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MAY 12, 1988

EDN®

Neural networks

DACs enhance stability of closed-loop designs

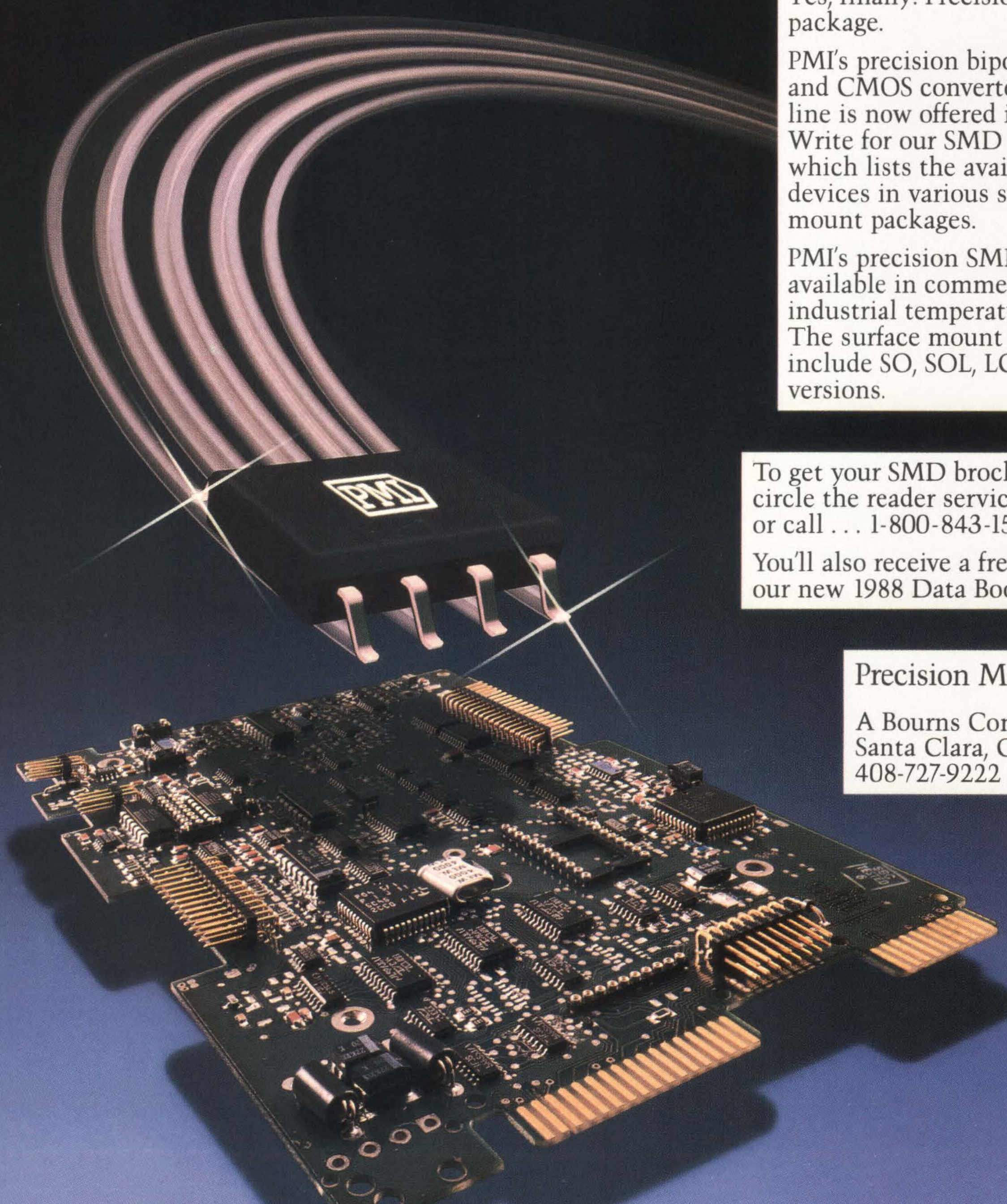
Designer's Guide to noise analysis—Part 1

Operating systems for the 80386

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

Advanced functions gravitate toward monolithic ADCs

Finally . . . Precision In Surface Mount Devices



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CIRCLE NO 119

WHY VTC? ASK THE VME CONSORTIUM.

"For a bunch of companies that don't always agree on everything, we sure were unanimous on VTC."

Joseph Ramunni, chairman (left), and Jack Regula, technical director, VME Technology Consortium.

The VME Consortium needed an economical, yet highly functional VME bus interface chip, to minimize design time . . . and to help raise the VME standard to higher levels.

"We looked at the leading suppliers," said Joe Ramunni, consortium chairman (and president of Mizar), "and VTC came out on top. Their CMOS standard-cell ASIC approach gave us the high drive capability we needed, optimized for bus interfacing. And, it proved much more cost-effective, with higher performance, than gate array technology."

The VME Consortium is made up of such firms as Plessey Microsystems, Omnibyte Corporation, Mizar Inc., Ironics Inc., Heurikon Corporation, Matrix Corporation, and Clearpoint Inc., among others. What did they look for in a supplier?

"We needed a credible business partner," said Ramunni, "with a proven track record, who could provide a turnkey package . . . both design and fab. A supplier that could produce in quantity, and provide technical support to the market at large.

"We also needed a firm with an international marketing structure, because we expect this chip to be the de facto standard worldwide.

"But, we needed *people* we could work with, too. VTC had the right 'comfort factor'."

Jack Regula, consortium technical director (and VP-R&D, Ironics) added: "Our requirements for high speed, high gate-count, low power consumption, and VME bus drive capability were all met well with VTC's 1-micron CMOS standard cell library. And we were extremely impressed with VTC's facilities, its people, and its customer list."

In the future, the VME bus chip (VIC) will become a standard cell within VTC's CMOS library, to allow customers to further customize the chip.

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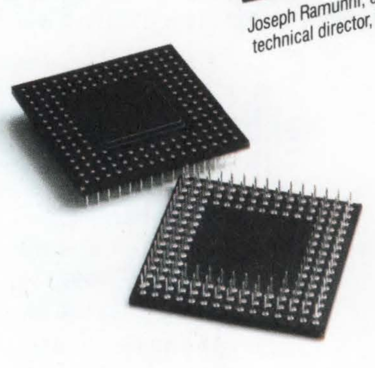

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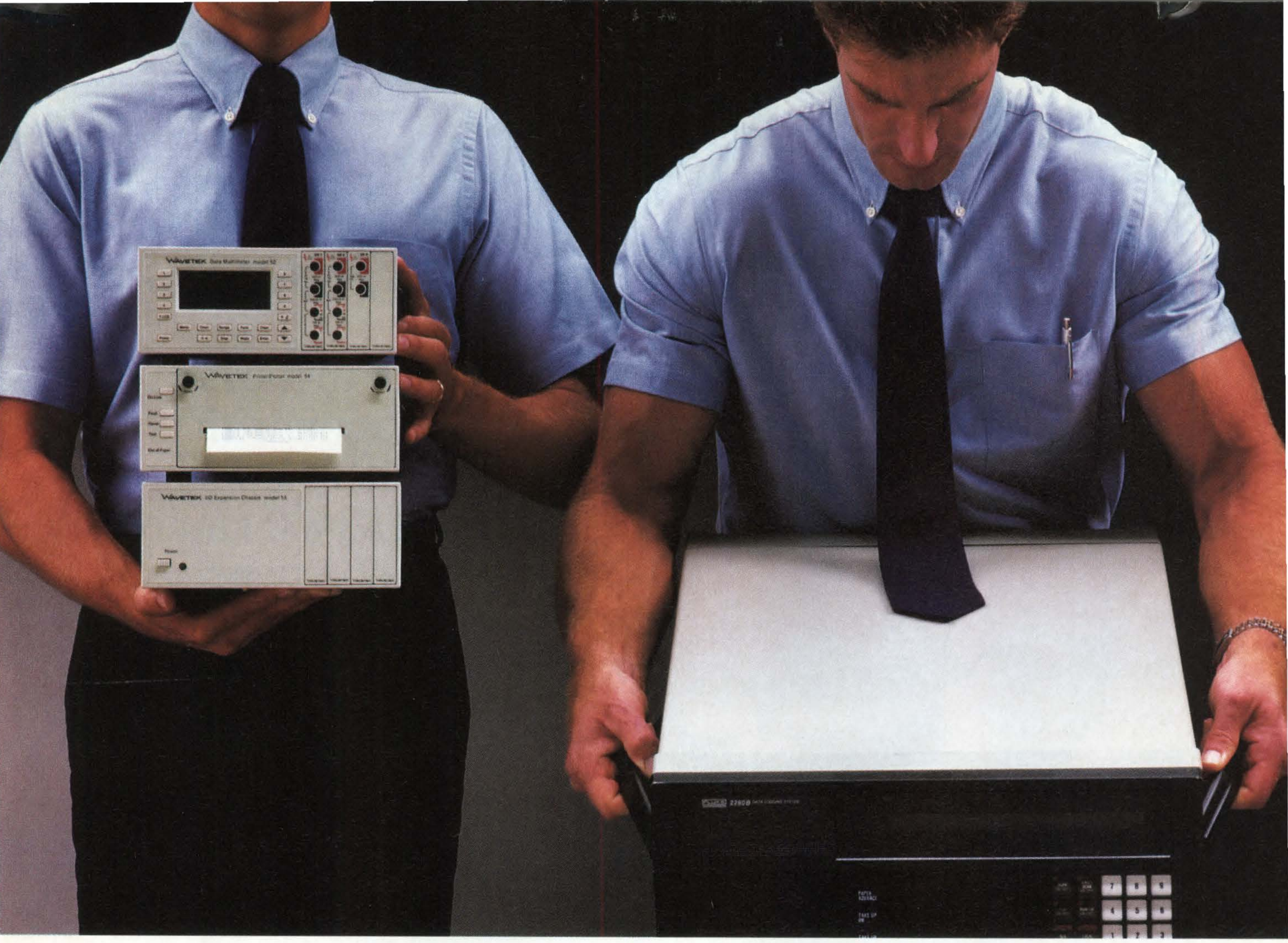

Side by side comparison of our data logger and theirs.

Wavetek has brought an exciting new dimension to data logging—small. Our Series 50 Data Logger is a fraction the size and considerably less expensive than the one on the right. And our data logger is light enough to be easily carried by mere mortals. When you compare the rest of the features, the competition drops right out of sight.

For instance, the Series 50 Data Logger scans 260 channels, provides digital and stripchart printouts and can operate on its internal battery for days, storing up to 100,000 readings in non-volatile memory.

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- **Temperatures, 6 Thermocouple Types, °C, °F, °K**
- **AC/DC Current**
- **DC Watts, AC Volt-Amperes**
- **dBw, dBm**
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All are STANDARD FEATURES, not options! In addition, there are four independent A/D converters, so you can make four different types of measurements simultaneously.

We could go on for pages, but rather than weigh you down with specifications, we'd rather show you how Series 50 will make your job easier. Please call, or write for our brochure. Wavetek San Diego, Inc., P.O. Box 85265, San Diego, CA 92138. Tel. (619) 279-2200; TWX 910-335-2007.

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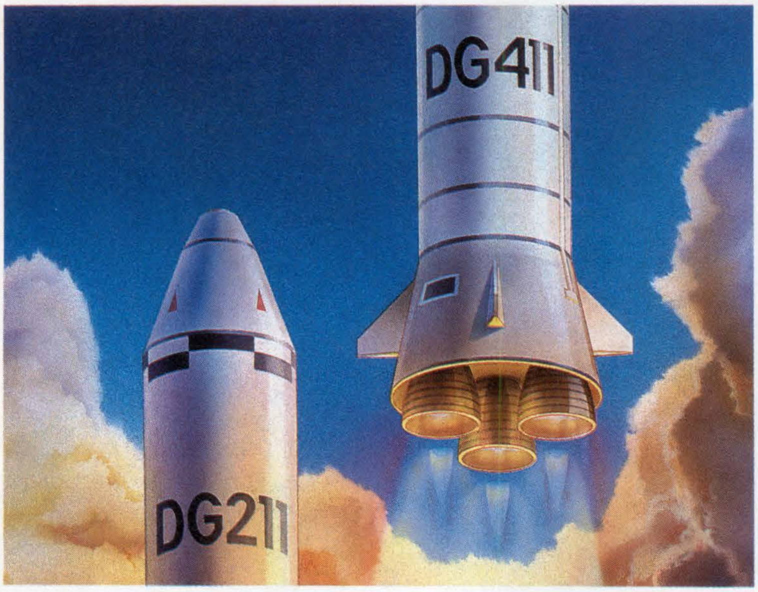
WAVETEK

330,000 X Performance Booster



Switch to the next generation with Siliconix' new silicon-gate DG400 family of analog switches.

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The next generation DG411/12/13 series of CMOS quad analog switches combine high performance, precision and low power. Previous technologies have forced the trade-offs of speed for low power, or ON-resistance for leakage. But the DG400 family lets you maximize all these parameters.

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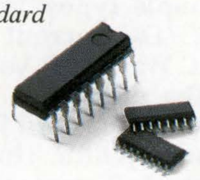
Quad Analog Switch Performance Comparison

DG211		DG411
1000 ns	Switching Speed	175 ns
20.4 mW	Power Dissipation	35 μW
5 nA	Leakage	250 pA
175 Ω	On Resistance	35 Ω
1	**Normalized Performance Product**	**330,000**

The DG411 family is optimized for minimum charge injection and for TTL-compatibility: Either unipolar 12 V supply or split supply operation.

◀ *The performance product, $r_{DS(ON)} \times I_{S(ON)} \times t_{ON} \times PD$, indicates that the DG411 is 330,000 times better than the industry standard DG211.*



Get a 330,000 X performance boost! Call Siliconix at 1 (800) 554-5565 ext. 933 for a free DG411 sample and Design Kit.

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Volume 33, Number 10

EDN

May 12, 1988

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

On the cover: *A/D-converter manufacturers are placing complex, high-speed designs on monolithic chips. And as architectural innovation rolls on, monolithic ADCs will continue to make quantum leaps in performance. See pg 116. (Photo courtesy Analog Devices)*

DESIGN FEATURES

Continued on page 7

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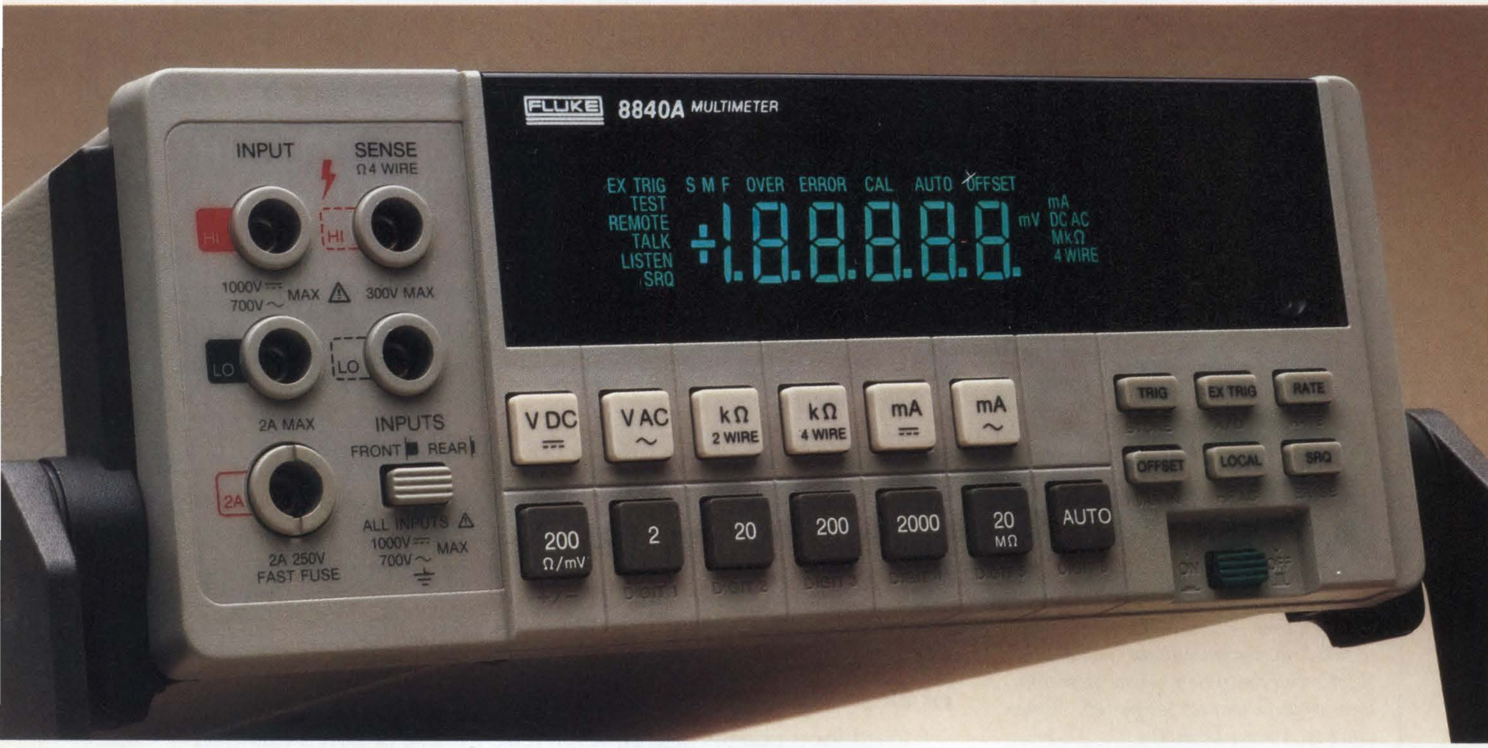

This meter has what you need most—Superb accuracy and proven reliability

The Fluke 8840A is your best choice for accuracy, readability and overall performance in a 5½ digit multimeter.

The Fluke 8840A is the world's best selling 5½ digit DMM. For good reason. Basic dc accuracy is 0.005% at one year. Basic ac accuracy at one year is 0.16%, and one year basic resistance accuracy is 0.013%. With users discovering their 8840A's typically exceeding these specs at each one-year calibration cycle.

The specs are even better for the 8842A. It offers 0.003% basic dc accuracy and 0.08% basic ac accuracy at one year. Resolution is 100 nV on dc readings, and 100 μΩ resolution on resistance readings. Plus a two year calibration cycle and warranty.

Nothing in its class can match the 8840 Series for field-proven reliability: 60,000 hours MTBF for the 8842A, and nearly 70,000 hours for the 8840A.

And nothing can match the 8840 Series for ease of operation. The vacuum fluorescent display is the most readable you've ever seen. True-RMS ac and IEEE-488 interface options let you configure the unit the way you need, so you aren't stuck with features you don't want.

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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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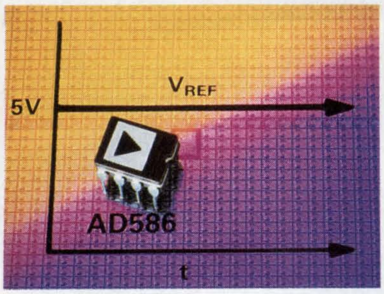
Continued from page 5



***Advances in voltage-reference-circuit** performance give your applications the high accuracy and stability they require (pg 73).*

Continued on page 9

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Continued from page 7

EDN

May 12, 1988


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perfect dud the first time
you plug it in.

(Forward Thinking, Re

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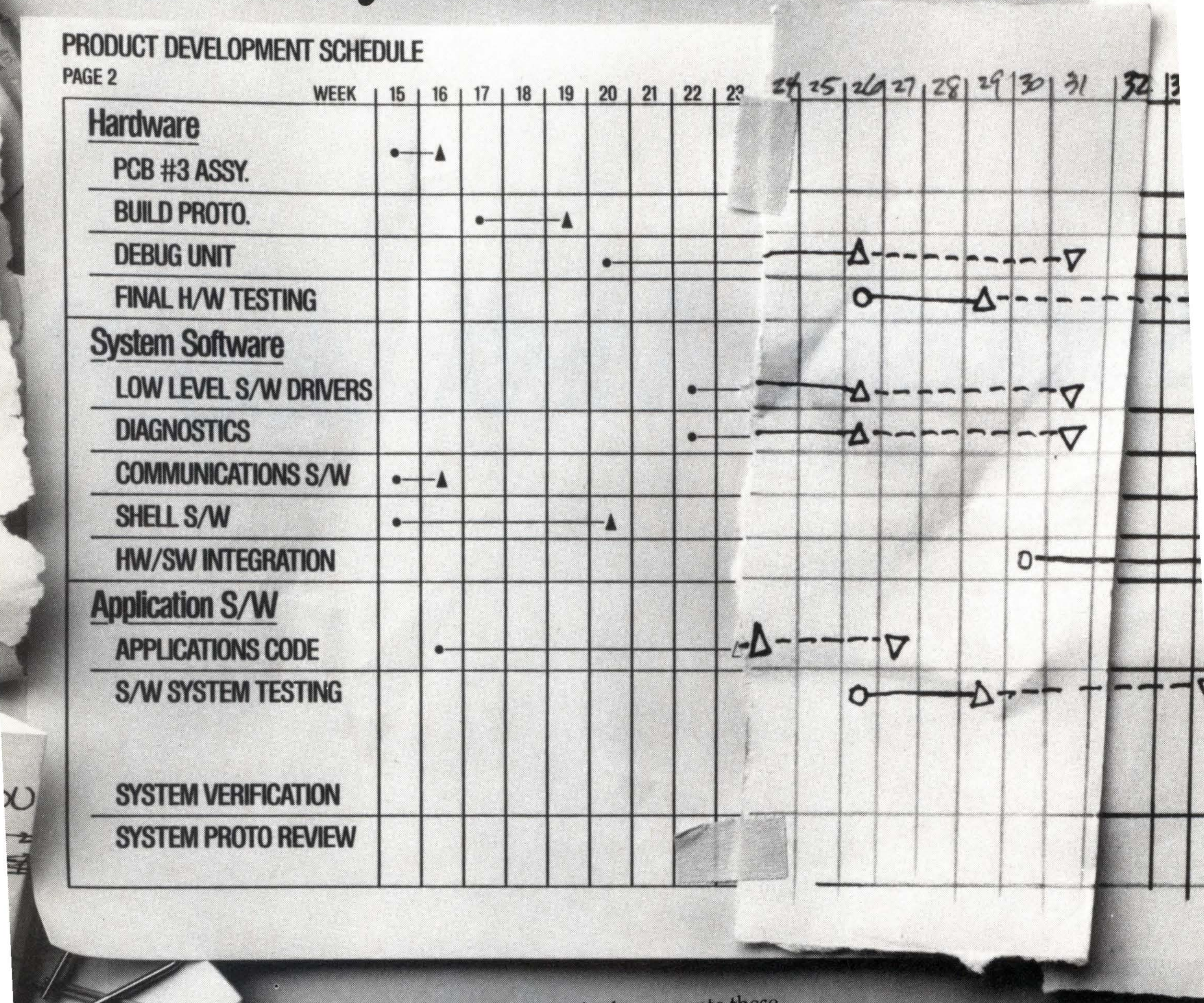

Let's face it.

Slipped development schedules and budget overruns can mean lost opportunities. Yet many traps that seriously delay a development schedule are quite complex, especially when they are compounded by problems that arise in cross development work.

Like not knowing whether the errors you are getting from your prototype processor are real. Or losing bugs in the cracks between your development system and the prototype.

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Each package includes a powerful in-circuit emulator, the only tool that can successfully bridge the gap between host computer and prototype. With features like complex triggering, reliable memory, built-in target diagnostics, I/O simulation, and special interrupt handling.

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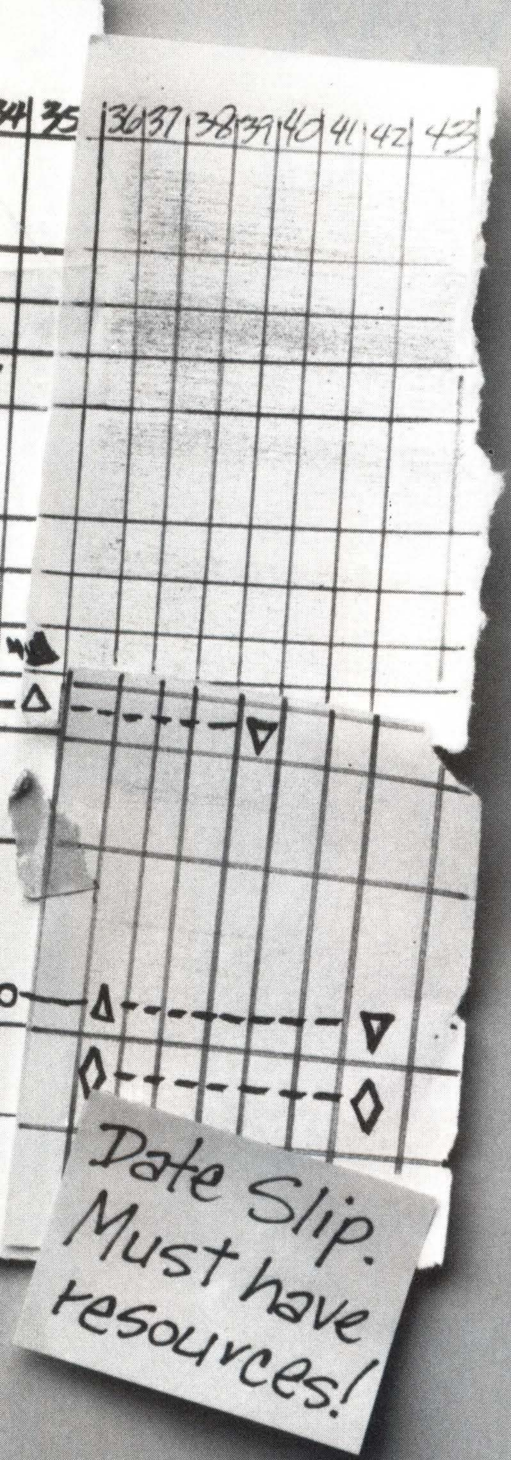

development tools available.

Source Level Debugging for Intel Microprocessors

Our VALIDATE/Soft-Scope and VALIDATE/Soft-Scope 286 packages are designed for any language producing complete Intel OMF information.

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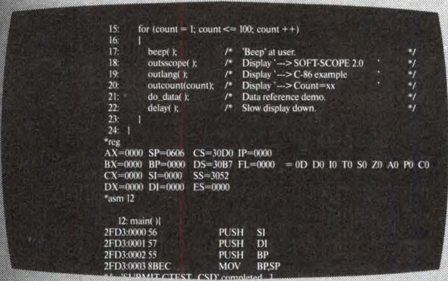
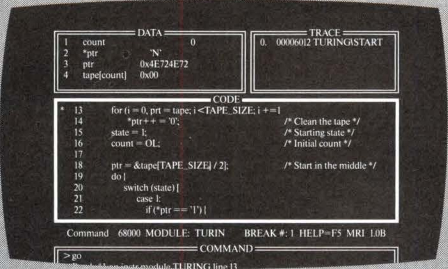


pled with our ES 1800 emulator. You can use commands to examine variables on the fly, check contents of registers, and determine current position in code. And real-time trace is displayed as source level statements, machine instructions or bus cycles.

The packages also include a logic state analyzer probe, and provide up to 2 Megabytes of overlay memory plus full protect mode support for the 80286.

Source Level Debugging for Motorola Microprocessors

The window-oriented VALIDATE/XEL package combines our XEI source-level debugger, a simulator and the MCC68K compiler with our ES 1800



emulator. The package also includes a logic state analyzer probe and our well-known SCSI interface option, that significantly decreases download time.

In addition to up to 2 Megabytes of overlay memory, you get target control from your source code; powerful "C" language macros for code patching, remote control and simulation of I/O; plus user-definable windows for viewing registers, stacks and variables.

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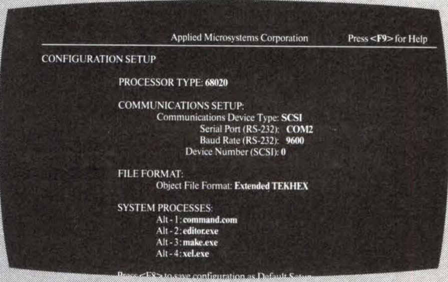

Also included are a logic state analyzer probe; the SCSI option for increasing download speeds by up to 30 times; plus up to 2 Megabytes of overlay memory.

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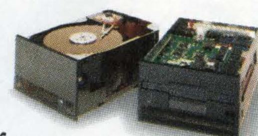

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Hewlett-Packard provides a wide range of instrument controllers and operating systems to meet your performance needs, allowing you to choose the most cost effective controller for your job.

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*Sometimes called Rocky Mountain BASIC or BASIC 5.0.

we never stop asking "What if..."

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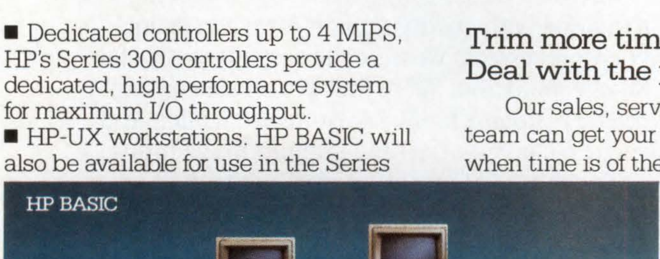

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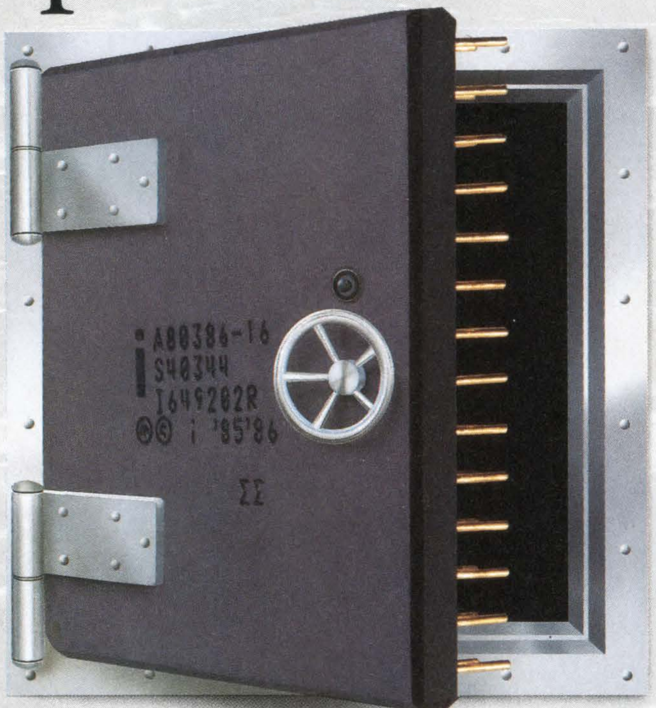
How to crack 386 protected mode.



Unlock selectors and descriptor tables. Break open task state segments (TSS) and call gates. Microtek's In-Circuit-Emulator (MICE) cracks 80386 protected mode with real-time, non-intrusive emulation to 20 MHz.

MICE unravels all the intricacies of the 80386, so you harness its full potential. Internal registers, including GDT and IDT base values are all directly accessible. And MICE also provides decoded access to all selector and descriptor bits, like privilege level, segment type and page accessed bits.

Use MICE as a stand-alone device, or integrate it into your development environment. MICE easily interfaces with the IBM® PC/XT/AT, VAX,® Apollo® and Sun® computers.

And the 80386 emulation system is just one of our many embedded software development tools.

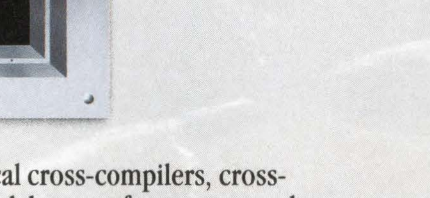
Our Software Analysis Workstation (SAW) delivers hardware-based, real-time software analysis in a source code environment. For source code development, our Microtec® Research products provide you with C and Pascal cross-compilers, cross-assemblers and debuggers for many popular microprocessors.

And MicroCASE™ backs all of its products with solid applications support, both at the local and factory level.

Microtek enjoys a long track record of being first to market with quality support for many major microprocessors. We were the first alternative for 80386 emulation. We're first to provide non-proprietary support for 80386 protected mode.* And you can count on the same support in the future.

For more information and product literature on our full line of MICE, call us toll-free at 1-800-547-4445.

Crack 80386 protected mode, and open the door to exciting design possibilities—with the best 80386 emulation system now available. From MicroCASE.



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EDITED BY JOANNE CLAY

DIGITAL FILTER CUTS NOISE FROM T1 COMMUNICATIONS LINES

The S3541 digital-filter IC implements the C message-weighted, highpass, and 1-kHz notch filtering required by T1-carrier communications lines installed in the US telephone network. The chip meets all the specifications of Bell Pub #41009 (May 1975) and IEEE standard 743 (1984). It uses digital filtering—which provides manufacturing repeatability, zero temperature drift, and zero drift over time—to solve the noise problem, which is traditionally solved with analog filtering. Gould Inc's Semiconductor Div (Santa Clara, CA, (408) 246-0330) offers the device in a 28-pin DIP for $17.95 (1000).

—Steven H Leibson

LOGIC ANALYZER EXPANDS FROM 16 TO 64 CHANNELS

If you're looking for test equipment that expands with your needs, consider the Model 1230 logic analyzer from Tektronix (Portland, OR, (800) 245-2036). You can purchase the unit with 16 channels and then add capacity as your needs grow. The basic unit offers a built-in display with RS-170 output, nonvolatile storage for setups, glitch catching, and timing to 100 MHz. Your expansion options include additional data channels in groups of 16 (to a total of 64), a parallel port for dumping screen data to a printer, and a control-I/O port. You can choose the RS-232C or the IEEE-488 (GPIB) interface for remote control. The basic unit costs $2795; delivery is four weeks. The 16-channel expansion boards cost $1200 each. Other options begin at $200; delivery is 10 weeks.—Richard A Quinnell

FULL-FEATURE TIME-INTERVAL COUNTER COSTS $3850

The SR620 time-interval counter from Stanford Research Systems Inc (Sunnyvale, CA, (408) 744-9040) costs $3850 and allows you to make frequency, period, rise-time, fall-time, and phase measurements in addition to time-interval measurements. You can measure frequencies from 0.001 Hz to 1.3 GHz and time intervals to 1000 sec. The instrument measures time intervals with 30-psec jitter and 4-psec resolution. You can make phase measurements from 0.001 Hz to 100 MHz with 0.001° resolution. The SR620 provides mean, min, max, and Allan variance statistics on as many as 1 million samples. Measurements are displayed on a digital front panel; alternatively, you can use an oscilloscope to display histograms using the oscilloscope's X-Y inputs. The instrument comes with RS-232C and GPIB interfaces and a Centronics printer port. An optional, oven-stabilized crystal timebase costs $950.—Doug Conner

COLOR-PALETTE CHIP IS ALTERNATE SOURCE FOR PS/2 GRAPHICS

Available in 35-, 45-, and 80-MHz versions, the VDA-176 color-palette IC from VLSI Design Associates (Campbell, CA, (408) 371-7400) provides a pin-compatible alternative to the IMS-176 from Inmos (Colorado Springs, CO), which is used in IBM's PS/2 computers and on VGA graphics boards. The color-palette chip incorporates a 256×18-bit RAM, three 6-bit D/A converters, and output circuitry capable of driving standard RS-170 video cables. Packaged in a 28-pin DIP, the 35-MHz devices cost $10 (1000).—Steven H Leibson

25-MHz CACHE CONTROLLER INTERFACES DIRECTLY TO 80386 μP

The A38152-25 Microcache from Austek (Mountain View, CA, (415) 960-1315) is a speed upgrade of the company's earlier 20-MHz version. The device is a 4-way set-associative controller that supports a 32k-byte zero-wait-state cache memory and has a direct interface to an 80386 μP and to four 8k×8-bit static RAMs. The A38152-25 comes in an 84-lead PLCC and is available immediately in sample quantities for $145.—David Shear

NEWS BREAKS

BED-OF-NAILS TEST PROBES HAVE 1-MΩ, 3.8-pF LOADING

The P6511 and P6513 spring-loaded active test probes from Tektronix (Vancouver, WA, (800) 835-9433, ext 170) allow you to obtain high-fidelity waveform data using bed-of-nails fixtures, without loading down critical circuit nodes. The active hybrid probes have a 300-MHz bandwidth, 1-MΩ resistance, 3.8-pF input capacitance, and 50Ω output impedance. You can mount the probes on 100-mil centers for bed-of-nails and other board-testing applications. The probes cost $225; delivery is six weeks.—Doug Conner

DIGITAL CELL LIBRARY LETS YOU DESIGN 1.2-μm CMOS ASICs

Designers of CMOS ASICs can now obtain a 1.2-μm process and a digital-cell library from International Microelectronic Products (San Jose, CA, (408) 432-9100). The company plans to offer an analog-cell library for the process later this year. The double-layer-metal, double-poly CMOS process allows for system clocks running at as much as 40 MHz and provides typical gate delays of 300 psec. The digital-cell library, DCL 1.2, features 70 cells and includes a RAM, ROM, and PLA compiler. The price of the library is included in the NRE costs of your ASIC design. Typical NRE costs are between $40,000 and $100,000.—Richard A Quinnell

PRICE OF 12-BIT A/D CONVERTERS CONTINUES TO DROP

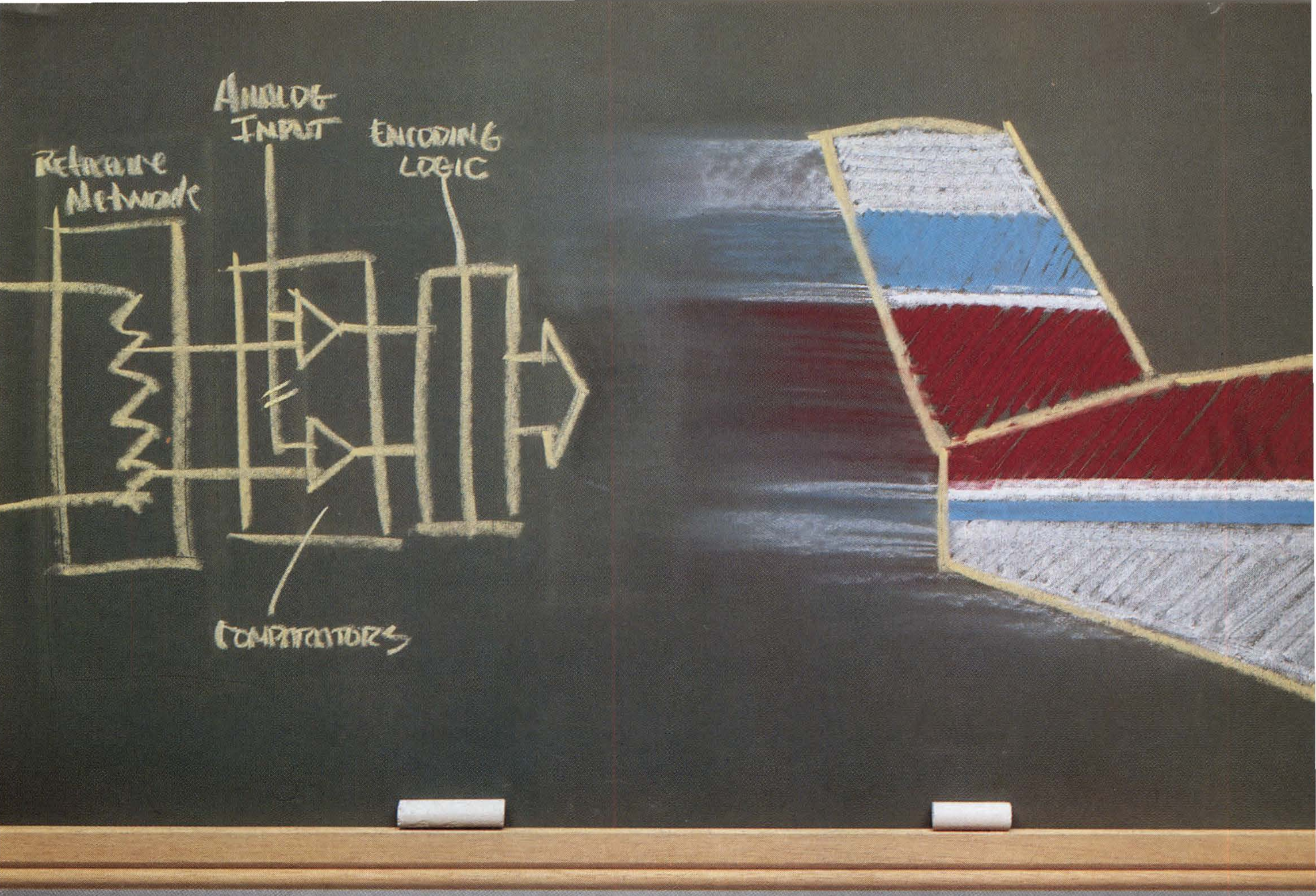
The MAX172 from Maxim Integrated Products (Sunnyvale, CA, (408) 737-7600) is a 12-bit, 10-μsec CMOS A/D converter that costs just $10 (1000). The device requires a 5V and −12V or −15V supply; it converts an analog input ranging from 0 to 5V. The result is available as a 12-bit word or two 8-bit words via a parallel 3-state output. An on-chip voltage reference allows a full-scale temperature coefficient of 45 ppm/°C. The MAX172 is packaged in a 24-pin, 0.3-in.-wide DIP or a 24-pin SOIC.—David Shear

OPTICALLY STORED DOCUMENTS ARE LEGALLY ACCEPTABLE

Three years of research by Cohasset Associates Inc (Chicago, IL, (312) 527-1550) has culminated in the book *Legality of Optical Storage,* a 320-page, looseleaf volume edited by Cohasset's president, Robert F Williams. By relating optical-storage methods to microfilm and magnetic storage techniques, the book concludes that a solid legal foundation exists for the use of optically stored documents in court proceedings and regulatory hearings. The book's $230 price also covers a 1-year subscription to an update service that tracks the incorporation of optical document storage in new laws and regulations.—Steven H Leibson

FLASH EEPROM APPROACHES EPROM STORAGE DENSITY AND COST

Flash EEPROMs offer two advantages over conventional UV EPROMs: onboard programmability and faster program and erase times. Their drawbacks, however, have been lower storage capability and higher cost. The 48F512 flash EEPROM from Seeq Technology Inc (San Jose, CA, (408) 432-7400) reduces these drawbacks with its 512k-bit storage density and $33 (100) price. The write time is 1 msec/byte; the chip-erase time is 5 sec. The vendor specs the chip's endurance (the number of times the chip can be erased and rewritten) at 100 cycles.—Margery S Conner


Analog Input
Encoding Logic
Reference Network
Comparators

NEWS BREAKS: INTERNATIONAL

STE BUS CARDS IMPLEMENT A LOW-COST, IBM PC-COMPATIBLE TARGET

In addition to providing MDA/CGA-compatible display capabilities, the £195 SPCGA STE Bus card from Arcom Control Systems Ltd (Cambridge, UK, TLX 94016424) includes sockets for as much as 256k bytes of ROM/EPROM or 128k bytes of static RAM. Firmware available for the card allows ROM/EPROM on the SPCGA card to operate as a silicon disk, which appears to the system as the A drive in a normal MS-DOS environment. As a result, you can create a low-cost, 2-card IBM PC-compatible STE Bus target system by adding the company's £345 SCPC88 8088-based CPU card. In this configuration, the CPU card provides the system with as much as 256k bytes of RAM. By selecting from a wide range of STE Bus-compatible I/O and signal-conditioning cards, you can tailor the system for use as an embedded controller in industrial-control applications. Because your target system will be IBM PC compatible, you can develop software for it on your IBM PC.—Peter Harold

LOW-FREQUENCY SPECTRUM ANALYZER HAS VARIETY OF ANALYSIS MODES

Although some of its main application areas lie in the realm of mechanical engineering, the SI-1220 multichannel spectrum analyzer's bandwidth—dc to 50 kHz—makes the instrument suitable for use in designing a variety of low-frequency and audio-frequency electronic systems, such as closed-loop control systems and hi-fi equipment. The analyzer is manufactured by Schlumberger Technologies' instrument division (Farnborough, UK, TLX 858245; in the US: Burlington, MA, (617) 229-4825). It provides two or four input channels, and it can simultaneously measure frequency-response functions between all its channel pairs. In addition, the analyzer has a maximum resolution of 1000 spectral lines, and it allows you to zoom to 1-mHz resolution.

Its optional waveform generator provides continuous or burst-mode stimulation of your system with a variety of standard or user-defined waveforms. The instrument's standard sample memory is 256k samples deep, but you can optionally expand it to a depth of 1M samples. Its analysis features include logarithmic frequency resolution, octave analysis, twin-band analysis, and swept-sine frequency-response analysis. The analyzer's waterfall displays, with optional gray scales (Z-modulation), allow you to highlight system performance. A 2-channel version costs approximately £13,000.—Peter Harold

SINGLE CHIP HOLDS FLOPPY-DISK-DRIVE CONTROLLER CIRCUITRY

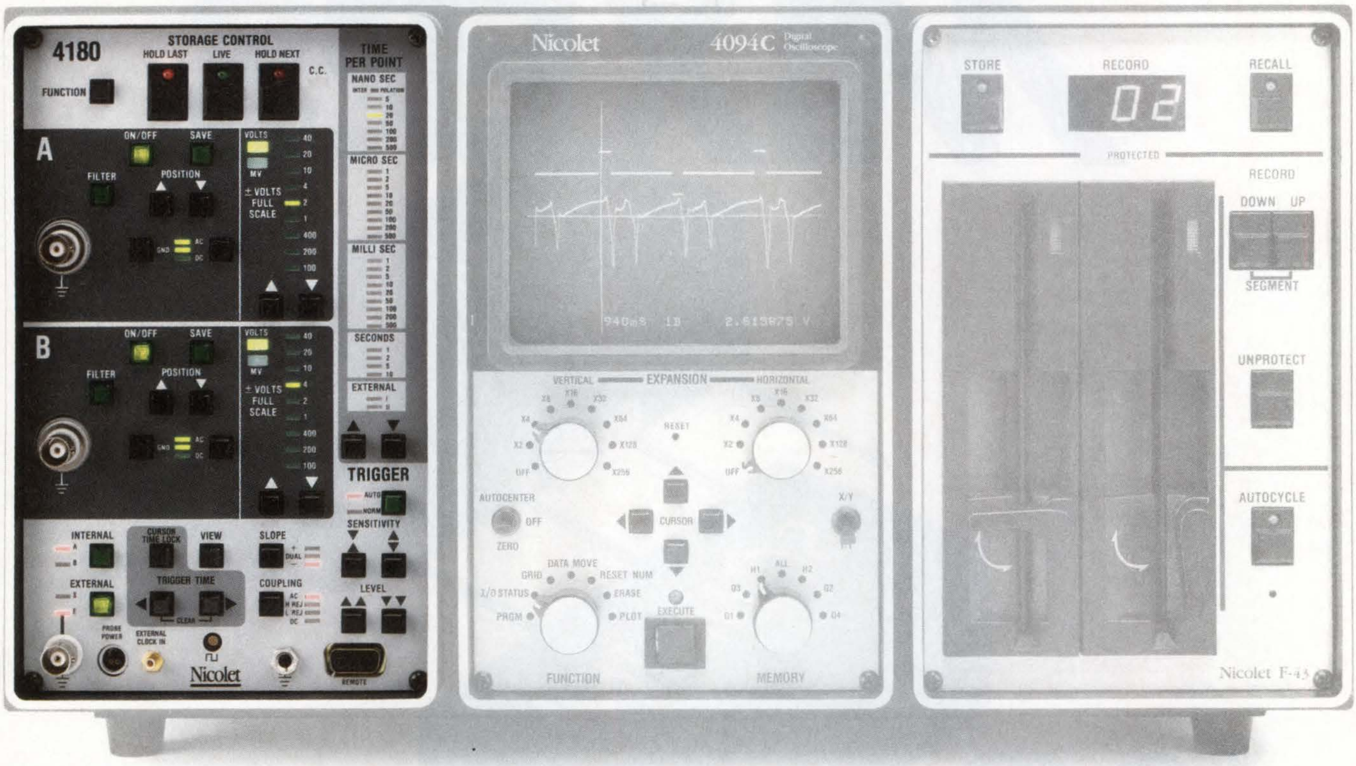
The μPD72068 CMOS chip from NEC integrates all the main functions of a floppy-disk-drive controller. The LSI circuit's die size is 6.33×6.18 mm. According to the Japanese press, engineers can use the chip to reduce the mounting area of floppy-disk-drive components to one-fifth the area of conventional controllers, and can expect to achieve floppy-drive data-transfer rates of 600k bps. The chip dissipates 50 mW while operating and 0.5 mW while on standby. You can obtain samples of the part for ¥5000 (about $38) each.—Joanne Clay

ASICs OFFER 0.4-NSEC DELAY AND A MAXIMUM OF 129,000 GATES

Toshiba Corp has recently introduced the TC120G Series master-chip ASICs, which feature a delay time of 0.4 nsec/gate. The devices are fabricated with a 1-μm process that forms transistor elements on the entire surface of the chip. The series comprises five devices having densities ranging from 38,000 to 129,000 gates. The chips are reportedly compatible with the company's earlier ASIC devices, but will cost 20% more.—Joanne Clay

The New 4180 Plug-In

SPEED TRIALS.



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- ***Unmatched single-shot capabilities.***
- ***High speed, 200 MHz digitizing.***
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Speed. Using the latest designs in ADC technology, your input signal can be digitized at speeds up to 200 MHz (5ns per data point) and saved for analysis. The wide band input amplifiers allow signals up to the 100 MHz Nyquist limit to be input without distortion. Sophisticated trigger setup displays allow you to accurately set the level, sensitivity, and slope to make one-shot transients easy to catch; eliminating the usual hit or miss guesswork. For multi-channel applications two 4180's can operate together in one mainframe producing a four channel scope with no degradation in speed or performance.

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INSTRUMENTS OF DISCOVERY

CIRCLE NO 165

how wide is a wideband amplifier ?

10 MHz to 4.2 GHz

With its ultra-wide 10 to 4200MHz bandwidth, Mini-Circuits' ZHL-1042J 100mW amplifier is ideally suited for EW, TACAN, mobile radio, and satellite communications. A single ZHL-1042J can replace several "wideband" amplifiers in lab and production test setups. *The three-stage,* 27dB gain 50-ohm class A design provides unconditional stability; any load impedance can be connected without concern for damage or oscillation. With 50dB reverse gain, excellent isolation is offered over the entire band, critical for closely-spaced frequency tests. *The noise figure* of 18dB at 10MHz rapidly drops to 4.5dB at 100MHz and above; input SWR is 2.5. Output at the +1dB compression point is +20dBm and the intercept point is +30dBm. *The rugged heat-sinked* 1.25 by 2.18 by 1.5 in. unit requires 15V, 0.3A. Price is $495 (1-9 qty). Immediate delivery, 1-year guarantee.

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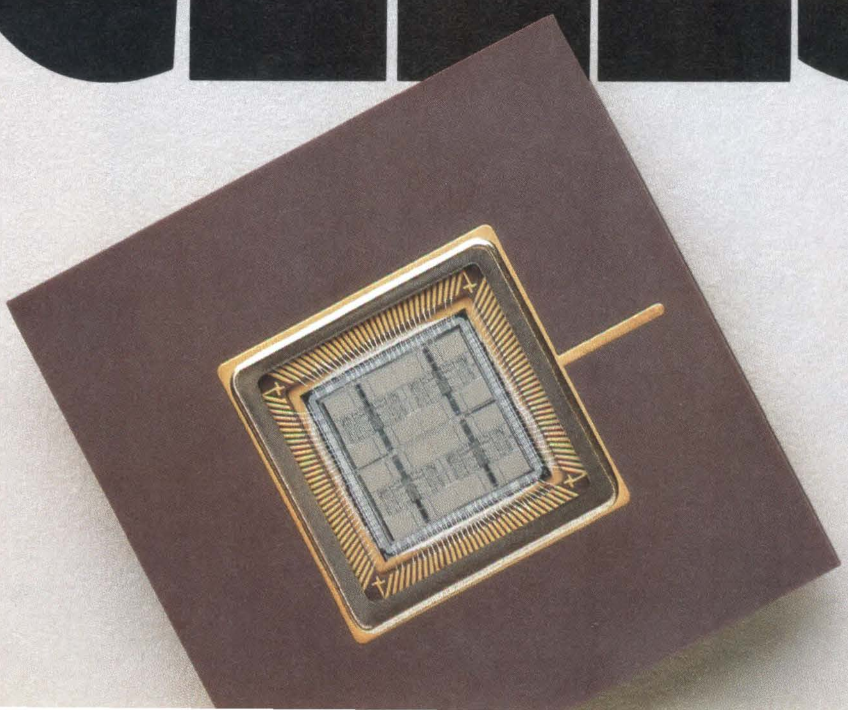
C106 REV. ORIG.

CIRCLE NO 167

BUILD KILLER CELLS.



This is the stuff reputations are built on.

A cell design with 100,000 gates. More than 1000 library elements. 2MB of memory. And sub-micron HCMOS technology.

You can search high and low, but there's only one place in the world you can find a chip of such staggering complexity.

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Designs like this are precisely why we're the #1 domestic ASIC supplier with more than 4,000 working cell and array-based designs in the field.

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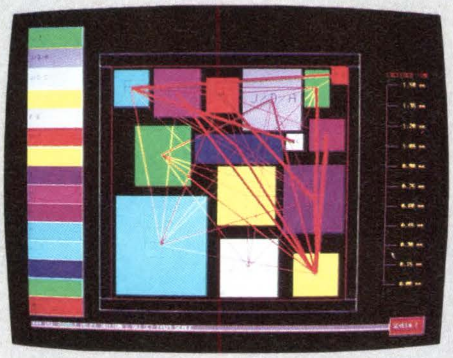

High complexity Cell-Based ASICs require advanced tools like the MDE chip floorplanner to optimize delays and verify performance prior to layout.

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CIRCLE NO 168

You wouldn't do this with your Analog VLSI devices.

You'll have to if you go to most ATE companies for a solution to today's sophisticated "system silicon" testing problems. Because all you'll get is a make-shift tester. And that means resigning yourself to man-months of custom hardware work integrating analog and digital instrumentation. And putting up with the long hours of low-level software development that go with custom solutions. Worse, you can expect these delays to cut your chances of getting your product to market on time.

Teradyne now has a simple answer to this complex testing problem. The A500 Analog VLSI Test System. It's the first of a new generation of systems specifically for AVLSI "system silicon" devices. A test system that can help you cut critical product development time by months or even years.

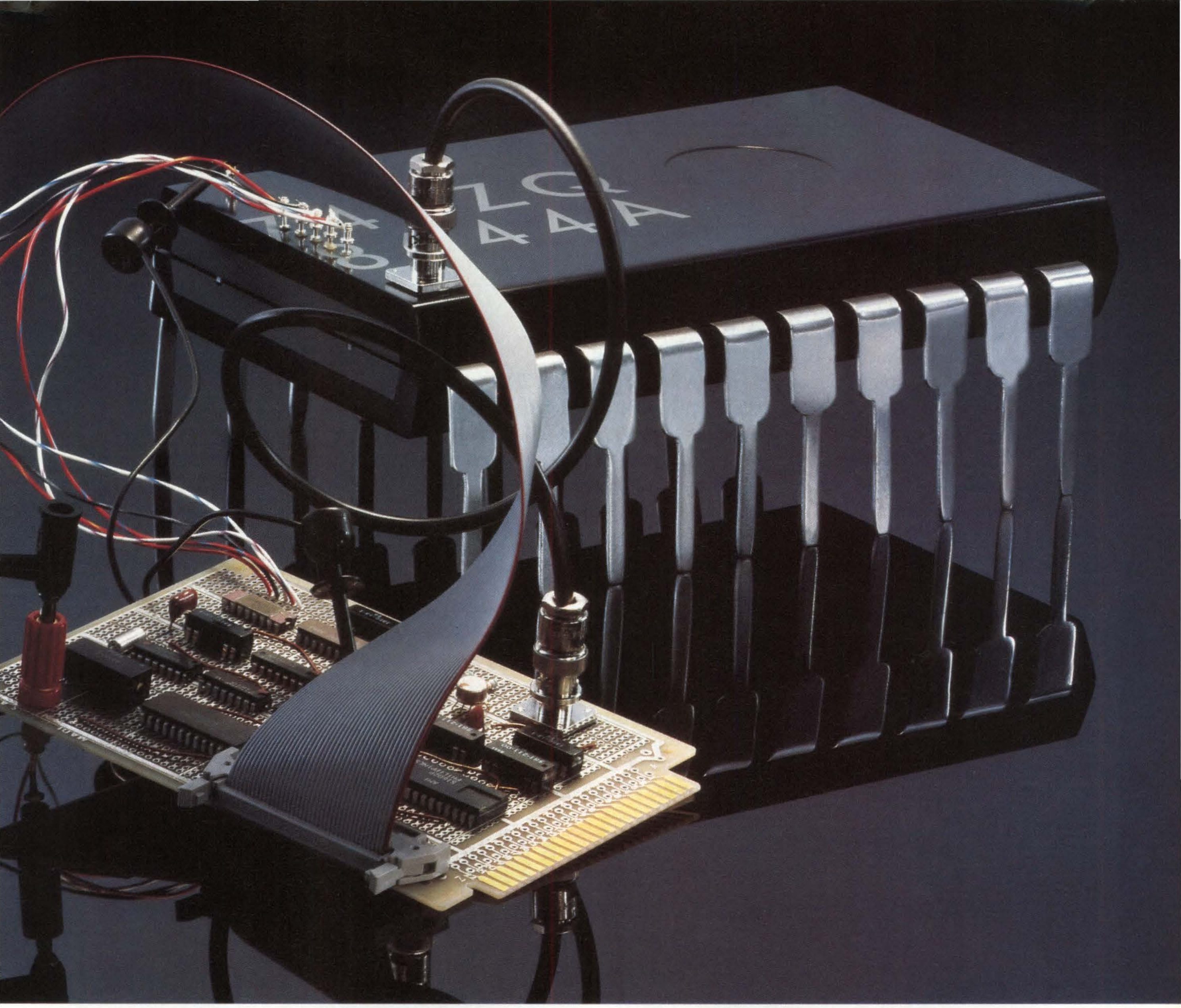
One Test System, Once and for All

With AVLSI devices you won't get fast design feedback, unless you test individual components—the "building blocks" of system silicon. And you won't comply with customer and industry requirements if you don't do complete "system" functional testing. With conventional test systems it means two of everything. Two testers, two test programs, two insertions, two data bases. And more than twice the time to get to market.

The A500 allows you to do it all with one system. So there's only one system to program. One insertion to make for both component and functional testing. And only one data base to work with. Which means significantly less time to market.

Vector Bus II™: the Great Integrator

The heart of the A500 is Teradyne's unique Vector Bus II architecture. It integrates analog and digital VLSI test capability at the system level. Which means you won't have to build special applications hardware for every new device you design. Vector Bus II eliminates that costly custom-work bottleneck



Why accept it in an Analog VLSI Test System?

with such features as TimeMaster™ Synchronization, Mixed-Signal Event Control, and MultiSource Data Mixing.

A Picture's Worth a Thousand Keystrokes
The A500 also revolutionizes program development. Our IMAGE™ (Interactive Menu-Assisted Graphics Environment) software gives you graphics programming as powerful as device designers' CAD/CAE tools. Using a mouse to control multiple windows, pop-up menus and software "power tools," you move ideas rapidly from mind to screen. And much faster to market.

Teradyne's new A500 is the only test system with the features you need to win the race for Analog VLSI market opportunities. To find out more, call Beth Sulak at (617) 482-2700, ext. 2746. Or call your nearest Teradyne sales office or write: Teradyne, Inc., 321 Harrison Avenue, Boston, MA 02118.

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CIRCLE NO 169

CAD systems can't replace breadboards

Thanks for printing Jim Williams's timely guest editorial ("Should Ohm's law be repealed?" EDN, March 3, 1988, pg 47). CAD systems certainly save time, especially when they're used for digital design. But claiming that a CAD system can eliminate the need for breadboarding analog circuits is like claiming that a text-processing package can produce a finished manuscript without any editing.

I would very much like to see EDN further explore the current status of analog circuit design. The gradual demise of analog courses in engineering schools is an important area of concern. Another is the replacement of simple analog circuits with complex programmable logic. Still another is the shunning, by digital-computer designers, of the analog computer, which is a well-established, real-time, parallel processor.

Forrest M Mims III
Seguin, TX

A lesson in bridge building

I read with interest Jon Titus's editorial "Building bridges" (EDN, February 18, 1988, pg 53). It caught my eye because my son and I had a somewhat similar experience. Our experience was slightly different from Jon's, however, and as a result I believe I had a different outcome and a different lesson.

My son is in eighth grade. His science teacher provided a chance for the students to earn extra credit by designing a toothpick bridge that had to span approximately 11 in. and had to support a 10-lb lead ball. Every student who tried would get some credit, those who built bridges that supported the weight would get more credit, and the student who built the lightest bridge that supported the weight would receive the most points.

I felt that this assignment was a good chance to provide some home education on how to approach problems that you are not especially trained to handle. (I am an electrical engineer, and my Statics class was many years ago.) We first determined how strong a toothpick was. Then we built a few small trial structures to determine how much they would support. This experiment led us to a design that not only supported the weight but was also the lightest. We did it without calculations or detailed engineering. We used a logical step-by-step approach and trial and error. Although it wasn't the fastest approach, it got the job done.

My point is that too often we get

THERE'S MORE IN STORE FROM SEEQ.

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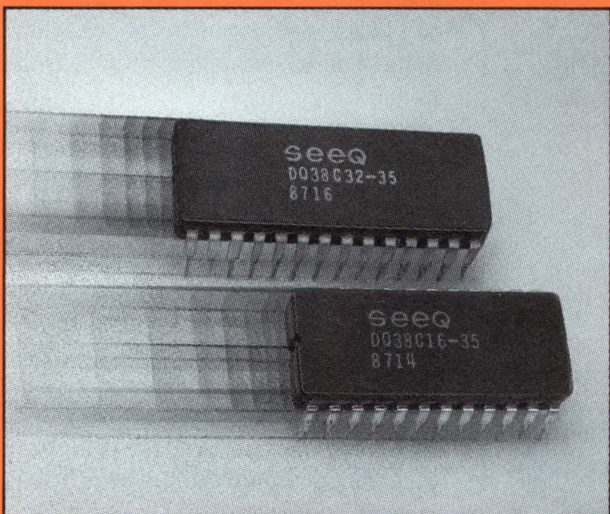

Org.	Part No.	Pin Out	I_{cc}	T_{aa}	T_{ce}	Packages
2K x 8	36C16	Same as bipolar PROM	100 mA	45 ns	30 ns	DIP, LCC
4K x 8	36C32	Same as bipolar PROM	100 mA	45 ns	30 ns	DIP, LCC
2K x 8	38C16	JEDEC STD. E²	100 mA	45 ns	30 ns	DIP, LCC PLCC
4K x 8	38C32	JEDEC STD. E²	100 mA	45 ns	30 ns	DIP, LCC PLCC

All parts are available in MIL-STD 883, Class B.

There was a time when you couldn't consider E²PROMs for writeable control-store applications. Because their speeds couldn't keep up with today's faster microprocessors, without introducing wait states.

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SEEQ high-speed E²PROMs can also replace—and outperform—your other traditional alternative, slower E²s combined with fast SRAMs. That simplifies designs by eliminating the need to load RAM for program execution. And, fast E²s cut the number of required devices by more than half.

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E² Is Our Middle Name

CIRCLE NO 170

SIGNALS & NOISE

wrapped up in the requirement that we must always have the slickest, best, fastest, and most state-of-the-art tools to get the job done. Sometimes I wonder how anything was ever designed before we had HP calculators, personal computers, and engineering workstations. Many designs have been done without the aid of any of these tools, and hopefully many more will be in the future.

I am not a Luddite when it comes to using tools to do a better job. However, I think that our colleges are turning out students that need the latest equipment to get the job done. This situation has been caused in part by employers who expect engineers fresh out of school to be versed in the latest equipment and ready for design work. The end result is that the education the students receive is leaning more toward practical skills and less toward theoretical skills and a broad education. I believe that in the long run this situation will be detrimental to the engineer's ability to keep up with technology or adapt to a different technology should the job require it.

Let's not forget that you can accomplish a lot by using the best computer available (the one between your ears), a little common sense, and a logical approach to a problem. Sometimes the simplest solution is the best solution.

Joe Blaschka, Jr, P E
President
Adcomm Engineering Co
Kirland, WA

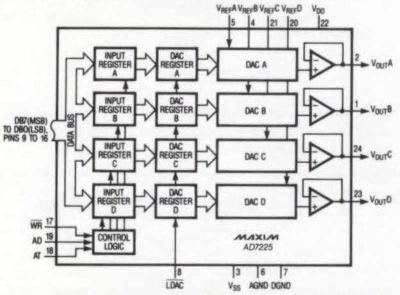
Sorry, wrong number

The phone number listed for Softaid Inc (Columbia, MD) on pg 253 of EDN's March 17, 1988, issue is incorrect. The correct number is (301) 964-8455.

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

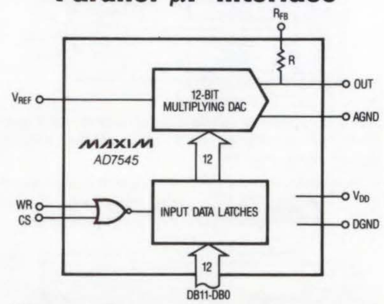
New D/A Converters Expand Design Choices

Voltage output, quad 8-Bit



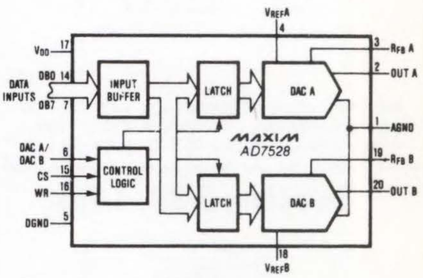
AD7226/5 – 8-Bit with μP interface, buffered outputs with good sink current, single or dual supply, 1LSB accurate

Parallel μP interface



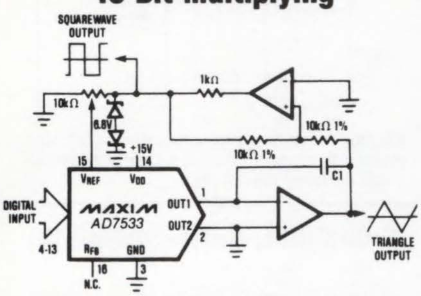
MAX7645/AD7545A – 12-Bit multiplying, 100ns WR pulse, 1LSB gain error, low glitch, +5V or +15V supply with TTL/CMOS compatible

8-Bit dual multiplying



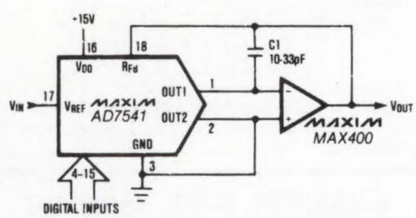
AD7528/AD7628 – μP interface and data latches, 1% DAC matching, +5V or +15V supply and TTL/CMOS compatible

10-Bit multiplying



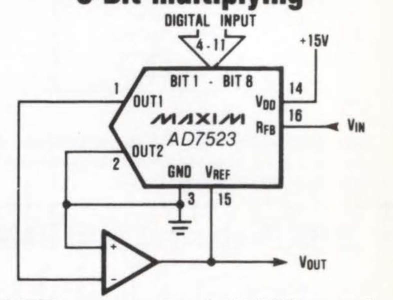
AD7533 – current output DAC, TTL/CMOS compatible inputs, single +15V supply, 30mW power consumption

12-Bit multiplying



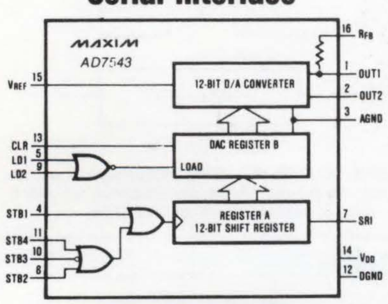
AD7541A/AD7541 – current output, 1LSB gain error, low glitch energy, single +15V supply, 30mW power consumption

8-Bit multiplying



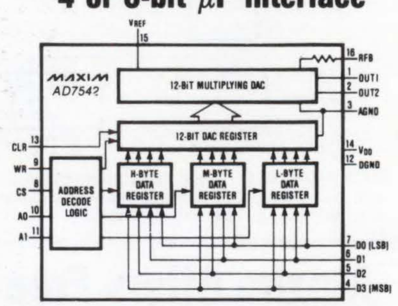
AD7523 – current output, TTL/CMOS compatible inputs, single +15V supply, 1.5mW power consumption

Serial interface



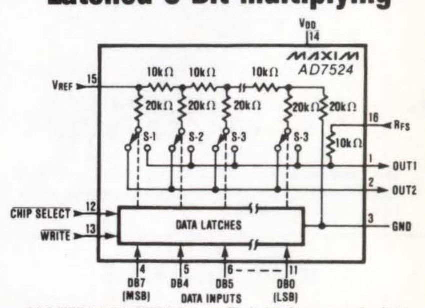
AD7543 – 12-Bit multiplying, LOAD and CLEAR functions, single +5V supply, 12mW power consumption

4 or 8-bit μP interface



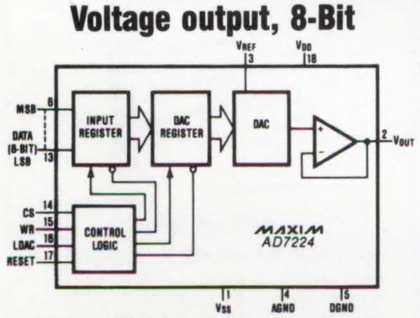
AD7542 – 12-Bit multiplying, 4-bit data input, 1LSB gain error, low glitch, single +5V supply, 12mW power consumption

Latched 8-Bit multiplying



MAX7624/AD7524 – μP interface and data latches, +5V to +15V supply and TTL/CMOS compatible, 37/5mW power consumption

Voltage output, 8-Bit



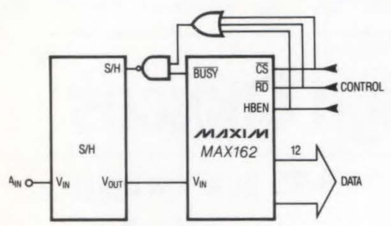
AD7224 – 8-Bit voltage output with μP interface, buffered output with good sink current, single or dual supply, 1LSB accurate

New 1988 Databook Details 65 Data Converter Devices

The devices above are but a sample of Maxim's growing line of D/A conversion products. The rest can be found in our new 1988 Data Conversion Databook which is FREE for the asking (see pg. 2). These devices are engineered in enhanced silicon-gate, bipolar or hybrid technologies and deliver superior performance— faster conversion speeds, greater accuracy and higher stability. What's more, they're all available in space-saving 0.3″ DIP or small-outline (SOIC) packages.

New A/D Converters Expand Design Choices

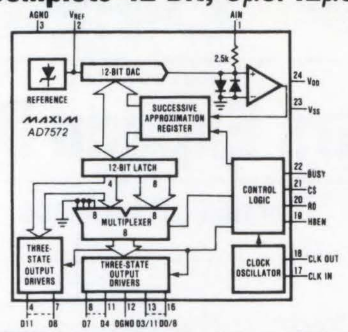
Complete CMOS 12-Bit, 3μs



DSP Analog Front End (f_S=250 kHz)

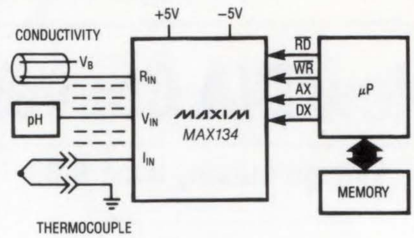
MAX162 – with internal reference, +5V and −12V to −15V supplies, μP interface, 215mW power consumption, replaces AD7572 pin-for-pin

Complete 12-Bit, 5μs/12μs



AD7572 – internal reference, +5V and −15V supplies, μP interface, +5V input range, 215mW power consumption

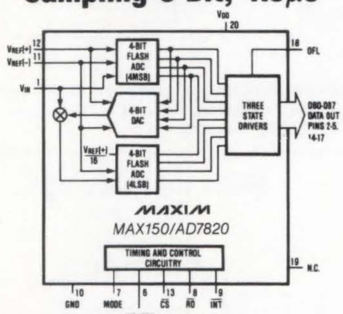
Very low power, 5μV



μP controlled DAS

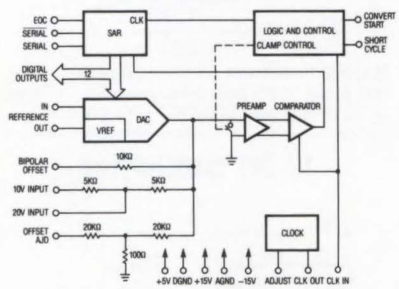
MAX133/4 – μP controlled integrating 3¾-digit ADC with low external component count, 2.2mW power consumption, DEMO KIT available

Sampling 8-Bit, 1.3μs



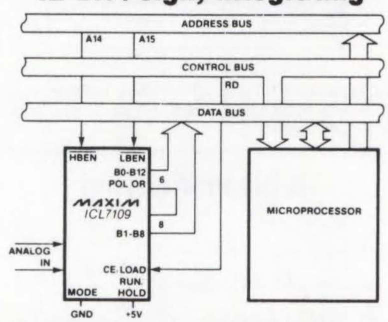
MAX150/AD7820 – Fast ADC with track/hold, no adjustments or clock required, internal reference (MAX150), easy μP interfacing

Complete 12-Bit, 3μs



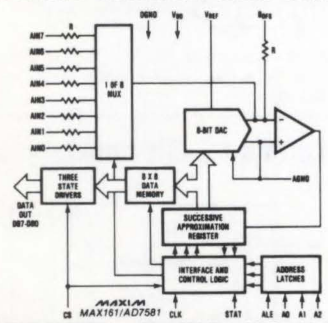
AD578 – 12-Bit 3μs ADC, internal +10V reference, adjustable internal clock, short cycle capability

12-Bit+sign, integrating



ICL7109 – 12-Bit+sign integrating ADC with binary output and μP interface, UART handshake mode for serial interfacing

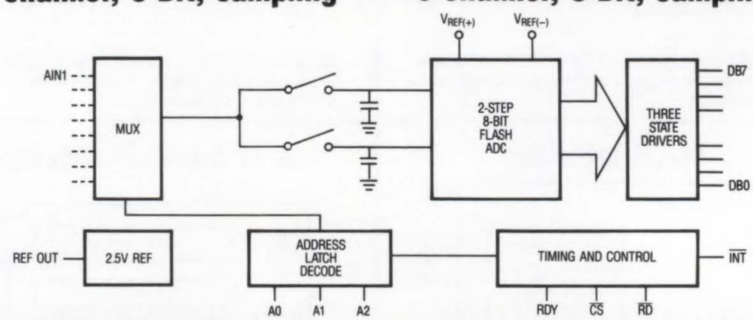
8-Bit/8-channel with RAM



MAX161/AD7581 – 20μs/66.7μs ADC with 8×8 Dual Port RAM for data storage, ratiometric capability, DMA operation

4-channel, 8-Bit, sampling

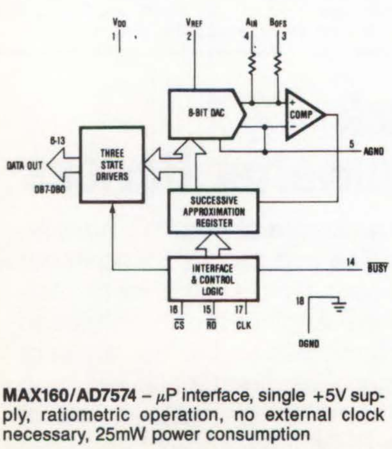
8-channel, 8-Bit, sampling



MAX154/AD7824 – Data Acquisition Systems with track/hold, 2.5μs per channel, no clock required, internal reference (MAX154)

MAX158/AD7828 – Data Acquisition Systems with track/hold, 2.5μs per channel, no clock required, internal reference (MAX158)

8-Bit, 4μs/15μs



MAX160/AD7574 – μP interface, single +5V supply, ratiometric operation, no external clock necessary, 25mW power consumption

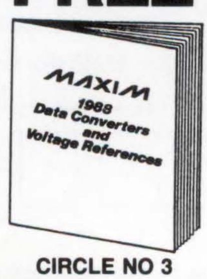
Maxim Offers Free 100% Burn-in

Maxim minimizes IC failures by improving designs, building parts better and testing them to an exent that commercial parts have never been tested before.

Every DIP is burned-in at 150°C for 24 hours—absolutely FREE. And all pins are designed to withstand over 2000V of electrostatic discharge (ESD). This results in an incredibly low failure rate of 6.8 failures per billion hours of operation.

For the details on all of Maxim's data acquisition products, send for our new 1988 Data Conversion Databook.

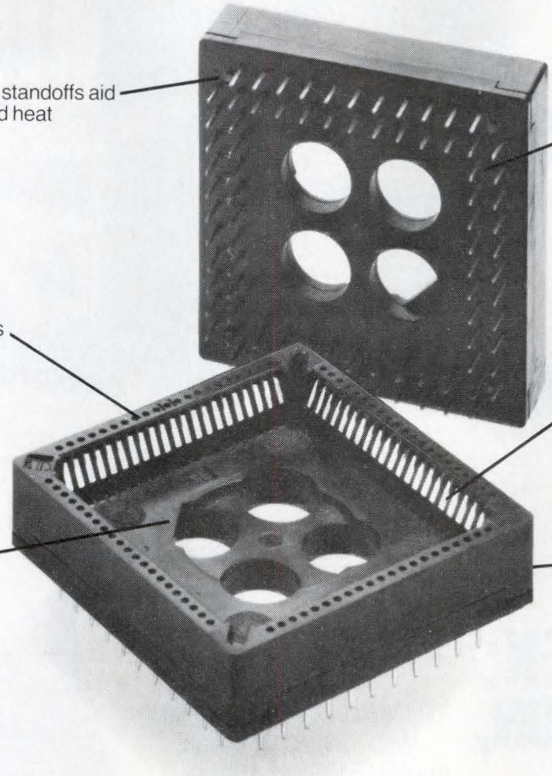
★ FREE ★



CIRCLE NO 3

For **FREE SAMPLES** or applications assistance call (408) 737-7600 or write Maxim Integrated Products, 120 San Gabriel Dr., Sunnyvale, California 94086.

WITH ALL THIS GOING FOR YOU,



WHY SETTLE FOR ANYTHING LESS IN A CHIP CARRIER SOCKET?

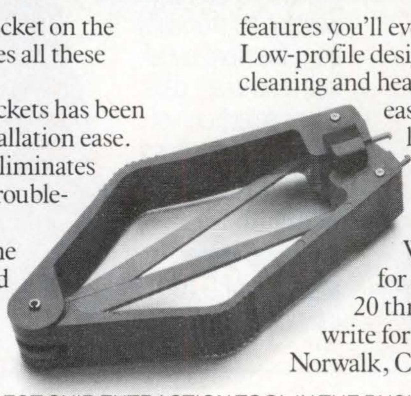
CHIPAK™—it's the finest chip carrier socket on the market today. And the only one that combines all these important features in a single design.

In fact, everything about our CHIPAK sockets has been engineered for maximum reliability and installation ease.

Our closed-bottom design, for example, eliminates the danger of solder wicking—without the troublesome mylar covers required in open-bottom designs. Our GTH™ contact system grips the chip tightly in place and insures good-as-gold performance—without cumbersome chip retention clips.

In short, CHIPAK combines all the features you'll ever want or need in a chip carrier socket. Low-profile design to save space. Convenient standoffs to aid cleaning and heat dissipation. Easy-access probe holes and easy-to-spot orientation guides to speed installation and testing. And finally, an easy-to-use chip extraction tool that, unlike others, accommodates every socket size—quickly and safely.

With all this going for you, why settle for anything less? Available in sizes from 20 through 84 contact positions. Call or write for complete details: Burndy Corporation, Norwalk, CT 06856. (203) 852-8337.



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CIRCLE NO 171

58158

NEW FROM TEK: ANALOG FUNCTION, ARBITRARY WAVEFORM AND SWEEP GENERATION IN ONE COMPACT PACKAGE.

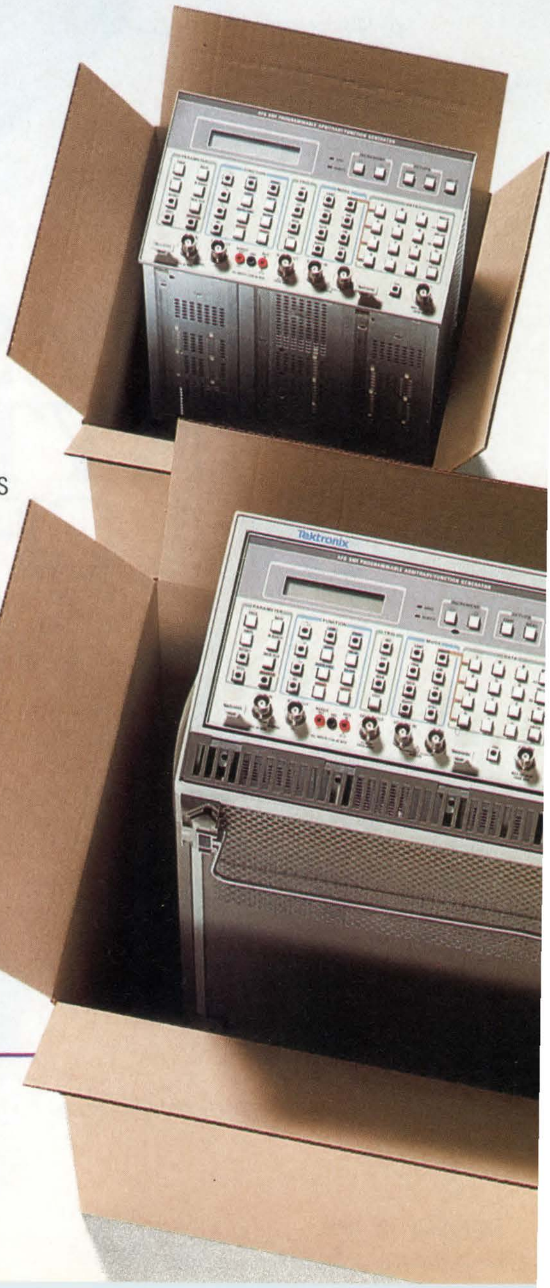
The Tek AFG 5101 Programmable Arbitrary/Function Generator is the latest addition to Tek's TM 5000 family of proven, programmable, modular test instruments.

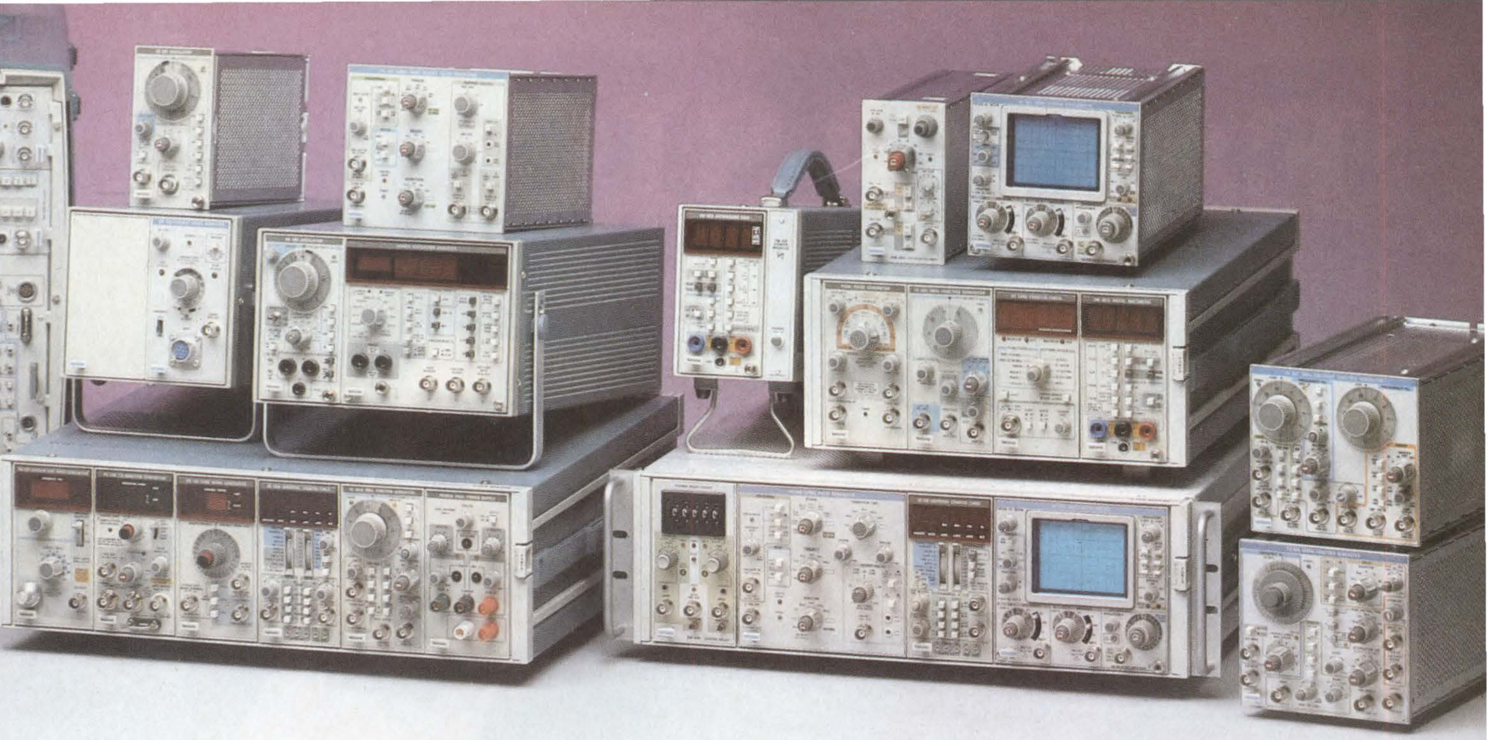
An analog function generator, the AFG 5101 can generate standard sine, square and triangle waveforms, plus dc level, with frequencies from .012 Hz to 12 MHz and amplitudes of 10 mV to 9.99V peak-to-peak, into 50 ohms. Waveforms can be continuous, triggered, gated or burst, from a full range of triggering modes.

With synthesizer option, the AFG 5101 achieves frequency accuracies to .005% (120 Hz to 12 MHz) over and above the .2% frequency accuracies in the standard instrument.

An arbitrary waveform generator, the AFG 5101 uses two independent 12-bit by 8K waveform memories to build any imaginable signal from an array of 8,192 horizontal addresses and 4,096 vertical addresses. Enter the waveforms manually from the front panel, from computer data —or select one of the unit's predefined, 1,000-point waveforms.

A sweep generator, the AFG 5101 includes linear,





logarithmic and arbitrary sweeps, with any sweep usable in continuous, triggered, gated or burst mode. Users can receive instant frequency readout of breakpoints, notches, or response anomalies.

The applications are wide open. Use the AFG 5101 to drive sensors, timers, and other R&D equipment. To simulate metal stress or vibration characteristics. To teach waveform theory to students. And much more.

Easy waveform editing capabilities . . . non-volatile storage of up to 99 front panel settings and two 8K point waveforms . . . binary block GPIB transfer . . . two waveform memories plus third, execution memory—these and other features make the AFG 5101 a simple, powerful and uniquely flexible tool.

AVAILABLE IN THREE CONFIGURATIONS.

The first triple-duty test instrument of its kind, it is available in monolithic (AFG 5501), as a plug-in (AFG 5101), or in our Programmable Arbitrary Stimulus/Measurement package (EBS 5002).

Take 10% off with our package offer. Order the AFG 5101 in our Programmable Arbitrary Stimulus/ Measurement package and take 10% off catalog prices.

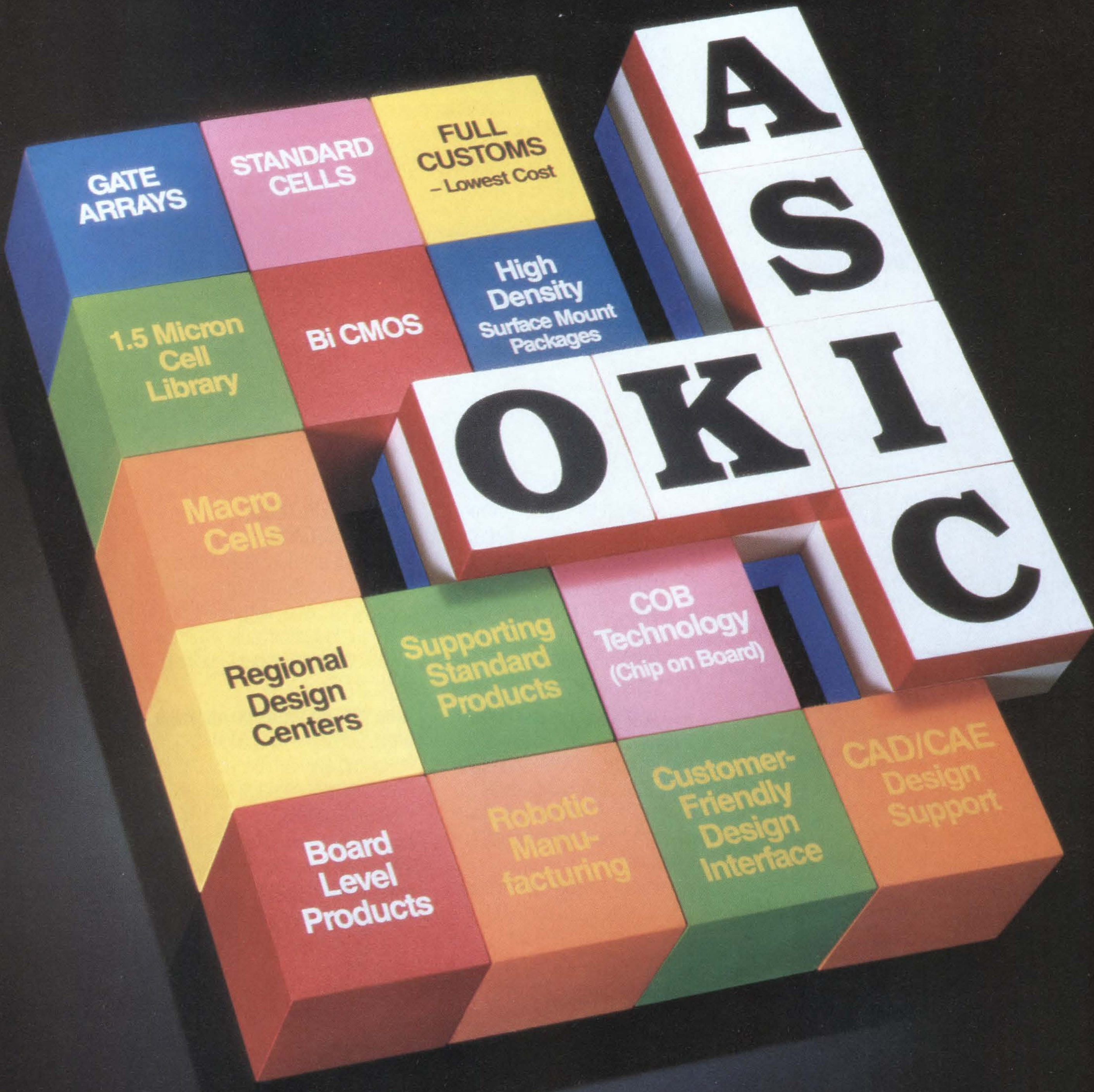
For the full story on these and other Tek modular instruments, call 1-800-426-2200. Or contact your nearby Tektronix field office.

