, 8250-COMPATIBLE RS-232C, BIDIRECTIONAL PARALLEL I/O, PC/AT-COMPATIBLE REAL-TIME CLOCK, ROM DISK SUPPORT LOGIC.

TABLE GROUP 3—PERIPHERAL-DEVICE CONTROLLER CHIPS

3A DISK CONTROLLERS

RELIEVE μP AND ITS OPERATING SYSTEM OF HARDWARE AND SOFTWARE OVERHEAD REQUIRED TO READ, WRITE, AND SEARCH FOR RECORDS IN PROPER DISK FORMAT. CHORES INCLUDE HEAD POSITIONING, CRC GENERATION, PROGRAM SECTOR SIZE, ETC. SEVERAL STANDARDS LIKE SCSI APPLICABLE (SEE **TABLE 1A** FOR SCSI CHIPS).

μP BUS COMPAT-IBILITY	SUPPLIER	MODEL	SPEED	COMPAT-IBILITY	FEATURES	TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
INTEL	ADAPTEC	6160 6110	20 MHz NRZ 15 MHz RLL	IBM PC/AT SCSI	HOST BUS DRIVER DRAM BUFFER MEMORY	CMOS 5V PLCC OR QUAD FLAT PACK	$30 $25	COMPATIBLE WITH INDUSTRY-STANDARD ARCHITECTURE.
80286 80386	INTEL	82077	25 MHz	FLOPPY	16-BYTE FIFO. SINGLE-CHIP VERTICAL RECORDING FORMAT. HIGH-SPEED PROCESSOR INTERFACE	CMOS 68-LEAD PLCC	$20	HARDWARE COMPATIBLE WITH PC/AT AND PS/2.
GENERAL	ZILOG	765A	8 MHz	FLOPPY ST506	IBM COMPATIBLE. TRANSFERS DATA IN DMA OR NON-DMA MODE; MULTISECTOR AND MULTITRACK TRANSFER	40-PIN DIP 44-PIN PLCC	$2.86	COMPATIBLE WITH 052 MULTITASKING OPERATIONS.
GENERAL	INMOS	M212-G155	15 MHz	ST506 ST412 SA400 SA450	TWO 8-BIT BIDIRECTIONAL DATA PORTS, 2k BYTES ON-CHIP RAM. BOOTSTRAP FROM ROM, LINK, OR DISK	CMOS 5V 68-PIN PGA 68-PIN PLASTIC J-LEAD	$90	COMPATIBLE WITH TRANSPUTER.
GENERAL	NEC	72061	24 MHz	SMD SMD-E ST506 ST412	8-BYTE FIFO. PARALLEL SEEK. PROGRAMMABLE TRACK FORMAT	CMOS 5V 40-PIN DIP 52-LEAD QUAD FLAT PACK 52-PIN PLCC	$30	CMOS VERSION OF 7261, SUPPORTING SMD-E DRIVES AND BATTERY APPLICATIONS.

3B SERIAL TAPE CONTROLLERS

THESE DEVICES INTERPRET HIGH-LEVEL READ, WRITE, AND SEARCH COMMANDS ISSUED BY μP AND GENERATE DETAILED MOTION-CONTROL SIGNALS. ALSO CONVERT PARALLEL DATA FROM μP BUS TO SERIAL FORMAT, SOMETIMES PROVIDING ERROR DETECTION. SOME INTEREST IN HAVING STANDARD BUSES LIKE SASI, SCSI, ETC.

μP BUS COMPAT-IBILITY	SUPPLIER	MODEL	SPEED	KEY SPECIFICATIONS			TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
				COMPAT-IBILITY	DRIVES HANDLED	FEATURES			
Z80 8085 80188	WD	4360	6 MHz	QIC36 QIC24 QIC11	—	SEPARATE μP AND TAPE DATA BUS. SYNC AND ASYNC TAPE DATA-BUS TRANSFERS. BUILT IN CRYSTAL DRIVER, NRZ SERIAL INPUT/OUTPUT DATA COMPARE.	CMOS 5V 68-LEAD PLCC	$33	HANDLES ALL OPERATIONS INVOLVING SERIAL-TO-PARALLEL AND PARALLEL-TO-SERIAL DATA CONVERSIONS. SEPARATE TAPE AND μP BUSES SUPPORT HIGH-BANDWIDTH SYSTEMS.

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3C CRT AND LASER-PRINTER CONTROLLERS AND GRAPHICS GENERATORS

ACCEPT SETUP COMMANDS FROM μP THAT DEFINE DESIRED DISPLAY (USUALLY A RASTER TYPE) AND THEN IMPLEMENT AND MAINTAIN THE DISPLAY AUTOMATICALLY. FUNCTIONS OFTEN INCLUDE FORMATTING DATA FROM μP BUS FOR VIDEO PRESENTATION TO CRT, USING CHARACTER-GENERATING CHIP IF REQUIRED. TEXT AND GRAPHIC MODES, AS WITH DISKS (**TABLE 3A**) STANDARDS ARE EMERGING. RECENT TREND IS POWERFUL GRAPHIC ENGINES THAT CAN, FOR EXAMPLE, CREATE 3D PICTURES OF OBJECTS WITH PERSPECTIVE AND SHADING, AND ROTATE THEM. LASER PRINTER CONTROLLERS MAY BE INCLUDED, BECAUSE THEY HAVE SIMILAR "RASTER" SCAN.

μP BUS COMPATIBILITY	SUPPLIER	MODEL	SPEED	KEY SPECIFICATIONS				TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
				PROGRAMMABLE DISPLAY FORMAT	PROGRAMMABLE MONITOR FORMAT	GRAPHIC CAPABILITY	CURSOR/ LIGHT PEN			
GENERAL	CIRRUS	GD-610/620	33 MHz	YES	YES	YES	YES	CMOS 100-PIN QUAD FLAT PACK	$52.50	CAN BE USED WITH FLAT-PANEL DISPLAYS AS WELL AS CRT DISPLAYS. AUTOMATICALLY MAPS COLORS INTO AS MANY AS 32 SHADES OF GREY FOR LCD DISPLAYS.
GENERAL	CIRRUS	GP-340	10 MHz	—	—	40 PAGES PER MINUTE AT 300 DPI WITH 5000 CHARACTERS PER PAGE USING 10-POINT FORMAT	—	CMOS 5V 84-PIN PLCC	$53.30	BUILDS RASTER IMAGE OF PAGE, SCANS IT TO A RASTER ENGINE AND PERFORMS DYNAMIC-RAM REFRESH AND CONTROL. OFF-LOADS CPU AND REDUCES MEMORY REQUIREMENTS.
GENERAL	INMOS	G300	66 MHz 85 MHz 100 MHz 110 MHz	YES	YES	—	—	CMOS 5V 84-PIN PGA 84-PIN QUAD CERPACK	$107 85 MHz	PROGRAMMABLE COLOR VIDEO CONTROLLER, WHICH INCORPORATES A COLOR LOOK-UP TABLE AND VIDEO TIMING GENERATOR, FULL BIT-MAP MANAGEMENT, TRIPLE 8-BIT DACs AND A PLL.
GENERAL	NATIONAL	8530	125 MHz	—	—	—	—	BIPOLAR 44-PIN PLCC	$16	ON-CHIP CRYSTAL OSCILLATOR AND PLL GENERATE SYSTEM, LOAD, AND PIXEL CLOCKS.
GENERAL	NATIONAL	32CG16	10 MHz 15 MHz	—	—	BILBLT	—	CMOS 5V 68-LEAD PLCC	$24.90	32-BIT PROCESSOR WITH 16M-BYTE ADDRESS SPACE, 16-BIT DATA BUS, 32-BIT ALU, 8-BYTE PREFETCH QUEUE, AND A SLAVE PROCESSOR INTERFACE.
GENERAL	NEC	72020	8 MHz	YES 2k×2k	YES	YES	YES	CMOS 5V 40-PIN DIP 52-PIN QUAD FLAT PACK	$20	CMOS 7220 WITH 2M VIDEO MEMORY, VIDEO RAM CONTROL, WRITE MASK CONTROL, AND ENHANCED SYNCHRONIZATION FUNCTION.
GENERAL	NEC	72123	10 MHz	YES 4k×4k 32 MB	YES	YES	YES	CMOS 5V 94-PIN QUAD FLAT PACK 84-PIN PLCC	$45	72120 WITH 2 X-Y COORDINATE SYSTEMS, 32-BIT LINE PATTERNS, 3 RASTER OPERATIONS, TRAPEZOID FILL, HIGHER PAINT FILL. ADDITIONAL LASER-PRINTER CONTROL OPTIONS.
GENERAL	ZILOG	Z7220A	2 MHz (PIXEL) 8 MHz (CLOCK)	YES		YES	INPUT, YES	NMOS 5V 40-PIN DIP	$10	HIGH-PERFORMANCE (HGDC). GENERATES RASTER DISPLAY AND MANAGES MEMORY. HGDC CAN BE CONFIGURED IN MANY FORMATS AND SIZES UP TO 256k 16-BIT WORDS.
GENERAL	WEITEK	XL-8200 (TWO CHIPS)	3, 5, 8, 12 MHz	—	—	DRAWS 60k VECTORS/ SEC. FILLS 9.6 PIXEL/SEC	—	CMOS 144-PIN PACKAGE	$195 TO $360	FAMILY OF 32-BIT μPs OPTIMIZED FOR POSTSCRIPT PROCESSING. PERFORM 2D DRAW AND FILL OPERATIONS AND ARE SUPPORTED BY C AND FORTRAN COMPILERS. XL-8200 IS 32-BIT μP FOR BLACK-AND-WHITE PAGE PRINTERS; XL-8232 IS FLOATING-POINT μP FOR COLOR AND KANJI PAGE PRINTERS.
		XL-8032 XL-8232 (THREE CHIPS)	5, 8 MHz	—	—	SAME AS 8000 PLUS TRANSFORMS 200k 3D VECTORS/SEC	—	CMOS 144-PIN PGA	XL-8232 $420 TO $540	

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GENERAL DYNAMICS LAND SYSTEMS

Generations from now, when today's state-of-the-art fighting systems have taken their place in armament history books, today's Abbott power supplies will still be operating reliably.

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3D KEYBOARD AND NON-CRT DISPLAY INTERFACES

μP BUS COMPAT-IBILITY	SUPPLIER	MODEL	SPEED	DISPLAY BIT PATTERNS	TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
GENERAL	CYBERNETIC MICROSYSTEMS	CY325	—	16 ROWS×40 CHARACTERS. 128×240-PIXEL GRAPHICS. UP TO 256 BUILT-IN WINDOWS WITH FIRMWARE PROVIDING EASY-TO-USE HIGH-LEVEL COMMANDS.	CMOS 5V 40-PIN DIP	$35	LCD WINDOWS CONTROLLER. 8 SOFT KEYS FOR MENU RESPONSE, ETC.
GENERAL	MAXIM	MAX7231	250 kHz	8-DIGIT PLUS 16-ANNUNCIATOR LCD DRIVER. HEX, BCD, CODE B	CMOS 40-LEAD PLASTIC DIP	$5.25	6-BIT PARALLEL INPUT.
GENERAL	MAXIM	MAX7232	1 MHz	10-DIGIT PLUS 20-ANNUNCIATOR LCD DRIVER. HEX, BCD, CODE B	CMOS 40-LEAD PLASTIC DIP	$5.06	BIT SERIAL INPUT.
GENERAL	MAXIM	ICM7218 AND ICM7228	800 kHz	8-DIGIT LED DRIVER. HEX, BCD, CODE B AND NO DECODE	CMOS 28-LEAD PLASTIC DIP	$5.09	8-BIT PARALLEL INPUT.
GENERAL	VADEM	VG-600	16 MHz	640×200 OR 640×400 RESOLUTION. CGA, DOUBLE-SCAN CGA, AT&T GRAPHICS MDA. 8-LEVEL GREY SCALE IN CGA MODE.	CMOS 100-PIN QUAD FLAT PACK	$28	SINGLE-CHIP LCD CONTROLLER. REQUIRES NO GLUE LOGIC IN MOST CONFIGURATIONS. SUPPORTS DRAM OR SRAM AS VIDEO MEMORY.

3E POWER DRIVERS AND CONTROLLERS

MANY OF THESE DEVICES CAN DRIVE THE INDUCTIVE LOADS OF ELECTROMECHANICAL MACHINERY. NEW EMPHASIS IS TO MAKE THEM "SMART," INCORPORATING SELF-CONTROL AND THE ABILITY TO FEED BACK INFORMATION TO THE HOST μP.

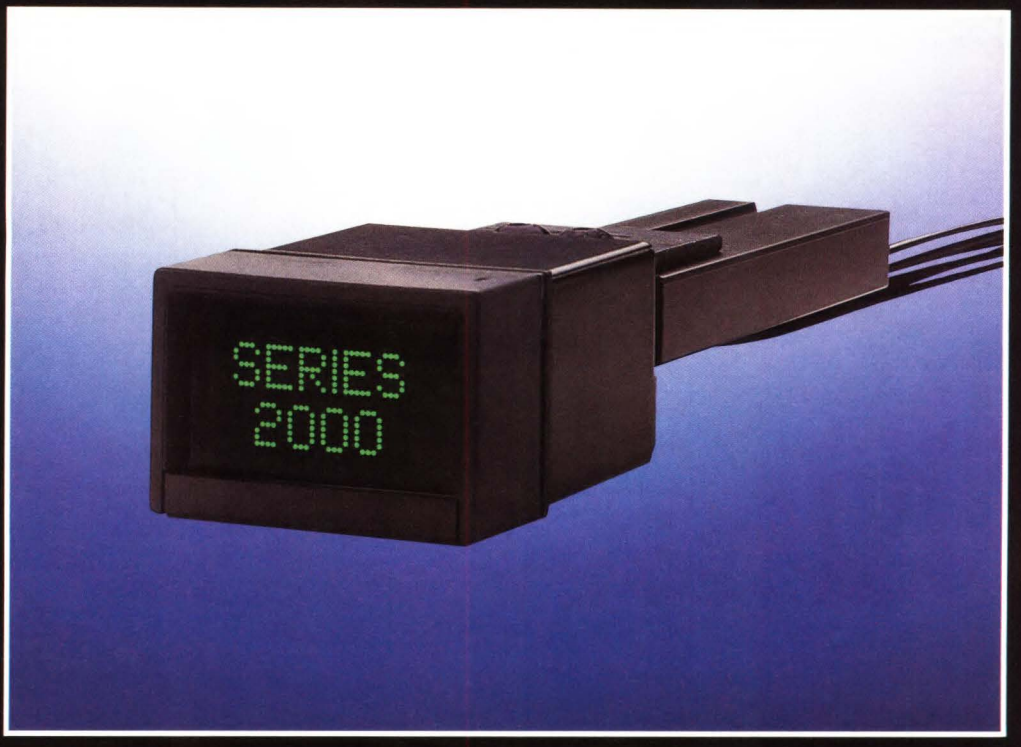
μP BUS COMPAT-IBILITY	SUPPLIER	MODEL	KEY SPECIFICATIONS		TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
			OUTPUT SPEED	OTHER FEATURES			
GENERAL	CALMOS	2862	—	2.5V PRECISION REFERENCE 3 SEPARATE WINDOW COMPARATORS	BIPOLAR 16-PIN SOIC	$3.30	MONITORS 3 POWER SUPPLIES FOR OVER/ UNDERVOLTAGE TRANSIENTS.
GENERAL	SILICONIX	9950	25-NSEC SWITCHING TIME	2A, 50V	DMOS 16-PIN SOIC	$2.33	COMPLIMENTARY HALF-BRIDGE DRIVER FOR SMALL MOTORS AND INTERFACE TO LARGE MOSFETs.
GENERAL	SPRAGUE	UDN2547B UDN2547EB	—	600 mA, 60V OUT	BIPOLAR 16-PIN DIP 28-LEAD PLCC	$2.72 $3.28	PROTECTED QUAD DRIVERS, INDEPENDENT OVERCURRENT AND THERMAL PROTECTION FOR EACH CHANNEL, OUTPUT SAFE-OPERATING-AREA PROTECTION.
GENERAL	SPRAGUE	UDN2916B UDN2916EB	—	750 mA, 45V OUT	BIPOLAR 24-PIN DIP 44-LEAD PLCC	$2.72 $3.13	DUAL FULL-BRIDGE PWM MOTOR DRIVERS, INTERNAL CLAMP DIODES, PWM CURRENT CONTROL AND THERMAL SHUTDOWN, LOW SATURATION VOLTAGE.
GENERAL	SPRAGUE	UCN5929B	—	1.7A, 80V OUT	BiMOS 16-PIN DIP	$2.87	3-BIT SERIAL-INPUT LATCHED SINK DRIVER, INTERNAL HIGH-CURRENT CLAMP DIODES, GUARANTEED 3.3-MHz DATA RATE INPUT.

TABLE 4—μPs AND μP-LIKE CHIPS

THE ULTIMATE IN FLEXIBILITY, THESE GENERAL-PURPOSE μCs AND μPs ARE INCLUDED HERE BECAUSE THEY ARE SO WIDELY USED IN LIEU OF THE DEDICATED CONTROLLER CHIPS LISTED IN OTHER TABLES OF DIRECTORY (FOR EXAMPLE, THE 8051 μC—LIKE ITS FORERUNNER, THE 8048—IS WIDELY USED IN LIEU OF THE KEYBOARD CONTROLLERS OF **TABLE 3D**). THE CURRENT TREND IS THE USE OF MORE POWERFUL 16-BIT AND 32-BIT μP/μCs FOR SOPHISTICATED PERIPHERALS LIKE LASER PRINTERS.

μP BUS COMPAT-IBILITY	SUPPLIER	MODEL	SPEED	KEY SPECIFICATIONS				TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
				ROM (BYTES)	RAM (BYTES)	PORT (BITS)	TIMER (BITS)			
GENERAL 16 BIT	INMOS	T222-J175 T222-G175 T222-G205	17, 20 MHz	—	4k BYTES	—	2×16	CMOS 5V 68-PIN PGA PLCC	$100	PIN COMPATIBLE WITH T212 BUT IS EASIER TO CONNECT WITH MEMORY SUBSYSTEM AND HAS BETTER BIDIRECTIONAL LINKS.
GENERAL 16 BIT	NATIONAL	HPC 16083	17, 30 MHz	8k	256	53	8×(16)	CMOS 5V 68-PIN PCC, LCC, PGA, AND 84-PIN TAPEPAK	$10	16-BIT CONTROLLER WITH UART, MICROWIRE SERIAL PORTS, AND UNIVERSAL PERIPHERAL INTERFACE PORT.
Z80	ZILOG	Z80280	10 MHz	—	—	—	—	CMOS 16-BIT MPU	$28.57	CODE COMPATIBLE TO Z80, 8- AND 16-BIT BUS SELECTABLE, MMU, CACHE MEMORY, 3-STAGE PIPELINE.

— = NOT APPLICABLE
NA = NOT AVAILABLE
THE VOLUME OF AVAILABLE SUPPORT CHIPS PREVENTS INCLUSION OF ALL APPROPRIATE DEVICES IN THIS DIRECTORY. FOR MORE INFORMATION, REFER TO THE MANUFACTURER/PRODUCT LISTING AT THE BEGINNING OF THE DIRECTORY.



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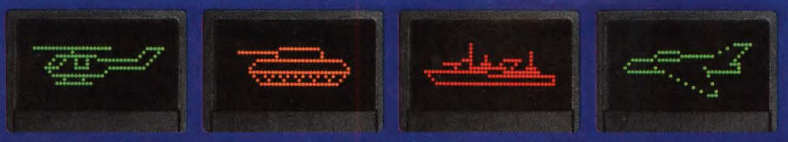

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CIRCLE NO 86

TABLE 4—μPs AND μP-LIKE CHIPS *(continued)*

μP BUS COMPATIBILITY	SUPPLIER	MODEL	SPEED	KEY SPECIFICATIONS				TECHNOLOGY/ PACKAGE	PRICE (100)	COMMENTS
				ROM (BYTES)	RAM (BYTES)	PORT (BITS)	TIMER (BITS)			
Z8000	ZILOG	Z08160	6, 10 MHz	—	—	—	—	44-PIN PLCC	$11.29	2M-BYTE CPU IN Z8000 ARCHITECTURE. 16-BIT OPERATIONS COMPATIBLE CODE TO Z08001 AND Z08002.
GENERAL 8 BIT	SIERRA	SC44820	1-μSEC INSTR CYCLE	1k	64	16 TO 36	16 (ALSO WATCHDOG AND IDLE)	CMOS 2.5 TO 6.0V 20- AND 28-PIN DIP & PLCC	$2	SAID TO BE 8-BIT VERSION OF ORIGINAL 4-BIT COP BUT DIFFERENT ARCHITECTURAL DETAILS AND INSTRUCTION SET.
GENERAL 8 BIT	SIERRA	SC48620	1-μSEC INSTR CYCLE	1k	64 RAM & 64 EEPROM	16 TO 36	16 (ALSO WATCHDOG AND IDLE)	CMOS 2.5 TO 6.0V 20- AND 28-PIN DIP & PLCC	$6 TO $8	SAID TO BE 8-BIT VERSION OF ORIGINAL 4-BIT COP BUT DIFFERENT ARCHITECTURAL DETAILS AND INSTRUCTION SET.
GENERAL 8 BIT	SIERRA	SC48720	1-μSEC INSTR CYCLE	1k EEPROM	64 RAM & 64 EEPROM	16 TO 36	16 (ALSO WATCHDOG AND IDLE)	CMOS 2.5 TO 6.0V 20- AND 28-PIN DIP & PLCC	$10 TO $12	SAID TO BE 8-BIT VERSION OF ORIGINAL 4-BIT COP BUT DIFFERENT ARCHITECTURAL DETAILS AND INSTRUCTION SET.
GENERAL 32 BIT	VLSI TECH	86C020	20 MHz (12 MIPS)	—	27×(32) REGISTER FILE 4k-BYTE CACHE MEMORY	—	—	CMOS 5V 84-PIN LCC 100-LEAD QUAD FLAT PACK	$170 PRODUCTION 4Q89	32-BIT μP EXAMPLE OF NEW RISC ARCHITECTURE SAID TO MAKE FOR SIMPLICITY AND LOW COST WITH 32-BIT PERFORMANCE WILL PROBABLY BE USED FOR SUPPORT SUBSYSTEMS.
DSP56001 56 BIT	MOTOROLA	56001XL20	20 MHz	—	2×512×24	24	—	CMOS 5V 100-PIN SLAM PAK	$67	DIGITAL SIGNAL PROCESSOR.
6800	MOTOROLA	68HC11A8	2.1-MHz BUS	8k×8	256×8	38	1×16 1×8	CMOS 5V 52-PIN PLCC	$12.62 (1000)	256×8 EEPROM ON CHIP.
88100 32 BIT	MOTOROLA	88000	20 MHz	—	—	—	—	CMOS 5V 180-PIN PGA	$395	ONBOARD FLOATING-POINT UNIT. 32×32-BIT REGISTER FILE. MULTIPLE CONCURRENT INSTRUCTION EXECUTION.
68000	SIGNETICS	68070	10, 12.5, 15 MHz	—	—	—	3×16	CMOS 5V 84-PIN PLCC	10 MHz, $29.95 12.5 MHz, $33.35 15 MHz, $39.95	68000 CPU+MMU+DUAL DMA+UART+TIMERS+I²C SERIAL BUS.
GENERAL	SIGNETICS	80C552	12 AND 16 MHz	8k	256	48	4 (16 BITS EACH)	CMOS 68-PIN PLCC	$10	10-BIT ADC, WATCHDOG TIMER, 2 PULSE-WIDTH MODULATORS.
		80C652	12 AND 16 MHz	8K	256	32	4 (16 BITS EACH)	CMOS 40-PIN DIP 44-PIN PLCC	$6	I²C SERIAL BUS.

