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JUNE 23, 1988

EDN®

Designer's Guide to Transmission Lines and Interconnections

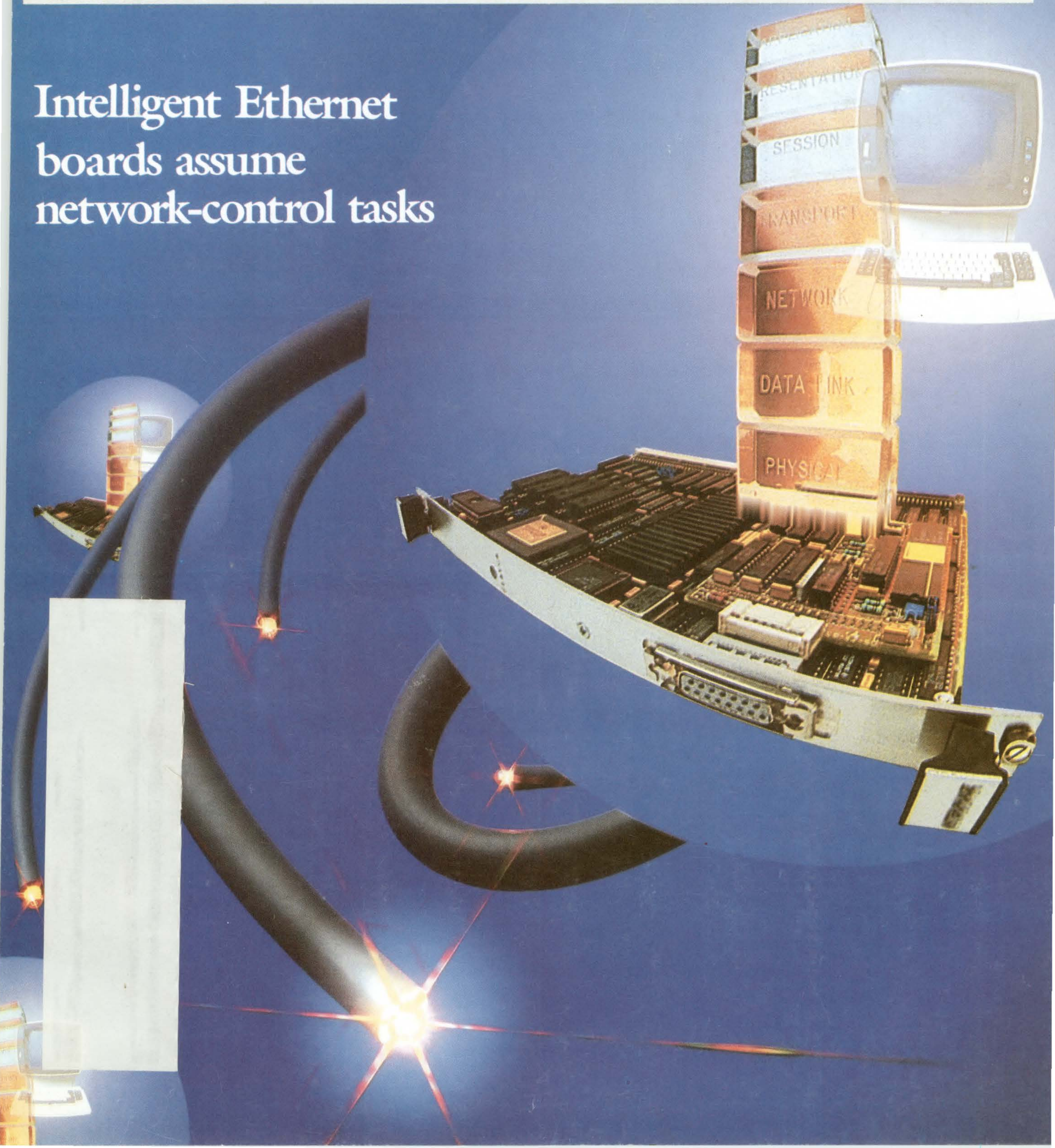
HLL compilers for DSP applications

Floating-point processors

Keyboards

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Intelligent Ethernet boards assume network-control tasks



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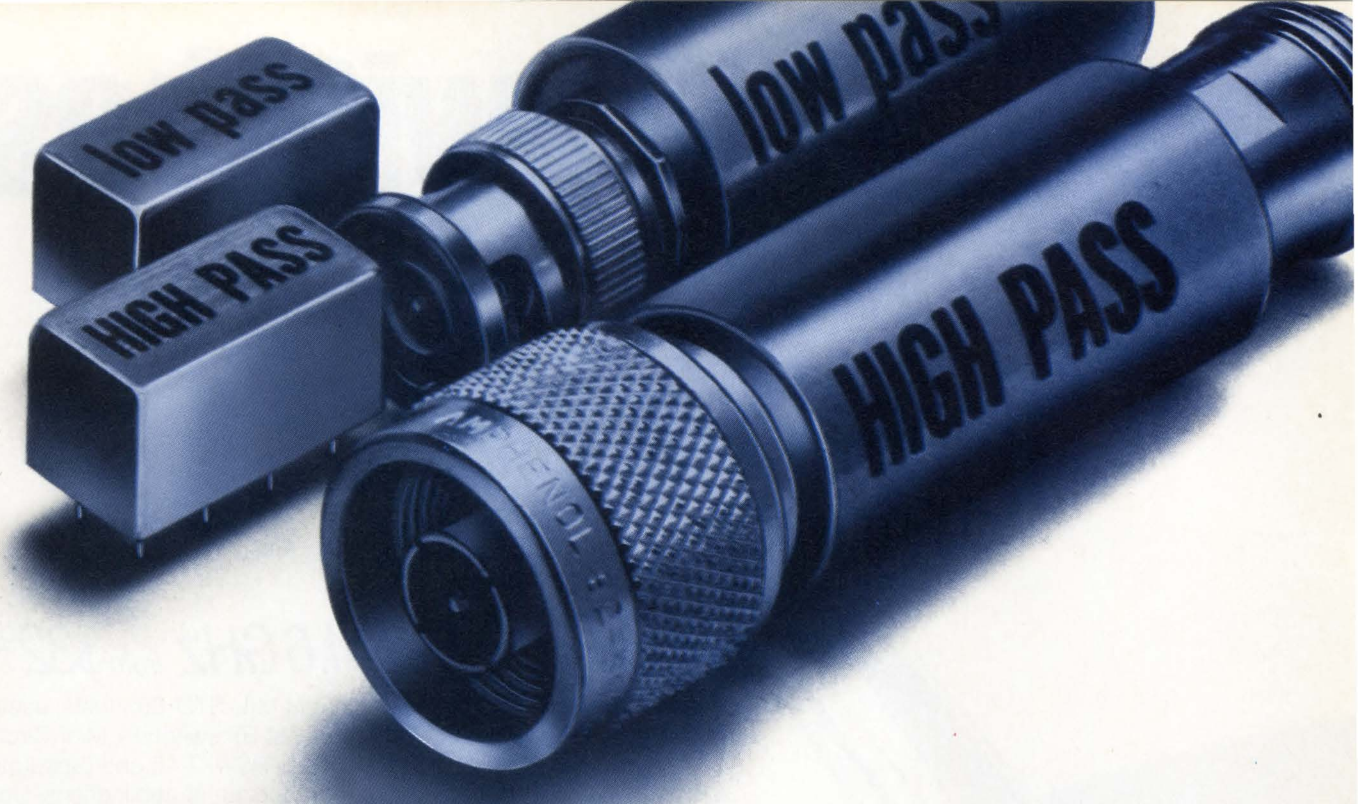

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C105 REV.D

Volume 33, Number 13

EDN

June 23, 1988

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

On the cover: Intelligent Ethernet boards include a local μP and memory and actually perform front-end execution of the network protocol without impacting the host CPU's performance. See pg 114. (Photo courtesy Interphase Corp)

DESIGN FEATURES

Continued on page 7

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CIRCLE NO 222

Continued from page 5

***Keyboard vendors** are concentrating their design efforts on low-profile, stand-alone units (pg 55).*

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TECHNOLOGY UPDATE

PRODUCT UPDATE

DESIGN IDEAS

Continued on page 9

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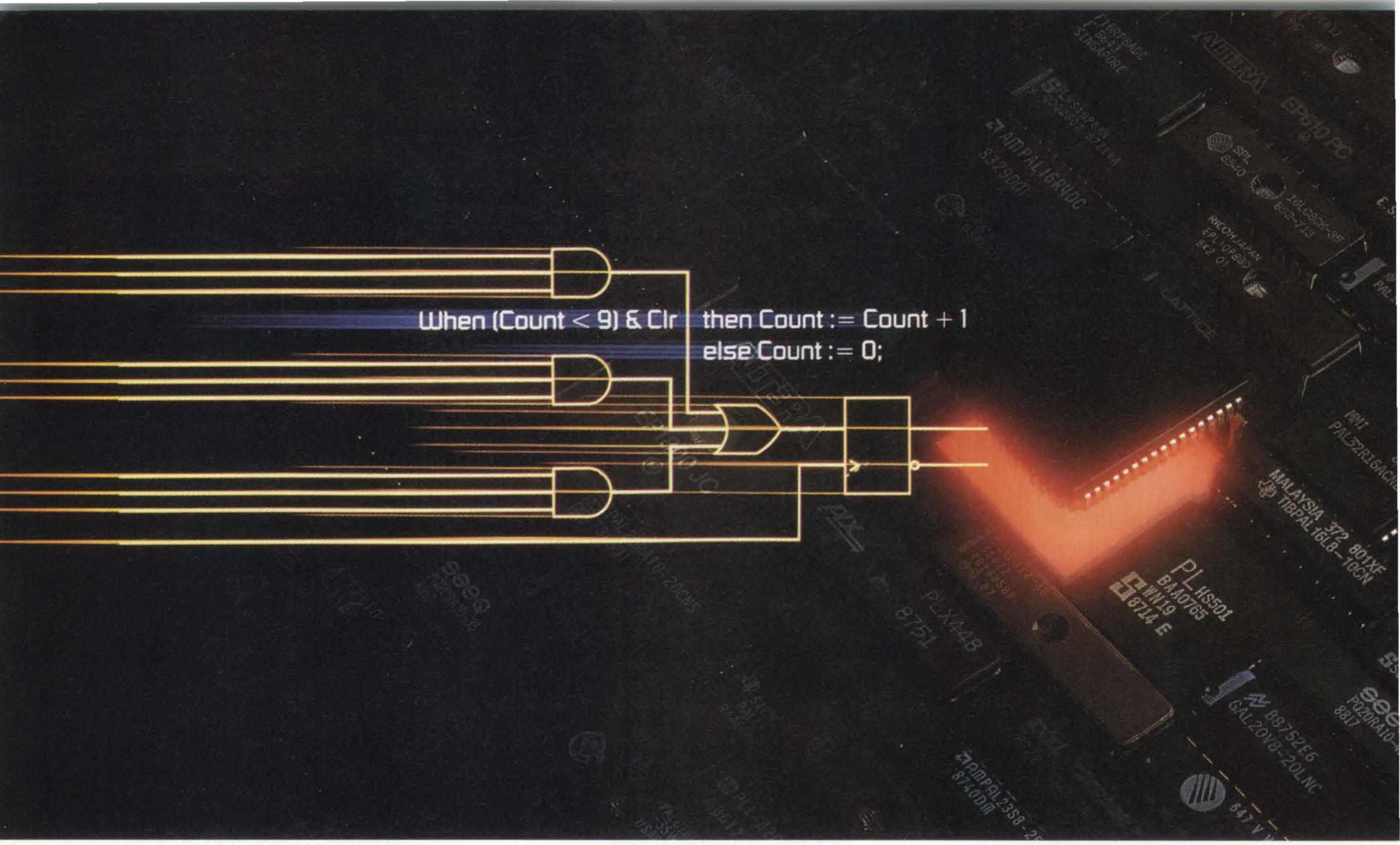

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People have a place in space, particularly if we keep expanding satellite-based communications.

NEW PRODUCTS

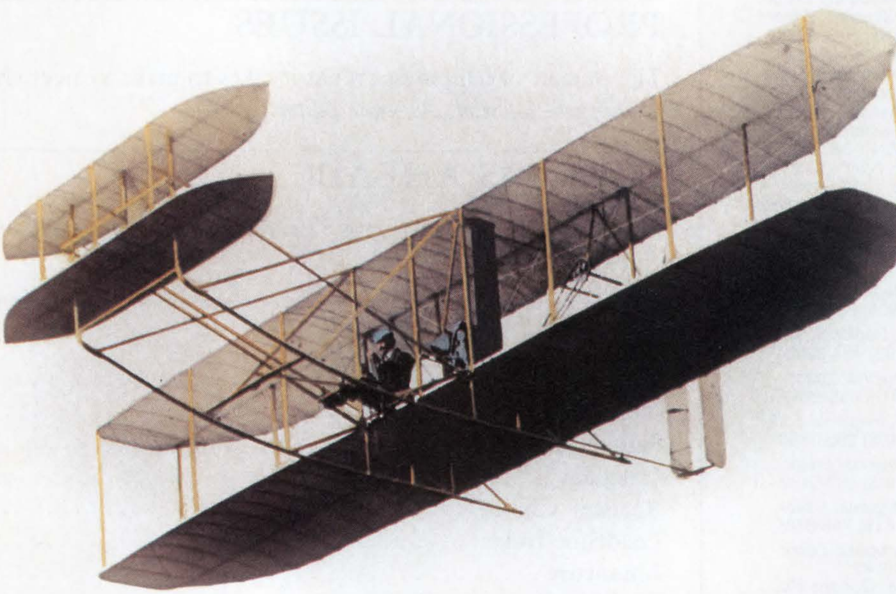
PROFESSIONAL ISSUES 281

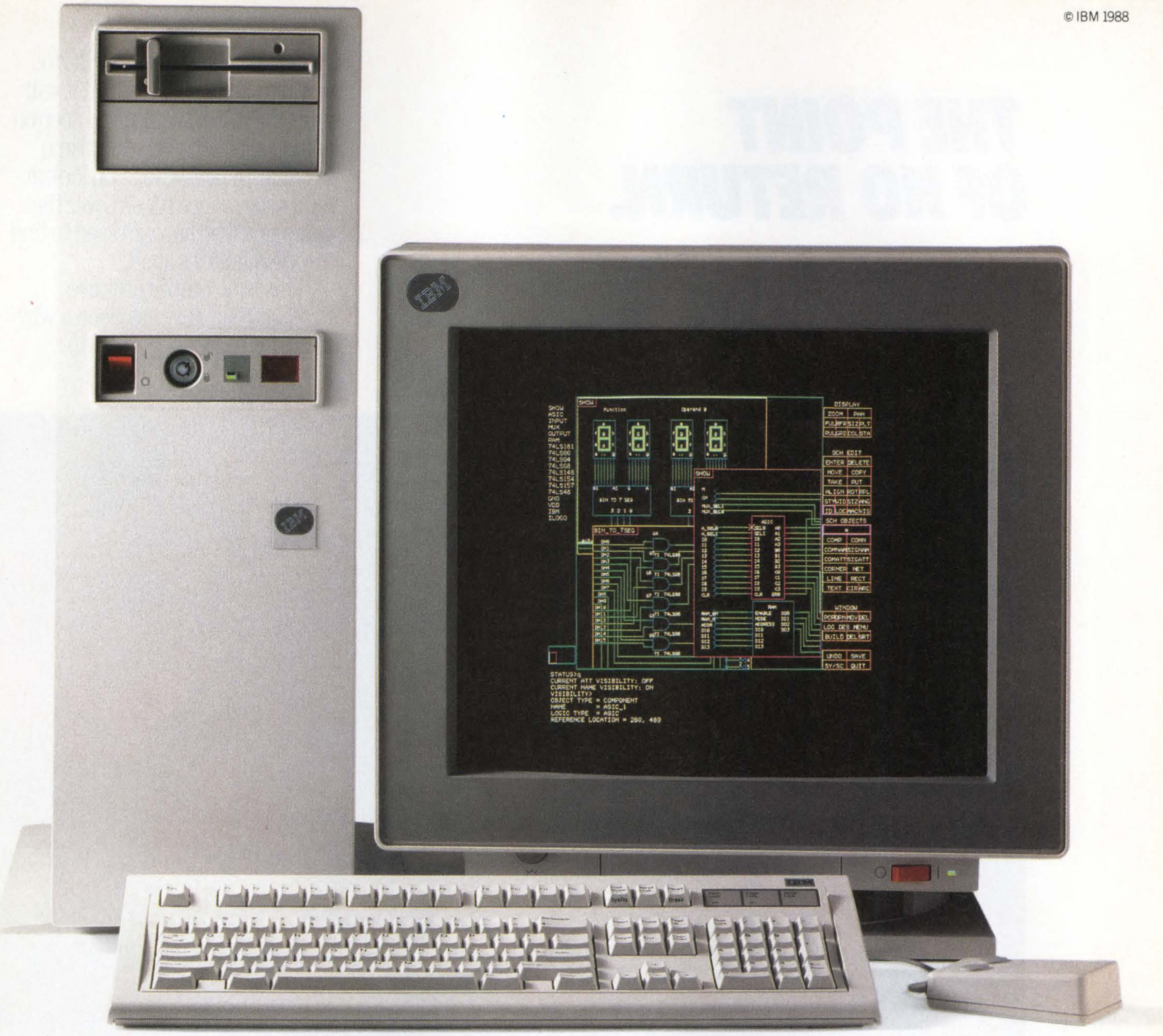
The pursuit of happiness: What it takes to make a career change.
—Deborah Asbrand, Associate Editor

LOOKING AHEAD 299

Laser-based IC tools to gross $722M in '92. . . Helical-scan tape drives come of age.

DEPARMENTS





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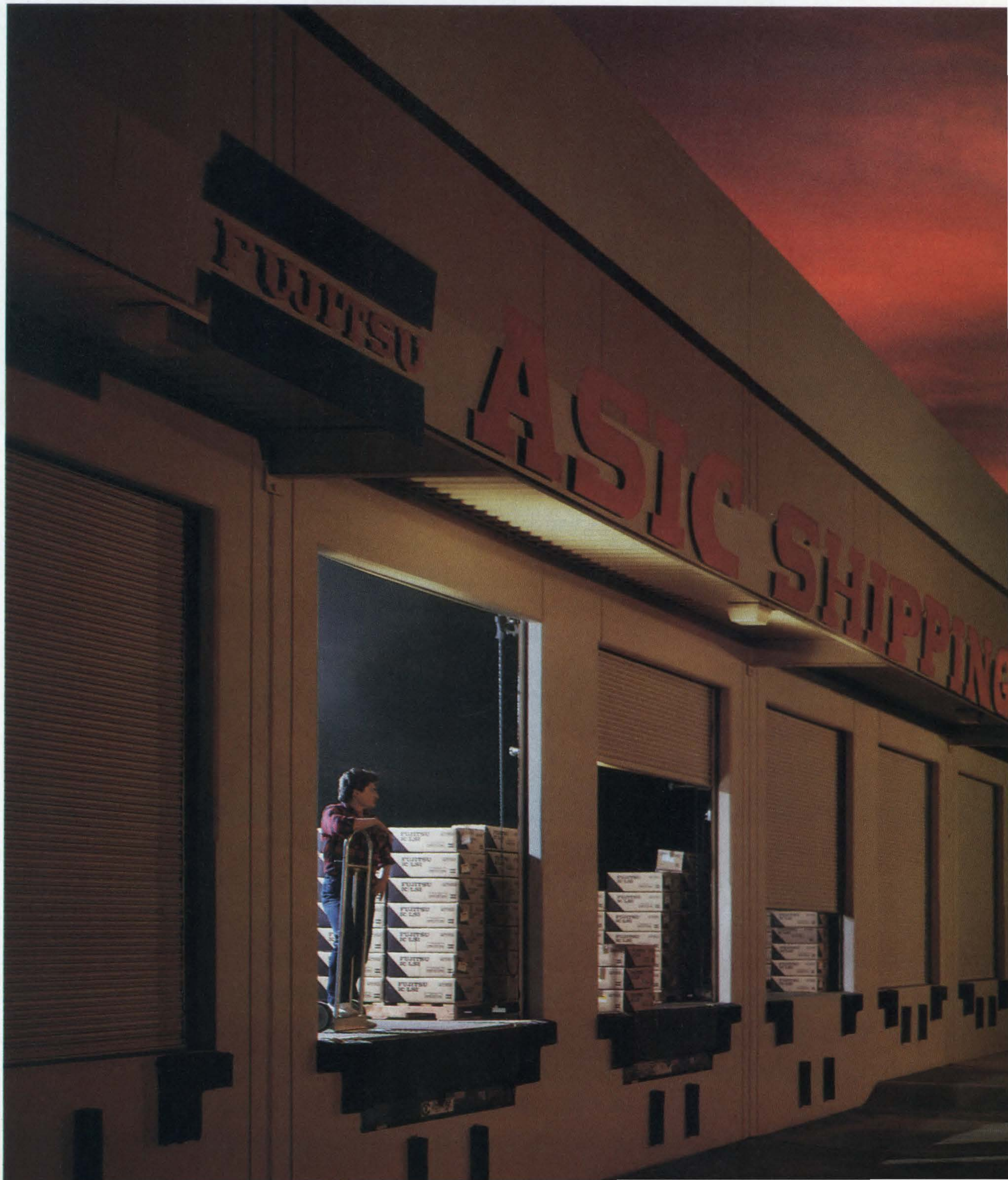

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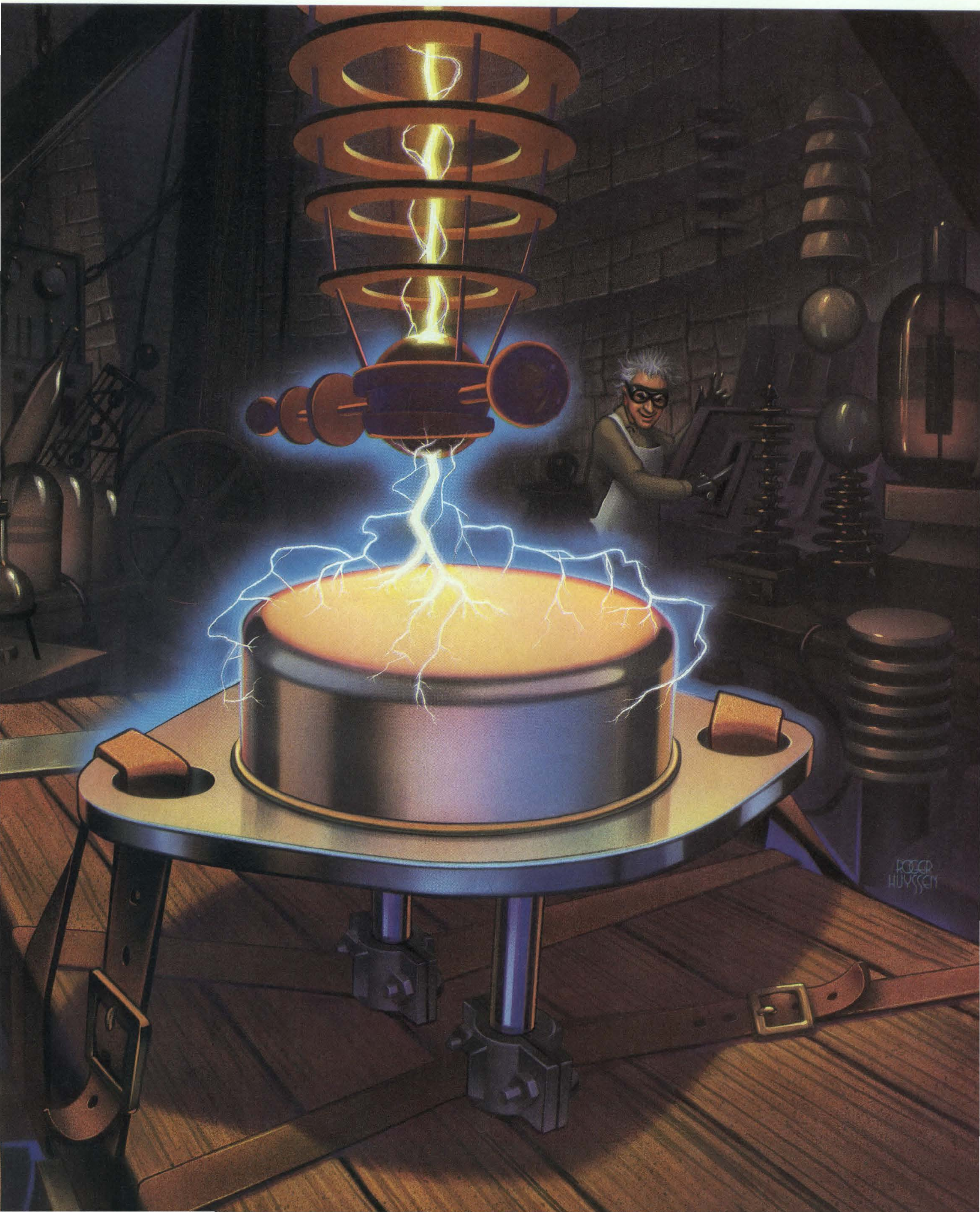
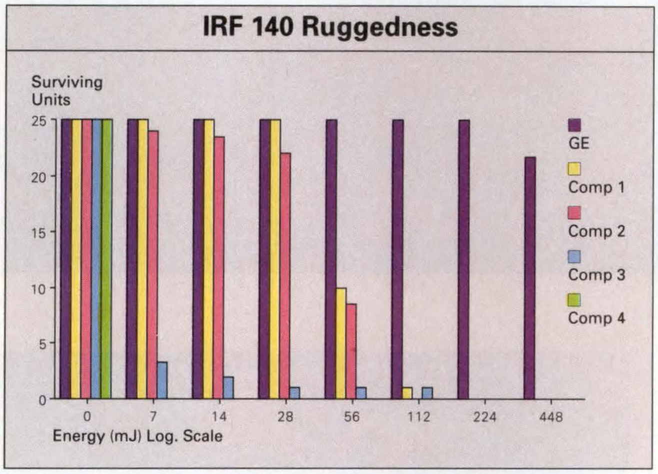


make sure it's rugged.

Order GE/RCA Rugged MOSFETs, the only ones with an "R" on the label. Because the wrong device can ruin your creation.

Two years ago an independent testing company compared GE Ruggedized MOSFETs with all leading competitive units. The results were even better than we expected.



In this test conducted by Associated Testing Laboratories, Inc., the ruggedness of 25 GE IRF-series MOSFETs was compared with 25 devices from each of four competitors. As you can see, the GE parts significantly outperformed the others.

Today, the situation is different.

Because our MOSFETs are more than *twice as rugged* as they were then. Yet our ruggedized MOSFETs cost no more than competitors' standard MOSFETs.

A powerful combination.

We've achieved this by combining the rugged technology of GE products with the outstanding manufacturing, quality control and cost-effectiveness of RCA power MOSFETs. So we can bring you the best line of rugged PowerFETs in the industry.

And the benefits are considerable.

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When you design with our Rugged devices, you can eliminate zener diodes, snubbers and other costly circuitry.

So you save money. And by simplifying your design, you improve system reliability.

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Because you can never be sure when your system will be subjected to voltages beyond what you expected.

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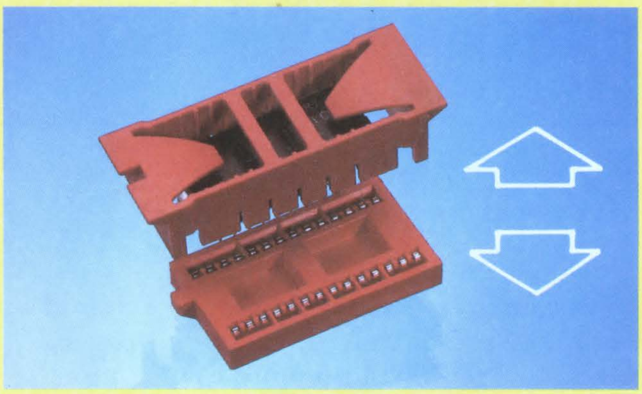
Need to replace fragile EPROMS in the field?

Carrier unit contains and protects delicate EPROM.

Our OEM customer presented some very difficult specifications to the RN "P/Q TEAM"—as well as to other well known connector firms. They required a device that would allow replacement of delicate EPROMS in the field by non-electronic auto service people. In addition, the device had to withstand the extremes of heat and cold present in an automobile control environment.

Working closely with our customer's engineers who set forth the performance parameters to be met, RN engineers designed, tested and produced the highly reliable EPROM socket/carrier that competition couldn't build! Economical, reliable repair or modification is now a reality. Another example of the added value that the RN "P/Q TEAM" can contribute to the solution of *your* socket and interconnection problems.



EPROM SOCKET/CARRIER—With the ever-increasing use of electronic controls to enhance auto engine performance, the need for reliable, easy field repair is imperative. This RN 2-piece socket/carrier enables mechanics to remove delicate EPROMS for reprogramming or replacement without harm to the IC itself. Color-coded, durable and protected against static discharge, they are now in use in millions of cars.

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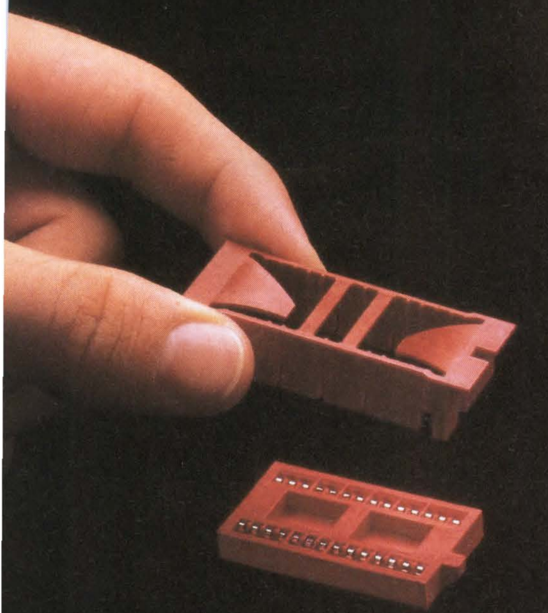
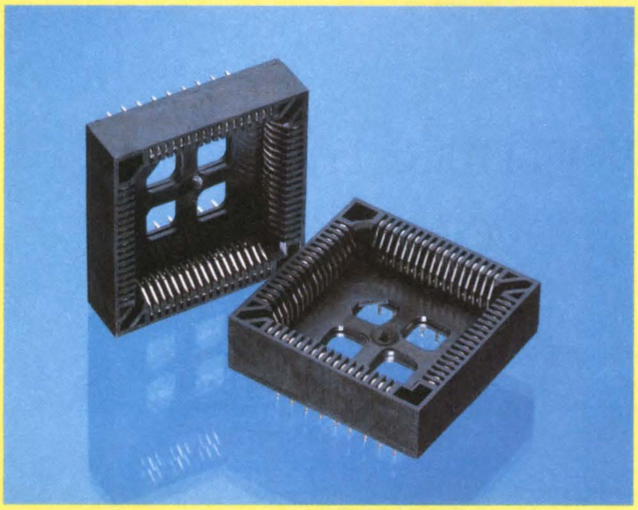


The RN "Partners in Quality Team" delivered a new socket/carrier that makes EPROM replacement easy!

Protected EPROM goes into (or comes out of) socket, keyed to proper position.



Latest 68-pin PLCC Socket
Conforming to the latest Jedec specifications, a new Robinson Nugent 68-pin socket accepts plastic chip carriers. Designated PLCC-68PT, it features: closed bottom to prevent solder wicking, stand-offs for easy cleaning, easy access probing with chip carrier in place, dual polarization indicators as well as #1 pin locator for positive chip alignment, .050″ spacing. Write today for specifications.

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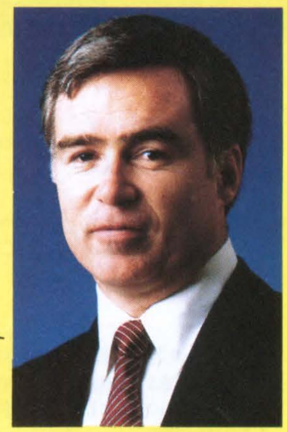
"The RN 'P/Q TEAM' concept brings all of our design, engineering and production skills to bear on *your* unique socket/connector problems. We work closely with your people to create solutions that are delivered on-time and defect-free. *You have my personal guarantee on it.*"

R. A. Lindenmuth
President/CEO



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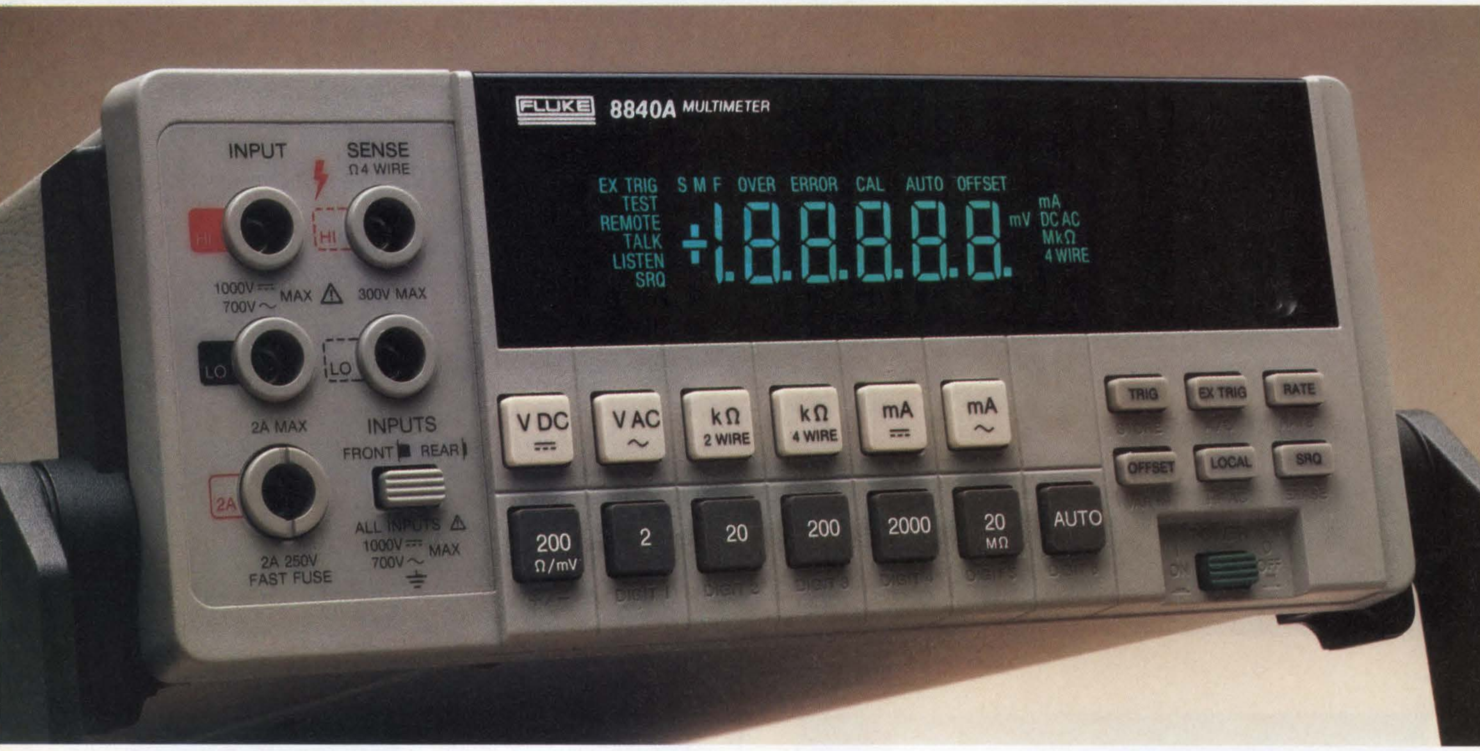

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0.005% basic dc accuracy (1 Yr.)		0.003% basic dc accuracy (1 Yr.)	
0.16% basic ac accuracy (1 Yr.)		0.08% basic ac accuracy (1 Yr.)	
0.013% basic ohms accuracy (1 Yr.)		0.008% basic ohms accuracy (1 Yr.)	
Resolution to 1 μV, 10 μA, 1 mΩ		Resolution to 100 nV, 1 μA, 100 μΩ	
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8840A	$795	8842A	$995
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CIRCLE NO 214

NEWS BREAKS

EDITED BY JOANNE CLAY

POPULAR PLDs NOW COME IN 7.5-NSEC VERSION

The PAL programmable logic devices—the PAL16L8, PAL16R8, PAL16R6, and PAL16R4—are now available from Advanced Micro Devices (Sunnyvale, CA, (408) 732-2400) in versions that exhibit a 7.5-nsec propagation delay. This speed enhancement makes the PAL family faster than the fastest SSI/MSI TTL families. Previously, the fastest versions of these PALs had a 10-nsec propagation delay. The vendor offers the parts in 20-pin DIPs and plastic leaded chip carriers (PLCCs) for $10.45 (100).

—Doug Conner

DISK-CONTROLLER CHIP SUPPORTS 5M-BYTE/SEC SYNCHRONOUS SCSI

The AIC-6110 SCSI-controller IC includes most of the functional blocks required to implement a 5M-byte/sec synchronous embedded SCSI controller on a disk drive. In fact, to implement an embedded controller, you need only add a static-RAM or dynamic-RAM buffer memory (the IC includes a memory controller for both types of memory) and a data separator. The IC supports drive data rates as high as 20 MHz. A single μP can interface with the AIC-6110 and still handle other drive functions such as motor and head control. Adaptec (Milpitas, CA, (408) 945-8600) plans to ship samples of the chip in the third quarter and production quantities in the fourth quarter. The IC costs $25 (1000).—Maury Wright

SOFTWARE TOOL SIMULATES AND DEBUGS μC PROGRAMS ON A PC

You can simulate and debug code for embedded 8051 μC systems without building target hardware by using the SimCase-51 software tool. The tool incorporates a simulator, a C and assembly-language source-code debugger, a performance analyzer, and a stimulus generator. The simulator executes μC instructions and also simulates the operation of the μC's interrupt-handling system and I/O ports. The debugger accepts symbolic information from the company's 8051 C compiler, so you can use your own labels and variable names to trace through the program. The debugger also provides breakpoints and allows single-step operation.

The simulator tool's performance analyzer draws a histogram representation of the time spent in each section of your code, so you can fine-tune your software's efficiency. Finally, the input-stimulus generator allows you to create a file containing stimulus vectors that are applied to the simulated μC's I/O ports at the times you appoint during program execution. SimCase-51 is available from Archimedes Software (San Francisco, CA, (415) 567-4010). It normally costs $895, but the company is offering it at an introductory price of $595 through June 30, 1988. You can obtain a free demonstration disk by calling Archimedes. The company also offers C compilers for several other μCs *(see EDN, December 24, 1987, pg 126)*, and it plans to create similar SimCase products for those processors in the future.—Steven H Leibson

AI-BASED ASIC-DESIGN TOOLS RUN ON ENGINEERING WORKSTATIONS

Previously offered only as an evaluation service, the Design Advisor from NCR Microelectronics Div (Fort Collins, CO, (800) 334-5454) now runs on Mentor Graphics workstations. This expert-system package evaluates circuits designed with the company's 1.5- and 2-μm Visys standard-cell and gate-array ASICs and recommends design improvements based on expertise distilled from NCR's IC engineers and designers. Design Advisor evaluates designs by using expertise stored in five knowledge modules that address chip performance, timing and clocking, testability, system interface requirements, and general design practices. During operation, the program scans a completed circuit diagram and displays recommendations along with the relevant piece of your schematic. A Design Advisor license costs $57,950.

The company has also introduced its NCR Design Synthesis software package, which also runs on Mentor Graphics workstations. The program uses knowledge-based logic-transformation rules to transform text-based behavioral descriptions of complex, general-purpose logic blocks into circuits built from the company's 2- and 1.5-μm analog and digital cells, supercells, and compiled functions. Because this program lets you use behavioral descriptions to design ASICs, you can simulate large chips very quickly and then synthesize the circuit from those descriptions once you've verified your conceptual design. NCR developed this AI-based tool in conjunction with Silc Technologies Inc (Burlington, MA, (617) 273-1144). A license for the NCR Design Synthesis tool costs $51,500; the company also offers the program's capabilities as a design service.—Steven H Leibson

SIMULATOR MODELS ANALOG/DIGITAL DESIGNS FROM ICs TO SYSTEMS

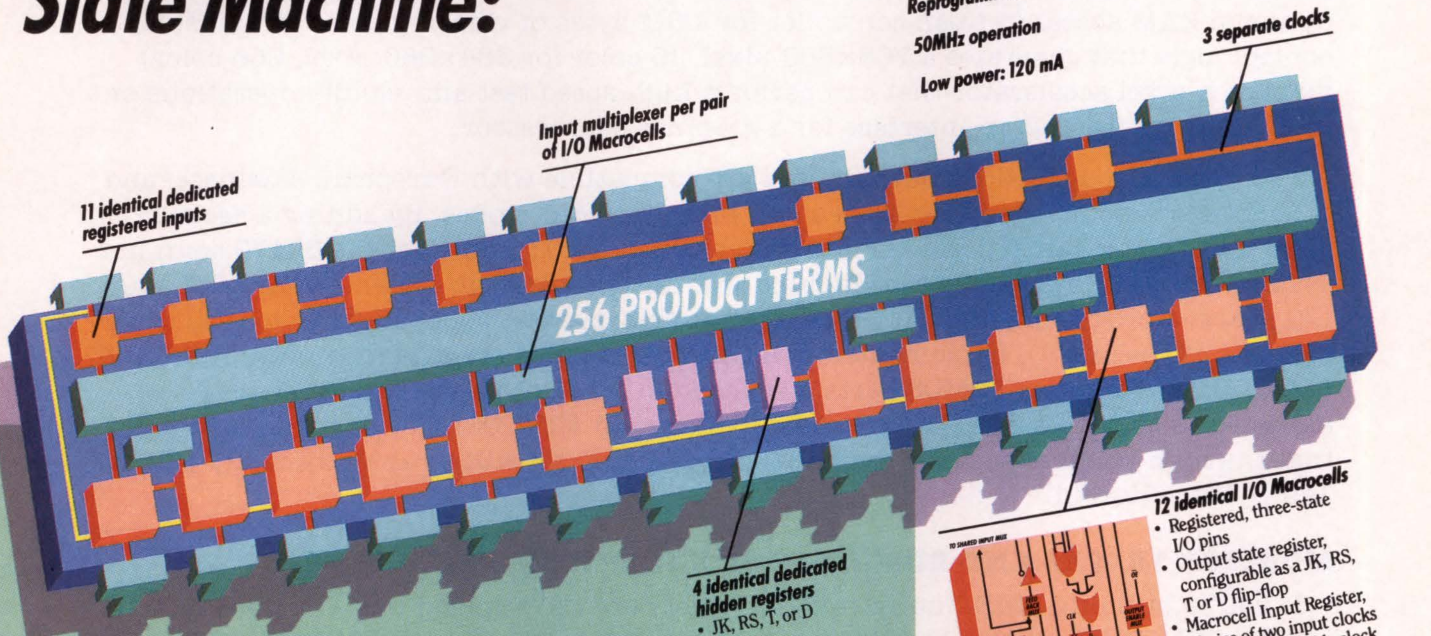
No matter what kind of design you've created—what combination of analog and digital technologies it contains; whether it's an IC, a pc board, or a complete system; or whether the analog portion is electrical, mechanical, thermal, or a combination of these elements—Saber/Cadat should be able to simulate it. Saber/Cadat is a mixed-mode simulator that was developed jointly by HHB Systems (Mahwah, NJ, (201) 848-8000) and Analogy (Beaverton, OR, (503) 626-9700). The $35,000 to $67,000 product, which is mostly software, runs on Sun, Apollo, and VAX workstations. The product is in beta testing and will ship in the fourth quarter of this year.

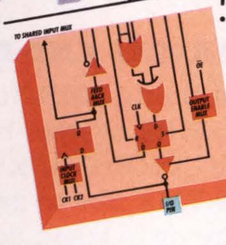
Saber/Cadat accepts net lists in EDIF format from schematic-capture programs. It can make use of a hardware accelerator and is compatible with hardware-modeling techniques. In a networked configuration, several workstations can share the accelerator and the modeling hardware. Saber/Cadat gives analog designers the freedom to work in either the time or the frequency domain. It allows designers to use hardware-based or behavioral-language-based models of devices and functional blocks. To speed execution, it incorporates an algorithm named Calaveras (in honor of the home of Mark Twain's notorious jumping frog) that allows the analog simulation to "leapfrog" ahead of the digital simulation until it needs an input from the other simulation.
—Dan Strassberg

PROGRAM ADDS TARGET-EMULATION CAPABILITY TO SCSI ANALYZER

Pacific Electro Data (Irvine, CA, (714) 770-3244) now offers the PED-4020 target-emulation program for its IBM PC-compatible PED-4001 SCSI data-acquisition and -emulation module. The target-emulation program emulates a single target device on the SCSI bus, and features user-definable device-description libraries (DDLs). You can create and edit DDLs by using the editor included with the program. The emulation program supports Group 0, 1, and 5 commands, and mandatory messages. The program also includes DDLs that implement the CCS (Common Command Set). The program costs $795; to use the software, you need to purchase the $3950 PED-4001 module.—Maury Wright

Why high performance designers are so excited about the new PLD 7C330 State Machine:





As state machines go, this one goes the fastest. With the highest functional density available.

A system that lets you design state machines that can execute control sequences at a full 50MHz without even breathing hard.

High performance designers are excited by the extensive features, led by the richness of 256 product terms.

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By the ease of programming, using popular programming languages and machines.

And by the ability to design the highest performance state machines, with 1000 to 1500 gate functionality, using reprogrammable PLD technology.

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NEWS BREAKS: INTERNATIONAL

VIDEO- AND SYSTEM-CONTROLLER IC MINIMIZES SYSTEM COST

Operating alongside the company's 68070 μP, the 66470 video- and system-controller IC from Philips' Components Div (Eindhoven, The Netherlands, TLX 51573; in the US: Signetics Corp, Sunnyvale, CA, (408) 991-4571) allows you to build a complete 16/32-bit processor and video-display controller with only 10 ICs. The device contains a dynamic-RAM access/refresh controller for 1.5M bytes of video/system RAM; display-control logic that generates a 768×560-pixel, 16-color (or 384×280-pixel, 256-color) display; a pixel accelerator that can perform high-speed test-and-modify operations on individual pixels; and an interface for a graphics coprocessor.

The IC can produce video outputs that are compatible with European, Japanese, and US television standards in interlaced and noninterlaced modes. By adding a second, slave 66470, you can generate studio-quality displays. In addition, the 66470 contains system-controller functions that include address decoding for system RAM, ROM, and I/O space; a programmable DTACK generator; system-reset logic; and a watchdog timer. Samples of the 66470, implemented in a CMOS gate array, are available now for around $50 (100). Fully custom CMOS parts, packaged in a 124-pin quad flat pack, are expected to become available during 1989 at around $25 (100). The company estimates that the high-volume price for the 68070/66470 chip set will be approximately $30 by 1991.—Peter Harold

MONITOR TRACKS AND REPORTS VME BUS SYSTEM FAILURES

If you're building VME Bus systems for safety-critical applications, consider installing the CVMEHM1 system-health monitor from Concise Technology (Cardiff, UK, TLX 975646). The CVMEHM1, which occupies a single VME Bus slot, continuously monitors the VME Bus to detect system malfunctions. It can help you to pre-empt system failure or to track down the causes of failures that are difficult to simulate in your service department.

To set up a fault-handling procedure, you can program the monitor to automatically dial up a remote computer via a modem, log fault information on a printer, and shut down and restart the system by driving the SYSRESET*, SYSFAIL*, and ACFAIL* signal lines. You can also use the modem connection to initiate the execution of system diagnostics. The CVMEHM1 can detect a wide variety of anomalies on the VME Bus signal lines; it also monitors the system's internal temperature, a number of user-defined inputs, and the voltages on the VME Bus power-supply rails. It will be available during the third quarter of 1988 at a cost of around $1900.—Peter Harold

COMPANY GROWS MONOCRYSTALLINE THIN FILM FROM SUPERCONDUCTOR

According to reports in the Japanese press, Fujitsu Laboratory has grown a monocrystalline thin film from high-temperature, bismuth-based superconductive material. The film's developers employed a chemical-vapor deposition technology that uses a halogen compound as a source material. They grew a 0.3-μm-thick monocrystalline film comprising bismuth, strontium, calcium, and oxygen on a 3-cm^2 magnesium oxide substrate heated to 825°C. The epitaxial wafer grown with this method has a 70 to 80° Kelvin critical temperature. The company did not measure the Meisner effect or the critical current, but the critical temperature reportedly exhibited no deterioration after one week's exposure to the atmosphere. Fujitsu plans to use the material to create superconductive transistors based on tunnel-type Josephson-junction elements, and LSI chips with superconductive traces.—Joanne Clay *we never stop asking*

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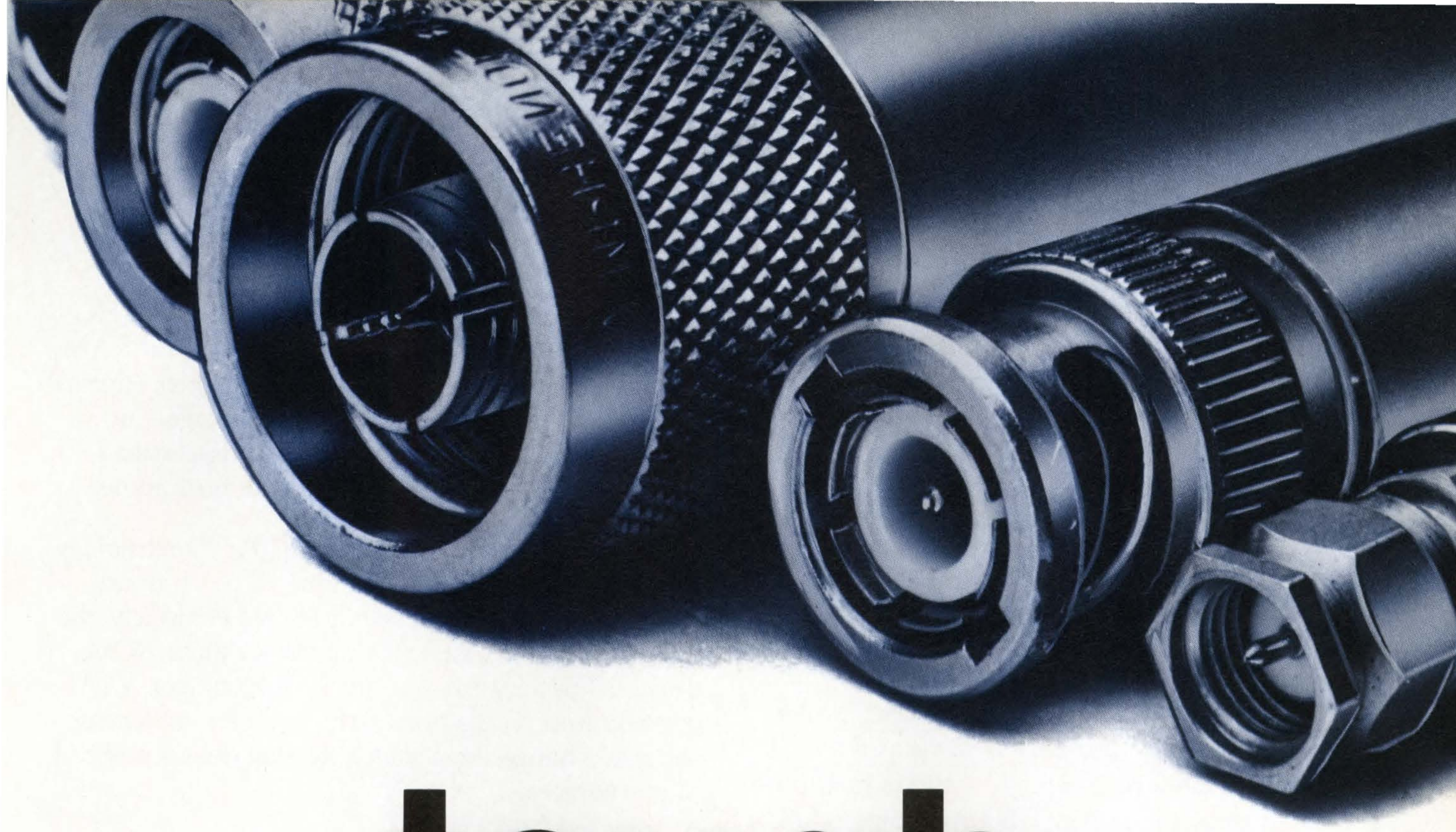

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*Freq. (MHz)	Atten. Tol. (Typ.)	Atten. Change, (Typ.) over Freq. Range		VSWR (Max.)	
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DC-1500 MHz	±0.3	0.6	0.8	1.3	1.5

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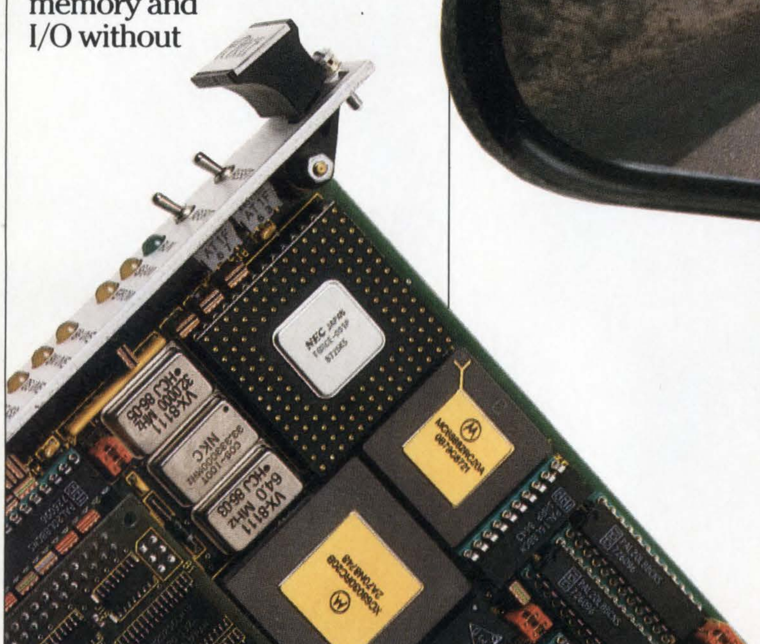
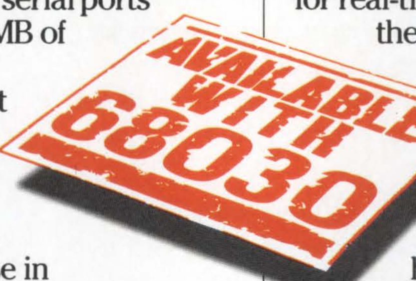


increasing bus overhead. You also get two serial ports and up to 4MB of EPROM.



The result is system throughput that's way ahead of anything else in the VME world.

Think about the possibilities for real-time applications. For the first time, you can squeeze every ounce of performance from every processor. With no wasted overhead. And no stalls.

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PROCESSOR	68030/16.7 TO 25 MHz
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ZERO-WAIT-STATE SRAM	1MB
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EPROM	UP TO 4MB @ 1 WAIT-STATE
SERIAL I/O	2 RS-232 CHANNELS
SECONDARY BUS SUPPORT	VSB

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CIRCLE NO 109

SIGNALS & NOISE

Forth compilers are hard to find

I read Robert Johnson's letter (EDN, February 18, 1988, pg 34) with bittersweet amusement. Unlike Robert, I find it difficult to fault Steve Leibson's overlooking Forth as a high-level language (HLL) for single-chip computers (in "HLL cross compilers speed 1-chip-μC software development," EDN, December 24, 1987, pg 126). The reason, though, has to do with the use of such outmoded concepts as HLL or LLL, or perhaps even the term "computer language." Forth is all and none of the above. It is not high-level: It allows you to get too close to the processor's native behavior. It is not low level: No other programming system yet devised has the richness of expression available to the competent Forther. It's even difficult to decide that Forth is a "computer language" at all. After all, computer languages have fixed syntax, strong typing, carefully limited structures, etc. You won't find many of these so-called benefits in a real Forth system.

Perhaps Steve didn't find any Forth for these chips because he didn't look in the right places. It's easy to overlook. The big companies with a stake in selling what they have wouldn't tell you if they did have a Forth. Forth has been around for years and it just doesn't *sell*. It's not pedagogical enough. Some of those same big companies have a handful of people who do prototypes in Forth because they can get it done faster than anyone else; then they turn it into C or some other patent form of computer language. These companies just don't want anyone to know they'll have any truck with such an oddball thing as Forth.

Further, almost all Forths are interpreted, which means you can usually gain some speed advantage by compiling the conventional language representation into machine code. But even that reason is nearly vanishing. Not only are a number of Forths able to run and compile as direct machine code, but you can even buy a single-chip computer that executes Forth primitives as its paradigm—Harris's Force system, which is based on the Novix effort. Unfortunately, that product isn't a jellybean item.

It's my belief that you do the engineering community some disservice by not being more cognizant of Forth. Forth provides a particularly efficient architecture for computing that has been ignored by the mainstream, largely because of vested-interest lobbying. For example, if Apple Computer had not chosen the classical single-stack calling sequences for its toolbox functions, Forth might well be "language" of choice for the Macintosh. Far less stack flagellation would be required. As it is, Forth is popular for use on the Mac. Likewise, VAXes run Forth well, and much of the scientific community knows that and uses Forth, even in astronomy, where they've had a long time to make up their minds about what to use.

In response to Steve's request for information on Forths for single-chip computers, I think the TMS7000 family of single-chip μCs from Texas Instruments qualifies. If Steve agrees with that, then my company supplies a ROMable, direct-execution, headerless code version of Forth for a single-chip computer. With due respect to Steve and his efforts, I *am* rather hard to find.

Walt Pawley
Wump Research & Co
Roseburg, OR

Hardware models vs software models

As director of marketing for my company, I have spent a great deal of time researching engineers' requirements for modeling of complex

devices. The research is being incorporated in the design of a next-generation hardware modeler that my company will sell to simulator vendors. I read Margery Conner's article "ASIC simulators" (EDN, February 4, 1988, pg 118) with great interest, but discovered some common press misconceptions or misinterpretations involving behavioral and hardware modeling.

Contrary to a statement made in the article, my survey of the industry showed clearly that software models are actually more difficult to change to accommodate design revisions than hardware models are. The reason is that fixing a software model means editing a 5000- to 10,000-line software program, whereas changing a hardware model means unplugging a chip and plugging a new chip into an adapter board, or editing a small table. One typical user of both hardware models and behavioral models cited a 14:1 difference in the amount of time —in favor of hardware models.

Holly Stump
Director of Marketing
Logic Modeling Systems Inc
San Jose, CA

Company makes hardware simulators

The Special Report on ASIC simulators in EDN's February 4, 1988, issue (pg 118) incorrectly listed Ikos Systems as a supplier of hardware modelers.

Just to clear the record, Ikos's product is an integrated logic/fault-simulation and analysis system, not a hardware modeling system. We often characterize the system as a hardware simulator to contrast it with hardware accelerators.

Because the simulation market is confusing enough, I think your readers should be made aware that Ikos's product is an ASIC logic-simulation system, not a hardware modeler.

Robert P Smith
Director of Marketing
Ikos Systems Inc
Sunnyvale, CA

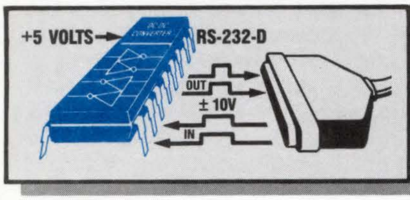
(Ed Note: The article did erroneously include Ikos in a list of suppliers of hardware modelers (on pg 124). The specific information about Ikos on pg 127, however, clearly characterizes the company's product as a simulator.)

WRITE IN

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

MAXIM
DESIGN NEWS
Analog Design Insights from Maxim Integrated Products June '88

EIA Changes Old RS-232 Standard.



Who in their right mind would choose a computer interface standard that uses ±12V supplies, requires expensive connectors, works over a limited distance, is error prone, difficult to network, and has no current loop isolation? Well, someone did, and now we have to live with it.

The RS-232-C interface standard was first introduced in 1962 by the EIA to standardize the interfacing of data terminal equipment (DTE) with data communication equipment (DCE) over short distances. The standard was revised in 1969, 1972 and rewritten in 1986 (as EIA-232-D) to update the terminology and to bring RS-232 more closely in line with the international interface standards CCITT V.24 and V.28. EIA-232-D has tried to accommodate modern day requirements, but the ±12V supplies used by the drivers still create system problems. Many of these problems have been solved by a new family of single 5V supply RS-232 chips from Maxim.

What is an EIA-232-D interface?

EIA-232-D defines the electrical characteristics, mechanical requirements, and signal functions of the interface between the data terminal equipment (DTE) and data communication equipment (DCE).

EIA-232-D SPECIFICATION

PARAMETER	SPECIFICATION
Max. Cable Length	Limited by cable capacitance*
Max. data rate	20kbits/sec.
# of drivers & receivers allowed on line	1 driver 1 receiver
Driver output swing	±5V min.; ±15V max.
Driver load	3 to 7k ohms
Driver slew rate	30V/μs max.
Driver output short-circuit current limit	500mA to V+ or GND
Driver output resistance with power OFF	300 ohms
Receiver input res.	3 to 7k ohms
Receiver input thresh.	±3V

*RS-232-C recommended a maximum cable length of 50 ft. EIA-232-D limits the effective shunt capacitance at the receiver side of the interchange to 250pF.

The mechanical interface for EIA-232-D is the DB25 or 25 way "D" connector.

Signal functions are defined to facilitate communication between the DTE and DCE with a fully interlocked handshake of data. 22 of the 25 connector pins have designated functions under the new EIA-232-D. However, not all of the signals are used. For example, some printers only use four wires, while others use all 25 pins of the DB25 connector.

Pin 1 used to be the protective ground but is now (EIA-232-D) defined as "shield." It is normally connected to the frame of the DTE. The DCE end is normally left open to avoid ground loops. The signal ground must be returned via pin 7. The two ground lines, pin 7 and pin 1, should not be tied together. It is also important to prevent any ground loop currents or system noise from flowing into the signal ground.

New EIA-232-D Defined Signals

Pin 21, Remote Loopback (RL), is one of three new signals that have been defined by EIA-232-D to enable remote and local loopback testing. RL is used by the DTE to tell the local DCE to loopback. This enables the DTE to test the communication connection between the two devices. Pin 18 Local Loopback (LL) is similar to RL except that loopback is channeled through the DCE's own communications input and consequently back to the DTE. Pin 25 Test Mode (TM) is used to inform the DTE by the DCE that is has received an RL or LL signal from the DTE. The addition of these signals brings EIA-232-D much closer to the CCITT V.24 specifications.

(Please see EIA Changes on back)

40,000 Count A/D Performs 20 Conversions/Sec

Using a unique A/D architecture and relying upon an external microprocessor for data manipulation and control, Maxim's new CMOS MAX133/134 3¾ digital integrating A/D converters offer high performance and low power (1mW) at a low cost. These A/D converters perform 20 conversions/second while maintaining high Normal Mode Rejection — that's 10 times the normal conversion rate of other integrating A/Ds. Priced under $10.00, the MAX133 offers significant systems savings versus the $40-50 equivalent A/Ds. These factors and others will open up many new applications in data acquisition, data loggers, weigh scales and digital multimeters.

Although the MAX133/134 are described as '3¾ digit,' implying an accuracy of one part in ±4,000, their internal resolution is ***±40,000 counts.*** The extra digit provides noise free performance at the 3¾ digit level, as well as allowing digital autozero or tare to 1/10 of a count for a 4,000 count displayed reading. These circuits are designed to be microprocessor controlled. However, they do provide all the logic and control of the conversion sequence, and the external microprocessor is not required to perform any critical timing or complex control functions.

The MAX133 and MAX134 differ only in their microprocesor interface. The MAX133 has a 4-bit multiplexed address/data bus while the MAX134 has 3 separate address lines and a 4-bit bi-directional data bus. The devices can be used with 4-, 8-, and 16-bit microprocessors. Both devices can be operated from either a 9V battery or ±5V supplies. Maximum supply current is only 250μA, with a typical of 100μA. Additionally, the devices can be put into a 'sleep' or low current mode where the internal analog circuitry is turned off and the supply current is reduced to 25μA.

0.025% Resolution

The MAX133/134's 50ms conversion time and 0.025% resolution make them ideal for data acquisition and data logging applications. The A/D contains a 7 input channel multiplexer, plus the ability to digitally short together the analog inputs of the A/D converter, allowing for zero offset correction to be performed by the microprocessor. The microprocessor-friendly architecture enables system/instrument designers to add features of their choice through software such as digital averaging of readings, set point alarms, etc.

(Please see 40,000 Count on back)

EIA-232-D recommends standard interfaces for certain systems. However, the industry has tended to ignore these recommendations in favor of their own subset. The most popular interface is two wires in each direction — Transmit Data (TD), Receive Data (RD), plus two handshake lines. Computer interface communication is becoming increasingly more complex so that additional lines are needed. ***By using different combinations of RS-232 drivers and receivers any requirement can be met.***

New RS-232 Circuits For The New Standard

Maxim has a family of 10 CMOS RS-232 interface circuits that operate from just a ***single +5V supply*** — generating ±10V supplies using a patented two stage charge pump technique. This saves the user from having to generate the additional supplies required by the old workhorses, the 1488 (4 RS-232 drivers) and 1489 (4 RS-232 receivers), as well as some of the newer CMOS and bipolar equivalent driver and receiver circuits.

MAX232 FAMILY OF DRIVERS AND RECEIVERS						
PART #	# OF DVRS	# OF RCVRS	SHUT* DOWN	3–** STATE	COMMENTS	AVG. PRICE PER*** TRANS/REC (5000pcs)
MAX230	5	0	Yes	No	Requires 4 ext. caps	$ .55
MAX231	2	2	No	No	+5V, +12V supplies, 2 caps	1.05
MAX232	2	2	No	No	Requires 4 ext. caps	1.50
MAX233	2	2	No	No	No ext. components req.	1.90
MAX234	4	0	No	No	Requires 4 ext. caps	.75
MAX235	5	5	Yes	Yes	No ext. components req.	1.70
MAX236	4	3	Yes	Yes	Requires 4 ext. caps	.85
MAX237	5	3	No	No	Requires 4 ext. caps	.75
MAX238	4	4	No	No	Requires 4 ext. caps	.75
MAX239	3	5	No	Yes	+5V, +12V supplies, 2 caps	.75
MAX240	5	5	Yes	Yes	44-Pin Plastic flat pack	.75

*Low power shutdown reduces supply current to less than 10µA. ***Contact Maxim for details on quantity pricing.
**3-state enable of receiver outputs for bus interfacing.

The Maxim family offers a variety of driver and receiver combinations on the same chip ranging from a 2 transmitter/2 receiver (MAX231/232/233) to a 5 transmitter/5 receiver combination (MAX235). Some of the devices (MAX235/236/239) have 3-state enable for the receiver outputs allowing the devices to be connected to a µP bus. Some also have low power shutdown mode (MAX230/235/236) where the total power dissipation is reduced to less than 50µW — making the devices suitable for battery applications. Two of the devices (MAX233/235) have on board capacitors — replacing the 4 external capacitors normally required by the charge pump converters. All but the MAX235 and 240 are available in SOIC packages — when a small footprint or automatic assembly is important.(The 5 transmitter/receiver devices are available in a 44-pin plastic flatpack.) Pricing on the MAX233 is now just $1 over the MAX232. In quantity, the MAX238 (4 transmitter/receiver) drops to just 75¢ per channel (see table above).

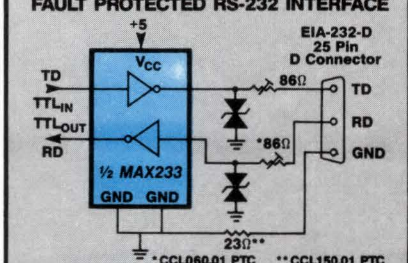
The drivers are CMOS inverters powered from the ±10V internally generated supplies. The driver inputs are TTL and CMOS compatible, with logic thresholds set to 1.3V for 5V Vcc. These inputs have internal pull-up resistors that force the unused RS-232 driver low when the input is not connected. RS-232 outputs are guaranteed to meet EIA-232-D specification of minimum output swing of ±5V under the worst case condition of output loading, ambient temperature and power supply voltage. The slew rate of the RS-232 outputs are limited to less than 30 V/µsec, eliminating the need for external slew-rate-limiting capacitors.

The receivers on these devices also conform to the EIA-232-D specifications, with an input impedance of 3k ohms to 7k ohms. Each input can withstand ±30V even when no power is applied. Switching thresholds are within the ±3V limits of RS-232 and are TTL and CMOS compatible. All receivers have 500mV of hysteresis to improve noise rejection.

System Protection

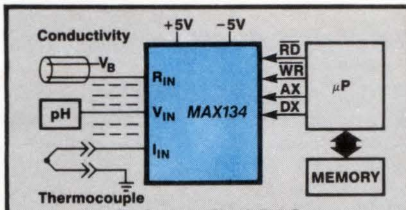
Even though the Maxim family of RS-232 devices are very rugged and designed to withstand 2000V of ESD, one cannot prevent destruction if a 110V line is inadvertently connected to the DB25 connector (without some form of protection). Combining positive temperature coefficient (PTC) current limiting resistors with back-to-back series diodes or transient suppressors can provide protection for the input and output of the MAX233 as shown below.

FAULT PROTECTED RS-232 INTERFACE



The CCL060.01 PTC from Midwest Components (Muskegon, Michigan) has a nominal resistance of 86 ohms at 25°C, but if heated by I^2R power dissipation, the resistance goes up dramatically. The voltage at the terminals of the MAX233 can be clamped either by transient suppressors, or by two 10V zener diodes connected in series. The 23 ohm PTC in the ground lead limits the current if 110VAC is applied to the MAX233 ground. The series resistance in the ground connection must be kept low so that any voltage drop across the resistance will be significantly lower than the EIA-232-D noise margin of 2V.

Despite it's shortcomings the EIA-232-D (RS-232) serial interface standard is here to stay. The challenge, as it stands, is to find ways to overcome its weaknesses. Look for more RS-232 solutions from MAXIM in the months to come.



µP Controlled DAS

40,000 Count DMM & DPM Under µP Control

The MAX133 and MAX134 contain many important features that will allow manufacturers to build improved digital multimeters and panel meters. For example, range switches for a 5 decade attenuator are included for use with external resistors. Additional mode selection circuitry is provided for performing voltage, current, AC or DC, ohm, and continuity measurement. The devices also contain auxiliary circuitry such as a piezo-electric beeper driver, an active filter, low battery detector, and both analog and digital power supplies. Both devices combined with the microprocessor can present the converted readings as a bar graph display.

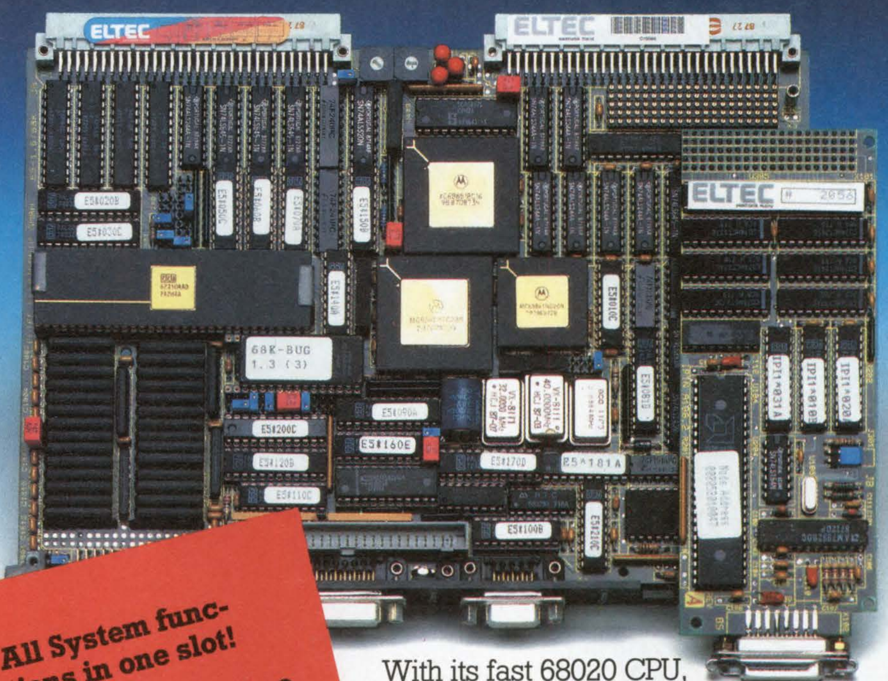
A Ready-Made System For Evaluation

Maxim makes available just such a system. It comes as a completely assembled board capable of making actual voltage, current and resistance measurements. It plugs directly into the RS-232 port of an IBM PC™ or compatible. And the supplied software drives the board and facilitates complete evaluation of the MAX133/134.

The MAX134EVSYS1 (110V) and SYS2 (220V) can generate histograms of repetitive readings so noise performance can be evaluated. And, it can also serve as a development tool for writing operating software. Full documentation is included: system board schematic, assembly drawing, source code and comprehensive users manual.

WE BRING YOUR IDEAS DOWN TO EARTH . . .

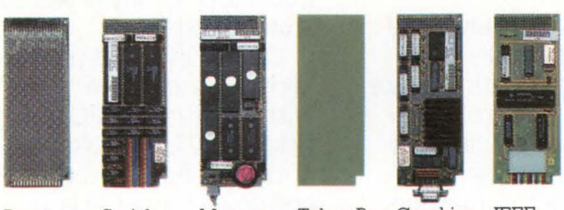
EUROCOM® 5
AND THE IPIN PHILOSOPHY*



EUROCOM 5 with Ethernet IPIN

*
- **All System functions in one slot!**
- **The VMEbus is free for your dedicated application!**
- **Customized extensions possible!**
- **Power without the Price!**

With its fast 68020 CPU, the 68881 FPU and the 68851 PMMU, the EUROCOM 5 CPU module forms the ideal basis to run UNIX, OS9, PDOS and Versados locally without any VMEbus load. The main memory of 1 or 4 MByte capacity can be accessed locally as well as via the VMEbus. The embedded SCSI interface supports all traditional mass storage devices as well as optical disks. The range of available local functions can further be extended by daughterboards (IPIN's) for specific functions. Apart from a large range of off-the-shelf IPIN modules available from Eltec, development of custom daughterboards is also supported.



Prototype IPIN | Serial IPIN | Memory IPIN | Token Bus IPIN* | Graphics IPIN | IEEE IPIN

PROTOTYPE KIT AVAILABLE

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France Eltec International SARL 1, Allée des Garays F-91120 Palaiseau
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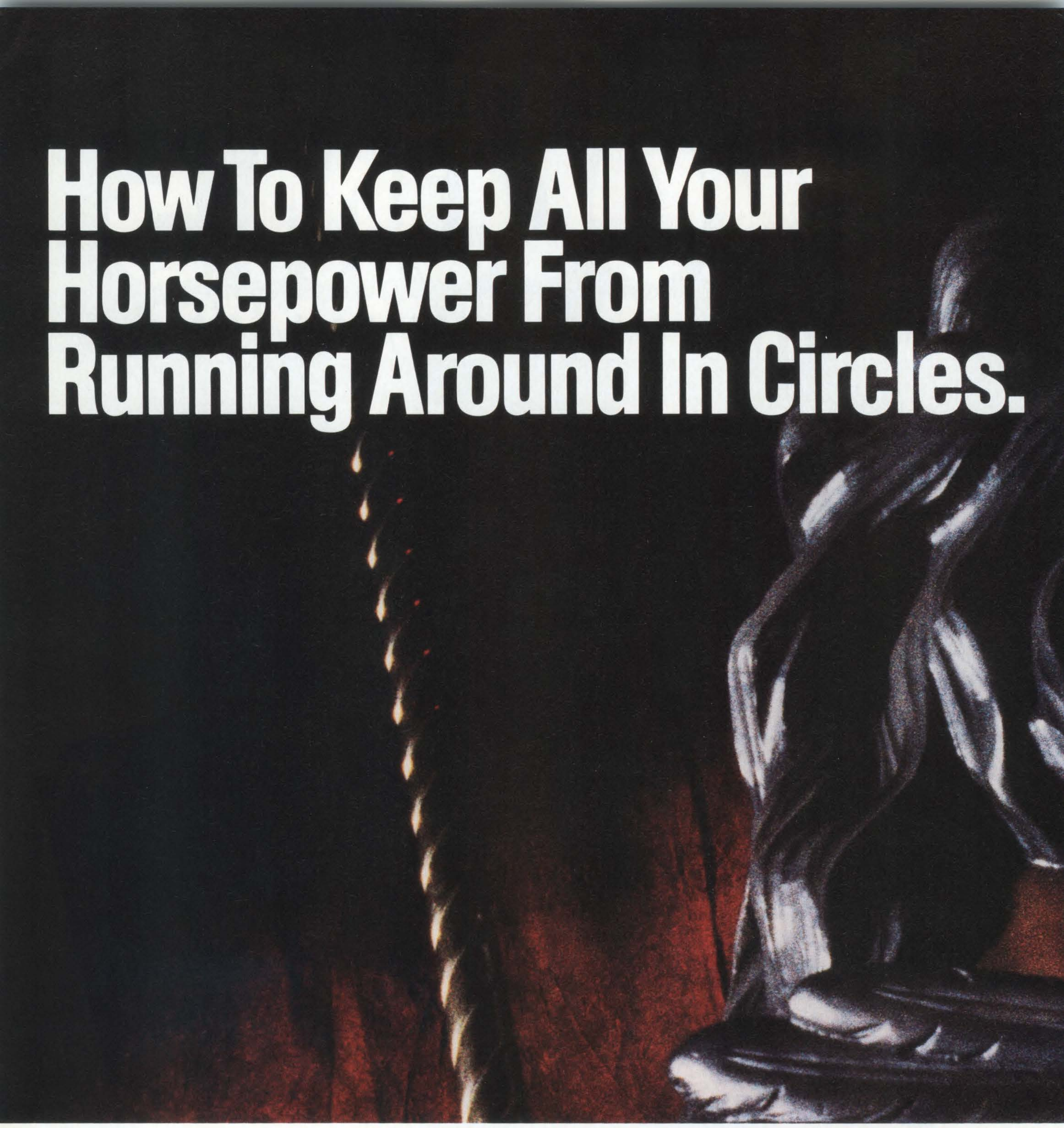
CIRCLE NO 92



To really understand your performance problem, just turn traditional thinking around.

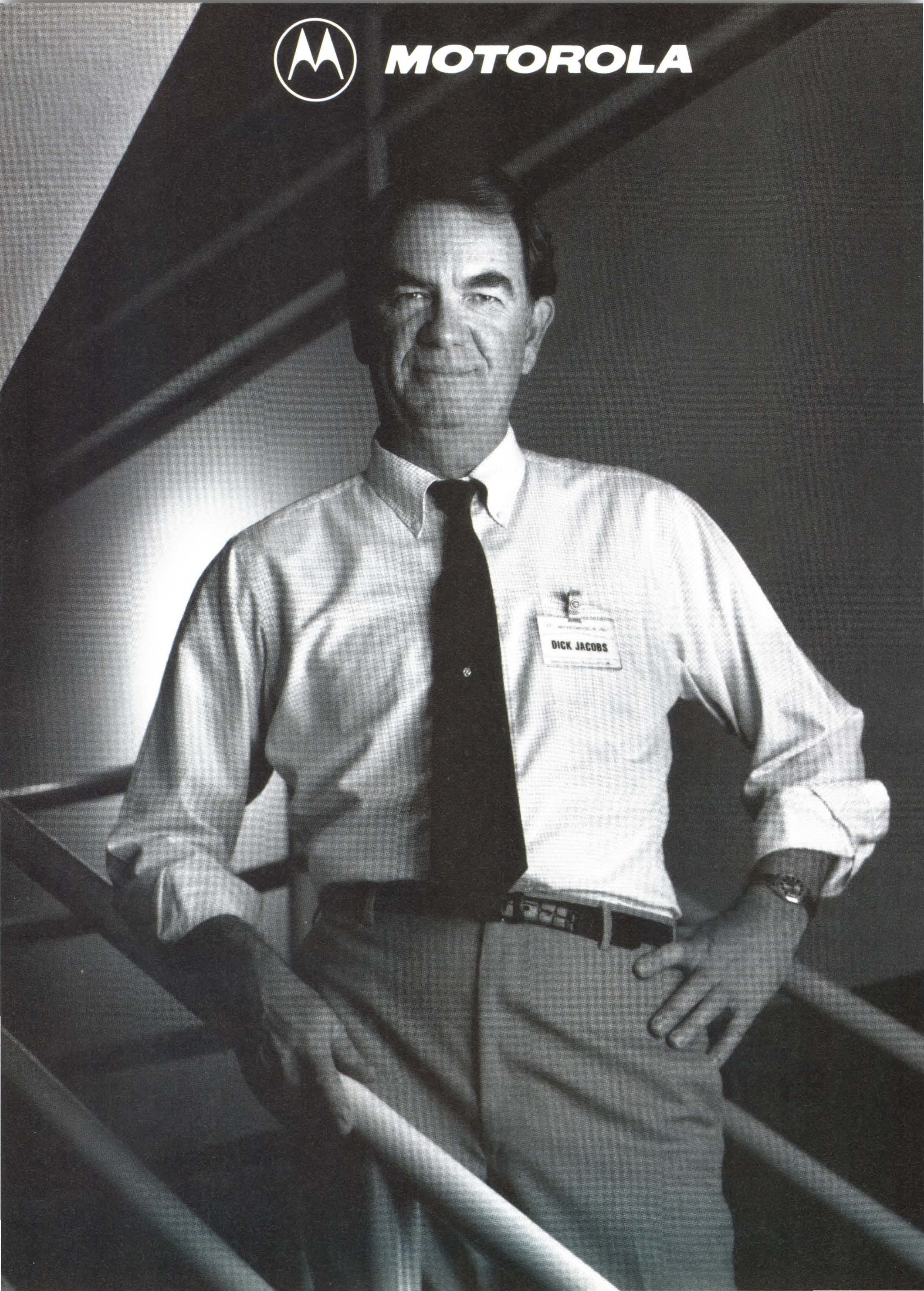
You see, your CPU is really more like a peripheral—it's usually your storage subsystem that sets the pace.

When you look at the problem that way, it's a horse of a different color. The solution, of course, isn't a CPU upgrade. It's better management of the data.

At System Industries, that's an idea we've championed all along. And the same one behind our new CLUSTOR™ family of shared data storage systems.

CLUSTOR allows you to integrate MicroVAXs and other small VAX CPUs, with or without DEC's bigger, high ticket iron. And it takes over most of the I/O functions that normally bog down those CPUs.

CLUSTOR is built around a true multitasking controller, capable of


MOTOROLA
DICK JACOBS

Dick Jacobs is looking for business partners.

In his years with Motorola ASICs, Dick Jacobs has seen thousands of successful designs. He manages Motorola's North American ASIC Design Centers—9 of our 17 centers worldwide. But he's not looking to sell parts, he's looking for business partners. Dick doesn't believe in quick fixes and he doesn't believe that his responsibilities end with delivery or begin with an order. It's an attitude he shares with everyone at Motorola's ASIC division.

"At Motorola we offer a multitude of different solutions because every customer has different needs. Some companies offer just one technology, or a very limited range.

"We don't build parts, we build opportunities. We have so many different solutions and technologies that we can't afford a *whadda-ya-need* attitude. We establish a relationship with our customers where we understand their requirements and capabilities and match them with our own. That way, a customer can take advantage of the latest advances without missing the boat on production cycles or getting locked into a partnership that can't do everything they need."

"It's the difference between a product that performs on paper and one that performs in the marketplace."

Dick has been with Motorola for 28 years. In that time he's developed a philosophy that reflects our entire ASIC program. "We're supplying a foundation that allows our customers to produce an end product which comes out competitive and *stays that way* through several generations. We get the design cycle working for them, so their products don't fizzle as soon as newer parts come out. It's the difference between a product that performs on paper and one that performs in the marketplace.

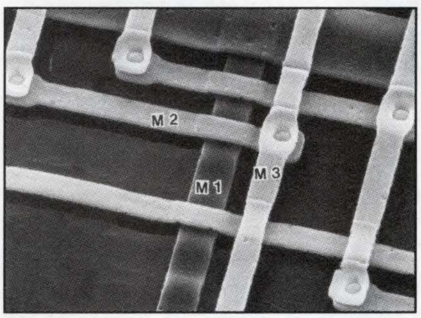
It takes technology.

A philosophy like Motorola's requires technology to back it up. Motorola gives you experience and superior capability in every major semiconductor technology. Plus you get the ongoing R & D muscle of a multi-billion dollar semiconductor manufacturer. So as your business evolves, we'll stay right beside you, making sure you've got the technological edge to stay in the winner's circle.

High-speed ECL leadership.

For three generations Motorola has remained the undisputed leader in high-performance bipolar array technology. Our latest, third generation ECL arrays continue the tradition. The MCAIII series features 100 picosecond speeds, a wide range of speed-power programmability, and over 95 percent utilization on chips optimized for total system performance.

Tape Automated Bonding (TAB), combined with our 10,000 gate ECL array, provides 256 I/Os, frequency capability exceeding 1000 MHz, and a die measuring only 385 mils per side.



Triple layer metal routing improves utilization to over 75% on sea of cells architecture.

High-density CMOS arrays.

Because high gate counts by themselves aren't enough, Motorola uses intelligence to increase usable densities. Innovative, high technology solutions, like our three-layer-metal routing and power distribution, achieve high utility on smaller die sizes, with vastly improved performance. Over 75 percent utilization is possible while maintaining extremely small die sizes (486 mils a side for 105,000 gates; over 8,000 gates in less than 180 mils per side). Performance is increased too, with 250 picosecond typical gate delays (Fan Out = 1).

Innovative, intelligent solutions that deliver high gate counts with design efficient utilization, smaller die sizes, and higher performance—it's at Motorola, of course.

Advanced design automation.

One of our advanced design tools, our library of Silicon Compiler Modules, frees your ASIC designer to create customized cells that meet exact system specifications without compromise. With them you can set the parameters and mold the architecture of memory cells, timers, state machine functions, and a portfolio of data path elements.

The result is shortened design time, error-free cell layouts, and improved silicon efficiency. By simplifying the development tasks while maintaining flexibility and improving accuracy, your designers are freed from unproductive chores that shackle imagination.

One-on-one design-in help.

If you'd like more information about any of Motorola's advanced ASIC capabilities, talk to Dick, or one of his partners.

1-800-521-6274

Call toll-free any weekday, 8:00 a.m. to 4:30 p.m., M.S.T. If the call can't answer your questions, we'll have a local ASIC specialist contact you. For published data on Motorola ASICs, just complete and return the coupon below.

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CALENDAR

IEEE COMPASS '88 (3rd Annual Conference on Computer Assurance), Gaithersburg, MD. Frank Houston, COMPASS '88, Box 5314, Rockville, MD 20851. (301) 443-5020. June 27 to 30.

Principles of RF and Microwave Circuit Design (short course), Santa Clara, CA. Besser Associates, 3975 E Bayshore Rd, Palo Alto, CA 94303. (415) 969-3400. July 6 to 8.

Worst-Case Circuit Analysis (seminar), Honolulu, HI. Design and Evaluation, 1000 White Horse Rd, Suite 304, Voorhees, NJ 08043. (609) 770-0800. July 11 to 13.

CASE '88 (2nd International Workshop on Computer-Aided Software Engineering), Cambridge, MA. Pamela Meyer, Index Technology Corp, 1 Main St, Cambridge, MA 02142. (617) 494-8200, ext 1988. July 12 to 15.

Principles of RF and Microwave Circuit Design (short course), College Park, MD. Besser Associates, 3975 E Bayshore Rd, Palo Alto, CA 94303. (415) 969-3400. July 25 to 27.

Siggraph, Atlanta, GA. Barbara Voss, Robert P Kenworthy Inc, 866 United Nations Plaza, Suite 424, New York, NY 10017. (212) 752-0911. August 1 to 5.

Midcon, Dallas, TX. Electronic Conventions Management, 8110 Airport Blvd, Los Angeles, CA 90045. (800) 421-6816; in CA, (213) 772-2965. August 30 to September 1.

Surface Mount '88, Marlborough, MA. MG Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126; in MA, (617) 232-3976. August 30 to September 1.

Modern Electronic Packaging (seminar), Santa Clara, CA. Technology Seminars, Box 487,

CALENDAR

Lutherville, MD 21093. (301) 269-4102. September 7 to 9.

International Test Conference, Washington, DC. Doris Thomas, ITC, Box 264, Mount Freedom, NJ 07970. (201) 267-7120. September 12 to 14.

