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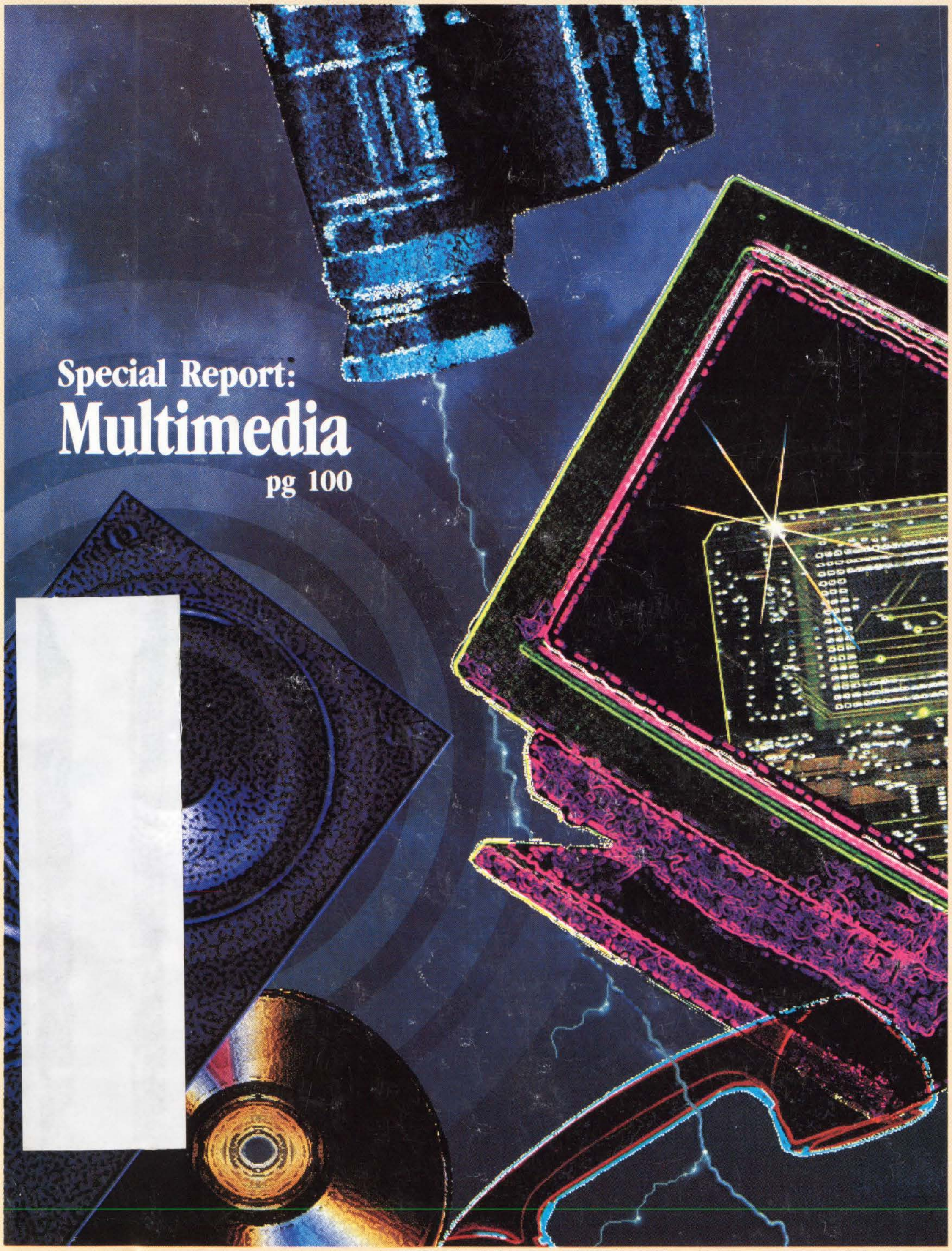
A CAHNERS PUBLICATION

March 16, 1992

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS WORLDWIDE



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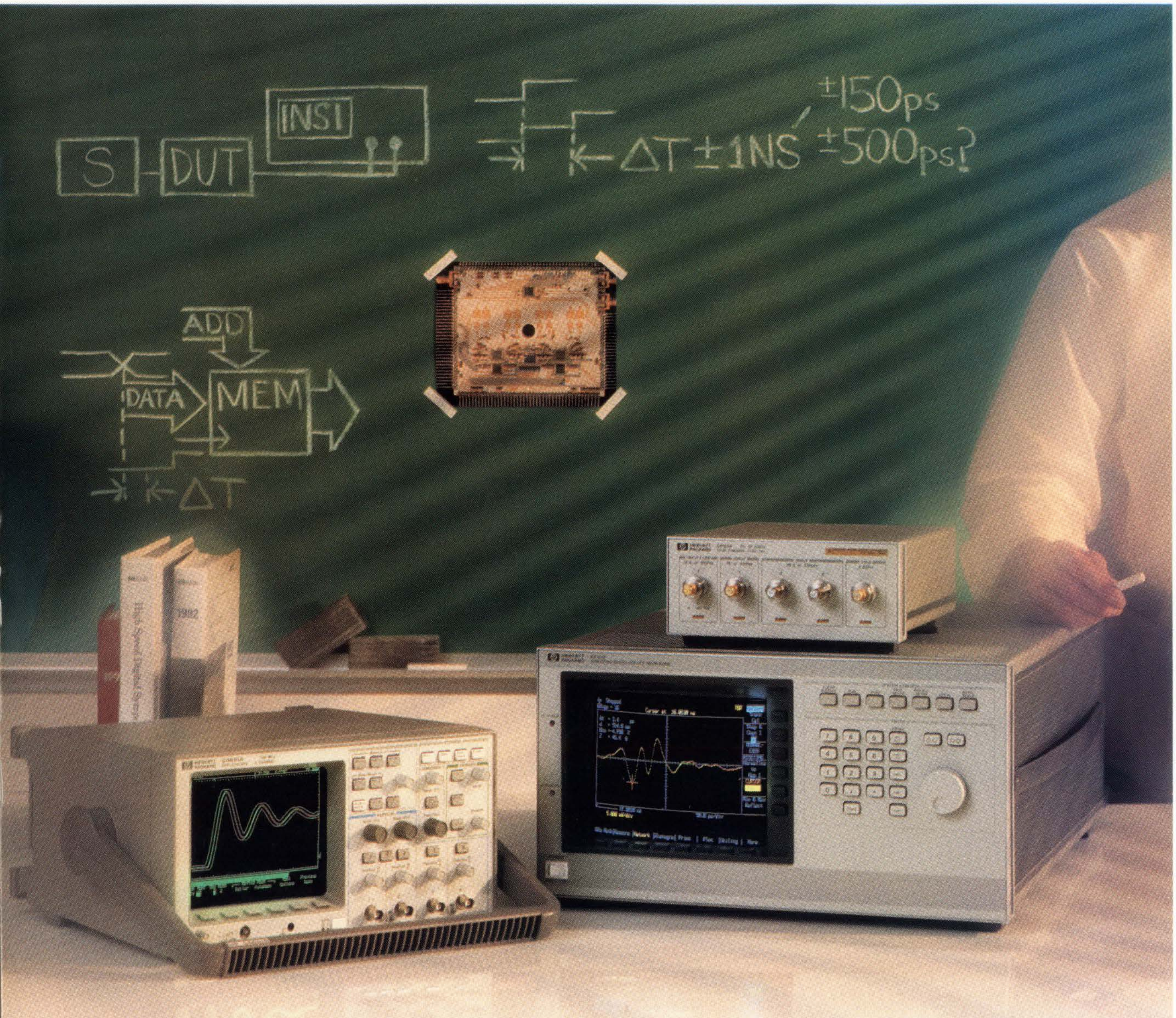

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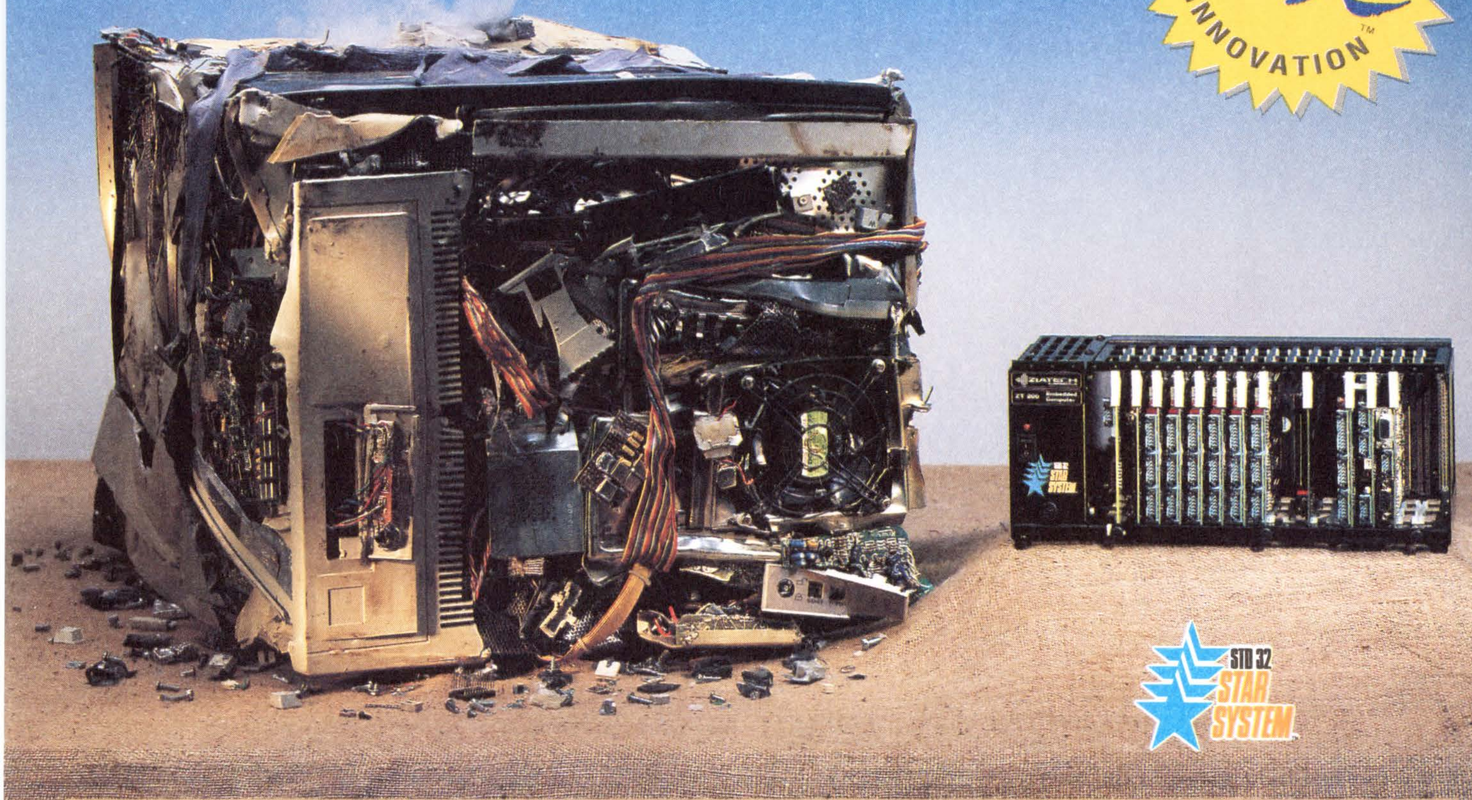

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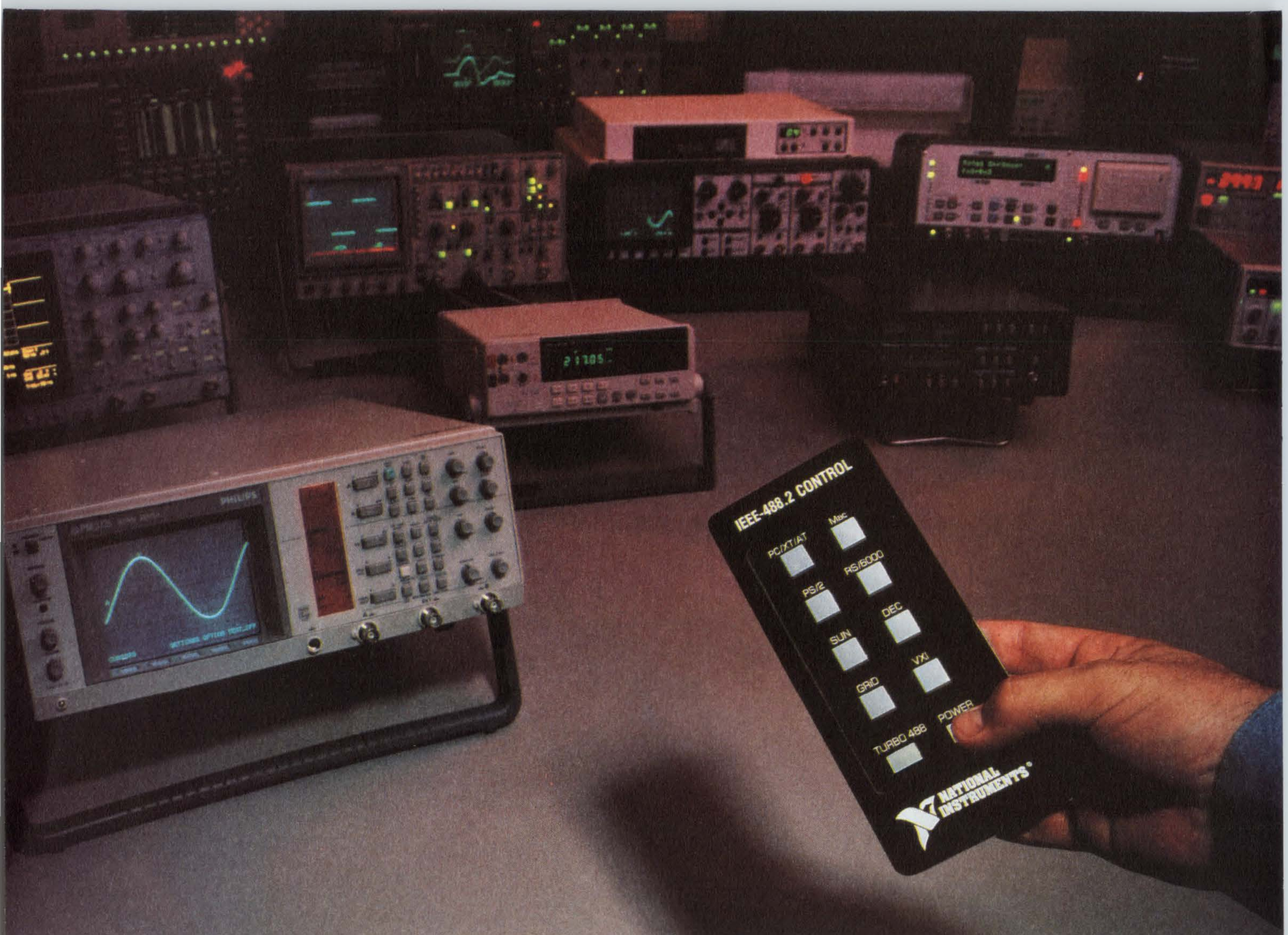

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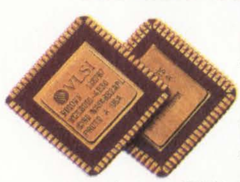

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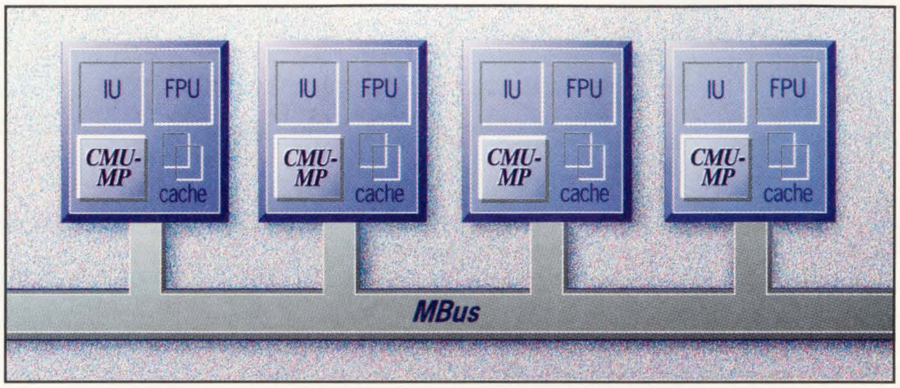

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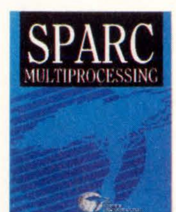

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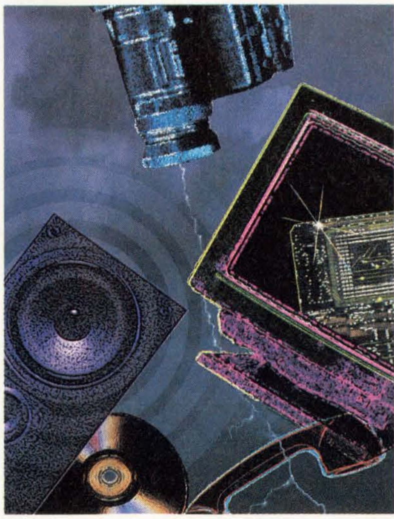
MARCH 16, 1992 VOLUME 37, NUMBER 6

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS WORLDWIDE



On the cover: Mulitmedia can reshape the way you do business. Although standardization and compatibility remain primary concerns, designers are contemplating the benefits of using multimedia's audio and visual capabilities to design, confer with colleagues, and present engineering data. (Photo courtesy Truevision Inc; image created by Keith Hampton). . . . . **PAGE 100**

COMPUTER TECHNOLOGY SPECIAL ISSUE

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EDN

MAGAZINE EDITION

MARCH 16, 1992

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A summary and analysis of articles in this issue

Welcome to EDN Magazine Edition's computer issue. Most of the feature articles you'll read are devoted to that topic. To start off, we direct your attention to Technical Editor J D Mosley's Special Report on multimedia—a subject that has received a great deal of attention lately. Multimedia applications demand a lot of hardware and software support and processor cycles. However, instead of just focusing on the hardware and software you need to add multimedia features to a computer, Mosley also tells you why you might want to add multimedia capabilities to your next design.

Graphics are a key component of multimedia machines, and Technical Editor Richard A Quinnell looks at a key hardware component for graphics subsystems—video DRAMs—in his Technical Update. The latest devices in the video-DRAM family have 2-Mbit capacities and, unlike earlier video DRAMs, you can count on a set of standard features from all of the 2-Mbit devices. That's good news for companies seeking multiple-sourced products. However, as Quinnell's article explains, the video-DRAM vendors couldn't resist putting unique features into their newest products. Use those features and you'll find yourself in a single-source situation again.

Optical disk drives are also important components for multimedia applications. In his Technical Update on multifunctional 3½-in. optical drives, Technical Editor Maury Wright examines a product group that's likely to become the next defacto standard in personal-computer mass storage. These drives accept rewritable magneto-optical media, optical ROMs that resemble CD-ROM disks but hold "only" 120 Mbytes, and "partial ROMs," which are writeable disks with some prerecorded data.

This issue marks the fourth "enhanced" issue of EDN Magazine, and we would like to know what you think of the changes we've made. Please take a moment to circle a reader service number below or write to us, either on the reader service card or in a separate note. We made the changes based on discussions with readers like you and we continue to ask for your thoughts. Thanks.

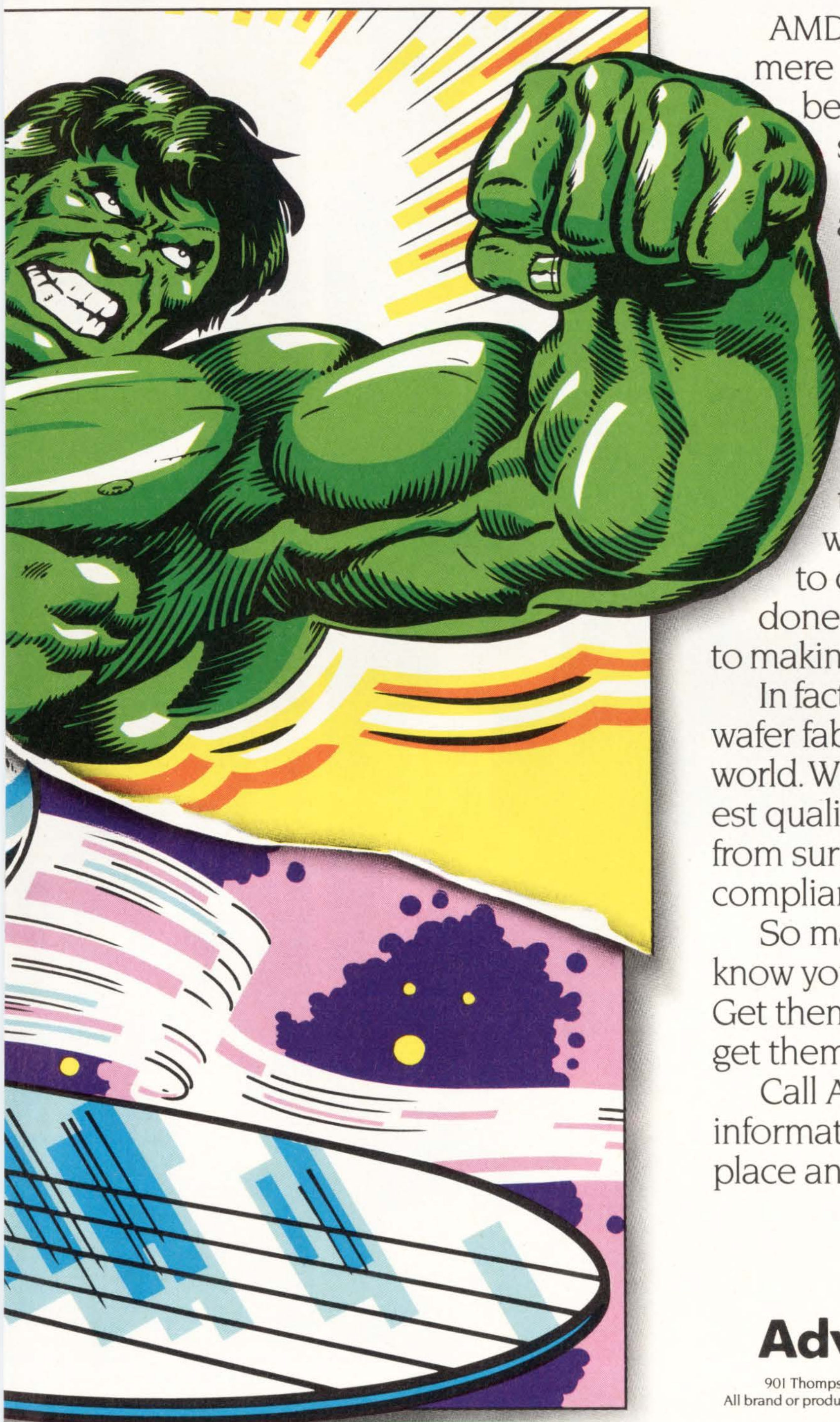
Steven H Leibson
Executive Editor

I like the new, enhanced EDN. **Circle No. 724**

Give me back my old EDN! **Circle No. 725**

Sorry, I didn't really notice the difference. **Circle No. 726**

It Takes Some Characteristics To

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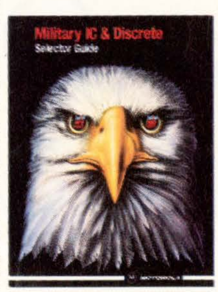

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CIRCLE NO. 8

EDITED BY SUSAN ROSE

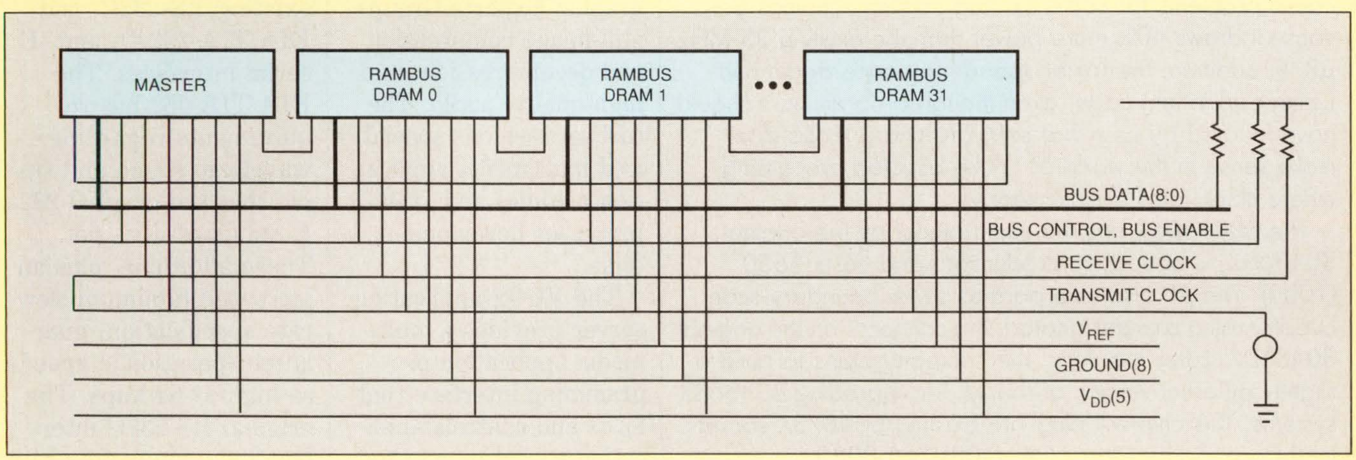
Clocked memory interface gives 500-MHz access

Rambus Inc is licensing a technology it developed for high-speed data transfers between CPUs and dynamic RAMs (DRAMs). The RAMbus interface uses a 9-bit synchronous data transfer to achieve 500-Mbyte/sec data rates. The company's technology includes the interface design, serial transfer protocol, and design assistance for semiconductor vendors adding the interface to their DRAMs, CPUs, and ASIC libraries.

The interface comprises 28 lines, including nine data, eight ground, and five power lines. To achieve the high data rates, the interface requires that the components be arranged in a line, with the CPU or bridge at one end. The 250-MHz clock that synchronizes data transfers to the CPU originates at the end opposite the CPU so that the clock and data propagate side by side down the bus. The clock loops back at the CPU end to handle data transfer to the memory devices.

DRAMs based on the RAMbus use their sense amplifiers as an internal cache to speed data access. The devices are self-refreshing and have mapping registers that let you specify their location in address space and mask out faulty memory banks. Each memory device monitors the data lines for a transfer request from the CPU, responding when addressed. The transfer can include from 1 to 256 9-bit words on the same DRAM page.

The company is licensing its technology to IC and ASIC vendors, who pay all the licensing and royalty fees. OEMs wishing to use the RAMbus technology simply purchase standard parts or use ASIC cell libraries as with standard logic. Several manufacturers, including Fujitsu, Toshiba, and NEC, already are developing RAMbus-based DRAMs (512k×9 bits) and an ASIC bridge between the RAMbus interface and conventional CPUs. Parts should be available this year. Rambus Inc, Mountain View, CA, (415) 903-3800, FAX (415) 965-1528.—Richard A Quinnell



The RAMbus interface uses 28 lines to connect memory to CPU with a 500-Mbyte/sec bandwidth.

Program automates test for Windows

Microsoft's Test for Windows lets programmers develop test suites that can run automatically. The tool set is the first automated test tool from a PC software vendor. Test sequences can exercise an application's Windows interface, varying control states and simulating keyboard and mouse inputs. A testing tool compares the test-generated windows with the window interfaces you expect. The tool works on any Windows program and does not require special hooks or debug code. The tool set supports standard bit-mapped monitors including EGA, VGA, and Super VGA.

Automated tests are created using a variation of the Visual Basic language, called Test Basic. The tools contain two programming mechanisms: FastTest, which provides defaults and a set of high-level test functions, and Test Driver, which has a Windows-hosted Basic interpreter.

The $395 test package includes a Basic environment with a recorder and FastTest. The package also performs screen capture and comparison, Windows controls comparison, a keyboard- and mouse-entry simulator, and timing control, which identifies and manipulates any control state. Microsoft Corp, Redmond, WA, (206) 882-8080, FAX (206) 883-8101.—Ray Weiss

Module adds video to VXI and VME

The EXM-14 video-expansion board works in conjunction with a VGA or super-VGA graphics board to add live video to your system display. The EXM-14 is one of a series of expansion boards that plug into Radisys Corp's 386- and 486-based VXI and VME embedded controllers.

The board accepts incoming signals in RGB, NTSC, PAL, SECAM, or VHS formats, then stores incoming images in a 1-Mbyte video frame buffer. Then, the board lets you merge that buffer's data with a VGA controller's output data stream, either at a specific position or to replace pixels having a specified color. Software supplied with the board includes device drivers and application program-interface libraries for Microsoft Windows and OS/2 Presentation Manager. The board, including software and cables, costs $1400. Radisys Corp, Beaverton, OR, (503) 690-1229, FAX (503) 690-1228.

—Richard A Quinnell

Clock-doubling μP retrofits older systems

You can substantially boost the performance of existing 25-MHz, 80486DX-based systems with very little effort by replacing the system's existing processor with a clock-doubling part. The 80486DX2 μP's external bus runs at 25 MHz, but the processor core inside the chip runs at 50 MHz. Intel's performance testing indicates that the 25-MHz clock-doubling processor provides nearly the same performance as the 50-MHz nonclock-doubling processor for code segments that fit entirely inside the processor's internal cache. For larger programs, the 25-MHz clock-doubling μP's performance falls between the 33- and 50-MHz nonclock-doubling 80486DXs. Consequently, your design can achieve substantial performance improvements without resorting to special pc-board layouts and high-speed external cache memories that very-high-speed CPUs usually require.

The chip's clock-doubling circuits convert an external 25-MHz clock into an on-chip 50-MHz clock; the μP's external bus continues to operate at 25 MHz. Therefore, the part should be electrically compatible with existing 25-MHz system designs. But the clock-doubling part may cause problems for some existing cooling schemes because it draws 40% more power than the existing 25-MHz μP. In addition, the faster speed may once again ruin timing-dependent code, even though programmers should have learned by now that software timing loops don't make sense in the world of cache-assisted processing, where clock rates double yearly.

The 80486DX2 has the same pinout as the original 80486DX, is already in production, and costs $550 (1000). The μP also incorporates serial boundary-scan circuitry using pins designated "no connect" on the original 80486DX. Later this year, the company plans to build a slightly different version of this μP for upgrading 80486SX systems. This chip will plug into existing 80487SX sockets. Intel Corp, Santa Clara, CA, (408) 765-8080.

—Steven H Leibson

Multimedia tool kit integrates DSP and applications

The lack of a development base for software tools and utilities has been a major barrier to multimedia applications. DSP chip vendors are moving to change this situation. AT&T is introducing an integrated development tool set, the VCOS Multimedia Development Environment (VDME), for its 32-bit DSP3210 processor. The tool set is built around VCOS (Visible Caching Operating System), a DSP operating system that links to a host and provides multitasking DSP-application processing.

The tools support application development for multimedia applications that include real-time speech coding, facsimile, data modem, high-resolution MPEG (Motion Picture Experts Group) and JPEG (Joint Photographic Experts Group) still-image compression and decompression, and high-quality audio. The tool set includes specialized multimedia application modules and DSP processor development tools.

The VCOS application server provides a multimedia application programming interface that loads and controls application execution on the DSP coprocessor. The $3000 tool set for Windows is available now. DSP3210-based plug-in boards are available from Ariel Inc for the PC and from Spectral Innovations Inc for the Macintosh. AT&T Microelectronics, Allentown, PA, (800) 372-2447. Ariel Inc, Highland Park, NJ, (908) 249-2900. Spectral Innovations Inc, San Jose, CA, (408) 727-1314.

—Ray Weiss

Specification and IC bow to 3V interfaces

The move from 5 to 3V supplies for battery-powered equipment creates problems for the serial interface because of the lack of 3V-interface ICs and the fact that the serial interface becomes a higher percentage of total power dissipation. The EIA/TIA-562 specification defines a lower-voltage interface—±3.7V is the minimum allowable output voltage at the driver output—which is compatible with existing RS-232C, and EIA/TIA-232-D, and -E serial interfaces. The EIA/TIA-562 has requirements regarding waveform shape and ripple that the original 232-E standard does not. These additions, plus an increased minimum slew-rate specification, guarantee operation at speeds as high as 64 kbps. The original RS-232C interface's maximum data rate is 20 kbps.

The Max561 is a low-voltage interface IC that meets EIA/TIA-562 specifications and operates to 3V at a data rate of 20 kbps. Onboard charge pumps working with 1-μF external capacitors convert the nominal 3.3V input to the ±6.6V needed to generate the EIA/TIA-562 output levels. The chip contains four drivers and five receivers, and it consumes 8 mA of quiescent current, compared with 15 mA for a similar 5V RS-232C device. A low-power shutdown mode reduces supply current to 1 μA when the serial port is inactive. The $4.19 (1000) IC comes in a 28-pin small-outline package and operates over a temperature range of 0 to 70°C. Maxim Integrated Products, Sunnyvale, CA, (408) 737-7600, FAX (408) 737-7194.

—Anne Watson Swager

Control modules open up industrial networks

Developers no longer have to build their own control modules for Echelon Corp's Neuron control chip. The company is delivering twisted-pair control modules built around Neuron chips. You can build these modules directly into control electronics and use them to link to a sophisticated control network. The modules support both analog and digital interfaces and can control output devices such as triacs, relays, and industrial displays.

Each chip is really three processors in one, all sharing memory and bus resources. The three processors each take on a major function (control, networking, and I/O). By using three processors, each chip has a minimum of switching overhead because each task resides in a processor. The chips are made under license by Toshiba and Motorola. Echelon sells a development environment, which includes Neuron-C.

Initially, there will be three control modules for the Echelon Lonworks control networks. These are linked to the network via twisted-pair wires. The modules are an RS-485 module (to 78 kbps), a transformer-isolated module (to 78 kbps in noisy environments), and a high-speed transformer-isolated module (to 1.25 Mbps). The transformer-isolated modules use a form of Manchester coding for signals. Each module has a Neuron processor, a socketed PROM, and a communications transceiver. Prices start at $35 (OEM qty) for the RS-485 module.

The company is also releasing the Lonmanager API (application program interface) for MS-DOS machines. This API lets PC applications interact with the network and act as network servers, control points, and graphics-display consoles. The interface costs $9850, plus royalties. Echelon Inc, Palo Alto, CA, (415) 855-7416, FAX (415) 856-6153.—Ray Weiss

Protocol upgrades IEEE-488 to 5 Mbytes/sec

A streaming-data protocol, an upgrade to the venerable IEEE-488 standard for instrument communication and control, will be unveiled within two weeks by Capital Equipment Corp, a supplier of IEEE-488 interface cards for PCs. The new protocol, which transfers data blocks of unlimited size bidirectionally at speeds as great as 5× the maximum heretofore possible, causes no problems with older instruments; they continue to function as they always have. Capital Equipment Corp, Burlington, MA, (617) 273-1818.

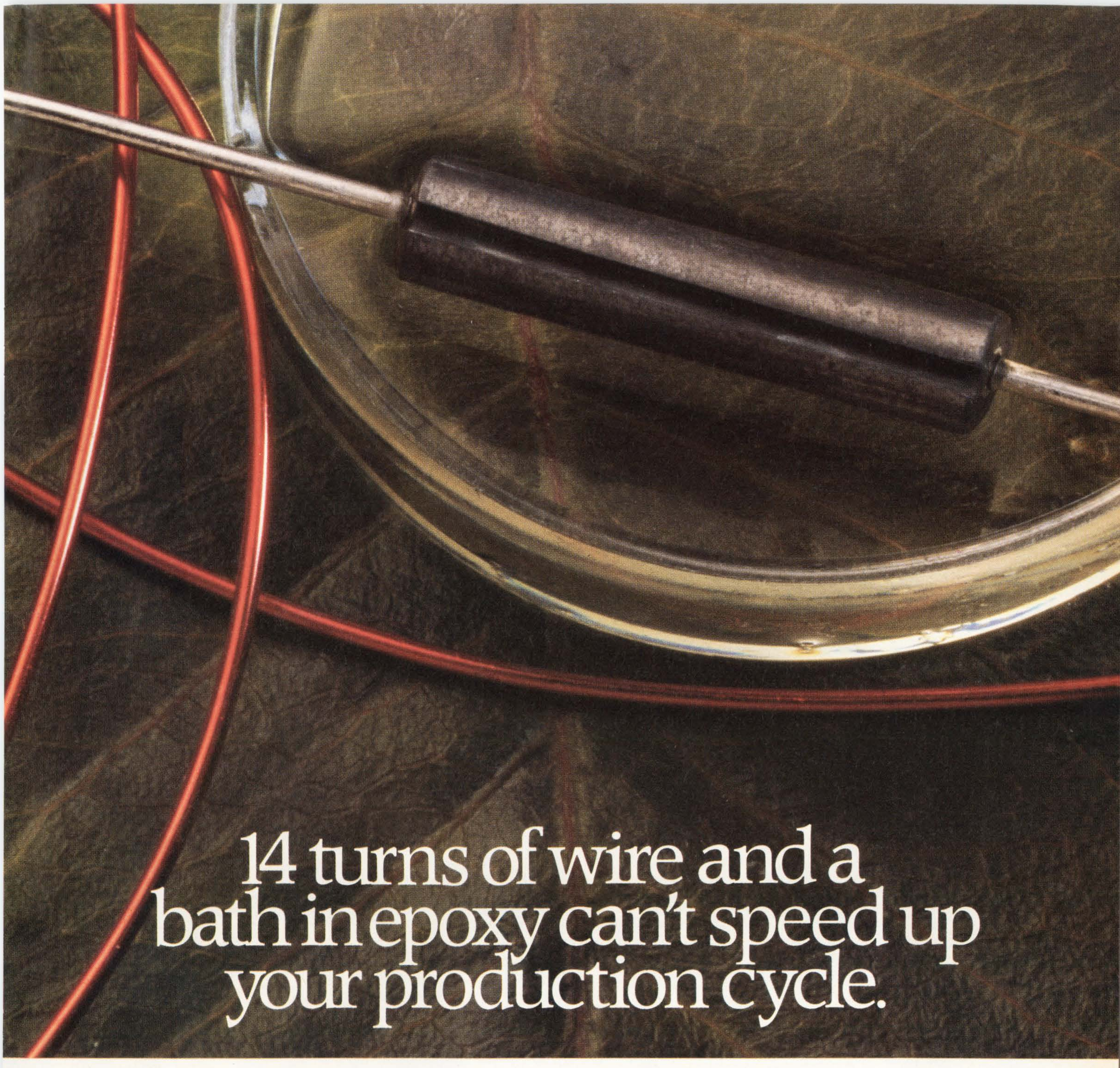
—Dan Strassberg

Single-board computer draws 4.3W

The SBC-SX1p 16-MHz 80386SX-based computer board measures 5.75× 7.75 in. and draws 4.3W from a single 5V supply. Standard features include keyboard and speaker interfaces, two serial port, one parallel port, a battery-backed clock/calendar, and hard- and floppy-disk interfaces. You can add as much as 4 Mbytes of dynamic RAM, and you can install 1 Mbyte of ROM, static RAM, or flash EPROM for use as a RAM disk. The board also includes a VGA controller that can drive CRT, EL, vacuum-fluorscent, and color and monochrome LCDs. Software support includes an onboard BIOS ROM for running MS-DOS and embedded software that lets you run code developed on an MS-DOS system without buying an MS-DOS license for the single-board computer. Computer Dynamics, Greer, SC, (803) 877-8700, FAX (803) 879-2030.—Maury Wright

VME interface IC handles 64-bit transfers

Cypress Semiconductor's 64-bit VIC64 is pin and software compatible with the company's VIC068 VMEbus interface controller. Both parts can serve as master or slave and support read, write, write-posting, and block transfers. During block transfers, however, the 64-bit part can handle either 32- or 64-bit transfers. The part achieves 64-bit transfers by using the VME address lines, which are idle during a block transfer. Samples cost $140 (100) and are available in 144-lead pin-grid arrays and 160-lead plastic quad flatpacks. Cypress Semiconductor, San Jose, CA, (408) 943-2600.—Richard A Quinnell



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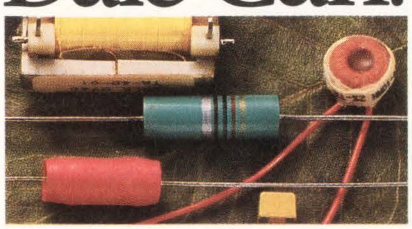

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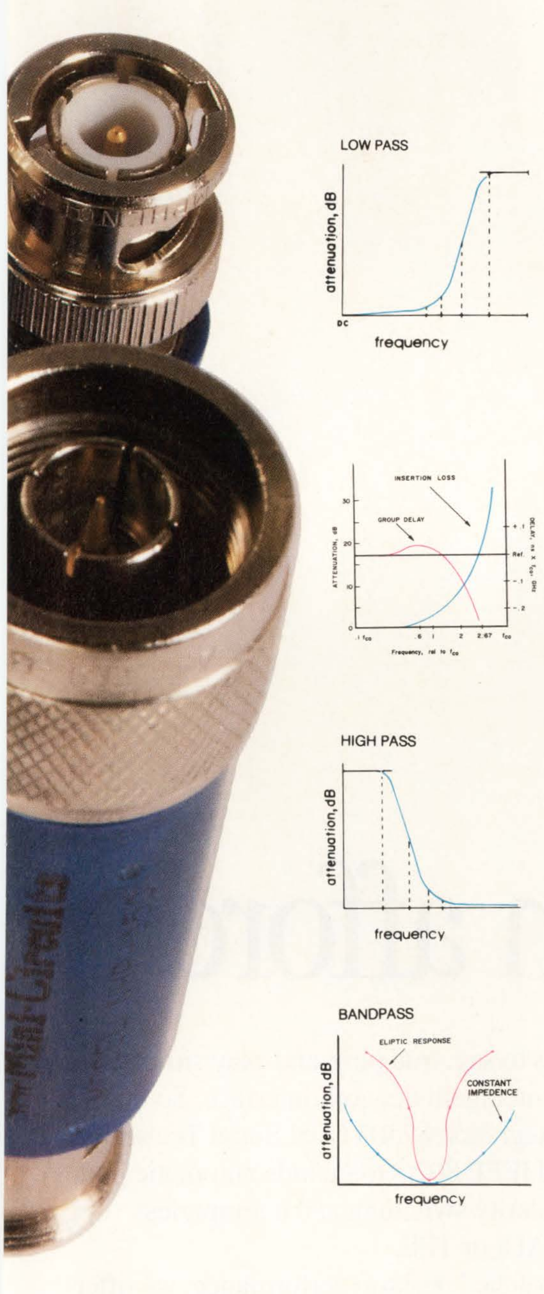

low pass, Plug-in, dc to 1200MHz

Model No.	Passband MHz loss < 1dB	Stopband, MHz loss > 20dB	Stopband, MHz loss > 40dB
PLP-5	DC-5	8-10	10-200
PLP-10.7	DC-11	19-24	24-200
PLP-21.4	DC-22	32-41	41-200
PLP-30	DC-32	47-61	61-200
PLP-50	DC-48	70-90	90-200
PLP-70	DC-60	90-117	117-300
PLP-90	DC-81	121-137	167-400
PLP-100	DC-98	146-189	189-400
PLP-150	DC-140	210-300	300-600
PLP-200	DC-190	290-390	390-800
PLP-250	DC-225	320-400	400-1200
PLP-300	DC-270	410-550	550-1200
PLP-450	DC-400	580-750	750-1800
PLP-550	DC-520	750-920	920-2000
PLP-600	DC-680	840-1120	1120-2000
PLP-750	DC-700	1000-1300	1300-2000
PLP-800	DC-720	1080-1400	1400-2000
PLP-850	DC-760	1100-1400	1400-2000
PLP-1000	DC-900	1340-1750	1750-2000
PLP-1200	DC-1000	1620-2100	2100-2500

Price, (1-9 qty), all models: plug-in $14.95, BNC $32.95, SMA $34.95, Type N $35.95

Surface-mount, dc to 570MHz

SCLF-21.4	DC-22	32-41	41-200
SCLF-30	DC-30	47-61	61-200
SCLF-45	DC-45	70-90	90-200
SCLF-135	DC-135	210-300	300-600
SCLF-190	DC-190	290-390	390-800
SCLF-380	DC-380	580-750	750-1800
SCLF-420	DC-420	750-920	920-2000

Price, (1-9 qty), all models: $11.45

Flat Time Delay, dc to 1870MHz

Model No.	Passband MHz loss < 1.2dB	Stopband MHz loss > 10dB	Stopband MHz loss > 20dB	VSWR Freq. Range, DC thru 0.2fco X̄	VSWR Freq. Range, DC thru 0.6fco X̄	Group Delay Variations, ns Freq. Range, DC thru fco X̄	2fco X̄	2.67fco X̄
PBLP-39	DC-23	78-117	117	1.3:1	2.3:1	0.7	4.0	5.0
PBLP-117	DC-65	234-312	312	1.3:1	2.4:1	0.35	1.4	1.9
PBLP-156	DC-94	312-416	416	0.3:1	1.1:1	0.3	1.1	1.5
PBLP-200	DC-120	400-534	534	1.6:1	1.9:1	0.4	1.3	1.6
PBLP-300	DC-180	600-801	801	1.25:1	2.2:1	0.2	0.6	0.8
PBLP-467	DC-280	934-1246	1246	1.25:1	2.2:1	0.15	0.4	0.55
▲BLP-933	DC-560	1866-2490	2490	1.3:1	2.2:1	0.09	0.2	0.28
▲BLP-1870	DC-850	3740-6000	5000	1.45:1	2.9:1	0.05	0.1	0.15

Price, (1-9 qty), all models: plug-in $19.95, BNC $36.95, SMA $38.95, Type N $39.95
NOTE: ▲: -933 and -1870 only with connectors, at additional $2 above other connector models.

high pass, Plug-in, 27.5 to 2200MHz

Model No.	Stopband MHz loss < 40dB	Stopband MHz loss < 20dB	Passband MHz loss < 1dB	VSWR Pass-band Typ.
PHP-25	DC-13	13-19	27.5-200	1.8:1
PHP-50	DC-20	20-26	41-200	1.5:1
PHP-100	DC-40	40-55	90-400	1.8:1
PHP-150	DC-70	70-95	133-600	1.8:1
PHP-175	DC-70	70-105	160-800	1.5:1
PHP-200	DC-90	90-116	185-800	1.6:1
PHP-250	DC-100	100-150	225-1200	1.3:1
PHP-300	DC-145	145-170	290-1200	1.7:1
PHP-400	DC-210	210-290	395-1600	1.7:1
PHP-500	DC-280	280-365	500-1600	1.8:1
PHP-600	DC-350	350-440	600-1600	2.0:1
PHP-700	DC-400	400-520	700-1800	1.6:1
PHP-800	DC-445	445-570	780-2000	2.1:1
PHP-900	DC-520	520-660	910-2100	1.8:1
PHP-1000	DC-550	550-720	1000-2200	1.9:1

Price, (1-9 qty), all models: plug-in $14.95, BNC $36.95, SMA $38.95, Type N $39.95

bandpass, Elliptic Response, 10.7 to 70MHz

Model No.	Center Freq. (MHz)	Passband I.L. 1.5 dB Max. (MHz)	3 dB Bandwidth Typ. (MHz)	Stopbands I.L. > 20dB at MHz	Stopbands I.L. > 35dB at MHz
PBP-10.7	10.7	9.6-11.5	8.9-12.7	7.5 & 15	0.6 & 50-1000
PBP-21.4	21.4	19.2-23.6	17.9-25.3	15.5 & 29	3.0 & 80-1000
PBP-30	30.0	27.0-33.0	25-35	22 & 40	3.2 & 99-1000
PBP-60	60.0	55.0-67.0	49.5-70.5	44 & 79	4.6 & 190-1000
PBP-70	70.0	63.0-77.0	68.0-82.0	51 & 94	6.0 & 193-1000

Price, (1-9 qty), all models: plug-in $18.95, BNC $40.95, SMA $42.95, Type N $43.95

Constant Impedance, 21.4 to 70MHz

Model No.	Center Freq. MHz	Passband MHz loss < 1dB	Stopband loss > 20dB at MHz	VSWR 1.3:1 Total Band MHz
PIF-21.4	21.4	18-25	1.3 & 150	DC-220
PIF-30	30	25-35	1.9 & 210	DC-330
PIF-40	42	35-49	2.6 & 300	DC-400
PIF-50	50	41-58	3.1 & 350	DC-440
PIF-60	60	50-70	3.8 & 400	DC-500
PIF-70	70	58-82	4.4 & 490	DC-550

Price, (1-9 qty), all models: plug-in $14.95, BNC $36.95, SMA $38.95, Type N $39.95

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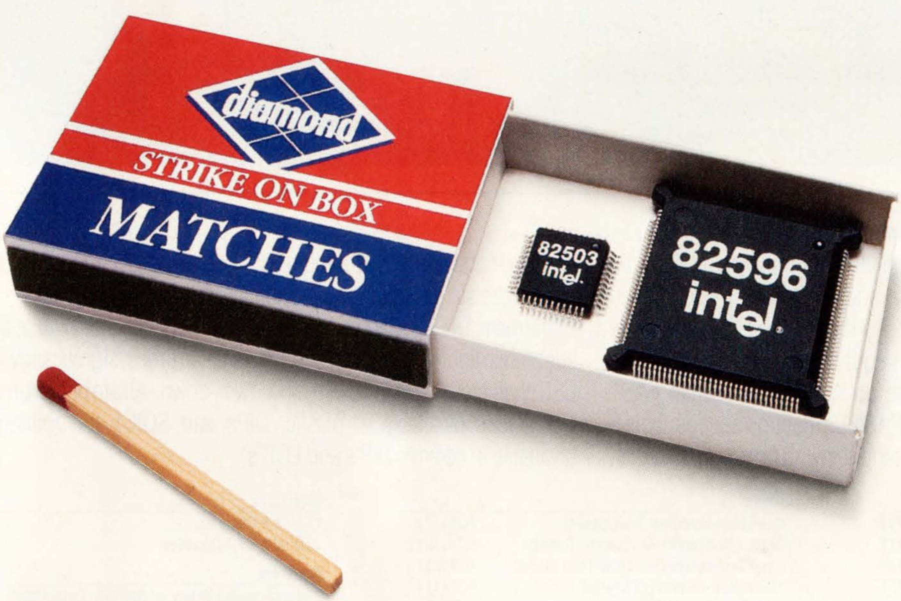

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Parameters	Performance's FCT-T	Leading Competitor's FCT-T
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V_{OLV}*	0.8	1.0
V_{IHD}*	1.5	1.7
V_{ILD}*	0.8	0.8

*V_{OLP} = Peak Ground Bounce V_{OLV} = Undershoot
V_{IHD} = Dynamic Input High V_{ILD} = Dynamic Input Low

Performance's FCT-T vs. Leading Competitor's FCT-T

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□ Non-inverting Octal	FCT241T
□ Non-inverting Octal	FCT244T
□ 10-bit Non-inverting	FCT827T
□ 10-bit Inverting	FCT828T

Transceivers	
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□ Non-inverting Registered	29FCT53AT
□ Non-inverting	FCT245T
□ Non-inverting Registered	FCT543T
□ Inverting Registered	FCT544T
□ Inverting Bus Transceiver w/ 3 States	FCT620T
□ Non-Inverting Bus Transceiver w/ 3 States	FCT623T
□ Non-inverting Buffered	FCT643T
□ Non-inverting Registered	FCT646T
□ Inverting Registered	FCT648T
□ Inverting Registered	FCT651T
□ Non-inverting Registered	FCT652T
□ Non-inverting w/ Odd/Even Parity	FCT657T
□ 10-bit Non-inverting Transceiver	FCT861AT
□ 9-bit Non-inverting Transceiver	FCT863AT
□ 9-bit Inverting Transceiver	FCT864AT

Latches	
□ Octal Non-inverting Transparent	FCT373T
□ Octal Transparent w/ Inverted Outputs	FCT533T
□ Octal Transparent w/ Flow Thru Pinout	FCT573T
□ 10-bit Non-inverting Buffered	FCT841T
□ 9-bit Non-inverting Buffered	FCT843T
□ 8-bit Non-inverting Buffered	FCT845T

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□ Multilevel Pipeline w/ Dual 2-Level Shift	29FCT520T
□ Multilevel Pipeline	29FCT521T
□ Diagnostic Scan	29FCT818T
□ Octal D Flip-Flop w/ Master Reset	FCT273T
□ 8-Input Universal Shift	FCT299T
□ Octal D Flip-Flop w/ Output Enable	FCT374T
□ Octal D Flip-Flop w/ Clock Enable	FCT377T
□ Quad Dual-port w/ True Outputs	FCT399T
□ Octal D Flip-Flop w/ Inverted Outputs	FCT534T
□ Octal D Flip-Flop w/ Flow-Thru Pinout	FCT574T
□ 10-bit Non-inverting Buffered	FCT821AT
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Decoders	
□ 1-of-8 Decoder	FCT138T
□ Dual 1-of-4 Decoder	FCT139T

Counters	
□ Synchronous Binary w/ Asynchronous Reset	FCT161T
□ Synchronous Binary w/ Synchronous Reset	FCT163T
□ Up/DownBinary Counter	FCT191T
□ Up/Down Binary Counter	FCT193T

Multiplexers	
□ Non-inverting Quad 2-input	FCT157T
□ Inverting Quad 2-input	FCT158T
□ Non-inverting Quad 2-input w/ 3-State	FCT257T
□ Inverting Quad 2-input w/ 3-State	FCT258T

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□ 8-bit Identity Comparator	FCT521T

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CIRCLE NO. 21

Coping with automatic telephone systems

In response to the letter from Ken Wood in Newport, Wales (EDN, November 7, 1991), I agree that the *default* mode for automatic telephone systems should revert to the operator. However, if you try calling Analog Devices at midnight, you'll get worse than that.

I think even in Wales, you can buy from Tandy, for barely $30, a telephone that can start out in pulse mode. But when you want to play games with tones, they switch over. I have one of these myself.

Robert A Pease
San Francisco, CA

Offer free software for basic PLDs in small companies

I agree with Charles Small's editorial, "Make FPGA design easier" (EDN, October 10, 1991, pg 49). I work for a small company, and we simply aren't willing to spend the money to get involved with PLDs. Years ago, as mentioned, the software was free. However, it costs quite a bit to get involved with programmable devices today. The software is usually limited to a specific manufacturer's devices, or you can spend more to get more versatility. At any rate, we don't even consider PLDs as an option in our designs. If the device manufacturers wish to increase the sale and usage of their parts, they need to change this situation.

At the very least, I'd like to see some free software, even if it had reduced capabilities, for more basic PLDs. Even if we didn't use it for our daily designs, I could certainly use it as a learning tool so I would have a better understanding of PLD capabilities. I might even be able to better explain and justify the cost of a more complete software to my managers so we could at least consider using PLDs for future designs.

Personally, I feel the companies involved should decide whether they are hardware or software vendors. If their intent is to sell their devices, they need to provide free or low-cost software to their prospective customers. Perhaps they should engage in a software developer's effort, in which they would provide assistance to programmers who might wish to develop shareware software for them.

Timothy A Rusco
Electronics Engineer
Radiographic Equipment Services
Riverside, CA

Correction

In the Product Showcase Issue (EDN, December 5, 1991, pg 133), the write-up about the ADXL-50 acceleration sensor contains an error in the first paragraph. It describes Analog Devices' model ADXL-50 as a bulk-micromachined (membrane) device that uses thin-film resistors.

The fact that the ADXL-50 is *not* a bulk-micromachined type is what makes it unique. The device is a single monolithic chip that incorporates an interdigitated "floating" sensor with diffused resistors and all the necessary signal-processing circuitry. It eliminates the temperature-sensitive and costly bulk-micromachined sensor and the need for thin-film resistors.

HAVE YOUR SAY

EDN's Signals & Noise column provides a forum for readers to express their opinions on issues raised in the magazine's articles or on any topic that affects the engineering industry. Send your letters to Signals & Noise Editor, EDN Magazine, 275 Washington St, Newton, MA 02158. You can also send a note via MCI mail at EDNBOS or use EDN's bulletin-board system at (617) 558-4241: From the Main System Menu, enter SS/SOAPBOX, then W to write us a letter. You'll need a 2400-bps (or less) modem and a communications program set for 8,N,1.

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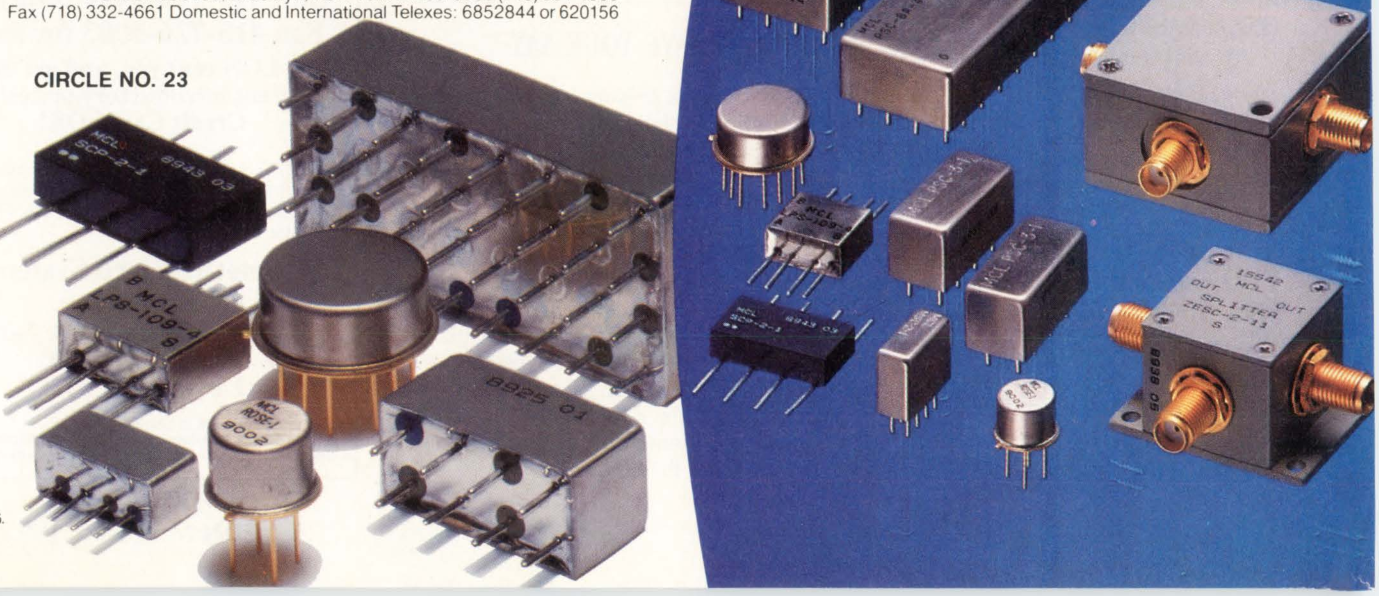

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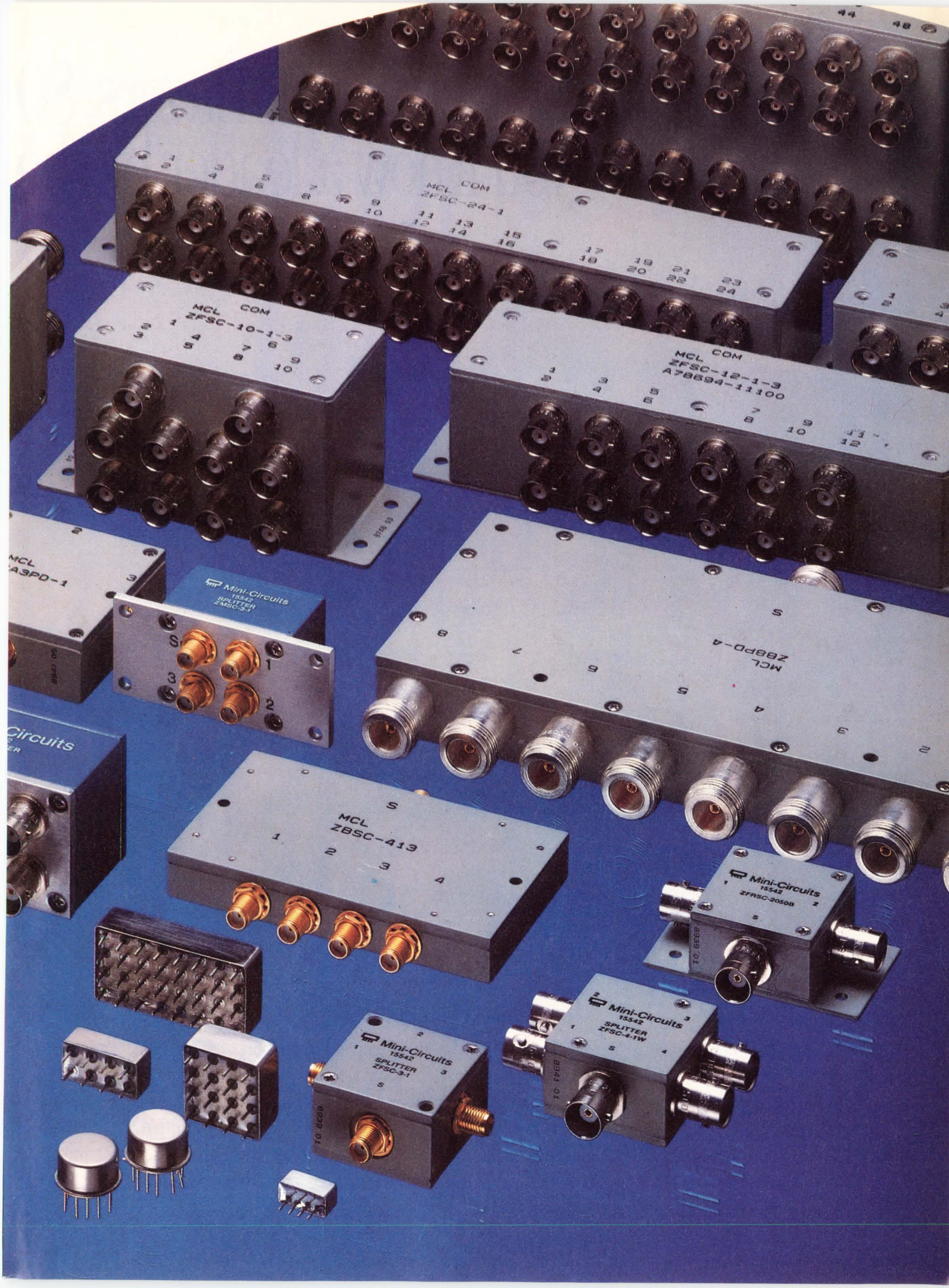
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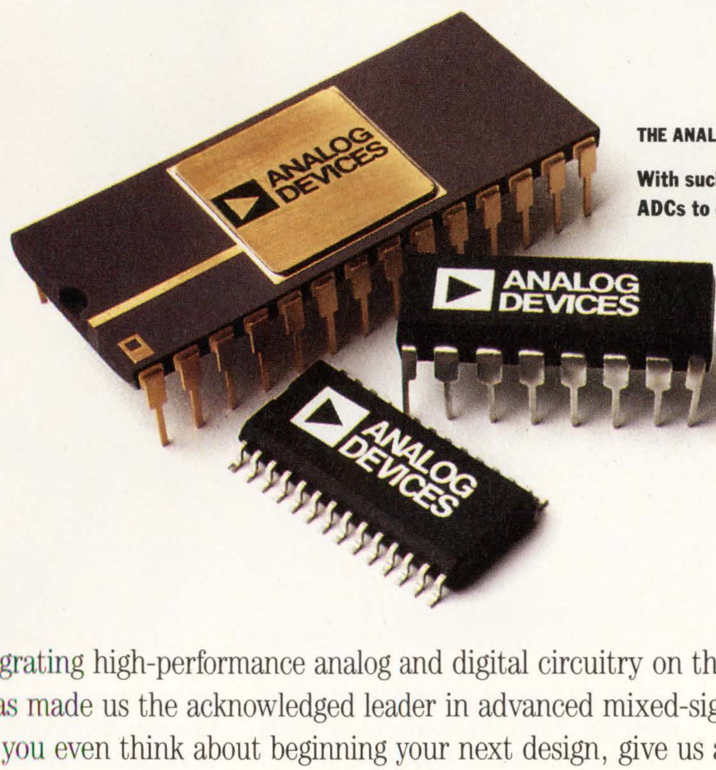

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CIRCLE NO. 24

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Circle 26 For Information

Companies can still profit while fostering innovation

Peter Gottlieb is a self-employed engineer who recently wrote to Ask EDN about the difficulty he has getting small quantities of state-of-the-art parts. His customers require prototypes that they can evaluate before committing to production. He says, however, that the high-end components he needs for building prototypes are not available from hobbyist suppliers, and nationwide distributors, such as Digi-Key and Newark Electronics, often don't carry such parts.