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NA = NOT AVAILABLE
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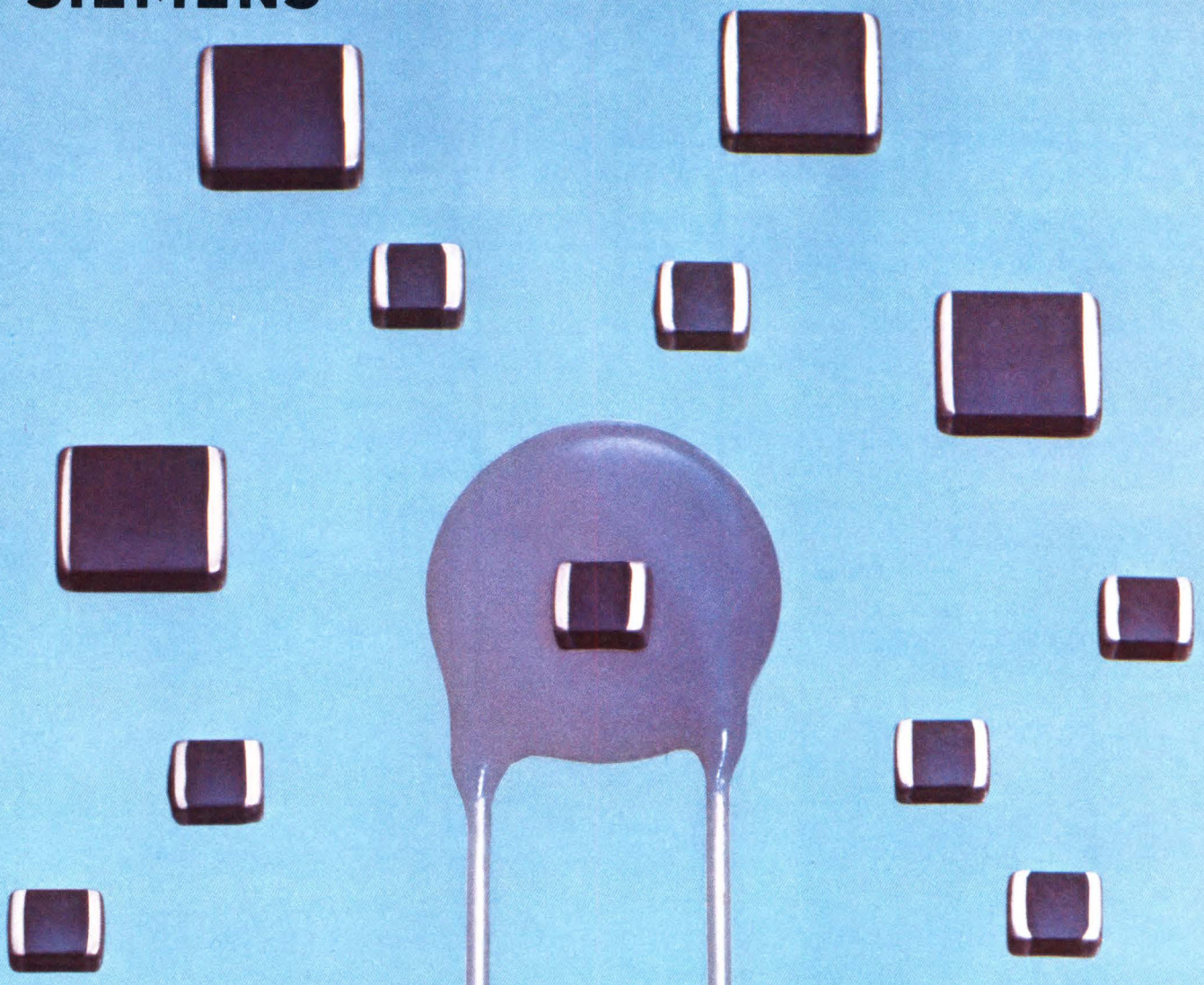

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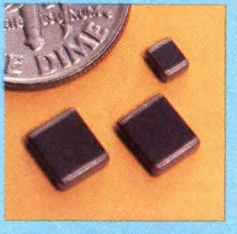

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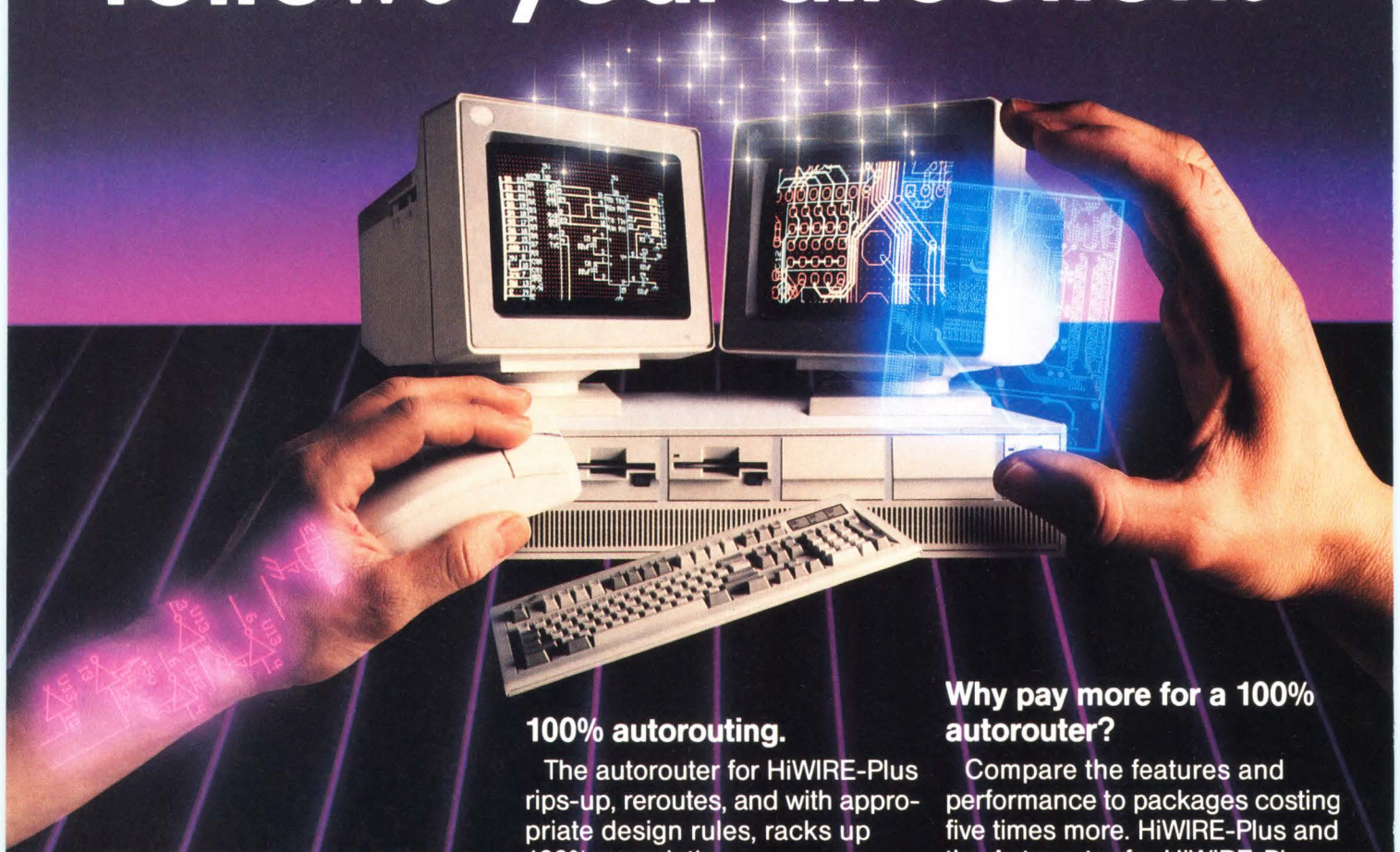

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CIRCLE NO 137

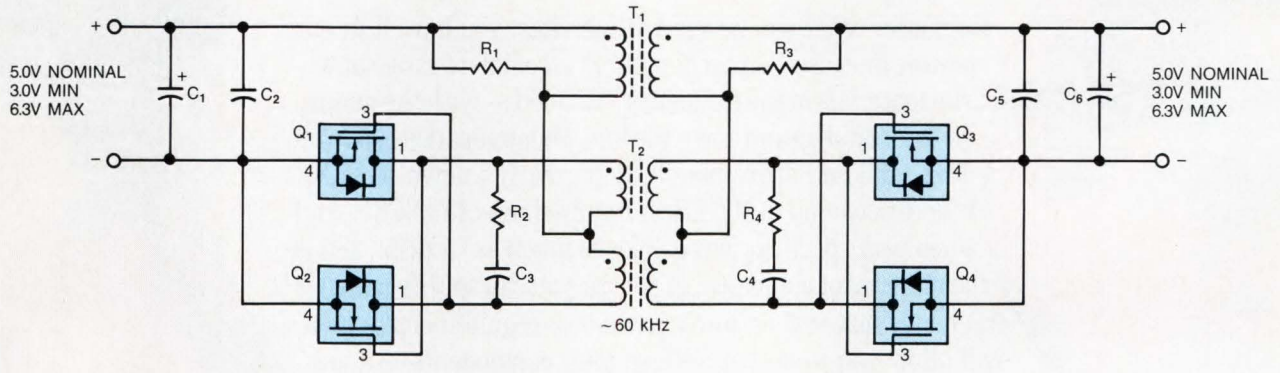
EDITED BY CHARLES H SMALL

Power isolators are bidirectional

John LaBelle
Logical Control Engineering, Long Beach, CA

The power isolators in **Figs 1** and **2** have the remarkable property of being bidirectional. That is, you can energize either side of the circuits with the appropriate voltage and draw regulated current from the other side.

In operation, the FETs on the powered side of the isolator drive transformer T_2 into saturation first in one direction, then in the opposite direction. T_2's winding inductance disappears when the transformer goes into saturation. Transformer T_1 provides the input-to-output power coupling during T_2's saturation. Resistors R_1, R_2, R_3, and R_4 and capacitors C_3 and C_4 control the voltage overshoot from the winding's leakage induc-



PARTS LIST

REFERENCE	DESCRIPTION
C_2, C_5	0.1 μF 50V CERAMIC CAPACITOR KEMET C320C104M5U5CA
C_1, C_6	100 μF 6.3 VDC TANTALUM CAPACITOR SPRAGUE 199D107X96R3DA1
C_3, C_4	0.0015 μF 50V CERAMIC CAPACITOR KEMET C320C152M2R5CA
R_2, R_4	3.3Ω 0.25W CARBON RESISTOR ALLEN BRADLEY RCR07-3.3
R_1, R_3	10Ω 0.25W CARBON RESISTOR ALLEN BRADLEY RCR07-10
Q_1, Q_2, Q_3, Q_4	N-CHANNEL POWER MOSFET INTERNATIONAL RECTIFIER IRFD120
T_1	2 STRANDS OF #28 AWG KYNAR INSULATED WIRE-WRAP WIRE. 7 TURNS BIFILAR WOUND ON FERROXCUBE 266T125-3E2A CORE
T_2	4 STRANDS OF #28 AWG KYNAR INSULATED WIRE-WRAP WIRE. 7 TURNS QUADFILAR WOUND ON FERROXCUBE 266T125-3E2A CORE

OUTPUT VOLTAGE VERSUS LOAD

INPUT VOLTS	INPUT AMPS	OUTPUT VOLTS	LOAD OHMS	OUTPUT AMPS	OUTPUT WATTS
5.	0.063	4.98	OPEN	0.000	0.000
5.	0.112	4.95	100	0.050	0.245
5.	0.160	4.92	50	0.098	0.484
5.	0.255	4.86	25	0.194	0.945
5.	0.439	4.74	12.5	0.379	1.80

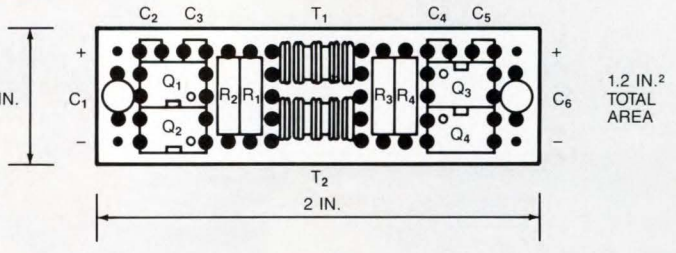


***Fig 1—This 5V, 1W power isolator** is bidirectional and provides 3750V ac isolation.*

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tance. The FETs on the load side of the isolator act as rectifiers.

The isolators operate at around 60 kHz. Their output impedance is essentially the on-resistance of the two FETs in the 5V isolator—0.6Ω—or the four FETs in the 12V isolator—2.4Ω. You can obtain stepped-up or stepped-down voltages by mating one side of the 5V circuit to one side of the 12V circuit.

If you use the specified Kynar-insulated wire (0.005-in. insulation), the transformers will provide 3750V ac rms isolation. They will also pass a 1-sec, 5000V ac rms hipot test. You can use identical transformers for T_1 and T_2 in the 5V isolator by connecting the windings of T_2 in parallel and using it as T_1. EDN

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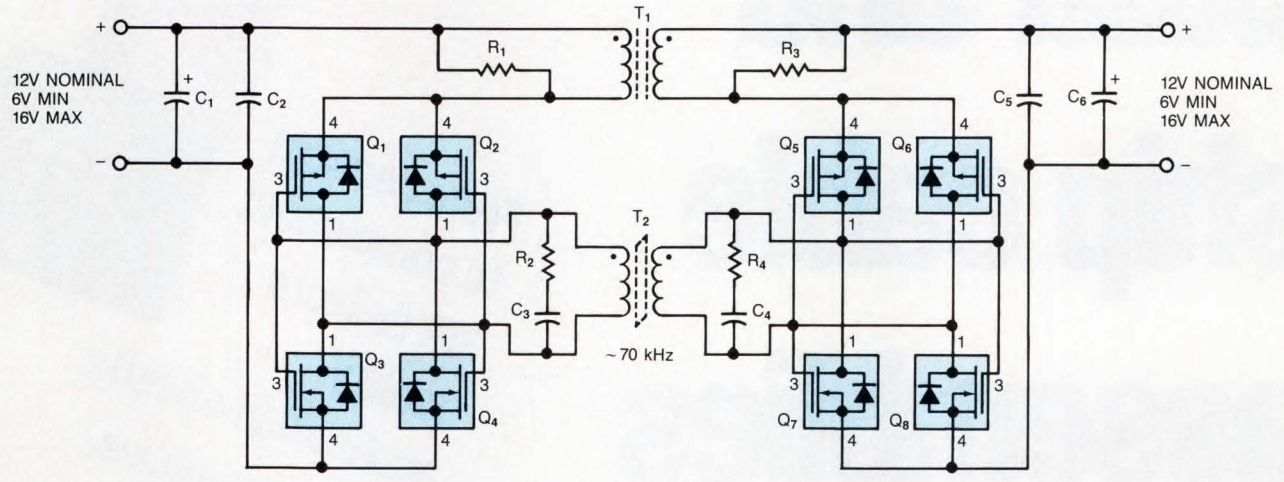

PARTS LIST

REFERENCE	DESCRIPTION
C_2, C_5	0.1 μF 50V CERAMIC CAPACITOR KEMET C320C104M5U5CA
C_1, C_6	100 μF 16 VDC TANTALUM CAPACITOR SPRAGUE 199D107X8016FE2
C_3, C_4	0.0047 μF 50V CERAMIC CAPACITOR KEMET C320C472M2R5CA
R_2, R_4	3.3Ω 0.25W CARBON RESISTOR ALLEN BRADLEY RCR07-3.3
R_1, R_3	10Ω 0.25W CARBON RESISTOR ALLEN BRADLEY RCR07-10
Q_3, Q_4, Q_7, Q_8	N-CHANNEL POWER MOSFET INTERNATIONAL RECTIFIER IRFD110
Q_1, Q_2, Q_5, Q_6	P-CHANNEL POWER MOSFET INTERNATIONAL RECTIFIER IRFD9120
T_1, T_2	2 STRANDS OF #28 AWG KYNAR INSULATED WIRE-WRAP WIRE. 14 TURNS BIFILAR WOUND ON FERROXCUBE 266T125-3E2A CORE

OUTPUT VOLTAGE VERSUS LOAD

INPUT VOLTS	INPUT AMPS	OUTPUT VOLTS	LOAD OHMS	OUTPUT AMPS	OUTPUT WATTS
12	0.059	11.93	OPEN	0.000	0.000
12	0.119	11.80	200	0.058	0.696
12	0.176	11.67	100	0.117	1.36
12	0.286	11.42	50	0.228	2.61
12	0.498	10.92	25	0.437	4.77

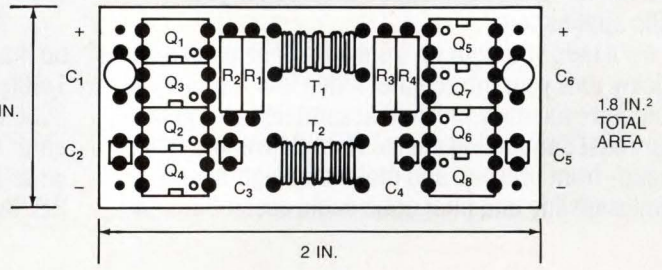

Fig 2—Similar to the circuit in Fig 1, *this circuit handles 12V at 2W.*

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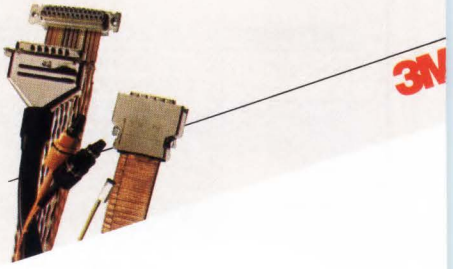

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3M

Counter divides by odd numbers

Richard Kuether
SRX, Dallas, TX

The circuit shown in **Fig 1** symmetrically divides an input by virtually any odd number. The circuit counts $n+\frac{1}{2}$ clocks twice to achieve the desired divisor. By selecting the proper n, which is the decoded output of the LS161 counter, you can obtain divisors from 3 to 31. The circuit as shown divides by 25; you can obtain higher divisors by cascading additional LS161 counters.

The counter and IC_{5A} form the $n+\frac{1}{2}$ counter. Once the counter reaches the decoded count, n, IC_{5A} ticks off an additional ½ clock, which clears the counter and puts it in hold. Additionally, IC_{5A} clocks IC_{5B}, which changes the clock phasing through the XOR gate, IC_1. The next edge of the input clocks IC_{5A}, which re-enables the counter to start counting for an additional $n+\frac{1}{2}$ cycles.

Although the circuit has been tested at 16 MHz, a worst-case timing analysis reveals that the maximum input frequency is between 7 and 8 MHz. EDN

To Vote For This Design, Circle No 748

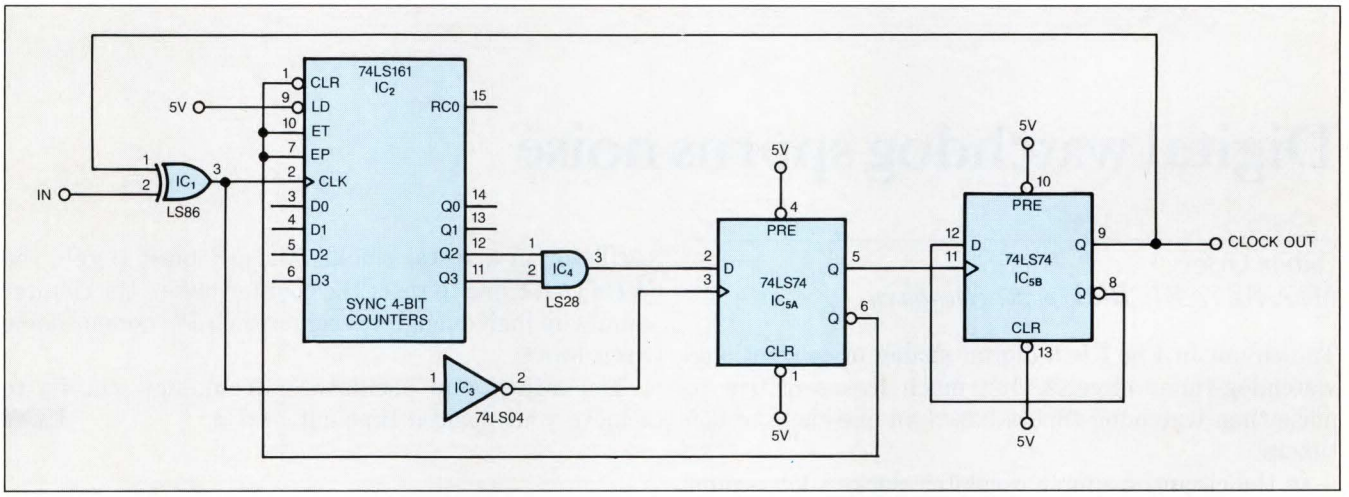

Fig 1—Depending on which outputs of the counter *you decode, this circuit can symmetrically divide the input signal by any odd number between 3 and 31.*

Routine interrupts interrupts

Woody Baker
Eagle Signal Controls, Austin, TX

The 8051 family of single-chip μPs doesn't allow more than one interrupt at a time from inputs at the same interrupt-priority level. The trick in **Listing 1** lets you re-enable interrupts during an interrupt routine.

During normal operation, when an interrupt occurs, the single-chip μP determines the interrupt's priority, vectors to the correct interrupt routine, and sets a flag that only an RETI (return from interrupt) instruction can clear. This quirk means that the single-chip μP latches only the first of several equal-priority interrupts and ignores subsequent ones.

Normally, you would only use an RETI instruction at the end of your interrupt routine. However, if you CALL an RETI instruction early in your interrupt routine, you will clear the interrupt flag without termi-

nating the interrupt routine. Don't forget to end your interrupt routine with the usual RETI instruction. Executing this second RETI instruction terminates the interrupt routine and returns control to the main program without causing any problems. EDN

To Vote For This Design, Circle No 749

LISTING 1—INTERRUPT-ENABLE WORKAROUND

```
TMRHND  PUSH    PSW     ; save registers etc...
        ...
        ...
        CALL    CLEARIN ;enable interrupts
        ...
        ...             ;rest of interrupt handler body, ending with iret.
        ...             ; the redundant RETI execution won't hurt anything
CLEARIN RETI            ;return from this interrupt.
```

Digital watchdog spurns noise

Gábor Örley
MTA-SZTAKI, Budapest, Hungary

The circuit in **Fig 1** is a digital analog of conventional watchdog-timer circuits. It's much less sensitive to noise than watchdog timers based on one-shots or 555 timers.

In the circuit, a simple oscillator clocks a long-count counter, such as an MC14020. You should enclose the oscillator in a metal shield. The μP must toggle the $\overline{\text{WDSTART}}$ line to reset the counter before the counter counts up high enough to trigger the μP's nonmaskable reset input.

You adjust the oscillator's frequency via R_2 to achieve your desired time-out period. EDN

To Vote For This Design, Circle No 747

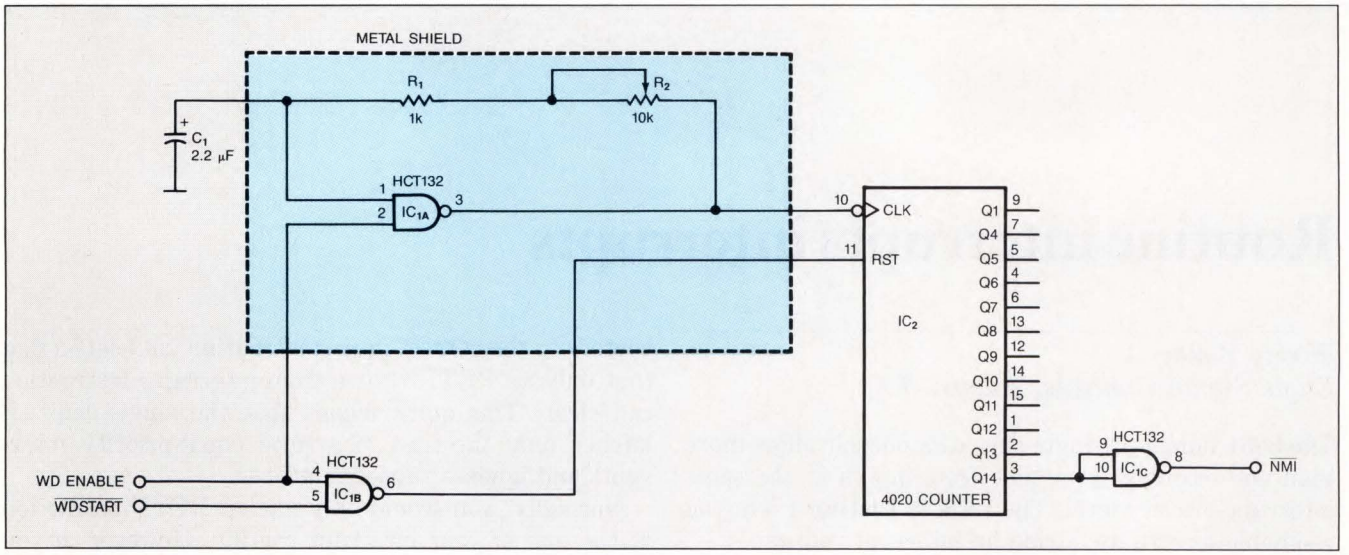

***Fig 1—This digital watchdog timer provides** noise immunity superior to that of conventional watchdog timers based on one-shots or 555 timers.*

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Insert. Loss (dB)	typ.	max.	typ.	max.
10-100MHz	1.3	1.7	1.3	1.7
100-1500MHz	1.1	1.7	1.1	1.7
1500-3000MHz	1.8	2.5	1.8	2.5
Isolation(dB)	typ.	min.	typ.	min.
10-100MHz	60	40	60	40
100-1500MHz	40	30	40	30
1500-3000MHz	35	22	35	22
1dB Compression(dBm)	typ.	min.	typ.	min.
10-100MHz	17	6	17	6
100-1500MHz	27	19	27	19
1500-3000MHz	30	28	30	28
VSWR(ON)	typ.	max.	typ.	max.
	1.3	1.6	1.3	1.6
Switching Time (μsec) (from 50% TTL to 90% RF)	typ. 2.0	max. 4.0	typ. 2.0	max. 4.0
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CIRCLE NO 113

F126 REV.ORIG.

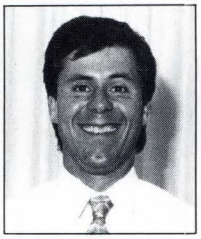
Low-capacitance probes tame prototypes

Michael J Sedayao
Signetics, Sunnyvale, CA

When troubleshooting a balky analog circuit, you often need to try adding various small amounts of capacitance to different circuit nodes to tame such aberrations as excessive overshoot of a step response, noise riding on a signal, or spurious oscillations. If you simply hold a capacitor in your fingers and poke around your circuit with it, you won't find the actual value of the capacitance that you need because your fingers introduce a significant—but unknown—amount of capacitance. Additionally, your body capacitance could—with unpredictable results—couple other parts of the circuit to the node you are probing.

Building shielded, low-capacitance probes is straightforward. Simply slip the capacitor into a length of heat-shrink tubing and heat the tubing to fix the capacitor in place. The tubing should extend about 1 to 1½ in. beyond the capacitor to form a handle, so that you can grasp the probe without actually coming near the capacitor. Snip off all but ½ in. of the capacitor's leads—¼ in. if you plan to probe IC pins. And don't forget to label each probe as you make it because, obviously, the heat-shrink tubing now covers the capacitor's markings. A good starting set would include 2-pF, 4.7-pF, 1-nF, and 0.1-μF capacitors. EDN

To Vote For This Design, Circle No 750



Compensating a job well done: 1988's Design Idea award winner

Glenn DeMichele's Design Idea, "Compensate op amps without capacitors," is EDN's 1988 Design Idea of the year, and DeMichele is the recipient of a $1500 cash award for his efforts. His idea first appeared in the July 21, 1988, issue of EDN.

"My boss congratulated me for being the issue winner," said DeMichele, "but it took the Grand Prize to knock people out."

The setup for the knockout blow was self-evident: "There was a need for uncompensated op amps in low-gain configurations. I wanted to see how high-bandwidth amps worked in the circuit. They worked well."

DeMichele's idea has a wide variety of applications. "You can use the circuit anywhere uncompensated op amps would be used," he said. "It addresses the general application of uncompensated op amps, and it's good in hybrids because the circuit requires no external capacitors." Some applications of the circuit include sonar processing systems, video processing systems, medical electronics, and such electronic counter measures as radar processing and jamming systems.

DeMichele is a field applications manager for Harris Semiconductor (Wood Dale, IL). He provides technical support to customers and salespeople and conducts seminars throughout a 10-state region in the Midwest. Prior to Harris, he worked for three years in the field of laboratory instrumentation for Precision Scientific in Chicago, IL; he also worked for three years on RF design for Collins Radio in Cedar Rapids, IA.

Born and raised in Chicago, DeMichele received a bachelor's degree in electrical engineering from the University of Illinois-Champaign in 1977. He is currently pursuing a Master's in EE from the Illinois Institute of Technology.

In his "spare" time, DeMichele plays bass guitar at jazz nightclubs, weddings, and Bar Mitzvahs in and around the Windy City. Having no time to rehearse with a regular band, he engages in "jobbing"—working as a free-lancer or stand-in with local bands. He neatly ties together his work, graduate school, and extracurricular activities with his own unique adaptation of time-management theory: "I never sleep."