Worst-Case Circuit Analysis (seminar), Boston, MA. Design and Evaluation, 1000 White Horse Rd, Suite 304, Voorhees, NJ 08043. (609) 770-0800. September 12 to 14.

C Programming Workshop (short course), Seattle, WA. SSC, Box 55549, Seattle, WA 98155. (206) 527-3385. September 12 to 15.

12th International Fiber Optic Communications and Local Area Networks Exposition, Atlanta, GA. Information Gatekeepers, 214 Harvard Ave, Boston, MA 02134. (800) 323-1088; in MA, (617) 232-3111. September 12 to 16.

Connector and Interconnection Technology Symposium, Dallas, TX. Electronic Connector Study Group, 104 Wilmot Rd, Suite 201, Deerfield, IL 60015. (312) 940-8800. October 3 to 5.

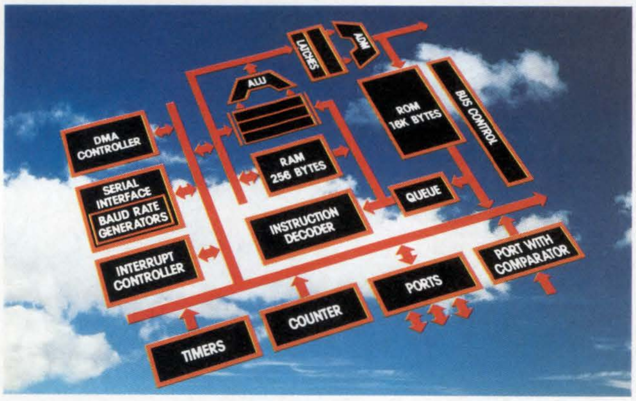
Autotestcon, Minneapolis, MN. Steve Palmer, Unisys, 3333 Pilot Knob Rd, Eagan, MN 55121. (612) 456-2349. October 4 to 6.

Buscon/88 East, New York, NY. Conference Management Corp, 200 Connecticut Ave, Norwalk, CT 06856. (203) 852-0500. October 4 to 6.

Electronic Imaging Conference East, Boston, MA. MG Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126; in MA, (617) 232-3976. October 4 to 6.

Simplify your life with single source supply.

THE MOST POWERFUL 16-BIT SINGLE-CHIP MICROCOMPUTER.



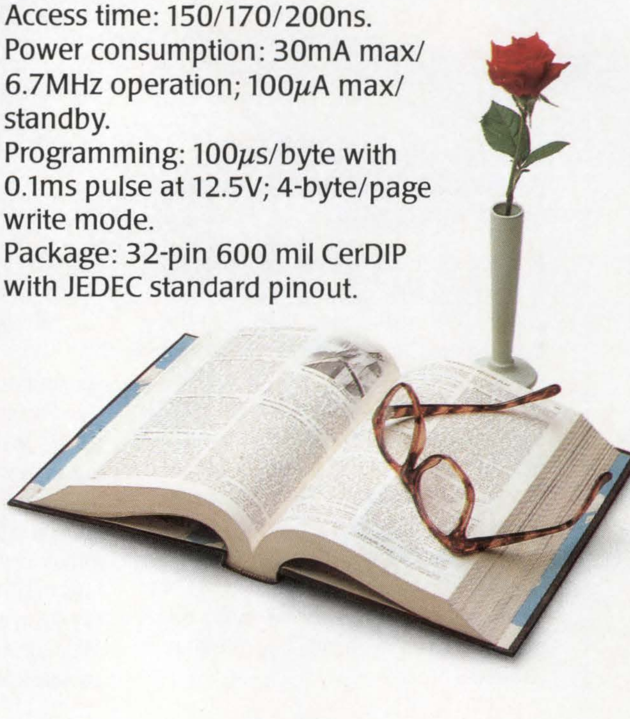
Offering higher integration, higher speed and enhanced functionality, the V25 meets more of your design needs. Which is why so many innovative designers are choosing the V25 for their 16-bit micro-based systems.

- ☐ High integration: programmable interrupt controller; 2-channel serial I/O port; three 16-bit timers; time-base counter and more.
- ☐ High speed: 16/32-bit temporary register/shifter; 16-bit loop counter and prefetch pointer.
- ☐ Enhanced interrupt handling: 8 programmable priority levels, hardware context switching for 8 register banks; 8-channel macro service controller.
- ☐ Two stand-by modes: halt and stop.

THE FIRST 2M-BIT CMOS EPROM.

NEC has just launched UV EPROMs into the 2M-bit era. The new μPD27C2001D gives you 2M-bit capacity in a 256K x 8 organization. High integration is complemented by high speed. With access times as fast as 150ns, our 2M-bit devices eliminate wait states for your CPU. Programming is also fast at 100μs per byte. The 4-byte page write mode multiplies programming speed.

- ☐ Organization: 256K x 8.
- ☐ Access time: 150/170/200ns.
- ☐ Power consumption: 30mA max/ 6.7MHz operation; 100μA max/ standby.
- ☐ Programming: 100μs/byte with 0.1ms pulse at 12.5V; 4-byte/page write mode.
- ☐ Package: 32-pin 600 mil CerDIP with JEDEC standard pinout.



For further information, please contact:

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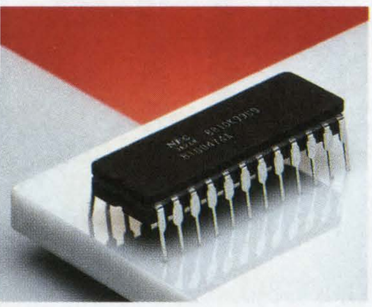
When you're buying semiconductors, multiple vendors can cause major mixups. To simplify everything, build a committed single-source relationship with one supplier: NEC.

We're the world's largest semiconductor manufacturer. We offer the industry's broadest lineup. The technology and quality of our components have made us an international leader in computers, communications and home electronics.

How do you get volume, variety, on-time delivery and applications support across the full spectrum of your semiconductor needs? It's simple. Build a single source relationship with NEC.

THE FASTEST 4K-BIT ECL RAM.

Read and write speeds are the critical parameters for ECL RAM performance. NEC has cut access time to 5ns and write cycle time to 7ns with our new ultra-fast 4K-bit ECL RAMs. How did we boost performance that high?



By using super-shallow junction transistors, trench isolation technology and Schottky diode clamp-type memory cells. Both ECL 10K (μPB10474A) and 100K (μPB100474A) interface devices are available.

- □ Organization: 1K x 4.
- □ Access time: 5/7ns.
- □ Power consumption: 1.2W.
- □ Package: 10K – 24-pin ceramic DIP; 100K – 24-pin ceramic DIP/QFP.
- □ Broad line of other ECL RAMs available: from 1K to 16K-bits; supplied in a diversity of organizations and speeds.

FAST AS A FLASH: 1M-BIT DUAL-PORT GRAPHICS BUFFER.

NEC's new megabit dual-port buffer chip is designed for super fast graphics processing. A unique "Flash Write" function clears the screen in a flash. The 256K x 4 RAM port allows bit write and fast page mode for high-speed bit operations. The 512 x 4 serial port operates at clock speeds up to 33MHz to handle high resolution graphics. To add value to your image processing system, design-in our μPD42274.

- □ Speed: RAS access – 100/120ns; CAS access – 25/30ns; serial read cycle – 30/40ns.
- □ Power consumption: stand-by–3mA; random read/write (serial port active) – 100/90mA.
- □ Package: 28-pin 400 mil ZIP and SOJ.*

*Under development.

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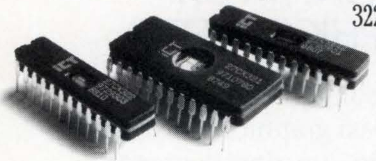
Let our PROMs take the danger out of going fast.

When it comes to high-speed PROMs, most of us will do anything for the speed we need. But that can mean living dangerously. ICT's CMOS High-Speed Erasable PROMs will take the danger out of going so fast.

Hold On Tight

We'll lower your risk, but not slow things down. Our CMOS PROMs are fast, with speeds from *35 to 55ns.* The 24-pin 27CX321/322 (4K x 8) and 27CX641/642 (8K x 8) are plug-in-compatible, with high-speed bipolar PROMs in standard 600-mil and space-saving 300-mil packages.



Beat The Heat

Bipolar PROMs run red-hot. Our *low-power CMOS* PROMs keep their cool at less than one-third the power. This brings operating temperatures way down to assure reliability and minimize supply requirements.

Cut Your Costs

Fast PROMs at these densities are not inexpensive. So, even development use of one-time-programmable PROMs can cost a fortune. Not to mention programming mistakes or design changes when in production. Our UV-Erasable PROMs are re-programmable, making them cost-effective and convenient.

Know They'll Work

Bipolar PROMs have limited factory testability. Some may not even program. Our UV-Erasable PROMs are *100% factory-tested* to ensure complete programmability, function and AC/DC performance. This means higher quality, and eliminates program and test fallout.

Get the Facts Fast

If you want to live in the fast lane, be sure to find out how to do it safely. Call us now and we'll send you the risk-free facts on our CMOS High-Speed Erasable PROMs, and information on our Serial EEPROMs and PEEL™ (Programmable Electrically Erasable Logic) devices, too. International CMOS Technology, Inc., 2125 Lundy Avenue, San Jose, CA 95131. **(408) 434-0678.**

All ICT products are exclusively distributed through Marshall Industries.

ICT CMOS High-Speed Erasable PROM Selection Guide

Device	Pins	Package	Organization	Speed (T_{AC})	Power (I_{CC})
27CX321	24	600 mil	4K x 8	35, 40, 45ns	40mA*
27CX322	24	300 mil	4K x 8	35, 40, 45ns	40mA*
27CX641	24	600 mil	8K x 8	40, 45, 55ns	60mA
27CX642	24	300 mil	8K x 8	40, 45, 55ns	60mA

* User-programmable 500 μA low-power standby mode

ICT

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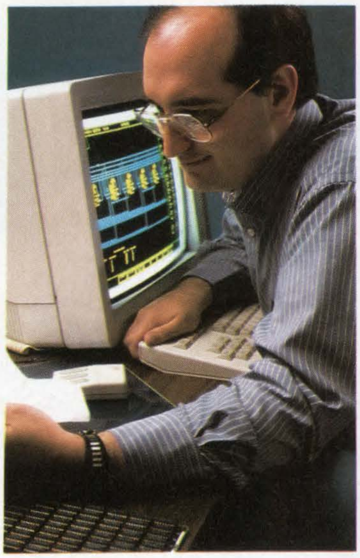
CIRCLE NO 89

EDITORIAL

People have a role in space



The Challenger space-shuttle disaster killed seven brave people, destroyed a multibillion dollar spacecraft, and put the US manned space program into temporary hibernation. The accident renewed the debate about why we send people into space. Is space too dangerous for people? Should we send people into space just to perform esoteric experiments and to manufacture ultrapure substances? The answer to both questions is probably not. But like any frontier, space offers myriad opportunities, many of which will remain unexplored until we actually start sending people into space again. If hopes are realized, this process will begin later this year.

Today, when we want to put a communications satellite into a geostationary orbit, we find an appropriate slot in a belt about 22,000 miles above the Earth and place our hardware into that position. Such satellites already support much of the world's voice, video, and data communications. Despite the advent of fiber-optic communication channels, we are becoming even more dependent on orbiting communications satellites. And two problems with such space equipment will create pressure to put people back into space.

First, the geostationary belt has limited room. We separate satellites by a minimum distance to reduce the chances of collision, and we put about 22 satellites into orbit each year. So, as we launch more equipment into space, the geostationary belt is becoming very crowded. Second, radiation damage limits the useful life of satellites to about 10 years. Satellites often achieve longer lifetimes in space through redundant and fault-tolerant design, but eventually their hardware fails. Because periodic maintenance is not currently part of any space-operations protocol, when a mission fails, a dead hunk of iron is left in a valuable geostationary slot.

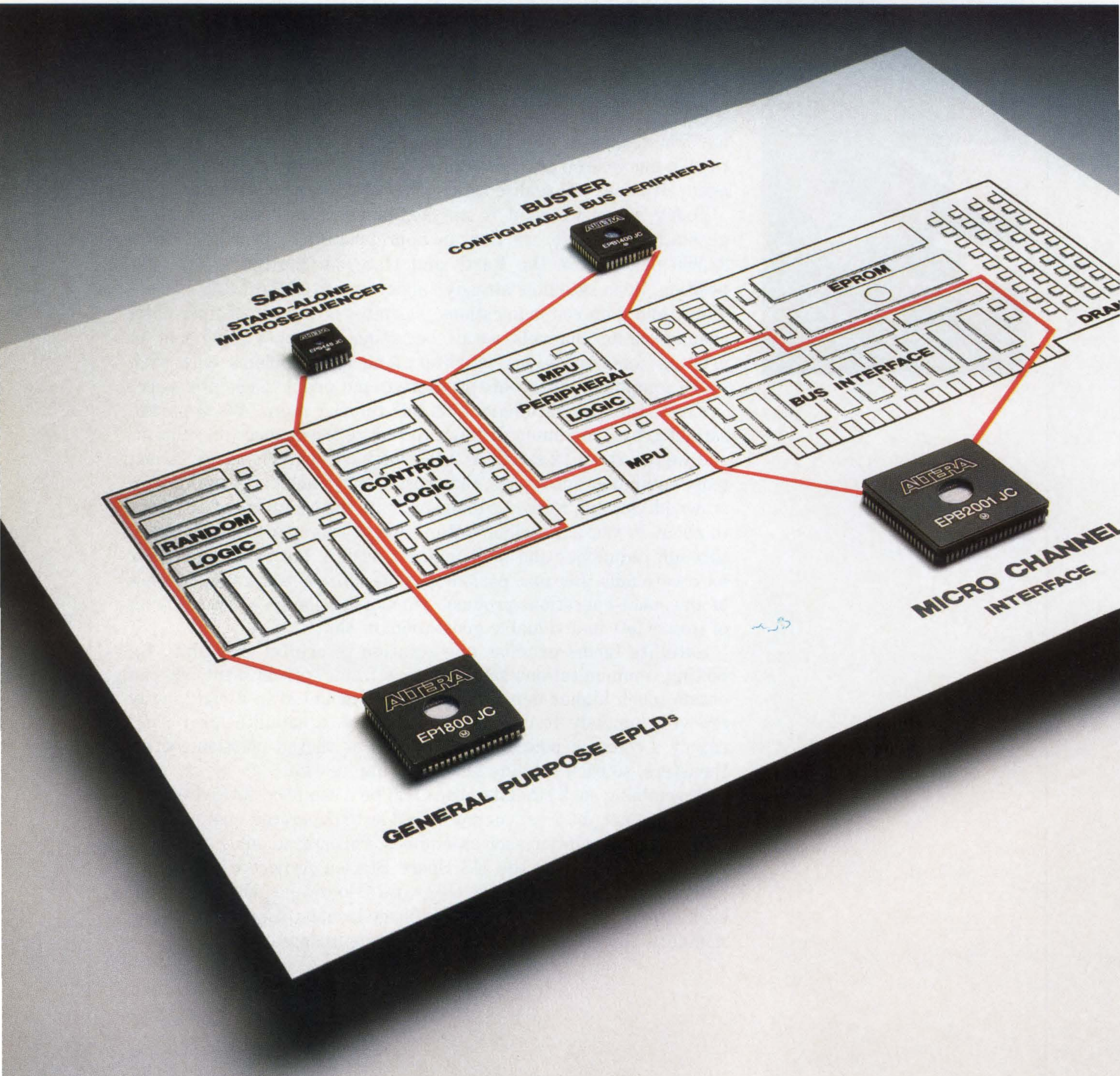
Satellite farms promise one solution to orbital crowding: By bolting communications satellites to a framework in orbit, we can obtain much higher densities. Satellites mounted in a rigid array are very unlikely to collide. Furthermore, a satellite farm could supply a common power source as well as shared position-control thrusters, so each satellite needn't bring its own.

Assembling such satellite farms will be a complex, intricate task, and we cannot yet trust computerized or teleoperated manipulators to create and maintain such assemblies. Perhaps, at some point, the robotics research for the US Space Station project will produce automatons that can perform this work. However in the meantime, such complex jobs require that people go back into space in growing numbers. Simply put, people have a place in space.

Steven H. Leibson

Steven H Leibson
Regional Editor

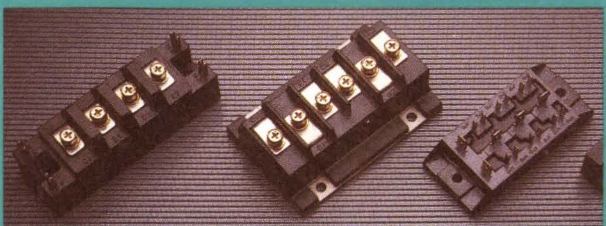
After 4 years of we're announcing



Who offers you the broadest line of power semiconductors... Darlington, FETMOD™, MOSBIP™, SCR/diode modules, rectifiers and thyristors?

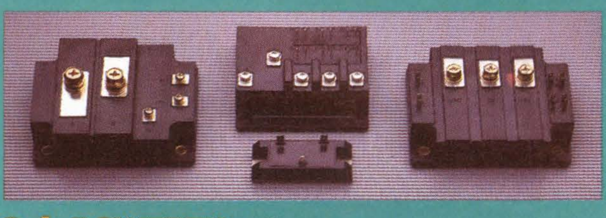
Only POWEREX.

Powerex gives you what no one else does. Our one-source convenience and compatibility eliminate multi-source doubt. Our off-the-shelf availability means just-in-time delivery, instead of back-order delays or high inventory costs. We'll provide engineer-to-engineer phone conversations for an unbiased view of application needs and alternative component solutions. Best of all, POWEREX gives you leading-edge technology, rather than last-generation obsolescence. Take a look.

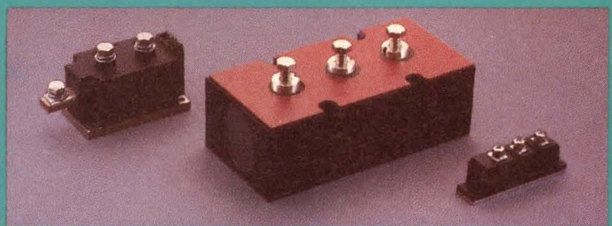


Only POWEREX offers you such a broad line of advanced power semiconductor modules, including next generation FETMOD and cascade or cascode MOSBIP, rated at 8-300 A, 50-1,000 V for applications up to 100 kHz.

Only POWEREX offers you the complete line of GE/RCA low-power triacs and SCRs as part of the broadest line of power semiconductors available.



Only POWEREX offers you more advanced Darlington modules, including Application Specific (ASM™) modules: Single device, Phase-Leg, H-Bridge, Three Phase, Chopper and Common Emitter, 5-600 A, with $V_{CEV(SUS)}$ from 200 to 1400 V.



Only POWEREX can provide a modular solution for all the key power components from logic interface devices, input rectifiers and DC regulating components to the output power stage. POWEREX now offers the world's widest array of input power stage thyristor and diode modules. Ratings of 20-800 A, with V_{DRM}/V_{RRM} from 400 to 3000 V. Circuit configurations include Single device, Phase-Leg, Three Phase Bridge and Center Tap in common cathode or common anode configuration.

Recent additions to the product line are a family of Center Tap fast recovery diodes rated at 20-100 A up to 1200 V, a new compact 150 A/1600 V Dual thyristor module, and a new 1200 V/300 A GTO thyristor module.

Only POWEREX offers you all this. For product literature, call POWEREX at 1-800-451-1415, Ext. 300. (In New York, 315-457-9334.) For application assistance, call 412-925-7272, or write POWEREX, Inc., Hillis Street, Youngwood, PA 15697.

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CIRCLE NO 83

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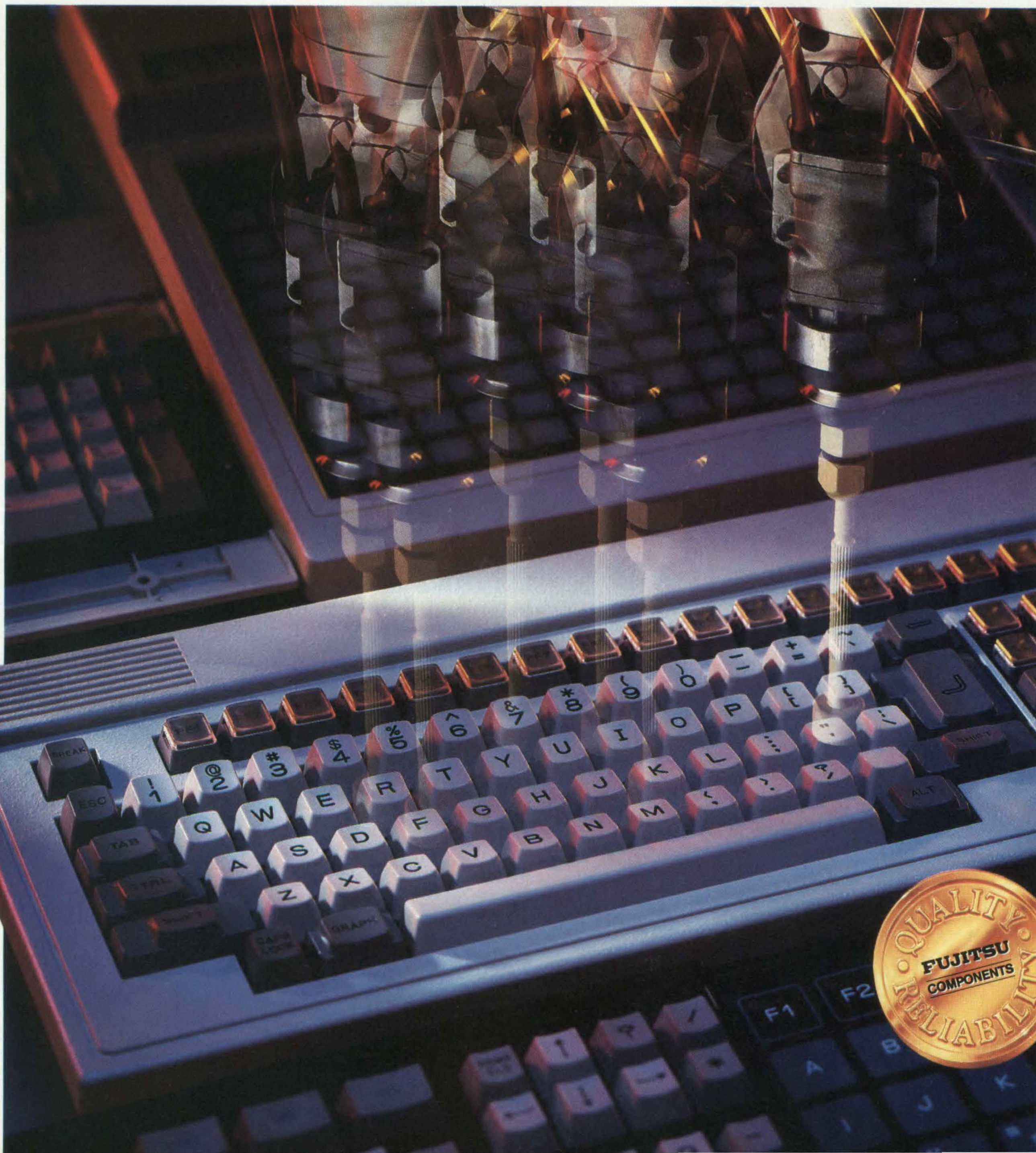

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Keyboards enhance their flexibility with cost-effective keyswitch technologies

Tom Ormond, *Senior Editor*

No longer do keyboards serve simply as minimal man-machine interfaces. Microcontroller-based electronics has made it possible for manufacturers to include features that significantly increase a keyboard's capabilities and flexibility. In fact, fully encoded keyboards are almost the norm today rather than the exception. Microprocessors with 2k bytes of memory prevail in recent keyboard designs. This memory capacity allows the keyboards to accommodate a number of different machine-specific interfaces—a must in today's personal-computer market.

Offering full compliance with DIN standards, *FKB4700 Series keyboards from Fujitsu are available in US 101-key and European 102-key versions.*

Vendors are concentrating design efforts on low-profile, stand-alone keyboards. In Europe, ergonomic concerns show up in the DIN standards with which the keyboards must comply, and the same is true of keyboards in the US: Low-profile keyboards are the only way manufacturers can compete in the full-travel market today.

One more significant trend is worth mentioning. Manufacturers are shifting their design efforts toward three technology areas, conductive rubber (elastomer), membrane, and mechanical (hard contact). OEMs are finding that the cost savings associated with these three technologies is quite important.

Products prove the point

Conductive-rubber technology, long accepted for low-duty-cycle keypads (**Ref 1**), is making significant inroads into the full-travel keyboard sector. Good designs—with keyswitch lifetimes of 10 to 20 million operations—accommodate a number of applications, and conductive-rubber keyboards are cost effective.

The military products group of IEE has developed a low-profile, environmentally resistant keyboard for tactical computers and other weight-sensitive systems at a cost of \$400 (100). The company is using conductive-rubber technology in its entire line of full-travel military keyboards.

The keyboard's 1-piece molded-silicone-rubber sheet features conductive-rubber inserts. Plastic keycaps snap onto protrusions on the silicone rubber directly above the conductive inserts and are retained by a precision metal bezel. The keyboard subassembly is then attached to a military-grade pc board that includes interdigitated etched contacts located below each of the conductive actuators. The resultant keyboard assembly exhibits tactile response and is totally sealed from the effects of severe environments.

A typical model specs a key travel of 0.093 in. and an initial contact resistance of 200Ω. Standard plastic keys have legends printed with an epoxy paint; the end user can specify double-shot-molded legends as an option, however. Keycaps and legends are also available in a variety of colors.

What do you do when it looks like there's no standard off-the-shelf keyboard that meets your needs? Don't jump to the conclusion that a custom design is your only option—another solution might be at hand.

A roll-your-own keyboard

Advanced Input Devices offers one such solution, the Modulkey EKT 109. The EKT 109 is an off-the-shelf keyboard, but you can use its six snap-in key modules and change the key layout (from 109 keys to 115) in the field. The snap-in molded-plastic modules include only keytops, housings, and plungers; the elastomer-switch matrix remains intact and is not an integral part of the modules. You can also opt to have the manufacturer recon-

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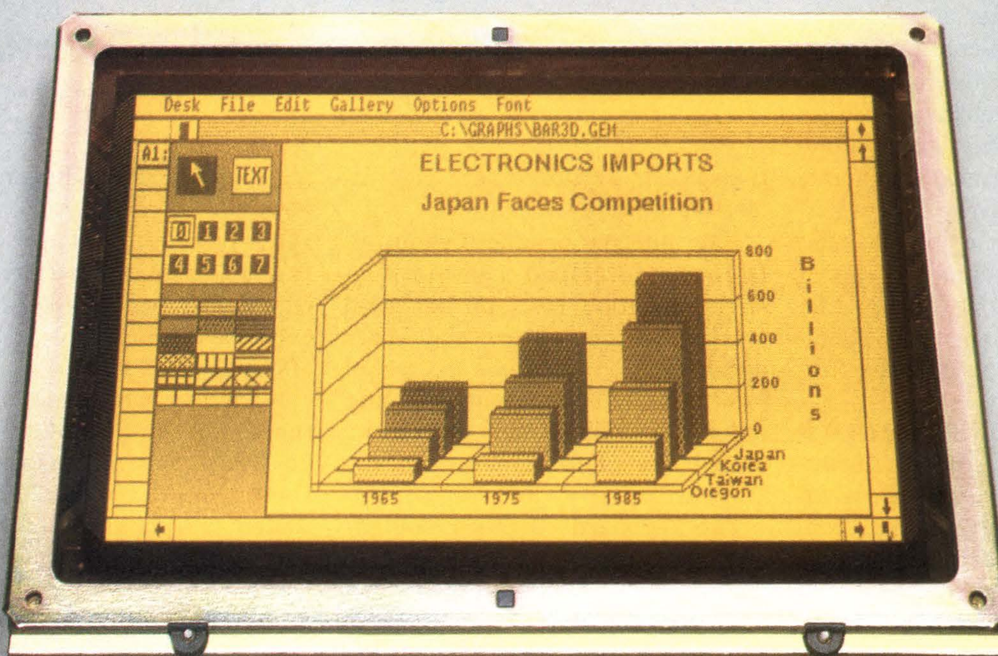

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figure the keyboard in the factory.

Internal autosense electronics allows the Modulkey keyboard to automatically establish either an IBM/PC, PC/XT, or PC/AT interface. The keyboard's single-piece elastomer switch mat provides breakover tactile feel and protection from dust and spills, and it is cost efficient and reliable for high-speed data-entry office applications. The EKT 109 costs approximately $75 in OEM quantities.

The keyboard comes with a shielded coil cord and has four LEDs—caps lock, scroll lock, numbers lock, and power-on—located on the top housing. It complies with DIN, UL, CSA, VDE, and TUV standards.

The Memory Pro from Eeco's Maxi-Switch Div is another example of an off-the-shelf, yet flexible, keyboard. Its programmable capabilities and layout options provide additional system power and increase typing (and thus computing) speed.

The 2k-byte nonvolatile memory can hold over 90 macros (soft keys) and retain those macros regardless of the software running in the host computer. The keyboard's design lets you automatically upload and download your custom macros for specific application programs, and you can also use the host to read and load the memory.

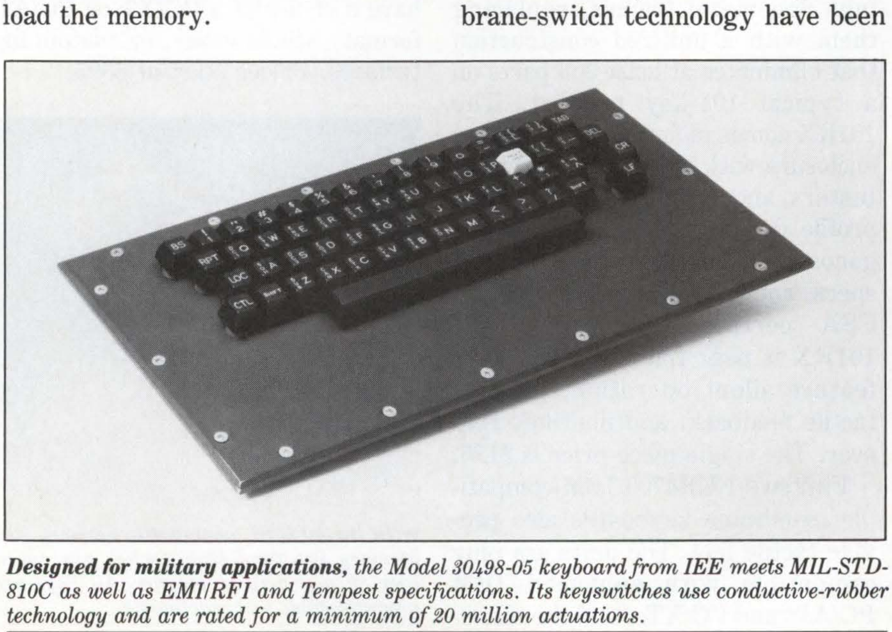
Depending on the program you want to run, the Memory Pro lets you establish different meanings for the soft keys. You can also include delays and fixed or variable fields when defining the keys. And, you can edit soft-key definitions (using an appropriate program) while you're recording the keys' data. The keyboard saves the definitions in an ASCII file. The key click is programmable to four different volume levels, and you can also program key-repeat rates from 0 to 30 cps.

The keyboard's 12 function keys are located on the left to ease word-processing applications. Separate numeric and cursor pads make it relatively easy to use the keyboard for spreadsheet tasks, for instance. The 22 legend keys, which are also programmable, allow for a good deal of user customization.

A number of other customizing features are also available for the Memory Pro. Data-rate options, for example, span 300 to 9600 baud. A linkable utility is available to download macros and to set up parameters, and an RS-232C output interface is also available. Prices for a Memory Pro keyboard start at $150.

Keyboards made of conductive rubber aren't your only choice if you need—or want—customization. Full-travel keyboards using membrane-switch technology have been around about twice as long as conductive-rubber types. Such keyboards utilize two flat sheets of insulating material, each of which has flexible conductors screened onto one surface. The top membrane layer must be flexible, but the bottom layer can be either flexible or a pc board.

To maximize flexibility, *the Modulkey EKT 109 keyboard from Advanced Input Devices allows you to use snap-in key modules to reconfigure the layout from 109 keys to 115.*



Designed for military applications, *the Model 30498-05 keyboard from IEE meets MIL-STD-810C as well as EMI/RFI and Tempest specifications. Its keyswitches use conductive-rubber technology and are rated for a minimum of 20 million actuations.*

If you want more versatility

The 101RX from Honeywell is the second in a planned series of curved, remappable keyboards. The term "curved" refers to the fact that the keyboard is built on a curve from the bottom up. Traditional keyboards have a flat design and use keytops of different slopes in each row to provide the standard sculptured key array that accommodates the natural shape of the hands.

In a curved keyboard, all keytops are on the same slope, which allows remappability: You can interchange all keys in the array—something that's not possible with most flat sculptured keyboards. Remappability gives you the luxury of customizing a keyboard layout to meet specific application needs.

The 101RX features the 101-key enhanced array and is plug compati-

Offering a suite of options, such as a card reader, mouse, and remote bar code reader, Cherry's G80-2000 has a layout like the IBM 3270 terminal controller with 24 function keys along the top, in addition to the 10 at the left of the board.

ble with the enhanced IBM PC keyboard. The 101-key layout incorporates a typewriter-style alphanumeric array and separate numeric and cursor-control pads. Twelve function keys located across the top of the keyboard enhance recognition and use. Status LEDs on the caps-lock, number-lock, and scroll-lock keys also aid user throughput by illuminating the mode in use.

Compatible with systems running clock speeds ranging to 16 MHz, the keyboard is available in five popular 102-key European versions as well as the standard US 101-key version; a 3270-terminal version is also available. An integral autosensing μP selects the proper electrical interface.

The completely integrated, membrane-switching-technology design eliminates individual switch housings and metal frames, replacing them with a unitized construction that eliminates at least 300 parts on a typical 101-key product. The 101RX comes in an injection-molded enclosure with 2-position height adjusters and a 7-ft cord. Its low-profile design meets European ergonomic standards, including DIN specs, and it is UL recognized and CSA certified. Moreover, the 101RX is user friendly. The keys feature silent operation, positive tactile feedback, and multikey rollover. The single-piece price is $175.

Fujitsu's FKB4700 IBM-compatible membrane keyboards also provide tactile feel. The units are plug compatible with enhanced IBM PC/ATs and PC/XTs, and the manufacturer will configure a standard keyboard to accommodate custom and semicustom applications.

The low-profile keyboards comply with DIN standards and are available in 101-key versions as well as many European (German, French, Italian, Swedish, Spanish, and Swiss) 102-key models. The key operating-force specification is 55 ± 25g, the stroke length measures 0.150 in., and the contact resistance equals 500Ω. You can expect a keyboard lifetime of 10 million operations min.

Take your pick of formats

Like the 101RX, FKB4700 keyboards feature LED indicators for caps-lock, number-lock, and scroll-lock positions. A serial synchronous data interface is standard. The keyboards have either an 11-bit data format (IBM PC/AT versions) or a 9-bit format (PC/XT models). Their operating range spans 0 to 50°C, and they require 5V at 250 mA. A fully encoded keyboard sells for $48.50 (500).

If you're interested in an intelligent keyboard, the Touch-Screen from the Digitran Div of Excel Corp combines an IBM PC-compatible keyboard with a fully programmable LCD touch-sensitive screen capable of displaying graphics. You have a choice of a PC/XT or PC/AT format, ASCII codes, or custom interfaces. Prices start at $395.

With its onboard, nonvolatile memory, the Memory Pro from Maxi Switch can retain over 80 user-defined macros. All keys are programmable and redefinable.

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The Touch-Screen is useful as a cursor control for spreadsheets or CAD programs. In addition, it can serve as a programmable-function keypad or as a combination cursor-control/keypad area. The LCD area is programmable from the keyboard, and the keyboard can save menus or graphic displays for future use. You can transmit display data through the keyboard; consequently, the host system always receives standard keyboard codes.

Users can incorporate macrokey words, short and long word strings, and icons into programmed screen options to maximize input flexibility. For optimum efficiency, you can create the macrocommands as 1-key inputs on the LCD. The 128×256-dot LCD offers approximately 2.75×5-in. of usable display and touchpad area and normally mounts to the right of the QWERTY area in place of the numeric keypad. It is capable of displaying text as well as unlimited graphics symbols.

Making contact the hard way

Mechanical-switch technology, the third keyswitch technology that manufacturers are emphasizing, is fairly mature (about 20 years old). Although it is most reliable for applications where lifetimes of 20 million cycles are acceptable, don't underestimate its capabilities for customization and flexibility.

Mechanical-switch technology usually involves a pair of moving metal contacts touching one another in a butting action. Cherry's Series G80-2000 keyboards, for instance, employ gold-crosspoint mechanical-keyswitch technology to ensure long life and high reliability. The keyboards have a layout identical to IBM's 3270 terminal controller and are available with a host of options.

For example, you can order a 123-position keyboard—in a completely assembled housing and equipped with all electronic options to accommodate bar-code reading, a mouse, and a magnetic card reader—for $765. The bar-code reader, light pen, and mouse sell for $170 and $45, respectively.

Designed to European ergonomic standards, *Honeywell's 101RX keyboards feature an autosensing μP that selects the proper electrical interface and provides compatibility with systems running at 16-MHz clock speeds.*

Smartkey helps

In addition to the 10 function keys located on the left side of the keyboard, 24 function keys are arranged in 2 rows across the top. These extra keys are especially useful for rapid data entry and allow you to input lengthy product descriptions or codes with just a few keystrokes. The manufacturer bundles an enhanced version of Smartkey software with the G80-2000 to make it compatible with IBM PC/XT and PC/AT applications. Otherwise, only software written for the 3270 terminal controller would recognize the extra function keys. In effect, Smartkey provides 96 extra functions: You can operate each function key alone, shifted, control-shifted, or alternate-shifted.

An onboard LCD readout guides the user. Programmable multikey rollover, LED actuation indicators, and programmable autorepeat commands are also available. You have the option of ordering a keyboard with or without its housing (which conforms to DIN standards).

The Right Touch (RT) keyboard line, available from NMB Technologies' Hi-Tek Keyboard Div, also employs mechanical-switch technology. The manufacturer claims keyswitch lifetimes of 10^8 cycles. The keyboards operate with IBM/PC, PC/XT, and PC/AT systems. You can select the appropriate electronics interface using a slide switch easily accessible on the bottom of the keyboard housing.

RT keyboards come with an 8-ft cable that can protrude either from the right or left side of the housing; you can easily move the cable to change the placement of the keyboard. Ergonomically placed cursor-control and dedicated screen-control keys make software programs easier to use because the user can simultaneously operate the numeric pad and cursor keys without having to toggle the number-lock key.

The keyboards also offer autorepeat operation and programmable multikey rollover as standard features. If the system is unable to accept scan codes, the keyboard will buffer as many as 16 keystrokes in a FIFO memory. The keyboards operate from 5V supplies (300 mA) over the range of 0 to 55°C and generate TTL output levels.

Right-Touch keyboards meet relevant UL, FCC, and CSA requirements and comply with the FCC limits for a class B computing device. They are protected against ESD to 20 kV without experiencing catastrophic failure and to 12.5 kV

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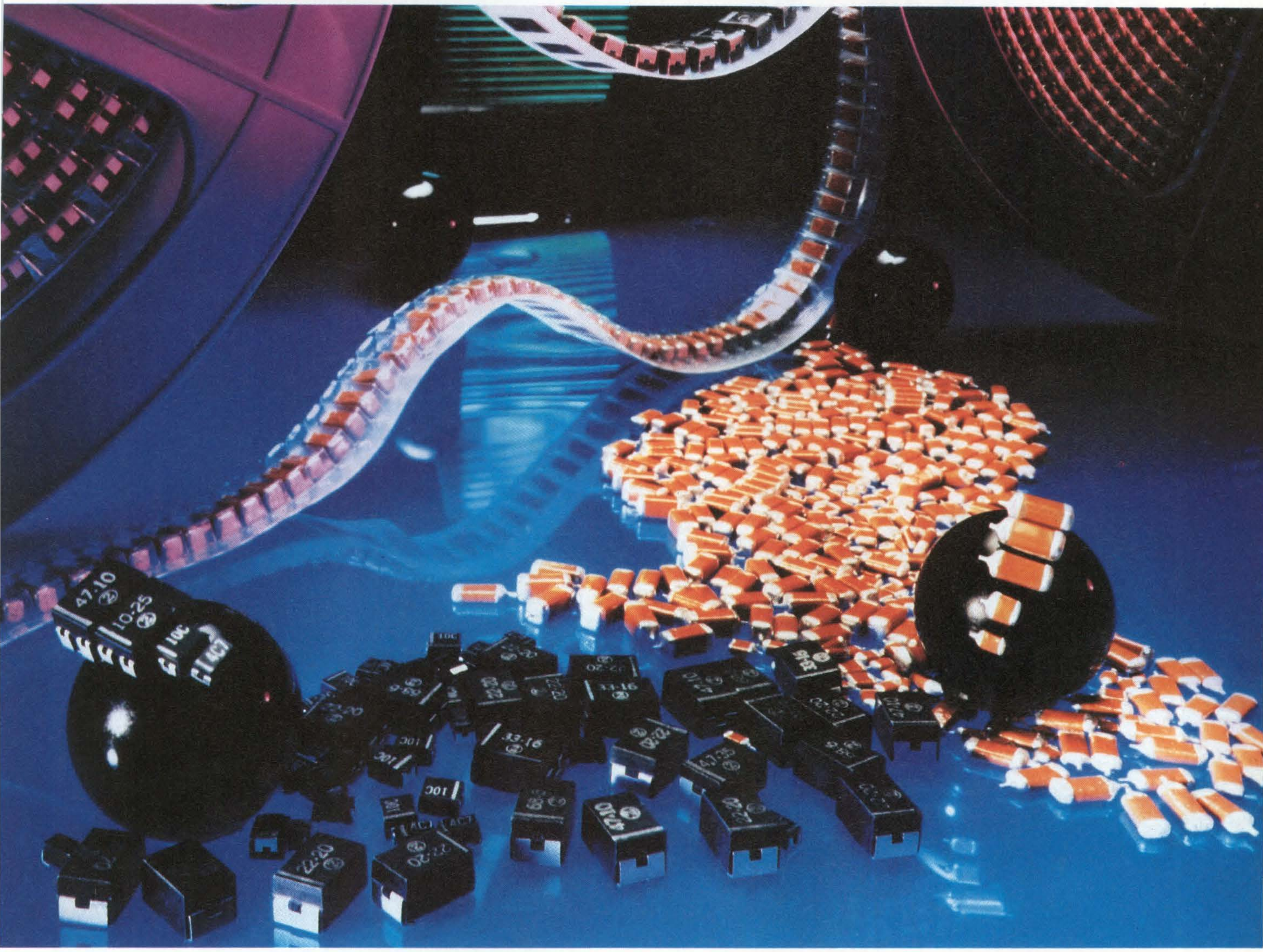

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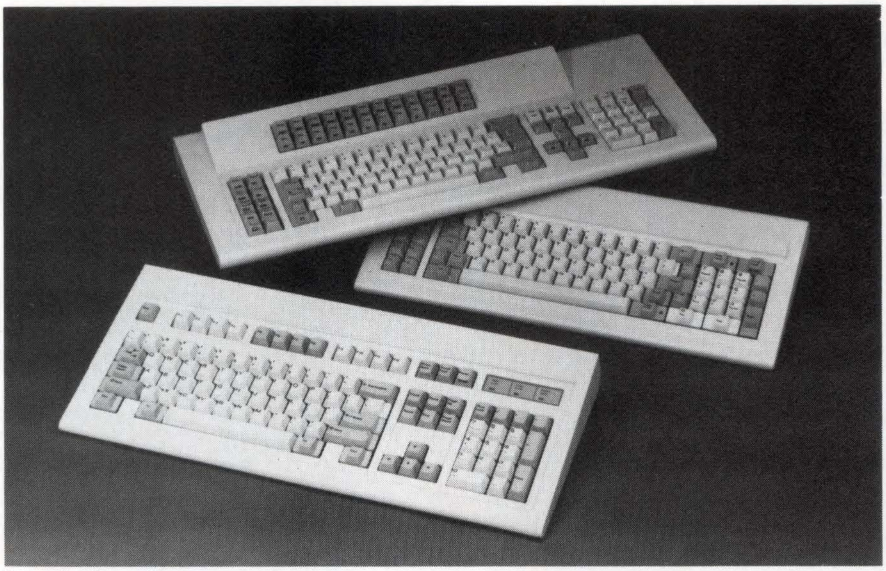

To make it easier to use software programs, *the RT-101 keyboards from Hi-Tek feature an ergonomically placed cursor-control pad and dedicated screen-control keys.*

without generating any screen errors. They cost $41 (50).

You can expect that the use of these three types of keyswitch technologies—conductive rubber, membrane, and mechanical—will continue to increase. After all, cost savings and cost efficiency will continue to be paramount concerns for OEMs. However, when it comes time to shop around for a keyboard, don't overlook other switch technologies, such as ferrite core, Reed switch, Hall effect, and capacitive, which all have their niches, too.

EDN

Reference

1. Conner, Margery S, "Ubiquitous conductive-rubber switches adapt to fit your application and budget," *EDN*, April 30, 1987, pg 91.

Article Interest Quotient
(Circle One)
High 518 Medium 519 Low 520

For more information . . .

For more information on the keyboards described in this article, contact the following manufacturers directly, circle the appropriate numbers on the Information Retrieval Service card, or use EDN's Express Request service.

Advanced Input Devices
W 250 Aid Dr
Coeur d'Alene, ID 83814
(208) 765-8000
TWX 510-776-0584
Circle No 701

Cherry Electrical Products
3600 Sunset Ave
Waukegan, IL 60087
(312) 662-9200
TWX 650-299-7605
Circle No 702

Eeco Inc
Maxi-Switch Div
5436 W Latham St
Phoenix, AZ 85043
(602) 272-5645
TLX 678420
Circle No 703

Fujitsu Component of America
3330 Scott Blvd
Santa Clara, CA 95054
(408) 562-1000
FAX (408) 727-0355
Circle No 704

Honeywell Inc
Keyboard Div
4171 N Mesa
El Paso, TX 79902
(915) 544-5511
Circle No 705

IEE Inc
Planar Products Div
7740 Lemona Ave
Van Nuys, CA 91409
(818) 787-0311
FAX (818) 902-3723
Circle No 706

NMB Technologies Inc
Hi-Tek Keyboard Div
11621 Monarch St
Garden Grove, CA 92641
(714) 898-9511
TLX 678486
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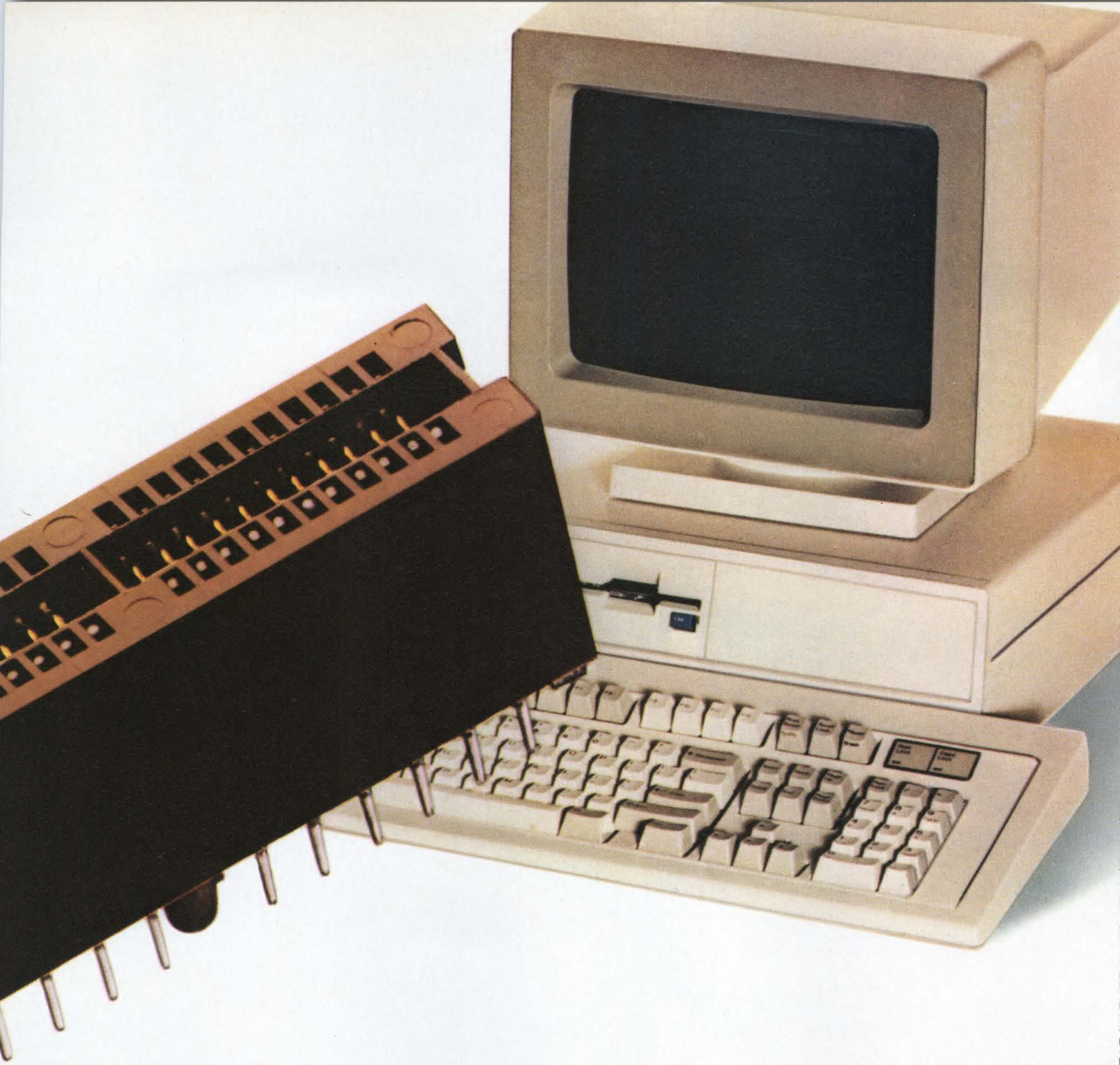

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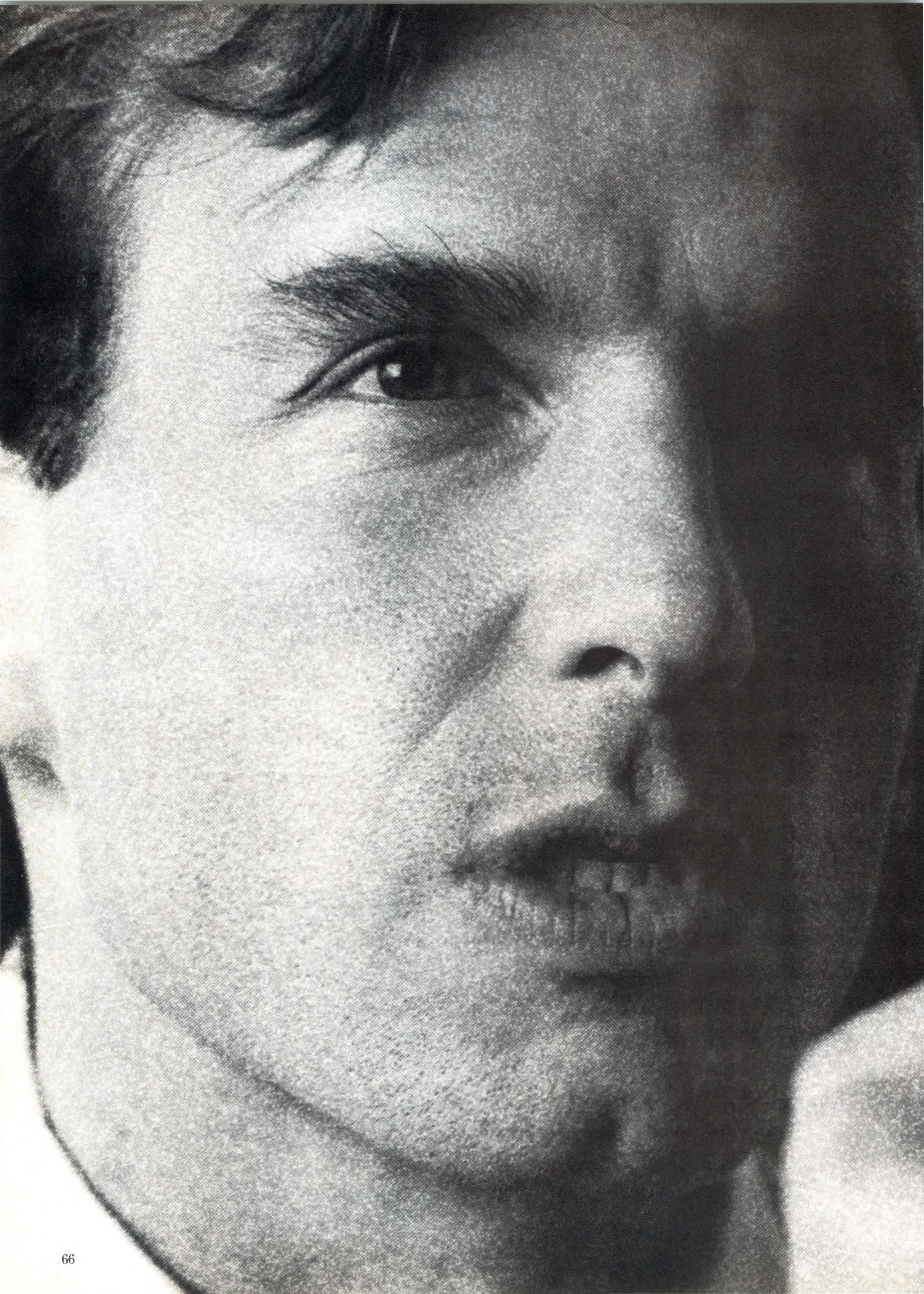

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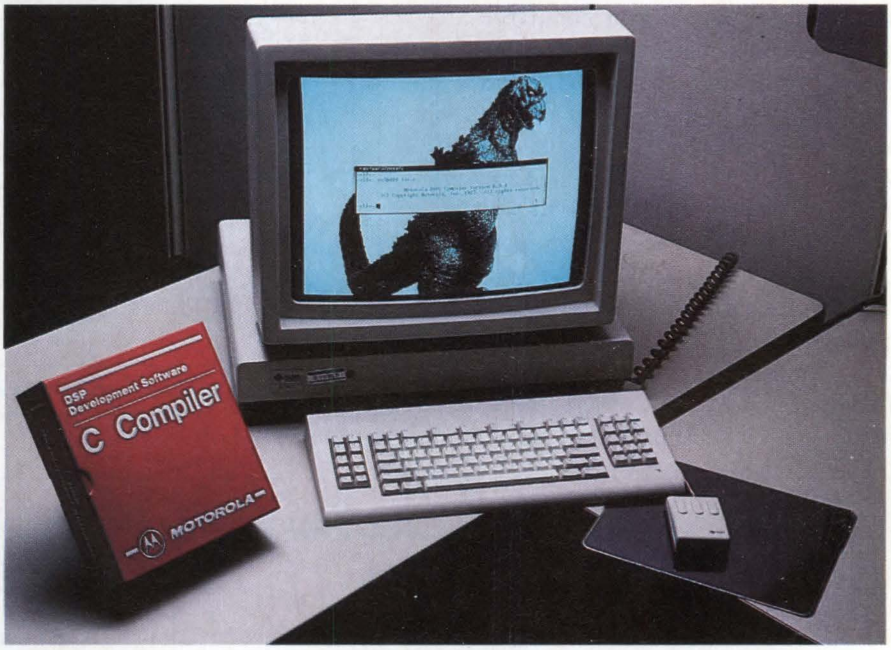
HLL compilers and DSP run-time libraries make DSP-system programming easy

David Shear, *Regional Editor*

You no longer have to be an algorithm expert to accomplish a DSP-based design: High-level languages (HLLs) have arrived en masse for digital-signal-processing (DSP) applications. As recently as a year ago, no viable HLLs were even available for DSPs. Now, however, almost all of the general-purpose floating-point DSP chips offer HLL compilers, and many of the fixed-point chips do so as well. You can create applications software for your DSP system in C, Pascal, or Forth, though C is by far the dominant language. DSP run-time libraries that contain useful, prewritten routines for many popular DSP algorithms are also available.



A high-level language will help you conquer the monstrous task *of developing software for DSP applications. (Photo courtesy Motorola)*

High-level languages offer many proven advantages, but the most important is that they reduce the time and money you need to spend on the software portion of your projects. HLLs let you generate code faster than assembly language does, and—unlike assembly language—they spare you from learning the details of the hardware the program will run on. Further, a program written in a high-level language is easier to maintain than its assembly-language equivalent.

HLLs simplify system design

Another major advantage of using a high-level language for DSP programming is that it lets you use the DSP for more than just digital signal processing. In the past, the DSP has typically been a coprocessor to a host microprocessor, because the general system programs were too complicated to write in assembly language. But now that HLL compilers are available for DSPs, you can use a DSP as the only processor in a system, which will give you a much simpler and less-expensive system design.

Furthermore, DSPs have not reached the end of their performance growth. Next year, newer and faster DSPs will be available. Using a high-level language will help guarantee that your software doesn't become obsolete as each new generation becomes available. C, in particular, allows you to transport programs between machines, so you can easily upgrade your product to use new DSPs as they become available.

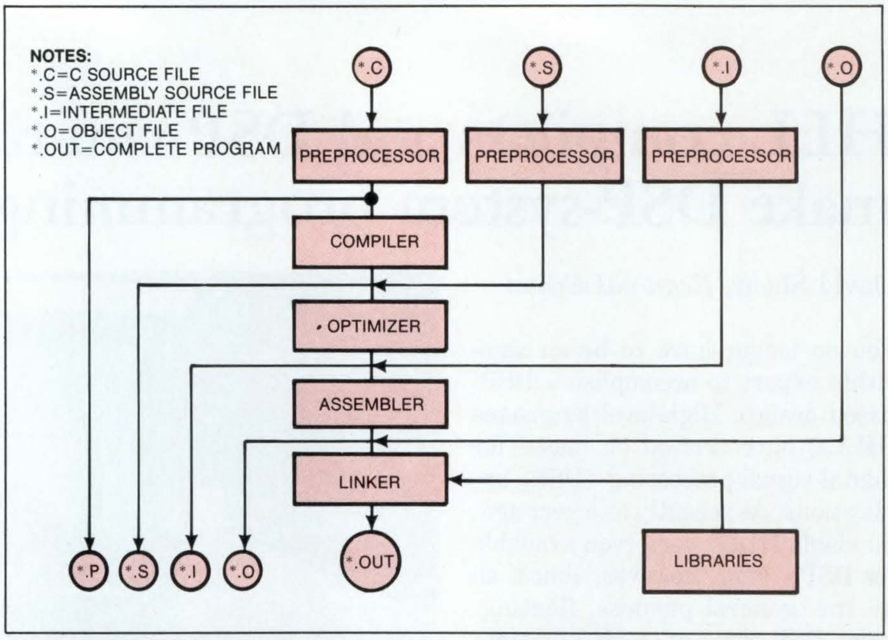
Ideally, all you'd have to do to upgrade your software for a new DSP would be to recompile your program with the new DSP's compiler, and it would run. In practice, you usually have to make some modifications to your program, but these modifications are minor in comparison to the massive effort it takes to convert an assembly-language routine for one machine to a version that works with another. When you upgrade your system by using a more advanced DSP from the same family, you may find it easy to modify your assembly-language software to run on the upgraded system. But if you change vendors or use a radically new DSP device, you'll find that modifying your assembly-language software is a very time-consuming process.

Retarget code to new DSPs

A high-level language gives you a lot more flexibility than assembly language does in creating a system design and upgrading it later, but a retargetable compiler is even better. A retargetable compiler is a compiler that you can customize to fit any hardware configuration by describing that hardware's architecture in a configuration file. During compilation, the compiler refers to this file to create an assembly file that's specific to that system.

Quantitative Technology Corp offers a suite of tools based on retargetability. The tools include a C compiler, assembler, optimizer, symbolic debugger, and simulator, all of which are retargetable. If you use a retargetable compiler, you can use whatever processor you decide, and you'll be able to use much of your existing software and the same set of tools: You won't have to wait for new tools to be released or spend time learning to use them.

To appreciate how much easier a high-level language can make your program-development task, refer to **Listing 1,** which is a C program that performs a spectrum analysis. In



Optimizing compilers attempt to reduce the speed penalty *inherent in high-level languages. The AT&T C compiler, for example, preprocesses the C source code, compiles it, optimizes it, and then assembles and links it.*

REPRESENTATIVE HIGH-LEVEL-LANGUAGE COMPILERS FOR GENERAL-PURPOSE DSPs

COMPANY	COMPILERS	LANGUAGE	DSP SUPPORTED
ANALOG DEVICES	C COMPILER	ANSI X3J11 C	ADSP2100, ADSP2101/2
AT&T	WE DSP32C-CC	KERNIGHAN & RITCHIE C	DSP32, DSP32C
FORTH INC	FB320	FORTH	TMS32020, TMS320C25
LOUGHBOROUGH SOUND IMAGES LTD	LSI C COMPILER	KERNIGHAN & RITCHIE C	TMS320C25
	JL320 PASCAL COMPILER	PASCAL	TMS32020, TMS320C25
MOTOROLA INC	DSP56KCCX	KERNIGHAN & RITCHIE C	DSP56000/1
QUANTITATIVE TECHNOLOGY CORP	SOFTWARE FOUNDRY	ANSI X3J11C	RETARGETABLE
SKY COMPUTERS INC	SKYC20	KERNIGHAN & RITCHIE C	TMS32020, TMS320C25
SPECTRUM SIGNAL PROCESSING INC	LSI C COMPILER	KERNIGHAN & RITCHIE C	TMS320C25
TEXAS INSTRUMENTS INC	C25 C COMPILER	KERNIGHAN & RITCHIE C	TMS320C25
	C30 C COMPILER	KERNIGHAN & RITCHIE C, ANSI C	TMS320C30

this example, the program calls the function *get_spectrum* to read data from an A/D converter, multiply the data by a Hanning window, convert the data to the frequency domain with an FFT, and then convert the complex data from the FFT to the real magnitude. The result will be stored in an array of floating-point values called *freq_array*.

Beware the speed trap

So far, HLL compilers sound pretty good, eh? Alas, there's trouble in paradise. High-level languages can incur speed penalties. When you use a high-level language, the compiler takes care of all the details of the program and creates the assembly-language code. For the most part, compilers are stupid; therefore, the code they generate isn't very efficient. HLLs also spend a lot of time moving such things as variables, parameters, and addresses on and off the stack. Further, HLLs consist of very capable high-level instructions that don't efficiently map to assembly-language routines. The situation is ironic: You probably chose a DSP approach in order to achieve execution times that weren't available elsewhere. Obviously, you'll be reluctant to sacrifice this hard-won speed increase.

Fortunately, although you need to be aware of the speed penalty HLLs can incur, it's not the Catch-22 situation it seems. For one thing, you could solve the problem by writing part of your code in assembly language. Another solution is to use an optimizing compiler, which a number of manufacturers offer. An optimizing compiler goes through the code and reorganizes it, using a variety of tricks to enhance the program's efficiency.

Some of these tricks are machine dependent; they enhance system performance by taking advantage of a DSP chip's special features, such as multiply/accumulate, zero-overhead looping, and postregister modification. Other techniques—such as the use of registers, the elimination of common subexpression code, the removal of redundant evaluations, loop invariant code elimination, and jump-jump elimination—are not machine dependent. Some optimizing compilers can also enhance the program's efficiency by keeping the pipeline of the DSP chip full at all times.

Although any correct high-level-

OPTIMIZING CAPABILITY	ALLOWS W-LINE ASSEMBLY CODE	DSP RUN-TIME LIBRARY	OPERATING SYSTEM OR COMPUTER	PRICE
AVAILABLE IN 4TH QTR OF 1988	•	AVAILABLE IN 4TH QTR OF 1988	MS-DOS	$1950
			VAX/VMS	$4350
			UNIX BSD 4.2	$2990
•	•	•	MS-DOS	$1500
			UNIX V	$3800
			UNIX BSD 4.2	$3800
	•	•	MS-DOS	$2850
			WITH 32020 BOARD	$3950
			WITH 320C25 BOARD	$4350
			MS-DOS	£995
	•		MS-DOS	£745
•	•	AVAILABLE IN 3RD QTR OF 1988	IBM PC	$709
			MACINTOSH II	$709
			SUN-3	$4709
			VAX	$4709
•	•	•	FOR VARIOUS WORKSTATIONS	$50,000
			FOR VAX 8600, 8800	$95,000
	•		IBM PC	$1700
			SUN	$3500
			VAX	$3500
			IBM PC	$1995
•	•	AVAILABLE IN 3RD QTR OF 1988	IBM PC	$2500
			VAX/VMS	$5000
•	•	4TH QTR OF 1988	IBM PC	$2500
			VAX/VMS	$5000

language program will run on a DSP chip, don't expect it to run efficiently if you just blindly write code without taking the hardware into consideration, as you might for a general-purpose μP. To exploit a DSP's special capabilities, you'll need to take a little extra care in writing your application software. Ordinary microprocessors may be able to use poor programs without too much performance degradation, but DSPs won't give you top performance unless you program well.

When you use a high-level language, you can still write your code fairly independently of the hardware; you merely need to put a few restrictions on your programming practices. The restrictions are simple, however, and they're good programming practices as well.

You can develop efficient code with an optimizing compiler, for example, by following some simple rules, which are usually defined in the compiler's manual. A case in point is the manual for AT&T's WE DSP32C-CC compiler, which contains a table of programming hints. Each hint comes with a figure of merit to give you an idea of how hard you should try to follow it.

The book also presents some general rules for all compilers; for example, it advises you to use pointers to array elements, use postmodify pointers, avoid long data types, and avoid bit fields. These rules aren't difficult to follow, and they'll result in faster code.

Although optimizing compilers are useful, there'll be times when the code resulting from your optimizing compiler just doesn't run fast enough for your purposes. You can speed up those sections of code by rewriting them as in-line assembly-language code or by using an assembly-language routine called from the high-level language.

Many compilers allow you to reference HLL variables from within the in-line assembly code by their labels. This feature makes it easier for you to create the assembly-language section, because it lets you use and/or modify variables without calculating stack positions or absolute memory locations.

Optimizing compilers usually don't operate on the in-line assembly language. The vendor assumes, instead, that you've already optimized the code yourself. AT&T's C compiler allows you to switch the optimization back on if you want to use it on the in-line assembly-language code. The company recommends that you always send your entire program, including the in-line assembly-language code, through the optimizer even if it doesn't require optimization, so that your code will always be compatible with future releases of the compiler.

DSP run-time libraries

An enormous advantage of some HLL compilers is a DSP run-time library, a collection of useful routines that you access with a simple function call from the high-level language. Run-time libraries allow people who are not DSP experts to program DSP systems. Not all vendors of high-level-language compilers offer run-time libraries, but many do, and most plan to do so before the end of the year. Whether or not you need a run-time library depends on both your application and the extent of your knowledge of DSPs.

LISTING 1

```
#include <stdio.h>
#include <libap.h>
#define N 1024        /* Number of points in the window */
#define M 10          /* log2(N), N = 2^M  */

main () {

     static float freq_array[N/2];

/*   The other part of your program goes here.

     When you need to use the spectrum analyzer use the following
          function call. */

     get_spectrum (freq_array);

/*   use the frequency domain data acquire by get_spectrum */

}

/* get_spectrum  -  spectrum analyzer

               This routine will read the input from an ADC,
               perform a Hanning window on the data, do an
               FFT, and convert the resulting complex data
               into floating point amplitude.

               Data returned is an array of amplitude of type
               float in the frequency domain.
*/

get_spectrum (freq_array){

     register float *data, real, imaginary, ampsqrd, *freq;
     register int i;
     static float data_array[2*N];

     data = data_array;
     for (i = 0; i < N; i++){        /* read buffer full of data */
          *data++ = read_adc();
          *data++ = 0.0;}            /* all complex values = 0 */
     chann0 (N,M,data_array);        /* complex Hanning window */
     fft (N,M,data_array);           /* FFT of the data */
     data = data_array;
     freq = freq_array;
     for (i = 0; i < N/2; i++){      /* get the amplitude */
          real = *data++;
          imaginary = *data++;
          ampsqrd = (real * real) + (imaginary * imaginary);
          *freq++ = sqrt(ampsqrd);}
}
```

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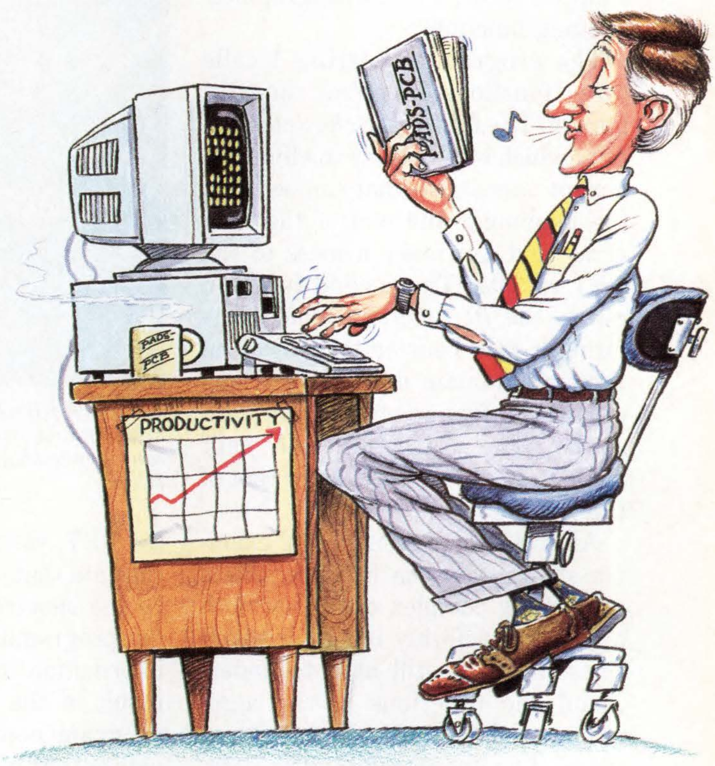

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DSP run-time libraries include many of the most popular DSP algorithms. At present, the AT&T library is the most complete: It includes math, matrix, filter, adaptive-filter, FFT, and graphics/imaging functions.

The program in **Listing 1** calls three functions from the run-time library. The first is the *chann0* function, which is necessary to eliminate abrupt transitions that can occur at the beginning and end of the data array and can make a mess of the FFT results. The second function call is the *fft* function, which performs a fast Fourier transform on the time-domain data array, thus creating a frequency-domain data array. The third function call, named *sqrt*, takes the square root of the passed value.

You can shorten the development time *of your next DSP-based system by using a high-level language and an evaluation system. If the evaluation isn't quick enough for your needs, you can use assembly language to speed up the time-consuming portions. (Photo courtesy Analog Devices)*

As this spectrum-analyzer example shows, you can easily create a reasonably complex operation with a library of highly optimized routines. But you still have to understand the functions of the algorithms and how to select and use them. When you need to filter data, you have to decide whether you want to use a finite-impulse-response (FIR) or infinite-impulse-response (IIR) filter. Or, in the case of the FFT, you must know how to use the data that returns from the FFT. In the spectrum-analyzer example, the programmer desires magnitude information instead of the complex result of the FFT. Therefore, the program converts each complex-pair output from the FFT to magnitude by taking the square root of the sum of the squares.

A long list of application notes does not make a DSP run-time library, despite some manufacturers' claims. The application notes and assembly-language source code that many DSP-chip vendors provide are very useful. But the routines and source code just don't come with the quality assurance—such as programming discipline, exhaustive testing, beta-site qualification, and so on—that manufacturers provide for their DSP run-time libraries.

Another advantage of high-level

For more information . . .

For more information on the high-level languages described in this article, contact the following manufacturers directly, circle the appropriate numbers on the Information Retrieval Service card, or use EDN's Express Request service.

Analog Devices
2 Technology Way
Norwood, MA 02062
(617) 329-4700
TLX 174059
Circle No 709

AT&T
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555 Union Blvd
Allentown, PA 18103
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Motorola Inc
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Austin, TX 78735
(512) 440-2030
Circle No 713

Quantitative Technology Corp
8700 SW Creekside Pl
Beaverton, OR 97005
(503) 626-3081
Circle No 714

Sky Computers Inc
Foot of John St
Lowell, MA 01852
(617) 454-6200
Circle No 715

Spectrum Signal Processing Inc
240 H St, Suite 108
Blaine, WA 98230
(604) 438-7266
in US, (800) 663-8986
Circle No 716

Texas Instruments Inc
Semiconductor Group, SC-828
Box 809066
Dallas, TX 75380
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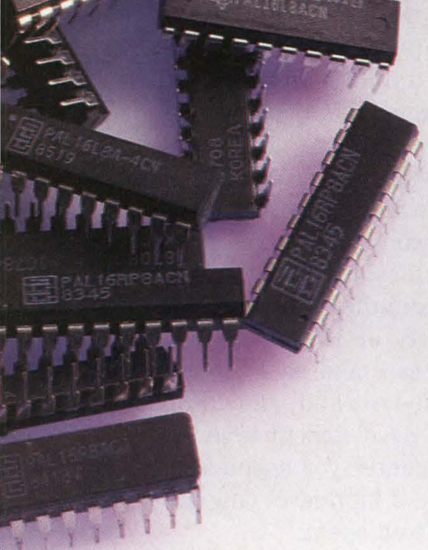

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languages is that they provide a common software interface for all of your routines. An assembly-language routine that's called from a high-level language must adhere to an exact format, which is defined in the compiler's manual. When you use this format to create assembly-language routines, you'll obtain routines that are easy to use and incorporate in your own run-time library.

Run-time libraries are not usually transportable, because they're written in assembly language and optimized for a particular architecture and instruction set. The retargetable/optimizing C compiler from Quantitative Technology Corp is different, however: It offers Math Advantage, a library of math functions written entirely in C. You can transport the library, along with your application program, to new hardware simply by using a configuration file that describes the new system.

The advantages of using a high-level-language compiler for DSP applications are immense. As optimizing compilers improve, the speed penalty of HLLs will continue to decrease, and as DSP run-time libraries expand, they'll make software development even easier. The few months you spend learning how to use a high-level language will be time well spent. **EDN**

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2. Hartung, John, "A practical C language compiler/optimizer for real-time implementations on a family of floating point DSPs," *ICASSP 88*, pg 1674.

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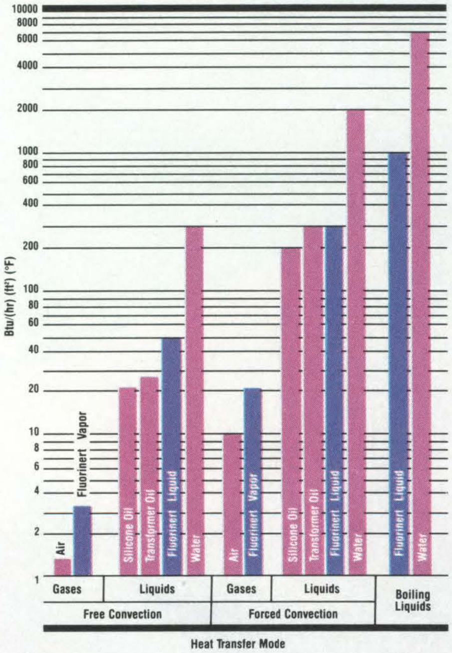

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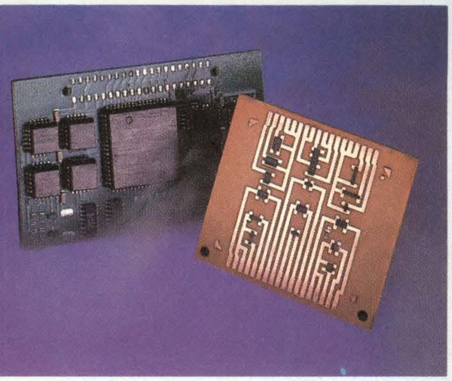

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Military Standard 883-1011			Military Approved Fluorinert Liquids	
Test Condition	Hot Test Step 1	Cold Test Step 2	Hot Test Step 1	Cold Test Step 2
A	100°C	−0°C	Water , FC-40	Water , FC-40, FC-77
B	125°C	−55°C	FC-40, FC-70, FC-5311	FC-77
C	150°C	−65°C	FC-40, FC-70, FC-5311	FC-77
D	200°C	−65°C	FC-70, FC-5311	FC-77
E	150°C	−195°C	FC-40, FC-70, FC-5311	Liq. N_2
F	200°C	−195°C	FC-70, FC-5311	Liq. N_2

GROSS LEAK TEST CONDITIONS

	Military Approved Fluorinert Liquids		
Military Standards	Indicator Fluids	Detector Fluids	Absorption Fluids
MIL-STD 883-1014	FC-40, FC-43	FC-72, FC-84	Do not apply
MIL-STD 750-1071	FC-40, FC-43	FC-72, FC-84	FC-43, FC-75, FC-77
MIL-STD 202-112	FC-40, FC-43	FC-72, FC-84	Do not apply

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VPS with Fluorinert Liquids is especially suited for boards with high mass or complex geometries. The liquid vapors completely surround the assembly and penetrate remote recesses to heat all surfaces evenly. The vapors are 15 to 20 times heavier than air so they can be contained easily within the work area. The system offers an oxygen-free, non-corrosive environment to minimize rejects from oxidation contamination.

Some typical applications using Fluorinert Liquids in VPS include surface mounted leaded or leadless components, through-hole leads and wire-wrap pins, lead frame attachment, reflow of electroplated solder or tin and miscellaneous metal joining.

VPS SELECTION GUIDE

Fluorinert Liquid	Boiling Point	Typical Solders
FC-43	174°C/345°F	70 Sn/18 Pb/12 In 100 In 58 Sn/42 In 58 Bi/42 Sn
FC-70, FC-5311 FC-5312	215°C/419°F	63 Sn/37 Pb 60 Sn/40 Pb 62 Sn/36 Pb/2 Ag
FC-71	253°C/487°F	100 Sn 95 Sn/5 Ag 60 Pb/40 Sn

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Fluorinert Liquid FC-77 (English Units)	Liquid		Vapor
	Room Temp. (77°F)	Boiling Point (207°F)	Boiling Point 207°F @/ATM
Density lb./ft³	111	100	0.85
Thermal Conductivity Btu/(hr) (ft²) (°F/ft)	0.037	0.033	0.008
Specific Heat Btu/(lb.) (°F)	0.25	0.28	0.23
Viscosity c.p.	1.42	0.46	0.02
Coefficient of Thermal Expansion ft³/(ft³) (°F)	0.0008	0.0009	0.0015

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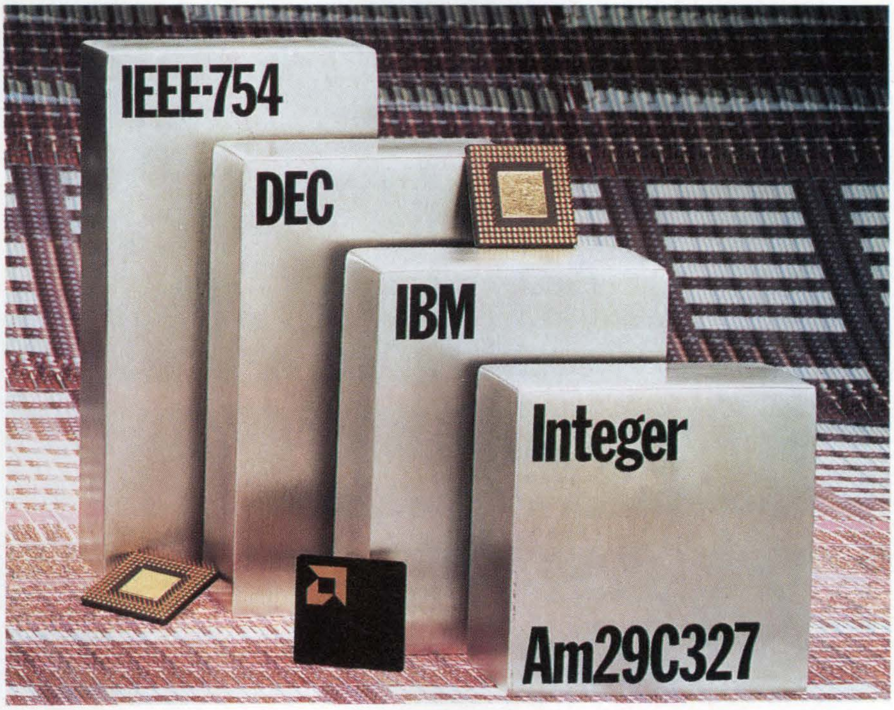
Monolithic floating-point processors streamline microcomputer design

Tarlton Fleming,
Associate Editor

Floating-point math has become an essential capability for standard microprocessor families, largely because an extensive and growing base of microcomputer systems must do massive amounts of numerical computation at high speed. Although any μP can process floating-point numbers when supplied with the appropriate software, the execution is much too slow for applications such as 3-D graphics, linear programming, or CAD simulations. Just as system designers in general have found that the advent of RISC-based μPs has added a variety of products to the general μP marketplace, so designers of numerically intensive applications now face a marketplace for monolithic and multichip floating-point units (FPUs) that VLSI vendors have expanded and diversified to meet growing demands.



***The Am29C327 floating-point unit** from Advanced Micro Devices handles all of the major formats for floating-point numbers.*

Variety's mixed blessing

The situation bestows a mixed blessing on those designers who need to incorporate floating-point math: While options are increased, so too is the room for confusion. Although all FPUs are by definition capable of executing arithmetic operations on floating-point numbers while under control of a host processor, it's still not easy to compare these chips with one another. What's more, the fact that most floating-point units (FPUs) can work with various μPs can make the choice a subtle one, because you need to coordinate carefully your choices of FPU and processor for maximum efficiency.

With few exceptions, these new VLSI chips integrate an arithmetic logic unit (ALU) and a multiplier along with multiplexers, control logic, and programming registers. They handle single-precision (32-bit), single- and double-precision (64-bit), or single-, double-, and extended-precision (80-bit) numbers. Because the IEEE standard for floating-point numbers has gained rapid acceptance, all recently introduced FPU products comply with the 754-1985 standard for binary floating-point numbers. Some FPUs comply with earlier floating-point standards as well.

In addition to speed and functions, you should consider density. The monolithic devices use CMOS technology that employs fine-line geometry to achieve the high circuit density necessary to combine an ALU and multiplier on one chip. In doing so, not only do they reduce the package count on a board; they also simplify program execution by eliminating the interchip connections and their associated signal delays.

Single-precision saves money

In spite of the fact that the array of available FPUs may make it more complicated to choose one product, the current variety of products does provide better matches between the μP and the FPU for specific applications than were available just a year ago. If single-precision arithmetic suits your application, for instance, you're no longer forced to buy a double-precision chip. Instead, you can select a single-precision part like GE-Intersil's ISP9326. It's compatible with the bipolar Am29325 from Advanced Micro Devices but

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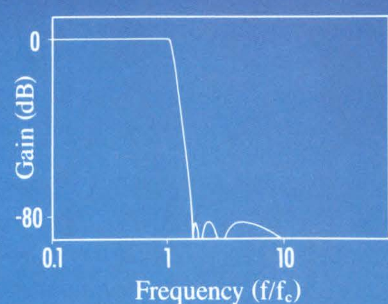

The SR640 offers a unique combination of filter specifications, preamplifier performance, and programmability at a price far less than other instruments. Featuring two fully independent 8-pole, 6-zero elliptic filters with less than 0.1 dB p-p passband ripple and 115 dB/octave rolloff, the SR640 is the ideal filter for general purpose signal processing as well as anti-aliasing for digital signal processing systems.

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- 60 dB prefilter gain
- 20 dB postfilter gain
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CIRCLE NO 139

consumes 1W—about one-ninth that of the Am29325. (AMD also plans to introduce a CMOS version this month. The AM29C327 dissipates less than one-fourth that of the 9W Am29325.)

In its multiply-accumulate mode, the ISP9326 performs single-precision arithmetic at 16M flops. A single pin programs the chip for handling floating-point numbers in either the IEEE or the DEC-F format, and a 3-bit input code programs one of eight operations (addition, subtraction, multiplication, 2−S subtraction (for Newton-Raphson division), and conversions between DEC and IEEE formats as well as between integer and floating-point formats). As in most FPUs that lack an instruction for division, this device divides floating-point numbers by using the Newton-Raphson algorithm—it multiplies the reciprocal of the divisor times the dividend. The part comes in a 144-pin PGA (pin-grid array), operates on 5V, and costs $495 (100).

ASIC possibilities

LSI Logic also offers a monolithic single-precision FPU, the L64132. Like the Intersil unit, this coprocessor also handles numbers in either the IEEE or DEC-F formats. It comes in versions with clock cycles of 60, 80, or 125 nsec. The 125-nsec unit costs $300 (25). Because the ALU and the multiplier have separate instruction registers, they can operate independently and simultaneously, and the absence of pipeline registers in these processing sections further increases the maximum throughput for random, nonsequential arithmetic calculations (as opposed to iterative, sequential ones). Major sections of this chip are available as building blocks in the company's ASIC design library. By combining these gate-level blocks with registers and miscellaneous logic, customers can specify their own semicustom FPU.

For double- or extended-precision formats, the FPUs are usually microprogrammable. The microsequencer and microcode control storage that are necessary for operation of these devices can be on the chip (as in the Motorola MC68882 and Intel 80387 arithmetic coprocessors), or they can be in separate building-block ICs. Two double-precision FPUs that take the latter route are the SN74ACT8847 from TI and the WTL 3364 from Weitek.

Both of these chips comply with the IEEE floating-point standard. They provide a 32-bit output data port, two 32-bit input data ports, and 64-bit internal data paths. The chips contain separate ALU and multiplier sections that can process instructions simultaneously, in parallel. TI maintains that the 8847's 11-cycle divide operation (initiated by a single microinstruction) is the fastest in the industry. The ALU and multiplier are both active during this operation. The 3364, on the other hand, takes longer (17 cycles to divide; 30 cycles to do a square root), but its separate divide and square-root unit involves the ALU and multiplier only for the first cycle; they are then both free to accept other instructions during the remainder of the division or square-root operation.

Concurrent operations

These and other overlapping circuit operations can help you program these FPUs for maximum throughput. Both the Weitek and the TI chips include pipeline registers that reduce the overall execution time for iterative or sequential data processing. However, both parts also allow you to disable these registers, which speeds the execution of random or nonsequential algorithms by creating a direct flow-through data path. As a further aid in programming, the 8847's high pin count (its package is a 208-pin PGA) provides access to most of the internal registers and processor sections. The 8847 costs $650 (100). The 3364 comes in a 168-pin PGA and costs $750 (100).

The CMOS NS32381 from National Semiconductor is a microprogrammed FPU with an on-chip sequencer and control storage. The sequencer in this case controls three onboard processors—one each for the mantissa, sign, and exponent. This device conforms to the IEEE standard for performing single- or double-precision arithmetic. It operates as a slave processor to any of the company's 32000 series μPs. This FPU supports IEEE extended-precision operations in software.

Available in 15- and 30-MHz versions that match the corresponding CPU clock rates, the NS32381 is 50% faster than its NMOS predecessor, the 10-MHz NS32081. It's faster in part because of an algorithm that anticipates the early completion of an instruction based on the type of instruction and data involved (this algorithm works only for instructions whose result is destined for an onboard register). The NS32381 converts between integer and floating-point formats and between different floating-point formats. It performs add, subtract, multiply, divide, and other IEEE operations, but supports square-root operations only in software. It also supports trigonometric and other transcendental functions in software.

Finding a bargain

The addition of TTL glue logic enables either the NS32381 or the 10-MHz 32081 FPU to operate with host processors other than 32000 series μPs. But the NS32081-10 is very low in price as well—$67.10 (100) for the 24-pin, plastic DIP version, a price National claims is the lowest available for a double-precision FPU. This combination of system flexibility and low price makes the older part still a very popular choice. The newer NS32381, which comes in a 68-pin PGA, costs $262.50 (100) for the 15-MHz version, and $625 (100) for the 30-MHz model.

Although multichip FPUs based

on specialized building-block ICs can offer the highest clock rate and throughput, the latest general-purpose arithmetic coprocessors, like the AM29C327, have the most functions in a single chip. Unlike the Am29027, which is an FPU dedicated to the company's RISC-flavored 29000 μP, the Am29C327 is a versatile device that can serve as a coprocessor for any 32-bit μP. After you program the chip for pipelined instead of flow-through operation, it can perform 64-bit floating-point arithmetic under microprogram control in applications such as array processors. The FPU has two 32-bit input ports and one 32-bit output port.