Gottlieb has resorted to ordering initial production quantities of hard-to-get parts. When he orders such large quantities, he risks losing a lot of money if requested changes eliminate the need for those parts. In closing his letter, Gottlieb asked "What can be done to keep the small engineer alive in this country?" and I asked readers whether Gottlieb's experiences were typical.

During the time I've been editing Ask EDN, no other letter has struck such a nerve. Dozens of engineers have written in to second Gottlieb's complaint. These readers added that they also have trouble getting small quantities of parts for designing test equipment and making repairs.

Engineers can't design-in parts they can't get their hands on. It's that simple. And they're not looking for freebies or handouts: These engineers are willing to pay full—or even higher—prices to get the small quantities they need.

Component-company sales people are usually too busy giving out sample parts to big companies to have time for the little guy. Also, it's not in their interest to go after small companies that would only buy a couple dozen parts when so many big companies are willing and able to buy thousands.

But at least one company doesn't subscribe to this reasoning. Dallas Semiconductor (Dallas, TX) has made getting small quantities of its parts as easy as making a phone call. Engineers dialing (800) 336-6933 can use a personal or corporate credit-card number to order any size quantity of any part—from the lowest-cost chip to the most sophisticated IC—the company has in stock. What's more, the parts arrive in two or three days, rather than the two to three weeks engineers must often wait to get parts from distributors. Certainly, there's a demand for this service: Dallas Semiconductor generates $7000 to $8000 a week via credit-card orders.

More companies should follow Dallas Semiconductor's example by making available small quantities of both low-end and sophisticated parts. Not only would such companies generate additional income, they would also be laying the groundwork for future, potentially large orders.

Julie Anne Schofield

Julie Anne Schofield
Associate Editor

Send me your comments via FAX at (617) 558-4470, or on the EDN Bulletin Board System at (617) 558-4241 300/1200/2400, 8, N, 1.

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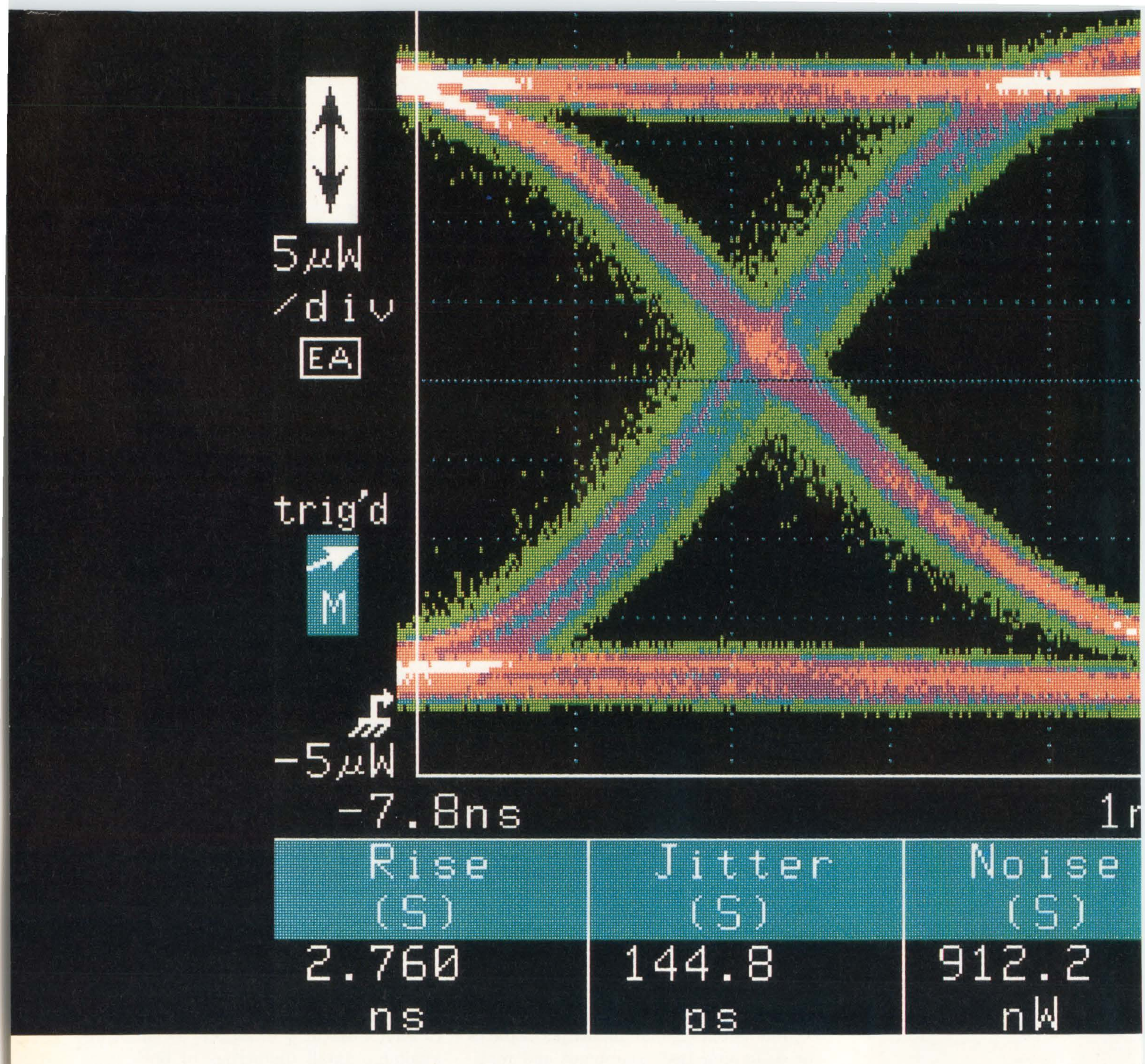

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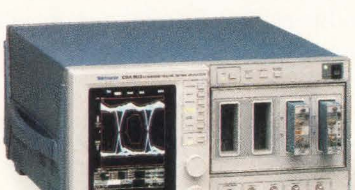

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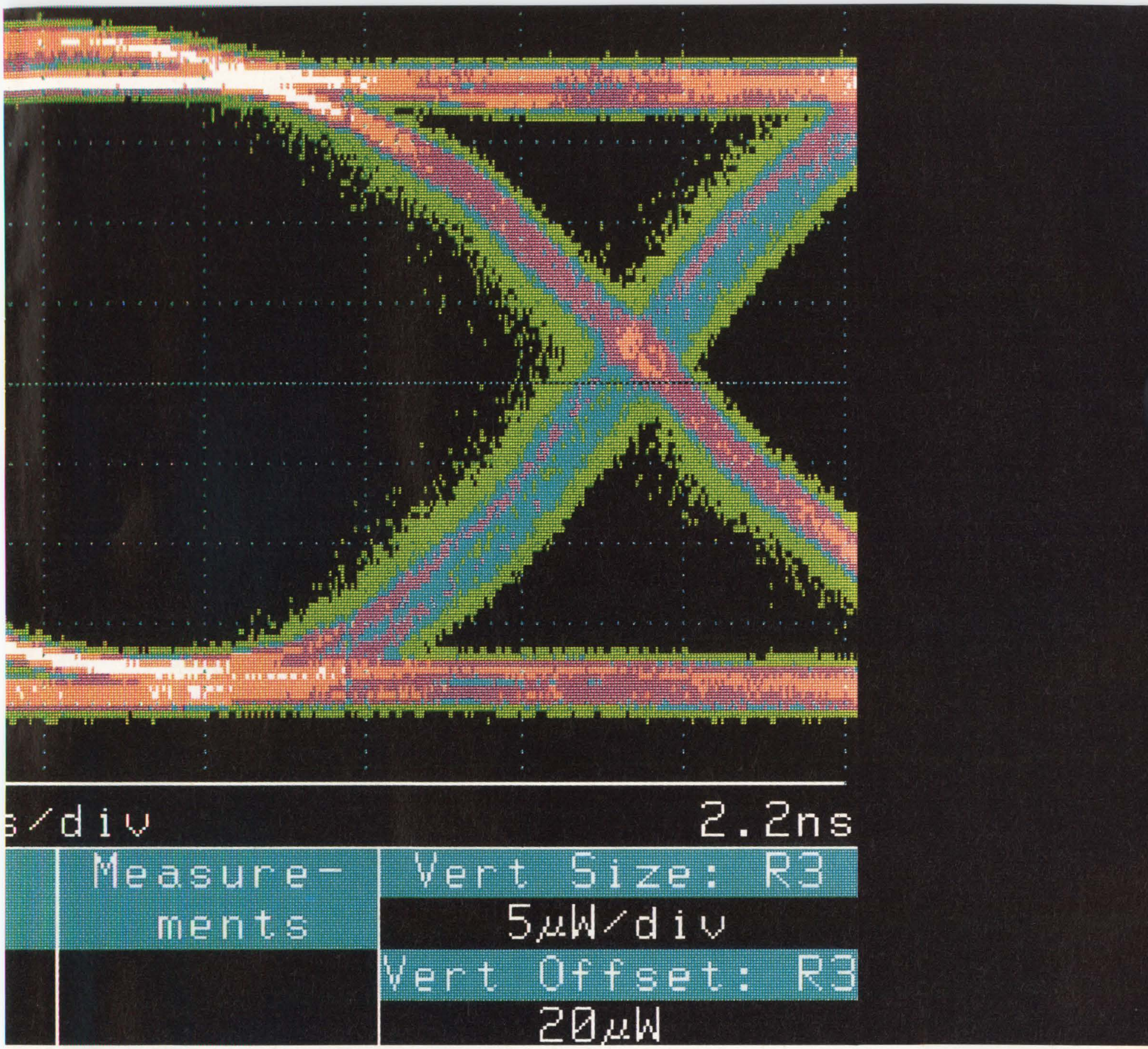

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CIRCLE NO. 28

2-MBIT VIDEO RAMs

Standardized feature sets add versatility and speed

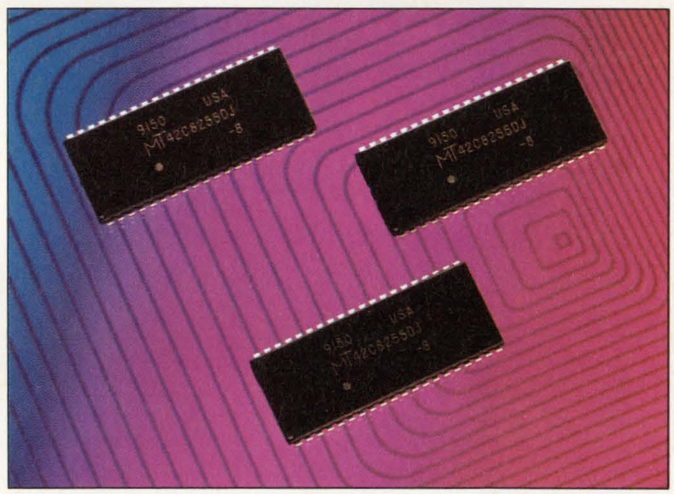
RICHARD A QUINNELL, Technical Editor

Emerging 2-Mbit video RAMs offer more features and a wider interface to boost speed beyond that of earlier devices. Different manufacturers' products also conform more to a single standard, coming a bit closer to eliminating second-sourcing problems.

During the four years since the introduction of 1-Mbit video RAMs (VRAMs), manufacturers have been listening to users. The 2-Mbit devices now appearing attend to users' needs for second sourcing by offering a standardized array of features, including the most popular 1-Mbit functions and some user-suggested functions unique to the 2-Mbit generation.

The feature sets of most 2-Mbit devices conform to a JEDEC standard jointly developed by the major manufacturers. The devices' organization is also standard at 256×8 bits—twice the width of older, 1-Mbit devices (256×4 bits). The effort to standardize came in reaction to the varied options available in 1-Mbit VRAMs (**Ref 1**). Because each manufacturer offered a different mix of functions, parts seldom had many features in common. To make second sourcing possible, designers had to use only the few common features, sacrificing much of the parts' capabilities. By offering broader standard feature sets in 2-Mbit parts, manufacturers now aim to minimize that sacrifice.

The feature sets constitute a hierarchy, offering foundation, core, and extended functions. The foundation of all VRAMs is a dual-memory structure: a dynamic-random-access-memory (DRAM) array coupled to a serial-access-memory array (SAM). The DRAM array behaves like a conventional page-mode DRAM, requiring the same address, control, and refresh signals. The SAM array provides a second port into the DRAM array, allowing you to transfer a row of DRAM data to the SAM in a single cycle, then shift out the SAM data independent of the DRAM array's operation.



The emerging 2-Mbit video-RAM generation reduces some of the diversity found in the 1-Mbit generation by offering a hierarchy of feature sets. The Micron MT42C8255 shown here offers the core features.

In some cases, the SAM array can also accept serial data for transfer to the DRAM array. Using both ports, you can transfer data into and out of the VRAM simultaneously.

Several core functions taken from the 1-Mbit VRAM generation build on this foundation. One such core function is the split data transfer. A basic data transfer has you provide row and column addresses to the DRAM along with a transfer command bit. The row address selects the DRAM row to transfer into

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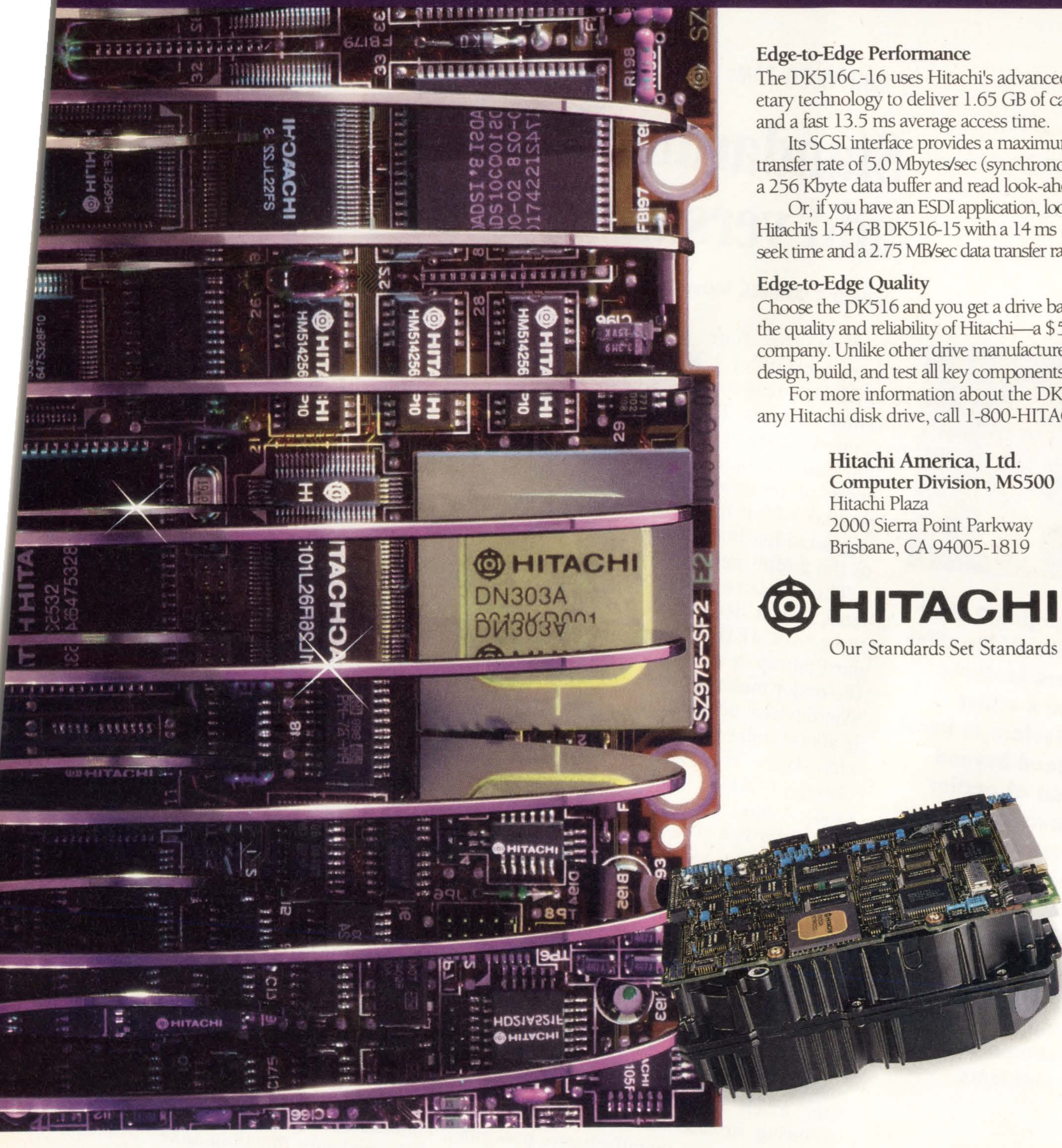

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Circle #30 To have Hitachi Representative Call the SAM; the column address selects a tap point (the location in the SAM that is first in the serial output stream). A drawback to the basic transfer becomes apparent if you attempt to produce a continuous serial data stream. When the SAM reaches its last location, you only have one clock period in which to execute the next transfer.

The split data transfer extends this time window by allowing you to load one half of the SAM while the other half is shifting data. To use the split transfer, you first execute a basic transfer. Once the first half of the SAM has shifted out, you can execute a split transfer to refill that half anytime before the second half finishes shifting.

When the second half of the SAM has finished shifting, the memory pointer automatically wraps around to the beginning of the first so that shifting continues uninterrupted. You can then execute a split data transfer to the second half, and so on. The device automatically controls which half-transfer occurs, so you can maintain a continuous data stream by performing a succession of split transfers.

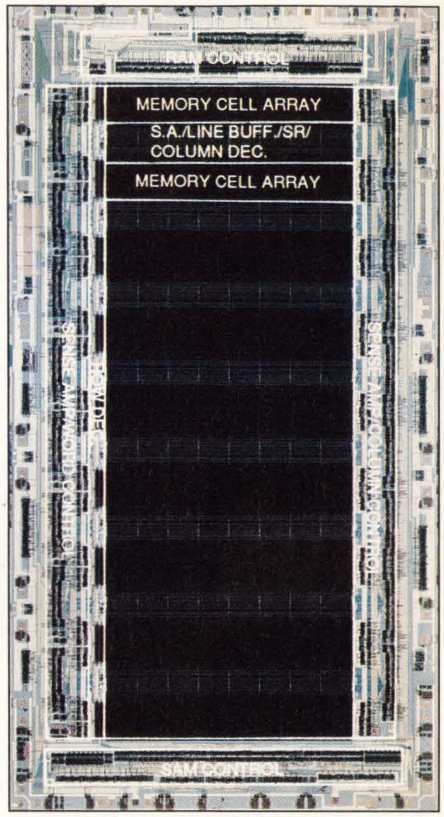
Another core function that adds to the foundation VRAM is the ability to perform a masked write, a fast alternative to the read-modify-write cycle. The masked write, also called write-per-bit, lets you prevent alteration of selected bits within a word during a write operation.

Two types of masked write are available, persistent, and nonpersistent. In nonpersistent masked write, you must provide the mask pattern during the row address portion of each write cycle. In persistent write, you first load a mask register. The device will then apply that mask during all succeeding write operations until the mask is cleared.

Multiple-location writes

A third core function is the ability to write the same data to multiple DRAM locations simultaneously. The duplicated data comes from an internal register called the color register, which you must load beforehand.

The ability to write to multiple locations takes on two forms, a block write and a flash write. The flash write replicates the color register data into an entire row of the DRAM array. The block write writes to as many as four adjacent



Including such extended functions as stop-column control and extended-data-output page-mode access, the NEC μPD422835/6 2-Mbit video RAM is organized as a standard 256k × 8-bit device.

memory locations (columns) in a single row. You can selectively mask out columns in the block write, but not in the flash write. Both forms include the option of performing write-per-bit.

The top level in the feature set hierarchy includes two extended functions unique to the 2-Mbit VRAM generation. Both aim at improving the VRAM's performance during DRAM write operations.

The first of these extended functions is the extended-data-output page mode, also called hyper page mode. This variation on page mode has the DRAM latch its output data internally so that the output remains valid while the DRAM column-control circuits prepare for the next access cycle. In conventional page mode, the DRAM must wait for the system to finish reading data

For more information . . .

For more information on the VRAMs 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 read about their products in EDN.

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before the column-control circuits can prepare for the next access. By allowing the two operations to occur in parallel, the latch speeds data access.

The second extended function is a column-stop control on split data transfers. Although this function seems to affect only the SAM, its effect is to improve write access to the DRAM array by simplifying use of a tiled memory-to-display map.

The most intuitive method for mapping memory locations in the DRAM array to pixels on the display is shown in **Fig 1a**. Each row or page of the array maps to a line of pixels. While this is an intuitive map, it suffers from reduced performance when the system attempts to draw a diagonal line. As the figure shows, the line cuts across multiple pages in the DRAM, using only one or two locations in each page. Having only a few locations to be written in each page, you cannot use page mode's fast access time effectively.

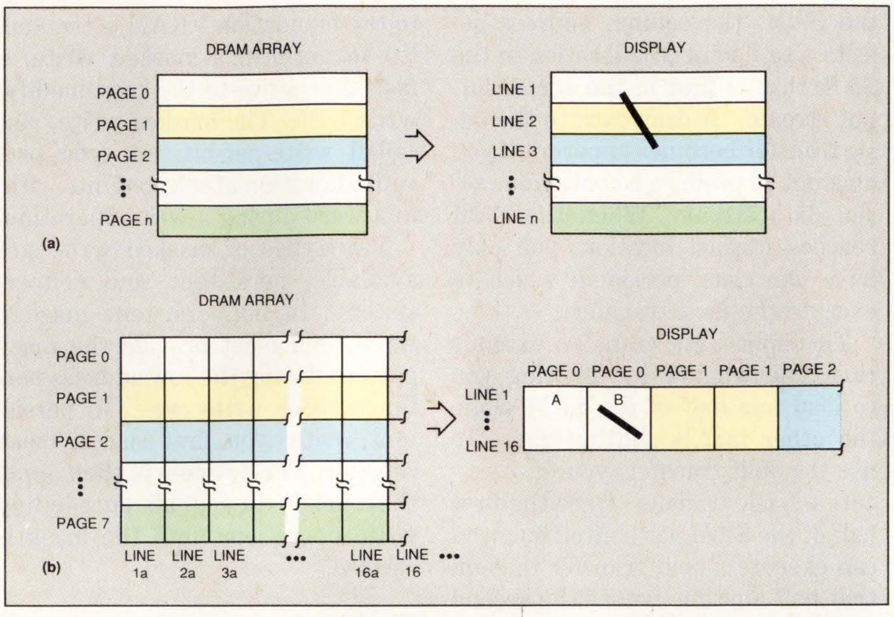

Fig 1—The mapping you use between VRAM address and display locations affects your line-drawing rate. A direct map (a) allows simple serial data transfers but doesn't allow line drawing to use page mode effectively. A tiled map (b) allows more frequent use of page mode for drawing but complicates the serial data transfer to screen.

Tiled map speeds line draw

The tiled approach shown in **Fig 1b** maps a 512-byte DRAM page into two 16×16-pixel display tiles. Any line drawn on the screen will use several pixels from the same tile and thus from the same DRAM page. Access within a page is twice as fast as access between pages. Therefore, by making more effective use of page mode, the tiled map reduces line drawing time.

The drawback to the tiled map is that it complicates the reading of data into the SAM for presentation to the display. You must initiate a basic data transfer at each tile boundary—in this case every 16 bits—under the tight timing conditions needed to maintain a continuous serial data stream. You cannot ease those timing constraints by using a split data transfer because you cannot jump between the split registers when you reach a tile boundary; you can only wrap around register boundaries.

The column-stop control, however, does allow you to jump between split registers. You initiate column stop by selecting one of five column-stop patterns. You can then

Table 1—2-Mbit video RAMs

Manufacturer	Part no.	Cycle time (nsec): Page mode	Cycle time (nsec): Serial	Features: Serial input	Split transfer	Block write	Flash write	Masked write: Persistent	Masked write: Nonpersistent	Extended-data-output page mode	Stop-column control	Price (100)	Unique features
Micron Technology	MT42C8254	45	25		X	X			X			$25	
	MT42C8255	45	25		X	X			X			$25	Dual write enable for VGA
Mosaic Semiconductor	MVM8256	55	35	X								$378	MIL-STD-883C qualified
NEC Electronics	µPD482234	45	22	X	X	X	X	X	X		X	$30	
	µPD482235	35	22	X	X	X	X	X	X	X	X	$30	
Toshiba America Electronic Components	TC528257	45	25	X	X	X	X	X	X		X	$27	30-nsec cycle time piplined-page mode
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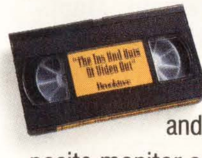

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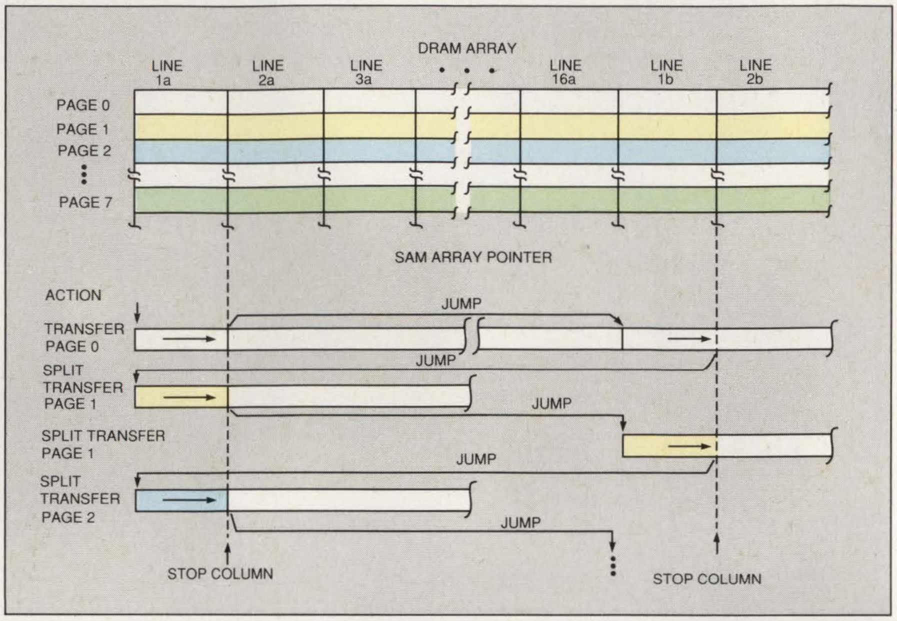

Fig 2—By permitting the serial data pointer to jump to the other half-register upon reaching a stop point, the stop-column control function simplifies timing of tiled-map serial readout.

specify a tap point with each split transfer. The serial data pointer will jump from the stop boundary in one split register to the tap point you specify for the other split register. Column stops can be as close together as 16 columns. **Fig 2** shows the transfer and jump sequence for the tiled map of **Fig 1b**.

Similar, but not identical

The hierarchy of foundation, core, and extended feature sets is reflected in **Table 1**. The Mosaic MVM8256 is a foundation part, the Micron devices offer core functions, and the NEC and Toshiba parts have extended functions. Even though several devices have unique additions to the standard feature sets, the commonality is much greater than it is in the 1-Mbit generation. Unless you absolutely need them, sacrificing the extra features to permit second sourcing now presents no great hardship.

Simply comparing feature sets is somewhat misleading, however. You may have to design carefully to accommodate possible physical differences. The Toshiba parts, for example, need an extra I/O pin to activate their pipeline mode. That pin is a ground pin on the Micron parts and a no-connection on the NEC parts. You can't design to accommodate all differences, though. The Mosaic part, for example, has a pinout different from the other VRAMs.

The VRAM evolution won't stop at the 2-Mbit generation. Both NEC and Texas Instruments are working on 4-Mbit devices, organized as $256k \times 16$ bits, that may be available by year's end. Whether the compatibility trend will continue, however, is uncertain. Manufacturers haven't agreed on any specifications for the 4-Mbit generation. EDN

Reference

1. Conner, Margery S, "1M-bit video RAMs offer speed for high-resolution graphics displays," *EDN*, March 31, 1988, pg 79.

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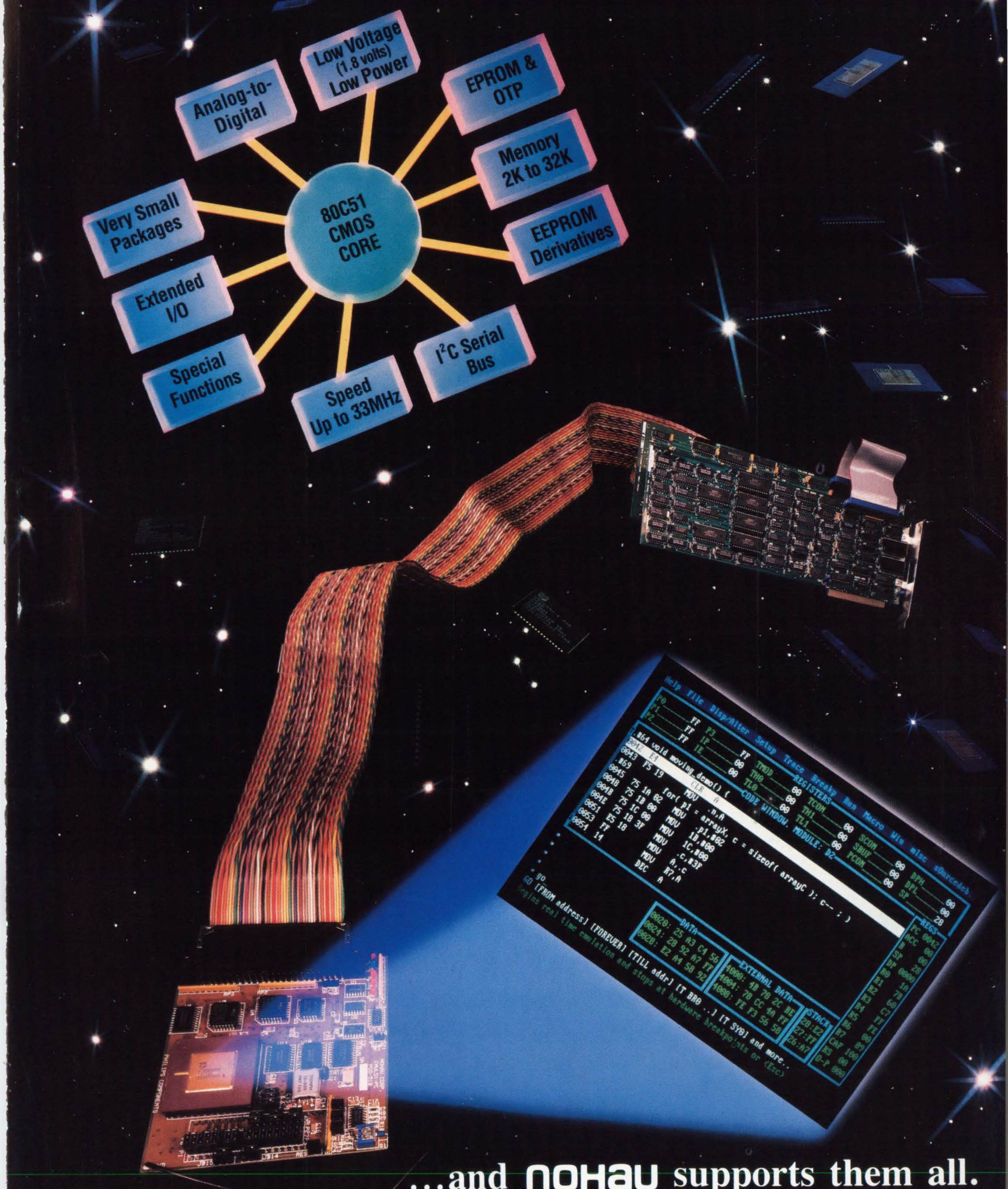

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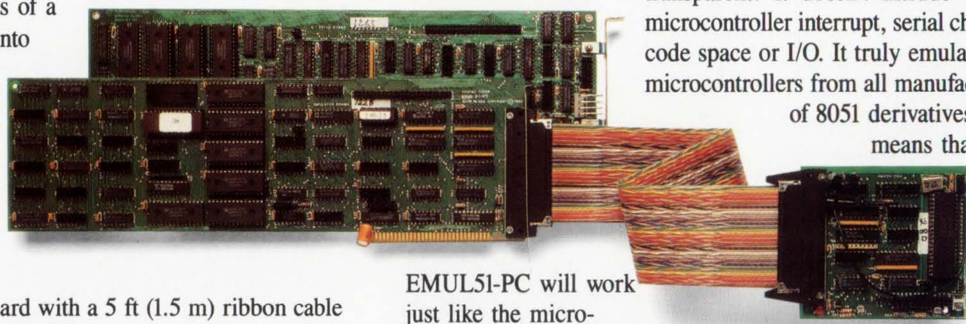

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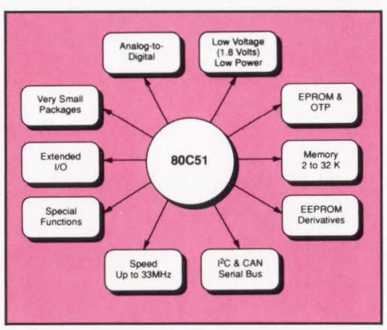

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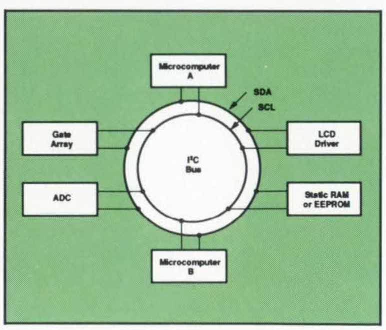

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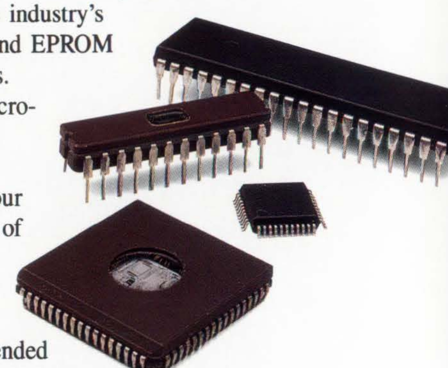

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8XC752	•	2K	64	2 + 5/8		•	1	8-bit A/D (5 ch.), PWM	A28, F28, N28
80C31/8XC51	•	4K	128	4	•		2	Industry Standard	A44, B44, F40, K44, N40
80CL31/80CL51		4K	128	4	•		2	Low Voltage/Power (1.8–6 votls)	N40, D40
8XCL410		4K	128	4		•	2	Low Voltage/Power (1.8–6 volts)	N40, D40
8XC851		4K	128	4	•		2	256 EEPROM	A44, B44, N40
8XC550	•	4K	128	4	•		2 + WD	8-bit A/D (8 ch.), WD	A44, B44, F40, K44, N40
8XC451	•	4K	128	7	•		2	7 I/O Ports	A68, F64, K68, N64
8XC852		6K	256	2/8			2	Smart Card, 2K EEPROM, CCU	Die only
8XC652	•	8K	256	4	•	•	2	8K ROM, I²C Serial Bus	A44, B44, F40, K44, N40
80C32/8XC52	•	8K	256	4	•		3	Industry Standard	A44, B44, F40, K44, N40
8XC562	•	8K	256	6	•		3 + WD	8-bit A/D (8 ch.), PWM, WD, T2	A68, B80
8XC552	•	8K	256	6	•	•	3 + WD	10-bit A/D (8 ch.), PWM, WD, T2	A68, B80, K68
83C053	•	8K	192	3 + 4/8			2	TV Display (OSD), PWM, D/A	N42
8XC054	•	16K	192	3 + 4/8			2	TV Display (OSD), PWM, D/A	N42
8XC654	•	16K	256	4	•	•	2	16K ROM, I²C Serial Bus	A44, B44, F40, K44, N40
8XC592	•	16K	512	6	•		3 + WD	CAN Bus, 10-bit A/D (8 ch.), WD	A68, K68, B80
8XC524	•	16K	512	4	•	•	3 + WD	16K ROM, 512 RAM, WD	A44, B44, F40, K44, N40
8XC528	•	32K	512	4	•	•	3 + WD	32K ROM, 512 RAM, WD	A44, B44, F40, K44, N40

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Emulation Memory — 64K XDATA memory and 64K CODE memory. Up to 320K Bank switching is supported as an option.
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MULTIFUNCTIONAL 3½-IN. OPTICAL DRIVES

Drives meet standards for removable data storage

MAURY WRIGHT, Technical Editor

A look at the list of all-star companies planning to offer industry-standard 3½-in. optical drives gives a good indication of the potential success of the product class.

The emerging class of 3½-in. multifunctional optical disk drives stands a good chance to become a widely accepted standard for desktop computers. Previous classes of optical drives have failed to achieve this status because of a lack of industry standards. The new drives meet ANSI and ISO standards for MO (magneto-optical) drives that store 128 Mbytes on a rewritable cartridge that resembles a 3½-in. floppy disk.

What makes the 3½-in. drives multifunctional is that they can also use two other media. The drives can read 120-Mbyte O-ROM (optical ROM) prerecorded disks, which software publishers can produce much like they do the larger CD-ROMs (compact-disc read-only memory). The drives can also use a medium called partial ROM. On partial-ROM disks, some sectors have prerecorded data and others can be written to using the MO capability of the drive.

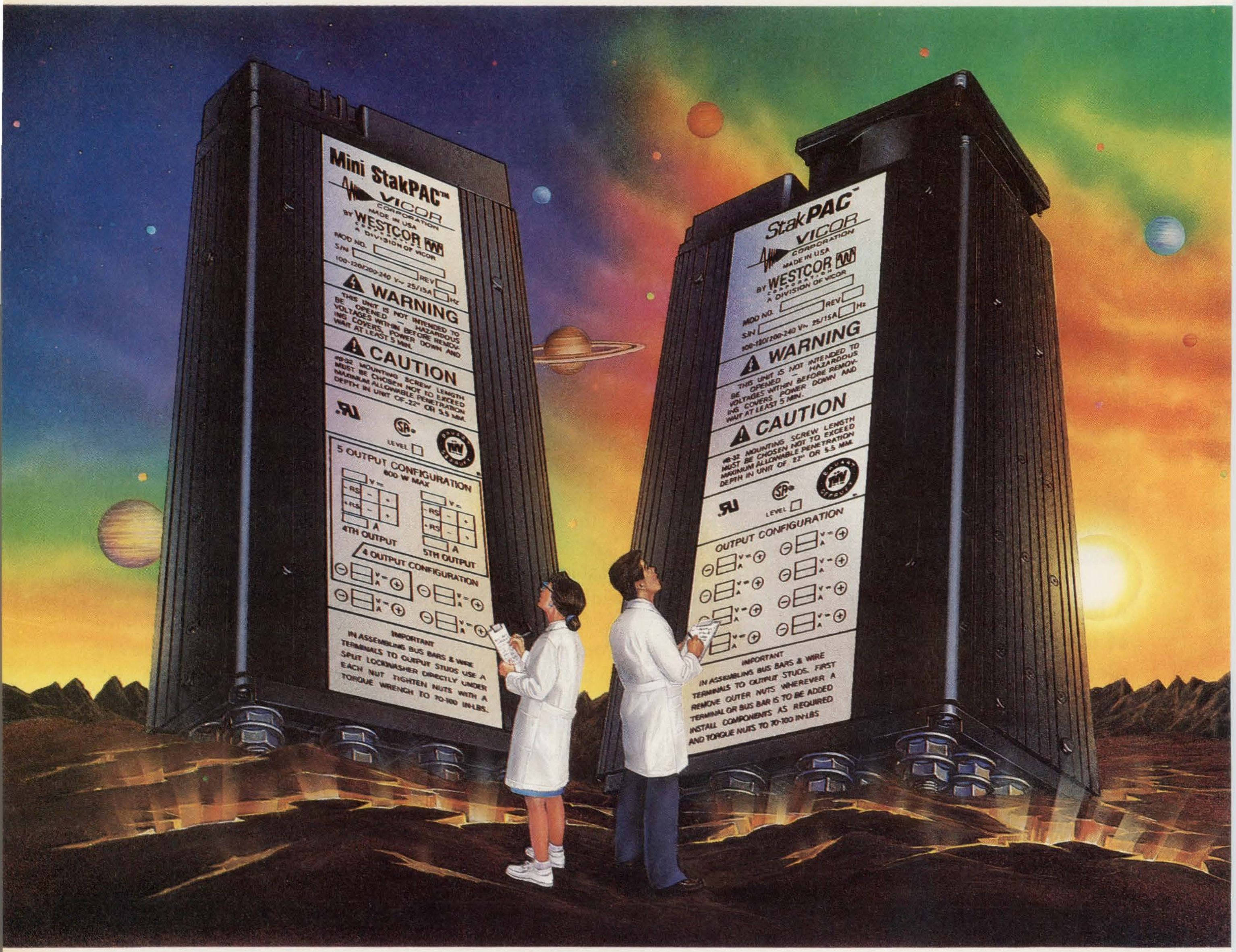
Mike Helsel, manager of tape and optical products at Teac, maintains that 3½-in. optical drives have a shot at eventually replacing the floppy-disk drives used in every system. Helsel qualifies his statement by saying that the transition might take 10 years and that standards must be strictly maintained for the scenario to occur.

Low price ultimately will key the acceptance of these multifunctional drives into mainstream office use. An end user will pay approximately $2000 for a drive right now, but drive manufacturers have just begun volume production. According to Robert Abraham, vice president of Santa Barbara, CA, research firm Freeman Associates, the average OEM price for 3½-in. optical drives shipped in 1992 will be $810. Therefore, you can expect end-user prices less than $1500.

The optical-drive industry has failed to deliver optical drives that achieve the performance and price of magnetic disk drives more times than anyone cares to

Sony leads the pack in shipments of 3½-in. optical drives. The company used the experience gained in pioneering MO technology in larger drives to produce its SMO-300 optical-drive family.

Power Revelation



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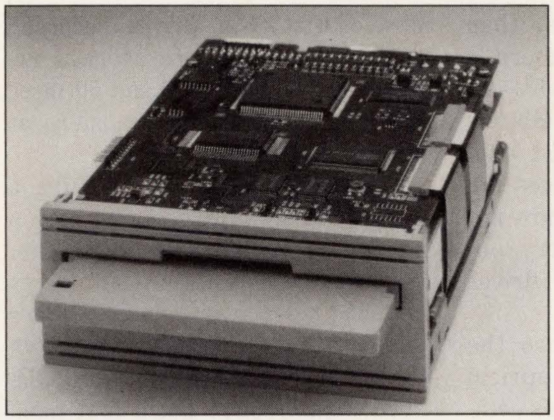
remember. No optical drives—including the 3½-in. units—have reached the performance level of magnetic drives. The average access times and data-transfer rates the small drives offer match those of a 20- to 40-Mbyte hard drive shipped in the typical PC a few years ago.

But optical drives in general can perform the primary-storage role in place of hard-disk drives in applications in which fast data-access times and data-transfer rates aren't paramount. And the random-access capability of optical drives makes them preferable to tape drives in some secondary-storage applications including archival storage and disk backup. However, optical storage can't come close to the drive or media price tape storage offers.



The OD-3000 optical drive from Teac has a 128-kbyte buffer and fits the standard 3½-in. form factor.

Applications open niches

Optical drives have found niches in which high-capacity random-access removable storage proves invaluable. In fact, desktop publishing and emerging multimedia applications have essentially created the need for a third class of storage that complements traditional disk and tape drives. Optical drives can be used to store images, encyclopedias, music, and video on high-capacity removable cartridges. Optical disks can also be used for software distribution in this graphics age where a word-processing program can require a dozen floppy disks.

These applications have created a potentially large market for all optical drives, but several factors have stymied growth in the market. Certainly high price and low performance don't help. But lack of standards and disarray in the optical-drive industry have been the biggest obstacles to success. For example, optical drives use media ranging in diameter from 3½ to 14 in. And drives from different vendors that use the same size media often used different recording formats. Finally, customers have had to choose between WORM (write once, read many), rewritable, and CD-ROM drives.

Standardization, multifunctional capability, and size set the new class of 3½-in. drives apart from the grab bag of larger optical drives. ANSI and ISO committees had defined standard recording formats for MO and O-ROM 3½-in. media before any companies produced drives. Thus, all potential 3½-in. optical-drive manufacturers could produce standard drives from the start. And media-interchange standards are key for removable storage technologies. You only have to look at the stalled market for 20-Mbyte floppy-disk drives to see how incompatibility can hurt a new class of storage products.

Manufacturers of the 3½-in. drives say their products suit desktop personal computers and workstations rather than LAN servers, where larger optical drives often see duty. The small form factor matches the physical space provided in newer desktop computer cabinets. And the 128-Mbyte capacity of the rewritable MO cartridge matches the needs of a single-user graphical-user-interface-based computer.

You can argue that 5¼-in. optical

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drives provide more capacity than the 3½-in. drives and that more is usually better. Available 5¼-in. drives store more than 500 Mbytes on an MO cartridge yet cost only double what the 3½-in. drives do. However, the 5¼-in. drives are not multifunctional, and industry observers expect the smaller drives to drop in price quickly.

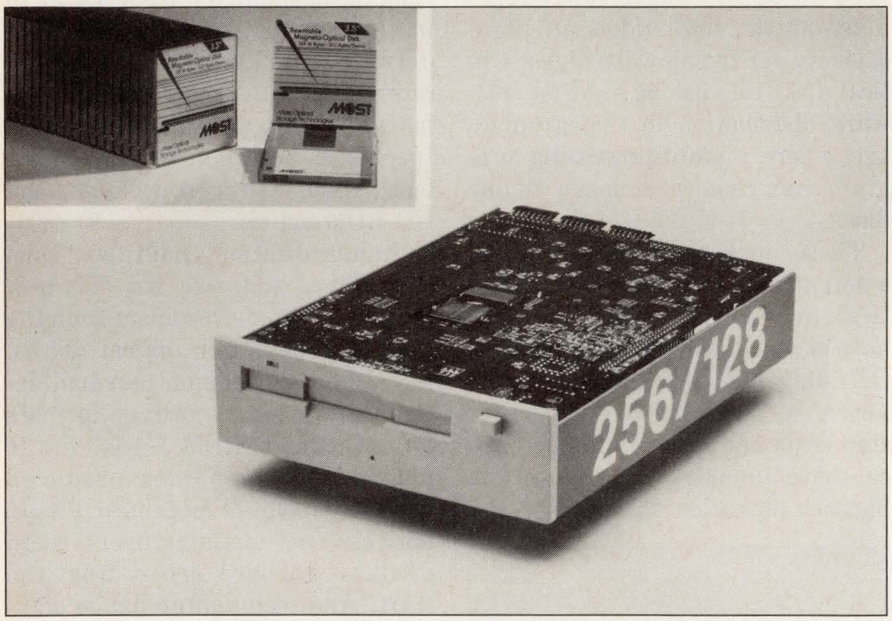
You can't directly compare the 3½-in. drives with other optical drives because no other drives combine the same capabilities. For example, no 5¼-in. MO drives also read CD-ROMs. The 3½-in. drives can read O-ROMs, which are similar to CD-ROMs. Software publishers can mass-produce O-ROM cartridges using the same stamping process they use to make CD-ROMs and their close relative, the audio compact disc. Thus, O-ROMs and CD-ROMs share the characteristic of being cheaper than paper for distributing large amounts of data.

O-ROM drives have several advantages compared with CD-ROM drives, however. O-ROM disks use a sector-and-track format geometry just as magnetic disk drives do. Most of the 3½-in. drives discussed in this article feature average access times between 40 and 50 msec and can sustain data transfers at more than 600 kbytes/sec.

CD-ROMs, however, feature a single spiral track much like a groove in an audio record album. State-of-the-art CD-ROM drives have 300-msec average access times and data-transfer rates in the 150-kbyte/sec range. Furthermore, CD-ROM disks' spiral track and need for a variable-speed spindle motor that produces constant linear velocity will delay or eliminate the possibility of MO/CD-ROM multifunctional drives.

The larger CD-ROMs do offer 540 Mbytes of capacity compared with the 120 Mbytes offered by O-ROM cartridges. So publishing large data sets such as encyclopedias can make more sense on CD-ROMs now, although you can expect higher-capacity O-ROM cartridges as early as next year. Currently, publishers offer thousands of titles on CD-ROM; O-ROM publishing has just begun.

You can buy Corel Draw from Corel Systems (Ottawa, Canada) on O-ROM today. And Autodesk (Sausalito, CA) has created a sample image library on O-ROM using animations created via its CAD and drawing software packages. Other publishers are waiting for more widespread use of drives that can use O-ROM media before offering titles.



The "Free Format" 265-Mbyte mode that the Most RMD-5200 can operate in doesn't prevent the drive from using standard 128-Mbyte cartridges as well.

Art Rancis, vice president of data-storage products at Sony, says that O-ROM will be a more affordable medium than CD-ROM for many publishers. Rancis heads up Sony's operations that produce 3½-in. O-ROM and MO media. He says CD-ROM production facilities have been geared toward producing hundreds of thousands of copies of a title. But Rancis also says Sony has used the experience gained in producing CD-ROMs to create smaller O-ROM production facilities. He predicts that smaller satellite O-ROM production facilities will enable publishers to use the medium cost effectively for much smaller production runs.

Partial ROM adds flexibility

The 3½-in. drives can also use a third type of medium called partial ROM. On partial ROM cartridges, some sectors are prerecorded data and others can be written to using the MO capability of the multifunctional drives. Clip-art libraries are an example of a partial-ROM application. You might buy a library of such art and add your own variations. Most industry experts predict that O-ROM and partial ROM will ultimately ensure success for 3½-in. optical drives.

So, the keys to success are in place for this new class of optical drives. And you won't find many PC or workstation users who couldn't find uses for these small drives. Therefore, drive and media price will determine how quickly the drives proliferate.

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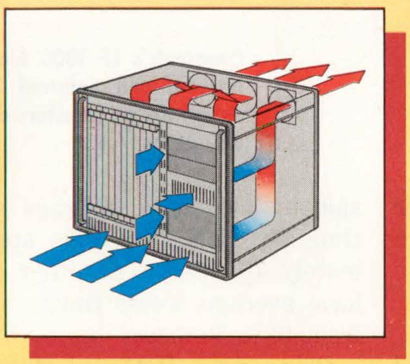

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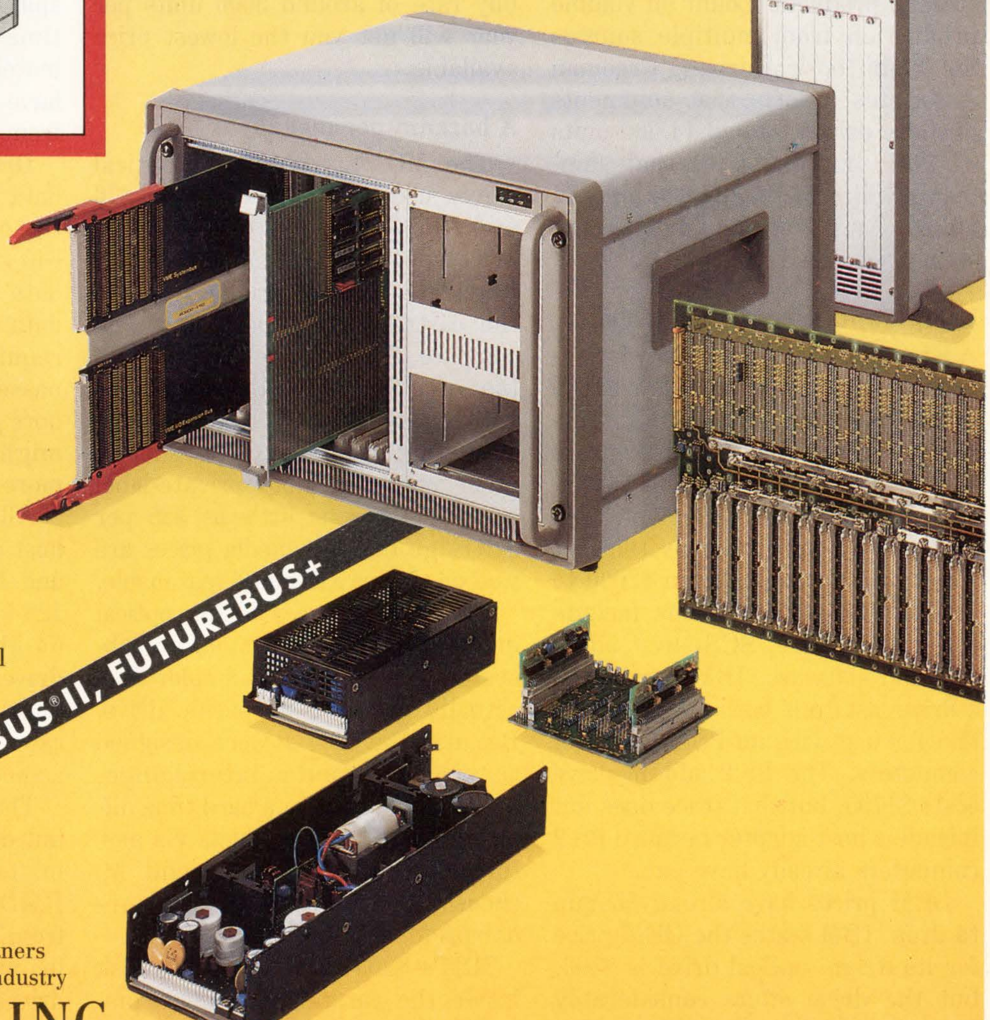

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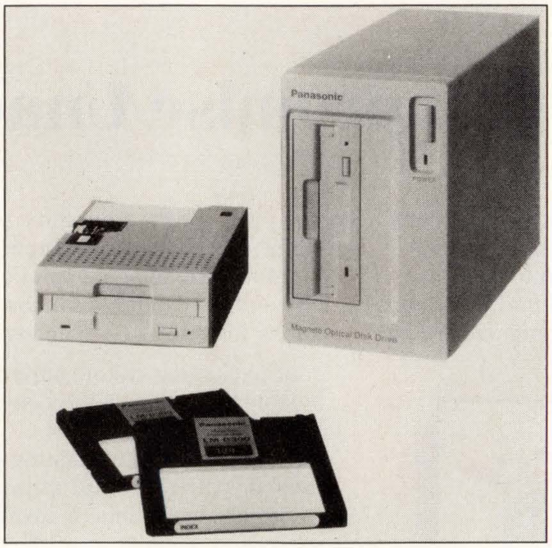
up to produce 3½-in. optical drives reads like a who's who of the computer-peripheral business. IBM, Most Inc, Panasonic, Ricoh, Sony, and Teac have all started shipping these small optical drives. Epson (Torrance, CA), Fujitsu (San Jose, CA), and NEC (Melville, NY) will be making the drives as well. And Mitsubishi (Torrance, CA), Olympus (Torrance, CA), and Toshiba (Irvine, CA) have manufactured optical drives and could introduce products any day now. Sony, according to most sources, has shipped more drives than any other manufacturer.

These companies don't target niche markets with their new data-storage products. Count on volume production from multiple sources for 3½-in. optical drives. Freeman Associates reports that shipments of these drives totaled 14,600 units in 1991, but estimates that shipments will grow to 137,000 units in 1992. And volume production should soon lead to low prices.

Users want prices below $1000

Freeman's Abraham says end-user prices must drop below $1000 before the market takes off. Currently, subsystem manufacturers such as Storage Dimensions (Milpitas, CA) and PLI (Fremont, CA) offer 3½-in. optical subsystems at retail prices ranging from $2000 to $2500. These subsystems include the optical drive, SCSI host adapter, and software. IBM introduced a drive last June both for OEM sale and for use with its PS/2 family of computers. The PS/2 add-on drive costs $1795, but that price does not include a host adapter because PS/2 computers already have one.

OEM prices have already begun to drop. IBM states the OEM price for its 3½-in. optical drive is $803, but the drive offers considerably lower performance than others. The other five vendors shipping drives peg the OEM price between $900 and $1000 for volume purchases. A buy rate of around 3000 units per year will get you the lowest price available.



Panasonic's LF-3000 family of internal and external 3½-in. optical drives transfers data at 640 kbytes/sec.

A bargain per megabyte

The MO cartridges the optical drives use cost approximately $70 each. Sony and 3M (Minneapolis, MN) will be the major name-brand providers of the cartridges. At $70, the cartridge is a bargain if you compare its cost per megabyte with that of other media. But consumers will surely demand lower prices. According to several drive vendors, other media vendors private-label cartridges for as little as $25 per cartridge now, so media prices are well on the way to being reasonable.

Deciding to use a 3½-in. optical drive in your next system or subsystem design may be simpler than actually choosing a specific drive. Because the drives were designed to promote media interchange, manufacturers have a hard time differentiating their products via performance specs. You'll end up choosing a drive based on your vendor preference.

IBM's $803 drive spins the disk inside the cartridge at 1800 rpm, and therefore trails the other drives slightly in access time and performance. Most's drives spin at 2400 rpm; drives from the other vendors spin at 3000 rpm. Average access time for IBM's drive is approximately 70 msec. The other drives have average access times ranging from 40 to 50 msec.

Drives from IBM and Most read data at 500 kbytes/sec; drives from the other four vendors can sustain 640 kbytes/sec. All the drives write data at about one-third the read-data rate because MO technology requires erase, write, and verify passes on write operations. Vendors gearing up to enter the market might boost performance even more.

All of the drives use SCSI as a host interface. Both Teac's OD-3000 and Panasonic's LF-3000 include a 128-kbyte buffer compared with the 64-kbyte buffers on the other drives. The larger buffer should boost performance, although you can't discern the improvement on a spec sheet.

The drives all use 3½-in. media but don't all fit in the standard 3½-in. form factor. For example, the RMD-5100 and RMD-5200 drives from Most require a half-height 5¼-in. mounting slot. The rest of the drives meet the 3½-in. form factor in the 41.3-mm height and 101.6-mm width dimensions, but only Teac's OD-3000 and Ricoh's Transporter stay within the 146-mm

depth spec including the SCSI controller. However, many computer cases can provide the extra depth some drives require.

Higher capacity emerges

Most Inc has broken from the pack by including what the company calls a "Free Format" mode in its RMD-5200 optical drive. This mode enables the drive to store 256 Mbytes on a cartridge—standard cartridges store 128 Mbytes. Most has preproduction units available and expects the drive to cost about \$1300 in OEM volumes. The drive requires special cartridges to attain the large storage capacity, but also maintains full read/write compatibility with standard cartridges.

Some industry participants are uneasy about Most's higher-capacity product, which doesn't conform to a standard. These people are especially concerned because higher-capacity 3½-in. optical drives are still in the developmental stages and are a product class dependent on standardization. Jeff Segers, vice president of marketing at Most, says the company does not intend to upstage the standards effort, but rather produced the product in response to customer demand.