—Jim Scanlan

Text continued on pg 214

LINEAR TECHNOLOGY

DESIGN NOTES

Number 23 in a series from Linear Technology Corporation *June, 1989*

Micropower, Single Supply Applications:
(1) A Self-Biased, Buffered Reference
(2) Megaohm Input Impedance Difference Amplifier

Walt Jung
George Erdi

A Self-Biased, Buffered Reference

Voltage reference circuits are common to precision analog designs, in a wide variety of forms. They can be either two or three terminal in basic configuration, and may or may not also provide buffering against line and/or load immunity. Micropower analog circuits are growing in both fashion as well as performance, and micropower voltage references have been available. However, it is not often that a micropower reference combines common features of very low DC errors, and line/load buffering. The circuit of Figure 1 is an unusual form of reference circuit, in that it achieves these goals.

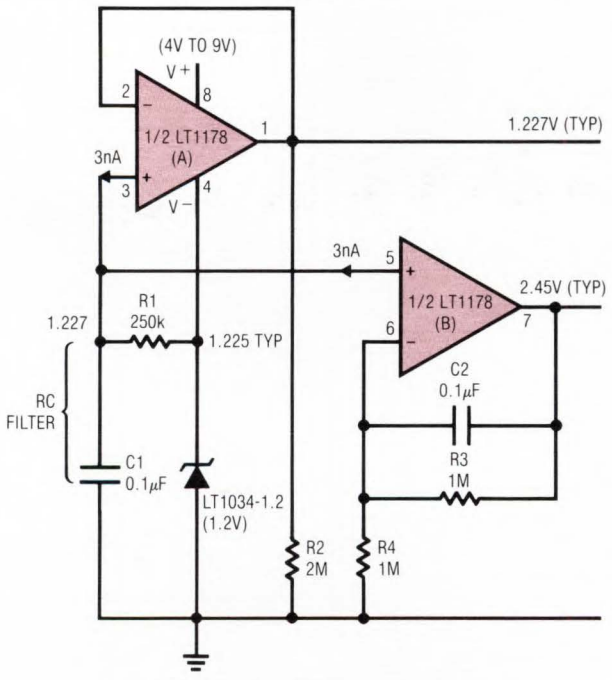


Figure 1. Self-Buffered Micropower Reference

The leading virtue of this circuit lies in how it capitalizes on some key operating features for all of the devices used. First, the LT1034, a 1.2V two terminal reference diode allows basic low TC micropower operation, by virtue of its low minimum current requirement of only 20μA. Normally, such a diode would be fed with a simple source resistor to V+, to maintain the bias current plus the load current. This standard shunt regulator type of use is unbuffered, so for higher load currents, the micropower aspect is lost. It can also be sensitive to line voltage changes.

When the LT1178 op amp enters the picture, a "free" and constant bias current source is available — *the 30μA quiescent supply current of the op amp itself!* To allow the op amp to self-bias as well as voltage-buffer the reference diode, the op amp used must have both input and output swings which include the amplifiers V– pin potential. In the case here, this potential is nominally 1.2V above ground, by virtue of the reference diode's terminal voltage. More precisely, this will be 1.225V ± 15mV, at the diode cathode. The overall TC of the circuit is essentially that of the LT1034 reference, or 20ppm/°C (maximum for "B" grade).

With an op amp such as the LT1178, whose input and output swing does include the negative rail, a simple follower configuration can be set up to buffer the reference voltage. R1 feeds a filtered version of the reference voltage to the A section op amp's (+) input, which is then replicated with a low source impedance by the DC follower of the A section. The second op amp section is also connected to this node, and is shown here as a precision 2X DC amplifier, providing a buffered +2.45V output. A subtle biasing step is used, where

the two amplifier bias currents are combined in R1. This produces a drop of a few mV above the 1.225V, so as to set up the output stage of the A section in a more linear region. The output bleed resistor R2 also helps this biasing, by pulling a constant 0.6μA from the output of this stage.

Overall, the circuit's quiescent current is 30μA, which is essentially the bias current of the dual amplifier, plus the currents in R2 and R3. It can however source several mA of load current, to external loads. For example, the "A" stage output of 1.225V has a typical output impedance of 30μV/mA, for currents of 10mA or less.

Note that current *sinking* types of loads should be used with caution, as the sink current must necessarily flow through the reference diode. While this can be as high as 20mA for the diode itself, the saturation characteristics of the A stage as used here will add some error, proportional to the current. The circuit's greatest application advantage lies with loads which source current, and so allow the true micropower operation. It operates from supplies of 3V greater than the reference voltage, in this case a battery stack of +4V to +9V. Typical line regulation is on the order of 10ppm/V.

More generally, the circuit will also function with the LT1078 op amp, a related micropower dual with a nominal 40μA/channel quiescent current, and input/output ranges similar to the LT1178. It also functions with the LT1004 type 1.2V or 2.5V references, producing proportionally scaled DC outputs, with somewhat greater drift.

If only one of the two reference outputs is needed, the LT1077 single op amp can be substituted for either side A or side B. Supply current is 45μA.

References

Jung, W.G. *IC Op Amp Cookbook, 3d Ed.,* Ch 4, "References" Howard W. Sams, Indianapolis, IN 1986.

Megaohm Input Impedance Difference Amplifier

The usefulness of difference amplifiers is limited by the fact that the input resistance is equal to the source resistance. The picoampere offset current and low current noise of the LT1077 allows the use of 1MΩ source resistors without degradation in performance. In addition, with megaohm resistors micropower operation can be maintained.

Typical performance is:

Bandwidth = 25kHz
Output Offset = 0.7mV
Output Noise = 80μVpp (0.1Hz to 10Hz)
260μV RMS over full bandwidth
Supply Current = 45μA

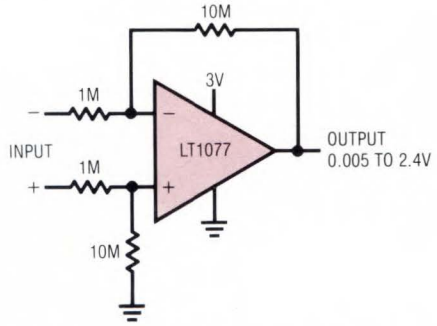


Figure 2. Gain of 10 Difference Amplifier

Although the difference amplifier operates on a single 3V battery, the input common mode range extends to 250mV below ground with proper gain of ten amplification. As the positive input is pulled further below ground to as low as –1V, the input stage saturates, but the output still stays low because the LT1077 is equipped with a unique phase reversal protection circuit. Using competitive single supply op amps in this application, the output switches high.

Another interesting feature of the LT1077 in the differential amplifier configuration is its ability to sink current while swinging to ground. Competitive micropower single supply op amps need a pull down resistor at the output to sink current, the LT1077 does not. When the input common mode voltage is 1.8V, the output has to sink a minuscule 0.16μA. However, competitive devices cannot sink any current, and need a 30k resistor from output to ground to pull the output to 5mV (5mV ≈ 30k × 0.16μA). When the output now swings to 2.4V, 80μA will flow in the pull down resistor, completely dominating the micropower current budget.

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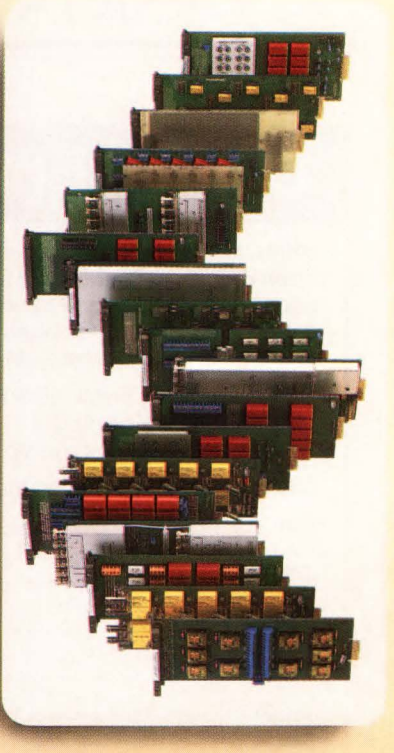

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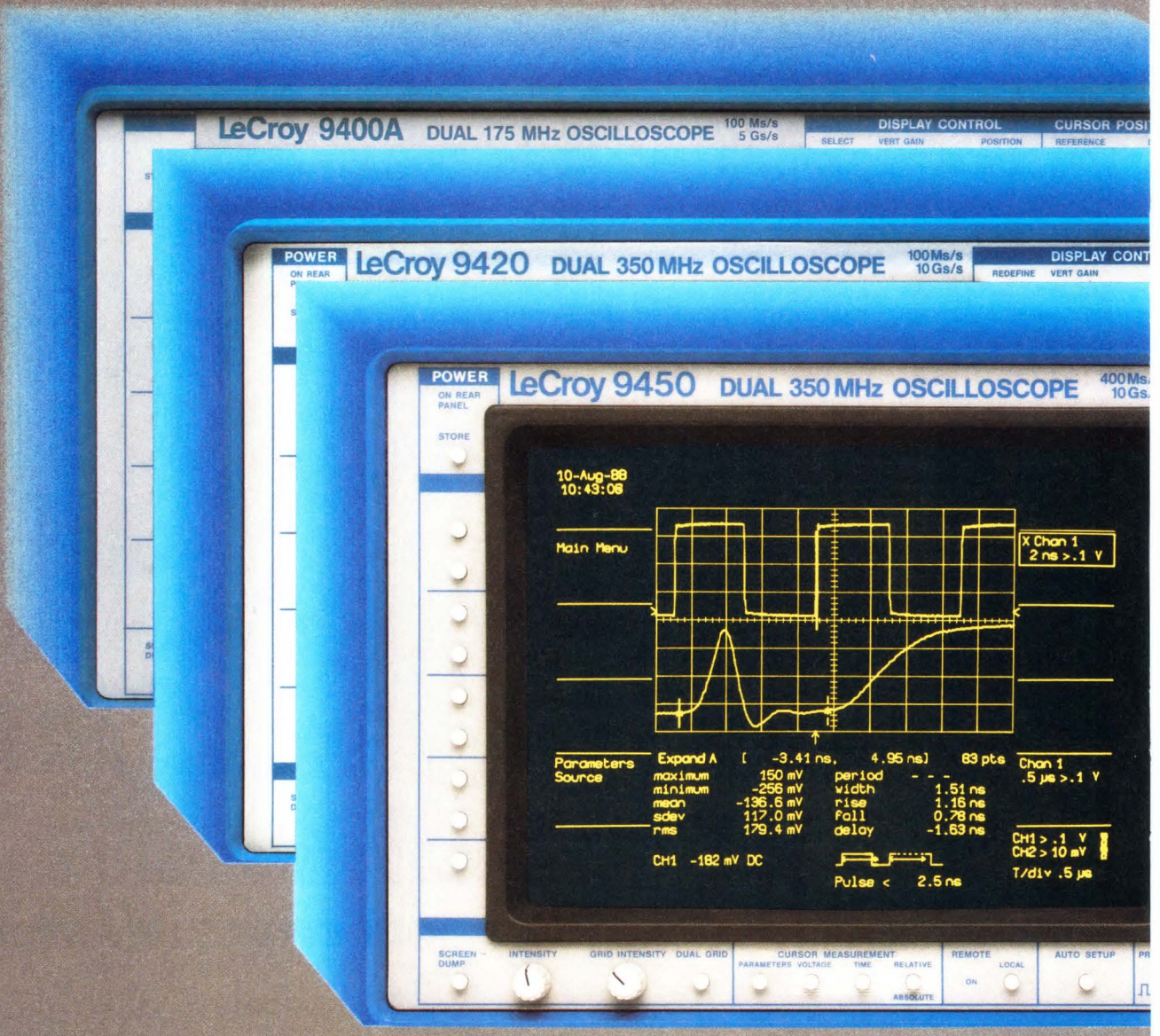

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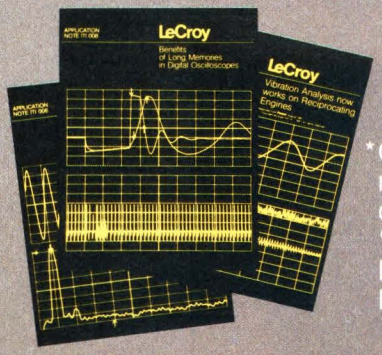

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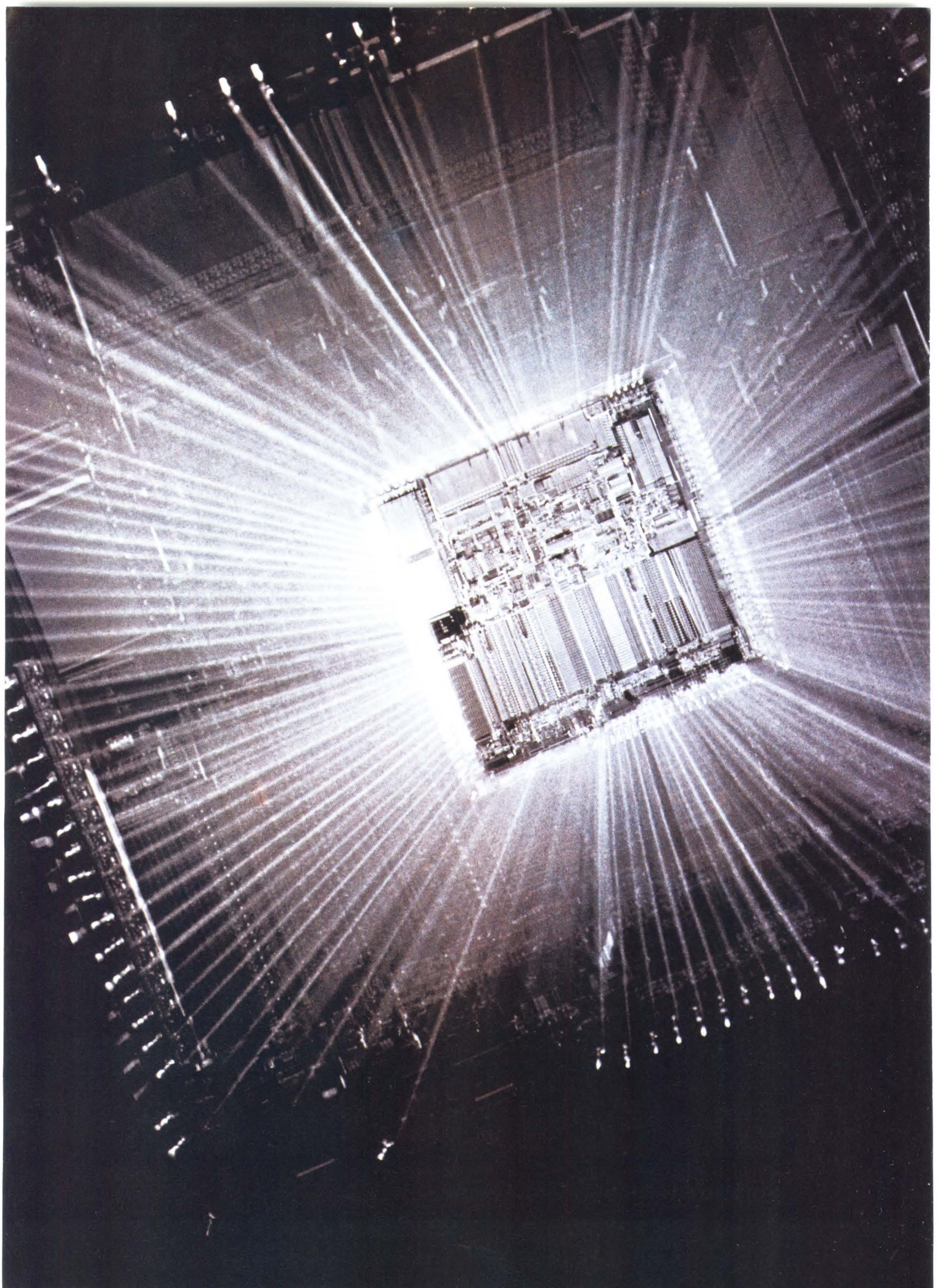

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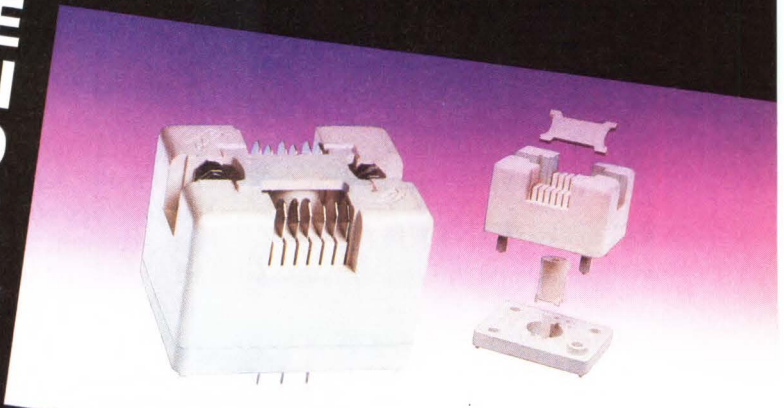

Xydar® resin was chosen by J.M. Ney for this extremely high temperature burn-in socket because of its dimensional and creep stability at temperatures above 200°C.

CIRCLE NO 67

NEW PRODUCTS

COMPUTERS & PERIPHERALS

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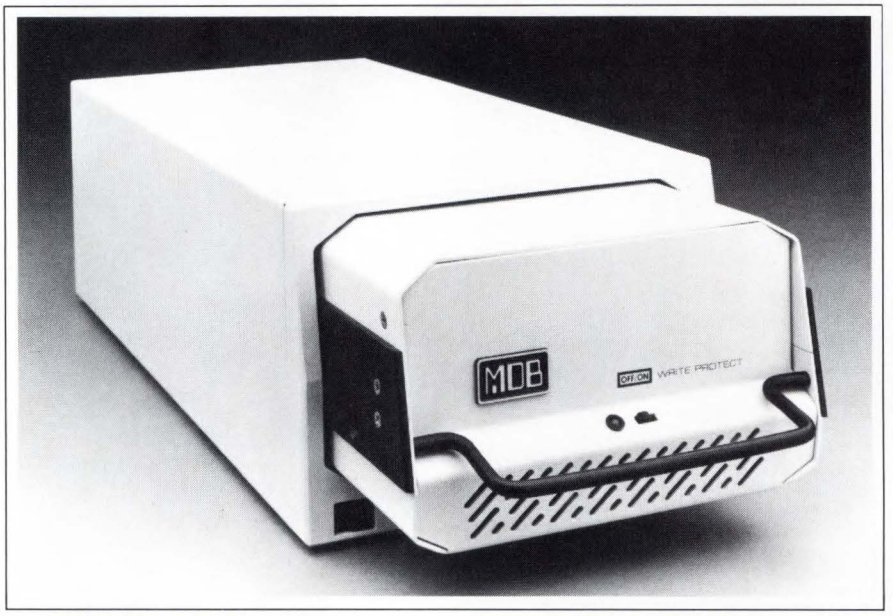
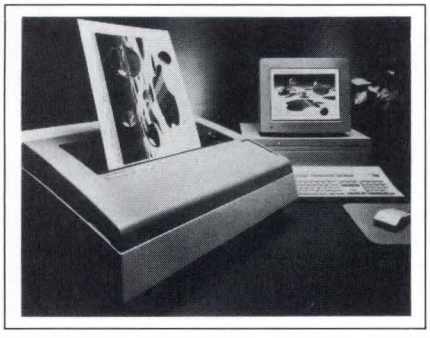
- *Houses disk drives with 86M- to 760M-byte capacity*
- *Attenuates a 100G shock to a 20G shock level felt by the drive*



The Data Shuffle 1000 consists of a chassis and a canister for mounting a single 5¼-in. drive. The unit shock absorber isolates a disk drive with unformatted capacities ranging from 86M to 760M bytes and with a SCSI interface. The canister with a drive installed meets the requirements of MIL-STD-810D bench-handling criteria. If the canister experiences a 100g shock level, it attenuates the shock level to 20g felt by the disk drive. The removable unit has a write-protect mode, which is activated by a front-panel switch. It also has an automatic head-parking feature that activates if you try to remove the unit before the disk spins down. The chassis can also accommodate the company's full- or half-height removable media, which can contain a tape unit or a laser disk. The chassis measures 8.6×5.6×17.5-in. It weighs <20 lbs with a canister and drive installed. Data Shuttle 1000 chassis, $1195; empty canister, $485; removable canister, $600.

MDB Systems Inc, 1110 W Taft Ave, Orange, CA 92613. Phone (714) 998-6900.

Circle No 359



VIDEO PRINTER

- *Provides 300-dpi color images for MAC II*
- *Prints on A- or B-size paper and transparencies*

The TPG-4300 thermal-transfer video printer for the Mac II computer prints color images at 300 dpi on A- or B-size paper and transparencies. It has a 125-MHz interface that automatically adjusts to monitors with interlaced or noninterlaced scan rates from 15 to 75 kHz and frame rates from 30 to 80 Hz. The interface accepts pixel video frequencies from 7.5 to 125 MHz and RGB video levels from 0.5 to 1.5V. You can program eight different preset times for copying data from shared computers. The unit can capture an image in <1 sec and print a full-color image on B-size paper in 180 sec or less. The printer outputs one color per pass. In addition, the unit can reverse black and white, adjust tones, enlarge images as much as 16×, rotate images 90°, and center or designate an image location to an x,y location. Users can select 8, 125, and 4096 colors, or 16 levels of gray. Printer, including controller, $13,750.

Toyo Spectrum Corp, 2934 Corvin Dr, Santa Clara, CA 95051. Phone (408) 739-7913. FAX 408-720-9643. TLX 297584.

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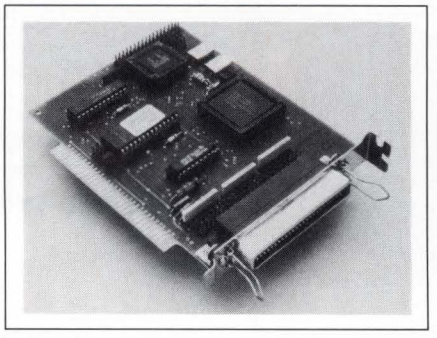


DISK CONTROLLER

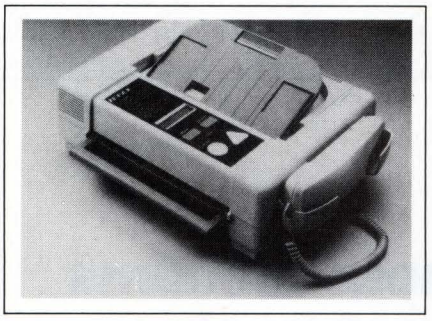
- *BIOS ROM lets SCSI hard-disk drive boot system*
- *Tape backup utility lets you back up disk with SCSI tape drive*

The RT1000 is a SCSI host adapter on a half-card for the IBM PC, PC/XT, PC/AT, and PS/2 Model 30 computers. The adapter comes with a BIOS ROM that lets you connect or boot the system to a SCSI hard-disk drive. A full-screen tape backup utility lets you back up a

hard disk with a SCSI tape drive. Using the utility in a batch mode allows unattended backups. You can connect as many as four floppy-disk drives to the unit—two internal and two external drives. Options include a floppy-disk controller and a SCSI differential-ended converter that provides improved noise immunity and the ability to drive 25-meter cables. RT1000-2, including BIOS, tape backup utility, and documentation, $50 (1000).

Rancho Technology Inc, 8632 Archibald Ave, Suite 109, Rancho Cucamonga, CA 91730. Phone (714) 987-3966. FAX 714-989-2365.

Circle No 361



MAC FAX SYSTEM

- *Combines facsimile, scanner, printer, modem, and interface*
- *Image scanning at 200-dpi resolution and 16 levels of gray*

The TeFax System Model RA2110M, a fax system for any Apple Macintosh computer, combines a facsimile, scanner, line printer, modem, and computer interface in one unit. The system provides image scanning at 200-dpi resolution for 16 different gray-scale levels. It also receives documents from remote facsimile machines. A 20M-byte disk can store as many as 500 pg of letter-size documents. You can send stored documents directly through the system to another fax machine without transferring the data to paper. The system can store a group directory of more than 200 numbers along with an index of more than 1000 names, addresses, and telephone numbers. The unit's modem transmits a letter-size document at 9600, 7200, 4800, or 2400 bps. $1495.

Relisys, 320 S Milpitas Blvd, Milpitas, CA 95035. Phone (408) 945-1062. FAX 408-945-0587.

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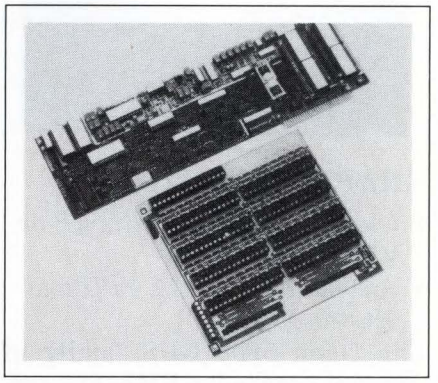
WORKSTATION

- *Provides a multiuser Unix environment*
- *Has comprehensive Ethernet networking capabilities*

The R140 Unix workstation has integrated multitasking, multiuser, graphics, windowing, and networking capabilities. It maintains full connectivity to other standard workstations, PCs, and multiuser systems. The workstation incorporates the company's 32-bit RISC μP, and has 4M bytes of RAM, a 60M-byte hard disk, a 3½-in. 1M-byte floppy disk, and four system expansion slots, one of which accommodates its Ethernet interface. It runs the company's RISC-iX operating system—an implementation of Berkley 4.3 Unix with System V extensions—together with X-Windows for graphics, windowing, and terminal emulation, and X.desktop for an easy-to-learn Unix user interface. The company will offer X/Open and Posix compatibility by the end of the year. Alternative operating systems include MS-DOS and the company's RISC-OS. Ethernet interfacing is supported by NFS, Yellow Pages, TCP/IP, and X11 client/server software, which is provided as standard. The workstation supports monochrome monitors with resolutions as high as 1152×900 pixels, and color monitors with resolutions as high as 640×480 pixels. From £3500.

Acorn Computers Ltd, Fulbourn Rd, Cherry Hinton, Cambridge CB1 4JN, UK. Phone (0223) 245200. TLX 817875. FAX 0223-210685.