(Center photo) The AFG 5101 can be ordered in either monolithic version, top right, or as a plug-in for the TM 5000 series mainframes, top left. Or, combine it with the DM 5010 4.5 Digit Multimeter and DC 5009 135 MHz Digital Counter within a TM 5006 mainframe (EBS 5002), as shown at bottom, and take 10% off the normal catalog price.

Tektronix
COMMITTED TO EXCELLENCE

CIRCLE NO 172

Easy ASIC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Macro Cells
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Opt for OKI ASIC, and you open up your options across the board. Only OKI now offers the system designer the unique security and entry ease that only a proven track record in CMOS ASIC problem-solving can provide. This history of performance built up since 1977 has produced the widest range of solid building blocks yet: advanced ASIC products and packaging including surface-mount, backed up with the most flexible cell libraries, CAD/CAE design tools and development aids.

As your working partner, OKI ASIC expertise is available to you at any stage of the development process. We'll help you define system requirements, determine the most cost-effective product solutions and supply complete design software—accessible at your own workstation or through our regional design centers. And then we take it from there: with high volume fabrication, assembly and testing completed in one of the world's most highly robotized manufacturing facilities.

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Macro Cells	●	●	
Bi CMOS	●		
High Density Surface Mount Packages	●		
Board Level Products	●		
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CIRCLE NO 173

CALENDAR

31st Annual Instrument Society of America Power Symposium, St Petersburg, FL. Bill Blazier, Illinois Power Co, 500 S 27th St, Decatur, IL 62525. (217) 424-6622. May 23 to 25.

Society for Information Display International Symposium, Anaheim, CA. Palisades Institute for Research Services, 201 Varick St, Rm 1140, New York, NY 10014. (212) 620-3388. May 23 to 27.

C Programming: Hands-on Workshop (short course), Washington, DC. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. May 24 to 27.

Troubleshooting Microprocessor-Based Equipment and Digital Devices (seminar), Kansas City, MO. Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032. (800) 247-5239; in KS, (913) 898-4695. May 24 to 27.

DOD-STD-2167A and DOD-STD-2168—Defense System Software Development (seminar), San Diego, CA. David Maibor Associates, Box 846, Needham, MA 02194. (617) 449-6554. May 26 to 27.

Troubleshooting Microprocessor-Based Equipment and Digital Devices (seminar), Dallas, TX. Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032. (800) 247-5239; in KS, (913) 898-4695. May 31 to June 3.

42nd Annual Frequency Control Symposium, Baltimore, MD. R L Filler, US Army Electronics Technology and Devices Lab, Attn: SLCET-EQ, Ft Monmouth, NJ 07703. (201) 544-2467. June 1 to 3.

Personal Computer Interfacing for Scientific Instrumentation Automation (short course), Blacksburg, VA. Linda Leffel, CEC, Virginia Tech, Blacksburg, VA 24061. (703) 961-4848. June 2 to 4.

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Sustained 20-MIPS, 7-MFlop throughput in a 32-bit CMOS CPU and FPU.

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CIRCLE NO 174

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CALENDAR

International Summer Consumer Electronics Show, Chicago, IL. Consumer Electronics Shows, 2001 Eye St NW, Washington, DC 20006. (202) 457-8700. June 4 to 7.

FiberTour 88, Boston, MA. Joan Barry, Xpos, Box 8872, Salem, MA 01971. (617) 744-9767. Conference cosponsored by Lightwave magazine. June 7 to 8.

ATE & Instrumentation Conference East, Boston, MA. MG Expositions Group, 1050 Commonwealth Ave, Boston, MA 02215. (800) 223-7126; in MA, (617) 232-3976. June 7 to 9.

International Conference on Consumer Electronics, Rosemont, IL. Geriann Van Calbergh, 4924 N Cumberland, Norridge, IL 60656. June 7 to 10.

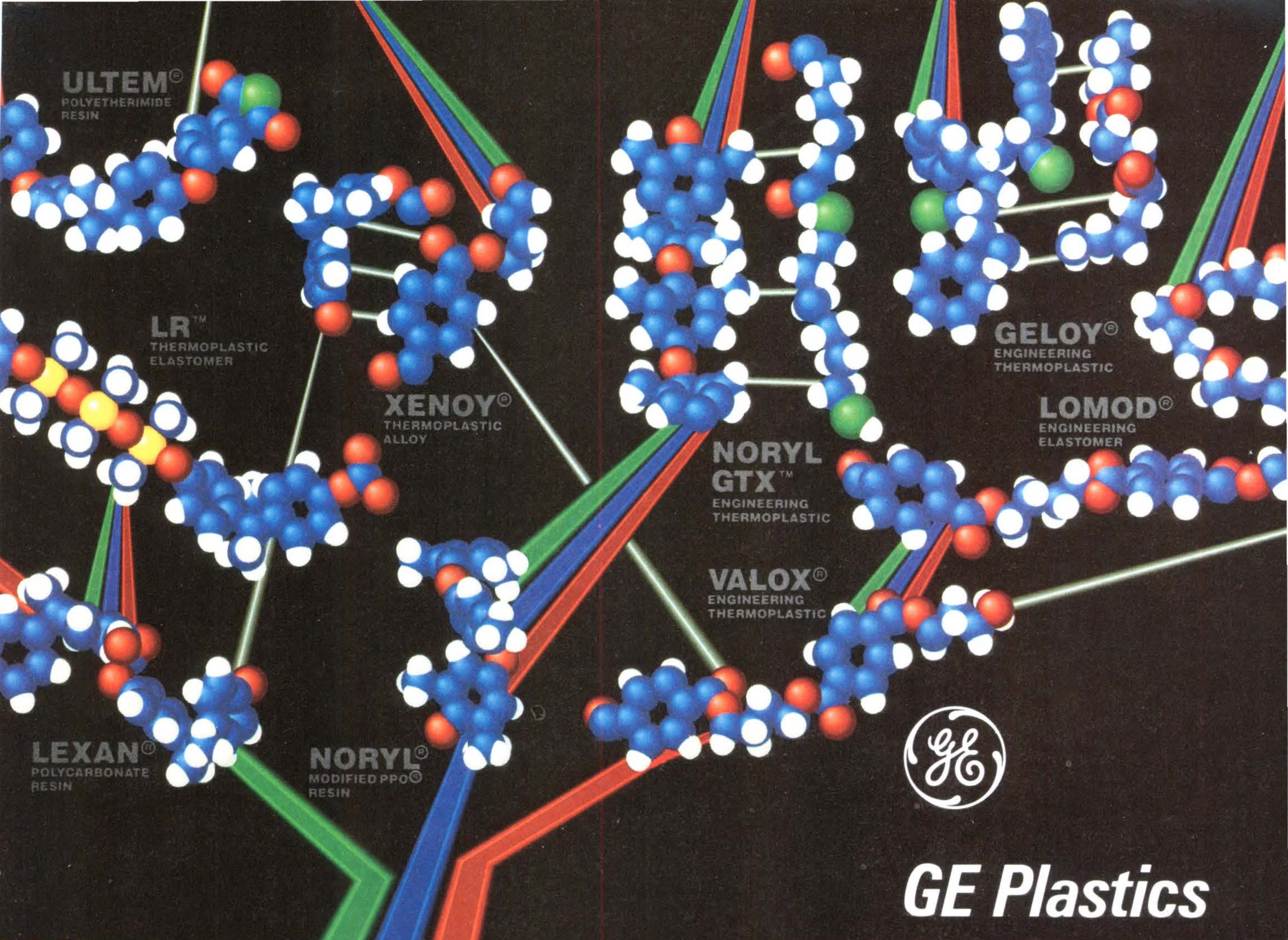
25th Design Automation Conference, Anaheim, CA. MP Associates, 7366 Old Mill Trail, Suite 101, Boulder, CO 80301. (303) 530-4333. June 12 to 15.

Nepcon East, Boston, MA. Cahners Exposition Group, 1350 E Touhy Ave, Des Plaines, IL 60018. (312) 299-9311. June 14 to 16.

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.

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.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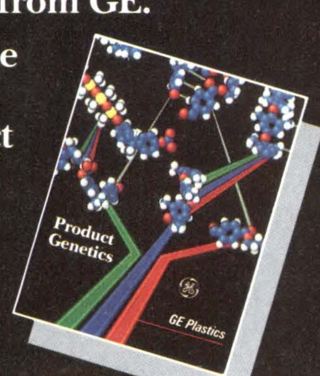
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Not long ago, designing ASICs wasn't even part of your job. Now it's the part everyone's counting on.

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Daisy CAE tools are used by more ASIC designers than any other CAE workstations.

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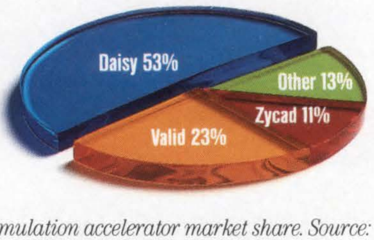


Simulation accelerator market share. Source: Prime Data, 1985 and 1986 unit shipments.

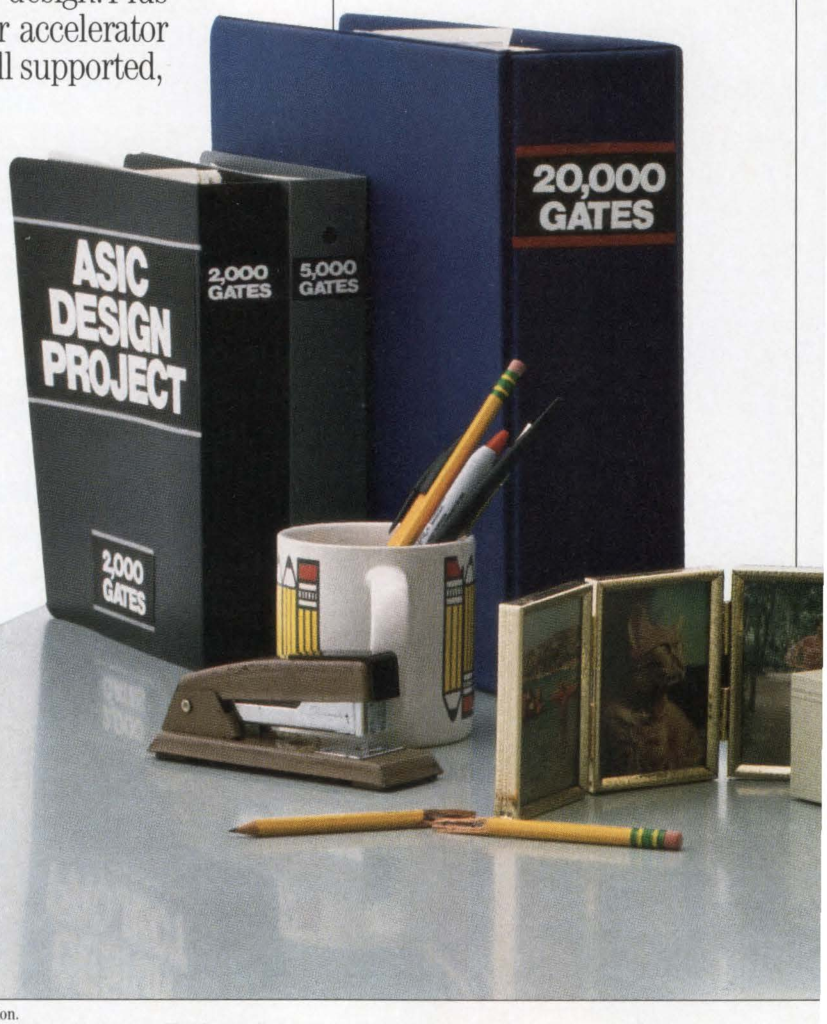
simulation, Daisy has what it takes to keep ASICs on time and on budget.

For example, our MegaLOGICIAN™ simulation accelerator is seamlessly integrated with the schematic, so you can locate and correct design problems interactively.

That means faster debugging and more time to improve the quality of your design. Plus no other accelerator is as well supported, with more than 170 design kits supplied by 70 different vendors. So you can build productivity instead of libraries.

Which may explain why more MegaLOGICIANs are in use today than all other accelerators combined.

Speaking of combining, you



*Based on minimum 10x performance improvement compared to 32-bit workstations. Source for design kit estimates: VLSI Systems Design's Semicustom Design Guide, 1987.

can share a MegaLOGICIAN with a network of our 386-based desktop workstations, for a high-powered low cost ASIC design environment.

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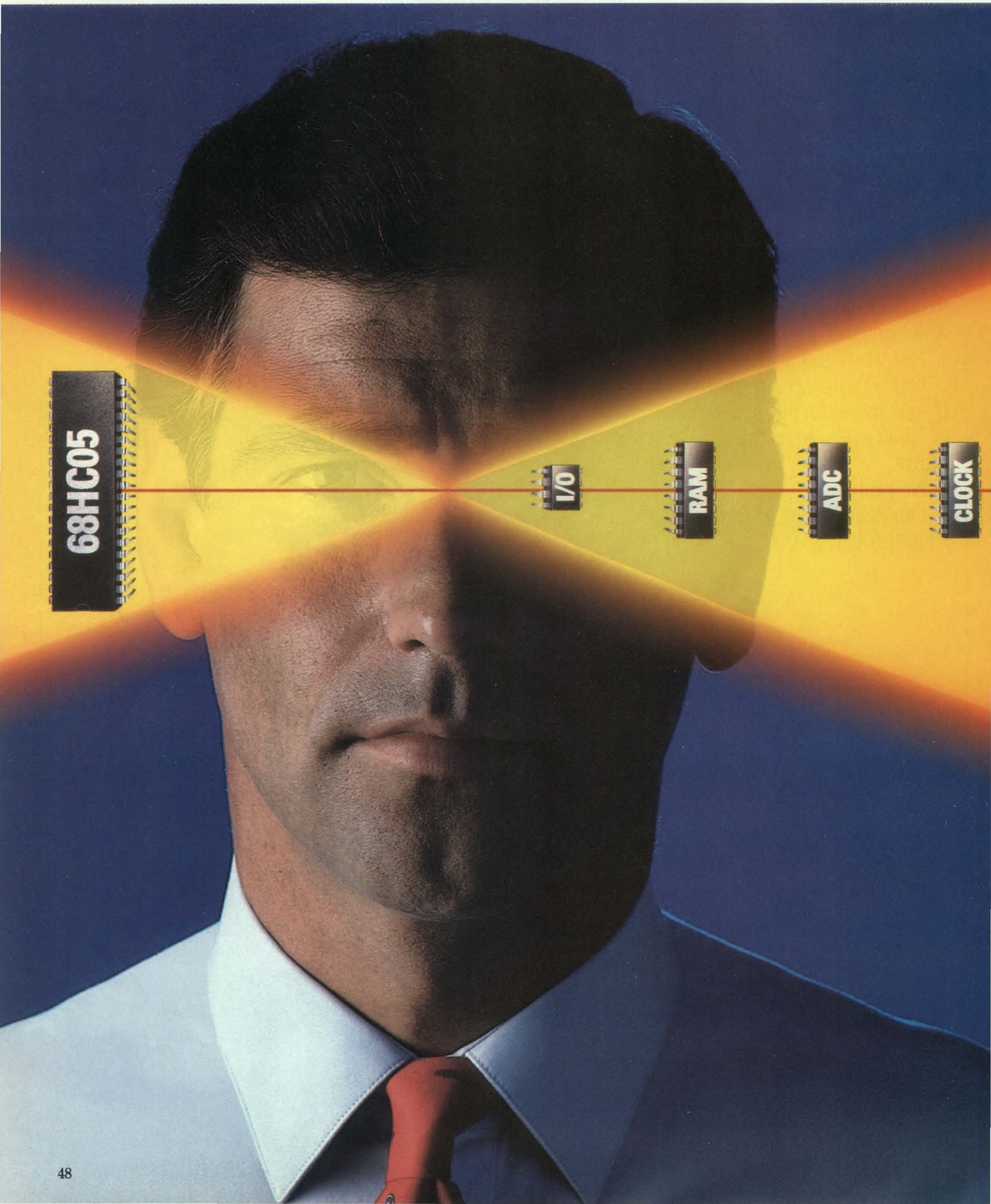


design vision.

Enhance your design at any stage with RCA CMOS 6805 micros and SPI peripherals.

Your challenge is to increase system performance and capability while reducing board size.

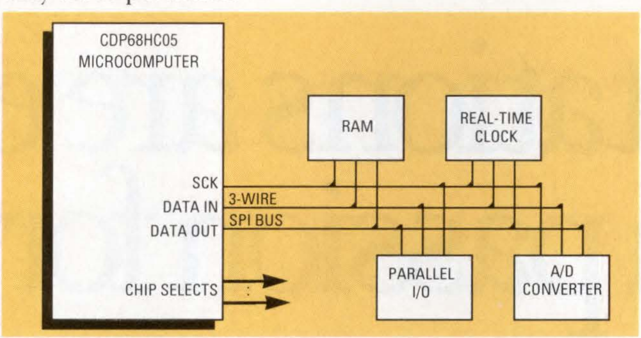
Not an easy job. But certainly easier when you use our 6805 and 68HC05 micros and serial peripheral interface devices.

Extend your micro's power.

Many microcomputers rely on parallel I/O ports to communicate with peripheral devices. An inefficient method at best.

That all changes with the serial peripheral interface incorporated into our 68HC05 microcomputers.

This three-wire (plus device select) synchronous, full-duplex, serial communication system contains separate lines for input and output data, serial clock and device select. You don't have to sacrifice I/O ports to communicate off-chip: our 68HC05 micros can communicate with our own serial peripherals, the serial peripherals of other manufacturers, and even with other microcomputers via only three port lines.



True design versatility.

The real beauty of the SPI is that it eliminates limitations imposed by microcomputers.

For example, you can easily extend the amount of I/O or memory with SPI RAMs, I/O chips or shift registers. And the modular SPI bus gives you the ability to expand without losing lots of PC-board space. Reduced package sizes and minimized interconnect wiring lead to reduced board size.

And since you don't need complex software to operate the bus, you save ROM space.

Right now, we can offer you a versatile family of peripheral devices, including 128-byte and 256-byte static RAMs, a real-time clock with RAM, an 8-bit programmable I/O port, and a 10-bit 8-channel A/D converter. And more parts are coming soon, including a digital pulse-width modulator and a serial bus interface chip for networking microcomputers. These serial peripherals are also compatible with other microcomputer types.

Powerful family of micros.

We can provide 6805 microprocessors for external memory address, but the heart of our SPI system is the 6805 Series high-speed CMOS microcomputers:

68HC05 Microcomputers

Features	68HC05C4	68HC05C8	68HC05D2	68HC05D2A
Pins	40	40	40	28
On-Chip RAM (bytes)	176	176	96	96
On-Chip User ROM (bytes)	4160	7744	2176	2176
Bidirectional I/O Lines	24	24	28	16
Unidirectional I/O Lines	7 inputs	7 inputs	3 inputs	3 inputs
Timer size (bits)	16	16	16	16
Prescaler size (bits)	*	*	*	*
External timer oscillator	no	no	yes	yes
Serial peripheral interface	yes	yes	yes	no
Serial communications interface	yes	yes	no	no

*prescaler fixed as ÷4

Easy to prototype, too.

If you need another reason to choose our 6805 family, here it is: they're so easy to prototype with our Piggyback! We have the 68EM05C4 and 68EM05D2 Emulators, custom 40-pin packages that contain the C4/C8 or D2 micros with a Piggyback EPROM socket.

When installed with a 27C64 EPROM, these devices together become functionally identical to a CDP68HC05C4, CDP68HC05C8 or CDP68HC05D2.

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For more information, call toll-free 800-443-7364, extension 22. Or contact your local GE Solid State sales office or distributor.

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Our workstations are en
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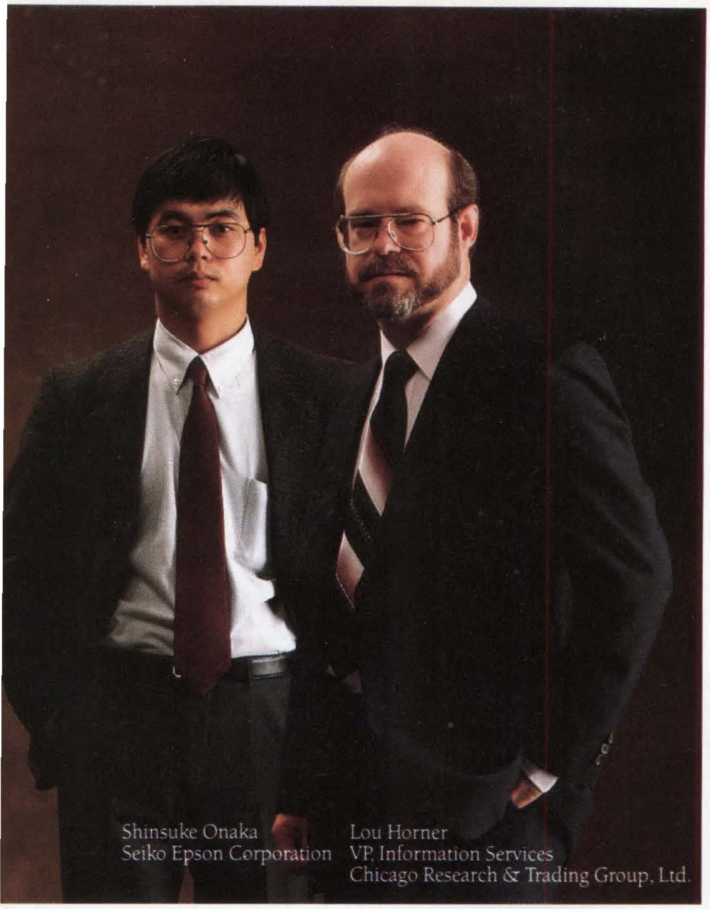

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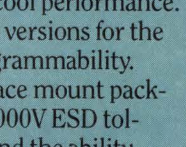

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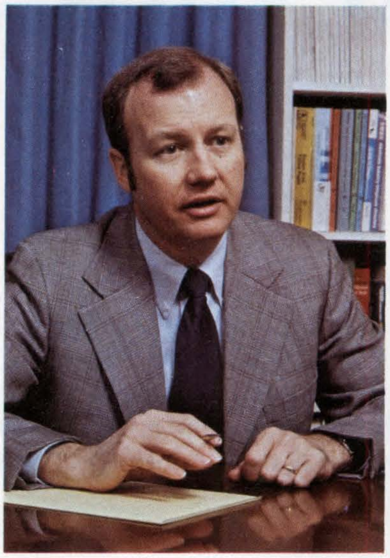
Time for a public-image boost



Electrical and electronic engineers should be pleased by IEEE-president Russell Drew's recent call on the Office of Management and Budget (OMB) to review US government contract-award practices. Drew was responding to the publication of terms in a 1987 Navy contract under which a firm was supplying engineers at a $7.29 hourly rate. That pay rate included the engineers' benefits. In a strong letter to Robert P Bedell, Administrator of the US Office of Federal Procurement Policy, Drew says he wants the OMB to ". . . ensure that degreed engineers are not receiving unrealistically low hourly rates in other Government contracts."

Drew's letter is a step in the right direction, as is his request that IEEE members report similar "wage-busting" contracts to the organization's US Activities Board (USAB) in Washington, DC, (202) 785-0017. We hope the USAB will listen to nonmembers, too. Exposing such low hourly wages is commendable, but the IEEE must follow through with more than calls for action. Unfortunately, the organization has little power beyond asking Government agencies to enforce hiring directives and policies.

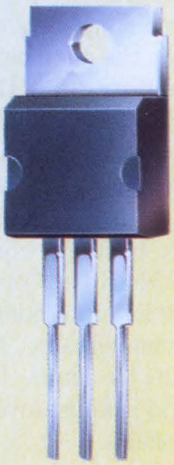
Perhaps some of the IEEE's lack of strength results from the electrical engineer's poor public image. After all, why should anyone worry about an all-but-invisible profession? Few people can describe what an EE does or where such an engineer might work. Drew addresses engineering's PR problem in the April 1988 issue of *The Institute*. For example, he says that although most people perceive outer-space activities as the result of scientific endeavors, they are generally engineering triumphs. So, the IEEE acknowledges the problem, but Drew goes on to say that the organization doesn't know what to do about it.

As a partial solution, Drew suggests that individual members seek media coverage that draws attention to the IEEE and its role in the profession. That's the wrong approach. If people don't know much about engineering, why should they care about the IEEE? Drew's additional suggestions include putting on a presentation about engineering, supporting public-service activities, and getting involved with local education groups. These activities can enhance *your* image, but without a comprehensive plan, they'll do little to enhance the profession's.

So, I'm still wondering why an organization of 290,000 professional members in over 130 countries is calling on individuals to solve a problem it should have tackled years ago. It's time to get a complete electrical- and electronic-engineering PR plan and timetable from the IEEE. The goal must be to make engineers a visible part of society and to tell people what we do, who we are, where we work, why we engineer, and how we affect daily life.

Jon Titus
Editor

This Year's Brightest a Variety



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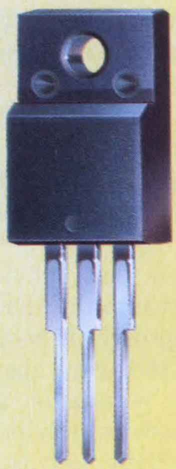

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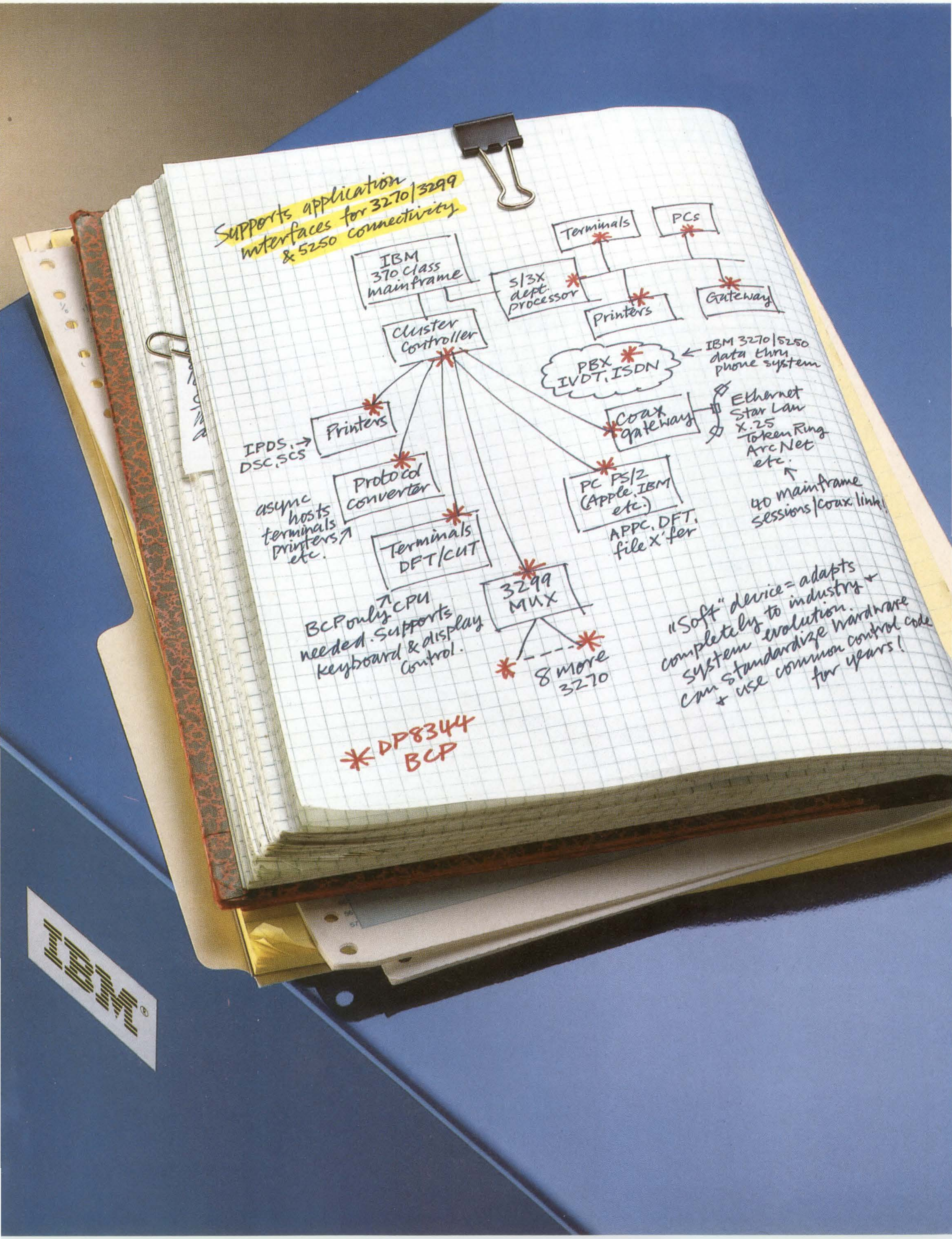

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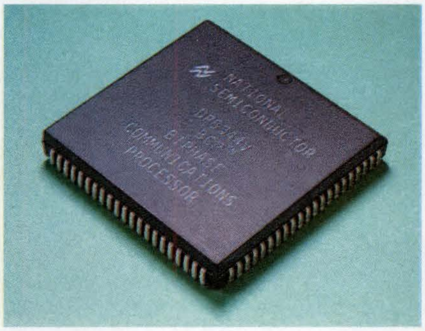

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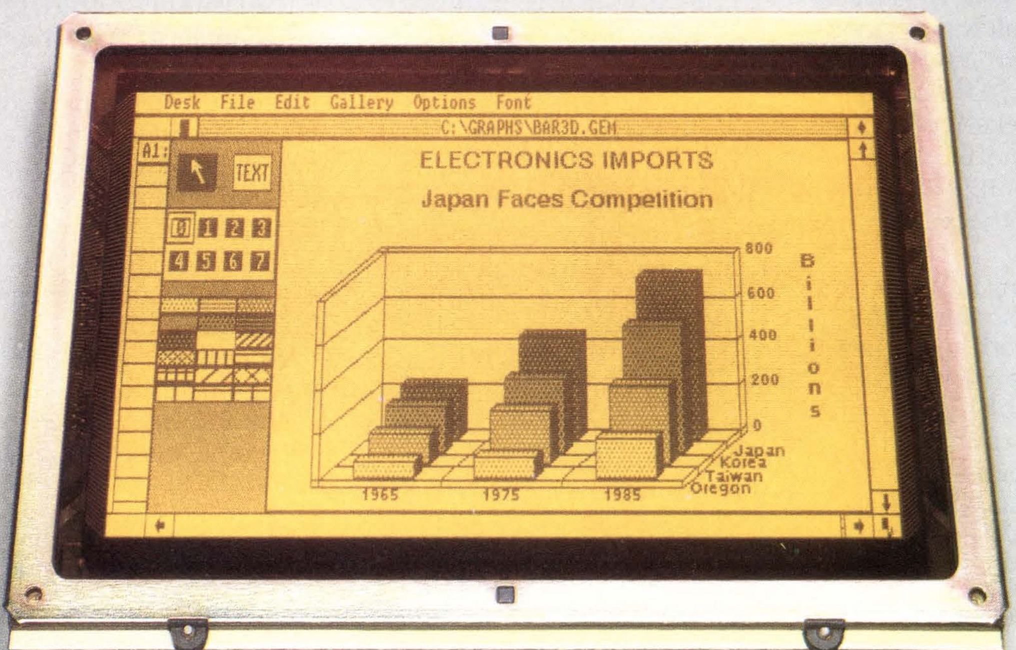

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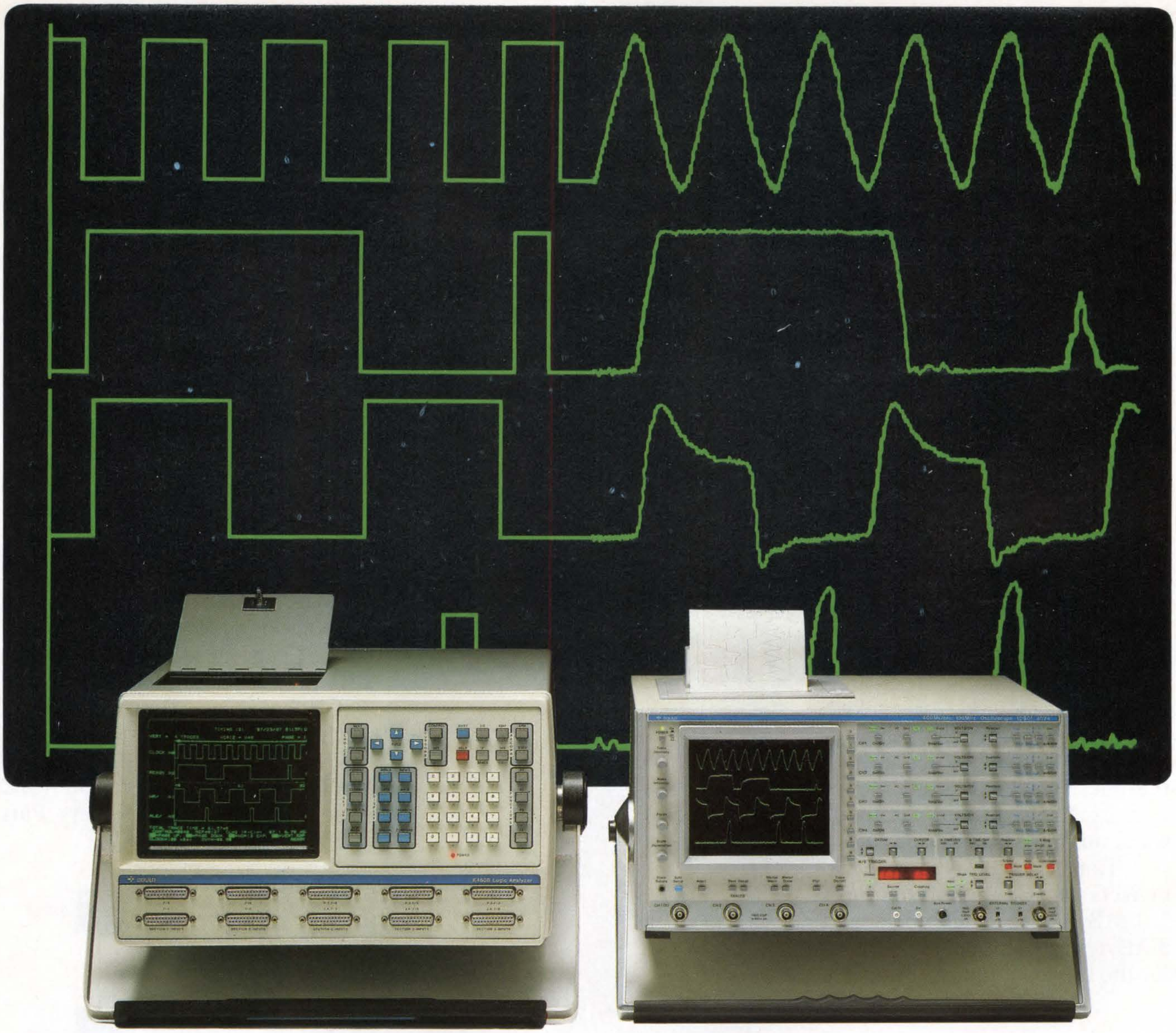

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	6th CDB to Disconnect message	0.9μs	—μs
	Disconnect message to Bus Free	0.2μs	—μs
Reselect and Transfer	Reselection to ID message	4.2μs	—μs
	ID message to 1st Data Byte	0.6μs	—μs
	Data Transfer	—	—
	Last Data Byte to Status	0.2μs	—μs
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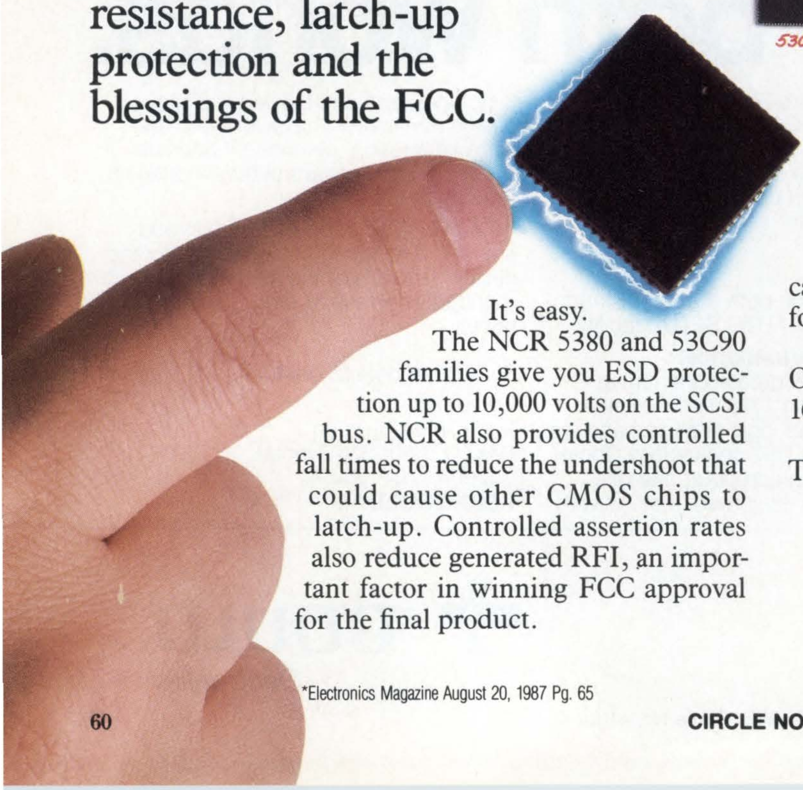

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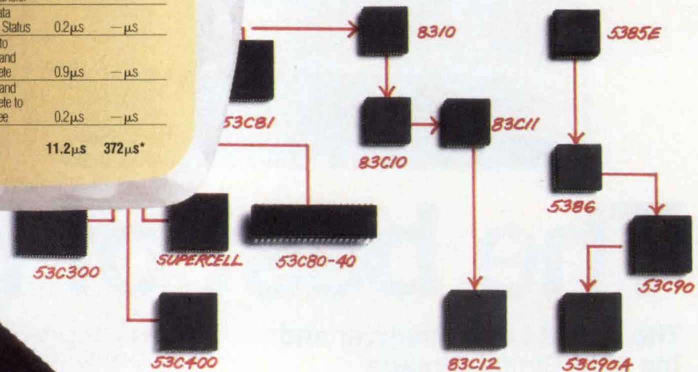

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*Electronics Magazine August 20, 1987 Pg. 65

CIRCLE NO 182

OS designers consign much of 386's power to writers of applications programs

Charles H Small,
Associate Editor

The designers of the 32-bit 80386 μP packed the device with so many built-in hardware features to support complex multitasking operating systems that no operating-system designer has yet made use of them all. Consequently, you can exploit the remainder of the 386's sophisticated hardware in your applications programs without the risk of colliding with the operating system.

The 386's μP designers envisioned an execution environment where a powerful operating system, running at the highest priority level, would completely control lower-level tasks. These lower-level tasks would each run in their own virtual memory spaces and communicate with other tasks through carefully specified and restricted common memory areas.

In addition, the tasks would communicate with the operating system by making function calls through a protected call-gate mechanism. When the operating system relieved one task and gave control of the CPU to another task, a task-switching mechanism would handle the transferral chores with a single command (see **box,** "386 architecture makes OS design easy").

But as yet operating-system designers have actually taken advantage of surprisingly few of these powerful, special-purpose facilities. Even Unix, running on a 386, leaves virtually all the facilities of the 386 at your disposal for your applications. In fact, designers who wish to embellish existing 386 operating systems by adding features, or those who want to combine several operating systems into one, have ample facilities remaining within the μP.

OS need not be a mystery

When using the 386's predecessors, applications programmers often clash with the operating system by using μP features reserved for the operating system. Although the inner workings of operating systems are by and large not well known to most applications programmers, any operating system is, after all, just another program and need not be mysterious.

The code in an operating system runs, generally, when one of four things happens:

- Operating-system call. The application program—or the user directly—requests the operating system to perform a function.
- Exception handling. The application program makes an error that it cannot by itself rectify.
- External interrupts. An external device, one which is not under the control of the CPU, demands attention.
- Timer interrupt. In time-sliced systems, an internal-timer interrupt often initiates a complex series of decisions and actions on the part of the operating system as it chooses which application program should get the next time slice.

The 386's mechanisms for handling external interrupts and timer interrupts are completely conventional. An external device supplies the 386 with an 8-bit, identifing vector as part of the external-interrupt handshake. The 386 uses the 8-bit vector to find the beginning address of the appropriate interrupt handler in a 256-entry table.

Timer interrupts for time-sliced, multitasking systems generally use the 386's nonmaskable interrupt (NMI). Like virtually every other μP's NMI, the 386's NMI causes the μP to jump directly to the start of the timer-interrupt routine using an address found at a predefined location.

The 386's extensive artillery takes aim at the first two jobs of an operating system: providing simple but common functions for applications programs, and handling task errors —or even better, keeping the tasks from making errors in the first place.

> The 386's μP designers envisioned an execution environment where a powerful operating system would completely control lower-level tasks.

Influencing these two operating-system jobs are three interrelated and unique aspects of the 386: the 4-level hierarchical memory-protection scheme, the segmented and paged memory units, and the function-calling and exception-handling mechanisms.

What makes Unix a portable operating system is its use of the lowest common denominator of the facilities available in all processors. Consequently, most Unix and Unix-like implementations for the 386 do not use the 386's segmentation and protection facilities other than to set up one segment for the entire system.

Similarly, other operating-system designers often write their operating-system code in C in order to make their systems portable. C provides no constructs that use the segmentation and protection mechanisms of the 386. In the programming universe that the C language presupposes, the address space is linear and all pointers can point to any place in the memory. Also, C assumes that all memory is undifferentiated, read/write memory. C compilers, therefore, do not generate code for the 386's protection facilities. So, if you need to set up areas of protected memory under Unix, or any other operating system written in C, chances are that the entire protection mechanism of the 386 is at your disposal.

386 architecture makes OS design easy

The key to understanding how an operating system interacts with your application program when running on an 80386 lies in the address-calculating hardware of this µP's complex architecture.

Fig A shows the 386's internal registers. This diagram is quite familiar to anyone used to the 8086/186/286 family. In fact, if this diagram were all there was to the 386's architecture, you would be justified in classifying it as just a souped-up 8086. But the 386's address-calculating hardware has hidden features.

Fig B reveals more of the processes. In 8086/186 fashion, the 386 combines, depending on addressing mode specified by an op code, the values in several registers: the value in a base register (from among the general registers); in an index register (optionally scaled by 1, 2, 4, or 8); and in a displacement register. The sum of these three values is a 32-bit effective address.

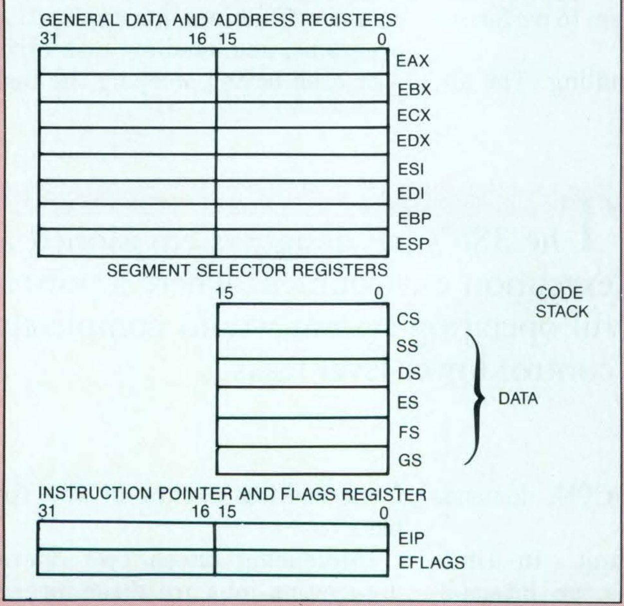

***Fig A—The 80386's 32-bit register set bears a superficial** resemblance to earlier members of the 8086 family.*

Descriptor registers are hidden

The major difference between the 386 and its forebears is the descriptor registers. Unlike the 8086/186, which uses the segment registers' contents directly, the 80286/386 uses the contents of the 16-bit segment registers as pointers. Each of the six selector registers has a descriptor register associated with it. (These descriptor registers are hidden from the software engineer's view.) When an op code designates a 16-bit selector register, the 386 also factors in addresses and attributes from the descriptor register. Thus when you command the CPU to load a selector register, it actually gets a selector-descriptor pair from a table.

A descriptor register holds a wealth of information. It has a 32-bit base address and 16-bit offset that sets the lower and upper limits (in 4k-byte min increments) of the corresponding selector's memory segment. Each segment can encompass as many as 4G bytes or as few as 4k bytes. The 32-bit sum of the descriptor's base address and the effective address is the linear address. (In virtual-memory systems, the page-address section further modifies the linear address to generate the physical address.)

In addition, the hidden attribute fields of a descriptor determine not only the length of a memory segment but also whether the segment is read-only memory, read-write memory, or executable code. Further the attributes specify the protection level of the memory segment. For example, you can set up a segment so that only tasks at a particular protection level can access it or so that tasks at differing levels can share the segment.

Unix also makes no assumptions about I/O. Therefore Unix I/O drivers can use either the general-purpose memory-mapped I/O or the special-purpose I/O space of the 386. Furthermore, Unix does not use the 386's ability to restrict access to I/O facilities depending on a task's I/O priority.

Even Unix System V version 3.1 exploits only two of the four levels of software protection available on the 386: the Unix kernel at the highest level and all the tasks at the same lower level. Therefore, with the 386, two levels of software protection remain for your use as well.

Paged virtual memory

Because the 386's paging scheme is very similar to the paging scheme of AT&T's μPs, however, Unix operating-system designers have taken advantage of the 386's paging mechanism for AT&T's Unix System V version 3.1, so you can't use it for applications or enhancements at all.

Unix function calls need only minimal CPU support. A Unix function call typically involves loading the function-call identifier and arguments into registers and then calling the operating system through a sin-

The selector-descriptor pairs also effect Intel's call-gate mechanism. With appropriate attribute bits set in a descriptor, a lower-level task can invoke a higher-level routine, such as an operating-system primitive, by using a simple function call. The 386 also uses this call-gate mechanism for task switches, interrupt handling, and software traps. (Similar to a hardware trap, a software trap is an unconditional jump (through a vector) that is activated by an instruction rather than an external interrupt.)

Understanding the call gate mechanism

The call gate appears to the calling task exactly like any other memory area. But when the calling task makes a function call to a memory area designated as a call gate, the 386 automatically changes the priority level to the level of the called function. When the called function finally returns control of the CPU to the original lower-level task, the 386 automatically resets the priority level. Other μPs require you to make a software trap to change priority levels. Only the 386 has this transparent call-gate mechanism.

Note that although any task can invoke a call gate, only a program running at the highest protection level can actually set up a call gate and modify the protection mechanisms inherent in the descriptor; the lower-level tasks can only read tables of selector-descriptor pairs.

The 386 also has an elaborate task-switching facility that saves and restores the entire state of the 386 with a single command.

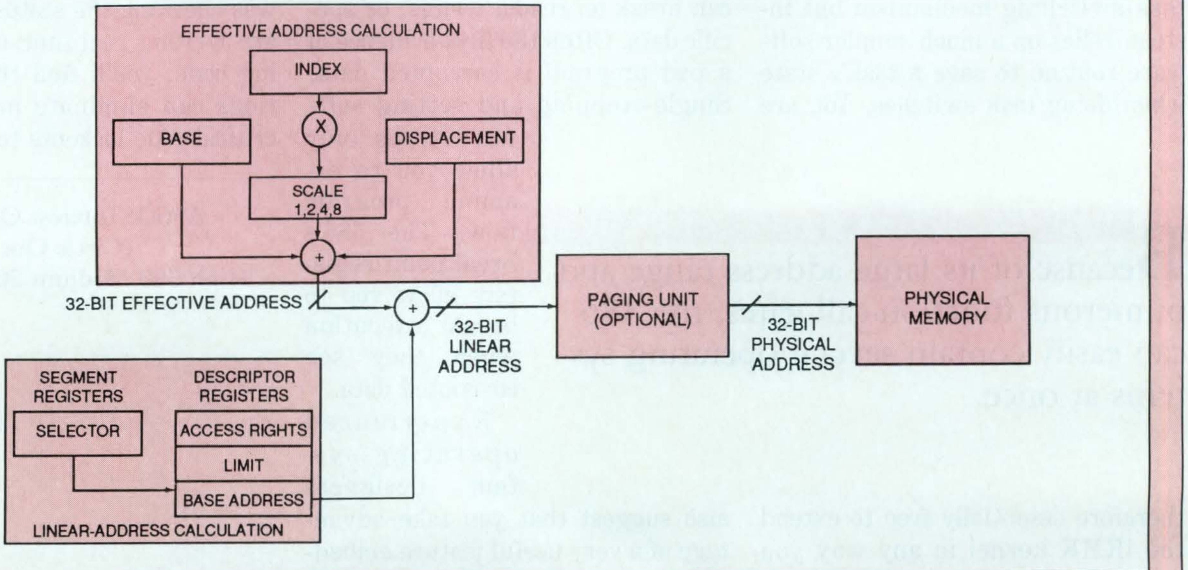

***Fig B—The 386's descriptor registers are hidden** from the software engineer's view. Each of the six selector registers has a descriptor register associated with it. When an op code designates a 16-bit selector register, the 386 also factors in address limits and attributes in the descriptor register.*

gle location. Consequently, 386 Unix function calls use only a single call gate. If you wish to add custom functions to a 386 Unix system, you have plenty of call gates left over to use. Because of its large address range and numerous function-call gates, the 386 can easily contain several operating systems at once.

Real-time systems

Real-time systems such as Intel's kernel version of iRMX, named iRMK, strain the capabilities of the 386 even less than systems like Unix do. Real-time operating-system designers strive to minimize operating-system overhead. Consequently, they tend to place all of the operating-system and applications code in RAM. They also try to minimize the amount of state-dependent information that must be saved when doing a task switch.

Intel's iRMK real-time kernel for the 386 puts all the kernel and task code in a single segment. The kernel and tasks all run at the highest priority level. The tasks make kernel calls with simple function calls—they don't use the task-gate mechanism. The kernel does not use the task-switching mechanism but instead relies on a much simpler software routine to save a task's state when doing task switches. You are therefore essentially free to extend the iRMK kernel in any way you wish.

Not all of the 386's facilities that operating-system designers find useful need to be reserved for the operating system. You can tap their experience when planning your applications programs.

Operating-systems designers applaud the 386's 64-bit barrel shifters for graphics operations. Moving objects on a bit-mapped graphics screen involves reading the screen memory, shifting the bits, and writing the shifted bits back to the graphics RAM. Earlier 8086/186/286 bit-shifting mechanisms cannot handle as many bits as the 80386 can. Consequently, bit-shifting operations in the earlier μPs consume multiple CPU cycles. The 386 proves to be at least 12 times faster in this regard than its older siblings.

Operating-system designers also appreciate the 386's built-in breakpoint registers. Other μPs merely have single-stepping and software-trap mechanisms for debugging. Using software traps to set breakpoints means that you can break only on instruction fetches. The 386's internal breakpoint registers work more like the word recognizers in the trigger sections of logic analyzers and in-circuit emulators.

In addition to breaking on instruction fetches, these registers can break on reads, writes, or specific data. Often the first evidence of a bad program is corrupted data. Single-stepping and setting software traps only allow you to examine program flow. The 386's breakpoint registers allow you to break execution when they see corrupted data.

> Because of its large address range and numerous function-call gates, the 386 can easily contain several operating systems at once.

Experienced operating-system designers also suggest that you take advantage of a very useful feature embedded in the 386's companion numerical coprocessor: The coprocessor can remember the identity of the most recent task that did numerical calculations. If you restrict all your computations to one task, the multitasking operating system never has to save the state of the coprocessor when doing task switches. And not having to save and restore the state of the numerical coprocessor can eliminate considerable overhead.

Cache problems

Operating-system designers do wish that the 386 did not flush its entire cache during task switches. Some of the contents of the virtual memory controller's translation-lookaside buffer (TLB) refer to operating-system program and data that must be present no matter which task is running.

Like the 68000 family, the 386 has single-bit test-and-set instructions. Operating-system designers like these instructions because they can use them to manipulate flags and semaphores in a single CPU cycle. When testing and setting status bits takes several cycles (as it does on most μPs), operating-system designers have to suspend interrupts during bit-manipulation operations to insure that the status didn't change while the operating system was checking the status bits. If you are writing real-time or multitasking code, you'll find these instructions can eliminate many of your critical-code lockouts too. **EDN**

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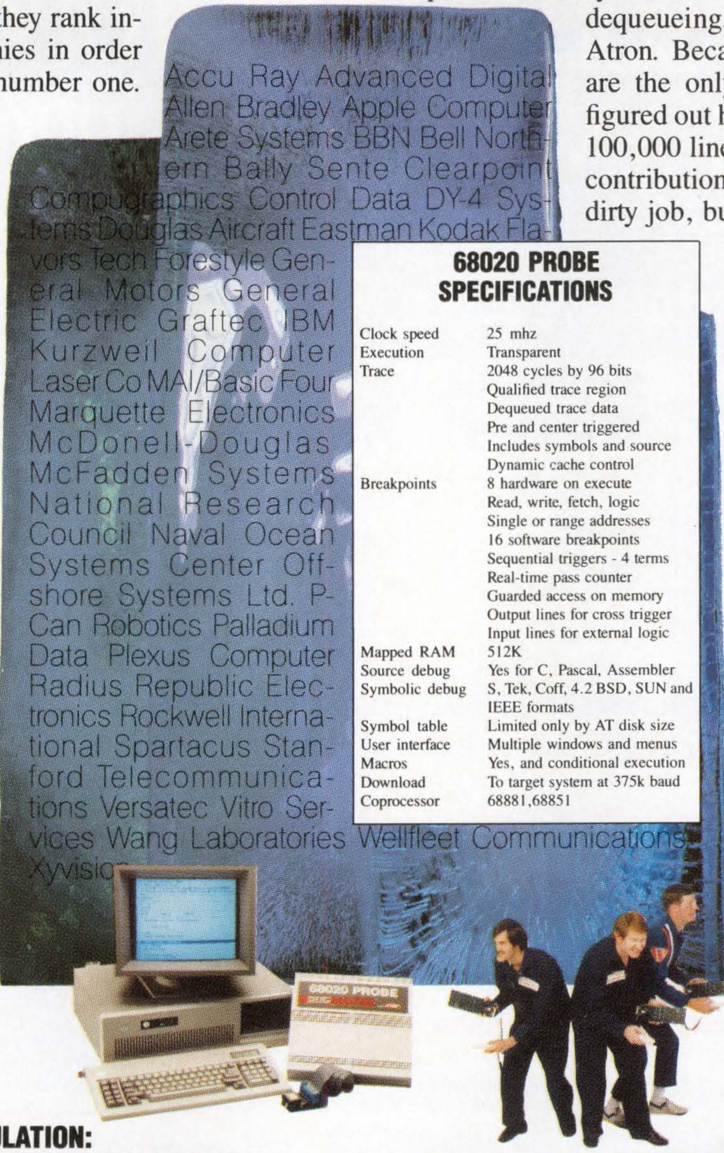

68020 PROBE SPECIFICATIONS

Clock speed	25 mhz
Execution	Transparent
Trace	2048 cycles by 96 bits Qualified trace region Dequeued trace data Pre and center triggered Includes symbols and source Dynamic cache control
Breakpoints	8 hardware on execute Read, write, fetch, logic Single or range addresses 16 software breakpoints Sequential triggers - 4 terms Real-time pass counter Guarded access on memory Output lines for cross trigger Input lines for external logic
Mapped RAM	512K
Source debug	Yes for C, Pascal, Assembler
Symbolic debug	S, Tek, Coff, 4.2 BSD, SUN and IEEE formats
Symbol table	Limited only by AT disk size
User interface	Multiple windows and menus
Macros	Yes, and conditional execution
Download	To target system at 375k baud
Coprocessor	68881,68851

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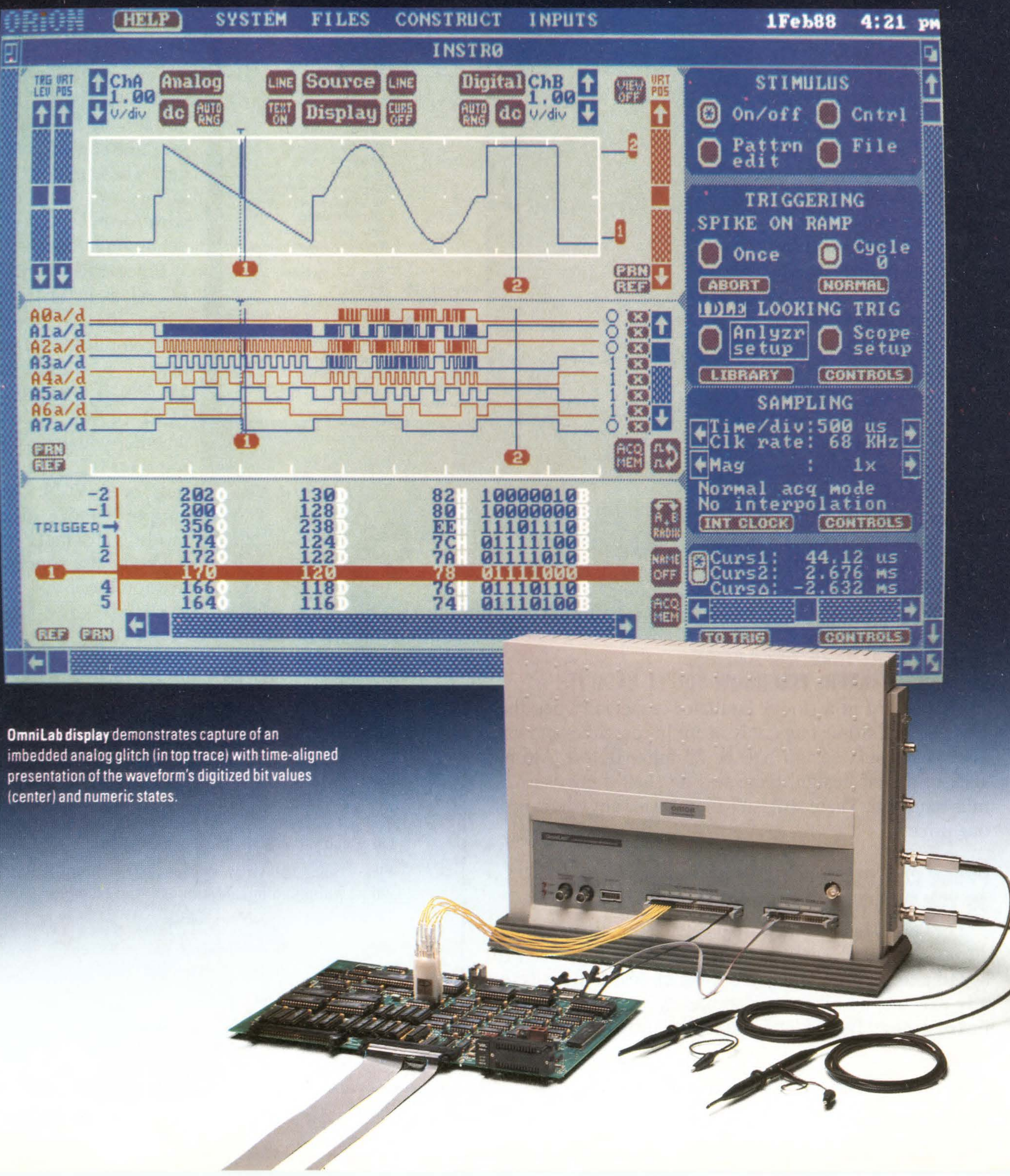

OmniLab display demonstrates capture of an imbedded analog glitch (in top trace) with time-aligned presentation of the waveform's digitized bit values (center) and numeric states.

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■ The 9240 is based on an innovative new instrument architecture that merges high-speed universal hardware and seamlessly integrated software to create high-performance capabilities not available in separate instruments. Analog and digital traces are always time-correlated in a unique, single screen display. SELECT™ triggering bridges scope and analyzer techniques. And OmniLab's stimulus generators can playback captured or edited signals.

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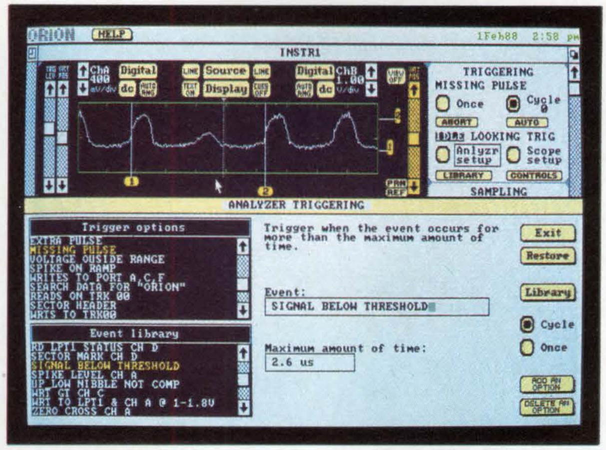
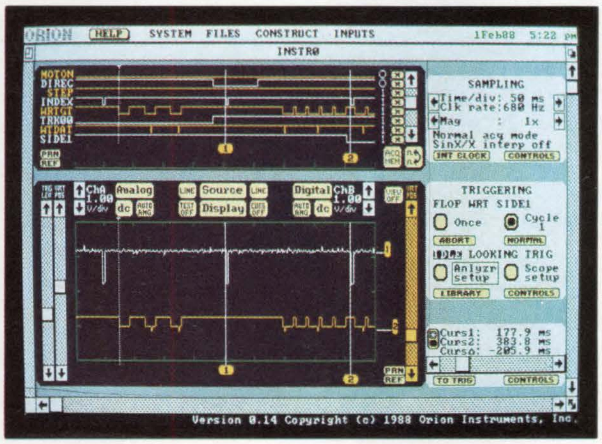


SELECT triggering on a rare event. Using Trigger Options and Event Library from the popup panel (at bottom), a trigger is selected to capture a dropout occurring when a disk drive index signal is below threshold for too long.



Logic timing analysis (top) of entire sequence for writing data to a floppy disk. Scope simultaneously displays detailed amplitude and multichannel timing information (bottom).

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Single-Shot Digitizing:	34 S/s to 204 MS/s		
Repetitive Sampling:	680 MS/s	Repetitive Sampling:	680 MS/s on 48 inputs
Scale Factor:	5 mV/div to 10V/div in 1-2-5 sequence	Synchronous Clocking:	0 to 34 MS/s
		Acquisition Memory:	4K samples (16K, 64K optional)
Record Length:	4K (16K, 64K optional)	Disassembly Options:	Over 150 microprocessors
ANALOG STIMULUS		**DIGITAL STIMULUS**	
Output:	8mV to 8 V peak-to-peak, 8 bit	Outputs:	24, 74F tri-state drivers
Cycle Length:	4 to 4K samples (16K optional)	Cycle Length:	4 to 4K samples (16K optional)
Clocking:	34 S/s to 34 MS/s	Timing:	34S/s to 34MS/s
Functions:	Record, edit and playback	Functions:	Record, edit and playback

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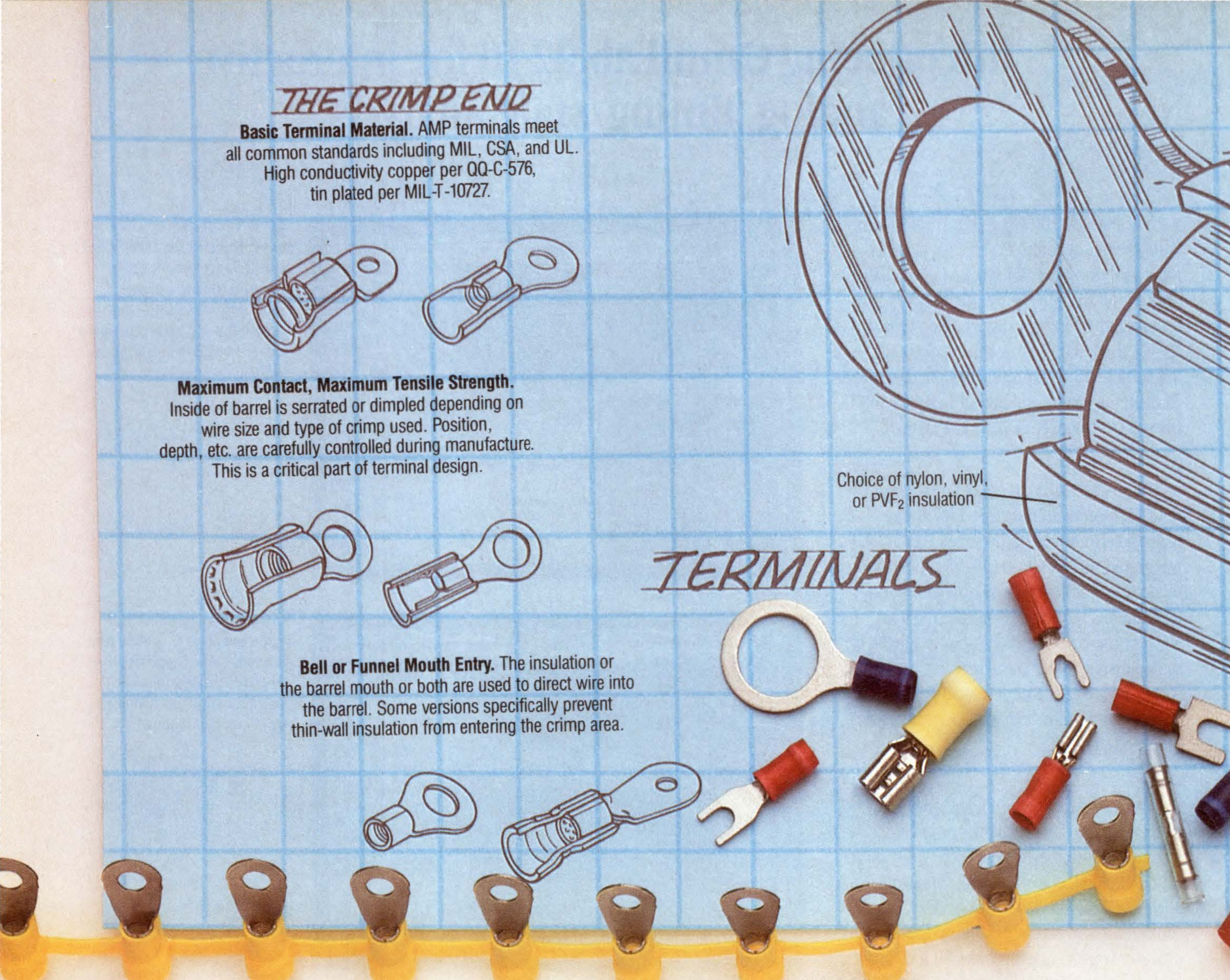

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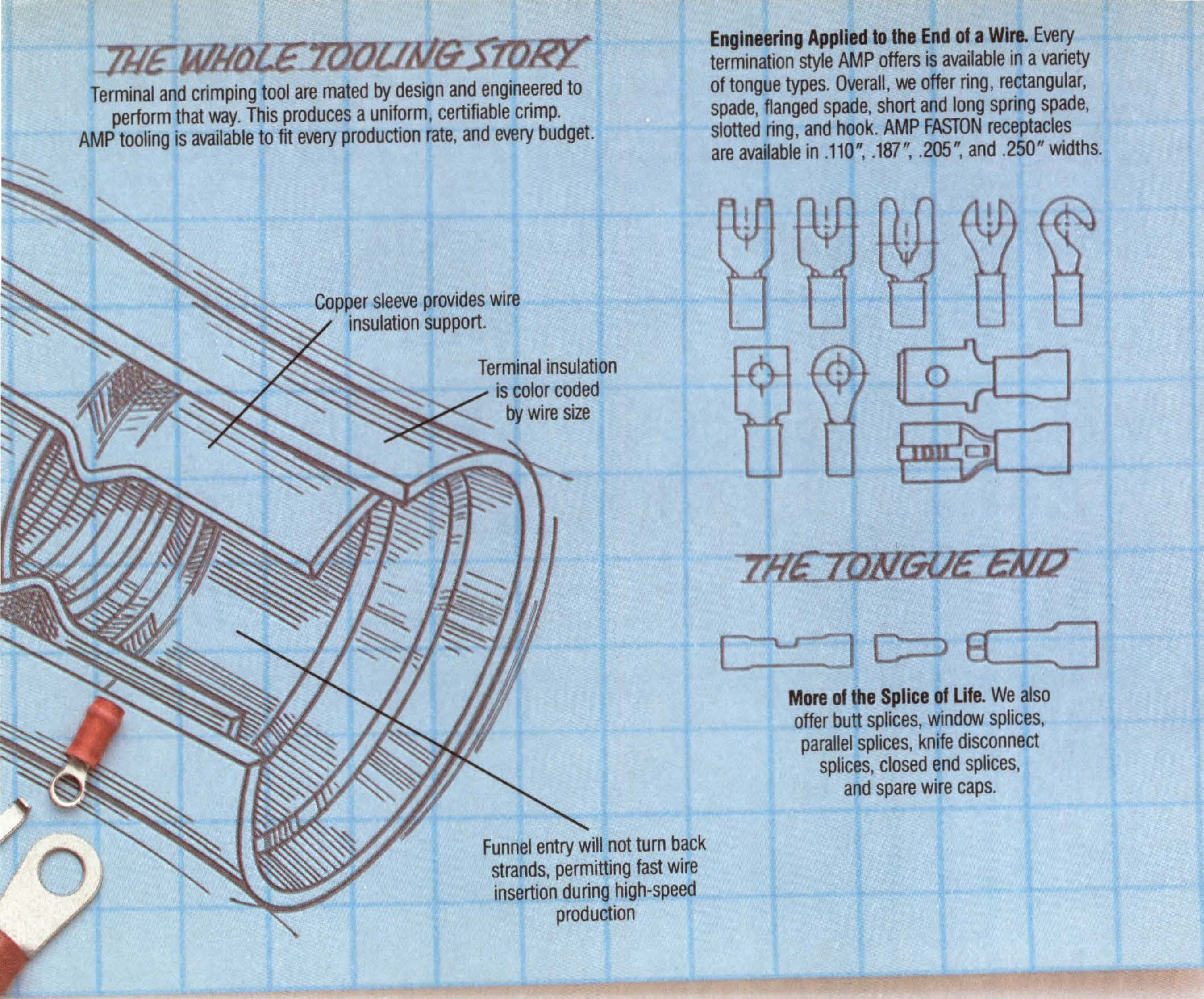

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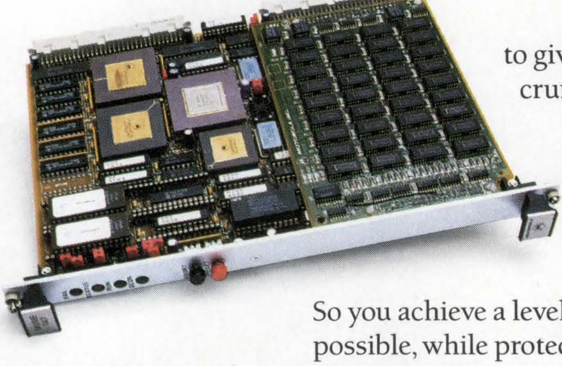

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CIRCLE NO 96

Improved voltage-reference circuits satisfy high accuracy and stability needs

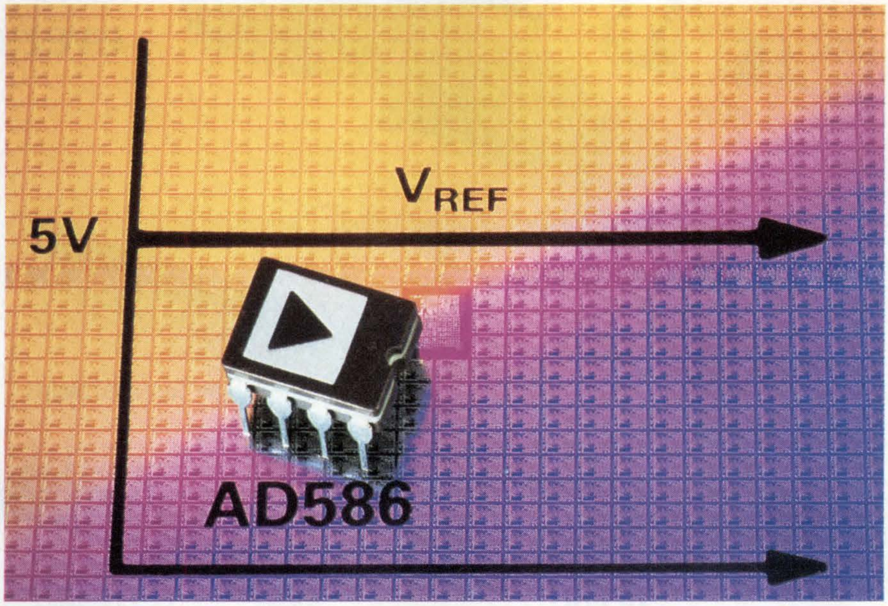
Tom Ormond, *Senior Editor*

In the last few years, reference manufacturers have markedly improved device performance. When it comes to accuracy, stability, and thermal drift specifications, today's IC references have truly impressive figures. In all three areas, they easily outperform zener diodes.

IC voltage references employ one of two technologies—subsurface zener or bandgap. In the first case, a buried zener provides the basic reference output. Typically, this subsurface zener provides very good long-term stability and low thermal drift.

Bandgap references are more complex devices. To generate the reference level, they employ two transistors in combination with the emitter-base diode of a third transistor. As a rule, bandgap references are a little noisier than subsurface zener-type references, but their noise parameters are still very respectable and quite repeatable.

Given this narrow technology base, you might think that voltage-reference choices would be rather limited. Such is not the case, however; you can find a good deal of differences in product offerings. Some references stress low power consumption, and others feature high accuracy and/or stability. You can even opt for programmable references. In fact, you can find references that are essentially application-specific.



***You can reduce wideband noise** to 160 μV p-p in the AD586 from Analog Devices by connecting a 1-μF capacitor to the noise-reduction pin. Using one potentiometer, you can also fine-trim the reference value to provide exactly 5.000V or to develop application-specific values such as 5.12V for binary applications.*

Satisfying low-power applications

If you have an application where power consumption is critical, don't despair. Precision Monolithics, Motorola, and Datel all offer references that stress low power consumption.

Precision Monolithic's REF-43, a low-power, precision reference, provides a stable 2.5V output that's impervious to variations in supply voltage, load conditions, or ambient temperature. The device is compatible with any application that requires a known stable voltage and is suitable for use in 8-, 10-, and 12-bit data-acquisition systems, including those that operate from a single 5V rail.

The reference's output voltage and temperature coefficient are both zener-zap-trimmed to ensure a tight 1.5-mV initial output tolerance and a 10-ppm/°C max thermal drift. An internal correction circuit reduces thermal curvature effects that are characteristic of many bandgap references.

Operating with supply voltages from 4.5 to 40V, the REF-43 shows less than 178 μV of output change over the full supply range—only 2 ppm/V max. The unit requires only 450 μA of quiescent current and can deliver a 10-mA output current with better than 20-ppm/mA load regulation.

The reference has a temperature output pin that lets you monitor a systems' ambient temperature. You can use this pin to develop a basic overheating indicator or in autocalibration routines.

The REF-43 is available in 8-pin metal cans, ceramic DIPs, plastic DIPs, and 20-contact leadless chip carriers. It comes in two operating-range grades—−55 to +125°C (B) and −40 to +85°C (F and G). Units processed in accordance with MIL-STD-883 will be available by mid summer. Prices start at $3.75 (100) for the REF-43GP.

Motorola offers the LM285/LM385 Series, a line of micropower, 2-terminal, bandgap voltage-reference diodes. The references go

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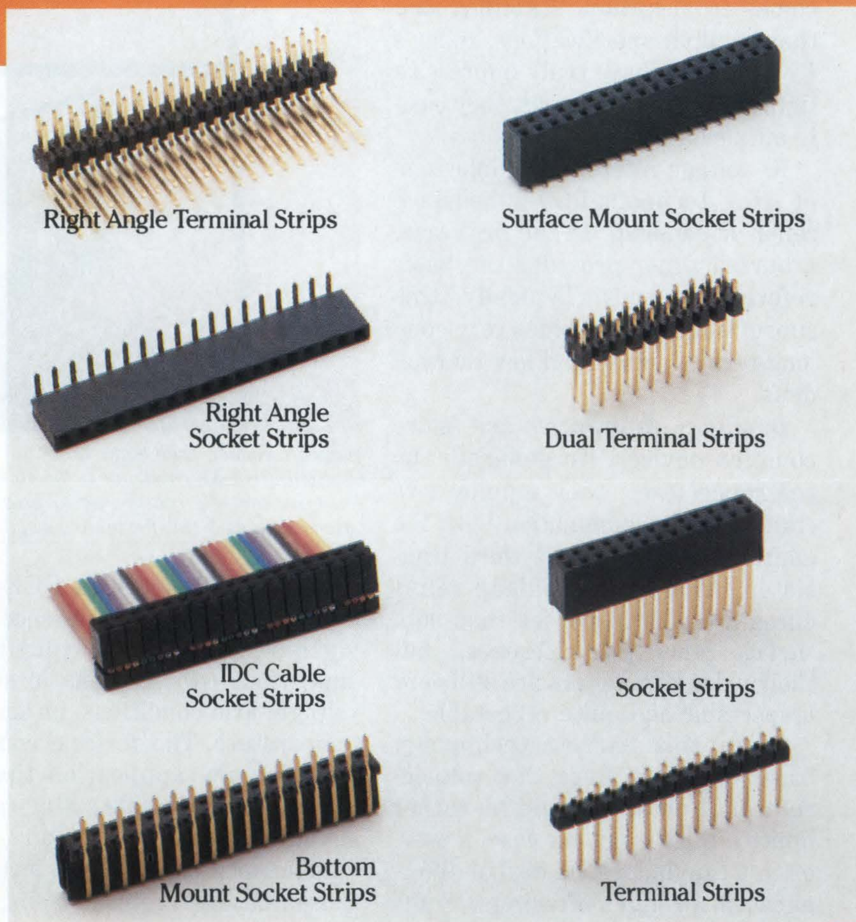

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CIRCLE NO 97

through an on-chip trimming process that tightens initial output tolerances; they feature low dynamic impedance, low noise, and stable operation over time and temperature. Low operating-current requirements make these references suitable for micropower circuitry where extended battery life is a prime design requirement.

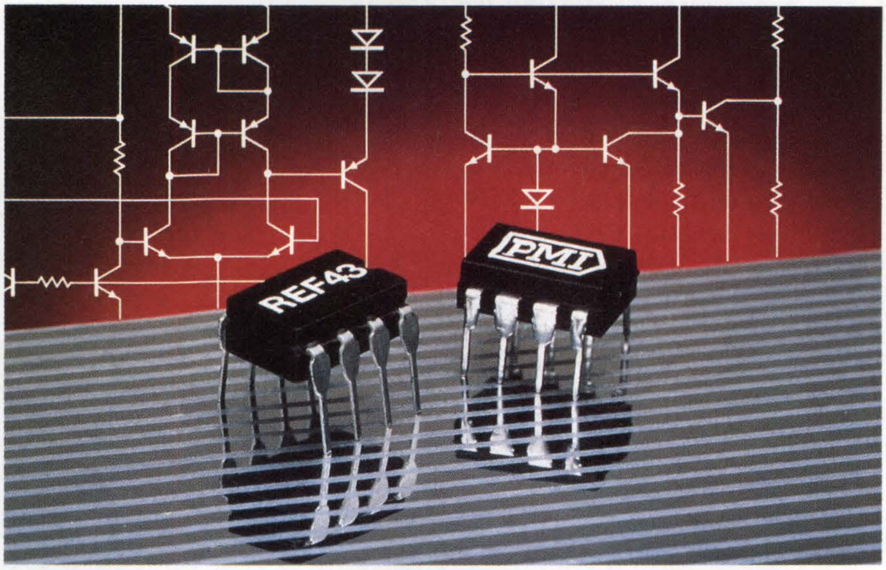
The references are available in two voltage versions (1.235 and 2.500V) and in four initial-tolerance grades (1, 1.5, 2, and 3%). Operating currents range from 10 μA to 20 mA. Dynamic impedance equals 1%, and wideband noise specs at 60 and 120 μV rms for the 1.235 and 2.5V versions, respectively. Average temperature coefficient is 80 ppm/°C, and long-term stability measures 20 ppm/1000 hours.

The LM285 and LM385 references are rated for operation over −40 to +85°C and 0 to 70°C, respectively, and are housed in TO-226AA (TO-92) plastic packages. Both versions of the LM385 are also available in surface-mountable plastic packages. Prices range from $1.10 to $1.45 (100).

Datel's VR-182 Series monolithic bandgap-type devices feature 2.455V outputs. Designed for applications involving A/D and D/A converters that do not have an internal reference, they are also useful in voltage regulator circuits, switching power supplies, comparator circuits, and other analog signal-processing applications.

Maximum reference-current and power-dissipation ratings for the VR-182 devices spec at 120 mA (derated by 1 mA/°C above 25°C) and 300 mW, respectively. Temperature coefficients equal 100, 50, and 30 ppm/°C for Models 182A, 182B, and 182C, respectively. Output tolerance equals ±35 mV (±1.43%).

An active regulator around the bandgap circuit provides a 0.1Ω typ dynamic impedance over the 2- to 120-mA reference current range. In addition, the dynamic impedance is flat to 4 kHz, rising to only 1.2Ω at 50 kHz. Other specifications include a 10-μV output noise and 10-ppm/1000-hours long-term stability.



A low-power precision reference, *the REF-43 from Precision Monolithics Inc requires only 450 μA of quiescent supply current. It features a 1.5-mV initial output tolerance and a thermal drift of 10 ppm/°C max.*

The low 2.455V reference output allows you to use these units with 5V logic supplies. In fact, you can use VR-182 Series references with supply voltages as low as 3.5V. The devices are supplied in 2-lead, hermetically sealed TO-18 packages and operate over 0 to 70°C. The A, B, and C models cost $0.75, $0.90, and $1.05 (100), respectively.

High accuracy is no problem

Voltage references are inherently accurate devices. However, not all available references offer the same degree of accuracy. National Semiconductor's LM169 10.000V unheated precision monolithic voltage reference, for example, has a 5 mV (0.05%) guaranteed initial accuracy —1 mV (0.01%) typ. It also features a guaranteed 8-ppm/mA load regulation and a 3-ppm/V line regulation. It has a guaranteed temperature coefficient of 3 to 10 ppm/°C (depending on device grade) across its entire operating range. The LM169 is characterized and guaranteed over the −55 to +125°C military range; the LM369 is characterized for the 0 to 70°C commercial range.

The reference fabrication cycle involves two separate trims—one for V_{OUT} (initial accuracy) and a second independent trim for temperature drift. This dual-trim technique optimizes temperature coefficient figures without compromising the accuracy parameter. Resistor networks are laser-cut (patent pending), rather than shaved or notched, to trim to the correct values. This scheme avoids resist drift problems attributable to electromigration.

The references also have pins available for postassembly trims for both temperature coefficient and accuracy. These pins allow users to compensate for changes in output voltage due to piezoelectric effects on the die from the die-attach or molding process, as well as any shift due to the high temperatures associated with some of the package sealing processes. You can trim the LM169 with a potentiometer in applications requiring additional accuracy. This V_{OUT} trim does not affect the temperature coefficient.

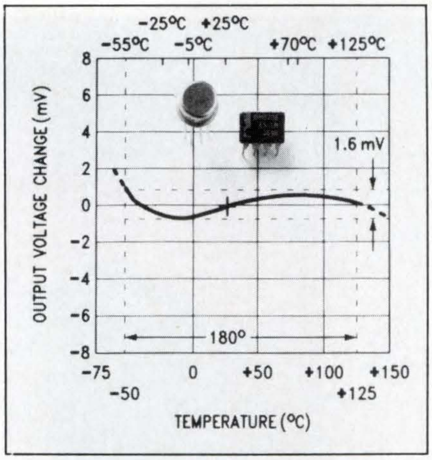
LM369 references are available in four package styles—an 8-pin plastic miniature DIP, a surface-mount SO-8, a 3-pin plastic TO-92, and an 8-pin metal TO-5 can. The LM169 is available in an 8-pin metal can only.

Prices range from $1.50 (100) for standard commercial-grade models to $19 (100) for the highest grade military-operating-range versions.

Analog Devices also offers a voltage reference that satisfies high-accuracy requirements. The AD586 5V reference features initial offset error and drift specs as low as 2.5 mV and 5 ppm, respectively. Housed in an 8-pin hermetic ceramic DIP, the unit is suited for operation as a system reference with 16-bit D/A converters, power-supply controllers, and autocalibration systems.

Internal noise-reduction circuitry lets you reduce reference wideband noise by adding a single external capacitor. A proprietary buried zener diode and production laser trimming provide low error, low noise, and high stability over time and temperature.

Typical long-term stability is 15 ppm/1000 hours. Output noise measures 4 μV p-p in the 0.1- to 10-Hz band and is only 200 μV p-p to 1 MHz. By connecting a 1-μF capacitor to the noise-reduction pin, you can reduce this wideband noise to 160 μV p-p. Using one potentiometer, you can also fine-trim the reference value to provide exactly 5.000V or to develop application-specific values such as 5.12V for binary applications. Total reference-



To optimize temperature-coefficient figures *without compromising the accuracy parameter, National performs two independent trims on their LM169 references—one for* V_{OUT} *(initial accuracy) and one for temperature drift.*

output trim capability ranges from −100 to +300 mV.

The AD586's 100-μV/mA load-regulation capability provides output stability as the load current changes. The device requires a 10.8 to 36V supply level to provide the 5V output. It will supply as much as 10 mA of load current and dissipates 30 mW typ.

The AD586 is available in five performance grades. All versions are supplied in hermetic ceramic DIPs that are compatible with auto-insertion equipment, as well as dice that are tested to commercial-temperature-range specifications. Initial errors and temperature coefficients range from 2.5 mV and 5 ppm/°C to 20 mV and 25 ppm/°C. References are available with 0 to 70 and −55 to +125°C operating ranges. Depending on grade, prices range from $2.95 to $7.65 (100).

Another high-accuracy line comes from Maxim. Its MAX672 and MAX673 monolithic bipolar voltage references are pretrimmed to within ±0.05% of 10V and 5V, respectively. Both references feature tight temperature stability (as low as 5.0 ppm/°C worst case), low current drain (1.4 mA max), and low noise (10 μV p-p for the MAX673).

Maximum input voltage for both reference families specs at 40V. Typical line-regulation figures range from 0.007 to 0.009%/V, and load regulation equals 0.002%/mA max. In both cases, the regulation figures include the effects of self heating. All units are protected against output short-circuit conditions for an indefinite period.

You can use the trim terminal on the MAX672 and MAX673 to adust the output voltage over a ±300-mV range. This feature allows designers to trim system errors by setting the reference to a voltage other than 10V or 5V, including 10.240V for binary applications. Adjusting this output has no significant effect on the device's temperature performance. The temperature-coefficient change is approximately 0.7 ppm/°C for 100 mV of output adjustment.

The MAX673 also provides a temperature-dependent output voltage on the Temp pin. This voltage is proportional to the absolute temperature and has a scale factor of approximately 2.1 mV/°C. The references are available characterized for operation over three ranges—0 to 70, −40 to +85, and −55 to +125°C. They come in TO-99 and small-outline packages as well as in plastic DIPs. Prices range from $4.35 to $10 (100).

Device stability is a key factor when you're evaluating any electronic component. While high initial

For more information . . .

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

Analog Devices Inc
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Norwood, MA 02062
(617) 329-4700
Circle No 704

Datel Inc
11 Cabot Blvd
Mansfield, MA 02048
(617) 339-3000
Circle No 705

Linear Technology Corp
1630 McCarthy Blvd
Milpitas, CA 95035
(408) 942-0810
Circle No 706

Maxim Integrated Products
510 N Pastoria Ave
Sunnyvale, CA 94086
(408) 737-7600
Circle No 707

Motorola Inc
Box 52073
Phoenix, AZ 85072
(602) 897-3842
Circle No 708

National Semiconductor Corp
2900 Semiconductor Dr
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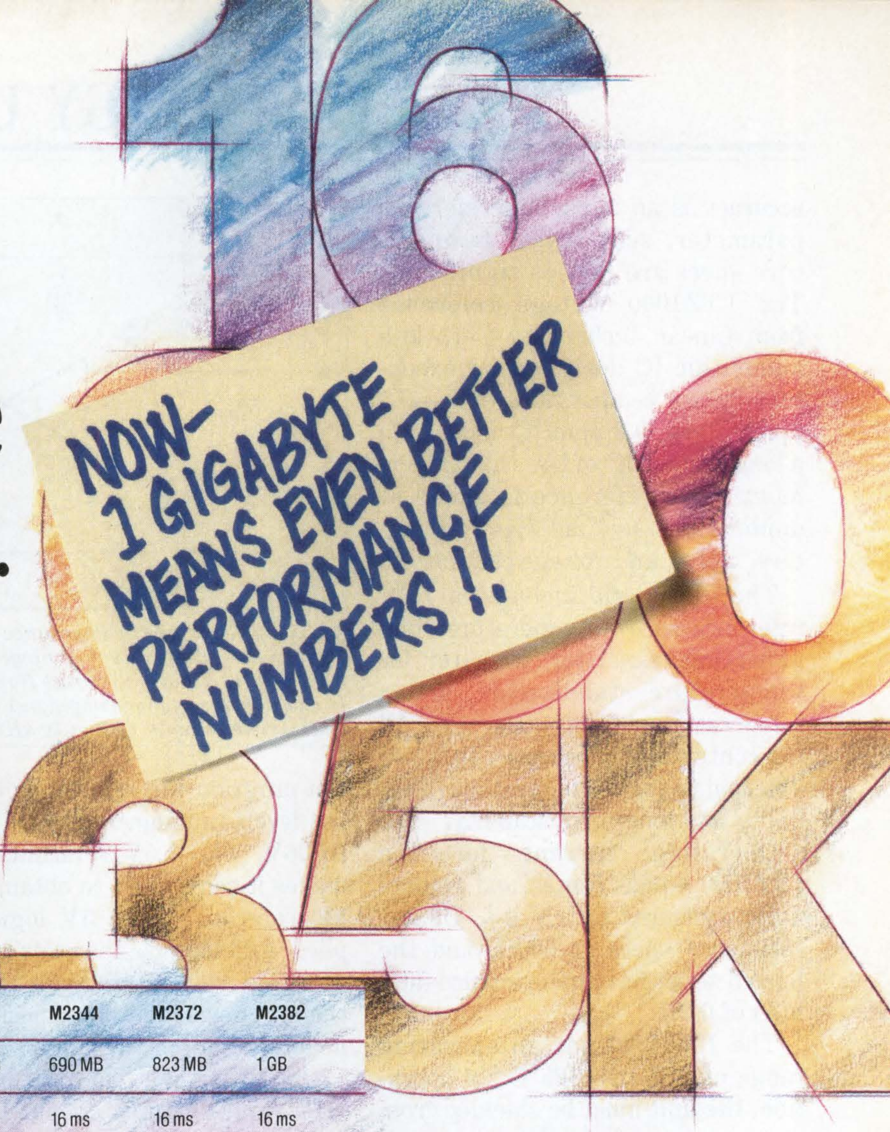

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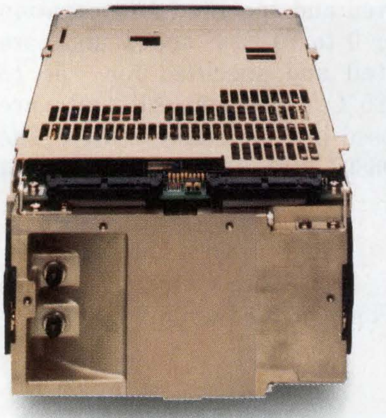

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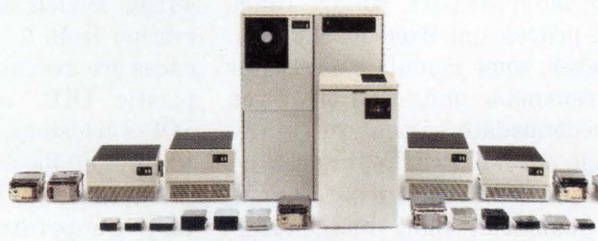

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CIRCLE NO 98

accuracy is an important reference parameter, accuracy vs temperature specs are just as significant. The LTZ1000 voltage reference from Linear Technology Corp is a monolithic IC designed for exceptionally low temperature drift—0.1 ppm/°C typ, 0.3 ppm/°C max. With a long-term drift of less than 2 ppm/month, the reference is aimed at applications such as 7½-digit meters, scales, and voltage calibrators.