Only the Am29C327 supports all of the industry's major floating-point formats: IEEE-754; DEC D, F, and G; and the single- and double-precision formats from IBM. What's more, compliance with the IEEE standard is exact, according to the company. This chip, for example, complies in recognizing denormalized numbers, which are small numbers that fall below a coprocessor's underflow threshold. Most floating-point systems don't recognize these numbers as valid inputs; instead, they flush them to zero.

Development tools

The Am29327's large repertoire of instructions—over 70—simplifies programming and speeds program execution. In addition, the device includes sign-change circuits in the ALU that allow negations and absolute-value operations to proceed simultaneously with core arithmetic operations. The 100-nsec model sells for $595; the 120-nsec version, $395 (100). The company plans to make a software model of the FPU available this month. Other development tools, including a PC-based C compiler for 68020/30 applications, software libraries for floating-point functions not available on the FPU, and an evaluation board, will be offered in the third quarter.

For more information . . .

For more information on the floating-point-math ICs discussed in this article, contact the following manufacturers directly, circle the appropriate numbers on the Information Retrieval Service card, or use EDN's Express Request service.

Advanced Micro Devices Inc
901 Thompson Place
Sunnyvale, CA 94088
(408) 732-2400
TLX 346306
Circle No 718

GE-Intersil Inc
10600 Ridgeview Ct
Cupertino, CA 95014
(408) 996-5000
Circle No 719

Hitachi America Ltd
Semiconductor and IC Div
210 O'Toole Ave
San Jose, CA 95131
(408) 435-8300
Circle No 720

Intel Corp
3065 Bowers Ave
Santa Clara, CA 95051
(408) 987-8080
Circle No 721

LSI Logic Corp
1551 McCarthy Blvd
Milpitas, CA 95035
(408) 433-8000
TLX 172153
Circle No 722

Motorola Inc
Box 2953
Phoenix, AZ 85062
(602) 244-6900
Circle No 723

National Semiconductor Corp
2900 Semiconductor Dr
Santa Clara, CA 95051
(408) 721-5000
TWX 910-339-9240
Circle No 724

Texas Instruments Inc
Semiconductor Group
Box 809066
Dallas, TX 75380
(800) 232-2300, x700
Circle No 725

Weitek Corp
1060 E Arques Ave
Sunnyvale, CA 94086
(408) 738-8400
TWX 910-339-9545
Circle No 726

Motorola now has an enhanced version of the MC68881—the pin- and software-compatible MC68882, which costs $209 (100). Both chips are intended as coprocessors for the 68020 or 68030 μPs. Like its predecessor, the 68882 comes in a 68-pin PGA and communicates through a single, 32-bit, bidirectional data port. The MC68882 has 46 instructions for various logarithmic and trigonometric functions. The chip handles single-, double-, and extended-precision floating-point numbers. An on-chip ROM contains 22 numerical constants including π, e, and powers of 10.

Conversion unit speeds execution

The MC68882 computes 2 to 3 times faster than the MC68881 when operating with a 68020 or 68030 μP. The faster execution depends on a 68882 circuit called the conversion unit that allows certain operations to proceed in parallel rather than forcing the μP to stand by in an idle mode.

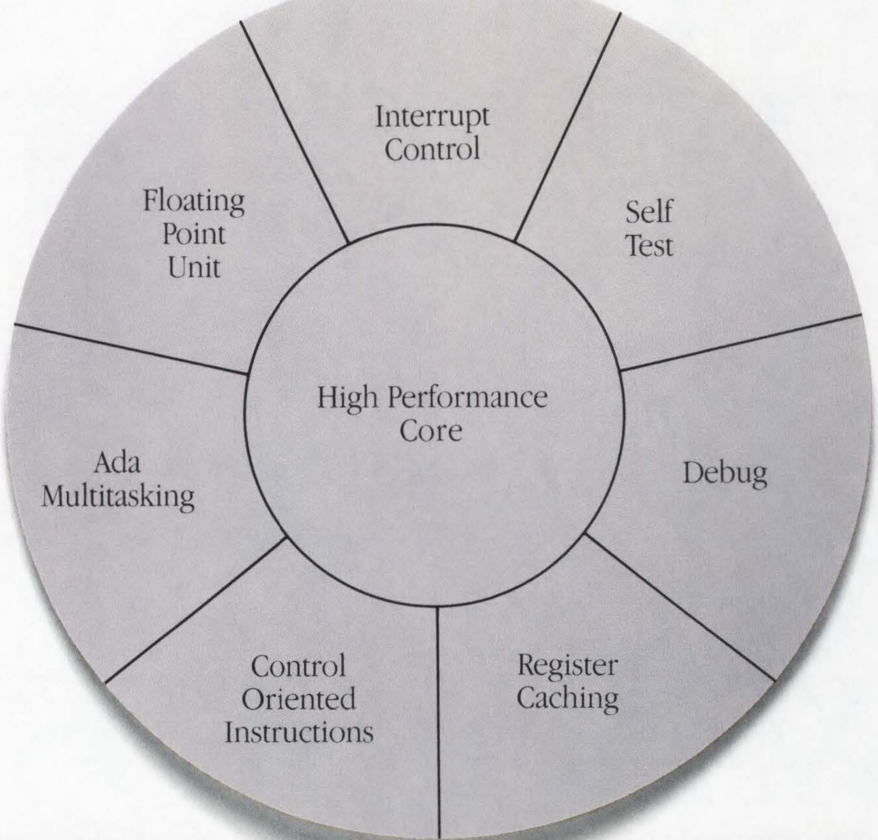
Joint project

You can now expect to find an FPU among the support chips for any new μP family. Scheduled for introduction near year's end, for instance, is an FPU for the H32 family of 32-bit μPs from Hitachi. A joint effort by Hitachi, Fujitsu, and Mitsubishi, the development team is designing 20-MHz μPs and peripheral chips, including FPUs, without regard for any existing architecture. Instead, their priorities include efficient execution of real-time applications, room for expansion, and the efficient support of compilers and operating systems such as Unix. Acting as an IEEE-compatible coprocessor, the FPU will offer 32-, 64-, and 80-bit floating-point processing, arithmetic and vector operations, and logarithmic and trigonometric functions. An onboard peripheral interface will allow the device to operate with non-H32 host processors. **EDN**

Article Interest Quotient
(Circle One)
High 515 Medium 516 Low 517

NEW INTEL TECHNOLOGIES OFFER EMBEDDED CONTROL DESIGNERS WHAT THEY WANT MOST.

MORE CONTROL.



A NEW 32-BIT ARCHITECTURE SPECIFICALLY DESIGNED FOR EMBEDDED CONTROL.

Now you can go beyond the performance limitations of existing microprocessors and microcontrollers. And get to a whole new level of embedded control capabilities.

With the Intel 80960. We created its architecture with the intelligent use of RISC techniques and extensive use of parallelism. This will provide a level of performance far beyond today's microprocessors which are scaled to linear clock speed increases.

The 80960 also supports on-board register caching, which significantly reduces the number of memory accesses for every subroutine executed. Even more performance is gained through the 80960's register score-boarding capability that allows overlap of memory and CPU operations for maximum possible throughput.

And you can begin designing with our new 32-bit technology today. With our highly-integrated 80960KB microprocessor. It's a complete CPU sub-system on a single chip that delivers 7-10 VAX* MIPS, with burst rates of up to 20 VAX MIPS.

To make it even better for embedded control designs, the 80960KB integrates Boolean and bit instructions, self-test and built-in debug capability. Add to that an on-chip instruction and register cache, plus a 4-input interrupt controller. And you have the most highly integrated single-chip, 4 Mega-Whetstones floating-point solution available.

Best of all, it's on your distributor's shelf today.

Then there's our pin-compatible 80960KA without floating point, which will be available later this year. Or, if you require a military temperature range, the 80960MC military version, optimized for Ada, will be available in Q3 '88.

Of course, we provide the wide range of development tools it takes to get started on your design today. The 80960 architecture can easily be evaluated and code developed immediately with your PC and a Starter Kit that includes languages and an evaluation board.

As a result, you'll get to market faster.

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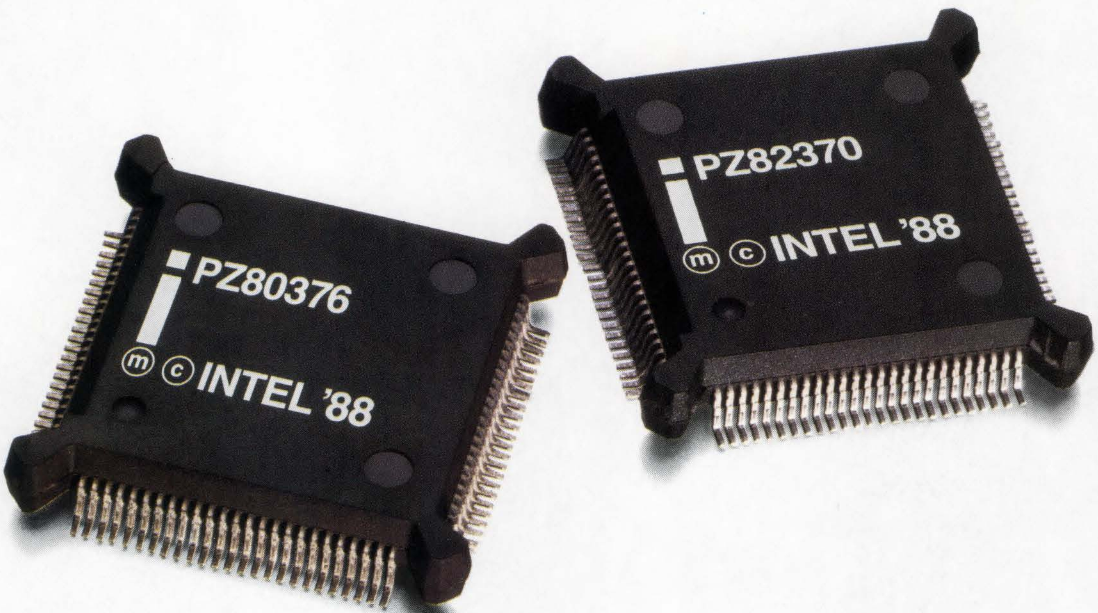


OUR 386™ MICROPROCESSOR TECHNOLOGY ADAPTED ESPECIALLY FOR EMBEDDED CONTROL.

Consider the power of 386™ microprocessor technology controlling a robot arm. Or pumping data through a PBX. Now, with Intel's new 376™ processor it's simple.

We simplified the Intel386™ architecture by eliminating the features not necessary for embedded control applications. The result is a full 32-bit architecture capable of handling high performance embedded applications and a 16-Mbyte address space that is easy to use.

Together with the 82370 multifunction peripheral, the

376 processor offers you a complete CPU and I/O subsystem with the cost and form factor of 16-bit systems. And if you've ever worked with other products from our '86 family, this new 376 processor technology will be even easier to work with.

To make things easier yet, we simplified your I/O subsystem design. The 82370 packs 22 chips into one small package, providing eight channels of 16-Mbyte/sec DMA transfer rate.

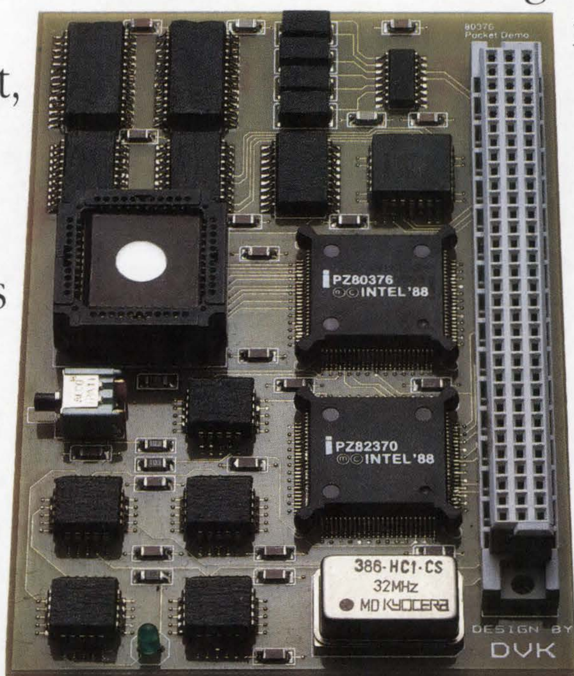
Which means you'll have no more problems matching DMA memory timing to CPU memory timing. Or fitting DRAM refresh into the memory controller. Or getting a refresh into long DMA activities.

We also simplified our proven 386 microprocessor technology and used it in the 376 processor. To make it an even better fit, we produced the 376 chip in an inexpensive, plastic surface mount, gull wing, fine pitch package. So we can offer you 5000 Dhrystone performance in a smaller, lower-cost package.

And getting the development support you need for the 376 processor couldn't be simpler. There's a full line of proven 386 microprocessor software tools that can be used on the 376 processor. Even for debugging. You can use established real-time 32-bit kernels like our iRMK™ kernel. Of course, we have the ICE™386 in-circuit emulator available for the fastest and simplest integration of hardware and software. You can even run and debug your application on any 386 microprocessor based PC.

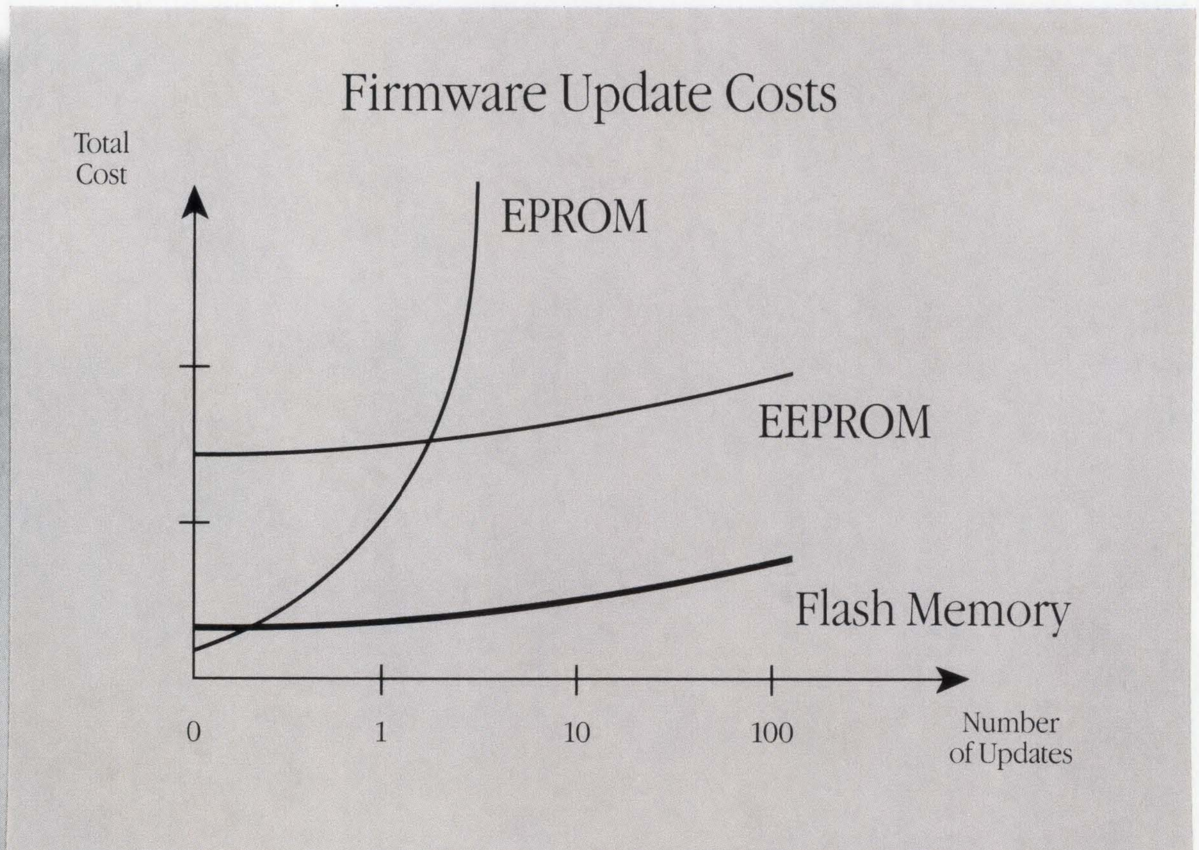
Simpler control.

Isn't that something every designer wants?



THE INTEL 376™ PROCESSOR CARD IS A COMPLETE 32-BIT SYSTEM SMALLER THAN 3″ x 5″.

COST CONTROL.



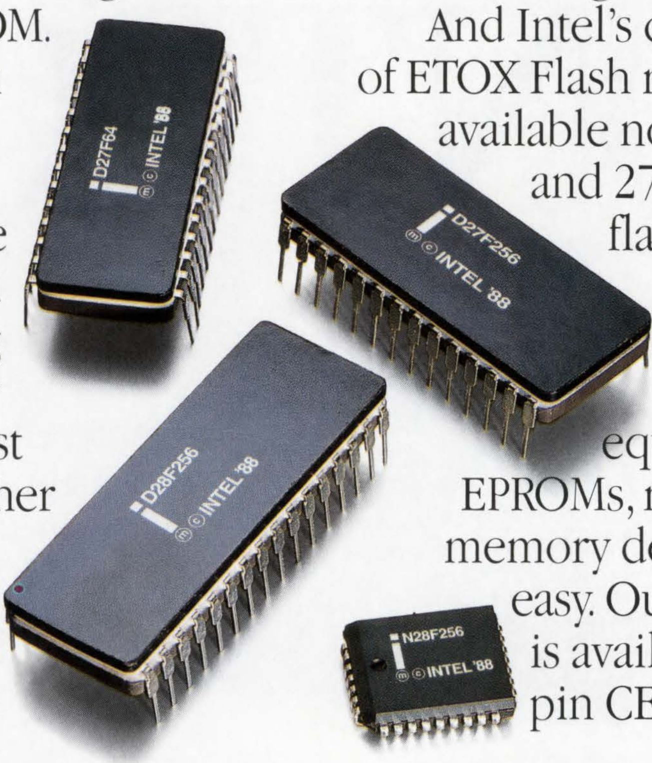
Until now, the only way designers could easily alter code in an embedded system was to upgrade from low-cost EPROM to expensive EEPROM.

Now, we've invented a way to incorporate electrical erasure into our proven EPROM process. We call it ETOX™ (EPROM Tunnel Oxide) Flash technology. And we think it's a major breakthrough in non-volatile memory technology. ETOX Flash memory allows you to cut the cost of code or parameter changes by over 50%.

The ETOX process breaks through the technology barrier between low-density, high-cost EEPROM and dense, low-cost EPROMs. It combines the electrical erase capability of an EEPROM with the single transistor cell of EPROM. And ETOX Flash technology delivers 10,000 cycle endurance capability with a reprogramming failure rate at or below the lifetest failure rate of other components in your system. Our proven EPROM manufacturing process assures unmatched reliability for your embedded control applications.

With Intel's new flash memory, you can execute code changes almost instantaneously. Over phone lines, in-system, or at the end of the production line. Without the hassle of UV erasure. So after just one update it can be cheaper than EPROM. Making it the most cost effective, nonvolatile memory solution for updating code in advanced embedded control designs.

Reprogramming Failure Rate		
Technology	100 Cycles	10,000 Cycles
Flash Memory	<.01%	.1%
EPROM	2%	–
EEPROM	–	5%



A NEW FLASH MEMORY THAT DRAMATICALLY LOWERS THE COST OF EMBEDDED CODE UPDATES.

And Intel's complete family of ETOX Flash memories is available now! Our 27F64 and 27F256 28-pin flash devices provide pinout and read compatibility with equivalent density EPROMs, making the flash memory design-in process easy. Our 28F256 device is available in both 32-pin CERDIP and 32-lead PLCC packages that provide upgrade capabilities to 2 megabits. So you can start designing Intel's ETOX Flash memories into your 8-, 16- and 32-bit embedded control applications today.

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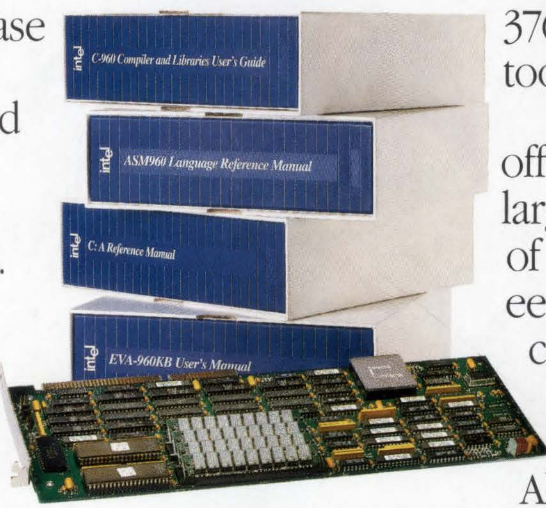

To help you increase control over your designs, we're committed to supporting you at every stage of the development process.

To begin with, we offer a complete line of highly integrated development tools. We've designed them to work with each other, to maximize the power and performance of each component, and to give you the most powerful debug capability available.

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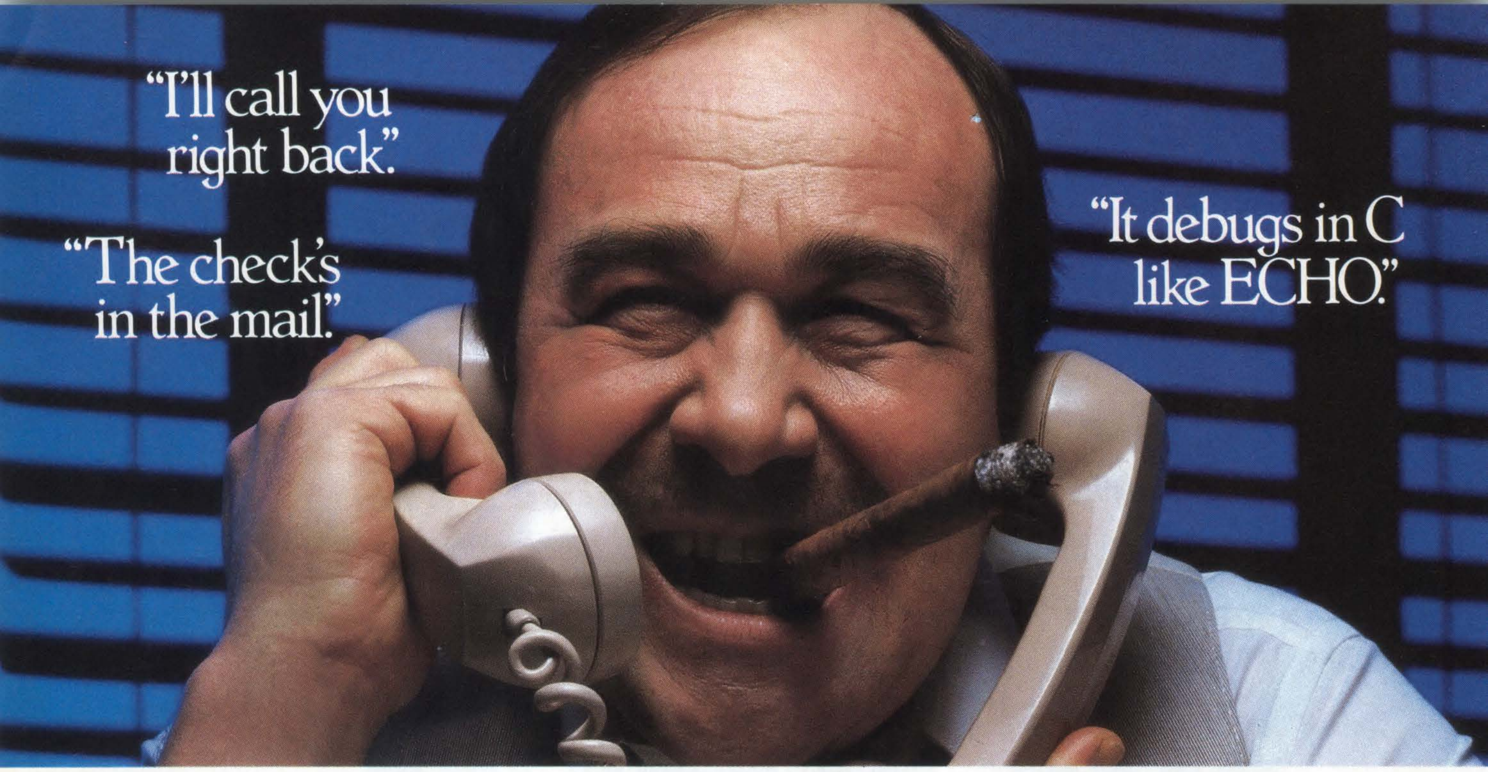


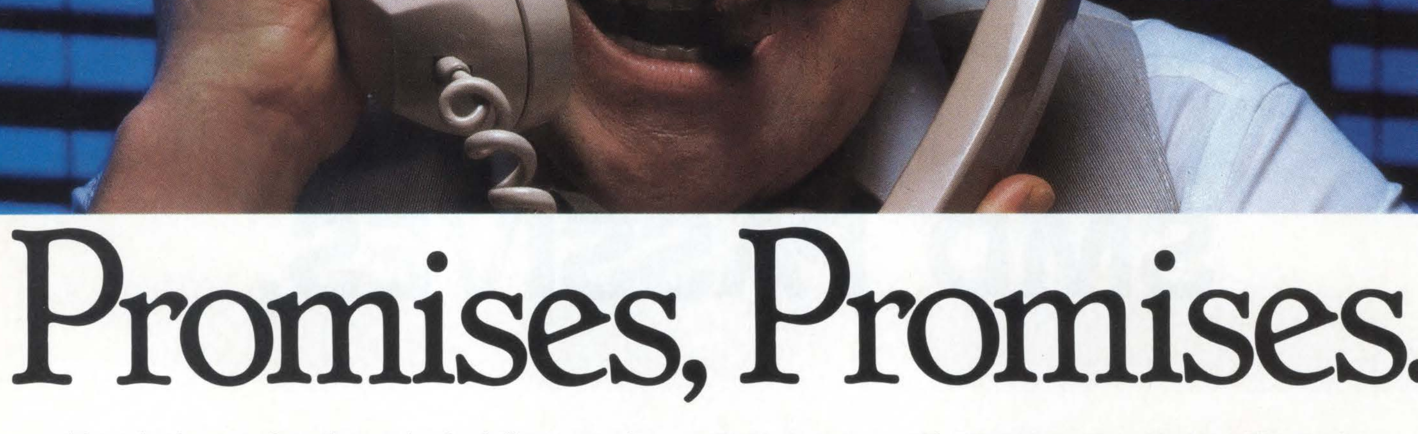
Promises, Promises.

Everybody promises, but nobody delivers a real-time, emulator-based C-debug environment like Arium's ECHO. 16-bit, true multitasking and UNIX®-based, ECHO gives you more power, speed and menu-driven features to handle the 68000 and other μPs better than the HP 64000, or anything else.

Just words, you say, promises like all the rest?

Prove it to yourself. Read the screens below. Then ask any other development system—standalone or host control—to match them. We'll wait.

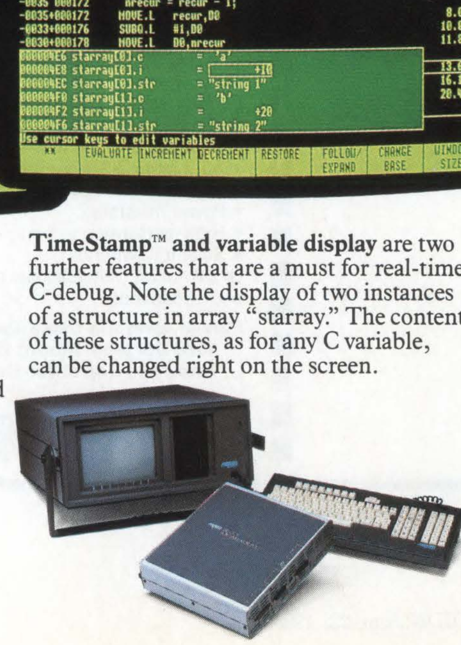
Now you know a few reasons (and there are plenty more) why ECHO should be your emulation tool for today's increasingly complicated software debugging.



Code Preview™ lets you see where your code is going. You can follow calls and branches (to 99 levels) on the screen, to select the source line on which to trigger, then set and break in one keystroke! The highlighted trace display (in source) and stack trace window show the path your program took.

Stack-Relative Trigger lets you trigger on the addresses and values of stack-relative variables—a "must" for effective C-debug where the address of an automatic variable is different each time the function is called and is determined at execution. Here, a read of the local variable "nrecur" is included in the trigger sequence.

TimeStamp™ **and variable display** are two further features that are a must for real-time C-debug. Note the display of two instances of a structure in array "starray." The contents of these structures, as for any C variable, can be changed right on the screen.



For a demonstration call
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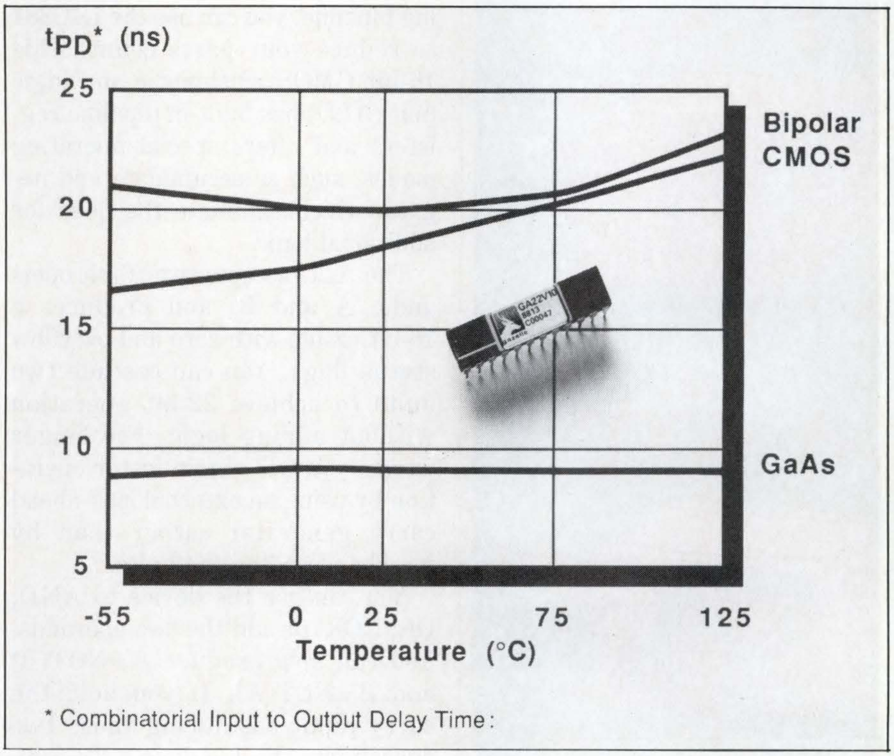
CIRCLE NO 137

10-nsec, laser-programmed GaAs PLD replaces equivalent silicon devices

The GaAs GA22V10 PLD can boost performance in electronic systems by plugging into existing silicon 22V10 PLD sockets. Its input, output, and power-supply requirements are all compatible with standard 5V logic, and the device draws 200 mA, which is no more supply current than that drawn by equivalent silicon PLDs. However, the GA22V10's GaAs constitution gives the commercial version of the part a maximum propagation delay of just 10 nsec and a minimum, guaranteed toggle frequency of 90 MHz over a 0 to 75°C operating range.



Wide temperature excursions have very little effect *on the 10-nsec propagation delay of the laser-programmed GaAs GA22V10 PLD.*

Unlike silicon PLDs, the GA22V10 is not field programmable. The factory programs the device, using a laser to cut links on the chip's surface prior to final packaging. Lack of field programmability may not be as much of a disadvantage as it first appears. You can test prototype systems, using existing field-programmable, silicon 22V10s. When you have verified the logic of your design, you then obtain samples of the GaAs parts and crank your circuit up to full speed.

The company has taken additional measures to ensure that the laser-programming step does not interfere with your development cycle. You can buy a GaAs Pack for $875, which contains a prepaid, preaddressed Federal Express envelope and an order form. This package helps you avoid delays through your purchasing department because you can purchase the GaAs Pack long before you need parts. When you have a PLD design ready, you fill out the GaAs Pack order form and ship it to the company along with a floppy disk containing a JEDEC file representation of your PLD's fuse map. Or, you can send two silicon 22V10s that you have programmed, taking care not to blow the security links in the devices; if you do, the company won't be able to read your fuse maps. You will receive five programmed and 100%-tested GA22V10 samples within five working days.

Normally, you must make a considerable effort to add GaAs devices to a design, but several design innovations make such effort unnecessary for the GA22V10. The device incorporates TTL-compatible inputs and outputs, and uses the conventional 5V power supply. In addition, the design of the PLD's output drivers limits rise and fall times to 3 nsec, thus preventing noise-spike and ground-bounce problems. As a result, the GA22V10 requires no extra bypass capacitors on the power supply. These TTL-compatible features not only help you design the part into your circuit, but they also allow you to test the part on conventional IC testers.

Samples of the GA22V10 are currently available through the GaAs Pack program and come in 24-pin, side-brazed, ceramic DIPs. Volume production is scheduled for early 1989. Programmed commercial devices will cost $31 (10,000).

—Steven H Leibson

Gazelle Microcircuits Inc, 2300 Owen St, Santa Clara, CA 95054. Phone (408) 982-0900.

Circle No 700

16-bit ALU offers registered inputs and output

If you are designing a data-processing pipeline, you can use the L4C381 to reduce your parts count. This 16-bit CMOS arithmetic and logic unit (ALU) has built-in pipeline registers and offers special operating modes, such as accumulate and negate, which eliminate the need for additional logic.

The ALU accepts two 16-bit operands (A and B) and produces a 16-bit result with zero and overflow status flags. You can cascade two units to achieve 32-bit operation without adding logic. For longer words, you will obtain faster operation by using an external look-ahead carry generator rather than by merely cascading the units.

You can use the device to AND, OR, XOR, or add the two operands. You can also produce A+NOT(B) and B+NOT(A). If you hold the carry input set during these two operations, the result is a 2's complement subtraction. The unit's two remaining operations permit you to set the output to zero or to all 1s.

The unit's output and two inputs feature register latches that are triggered with a common clock but whose use you can control independently. You can employ them to register the data to and from the ALU, or you can bypass them, in which case they continue to operate.

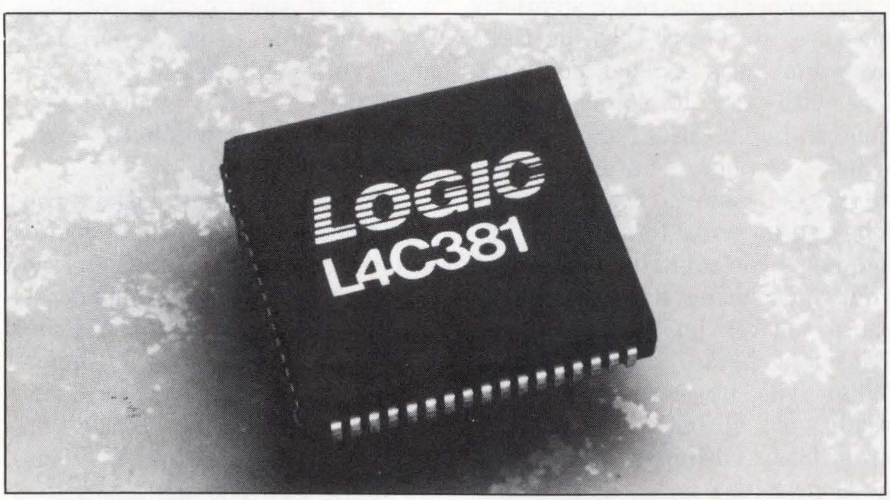
Using the operand-select control lines, you can perform special functions in the ALU. You can force the unit to use zero for either operand or the output register as the B operand. This allows you to generate a 1's complement or 2's complement for either operand (subtract from zero), pass the data without change (add to zero), or use the ALU as an accumulator—without having to add logic.

You can obtain the unit in versions that operate at 26, 40, or 55 nsec, and that are specified for use over the military or commercial temperature range. The units come in 68-pin LCCs, plastic leaded chip carriers (PLCC), and pin grid arrays (PGA). From $20 to $24 (1000).

—Richard A Quinnell

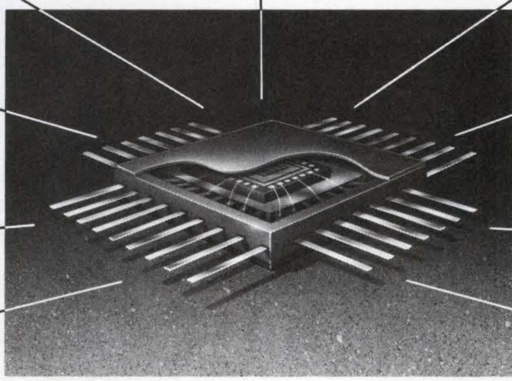
Logic Devices Inc, 628 East Evelyn Ave, Sunnyvale, CA 94086. Phone (408) 720-8630. TLX 172387.

Circle No 698



This 16-bit cascadable arithmetic logic unit has built-in latches for pipelining. *It offers six arithmetic and logic functions and can be operated as an accumulator.*

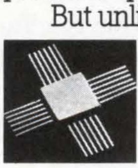
SONY'S ECL LOGIC HAS THE GUTS TO CHALLENGE GaAs PERFORMANCE.



When you need high-speed logic, it really pays to look into Sony's ECL logic family.

Because like GaAs technology, you'll find incredibly fast process speeds. Up to 4 GHz.

But unlike GaAs technology,



you'll also find amazingly low costs and design simplicity.

Not to mention that our ECL technology, unlike most, requires very low power. Under 1 watt, in many cases.

Sony's ECL logic family is made possible by our unique 1-micron, 10-GHz, FT process. The very process that's made our high-speed, 8-bit, 300 MSPS, A/D converters so popular.

And via our 200-gate array technology, we offer a limitless range of logic functions. Many available in 24 and 32-lead flat packs. The list you see here is only partial. So if you don't see what you need, please inquire with your specific requirements.

SONY'S HIGH-SPEED ECL LOGIC FAMILY

Part Number	Function	tpd	fmax	Power	Package
CXB1100Q	Quad 3-in OR/NOR	390 ps	1.5 GHz	530 mW	24 FLAT
CXB1101Q	Quad 3-in AND/NAND	470 ps	1.5 GHz	700 mW	24 FLAT
CXB1102Q	Quad 2-in EXOR/NOR	490 ps	1.5 GHz	680 mW	24 FLAT
CXB1103Q	Quint Line Receiver	410 ps	1.5 GHz	650 mW	24 FLAT
CXB1104Q	Dual D Flip Flop	620 ps	3.2 GHz	520 mW	24 FLAT
CXB1105Q	Triple Fan-out Buffer	590 ps	1.5 GHz	720 mW	24 FLAT
CXB1106Q	4-Stage Ripple Counter		3.4 GHz	720 mW	24 FLAT
CXB1107Q	Decision Circuit		3.2 GHz	430 mW	24 FLAT
CXB1108Q	Laser Driver		2.0 GHz	740 mW	16 FLAT
CXB1109Q	Quad D-FF with Master Reset	620 ps	3.4 GHz	790 mW	24 FLAT
CXB1110Q	16 to 1 Multiplexer	610 ps	1.5 GHz	680 mW	24 FLAT
CXB1111Q	Look Ahead Carry Block	580 ps	1.5 GHz	610 mW	24 FLAT
CXB1112Q	Phase Frequency Detector	720 ps	0.8 GHz	500 mW	24 FLAT
CXB1113Q	4 to 1 Multiplexer		2.0 GHz	950 mW	24 FLAT
CXB1114Q	1 to 4 Demultiplexer		2.5 GHz	1100 mW	24 FLAT
CXB1130Q	9, 8, 4-bit Multiplexer		1.6 GHz	730 mW	32 FLAT
CXB1131Q	9, 8, 4-bit Demultiplexer		1.6 GHz	1000 mW	32 FLAT
CXB1132Q	9, 8, 4-bit Universal Shift Register		1.3 GHz	910 mW	32 FLAT
CXB1133Q	22, 15, 7-Stage Scrambler		1.6 GHz	600 mW	24 FLAT
CXB1134Q	22, 15, 7-Stage Descrambler		1.6 GHz	610 mW	24 FLAT
CXB1135Q	8-16 bit Comparator		1.3 GHz	630 mW	32 FLAT
CXB1136Q	8-bit Universal Counter		1.2 GHz	730 mW	32 FLAT
CXB1137Q	8-bit Shift Matrix	1250 ps		700 mW	24 FLAT
CXB1138Q	4-bit Arithmetic Logic Unit	1460 ps		680 mW	24 FLAT

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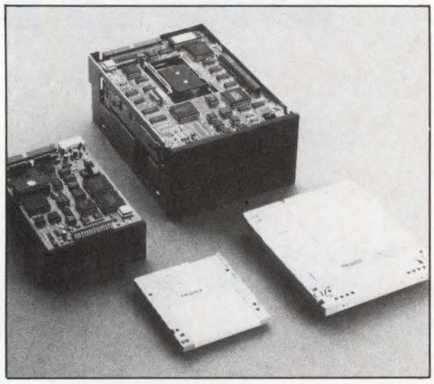
CIRCLE NO 136

Pair of optical-disk drives accepts erasable cartridges

Employing erasable magneto-optic recording technology, the 3½-in. Fiji I disk drive and the 5¼-in. Tahiti I disk drive store 160M and 1G bytes of information, respectively. The Fiji I accepts a proprietary, 3½-in., single-sided disk cartridge and the Tahiti I can use either the company's proprietary 5¼-in. cartridge on which it can pack 500M bytes/side or an ANSI-standard optical-disk cartridge that holds 325M bytes/side. Both drives incorporate SCSI interfaces and support the SCSI common command set (CCS-4B).



Removable, erasable, magneto-optic cartridges *for the 5¼-in. Tahiti I and 3½-in. Fiji I optical-disk drives store 1G and 160M bytes, respectively.*

Not only can the larger Tahiti I store more data than the smaller Fiji I, but it can also access information faster because it sports a 30-msec average access time (60 msec max) and a 10M-bps data-transfer rate. Its SCSI bus interface attains a burst rate of 4M bytes/sec. As a consequence of these specifications, the manufacturer claims that the drive can supplant magnetic hard-disk drives in many applications.

If you need a more compact peripheral device and can manage with a bit less storage capacity and somewhat less performance, the Fiji I will nestle in a standard 3½-in.-drive berth. It can read or write data at an average rate of 1.9M bps and realizes an average access time of 100 msec (225 msec max). The drive's SCSI interface supports burst rates of 2M bytes/sec. Though the Tahiti I incorporates its SCSI interface, the Fiji I uses an interface board that does not fit within the standard 3½-in.-drive envelope.

Both drives use error-correcting algorithms that provide bit-error rates of 1 in 10^{13}. In addition, the drives perform automatic retries on seek or read errors, and automatically map out defective sectors on each disk cartridge. The media life for the magneto-optic disks exceeds 10 years.

Production quantities of these optical-disk drives will be available in September, but samples are available now. Volume OEM pricing will be approximately $2500 for the Tahiti I and $1000 for the Fiji I. In OEM quantities, the cartridges for the Tahiti I and Fiji I cost $250 and $85, respectively. The company expects to drop these respective cartridge prices to $175 and $49 next year.—***Steven H Leibson***

Maxtor Corp, 211 River Oaks Parkway, San Jose, CA 95134. Phone (408) 432-1700. TLX 171074.

Circle No 699

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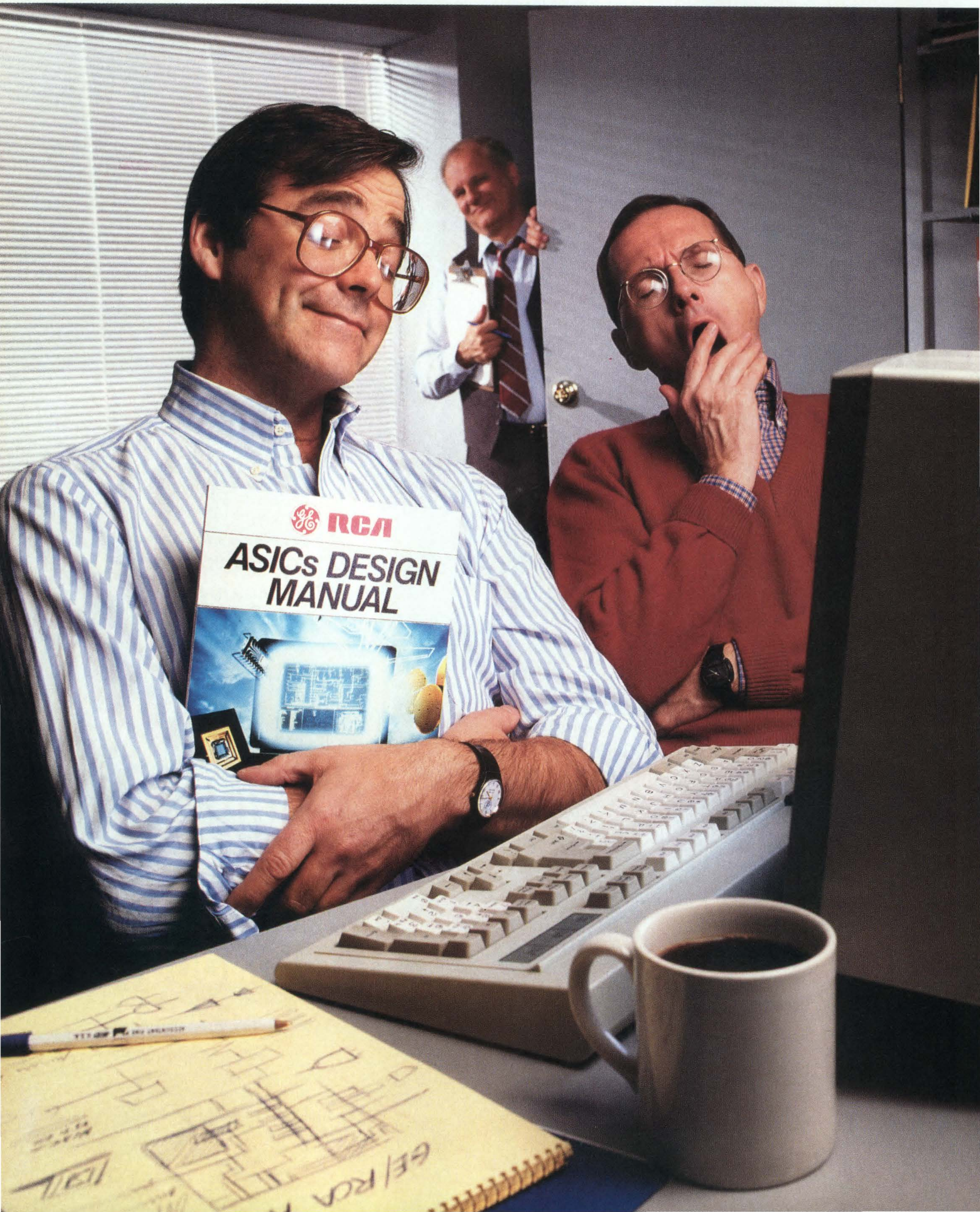

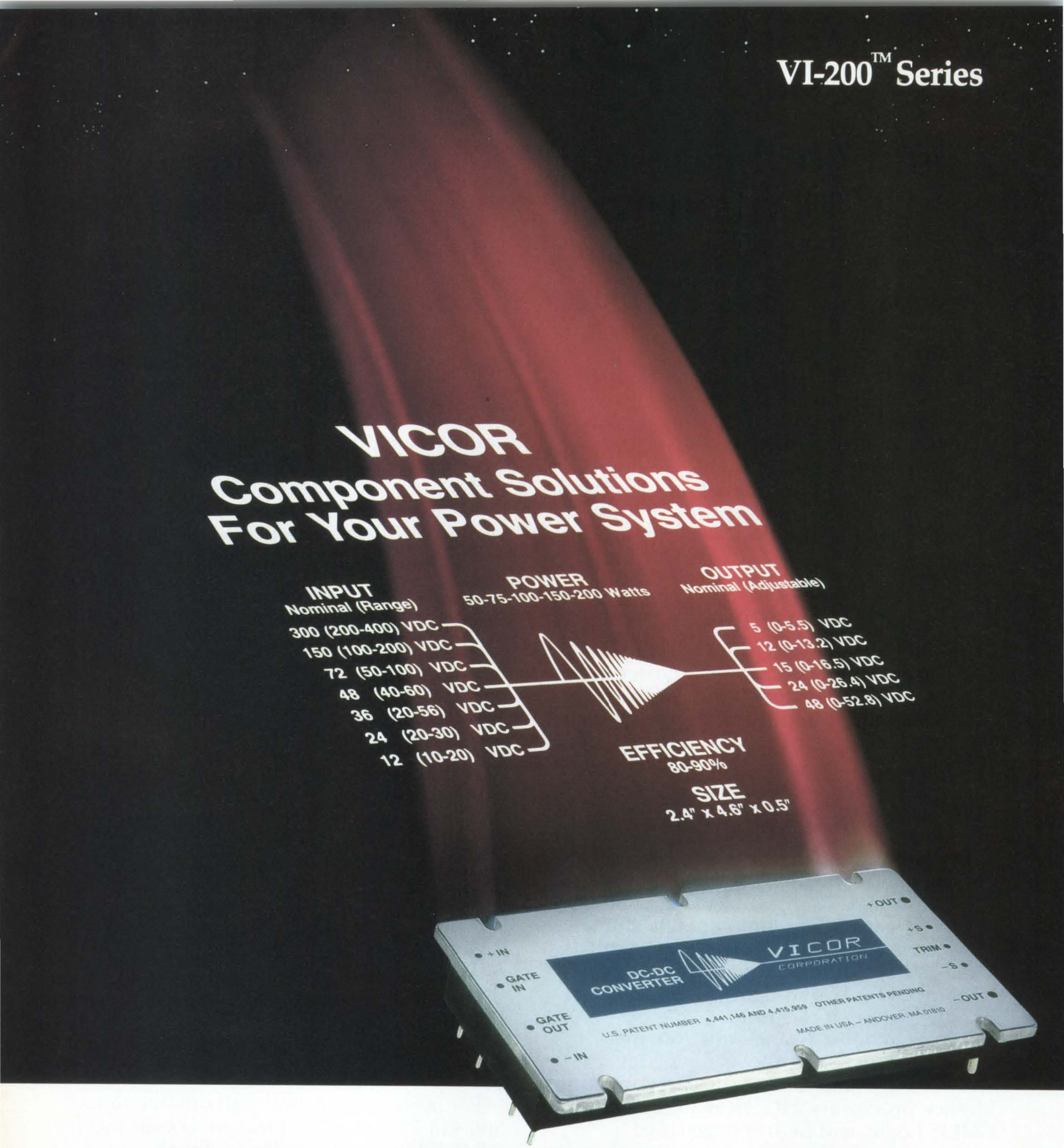

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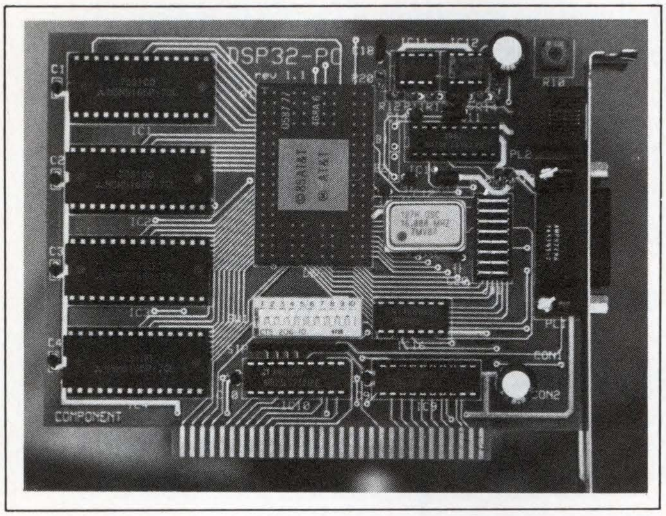
CIRCLE NO 134

READERS' CHOICE

Of all the new products covered in EDN's **March 31, 1988,** issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, use EDN's Express Request service, or refer to the indicated pages in our **March 31, 1988,** issue.

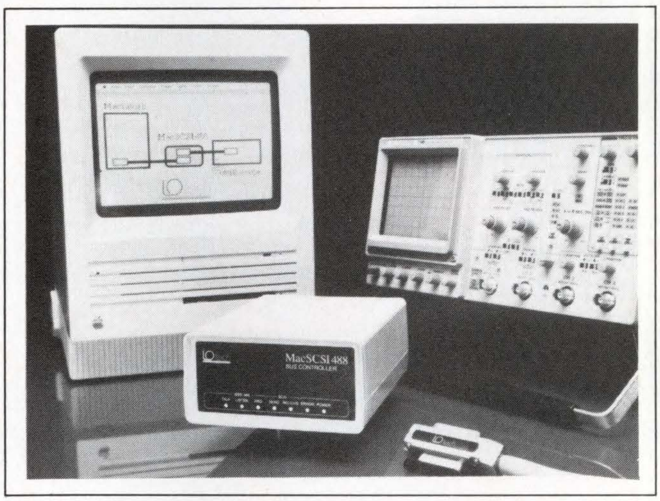


◀ ARRAY-PROCESSOR BOARDS

The DSP32-PC add-in boards accelerate general-purpose math applications on the IBM PC, PC/AT, and compatible computers (pg 102).
Communications Automation & Control
Circle No 602

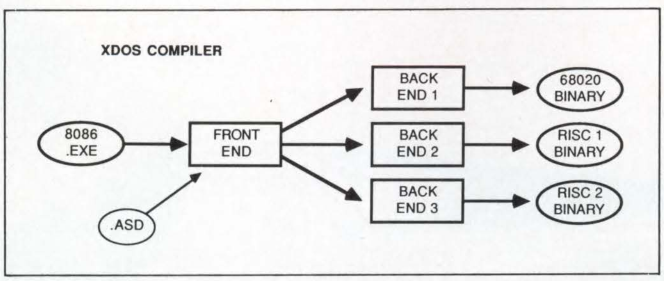
PROGRAMMABLE FILTER

Designed primarily for instrumentation and data-acquisition systems, the HSCF24040 implements both RC (resistor-capacitor) and SC (switched-capacitor) filters on the same chip (pg 212).
Honeywell Inc SPT
Circle No 604



▲ IEEE-488 INTERFACE

The MacSCSI 488 interface plugs into the Small Computer Systems Interface (SCSI) port of your Mac Plus, Mac SE, or Mac II computer to facilitate data transfers at 600k and 800k bytes/sec (pg 104).
IOtech Inc
Circle No 603



▲ UNIX UTILITY PROGRAM

The XDOS utility program for 68020-based systems employs a binary-to-binary-code-conversion facility to allow programs written for the IBM PC and compatible computers to execute on Unix-based systems (pg 100).
Hunter Systems
Circle No 601

HEAT SENSOR

The IR1000 digital sensor module outputs a logic signal when a person moves into its field of view (pg 221).
Infrared Inc
Circle No 605

Launch your design with 100% factory testable GALs* that emulate 21 different PLDs.

New Generic Array Logic (GAL) E²CMOS devices from SGS-THOMSON Microelectronics can save you time and money at every stage: design, testing, modification and even inventory control.

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With our 16V8 GAL on board, your programming logic will always be right on course. But before you launch your design, contact the Winning Team and we'll send you a FREE GAL DEMO DISK.* Call 867-6259, or write SGS-THOMSON Microelectronics, 1000 E. Bell Road, Phoenix, AZ 85022.

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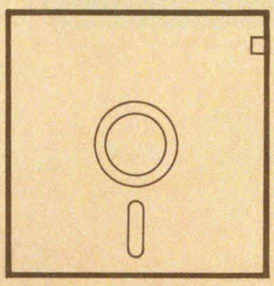
- 50% less power consumption than comparable speed bipolar devices
- 64 bit signature stores user-defined data
- Wide support from popular design and programming tools



*Offer valid while quantities last, and in U.S. only. Limit one per inquiry.

*GAL is a registered trademark of Lattice Semiconductor Corp.
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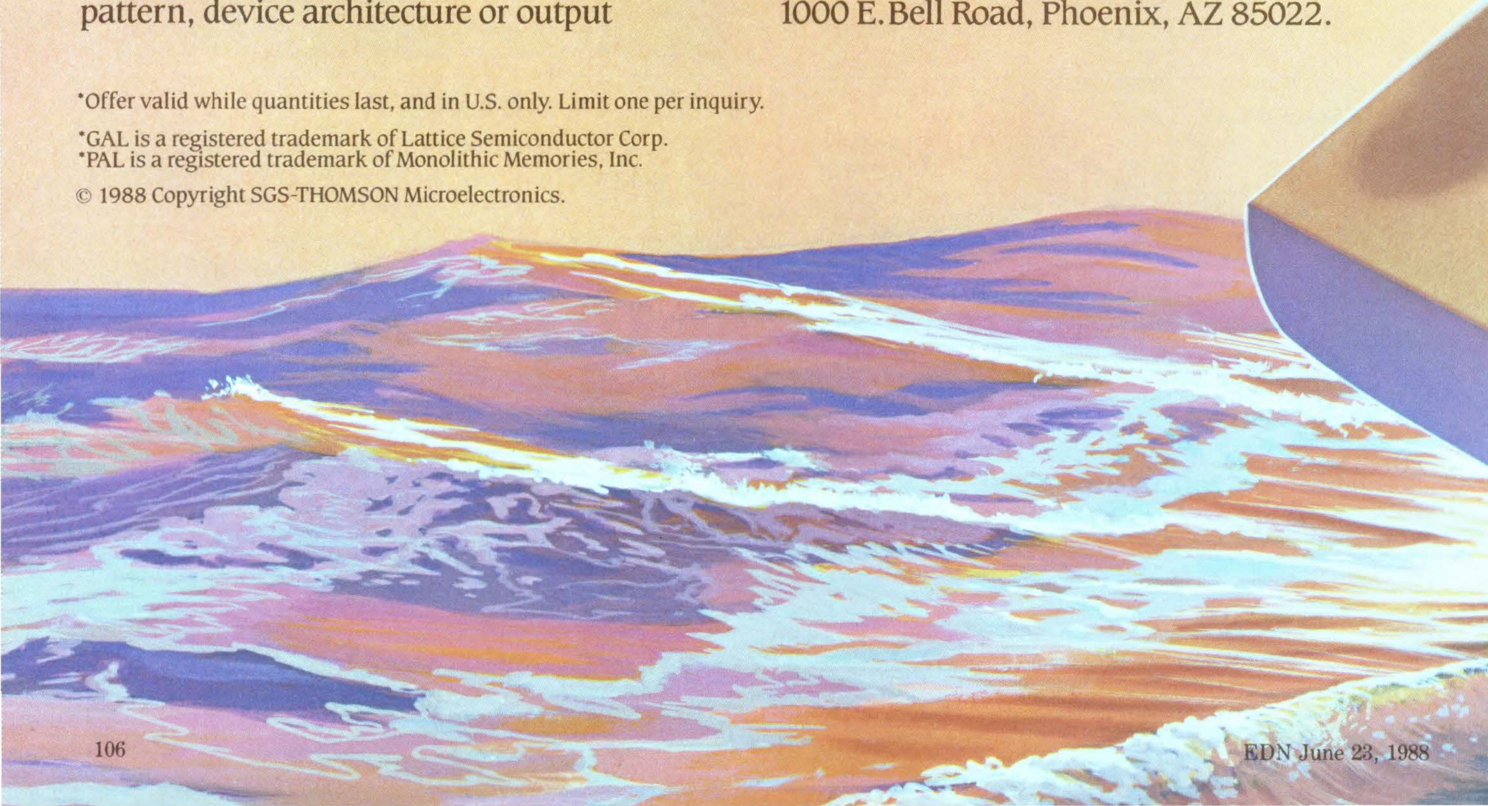


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CIRCLE NO 133
SGS-THOMSON
MICROELECTRONICS

LEADTIME INDEX

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
TRANSFORMERS								
Toroidal	10	0	60	30	0	0	**9.6**	**9.7**
Pot-Core	11	0	67	22	0	0	**8.8**	**10**
Laminate (power)	12	29	29	24	6	0	**8.3**	**9.6**
CONNECTORS								
Military panel	0	33	67	0	0	0	**6.0**	**10.4**
Flat/Cable	8	23	46	8	15	0	**9.3**	**4.7**
Multi-pin circular	8	23	46	8	15	0	**9.3**	**11.6**
PC (2-piece)	0	46	54	0	0	0	**5.2**	**7.2**
RF/Coaxial	12	47	41	0	0	0	**4.2**	**5.2**
Socket	15	55	30	0	0	0	**3.5**	**3.7**
Terminal blocks	10	52	33	5	0	0	**4.4**	**5.7**
Edge card	6	50	44	0	0	0	**4.5**	**5.8**
D-Subminiature	24	47	29	0	0	0	**3.2**	**4.4**
Rack & panel	0	58	33	9	0	0	**5.2**	**6.4**
Power	21	43	36	0	0	0	**3.7**	**5.4**
PRINTED CIRCUIT BOARDS								
Single sided	5	43	47	5	0	0	**5.4**	**3.7**
Double sided	4	39	53	4	0	0	**5.6**	**6.5**
Multi-layer	0	15	80	5	0	0	**7.4**	**7.8**
Prototype	4	79	13	4	0	0	**3.2**	**5.4**
RESISTORS								
Carbon film	41	31	24	4	0	0	**3.1**	**2.7**
Carbon composition	32	23	31	14	0	0	**5.1**	**4.3**
Metal film	41	19	33	7	0	0	**4.1**	**4.1**
Metal oxide	29	14	28	29	0	0	**7.1**	**4.0**
Wirewound	12	36	40	12	0	0	**5.8**	**6.5**
Potentiometers	15	36	26	19	4	0	**6.8**	**5.2**
Networks	36	23	32	9	0	0	**4.4**	**5.7**
FUSES	50	13	33	4	0	0	**3.5**	**2.9**
SWITCHES								
Pushbutton	13	41	33	13	0	0	**5.5**	**4.6**
Rotary	5	30	45	20	0	0	**7.4**	**5.4**
Rocker	10	40	30	20	0	0	**6.4**	**5.4**
Thumbwheel	19	25	25	25	6	0	**8.0**	**9.4**
Snap action	13	40	33	14	0	0	**5.6**	**6.7**
Momentary	13	47	27	13	0	0	**5.1**	**5.9**
Dual-in-line	8	54	23	15	0	0	**5.3**	**6.1**
WIRE AND CABLE								
Coaxial	25	50	15	10	0	0	**3.8**	**3.6**
Flat ribbon	36	36	23	5	0	0	**3.3**	**3.1**
Multiconductor	32	47	16	5	0	0	**3.0**	**4.1**
Hookup	46	32	18	4	0	0	**2.7**	**2.8**
Wirewrap	47	23	24	6	0	0	**3.3**	**2.8**
Power cords	30	29	26	15	0	0	**5.0**	**3.1**
POWER SUPPLIES								
Switcher	0	46	31	23	0	0	**7.0**	**7.9**
Linear	6	39	44	11	0	0	**6.0**	**8.6**
CIRCUIT BREAKERS	11	33	33	23	0	0	**6.9**	**8.7**
HEAT SINKS	14	41	27	18	0	0	**5.8**	**5.3**
BATTERIES								
Lithium coin cells	7	53	33	7	0	0	**4.8**	—
9V alkaline	47	20	20	13	0	0	**4.1**	—
Real-time clock back-up	10	40	40	10	0	0	**5.6**	—
RELAYS								
General purpose	20	40	25	15	0	0	**5.2**	**6.1**
PC board	9	32	27	27	5	0	**8.4**	**8.5**
Dry reed	0	23	46	31	0	0	**9.1**	**11.8**
Mercury	0	13	74	13	0	0	**8.2**	**10.7**
Solid state	11	39	28	22	0	0	**6.5**	**10.8**
DISCRETE SEMICONDUCTORS								
Diode	28	24	21	21	7	0	**7.2**	**7.0**
Zener	22	19	22	29	4	4	**9.0**	**9.2**
Thyristor	16	16	31	32	0	5	**9.4**	**8.5**
Small signal transistor	14	14	31	27	9	5	**10.9**	**6.9**
MOSFET	25	13	31	25	0	6	**8.6**	**7.9**
Power, bipolar	21	29	21	29	0	0	**6.9**	**8.3**
INTEGRATED CIRCUITS, DIGITAL								
Advanced CMOS	6	22	39	33	0	0	**8.8**	**9.5**
CMOS	9	23	27	36	0	5	**9.9**	**7.7**
TTL	16	26	32	21	5	0	**7.7**	**5.9**
LS	17	22	33	22	0	6	**8.4**	**6.1**
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	0	42	33	25	0	0	**7.4**	**5.6**
OP amplifier	5	35	30	25	0	5	**8.6**	**6.4**
Voltage regulator	9	41	27	18	0	5	**7.4**	**6.4**
MEMORY CIRCUITS								
DRAM 16K	0	23	23	38	0	16	**13.3**	**7.7**
DRAM 64K	0	19	25	37	6	13	**13.8**	**10.4**
DRAM 256K	0	6	25	37	13	19	**17.3**	**15.8**
DRAM 1M-bit	0	1	0	58	8	33	**21.6**	**17.5**
SRAM 4K × 4	0	10	30	40	20	0	**14.2**	—
SRAM 8K × 8	0	0	15	62	23	01	**17.1**	—
SRAM 2K × 8	0	18	9	45	18	91	**15.9**	—
ROM/PROM	11	23	44	22	0	0	**7.5**	**10.3**
EPROM 64K	8	23	23	38	0	8	**10.8**	**10.3**
EPROM 256K	0	21	29	43	0	7	**11.7**	**9.3**
EPROM 1M-bit	0	14	29	43	0	14	**13.8**	**19.4**
EEPROM 16K	11	1	44	33	11	0	**11.6**	**13.2**
EEPROM 64K	0	18	36	36	0	10	**12.1**	**11.5**
DISPLAYS								
Panel meters	9	28	27	36	0	0	**8.4**	**5.8**
Fluorescent	15	31	0	46	0	8	**10.4**	**7.8**
Incandescent	25	25	17	33	0	0	**7.1**	**5.4**
LED	19	33	33	15	0	0	**5.7**	**5.3**
Liquid crystal	8	17	33	33	0	9	**11.0**	**8.4**
MICROPROCESSOR ICs								
8-bit	7	27	27	39	0	0	**8.9**	**6.6**
16-bit	9	28	27	36	0	0	**8.4**	**7.3**
32-bit	0	21	36	36	7	0	**10.8**	**9.8**
FUNCTION PACKAGES								
Amplifier	11	23	22	44	0	0	**9.2**	**9.3**
Converter, analog to digital	0	19	36	45	0	0	**10.4**	**9.8**
Converter, digital to analog	0	19	36	45	0	0	**10.4**	**9.2**
LINE FILTERS	8	53	8	31	0	0	**6.6**	**6.0**
CAPACITORS								
Ceramic monolithic	17	33	29	21	0	0	**6.3**	**4.7**
Ceramic disc	9	39	22	30	0	0	**7.3**	**5.8**
Film	14	24	24	38	0	0	**8.4**	**5.7**
Aluminum electrolytic	8	36	12	44	0	0	**8.7**	**6.5**
Tantalum	14	27	32	27	0	0	**7.4**	**7.1**
INDUCTORS	5	37	32	26	0	0	**7.4**	**6.8**

Source: Electronics Purchasing Magazine's survey of buyers.

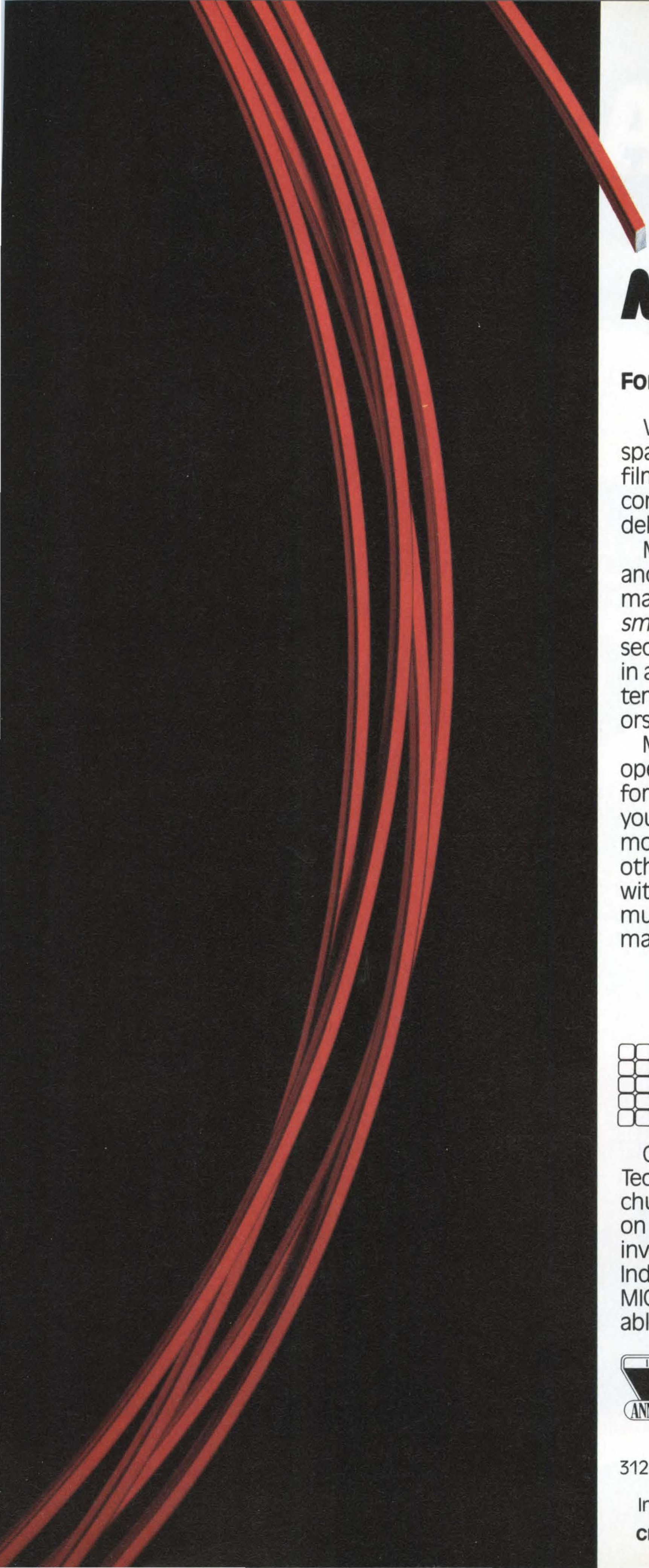

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Illustration of cross-section of typical coil winding using round magnet wire.

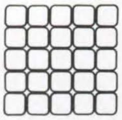

Illustration of cross-section of coil winding using MWS MICROSQUARE magnet wire. Note improved winding uniformity and maximum use of space.

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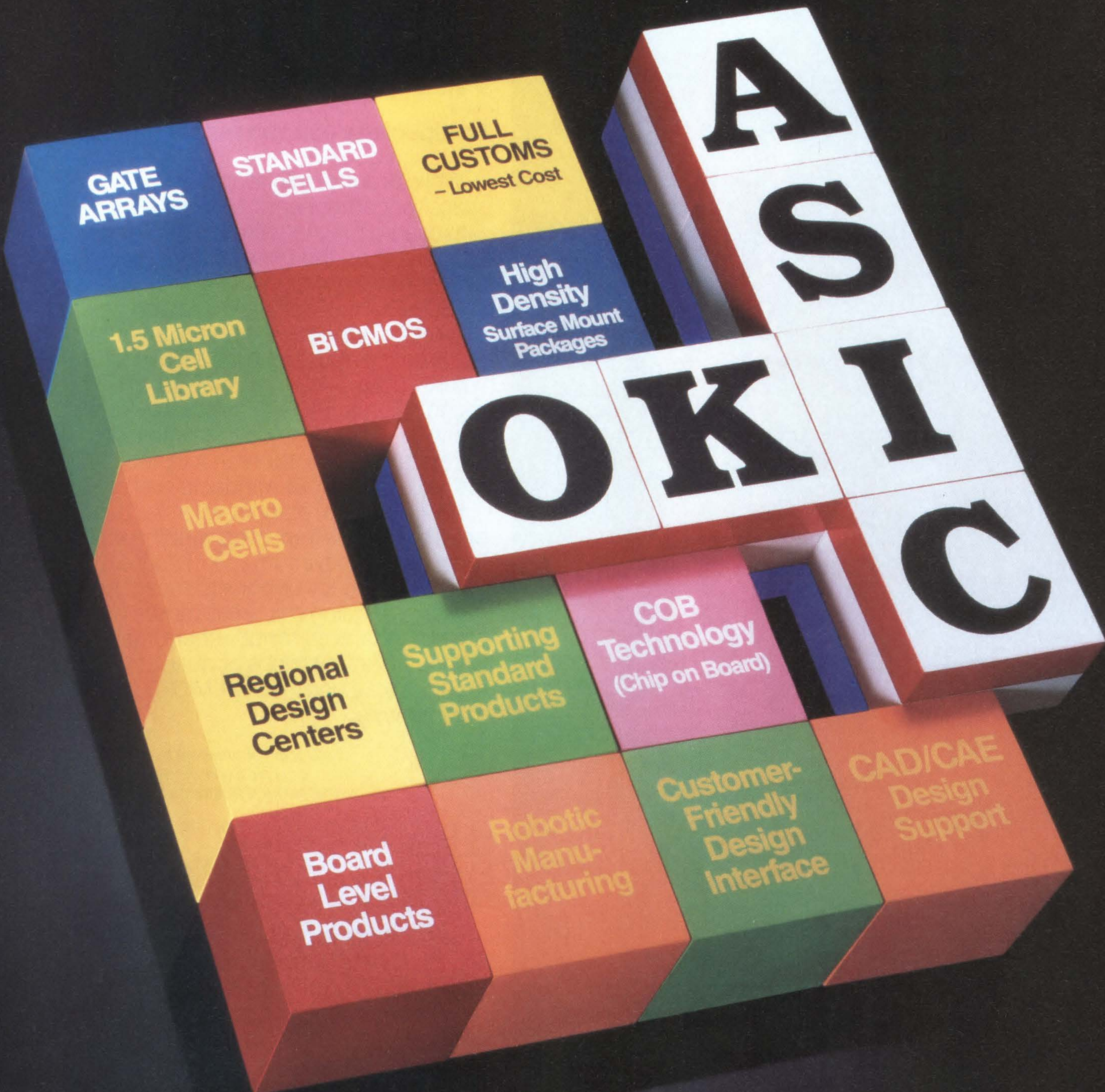

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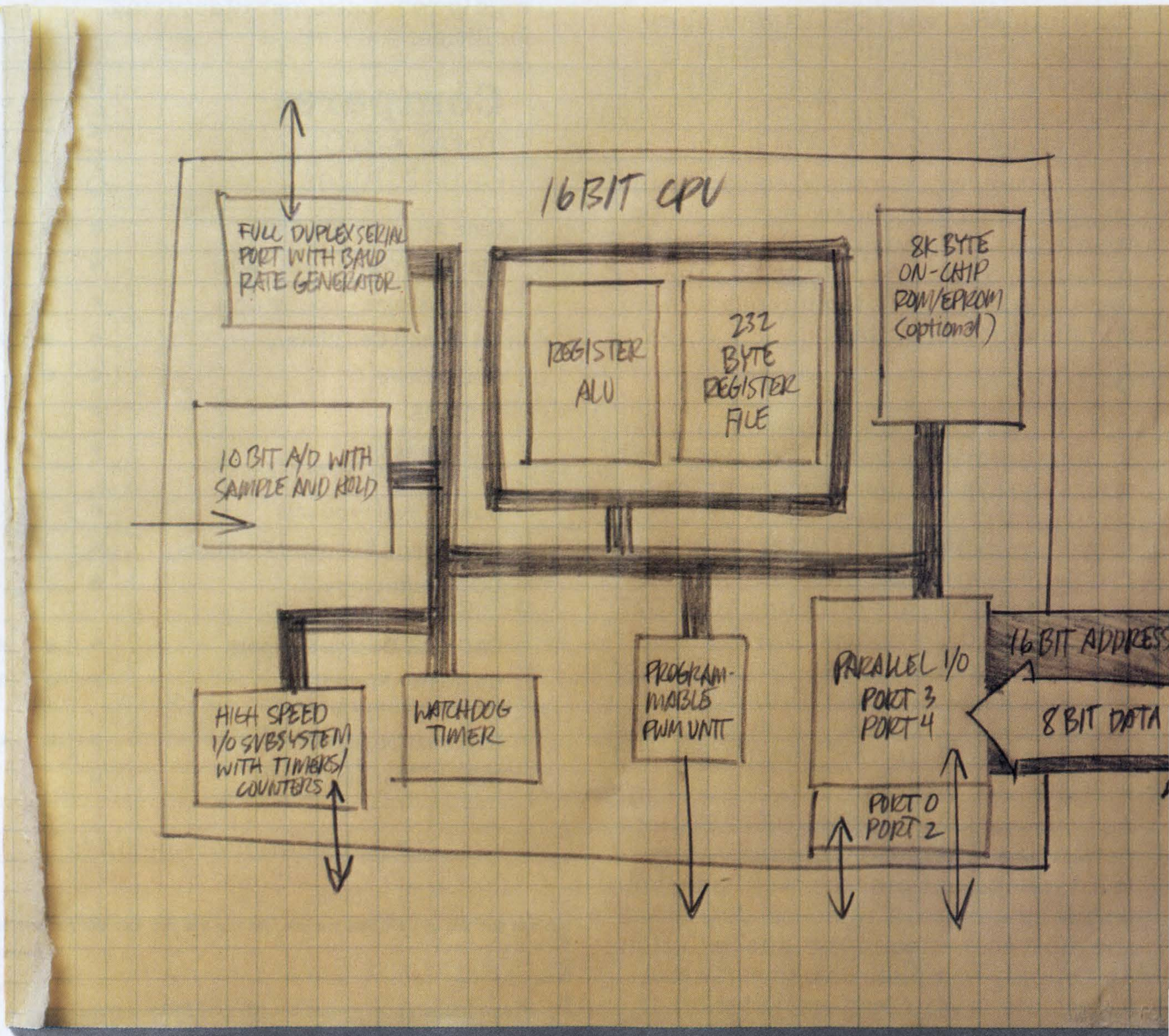

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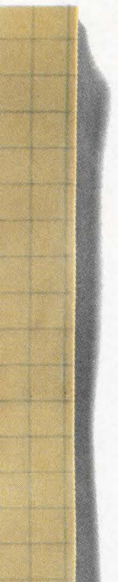

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SPECIAL REPORT

Intelligent Ethernet boards

Computer users today demand LAN interfaces on systems ranging from microcomputers to mainframes. Intelligent Ethernet boards relieve the host CPU of its network-control chores and optimize system communications. Some manufacturers even ship standard protocols such as TCP/IP along with their VME Bus and Multibus boards.

Maury Wright, *Regional Editor*

Designers building systems based on an open bus such as VME Bus or Multibus I or II can choose from a plethora of board-level products to interface to an Ethernet network. In cases where system performance is your top priority, however, you should consider using an intelligent network board. Intelligent boards include a local μP and memory and actually perform front-end execution of the network protocol without impacting the host CPU performance. In fact, you often have the choice of having the protocol embedded on the board.

Intelligent LAN boards—for Ethernet or otherwise—fit the trend of partitioned-system and distributed-intelligence concepts. In a partitioned system, each functional block (such as network communications or peripheral control) is implemented on an intelligent board—essentially you have a subsystem on a board. The bus connects the boards, and the boards communicate by sending and receiving blocks of data in bursts. You can think of the bus as a high-speed "very-local-area" network.

No matter whether your system *will reside on a local or wide area network, intelligent network boards can provide the improved system performance today's world demands. (Photo courtesy CMC)*

Bus bandwidth supports partitioning

Multibus II and VME Bus system designs benefit from intelligent boards in part because of the buses' 32-bit data paths and their theoretical 40M-byte/sec bandwidth. The bandwidth provides for fast memory-to-memory transfers with minimal impact on system performance. Systems based on older-generation buses, such as the 16-bit Multibus I, benefit simply because the intelligent network controller offloads the communication task from the host.

At present, the de facto standards for applications such as data processing, scientific computing, and CAE/CAD appear to be Ethernet and TCP/IP (Transmission Control Protocol/Internet Protocol). Before deciding on such an implementation, however, consider your target-system application carefully. Of course you want to choose a network, protocol, and board that meets the *performance* requirements of your application—its

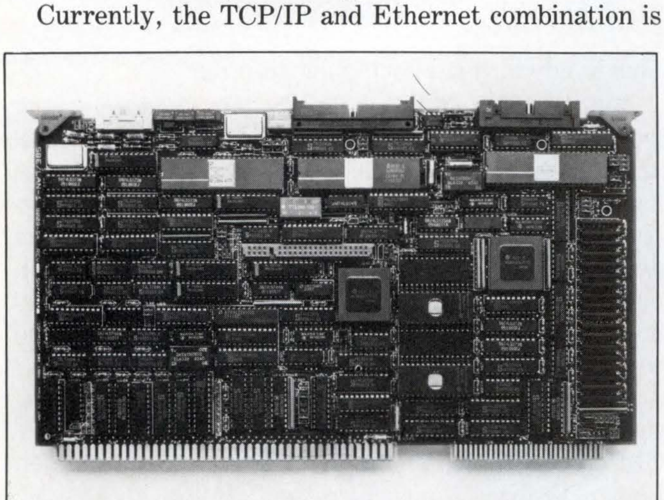
Intelligent Ethernet boards maximize both system and network performance by offloading the host CPU of the data-communication task.

data-rate specs, for instance. Of more importance, though, is a network and protocol that will match your system with its target-system application. Ultimately, your system must be compatible with the networks common to the marketplace you're targeting.

To ensure this compatibility, you may have to incorporate multiple LAN boards or options in your system design: You may need an Arcnet board, an Ethernet board, the TCP/IP protocol, and the Netbios protocol, for example. Systems destined for the factory floor, for instance, may or may not be best suited to the Ethernet-TCP/IP combination: It is up to you to find out (see **box**, "No de facto standard exists for factory floor"). The same situation is true of personal-computer-class systems. A number of proprietary protocols are available for PCs, and manufacturers offer boards for virtually every network (see **box**, "Intelligent boards target personal computers, too").

When considering a LAN protocol, you have to at least investigate the work of the ISO (International Standards Organization). As everyone knows, the ISO has defined a 7-layer OSI (Open Systems Interconnect) model and developed specifications for each layer, including transport and network layers that differ from TCP/IP (for background on layered networks and TCP/IP, see **Ref 1**). Eventually, the OSI layers will become the standard for connecting heterogeneous systems. Most industry observers agree that widespread acceptance and availability of OSI-based products is two to five years away, however.

Currently, the TCP/IP and Ethernet combination is the LAN implementation of choice for connecting heterogeneous systems. Ethernet LANs operate over coaxial cable at 10M-bps rates. Later this year you can expect a barrage of products for 10M-bps Ethernet communications over twisted-pair wiring. All buildings have twisted-pair wiring in place for the phone system, and therefore the cabling cost for implementing a network based on twisted pair is negligible.



The Ethernet and WAN interfaces *on the SBE MLAN-E Multibus I board can function as a bridge between LANs and WANs. Data passing over the bridge does not suffer from host-bus transfer delays.*

Ensure connection to CAD/CAE systems

For now, by implementing TCP/IP and Ethernet, you can ensure that your system will connect to a wide variety of systems in CAE/CAD, data-processing, and scientific-computing applications. For example, CAE workstation giants such as Sun Microsystems and Apollo Computer offer TCP/IP and Ethernet on their systems. And many products exist to connect minicomputers and mainframes from IBM and DEC to TCP/IP and Ethernet LANs. Finally, the move to the OSI standards will be gradual, and you can expect many companies to offer products that bridge TCP/IP- and OSI-based networks.

Choosing TCP/IP has yet another advantage. The TCP/IP protocol is widely used on X.25 WANs (wide area networks). In fact, you can include both LAN and WAN interfaces in your design, and employ TCP/IP on both. With such a system, a computer operator sees virtually no difference in sharing data with a system down the hall than in sharing data with a system across the country. From a user's standpoint, the only difference is the slower data transfers resulting from the slower WAN data rates (see **box,** "A fine line separates WANs from LANs," pg 122).

Board combines LAN and WAN interfaces

SBE, in fact, offers the MLAN-E board for Multibus I that includes both an Ethernet interface and a high-speed serial WAN interface. You can purchase the board for $1305 (100); the TCP/IP protocol to drive the Ethernet interface costs $150. The company does not offer TCP/IP for the WAN interface at this time, but plans to in the future.

For applications in which only occasional LAN access is required, or where LAN access occurs often but the workload of the host CPU is light, you may consider buying a low-cost nonintelligent Ethernet board or implementing the Ethernet interface on the CPU board. A number of CPU-board manufacturers offer Ethernet ports on CPU boards or offer optional modules that connect to the CPU via a local bus. In these situations, the host CPU takes responsibility for all LAN tasks, including programming the LAN interface chip, setting up I/O buffers, assembling and disassembling data packets, and handling the LAN protocol. If you choose to implement TCP/IP on the host CPU, companies such as Network Research Corp (Oxnard, CA) and The Wollongong Group Inc (Palo Alto, CA) offer Unix-based TCP/IP software packages that you can port to your hardware.

But to maximize system and communication performance, you will probably find an intelligent board to be your best choice. CMC's (Communication Machinery Corp's) boards for the VME Bus and Multibus I serve as good examples. The ENP-30 Multibus I board and the ENP-10 VME Bus board are identical except for their bus interfaces. Both include a 10-MHz 68010 μP and 512k bytes of memory. They cost $2000 and $2300, respectively. You can specify a 12.5-MHz processor for a $200 premium.

Both CMC products employ the proprietary K1 kernel, a real-time communications executive. The kernel supervises board activities, network-event timing, and

No de facto standard exists for factory floor

Although a number of suitable network technologies exists for factory-floor applications, the factory-automation industry hasn't endorsed a particular network and protocol as a de facto standard. And the chances of a standard appearing overnight are slim.

Motorola remains dedicated to producing MAP (Manufacturing Automation Protocol) boards, but MAP hasn't been widely adopted thus far. As prices for MAP chips, boards, and software drop, however, you can expect the protocol's popularity to rise.

Other companies such as Intel and Micro/Sys support Bitbus, and claim greatly increased market acceptance over the last year. Ken Finster from Micro/Sys claims that Bitbus is the best for factory-floor applications because it was designed for real-time data acquisition and control, not for file services.

The Arcnet Trade Association (Arlington Heights, IL, (312) 369-2355) is actively promoting Arcnet as the factory-network standard. The trade group plans to make Arcnet an ANSI standard and has made some modifications to the Arcnet spec. The enhanced Arcnet will feature mixed-speed operation and support transfer rates as high as 20M bps. The trade association also has adopted Netbios as the standard protocol for Arcnet networks.

Several board manufacturers are supporting the Arcnet Trade Association with products designed for various buses. These include C&C Marketing (Batavia, IL)—VME Bus and Q Bus; Comendec Ltd (Aston Triangle, Birmingham, UK)—VME Bus and Q Bus; Contemporary Control Systems Inc (Downers Grove, IL)—Multibus I and STD Bus; Pro-Log Corp (Monterey, CA)—STD Bus; and Ziatech Corp (San Luis Obispo, CA)—STD Bus.

TCP/IP may also fit in factory

Other manufacturers don't believe that any of the aforementioned networks fit the need for a standard factory network. Ray Alderman, vice president of sales and marketing at Matrix Corp (Raleigh, NC), claims that what customers really want is the TCP/IP protocol, and that the type of network is not of prime concern to them. Matrix manufactures single-height VME Bus boards and STD Bus boards, but has yet to offer a network product.

According to Alderman, the Arcnet/Netbios combination is popular mainly in small companies that primarily use MS-DOS-based personal computers. Based on customer feedback, Alderman believes that larger companies with Ethernet and TCP/IP on their mainframes and minicomputers would prefer to link those computers to similar factory networks.

Alderman concedes, however, that because Ethernet suffers from data collisions, Arcnet with its token-bus, deterministic architecture may oftentimes be better for some factory applications. He also believes, though, that Arcnet should be combined with TCP/IP in the factory. You can expect Matrix to announce TCP/IP products late this year. PEP Modular Computers already offers a single-height VME Bus Ethernet board with TCP/IP.

Notwithstanding that many networks and protocols exist, Ethernet and TCP/IP have become standard for connecting heterogeneous systems.

network-statistics gathering. It also provides the interface to the upper layers of the protocol, and therefore CMC can use the same TCP/IP protocol implementation across all its products.