Circle No 363



ACQUISITION BOARD

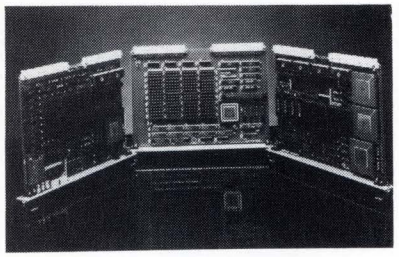
- *Provides 64 analog-input channels for IBM PCs*
- *Digitizes signals with 16-bit resolution at 165 kHz*

The Model ADA-64-4 is a data-acquisition board for the IBM PC, PC/XT, PC/AT, AT386-20 computers, and compatibles, and it can digitize 64 single-ended or 32 double-ended analog-input channels with programmable gain. The unit can digitize an input channel at rates as high as 166 kHz with 16-bit resolution. In addition, the board has a DAC that drives four analog-output channels and 16 digital I/O channels. The unit contains three 16-bit counter/timers and 2k bytes of RAM for real-time data collection without host CPU intervention. A DMA channel can continuously transfer data to the PC at 340,000 bytes/sec. An interrupt controller interfaces directly to the 2 through 7 interrupt vectors on the host via selectable jumpers. An interconnect board, the ADINT-1B, provides easy connection for the 64 analog inputs and four analog outputs.

ADA-64-4 and software drivers, $3599; ADINT-1B, $399. Delivery, stock to six weeks ARO.

Prodevco, 1071 Avenida Acaso, Suite F, Camarillo, CA 93010. Phone (805) 388-5957.

Circle No 364



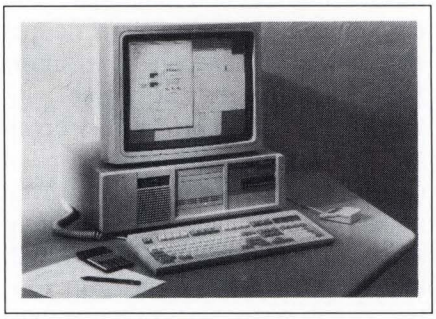
GRAPHICS SYSTEM

- *Uses TMS34020 graphics μP on VME-based boards*
- *Also uses TMS34082 FPU and MC88000 CPU*

The Omni 8800 GDS family of graphics boards for VME Bus system boards are compatible with Sun and Apollo workstations. The graphics display-controller card uses TI's TMS34020 graphics processor and TMS34082 floating-point coprocessor. A graphics database-manager board uses Motorola's MC8800 as a data manager for parallel graphics processing. A Z-buffer board accelerates 3-D graphics, and a frame-grabber board can capture $756 \times 485 \times 8$-bit NTSC-compatible or $768 \times 575 \times 8$-bit PAL-compatible frames for real-time image processing. A frame buffer extension expands the display controller's memory from $2k \times 2k \times 12$ bits to $4k \times 4k \times 12$ bits. The expanded memory is capable of 1600×1280-pixel display resolution, 24 bits of color, and as many as 12 independent overlay planes. The software features the Omni*Kernel System, GKS, PHIGS, or DORE 3-D command sets. From $3000 (OEM qty).

Omnicomp Graphics Corp, 1734 W Belt North, Houston, TX 77043. Phone (713) 464-2990. TLX 285801.

Circle No 365



UNIX WORKSTATIONS

- *Have an 88000 CPU and an 80386 I/O processor*
- *Run Unix System V and MS-DOS simultaneously*

The Personal Mainframe Series 8000 comprises Unix workstations that use the Motorola 88000 RISC

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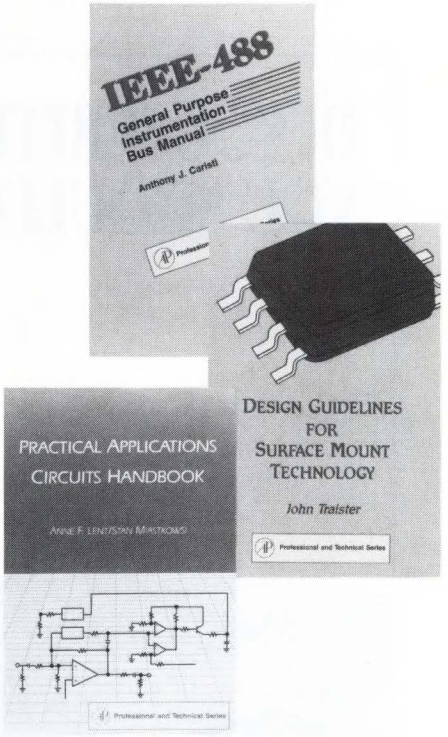

IEEE-488 General Purpose Instrumentation Bus Manual
Anthony Caristi
This is the essential guide to the IEEE-488 bus and its applications. It covers GPIB addressing and communications, complete GPIB protocols and hardware (including the new IEEE-488.2 standards), programming requirements, and increasing systems performance.
May 1989, 256 pages, $42.50
ISBN: 0-12-159820-9

Operational Amplifier Circuit Manual
Robert J. Traister
Here's the only op amp guide you need. This practical reference presents more than 200 different applications circuits—grouped by functional categories.
May 1989, 158 pages, $35.00
ISBN: 0-12-697405-5

Design Guidelines for Surface Mount Technology
John E. Traister
This book has the information you need to do successful board-level design using SMT. You'll get the latest on optimizing component placement...contact geometry ...utilizing both sides of a substrate ...CAD tools for SMT.
August 1989, c. 320 pages, $42.95
ISBN: 0-12-697400-4

Practical Applications Circuits Handbook
Anne Fischer Lent and Stan Miastkowski
Increase your design effectiveness with this collection of the latest applications circuits taken from recent data sheets, applications notes, and magazines. Each complete circuit offers operating details, construction tips, and other essential data.
August 1989, 261 pages, $39.95
ISBN: 0-12-443775-3

Linear Integrated Circuits Applications Manual
Robert J. Traister
Here is a complete, one-stop reference for applications circuits using linear ICs. You'll find circuits for active filters...floppy disk read/write systems...function generators... modems...video amplifiers and modulators...and more.
August 1989, c. 138 pages, $29.95
ISBN: 0-12-697403-9

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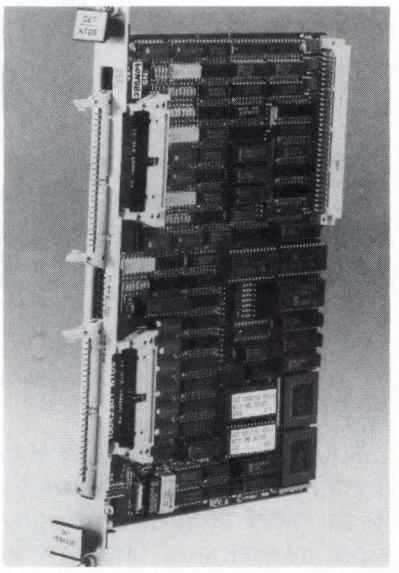
μP as a CPU and Intel's 80386 μP in an I/O subsystem. The dual-processor architecture results from a marriage between the company's processor board and Everex's I/O subsystem. The workstations run Unix System V and MS-DOS simultaneously. In addition, Network File System and TCP/IP software are optionally available. Because the kernel can support Berkeley system and library calls, transporting Berkeley-style Unix source code is a simple matter. Standard hardware features include as much as 20M bytes of RAM, a graphics terminal, an Ethernet controller, and hard-disk and floppy-disk drives. Hardware options include a streaming-tape cartridge system, an ESDI hard-disk drive, and multiport adapters. From $9995.

Opus Systems, 20863 Stevens Creek, Bldg 400, Cupertino, CA 95014. Phone (408) 446-2110.

Circle No 366



NTDS/VME ADAPTER

- *Interfaces a VME Bus system to a 32-bit NTDS computer*
- *Occupies one VME Bus slot and provides a parallel path*

The NTDS/VME Interface Adapter is a 6U plug-in board for VME Bus systems. The board has an MC6800 μP and an MC68450 4-channel DMA controller for performing full-duplex 16-bit or 32-bit transfers. The VME interface features a 16-bit data path, 24 bits of address, programmable interrupt levels and vectors, and a 32k-word dual-port static RAM buffer. The NTDS (Navy Tactical Data System) I/O connectors are on top of the card. Firmware located in EPROM consists of device drivers for buffer transfers, interrupt control, asynchronous data transfers, and board configuration. The user can control the board using C, Fortran, or Ada operating with a Unix or a Sun OS system. The board is software configurable to emulate an NTDS computer or peripheral in the SLOW or FAST classifications. An NTDS ANEW compatible model is also available. Both models, $4425. Delivery, six weeks ARO.

GET Engineering Corp, 9350 Bond Ave, El Cajon, CA 92021. Phone (619) 443-8295.

Circle No 367

ACQUISITION SYSTEM

- *Has remote acquisition module and host adapter*
- *Transmits data over 3-km links using fiber optics*

The REM500 remote data-acquisition module and the RVME1000 host-interface module form a remote data-acquisition system for the VME Bus. The unit communicates over links as long as 3 km, using 62.5- or 125-μm multimode fiber-optic cable. The REM500 module digitizes eight analog inputs with 12-bit resolution at a sampling rate as high as 500 kHz. This module contains a fiber-optic uplink and downlink receiver. The uplink receiver provides a sample clock, a serial-output channel, and a command-output signal. The RMVE-1000 module resides on a double-height VME Bus card and also contains an uplink and downlink receiver. Its uplink transmitter provides sample clocks, status/control signals, and a serial data channel for the remote unit. It also contains 128k bytes of static RAM, a VME slave interface, a programmable clock synthesizer, and a direct data port on the P2 connector. REM500, $2075; RVME1000, $2719 (50). Delivery, eight to 12 weeks ARO.

RKB Corp, Box 2341, Waldorf, MD 20604. Phone (301) 843-5925.

Circle No 368

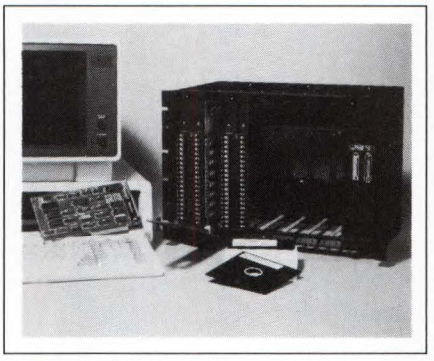
MAC DISK DRIVES

- *Have 18-msec access speeds and a 16k-byte cache buffer*
- *Have capacities of 45M, 70M, 100M, and 215M bytes*

The Cobra series of external and internal hard-disk drives for the Macintosh SE, SE/30, II, IIx, and IIcx consists of models with 45M, 70M, 100M, and 215M bytes of formatted capacity. The 3½-in. disk drives have an average access time of 18 msec and a 16k-byte look-ahead cache buffer that provides disk transfer rates as high as 12M bps. The drives also have SCSI ports and automatic head parking and locking. The external models have two SCSI ports for daisy-chaining as many as seven SCSI peripherals, two surge-protected AC receptacles, and LEDs, which indicate power-on, drive activity, and 17 different faults. The supplied software includes the company's Utility software which has password and write protection, media verification, and driver routines. The drives also come with Fastback software for disk backup. The series boasts a 30,000-hour MTBF and comes with a 1-year warranty. 215M-byte internal model, $150.

Rodime Systems, 851 Broken Sound Parkway NW, Boca Raton, FL 33487. Phone (407) 994-5585.

Circle No 369



I/O CONTROLLER

- *Consists of a remote chassis holding seven I/O cards*
- *Connects to IBM PCs via a 25-conductor cable*

The Workhorse is an industrial control and monitoring system for the IBM PC, PC/XT, PC/AT, and compatibles. A remote chassis, which holds as many as seven I/O cards and a parallel interface board, connects to the host via a 25-conductor ribbon cable. The cable consists of shielded twisted pairs that permit cable lengths as long as 4000 ft. A driver card, which resides in an I/O slot in the host, can control as many as 3584 analog I/O points or 1024 digital I/O points when multichassis are connected. Each chassis measures 12.25×17.25×10.25 in. and can control 112 3-A relays and 112 analog inputs, or 224 low-level digital I/O points. The system communicates with the host at speeds as high as 500,000 bytes/sec. WH-PCDB-PAR driver board, $395; WH-CIB-PAR interface board, $399; WH-CH-7 chassis, $750; 50W power supply, $650; 100W supply, $750.

MetraByte Corp, 440 Myles Standish Blvd, Taunton, MA 02780. Phone (508) 880-3000. FAX 508-880-0179. TLX 503989.

Circle No 370

STAND-ALONE SBC

- *Uses the Harris RTX2000 μC and PolyForth*
- *Has a parallel output, a parallel input, and two RS-232C ports*

The FB2000 stand-alone single-board computer features the Harris RTX20000 μP. Because it contains an onboard ROM with the PolyForth operating system, the board can serve as a development system. The ROM also contains rou-tines for communicating with graphics-terminal software running on an IBM PC/AT or a compatible computer with an RS-232C interface. The board can communicate with the PC at 115,200 baud. Other features include a spare RS-232C port; 64k bytes of static RAM; 10- or12-mHz operation; 14 interrupts, five of which are external and maskable; an onboard reset switch; and single 5V-supply operation. In addition, you can interface the SBC to peripheral I/O boards through two application connectors containing seven input and seven output-strobes, an 8-bit input port, a 16-bit output port, an ASIC data bus, and interrupt lines. The board measures 4.2×4.2 in. Board and PolyForth operating system, $995.

Innovative Integration, 4086 Little Hollow Pl, Moorpark, CA93021. Phone (805) 529-7570.

Circle No 371

Don't swallow that line about what a RISC processor can do for your real-time system.

Harris RTX 2000™: Superior Performance, Dramatic Cost Savings.

They dangle a RISC chip in front of you and tell you how well it performs in real-time systems. Bite... and you'll regret it.

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Our unique RTX 2000 does away with the caches and pipelines that cause erratic execution speeds and response times in RISC processors. In fact, in an asynchronous interrupt driven environment, the RTX 2000 is so agile and predictable, it can outperform RISC processors by up to 10x. And its 16-bit architecture is a better fit for the majority of real-time applications.

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With 84 pins, our RTX 2000 package is about half the size of many conventional RISC machines. In many cases, RISC chips require support circuits to reach their promised performance benchmarks. Not the RTX. And consider power use. The RTX 2000™ uses a mere 7 mA/MHz at full speed: about 1/6 the power consumption of basic RISC chips. That power and space savings is critical when sealed enclosures, high-density packaging and battery operation are considerations. And systems that run cooler, run more reliably.

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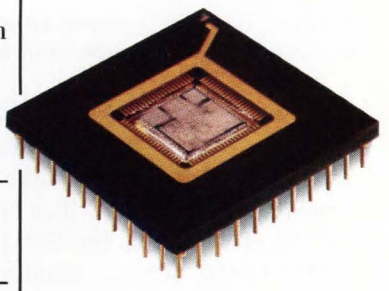
Contact us for technical briefs or to register for our real-time design workshops. In U.S.: 1-800-4-HARRIS, Ext. 1291. In Canada: 1-800-344-2444, Ext. 1291.



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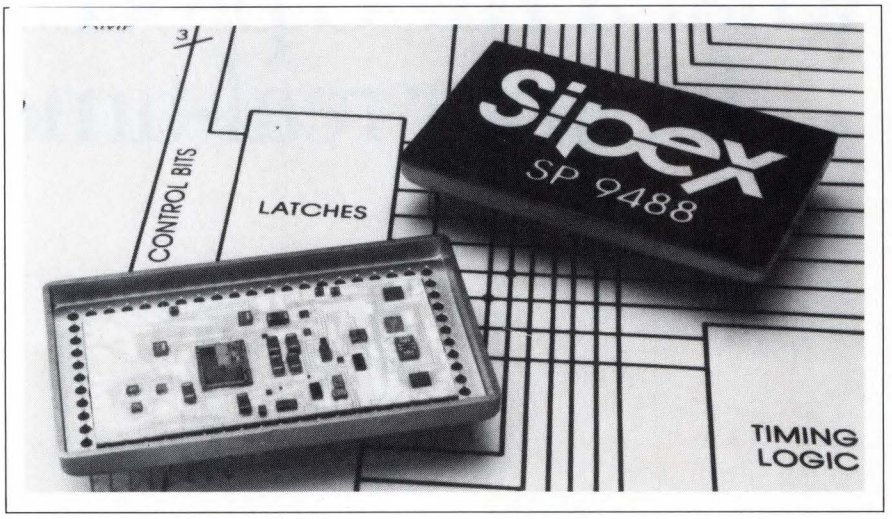
HYBRID IC

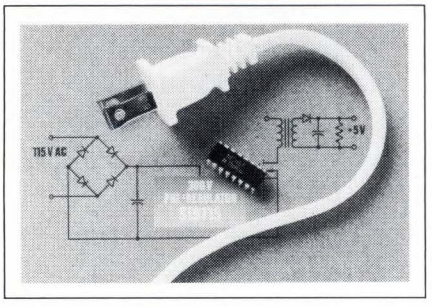
- *16-bit data acquisition*
- *Contains 16-channel multiplexer*

The SP9488 functionally complete, 16-bit data-acquisition system features a 50-kHz throughput rate. The hybrid IC contains a 16-channel multiplexer, instrumentation amplifier, precision reference, and a 16-bit sampling A/D converter with a μP interface. The user can configure the multiplexer for 16 single-ended inputs or eight differential inputs. Multiplexer addressing is controlled by the μP via the bidirectional data bus shared with the A/D output. The unipolar and bipolar input ranges are 0 to 2.5V, 0 to 5V, 0 to 10V, ±2.5V, ±5V, and ±10V. The integral linearity of the SP9488 is ±0.001% of FSR, and the differential linearity is ±0.003%. The A/D converter is self calibrating, and most offset and gain errors associated with front-end circuitry are adjustable to zero. Available in a hermetically sealed 62-pin package, the SP9488 operates from ±15V and 5V supplies. SP9488C (0 to 70°C), $425; SP9488B (−55 to +125°C), $549 (100). Delivery, stock to 12 weeks ARO.



Sipex Corp, Hybrid Systems Div, 22 Linnell Circle, Billerica, MA 01821. Phone (508) 667-8700. FAX 508-667-8310.

Circle No 388



SWITCHMODE ICs

- *Have 10 to 300V input range*
- *Provide power conversion to 250W*

The Si9115 and Si9116 CMOS ICs can operate from the rectified, filtered ac power line. Unlike their bipolar counterparts, which are limited to 60V inputs, the Si9115 and Si9116 CMOS ICs can handle input voltages to 300V. The smartpower devices include start-up circuitry, an oscillator, an error amplifier, and a voltage reference. The Si9115 is suitable for conversion in the 1 to 50W range and features an inverted output, which can directly drive an external MOSFET. The Si9116 features a noninverted output for use with an external driver such as the Si9950DY half bridge for driving a high-power MOSFET in 150 to 250W applications. Both devices are designed for use in single-ended topologies such as flyback and forward converters. The Si9115 and Si9116 are available in 14-pin plastic or ceramic DIPs for operation over the industrial and military temperature ranges. $4.11 to $20.40 (100).

Siliconix Inc, 2201 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 988-8000.

Circle No 389

D/A CONVERTER

- *Operates at clock frequencies as high as 450 MHz*
- *Has an on-chip reference and reference amplifier*

The SP98608 multiplying D/A converter settles to ½ LSB in 2.5 nsec, allowing you to clock it at 450 MHz and still achieve full 8-bit accuracy. The converter has latched ECL 10K-compatible inputs, and complementary 40-mA outputs, which can drive a 1V signal into doubly terminated 50Ω lines. The device has an on-chip bandgap reference and reference amplifier to provide both current- and voltage-multiplying modes. The SP98608 operates from a −5.2V supply and has an operating temperature range of −40 to +85°C. It is packaged in a 24-pin ceramic DIP. £26.63 (1000).

Plessey Semiconductors, Cheney Manor, Swindon, Wiltshire SN2 2QW, UK. Phone (0793) 36251. TLX 449637.

Circle No 390

Plessey Semiconductors, 1500 Green Hills Rd, Scotts Valley, CA 95066. Phone (408) 438-2900. TLX 4940840. FAX 408-438-5576.

Circle No 391

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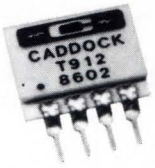
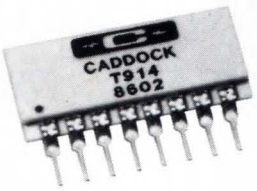
CADDOCK's Precision and Ultra-Precision Resistor Networks provide a designer's choice of performance that will optimize solutions in precision analog circuit designs.





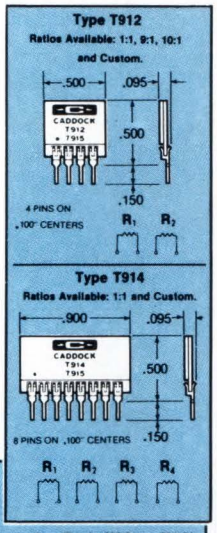
Precision and Ultra-Precision Resistor 'Pairs' and 'Quads' deliver a selection of Ratio Tolerance to as tight as ±0.01% and Ratio Temperature Coefficient to 2 PPM/°C combined with exceptional long-term stability.

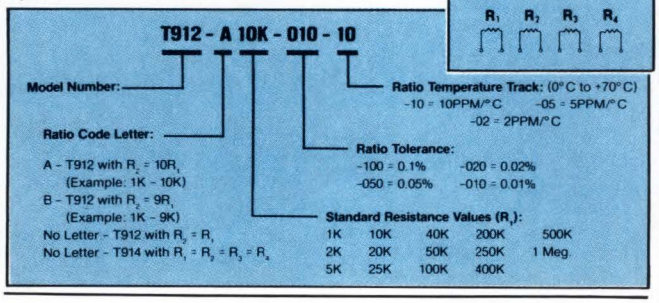
Standard Type T912 and T914 Precision and Ultra-Precision Resistor Networks.

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

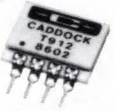
- **Absolute Tolerance:** 0.1% for all resistors.
- **Ratio Tolerances:** 0.1%, 0.05%, 0.02% and 0.01%
- **Ratio Temperature Coefficients:** from 10 PPM/°C to 2 PPM/°C.
- **Absolute Temperature Coefficient:** 25 PPM/°C from 0°C to +70°C.
- **Ratio Stability of Resistance at Full Load for 2000 Hours:**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

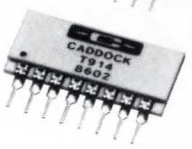
The standard part number below provides a selection of over 500 in-production models of Type T912/T914 precision and ultra-precision 'pairs' and 'quads':





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

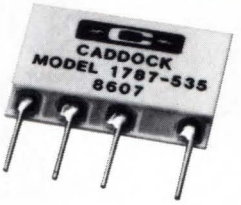


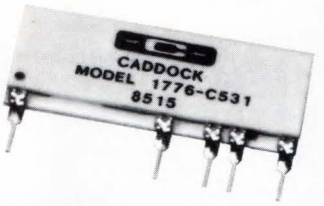


Custom models of these precision 'pairs' and 'quads' can include these special performance features:

- **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.

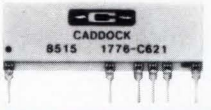
- **For Type T912/T914 data, circle Number 201.**



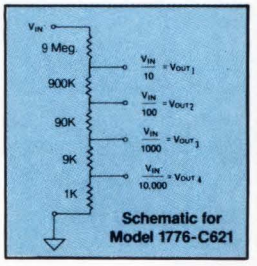


Precision Decade Resistor Voltage Dividers and Current Shunt Resistor Networks deliver many optimum combinations of precision and temperature coefficient performance for high accuracy range-switching circuitry.

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.

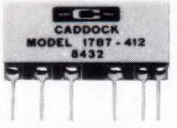


- **Absolute Tolerances:** from 0.25% to 0.1%.
- **Ratio Tolerances:** 0.25%, 0.1% or 0.05%.
- **Absolute TC:** from 50 PPM/°C to 25 PPM/°C.
- **Ratio TC:** from 50 PPM/°C to 5 PPM/°C.
- **Voltage Coefficient:** As low as 0.02 PPM/Volt.

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.**

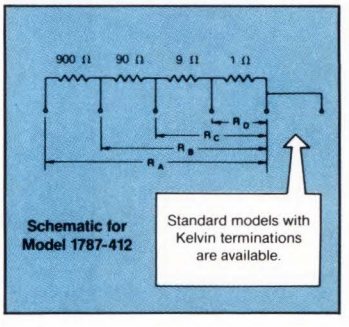
Standard Type 1787 Precision Current Shunt Resistor Networks.



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.

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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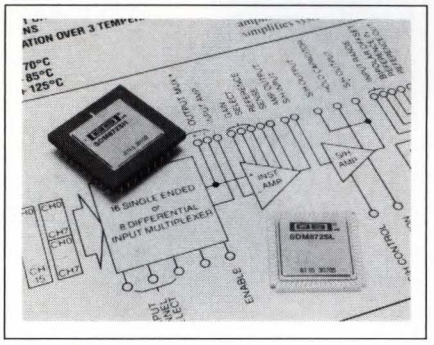
CADDOCK

HIGH PERFORMANCE FILM RESISTORS



HYBRID ICs

- *12-bit data acquisition*
- *50-kHz throughput rate*

The SDM872 and SDM873 are 12-bit data-acquisition systems that feature a throughput rate of 50 kHz. The SDM872 has 16 single-ended input channels; the SDM873 has eight differential channels. Both devices accept unipolar or bipolar inputs in the ranges of 0 to 10V, ±5V and ±10V. The hybrid ICs include an input multiplexer, an instrumentation amplifier with selectable gains of 1, 10, and 100, an S/H amplifier, and an A/D converter with a μP interface and 3-state output buffers. The ICs come in either 68-pin ceramic PGA or 68-pin LCC packages that feature a small footprint of about 1.0 in^2. The SDM872 and SDM873 are available in commercial, industrial, and military temperature ranges, and in accuracy grades of ±0.024% and ±0.012% FSR. From $119.23 (100).

Burr-Brown, Box 11400, Tucson, AZ 85734. Phone (800) 548-6132.

Circle No 392

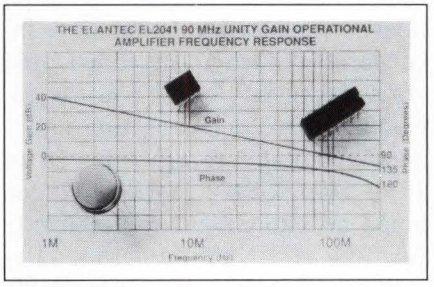
16-BIT ADC

- *Uses sigma-delta technology*
- *Operates from a single 5V supply*

Fabricated in low-power HCMOS, the 56ADC includes a complete set of A/D conversion functions on a single chip. Compared with conventional ADCs, which operate from multiple supplies, the 56ADC needs only a single 5V supply. The device uses a sigma-delta conversion technique, which filters out noise as it occurs and eliminates the need for special analog circuitry. With a 96-dB dynamic range, the 56ADC captures most natural phenomena such as speech and music. The chip's 16-bit output works with the company's 24-bit 56001 DSP. In addition, the chip's serial output can interface with other DSPs. The 56ADC samples each signal 6.4M times/sec. Each of these samples is filtered through the chip's proprietary signal-processing circuitry, which eliminates the need for special S/H and antialiasing functions. Other features include a 90-dB S/N ratio, in-band ripple of <0.001 dB, and output sampling rates of 100 kHz (16 bits) and 400 kHz (12 bits). $50 (OEM qty).