The device die includes a 7.2V reference with a temperature compensating transistor, a heater for temperature stabilization, and a temperature-sensing transistor. All the control and biasing circuitry are external to the die to maximize flexibility and long-term stability.

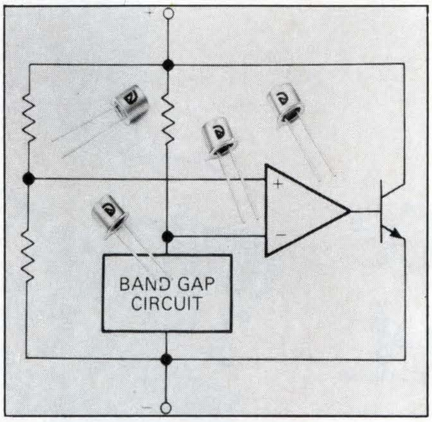
Operating current for the LTZ1000 equals 5 mA, and voltage noise measures 1.2 μV p-p. Heater resistance specs at 600Ω, and the buried zener has an impedance (at 5 mA) of 0.2Ω.

The LTZ1000 has an operating range of −55 to +125°C. In operation, the unit must be shielded from air currents; placing some thermal insulation around the package will optimize reference performance. Optimally, typical stabilized temperature is around 60°C. However, you can operate it at either higher or lower temperatures. Housed in a TO-5 package, the LTZ1000 costs $35.50 (100).

Programmability adds flexibility

For the most part, voltage references provide one fixed output level. However, some manufacturers offer programmable units that allow you to accommodate various reference-voltage needs. The TL431 and 431A ICs from Motorola are 3-terminal, programmable, shunt voltage references that operate as low-temperature-coefficient zeners. They exhibit characteristics that make them viable replacements for zener diodes in applications such as digital voltmeters, power supplies, and op-amp-based circuitry.

Using two external resistors, you can program the references to output levels ranging from V_{REF} (2.5V) to 36V. The 2.5V reference level makes it convenient to obtain a stable reference from 5V logic supplies. And because the units operate as shunt regulators, you can use them to develop either a positive or negative reference voltage source.



***A 0.1Ω typical dynamic impedance** over the 2- to 120-mA reference current range is a key feature of the VR-182 references from Datel. In addition, the dynamic impedance is flat to 4 kHz, rising to only 1.2Ω at 50 kHz.*

Output voltage tolerance specs at ±1%, and dynamic output impedance equals 0.22Ω. The references have a 1- to 100-mA sink current capability and an equivalent full-range temperature coefficient of 50 ppm/°C; they are temperature compensated for operation over the full operating range.

TL431M models are specified for operation over −55 to +125°C. TL431I and 431AI versions operate over −40 to +85°C, and 431C/431AC models are specified for operation from 0 to 70°C. The references are available in plastic TO-92, plastic DIP, ceramic DIP, and SOP-8 housings. Prices range from $0.54 (100) for a TO-92 commercial-grade device to $3.42 (100) for military-temperature-range units housed in ceramic DIPs.

Getting application-specific

Many peripheral devices on the market operate with a 12V±10% supply. In the worst case, the actual supply voltage level could be as low as 10.8V. Lack of operating headroom makes it very difficult to use a 10V reference under such circumstances. You can go to a lower reference level, of course, but you'll waste a lot of potential resolution.

With an output level of 8.192V, the AD689 from Analog Devices solves this problem. Although this output level might seem unusual, it works out to an even 2 mV/LSB for a 12-bit converter. The device uses a proprietary, ion-implanted, buried zener diode and laser-trimming to optimize initial output accuracy and temperature coefficient.

It also includes the reference cell and an amplifier, which is laser-trimmed for low drift. You can make force and sense connections on both the amplifier output and ground to maintain the accuracy of the reference cell. This scheme allows you to combine the AD689 with boosters to drive long lines or high current loads without degrading reference accuracy at the load.

Reference line regulation ranges from ±200 to ±250 μV/V, and load regulation equals 100 μV/mA. Quiescent current equals 5 mA max, and power consumption specs at 66 mW. Output gain adjustment ranges from −3 to +8%. Output voltage drifts range from 5 to 25 ppm/°C; long-term stability equals 15 ppm/°C. The AD689 has an output noise spec (from 0.1 to 10 Hz) of 2 μV p-p.

The reference is available in five grades. The J, K, and L versions are tested and specified for operation over 0 to 70°C; S and T units are tested and specified for −55 to +125°C operation. All units are housed in 8-pin ceramic DIPs. The AD689J costs $2.95 (100). **EDN**

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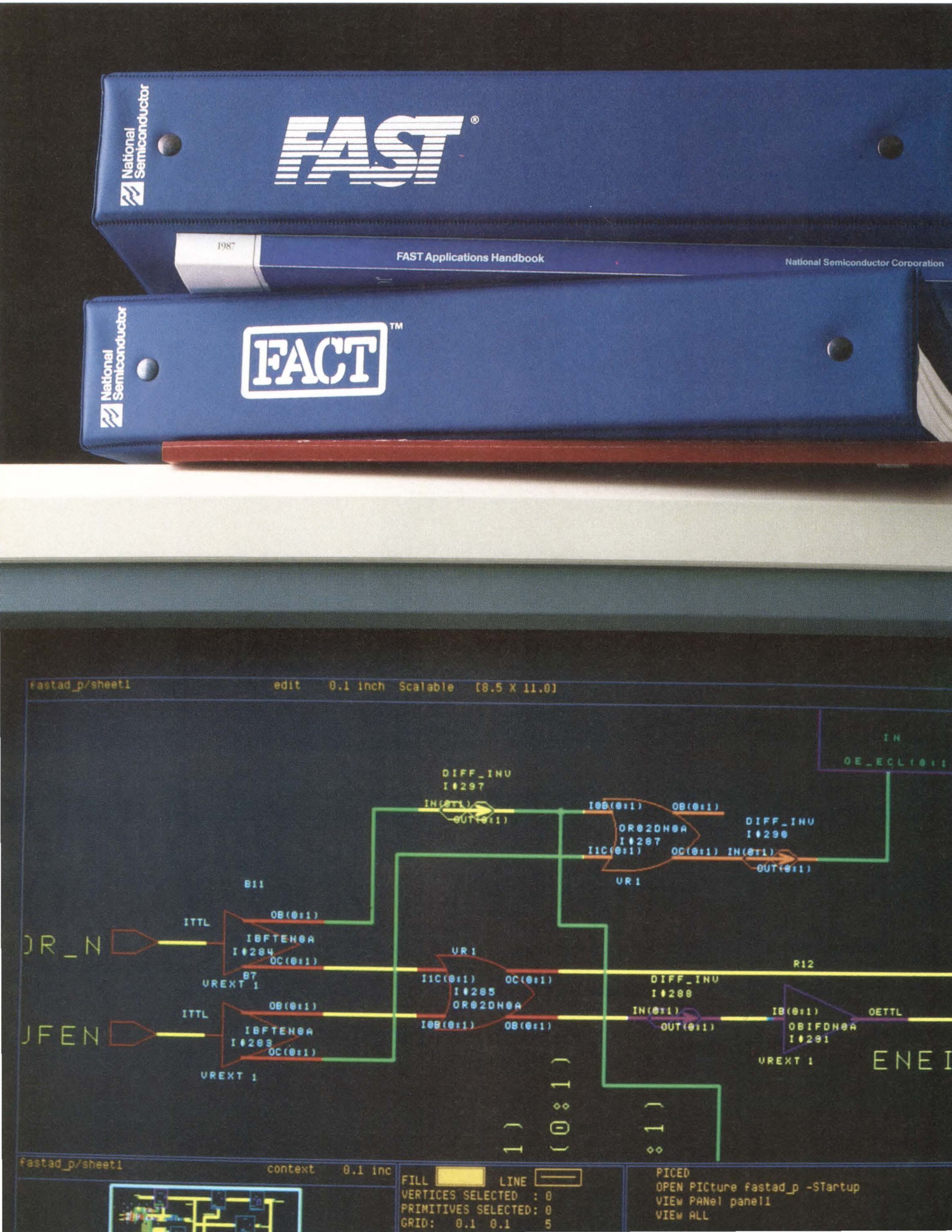

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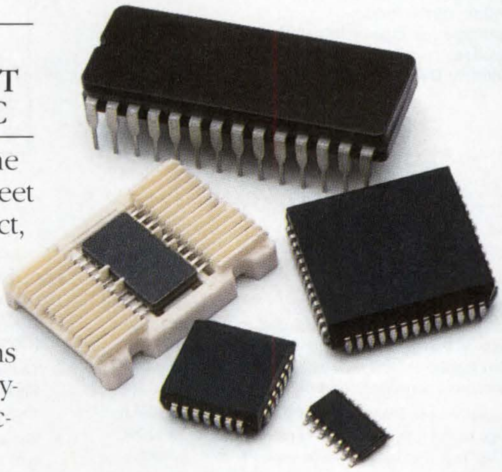

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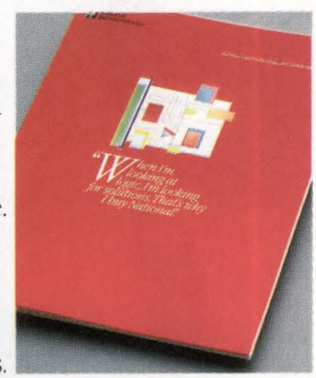

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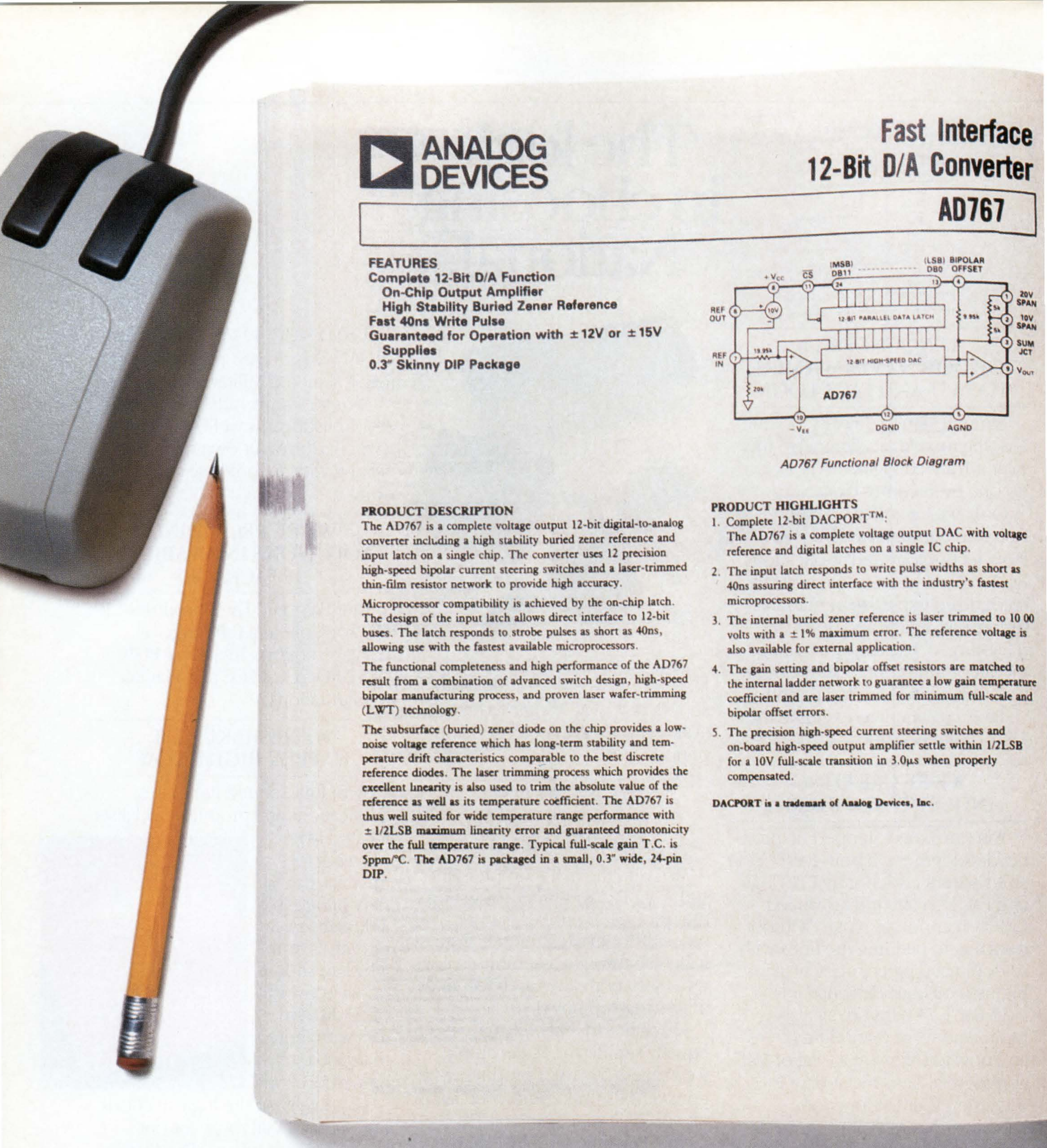


Fast Interface 12-Bit D/A Converter

AD767

ANALOG DEVICES

FEATURES
Complete 12-Bit D/A Function
On-Chip Output Amplifier
High Stability Buried Zener Reference
Fast 40ns Write Pulse
Guaranteed for Operation with ± 12V or ± 15V Supplies
0.3" Skinny DIP Package

AD767 Functional Block Diagram

PRODUCT DESCRIPTION

The AD767 is a complete voltage output 12-bit digital-to-analog converter including a high stability buried zener reference and input latch on a single chip. The converter uses 12 precision high-speed bipolar current steering switches and a laser-trimmed thin-film resistor network to provide high accuracy.

Microprocessor compatibility is achieved by the on-chip latch. The design of the input latch allows direct interface to 12-bit buses. The latch responds to strobe pulses as short as 40ns, allowing use with the fastest available microprocessors.

The functional completeness and high performance of the AD767 result from a combination of advanced switch design, high-speed bipolar manufacturing process, and proven laser wafer-trimming (LWT) technology.

The subsurface (buried) zener diode on the chip provides a low-noise voltage reference which has long-term stability and temperature drift characteristics comparable to the best discrete reference diodes. The laser trimming process which provides the excellent linearity is also used to trim the absolute value of the reference as well as its temperature coefficient. The AD767 is thus well suited for wide temperature range performance with ± 1/2LSB maximum linearity error and guaranteed monotonicity over the full temperature range. Typical full-scale gain T.C. is 5ppm/°C. The AD767 is packaged in a small, 0.3" wide, 24-pin DIP.

PRODUCT HIGHLIGHTS

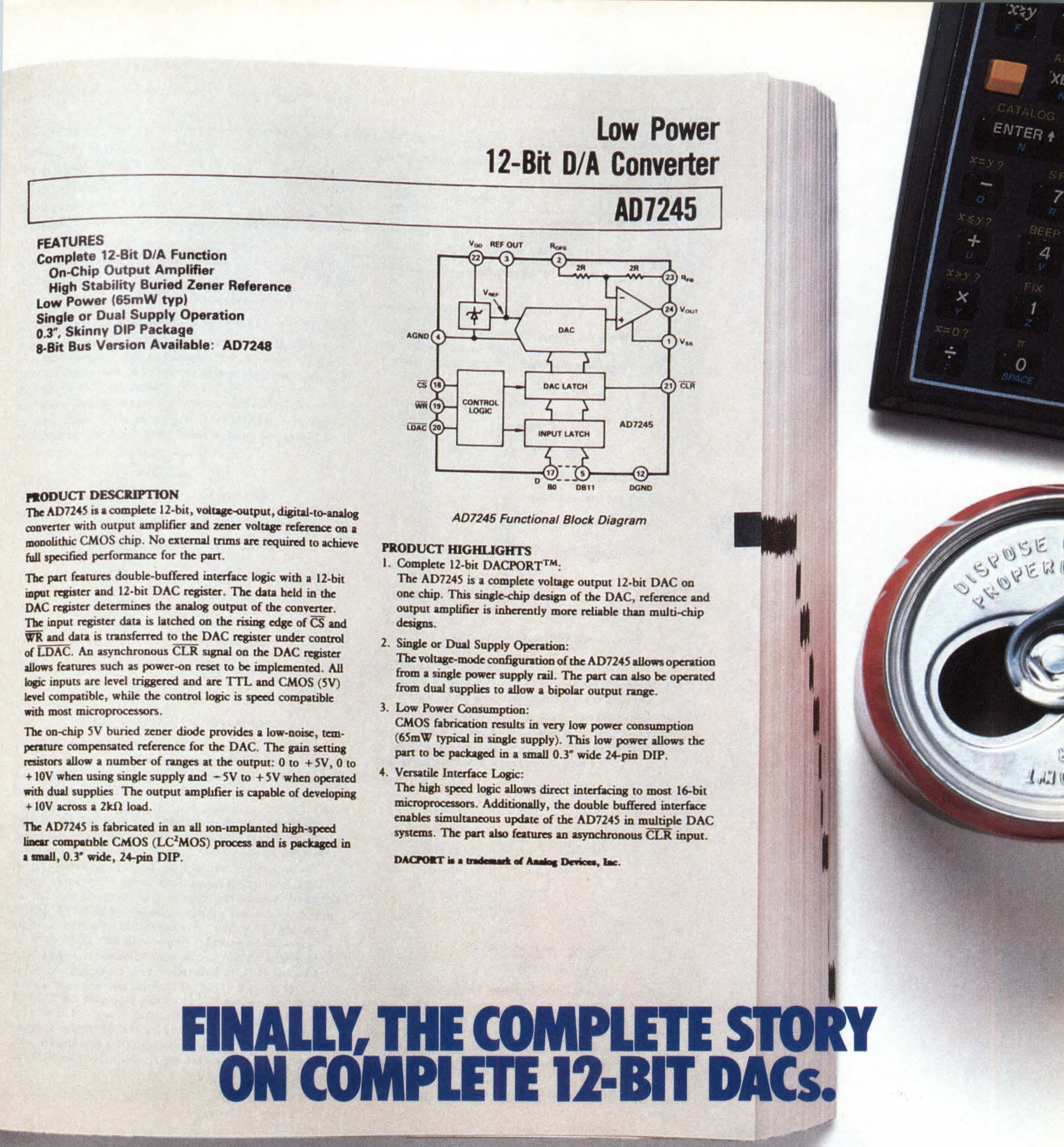
1. Complete 12-bit DACPORT™:
   The AD767 is a complete voltage output DAC with voltage reference and digital latches on a single IC chip.
2. The input latch responds to write pulse widths as short as 40ns assuring direct interface with the industry's fastest microprocessors.
3. The internal buried zener reference is laser trimmed to 10.00 volts with a ± 1% maximum error. The reference voltage is also available for external application.
4. The gain setting and bipolar offset resistors are matched to the internal ladder network to guarantee a low gain temperature coefficient and are laser trimmed for minimum full-scale and bipolar offset errors.
5. The precision high-speed current steering switches and on-board high-speed output amplifier settle within 1/2LSB for a 10V full-scale transition in 3.0μs when properly compensated.

DACPORT is a trademark of Analog Devices, Inc.

Bringing complete 12-bit DAC functionality and performance to your designs no longer requires having to deal with all the problems associated with external components. Instead, it simply requires specifying our new AD767 or AD7245.

Both the AD767 and AD7245 feature an on-chip stable buried Zener reference, output amplifier and microprocessor interface logic. And these complete functions come packed into skinny 0.3" DIPs. All this means you no longer have to deal with error budgets, product characterizations, or space constraints related to external components.

If digital interface speed is what you're after, the AD767 responds to pulse widths as short as 40ns, allowing it to be used with today's fastest processors. On the other hand, if low power dissipation is critical to your application, the LC²MOS AD7245 consumes only 65mW. There's also



Low Power 12-Bit D/A Converter

AD7245

FEATURES
- Complete 12-Bit D/A Function
  - On-Chip Output Amplifier
  - High Stability Buried Zener Reference
- Low Power (65mW typ)
- Single or Dual Supply Operation
- 0.3", Skinny DIP Package
- 8-Bit Bus Version Available: AD7248

AD7245 Functional Block Diagram

PRODUCT DESCRIPTION

The AD7245 is a complete 12-bit, voltage-output, digital-to-analog converter with output amplifier and zener voltage reference on a monolithic CMOS chip. No external trims are required to achieve full specified performance for the part.

The part features double-buffered interface logic with a 12-bit input register and 12-bit DAC register. The data held in the DAC register determines the analog output of the converter. The input register data is latched on the rising edge of $\overline{CS}$ and $\overline{WR}$ and data is transferred to the DAC register under control of $\overline{LDAC}$. An asynchronous $\overline{CLR}$ signal on the DAC register allows features such as power-on reset to be implemented. All logic inputs are level triggered and are TTL and CMOS (5V) level compatible, while the control logic is speed compatible with most microprocessors.

The on-chip 5V buried zener diode provides a low-noise, temperature compensated reference for the DAC. The gain setting resistors allow a number of ranges at the output: 0 to +5V, 0 to +10V when using single supply and −5V to +5V when operated with dual supplies. The output amplifier is capable of developing +10V across a 2kΩ load.

The AD7245 is fabricated in an all ion-implanted high-speed linear compatible CMOS (LC^2MOS) process and is packaged in a small, 0.3" wide, 24-pin DIP.

PRODUCT HIGHLIGHTS

1. Complete 12-bit DACPORT™:
   The AD7245 is a complete voltage output 12-bit DAC on one chip. This single-chip design of the DAC, reference and output amplifier is inherently more reliable than multi-chip designs.
2. Single or Dual Supply Operation:
   The voltage-mode configuration of the AD7245 allows operation from a single power supply rail. The part can also be operated from dual supplies to allow a bipolar output range.
3. Low Power Consumption:
   CMOS fabrication results in very low power consumption (65mW typical in single supply). This low power allows the part to be packaged in a small 0.3" wide 24-pin DIP.
4. Versatile Interface Logic:
   The high speed logic allows direct interfacing to most 16-bit microprocessors. Additionally, the double buffered interface enables simultaneous update of the AD7245 in multiple DAC systems. The part also features an asynchronous $\overline{CLR}$ input.

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FINALLY, THE COMPLETE STORY ON COMPLETE 12-BIT DACs.

an 8-bit bus version of the AD7245 (the AD7248) that loads in two bytes.

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To find out how the AD767 and AD7245 can tend to your complete 12-bit DAC needs, call Applications Engineering at (617) 935-5565 Ext. 2628 or 2629. Or write to Analog Devices, P.O. Box 9106, Norwood, MA 02062-9106.

ANALOG DEVICES

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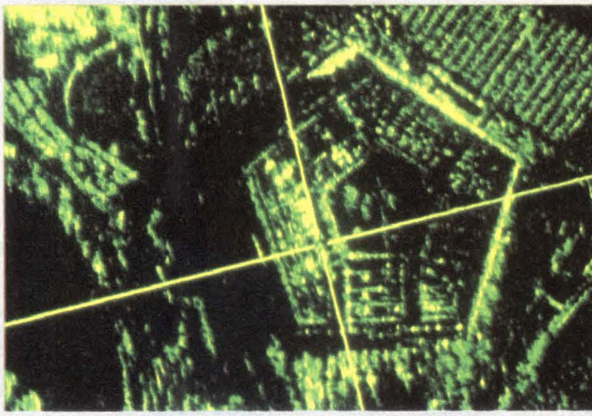

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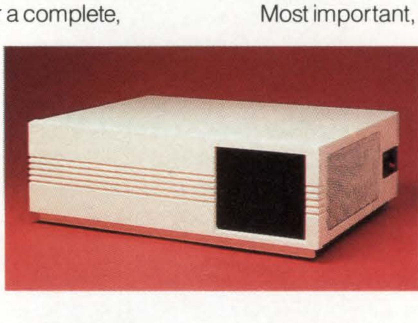

You do get a choice between two multiple-output power supplies: 190 Watts with 19A at +5V or 270 Watts with 30A at +5V. You can also choose a J2 backplane for VME extended addressing or iLBX II for a Multibus II system.

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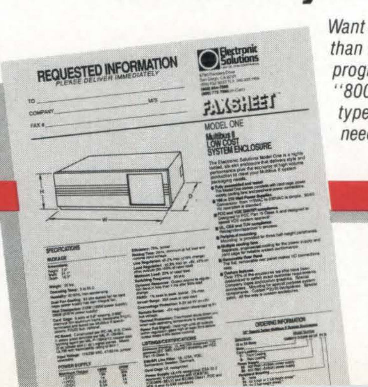

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CIRCLE NO 104

PC-based CAE software supports large memories and high-resolution displays

The Workview 2000 and 3000 CAE software packages transcend the usual limitations of IBM PC-based design software by breaking the MS-DOS 640k-byte memory limit and by supporting high-resolution video-graphics cards and displays. In fact, the company says these products bring the capabilities of the workstation to PCs, performing schematic capture, analog and digital simulation, and local-area-network communications tasks.

Workview 2000 runs on 80286-based computers and can use as much as 16M bytes of RAM. Workview 3000 runs on 80386-based machines and takes advantage of as much memory as you can stuff into your computer (to the processor's 4G-byte limit).

Both Workview 2000 and 3000 include the schematic-capture, simulation, waveform-processing, documentation, and network-communications tools offered in the company's earlier CAE products. In addition, the vendor has added a pre-placement capability, which lets you create a file of your preferred component placement for later reference by the pc-board layout designer. Using this option, you can incorporate your knowledge of critical nodes—nodes that might be sensitive to delays caused by long trace lengths—into your design documentation. Workview does not, however, include a module for performing full pc-board layouts. Instead it passes net-list and pre-placement information on to pc-board layout packages from other vendors.

A database manager named Viewfile acts as a schematic librarian, giving you more control over design changes. Viewfile performs the same functions for schematics and related design documents that source-code librarian or version-control software provides for software projects. The module allows you to group schematics together in sets, to store these sets, to lock sets so they cannot be accessed, and to mark sets for viewing only, thus preventing unauthorized modifications.

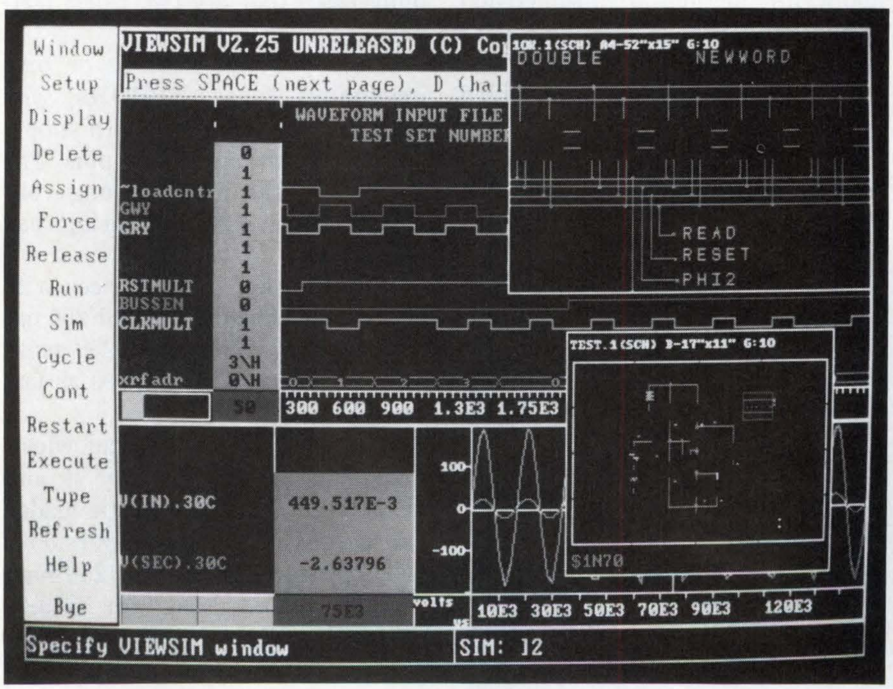
The new versions of Workview also incorporate support for the T4 graphics display card from Microfield Graphics Inc (Beaverton, OR) plus the VGA and 8514/A display cards, which are both from IBM. Using the T4 or 8514/A, Workview 2000 and 3000 can create 1024×768-pixel displays.

Previous versions of Workview used the XNS network communications protocol. The new versions of the package can also handle the TCP/IP networking protocol. In addition, the company has added support for the EDIF (Electronic Design Interchange Format) Version 2 0 0. Workview 2000 and 3000 cost $10,000 and $14,000, respectively, and will be available next month.

—Steven H Leibson

Viewlogic Systems Inc, 275 Boston Post Rd W, Marlboro, MA 01752. Phone (617) 480-0881. TLX 174242.

Circle No 700



***Support for 16M to 4G bytes of memory** and high-resolution displays makes the Workview 2000 and 3000 CAE packages for the PC competitive with workstations, according to the vendor.*

CMOS EPROMs feature in-circuit electrical erasing and reprogramming

If you need to update your EPROM-based code or data tables periodically, the 27F64 and 28F256 flash memories are 64k-bit and 256k-bit devices, respectively, that may fit your requirements. Each model lets you erase the memory in full and reprogram it in circuit—all within a few seconds.

Flash EPROMS are similar to EEPROMs in their ability to serve as alterable, nonvolatile memories. You program them one byte at a time. But, unlike EEPROMs, you erase the entire memory at once. In this respect they are more like conventional UV-EPROMs than EEPROMs. Although they are called EPROMS, you do erase flash memory electrically, thus securing simple and reliable in-circuit erasure in less than a second.

Both models are organized as byte-wide memories. The 27F64 is a direct socket replacement for JEDEC standard 64k-bit EPROMs. The 28F256, intended for new designs, has a 32-pin configuration, which is an extension of the JEDEC standard for 256k-bit devices. This extension lets you design a board that allows later EPROM replacements (to 2M bits) without any redesign.

You control the EPROMs' operations by writing commands into their control registers. The commands include setting the device to a read-only state, activating the erasure of the entire device, verifying byte erasure, programming a byte, or verifying the programming of a byte. These EPROMs are designed to safeguard against unintentional programming and erasures: You must issue the program or erase command twice, once to enable the command and the second to activate it.

These devices also incorporate other safeguards. They default to the read-only state at power-up and reset to the read-only state if you bring the programming voltage below 7V. If you hold the programming voltage below 7V, the erase and write functions are disabled and either device continues to operate as read-only memory. A reset command safely terminates an enabled erase or program command.

There is a limit on the reprogrammability of these flash memories: The company specifies that they can withstand a minimum of 100 erase/program cycles, exhibiting a failure rate less than 0.01% within that cycle range.

Neither the program nor erase commands stop on their own. Once you activate a command, you must issue either a reset or verify command to stop the process. The results of issuing these commands are cumulative, so that a series of short intervals between either a program or erase operation has the same effect as a single long interval. This feature helps minimize total programming time. It typically takes 100 μsec to program one byte.

Both devices operate at 5V and have a separate input pin for the programming voltage (V_{PP}). Both models are also available in two versions: One has a programming voltage of 12V, the other, 12.75V (the latter gives you erase and programming rates that are two times faster).

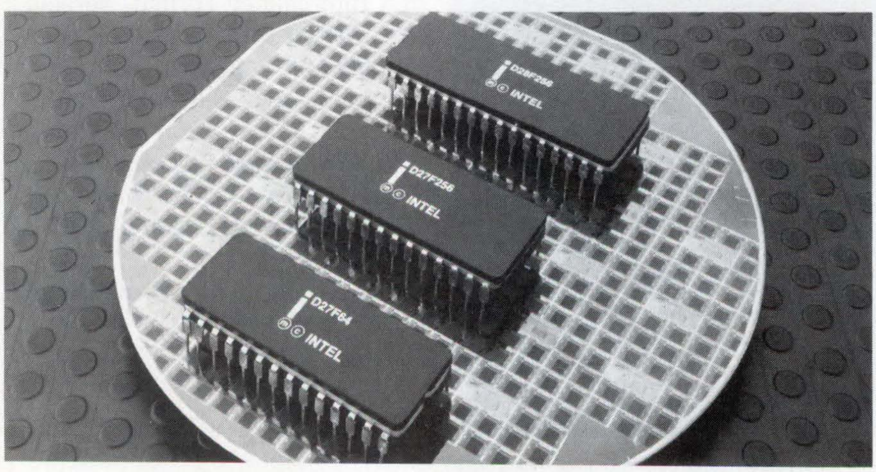
While you are erasing or programming these EPROMs, you must provide 30 mA at both supply and programming voltage pins. The demand at the programming voltage pin drops to 200 μA during read operations.

You can order these devices with a variety of speeds. The 28F256 has speeds of 170, 200, and 250 nsec. The 27F64 has access times as fast as 150 nsec.

Both devices come in windowless, ceramic DIPs. The 28F256 is also available in a 32-lead plastic leaded chip carrier. The 250-nsec version of the 27F64 costs $8; the 250-nsec 28F256 is available for $19.90 (10,000). ***—Richard A Quinnell***

Intel Corporation, 3065 Bowers Ave, Dept W-424, Santa Clara, CA, 95051. Phone (800) 548-4725.

Circle No 701



You can electrically erase these CMOS EPROMs *and reprogram them in circuit. Erasure requires less than a second. Reprogramming takes an average of 100 μsec/byte.*

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CG/2000-441A WLM 772

Mid-sized LCD controller eases window-display development

The software challenge of designing adequate interfaces between complex instruments and their users is becoming increasingly difficult to meet. Many large instruments are using CRTs and keyboards for this interface, but on smaller, (usually portable) instruments, LCD panels are showing up everywhere. The CY325 LCD-window controller eliminates most of the time spent on interface development. This device provides a high-level interface to many LCD panels that have as many as 240×64 pixels (8 rows ×40 characters).

When using LCDs with an instrument, windows can greatly simplify the operation of the product. They can display soft-key status, pull-down menus, pop-up error messages, and many other sophisticated features. However the software tasks of monitoring and controlling windows is not a trivial task. The largest portion of time spent in interfacing to these LCDs involves the making of the software driver that controls the LCD itself—and the CY325 controller facilitates this task.

Generally, the LCD panel has a low-level controller on its pc board that takes parallel information and affects pixels on the screen. Instead of having to send low-level pixel-oriented commands, the CY325 allows you to issue ASCII commands to create windows, erase windows, and draw bar graphs and logic waveforms. For graphics displays, this controller maps the image into a simple coordinate system within the selected window. You can display graphics and text in different planes within the same window.

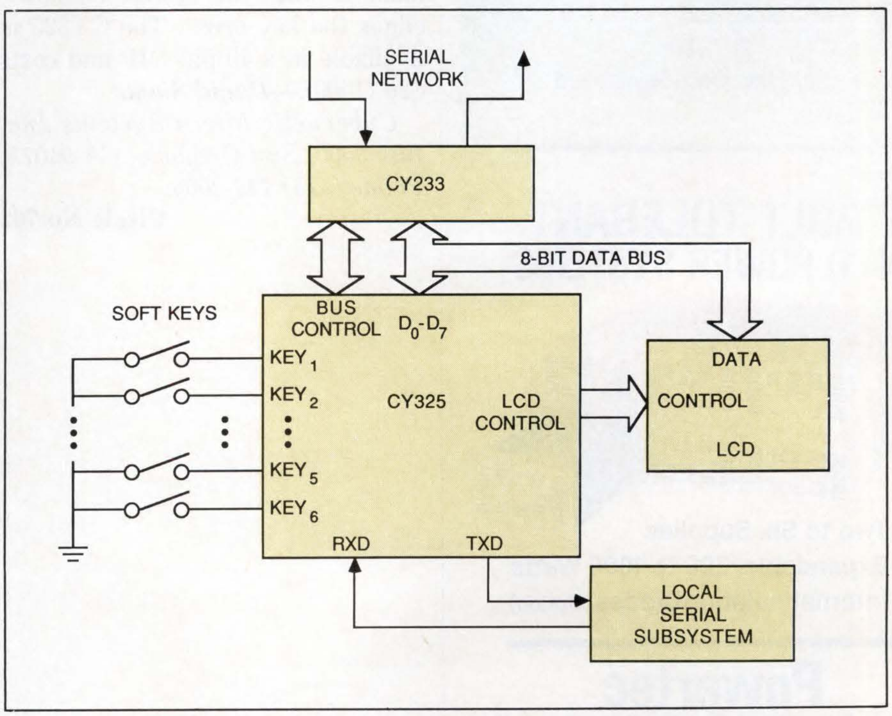
The controller can communicate with your system via either a serial or parallel interface, or both. Because of this flexibility, you can design complex distributed systems (the company's CY233 Local Intelligent Network Controller is particularly helpful in such applications).

The CY325 operates in two modes, command and display, and you can shift between them by issuing a one-stroke ASCII command. In the display mode, the device places the characters received on the screen at the cursor position. You can also clear a window, swap windows, and do a few other housekeeping operations. The display mode is the default mode at power up.

The command mode puts you directly in touch with the power of the controller. In this mode, you select a command by sending a character followed by the appropriate parameter values.

You can make a box of any size you wish and control its operation yourself, or you can just use one of the 255 available windows. Using the predefined windows greatly simplifies the basic operation. In the latter case, you can even swap windows and keep all of the last window's control data on a stack. In addition, after finishing with a new window, you can swap back to the last window and pick up where you left off.

The command list includes various simply executed operations, such as histograph generation and logic and waveform display. To generate a histograph, for example, you use the command "Hn, y1, y2, ... yn" and follow it with a carriage return. This command automatical-



The ability to use both the serial and parallel interfaces *allows the CY325 LED-window controller to work in conjunction with the CY233 network controller in distributed control applications.*

UPDATE

ly makes a histograph with "n" elements whose values are "y1" through "yn". The histograph can be either horizontal or vertical.

Another headache you can avoid using this controller arises from the difficulty involved in creating quick responses to soft keys. When the operator presses a soft key, the instrument should usually give instant feedback to the user. It's important that the first key pressed has been received and acknowledged and also that any other keys are not accepted until the first one is acknowledged. Otherwise, the user might, in confusion, press the key repetitively and thus make the instrument unusable.

The CY325 has six soft-key inputs, which it constantly scans. The switch connected to these inputs is a momentarily closed mechanism. If you want hardware feedback, the switch should have an LED in parallel. When the user presses a key, the LED lights up and the CY325 accepts the key press. Immediately, the key input is reconfigured to be an output, and the line is kept low. This action causes the LED to remain on until the system acknowledges the key press. The CY325 is available in a 40-pin DIP and costs $20 (1000).—***David Shear***

Cybernetic Micro Systems Inc, Box 3000, San Gregorio, CA 94074. Phone (415) 726-3000.

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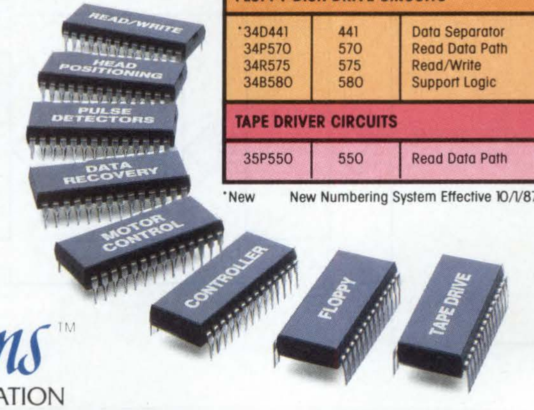
MICROPERIPHERAL IC SELECTION CHART

SSI Device Numbers New	SSI Device Numbers Old	Head Type	# of Channels	Max Input Noise nV/√Hz	Max Input Capacitance (pf)	Read Gain (typ)	Write Current Range (mA)	Power Supplies	Read/Write Data Port(s)
HDD READ/WRITE AMPLIFIERS									
32R104B	104	Ferrite	4	2.4	23	35	15 to 45	+6V, −4V	Differential, Bi-directional
32R104BLN	104L	Ferrite	4	1.7	23	35	15 to 45	+6V, −4V	Differential, Bi-directional
32R114	114	Thin Film	4	1.1	65	123	55 to 110	±5V	Differential/Differential
32R115	115	Ferrite	2, 4, 5	1.8	20	40	30 to 50	±5V	Differential, Bi-directional
32R117	117	Ferrite	2, 4, 6	2.1	23	100	10 to 50	+5V, +12V	Differential/TTL
32R117A	117A	Ferrite	2, 4, 6	1.7	20	100	10 to 50	+5V, +12V	Differential/TTL
32R188	188	Ferrite	4	2.4	18	43	35 to 70	+6V, −5V	Differential, Bi-directional
32R501	501	Ferrite	4, 6, 8	1.5	23	100	10 to 50	+5V, +12V	Differential/TTL
*32R510A	510A	Ferrite	2, 4, 6	1.5	20	100	10 to 40	+5V, +12V	Differential/TTL
*32R511	511	Ferrite	4, 6, 8	1.5	20	100	10 to 40	+5V, +12V	Differential/TTL
*32R512	512	Thin Film	8	0.9	32	150	10 to 40	+5V, +12V	Differential/TTL
*32R514	514	Ferrite	2, 4, 6	1.5	20	150	10 to 40	+5V, +12V	Differential/TTL
32R520	520	Thin Film	4	0.9	65	123	30 to 75	±5V	Differential/Differential
32R521	521	Thin Film	6	0.9	65	100	20 to 70	+5V, +12V	Differential/TTL
*32R522	522	Thin Film	4, 6	1.0	32	100	6 to 35	+5V, +12V	Differential/TTL

SSI Device Numbers New	SSI Device Numbers Old	Circuit Function	Features
HDD PULSE DETECTION			
32P540	540	Read Data Processor	Time Domain Filter
32P541	541	Read Data Processor	AGC, Amplitude & Time Pulse Qualification, RLL Compatible
HDD DATA RECOVERY			
32D531	531	Data Synchronizer	Data Synchronizer/Write Precompensation
*32D532	532	Data Separator	Data Synchronizer/2, 7 RLL ENDEC
*32D533	533	Data Synchronizer	Data Synchronizer/Write Precompensation
*32D534	534	Data Separator	Data Synchronizer/MFM ENDEC/Write Precompensation
*32D535	535	Data Separator	Data Synchronizer/2, 7 RLL ENDEC/Write Precompensation
HDD HEAD POSITIONING			
32H101A	101A	Preamplifier-Ferrite Head	AV = 93, BW = 10MHz, e_n = 7.0nV/√Hz
32H116	116	Preamplifier-Thin Film Head	AV = 250, BW = 20MHz, e_n = 0.94nV/√Hz
*32H567	567	Servo Demodulator	Di-bit Quadrature Servo Pattern: PLL Synchronization
*32H568	568	Servo Controller	Track & Seek Mode Operation; Microprocessor Interface
*32H569	569	Servo Motor Driver	Head Parking, Spindle Motor Braking
HDD SPINDLE MOTOR CONTROL			
32M590	590	2-Phase Motor Speed Control	±0.035% Speed Accuracy; Unipolar Operation
32M591	591	3-Phase Motor Speed Control	±0.05% Speed Accuracy; Unipolar Operation
*32M593	593	3-Phase Motor Speed Control	±0.037% Speed Accuracy; Bipolar Operation
HDD CONTROLLER/INTERFACE			
*32B450A	450A	SCSI Controller	Async transfer to 2MBPS; Initiate/Target Modes; Internal Drivers; CMOS
*32C452	452	Storage Controller	20Mbits/sec; CMOS; Programmable; AIC-010 Compatible
*32C453	453	Buffer Controller	Non-mux addressing to 16K; CMOS; AIC-300 Compatible
32B545	545	Support Logic	Includes ST506 Bus Drivers/Receivers
FLOPPY DISK DRIVE CIRCUITS			
*34D441	441	Data Separator	High Performance Analog Data Separator, NEC 765 Compatible
34P570	570	Read Data Path	2 Channel Read/Write With Read Data Path
34R575	575	Read/Write	2, 4 Channel Read/Write Circuit
34B580	580	Support Logic	Port Expander, Includes SA400 Interface Drivers/Receivers
TAPE DRIVER CIRCUITS			
35P550	550	Read Data Path	4 Channel Read/Write With Read Data Path

*New   New Numbering System Effective 10/1/87



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Circle No. 72 for product information

200M-sample/sec 8-bit A/D converter provides 250-MHz bandwidth

Assessing a converter's speed involves more than just looking at the conversion rate. You should consider both the input bandwidth and the input capacitance as well. The AD770 is an 8-bit 200M-sample/sec ADC with a full-power bandwidth of 250 MHz and an input capacitance of 19 pF. The device has an S/N ratio of 45 dB at 10 MHz and 30 dB at 100 MHz. This high-frequency S/N ratio falls short of the 48-dB S/N ratio considered ideal for an 8-bit A/D converter, but it's better than the rates offered by any competing converters.

Until now, all of the available high-speed (greater than 100M samples/sec) ADCs had a bandwidth that was less than the sample rate. By providing a bandwidth greater than its sample rate, the AD770 offers some advantages that may not be obvious at first glance.

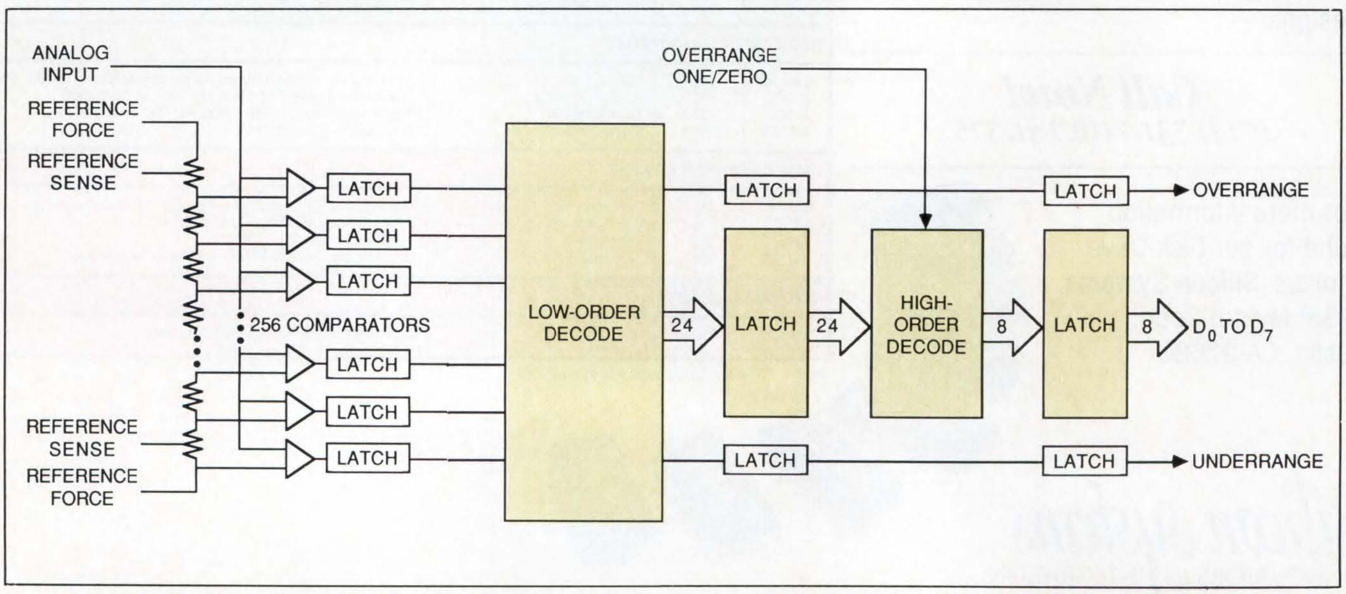
A high-speed front end is a plus in an ADC for many reasons. The 250-MHz bandwidth size in itself is important. The signal is attenuated 3 dB at this frequency and has therefore lost 50% of its power. If you are interested in the amplitude of all frequencies in the passband, you need a flat response. Having a bandwidth of 250 MHz provides a flat response to the Nyquist frequency.

Another benefit of a wide bandwidth is that the input voltage can change drastically, but you don't have to wait for the front end to settle in order to proceed. Dramatic voltage changes can occur when using a multiplexed input to the ADC; the voltage can change the full voltage range between channels. Naturally, the faster the input is and the less time you must wait for the input to settle, the faster your system can acquire data.

When acquiring repetitive signals, a converter also exploits a wide bandwidth. The standard technique for acquiring repetitive signals whose frequencies are greater than the sample rate is to sample one point on the waveform and then sample another on the next cycle, yet another on the next cycle, and so on. Eventually, the converter acquires all of the samples necessary to represent the waveform. With a wide input bandwidth, you can reproduce the input signal with less distortion.

When there are no errors, the comparators with references below the input voltage are all 1s and all those above are 0s. When noise or offsets cause a comparator that is above the input to erroneously go high (or one below to go low), the decoder logic gets confused, resulting in a large error in the output. The error detection and correction circuitry in the AD770 detects these mistakes (called sparkle codes) and modifies the input to the decoder logic to eliminate these errors.

An evaluation board is available



The AD770 8-bit ADC uses three levels of pipelining *to maintain a 200 MHz conversion rate. Overrange and underrange outputs indicate any out-of-range condition and can be ORed for a single out-of-range indication.*

for the AD770. The AD EB770 includes a socket for an AD770, an input-signal buffer, and a trimmable reference generator. On the output side, the digital data is latched and buffered and available along with the output clock. The board also includes hardware to scale the output clock by factors of 2 through 16, so you can interface slower logic analyzers to the output. An onboard DAC reconstructs the output.

The device can accept bipolar inputs, consumes 2100 mW, and requires power supplies of +5 and −5.2V. The AD770 is packaged in a 40-pin ceramic DIP and costs $175 (100). The AD EB770 evaluation board without the ADC costs $635. —***David Shear***

Analog Devices, Box 9106, Norwood, MA 02062. Phone (617) 329-4700. TLX 924491.

Circle No 703

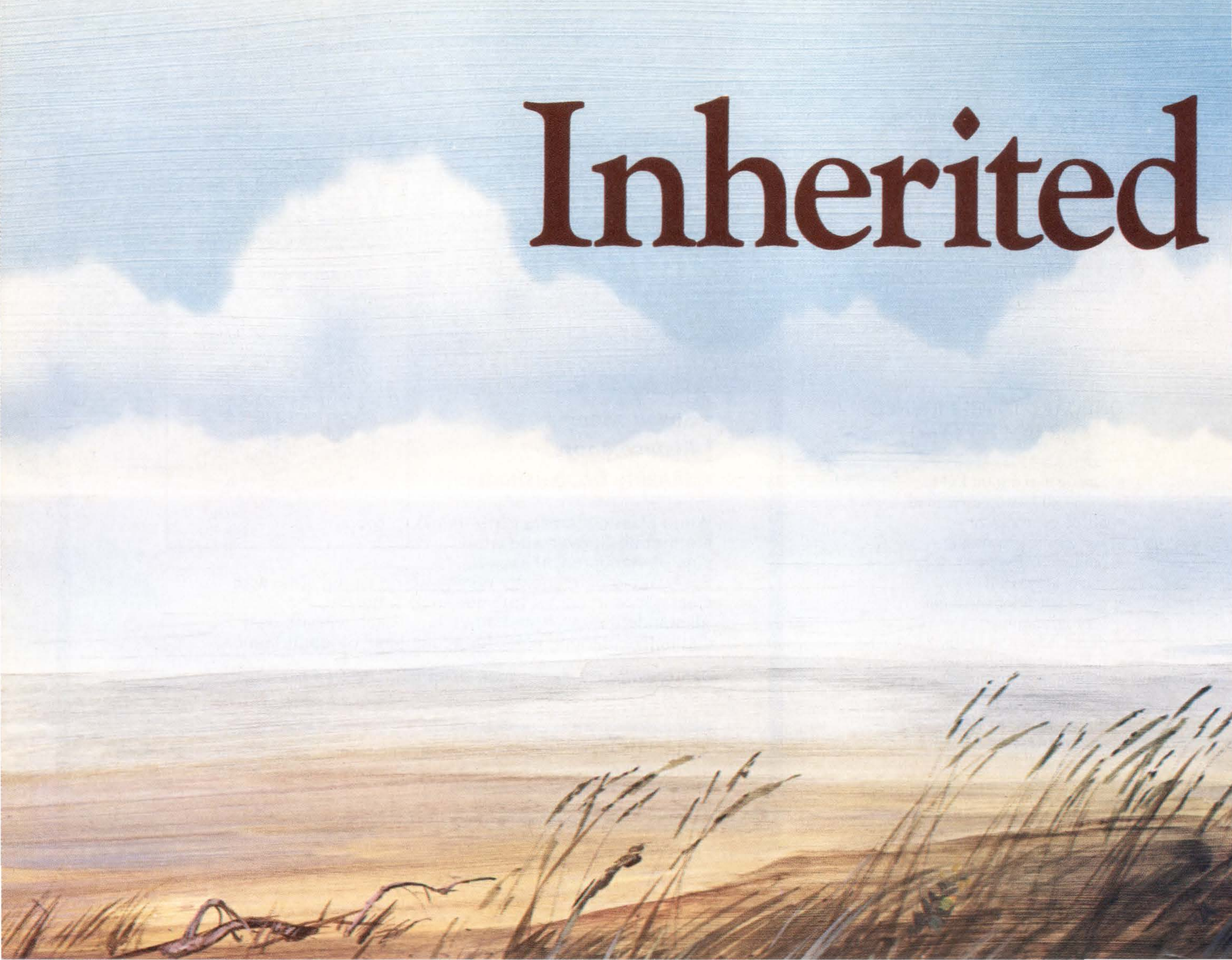
Hitachi's HD64180 Breeds Powerful New MPU Family

Thoroughbred horses are bred to be the best. Each successive generation refines and adds to the valuable traits of its ancestors. The same careful evolution also characterizes the growing Hitachi 180 family of high-integration 8-bit CMOS microprocessors. It started with the 64180 and now spans the range of general-purpose to application-specific.

The popular HD64180R and Z have earned the reputation of being the most powerful 8-bit microprocessors available. Each gives you the performance of a sophisticated 16-bit design, while maintaining 100% code compatibility with Z80 and 8080* families. Hitachi's HD64180R/Z simplify your high-performance designs and *significantly reduce your system costs* by integrating a multitude of powerful functions on chip, including an MMU, a two-channel DMAC, asynch ports, and much more.

The new 180-ZTAT™ device features even higher levels of integration, to become a complete single-chip microcontroller! It has the same CPU and capabilities of the HD64180R/Z, but adds 16K of one-time programmable ROM (EPROM), 512 bytes of RAM, an analog comparator, an extra timer, and I/O ports. The ZTAT construction gives you Zero Turn-Around Time, so you don't need to wait for mask ROM devices—the very *day* you finish design development, you're in production.

The 180-ZTAT also has the same software performance that has made the HD64180R/Z such champions. Off-the-shelf Z80 and 8080 family software runs up to 50% faster. And when you use the *enhanced* instruction set and the capability of addressing 1 Mbyte of memory, it's a whole new horse race!



Hitachi's family of powerful thoroughbreds continues to grow. Soon we'll be announcing the 180-NPU (Network Processing Unit). This device combines a high-speed Multi-protocol Serial Communications Interface with the powerful 64180 CPU. Next, we'll have the 180 Standard Cell for incredible ASIC performance.

Complete 180-Family development support is available on the IBM-PC, DEC VAX, and HP64000* from Hitachi and leading third-party vendors (such as: Hewlett-Packard, Microtec Research, American Automation, Tektronix, and many others).

For more information on the growing 180-Family, contact your local Hitachi Sales Representative or Distributor Sales Office today.

Fast Action: To obtain product literature immediately, CALL TOLL FREE, 1-800-842-9000, Ext. 6809. Ask for literature number SB-105.

*Z80 and 8080 are registered trademarks of Zilog Inc. and Intel Corporation, respectively; IBM-PC, DEC VAX, and HP64000 are registered trademarks of IBM Corp., Digital Equipment Corp., and Hewlett-Packard Corp., respectively.

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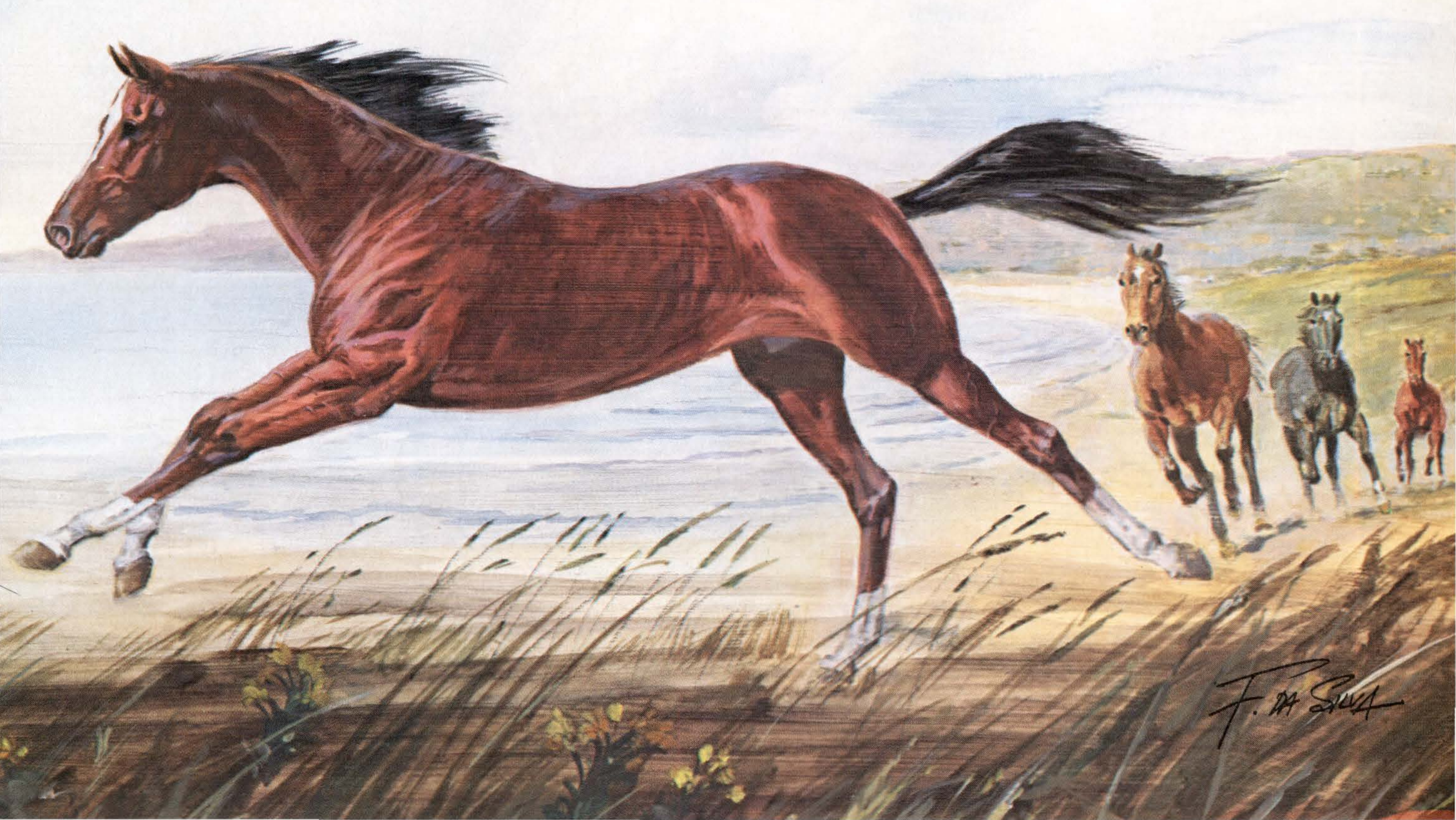
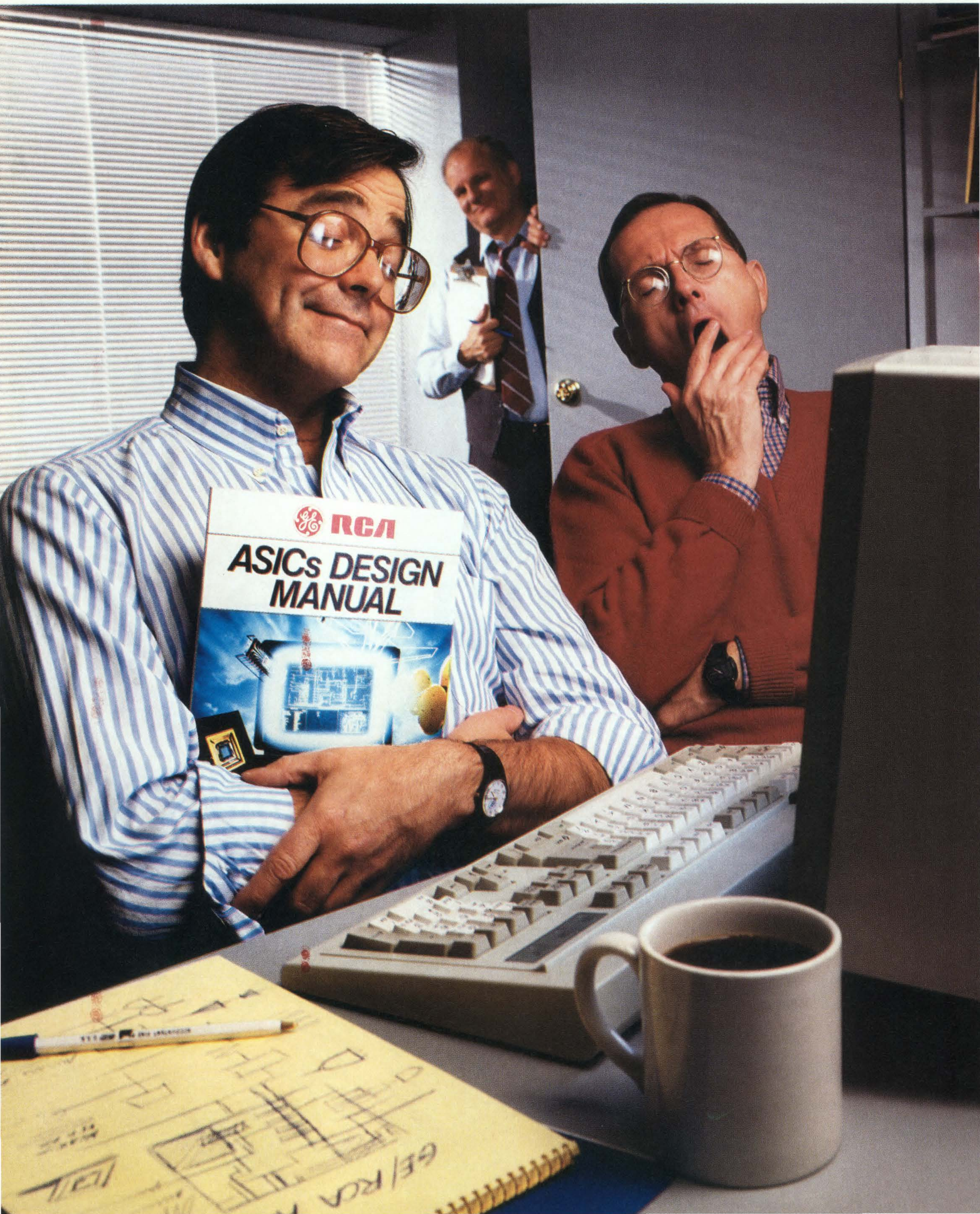
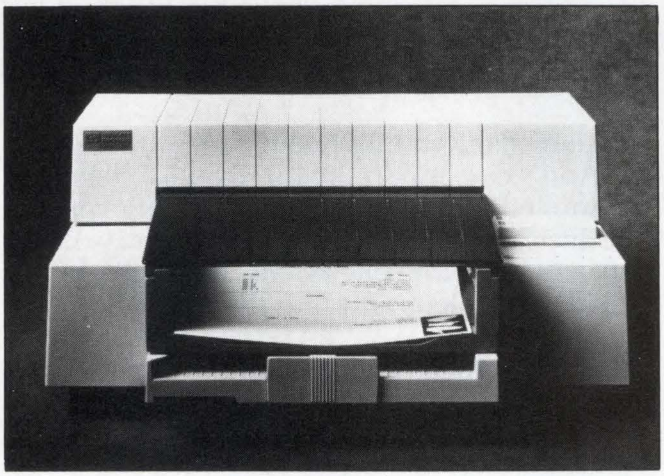


Our ASICs



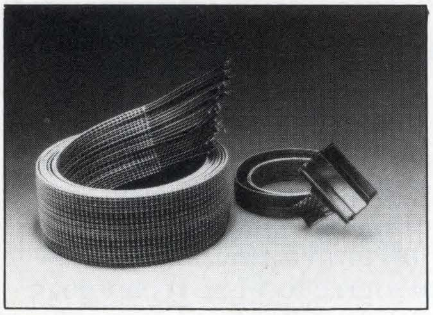
READERS' CHOICE

Of all the new products covered in EDN's **February 18, 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 **February 18, 1988,** issue.



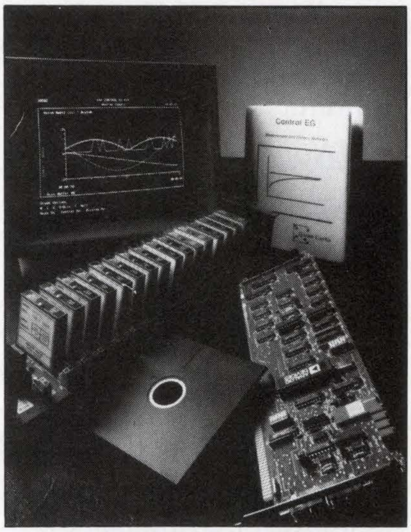
◀ PRINTER

The DeskJet is a personal printer with laser-quality output. It employs inkjet technology, but prints high-resolution text and full-page graphics at 300 dots/in. (pg 290).
Hewlett-Packard Co.
Circle No 603



◀ COAXIAL CABLE

This subminiature ribbon coaxial cable is highly flexible. You can fold it upon itself, bundle it in rectangular or round sections, or group it with other cable for routing (pg 265).
Woven Electronics.
Circle No 602

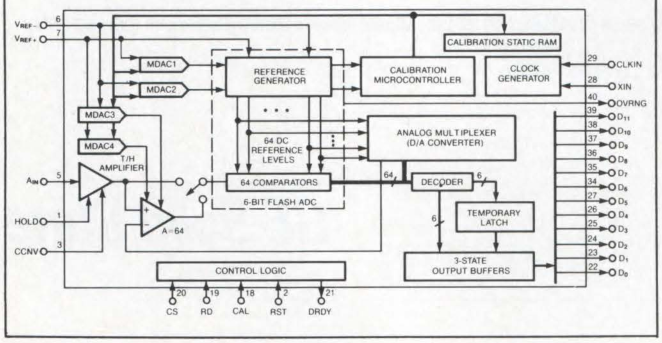


▲ CONTROL SOFTWARE

Control EG is a menu-driven, data-acquisition, process-control software package that can monitor as many as 128 analog inputs and control as many as 32 analog outputs (pg 299).
Analog Devices.
Circle No 604

PLD PROGRAMMER

The Avpal PLD programmer accepts JEDEC files created by CUPL and other PLD programming languages (pg 314).
Avocet Systems Inc.
Circle No 605



◀ A/D CONVERTER

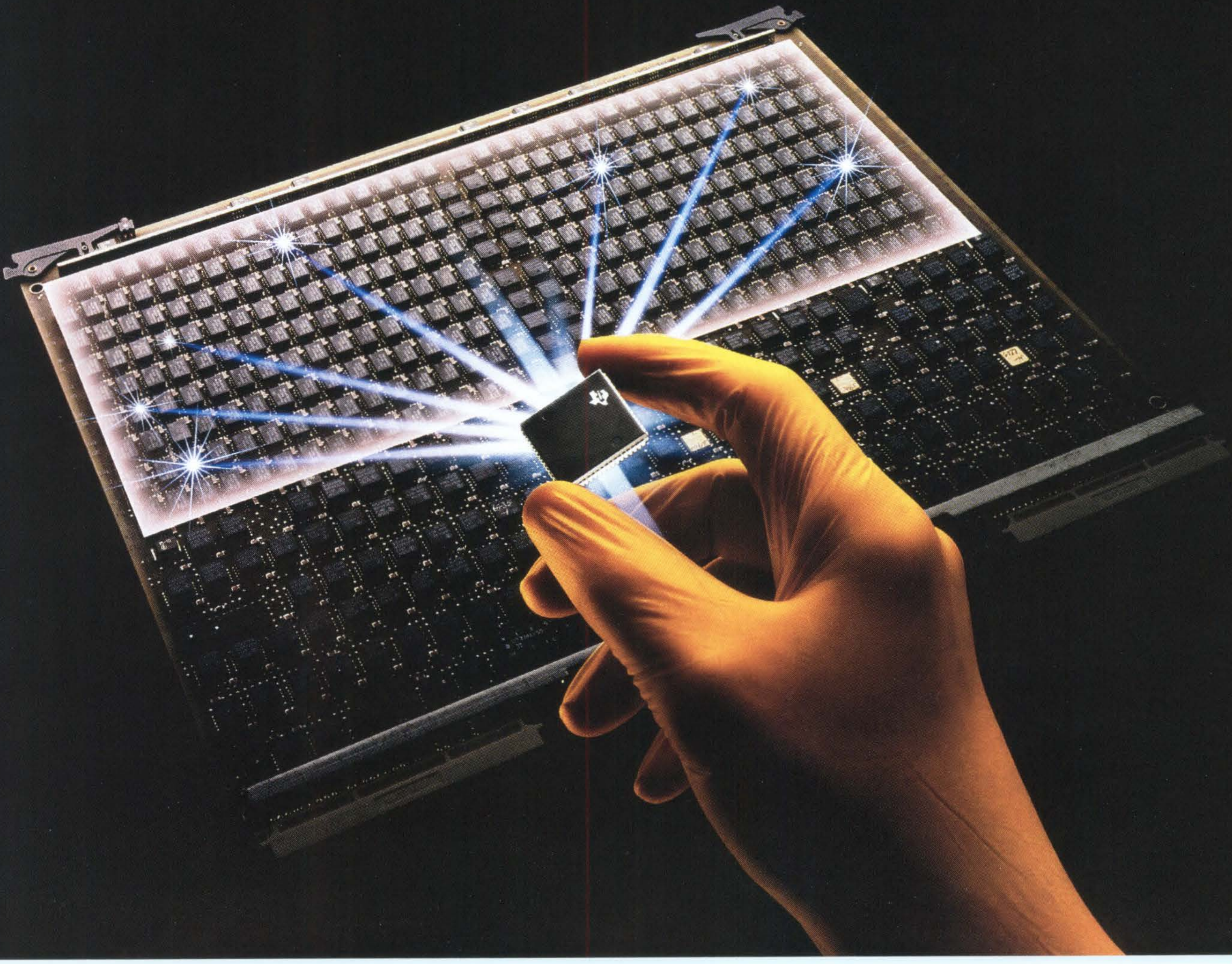
The CSZ5412-JC2 is a monolithic A/D converter that delivers 1-MHz, 12-bit performance at a low cost (pg 128).
Crystal Semiconductor Corp.
Circle No 601

TEXAS INSTRUMENTS REPORTS ON

MEMORY MANAGEMENT

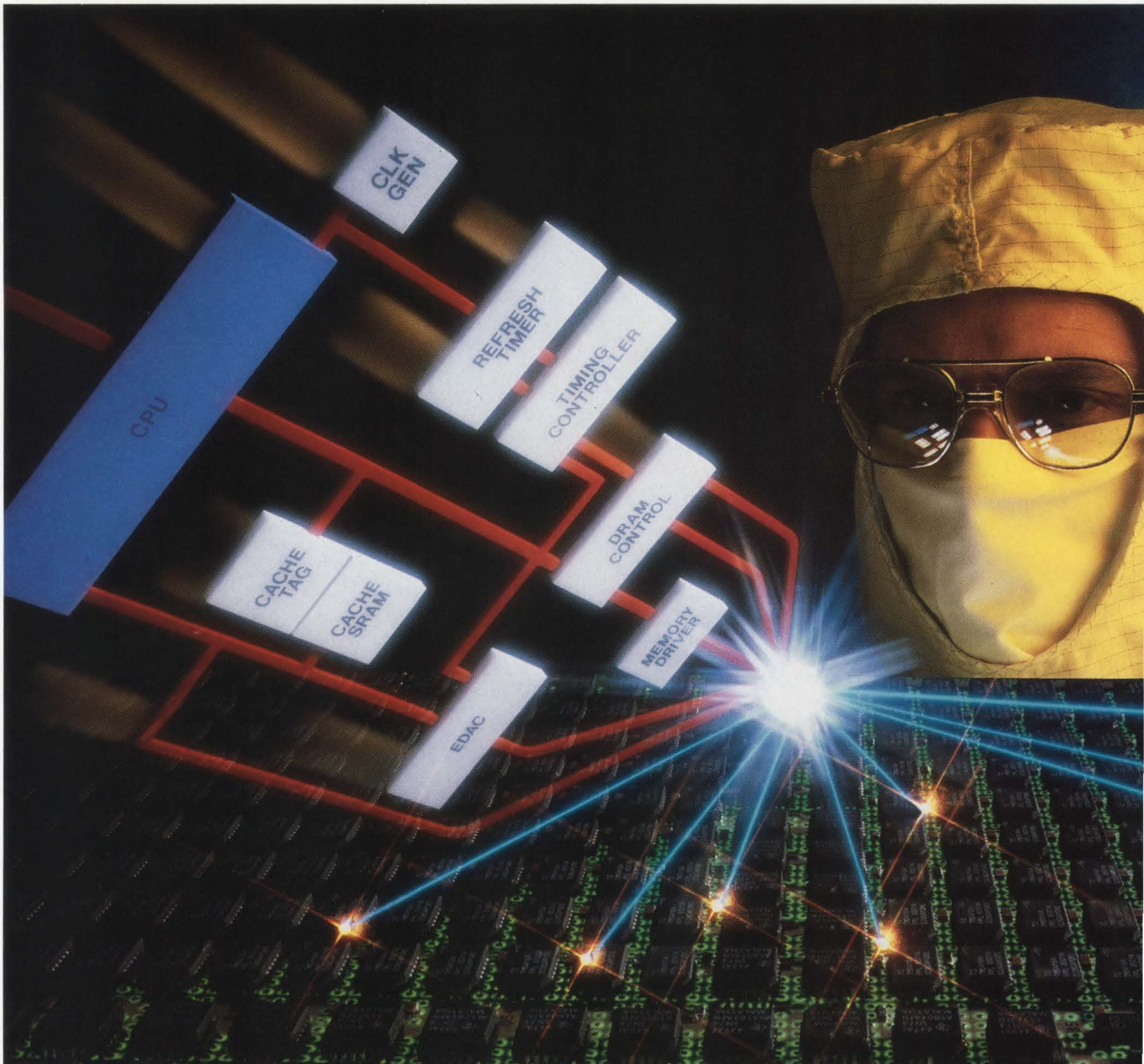
IN THE ERA OF

MegaChip
TECHNOLOGIES



Memory management in the Era of MegaChip Technologies:

Memory-management ICs from you bring memory arrays up to



Memory systems are a prime area for significant improvements in overall system throughput. Read how TI's memory-management ICs can get you in and out of memory faster no matter which processor you choose.

You can now solve a problem whose solution has eluded design eng neers for years: How to catch memor speeds up to CPU speeds. The soluti lies with TI's advanced memory-management circuits, and you can us them with whichever processor best suits your application.

Texas Instruments can help processor speeds.

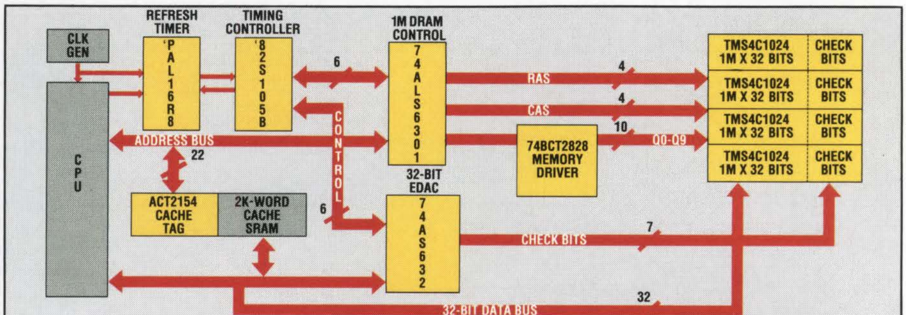
A universal architecture enables these TI devices to work with — and enhance — virtually any high-speed microprocessor or bus structure, even custom engines.

In addition, your component count is cut because these are single-chip VLSI circuits. Your design time and effort are shorter and easier because of TI's comprehensive Memory Management Design Kit *(see page 4)*.

TI addresses your major memory-design concerns

To immediately improve memory-access time, use both main and cache memories, as shown in the block diagram. This approach can produce up to a 3X increase in system performance.

Frequently accessed data and instructions are stored in a few high-speed static random-access memories and "tagged" by a TI industry-standard cache controller (SN74ACT2151/4). These 2K×8 CMOS controllers are the fastest available and can support deep cache architectures of 16K or even 32K.



High-speed memories can be designed with less effort and implemented more cost-effectively by using TI's family of universal memory-management ICs. These devices, all of which are contained in TI's Memory Management Design Kit, will work with and enhance almost any high-speed processor.

This scheme is cost-effective because slower, less expensive dynamic random-access memories (DRAMs) can be used for main memory.

When you must assure system integrity, use of an error-detection-and-correction (EDAC) circuit can improve system reliability 500-fold. Since this approach is necessary with memory arrays larger than half a million bits, TI offers its leadership 32-bit EDAC.

The SN74AS632 detects dual-bit errors and detects and corrects single-bit errors while avoiding processor wait states. And at 25 ns for error detection, it meets your high-performance needs.

Interfacing between processor and main memory gets tougher as speeds increase. But TI has the SN74ALS6301 DRAM timing controller. It can handle any DRAM up to 1 Mbit and incorporates only the essential functions on chip to improve flexibility and speed and to allow for custom timing routines. This controller supports nibble- and page-mode access and scrubbing-mode refresh to increase memory output.

TI's MegaChip Technologies

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

Soon to come: An ASIC (application-specific integrated circuit) solution.

Reducing over/undershoot is accomplished by TI's 2000 Series buffers and drivers — 25-ohm series-damping resistors on the output prevent false reads at DRAM input. For example, the SN74BCT2828 driver can reduce undershoot by 40% compared to traditional approaches. TI's 2000 Series has a high-drive current suitable for VME and MULTIBUS® II bus structures.

You can use any or all of TI's memory-management ICs to obtain the superior performance that marks a market winner. And there's no design rule that says your memory-management chips and your CPU have to come from the same supplier.

▶ *Turn page for more information.*

The tools you need to design a high-performance memory-management system are between these covers:

At $149, the value of TI's Design Kit far outweighs its cost. In one compact file, we've included just about everything you'll need to bring your memory array up to speed. Everything, that is, except your imagination in creating your own unique product differentiators. Here's what you get:

- All necessary high-performance ICs, including
  - —SN74ACT2154 2K×8 Cache Address Comparator
  - —SN74AS632 32-bit EDAC
  - —SN74ALS6301 16K to 1 Mbit DRAM Controller
  - —SN74BCT2828 10-bit Buffer/Driver with series-damping resistor
  - —TIBPAL16R8-10 and TIB82S105B High-speed Programmable-logic Devices for user-defined timing control
  - —TMS4464 256K DRAM
- *Memory Management Applications Handbook* containing applications reports and briefs that supply valuable insights into memory-management system design.
- Data sheets on TI circuits designed for efficient memory management.
- Memory-management-product software graphic-symbol libraries and supporting documentation for use with Futurenet™ or Mentor Graphics™ CAE systems.

For more information on TI's Memory Management Design Kit, call 1-800-232-3200, ext. 3203, or contact your nearest TI field sales office or authorized distributor.

Texas Instruments Incorporated SDVØ63EDØØC
P.O. Box 809066
Dallas, Texas 75380-9066

YES, please send me more details on TI's universal memory-management ICs.

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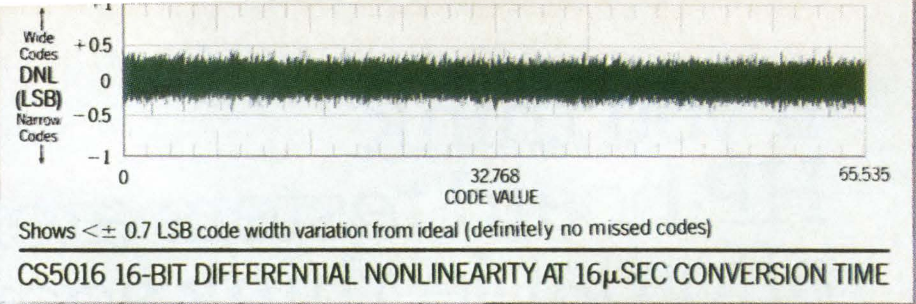
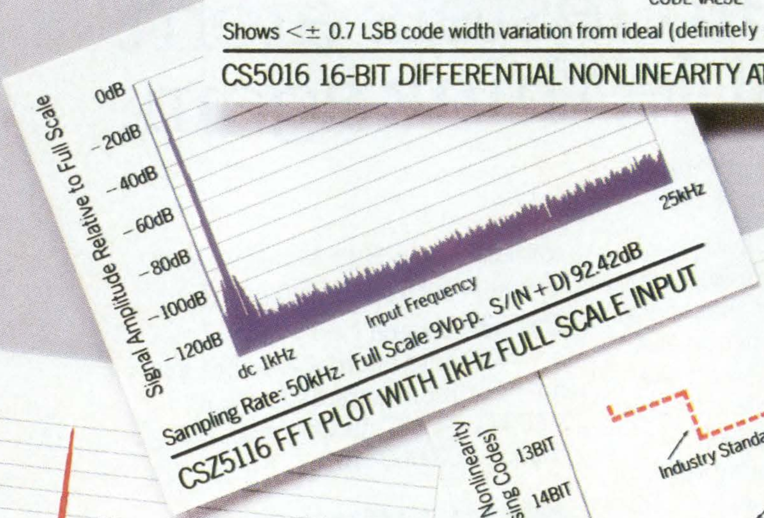
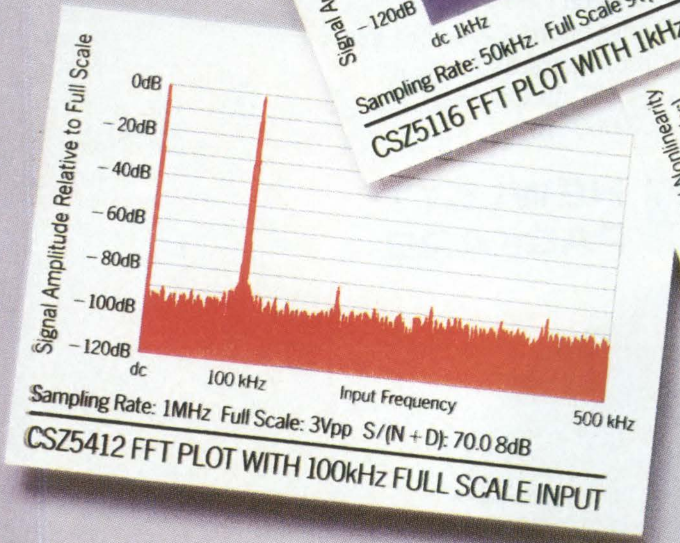
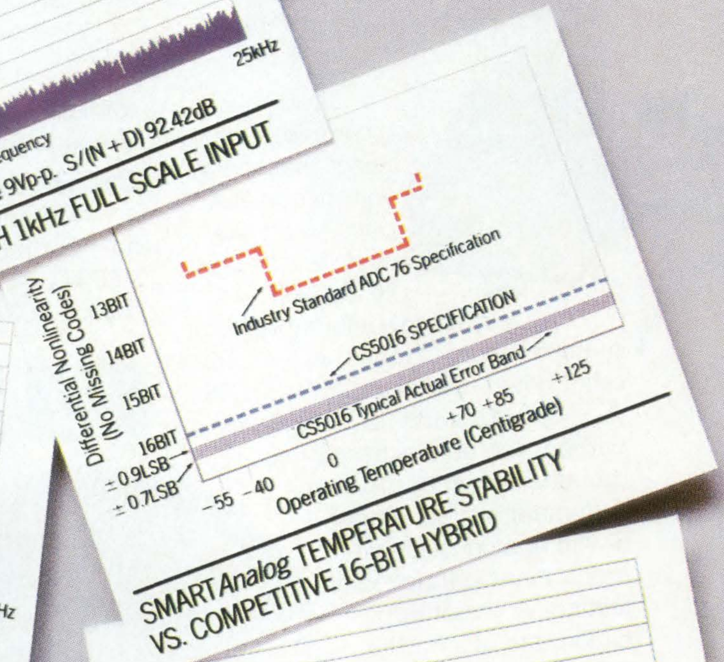
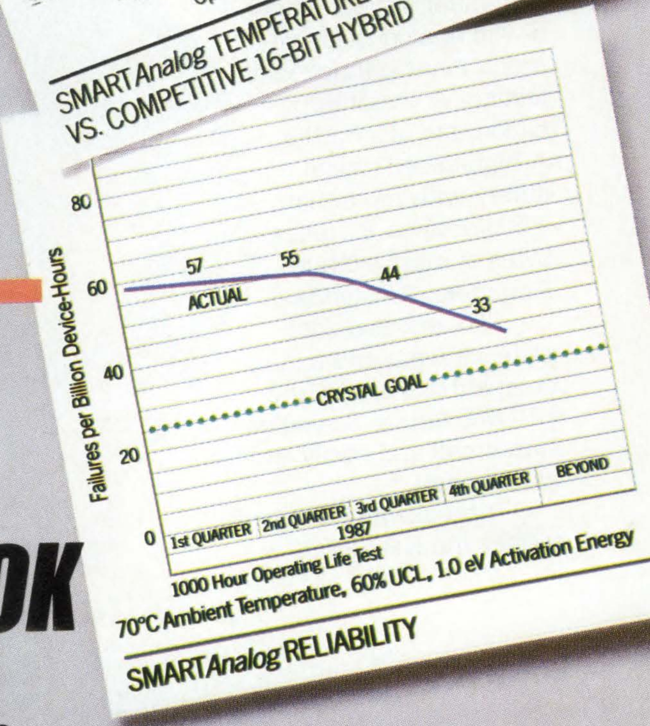
TEXAS INSTRUMENTS











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If that weren't enough, Crystal's SMART*Analog* line is the first line of 12- to 16-bit A/D converters with the converter, track/hold, digital interface, calibration circuitry and timing all on a single chip. So you can forget designing, building and characterizing discrete devices while trying to correlate component specifications with system requirements.

Prove to yourself how our revolutionary SMART*Analog* technology makes hybrids a very expensive proposition, indeed. Call 512-445-7222 today for your very own 12-, 14- or 16-bit evaluation board. Or ask for a demonstration at your facility.

Either way, you'll know why seeing a SMART*Analog* converter in action makes our promises on the opposite page seem flat by comparison.

DEVICE	STATIC-TESTED ADCs CS5016	CS5014	CS5012	CS7820	DYNAMIC FFT-TESTED ADCs CSZ5412	CSZ5316	CSZ5116	CSZ5114	CSZ5112
Resolution	16	14	12	8	12	16	16	14	12
Conversion Time (μsec)	16	14	7	1.3	1.25		16	14	7
Throughput Speed (kHz)	50	56	100		1000	20	50	56	100
Static Specifications:									
Linearity Error (% FS, max)	+/−.0015	+/−.003	+/−.012	+/−.2	+/−.01				
No Missing Codes (Bits)	16	14	12	8	12	16	16	14	12
Dynamic Specifications									
THD (%)					.02	.007	.001	.003	.008
S/(N+D) (dB)					70	84	92	83	73
Power Dissipation (mW)	120	120	120	40	700	220	120	120	120
On-Chip Sample and Hold	YES	YES	YES	YES	YES	YES	YES	YES	YES

The proof behind the promise: monolithic CMOS performance that beats even hybrids.