Protocol software improves performance

The company has concentrated its development efforts on streamlining its proprietary TCP/IP protocol software as much as it has worked on designing powerful hardware. For example, its software designers devised a way to perform checksum operations in instruction loops of the 68010/020 μPs. Performing these operations on chip minimizes memory accesses. The designers also improved performance by developing software that anticipates the address of data packets coming over the bus.

CMC has recently introduced another VME Bus Ethernet card. The ENP-100 includes a 68020 μP running at either 12.5 or 20 MHz. You can specify the board with 512k to 2M bytes of memory. A 12.5-MHz, 512k-byte version costs $3595 and is available 60 days ARO.

Due to the streamlined protocol code, the ENP-100 can perform transfers via Ethernet from one application program to another faster than 3M bps. Because of the overhead associated with TCP/IP packets, many boards operate at a rate much slower than 2M bps, application to application. But the ENP-100 does not include a DMA controller on board, and the board can only burst data across the VME Bus at 20M bytes/sec.

Excelan also has intelligent Ethernet boards with an onboard TCP/IP implementation. The company offers the $2595 Exos 301 board for Multibus I and the $2495 Exos 302 board for the VME Bus. The boards include an 80286 μP, a DMA controller, and 512k bytes of memory.

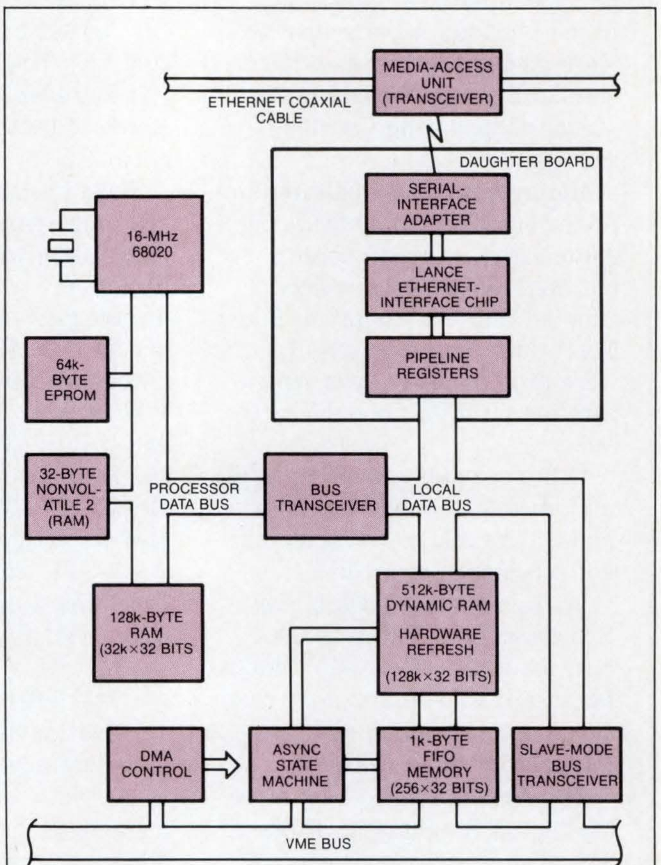
Third-party software drives link layer

Designers developed the Exos family of products with an open architecture. If the application calls for it, the boards can operate as link-level boards rather than as hosts for the TCP/IP protocol. In fact, the flexibility of front-end or link-level operation allows the Exos boards to work with a variety of third-party protocol-software packages. You can also employ the Excelan NX real-time kernel and develop your own protocols for the boards.

Interphase's 4207 Eagle board for the VME Bus is optimized for data throughput from a hardware standpoint, but does not presently carry TCP/IP. The company plans to make TCP/IP available in the third quarter. The $3495 (100) board employs the proprietary Buspacket interface, the same interface that the vendor uses on its disk controller boards. The Eagle can send bursts of data across the VME Bus at rates greater than 35M bytes/sec. Designers achieved the high bandwidth by partitioning the board in such a way that several operations can occur simultaneously. For example, the Ethernet interface, the 16-MHz 68020, and the DMA controller and VME Bus interface all can operate concurrently.

Real-time OS switches in 50 μsec

The Eagle operates under control of the proprietary real-time operating system, Smart. Designed for use in data-I/O applications, the operating system can perform a context switch in less than 50 μsec. An off-the-shelf, real-time operating system typically takes sever-



Because of concurrent operation of the μP, *the Ethernet interface, and the DMA bus interface on the Interphase 4207 Eagle, VME Bus burst-data transfers faster than 35M bytes/sec are possible.*

al hundred microseconds to perform a context switch.

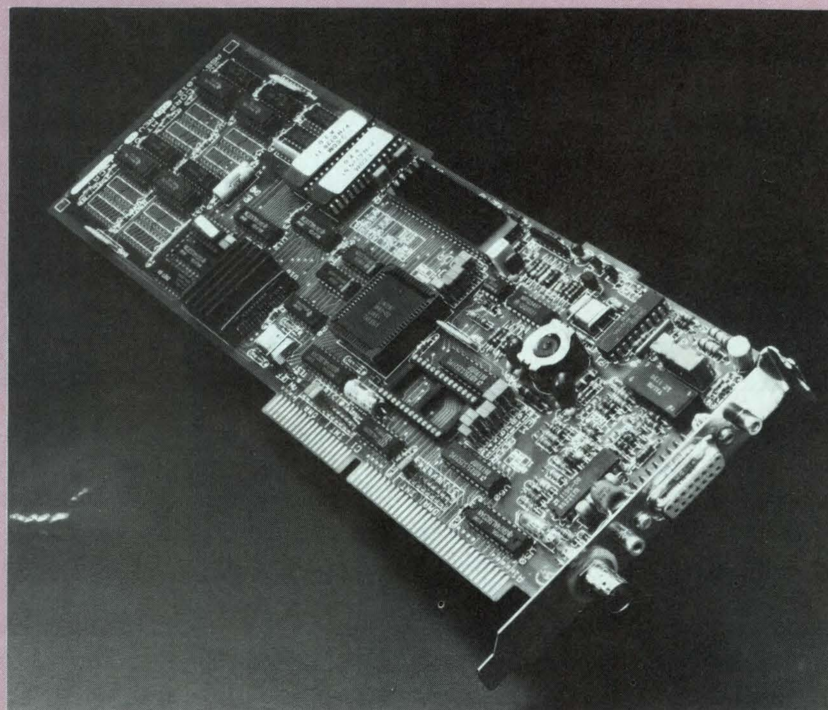
When the board becomes available with TCP/IP, the host operating system will access the protocol via the MACSI (multiple active-command software interface) that Interphase also uses on its data-storage boards. The MACSI scheme employs a ring buffer and appears to the host CPU as a command queue of unlimited size.

Besides all of these full-height boards, you can also

Intelligent boards target personal computers, too

Not only are intelligent Ethernet-TCP/IP boards available for workstations, manufacturers also offer such boards for IBM PCs and compatibles. In fact, you can justify the cost of an intelligent board for high-end 80286/386-based systems just as you can for 68020-based workstations.

Furthermore, to connect personal computers to the heterogeneous-computer network, you must use the TCP/IP protocol along with a Unix, MS-DOS, or OS/2 operating system. Proprietary network operating systems such as Novell's Netware, Microsoft's MS-NET, Banyan's Vines, and Western Digital's Vianet work fine for networks within a small company or department. For more far-flung personal-computer networks, however, these schemes don't suffice.



***An onboard 80186 μP** handles the task of managing the Netbios protocol on the 3Com Etherlink Plus adapter for IBM PC/ATs and compatibles.*

Boards host local protocol

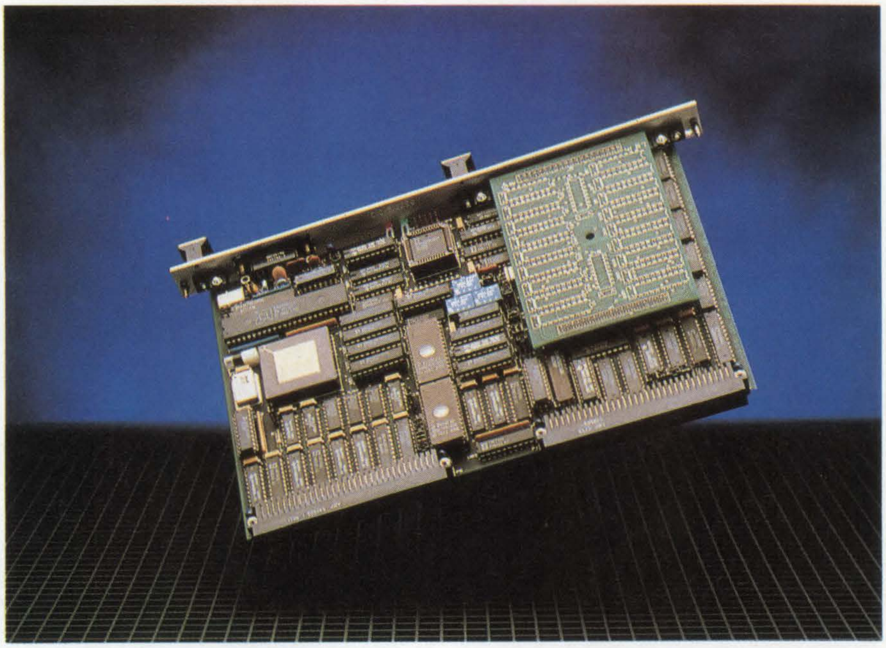
The Excelan Exos 205 intelligent Ethernet board for personal computers handles the TCP/IP protocol on its local μP, and it supports the Netbios transport on top of TCP/IP as well. The $995 board also offers compatibility with Netware. In fact, with an MS-DOS-based environment manager such as Desqview or Windows, an operator can concurrently manage Netware and TCP/IP sessions.

Communication Machinery Corp also offers an intelligent Ethernet board with TCP/IP. The ENP-66 is compatible with the IBM PC or PC/AT bus and includes a 68000 μP and 128k bytes of RAM. The $995 board also has an onboard 16-bit expansion bus. You can attach daughter boards to the expansion bus and use the ENP-66 with link layers other than standard Ethernet.

Finally, 3Com Corp offers personal-computer intelligent network adapters for Ethernet (and the 4M-bps token bus). The Etherlink Plus (and Tokenlink Plus) adapter costs $895 and includes an 80186 μP. Currently, the adapters only support 3Com protocols and Netbios.

The Bridge Communications Div of 3Com, however, offers the 68000-based PCS/1 family of intelligent Ethernet boards with TCP/IP hosted on board. Each board costs $1195; the TCP/IP software is an extra $200. You can specify this family of products for the IBM PC or PC/AT bus, and for Ethernet, thin Ethernet, or broadband networks.

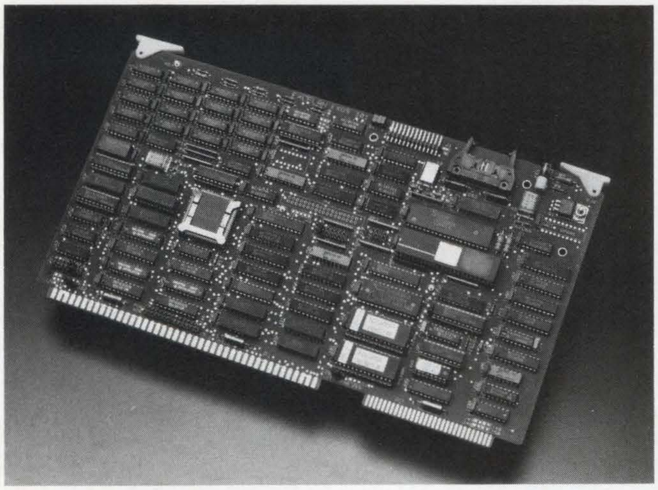
The ISO has defined a 7-layer model to guide network implementation, but it may take several years before networks based on it become widely used.



***The TCP/IP protocol that executes** on the CMC ENP-100 68020-based Ethernet board results in VME Bus application-to-application data rates in excess of 3M bps.*

purchase an intelligent Ethernet card in the single-height VME Bus card size. PEP Modular Computers offers the VLAN board for $1400. TCP/IP software will be available for $600 beginning in the fourth quarter. The board implements the VME Bus slave interface and includes a 12.5-MHz 68000 μP and 512k bytes of memory.

Not all manufacturers of intelligent VME Bus Ethernet boards believe that front-end execution of the TCP/IP protocol improves performance. When Tadpole Technology designed the 68000-based TP-INC board ($2045) for Ethernet and TCP/IP applications, it configured the board so that the 68000 only sets up and manages buffers in the board's memory.



***Supporting both link-layer and front-end modes** of handling the TCP/IP protocol allows the Exos 301 Multibus I board from Excelan to work with varied third-party protocol software.*

Vice president of sales James Bairey believes that the TCP/IP protocol should be handled by Unix, and he backs up his argument by pointing out that the latest revisions of Unix include TCP/IP. He also notes that processors used on peripheral boards such as Ethernet boards rarely keep pace with the system processor. He gives as an example Tadpole's new CPU board based on the Motorola 88000 RISC CPU. The board requires a 68020 to manage traffic. Bairey claims that a 68020 Ethernet board couldn't keep pace with the 88000 if the Ethernet board were to perform the protocol task.

Few Multibus II network options exist

Although you have several choices of VME Bus and Multibus I board-level products for Ethernet and TCP/IP, your choices for Multibus II systems are quite limited. Several companies offer Multibus II CPU boards with Ethernet interfaces as options or included, but at present only one intelligent Ethernet board is for sale—albeit sourced by three companies. Intel developed the 80186-based board and licensed Siemens to manufacture and sell it in Europe; Micro Industries has an agreement with Siemens to market Siemens products in the US.

Intel prices the iSBC/530 at $2395, and Micro Indus-

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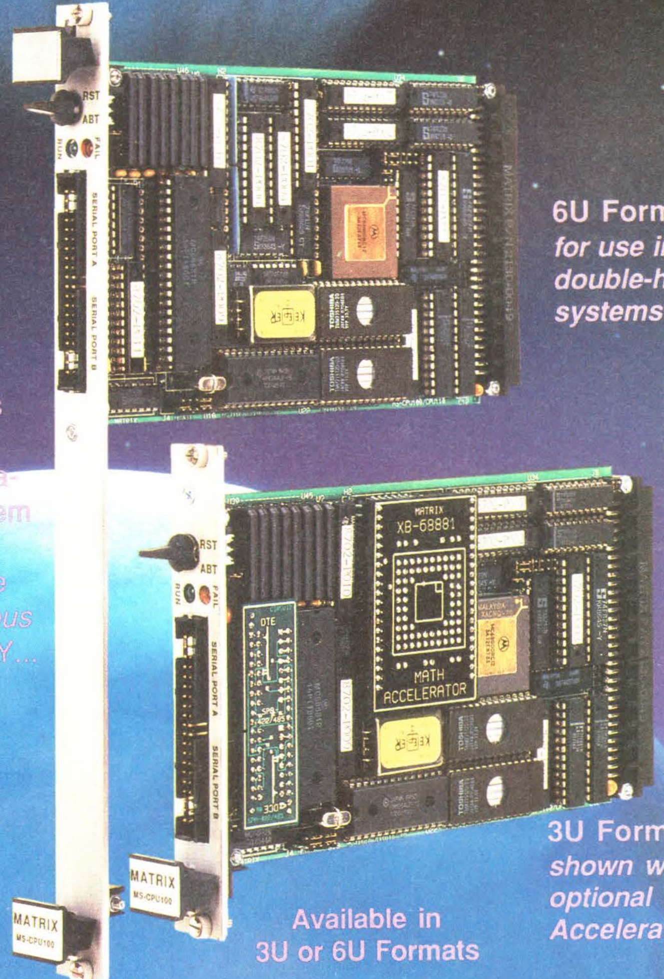

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3U Format *shown with optional Math Accelerator*

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tries sells it for $2500 (model number 186/158). Neither price includes protocol software, and in fact no TCP/IP software is currently available. Siemens and Micro Industries are investigating the possibility of having TCP/IP ported to the board, however. Intel offers OSI protocol software through the transport layer that is embedded on the board. You must pay a 1-time $9500 license fee and $350 per CPU to buy the OSI software.

A fine line separates WANs from LANs

A WAN (wide area network) interface connects one computer system to other computers worldwide via a high-speed serial link. In increasing numbers, users are demanding WAN capabilities to transfer files and data. You can design a WAN interface into Multibus, VME Bus, and IBM-compatible personal-computer systems. In fact, you can implement a WAN and a LAN in a system with similar user interfaces.

A computer with a WAN interface can connect to another system directly, via a public data network, or via leased lines. Communications over a public data network typically have a data-rate spec of 64k baud. When operating over leased lines or direct connections, WAN links can operate at 1M bps and in some cases 2M bps.

TCP/IP suits WANs also

WAN boards share several characteristics with LAN boards: You have the choice of an intelligent board that hosts a WAN protocol on board, or you can opt for slave boards and transfer the protocol task to the host CPU. You can also employ the same protocol—TCP/IP—on a WAN that you do on a LAN.

For example, consider the board-level products from Adax Inc (Berkeley, CA). The company is offering WAN boards for Multibus I and IBM-compatible personal computers, and plans to offer products for the VME Bus, Nubus, and Multibus II. For Multibus I, the 2-channel Model SCC WAN board includes 512 bytes of RAM per channel, operates at a maximum 1M-bps data rate, and costs $640 (100). Another Multibus I board, the 2M-bps APC-MBX, costs $1121 for a single-channel version or $1346 for a dual-channel model (100). Finally, the 2-channel PC-SDMA for the IBM PC and compatibles operates at 1M bps and costs $296 (100).

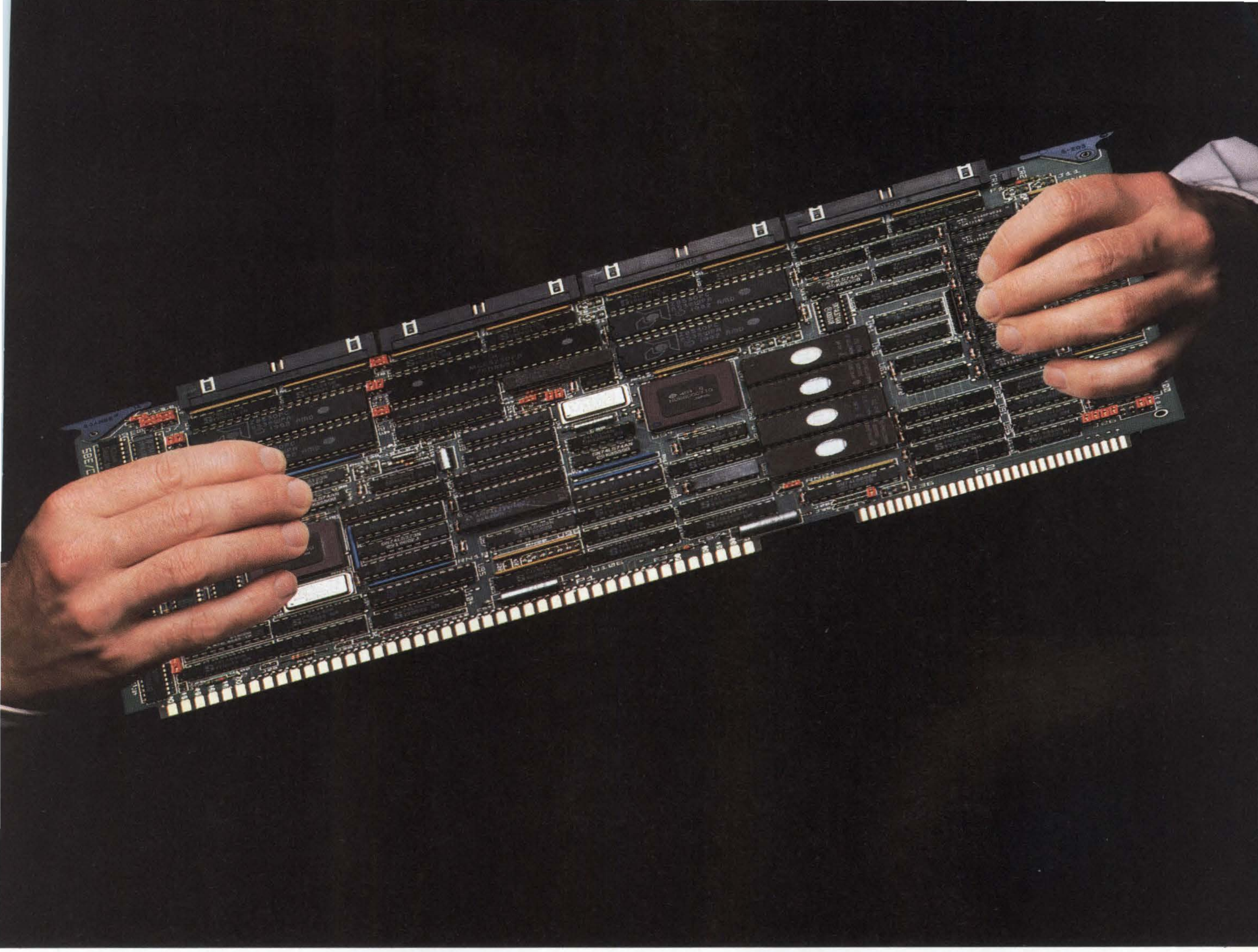
All of the Adax boards include an IC that handles the three layers of the X.25 WAN protocol but they do not include a μP. The company offers Unix-based X.25 software for 68000/10/20 μPs and for 80286/386-based systems. You can also purchase TCP/IP software that works with the X.25 network. Unix-based X.25 software for personal computers costs $371; for 68000-family systems, it costs $562 (100). You may also have to pay a porting charge to have the software customized for your hardware.

WAN boards include CPU

Other companies, such as Intel, SBE, and Systech, do offer WAN boards that incorporate a local μP. For example, the $1470 (100) Multibus I DCP-8804 and $1850 (100) VME Bus DCP-8820 from Systech (San Diego, CA) include an 80186. The boards feature similar architectures and include four full-duplex WAN channels. The channels operate at a maximum data rate of 1M bps. The dual-channel DMA controller that the 80186 includes handles bus communications, and two dual-channel DMA controllers link the WAN channels to local memory.

The Systech boards can host a variety of protocols on board, including X.25 and many protocols used in IBM mainframe communications such as SNA/SDLC and LU 6.2. Systech product manager Chuck Citron claims that he has had few requests to host TCP/IP on the boards and the company has no plans to implement TCP/IP. According to Citron, most customers for the Systech WAN boards design the boards into systems to provide a connection to IBM machines.

You can also port protocols to the Systech boards yourself. The boards include a version of the VRTX real-time operating system that acts as a basis for protocol development, and source listings of sample protocol software are also provided. Systech plans to offer a similar board for Multibus II.



When considering a LAN protocol, you have to at least investigate the work of the ISO (International Standards Organization).

Manufacturers of intelligent Ethernet boards

For more information on intelligent Ethernet boards such as those discussed in this article, contact the following manufacturers directly, circle the appropriate numbers on the Information Retrieval Service card, or use EDN's Express Request service.

Bridge Communications Div of 3Com Corp
3165 Kifer Rd
Santa Clara, CA 95052
(408) 562-6400
TLX 345546
Circle No 650

Communication Machinery Corp
125 Cremona Dr
Santa Barbara, CA 93117
(805) 968-4262
TWX 240876
Circle No 651

Excelan Inc
2180 Fortune Dr
San Jose, CA 95131
(408) 434-2300
Circle No 652

Intel Corp
5200 N E Elam Young Parkway
Hillsboro, OR 97124
(503) 681-8080
Circle No 653

Interphase Corp
2925 Merrell Rd
Dallas, TX 75229
(214) 350-9000
TLX 73-2561
Circle No 654

Micro Industries
691 Greencrest Dr
Westerville, OH 43081
(614) 895-0404
Circle No 655

Motorola Microcomputer Div
Marcom Dept DW283
2900 S Diablo Way
Tempe, AZ 85282
(800) 556-1234
In CA, (800) 441-2345
Circle No 656

PEP Modular Computers Inc
600 N Bell Ave
Pittsburgh, PA 15106
(412) 279-6661
TWX 412-279-6860
Circle No 657

SBE Inc
2400 Bisso Lane
Concord, CA 94520
(415) 680-7722
TWX 910-366-2116
Circle No 658

Siemens AG
Balanstrasse 73
D-8000 Munich, West Germany 80
089-4144-2430
Circle No 659

Tadpole Technology Inc
6747-K Sierra Ct
Dublin, CA 94568
(415) 828-7676
Circle No 661

Tadpole Technology plc
Titan House
Castle Park
Cambridge CB3 OAY, UK
223 461000
Circle No 662

3Com Corp
3165 Kifer Rd
Santa Clara, CA 95052
(408) 562-6400
TLX 345546
Circle No 663

Intel uses Netbios on top of the OSI transport. The vendor offers the software for other intelligent boards as well: two Multibus I boards, a board for IBM-compatible personal computers, and a DEC VAX board for Q Bus and Unibus systems.

VME Bus board hosts OSI TOP protocol

In its intelligent boards, Motorola has also chosen to begin by offering products compatible with OSI standards. The VME Bus MVME374 board, for instance, meets the OSI standard for TOP (Technical and Office Protocol). The board includes a 16-MHz 68020, 1M bytes of RAM, and sells for $1795; the TOP software is an added $600. Motorola does resell an intelligent Ethernet and TCP/IP board that it buys from CMC.

Around the end of the year, you can expect some major product announcements from Motorola. The company has committed to a standard communication-board architecture, and plans to offer several products that mix and match protocols and networks. The standard architecture should let you pick and choose the components of your communication subsystem with no impact on your system software. **EDN**

Reference

1. Wright, M; "Networking software," *EDN*, March 3, 1988, pg 102.

Article Interest Quotient (Circle One)
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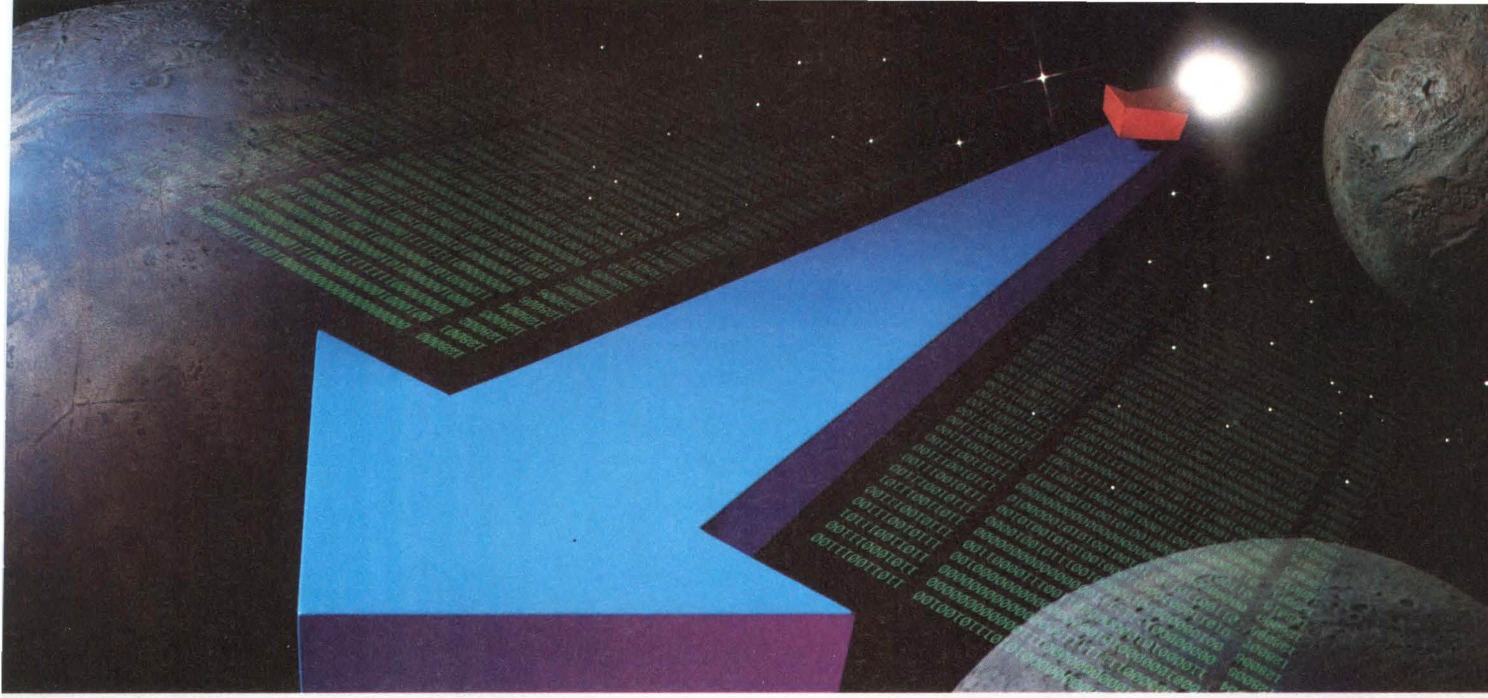

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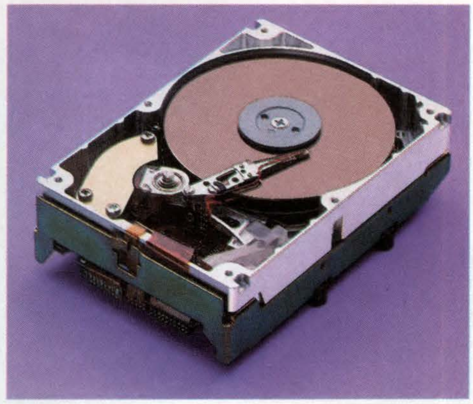

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DESIGNER'S GUIDE TO

TRANSMISSION LINES & INTERCONNECTIONS

PART ONE

Rules tell whether interconnections act like transmission lines

It can be hard to distinguish transmission lines from simple interconnections. This 3-part guide discusses how to identify transmission lines in system interconnections and eliminate the associated signal degradation. Part 1 poses four basic design problems. It also presents some rules for determining whether a signal path is lumped or distributed. Part 2 (pg 143) covers several methods for dealing with transmission-line effects, and Part 3 (pg 155) answers the questions posed in Part 1.

David Royle, *Litton/Amecom*

Although transmission-line fundamentals are fairly straightforward, the boundary between simple interconnections and transmission lines, which have distributed elements, is hard to define. Because the effects of these distributed elements in transmission lines can crop up in unexpected places, designers often overcompensate by preparing for wave reflections that cannot possibly occur. In order to efficiently design electronic systems that contain lossless interconnection elements like ribbon cables, backplane wiring, and pc-board traces, it's important to know how to identify a transmission line.

The propagation of signal information, whether an electrical signal in a conductor, a shock wave in a metal beam, or the flow of fluid down a pipe, never occurs instantaneously. In the physical world, you must consider the dimensions of elements within a system. For the purposes of this article, when the physical dimensions of an element significantly affect the propagation of signal information, the element is termed "distributed," and transmission-line effects can occur; when the physical dimensions are insignificant, the elements are called "lumped"; these latter elements involve the analysis techniques for simpler interconnections.

In electrical circuits, lumped elements permit the use of Kirchhoff's circuit laws; with distributed elements, Kirchhoff's laws fail and the mathematics of the system become more complex. Consider, for example, applying Kirchhoff's current law to a transmitter antenna where current enters but does not exit—at least in the classical sense **(Ref 1)**.

Try a transmission-line quiz

Examine the following four problems taken from real designs and see where you think transmission-line analysis techniques might apply:

- Problem 1—The physical layer of a local-area network consists of 19.2k-baud modems interconnected as shown in **Fig 1**. The carrier frequency is 200 kHz; 50Ω RG-22 coaxial cable connects the modems. Are bus terminations required? Should you use impedance-matching transformers at the cable junctions?
- Problem 2—A miniature reed relay energizes the coil of a larger 48V relay as shown in **Fig 2**. The

reed relay has a contact rating of 10 VA and a contact resistance of 0.2Ω. The coil resistance of the 48V relay is large and includes the usual diode protection. Approximately 20 ft of 100Ω twisted-pair cable with a capacitance of 20 pF/ft connects the relays. The contacts cycle on and off once per sec with a 50% duty cycle. Can you identify any transmission-line-related problems?

- Problem 3—The physical layer of a T1 digital-voice bus uses RS-422 (5V differential mode) as shown in **Fig 1.** Twisted-pair cable (120Ω) interconnects the drivers and receivers. The bus signals exhibit significant ringing and poor noise margins. What is the problem and where might you include terminations?
- Problem 4—A 1-ft backplane interconnects a pair of 74S00 Schottky-TTL NAND gates as shown in **Fig 3.** Are transmission-line effects important?

Identifying a transmission line

Before you begin any interconnection-system analysis that you suspect might require use of transmission-line principles, you need to ascertain whether a simpler, lumped-parameter analysis can adequately predict or explain the network's behavior. Essentially, you need to be able to differentiate a simple interconnection from a transmission line.

Some concrete guidelines do apply: You can analyze any interconnection from either a frequency- or time-domain perspective. When using frequency-domain analysis, if the length of the interconnection is greater than 1/15th of the wavelength of the signal it carries, consider the interconnection to be a transmission line. The frequency-domain relationship applies to wideband signals whose wavelength is that of the highest frequency present, f_{max} **(Ref 2 and 3).**

When using time-domain analysis, if the time required for the signal to travel the length of the interconnection is greater than 1/8th of the signal rise time, consider the interconnection to be a transmission line **(Ref 4).** In this domain, rise time refers to either the rise or fall time, whichever is smaller, and corresponds to the linear-ramp amplitude from 0% to 100% **(Table 1** provides specific guidelines for various logic families). Don't confuse rise time with slew rate, edge rate, or edge speed, which, by themselves, don't indicate signal bandwidth. Schottky TTL, for example, has an edge speed 20% faster than 100K ECL, but because of its larger signal amplitude, Schottky TTL's rise time is longer and its bandwidth is correspondingly smaller. (A 60-Hz (ac power) waveform with an rms value of 450 kV has a zero-crossing edge rate of 0.24 V/nsec, a value comparable to logic-signal edge rates, but its bandwidth is nonetheless only 60 Hz.)

The frequency- and time-domain guidelines, of

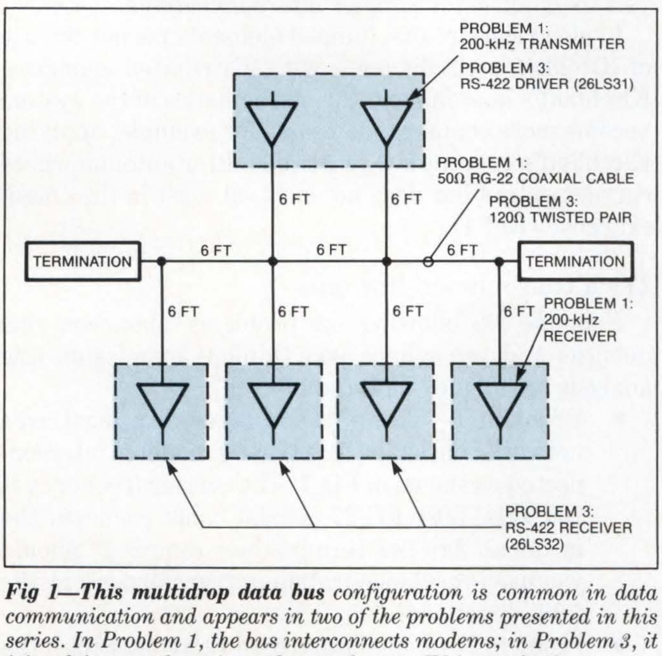


*Fig 1—**This multidrop data bus** configuration is common in data communication and appears in two of the problems presented in this series. In Problem 1, the bus interconnects modems; in Problem 3, it joins drivers and receivers that conform to EIA standards.*

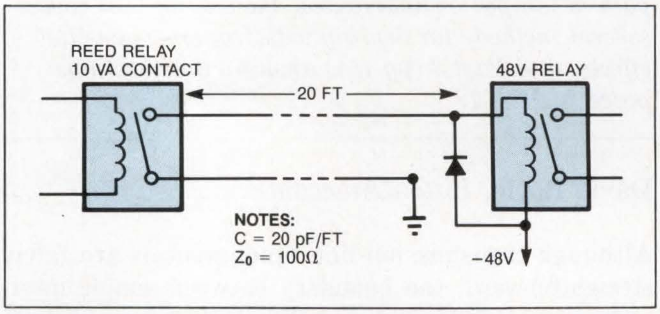


*Fig 2—**In Problem 2,** a reed relay drives a power relay through 20 ft of cable. Are transmission-line effects significant?*

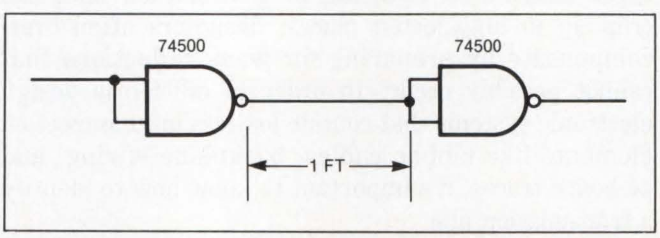


*Fig 3—**This configuration** could hardly be more common, and it could hardly look more innocuous. But is it? Problem 4 asks you to find out.*

course, make the same statement in different ways. Consider a step function of rise time (t_R) applied to the transmission line illustrated in **Fig 4**. The bandwidth of a pulse with rise time is

$$f_{max}=0.56/t_R,$$

which corresponds to

$$\lambda=v/f_{max}=vt_R/0.56.$$

The ratio of a wavelength to a line length then is

$$\lambda/l= vt_R/0.56l.$$

But because the one-way delay, τ, is equal to l/v,

$$\lambda/l=t_R/0.56\tau=1.8(t_R/\tau).$$

So in the time domain, if $t_R/\tau=8$, then

$$\lambda/l=1.8\times 8=14.4\approx 15,$$

which agrees with the frequency-domain guideline **(Ref 5** and **6)**.

After you've decided whether to analyze the system according to frequency or time domain, you can use a step-by-step methodology to expedite identifying whether an interconnection behaves as a transmission line.

Analyze in frequency domain

If you decide to use frequency-domain analysis, the following procedure facilitates the identification of transmission lines:

Determine the highest frequency, f_{max}, present in the signal.

Determine the velocity of propagation through the signal path, v in ft/sec (the velocity of light (c) equals 10^9 ft/sec).

Then determine the length of the signal path, l.

Next, calculate the signal wavelength, $\lambda=v/f_{max}$.

And calculate the wavelength-to-line-length ratio λ/l.

If $\lambda/l\geq 15$, consider the signal path to be a lumped element, not a transmission line.

To calculate the equivalent lumped element:

- Determine the characteristic impedance of the line, Z_0.
- Determine the source and load impedances, R_S and R_L.

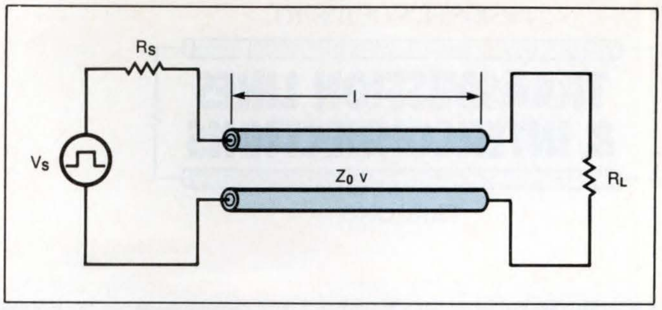


*Fig 4—**A classic transmission line** receives a signal from a voltage source, V_S, by way of source impedance, R_S. The line delivers the signal to a load, represented here as R_L.*

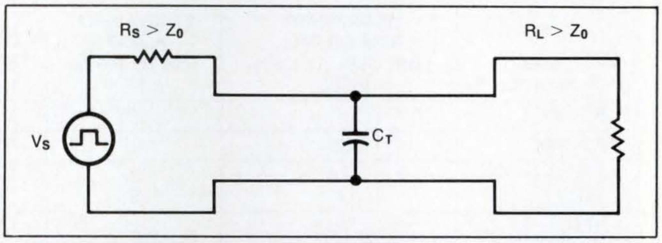


*Fig 5—**When the source impedance is large** in comparison to the line's characteristic impedance you might be able to represent the line as a lumped capacitance.*

- If $R_S>Z_0$, then use only lumped capacitance, $C_T=1/(v\times Z_0)$, when analyzing the circuit **(Fig 5)**.
- If $R_L<Z_0$, then use only lumped inductance, $L_T=Z_0/v$, for your analysis **(Fig 6)**.
- If both $R_S>Z_0$ and $R_L<Z_0$, then use only the lumped inductance, calculated as above.
- If neither $R_S>Z_0$ nor $R_L<Z_0$, then use no lumped element at all.

Analyze in time domain

For time-domain analysis, the following steps ease identification of a transmission line:

Determine the signal rise time, t_R.

Then determine the velocity of propagation through the signal path, v in ft/nsec (the velocity of light (c) equals 1 ft/nsec).

Determine the length of the signal path, l.

Next, calculate the one-way propagation delay, $\tau=l/v$.

Then calculate the ratio of the rise time to the propagation delay, t_R/τ.

If $t_R/\tau\geq 8$, the signal path isn't a transmission line—it's a lumped element.

To calculate the equivalent lumped element:

- Determine the characteristic impedance of the line, Z_0.
- Determine the source and load impedances, R_S and R_L.
- If $R_S>Z_0$, then include only lumped capacitance, $C_T=\tau/Z_0$, when analyzing the circuit **(Fig 5)**.
- If $R_L<Z_0$, then use only lumped inductance, $L_T=\text{tau}\times Z_0$, for your analysis **(Fig 6)**.
- If both $R_S>Z_0$ and $R_L<Z_0$, then include only lumped inductance, calculated as above, when analyzing the circuit.

TABLE 1—UNTERMINATED INTERCONNECTION LENGTHS FOR COMMON LOGIC FAMILIES

LOGIC FAMILY	PUBLISHED RISE OR FALL TIME (10% TO 100%) (nSEC)	EQUIVALENT t_R MAX (0% TO 100%) (nSEC)	MAX INTERCONNECTION $t_R/\tau=4$	MAX INTERCONNECTION $t_R/\tau=3$
ECL 100K	1	1.25	2.1 IN.	3 IN.
ECL 10K	3.5	4.4	7.5 IN.	10 IN.
ECL 10KH	1.8	2.3	3.9 IN.	5.5 IN.
TTL	4	5	9 IN.	12 IN.
STTL	1.6	2	4 IN.	4.8 IN.
LTTL	4	5	9 IN.	12 IN.
LSTTL	6	8	14 IN.	19 IN.
AS	1	1.3	2.3 IN.	3.1 IN.
ALS	6	7.5	14 IN.	18 IN.
FAST	2	3	5.5 IN.	7.2 IN.
CMOS (5V)	90	113	17 FT	23 FT
CMOS (15V)	50	63	9 FT	13 FT
HIGH SPEED CMOS	10	12.5	23 IN.	30 IN.
FACT	3	3.8	6.5 IN.	9.1 IN.
HC (MOTOROLA)	8	10	17 IN.	24 IN.
AC (TI)	2.4	3	5.1 IN.	7.2 IN.

NOTE:
SEMICONDUCTOR MANUFACTURERS PUBLISH RISE-TIME INFORMATION ON ALL CURRENT LOGIC FAMILIES. THEY NORMALLY SPECIFY THESE RISE TIMES BETWEEN THE 10% AND 90% OR THE 20% AND 80% AMPLITUDE POINTS. YOU MULTIPLY THESE FIGURES BY 1.25 AND 1.67, RESPECTIVELY, TO OBTAIN THE LINEAR-RAMP DURATION FROM 0% TO 100% AMPLITUDE.

- If neither $R_S>Z_0$ nor $R_L<Z_0$, then use no lumped element at all.

It's useful to keep in mind various information about several parameters when doing time- or frequency-domain analysis. These issues involves rise time, velocity of propagation, characteristic impedance, the length of the signal path, and loading effects.

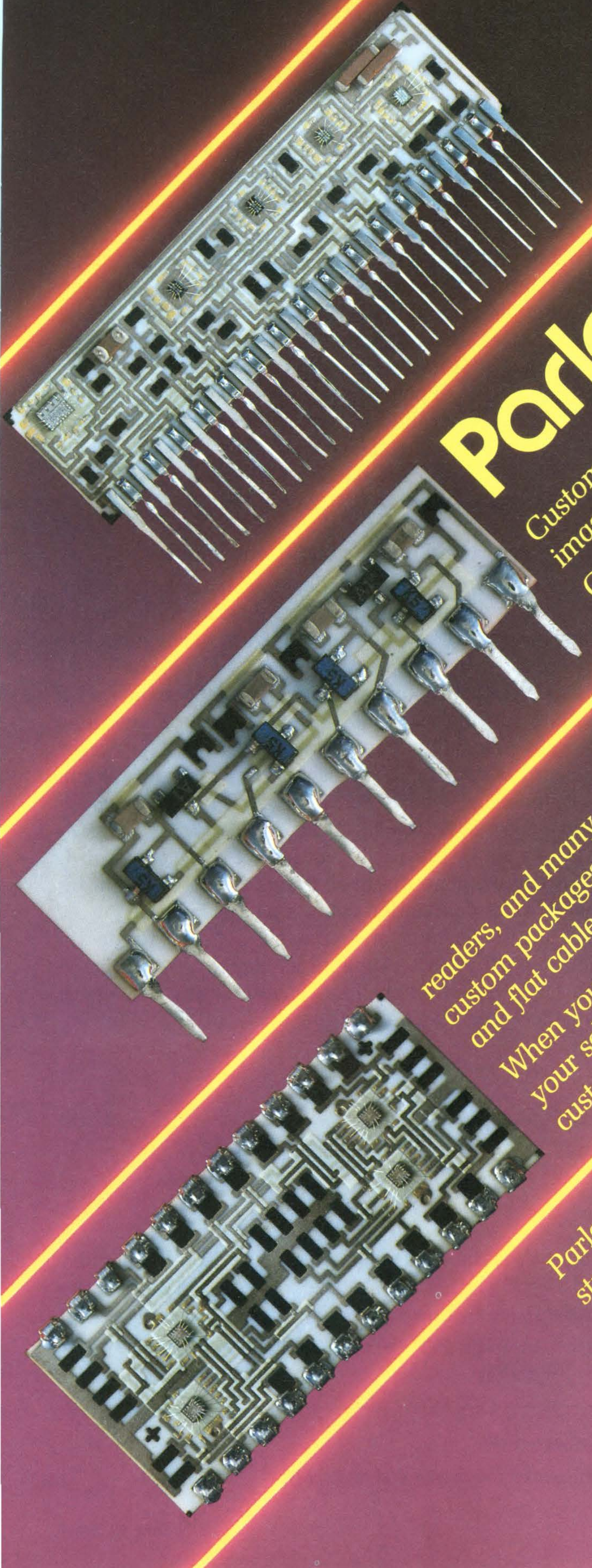
Use standardized rise times

Semiconductor manufacturers publish rise-time information on all current logic families. They normally specify these rise times between the 10% and 90% or the 20% and 80% amplitude points. You multiply these figures by 1.25 and 1.67, respectively, to obtain the linear-ramp duration from 0% to 100% amplitude. The rise-time data for older logic families is published in a number of manufacturer handbooks, most of which are out of print. **Table 1** provides the rise-time data for most logic families, including older ones. When interconnections are short, you can ignore transmission-line effects. But what constitutes "short" can be an interesting question. The table indicates the longest interconnection-path lengths that you can treat as lumped. You can relax the general 8:1 ratio for digital logic because digital circuits can tolerate transmission-line effects that analog circuits can't. For digital logic, the more conservative numbers assume a ratio of rise time to delay of 4:1.

Other data can often help you in determining rise times. You can, for example, use Spice or a similar program to simulate rise times from transient analyses. If you're already working with specific hardware, you can easily measure rise time. Or if you have a situation where a relay generates a step, you can often assume a rise time of zero (ie, an ideal step function).

Compute velocity of propagation

In determining velocity of propagation, *(v,)* keep in mind that some references cite propagation delay t_{PD}, the reciprocal of v. There are some further guidelines for cables, circuit-board traces, and backplane connections. For cables, note that if the manufacturer does not



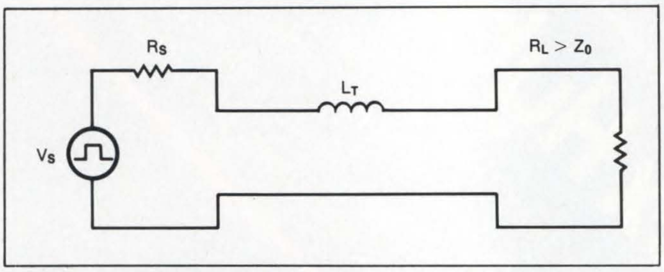


***Fig 6—You can sometimes represent** a transmission line as a single lumped element. Here the load resistance is lower than the line's characteristic impedance, and you can represent the line as an inductor.*

indicate the velocity, you can compute it from $v=1/\sqrt{LC}=1/(Z_0C)$, where L and C are inductance and capacitance per unit length.

When analyzing pc-board traces, keep in mind that the propagation velocity through striplines and microstrip lines depends only on the dielectric constant of the board material—it's independent of geometry. Thus you can accurately estimate v without controlling the characteristic impedance of your boards. For the microstrip configuration, which consists of an outer layer above a ground plane, you can estimate that v is equal to 0.56 ft/nsec. For the stripline configuration, where the conductor lies between a pair of ground planes, estimate that v is 0.44 ft/nsec. Both guidelines assume fiberglass-epoxy boards with $\epsilon_R=4.7$ **(Ref 6).**

For backplane connections, v is equal to 0.60 ft/nsec. In addition, you can use this figure for velocity of propagation when analyzing any stray interconnection that doesn't fit into the categories of cables, circuit-board traces, or backplanes.

Characteristic impedance harder to confirm

Characteristic impedance is often difficult to establish, especially for stray wiring and uncontrolled circuit-board traces. Fortunately, you don't have to know Z_0 to establish whether your interconnection is a transmission line. You must know Z_0, however, to determine equivalent lumped circuit elements.

Although textbook formulas suggest that Z_0 can range from zero to infinity, the rate of change of Z_0 with respect to physical dimensions is quite small. A wire-over-ground transmission line with a wire diameter equal to the diameter of an electron and a height above the ground plane of 50 light-years has a Z_0 of only 3000Ω.

For cables (including twisted-pair hookup wire), you find out the characteristic impedance value in one of three ways: The cable vendor provides it; you compute it from $Z_0=\sqrt{L/C}$; or, using standard formulas, you compute it from dimensions and relative dielectric constants.

When designed for controlled impedance, the range for circuit-board traces is 15 to 140Ω depending on the proximity of ground planes or ground conductors to the signal traces. If the board isn't designed for controlled impedance, the impedance varies from trace to trace, and from point to point on a given trace. Design tables for various controlled-impedance configurations are available in **(Ref 7, 8, 11, and 21).** For boards without controlled impedance, such as 2-sided boards without a ground plane, estimate that Z_0 is equal to 150Ω.

Cables or ground plane control impedance

You can control the impedance of backplane wiring by using twisted-pair cables or by including a ground plane close to the wiring. Use of these techniques lets you treat the interconnection either as a cable or a part of a pc board. Because of its small rate of change with respect to dimensions, Z_0 of stray interconnections typically remains in the range of 100 to 200Ω. As for pc-board traces, 150Ω is a useful approximation. When a ground plane is near the wiring, Z_0 is lower but rarely drops below 50Ω **(Ref 5).**

Determining the path length *(l)* is straightfoward. Basically, it's the distance a signal travels from its source to its destination along a particular path.

Capacitive loading of a transmission line by device inputs and by such elements as connectors along the line's length reduces the line's characteristic impedance and increases its propagation delay in the following way:

$$Z_0'=Z_0/\sqrt{1+(C_L/C_T)};$$

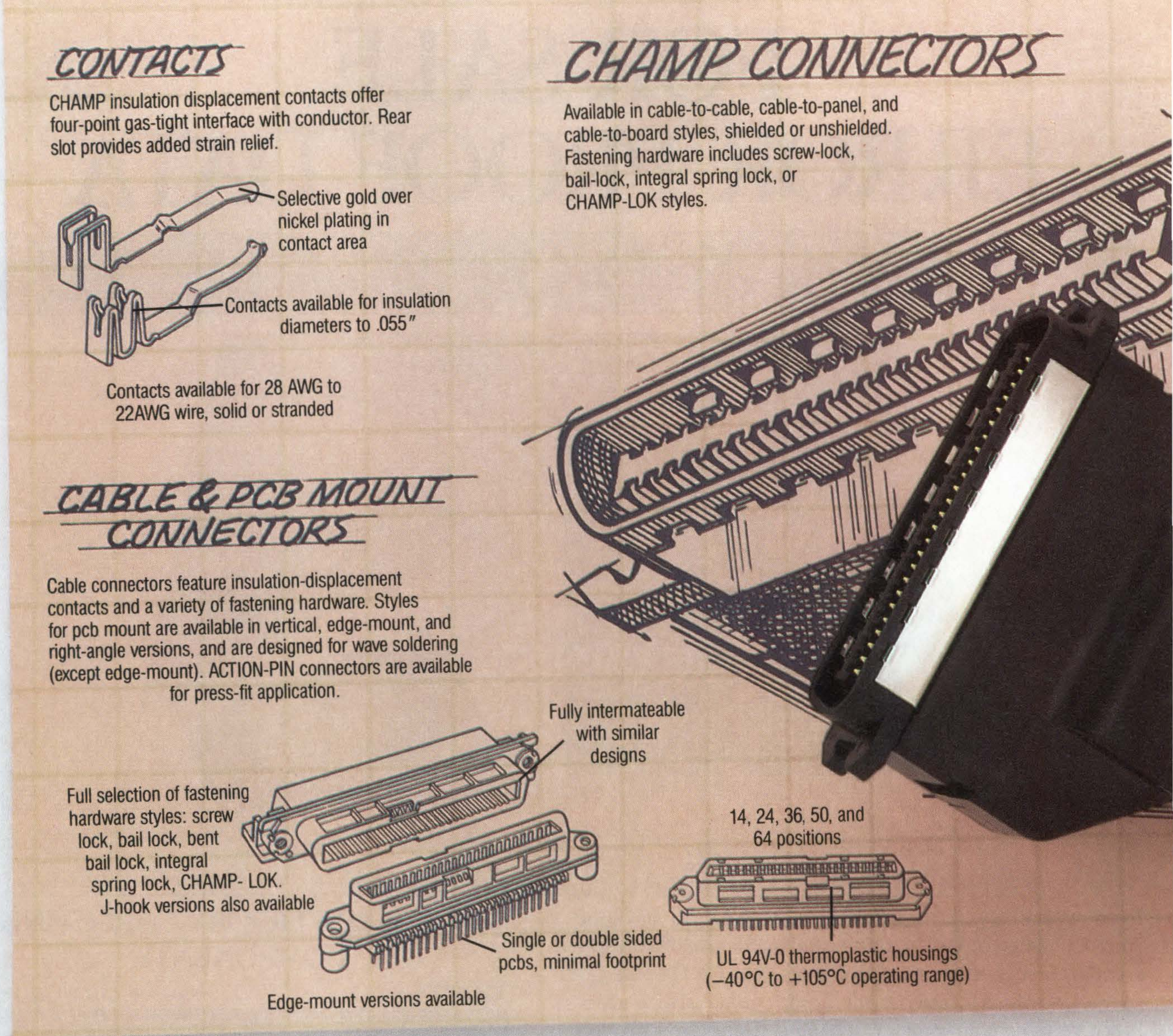
and

$$\tau'=\tau\sqrt{1+(C_L/C_T)},$$

where C_L is the total of all additional capacitive loading, and $C_T=C\times l=1/(v\times Z_0)$ is the total capacitance of the transmission line. For a typical bused signal $C_L/C_T=1.25$, Z_0 decreases by one-third, and τ increases by one-half.

References

References are at the end of Part 3.



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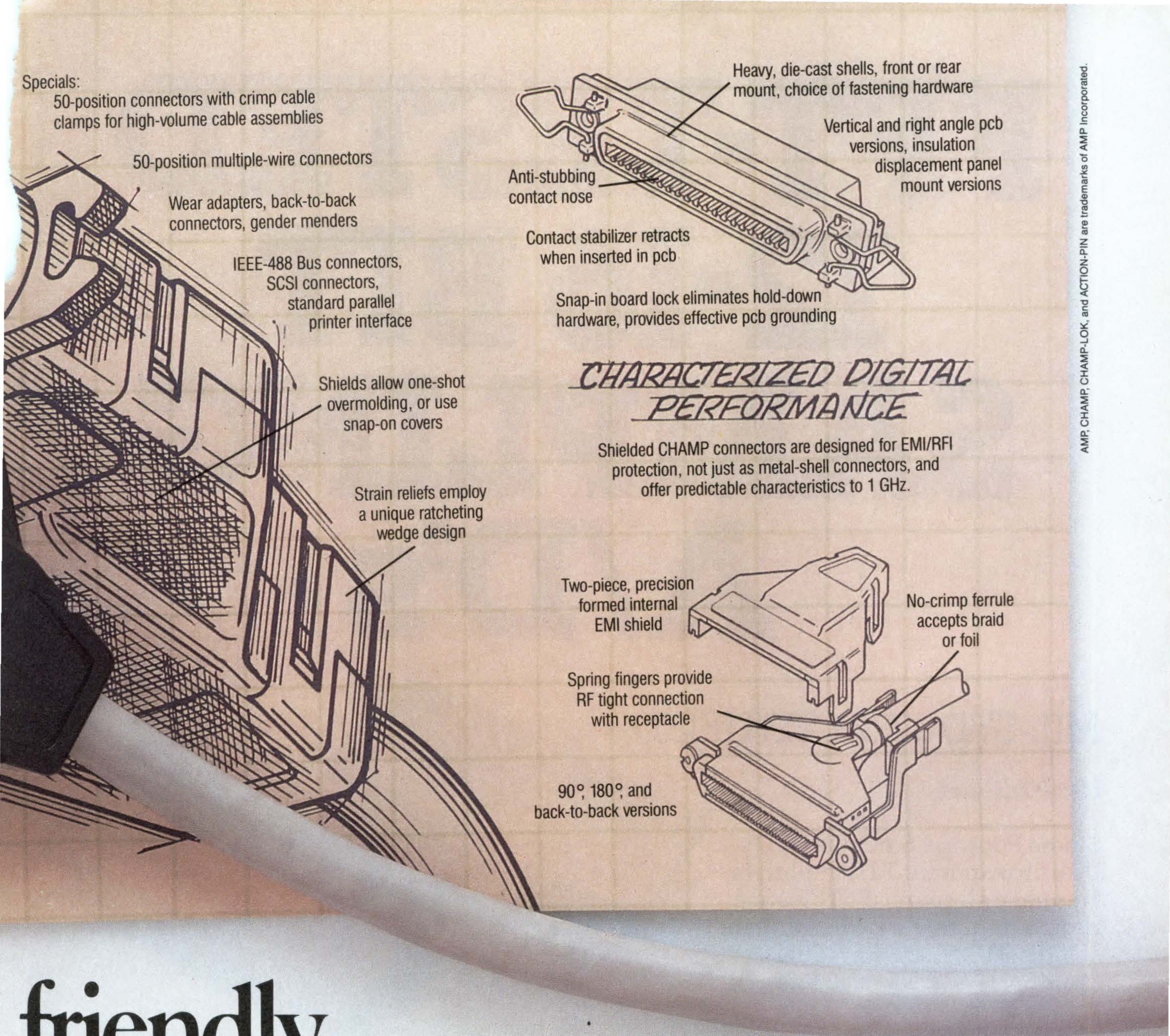

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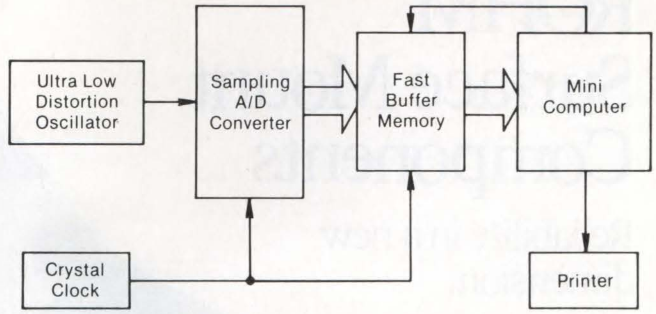
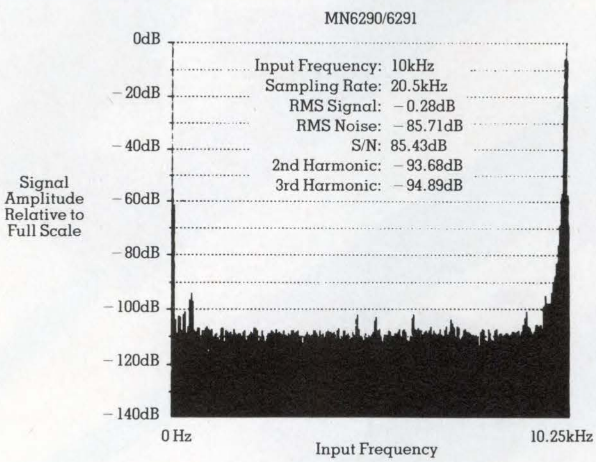
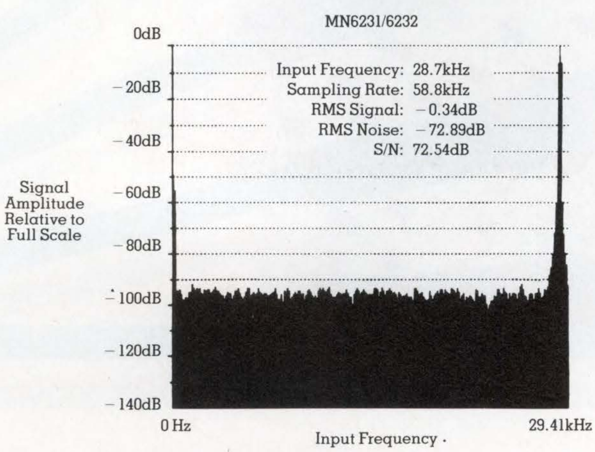


Frequency-Domain Testing of A/D Converters





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

1. Input bandwidth for which SNR and harmonic specs are guaranteed when sampling at the minimum guaranteed rate.
2. Signal-to-noise ratio (r.m.s. to r.m.s.) with full-scale (0dB) input.

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CIRCLE NO 105

DESIGNER'S GUIDE TO

TRANSMISSION LINES & INTERCONNECTIONS

PART TWO

Correct signal faults by implementing line-analysis theory

Once you've discovered transmission-line effects in your design, you must decide how to treat them. Part 2 offers some basic rules of thumb about when and how to deal with line effects that can degrade signals. In order to illustrate how transmission-line theory works, this second part also shows you how to compensate for impedance discontinuities in various circuits.

David Royle, *Litton/Amecom*

If, using the analysis discussed in Part 1, you discover your interconnection is really a transmission line, you can follow some general principles that can help you correct the problem: If standard guidelines exist, you should follow them; if they don't, you can either eliminate transmission-line effects entirely or design around them. But if you just try to ignore the problem, one of several things can go wrong.

For one thing, these line effects increase in magnitude as the ratio of the rise time to the propagation delay decreases below 8:1 (or as the ratio of the wavelength to line length decreases below 15:1). **Table 2** shows the percentage of signal overshoot at several t_R/τ ratios ranging from 1:1 to 8:1 in a system where R_S=5Ω, R_L=4.6 kΩ, and Z_0=75Ω **(Ref 4)**.

TABLE 2—EFFECT OF SIGNAL RISE TIME ON WAVEFORMS

t_R/τ	% OVERSHOOT AT R_L
1:1	87%
2:1	63%
3:1	30%
4:1	10%
6:1	5%
8:1	0%

Two additional effects involve impedance discontinuities: Occasionally excessive loading of the signal source occurs. Characteristic impedances of transmission lines are very low—usually less than 120Ω; line drivers must be able to drive these low impedances even if the receiver presents a lumped load of high impedance. In some cases, you can reduce loading by adding resistance in series with the source (this technique is also called backmatching). In other instances, you should select suitable drivers.

Other impedance discontinuities can also surface, and they generate reflections. From a frequency-domain viewpoint, reflections cause standing waves or amplitude modulation of the original signal. From a time-domain perspective, reflections increase such aberrations as ringing, overshoot, and undershoot; they can also make step functions turn into staircase signals. In either case, when reflections are severe enough, signals can violate system noise margins.

If a specific guideline exists for the particular hardware you're using (eg, 100K ECL) or for the data-transmission standard followed (eg, RS-232C), it supersedes the $t_R/\tau \geq 8$ or $\lambda/l \geq 15$ rules. For example, digital logic families tolerate limited levels of transmission line ringing, so you can relax t_R/τ ratios for logic as far as 3:1. Standard interfaces such as RS-232C and RS-422 also provide their own wiring rules.

In the absence of specific, established guidelines, you might want to redesign your system to avoid transmission-line effects in order to make the system's components conform to the time- or frequency-domain rules for lumped interconnections. These modifications may involve reducing cable lengths, increasing rise times, decreasing bandwidth, or increasing propagation velocity. In any event, they free you from having to deal with transmission-line equations, lattice diagrams, and

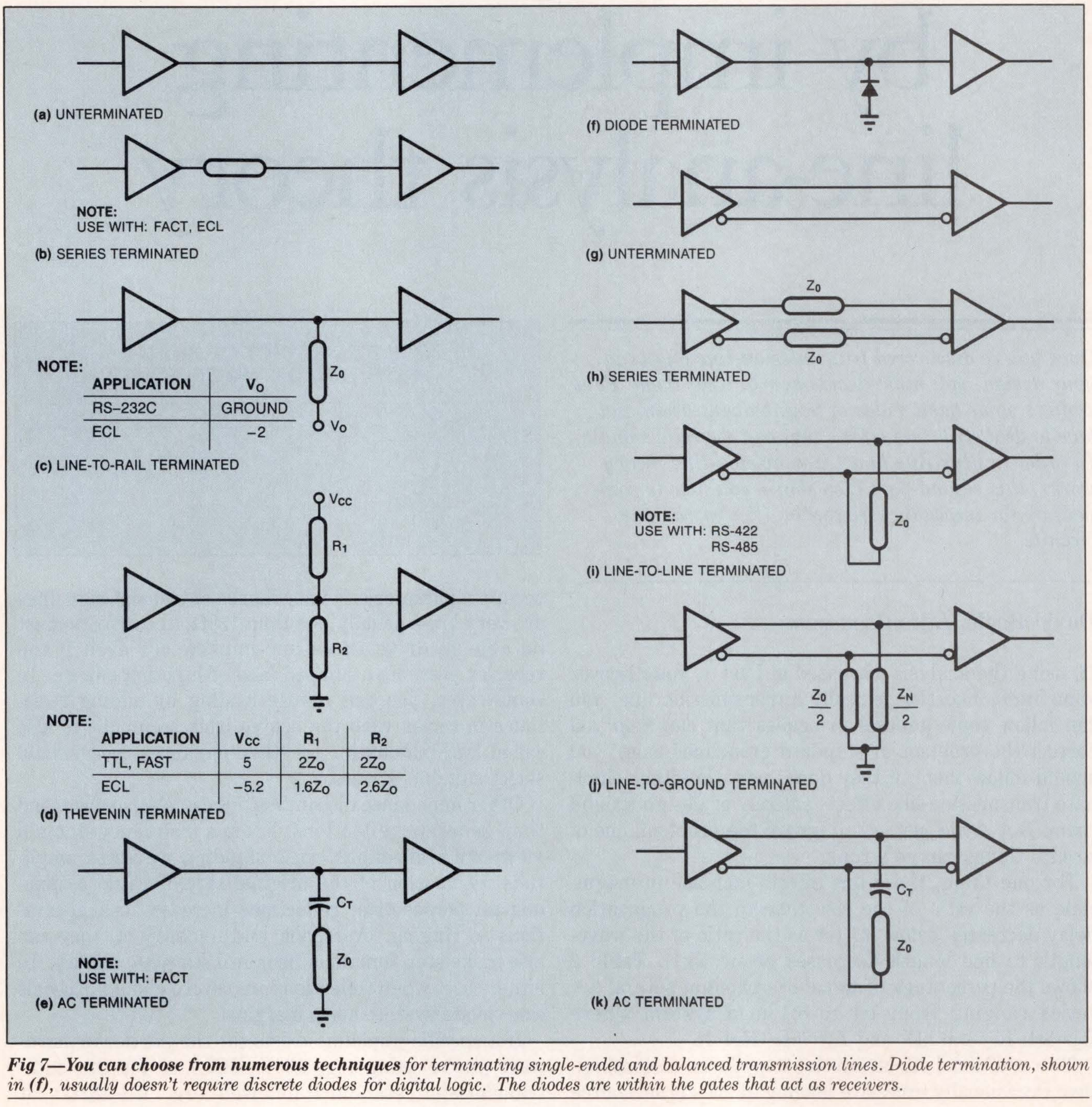


Fig 7—You can choose from numerous techniques *for terminating single-ended and balanced transmission lines. Diode termination, shown in (f), usually doesn't require discrete diodes for digital logic. The diodes are within the gates that act as receivers.*

Smith charts. What's more, these changes are frequently the most suitable solution to the problem.

Keep in mind that, in systems that use advanced-CMOS logic like FACT, your efforts to control bandwidth must not lengthen rise times to the point where they exceed the maximum specified for the device family. You must also make sure that the resulting signal delays are not excessive.

Analyze the transmission line

Of course, if you can't eliminate transmission-line effects (or you don't want to), you should apply transmission-line theory to ensure the proper operation of those circuits that drive or include transmission lines. Spice, a circuit-simulation program that is in the public domain, provides a powerful yet relatively easy-to-use tool for transmission-line simulation in both the time and frequency domains. The techniques that follow are for contending with impedance discontinuities and well illustrate how to implement transmission-line theory.

Termination methods vary with discontinuities

There are two types of impedance discontinuities: endpoint and stub. Endpoint discontinuities occur at the receiving end of a transmission line where the impedance changes from Z_0 to the load impedance, Z_L. You can minimize reflections from those discontinuities by using any one of several termination methods. **Fig 7** includes both single-ended lines and differential lines and illustrates the wide variety of termination methods available. Each has its advantages and limitations **(Ref 10)**.

One option is to leave the line, whether single-ended or differential, unterminated. You can use this alternative only after an analysis of transmission-line reflections indicates that an unterminated line will have no impact on the operation of the circuit. (Leaving a line unterminated can be a major omission, comparable to ignoring contact bounce in a mechanical switch.)

Series termination or backmatching introduces a signal onto the bus that is actually only half of the intended signal, so when the voltage doubles during reflection, the signal reaches the correct level. A properly terminated source absorbs the reflection after the round-trip propagation delay. A load located at the open end of the line sees only a single voltage step up to the full driver voltage. Unlike parallel termination, series termination adds no dc load to the drivers.

Any receiver placed along the length of a series-terminated line (that is, at locations other than the ends of the line) does not see the full signal level until the reflection from the load returns to their bridging points. The diminished signal amplitude severely reduces the bridging receiver's noise immunity for as long as 2τ. This complication restricts backmatching to receivers located at the end of the line opposite the driver. The FACT and ECL logic families commonly use this type of termination.

With parallel termination **(Fig 7c** and **Fig 7i,)** each receiver along the bus sees the full voltage swing produced by the driver; the driver's load is Z_0. When the wave reaches the line termination, the termination absorbs the wave, and the line current and voltage stabilize. The primary disadvantage of parallel termination is the power dissipated in the termination resistors.

In single-ended circuits, you can use a Thevenin-equivalent termination to provide a proper termination impedance with only half of the dc loading produced by a single Z_0 termination resistor **(7d)**. TTL circuits, especially advanced-Schottky families such as FAST, often use Thevenin-equivalent terminations. A common configuration terminates a line at the junction of a pair of 330Ω resistors that are connected in series between V_{CC} and ground **(Ref 11)**. With ECL, if you use line-to-rail terminations, you need a separate −2V supply, because an ECL output voltage is generally less than half the power-supply voltage. Often you can use Thevenin-equivalent termination to provide proper ECL termination from the −5.2V supply and thereby do away with the −2V supply.

Capacitor can prevent dc loading

In both single-ended and differential configurations, you can insert a capacitor into the parallel-termination network to prevent dc loading while providing a proper termination for the higher frequencies included in the wavefronts **(7e** and **7k)**. Such ac termination is popular for high-speed CMOS logic families where you desire low power consumption when idling. This type of termination works well with symmetrical data, such as a clock, or if the source resistance of the driver is very small compared with the Z_0 of the line.

Using ac termination is problematical because long strings of like bits cause the line and capacitor to charge to the maximum level of the driver's output voltage. Then a subsequent data bit of the opposite polarity takes longer than normal to cross the receiver threshold because it starts from a greater potential than normal. Consequently the recovered data exhibits time jitter that depends on the previous data pattern. For this reason, standard interface protocols (such as RS-422) do not generally recommend ac termination. You should always avoid ac termination when using current-mode drivers. In cases where you use ac coupling, you can derive the capacitance in one of two ways: For advanced CMOS (FACT), C is less than $\tau/2\pi$; typically, C is equal to 1 nF **(Ref 12)**. For differential line drivers and receivers, C is equal to $3\tau/Z_0$ **(Ref 13)**.

Line-to-ground termination reduces noise

For differential circuits, the line-to-ground termination **(Fig 7j)** is popular. Here the total termination, from line to line, is still Z_0. This configuration requires twice as much power from the drivers as does a line-to-line Z_0 termination **(Ref 14)**. However, in exchange for the increased power consumption, line-to-ground termination greatly reduces common-mode noise.

Time-varying magnetic fields induce a common-mode current in each line; this current in turn produces a common-mode voltage at the receiver equal to the product of the induced current times the resistance from the line to ground. (When the time-varying field surrounding an adjacent conductor induces the current, the problem is called crosstalk.) With line-to-line termination, the resistance from each line to ground is the large input resistance of the line receivers. As a result, magnetically induced common-mode voltages can also be large. In the line-to-ground configuration, line-to-ground resistance is $Z_0/2$ or typically 50Ω. Compared with line-to-line termination, line-to-ground termination's low common-mode resistance greatly reduces the levels of common-mode noise. Line-to-ground termination is mandatory when using current-mode drivers because each output must have a dc path to ground.

Diode termination uses clamp diodes to control ringing overshoots by clamping signal waveforms at strategic thresholds **(Ref 6)**. TTL families use this technique to prevent negative-voltage undershoots after transitions from logic 1 to logic 0. Gate schematics show these clamp diodes between each input transistor and ground **(Fig 7f)**.

A stub is a transmission-line appendage on an otherwise-ideal transmission-line bus. Either the bus or the stub can be the source of the signal. Stub discontinuities occur when a signal traveling along a transmission line encounters a junction with other transmission lines. You can't eliminate reflections from these branching points by using conventional termination methods, so this type of discontinuity is quite difficult to deal with; there are, however, some ways to design around them.

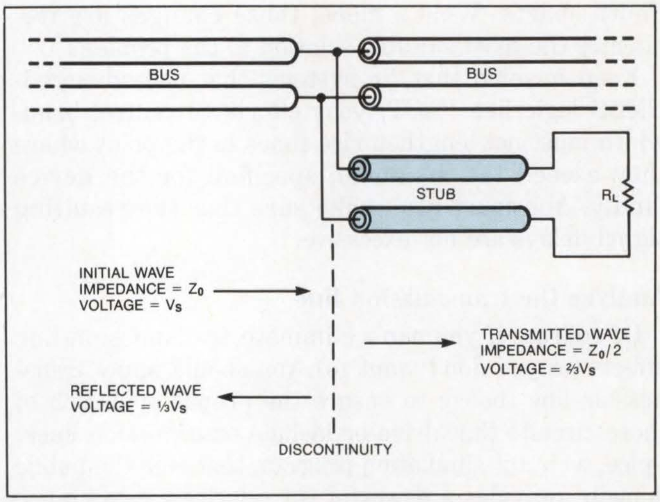


*Fig 8—**Without the use of matching transformers,** stubs often present intractable reflection problems. The best advice is to keep stubs short.*

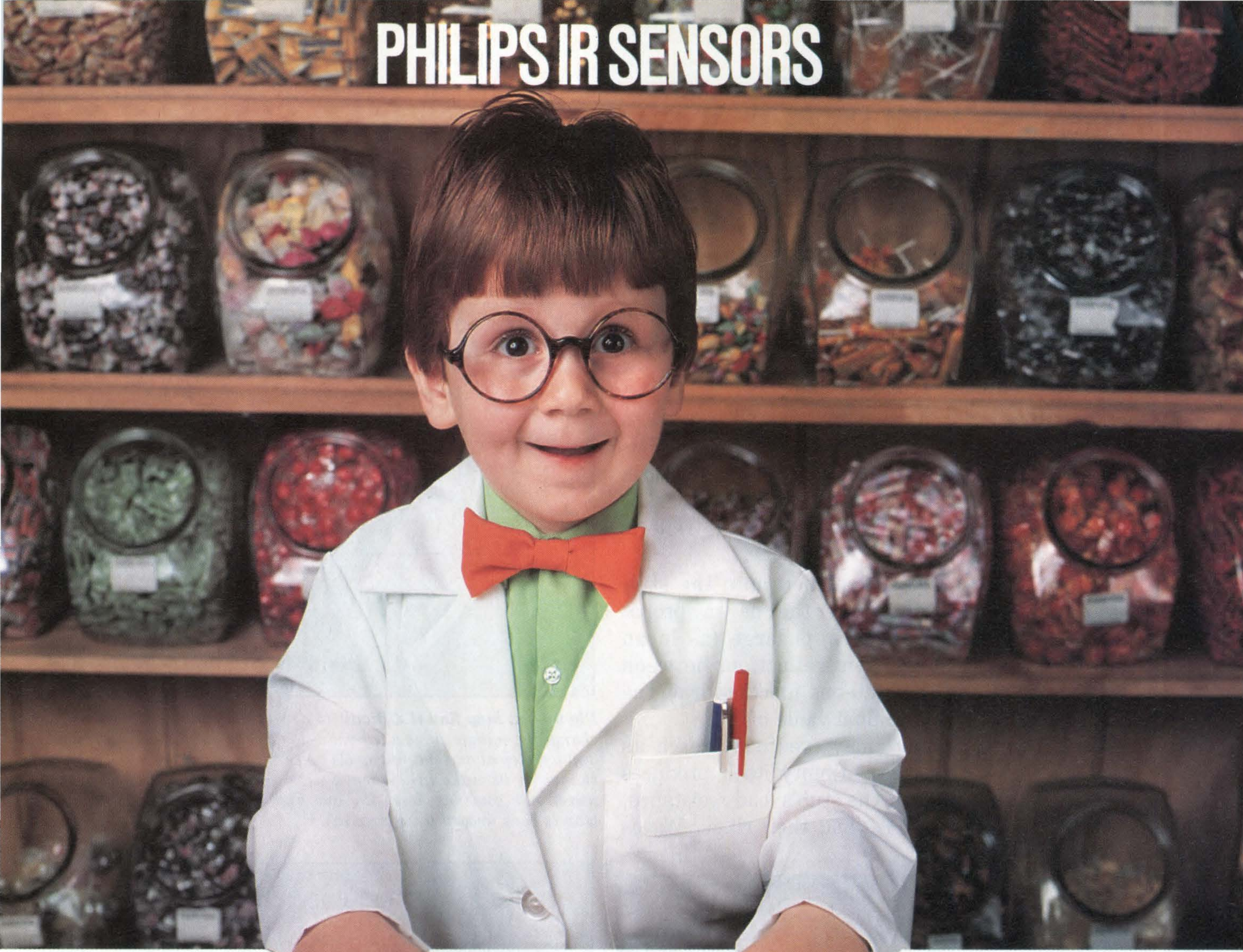
In **Fig 8**, both the bus and the stub are initially uncharged as a signal travels toward the bus-stub junction and leaves a voltage (V_S) on the bus. The stub and the continuation of the bus—the wavefront sees them in parallel—produce an impedance at the stub discontinuity of $Z_0/2$ and a reflection coefficient at the junction equal to

$$R = \frac{(Z_0/2) - Z_0}{(Z_0/2) + Z_0} = -\frac{1}{3}$$

As the reflected wave of magnitude $-⅓V_S$ travels back toward the source, the total voltage on the line at the discontinuity equals the voltage in the incident wave plus the voltage in the reflected wave:

$$V_S + (-V_S/3) = ⅔V_S.$$

Fig 9 shows how the reflection occurs at the stub. Initially, the wave approaches the stub discontinuity and deposits a voltage V_S on the bus **(9a)**. In the absence of discontinuities, it moves along until it reaches a properly terminated endpoint and leaves a voltage, V_S, along the length of the bus. However, when the wavefront reaches the stub discontinuity, the voltage on the bus drops to ⅔V_S **(9b)**. Wavefronts continue to the right down both the stub and the bus leaving ⅔V_S on each. Furthermore, a reflected wave travels back toward the source and subtracts $1/3V_S$ from the



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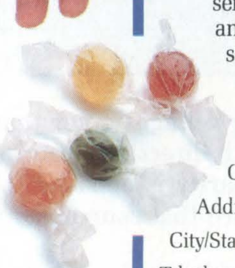

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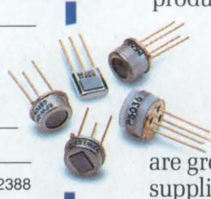

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bus voltage. The resulting voltage moving forward on the bus is $\frac{2}{3}V_S$.

Power is split between stub and bus

The power associated with each wave is equal to $V^2/\dot{Z}_0$. The transmitted power is split between the bus and the stub as shown in **Table 3.** Of the total power in the incident wave, $\frac{4}{9}$ of it continues along the bus, $\frac{4}{9}$ travels down the stub, and the remaining $\frac{1}{9}$ reflects back to the source.

In **Fig 8**, the $\frac{2}{3}V_S$ wave launched onto the stub encounters the termination R_L after the one-way propagation delay of the stub. If R_L is large (as in an unterminated stub), subsequent reflections between the stub endpoint and the stub-bus junction draw the signal voltages closer to the final value of V_S.

Although the bus voltage may eventually reach its normal value of V_S, the discontinuity itself produces three effects: The voltage at the stub's load resistance, R_L, first overshoots (to $\frac{4}{3}V_S$) and then rings. Waves containing voltages other than V_S propagate along the bus in both directions, causing noise. Finally, a wave, whose polarity is opposite that of the source, reflects back toward that source and reduces the signal's noise margin.

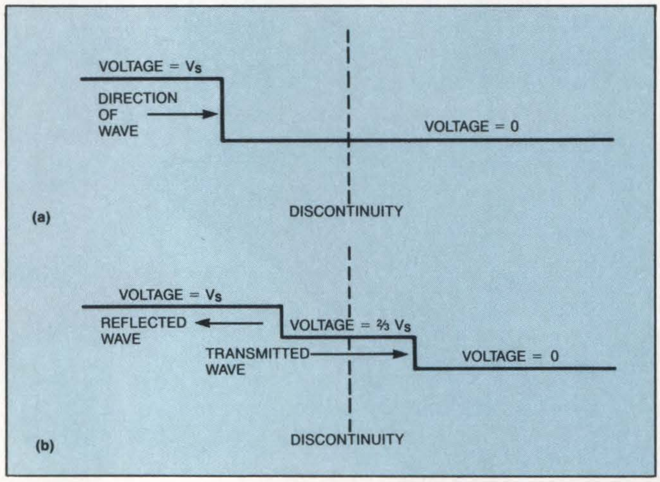

*Fig 9—**You may find it difficult to accept** the notion, but you can't change the voltage along a transmission line instantaneously. If you apply a step at one end, it travels down the line and leaves a voltage change in its wake* ***(a)****. When a wave encounters a discontinuity, wavefronts continue down the bus and the stub, and a reflection travels back toward the source* **(b).**

TABLE 3—DISTRIBUTION OF WAVE ENERGY

POWER OF INCIDENT WAVE	V_S^2/Z_0	P_{tot}
POWER OF REFLECTED WAVE	$V_S^2/9Z_0$	$P_{tot}/9$
POWER OF TRANSMITTED WAVE ON BUS	$4V_S^2/9Z_0$	$4P_{tot}/9$
POWER OF TRANSMITTED WAVE ON STUB	$4V_S^2/9Z_0$	$4P_{tot}/9$

Note that ordinary termination methods are useless against stub discontinuities because the reflection occurs at the junction rather than at an endpoint. Suppose, for example, that the stub in **Fig 8** were properly terminated (that is, $R_L=Z_0$). After the reflection of the initial wave at the stub, no further reflections would arise, and the voltage on the bus and stub would arrive at a final value of $\frac{2}{3}V_S$, a 33% loss in signal voltage.

Whenever possible, rather than designing around stub discontinuities, it's best to simply eliminate them: If the signal rise time, t_R, is sufficiently long compared to the one-way delay along the stub, no degradation occurs. With an 8:1 t_R/τ ratio along the stub, the stub becomes just a small capacitive load rather than a point

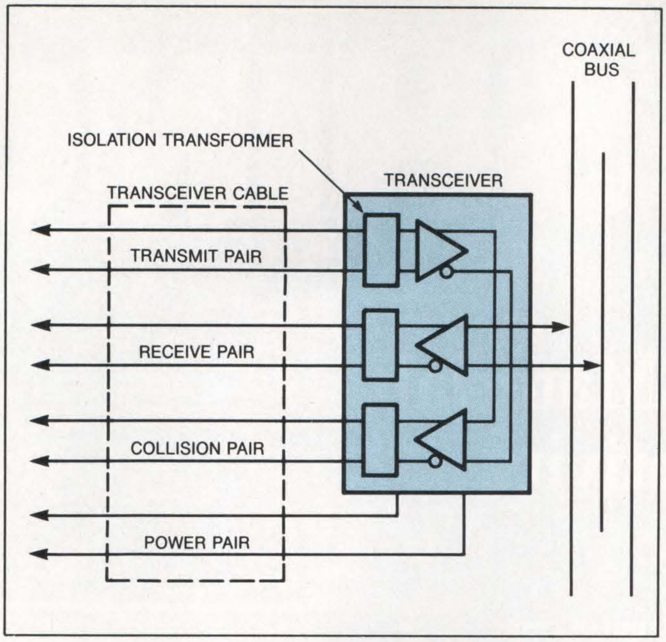

Fig 10—Ethernet is an example of a bus system *that looks as if it could have problems with stubs. In fact, the active transceivers hold stub length effectively to zero.*

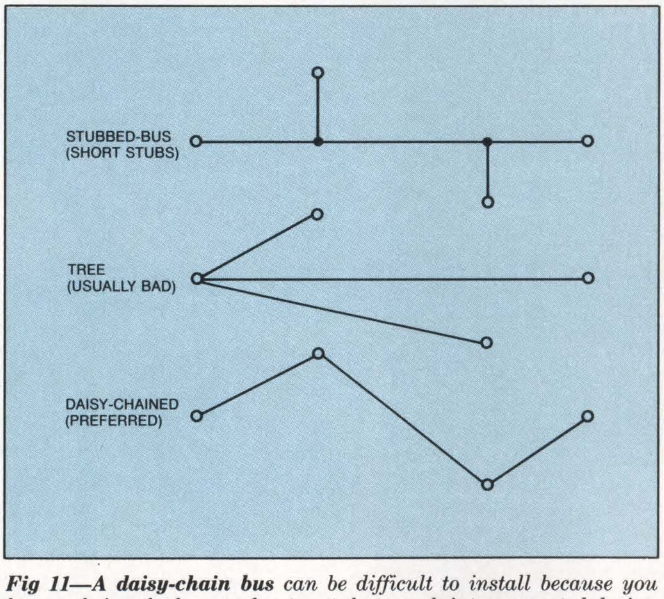

Fig 11—A daisy-chain bus *can be difficult to install because you have to bring the bus, and not a stub, to each interconnected device. Electrically, though, the daisy-chain configuration presents the fewest complications.*

of discontinuity. Ethernet uses this short stub length approach: A typical Ethernet bus may contain as many as 100 taps for what appear to be 50-ft stubs. Each stub, however, connects to the bus via an active transceiver that contains a small pointed probe. This probe pierces the side of the cable and touches the center conductor, providing a physical connection to the bus through virtually zero stub length **(Fig 10** and **Ref 15.)**

The second method of dealing with stubs uses transformer coupling at the bus-stub junction. It's complicated and generally not suitable for simple interconnections. Through the use of special (and expensive) pulse transformers, for example, the MIL-STD-1553 avionics bus used in the space shuttle allows t_R/τ ratios along stubs as low as 3:1 **(Ref 16).**

Fig 11 illustrates interconnection rules for pc boards and for networks with standard interfaces, such as RS-232C and RS-422. These rules were adapted almost entirely from RF design. You should avoid any configuration that consists of several transmission lines joined together. Instead, choose a daisy-chained single transmission line. The tree configuration is usually bad unless you place all drivers at the hub. If the number of branches is large, the drivers must supply current to the very low impedance of the parallel combination of transmission lines. In the stubbed bus, you must control the length of stubs so that $t_R/\tau \geq 8$. The expensive exceptions to this rule require carefully designed pulse transformers or impedance-matching transformers at the bus-stub junctions. **EDN**

References

References are at the end of Part 3.