The ANSI and ISO committees are committed to defining standards for doubling and tripling the 128-Mbyte storage capacity of 3½-in. optical media. But onlookers report that agreement on a 256-Mbyte standard is probably a year away. The efforts of the standards committees might hold the last key for the long-term success of 3½-in. optical drives. Standards are absolutely necessary to make these drives widely accepted. Unfortunately, standards also slow the introduction of new technology into the marketplace. EDN

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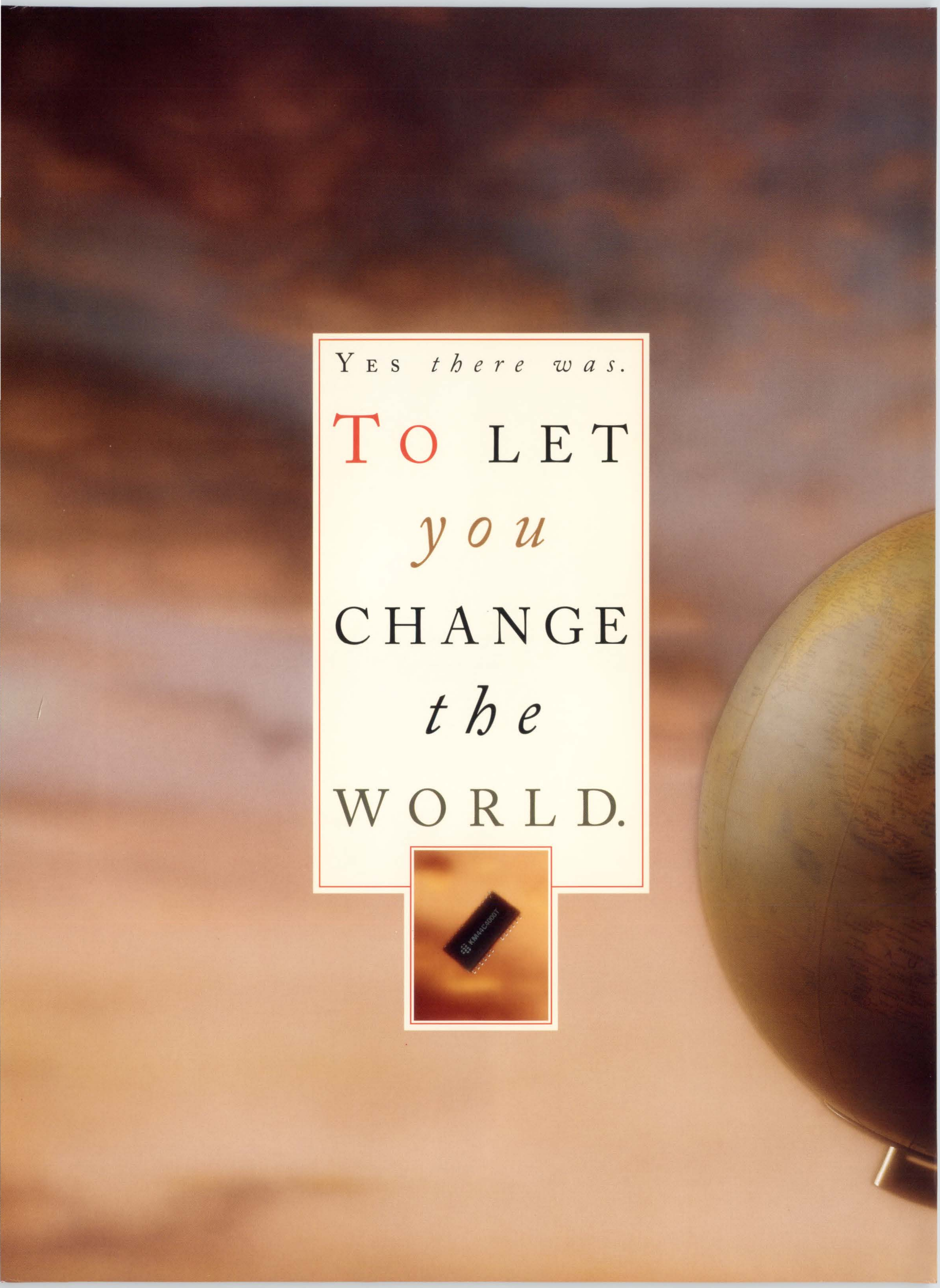
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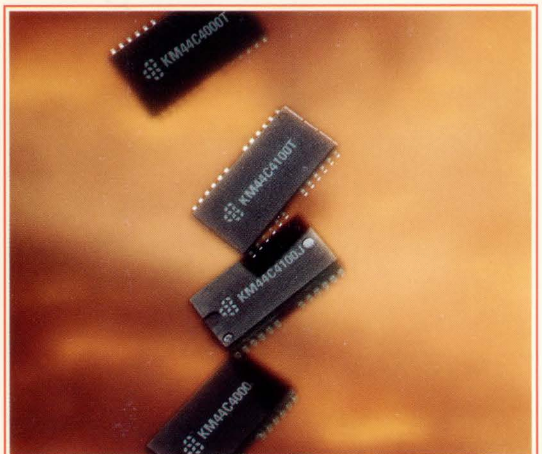

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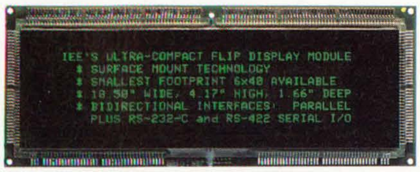

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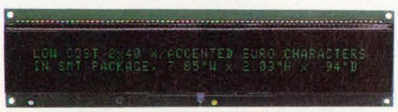

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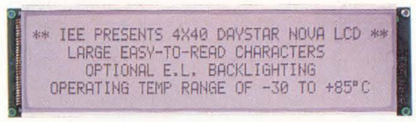

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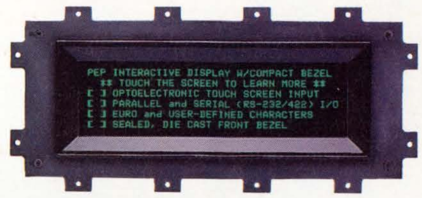

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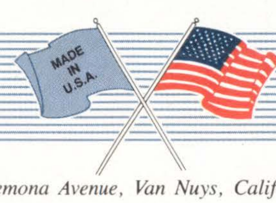

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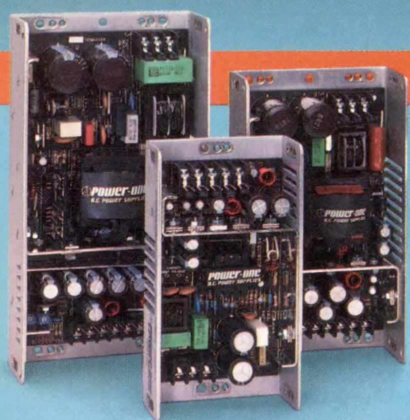

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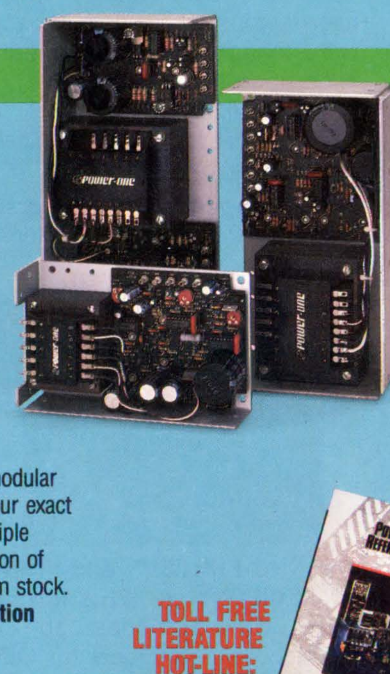

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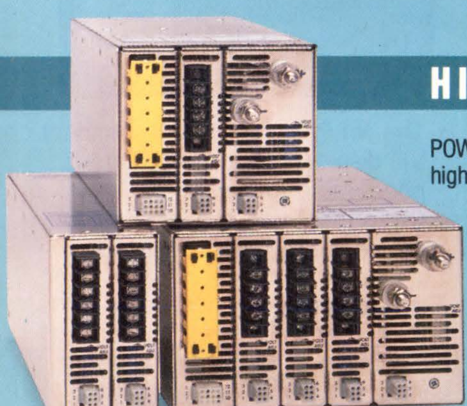

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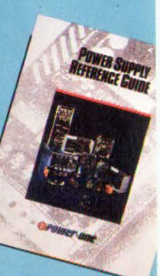

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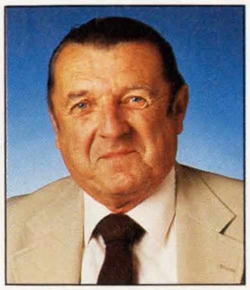
CIRCLE NO. 41

Solid-state relays meet requirements and handle demanding applications

TOM ORMOND, Senior Technical Editor



Because solid-state relays have no contacts and are housed in sealed packages, they are free from EMI and RFI problems and immune to dust, vibration, and shock.

The solid-state relay (SSR) has not totally supplanted the older electromechanical relay and probably never will. But many design engineers are finding that optically coupled MOSFET SSRs provide the leading-edge technology needed to handle the demands of the telecommunications world and meet UL, CSA, VDE, and FCC requirements.

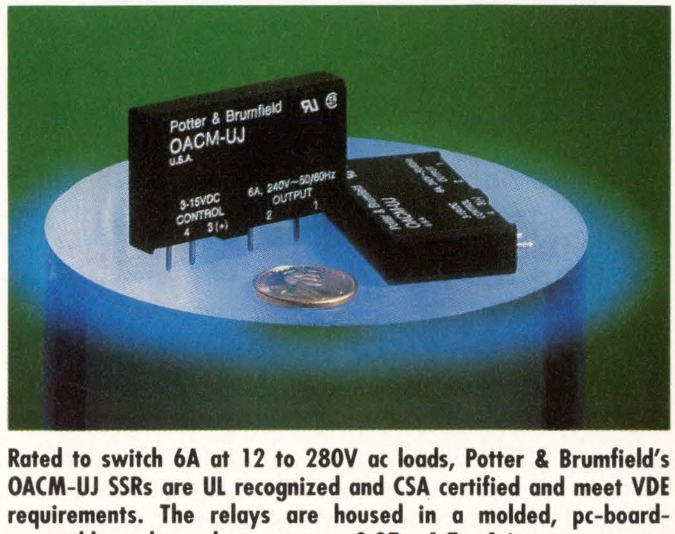
SSRs can switch both resistive and inductive loads at voltage levels ranging from millivolts to hundreds of volts. The devices suit modem switching, central-office equipment, communications equipment, data-access arrangements, and industrial control applications.

In the telecommunications area, the trend is toward SSRs with very low on-resistance, low drive current, and surface-mount packaging. In industrial control, SSRs are achieving higher surge-current ratings, zero-crossing detection, and higher blocking voltages. As the number of SSR sources increases and size and prices decrease, the devices should find their way into more industries.

SSRs have an impressive list of advantages compared with electromechanical relays. SSRs have lives as long as tens of millions of operations and outlive electromechanical relays by about a hundred thousand operations. The switching speeds of SSRs are measured in microseconds and sometimes nano-seconds. These speeds are 6 to 1000 times faster than electromechanical relays' switching speeds. SSRs require minimal maintenance and are immune to shock, vibration, and environmental problems. Most are logic compatible and are not plagued by EMI or RFI problems. The solid-state relay has no contact bounce, arcing, or chattering problems—in fact, there is no audible noise problem at all. Finally, the SSR is the best choice in applications involving explosion hazards because it doesn't suffer from arcing.

However, the SSR also has some drawbacks. For one, an SSR can cost a good deal more than an electromechanical relay. Military-grade SSRs can cost $100 each. Secondly, the SSR has a nominal voltage drop when the output switch is closed or on—the output switch is not a perfect short circuit. As a result, the SSR can generate heat, which you must take into consideration when laying out your pc boards.

Unlike electromechanical relays, SSRs have leakage current. In the off state, the output of an SSR isn't a true



Rated to switch 6A at 12 to 280V ac loads, Potter & Brumfield's OACM-UJ SSRs are UL recognized and CSA certified and meet VDE requirements. The relays are housed in a molded, pc-board-mountable package that measures 0.37 × 1.7 × 1 in.

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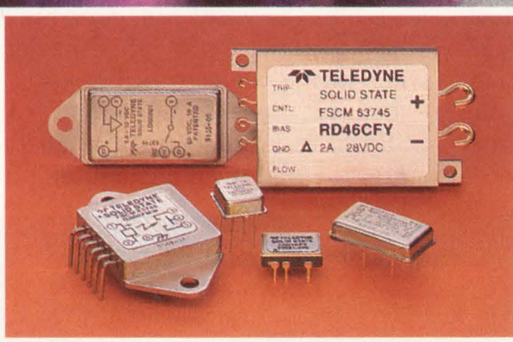

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CIRCLE NO. 42

SOLID-STATE RELAYS

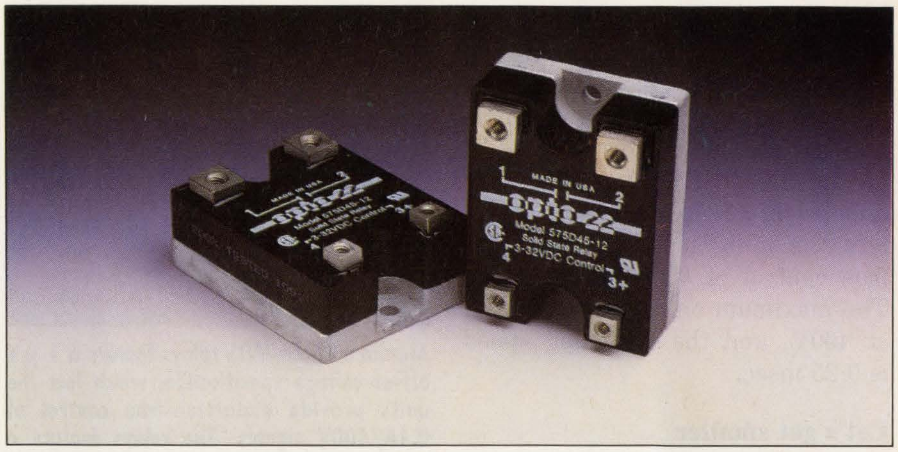
open circuit—there's always some leakage current flowing in the output switch. In high-power SSRs, this leakage current can be significant, reaching tens of milliamps.

Finally, the SSR does not offer the same variety of switching functions typically available in electromechanical relays. For the most part, SSR configurations are restricted to single or dual Form A (spst NO) or Form B (spst NC) configurations.

When you add up the pros and cons, the bottom line usually favors the SSR. **Table 1** illustrates the capabilities of some of today's SSRs. As you can see from the data, you should have little trouble finding a relay to handle your load's requirements. The numbers also highlight the fact that SSR input circuitry is indeed logic compatible. Today's SSRs are reasonably priced and have wide operating ranges.

Small size is also a key feature of today's relays. The smaller DIP housing has become more popular than the standard hockey-puck package. Also, more relays are available in surface-mount packages.

Gordos Inc has followed the miniaturization trend with its GSAC-01 solid-state relays. These units are housed in a SIP (single in-line package) that measures $0.7 \times 1 \times 0.18$ in. The devices offer a 12 to 240V ac output rated at 2A rms at a 25°C ambient temperature. The relays feature zero-voltage turn-on, 3750V ac optical isolation, and 10-mA dc input sensitivity.



To accommodate high-load industrial applications, the 575D45-12 relay from Opto 22 has both a 45A current-handling capability and a 2000V transient-voltage rating. The unit also features 4000V optical input-to-output isolation and a TTL-compatible control-voltage range.

Photo-MOS relays from Aromat are the result of combining photoelectric technology with MOSFET technology. The relays have some of the features of solid-state relays such as long life, high reliability and sensitivity, and quiet operation, but also provide some of the benefits associated with electromechanical relays.

In standard SSRs, the input signal is transferred via an LED to a photocell and then output through a triac or other solid-state device. Standard SSRs are primarily used to control comparatively large power loads—typically in excess of 1A—and they have problems handling signals less than 100 mA because of high leakage-current ratings and distortion problems caused by offset-voltage ratings.

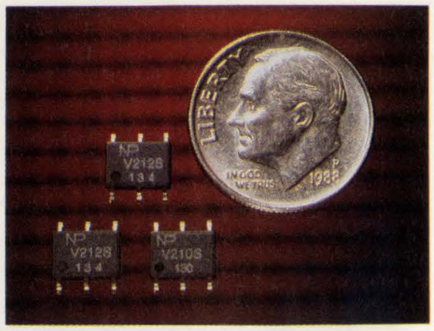
The Photo-MOS relays operate as follows: Current flowing to the input terminals activates an LED. Emissions from the LED pass through a transparent material to a photocell, which converts the light into a voltage. This voltage passes through the MOSFET gate-controlling circuit to the relay output. Standard SSRs require a power supply to drive the output MOSFET. In the case of the Photo-MOS relays, the built-in photoelectronic device makes the supply unnecessary.

Table 1—Representative solid-state relays

Manufacturer	Model	Load current (A)	Load voltage (V)	Control input (V)	Leakage current (mA)	Operating Range (°C)	Price
AT&T Microelectronics	LH1503AB	0.11	350	−5 to +5	0.001	−40 to +85	$4.20 (1000)
Aromat Corp	AQV414SX	0.1	400	1 to 48	0.001	−20 to +80	$4.30
C P Clare Corp	LBA	0.170	350	3 to 15	0.001	−40 to +85	$3.85 (10,000)
Crydom Co	CX240D5	5.0	12 to 280	3 to 15, 15 to 32	0.1	−30 to +80	$5.15 (1000)
Gordos Inc	GSAC-01	2	12 to 240	1 to 15	0.2	−30 to +85	$3.65 (1000)
Grayhill Inc	Mini Pack	25	120, 240	3 to 30	8.0	−40 to +100	$17.10 (100)
Opto 22	575D45-12	45	575	3 to 30	21.0	−40 to +100	$34
Potter & Brumfield	OACM-UJ	6	12 to 280	3 to 15	0.75	−30 to +80	$5.94 (500)
Teledyne Solid State	LD	10	60	0 to 18	2	−55 to +105	$94 (OEM qty)

SOLID-STATE RELAYS

Aromat's solid-state relays suit applications involving high packing densities. The relays measure 4.4×6.3×2 mm and are available in 1 Form A and 1 Form B contact arrangements. They feature a 1-μV offset-voltage specification, which lets the units provide distortion-free control of 0.1A/400V signals. The maximum on-resistance is 50Ω at 400V, and the switching speed is 0.25 msec.



Aromat's Photo-MOS relays feature a 1-μV offset-voltage specification, which lets the units provide distortion-free control of 0.1A/400V signals. The relays feature a maximum on-resistance of 50Ω at 400V, a 1-μA leakage current, and a 0.25-msec switching speed. The housing is 4.4 × 6.3 × 2 mm, and the relays are available in 1 Form A and 1 Form B contact arrangements.

Let's get smaller

The LBA Series devices from C P Clare are one Form A and one Form B relay combined in a miniature 8-pin DIP. This pair of independent relays have enhancement- and depletion-mode MOSFETs as the output elements.

The LBA devices can provide a normally closed and normally open switch combination even if you apply no bias or external power. This capability makes the devices ready replacements for bulkier electromechanical relays. The LBA relays suit a wide range of applications in telecommunications, data acquisition, and instrumentation. The units are compatible with CMOS logic levels, so they eliminate the need for driver-buffer circuit components. The units are available in through-hole and surface-mount housings. They feature a 3750V rms input-output isolation rating and come with UL, BS415, and BS6301 approvals.

The AT&T LH1500 family of high-voltage relays mirrors the trend toward smaller, faster, and more reliable SSRs. The line includes 21 products that cover the most common contact configurations: Form A, Form B, Form A/Form B, Form C (spdt), dual Form A, and dual Form B.

The Series 1500 relays employ a GaAlAs LED for actuation control and an integrated monolithic die for the switch output. The die is fabricated in high-voltage, dielectrically isolated BCDMOS (bipolar complementary double-diffused MOS). The die includes a photodiode array, various switch-control circuitry, and DMOS (double-diffused MOS) switches.

Some of the AT&T relays employ current-limiting circuitry, which enables the units to pass FCC and other regulatory voltage-surge requirements. And with a 3750V rating, the relays also meet or exceed domestic and international standards for input-output isolation. The Form A/B relays have integral make-before-break circuitry, which eliminates the need for additional timing logic and provides a true Form C switching function.

You can configure all units in the line for ac-dc or dc-only operation.

Dissipating heat is key to SSR design

Excessive heat remains the greatest enemy of semiconductors. Power semiconductors are especially at risk. Because transients add to the high power already being dissipated, power devices require additional design considerations. In the case of solid-state switches, the package's ability to distribute and dissipate heat is often the limiting performance factor. To gain insight into this design problem, look at the way C P Clare Corp designs its SSRs.

SSRs from Clare include three major circuits: an input drive circuit, conversion circuitry, and the output circuitry. The drive circuit must provide a reliable means of converting input drive power to infrared light. This light activates the conversion circuitry, which is an integrated array of photovoltaic devices. The conversion circuit generates the voltage needed to control the two output MOSFETs.

The output-drive MOSFETs handle high power, so they generate heat. In addition, the MOSFETs must provide the relay with its overall characteristics—speed, along with current and voltage specifications.

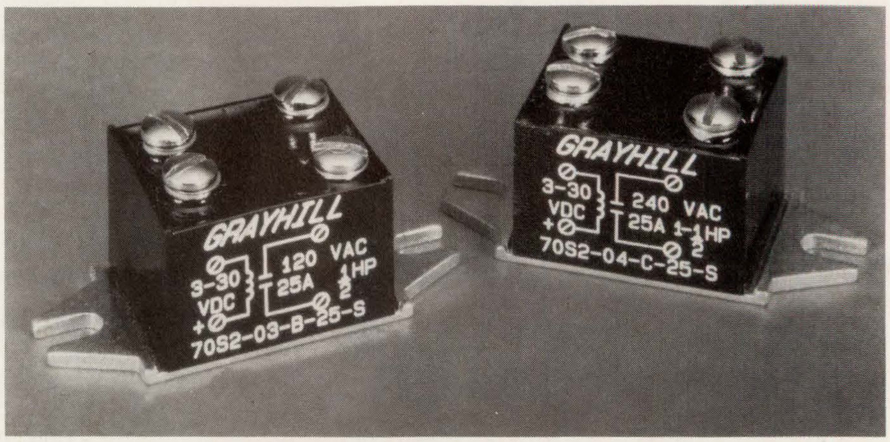
The Clare design employs four chips to achieve these objectives. One chip contains the input-drive circuitry. The second chip converts light to voltage, and the remaining two chips are the output MOSFETs. The first two chips are optically connected with a material that transfers light without transferring heat. Neither of these chips is exposed to the self-heating effect of the output circuitry. Each of the four chips is mounted on an extension of the package lead frame. Each extension serves as an individual heat sink to remove the generated heat.

SOLID-STATE RELAYS

Packaging options include 6-pin DIPs and surface-mount gull-wing housings.

Shrinking innards

Surface-mount-technology assembly let Grayhill Inc rate its Mini Puck SSR at 25A even though the unit is about half as high as a standard hockey-puck package. The size reduction has no effect on the device's operating life or efficiency ratings. In fact, the design lends itself to better thermal management in the power-switching and input-control sections of the relay. The unit has a mounting footprint identical to that of a standard hockey-puck package, so you can interchange the two units with no problems.



Offering a 50% volume savings when compared with standard hockey-puck packages, Grayhill's Mini Puck relays are rated for 25A switching. The relays feature transient protection and a 250A surge-current rating, and can readily switch motor and inductive loads.

The Mini Puck relay's 250A surge-current rating and 0.4 min power-factor circuit design lets it easily switch motor and inductive loads. Output-circuit characteristics include transient protection, a 400 or 600V blocking-voltage rating, and a dV/dt of 3000V/μsec. Low voltage-offset characteristics minimize line-interference problems. The Mini Puck relays are optically isolated and logic compatible and require no additional driver circuitry.

Using surface-mount components lets Potter & Brumfield house its OACM-UJ solid-state relays in a pc-board-mountable module that measures $0.37 \times 1.7 \times 1$ in.—somewhat small for a 6A device. The relays are UL recognized and CSA certified and meet VDE requirements.

The OACM-UJ relays incorporate a dV/dt snubber network across the output. This network protects the relay against false triggering by restricting the rise of most voltage transients within acceptable limits. The relays are available in zero-voltage and random-turn versions. Both versions

For more information . . .

For more information on the solid-state relays 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 read about their products in EDN.

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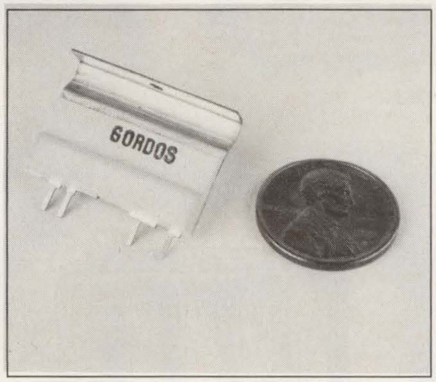
SOLID-STATE RELAYS

feature 4000V rms input-to-output optical isolation.

Teledyne screens its LD SSRs to MIL-R-28750 and packages them in low-profile hermetically sealed cases. The relays feature floating power-FET outputs. This technology lets you connect the load to either output terminal and provides a low on-resistance. The input and output are optically isolated to protect input logic circuits from output transients.



A SIP measuring 0.7 × 1 × 0.18 in. houses the GSAC-01 relay from Gordos Inc. The relay can switch 2A at 12 to 240V ac loads and features zero-voltage turn-on and 3750V ac optical isolation.

LD Series relays are available with options such as short-circuit and current-overload protection, which provides complete protection for both the relay and the system within. In addition to providing protection when a short or overload occurs when the relay is on, the circuitry also provides protection should the relay be switched into a short.

An output status line is another option. The line indicates the status of the output switch and is optically isolated from the load. Status indication is independent of the relay control circuitry. The status line provides a logic low when the relay output is off and load voltage is present, and a logic high when the relay output is on.

Designers of industrial lighting, heating, motor control, or other high-load-bearing systems will find that the 575D45-12 relay from Opto 22 delivers all the transient voltage protection they need. The three models can handle power voltages ranging to 277, 480, and 575V, and all three combine high-current capacity (45A) and high-voltage (2000V) transient protection in a single package.

The extended protection the 575D45-12 relay provides lets designers maintain an adequate margin of operational safety while eliminating the need for additional external protective components. The transient-proof relay can actually help designers lower overall end-product costs.

The relay is TTL compatible. It features 4000V optical input-to-output isolation, zero-voltage turn-on, built-in snubber circuitry, and a rugged encapsulated housing that has a die-cast mounting base. EDN

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CIRCLE NO. 45

On a much larger scale.

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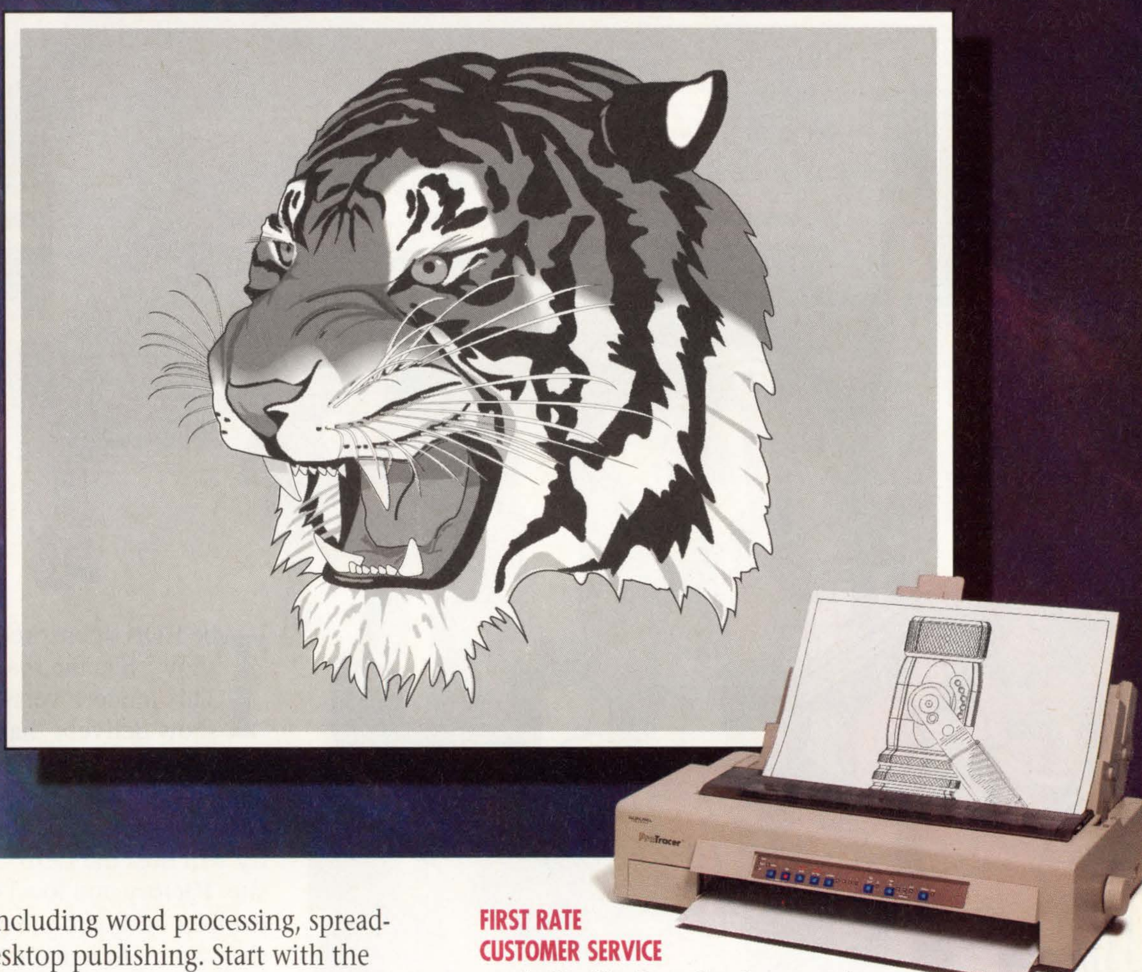

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CIRCLE NO. 157

EDN CARAVAN ELECTRONIC SHOW TOURS

The Electronic Trade Show on Wheels

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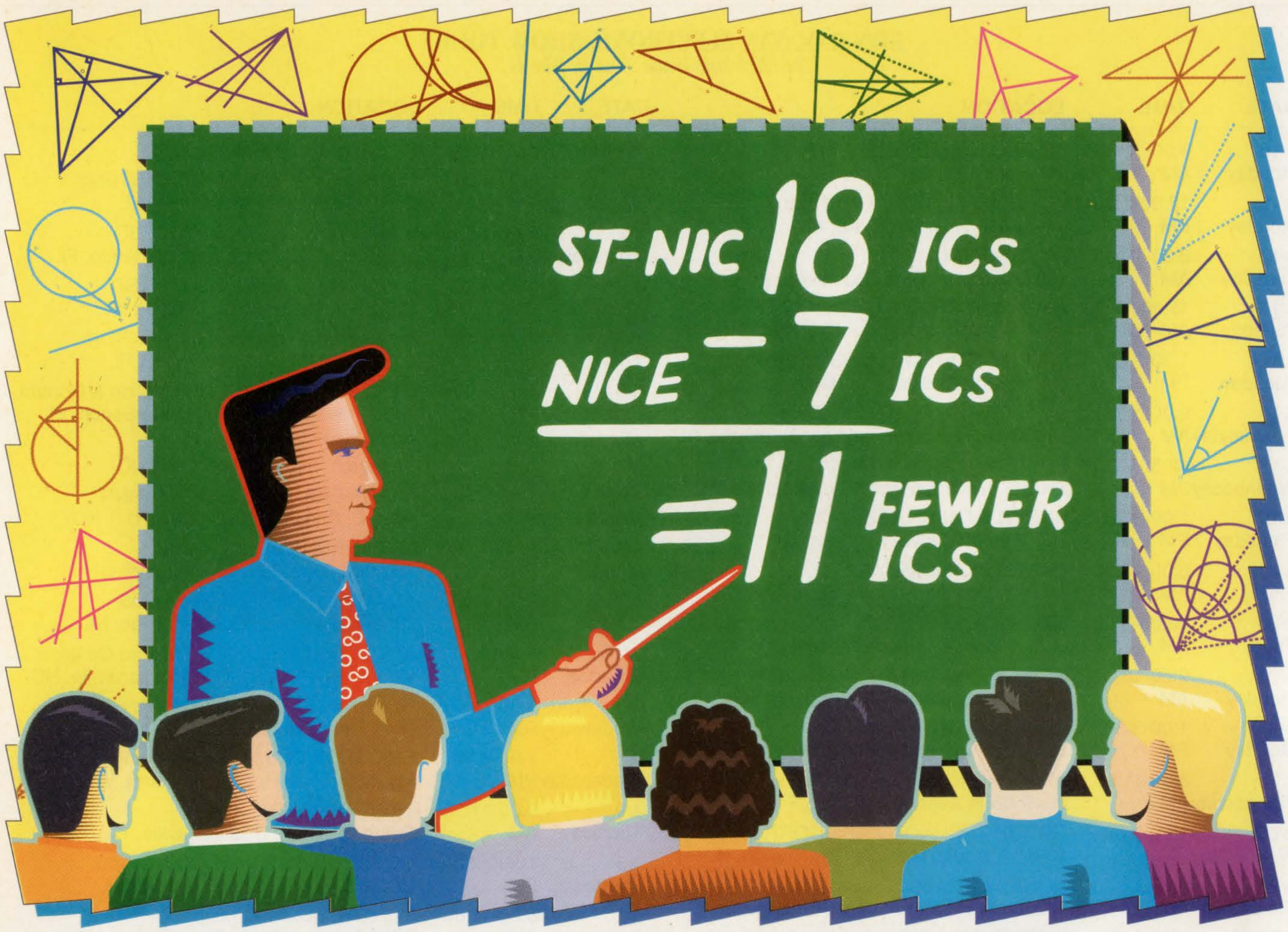
3/16 Monday	9:00-11:00 AM	BOEING HUNTSVILLE 499 Boeing Blvd., Huntsville, AL
3/16 Monday	12:30-2:30 PM	INTERGRAPH CORPORATION Intergraph Way, Huntsville, AL
3/17 Tuesday	8:30-10:00 AM	ACUSTAR INC. 100 Electronics Blvd., Huntsville, AL
3/17 Tuesday	11:00-12:30 AM-PM	AVEX ELECTRONICS 4807 Bradford Drive, Huntsville, AL
3/17 Tuesday	1:30-3:30 PM	TELEDYNE BROWN ENGINEERING 5021 Bradford Blvd., Huntsville, AL
3/18 Wednesday	9:00-11:00 AM	SCI TECHNOLOGY (Plant 3 & 13) 13000 So. Memorial Parkway, Huntsville, AL
3/18 Wednesday	12:30-2:30 PM	SCI TECHNOLOGY (Plant 1) 8600 S. Memorial Parkway, Huntsville, AL
3/19 Thursday	1:00-3:00 PM	BNR/NORTHERN TELECOM 705 Westech Drive, Norcross, GA
3/20 Friday	9:00-10:00 AM	OKI TELECOM GROUP 437 Old Peachtree Road, Suwanee, GA
3/20 Friday	12:30-2:00 PM	RELIANCE ELECTRIC Collins Industrial Blvd., Athens, GA
3/23 Monday	9:00-10:30 AM	NCR CORPORATION 7240 Moorefield Highway, Liberty, SC
3/23 Monday	1:00-3:30 PM	NCR CORPORATION 3325 W. Platt Springs Rd., W. Columbia, SC
3/25 Wednesday	8:30-11:00 AM	AT&T PARADYNE CORPORATION 8545 126th Avenue N., Largo, FL
3/25 Wednesday	1:00-3:00 PM	GROUP TECHNOLOGIES CORP. 10901 Malcolm McKinley Dr., Tampa, FL
3/26 Thursday	9:30-12:00 AM	HONEYWELL, INC., Avionics 13350 US Highway 19 So., Clearwater, FL
3/26 Thursday	1:00-3:00 PM	SMITHS INDUSTRIES, Aero. & Defense 14180 Roosevelt Blvd., Clearwater, FL
3/27 Friday	8:30-11:00 AM	E-SYSTEMS, INC., ECI Div. 1501 72nd Street N., St. Petersburg, FL
3/27 Friday	1:00-2:30 PM	LORAL DATA SYSTEMS 6000 Fruitville Road, Sarasota, FL
3/30 Monday	9:00-11:00 AM	RACAL-DATACOM, INC. 1601 N. Harrison Parkway, Sunrise, FL
3/30 Monday	12:30-3:00 PM	MOTOROLA INC. 8000 W. Sunrise Blvd., Plantation, FL
3/31 Tuesday	8:30-10:30 AM	BENDIX/KING, Air Transport Avionics 2100 N.W. 62nd Street, Fort Lauderdale, FL
3/31 Tuesday	12:30-3:00 PM	IBM CORPORATION 1000 N.W. 51st Street, Boca Raton, FL
4/1 Wednesday	8:30-10:00 AM	ROCKWELL INTL', Collins Aviation 600 John Rodes Blvd., Melbourne, FL
4/1 Wednesday	11:00-1:00 AM-PM	HARRIS CORPORATION, ESD Palm Bay Road, Palm Bay, FL
4/1 Wednesday	2:30-4:00 PM	GRUMMAN MELBOURNE SYSTEMS 2000 NASA Blvd., Melbourne, FL
4/2 Thursday	9:00-12:00 AM	MARTIN MARIETTA CORP., ESD 12506 Lake Underhill Road, Orlando, FL
4/2 Thursday	1:30-3:30 PM	MARTIN MARIETTA CORP., MSD 5600 Sand Lake Road, Orlando, FL
4/3 Friday	9:00-11:00 AM	SIEMENS STROMBERG-CARLSON 400 Rinehart Road, Lake Mary, FL
4/3 Friday	1:00-3:00 PM	GENERAL ELECTRIC, Simulation & Control 1800 Volusia Avenue, Daytona Beach, FL
4/6 Monday	9:00-11:30 AM	IBM CORPORATION Research Triangle Park, RTP, NC
4/6 Monday	12:30-2:00 PM	NORTHERN TELECOM, INC./BNR 4001 E. Chapel Nelson Hwy., RTP, NC
4/6 Monday	2:45-4:15 PM	NORTHERN TELECOM, INC. 400 Perimeter Park Dr., Morrisville, NC
4/7 Tuesday	9:00-11:00 AM	ALCATEL NETWORK SYSTEMS 2912 Wake Forest Road, Raleigh, NC
4/7 Tuesday	1:30-4:00 PM	AT&T TECHNOLOGIES, Guilford Center Mount Hope Church Rd., McLeansville, NC
4/8 Wednesday	9:00-11:00 AM	GENERAL ELECTRIC COMPANY 1501 Roanoke Blvd., Salem, VA
4/8 Wednesday	1:30-3:30 PM	ERICSSON/GE Mobile Communications Mountain View Road, Lynchburg, VA
4/9 Thursday	9:00-11:00 AM	SPERRY MARINE, INC. Route 29 North, Charlottesville, VA
4/9 Thursday	12:30-2:30 PM	GE FANUC AUTOMATION NA, INC. US 29 & Rt 606, Charlottesville, VA
4/10 Friday	8:30-11:00 AM	E-SYSTEMS, INC., Melpar Div. 7700 Arlington Blvd., Falls Church, VA
4/10 Friday	12:30-2:30 PM	E-SYSTEMS, INC., Melpar Div. 11225 Waples Mill Road, Fairfax, VA
4/13 Monday	9:00-10:30 AM	PULSECOM INC. 2900 Towerview Road, Herndon, VA
4/13 Monday	1:30-3:30 PM	LITTON SYSTEMS, Amecom Div. 5115 Calvert Road, College Park, MD
4/14 Tuesday	9:00-10:30 AM	FAIRCHILD COMM. & ELECTRONICS 20301 Century Blvd., Germantown, MD
4/14 Tuesday	11:30-2:00 AM-PM	HUGHES NETWORK SYSTEMS, INC. 11717 Exploration Lane, Germantown, MD
4/15 Wednesday	9:00-12:00 AM	WESTINGHOUSE CORPORATION (BWI) Route 170, Linthicum, MD
4/16 Thursday	9:00-11:00 AM	ALLIED SIGNAL AEROSPACE 1300 E. Joppa Road, Baltimore, MD
4/16 Thursday	12:30-2:30 PM	AAI CORPORATION 110 Industry Lane, Cockysville, MD

CIRCLE NO. 157



NICE and simple math exposes the myth of ST-NIC.

VISIT BOOTH #940 AT SUNWORLD EXPO

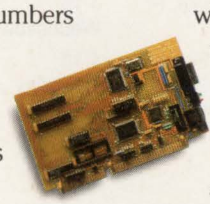
It doesn't take a mathematical wizard to see the superiority of the NICE® Ethernet solution from the Advanced Products Division of Fujitsu Microelectronics. We think the numbers speak for themselves.

Our NICE solution, for example, requires far fewer ICs than ST-NIC's™ so-called single-chip solution—7 vs. 18.* And that means fewer passive components as well. Making Ethernet LAN board design easier. Faster. And more cost effective than ever before.

Then, add on another factor—that NICE products are competitively priced—and systems designers clearly have a proven formula.

What's more, the fewer the parts, the smaller the size—and the lower the power consumption. All of paramount importance for motherboard applications.

Plus, because NICE is a highly automated controller, it offers substantially greater system performance for user applications—by freeing CPU and memory bandwidth. Fact is, benchmarks and customers report up to 33% higher performance over competitors' controllers. Quite an edifying statistic, don't you think?



And, unlike other available solutions, NICE has been designed to *fully* comply with Ethernet standards—ensuring international interoperability. And that's no myth.

For more enlightening facts, here's one more NICE number: **1-800-866-8608.** Or call your local sales office for our NICE Designer Kits. And discover the world's most advanced, highly-integrated, cost-effective Ethernet solution—the NICE family of high-performance products from Fujitsu. Because all it takes to expose a little myth is a little math.

FUJITSU

Delivering the Creative Advantage.

FUJITSU MICROELECTRONICS, INC., Advanced Products Division. 77 Rio Robles, San Jose, CA 95134-1807. Ph: 408-456-1161 Fax: 408-943-9293. FUJITSU MICROELECTRONICS ASIA PTE LTD. (Head Office, Singapore): Ph: 65-336-1600 Fax: 65-336-1609. HONG KONG SALES OFC: Ph: 852-723-0393 Fax: 852-721-6555. TAIPEI SALES OFC: Ph: 886-2-757-6548 Fax: 886-2-757-6571. JAPAN SALES OFC: Ph: 81-3-3216-3211 Fax: 81-3-3216-9771. KML CORP. (Rep., Korea): Ph: 82-2-588-2011 Fax: 82-2-588-2017. PACIFIC MICROELECTRONICS, PTY. LTD., (Rep., Australia): Ph: 61-2-481-0065 Fax: 61-2-484-4460. FUJITSU MIKROELEKTRONIK GmbH (Dreieich-Buchschlag, Germany): Ph: 06103-6900 Fax: 06103-690122. NICE is a registered trademark of Fujitsu Microelectronics, Inc. ST-NIC is a trademark of National Semiconductor Corporation. *Reference NSC app note DP839EB-ATT, 1/91.

CIRCLE NO. 52

4-Mbit DRAM integrates SRAM cache for 10-nsec cache-hit access

The greatest drawback to cache-memory subsystems is their miss penalty—that is, the time required to fill the cache with new data from main memory. The M5M44409TP cached dynamic RAM (CDRAM) reduces that penalty to a single 70-nsec access by integrating a 4k × 4-bit static-RAM (SRAM) cache with a 1M × 4-bit dynamic RAM (DRAM).

The SRAM has an access and cycle time of 10 nsec. The DRAM array has a 70-nsec access with a 140-nsec cycle time. The two memory blocks connect internally through a 64-bit bus, allowing the cache to receive a block of 16 lines with a single DRAM access. The device, therefore, can return data in 10 nsec during a cache hit and 70 nsec during a cache miss.

The internal data path has two 64-bit data-transfer buffers that let an external controller device use a fast copy-back operation to maintain coherency between the two memory blocks. When a cache miss occurs, the CDRAM transfers the cached block being replaced into one data buffer while the new data from the DRAM moves into the second buffer, then into the cache.

If the data in the first buffer is "dirty," meaning it was altered while in the cache, the external controller can then have the CDRAM copy the new data back into the DRAM array. Because the CDRAM has separate address buses for the two memory blocks, this copy-back operation can occur concurrently with subsequent cache accesses, hiding most of the DRAM's cycle times. In the worst case of back-to-back cache misses, the cycle time would be 280 nsec.

The CDRAM is a synchronous device with several modes of operation. It uses registered input lines, but, by programming various command registers, you can select transparent, latched, or registered output operation at the device's full 100-MHz clock speed. You can also select a transparent-output, low-power mode that lets you use an intermittent clock to control the device.

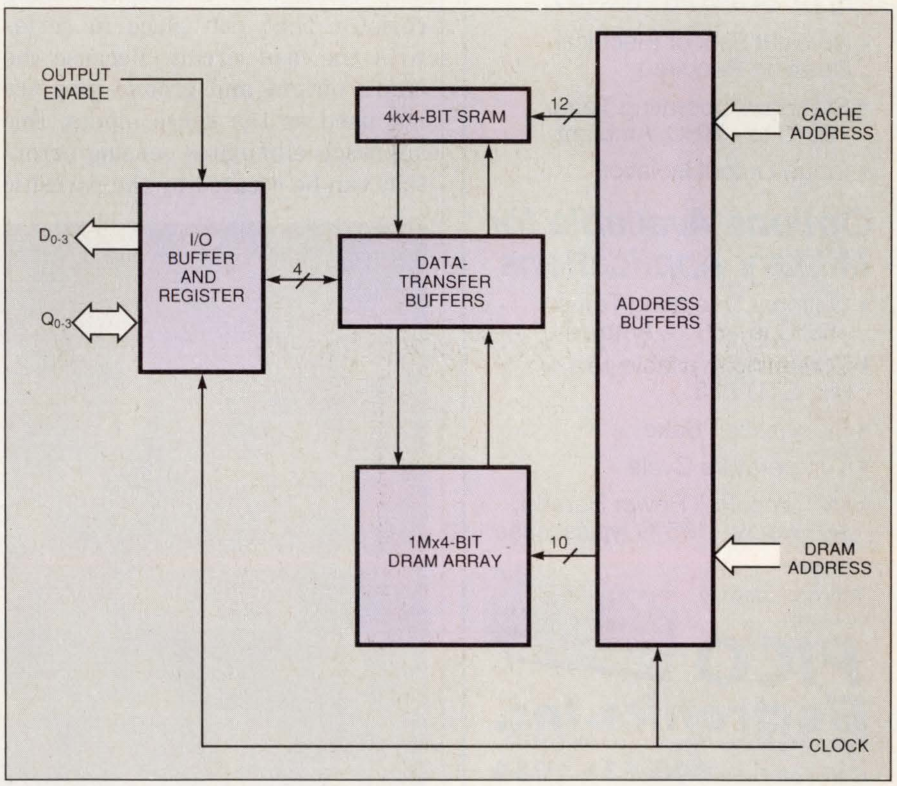
Write operations to the device can also take on several forms. The data input and output lines are separate, allowing you to begin a write cycle while the read data is still available. Alternatively, you can use the separate data lines to perform a masked write to the device.

The CDRAM comes in a 44-pin TSOP (thin small-outline package) with an 0.8-mm lead pitch. Samples will be available in the second quarter; production is scheduled for the third quarter. Three speed grades are available with cache access times of 10, 15, or 20 nsec. Initial pricing is $16.20, $15.50, and $15, respectively (100).

—Richard A Quinnell

Mistubishi Electronics America Inc, 1050 E Arques Ave, Sunnyvale, CA 94088. Phone (408) 730-5900. FAX (408) 720-0429.

Circle No. 731



Combining the SRAM cache on chip with a DRAM array allows the M5M44409TP CDRAM to transfer a 16-line block to cache within 70 nsec.

Op amp delivers 100V and 30A at 100V/μsec

High-power electromechanical and audio applications can literally get a boost from the PA05 power op amp. The 250W device operates with power-supply voltages to 100V and can source or sink as much as 30A. Further, the amp has a 100V/μsec slew rate and exhibits less than 0.02% THD operating at 200W over a 30-Hz to 30-kHz frequency range. The device has a 360-kHz power bandwidth and at dc the amp exhibits an open-loop gain of at least 94 dB. The device costs $189 (100).

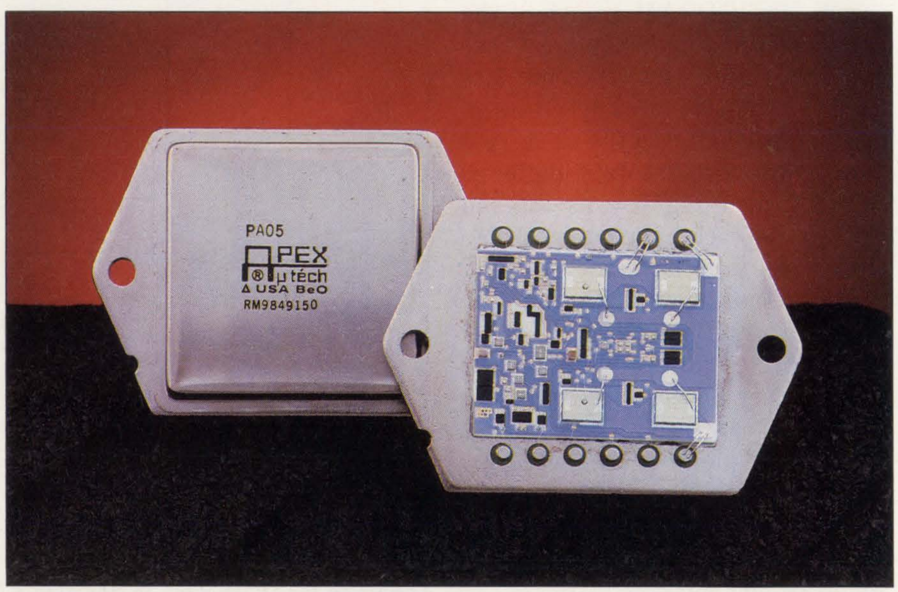
Several features let this amplifier safely operate at high power levels. Because the amp is designed for very high power applications, it offers a 4-wire current-sensing technique to limit the output current. Two current-sensing pins on the amp connect to a current-sensing resistor that you place in series with the load circuit. Because the amp's output and ground pins are not used as the sense inputs, this approach eliminates sensing errors that can be created by the parasitic series resistances of sockets and solder joints at high-output power levels.

The amp also provides a voltage-boost feature that lets you run the lower-powered input stages from a higher power supply voltage. An additional 5V of supply voltage for the input stage lets the amp's output swing closer to the output stage's supply rails, to the saturation point of the output transistors. You can also run the amp from one set of supply voltages by busing the input- and output-stage power pins together.

Thermal-limiting circuitry in the amp shuts down the output stage when junction temperatures exceed 175°C. In addition, you can use an external signal to disable the op amp's output stage by shunting the device's shutdown pin to ground.

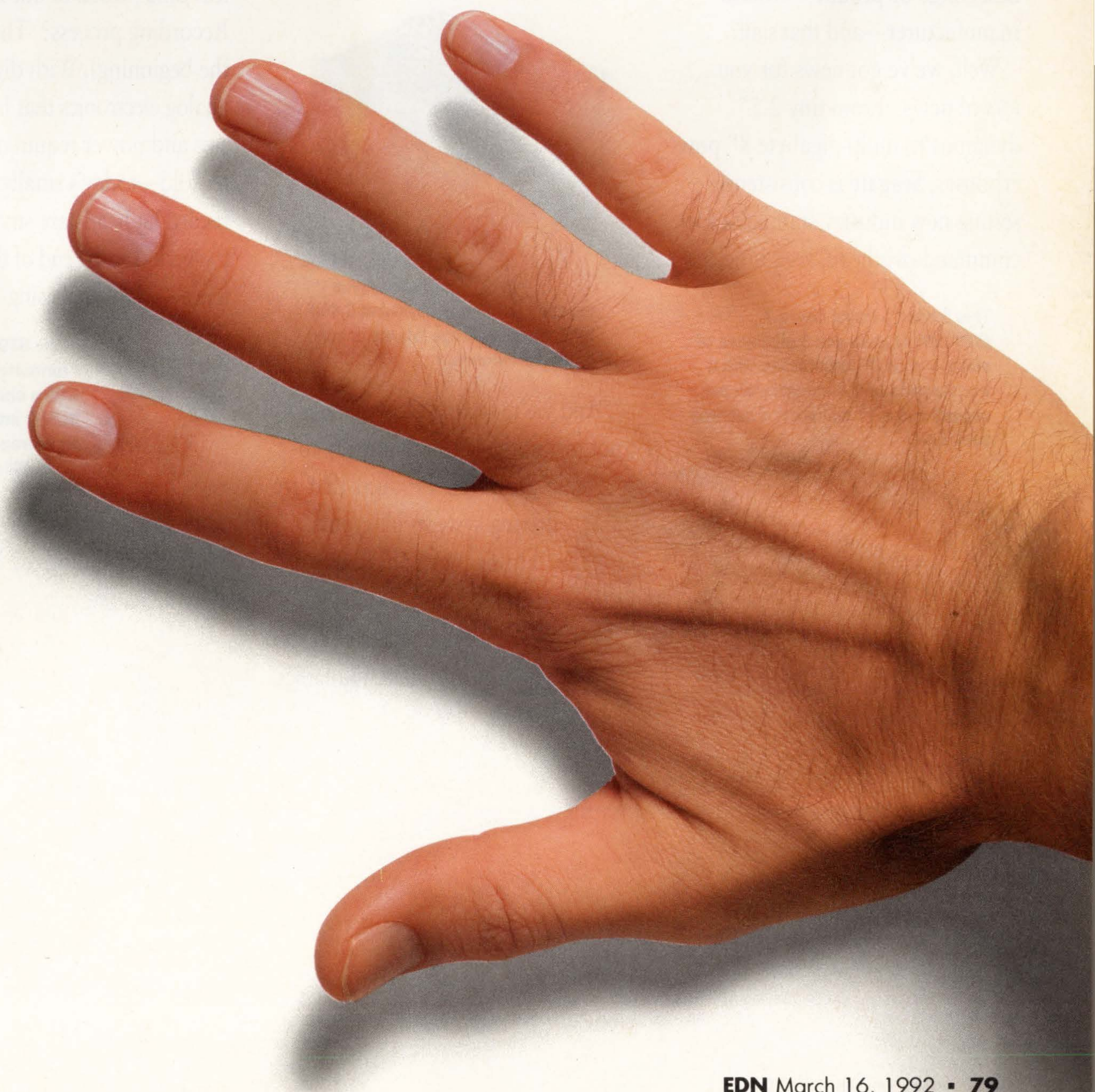
—**Steven H Leibson**

Apex Microtechnology Corp, 5980 N Shannon Rd, Tucson, AZ 85741. Phone (602) 742-8600. FAX (602) 888-3329. TLX 170631. **Circle No. 730**



Special high-power features such as 4-pin current sensing and thermal shutdown let this op amp source or sink 30A output currents with 100V swings.

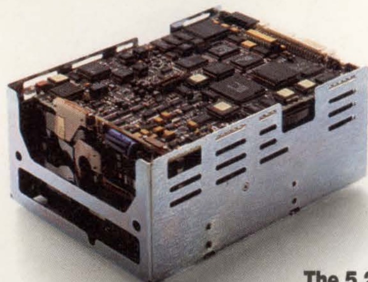
Quick—which company is the disc drive performance leader?



Surprised?

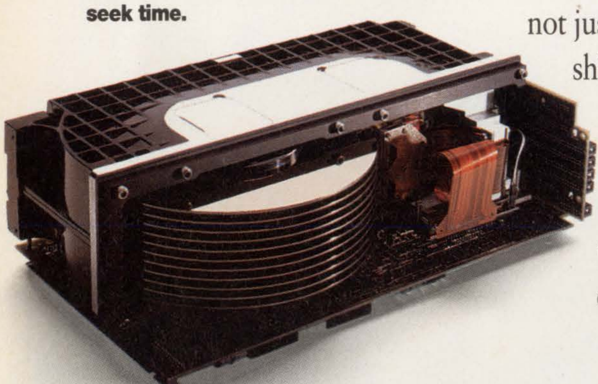
Used to thinking of Seagate as an easy-availability, great-reliability, best-range-of-products-around manufacturer—and that's all?

Well, we've got news for you ... *lots* of news. From tiny 2.5" dynamos to multi-gigabyte 8" powerhouses, Seagate is consistently setting new industry standards for command overhead, seek time, rotational latency and data transfer rate. In other words, for performance.



The 5.25" Elite 1 offers gigabyte-plus capacity (1352 megabytes) at 5,400 RPM, for an average latency of only 5.56 milliseconds.

This 2 head parallel Sabre-7 (ST83050K) gives you 3 gigabytes of storage in an 8" form factor, with a transfer rate of 9.34 megabytes per second and a 12 millisecond average seek time.



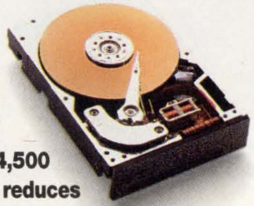
And we're setting those standards, not just in the lab, but in ready-to-ship products. Products that are driving systems like yours.

How? With physical advances adapted from the frontiers of magnetics, dynamics and fluid mechanics.

With recording advances that put more data into less space in less time (heard of our Zone Bit Recording process? That's only the beginning). With digital and analog electronics that have shrunk size and power requirements tenfold—today's smallest thin film recording heads are smaller than the period at the end of this sentence—while increasing intelligence.

At 2.5", the ST9144 offers 127 formatted megabytes with a choice of AT and SCSI-2 interfaces and an average seek time of only 16 milliseconds.

And with a company-wide commitment to expanding the limits of disc drive technology.

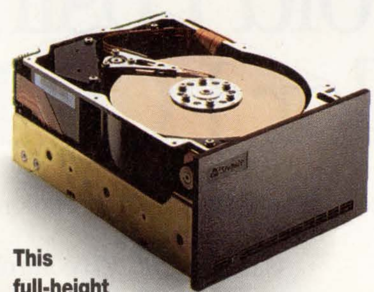


The ST3283 family of 1"- high, 3.5" drives holds more than 245 formatted megabytes, with a 4,500 RPM spindle which reduces latency to 6.67 milliseconds.

We keep on pushing for new levels of performance because, quite frankly, you need them. Your boss, your customers and your competitive environment are demanding faster, less expensive processing than ever before. And when you take a few milliseconds' performance advantage and multiply it by thousands of transactions a day… well, the results translate into some figures that might surprise you.

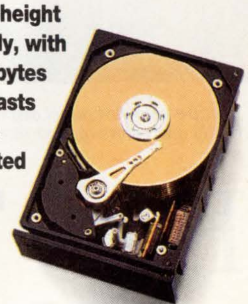
The digital servo on the ST3600 family of low-profile 3.5" drives reduces average seek time to 10.5 milliseconds, with capacities up to 525 formatted megabytes.

In fact, depending on the amount and nature of processing you do, high-performance drives like these can save you enough to pay back your disc drive investment within



This full-height 5.25" Wren-9 (ST42100ND) offers up to 2.2 gigabytes of storage and a synchronous data transfer rate of up to 20 megabytes per second.

weeks—or days. For help in selecting the drive you need, or for more information about any Seagate drive, call Seagate at 408-438-6550 or contact your authorized Seagate distributor.

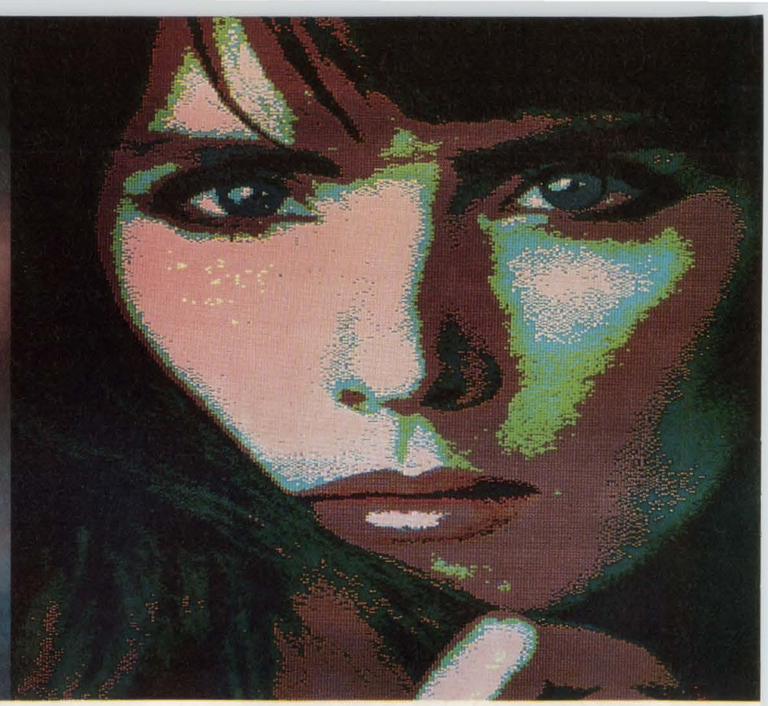


The 3.5", half-height ST11200 family, with up to 1.2 gigabytes of storage, boasts a 256 kilobyte multi-segmented cache buffer and an average seek time of 10.5 milliseconds.

And then, when you find yourself choosing a Seagate for your next high-performance system . . . well, don't be surprised.

Seagate

Picture your flat panel display using Cirrus Logic controller chips. They actually add colors to your display capabilities for more realistic shading.



The same panel looks flat without our enhanced VGA capabilities. And it will lose face faster without our optimized power management system.

How To Avoid Losing Face On Your Color LCD Display.

Face it. The first thing everybody notices about your newest laptop is the display quality. Is it bright? Are the images clear and well modeled? Are the colors vivid?