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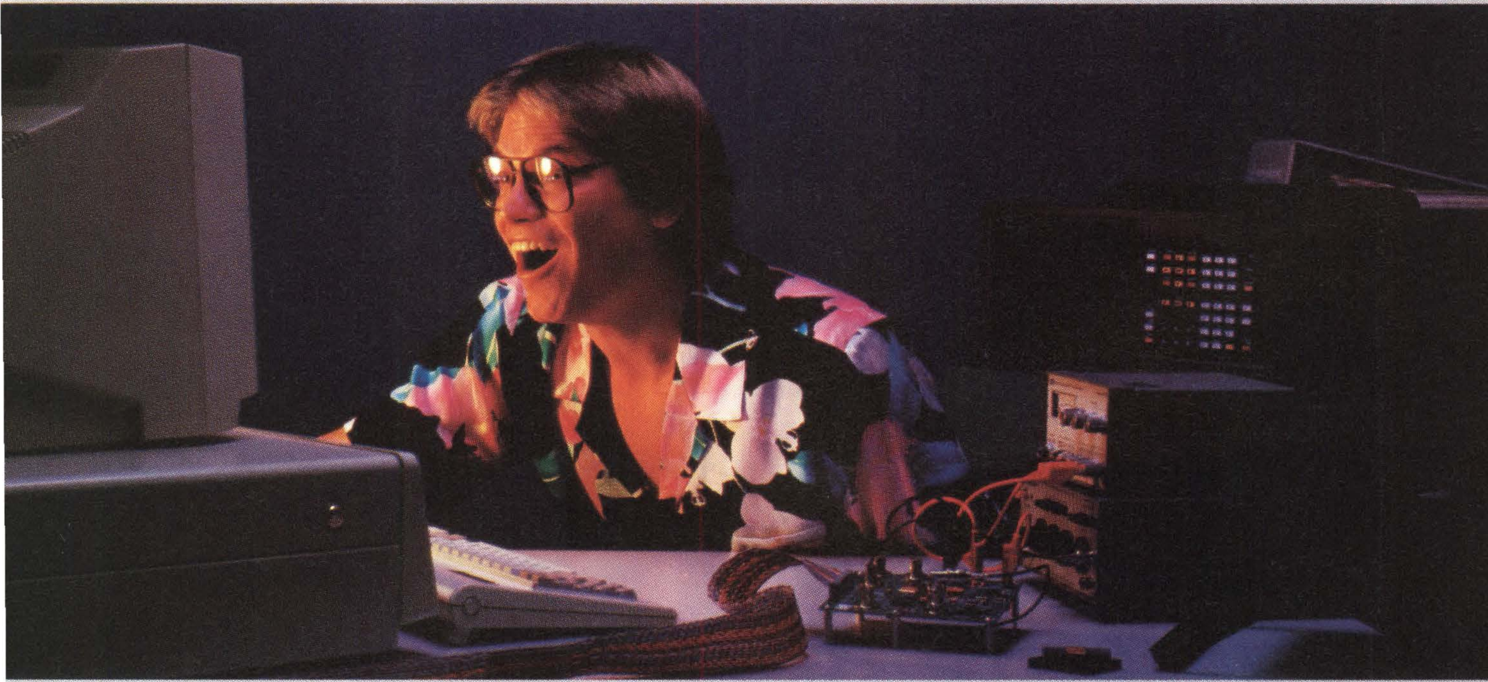

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CIRCLE NO 74

LEADTIME INDEX

Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
TRANSFORMERS								
Toroidal	0	25	50	13	12	0	9.7	7.3
Pot-Core	0	20	40	40	0	0	10.0	7.8
Laminate (power)	10	30	20	30	10	0	9.6	8.3
CONNECTORS								
Military panel	0	22	45	22	11	0	10.4	10.8
Flat/Cable	13	47	33	7	0	0	4.7	5.6
Multi-pin circular	0	25	33	25	17	0	11.6	9.4
PC (2-piece)	8	25	50	17	0	0	7.2	7.4
RF/Coaxial	13	47	27	13	0	0	5.2	5.3
Socket	12	63	19	6	0	0	3.7	4.7
Terminal blocks	19	31	37	13	0	0	5.7	5.4
Edge card	12	29	53	6	0	0	5.8	5.7
D-Subminiature	13	50	31	6	0	0	4.4	5.1
Rack & panel	10	40	30	20	0	0	3.2	6.4
Power	20	30	40	10	0	0	5.4	5.5
PRINTED CIRCUIT BOARDS								
Single-sided	0	71	29	0	0	0	3.7	5.4
Double-sided	0	25	75	0	0	0	6.5	5.8
Multi-layer	0	20	67	13	0	0	7.8	7.5
Prototype	6	81	13	0	0	0	2.7	4.3
RESISTORS								
Carbon film	47	32	16	5	0	0	2.7	4.2
Carbon composition	42	21	26	11	0	0	4.3	4.0
Metal film	30	25	45	0	0	0	4.1	4.4
Metal oxide	18	55	18	9	0	0	4.0	4.6
Wirewound	11	39	28	22	0	0	6.5	8.8
Potentiometers	5	53	32	10	0	0	5.2	6.1
Networks	19	38	24	19	0	0	5.7	6.3
FUSES	39	33	28	0	0	0	2.9	4.4
SWITCHES								
Pushbutton	10	50	35	5	0	0	4.6	5.8
Rotary	0	33	47	20	0	0	7.6	6.1
Rocker	0	55	36	9	0	0	5.4	5.4
Thumbwheel	0	33	25	42	0	0	9.4	7.7
Snap action	0	46	36	18	0	0	6.7	6.5
Momentary	0	58	25	17	0	0	5.9	6.3
Dual in-line	0	55	27	18	0	0	6.1	6.6
WIRE AND CABLE								
Coaxial	15	54	31	0	0	0	3.6	4.2
Flat ribbon	12	65	23	0	0	0	3.1	5.5
Multiconductor	13	47	40	0	0	0	4.1	4.6
Hookup	35	40	25	0	0	0	2.8	3.2
Wire wrap	31	46	23	0	0	0	2.8	4.2
Power cords	18	65	12	5	0	0	3.1	5.9
POWER SUPPLIES								
Switcher	7	43	21	22	7	0	7.9	7.4
Linear	0	29	50	14	7	0	8.6	7.7
CIRCUIT BREAKERS	20	27	13	33	7	0	8.7	8.0
HEAT SINKS	7	53	27	13	0	0	5.3	5.1
RELAYS								
General purpose	12	47	18	23	0	0	6.1	6.1
PC board	6	28	33	33	0	0	8.5	7.2

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
RELAYS								
Dry reed	0	23	31	31	15	0	11.8	8.6
Mercury	0	25	38	25	12	0	10.7	9.1
Solid state	0	25	33	33	9	0	10.8	8.9
DISCRETE SEMICONDUCTORS								
Diode	23	36	18	14	4	5	7.0	7.0
Zener	5	44	17	22	6	6	9.2	7.3
Thyristor	7	27	33	33	0	0	8.5	8.8
Small signal transistor	13	37	31	13	6	0	6.9	7.4
MOSFET	0	37	36	27	0	0	7.9	10.2
Power, bipolar	0	45	18	37	0	0	8.3	9.3
INTEGRATED CIRCUITS, DIGITAL								
Advanced CMOS	7	20	40	27	6	0	9.5	9.6
CMOS	6	29	41	24	0	0	7.7	7.1
TTL	23	15	54	8	0	0	5.9	6.5
LS	21	22	43	14	0	0	6.1	5.9
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	10	40	40	10	0	0	5.6	8.7
OP amplifier	20	27	33	20	0	0	6.4	6.3
Voltage regulator	16	28	39	17	0	0	6.4	7.2
MEMORY CIRCUITS								
RAM 16k	11	34	22	33	0	0	7.7	9.7
RAM 64k	8	25	25	34	0	8	10.4	8.8
RAM 256k	7	14	36	0	14	29	15.8	10.0
RAM 1M-bit	0	13	37	0	25	25	17.5	12.5
ROM/PROM	0	34	33	22	0	11	10.3	11.0
EPROM 64k	0	25	42	25	0	8	10.3	9.5
EPROM 256k	0	42	25	25	0	8	9.3	9.3
EPROM 1M-bit	0	0	33	17	33	17	19.4	11.6
EEPROM 16k	0	13	37	37	0	13	13.2	10.6
EEPROM 64k	0	20	40	30	0	10	11.5	10.9
DISPLAYS								
Panel meters	9	36	46	9	0	0	5.8	6.7
Fluorescent	0	33	45	22	0	0	7.8	8.5
Incandescent	0	66	17	17	0	0	5.4	6.5
LED	10	53	21	16	0	0	5.3	8.1
Liquid crystal	15	15	39	31	0	0	8.4	10.5
MICROPROCESSOR ICs								
8-bit	0	34	58	8	0	0	6.6	7.6
16-bit	0	12	88	0	0	0	7.3	9.3
32-bit	0	0	78	22	0	0	9.8	7.6
FUNCTION PACKAGES								
Amplifier	0	22	45	33	0	0	9.3	6.4
Converter, analog to digital	8	17	42	25	8	0	9.8	8.6
Converter, digital to analog	10	20	30	40	0	0	9.2	9.2
LINE FILTERS	17	33	33	17	0	0	6.0	9.4
CAPACITORS								
Ceramic monolithic	6	55	33	6	0	0	4.7	5.8
Ceramic disc	12	47	24	17	0	0	5.8	5.1
Film	0	57	29	14	0	0	5.7	4.8
Aluminum electrolytic	5	47	27	21	0	0	6.5	4.8
Tantalum	0	47	29	24	0	0	7.1	6.2
INDUCTORS	0	42	42	16	0	0	6.8	9.3

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

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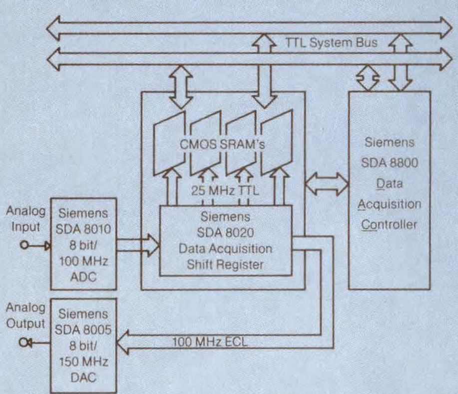

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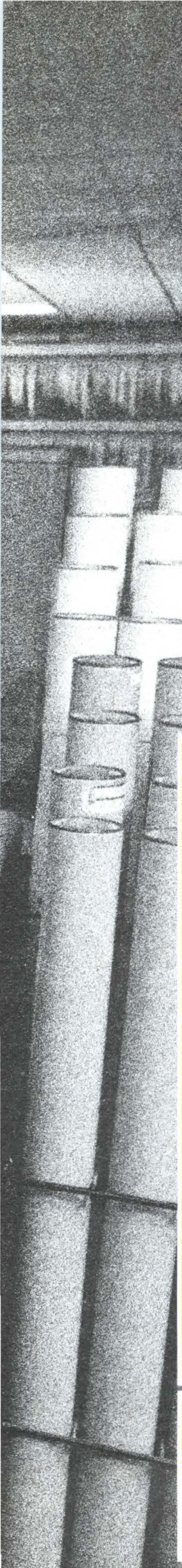

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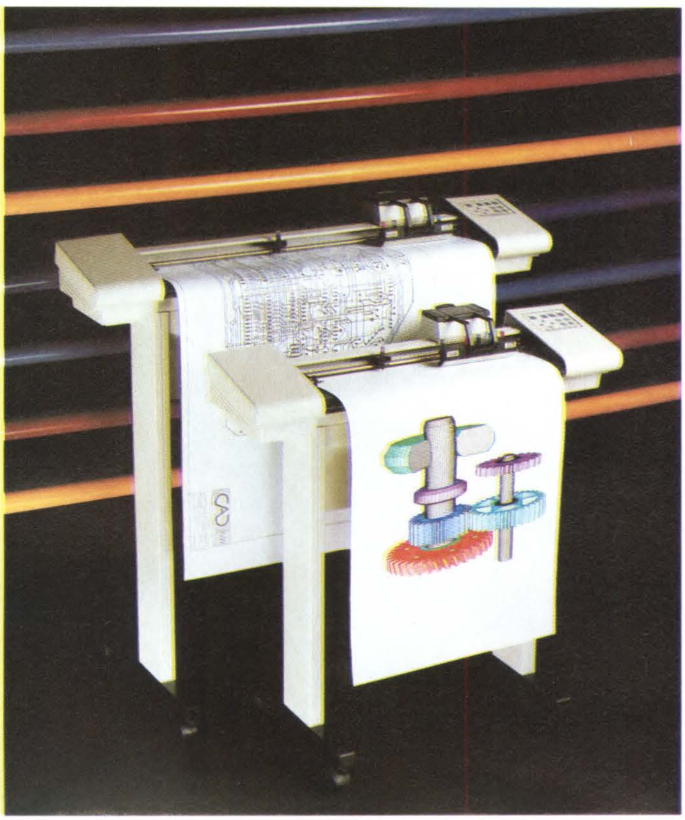

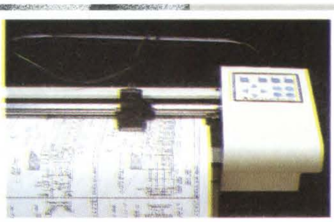

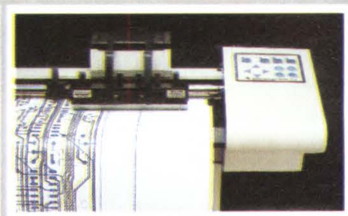

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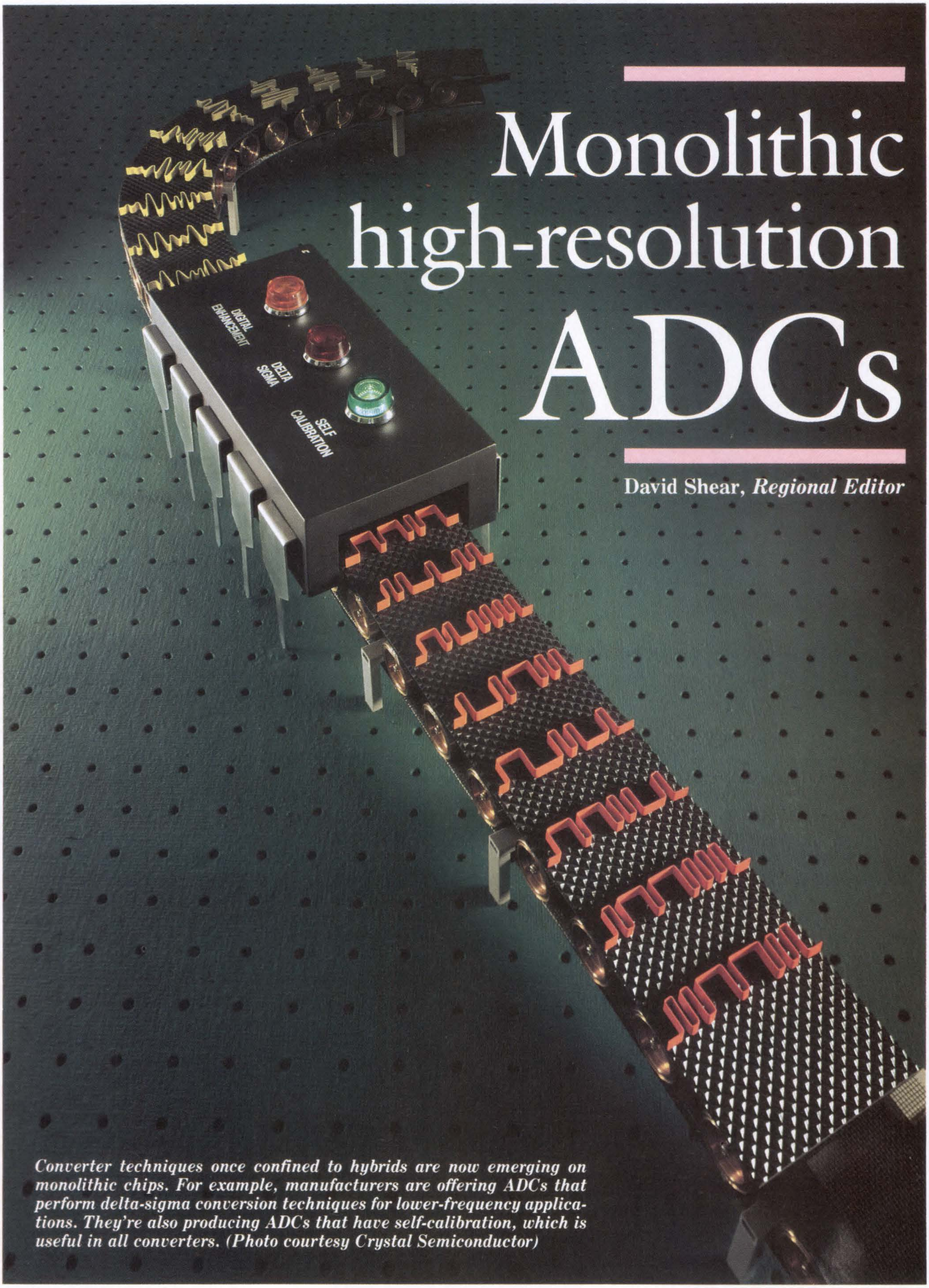
CIRCLE NO 77

Monolithic high-resolution ADCs

David Shear, *Regional Editor*



Converter techniques once confined to hybrids are now emerging on monolithic chips. For example, manufacturers are offering ADCs that perform delta-sigma conversion techniques for lower-frequency applications. They're also producing ADCs that have self-calibration, which is useful in all converters. (Photo courtesy Crystal Semiconductor)

SPECIAL REPORT

Improved manufacturing processes are already allowing manufacturers to realize innovative high-resolution-ADC designs on monolithic chips. Because ADC improvements will now be driven by architectural changes, you can expect to see phenomenal gains in these chips' performance in the near future.

Until the past year, engineers have had to stockpile their most innovative A/D-converter designs, because the available manufacturing processes simply couldn't put those designs onto monolithic chips economically. In fact, except for the introduction of successive-approximation, integrating, and flash ADCs, the electronics industry saw no major changes in monolithic ADCs in the past 10 years.

Now, however, the manufacturing processes have finally caught up with the technology: Manufacturers are placing complex, high-speed designs on monolithic chips. ADC techniques first described years, if not decades, ago are now finding their way to monolithic devices, and the ADCs are reaping increased speed and resolution from these architectural changes. And as architectural innovation continues, you'll see the trend of the past year continuing: Monolithic ADCs will continue to make quantum leaps in performance.

Recently, for example, manufacturers have introduced subranging flash ADCs, self-calibrating ADCs, and delta-sigma ADCs, all monolithics. The subranging-flash conversion method will yield a great increase in ADC speed; delta-sigma conversion techniques will lead to much higher resolution.

Furthermore, papers presented at the 1987 and 1988 International Solid-State Circuits Conferences (ISSCCs) have offered a glimpse of future ADC technology. Highly parallel, pipelined subranging flash ADCs will be the rule for high-speed, high-resolution ADCs, and oversampling delta-sigma converters will take over the dc and lower-band audio applications. Crystal Semiconductor, for example, already offers products based on these two architectures.

12- and 16-bit ADC prices will plummet

You can expect manufacturers to introduce many high-resolution converters during the next few years. These new ADCs will provide the performance of earlier high-resolution ADCs—which were pricey, multiple-chip devices—yet will offer the benefits of monolithics: lower price, lower power consumption, and alternate sources. Consumer digital audio equipment will provide a major application for these chips in the next few years; it will help to drive the price of 16-bit ADCs below that of today's 12-bit ADCs, thus forcing the price of 12-bit ADCs below $10. As the price of 16-bit ADCs drops, many OEMs will expect their engineers to design with them.

You may question the possibility of designing with 16-bit converters: The noise and drift problems seem insurmountable. A 16-bit converter with a 10V range has a least significant bit (LSB) of 153 μV; such a small voltage can easily be swamped by noise. To maintain the ADC's 16-bit accuracy, the reference of a 16-bit converter must have a temperature coefficient of at most 0.17 ppm/°C (25 to 70°C). These numbers do indeed sound insurmountable, but you can use certain techniques to take advantage of the full resolution of 16-bit ADCs.

16-bit converters suit DSP applications

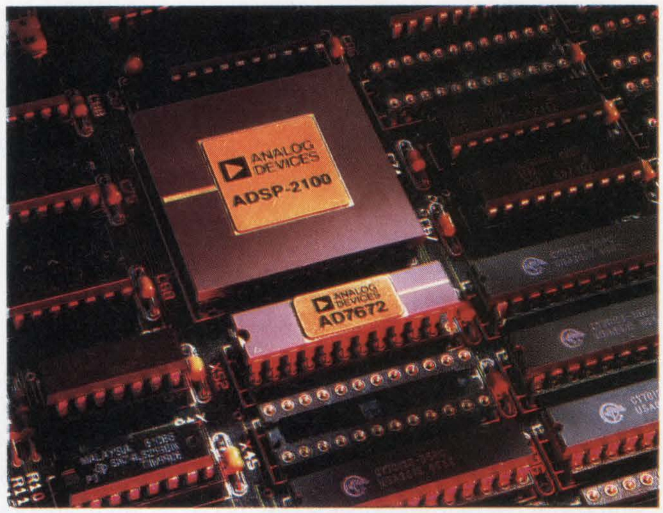
Such converters are useful, for example, in DSP applications: Digital signal processors don't require absolute accuracy. The important criteria are the ADCs' dynamic specifications—their total harmonic distortion, S/N ratio, in-band harmonics, intermodulation distortion, and input bandwidth. By keeping the signal pure (low distortion) and the noise floor low enough to analyze the signal, you can meet the needs of your digital signal processor.

It's difficult to design a system that's absolutely accurate to 16 bits, but it can be done. You need to design with this goal in mind from the start, by using proper grounding, shielding, and system-design techniques. You can take many approaches, however: For example, you could design the system to work in

Upgrading a system design from 12 bits to 16 bits requires more than merely replacing the ADC—you must upgrade your design techniques as well.

thermal equilibrium and use self-calibration once the temperature is stable. If your application is a highly digital system, where noise is everywhere, you could design the system to shut down all of the digital circuitry that might cause interference during the conversion process, thereby eliminating that source of noise.

When you're upgrading your design from a 12-bit system to a 16-bit system, you have to do more than merely replace the ADC. Some higher-resolution ADCs, especially the serial variety, are pin compatible with their lower-resolution versions. When your system requirements move from 12 to 16 bits, the noise floor and temperature drift must decrease by a factor of 16 (the LSB goes from 2.4 mV to 153 μV and the temperature coefficient goes from 2.7 to 0.17 ppm/°C—this and other useful data is contained in a wall chart on data acquisition that's available from Datel). So even if you can use a 16-bit converter as a drop-in replacement for a 12-bit one, it's doubtful that your system will be accurate to 16 bits without considerable redesign.



Engineers are using ADCs in DSP applications, *whose specification requirements differ from those of traditional, static-measurement applications. To facilitate your selection of an ADC for DSP applications, many manufacturers are placing dynamic specifications on ADC data sheets. (Photo courtesy Analog Devices)*

Don't overkill on speed or resolution

When determining the conversion time your application will require of an ADC, keep the Nyquist criterion in mind—you must sample at a frequency at least twice that of the highest frequency of the input. In other words, you must filter the input so that the signals above half the sample rate are less than 1 LSB.

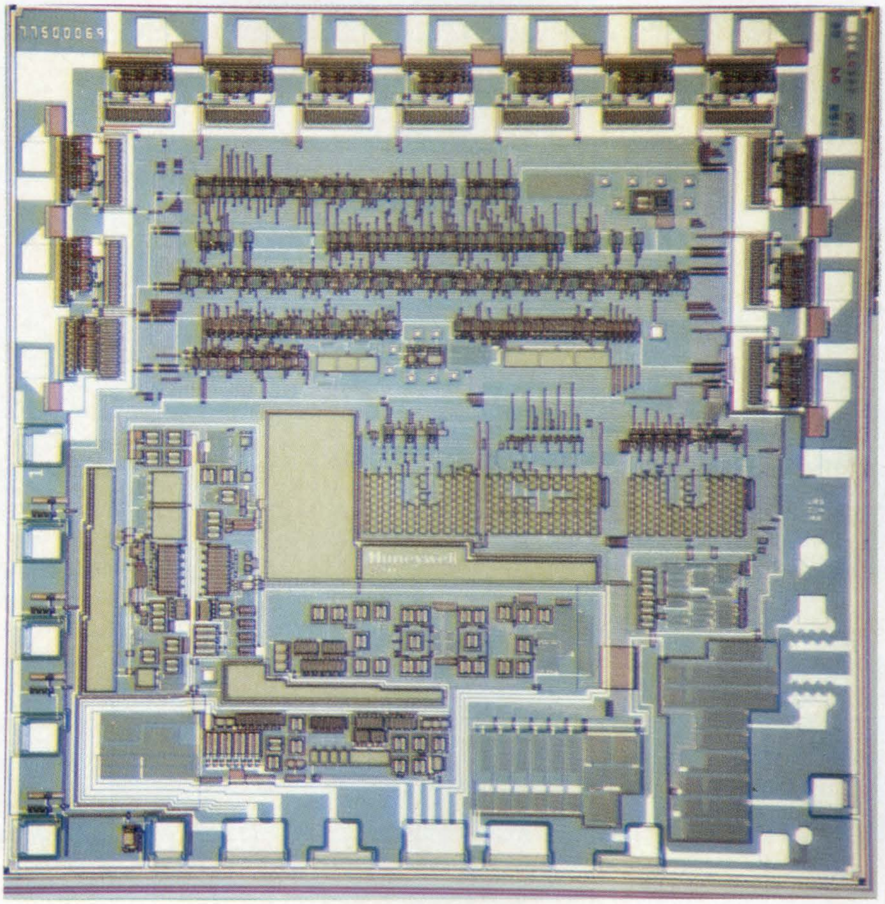
It is possible to *undersample,* which is to acquire data above the Nyquist frequency. If the incoming signal is band-limited so that it's between the sampling frequency and half of the sampling frequency, you can undersample the signal and extract the desired data.

Many applications require you to know the input bandwidth of the ADC, though it rarely appears on data sheets. Many ADCs have a bandwidth that's about half the sample rate. That bandwidth is sometimes not adequate. The bandwidth is a measure of the frequency at which the amplitude is attenuated by 3 dB; however, attenuation actually begins at a much lower frequency. If you desire the amplitude of the signal to be constant across your band of interest, the system's response will be off by the lower frequency at which attenuation actually begins. Also, when you multiplex the input, the input to the ADC could change from the negative rail to the positive rail as you switch inputs. The maximum slew rate of the input will determine the settling time of switching inputs, which you must add to the total conversion time (or which you must overlap with the conversion process if you're using an S/H amplifier).

Soon, all ADCs' data sheets will include the parts' bandwidth and other information useful in DSP applications. To ascertain the absolute accuracy of an ADC, manufacturers perform static testing on the devices. The traditional static tests don't determine an ADC's dynamic performance, however. If you're going to use the ADC in DSP applications, you need to perform dynamic testing to determine an ADC's signal-to-noise ratio, total harmonic distortion, intermodulation distortion, effective number of bits, and differential nonlinearity **(Ref 1).** Because it's costly to test ADCs, most manufacturers don't perform both static and dynamic testing on the same device. Crystal Semiconductor, however, offers two versions of each ADC it sells: The devices are identical except that the company performs static testing on one and dynamic testing on the other. In the future, you can expect to see dynamic-test data from all ADC manufacturers.

ADC manufacturers will also continue the trend toward including many functions on a single chip. For example, a complete data-acquisition system on a chip will include signal-conditioning circuitry, a multiplexer, an S/H amplifier, an ADC, and digital-control and interface circuitry. Vendors have been putting such complete data-acquisition systems into hybrid devices for some time, and it won't be long before they'll be able to fit the same circuitry on monolithic chips.

Another function that's finding its way onto mono-



This typical capacitive-DAC-based ADC— *the Honeywell HADC574Z—uses successive approximation, today's most dominant conversion technique. As this die shot shows, the chip's circuitry is mostly analog.*

lithic ADCs is sample-and-hold amplification. It has always been time consuming—and it's sometimes been costly—to design an S/H amplifier for a particular application (**Ref 2**). Many of today's ADCs solve that problem by including built-in S/H amplifiers. You must look carefully at these ADCs' data sheets, however, because in most cases, the S/H amplifiers are part of the conversion process and don't allow you to use very high frequencies. The limiting factor in S/H amplification is usually the aperture uncertainty or aperture jitter, which is the timing jitter that occurs during the transition from sample to hold.

The maximum frequency that an S/H amplifier can accurately work with is limited by the need to keep the input voltage within 1 LSB during the aperture-uncertainty time. For example, Honeywell's 12-bit HADC574Z ADC has a 25-µsec conversion time, and its S/H function has 3-µsec acquisition time, which would theoretically allow for 35.7-kHz throughput. The S/H amplifier's aperture uncertainty is 20 nsec, which limits the input frequency to less than 2 kHz. When the input is band-limited below 2 kHz, the internal S/H amplifier is enough; however, when the input is above this frequency, you must use an external S/H amplifier as well. Soon, manufacturers will begin to offer ADCs with good on-chip S/H amplifiers that are tuned to the ADCs, ensuring accurate performance.

Some ADCs offer on-chip references

ADC manufacturers have also begun to put voltage references on ADC chips. To maintain an ADC's 12-bit accuracy over 0 to 70°C, a voltage reference must have a temperature coefficient of less than 2 ppm/°C. However, most of the on-chip references available now have temperature coefficients of about 10 times that value, so they're not particularly accurate. For certain applications, therefore, you may elect to use an external reference as well. (See **Ref 3** for more information about selecting a voltage reference.)

For ADCs that have resolutions greater than 12 bits, however, an external reference may itself cause problems. The circuit path between the reference and the

REPRESENTATIVE MONOLITHIC HIGH-RESOLUTION A/D CONVERTERS

MANUFACTURER AND MODEL	RESOLUTION (BITS)	THROUGHPUT/ CONVERSION TIME	INPUT-VOLTAGE RANGE	POWER SUPPLY (V)	POWER DISSIPATION (mW)	INTERNAL REFERENCE	S/H AMPLIFIER
ANALOG DEVICES							
AD674A	12	15 μSEC	0 TO 10, 20 ±5, ±10	±12 OR ±15	390 TYP	•	
AD7550	13	40 mSEC	—	±5, +12	44 MAX		NA
AD7552	12 PLUS SIGN	160 mSEC	—	±5, +12	40 MAX		NA
AD7572	12	5 μSEC	0 to 5, ±2.5	+5, −15	215 MAX	•	
AD7672	12	3 μSEC	0 TO 5, 10, ±5	+5, −12	179 MAX		
BURR-BROWN							
ADC80MAH-12	12	25 μSEC	±2.5, ±5, ±10, 0 TO 5, 10	+5, ±12, OR ±15	705 MAX	•	
CRYSTAL SEMICONDUCTOR							
CS5012/CSZ5112	12	100 kHz	±5	±5	250 MAX		•
CS5014/CSZ5114	14	56 kHz	±5	±5	250 MAX		•
CS5016/CSZ5116	16	50 kHz	±5	±5	250 MAX		•
CSZ5126	16	100 kHz	±5	±5	250 MAX		•
CSZ5316	16	20 kHz	±2.75	±5	250 MAX	•	•
CSZ5412	12	1 MHz	0 TO 3, ±1.5	±5	700 TYP		•
CS5501	16	4 kHz (10-Hz MAX BANDWIDTH)	0 TO 4.5, ±4.5	±5	40 TYP		
DATEL							
ADC EK12B	12	24 mSEC	0 TO 10, ±5	±5	50 MAX		NA
ADC ET12B	12	24 mSEC	0 TO 10, ±5	±5	50 MAX		NA
ADC 800	15 PLUS SIGN	400 mSEC	±5	±5	35 MAX		NA
ADC 7109	12 PLUS SIGN	33 mSEC	±5	±5	15 MAX	•	NA
GE SOLID STATE							
ICL7112	12	40 μSEC	0 TO −10, 0 TO 10	±5	60 MAX		
ICL7115	14	40 μSEC	0 TO −5, 0 to 5	±5	60 MAX		
HONEYWELL							
HADC574Z	12	35.7 kHz	0 TO 10, 20, ±5, ±10	5, 12, OR 15	150 MAX	•	•
HADC674Z	12	59.5 kHz	0 TO 10, 20, ±5, ±10	5, 12, OR 15	150 MAX	•	•
HYBRID SYSTEMS							
HS574A	12	35.7 kHz	0 TO 10, 20, ±5, ±10	5, 15	150 MAX	•	•
SP674A	12	59.5 kHz	0 TO 10, 20, ±5, ±10	5, 15	150 MAX	•	•
MAXIM INTEGRATED PRODUCTS							
MAX162	12	3 μSEC	0 TO 5	5, −15	215 MAX	•	
MAX170	12	5 μSEC	0 TO 5	5, −15	250 MAX	•	
AD7572-5	12	5 μSEC	0 TO 5	5, −15	215 MAX	•	
MAX7109	12	33 mSEC	±5	±5	15 MAX	•	NA
MAX133/134	3¾-DIGIT	50 mSEC	±.4 TO ±4000	±5 OR +9	2.25 MAX		NA

NOTES:

LCC = LEADLESS CHIP CARRIER
PLCC = PLASTIC LEADED CHIP CARRIER
SO = SMALL-OUTLINE PACKAGE
NA = NOT APPLICABLE

INPUT CHANNELS	PARALLEL I/O	WORD WIDTH	SERIAL I/O	SELF-CALIBRATION	PACKAGE	PRICE (100)
1	•	8 OR 12			28-PIN DIP	$39.25
1	•	8 OR 13			40-PIN DIP	$26.30
1	•	8 OR 13			40-PIN DIP	$10.45
1	•	12			24-PIN, 0.3-IN. DIP 28-PIN LCC	$46
1	•	12			24-PIN, 0.3-IN. DIP, 28-PIN PLCC OR LCC	$75
1	•	12	•		32-PIN DIP	$35
1	•	8 OR 16	•	•	40-PIN DIP	$25.90
1	•	8 OR 16	•	•	40-PIN DIP	$45
1	•	8 OR 16	•	•	40-PIN DIP	$69
2		—	•	•	28-PIN DIP	$39.90
1		—	•		18-PIN DIP	$35.80
1	•	12		•	40-PIN DIP	$115
1		—	•	•	20-PIN DIP, 20-PIN SO	$16
1	•	12			24-PIN DIP	$25.50
1	•	12			24-PIN DIP	$12.25
1	•	8 OR 16			40-PIN DIP	$16.50
1	•	8 OR 13			40-PIN DIP	$8.95
1	•	8 OR 12			40-PIN DIP	$29
1	•	8 OR 14			40-PIN DIP, 40-PIN LCC	$49
1	•	8 OR 12			28-PIN DIP	$30
1	•	8 OR 12			28-PIN DIP	$38
1	•	8 OR 12			28-PIN DIP	$30
1	•	8 OR 12			28-PIN DIP 28-PIN LCC	$35
1	•	8 OR 12			24-PIN SO, 24-PIN, 0.3-IN. DIP	$23
1		—	•		8-PIN SO 8-PIN DIP	<$20
1	•	8 OR 12			24-PIN SO, 24-PIN, 0.3-IN. DIP	$27
1	•	8 OR 12			40-PIN DIP, 44-PIN PLCC	$8.95
7	•	4			40-PIN DIP, 44-PIN PLCC	$11

Table continued on pg 122

ADC is full of offset and drift error sources. Different metals often create small voltages, much as a thermocouple does, that drift with temperature. One way around this problem is to use a Kelvin-sensed reference. This type of reference senses the voltage at the load, and uses that voltage for regulation, thus removing errors between the reference and the ADC. To obtain the greatest benefit from this approach, you should use an ADC that has multiple inputs for the reference, so that the sense from the voltage regulator can connect directly to the ADC chip.

You can get around many temperature-related drift problems by using ratiometric measurements. As long as the sensor and the ADC are using the same reference, the drift of the reference won't matter, because it will cancel out.

Flash techniques will become prevalent

Even though the majority of available ADCs are using successive-approximation or multislope-integration techniques, these conversion methods will soon step aside for the subranging-flash and delta-sigma methods. Flash conversion is by far the fastest conversion technique. A flash converter has a separate comparator for each of the possible digital output values. The input voltage is fed to all of the comparators. Comparators whose reference is below the input will all generate ones; those that have a reference above the input will all generate zeros. The output of all of the comparators goes to an encoder, which converts the data to a binary value.

The limitation of this approach is the number of comparators required—a 12-bit converter would require 4095 comparators. To achieve the higher ADC resolutions, therefore, ADC manufacturers either use more than one internal flash converter or use the same converter more than once; this technique is called "subranging."

Crystal Semiconductor takes the latter approach in its CSZ5412, a 12-bit, 1-MHz subranging ADC **(Ref 4)**. It uses a 2-step technique: First, it samples the input into an S/H amplifier; then, once the input is held, the 6-bit flash ADC converts the six most significant bits of the digital output and latches them. These six bits are also loaded into the 6-bit DAC. The DAC's output is then subtracted from the input held in the S/H amplifier. The result of this subtraction is the remainder of the original input. The CSZ5412 includes a differential amplifier that multiplies this voltage by 64 to raise it to a value that the 6-bit ADC can convert. The six least

Vendors can already put a complete data-acquisition system on a hybrid device; before long, they'll fit the same circuitry on a monolithic chip.

REPRESENTATIVE MONOLITHIC HIGH-RESOLUTION A/D CONVERTERS *(Continued)*

MANUFACTURER AND MODEL	RESOLUTION (BITS)	THROUGHPUT/ CONVERSION TIME	INPUT-VOLTAGE RANGE	POWER SUPPLY (V)	POWER DISSIPATION (mW)	INTERNAL REFERENCE	S/H AMPLIFIER
MICRO LINEAR							
ML2200	12 PLUS SIGN	31.7 kHz	±2.5	±5	400 MAX	•	•
ML2208	12 PLUS SIGN	31.7 kHz	±2.5	±5	400 MAX	•	•
ML2230	12 PLUS SIGN	31.7 kHz	±2.5	±5	400 MAX		•
ML2233	12 PLUS SIGN	31.7 kHz	±2.5	±5	400 MAX		•
MICRO POWER SYSTEMS							
MP7550	13	40 mSEC	—	±5, 12	44 MAX		NA
MOTOROLA							
MC145402	13	21.3 kHz (ADC ONLY)	±3.2	±5V	50 TYP	•	•
NATIONAL SEMICONDUCTOR							
ADC1205	12 PLUS SIGN	100 μSEC	0 TO 5 OR ±5	5 OR ±5	25 MAX		
ADC1225	12 PLUS SIGN	100 μSEC	0 TO 5 OR ±5	5 OR ±5	25 MAX		
PRECISION MONOLITHICS INC							
ADC-9012	12	12.5 μSEC	0 TO 10	5, −12, OR −15	85 MAX		
SIGNETICS							
TDA1534	14	8.5 μSEC TYP	—	±5, −17	640 MAX	•	
TELEDYNE SEMICONDUCTOR							
TSC500A	16 PLUS SIGN	—	±4.2	±5	15 MAX		NA
TSC804	12 PLUS SIGN	33 mSEC	±5	±5	20 MAX	•	NA
TSC850	15 PLUS SIGN	25 mSEC	±5	±5	35 MAX		NA
TEXAS INSTRUMENTS							
TLC32040	14	19.2 kHz	±1.5, ±3, ±6	±5	285 MAX	•	•

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significant bits are then loaded into the output latch to form the full 12-bit digital value.

One complete conversion takes 1.3 μsec. To achieve 1-MHz throughput (1-μsec conversions), the CSZ5412 pipelines both the sampling process and the conversion process: It initiates the next hold command while the last result is being latched into the output. A second S/H amplifier also pipelines the acquisition of a sample by holding the input while the 6-bit ADC determines the remainder.

The CSZ5412 uses self-calibration to ensure 12-bit accuracy. An internal microcontroller performs the calibration; it maintains the 64 graduated reference levels, the gain, and the offset of the 6-bit flash ADC, and the gain and offset of the differential amplifier.

Subranging-flash techniques will be increasingly important in future ADCs. Speakers at this year's ISSCC discussed many such pipelined ADC designs that promise to realize high speed and high resolution. Analog Devices, for example, will soon be coming out with a 12-bit ADC that has 200-kHz throughput and a 14-bit, 10-μsec ADC, both of which use variations of the subranging-flash technique.

The other important conversion technique is the

INPUT CHANNELS	PARALLEL I/O	WORD WIDTH	SERIAL I/O	SELF-CALIBRATION	PACKAGE	PRICE (100)
4	•	8		•	40-PIN DIP	$41
8	•	8		•	40-PIN DIP	$43
1	•	8		•	24-PIN DIP 28-PIN PLCC	$15.95
1	•	13		•	28-PIN DIP 28-PIN PLCC	$15.95
1	•	8 OR 13			40-PIN DIP	$26
1		—	•		16-PIN DIP 16-PIN SO	$7.67 (1000)
1	•	8			24-PIN DIP	$19.95
1	•	12			28-PIN DIP	$19.95
1	•	8 OR 12			24-PIN 0.3-IN. DIP 24-PIN SO	$24.95
1		—	•		28-PIN	$12
1	—	—	—	—	16-PIN DIP, 16-PIN SO	$8.95
8	•	8 OR 13			68-PIN PLCC	$10.95
1	•	8			40-PIN DIP	$20 TO $25
2		—	•		28-PIN DIP	$26

delta-sigma method. The delta-sigma technique uses oversampling and digital filtering to achieve high resolution. A delta-sigma ADC consists of an analog modulator and a digital filter. The modulator's output provides a single-bit result at a very high rate that the digital filter can process into a high-resolution output at a lower rate.

The advantage of using delta-sigma conversion is mostly a reduction in cost, both of the converter and, in some applications, of the system. One delta-sigma ADC, the Crystal Semiconductor CS5501, is mostly digital; the analog circuitry consumes only the lower fifth of the device. The delta-sigma approach yields a device that's more digital than analog, so it's easier and cheaper to produce and will benefit from the shrinking geometries of the future.

Another advantage of the delta-sigma type of converter is that it includes a digital lowpass filter with a cutoff frequency of 0.1 to 10 Hz, so it eliminates common interference caused by ac power sources. Further, the serial output of this converter is ideal for use as input to a serial communication device, allowing the LAN-style connection of sensors. This scheme would facilitate the manufacture of high-resolution digital sensors, perhaps even on single chips.

A disadvantage of using the delta-sigma converter is that you'll require one converter for every channel. Because the digital filter contains historical data, you can't multiplex the input. Also, the filter's parameters are preset and may not fit your application. When evaluating these converters, consider the cost of getting the signals from the sensor to the multiplexed ADC. Serial digital cables are much less expensive than many analog cables, and digital transmission, by its nature, offers a number of advantages over analog transmission.

The Crystal CS5501 is a 16-bit delta-sigma converter with a bandwidth of 0.1 to 10 Hz, depending upon the clock rate. Also dependent upon the clock rate is the output-update rate, which is the rate at which the data is clocked out of the ADC. The CS5501's output-update rate varies from 40 Hz to 4 kHz. The company intends the ADC for use with low-frequency signals in such applications as scales and dc measurements.

The CS5501 includes self-calibration circuitry for system calibration. You could use the CS5501 in a data-acquisition system, for example **(Fig 1).** The calibration circuitry, along with an external multiplexer, will compensate for the gain and offset of the entire system.

In the near future, you can expect to see many more delta-sigma converters on the market. Crystal expects to have an 18-bit version of the CS5501 out before the end of the year; that chip will be pin compatible with the 16-bit version.

ADC manufacturers have also begun to include self-calibration circuitry on their monolithic ADCs. The most important advantage of self-calibration is that it lets you calibrate the device at any time. Self-calibration circuitry will appear in all types of converters over the next few years.

Micro Linear's ML2200 ADC family, for example,

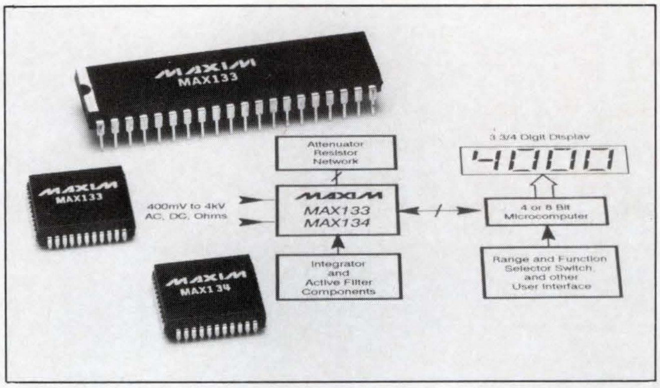
Consumer digital audio equipment will help drive the price of 16-bit ADCs below that of today's 12-bit ADCs, thus forcing the 12-bit ADCs below $10.

includes self-calibration **(Ref 5)**. The parts' conversion algorithm is a version of successive approximation; the devices, which Micro Linear calls "algorithmic ADCs," have two distinct advantages: They require compensation only for the internal offsets and the times-2 multiplier, and, compared with other types of converters, they have fewer components that require adjustment. The offsets of both the S/H amplifier and the times-2 amplifier are nulled before each conversion. The gain of the times-2 amplifier is determined by the ratio of two capacitors. During calibration, the chip sets the gain by automatically adjusting the capacitor ratio with one fixed capacitor and one variable capacitor. The variable capacitor comprises a selection of smaller capacitors.

GE Solid State's ICL7112 and ICL7114 ADCs use a self-calibration scheme that employs a one-time-programmable (OTP) ROM to store the calibration values. The ICL7112 is a 12-bit, 40-μsec converter; the ICL7114 produces a 14-bit result in the same 40 μsec.

Crystal Semiconductor also offers a line of self-calibrating ADCs: The CS5012, CS5014, and CS5016 are 12-, 14-, and 16-bit converters, respectively. They all use the popular successive-approximation technique. Instead of comprising the traditional resistor network, the DAC is an array of binary-weighted capacitors.

To achieve 16-bit accuracy, the ADC's comparator and DAC must both be very accurate. The comparator's offset is measured during the track mode and subtracted from the input when the conversion begins, so the offset is nulled. The DAC consists of a number of binary-weighted capacitors. Each of these capacitors,



Adding some external passive components *to the Maxim MAX133 integrating ADC is all you have to do to provide the converter with a voltage divider that has a software-selectable range of ±400 mV to ±4000V. The converter performs integrating A/D conversion by using a ±40,000-count residual-multiplication technique.*

in turn, is made up of many small capacitors. The automatic-calibration feature maintains the DAC's accuracy by selecting the capacitors to adjust the overall bit weight.

Just because an ADC supplies self-calibration circuitry doesn't mean that the device will drift away from its specifications quickly—it just means you have the opportunity to make corrections whenever necessary. The ADCs from Crystal, for example, maintain their accuracy over time and temperature, and also perform self-calibration every time you apply power. They don't have an on-chip reference, however, so you may have to recalibrate for variations in the external reference you use.

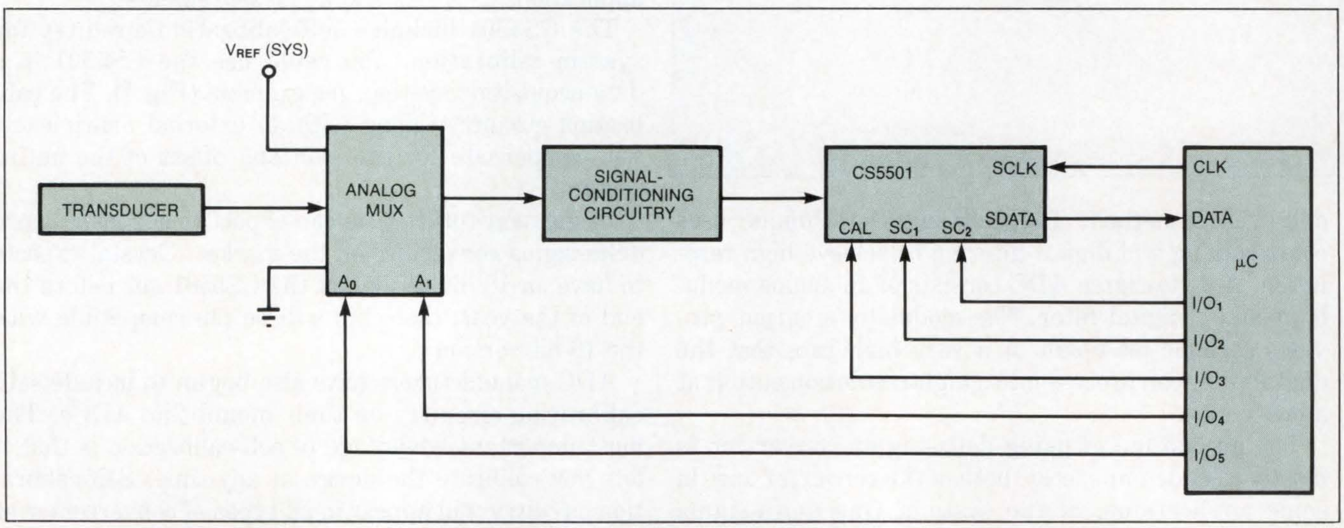
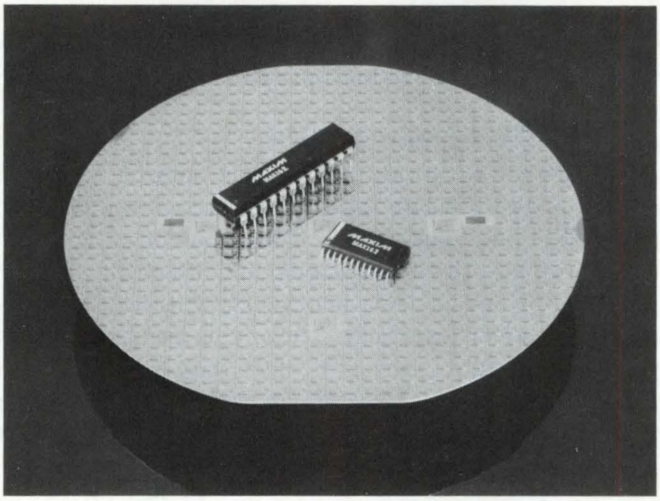


Fig 1—The ability to perform system self-calibration, *as the Crystal Semiconductor CS5501 does, allows you to compensate for the gain and offset errors of all of the system components. The CS5501 compensates for these errors by adjusting itself to counteract them.*



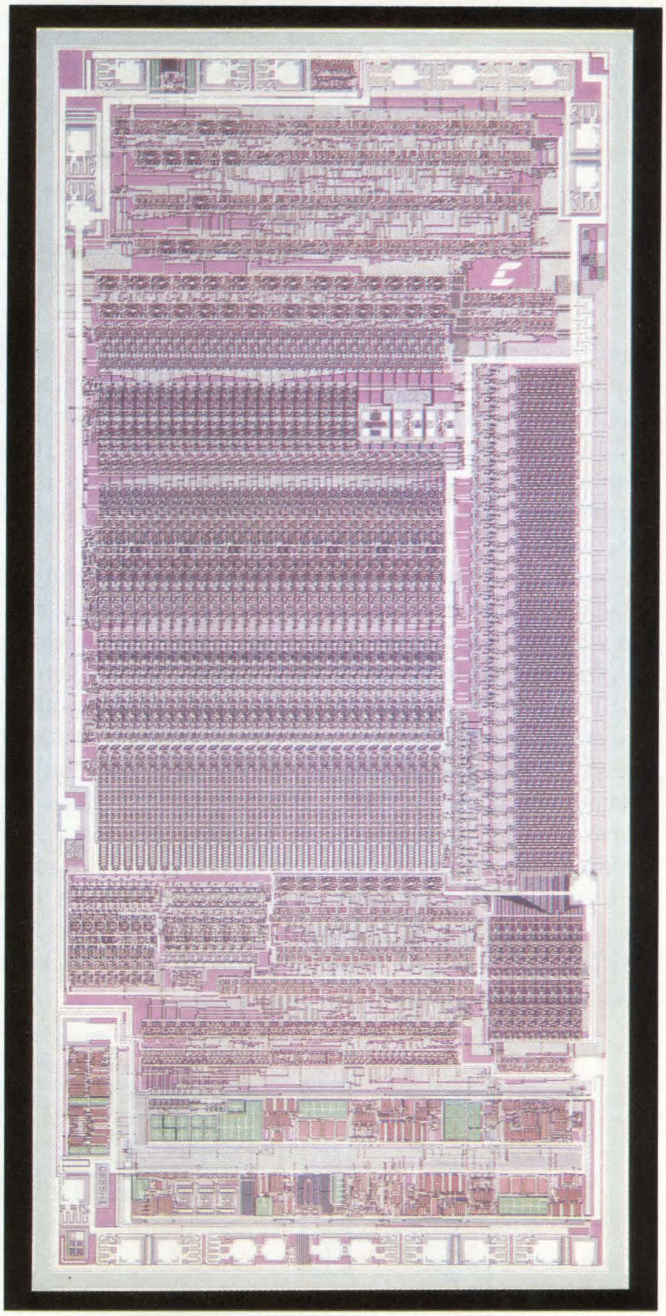
This 12-bit, monolithic ADC *(the MAX162 from Maxim Integrated Products) unites high speed with low cost: It offers a 3-μsec conversion time and costs $23 (100).*

Most other ADC manufacturers will soon produce self-calibrating ADCs, either one-time-programmable ones, such as those from GE Solid State, or ones that calibrate on command, as do those from Crystal and Micro Linear.

12-bit jellybean ADCs

The market is about to see a major price reduction in 12-bit ADCs, which are becoming commodity parts. Competition is fierce among the many companies that produce these parts: Even the price of high-speed (3-μsec) converters is down near $20. Remaining competitive in a commodity market usually means providing something that your competition doesn't. The range of 12-bit ADCs, therefore, includes a lot of niche parts that are expressly intended for particular applications.

Complete analog interfaces are also beginning to arrive in the marketplace. Texas Instruments' TLC32040 comes in a 28-pin package that contains a 2-channel input multiplexer, a programmable input filter, a 14-bit ADC with an S/H amplifier, a 14-bit DAC, a programmable output filter, a voltage reference, a serial interface, and a clock with a programmable sample rate **(Fig 2)**. The TLC32040 interfaces directly to the TMS320 family of digital-signal processors and handles the interface to your sensors. You can program the corner frequency of the switched-capacitor filters by using an internal divider and selecting the master clock frequency. The input bandpass filter is intended for telecomm applications; you can bypass it if it doesn't meet your needs.



Even though its die photo looks entirely digital, *the CS5501 from Crystal Semiconductor is a 16-bit A/D converter. The only analog circuitry resides on the lower fifth of the chip—the rest of the chip comprises an FIR filter, an IIR filter, some control circuitry, and a serial interface. The chip uses the delta-sigma conversion technique for signals from dc to 10 Hz.*

Another ADC that includes an output DAC on chip is the Motorola MC145402. This 13-bit ADC/DAC has an S/H amplifier, a voltage reference, and a serial interface. The ADC uses the same DAC that the output uses. To permit both input and output operations, the output has an S/H amplifier that can hold any value sent to the DAC while the DAC is being used in the A/D conversion. When the device is being used for both input and output, its maximum throughput rate is 16 kHz. When the part is being used for just A/D conversion, its maximum throughput rate is 21.3 kHz.

The Micro Linear ML2200/08 12-bit-plus-sign ADC is not necessarily easier to use, but it eases the burden on

Converters with 16-bit resolution are useful in DSP applications, which don't require absolute accuracy—it's the ADCs' dynamic specs that are important.

your system software because it includes many digital functions on chip. It contains a programmable sequencer, a double 8-word buffer, limit alarms, a 16-bit counter, and a μP interface. Because these functions are on chip, the ADC can perform many operations that would be time consuming to perform in software.

Note also that many μP and DSP chips have built-in serial interfaces, which are ideal for data acquisition. Most parallel-output ADCs can't keep up with the high-speed cycle times of DSP chips. Even when the DSP chip is using wait states, the ADC's 3-state output must relinquish the bus quickly. If it can't, you may need to use a 3-state buffer. ADCs that have built-in serial interfaces can easily interface to DSP chips that have built-in serial interfaces. To meet this need, ADC manufacturers are beginning to include serial interfaces on their ADC chips. The MAX170 from Maxim Integrated Products, for example, is a 12-bit, 5-μsec ADC with a serial output that comes in an 8-pin package. Burr-Brown's ADC80 and most of Crystal Semiconductor's converters have both parallel and serial outputs.

Serial I/O helps solve problems

A further advantage of the serial interface is that it lets you easily isolate the digital system from the ADC. The digital section contains many sources of noise that get back into the analog signal and affect the accuracy of the conversion. Isolating the digital section from the analog section can help reduce this noise. It's much easier to isolate a serial interface than it is to isolate a 12- or 16-bit parallel bus. Maxim will soon introduce the MAX171, a serial ADC (based on the MAX170) that has an optoisolated output.

Integrating ADCs are still going strong

The activity in other areas of the ADC market has recently obscured the humble integrating ADC, but that type of converter is still selling well. Even the ancient 7109 12-bit integrating ADC is still going

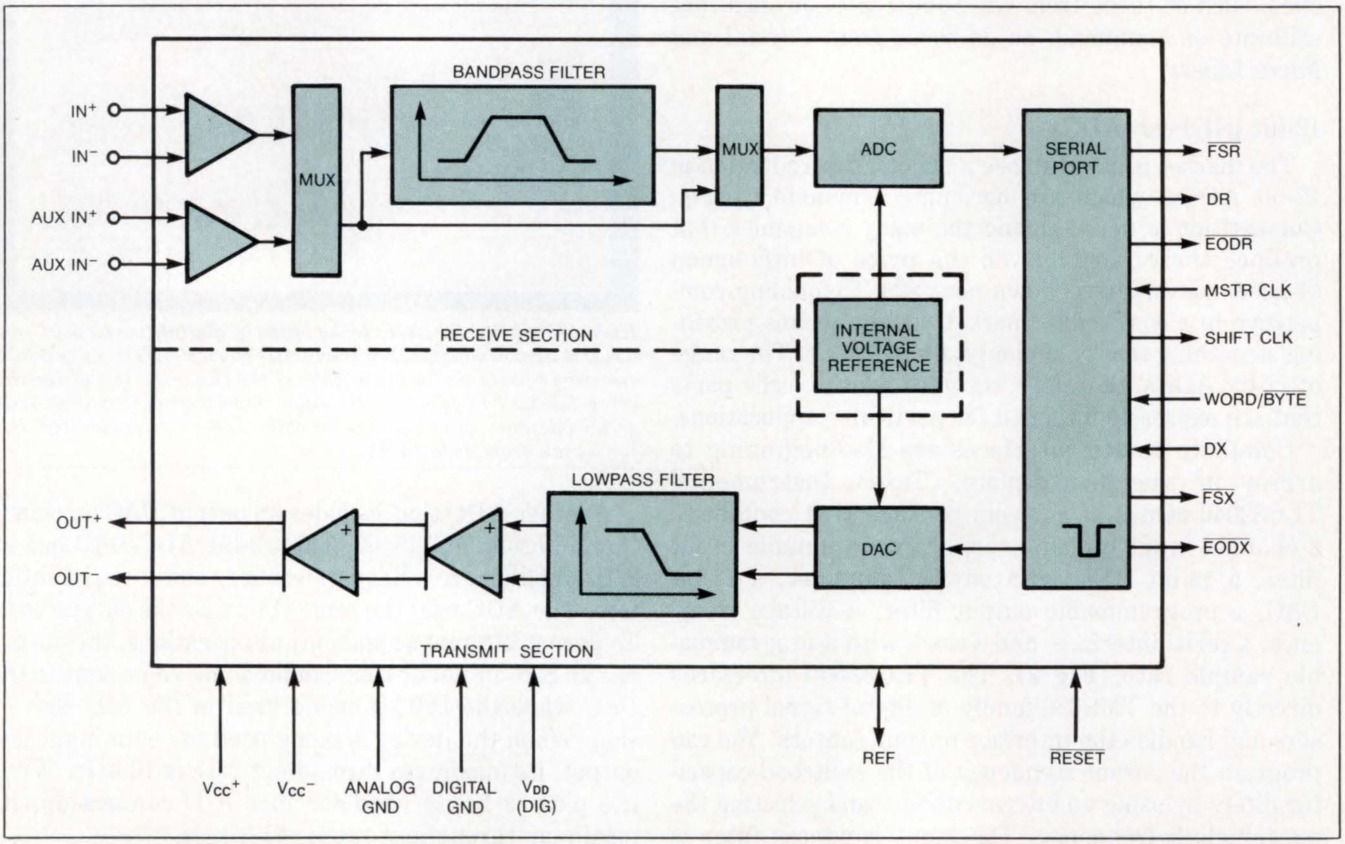


Fig 2—An example of the continuing trend toward placing more functions on a single chip is the Texas Instruments TLC32040 Analog Interface Chip. This single chip contains a 2-channel input multiplexer, a programmable input filter, a 14-bit ADC with an S/H amplifier, a 14-bit DAC, a programmable output filter, a voltage reference, a serial interface, and a clock with a programmable sample rate.

CIRCLE NO 80

The subranging-flash conversion method will greatly increase ADC speed; delta-sigma conversion techniques will lead to much higher resolution.

strong. Hybrid integrating ADCs have reached 22-bit resolution, so you can expect to see an ongoing increase in the resolution of monolithic integrating converters.

Integrating ADCs usually cost less than $12 (100), and designers will continue to use them in low-frequency and dc-measurement applications. One of the major advantages of integrating ADCs is that by selecting the appropriate integration time, you can eliminate much of the ever-present 60-Hz interference.

The TSC500A from Teledyne Semiconductor is an integrating ADC building block that contains all the analog circuits you need to construct an integrating, dual-slope ADC. Your system μP performs the digital functions. You can implement an ADC with any resolution—as high as 16 bits plus sign—by changing the software. The manufacturer offers an evaluation kit that includes IBM PC-based software.

The TSC804 is useful for measuring more than a single input. The device is a 12-bit integrating ADC that's similar to the 7109 and that has an 8-channel (4-channel differential) multiplexer on the input.

The Maxim MAX133 integrating ADC also allows multiple inputs—it accepts as many as seven. The manufacturer intended the multiplexer for automatic range selection in DMM applications. You add external resistors to create a voltage divider that has a software-selectable range of ±400 mV to ±4000V. The converter performs integrating A/D conversion by using a ±40,000-count residual-multiplication technique. During normal use of the ADC, you ignore the least significant digit. For high-resolution applications, you can read all the digits and average them over a number of readings (usually 10) to achieve full accuracy.

By using a 2-step conversion process, the Teledyne TSC850 converts a signal 16 times faster than does the TSC800, allowing 40 conversions/sec. This approach converts the nine MSBs quickly and then uses a slower, more precise conversion to resolve the six LSBs.

Over the next few years, monolithic ADCs will make quantum leaps in speed and resolution. High-end ADCs —ones having resolutions of 16 bits and higher—will continue to develop as they have in the past: ADCs that exist as board-level products today will become modules, then hybrids, and finally monolithic ICs.

Remember, however, that merely using a very accurate converter in a system won't guarantee that your

Manufacturers of monolithic high-resolution ADCs

For more information on high-resolution ADCs 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.

Analog Devices Inc
Box 9106
Norwood, MA 02062
(617) 329-4700
TLX 924491
Circle No 650

Burr-Brown
Box 11400
Tucson, AZ 85734
(602) 746-1111
TLX 666491
Circle No 651

Crystal Semiconductor Corp
4210 S Industrial Rd
Austin, TX 78744
(512) 445-7222
TWX 910-874-1352
Circle No 652

Datel Inc
11 Cabot Blvd
Mansfield, MA 02048
(617) 339-3000
TLX 951340
Circle No 653

GE Solid State
10600 Ridgeview Ct
Cupertino, CA 95014
(408) 996-5000
Circle No 654

Honeywell Inc
1150 E Cheyenne Mountain Blvd
Colorado Springs, CO 80906
(303) 577-1000
TLX 452433
Circle No 655

Hybrid Systems Div
22 Linnell Circle
Billerica, MA 01821
(617) 667-8310
Circle No 656

Maxim Integrated Products
120 San Gabriel Dr
Sunnyvale, CA 94086
(408) 737-7600
TWX 910-350-4114
Circle No 657

Micro Linear
2092 Concourse Dr
San Jose, CA 95131
(408) 433-5200 ext 412
TLX 275906
Circle No 658

Micro Power Systems
3151 Jay St
Santa Clara, CA 95054
(408) 727-5350
TWX 910-338-0154
Circle No 659

Motorola Semiconductor
3501 Ed Bluestein Blvd
Austin, TX 78721
(512) 928-6880
Circle No 660

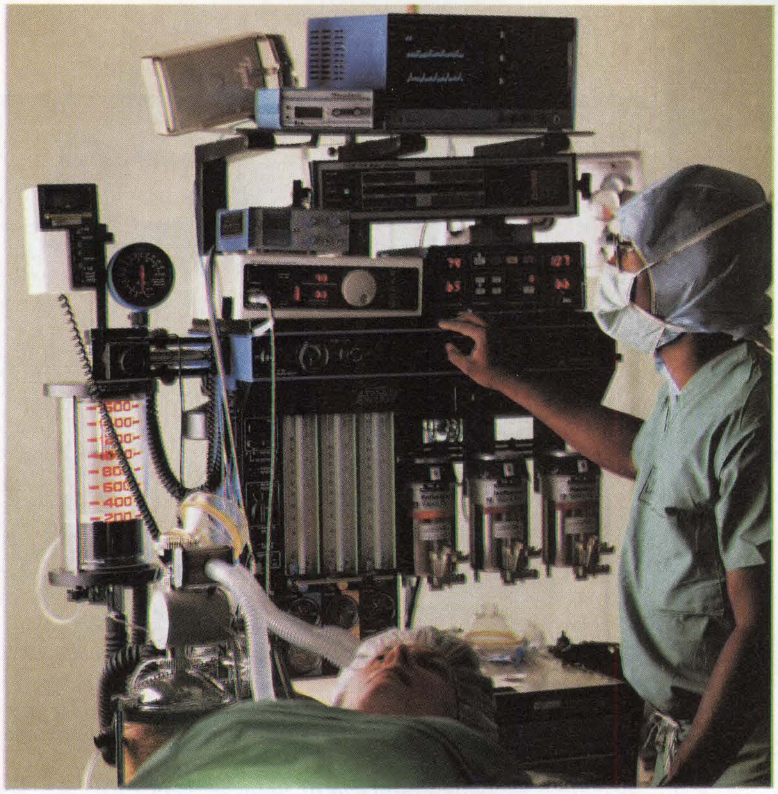
National Semiconductor
2900 Semiconductor Dr
Santa Clara, CA 95052
(408) 721-6230
Circle No 661

Precision Monolithics Inc
1500 Space Park Dr
Santa Clara, CA 95054
(408) 727-9222
Circle No 662

Signetics Corp
811 E Arques Ave
Sunnyvale, CA 94088
(408) 991-2000
Circle No 663

Teledyne Semiconductor
1300 Terra Bella Ave
Mountain View, CA 94039
(415) 968-9241
TWX 910-379-6494
Circle No 664

Texas Instruments
Semiconductor Group
Box 809066
Dallas, TX 75380
1-800-232-3200, ext 700
Circle No 665



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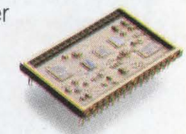

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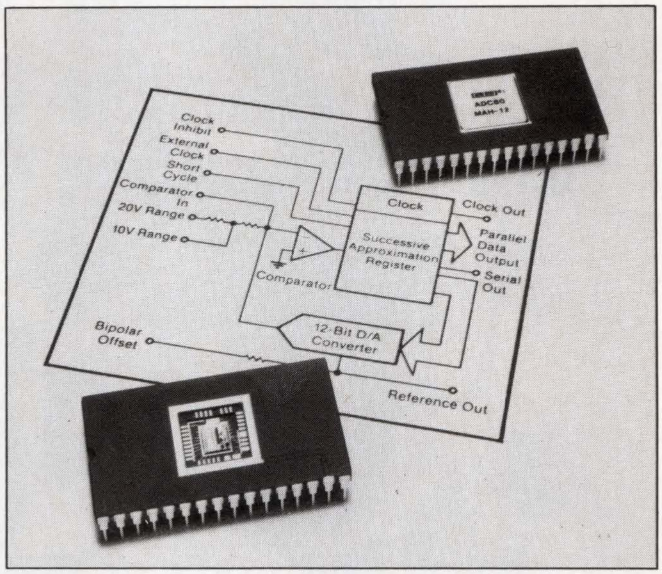

The hybrid ADCs of yesterday are monolithic devices today. The monolithic ADC80MAH-12 from Burr-Brown, for example, was a hybrid that the company originally introduced about 10 years ago.

system's measurements will also be accurate. As you begin to design with ADCs that have resolutions higher than 16 bits, your design abilities will have to improve. Each time you design with a high-resolution ADC, you can learn a little more about optimizing a design to take advantage of the ADC's capabilities. When the 22-bit ADCs that now exist in hybrid form become monolithic and their prices drop to an affordable level, you'll have to be well versed in high-precision analog-design techniques in order to take advantage of them. **EDN**

References

1. Coleman, Brendan, et al, "Coherent sampling helps when specifying DSP A/D converters," *EDN*, October 15, 1987, pg 145.
2. Little, Al, and Bob Burnett, "S/H amp-ADC matrimony provides accurate sampling," *EDN*, February 4, 1988, pg 153.
3. Knapp, Ron, "Selection criteria assist in choice of optimum reference," *EDN*, February 18, 1988, pg 183.
4. Mosley, J D, "Monolithic A/D converter delivers 1-MHz, 12-bit performance at low cost," *EDN*, February 18, 1988, pg 128.
5. Fleming, Tarlton, "Monolithic, self-calibrating ADC includes sample-and-hold amplifier," *EDN*, January 21, 1988, pg 87.

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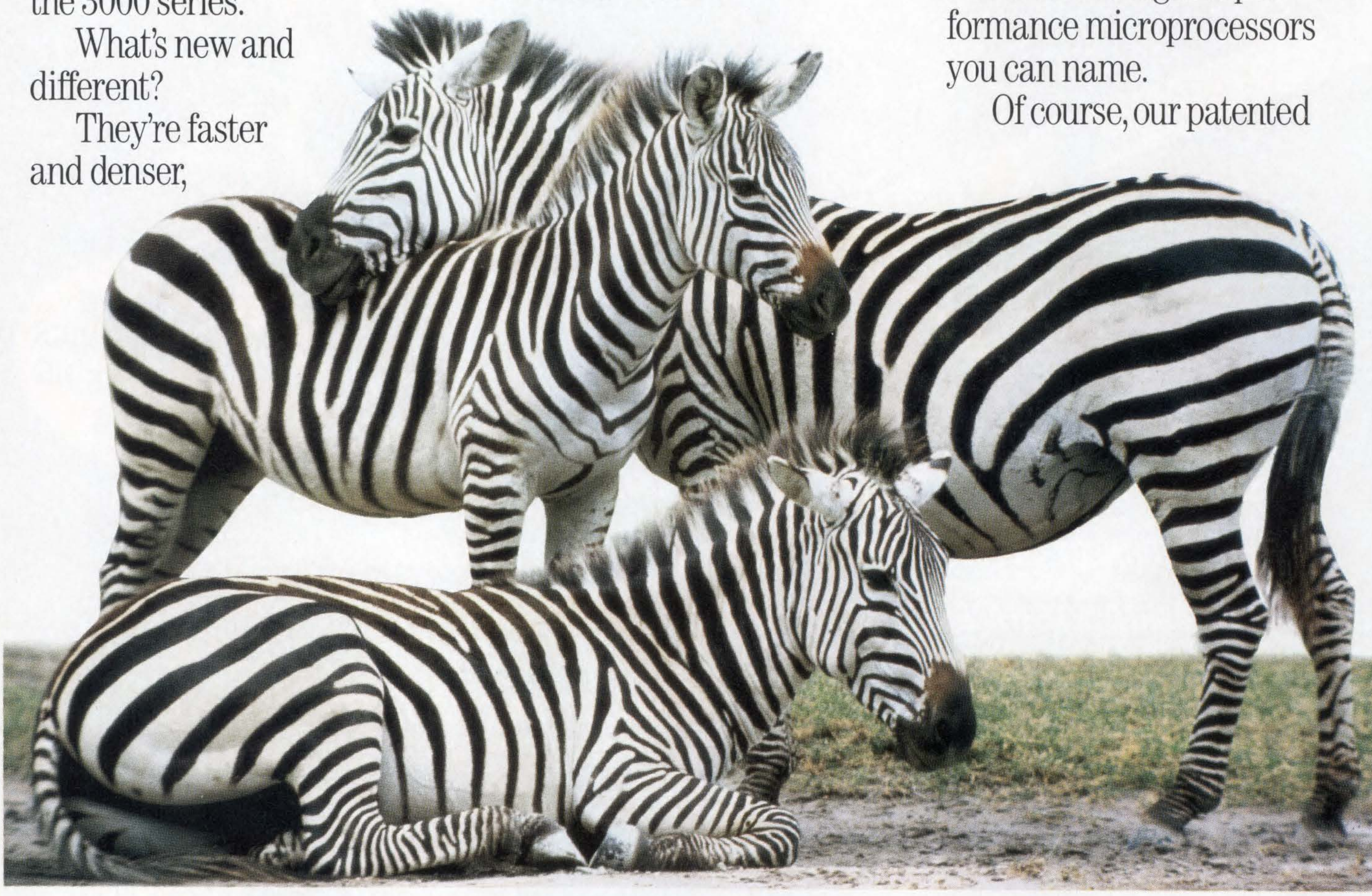

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Data transformation explains the basics of neural networks

Doug Conner, *Regional Editor*

For problems that digital computers can't readily solve, you might soon find that artificial neural networks offer a practical alternative. To obtain an overview of neural networks' capabilities, we developed two simple networks, we simulated them in software, and we built and tested one analog neural-network circuit.

The neural-network approach to data transformation is noteworthy for two reasons. First, neural networks are parallel computing architectures and therefore do not suffer the sequential bottlenecking problems that can occur when a serial processor tries to perform parallel processing. Second, neural networks aren't explicitly programmed with the algorithm that would solve the problem at hand; instead, they must *learn* to solve the problem.

The ability of feedforward neural networks (also called mapping neural networks) to learn a transformation isn't necessarily an advantage. Among the drawbacks are the need for training data sets (from which the networks can learn) and the need for a learning period. Moreover, neural networks are not well suited to problems requiring high accuracy.

Therefore, most problems for which a known algorithm exists are best solved by executing the algorithm on conventional computers. Neural networks can best solve problems for which no algorithm exists or for which the algorithmic solution is too slow.

Our simple example—a neural network that maps an input X to sin(X)—illustrates the basics of neural networks. A conventional approach to this problem would involve the use of an approximate mathematical function, such as Taylor's expansion, or the use of a lookup table filled with a series of X and sin(X) pairs. Of these two approaches, the latter more closely corresponds to a neural-network approach, although significant differences do exist (**Fig 1**).

With the lookup-table approach, a processor locates the table entries for X that bracket the X input value. Then, the processor interpolates (in the highly likely event that the input isn't identical to an X value in the table) to yield a sin(X) output. In contrast, a neural network does not perform interpolation. However, before it can convert any X to sin(X), it must learn to solve such problems. This learning requires a training data set, which could be the same X and sin(X) values that would go into a lookup table.

No relation to sin(X)

During training, the neural network receives an X input, and a learning algorithm compares the neural network's response with the correct sin(X) value. The learning algorithm then adjusts weighting factors internal to the network in order to minimize the error between the network's output and the correct response. Note that the learning algorithm has no relation to the sin(X) function and would be equally useful for enabling the network to learn $\sqrt{X}$ or e^X.

After running through a large number of sample

Because neural networks are parallel computing architectures, they aren't hindered by the bottlenecks that can result when a serial processor attempts parallel processing. Neural networks are best at solving problems for which no algorithm exists or for which an algorithmic solution is too slow.

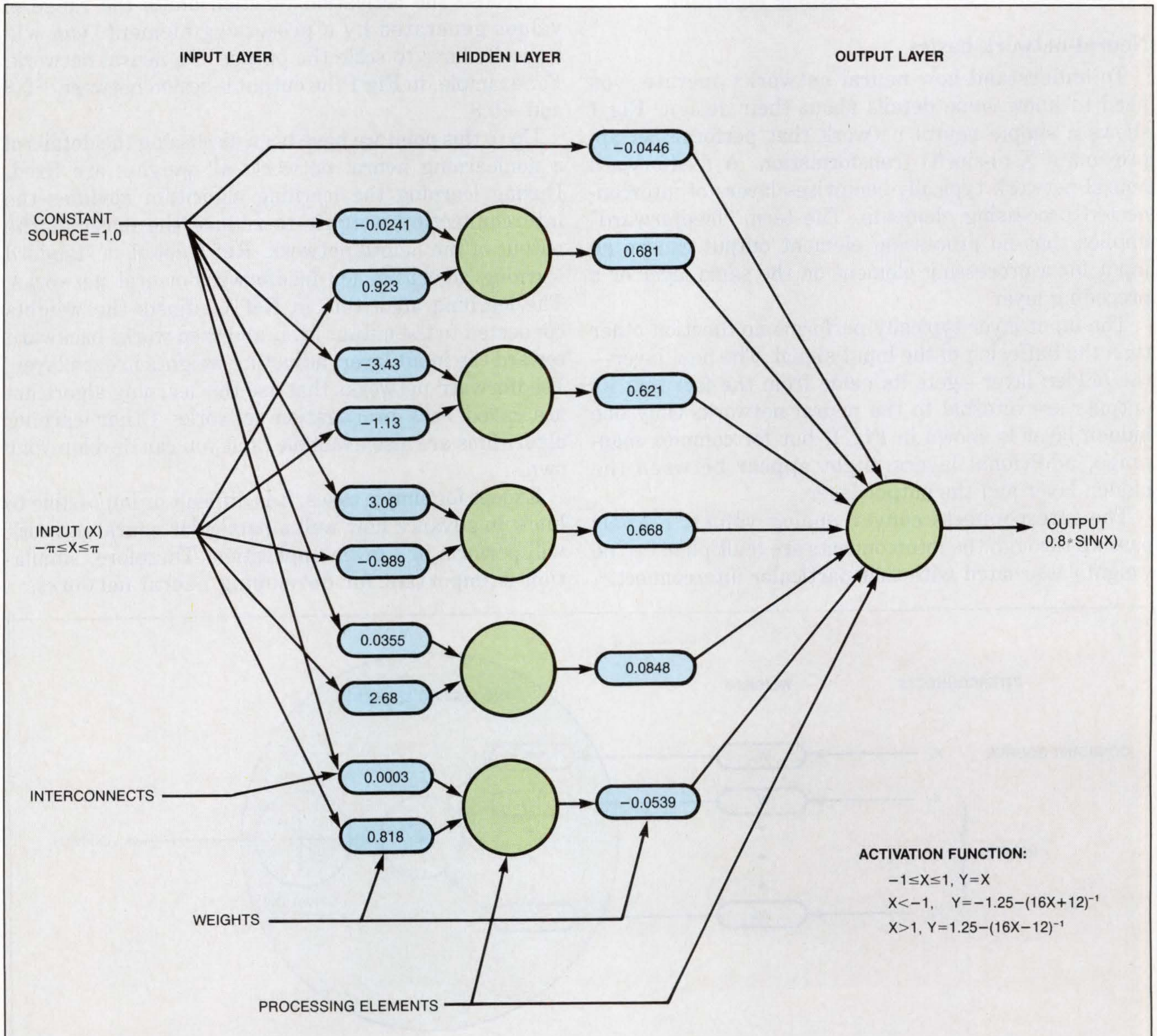

*Fig 1—**This simple neural network** approximates the transformation of X to sin(X). The network consists of six processing elements and 16 weights.*

The term "feedforward" implies that no processing element output can be an input for a processing element on the same layer or a preceding layer.

pairs from the training set, the neural network, which initially was in some random state, will have learned to some extent the X-to-sin(X) transformation. Once the network has learned the transformation, the learning algorithm is no longer necessary. If the learning algorithm is removed, the network behaves like an analog lookup table: The network receives an input value and generates an output. The ability of the network to learn a transformation is limited by the architecture of the specific network and by the learning algorithm.

Neural-network basics

To understand how neural networks operate, you need to know some details about their design. **Fig 1** shows a simple neural network that performs an approximate X-to-sin(X) transformation. A feedforward neural network typically comprises layers of interconnected processing elements. The term "feedforward" implies that no processing element output can be an input for a processing element on the same layer or a preceding layer.

The input layer typically performs no function other than the buffering of the input signal. The next layer—the hidden layer—gets its name from the fact that its outputs are internal to the neural network. Only one hidden layer is shown in **Fig 1,** but for complex mappings, additional layers might appear between the hidden layer and the output layer.

The interconnects convey analog values. Signals passing through the interconnects are multiplied by the weights associated with that particular interconnect.

Each processing element sums all its inputs and then performs a nonlinear transfer function on the sum, as shown in **Fig 2.** This nonlinear transfer function is also known as the activation function of a neural network. The activation function can take a number of different forms. **Fig 3** shows some typical ones. To provide an offset term for the activation function, all processing elements receive a constant-source input, as shown in **Fig 2.**

Because the activation function limits the range of values generated by a processing element, you will typically have to scale the output of a neural network. For example, in **Fig 1** the output is scaled between −0.8 and +0.8.

Up to this point we have been discussing the details of a nonlearning neural network; all weights are fixed. During learning the learning algorithm modifies the interconnection weights to reduce the error at the output of the neural network. **Ref 1** details a standard learning algorithm for feedforward neural networks. The learning algorithm in **Ref 1** adjusts the weights connected to the output layer and then works backward toward the input layer, adjusting weights in each layer. Feedforward networks that use this learning algorithm are called back-propagation networks. Other learning algorithms are also available, and you can develop your own.

Except for simple cases, it is difficult or impossible to know in advance how well a particular neural network will perform in a given application. Therefore, simulation is important for developing neural networks.

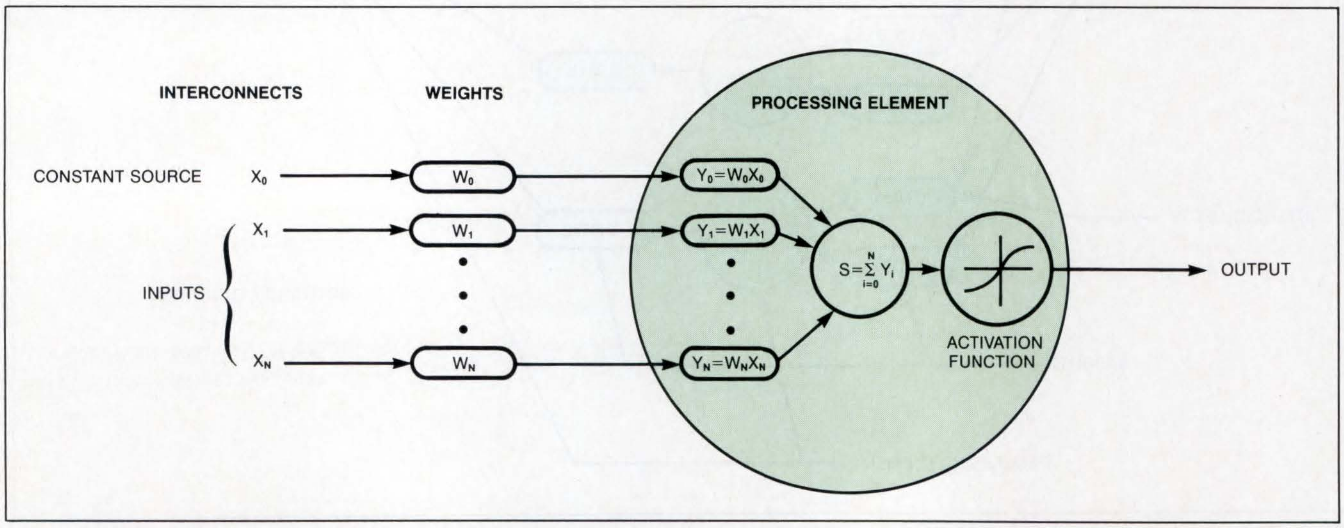

*Fig 2—**In this depiction of a neural network's** components, the inputs X_1 through X_N come from either network inputs or from the outputs of other processing elements.*

Most neural networks are currently being simulated and implemented on digital computers. By using the high speed floating-point processors now available, digital computers can perform simulations rapidly even though they are executing an inherently parallel process serially.

Two IBM PC/AT-compatible coprocessor boards suitable for neural-network simulation are the ANZA-Plus, from Hecht-Nielsen Neurocomputers Corp (San Diego, CA, (619) 546-8877), and the Delta FPP, from Science Applications International Corp (San Diego, CA, (619) 546-6290).

The ANZA-Plus coprocessor board supports a total of 2.5 million processing elements and interconnects and costs $14,900, including software. The Delta FPP coprocessor board supports a total of 3.1 million processing elements and interconnects and costs $14,895, including software. (Both companies also offer lower performance products with correspondingly lower prices.)

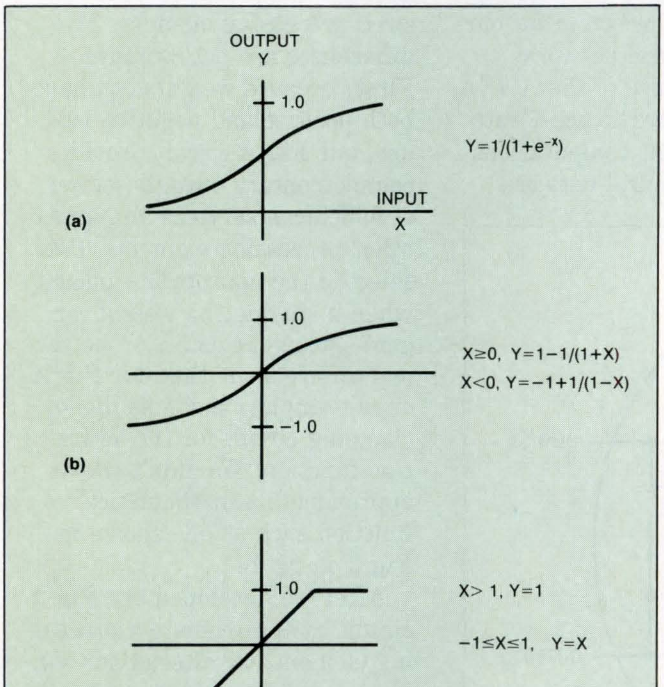

Fig 3—Some typical activation functions *include an exponential function that's often used* ***(a)****, one* ***(b)*** *that's faster to compute in a simulation than the exponential function is, and another* ***(c)*** *that's fast to compute but that places more demands on the learning algorithm.*

Neural-network simulation speeds are typically measured using the number of simulated interconnections per second; the ANZA-Plus and the Delta FPP each offer performance in the range of 1 to 10 million interconnections per second, depending on whether the network is in a learning or a nonlearning mode.

To understand how neural networks can be applied to problems, it is instructive to go through the steps involved in developing a simple analog neural network circuit. See **box,** "Neural network transforms X to sin(X)," for a description of our experience in developing a neural network that performs the X to sin(X) transformation.

An adaptive filter

Feedforward neural networks do not restrict you to simple single-input and single-output applications such as the X- to-sin(X) example. Another simulation we developed was an adaptive filter using 41 taps of an input waveform. These 41 taps provide inputs to a neural network with eight elements in the hidden layer, as shown in **Fig 4.** This example uses a total of nine processing elements and a total of 345 interconnects.

Text continued on pg 144

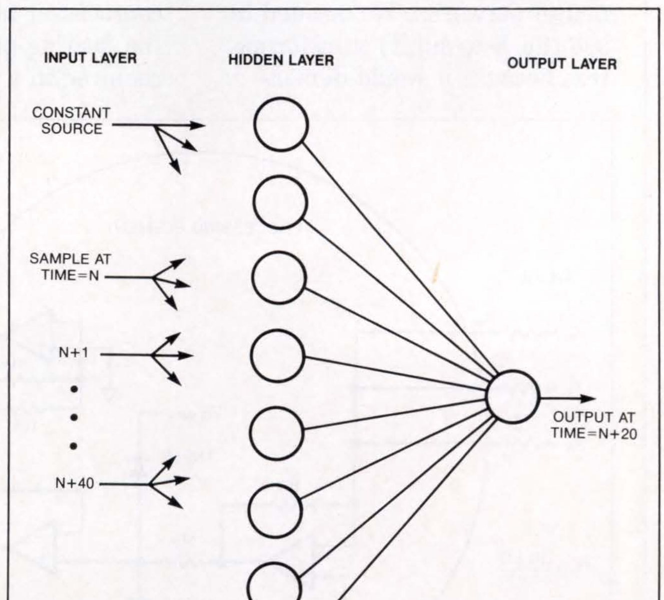

Fig 4—In a 41-tap neural-network filter, *each of the 41 inputs is connected to all eight processing elements in the hidden layer. This network has 345 interconnects and nine processing elements.*

Neural network transforms X to sin(X)

To learn more about neural networks and to try the concepts in a circuit, we simulated and then built a circuit that performs the transformation of X to sin(X) for inputs from $-\pi$ to $+\pi$.

The first step was to learn enough about neural networks to understand the details of how they function and to be able to simulate them on a computer. To satisfy both of these requirements we attended a week long course presented by Hecht-Nielsen Neurocomputers. This course taught us the basics about a variety of the most popular neural network architectures. We also learned to simulate neural networks on a PC/AT-compatible computer using the company's ANZA coprocessor board and Neurosoft software. The only prerequisites for this course were a basic familiarity with MS-DOS and a limited ability in C-language programming.

With the knowledge gained from the course, we were immediately able to start simulating neural networks. We decided to use the X-to-sin(X) transformation because it would demonstrate the operation of a mapping neural network yet be simple enough to allow us to build the neural-network circuit.

We experimented with the feedforward network architecture shown in **Fig 1** on pg 139. We tried various numbers of processing elements in the hidden layer and settled on five for the circuit. The hidden layer must have at least three processing elements to represent the basic characteristics of the X-to-sin(X) transformation; additional elements improve accuracy, provided the learning algorithm can make use of the additional elements.

The Neurosoft software package provided with the ANZA coprocessor board would not allow us to modify the activation function. Because we anticipated the need to use a special activation function that would be easy to approximate with an electrical circuit, we decided to write our own simulation program for our X-to-sin(X) neural network.

Without the use of the ANZA coprocessor board to accelerate the floating-point computations required in a neural-network simulation, our simulation program ran quite slowly, so we took the opportunity to fill the empty 80287 coprocessor socket in our PC/AT. With the coprocessor installed, we saw at least a fourfold improvement in our simulation's execution speed, although the simulation still ran slower than did one running on the ANZA coprocessor board using the canned activation function. Nevertheless, we had the flexibility we needed, and speed was not a problem for the simple network we were simulating.

With a simulation of the neural network to perform the X- to-sin(X) transformation, we were ready to translate the simulation into a circuit. Keeping in mind that we wanted to perform the function shown in **Fig 2** on pg 140 with a simple analog circuit, we developed the circuit shown in **Fig A.**

The circuit is almost an exact analog representation of the desired processing element. Two differences are noteworthy. First, because weights can have both positive and negative values, our **Fig A** circuit provides complementary outputs, either of which can serve as an input to other processing elements. (We selected the appropriate polarity when installing the weight, or gain-setting, resistors.) The second difference is that our **Fig A** circuit employs a simple diode clamping circuit for the activation function. We didn't try to approximate a mathematical function such as one shown in **Fig 3** on pg 141.

After we developed the **Fig A** circuit to approximate a processing element, we altered our simulation program to approximate the diode clamping we would be using for the activation function. The neural-network simulation relearned the X-to-sin(X) transformation, and the results of that simulation are the source of

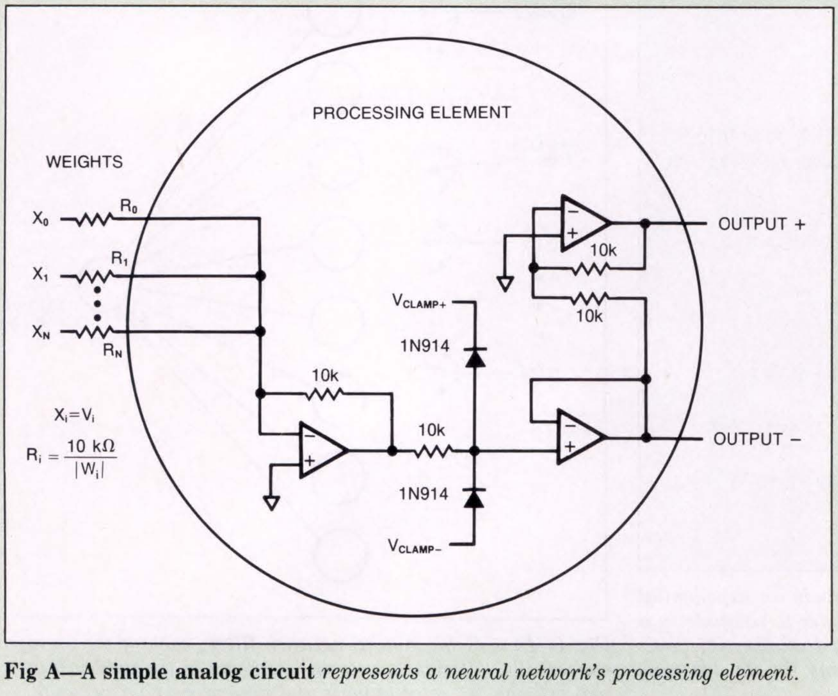

Fig A—A simple analog circuit *represents a neural network's processing element.*

the weights in **Fig 1**. The graphic results of the simulation are shown in **Fig B**.

Confident that our processing element provided an adequate approximation, we designed the remainder of the circuit, shown in **Fig C**. We built the circuit, and its response is shown in **Fig D**. The only change we suggest is to temperature compensate the diode clamping voltages.

This same circuit can approximate $\sqrt{X}$, e^X, and many other continuous functions of one variable; all that would change would be the 16 resistors that represent the weights.