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CIRCLE NO 147

DESIGNER'S GUIDE TO

TRANSMISSION LINES & INTERCONNECTIONS

PART THREE

Quiz answers show how to handle connection problems

In answering the questions posed in Part 1, this third and final part of the designer's guide applies the techniques described in Parts 1 and 2 to some practical examples. You may be surprised to discover that not all high-speed local-area networks act as transmission lines. What's more, the presence of a transmission line can occasionally simplify solving system problems that would be even more intractable in otherwise similar lumped-parameter networks.

David Royle, *Litton/Amecom*

Now you can apply the transmission-line methodology to the quiz problems that were posed in Part 1.

• Problem 1

The physical layer of a local-area network consists of 19.2k-baud modems interconnected as shown in **Fig 1,** pg 132. The carrier frequency is 200 kHz; 50Ω RG-22 coaxial cable connect the modems together. Are bus terminations required? Should you use impedance-matching transformers at the cable junctions?

First, assume that the bandwidth of the signal, f_{max} is equal to the carrier frequency of 200 kHz (this assumption implies quite accurately that the modulating signal frequencies are low compared with 200 kHz). If you use the steps outlined in the methodology for the frequency domain, you obtain the following values: The velocity of propagation *(v)* for RG-22 cable is 0.7c, or 0.7×10^9 ft/sec. The maximum interconnection length from transmitter to receiver *(l)* is 24 ft. The signal wavelength (λ) is equal to v/f_{max}, or 3500 ft, which makes the ratio of the wavelength to the line length 146:1.

Because this ratio is greater than 15, you don't have to apply transmission-line techniques nor do you have to terminate the line. If you use a low-impedance source ($Z_S<Z_0$) and a high-impedance load ($Z_L>Z_0$), the interconnection is ideal, and you can safely ignore it. Finally, adding impedance-matching transformers at the cable junctions is both costly and unnecessary.

• Problem 2

A miniature reed relay energizes the coil of a larger 48V relay as shown in **Fig 2,** pg 132. The reed relay has a contact rating of 10 VA and a contact resistance of 0.2Ω. The coil resistance of the 48V relay is large and includes the usual diode protection. Approximately 20 ft of 100Ω twisted-pair cable with a capacitance of 20 pF/ft connects the relays. The contacts cycle on and off once per sec with a 50% duty cycle. Can you identify any transmission-line problems?

This configuration illustrates what happens when you use a resistor to short out one end of a charged transmission line—a textbook case **(Fig 12.)** The voltage across the reed-relay contact falls from 48 to 0V almost instantaneously. The rise time is so short that almost any length of cable becomes a transmission line. In this case, it's appropriate to assume that the falling edge is an ideal step function. Because of the brief rise

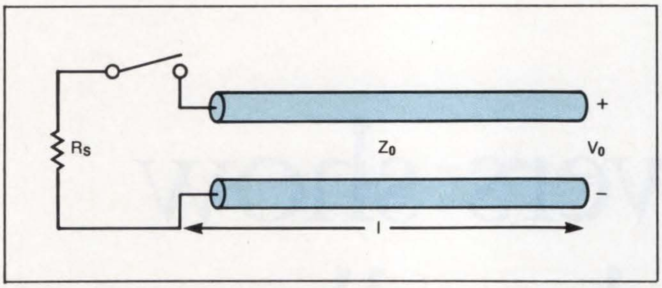

Fig 12—When the reed relay of Problem 2 closes, it shorts out the charged transmission line. The results are not the same as you would observe if you shorted out an equivalent lumped capacitor.

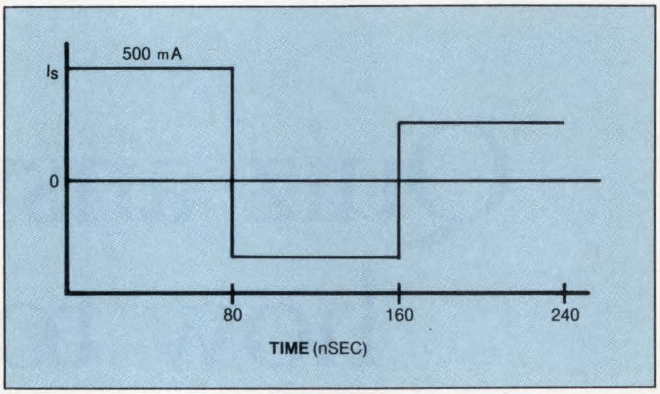

Fig 13—As a wave travels back and forth along an improperly terminated line, current polarity reverses. If there are any losses in the system, the oscillations eventually decay to zero. The losses determine the rate of decay.

time, you can identify a transmission line in this design without having to follow the identification methodology of Part 1.

To correct the problem, you can do one of two things: Either adjust the circuit to lengthen the rise time or analyze the circuit for transmission-line effects. If you want to adjust the circuit, you need to increase the rise time to 320 nsec or more (if the one-way delay is 40 nsec, then 8 times that delay is 320 nsec).

In order to analyze the circuit, you need to know the following values:

$C = 20$ pF/ft
$Z_0 = 100\Omega$
$v = 1/CZ_0 = 0.5$ ft/nsec
$l = 20$ ft
$\tau = l/v = 40$ nsec
$V_O = 48V$
$R_S = 0.2\Omega$ (contact resistance).

V_S is the voltage across R_S; I_S is the current through R_S and through the relay contact.

Using transmission-line theory **(Ref 7,)** you can calculate that just after contact closure:

$$V_S=V_OR_S/(R_S+Z_0) \quad (1)$$

and

$$I_S=V_O/(R_S+Z_0). \quad (2)$$

These two equations allow you to recognize that a charged transmission line behaves like a voltage source in series with a resistance of Z_0. Using **Eq 1** and **Eq 2,** you can calculate that V_S equals 100 mV and I_S is 500 mA.

V_S and I_S not only represent the voltage across the contacts and the current through them just after contact closure; they also indicate the voltage and current introduced into the transmission line in the form of a wave: The cable initially contains a voltage of V_O and a current of 0A prior to the contact closure, but as the wave travels down the transmission line at the speed v, it leaves on the line in its wake a voltage of V_S and a current of I_S. As the wave reflects back and forth between the open end and the contact, the current through the contact surges back and forth as shown in **Fig 13.** Damping of the reflections is proportional to R_S and to cable resistive losses, both of which are quite small.

Contact rating can be key

The contact rating in volt-amperes (VA) is the product of the voltage across the contacts just before closure and the current through the contacts just after closure:

$$V_O \times I_S=48V \times 500 \text{ mA}=24 \text{ VA}.$$

This value exceeds the relay's 10-VA specification; in fact, 24 VA fuses the contacts and causes the relay to fail. This example indicates excessive source loading, even though you don't normally consider the reed-relay contacts to be a source.

Two modifications to the circuit in Problem 2 are thus possible: You could use a reed relay with a 24-VA contact rating (the system designers had originally rejected such relays because of cost). Or, you could limit the switching current by adding resistance in series with the reed-relay contact as shown in **Fig 14.**

With 48V switching voltage and a 10-VA rating, the maximum switching current allowable is 10 VA/48V, or

200 mA. By using **Eq 2** where

$$I_S = 200\ \text{mA}$$
$$V_O = 48V$$
$$Z_0 = 100\Omega,$$

you can calculate that

$$R_S=(V_O/I_S)-Z_0=(48/0.2)-100=140\Omega.$$

Adding 140Ω in series with the contact limits the switching current to 200 mA. Naturally, you can derate the contact by increasing the series resistance as long as you keep that resistance small in relation to the coil resistance. This backmatching is inadequate for eliminating reflections because Z_0 is 100Ω. If R_S were 100Ω, reflections would cease after the first round trip. However, a 100Ω R_S would still produce excessive loading of the relay contact. Given the slow duty cycle of operation (½ sec on, ½ sec off), damping provided by the 200Ω source resistance is more than adequate.

Don't overestimate switching current

Note that you can't model the transmission line as a lumped capacitance of $C\times l=400$ pF that discharges from 48V through the 0.2Ω contact resistance. Such an assumption would lead to a grossly overestimated switching current of 48V/0.2Ω, or 240A. This switching-current calculation shows that, on rare occasions, the presence of a transmission line actually simplifies a design problem.

• Problem 3

The physical layer of a T1 digital-voice bus uses RS-422 (5V differential mode) as shown in **Fig 1**, pg 132. A 120Ω twisted-pair cable connects the drivers

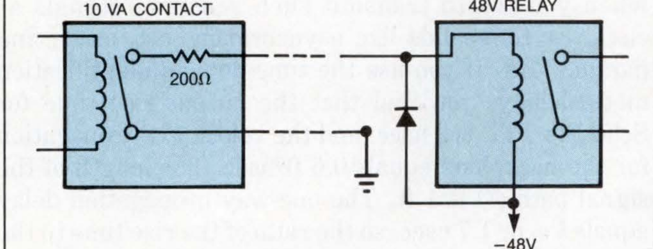

***Fig 14—Adding a 200Ω resistor** to the circuit of Problem 2 limits the current through the reed-relay contacts to about 200 mA. You still have to select a reed relay that can handle the energy delivered by the charged transmission line.*

and receivers. The bus signals exhibit significant ringing and poor noise margins. What is the problem and where might you include terminations?

Although superficially rather innocent, this bus arrangement suffers from a number of problems, including stub discontinuities, which render it very unreliable. To analyze the circuit, start with the transmission-line identification methodology for the time domain: The 10%-to-90% signal rise time of 26LS31 drivers is 20 nsec. The equivalent 0%-to-100% rise time, t_R equals 25 nsec. The velocity of propagation, v, is 50%c, or 0.5 ft/nsec. The maximum path length, l, equals 6×4, or 24 ft. The one-way propagation delay, τ, equals 48 nsec, so the ratio of the rise time to propagation delay ratio is 0.52:1.

Because this ratio is much less than 8:1, you can certainly expect to observe transmission-line phenomena. The 25-nsec rise time corresponds to a frequency bandwidth of 0.56/(25 nsec), or 22.4 MHz, which is high enough to warrant special precautions in a sinusoidal-RF application. Too often, unfortunately, designers of digital interfaces neglect these precautions even though the information processed by their circuits contains high frequencies that call for special care.

Try standard guidelines

Obviously, to correct these transmission-line effects, you want to try to conform to guidelines for RS-422. Whenever you use such an industry-standard configuration, you should consult the published guidelines on that subject. The RS-422 standard allows only two options: line-to-line termination or no termination **(Ref 17)**. RS-422 drivers do not have the surplus drive capability to accommodate line-to-ground termination, and the high source impedance (typically 100Ω) of the drivers can introduce output jitter when driving an ac termination.

In deciding when termination is necessary, RS-422 specifies that the ratio of t_R to τ should be 4:1: "Reliable operation of the circuit is not sensitive to the presence or absence of the cable termination at lower speeds (below 200k bits/sec) or at any speed where the signal rise time at the load end of the cable is greater than 4 times the one-way propagation-delay time of the cable." Since the ratio of t_R to τ is 0.52, you certainly need terminations. But the real questions are how many do you need and where.

In RS-422A section 4.2.7, as illustrated in **Fig 15,** the guideline states that RS-422 networks each include one driver located at one cable endpoint, as many as 10

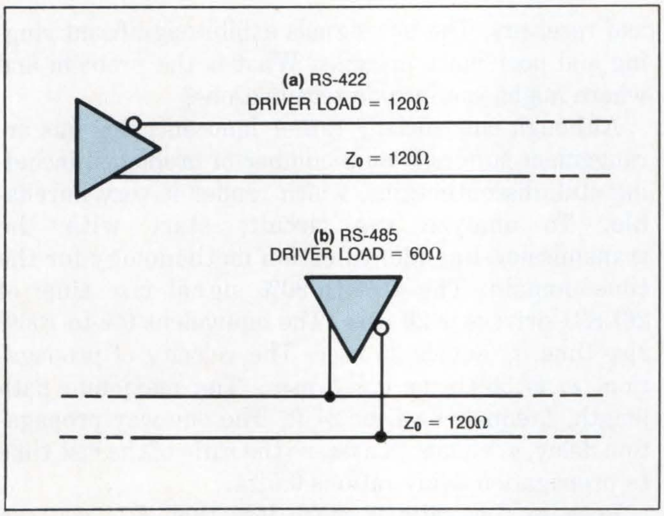

Fig 15—An RS-422 driver (a) can handle the load imposed by driving a line from one end, but it can't drive the lower impedance it sees when it has to drive a line from a tap in the middle. An RS-485 driver (b), can drive a line from a tap.

receivers, and one optional termination resistor of at least 120Ω at the other endpoint. The driver's loading limitations allow only one termination resistor, but you have six cable endpoints. Because RS-422 allows only one driver, the network is clearly outside the scope of that interface standard, even though the original question tells you to use RS-422. Solving the problem therefore requires the use of some other standard.

Compare RS-485 with RS-422

The more recent RS-485 interface is similar to RS-422 but includes additional features for multidrop applications that use multiple drivers and receivers **(Ref 18).** RS-485's maximum allowable driver load consists of 60Ω of cable impedance plus 32 receivers. Its drivers can therefore drive two parallel 120Ω cables **(Fig 15).** A 120Ω cable, when not driven from its endpoint, represents a load of 60Ω. Because two transmission lines operate in parallel, a signal generates two separate wavefronts, one traveling in each direction. Per RS-485, you can place terminations at each end of the resulting bus. (Hardware that complies with RS-485 has made possible LAN-type arrangements of differential drivers and receivers, like Intel's Bitbus.)

To solve Problem 3, you must also decide how to handle reflections from the unterminated receiver endpoints as well as how to treat reflections that arise from the stub discontinuities at the points where the bus joins the 6-ft receiver stubs.

The EIA RS-422A standard states: "The final ingredient in the cable-characteristics determination is the length needed to interconnect all parties in the multipoint system. This length is the total length of cable you need to interconnect everything without using stubs." The RS-485 standard also rules out stubs: "The guidelines assume length of stub to be effectively zero" (effectively zero means that the stubs are not transmission lines but are simple wire interconnections, or in time-domain language, $t_R/\tau \geq 8$).

Analysis of driver reveals stub length

If you choose Texas Instruments' SN75176 RS-485 driver and apply the transmission-line identification methodology once again, you find that: The output rise time of SN75176 drivers is 50 nsec (10%-to-90% specification), which is slower than the 26LS31's rise time. The equivalent 0%-to-100% rise time for the SN75176 is 62 nsec. The velocity of propagation *(v)* equals 50% of c, or 0.5 ft/nsec. The maximum path length, *l*, is the dependent variable. The one-way propagation delay (τ) is $l/0.5$ (nsec). The ratio of rise time to the delay ratio, $t_R/\tau=8$; so $62/(l/0.5)=8$, or $l=3.9$ ft. In other words, the limit on stub length is 3.9 ft.

To summarize, then, the Problem 3 configuration requires several modifications: You must replace the RS-422 drivers and receivers with RS-485 drivers and receivers. You must also terminate each end of the bus with 120Ω. Finally, reroute the bus to maintain stubs at lengths of less than 3.9 ft. **Fig 16** illustrates the desired configuration.

• Problem 4

A 1-foot backplane interconnects a pair of 74S00 Schottky-TTL NAND gates as shown in **Fig 3, pg 132.** Are transmission-line effects important?

This interconnection seems rather harmless, but it is subject to reflection and crosstalk problems—especially when you try to transmit such sensitive signals as clocks or commands like asynchronous set, clear, and parallel load. If you use the time-domain identification methodology, you find that the output rise time for Schottky TTL is 2 nsec, and the velocity of propagation for the backplane equals 0.6 ft/nsec. The length of the signal path *(l)* is 1 ft. The one-way propagation delay equals l/v, or 1.7 nsec, so the ratio of the rise time to the propagation delay equals 1.2:1. Because t_R/τ is less than 8, the signal path will exhibit transmission-line behavior.

To correct the design, you ought to consider the standard guidelines for the logic family (see **Table 1,** pg

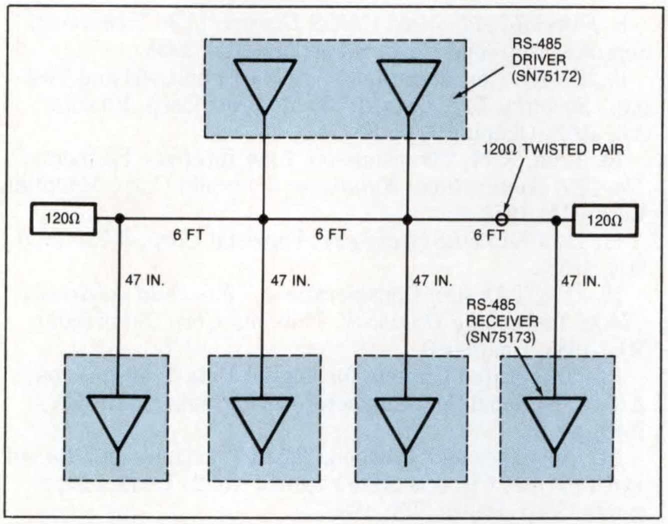

***Fig 16—Reconfiguring the bus** of Problem 3 by shortening the stubs from 6 ft to a little less than 4 ft, changing the drivers and receivers to RS-485-compatible ones, and selecting 120Ω terminators produces reliable operation.*

134). Inherent noise margins and the use of clamp diodes on inputs allow digital logic to accommodate some degree of transmission-line activity without performance degradation.

Digital-logic wiring rules aid in redesign

Almost every recently published manufacturer's data book includes the same basic wiring rules: Unterminated-interconnection distances correspond to t_R/τ ratios of 2:1 to 4:1, where 4:1 is the more conservative figure and 2:1 is generally too liberal **(Ref 4, 6, 8, 9,** and **19** through **23).**

In some cases, particular specifications can initially deceive you. Motorola's *MECL System Design Handbook*, for example, specifies the wiring rule as: $l_{max}=(t_R/2\tau$, which might seem too liberal. But the handbook gives the rise time from 20% to 80%. If you multiply the rise time by 1.67 to obtain the equivalent 0%-to-100% ramp time, you have $t_R/\tau=3.3:1$, which is relatively conservative.

In addition to minimizing transmission-line behavior, keeping t_R/τ large also greatly reduces crosstalk between signals. The 1-ft interconnection of Problem 4, with t_R/τ equal to 1.2, violates even the most liberal wiring rules; it's a noisy interconnection. Solutions include shortening the interconnection, using a Thevenin-equivalent termination, or replacing the Schottky TTL with devices using an alternate logic family that exhibits slower rise time (pin-compatible ALS(TTL) or LSTTL are good choices). If the signal carried by the 1-ft interconnection is sensitive to noise (like a μP interrupt line), you may have to redesign the interface using twisted-pair cable and/or line drivers and receivers.

Table 1, pg 134 provides the maximum unterminated interconnection lengths: For both ALS and LSTTL, if t_R/τ equals 4, the maximum length is 14 in. Limiting the interconnection length in this way frees you from the chore of treating each signal path as a transmission line and is convenient on backplanes and on pc boards without ground planes.

You can use interconnection lengths greater than those indicated in **Table 1,** but only if you treat the paths as transmission lines and design accordingly. A notable example is the IEEE-488 bus, which interconnects TTL-level signals through ribbon cables as long as 20m. The IEEE-488 bus is terminated using the Thevenin-equivalent method **(Ref 24).**

If you try to solve transmission-line effects during the process of designing your system, chances are you'll save time or money or both. If you avoid identifying potential transmission lines and dealing with their effects by designing in blanket overcompensations, your final design will probably cost more than it should. On the other hand, if you simply try to ignore the issue altogether, there's a good posssibility your design just won't work. Intermittent, elusive problems will more than likely plague your system, and those problems take time to find and more time to correct. Generally, such failures don't even surface until late in the production cycle, which can make your return to the drawing board very painful indeed. **EDN**

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Thomas J Dahlin and Marc L Denis,
Honeywell Ordnance Div

To connect nonstandard system components to a MIL-STD-1553 system, such as the systems used in land combat vehicles, you can choose either to build a nonstandard interface or to adapt the nonstandard equipment to MIL-STD-1553. Nonstandard interfaces would prove troublesome for a system that includes several different types of non-1553 equipment, because upgrading the system or integrating new equipment in it would be difficult. If you adapt all the equipment to the 1553 standard, however, you can easily upgrade the system capabilities or integrate new equipment in the system.

For non-1553 equipment whose communication requirements are substantially lower than the 1M-bps data rate specified by MIL-STD-1553, the universal 1553 adapter shown in **Fig 1** solves the compatibility problem. Equipment such as military radios and printers operates at data rates from 300 to 9600 baud, which is well within the adapter's capabilities. When operating at these lower speeds, the adapter's microcontroller can manage the traffic on the 1553 bus and also perform any data-formatting, type-conversion, and protocol-conversion tasks the host requires.

The universal 1553 adapter in **Fig 1** comprises a commercially available single-board computer—Binary Technology's (Meridian, NH) Sibec-51—and a custom 1553 I/O board. The single-board computer contains an Intel 8031 microcontroller and an EPROM programmed with a version of Tiny Basic. Equipment that doesn't have a standard 1553 interface can connect to the single-board computer's serial (RS-232C) and parallel ports.

The Sibec-51 has four 28-pin JEDEC sockets for storing as much as 64k bytes of program memory. The Tiny Basic EPROM and a debug monitor are installed in one of these sockets. In addition, the board comes with 2k bytes of static RAM (it's expandable to 8k bytes) and two unpopulated sockets. The custom-designed 1553 interface board connects to the SBC through a 40-pin expansion connector. The connector, which is designed for memory expansion, provides access to the address, data, and control lines on the single-board computer.

You'll find the onboard Tiny Basic EPROM and monitor quite handy when you're initially designing and debugging the interface. For example, if you connect the single-board computer to a personal computer via

The MIL-STD-1553 bus provides a flexible method of interconnecting various military equipment.

its RS-232C port, you can edit and assemble programs using a PC-based 8051/8031 crossassembler. Downloading the programs to the single-board computer is a straightforward operation. Tiny Basic lets you enter and change test routines in an interactive manner without having to reassemble the code between alterations.

A 1553 controller performs most of the tasks

The 1553 I/O board (**Fig 2**) contains a 1553 controller (the CTI-1606 remote-terminal hybrid from Circuit Technology Inc of Farmingdale, NY), which handles MIL-STD-1553's timing requirements and low-level protocol sequence. The hybrid device contains five LSI chips in a 90-pin package measuring 2.4×1.6 in. The hybrid automatically recognizes its terminal address, performs error-checking functions, and decodes the command words from the 1553 bus to determine the correct response. The controller interfaces to the 1553 bus through the CTI 1487D dual 1553-bus driver and receiver. You use dual isolation transformers to connect the I/O board to the bus.

The CTI-1606 uses direct memory access (DMA) to control data transfers between the I/O board and the single-board computer. This transfer must take place through a buffer memory, however, because the single-board computer can't relinquish control of the data and address lines during DMA. The buffer memory, an IDT-7132, is a 2k×8-bit dual-ported memory located on the interface board. One of the ports connects to the 1553 controller and appears to the controller to be a DMA interface. The other port connects to the single-board computer and appears to it to be a memory-expansion interface. To prevent the 8031 microcontroller and the 1553 controller from contending for the same address location in the dual-ported memory, the 8031 microcontroller sets the $\overline{\text{BUSY}}$ line on the 1553 controller whenever the single-board computer accesses the dual-ported memory.

Adapter works well in a round-robin configuration

The adapter operates as a remote terminal connected to the 1553 bus. It works well in systems that configure the 1553 bus controller as a round-robin sequencer. In this configuration, the bus controller, which is typically embedded in one of the subsystems, cyclically polls the remote terminals to exchange information. Assuming the poll rate is 1 Hz, the bus controller sends a message

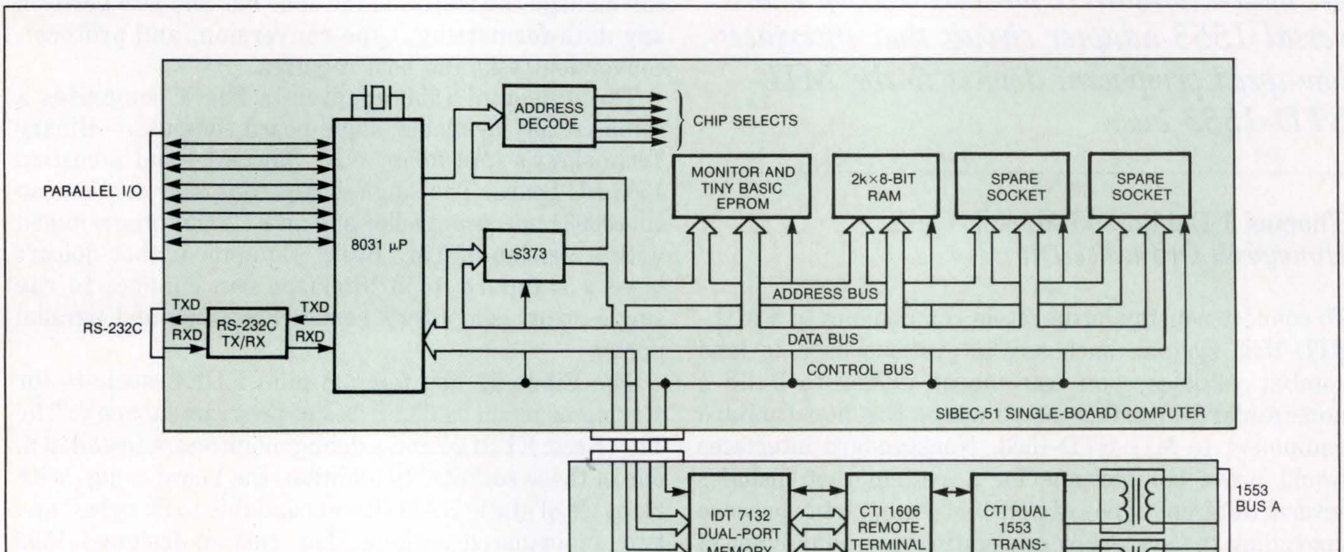


***Fig 1—The universal 1553 adapter** comprises a commercially available single-board computer (the Sibec-51) and a custom-designed 1553 I/O board.*

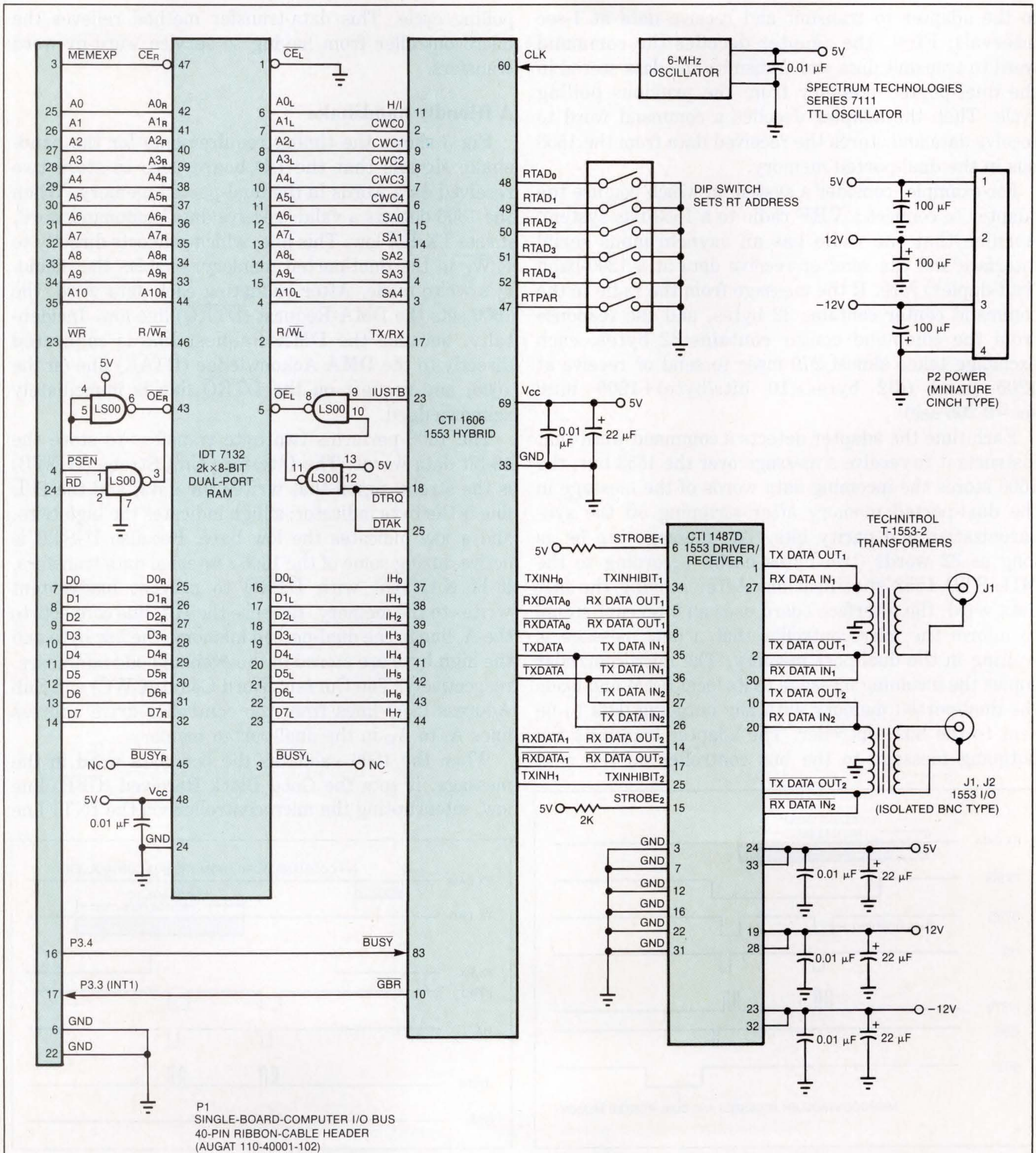


***Fig 2—This schematic for the 1553 I/O board** shows three major components: a 1553 controller, a driver and receiver hybrid, and a dual-ported memory.*

The universal 1553 adapter comprises a commercially available single-board computer and a 1553 I/O board that you build.

to the adapter to transmit and receive data at 1-sec intervals. First, the adapter decodes the command word to transmit data and transmits the data stored in the dual-ported memory from the previous polling cycle. Then the adapter decodes a command word to receive data and stores the received data from the 1553 bus in the dual-ported memory.

For example, consider a system in which you use the adapter to connect a VHF radio to a 1553-bus system. Assume that the radio has an asynchronous serial interface and can send or receive data at a 1200-baud (half-duplex) rate. If the message from the radio to the command center contains 32 bytes, and the response from the command center contains 32 bytes, each exchange takes almost 270 msec to send or receive at 1200 baud ((32 bytes×10 bits/byte)÷1200 bits/sec=0.266 sec).

Each time the adapter detects a command word that instructs it to receive a message over the 1553 bus, the 1606 stores the incoming data words of the message in the dual-ported memory after stripping off the synchronization and parity bits. The message can be as long as 32 words (two bytes each), according to the MIL-STD-1553 specification. After storing the last data word, the interface board uses an interrupt signal to inform the microcontroller that a new message is waiting in the dual-port memory. The microcontroller copies the incoming message to its local RAM and loads the dual-ported memory with any outgoing data to be sent to the bus controller. The adapter transmits the outgoing message to the bus controller on the next polling cycle. This data-transfer method relieves the microcontroller from having to service word-by-word transfers.

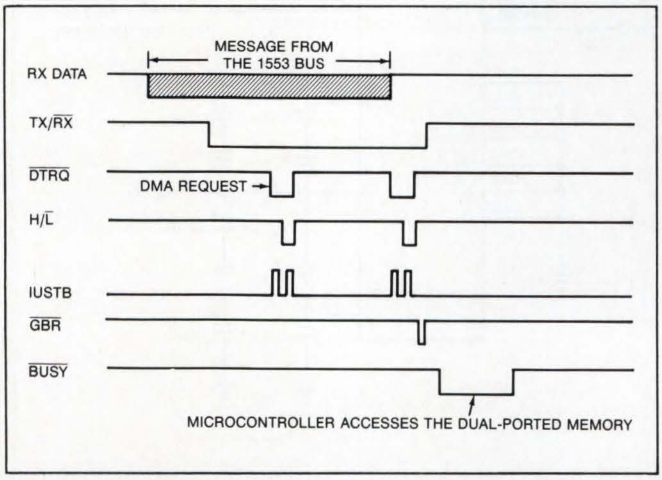


Fig 3—This diagram shows the timing requirements for storing two received data words *in the dual-ported memory. The microcontroller places the remote-terminal hybrid in a busy state whenever the microcontroller accesses the dual-ported memory.*

A friendly handshake

Fig 3 shows the timing requirements for the handshake signals that the I/O board uses to store two received data words in the dual-ported memory. When the 1606 detects a valid "receive data" command word, it sets TX/$\overline{RX}$ low. This line, which connects directly to R/$\overline{W}_L$ in the dual-ported memory, enables the memory's write mode. After validating each data word, the 1606 sets the DMA Request ($\overline{DTRQ}$) line low. Incidentally, because the DMA Request line is connected directly to the DMA Acknowledge ($\overline{DTAK}$) line on the 1606, any request on the $\overline{DTRQ}$ line is immediately acknowledged.

The 1606 performs two byte transfers to store the 16-bit data words. The Interface Unit Strobe (IUSTB) is the strobe signal that writes the data, and the H/$\overline{L}$ line is the byte indicator; a high indicates the high byte, and a low indicates the low byte. Because IUSTB is active during some of the 1606's internal data transfers, it is NANDed with $\overline{DTRQ}$ to prevent inadvertent writes to the memory. Because the H/$\overline{L}$ line connects to the A_0 line in the dual-ported memory, the low byte and the high byte are stored in the even and odd addresses, respectively. The Current Word Count (CWC) and Sub Address (SA) lines from the controller drive address lines A_1 to A_{10} in the dual-ported memory.

When the 1606 validates the last data word in the message, it sets the Good Block Received ($\overline{GBR}$) line low, interrupting the microcontroller via the INT1 line

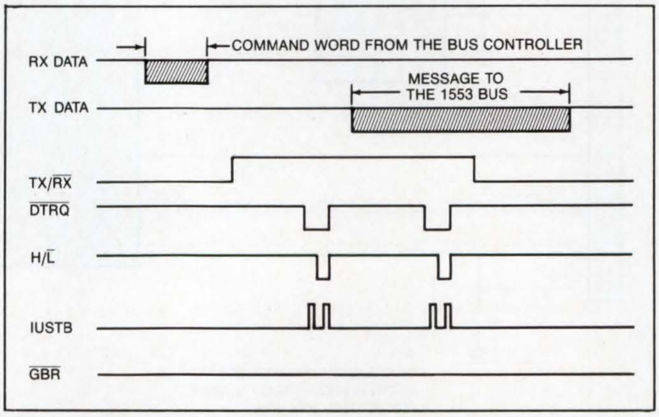


Fig 4—This diagram shows the timing requirements for the data-handshaking signals *needed to transmit two data words over the 1553 bus. The 1553 controller doesn't set the GBR line during this operation.*

```
ON POWER UP DO
    INITIALIZE LOCAL PARAMETERS
    INITIALIZE ANY SPECIAL HARDWARE
    DO FOREVER
        CLEAR MESSAGE RECEIVED FLAG
        WHEN MESSAGE RECEIVED FLAG IS SET DO
            READ MESSAGE FROM LOCAL RAM
                PERFORM CONVERSION, FORMATTING, ETC
                SEND DATA TO THE RADIO
                GET DATA FROM THE RADIO
                PERFORM CONVERSION, FORMATTING, ETC
                SAVE IN LOCAL RAM
                CLEAR MESSAGE RECEIVED FLAG
        END OF MESSAGE FLAG LOOP
    END OF FOREVER LOOP
ON INTERRUPT DO
    SET THE BUSY FLAG (P3.4)
    COPY THE INCOMING 1553 MESSAGE FROM SHARED TO LOCAL RAM
    COPY THE OUTGOING 1553 MESSAGE FROM LOCAL TO SHARED RAM
    CLEAR THE BUSY FLAG (P.3.4)
    SET MESSAGE RECEIVED FLAG
    RETURN FROM INTERRUPT
END OF INTERRUPT HANDLER
```

Fig 5—This pseudocode outline shows the structure *of the applications code you'd need to write to connect a remote VHF radio to the 1553 bus.*

on the 40-pin connector. The microcontroller, in turn, sets the 1606's $\overline{\text{BUSY}}$ line low to inhibit data transfers from the interface board. The microcontroller's application software then copies the buffered data into the local RAM and stores the outgoing data in the dual-ported memory. When the routine is complete, the microcontroller releases the $\overline{\text{BUSY}}$ line. Because the microcontroller runs at 12 MHz, it can execute most instructions in 1 to 3 μsec. Therefore, even a nonoptimized transfer routine can easily move 64 bytes in 1 msec. If the polling cycle is 1 sec, therefore, the microcontroller will be free for 999 msec of every second.

Fig 4 shows the timing for the data-handshaking signals when the 1606 receives a command to transmit two data words. The 1606 sets the TX/$\overline{\text{RX}}$ line high, placing the dual-ported memory in read mode. While the 1606 is transmitting its status word, it initiates a DMA request by pulling DTRQ low. The request is immediately acknowledged, because the $\overline{\text{DTACK}}$ line connects directly to the $\overline{\text{DTRQ}}$ line. To permit transmission, the controller must alternately latch the high and the low data bytes by using the H/$\overline{\text{L}}$ and IUSTB lines, as it did for the receive operation. The data for each byte must remain stable until IUSTB has returned low.

Software for the adapter is simple

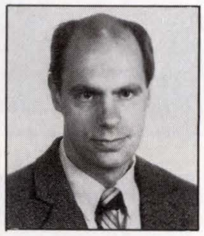
Because the 1606 handles most of the real-time data-transfer tasks, the software necessary to control the operation of the adapter is relatively simple. You can write the application code in C or assembly code, or, if your application doesn't require high speed, in Tiny Basic. The code for each application is unique, but it generally follows an outline similar to the pseudocode in **Fig 5**.

The adapter is particularly useful for evaluating prototype systems and connecting equipment in a test bed. Because it's programmable and can easily be implemented in hardware, the adapter suits one-time applications as well as it accommodates continual use. You can build custom versions of the adapter very quickly. Once the adapter is installed and tested in a system, you could build an application-specific version of it to meet the requirements of any form factor. **EDN**

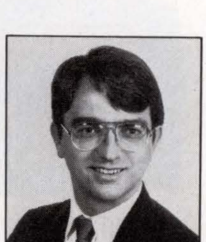
References

1. Josephson, Daryl C, "Hybrid modules help you implement a 1553B interface," *EDN*, August 20, 1987, pg 173.
2. Titus, Jon, "MIL-STD-1553 bus finds use in diverse military systems," *EDN*, April 11, 1985, pg 60.

Authors' biographies



Thomas J Dahlin was a staff engineer in the Technology and Product Development Group of Honeywell Defense Systems Div (Edina, MN) when he cowrote this article. He is currently a senior engineering specialist at the Software and Electronics Resource Center (SERC) Div of 3M Corp (St Paul, MN). He received a BS in computer science and electronics technology from Northern Michigan University in 1979. While at Honeywell, Tom designed several fire-control and navigation systems for use in Army land vehicles. His hobbies include electronic music, amateur radio, endurance running, and bicycling.



Marc L Denis was employed by Honeywell Defense Systems Div at the time he cowrote this article. At Honeywell, he was responsible for the development of a communications processor for the automated fire-control system in the Howitzer Improvement Program (HIP). Marc, who holds a BSEE from Michigan Technological University, is currently project manager at FMC Corp, where he is responsible for developing fire-control systems for advanced combat vehicles. In his spare time, he pursues interests in amateur radio and fishing.

Article Interest Quotient (Circle One)
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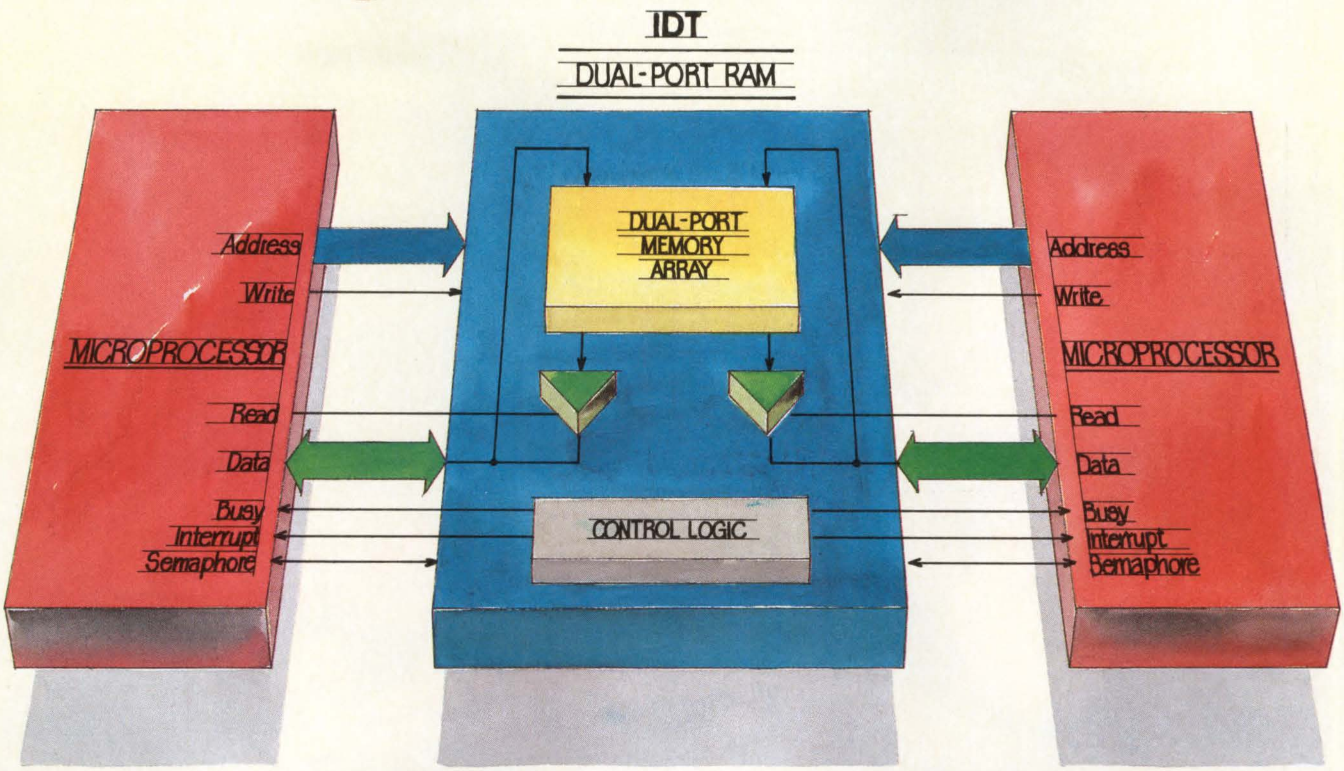

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2Kx8	IDT 7132	35ns		MASTER		
"	IDT 7142	35ns			SLAVE	
"	IDT 71321	35ns	x	MASTER		
"	IDT 71421	35ns	x		SLAVE	
"	IDT 71322	45ns				x
2Kx16	IDT 7133	55ns		MASTER		
"	IDT 7143	55ns			SLAVE	
4Kx8	IDT 7134	45ns				
"	IDT 71342	45ns				x
8Kx8 Module	IDT 7M134	50ns		MASTER		
"	IDT 7M144	50ns			SLAVE	
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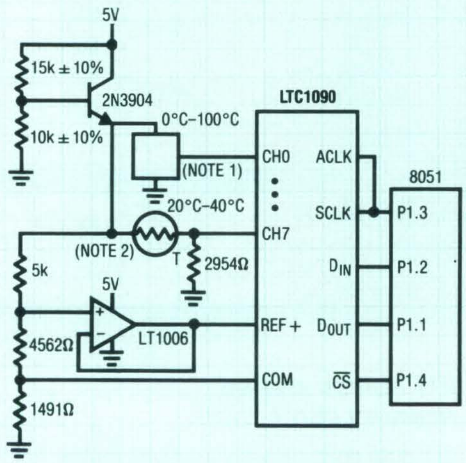

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Microphone controls voice-actuated switch

Jonathan Audy
Precision Monolithics Inc, Santa Clara, CA

The **Fig 1** circuit is a speech-actuated switch that enables voice operation of a radio transceiver or similar device. Low-current consumption and 5V operation make the circuit suitable for battery-operated applications. (The original application involved hands-free control of a radio on a hang glider.)

The input stage (IC_{1A}), a bandpass filter with gain, responds to the speech components that are most reliable for actuating the output switch—those at 800 Hz. The main speech components fall in the 200- to 300-Hz range, but centering the bandpass at these frequencies would make the circuit too sensitive to wind noise, breathing, and "banging-door-type" noises. Fortunately, normal speech includes harmonic peaks every 100 Hz or so, to beyond 1 kHz. Centering the filter's bandpass at 800 Hz provides a good compromise between sensitivity and the suppression of false signals.

To ensure the detection of two harmonics, the filter must provide at least 40 dB of gain over a 400-Hz bandwidth. The component values shown for R_1, R_2, C_1, and C_2 give the desired gain and 800-Hz center frequency. (Although not recommended, IC_{1A} can operate without feedback in this application because the op amp's open-loop gain attenuation acts as a lowpass filter.)

The microphone produces 5- to 10-mV signals, which undergo just enough amplification to trip the comparator's (IC_{1B}'s) output high, turning on Q_1. D_1, R_6, R_7, and C_4 make up a peak detector that stores this high state long enough to delay the turnoff of Q_1 for about 0.7 sec—long enough to allow pauses between spoken words. The $R_3/R_4/R_5$ voltage divider sets the comparator's threshold and the filter's dc reference level; adjusting R_4 determines the circuit's sensitivity. C_3 removes noise that might otherwise appear at the high-impedance node that serves as a reference for the gain stage.

The circuit's input connects directly to a microphone jack. For radio applications, connect the circuit output directly to the nongrounded side of the radio's transmit switch (or you can add a 5-kΩ pullup resistor, which allows Q_1 to drive a TTL-logic input). For transceiver applications, you don't need a voice-on/off switch because the circuit's open-collector output allows the transmit switch to operate normally when you remove the voice headset. **EDN**

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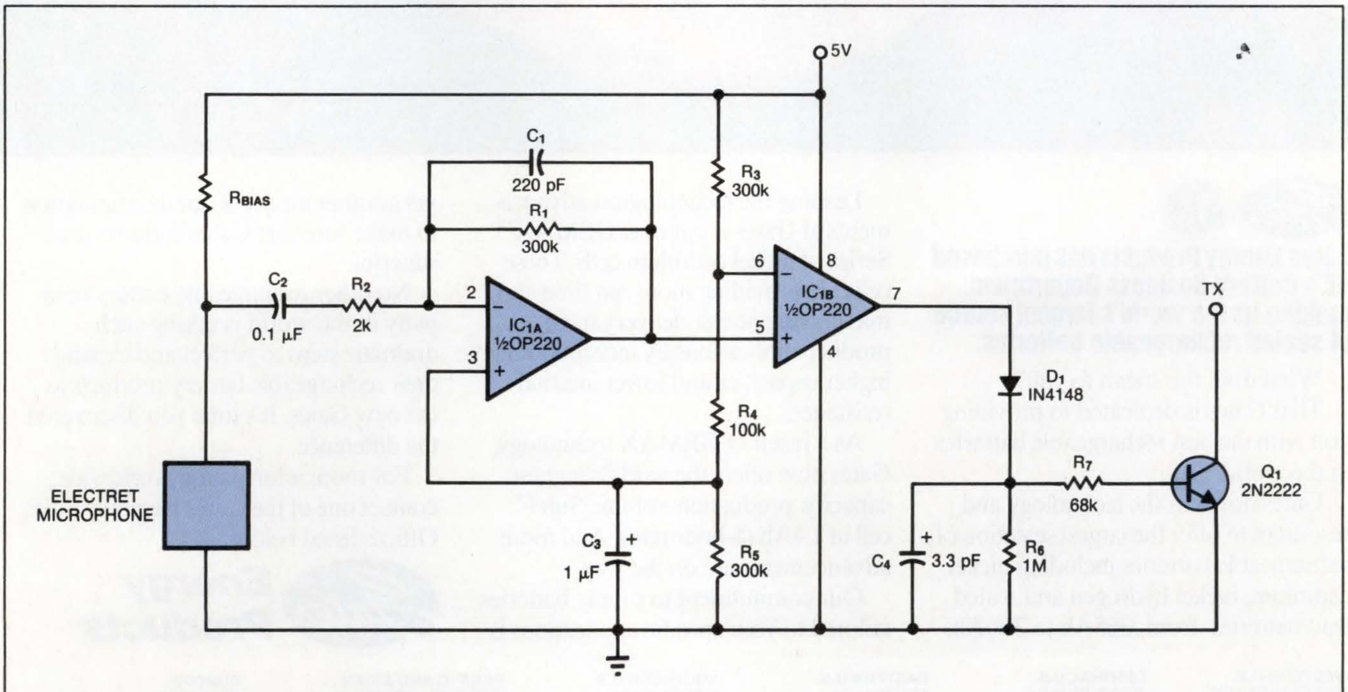

Fig 1—Speaking into this circuit's microphone *drives the TX output low. The output remains low for about 0.7 sec following the last word spoken.*

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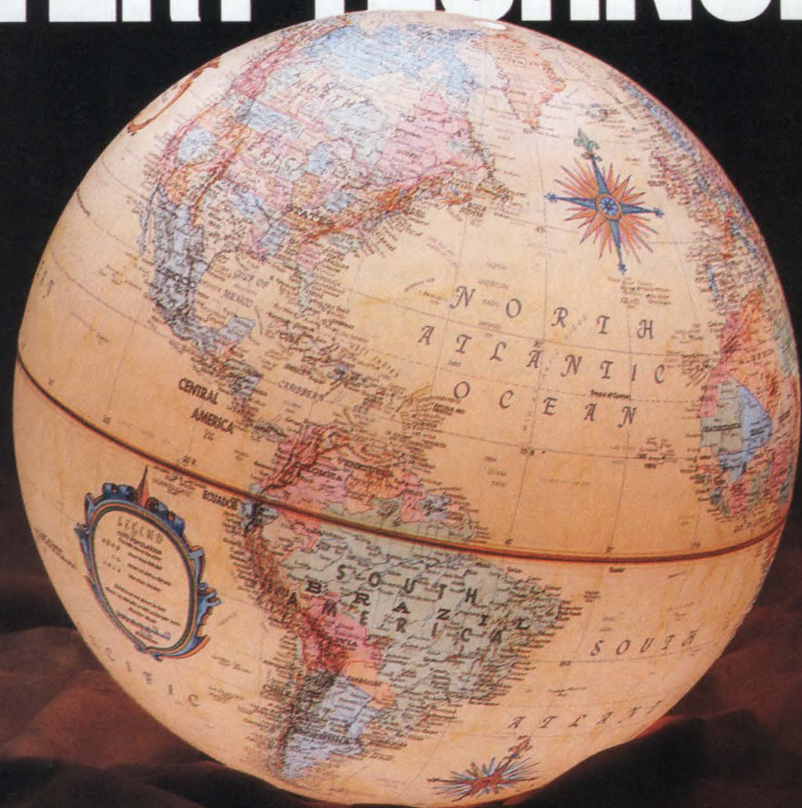

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Five volts powers negative 2W regulator

Leonard H Sherman
Maxim Integrated Products, Sunnyvale, CA

Using a 5V supply, the simple circuit of **Fig 1** generates a regulated, negative-voltage power source capable of delivering several hundred milliamperes. The circuit produces a −5 or −12V regulated output depending on whether IC_1 is a MAX635 or a MAX636. The circuit's output power is approximately 2W.

IC_1's L_X output (pin 5) drives the gate of Q_1 via the inverter, IC_2. (Form the inverter by connecting six inverters in parallel. Using the CD4069C, for example, connect the 1, 3, 5, 9, 11, and 13 inputs together, and the 2, 4, 6, 8, 10, and 12 outputs together.) Note that connecting the negative supply terminal of the inverter (pin 7) to the negative output voltage supplies maximum gate drive to Q_1, which improves efficiency by minimizing the MOSFET's on-resistance.

During operation, the inductor current (trace A in **Fig 2**) rises to a peak of 2A, which is much higher than the output current and typical of flyback-converter circuits. The inductor must handle these current peaks without saturating. Output ripple and noise are about 100 mV p-p (trace B). Trace C (node C in **Fig 1**) reveals that the inductor voltage begins near 5V when Q_1 is on and "flies back" to $-V_{OUT}$ when Q_1 turns off. Stray capacitance causes the inductor waveform to ring when Q_1 turns off, forcing the inductor current to zero. Only about 10 mV of this oscillation appears at the output.

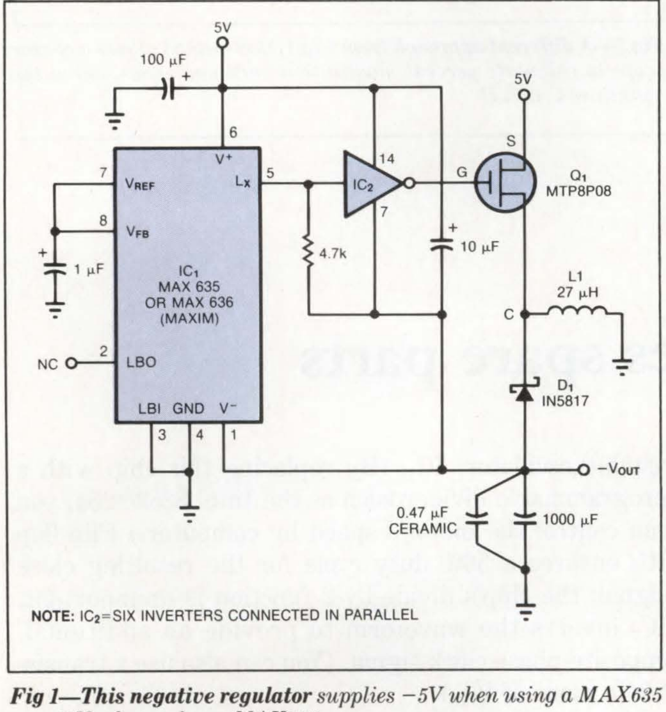
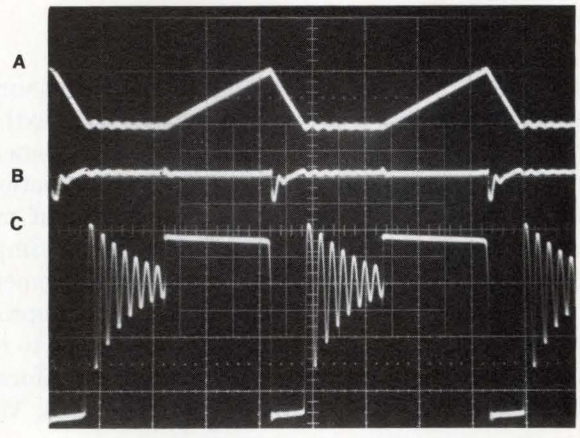


__Fig 1—This negative regulator__ supplies −5V when using a MAX635 or −12V when using a MAX636.



TRACE	HORIZONTAL	VERTICAL
A	5 µSEC/DIV	2A/DIV
B	5 µSEC/DIV	200 mV/DIV
C	5 µSEC/DIV	5V/DIV

__Fig 2—These Fig 1 waveforms show__ inductor current (trace A), output voltage (trace B), and flyback voltage across the inductor (trace C).

Table 1 lists circuit performance for several operating conditions. Lowering the inductor value from 27 to 18 µH, for example, boosts the output-current capability by 20 to 40%, but sacrifices some conversion efficiency. Reducing the inductance creates higher peak currents that increase output power, but increase energy losses as well. Q_1 needs a heat sink when operating with the 18-µH inductor. **EDN**

TABLE 1—PERFORMANCE CHARACTERISTICS

V_{IN}	$-V_{OUT}$	I_{OUT}	EFFICIENCY	IC_1	L_1
5V	−5V	400 mA	70%	MAX635	27 µH
5V	−5V	500 mA	64%	MAX635	18 µH
5V	−12V	150 mA	75%	MAX636	27 µH
5V	−12V	200 mA	70%	MAX636	18 µH

NOTES:
18-µH COIL=CADDELL-BURNS'S (MINEOLA, NY) MODEL 6860-04.
27-µH COIL=CADDELL-BURNS'S MODEL 6860-06.

To Vote For This Design, Circle No 747

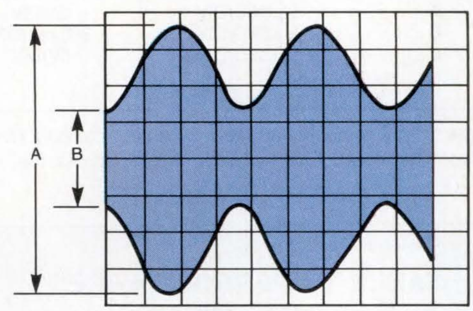
Cursor scope measures percent modulation

M J Salvati
Consultant, Flushing, NY

Fig 1 shows the traditional method for measuring percent modulation. This method is based on a textbook formula that requires two dimensional measurements, and addition, subtraction, division, and multiplication—operations that are beyond the capability of most cursor-readout oscilloscopes. **Fig 2** shows a simpler formula based on different dimensional measurements. By eliminating addition and subtraction, this approach enables the voltage-ratio mode of a cursor scope to read out the percent modulation of a displayed waveform.

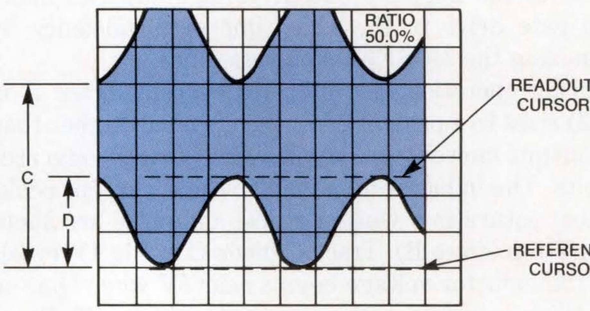
Using the scope's vertical-amplitude controls, Volts/Div and Variable, match the waveform's C dimension to the number of screen divisions representing full scale for the scope's cursor system. (Full scale for the Leader LB0-2060 scope, for example, is five divisions.) Don't be concerned if the waveform's top portion goes off the screen. Next, set the scope's reference cursor on the waveform's negative peak, and set the readout cursor (the Delta cursor on Leader scopes) on the waveform as shown. The scope will then display the percent modulation. **EDN**

To Vote For This Design, Circle No 748



$$\frac{A-B}{A+B} \times 100 = \%\ \text{MODULATION}$$

Fig 1—The traditional computation of percent modulation requires the measurement of quantities A and B, followed by subtraction, addition, division, and multiplication.



$$\frac{D}{C} \times 100 = \%\ \text{MODULATION}$$

Fig 2—A different approach from Fig 1, this method allows a cursor scope to calculate percent modulation once you've measured the quantities C and D.

Stepper-motor driver uses spare parts

Jim Kocsis
Allied-Bendix Aerospace, South Bend, IN

The circuit of **Fig 1** can drive any small 4-winding stepper motor. Although the circuit is more complex than a single-IC approach, circuit components are readily available and their cost is comparable to that of an IC.

Potentiometer R_1 lets you adjust the frequency of the astable oscillator, IC_1. (By replacing this chip with a programmable divider such as the Intel 8253/8254, you can control the motor's speed by computer.) Flip-flop IC_2 ensures a 50% duty cycle for the resulting clock signal; the chip's divide-by-2 function is unimportant. IC_3 inverts the waveform to provide an additional, opposite-phase clock signal. (You can also use a transistor in place of IC_3.)

You can also replace IC_2 with any other flip-flop, or

use another ½7474 instead of the IC_2/IC_3 combination. IC_4 generates the required waveforms of **Fig 2,** and the buffer transistors, Q_1-Q_4, drive the output transistors, Q_5-Q_8. If each winding draws more than a few hundred milliamps, you should substitute 2N3055s or comparable large transistors for the output devices.

The gates of IC_5 form an spdt switch, which is controlled by the clockwise/counter-clockwise (CW/CCW) switch (S_1). (IC_5 routes either the Q or $\overline{Q}$ output of IC_{4A} for use as a data input to IC_{4B}, pin 12.) **EDN**

To Vote For This Design, Circle No 750

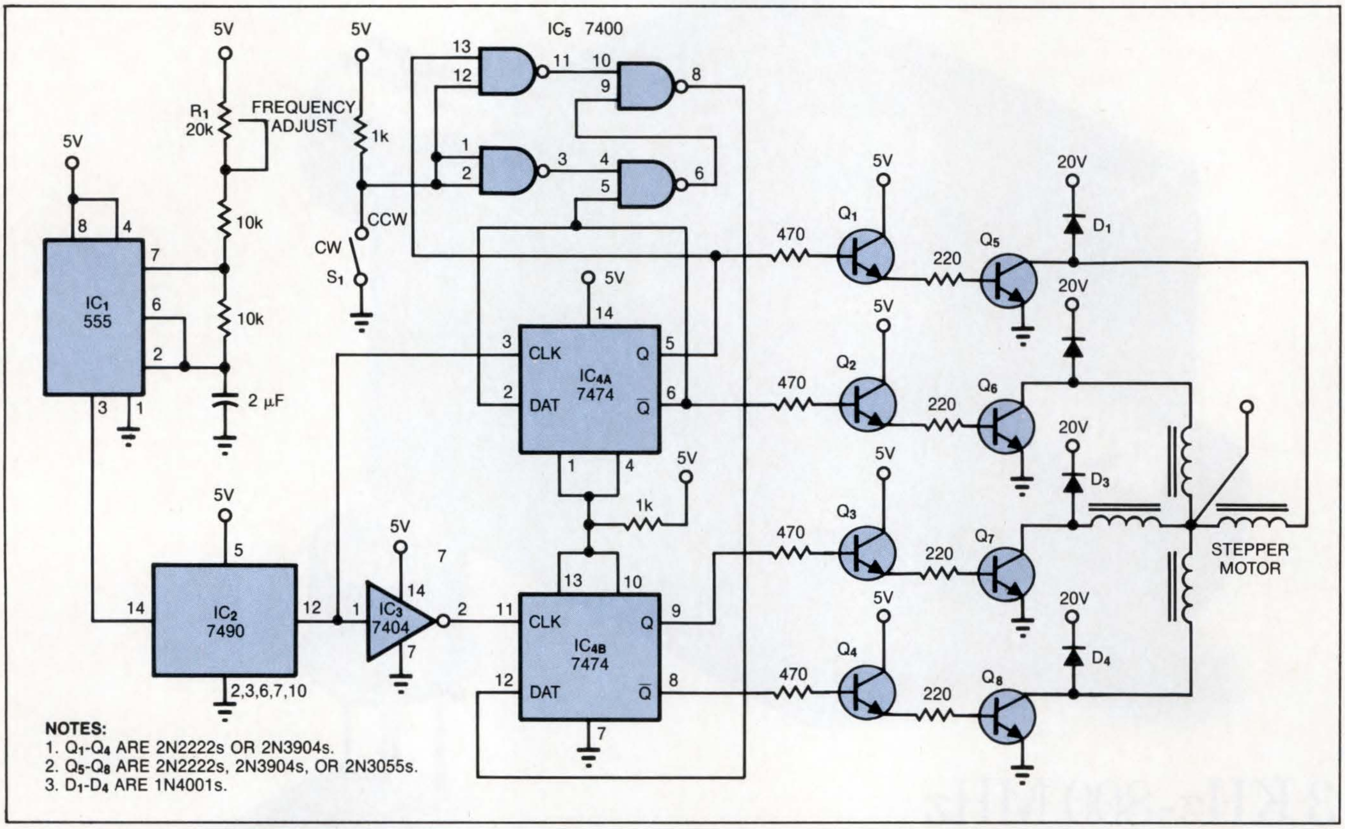


Fig 1—This stepper-motor controller *lets you adjust motor speed using R_1 and motor direction using S_1.*

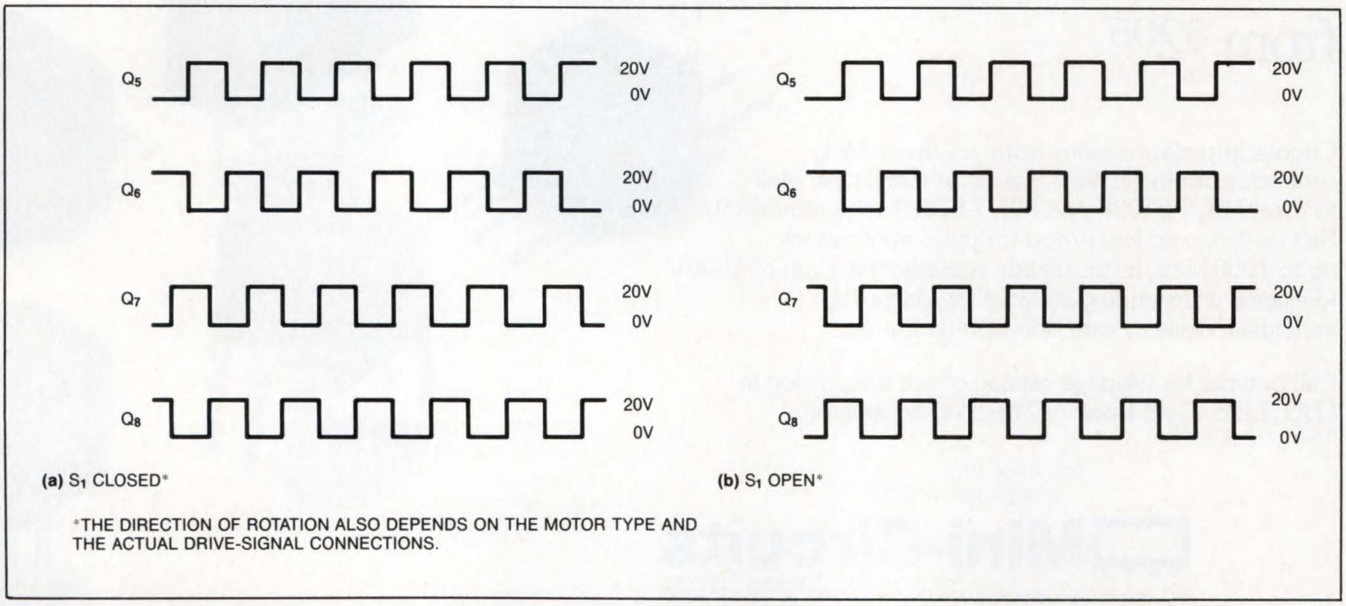


Fig 2—These transistor-collector waveforms of Fig 1 *illustrate the drive signal you obtain with the CW/CCW switch closed **(a)** and open **(b)**.*

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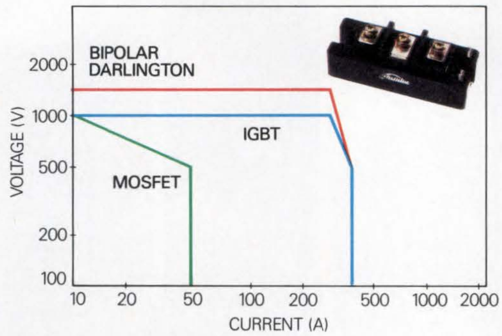

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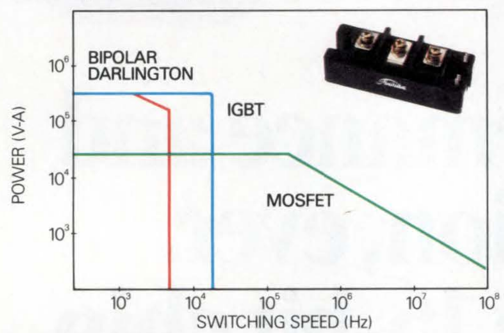

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	BS	500		GT15H101† MG15H1BS1	GT25H101† MG25H1BS1	GT50G101† (400V) MG50H1BS1	MG75H1BS1*	MG100H1BS1				
	BS	1000	GT8N101†*	GT15N101† MG15N1BS1	MG25N1BS1	MG50N1BS1	MG75N1BS1*					
	US	500									MG300H1US1	MG400H1US1
	US	600									MG300J1US1*	MG400J1US1*
	US	1000								MG200N1US1*	MG300N1US1*	
	US	1200								MG200Q1US1*	MG300Q1US1*	MG400Q1US1*
	YS	500			MG25H2YS1	MG50H2YS1	MG75H2YS1	MG100H2YS1	MG150H2YS1	MG200H2YS1		
	YS	600					MG75J2YS1*	MG100J2YS1*	MG150J2YS1*	MG200J2YS1*		
	YS	1000		MG15N2YS1	MG25N2YS1	MG50N2YS1	MG75N2YS1	MG100N2YS1	MG150N2YS1*			
	YS	1200			MG25Q2YS1*	MG50Q2YS1*	MG75Q2YS1*	MG100Q2YS1*	MG150Q2YS1*	MG200Q2YS1*		
	YS	1400			MG25S2YS1*							
	JS	1000			MG25N1JS1							
	ZS	500				MG50H1ZS1						
	ZS	1000			MG25N1ZS1							
	ES	500		MG15H6ES1*								
	ES	1000	MG8N6ES1*	MG15N6ES1*								

†Non Isolated Type TO-3P ▒ *Under Development

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SPD-88-003

Generate Gaussian noise with a DSP chip

A D E Brown
British Aerospace, Stevenage, Hertfordshire, UK

You can obtain a Gaussian probability-distribution function (PDF) by applying the central limit theorem to batches of random numbers. This function is useful in testing digital filters, in implementing spectral-estimation techniques such as the autoregressive moving average (ARMA), and in other digital signal-processing applications.

To produce the PDF, you first generate batches of pseudorandom numbers by using the following equation, taken from **Ref 1:**

$$r(n+1)=\text{FRACTION}\ (9821.r(n)+0.211327). \quad \textbf{Eq 1}$$

In this case, there are 16 numbers in each batch. The quantity r(0) represents the seed for the iterative process, which generates about one million pseudorandom numbers. The numbers have an even distribution (a flat PDF). To synthesize a Gaussian PDF from this data, you apply the central limit theorem

$$y(n)=\frac{1}{n}\sum_{i=0}^{i=n-1} x(i), \quad \textbf{Eq 2}$$

where x(i) represents a set of equally weighted random numbers. The set of numbers y(n) has a distribution that is close to Gaussian, provided that $n>10$.

Listing 1 gives the code to implement the algorithm on the TMS320C25 DSP chip. The software generates batches of 16 pseudorandom numbers using **Eq 1,** and calculates the mean value for each batch using **Eq 2. Fig 1** shows the PDF for 1864 mean values and is a result of running **Listing 1** on Texas Intruments' TMS320C25 simulator. The sample numbers have 16-bit resolution, providing a full-scale value of 65,535.

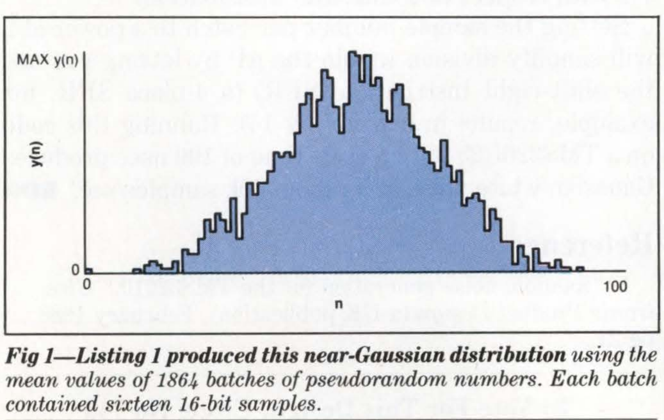


Fig 1—Listing 1 produced this near-Gaussian distribution *using the mean values of 1864 batches of pseudorandom numbers. Each batch contained sixteen 16-bit samples.*

ISSUE WINNER

The winning Design Idea for the March 31, 1988, issue is entitled "Voltage limiter restrains fast op amps," submitted by Joseph L Sousa of Hybrid Systems Inc (Billerica, MA).

Your vote determines this issue's winner. All designs published win $100 cash. All issue winners receive an additional $100 and become eligible for the annual $1500 Grand Prize. **Vote now,** by circling the appropriate number on the reader inquiry card.

LISTING 1—GAUSSIAN-NOISE GENERATOR

```
*  Gaussian white noise generator for the TMS320C25
*  based on the algorithm,
*
*        r(n+1) = FRC(9821.r(n) + 0.211327)
*
*  and employing the Central Limit Theorem.
*-----------------------------------------
                  IDT      'GAUSS'
*
P4       EQU      >40      P4 HOLDS PAGE 4 START ADDR
ROFN     EQU      >41      r(n)
CONST1   EQU      >42      9821
CONST2   EQU      >43      0.211327
TEMP     EQU      >44      TEMPORY STORAGE
SNUM     EQU      >F       SAMPLE NUMBER (16)
*
                  AORG     >0
                  B        START
                  AORG     >4
                  DATA     >200                PAGE 4 START
                  DATA     >5764               SEED VALUE
                  DATA     >265D               CONST1
                  DATA     >3619               CONST2
*
START    AORG     >A
                  CNFD                         BO DATA MEMORY
                  LDPK     >4                  POINT TO PAGE 4
                  LACK     >4
                  TBLR     P4                  PAGE 4 START
                  LACK     >5
                  TBLR     ROFN                SEED TO DATA MEM
                  LACK     >6
                  TBLR     CONST1              FIRST CONST
                  LACK     >7
                  TBLR     CONST2              SECOND CONST
*
* Set up the first SNUM registers for random data storage.
                  SSXM                         SET SIGN EXTENSION
LOOP1             LARK     AR1,SNUM            LOAD SAMPLE No.IN AR1
                  LAR      AR2,P4              MEMORY POINTER IN AR2
                  LARP     AR2                 POINT TO PAGE 4
*
* Pseudo random number generator for SNUM data points.
                  LT       CONST1              CONST1 IN T REG
LOOP2             MPY      ROFN                MULT CONST1 BY r(n)
                  PAC
                  ADDS     CONST2              ADD ON CONST2
                  SACL     *+,0,1              STORE DATA POINT
                  SACL     ROFN                STORE r(n+1)
                  BANZ     LOOP2,*-,2          NEXT DATA POINT
*
* Average the data points
                  LARP     AR1
                  LAR      AR1,P4
                  ZAC
                  RPTK     SNUM                LOAD REPEAT COUNTER
                  ADD      *+                  ADD NUMBERS TOGETHER
*
* Divide by 16, 4 right shifts
                  RPTK     >3                  LOAD REPEAT COUNTER
                  SFR
                  SACL     TEMP
                  OUT      TEMP,PA0            OUTPUT DATA
                  B        LOOP1
                  END
```

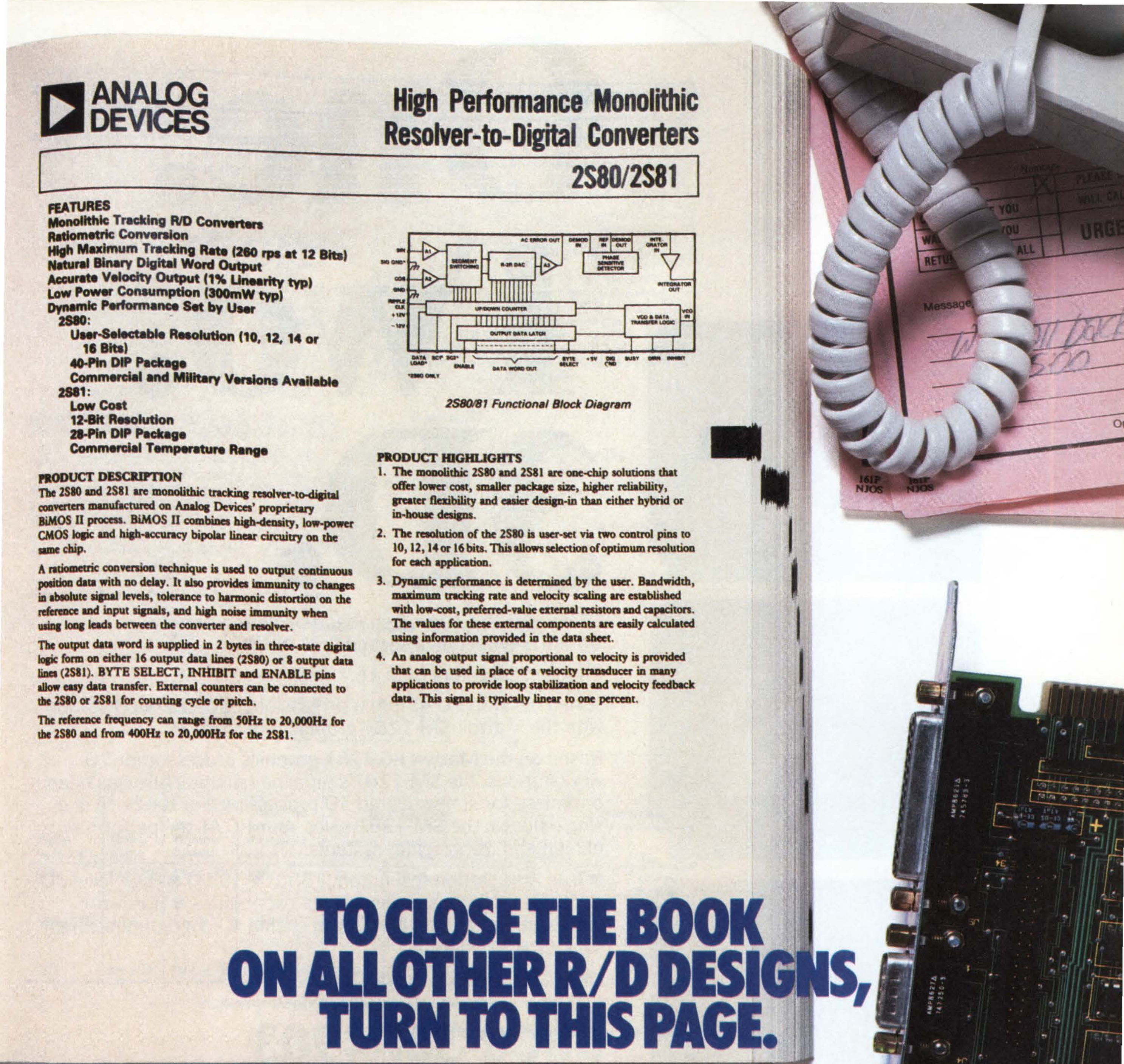
The resulting distribution has a standard deviation of 7% with respect to a Gaussian distribution.

Setting the sample number per batch to a power of 2 will simplify division within the μP by letting you use the shift-right instruction (SFR) (a 4-place SFR, for example, results in division by 16). Running this code on a TMS320C25 with a cycle time of 100 nsec produces Gaussian white noise at a rate of 60k samples/sec. **EDN**

Reference

1. "Random noise generation for the TMS32010," *Electronic Product Design* (a UK publication), February 1988, pg 21.

To Vote For This Design, Circle No 746



ANALOG DEVICES

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2S80/2S81

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2S80/81 Functional Block Diagram

PRODUCT DESCRIPTION

The 2S80 and 2S81 are monolithic tracking resolver-to-digital converters manufactured on Analog Devices' proprietary BiMOS II process. BiMOS II combines high-density, low-power CMOS logic and high-accuracy bipolar linear circuitry on the same chip.

A ratiometric conversion technique is used to output continuous position data with no delay. It also provides immunity to changes in absolute signal levels, tolerance to harmonic distortion on the reference and input signals, and high noise immunity when using long leads between the converter and resolver.

The output data word is supplied in 2 bytes in three-state digital logic form on either 16 output data lines (2S80) or 8 output data lines (2S81). BYTE SELECT, INHIBIT and ENABLE pins allow easy data transfer. External counters can be connected to the 2S80 or 2S81 for counting cycle or pitch.

The reference frequency can range from 50Hz to 20,000Hz for the 2S80 and from 400Hz to 20,000Hz for the 2S81.

PRODUCT HIGHLIGHTS

1. The monolithic 2S80 and 2S81 are one-chip solutions that offer lower cost, smaller package size, higher reliability, greater flexibility and easier design-in than either hybrid or in-house designs.
2. The resolution of the 2S80 is user-set via two control pins to 10, 12, 14 or 16 bits. This allows selection of optimum resolution for each application.
3. Dynamic performance is determined by the user. Bandwidth, maximum tracking rate and velocity scaling are established with low-cost, preferred-value external resistors and capacitors. The values for these external components are easily calculated using information provided in the data sheet.
4. An analog output signal proportional to velocity is provided that can be used in place of a velocity transducer in many applications to provide loop stabilization and velocity feedback data. This signal is typically linear to one percent.

TO CLOSE THE BOOK ON ALL OTHER R/D DESIGNS, TURN TO THIS PAGE.

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The 2S80 is available in both commercial and military temperature range versions, and in three accuracy grades (±8, ±4 and ±2 arc minutes, each ±1 LSB).

The 2S81 operates over the standard commercial temperature range of 0° to 70°C and features accuracy of ±30 arc minutes ±1 LSB, making it ideal for a wide variety of commercial and industrial applications.

All these high performance features are available without a high price tag. The 2S80 starts at only $89.10 in 100s, while the 2S81, at $70.00 in 100s, is the lowest priced R/D converter you can buy. And both the 2S80 and 2S81 are in stock now for immediate delivery.

To find out how the 2S80 and 2S81 are rewriting the book on R/D converters, call Ian Bruce at (617) 461-3210. Or write to Analog Devices, P.O. Box 9106, Norwood, MA 02062-9106.

ANALOG DEVICES

Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106; Headquarters: (617) 329-4700; California: (714) 641-9391, (619) 268-4621, (408) 559-2037; Colorado: (719) 590-9952; Maryland: (301) 992-1994; Ohio: (614) 764-8795; Pennsylvania: (215) 643-7790; Texas: (214) 231-5094; Washington: (206) 251-9550; Austria: (222) 885504; Belgium: (3) 237 1672; Denmark: (2) 845800; France: (1) 4687-34-11; Holland: (1620) 81500; Israel: (052) 911415; Italy: (2) 6883831, (2) 6883832, (2) 6883833; Japan: (3) 263-6826; Sweden: (8) 282740; Switzerland: (22) 31 57 60; United Kingdom: (932) 232222; West Germany: (89) 570050

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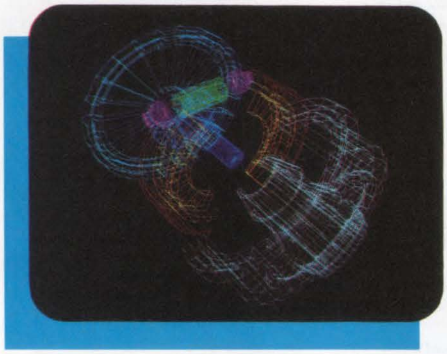

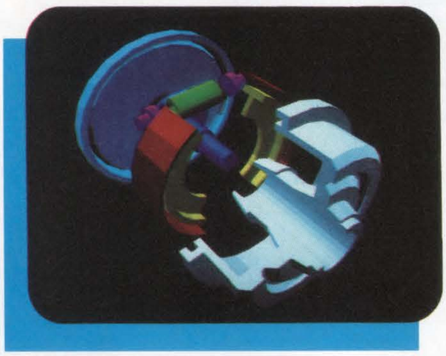

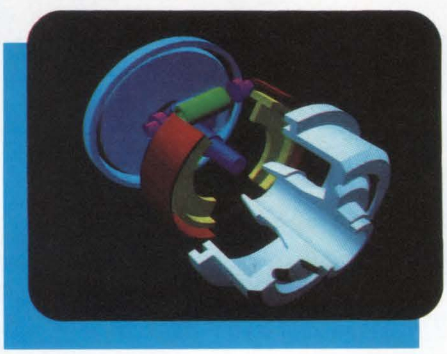

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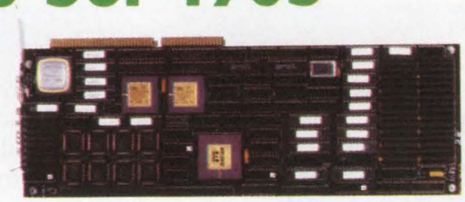

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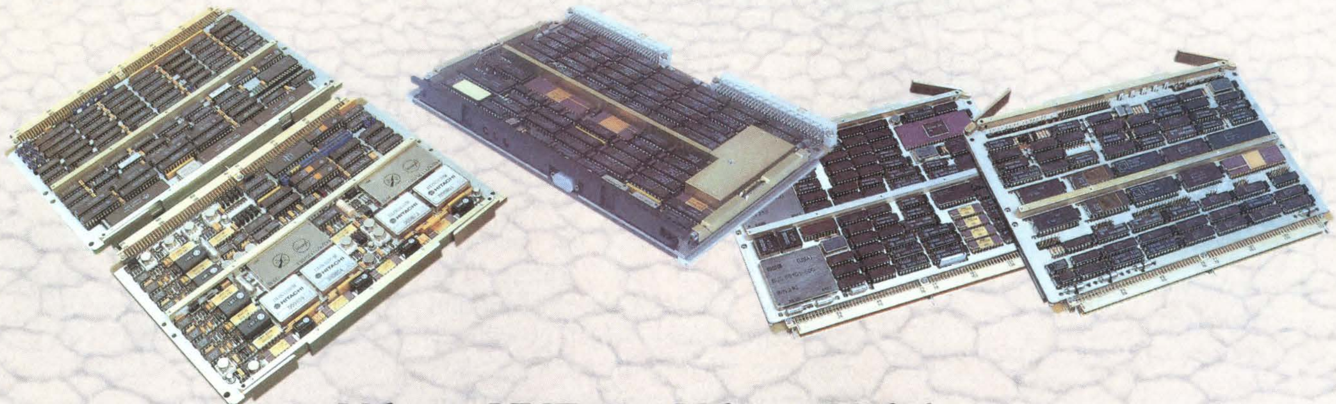

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- *Operates over −10 to +70°C range*
- *Features a 10-sec-max response time*

The HUM-20C and HUM-10V relative humidity (RH) sensors/transmitters measure 3 to 95% relative humidity with a ±2% accuracy. The -20C is a true 2-wire current transmitter for remote long-distance sensing while the -10V is a 3-wire voltage output unit. Both are temperature compensated for operation over a −10 to +70°C range. The units use a state-of-the-art thin-film capacitive sensor, which provides a response time of 10 sec max. You can remove the stainless-steel filter cap, which protects the sensor, for cleaning purposes. All transmitters come with a screw-on mating connector. $150.

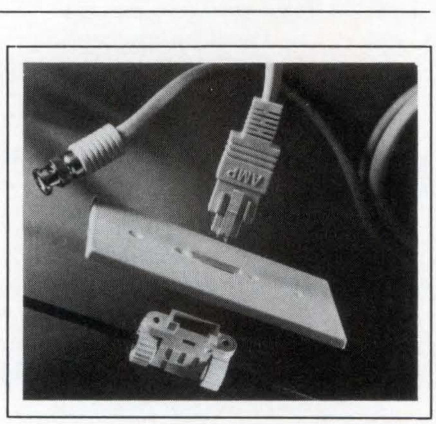
Analite Inc, 24 Newtown Plaza, Plainview, NY 11803. Phone (516) 752-1818.

Circle No 351

TAP SYSTEM

- *Does not require splicing or jumpering of trunk cable*
- *Switching function provides discretionary user access*

The Thinnet Tap system allows you to install and remove office equipment without having to cut, splice, or jumper the bus or trunk cable. The system will access IEEE 802.3 networks that use 50Ω, RG 58 solid or stranded center-conductor backbone cable with braided shields. The system consists of a tap assembly, a drop-cable plug, and a terminator. The system operates when you install the drop-cable plug into



the tap assembly; this transfers the network from a through-line condition to a series connection. You can install the tap system in a standard wall box, flush mount it within a wall structure, or in free-hanging ceiling, trench, or over-the-floor applications. The system can stay attached to the network when not in use, and features a switching capability that provides discretionary user access. Tap assemblies, $8 (1000); drop-cable plugs, $30 (500); terminators, $3.50 (100). Delivery, stock to eight weeks ARO.

AMP Inc, Box 3608, Harrisburg, PA 17105. Phone (717) 564-0100.