With Cirrus Logic LCD VGA controllers, your answer is yes. Which is why we're the leading supplier of display controller chips in the laptop and notebook market.

For life-like 3-dimensional imaging, Cirrus Logic color LCD controllers offer technology leadership for your color products. With direct support for the latest active-matrix color LCD panels. Our controller chips do more than support your panel's color capabilities — they enhance it with full VGA color support and a fuller color palette. To give you color so good it competes with CRT quality.

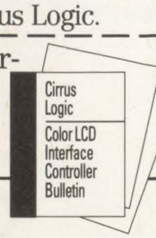
Our monochrome solutions give you displays that *PC Magazine* called "the stars of our VGA color-mapping tests"* with up to 64 shades of gray. And with a lower dot clock rate, your power consumption is lower than other solutions for longer battery operation.

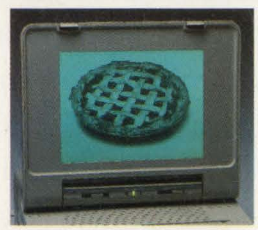
Cirrus Logic LCD controllers are fully compatible with the popular PC video standards and will work with LCD, plasma, or electroluminescent displays.

Simplify your design job. A higher level of integration gives you all this in the smallest form factor available. We also supply software and hardware design notes and full design support. You get the results you want quickly and easily.

Design a more competitive product. One that looks better — and makes you look better. That lasts longer on a battery. Use the display solutions from a proven technology leader in laptop and motherboard VGA: LCD controller chips from Cirrus Logic.

Get the picture. Get more information on LCD controllers.
Call 1-800-952-6300, ask for dept. LL24





Cirrus Logic monochrome LCD controllers will also make everything from realistic scanned images to business charts look tastier.

CIRRUS LOGIC

C L O S I N G T H E G A P

Enhanced 8051 delivers secure operation and protects software

Dallas Semiconductor's DS5002FP µC (microcontroller) offers security for a range of applications such as electronic-fund transfer, ATMs (automatic teller machines), secure pay services (cable TV), point-of-sale applications, and electronic locks.

The DS5002FP incorporates the 8-bit 8051 microcontroller (µC) with modifications for secure operation. The architecture supports the public data-encryption-standard (DES) algorithm, holding a 64-bit encryption key in secure memory. Using the 64-bit key, the µC encrypts both memory contents and addressing. Thus, an application can use external RAM or ROM and remain protected from exposing system operation to bus monitoring.

The system's other security features include random key generation, a vector RAM area that hides reset and interrupt vectors from tampering, a security lock, and a built-in self-destruct that wipes out memory and internal keys if tampering occurs. In addition, the chip die is protected with a metallic-die layer that prevents microprobing.

DS5002FP

Clock	12 MHz
Instruction cycle	12 clocks
Memory	128-byte scratchpad, 48-byte vector RAM, bootstrap ROM, 64-kbyte instruction address space 64-kbyte data address space
Timers	two 8 bit, one watchdog
I/Os	4 ports: 32 pins
Interrupts	1 external
Special features	power monitor, address/data bus encryptor with 40-bit encryption key
Package	80-pin quad flatpack
Price	\$18.80 (1000)

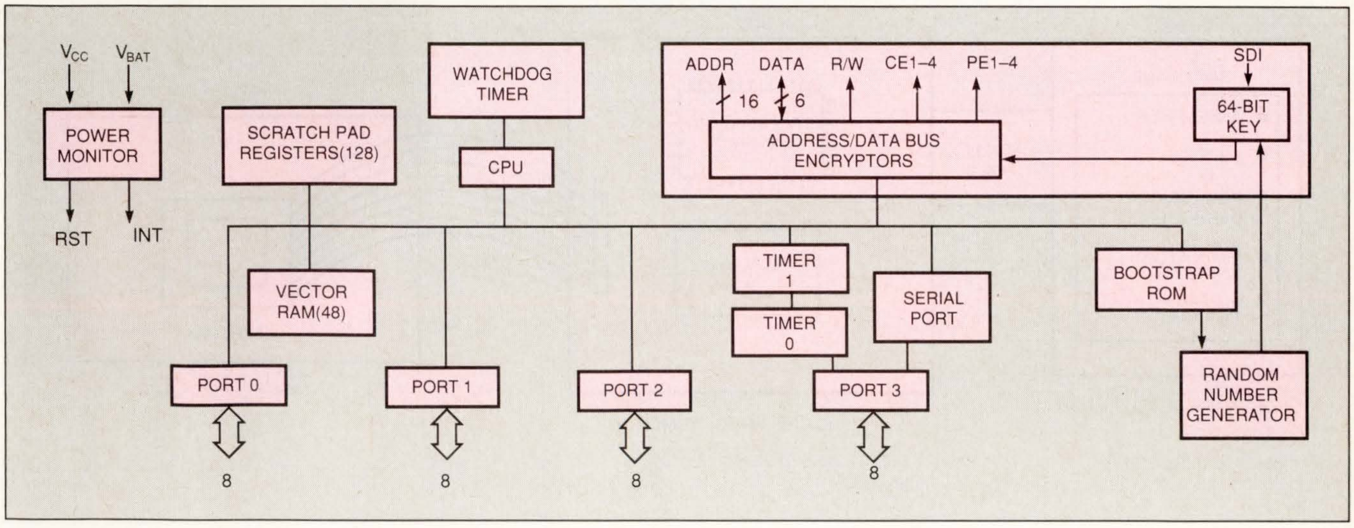
To ensure an orderly shutdown, power-monitoring features provide an early warning of power failure. The chip also includes a watchdog timer to detect runaway code or operation timeouts.

A key feature of the DS5002FP is a form of limited memory and address encryption—not full DES encryption, however, which reduces memory-operation speed. Bus activity is scrambled using nonsequential addresses with scrambled data. The running processor makes dummy fetches to confuse bus monitoring; it pretends to fetch program code from a random address, but the code isn't used. As a result, a code pirate can't trace application execution by using a bus analyzer or dumping an EPROM.

The DS5002FP is a second-generation encryption chip; this version has extended the internal address encryption key from 40 to 64 bits. Also, this chip's memory addressing has been opened to 128 kbytes of data and instruction memory.

The chip also comes in a single in-line memory module (SIMM) called the DS2252(T) Secure Microstik. The module integrates the DS5002FP with as much as 128 kbytes of SRAM, a lithium battery cell, and an optional real-time clock. The SIMM provides nonvolatile system memory with easy reprogrammability. Battery life is more than 10 years.—**Ray Weiss**

Dallas Semiconductor Corp, 4401 S Beltwood Pkwy, Dallas, TX 75244. Phone (214) 450-0400. FAX (214) 450-0470. **Circle No. 732**



Security demands more than an EPROM; this chip combines an 8051 with program and data encryption. It uses a random 64-bit key to encrypt data. Program addresses are encrypted and randomized, preventing bus analysis.

Kit simulates 8-bit processor and links to target-board I/O

Simulation has never done well in the 8-bit microcontroller (μC) world. One reason for this failure is the chasm between the simulated processor and board and system hardware. Motorola's 68HC05K Designer's Kit includes an in-circuit simulator that accommodates low-end 8-bit μCs. With the kit, users can simulate code running in a host PC. At the same time, the code can read and write I/O pins on the target board's μC socket.

The kit includes a circuit board or pod, a cable, and PC-based application development software. The software tools are integrated in a windowed development environment with a common debugger interface. They include a circuit simulator, a source-code debugger, an editor, an assembler, and a communications program to drive a ROM monitor-based μC. The pod plugs directly into the host PC's parallel port and has a programmer to burn in 68HC05K code.

Also in the kit are the tools needed to build and debug a 68HC05K application. You can write the code with the editor, assemble it, simulate the code to catch the early bugs, and then run the code in a target under host control.

The in-circuit simulator represents a unique approach to simulation-based debugging. It overcomes limitations of software-only simulation by allowing simulated code to interface to the target-board hardware. Users benefit from a controlled simulation environment because they can update their code without having to burn in new chips or download code. At the same time, users don't have to build software models of the surrounding hardware: They can interface directly to it.

There is, however, a price to pay for simulation: code execution and debugging takes place at simulation, not processor rates. The simulated clock rate of a 20-MHz 386 host CPU is roughly 59 kHz; it is 118 kHz for a 33-MHz 486.

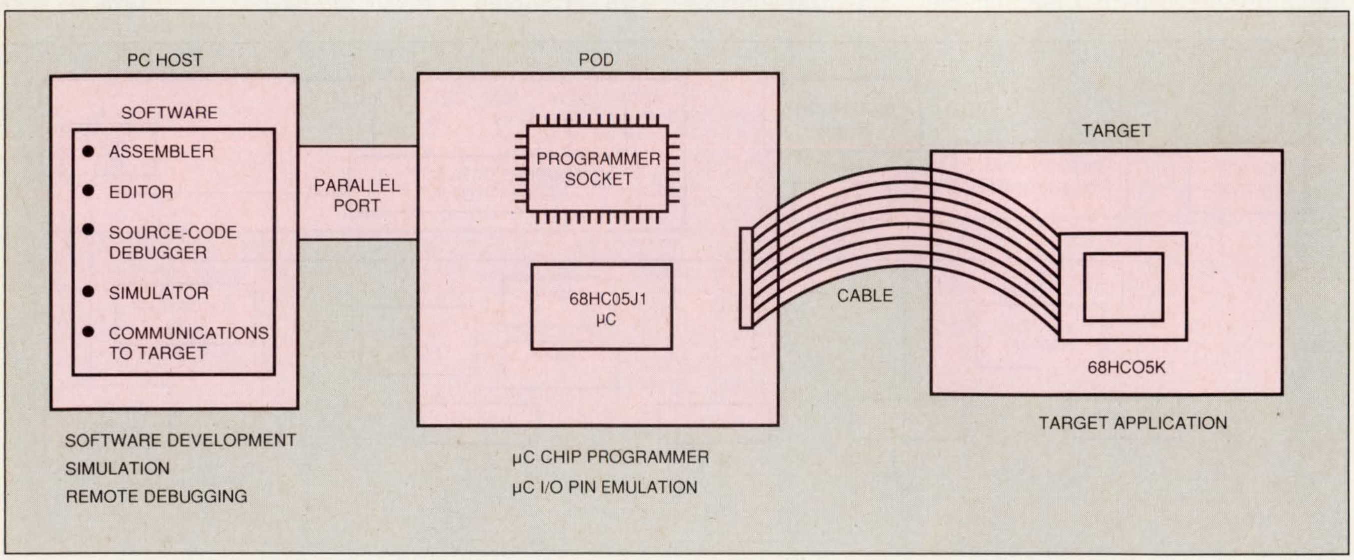
Application code executes in the in-circuit simulator on the PC host, which simulates 68HC05K CPU execution. The simulated application code links directly to the target board via the PC's pod at the parallel port. This pod has its own μC, a 68HC05J1, which interfaces to a 25-pin cable and header that, in turn, plugs into the target board's 68HC05K socket. The software also runs without a target board.

The simulated code generates application program outputs and passes them through the parallel port to the pod processor. The 20-bit packets carry data between the pod and simulator via a serial duplex channel. The pod's μC decodes the packets, setting the appropriate output pins. For inputs, the pod processor monitors target-μC socket-input pins. Changes are picked up, placed in a packet, and shipped to the simulator for processing. Approximately 400 bytes of code are needed in the pod μC to monitor and drive the target-board I/O pins.

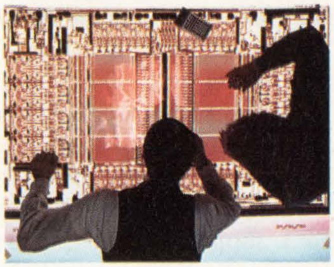
P&E Microcomputer Systems Inc (Woburn, MA) designed the Developer's Kit for Motorola. It will be available in April from Motorola distributors for approximately $50.

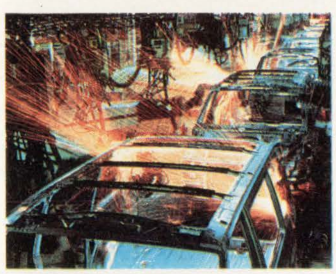
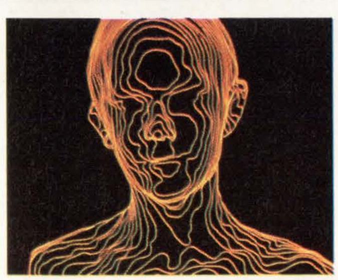
—**Ray Weiss**

Motorola Microprocessor Products Group, 6501 William Cannon Dr, W Austin, TX 78735. Phone (512) 440-2000. **Circle No. 733**



This developer's kit contains the tools for 68HC05K code development and debugging. A hardware pod on the PC's parallel port handles chip programming and emulates the target's I/O pins for in-circuit simulation.


Pipelined DSP combines 16-bit data with 32-bit instructions

Sixteen-bit DSP processors are a source of cheap, embedded MIPS. DSP CPUs support high throughput, math-intensive processing via built-in mechanisms for table walking, and multiply/accumulate operations. NEC's 16-bit DSP, the µPD77016 SPX, runs at an internal 33 MHz, delivering 30-nsec pipelined execution for high-throughput processing. SPX, according to NEC engineers, does a complex 1024×1024 FFT in 2.1 msec.

This DSP processor has a relatively high clock rate and a comparatively clean design. However, it has the disadvantage of new processors: no software base, including a C compiler.

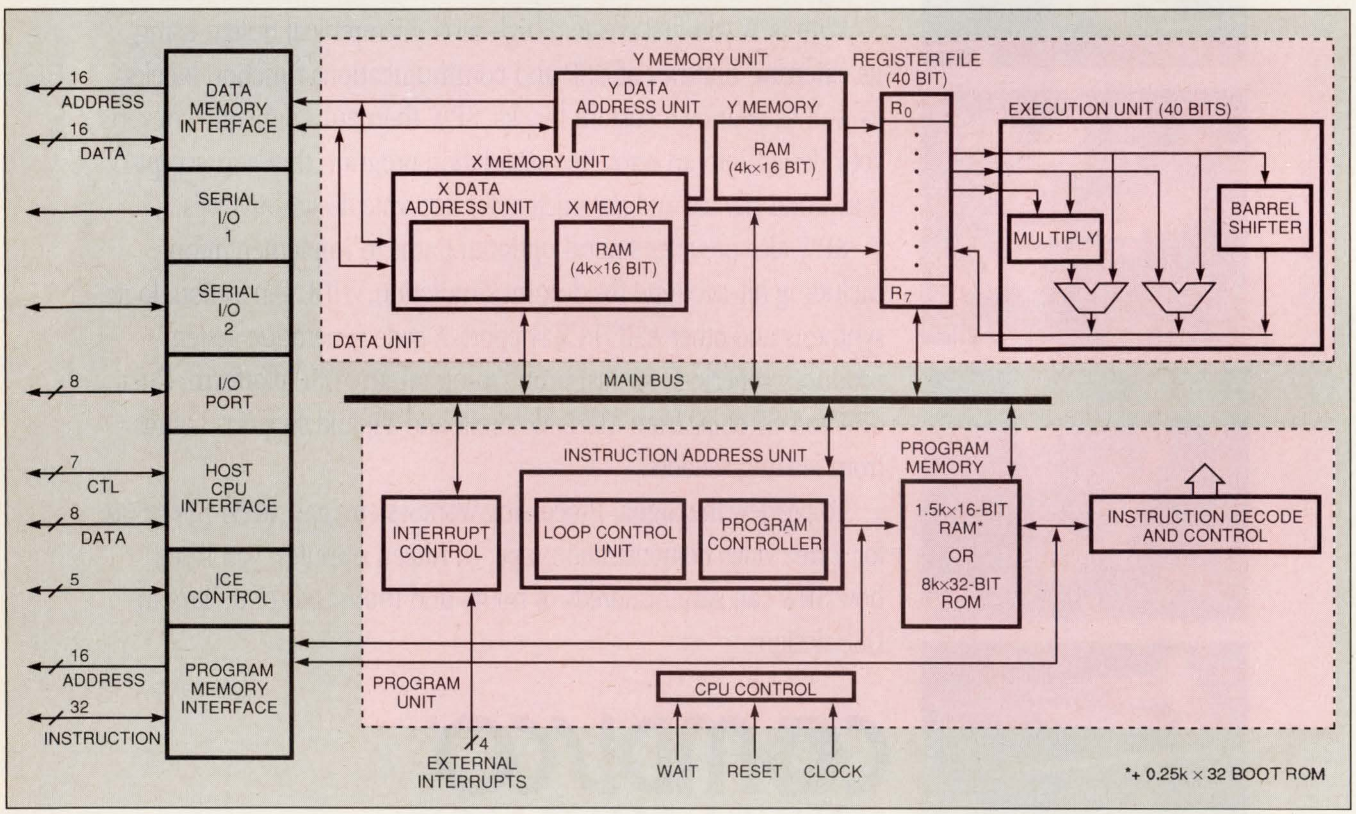
Like most DSP processors, the SPX has a true Harvard architecture, separating data and instruction memory. It combines 16-bit data paths for mid- to low-end DSP processing with 32-bit instructions for fast processing (fixed instruction length, three operand operations). Memory interfaces include one for instructions and one for data. The SPX supports two 64k-word data spaces (X, Y memories) and a 64k-word (double word) instruction space.

This DSP features a set of eight general-purpose registers, improving earlier accumulator-based designs. The processor supports 40-bit operands internally. The adder, multiplier, registers, shifter, and internal data paths are all 40 bits wide. These 40 bits comprise lower and higher 16-bit words and an extended byte. The DSP chip supports 16-, 32-, and 40-bit extended data types. For the 40-bit word, the sign

µPD77016 SPX

Clock	20, 33 MHz internal (2× external)
Instruction cycle	50, 35 nsec (pipelined)
Address space	64k×32-bit program 128k×16-bit data
On-chip memory	ROM and RAM versions 8k×32-bit ROM (instruction) or 1.5k×32-bit RAM (plus a 0.25k×32-bit boot ROM) two 2k×16-bit data RAM (X, Y) two 2k×16-bit data ROM (X, Y)
Arithmetic	40-bit ALU, barrel shifter, multiply/divide (MAC) units
Serial	2 serial ports to 16 Mbytes/sec
Miscellaneous	8 I/O pins, host CPU interface, JTAG support, including ICE functions
Package	120-pin RAM or 160-pin ROM quad flatpack
Price	$45 (100); sample qty in July (RAM version)

Comments. Two versions: a RAM version with off-chip memory access, and a ROM version with no off-chip access (end of 1992). Will also be available as an ASIC core.



This 16-bit DSP, the SPX, supports complex processing and has a 32-bit instruction with as many as three operands. The chip's architecture contains dual addressing engines, loops, and a 40-bit multiply/accumulate unit.

bit is fixed between bits 30 and 31.

Instructions are pipelined, with three major stages: Instruction Fetch, Decode, and Execute. Running from internal memories, instruction execution appears to be one internal clock cycle—30 nsec at 33 MHz—and instruction latency is three cycles or 90 nsec.

The DSP chip's execution unit has three functional units: a 40-bit multiply/accumulator, a 40-bit adder, and a 40-bit barrel shifter. In addition, the chip has two local memory units, X and Y. These units each include a 4k-word data memory with an address-calculation unit. Both X and Y memories can be accessed concurrently, with the results written into the chip's register bank for use in the next cycle.

You can define as many as three operations for each instruction. For example, you can set two registers and use the resultant values to set a third register in a multiply/accumulate (MAC) operation. This enables you to pick up two values from different tables and use them to build a running total in the next MAC cycle.

Unlike general purpose CPUs, the SPX has special registers set aside for addressing the X and Y memories. The chip has four sets of 16-bit data and index registers for the X and Y addressing units. Addressing mechanisms include bit reversal on address and a module counter for circular buffering addressing. The two X and Y memory address calculations can be done concurrently for fast DSP operations.

Like many DSP chips, the SPX incorporates a built-in loop controller, handling as many as four concurrent loops. Each loop spans to 255 instructions, repeating as many as 32,767 times. The SPX loop controller has a stack that is four elements deep; each stack element has three loop registers: a loop start address, end address, and counter. In addition, the processor supports an internal program counter stack—16 items deep—for fast task switching.

To ease coding, the assembly language has a C-like structure and syntax. A repeat instruction enables you to repeat a single complex instruction. A loop instruction takes advantage of the built-in loop control.

The SPX functions as a stand-alone processor or a coprocessor. NEC has extended its host CPU interface from earlier SPX 16-bit DSPs. The SPX has a duplex host interface with a defined handshake protocol. The chip has eight I/O lines that serve as a byte interface to the host or general use. The SPX also features built-in DMA support.

The SPX chips come in two speed grades, running with 20- and 33-MHz internal clocks. The first SPX version is RAM based. A ROM-based version will appear by the end of the year; NEC is also developing a 3V ROM version.

—**Ray Weiss**

NEC Electronics Inc, 401 Ellis St, Mountain View, CA 94039. Phone (415) 960-6000. FAX (800) 729-9288. **Circle No. 734**

50-MHz DSP chip draws 10 μA in power-down mode

Sixteen-bit, fixed-point DSP processors offer a high performance-to-price ratio for math-intensive, embedded applications. The TI TMS320C28's $16 (10,000) price tag, however, complements a 100-nsec instruction-cycle time and 8 kbytes of on-chip program memory.

The TMS320C28 low-power DSP processor has an internal power-down mode with a backup for the 534 bytes of internal RAM. In power-down mode, supply current drops to 10 μa typical, compared with 50 mA for the TMS320C25.

Power-down mode adds three pins to the processor's I/O: a non-maskable interrupt pin ($\overline{\text{PDI}}$) to initiate the power-down sequence; a power-down interrupt acknowledge ($\overline{\text{PDACK}}$); and a power-down reset ($\overline{\text{WAKEUP}}$). A memory-mapped register, PDC, is added for power control at address 0006_{HEX}. In addition, two interrupt vector entries are added for the $\overline{\text{PDI}}$ and $\overline{\text{WAKEUP}}$ interrupts.

The TMS320C25/28 second-generation DSP processor has a specialized architecture with distinct data- and program-processing areas. The data portion has a built-in 32-bit multiply/accumulate (MAC) unit fed from an internal data bus. The processor has two data RAM blocks (288 × 16 bits and 256 × 16 bits) and a set of eight auxiliary data registers to supplement the 32-bit accumulator. The data segment handles a multiply/accumulate in a single cycle.

TI is upgrading other members of its TMS320 family DSP processors. Among the new chips is the TMS320LC16, a 3.3V version of the TMS320C16 DSP controller. Chip

TMS320C28

Clock	10-MHz internal (external/2)
Instruction cycle	100 nsec
Address space	64-kbyte (instruction/data)
Memory	8k × 16-bit ROM (instruction) 256 × 16-bit RAM (instruction or data) 288 × 16-bit RAM (data)
Arithmetic	32-bit ALU, accumulator, multiply/divide (MAC) units
Serial	one
Miscellaneous	Power-down mode, triggered by external signal, external wakeup; power-down current = 10 μA; programmable wait states
Package types	68-pin PLCC without power down, 80-pin quad flatpack with power-down pins
Price	$16 (10,000)

supply voltage can range from 3.0 to 3.6V, with 3.3V typical. The external-clock rate ranges from 4.0 to 16.1 MHz. The TMS320C16 has 256 words of on-chip RAM, 8k words of program ROM (64k words off-chip address space), and a 114-nsec instruction-cycle time. The chip costs $7.60 (10,000).

The TMS320C53 is an upgrade to the TMS320C5x series of 16-bit, fixed-point DSPs with 35- and 50-nsec instruction-cycle times. The TMS320C53 expands on-chip program ROM to 16k words (32 kbytes), from 8k words for the TMS320C51. The TMS320C53 has 4k words of on-chip RAM, organized as 1056 words of dual-access RAM and 3072 words of single-access RAM. The single-access RAM can be configured as program or data. The chip costs $54 (10,000).—**Ray Weiss**

Texas Instruments Inc, Application-Specific Products Div, Box 1443, Houston, TX 77001. Phone (713) 274-2340. **Circle No. 735**

8051 derivative kicks clock rate to 22 MHz

Microcontroller (μC) applications such as 1.8-in. hard-disk controllers, tape controllers, and PCMCIA (PC Memory Card Interface Association)-based modems can benefit from the 83C154, a 16-kbyte version of the 8051, crammed into a 1.1-mm-high thin quad flatpack (TQFP).

The TQFP's height, including lead space, is 1.1 mm ±0.2 mm. In contrast, a standard plastic leaded chip carrier's (PLCC) height is 4.35 mm, and a quad flatpack's height is 1.5 mm ±0.25 mm. The TQFP provides an extremely low profile, suiting height-critical applications. Lead pitch is 0.8 mm with 0.35-mm leads. For example, TQFP chips enable board circuits to meet the stringent PCMCIA standards for plug-in memory and peripheral cards for PCs.

83C154

Clock	12, 16, 22 MHz
Memory	16-kbyte ROM 256-byte scratchpad RAM 64-kbyte instruction address space 64-kbyte data address space
Timers	Three 16-bit timer/counters
Serial	1 serial port (UART)
I/Os	4 ports: 32 pins
Interrupts	2 external
Package types	44-pin plastic quad flatpack or PLCC, 40-pin plastic DIP, 44-pin TQFP
Price	$4.49 to $5.25 (10,000)

The 83C154 is an enhanced version of the 8051 μC family. ROM based, it has 16 kbytes of program ROM and 256 bytes of data RAM. And, similar to the 80951, it supports a dual 64-kbyte address space for program and data memory.

The μC is a static design and has power-management functions with a power-down maximum current of 50 μA. At 12 MHz, the 83C154 is approximately a 1-MIPS processor, with a minimum instruction cycle of 1 μsec.—**Ray Weiss**

Oki Semiconductor, 785 N Mary Ave, Sunnyvale, CA 94086. Phone (408) 720-1900. FAX (408) 720-1918. **Circle No. 736**

ICE includes source-level debugger

ICEs (in-circuit emulators) remain a key tool for engineers designing μP-based systems. Huntsville Microsystems just added a 68040-μP model to its HMI-200 series of emulators. The ICE provides real-time emulation for 68040, 68EC040, and 68LC040 μPs operating at speeds as fast as 25 MHz with zero wait states. Furthermore, the ICE includes the company's Sourcegate high-level-language (HLL) debugger.

The emulator offers four break and trigger points that you can individually configure to respond to address, data, or status bit patterns, or to events monitored by 16 external trigger inputs. You can also set the ICE to trigger based on the occurrence of sequences of trigger events. Two 4k × 104-bit trace buffers store captured data including the 16 external trigger lines.

Two RS-232C 115.2-kbaud interfaces provide communications between the host computer and the ICE. And a parallel port can provide even faster transfers of large binary files. The units come equipped with 256 kbytes of program storage memory, and you can expand the memory array to a capacity of 1, 2, or 4 Mbytes.

The ICE hardware is closely coupled to the Sourcegate HLL debug software. You can buy versions of the product for IBM-compatible PCs, and for Apollo and Sun workstations. The Sourcegate software supports C, Pascal, and Ada compilers from most of the major compiler suppliers.

Sourcegate includes a windowed user interface that lets the operator set ICE parameters such as breakpoints or control single stepping. Code windows display your choice of assembly or HLL. And a mixed mode shows HLL statements and the corresponding assembly code. You can set other windows to monitor specific memory locations or variables including structures, arrays, and stack-relative variables.

The company also offers a performance-analysis feature as an option to the ICE. The analysis capa-

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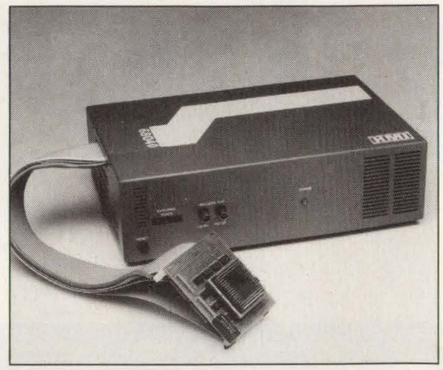
Concurrent Logic, Inc.

CIRCLE NO. 160



Testing a zero-wait-state 25-MHz 68040-based system requires an ICE, such as the HMI-200-68040, with a strong high-level-language debugger and fast hardware.

bility operates transparently to the system under test, and collects data in real time to create a performance profile of software execution. You can set eight code modules to be tested. The analysis software determines the time elapsed in each subroutine within a module, and the total time required for a module to execute. The analysis software can also display histograms of elapsed time for each module relative to the total time the system was under test.

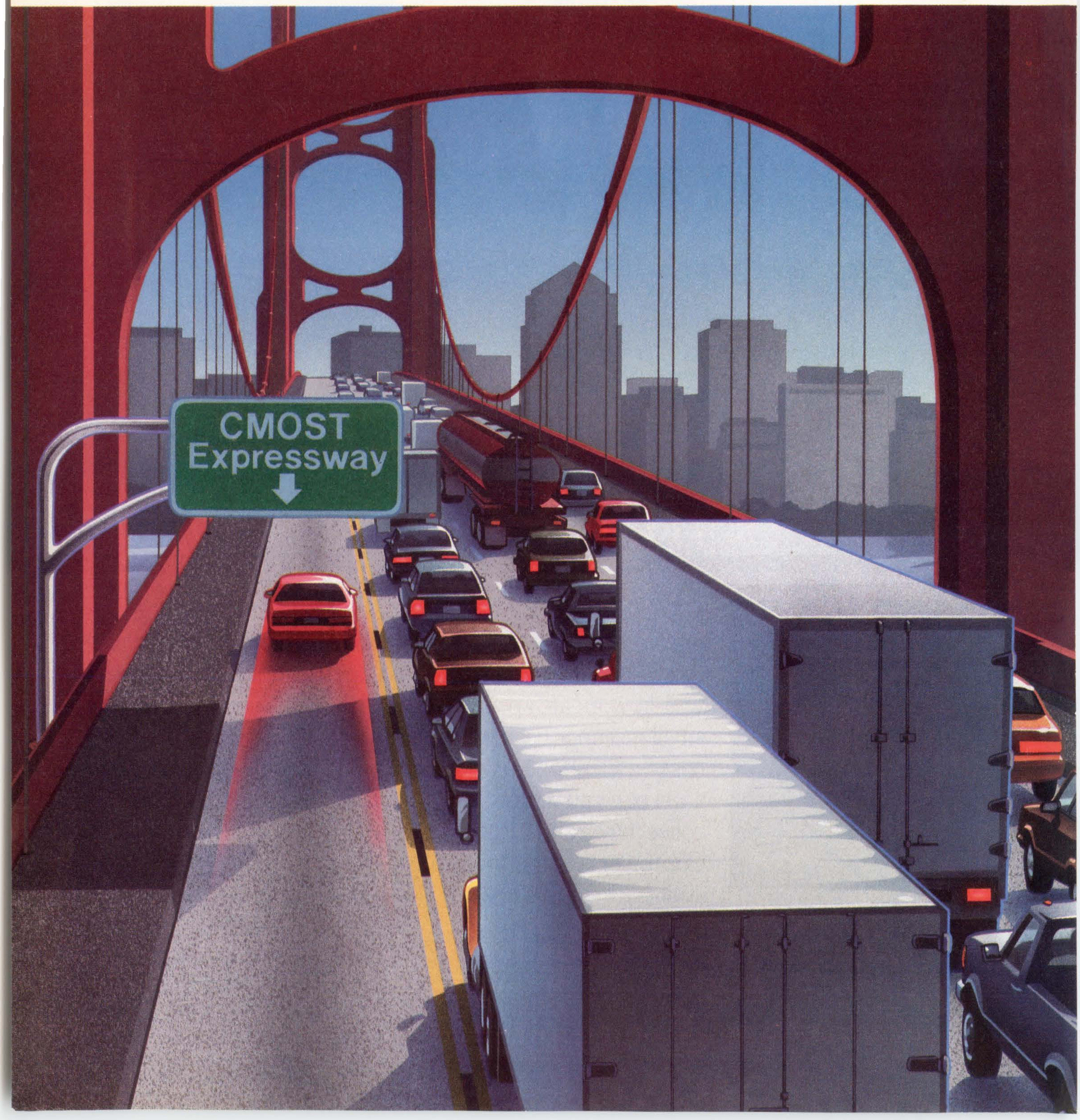
The performance-analysis package also tracks which code the modules execute during a test. And the software can trigger a breakpoint when program execution leaves the bounds defined for the test. Finally, the analysis option adds a 100-nsec-resolution time stamp to data in the trace buffer, and adds four address breakpoints.

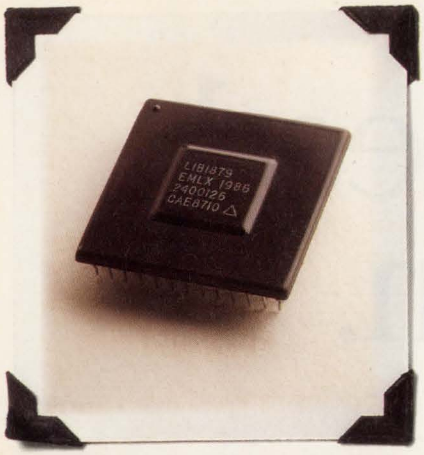
Available now, the ICE costs $25,000 for PCs and $26,000 for workstations. You can expect the company to add support for more variations of the 68040 as Motorola introduces them. The performance-analysis option costs $2500.

—**Maury Wright**

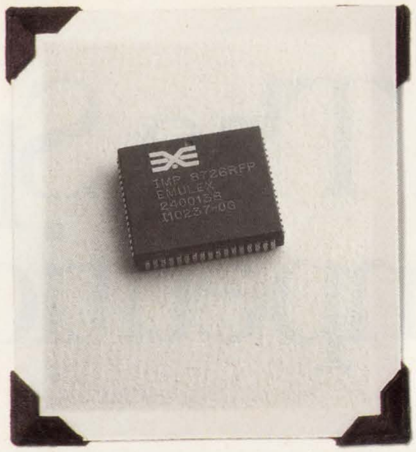
Huntsville Microsystems Inc, 3322 S Memorial Pkwy, Huntsville, AL 35801. Phone (205) 881-6005. FAX (205) 882-6701. **Circle No. 737**

Toshiba SRAMs You Need To Drive Past





1986-MAC100. We introduce a combined disk formatter and buffer controller in a single disk controller chip.

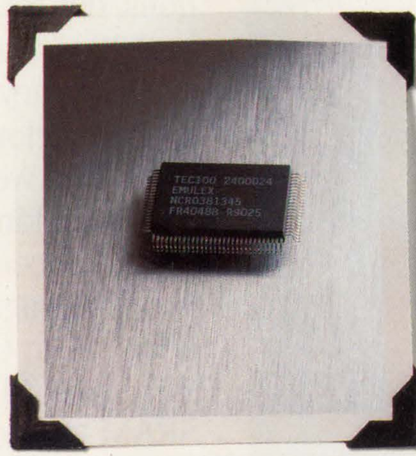


1987-ESP100. The industry's first high-performance SCSI chip is born at Emulex.

1988-ESP200. Second-generation SCSI arrives with SCSI-2 support and parity pass-through.

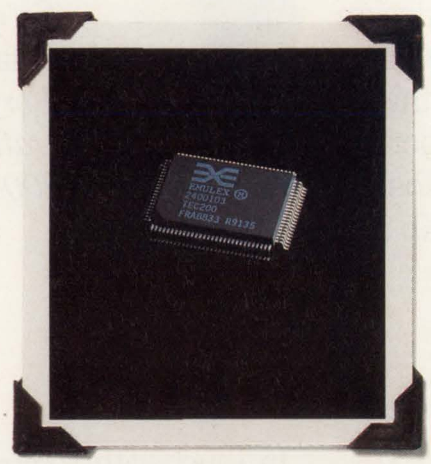
1988-MAC200. Our advanced merged architecture controller is the first to include an automated Data Flow feature for faster data handling.

1989-BC200. A dynamic 4-Port DMA controller for DRAMs is created.



1989-TEC100. EMD combines disk, buffer, and SCSI controllers in a single chip.

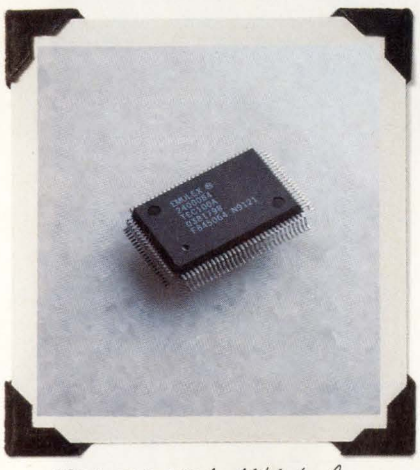
1990-FAS236. We deliver the first Fast SCSI chips with a 16-bit DMA Port.



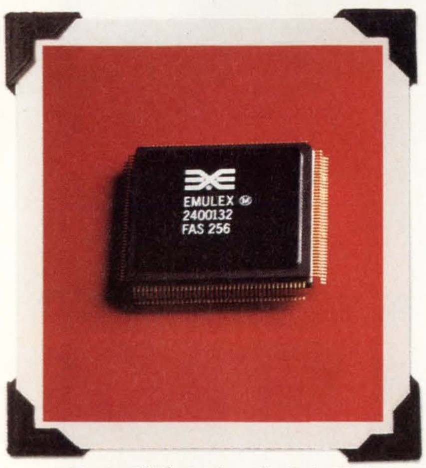
1991-TEC200. Our second-generation TEC becomes the industry's first Fast single-chip disk controller.

1991-TEC256. The first Fast and Wide SCSI disk controller also boasts the fastest disk data rate and highest system bandwidth.

1988-ESP2X6. We give SCSI a 16-bit split-bus architecture for greater efficiency and throughput.



1990-TEC 100A. Mid-to-low capacity SCSI drives get a reduced-price version of the TEC100.



1991-FAS256. 16-Bit Fast and Wide SCSI brings SCSI-2 support to host adapters and peripherals including drive array applications.

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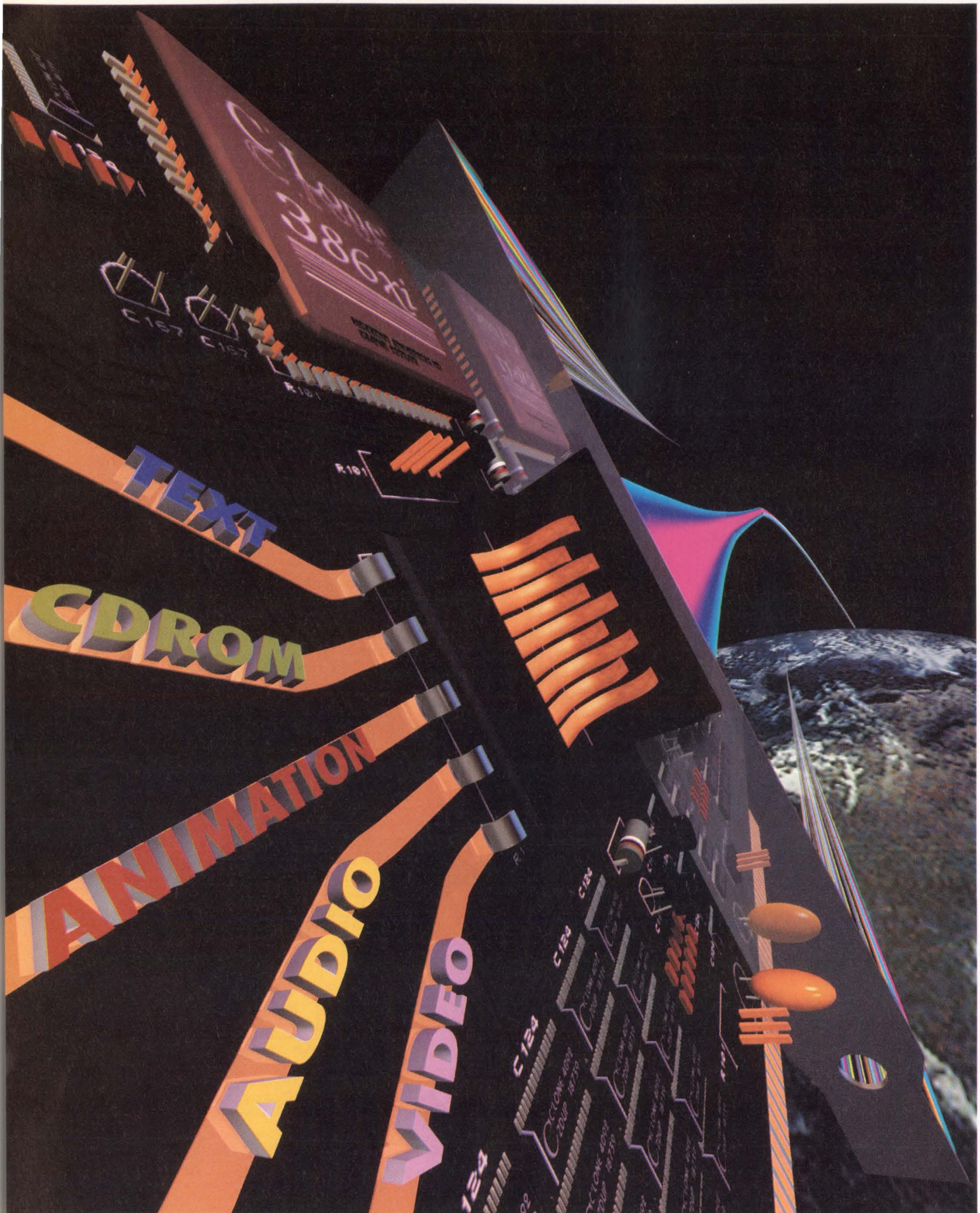
CIRCLE NO. 58



By using state-of-the-art communications peripherals, multimedia lets you circle the globe without leaving your office. (Photo courtesy Multimedia Div of Autodesk Inc)

MULTI MULTI MULTIMEDIA MEDIA MEDIA

Multimedia offers audio and video capabilities that can revolutionize the way you design circuits, discuss concepts, and interact with colleagues. But as usual, the primary issues revolve around compatibility and standardization.

J D Mosley, Technical Editor

Although on the surface multimedia looks like a gimmick to boost sales of computer peripherals in a mature market, it is much more than that. The software components that drive this technology include programs that control hypertext interaction, audio cues and annotations, voice and music synthesis, object animation, and the creation of digital motion video. Available hardware includes CD-ROMs, audio boards, videotape players, videodisk players, and an assortment of computer-controlled musical instruments.

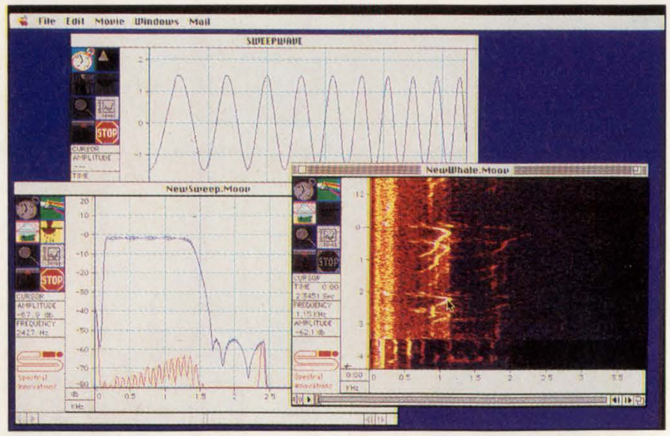
The most serious multimedia devotees will invest in the biggest, fastest CPUs and hard-disk drives they can afford, even though the Multimedia PC (MPC) Marketing Council's specification for a minimum configuration only calls for a 10-MHz 80286-based computer with 2 Mbytes of RAM and a 30-Mbyte hard-disk drive. However, if you are considering incorporating multimedia into an engineering environment, you will need a PC with enough power to run both your existing engineering applications and the additional software necessary to drive the animation and audio functions offered by multimedia peripherals.

One of the most vociferous companies on the multimedia bandwagon is Microsoft, the corporation that has sold more than six million copies of the Windows 3.0 graphical user-interface. Last August, Microsoft released Windows with Multimedia Extensions 1.0, spurring several MPC upgrade kits from some of the companies listed in **Table 1**.

Multimedia Windows includes a media control interface that controls such time-based media as videotape, animation, and audio. Included among the 144 new application programming interfaces (APIs) are such accessories as a sound recorder, a music box, and a media player. As of October 1991, Microsoft announced that the company had delivered 1700 Windows Multimedia Development Kits, which should soon translate into a wealth of applications. (You can obtain a copy of the MPC Titles Catalog from Glenn Ochenreiter or Jim Hassert of the MPC Marketing Council.)

Yet, you can't obtain a copy of Multimedia Windows for your existing PC without also buying hardware from a member of the MPC Marketing Council. And by agreement, the Council has stipulated that MPC upgrade kits include an audio board, a CD-ROM player, and Windows Multimedia 1.0, thus making it impossible to simply upgrade one component. Although that ensures that Multimedia Windows users will have MPC-compatible components attached to their PCs, people may balk at the limited selection currently offered. Therefore, they will simply delay their plunge into multimedia until more vendors join the Council, thus giving them more choices. If so, the Council may actually alienate the early technology adopters who are so critical in driving the demand for new products.

More than a million non-MPC audio boards have been installed in PCs. But since you can't buy an upgrade kit for the board alone, many of the people who are already dabbling in multimedia have dismissed Multimedia Windows in anticipation of Windows 3.1, which



Touted as the first engineering software product to embed multimedia enhancements, Signal Analyzer/QT from Spectral Innovations lets Apple Macintosh users tap the power of System 7.0's Quicktime multimedia extension.

Microsoft promises will have audio support. An object linking and embedding protocol will let developers draw upon the audio services code in Windows 3.1 for integrated audio and voice annotation in their applications. A subset of Windows 3.0 with Multimedia Extensions 1.0, Windows 3.1 is currently in beta test with release scheduled for the end of the first quarter of 1992. However, if you currently use a non-MPC CD-ROM player, you won't be able to circumvent the Council because Windows 3.1 will not have CD-ROM support.

Of course, the one business computer that has always had a way with pictures and sound is the Apple Macintosh. Therefore, many of the standards issues plaguing PC users will not affect Mac users. And engineers who

Table 1—Multimedia workstations and videoconferencing systems

Manufacturer	Product	Communication coverage	Price	Description
Commtex	Multimedia LAN	Novell Netware LAN	From $78,000	Includes one Cx-90 hub unit and 8 sets of demultiplexers, camcorders, headsets, and speakers.
Compression Labs	Rembrandt	Wide-area; multisite	From $31,500	Picture-within-picture option; NTSC-PAL conversion capability.
Compuadd	333MPC	Workstation	$4595	33-MHz 80386 CPU; MPC-compatible.
IBM	PS/2 Ultimedia M57 SLC	Workstation	$5995	20-MHz 80386-based CPU, 4-Mbyte RAM, 80-Mbyte SCSI hard-disk drive, XGA, CD-ROM, musical-instrument digital interface.
Picturetel	System 4000	Wide-area; multisite	From $19,900	Low-priced videoconferencing system uses integrated dynamic echo cancellation technology.
Tandy	4033 LX Multimedia	Workstation	$5499	33-MHz 80386 CPU, 4-Mbyte RAM, 105-Mbyte IDE hard-disk drive, Super VGA, CD-ROM, musical-instrument digital interface.
Videotelecom	Mediamax	Wide-area; multisite	$34,950 to $85,000	Wide-area videoconferencing; based on 80386 or 80486 ISA PC; LAN compatible; graphics.

have relied upon Macs for test and measurement applications from such companies as National Instruments (Austin, TX) and IOtech (Cleveland, OH) will be pleased to know that Apple's latest operating system now comes with a multimedia extension called Quicktime. (See **box**, "How many standards can the market bear?")

Spectral Innovations' Signal Analyzer/QT lets you create video and audio animations with engineering data. You can use this program to create, compress, and play back data sets of time-sequenced information. In a typical application, a researcher who is sampling signals and displaying their frequency components on a color display in real time can compress that data and store it on disk for subsequent playback. Using a mouse, the researcher can shift between the time domain and the frequency domain to view different aspects of the data set by selecting from a variety of display options, including histograms and spectrograms.

Sounds good to me

However, multimedia includes sound as well as video. And although the audio capability of multimedia is one of its most potent tools, most design engineers

How many standards can the market bear?

Comprising 40 software firms and 30 hardware manufacturers, the Multimedia PC (MPC) Marketing Council includes vendors such as AT&T Computer Systems, Compuadd Corp, Creative Labs Inc, Fujitsu, Headland Technology, Media Vision, NEC Technologies, Olivetti, Philips, Tandy, Zenith Data Systems, and (of course) Microsoft. A subsidiary of the Software Publishers Association (Washington, DC), this council endorsed a specification in May 1991 for a standard ISA multimedia-PC platform.

The council estimates that 15 million PCs worldwide are upgradable candidates for meeting the MPC spec. As a minimum configuration, the spec calls for a 10-MHz 80286 CPU, 2 Mbytes of RAM, a 1.44-Mbyte 3½-in. floppy-disk drive, a 30-Mbyte hard-disk drive, a CD-ROM drive, a VGA graphics adapter, an 8-bit audio board, and a musical-instrument digital interface I/O port. This basic configuration was established in an effort to provide a low-cost entry-level machine for home and small business usage. Unfortunately, such a computer realistically lacks the power to be effective in a multimedia environment, and the council is currently reassessing its edict.

Meanwhile, Tandy has launched a line of mulitimedia PCs ranging from the $2799 2500 SX with a 16-MHz 80386SX CPU and a 40-Mbyte hard-disk drive to the $5499 4033 LX that sports a 33-MHz 80386 CPU and a 105-Mbyte hard-disk drive. Each of the five PCs in this family comes with the MS-DOS 5.0 operating system, Windows 3.0 with Multimedia Extensions 1.0, a Tandy CDR-1000 CD-ROM drive, and an 8-bit audio board. You have to pay an extra $400 to $629 for a VGA monitor.

Big Blue eschews convention

IBM, on the other hand, has elected to ignore the MPC bandwagon and has introduced its PS/2 Ultimedia Model M57 SLC. Instead of 8-bit audio, the Ultimedia has enhanced internal speakers and contains a 16-bit audio capture and playback adapter. Its digital-video-interface-compatible CD-ROM/XA has an extended architecture that Multimedia Windows can't even communicate with.

The IBM machine comes with OS/2 2.0 and Multimedia Presentation Manager, although after you boot under OS/2, you can load DOS 5.0 and Multimedia Windows, which IBM is currently shipping with the Ultimedia PCs. The primary reason for this apparent concession to Microsoft and MPC is a lack of software for Multimedia Presentation Manager and a shipping date of March 1992 for OS/2 2.0. The Ultimedia comes with an 80-Mbyte SCSI hard-disk drive and a high-density 2.88-Mbyte 3½-in. floppy-disk drive.

It's Quicktime for Apple

And in the Apple arena, Macintosh users receive a free operating-system upgrade with multimedia extensions for System 7.0, called Quicktime. A Mac user can now drop a Quicktime icon into the screen's System Folder to manipulate animation sequences and audio just like any other type of data. Quicktime specifies a standard way of displaying, compressing, cutting, and pasting multimedia information.

So, once again, users seem to be faced with the dilemma of selecting an off-the-shelf machine that either lacks state-of-the-art performance or lacks the massive amount of software support generated by the sheer volume of MS-DOS machines in existence. Except, this time it seems that IBM is playing the part of the nonconformist renegade, while the ISA-proponents struggle to maintain the status quo. Meanwhile, Apple continues to set its own standards and ignore the DOS world.

Videotelecom's Mediamax is a PC-based video conferencing system. Companies can reduce the expense of business travel by communicating via video conferences, which save not only plane fares and hotel costs, but dramatically increase personal productivity by reducing the time executives spend away from the office.

fail to consider its value beyond background music and sound effects. Computers have always been capable of displaying information in a visual way, but now your PC can become a vocal member of your design team by providing voice annotation capabilities and explanatory dialogue.

You can add audio to your PC by plugging one of many available sound boards into an expansion slot. The two de facto standards that software and hardware vendors have embraced for compatibility purposes are Creative Labs' Soundblaster and Adlib's sound board (also called Adlib). However, if you find that all of your expansion slots are currently occupied, you can still use a product such as ATI Technology's VGA Stereo-F/X. This ISA board not only combines 32,768-color SuperVGA graphics with 8-bit stereo sound and a musical-instrument digital interface, but even includes a Microsoft-compatible mouse port and mouse.

Ed Callway, multimedia engineering manager at ATI agrees that the value of audio in engineering applications is often overlooked. "Adding sound to PCs brings users closer to real-world experiences—audio cues are just as important to people as video cues and tasks that include any kind of matching provide better retention when coupled with sound," Callway says. For example, a common engineering task involves comparing two listings. But instead of glancing continuously between the listings—and running the risk of losing your place—you can compare strings by having the computer read one to you while you keep your eyes on the other.

Callway further observes that digital-audio utilities included with ATI's multimedia boards will let you add voice annotations to your schematics. In fact, he suggests that audio would provide a useful enhancement for a schematic rule-checker, so that instead of generating page upon page of printed warning messages, a verbal message could be associated with a visual flag on the schematic itself. That way, the engineer could continue looking at the screen, listen to the error message, and fix the problem.

Similarly, CD-ROMs can replace service manuals. Beyond the obvious benefits of compact size and the simplicity of issuing revisions, these disks can include a voice narration that talks the technician through the repair process, explains what should be visible, and describes any processes that are occurring. These verbal messages provide insight without popping up a window that could cover much of a PC screen.

Likewise, a sound track can make product prototypes, presentations, and walkthroughs more effective because audio helps to focus your audience's attention. And as Callway observes, a single-slot portable PC coupled with a board such as ATI's VGA Stereo-F/X card provides a completely transportable multimedia presentation system that you can plug into any available VGA or multisync monitor.

The magic of multimedia will also let you tackle those

Table 2—Multimedia authoring software

Manufacturer	Product	Price	Description[1]
Aimtech	Iconauthor	$4995	Graphical interface, flowchart design for branching applications.
Asymetryx	Multimedia Toolbook	$695	Cut and paste simplicity, 250 prescripted objects, plays Animator .FLI files, C-language compatible.
	Toolbook1.5	$395	Same object-oriented features as Multimedia Toolbook, but without MPC-compatibility.
Authorware	Authorware Pro for Windows	$8000	Integrates text, graphics, sound, video, animation; no scripting language-flowchart design.
Autodesk Inc	3D Studio	$2995	3-D animation with modeler, materials editor, renderer, and keyframer.
	Animator Pro	$795	2-D animation with tweening, color cycling, and optical and cel animation.
	AutoCAD for Windows	$495	DDE facility, on-line reference manual.
Brown-Wagh Publishing	Curtain Call	$199.95	Windows-based multimedia authoring program; includes automatic rendering and paint box.
	PC Animate Plus	$199.95	DOS-based 2-D paint and animation program, compatible with Sound Blaster audio board.
Compton's Newmedia	Smartbuild	$7000	Multimedia database-building software; retrieves objects such as pictures, audio, and animation.
	Smartdoc	$1000	Provides Windows 3.0, DOS, and Macintosh user interfaces for Smartbuild databases.
	SmartAPI	$20,000	Set of C callable subroutines for custom development of DOS TSRs; Windows DLL and DDE.
First Byte	Monologue for Windows	$149	Speech synthesizer for Windows text and Excel spreadsheets, customizable dictionary.
Gold Disk Inc	Animation Works Interactive	$495	Vector-based animation, imports .FLI files, audio capabilities, Multimedia Extensions 1.0 recommended.
IBM Corp	Storyboard Live!	$495	Combine audio and video graphics for electronic slide show-style presentations.
Instant Replay Corp	Instant Replay Professional	$595	Authoring program with support for touchscreens, VCR output, frame capture, audio, and hypertext.
Jovian Logic Corp	Audio/Visual Link	$245	Interface program for firm's video and audio boards; JPEG compression; $295 PAL version.
Logos Systems Intl	AV+ Programmer's Toolkit	$300	Subroutine libraries for the firm's Doubletake AV+ audio/video-capture boards.
	Doubletake Runtime	$350	File viewer/player for runtime distribution of multimedia presentations; no special hardware required.
	Verify!	$250	dBASE-compatible program that integrates photo, signature, and voice with ASCII text.
Macromind Inc	Macromind Director	$995	Multiple-award-winning multimedia authoring package for the Macintosh; dual sound channels.
	Action!	$495	Windows 3.0 program with more than 100 presentation templates; sound and graphics library.
Matrox	Personal Producer	$695	Edits video, audio, graphics, titles, and digital video effects; Includes Multimedia Extensions 1.0.
MP Technologies Inc	Sound Palette	$69	DLL and control program with DDE support, plays digitized sound through PC speaker.
Ntergaid Inc	Hyperwriter 3.0	$495	DOS authoring program for interactive hypermedia and multimedia documents; $895 version.
	Hyperwriter 3.0 for Windows	$495	Windows authoring program for interactive hypermedia/multimedia documents; $895 pro version.
Paul Mace Software Inc	Grasp version 4.0	$349	Synchronized digital sound, creates run-time files, plays Autodesk Animator files, image capture.
Pix-L Laboratories	Tap Plus	$299	Audio/video authoring program provides an automatic interface with firm's touch-screen monitors.
Spectral Innovations Inc	Signal Analyzer/QT	$495	Multimedia authoring software for engineering signal-analysis, runs on Macintosh computers.
Texas Instruments	Multimedia Developer's Toolkit	$5000	DSP development board and software kit for implementing PC-based multimedia capabilities.
	Multimedia Evaluation Toolkit	$2000	For system developers who need to determine whether DSP would be useful in their application.
Turtle Beach Systems	56k Digital Recording System	$1995	Hardware/software combination for creating CD-quality audio on your hard-disk drive.
Vision Imaging	Multimedia Studio	$295	Database and presentation authoring software that combines graphics, text, sound, and animation.
	Imagebase	$595	Multimedia database package; image capturing and scanning into user-defined fields.
	Media Master	$995	Creates self-running interactive multimedia presentations, Hyperbutton, screen editing.

Note: 1. DLL=dynamic link libraries, DDE=dynamic data exchange, TSR=terminate and stay resident.

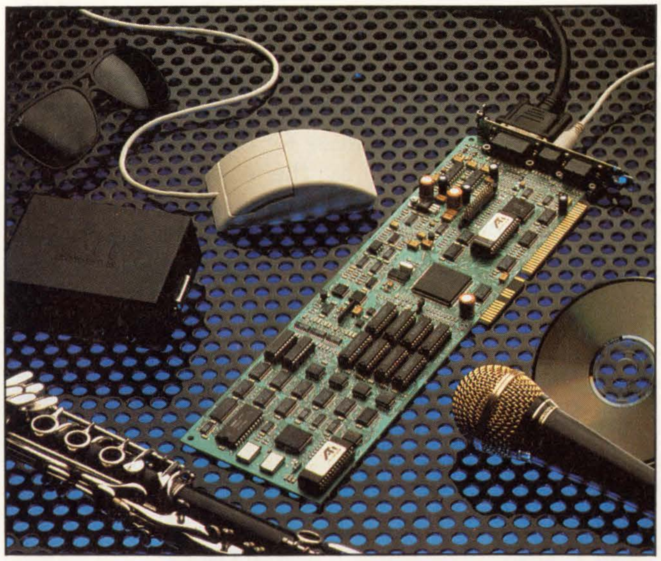
long-distance design problems that require face-to-face brainstorming without requiring you to hop on a plane. With PC-based video conferencing you can meet with engineers scattered across a local-area network (LAN) or even across the world. By taking the multimedia concept to its logical climax, video conferencing lets separated members of a design team observe, comment upon, and even manually annotate or alter files, such as schematics, graphs, photos, animations, and videos.

Suppose a designer in Silicon Valley needs to present the current revision of her latest circuit to an analyst in New York, a colleague in Houston, and a field engineer in Denver. Instead of spending her time trying to arrange air travel, hotel rooms, and meals, she could instead schedule a video conference for a fraction of the expense and personal-productivity downtime that cross-country travel entails. An actual example offered by Todd Clayton, vice president of Marketing at Videotelecom involves the common scenario of a corporate moratorium on all but essential travel. When nine engineers at Motorola in Austin, TX were faced with such an edict while developing ICs for Chrysler's 1996 cars, they conferred with the Detroit-based auto engineers via Videotelecom's video conferencing studios and Mediamac equipment. Their meeting cost $1800, but Motorola estimated that a business trip from Austin to Detroit for this design team would have cost the company around $27,000.

The Mediamac equipment is based upon an 80386 or 80486 PC with open expansion slots that let you customize the system to suit your needs. You can use your own MS-DOS-based software and plug the equipment into your company's LAN to share and manipulate files interactively with the other conference participants, print and review hard copies, and then send each participant away with the revised data on a floppy disk. Mediamac uses an in-band fax, which transmits on the same carrier that transmits the video and audio data, thus letting you exchange written documents during the conference. You can make interactive annotations of drafts and revisions using the systems graphics capability. You can also use an electronic white-

Table 3—Multimedia boards

Manufacturer	Product	Price	Description
Adaptec	Multimedia Connection	$179	SCSI host adapter interface for CD-ROM.
ATI Technologies Inc	VGAStereo-F/X	$449 (0.5-Mbyte RAM)	32,768-color VGA graphics with musical-instrument digital interface, stereo generator, and mouse port; $499 for 1-Mbyte version.
Cardinal Technologies Inc	Soundvision	$459 (1-Mbyte RAM)	Single ISA card contains SuperVGA, stereo sound, and CD-ROM interface, Multimedia PC-compatible.
Compuadd Co	Multimedia Upgrade Kit	From $1069	Includes an audio board, Sony CD-ROM drive, MS-Windows 3.0 with Multimedia Extensions 1.0.
	AM/FM Tuner	$299	Includes an infrared remote control.
	TV/Video Board	$525	Integrates audio and full-motion digitized video.
Creative Labs	Multimedia Upgrade Kit	From $849.95	Includes Soundblaster Pro audio board, Panasonic CD-ROM drive, lots of software.
Dolch	Multimedia PAC	$3995	Upgrades the company's line of portable computers to meet MPC standards.
Jovian Logic	SuperVIA	$895	Captures 640×480-pixel images with 65,536 colors in 1/30th of a sec; RGB and S-Video inputs.
	Gloria	$695	8- or 16-bit digital stereo audio-capture and playback adapter; CD quality; software included.
Logos Systems Intl	Doubletake AV+Monochrome	$295	8-bit audio and video digitizer for NTSC and PAL; ports for composite video input, mic, and audio.
	Doubletake AV+Color	$495	24-bit color video-capture board with 8-bit audio I/O.
Media Vision Inc	MPC Upgrade Kit	$995	Pro Audio Spectrum sound board, Sony CD-ROM drive, multimedia encyclopedia, software.
	Pro Audiospectrum	$389	22-voice musical-instrument digital interface-compatible stereo synthesizer, conforms to MPC spec, Audiomate TSR software.
New Media Graphics Corp	Super Videowindows	$895	Full-motion digital video in a window with stereo audio capability; runs under Windows or DOS.
Radius Inc	RadiusTV	$1699	Video-processing engine with external audio-video input and TV tuner for the Macintosh.
Tandy Corp	Multimedia PC Upgrade Kit	From $799.95	16-bit audio board, Tandy CDR-1000 CD-ROM drive, Windows 3.0 with Multimedia Extensions 1.0.
Video Seven	Multimedia Upgrade Kit	From $749	Texel America CD-ROM drive, MS-Windows 3.0 with Multimedia Extensions 1.0.
	Media FX	$349	Upgrades PC audio to digital stereo.