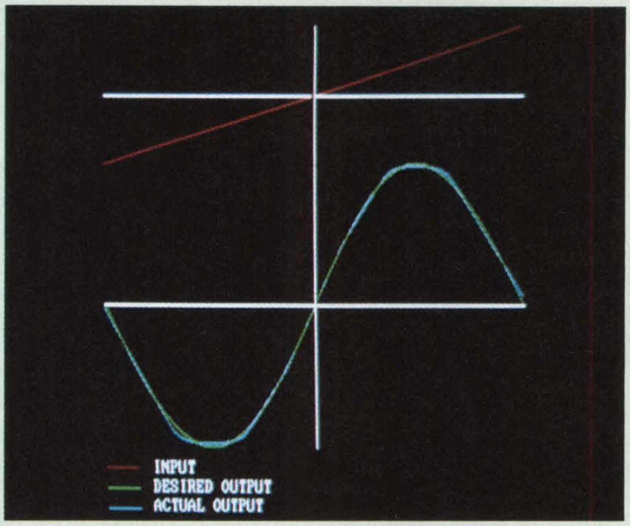

***Fig B—Shown here are the graphic results** of the neural-network simulation we developed to map X to sin(X). The input ranges from $-\pi$ to $+\pi$.*

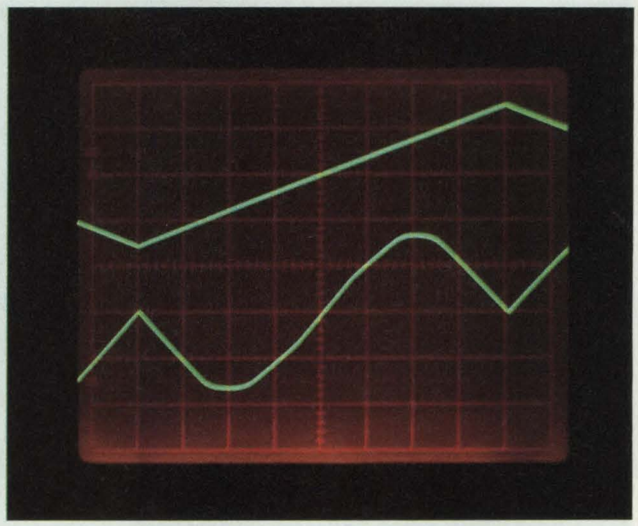

***Fig D—The circuit shown in Fig C** responds as shown here. The upper trace is the input at 2V/div; the lower trace is the output at 0.5V/div. Sweep speed is 0.1 msec/div.*

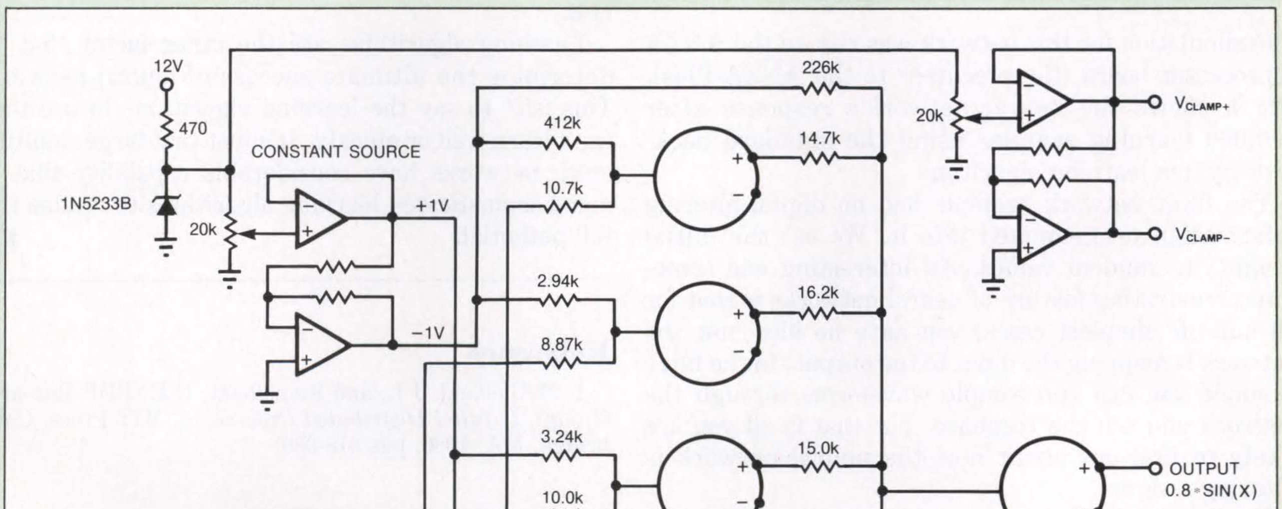

***Fig C—This analog circuit represents** an implementation of the neural network shown in **Fig 1** on pg 139.*

Neural networks aren't right for every application, but they do give you another option for solving design problems.

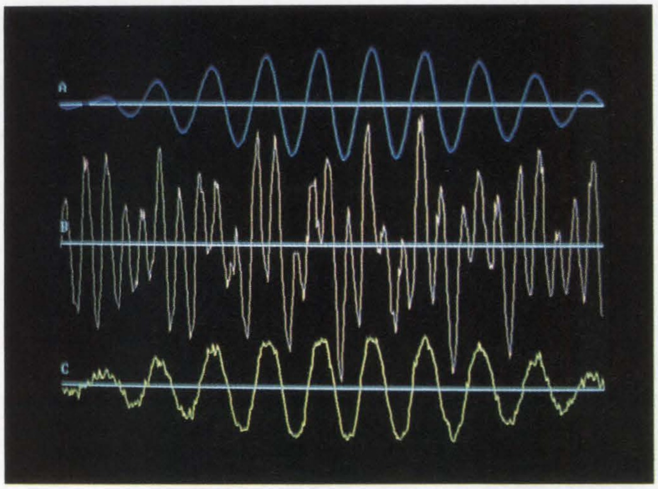

Fig 5—This figure shows the response of an adaptive neural-network filter. The top trace shows the original signal. The middle trace is the original signal plus noise, which was applied to the 41-tap neural network filter. The bottom trace is the filter's output. The photo was taken after 200,000 learning samples. The noise source was random within frequency and amplitude limits.

The simulation for this network was run on the ANZA coprocessor board (the precursor to the ANZA-Plus). **Fig 5** shows the neural network's response after 200,000 learning samples using the standard back-propagation learning algorithm.

The filter network example had no digital-filtering information programmed into it. We set the initial weights to random values. An interesting and sometimes frustrating feature of neural networks is that for all but the simplest cases, you have no idea how the network is mapping the input to the output. In the filter example you can run sample waveforms through the network and see the response, but that is all you are likely to find out about how the neural network is filtering a signal.

Working with mapping neural networks requires you to look at problems from a different perspective from the one most of us are accustomed to. The normal approach to solving a design or computational problem is to break the problem down into small units and develop an algorithm for each unit. Because neural networks do not require you to develop the algorithm for each unit, you can think of problems in terms of inputs, transformations and outputs.

For example, a typical control-system application can be viewed as a data-transformation problem. Although neural networks probably cannot compete for simplicity in standard linear control applications, neural networks do have potential in nonlinear applications. A neural-network control system can learn to use nonlinear sensor information and drive nonlinear actuators without requiring you to develop the control algorithms or use lookup tables. You do, however, have to provide a training set.

Neural networks aren't right for every application, but they do give you another option for solving design problems. At present you are limited to either building neural networks at the component level or using virtual neural-network implementations.

Before you can expect to take advantage of the high speeds possible with parallel implementations of neural networks, integrated circuits that pack more neural-network building blocks into one chip are needed. A number of different research organizations are currently working on the problem. As these neural-network building blocks become available, networks with large numbers of processing elements and real-time processing speed should become practical. The means of simulating large networks, however, is available right now.

Learning algorithms are the other factor that will determine the ultimate success of neural networks. This isn't to say the learning algorithms in use today can't learn well or quickly. It's just that large, multilayered, networks have considerable capability that demand sophisticated learning algorithms to realize their full potential. **EDN**

Reference

1. McClelland, J L, and Rumelhart, D E (PDP Research Group), *Parallel Distributed Processing*, MIT Press, Cambridge, MA, 1986, pgs 318-330.

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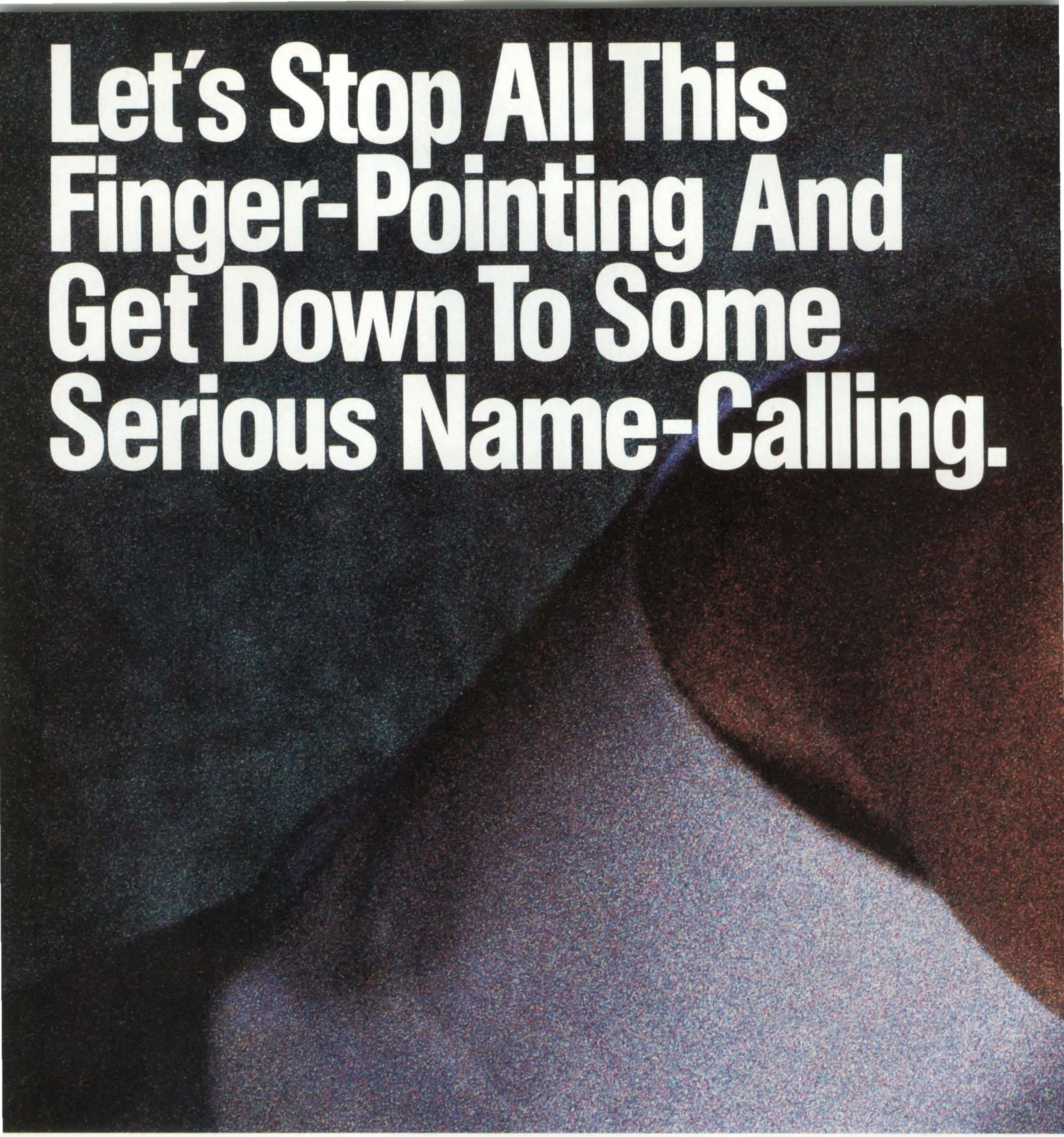

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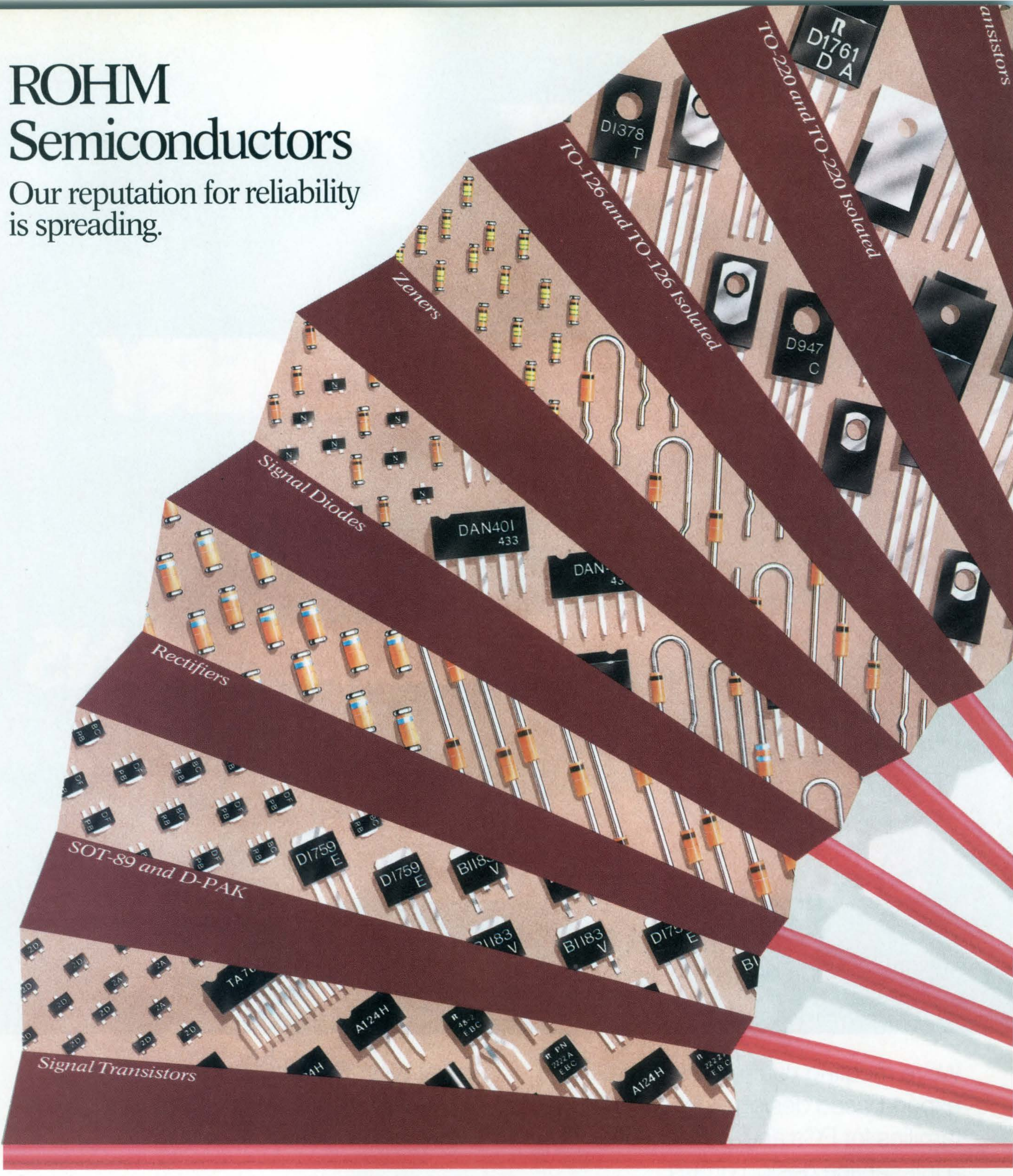

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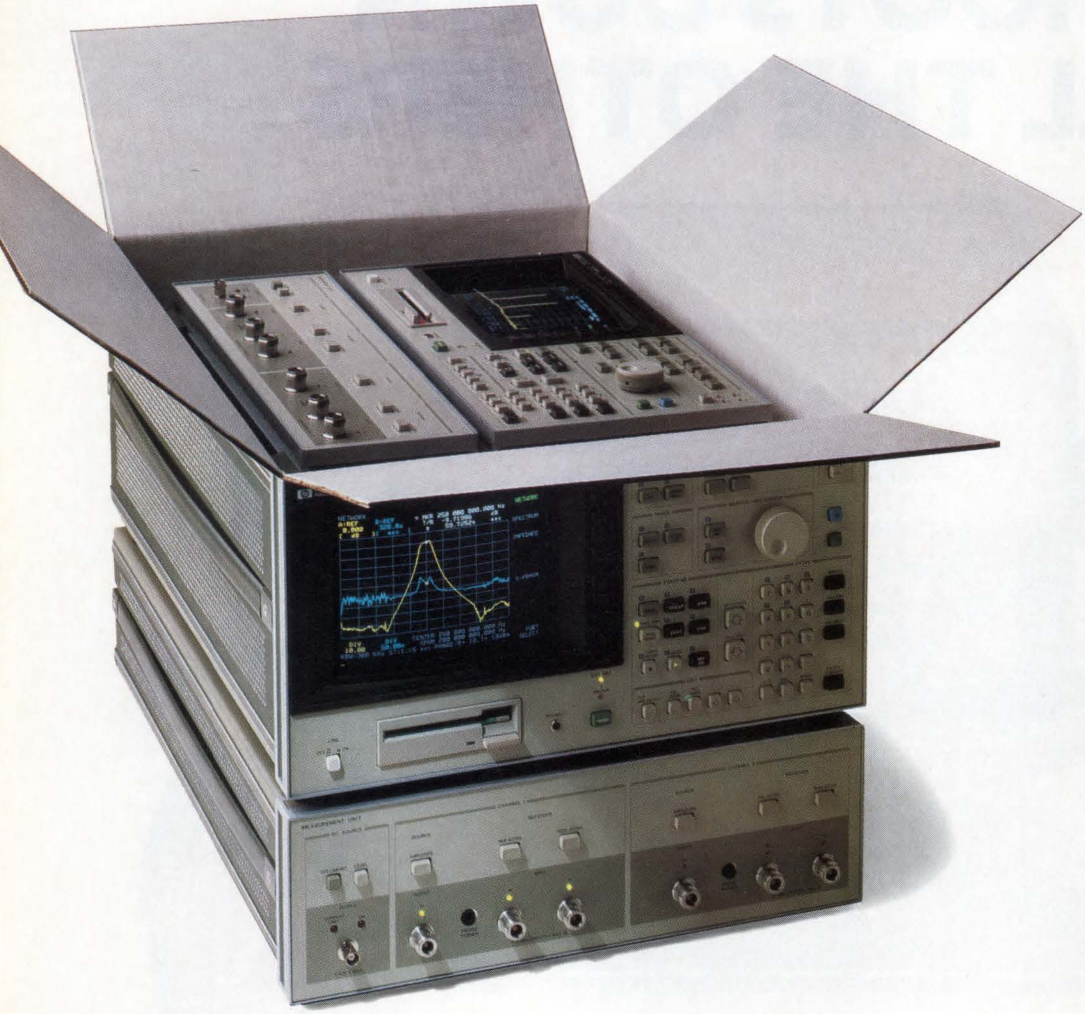

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Designer's Guide to noise analysis—Part 1

A systematic approach facilitates noise analysis

You can use a systematic analysis technique to determine the noise contributions of the individual elements in an electronic system, no matter how complex it is. This article, part 1 of a 2-part series, describes the noise-analysis technique. Part 2 will show you how to develop an electronic spreadsheet for evaluating the system's overall noise performance as you modify the individual sections for low-noise performance.

Peter Fazekas, *ILC Data Device Corp*

The magnitude of the noise in a given system may determine whether the system operates as expected, operates marginally, or doesn't operate at all. When you begin a design, therefore, it's essential to consider the effects of the various noise sources throughout the system. Once you've determined the noise contributions of the individual components, you can optimize the system for low-noise performance by replacing or modifying the sections you identify as problem areas.

The task is a complex one, however. Many different noise sources can contribute to the total noise in a system, and when you optimize a particular circuit section to maximize its performance or minimize its noise contribution, you may inadvertently increase the noise in other sections. Systems that have a large number of noise sources are often difficult to optimize for low-noise performance.

Tasks of this nature and complexity have long been a part of the business world in the form of "what-if" forecasting. The basic tool for this type of analysis is a spreadsheet program that presents statistical data in tabular form. An electronic spreadsheet can instantly show the effects of a change in any single parameter on the overall results. You can use this type of analysis to evaluate the effects of circuit changes on the overall noise performance of a system. Before you can perform such an analysis, however, you must first develop a mathematical model that represents the system in a suitable form.

The effects of noise in linear systems

The three types of noise you must consider when analyzing the performance of devices and circuits are thermal noise, shot noise, and 1/f noise (see **box**, "The physics of noise"). When optimizing the noise performance of a system, you'll have to determine the actual amount of noise voltage or noise current generated by each component.

If you apply a source having a voltage power spectral density of $P_V(f)In$ to a circuit with a voltage transfer function of $H_V(f)$, the resultant output-voltage power spectral density is

$$P_V\,(f)\,OUT = P_V\,(f)\,IN \cdot |H_V\,(f)|^2.$$

The three types of noise most important to electronic-circuit designers are thermal noise, shot noise, and 1/f noise.

The rms value of the voltage represented by the output power spectral density is

$$\sqrt{\overline{V_{OUT}^2}} = \left[\int_0^\infty P_V(f)_{OUT} \cdot df \right]^{1/2}.$$

Referenced to the source, the rms value of the voltage is

$$\sqrt{\overline{V_{OUT}^2}} = \left[\int_0^\infty P_V(f)_{IN} \cdot |H_V(f)|^2 df \right]^{1/2}.$$

You can represent the power spectral density of a noise source as either a voltage source, $P_V(f)$, in series with its generating resistance R, or a current source, $P_I(f)$, in parallel with resistance R. You can convert from one type to the other in the following manner:

- The value of the voltage power spectral density divided by the series resistance squared gives the current power spectral density: $P_I(f)=P_V(f)/R^2$.
- The value of the current power spectral density multiplied by the parallel resistance squared gives the voltage power spectral density: $P_V(f)=P_I(f)\cdot R^2$.

For example, the voltage power spectral density of the noise generated by a resistance, R, is $P_V(f)=4KTR$; as a current power spectral density, the noise is $P_I(f)=4KTR/R^2=4KT/R$.

You can also express the transfer function of the circuit as any combination of voltage or current input and voltage or current output. You should take care to use the correct form of the transfer function so as to match the input form to the type of output required.

Because the shape of an arbitrary filter can take a number of forms, the filter's −3-dB point alone can't define its noise characteristics. To determine total noise output, you can use the the concept of noise equivalent bandwidth (NEBW). The NEBW of a circuit is the bandwidth of an ideal filter (with vertical sides and identical midband gain) that passes the same amount of power that the real filter does. In this case, bandwidth is defined as the difference between the high and low corner frequencies of the ideal filter.

Therefore, the value of the power (voltage squared) due to a source P(f) passed through a circuit with a transfer function H(f) is

$$\overline{V_{OUT}^2} = \int_0^\infty P(f)_{IN} \cdot |H(f)|^2 df.$$

If the function P(f) is independent of frequency (as with thermal or shot noise at low frequency) you can move it outside of the integral sign, which results in

The physics of noise

The three types of noise you generally need to consider when designing electronic circuits are thermal noise, shot noise, and 1/f noise.

Thermal noise derives its name from its characteristic change in magnitude as a function of temperature. Any material that conducts electricity does so as a result of the free electrons that exist in the volume of the substance. These electrons are in constant motion, randomly colliding with each other. On the average, these electrons are evenly distributed throughout the bulk of the material. However, because of their random action, they do exhibit a statistical deviation from neutrality.

The effect of this deviation is to generate a voltage drop at the terminals of the conductor. The higher the temperature, the more energy the free electrons have, which greatly increases the probability that the electrons will be unevenly distributed. This uneven distribution results in a higher output voltage. Thermal noise, which is zero for a perfect conductor, also increases with an increase in the value of any resistance. The voltage power spectral density of thermal noise is $P_V(f)=4KTR$, where $P_V(f)$ is the frequency-dependent voltage power spectral density, K is Boltzman's constant (1.38^{-23} J/°K), T is the temperature in °K, and R is the resistance of the material in ohms.

Thermal noise exhibits no change in magnitude as a function of frequency, and can be considered to be *white noise*, whose name implies that all frequencies are present (just as all colors are present in white light). The contribution of white noise is limited only by the bandwidth of the circuit.

Shot noise is caused by the quantum nature of electron flow. In semiconductor devices, this effect is due to the random diffusion of minority carriers and the

$$\overline{V_{OUT}^2} = P(f)_{IN} \cdot \int_0^{\infty} |H(f)|^2 \, df.$$

The second half of this equation, normalized to unity, is the NEBW of the circuit. The resulting NEBW is

$$1/|H(fm)|^2 \cdot \int_0^{\infty} |H(f)|^2 \, df,$$

where H(fm) is the transfer function at the midband frequency, fm.

A sample calculation illustrates the approach. Let the filter be a simple first-order lowpass type with

$$H(f)=1/(1+j(f/f_c)),$$

where f_c is the −3-dB frequency.

The midband gain, H(fm), is unity, and

$$|H(f)|^2 = 1/(1+(f/f_C)^2).$$

Therefore, the NEBW is

$$1 \cdot \int_0^{\infty} 1/(1+(f/f_C)^2) \, df.$$

Since, by definition, $\int 1/(1+U \cdot f)df = 1/\sqrt{U} \cdot \arctan(f \cdot \sqrt{U})$, and the substitution $U=1/fc^2$ can be made, the NEBW is

$$1/f_C \cdot \arctan(f/f_C) \Big|_0^{\infty} = \pi/2 \cdot f_C - 0 = \pi/2f_C.$$

For a lowpass filter, the NEBW is $\Pi/2 \cdot fc$; for a highpass filter, the NEBW is $2/\Pi \cdot fc$.

The value $\sqrt{P(f)}$ is often provided by component manufacturers and referred to as the equivalent input noise in units of volts per root hertz ($V/\sqrt{Hz}$) or amps per root hertz ($A/\sqrt{Hz}$). The rms voltage at the output of the filter having a flat input-noise spectral density is

$$\sqrt{P(f)_{IN}} \cdot \left[\int_0^{\infty} |H(f)|^2 \, df\right]^{1/2}.$$

Evidently, this value is simply the input equivalent noise multiplied by the square root of the NEBW.

Filtered noise characteristics

Assuming that it's flat with respect to frequency, the total rms noise passed through a filter is the equivalent input noise multiplied by the square root of the NEBW. For example, a standard 741 op amp has a white-noise

random generation and recombination electron-hole pairs. At a given temperature and voltage, the current flowing through a semiconductor will be relatively constant. This current is the result of a large number of electrons flowing in the same general direction; each electron has a random component. It is this random component that causes shot noise. The current power spectral density of shot noise is $P_I(f)=2qi$, where $P_I(f)$ is the frequency-dependent current power spectral density, q is the charge on one electron (1.59^{-23}C), and I is the current flowing through the device. As is the case with thermal noise, shot noise is independent of frequency to very high frequencies, and it can be considered to be white noise.

As its name implies, 1/f noise has a voltage power spectral density that varies as $P_V(f)=Kf/f^a$, where *Kf* is a device parameter (such as $1\mu V$ in the relationship $1\mu V/\sqrt{Hz}$) and *a* is a factor between 0.8 and 1.4 (but it's normally set to 1).

This type of noise exists in all electrical devices—it has been measured in bulk resistors, junction semiconductors, metal film, superconductors, and electrolytic solutions. Regardless of where it occurs or what causes it, noise that varies with frequency is usually called 1/f noise. It's also referred to as current noise, excess noise, flicker noise, semiconductor noise, and contact noise.

The cause of 1/f noise is not well understood, but current knowledge of this type of noise is drawn from a large pool of experimental data. Noise of this power spectral density is measurable and observable in the 10^{-6}- to 10^{6}-Hz range, which agrees with theoretically predicted levels.

Because the magnitude of thermal noise is frequency independent over the circuit's bandwidth, it falls into the category of white noise.

floor that's specified as 15 nV/$\sqrt{Hz}$. If this noise passes through a filter with an NEBW of 10 kHz, the total rms voltage at the output is

$$15\ nV/\sqrt{Hz} \cdot NEBW = 1500\ nV$$

If the noise spectral density is not independent of frequency, you'll have to evaluate the integral of

$$V_{OUT} = \left[\int_0^\infty P_V\ (f)_{IN} \cdot |H\ (f)|^2\ df\right]^{1/2}.$$

Designers frequently use numerical methods for the integration because the integration is often complex.

A common noise spectral density that's frequency dependent is 1/f noise, which has a voltage power spectral density of $P_V(f)=en/f^a$ (a is set at unity). The rms voltage due to this type of source is

$$V_{OUT} = \int_{F_L}^{F_H} (e_n/f)df = e_n \cdot \log n\ (f)\ \Big|_{F_L}^{F_H}.$$

If you take the low-frequency limit as 0 Hz, the output voltage is infinite. To have a true 0-Hz limit, the circuit would have to exist in its On state for an infinite period of time. Even a measurement period of 30 days generates a low-frequency limit of only 0.00000039 Hz, thus limiting the total noise to a finite value.

You determine the total rms noise voltage by evaluating V_{OUT} with the appropriate frequency limits. These frequencies are the corner points of the ideal filter, represented by the NEBW. For example, assume you wish to calculate the rms noise voltage of a circuit with the following characteristics:

- First-order low-frequency corner at 0.3 Hz
- First-order high-frequency corner at 30 kHz
- 1/f noise source of 1 nV/$\sqrt{Hz}$ at 1 kHz

The results of the calculations are

- Low-frequency corner: $f_L=0.3\cdot(2/\Pi=0.191$ Hz
- High-frequency corner: $f_H=30{,}000\cdot(\Pi/2)=47.124$ kHz
- Total rms noise voltage: 1 nV$\cdot\log_n(f_H/f_L)=12.4$ nV

Multiple filter combinations

In a system that has a number of filters in the noise path, each with different frequency characteristics, you'll have to combine these characteristics into a final result to determine the NEBW of the circuit. This process is often long and difficult because of the complexity of the integrations. If an approximation of the NEBW is adequate, the following relationships are useful: If two first-order filters are in series, the combined filter has an NEBW higher than either one for highpass filters, and lower than either one for lowpass filters. If the ratio of the higher-to-lower corner frequency is R, then the ratio of the combined NEBW to the −3-dB corner frequency of the dominant pole is equal to $\Pi/2\cdot(1-(1/1+R))$ for a lowpass filter and $2/\Pi/(1-(1/1+R))$ for a highpass filter. The coefficient $(1-(1/1+R))$ adjusts the NEBW of the dominant frequency.

If more than two filters are in series, you should combine their characteristics by calculating the NEBW for the first two, and then combine the result with the next filter. You continue this process until you've considered all of the filters. For example, if there are two first-order lowpass poles, one at 10 Hz and the other at 45 Hz, the ratio R is 4.5 and the correction factor is $1-(1/(1+R))=0.818$. The NEBW of the dominant 10-Hz pole is 15.7 Hz, and the combined NEBW of the two filters is $15.7\cdot0.818=12.85$ Hz.

Superposition and noise-source combinations

The superposition theory holds for noise sources in the frequency domain. In other words, if two independent sources, $V_1(t)$ and $V_2(t)$, are summed to form V(t), the resultant power spectral density is $P_V(f)=P_1(f)+P_2(f)$. The implication is that when two sources are combined, the rms value of the result is equal to the root of the sum of the squares of the rms value of the individual sources.

You can extend this principal to an arbitrary number of sources. If you write the rms value of each noise source as V_N, the total output is

$$V_T = \sqrt{V_1^2 + V_2^2 + V_3^2 \ldots V_N^2}).$$

By using this theory, you can evaluate the total noise of a large system that has multiple noise sources. With this basic knowledge of the properties of electronic noise and how it behaves in electrical circuits, you've taken the first step in being able to predict the noise performance of entire systems. The next step is to understand the noise contributions of the individual components.

The dominant noise in bulk conducting material is thermal noise. The model used to represent bulk material is a noiseless resistor with an ohmic value the same as that of the bulk material, and an ideal noise source (either in series with or parallel to the resistor). If the source is in series, it has a voltage power spectral density of $P_V(f)=4KTR$. If the source is parallel, it has a current power spectral density of $P_I=4KT/R$. $P_V(f)$ and $P_I(f)$ are the voltage and current power spectral densities, respectively; K is Boltzman's constant ($1.38 \cdot 10^{-23}$ J/°K; T is the temperature in °K; R is the resistance in ohms.

The actual noise measured may be greater than the predicted value. This additional noise is known as excess noise, and it has a 1/f spectral response. This noise is proportional to the voltage drop across the resistor and is usually defined by a quantity called the "noise index." The noise index (measured in dB) is the microvolts of noise per dc volts across the resistor in each decade of frequency. The amount of excess noise depends on the method of manufacture of the resistor. Carbon-composition resistors generally have a noise index in the range of +10 to −20 dB. Carbon-film resistors range from −10 to −25 dB, and metal-film resistors and wire-wound resistors range from −15 to −40 dB. **Fig 1a** illustrates the model.

You can model a junction diode **(Fig 1b)** by a resistor (R_S), which represents the ohmic region of the diode, in series with a current source (I_D), which represents the diode current. The thermal noise of the diode has a current power spectral density of $P_I(f)=4KT/R_S$. The noise representing the current source has two components: shot noise and 1/f noise. Shot noise has a current power spectral density of $P_I(f)=2q \cdot I_D$, where q is the charge on one electron. The 1/f noise has a current power spectral density of

$$P_I\,(f) = (Kf/f^a)\ I_D^{Af}.$$

You must determine the values of *Kf*, *Af*, and *a* either experimentally or from curves provided by the manufacturer. *Kf* is a device constant, *Af* is a process parameter, and *a* is a constant with a value near unity. The characteristics of the device and the nature of the circuit that it's used in determine the need to include the 1/f component in the overall evaluation.

Fig 1c is a simple model of a bipolar junction transistor (BJT). The three resistors produce current power spectral densities of $P_I(f)=4KT/R_B$, $P_I(f)=4KT/R_C$, and $P_I(f)=4KT/R_E$. The base-current source contains components of shot noise and 1/f noise, and has a current power spectral density of:

$$P_I\,(f) = 2q \cdot I_B + (Kf/f^a)\ I_B^{Af}.$$

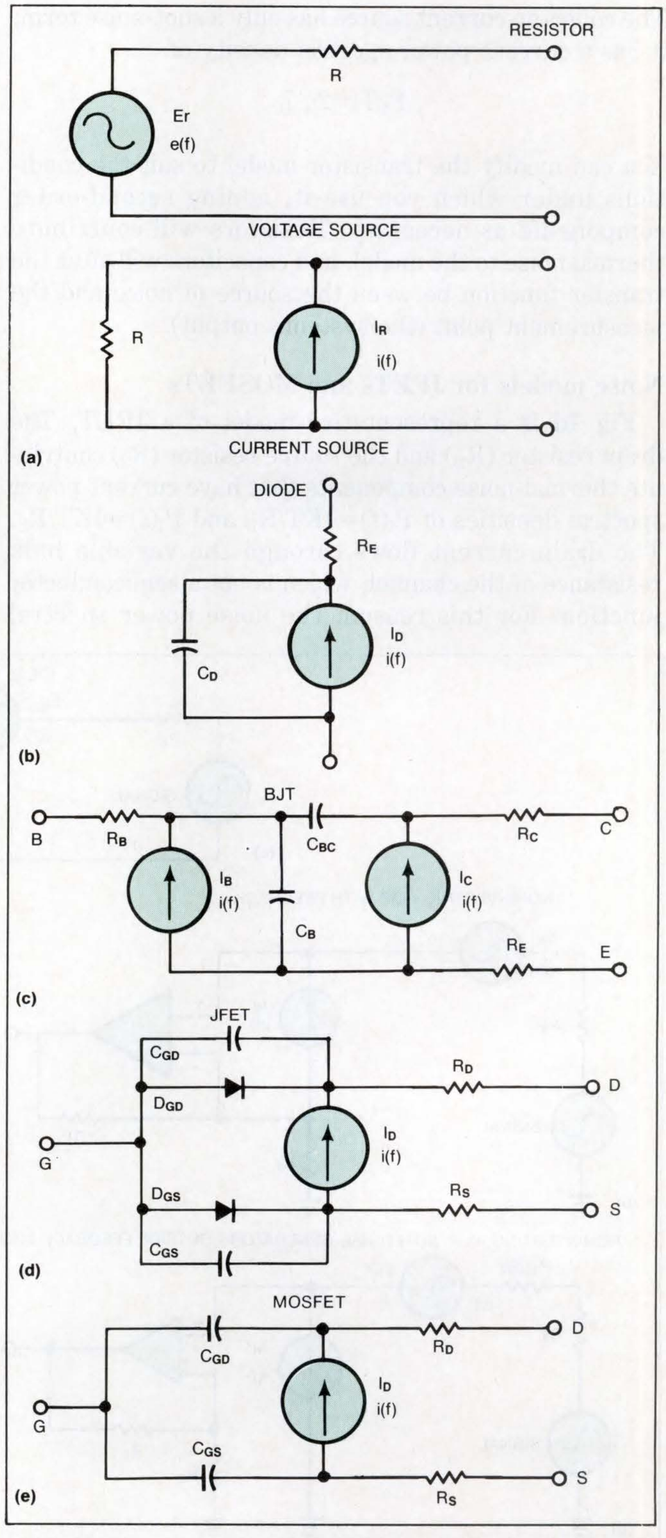


__Fig 1—You can use these models to evaluate__ the noise characteristics of passive and active components.

As its name implies, 1/f noise is frequency dependent. Although it exists in all electrical devices, 1/f noise is poorly understood.

The collector-current source has only a shot-noise term; it has a current power spectral density of

$$P_I(f)=2q \cdot I_C$$

You can modify the transistor model to suit the conditions under which you use it, adding second-order components as necessary. Resistors will contribute thermal noise to the model, and capacitors will alter the transfer function between the source of noise and the measurement point (the system's output).

Noise models for JFETs and MOSFETs

Fig 1d is a representative model of a JFET. The drain resistor (R_D) and the source resistor (R_S) contribute thermal-noise components that have current power spectral densities of $P_I(f)=4KT/R_D$ and $P_I(f)=4KT/R_S$. The drain current flows through the variable bulk resistance of the channel, which is not a semiconductor junction. For this reason, the noise power spectral density is that of the equivalent channel resistance:

$$P_I(f)=4KT/R_D+(Kf/f^a) \cdot I_D^{Af},$$

where R_D is the small-signal channel resistance at the operating point. Because the conductance of the channel ($1/R_D$) is equal to ⅔·gm (sat) over the normal biasing range, the current power spectral density is

$$P_I\ (f) = 8KT \cdot gm(SAT)/3 + (Kf/f^a)\ I_D^{Af}.$$

Note that a good silicon JFET has no observable 1/f noise, and its *Kf* coefficient is zero. Gallium arsenide JFETs do exhibit 1/f noise, and you'll have to include that noise in your calculations.

Fig 1e is the model for a MOSFET. The formulas for the current power spectral density of the drain resistor and the source resistor are the same as those for the JFET, as is the formula for the drain-current power spectral density.

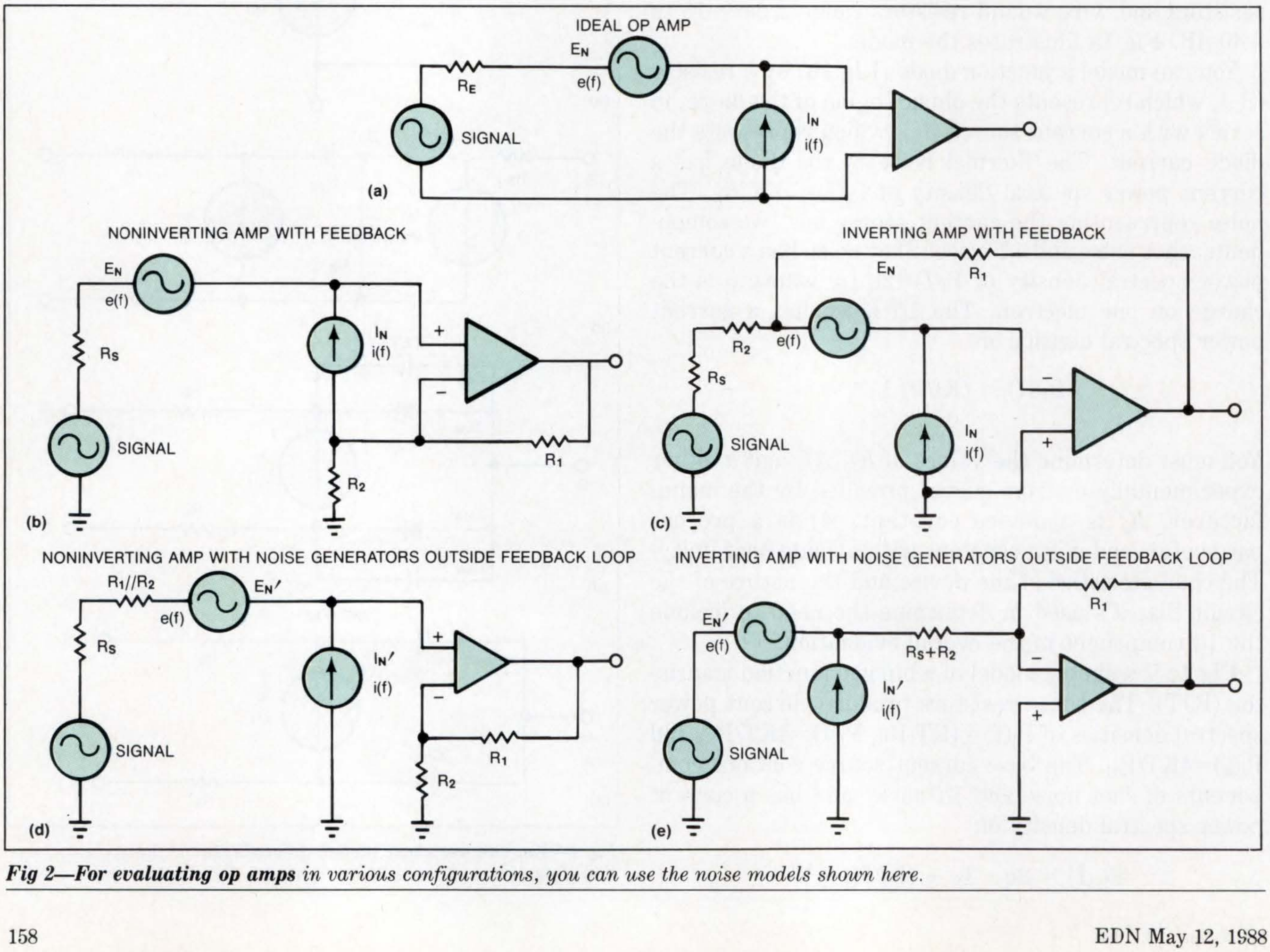
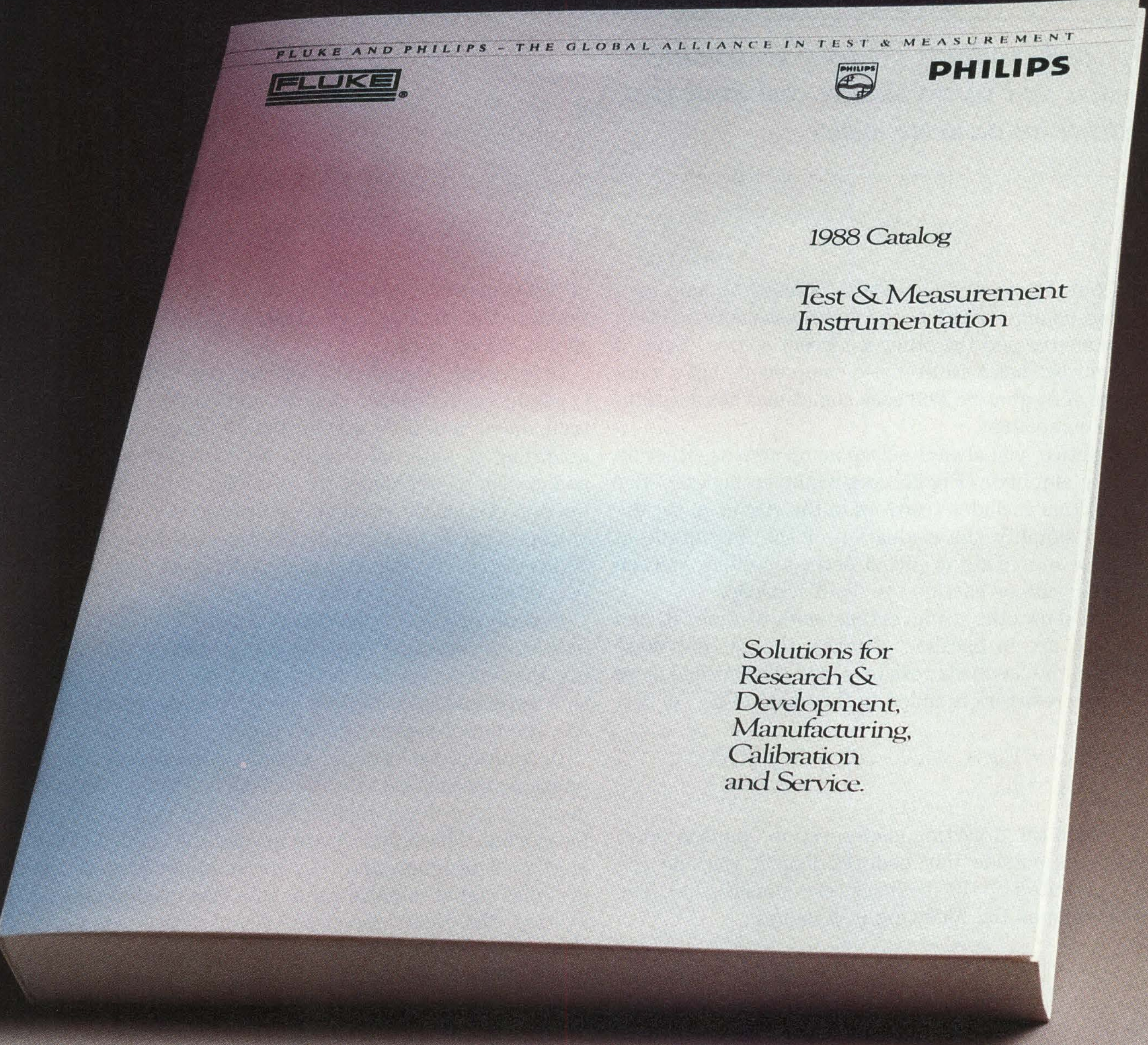


***Fig 2—For evaluating op amps** in various configurations, you can use the noise models shown here.*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To properly evaluate the noise contributions of active and passive devices, you must first construct an accurate model.

You can represent the model of a noisy op amp by a noiseless op amp **(Fig 2a)** and two noise sources, one a voltage source and the other a current source. Each of these sources has a white-noise component that's independent of frequency, and each sometimes has a significant 1/f component.

In practice, you always set up an op amp as either an inverting amplifier **(Fig 2c)** or a noninverting amplifier **(Fig 2b)** that includes resistors in the circuit to set the gain. To simplify the evaluation of the magnitude of each noise source at the output of the amplifier, you can bring the sources outside the feedback loop.

Fig 2d shows the noninverting configuration. R_1 and R_2, which are in parallel, simulate the current noise flowing in the feedback resistors, and the thermal noise of the two resistors is added to the value of E_N' so that

$$E_{N'}^2 = E_N^2 + (4KT \cdot (R_S + R_1 // R_2))^2$$
$$I_{N'} = I_N.$$

To obtain the inverting configuration, you can move the sources outside the feedback loop if you add the noise generated by the feedback resistors **(Fig 2e)**. The sources take on the following new values:

$$E_N'^2 = E_N^2 + (4KT \cdot (R_S + R_2))^2$$
$$\text{and } I_N'^2 = I_N^2 + (4KT/R_1)^2.$$

You can find out the op amp's noise characteristics from its data sheet. The data sheet usually gives the white-noise component (comprising thermal noise and shot noise) in $A/\sqrt{Hz}$ or $V/\sqrt{Hz}$, either of which is the square root of the power spectral density, and represents the amount of noise in a 1-Hz segment of the spectrum. The data sheet usually gives the 1/f noise as the 1/f corner frequency, and, at this frequency, the amplitudes of the 1/f noise and the white noise are equal. Because the amplitude of the 1/f noise at a specific frequency is known, and the shape of the power spectral density curve is $\Pi(f) = Kf/f^a$, you can generate the equation for the overall curve. If you don't have a value for the a coefficient, you can set it to 1 without significant error.

Digitization noise

An A/D converter takes a continuous function of time and breaks it into discrete steps represented by a digital word. By its very nature, the digital representation of the voltage is an approximation. This approximation introduces a quantization error at each conversion, which is observable as quantization noise. This noise is equal to the amplitude of 1 LSB of the A/D converter, multiplied by $\sqrt{12}$.

In general, electronic systems use two different types of transducers: passive and active. A passive transducer modifies a reference voltage or current according to external stimuli. Resistive strain gauges and carbon microphones are examples of passive transducers. An active transducer produces a current or voltage that is proportional to the external stimuli. Piezoelectric crystals and photovoltaic cells are examples of active transducers.

In analyzing each type of transducer for noise performance, consider that resistive components will contribute thermal noise, and active sections will contribute shot noise and (possibly) 1/f noise. In passive transducers, the power source adds to the total noise.

In addition, background acoustic noise from a microphone or mechanical vibration from a strain gauge can generate transducer-related noise in the system you're measuring. These factors are beyond the control of the electronic designer, and they set an upper limit on the system's signal-to-noise ratio. In a background-limited system, the electronic circuits contribute less noise than does the background, and no further electronic improvements are necessary.

Power-supply noise contributions

Further, don't ignore the noise contributions of the power supply. Every component that operates from the power supply has a limited ability to isolate noise at its supply terminals and prevent that noise from passing through to the circuit's output. This ability is called the power-supply rejection ratio (PSRR), and it's usually expressed in dB. For example, a PSRR of 20 dB means that the noise passing into the signal path from the power supply is attenuated by 20 dB. In the case of active components, this noise is multiplied by the stage gain.

The PSRR curve is not independent of frequency. It has approximately the same shape as a first-order lowpass filter: It's essentially flat until the breakpoint, and then it decreases at a rate of 20 dB per decade. To perform noise analysis, you apply a source (specifically, a source whose noise spectrum is identical to that of the power supply) to the input of the amplifier through a lowpass filter. This filter's attenuation characteristics should be the same as the PSRR curve of the amplifier. If, for example, the PSRR of the amplifier is 80 dB, the filter should have 80 dB of attenuation to the specified

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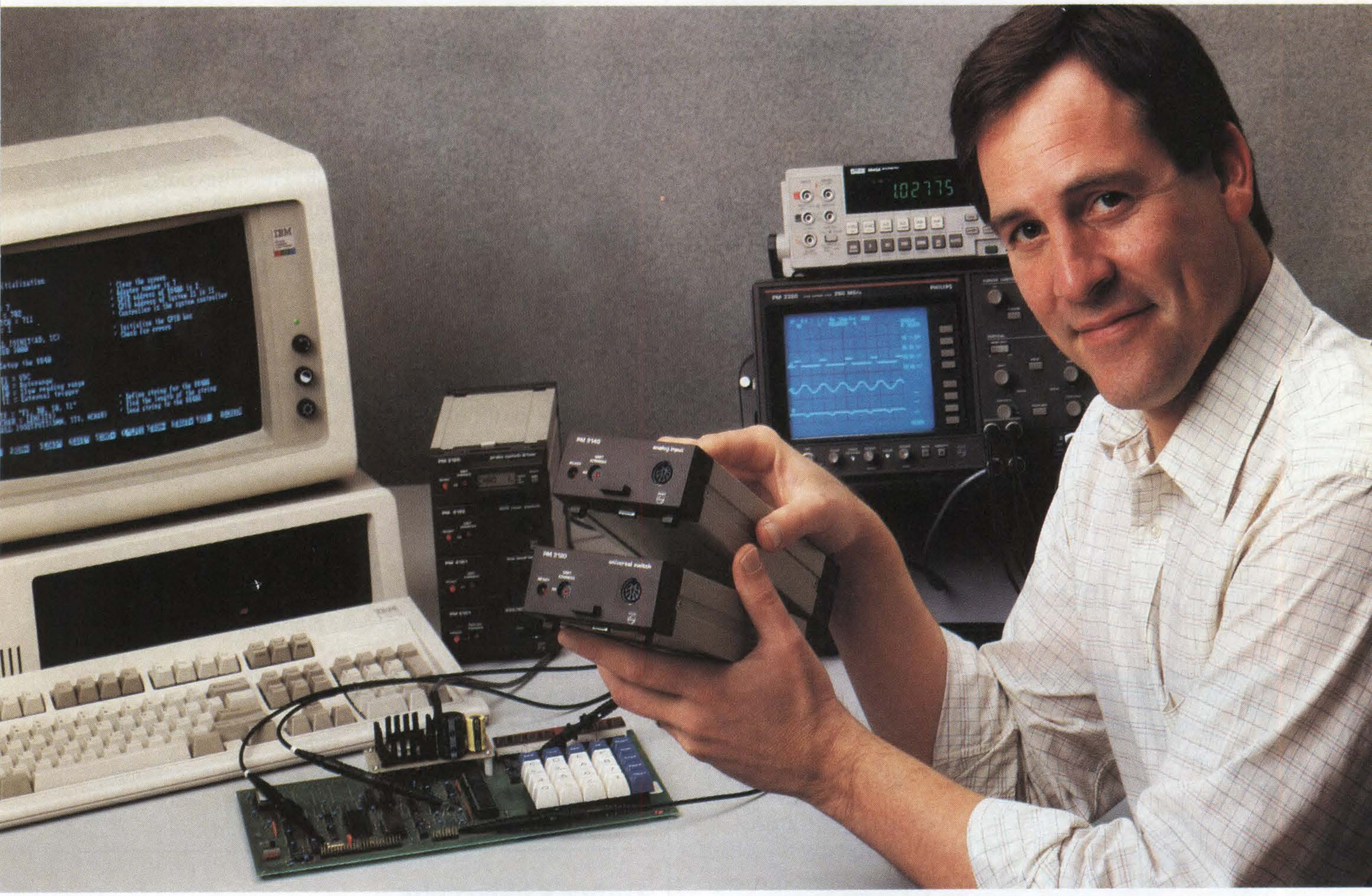

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breakpoint, and then should reduce its attenuation by 20 dB per decade.

Power-supply noise can take the form of white noise (both thermal noise and shot noise), 1/f noise, and noise at discrete frequencies such as 60 Hz. This noise usually has some form of bandlimiting, either in the power supply itself or outside the power supply. The attenuation of the filter limits the amount of noise entering the system.

Once you've analyzed both the noise characteristics of the components in an electronic system, and the way the system modifies the noise, you need only compile the results to understand the system's entire operation. Part 2 of this series will demonstrate a method for compiling the results with an electronic spreadsheet. **EDN**

References

1. Bohn, D, *Audio Handbook*, National Semiconductor Corp, 1976.
2. Buckingham, M J, *Noise in Electronic Devices & Systems*, John Wiley & Sons, New York, NY, 1983.
3. Fitchen, F C, *Low Noise Electronic Design*, John Wiley & Sons, New York, NY, 1973.
4. Lathi, B P, *Signals, Systems & Communications*, John Wiley & Sons, New York, NY, 1965.

Author's biography

Peter Fazekas is a senior design engineer at ILC Data Device Corp (DDC) (Bohemia, NY), where he's currently responsible for the design of hybrid microcircuits. Before joining DDC two years ago, he was employed by Spar Aerospace Ltd in Toronto, Canada. Peter holds a BA in science from the University of Toronto. In his spare time, he enjoys racquetball, scuba diving, and underwater photography.

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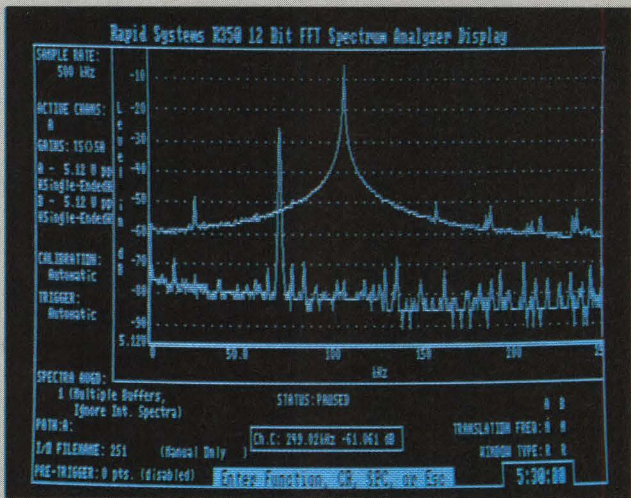

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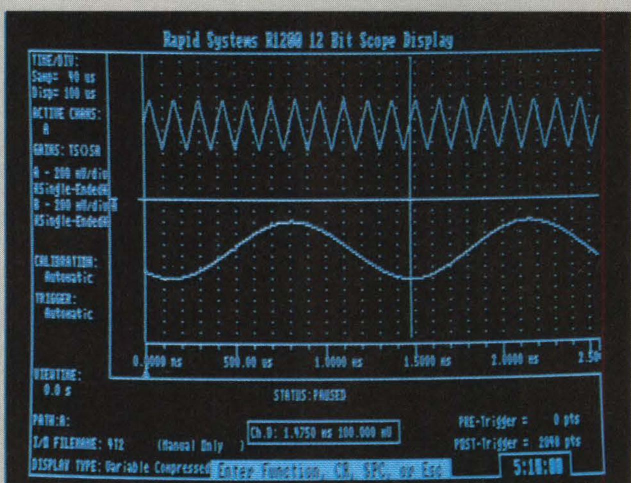

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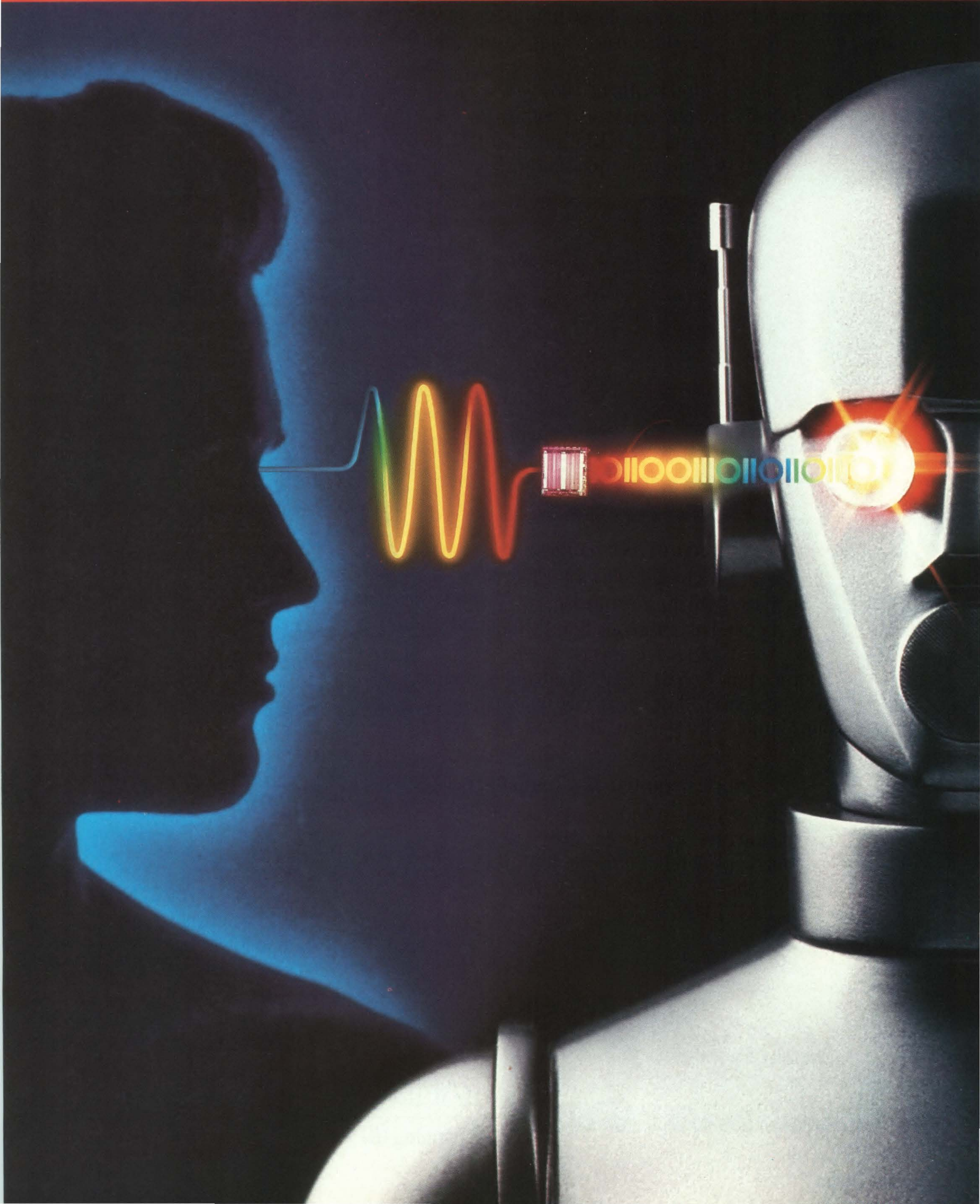

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CA3318E/3318CE	8	15M	150	24	38.50/24.00
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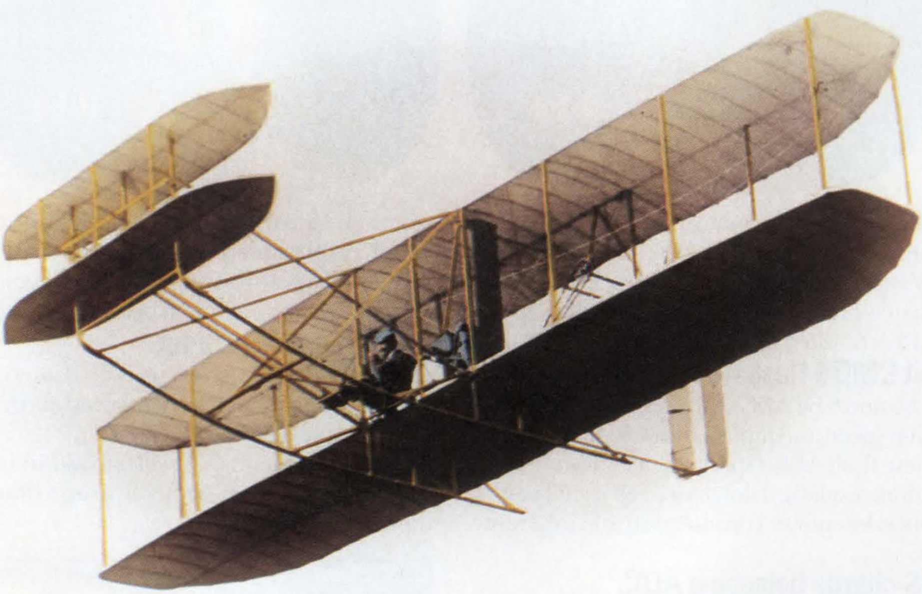

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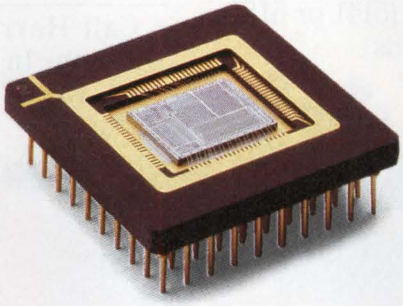
DESIGN ENGINEER, 1988



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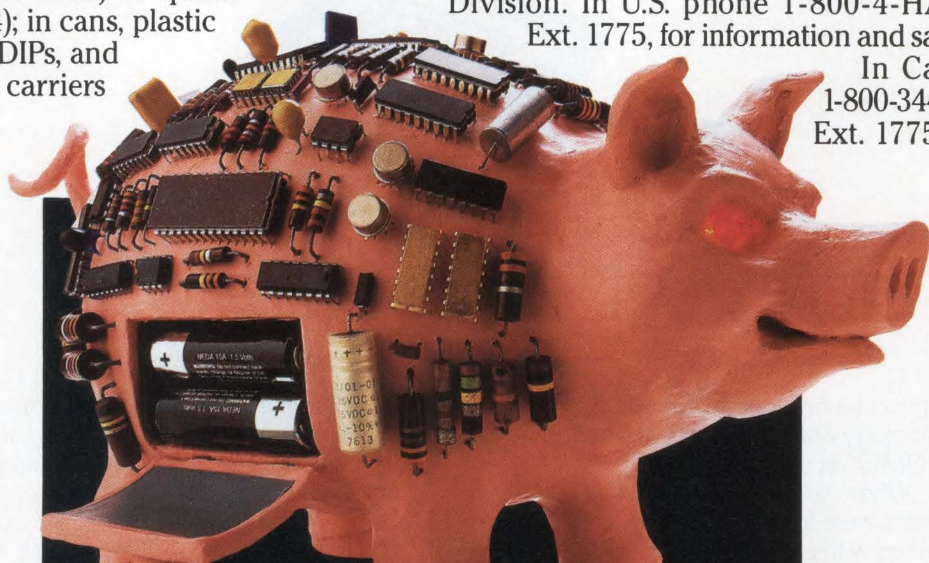

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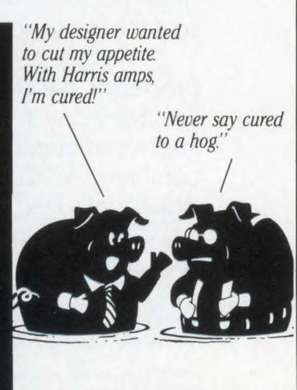

Precision DACs enhance the stability of closed-loop designs

Closed-loop designs oftentimes require the use of D/A converters that have both monotonic response and data readback. This combination of capabilities is now available in off-the-shelf ICs, and thus you'll find it simpler to design stable control loops with 16 bits of resolution and monotonicity.

Damien McCartney and Mike Curtin,
Analog Devices, BV

Closed-loop designs require that the response of the control system be monotonic: For an increasing digital input code, the output voltage should never decrease and, preferably, it should always increase. Further, if the system operates in a noisy environment, or if it is located remotely from the master computer, there is the risk that invalid data may be written to the D/A converter controlling the loop. Data errors can have serious safety implications and cause loop instabilities.

Double-rank input registers with data-readback capability allow you to verify that a converter has received correct data before you update its output. Integrated D/A converters with guaranteed monotonicity—albeit often with limited resolution—have been available for years. Converters capable of data readback have become available more recently. Now, devices that combine 16-bit resolution, guaranteed monotonicity, and readable double-rank registers are becoming available. One of these, a CMOS part with an unusual, voltage-segmented architecture, serves as a representative example and illustrates how you can advantageously use DACs such as these in your closed-loop designs.

The AD7846 (see **box,** "Voltage segmentation enhances DAC performance") inherently guarantees monotonicity. The device also incorporates a bidirectional input latch, so that you can both write data to and read data from the DAC's input. After verifying the data's validity, you can transfer the contents of the input latch to the secondary converter latch, updating the device's output.

End phantom memory

For instance, you can use the AD7846's monotonicity and readback function to enhance ATE system reliability. VLSI test systems can contain as many as 1000 D/A converters. Such testers need to run automatic diagnostic, calibration, and debugging routines to maintain reliable system performance. One debugging technique uses "phantom memory" to check if proper data has been written to the converter; the data in a phantom memory location should be the same as the data in the DAC's latch. Not only does this technique use 1k×16 bits of RAM for 1000 converters, it doesn't guarantee that the data in a D/A converter is correct, especially if

Data errors can have serious safety implications and can cause loop instabilities.

the phantom memory is located at a distance from the D/A converters.

You can overcome both of these drawbacks by using a readback D/A converter. First, load the data word into the DAC's input latch. (On the AD7846 you use the $\overline{CS}$ and R/$\overline{W}$ control inputs.) Next, read the contents of the latch. (On the AD7846 you bring $\overline{CS}$ low and R/$\overline{W}$ high.) Once you've applied the control signals, complete the data transfer. (On the AD7846 you do it by bringing the asynchronous $\overline{LDAC}$ control line low.) The analog equivalent of the digital word will appear at the output of the converter.

Pin driver resolves 300 μV

If you're an ATE system designer, you'll recognize the circuit in **Fig 1.** It's a pin driver/receiver. Each pin on the device under test (DUT) may be a digital input or output. IC_1, an AD345, is the pin driver for the digital inputs, and IC_2, a dual high-speed comparator, is the receiver for the digital outputs. The digital control circuitry determines the signal timing and format.

You set the pin-driver (V_H and V_L) and receiver voltage levels by programming the digital inputs to the DACs. The dc-parametric test routines close the loop by feeding back the pin voltage to the system controller. With 16-bit converters, you can use the D/A converters' resolution to compensate for input/output nonlinearities. Fine-tune the pin test voltage by incrementing or decrementing the converter inputs until you obtain the desired voltage. In a typical digital test system, the voltage span is −3 to +10V. Accordingly, configure the AD7846s for ±10V operation. The resolution will correspond to 300 μV per LSB.

You can employ a high-precision reference for each pin-driver circuit. The circuit of **Fig 1** uses an AD588, IC_3, to generate a ±5V tracking reference for the V_{REF+} and V_{REF-} of the AD7846s. Internal circuitry in the D/A converter scales the reference input to produce an

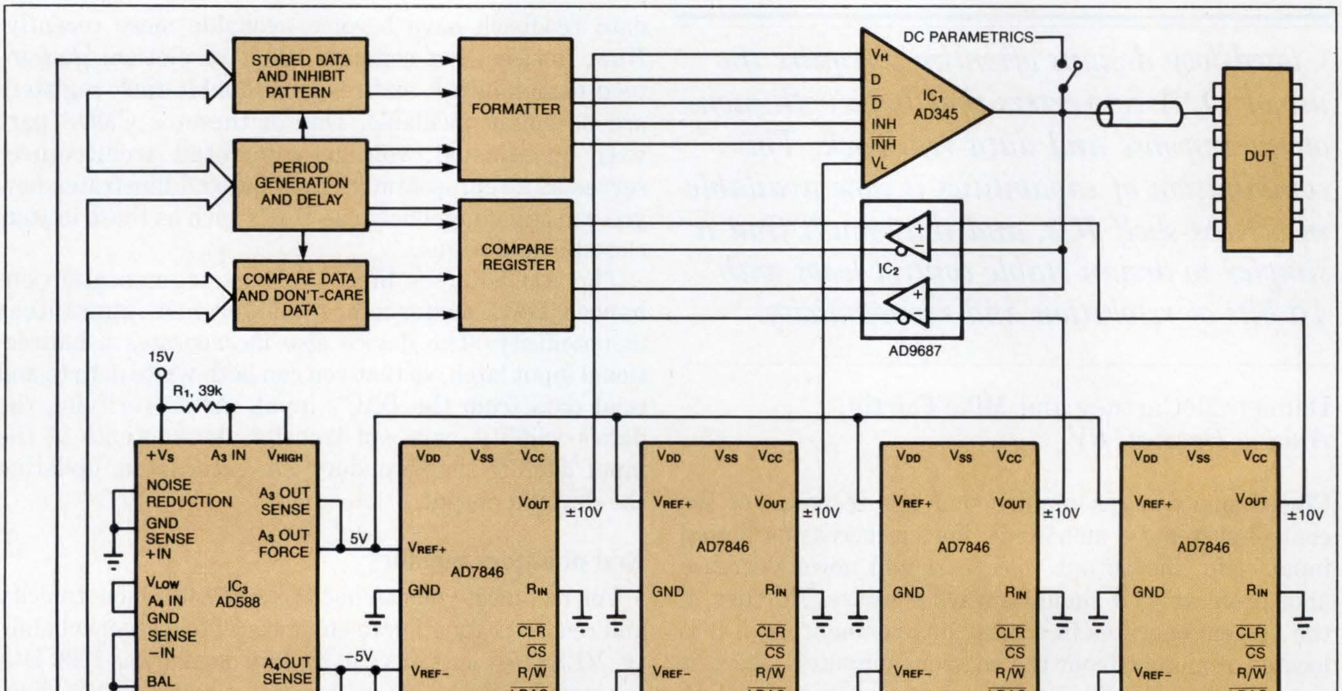

Fig 1—Pin-driver/receiver circuits *for VLSI test systems require numerous high-resolution D/A converters, as you can see. The four AD7846 D/A converters set the high and low logic levels for the AD345 pin driver and the AD9687 receiver. During a calibration cycle, the system controller can both write and read data from the converters' latches, eliminating the need for phantom memory.*

Voltage segmentation enhances DAC performance

The AD7846 DAC, from Analog Devices (Norwood, MA), achieves ±1-LSB differential linearity error and better than ±2-LSB integral nonlinearity. In addition to a 16-bit CMOS D/A converter, the IC incorporates a number of bipolar amplifiers, including an output buffer. All you need to do is supply a external reference voltage. The IC fits in a small 28-pin dual-in-line or surface-mount package.

At the heart of the AD7846 **(Fig A)** is a voltage-segmented D/A converter. It actually comprises three D/A converters, each with its own buffer amplifier. Two 4-bit D/A converters, DAC_1 and DAC_2, share a 16-resistor string, but have their own analog multiplexers. (You apply the external reference voltage to this resistor string.) Another 12-bit R/2R D/A converter, DAC_3, operates in the voltage mode.

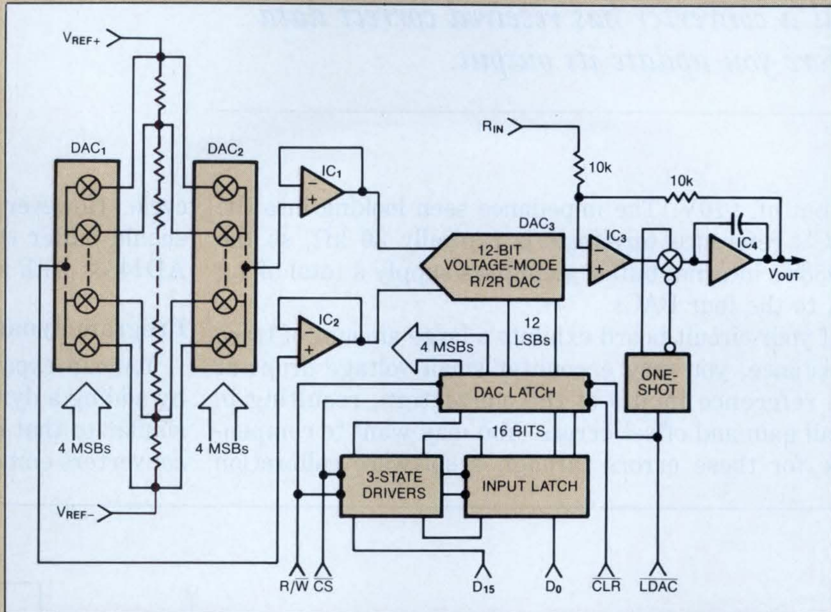

Fig A—This voltage-segmented D/A converter *employs three internal D/A circuits and buffer amplifiers to ensure monotonic operation. The fast bipolar amplifiers deliver a settling time of 7 μsec to ½ LSB.*

The 4 most significant bits of the 16-bit digital code drive DAC_1 and DAC_2; the 12 least significant bits control DAC_3. The MSBs select a pair of adjacent nodes on the resistor string and present the generated voltage to the positive and negative inputs of DAC_3. DAC_3 then interpolates between these two voltages to produce an analog output voltage. Because the voltages at successive nodes on the resistor string are always higher than those at the preceding node, the voltage applied to DAC_3 will always be positive. Furthermore, if the DAC_3 is monotonic, the overall converter will also be monotonic. (It is much easier to build a monotonic 12-bit R/2R D/A converter than it is to build a 16-bit one.)

The design of the AD7846 also compensates for the nonideal behavior of the amplifiers. Consider an 8FFFH to 9000H transition with an applied reference of ±5V. At the former code, DAC_1 generates 0V and DAC_2 produces 0.625V. DAC_3, therefore, will generate a 0.624847V output. At 9000H, DAC_1 changes its output to 0.625V and DAC_2 switches to 1.25V. DAC_3, receiving a zero code, will produce a 0.625V output. If DAC_1's amplifier has a −1-mV offset, however, the generated voltage will decrease to 0.624V, a nonmonotonic response.

To prevent offsets from influencing monotonocity, DAC_2 remains at 0.625V while DAC_1 "leapfrogs" from 0 to 1.25V. At the same time, the input code to DAC_3 is complemented. Now, offset in the amplifiers won't cause nonmonotonocity, because the outputs at both 8FFFH and 9000H are determined principally by the output of DAC_2, which doesn't change between the two adjacent codes. This scheme actually simplifies the multiplexers in DAC_1 and DAC_2 because the former has the even nodes as inputs, and the latter operates from the odd-numbered nodes.

Other useful features on the AD7846, some of which are central to the accompanying article, are fast JFET amplifiers, a resistor feedback network, a track-and-hold amplifier, double-rank input registers whose outer rank can be read back, and a reset input. On a full-scale output swing of −10 to +10V, the D/A converter settles to within ½ LSB in 7 μsec. You can configure the internal feedback network for gains of 1 or 2; with a ±5V reference, the AD7846 generates a ±5 or ±10V output. The addition of a track-and-hold amp to the output buffer amplifier reduces glitches at major code transitions, making the AD7846 useful in audio reconstruction and waveform generation. You can reset the D/A converter's output by selecting the $\overline{CLR}$ and $R/\overline{W}$ pin. Strobing to the $\overline{CLR}$ terminal with the $R/\overline{W}$ pin low resets the output to 0V if you configure the converter for unipolar operation; strobing the $\overline{CLR}$ terminal with the $R/\overline{W}$ pin high resets the output to 0V if you're using a bipolar output range.

Double-rank input registers with data-readback capabilities allow you to verify that a converter has received correct data before you update its output.

output of ±10V. The impedance seen looking into the DAC's reference terminals is typically 30 kΩ, so the AD588's internal buffer amplifiers supply a total of 1.3 mA to the four DACs.

If your circuit board exhibits a large amount of trace resistance, you may encounter small voltage drops at the reference inputs of the converters, resulting in small gain and offset errors. You may want to compensate for these errors through a software calibration cycle. However, if you need very high accuracy, you should buffer the reference inputs of each of the four AD7486s with separate amplifiers.

Program dynamic loads

You can expand the capabilities of your test system by adding a dynamic load. The circuit in **Fig 2,** though similar to that of **Fig 1,** includes three additional D/A converters embodied in two IC packages. The AD7547,

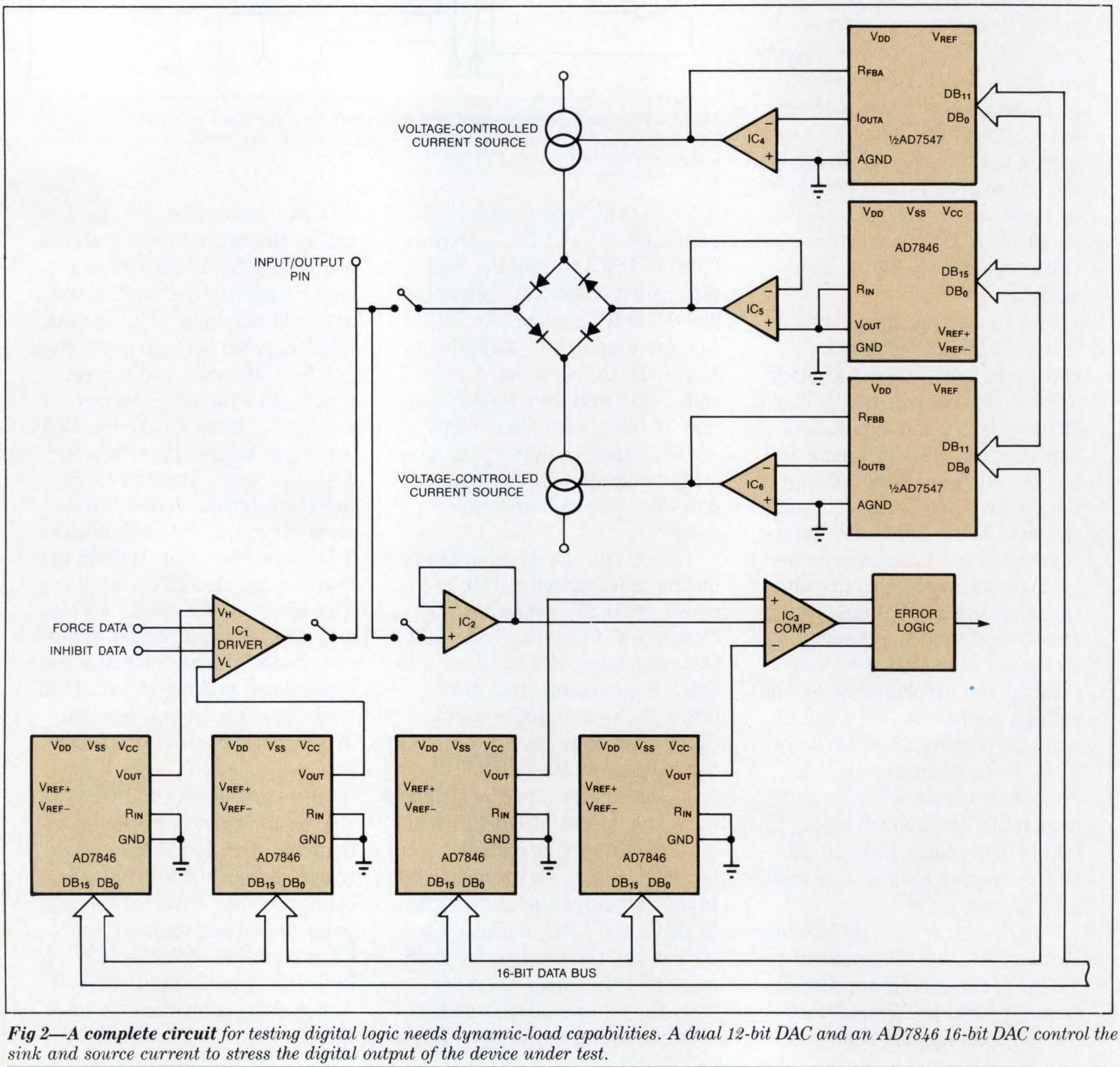

***Fig 2—A complete circuit** for testing digital logic needs dynamic-load capabilities. A dual 12-bit DAC and an AD7846 16-bit DAC control the sink and source current to stress the digital output of the device under test.*

a dual 12-bit D/A converter, controls the current-source and current-sink setup to stress the digital output of the DUT. The additional AD7846 sets the threshold logic level. If you're testing a TTL output, set the current source to 1.6 mA and the current sink to 400 μA. For an ECL output, you'll need the current sink set to two different values: 20 mA for the V_{OL} level, and 7 mA for the V_{OH}. Configure the AD7846 for bipolar operation so that, when testing a TTL output, you'll be able to set the crossover point between V_{OH} and V_{OL} at 1.6V. (With an ECL output, use −1.3V.) You can use the same reference-driving circuitry for this circuit as that of **Fig 1.**

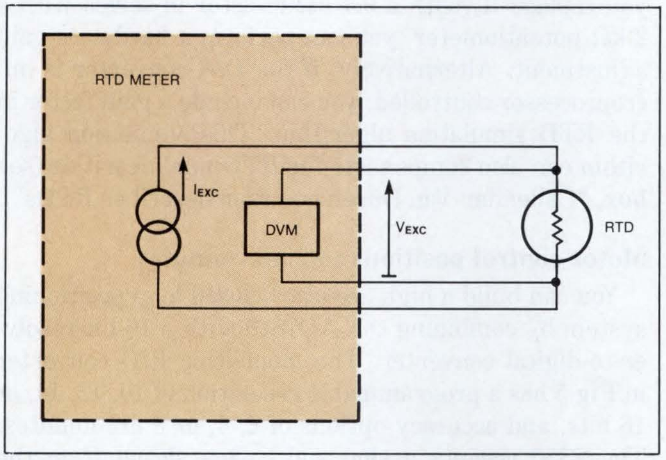

Fig 3—RTDs use a 4-wire configuration *to force a current through the sensor and monitor the corresponding voltage drop. Once calibrated, the RTD can offer high measurement accuracies over a wide temperature range.*

RTD simulator mimics changing temperature

Many closed-loop temperature-control systems use resistance temperature detectors (RTDs). Commonly made from platinum, they operate over the −150 to +600°C temperature range, which makes them ideal for industrial applications. Most RTDs are configured with four terminals (**Fig 3**). The current source forces a "known" current into the transducer, and two sense wires monitor the voltage drop across the RTD. Because the digital voltmeter has a high input impedance, the generated voltage at the input terminals of the meter is proportional to the resistance of the sensor.

You can build a portable battery-powered RTD simulator to test and calibrate the accuracy of any RTD-based temperature-monitoring system you might have. With the simulator, you can calibrate a system without bringing the controlled processes to their operating temperatures. In addition, the simulation of alarm conditions can test your control system's response to dangerous fault conditions. The circuit in **Fig 4** uses an AD7846 to accurately simulate an RTD. In this case, the 16-bit D/A converter generates calibration signals

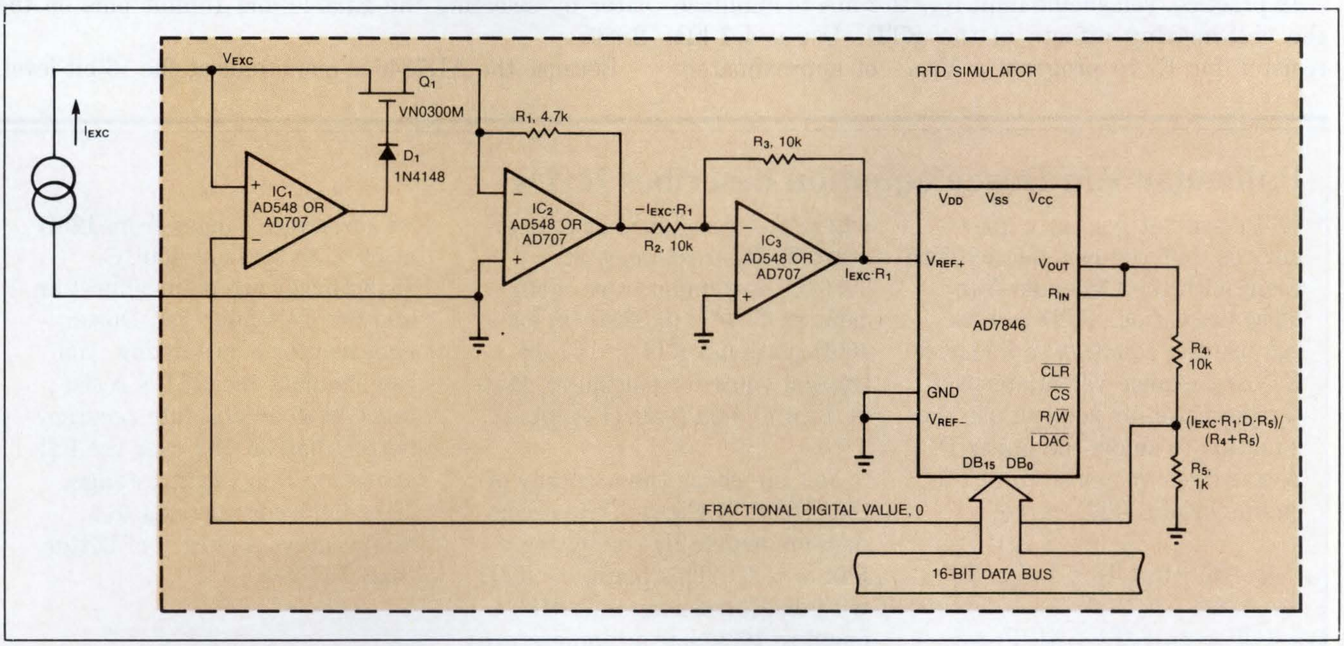

Fig 4—You can use a battery-powered RTD simulator *for field calibration of temperature-measurement systems. This circuit can accurately simulate RTDs with a temperature resolution and accuracy better than 0.1°C.*

You can build a portable battery-powered RTD simulator to test and calibrate the accuracy of any RTD-based temperature-monitoring system you might have.

that simulate RTD outputs with an accuracy of better than 0.1°C. Furthermore, the low power dissipation (250 mW if you use low-power amplifiers such as the AD548) extends the battery life of handheld calibration meters.

Amplifer IC_1 drives the n-channel MOSFET, Q_1, so that V_{EXC}, the excitation voltage, is equal to the voltage on the amplifier's inverting terminal. Install diode D_1 to prevent any negative excursions at the gate of the MOSFET. Resistor R_1 mirrors the constant current, I_{EXC}, from the RTD, setting up a voltage $(-I_{EXC} \cdot R_1)$ at the output of amplifier IC_2. Resistors R_2 and R_3 and amplifier IC_3 invert this voltage to supply a reference of $(I_{EXC} \cdot R_1)$ at the V_{REF+} input of the AD7846. The D/A converter's output voltage is $D \cdot I_{EXC} \cdot R_1$, where D is the fractional code applied to the converter. Resistors R_4 and R_5 feed back a portion of this signal to the inverting input of IC_1 to complete the loop. Therefore,

$$V_{EXC}=I_{EXC} \cdot R_1 \cdot D \cdot \frac{R_5}{R_4+R_5}.$$

The simulated RTD resistance is

$$R_T=\frac{V_{EXC}}{I_{EXC}}=R_1 \cdot D \cdot \frac{R_5}{R_4+R_5}.$$

In practice, you should limit I_{EXC} to 2 mA to minimize the self-heating effects in the RTD. Use a 4.7-kΩ resistor for R_1 to program a V_{REF+} of approximately 10V maximum at the AD7846's input. **Fig 4**'s R_4 and R_5 values permit you to simulate an RTD range from 427 to 1Ω; the R_{ON} of the MOSFET determines the 1Ω minimum. You can easily change the resistance range, however, by varying the ratio of resistors R_4 and R_5.

If you use low input-offset-voltage amplifiers in this circuit (AD707s, for example), then offset calibration isn't necessary. You might, however, still have to reduce gain errors due to resistor tolerance and mismatch. If you replace R_3 with a 9.1-kΩ resistor in series with a 2-kΩ potentiometer, you can perform a hardware gain adjustment. Alternatively, if the D/A converter is microprocessor controlled, you can include a gain factor in the RTD simulation algorithm. This simulation algorithm can also compensate for RTD nonlinearities (see **box**, "Callendar-Van Dusen equation describes RTDs").

Motor control positions to 2 arc-minutes

You can build a high-accuracy closed loop positioning system by combining the AD7846 with a 16-bit resolver-to-digital converter. The monolithic R/D converter in **Fig 5** has a programmable resolution of 10, 12, 14, or 16 bits, and accuracy options of 2, 4, or 8 arc-minutes. The 2S80 accepts a sine and cosine signal from the resolver and converts it into a 16-bit word. A Busy signal informs the microprocessor when the output data is valid. The μP reads the information into its accumulator by selecting the Enable and Inhibit pins on the 2S80.

Because the AD7846 is monotonic at the 16-bit level,

Callendar-Van Dusen equation describes RTDs

RTDs are not perfectly linear devices, but you can characterize them with the Callendar-Van Dusen equation. RTD meters can use the equation to linearize RTD-resistance variations over temperature, or you can use the equation to shape the linear D/A-converter response to fit the characteristic RTD curve:

$$R_T=R_0+R_{0\alpha}\left[T-\delta\left(\frac{T}{100}-1\right)\left(\frac{T}{100}\right)-\beta\left(\frac{T}{100}-1\right)\left(\frac{T^3}{100}\right)\right],$$

where R_T=resistance at temperature T, R_0=resistance at T=0°C, α=temperature coefficient at T=0°C (0.385Ω/°C for 100Ω platinum RTD), δ=1.49 (typical value for platinum), β=0 at T≥0°C, and β=0.11 (typ) at T<0.

You can check the accuracy of the circuit in **Fig 3** of the accompanying article by simulating a PT100 RTD. This platinum RTD with an R_0 (resistance at 0°C) equal to 100Ω has a temperature coefficient of 0.385Ω/°C. Thus, its resistance ranges from 120Ω at 50°C to 290Ω at 500 °C. Using hardware gain calibration and the Callendar-Van Dusen equation for curve fitting, you can simulate the RTD's resistance with an absolute accuracy better than 30 MΩ over the full operating temperature range. This error corresponds to a temperature accuracy of better than 0.1°C.