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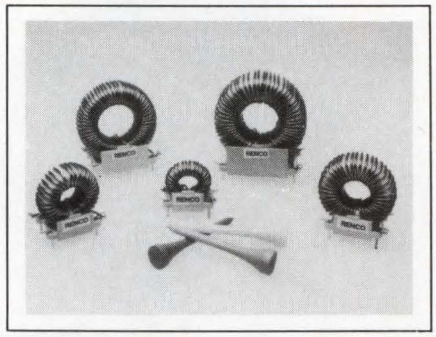

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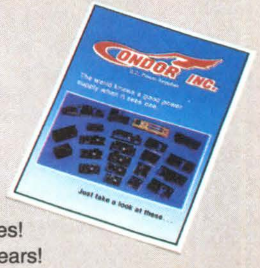

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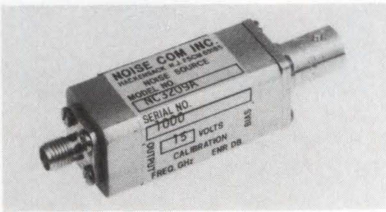


NOISE SOURCE

- *Operates from 18 to 26 GHz*
- *1-μsec max rise/fall times*

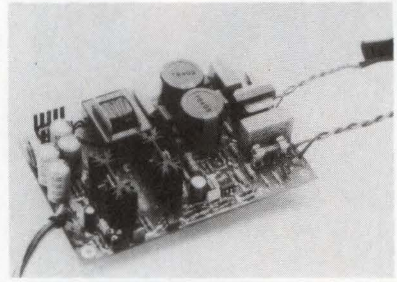
The NC3209 coaxial noise source delivers 31±0.5 dB output over an operating range of 18 to 26 GHz. The device offers output rise and fall times of less than 1 μsec max. It features temperature stability of better than 0.01 dB over a −55 to +85°C range and virtual immunity to variation better than 0.01 dB/%V. Standard units operate from 28V dc supply levels, but 15V dc units are available. These noise diodes are hermetically sealed and come with SMA-type connectors. Each noise source comes with calibration points and charts. $850.

Noise Com Inc, E.64 Midland Ave, Paramus, NJ 07652. Phone (201) 261-8797.

Circle No 354

POWER SUPPLY

- *Designed for tape/disk drive applications*
- *Meets UL, CSA, and VDE regulations*



The 9M23 dual-output, open-frame, switching power supply fits into a half-height package. The unit is designed to supply a 3-½- or 5-¼-in. floppy or hard disk drive or a ¼-in. tape drive. The 12V output is rated for 1.6A continuous (3A pk) to start and run the drive itself. The 5V output delivers 0.7A to power the drive's controller logic. The supply meets applicable UL, CSA, and VDE requirements. An input filter that complies with both FCC and VDE 0871 for level B equipment is also included in the supply. The supply features input voltage requirements from 85 to 132 or 170 to 264V ac. Standard features include overvoltage and overload protection on each output, and a 16-msec hold-up time. For full power output, the device operates over a temperature range from 0 to 50°C. $25 (OEM qty).

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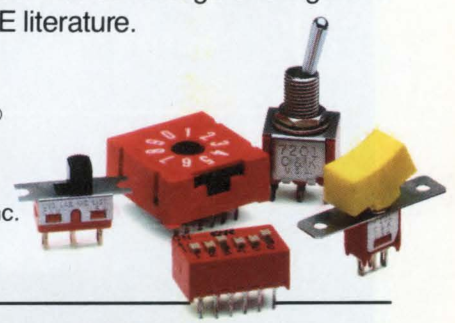

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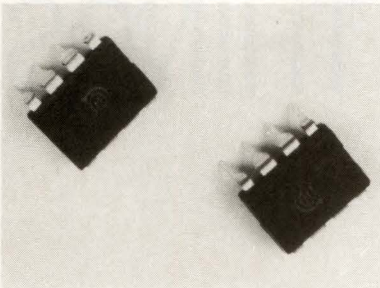


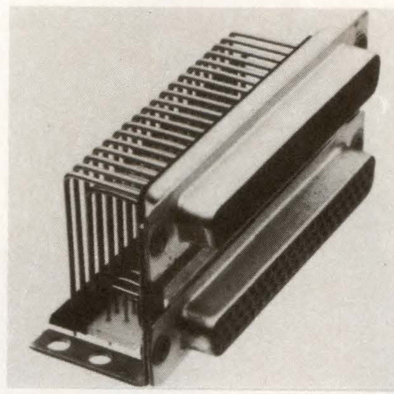
SWITCHES

- *Available in UL-recognized versions*
- *Have form C capability*

LBA and LCC Series solid-state switches feature blocking voltage ratings to 350V ac or dc and load currents to 350 mA. Available in UL recognized versions, the units have I/O isolation voltage ratings ranging to 3750V. The devices provide an NC and NO combination without bias or external power applied. This form C capability makes the units ideal replacements for bulkier electromechanical relays. You can drive switch inputs directly with CMOS logic levels. \$3.55 to \$4.20 (10,000).

Theta-J Corp, 107 Audubon Rd, Wakefield, MA 01880. Phone (617) 246-4000.

Circle No 356



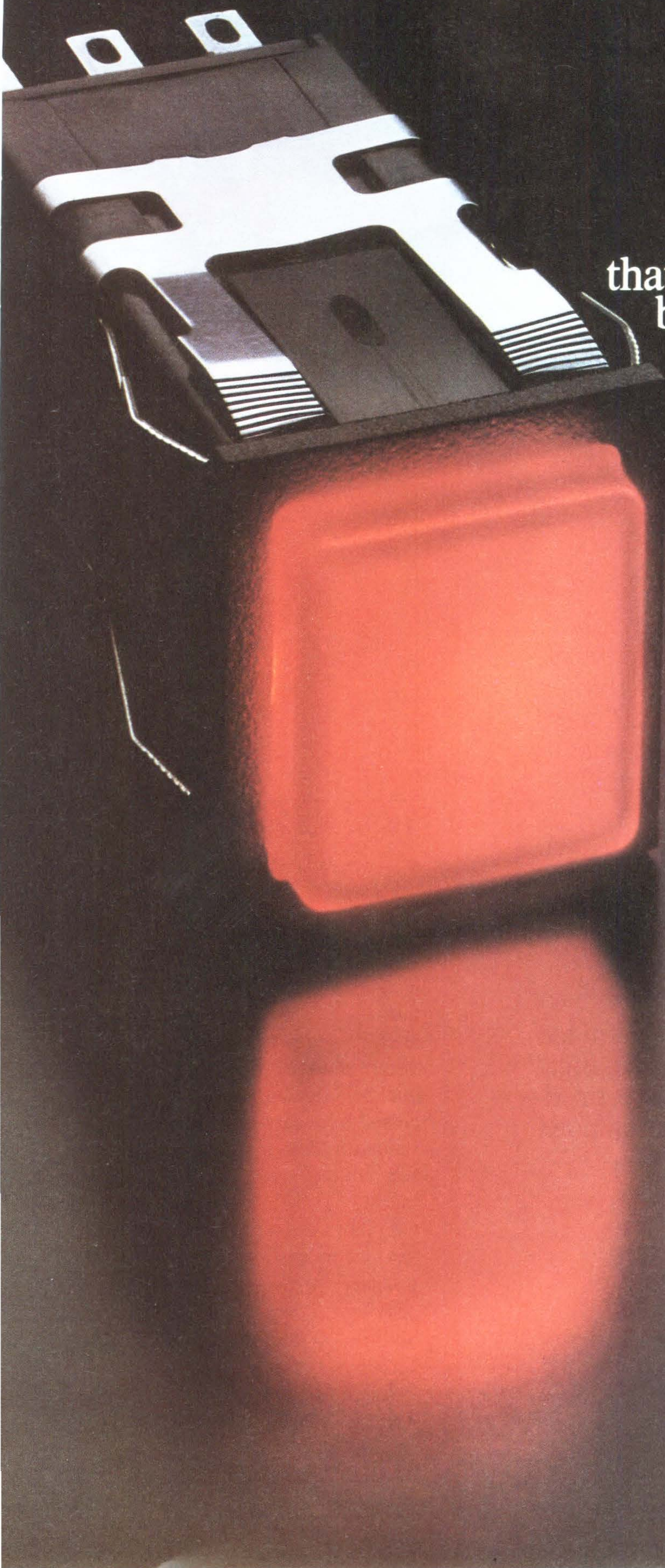
CONNECTORS

- *Feature vertical stacking for saving space*
- *Available in either contact gender*

These mixed-density dual-port D connectors have two individual devices vertically stacked into a single connector unit. The upper connector has a normal contact density while the lower unit has a high contact density. The connectors are available in 9 over 15, 15 over 26, 25 over 44, and 37 over 62 contact versions. You can specify either male or female connector genders for the upper and lower units, and you can order the connectors with contacts selectively loaded. Nine over 15 contact model, \$5 (1000). Delivery, six to eight weeks ARO.

Positronic Industries Inc, Box 8247, Springfield, MO 65801. Phone (417) 866-2322.

Circle No 357



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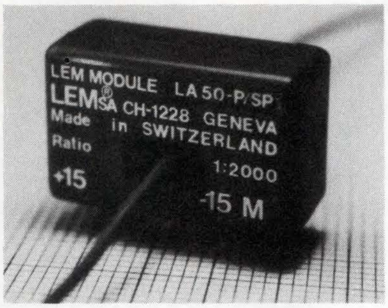
For more information, or the location of a sales office or authorized distributor near you, write MICRO SWITCH, Freeport, IL 61032. Or call 815-235-6600.

Together, we can find the answers.

MICRO SWITCH
a Honeywell Division

CIRCLE NO 127



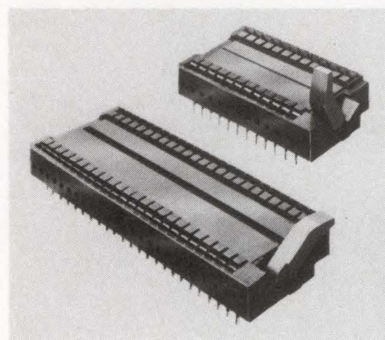
CURRENT SENSOR

- *Measures currents to 70A*
- *Accurate to ±1% of input current*

The LA50-P is a miniature noncontact electronic current sensor that can measure current levels to 70A. The sensor is designed for pc board mounting and measures 1×1.6×0.7 in. Based on the magnetic-field-compensation principle, the sensor supplies a measuring current proportion to the primary current. The device is accurate to ±1% of input current. Its circuitry for the electronic current sensing is surface mounted on a pc board along with the sensing coil. The board mounts in an insulated plastic case, which features a sensing pass-through opening. Three pins mount the package to the pc board. $21 (1000). Delivery, stock to six weeks ARO.

Rekco Inc, N114W19225 Clinton Dr, Germantown, WI 53022. Phone (414) 784-3430.

Circle No 358



TEST SOCKETS

- *Feature zero-insertion-force design*
- *Bodies carry UL-94V-0 rating*

Series 526 zero-insertion-force test sockets are available in 24-, 28-, 40-, and 48-pin sizes. The devices' have a socket heights of only 0.554-in. when their handles are open. The socket contacts are NO and are closed by a cast-metal cam that provides uniform pressure over the entire contact area. The contacts are made of tin-plated, spring-temper beryllium copper. The sockets bodies are made of UL-94V-0-rated plastic. Test-point apertures are provided at the sides of the socket bodies. A 24-pin model, $1.36 to $2.30.

Aries Electronics Inc, Box 130, Frenchtown, NJ 08825. Phone (201) 996-6841.

Circle No 359

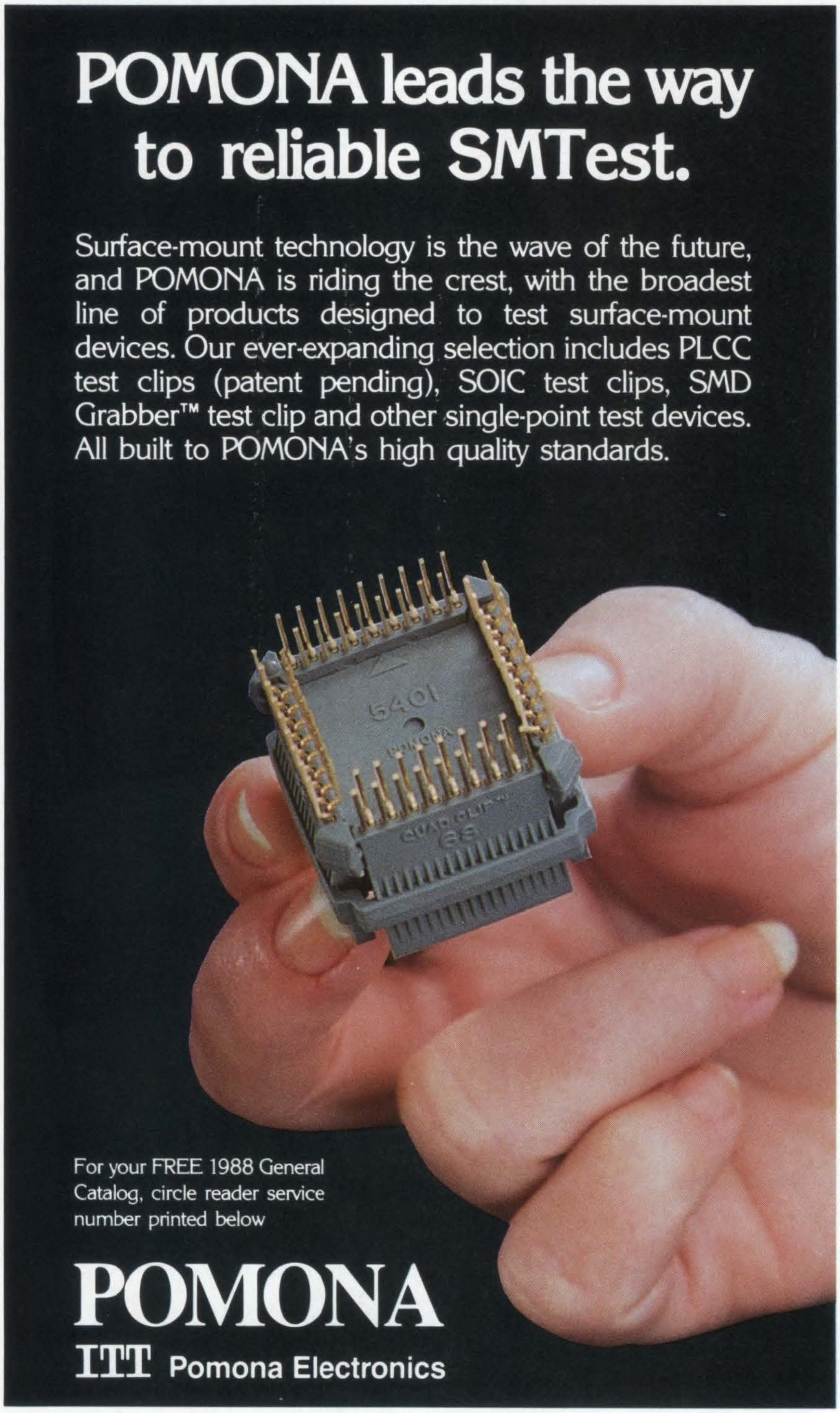
RELAYS

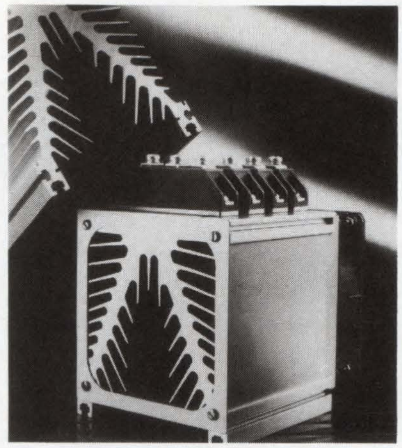
- *Available in 1A or 1C configurations*
- *10^8 operations/lifetime*

SM Series surface-mount relays are available with 5 or 12V coils in either spst NO and spdt contact configurations. They are available with J-lead, gull-wing, and strip-line type terminations. The spst devices are available in both shielded and unshielded versions while the spdt devices come in unshielded versions only. Life expectancy equals 10^8 operations min. The shielded relays have a 0.1 pF capacitance and are supplied with 50, 75, and 93Ω impedances. Coil and switch leads are configured diagonally opposite so the relay will work no matter how you install it. $2.85 and $4.50 for unshielded and shielded spst relays, respectively.

Gordos Corp, 1000 N Second St, Rogers, AR 72756. Phone (800) 643-3500.

Circle No 360





CONVERSION COOLERS

- *Come in kit form*
- *Designed for easy installation*

Available in kit form, 6860 Series forced convection coolers have a thermal resistance of 0.08°C/W when operating with a 100-cfm fan. Extruded channels on the top are used to mount the power modules flat to the surface of the heat sink to optimize heat transfer. The channels eliminate the need to tap holes for module mounting. The kit consists of a 1-piece heat sink surrounded by side panels, an end plate, and a fan-mount transition plate to assure efficient air flow. The transition plate is designed to hold a 4.5-in. square muffin fan (not included). The 5.315×4.921-in. coolers are available in three lengths—4.72, 7.09, and 11.81 in. Made entirely of aluminum, the coolers are available in gold chromate or black anodize finishes. $26.53 (100) for a 4.72-in. cooler.

Aavid Engineering Inc, Box 400, Laconia, NH 03247. Phone (603) 528-3400.

Circle No 361

DESIGNED TO TAKE ON THE WORLD'S TOUGHEST ASSIGNMENTS.

Mallory designs and manufactures a broad line of high-reliability, wet tantalum capacitors to meet your specific design needs.

The CLR-79 and CLR-81 hermetically sealed, all tantalum wet slug capacitors meet MIL-39006 requirements with low DC leakage, low ESR, high ripple current ratings and 3 volts reverse voltage capability. These high and extended range capacitors maintain quality approval up to failure levels R (CLR-79) and P (CLR-81).

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Mallory Capacitor. Stronger Than Ever.

WET SLUG TANTALUMS

Style	Mil Spec (or description)	Mallory Type
CLR-79	M39006/22	TLT
CLR-81	M39006/25	W18
CLR-65	M39006/09	TLX
CLR-69	M39006/21	TXX
CLR-10/14/17	Mil-C-39006/18/19/20	XT
CRL-01/02	Mil-C-83500	W13
	Silver Tubular	MTPH
	All Tantalum Module	TMX

Mallory Capacitor Company
3029 E. Washington Street
Indianapolis, Indiana 46201
Phone: (317) 636-5353

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ELECTRICAL/ELECTRONIC GROUP

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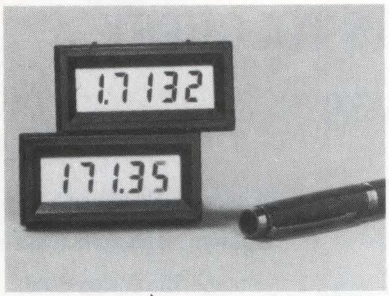


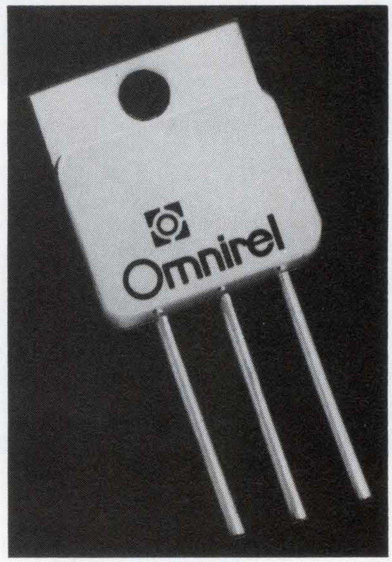
PANEL METERS

- *Draw only 17.5 mW*
- *Feature 100-mm-high digits*

DP-2000 Series 4½-digit liquid-crystal-display panel meters are multi-range voltage input devices. Models in the series have full-range inputs of ±200 mV and ±2V dc (2000), ±2V and ±20V dc (DP-2002), and ±20 and ±200V dc (DP-2020). The series' display digits are 10-mm high. The meters draw only 3.5 mA from 5V and feature a low-battery indicator (low voltage) as well as automatic polarity and under/over range indication. A hold-display pin is also standard. You can wire this pin to a pushbutton switch to momentarily freeze the display. $95.

Acculex, 440 Myles Standish Blvd, Taunton, MA 02780. Phone (617) 880-3660.

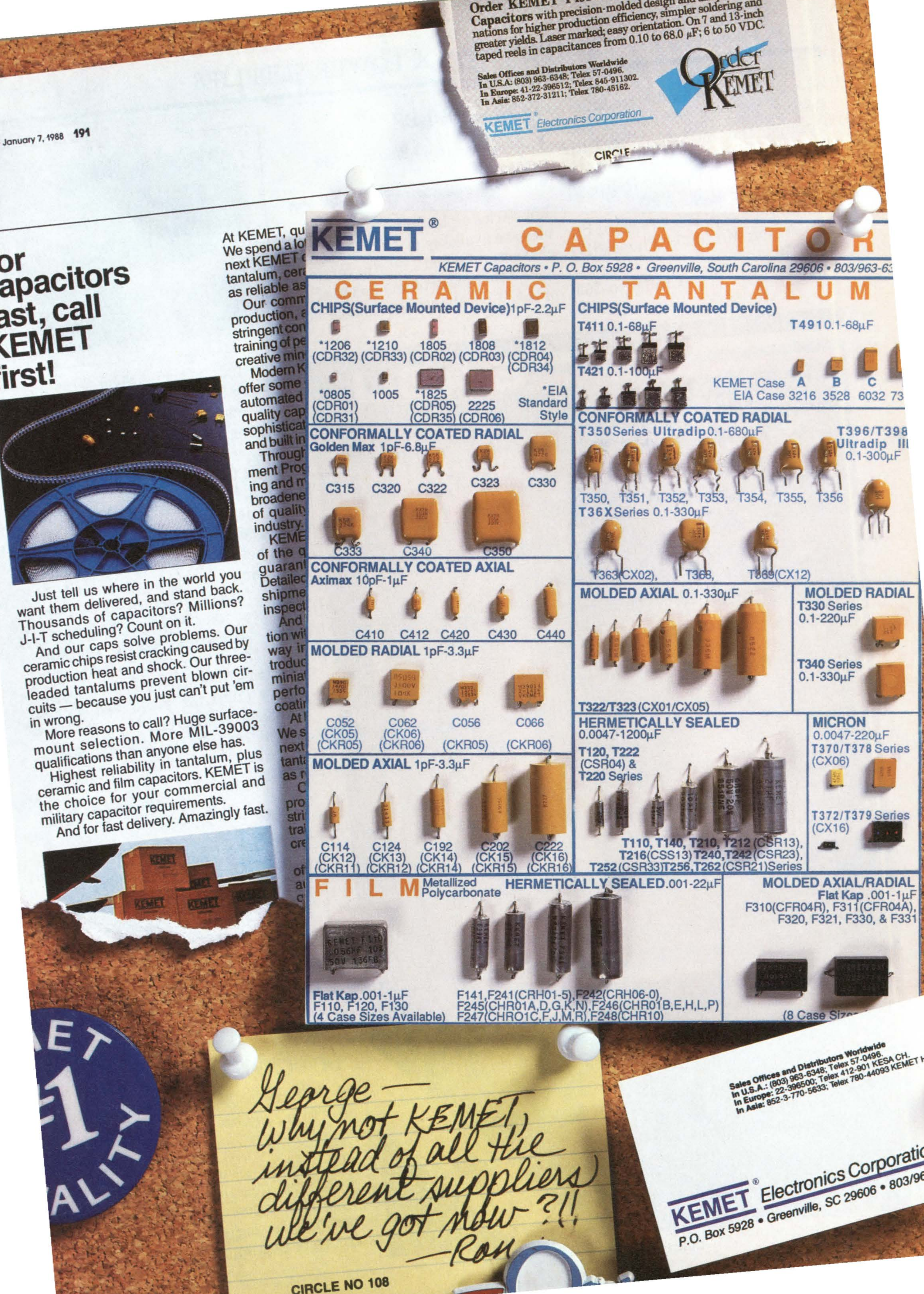
Circle No 362



RECTIFIERS

- *Eliminate momentary shoot-through problems*
- *High-reliability screening available*

The OM5227SC Series devices are designed to eliminate the momentary shoot-through conditions caused by the slow-recovery characteristics of the built-in parasitic diode in power MOSFET devices. The units combine a high-efficiency 15A, 50 to 600V, 35- to 50-nsec power rectifier and a 15A, 45V power Schottky diode in a single TO-258AA hermetic package. The rectifier and diode are configured with the anode of the Schottky diode that is connected to the cath-



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CHIPS(Surface Mounted Device) 1pF-2.2μF
*1206 (CDR32) *1210 (CDR33) 1805 (CDR02) 1808 (CDR03) *1812 (CDR04) (CDR34)
*0805 (CDR01) (CDR31) 1005 *1825 (CDR05) (CDR35) 2225 (CDR06) *EIA Standard Style
CONFORMALLY COATED RADIAL
Golden Max 1pF-6.8μF
C315 C320 C322 C323 C330
C333 C340 C350
CONFORMALLY COATED AXIAL
Aximax 10pF-1μF
C410 C412 C420 C430 C440
MOLDED RADIAL 1pF-3.3μF
C052 (CK05) (CKR05) C062 (CK06) (CKR06) C056 (CKR05) C066 (CKR06)
MOLDED AXIAL 1pF-3.3μF
C114 (CK12) (CKR11) C124 (CK13) (CKR12) C192 (CK14) (CKR14) C202 (CK15) (CKR15) C222 (CK16) (CKR16)
TANTALUM
CHIPS(Surface Mounted Device)
T411 0.1-68μF
T421 0.1-100μF
T491 0.1-68μF
KEMET Case A B C
EIA Case 3216 3528 6032 73
CONFORMALLY COATED RADIAL
T350 Series Ultradip 0.1-680μF
T350, T351, T352, T353, T354, T355, T356
T396/T398 Ultradip III 0.1-300μF
T36X Series 0.1-330μF
T363(CX02), T368, T369(CX12)
MOLDED AXIAL 0.1-330μF
T322/T323 (CX01/CX05)
MOLDED RADIAL
T330 Series 0.1-220μF
T340 Series 0.1-330μF
HERMETICALLY SEALED 0.0047-1200μF
T120, T222 (CSR04) & T220 Series
T110, T140, T210, T212 (CSR13), T216(CSS13) T240, T242 (CSR23), T252 (CSR33) T256, T262 (CSR21) Series
MICRON 0.0047-220μF
T370/T378 Series (CX06)
T372/T379 Series (CX16)
FILM Metallized Polycarbonate
HERMETICALLY SEALED .001-22μF
Flat Kap .001-1μF
F110, F120, F130
(4 Case Sizes Available)
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F245 (CHR01A,D,G,K,N), F246 (CHR01B,E,H,L,P)
F247 (CHR01C,F,J,M,R), F248 (CHR10)
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Flat Kap .001-1μF
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CIRCLE NO 108

ode lead of the power rectifier, thereby blocking the current path through the MOSFET parasitic diode. High-reliability screening is available. $42.50 (100). Delivery, stock to eight weeks ARO.

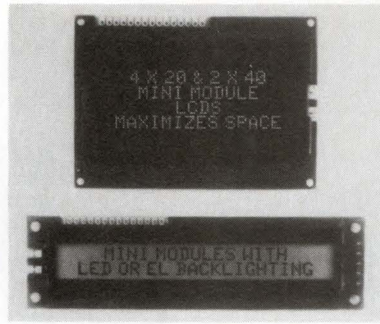
Omnirel Corp, 205 Crawford St, Leominster, MA 01453. Phone (617) 534-5776.

Circle No 363

LCD MODULES

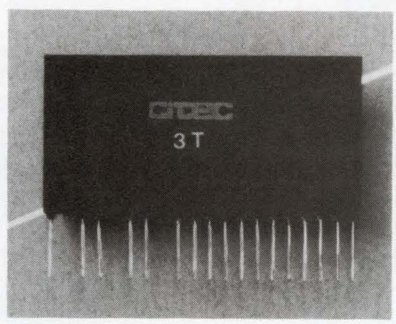
- *Available in 4×20 and 2×40 formats*
- *Interface via an ASCII 8-bit bus*

LM Series alphanumeric LCD modules are available in 4×20 and 2×40 character formats. Both versions have either electroluminescent (EL) or LED backlighting available and interface via an ASCII 8-bit bus. The 2×40 LM2402 module, in reflective mode, comes with EL backlighting while the LM4402 features LED backlighting. Character height (5×7 matrix) for each unit is 4 mm. The 4×20 LM2043 in reflective mode has EL backlighting and the LM4043 employs LED. Character height for these units equals 3.51 mm. All models are available with dark characters on a light background or with light characters on a dark background. You can order the devices with either a top or bottom viewing angle. $35.01 and $28.74 (100) for 2×40 and 4×20 modules, respectively.



Densitron Corp, 2540 W 237th St, Torrance, CA 90505. Phone (213) 530-3530.

Circle No 364



DC/DC CONVERTER

- *Delivers a 50W output*
- *Has a programmable output voltage*

By employing surface-mount technology on a ceramic substrate, the type 3T switchmode dc/dc converter produces an output power of 50W from a pc board mounting SIL pack-

NDK: When timing is critical rely on the leader.

Clock frequencies from 28 kHz to 70 MHz. Only from NDK

Tiny tornado. NDK's 1300 Series Compact Crystal Clock Oscillators pack up to 70 MHz in a package 0.52" on a side. That means you can pack higher frequency oscillators on a smaller board. They're perfect for high speed applications such as modems, computers and CAD/CAM workstations. And the 1300 Series offers the widest range of TTL and CMOS-compatible oscillators you'll find. Enable/disable is standard. Dual frequency output is an option.

Actual Size: 0.52" square. Less real estate. Full frequency range.

Think Small. These half-size clock oscillators are ideal for rugged, high density board applications. Particularly portable instruments, PCs and "harsh environment" applications.

Absolute quality control. Because we're the world's largest manufacturer of synthetic quartz crystals, we can establish and maintain absolute quality control. NDK unconditionally guarantees all of our crystal products to be free of impurities and defects. Thus, you can expect not only longer product life, but absolutely accurate frequencies over the full NDK product spectrum.

NDK 1300 Series: Broadest range of frequencies — 28 kHz to 70 MHz. Low power/low heat CMOS. Choice of TTL, CMOS or dual-compatibility. Rise and fall times (5, 7, 10 ns). Fan out (2 or 5 TTL gates). Sealed, grounded metal case is ideal for harsh environments.

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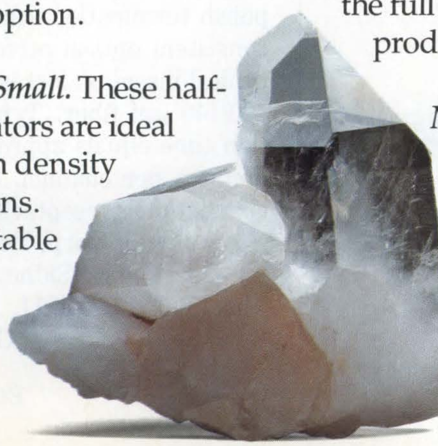

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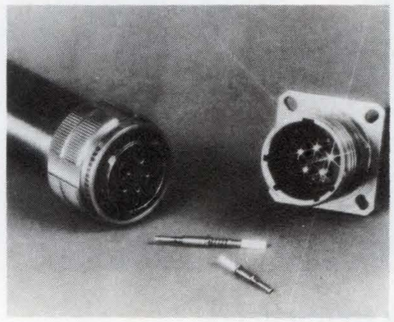
CIRCLE NO 130

age that measures only 51×27×4 mm (2.0×1.1×0.16 in.). In addition, it can provide full output power over a 0 to 70°C temperature range without additional heat sinking. You can program the converter with shorting links so that it produces an output voltage of 5, 12, 15, 18, or 24V. At 12V it achieves an operating efficiency of around 94%. The converter accepts a dc input voltage of between 11V and 40V, and you can also configure the input so that it operates as an ac/dc converter. Zero to full-load output regulation is 0.5% for an output voltage of 5V, and 1.0% for all other output voltages. Line regulation over the full 11V to 40V input range is 1.0% for a 5V output, and 2.0% for other output voltages. However, for ±10% input changes line regulation for all output voltages is only 0.2%. The output current is 3A max, but you can add external power transistors to provide greater output currents. £10 (100).

Bicc-Citec Ltd, Westmead, Swindon, Wiltshire SN5 7YT, UK. Phone (0793) 487301. TLX 449112.

Circle No 365



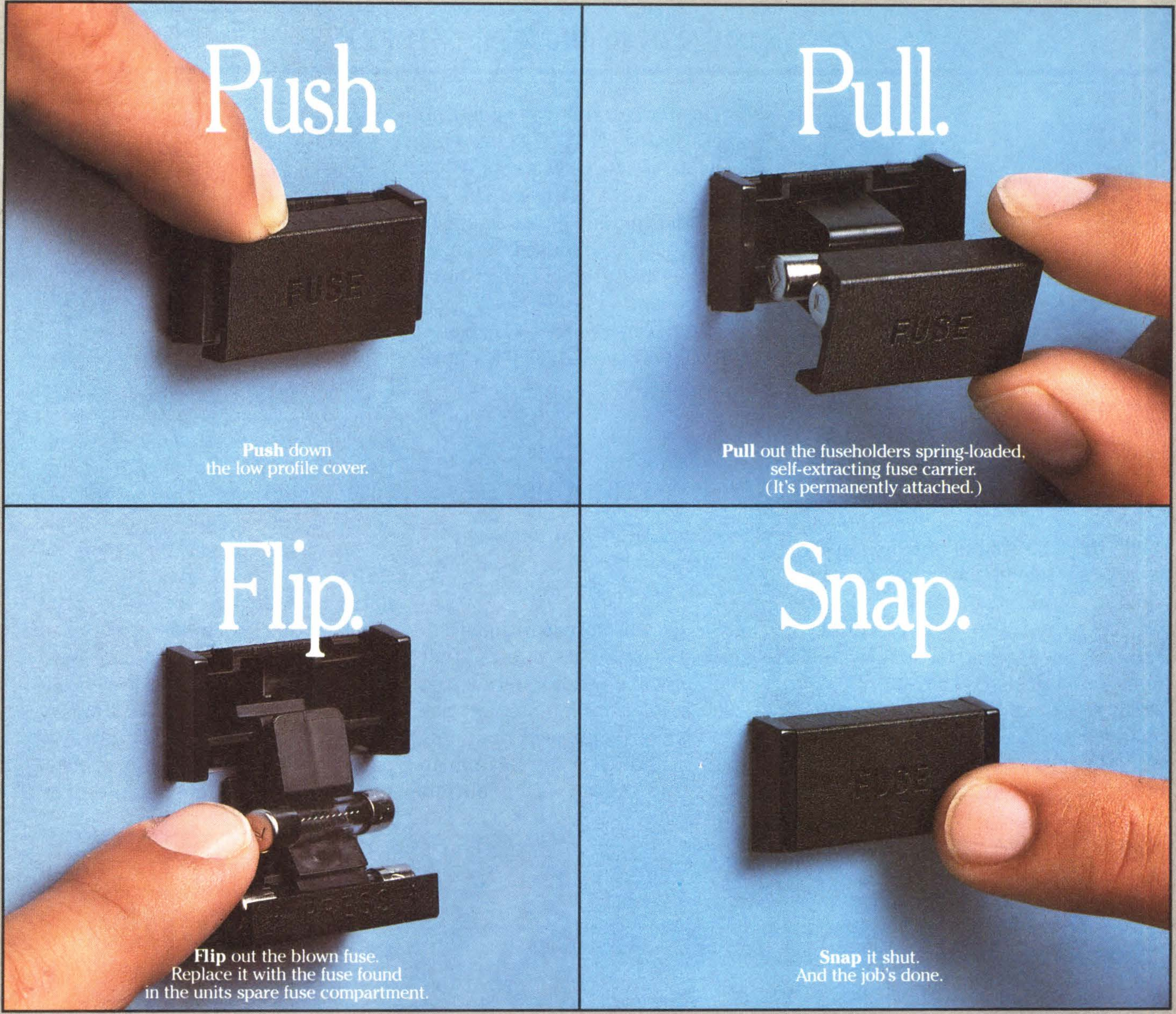
OPTICAL CONNECTORS

- *Use MIL-C-38999 Series III connector shells*
- *Operate over −55 to +200°C range*

The optical termini in these multichannel devices are designed to operate in the size-16 contact cavity of the MIL-C-38999 Series III connector. The connectors are available in 2- to 29-channel configurations. The fiber-to-fiber design will operate over a −55 to +200°C range, withstand the shock and vibration requirements of MIL-C-38999, and exceed the optical requirements of MIL-T-29504. The heart of the fiber-to-fiber system is the ceramic ferrule employed to align the fibers at the interface. A simple epoxy/polish termination scheme provides consistent optical performance with typical insertion losses of 0.5 dB for 100/140 μm fiber. Typical termination time equals approximately five minutes per channel. $150 for a 5-channel plug/receptacle pair.

Amphenol Corp, Bendix Connector Operations, Sidney, NY 13838. Phone (607) 563-5011.

Circle No 366



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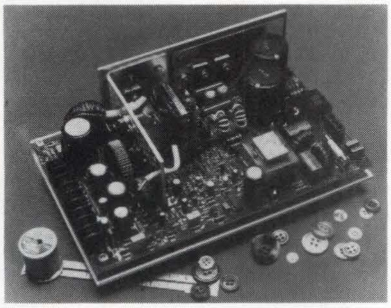

POWER SUPPLY

- *Delivers 265W continuous power*
- *Meets FCC and VDE noise level B*

The MD265 triple-output, open-frame switching power supply delivers 265W continuous power and has a 340W surge-power capability. Based on a 50 kHz, PWM half-bridge topology, the supply has UL, CSA, and TUV certification and meets FCC and VDE noise level B. The outputs are rated for 5V at 28A, 12V at 10A, and −12V at 600 mA. The device's full-load operating temperature (with 15 cfm of moving air) equals 0 to 40°C. The supply has overvoltage protection on the 5V output, and current-limit protection on all outputs as standard features. The supply features MTBF ratings of 100,000 hours min. $0.55/W.

Modular Devices Inc, 4115 Spencer St, Torrance, CA 90503. Phone (213) 542-8561.

Circle No 367

ROTARY ENCODER

- *Provides 24-bit positional resolution*
- *Features a 58×64 mm case*

The Saturn absolute positional encoder can maintain its 24-bit output resolution while rotating at a speed of 3000 revolutions/minute, yet the body of the encoder measures only 58 mm in diameter by 64 mm in length. The overall 24-bit output

resolution is provided by a resolution of 12-bits per revolution for 4096 revolutions. The encoder is sealed to IP65 requirements and has an operating temperature range of −10 to +80°C. Its serial output can drive as much as 50m of coaxial cable. Interface circuitry, supplied with the encoder on a Eurocard sized pc board, processes the encoder output to produce either a binary or Graycode, TTL-level, parallel output. A version with open-collector outputs is also available. The

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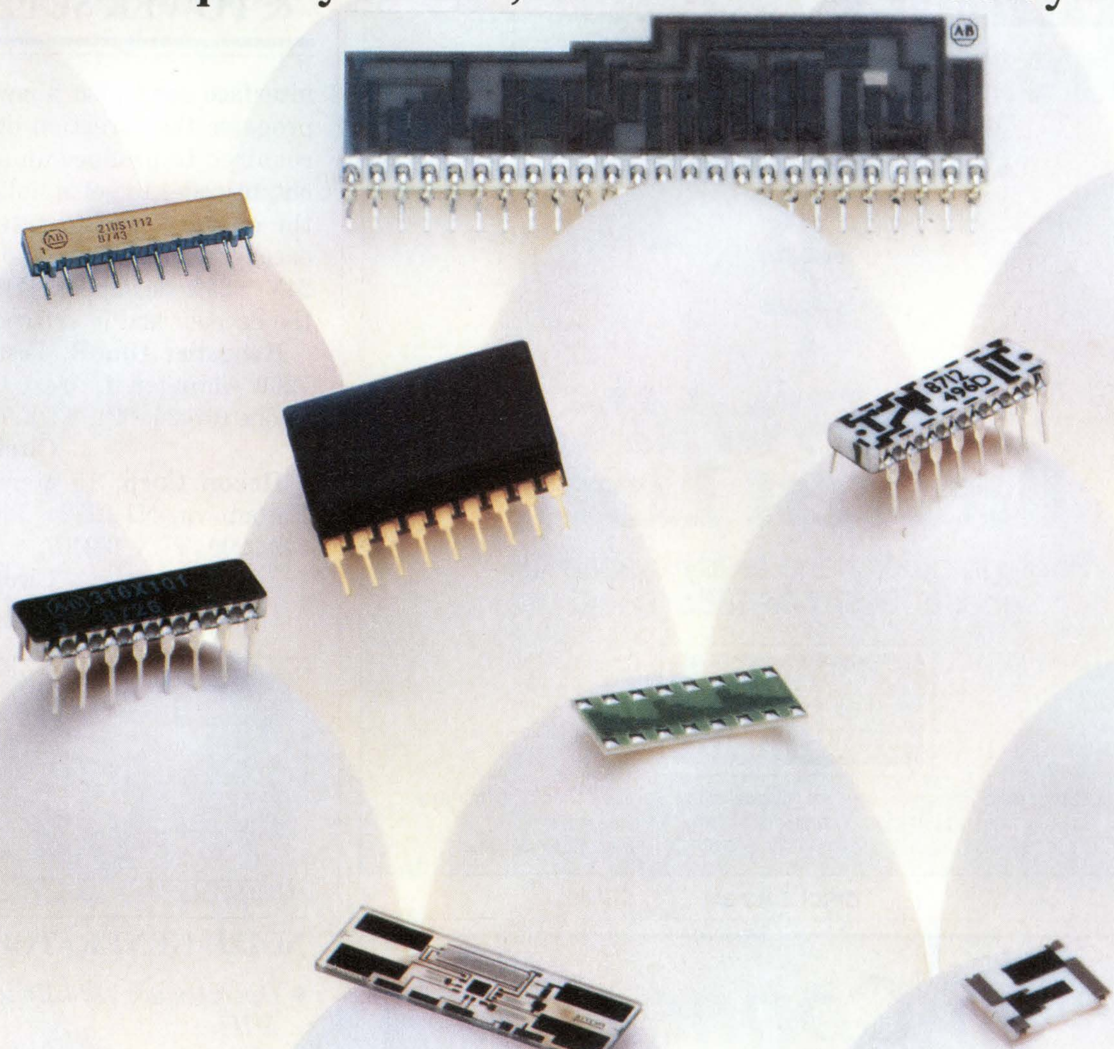

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CIRCLE NO 175

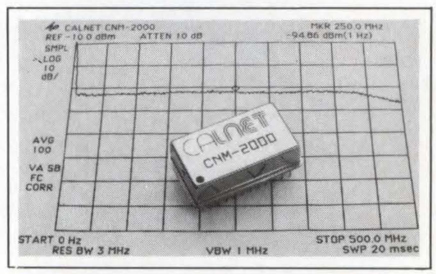
interface card also allows you to program the direction of rotation required to produce an ascending output code, to set a null-point for the encoder, and to reset it. The encoder and interface card require a 24V ±25% dc supply. DM 1500 for the encoder and interface card.

Hengstler GmbH, Postfach 100, 7209 Aldingen 1, West Germany. Phone (07424) 891. TLX 760422.

Circle No 368

Hecon Corp, 15 Meridian Rd, Eatontown, NJ 07724. Phone (201) 542-9200. TLX 132457.

Circle No 369



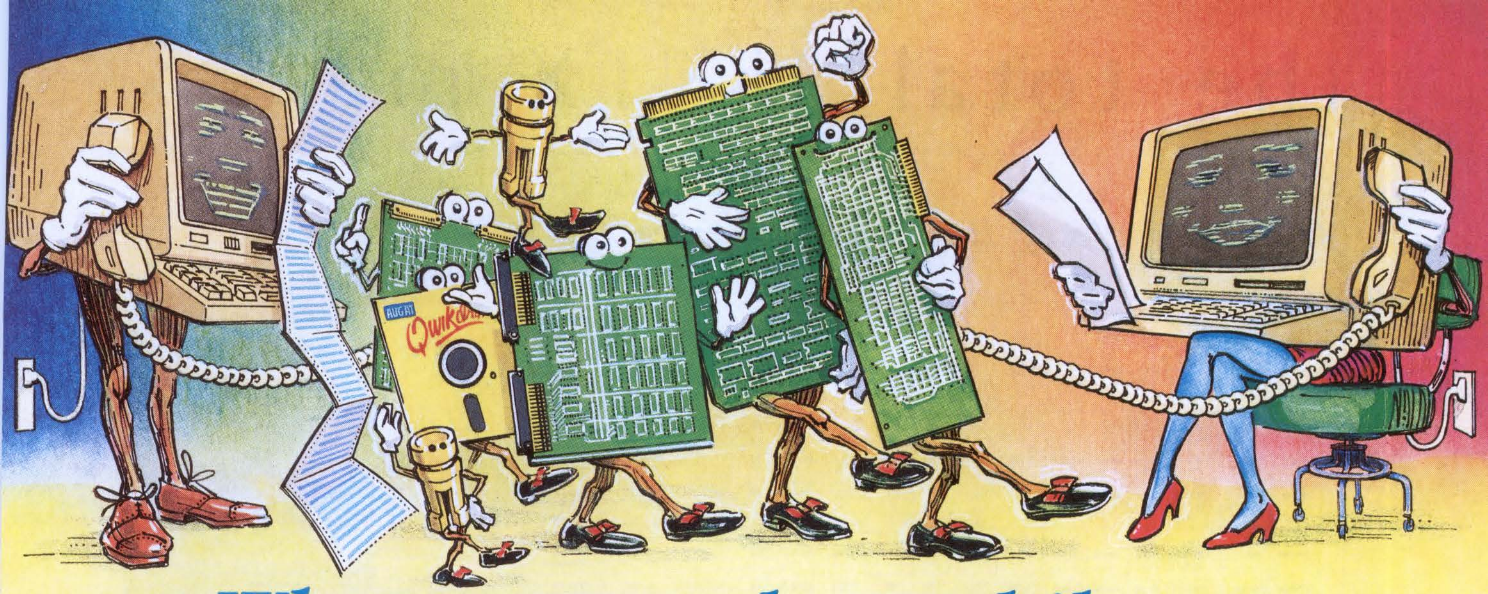
NOISE GENERATOR

- *Operates over 10 kHz to 500 MHz*
- *Maintains output within ±1 dB*

Model CNM-2000 produces true-white-Gaussian noise over a range of 10 kHz to 500 MHz into a 50Ω load. The generator uses shot and thermal noise as its source and produces a stable output with no aging problems. The random noise output is within 0.2% of the ideal Gaussian shape factor. Over 10 kHz to 430 MHz, the CNM-2000 maintains its 50 mV rms output to within ±1 dB. It operates from supplies of 5 to 7V dc and draws 100 mA max. An evaluation kit, containing the generator, a pc board complete with mounting socket and circuitry that increases generator output by 20 dB, is also available. The unit is housed in a 24-pin hermetic metal enclosure. Model CNM-2000, $149; kit, $169.

Calnet Electronics Inc, Box 13113, Kanata, Ontario, Canada K2K 1X3. Phone (613) 831-0424.

Circle No 370



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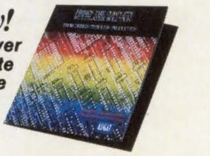
A major part of Augat's total vertical integration is our board fabrication capability. With precision artwork generated by our experienced staff of PC design engineers, coupled with our 30 years of board-level interconnection experience, top quality multilayer boards are guaranteed. The complete process, from imaging to testing, is achieved by our UL and MIL-P-55110D approved fabrication facilities. For even greater "product to market pressures", a quickturn fabrication service is available.

Add zero-profile pluggability with Holtite® Contacts

By investing just pennies per plated-thru hole, spec in Holtite® contacts and increase your assembly throughput and yields. Augat's patented and proven Holtite® contacts are solderless, zero-profile, automatically insertable and available in a wide choice of options. Ask for the complete Holtite® story and specs.

New! Multilayer & Holtite Literature Available



AUGAT® INTERCONNECTION SYSTEMS

40 Perry Avenue, P.O. Box 1037, Attleboro, MA 02703
(617)222-2202 FAX (617)226-5257 TWX 710-391-0644

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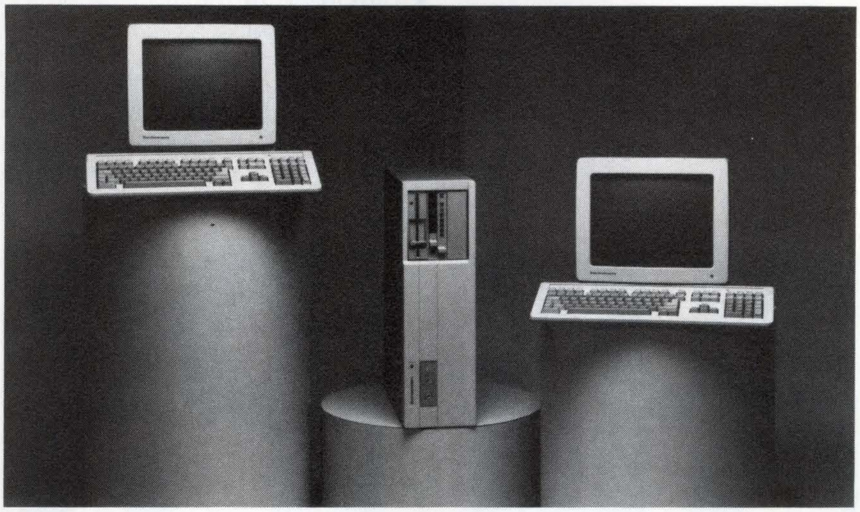
CIRCLE NO 166

COMPUTERS & PERIPHERALS

80386 COMPUTER

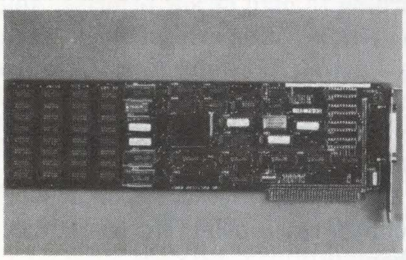
- *Has 16-MHz CPU and can accommodate 16 users*
- *Supports Xenix-Net for LAN communications*



The System SP1000 80386-based computer for 8 users, runs at 16 MHz, and is expandable to accommodate 16 users. It runs under the TI System V operating system, which is a derivative of the Unix System V operating system. In addition, it supports communications software such as 3780/2780 System V, 3270 SNA System V, and Xenix-Net for LAN communications. The basic system includes 1M byte (expandable to 9M bytes) of RAM, a floppy-disk drive, eight expansion slots, and an adapter for serial and parallel communications. The mass storage is expandable to 140M bytes, and an 80387 numeric coprocessor is optional. The company has instituted a trade-in policy that allows you to apply the cost of the computer toward the purchase of an upgraded model at a future date. From $3795 to $7700.

Texas Instruments Inc, Data Systems Group, Box 181153, DSG-189, Austin, TX 78718. Phone (800) 527-3500.

Circle No 375



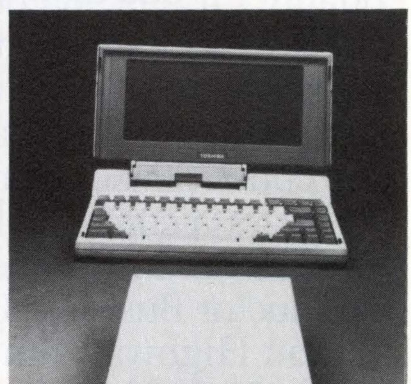
STORAGE CARD

- *For the IBM PC, PC/XT, and PC/AT*
- *6:1 to 25:1 ratios for 8½×11-in. documents*

The HIS-7900 document-storage and -retrieval card for the IBM PC, PC/XT, PC/AT, and compatibles contains an image-compression and -expansion processor and provides 1M byte of memory. The board uses the compression and expansion algorithms to store documents and transmit facsimiles in accordance with CCITT group 3 and 4 standards. Its typical compression ratios vary from 6:1 to 25:1 for 8½×11-in. documents, depending on the scan density and compression type. An image function library provides drivers for the Wyse 700, the Moniterm Viking I, the Hercules, and IBM EGA compatible displays. The library functions include zoom, pan, scroll, text windows, and memory peek and poke. You can obtain an optional laser-printer card for interfacing with Canon CX/SX and HP Laser Jet laser printers. HIS-7900, $1295; laser-printer adapter card, $295.

Hawkeye Image Systems Inc, 5785 Arapahoe Rd, Suite D, Boulder, CO 80303. Phone (303) 443-6699.

Circle No 376



DISK SUBSYSTEM

- *For the Toshiba 1100+ laptop computer*
- *Lets you port software to your destktop computer*

The Matchmaker Plus external floppy-disk subsystem for the Toshiba 100+ laptop computer employs a 5¼-in. format, features a formatted capacity of 360k bytes, and offers 81-msec access time typ. The subsystem provides a convenient means of porting software between your laptop and desktop personal computers. Because it weighs 3.9 lbs and measures 2×6×10 in., you can carry it with your laptop. The system operates with MS DOS 3.2 or later and comes with a 1-year warranty. $399.

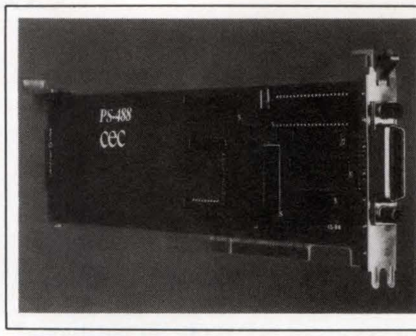
Dolphin Systems Tech, 603-B E Alton Ave, Santa Ana, CA 92705. Phone (714) 546-6938. FAX 714-546-1435.

Circle No 377

IEEE-488 CARD

- *For the IBM PS/2 supports shared interrupts*
- *Can arbitrate as many as 16 DMA channels*

The PS-488 IEEE-488 adapter card for the IBM PS/2 employs the vendor's 88C01 Micro Channel interface chip. The chip features automatic



board identification, shared interrupts, and direct memory access (DMA), and it can accommodate as many as 16 channels of DMA arbitration. Programs written for the vendor's IEEE-488 interfaces for the IBM PC, PC/XT, PC/AT, and compatible computers are fully compatible with the board. Its software includes language-support for Basic, Pascal, C, and Fortran, and a library of over 20 programs for instruments. You don't have to reserve any space in memory for device drivers since the board contains all of the program memory. You can program the shared interrupts according to high or low priority. You can employ standard software, such as Lotus 1-2-3 and AutoCAD, to control HPIB (Hewlett-Packard Interface Bus) printers and plotters. $450.

Capital Equipment Corp, 99 S Bedford St, Burlington, MA 01803. Phone (617) 273-1818.

Circle No 378

IMAGE PROCESSOR

- *Provides video I/O, and image processing on VME Bus board*
- *Accepts a variety of video formats*

Including a frame grabber, frame store, color lookup table, analog video output, a 68020 μP, and 1M byte of dynamic RAM, the IPC image-processor board is suitable for use as a stand-alone image processor, or as an image processing subsystem in VME Bus systems. You can add an optional 68881 math coprocessor. The board has four video

"We bet our entire company's future on our partnership with Hitachi."

—Jim Balkcom
President and Chief Executive Officer
Humminbird® Depth Sounders
Techsonic Industries, Inc.

"As the second largest manufacturer of depth-sounding equipment, we were determined to become the leader. We knew it would take a breakthrough in meeting the fisherman's needs.

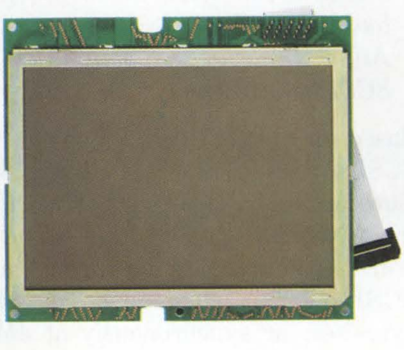
"In strategic partnership with Hitachi, we developed the LCD technology that redefined the depth-sounder market and ultimately quadrupled its size. Our share went from 20 to over 50%. The new technology was a big risk for us. We laid the whole future of our company in Hitachi's hands, and it paid off."

"Whether between two people, or two companies, trust is what makes partnerships work."

"We've shared technologies, design concepts, marketing plans and other critically confidential information across both sides of the table. That's partnership. Trust makes it work . . . and continue to grow."

"Hitachi defines quality the same way we do— meeting customers' needs."

"Hitachi gives Techsonic the technological edge, and more. We've learned it's a waste of time to do incoming testing on Hitachi LCDs. And when we sold over three times our forecast, they were flexible enough to come through for us. Whatever support we need, we get.



And the best part is, we never have to ask for it."

"Hitachi makes it clear that their most important product is our product."

"We needed to team up with an LCD supplier who had the expertise, the capabilities, and the desire to work with us to develop the right solutions. Partnering with Hitachi made Humminbird No. 1, and we're sure it's going to keep us there."

To learn about how partnering with Hitachi can benefit your company, call Tom Klopcic or David Ross at (312) 843-1144. Or write to Hitachi America, Ltd., Electron Tube Division, 300 N. Martingale Road, Suite 600, Schaumburg, IL 60173.

HITACHI®

Hitachi America, Ltd.
Electron Tube Division

CIRCLE NO 164

inputs that you can multiplex under CPU control to an 8-bit A/D converter. You can program the board to accept CCIR- or EIA-compatible video signals, or non-standard video signals. The maximum sample rate of the A/D converter is 15M samples/sec. External pixel-clock and trigger inputs allow you to externally synchronize the frame grabber. Pixel information is stored in 512k bytes of dual-port video RAM that can store a single frame with a resolution as high as 1024×512 pixels, or two 512×512-pixel frames. The video RAM is separate from the processor's 1M byte of local memory. A video D/A converter and a color lookup table allow you to display gray-scale or pseudo-color images on a monitor. The board provides two serial I/O lines and space for 512k bytes of EPROM. The board has an A32, D32 VME Bus interface, and operates as a VME Bus slave with interrupt capabilities. Software support includes the OS/9 operating system with drivers for communication to a VME Bus host processor, and the company's TopPic image-processing software development tools. DM 6800.

Eltec Elektronik GmbH, Galileo-Galilei-Strasse 10, 6500 Mainz 42, West Germany. Phone (06131) 50630. TLX 4187273.

Circle No 379

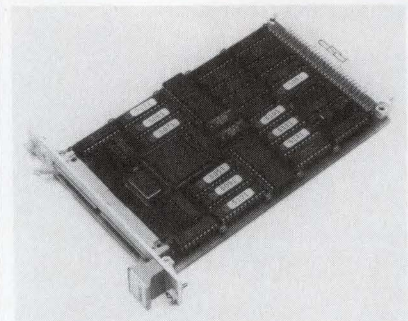
American Eltec Inc, 569 S Marengo Ave, Pasadena, CA 91101. Phone (818) 449-1558.

Circle No 380

SCSI BOARD

- *Supports the ANSI X3.131 SCSI bus standard*
- *Allows multitasking within the SCSI bus I/O subsystem*

Based on the NCR53C90 enhanced SCSI processor, the VSCSI single-Eurocard VME Bus board supports the ANSI X3.131 SCSI bus standard. It can transfer data over the SCSI bus asynchronously at 3M bytes/sec, or synchronously at 4M



bytes/sec. The board performs many of the standard SCSI bus sequences without host CPU intervention. By allowing peripheral devices to disconnect from the SCSI bus after receiving commands, the board allows you to implement a degree of multitasking between various peripheral devices. Implemented largely with CMOS devices, the VSCSI board has a power consumption of 5W. Approximately DM 1000 (100).

Pep Modular Computers GmbH, Am Klosterwald 4, 8950 Kaufbeuren, West Germany. Phone (08341) 81001. TLX 541233.

Circle No 381

Pep Modular Computers Inc, 600 N Bell Ave, Pittsburgh, PA 15106. Phone (412) 279-6661. TLX 825098.

Circle No 382

STE BUS BOARDS

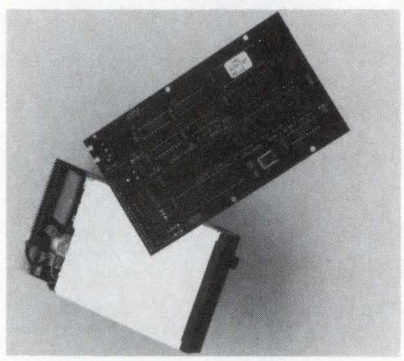
- *Include SBC, memory, parallel I/O, and serial I/O*
- *Use CMOS technology and conform to IEEE 1000*

The vt1088, vt1100, vt1210, and vt1400 comprise a series of STE Bus boards. They utilize CMOS technology and conform to the IEEE-1000 STE Bus. The vt1088 single-board computer uses a 5-MHz 80C88 µP and an 82C85 clock generator that can combine to halt the µP without losing the current program state. It features a programmable interrupt controller, a real-time clock/calendar with lithium battery backup, and a watchdog timer. A 32k×8-bit CMOS EPROM with an 8k×8-bit

CMOS static RAM provide enough memory for a resident real-time operating system. The vt1100 STE memory board has eight 28-pin JEDEC sockets that accommodate 8k×8-bit through 64k×8-bit CMOS EPROMs, EEPROMs, or static RAMs. The vt1210 parallel I/O board has 4-byte-wide I/O ports for a total of 40 I/O lines. The vt1400 serial I/O board provides RS-232C and RS-485 ports with full modem control functions. vt1088, $624; vt1100, $430; vt 1210, $238; vt1400, $360.

Val-Tech Inc, 24 McMillan Way, Newark, DE 19714. Phone (302) 738-0500.

Circle No 383



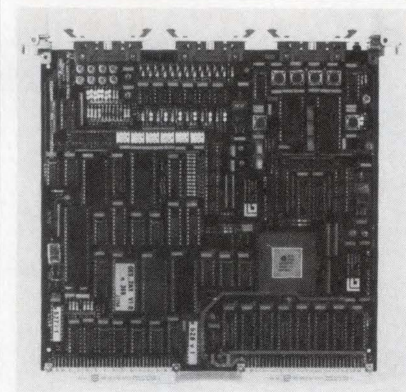
SCSI CONTROLLER

- *Mounts in standard 3½-in. floppy-disk drives*
- *Connects directly to the 34 conductor SCSI cable*

The PT-SCS350 3½-in. floppy-disk controller for the SCSI bus mounts in a standard 3½-in. floppy-disk drive. The card connects to the data-interface and power connections of the drive as well as to the 34 conductor SCSI ribbon cable. It conforms to the ANSI standard REV 17B and to the Common Command Set 4.B of the SCSI specification, and supports the SCSI arbitration, disconnect, and reconnect protocols. The board features a ROM that the vendor can modify to include default parameters of your own definition, and a static RAM that functions as a buffer between the high-speed SCSI bus and the floppy disk. PT-SCS350, $150; PT-SCS351, a version of the controller mounted in a 3½-in. floppy-disk drive with 1M-byte or 2M-byte capacity, $295 (100).

Performance Technologies Inc, 300 Main St, E Rochester, NY 14445. Phone (716) 586-6727. TWX 650-293-8297.

Circle No 384



MOTOR CONTROLLER

- *Provides Multibus II systems with motor control*
- *Microcontroller executes complex motor movements*

The FAB540 intelligent motor controller for Multibus II systems provides position and speed control for two dc servo motors. The board features two 12-bit A/D channels, two 12-bit D/A channels, incremental encoder inputs, with a digital I/O interface for switching, and supervisory functions. You can select the analog inputs and outputs to operate with ±10V or 0 to 24V ranges, and the analog outputs can deliver 10 mA. Both the analog inputs and outputs have 500V isolation from the Multibus II system, and the encoder and digital inputs and outputs have 1500V isolation. An onboard 8032 microcontroller, provided with 8k bytes of RAM and space for 32k bytes of EPROM, allows you to execute complex motor movements, using only high-level commands from the system's host processor. The board's Multibus II

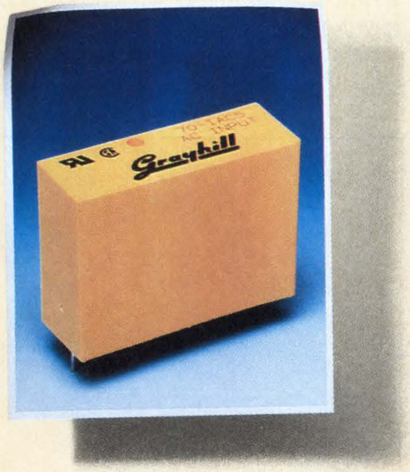
Grayhill shrinks the I/O module

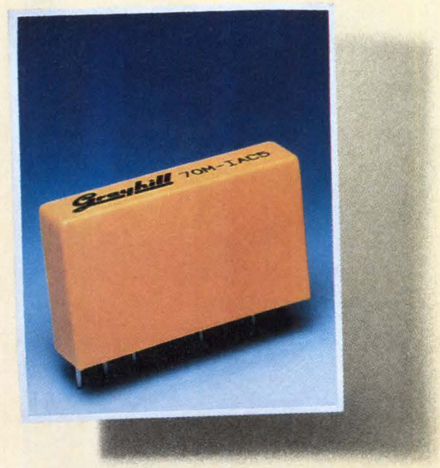
to save you space, money, and problems

This new series of space-saving I/O modules for control applications measures 0.40″ deep and 1.00″ high, compared to 0.60″ and 1.25″ for "standard" models, and reduces the length of a 16-module rack by 4 inches! (The wide side is the same 1.70″ as standard modules, for plug compatibility.)

Grayhill mini-modules consume 30% less power than their big brothers, and offer immunity from false triggering caused by electrical transients (per IEEE-472). Using SMT construction, Grayhill shrinks the package, yet upgrades performance even compared to its own standard modules, much less anyone else's. AC output units have lower leakage current, DC output units offer faster switching, and AC input modules have a higher input impedance.

The new mini-modules come in all standard configurations, at pricing comparable to standard-size I/O modules.

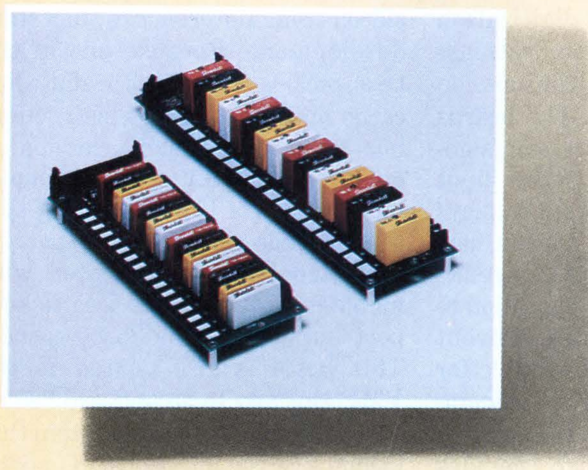




They plug into 16 module racks without screws; a hold-down strip keeps them in place. Surface-mount LEDs with writing space provide status and function indication.

Using the new modules saves you cost at least four ways—you use a smaller rack, a smaller power supply, a smaller enclosure, and you save the labor of screwing modules into place. And you get better performance besides.

What else could you ask for? How about local availability from Grayhill distributors worldwide! You get that too. So now your next step is send or call for free literature. Do it today.



COMPARISON CHART

PHYSICAL CHARACTERISTICS	STANDARD I/O MODULES	MINI I/O MODULES
Module dimensions	0.60″x1.70″x1.25	0.40″x1.70″x1.00
16-position rack length	14″	10″
Installation	Individual screw-down	Hold-down strip
ELECTRICAL CHARACTERISTICS		
Power consumption/ module-AC output	18 milliamps	12 milliamps
Pass IEEE-472	No	Yes
Switching speed—DC output	75 μs turn on 500 μs turn off	20 μs turn on 40 μs turn off
Input impedance—AC input	14K Ohm (120 VAC) 45K Ohm (240 VAC)	22K Ohm (120 VAC) 60K Ohm (240 VAC)

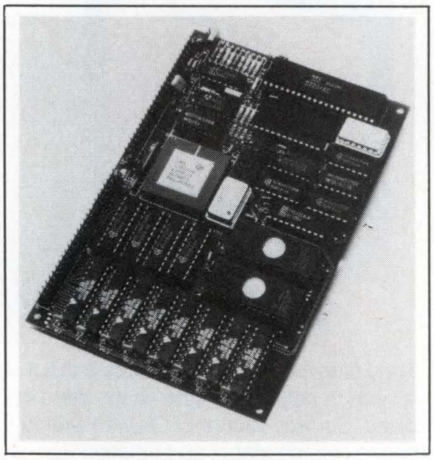
Grayhill INC.

561 Hillgrove Avenue, P.O. Box 10373
LaGrange, Illinois 60525-0373 USA
Phone: (312) 354-1040 FAX: (312) 354-2820
TLX or TWX: 190254 GRAYHILL LAGE

iPSB interface has full message-passing capability, as well as interconnect space and built-in self-test support. The board typically draws 2A from its 5V supply, and 350 mA from its ±12V supplies. Fr Fr 18,300.

Centralp Automatismes, 16 rue Gabriel Péri, 92120 Montrouge, France. Phone (1) 42533617. TLX 632380.

Circle No 385



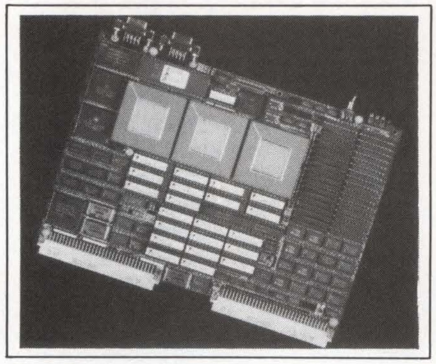
VOICE BOARDS

- *Transmit communications-grade voice quality at 8k bps*
- *Provide real-time operation*

OM-1 and OM-3 voice digitization boards provide communications-grade voice quality at transmission rates as low as 8k bps. The boards use a proprietary compression algorithm to digitize analog voice input in real time; this algorithm employs a combination of time domain harmonic scaling and adaptive predictive coding-dynamic bit allocation to remove the redundancies inherent in speech. The OM-1 is suitable for secure voice systems, voice annotation of documents, and voice recognition. The OM-3, which provides adaptive echo cancellation and suppression, is useful when you want to rout the digitized voice through phone lines and PBXs. The boards combine a codec and a TI TMS320 DSP Chip to provide real-time operation. OM-1, $399; OM-3, $599 (OEM).

Advanced Compression Technology Inc, 31368 Via Colinas, Suite 104, Westlake Village, CA 91362. Phone (818) 889-3618. FAX 818-889-2041.

Circle No 386

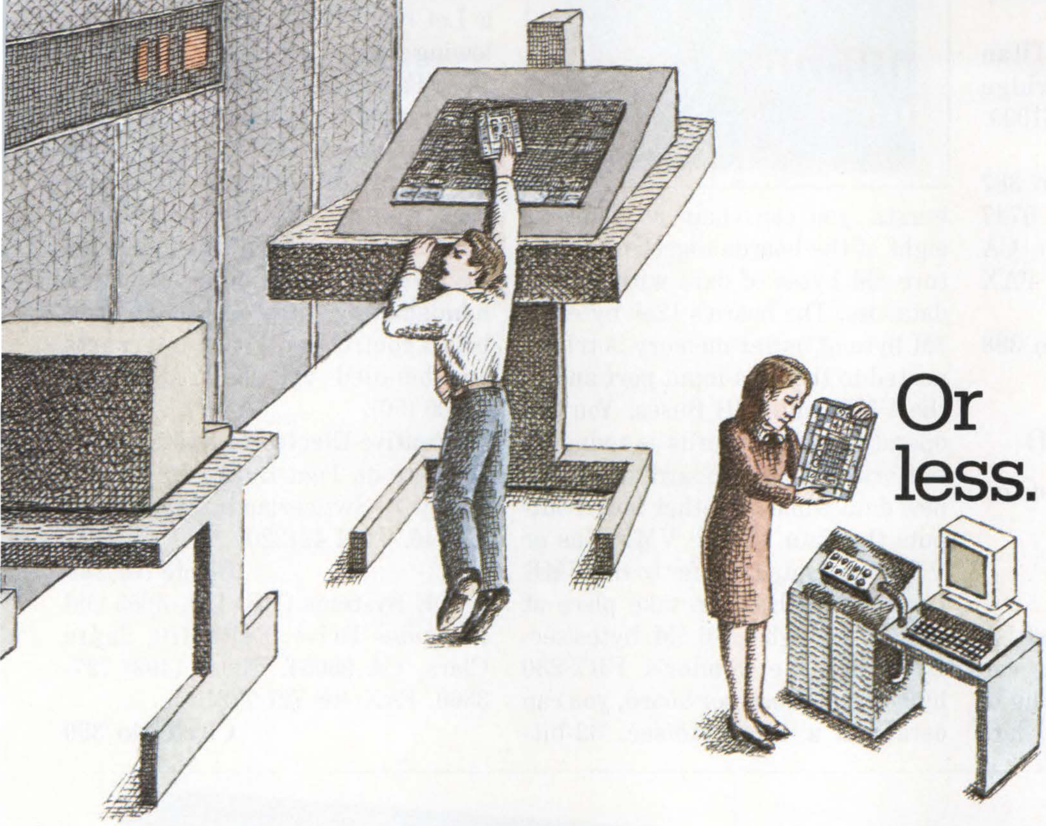


RISC BOARD

- *Based around the 88100 RISC processor*
- *Provides an environment suitable for running Unix*

The TP880V high-performance CPU card for VME Bus systems is based around Motorola's 88100 RISC processor and two 88200 cache-memory-management units. The vendor is currently offering the board without these devices installed; users who can obtain early silicon from Motorola can thus start development. Because one of the two 88200s features a data-bus cache and the other an instruction-bus cache, the board provides an environment suitable for the implementation of a Unix operating system. It has 4M bytes of parity-protected RAM implemented with nibble-mode DRAM devices to support burst-fill of the 88200 caches. This RAM is also ported to the VME Bus and to an onboard 68000-based intelligent I/O subsystem that includes SCSI and serial I/O ports, a real-time clock, and a local RAM and EPROM. The board operates as a VME Bus master capable of release-when-done or release-on-request bus arbitration schemes. It provides control of read-modify-write bus cycles and has slave support for unaligned data-bus trans-

You shouldn't buy more board tester than you need.



Now, you don't have to settle for too little or too much in a board tester. You can get one that's just right for you. From HP.

The HP 3065 family of board testers offers you flexibility. So you can get a system that fits your board mix, process, volume, and budget. Right now. And you can add capability or upgrade at any time to keep pace with your needs.

Our family begins with the HP 3065ST, our standard digital in-circuit tester starting under $100,000. And goes all the way to the HP 3065AT, one of the most advanced combinational testers on the market. You can combine controllers, test stations, and options for the exact system you need.

And no matter which you choose, you get software and fixture compatibility up and down the line. Networking with CAE/CAD workstations and simulators. Built-in analog functional instruments. A digital test library for 4,500 devices.

You get something else, too: HP experience in ATE dating back to 1975, with more than 85 service offices and 2,000 in-circuit testers installed worldwide. Plus, product reliability backed by our exclusive 99% Guaranteed Uptime Program.*

It all means better value for you. And, because our board test family offers systems at each level of price/performance, you buy just what you need . . . no more and no less.

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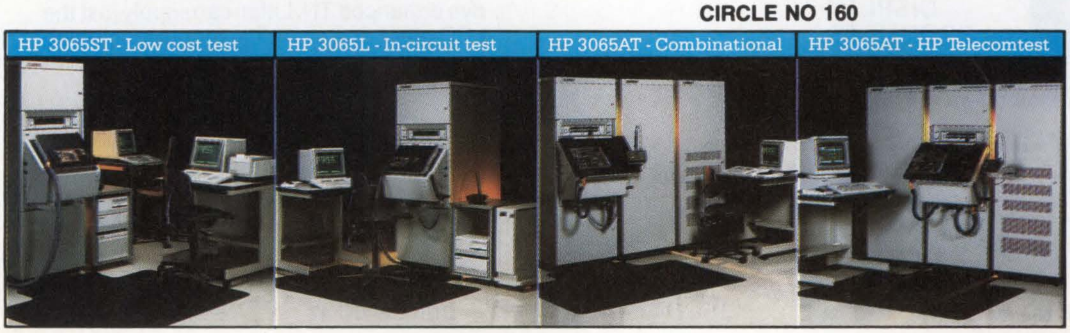
For a free videotape on the HP board test family, or more information, call 1-800-634-TEST (in Colorado, call collect: 303-669-9325.)

HEWLETT PACKARD

CIRCLE NO 160



*Some restrictions apply.

fers. It includes a VME Bus interrupt generator and an interrupt handler. Without 88000 chip set, £2995.

Tadpole Technology plc, Titan House, Castle Park, Cambridge CB3 0AY, UK. Phone (0223) 461000. TLX 818152.

Circle No 387

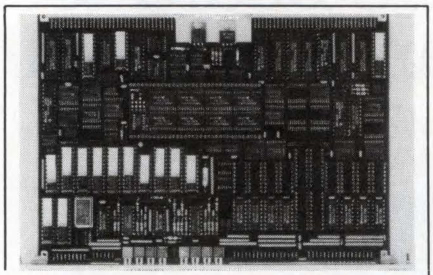
Tadpole Technology Inc, 6747 Sierra Court, Suite K, Dublin, CA 94568. Phone (415) 828-7676. FAX 415-828-9340.

Circle No 388

DATA-CAPTURE BOARD

- *Captures 1M-byte data bursts at 40M bytes/sec*
- *Transfers data to either the VME or VSB Buses*

The HSM8170 data-acquisition board for VME Bus systems can capture 1M byte of data arriving at 40M bytes/sec. For longer data



bursts, you can chain as many as eight of the boards together to capture 8M bytes of data without any data loss. The board's 128k bytes or 1M byte of buffer memory is triple-ported to the data-input port and to the VME and VSB Buses. You can operate a pair of boards as swinging buffers, with one board accepting new data while the other board outputs the data via the VME Bus or VSB Bus. Data transfer to the VME Bus or VSB Bus can take place at speeds as high as 6.5M bytes/sec. By using the vendor's FIC8230 high-speed processor board, you can establish a 40M-byte/sec, 32-bit-wide DMA channel to the HSM8170 on the VSB Bus. The standard board's data-input port interfaces to a LeCroy FERA read-out bus, allowing you to connect it to FERA Bus, Fast Bus, or Camac systems. Other input configurations allow the board to accept ECL-, single-ended TTL-, or differential TTL-level data. You can transfer data to the data-input port synchronously or asynchronously using a variety of handshaking protocols. Overall board control and board interrupts are handled via the VME Bus. $4500 (50).

Creative Electronic Systems SA, 70 route du Pont-Butin, 1213 Petit-Lancy 1, Switzerland. Phone (022) 925745. TLX 421320.

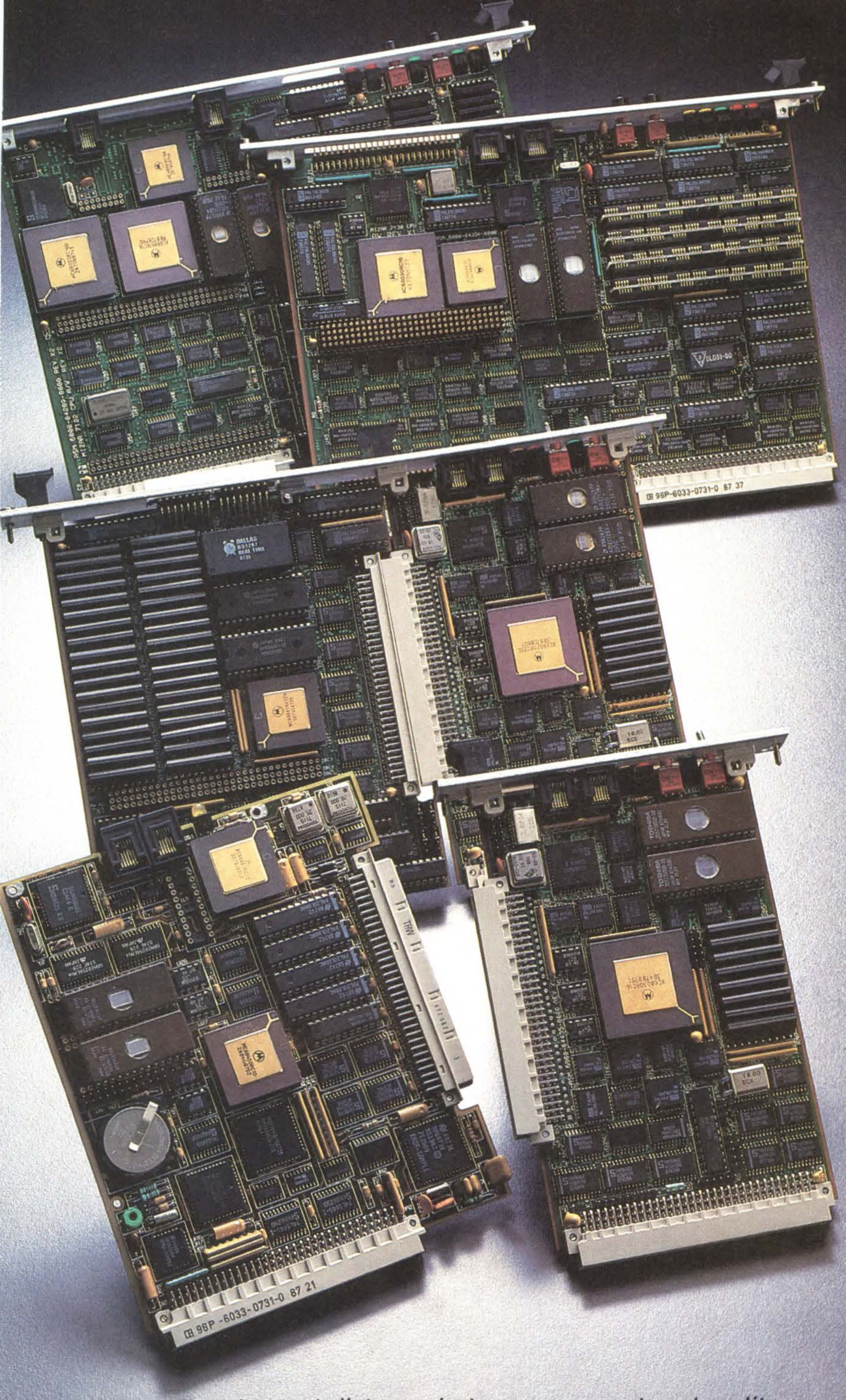
Circle No 389

C E Systems (US) Inc, 4655 Old Ironsides Drive, Suite 370, Santa Clara, CA 95054. Phone (408) 727-3360. FAX 408-727-7721.

Circle No 390

The Application Servers

Build your application with Mizar's new generation of 32-bit microcomputers.



New standards of VME performance.

Mizar presents a new line of microprocessors for VME-based applications. With powerful Motorola 68020 and 68030 CPUs at up to 30 MHz, and the latest in memory interface and surface mount technology, Mizar provides the performance and functionality your application demands.

Platforms for every application.

Mizar designed its new processors with the application developer in mind. Mizar's single-height processors are not only excellent computing engines, but through Mizar's MXbus™, become uniquely configurable to meet specific I/O, memory and processing needs. MZ 8100 Series single-height processors can be transformed into double-height solutions with complete single-board functionality and performance. Similarly, the MZ 7100 Series of double-height processors provide all you expect from a single board computer, and can be tailored with easy-to-use plug-in modules. With either solution, you can start development today.

Superior memory handling.

Mizar's engineers have reduced critical wait-states to zero at 16.7, 20 and 25 MHz in many cases. To enhance multiprocessor system performance, Mizar's new on-card memory arbitration logic frees the CPU during time-consuming memory operations across the VMEbus, allowing concurrent local processing. And for more demanding applications, Mizar's 68030 based MZ 7130 even includes cache options.

Your application demands the latest in 32-bit VME technology. Call Mizar.

1-800-635-0200

Ask for extension 140

Mizar. The shortest distance between concept and reality.

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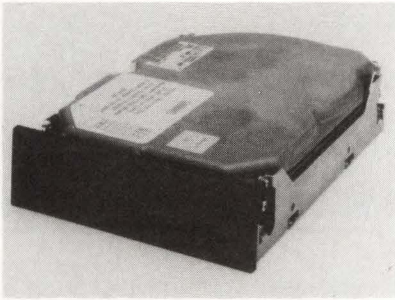
CIRCLE NO 159



5¼ DISK DRIVE

- *179.8M-byte unformatted capacity in a half-height format*
- *Provides 18-msec access time typ*

The D5655 5¼-in., floppy-disk drive features 179.8M bytes of unformatted storage capacity. Its half-height package permits you to install it in low-end workstations with space for full-height drives, thus providing a migration path to the 380M-byte capacities of high-end workstations. The drive features 18-msec access time and a 1.25M-byte/sec data-transfer rate. It has an enhanced small device interface (ESDI) and boasts a 30,000-hour MTBF. $885.

NEC Information Systems Inc, 1414 Massachusetts Ave, Boxborough, MA 01719. Phone (617) 264-8000.

Circle No 391

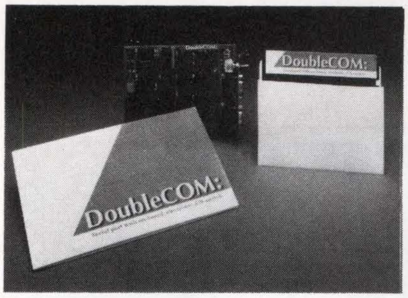
CCD CAMERA

- *Conforms to CCIR specifications*
- *Has CCD imager that offers 756×581 square pixels*

Th XC-77CE black-and-white CCD video camera conforms to CCIR specifications and features a CCD imager that provides 756×581 square-pixel resolution. Each image cell measures 11×11 μm. Because the unit measures 1.1×1.7×4⅕-in. and weighs 0.4 lbs, it is suitable for machine-vision applications. The camera is sensitive to light of as little as 0.5 lux when it is set at an F-stop of 1.4. The unit exhibits a signal-to-noise ratio of more than 50 dB and operates from −5 to +50°C. Its features include selectable automatic gain control, a C-style lens mounting with a removable infrared cutoff filter, internal or external synchronization, interlaced or non-interlaced scanning, and automatic iris control. $1400.

Sony Corp of America, Component Products Div, 10833 Valley View St, Cypress, CA 90630. Phone (714) 229-4181. FAX 714-229-4271.

Circle No 392



I/O CARD

- *For the IBM PC operates as COM1 or COM2*
- *Has electronic A/B switch*

The DoubleCOM: half-size serial I/O card for the IBM PC, PC/XT, PC/AT, PS/2 models 25 and 30 and compatible computers contains an electronically controlled A/B switch to interface two peripheral devices to these computers. The card is addressable as either COM1 or COM2. Its A/B switch is software controlled; the use of two cards allows you to interface four peripherals to the computer without the need for a mechanical A/B switch. You can switch peripherals via a keyboard command without exiting an application program. The peripherals connect through a standard IBM PC/AT style 9-pin connector. Software utilities run under PC-DOS, MS-DOS, and Microsoft Windows. The unit conforms to FCC Class B specifications. $149.

D-G Electronic Developments Co, 700 S Armstrong, Denison, TX 75020. Phone (214) 465-7805.

Circle No 393

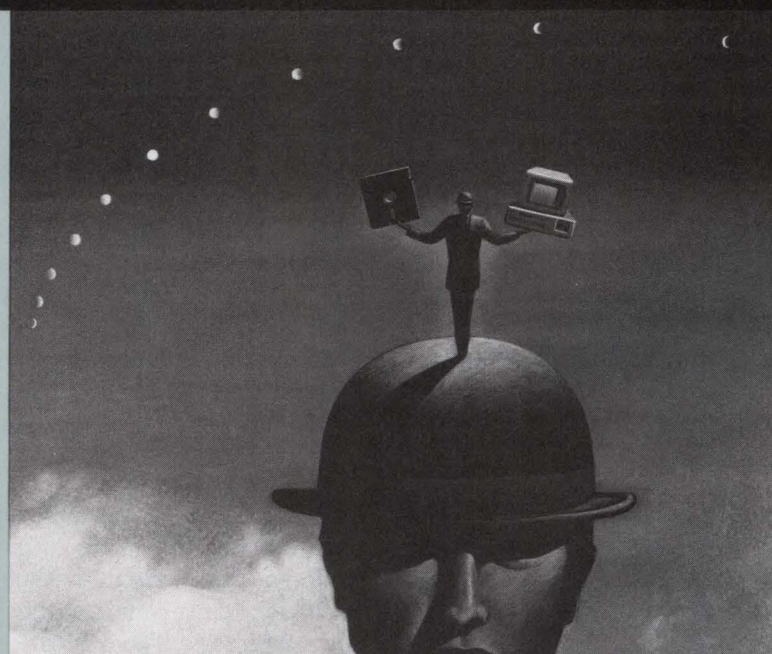
GRAPHICS SYSTEM

- *Updates screen at 30 frames/sec for real-time animation*
- *Provides 1024×1024-pixel resolution*

The Falcon-PC graphics system for the IBM PC, PC/AT, and compatibles consists of a graphics board, an array processor, a 19-in. monitor, and software. The PG-2000 graphics board can display 30,000 flat-shaded polygons/sec, fill them at 160 million pixels/sec, and update the graphics screen at 30 frames/sec for real-time animation. The board, which occupies one slot, drives a 19-in., 60-Hz noninterlaced color monitor. You can obtain versions of the unit that provide either 1024×1024- or 1024×768-pixel resolution and 256 colors from a palette of 16.8 million. The AP-2000 array processor occupies two slots; you can obtain it in either a 10M- or 20M-flop, 32-bit array version. The software lets you interface graphics databases and subroutines to AutoCAD. $19,095.