You can really jazz-up a presentation by adding sound to clarify your point and focus your audience's attention. ATI Technologies' VGA Stereo-F/X board lets you add audio capability to your PC without sacrificing another expansion slot.

board (the electronic equivalent of a blackboard, which all participants can write on at the same time) for brainstorming.

But what if our hypothetical designer needs to confer with engineers in the Pacific Rim and Europe? The time differences involved would seem to make video conferencing an inappropriate forum. However, Mediamax lets you send all of your video, audio, documents, and computer information to remote sites for later review by distant colleagues. A video tape that illustrates these and other video conferencing scenarios is available upon request from the company.

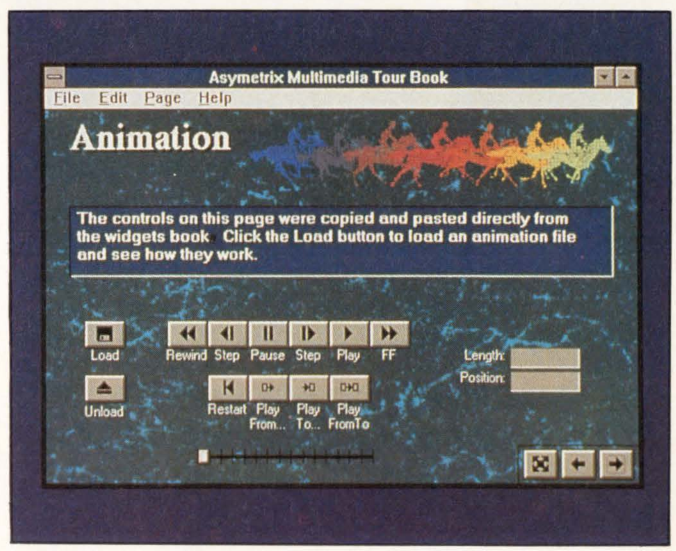
The disk is in the mail

Yet, even at the current price of $400 per hour on a high bandwidth video conferencing telephone line, such a solution may be too costly for some projects. But with a bit of work, you can stay within your budget and still provide interactive, animated, voice-annotated information to members of your design team who may be in different locations. Asymetryx's Multimedia Toolbook and Paul Mace Software's Grasp version 4.0 are multimedia authoring programs that let you develop and distribute runtime versions of your presentation that will operate on almost any engineer's PC with a VGA monitor. Then transmit the data via modem or download the presentation onto a floppy and mail it. Make sure your presentation is limited to the hardware capabilities of the recipient's PC.

If you are a Windows 3.0 devotee, Toolbook is an icon-driven authoring program that lets you write multimedia applications for MPC platforms. Using a simple copy-and-paste approach to building applications, you can tap a library of more than 250 multimedia-script objects, which the company calls widgets. So, by pointing and clicking to access engineering drawings stored on the Windows Clipboard, you can create a multimedia presentation without learning yet another paint program or programming language.

More experienced programmers can combine Toolbook's prescripted widgets with their own C-language subroutines. A graphics display facility lets you store as many as 256 bitmaps for display as pop-up or overlap windows. So you can actually add hundreds of annotations to your schematic without obliterating the screen with messages. Incidentally, for PCs that aren't yet running Windows 3.0 with Multimedia Extensions 1.0, Toolbook 1.5 is a similar Windows authoring program. It includes a runtime module for free distribution of interactive applications that don't include MPC-compatible audio and video capabilities.

On the other hand, if you want to create a disk-based presentation that combines both MS-DOS and Windows 3.0 images, Steven Belsky, Business Manager for Paul Mace Software, suggests using Grasp 4.0. Like Toolbook, Grasp offers a runtime module that lets you distribute tamper-proof executable files that incorporate sound, animation, and text. Belsky notes that you can use Grasp to capture a CAE drawing of a circuit, access Grasp's Pictor paint program to draw bright dots representing electrical signals, and then tap



Multimedia Toolbook is an MPC-compatible authoring program that lets you combine text, graphics, digital video, audio, and animation to create multimedia presentations within Windows 3.0 and distribute your presentations for free.

Grasp's Artools module to animate those dots for illustrating signal flow, delays, and critical paths. The Realsound enhancement for Grasp lets you add verbal comments as clarification, questions, or warnings.

Of course, the limiting factor for such disk-based distribution techniques is the size of the disk you are sending. A floppy disk gives you little more than 1 Mbyte in which to get your point across. Even with compression techniques such as those offered by the JPEG and MPEG standards, you will probably find that a floppy will provide minimal options for a multimedia presentation. You can send greater amounts of information via modem, but the recipient's available disk space may not be sufficient to accept all of it.

Obviously, the opportunities for engineers to exploit the technology promised by the ensuing multimedia tidal wave of applications is limited only by imagination, budget, CPU power, and storage capacity. Just as a slide rule on someone's desk is a nostalgic oddity in today's design departments, it may not be long be-

Manufacturers of multimedia products

For more information on multimedia products 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.

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fore a silent, text-based computer is considered a relic for any engineering team. EDN

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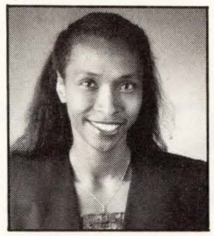

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Piecewise analysis and accurate emulation yield precise power estimates

William Hall and Ray Mentzer, National Semiconductor Corp

Newer logic-IC families let you obtain high speed and low power simultaneously. But with these ICs, if you use time-honored ways to estimate system power consumption, the errors can kill your design.

Designers have long sought low-power components for their system designs. Low power dissipation allows denser component packing, reduces the temperature inside equipment, and permits the use of batteries. These three advantages facilitate miniaturization, increase reliability, and make portability possible. In addition, low power dissipation reduces or eliminates the need for cooling hardware and decreases system cost.

In the past, to obtain low power you had to pay a steep price in operating speed. Now you don't have to choose between high speed and low power. Using advanced CMOS and BiCMOS logic-IC technologies, several IC families combine microwatt power dissipation with speed similar to that of ECL. At low frequencies, CMOS logic families clearly are the minimal power consumers; but at higher frequencies, the need to continually charge and discharge CMOS device capacitances raises the ICs' current requirements. Above some crossover frequency, CMOS actually draws more current than bipolar TTL or BiCMOS.

Many engineers have tried to define the crossover frequency by using data-book calculations and data collected from standard test fixtures. Using these approaches can yield crossover frequencies anywhere from 3 to 50 MHz. Because of their unrealistic load values and their inability to compute average power over time as devices change operational modes, these approaches fail to emulate actual system conditions. For example, they ignore the effects of 3-state devices going in and out of the high-impedance (high-Z) state.

Determining total system power requires a piecewise analysis of a system's many circuit structures and an accurate emulation of those structures. Such an analysis will help you minimize a system's power dissipation by tailoring your selection of ICs to the system's specific parameters and configuration.

Start with a single device

The following equation describes the energy used in any electric circuit:

$$W = \int_{t_1}^{t_2} (vi)dt,$$

where

v = voltage across the two nodes where power is measured,
i = current through the two nodes where power is measured, and
(t_1, t_2) = interval of time in which total power is measured.

For a trapezoidal waveform, you can break time into segments and develop a piecewise solution to the energy equation. IC vendors have simplified this approach by providing all of the key parameters you need to determine the power for a single device. A plethora of specifications exists: I_{CC}, I_{CCQ}, I_{CCT}, I_{CCD}, C_{PD}, I_{CCL}, I_{CCH}, and I_{CCZ}, for example, each specify different aspects of power-supply current. Which parameter is most significant at any instant depends on the I/O conditions, the operating mode, and the state of the device's outputs.

The normal starting point for calculating the power dissipation of any digital IC is to break power into its three main components:

Power = static power + dynamic power + TTL power.

Static power is the easiest to calculate. Bipolar ICs consume significant amounts of static power because their circuit structures have transistor bias currents that always flow from V_{CC} to ground. The amount of current flowing depends on the ICs' output state. Therefore, bipolar ICs specify three static-power components: I_{CCL} in the output-low state, I_{CCH} in the output-high state, and I_{CCZ} in the high-Z (output-disabled) state.

For a 74F245, the maximum data-book specifications are $I_{CCL}=120$ mA; $I_{CCH}=90$ mA; and $I_{CCZ}=110$ mA. The total static power dissipated by active and output-disabled bipolar devices is

$$I_{STATIC\ (ACTIVE)} = DDC \times I_{CCH} + (1-DDC) \times I_{CCL},$$
$$I_{STATIC\ (HIGH\text{-}Z)} = I_{CCZ},$$

where DDC is the data duty cycle (% of time high).

The total static power consumed by a bipolar IC takes into account the percent of time that the outputs are active vs disabled, and is given by the equation

$$I_{STATIC\ (TOTAL)} = EDC \times I_{STATIC\ (ACTIVE)} + (1-EDC) \times I_{STATIC\ (HIGH\text{-}Z)},$$

where EDC is the enable duty cycle (% of time the outputs are enabled).

BiCMOS spec'd in manner similar to bipolar

BiCMOS logic families have specifications equivalent to the bipolar I_{CCL}, I_{CCH}, and I_{CCZ}. Moreover, you calculate the total static power dissipation in the same way. The major difference results from BiCMOS's strategic use of MOS devices that switch to a high-impedance state to block the flow of dc current in 3-state enable paths. This approach lowers I_{CCZ} to about one-sixth of the value in bipolar devices. The data-book maximum specifications for a 74BCT245 are $I_{CCL}=90$ mA; $I_{CCH}=57$ mA; and $I_{CCZ}=15$ mA.

Pure CMOS logic families have long been known for their extremely low static-power characteristics. The input, internal, and output stages of CMOS devices consist of pairs of PMOS and NMOS transistors in the V_{CC}-to-ground path (more properly, in the V_{DD}-to-ground path). If the input of any of these stages is at one of the power rails (V_{CC} or ground), either the PMOS or the NMOS device will be in a high-impedance state, limiting the flow of current to microamperes. Because the current is negligible no matter what the output state, data books provide only one specification for CMOS static current drain: I_{CC} (some CMOS logic families call it I_{CCQ}). The maximum data-book specification for a 74ACT245 is 80 μA.

Dynamic power dissipation is misunderstood much more often than static power dissipation is. Dynamic dissipation consists of the power dissipated under switching conditions within the IC and the load. In CMOS devices, under dynamic conditions, three factors cause large amounts of current to flow:

- CMOS ICs have output swings as much as 50% greater than those of bipolar ICs.
- CMOS ICs have more capacitive stages in parallel than bipolar ICs have.
- When the voltage to an NMOS/PMOS pair is in transition, both transistors turn on partially, creating a relatively low impedance path from V_{CC} to ground (a phenomenon called simultaneous conduction).

For these reasons, CMOS-device vendors specify a dynamic power component for an IC, whereas vendors of bipolar and BiCMOS devices do not. For bipolar and BiCMOS logic families, you need to consider only the dynamic power dissipation caused by the load.

The dynamic power for a CMOS device is specified in one of two ways: as I_{CCD} or as C_{PD}. I_{CCD} is the dynamic current as a function of frequency. Each of the noninverting buffers in a 74FCT245 has a maximum I_{CCD} of 0.25 mA/MHz. Therefore, at 10 MHz, each buffer has a guaranteed dynamic current of less than 2.5 mA. Instead of I_{CCD}, some logic families choose to specify dynamic power via C_{PD} (power dissipating capacitance—a misnomer; capacitors don't dissipate energy, they store it). Both C_{PD} and I_{CCD} come from the same JEDEC equation for power; however, C_{PD} lets you represent the device as a capacitance and integrate it more easily into an analysis that accounts for the power consumed by both the IC and its load. For ICs having the same output frequencies and loads:

$$I_{DYNAMIC\ (TOTAL)} = (C_{PD} + C_l) \times V_{SW} \times f \times N,$$

where:

- C_l is the total load capacitance, including transmission-line capacitance, IC input capacitances, and termination capacitance,
- V_{SW} is the output voltage swing of the device (for CMOS, $V_{SW}=V_{CC}$),
- f is the output frequency, and
- N is the number of outputs toggling.

The data-book specification for a 74ACT245 is

C_{PD}=45 pF. Note that for bipolar and BiCMOS devices, you can consider C_{PD} to be zero, but you must still calculate the dynamic power needed to drive the load capacitance.

The final component of total CMOS-IC power dissipation is "TTL power." Contrary to its name, this component is associated only with CMOS devices. Bipolar and BiCMOS devices have no TTL-power component. This power component is the steady-state power consumed by a CMOS device whose input is at a voltage between the power rails. Logic levels between the rails are common in mixed CMOS/TTL systems where a TTL output drives a CMOS input. In such cases, both transistors of an NMOS/PMOS input pair turn on and allow a large dc current to flow from V_{CC} to ground. (The most common TTL output levels are 2.4 to 3.4V.) The additional current beyond the standard I_{CC} is called I_{CCT}. The data-book specification for a 74ACT245 is I_{CCT}=1.5 mA for each high input (defined as $V_{IN}=V_{CC}-2.1V$). To calculate the total TTL power, you must also incorporate the input-data duty cycle, DDC, and N, the number of high inputs:

$$I_{TTL\ (TOTAL)} = I_{CCT} \times N \times DDC.$$

The complexity of static, dynamic, and TTL power components has led many designers to develop comparisons from data gathered in simple lumped-load test fixtures. Unfortunately, data gathered using such industry-standard fixtures does not give designers an "apples-to-apples" comparison of power consumed by different logic families.

Data from classic test fixtures can mislead

Test fixtures have evolved over the last 20 years to provide repeatable standards for measuring ac and dc specifications. Test-fixture data is easy to measure in any laboratory and is also readily available from most IC vendors. In addition, some data-book specifications (like C_{PD} and I_{CCD}) are based on measurements from industry-standard fixtures. However, the fixtures don't accurately simulate the power consumed by real systems, nor do they predict which logic family will dissipate the least power in a particular application.

The fixtures use lumped loads, whereas real systems present distributed loads. A fixture's standard load is a 500Ω resistor in parallel with a 50-pF capacitor from output to ground (see **Fig 1**). The 50-pF load capacitance, standardized in the late 1970s, represents 10 5-pF IC inputs. The 500Ω resistor provides a convenient 10:1 voltage divider with the 50Ω input impedance of an oscilloscope. Yet, for all its convenience, this setup often yields misleading measurements.

Dynamic power measurements in a test fixture also can prove misleading. The problem arises from test fixtures' favorable bias toward logic families that produce TTL output swings—for example, bipolar and BiCMOS. The power dissipated in the test-fixture load for an 8-bit device is calculated below:

$$I_{TEST\ FIX} = I_{CAPACITOR} + I_{RESISTOR}$$
$$= V_{sw} \times f \times C_l \times 8 + (V_{sw}/R_L) \times DDC \times 8.$$

Because the CMOS output swing is 5.0V (if V_{CC}=5.0V) and the TTL-output swing is 3.4V, the additional current used by a CMOS-populated test fixture vs a TTL test fixture is

$$I_{DELTA} = (5.0-3.4) \times f \times 50 \times 10^{-12} \times 8$$
$$+ ((5.0-3.4)/500) \times 0.5 \times 8$$
$$= 0.64\ mA/MHz + 12.8\ mA.$$

From the equation, you can see that the power consumed in the 500Ω resistor provides a constant 12.8-mA bias in favor of families that have TTL output swings. The power difference in the 50-pF load capacitor is a linear function of frequency. At 20 MHz, the capacitor would contribute another 12.8 mA to the CMOS-based test fixture.

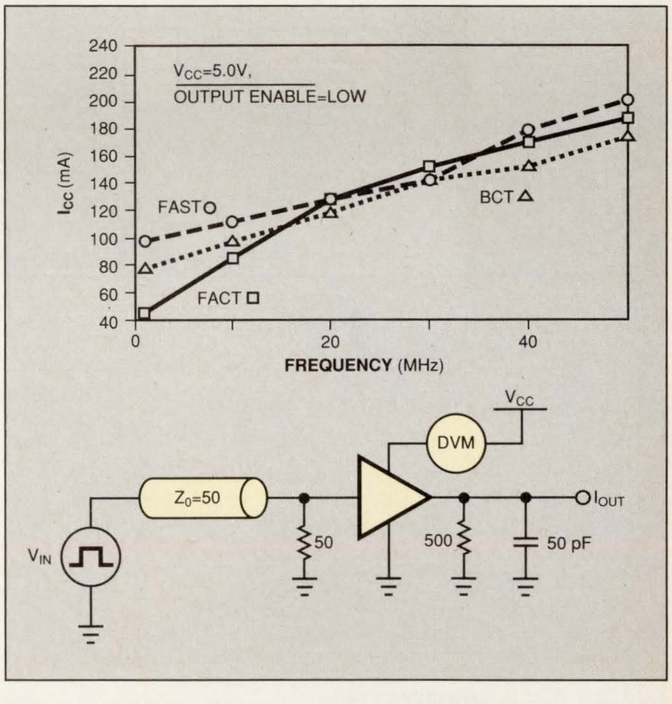

Fig 1—At 16 MHz, the power consumed by ACMOS (FACT) devices becomes greater than that used by BiCMOS (BCT). The crossover points shown here are not necessarily accurate, however, because the test setup contains an unfavorable bias against ACMOS that adds 12.8 mA to its current drain.

The graph in **Fig 1** shows an actual test fixture comparison of CMOS (FACT—Fairchild Advanced CMOS Technology), bipolar (FAST—Fairchild Advanced Schottky TTL), and BiCMOS (BCT—Bipolar CMOS Technology). In the test fixture, CMOS begins to draw more current than BiCMOS at 16 MHz and to draw more current than bipolar at 19 MHz.

In a pure CMOS system, the load's resistance measures in the megohms, reflecting the ultra-high input impedance of CMOS. Even TTL loads approach 100 kΩ for logic-high input signals. CMOS systems designed for low power generally don't use parallel or Thevenin terminations. Thus, they eliminate other possible low-output-state resistive paths. The test fixture's 500Ω load therefore does not accurately represent the megohm load of a CMOS system and overstates the power dissipated by CMOS.

The 50-pF capacitive load may or may not correlate to that of a real system. If the real system has fewer than 10 IC input loads, minimal distributed capacitance, and no termination capacitance, the test fixture will again be overly pessimistic when measuring CMOS power consumption. However, if the equivalent load capacitance is higher than 50 pF, the test fixture may understate CMOS power. This confusion reinforces the point that to obtain a true picture of system power or to select a logic family, you must analyze the actual system.

Application determines capacitance

Three circuit applications: pipelines, bus drivers, and memory-array drivers (**Fig 2**), tend to dominate in many systems. Radically different capacitive loads and active duty cycles distinguish these applications.

The capacitance associated with a pipeline is small (on the order of 5 to 10 pF) and consists of input and trace capacitance. As shown in **Fig 2**, pipelines generally have small fanouts and usually drive a single load. Typical embodiments include pipeline registers and serial structures in DSP systems, synchronization blocks, and clock rejuvenation circuits. Reducing the power consumption of these circuits depends largely on selecting a logic family or on using a power-down scheme to shut down entire sections of logic when they aren't in use.

Bus driving is perhaps the most common digital-circuit application and definitely is the most complex

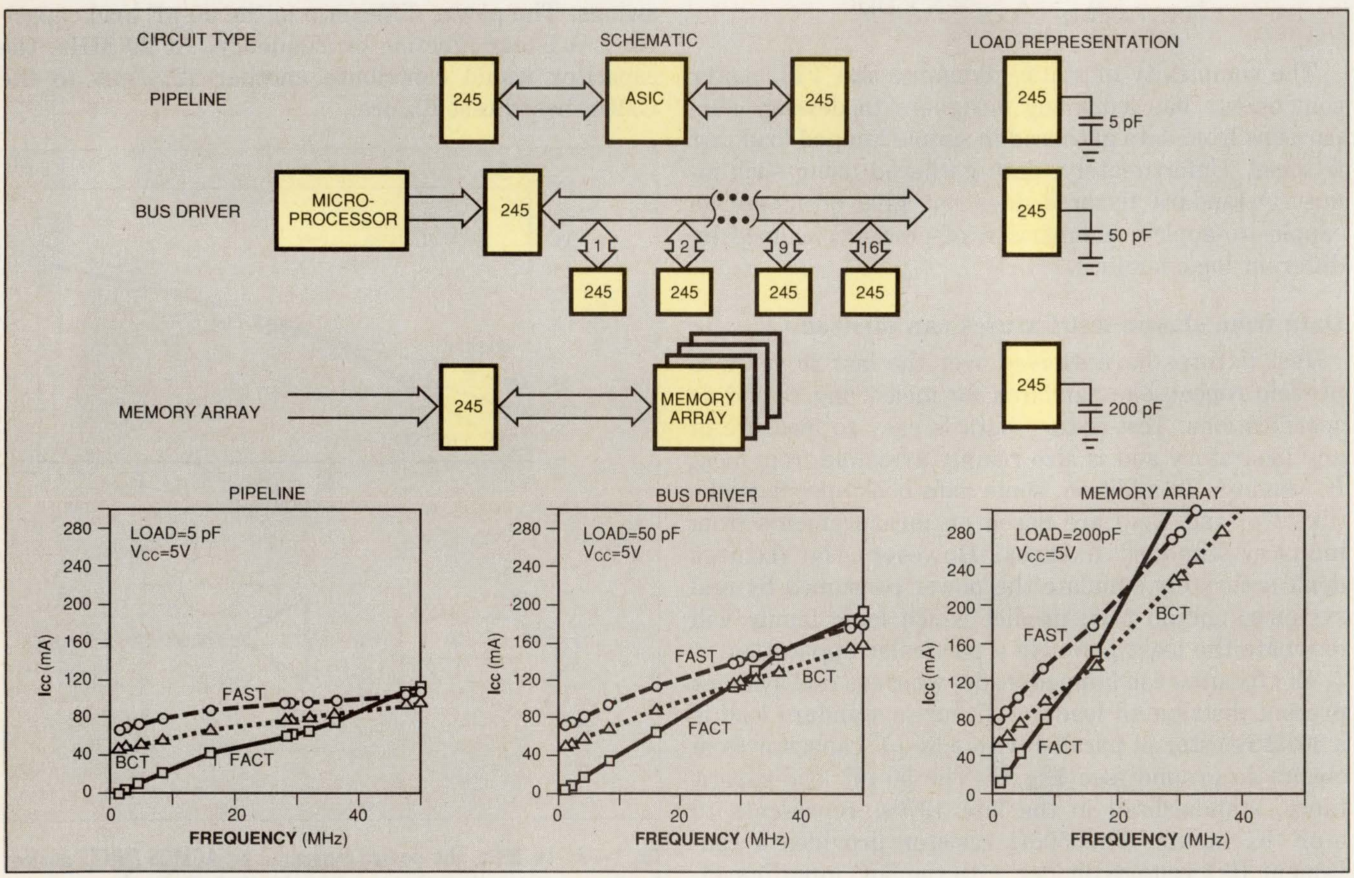

Fig 2—A logic IC's power consumption depends on its capacitive load. This figure shows how to model pipeline, bus, and memory circuits when calculating power dissipation. The curves show the supply current drawn as a function of frequency by equivalent circuit configurations using three logic families (BCT, FACT, and FAST) under differing capacitive loads.

from a power perspective. A bus-driver IC drives several listeners; a listener is any IC other than the driver itself whose inputs or outputs load the bus. Commonly, a bus driver drives longer traces than pipeline or memory-array drivers do. In addition to IC loads, bus drivers often drive such elements as the bus trace, edge connectors for daughter boards, pin sockets, ribbon cables, connectors, and plated through holes. Because buses are usually terminated, you must also consider the termination elements. The sum of all capacitive elements may range from 30 to 70 pF for a small internal bus to 220 pF for an EISA-bus application. A fully configured VMEbus—21 slots at a maximum of 20 pF per slot—can present a severe, worst-case, 420-pF bus load.

You can minimize bus power consumption through logic-family selection, termination selection, and the design of bus loads and enable schemes. More importantly, the enable cycles of the bus elements significantly affect the power consumption of complex buses. A later section covers this topic in detail.

Take your lumps from a memory array

Memory arrays usually are densely packed, and their data and address drivers are apt to have very high fanouts. Typical values of total capacitance are on the order of 200 pF, but this value can vary widely with the size and composition of the array. Memory-array designers can control the amount of power dissipated in an array by carefully selecting the array organization.

Consider a memory-array architecture commonly found in personal computers: 4M words deep by 16 bits wide. **Table 1** gives the fan-in capacitances for seven configurations using 5 pF per input; this example neglects other capacitive elements that add to the values shown—traces and sockets, for example. In **Table 1**, observe that the address load depends directly on the number of ICs in the array. Using higher storage capacity devices will reduce the address load in proportion to the storage capacity of the individual ICs. If you fix the memory size, choosing to maximize the memory depth will save power by reducing the data-path fan-in.

When you make comparisons among logic families, segmenting systems into capacitive categories can be very useful. You can use this approach, for example, when you compare an ACMOS (advanced CMOS) function to a bipolar or BiCMOS one. The plots at the bottom of **Fig 2** come from data gathered in a realistic system environment. The plots show the effect of load capacitance on different families. As you increase the capacitance from 5 to 200 pF, the CMOS crossover frequency decreases from the 40-to-50-MHz range to the 10-to-20-MHz range. Therefore, you can see that

Table 1—Capacitive loads presented by different memory configurations

Memory IC size	Architecture	No. of ICs	Data load	Address load
4 Mbit	4M×1	16	5 pF	80 pF
4 Mbit	1M×4	16	20 pF	80 pF
1 Mbit	1M×1	64	20 pF	320 pF
1 Mbit	256k×4	64	80 pF	320 pF
256 kbit	256k×1	256	80 pF	1280 pF
256 kbit	64k×4	256	320 pF	1280 pF
64 kbit	64k×1	1024	320 pF	5120 pF

not just the architecture, but also the external capacitive load dictates the choice of logic family.

So far, the examples and discussions have taken a worst-case approach; all data bits were assumed to be switching at the highest frequency. This situation is likely to occur only in a subset of clock-distribution applications. If you were to design for this case everywhere, power supplies would need unrealistic excess capacity to account for an unlikely set of conditions. Consider the clock-distribution example shown in **Fig 3**. Also recall the results in **Fig 2**, where the plot shows that with a 50-pF load, the data-pattern frequency at which FACT begins to draw more current than BCT is 28 MHz. In the same plot, FACT begins to draw more current than FAST at 39 MHz. In **Fig 3**, the

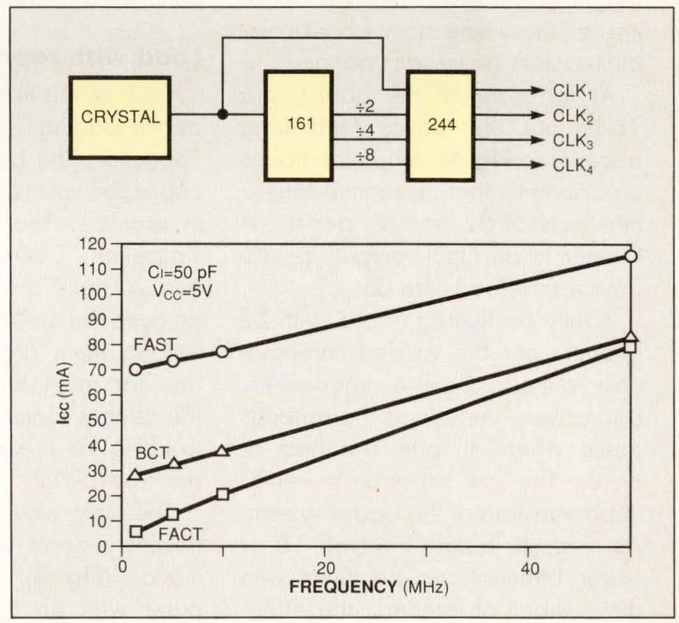

Fig 3—Above 30 MHz, a single-frequency clock-distribution system will dissipate the least power if you implement it with BiCMOS (BCT) or bipolar (FAST) logic. Because many circuit elements operate well below the clock frequency, CMOS (FACT) can be a better choice in multifrequency systems—even at 50 MHz.

FACT/BCT crossover lies beyond 50 MHz. The change really shouldn't surprise you; in effect, the circuit is operating at a lower frequency. The general equation for $I_{DYNAMIC}$ is

$$I_{DYNAMIC} = N' \times f \times V_{SW} \times C_L,$$

where N' equals the effective number of bits switching at the maximum clock frequency, f. For the multifrequency case of **Fig 3**:

$$N' \times f = f + f/2 + f/4 + f/8 = 1.875f.$$

Therefore, in this case, N' and the resulting dynamic power are 46% of the equivalent quantities in the case where four outputs are toggling at f.

System emulation predicts power precisely

The right kind of emulation board can help designers think about system power and get away from a test-fixture mindset. To accomplish this objective, a universal bus board emulates a generic bus architecture with enough flexibility to allow measuring the effect of the following variables on I_{CC}:

- Frequency
- Termination
- Enable duty cycle
- Bus data pattern
- Listener load
- Logic family

The authors have constructed a multifunction bus-emulation board that makes its LCD's ammeter reading tell the whole story about complex-system power dissipation.

At the core of the board is a 16-bit bus that drives 18-in.-long traces (see **Fig A**). Along the traces are sockets that accommodate a maximum of 32 listeners per bit. A listener is an input, output, or I/O device that loads the bus.

A fully configured board, with 32 listeners per bit, yielded unrealistically low effective line impedances. (Moreover, there was horrendous noise when all bits switched at once). The low impedance limited the bandwidth of the board system. As a result, testing involved 16 or fewer listeners per bit. Even with this number of listeners, the effective line impedances still ranged from 30 to 55Ω. Driving these impedances was a device of the same logic family as the listeners.

Because of Miller capacitance in the pull-down transistors, bipolar and BiCMOS devices generally produced the lowest impedance lines. The bipolar devices also include an output short-circuit current-limiting resistor that raises their output impedance under some conditions. The result is lower bandwidth for these families than for CMOS or BiCMOS.

At the end of the bus are pin sockets that accept ac, parallel, or Thevenin SIP terminators. The component values in the terminations are appropriate for each logic family and for the number of devices connected to the bus.

Load with representative C

Each of the listeners has pads to permit loading its output with a chip capacitor. The goal was to choose capacitor values that have a basis in practice. The options are 5-pF "pipeline," 50-pF "bus-driver," and 200-pF "array-driver" capacitances. The board has five layers. Among them are two V_{CC} planes, one for the listeners and one for the control logic. This setup allows isolating the I_{CC}s of the devices under test (DUTs).

The only way to meet the test-flexibility goals was through automation (**Fig B**). A personal computer with an IEEE-488 interface card controls the system. At the heart is a Hewlett-Packard word generator that can operate at 50-MHz. Downloading vectors from the PC to the word generator is quite flexible and permits generating any data pattern and emulating any enabling scheme.

System designers often use several bus architectures in a single product. Multiple architectures are also an issue when upgrading an existing design. The flexible evaluation board satisfies the multiple-architecture requirement and reduces project cost and evaluation time.

The graph in **Fig A** is one example of data taken on the power-emulation board. The setup had 16 listeners per bit, for a total of 34 monitored devices. The enable duty cycle was set to 6.25% × 1/16. Hence, at any instant, only one pair of listeners was enabled.

In conjunction with the control logic, the word generator writes two bytes of checkerboard data to the enabled bank and then steps through the banks one by one before looping back to the beginning. Because of **Fig A**'s low enable duty cycle, the ac termination's capacitance controls the shape of the curve. Compare the curve shapes in **Fig A** with the ac-termination curve in **Fig 5** (see main text). The low enable duty cycle also demonstrates the differences between families with high and low I_{CCZ} values (note that FAST's typical I_{CCZ} is 85 mA).

When you compare the measured results with the calculations of **Table 2**, you can see that, at

Though this example is for clock distribution, you can apply its principles more broadly. Power measurements are almost always based on "worst-case" checkerboard data patterns. Average system power will be considerably lower than the worst case because of the random nature of most data. In addition, some system structures have frequencies predictably lower than the maximum. You should take this effect into account during circuit design and logic-family selection. Examples of lower frequency structures include clock and memory-address generators, address comparators, circuits that perform some arithmetic operations, and virtually all circuits that use counters.

Resistors serve many purposes in system design, but no resistors have a larger impact on power consumption than those used as terminators. Termination

different frequencies, the calculations exaggerate the CMOS power requirements by 10 to 50%. For battery-operated designs, the calculations' pessimism will most certainly be critical. In other designs, the pessimism may cause you to add an unnecessary cooling fan, or change from a 150W supply to a 225W supply.

You can use the hardware model for more than just power measurement; you can use it to evaluate crosstalk and ground bounce, as well as line-driving and termination schemes. For your next design, give some thought to using hardware modeling for comparing logic families. The technique can be a quick and easy route to accurate power optimization, and more.

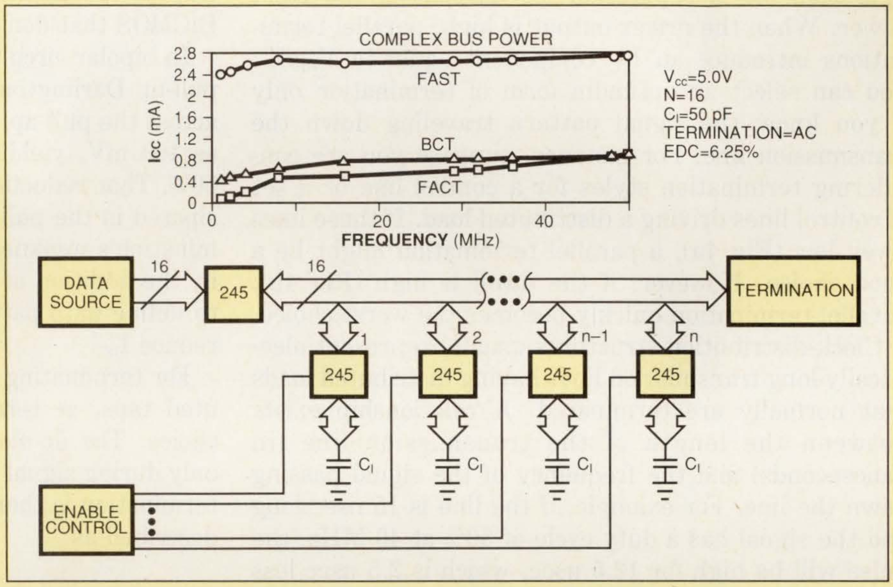

Fig A—A bus-emulation system is the best tool for predicting how much power a complex bus will consume. Although the calculations of Table 2 predict that FACT will consume more power than BCT above 28 MHz, the actual crossover occurs at 48 MHz.

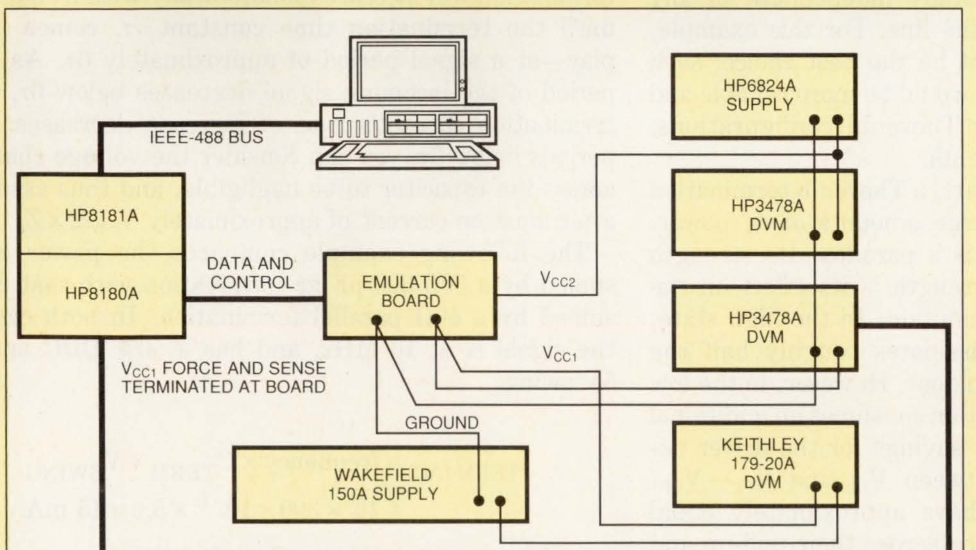

Fig B—Although the bus-emulation board is the heart of a system for predicting bus power consumption, the test setup includes a personal computer, a word generator, several power supplies, and three multimeters. The Keithley meter monitors the current from the V_{CC1} supply.

resistors can appear in series, in parallel, in Thevenin-equivalent networks, or in conjunction with a capacitor in ac-termination schemes. As long as terminations properly match the transmission-line impedance, their topology will have little affect on the degree of noise reduction they achieve. Termination topology will significantly affect cost, circuit-board area, and power dissipation, however. When you choose a termination design, you must thoroughly understand how to apply each type of termination network.

Of the possible termination styles, the parallel configuration has a reputation for dissipating the most power. When the driver output is high, parallel terminations introduce an I_{CC} component equal to V_{OH}/Z_0. You can select an optimum form of termination only if you know the signal pattern traveling down the transmission line. For instance, suppose you are considering termination styles for a control line or a set of control lines driving a distributed load. If these lines dwell low (**Fig 4a**), a parallel termination might be a good choice. However, if the dwell is high (**Fig 4b**), parallel termination quickly becomes the worst choice.

Clock-distribution structures usually represent electrically long transmission lines having distributed loads that normally are terminated. A relationship exists between the length of the transmission line (in nanoseconds) and the frequency of the signal passing down the line. For example, if the line is 15 nsec long and the signal has a duty cycle of 50% at 40 MHz, the pulse will be high for 12.5 nsec, which is 2.5 nsec less than the length of the line. The driver therefore has no insight into what is at the end of the transmission line. The load current for the driver, although still equal to V_{OH}/Z_0, is now totally independent of any termination at the end of the line. For this example, a parallel termination might be the best choice; such a single-component solution would be more reliable and less expensive than ac or Thevenin configurations, which use multiple components.

Like its parallel counterpart, a Thevenin termination also consumes relatively large amounts of dc power. The Thevenin termination is a paradox: Its strength is also its weakness. Its strength is its effect on the driver circuit's power consumption. In the high state, a Thevenin termination dissipates roughly half the power a parallel termination does. However, in the low state, the Thevenin termination consumes an additional $I_{OL} \times V_{OL}$. The actual power savings for the driver depend on the difference between V_{OL} and $V_{CC} - V_{OH}$. Because ACMOS devices have approximately equal source-to-drain voltage drops across their pull-up and pull-down transistors, the choice of Thevenin or parallel terminations has little effect on such circuits' dissipation. However, Thevenin terminations reduce the chip power used by logic families such as bipolar or BiCMOS that don't switch from rail to rail.

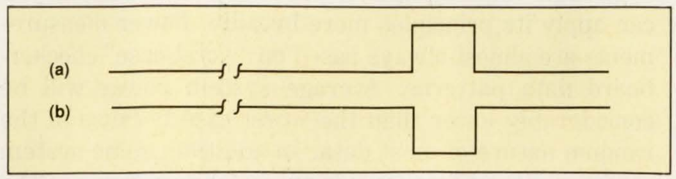

Fig 4—Signal dwell time or duty cycle can affect your choice of termination styles and component values. If you use a parallel termination, the signal of (b) will dissipate much more power than the one in (a).

In bipolar circuits, halving the source current of the pull-up Darlington pair has little effect on the voltage across the pull-up; that voltage may change by as little as 100 mV, yielding a dissipation decrease of nearly 50%. That reduction exceeds the additional power dissipated in the pull-down transistor. The Thevenin termination's weakness is its constant current drain; that is, the addition of an I_{OL} component. There is no way to define data patterns or system characteristics that reduce I_{OL}.

For terminating transmission lines that have distributed taps, ac terminations can be the lowest power choice. The dc-blocking capacitor allows current flow only during signal transitions. The current drain of the termination is therefore a function of frequency and is described as

$$I_{TERM} = \text{frequency} \times C_{TERM} \times V_{SWING}.$$

For a signal with a 50% duty cycle, the current in the termination will increase monotonically with frequency until the termination time constant, τ, comes into play—at a signal period of approximately 6τ. As the period of the incoming signal decreases below 6τ, the termination current's rate of increase decreases. At periods below 3τ, you can consider the voltage change across the capacitor to be negligible, and thus assume a termination current of approximately $V_{SW}/2 \times Z_0$.

The following example compares the power consumed by a 50Ω/300-pF ac termination with that consumed by a 50Ω parallel termination. In both cases, the signal is at 10 MHz, and has a 50% DDC and a 5V swing.

$$I_{TERM\ (AC)} = \text{frequency} \times C_{TERM} \times V_{SWING}$$
$$= 10^6 \times 300 \times 10^{-12} \times 5.0 = 15 \text{ mA}.$$
$$I_{term\ (parallel)} = (V_{swing}/Z_0) \times \text{Duty Cycle}$$
$$= (5.0\text{V}/50\Omega) \times 0.5 = 50 \text{ mA}.$$

In this and many other examples, ac terminations save significant power compared with dc terminations. Therefore, ac terminations are an excellent choice in many systems, particularly those using battery power. (To conserve board space, passive component manufacturers make off-the-shelf ac terminators in various RC combinations in a SIP format. If you buy sufficient quantities, you should be able to find vendors that will manufacture custom termination networks in several standard packages.)

The series termination is far and away the lowest power consumer (**Fig 5**). At 50 MHz, series terminations consume half the power of parallel or Thevenin ones. However, in many situations, series terminations are not useful. A series-terminated driver sends a half-height signal down the trace, preventing incident-wave switching at any tap along the line except the one at the very end. The series termination actually uses reflections to achieve full-voltage swings. Until the initial wave has made its round trip from the driver to the end of the line and back, the logic levels at stubs along the line may not be valid. This phenomenon can cause oscillations (which raise power) and can raise the TTL current drawn by CMOS devices. Thus, series terminations are effective only in point-to-point connections.

The power and noise benefits of series terminations come from the series resistor's limiting of the dynamic current that flows into and out of the driver. Limiting the dynamic current reduces the di/dt seen by the inductance of the driver's power leads. Therefore, both power and noise (that is, the undershoot and the transient-peak low-state output voltage, V_{OLP}) decrease. This noise reduction is the reason that many designers of memory arrays use series limiting resistors.

When implemented in an integrated resistor package, series termination requires twice as many pins as the other termination forms. Driver ICs can easily integrate series terminations, however. Such terminations are especially attractive to ASIC designers. IC vendors already implement 25 or 33Ω series resistors within standard devices.

Proper selection of termination schemes and components is essential to reducing power consumed by a bus; however, numerous other factors affect bus power.

Bus power is a function of the logic family, load, data characteristics, and the amount of time that bus elements are enabled and disabled.

As stated earlier, the input and output capacitance of the bus elements and the capacitive loading on those elements dictates the load on the bus. In addition, pc-board trace capacitance, termination capacitance and resistance, and other stray loads affect a bus's power dissipation.

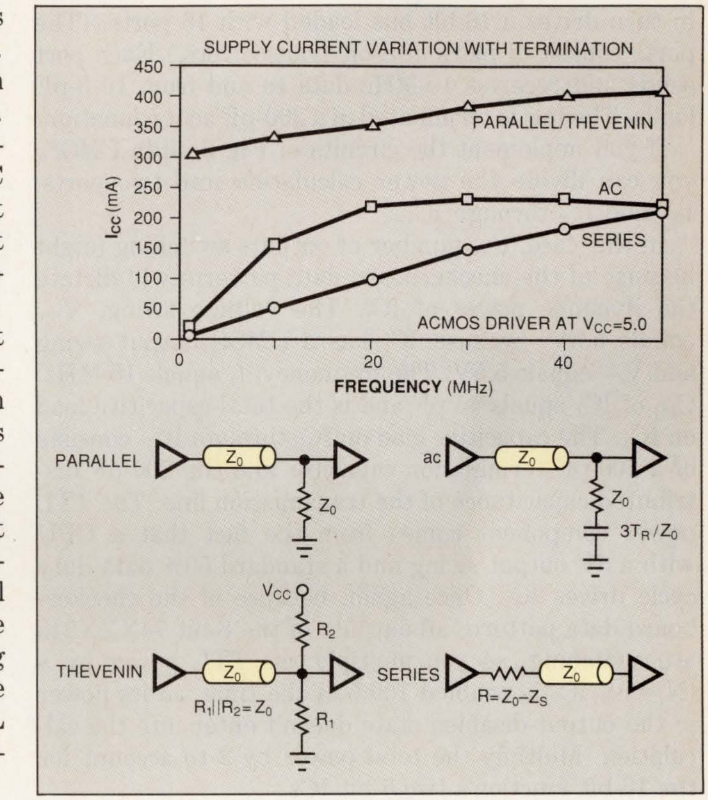

Fig 5—Because ac and series terminations do not draw dc bias currents, they consume the least power. However, before you select such low-power termination styles, you must understand their limitations.

The data pattern and duty cycle will also affect the dynamic, static, and TTL power components. In power tests that exercise all bits, checkerboard patterns are the worst case, pseudo-random patterns are middle-of-the-road, and counting patterns consume the least power. You usually assume the duty cycle to be 50%. If the duty cycle is greater than 50%, TTL power for CMOS suffers; if it is less than 50%, static power for bipolar and BiCMOS suffers. As discussed, the duty cycle also has a major effect on the termination power.

The most important factor on bus power is bus-enable duty cycle (EDC). This factor determines the average amount of time the bus elements are active vs disabled. Typically, two bus elements (one talker and one listener) are active at any instant. If there are eight listeners, each one has EDC = 12.5%. EDC determines if the bus power is mostly static or mostly dynamic.

The following data-book calculation and logic-family comparison illustrate how complex determining bus power can be. **Fig 6** represents a complex bus that exercises all of the power-dissipating mechanisms of the different logic families. In this example, a CPU

POWER OPTIMIZATION

with a 3V output swing drives a transceiver (IC_1) that in turn drives a 16-bit bus loaded with 16 ports. (The ports consist of pairs of 8-bit transceivers.) Each port sends and receives 10-MHz data to and from 10 5-pF loads. The bus is terminated in a 300-pF ac termination.

If you implement the circuits of **Fig 6** all in CMOS, you can divide the power calculation into two parts: I_{IC1} and I_{IC2} through IC_{17}.

In this case, the number of outputs switching (eight because of the checkerboard data pattern) will dictate the dynamic power of IC_1. The voltage swing, V_{SW} equals 5.5V, because IC_1 has a CMOS output swing and V_{CC} equals 5.5V. The frequency, f, equals 10 MHz. C_{PD} of IC_1 equals 45 pF and is the total capacitive load on IC_1. The capacitive load on IC_2 through IC_{17} consists of a 300-pF termination capacitor and the 200-pF distributed capacitance of the transmission line. The TTL power component comes from the fact that a CPU with a 3V output swing and a standard 50% data duty cycle drives IC_1. Once again, because of the checkerboard data pattern, all outputs of the 8-bit 74XXX245 are switching, so you multiply the TTL power by 8 ($N_1=8$). IC_1 is enabled 100% of the time, so its power in the output-disabled state doesn't enter into the calculation. Multiply the total power by 2 to account for the 16-bit function's two 8-bit ICs.

Total power = static power + dynamic power + TTL power

$$
\begin{aligned}
I_{IC1} &= 2(I_{CC} + N_1 \times V_{SW} \times f \times (C_{PD} + C_{TERM} + C_{DIST}) \\
&\quad + N_1 \times I_{CCT} \times DDC) \\
&= 2(80\times10^{-6} + 8\times5.5\times10^{6}\times(45\times10^{-12} + 300\times10^{-12} \\
&\quad + 200\times10^{-12}) + 8\times1.5\times10^{-3}\times0.5) \\
&= 160\times10^{-6} + 479\times10^{-3} + 12.8\times10^{-3} \\
&= 492\text{ mA.}
\end{aligned}
$$

For this example, the fact that IC_1 passes data through only one of the other 16 ($N_2=16$) bus transceivers at a time heavily influences the total power consumed by IC_2 through IC_{17}. The enable duty cycle is $6.25\% \times 1/16$. Also, because IC_1 has CMOS output swings, the steady-state inputs to IC_2 through IC_{17} will always be at one of the power rails, eliminating any TTL power components. You can also assume that IC_2 through IC_{17} each drive 10 5-pF devices, so the total load on each output is approximately 50 pF. The total power dissipated by IC_2 through IC_{17} is

$$
\begin{aligned}
I_{IC2\ THROUGH\ IC17} &= 2(N_2 \times (I_{CC} + EDC \times V_{SW} \\
&\quad \times f \times N_1 \times (C_{PD} + C_l))) \\
&= 2(16(80\times10^{-6} + 0.0625\times5.5\times10^{6} \\
&\quad \times 8\times(45\times10^{-12} + 50\times10^{-12}))) \\
&= 86\text{ mA.}
\end{aligned}
$$

The total power for the CMOS system of **Fig 1** is

$$
\begin{aligned}
P_{CMOS} &= V_{CC} \times (I_{IC1} + I_{IC2\ through\ IC17}) \\
&= 5.5V \times (492\text{ mA} + 86\text{ mA}) \\
&= 3.179W.
\end{aligned}
$$

If you implement the circuit in **Fig 6** in a bipolar logic family, you can calculate the power using the same approach as with CMOS but with these differences:

- Divide the static component into a high and a low component. Devices that are in the output-disabled state have an I_{CCZ} component.
- The bipolar circuit has no TTL power component or dynamic power-dissipating capacitance (except for the load).
- The voltage swing on the bus is 1.6V ($2\times V_{BE}$) less than V_{CC}.

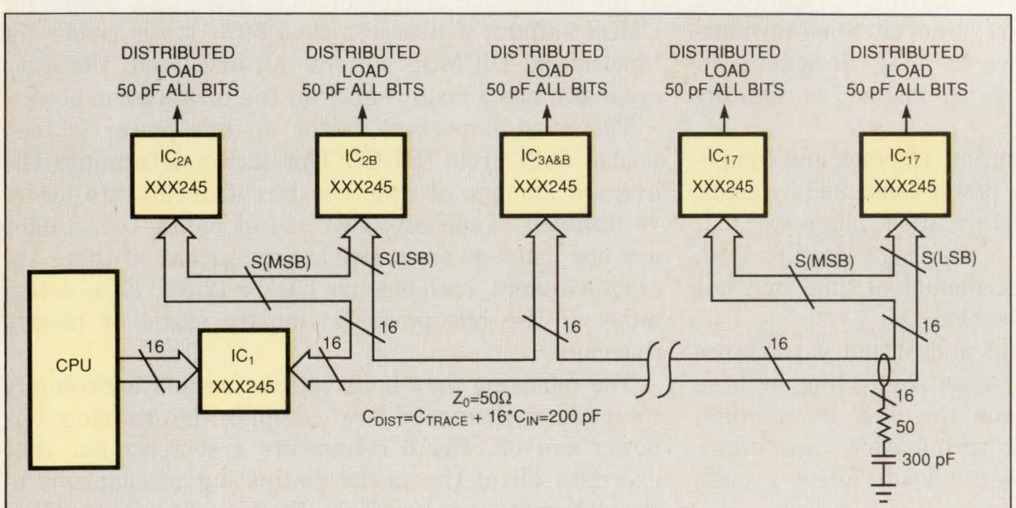

Fig 6—Power calculations for complex buses must account for transmission-line impedance, talker I/O levels, driver and listener load capacitance, trace and input capacitance, enable and data duty cycles, data pattern and frequency, and V_{CC}.

RATING		VALUE	UNIT
OPER. VOLTAGE		5 ±0.5	V
OPER. TEMPERATURE		-10 TO 70	°C
CURRENT CONSUMPTION	OPER.	15 (MAX)	mA
	STAND-BY	2 (MAX)	μA
	BACK-UP	0.5 (TYP)	μA

Table 2—Data-book power calculations for the complex system in Fig 6

Table 2A:	I_{cc}	I_{cc1}	I_{cch}	I_{ccz}	C_{pd}	I_{cct}
CMOS ('ACT245)	80 μA	N/A	N/A	N/A	45 pF	1.5 mA
Bipolar ('F245)	N/A	120 mA	90 mA	110 mA	N/A	N/A
BiCMOS ('BCT245)	N/A	90 mA	57 mA	15 mA	N/A	N/A

	IC_1 power (at 10 MHz)				IC_2 to IC_{17} power (total at 10 MHz)	System power			
Table 2B:	**Static**	**Dynamic**	**TTL**	**Total**		**10 MHz**	**20 MHz**	**30 MHz**	**40 MHz**
CMOS ('ACT245)	0.16 mA	479 mA	12 mA	492 mA	86 mA	3.12W	6.3W	9.4W	12.5W
Bipolar ('F245)	210 mA	312 mA	N/A	522 mA	3541 mA	22.3W	24.2W	26.1W	28.0W
BiCMOS ('BCT245)	147 mA	312 mA	N/A	459 mA	628 mA	6.0W	7.8W	9.7W	11.6W

N/A=not applicable.

Calculate the power as:

$$\begin{aligned} I_{IC1} &= 2(DDC \times I_{CCH} + (1-DDC) \times I_{CCL} + N_1 \times V_{SW} \\ &\quad \times f \times (C_{TERM} + C_{DIST})) \\ &= 2(0.5 \times 90 \times 10^{-3} + (0.5) \times 120 \times 10^{-3} + 8 \times 3.9 \times 10^{6} \\ &\quad \times (300 \times 10^{-12} + 200 \times 10^{-12})) \\ &= 210 \times 10^{-3} + 312 \times 10^{-3} \\ &= 522 \times 10^{-3}. \end{aligned}$$

$$\begin{aligned} I_{IC2\ THROUGH\ IC17} &= 2N_2 \times EDC \times (DDC \times I_{CCH} + (1\text{-}DDC) \\ &\quad \times I_{CCL} + N_1 \times V_{SW} \times f \times C_l) \\ &\quad + (1-EDC) \times I_{CCZ} \\ &= 2(16(0.0625 \times (0.5 \times 90 \times 10^{-3} \\ &\quad + 0.5 \times 120 \times 10^{-3} + 8 \times 3.9 \times 10^{6} \\ &\quad \times 50 \times 10^{-12}) + 0.938 \times 110 \times 10^{-3})) \\ &= 3542 \text{ mA}. \end{aligned}$$

$$\begin{aligned} P_{BIPOLAR} &= V_{CC} \times (I_{IC1} + I_{IC2\ THROUGH\ IC17}) \\ &= 5.5V \times (522 \text{ mA} + 3542 \text{ mA}) \\ &= 22.35W. \end{aligned}$$

The method for calculating the power of a BiCMOS system is identical to that for a bipolar one except that BiCMOS has much lower I_{CCZ} components than bipolar. The circuit of **Fig 6** implemented in BiCMOS would have a total power of $P_{BiCMOS} = 5.9W$.

Table 2b summarizes the results of comparing the power of CMOS, bipolar, and BiCMOS logic families in the complex system of **Fig 6**. Note that at 10 MHz the total power of IC_1 (IC_1 is 100% enabled) is larger for the pure CMOS system than for the BiCMOS because of the large dynamic power component. However, the CMOS system has the lowest total power at 10 MHz because of the low output-disabled-state power consumed in IC_2 through IC_{17}. As the bus frequency increases from 10 to 40 MHz, CMOS begins to lose its advantage and, because of its negligible dynamic currents, BiCMOS becomes the lowest total-system-power consumer at approximately 31 MHz. Bipolar always consumes more power.

Use data-book values with utmost caution

Remember that this calculation is based on data-book worst-case values, which can introduce inaccuracies into a power calculation (for example, test fixture bias and parametric guard band). Also, in a real system the voltage across the load capacitance decreases with frequency, lowering the actual system power. You can overcome these inaccuracies by using power emulation tools.

Based on data-book specifications, at 10 MHz, the system in **Fig 6** will use the least current if you implement it in CMOS (because of the low output-disabled-state power of IC_2 through IC_{17}). As the frequency increases beyond 20 MHz, dynamic power becomes the dominant component, allowing BiCMOS to consume the least power.

Begin a system design by understanding all of the system's functional, performance, and I/O requirements. Next, devise a strategy for reducing power consumption. (For example, determine the optimum configuration for the memory, bus, and power-down subsystems.) Finally, minimize the power consumption through your selection of a logic family. Of course, all of these steps are related, and the approach is iterative. That is, you may choose certain strategies with a specific logic family in mind; but with the family you settle on, the tradeoffs may be different. In general, complex systems that use several families consume the least possible power. For this reason, a piecewise approach to calculating power dissipation is best.

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CIRCLE NO. 61

POWER OPTIMIZATION

The example, **Fig 7** shows a standard personal-computer system. The piecewise approach would divide the system into sections in which you calculate power using capacitive and frequency-based approaches. For example, you would separately calculate the power dissipation in the clock generator/buffer and in the subsequent loads. Keep in mind that the system operates at several frequencies and you should calculate the power at the average frequency. For subsystems of this type, if the crystal is toggling at less than 66 MHz, CMOS logic families will usually use the least power.

The video controller and peripheral controller represent pipeline elements. For pipeline elements operating at speeds above 40 MHz, if CMOS-voltage-level compatibility is not an issue, bipolar or BiCMOS will normally yield the lowest power. For pipeline systems, data-book calculations are normally accurate.

You should treat the dynamic-RAM array as a highly capacitive load. Once you have determined the memory organization and you know the capacitance, you can determine the power by emulating the subsystem in a test fixture. You should remove the load resistor bias (either mechanically or mathematically) before comparing logic families. In most cases, BiCMOS and bipolar are preferable for driving memory arrays at frequencies above 20 MHz.

Finally, analyze the bus itself. A complex data-book calculation can point you in the right direction, but a power emulation tool, such as the one discussed in the **box**, "System emulation predicts power precisely," will more accurately predict which logic family will dissipate the least power. Moreover, an emulation tool can help in selecting a termination scheme or in segmenting the number of loads. In most cases, to conserve power, you should use CMOS to implement bus elements that have low EDCs (for example, keyboards, peripherals, BIOS ROMs, and video transceivers). On the other hand, you should implement the CPU transceiver, which toggles constantly, in bipolar or BiCMOS.

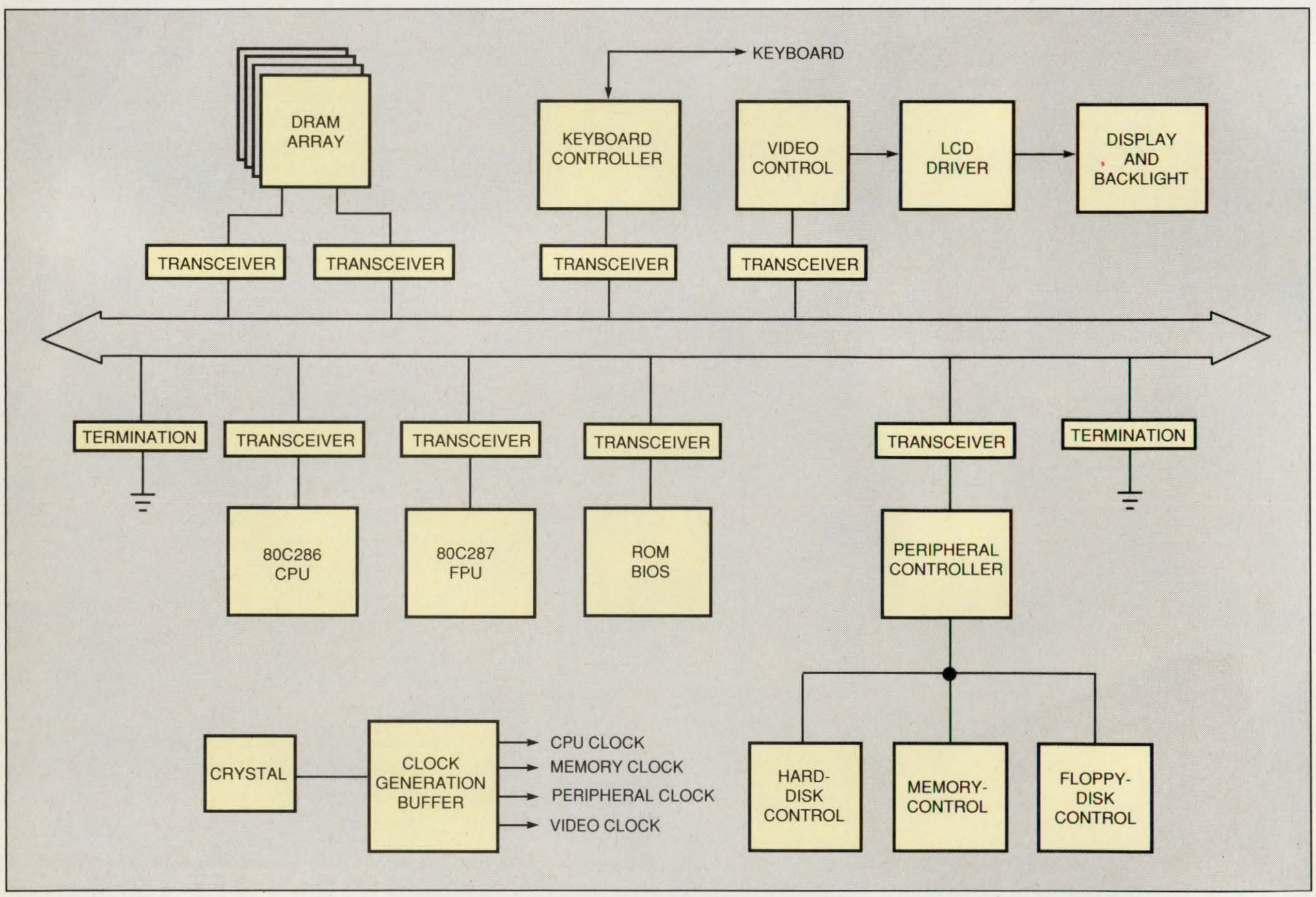


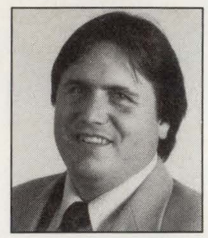
Fig 7—When you determine a strategy for minimizing a system's power consumption, you may want to implement different portions of the system using different IC families. The major subsystems of a high-performance personal computer are no exception.