Motorola Inc, Microprocessor Products Group, 6501 William Cannon Dr W, Austin, TX 78735. Phone (512) 440-2039.

Circle No 393



HIGH-SPEED OP AMP

- *Has 90-MHz bandwidth*
- *Supply current is only 13 mA*

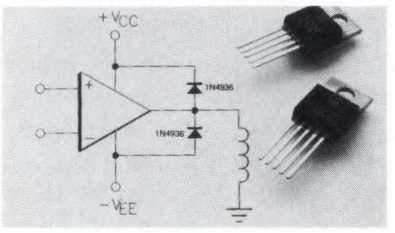
Unity-gain stable at 90 MHz, the EL2041 monolithic op amp has a supply range of ±5 to ±15V and draws only 13 mA of current. Because of its wide bandwidth, the EL2041 will amplify and transmit NTSC and PAL video signals with low distortion. Other specs include a 250V/μsec slew rate, a settling time to 0.05% of 90 nsec, and an open-loop gain of 10,000 V/V into a 1000Ω load. The EL2041 is fabricated using a dielectric isolation process that creates fast npn and pnp transistors. Thus, the op amp has inherent tolerance to radiation effects, a required spec for many

INTEGRATED CIRCUITS

military applications. The EL2041 is available in 8-pin plastic DIPs, 14-pin ceramic DIPs, and 12-pin TO-8 metal cans. From $5 (100).

Elantec, 1996 Tarob Ct, Milpitas, CA 95035. Phone (408) 945-1323.

Circle No 394



OP AMPS

- *Handle loads to 3A*
- *Feature low quiescent current*

The SG2172 and SG3172 monolithic power op amps can operate with load currents to 3A. The typical low quiescent current of 7 mA provides power savings under no-load conditions. To ensure reliable operation under heavy loads, the op amps incorporate thermal shutdown and current limiting. Other features include internal compensation and a supply voltage range from 10 to 18V. The SG2172 and SG3172 op amps are functional replacements for the ULN3751, L165, and LM675. The devices are available in TO-220 and TO-66 packages. From $1.80 (100). Delivery, stock to 60 days.

Silicon General, 11861 Western Ave, Garden Grove, CA 92641. Phone (714) 898-8121. FAX 714-893-2570. TWX 910-596-1804.

Circle No 395

HIGH-SPEED OP AMPS

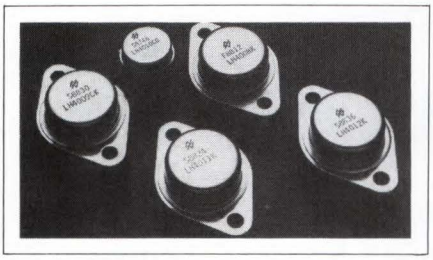
- *175- and 725-MHz versions*
- *Low quiescent current*

Fabricated in a complementary bipolar process, the AD848 and AD849 are high-speed, low-power op amps that require a supply current of only 5 mA typ. The partially compensated AD848 has a gain-bandwidth product (GBW) of 175

MHz for gains ≥5. The totally decompensated AD849 has a GBW of 725 MHz for gains ≥25. Other ac specs include a typical slew rate of 300V/μsec (±15V operation), 0.1% settling times of 100 nsec for the AD848 and 80 nsec for the AD849 for a 10V step, and differential gain and phase errors of 0.1 dB and 0.1°, respectively. The AD848 is specified at 8000 V/V open-loop gain into 150Ω, using ±5V supplies. Both devices feature a 1-mV-max input-offset voltage. Both devices are available in 8-pin miniature DIPs, ceramic DIPs, and SO packages. From $2.95 (100).

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (508) 935-5565.

Circle No 396



HIGH-SPEED BUFFERS

- *Provide high drive current*
- *Feature wide bandwidths*

A group of five voltage-follower buffers provide high-current drive at frequencies from dc to more than 400 MHz, depending on type. The devices operate from supplies of ±5 to ±20V or with a single 10V supply. The LH4008 and LH4009 provide ±200 mA of drive into a 50Ω load at slew rates of 10,000V/μsec and a power bandwidth of 130 and 150 MHz, respectively. The LH4010 provides ±100 mA of drive, a 2500V/μsec slew rate, and a power bandwidth of 20 MHz. The LH4011 provides ±200 mA of drive, a slew rate of 5000V/μsec, and a power bandwidth of 160 MHz. The LH4012 provides ±200 mA of drive, a slew rate of 11,500V/μsec, and a power bandwidth of 490 MHz. All except the LH4012 have FET inputs and feature bias currents of <30 nA at room temperature. The LH4008, 4009, 4011, and 4012 come in a 3W, 8-pin TO-3 package; the LH4010 comes in a 1.5W, TO-8 package. The devices are available in either industrial or military temperature grades. $21.60 to $50.75 (100).

National Semiconductor Corp, Box 58090, Santa Clara, CA 95052. Phone (408) 721-3836. TLX 346353.

Circle No 397

DIGITAL FILTER

- *Accepts 16- or 18-bit serial data*
- *Operates in 4× or 8× oversampling mode*

The SM5803 CMOS IC is a multifunction digital filter that operates in either a 4× or 8× oversampling mode. The serial input data is selectable as either 16 or 18 bits, and the serial output data can be 16, 18, or 20 bits. Key features of the SM5803 include digital de-emphasis and attenuation, a jitter-free run-

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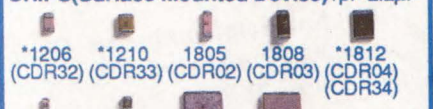
CERAMIC

CHIPS(Surface Mounted Device) 1pF-2.2μF

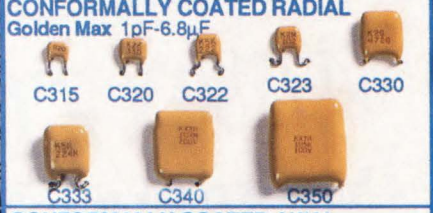


*1206 (CDR32) *1210 (CDR33) 1805 (CDR02) 1808 (CDR03) *1812 (CDR04) (CDR34)

*0805 (CDR01) (CDR31) 1005 *1825 (CDR05) (CDR35) 2225 (CDR06)

*EIA Standard Style

CONFORMALLY COATED RADIAL
Golden Max 1pF-6.8μF



C315 C320 C322 C323 C330 C333 C340 C350

CONFORMALLY COATED AXIAL
Aximax 10pF-1μF

C410 C412 C420 C430 C440

MOLDED RADIAL 1pF-3.3μF

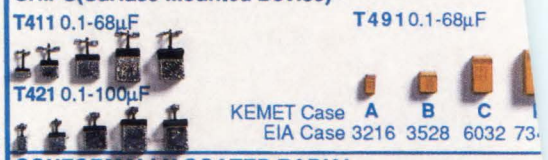
C052 (CK05) (CKR05) C062 (CK06) (CKR06) C056 (CKR05) C066 (CKR06)

MOLDED AXIAL 1pF-3.3μF

C114 (CK12) (CKR11) C124 (CK13) (CKR12) C192 (CK14) (CKR14) C202 (CK15) (CKR15) C222 (CK16) (CKR16)

TANTALUM

CHIPS(Surface Mounted Device)



T411 0.1-68μF **T491** 0.1-68μF
T421 0.1-100μF
KEMET Case A B C
EIA Case 3216 3528 6032

CONFORMALLY COATED RADIAL
T350 Series **Ultradip** 0.1-680μF **T396/T398 Ultradip III** 0.1-300μF

T350, T351, T352, T353, T354, T355, T356
T36X Series 0.1-330μF

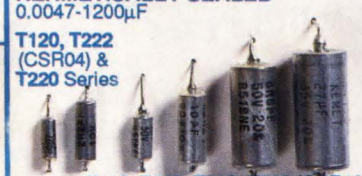
T363(CX02), T368, T369(CX12)

MOLDED AXIAL 0.1-330μF

T322/T323 (CX01/CX05)

MOLDED RADIAL
T330 Series 0.1-220μF
T340 Series 0.1-330μF

HERMETICALLY SEALED 0.0047-1200μF
T120, T222 (CSR04) & **T220** Series



T110, T140, T210, T212 (CSR13), **T216**(CSS13) **T240, T242** (CSR23), **T252** (CSR33) **T256, T262** (CSR21) Series

MICRON 0.0047-220μF
T370/T378 Series (CX06)
T372/T379 Series (CX16)

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Flat Kap .001-1μF
F110, F120, F130
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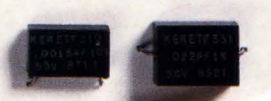
MOLDED AXIAL/RADIAL
Flat Kap .001-1μF
F310(CFR04R), F311(CFR04A), F320, F321, F330, & F331



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— Ron

CIRCLE NO 109

ning mode, and soft-mute capabilities. The device limits the passband ripple within 0.00005 dB and delivers a stopband attenuation of more than 110 dB. The SM5803, which comes in a 28-pin plastic DIP, operates from a 5V supply. $30 (1-24).

NPC, 2151 O'Toole Ave, San Jose, CA 95131. Phone (408) 922-0133.

Circle No 398

SPEECH SYNTHESIS IC

- *Combines two synthesizing systems*
- *Includes 1-time-programmable ROM*

The μPD77P56 is the latest member of the company's speech synthesis family. The device decodes stored voice data, then converts it to analog form and outputs the result. The 1-time programmable 256k-bit ROM speeds turnaround time and permits a larger number of diverse voices in a system. The 77P56 combines two synthesizing systems: the ADPCM system for voice synthesis and a PCM-waveform system for sounds and melodies. The 77P56 also provides a full range of sampling frequencies from 4 to 8 kHz. The typical voice-synthesizing time is 12 sec during 6-kHz voice sampling. In a 20-pin DIP, $9.55; in a 24-pin SO package, $10.50 (1000).

NEC Electronics Inc, Box 7241, Mountain View, CA 94039. Phone (415) 960-6000. TWX 910-379-6985.

Circle No 399

STATIC RAM MODULE

- *Organized as 16k×32 bits*
- *Has high memory-packing density*

The CYM1821 16k×32-bit CMOS static RAM offers the benefits of improved packing density and superior performance. The module's vertical configuration offers 5× greater board density than is possible with standard dual-in-line packages. Occupying only 1.2 square inches of board real estate, the module uses fine-line substrate technology, SOJ packaging, and zig-zag pins to achieve its packing density. The module height is a maximum of 0.5 in. to accommodate VME-type card cages. The CYM-1821 is offered in 25-, 35-, and 45-nsec versions. The module features byte addressability via independent chip selection and offers user-configurable options for 32k×16-bit or 64k×8-bit organizations. 45-nsec version, $195 (100).

Cypress Semiconductor, 3901 N First St, San Jose, CA 95134. Phone (408) 943-2600.

Circle No 400

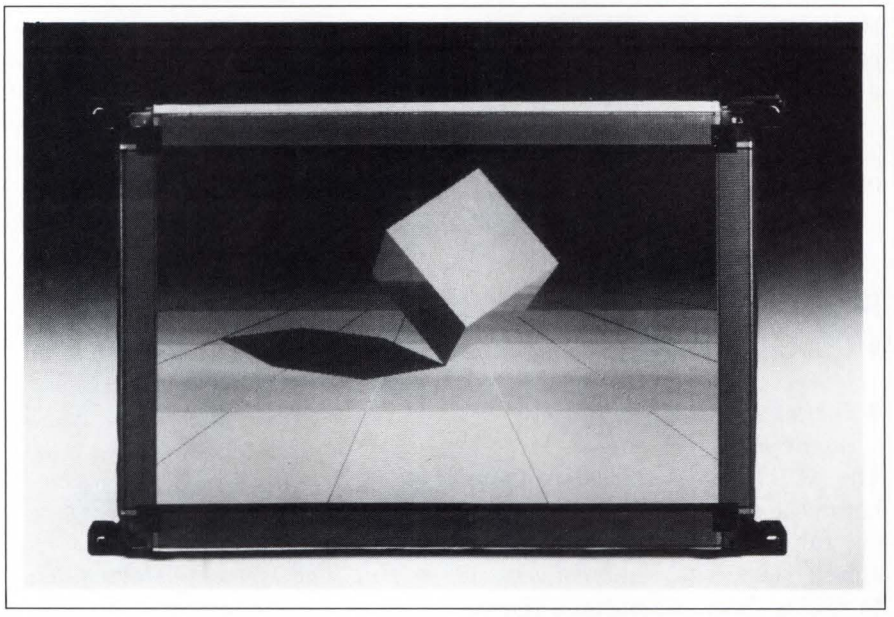
NEW PRODUCTS

COMPONENTS & POWER SUPPLIES

PANEL DISPLAYS

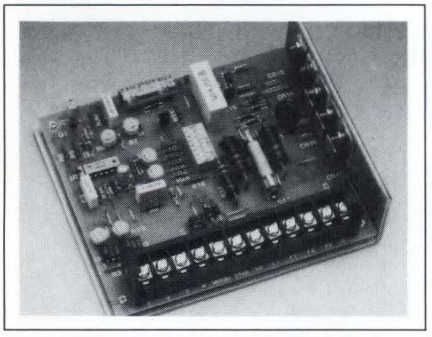
- *Feature 16 levels of gray scale*
- *Available in high-temperature versions*

This line of electroluminescent displays features 16 levels of gray scale. Model LJ64ZU48 offers 640×480-dot resolution with a dot pitch of 0.3×0.3; it features a 191.9×143.9-mm display area, requires an LSTTL input signal, operates from 5 and 24V supplies, and consumes 20W. Model LJ64ZU26 provides a 640×400-dot resolution, has a 191.9×119.9-mm effective display area, and consumes 15W. Two units—Models LJ32OU30 and LJ32OU26—are designed for more rugged environments and provide a 640×200-dot resolution. $603 to $1023.



Sharp Electronics Corp, Sharp Plaza, Mahwah, NJ 07430. Phone (201) 529-8757. FAX 201-529-8759.

Circle No 401



MOTOR CONTROLLERS

- *Feature 1500V isolation*
- *Control 2-hp dc motors*

Model 2746 motor controllers control the speed of dc motors with ratings to 2 hp. When driven from an analog source of 0 to 5V dc, the controllers produce an approximately linear motor voltage of 0 to 90V dc. For digital signal sources, a pulse-width modulated signal in the 1- to 10-kHz range produces linear output variations. The units feature a 1500V dc isolation rating between signal inputs and motor/power line outputs. Onboard DIP switches let you accommodate a range of motor horsepowers; the controllers regulate motor speed to within 2%. Onboard controls include maximum and minimum speed, acceleration, deceleration, current limit, and regulation. An opto-isolated inhibit circuit prevents unsafe or uncontrolled motor operation. $83.30 (100).

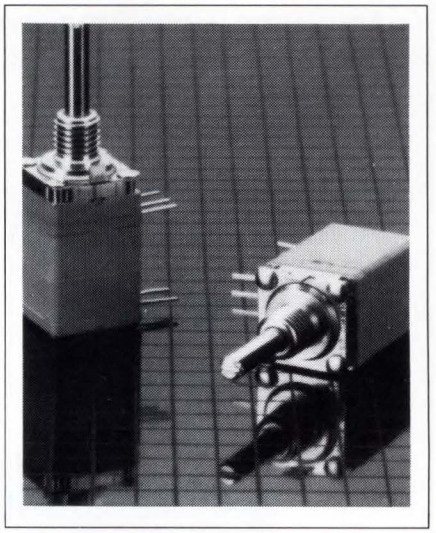
Powr-Ups Corp, 1 Roned Rd, Shirley, NY 11967. Phone (516) 345-5700.

Circle No 402

ENCODERS

- *Output 2-bit Gray code*
- *Have 100,000-cycle life*

Series 388EN-DJ rotary mechanical encoders feature a dome switch mechanism, a flexible-membrane dome that covers an on/off momentary switch to provide precise control. Available in 4-and 6-pulse models, the encoders measure just 0.5-in. square, output a 2-bit Gray code, and have a minimum rotational life of 100,000 revolutions.



The units operate over −40 to +100°C and have a 2.5-kΩ max contact resistance, a 10-MΩ operating resistance, and a 1- to 5.5-oz-in. torque. Gold-plated pc-board-type terminals are standard. $4.85 (1000).

Clarostat, Box 1507, Dover, NH 03820. Phone (603) 742-1120. FAX 603-742-0481.

Circle No 403

DC/DC CONVERTERS

- *Have isolation values to 500V dc*
- *Operate at 20 kHz*

The LP Series of 1 to 10W dc/dc converters includes over 50 models in single- and dual-output versions. The converters provide output levels from 5 to ±15V and have input/output isolation values from 300 to 500V dc. The units provide output-current-limiting, short-circuit protection, and they feature input filtering to minimize reflected input current. All converters operate at 20 kHz and have efficiencies as high as 65%. Output-voltage accuracy measures ±1%. From $43.

Datel Inc, 11 Cabot Blvd, Mansfield, MA 02048. Phone (508) 339-3000.

Circle No 404

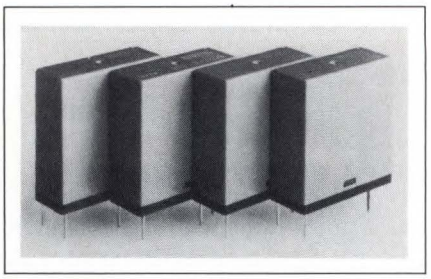
DC/DC CONVERTERS

- *Require no fan or heat sink*
- *Comply with MIL 810D*

RO Series 125 to 150W dc/dc converters produce full output power at 20°C without the need for heat sinks or fans. The RO 48 unit operates from inputs of 36 to 66V dc; the RO 300 unit operates from 200 to 400V dc. The converters provide a single output of 5V/25A, 12V/12A, 15V/10A, 24V/6A, or 28V/5A. The units feature N+1 redundancy and have current sharing, paralleling, and hot plug-in capability. Nonshutdown overvoltage protection, logic on/off, short-circuit protection, and overtemperature protection are standard. The converters comply with MIL 810D, UL, CSA, and VDE requirements. Input overvoltage protection equals 100 and 450V for RO 48 and RO 300 units, respectively. $249. Delivery, stock to 60 days ARO.

RO Associates Inc, 246 Capstan Dr, Sunnyvale, CA 94088. Phone (408) 744-1450. FAX 408-744-1521.

Circle No 405



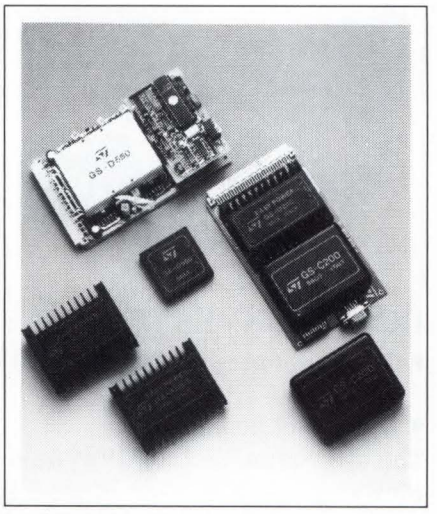
POWER RELAYS

- *PC-board mountable*
- *Have 100,000-cycle lifetime*

OSH Series miniature power relays are designed for mounting on pc boards. Measuring only 0.96 × 0.406 × 0.976 in., the relays handle 10A at 30V dc resistive loads or 3A at 12V ac inductive loads. A 0.25-in. creepage distance provides a 4000V ac dielectric-strength rating. Coil operating voltages range from 3 to 48V dc. The relays conform to UL, CSA, SEV, and SEMKO requirements and have a 100,000-cycle operating lifetime at rated load. $2.37 (1000). Delivery, eight to 12 weeks ARO.

Original Electric Mfg Co, 123 Lincoln Blvd, Middlesex, NJ 08846. Phone (201) 271-5770.

Circle No 406



MOTOR DRIVERS

- *Drive stepper motors from TTL or CMOS control signals*
- *Cater to phase-winding currents from 0.5 to 2.5A*

The GS-D050, -D200, and -D200S are fully encapsulated stepper-motor driver modules that drive permanent-magnet bipolar stepper motors from TTL- or CMOS-compatible inputs. The GS-D050 module, which measures 50.8 × 50.8 × 12.7 mm, directly interfaces with the parallel port of a μP to a permanent-magnet bipolar stepper motor. It can drive motors that require a phase-winding current as high as 0.5A. The module's internal logic lets you operate the motor in a full-, half-, or quarter-step mode, and you can control the phase current by applying a dc voltage to one of the module's input pins. The 85.5 × 67 × 22-mm GS-D200 module drives motors that require phase currents as high as 2A. This module is supplied with the phase-current set to 1A, but you can program it to other values by adding a single external resistor. You can modify the 17-kHz chopping rate of its phase-current control circuitry, and you can make

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the module a slave to others in order to eliminate the generation of system noise at beat frequencies. The module has an enable input in addition to step and direction inputs; it also provides operating mode-control inputs that select full- or half-step operation and a fast or slow phase-current decay. Its asynchronous reset input drives the stepper motor to its home position, and a status output indicates when it reaches that position. The GS-D200S, an enhanced version of the GS-D200, drives phase currents as high as 2.5A. It features comprehensive output short-circuit protection and a power MOS output stage that reduces power dissipation. GS-D050, approximately $15; GS-D200, $18 to $20; GS-D200S, $23 to $25 (5000).

SGS-Thomson Microelectronics, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (039) 65551. TLX 330131.

Circle No 407

SGS-Thomson Microelectronics, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 408

ATTENUATOR

- *Allows jumper-link selection of attenuation value*
- *Provides attenuation values as high as 31.5 dB in 0.5-dB steps*

The Model 691601 attenuator allows installation and service engineers to adjust attenuation values without desoldering components. The attenuator has 6 attenuator pads with attenuation values of 0.5, 1, 2, 4, 8, or 16 dB. By using arrow-shaped shorting links, you can configure the attenuator to provide an overall attenuation of 0 to 31.5 dB with 0.5-dB resolution. The device is pc-

board mounting, has a footprint of 1.2×0.7 in., a height of 0.5 in., and meets BT RC500/5348 specifications. Approximately £5 (1000).

Welwyn Electronics, Bedlington, Northumberland NE22 7AA, UK. Phone (0670) 822181. TLX 53514. FAX 0670-829465.

Circle No 409

SOCKET BOARDS

- *Compatible with Versabus*
- *Available custom pinned*

Series 031-035-XX wire-wrappable socket boards are compatible with Motorola's Versabus and plug into any Versabus-compatible backplane and card cage. The boards are available either fully populated with socket pins or custom pinned to your specifications. They will accept any DIP that has 0.3-, 0.6-, or 0.9-in. center spacings. You can install discrete components in any location by using the socket pins or the manufacturer's HD Series component pins. The boards are made of 0.062-in. epoxy fiberglass; the 2-oz copper etch is tin plated and solder reflowed, and the connector fingers have 50 µin. of gold over 150 µin. of nickel plating. Socket pins are available in a choice of platings and lengths. Model 031-035-10 (with gold-plated 2-level socket pins), $735.

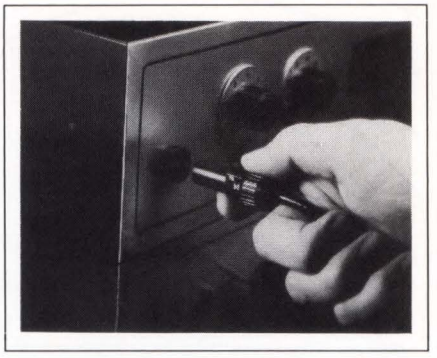
Hybricon Corp, 12 Willow Rd, Ayer, MA 01432. Phone (508) 772-5422.

Circle No 410

CONNECTORS

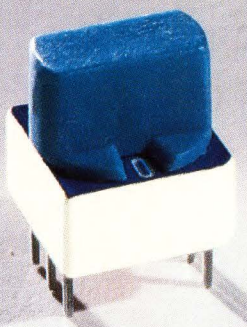
- *All contacts are shrouded*
- *Include novel latches*

These 3-position DO2 Series circular connectors are designed for cable-to-cable or cable-to-chassis applications. They feature a shock-



free polycarbonate housing that includes a novel pushbutton-style, plug-to-receptacle latch. You can use the pin or socket contacts in either the plug or the receptacle, and all contacts are shrouded to prevent electrical shock. Connector housings are molded from a high-impact, shockproof polycarbonate. The connectors are available in two termination styles: crimp for #18 and #20 AWG conductors and solder-cup for #16 AWG conductors. $10.91 (1000). Delivery, four to six

If you still believe a DIP switch has to be error prone and hard to use . . .



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Contact EECO Incorporated, Switch Marketing, P.O. Box 659, Santa Ana, California 92702-0659, telephone (714) 835-6000. In Europe, contact EECO Limited, Trafalgar Way, Bar Hill, Cambridge, CB3 8SQ, England, phone (0954) 80257.

EECO®

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Hypertronics Corp, 16 Brent Dr, Hudson, MA 01749. Phone (508) 568-0451. FAX 508-568-0680.

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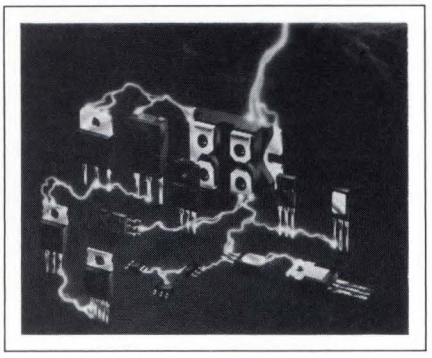

MOSFETs

- *Suitable for use in automotive switching*
- *Handle drain currents as high as 40A*

BUK500 Series MOSFETs withstand gate-source voltages as high as 15V, making them suitable for applications such as automotive load switching, where battery voltages may vary widely during operation. The range includes 14 transistors with maximum drain-source voltage ratings of 50, 100, or 200V. Drain-current ratings range between 12 and 40A for the 50V devices, 8 and 25A for 100V devices, and 5.3 and 12A for 200V devices. Some of the devices withstand drain-source voltage spikes as high as 400V. Their switching times, which are in the region of a few tens of nanoseconds, are comparable to standard logic-level drive MOSFETs. The MOSFETs have a projected MTBF of 2070 years at 90 °C, and you can operate them safely at a maximum operating temperature as high as 175 °C. They are available in a range of power packages. For a 50A device, approximately Gld 1.20.