XTAR Corp, 9915C Business Park Ave, San Diego, CA 92131. Phone (619) 271-4440. FAX 619-271-4443.

Circle No 394

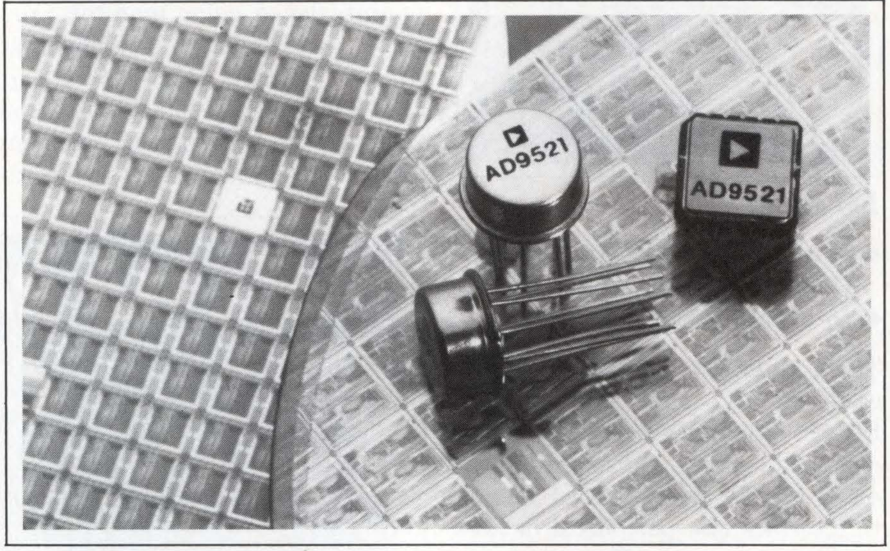


NEW PRODUCTS

INTEGRATED CIRCUITS

AMPLIFIER

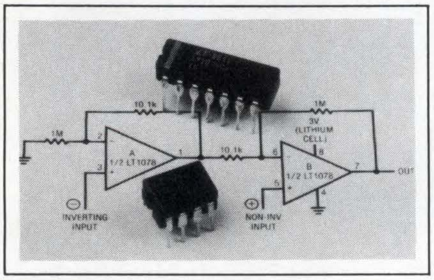
- *Offers 7- to 250-MHz bandwidth*
- *Features monolithic construction*



The monolithic AD9521 is a logarithmic amplifier that provides a 7- to 250-MHz bandwidth typ and thus approaches the performance of hybrid devices. The device's voltage gain varies 1.2 dB from 30 to 160 MHz. The output-current matching from device to device is guaranteed to within ±50 μA—an important parameter if you are designing logarithmic amplifier strips that will work over a wide dynamic range. The close output matching, combined with a 4.7-dB noise spec, lets you design logarithmic strips that have 80- to 90-dB dynamic ranges and better than ±1-dB linearity. The device runs from a 6V supply, has a full-scale 0.9-mA min output current at 60 MHz, and dissipates 90 mW typ. It comes in two gain-tolerance grades and in commercial- and military-temperature range versions. The vendor offers the device in an 8-pin metal can and in a 20-pin LCC. Commercial-temperature range versions, from $16; military-temperature range versions, from $32 (100).

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 935-5565. TWX 710-394-6577.

Circle No 395



PRECISION OP AMPS

- *Dual and quad types available*
- *Low supply current required*

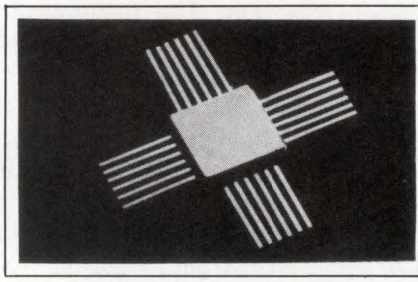
The dual LT1078 and quad LT1079 op amps operate from a 5V supply and consume only 50 μA per amplifier. The offset voltage is 70 μV max, and the offset current is 250 pA max. The voltage noise is 0.6 μV p-p, and the current noise is 3 pA p-p from 0.1 Hz to 10 Hz. The gain-bandwidth product of the devices is 200 kHz. Both devices can operate from one lithium battery or two Ni Cad batteries. The input common-mode range goes below ground, and the all-npn output stage swings to within a few millivolts of ground while sinking current, without the need for power-consuming pull-down resistors. The LT1078 comes in an 8-pin DIP or a metal package; the LT1079 is available in a 14-pin DIP. In plastic commercial versions: LT1078, $2.80; LT1079, $3.50 (100).

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

Circle No 396

ECL LOGIC CHIPS

- *Use gate-array technology*
- *Feature speeds to 4 GHz*



The CXB1100 family of ECL logic devices rival GaAs ICs for high-speed performance, achieving speeds to 4 GHz at power dissipations of less than 1W. The 24 devices, the majority of which come in 24-lead flat packs, include quad OR/NOR gates, quad AND/NAND gates, flip-flops, buffers, multiplexers, demultiplexers, shift registers, and counters. They feature ECL-compatible output levels and temperature compensation. The devices are fabricated in the company's ECL-3 process, a 1-μm technology with a 10-GHz transition frequency and a 80-psec gate delay at 300 μA. $40 to $150.

Sony Corp of America, 10833 Valley View St, Cypress, CA 90630. Phone (714) 229-4192. FAX 714-229-4271.

Circle No 397

Saratoga Cache Tag.

Introducing the world's fastest family of cache tag RAMs—starting at 15 nsec.

When you're trying to squeeze the last few MIPS out of your system, a little fast cache can help. And nothing speeds it up faster than high-performance cache tag RAMs from Saratoga.

More bang for your buck with BiCMOS.

Our new family of BiCMOS cache tag RAMs features address compare times as low as 15 nsec—the fastest in the industry. So now you can break the CPU/memory bottleneck in high-end 32-bit RISC applications. Even the new 020/030 and 386-based designs running at much higher clock speeds will operate faster with Saratoga cache tag RAMs.

These chips are loaded.

These 4K by 4 and 2K by 9 parts offer more flexibility in design, with speeds of 15, 20, 25 and 35 nsec. They come complete with built-in functions such as parity generation/checking, on-chip comparator, fast flash clear, and totem pole MATCH or open drain outputs. Plus they can be easily cascaded to expand word widths and depths.

Other ways to leverage your cache.

These TTL-compatible parts are the first in a complete family of cache tag RAMs from Saratoga. Another part of our high-performance memory solutions—along with fast TTL and ECL static RAMs, and the world's fastest FIFO memories. All in high-performance BiCMOS.

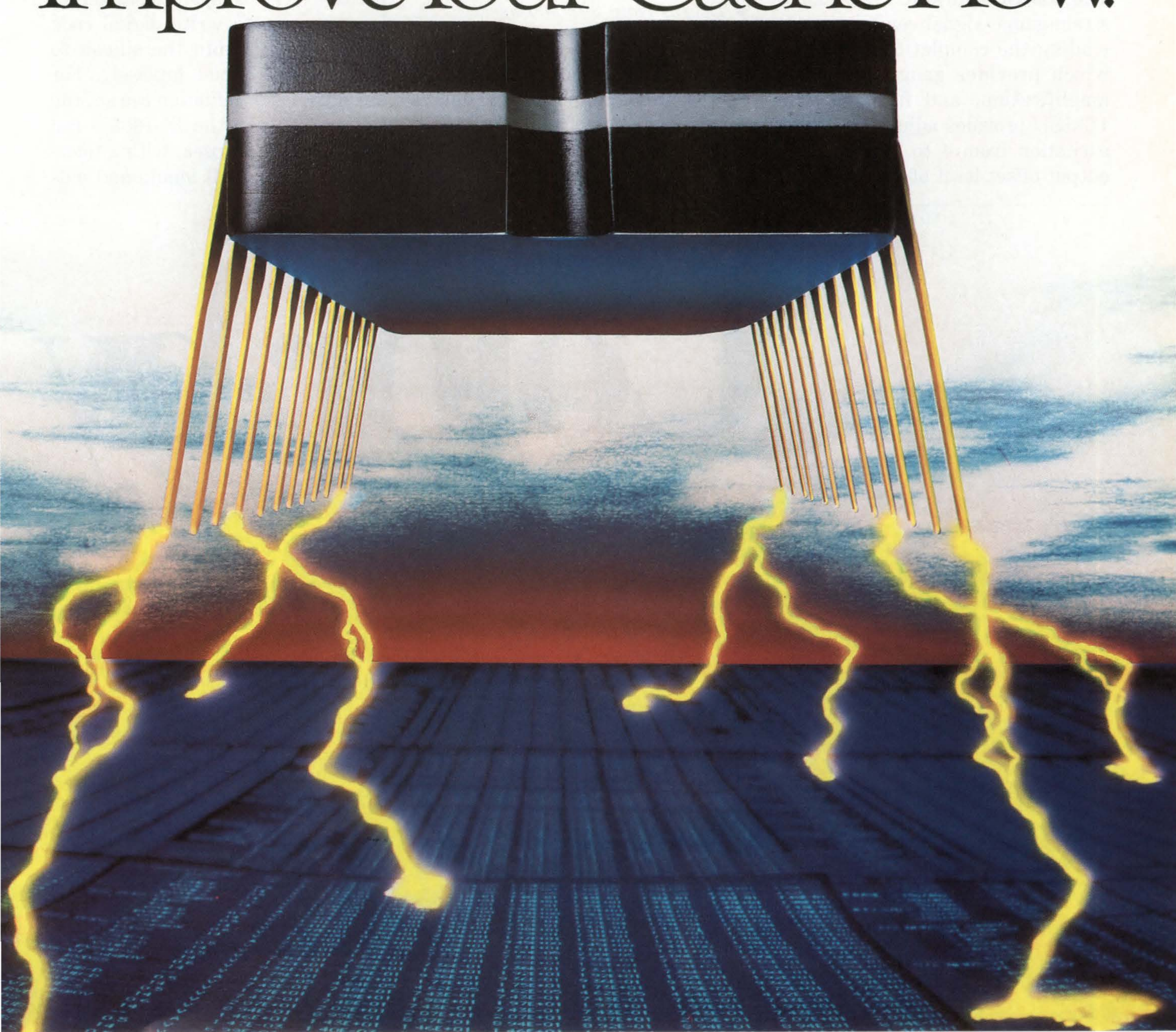
To find out how better cache flow can improve your system performance—and your bottom line—contact Saratoga today. Phone (408) 864-0500, or write: Saratoga Semiconductor, 10500 Ridgeview Court, Cupertino, CA 95014.

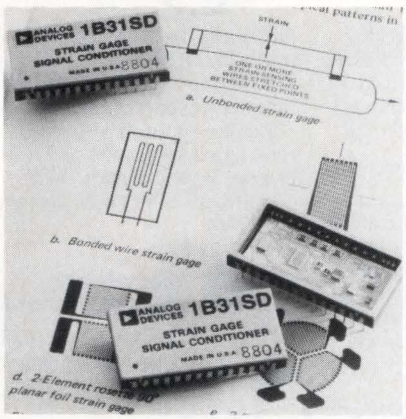
Saratoga Semiconductor

The Leader in BiCMOS.

CIRCLE NO 158

The Fastest Way To Improve Your Cache Flow.





INTERFACE IC

- *Strain-gauge conditioner*
- *Wide temperature range*

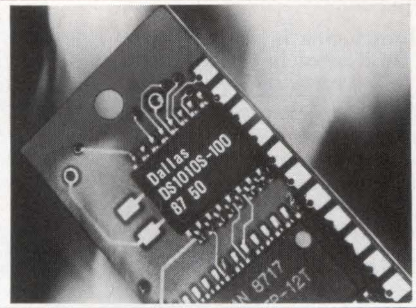
The 1B31SD hybrid IC is a complete strain-gauge signal conditioner (including the completion resistors), which provides gauge excitation, amplification, and filtering. The 1B31SD provides adjustable bridge excitation from 4 to 15V, with an output-offset level of ±10V. External resistors set the gain from 2 to 5000 V/V, with a maximum nonlinearity of ±0.005%. Other features include a minimum common-mode rejection ratio of 140 dB and the ability to drive a 350Ω load with 10V of excitation. Specified over the −55 to +125°C range, the 1B31SD comes in a 28-pin double-width ceramic DIP. $98 (100).

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 935-5565. TWX 710-394-6577.

Circle No 398

CMOS DELAY LINES

- *Delays from 3 to 500 nsec*
- *TTL compatible*



Consisting of four CMOS devices, the DS1000 family offers delays ranging from 3 to 500 nsec. Available now are the 5-tap DS1005, the 10-tap DS1010, the 3-in-1 DS1013, and the 7-in-1 DS1007 delay lines. The tapped versions divide the time into either 5 or 10 equal intervals. The 3-in-1 and 7-in-1 versions provide independent delays for three or seven signals, respectively. Unlike previous hybrid devices, the delay lines need no additional coils or capacitors. The company uses direct laser writing to write digital code words directly into the silicon to calibrate the circuit precisely. For example, laser definition can set the timing specs in the DS1005 5-tap delay line to 100 nsec, with a tolerance of 2 nsec. All inputs and outputs are buffered to TTL levels. DS1005, $2,60; DS1010, $3.75; DS1013, $3.20; DS1007, $3.70 (10,000).

Dallas Semiconductor, 4350 Beltwood Parkway, Dallas, TX 75244. Phone (214) 450-0400.

Circle No 399

ECL CHIPS

- *Speeds from 0.8 to 3.4 GHz*
- *Power requirements under 1W*

Rivaling GaAs devices in high-speed performance, the ECL chips in the CXB1100 family achieve frequencies from 0.8 to 3.4 GHz and have power requirements of 400 to 1000 mW, depending on type. The first release of the family consists of 24 devices, packaged primarily in 24-lead flatpacks; the remainder come in 16- or 32-lead flatpacks. The logic chips operate from a −4.5V supply, have ECL 100K-compatible output levels, and are temperature compensated. Included in the family are standard AND/NAND, OR/NOR, and EXOR/NOR logic gates, a Dual-D flip-flop, a 4-stage ripple counter, multiplexers and demultiplexers, shift registers, and counters. From $40 to $150.

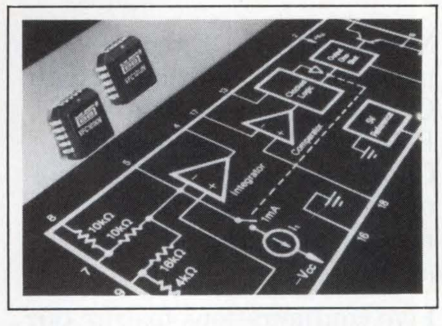
Sony Corporation of America, Component Products Div, 10833 Valley View St, Cypress, CA 90630. Phone (714) 229-4192.

Circle No 400

V/F CONVERTER

- *System clock sets frequency*
- *Three full-scale input ranges*

The VFC101 V/F converter uses multiple laser-trimmed input resistors to provide full-scale input ranges of 5, 8, or 10V. An external clock signal establishes the reference timing and precisely sets the full-scale operating frequency. The



device provides a precision 5V reference output, useful for applications involving the excitation of a bridge or sensor. By means of pin connections, the 5V reference provides a half-scale offset for use with bipolar input voltages. The converter also features a maximum linearity error of ±0.02% FSR (full-scale resolution) at 100 kHz and a maximum gain-drift of ±40 ppm of FSR/°C. 20-pin PLCC, $8.60 (100).

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TLX 666491.

Circle No 401

EMI SHIELDING AT A FAST CLIP

Meeting FCC/VDE requirements is quick and simple with Chomerics' low-cost clip-on EMI gaskets. Each combines Chomerics quality and technology with labor-saving attachment mechanisms. All are available off-the-shelf.

Five configurations feature our new CHO-SEAL® 1000 series conductive elastomers, priced at a fraction of their military counterparts. They deliver up to 60dB of shielding from 30MHz to 1GHz, even when deflected only 25% under low closure force.

Our METALKLIP™ gaskets offer a choice of wire mesh-over-elastomer, or hollow carbon-filled silicone.

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FREE: SELECT UP TO THREE

CHO-SEAL® 1000 Gaskets
- ☐ Plastic Clip, Black
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- ☐ Steel Clip
- ☐ Stick-On Shield & Seal
- ☐ Aluminum Frame Mount

METALKLIP™ Gaskets
- ☐ Mesh-Over-Elastomer
- ☐ Carbon-Filled Silicone

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4. Stick-On Shield & Seal. Co-extruded conductive/nonconductive elastomers provide best environmental seal. Permanently mounts with pressure-sensitive adhesive. Closure force as low as 3 lb/in.

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7. Carbon-Filled Silicone. UL94V-0 rated hollow gasket in the same series 302/304 SS clip. Lowest cost, for lower shielding requirements with low closure force.

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Rue Jacques Brel
Zone Industrielle Les Bellevues
95610 Eragny-sur-Oise
FRANCE
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Telex: 608255F CHOMESA

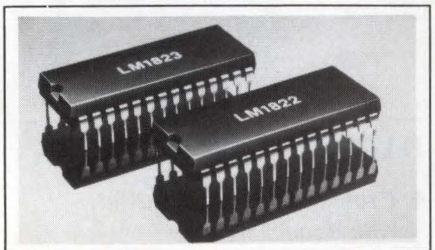
CMOS STATIC RAMs

- *Available in SOJ package*
- *Speeds from 25 to 45 nsec*

With leads on only two sides, these two 64k-bit CMOS static RAMs in surface-mount, small-outline-J packages reduce planarity problems encountered in PLCC (plastic leaded chip carrier) packages, which have leads on four sides. Organized as 8k×8 bits, the MCM6264J offers speed selections of 35 and 45 nsec, and comes in a 400-mil package. The 16k×4-bit MCM6290J is available in speed selections of 25, 30, and 35 nsec, and comes in a 300-mil package. The company is also releasing its existing 4k×4-bit MCM6268 25- and 35-nsec device in a 300-mil, 24-pin SOJ package. From \$4.77 to \$25.12 (100).

Motorola Inc, Technical Information Center, Box 52073, Phoenix, AZ 85072. Phone (512) 928-7144.

Circle No 402



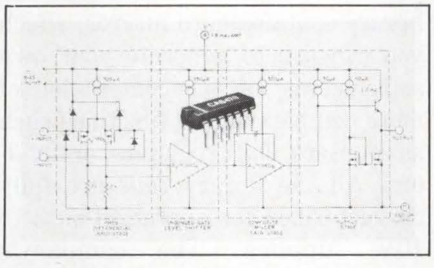
VIDEO IF AMPLIFIER

- *Operation to 70 MHz*
- *Includes PLL detector*

The LM1822 video IF signal-processing system for TV receivers and cable converters incorporates a 5-stage IF amplifier, a phase locked-loop synchronous detector with white-spot noise inversion, an automatic frequency-control detector, and a gated automatic gain control. A second version, the LM1823 contains the same circuitry with the exception of the noise inverter. Both types accept input signals from surface acoustic-wave filters and operate to frequencies of 70 MHz. The IF gain-control range for both versions is 55 dB. The video bandwidths for the LM1822 and the LM1823 are 7 and 9 MHz, respectively. The ICs operate from a 12V supply and come in 28-pin DIPs. \$2.95 (100).

GE Solid State, Route 202, Somerville, NJ 08876. Phone (201) 685-6228.

INQUIRE DIRECT



BIMOS QUAD OP AMP

- *Features μP compatibility*
- *Offers wide supply-voltage range*

The CA5470 quad op amp, which combines high-speed CMOS and bipolar transistors, is specified for 5 and ±7.5V operation over the −55 to 125°C military temperature range. The BIMOS process permits the device to operate from 3 to 16V (±1.5 to ±8V). Each of its four internal op amps features a 12-MHz unity-gain bandwidth product and 5V/μsec slew rate. The device is protected against electrostatic discharge to 2000V. You can obtain it in a 14-pin DIP or a in a 14-lead small-outline IC. \$1.21 (1000).

GE Solid State, Box 2900, Somerville, NJ 08876. Phone (201) 685-6652.

INQUIRE DIRECT

A/D ASIC

- *Provides mixed analog/digital standard-cell ASICs*
- *Analog cell library has high-level analog functions*

Series TGSM mixed A/D standard-cell ASICs are supported by a library that includes 66 analog cells, 66 digital macrocells, and 28 I/O cells. The library's high-level analog functions include 8- and 12-bit ADCs, 8- and 12-bit DACs, 12th-order switched-capacitor filters, 120-nsec comparators, and LCD driver circuitry. When necessary, you can bias circuits from current or voltage bias generators and can include programmable current mirrors. You can also introduce grounded shielding around analog circuitry to improve its power-supply rejection ratio. The digital cell library contains hard macros, which you can use to generate your own soft macros for the compilation of more complex digital functions such as counters, shift registers, or dividers. All the library cells are fully characterized for operation on 3 to 10V supplies. The company's TCAD2A CAD software supports Series TGSM-based design. This CAD package, which includes H3Spice for analog simulation, lets you perform mixed A/D simulation by modeling the analog functions. You can use the company's FILCAD software to design switched-capacitor filters and then import the designs into TCAD2A. Typical NRE charges for a design done by the company, $55,000. Volume pricing for devices, $1 to $8.

SGS-Thomson Microelectronics, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (039) 65551. TLX 330131.

Circle No 403

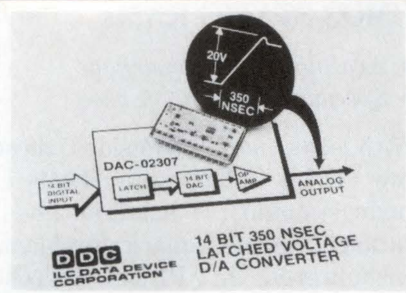
SGS-Thomson Microelectronics, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 404

14-BIT HYBRID DAC

- *Pin-programmable output*
- *Linearity-grade options*

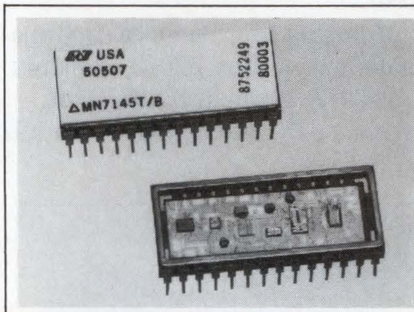
The DAC-02307 high-speed latched DAC features a low-impedance voltage output. Besides latches, it includes an internal voltage reference, a 14-bit D/A converter, and a high-speed op amp in a hermetic 24-pin DIP. The output voltage ranges are



±2.5, ±5 and ±10V. You can select either a 13- or a 12-bit linearity grade. For a full-scale step change, the device settles to within 1 LSB of its final value in 50 nsec. MIL-STD-883 screening is available. From $209. Delivery, stock to 90 days.

ILC Data Device Corp, 105 Wilbur Pl, Bohemia, NY 11716. Phone (516) 567-5600. TWX 310-685-2203.

Circle No 405



DATA-SYSTEM HYBRIDS

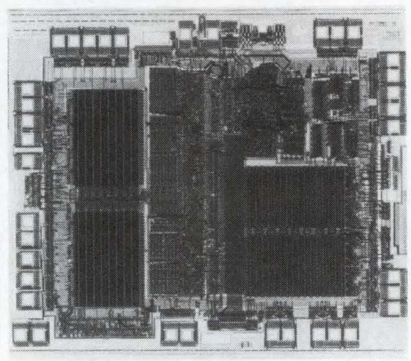
- *Provide 8-channel, 12-bit, 25-kHz systems*
- *Microprocessor interface*

The MN7145, MN7146, and MN7147 hybrid data-acquisition systems combine the advantages of CMOS, BiFET, bipolar, and thin-film technologies to achieve their performance. Each μP-compatible hybrid circuit contains an 8-channel multiplexer, a track-and-hold amplifier, a 12-bit A/D converter, a 3-state output buffer, and all necessary timing and control logic. The three model numbers in the series correspond to a specific input voltage range: MN7145, 0 to 10V; MN7146, ±5V; MN7147, ±10V. Four electrical-performance grades are available for each model number. The devices feature a bias current of ±1 nA, an

integral linearity of ±½ LSB for K and T types, a maximum offset error of ±0.05% FSR, and a guaranteed throughput of 25,000 channels/sec. MIL-STD-883 screening is optional. From $89 to $225 (100).

Micro Networks, 324 Clark St, Worcester, MA 01606. Phone (617) 852-5400.

Circle No 406



MICROCONTROLLERS

- *Two versions available*
- *Flexible watchdog timer*

Software- and pin-compatible with the industry-standard 80C51, the 80C521 and 80C321 microcontrollers feature a flexible watchdog timer that's the industry's most secure, according to the vendor. The 80C521 contains 256 bytes of RAM and 8k bytes of ROM; the 80C321 is identical, except for the absence of ROM. The flexible watchdog timer is programmable from 128 μsec to 4 sec at 12 MHz and is disabled only by a reset. This feature provides added safety against unexpected external events, supply-line noise, electrostatic discharge, and errant software. Dual data pointers accelerate external data transfers, and a software reset feature allows the device to reset itself without the need for external logic components. Emulators from MetaLink Corp (Chandler, AZ), and C-compiler libraries from Micro Computer Control (Hopewell, NJ), provide development tools to assist designers. The 80C521 and 80C321 are available in 40-pin DIP or 44-pin PLCC packages. 80C521, $8.50 (1000) with a $3000 mask charge; 80C321, $8.85 (100).

Advanced Micro Devices Inc, Box 3453, Sunnyvale, CA 94088. Phone (408) 732-2400.

Circle No 407

FIFO MEMORIES

- *Provide clock frequencies to 50 MHz*
- *Feature built-in status flags*

The SSL7409S 64-word×9-bit array FIFO memory can attain speeds to 50 MHz and permits expansion of its word width. The similarly organized SSL7409C operates to 40 MHz and allows expansion of its word width and depth. Both have status flags that indicate Almost Full, Almost Empty, and Half-Full states. Their 9-bit word structure suits them for use in systems that require byte parity to protect data integrity. Each device comes in a 28-pin side-brazed, DIP; a plastic DIP; or a 28-pin LCC. The SSL7413S and SSL7413C feature 64-word×5-bit organization. The first can attain a speed of 50 MHz and offers word-width expandability, whereas the second operates to 40 MHz and permits expansion of both its word width and depth; each device features status flags. You can obtain either in a 24-pin plastic DIP. Series SSL7409, $39.60 to $66.75; Series SSL7413, $19.25 to $46.75 (1000).

Saratoga Semiconductor, 10500 Ridgeview Court, Cupertino, CA 95014. Phone (408) 864-0500. FAX 408-446-4416.

Circle No 408

ANALOG DELAY LINE

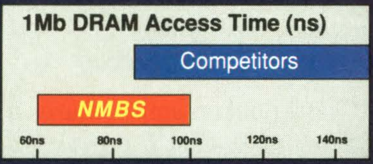
- *Provides a programmable analog signal delay*
- *Includes an output sample/hold*

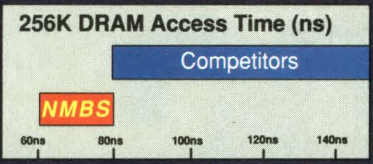
Suitable for use in television, video, radar, or sonar equipment, the WA1101 programmable CCD analog delay line lets you select signal de-

DRAMATIC!

Now...Highest speeds AND production... 60/70/80ns 1Mb AND 256K DRAMS...

Exclusively from NMB Semiconductor - the high speed DRAM specialist - we've broken the speed barrier with FutureFast™ 256K and 1Mb DRAMS...first with access times of 60/70/80ns. This means designers can now have true "0" wait state systems without using complex, expensive cache memory techniques.

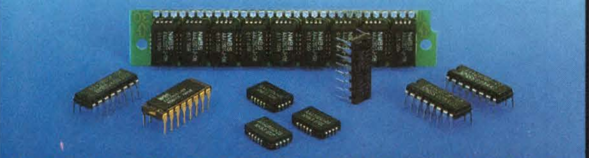




We've broken the delivery barrier too. NMBS offers much higher volume production than our competitors. These dramatic advances are made possible in the most advanced CMOS/VLSI plant in the world optimized for volume production of high speed DRAMS. With computerized operation and robot control in Class 1 ultra-clean rooms. Plus state-of-the-art design, processing and testing.

Product Line Summary

Series*	Access Time	Organization	Package**	Availability
AAA2800 256K	60/70/80 (ns)	256Kx1	P-DIP PLCC C-DIP	Production Production Production
AAA1M100 1Mb	100/120 (ns)	256Kx4 1Mbx1	P-DIP SOJ ZIP	Production Production Production
AAA1M200 1Mb	60/70/80 (ns)	256Kx4 1Mbx1	P-DIP SOJ ZIP	2Q88 2Q88 2Q88



* All Series available in Static Column and Page Modes ** SIMM'S and SIPS available for each series

Available in the packages and organizations designers want for high performance projects.

More good news. We're now shipping qualification samples of our new 1Mb DRAM.

So for complete specs, evaluation units, quantity prices and delivery call NMBS - the high speed DRAM specialists - today. Prove to yourself that with FutureFast™ DRAMS, your future is now.

NMB | NMB TECHNOLOGIES INCORPORATED

SEMICONDUCTOR DIVISION
9730 Independence Ave. • Chatsworth, CA 91311
Tel: 818/341-3355, FAX: 818/341-8207, TLX: 651340

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CIRCLE NO 155

lays of 4, 5, 10, or 14 clock periods via a 2-bit control code. By choosing the appropriate clock frequency, you can have the device delay an analog signal by a period as short as 100 nsec or as long as 10 msec. The device has both a signal and a reference input, a configuration that usually results in an output inverted with respect to the signal input. However, you can avoid this output inversion by interchanging the signal and reference inputs—albeit at the cost of a slight degradation in linearity. An on-chip sample-and-hold circuit is provided to reconstitute the analog waveform at the output. The WA1101 has a 68-dB typ dynamic range and a TTL-compatible clock input. It draws around 15 mA from a 15V power supply. Commercial-grade version, around \$28; hi-rel version, around \$65 (1000).

Walmsley Microsystems Ltd, Aston Science Park, Love Lane, Birmingham B7 4BJ, UK. Phone 021-359-0981. TLX 334535.

Circle No 409

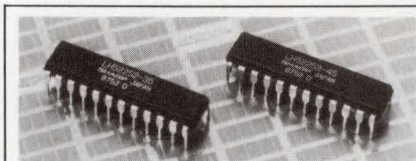
DUAL OP AMP

- *Low noise, high gain*
- *Fits 1558 and 4558 sockets*

The RC4207 dual op amp features a noise level of 0.35 μV p-p and a minimum gain of 400 V/mV. The device is pin compatible with industry types 1558 and 4558. Each OP07-type op amp in the RC4207 is complete and requires no external compensation capacitors or offset nulling potentiometers. Other features include a maximum offset voltage of 75 μV, a maximum offset-voltage drift of 1.3 μV/°C, and a maximum bias current of 5 nA. The RC4207 is available in commercial and military temperature grades, and comes in plastic or ceramic 8-pin DIPs. Commercial grade, \$0.91 (100).

Raytheon Company, 350 Ellis St, Mountain View, CA 94043. Phone (415) 968-9211.

Circle No 410



CMOS STATIC RAM

- *35-nsec access time*
- *Organized as 64k×4 bits*

Available in 35- and 45-nsec versions, the LH52252 CMOS static RAM is organized as 64k×4 bits. The device comes in a 24-pin 300-mil DIP, which offers high packing density. An automatic power-down mode drops the device's power by 80% during long cycles following

SPECTACULAR DISPLAYS OF SPEED.

Introducing video driver hybrids from Teledyne Philbrick.

High-resolution graphic displays require quick response. That's why Teledyne Philbrick has combined all the driver ICs and transistors you need in one powerful space-saving package.

Where discrete components fall short, new 1900 Series Video Display hybrids come on strong as high speed trans-conductance amplifiers with high voltage, open collector outputs. They accommodate standard RS-170 or RS-343 interfaces. And accept differential or single-ended inputs with a common-mode input voltage range of +3V.

The 1901 is capable of driving up to 50V pp swings into 6pF loads with bandwidths of over 146MHz. Combining an output buffer stage with the 1901, the 1902 provides up to 100V pp swings in 20pF loads. These specifications provide flexibility in CRT selection and ease of mechanical mounting in projection and high brightness displays. Both the 1901 and the 1902 eliminate the need for pre-amps, ensure rise times of 2-4ns and provide easy thermal management.

Altogether, the 1900 Series gives you a powerful, new edge in designing sophisticated, compact imaging systems for CAD, avionics and large screen applications.

Qualified to MIL-STD-1772, Teledyne Philbrick is a leading manufacturer of high performance, high reliability standard and custom microcircuits for industrial, medical, military and space applications worldwide. Send for complete specifications. Or call us toll-free at 1-800-325-1330 (outside MA).

MIL-STD-1772 Qualified

TELEDYNE PHILBRICK

40 Allied Drive, Dedham, MA 02026-9103, Tel: 617-329-1600 Fax: 617-326-6313

WEST:
30423 Canwood St.,
Suite 212
Agoura Hills
CA 91301
Tel: 818-889-3827
Fax: 818-889-8215

U.K.:
The Harlequin Centre
Southall Lane
Southhall
Middlesex
UB2, 5NH, U.K.
Tel: 571-9596
Telex: 935008
Fax: 571-9439

JAPAN:
4th Floor
Taiko No. 3 Bldg.
2-10-7 Shibuya-Ku
Tokyo 542, Japan
Tel: 797-5251
Telex: 781-24335
Fax: 797-5255

CIRCLE NO 153

data access. The standby power drops as low as 100 μA when the static RAM is deselected. Samples are now available for distribution. 35-nsec version, $97.50; 45-nsec version, $79.85 (100). Delivery, 8 to 12 weeks ARO.

Sharp Electronics Corp, Sharp Plaza, Mahwah, NJ 07430. Phone (201) 529-8757.

Circle No 411

CMOS static RAM

- *Small surface-mount package*
- *Organized as 32k×8 bits*

The M5M5256VP in a very-small-outline package has a footprint that is less than half the size of a standard small-outline, surface-mount package. The device is also available in a reverse version, the M5M5256RV, which is designed for double-sided PC boards and is a mirror image of the VP pinout. Organized as 32k×8 bits, the 256k-bit static RAM is offered in 100-, 120-, and 150-nsec versions. Combining the advantages of CMOS peripheral logic with resistor-load memory cells, both devices are TTL compatible. They operate from a single 5V supply and typically draw 35 mA in the operating mode. The maximum standby current is 2 mA. 150-nsec version, $16.75 (100).

Mitsubishi Electronics Inc, 1050 E Arques Ave, Sunnyvale, CA 94086. Phone (408) 730-5900.

Circle No 412

4-CHANNEL AMPLIFIER

- *Slew rate of 30V/μsec*
- *40-MHz bandwidth*

Featuring dielectric isolation, the EHA2400 and EHA2400A are, respectively, an alternate source and an enhanced source for the HA2400 4-channel programmable amplifier. The monolithic ICs contain four high-speed input amplifiers and a single output amplifier. The selected differential-input amplifier and the output amplifier form an op amp with a slew rate of 30V/μsec and a bandwidth of 40 MHz. A 15-pF capacitor compensates all four channels for unity gain. By means of suitable feedback networks, you can control each channel of the EHA2400 in any standard op-amp configuration. Other specs include a gain of 150,000 V/V, an offset current of 5 nA, and crosstalk of −110 dB. The EHA2400A features an offset voltage of 4 mV. The devices come in 16-pin ceramic DIPs and include commercial and MIL-STD-883 grades. From $11.27 to $35 (100).

Elantec Inc, 1966 Tarob Ct, Milpitas, CA 95035. Phone (408) 945-1323.

Circle No 413

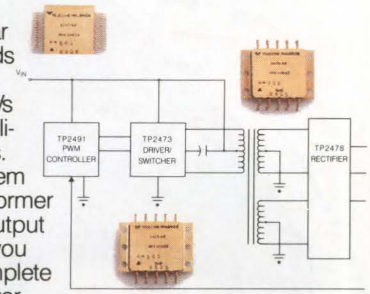
POWER SUPPLIES AT YOUR COMMAND.

Introducing a complete system of modular hybrid components for military SMPS designs.

What do you do when all the primary electronics are in place, but there's precious little time, budget or real estate left for the power supply?

Call Teledyne Philbrick. We offer a unique, new series of complete modular hybrid power components that are designed to be customized to your exact specifications.

Just choose the configuration you need. The 2491 Regulating Pulse Width Modulator provides all the control functions for the PSU. The 2473 is a dual MOFSET switch with high speed drivers and current sensing circuitry. And the 2478 Dual Schottky Bridge Rectifier provides up to three output voltages from a single power package.



New modular power hybrids are ideal for missiles, RPVs and other military systems. Combine them with a transformer and input/output filters, and you create a complete custom power supply—in a fraction of the time, and at a fraction of the cost, it would take to start from scratch.

Qualified to MIL-STD-1772, Teledyne Philbrick is a leading manufacturer of high performance, high reliability standard and custom microcircuits for industrial, medical, military and space applications worldwide. Send for complete specifications. Or call us toll-free at 1-800-325-1330 (outside MA).

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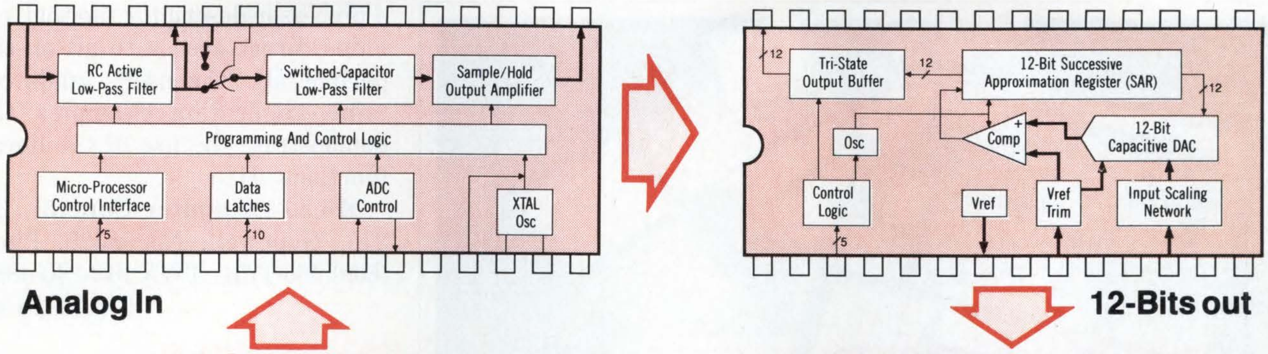
Taiko No. 3 Bldg.
2-10-7 Shibuya-Ku
Tokyo 542, Japan
Tel: 797-5251
Telex: 781-24335
Fax: 797-5255

CIRCLE NO 154

TOGETHER WE FOUND THE ANSWER...



HSCF24040

- 7th Order Monolithic Low-Pass Filter
- 85dB Dynamic Range
- Internal RC Anti-Alias Filter
- Sample/Hold Output Amplifier
- Low Power CMOS Technology

Ideal for 12-bit data acquisition systems, the HSCF24040 is unsurpassed as an anti-alias filter or a DAC output smoothing filter. The cutoff frequency of the active RC and switched capacitor sections is digitally programmable from 78Hz to 20kHz. The sample/hold rate and dc gain of the output amplifier are also programmable. Internal clocking of the HSCF24040 is controlled by an external reference clock or an optional crystal. This remarkable filter has less than 0.1dB passband ripple and >72 dB of stopband attenuation, yet requires no external components and consumes less than 150mW of power!

HADC574Z/HADC674Z

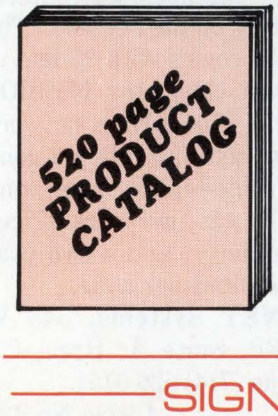
- 12-bit Monolithic CMOS A/D Converter
- Improved 574/674 Alternate Source
- Transparent Sample/Hold Input Circuit
- Fast Conversion - 15μs-674, 25μs-574
- Low Power CMOS Technology

The HADC574Z and HADC674Z herald major performance breakthroughs. Honeywell's state-of-the-art BiCMOS process makes it possible to use ratioed capacitors instead of a traditional R-2R DAC in the HADC574Z/HADC674Z successive approximation A/D converters. The result is a built-in sample/hold function that allows sampling signals to 5kHz without an external sample/hold amplifier. Also, transient noise on the analog input during conversion has been eliminated and **no negative power supply** is required. Even with all of these features, power consumption is less than **150mW!**

Signal Processing Technologies (SPT) has created a state-of-the-art product line that includes leading-edge DSP products, flash A/D converters with 10-bit 50MSPS (million samples per second) and 8-bit 125MSPS performance and high speed DACs with update rates to 400 MWPS (million words per second). SPT offers the highest performance ECL comparators, switched capacitor filters and high precision 12, 14 and 16-bit A/D and D/A converters available.

Signal Processing Technologies was established in 1983 to develop standard products for the worldwide digital signal processing and data conversion market based on Honeywell's production-proven semiconductor capability. These technologies include one micron CMOS, Bipolar and BiCMOS. In addition, an extensive amount of research and development is being conducted in sub-micron technologies.

Honeywell SPT is constantly pushing the frontiers of technology. Together, we can give your business a push.



For more Information on these and other SPT Products Call or Write:

Honeywell Inc.
Signal Processing Technologies
1150 E. Cheyenne Mountain Blvd.
Colorado Springs, CO 80906
(719) 540-3900 TELEX #452433
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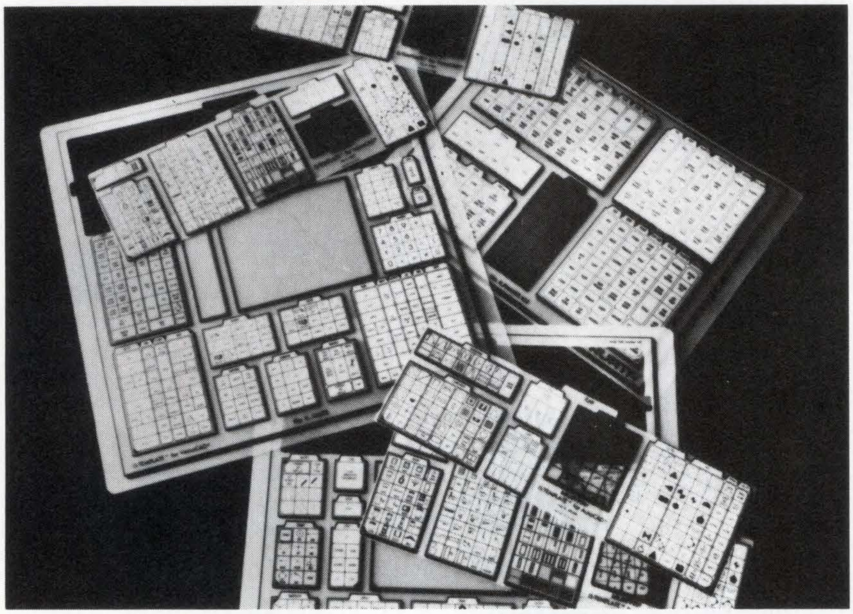


TABLET DRIVER

- *Lets you use tablet input with AutoCAD and VersaCAD*
- *Soft keys let you define macros for execution from tablet*

The Is Pensmith version 6.1 Autodesk device interface (ADI) driver is for use with the vendor's Is/One tablet input system. The driver ensures that you will be able to employ all the tablet's features with every version of Autodesk's AutoCAD software. Templates allow you to select most major AutoCAD and VersaCAD commands directly from the tablet. The driver lets you expand the monitor area, which mirrors the screen, to encompass the tablet's entire surface; by comparison, most other templates permit the use of less than 25% of the tablet's active drawing surface. The Is Template Master, with the new ADI driver, costs $295 for the AutoCAD version and $139 for the VersaCAD version.

Kurta, Box 60250, Phoenix, AZ 85082. Phone (602) 276-5533.

Circle No 420

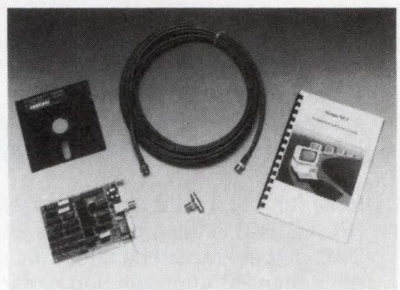
C LIBRARY

- *Provides functions to control devices on 80C521 μC*
- *Contains other functions useful in μC applications*

CLIB-521 is a linkable library of C functions that aid in the development of software for AMD's 80C521 microcontroller. The library works with the vendor's MICRO/C-51 cross compiler, which runs on IBM PCs and compatibles. The AMD 80C521 chip provides all standard 8051 on-chip hardware, but also includes on-chip devices such as dual data pointers, a watch-dog timer, and facilities for switching into a low-power mode. The library contains functions to support these chip-specific peripherals; they perform fast block moves, maintain a pseudostack in external RAM, initialize and control the watchdog timer, and control entry to and exit from the idle and power-down modes. The library also includes an automatic memory-status check to help in recovering system operation after a power-down reset, as well as a processor-descriptor file that provides direct access to all on-chip peripherals. The user's guide contains application examples that demonstrate the use of the library functions. $125.

Micro Computer Control, Box 275, Hopewell, NJ 08525. Phone (609) 466-1751. TWX 910-240-4881.

Circle No 421



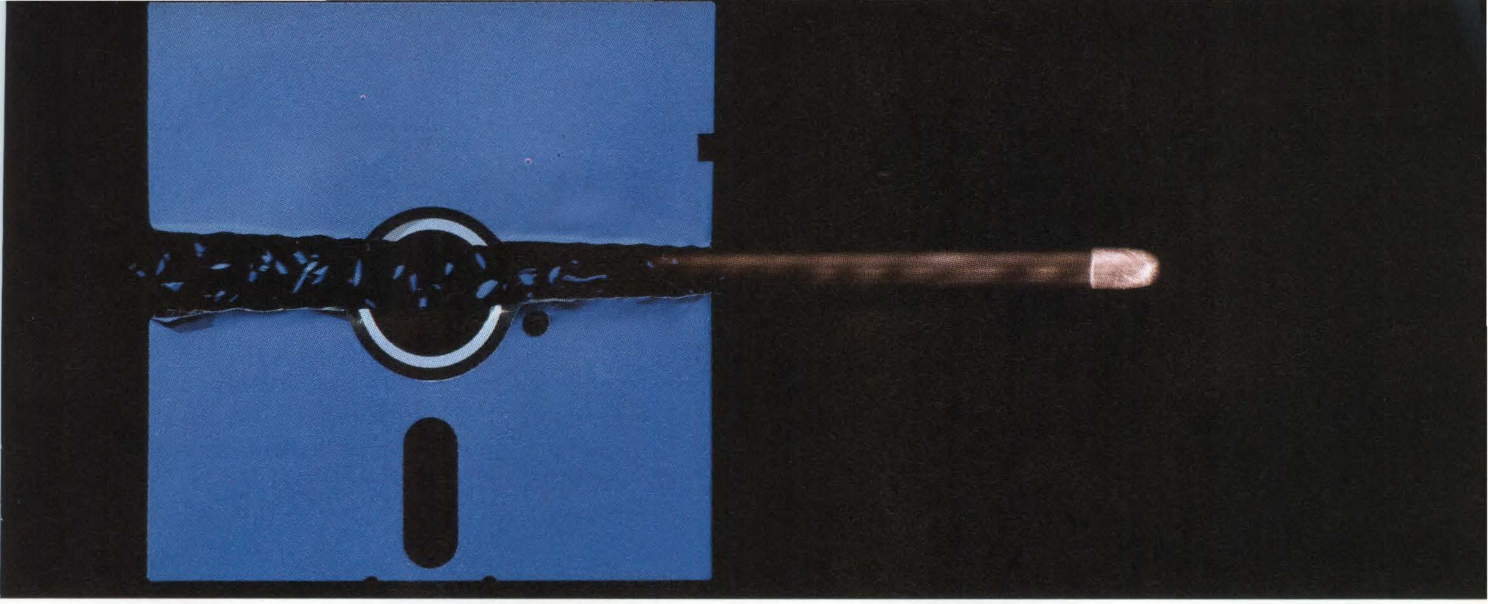
10M-BIT/SEC NETWORK

- *Completely compatible with Ethernet standards*
- *Runs on PCs and PS/2s, and on many 80386 machines*

The EtherLAN Plus networking software package operates with Western Digital's EtherCard Plus adapter cards, which plug into IBM PCs, PS/2s, and compatible computers. You can also use the system on many 80386-based machines that run at clock speeds of 16 MHz and above. On-board memory buffering eliminates the need for DMA channels and prevents memory conflicts from occurring on the network. The half-size card comes with 25 feet of thin Ethernet cable, the NetBIOS interface, the SimpleWare network operating system (including a complete electronic-mail system), and manuals. You get two years of free software updates, and a two-year warranty. $799.95 per node.

Simple-NET Systems, 545 W Lambert Rd, Suite A, Brea, CA 92621. Phone (714) 526-5151.

Circle No 422



NEW AVOCET C™ FOR MICROCONTROLLERS-
A BREAKTHROUGH IN SPEED AND QUALITY.

Introducing Avocet C.™ Fast, *optimizing* cross-compilers that can cut microcontroller development time in half—without sacrificing code quality.

From concept to code in a fraction of the time.

Programming in C lets you concentrate on end results, not annoying details—so you get more done, faster. And rapid compilation takes the frustration out. But for microcontrollers, you need more than speed. You need tight, high-quality code.

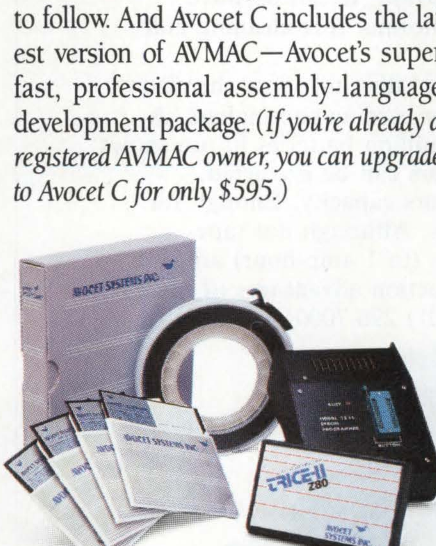
That's why we spent two years field-testing and perfecting Avocet C for both speed and quality. We built in three separate phases of optimization—for object code tight enough for real applications. And we integrated Avocet C with an assembler package that's mature in its own right—not an afterthought. So you can still work magic at the bits-and-bytes level.

Avocet C saves you time in all phases of development. Our run-time library is extensive—no need to write the routines yourself. You'll arrive at bug-free code faster, thanks to LINT-like type checking. And your program's useful life is extended, because you can recompile for other target chips.

Testing is easier, too. Avocet C is ANSI-standard—so you can test generic parts of your program with host-resident systems like Microsoft Quick-C™ and Codeview.™ And when you're ready for hardware-specific testing, Avocet's AVSIM Simulator/Debugger tests microcontroller code right on your PC.

An excellent value.

Just $895 buys Avocet C for your favorite chip: Intel 8051 or 8096, Hitachi 64180, or Zilog Z80—with more to follow. And Avocet C includes the latest version of AVMAC—Avocet's super-fast, professional assembly-language development package. *(If you're already a registered AVMAC owner, you can upgrade to Avocet C for only $595.)*



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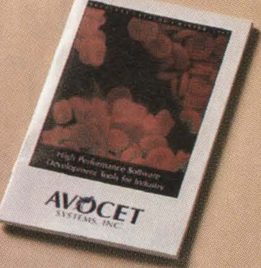

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CIRCLE NO 206

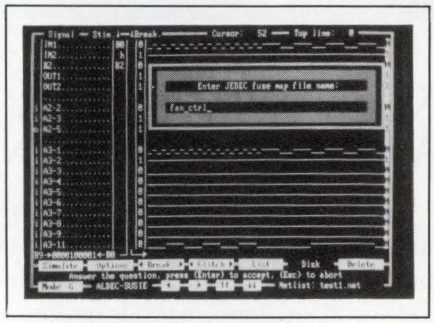
TEXT RETRIEVAL

- *Reads a wide variety of file types*
- *Permits searches using single or multiple key words*

CC Search is a text-retrieval system for VAX/VMS computers. It reads many VAX/VMS files directly, as well as RMS sequential files, LEX-11 documents, and WordPerfect documents, and lets you use single-word, multiple-word, or proximity-search criteria to find a file or document. You can create multiple indexes, each containing thousands of files or documents. To reduce disk-space requirements, each index uses pointers to the text contained in the original files. Standard VMS file-protection methods ensure the security of sensitive files. You can use this tool not only in MIS applications, but also in R&D offices to find design documents, reports, and proposals, and in a software-development office to find source-code files.

CC Software Inc, 5515 Security Lane, Suite 540, Rockville, MD 20852. Phone (301) 231-5115.

Circle No 423

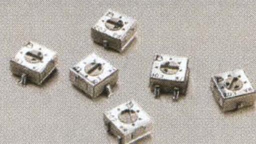


CAE SIMULATOR

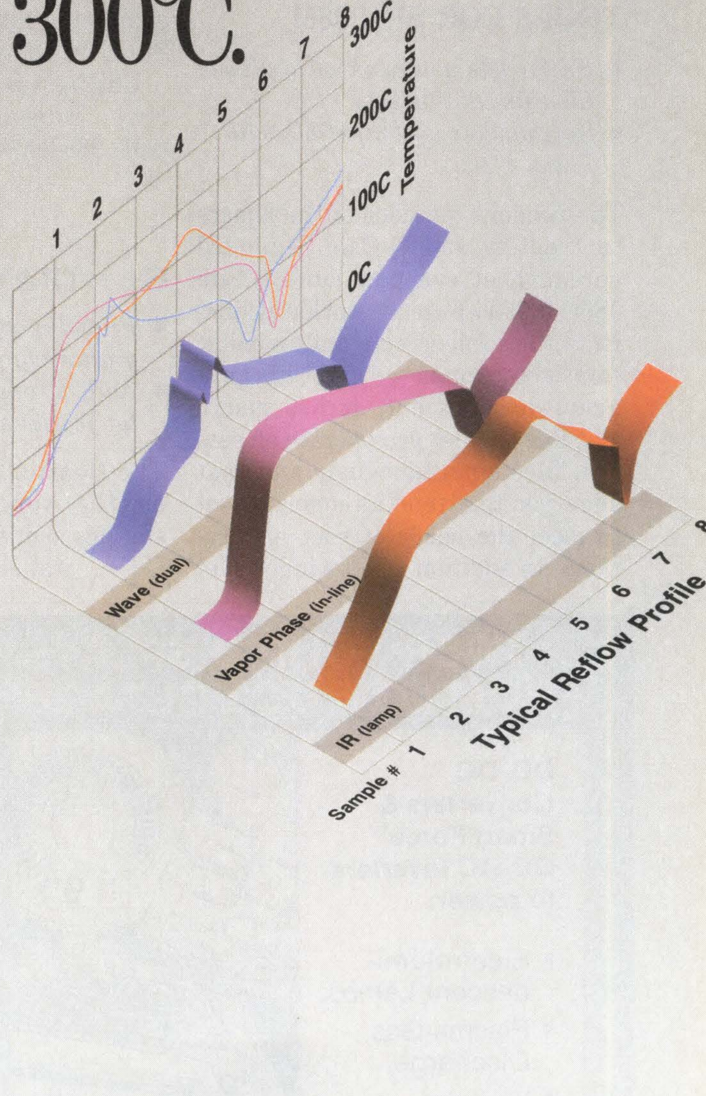
- *Simulates more than 500,000 gates per second*
- *Runs on 80386-based machines in protected mode*

Susie-5, an upgrade of the vendor's IBM PC-based Susie-4 interactive design simulator, runs on 80386-based computers. The package simulates the operation of digital-logic designs and accepts its input from schematics generated by CAE systems such as P-CAD, OrCAD, Schema, and others. Because the package operates in 386 protected mode, design size is limited only by the amount of memory your system can accommodate; each 1M-byte block of memory can simulate 20,000 gates or cells. The chip libraries (TTL, ECL, CMOS) that come with the simulator have been optimized for minimum code, and you can therefore simulate more than 500,000 gates or cells per second without a hardware accelerator. Because you can toggle switches, move jumpers, replace chips, and load JEDEC fuse maps and hex files without having to recompile, the simulation immediately reflects the effects of such modifications on the screen display.

BOURNS



A New Degree of SMT Trimmer Processability. 300°C.



The new 3314 from Bourns Trimpot beats the heat of virtually any SMD solder reflow process. Here is the first sealed trimmer designed to withstand TOTAL IMMERSION during dual wave soldering. In fact, in tests at 300°C...where conventional SMD trimmers failed...every Bourns 3314 met all electrical performance specifications.

Now with the Model 3314, you can place trimmers on both sides of the PCB, no matter which SMD soldering process you use--vapor phase, infrared, or dual wave!

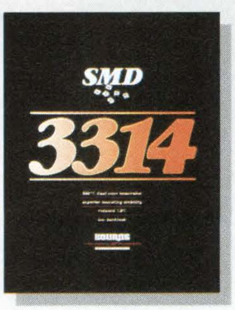
AND WE'RE JUST GETTING WARMED UP

The 3314 includes many features that make it the hottest choice in SMT trimmers:

-hoe tip wiper design that maintains uniform wiper to element footprints, which lower contact resistance variation and improve stability

-rugged unitized construction retains higher stop strength and constant rotational torque after SMD processing

-miniaturized 4mm design allows for higher component density



Have we hit your hot button? For a new data guide on 3314, simply contact your local Bourns Trimpot rep today!

BOURNS®

THERE'S STILL NO EQUIVALENT

Bourns, Inc., 1200 Columbia Avenue, Riverside, California 92507; (714) 781-5500; European Headquarters: Zugerstrasse 74, 6340 Baar, **Switzerland:** 042-333333; **Benelux:** 070-874400; **France:** 01-40033604; **Germany:** 0711-22930; **Ireland:** 021-357001; **United Kingdom:** 0276-692392; Asia Pacific Headquarters: 1401 Citicorp Centre, 14th Floor, 18 Whitfield Road, **Hong Kong:** (852) 5-702171; **Singapore:** (65) 339-3331; Japan Headquarters: 2nd Floor, Time 24 Building, #35 Tansu-cho, Shinijukuku, Tokyo, 162, **Japan:** (03) 260-1411

Susie-5, $1495; high-resolution timing option Tim, $2495.

Aldec, 3525 Old Conejo Rd, #111, Newbury Park, CA 91320. Phone (805) 499-6867.

Circle No 424

TOOLS FOR SUN 386i

- *Editor lets you work on multiple files simultaneously*
- *Spreadsheet is compatible with Lotus 1-2-3*

The vendor's versions of the Emacs text editor and Q-Calc Standard spreadsheet can now run on Sun 386i 80386-based workstations. Emacs is a full-screen, multiwindow text editor employed for Unix program development. It has macro features that let you operate on several files simultaneously and that allow you to extend its command set to meet the needs of your applications. In addition, shell windows let you execute Unix operating-system commands from within the editor. The Q-Calc Standard is a Unix spreadsheet that features a Lotus 1-2-3 work-alike interface and is 100% compatible with 1-2-3 files. Emacs binary code, $395; source code in the vendor's MLisp programming language, $995; Q-Calc Standard (binary only), $595.

UniPress Software, 2025 Lincoln Hwy, Edison, NJ 08817. Phone (201) 985-8000. TLX 709418.

Circle No 425

C++ TRANSLATOR

- *Provides object-oriented programming facilities*
- *Adds strong type checking to the features of standard C*

The Domain/C++ translator runs on the vendor's Domain workstations and is based on the original C++ translator developed by AT&T. The C++ language is completely compatible with standard C, but provides strong type checking facilities absent in the standard language. In addition, C++ lets you define files, records, windows, icons, and other conceptual objects as software objects; a software object contains both definitions of data and of all the functions that can operate on that data. The use of software objects in the design process results in easily maintained and modified programs and also facilitates the incorporation of AI concepts. Domain/C++ is fully integrated with the Domain/C compiler and with the vendor's CASE tools. Domain/C++ Translator, $1050; Domain/C++ Translator/C compiler package, $1600.

Apollo Computer Inc, 330 Billerica Rd, Chelmsford, MA 01824. Phone (617) 256-6600. TWX 710-343-6803

Circle No 426

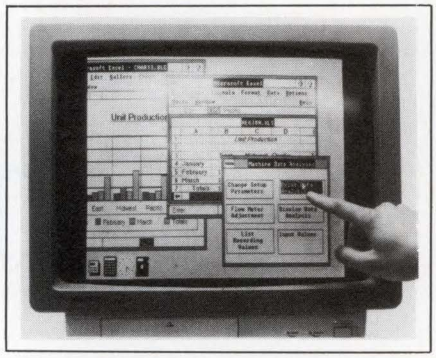
CASE FOR SUN

- *Tool set now runs on the Sun 386i workstations*
- *Lets you combine Unix and DOS tools*

The vendor's Teamwork suite of CASE tools can now run under Unix on Sun Microsystems' 386i/150 and 386i/250 workstations. Because these workstations support Unix and DOS, you can use them to run DOS-based tools for performance-testing and code-coverage functions, as well as to run the Teamwork tool set in the requirements-analysis and implementation phases of your software development. All these applications can run simultaneously in separate windows. Running both categories of software on the same workstations minimizes the need for translation utilities to transfer data from one tool to another and, because there are many DOS-based testing and maintenance tools available, improves the integration of the tools needed for every developmental stage, from concept through maintenance. From $7500.

Cadre Technologies Inc, 222 Richmond St, Providence, RI 02903. Phone (401) 351-5950.

Circle No 427



TOUCH-SCREEN DRIVER

- *Lets you use a touchscreen with MS Windows software*
- *Averages finger-contact area to a point above the finger*

Touch WindowsDriver lets you use a touchscreen instead of a mouse to operate any software that runs under Microsoft's Windows. You control the cursor by pointing with a finger; the driver averages the area of the finger contact to a discrete touch point just above your finger. The screen's 1024×1024-point resolution permits accurate cursor placement to the pixel level. Because the capacitive screen is sensitive even to a light touch, you can use mouse movements to drag graphic elements around the screen. You can register mouse clicks in several ways, such as by tapping the screen or lifting your finger, and can program into your application software the manner that best suits you. The driver works with versions of Windows through release 1.03; versions compatible with Windows

Omron switches are slightly unconventional

Omron responds to your application needs by adding innovation to even the most basic switch. Automated assembly and 100% quality assurance are just the beginning of our attention to detail; we take pride in designing the "fine points" that distinguish an Omron switch from the others.

Internal Seals Reduce Soldering and Cleaning Time

Our internally-sealed DIP switches, basic switches and mechanical keyswitches are immersible for cleaning without a time-consuming taping operation. Sealed construction also prevents flux entry during automatic flow soldering. Designed for efficiency, our top-actuated DIP switches are also auto-insertable for quick assembly.

Advanced Computer Design Maximizes Performance

Omron's extensive line of pushbutton and lighted pushbutton switches are designed with the operator in mind. Using advanced computer techniques, we've designed a unique "triangle structure" actuator which provides constant force and ideal operating feel for maximum performance. Omron lighted pushbutton switches also feature uniform color illumination to add a quality appearance to your control panels.

Custom Options Accommodate Unique Applications

Omron's snap-action, miniature and subminiature basic switches are available in a wide variety of actuator types and contact configurations to meet your specifications. Switching capacities range from 0.1 to 21 amps, and sealed versions are available for direct soldering to PC boards. In addition, our new A3B lighted pushbutton switches provide water and oil resistance ideal for your machine tool and other harsh industrial applications.

Unconventional Switches for Exceptional Performance

Remember Omron when your switch application requires more than just standard performance. We'll work with you to develop solutions to your specific application problems, if we haven't developed one already. When it comes to photomicrosensors (optical), thumbwheel, basic snap action, keyswitches, DIP, or pushbutton switches, we don't mind being a little unconventional.

1-800-62-OMRON

OMRON®

Responsive Innovation

OMRON ELECTRONICS, INC.
One East Commerce Drive
Schaumburg, Illinois 60173

Circle Reader Service Number 201 for more information on Keyswitches, Pushbutton, Thumbwheel or DIP Switches.

Circle Reader Service Number 202 for more information on Basic Switches.

2.0 and Windows/386 will be released in the second quarter. Touchscreen end-user kit with interface and WindowsDriver, $995.

Micro Touch Systems Inc, 10 State St, Woburn, MA 01801. Phone (617) 935-0080. TLX 530264.

Circle No 428

DIAGNOSIS TOOL

- *Helps an expert to capture diagnostic and repair information*
- *Guides a technician through troubleshooting procedures*

The TestBench software package uses AI (artificial intelligence) technology to build expert systems for the diagnosis and repair of malfunctions in complex machines and processes. It consists of three modules: TestBuilder, TestBridge, and TestView. The TestBuilder expert-system development system, which runs on a TI Explorer, helps you acquire an expert technician's knowledge of the diagnostic and repair procedures for a complex machine or process and builds a knowledge base that combines this information with documentation and rules of thumb. When you have completed the knowledge base, a less expert technician can run the expert system and receive guidance in troubleshooting and repairing the target equipment. TestBridge translates the information captured by the development system into a form that can be used by TestView, a similar expert system that runs on an IBM PC/AT or compatible. Thus, you can develop a diagnostic expert system on the Explorer and distribute it to several repair stations that can run it on the less expensive PC/AT. Complete TestBench package, including one week of training and one year of software maintenance, $42,000.

Texas Instruments Data Systems Group, Box 2909, Austin, TX 78769. Phone (512) 250-6314.

Circle No 429

Carnegie Group Inc, 5 PPG Place, Pittsburgh, PA 15222. Phone (412) 642-6900. TLX 4970240.

Circle No 430

FIBER ANALYSIS

- *Works with reflectometer to log test data on optical fibers*
- *Calculates as many as 10 splice-loss values*

The PC3110 hardware/software package lets you collect and analyze data measured by the vendor's Model 3100 series optical time-domain reflectometers while testing optical fibers. The package consists of an IBM PC-compatible laptop computer equipped with 3.5-in. floppy-disk drives and an IEEE-488 interface for controlling and reading the vendor's 3100, 3100H, and

3100T optical time-domain reflectometers. The software is menu driven and offers extensive on-line help. You can set installation data; set system-configuration parameters; and acquire and store a fiber signature from the optical time-domain reflectometer and then display the signature, or retrieve a signature from disk and display it. The analysis features let you measure the splice loss at the marker position, measure splice-loss points, make relative-distance and loss measurements, display two signatures simultaneously to compare differences over time, and perform many other functions that aid in thoroughly testing and characterizing an optical-fiber link. A complete package (computer, GPIB interface, DOS 3.3, and PC3110 software) costs $2600. Delivery, nine weeks ARO.

Photon Kinetics Inc, 9350 SW Gemini Dr, Beaverton, OR 97005. Phone (503) 644-1960. TLX 4992356.

Circle No 431

COMMON LISP

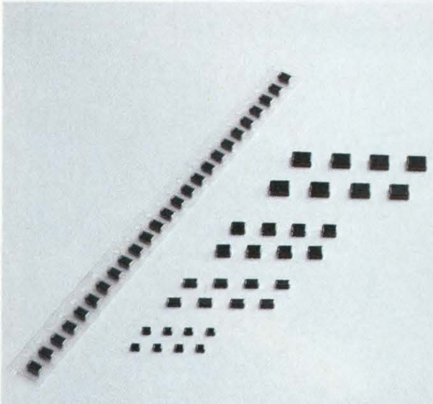
- *Runs on Sun 386i family of 80386-based workstations*
- *Provides interfaces to X-Windows and Emacs*

IBCL (Ibuki Common Lisp) is now available for the Sun 386i family of 80386-based workstations. IBCL is a complete implementation of Common Lisp, and the package includes an interpreter, a compiler, and a debugger. You also get an interface to X-Windows, a standardized interface to Emacs editors, and a foreign-function interface that allows you to call programs written in Fortran or C from within a Lisp program, or a Lisp program from within a C program. A binary copy of IBCL that will run on any Sun workstation from the 386i to the Sun-4 costs $700.

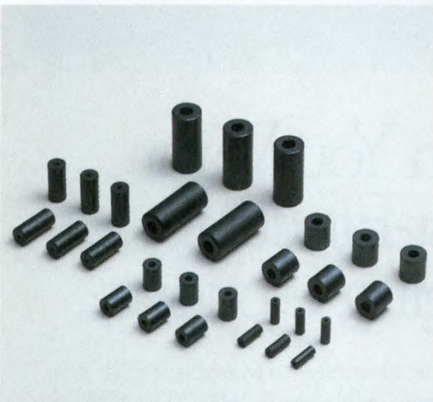
Ibuki, 1447 Stierlin Rd, Mountain View, CA 94043. Phone (415) 961-4996.

Circle No 432

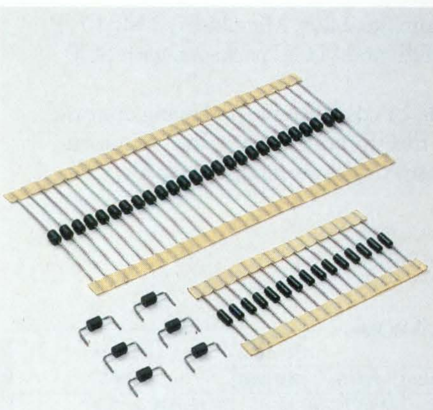
TDK Ferrite Technology Blocks out EMI/RFI



Chip Type Microbeads
CB Series



Ferrite Bead Cores
BF Series



Ferrite Beads
Axial-lead taped type

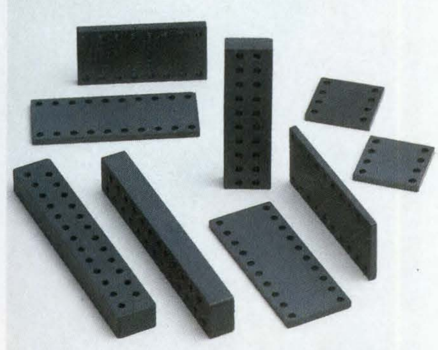
Ferrite Core for EMI/RFI
For electronic equipment electromagnetic interference is a major concern. That's why so many turn to TDK for assistance. TDK, the ferrite expert has been researching EMI for years. And now, backed by the full complement of TDK ferrite material technology, our products are ready to protect your products from EMI/RFI.

With its phenomenal EMI absorption properties, ferrite was destined to lead the charge against EMI/RFI. And TDK ferrite cores comprise a rich μiac 45—2700 material composition. They also come in multiple configurations for maximum protection over a wide range of frequencies.

TDK offers you a wide selection of ferrite products from which to choose, ferrite bead cores, chip-type bead cores, a newly developed multi-hole ferrite substrate MH series, and angular cores for flat cables. All are highly effective in eliminating EMI on circuit boards and between interfaces, as well as preventing undesirable signal feedback and interfering oscillation. All of TDK's EMI/RFI products boast high quality materials, and are fabricated according to integrated production processes. Naturally, all of our ferrite products carry the TDK guarantee of reliability, and are suitable for a variety of applications, including advanced computers, automobile electronics, and OA and FA equipment.

If you're ready to fight noise in the electronic environment, it's time you got to know TDK!

NEW PRODUCT



For ICs and Connectors
EMI Suppression Multi-hole Substrate

NEW PRODUCT

For cables
EMI Suppression Ferrite Cores

CEL

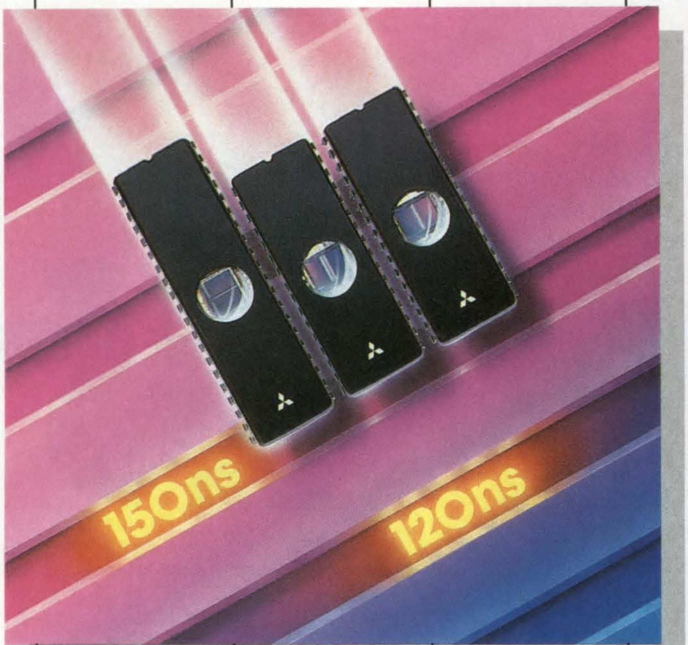
CEL is at your service. CEL, TDK's Component Engineering Laboratory in Torrance, CA, can assist you by custom designing and test manufacturing TDK EMI/RFI Components to meet your specific requirements. Call (213) 530-9397.

TDK Electromagnetic Compatibility Technology—At Your Service!

TDK®

TDK CORPORATION OF AMERICA HEAD OFFICE 1600 Feehanville Drive, Mount Prospect, IL 60056, U.S.A. Phone: (312) 803-6100 CHICAGO REGIONAL OFFICE Phone: (312) 803-6100 INDIANAPOLIS REGIONAL OFFICE Phone: (317) 872-0370 NEW YORK REGIONAL OFFICE Phone: (516) 625-0100 LOS ANGELES REGIONAL OFFICE Phone: (213) 539-6631 DETROIT DISTRICT OFFICE Phone: (313) 353-9393 NEW JERSEY DISTRICT OFFICE Phone: (201) 736-0023 HUNTSVILLE DISTRICT OFFICE Phone: (205) 539-4551 GREENSBORO DISTRICT OFFICE Phone: (919) 292-0012 DALLAS DISTRICT OFFICE Phone: (214) 506-9800 SAN FRANCISCO DISTRICT OFFICE Phone: (408) 437-9585 **TDK CORPORATION.** TOKYO, JAPAN.

CIRCLE NO 199



When You Want Fast 1 Mb EPROMs.

Mitsubishi delivers with a family of 150ns, CMOS 1 megabit UV EPROMs. Available now. And, for applications requiring even higher performance, 120ns versions are on the way.

Now, you can combine the advantages of fast access times and low power CMOS operation in the organizations and pin-outs you need.

There's a 128K x 8 that's pin-compatible with 1 Mb mask ROMs for easy conversion when you reach high volume production. Another device offers the JEDEC-standard pin-out allowing easy upgrade from lower density EPROMs. Plus, there's a 64K x 16, ideal for applications requiring wider data paths. And, they're all available in 150ns speeds. From Mitsubishi.

When You Want Cost-Effective Packaging Options.

If you want all the advantages of Mitsubishi EPROMs, but don't need to reprogram, Mitsubishi's 1Mb, 200ns CMOS OTP ROMs provide cost-effective alternatives for volume production.

And, for maximum flexibility, Mitsubishi's 1 Mb OTP ROMs are available in PDIP and PLCC packages, with SOP available soon.

For fast EPROMs, or cost-effective packaging options, call or write: Mitsubishi Electronics America, Inc., Semiconductor Division, 1050 East Arques Avenue, Sunnyvale, CA 94086. (408) 730-5900.

MITSUBISHI EPROMs

				Access Time (ns)						Package
	Density	Organization	Part No.	100	120	150	170	200	250	(CERDIP)
CMOS	128K	16K x 8	M5M27C128K			■		■	■	28 pin
	256K	32K x 8	M5M27C256K		■	■			■	28 pin
	512K	64K x 8	M5M27C512AK	■	■	■				28 pin
	1 Mb	128K x 8 64K x 16	M5M27C100K/M5M27C101K M5M27C102K			■ ■		■ ■	■ ■	32 pin 40 pin
NMOS	64K	8K x 8	M5L2764K					■	■	28 pin
	128K	16K x 8	M5L27128K					■	■	28 pin
	256K	32K x 8	M5L27256K					■	■	28 pin
	512K	64K x 8	M5L27512K				■	■	■	28 pin

MITSUBISHI OTP ROMs

				Access Time (ns)		Package Options
	Density	Organization	Part No.	200	250	
CMOS	256K	32K x 8	M5M27C256	■		28 pin PDIP and SOP
	1 Mb	128K x 8	M5M27C100	■		32 pin PDIP, PLCC and SOP
	1 Mb	128K x 8	M5M27C101	■		32 pin PDIP, PLCC and SOP
	1 Mb	64K x 16	M5M27C102	■		40 pin PDIP and 44 pin PLCC
NMOS	64K	8K x 8	M5M2764		■	28 pin PDIP
	128K	16K x 8	M5M27128		■	28 pin PDIP
	256K	32K x 8	M5M27256		■	28 pin PDIP and SOP
	512K	64K x 8	M5M27512		■	28 pin PDIP and SOP

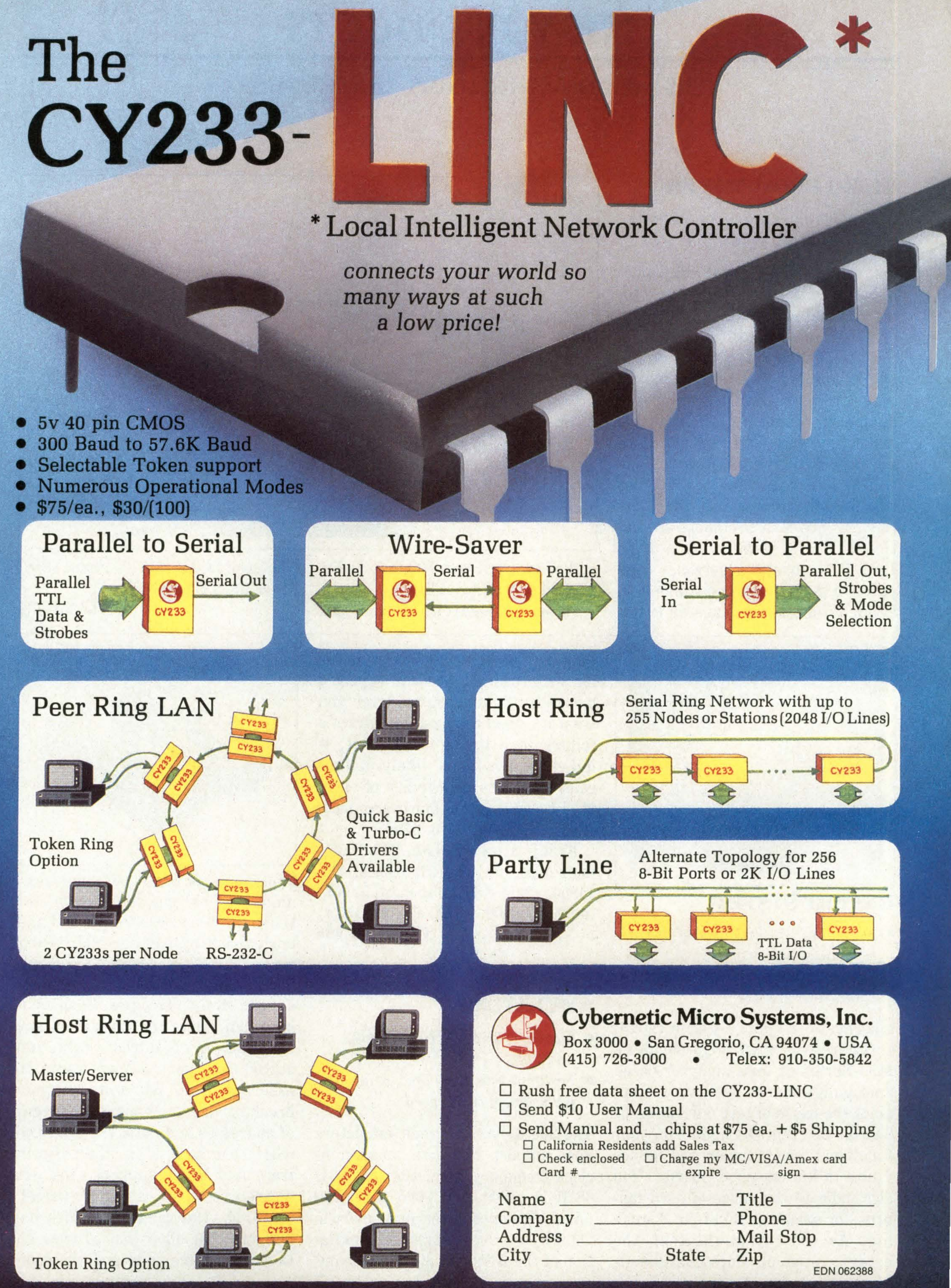
Products subject to availability.

CIRCLE NO 197

Quality Through Commitment.

MITSUBISHI ELECTRONICS

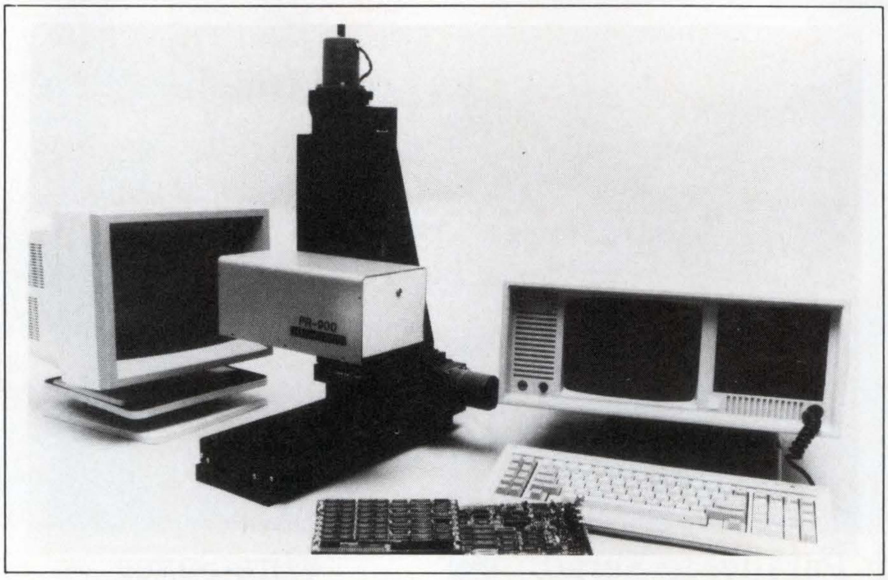
Regional Offices:
NORTHWEST, Sunnyvale, CA (408) 730-5900
SOUTHWEST, Torrance, CA (213) 515-3993
SOUTH CENTRAL, Carrollton, TX (214) 484-1919
NORTHERN, Minnetonka, MN (612) 938-7779
NORTH CENTRAL, Mt. Prospect, IL (312) 298-9223
NEW ENGLAND, Woburn, MA (617) 938-1220
MID-ATLANTIC, Piscataway, NJ (201) 981-1001
SOUTH ATLANTIC, Norcross, GA (404) 662-0813
SOUTHEAST, Boca Raton, FL (305) 487-7747
CANADA, St. Laurent, Quebec, (514) 337-6046.



CIRCLE NO 198

VIDEO PHOTOMETER

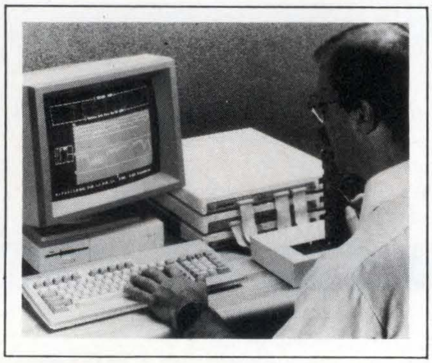
- *Inspects imaging displays*
- *Runs on IBM-compatible PCs*



You can use the PR-900 video photometer to perform spatial, photometric, and colorimetric inspection of color and monochrome CRTs, flat-panel displays, and other image-producing devices. It makes video-frame-rate measurements of luminance, luminance profiles in 2-D and 3-D, display uniformity (including pseudocolor presentation), line width, and character size. Modules that permit chromaticity and misconvergence measurements are optional. The system consists of an IBM PC-compatible personal computer, a multisynchronous monitor, a video camera, an image digitizer, and software. From $30,000. Delivery, 60 to 90 days ARO.

Photo Research, Box 2192, Chatsworth, CA 91313. Phone (818) 341-5151. TLX 691427.

Circle No 435



EXPERT SYSTEM

- *Speeds fault diagnosis of board-level assemblies*
- *Learns how faults affect functional-test results*

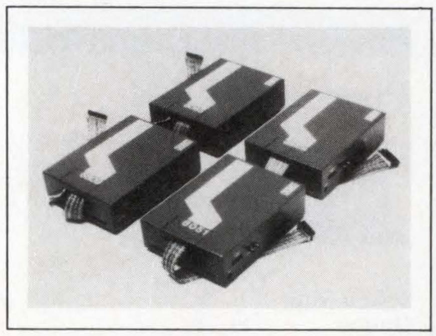
Diagnostic Expert System (DES) software works with the vendor's MFI-Series of logic-analyzer-based analog/digital test systems to pinpoint the cause of test failures on pc boards. To train DES, you run your functional test program and induce faults in known-good boards. You also indicate the cause of each failure—for example, IC-14 pin 3 stuck low. As you repeat the test, the expert system develops guardbands that define the range of responses for which the system will report a particular failure cause. After you train it, when the system detects a failure in a board under test, it indicates the most likely failure causes and the probability of each. MFI-Series system hardware, from $2985; DES software, $1985.

Array Analysis Inc, 200 Langmuir Lab, Brown Rd, Ithaca, NY 14850. Phone (800) 451-8514; in NY, (607) 257-6800. TWX 490-000-1912.

Circle No 436

EMULATORS

- *Support 8051, 68HC11, 6809, and 8085 μPs*
- *Perform real-time emulation at μP's maximum speed*



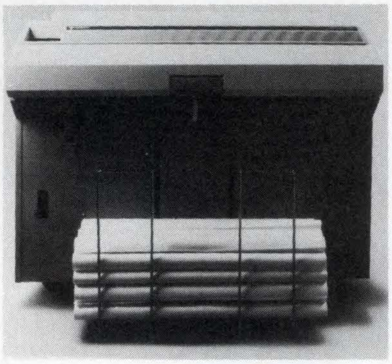
The 200 Series in-circuit emulators now support real-time, maximum-clock-frequency emulation of 8051, 68HC11, 6809, and 8085 μPs. The units' high-speed overlay memory is 256k bytes deep—even for emulation of the 6809 and 8085. The emulators support bank-switching techniques to extend the memory of these 8-bit processors beyond the normal 64k-byte linear-addressing range. Two 4k-word-deep trace buffers, whose width is 72 or 88 bits, depend on the processor. Each emulator can break and trigger on any combination of address, data, and status functions, as well as on 16 external lines. All units support breaking and triggering on ranges of addresses and data; the 8051 and 68HC11 units also provide I/O-port trace and break support. You can develop your software in C, Pascal, or PL/M—the vendor provides debuggers that allow you to view either the source code and the com-

CIRCLE NO 194

piled assembly-level code or only the assembly-level code. $4750. Source-level debuggers: $750 for MS-DOS-based host computers; $1500 for Unix-based host systems.

Huntsville Microsystems Inc, Box 12415, Huntsville, AL 35082. Phone (205) 881-6050. TWX 510-600-8258.

Circle No 437



LASER PLOTTER

- *Resolves 400 points/in.*
- *Handles drawings to 34×44 in.*

The 8836 laser plotter produces output with a resolution of 400 dots/in. on plain paper as large as 34×44 in. (E size). It can produce a 22×34-in. (D size) printout in less than 70 sec. For check drawings, a 200-dot/in. print density reduces data-processing time by a factor of 4. The unit can operate unattended: A finishing process rolls drawings with lengths of 29 in. to 15 ft into 2-in.-diameter rolls, tapes them with reusable tape, identifies the author on the outside of the roll, and deposits the rolls in a wire bin. The plotter's ability to operate over a 60 to 80°F temperature range and a 10 to 80% relative-humidity range obviates the need for tight control of environmental conditions. The vendor offers the unit with a choice of interfaces: RS-232C (capable of 38.4k-bps data transfer), Versatec parallel, Centronics parallel, and Ethernet. The plotter accepts several data formats, such as Versatec Random and 906/907 pen plotter. Without controller, $28,000; with controller, $37,900.