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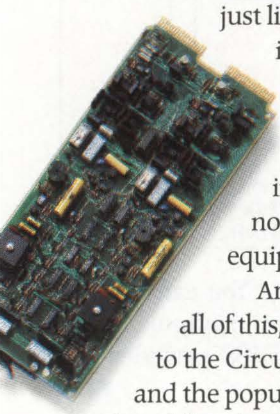

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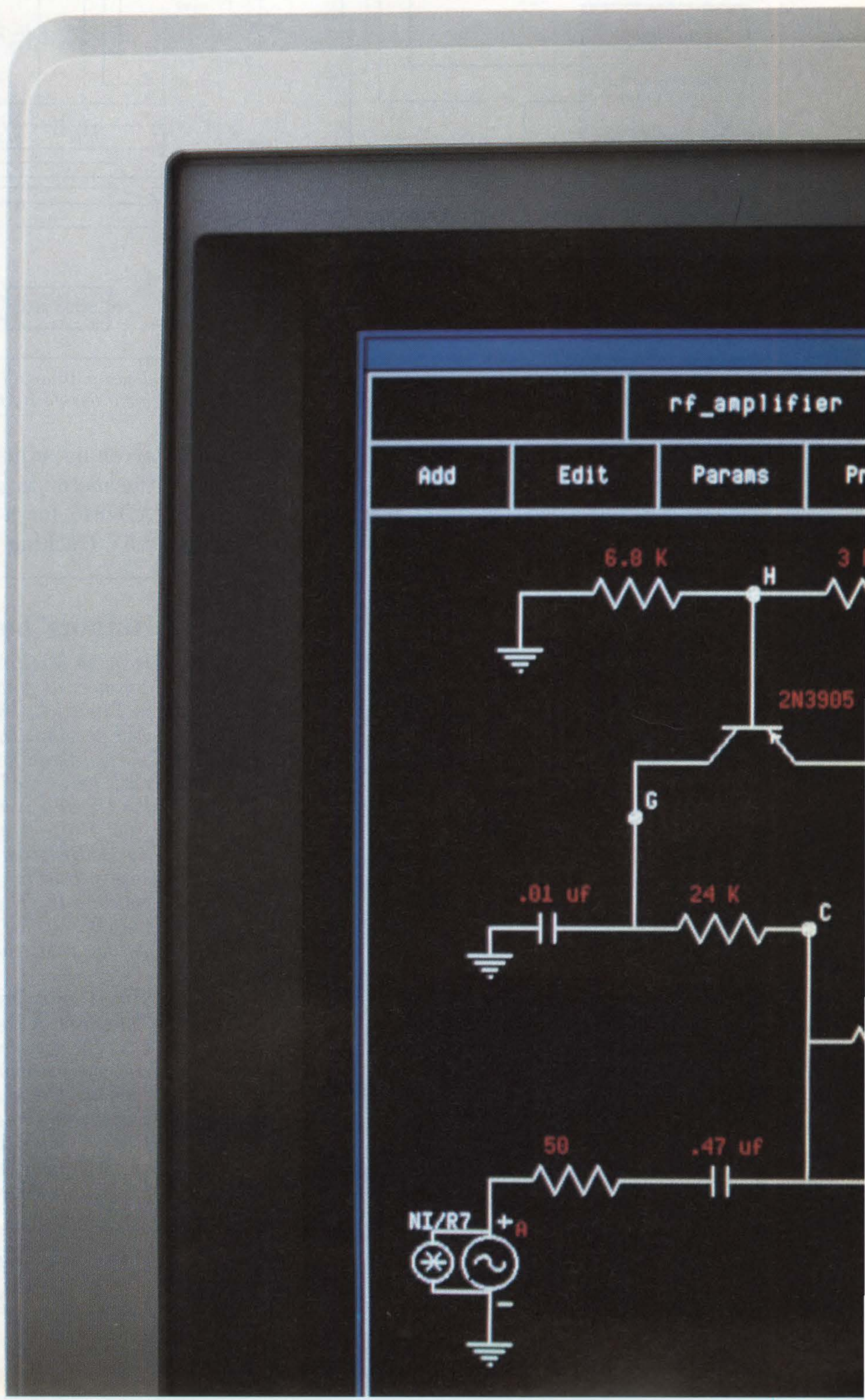


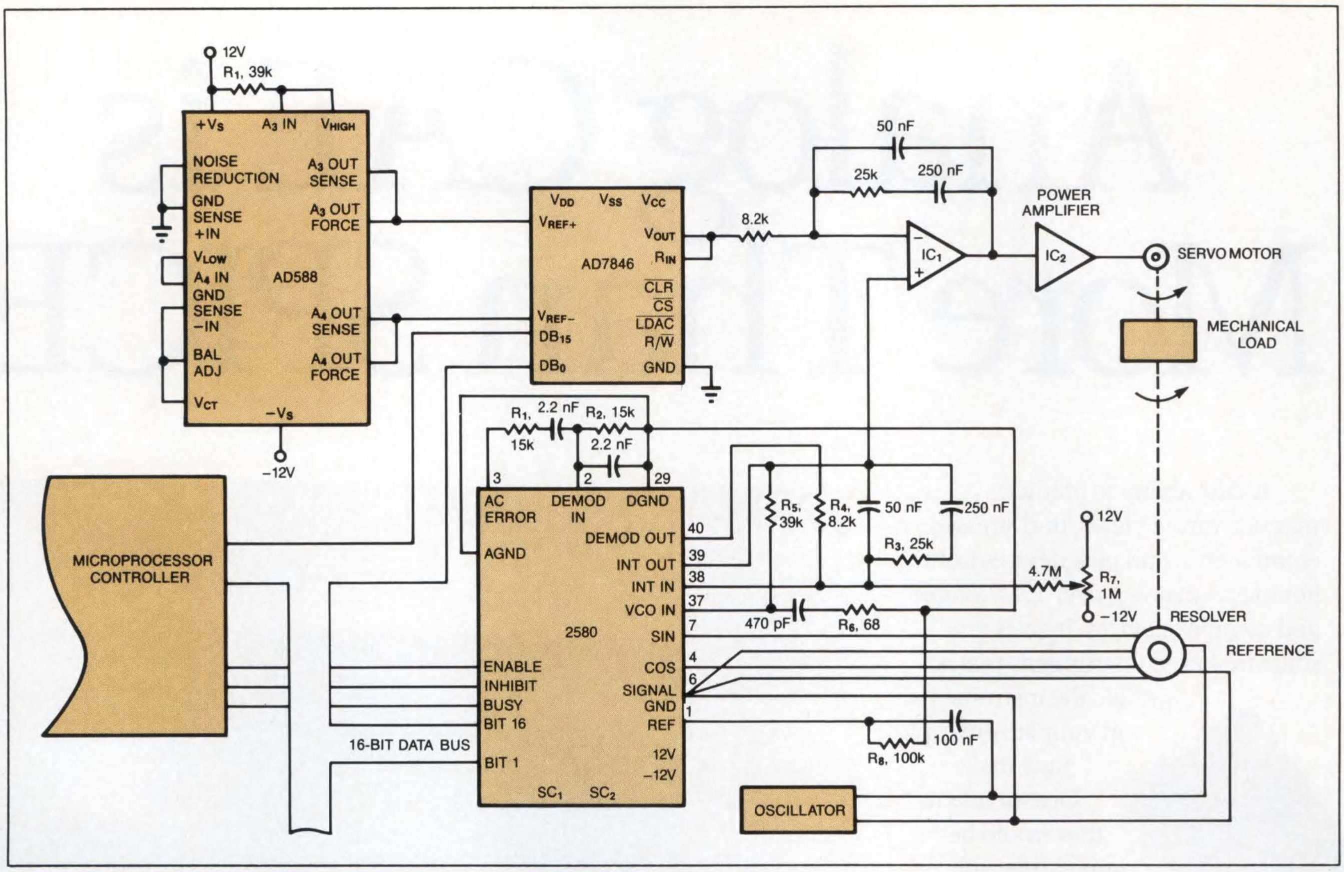


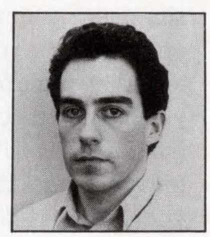
Fig 5—This closed-loop positioning system *has no loop instabilities and can position a load to an accuracy of less than 2 arc-minutes. The 2S80 resolver-to-digital converter IC provides an analog output proportional to velocity for tight speed control of a motor.*

you can theoretically drive the motor in **Fig 5** to within 1 LSB of the desired position. In practice, the feedback element, the 2S80 in this circuit, will restrict the overall accuracy. The top grade of the 2S80 has an absolute accuracy of ±2 arc-minutes +1 LSB.

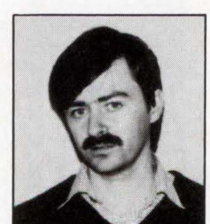
You program the microprocessor with the desired motor position. Until the desired and actual positions are equal, the processor will generate an error signal for the D/A converter, which, in turn, drives the motor in the proper direction through a standard control circuit implemented by IC_1, power amplifier IC_2, and associated circuitry. The error signal becomes progressively smaller until the desired motor position is finally reached. Both the 2S80 and AD7846 are 16-bit monotonic, making the loop inherently stable. Furthermore, the signal at the integrator output of the 2S80 relative to AGND is an analog voltage proportional to the rate of change of the input angle. You can use this velocity signal to provide velocity stabilization of the servo loops without having to add an expensive electromechanical tachometer. Configured for 16-bit resolution, the R/D converter's maximum tracking rate is 16.25 rps.

You program the resolution of the 2S80 through SC1 and SC2. If both inputs are left unconnected, the resolution is 16 bits (two 100-kΩ internal resistors pull SC1 and SC2 high). You can change the resolution by grounding one or both of the inputs. The choice of resolution, however, will affect the selection of R_4 and R_6, which scale the inputs to the device's internal integrator and VCO, respectively. Trim any offset error by adjusting potentiometer R_7. You can operate the motor in a bidirectional mode by configuring the AD7846 for a ±5V output. The AD588 provides the ±5V tracking reference. **EDN**

Authors' biographies



Damien McCartney is a senior design engineer at Analog Devices' CMOS Div in Limerick, Ireland, where he designs and develops DAC products. He has worked there for 3½ years. Prior to that, he worked for Centronics in both the US and Ireland. He holds a BE from University College in Dublin and an MSEE from Northeastern University in Boston. Damien is a member of both the IEEE and its English cousin, the IEE. In his spare time, he runs, swims, and reads.



Mike Curtin has worked for the past five years at Analog Devices' CMOS Div. He is currently an applications engineer supporting the DAC product line. He holds a BSc degree in electronics from the National Institute of Higher Education in Limerick. His spare-time activities include squash, football, and reading.

Article Interest Quotient (Circle One)
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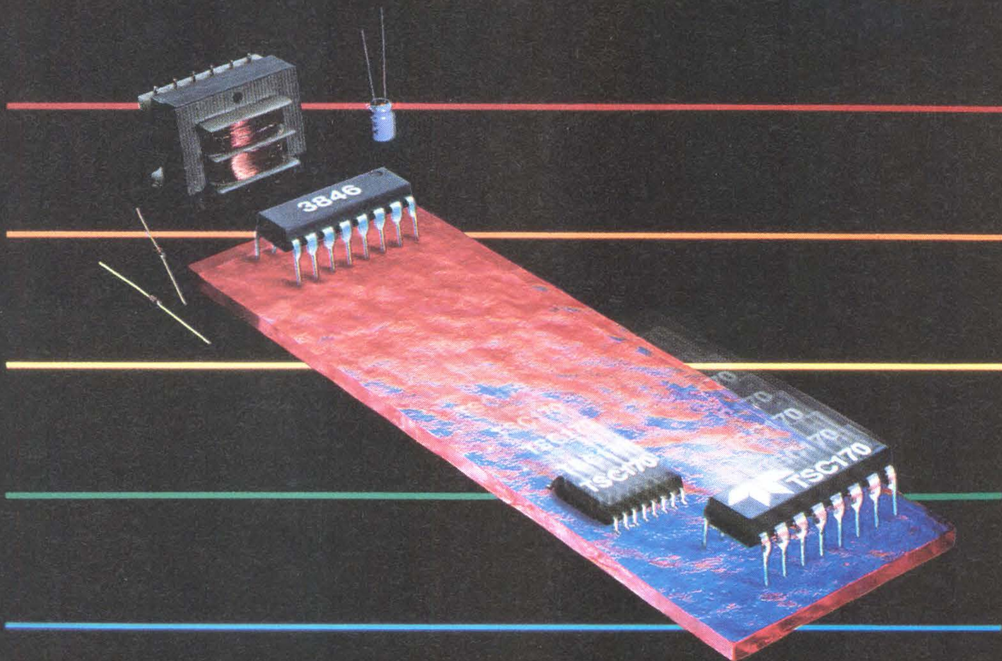
One-fifth the power makes for one cool breakthrough in SMPS controllers



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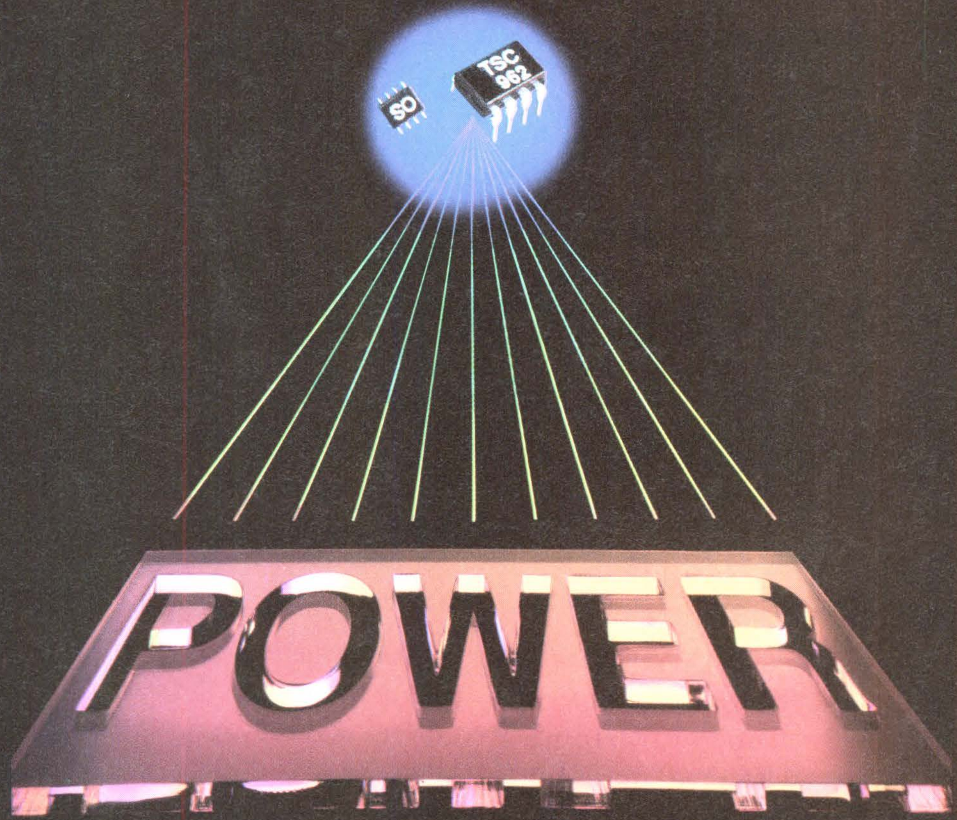
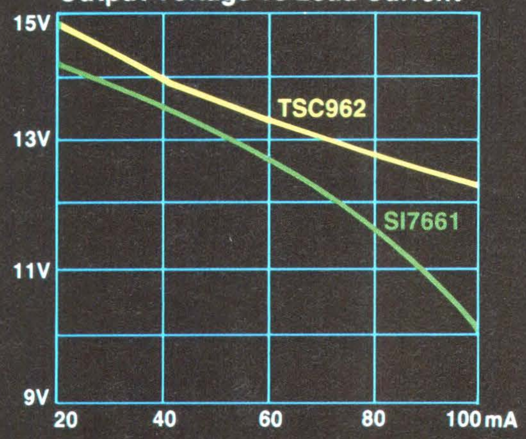


Output Voltage vs Load Current



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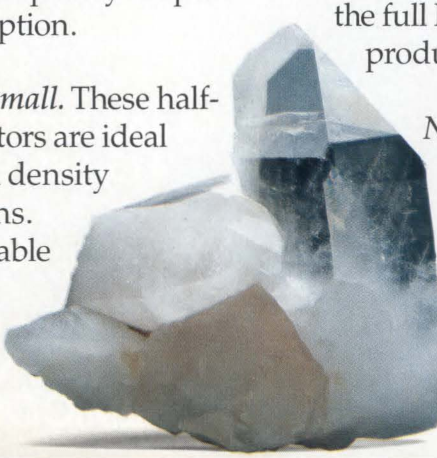

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CIRCLE NO 70

Microcontrollers simplify the design of X-Y plotters

Modern μcontrollers have reduced the amount of circuitry needed for a plotter controller to a single chip and a few motor-drive components. Interrupt-handling features can provide aid when you're developing the control firmware.

Marc Birnkrant and Steve Beckwith,
NEC Electronics Inc

The μcontrollers available today have so many on-chip features that control tasks have largely become a feat of software. Many of these devices have sufficient memory space, along with USARTs, interval timers, A/D converters, and multiple I/O ports, to handle control tasks that once would have required an entire CPU board. Microcontrollers with on-chip features such as these are well suited to the task of controlling an X-Y plotter.

Any X-Y plotter design requires two stepper motors. One motor drives a track feeder to move the paper along the Y axis, and the other motor drives a belt, with a pen attached, along the X axis. A solenoid controls the position of the pen. When you drive the solenoid, the resulting magnetic field produces a force sufficient for the pen to make contact with the paper. A limit switch senses when the position of the X-axis motor exceeds the plotter width.

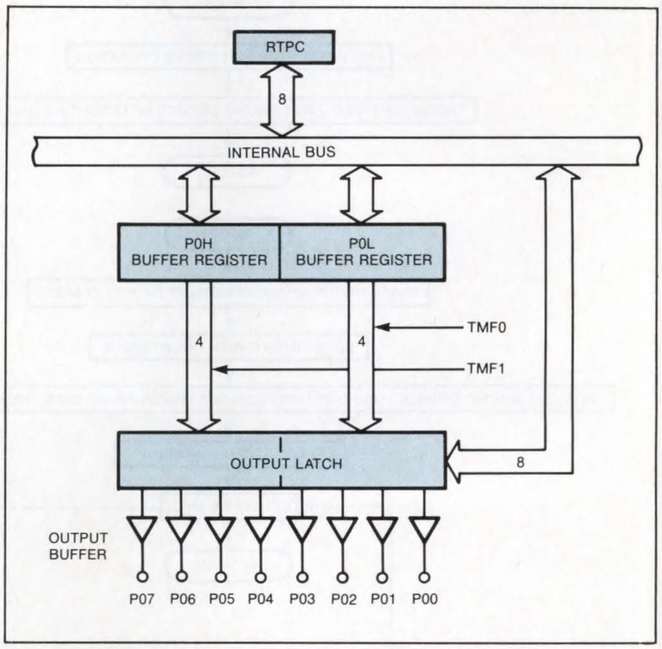
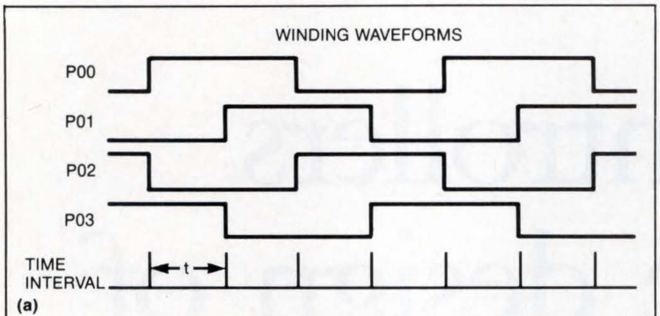


Fig 1—The real-time output port *on the μPD78312 μcontroller eliminates the need for external latches.*

In order to perform these real-time control tasks, the plotter has to be able to interpret data from two control sources. One source is a matrix keyboard, usually located on the front panel of the plotter. Using such a keyboard, you manually transmit setup parameters and pen-position information to the plotter. Plot scaling, drawing speed, and paper size are typical examples of setup parameters.

To perform the real-time control tasks, the plotter has to be able to interpret data from two control sources.



P00	P01	P02	P03
1	0	0	1
1	1	0	0
0	1	1	0
0	0	1	1
⋮	⋮	⋮	⋮

(b)

Fig 2—To control the speed of the stepper motor, *you sequentially alter the time between phase changes of the stator windings.*

A serial-communication link, which connects the plotter to a computer, provides the other control source. A USART provides the handshake lines necessary for communications. This link can transmit the data to be plotted as well as setup parameters. The μcontroller interprets the data stream and positions the pen to automatically create the drawing.

Features aid in real-time control

Not surprisingly, many μcontrollers are available that possess the features necessary to handle all of these control tasks. In fact, some μcontrollers have features optimized for the real-time control tasks: overseeing the X- and Y-axis motors, governing the solenoid (and therefore the pen), and sensing the width of the paper.

NEC's μPD78312 μcontroller, for example, contains

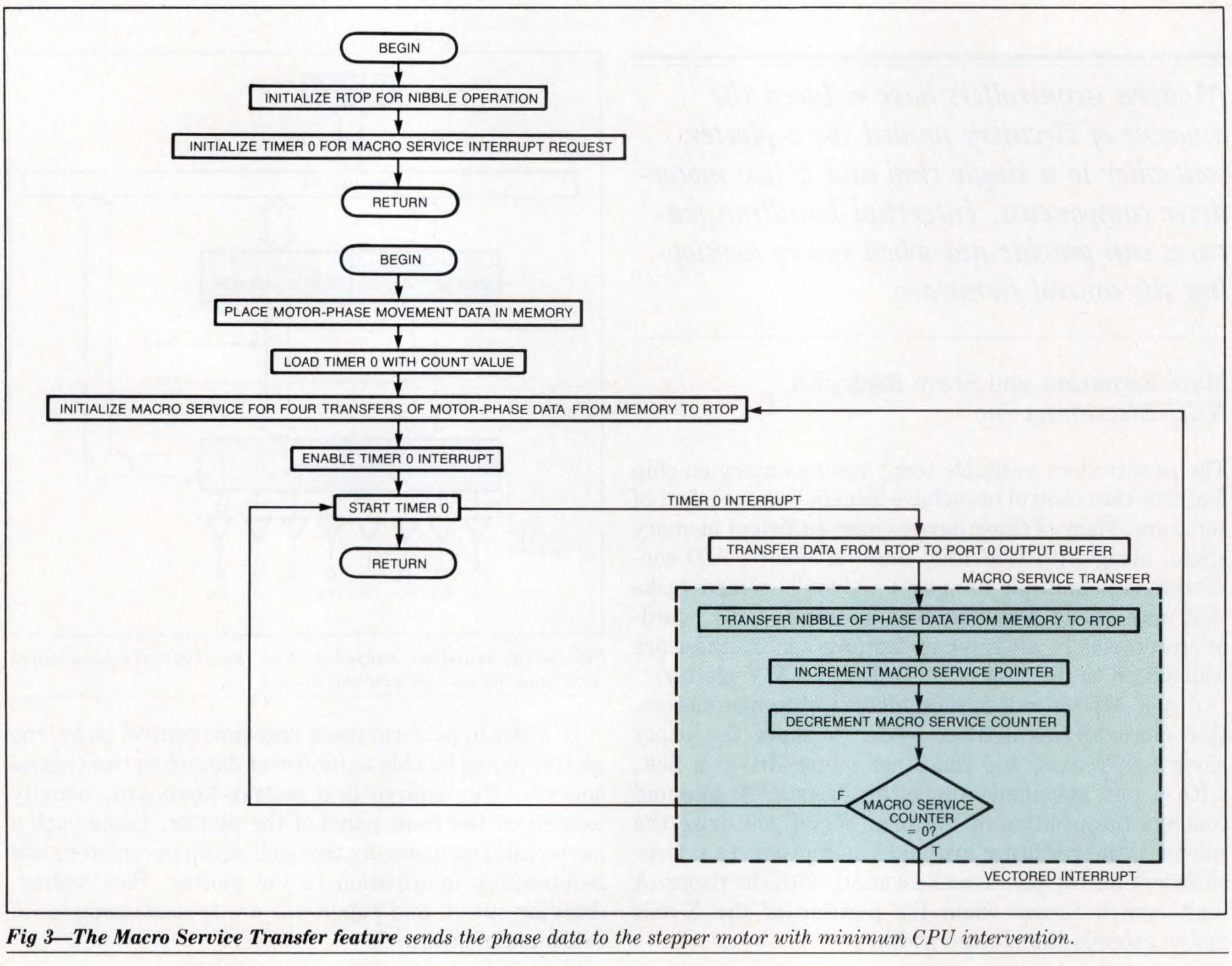


Fig 3—The Macro Service Transfer feature *sends the phase data to the stepper motor with minimum CPU intervention.*

a real-time output port (RTOP) that is well suited to the control of the two stepper motors. The RTOP consists of two 4-bit buffer registers (P0H and P0L), an 8-bit real-time port control register (RTPC), and an output latch for port 0 **(Fig 1)**. Two on-chip programmable 16-bit timers (timer 0 and timer 1) set interrupt-request flags (TMF0 and TMF1) to transfer the data in the buffer registers to the output latch.

To see how to use the RTOP to control the motors, consider the typical waveforms for the stator windings of a 2-phase stepper motor **(Fig 2a)**. You must ensure that the firmware first determines in which direction to step the motors and that it then stores four data words into memory as a table **(Fig 2b)**. The words, which contain the phase data for each of the windings, are sequentially sent to the RTOP to drive the motors in the desired direction. (To reverse the motor direction, you must reverse the word sequence.)

The time interval, *t*, fixes the time between phase changes and, subsequently, the motor speed. To control one of the motors, you program timer 0 to set the TMF0 flag at the end of the time interval. The TMF0 flag initializes the transfer of data from the low nibble of the RTOP (P0L) to the low nibble of the output latch at Port 0. Similarly, to control the time interval of the other motor, you program timer 1. The TMF1 flag initializes the transfer of data from the upper nibble of the RTOP (P0H) to the upper nibble of the output latch at Port 0. Immediately following a data transfer to the output latch, the firmware loads the buffer registers with data from the memory table for the next step in the sequence.

The RTOP relies on its interrupt-handling scheme, which the vendor calls Macro Service Transfer, to transfer the data in the memory table to the RTOP buffer registers with only minimal CPU intervention

Interrupt-handling features reduce overhead

By their very nature, real-time-control systems are dependent on the efficient handling of interrupt requests. When an interrupt occurs, the μcontroller must be able to service the request as soon as possible. The μPD78312 μcontroller (NEC Electronics, Natick, MA) utilizes conventional vectored-interrupt handling and, in addition, it incorporates two interrupt-handling features that reduce the amount of software overhead.

NEC calls the first feature Macro Service Transfer. In response to an interrupt request, the facility transfers data between memory and a special-function register without any software intervention. The μcontroller has a number of separate Macro Service Channels located in the on-chip RAM, each of which consists of one 16-bit register and two 8-bit registers. One of the 8-bit registers, called the Macro Service Counter, determines the number of transfers—as many as 256 are feasible. The counter decrements after each transfer.

The other 8-bit register, called the Special Function Register Pointer, specifies which special-function register is involved in the data transfer. The 16-bit Macro Service Pointer contains the source or destination memory address. In addition, an 8-bit Macro Service Control Register, associated with each interrupt, selects the designated Macro Service Channel.

The second feature, which the manufacturer calls Context Switching, makes use of the eight sets of general-purpose register banks located in the internal RAM. Each bank consists of sixteen 8-bit registers. You can pair two 8-bit registers to form a 16-bit register. For example, two of the 8-bit registers can function as the low-order and the high-order byte of a 16-bit accumulator.

When you enable the Context Switching feature, an interrupt request selects a register bank associated with the priority level of the interrupt. The new register bank loads a prestored vector address into the Program Counter (PC) while the current contents of the PC and Program Status Word (PSW) are saved in the RP2 and RP3 registers of the new register bank.

The program jumps to an interrupt routine pointed to by the new address in the PC and uses the new active register bank to perform the routine. When the routine is complete, the current active register bank transfers the saved words back into the PC and the PSW, respectively. Therefore, the firmware can select a new register bank for each interrupt request without needing additional software to save the current register contents.

Some μcontroller features are optimized for real-time control tasks.

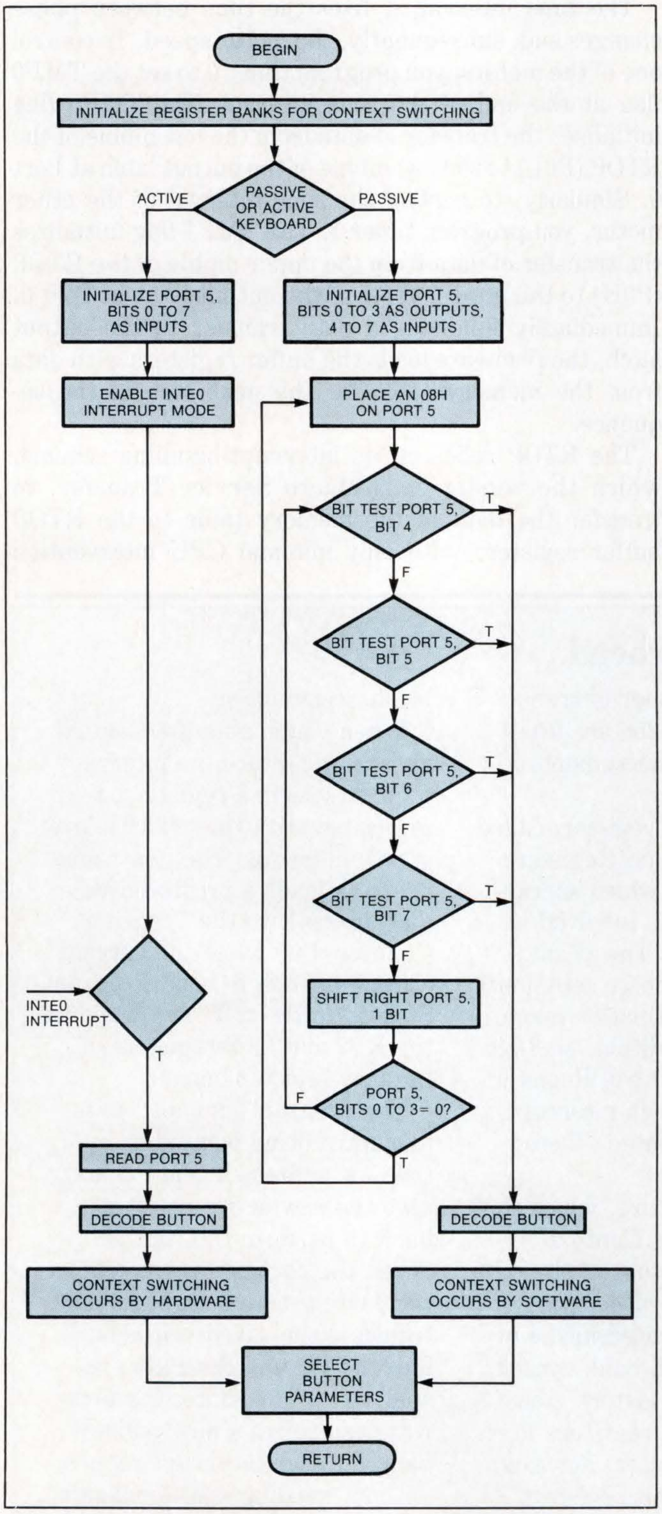


Fig 4—When the keyboard scan routine determines which key has been depressed, *the Context Switching feature selects a register bank with preloaded data to service the interrupt.*

(see **box,** "Interrupt-handling features reduce overhead"). The firmware first initializes the Macro Service Channel for four data transfers corresponding to the four motor phases. Upon recognizing an interrupt-request flag, the Macro Service Controller transfers data from memory to the buffer registers. Following the fourth transfer, a vectored interrupt reinitializes the Macro Service Channel. This type of interrupt-handling scheme allows the motor to be stepped four times with minimal CPU intervention. **Fig 3**'s flow chart shows how to send data to the lower nibble of port 0 to control the stepper motor.

I/O, interrupt ports provide control links

One of the μPD78312's I/O ports drives the solenoid that controls the pen height. To plot a point on the paper, the μcontroller has to place this port in an active high state. The pen remains in the down position as long as the I/O port is in the active-high state. Driving the I/O port to its inactive-low state de-energizes the solenoid, allowing the pen to return to its up position.

If the program attempts to drive the pen beyond the maximum width of the plotter, a mechanical limit switch sends a command to the μcontroller's nonmaskable interrupt (NMI) input. The edge-triggered interrupt initiates an NMI routine, which disables the X-axis stepper motor. To reset the X-axis motor, the routine initializes a counter to a count value equal to the width of the plotter.

To initialize the plotter and its limits at power-up, the Macro Service Transfer facility drives the X-axis motor to its limit. When the NMI signal occurs, the routine reverses the direction of the motor and places the pen position in the center of the plotter. During this centering motion, every fourth macro service step decrements the counter from the home position and provides a displacement to the other limit.

A scan routine interfaces to the keyboard

As mentioned earlier, the μcontroller has to have a means of interfacing with each of the two control sources. A representative configuration of the keyboard control source, which serves as a good example, has 16 keys arranged in a 4×4 matrix. This keyboard interface occupies eight I/O ports on the μcontroller. There are two types of keyboard, passive and active.

A passive keyboard, which is the most common, receives its power from the μcontroller. To interface to a passive keyboard, the firmware must configure the eight I/O ports for four input and four output ports. The

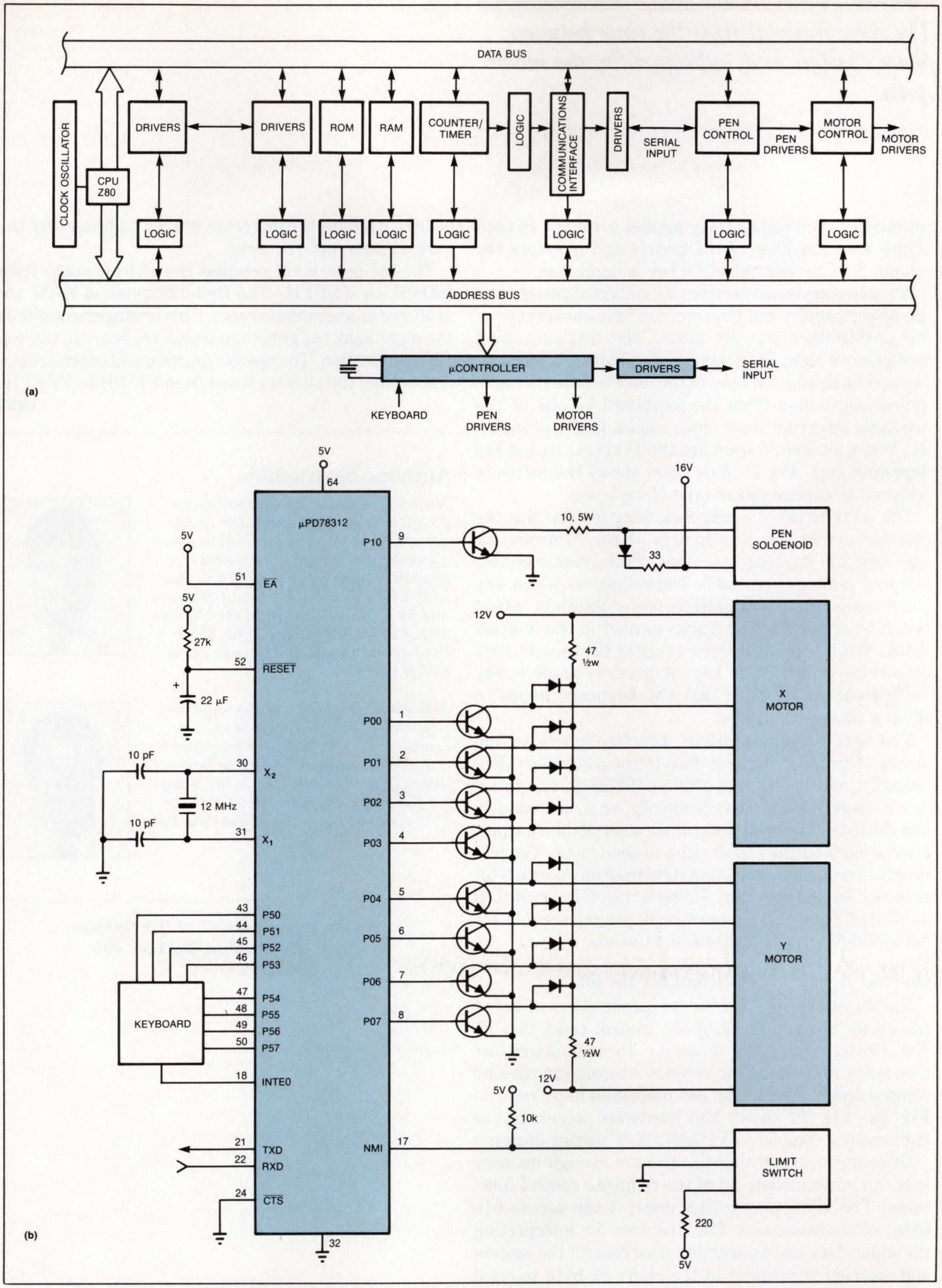


Fig 5—Compared with a traditional CPU board for an X-Y plotter, *a µcontroller requires minimal external hardware* ***(a)****. The schematic in* ***b*** *shows the hardware you need to use the µPD78312 in an X-Y plotter application.*

The time interval fixes the time between phase changes and, subsequently, the motor speed.

μcontroller then sequentially applies a voltage to each of the four row lines of the matrix and monitors the column lines to determine if a key is depressed.

An active keyboard receives its voltage directly from the power supply, and thus you can take advantange of the μcontroller's standby mode. The firmware must configure all eight I/O ports as input ports that connect to the column and row lines of the matrix. When a key is depressed, a line from the keyboard to one of the maskable interrupt input lines wakes up the μcontroller. When awoken, it searches the I/O ports to find the depressed key. **Fig 4**'s flow chart shows the software required to service either type of keyboard.

The μPD78312's Context Switching feature aids the programmer in the development of the firmware for servicing the keyboard (see **box,** "Interrupt-handling features reduce overhead"). Depending on which key you depress, the feature selects one of the eight sets of general-purpose register banks located in the internal RAM. You can preload these register banks with data to service a particular key. A good example is the scaling-parameter data that the keyboard needs to select a plot-scale change.

The serial-communication interface provides the means of transferring plot data to the controller. Customarily, and in the case of the μPD78312, this interface transfers data asynchronously or synchronously and consists of a serial data input, a serial data output, a serial clock output, and a clear-to-send input. The plot program accesses serial input data from an on-chip 8-bit receiver buffer register. Using a 12-MHz crystal, a dedicated baud-rate generator is programmable for data-transfer rates of 110 to 38.4k baud.

On-chip memory is sufficient for the job

The functions resident on the μcontrollers of today can easily accomplish all of the control tasks that an X-Y plotter application demands. To understand just how much real estate and components you can save by using a design such as the one presented here, refer to **Fig 5a. Fig 5b** shows the hardware necessary to implement a complete μPD78312 X-Y plotter design.

Of course a μcontroller has to have enough memory space to accommodate all of the requisite control functions. The NEC μcontroller does; it can access 64k bytes of address space. The firmware for interpreting the input data and translating it to control the motors and solenoid is resident in the chip's 8k-byte internal ROM. The ROM address space ranges from 0000H to 1FFFH. A vector table, located from address 0000H to 003FH, contains the interrupt branch addresses for the various interrupt requests.

The 256-byte RAM occupies the address space from FE00H to FEFFH. The first 128 bytes of RAM are available as a scratchpad area. This arrangement places the eight banks of general-purpose registers in the top 128-byte section. The special-function and control registers occupy the address space from FF00H to FFFFH.

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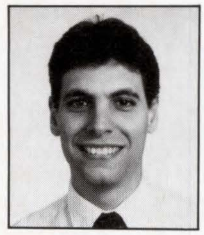
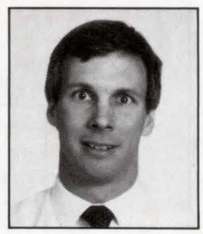
Authors' biographies



Marc Birnkrant is an application engineer at NEC Electronics Inc in Natick, MA, where he is involved in single-chip-microcomputer technical support. He previously worked for the Link Flight Simulation Div of Singer, and he holds a BSEE from the University of Rochester in New York. Marc fixes up old homes and likes to ski in his off hours.



Stephen Beckwith is a senior application engineer at NEC and is also responsible for single-chip-microcomputer technical support. Before he began working for NEC, he was in the Navy for five years. Stephen attended the University of Lowell in Massachusetts.

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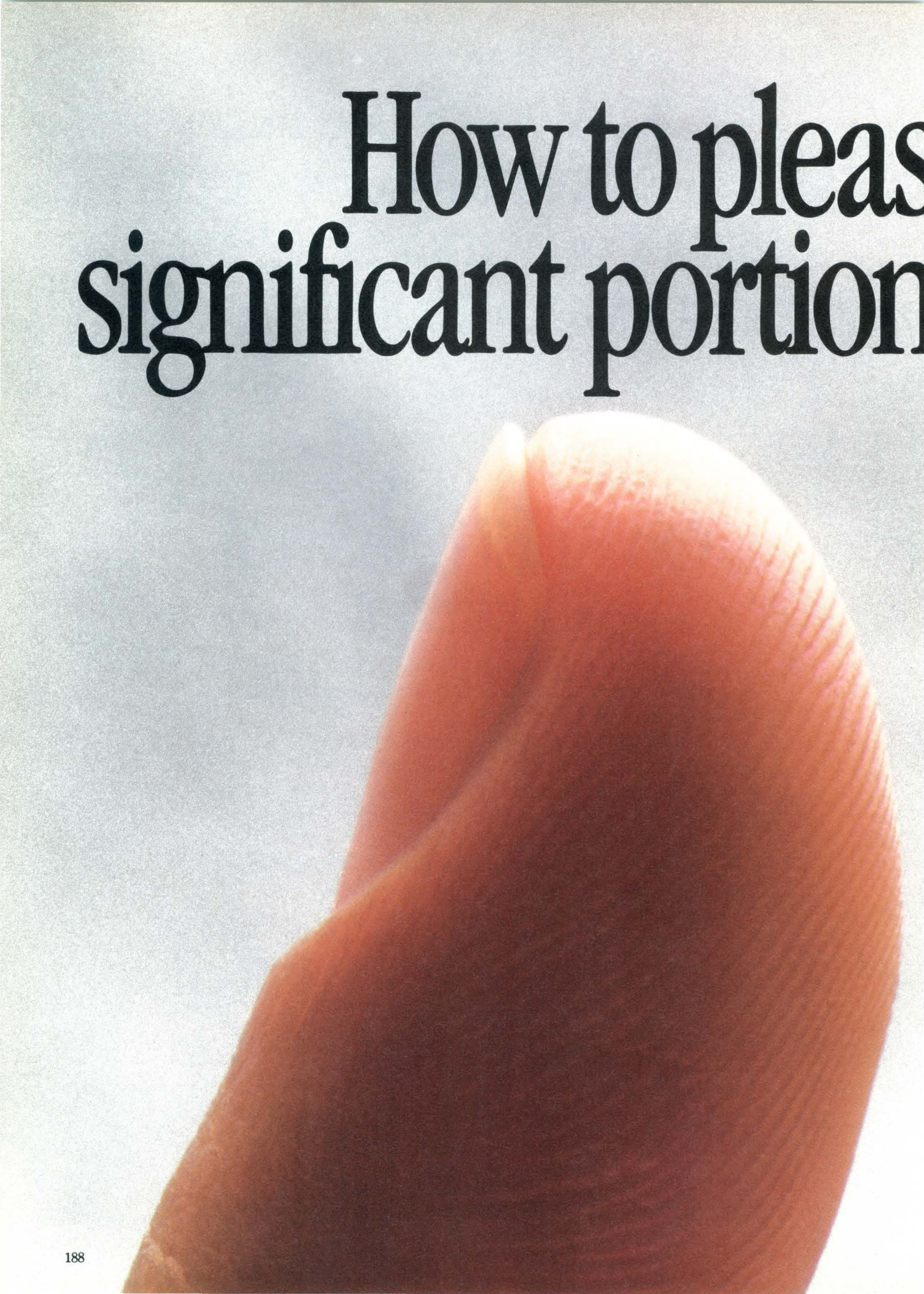
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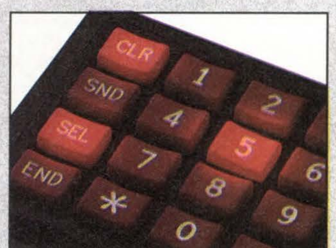

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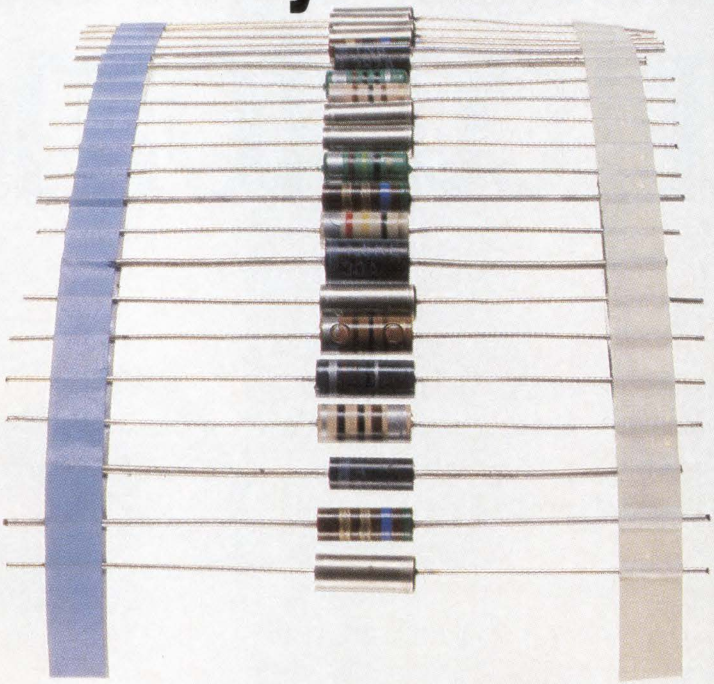

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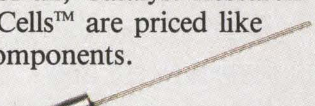

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Lithium cells keep CMOS RAM alive during line outages

Until recently rechargeable nickel cadmium batteries were the only choice for memory backup. The advent of CMOS RAM has lowered typical memory-backup power requirements to 2 to 3 μA at 2.0V, even for memories of 1M bits or larger, and now lithium batteries are feasible for such applications.

Nicolas Müller and Henry Uebelhart, *Renata*, and Jack F Swartz, *International Power Sources*

In the past, an engineer was forced to design with nickel cadmium (NiCd) batteries and had to account for all their limitations: NiCd batteries have a high self-discharge rate, require a sophisticated charging system for optimal performance, occupy a great amount of board space, cannot be wave soldered, and have disposal restrictions due to their poisonous cadmium content. CMOS RAM, however, doesn't need a backup power source with high drain capability. Moreover, NiCd batteries require three cells in series to satisfy such an application, but lithium batteries require only a single cell.

For a typical 250-mAhr lithium cell, the calculated battery life at CMOS drain levels, operating continuously, is about nine years. Lithium cells need no recharging during their service life. Further, because lithium cells exhibit extremely low rates of self-discharge (<1%/yr), they have a long shelf life if not subjectd to high temperatures or short circuits.

You should always calculate battery-backup capacity based on a 100% duty cycle, even if your system will receive its power mostly from the mains power supply. The battery's surplus capacity will compensate for leakage currents as well as the self-discharge of the battery caused by possible rises in ambient temperature.

Which lithium chemistry is right?

The lithium in a lithium cell forms only the anode material of the cell; manufacturers use a wide variety of materials for the cathode and electrolyte. The two main lithium-cell types are the liquid-cathode chemistries such as thionyl chloride ($Li/SOCl_2$) and sulphur dioxide (Li/SO_2) and the solid-cathode types such as manganese dioxide (Li/MnO_2) and carbon monofluoride (Li/CF). You must give careful consideration when selecting a lithium chemistry because each has advantages and disadvantages.

Liquid-cathode batteries have higher cell voltages and drain currents, but possess significant drawbacks such as a varying capacity dependent on cell orientation, caustic and polluting chemicals, and susceptibility to explosion. Consequently, liquid-cathode cells aren't suitable for user-replaceable applications. Although liq-

Because data retention now requires such little power, you can use primary cells.

uid-cathode cells have a high theoretical energy density, their actual energy density is lower because of the rugged construction techniques required to safely hold their reactive constituents.

For memory-backup applications, the most significant disadvantage of liquid-cathode cells compared to solid-cathode cells is, paradoxically, their higher cell voltage. Their 20% higher cell voltage over solid-cathode cells (3.6 vs 3.0V) results in a 20% higher drain current for the same load. Therefore, a liquid-cathode cell requires a capacity 20% higher than a solid-cathode cell to achieve the same useful life. Note, however, that some older clock-chip designs, unlike memory ICs, have a strict 3V minimum requirement; in these cases, a single lithium cell won't suffice. The IBM PC employs a module containing two lithium cells in series to ensure adequate backup voltage.

Solid-cathode cells are available encapsulated in plastic. Encapsulated cells avoid the problems associated with exposed cells that have been mounted in holders or with solder tabs. Exposed cells, in time, can suffer the additional self-discharge arising from accumulated residue on the cell's surface. This residue can come from dust, soldering and washing operations, and handling. Encapsulation not only protects cells from the environment, but provides extra sealing against moisture diffu-

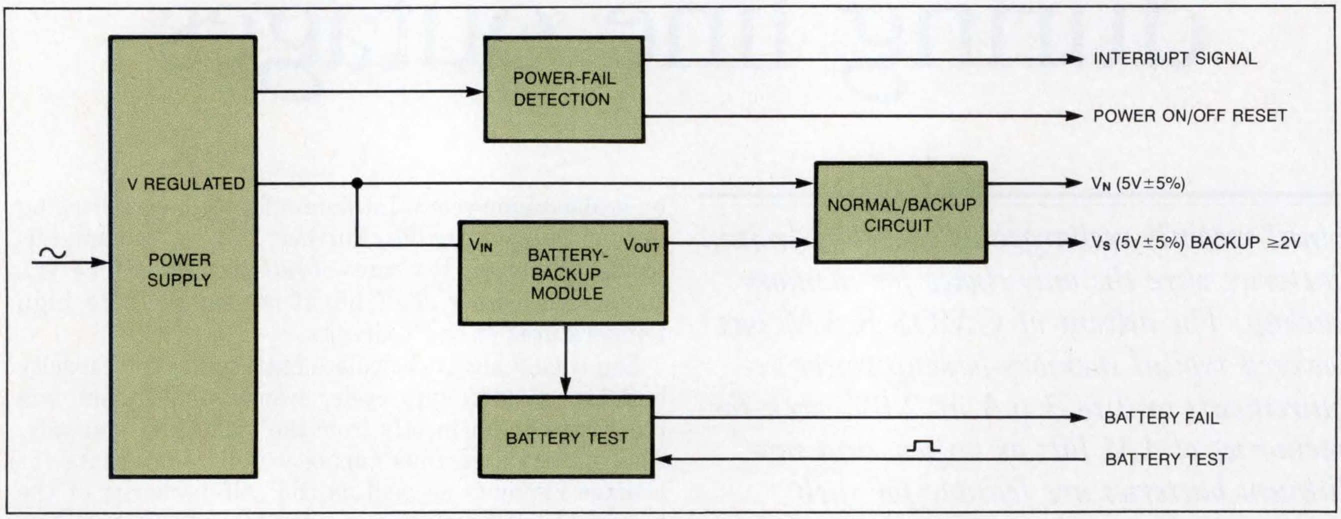


***Fig 1—This circuit provides safe data retention** during a power interruption.*

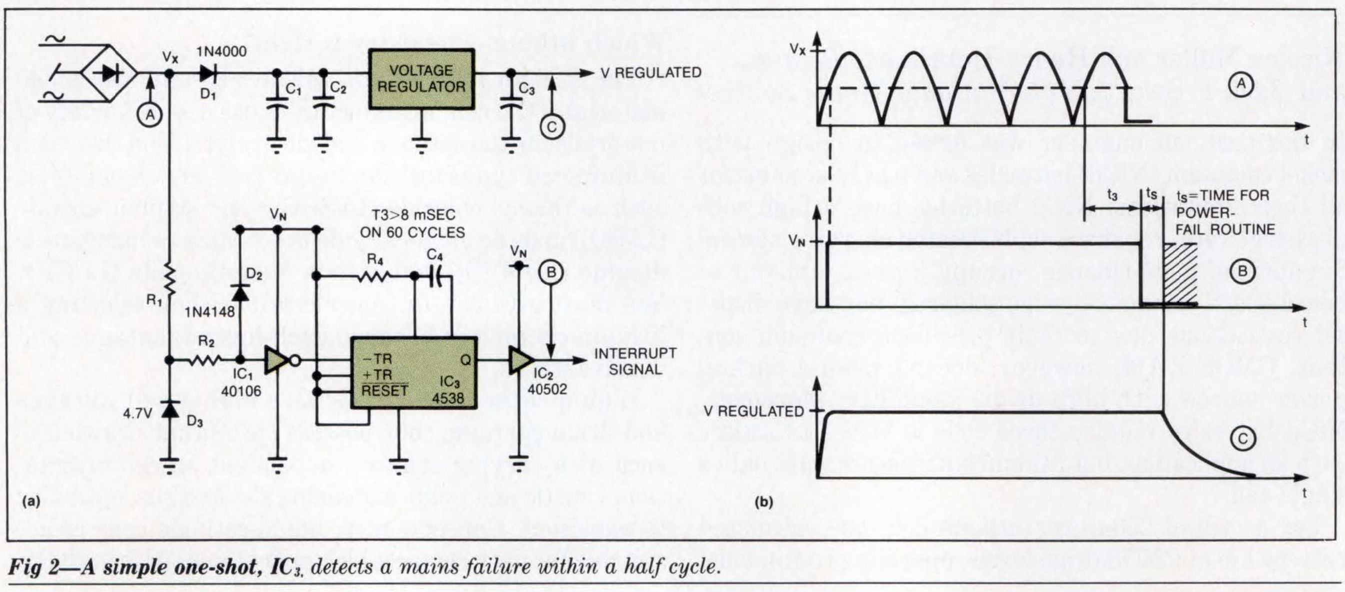


***Fig 2—A simple one-shot, IC_3,** detects a mains failure within a half cycle.*

sion and electrolyte evaporation. It also reduces the possibility of shorting cells.

You can also obtain encapsulated cells with optional decoupling diodes. Memory-backup applications normally require two decoupling diodes: one to avoid discharge through the mains power supply when it's shut down and another to prevent the charging of the battery during normal power conditions.

Saving data during power outages requires more than simply plugging a battery into your circuit. **Fig 1** shows the block diagram of a circuit that provides safe data retention during a power interruption. The CPU must be capable of early recognition of an interrupt if its power-fail routine is to store critical data in the buffered RAM before the voltage drops below the allowed tolerance of the processor. The circuit in **Fig 2a** detects a mains failure within a half cycle (f=60 Hz, t_s<8 msec.) (**Fig 2b** is the timing diagram.)

If your system doesn't provide a 120-Hz signal, you must monitor the input level to your power supply's voltage regulator with a comparator. The circuit in **Fig 3a** uses an Intersil ICL 8211, a special-purpose, low-voltage detector. Because the input voltage to the regulator includes ac interference, the ICL 8211's hysteresis pin is connected (pin 2) to avoid forming unwanted pulses at the output of the device (**Fig 3b**). You must carefully select C_1 (**Figs 2a** and **3a**) to maintain a minimum voltage (5V±5% typ) through the duration of the CPU's power-fail routine.

In most cases, the CPU can provide the power-on signal. If it can't, you'll need an additional RC circuit. **Fig 4a** shows a typical circuit, and **Fig 4b** shows its timing diagram. The RC circuit introduces an added delay, t_{ON}, after the power supply returns to its normal level, V_N, to protect the CPU from transients on the

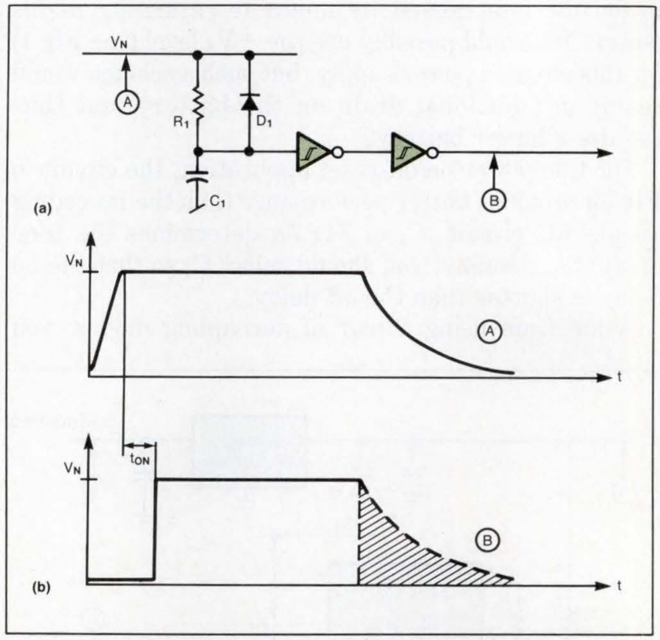


*Fig 4—**If your CPU doesn't provide a power-on signal,** you will need an additional RC circuit such as this one. The circuit introduces an additional delay, t_{ON}, after the power supply returns to its normal level, V_N, to protect the CPU from transients on the interrupt line caused by unstable returning mains power.*

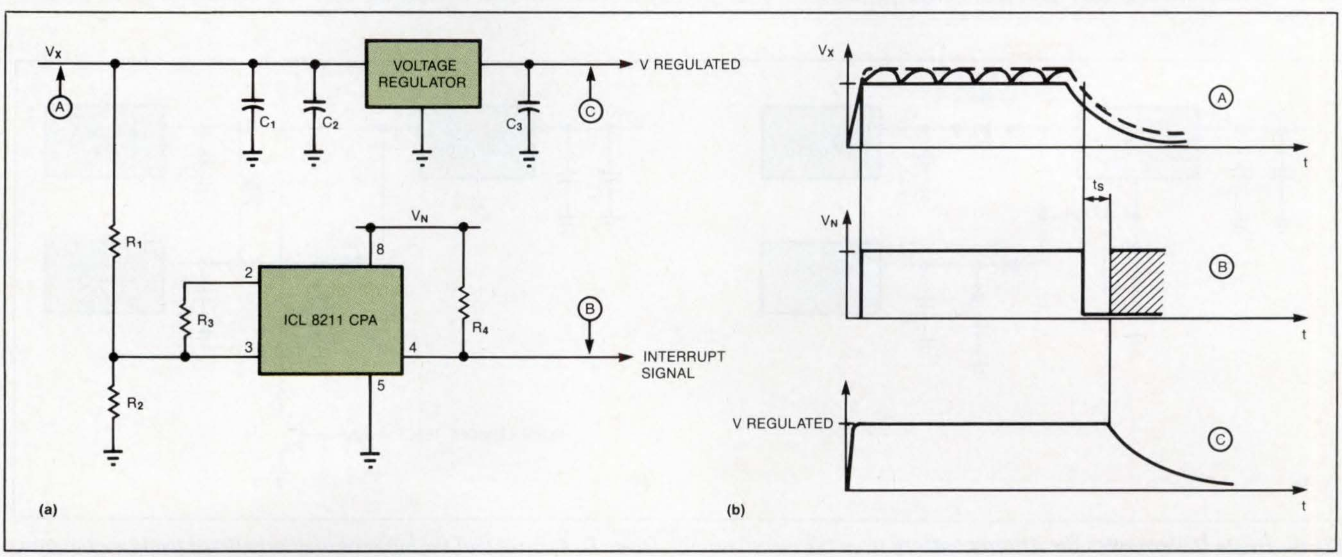


*Fig 3—**A special-purpose, low-voltage detector** provides superior performance to **Fig 2's** one-shot. Because the input voltage to the regulator includes ac interference, the ICL 8211's hysteresis pin (pin 2) is connected to avoid forming unwanted pulses at the output of the device.*

You should always calculate battery-backup capacity based on a 100% duty cycle even if your system will be powered mostly by the mains power supply.

interrupt line caused by unstable returning mains power. You could possibly use the $+V_S$ level (see **Fig 1**) for this circuit's power supply, but such a scheme would result in additional drain on the battery and thus require a larger battery.

For this power on/off-reset application, the circuit in **Fig 5a** provides better performance than the preceding simple RC circuit. C_4 in **Fig 5a** determines the time delay, t_{ON}. Usually, you should select C_4 so that the on delay is shorter than the off delay.

Aside from using a pair of decoupling diodes, you have the choice of several other power-supply decoupling techniques. The circuits that follow assume a typical power supply with an output voltage of 5V dc ±5%. As **Fig 6a** shows, diode D_1 decouples the lithium battery from the power supply, preventing battery discharge through the power supply when it is off. When the power supply is operating normally from mains power, voltage to the buffered circuits drops by V_1, the voltage drop across D_1. If your application requires that your unbuffered and buffered circuits operate at the same voltage level, you must add a diode,

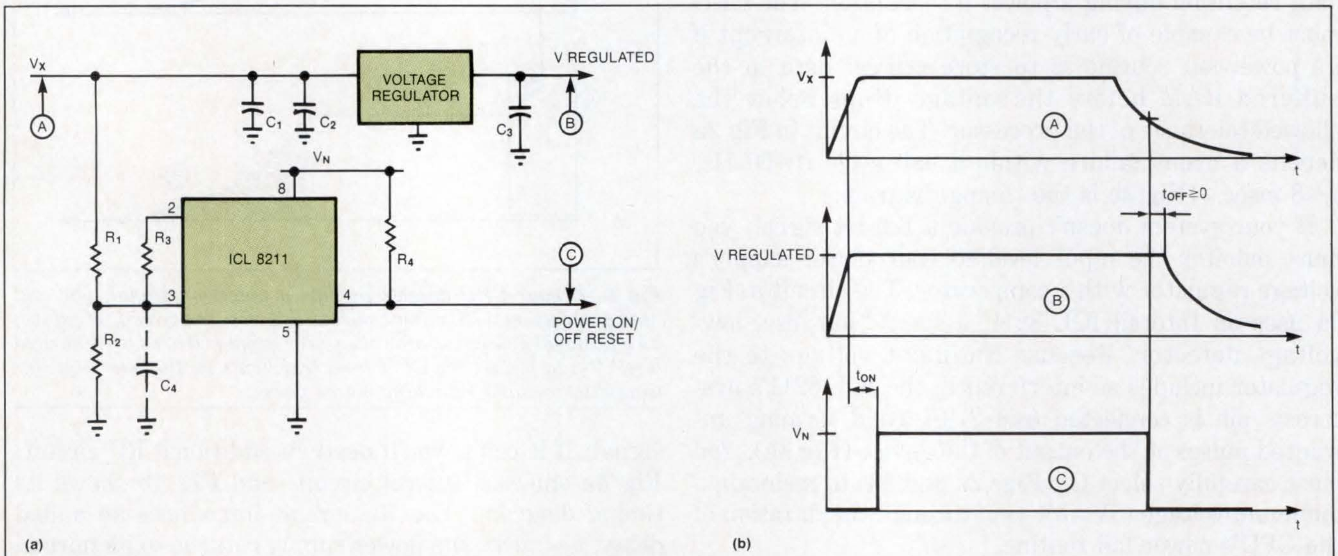


*Fig 5—***Again, the ICL 8211 provides better** *performance than a simple device. In this circuit, the ICL 8211 replaces* **Fig 4's** *Schmitt triggers.*

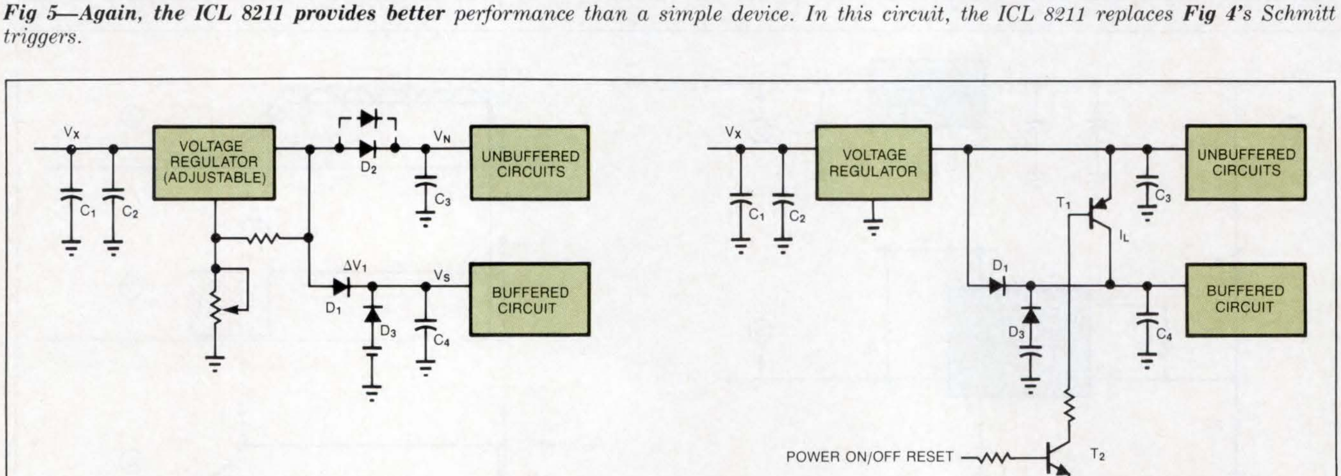
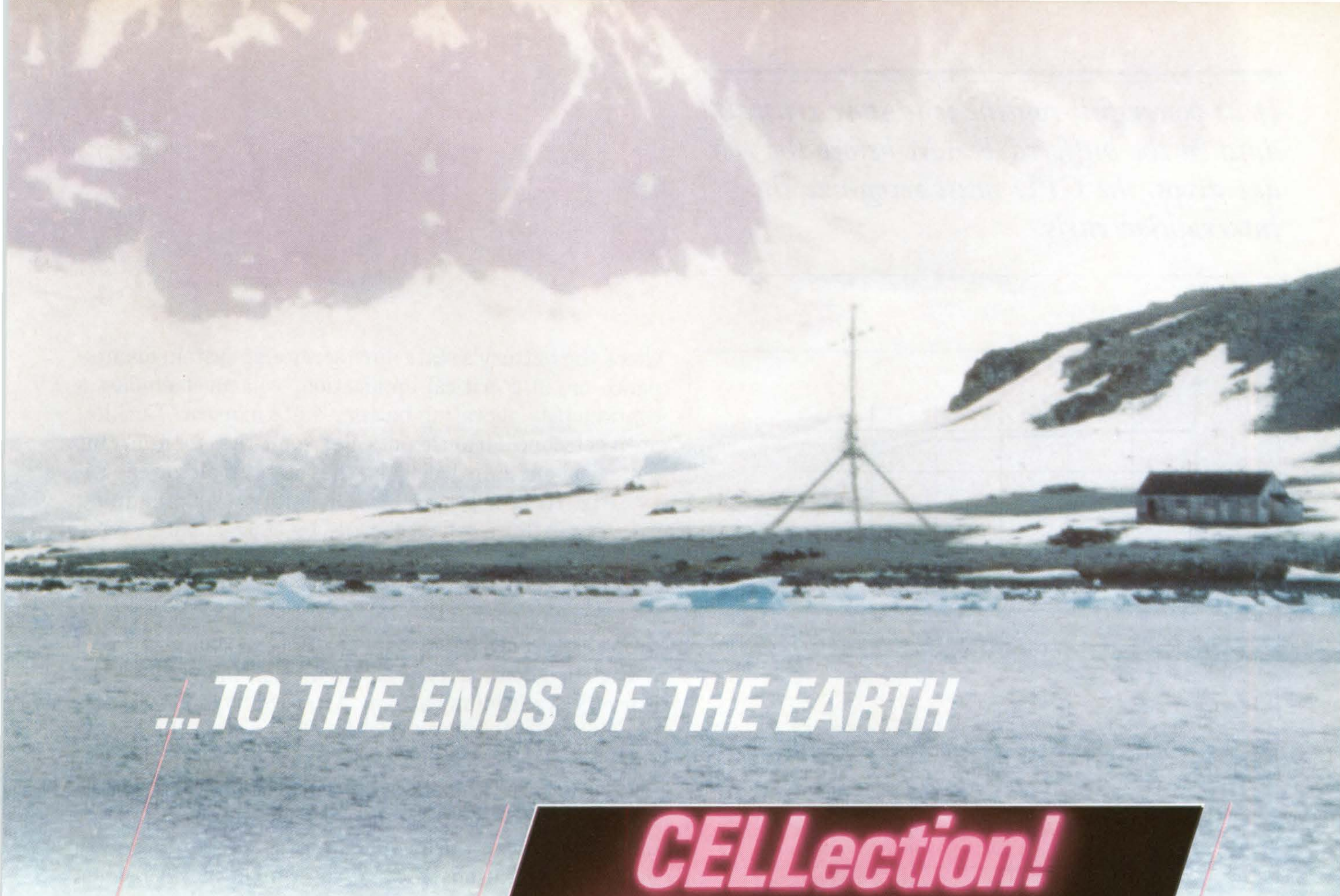


*Fig 6—***Diode D₁ decouples the lithium battery** *from the power supply. Diode D₂ ensures that the buffered and unbuffered loads see the same voltage level. This scheme requires an adjustable regulator; if you select a fixed regulator, you will have to use a decoupling transistor (or relay) as in* ***b***.



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If its power-fail routine is to store critical data in the buffered RAM before the voltage drops, the CPU must recognize the interruption early.

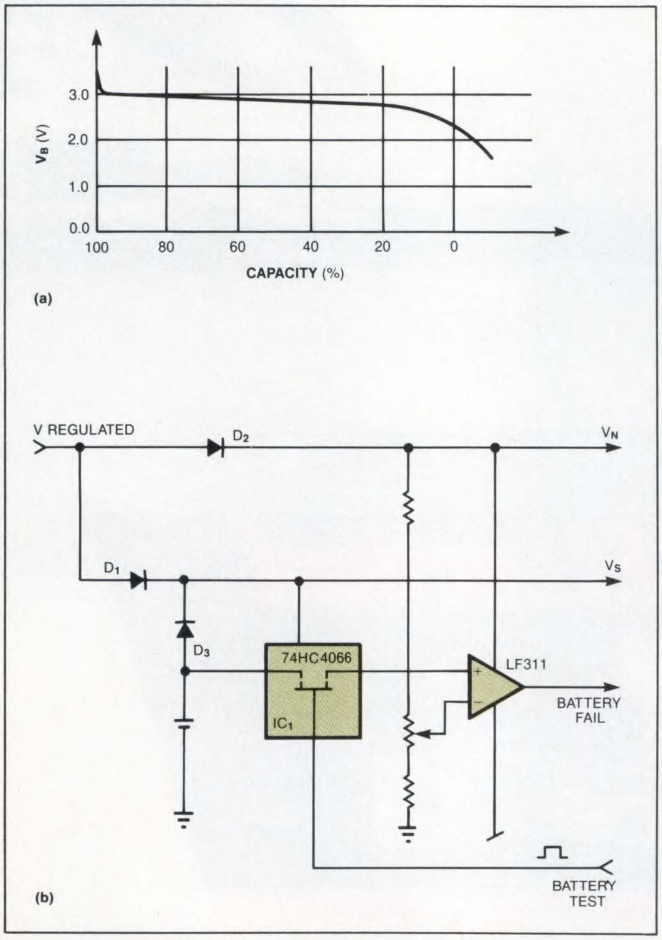


Fig 7—The circuit in b takes advantage of a lithium cell's *drop in open-circuit voltage to respond to a query from the CPU with the cell's charge state.*

D_2. If currents to the two loads are significantly different, you can add a parallel diode to diode D_2 to compensate for the resulting difference in diode-voltage drops. In this configuration, you'd also need a variable regulator, adjustable over the required tolerance range.

If you have a fixed voltage regulator instead of an adjustable one, you can employ a decoupling transistor such as T_1 in **Fig 6b** to equalize the buffered and unbuffered supply voltages. This solution, however, is more complicated and expensive and requires additional board space. You should select T_1 to have the lowest reverse-leakage current (I_L) possible to minimize battery drain. To eliminate T_1's reverse leakage, you could replace it with a relay, but not all relays can conduct microamperes of current successfully. A mercury-wetted relay works best in this application.

To ensure uninterrupted memory backup, you must check the battery's state during regular system maintenance or, in a critical application, you must employ a continuously operating battery-state monitor. Luckily, a direct correlation exists between the open-circuit voltage of an $LiMnO_2$ cell and the cell's remaining capacity. **Fig 7a** is a graph of cell voltage vs remaining capacity. After a cell discharges by approximately 80%, you can detect a gradual drop in its output voltage. Liquid-cathode batteries, in contrast, do not exhibit this warning behavior; they have an abrupt voltage drop that occurs when they are fully discharged.

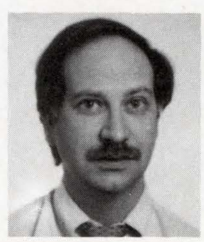
Fig 7b shows a typical circuit for monitoring the capacity of a lithium battery. After the system switches to power-supply operation, the CPU pulses the analog switch (74HC4066) and checks the state of the battery-fail output. You should use a reference level of 2.5V to compensate for the 0.3V drop across D_3 that will occur during a power interruption. Also, don't forget to include the additional drain (2 μA typ) of the 4066 when calculating the capacity of the battery. **EDN**

Authors' biographies

Nicolas Müller is responsible for worldwide marketing sales and marketing for OEM lithium batteries for Renata AG in Switzerland. He previously worked for several electronic component manufacturers in South America and Switzerland. Nicolas enjoys skiing and is an avid collector of model trains and trolleys.

Henry Uelbelhart is involved in the design and development of control and test systems for a fully automated production facility for Renata AG in Switzerland. Henry enjoys hiking and swimming and has traveled extensively throughout Europe.

Jack F Swartz is one of the founders of International Power Sources Inc in Natick, MA. He previously worked for the power supply division of General Instrument. Jack's leisure activities include photography and computer programming.



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LINEAR TECHNOLOGY
DESIGN NOTES

Number 10 in a series from Linear Technology Corporation *May, 1988*

Electrically Isolating Data Acquisition Systems

Guy Hoover
William Rempfer

Introduction

In data acquisition systems it is often necessary to electrically isolate the measurement points from the system controller. Reasons for the electrical isolation include the following: to allow floating measurements at high voltages; for safety, to reduce the danger of electrical shock, as might occur in medical applications; and to eliminate ground loops between measurement points and the system controller which can cause errors.

The data transmitted over the isolated lines can be either analog or digital. Analog signals have poor noise immunity and one isolator is required for each signal point. Traditionally, the highly noise immune, digitally encoded signals required many isolated lines for each channel. Now, with the LTC1090 family of serial data acquisition systems, it is possible to transmit eight channels of data with only four isolated lines. Each additional eight channels requires only one additional isolated line.

Both opto isolators and pulse transformers could be used to isolate the signals. However, since opto isolators tend to be smaller and less expensive than pulse transformers, they will be the only type of device considered here.

The circuit to be demonstrated is an eight channel data acquisition system with 500V of isolation that uses the LTC1090 and four opto isolators. With the addition of another opto isolator, the circuit can be battery operated, drawing only 50μA while taking a reading once every two seconds. The number of channels can be increased to 16, 24, 32, etc., with one additional opto isolator used to increase the number of channels in multiples of eight. Up to 24 channels can be powered directly by the LT1021.

Circuit Description

The LT1021 powers the analog circuitry and provides an accurate reference. A 1Ω resistor isolates the reference from power supply transients.

The 4N28s in Figure 1 are very commonly used opto isolators. They provide only 500V of isolation, however. If more isolation is desired, up to 2500V of isolation can be obtained by using 4N25s with no other circuit modifications.

PNP transistors were chosen to drive the opto isolators to optimize signal fall time and clock rate. D_{OUT} of the LTC1090 is transmitted on the falling edge of SCLK. Data is clocked into the processor on the rising edge of SCLK. It is therefore necessary that the falling edge of SCLK have as little delay as possible through the opto isolator. This insures that D_{OUT} can be output by the LTC1090 in time to be captured by the processor on the rising edge of SCLK. NPNs could be used at slower data rates or if burning more current is not objectionable.

The current limiting resistors in the collectors of the opto drivers are chosen with the Current Transfer Ratio (CTR) of the opto isolator in mind. The output transistor of the opto isolator must have enough base current to drive the desired

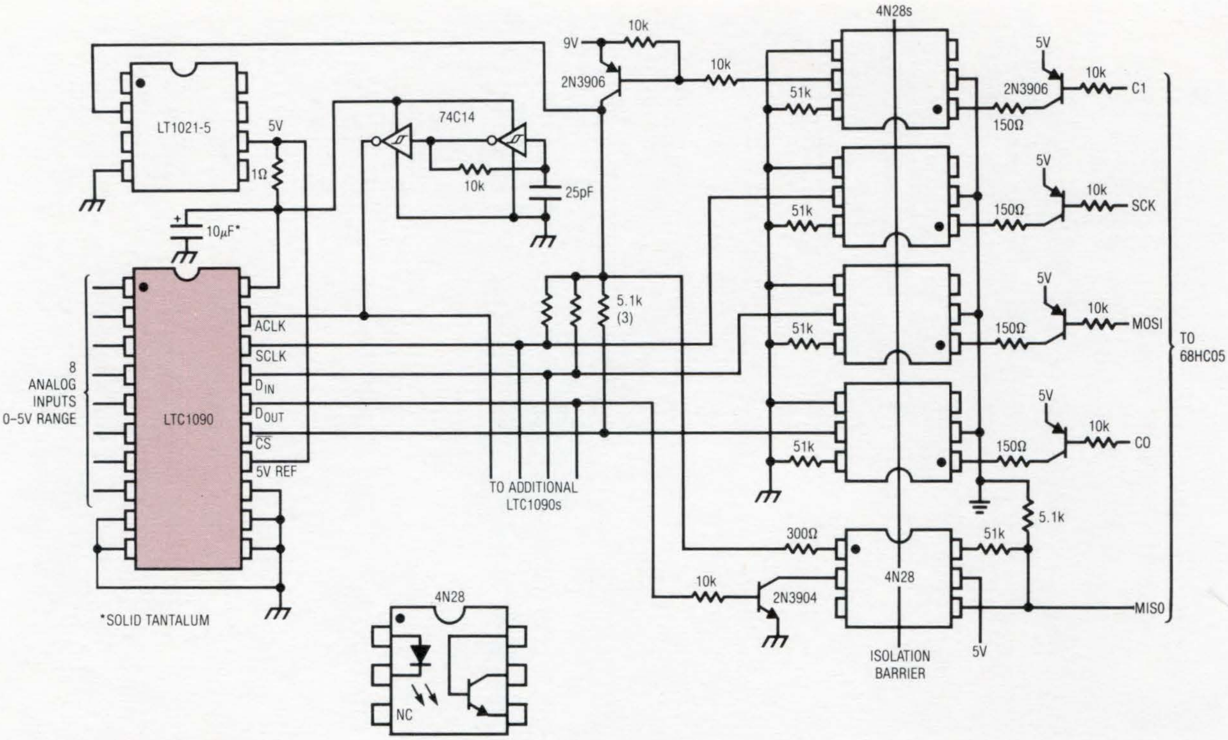

Figure 1. Micropower, 500V Opto Isolated, Multichannel, 10-Bit Data Acquisition System is Accessed Once Every Two Seconds

load. The base resistor on the opto output transistor is there to decrease the turn off time of the opto isolator.

The code written for the Motorola 68HC05 processor is available from Linear Technology. The code powers up the circuit, allows 6.0ms for the 10μF cap to charge to its final value, reads 9 channels in 12ms, and then powers down until the next set of readings is required. Nine channel readings are required because, when the LTC1090 is powered up, a dummy read is necessary to initialize the device. The frequency of the ACLK generated by the 74C14 is not too critical. The software must provide a delay of at least two ACLK cycles between the time $\overline{CS}$ goes low and the first SCLK edge is generated. Another delay of 44 ACLKs is required during the time that $\overline{CS}$ is high between data transfers.

Alternatives

The circuit demonstrated in Figure 1 is capable of transferring serial data at about a 15kHz rate, which is fast enough for many applications. For higher data transfer rates, pulse transformers from companies such as Sprague or Pulse Engineering, or high speed opto isolators such as Hewlett Packard's HCPL2200 are available which can transmit data at the full 1MHz rate that the LTC1090 is capable of.

Summary

The LTC1090 with its serial architecture is ideally suited for isolation applications. It requires only four isolated lines for eight channels of data and can be expanded by adding only one additional isolated line for each additional eight channels of data required. Possible applications for this and similar circuits are PC-based measurement systems, medical instrumentation and other applications where large common-mode voltages or ground loops exist.

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

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Compute square root of bipolar magnitudes

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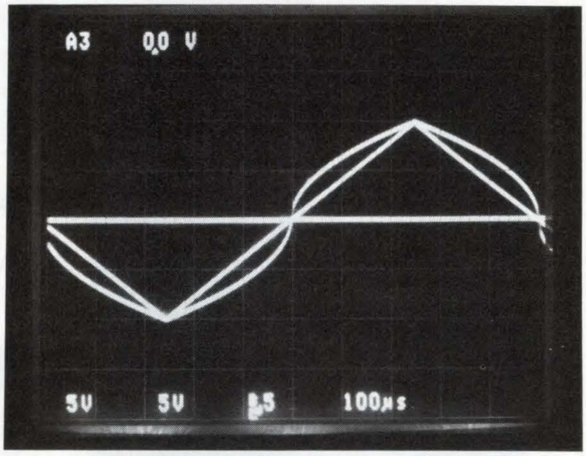

***Fig 2—This photo shows Fig 1's V_O waveform** superimposed on V_{IN}—a 20V p-p triangle wave.*

In **Fig 1**, a single analog-multiplier IC calculates the square-root magnitude for bipolar input signals. You normally define the square root only for positive arguments, but this circuit generates $\sqrt{V_{IN}}$ for positive inputs and

$$-\sqrt{|V_{IN}|}$$

for negative inputs.

Although IC_1 handles both input polarities, an output summing amplifier (IC_2) must combine the signals corresponding to each polarity, which appear on the separate load/summing resistors, R_2 and R_3. The circuit produces ±10V output swings, limited to about 10 kHz by the multiplier's output amplifier (A). (This amplifier ensures equality in the V_{OUT} equation **(Fig 1)** by forcing the two terms within the brackets to have equal magnitudes.)

Fig 2 shows the circuit's output (V_O) superimposed on a ±20V p-p, triangle-wave V_{IN}. Note that $V_O = V_{IN}$ at 0V and at the 10V peaks. You can create an inverting version of the circuit by swapping the Z1 and Z2 inputs (pins 3 and 8). As shown, the circuit delivers accuracy as high as ±0.5%, depending on the electrical grade of IC_1. If you can tolerate ±5% accuracy, you can remove D_1, D_2, and R_1, and connect pin 4 directly to pin 7. **EDN**

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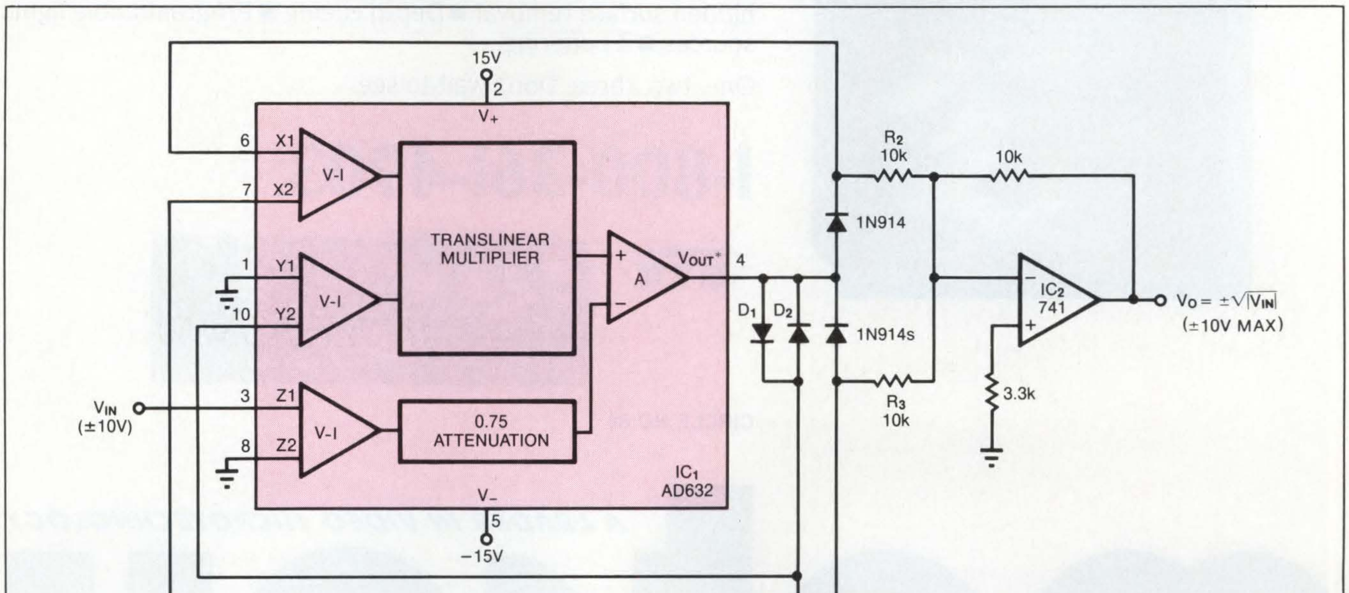

***Fig 1—These circuit connections enable** a single analog multiplier (IC_1) to calculate square-root magnitude for a bipolar input signal. Summing amplifier IC_2 combines the signals corresponding to each polarity.*

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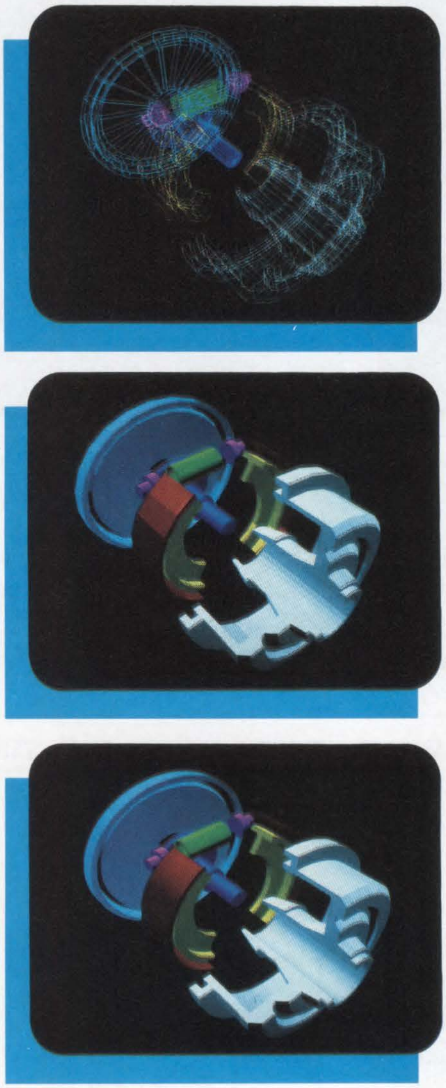

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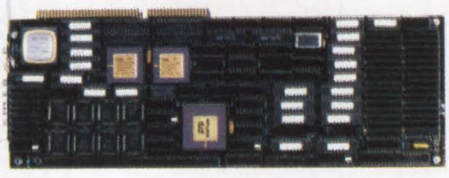

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Counter controls its own clock frequency

Shantha Fernando
Arthur C Clarke Centre, Moratuwa, Sri Lanka

You can implement a finite-state machine by properly decoding the outputs of a binary counter. Driving the counter with a constant-frequency clock signal produces output states of equal duration. **Fig 1**'s circuit, however, produces output states with different time intervals, as most applications require.

The analog multiplexer, IC_3, selects a timing resistor for the timer, IC_1. The timer's output clocks the counter (IC_2) and the counter outputs drive the multiplexer's address inputs. The resistor values shown (R_{T0} through R_{T7}) produce a chirped clock and an ascending sequence of output-state durations, but you can generate arbitrary durations by choosing other resistor values. You can obtain longer durations by increasing the resistor values or by inserting a digital divider between the timer and the counter. **EDN**

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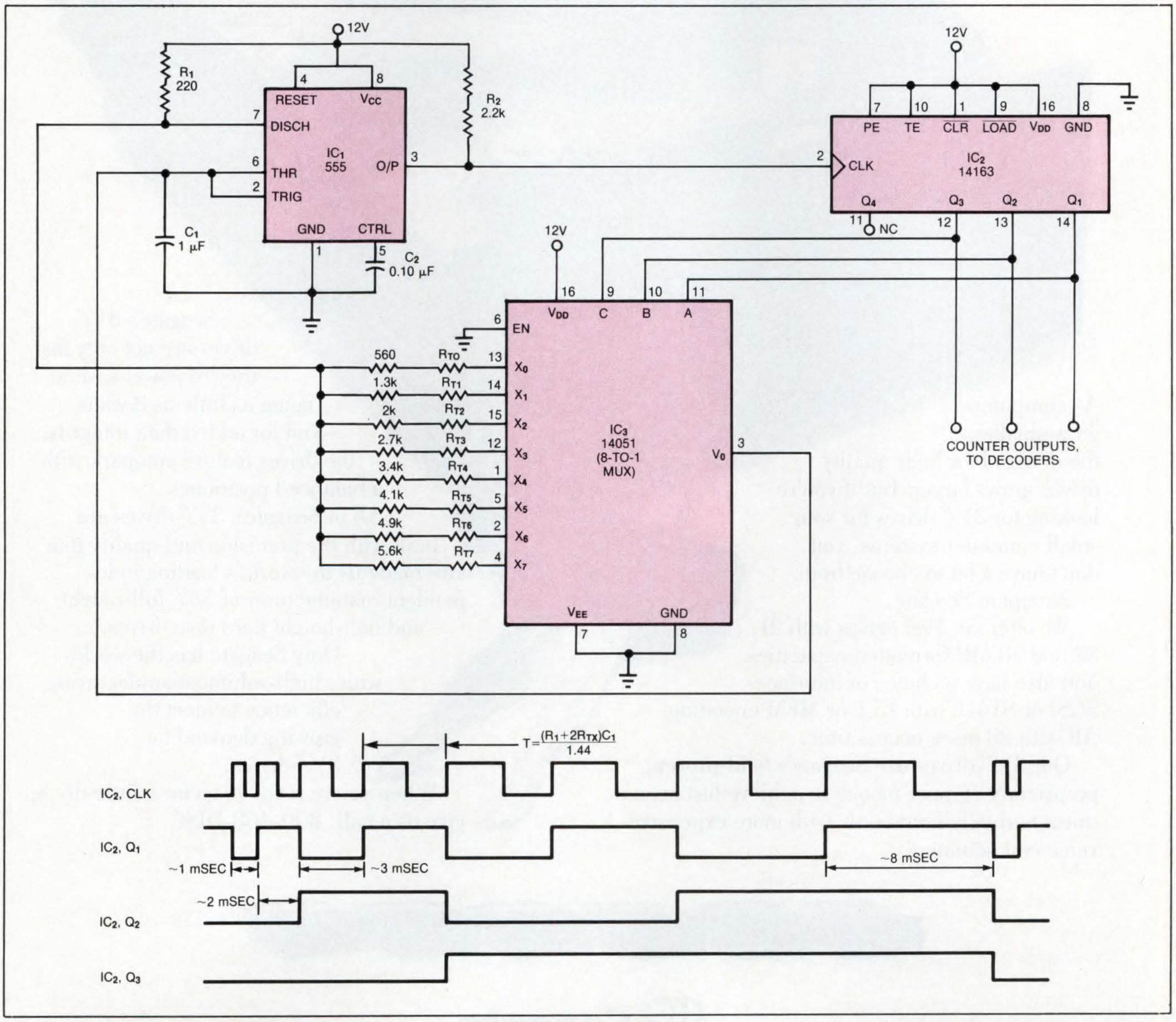

***Fig 1—In this loop, the multiplexer** selects a timing resistor for the timer, which clocks the counter, IC_2. The counter's resulting output-state durations depend on the values you select for resistors R_{T0} through R_{T7}.*

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Reduce ac-coupled flip-flop's dissipation

Dan Awtrey
Consultant, Garland, TX

Fast RC time constants can dominate power consumption in a conventional ac-coupled, RS flip-flop (**Fig 1a**). The 100-nsec components shown, for instance, dissipate 10 mW—more than twice the dissipation of two LSTTL gates. By simply reconnecting R_2 and R_4, (**Fig 1b**), you can halve the circuit's power dissipation and obtain other benefits as well.