Philips, Components Division, Box 218, 5600 MD Eindhoven, Netherlands. Phone (040) 757189. TLX 51573.

Circle No 412

Amperex Electronic Corp, George Washington Highway, Smithfield, RI 02917. Phone (401) 232-0500. FAX 401-232-1047.

Circle No 413

TRANSCEIVER

- *Combines an F-O transmitter and a receiver in one package*
- *Operates from ECL, TTL, or CMOS logic*

The DLX2000 fiber-optic transceiver is suitable for use in a variety of data communications systems and is housed in a package that occupies less than 2 in.^{2} of pc-board space. The transceiver comforms fully with the ANSI Fiber Distrib-

Text continued on pg 248

TEAR ON DOTTED LINE TO REMOVE AND SAVE.

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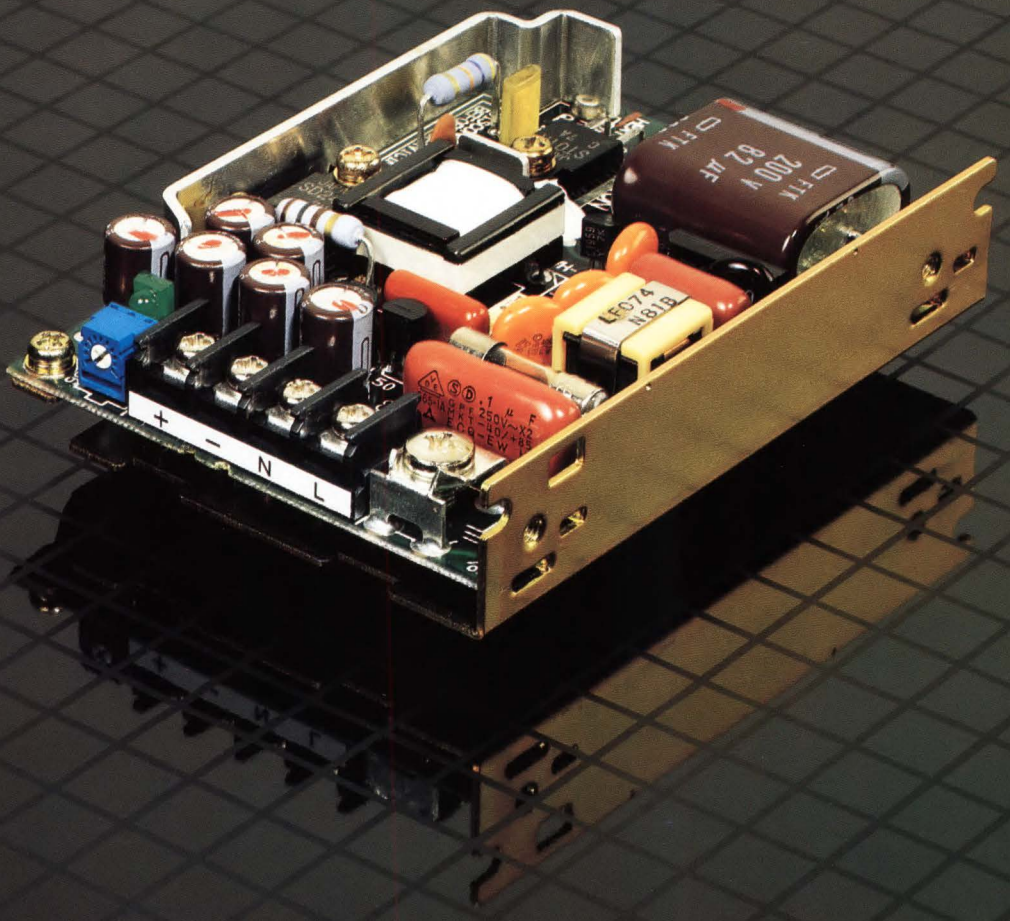

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Shown Actual Size

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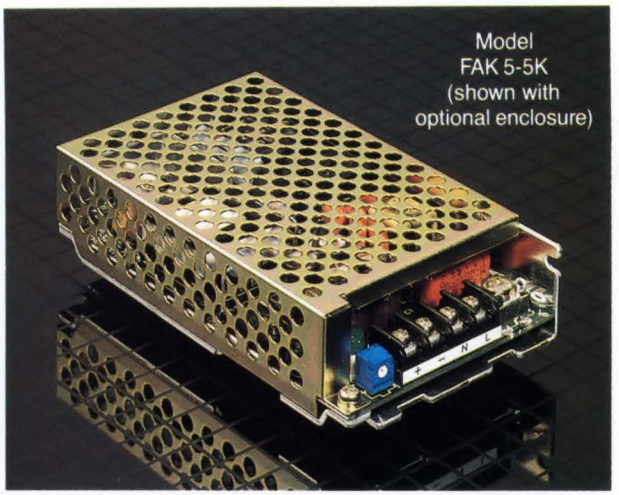

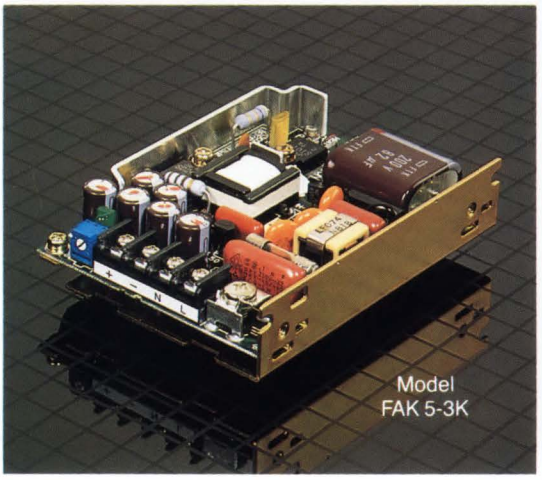

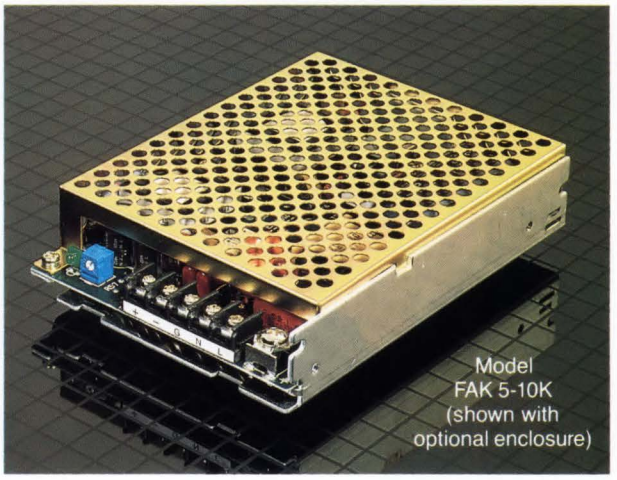

FAK MODEL TABLE

SPECIFICATION	OUTPUT VOLTAGE		OVP SETTING	OUTPUT CURRENT	CURRENT LIMIT(2)	RIPPLE(3)				NOISE(3) (SPIKE)	EFFICIENCY
Unit	Volts		Volts	Amps	Amps	mV				mV	percent
Condition	Factory set(1)	Adjustment range		0-50°C (see Fig 1)	nom input, 25°	Source p-p typ	Source p-p max	Switching p-p typ	Switching p-p max	d-c to 50MHz p-p max	nom input max load typ
15 WATT MODELS					Size: 0.78″ H x 2.76″ W x 3.74″ D Net weight: 5.60 oz.						
FAK 5-3K	5	4.5- 5.5	NA	0-3.0	3.3~ 5.0	10	30	30	60	120	70%
FAK 12-1.3K	12	10.8-13.2	NA	0-1.3	1.4~ 2.3	10	30	30	70	190	
FAK 15-1K	15	13.5-16.5	NA	0-1.0	1.1~ 2.0	10	30	30	70	220	
FAK 24-0.7K	24	21.6-26.4	NA	0-0.7	0.8~ 1.4	10	30	30	80	310	
25 WATT MODELS					Size: 0.98″ H x 2.76″ W x 4.53″ D Net weight: 5.98 oz.						
FAK 5-5K	5	4.5- 5.5	6.0~ 6.9	5	5.5~ 7.5	10	30	30	70	120	70%
FAK 12-2.1K	12	10.8-13.2	13.7~15.7	2.1	2.3~ 3.3	10	30	30	70	190	
FAK 15-1.7K	15	13.5-16.5	17.0~19.0	1.7	1.9~ 2.8	10	30	30	70	220	
FAK 24-1.1K	24	21.6-26.4	27.0~30.5	1.1	1.2~ 1.8	10	30	30	80	310	
50 WATT MODELS					Size: 0.98″ H x 3.74″ W x 5.12″ D Net weight: 8.80 oz.						
FAK 5-10K	5	4.5- 5.5	6.0~ 6.9	0-10.0	10.5~12.0	10	30	25	50	120	75%
FAK 12-4.2K	12	10.8-13.2	13.7~15.7	0- 4.2	4.4~ 5.1	20	40	25	50	190	
FAK 15-3.4K	15	13.5-16.5	17.0~19.0	0- 3.4	3.6~ 4.1	20	40	25	50	220	
FAK 24-2.1K	24	21.6-26.4	27.0~30.5	0- 2.1	2.2~ 2.6	30	60	25	60	310	

(1) Nominal input, maximum load, 25°C (2) 15W & 25W models: Foldback, fixed. 50W models: Rectangular, fixed.
(3) 0 to 50°C, 10% to 100% load.

For complete specifications send for Switcher Catalog 146-1605

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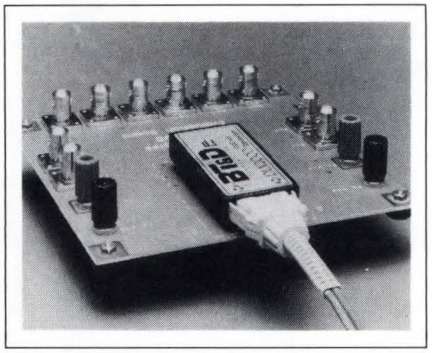


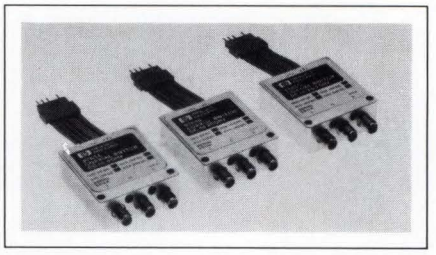
uted Data Interface (FDDI) and Physical Media Dependent (PMD) standards. The device includes a 1300-nm InGaAsP laser-diode transmitter and a planar PIN photodiode receiver, with electronics to provide logic-level transmit-and-receive data, a transmit disable input, and a received-signal-detect output. The transceiver operates from ECL or pseudo-ECL power supply voltages, and has complementary ECL-compatible inputs and outputs. You can also configure the device to operate with TTL- or CMOS-compatible logic levels on its inputs. It connects directly to the AMD TAXI or Supernet data-communication chip sets. When used at both ends of a fiber-optic link, the transceiver can cope with a signal loss of 18 dB typ over an operating temperature range of 0 to 70 °C. Its power dissipation is 1W typ. Approximately £675.

BT&D Technologies Ltd, Ipswich, Suffolk IP1 5PB, UK. Phone (0473) 42250. TLX 98409. FAX 0473-241110.

Circle No 414

BT&D Technologies, Delaware Corporate Center 2, 2 Righter Parkway, Suite 200, Wilmington, DE 19803. Phone (302) 479-0300. FAX 302-479-9560.

Circle No 415



COAXIAL SWITCHES

- *Have 5-million-cycle lifetime*
- *Include SMA connectors*

The three units in this line of spdt coaxial electromagnetic switches feature a 5-million-cycle lifetime and have a repeatability figure of ±0.3 dB. The HP 8765A includes SMA connectors and has an insertion loss/isolation ratio of 0.18/111 dB at 4 GHz. Ratios for the HP 8765B and HP 8765C are 0.46/80 dB at 20 GHz and 0.63/60 dB at 26.5 GHz, respectively. All models have a 15-msec switching speed. Coil voltages of 5, 10, or 24V dc are available. The coaxial switch ports are unterminated and can switch 2W and carry 500W avg. Standard coil connections employ ribbon cable and Berg connectors; a solder-terminal termination is optional. HP 8765A, $185; HP 8765B, $215; HP 8765C, $265.

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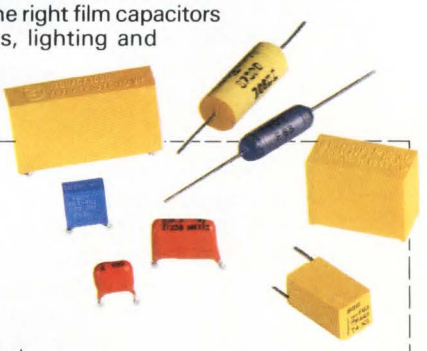

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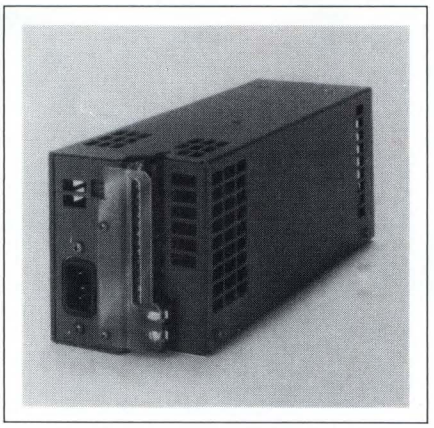


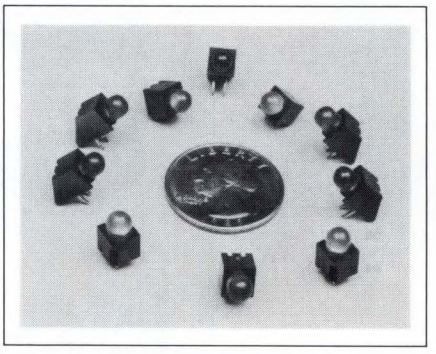
POWER SUPPLIES

- *Have 2W/in.³ power density*
- *Line has 25 models*

LMS Series power supplies are designed for constant-voltage or constant-current applications. The line includes 25 models that offer output voltages to 120V dc, output current to 100A, and output-power ratings as high as 800W. The supplies feature efficiency ratings to 77.5% and power density of 2W/in.³. They operate from 110 or 220V ac inputs and have 3750V ac input-to-output isolation. Standard features include remote on/off (TTL-compatible), remote sense, and remote programming capabilities (current and voltage). From $250.

Lambda Electronics, 515 Broad Hollow Rd, Melville, NY 11747. Phone (516) 694-4200.

Circle No 417



INDICATORS

- *Designed for low-power applications*
- *Available in a variety of package styles*

Designed for low-power applications, 550 Series GaAlAs indicators provide full-level output at a forward current of only 2 mA. The indicators' T-1¾ LED is available in red, green, and yellow in a choice of four pc-board-mountable package styles: one that mounts perpendicularly; three right-angle packages; two with right-angle mounts (LED and leads 90° apart); and one that has a slant back and small standoff feet molded into the package bottom to facilitate board cleaning. The four styles are made of black Valox, which carries a 94V-0 UL rating. $0.54 (1000).

Dialight Corp, 1913 Atlantic Ave, Manasquan, NJ 08736. Phone (201) 223-9400.

Circle No 418

"I'm not a writer who writes about engineering; I'm an engineer who writes."

Anne Swager, EDN Magazine Edition Associate Editor

Anne's been reading EDN since she became an electrical engineer. And as an engineer, she has always counted on EDN to keep her up to date on new products and technology in the electronic markets. "As an engineer, I found myself always focusing on one project. I read EDN to find out what was going on in other areas of electronic engineering. Becoming a technical editor gave me greater exposure to the entire spectrum of electronics."

Not too long ago, Anne saw an ad like this one and answered it. "When I saw EDN's ad, I sent in my resume. I never even considered working for another publication."

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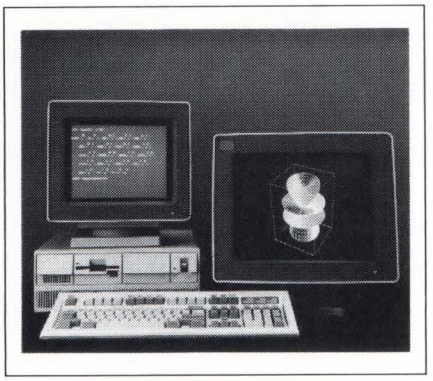


MATH SYSTEM

- *Interactive computation system for scientists and engineers*
- *Runs on 80386-based computers with numeric coprocessor*

The Mathematica interactive computational system for scientists and engineers runs on any 80386-based computer under MS-DOS or PC-DOS, as well as on a variety of other PCs and workstations. It operates with the 386/VMM virtual-memory system from Phar-Lap Software (Cambridge, MA) to allow the use of more than 1M byte of RAM, limited only by the available hard-disk space. You can perform numeric, symbolic, or graphical computations. Numeric functions include integer functions, transcendental orthogonal polynomials, integrals, matrix operations, generalized least-squares fit and Fourier transforms. Symbolic operations include polynomial operations, rational-function operations, calculus, equation solving, symbolic matrix operations, list operations, and tensor operations. The system has both 2- and 3-dimensional graphics capabilities, including full hidden-surface removal. Standard version, $695; version for 80287 and 80387 numeric coprocessors, $995; version for Weitek 1167 or 3167 numeric coprocessors, $1295.

Wolfram Research Inc, Box 6059, Champaign, IL 61821. Phone (217) 398-0747. FAX 217-398-0747.

Circle No 351

32-BIT REAL-TIME OS

- *Provides multitasking, multiuser facilities*
- *Lets a program use the full 32-bit address space for data and code*

The pF/x 32-bit, real-time operating system for embedded systems is based on the Intel 80386 μP and features multitasking, multiuser capabilities. The complete package contains a superset of the Forth compiler, macro assemblers for

both the 80386 and the 80387 numeric coprocessor, a program editor, target and turnkey compilers, a graphics manager, a database manager, and utility programs for software development. PF/x allows an application program to use the full 32-bit memory space for both code and data. When the program needs to access a system resource, pF/x switches to real mode and establishes a link to MS-DOS, which performs the requested operation. The interface is transparent to the user, and the switch between real and protected modes is very fast. The operating system links time-critical interrupt-service routines directly to the hardware interrupt vectors, so that interrupt latency is zero. $3850.

Forth Inc, 111 N Sepulveda Blvd, Manhattan Beach, CA 90266. Phone (213) 372-8493.

Circle No 352

PROGRAM EDITOR

- *Runs on 80386-based Unix workstations*
- *Has built-in compile command for the vendor's compilers*

CoEdit is a language-sensitive program editor that works with the vendor's family of compilers for C, Pascal, Ada, Cobol, and other programming languages. It runs on 80386-based workstations under the 386/ix Unix operating system. The editor provides pop-up menus and an unlimited number of windows on conventional terminals; context-sensitive on-line help; keyword templating; automatic file saving as a background operation; and an extensive Undo capability. The editor includes an expression evaluator, a pre-compile syntax checker, and a macro language with its own compiler and debugger. The built-in Compile command allows you to compile your program from within the editor and to correct any errors that the compiler detects. The vendor plans to produce other versions of CoEdit for Unix systems based on Motorola's 68000 family and 88000 RISC processors or on the Sun SPARC processor. $349.

Language Processors Inc, 959 Concord St, Framingham, MA 01701. Phone (508) 626-0006.

Circle No 353

LOGIC SYNTHESIZER

- *Accepts input in a combination of notations*
- *Extracts the don't-care set for use in minimizing gate counts*

The Bool logic synthesizer accepts input in a combination of equations, tables, behavioral constructs, and state-machine descriptions, all written in a high-level language that is somewhat similar to C language. The program uses algorithms that

can extract the don't-care set from the input descriptions and use it in the gate-minimization process. This feature is particularly valuable for random-logic designs, where it can reduce the gate count by as much as 30%. The proprietary minimization algorithms include a very fast minimizer and an absolute minimizer, both of which handle complex designs with hundreds of product terms. The program produces standard output in the form of a sum-of-products or PLA table; however, you can write special procedures to generate output in Intel HEX86 format for downloading to PROM programmers (an example is included), or in a form that PLA synthesizers can use. A built-in simulator, which operates at the same level of abstraction as your specifications, lets you verify the operation of your design before you commit it to hardware. The program runs on IBM PCs, PS/2s, and compatibles. $390.

Cornell Design Tools, 761 Cornell Dr, Santa Clara, CA 95051. Phone (408) 984-0777.

Circle No 354

C CROSS-DEBUGGER

- *Lets you debug C software for embedded systems on the host*
- *Interrogates an emulator's trace buffer for execution history*

XDB 5.0 is a C source-level cross-debugger that runs on IBM PCs and on VAX, Sun, Apollo, and Hewlett-Packard workstations. Using the host—with or without an in-circuit emulator—you can debug C programs for target systems that are based on the Intel 8086, Motorola 68000 and 6800, NEC V, and Zilog Z80 family processors, or on the Am29000 RISC processor. Ten new windows allow you to view source code, XDB commands, registers, monitored variables, stack contents, and simulated input and output; you can also view the active breakpoints and all user-defined functions. If you're using XDB with an in-circuit emulator (ICE) in the target, you can interrogate the ICE's trace buffer and obtain an execution history. The simulated-I/O feature lets you debug your own input and output routines before the actual hardware devices are connected to the target system. The user-defined-function feature lets you store and recall complex commands and expressions with only a few keystrokes. IBM PC versions, from $1500.

Intermetrics Inc, 733 Concord Ave, Cambridge, MA 02138. Phone (617) 661-0072. TWX 710-320-7523.

Circle No 355

CASE TOOL

- *Permits multiple methodologies*
- *Runs on IBM PCs equipped with Microsoft Windows*

DesignVision$_{ELS}$ is an entry-level version of the vendor's DesignVision CASE tool. The entry-level system runs on IBM PCs and compatibles that are equipped with 640k bytes of RAM and the Microsoft Windows graphics manager. The entry-level system and the full version use the same design dictionary—a repository for all information that you consider critical to the application-software components, which are represented in the diagrams created by the tool. The package provides predefined models for ten of the most widely used diagramming methods, such as Warnier/Orr, Yourdon/DeMarco, and Gane/Sarson data-flow diagrams, or Chen entity-relationship diagrams. $995.

Optima Inc, 1300 Woodfield Rd, Suite 400, Schaumburg, IL 60173. Phone (312) 240-1888.

Circle No 356

MULTIUSER OS

- *Lets as many as 128 users run DOS or Theos on 80386 machine*
- *Takes advantage of the 80386's 32-bit technology*

Theo-DOS Plus Pack is an add-on product for the Theos 386 operating system and allows as many as 128 users to share a single 80386-based computer. You can run applications software under Theos 386, but you also have full access to DOS internal, external, and batch programs. Because Theo-DOS makes use of the original DOS supplied with your system, you can run TSR (terminate and stay resident) programs and applications that use a numeric coprocessor or expanded memory. In addition, the operating system emulates many of the capabilities that are provided by DOS networking software. When running networking versions of DOS application programs, users can share files. Theo-DOS runs on any 80386-based computer that runs Theos 386. $399.

Theos Software, 1777 Botelho Dr, Suite 360, Walnut Creek, CA 94596. Phone (415) 935-1118. FAX 415-935-1177.

Circle No 357

PROGRAM-LOGIC TOOL

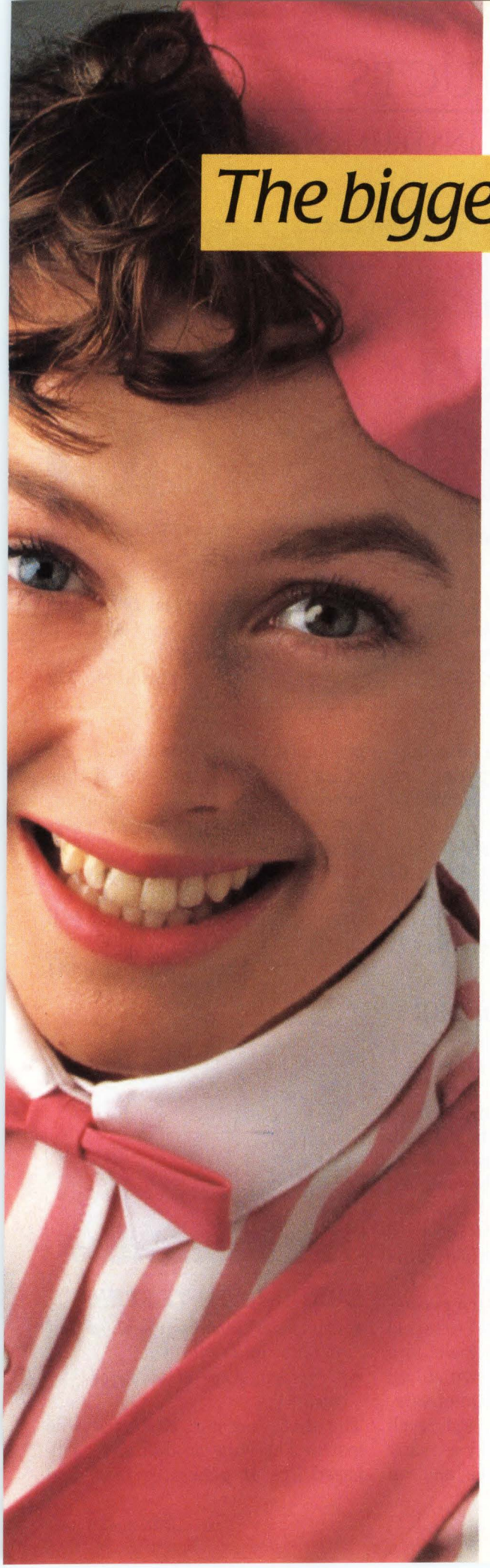
- *Helps you develop the logic portion of any computer program*
- *Automatically generates code in C, Fortran, and other languages*

Logic Gem (LG) is a collection of three design tools that allow you to create and test the logic portion of your design and then automatically generate code in C, Basic, Fortran, dBASE, Pascal, or English. The logic-editor module is an electronic decision table that is structured like a spreadsheet. First, you enter a series of independent conditions and actions that describe your program logic. The logic editor then completes the logic for you if the table is incomplete; automatically generates a set of decision rules for you to edit; eliminates redundant or contradictory rules; and reduces, sorts, and optimizes the logic. The logic-interpreter module lets you step through the logic to view its operation and correct any design errors. The logic compiler translates the verified, logically complete decision table into English pseudo-code for documentation purposes, or into compilable source code in C, Fortran, Basic, Pascal, or dBASE. The program runs on IBM PCs, PS/2s, and compatibles that have 640k bytes of RAM and a color or monochrome monitor. $198.