Versatec, 2710 Walsh Ave, Santa Clara, CA 95051. Phone (800) 538-6477; in CA (800) 341-6060. TWX 910-338-0243.

Circle No 438

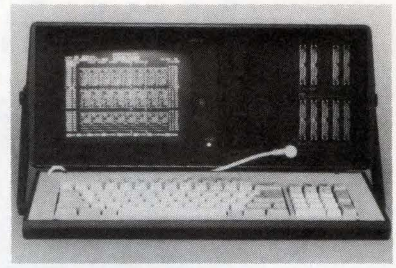
3200-COUNT DMM

- *Includes 32-segment bar-graph display*
- *Allows manual as well as auto ranging*

The 3060 full-scale, 3200-count DMM with its test leads fits in a shirt pocket. Besides measuring diode forward voltage at 1 mA and performing continuity checks, it measures dc voltage from 100 μV to 450V, ac voltage from 1 mV to 450V, and resistance from 0.1Ω to 32 MΩ. On the 3.2V dc range, the maximum error is ±0.7% of reading ±2 digits. In addition to the numeric readout, the meter's LCD presents the measured quantity as a 32-segment analog bar graph. Normally, the unit selects the most appropriate range for the quantity you are measuring. However, you can prevent it from changing ranges—and resolution—when you are measuring a quantity whose value is near a range change point. $60.

CG Soar Corp, 434 Windsor Park Dr, Dayton, OH 45459. Phone (513) 434-6952.

Circle No 439



LOGIC ANALYZER

- *Can acquire 96-channel data at 100 MHz*
- *Integrates portable, 10-MHz MS-DOS computer*

You can install 24, 48, 72, or 96 channels in the PM 3655 logic analyzer. In both state- and timing-analysis modes, it can acquire data at speeds to 100 MHz, regardless of the number of channels. The memory depth is 2k words at all sampling speeds. The unit can capture 5-nsec-wide glitches without sacrificing memory. Within the portable unit is a turbo IBM PC/XT-compatible computer with open bus slots. You can store setups and acquired data on the unit's floppy-disk drive. The unit includes RS-232C, IEEE-488, and Centronics-compatible I/O ports. $4550 to $9950. Delivery, 12 weeks ARO.

John Fluke Mfg Co Inc, Box C9090, Everett, WA 98206. Phone (800) 443-5853; in OR, (206) 347-6100. TLX 185102.

Circle No 440

CONTROLLER

- *Aids detection of assembly flaws*
- *Drives commercial amplifiers and shakers*

The GR2530 random-vibration controller is an integrated hardware/software system for environmental-stress screening of products. Such testing can reveal latent manufacturing defects, such as cold solder joints. Though intended for production testing, you can also use the system at the prototype stage to uncover a product's designed-in structural weaknesses. The control-

If indicator lights look like this to you, look away.

Perhaps it's the brilliant colors. Or the sparkle of chrome. Somewhere along the way, the people who buy, and even the people who build indicator lights have come to think of them as little more than ornamentation.

Dialight disagrees. The way we see it, an indicator light might be the only way of knowing a critical system is on, off, up, down, hot, cold, dead or alive. An attitude you can see in every model of our incredibly wide selection.

Take our sub-sub-miniature incandescents, for example. Each fitted with a high reliability filament lamp enclosed in a high-impact, plastic cap. The lens is molded directly to the mounting bushing for added strength. The entire assembly is available in a wide variety of colors and meets the requirements of MIL-L-3661B.

With caps constructed of lexan to survive high-heat lamps, we've engineered indicators for continuous usage at levels to 250V.

And to provide operation at a specific voltage level while preventing instantaneous burnout, our neon indicators are ballasted with integral current limiting resistors.

We've even designed a line of ultra-miniature incandescent and neon indicators with plug-in replacement cartridges that make changing lamps a snap.

Incandescents, neon and LED indicators available in a virtually limitless range of colors, sizes, configurations and mounting styles. In fact no one makes more indicator lights for more applications than Dialight. Even designs that meet MIL-L-85762A night vision requirements and other military specifications.

If you're starting to look at indicator lights the way we do, we suggest you continue to do so in our catalog. It's available free by dialing 201-223-9400. Or by writing; Dialight Company, 1913 Atlantic Avenue, Manasquan, NJ 08736.

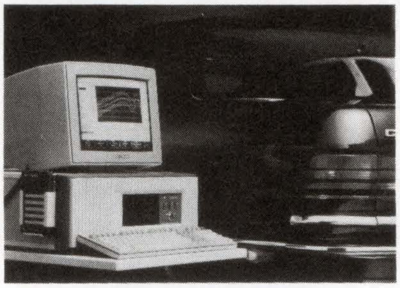
DIALIGHT COMPANY A Division of North American Philips

DIALIGHT·KULKA·HHSMITH

Engineering is the only commodity we sell.

CIRCLE NO 193

ler connects to commercial electrodynamic and electrohydraulic shakers and amplifiers. The unit, which is based on Digital Equipment Corp's Q Bus, sports a color display and uses a multiprocessor architecture to decrease test time. Its open architecture allows you to connect it to networks. You can control vibration frequency in nine ranges over a



75-dB dynamic range. Two input channels are standard; the controller can accommodate eight. To safeguard the operators, the unit under test, and the test operations, the GR2530 controller performs 13 safety checks. $27,900.

GenRad Inc, 510 Cottonwood Dr, Milpitas, CA 95035. Phone (408) 432-1000.

Circle No 441

IEEE-488 SOFTWARE

- *Runs under MS-DOS*
- *Combines instrument control and data analysis*

Assystant GPIB runs under MS-DOS on IBM PC, PX/XT, PC/AT, and compatible computers. It combines the data-manipulation capabilities of the vendor's Assystant software with extensive facilities for controlling devices interfaced to the computer via the IEEE-488 Bus. The menu-driven software allows you to define devices, interactively execute bus commands, issue device-dependent commands, perform serial polling, and construct automated instrument-control programs. In an interactive mode, you select commands from a menu; the software then combines them into a routine and saves the routine on disk. Routines can call each other. The data-manipulation functions include calculation of statistics, linear and nonlinear curve fitting, waveform processing (which includes performing FFTs), smoothing, convolution, waveform generation, and solution of differential equations. Graphics

The Blues always help you see things more clearly.

If you've been singing for higher contrast Liquid Crystal Displays, Seiko Instruments has some happy news for you. Thanks to the unique blue characters on their LCD modules, seeing what's on the screen is easier than ever.

Another big advantage of getting the blues from Seiko is their extremely wide viewing angle. The widest available for small LCDs. So your customers can read the screen from positions that are comfortable to them. Little extras that mean a lot when it comes to making a design decision.

If all this sounds good, there's one more feature that'll be music to your ears. Plug-in compatibility.

Simply drop in the new modules wherever you were using Seiko's parallel interface, TN type modules. Making a visible improvement in your products easy. Quick. And free of retooling costs.

And, with a variety of these easy-to-read modules ranging from 1x16 to 4x40, Seiko's bound to have what you need.

Call Seiko Instruments today at (213) 517-7770 and ask about their LCDs with the blue characters. It'll give you, and your customers, a whole new outlook on your products.

Seiko Instruments, USA, Inc.
Electronic Components Division
2990 West Lomita Blvd.
Torrance, CA 90505
(213) 517-7770
FAX (213) 517-7792

Seiko Instruments

CIRCLE NO 192

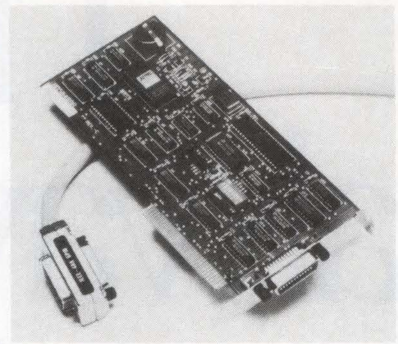
options include cartesian, contour, and scatter plotting. Supported file formats include ASCII, binary, and DIF (data-interchange format). $695.

Asyst Software Technologies Inc, 100 Corporate Woods, Rochester, NY 14623. Phone (716) 272-0070. FAX (716) 272-0073.

Circle No 442

IEEE-488 INTERFACE

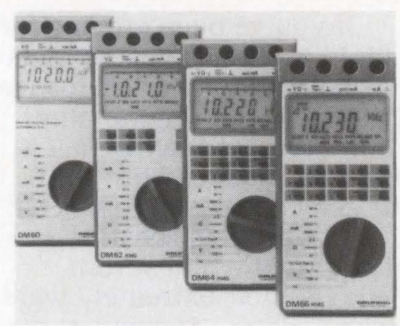
- *Plugs into IBM PC bus*
- *Includes software usable with Basic, C, and Pascal*



The R748 ¾-length PC bus board houses an IEEE-488 controller and a battery-backed real-time clock. The controller supports all IEEE-488 Bus commands using standard mnemonics and can drive 14 devices via a standard cable. Using DMA, it can transfer data to the computer at 300k bytes/sec; it also operates in programmed-I/O mode. The software resides in RAM on the board, and hence does not occupy any of the computer's memory. Support software enables you to write instrument-control programs in Basic, C, and Pascal. $495.

Rapid Systems Inc, 433 N 34th St, Seattle, WA 98103. Phone (206) 547-8311. TLX 265017.

Circle No 443



HANDHELD DMMs

- *Provide 4- or 4½-digit resolution*
- *Can interface with computer systems*

The DM Series handheld autoranging digital multimeters comprise four models. The DM60, DM62-RMS, and DM64-RMS 4-digit models offer dc voltage ranges from 100 mV to 1 kV, ac voltage ranges from 1V to 750V, dc or ac current ranges from 10 mA to 10A for the DM60 and DM62-RMS, and 1 mA to 10A for the DM64-RMS; the resistance

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CIRCLE NO 191

measurements range from 100Ω to 100 MΩ. The DM66-RMS 4½-digit model provides equivalent bottom ranges of 200 mV, 2V, 2 mA, and 200Ω, respectively. In addition to digital display, all the models feature an analog scale in the LCD display area with a maximum resolution of 2 mV/div. The DM62-RMS, DM64-RMS, and DM66-RMS measure the true rms value of nonsinusoidal waveforms and offer relative measurement, storage/recall of measured values, and storage of threshold values, as well as a continuity test buzzer and display illumination. The DM64-RMS and DM66-RMS can measure dB ratios, frequencies from 1 Hz to 100 kHz, and temperatures from −20 to +1200°C. These two models also offer auto- or manual ranging, analog-scale magnification, and keyboard entry of threshold and reference values. The DM66-RMS features storage of measured values during preselected time intervals. An optional interface unit is available that allows you to control the DMMs via an IEEE-488, RS-232C, or Centronics interface. From DM 430 to DM 956.

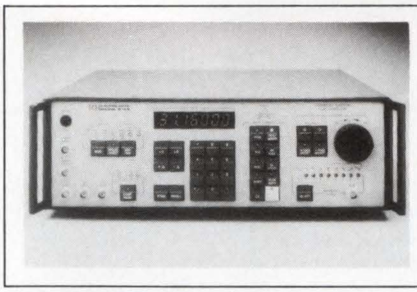
Grundig AG, Wurzburger Strasse 150, 8510 Furth/Bay, West Germany. Phone (0911) 73301. TLX 623435.

Circle No 444

SIGNAL GENERATOR

- *Produces three waveforms and two pulse polarities*
- *Operates from 0.01 Hz to 31.16 MHz*

The Model 2100A synthesized function/pulse generator produces sine, square, and triangular waves as well as positive and negative programmable-width pulses. It covers the frequency range of 0.01 Hz to 31.16 MHz (to 10 MHz for pulses)



with 7-digit resolution and accuracy of 0.5 ppm. The main output provides open-circuit voltages that you can set from 10 μV to 30V p-p. Optionally, you can obtain outputs whose amplitude accuracy is 0.05 dB. An auxiliary output supplies TTL levels. The pulse rise times and fall times are less than 11 nsec. The unit sweeps the output frequency linearly or logarithmically between start and stop frequencies that you program. You can also vary the frequency by supplying a programming voltage. Below 30 kHz, the unit can produce bursts of 1 to 255 waveforms with start and stop

points programmable in 1° increments from −90 to +267°. $4250. Delivery, six to eight weeks ARO.

Kron-Hite Corp, Avon Industrial Park, Bodwell St, Avon, MA 02322. Phone (617) 580-1660. TWX 710-345-0831.

Circle No 445

PROGRAMMER

- *Handles 20- and 28-pin DIPs to 64k bits*
- *Operates in stand-alone mode or with terminal*

The PP38 programs 2k- to 64k-bit EPROMs and EEPROMs in 24- and 28-pin DIPs. It operates in stand-alone mode or in conjunction with a terminal or computer connected to its rear-panel-mounted RS-232C port. The programmer can contain from 512k- to 1M bits of RAM. Its two sockets allow it to program 2-unit sets of byte-wide devices that together contain 16-bit-wide data or to simultaneously gang-program identical byte-wide data into a pair of devices. You can store all data for a 32-bit-wide set in the programmer's RAM and program the devices in groups of two. An autorecall mode stores as many as nine sets of device parameters. $1250.

Stag Microsystems Inc, 1600 Wyatt Dr, Santa Clara, CA 95054. Phone (800) 227-8836; in CA (408) 988-1118. TWX 910-339-9607.

Circle No 446

DATA-LINK ANALYZER

- *Allows you to diagnose and monitor SNA/SDLC data links*
- *Runs on an IBM PC or PS/2 computer*

Comprising an add-in board for the computer, an RS-232C/V.24 cable, and disk-based software, the DPA-10 data-performance analyzer turns your IBM PC/XT, PC/AT, PS/2-30, or a compatible computer into a data-link analyzer for SNA/SDLC (systems network architecture/synchronous data link control) networks. The analyzer allows you to measure network response time in its host, transmission, and poll delay components; it also indicates utilization measurement at the terminal level. You can use the analyzer in a surveillance mode to monitor the network's response time, retransmission, and time-out thresholds, and to detect line/system outage. The analyzer improves network management, tunes the network, and provides fault isolation. It operates via on-screen menus and at line speeds as high as 19.2k baud.

Wandel & Goltermann GmbH, Postfach 1262, 7412 Eningen uA, West Germany. Phone (07121) 861570. TLX 729833.

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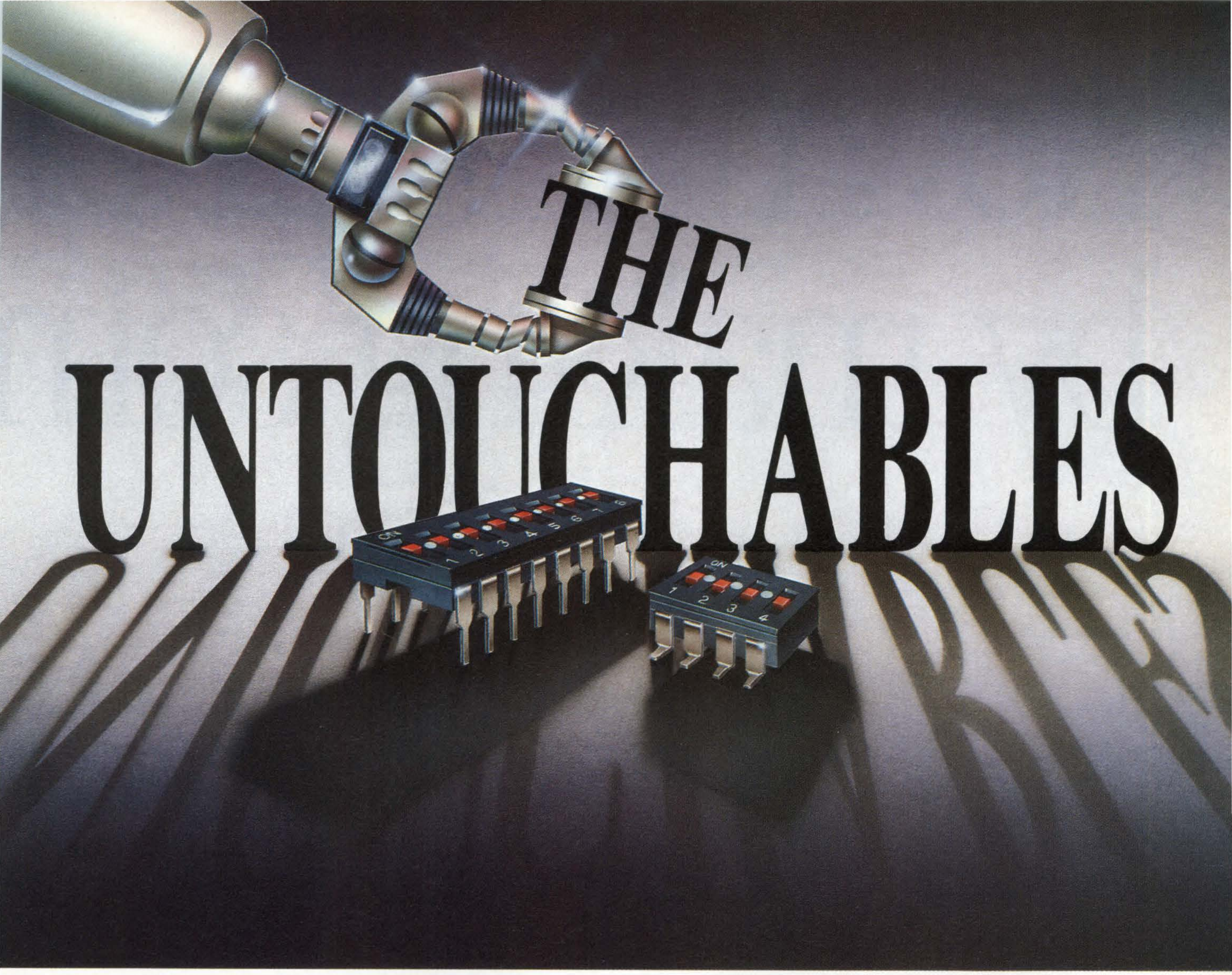

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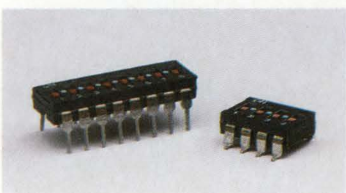

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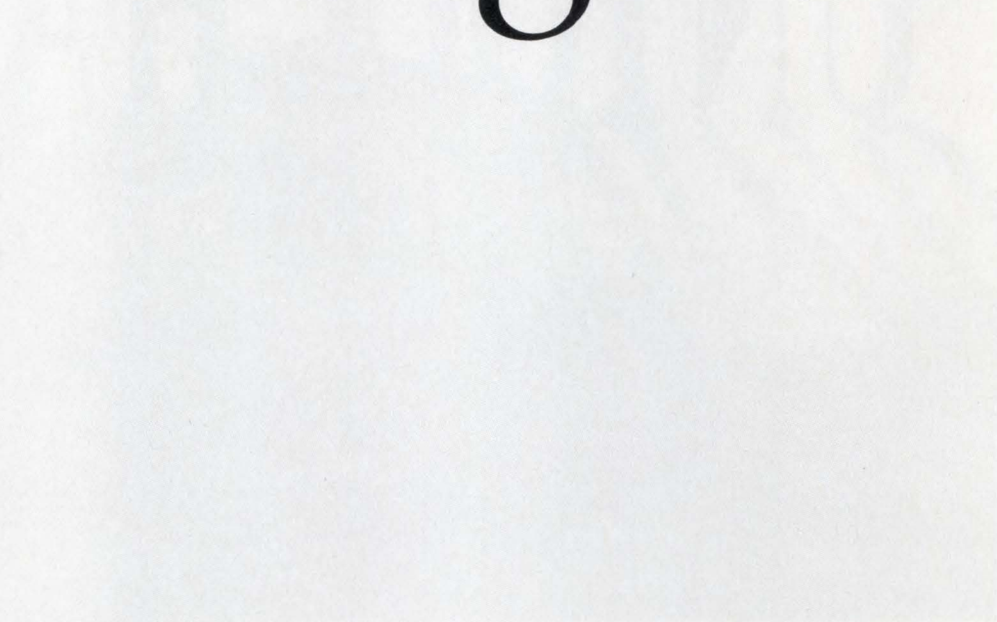

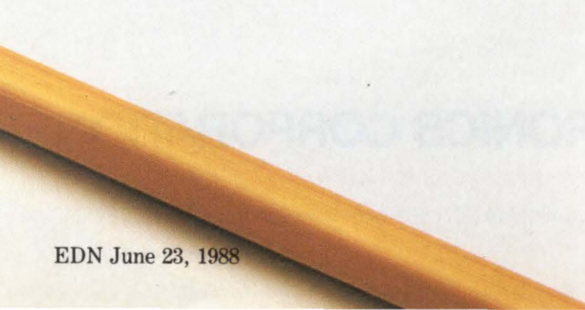

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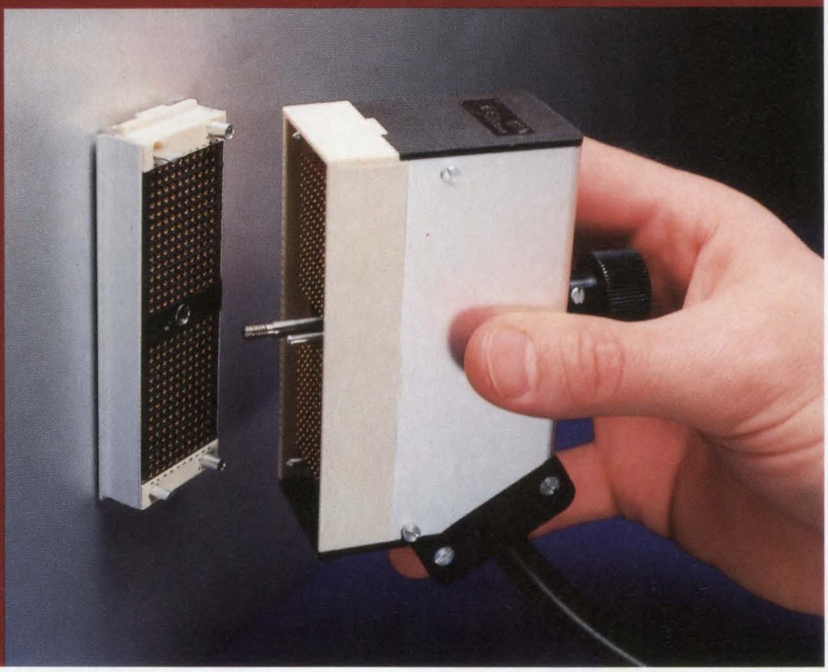

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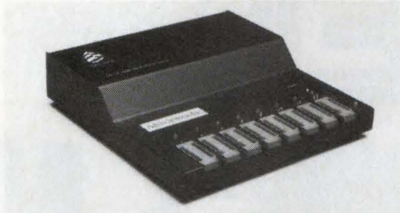

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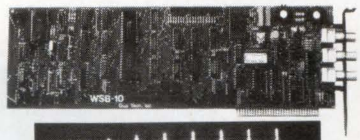

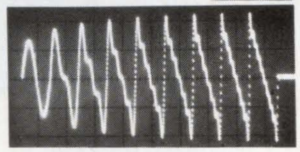

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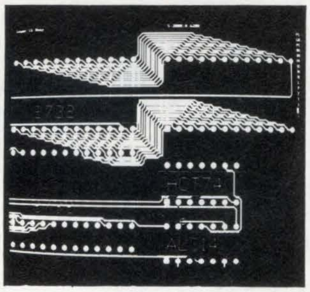

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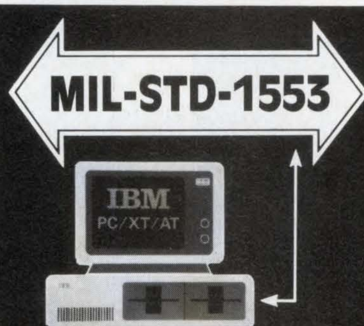

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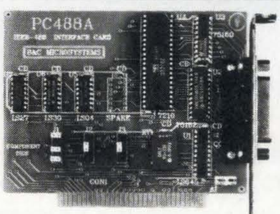

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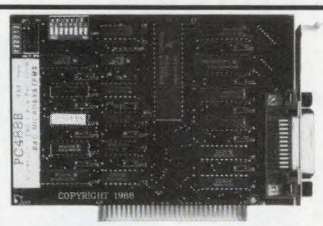

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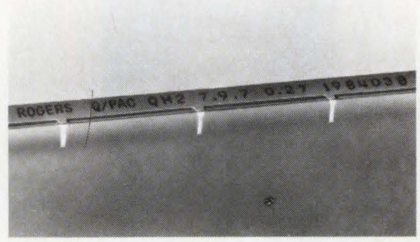

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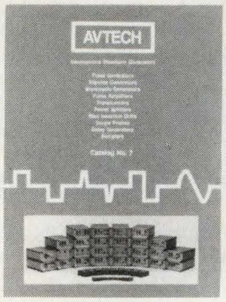

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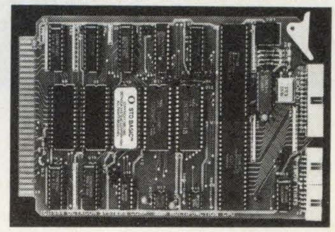

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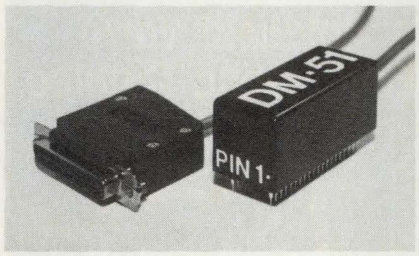

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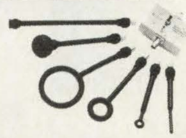

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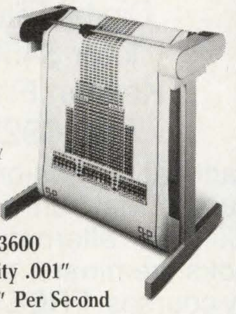

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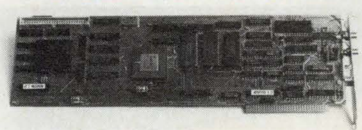

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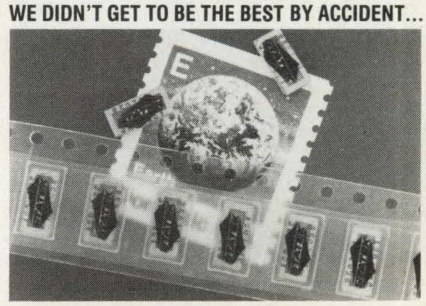

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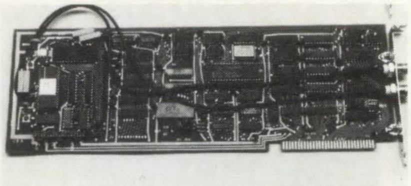

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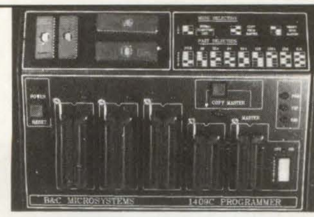

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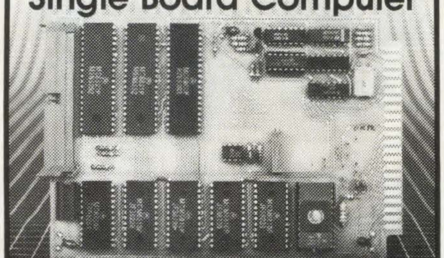

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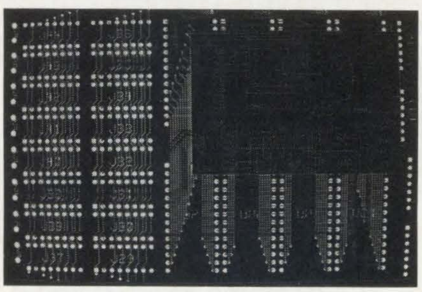

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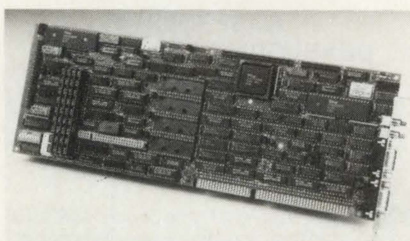

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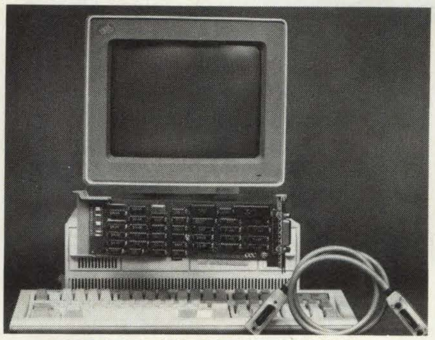

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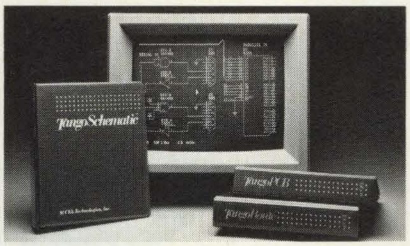

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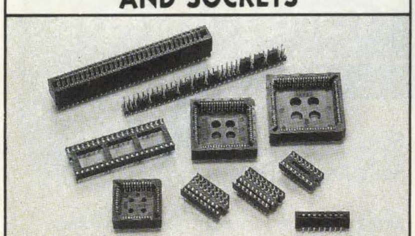

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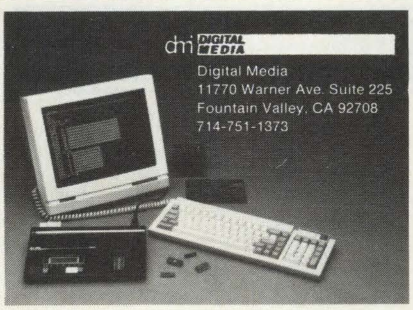

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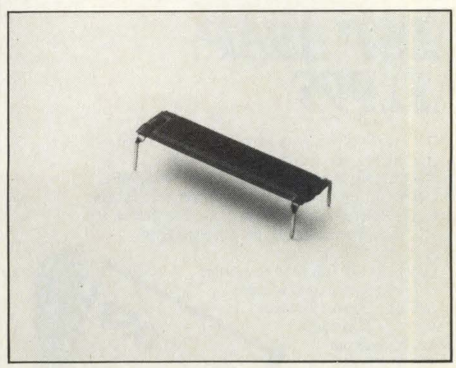

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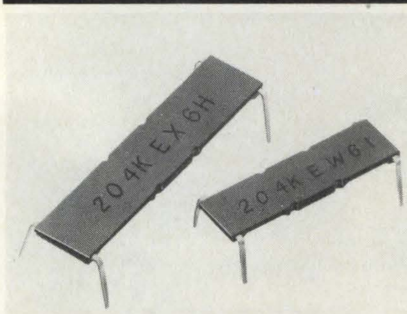

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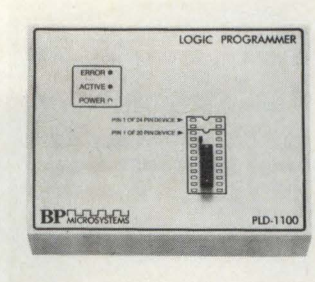

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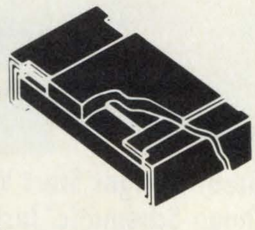

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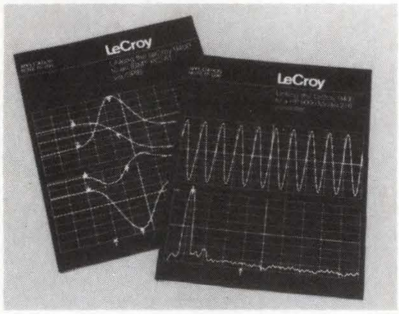

Applications for 9400 computer explained

Application Notes ITI 005 and ITI 006 *Linking the LeCroy 9400 to an IBM PC/AT via GPIB* and *Linking the LeCroy 9400 to an HP9000 Model 216 Controller*, respectively, examine programs for remote control of the vendor's 9400/9400A digital oscilloscope. The ITI 005 provides a sample program in C that controls as many as 16 digital scopes over an IEEE-488 bus, using an IBM PC/AT or compatible. The ITI 006 describes interactive remote control of the 9400 over an IEEE-488 bus. It also demonstrates waveform data storage and retrieval from disk via a program using a Model 216 controller and the HP Basic 3.0 language.

LeCroy Corp, 700 Chestnut Ridge Rd, Chestnut Ridge, NY 10977.

Circle No 450

Image-processing publications available

The vendor's 1988 Image Processing Handbook Set consists of two books, the Image Processing Catalog and the Product Summary. The handbooks present microcomputer analog I/O systems, image-processing products, and array-processing boards, as well as software support and media. DT-Connect, PC-based image processing, and digital image processing are among the applications described in the catalog. In the product summary, a lengthy data-acquisition section describes boards for systems such as the IBM PC/XT, PC/AT, and PS/2; and the Macintosh II; and for bus structures, such as the MicroVAX II/Q Bus; Unibus; Multibus; VME Bus; and STD Bus. Both publications contain numerous illustrations.

Data Translation Inc, 100 Locke Dr, Marlborough, MA 01752.

Circle No 451

PC-based equipment cataloged

This full-line catalog features PC-based instruments, encompassing FFT spectrum analyzers, digital scopes, logic analyzers, data-acquisition cards, IEEE-488 controller cards, stepper-motor control cards, and scientific data-analysis software. The publication deals with test and measurement devices that use the IBM PC, PC/XT, PC/AT, and compatibles for control, display, and data storage and conversion. It lists local suppliers and provides a product-selection table.

Rapid Systems, 433 N 34th St, Seattle, WA 98103.

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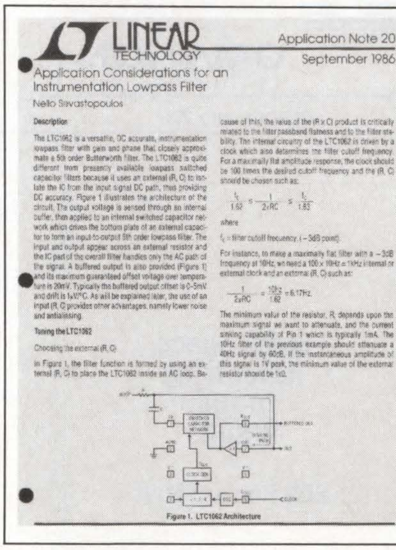

Applications for lowpass filter discussed

Application Considerations for an Instrumentation Lowpass Filter sheds light on the LT1062, a monolithic lowpass filter that approxi-

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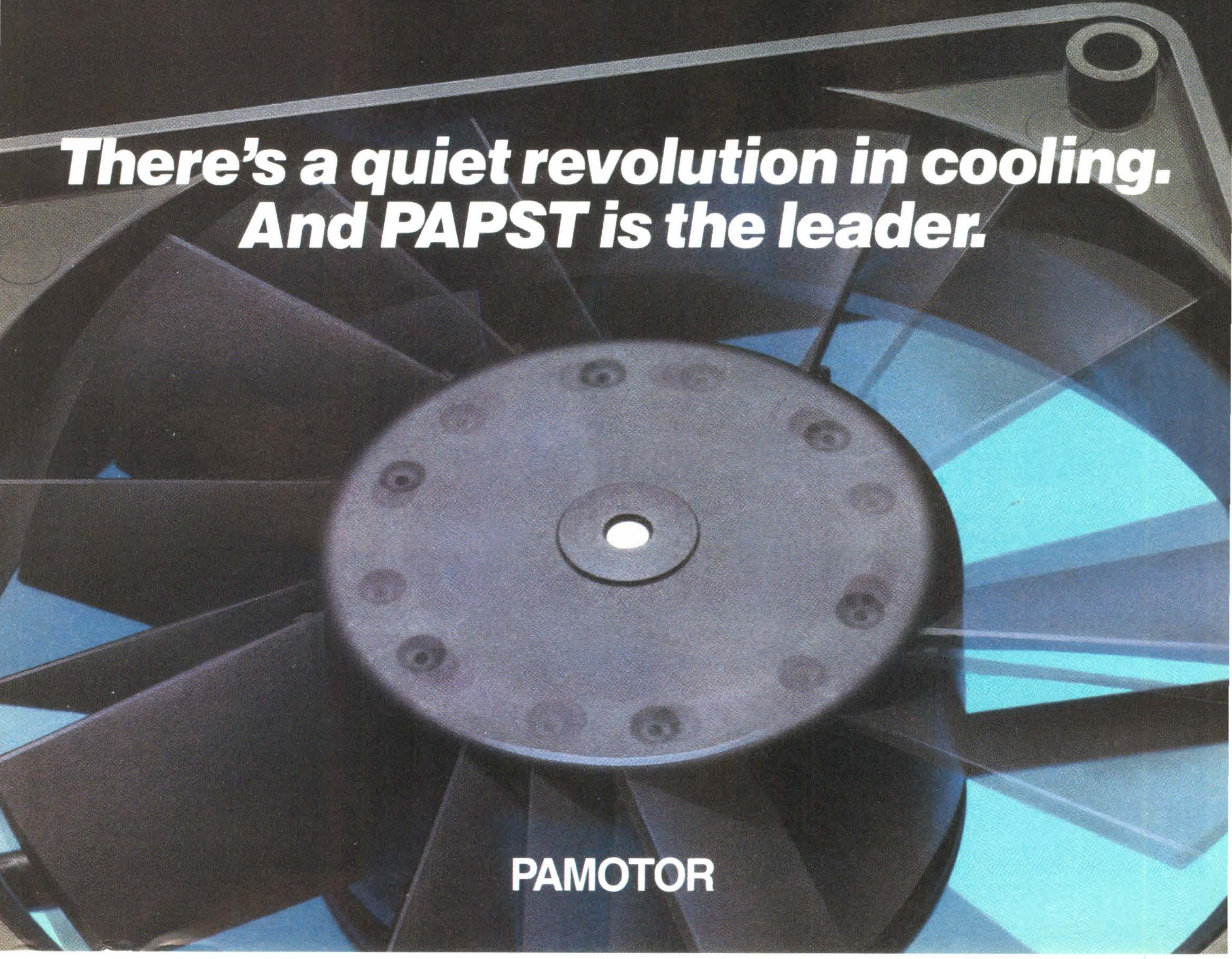

mates a fifth-order Butterworth-type filter. It includes a complete schematic and circuit description for a twelfth-order maximum-flatness, lowpass filter with a very low offset. Also included are several fully tested oscillator circuits, with schematics and descriptions, using the LTC1062.

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035.

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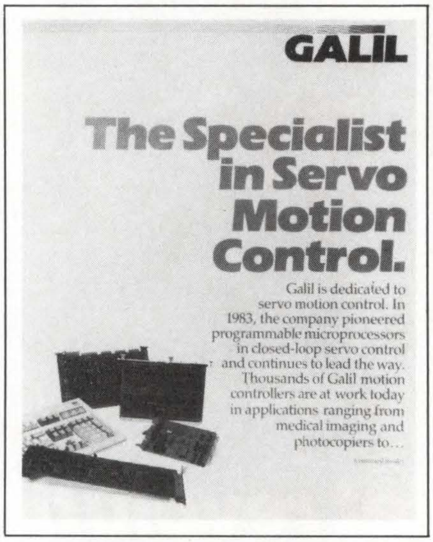


Servo motion-control devices summarized

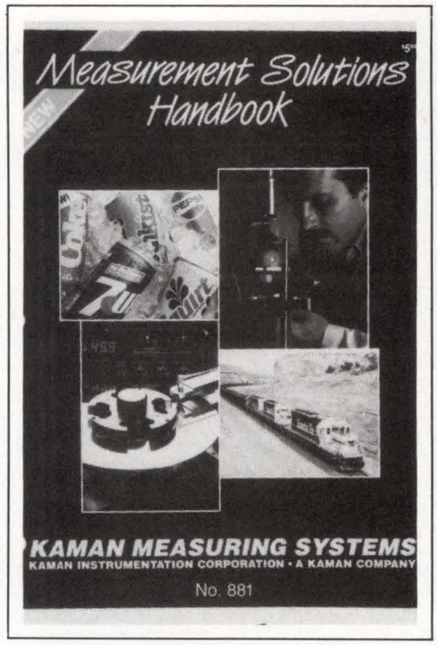
The 8-pg brochure, *The Specialist in Servo Motion Control*, presents the vendor's full line of programmable servo motion-control products. The devices listed include plug-in control cards, power amplifiers, motors, and encoders, as well as bus options. The product selection guide allows you to see each product's features at a glance.

Galil Motion Control Inc, 1054 Elwell Ct, Palo Alto, CA 94303.

Circle No 454

Measuring systems presented

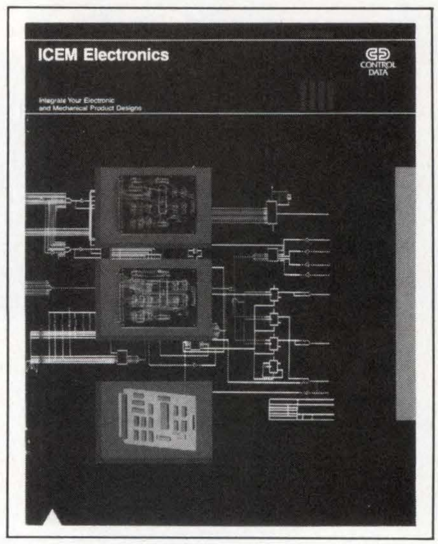
The vendor's 62-pg *Measurement Solutions Handbook* focuses on noncontacting position-measuring systems/sensors that provide continuous linear-analog output proportional to displacement. This updated edition features an ex-



panded discussion of applications and new sensor options. It includes descriptions of systems that measure dimension, displacement, alignment, and vibration.

Kaman Instrumentation Corp, Box 7463, Colorado Springs, CO 80933.

Circle No 455



Booklet features integrated electronic design

This 20-pg publication discusses the integrated ECAD (electronic computer-aided design) capabilities found in the vendor's ICEM (integrated computer-aided engineering and manufacturing information system). It includes data flow charts and speaks about the software tools you can use on mainframes, Cyber 910 workstations, or any DOS-compatible personal computer. The brochure illustrates a sample design process, and it describes 13 different applications packages.

Control Data, Box 0, Minneapolis, MN 55440.

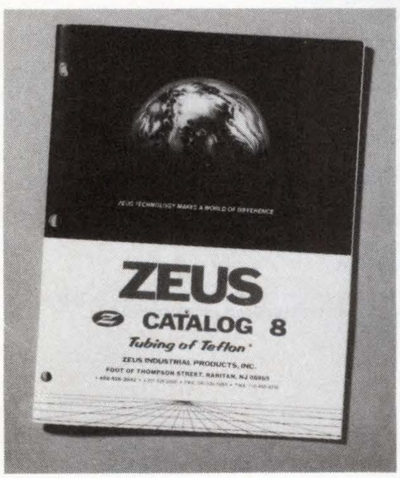
Circle No 456

App note deals with op-amp circuits

Application Note OA-07 *Current-Feedback Op Amp Applications Cookbook* delves into the design and circuits of more than 30 high-speed op-amp circuits. The note can help you obtain maximum performance from high-speed op-amp circuits.

Comlinear Corp, 4800 Wheaton Dr, Fort Collins, CO 80525.

Circle No 457



Exploring the merits of tough and tiny tubing

This 48-pg catalog highlights the company's Sub-Lite-Wall tubing that comes in sizes as small as 0.0015 in. ID. It presents Teflon TFE, FEP, PFA, and Tefzel, all available as extruded or in heat shrink, with ratios as high as 4:1. The table of properties helps you find the right tubing for your particular application. Specialty items listed include heavy-duty construction tubing, multilumen tubing, Snaptube, Dual-Shrink and Dual-Tube, heat-shrink roll covers, medical-grade tubing, and beverage tubing.

Zeus Industrial Products Inc, Box 298, Raritan, NJ 08869.

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Catalog highlights diverse software

This software catalog describes 49 scientific, engineering, and business programs for the IBM PC, PC/XT, PC/AT, and compatibles, as well as programs for handheld calculators and interactive videotape/software training. It also features Estipipe, a piping man-hour estimating program; MathTool, a tool box of numerical analysis techniques; and InstruCalc 2.1, a recent version of the instrument engineering calculation program. Further additions include the ChemCalc, PetroCalc, and PipeCalc series.

Gulf Publishing Co, Software Div, Dept G9, Box 2608, Houston, TX 77252.

Circle No 459

Listing of fiber-optic cable assemblies

This 11-pg booklet of single and multimode fiber-optic cable assemblies focuses on single- and multi-fiber cables, terminating in all-fiber-optic connectors. The publication provides specifications, illustrations, and current price listings.

Pasternack Enterprises, Box 16759, Irvine, CA 92713.

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CIRCLE NO 184

The pursuit of happiness: What it takes to make a career change

Deborah Asbrand, *Associate Editor*

Bill Collins admits he got into engineering for all of the wrong reasons. "My family said to me, 'Go into engineering. It's where the money is.' At the age of 19, I just didn't do a lot of forward thinking." Now, at age 45, Collins is again contemplating his future. This time, he says, his career goal is quite different: "I'm looking for something that makes me happy." He's considering leaving his current job, but not the field: He hopes to teach electrical engineering at the college level.

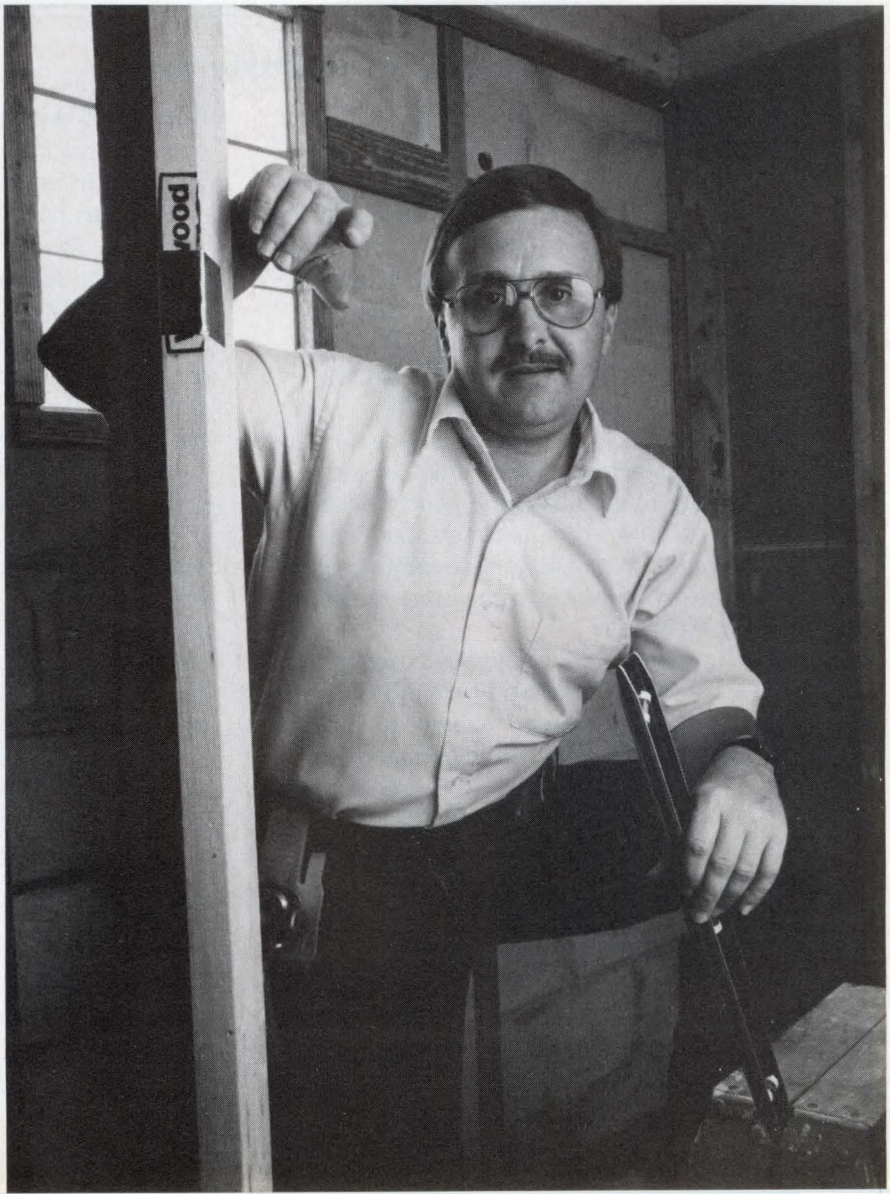
Not every engineer who contemplates a career change wants to leave the general field of engineering. They may, like Collins, desire a teaching role, or the problem may be simply that a promotion into management has left them longing for the design work they used to do.

The world of work used to be a much simpler place. You hired on with a company, and 40 years later, you counted up your pension dollars and retired from the same company. Nowadays, it's those four decades between entering and exiting the workforce that are giving people pause. Work is no longer considered just an income-producing endeavor, and many people are seeking jobs that not only pay the mortgage but also leave them intrinsically satisfied.

Self-fulfillment, though, is a much more elusive goal than, say, a high-paying salary, an impressive title, or a corner office. Many people underestimate the amount of hard work—and the guts—that it takes to start a second career or redirect the career they've chosen.

Mira Furth believes it's the baby-boomers like herself who gave rise to the idea of work-as-fulfillment. "I grew up in the 60s," says Furth, a 38-year-old Boston, MA, career consultant. "People of my generation feel we deserve satisfaction in our jobs. We feel it's our entitlement. That message is everywhere today."

What's more, the importance of making a thoughtful career choice is being broadcast to an increasingly



George Johnson

***The renovations that Bill Collins is making** to his Florida home provide him with a creative outlet for his problem-solving aptitudes—minus the constraints he finds in the workplace.*

People fear career change, with good reason: It can mean a pay cut or a return to college studies, both of which can wreak havoc on a family's finances.

younger audience. More counselors and testing services report that large numbers of their clients are high-school and college-age students as well as recent graduates. Michael Dansker, a Palo Alto, CA, psychotherapist who specializes in career advice, says he works with many clients ages 16 to 19. "Young people come in with different needs [than older people have]," Dansker says. "They're inquisitive and open to anything that might come up in the testing."

If inexperience and openness to new ideas characterizes the younger people who visit Dansker's office, cold fear is the mark of the older ones. "People come in with a lot of fears," says Dansker. Indeed, they have good reason to be afraid. Changing careers often means shedding a professional identity that in many cases a person has gone to great lengths to mold. The pressure is high to be sure that the career picked *this* time is the *right* one. Change can also bring with it a pay cut or, in some instances, a return to college studies, both of which can wreak havoc on a family's financial security.

There's also the burden of listening to the well-intentioned friends and relatives who, disinclined to take such a risk themselves, quizzically raise one eyebrow and ask "Are you sure you know what you're doing?" In 1980, when Bob McCabe began telling his colleagues that he would soon be leaving teaching to go to engineering school, the responses

The agony and the ecstasy of aptitude tests

When my eight hours of testing at the Johnson O'Connor Research Foundation's Boston office began at 8:20 AM on a Thursday morning, I was all set—although for what, I wasn't sure. On the one hand, I was curious to find out if I was making the best use of my skills. Then again, I wondered what the tests would reveal about me and pondered further whether I really wanted to know.

My morning test administrator, Daniel, explained to me the point of aptitude tests—to measure natural abilities—and then gave me an important warning: American culture emphasizes excellence in all areas, and some people bring that competitive attitude to the testing table. That's a problem, he adds, because, statistically speaking, test takers always discover some areas in which their aptitudes are low.

Secretly ignoring Daniel's advice, I plunged ahead into the tests. I whizzed through the tests for visual memory and paper folding, scoring above the 90th percentile in both. Vindication at last, I thought. I was going to be one of those rare birds who has a high aptitude for everything.

Then came The Tweezer Test. It measures a person's ability to manipulate small tools. In front of me on the table was a wooden board with two sets of 100 small holes drilled into it. One set of holes had a small nail in each cavity; the other set of holes was empty. My job was to use a pair of tweezers to transfer all the nails neatly from the first set of holes to the second set. Dropping a nail or putting it into the hole sloppily would subtract points from my score.

I worked laboriously until the transplant was complete. Daniel tallied my score immediately and pronounced me in the fifth percentile. The *fifth* percentile? Daniel had obviously made a computing error. I asked him to recalculate. He assured me the figure was correct and advised me not to worry about it. I remembered his initial advice, but still I wondered. Did 95% of the people who took The Tweezer Test really relocate those nails so much faster than I did?

Newly humbled, I moved on to the next test, which measured analytical reasoning. Daniel placed several chips on the table. Each chip had a word written on it. My job was to take the chips and place them in the correct spot on the flowchart in front of me, making sure that the pattern of the words followed the arrows on the flowchart.

Test scores in the 70th percentile or higher are said to indicate natural aptitude. People who score high on the analytical-reasoning test, Daniel explained, are likely to succeed in areas such as computer programming and editing, in which they need to link ideas and see relationships between numbers and words. I just made it, squeaking by with a borderline score of 70. I had only a moderate natural aptitude for my job. I prayed my editor would never find out.

he got became predictable. "People saw the decision in one of two ways," says McCabe, who's now a support engineer for Hewlett-Packard's Telecomm Div in Colorado Springs, CO. "Some people looked at the outcome of going to school as being exciting. Other people didn't look down the road. They said, 'you're going to go to engineering school? That's a tough program.'"

All these pressures prompt people who are exploring a career change to entertain second thoughts. But Dansker finds that his clients share another attribute besides apprehension—the willingness to swallow their doubts and take risks. "They have substantial courage. They're willing to do something about their lives."

The urge for change

Some career changers have a clear sense of what that "something" is. They know what direction in which they want to channel their energies. After a career that saw him go from engineer to cofounder of minicomputer maker Prime Computer to chief executive officer of Acorn Computer, Joe Cashen wanted to take a turn working in the nonprofit sector. In early 1987, he joined the Boston Computer Museum as its director. "I felt computers had done a lot for me, and I wanted to be able to help them do things for other people."

McCabe, too, had a ready sense of the direction in which he wanted to turn. Ten years of teaching ad-

Next, I joined three other examinees in a room with a slide projector and four desks. Atop each desk was a set of headphones and a canister of perfectly pointed number 2 pencils. For the next hour and a half, the program tested my ability to memorize words quickly, generate ideas, and distinguish musical tones. For that last test, I crossed my fingers and hoped I'd finally derive some utility from the five years of piano lessons I'd endured as a child.

After a lunch break, I resumed testing. On I went, trying to memorize numbers, picking out numerical patterns, and putting large block puzzles together. For one test, an abstract pattern of lines flashed on the slide screen for five seconds. My job was to turn over the piece of paper in front of me, and, using the dots that were provided as a guide, reconstruct the placement of as many of the lines as I could remember. I was allowed two minutes for the reconstruction—which was about one minute and 50 seconds longer than I needed, because as soon as the design vanished from the screen, it also disappeared from my memory. Glancing at the dots on the paper only seemed to push any memory of the design further away. I spent most of the allotted two minutes examining my pencil, tapping it on the table, and discreetly observing the other two people in the room to find out whether they were having any more success at this than I was.

By 3:45 PM, I had completed my last test. How did I do? My scores told me I had high visual and musical aptitudes, and that I'm happiest working with people (as opposed to working alone for long periods of time) and sharing some responsibility in decisions. Robert suggested that the areas in which I might find the greatest satisfaction were science, technology, and the arts—all fields with a distinct three-dimensional component to them. No mention of journalism, but engineering was listed as a possibility.

The aptitude tests can indeed tell you a few things about yourself that you'd rather not hear. The test interpreters—such as Robert, who analyzed my scores at the follow-up session—who seem to have an uncanny ability to intuit an individual's personality from his or her test scores. Robert asked if I'd ever heard the adjectives "hardheaded" and "stubborn" applied to myself. Hardheaded? Stubborn? Who had he been talking to, anyway?

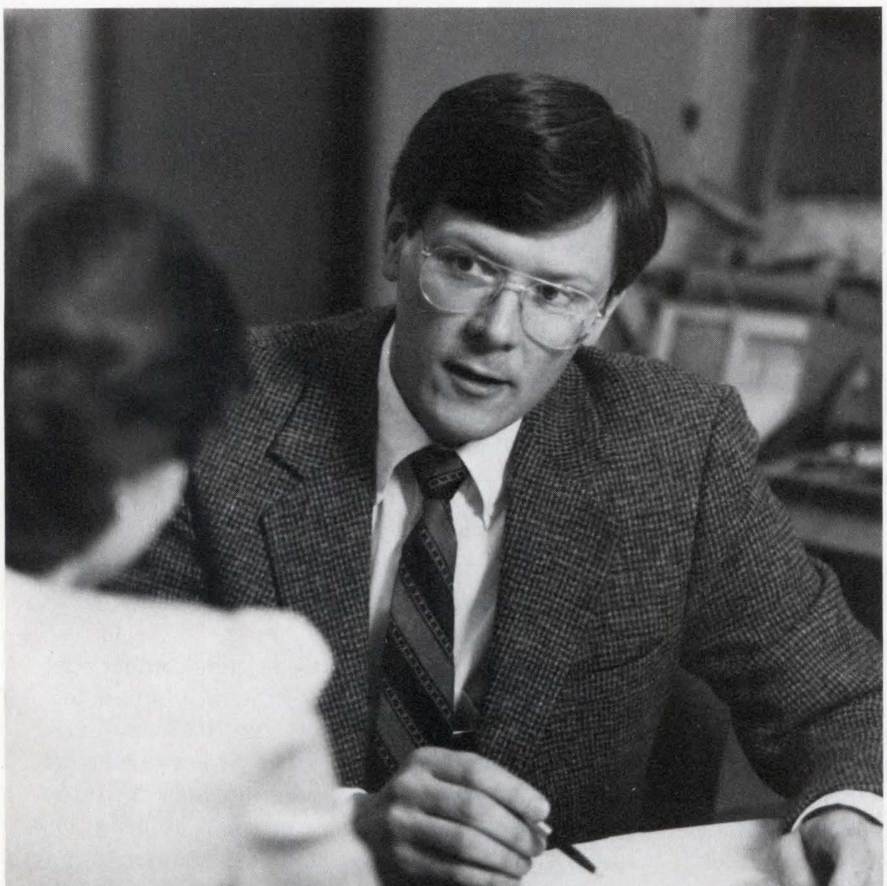
In sum, the experience was an enlightening one. If you decide to take this type of test, it's best to shelve the belief that low scores are bad and high scores are good. The tests you score low on are not the ones that matter, except as they help the interpreter to better analyze your intrinsic abilities. Ultimately, the purpose of such analysis is not to find out what you *don't* have an affinity for, but to suggest new ways that you can apply the natural talents you *do* have.—*DA*

Many people have little more guiding them than a vague but gnawing sensation that they'd be happier doing other work.

vanced high-school math confirmed for him that he wanted to pursue a second career in a technical area. McCabe began talking to friends. "I went on a let's-see-what's-available kind of search," he recalls. After narrowing his choices to programming or engineering, he opted for the latter because of its strong math component.

Many people, though, have little more to guide them than a vague but gnawing sensation that they'd be happier doing other work. Their inner compass tells them they should be somewhere else—but it doesn't specify where. Over the past 10 years, a slew of self-help books have appeared, and numberless testing services and counselors have set up shop to help this group of people. If the sales of self-help books are any indication, the purveyors of such services appear to have a ready market. More than 3.5 million copies of *What Color is Your Parachute?* have been sold since the book, the seminal work in the area of career and life planning, was first published in 1970. Interest in the book doesn't appear to dwindle over time: The 1988 projected sales of the book had already been surpassed by May of this year.

Reg Francklyn



For some people, identifying what they like to do is difficult, primarily because they've never thought about it. Even more startling can be the idea that they can make a living doing what they enjoy.

Career choice is, in fact, surprisingly complex. To examine why they entered a particular field, many people have to peel back several layers of personal history. They may have chosen a field because their family had a long history in it, because an influential relative did that kind of work, or because the field appeared to offer steady employment—none of which has anything to do with whether they were suited for the work.

People can be successful in work that doesn't fit them, but the chances of their liking it are slim. "I've known some awfully good engineers who hated what they were doing," says Walker Weston, owner of The Weston Company, a Shreveport, LA, engineering and sales company he founded in 1955. "If you don't have the aptitude for engineering, it's awfully hard and dull."

Industry further confuses people by basing promotions on seniority rather than talent or career interests. Such corporate chess-playing can take a heavy toll on engineers who enjoy hands-on design work but get moved into managerial work. "One day they're individual contributors, and then on Monday, they're made managers," says Furth. "It has nothing to do with what they're good at. They were just the most promotable."

In his job as a support engineer, *Bob McCabe relies on the communication skills he polished during his 10 years as a high-school teacher.*

"We've found that if people pay attention to what their aptitudes are saying, they're apt to pick out an occupation that they enjoy."

One way to pinpoint natural gifts is through aptitude testing. The granddaddy of aptitude-testing centers is the Johnson O'Connor Research Foundation. In the 1920s, Johnson O'Connor worked as an engineer for General Electric in Lynn, MA. O'Connor's tasks included masterminding the assembly line. He noticed that some people did well at assembly work while others fared poorly. Intrigued by the causes of those differences, he developed a series of tests that measured, among other things, concentration and visual acuity. In 1929, O'Connor founded his own company, and referred to it as a "human engineering laboratory."

Today, the Johnson O'Connor Research Foundation has offices in 15 cities and has tested 350,000 people to date. (The testing is expensive: The fee is $450.) Clients of the center go through a battery of 19 tests in one 8-hour session. They return, usually within the next couple of days, for a 90-minute session during which their scores are analyzed and interpreted for them. "We know most people are capable of doing anything they set their minds to, but that doesn't mean they'll be happy," says Robert Westmoreland, a test analyst and former director of the Boston, MA, office. "What we've found is that if people pay attention to what their aptitudes are saying, they may be more apt to pick out [an occupation] that they enjoy."

Engineer Bill Collins estimates that he's thought about a job change for 10 years. "You hear the term 'midlife crisis' used often," says Collins. "I don't know if there is such a thing, but there are a lot of things about my job ,that frustrate me. I often feel I have to compromise my engineering skills, and I don't feel utilized to my full capabilities." Collins says that his job supervising the electrical operations of a Florida mining company involves a lot of paperwork, and that in recent years, he's been asked to accomplish more work with fewer people.

Earlier this year, he submitted to Johnson O'Connor's grueling tests and emerged with some grim, but not unexpected, news: "For a person with my aptitudes, I'm in the wrong job." Collins' tests revealed him to be highly creative. That pronouncement certainly doesn't rule out engineering, but it does explain why Collins felt confined within rigid corporate structures.

Collins says that as a young man he circumvented his interest in com-

A consumer's guide to selecting a career counselor

Hiring a career counselor to work with you requires time and money, so be prudent in deciding whether to work with an advisor and in choosing your advisor. The following guidelines can help you decide whether counseling is for you.

- Talk with or meet the person who'll counsel you. Is the counselor a person with whom you feel comfortable, someone with whom you can develop rapport?
- Ask about the counselor's credentials. Some counselors are psychotherapists; others have master's degrees in counseling. In addition, state requirements and licensing policies differ. Make sure the person you choose to work with meets all the necessary guidelines.
- Inquire about the counselor's work background. Has the counselor worked in industry? Remember that a person who's never worked outside a counseling practice has only secondhand knowledge of corporations' political and organizational nuances.
- Find out where the counseling will take place. Is it a relaxing environment for you? Would you feel comfortable talking on a personal level with someone in that office?
- Find out the ratio of testing to counseling. Be wary of counselors who rely too heavily on testing. Be sure that the time you'll spend together incorporates a large amount of talking.
- Ask to speak with some former counseling clients. Although these references are important, remember to keep your own personality and needs in mind. What works for one person might not necessarily work for you.
- Compare fees. Inquire about how many hours of counseling most clients need, what the fees are, and whether there's a one-time fee or an hourly charge.

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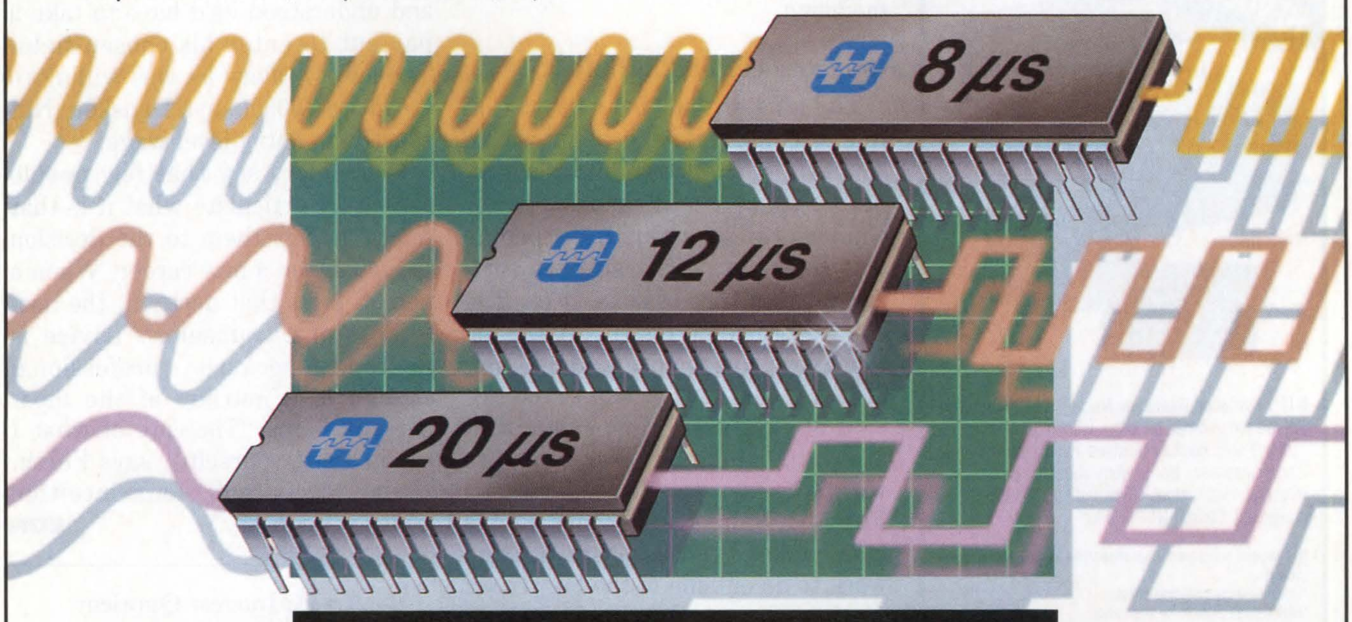

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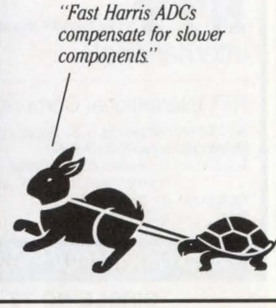

"The core of what I say is 'trust yourself,'" says career counselor Mira Furth. "Very rarely will your intuition guide you wrong."

munications and media work in favor of the greater material gains he expected from engineering. "I had friends who worked in radio, and I enjoyed visiting them and hanging around the station. Why didn't I pursue it? Money." For a while, Collins enjoyed his job, and he says he pushed himself hard to succeed. The routine, though, quickly wore thin. "I realized by the time I was 30 that I wasn't happy in my work." Collins says that he and his wife have entered a new, more content phase of their lives. While he contemplates teaching as a profession, his wife, a registered nurse, is considering studying veterinary medicine.

Commitment and initiative

The kind of real change that Collins is contemplating requires no small effort. It also entails sacrifice, both personal and financial. Career counselors can help those people who feel they need assistance sorting out their professional lives. The counselors emphasize, however, that they provide only guidance, not easy answers.

"I always ask, 'How committed are you?' and 'Are you ready to work?'" says career consultant Furth. Furth says that her clients have much self-assessment and work to do outside of the four to six sessions she spends with each client over a span of two to three months. "It's a lot of homework, whether you're in the library doing research, talking with people, or sorting things out for yourself."

Counselors either charge on an hourly basis or collect a one-time fee for a fixed number of sessions. The fees can be a motivating factor for people. The accountability inherent in the counselor-client relationship also plays an important role: When a person schedules appointments with a counselor to discuss his or her job-search progress, that person is less likely to put off the work.

The possibility of financial sacrifice, too, has to be taken into account. Many people who'd like to switch careers say they're unable to do so because of financial obligations. Other people don't realize the extent of the salary loss they may incur by switching careers. Dansker recalls one client who worked as director of engineering for a California company and seemed sincere about wanting to make a radical job change. He earned $100,000 a year and understood he'd have to take a pay cut to enter his chosen field. The lowest salary he was willing to accept? $80,000, says Dansker. Not exactly an entry-level wage.

Counselors say that few people can easily articulate what it is that finally brings them to the decision to embark on a new career. When a person faces that decision, the usefulness of a counselor's advice is limited, because professional change is a journey of the most personal kind. "The core of what I say is 'trust yourself,'" says Furth. "Very rarely will your intuition guide you wrong." **EDN**

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CIRCLE NO 181

CAREER OPPORTUNITIES

1988 Editorial Calendar and Planning Guide

EDN

Issue Date	Recruitment Deadline	Editorial Emphasis	EDN News
July 21	June 30	Product Showcase—Vol. II, CAE, Test & Measurement	Closing: June 23 Mailing: July 14
Aug. 4	July 14	Sensors & Transducers, Analog ICs, Graphics	Closing: July 21 Mailing: Aug. 11
Aug. 18	July 28	Military Electronics Special Issue, Displays, Military ICs	
Sept. 1	Aug. 11	Instruments, Op Amps, Computers & Peripherals	Closing: Sept. 1 Mailing: Sept. 22
Sept. 15	Aug. 25	Data Acquisition, Data Communications, Digital ICs	
Sept. 29	Sept. 8	DSP, Grahics, Optoelectronics	
Oct. 13	Sept. 22	Test & Measurement Special Issue, Instruments, Computers & Peripherals	Closing: Sept. 29 Mailing: Oct. 20
Oct. 27	Oct. 6	CAE, Computers & Peripherals, Integrated Circuits, Wescon '88 Show Preview	
Nov. 10	Oct. 20	Programmable Logic Devices, Integrated Circuits, Test & Measurements, Wescon '88 Show Issue	Closing: Oct. 27 Mailing: Nov. 17
Nov. 24	Nov. 3	Microprocessor Technology Directory Graphics, CAE	
Dec. 8	Nov. 16	Product Showcase—Vol. I, Power Sources, Software	Closing: Nov. 21 Mailing: Dec. 15
Dec. 22	Dec. 1	Product Showcase—Vol. II, Computers & Peripherals, Test & Measurement	

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MIL-STD 2167

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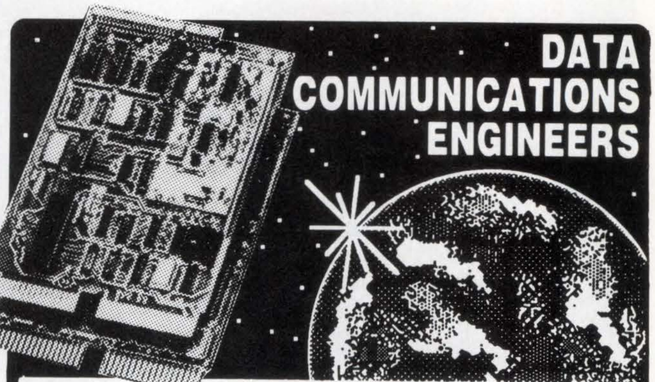

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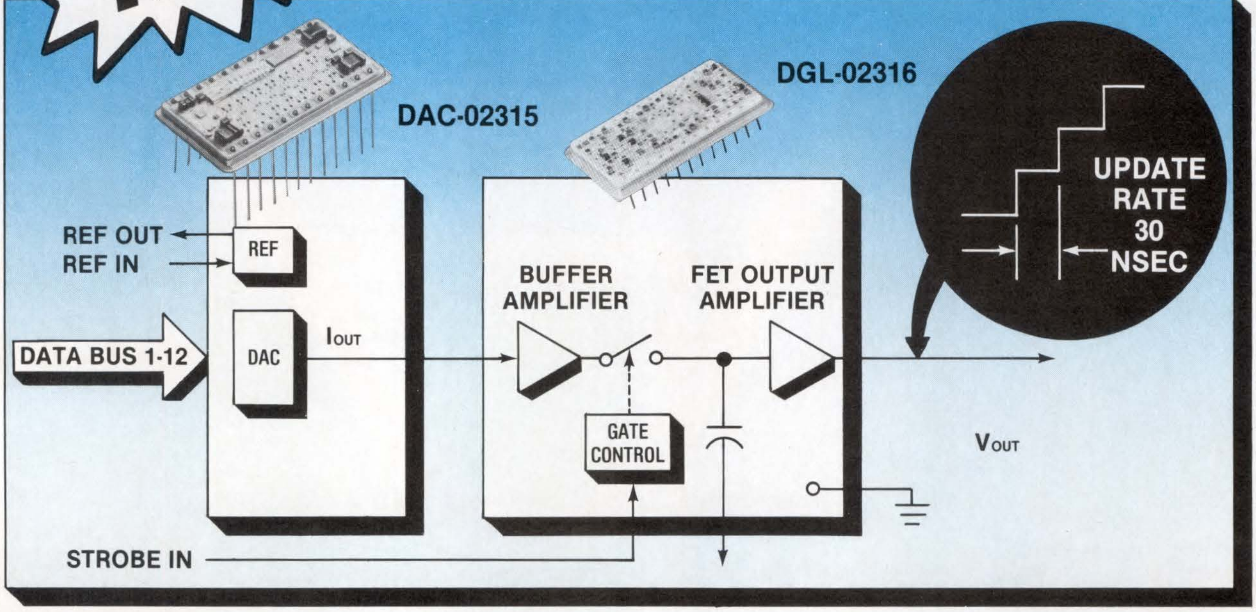
DDC NEWS

ABOUT SYNCHRO-CONVERSION • HIGH-SPEED, HIGH ACCURACY D/A & A/D CONVERSION • 1553 BUS DEVICES

PUBLISHED BY **ILC DATA DEVICE CORPORATION** JUNE 1988

NEW 35MHz 12 BIT DEGLITCHED DAC



DDC is proud to announce the next generation in high speed deglitched DACs: the DAC-02315 and DGL-02316 hybrid pair, which provides 12 bits and an update rate of 35 MHz for full scale output changes. Following in the footsteps of its predecessor, the industry standard DAC-02310, the DAC-02315 and DGL-02316 are ideal for the highest speed vector-stroke CRT displays and signal generators. Offering a low glitch of 14 millivolts, these 24 pin DDIP hermetic hybrids operate over the -55 to +125 degrees temperature range and are available screened to MIL-STD-883.

The DAC-02315 is a D/A converter and the DGL-02316 is a track/hold deglitcher. Input registers are used with these hybrids to reduce the skew in the input data applied to the DAC. Operation of the deglitched DAC starts with the application of a strobe pulse to the latches and deglitcher. This strobe pulse causes the input word to be transferred to the latch and applied to the DAC. The deglitcher is simultaneously placed in the "hold" mode, thereby freezing the output voltage. After a brief interval, during which the D/A converter glitch settles to zero, the deglitcher is placed back in the "track" mode and the output settles smoothly to the new voltage.

Glitches in conventional DACs, without deglitchers, are caused by data skew in the digital input signals and the DAC switches, which cause faster turn-on than turn-off times. Thus, whenever a code change occurs, there will be a short period of time when some spurious code exists internal to the DAC. The DAC will attempt to follow these codes, resulting in a transient known as a glitch. The worst case occurs at the major carry point when the input codes are transitioning from 10..0 to 01..1. In this case, the spurious code may be 11..1 and the DAC output will momentarily slew to full scale.

When used together with input latches, the DAC-02315 and DGL-02316 limit the output glitch to a width of 38 nanoseconds and an amplitude of 14 millivolts. Linearity error of the hybrid pair is 0.0125% FSR and settling time for a full scale change is 35 nanoseconds. The deglitcher output is 1 volt p-p and it will drive a 1 milliamp load. Power supply current drains are +15 volt @ 85 milliamps, -15 volt @ 110 milliamps, and -5.2 volt @ 45 milliamps.

For further information about the next generation in high speed deglitched DACs call toll-free (outside N.Y. state): 800-DDC-1772. □

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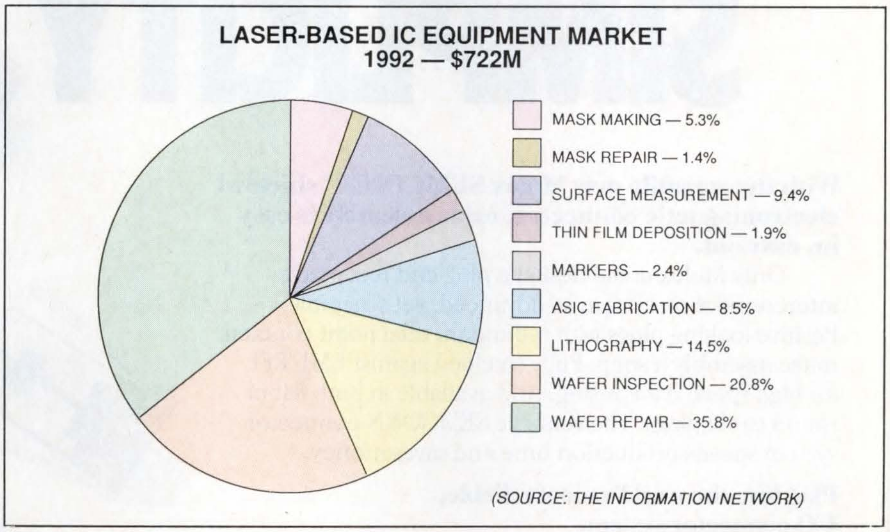
LOOKING AHEAD

EDITED BY CYNTHIA B RETTIG

Laser-based IC tools to gross $722M in '92

Several factors affecting individual segments of the market for laser-based IC processing equipment will influence the market's growth over the next few years, according to The Information Network (San Francisco, CA). Sales of laser-based step-and-repeat aligners, for example, will probably start sometime next year as semiconductor manufacturers begin considering them for production purposes. The strongest part of the lithography market, this segment should gross $75M in sales by 1992. Laser-based x-ray lithography should grow at a 61.5% rate from 1987 to 1992; its market share is expected to decrease, however, as x-ray steppers that employ synchrotron radiation sources become popular.

The market for laser pattern generators, which can make 5X and 10X reticles more economically than can electron-beam equipment, will grow dramatically within the next few years. The compound annual growth rate through 1992 should amount to 40%. The laser repair sector, however, is expected to stagnate as device geometries decrease and x-ray lithography becomes a substantial force in the market.



Sales for laser-based wafer-inspection equipment should grow at a compound annual rate of 37.1% and reach $150 million by 1992. Within this segment, sales of confocal lasers—which can accommodate a line-width of 0.3 microns with a repeatability rate of 0.005 microns —will show the greatest growth at 46.7%. Image-processing equipment sales will also grow steadily at a compound annual rate of 31.3%.

The Information Network suggests that laser-based systems may permit gate-array vendors to compete in new areas by reducing their turnaround time from weeks to a matter of hours. The two basic methods employed to obtain fast turnaround times are the subtractive method, whereby the laser cuts interconnects on the metallization levels for customization, and the additive method, whereby the laser deposits the metallization.

Helical-scan tape drives come of age

The helical-scan tape-drive market, which had an estimated value of $5 million at OEM price levels in 1987, is still in its infancy, but will grow at a phenomenal rate over the next few years. Indeed, by 1993 the market for computer tape drives that use helical-scan technology should exceed $470 million, according to Freeman Associates, a management consulting firm based in Santa Barbara, CA.

This forecast posits a 111% annual growth rate over the next five years. Increasing shipments of high-capacity hard-disk drives will in general serve as a factor in this growth, spurring demand for high-capacity tape drives with small form factors.

The market for digital audio-tape (DAT) drives employed in data recording will enjoy the largest annual growth rate—296%. Whereas fewer than 1000 such drives will be shipped this year, by 1993 manufacturers will ship 585,000. DAT drives are attracting a great deal of attention and inciting some demand because they are both compact and low priced. Many manufacturers not currently in the data-storage markets will start selling DAT drives, and a fairly competitive market for the drives should develop.

Drives that employ 8-mm video media are becoming popular for use with networked desktop systems. This market segment should approximately double each year throughout the forecast period: In contrast to the 1500 units shipped by manufacturers last year, 97,100 will be shipped in 1993.

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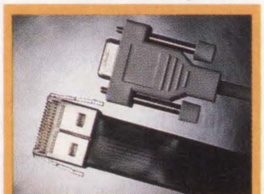

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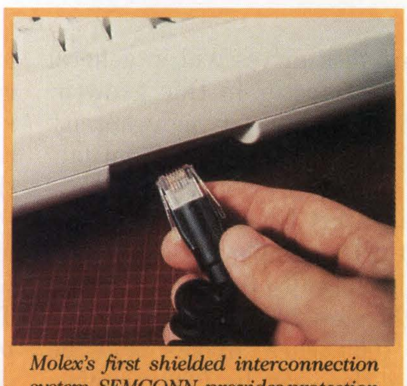

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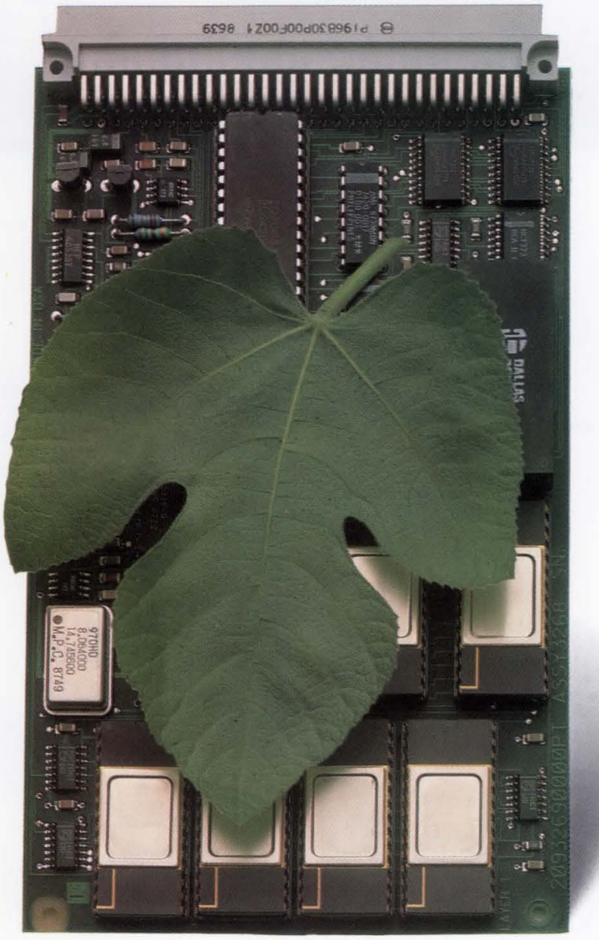

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For the bare facts about technical details and quantity pricing, contact Universal Data Systems, 5000 Bradford Drive, Huntsville, AL 35802. Telephone 205/721-8000; Telex 752602 UDS HTV.

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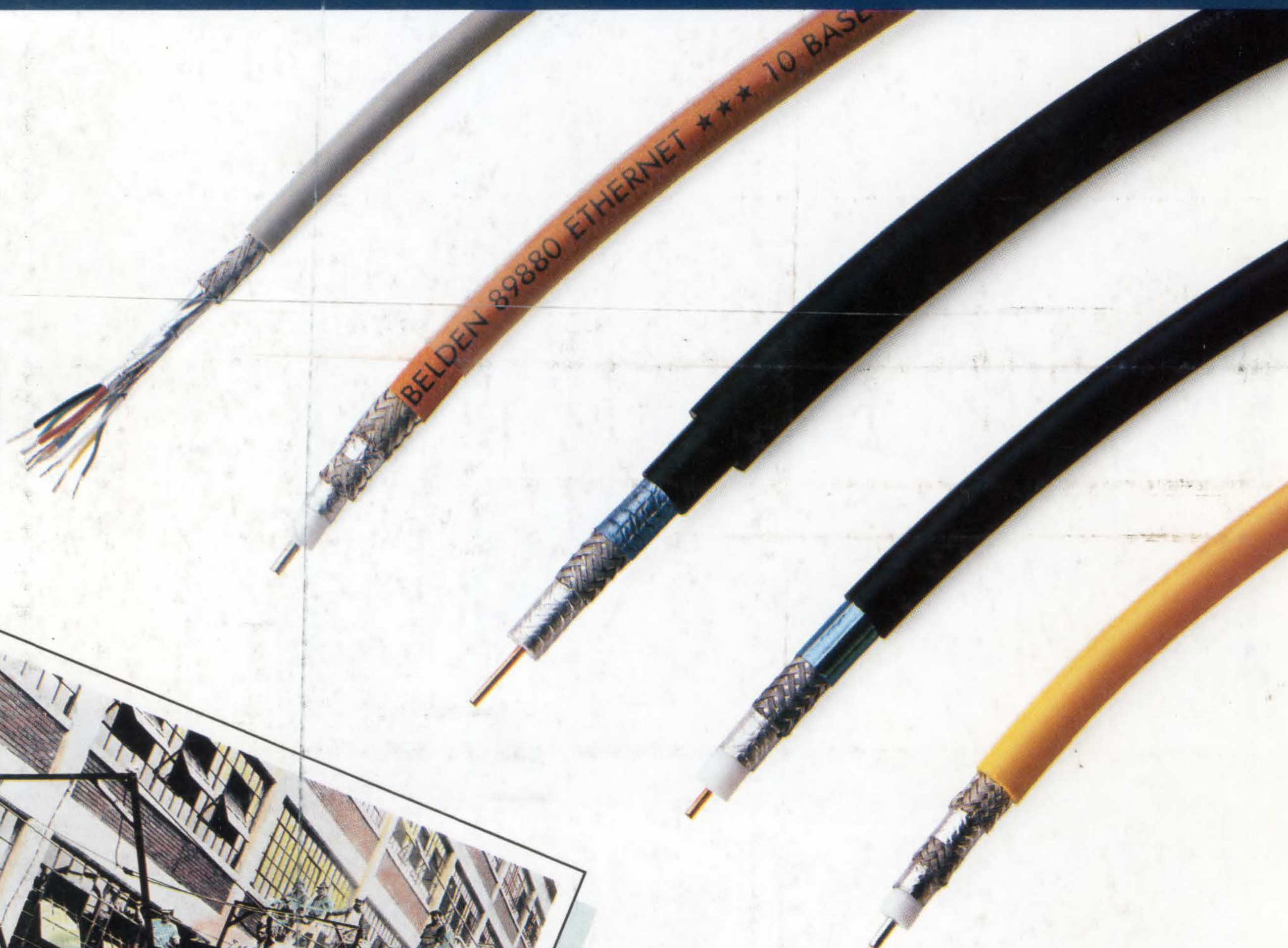

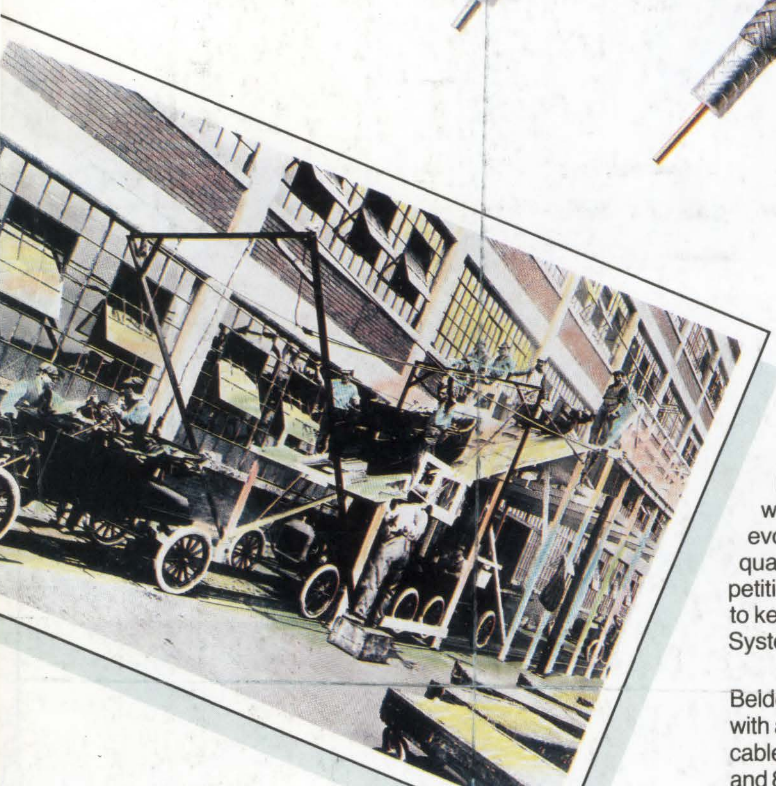

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