Fig 1b's resistor connections eliminate dissipation in the circuit's inactive RC network. When IC_{1a}'s pin-2 input is at logical zero, for instance, the dissipation in R_1 and R_2 is zero, because both ends of the resistors are at 5V. Meanwhile, the logical zero at IC_{1b}'s output allows current flow in R_3 and R_4, producing 3V (logical one) at the pin-5 input. Applying a negative-going edge to C_2 toggles the flip-flop; then, a similar signal to C_1 will toggle the flip-flop again. Note that in each case, the inactive network pulls the gate voltage to V_{CC} (and away from the gate input's linear region, which would dissipate additional power).

R_2 and R_4 also serve as pullup resistors for the gate outputs, ensuring that logical-one outputs reach the V_{CC} level for active- or passive-pullup gates. You can build the circuit with active- or passive-pullup, TTL or CMOS 2-input NAND gates. **EDN**

To Vote For This Design, Circle No 749

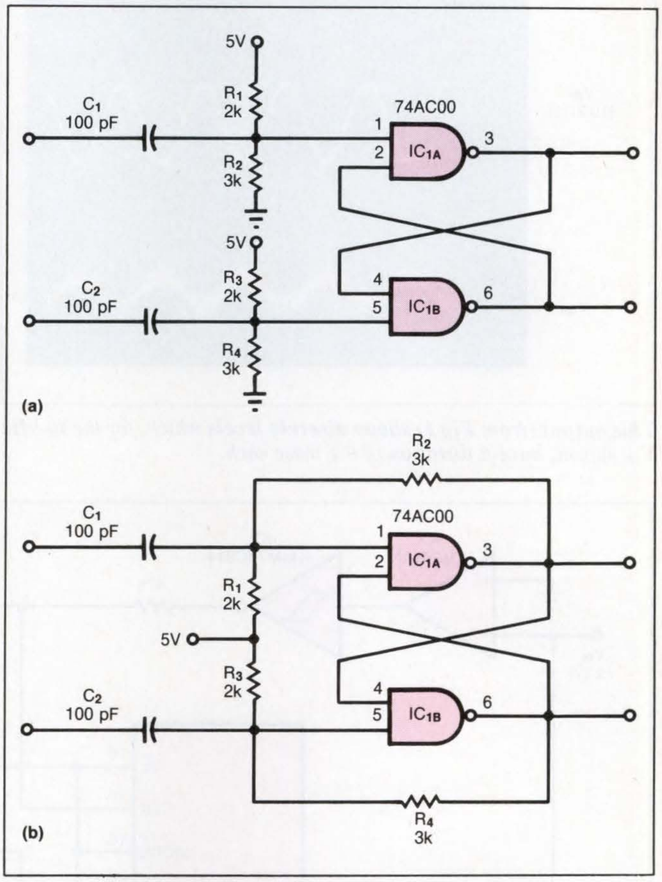


*Fig 1—**To halve the power dissipation** in the conventional ac-coupled RS flip-flop **(a)**, simply reconnect R_2 and R_4 as shown in **b**.*

Swept amplitudes enhance signal generator

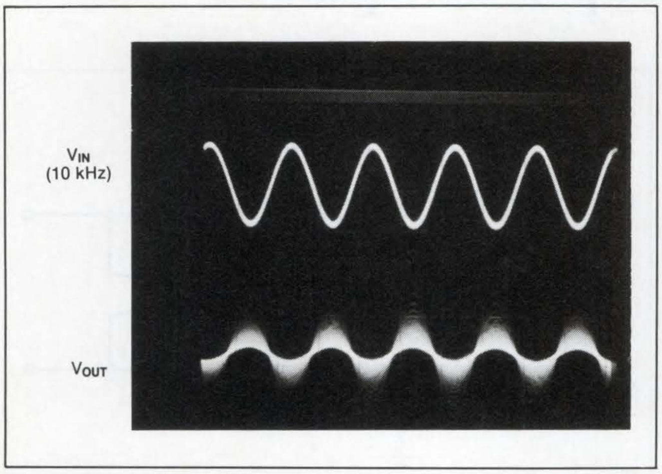
J Millar and T G Barnett
The London Hospital Medical College, London, UK

Adding **Fig 1**'s circuit to an existing waveform generator provides a swept-amplitude function. That is, the V_{OUT} amplitude changes by a fixed amount on alternate zero crossings and remains constant during each full cycle. For the connections shown, the successive cycles grow in this manner to a ±10V maximum, return to a ±1V minimum, and repeat. This capability is useful for evaluating certain biomedical sensors and electrodes, for instance, which may exhibit voltage-dependent characteristics that other test methods don't reveal.

The circuit provides a frequency range of dc to 100 kHz while preserving other waveform capabilities the generator may have (waveform type, swept frequency, gated operation, etc). In short, the circuit uses an analog divider (IC_6) to divide V_{IN} by a constant whose value changes with each successive cycle.

Op amp IC_1, connected as a zero-crossing comparator, produces a square wave that is synchronous with the V_{IN} frequency. After being inverted by the Schmitt-trigger gate (IC_2), this signal drives the clock input (pin 17) of the multifunction converter, IC_3. IC_3 includes an 8-bit D/A converter and an up/down counter configured to count up, reverse at full scale, then count down and reverse at zero, and so on. The counter's output drives the converter to produce a 0 to 9V staircase waveform at the output of amplifier IC_4. (Note that you can lower the staircase frequency by reducing IC_3's clock rate. You can introduce a CD4040 binary counter between the timer and the converter, for example, to divide that signal by a suitable factor.)

The analog divider, IC_6, then divides successive V_{IN} cycles by successive discrete levels of the staircase waveform. Note that the divider and the op amps require ±15V supply voltages. **EDN**



***This output (from Fig 1) shows discrete levels** which, for the 10-kHz V_{IN} shown, have a duration of 0.1 msec each.*

To Vote For This Design, Circle No 747

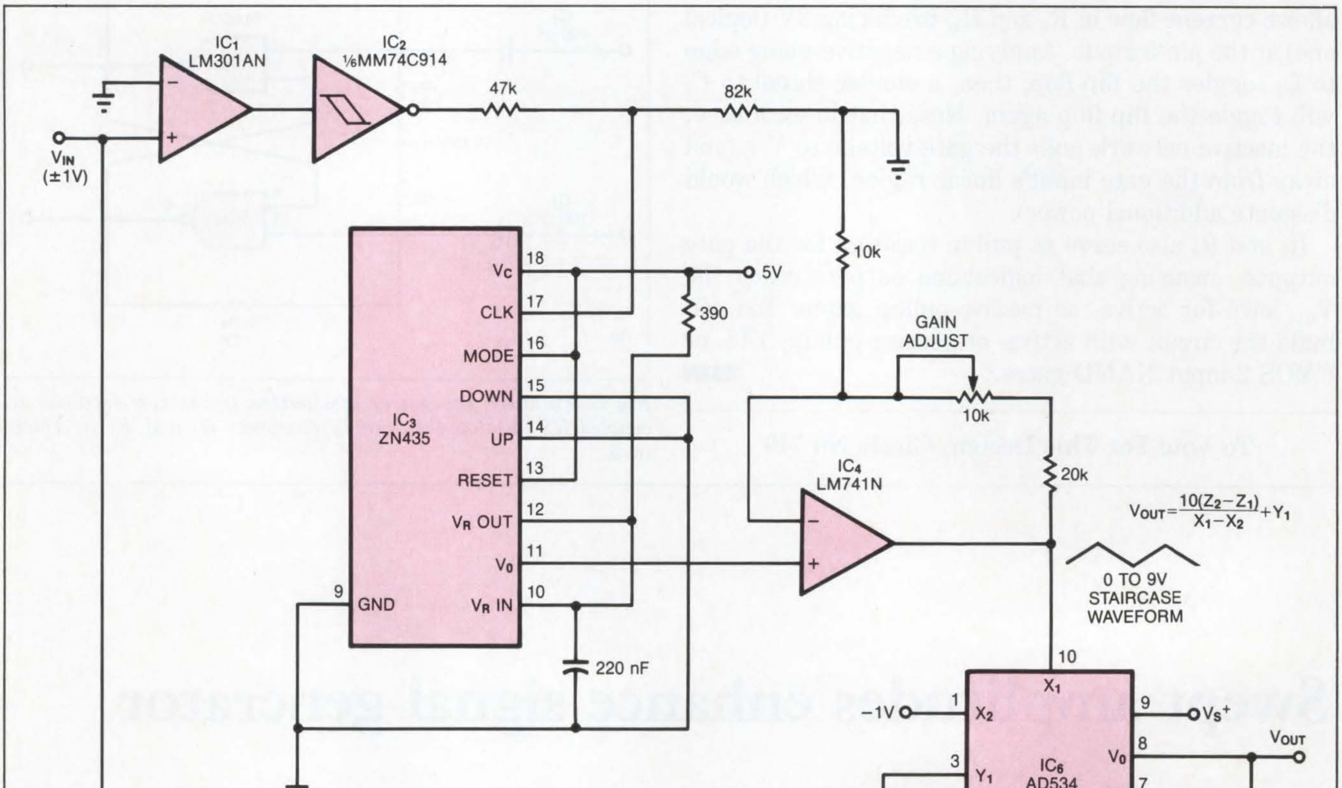


Fig 1—This circuit sweeps the amplitude of V_{IN} by providing discrete levels of gain for each successive cycle, in a staircase pattern.

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SPECIFICATIONS

	KSW-2-46		KSWA-2-46	
Pin Model	**KSW-2-46**		**KSWA-2-46**	
Connector Version	**ZFSW-2-46**		**ZFSWA-2-46**	
FREQ. RANGE	dc-4.6 GHz		dc-4.6 GHz	
INSERT. LOSS (db)	typ	max	typ	max
dc-200MHz	0.9	1.1	0.8	1.1
200-1000MHz	1.0	1.3	0.9	1.3
1-4.6GHz	1.3	1.7	1.5	2.6
ISOLATION (dB)	typ	min	typ	min
dc-200MHz	60	50	60	50
200-1000MHz	45	40	50	40
1-4.6GHz	30	23	30	25
VSWR (typ) ON	1.3:1		1.3	
OFF	—		1.4	
SW. SPEED (nsec) rise or fall time	2(typ)		3(typ)	
MAX RF INPUT (bBm)				
up to 500MHz	+17		+17	
above 500MHz	+27		+27	
CONTROL VOLT.	**-5V** on, OV off		**-5V** on, OV off	
OPER/STOR TEMP.	-55° to +125°C		-55° to +125°C	
PRICE (1-24)	**$32.95** **$72.95**		**$48.95** **$88.95**	

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C 117 REV. D

CIRCLE NO 87

ISSUE WINNER

The winning Design Idea for the February 18, 1988, issue is entitled "Derive ±15V and 5V from a 12V battery," submitted by Andy Jenkins of Maxim Integrated Products (Sunnyvale, CA).

Alterable code enhances instructions

Noor Singh Khalsa
EG&G Inc, Los Alamos, NM

By using a static RAM with built-in battery backup, you can create self-modifying code that enhances the instruction set of your µP. The 8031, for example, has a built-in bit map, but you must address the bits directly. A few instructions (**Fig 1**) let you implement an indexed addressing scheme that dynamically alters the second byte of the bit-addressing instruction (which is the bit's address).

```
EXAMPLE:                               ; implementing MOV C,

          MOV    DPTR,#INSTR+1         ; point to bit address
          MOVX   @DPTR,A               ; set address
INSTR:    MOV    C,0                   ; this is the modified
                                       ; instruction
          RET
```

***Fig 1—You can use these instructions to implement** an indexed addressing scheme that dynamically alters the second byte of the 8031's bit-addressing instruction.*

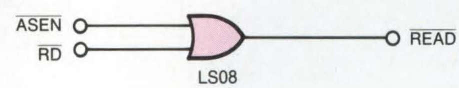

***Fig 2—This external OR gate causes a complete overlap** in the 8031's otherwise separate 64k-byte memory spaces for code and data.*

The 8031 maintains a separate memory space for code and data. The **Fig 1** scheme, however, requires that you combine these memory spaces by making them overlap. To do so, you simply OR the instruction-fetch signal (PSEN) with the external-memory read signal (RD) as shown in **Fig 2.** This circuit reduces the total memory space to 64k bytes (instead of 64k bytes each for code and data), but you gain the programming advantage of being able to mix the MOVX and MOVC instructions. For example, you can eliminate a CLR A instruction by using MOVX A,@DPTR instead of the MOVC a,@A+DPTR instruction. **EDN**

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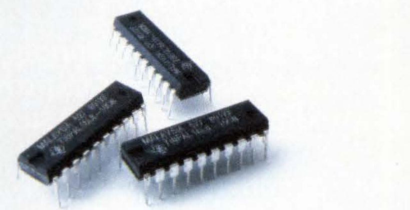

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CIRCLE NO 88

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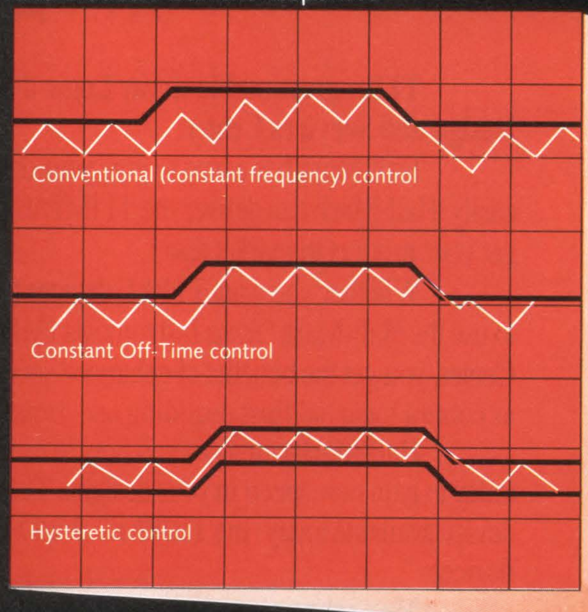

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The CS-320. A power supply control IC so advanced it is the first to provide for unconditionally stable Hysteretic control.

The CS-320. A power supply control IC so advanced it is the world's first to offer power supply designers the option of working in any one of three modes of control: Hysteretic, Constant-Off-Time or Conventional (constant frequency).

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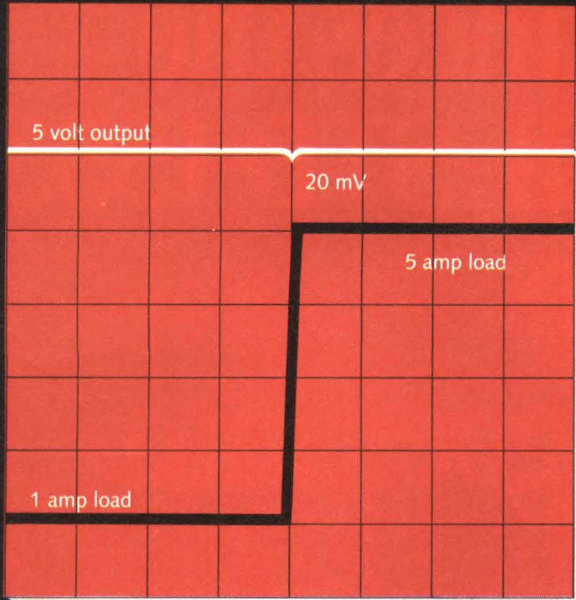
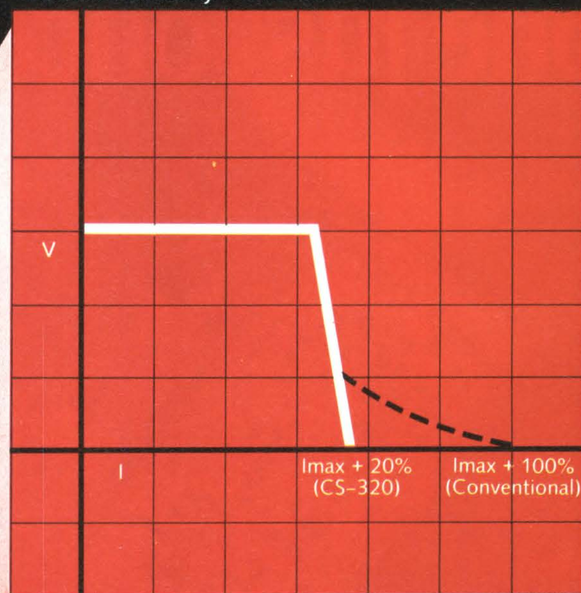
Output Voltage Response to a 5:1 Load Change.

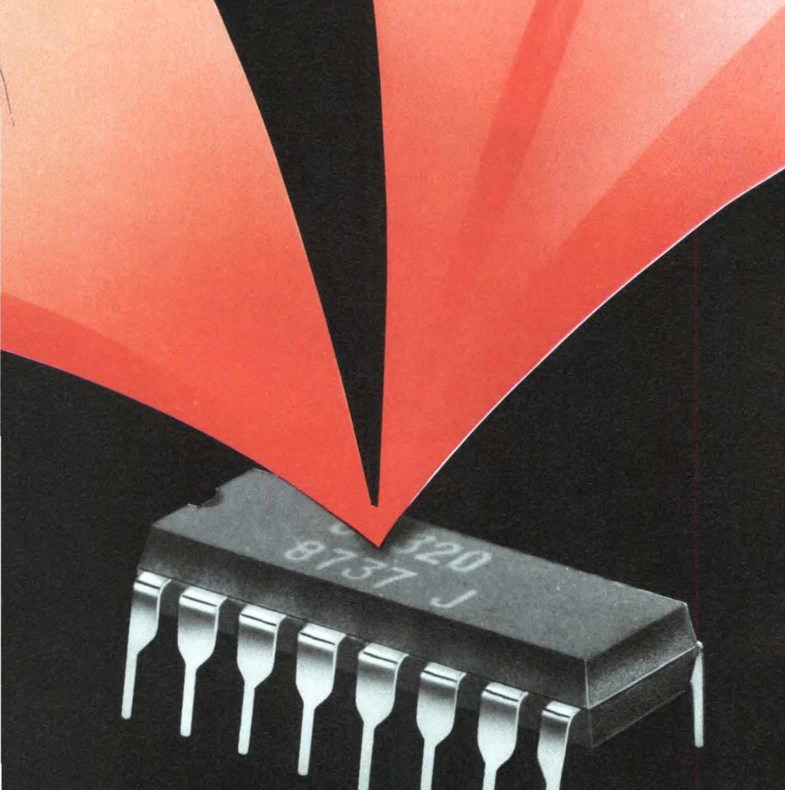


Unconditional Stability.

Hysteretic control directly controls both the peak and valley inductor current. Additionally, slope compensation is not required. A power supply using Hysteretic control is free from subharmonic oscillation and is unconditionally stable. Figure 2 shows the response of a CS-320 controlled Hysteretic DC-DC converter to a 5:1 variation in load current.

Current Runaway Prevented





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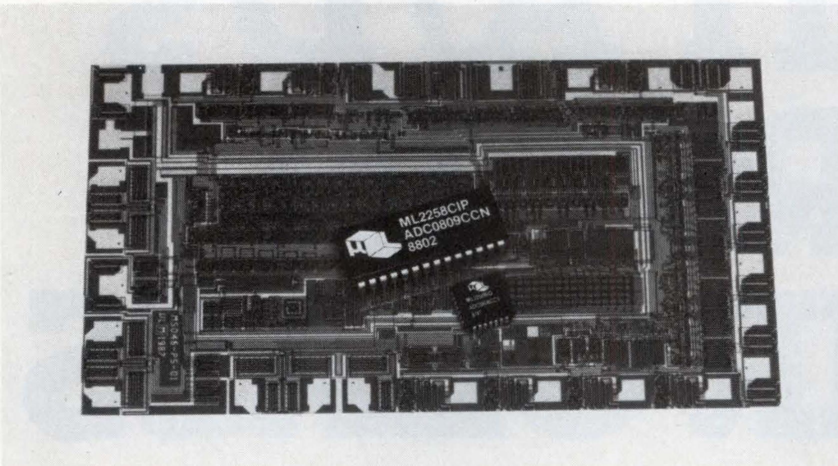
CIRCLE NO 90

INTEGRATED CIRCUITS



8-BIT ADC

- *Features 6.6-μsec conversion rate*
- *Includes 8-channel multiplexer*

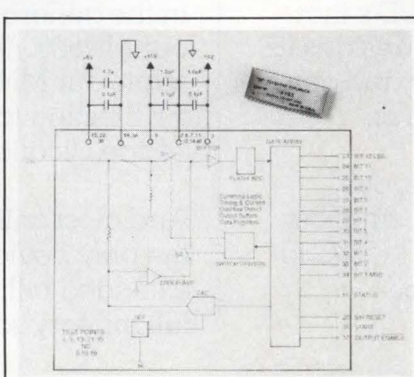
Designed for μP-based applications, the ML2258 is an 8-bit, SAR-type A/D converter, with a built-in 8-channel multiplexer. The on-chip sample-and-hold function features a 375-nsec acquisition time and, combined with the ADC's 6.6-μsec conversion rate, enables the device to digitize a 50-kHz, 0-to-5V sine wave with less than −60 dB of harmonic distortion. The ML2258 is a pin-compatible, enhanced alternate-source for the industry-standard ADC0808 and ADC0809. The μP interface of the ML2258 operates asynchronously to the converter clock, allowing the μP to utilize the A/D converter's speed while saving hardware and program space. The ML2258 operates from a 5V supply and has an analog input range of 0 to 5V. In 28-pin DIP, $3.35; in 28-pin PLCC, $3.95 (100).

Micro Linear Corp, 2092 Concourse Dr, San Jose, CA 95131. Phone (408) 262-5200.

Circle No 351

A/D CONVERTERS

- *500-nsec conversion speed*
- *Choice of input range*



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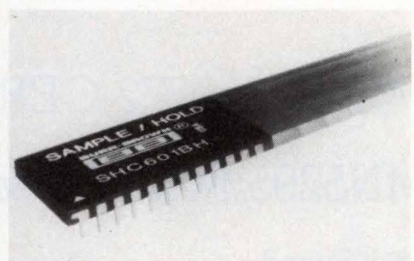
Teledyne Philbrick, 40 Allied Drive, Dedham, MA 02026. Phone (617) 329-1600.

Circle No 352



S/H AMPLIFIER

- *100-MHz sample rate*
- *115-MHz analog bandwidth*

Designed for use in high-speed, 12-bit data-acquisition and signal-processing systems, the SHC601 S/H amplifier combines a 100-MHz sampling rate with high accuracy and low distortion. Linearity error is ±0.02% max, and harmonic distortion is −55 dB at 20 MHz. When used with flash A/D converters, the SHC601 significantly improves the signal-to-noise performance of these circuits. The amplifier acquires 2.5V input step changes to 0.1% accuracy in 12 nsec, has a slew rate of 350 V/nsec, and an analog bandwidth of 115 MHz. The device comes in a 24-pin ceramic DIP and has a specified temperature range of −25°C to +85°C. $392.50 (100).

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Circle No 353

Text continued on pg 218

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Widest Temperature Range:
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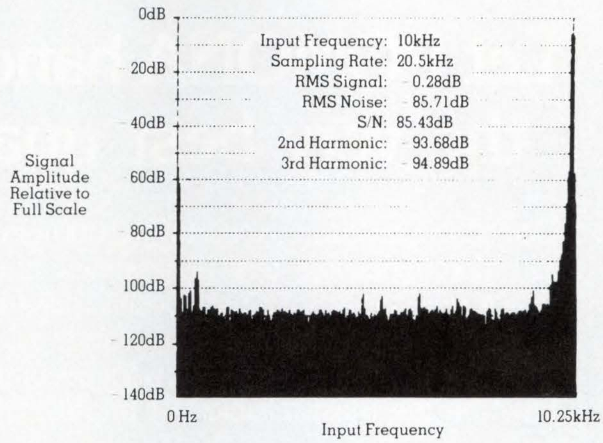
Signal-to-Noise Ratio: 84dB
Harmonics: −88dB
Temperature Range: −55°C to +125°C
Available with MIL-STD-883 Screening



These devices eliminate the hassle of evaluating T/H specs that are difficult to understand and often don't relate.

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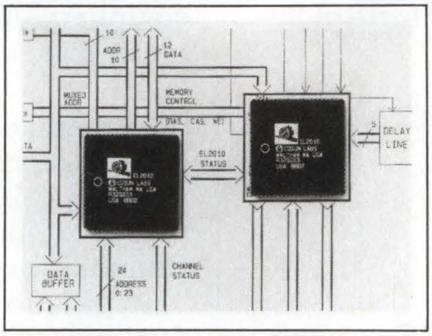
CIRCLE NO 91

MEMORY INTERFACE

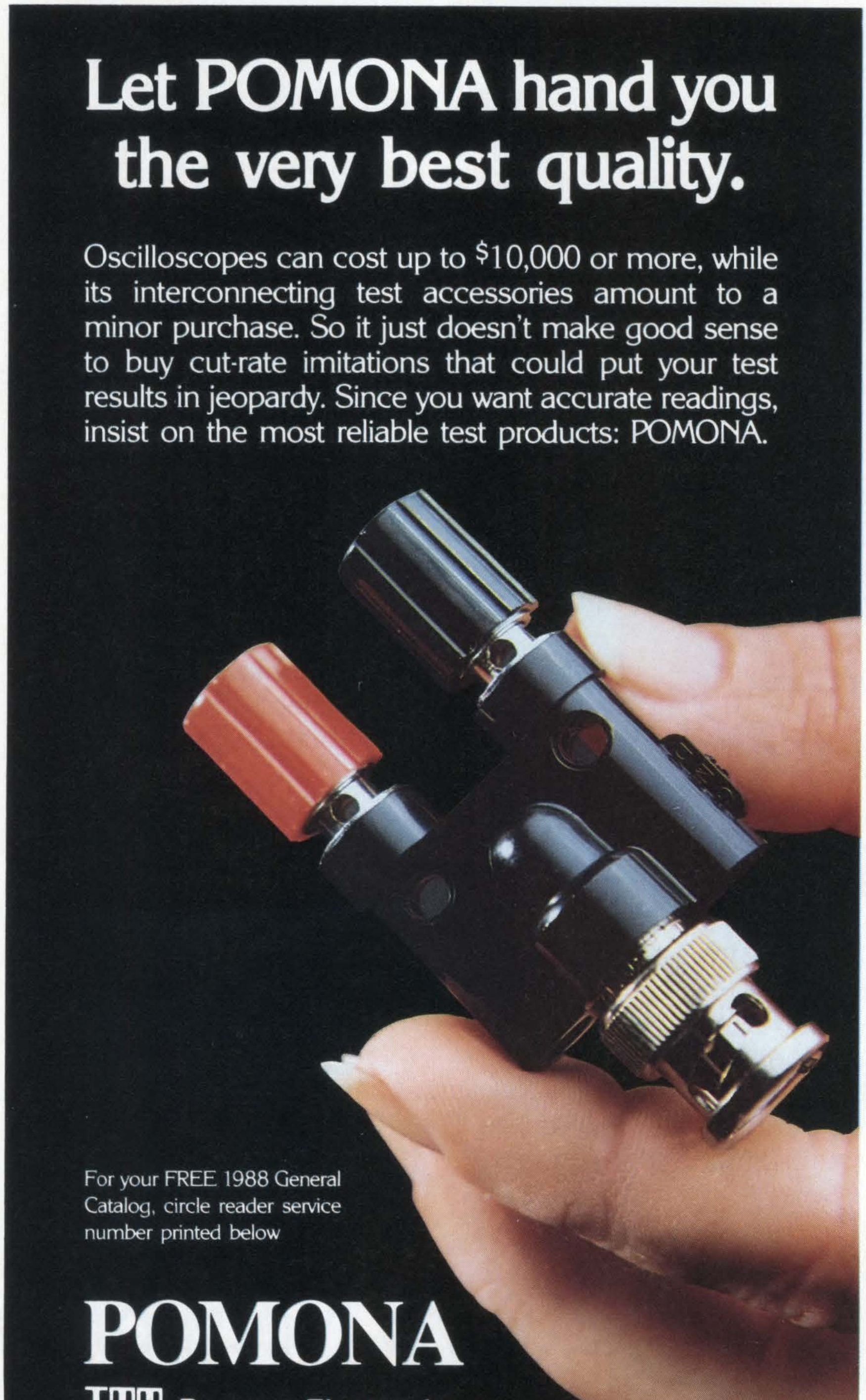
- *2-chip interface set for memory boards*
- *LIM-EMS 4.0 and OS/2 compatible*

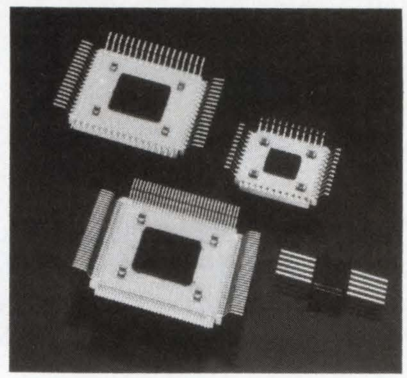


The EL2010 2-chip set provides the Micro Channel interface for memory boards used with the IBM PS/2 Models 50 and 60. The chips support memory to 14.25M bytes and are compatible with the LIM-EMS 4.0 memory standard. The EL2010 includes a full set of power-on setup registers, selectable ID codes, parity logic, RAM control, and decoding for one parallel port and two serial ports. The chip set can function in systems operating to 16 MHz and can replace as many as 30 ICs. Implemented in low-power CMOS, the EL2010 chips come in 84-pin plastic leaded chip carriers. The 2-chip set, $35 (1000).

Edsun Laboratories Inc, 9 Spring St, Waltham, MA 02154. Phone (617) 647-9300. TLX 853664.

Circle No 354





GaAs STANDARD CELLS

- *6000 equivalent gates*
- *Toggle rates as high as 2 GHz*

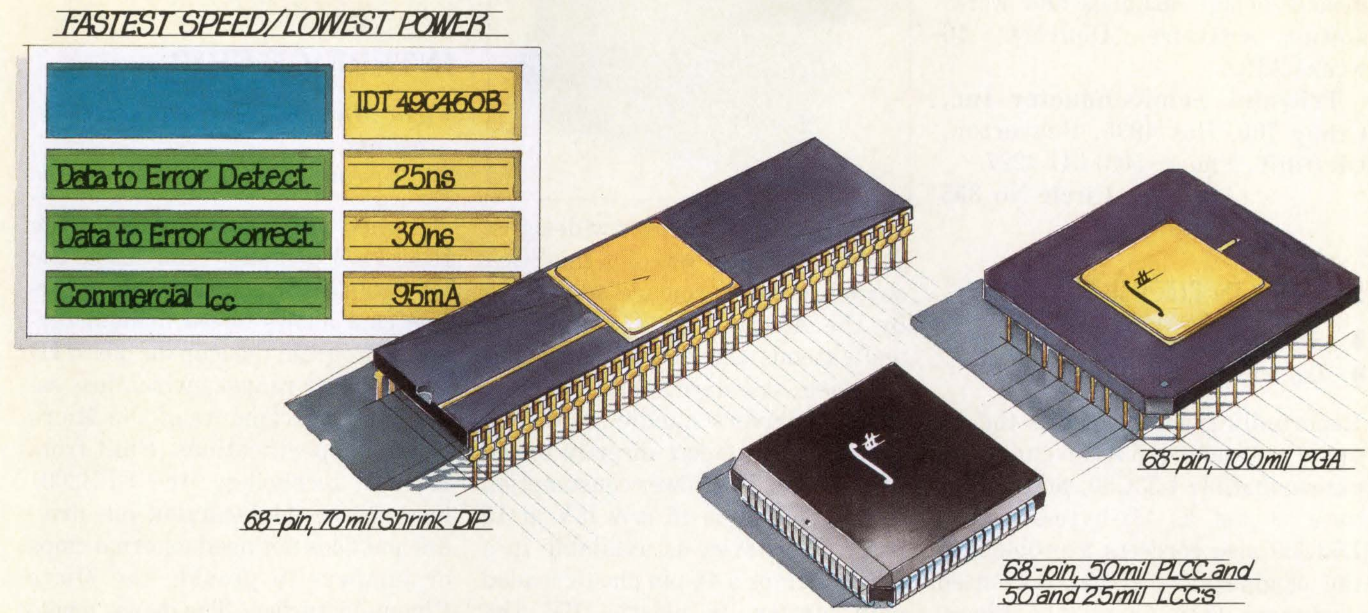
Fabricated in a gallium arsenide enhancement/depletion process, the QLSI standard-cell family supports LSI applications for as many as 6000 equivalent gates. The device's toggle rates, as high as 2 GHz, are two to three times faster than those of most bipolar silicon gate arrays. Two FET logic families are available: the ZFL and the SCFL cell families. The ZFL cells are similar to those used in the company's TQ3000 LSI gate array, which provides low-power gates capable of high fan-out at toggle rates reaching 1 GHz. The differential current-switched SCFL cells are similar to silicon ECL logic, but have toggle rates as high as 2 GHz. The ability of the SCFL cells to operate from a

Text continued on pg 226

World's Fastest

32-bit CMOS EDC

25ns | DETECT TIME



IDT49C460B: fastest speed, lowest power 32-bit EDC.

Your memories are getting bigger and with that comes higher error rates. Use the new, faster IDT49C460B to enhance data integrity. It corrects all single-bit errors, detects all double and some triple-bit errors.

Replaces 2960s. You can easily upgrade existing 2960 systems with the IDT49C460B because both devices use the same Hamming code. Your design benefits from faster speed, improved power consumption and a 3-to-1 reduction in chip count. Byte writes, byte operations and diagnostics are included.

Faster than bipolar. The IDT49C460B detects an error in 25ns and corrects in 30ns. Nothing is faster.

Lowest power. The only 32-bit EDC in CMOS consumes just 95mA commercial. Now you can get EDC faster than the fastest bipolar but with CMOS power.

Cascades to 64 bits. Only IDT offers you a simple, two chip solution for 64-bit EDC. (The TI632 cannot be cascaded to 64-bits; while the Am2960 approach requires 14 devices.)

16-Bit EDC

	IDT39C60A	IDT39C60-1	IDT39C60
Data to error detect	20ns	25ns	32ns
Data to error correct	30ns	52ns	65ns
Commercial I_{CC}	85mA	85mA	85mA

Speed leadership in 16-bit EDC.

We also make a family of 16-bit CMOS EDCs. All are 2960 pin compatible with improved output drive while consuming only 1/4 the power.

The IDT39C60A is unquestionably the highest performance TTL compatible CMOS 16-bit EDC in the world. And more than just some "specs on paper," it's *available now—in volume.*

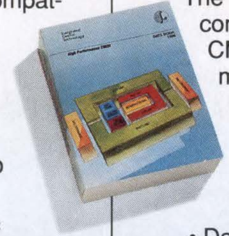
The IDT39C60-1 and IDT39C60 are equal in speed to both the 2960-1 and 2960.

Packages. ☐ 48-pin plastic and ceramic DIPs. ☐ 52-pin PLCC/LCCs.

Cascadable. Up to 64 bits.

Ask for your FREE Data Book!

Everything you want to know about cool and fast EDC is in our new, 1800 page ***1988 DATABOOK.*** Call your local IDT representative or **(408) 492-8314** and ask for your FREE copy.



The DATABOOK also contains complete information on our CMOS Static RAMs • specialty memory products such as FIFOs and DUAL-PORTs • ultra-fast RISC processors and bit-slice ALUs • Multiplier-Accumulators and Floating-Point Processors • TTL logic • Data Conversion products • ECL Interface products.

3236 Scott Blvd.
Santa Clara, CA 95054-3090
(408) 492-8314
FAX: 408 727-2328

CIRCLE NO 111

single 5V supply provides compatibility with existing silicon-based logic. The QLSI standard-cell ICs are available in both die and packaged form. Nonrecurring engineering charges start at $60,000 and include design manuals and workstation software. Delivery, 16 weeks ARO.

TriQuint Semiconductor Inc, Group 700, Box 4935, Beaverton, OR 97076. Phone (503) 641-4227.

Circle No 355

SCSI CONTROLLER

- *4M-bytes/sec transfer rate*
- *Asynchronous SCSI interface*

Reportedly twice as fast as the industry-standard 53C80 chip, the pin-compatible L53C80 can transfer data as fast as 4M-byte/sec. The L53C80 also corrects a problem in the original device that prevented designers from using the block-mode DMA feature in new designs. The L53C80 also satisfies the SCSI asynchronous interface as defined by the ANSI X3T9.2 committee, and extends the range of this 2M-byte/sec standard. The device's built-in drivers handle 48 mA of current and connect directly to the SCSI cable. The power consumption of the L53C80 is 15 mW (5V at 15 mA). The device is available in a 48-pin DIP or a 44-pin plastic leaded chip carrier. In plastic DIP, the L53C80PC-2 costs $6.65; the L53C80PC-4 is $9 (100).

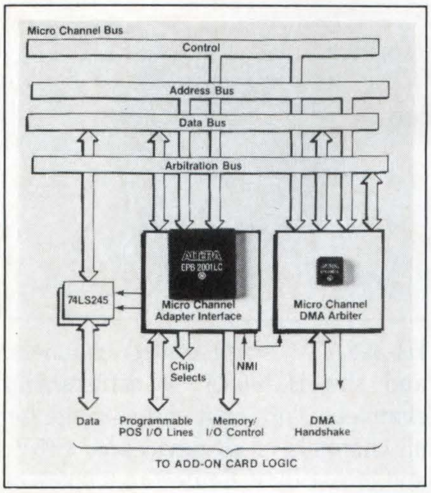
Logic Devices Inc, 628 E Evelyn Ave, Sunnyvale, CA 94086. Phone (408) 720-8630.

Circle No 356

INTERFACE CHIP

- *For Micro Channel add-on boards*
- *User-configurable programming*

Designed for add-on boards for the IBM PS/2 personal computers, the EPB2001 user-configurable interface chip allows board manufacturers to program the chip for board ID and address ranges, which are essential requirements of the Micro Channel specifications. Built from EPROM technology, the EPB2001 incorporates high-current bus drivers and does not need external chips or jumpers to provide the Micro Channel interface. The device meets



all ac-timing and dc-drive requirements without any additional buffer components. The EPB2002 DMA arbitration chip works with the EPD2001 interface chip to integrate the additional logic required for DMA capability. The EPB2001 comes in a windowed 84-pin, J-lead surface-mount package and a windowless, 1-time programmable device. The EPD2002 comes in a 28-pin DIP and a 28-pin J-lead package. $12 (EPD2001); $5 (EPD2002) (10,000). Samples will be available this quarter; production of both versions is scheduled for the second half of 1988.

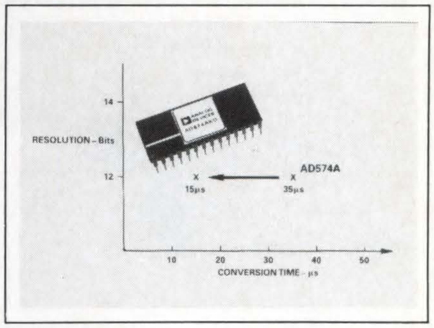
Altera Corp, 3525 Monroe St, Santa Clara, CA 95051. Phone (408) 984-2800.

Circle No 357

12-BIT ADC

- *15-μsec conversion time*
- *150-nsec data-access time*

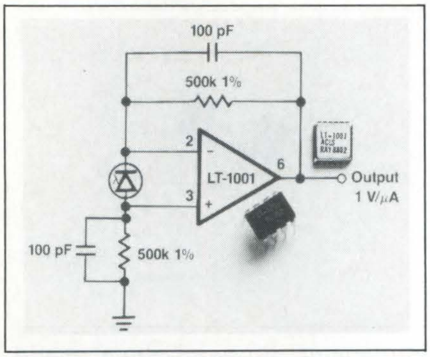
The AD674A 12-bit A/D converter is pin-compatible with the AD574 but features a 15-μsec conversion time. It has 3-state buffers, a maximum data-access time of 150 nsec, and interfaces to most digital processors. The converter can read data as one 12-bit word or as two 8-bit bytes. Typical operation is under μP control, but you can also



implement a stand-alone mode. Specified for use with either ±12V or ±15V supplies, the AD674A provides 4 signal-input ranges of 0 to 10V and 0 to 20V (unipolar), and ±5V and ±10V (bipolar). The device includes an internal buried-zener reference trimmed to 10V, which can drive external loads to 2 mA. The AD674A is available in 6 grades starting at $39.25 (commercial) and $107.25 (military) (100).

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

Circle No 358



PRECISION OP AMP

- *15-μV offset voltage*
- *High CMRR and PSRR*

The LT1001 precision op amp features a maximum offset voltage of 15 μV and a maximum offset drift of 0.6 μV/°C. It's offered as a true second source to the industry part bearing the same designation. The device also features a maximum input-bias current of 2 nA, a CMRR of 114 dB, and a PSRR of 110 dB. Input noise is 0.6 μV p-p from 0.1 to 10 Hz. Maximum power dissipation is 75 mW. Package options for the LT1001 include SOIC, PLCC, TO-99, and ceramic and plastic DIPs. From $1.10 (100).

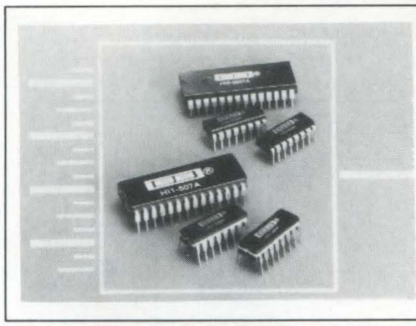
Raytheon Co, 350 Ellis St, Mountain View, CA 94043. Phone (415) 968-9211.

Circle No 359

ANALOG MULTIPLEXERS

- *Single-ended or differential*
- *Offers versions having between 4 and 16 channels*

Fabricated in CMOS, the HI-506A, HI-507A, HI-508A, and HI-509A are analog multiplexers that have transfer accuracies of better than 0.1% at sampling rates to 200 kHz. The analog inputs of the devices can withstand an overvoltage to 70 V p-p, and feature break-before-make switching. The HI-506A provides 16 single-ended channels; the HI-507A, 8 differential channels; the

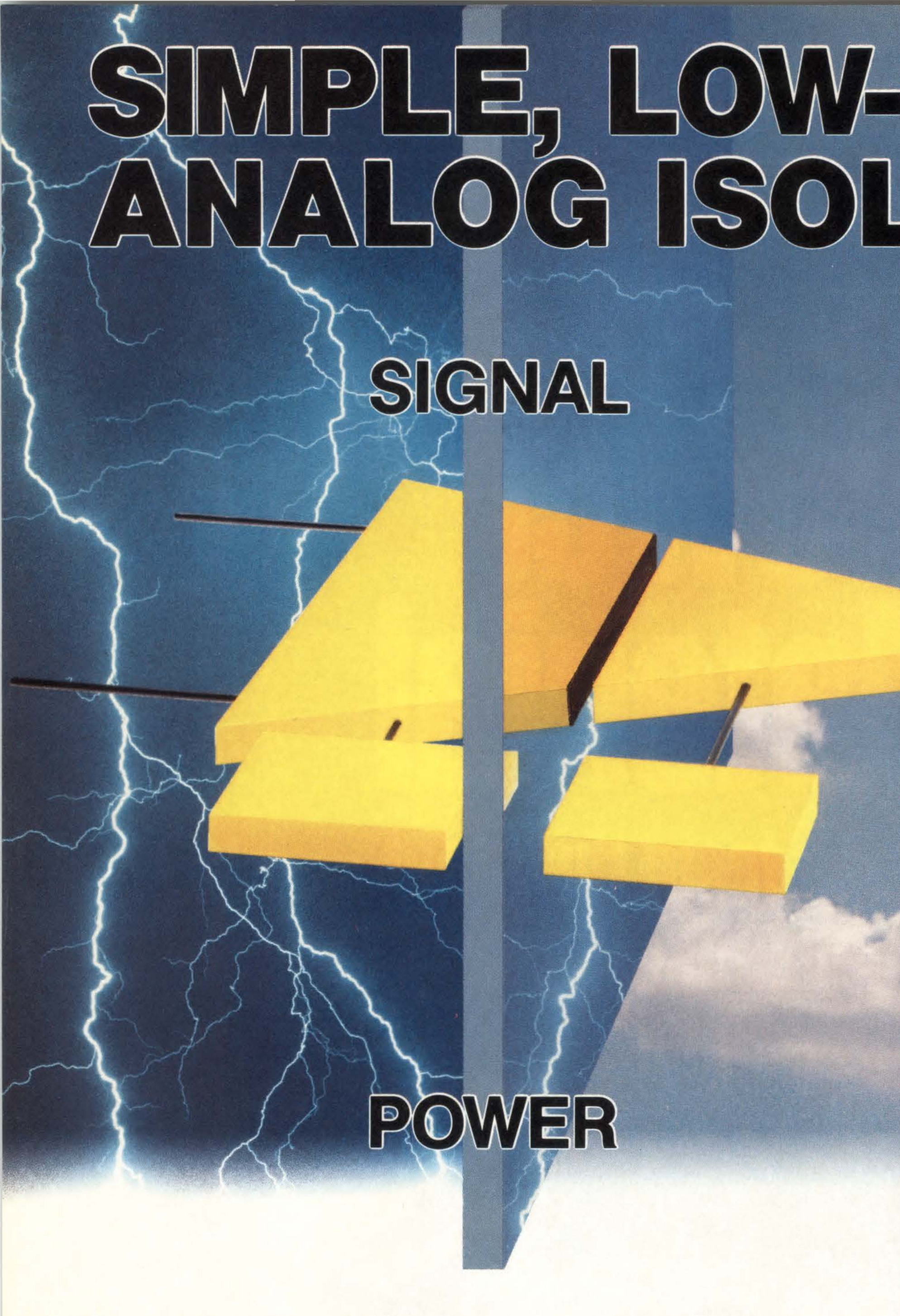


HI-508A, 8 single-ended channels; and the HI-509A, 4 differential channels. The input signal range for all channels of all devices is ±15V, and crosstalk is limited to 0.005% of the voltage level when the channel is off. The multiplexers are packaged in ceramic or plastic DIPs, specified for 0 to 75°C or −55 to +125°C. Prices start at $13.50 for the HI-506A/HI-507A, and $7.35 for the HI-508A/HI-509A (100).

Burr-Brown, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TWX 910-952-1111.

Circle No 360

SIMPLE, LOW-COST ANALOG ISOLATION



NEW SIGNAL AMPLIFIERS AND POWER CONVERTERS GIVE YOU COMPLETE, GUARANTEED ISOLATION SOLUTIONS.

When you need to protect low-level analog signals from noise or high-voltage potentials, choose the industry's most advanced isolation solutions.

Easy-to-use, hermetic isolation amplifiers.

The patented capacitive ceramic isolation barrier of Burr-Brown's unique ISO102/106 buffer amps provides superior protection at extremely low cost:

- 1500Vrms or 3500Vrms isolation voltages, 100% tested and guaranteed;
- industry's first hermetic isolation amps;
- low priced, from 17.35* (ISO102).

Economical, isolated DC/DC converters.

PWS725/726 converters supply isolated, ±7-to-18VDC, 40mA outputs from single 7–18V supplies. Use them with ISO102/106 amps for complete, low-cost systems:

- 1500Vrms or 2500Vrms isolation voltage protection;
- from $22.35* (PWS725)

New distributed power system delivers lowest isolation cost-per-channel.

PWS740 modular DC/DC converter systems save board space and minimize multichannel isolation costs. Compact driver, transformer, and rectifier components provide 30mA, ±7-to-20VDC outputs with rated 1500Vrms isolation:

- 8-channel isolation costs under $5.50/channel*.

For complete details, contact your nearest sales office or Applications Engineering, 602/746-1111. Burr-Brown Corp., P.O. Box 11400, Tucson, AZ 85734.

BURR-BROWN®

*U.S. prices, in 100s.

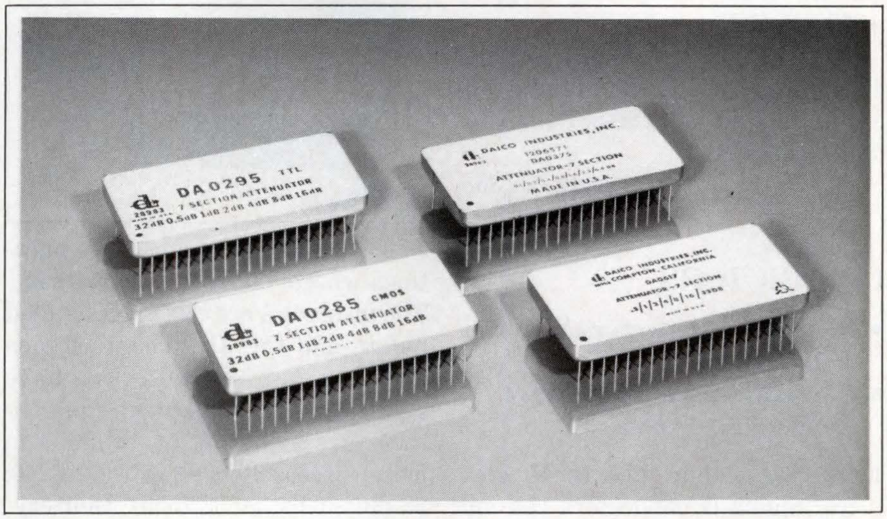
CIRCLE NO 113

NEW PRODUCTS

COMPONENTS & POWER SUPPLIES

ATTENUATORS

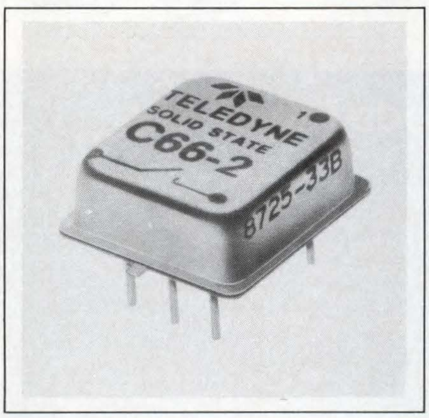
- *30- to 500-MHz operating range*
- *63.5-dB attenuation*



This 7-bit RF attenuator family features a 63.5-dB attenuation capability in 0.5-dB steps. The devices operate over a 30- to 500-MHz spectrum, have a −55 to +125°C range, and accommodate as much as 13 dBm of input power. Available in both DIP and connectorized versions, the attenuators operate from a 5V supply. The DA0617 provides a 7-nsec transition time, a 25-nsec total switching time, and 50-mV peak transients. The DA0285 and DA0295 low-power alternatives offer CMOS and TTL compatibility, respectively. DA0617, $630; DA0285 and DA0295, $511 (10).

Daico Industries Inc, 2139 E Del Amo Blvd, Compton, CA 90220. Phone (213) 631-1143.

Circle No 365



RELAYS

- *Designed for ATE applications*
- *Optically isolated to protect input logic and minimize EMI*

Designed to replace electromechanical relays in ATE systems, C66 Series solid-state relays are optically isolated to protect input logic circuitry from output voltage transients, thus minimizing EMI problems. The C66-1 is a power instrumentation relay with an output rating of 800 mA at ±180V continuous. The maximum resistance and leakage current spec at 1Ω and 200 nA, respectively. The C66-2 features a continuous load rating of ±350V at 300 mA. The output leakage current specs at 50 nA max and the on-resistance equals 7.2Ω max. With a 25-mA input current, the turn-off time for both devices equals 300 μsec. C66-1, $64.35; C66-2, $65.90 (100). Delivery, stock to eight weeks ARO.

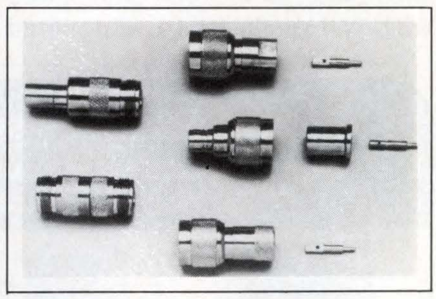
Teledyne Solid State, 12525 Daphne Ave, Hawthorne, CA 90250. Phone (213) 777-0077.

Circle No 366

CONNECTORS

- *Feature 50Ω line impedance*
- *Designed for Ethernet systems*

This Type N connector, termination, and splice series works with Ethernet systems. Available in coaxial Type N formats, the devices feature twist-on plug connectors for popular RG, Proflex Ethernet PVC, and Teflon-jacketed cables. Typical specifications include a nominal line impedance of 50Ω, a working voltage of 500V rms at sea level, and a VSWR of 1.3 max at 10 GHz. The insulation resistance equals 5000 MΩ and the sea-level dielectric withstanding voltage is 1500V rms. $1.80 to $2.80 (OEM qty).



Cambridge Products Corp, 244 Woodland Ave, Bloomfield, CT 06002. Phone (203) 243-1761.

Circle No 367

MOSFETs

- *Available in packaged or die form*
- *Drain-to-source voltage ratings range as high as 600V*

The 23 units in the Power MOS IV line offer usable current ratings as high as 22A, 0.2Ω on-resistance ratings to meet low drive requirements, 800 pF input capacitance, and drain-to-source voltage ratings of 600V max. The input capacitance values range from 2400 to 800 pF, and reverse transfer capacitance values are as high as 60 pF. The units are available in TO-3 packages and die form. TO-3 packages, $4.63 to $28.86 (100).

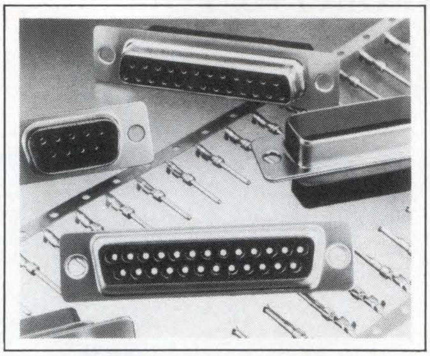
Advanced Power Technology, 405 SW Columbia St, Bend, OR 97702. Phone (800) 222-8278; in OR, (503) 382-8028.

Circle No 368

CONNECTORS

- *Crimp-type contacts reduce installation time*
- *Compatible with all standard D subminiature connectors*

Featuring crimp-insertable contacts, Sigma-D connectors can cut installation time and lower replacement costs. The units are fully compatible with all standard D-subminiature connectors. The connector shell material is steel, zinc-plated with yellow chromate. Tin-plated



shells are also available for applications where shielding is important. The insulators are black, glass-filled nylon, and the brass contact pins and phospher-bronze sockets have gold over nickel plating. The contacts are available on reels or in loose pieces. 10,000-pin reel, $240; 25-pin shells, $0.33 (500). Delivery, stock to six weeks ARO.

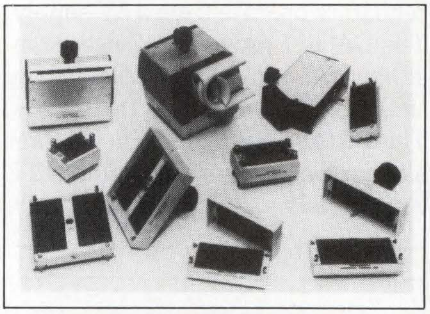
Vernitron Corp, Beau Products Div, Box 10, Laconia, NH 03247. Phone (603) 524-5101. TWX 710-364-1843.

Circle No 369

LIF CONNECTORS

- *Feature 700-contact capability*
- *Offer various termination options*

The N Series low-insertion-force (LIF) connectors are available in cable (120 and 700 positions) and rack-and-panel (110 and 350 position) versions. You can specify a model to handle either signal (5A) or power (9A) applications. The signal contacts feature a 0.1×0.1-in. center-to-center grid and are available with a choice of crimp, solder-cup, dip-solder, or wire-wrap termi-



INTEL'S NEW 80960 FAMILY OF HIGHLY-INTEGRATED, HIGH-PERFORMANCE CHIPS, NOW AVAILABLE THROUGH ALL 58 LOCATIONS

Imagine microprocessors with an architecture that lets you take high-speed shortcuts to solutions for embedded applications.

Intel did, and they're in stock at Hamilton/Avnet.

Their 32-bit 80960 microprocessors were created with an entirely new architecture, using RISC design techniques and many highly-integrated, on-chip features that give them the best functionality, flexibility and price/performance of any microprocessor for embedded applications.

FUNCTIONALITY: The 80960s are highly-integrated, containing a high-performance FPU, interrupt controller, 512K byte instruction cache, multiple register sets, 32-bit MUXed, burst bus and self test.

FLEXIBILITY: Since so many functions are embedded in the 80960s, they're easy-to-use in a wide range of embedded applications: Systems Controllers such as image processing, robotics and process control; Data Controllers, such as protocol handlers, data formatters and I/O controllers; Event Controllers, such as motor control, engine control and machine and instrument control.

PRICE/PERFORMANCE: They utilize the best of RISC design techniques to provide cost-effective higher performance levels in embedded applications.

Plus, their ability to execute multiple instructions per clock cycle through increased parallelism allows exponential performance growth.

And, because of the high integration of functions, they take up less board real estate and consume less power.

Right now, Hamilton/Avnet can supply you with immediate delivery of 16 and 20 MHz versions, with 7.5 MIPS sustained operation.

Call Hamilton/Avnet today and you can begin building your next embedded application solution with an architecture that can take you everywhere.

For the Hamilton/Avnet location nearest you, call toll free: 1-800-442-6458 (1-800-387-6879 in Canada; 1-800-387-6849 in Ontario and Quebec).

Hamilton Avnet
ELECTRONICS
AN AVNET COMPANY

A NEW ARCHITECTURE THAT LEADS TO NEW SOLUTIONS IN EMBEDDED APPLICATIONS:

INTEL 80960 from HAMILTON/AVNET

CIRCLE NO 114

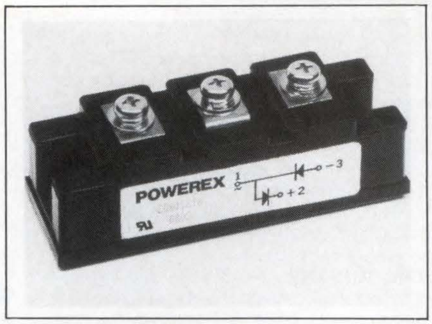
nations. The power contacts are on 0.2×0.2-in. centers and are available with crimp, solder-cup, or 0.47-in. wire-wrap type terminations. $73 to $375 (100). Delivery, 14 to 16 weeks ARO.

Hypertronics Corp, 16 Brent Dr, Hudson, MA 01749. Phone (617) 568-0451. TLX 951152.

Circle No 370

RECTIFIERS

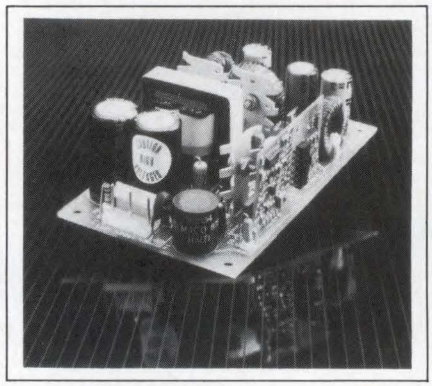
- *Mounted on heat sinks*
- *Feature 2500V isolation*



The CD6 family includes the CD63 dual-SCR module, the CD61 dual-diode module, the CD62 SCR/diode module, and the CS61 single-diode module. All units are available with 800, 1200, 1400, and 1600V blocking voltage ratings and are isolated to 2500V rms for 1 minute. The CD63 and CD62 devices are rated for continuous current operation at 150 mA, and the diode modules can control 160 mA. The glass-passivated devices are mounted and packaged on electrically isolated copper nickel heat sinks. 160A, 800V dual-diode module, $44.50 (100).

Powerex Inc, Hillis St, Youngwood, PA 15697. Phone (412) 925-4422.

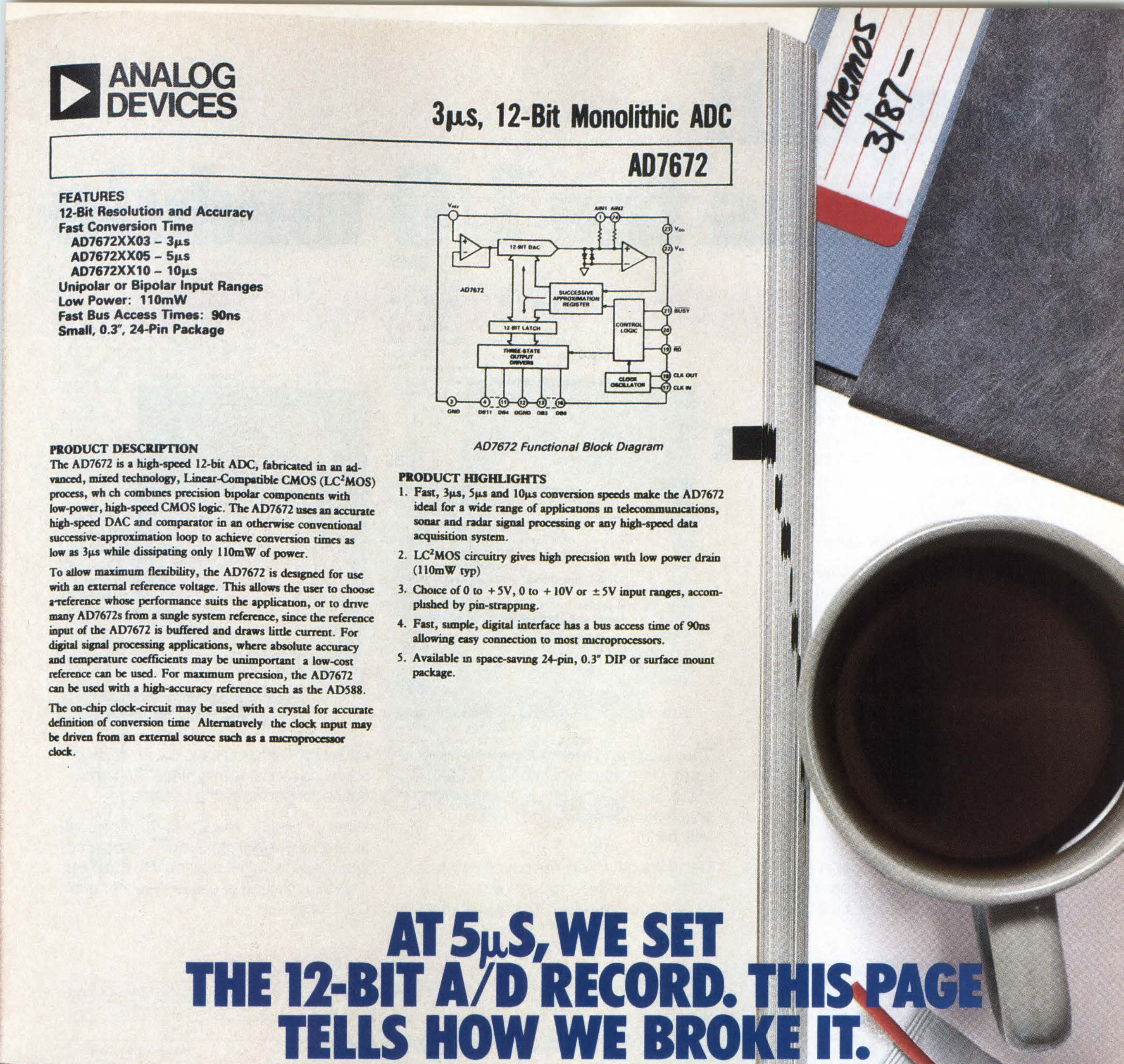
Circle No 371



POWER SUPPLIES

- *Feature a 215,000-hour MTBF*
- *Designed to meet international safety standards*

The SP3-40 Series 40W switching power supplies meet UL, CSA, and VDE safety standards. All three models utilize a single-ended forward converter topology that operates at a 45-kHz switching frequency to achieve a 215,000-hour MTBF. The units supply output combinations of 5V and 12/12V, 24/12V, or 12/5.2V. The minimum specified load on all outputs is 0%. Their efficiency equals 75% min, and short-circuit protection is indefi-



ANALOG DEVICES

3μs, 12-Bit Monolithic ADC

AD7672

FEATURES
12-Bit Resolution and Accuracy
Fast Conversion Time
AD7672XX03 – 3μs
AD7672XX05 – 5μs
AD7672XX10 – 10μs
Unipolar or Bipolar Input Ranges
Low Power: 110mW
Fast Bus Access Times: 90ns
Small, 0.3", 24-Pin Package

AD7672 Functional Block Diagram

PRODUCT DESCRIPTION

The AD7672 is a high-speed 12-bit ADC, fabricated in an advanced, mixed technology, Linear-Compatible CMOS (LC^2MOS) process, wh ch combines precision bipolar components with low-power, high-speed CMOS logic. The AD7672 uses an accurate high-speed DAC and comparator in an otherwise conventional successive-approximation loop to achieve conversion times as low as 3μs while dissipating only 110mW of power.

To allow maximum flexibility, the AD7672 is designed for use with an external reference voltage. This allows the user to choose a reference whose performance suits the application, or to drive many AD7672s from a single system reference, since the reference input of the AD7672 is buffered and draws little current. For digital signal processing applications, where absolute accuracy and temperature coefficients may be unimportant a low-cost reference can be used. For maximum precision, the AD7672 can be used with a high-accuracy reference such as the AD588.

The on-chip clock-circuit may be used with a crystal for accurate definition of conversion time Alternatively the clock input may be driven from an external source such as a microprocessor clock.

PRODUCT HIGHLIGHTS

1. Fast, 3μs, 5μs and 10μs conversion speeds make the AD7672 ideal for a wide range of applications in telecommunications, sonar and radar signal processing or any high-speed data acquisition system.
2. LC^2MOS circuitry gives high precision with low power drain (110mW typ)
3. Choice of 0 to +5V, 0 to +10V or ±5V input ranges, accomplished by pin-strapping.
4. Fast, simple, digital interface has a bus access time of 90ns allowing easy connection to most microprocessors.
5. Available in space-saving 24-pin, 0.3" DIP or surface mount package.

AT 5μS, WE SET THE 12-BIT A/D RECORD. THIS PAGE TELLS HOW WE BROKE IT.

When we introduced our AD7572, it set the monolithic 12-bit A/D conversion speed record at 5μs.

Now, our AD7672 establishes a new record with an even faster conversion time of only 3μs.

This blazing speed is reached with only 110mW of power dissipation because the AD7672, like the AD7572, is manufactured on an advanced merged bipolar/CMOS process.

The 90ns bus access time of the AD7672 affords easy interfacing with most microprocessors, while the +5V and −12V nominal power supply voltages allow its use in PC and modem designs. All this is available in a narrow 0.3" DIP or a surface mount package.

The AD7672 also features unipolar or bipolar analog inputs that are selected by pin-strapping. This lets you avoid external circuitry for input range changing.

The 3μs version of the AD7672 is available for as little as $63.75; the 5μs version, from $37.40; and the 10μs model, from $28.05 (1000s).

For more information on how the AD7672 can speed up your designs, call Applications Engineering at (617) 935-5565, Ext. 2628 or 2629. 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: (303) 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) 28995; 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

CIRCLE NO 115

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.)

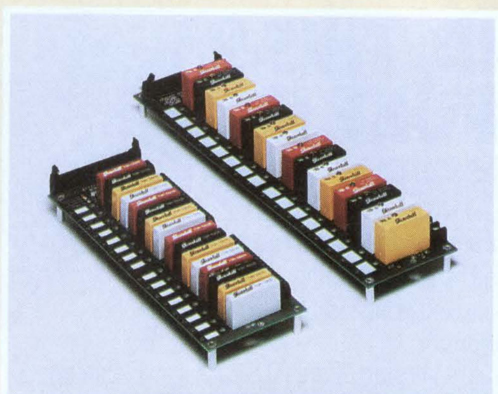
Grayhill mini-modules consume 30% less power than their big brothers, and offer immunity from false triggering caused by electrical transients (per IEEE-472). Using SMT construction, Grayhill shrinks the package, yet upgrades performance even compared to its own standard modules, much less anyone else's. 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

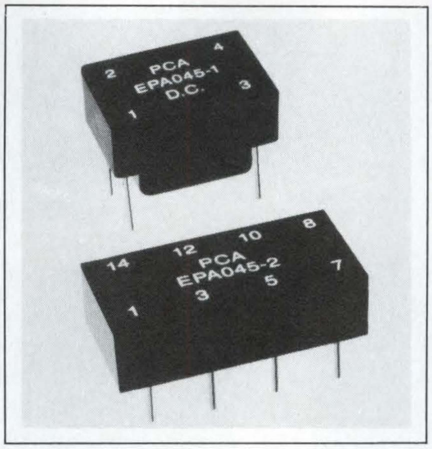
nite. The line and load regulation is 0.1% on the primary output and 0.5% and 3.0% on the auxiliary outputs. With natural convection cooling, the devices' operation is specified over a 0 to 70°C range. $129. Delivery, stock to eight weeks ARO.

Power General, Box 189, Canton, MA 02021. Phone (617) 828-6216. TWX 710-348-0200.

Circle No 372

ISOLATION MODULES

- *Available in 1- and 2-transformer versions*
- *Pass a 2000V high-potential test*



The EPA045 Series Starlan isolation modules are available with one or two transformers (EPA 045-1 and -2, respectively). Designed for hub and node applications, the devices meet the specifications of the IEEE 802.3 standard. To comply with LAN safety requirements, the transformers pass a 2000V rms high-potential test between the primary and secondary windings (coil-to-coil in the -2 version). The transformers have a 1:1 (±5%) turns ratio and a maximum dc resistance (both primary and secondary) of 1Ω. Maximum primary-to-secondary leakage inductance and interwinding capacitance are 8 μH and 25 pF, respectively. Rise time is 100 nsec max. EPA045-1, $1.55 (1000); EPA045-2, $2.40.

PCA Electronics Inc, 16799 Schoenborn St, Sepulveda, CA 91343. Phone (818) 892-0761.

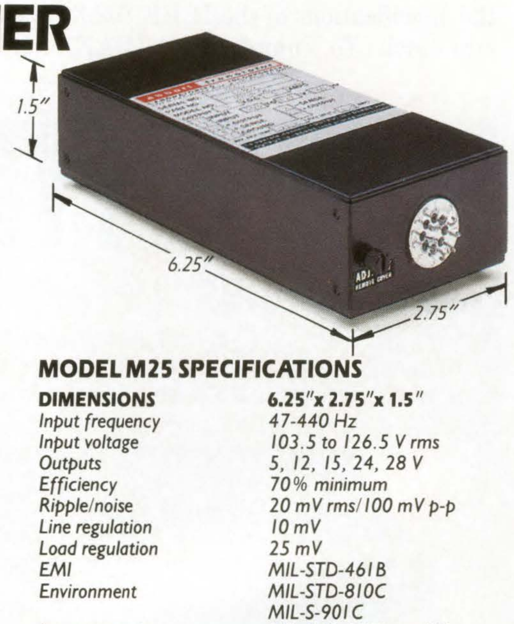
Circle No 373

AMPLIFIERS

- *Can operate in velocity and torque modes*
- *Include an integral power supply*

Featuring an integrated power supply, the VXA Series pulse-width-modulated amplifiers provide incremental and continuous motion control for dc servos requiring as much as 384W (768W peak). These compact 8.7×2.9×7-in., 4-quadrant amplifiers can operate in velocity and torque modes. The devices' adjustable compensation simplifies servo system stabilization. Operating on 12 to 36V ac or 14 to 50V dc,

ABBOTT'S NEW M25; A HIGHER PERFORMANCE, 25-WATT SWITCHING POWER SUPPLY



Abbott's new M25 exceeds the performance of one of the best selling mil-spec power supplies; our own VN25. Our VN25 has been widely used in critical naval and airborne applications for over 10 years. Now the M25 offers higher performance in this proven design.

Higher Density. *The M25 has a 1¼ inch lower profile than our VN25 while maintaining the same footprint. This adds up to a* ***45% reduction*** *in volume.*

Better Specs. *By doubling the switching frequency, our M25 is 10% more efficient, while at the same time providing a* ***23% wider*** *operating temperature range.*

Greater Reliability. *By using innovative design techniques, the M25 achieves a* ***4-fold increase*** *in MTBF.*

EMI Compliance. *All M25 standard units meet MIL-STD-461B for emissions and susceptibility.*

The M25 is encapsulated and hermetically sealed, and meets the stringent environmental requirements of MIL-STD-810C and MIL-S-901C.

Abbott's new M25: higher performance in a proven design.

Call or send for specs and our full line catalog.

Abbott Transistor Laboratories, Inc. Power Supply Division, 2727 La Cienega Blvd., Los Angeles, CA 90034 (213) 936-8185. Eastern Office: (201) 461-4411, Southwest Office: (214) 437-0697, London Office: 0737-82-3273.

MODEL M25 SPECIFICATIONS

DIMENSIONS	**6.25"x 2.75"x 1.5"**
Input frequency	*47-440 Hz*
Input voltage	*103.5 to 126.5 V rms*
Outputs	*5, 12, 15, 24, 28 V*
Efficiency	*70% minimum*
Ripple/noise	*20 mV rms/100 mV p-p*
Line regulation	*10 mV*
Load regulation	*25 mV*
EMI	*MIL-STD-461B*
Environment	*MIL-STD-810C*
	MIL-S-901C
Input protection	*MIL-STD-1399 sec 103*
Operating temperature range	*−20°C to 71°C*
Storage temperature range	*−55°C to 85°C*
MTBF (ground benign)*	
Standard	*176,000 hours*
ER Option	*759,000 hours*
MTBF (naval sheltered)*	
Standard	*33,000 hours*
ER Option	*125,000 hours*

**MIL-STD-217D (50°C baseplate)*

abbott

MILITARY POWER SUPPLIES

CIRCLE NO 117

the amplifiers have a 1.01 form factor. $349. Delivery, six to eight weeks ARO.

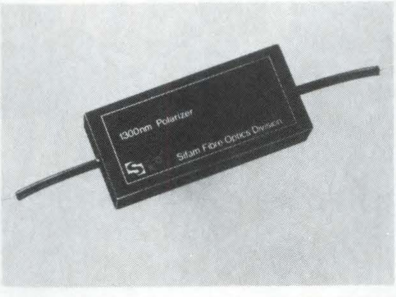
PMI Motion Technologies, 49 Mall Dr, Commack, NY 11725. Phone (516) 864-1000. TLX 510-223-0007.

Circle No 374

FIBER POLARIZER

- *Has an extinction ratio in excess of 40 dB*
- *Suitable for use with fiber-optic telecomm links*

This single-mode fiber-optic polarizer provides an extinction ratio of >40 dB, and an insertion loss for transmitted light of <0.5 dB. It works by coupling light in the unwanted polarization state into a plasma wave that's supported on a thin film deposited on the fiber. The polarizer has an operating temperature range of −40 to +85°C; the



extinction ratio varies by ±2 dB. Versions are currently available with operating wavelengths of 1300 and 1550 nm. The polarizer is housed in a 45×20×10-mm package with 1m fiber pigtails. The company can adapt the technique for use with all types of single-mode optical fibers, including low and high birefringence types. Approximately £800 (10).

Sifam Ltd, Fibre Optics Division, Woodland Rd, Torquay, Devon TQ2 7AY, UK. Phone (0803) 63822. TLX 42864.

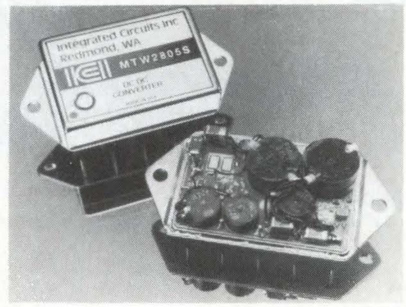
Circle No 375

DC/DC CONVERTERS

- *Has 30W outputs*
- *300-kHz typ switching frequency*

The MTW Series of 30W dc/dc converters includes four models, whose individual outputs are 12V at 2.5A, 15V at 2A, ±12V at ±1.25A, and ±15V at ±1A. All models accept inputs from 18 to 40V. Housed in a 1.95×1.35×0.5-in. package, the converters have a power density of 22.8 W/in. Switching frequencies range from 240 to 300 kHz, and the converters' efficiency rate is 84% to

Text continued on pg 243



Experience Counts.

EZ-PRO Emulators

Experience quick delivery, easy operation, fast development schedules. EZ-PRO® users reap the benefits of the C language fully integrated with advanced emulation tools, including precedence triggering, Deep Trace,™ on-line code revisions, and performance analysis tools.

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	8032		68B00	6301V1	6503	1805	Z80B
8086	8035	68HC11A2	6801	6301X	6504	1806	Z80H
8088	8039	68HC11A8	6802	6301Y	6505	CDP6805C4	Z180
80186	8344		68B02	6303R	6506	CDP6805C8	Z8001
80188	8048	68000	146805E2	6305V	6507	CDP6805D2	Z8002
80286	8049	68008	6803	63705	6512	CDP6805E3	
	8050	68010	6808	6309	6513	Harris: 80C86	NEC: V20 V40
	8051		68B08	6309E	6514	80C88	V30 V50
	8085A		6809	64180R0	6515	National:	Signetics: 8X300
	8085A2		6809E	64180R1		NSC800	8X305
	8096/97		68B09				
			68B09E				

...AND MORE

*Assumes EZ-PRO Development Station connected to MSDOS host.

american automation

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FAX: 714/731-6344

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CIRCLE NO 118

86%. Additional features include short-circuit protection, input and output filtering, and an inhibit-function input. Environmental screening to MIL-STD-883 is available as an option. Single and dual output models, $453 and $487 (100), respectively. Delivery, stock to 8 weeks.

Integrated Circuits Inc, Box 97005, Redmond, WA 98052. Phone (800) 822-8782. TWX 910-443-2302.

Circle No 376

5-YEAR BATTERY

- *Offers 1.23 Whrs of energy per in^3*
- *5-year (min) lifetime*

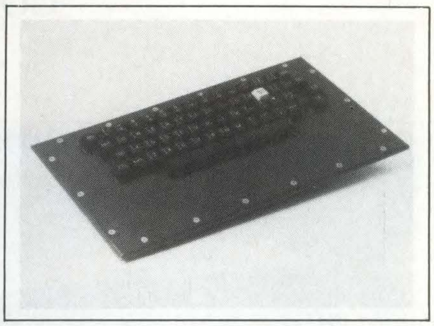
The Model PS-1242 is a 12V, sealed lead-acid battery. It's maintenance free, rechargeable, usable in any position, and suitable for both standby and deep-cycle applications. With a 4-Ahr capacity and a 3.54×2.75×4.01-in. package, the unit offers 1.23 W-hrs of energy per in^3. The device delivers as much as 40A of high-rate discharge current. Battery lifetime is at 5 years min. You can recharge it between 200 to 500 times, depending on the average depth of discharge. $16 (500).

Power-Sonic Corp, Box 5242, Redwood City, CA 94063. Phone (415) 364-5001. TLX 348400.

Circle No 377

KEYBOARD

- *Meets MIL-STD-810C*
- *Keyswitches have 20 million actuation lifetime*

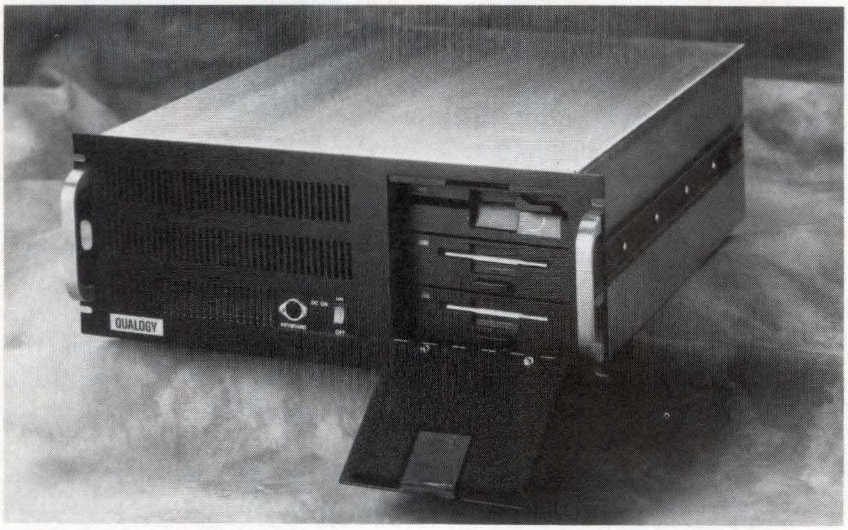


The 30498-05, a standard Type 1/ Class 1 Qwerty full-travel military keyboard, features 59 metal-housed keyswitches that are mounted on a metal base. It meets the requirements of MIL-STD-810C as well as specifications for EMI/RFI and Tempest. Its keycaps are 0.5 in. square and are mounted on 0.75-in. centers. They are black with gray legends that are pad printed according to MIL-M-18012. The keyswitches utilize conductive rubber technology and are rated for 20 million actuations. The keyboard comes with an X-Y matrix for a standard output; optional serial and parallel interfaces are available. $1095 (100). Delivery, eight to 10 weeks ARO.

IEE Inc, 7740 Lemona Ave, Van Nuys, CA 91409. Phone (818) 787-0311. TLX 4720556.

Circle No 378

COMPUTERS & PERIPHERALS



RACK-MOUNT PC/AT

- *Features an 80286 μP and 1M byte of RAM memory*
- *System meets EIA standards for installation in 19-in. rack*

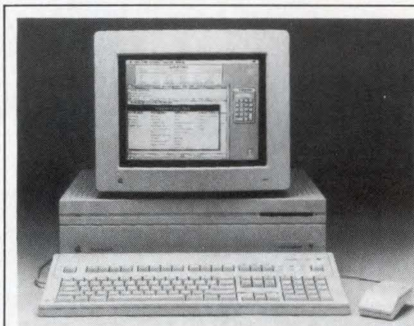
The QPC-7000 IBM PC/AT-compatible computer meets EIA standards for mounting in a standard 19-in. rack. A single-board computer (SBC), the QPC-521, occupies one slot of a 12-slot passive backplane. The SBC features an 80286 μP operating at 10 MHz, 1M byte of RAM, a socket for an 80287 coprocessor, a floppy-disk controller, a SCSI Winchester-disk controller, a serial port, a parallel port, and a clock/calendar with battery backup. The remaining 11 slots are available for the user. The system has a 200W power supply and a carrier assembly capable of handling three half-height drives. The unit measures 19×24×8.75 in. $2790.

Qualogy Inc, 2241 Lundy Ave, San Jose, CA 95131. Phone (408) 434-5200. TLX 4993489.

Circle No 380

AI WORKSTATION

- *Macintosh II PC equipped with a TI Explorer Lisp board*
- *Board runs Lisp software and accesses MAC II software*



The microExplorer AI workstation, built in a Macintosh II personal computer, incorporates a coprocessor board that utilizes the Explorer Lisp μP. The board can address as many as 12M bytes of memory and occupies a single NuBus slot. All systems come with a run-time version of the Explorer software that reduces memory and mass-storage requirements. The software provides symbolic processing power, as well as access to the large base of systems and applications software available for the MAC II. Explorer and Macintosh operating environments execute concurrently. The system includes a math coprocessor, and disk-storage space can be expanded to 500M bytes. A configuration with a 21-in. monochrome monitor, 4M bytes of memory, three 80M-byte disks, and development software costs $26,795.

Texas Instruments Inc, Data Systems Group, Box 181153 DSG-179, Austin, TX 78718. Phone (800) 527-3500.

Circle No 381

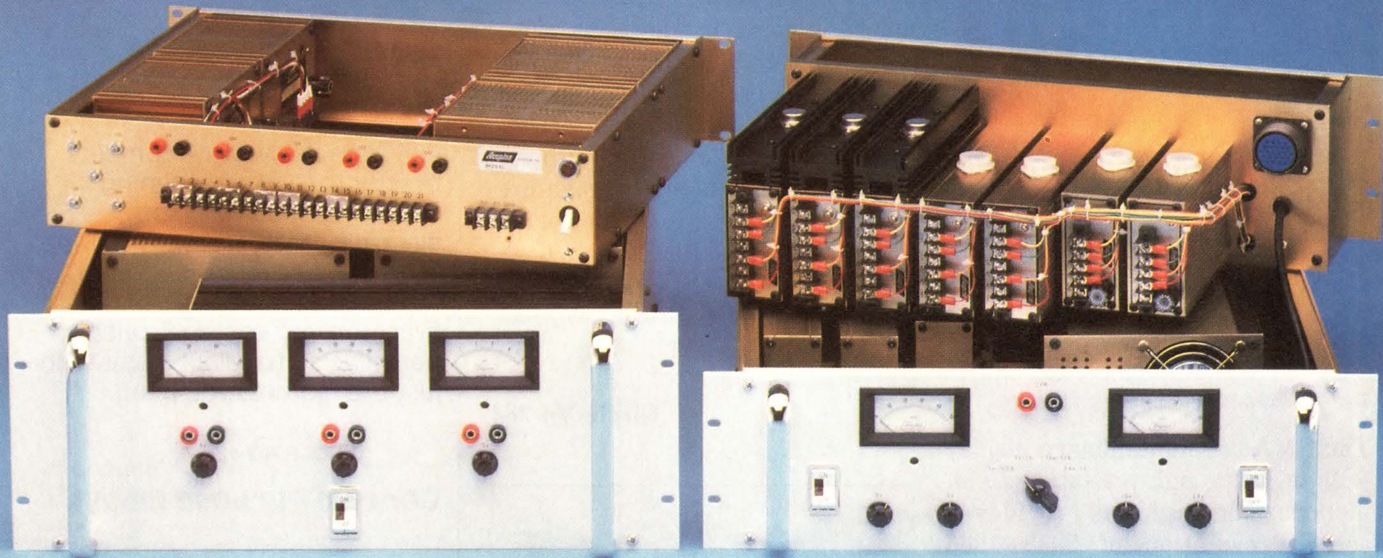
MODEM CARDS

- *14.4k-bps full-duplex operation over 4-wire leased lines*
- *Boards conform to CCITT V.33 and V.29 recommendations*

The AJ 1441-1 and AJ 1441-1D 14.4k-bps modem cards for the company's modular modem system provide synchronous, full-duplex operation over 4-wire unconditioned leased lines with Trellis-coded modulation. They both meet the CCITT V.33 recommendation at 14.4k and 12k bps, and CCITT V.29 at 9600, 7200, and 4800 bps. The diagnostic features include a numeric display indicating signal quality and the ability to read the received signal quality of individual remote modems. An eye pattern generator is available as an option. The AJ 1441-1D provides disaster recovery via its unattended dial backup feature. AJ 1441-1, $2045; in a case, $2295; AJ 1441-1D, $2345; in a case, $2595.

Anderson Jacobson Corp, 521 Charcot Ave, San Jose, CA 95131. Phone (408) 435-8520.

Circle No 382



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Call the toll-free number below and ask for our Power Systems Department. Specify the voltages and currents you require. Also, tell us the operating features and accessories you need, such as voltmeters, ammeters, front panel controls, handles and chassis slides.

We'll promptly call you back with a detailed description, firm price and a special model number to use when ordering. Then, in only nine days after we receive your order, we'll ship your power system to you...completely assembled, wired and tested.

If you prefer to select the complement of power supplies for your system, call us and **ASK FOR OUR 52-PAGE CATALOG.** It includes specs, drawings and prices for our full line of single, dual and triple output power supplies.

Acopian

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Call toll-free (800) 523-9478
In Pennsylvania, call (215) 258-5441

Acopian ships power modules in 3 days, systems in 9 days.

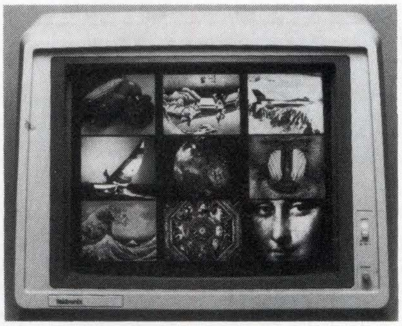


IMAGE DISPLAY

- *Updates images every 0.2 sec with 256 shades of gray*
- *2048×1536 viewable pixels*

The GMA 251 digital image display with an ultra-high-resolution 19-in. monochrome monitor provides a screen resolution of 2048×1536 viewable pixels. It can store 2048×2048 pixels and its scroll feature can access and display the entire image stored in memory. Incorporating a high-speed frame buffer, a D/A converter, and a display in one self-contained unit, the system achieves updates of images with 256 shades of gray every 0.2 sec. Astigmatism correction and dynamic focusing enhance the screen's resolution by providing image focusing in the corners as well as in the center of the screen. An optional WB (P45) phosphor with a high-contrast filter is available for high-contrast viewing. $16,250. Delivery, 12 weeks ARO.

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

Circle No 383

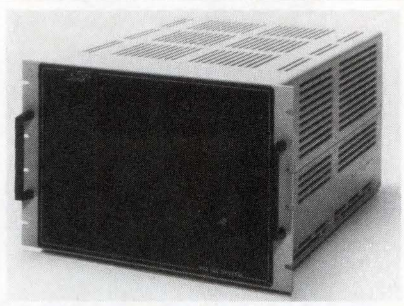
PRINTER ADAPTER

- *HP's LaserJet Series II for IBM's System/36 and 38*
- *Card appears plug-compatible with an IBM 5219 printer*

The I-O 8200HP LaserCard adapter plugs into the optional I/O slot at the rear of an HP LaserJet Series II printer. To an IBM System/36 or a System/38 computer, the card appears plug-compatible with an IBM 5219 printer and provides many of the features of IBM's 3812 printer. You can gain access to HP LaserJet fonts by specifying an IBM Type-Style number in a DisplayWrite/36 word processor. The word processor supports A, B, D, E, G, H, L, M, N, Q, and R cartridges. An Auto DP mode provides automatic page orientation and font selection for printing 80, 132, and 198 column data. $995.

I-O Corp, 2256 S 3600 W, Salt Lake City, UT 84119. Phone (801) 973-6767. TLX 383783.

Circle No 384



VXI BUS SYSTEM

- *Instruments and test functions on a card*
- *Comes with an IEEE-488-to-VXI Bus interface*

The Model 73A-PRT prototyping system is based on the VXI Bus standard. VXI stands for VME eXtensions for Instrumentation, and you can use the system in automatic testing areas. The unit contains an IEEE-488-to-VXI Bus interface located on the 73A-151 card and two wire-wrap cards for developing prototype instruments. The 73A-151 contains the VXI Bus slot-0 functions and hardware/software to communicate with an adapter card. The adapter card lets you connect to more than 60 of the company's field-tested instruments. The system serves as a resource manager that oversees power-up self-test, module address allocation, and definition of system hierarchy. Each of the system's 13 card slots accommodates a VXI module that dissipates as much

SHARP FLAT PANEL DISPLAYS

Thin is In.

As any designer will attest, the latest rage in the electronics industry are liquid crystal and electro-luminescent flat panel displays. The reason for their popularity is clear — thin displays mean sleeker, more efficient designs.

Sharp is the recognized leader in LCD and EL flat panel displays. With over 30 years experience in building the world's clearest, most reliable displays, Sharp is sure to make an LCD to fit your needs.

Of course, the most popular place to order your Sharp displays is Marshall Industries. In fact, Marshall is the only national distributor of Sharp LCDs. But that's the kind of privilege you expect when you have over 30 years experience serving the electronics industry.

When you need a clear display that fits just right, remember the leader in flat panel displays. Sharp. And remember the best place to find them. Marshall.

Because Marshall knows you can never be too sharp or too thin.