POWER OPTIMIZATION

Of course, these steps are just guidelines. The real keys to designing low-power systems are having an intimate understanding of the systems' requirements, being aware of the complexities of power, and being willing to use several logic families in a single design. EDN

Authors' biographies

William M Hall is National Semiconductor's advanced CMOS logic marketing manager for its Standard Products Div. He is a graduate of Drexel University in Philadelphia, PA. Prior to joining Fairchild Semiconductor in 1985 (which later became part of National Semiconductor), he was responsible for designing and testing radar-based digital signal processors at RCA. Bill has written numerous papers on topics ranging from device and system noise to high-speed-design techniques.



Ray Mentzer is National's staff advanced bipolar design engineer for the FAST, FASTr, BCT, and F100K/300 Series ECL logic families. With more than 10 years in design, applications, and product engineering at Fairchild and National Semiconductor, his expertise covers bipolar, BiCMOS, and ECL device design as well as board-level design. A graduate of Purdue University, Ray has authored several papers on topics that include designing to deter metastable conditions, ground bounce, and EMC faults. He has one patent pending and has developed 18 new products.

Article Interest Quotient (Circle One)
High 476 Medium 477 Low 478

WHAT'S COMING IN EDN

EDN Magazine's April 9, 1992 and April 23, 1992, issues will present a 2-part, hands-on FPGA (field-programmable gate-array) project. EDN Regional Editor Doug Connor takes you through an actual FPGA design from start to finish: Part 1 describes the design specifications, what the circuit does, and differences between FPGAs and tools. Part 2 picks up with the FPGA's place-and-route and timing-verification functions and an analysis of the completed design.

In addition, the News edition's April 30, 1992, Product Watch section will examine FPGAs and EPLDs. This round-up will look at what silicon is on the market as well as the availability and cost of related tools. Look for both editions of EDN for complete coverage on FPGA design.

LINEAR TECHNOLOGY

Battery Powered DC/DC Conversion Circuit Collection

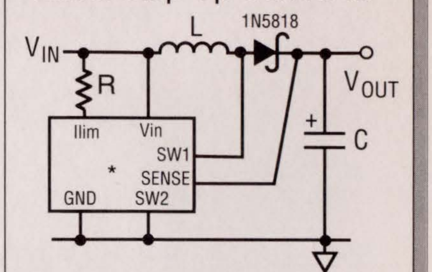
The following tables form a shortform component selection guide for a collection of commonly used battery powered DC to DC conversion applications. No design is required since inductor, capacitor and resistor values are completely specified. Choose the appropriate LTC DC to DC converter for your application from the following tables.

Step Up From One Cell (1V)

V_{OUT}	I_{OUT}	P/N	I_Q	L	C	R	
5V	40mA	LT1073-5	95µA	82µH	100µF	0Ω	Lowest I_Q
	40mA	LT1110-5	350µA	27µH	33µF	0Ω	**Best For Surface Mount**
12V	15mA	LT1073-12	95µA	82µH	100µF	0Ω	Lowest I_Q
	15mA	LT1110-12	350µA	27µH	33µF	0Ω	**Best For Surface Mount**

•ADJUSTABLE VERSIONS ALSO AVAILABLE FOR V_{OUT} UP TO 50V

Basic Step Up Converter



* See Tables For Recommended Part, Inductor, Capacitor and Resistor Values

Step Up From Two Cells (2V)

V_{OUT}	I_{OUT}	P/N	I_Q	L	C	R	
5V	90mA	LT1173-5	110µA	47µH	100µF	47Ω	Lowest I_Q
	90mA	LT1111-5	350µA	18µH	33µF	47Ω	Smallest Board Space/**Best For Surface Mount**
	150mA	LT1073-5	95µA	100µH	100µF	47Ω	More Output Current/Lowest I_Q
	150mA	LT1110-5	350µA	33µH	33µF	47Ω	More Output Current/Smallest Board Space/**Best For Surface Mount**
	20mA	LT1109CZ-5	1mA	33µH	10µF	N/A	3 Pin Package/Lowest Cost/**Best For Surface Mount (8 Lead Version)**
12V	20mA	LT1173-12	110µA	47µH	47µF	47Ω	Lowest I_Q
	20mA	LT1111-12	350µA	18µH	22µF	47Ω	Smallest Board Space/**Best For Surface Mount**
	40mA	LT1073-12	95µA	82µH	100µF	47Ω	More Output Current/Lowest I_Q
	40mA	LT1110-12	350µA	27µH	33µF	0Ω	More Output Current/Smallest Board Space/**Best For Surface Mount**
	20mA	LT1109CZ-12	1mA	20µH	4.7µF	N/A	3 Pin Package/Lowest Cost/**Best For Surface Mount (8 Lead Version)**

• ADJUSTABLE VERSIONS ALSO AVAILABLE FOR V_{OUT} UP TO 50V

Step Up From 5V To 12V

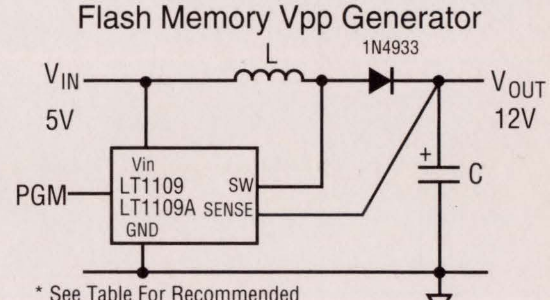
V_{OUT}	I_{OUT}	P/N	I_Q	L	C	R	
12V	90mA	LT1173-12	110µA	120µH	100µF	0Ω	Lowest I_Q
	90mA	LT1111-12	350µA	47µH	33µF	0Ω	Smallest Board Space/**Best For Surface Mount**
	175mA	LT1073-12	95µA	180µH	100µF	0Ω	More Output Current/Lowest I_Q
	175mA	LT1110-12	350µA	60µH	33µF	0Ω	More Output Current/**Best For Surface Mount**
	60mA	LT1109CZ-12	1mA	33µH	10µF	N/A	3 Pin Package/Lowest Cost/**Best For Surface Mount (8 Lead Version)**

• ADJUSTABLE VERSIONS ALSO AVAILABLE FOR V_{OUT} UP TO 50V

Flash Memory Vpp (12V) Generation

V_{IN}	V_{OUT}	I_{OUT}	P/N	I_Q	L	C	
5V	12V	60mA	LT1109-12	350µA	33µH	22µF	All Surface Mount
		120mA	LT1109A-12	350µA	27µH	47µF	All Surface Mount
2 Cells	12V	60mA	LT1109A-12	350µA	10µH	22µF	All Surface Mount

Flash Memory Vpp Generator



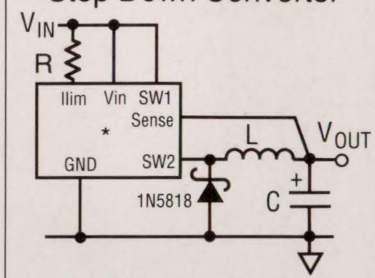
* See Table For Recommended Inductor, and Capacitor Values

LINEAR TECHNOLOGY Linear Technology Corp. 1630 McCarthy Blvd., Milpitas, CA 95035 (408) 432-1900

Step Down Conversion to 5V

V_{IN}	I_{OUT}	P/N	I_Q	L	C	R	
6.5V to 12V	50mA	LT1173-5	110μA	47μH	100μF	100Ω	Lowest I_Q
	50mA	LT1111-5	330μA	18μH	33μF	100Ω	**Best For Surface Mount**
	90mA	LT1073-5	95μA	47μH	100μF	220Ω	More Output Current/Lowest I_Q
	90mA	LT1110-5	330μA	15μH	33μF	220Ω	More I_{OUT}/**Best For Surface Mount**
9V to 20V	300mA	LT1073-5	95μA	180μH	330μF	100Ω	Lowest I_Q
	300mA	LT1110-5	330μA	60μH	100μF	100Ω	**Best For Surface Mount**
12V to 20V	300mA	LT1173-5	110μA	220μH	220μF	220Ω	Lowest I_Q
	300mA	LT1111-5	330μA	82μH	100μF	220Ω	**Best For Surface Mount**
20V to 30V	300mA	LT1173-5	110μA	470μH	470μF	100Ω	Lowest I_Q
	300mA	LT1111-5	330μA	180μH	220μF	100Ω	**Best For Surface Mount**

Step Down Converter



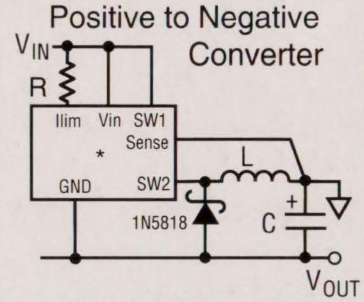
* See Tables For Recommended Part, Inductor, Capacitor and Resistor Values

• ADJUSTABLE OUTPUT VOLTAGES UP TO 6.2V CAN BE OBTAINED WITH THE ADJUSTABLE VERSIONS OF LT1173, LT1111, LT1073 OR LT1110

Positive to Negative Voltage Conversion

V_{IN}	V_{OUT}	I_{OUT}	P/N	I_Q	L	C	R	
5V	-5V	75mA	LT1173-5	250μA	100μH	100μF	100Ω	Lowest I_Q
	-5V	75mA	LT1111-5	650μA	33μH	33μF	100Ω	**Best For Surface Mount**
	-5V	150mA	LT1073-5	220μA	180μH	470μF	100Ω	More Output Current
	-5V	150mA	LT1110-5	650μA	68μH	150μF	100Ω	More I_{OUT}/**Best For Surface Mount**
12V	-5V	250mA	LT1173-5	110μA	470μH	220μF	100Ω	Lowest I_Q
	-5V	250mA	LT1111-5	330μA	180μH	82μF	100Ω	**Best For Surface Mount**

Positive to Negative Converter



* See Tables For Recommended Part, Inductor, Capacitor and Resistor Values

Inductor and Capacitor Part Numbers/Manufacturers

Inductor Value	Caddell-Burns	Coiltronics †	Sumida †
15μH	7070-15	----	CD54-150LC
18μH	7070-16	CTX20-1	CD54-180LC
20μH	----	CTX20-1	----
22μH	7070-17	CTX20-1	CD54-220LC
27μH	7070-18	----	CD54-270LC
33μH	7070-19	----	CD54-330LC
47μH	7300-09	CTX50-1	CD74-470LC
68μH	7300-11	----	CD74-680LC
82μH	7300-12	CTX82-1	CD74-820LC
100μH	7300-13	CTX100-1	CD105-101MC
120μH	7300-14	CTX100-1	CD105-121MC
180μH	7200-16	CTX250-4	CDR125-181MC
220μH	7200-17	CTX250-4	CDR125-221MC
470μH	7200-21	----	CDR125-471MC

† Surface Mount Inductors

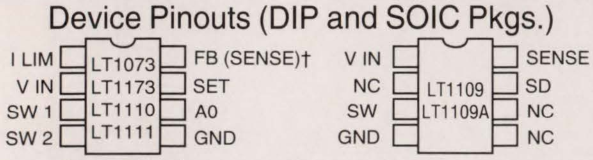
Inductor Manufacturers

Caddell-Burns	Mineola, NY, USA 11501	516-746-2310	FAX: 516-742-2416
Gowanda Elect.	Gowanda, NY, USA 14070	716-532-2234	FAX: 716-532-2702
Coiltronics Intl.	Pompano Beach, FL, USA	305-781-8900	FAX: 305-782-4163
Sumida	Arlington Heights, Ill, USA	708-956-0666	FAX: 708-956-0702

Capacitor Manufacturers

Best:	OS-CON Series	Sanyo Video	San Diego, CA, USA 92073	619-661-6322
Better:	PL Series	Nichicon America	Schaumberg, IL, USA 60173	708-843-7500
Good:	150D or 550D	Sprague Electric	Sanford, ME, USA 04073	207-324-4140

Device Pinouts (DIP and SOIC Pkgs.)



† -5, -12 Versions

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Multipliers implement tunable filters

Tom Napier, Aydin Computer and Monitor Div, Horsham, PA

The circuits illustrated in **Fig 1** use multiplier ICs to implement tunable filters. Tunable filters perform important antialiasing functions in sampled data systems that have variable sampling rates. The circuit in **Fig 1a** is a simple 1-pole filter. **Fig 1b** is a form of 2-pole state-variable filter. You can use the same architecture to build higher order filters. The Harris HA-2547 analog multiplier chip is essentially a voltage-controlled transimpedance amplifier with a very high output impedance and a large output compliance. When driving capacitive loads, the multipliers behave like voltage-tunable integrators with a ±6V output. With a 2V control input, the multiplier's effective transimpedance is 2500Ω. With a 100-mV control input, the transimpedance rises to 50 kΩ.

Each filter requires only two or four parts, with the exception of the bypass capacitors. The filters' cut-off frequencies are voltage tunable over a 20-to-1 range and usable from very low frequencies to as high as several megahertz. The filters do exhibit high input impedances and high output impedances. Thus, unless the filter drives a high-input-impedance ADC, it requires an output buffer. Offset trimming may be necessary in critical applications.

The theoretical transfer functions of **Fig 1a** and **Fig 1b**, respectively, are as follows:

$$\frac{1}{1+sT_1}$$

and

$$\frac{1}{1+sT_2+s^2T_2T_3}.$$

Time constants T_1, T_2, and T_3 equal the variable transimpedances multiplied by C_1, C_2, and C_3, respectively. In **Fig 1b,** the product of T_2 and T_3 sets the cut-off frequency, and the ratio of T_2 to T_3 controls the Q. For a Butterworth response, C_2 should be twice C_3. With capacitor values of 62 and 30 pF, the 2-pole filter's tuning range spans 50 kHz to 1 MHz. The filter's useful range is limited to about 5 MHz by the output capacitance of the multiplier, which is approximately 10 pF. The measured response indicates that a zero exists due to feedthrough, but the measured stopband attenuation is over 30 dB. **EDN BBS /DI_SIG #1097**

To Vote For This Design, Circle No. 746

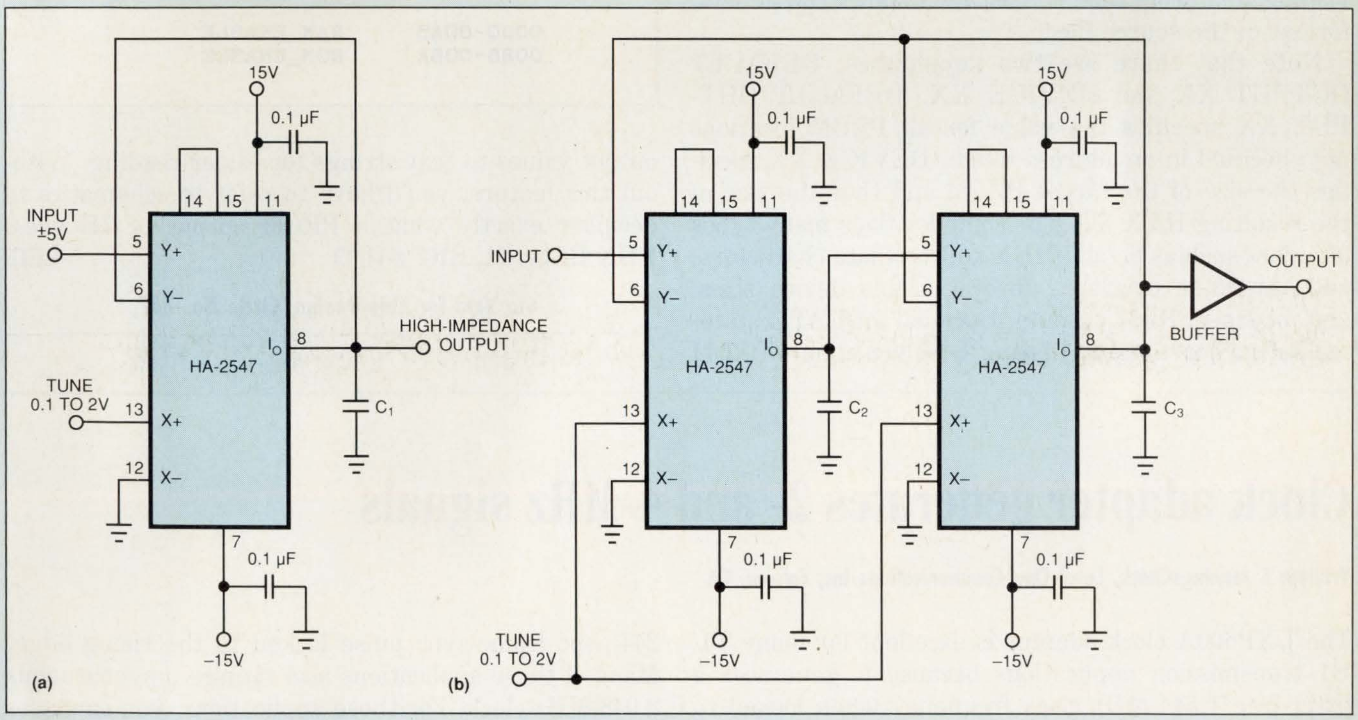

Fig 1—Using multipliers as voltage-controlled transimpedance amplifiers gives these filters a 1-pole and 2-pole state-variable low-pass filter and a tuning range of 20 to 1.

Compiler generates PROM decoder HEX file

Ralph Ursoleo, Inovec Inc, Eugene, OR

PROMs have long been recognized as excellent address decoders because of their great flexibility compared with discrete logic decoders. PROMs can generate contiguous chip-select signals for multiple devices of different sizes without wasting address space, and the PROM implementation uses only one level of logic so it's relatively fast. PROMs also allow for device-size changes without hardware modifications.

Unfortunately, generating the PROM data has always been a tedious, manual process, usually involving large tables of binary/HEX addresses to map the entire PROM. Once you generate the table, you manually enter the PROM data into a programming device and upload to a computer that creates the .HEX file for later use. Entering or changing the .HEX file requires that you use a typically crude programmer editor, which can be a frustrating, error-prone experience.

The compiler called PROMGEN, which you can download using EDN's BBS, lets you describe the decoder in text format using a standard text editor. This text (source) file, which allows descriptive comments, can be as detailed in its explanation as you wish. Once generated, PROMGEN scans the source file for errors and generates an Intel HEX format file for downloading to a programmer. **Listing 1** shows the general format of the source file.

Note that there are two keyphrases: DEFAULT OUTPUT XX and DEVICE XX. DEFAULT OUTPUT XX specifies the value for all PROM locations not specified in an address range. DEVICE XX specifies the size of the target PROM and thus the size of the resulting HEX file. The compiler flags many types of errors such as invalid HEX address/data characters, address range overlaps, unrecognizable device sizes, and missing PROM outputs. Optional EQUATE statements, such as those in **Listing 2,** let you equate PROM output values to text strings for easier reading. Without this feature, you'd have to refer to schematics to decipher exactly what a PROM output of 7E does.

EDN BBS /DI_SIG #1099

Listing 1—General format of compiler source file

```
;DESIGNER                        [comments preceeded with semi-colon]
;DESCRIPTION
;REVISION
;   |
;COMMENTS

DEFAULT OUTPUT FF                [for address locations not specified]

DEVICE  2KX8                     [size of target device]

; PROM
;address     PROM        Comments
;range       output

0000-0005     FE      ;corresponds to system I/O address 8000H-8005H
                      ;selects the timer chip

0006-0006     F7      ;corresponds to system address 8006H
                      ;accesses the control latch

0020-009F     7E      ;comments

0100-0200     55      ;comments
```

Listing 2—Equate-statement examples

```
EQUATE        RAM_ENABLE      FE
EQUATE        ROM_ENABLE      7F

;address          PROM
; range          output

0000-00A5       RAM_ENABLE
00B8-00BA       ROM_ENABLE
```

To Vote For This Design, Circle No. 747

Clock adapter generates 2- and 4-MHz signals

William S JenningsCheck, Level One Communications Inc, Folsom, CA

The LXP600A clock adapter is excellent for many T1/E1 transmission applications because it generates a jitter-free 1.544-MHz clock frequency when locked to a 2.048-MHz master clock or vice-versa. However, some applications require a 4.096-MHz clock with a 244-μsec frame-sync pulse locked to the rising edge. Many of these applications also require a synchronous 2.048-MHz clock. For these applications, you can combine a clock adapter with an HCT4046A phased-locked loop (PLL), two 74HCT00 NAND gates, and three

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SPECIFICATIONS (typ)

	Absorptive SPDT YSWA-2-50DR ZYSWA-2-50DR			Reflective SPDT YSW-2-50DR ZYSW-2-50DR		
Frequency (MHz)	dc-500	500-2000	2000-5000	dc-500	500-2000	2000-5000
Ins. Loss (dB)	1.1	1.4	1.9	0.9	1.3	1.4
Isolation (dB)	42	31	20	50	40	28
1dB Comp. (dBm)	18	20	22.5	20	20	24
RF Input (max dBm)		20		22	22	26
VSWR "on"	1.25	1.35	1.5	1.4	1.4	1.4
Video Bkthru (mV,p/p)	30	30	30	30	30	30
Sw. Spd. (nsec)	3	3	3	3	3	3
Price, \$ (1-9 qty)	YSWA-2-50DR (pin) 23.95 ZYSWA-2-50DR (SMA) 69.95			YSW-2-50DR (pin) 19.95 ZYSW-2-50DR (SMA) 59.95		

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Mini-Circuits

CIRCLE NO. 101

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F141 REV. C

74HCT74 leading edge-triggered flip-flops to produce the desired outputs.

Fig 1 shows a clock adapter, IC_1, functioning in the 1.544- to 2.048-MHz mode. In this mode, the clock adapter produces a 2.048-MHz clock output plus an 8-kHz frame-sync output. The frame-sync output is a 488-μsec pulse that is locked to the falling edge of the clock output. The potentiometer attached to IC_2's PLL's R_1 pin lets you tune the PLL's VCO (voltage controlled oscillator) to 4.086 MHz. The VCO's output is synchronized to the clock adapter's clock output. The comparison input is provided by the Q output of flip-flop 1, at one-half the VCO frequency.

The VCO produces both the 4.096- and 2.048-MHz clock frequencies at the $\overline{C_4}$ and C_2 outputs, respectively (**Fig 2**). IC_{3A} functions as a simple inverter, producing the $\overline{C_4}$ clock from the clock-adapter-synchronized VCO output. The $\overline{Q}$ output of IC_{4A} produces the C_2 clock, which is also tied back to the D input. Flip-flops IC_{4B} and IC_{5A}, and IC_{3B} produce $\overline{FO}$ from the clock adapter's FSO output. **EDN BBS /DI_SIG #1098**

To Vote For This Design, Circle No. 748

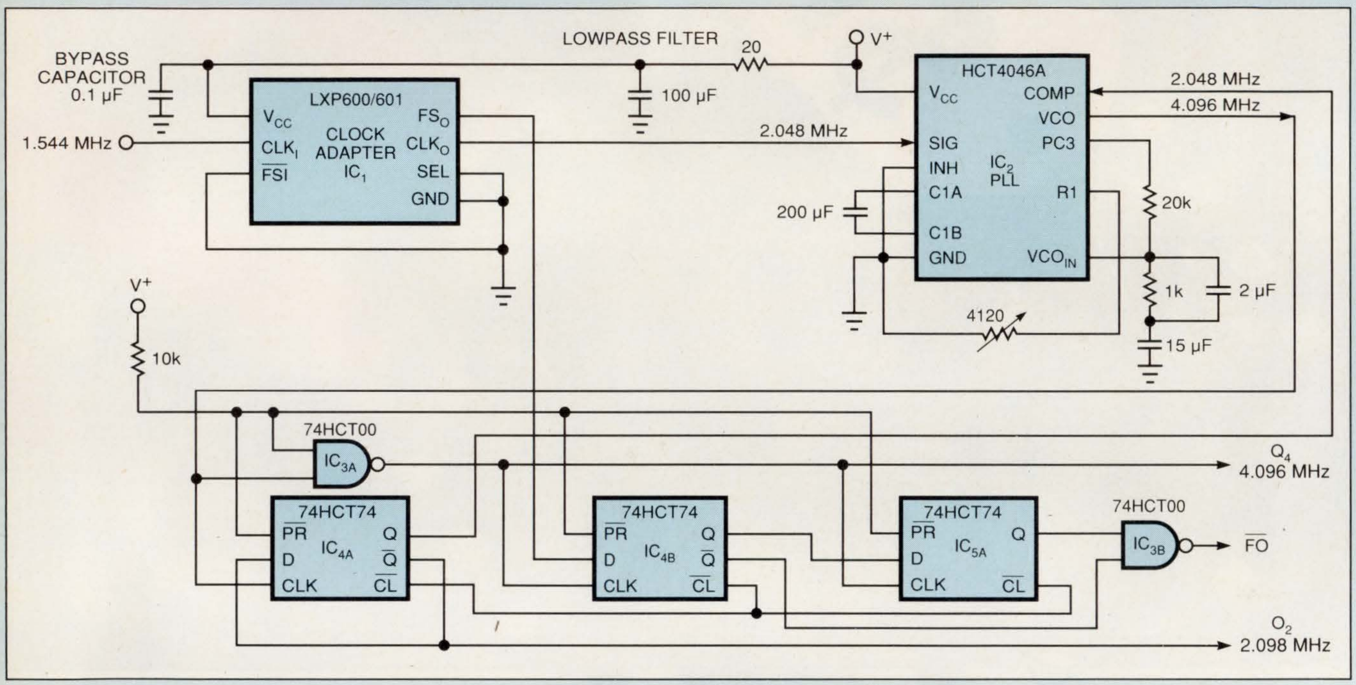

Fig 1—Adding a phase-locked loop, three flip-flops, and a pair of NAND gates to a clock-adapter IC gives you a 4.096-MHz clock with a 244-μsec frame-sync pulse, plus one synchronous 2.048-MHz clock.

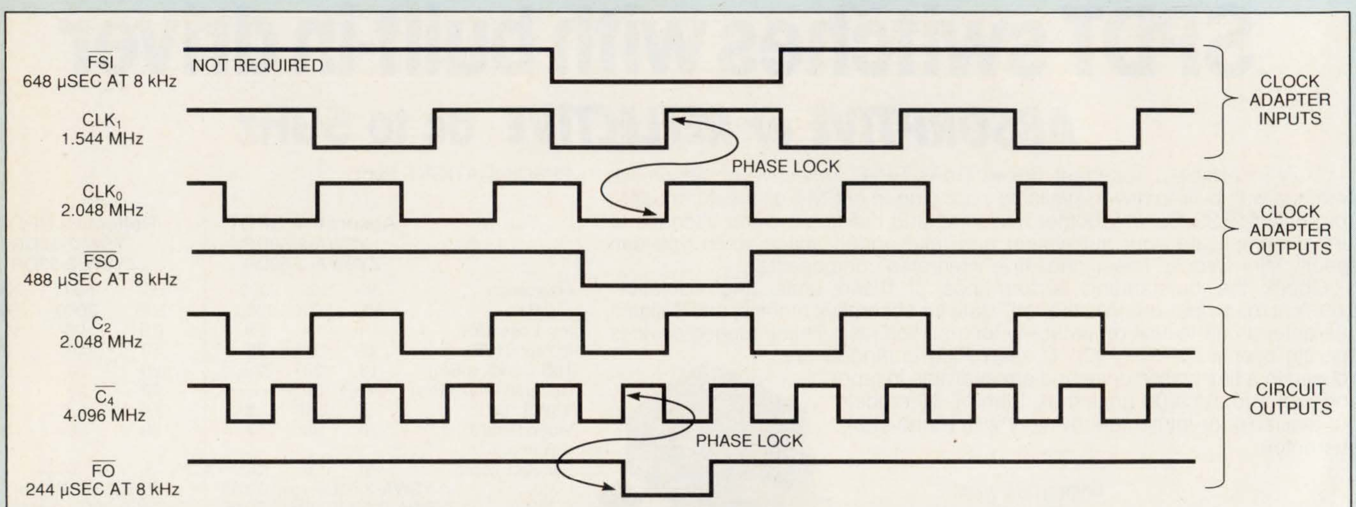

Fig 2—This timing diagram illustrates the relationships between the 2- and 4-MHz clock signals generated by Fig 1's circuit.

High-voltage regulator has low dropout

Dana W Davis, Maxim Integrated Products, Sunnyvale, CA

The positive voltage regulator of **Fig 1** maintains 5V regulation at 1A with inputs as low as 5.02V. The circuit's pass transistor is an n-channel MOSFET. MOSFETs having low $R_{DS(ON)}$ are the key to this application because dropout voltage is proportional to $R_{DS(ON)}$. Fortunately, high-power MOSFETs having extremely low $R_{DS(ON)}$ are both inexpensive and readily available.

IC_2, an LM10, contains a precision op amp, a voltage reference, and a variable-gain buffer. External resistors configure the buffer for a gain of 25, boosting the 0.2V reference to a regulated 5V at IC_2's pin 1. By comparing this 5V reference with the regulated output, V_{OUT}, IC_2's internal op amp produces an error voltage that drives the MOSFET's gate. Powered by the high-side power supply, IC_1, IC_2 delivers a gate drive of $V_{CC}+11V$ (approximately 16V). At $I_{OUT}=5A$, the resulting dropout voltage is under 400 mV for an IRF541 MOSFET, and under 100 mV for an SMP60N06. The output voltage depends on R_1 and R_2:

$$V_{OUT}=0.2((R_2/R_1)+1).$$

Gate-leakage current in the MOSFET, unlike base current in a bipolar transistor, does not change with the load current. Therefore, the operating supply current of **Fig 1**'s circuit, drawn only by IC_1 and IC_2, is relatively independent of the load current.

The ENABLE/$\overline{\text{SHUTDOWN}}$ input controls the regulator and must supply at least 2 mA. Diode D_1 shortens the turn-on time following an ENABLE/$\overline{\text{SHUTDOWN}}$ command. During shutdown, the only current that the circuit draws is leakage current through the pass transistor. If you do not need the shutdown function, eliminate D_1 and connect V_{CC} directly to the input power.

At power-up with the regulator enabled, the PR output of IC_1 remains low, holding the MOSFET off by depressing the reference voltage at the noninverting input of IC_2. The regulator thus remains off until the gate-drive voltage rises to an acceptable level, typically $V_{CC}+8.5V$.

The output capacitor, C_1, stabilizes the output voltage against load changes. If your load is relatively constant, you can reduce or eliminate C_1.

Input voltage may range as high as 16.5V, but a lower level (produced by a stack of five NiCd cells, for example) offers higher efficiency.

EDN BBS /DI_DIG #1090

To Vote For This Design, Circle No. 749

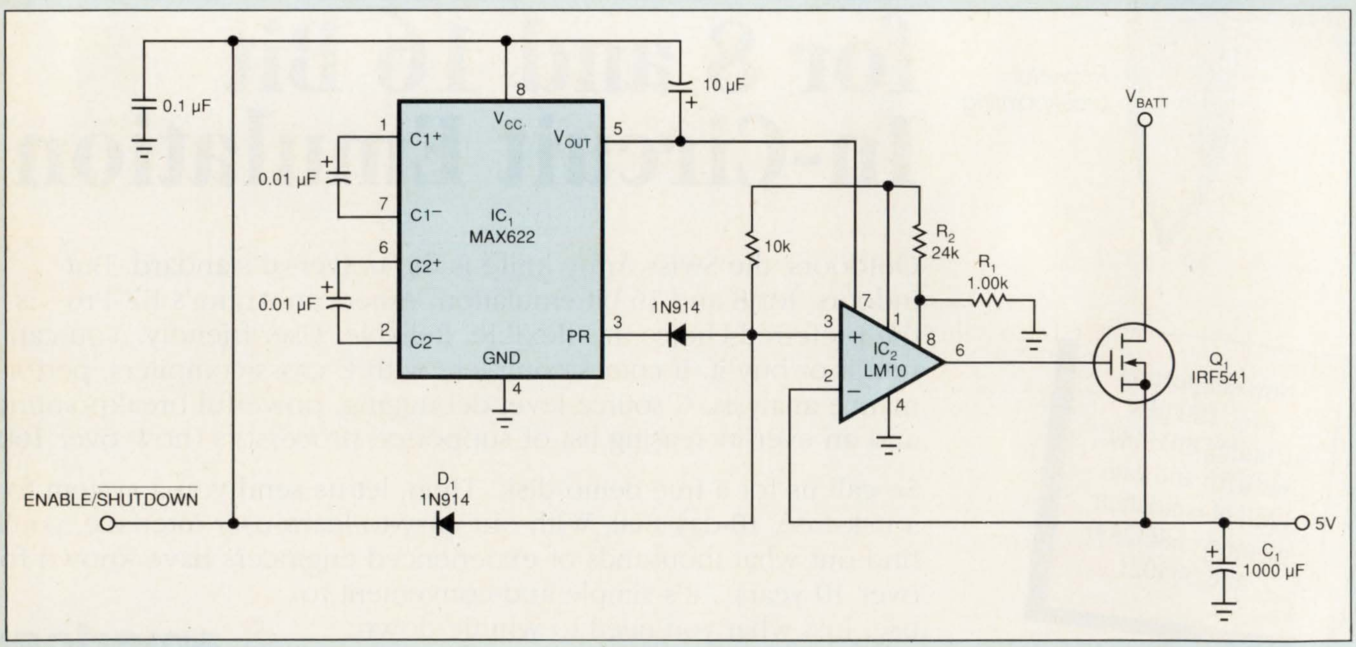

Fig 1—This power supply takes advantage of n-channel MOSFETs' low $R_{DS(ON)}$ to provide dropout voltages measured in hundreds of millivolts.

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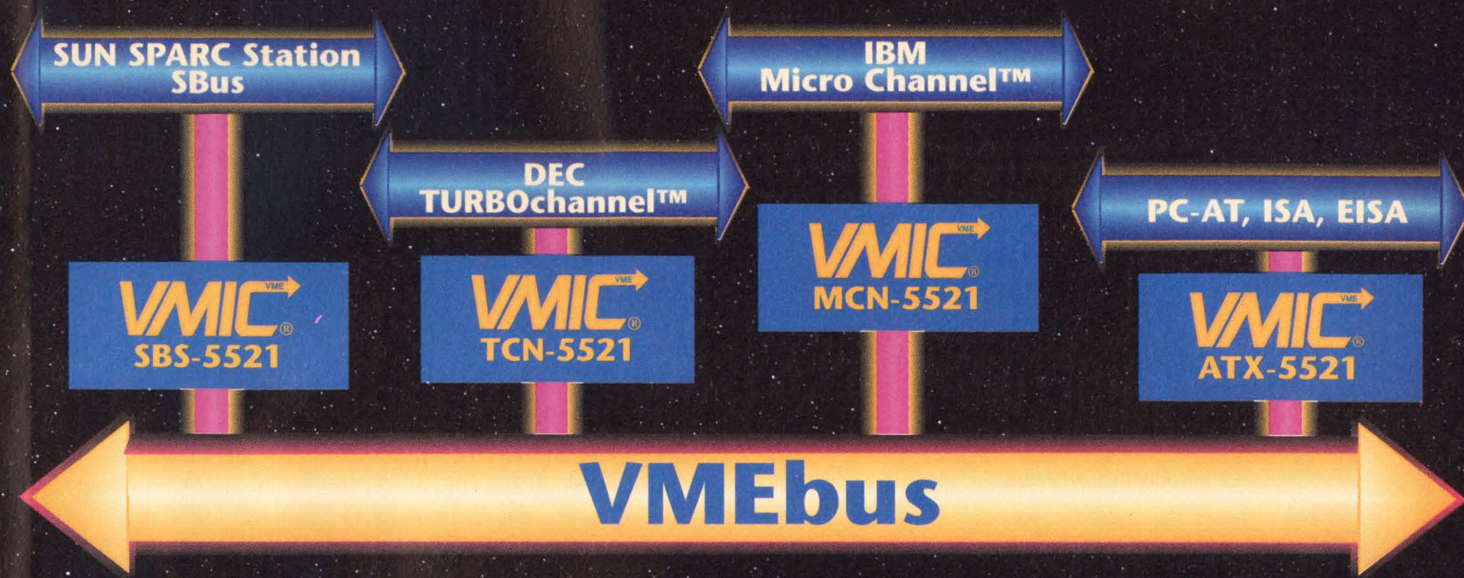

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CIRCLE NO. 105

Reader questions circuit

I believe the printed schematic of Mr Cuthbert's interesting circuit, "Charge pump halves voltage," on pg 204 of the December 5, 1991, issue of EDN contains a critical error. Q_3's drain-source connections are across the C_1 330-μF capacitor. When Q_3 turns on, this connection will create a short circuit across C_1. Also, why use two inverters, IC_{1E} and IC_{1F}, in parallel?

Finally, there was no mention of another key point. IC_1's dc supply voltage must be large enough to ensure proper turn on of Q_1 to Q_4. For example, the gate-to-source voltage of Q_3 is IC_{1C}'s V_{OUT} minus ½ V_{IN}. Therefore, with an input of 12V, the 4049 inverter should be supplied by at least $V_{GS(ON)}+6V$. So the typical 5V regulated V_{CC} on IC_1 wouldn't work. However, I think he could use the V_{IN} voltage itself as the supply to guarantee turn on.

Tony Veneruso
Schlumberger
228, rue Einstein
BP 592 77005 Melun Vedex, France

Author reply

Mr Veneruso is correct concerning the circuit connections. The drain-source connections of Q_3 connect to the opposite drain lead of Q_2, and not to C_1 as incorrectly drawn. To address his other questions, I used two inverters in parallel because I had one left over, and the input capacitance of Q_1 is double that of Q_2, Q_3, or Q_4. Also, I thought it was implied that the V_{CC} for IC_1 is the same as V_{IN}.

Two other minor discrepancies exist between my original circuit and the one published. The resistor between IC_{1B} and IC_{1D} was supposed to be 100 kΩ. Also, the gate resistor Q_2 is 100 ohms. Neither of these resistor-value differences will degrade the circuit's performance.

Dave Cuthbert
Tektronix
Box 500, M/S W3-100
Beaverton, OR 97077

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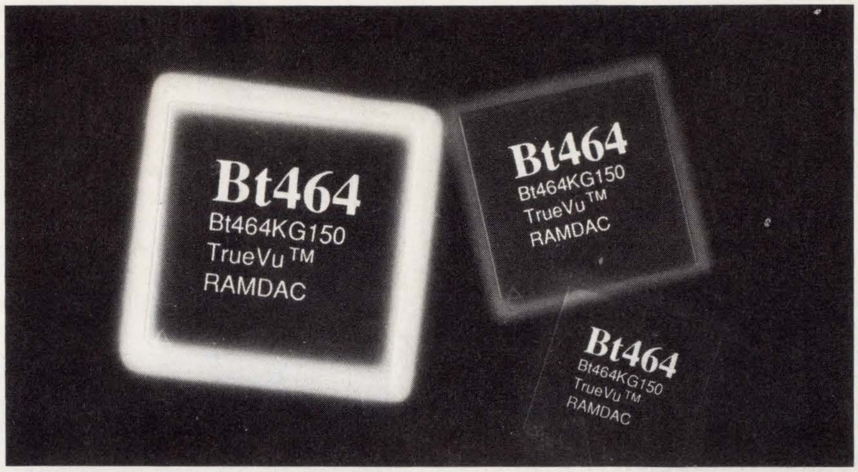
RAMDAC With Resolution Of 1280×1024 Pixels

- *Supports 24-bit color displays*
- *Features a 5:1 input multiplexer*

The Bt464 RAMDAC supports true 24-bit color displays at resolutions to 1280×1024 pixels. Multiplexed input ports provide multiplexer options of 1:1, 2:1, 4:1, and 5:1, and a 5:1 frame buffer reduces video RAM (VRAM) memory requirements. With binary frame-buffer addressing, 48 1-Mbit VRAMs are needed to support 1280×1024 monitors for 24 bits. With a 5:1 multiplexer, a frame buffer using quinary addressing can reduce the number of VRAMs to 30, lowering memory costs. Other features of the Bt464 include pixel interleaving, which provides the end user with a faster line-drawing time in complex CAD/CAM applications, and the ability to allow users to switch between true color and pseudocolor on a pixel-×-pixel basis. The RAMDAC is available in speed grades of 110, 135, and 150 MHz and comes in a 208-pin, pin-grid-array package. 135-MHz version, $328 (100).



Brooktree Corp, 9950 Barnes Canyon Rd, San Diego, CA 92121. Phone (619) 452-7580. FAX (619) 452-1249. TLX 383596. **Circle No. 413**

Simultaneous-Sampling 4- or 8-Channel ADCs

- *Low channel-to-channel phase delay*
- *Have track-and-hold circuits for each channel*

The MAX155 (8-channel) and MAX156 (4-channel) A/D converters simultaneously sample each analog input signal and sequentially digitize them to 8-bit accuracy in 3.6-μsec/channel. Each channel has its own track-and-hold (T/H) circuit, which reduces channel-to-channel phase delay to less than 4 nsec, compared with several μsec for ADCs with a single T/H circuit. Both devices contain a 2.5V reference, an 8×8-bit RAM to store results, and an 8-bit microprocessor interface. The ADCs operate from ±5V supplies or a single 5V supply and perform unipolar or bipolar conversions with either single-ended or differential inputs. The internal data bus provides for bidirectional data flow, allowing user-defined setup and access to stored RAM conversion data. The MAX155 comes in 28-pin DIP and SO packages; the MAX156 comes in 24-pin DIP and 28-pin SO packages. From $10 (1000).

Maxim Integrated Products, 120 San Gabriel Dr, Sunnyvale, CA 94086. Phone (408) 737-7600. **Circle No. 414**

Baseband I/O Ports For Digital Radio Systems

- *Combine A/D and D/A converters*
- *Provide audio-to-IF/RF interface*

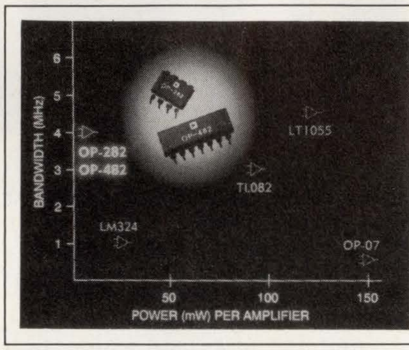
Designed for digital-mobile-radio systems such as the Pan-European Digital Cellular Telephone, the AD7001 and AD7002 baseband I/O ports provide key functions in the transmit and receive paths. Combining A/D and D/A converters for I and Q channel information, along with filtering, a serial interface, and pulse-shaping ROM, these devices perform signal conversion between the audio section and the IF/RF sections in mobile telephones. By digitizing and encoding the voice at the source and transmitting entirely in digital format, several on-line users can share each available channel. Although both I/O ports perform similar functions, they use different internal architectures to meet specific user needs. The AD7001 uses a successive-approximation A/D converter; the AD7002 features a sigma-delta converter, along with additional DACs for frequency control, gain control, and signal shaping. Both devices operate from a 5V supply and come in 44-pin quad flatpacks. $25 (1000).

Analog Devices, 181 Ballardvale St, Wilmington, MA 01887. Phone (617) 937-1428. **Circle No. 415**

Field-programmable gate arrays. The CLi6000 series of high-speed, static-RAM-based, field-programmable gate arrays (FPGAs) feature a toggle rate of 150 MHz and run to 70 MHz. Power consumption is less than 2 mA/MHz. The first members of the series are the CLi6002, CLi6003, and CLi6005, with 2000, 3000, and 5000 gates, respectively. Package options include 84-pin plastic leaded chip carriers and 132-pin plastic quad flatpacks. From $58 to $180 (OEM qty). **Concurrent Logic Inc,** 1290 Oakmead Pkwy, Sunnyvale, CA 94086. Phone (408) 522-8700. FAX (408) 732-2765. **Circle No. 416**

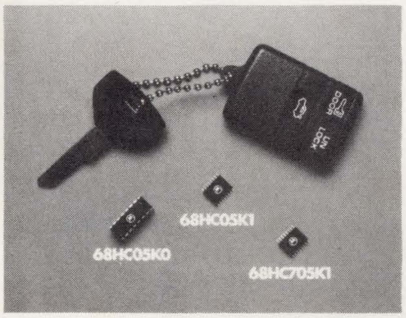
30-MHz Transputer. A 30-MHz version of the IMS T805 Transputer, the T805-G30S, provides a peak performance of 30 MIPS and 4.3 Mflops, 50% greater than the 20-MHz version. This version features an interrupt response time of 630 nsec and average power consumption of 660 mW. The T805 integrates a 32-bit CPU, a 64-bit floating-point unit, 4-kbytes of memory, a 4-Gbyte multiplexed memory bus and four communications links. In an 84-pin pin-grid array or 100-pin ceramic flatpack. From $390 (500). **SGS-Thomson Microelectronics,** 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6228. **Circle No. 417**

Low-power op amps. The OP-282 (dual) and OP-482 (quad) op amps combine precision and moderate speed with low-power operation. Drawing a maximum supply current of 250 μA, each amplifier features a unity-gain bandwidth of 4 MHz, a slew rate of 7V/μsec and a settling time of 1.6 μsec to 0.01%. Typical bias current is 3 pA at 25°C. Offset voltage is 3 mV for dual units and 4 mV for quad units. OP282 and OP482, $1.05 and $1.72, respectively, (1000). **Analog Devices Inc,** PMI Div, 1500 Space Park Dr, Santa Clara, CA 95052. Phone (408) 562-7456. **Circle No. 418**



20-MHz floating-point DSP. The ADSP-21020 floating-point DSP features a clock speed of 20 MHz (50-nsec cycle time). The DSP performs a 1024-point complex FFT in 0.96 nsec, three times faster than comparable devices. The DSP, which comes in a 223-pin pin-grid-array package, is available in commercial (0 to 85°C) and military (−55 to +125°C) temperature grades. From $198 (1000). **Analog Devices Inc,** Box 9106, Norwood, MA 02067. Phone (617) 461-3881. **Circle No. 419**

High-resolution audio DAC. Using bit-stream (delta-sigma) technology, the SAA7350 20-bit DAC interfaces with all known digital input formats, including the Sony serial format and the Philips intersound bus. The DAC provides a choice of two clock frequencies, which results in internal oversampling factors of 128 or 192. Connecting the SAA7350's third-order noise-shaper outputs to the companion TDA1547 1-bit DAC results in a THD + N of −104 dB (0.0006%), linearity deviation of 0.2 dB, and channel separation of better than 120 dB. The SAA7350 comes in a 44-pin quad flatpack; the TDA1547 comes in a 32-pin DIP. $26 and $17.50, respectively, (100). **Signetics Co,** Box 3409, Sunnyvale, CA 94088. Phone (408) 991-2111. **Circle No. 420**



Low-cost, 8-bit microcontrollers. Combining a 68HC05 CPU with peripherals and memory, the K-series microcontrollers (μCs) offer design flexibility. The 68HC05K0 adds 32 bytes of RAM, 504 bytes of ROM, a 15-stage multifunction timer, 10 bidirectional I/O lines, an oscillator, a watchdog timer, and other features. The 68HC05K1 has all of the common features of the 68HC05K0 plus 64 bits of personality EPROM, programmed via software. The 68HC705K1 incorporates all of the features of the other μCs, 504 bytes of one-time-programmable EPROM that replaces the 504 bytes of ROM, and an EPROM mask-option register. 68HC05K0, 68HC05K1, and 68HC705K1, $1, $1.50, and $2.50, respectively, (50,000). **Motorola Inc,** 6501 William Cannon Dr W, Austin, TX 78735. Phone (512) 891-2035. **Circle No. 421**

High-speed ECL comparators. The MAX905 (single) and MAX906 (dual) edge-triggered, ECL-compatible comparators feature an overdrive-insensitive propagation delay of 2 nsec. Whether the input overdrive is 3 mV or 1V, the propagation delay does not change. You can clock the comparators at speeds to 500 MHz, and both devices have separate analog and digital power supplies to isolate the noisy digital circuitry from the analog input section. The MAX905 (14-pin) and MAX906 (16-pin) come in DIPs and SO packages. From $3.98 and $5.98, respectively, (1000). **Maxim Integrated Products,** 120 San Gabriel Dr, Sunnyvale, CA 94086. Phone (408) 737-7600. **Circle No. 422**

Mixed-signal array. Fabricated in a 32V process that supports industrial and control applications, the RLDA80 semicustom array combines analog and digital macrocells on a single chip. The analog macrocells accommodate applications from dc to 1 MHz, and the digital macrocells deliver propagation delays typical of LS TTL logic. RLDA80, in 44-pin ceramic leadless chip carriers and plastic leaded chip carriers, from $30,000 (includes layout 10 prototypes and test development). **Raytheon Co,** Semiconductor Div, 350 Ellis St, Mountain View, CA 94043. Phone (415) 968-9211. **Circle No. 423**

CIRCLE NO. 109

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How to stay ahead in telecommunications design

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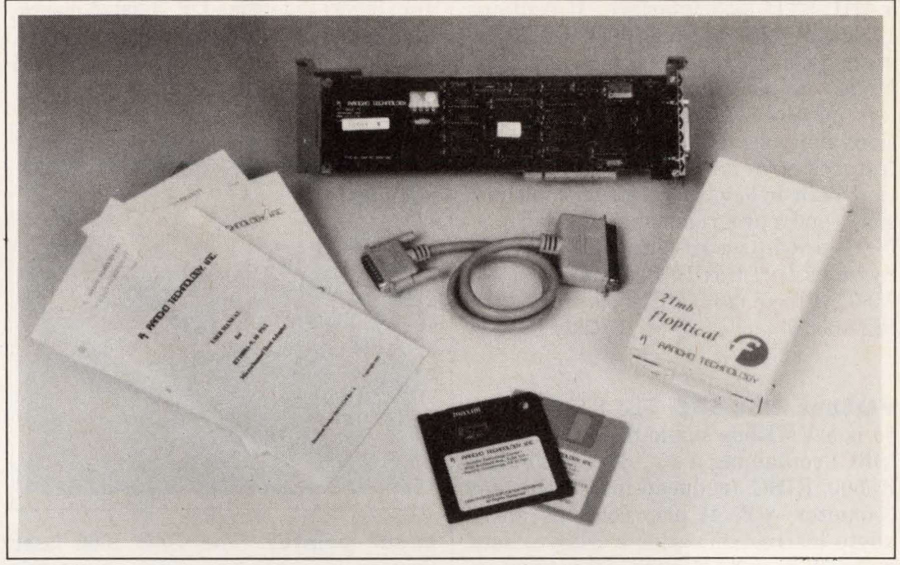
ERICSSON

CIRCLE NO. 113

Floptical-Disk Drives

- *Versions for ISA and Micro Channel Architecture buses*
- *Provide 21-Mbyte formatted capacity on 3.5-in. media*

Four versions of Floptical-disk-drive subsystems are available. The RT3000I and RT3000E connect an internal or an external, respectively, Floptical-disk drive to an ISA bus computer. The RT4000I and RT4000E connect an internal or an external, respectively, Floptical-disk drive to an IBM Micro Channel Architecture computer. The drives have 21 Mbytes of formatted capacity on 3½-in. media. Dual-mode heads can also read and write to standard 1.44-Mbyte and 720-kbyte, 3½-in. disks. The subsystems include a SCSI host adapter and come with SCSI hard-disk software and a SCSI tape-backup utility. RT3000I, $750; RT3000E, $950; RT4000I, $800; RT4000E, $1000.



Rancho Technology Inc, 8632 Archibald Ave, Suite 109, Rancho Cucamonga, CA 91730. Phone (714) 987-3966. **Circle No. 351**

Radio Modem

- *Transmits and receives over a 2-mi line of sight*
- *Operates over a 450- to 470-MHz FM band*

The Model IC-20 radio modem for wireless LANs has a 2W transmitter and a receiver sensitivity of 0.5 μV, allowing the modem to communicate over a 2-mi line of sight. The unit operates over a 450- to 470-MHz FM band, and it uses Manchester II frequency-shift keying to encode asynchronous data at baud rates from 50 baud to 19.2 kbaud. The modem accepts data from an RS-232C port, assembles the data in packets as large as 128 bytes, and appends a 16-bit cyclic redundancy check. The transmit and receive response time is less than 2 msec, and the unit polls mobile stations at a 30-station/sec rate. The modem operates in temperatures ranging from −30 to +60°C and in humidity as high as 90%. FCC Certification No. is GES4BA IC-20. $1999 to $2499.

Monicor Electronic Corp, 2964 NW 60th St, Fort Lauderdale, FL 33309. Phone (305) 979-1907. FAX (305) 979-2611. **Circle No. 352**

PA-RISC μP Workstations

- *Use 35- or 50-MHz PA-RISC CPU*
- *Grayscale or color options for a 1280×1024-pixel monitor*

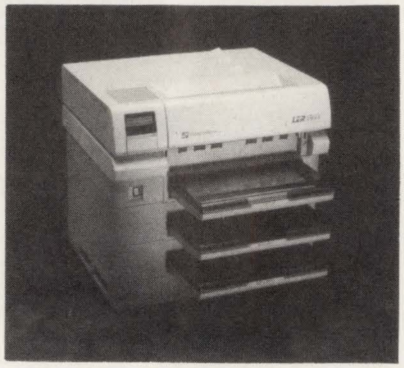
The Series 9000 Model 705 and 710 are low-end workstations based on HP's PA-RISC μP. Model 705 has a 35-MHz CPU, 8 Mbytes of RAM, and a 19-in., 1280×1024-pixel grayscale monitor. Model 710 uses a 50-MHz CPU, 16 Mbytes of RAM, an 8-kHz audio channel, and three 8-bit monitor options. The workstations run the HP-UX 8.07 operating system. Model 705 delivers 35 MIPS, 34 SPECmarks, and 8 Mflops. Model 710 delivers 57.9 MIPS, 49.7 SPECmarks, and 12.2 Mflops. Both units have a 32-kbyte instruction cache, a 64-kbyte data cache, as much as 840 Mbytes of internal hard-disk capacity, and internal removable media. Model 705, $4990; Model 710 with 19-in. 1280×1024-pixel grayscale monitor, $9490; with 16-in., 1024×768 color monitor, $11,490; with 19-in., 1280×1024 color monitor, $13,900.

Hewlett-Packard Co, Inquiries, 19310 Pruneridge Ave, Cupertino, CA 95014. Phone (800) 752-0900. **Circle No. 353**

Computers & Peripherals

VMEbus MIL-STD-1553 board. The BCU-VME-M 6U VMEbus board has a MIL-STD-1553 interface. It contains 128k×16 bits of dual-port RAM for storing control block and message data. Modes of operation include bus controller; multiple-remote-terminal simulation; and concurrent monitor. The unit features error detection; bit-error injection; built-in loopback tests on transmissions; and a programmable time lag having 1- or 64-μsec resolution. $5495. **SCI Systems Inc**, Box 1000, Huntsville, AL 35807. Phone (205) 882-4569. FAX (205) 882-4652. **Circle No. 354**

VMEbus RISC SBC. The RISQengine/5e is a VMEbus single-board computer (SBC) containing a 25-, 33-, or 40-MHz R3000 RISC (reduced-instruction-set computer) μP. It also contains an 8-kbyte instruction cache; a 2-kbyte data cache; 2, 8, or 32 Mbytes of 2-way interleaved dynamic RAM (DRAM); 256 kbytes of EPROM expandable to 1 Mbyte; two RS-232C ports; a real-time clock; 8 or 32 kbytes of nonvolatile RAM; and three counter/timers. 25-MHz board with 2 Mbytes of DRAM and 256 kbytes of EPROM, from less than $3000. **RISQ Modular Systems Inc**, 39899 Balentine Dr, #200, Newark, CA 94560. Phone (415) 490-0732. FAX (415) 489-0635. **Circle No. 355**



Laser printer. The LZR 1560 laser printer incorporates Adobe System's Postscript Level 2 software. The 400-dpi printer handles 11×17-in. paper and prints at 15 pages/minute. Models are available with one to three paper trays. Each model has an Appletalk, RS-232C and a Centronics parallel port. In addition, the printer has a SCSI port to connect a hard-disk drive and you can configure the unit as a network printer. Less than $6000. **Dataproducts Corp**, Box 746, Woodland Hills, CA 91367. Phone (818) 887-8000. FAX (818) 887-4789. **Circle No. 356**

Terminal concentrator. The 8/tctp+ concentrator connects as many as eight terminals to a host containing one of the company's 8×4AT, 8×4GT, 8×4MC, or 8×2 adapters. The concentrator has RS-422 or RS-423 ports to communicate with terminals located 2500 ft away. You can connect RS-232C over standard distances. An optional power supply lets you install the concentrator at long distances from the host. $695. **Corollary Inc**, Box 18977, Irvine, CA 92713. Phone (714) 250-4040. FAX (714) 250-4043. **Circle No. 357**

MicroVAX memory board. The DCME-576 board provides 4 or 8 Mbytes for DEC's MicroVAX Models 30, 40, 76, and 80 computers. It uses double-sided surface-mount chips on the same form factor as DEC's MS44-AA memory board. The company provides 24-hour repair or replacement and 24-hour technical hotline support. 4-Mbyte version, $780; 8-Mbyte version, $1560. **Clearpoint Research Corp,** 35 Parkwood Dr, Hopkinton, MA 01748. Phone (508) 435-2000. FAX (508) 435-7504.

Circle No. 358

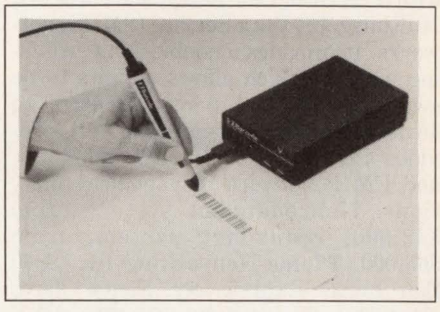
Dot-matrix printer. The NX-2430 24-pin dot-matrix printer has a front-panel LCD. It comes with two 5¼-in. floppy disks containing utilities and fonts. The printer's 11 resident fonts include nine letter-quality and two draft fonts. You can download 256 font characters to 16 kbytes of RAM. $399. **Star Micronics America Inc,** 420 Lexington Ave, Suite 2702, New York, NY 10170. Phone (212) 986-6770. FAX (212) 286-9063.

Circle No. 359

Transputer graphics system. This graphics subsystem comprises three boards for the company's TIP bus. The TIP-VPU/T8 processor board uses a T805 Transputer and 1 or 4 Mbytes of dynamic RAM. A T400 Transputer serves as the bus controller. The TIP-MFG frame grabber captures images from RS-170- or CCIR-compatible CCD (charge-coupled-device) cameras and video recorders. The TIP-CGD color-graphics display generates 800×600- or 1280×1024-pixel images. 1 Mbyte TIP-VPU/T8, $4600; TIP-MFG, $5200; TIP-CGD, $5800. **Parsytec Inc,** Bldg 9, Unit 60/61, 245 W Roosevelt Rd, West Chicago, IL 60185. Phone (708) 293-9500.