Sterling Castle, 702 Washington St, Suite 174, Marina del Rey, CA 90292. Phone (213) 306-3020. FAX 213-821-8122.

Circle No 358


1M
GRAPHICS BUFFER



The biggest scoop in graphics.

NEC announces the 1-megabit dual-port graphics buffer.

If you're designing a high-end workstation, PC, or office automation system, the announcement of NEC's 1M-bit graphics buffer is the best news you'll hear all day. Our new dual-port chip gives you a critical edge in the most competitive areas — higher resolution, more colors and increased speed.

The μPD42274 offers precisely what your system needs to excel in graphics. The 256K x 4 random access port features write-per-bit control and fast-page operation for high-speed reads and writes. The 512 x 4 serial port handles high resolution graphics with clock speeds up to 33MHz. And a unique flash-write function clears the screen in a flash.

Other advanced features include:

- ☐ High speed.
  RAS access: 100 or 120ns.
  CAS access: 25 or 30ns.
  Serial read cycle: 30 or 40ns.
- ☐ Low power consumption. Standby: 5mA.
  Random read or write: 140 or 125mA (serial port active).
- ☐ Standard 400-mil, 28-pin plastic ZIP and SOJ packaging.

NEC led the industry with the first 256K dual-port graphics buffer. Now we're inaugurating the 1M-bit era. To get the scoop on what the latest graphics chip technology can do for you, call NEC today.

For fast answers, call us at:

USA Tel:1-800-632-3531. TWX:910-379-6985. W. Germany Tel:0211-650302. Telex:8589960. The Netherlands Tel: 040-445-845. Telex:51923. Sweden Tel:08-753-6020. Telex:13839. France Tel:1-3946-9617. Telex:699499. Italy Tel:02-6709108. Telex:315355. UK Tel:0908-691133. Telex:826791. Hong Kong Tel:3-755-9008. Telex:54561. Taiwan Tel:02-522-4192. Telex:22372. Singapore Tel:4819881. Telex:39726. Australia Tel:03-267-6355. Telex:38343.

NEC

CIRCLE NO 74

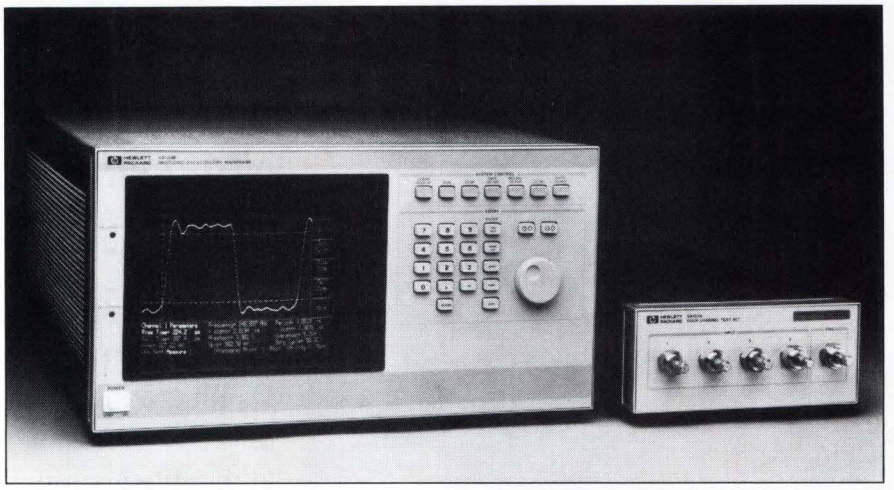
NEW PRODUCTS

TEST & MEASUREMENT INSTRUMENTS

12.4-GHz DSO

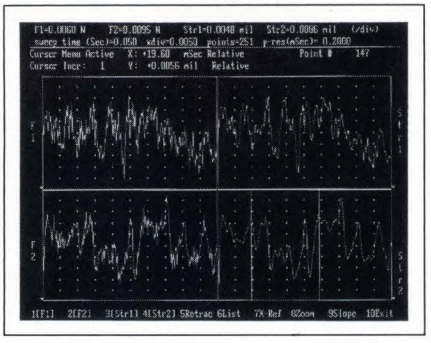
- *Has four inputs that include programmable attenuators*
- *Firmware performs statistical analysis; constructs histograms*

The 54122T 4-channel digitizing oscilloscope digitizes and displays in color repetitive signals whose frequency content extends to 12.4 GHz. Though DSOs from this and other vendors offer 20-GHz bandwidth, the 54122T provides programmable input attenuators, an unusual feature in instruments with extremely high bandwidth, and a feature whose presence is virtually mandatory when you use a scope as part of an automatic-test setup. The attenuators divide the input voltage by factors of 1, 3, 10, and 30. The scope also performs statistical analysis and constructs histograms and eye diagrams. $27,850.



Hewlett-Packard Co, 19310 Pruneridge Ave, Cupertino, CA 95014. Phone (800) 752-0900.

Circle No 372



SCOPE SOFTWARE

- *Allows acquisition, storage, and display of analog data*
- *Supports more than 100 boards from six vendors*

Release 3.0 of the Snapshot Storage Scope software package requires no programming and allows acquisition, storage, and display of analog data. It runs on IBM PCs and compatible computers and works with more than 100 configurations of PC bus-based analog I/O boards from Acrosystems, Analog Devices, Burr-Brown, Contec, Data Translation, and Metrabyte. The software supports systems that have as many as 80 channels. It allows acquisition of 1M samples/sec with different voltage gains on individual channels. The software also supports pre- and post-triggering, external clocks, and cursor-controlled zooming. $495.

HEM Data Corp, 17336 Twelve Mile Rd, Suite 200, Southfield, MI 48076. Phone (313) 559-5607. FAX 313-559-8008.

Circle No 373

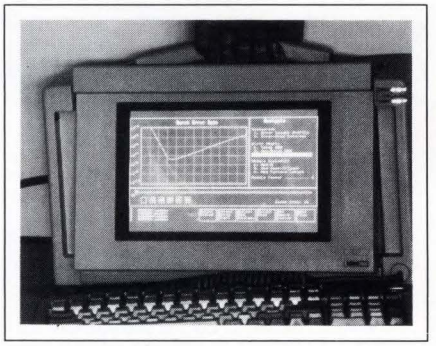
WAVEFORM RECORDER

- *Plugs into IBM PC bus*
- *Digitizes to 12 bits at 1M samples/sec*

The SRA 1200 waveform recorder plugs into the IBM PC bus. It can take 1M 12-bit samples/sec and can store from 64k to 256k samples. Both the hardware and the accompanying Signal Graphics software support the use of multiple cards in multichannel applications. You can select pre- or post-triggering, trigger from internal or external signals, and operate the cards in a master/slave mode in which all channels sample simultaneously. The software can store and recall waveforms on disk, display as many as eight waveforms at once, and can produce waveform printouts. A pair of cursors permit readouts of time or voltage and allow "zooming in" for detailed examination of waveform segments. $1795.

Scientific Recording Associates, 59 Princeton Terr, Watertown, CT 06795. Phone (203) 274-7761.

Circle No 374



ERROR-RATE TESTER

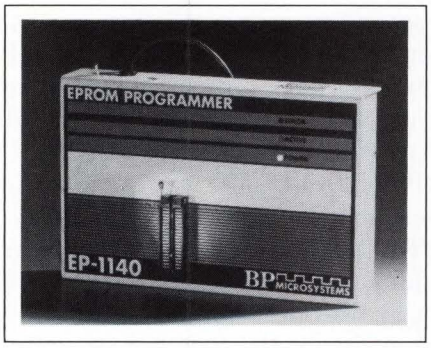
- *Generates and receives fixed and pseudorandom data*
- *Graphically correlates error events*

The BitAlyzer is a 20-lb, portable instrument built around an 80386-based PC. It generates fixed and

pseudorandom data streams, detects errors in the received data, and produces graphics displays that help you pinpont sources of errors. Through software, you can program the clock rate from dc to 160 MHz. Not only can the instrument test digital communications channels and aid in troubleshooting them, it can help you diagnose faults in such products as high-density digital-storage systems. Reel-to-reel tape drives are an example. The software performs many functions that assist in isolating problems: For instance, you can obtain plots of the points in a data pattern where error probability is highest, and histograms are the length of error bursts. $29,400.

Design Ware Associates, 983 Emerald Hill Rd, Redwood City, CA 94061. Phone (415) 364-1853. FAX 415-364-5716.

Circle No 375



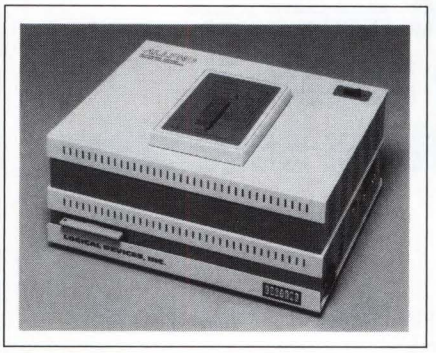
EPROM PROGRAMMER

- *Programs (E)EPROMs to 4M bits and 40 pins*
- *Programs a 2764 in 3 sec*

The EP-1140 universal PROM programmer allows you to program devices in 24-, 28-, 32-, and 40-pin packages. The unit programs devices that store as many as 4M bits and also programs microcontrollers in the 874X and 875X families. It can program a 2764 device in 3 sec and a 27210 in 30 sec. The unit requires an IBM PC or compatible computer for operation. The accompanying software, which supports six hexadecimal file formats and includes a full-screen editor, splits large files so you can program PROM sets. EP-1140, $895; EP-1132, for 24- to 32-pin devices, $695; demonstration disk, free of charge.

BP Microsystems Inc, 10681 Haddington, Suite 190, Houston, TX 77043. Phone (800) 225-2102; in TX, (713) 461-9430. FAX 713-461-7413.

Circle No 376



PROGRAMMER

- *Works with any host computer via an RS-232C port*
- *Includes a 3½-in. floppy-disk drive for algorithm updates*

The Allpro-S universal device programmer connects to any host computer or ASCII terminal via an RS-232C port. Within the unit is an 8088-based computer with a 3½-in. floppy-disk drive and 256k bytes of RAM that you can expand to 640k bytes. The unit is completely compatible with an earlier version of the product which the vendor continues to sell. That version requires a separate IBM PC-compatible host computer. Both versions can program EPROMs, EEPROMs, PROMs, PLDs, EPLDs, and single-chip μCs. You select devices via software without using plug-in modules or personality adapters. The vendor distributes updates to the device library and programming algorithms on disk. $5995.

Logical Devices Inc, 1201 NW 65th Pl, Fort Lauderdale, FL 33309. Phone (800) 331-7766; in FL, (305) 974-0975. TLX 383142.

Circle No 377

DMMs

- *Incorporate autoranging and audible indicator*
- *Protected by self-resetting fuse*

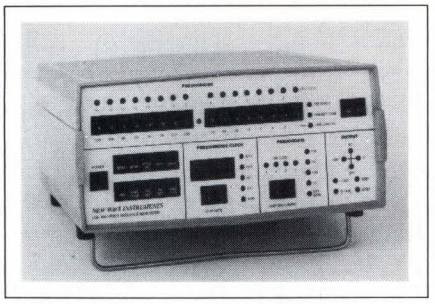
The 200 Series 3½-digit DMMs incorporate features that facilitate taking measurements when you don't have both hands free or when you can't look directly at the meter. The units incorporate autoranging; one model, the 223, includes an audible output whose pitch can give you an idea of the value of the displayed reading. If the circuit under test exhibits intermittent behavior, you hear a crackling sound. When you connect the unit to TTL or CMOS logic, a pulse detector emits an audible "beep" each time it senses a pulse whose duration exceeds 50 nsec. When you connect the 223 to a charged capacitor, the pitch of the tone lets you hear how rapidly the charge is decaying. In situations where it's awkward to hold the instruments, a Skyhook clip lets you suspend the instruments. The units measure dc voltages from 100 μV to 1 kV, ac voltages to 750V, and ac and dc currents from 10 μA to 10A. A self-resetting fuse protects the current-measurement circuits. Basic accuracy is 0.5% for the model 222 and 0.25% for the 223. Model 222, $129; Model 223, $149.

Beckman Industrial Corp, 3883 Ruffin Rd, San Diego, CA 92123. Phone (619) 495-3200. FAX 619-268-0172. TLX 249031.

Circle No 378

SEQUENCE GENERATOR

- *Generates pseudorandom sequences in programmable length*
- *Operates to 25 MHz (to 20 MHz from internal clock)*



The LRS-100 pseudorandom bit-sequence generator is intended for testing of conventional and spread-spectrum data-communications systems. You select the linear, recursive sequence by setting the feedback pattern and the initial contents of a 16-bit shift register. You can vary the sequence length from 1 to 65,535 clock periods. Maximum clock rate is 25 MHz; maximum internal clock frequency is 20 MHz settable as low as 1 Hz in 1-2-5 steps. The unit is capable of binary, quadrature, and staggered-quadrature phase-shift keying. $9500. Delivery, 60 days ARO.

New Wave Instruments, 3760 Masters Ct, San Jose, CA 95111. Phone (408) 629-3105. TWX 510-601-2474.

Circle No 379

DEVELOPMENT SYSTEM

- *Consists of tools for RTX 2000 μP*
- *Hosted by IBM PC or compatible computer*

The RTXDS-10 real-time express development system comprises a set of integrated tools for developing software for the RTX 2000 μP family. The software consists of host and target portions. The host portion, which runs on the IBM PC, PC/XT, PC/AT, and compatible computers, operates interactively. The target portion resides in your RTX-based application hardware and provides run-time debugging support for the code you generate. The system allows you to generate code in the Forth language without forcing you to develop a full Forth implementation. Because the RTX 2000 uses a static clock and does not use pipelined instructions, you can test and debug your programs by single-stepping through them without using an in-circuit emulator. The target monitor enables you to perform any Forth operation as part of an embedded debugging command. $2995.

Harris Semiconductor, Box 883, Melbourne, FL 32901. Phone (407) 724-3800.

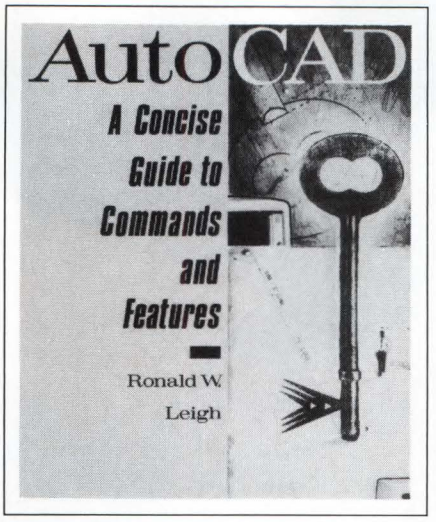
Circle No 380

Handbooks for circuit building and ham radio

The Master Handbook of IC Circuits—2nd Edition presents more than 950 schematics and pinout diagrams, arranged by function, for making simple-to-build circuits. The book illustrates popular ICs, including op amp, linear, voltage regulator, CMOS, TTL, and some special-purpose types. Paperback, $24.95; hard cover, $34.95. *The Packet Radio Handbook—2nd Edition* provides an overview of packet radio, its history, capabilities, and limitations. The publication explains how to set up and operate a station, and discusses the latest improvements in terminal node and multimode digital controllers, high-speed modems, and networking systems. Paperback only, $15.95.

TAB Books Inc, Blue Ridge Summit, PA 17294.

INQUIRE DIRECT



Publication deals with AutoCAD release 10

AutoCAD: A Concise Guide to Commands and Features, the most recent publication in the vendor's AutoCAD Reference Library, consists of 40 chapters of AutoCAD's basic features and commands with accompanying exercises for beginning users. The 330-pg softcover book also serves as a reference for seasoned users. More than 200 illustrations complete the issue. $19.95; with optional disk, $39.

Ventana Press, Box 2468, Chapel Hill, NC 27515.

INQUIRE DIRECT

Note details DRAM reconfiguration

The vendor's application note, *Reconfiguring DRAM Memory Arrays with the HDMP-25 High Density Switch,* discusses this high-density switch as a solution when trying to decide which dynamic RAM format to use in reconfiguration. The note provides detailed information and three diagrams.

Annulus Technical Industries Inc, Box 7407, Ancaster, Ontario, Canada L9G 4G4.

Circle No 381

problem."

"How so?"

"You can reprogram in-circuit. It's pin-compatible with standard 256K EPROMs and ROMs. And it's affordable."

"Whew! That could save us some real dollars."

"You catch on fast."

The newest member of Toshiba's high-speed, high-density non-volatile memory family is nothing less than brilliant. A CMOS 256Kb Flash EEPROM that offers operating power of 30mA at 5.9MHz and standby of 100μ amps.

The new Flash EEPROM electrically erases all pre-recorded information simultaneously and instantly. (Less than one second.) It also offers 12 volt programming which is compatible with most users' systems.

The Flash EEPROM offers an access time of 170ns and uses 1.2 micron design rule and a triple-layer polysilicon cell structure to shrink the chip size to that of conventional EPROMs.

Ideal for remote, down-loadable applications such as POS, printer fonts, memory cards and telecommunications, the new Flash EEPROM can be reprogrammed in-circuit via modem. So it can be field-updated, avoiding costly on-site updates and delays. In addition, last minute programming simplifies manufacturing to a single configuration.

NON-VOLATILE PRODUCT OFFERING

Density	Organization	Type	Process	Access Times (ns)					Package C-DIP	Package P-DIP	Package SOG	Package SOJ
256K	32 x 8	EPROM	NMOS	150	200				X			
		OTP	NMOS	170	200					X	X	
	32K x 8	EPROM	CMOS	70	85	120	150	200	X			
		OTP	CMOS	100	150	200				X	X	
		MROM	CMOS	200						X	X	
		FEEPROM	CMOS	170	200	250				X	X	*
512K	64K x 8	EPROM	NMOS	170	200	250			X			
		OTP	NMOS	200	250					X	X	
	64K x 8	EPROM	CMOS	150	200				X			
		OTP	CMOS	170	200					X	X	
		MROM	CMOS	150	200					X	X	
1 MEG	132K x 8	EPROM	CMOS	150	200				X			
		OTP	CMOS	200	250					X	X	*
		MROM	CMOS	120	150	200				X	X	*
1 MEG	64K x 16	EPROM	CMOS	85	100	150	200		X			
		OTP	CMOS	200	250					X	X	*
		MROM	CMOS	120	150					X	X	*
4 MEG	512K x 8	EPROM	CMOS	150	200				X			
		MROM	CMOS	250						X	X	*

*Indicates this package is under development.

It's available in a 28-pin plastic DIP and a plastic flat pack; both are pin-for-pin compatible with standard 256Kb EPROMs, OTPs and ROMs. Which means it can be placed in existing sockets with no design changes required. By eliminating the separate programming step, the coplanarity of the surface-mount Flash EEPROM is preserved.

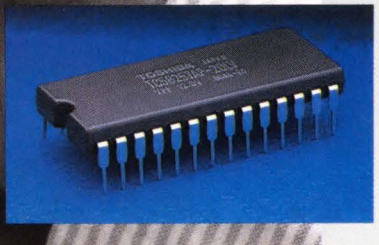
Plus Toshiba's volume production can give you the non-volatile devices you need with the high-speed and leading-edge densities you want for your applications. For high reliability, low cost and automatic insertion capability, select plastic package OTPs in densities to 1Mb.

Choose from a wide selection of high-speed, high-density EPROMs, including one of the fastest 1Mb's available. EPROMs that reduce the number of wait states for accessing data on the CPU by loading code directly without SRAMs. These EPROMs simplify operating systems and designs and reduce the total in-circuit costs.

And in ROMs, you get up to 4Mb in CMOS today.

You get it all from Toshiba non-volatiles, including wide-operating voltage range of ±10% VCC and a –40°C to +85°C temperature range which meets industrial temperature ranges.

For technical literature call 1-800-888-0848 ext. 517 today. And see what we can do for you.



In Touch with Tomorrow

TOSHIBA

TOSHIBA AMERICA ELECTRONIC COMPONENTS, INC.

MST-88-011

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Binary compatibility standard available

The 215-pg Binary Compatibility Standard (BCS) version 1.0 contains 10 chapters and appendixes. The BCS document features specifications (1) for interfaces between the binary executable file and the operating systems, and (2) for data interchange standards when installing software from removable media. Nonmembers, $40.

88open Consortium Ltd, 8560 SW Salish Lane, Wilsonville, OR 97070.

INQUIRE DIRECT

Catalog lists trimmers on a floppy disk

The company's SpecTrim electronic catalog lists more than 8600 standard trimmer part numbers, providing a software solution to trimmer selection. To find the trimmer

data you need, you either define performance parameters or enter the part number. The catalog disk is compatible with IBM PCs, and you can transfer it to a hard disk on a workstation.

Bourns Inc, 1200 Columbia Ave, Riverside, CA 92507.

Circle No 382

Brochure highlights hardware and components

This 12-pg brochure describes the company's complete line of precision pins and shafts, including motor shafts, planet pins, hydraulic pump vanes, and other standard pins and shafts, as well as custom-made components. The publication offers hardened and ground pins and shafts with a variety of end shapes, including flat ends with radius corners, spherical, chamfered, ball, conical, and tenon.

The Torrington Company, 59 Field St, Torrington, CT 06790.

Circle No 383

Complete listing of turnkey instruments

According to the vendor, the PC Instrumentation Catalog contains a complete listing of turnkey instruments, all using PCs. The publica-

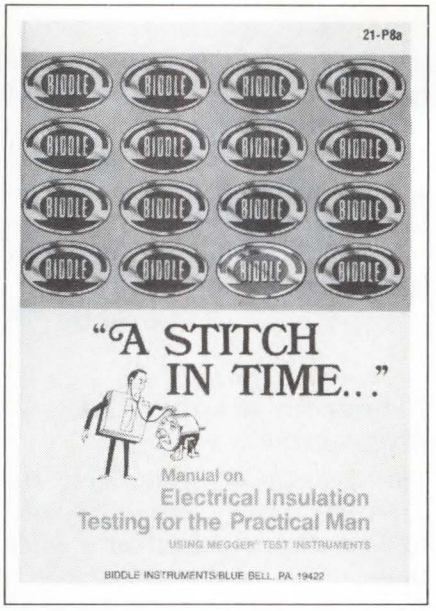
tion presents a comprehensive overview of products, including specifications, photos, screen displays, and prices. Some of the products listed include digital scopes, real-time FFT spectrum analyzers, DSP systems, and function generators and arbitrary waveform synthesizers.

Rapid Systems Inc, 433 N 34th, Seattle, WA 98103.

Circle No 384

Guide to testing electrical insulation

A Stitch in Time, a Manual on Electrical Insulation Testing for the Practical Man, provides a step-by-step guide to preventive maintenance for electrical insulation of wires, cables, motors, generators, transformers, switches, and other electrical equipment. After defining what good insulation is, it explains what makes insulation go bad. The publication provides aptitude tests consisting of three common test methods. Further information covers test voltage vs equipment rating, ac vs dc testing, and use of a dc dielectric test set for routine in-plant maintenance. Photos, charts, and drawings complete the publication. $5.



Biddle Instruments, 510 Township Line Rd, Blue Bell, PA 19422.

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Application software and hardware depicted

The company's 1989 Spring Catalog describes its comprehensive line of hardware and software products for engineering and scientific applications. The publication includes tutorial sections, as well as coverage of RS-232C and IEEE-488 instruments and PC data-acquisition applications. The catalog has been reorganized into four color-coded sections: Application Software; IEEE-488 Interfaces; Data Acquisition; and VXI Bus. The application-software section features the ven-

dor's LabView 2, LabWindows, and Measure packages.

National Instruments, 12109 Technology Blvd, Austin TX 78727.

Circle No 385

Dual-purpose publication

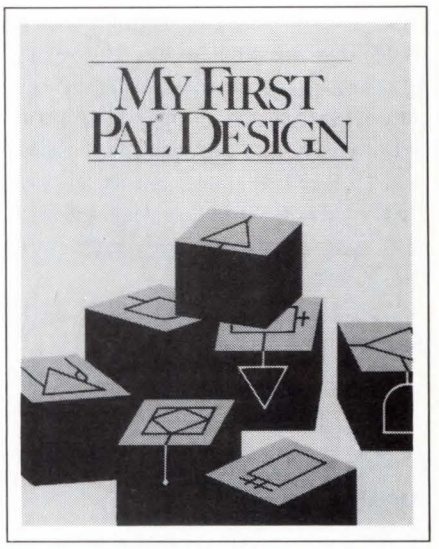
The company's *Export Designer's Reference and Catalog #5* serves as both a design reference and a catalog of power components for electrical and electronic equipment, including cords, cord sets, power-inlet connectors and modules, fuses, plugs, and power sources. If you are new to export design, the Introduction and the International Designer's Charts provide an easy-to-use overview. Introductions to each section also help you in the component-selection process by providing approvals, performance data, dimensioned drawings, and geographical and applications limitations where applicable. Further, the Designer's Reference presents tables and listings on international plug and socket standards; line voltages and frequencies; approval agencies and their symbols; and international standards.

Panel Components Corp, Box 6626, Santa Rosa, CA 95406.

Circle No 386

Primer for primary PAL programmers

The vendor's 40-pg booklet, *My First PAL Design*, is not intended to be a manual but rather a guide through the basics—its purpose is "solely to help break the ice when you start your first PAL design." The publication provides easy-to-read diagrams with page headings such as "What's it take to be a PAL device?" and "Be a PAL and change the points on my Demorgan, will you?" The book ends with state machines and uses a subway turnstile as an illustration of the world's most simple state machine.