Circle No. 360

Fax-data modem. The COMstation Five modem sends and receives facsimiles and data for Apple Macintosh computers. It conforms to V.17 fax/modem and V.32 bis data-modem specifications for 14.4-kbps communications. The unit also conforms to V.42, V.42 bis, and MNP5 CCITT standards for error correction and data compression. The unit runs on the System 7.0 operating system and measures 2×8×5.5 in. $899. **PSI Integration Inc,** 851 E Hamilton Ave, Suite 200, Campbell, CA 95008. Phone (800) 622-1722; (408) 559-8544. FAX (408) 559-8548. **Circle No. 361**

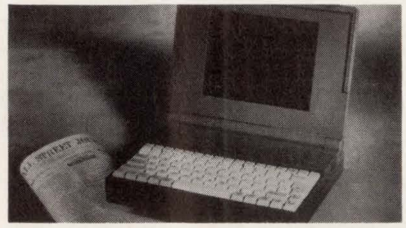


Bar-code reader. The PC-Wedge II reader connects between the keyboard and a DOS-compatible computer. It reads bar-code type automatically in both directions. Bar-code types include Code 39, UPC/EAN, 2 of 5, Codabar, Code 93, Code 11, Code 128, and MSI. Stainless-steel-wand version, $349; plastic-wand version, $289. **Timekeeping Systems Inc,** 1306 E 55th St, Cleveland, OH 44103. Phone (216) 361-9995. FAX (216) 361-0030. TWX 650-318-3986. **Circle No. 362**

Network hub. The BMX45N bandwidth manager provides hub functions for Synchronous Optical Network

(SONET) OC3, Cell-Relay, and Switched Multimegabit Data Service (SMDS) networks. It provides a nonblocking switching matrix, which allows circuits to be switched from one port to another to achieve load balancing. The unit provides SNMP, OSF Motif/X-Windows, and CMIP network management functions. Nonredundant system, from \$42,000; redundant system, from \$65,000. **T3plus Networking Inc,** 2840 San Tomas Expressway, Santa Clara, CA 95051. Phone (408) 727-4545. FAX (408) 727-5151. **Circle No. 363**

SCSI bus switches. The SM-90/R can connect as many as 21 SCSI peripherals to a single host computer. You can switch the units manually or automatically under program control. The SM-90/12 connects a single SCSI port to one of two SCSI branches. The SM-90/13 connects a single SCSI port to one of three SCSI branches. The SM-90/22 connects two SCSI ports to two SCSI branches. From \$3290. **Ancot Corp,** 115 Constitution Dr, Menlo Park, CA 94025. Phone (415) 322-5322. FAX (415) 322-0455. **Circle No. 364**



Notebook computer. The 20-MHz 80386SX notebook computer has an internal 9600/2400 fax/modem. Standard configuration includes 2 Mbytes of RAM, expandable to 5 Mbytes; an 80-Mbyte 2½-in. hard-disk drive; and a 1.4-Mbyte, 3½-in. floppy-disk drive. The unit has AMI's BIOS in shadow RAM and a socket for an 80387 coprocessor. The monitor displays 32 gray scales composed of 640×480 pixels. The unit weighs 7.1 lbs, including batteries. \$2395. **Centrix Computer,** 15316 Valley Blvd, Industry, CA 91746. Phone (800) 888-9988; (818) 855-2800. **Circle No. 365**

Macintosh video board. The EyeQ Authoring System contains a video display board for Nubus Macintosh computers. It uses an Intel i750 videoprocessor chip to implement the digital video interactive (DVI) mode. The board compresses and decompresses 30-frame/sec video data to hard-disk format in real time. The media files produced by MacDVI software are compatible with files for DVI implementations on IBM PS/2 and DOS-compatible computers. \$4495. **New Video Corp,** 220 Main St, Suite C, Venice, CA 90291. Phone (213) 396-4000. FAX (213) 396-0282. **Circle No. 366**

Ethernet adapter cards. These two Ethernet adapter cards have an RJ-45 connector for 10Base-T twisted-pair and a DB-15 connector for attached-unit-interface (AUI), coaxial-cable communications. The Model 513 is an 8-bit ISA bus board, and the Model 515 is a 16-bit ISA bus board. Novell users can switch to 10Base-T communications using existing software drivers. Model 513, \$295; Model 515, \$355. **Telebyte Technology Inc,** 270 E Pulaski, Greenlawn, NY 11740. Phone (800) 835-3298; (516) 423-3232. FAX (516) 385-8184. **Circle No. 367**

Bigger capacitance. Smaller cases.

Our technology constantly succeeds in putting a given rating in a smaller case. Our popular 10μF/16V chip now comes in a B_2 case measuring 2.8 x 3.5 x 1.9mm. The case size has been reduced by almost 80% since 1983.

NEC's chip tantalum capacitors have three more advantages. One is our lineup – among the broadest in the industry. Another is our production volume – the largest in the world. And the third is reliability – 100% burn-in.

So if you're looking for the right chip tantalum caps, come to NEC. It's an open-and-shut case.

μF VDC	2.5	4	6.3	10	16	20	25	35	50
0.047								A	
0.068								A	
0.10						A_2		A	A
0.15						A_2		A	A
0.22						A_2		A	B_2
0.33						A_2		A	B_2
0.47						A_2	A	A B_2 B	B_2
0.68					A_2	A_2 A		A B_2 B	C
1.0				A_2	A_2 A		A	B_2 B	C
1.5			A_2	A_2 A	A	A	B_2 B	B_2 B C	
2.2		A_2	A_2 A	A	A	B_2 B	B_2	B_2 B C	D
3.3		A_2 A	A	A	A B_2 B	B_2	B_2 B C	C D	
4.7	A_2	A	A	A B_2 B	B_2	B_2 B C	C	C D_2 D	
6.8		A	A B_2 B	B_2	B_2 B C	B_2 C	C D_2 D	D_2 D	
10		A B_2 B	A B_2	B_2 B C	B_2 C	C D_2	D_2 D	D	
15	A	A B_2	B_2 B C	B_2 C	C D_2	D_2 D	D		
22	A	B_2 B C	B_2 C	C D_2 D	D_2 D	D_2 D			
33	B_2	C	C D_2 D	D_2 D	D_2 D	D			
47		C D_2 D	D_2 D	D_2 D	D				
68		D_2 D	D_2 D	D					
100		D_2 D	D						
150		D							

	W		L		H	
A_2 case	1.6 mm	.063 inch	3.2 mm	.126 inch	1.2 mm	.039 inch
A case	1.6	.063	3.2	.126	1.6	.063
B_2 case	2.8	.110	3.5	.138	1.9	.075
B case	2.6	.102	4.7	.185	2.1	.083
C case	3.2	.126	6.0	.236	2.5	.098
D case	4.3	.169	7.3	.287	2.8	.110
D_2 case	4.6	.181	5.8	.228	3.2	.126

CIRCLE NO. 117

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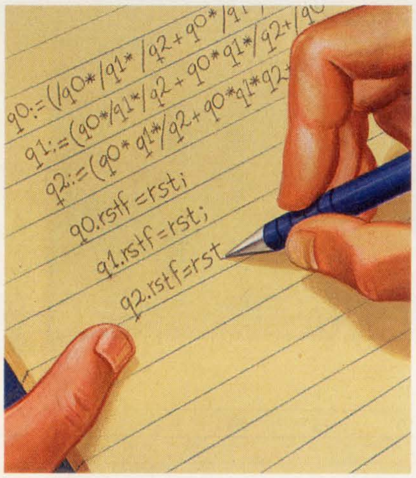

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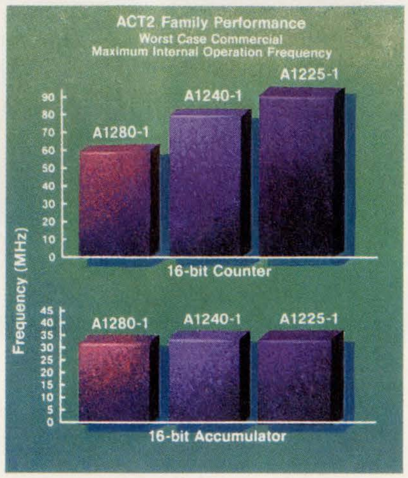
You design Actel FPGAs using the same tools as you would a PLD: ABEL,™ CUPL,™ LOG/iC™ and PGADesigner.™ But that's where the similarity ends.



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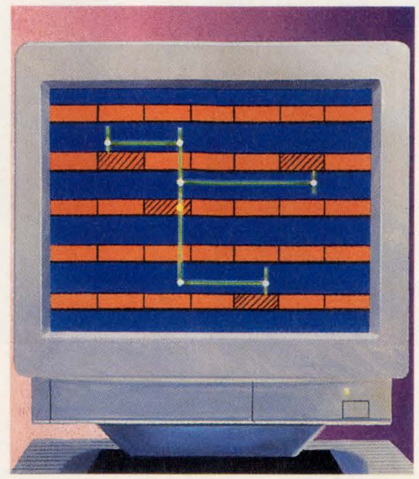
Our FPGAs are real speed demons. Whatever application you may be working on, our parts will give you the kind of performance you're looking for.



100% Automatic Place And Route.

Coupled with your PLD tools, Actel's Action Logic™ System (ALS) software lets you create your own FPGAs—using a 386 PC or workstation—right at your own desk. With Auto Place and Route that's proven in thousands of applications.

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If you're a PLD designer with an interest in fast, flexible FPGAs, but you think you don't have time to learn new design techniques, we'd like to change your mind.

First of all, you don't have to give up your existing PLD design tools or Boolean equations. Actel's ALES™ 1 program translates the output of PLD tools like CUPL™ and LOG/iC™ into logic optimized for our ACT™ devices. ABEL™ 4.0 includes optimization for Actel devices. Entire FPGA designs can be developed with PGADesigner.™

Actel devices offer everything you want in an FPGA. Like high I/O and flip-flop counts. And 100% automatic place and route gets you to market fast.

Once your FPGA is designed, our Action Logic™ System (ALS) converts the captured design into a completed device in minutes. To give you true, high-density, field-programmable, channeled gate arrays.

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It's never been easier to make your innovative designs a reality. We offer you a complete family of powerful FPGAs, like the A1010 and A1020, available in 44, 68 and 84 pin PLCC versions and implementing up to 273 flip-flops or up to 546 latches. And the first member of our ACT 2 family, the power-

GAs The Same Way
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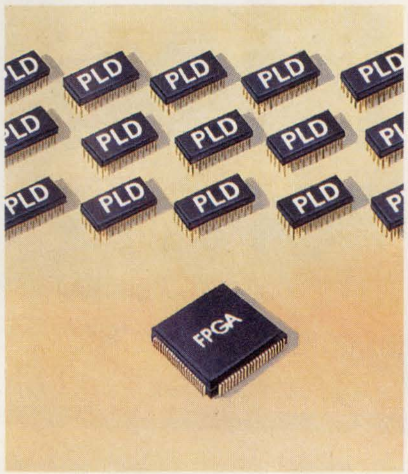

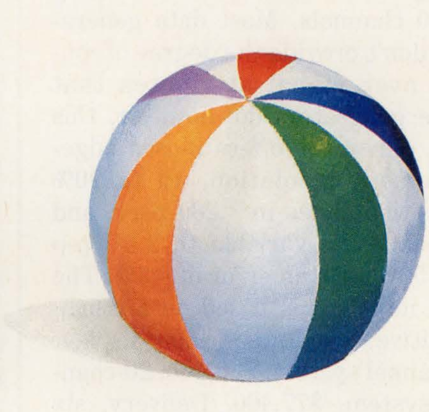

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Designing with Actel FPGAs gives you more freedom than you ever imagined. More gates. More flip-flops. More I/O. In fact, our new A1280 is the largest FPGA in the world.

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ful A1280. With 8,000 gates, up to 998 flip-flops, and 140 I/O pins, it's the highest capacity FPGA today. And our A1240-1 is the fastest. In the A1240-1, 16-bit counters run at 75 MHz, 16-bit accumulators at 33 MHz. Enough capacity and speed to handle almost any application.

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The FPGA Design Guide

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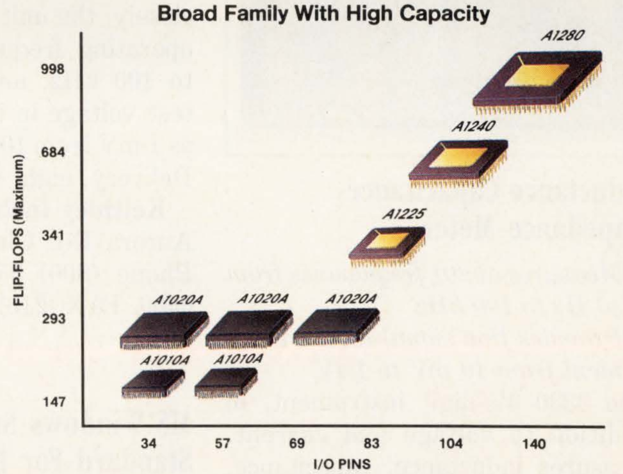


Actel

Risk-Free Logic Integration

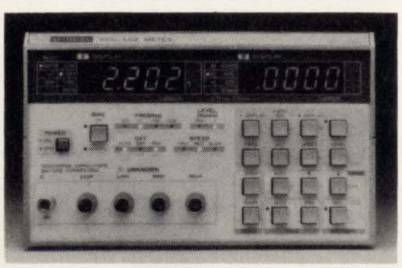
1-GHz Data-Generator System

- *Provides 2-psec edge-placement resolution*
- *Modular construction allows 20 channels*

The mainframe of the 80000 modular system accommodates as many as 20 channels. Most data generators don't provide the degree of control over signal attributes that pulse generators do; however, this data generator offers 2-psec edge-placement resolution, 10 to 90% transition times in <200 psec, and output levels variable to 2.5V p-p into 50Ω with an error of <3%. The user interface is based on a touch-sensitive, windowed color display. 4-channel system, $30,100; 20-channel system, $77,400. Delivery, six weeks ARO.

Hewlett-Packard Co, Inquiries, 19310 Pruneridge Ave, Cupertino, CA 95014. Phone (800) 752-0900.

Circle No. 368



Inductance-Capacitance-Impedance Meter

- *Measures at 201 frequencies from 40 Hz to 100 kHz*
- *Provides fine signal-level adjustment from 10 mV to 1.1V*

The 3330 4½-digit instrument, in addition to voltage and current, measures inductance, capacitance, resistance, impedance magnitude, quality and dissipation factors, equivalent series resistance, conductance, reactance, and phase angle. It controls sorting and binning of parts and allows programming from its front panel or via an IEEE-488 interface. To simulate components' actual operating conditions closely, the unit lets you choose 201 operating frequencies from 40 Hz to 100 kHz, and lets you set the test voltage in increments as small as 1 mV from 10 mV to 1.1V. $4590. Delivery, eight weeks ARO.

Keithley Instruments Inc, 28775 Aurora Rd, Cleveland, OH 44139. Phone (800) 552-1115; (216) 248-0400. FAX (216) 248-6168.

Circle No. 369

MS-Windows Software Standard For Data Acquisition

- *Standardizes interface between programs and functions*
- *Allows hardware upgrades without changes to applications*

DT-Open Layers software provides standard ways for MS-Windows-based data-acquisition application programs to interface with libraries of functions and with instruments. Applications that follow the standards will support new hardware and functional extensions without recompilation. Copies of the standards are free of charge; 1.0 versions of data-acquisition and signal-processing libraries include Global Lab Data Acquisition software, $1495; Global Lab Image software, $1995; data-acquisition library, free with purchase of the firm's data-acquisition hardware, otherwise $95; image library, $1995. Users of Global Lab V2.1, which does not support Windows, will receive a $500 credit when they upgrade to the Windows-compliant version.

Data Translation Inc, 100 Locke Dr, Marlborough, MA 01752. Phone (508) 481-3700.

Circle No. 370

PC-board test systems. Three systems meet the challenges of what the vendor calls RCT (reduced-contact testing). The 576-channel L323RCT and L353RCT, and the 1152-channel L357RCT test at clock rates to 40 MHz, perform combinational (functional and in-circuit) testing, and provide deeper pattern memory than traditional board testers. The systems use VXIbus modules to implement analog functions. The L323RCT is smaller and less expensive than earlier systems. Depending on the model, $400,000 to approximately $1 million. **Teradyne Inc,** 321 Harrison Ave, MS L-57, Boston, MA 02118. Phone (617) 422-3567. FAX (617) 422-3440.

Circle No. 371

Trouble-shooting aid for pc boards. The 9110FT isolates faults to the component level by using emulative functional and stimulus routines and a single-point probe. Among the test techniques the unit uses are signature analysis, logic-level detection, frequency and event counting, and pulsing. From $13,000; typically less than $20,000. Delivery, six weeks ARO. **John Fluke Mfg Co Inc,** Box 9090, Everett, WA 98206. Phone (800) 443-5853. **Circle No. 372**

Philips Test and Measurement, Bldg TQ III-4, 5600MD Eindhoven, The Netherlands. Phone local office.

Circle No. 373

Universal IC programmers. Systems 1040 (40 channels, $2995) and 1084 (84 channels, $3995) are universal IC programmers using a DAC per pin. They accommodate center-ground-pin devices without needing adapters. The programmers interface to the host PC via the parallel-printer port. This arrangement combines the advantages of PC hosting with fast downloading and simplifies moving the programmer from PC to PC. **Stag Microsystems Inc,** 1600 Wyatt Dr, Santa Clara, CA 95054. Phone (800) 227-8836; (408) 988-1118. TWX 910-339-9607. **Circle No. 374**

Tester for digital communications links. With the $2280 E1 option, the PF-45 analyzer can drop (separate for analysis) 2.048-Mbit/sec European-standard channels from a 44.736-Mbit/sec signal. Data-link option, $2090; software upgrades to existing PF-45s (for example, to sound an alarm on a bit error), $800. **Wandel and Goltermann Inc,** 2200 Gateway Center Blvd, Morrisville, NC 27560. Phone (800) 346-6332. **Circle No. 375**

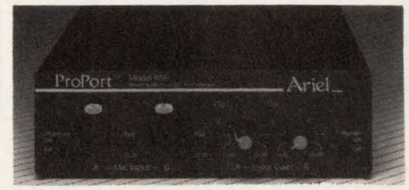
PC-based emulator for 68HC16s and 68300s. The Emul16/300-PC consists of an ISA bus plug-in emulator board, a 5-ft twisted-pair cable, a pod board, and an optional trace board. The pod board includes 1 Mbyte of breakpoint RAM; the emulator board contains 1 Mbyte of shadow RAM. The emulator does not slow µP operation. You can connect the unit to the target board by clipping onto the processor, plugging the emulator into a socket you substitute for the µP, or soldering the emulator cable in place of the µP. $1995. **Nohau Corp,** 51 E Campbell Ave, Campbell, CA 95008. Phone (408) 866-1820. FAX (408) 378-7869. **Circle No. 376**

PC-based SCSI-bus analyzer. The PED-4572 is a daughter card for the vendor's SCSI bus analyzer. It increases the analyzer's speed and permits tracing signals as brief as 20 nsec (2/3 of the nominal minimum duration of signals on the bus). Configuration software lets the daughter card work with unshielded single-ended or differential 50-pin connectors. $995, including software. **Pacific Electro Data Inc,** 14 Hughes, Irvine, CA 92718. Phone (800) 676-2468; (714) 770-3244. FAX (714) 770-7281. **Circle No. 377**

Memory-IC test systems. The J997, optimized for use in engineering and for wafer probing, runs at speeds to 200 MHz and exhibits an overall timing inaccuracy of 300 psec. It can test as many as 32 devices in parallel on two test stations. The corresponding specs for the J994, a model optimized for final test of packaged ICs, are 120 MHz, 500 psec, and 64 devices. Both models accommodate devices that store as much as 1 Gbit each. **Teradyne Inc,** 30801 Agoura Rd, Agoura Hills, CA 91301. Phone (818) 991-2900. FAX (818) 707-2805. **Circle No. 378**

1-MHz to 1-GHz spectrum analyzer. The P-7802 displays center frequencies with ±1% error and 1% resolution. It measures amplitudes from 15 to 129 dBµV with 70 dB of dynamic range. The ac-powered unit weighs 25 lb. $3500. **Protek,** Box 59, Norwood, NJ 07648. Phone (201) 767-7242. FAX (201) 767-7343. **Circle No. 379**

Digital audio interface. The Proport Model 656 self-contained unit enables PCs and workstations to record studio-quality 2-channel audio via 16-bit oversampling ADCs. You can select sampling rates from 5 to 96k samples/sec. The passband response is flat within ±0.1 dB from 20 Hz to 40 kHz. Interpolating reconstruction filters provide 20-bit output signals that, via DACs, drive balanced, low-impedance line drivers. $1595. **Ariel Corp,** 433 River Rd, Highland Park, NJ 08904. Phone (908) 249-2900. FAX (908) 249-2123. FAX (908) 249-2123. TLX 4997279. **Circle No. 380**



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IBM 220W	$7,185	$9,995
HP 705/710	$8,415	$14,065

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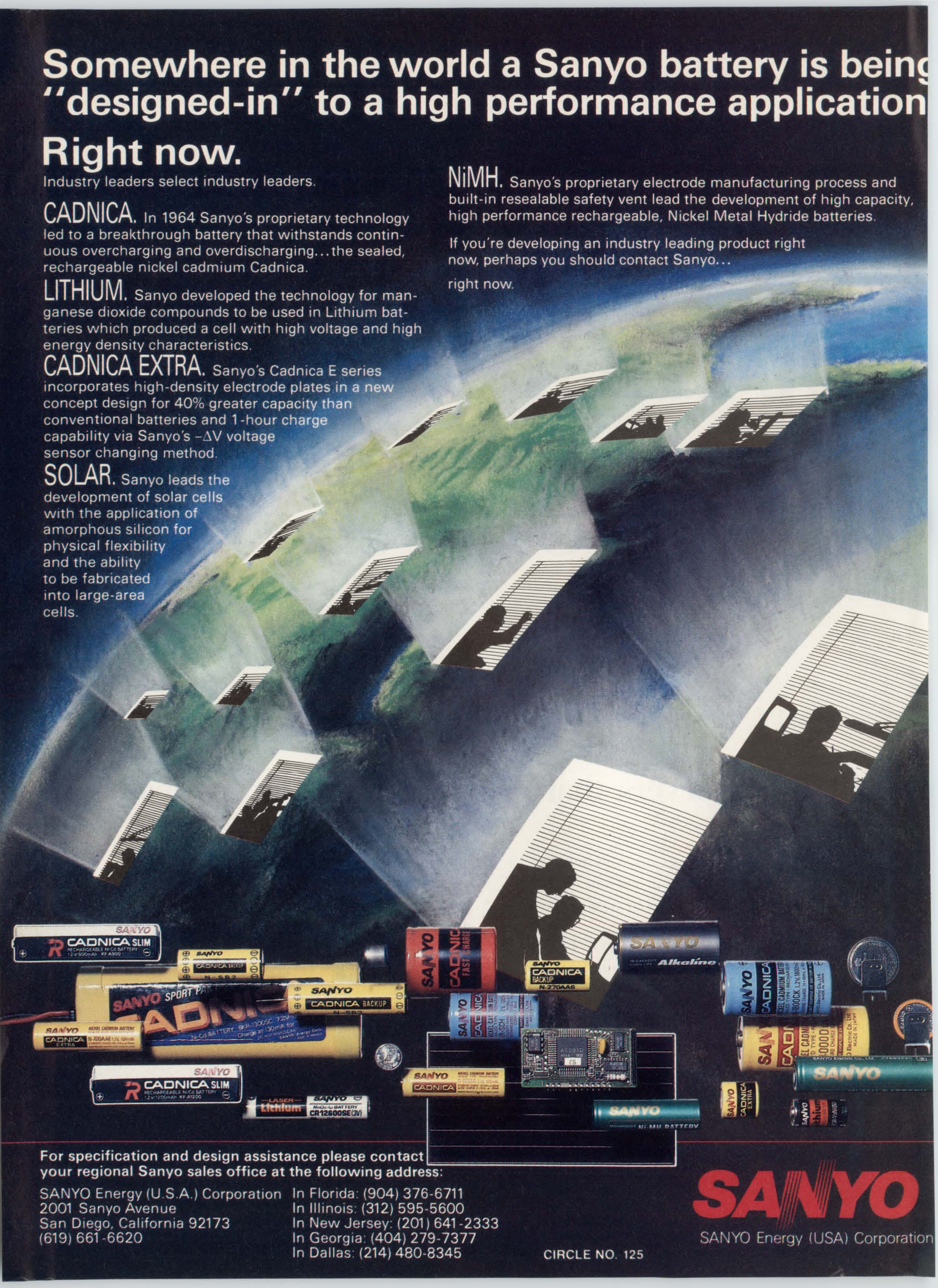
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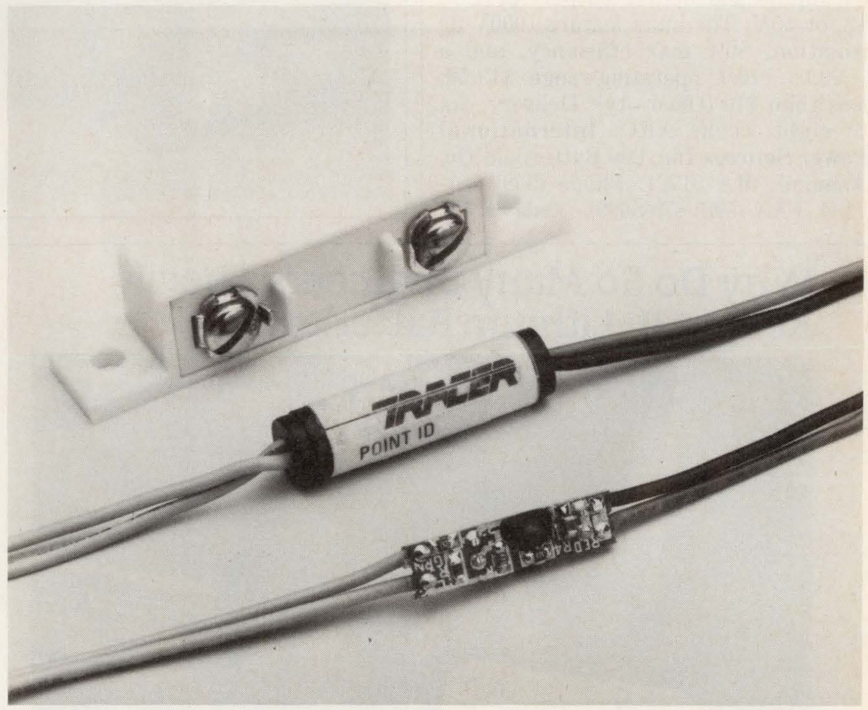
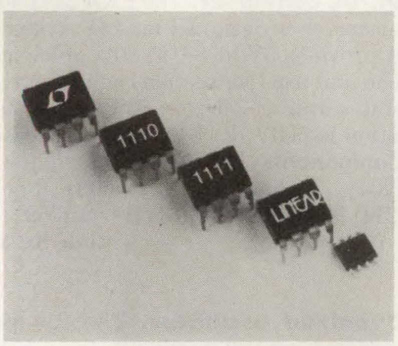
General-Purpose Transponder

- *Has an address range of 1 to 255*
- *Measures 8×15 mm*

The 3135 general-purpose transponder connects to a 2-wire parallel multiplex bus on one side and to a sensor/contact on the other side. It provides identification to each sensor connected on the bus as well as continuous supervision for reporting failure in normal operation. Key specifications include an address range of 1 to 255, operating voltage of 5 to 15V, and a current drain of 25 μA typ. The transponder measures 8×15 mm and operates over a −25 to +70°C range. It provides nonvolatile memory for address storage if desired. $6.95.

Tracer Electronics Inc, 200 Broadacres Dr, Bloomfield, NJ 07003. Phone (201) 338-1234. FAX (201) 338-1125. **Circle No. 424**





DC/DC Converters For Battery-powered Applications

- *Available in surface-mount packages*
- *Available in adjustable and fixed versions*

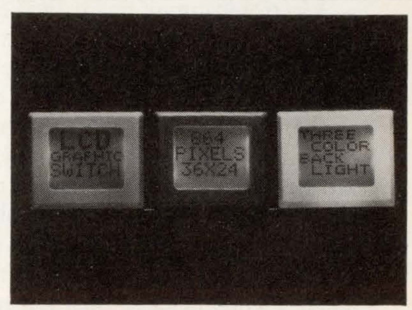
LT1110 and LT1111 dc/dc converters are available in adjustable versions and in fixed 5 and 12V models. The devices are housed in either 8-pin DIPs or 8-lead SO surface-mount packages. The LT1110 operates from a 1V input, and the LT1111 requires a 2V input. Both devices operate in step-up, step-down, or inverting mode. The 1111 delivers 5V at 100 mA from a 2-cell input; the 1110 delivers 5V at 150 mA from the same input level. The 1110-12 also generates a 12V output. Both units also contain low-battery detector circuitry. In 8-pin DIPs: LT1110, $3.15; LT1111, $2.40 (100); in SO-8 packages: LT1110, $3.60; LT1111, $2.80 (more than 100).

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 432-1900, ext 359. FAX (408) 434-0507. **Circle No. 425**

LCD Module

- *Fits in a keyswitch cap*
- *Features 864 pixels*

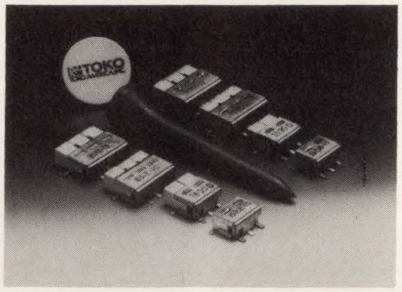
The D880 LCD module integrates a low-power graphics LCD, which utilizes super-twist technology with a custom IC driver and multicolor backlighting. The entire unit fits in the key cap of an spst momentary-contact switch, which measures approximately 1 in^2. The display consists of 864 pixels configured in a 24×36 matrix that provides full-screen graphics. Using a 5×7 font, the display has an 18-character capability—3 lines×6 characters. You can change the red and green backlighting by reversing the 5V



applied to the LED terminals. Amber is obtained by using an ac voltage across the LED terminals. $37.50 (250).

C Itoh Technology Inc, Box 19657, Irvine, CA 92713. Phone (800) 347-2484, ext 4529. FAX (714) 757-4423. **Circle No. 426**

Surface-mount dc/dc converters. NME Series converters are surface-mount, single-output units. They accept 5V inputs and deliver outputs of 5, 9, 12, or 15V. The units feature 1000V dc isolation, 80% max efficiency, and a −50 to +85°C operating range. $19.50; less than $10 (OEM qty). Delivery, six to eight weeks ARO. **International Power Sources Inc,** 200 Butterfield Dr, Ashland, MA 01721. Phone (508) 881-7434. FAX (508) 879-8669. **Circle No. 427**



Dielectric filters. Series 4DF surface-mount dielectric filters have center frequencies ranging from 800 to 2500 MHz. The units are available in 2- and 3-pole versions. They offer low loss performance—2 dB max for 2-pole versions. The 2- and 3-pole units measure 12.5×14.5×5 mm and 17.5×14.5×5 mm, respectively. From $6 (100). **Toko America Inc,** 1250 Feehanville Dr, Mount Prospect, IL 60056. Phone (708) 297-0070. FAX (708) 699-7864.

Circle No. 428

3-terminal power MOSFET. The BUK101-50 3-pin power MOSFET provides integrated short-circuit, overtemperature, and overvoltage protection. Housed in a TO-220 package, the device can be driven directly from conventional FET driver circuitry. All the protection circuitry is powered from the control input allowing the unit to achieve a 25°C off-state I_{DSS} rating of 1 μA for a V_{DS} voltage of 12V. 3 gld (50,000). Delivery, eight weeks ARO. **Philips Semiconductors,** 5600 MD, Eindhoven, The Netherlands. Phone 31 40 722091. FAX 31 40 724825.

Circle No. 429

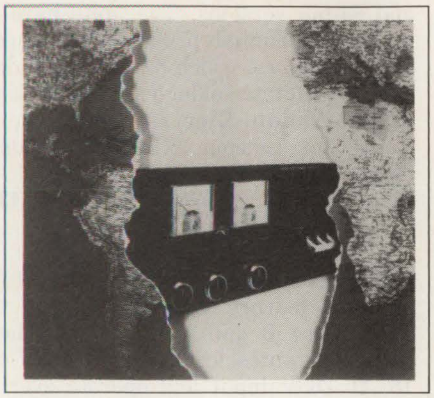
DC/DC converter. The PKA 2411 40W converter is designed for 24V systems. It provides 5V at 8A at 80% efficiency. The unit uses convection cooling and operates over a −45 to +65°C range. Isolation is 500V dc. $105 (100). **Ericsson Components Inc,** 4031 International Pkwy, Richardson, TX 75081. Phone (214) 997-6561. FAX (214) 680-1059.

Circle No. 430

Ovenized oscillator. The 250-0504 ovenized crystal oscillator has phase-noise figures ranging from −100 dBc at 1 Hz to −160 dBc at 10 kHz. The unit develops a 7-dBm output level, operates from a supply of 11 to 15V, and has a stability of $1.5\times10^{-[illegible]}$ over −30 to +70°C. Aging per year is $3\times10^{-[illegible]}$. $355 (1 to 1000). **QK Genware Corp,** 2 New Pasture Rd, Newburyport, MA 01950. Phone (508) 465-6064. FAX (508) 465-6637. **Circle No. 431**

Noise-blocking triacs. BT139H Series triacs feature a built-in trigger threshold of 10 mA to eliminate tendencies for the devices to be triggered by noise impulses. They are available with blocking-voltage ratings of 500, 600, or 800V. The units have a 10V/μsec com-

mutating voltage for a commutated current of 7.2A/msec and a peak current rating of 140A. The triacs are housed in TO-220 packages. $0.75 (1000). Delivery, four to six weeks ARO. **Philips Components,** 2001 W Blue Heron Blvd, Riviera Beach, FL 33404. Phone (800) 447-3762. **Circle No. 432**



Power supplies. LT-GPIB Series supplies provide outputs as high as 60V at currents ranging to 500A. They feature 3-phase input ranges of 187 to 265, 340 to 455, and 430 to 530V ac. The units operate in both constant-current and constant-voltage modes with automatic crossover. $3745 to $3938 (25). **Lambda Electronics Inc,** 515 Broad Hollow Rd, Melville, NY 11747. Phone (516) 694-4200. **Circle No. 433**

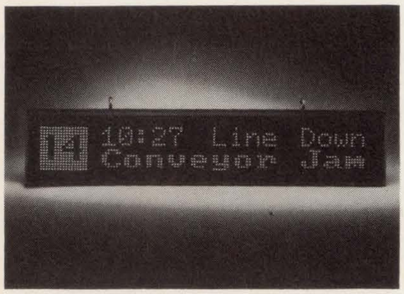
Precision termination. Model 6003 is a 50Ω SMA female termination. It is designed for dc to 18-GHz applications and has a 1.2:1 max VSWR. The unit has a 1W average power-handling capability at 25°C and is made of passivated stainless steel. The contact is gold plated. $29.95. **Pasternack Enterprises,** Box 16759, Irvine, CA 92713. Phone (714) 261-1920. **Circle No. 434**

SCSI adapters. These units are designed to interconnect SCSI I and SCSI II devices. They are fully EMI shielded and are available with both bail-lock and jackscrew fixtures. The adapters conform to all applicable ANSI standards and FCC specifications. From $20 (1000). **Honda Connectors,** 960 Corporate Woods Pkwy, Vernon Hills, IL 60061. Phone (708) 913-9566. **Circle No. 435**

DC/DC converter. The CPS873 device features three outputs—5V at 13.5A, and ±12V at 0.5A. Standard devices operate on a 28V input. The unit is conduction cooled. Regulation is 0.4%, and operating range spans −40 to +85°C. Approximately $700 (OEM qty). Delivery, stock to 12 weeks ARO. **Custom Power Systems Inc,** 33 Comac Loop, Ronkonkoma, NY 11779. Phone (516) 467-5328. **Circle No. 436**

Crimp-style connector. The Type VR insulation-displacement-style connector can be daisy chained or end connected to accommodate various power-supply circuits. It is available in versions having 2 to 15 positions with pins on 0.156-in. centers. The connector is color coded for AWG wire sizes from #26 to #18. Contacts are rated for 7A at 250V ac or dc. From $0.04 to $0.25 (OEM qty). **JST Corp,** 1200 Business Center Dr, Suite 400, Mount Prospect, IL 60056. Phone (800) 947-1110; (708) 803-3300. FAX (708) 803-4918. **Circle No. 437**

CIRCLE NO. 130



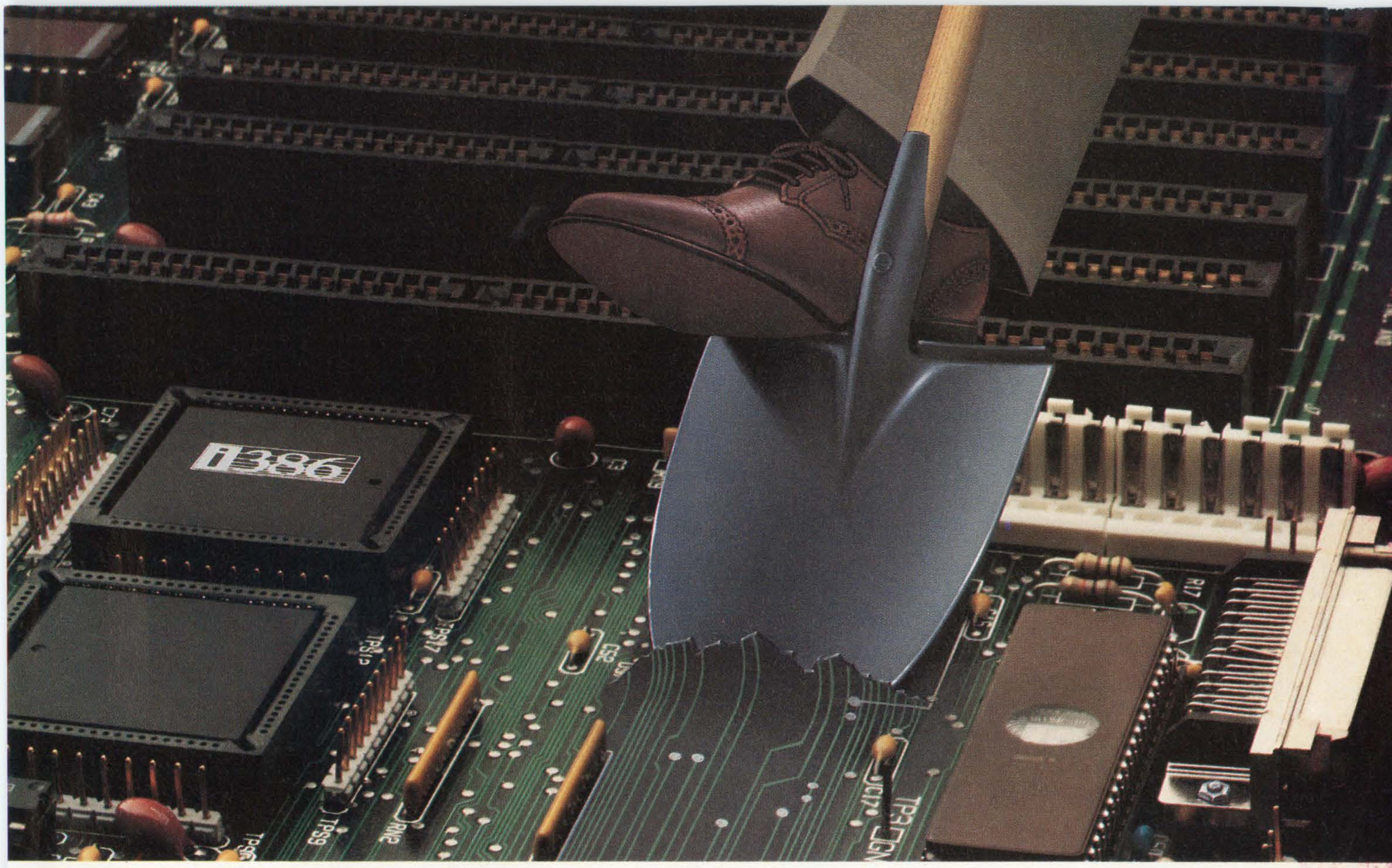
Alphanumeric and graphics display. The M1000 display combines AlGaAs LEDs, multiple-character fonts, and graphics capability in an extruded NEMA 12 enclosure. Simple escape commands control all display functions. Six different fonts provide 2- to 4.5-in. characters that are easily read from 200-ft distances. Users can mix any of the fonts to the limits of 40 2-in. characters or 10 4.5-in. characters. $1650. **Vorne Industries Inc,** 5831 Northwest Hwy, Chicago, IL 60631. Phone (312) 775-9440. FAX (312) 775-3854. **Circle No. 438**

Sockets. Series 654-SMO plastic-leaded-chip-carrier sockets accept MO-47 and MO-52 devices with 0.05-in. pin spacings. The surface mount units are available in 20-, 28-, 32-, 44-, 52-, 68-, and 84-pin versions. The units have a 0.173-in. mounted profile and feature PPS insulators, which have an open design to facilitate solder-joint inspection. $2.53. **Andon Electronics Corp,** 4 Court Dr, Lincoln, RI 02865. Phone (401) 333-0388. FAX (401) 333-0287. **Circle No. 439**

Power supplies. LZ Series 1000W supplies feature EMI compliance to FCC Class B and VDE 0871B. They feature an autoselectable 85 to 132V or 187 to 265V input and operate over a −30 to +71°C range. The units feature a power-fail alarm, inverter-good indicator, and overtemperature protection. The supplies are UL, CSA, TUV, and SELV compliant. From $1025 (25). **Lambda Electronics Inc,** 515 Broad Hollow Rd, Melville, NY 11747. Phone (516) 694-4200. **Circle No. 440**

Hygristor. The Veco hygristor features a −90 to +50°C operating range. Relative humidity ranges span 0 to 100%. and the nominal time constant is 2 sec. Available in sizes as small as 0.25 × 0.25 in. square and disks of 0.375 in. in diameter, the unit is comes in leaded or unleaded versions. Resistance values of 4 to 20 kΩ are available. From $6 (1000). Delivery, six to eight weeks ARO. **Victory Engineering,** Victory Rd, Springfield, NJ 07081. Phone (201) 379-5900. FAX (201) 379-5982. **Circle No. 441**

Box-header connectors. Constructed of glass-filled polyester with a UL 94V-0 rating, the NFHL and NFHLR Series box-header connectors feature phosphor bronze contacts plated with 12 μin. of gold in the contact area and 100 μin. of tin lead in the tail area. The contacts are rated for 0.5A. Dielectric voltage is 500V ac, and insulation resistance measures 10 Ω min. Approximately $0.08/contact (1000) for the NFHL header. **Circuit Assembly Corp,** 18 Thomas St, Irvine, CA 92718. Phone (714) 855-7887. FAX (714) 855-4298. **Circle No. 442**



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You're already a big believer in the performance and connectibility of SCSI. But you're also digging around for an uncomplicated way to design-in SCSI to your AT motherboard. Well... Eureka! Now with Adaptec's new AIC-6260, you've just hit pay dirt.

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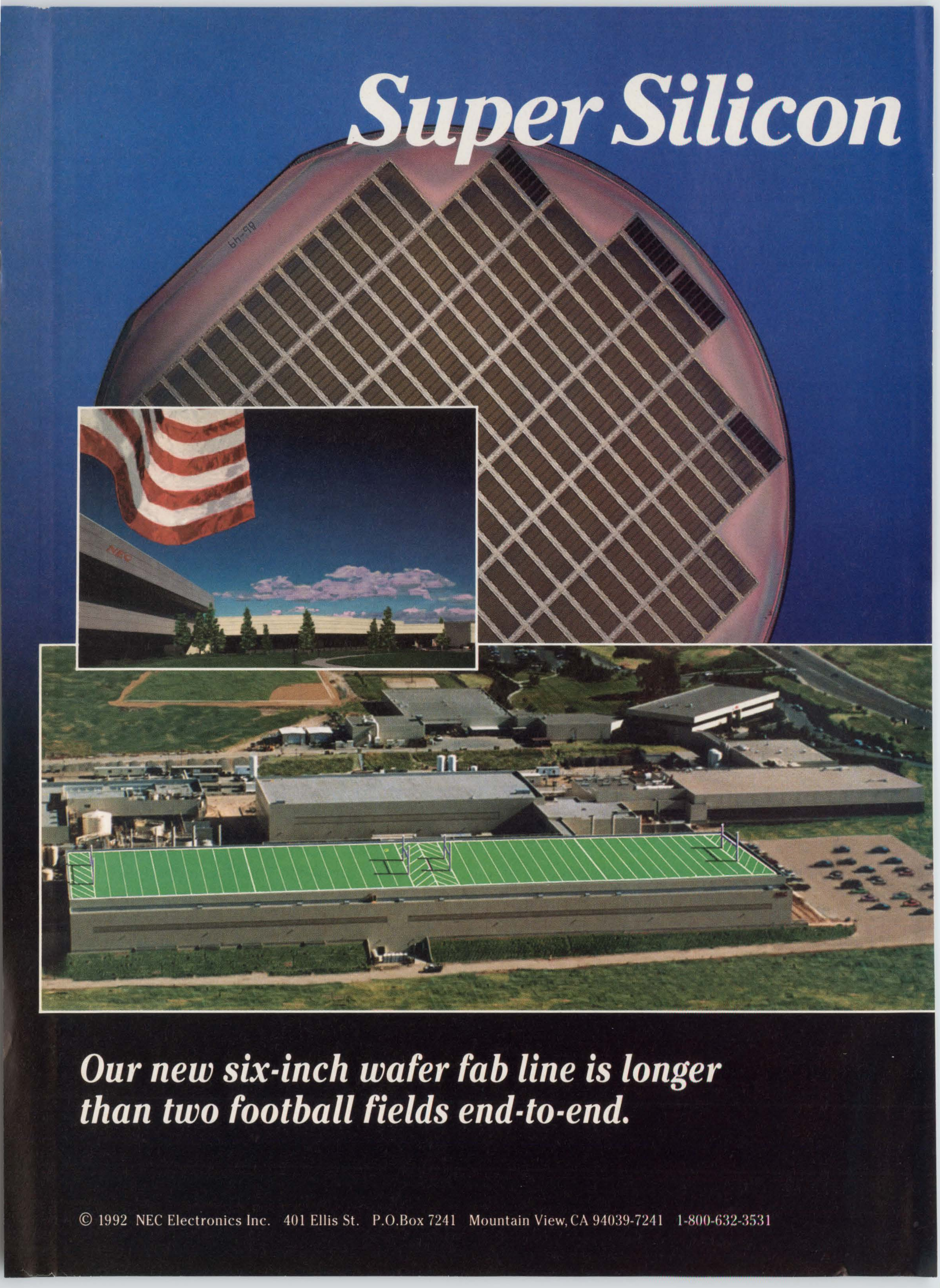
CIRCLE NO. 106


Super Silicon
Our new six-inch wafer fab line is longer than two football fields end-to-end.
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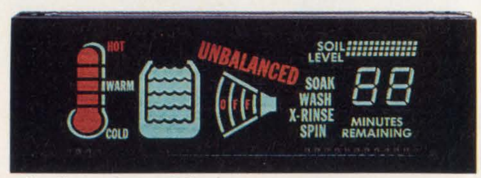

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CIRCLE NO. 148

CAE & Software Development Tools

Software Development System

- *Compiles code for multiple target processors*
- *Runs on DOS-based personal computers*

The Isil 4.0 Development System compiles C, assembly, and a proprietary high-level language that offers features more typical of assembly into a wide range of target processors. The compiler produces optimized code for 80386, 8051, 8096, 6801/3, HC05, HC11, HC16, 32000, COPS, Z8, Z80, Z180, and Super8 processors. The system uses subexpression elimination, variable preservation, and loop optimization to produce dense, fast code. Among the features of the proprietary language are 10 parameter-passing modes. The language also simplifies programming loops, byte indexing, and stack access. The software comes with a 30-day money-back return option. From approximately $250.

Eris Systems Inc, 2301 Newton Ave S, Minneapolis, MN 55405. Phone (612) 374-2967. **Circle No. 381**

32-bit extender for MS-Windows. Ezwin32 allows the company's numeric data-processing (NDP) Fortran, C, C++, and Pascal compilers to take advantage of MS-Windows' enhanced mode. The compilers cost $595 each and include one year of upgrades. Compiler owners can purchase the Ezwin upgrade for $395. **Micro Way**, Box 79, Kingston, MA 02364. Phone (508) 746-7341. FAX (508) 746-4678. **Circle No. 382**

Project-management software. CIM/AIT (Concurrent Information Management/Action Item Tracking) manages and tracks projects and activities. The software runs on PCs, Macs, workstations, minicomputers, and mainframes. From $290 for single-user licenses on a networked PC. **CIMware Technologies Inc**, 3031 E LaJolla St, Anaheim, CA 92806. Phone (714) 666-1200. FAX (714) 666-0400. **Circle No. 383**

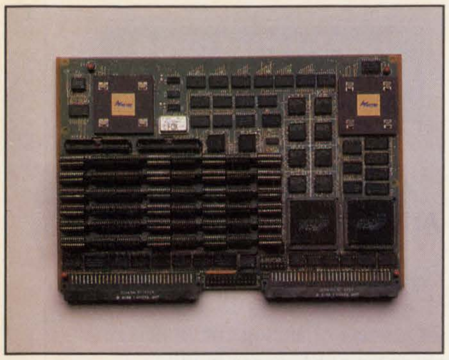
SCSI programming interface software. The SCSI Software Developer's Kit simplifies programming for the Advanced SCSI Programming Interface (ASPI). The kit contains a copy of the ASPI specification, programming guides for DOS, OS/2, and Netware, a DOS/ASPI interface to test device drivers, and an exerciser program. $150. **Adaptec, Inc**, 691 S Milpitas Blvd, Milpitas, CA 95035. Phone (408) 945-6761. **Circle No. 384**

32-Bit Extender. Aimax-Plus/Pro is a DOS Extender for the vendor's man-machine-interface control and data-acquisition software. The software provides 4 Gbytes of linear addressing and permits accessing parameters with process controllers. From $4500. **TA Engineering Co Inc**, 1605 School St, Moraga, CA 94556. Phone (510) 376-8500. FAX (510) 376-4977. **Circle No. 385**

Data-management system. Tekbase is a data-management system designed for scientists and engineers who work with large amounts of technical data. It is suited for applications in the aerospace, automotive, telecommunications, and semiconductor industries. Users can create applications based on Motif or Open Look. From $4875/seat for 4-user system. **Leading Technology Inc**, 6 New England Executive Park, Suite 400, Burlington, MA 01803. Phone (617) 229-8686. **Circle No. 386**

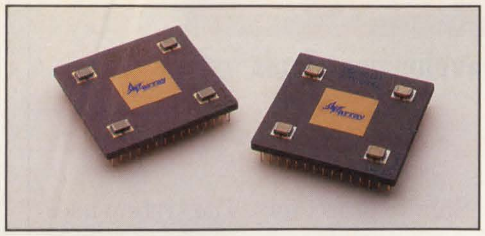
Prolog Runtime Generator. The Quintas Prolog Runtime Generator moves Quintas Prolog applications from Unix and VAX workstations to DOS 386/486 computers. The supplier charges no runtime fees for the ported applications. The software includes a basic development system, a Prolog compiler, and a link editor. $4000. **Quintas Corp**, 2100 Geng Rd, Suite 101, Palo Alto, CA 94303. Phone (415) 813-3800. FAX (415) 494-7608. **Circle No. 387**

OOP for Windows. Version 2.0 of Knowledgepro Windows, an object-oriented programming (OOP) environment, adds visual design tools, simplified access to dynamic-link libraries, and support for Windows multimedia



400 MOPS FOR 6U VMEbus SYSTEMS

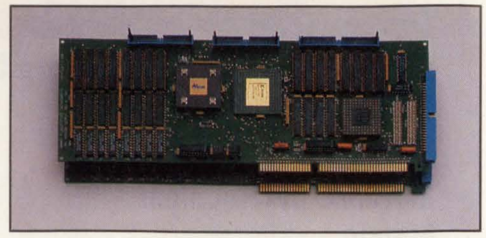
This 6U VMEbus board performs 400 million operations per second and is optimized for frequency domain processing such as FFTs and finite impulse response (FIR) filters using fast convolution. The FDaP features a private 32-bit, 20 MHz high-speed data I/O bus and extensive double buffering for continuous processing of real-time data. An additional 32-bit complex output provides phase/magnitude data. The a66540 is available in 25 MHz and 40 MHz versions. A single 40 MHz version can execute a 1K point FFT in 132.7 µs and a 64K point FFT in 13.1 ms. These times are nearly halved for real input. Multiple FDaPs can be cascaded to achieve almost linear improvement in FFT performance. Plug 400 MOPs into your system by calling **array** Microsystems' Hotline: 719-540-7999.



THE DaSP/PaC CHIPSET:

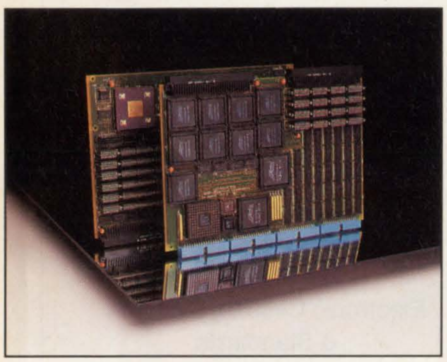
The heart of the world's fastest DSP product family

The Digital array Signal Processor (DaSP) executes 16 high-level instructions, including FFT butterflies, windowing, complex multiplies, and general-purpose functions. The Programmable array Controller (PaC) manages the entire system, including address generation for the DaSP and memory, and I/O up to 80 MHz. Using a single chipset, for example, a 1024 point FFT requires only 12 instructions and can execute in only 131 µsec; a complex FIR filter, using 28 instructions, processes at a 2.3 MHz rate. For even higher performance, you can cascade the chipset. Both utilize a 144-pin PGA format and are available in 30 and 40 MHz versions. To receive complete technical information, call **array** Microsystems' Hotline: 719-540-7999.



PC-FDaP PERFORMS 250 MOPS!

The a66550 Frequency Domain array Processor (FDaP) brings high performance FFT processing to any PC-AT compatible computer. The two board set will fit into two full size PC-AT slots, operate on the 16 bit PC-AT (ISA) bus, and allow real or complex input from either the high speed connectors on the back panel or from the PC-AT bus. The FDaP accommodates an optional complex I-and-Q to magnitude-and-phase converter for post-FFT processing. Available in two memory configurations, the a66550 handles complex FFTs up to 32K points and real FFTs up to 64K points. The a66550 can compute a 1024 point complex FFT in just 210 µs. For complete technical information, call **array** Microsystems' Hotline: 719-540-7999.



CORNERTURN PROVIDES QUANTUM LEAP IN 2D IMAGE PROCESSING PERFORMANCE

The a66545 Cornerturn™ board, used in conjunction with the a66540 FDaP board for real-time two-dimensional image processing, is the first capable of processing an entire 256 x 256 pixel frame of image data in 15.2 milliseconds. This equates to a continuous, real time rate of 65 frames per second. For 512 x 512 images, the board set transforms images in 71 milliseconds, or 14 frames per second. Designed for medical imaging, radar, sonar, machine vision, and other real-time 2D image processing applications, the board set features performance of 400 MOPS at a clock rate of up to 40 MHz. The Cornerturn accepts 32-bit complex I/O data through 10 MHz double-buffered external I/O connectors or through the VMEbus and stores it in one of four on-board frame store memory buffers. For technical assistance, call **array** Microsystems' Hotline: 719-540-7999.

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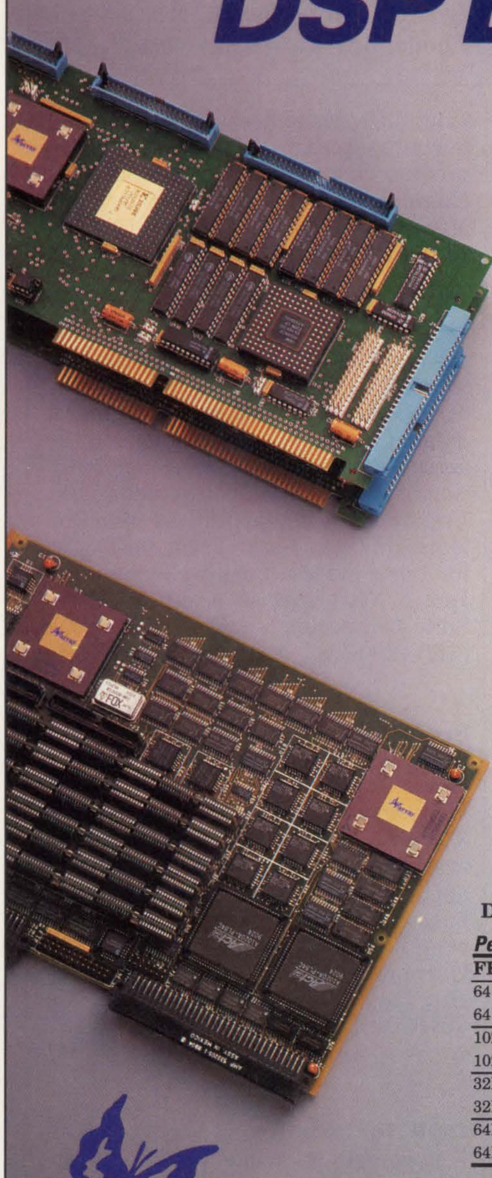
arraysoft, a complete DSP software development system supporting **array** Microsystems' a66 Family of Products, provides a menu driven user interface allowing easy access to a suite of powerful development tools at the click of a mouse. This development system features a DaSP/PaC code generator, assembler, disassembler, window generator, full DaSP/PaC program control, on-screen display of data, and board-level diagnostics. For technical information or original program assistance, call **array** Microsystems' Hotline: 719-540-7999.