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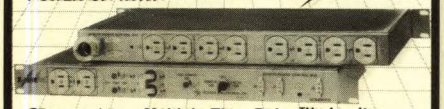

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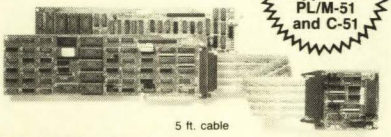

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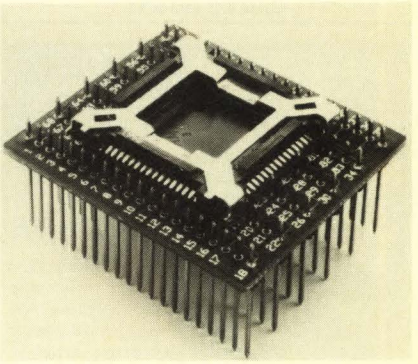

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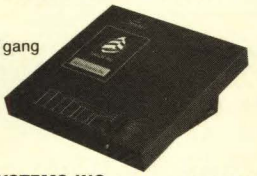

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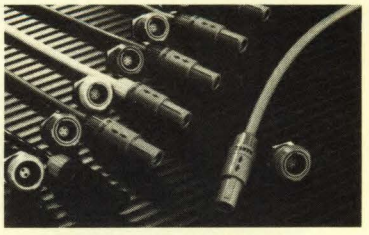

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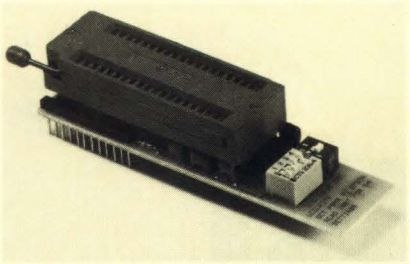

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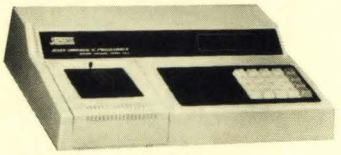

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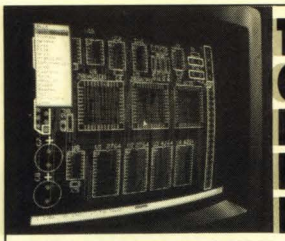

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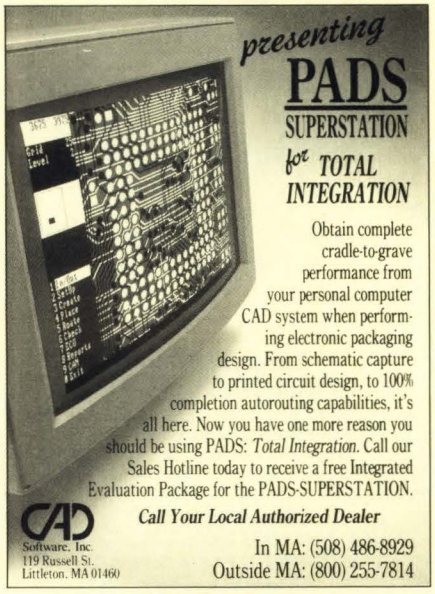

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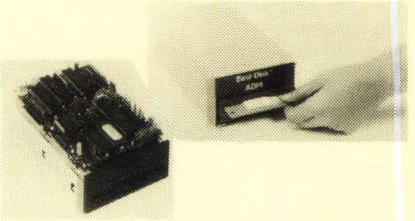

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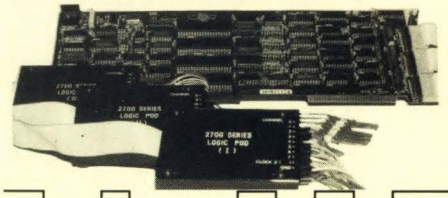

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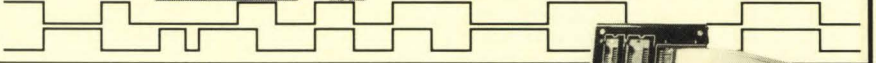

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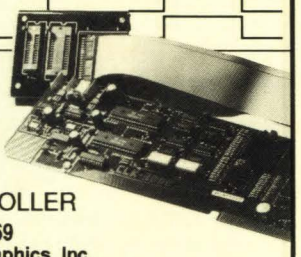

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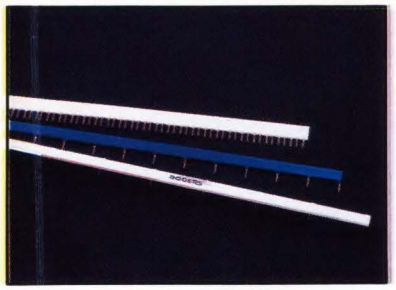

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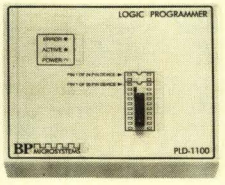

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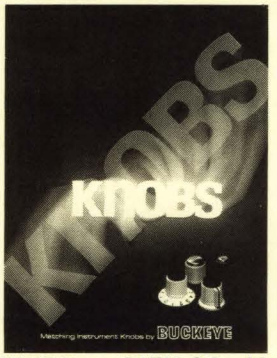

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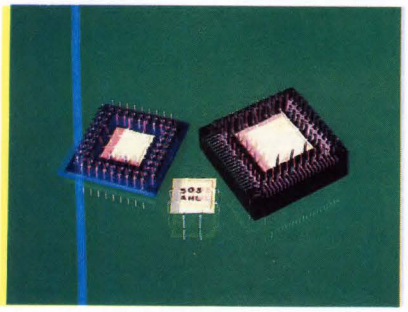

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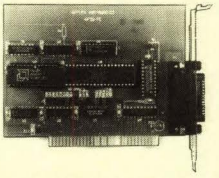

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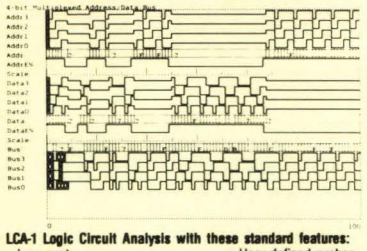

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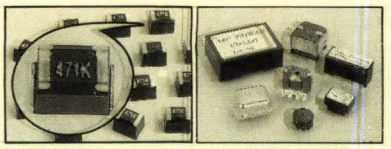

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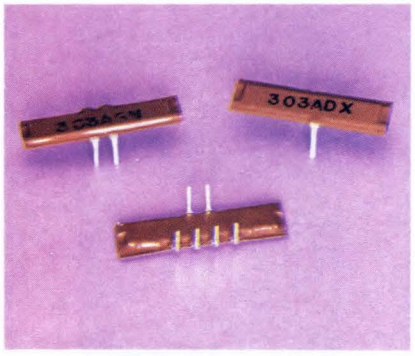

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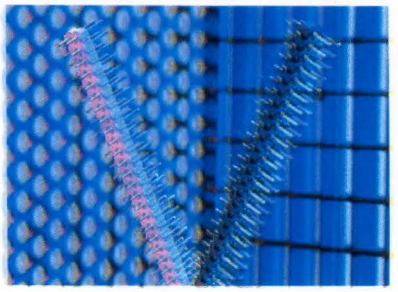

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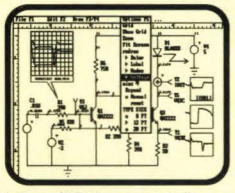

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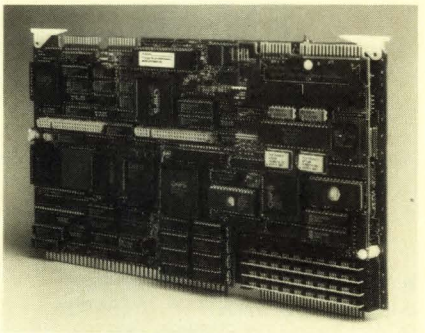

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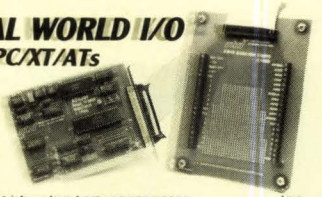

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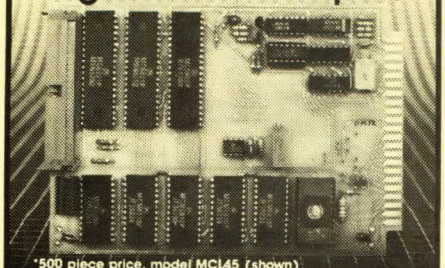

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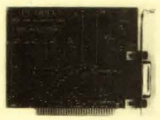

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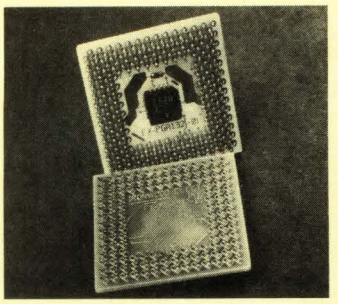

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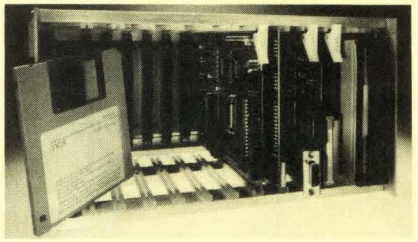

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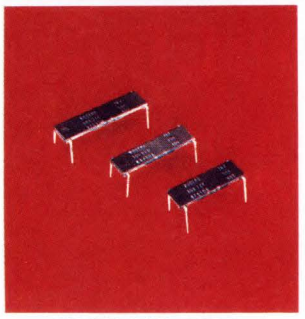

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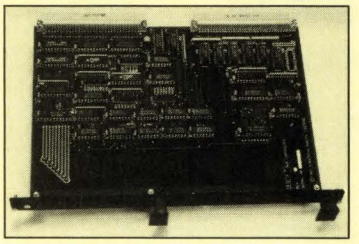

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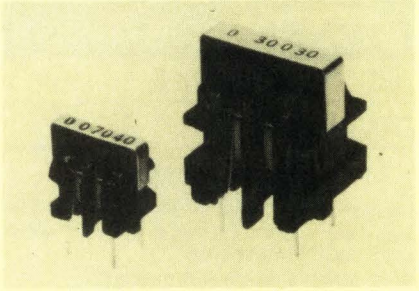

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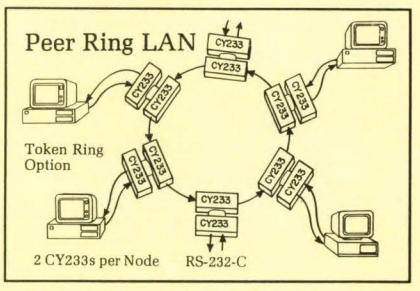

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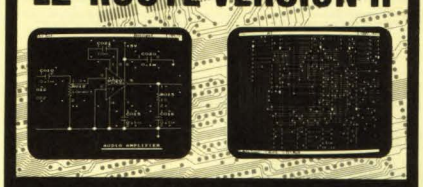

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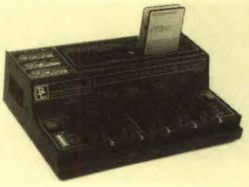

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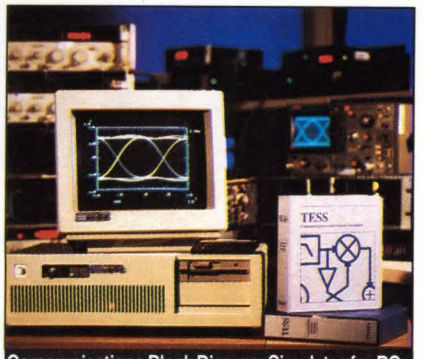

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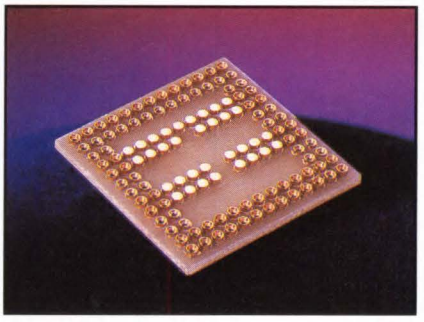

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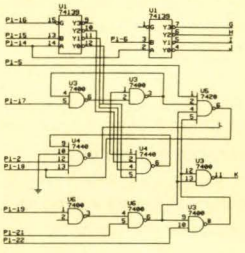

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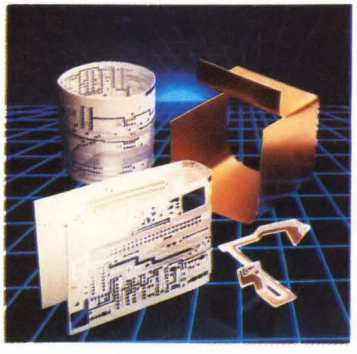

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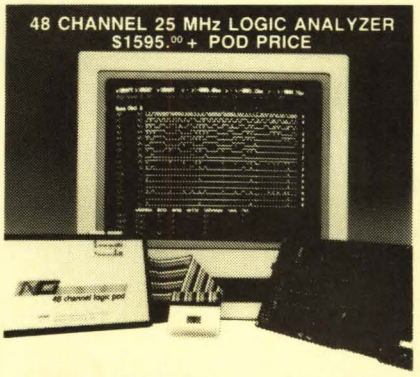

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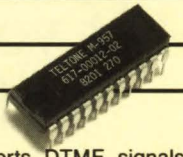

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CAREER OPPORTUNITIES

1989 Editorial Calendar and Planning Guide

EDN

Issue Date	Recruitment Deadline	Editorial Emphasis	EDN News Edition
July 6	June 15	Product Showcase — Volume I, Power Supplies	Closing: June 22 Mailing: July 13
July 20	June 29	Product Showcase — Volume II, Components	Closing: July 21 Mailing: Aug. 10
Aug. 3	July 13	Integrated Circuits, Computer Boards	
Aug. 17	July 27	Military Electronics Special Issue Military Software	Closing: Aug. 4 Mailing: Aug. 24
Sept. 1	Aug. 10	Test & Measurement, Integrated Circuits	Closing: Aug. 18 Mailing: Sept. 7
Sept. 14	Aug. 24	Industrial Product Showcase, Digital ICs	Closing: Aug. 30 Mailing: Sept. 21
Sept. 28	Sept. 7	Integrated Circuits, Computer Peripherals	Closing: Sept. 15 Mailing: Oct. 5
Oct. 12	Sept. 21	DSP Chip Directory, Integrated Circuits	Closing: Sept. 28 Mailing: Oct. 19
Oct. 26	Oct. 5	Test & Measurement Special Issue Computers & Peripherals	Closing: Oct. 27 Mailing: Nov. 16
Nov. 9	Oct. 19	CAE, Integrated Circuits	
Nov. 23	Nov. 2	16th Annual μP/μC Directory, Integrated Circuits	Closing: Nov. 9 Mailing: Nov. 30
Dec. 7	Nov. 16	Product Showcase — Volume I, Power Supplies	Closing: Nov. 22 Mailing: Dec. 14
Dec. 21	Nov. 30	Product Showcase — Volume II, Components	

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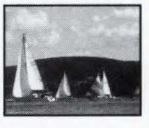
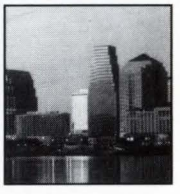

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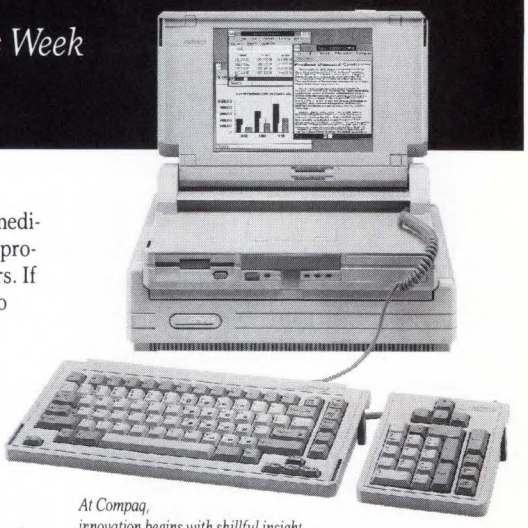

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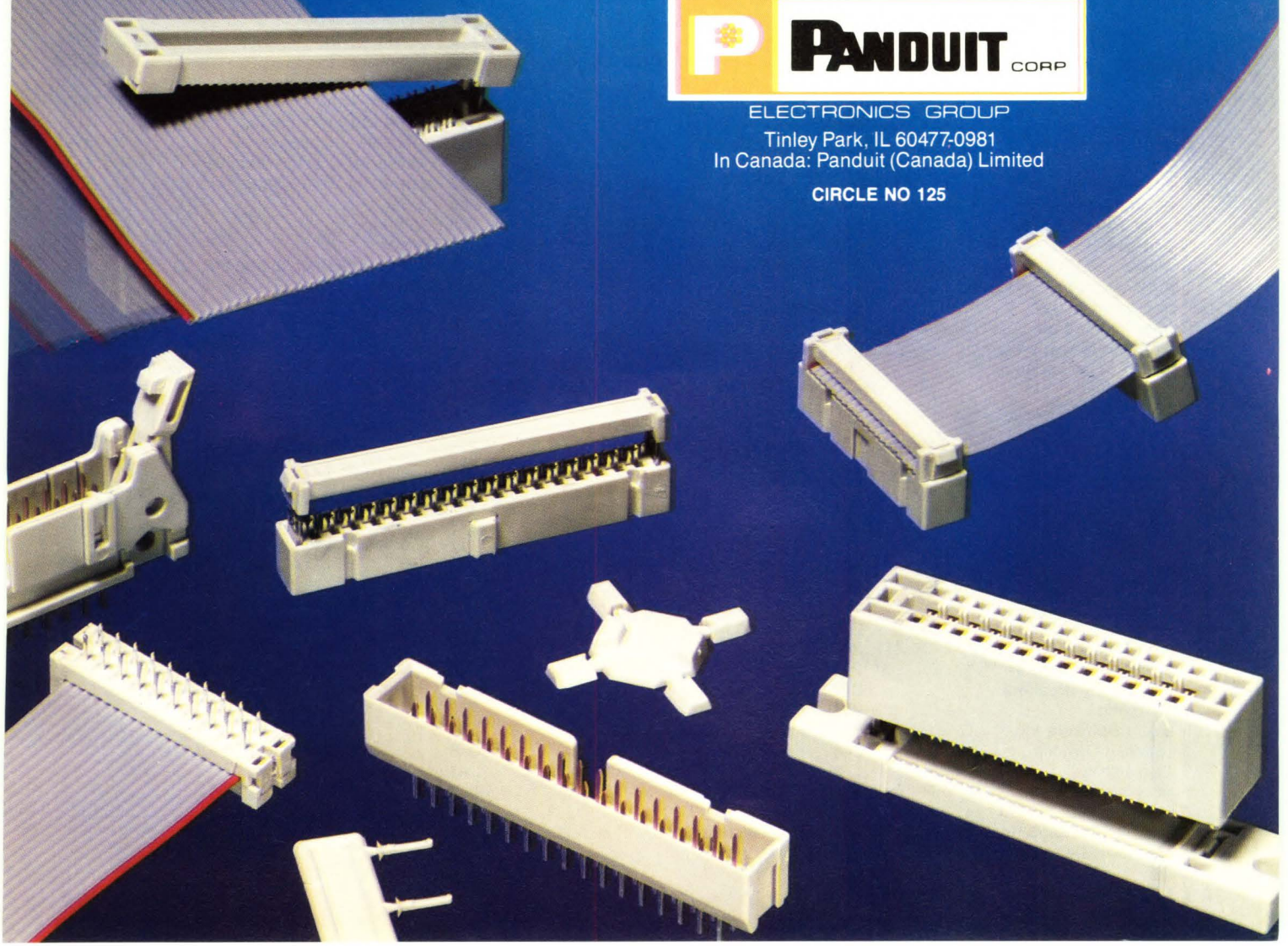

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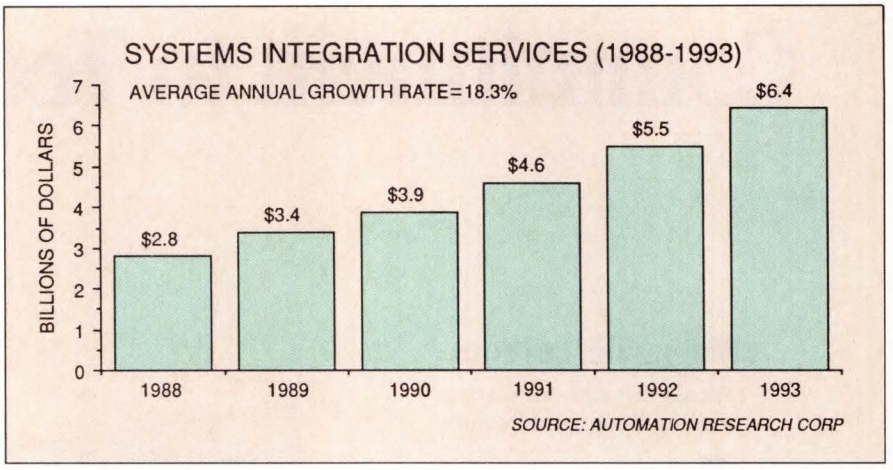
EDITED BY JULIE ANNE SCHOFIELD

Systems-integration market to hit $6.4 billion in 1993

The 1988 market for systems-integration (SI) services was worth $2.8 billion and will grow at an average annual rate of more than 18% to $6.4 billion in 1993, predicts Automation Research Corp (Medfield, MA) in its market study on plantwide systems integration. The management consulting firm estimates that industry will spend $3.4 billion on SI services this year, which is an increase of more than 21% over the 1988 figure. The management consulting firm based its forecast on data from over 300 companies providing SI services and 450 executives in US manufacturing plants.



The reason for the growth in the SI market, according to the study, is that due to global competition, the growing complexity of plant operations, and new technologies, US manufacturers' traditional way of implementing systems in a piecemeal fashion will not be sufficient. Today's global environment requires that manufacturing not be considered an isolated activity but an integrated system that incorporates all the elements necessary to make a company's entire business function as a single entity. Companies are under increasing pressure to automate and reduce costs to compete effectively in this world marketplace. The study predicts that increasing government regulations regarding toxic-waste disposal, air pollution, and the handling of hazardous chemicals will also force manufacturers to automate their plants.

First-quarter US factory electronics sales total $63.8B

US factory shipments of electronics equipment, components, and related products—excluding imports—totaled $63.8 billion in the first quarter of 1989, according to the Electronics Industries Association (Washington, DC). This figure represents an increase of 6.5% over the 1988 first-quarter total-industry-sales figure of $59.9 billion.

A breakdown of the first-quarter factory sales by industry group shows that electronic-component shipments totaled $12.8 billion, an increase of approximately 9% over the 1988 total of $11.7 billion, according to EIA figures. First-quarter sales of communications equipment increased to $16.2 billion, 2.6% more than last year's figure of $15.7 billion. Computers and industrial electronics had sales of $20.7 billion, an increase of 6% over last year's first-quarter total of $19.5 billion. The consumer-electronics industry recorded $7.4 billion—including imports—in first-quarter sales, 4% more than the 1988 first-quarter figure of $7.1 billion.

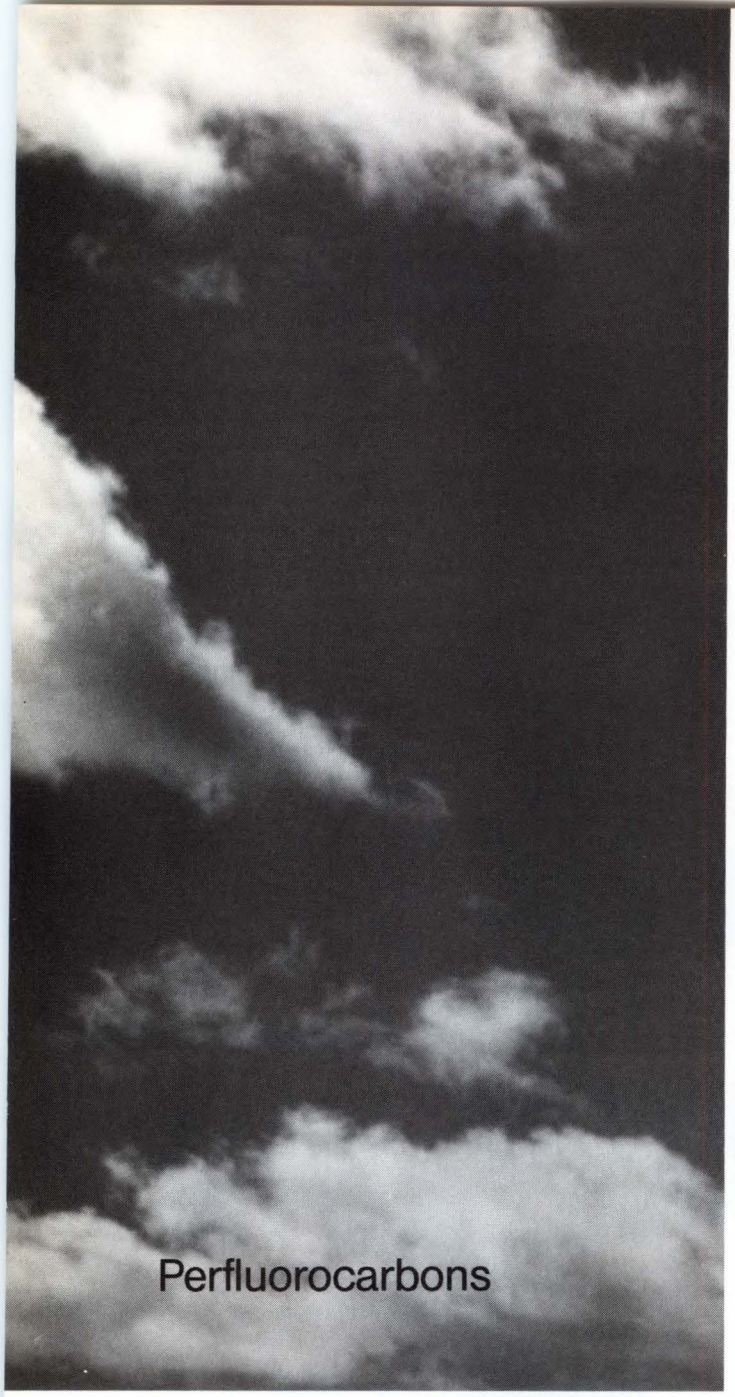
FIRST-QUARTER AND FULL-YEAR 1988–1989 US FACTORY SALES OF ELECTRONIC PRODUCTS
(MILLIONS OF DOLLARS)

	COMMUNICATIONS EQUIPMENT	ELECTRONIC COMPONENTS	COMPUTERS AND INDUSTRIAL	CONSUMER* ELECTRONICS	OTHER ELECTRONICS RELATED PROD/SERVICES	TOTAL**
FIRST QUARTER 1989	$16,150	$12,754	$20,714	$7,400	$12,940	$63,776
FIRST QUARTER 1988	$15,740	$11,732	$19,533	$7,131	$11,765	$59,883
PERCENT CHANGE	2.6%	8.7%	6.0%	3.8%	10.0%	6.5%
1989	$64,235	$49,953	$84,945	$31,753	$53,248	$257,431
1988	$64,235	$49,458	$80,900	$30,597	$48,407	$247,777
PERCENT CHANGE	0.0%	1.0%	5.0%	3.8%	10.0%	3.9%

*INCLUDES IMPORTS AND FACTORY SALES OF PRODUCTS NOT CLASSIFIED AS CONSUMER ELECTRONICS BY THE DEPARTMENT OF COMMERCE.
**TOTAL DOES NOT INCLUDE CONSUMER ELECTRONICS IMPORTS.

(SOURCE: ELECTRONIC INDUSTRIES ASSOCIATION)

Based on first-quarter sales figures, the EIA predicts that 1989 total US factory sales will be approximately $257 billion, a 3.9% increase over the 1988 total of $248 billion.



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