DSP Built For Speed



PC-AT DSP
1K FFT/126µs

DSP engine for the 16-bit PC-AT Industry Standard Architecture (ISA) bus

Performance Benchmarks

FFT size	a66550/32K @25MHz
64 Real	7.2 µs
64 Complex	10.9 µs
1024 Real	125.9 µs
1024 Complex	209.9 µs
32K Real	5.90 ms
32K Complex	10.49 ms
64K Real	15.73 ms
64K Complex	N/A

VME DSP
1K FFT/79.6µs

DSP engine for industry-standard VMEbus

Performance Benchmarks

FFT size	a66540A @40MHz	a66540A Cascade Sys.
64 Real	5.1 µs	2.9 µs
64 Complex	5.0 µs	3.7 µs
1024 Real	79.6 µs	29.6 µs
1024 Complex	132.7 µs	59.1 µs
32K Real	3.69 ms	0.91 ms
32K Complex	6.56 ms	1.82 ms
64K Real	7.37 ms	1.82 ms
64K Complex	13.11 ms	3.64 ms

array™ MICROSYSTEMS

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1420 Quail Lake Loop, Colorado Springs, CO 80906

CIRCLE NO. 134

extensions. You can point and click to select from a library of objects and then drop them into a window, specify their size, and choose fonts, colors, and styles. Multimedia support covers CD-ROM and stereo sound. $249. **Knowledge Garden Inc,** Stony Brook Technology Center, 12-8 Technology Dr, Setuaket, NY 11733. Phone (516) 246-5400. FAX (516) 246-5452. **Circle No. 388**

Solder-process analyzer. PCB Soldersim is a simulation tool for analyzing the preheating, soldering, and curing operations of a pc-board soldering process. It can help you avoid problems such as cold solder joints, solder starvation, poor wetting, board warpage, and interconnect cracking. Boards to be simulated must have been previously analyzed with the supplier's PCB Explorer product. PCB Soldersim, $10,000; PCB Explorer, $20,000 to $30,000. **Pacific Numerix,** 1200 Prospect St, Suite 300, La Jolla, CA 92037. Phone (619) 587-0500. FAX (619) 459-4031. **Circle No. 389**

ASIC-design software. The ASIC Navigator Design System links your graphical ASIC system specification to system design tools by generating behavioral VHDL (VHSIC Hardware Description Language). Simulation of the specification at the behavioral level allows design changes and debugging to occur early in the design process. The package is suited for two types of users: the ASIC end user who is part of a product-design team in a systems house and the application-specific standard product designer. From $100,000. **Compass Design Automation,** Inquiry Dept 231, 200 Parkside Dr, San Fernando, CA 91340. Phone (408) 433-4880. FAX (408) 434-7820. **Circle No. 390**

GUI development tool. The Teleuse development tool for graphical-user interfaces (GUIs) is now available on the Hewlett-Packard 9000/700 family of workstations and servers. The software is a user-interface management system for interactive development of user interfaces based on OSF/Motif. By letting you paint a static user interface with a WYSIWYG approach, it avoids manually coding calls to the X-Window System or OSF/Motif. Including OSF/Motif, $7500. **Telesoft,** 5959 Cornerstone Ct W, San Diego, CA 92121. Phone (619) 457-2700. FAX (619) 452-1334. TLX 855300. **Circle No. 391**

Object-oriented libraries. CV-DORS (Developers Open-Resource Software) consists of a set of object-oriented software libraries which provides access to the supplier's CADDS-5, an integrated wire frame, surfaces, and solid-geometric modeler. You can also use the product independently of CADDS-5. The product is available on SPARC-based computers. Development license, $50,000; OEM runtime licenses, $1000 to $2500/seat. **Computervision,** 100 Crosby Dr, Bedford, MA 01730. Phone (617) 275-1800. **Circle No. 392**

Imaging library. The T-Base Version 3 software library lets you add pictures and document images to database applications written in C, C++, and most Xbase dialects. It works with any image in the PCX file format. The package includes Chromatools, a color manipulation and image-conversion utility. It works with Super VGA, VGA, EGA, CGA, and monochrome displays and with HP Laserjet II and III printers. $495. **Videotex Systems Inc,** 8499 Greenville Ave, Suite 205, Dallas, TX 75231. Phone (800) 888-4336; (214) 343-4500. FAX (214) 348-3821. **Circle No. 393**

RS-232C data trapper. Easydata helps eliminate manual data entry. While your program is running in the foreground, it traps incoming RS-232C data and fools your program into thinking that the data is coming from the keyboard. The package is compatible with any software that allows manual data entry. $145. **Labtronics Inc,** 2C-95 Crimea St, Guelph, ON, Canada N1H 2Y6. Phone (519) 767-1061. **Circle No. 394**

Metric shareware. Metric-X utility helps you convert between English and metric units. It features drop-down menus from which you can select any of 10 categories and 138 units of measure. It meets ANSI/IEEE Standard 268-1982 for accuracy. The program runs on DOS systems and comes with a comprehensive user's manual. Single-user registration, $15. **Orion Development Co,** Box 2323, Merrifield, VA 22116. Phone (800) 992-8170. **Circle No. 395**

FPGA design kits. These two design kits allow FPGA device models from Actel and Xilinx to run in the Dazix EDA environment for device- and board-level-design analysis, simulation, and test. Additional tools in the environment assist in board, hybrid, and multichip-module design, analysis, layout, and manufacturing. The kits are available as part of the latest Dazix Gemini software release. Each kit, $2500. **Dazix,** 1 Madison Industrial Park, Huntsville, AL 35894. Phone (205) 730-2000. **Circle No. 396**

ASIC-design translators. The Ikos Compass tool kit lets users of design tools from Compass Design Automation migrate their designs to Ikos systems for high-speed hardware-assisted simulation. It runs on workstations from Sun and HP/Apollo and supports the Compass Navigator series of ASIC design tools. The Ikos hardware-assisted simulators can simulate as many as 1.2 million gates at speeds as high as 75 million events per second. Tool kit, $10,000. **Ikos Systems Inc,** 145 N Wolfe Rd, Sunnyvale, CA 94086. Phone (408) 245-1900. FAX (408) 245-6219. **Circle No. 397**

OCR software tool kit. The Textpert Developer's Tool kit lets you put optical-character-recognition capabilities into your software applications. The package comes in versions for Macintosh Systems 6 and 7, MS-DOS, OS/2, and Microsoft Windows. It works with numerous scanners. Tool kit with one runtime license, $495. **CTA Inc,** 25 Science Park, New Haven, CT 06511. Phone (203) 786-5828. **Circle No. 398**

Database-design tool. DB Designer helps you design and reverse engineer relational databases. It also assists in migrating nonrelational files and databases to Oracle Corp's Oracle database and IBM's DB2 database. The tool runs on IBM PS/2 and compatible computers under the OS/2 operating system. From approximately $20,000. **Cadre Technologies Inc,** 222 Richmond St, Providence, RI 02903. Phone (401) 351-5950. **Circle No. 399**

Project-management software. Primavera 5.0 is a DOS-based program that combines scheduling; resource allocation and leveling; cost control; custom reporting; and presentation graphics. The software allows for multiproject control. Software licenses, $4000. **Primavera Systems Inc,** 2 Bala Plaza, Bala Cynwyd, PA 19004. Phone (215) 667-8600. **Circle No. 400**

Bar-code software. Mac-Barcode Version 2.0 lets Macintosh users design bar codes for labels. This Version 2.0 supports the UCC/EAN 128 application identifiers and the bar codes of Version 1.1: 128, 39, interleaved 2 of 5, Codabar, UPC/EAN, 93, and 11. The software comes with templates for Avery laser-printer labels. $199. **Data Capture Institute,** Box 1625, Duxbury, MA 02331. Phone (800) 733-7592; (617) 934-7585.
Circle No. 401

Data-analysis tool. Muse lets users interactively analyze complex data. By combining features of spreadsheets and relational database managers, it helps you answer questions about your data. It also has graphics capabilities. $695. **Occam Research Corp,** 42 Pleasant St, Watertown, MA 02172. Phone (617) 923-3545. FAX (617) 926-3262. **Circle No. 402**

Design and drafting tool. Version 6.0 of Generic CADD enhances the compatibility of that product with AutoCAD. It directly loads any 2D (.DWG) file for review, editing, printing, and plotting. The software comes with matching AutoCAD Release 11 fonts and hatch patterns. $495. **Autodesk Retail Products,** 11911 North Creek Pkwy S, Bothell, WA 98011. Phone (206) 487-2233. **Circle No. 403**

Employee-evaluation software. The Employee Evaluator and Salary Manager, version 3.0 is a tool to standardize review and appraisal of employees. This network version provides centralized control of criteria, salary, and performance. Software, $590; standalone version, $195. **Hi Tech Enterprises,** 857 Taylor St, #5, Monterey, CA 93940. Phone (800) 437-1222; (408) 373-5117. **Circle No. 404**

Microcode development system. This user-retargetable microcode development system lets you create high-level-language compilers and other software development tools for any microprogrammable architecture. Microcode tools include a macropreprocessor, C compiler, peephole optimizer, code converter and compactor, retargetable microcode assembler, linker, object librarian, and vertical-operations level simulator. The system is available for MS-DOS and for Unix on 386-based and Sun workstations. $3495 to $4995. **Archelon Inc,** 460 Forestlawn Rd, Waterloo, ON, Canada N2K 2J6. Phone (519) 746-7925.
Circle No. 405

PC diagnostic software. The Microscope diagnostic software package lets you format—at low level—any IDE hard-disk drive. It can repair IDE drives that have been incorrectly formatted so you don't have to return them to the factory. It runs under DOS, Novell, OS/2, Unix, Xenix, Pick, PC MOS, C.DOS, and other systems. $449. **Micro 2000 Inc,** 1100 E Broadway, 3rd Fl, Glendale, CA 91205. Phone (818) 547-0125. **Circle No. 406**

Multiprocessing operating system. OS/MP 4.1A.2 is a symmetric multiprocessing operating system that has been tuned for database performance. The software, fully compatible with SunOS, will be offered at no cost to existing customers under their maintenance agreements. **Solbourne Computer Inc,** 1900 Pike Rd, Longmont, CO 80501. Phone (303) 772-3400. FAX (303) 772-3646. **Circle No. 407**

Expert troubleshooting development tools. Testbench contains the Testbuilder and Testview development and delivery tools. Where the development tool creates and maintains knowledge bases, the delivery tool provides diagnostic assistance to field engineers. A client/server capability lets you embed the software in your applications. Optional modules link the software to existing knowledge bases and generate reports. From approximately $33,000. **Carnegie Group Inc,** 5 PPG Pl, Pittsburgh, PA 15222. Phone (412) 642-6900. FAX (412) 642-6906. **Circle No. 408**

Help-system aid. Robohelp assists you in writing help systems for applications that run under Windows. It lets you concentrate on the content of your help system rather than on the Windows help compiler's source-code format. It generates source code for indexes, topics, keywords, categories, defined terms, pop-up definitions, bit maps, cross references, and hypertext links. $495. **Blue Sky Software Corp,** 7486 La Jolla Blvd, Suite 3, La Jolla, CA 92037. Phone (800) 677-4946; (619) 459-6365. FAX (619) 459-6366. **Circle No. 409**

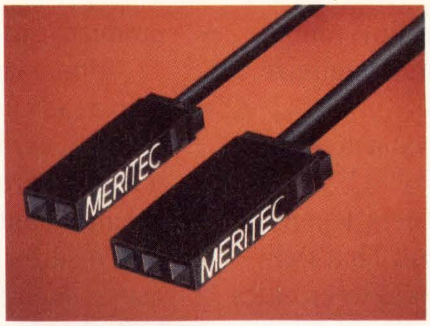
Pascal compiler. Version 2.0 of FS:pascal is a protected-mode Pascal compiler that generates native 32-bit code. It does away with the 64-kbyte segment-size limit of real-mode programs and allows variables and arrays to be as large as available RAM. The compiler is compatible with Turbo Pascal; it runs on 80386- and 80486-based computers under MS-DOS versions 3.0 and higher. $149.95. **Frontier Software,** 66-22 Fleet St, Suite 2C, Forest Hills, NY 11375. Phone (800) 934-3732; (718) 520-4197. **Circle No. 410**

MAP software. MicroMAP, an implementation of the ISO/IEEE Manufacturing Automation Protocol (MAP), allows communication on the factory floor among computers from multiple vendors. This release works simultaneously with Ethernet and token-ring bus interfaces and also improves the communications stack's performance. It runs on the supplier's Deltaseries 3000 and 4000 computers. $1250. **Motorola Inc,** Computer Group, 2900 S Diablo Way, Tempe, AZ 85282. Phone (800) 234-4863. **Circle No. 411**

Connectivity software for Windows 3. Dynacomm/Elite APPC is a program-to-program communications software tool that generates transaction programs. These programs can communicate on a peer-to-peer basis with transaction programs on other computers. Featuring a nonlanguage-specific application programming interface (API) based on IBM's OS/2 API, you can generate programs using any language offering Windows Dynamic Link Library calling. Stand-alone pricing, from $495. **Network Software Associates,** 39 Argonaut, Laguna Hills, CA 92656. Phone (800) 352-3270; (714) 768-4013. FAX (714) 768-5049. **Circle No. 412**

Single Signal Interconnects —high performance in a subminiature package

Meritec's economical 1×2 and 1×3 Single Signal Interconnects (SSI™), are engineered to match application requirements for controlled impedance and propagation rate while minimizing crosstalk. A spring latch connects the termination to the housing or to Meritec's Single Signal Carrier Systems (SSC™), which allow grouped interfacing with single, dual or triple row headers. Precision, high strength molded terminations provide reliability in critical applications. Boxed contacts with thermo resistance welding provide the ultimate in electrical continuity.



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96 Position DIN Cable Assembly

- *Impedance matched*
- *Programmed grounds and signals*

Meritec's impedance matched 96 Position DIN Cable Assemblies feature an internal PCB which allows programming of grounds and signals to customer specifications. The high speed, low noise controlled impedance assemblies are designed for TTL fast and fast CMOS logic. Standard impedances are available from 50 to 120 ohms using low dielectric FEP cable to ensure less propagation delay. EMI/RFI electrical shielding is optional. Signal and ground wires are mass solder terminated to the PCB. Insert molded strain relief provides high reliability in critical applications.

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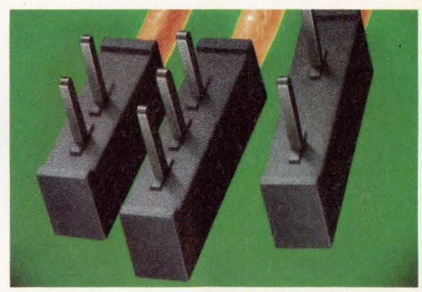
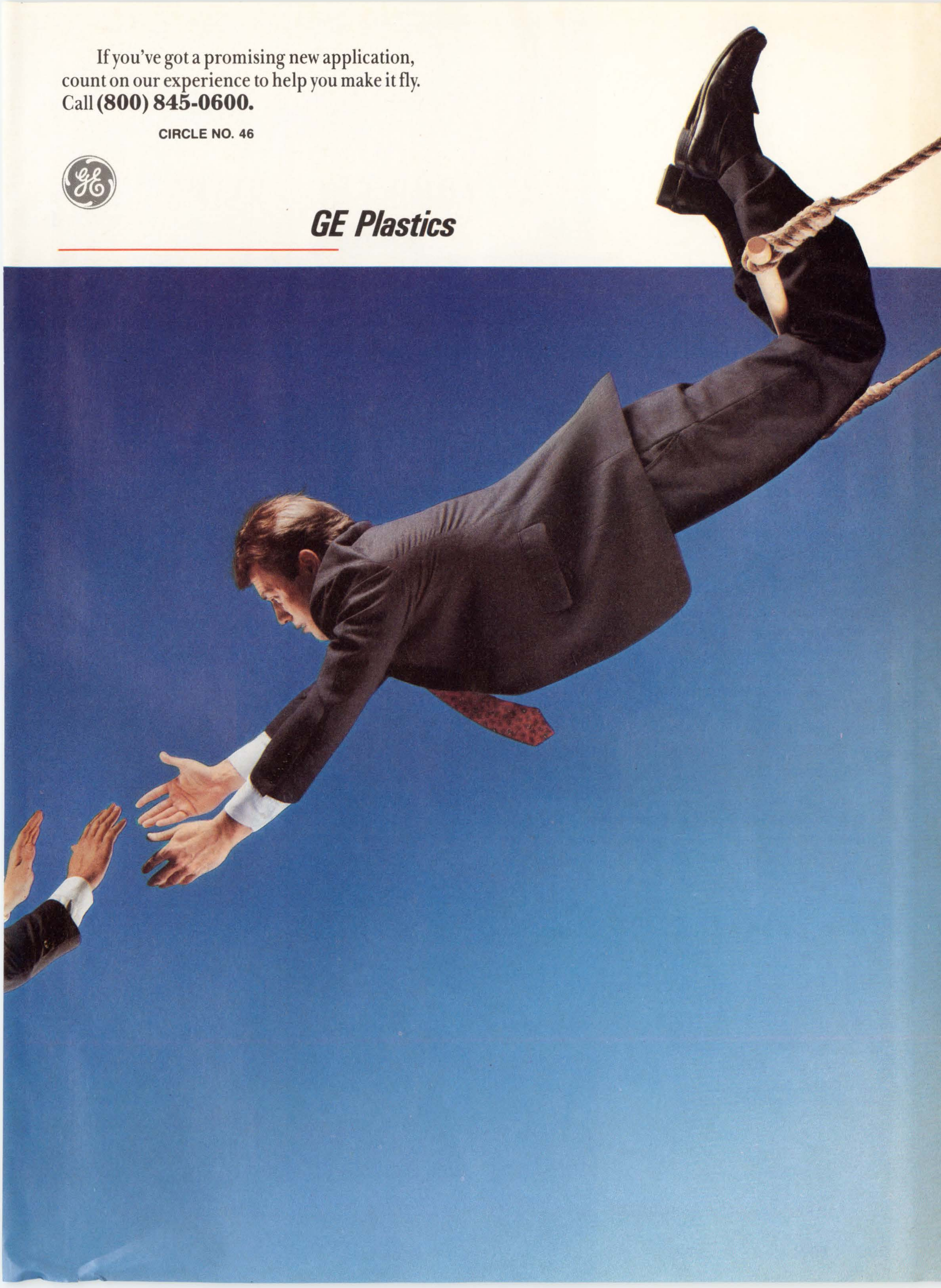


Impedance matched PCB Solderable Interconnects

- *Solders directly to the PCB*
- *Low profile*

Meritec's PCB Solderable Interconnects can be soldered directly to the PCB for a permanent connection. Pin lengths of .110″ and .160″ are available for different board thicknesses. The impedance matched connectors feature precision, high strength molded terminations for reliability in critical applications. Available in 1×2 and 1×3 configurations, the connectors are side-to-side stackable and feature heights as low as .150″ from the PCB, making them ideal for dense package applications. The connectors can be terminated to a variety of different cable styles.

CIRCLE NO. 170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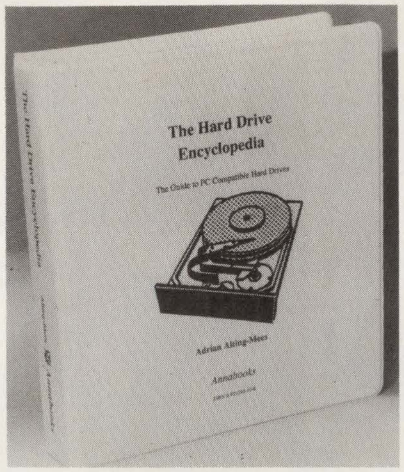
CIRCLE NO. 46
GE Plastics

Test-and-measurement-interface handbook. The *Instrument Communication Handbook* describes interfaces used for test-and-measurement applications. It focuses on the IEEE-488 and IEEE-488.2 standards and evaluates the RS-232C, RS-422, RS-485, and VXI standards. Topics include SCSI, SCPI (standard commands for programmable instruments), and local-area networking using Ethernet. $14.95. (Free to qualified requesters.) **IOtech Inc,** 25971 Cannon Rd, Cleveland, OH 44146. **INQUIRE DIRECT**

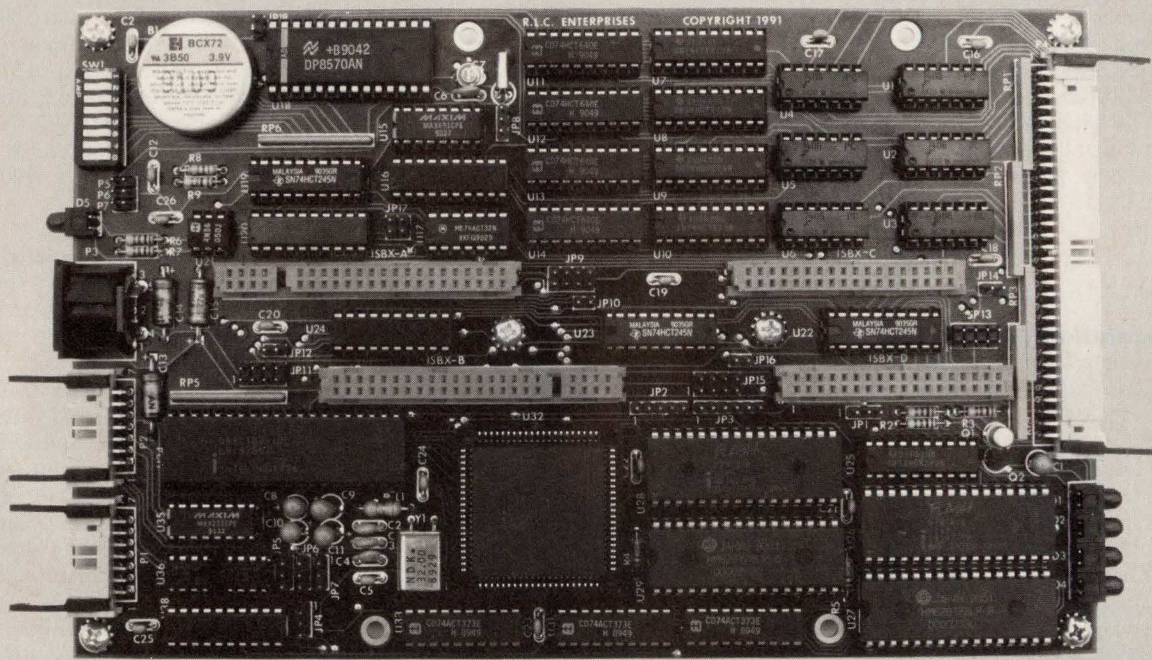
Instrumentation-amplifier guide. The *Instrumentation Amplifier Application Guide* explains instrumentation amplifiers in medical instrumentation, audio, data acquisition, and high-speed signal conditioning. The 44-pg guide's three sections cover basic instrumentation-amplifier theory, designing instrumentation amplifiers, and instrumentation-amplifier applications. The guide also contains an introduction to operating this type of amplifier and application notes. It provides two appendices. The first appendix reviews specifications such as operating conditions, gain, gain range, and nonlinearity. The second appendix provides an instrumentation-amplifier selection chart. **Analog Devices,** Literature Center, 70 Shawmut Rd, Canton, MA 02021. **Circle No. 443**



Encyclopedia of hard drives. The *Hard Drive Encyclopedia* is a reference work covering PC-compatible hard drives; it comes with a disk full of utilities. The 3-ring binder holds almost 600 pages, covering ST506, ESDI, IDE, and five other types of interface specifications. The listings present controller parameters, hard-disk parameters, and manufacturers. More than 1600 models are listed by manufacturer. $89 plus shipping. **Annabooks,** 12145 Alta Carmel Ct, Suite 250-262, San Diego, CA 92128. Phone (800) 462-1042; (619) 271-9526. FAX (619) 592-0061. **INQUIRE DIRECT**

EMI-measurement publication. This revised edition of the News Special, totaling approximately 120 pages and entitled *Measuring EMI and wanted signals,* surveys electromagnetic compatibility measurement technology. It describes test receivers and interference-measurement systems and peripherals. Articles deal with current standards, regulations, and measurement procedures, as well as those that will be adopted in the European Community in 1992. Evaluations from 17 users report on their applications of the vendor's instruments for signal strength and interference measurements. **Rohde & Schwarz,** Mühldorfstr 15, 8000 Munich 80, Germany. **Circle No. 444**

NO BUS! 80C186EB NO FUSS!



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* 16-Bit 80C186EB Up To 16 MHz
* On-Board 80C187 Co-Processor
* 8570 Real Time Clock
* Four 8/16-Bit iSBX Expansion Ports
* Watch Dog Timer And Power Fail Detect
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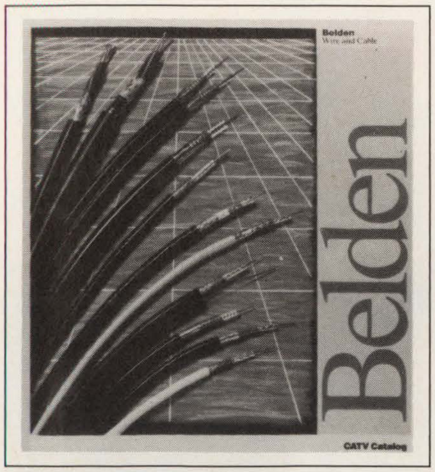


Catalog of CATV products. This 28-pg catalog presents CATV (community-antenna TV) products, including 18 new drop cables and fiber-optic Supertrunk cables. The cable-to-connector cross reference highlights PPC F-connectors and Gilbert and LRC connectors. The CATV technical section features shield effectiveness. **Cooper Industries, Belden Div,** Box 1980, Richmond, IN 47375. Phone (800) 235-3364.
Circle No. 445

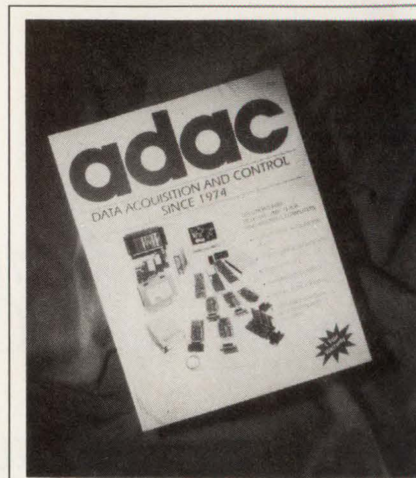
Data-acquisition-products brochure. This 4-pg brochure describes Microsoft Windows 3.0-compatible Data-Link Libraries for data-acquisition and instrument control. The products covered in the publication consist of NI-DAQ, NI-488.2, and NI-VXI Windows software drivers. Applications for these products encompass laboratory automation, data acquisition, process monitoring and control, physiological monitoring, personal instrumentation, and automated testing. **National Instruments Corp,** 6504 Bridge Point Pkwy, Austin, TX 78730. **Circle No. 446**

Embedded software standards. *The Guide to Embedded Software Standards* is part of an applications-guide series for developing embedded systems. This set of ground rules for programmers of 8- and 16-bit embedded systems is essentially a pro forma document that even very small companies can use. **Softaid Inc,** 8300 Guilford Rd, Columbia, MD 21046. Phone (800) 433-8812; (301) 290-7760. FAX (301) 381-3253. **Circle No. 447**

Demonstration program. Labwindows 2.0 demonstration program provides an overview of the Labwindows 2.0 software development system for programming C and Basic data-acquisition and instrument-control applications. **National Instruments Corp,** 6504 Bridge Point Pkwy, Austin, TX 78730. Phone in US and Canada, (800) 433-3488; (512) 794-0100. FAX (512) 794-8411. **Circle No. 448**

Catalog of development tools. This 76-pg catalog is divided into eight sections. The first five sections present development tools for series x86 μPs; MCS-51 microcontrollers (μCs); MCS-96 μCs; i960 μPs; and i860 μPs. The three remaining sections deal with service and support, reference, and resources. Each product section furnishes a development cycle for the products described within the section. **Intel Corp,** Development Tools Operation, 5200 NE Elam Young Pkwy, MS JF1-15, Hillsboro, OR 97124. Phone (800) 874-6835. FAX (503) 696-4633.
Circle No. 449

Text continued on pg 206



Combined catalog and application handbook. This 1992 catalog and application handbook provides a set of application notes on data-acquisition products. The notes discuss topics such as comparisons of program control, program interrupt, and DMA; gain and system resolution; how to select a high-resolution A/D board; and signal-conditioning solutions and techniques. **ADAC Corp,** 70 Tower Office Park, Woburn, MA 01801. Phone (800) 648-6589; (617) 935-6668. FAX (617) 938-6553.

Circle No. 450

Catalog of nuclear-research instruments. The 368-pg *Research Instrumentation Catalog,* summarizes a product line and presents technical data sheets and specifications, application notes, and ordering information. The introductory tutorial deals with research instrumentation and has a glossary of technical terms. Products covered in the publication include instruments in VME, CAMAC, and Fastbus formats. **LeCroy,** 700 Chestnut Ridge Rd, Chestnut Ridge, NY 10977.

Circle No. 451

Newsletter of MIL-STD-1553 products. This 4-pg newsletter describes boards, transformers, and development software that meet the requirements of MIL-STD-1553. It features a question-and-answer column and an application note. The newsletter also publishes related information, such as the opening of a manufacturing facility in Ireland, which will export products to the European market, the US, and the Far East. **ILC Data Device Corp,** 105 Wilbur Pl, Bohemia, NY 11716. Phone (516) 567-5600. FAX (516) 567-7358. TWX 310-685-2203.

Circle No. 452

FM SERIES MODUFLEX SWITCHERS WITH 0.99 POWER FACTOR

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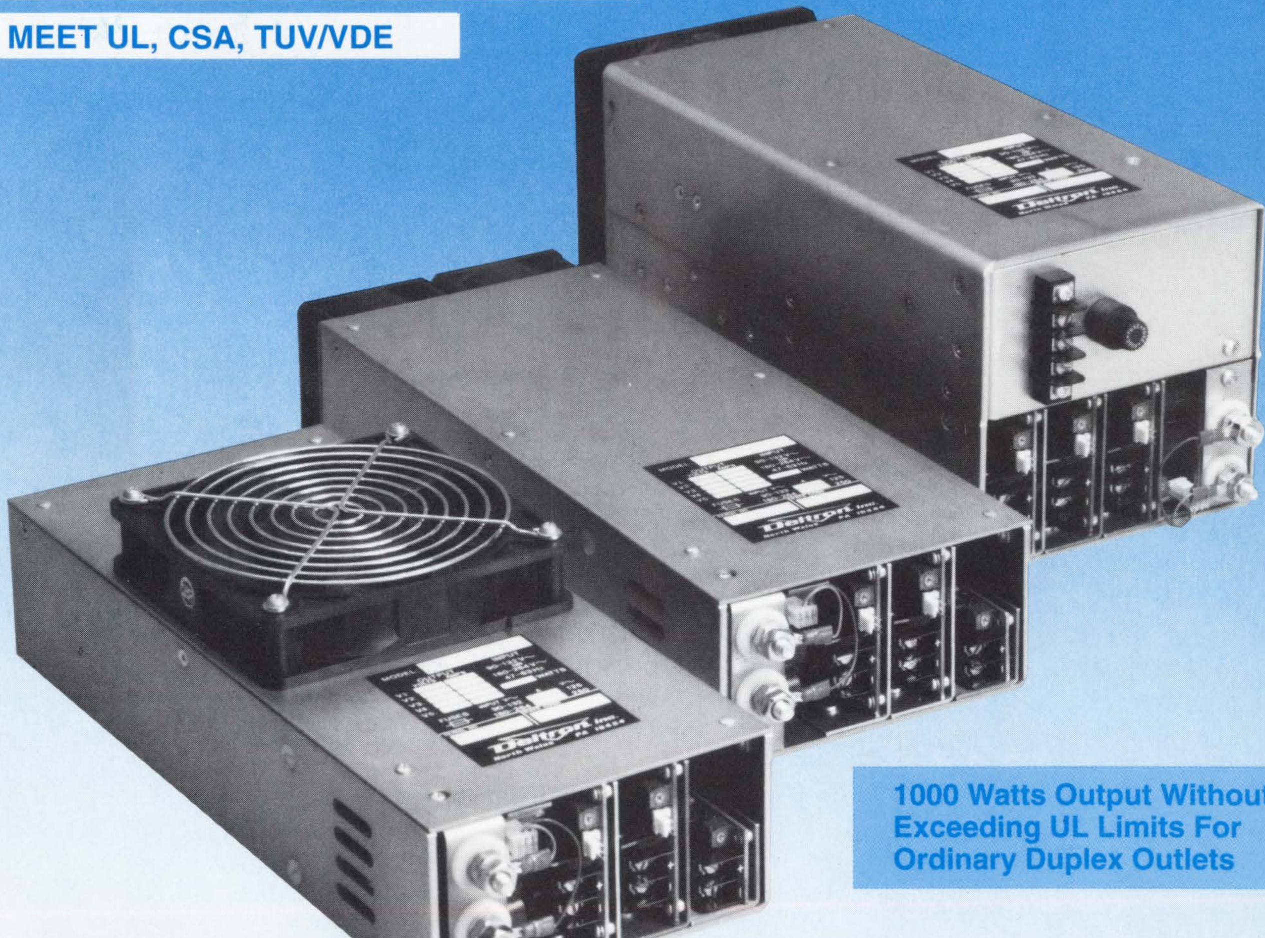

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OUTPUT LOCATIONS

600 Watt FM Configurations

Config	Output 1	Output 2	Output 3	Output 4
12	#1 M5			
24	#1 M4	#2 K		
26	#1 M4	#2 L		
30	#1 M3	#2 L	#3 K	
36	#1 M3	#2 K	#3 K	
48	#1 M3	#2 K	#3 K	#4 K
56	#1 M3	#2 K	#3 K	#5 J / #4 J
64	#1 M3	#2 K	#6 J / #3 J	#5 J / #4 J
72	#1 M3	#7 J / #2 J	#6 J / #3 J	#5 J / #4 J

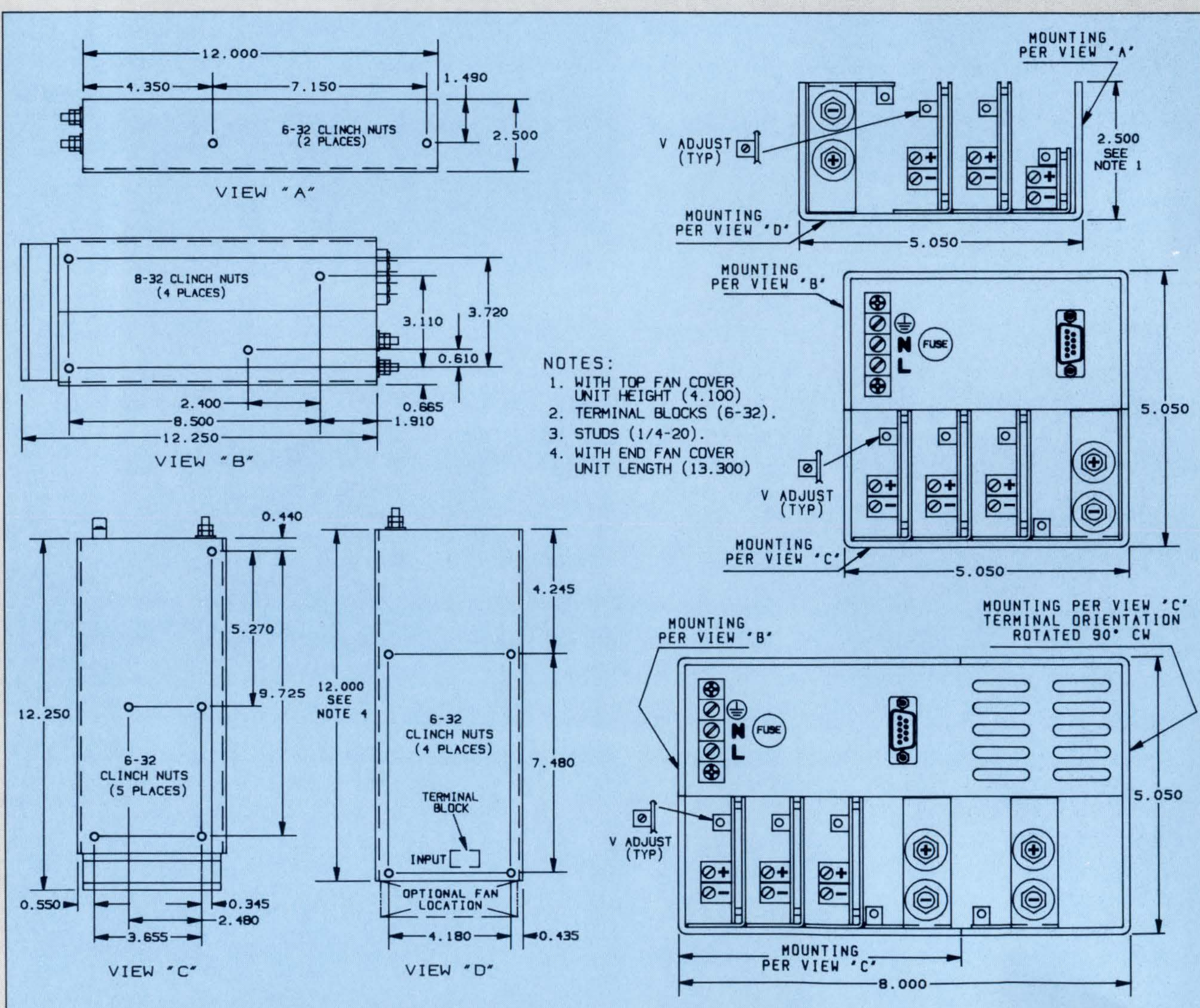
1000 Watt FM Configurations

Config	Top	Output 1	Output 2	Output 3	Output 4
11	AC	#1 M7			
21	AC			#2 L	#1 M6
31	AC		#3 L	#2 L	#1 M6
41	AC	#4 G	#3 G	#2 G	#1 M6
43	AC	#4 K	#3 G	#2 G	#1 M6
51	AC	#5 J / #4 J	#3 G	#2 G	#1 M6
61	AC	#5 J / #4 J	#6 J / #3 J	#2 G	#1 M6
71	AC	#5 J / #4 J	#6 J / #3 J	#7 J / #2 J	#1 M6

2000 Watt FM Configurations

Config	Top	Output 1	Output 2	Output 3	Output 4	Output 5
13	AC	#1 M9				
23	AC			#2 M7	#1 M7	
33	AC		#3 L	#2 M6	#1 M7	
45	AC		#4 L	#3 L	#2 M6	#1 M7
53	AC	#5 G	#4 G	#3 G	#2 M6	#1 M7
55	AC	#5 K	#4 G	#3 G	#2 M6	#1 M7
63	AC	#6 J / #5 J	#4 G	#3 G	#2 M6	#1 M7
73	AC	#6 J / #5 J	#7 J / #4 J	#3 G	#2 M6	#1 M7

FM SERIES DIMENSIONS



DESCRIPTION

Moduflex switchers form a comprehensive line of open frame power supplies assembled from standard "off the shelf" modules. These subunits and assembly hardware are pre-approved by safety agencies so that certifications can automatically apply to custom models. Additional advantages include first piece delivery within two weeks and the elimination of engineering costs for qualified "OEM" requirements using stock modules.

FM Series are corrected to produce a 0.99 power factor. The resultant input current waveform is nearly a perfect sine wave compliant to the harmonic requirements of IEC 555-2.

Modular construction permits high volume manufacturing with an outstanding quality level and at competitive cost.

FEATURES

- 0.99 power factor.
- 5 watts per cubic inch.
- 600-2000 watts output.
- 120 kilohertz design.
- TUV/VDE, UL, CSA.
- All outputs:
  - *Adjustable*
  - *Fully regulated*
  - *Floating*
  - *Overload and short circuit proof*
  - *Overvoltage protected*
- Standard features include:
  - *System inhibit*
  - *Fan output*

MODEL SELECTION

Input modules are available in ratings of 600, 1000, and 2000 watts with corresponding code letters of C, E and G. Refer to Power Code Table.

Output modules are available in ten types ranging in nominal power from 75 to 2000 watts. Refer to Output Code Table for codes and nominal power output.

Input Power Codes	
Codes	Watts
C	600
E	1000
G	2000

Output Codes	
Codes	Nominal Power
J	75
K	150
G	300
L	300
M3	400
M4	500
M5	600
M6	750
M7	1000
M9	2000

The Table of Ratings for the various types of output modules lists the maximum current for each type as a function of corresponding voltage rating.

Ratings in the shaded area are Preferred and are stocked for fast delivery.

Note: When computing output load power, multiply the fraction of actual current to max. rated current by the nominal power rating of the output module.

RATINGS OF OUTPUT MODULES

Nominal Power		75W	150W	300W	300W	400W	500W	600W	750W	1000W	2000W
Code	Volts	J	K	G	L	M3	M4	M5	M6	M7	M9
0	2	10	20	20	30	80	100	120	150	200	400
1	3.3	10	20	20	30	80	100	120	150	200	400
2	5	10	20	30	30	80	100	120	150	200	400
3	12	6	12	20	24	34	42	50	62	84	168
4	15	5	10	20	20	26	33	40	50	67	134
5	18	4	8	16	16	22	28	33	42	56	112
6	24	3	6	12	12	17	21	25	31	42	84
7	28	2.5	5	10	10	14	18	21	27	36	72
8	36	2	4	8	8	11	14	17	21	28	56
9	48	1.5	3	6	6	8	10	12	16	21	42

HOW TO ORDER

Select the letter F for power factor correction, then select the letter M to designate the series. Choose the desired configuration of output modules and list the configuration code. Insert the power code letter and follow with the output code numbers for each individual output. Enter a dash and from the option table insert the sum of the option codes. See example below.

F M 41 E 2 3 3 6 – Y

- F: P. F. Corrected
- M: Series
- 41: Configuration
- E: Power Code
- 2: Output #1 Code
- 3: Output #2 Code
- 3: Output #3 Code
- 6: Output #4 Code
- Y: Sum of Option Codes

	OPTIONS
Option Code	Function
1	Power Fail Monitor
2	Cover (600W only)
4	End Fan Cover (600W only)
8	Top Fan Cover (600W only)

SPECIFICATIONS

INPUT
90-264 VAC, 47-63 Hz.
190-264 for 2000W units.

POWER FACTOR
0.99 at full load.

HARMONIC CURRENTS
Compliant to IEC 555-2.

INPUT SURGE
230 VAC – 75A max.
115 VAC – 40A max.

HOLDUP TIME
20 milliseconds from loss of AC power.

OUTPUTS
See model selection table.

ADJUSTABILITY
±5% trim adjustment.

OUTPUT POLARITY
All outputs are floating from chassis and each other and can be referenced to each other or ground as required.

LINE REGULATION
Less than ±0.1% or ±5mV for input changes from nominal to min. or max. rated values.

LOAD REGULATION
±0.2% or ±10mV for load changes from 50% to 0% or 100% of max. rated values.

MINIMUM LOAD
Main output requires a 10% minimum load for full output from auxiliaries. Main output is #1 on 600W and 1000W units and #2 on 2000W units.

REMOTE SENSING
On all outputs except type J modules.

RIPPLE & NOISE
1% or 100mV pk-pk, 20 MHz bandwidth.

OPERATING TEMPERATURE
0-70°C.- Derate 2.5%/°C above 50°C.

COOLING
A min. of 10 LFS cooling air directed on cooling surfaces over the 600W units for full rating. Two test locations on chassis rated for max. temperature of 90°C. 1000W and 2000W models have built-in ball bearing fan.

TEMPERATURE COEFFICIENT
±0.02%/°C.

EFFICIENCY
70% to 80%.

SAFETY
Units meet UL 1950, CSA 22.2 No. 234, IEC 950, EN 60 950, VDE 0804, VDE 0805, VDE 0806. Certifications in process.

DIELECTRIC WITHSTAND
3750 VRMS input to ground.
3750 VRMS input to output.
700 VDC output to ground.

SPACING
8 mm primary to secondary.
4 mm primary to grounded circuits.

LEAKAGE CURRENT
3.5mA max.

EMISSIONS
Units meet FCC 20780 Part 15 Class A and VDE 0871 Class A for conducted emissions. Compliance with Class B limits by use of additional external filter.

DYNAMIC RESPONSE
Peak transient less than ±2% or ±200mV for step load change from 75% to 50% or 100% max. ratings.

RECOVERY TIME
Recovery within 1%.
M3, M4, M5, M6, M7, and M9 modules – 200 microseconds.
J, K, G, and L modules – 500 microseconds.

UNDERVOLTAGE
Protects against damage for undervoltage operation.

OVERVOLTAGE PROTECTION
Standard on all outputs.

REVERSE VOLTAGE PROTECTION
All outputs are protected up to load ratings.

OVERLOAD & SHORT CIRCUIT
Outputs protected by duty cycle current foldback circuit with automatic recovery. Auxiliaries have additional backup fuse protection.

THERMAL SHUTDOWN
Circuit cuts off supply in case of local over temperature. Units reset automatically when temperature returns to normal.

SOFT START
Units have soft start feature to protect critical components.

FAN OUTPUT
Nominal 12 VDC @ 12 watts maximum.

INHIBIT
TTL compatible system inhibit provided.

SHOCK
MIL-STD 810-D Method 516.3, Procedure III.

VIBRATION
MIL-STD 810-D Method 514.3, Category 1, Procedure I.

MECHANICAL
600W – Case 1. – 2.5 x 5.05 x 12
1000W – Case 2. – 5.05 x 5.05 x 12
2000W – Case 3. – 5.05 x 8 x 12

POWER FAIL MONITOR
Optional circuit provides isolated TTL and VME compatible power fail signal providing 4 milliseconds warning before main output drops by 5% after an input failure.

FAN COVER
Optional covers with brushless DC ball bearing fan which provides the required air flow for full rating of 600W units. Choice of low profile or top mounted types.

Specifications subject to change without notice.

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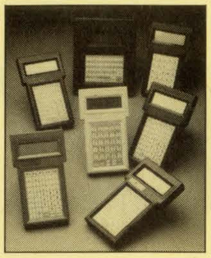

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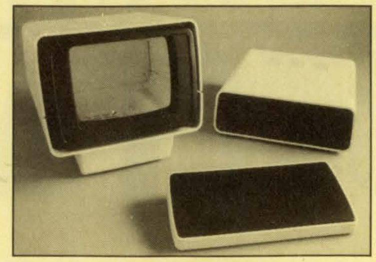

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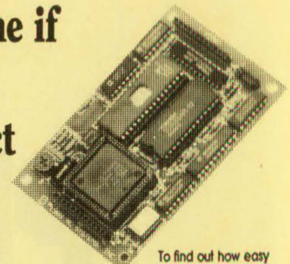

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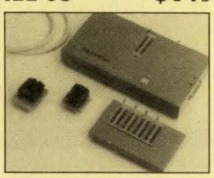

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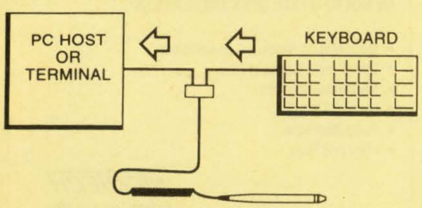

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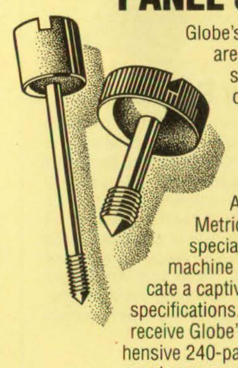

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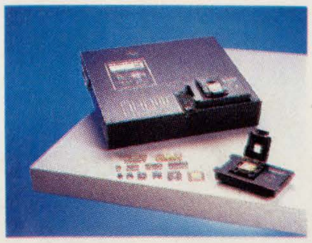

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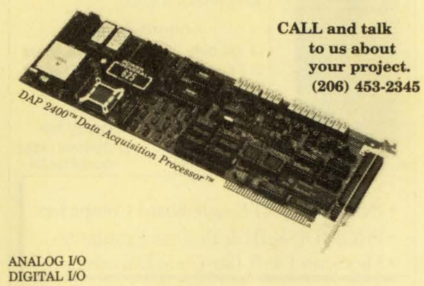

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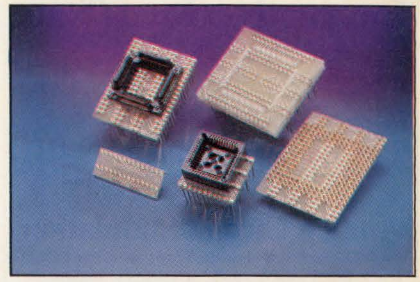

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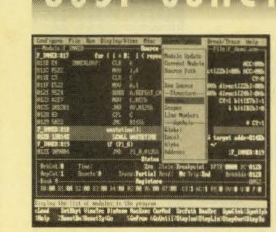

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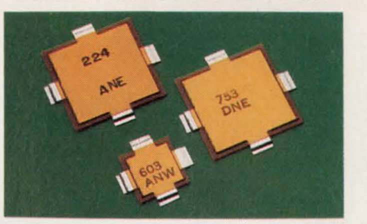

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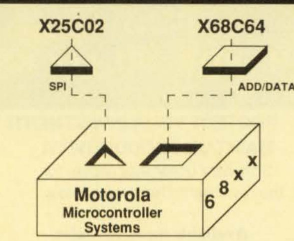

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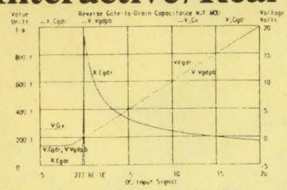

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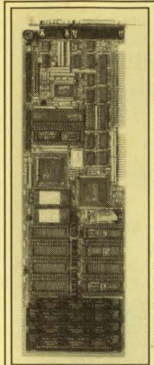

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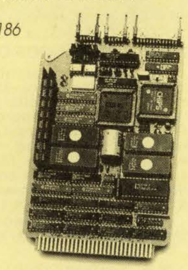

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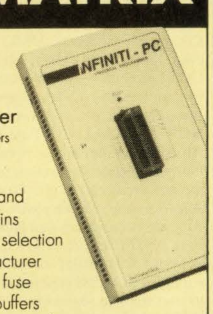

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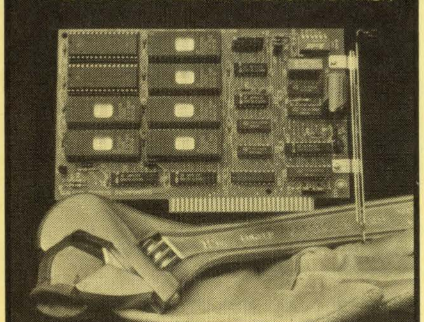

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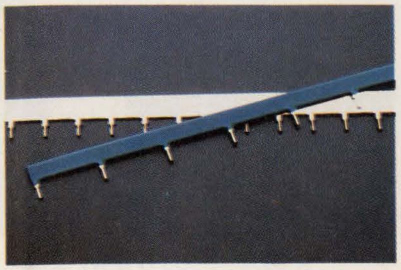

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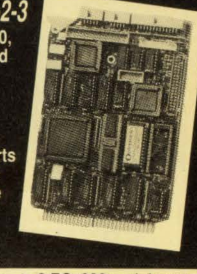

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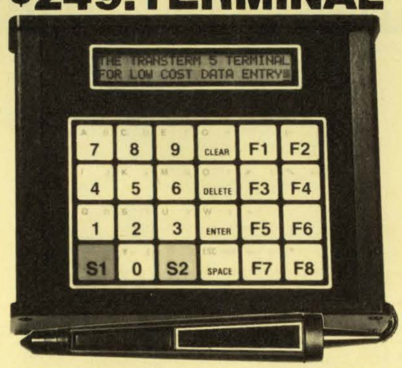

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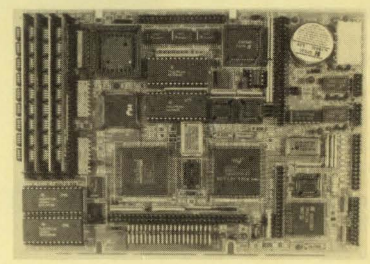

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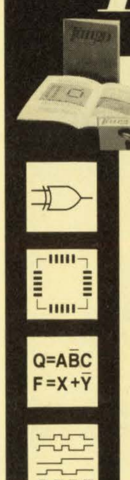

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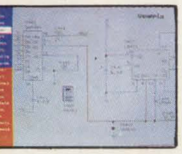

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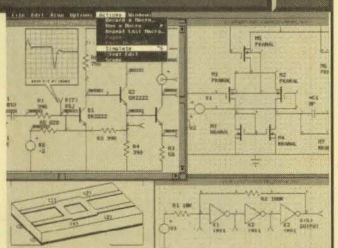

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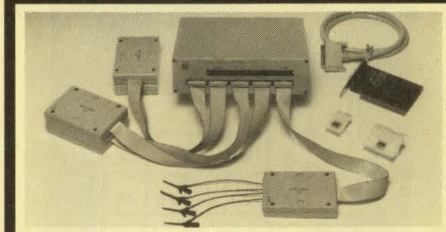

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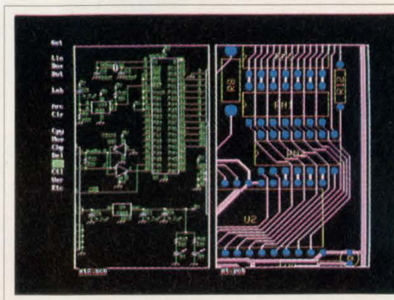

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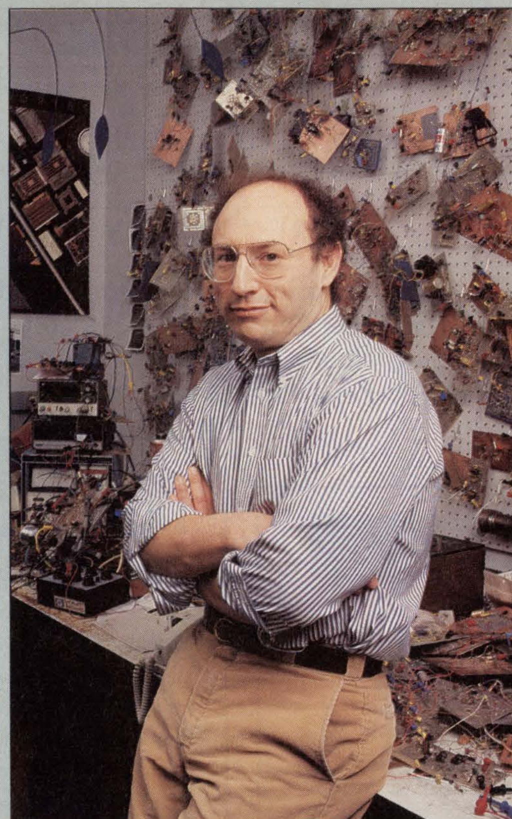

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Issue	Issue Date	Ad Deadline	Editorial Emphasis
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Magazine Edition	Apr. 9	Mar. 19	CAE • EDN Hands-on Special Project—Part I: Field-programmable Gate Arrays • Software • Memory Technology
Magazine Edition	Apr. 23	Apr. 2	Portable Computer Design • EDN Hands-on Special Project—Part II: Field-programmable Gate Arrays • Electromechanical Devices • Computer Peripherals
News Edition	Apr. 30	Apr. 16	ASICs SPECIAL ISSUE • FPGAs and EPLDs • CICC Hot Products • ASICs • Regional Profile: Northern California
Magazine Edition	May 7	Apr. 16	Communications/Networks • Test & Measurement • Surface-Mount Components • Power Sources • Electro Show & Products Issue
ELECTRO SHOWGUIDE & PRODUCT SPOTLIGHT		Apr. 3	A free page available to all advertisers running a full page in 2 out of 3 Electro issues
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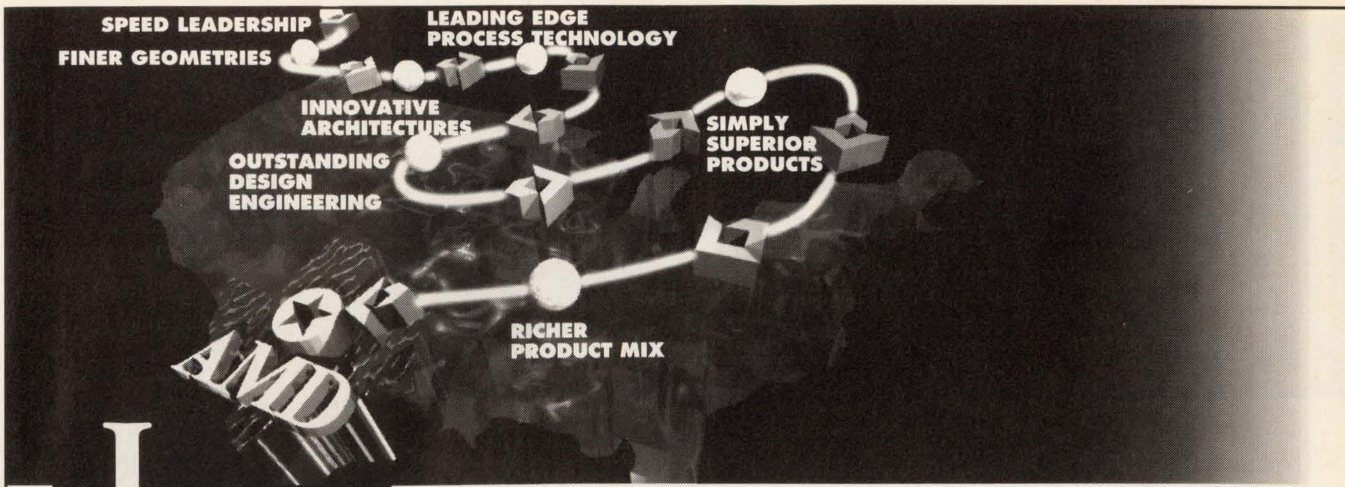

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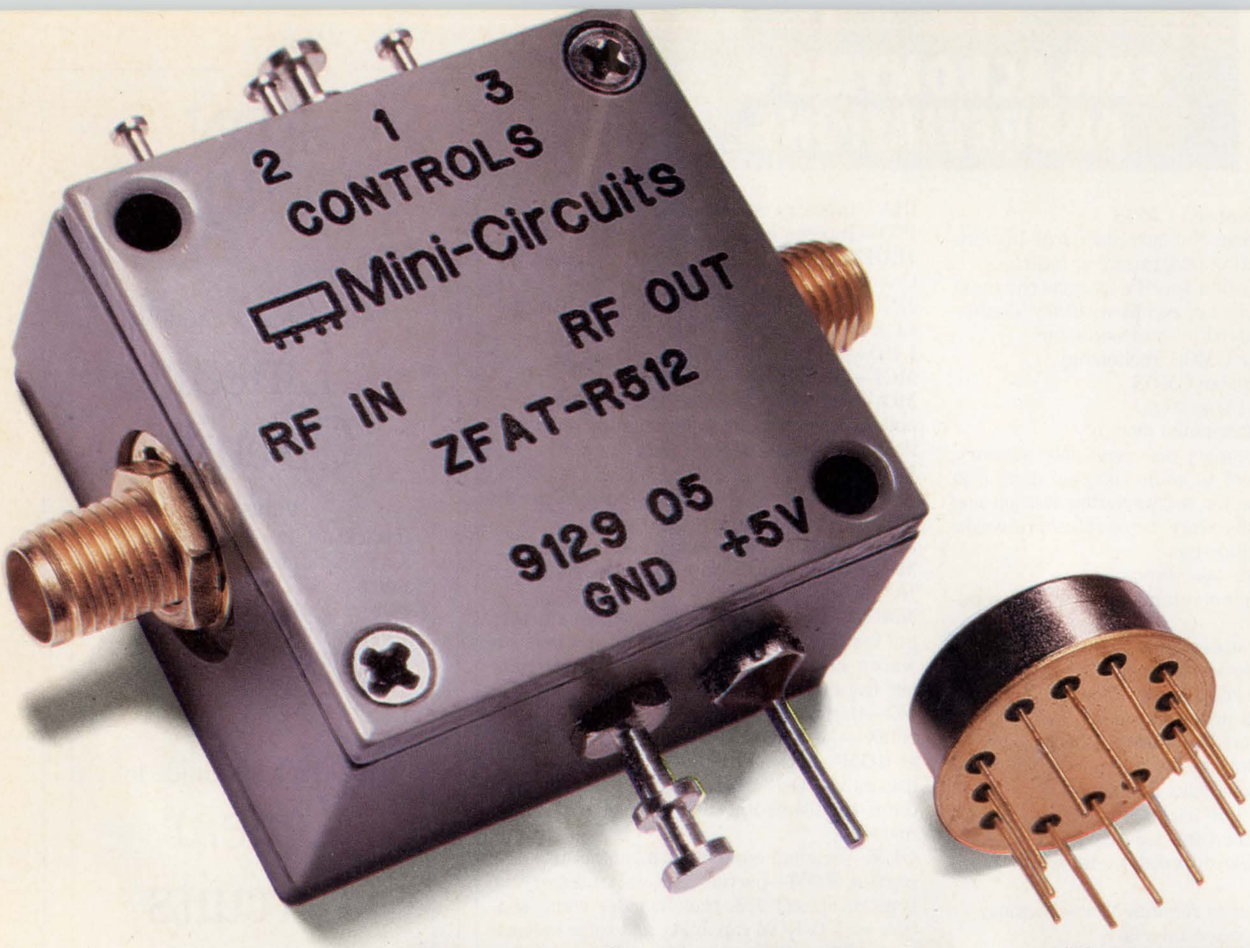
EDN-ACRONYMS & ABBREVIATIONS

ACMOS—Advanced CMOS
ANSI—American National Standards Institute
API—application programming interface
ASIC—application-specific integrated circuit
BCDMOS—bipolar complementary double-diffused metal-oxide semiconductor
BCT—Bipolar CMOS Technology
BiCMOS—bipolar CMOS
BIOS—basic I/O system
CAD—computer-aided design
CD-ROM—compact disc read-only memory; a sister product to audio compact discs that publishers use for software distribution and to electronically store large reference works such as encyclopedias
C_L—total load capacitance
CMOS—complementary metal-oxide semiconductor
C_{PD}—"power-dissipating" capacitance of a CMOS logic device (a misnomer, because capacitance doesn't dissipate power)
CPU—central processing unit
CSA—Canadian Standards Association
DDC—data duty cycle
DDE—Dynamic Data Exchange
DIP—dual in-line package
DLL—Dynamic Link Library
DMOS—double-diffused metal-oxide semiconductor
DRAM—dynamic random-access memory
DVI—digital video interface
DVM—digital voltmeter
ECL—emitter-coupled logic
EDC—enable duty cycle
EISA bus—Extended Industry Standard Architecture bus
EMI—electromagnetic interference
FACT—Fairchild Advanced CMOS Technology (now a trademark of National Semiconductor Corp)
FAST—Fairchild Advanced Schottky TTL (now a trademark of National Semiconductor Corp); a member of the bipolar logic-IC family
high-Z—high impedance; the state of a 3-state device whose output you've disabled
IC—integrated circuit
I_{CC}—collector current (that is, a device's power-supply current; also applied incorrectly to the drain current of MOS ICs because the drain current is also the power-supply current)
I_{CCD}—the dynamic component of the supply current of a CMOS logic device. (I_{CCD} is directly proportional to the frequency at which the device's output is switching.)
I_{CCH}—a logic device's high-state quiescent current
I_{CCL}—a logic device's low-state quiescent current
I_{CCQ}—quiescent supply current
I_{CCT}—the extra supply current drawn by a CMOS logic element when its inputs are held between the supply rails by the output of a TTL device
I_{CCZ}—the quiescent current of a 3-state device in the output-disabled high-Z state
I_{DD}—the drain current (power-supply current) of a MOS IC
IEEE-488—a standard interface that connects peripherals to a computer, also known as the GPIB or general-purpose interface bus
I/O—input-output
I_{OL}—output-low current for a Thevenin termination
ISA—Industry Standard Architecture
ISO—International Standards Organization
JEDEC—Joint Electron Device Engineering Council
JPEG—Joint Photographic Experts Group
LCD—liquid-crystal display
LED—light-emitting diode
MCI—media control interface
MO—magneto-optical; a data-storage technology that uses a combination of magnetic fields and lasers to store data
MOS—metal-oxide semiconductor
MOSFET—metal-oxide-semiconductor field-effect transistor
MPC—multimedia personal computer
MPEG—Motion Picture Experts Group
NC—normally closed
NMOS—n-type metal-oxide semiconductor; an insulating-gate field-effect transistor whose channel is n-type silicon (Electrons are the majority carrier).
NO—normally open
NTSC—National Television System Committee
O-ROM—optical read-only memory. Publishers use O-ROM data cartridges as a medium to distribute software and reference material.
OEM—original equipment manufacturer
partial ROM—partial read-only memory; a type of optical disk that includes some sectors with O-ROM capability and some sectors with MO capability
PC—personal computer
PMOS—p-type metal-oxide semiconductor; an insulating-gate field-effect transistor whose channel is p-type silicon (Holes are the majority carrier).
R_L—load resistance
RAM—random-access memory
RFI—radio-frequency interference
ROM—read-only memory
SAM—serial-access memory
SCSI—Small Computer System Interface
SIP—single in-line package
spdt—single-pole, double-throw
spst—single-pole, single-throw
SSR—solid-state relay
TTL—transistor-transistor logic
UL—Underwriter's Laboratories Inc
V_{BE}—a transistor's base-to-emitter voltage
V_{CC}—the (positive) power-supply voltage for TTL-compatible logic families, including CMOS families
V_{DD}—in CMOS, the positive power-supply voltage
VDE—Verband Deutscher Elektrotechniker
VGA—video graphics array
V_{IN}—the input voltage
VMEbus—32-bit data bus that has a theoretical maximum data-transfer rate of 40 Mbytes/sec
V_{OH}—the high-state output voltage
V_{OL}—the low-state output voltage
V_{OLP}—the transient-peak low-state output voltage
VRAM—video random-access memory
V_{SW}—voltage swing
WORM—write once, read many; a type of optical disk that can have data written to it once
Z_0—characteristic impedance

This list includes acronyms and abbreviations found in EDN's Special Report, Technology Updates, and feature articles.



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2.0	**0.2**	**4.0**	**0.3**	**10.0**	**0.3**	**16.0**	**0.5**	**20.0**	**0.4**
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3.0	0.4	6.0	0.5	16.0	0.6	24.0	0.8	30.0	0.7
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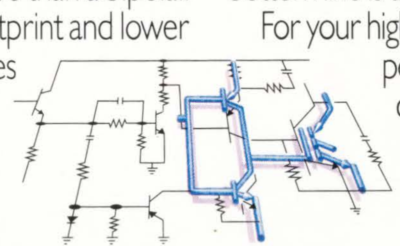

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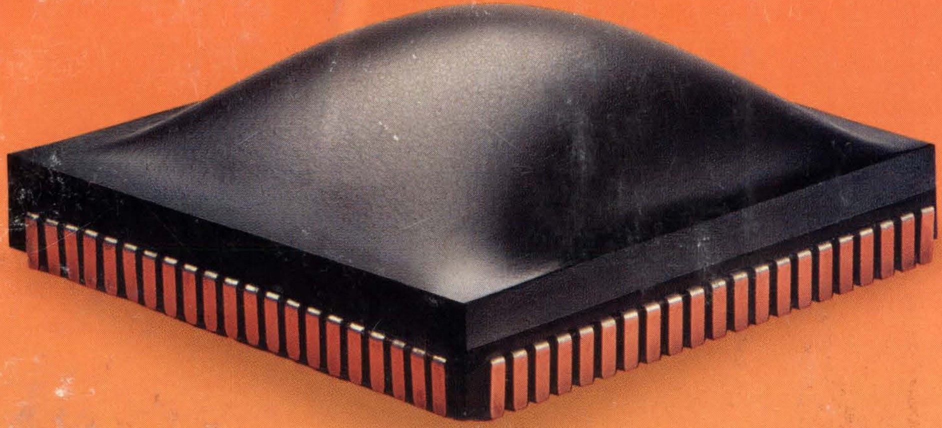

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