Marshall

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KS Kansas City (913) 492-3121*
Wichita (316) 264-6333*
MA Boston (617) 658-0810*
MD Maryland (301) 840-9450*
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MN Minneapolis (612) 559-2211*
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NC Raleigh (919) 878-9882*
NJ N. New Jersey (201) 882-0320*
Philadelphia (609) 234-9100*
NY Binghamton (607) 798-1611*
Long Island (516) 273-2424*
Rochester (716) 235-7620*
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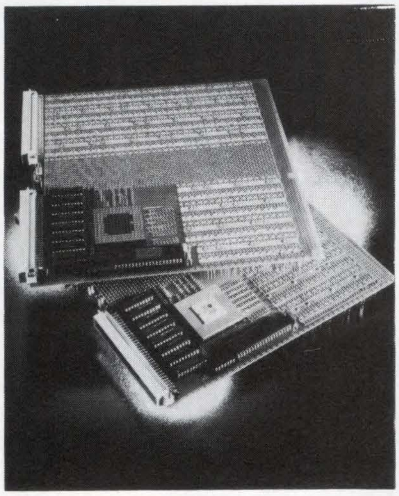
San Antonio (512) 734-5100
UT Salt Lake City (801) 485-15
WA Seattle (206) 747-9100*
WI Wisconsin (414) 797-8400*

as 35W. $7490.

Colorado Data Systems Inc, 3301 W Hampden Rd, Unit C, Englewood, CO 80110. Phone (303) 762-1640.

Circle No 385



PROTOTYPING CARD

- *Includes Multibus II iPSB bus interface logic*
- *Terminals accept DIP, SIP, PGA, and discrete components*

This Multibus II prototyping card provides interface circuitry for the Multibus II iPSB bus already tracked onto the board. It comes complete with bus drivers, an 8751H microcontroller to control the Multibus II interconnect space, and a socket for an Intel message-passing coprocessor. The interface logic occupies 30% of the 233.3×220-mm board area. More than 260 cm² of this area contains either wire-wrap or Speedwire terminals on a 0.1-in. pitch for DIP, SIP, and discrete components, and 80 cm² of 0.1-in. matrix terminals suitable for pin-grid-array devices. The 8-layer board includes three independent power-supply planes, a ground plane, and surface-mount decoupling capacitors. The interface logic allows you to isolate the board from the iPSB bus for test purposes. Documentation for circuit and microcontroller firmware comes with the package. £850.

Bicc-Vero Electronics Ltd, Flanders Rd, Hedge End, Southampton SO3 3LG, UK. Phone (0703) 266300. TLX 477984.

Circle No 386

Bicc-Vero Electronics Inc, 1000 Sherman Ave, Hamden, CT 06514. Phone (203) 288-8001. TWX 510-227-8890.

Circle No 387

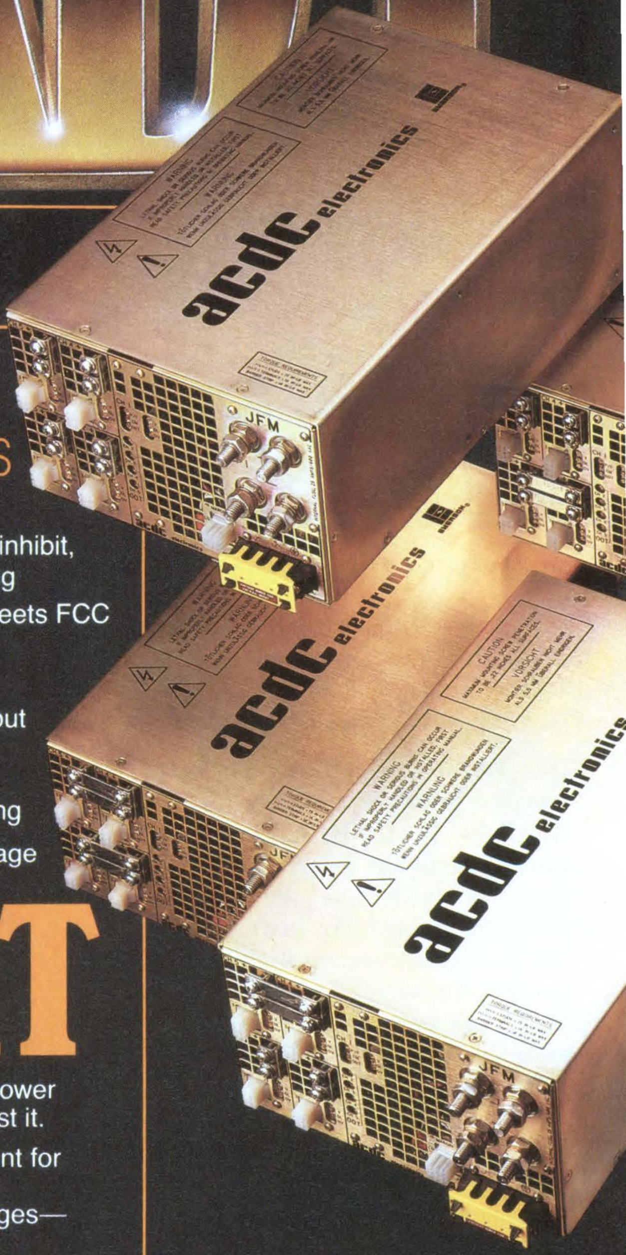
ETHERNET ADAPTER

- *Provides 10M-byte/sec rate for the Macintosh II*
- *The IEEE-802.3-compatible board occupies one NuBus slot*

The EtherLink/NB Ethernet adapter for the Macintosh II operates with the company's 3+ or Apple's AppleShare network operating sys-

READY

OUR NEW 1600 WATT, MULTI OUTPUT POWER SUPPLY IS READY…



READY TO SOLVE YOUR MOST DEMANDING HIGH POWER REQUIREMENTS

You can have a main output of 5V @ 200A Plus four more outputs, up to 600 watts, in one small package.
Check the chart below.

READY FOR YOUR TOUGHEST SIZE REQUIREMENTS

acdc electronics put 1600W in a 5″ x 8″ x 13″ package. That makes it, the JFM Series the SMALLEST 1600W multi output power supply available. Anywhere.

READY FOR DELIVERY

Don't wait for the power supply you need.

You can have the output voltage combination you choose* in two weeks.

**From the model selection chart*

READY WITH UNBEATABLE SPECIFICATIONS

- ☐ Current monitor
- ☐ Independent output inhibit, margining, monitoring
- ☐ Internal EMI filter meets FCC & VDE Class A
- ☐ No minimum load required on any output
- ☐ Floating outputs
- ☐ Single-wire paralleling
- ☐ 30 Ms holdover storage

WAIT

Wait until you see this power supply. Wait until you test it.

If you have a requirement for reliable high power with flexibility in output voltages—don't wait.

Call for an immediate demo. 619/439-4200.

1600W MULTI

MAIN OUT	CH2	CH3	CH4	CH5
5V/200A	TABLE A or B	TABLE A or B		
5V/200A	TABLE A or B	TABLE B	TABLE A or B	
5V/200A	TABLE B	TABLE B	TABLE B	TABLE B

TABLE A AUX's	TABLE B AUX's
5V/60A	5V/30A
12V/30A	12V/15A
15V/24A	15V/12A
24V/15A	24V/7.5A

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

ACDC's POWER OFFERING

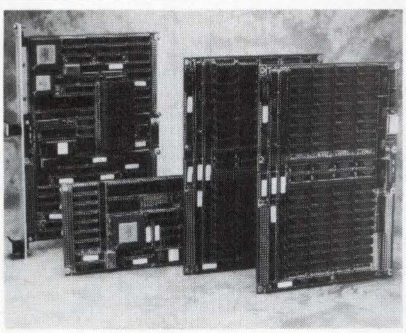
CIRCLE NO 138

acdc electronics
401 Jones Road, Oceanside, CA 92054.
TEL: 619/757-1880. TLX: 350227. FAX: 619/439-4243

tems. It can interface with a 10M-bps Ethernet network, using coaxial or twisted-pair wiring. An onboard transceiver drives twice the length of the IEEE-802.3 specification, which measures 1000 ft. The bus interface provides 32-bit data transfers for high-speed network operation. According to the vendor, the use of VLSI components improves reliability and reduces power consumption. A 32k-byte ROM provides automatic hardware identification and configuration of parameters to simplify installation and use. A 16k-byte packet buffer permits reception of back-to-back packets, reducing network traffic. The board's design is based on the National Ethernet chip set. $595.

3Com Corp, 3165 Kifer Rd, Santa Clara, CA 95052. Phone (408) 562-6400.

Circle No 388



COMPUTER BOARD

- *Runs a 68030 μP and a floating-point coprocessor*
- *Accepts daughter boards to increase its functionality*

The JT-68030SBC CPU card for VME Bus systems accepts a variety of daughter boards that increase its functionality. It runs a 68030 μP and an optional 68881 or 68882 floating-point coprocessor. The board also provides 1M or 4M bytes of dual-port, parity-checked RAM, space for as much as 2M bytes of EPROM, and two serial I/O lines. The daughter boards interface to the CPU card via a local 68020-style bus. Available daughter boards include memory expansion, SCSI interface, and prototyping modules. The JT-Duram daughter board provides an additional 1M, 2M, 4M, or 8M bytes of RAM, and either 6 or 8 RS-232C I/O ports. You can add two JT-Duram boards to the CPU card. The JT-SCSI daughter board is an intelligent disk and tape controller card. Its onboard 68020 μP provides DMA that can transfer data to and from as many as seven SCSI devices at data rates as high as 4M bytes/sec. The JT-Proto daughter board, which accepts Speedwire terminals on a 0.1-in. pitch, allows you to construct your own add-on boards. You can plug as many as three daughter boards into the CPU card to produce an assembly that still fits into two VME Bus slot widths. These assemblies are suitable for running Uniplus+ V2.2 or OS-9 operating systems. The prices for the following models are approximate: JT-68030SBC, £3500; JT-Duram from £1000 to £4700; JT-SCSI, £660; JT-Proto, £250 (100).

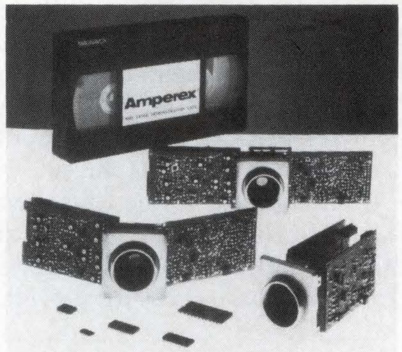
Integrated Micro Products, Number One Industrial Estate, Medomsley Rd, Consett, County Durham DH8 6TJ, UK. Phone (0207) 503481. TLX 537747.

Circle No 389

VIDEO MODULE

- *Based on the company's solid-state image sensors*
- *Sensors' image can achieve intensity of 0.05 lux*

The CCD video module is a video imaging system based on the company's solid-state image sensors (SSIS). It consists of an SSIS with



full drive, preprocessing, video-processing, and power-supply circuits. The two basic versions, models 56473 and 56474, for 525- and 625-line TV systems, respectively, meet EIA or CCIR standards. The unit utilizes the NXA1011, -1021, -1031, and -1041 solid-state image chips that operate on the frame-transfer principle, where each field of the picture frame is integrated within a photosensitive imaging region. CCD shift registers transfer the field data into storage during vertical blanking. The data is then clocked out serially to produce the video signal. The sensors can provide recognizable images with a light intensity as low as .05 lux. From $500 to $600.

Amperex Electronic Co, Imaging Products Group, Slatersville, RI 02876. Phone (401) 762-3800.

Circle No 390

DISK DRIVES

- *42M to 168M bytes of storage in 3½-in. sizes*
- *Interfaces for SCSI, IBM PC/AT bus, and ESDI*

The ProDrive Series consists of 10 3½-in. disk drives with formatted capacities, ranging from 42M to 168M bytes. A variety of interfaces include a SCSI, an IBM PC/AT bus, and an ESDI. All drives in the series have average access times of 19 msec or less. A Discache buffer-

management system decreases disk transaction times as much as 50%, resulting in an effective seek time of 12 msec in many applications. The drives' MTBF is rated at 50,000 hours. Evaluation units for the 42M- and 84M-byte drives with integrated SCSI controllers are available. The units have a synchronous transfer rate of 4M bytes/sec and an asynchronous transfer rate of 2M bytes/sec. 42M-byte version, $520; 80M-byte version, $845.

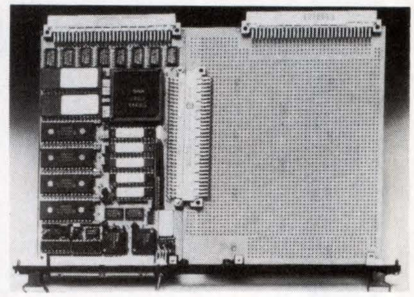
Quantum Corp, 1804 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 432-1100. TWX 910-338-2203.

Circle No 391

CPU CARD

- *Runs a 68070 μP on a single-Eurocard board*
- *Allows daughter-board expansion*

The SAC-700 single-Eurocard CPU board for VME Bus systems runs a 68070 μP (a 68000-compatible processor with an on-chip DMA controller and a memory-management unit). Four 32-pin JEDEC sockets with battery backup are provided for CMOS static RAM, and two 32-pin sockets are provided for EPROM. The entire RAM area is dual-ported to the VME Bus and to the processor's local bus. The board also has two synchronous/asynchronous serial I/O ports, one additional asynchronous serial I/O port, and a 16-bit parallel I/O port. An expansion connector, which carries the 68070's data, address, and control buses allows you to add daughter boards to the CPU card. An alternative version with a right-angle expansion connector allows you to mount an expansion board in the same plane as the CPU board behind a 6U front panel. The board's VME Bus interface has system-controller and slot-1 functions. From $595.

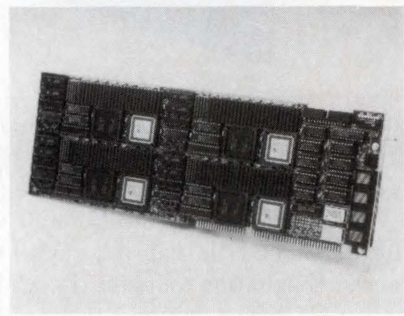


Eltec Elektronik GmbH, Galileo-Galilei-Strasse 10, 6500 Mainz 42, West Germany. Phone (06131) 50630. TLX 04187273.

Circle No 392

American Eltec Inc, 569 S Marengo Ave, Passadena, CA 91101. Phone (818) 449-1558.

Circle No 393



NETWORK BOARD

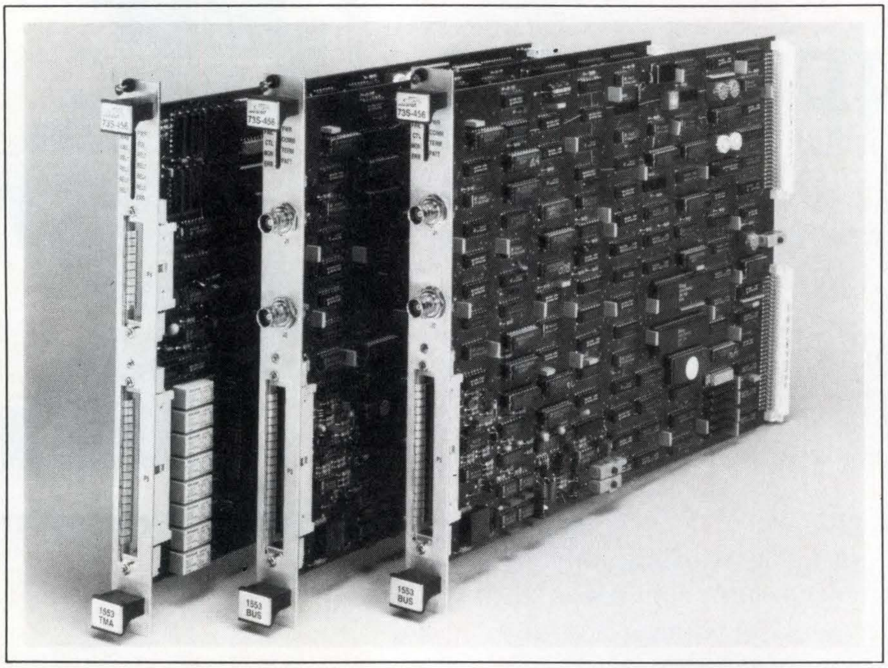
- *Four complete PCs on one IBM PC/AT add-on card*
- *Connects to PC, ASCII, and ANSI terminals*

The QuickLink-IV 4-user network on one IBM PC/AT add-on board has four complete PCs, each of which connect to terminals or modems via RS-232C or RS-422 interfaces. It's plugged into a file server's bus, providing multiuser power with the ability to share files and peripherals attached to the AT computer. You can use it with IBM PC, ASCII, and ANSI terminals as well as Hercules graphics terminals. The board utilizes four NEC V40, 8-MHz μPs. Each processor has 768k bytes of no-wait-state memory. The board draws 2.5A when supporting four users. Networking software includes Netware 286 and Novell's 4-user ELS. If you want to serve more than four users, just add another board. $2295.

Intercontinental Microsystems, 4020 Leaverton Ct, Anaheim, CA 92807. Phone (714) 630-3714. TLX 821375.

Circle No 394

TEST & MEASUREMENT INSTRUMENTS



MIL-STD-1553 TESTERS

- *Plug into VXI bus*
- *Comply with USAF Mate guides*

The 73S-456 is a 2- to 8-channel emulator/tester for the MIL-STD-1553 bus, whereas the 73A-453 multimodal simulator/tester can test all devices that conform to MIL-STD-1553. Both board-level products comply with the US Air Force's Mate (modular automatic test equipment) guidelines and plug into VXI (VME extensions for instrumentation) bus backplanes, such as the vendor's 73A system. The 73A system accommodates cards that use only the VXI bus's P1 connector or that also use its P2 connector. Under the VXI standard, the 73S-456 and 73A-453 are considered message-based devices. The 73S-456 tests 1553 bus controllers and remote-terminal simulators and can also serve as a bus monitor that stores 30k words/channel max. You can program the 73A-453 to act as a bus controller, remote terminal, or bus monitor; it allows control of message formats. 73S-456, $7995; 73A-453, $3200. Delivery, 10 to 12 weeks ARO.

Colorado Data Systems Inc, 3301 W Hampden Ave, Unit C, Englewood, CO 80110. Phone (800) 237-2831; in CO, (303) 762-1640. TWX 910-933-0193.

Circle No 400

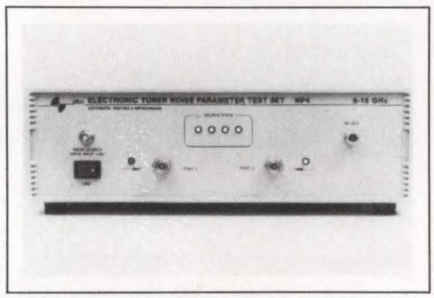
80386 ANALYSIS TOOLS

- *Analyze software performance nonstatistically*
- *Operate at 20 MHz with no wait states*

You use the 80386 probe and disassembler with the vendor's SAW (software analysis workstation) to trace, optimize, and verify software performance in real time on your target system's hardware. The probe supports the 80386's real and protected modes. When used with the vendor's interactive state analyzer or Softanalyst tools, it allows target-system operation at 20 MHz with no wait states or at 25 MHz with one wait state. The probe supports pipelined and nonpipelined addressing and 16 or 32-bit dynamic bus sizing. The nonstatistical performance analyzer captures bus activity and displays it in 80386 assembly code. In multiprocessor systems, a time-aligned trace display allows you to correlate the activity of the processors. 80386 probe, $2500; SAW, without host IBM PC or compatible computer, $24,690.

Northwest Instrument Systems Inc, 19545 NW Von Neumann Dr, Beaverton, OR 97075. Phone (503) 690-1300.

Circle No 401



NOISE TEST SET

- *Covers 6 to 18 GHz*
- *Tests with 16 selectable source impedances*

The NP4 618 noise-parameter test set covers 6 to 18 GHz and can function under IEEE-488-bus control. It automatically determines the noise and the available gain of linear two-port devices driven from 16 selectable source impedances. A tuned power meter, which doesn't have any moving parts and which operates under μP control, calculates the noise power. The electronic load switches in less than 1 msec. The vendor reports that units remain in calibration for over a year. $56,160. Delivery, 14 weeks ARO.

Automatic Testing and Networking Inc, 600 W Cummings Park, Suite 3400, Woburn, MA 01801. Phone (617) 935-3420.

Circle No 402

This impressive lightning display is power in its most primitive state. At Sorensen, we have devoted ourselves to the task of developing products that will effectively harness, manage and transmit power. The result of this endeavor is a comprehensive line of both high quality laboratory and industrial power supplies.

For example in our laboratory line we offer a complete selection of resistance, voltage and IEEE-488 programable power instruments. These include:

The XT Series. Fast, programmable 60-watt linear power supplies with low cost, low noise and low ripple, digital and analog display. Available in over 30 standard models and more than 1,500 user-specified configurations.

The QRD Series. Offering high-speed, high-performance with low noise. Available in 6 models, all half-rack mountable and free standing. 5 fully adjustable voltage and current ranges from 0-15 to 0-60 Vdc from 0.75 to 4 amps.

The SRL Series. Medium-power, high-efficiency, programmable, with low RMS ripple and pk-pk noise. The best selling power supply of its type. Available in 14 models in 4 adjustable voltage and current ranges from 0-10 to 0-60 Vdc and 250 to 2100W power.

The DCR Series. This series combines over 50 models of both single and three-phase input units. This includes the DCR-T series, an exciting, highly advanced concept in power supply design with built-in OVP. These units are fully remote-controllable and provide greater power, safety and flexibility than conventional supplies.

Most Sorensen power supplies are backed with our Five Year limited parts and labor warranty.

No other manufacturer can match Sorensen's experience and reputation in power supplies, earned over the past 44 years.

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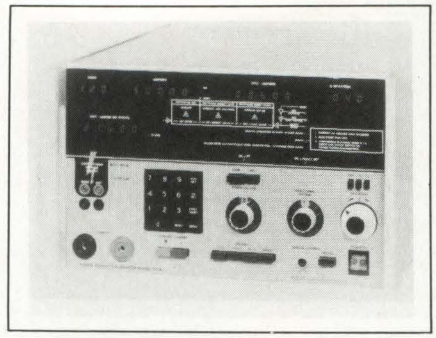


POWER CALIBRATOR

- *Features ±0.015% error spec at 0.01 power factor*
- *Calibrates instruments that can measure 35 kW*

The 800LPF is a standard for calibrating instruments that measure power at ac line frequencies. It works with instruments that accept 10 to 700V rms and 100 mA to 50A rms (ie, 1W to 35 kW) at 50, 60, and 400 Hz. It maintains its ±0.015% error spec at power factors as low as 0.01. You can obtain units with an IEEE-488 interface. $12,000 to $14,000. Delivery, 90 to 120 days ARO.

Rotek Instrument Corp, 390 Main St, Waltham, MA 02154. Phone (617) 899-4611.

Circle No 403

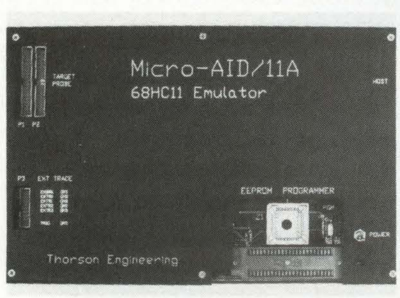
3¾-DIGIT DMM

- *Measures 220V with 0.1V precision*
- *Fits in a shirt pocket along with probes*

The DM79 can provide ten times the resolution supplied by 3½-digit meters on many measurements. On any range, it offers a full-scale display that extends to 3199 counts instead of the more commonly provided 1999 counts. This greater number of counts contributes to the instrument's improved resolution; for example, it permits the meter to measure 220V ac with a resolution of 0.1V rather than 1V. The credit-card-size unit sports five dc-voltage ranges from 0.32 to 400V; four ac-voltage ranges from 3.2 to 400V; and six resistance ranges from 320 to 3.2 MΩ. The meter meets UL94V-2 flammability requirements. It features an overvoltage protection rating of 700V and a case whose insulation is rated at 2 kV. When in its carrying case, the meter will withstand a fall of as much as three feet without sustaining damage. The range switch's life expectancy exceeds 2000 rotations. $49.95.

Beckman Industrial Corp, 3883 Ruffin Rd, San Diego, CA 92123. Phone (619) 495-3240.

Circle No 404

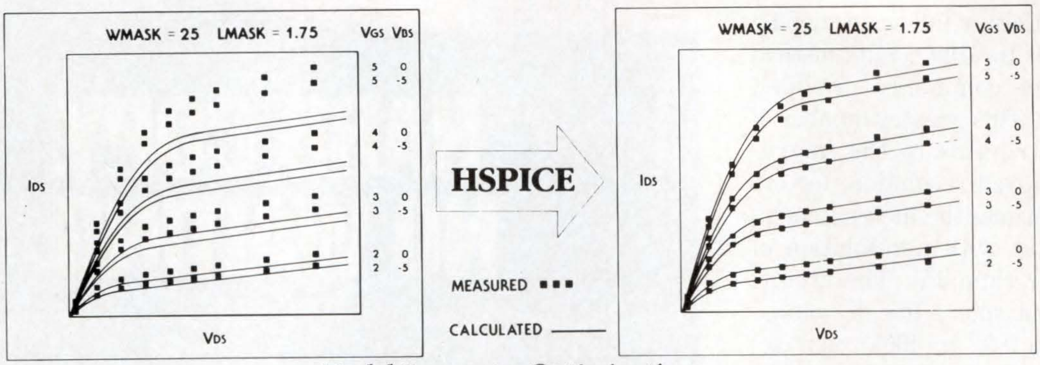


68HC11 DEVELOPER

- *Includes ICE and EEPROM programmer*
- *Plugs into PC Bus*

The Micro-Aid/11A board plugs into the IBM PC Bus to provide complete development support for the Motorola 68HC11 μP family. The board incorporates an EEPROM programmer with zero-insertion-force sockets for EEPROMs in DIPs or leadless chip carriers, and an in-circuit emulator (ICE) that emulates the MC68HC11A8 in both sin-

***NEW* From** META-SOFTWARE



Model Parameter Optimization

Optimizing HSPICE

Meta-Software announces Optimizing HSPICE, incorporating full optimization into the HSPICE circuit simulator.

HSPICE is now a multi-target optimizer that supports all SPICE and HSPICE models. Optimization is included with HSPICE as a new feature, and is available to all HSPICE customers on Software Maintenance at no extra charge.

HSPICE is an integrated solution, optimizing not only DC currents for models, but also capacitance for AC analysis and transient parameters for transient analysis.

HSPICE effectively replaces the functionality of SUXES-10 with full multi-target optimization capabilities. No pre- or post-processing is required.

HSPICE is the result of more than ten years of research in both optimizing algorithms and in user interface. The optimizing function has been integrated into the core of HSPICE, resulting in optimum efficiency. Optimizing HSPICE results will always agree with HSPICE circuit simulation.

Special features of Optimizing HSPICE include:

- Incremental optimization technique, DC, AC and transient optimization
- Uses HSPICE language format
- Model, device, subcircuit and circuit level parameters may all be optimized
- Optimizing Results Targets include Device Currents, Capacitance, Power, Time Delays, Unity Gain Frequency and S Parameters

Meta-Software also offers an extensive Discrete Device Library, HSPLOT graphics post-processor, ATEM process characterization system, Discrete ATEM for characterizing BJTs, MOSFETs, JFETS, HEXFETs and diodes, MetaTestchip™, and the Circuit PathFinder path timing analysis tool.

Other new features of HSPICE:

- Monte Carlo Analysis
- Pole Zero Analysis
- S Parameter Output
- Mixed Domain Analysis
- Instantaneous and RMS power
- Individual element temperature
- Measure Statement
- Multi-Gamma Model for MOS 6 Level
- Small Signal Network Analysis
- ALTER Statement
- Improved BSIM Model
- Data Statement

Meta-Software, Inc. • 50 Curtner Avenue, Suite 16 • Campbell, CA 95008
Phone (408) 371-5100 • FAX (408) 371-5638 • TLX 910-350-4928

CIRCLE NO 141

gle-chip and expanded multiplexed modes. The ICE includes 64k bytes of overlay RAM and allows 65,536 breakpoints. The trace memory is 2048 32-bit words. The software shipped with the board includes a symbolic debugger, a crossassembler, and a program editor. The software that supports the programmer allows you to fill and examine memory and to erase, copy, and verify PROMs. $2395.

Thorson Engineering Co, 6225 76th St SE, Snohomish, WA 98290. Phone (206) 334-4214.

Circle No 405

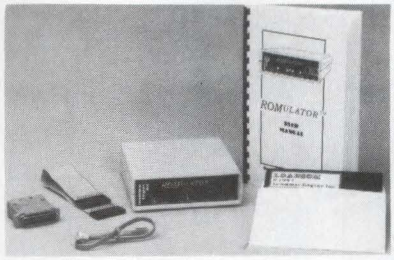
TEMPERATURE METERS

- *Cover 200 and 1200°F and 200 and 650°C*
- *Provide automatic overrange and polarity indication*

The 2871 and 2872 are 3½-digit temperature-measuring panel meters that accept type J thermocouples terminated in plug-in connectors and that include cold-junction compensation. The 2871 runs off 120V ac; the 2872 runs off 5V dc. The vendor offers each with a choice of four calibration factors: 0 to 200°F, 0 to 1200°F, 0 to 200°C (with accuracy specified from −30 to +200°C), and 0 to 650°C. The accuracy equals 0.2% of reading plus 1.8 to 2.5°, depending on the range. The units perform within specifications when the thermocouple's resistance is ≤50Ω (the equivalent of 50 ft of type J thermocouple wire), and they withstand 250V between the thermocouple and power-line ground. $159.

Simpson Electric Co, 853 Dundee Ave, Elgin, IL 60120. Phone (312) 697-2260. TLX 722416.

Circle No 406



ROM EMULATORS

- *Support access times as short as 50 nsec*
- *Emulate 1M-byte devices*

The Romulator family of ROM emulators now includes a unit that permits access times as short as 50 nsec and another that emulates 1M-byte devices. Yet another unit allows the target system to write into the ROM emulator. The emulator family supports 8-, 16-, and 32-bit target systems. The emulators are self-contained; they don't use an I/O slot in the host computer. The units communicate via an RS-232C port. You can obtain host software for MS-DOS, Unix, VMS, and Macintosh operating systems. Eight-bit versions, $375 to $565; 16-bit versions, $590 to $965; bidirectional versions, $575 to $1225; 1M-word versions, $710 to $1645.

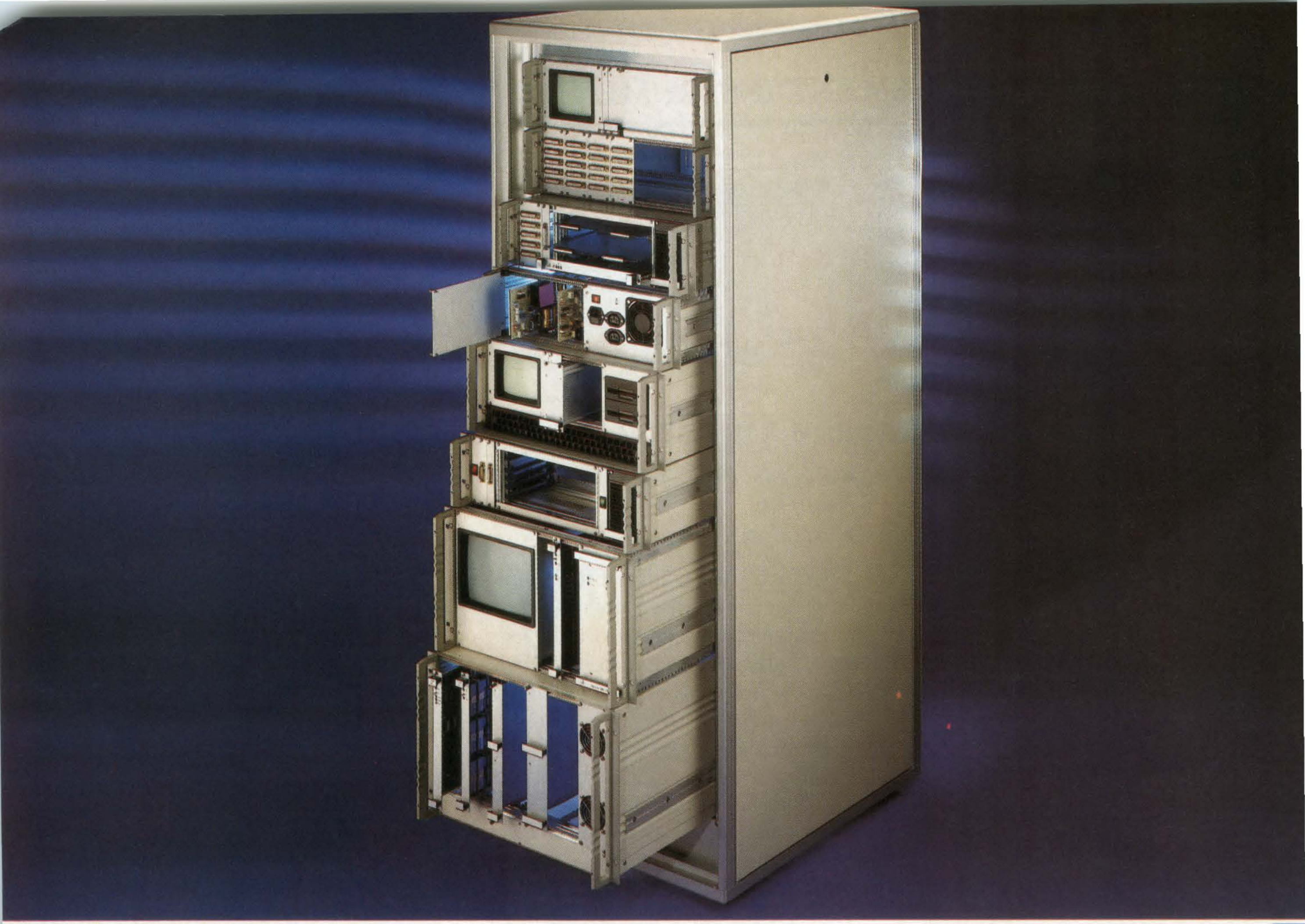
Grammar Engine Inc, 1021 Tipton Ct, Westerville, OH 43081. Phone (614) 882-6366.

Circle No 407

MODULATION ANALYZER

- *Performs vector analysis from 50 to 200 MHz*
- *Calibration corrects quadrature and balance errors*

The HP 8981A vector modulation analyzer utilizes a broadband, coherent, in-phase/quadrature demod-



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For 20 years Knürr AG has been a major supplier in the area of 19" systems.

The programme includes 19" racks, 19" cabinets, 19" consoles, 19" card-frames, 19" chassis, 19" fan units and many more products. The excessive range of accessories enables the economical installation of your electronics.

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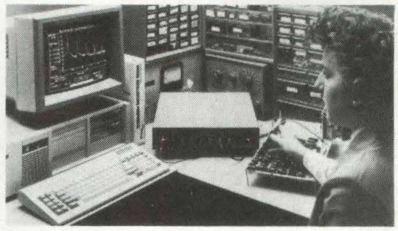
tm 5209

ulator to cover the 50- to 200-MHz IF and carrier frequency range. The instrument uses a statistical calibration routine to enhance its accuracy, performs all the functions of the vendor's 8980A vector analyzer, and includes a front-end vector demodulator that handles a 35-MHz in-phase/quadrature bandwidth. The calibration algorithm corrects for quadrature-angle error, in-phase and quadrature-phase channel balance, and dc offsets. The calibration reduces the quadrature error to ±0.5°, the in-phase/quadrature channel balance to ±0.1 dB, and the dc offset to ±1% of full scale. This accuracy yields an image rejection spec of 50 dB. The unit can display in X-Y, "constellation," and "eye" modes. $29,000. Delivery, 12 weeks ARO.

Hewlett-Packard Co, 19310 Pruneridge Ave, Cupertino, CA 95014. Phone local office.

Circle No 408



ANALYZER/SCOPE

- *Has two channels, each with a 12-bit ADC*
- *Displays 1024-point FFT spectrum in real time*

The R350 is a 2-channel FFT spectrum analyzer and digital oscilloscope based on an IBM PC or compatible computer. It features a 1-MHz max sampling speed and a 500-kHz max bandwidth. Each of its channels has its own 12-bit analog-to-digital converter, 32k-word storage buffer, and digital signal processor. The analog inputs are differential for rejection of common-mode noise, and each channel incorporates an anti-aliasing filter. You can select sensitivities from 1 mV/div to 20 V/div. The trigger modes include pretriggering, post-triggering, internal triggering, and external triggering. You can average from one to 64 spectra, and you can display spectra on a linear or logarithmic frequency scale. $3995.

Rapid Systems Inc, 433 N 34th St, Seattle, WA 98103. Phone (206) 547-8311. TLX 265017.

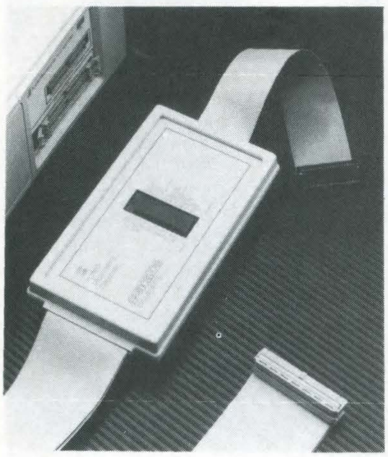
Circle No 409

80C86 EMULATOR

- *Zero-wait-state emulation at μPs' max clock speeds*
- *State-machine triggering and control*

The ES 1800 host-independent, in-circuit emulator emulates the 80C86 and 80C88 CMOS μPs from Harris and Intel. It performs transparent,

real-time, zero-wait-state emulation at the μPs' maximum-rated clock speeds. The emulator comes with the vendor's event-monitor system, which provides state-machine triggering as well as breakpoint and emulation control. The event-monitor system allows you to break on any combination of address, data, status, pass-counter, and logic-state fields. You can obtain the Validate/Soft-Scope high-level-language debugger and the Geneprobe symbolic debugger as options. Both debuggers run on the IBM PC/AT, PC/XT, or compatible computers. $11,495.



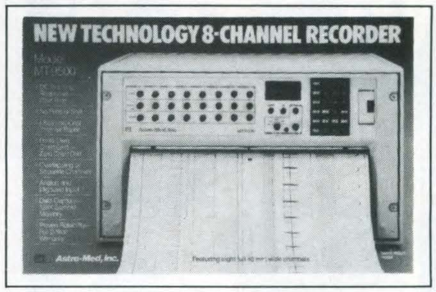
Applied Microsystems Corp, Box 97002, Redmond, WA 98073. Phone (206) 882-2000. TLX 185196.

Circle No 410

8-CHANNEL RECORDER

- *Eliminates galvanometers and styluses*
- *Has −3dB response at 5 kHz*

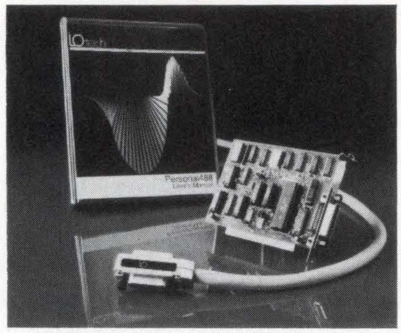
The MT-9500 8-channel oscillographic recorder's only moving parts are its chart drive and thermal imaging paper. It can reproduce 3-kHz analog signals with negligible attenuation; at 5 kHz, its response is −3 dB. The unit digitizes data with 12-bit precision at 32k samples/sec.



Every msec, it energizes the elements in its stationary printhead that span the highest and lowest amplitudes achieved by each signal during the last 32 samples. The printing elements are spaced 0.005 in. apart. You can select the side-by-side display of 40-mm-wide channels or the overlapping display of two groups of four channels, each in a 160-mm-wide area. The stepper-motor chart drive allows you to advance the roll or Z-fold paper, at any integer value of speed, to run at 150 or 200 mm per sec or to run from 1 to 100 mm per sec, minute, or hour. The unit prints the chart grids along with the data and includes facilities for event marking, time coding, and annotation. $12,950. Delivery, four to six weeks ARO.

Astro-Med Inc, Astro-Med Industrial Park, W Warwick, RI 02893. Phone (800) 343-4039; in RI, (401) 828-4000. TWX 710-382-6409.

Circle No 411



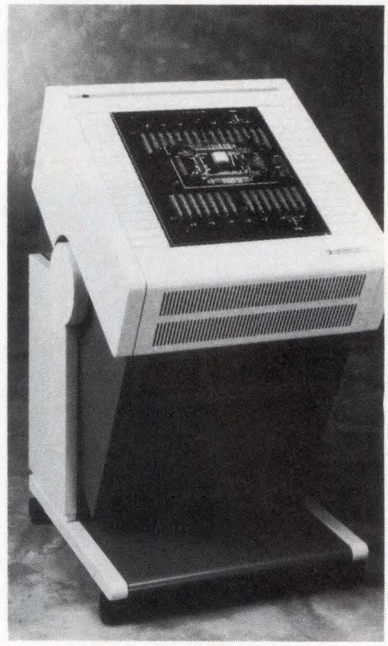
IEEE-488 INTERFACE

- *Lets multiple boards share DMA and interrupt channels*
- *Eliminates repeated parameter definition*

The Personal488 is a device-driver-based IEEE-488 interface for the IBM PC, PC/AT, and compatible computers. Its new software, which the vendor claims is compatible with all popular MS-DOS- and PC-DOS-based languages, lets you employ a single definition of an instrument's parameters (eg, device name, IEEE address, and terminators), and thus enables you to write code that consumes as little as ⅕ the memory needed by programs employing other approaches. When you install a driver in DOS, it remains there; you need not install it each time you use the computer. The interface-board hardware permits multiple boards to share the same DMA and interrupt channels, and a selectable wait-state generator makes the vendor's boards compatible with high-clock-speed computers that don't slow down during bus activity. $395; board without software (for use with Asyst, Lotus Measure, and TBasic), $295.

IOtech Inc, 23400 Aurora Rd, Cleveland, OH 44146. Phone (216) 439-4091. TWX 650-282-0864.

Circle No 412



ASIC VERIFIER

- *Accommodates 60-MHz max clock and data rates*
- *Uses "per-pin" architecture*

The Logic Master XL-60 16- to 224-channel ASIC-prototype verification system accommodates 60-MHz clock and data rates. Its "per-pin" architecture is the same as that used in the vendor's 100-MHz system. The architecture allows the independent assignment of all system resources to any pin. The system features 100-psec edge placement and sampling resolution, 125-psec frequency resolution, and <±1 nsec skew after autocalibration. An automated fixturing system eliminates wiring and maintains a 50Ω transmission line to the device pins. The system accommodates DIPs and pin-grid-array packages. $180,000 to $220,000. Delivery, eight weeks ARO.

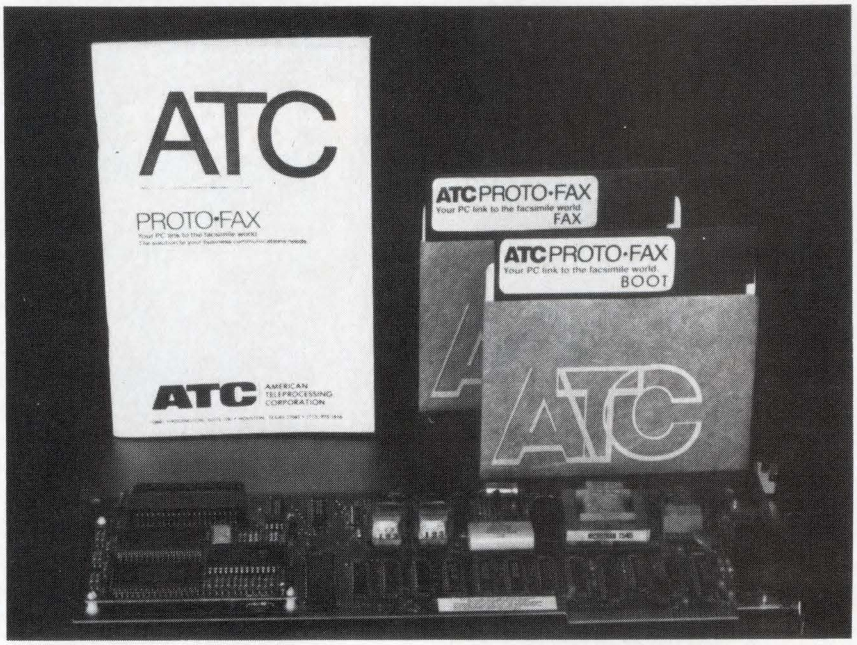
Integrated Measurement Systems Inc, 9525 SW Gemini Dr, Beaverton, OR 97005. Phone (503) 626-7117.

Circle No 413

CAE & SOFTWARE DEVELOPMENT TOOLS

FAX+TELEX

- *Lets you use PC for both fax and telex*
- *Conforms to CCITT Group III standard*



Proto.Fax Plus is a hardware-software package that lets you use your IBM PC or compatible as both a telex terminal and a facsimile terminal. The hardware portion consists of a full-length board that you can plug into any expansion slot of a PC that has at least 640k bytes of RAM, a hard-disk drive, and MS-DOS 3.0 or higher version. You'll also need a CGA, EGA, or Hercules graphics adapter, and an IBM Graphics (dot-matrix) printer or a Hewlett-Packard or QMS laser printer. The software provides extensive on-line help and is menu-driven for ease of use. Its features include a call directory and automatic dial and answer. It can receive documents in background mode while you're working on another applications program in the foreground. A built-in editor lets you create text messages (you can also use a standard word processor) and store them on disk for later transmission via telex, fax, or electronic mail. Fax transmission takes place at 9600 bps, with automatic fallback to lower speeds over noisy lines. The software works with any of the major telex carriers including FTC, Graphnet, ITT, MCI International, RCA, TRT, and Western Union. Three versions of the package are available: Proto.call (telex only) or Proto.fax (fax only), $975 each; Proto.fax plus (both fax and telex), $1595.

American Teleprocessing Corp, 10681 Haddington, Houston, TX 77043. Phone (713) 973-1616. TLX 774444. **Circle No 415**

CAE INTERFACE

- *Between HP and other CAE systems*
- *Based on EDIF 2 0 0*

The 74220A bidirectional EDIF (Electronic Design Interchange Format) interface lets you transfer schematic-capture data between the vendor's CAE tools and other, dissimilar, CAE tools. This standard interchange format lets you accept symbol libraries from ASIC vendors, for example, and return information about the finished design to the foundry. Version 2 0 0 of EDIF guarantees upward compatibility with future versions of the standard. The vendor's interface also works with data in EDIF 1 1 0 format, which the vendor's Printed Circuit Design System and Engineering Graphics System uses. $15,000. Delivery, eight weeks ARO.

Hewlett-Packard Co, Customer Information Center, 19310 Pruneridge Ave, Cupertino, CA 95014. Phone local office.

Circle No 416

EXPERT-SYSTEM SHELL

- *Runs in protected mode on 80386-based μCs*
- *Forward- and backward-chaining*

TWAICE, a tool for creating rule-based expert systems, allows a domain expert to verify the knowledge base without having to learn any programming language. The program's rule syntax is simple: You create rules and other knowledge-base components with the aid of a standard text editor. The tool then checks them for syntactic correctness and internal consistency, and you correct errors. After error correction, the software compiles final rules and taxonomy frames into a compact representation that the computer can load quickly. While you're building a knowledge base, you can use Why commands to find out the chain of reasoning that makes the program ask certain questions, and How commands to learn how the tool derived a particular result. (The package provides extensive on-line help on how to use the various commands.) This tool

has been available since 1985 for IBM mainframes, VAX machines, and 68000-based workstations; the current version works on the IBM PS/2 Model 80, the Compaq 386, and other 80386-based machines. The $7500 price includes the vendor's MProlog development language (an implementation of Prolog) and two 1-week TWAICE training classes.

Logicware Inc, 237 Park Ave, Suite 2100, New York, NY 10017. Phone (212) 551-3536.

Circle No 417

SYSTEM BUILDER

- *Automates system rebuilding upon source-code change*
- *Provides facilities for pre- and postprocessing*

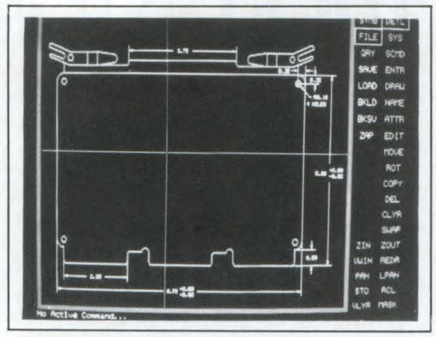
PolyMake version 2.1, which is modeled on the Unix utility Make, lets you define dependencies between the programs and modules of a software system. After making changes to the source code of one or more modules, you can run the utility to recompile the changed modules and link them with unchanged modules to build the new version of the system. New features introduced in this version include special dependencies for pre- and postprocessing, new dependency types, conditional constructs, and more powerful macros than those in previous versions. According to the vendor, this version runs as much as 10 times faster than do previous versions and consumes about 40% less memory. The program is compatible with the vendor's other tools, such as the Version Control System and the Librarian. To run the program, you'll need an IBM PC or compatible that has at least 256k bytes of memory and that operates under MS-DOS version 2.0 or higher. $149; users of previous versions can upgrade to version 2.1 for $50.

Polytron Corp, 1700 NW 167th Pl, Beaverton, OR 97006. Phone (503) 645-1150. TLX 325800.

Circle No 418

CAE TRANSLATOR

- *Sends data between P-CAD and AutoCAD*
- *Lets you add P-CAD drawings to documentation*



The 2.0 version of PC-Trans provides bidirectional translation of data between the vendor's P-CAD CAE system and AutoDesk's Auto-

CAD system, via the AutoCAD .DXF file format. You can now create your pc-board outline with AutoCAD, reaching levels of detail that are not easy to do with P-CAD; you can then create a .DXF file and complete the design with P-CAD. The program translates the .DXF file into a P-CAD command macro that can create P-CAD symbols and parts from the AutoCAD blocks; when you start P-CAD and execute the macro, you can watch the design being recreated. Because this version is also bidirectional, you can transfer P-CAD designs to AutoCAD or to any other CAE and documentation tool that can read the .DXF format. $495 for new users; registered users of the unidirectional PC-Trans version 1.0 can upgrade to version 2.0 at no charge.

CAD Solutions Inc, 2880 Zanker Rd, #103, San Jose, CA 95134. Phone (408) 943-1610.

Circle No 419

286 MULTITASKING

- *Operates under PC-DOS and OS/2*
- *Builds systems with >32,000 objects*

Smalltalk/V 286 is an object-oriented programming language for 80286- and 80386-based computers. It's an expanded version of Smalltalk/V for the IBM PC that allows multitasking and provides portability of applications from IBM PCs to Apple's Macintosh machines. You can build systems that have more than 32,000 objects and, because of the expanded-memory feature, objects can be larger than 64k bytes. An enhanced debugger shows currently executing methods and highlights the source-code statement as it is executing; it allows you to inspect and change all objects and correct errors without exiting the debugger, and lets you single-step through the program or run it at full speed. The windowing system and animation features operate twice as fast as in the original Smalltalk/V, according to the vendor. This version also works with EGA and VGA displays. Smalltalk/V 286, $199.95; upgrades from the vendor's Smalltalk/V, $75.

Digitalk Inc, 9841 Airport Blvd, Los Angeles, CA 90045. Phone (213) 645-1082.

Circle No 420

IEEE-488 MANAGER

- *Provides facilities for IEEE-488 network control*
- *Lets you use any number of IEEE-488 controllers*

GPIB Manager software allows a real-time multitasking and multi-user VME Bus system to control an IEEE-488 network. You can incorporate any number of IEEE-488 controller boards into the system and can attach as many as 15 devices to each board, which is the maximum number permitted by the bus specification. The software package consists of GPIB Manager, GPIB device drivers, sample device descriptors, a system test program, and sample application programs. The test program is for use during development and installation; it can generate GPIB commands, and you can use it to test the GPIB bus communications and timing. GPIB Manager runs as a background process under the OS/9-68K operating system; it configures and initializes the IEEE-488 bus, after which application programs can request GPIB-related commands for execution by the GPIB driver. The software package runs on the vendor's CC-91 VME-GPIB interface board, which performs standard IEEE-488 functions such as controller, listener, and talker. GPIB Manager software, $750; CC-91 interface board, $1675.

Compcontrol Inc, 15466 Los Gatos Blvd, Suite 109-365, Los Gatos, CA 95030. Phone (408) 356-3817. TWX 510-601-2895.

Circle No 421

SIMULATOR FOR MAC

- *Simulates analog circuits on Mac II*
- *Has same options as earlier versions*

PSpice is a simulator of analog electrical circuits that is widely used in its VAX, Sun, and IBM PC versions. The current release allows you to run the simulator on Apple's Macintosh II computer. Four options—Device Equations, Monte Carlo, Probe, and Parts Estimator—are also available for the Macintosh II. Both Probe and Parts use Apple's standard graphics interface, so they work with all graphics devices for which Apple supplies device drivers. Pricing for the Macintosh versions: PSpice, $1450; Device Equations, $550; Monte Carlo, $550; Probe, $700; and Parts, $700.

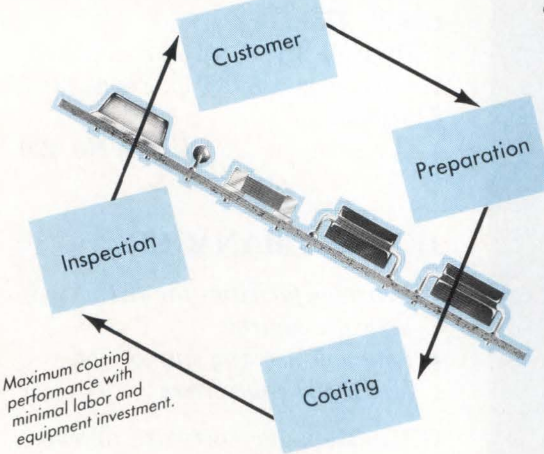
MicroSim Corp, 23175 La Cadena Dr, Laguna Hills, CA 92653. Phone (800) 826-8603; in CA, (714) 770-3022. TLX 265154.

Circle No 422

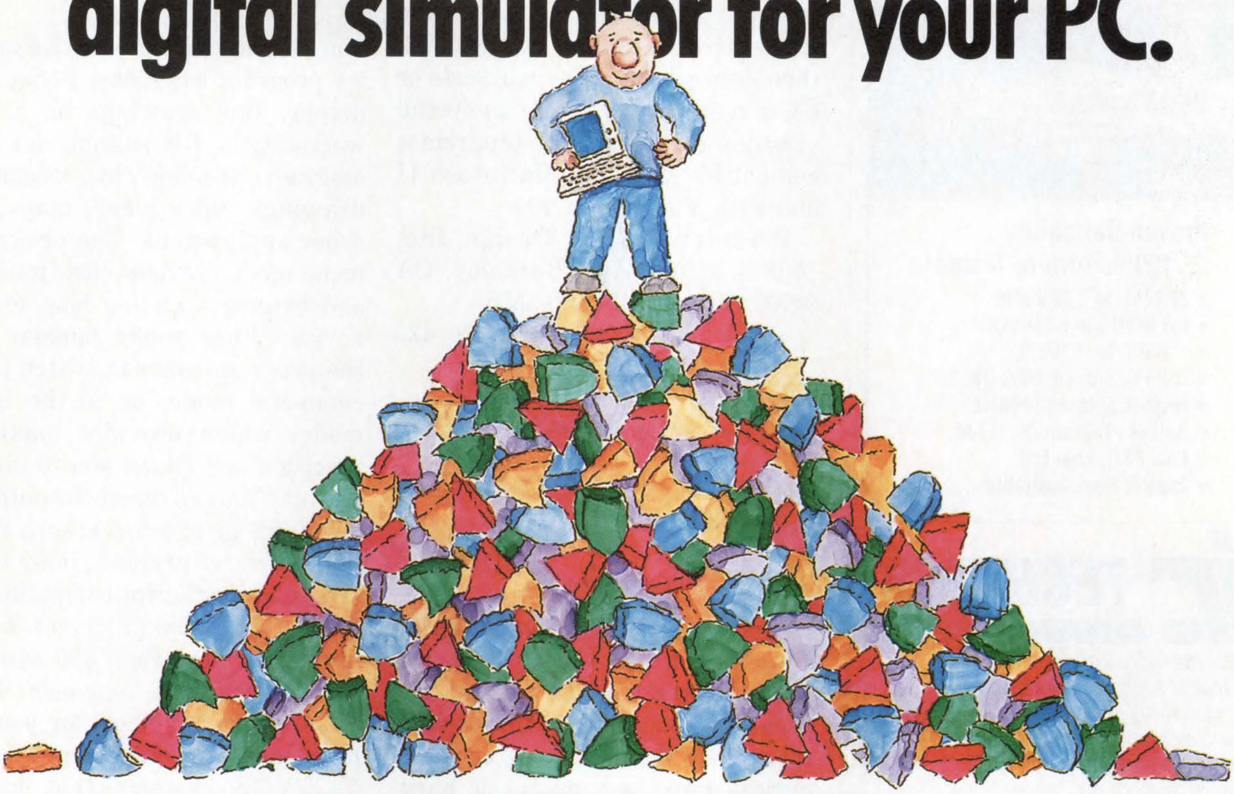
SCREEN EXTENDER

- *Enables images 16 times larger than the Macintosh screen*
- *Lets you view your image at reductions of 25%, 50%, or 75%*

The Stepping Out II graphics program for the Apple Macintosh can create a virtual screen as much as 16 times larger than the machine's ac-

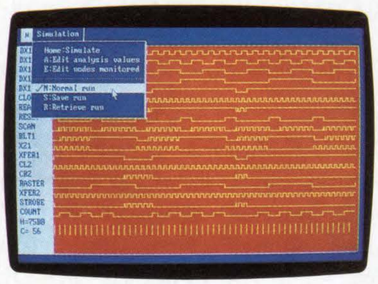


MICRO-LOGIC II.™
The CAE tool with a 10,000-gate digital simulator for your PC.



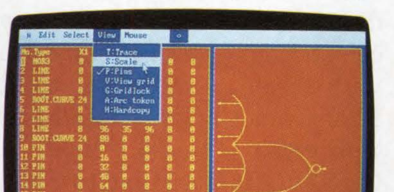
Spectrum Software's MICRO-LOGIC II® puts you on top of the most complex logic design problems. With a powerful total capacity of 10,000 gates, MICRO-LOGIC II helps engineers tackle tough design and simulation problems right at their PCs.

MICRO-LOGIC II, which is based on our original MICRO-LOGIC software, is a field-proven, second-generation program. It has a high-speed event-driven simulator which is significantly faster than the earlier version.



Timing Simulator

The program provides you with a top-notch interactive drawing and analysis environment. You can create logic diagrams of up to 64 pages with ease. The software features a sophisticated schematic editor with pan and zoom capabilities.



Shape Editor

A 200-type library of standard parts is at your fingertips. And for a new high in flexibility, a built-in shape editor lets you create unique or custom shapes.

MICRO-LOGIC II is available for the IBM® PC. It is CGA, EGA, and Hercules® compatible and costs only $895 complete. An evaluation version is available for $100. Call or write today for our free brochure and demo disk. We'd like to put you in touch with a top digital solution.

- Total capacity of 10,000 gates
- Integrated schematic editor
- Fast assembly language routines
- Standard parts library of 200 types
- Event-driven timing simulator
- Built-in shape editor
- Multiple delay models
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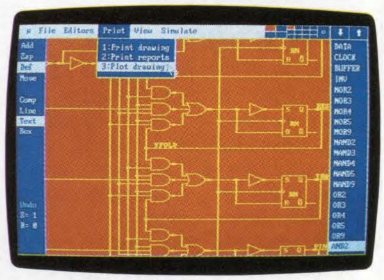

Schematic Editor

spectrum

1021 S. Wolfe Road, Dept. E
Sunnyvale, CA 94087
(408) 738-4387

tual screen. Whenever the cursor hits the edge of the actual screen, the view of the image scrolls up, down, left, or right. You can use the program with CAE/CAD and word-processing applications programs to create large text and images, and then either work on a small scale or use a reduction to obtain an overall view of the drawing. The program is compatible with the Macintosh II and with Multifinder. $95.

Berkeley System Design Inc, 1708 Shattuck Ave, Berkeley, CA 94709. Phone (415) 540-5536.

Circle No 423

WORM FOR UNIX

- *Makes an optical-storage drive emulate a magnetic drive*
- *Works with three 12-in. and two 5¼-in. drive models*

Dorofile software lets you integrate a worm (write once/read many) optical drive into a Unix system. The package creates a new file system that causes the CPU to perceive the optical drive as a magnetic hard-disk drive, yet grants access to optical storage. The software works with three 12-in. drives (the LD-1200 from Control Data/Phillips, Optimem's Model 1000, and Gigadisc's DG1001) and two 5.25-in. drives (Optotech's Model 5984 and Maxtor's Model 800S). Optical disks provide 2G bytes of storage apiece and feature a life expectancy in excess of 10 years. You access the optical disk in the same manner as you would access disk or tape drives —via Unix-like commands and calls. You can connect the disk drive and controller directly to processors that already have SCSI interfaces, or you can add external SCSI controllers to systems that don't have them. The package comes on ¼-in. tape and includes a device driver. $3000 (50).

Zetaco, 6850 Shady Oak Rd, Eden Prairie, MN 55344. Phone (612) 941-9480. TLX 290975.

Circle No 424

VAX GRAPHICS

- *Lets you create logic diagrams and other line art*
- *Provides a menu mode for novices*

You use the Draw interactive graphics program to create, revise, and display line drawings on a VAX workstation. It's suitable for logic diagrams, training aids, mechanical drawings, floor plans, maps, and other applications. The program's menu mode provides clear guidance and extensive on-line help for the novice. When you're familiar with the program, you can switch to the command mode, or to the tablet mode, which provides maximum precision and allows you to digitize line art. You can direct the output to a wide range of devices, such as pen plotters, laser printers, ink-jet plotters, and PostScript-compatible devices. The package comes with a library of more than 300 symbols, and you can build your own library of specialized symbols for your application. The program runs on VAX/VMS systems that have a VT-240, VT-340, or Tektronix display-list graphics terminal or its equivalent. From $3500.

Precision Visuals, 6260 Lookout Rd, Boulder, CO 80301. Phone (303) 530-9000.

Circle No 425

LANGUAGE

- *Provides the Simula programming language on PCs*
- *Has cross-compilation support between operating sytems*

The PC-Simula version of the Simula object-oriented programming language runs on IBM PCs. The vendor offers the language configured to run under the MS-DOS, Xenix, or OS/2 operating systems. The MS-DOS version, tested on an IBM PC/XT and PC/AT, requires 640k bytes of RAM to run. The vendor tested the Xenix version under Santa Cruz Operation's Xenix

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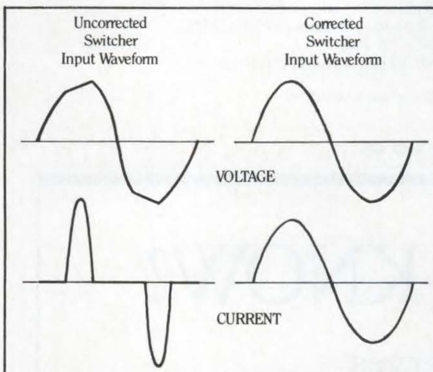

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System V and under Microsoft Xenix, and the OS/2 version, on an IBM PC/AT running Microsoft OS/2; you need a computer with 1.5M to 3M bytes of RAM to run either version. All versions call for a computer with a math coprocessor and a hard disk. You can order cross compilers to transfer programs between MS-DOS and Xenix and between MS-DOS and OS/2. Single-user licenses for the various versions, 10,000 to 15,000 Norwegian Kroner; cross compilers, 20,000 Norwegian Kroner.

Simula as, Box 4403, Torshov, 0402 Oslo 4, Norway. Phone (2) 156710.

Circle No 426

TURBO C DEBUGGER

- *Provides breakpoints and single-stepping*
- *Switches between program and debugger screens*

The A-COM debugger is a full-screen, source-level debugger for use with Borland International's (Scotts Valley, CA) Turbo C programming tools. The debugger is menu driven: You select the most commonly used functions via function keys. You can set breakpoints to stop the program you're testing when it reaches specified statements. In addition, you can make your program run until it reaches a breakpoint, or you can execute it statement by statement; in the latter case, you have the option of skipping over the functions called by a statement, or of stepping through the functions. You can also toggle-switch the display between the debug screen, which shows you the statements as they run and variables as they change, and the program screen, which you normally see while running the program. $24.95.

A-Com, 13511 NE 129th Pl, Kirkland, WA 98034. Phone (206) 821-2192.

Circle No 427

Plessey Microsystems puts the 68030 in its proper place

...and doubles your VME processing power!

If you've been yearning to double the processing power and throughput of your VME system, the wait is over. Once again, Plessey Microsystems has taken the lead... with our new 68030-based PME 68-32 VME Single Board Computer. It puts all the power of the 68030 into the industry's fastest, most powerful and versatile VMEbus processor board. And we're not talking about a board that's under development. The PME 68-32 is here...right now!

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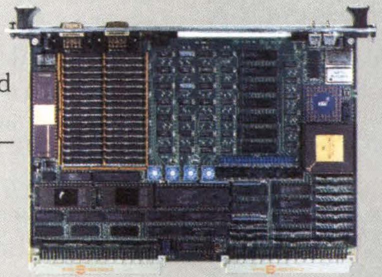
- Two high-speed serial ports–up to 1 Mbit/sec.
- Remote reset
- Mailbox interrupts
- Flexible dual-ported address mapping
- Complete VMEbus system control functions



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The PME 68-32 is part of a complete family of Plessey Microsystems processor boards incorporating the 68000 series of processors. That means minimal–or even zero–software changes from one product to the next. If you're using our 68020-based processors now, you can easily upgrade to the PME 68-32...now!

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FFT LIBRARY

- *>300 data array sizes*
- *Math coprocessor speeds calculations*

Two-Dimensional Prime Factor FFT is a subroutine library of fast Fourier transforms. Its prime-factor algorithm allows you a choice of more than 300 data-array sizes and, according to the vendor, is both faster and more accurate than power-of-2 algorithms. On an 80386-based PC, you can perform frequency analysis on data sets as small as 2×2 data points and as large as 65,520×65,520 data points. Furthermore, the vendor claims that this is the first PC-based FFT product to calculate rectangular FFTs, so that you can match the FFT calculation to an experimental array whose width is not equal to its length. You can call the routines from any high-level language; the manual provides interface examples for Turbo Pascal, Microsoft C, Lattice C, QuickBasic, Microsoft Fortran, Lahey Fortran-77, and assembly language. $159.

Alligator Technologies, Box 9706, Fountain Valley, CA 92708. Phone (714) 850-9984.

Circle No 428

STRESS ANALYSIS

- *For electronic and mechanical systems*
- *Includes import and export facilities*

Reliability Prediction Program (RPP) 3.1 provides stress analysis of parts in accordance with MIL-HDBK-217. This version has more than 40 new features, including quality-level default values for all parts, junction-temperature default values for ICs, and voltage default values for transistors and diodes. The program now lets you make full use of the MS-DOS path features, and you can also transfer data freely between the program and ASCII files or dBASE III-compatible files. In addition, this version can exploit a math coprocessor (if your system has one) to increase calculation speed. Optional enhancements allow parts cataloguing, global data changes, batch input, and stress analysis in accordance with MIL-HDBK-1547. To run the program, you'll need an IBM PC/XT or PC/AT that has at least 512k bytes of RAM and a hard-disk drive. RPP 3.1, $1700; options, $500 each.

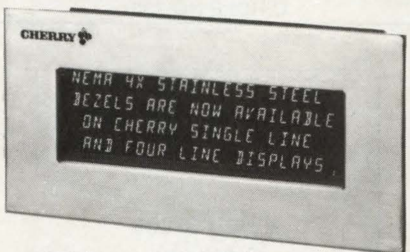
Powertronic Systems Inc, Box 29109, New Orleans, LA 70189. Phone (504) 254-0383.

Circle No 429

EDN PRODUCT MART

This advertising is for new and current products.

Please circle Reader Service number for additional information from manufacturers.



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CIRCLE NO 325

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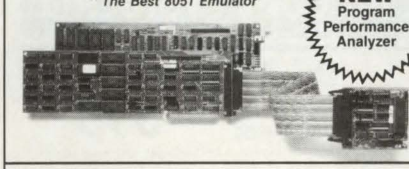
NEW Program Performance Analyzer



8051

PC based emulators for the 8051 family

(8051, 8751, 8052, 8752, 8031, 8032, 8344, 80C452, 80C152, 80535, 80C451)

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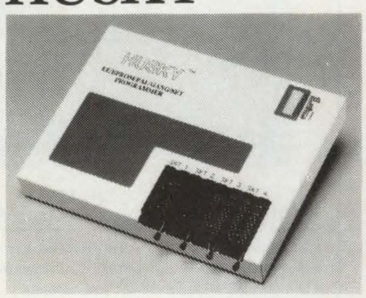

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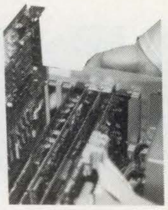

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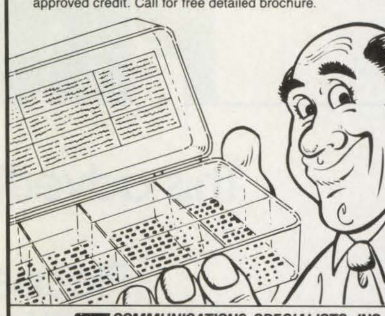

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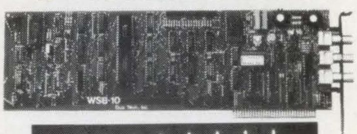

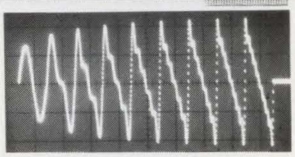

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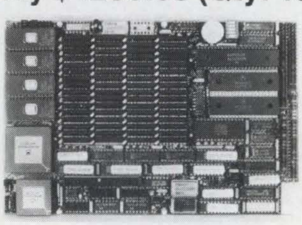

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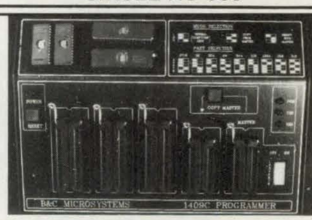

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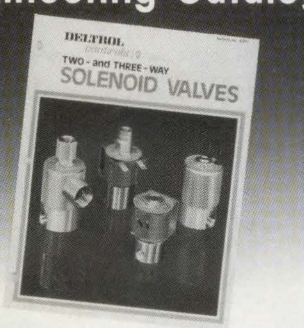

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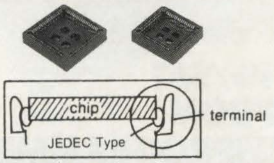

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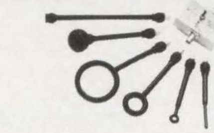

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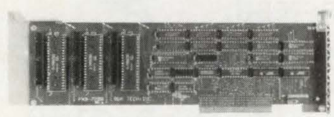

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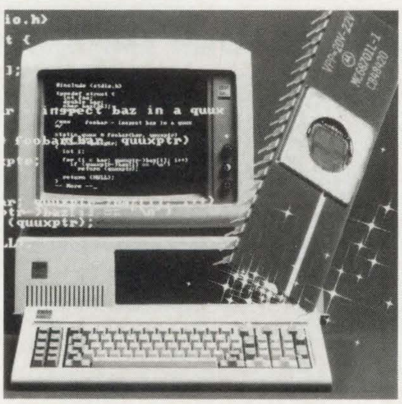

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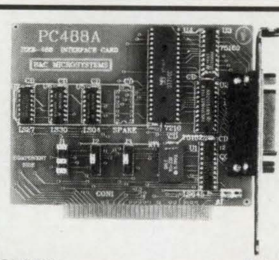

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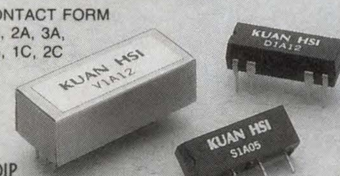

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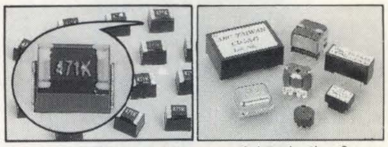

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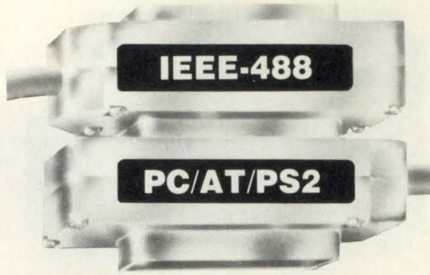

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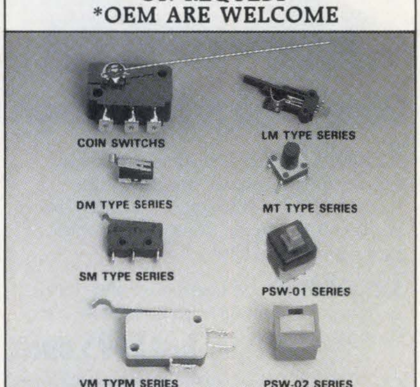

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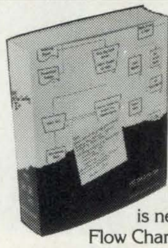

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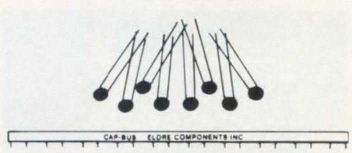

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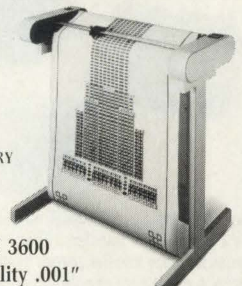

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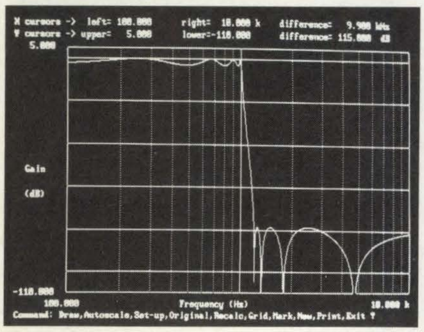

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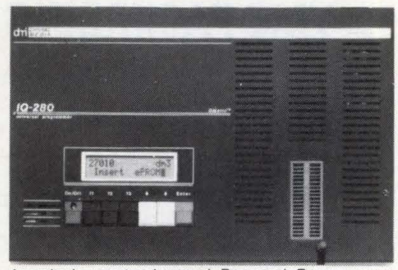

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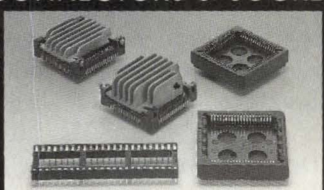

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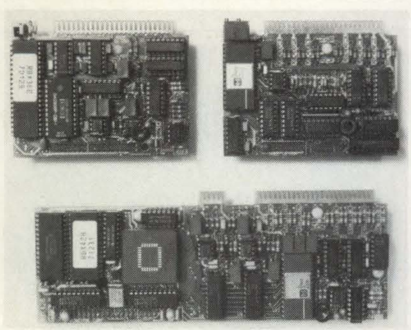

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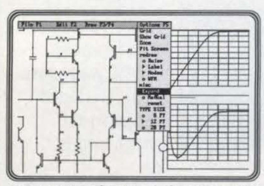

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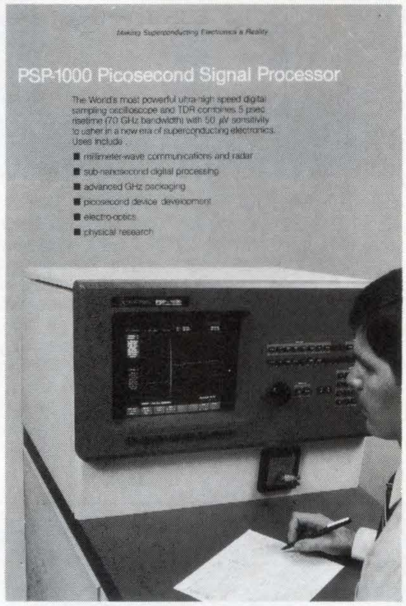
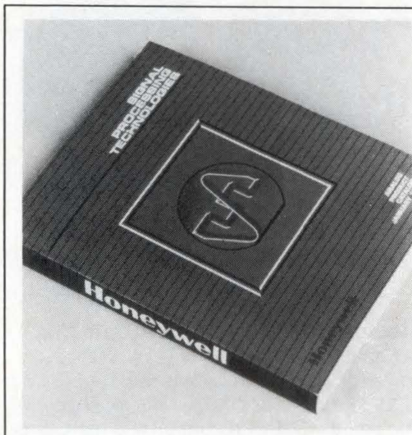


Superconducting electronics explored

The 8-pg brochure *PSP-1000 Picosecond Signal Processor* describes the combination of a digital sampling oscilloscope and time-domain reflectometry which, according to the vendor, is functioning at the threshold of superconducting electronics. The publication presents background information, annotated illustrations, and specifications.

Hypres Inc, 500 Executive Blvd, Elmsford, NY 10523.

Circle No 435

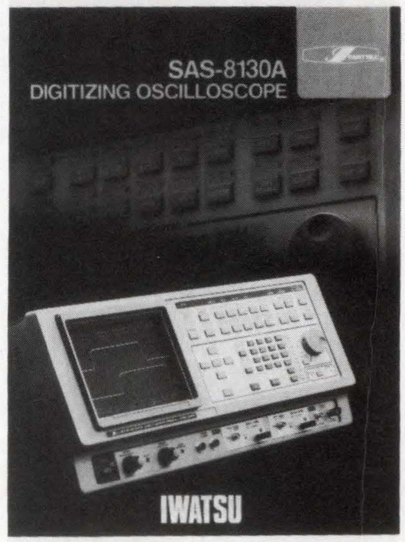


Catalog contains analog products

The 520-pg 1988 Analog Product Catalog categorizes A/D converters, comparators, track/hold amplifiers, switched capacitor filters, and D/A converters. It also includes advance information about many new products to be introduced this year, as well as application notes on flash converters, video DACs, and switched capacitor filters.

Honeywell Inc, Signal Processing Technologies, 1150 E Cheyenne Mountain Blvd, Colorado Springs, CO 80906.

Circle No 436



Scope helps you analyze high-speed waveforms

The vendor's 10-pg brochure describes its SAS-812A digitizing oscilloscope with which you can observe and analyze ultra-high-speed waveforms. It discusses features such as jitter reduction, an autotrigger function, and remote control with an external controller via RS-232C and IEEE-488 STD interfaces. Detailed descriptions, including illustrations, provide more information about applications such as rise and fall times, and evaluation of wide bandwidth differential amplifiers. The publication also includes an overview of the display screen, as well as specifications and options for the scope.

Iwatsu Instruments, 430 Commerce Blvd, Carlstadt, NJ 07072.

Circle No 437

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CIRCLE NO 149

Software development courses offered

This brochure describes the courses in languages, operating systems, and software engineering that are available. Four new courses in Advanced C Programming comprise Hands-On Workshop, Software Requirements and Specifications, Software Quality Assurance and Testing, and Software Maintenance. The publication discusses the subjects and applications covered, hands-on activities, benefits, materials provided, authors and instructors, and locations. Three- and four-day programs, from $1095 to $1395.

Integrated Computer Systems, Box 3614, Culver City, CA 90231.

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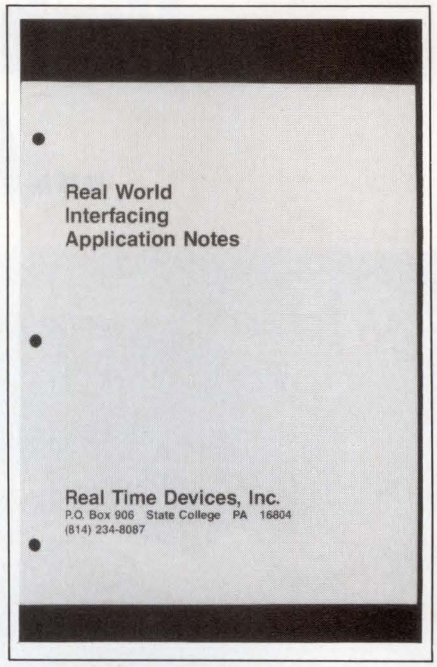

App notes address interfacing problems

The publication *Real World Interfacing Application Notes* contains 12 application notes that shed light on common interfacing problems in the laboratory and in industry. It provides tips and expounds on useful circuits for interfacing thermocouples, thermistors, solid-state temperature sensors, pH probes, and piezoresistive pressure transducers to personal computers. It also deals with solid-state relays to activate 110V ac lines, sensing incident light, and selecting an appropriate method of A/D conversion. These notes do not provide solutions for a particular interfacing problem, but rather guide you in the right direction. They provide sample circuits, and list references and companies for further information.

Real Time Devices Inc, Box 906, State College, PA 16804.

Circle No 439

Applications for power MOSFET IC

Application Note 28 focuses on the many uses of the TSC429 universal power MOSFET driver IC. It details the IC's parameters and tells you how the product can help with your

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designs. The paper shows typical applications for the part—as a small motor controller, as a voltage doubler, as a voltage inverter, and as a high-power pulse-transformer driver.

Teledyne Semiconductor, 1300 Terra Bella Ave, Mountain View, CA 94039.

Circle No 440

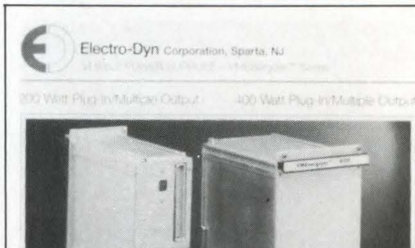
Listing of test and measurement equipment

The vendor's 1988 Catalog of Laboratory and Field Service Test & Measurement Equipment contains more than 75 new products ranging from digital multimeters to digital storage oscilloscopes. The 36-pg booklet also lists complete specifications for at least 400 items, includ-

ing multimeters, oscilloscopes, circuit analyzers, power equipment, signal generators, frequency counters, and a full range of accessories.

Anasco Corp, 42A Cherry Hill Dr, Danvers, MA 01923.

Circle No 441



Brochure details VME power supplies

This 4-pg pamphlet outlines the specifications and features of the company's 200 and 400W VME plug-in/multiple output power supplies. It also includes voltage/current selector charts, as well as outline and pin-connection drawings.

Electro-Dyn Corp, 90 Sparta Ave, Sparta, NJ 07871.

Circle No 442

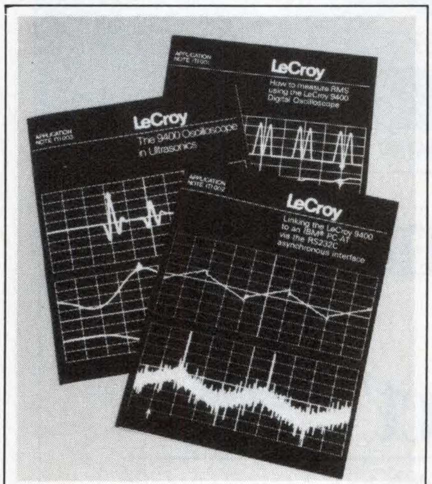
LITERATURE

Heeding data storage needs

The vendor's 8-pg brochure features DEC-compatible storage-module-disk interconnect subsystems and digital-storage, architecture-compatible disk drives. It discusses each product's advantages and provides specifications and illustrations.

Emulex Corp, Box 6725, Costa Mesa, CA 92626.

Circle No 443



How to use scope in three different applications

This series of application notes, *How to Measure RMS Using the LeCroy 9400 Digital Oscilloscope*, *Linking the LeCroy 9400 to an IBM PCAT Via the RS-232C*, and *The 9400 Oscilloscope in Ultrasonics*, examines three uses of the vendor's Model 9400 digital oscilloscope. AN ITI 001, the first note, presents a step-by-step procedure to calculate any waveform rms value. The second note, AN ITI 002, presents communication protocol and provides a short Basica interactive program that brings the remote control of Model 9400 into play. Finally, AN

LITERATURE

ITI 003 outlines traditional nondestructive-test ultrasonic waveforms.

LeCroy Corp, 700 Chestnut Ridge Rd, Chestnut Ridge, NY 10977.

Circle No 444

LINEAR TECHNOLOGY
Application Note 14
July 1985

Designs for High Performance Voltage-to-Frequency Converters

Jim Williams

Ultra-High Speed 1Hz–100MHz V → F Converter

App note features V/F converters

The application note *AN-14: Designs for High Performance Voltage-to-Frequency Converters,* investigates circuit considerations when designing V/F converters. It also examines the advantages and drawbacks of various approaches to V/F conversion, and contains complete schematics for the converters.

Linear Technology Corp, 1630 McCarthy Blvd, Milpitas, CA 95035.

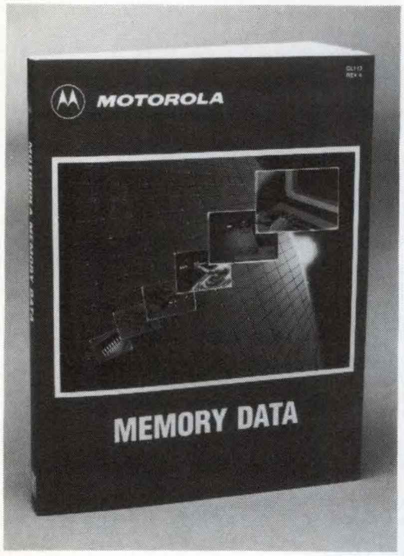
Circle No 445

Listing of MIL-STD and semicustom ICs

The vendor's product directory encompasses semicustom and radiation-hardened ICs, as well as MIL-STD-1553 and MIL-STD-1750 products. It describes each product, lists specifications, and includes block diagrams. Inside the cover pages, the 24-pg catalog provides an overview of the company and a list of sales representatives.

UTMC, Communications Dept, 1575 Garden of the Gods Rd, Colorado Springs, CO 80907.

Circle No 446



Memory data reference

The Memory Data Manual DL113, revision 4 presents specifications for the vendor's MOS static RAMs, dynamic RAMs, and PROMs, as well as CMOS and MECL memory technology and information about devices that meet military standards. A total of 12 chapters deals with support for system-level designs. The information includes pin assignments, packaging options, a list of basic features, electrical features, operating conditions, and timing diagram specifications. $1.35 (25).

Motorola Inc, Technical Information Center, Box 52073, Phoenix, AZ 85072.

INQUIRE DIRECT

Public-domain software listing available

The 1988 Catalog of Public Domain PC Software (Shareware and User Supported Software) provides the classification of user-supported software, several drafting programs, and a 3D CAD program that has animation capabilities. The main body of programs covers 14 topics, including statistical process control, project management, surveying, flowcharting, heat load, and dBase III clone. Copying fee, $3/disk (10).

Sector Systems Co Inc, 416 Ocean Ave, Marblehead, MA 01945.

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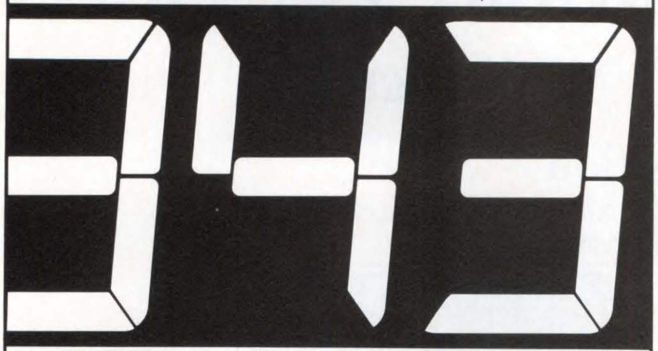

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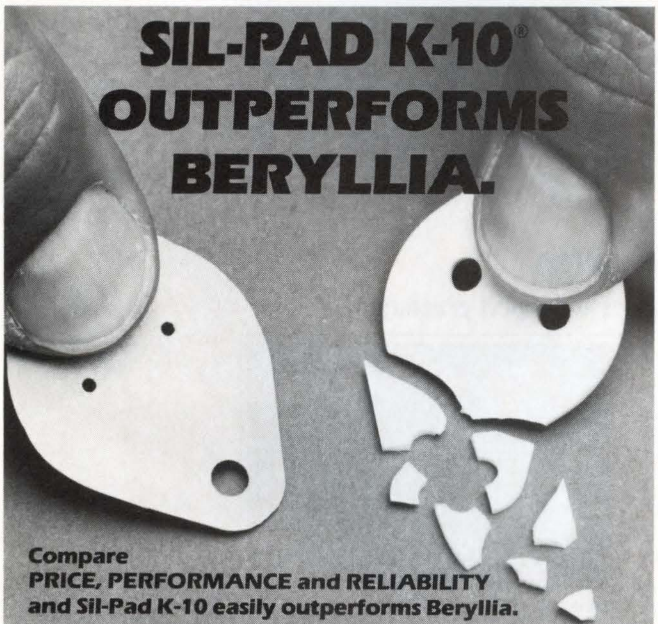

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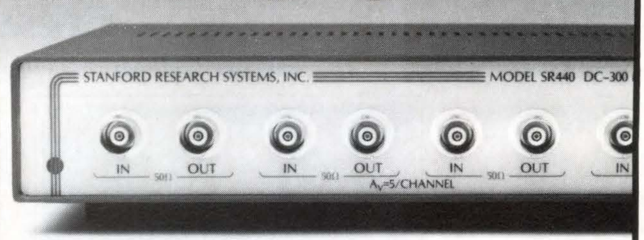

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Stanford Research Systems

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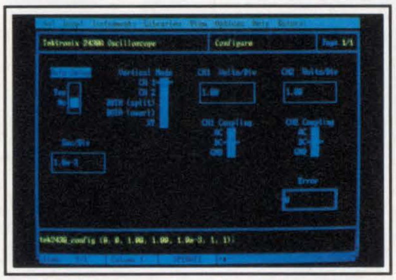

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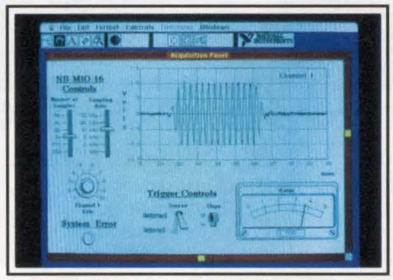

Front panel user interface with virtual instrument block diagram programming.

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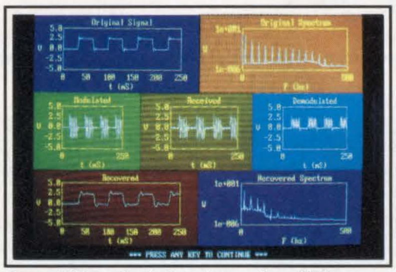

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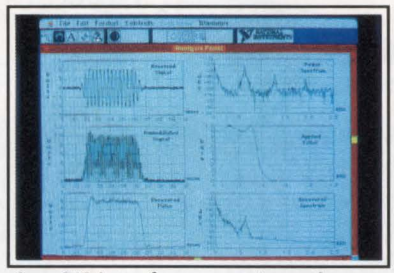

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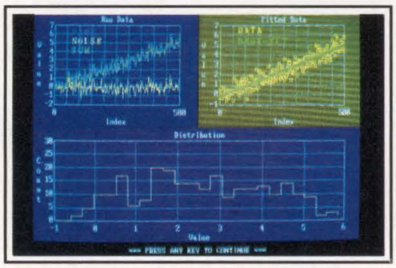

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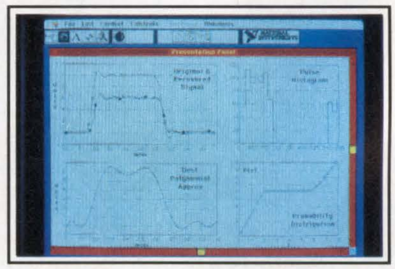

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DICK BURWEN

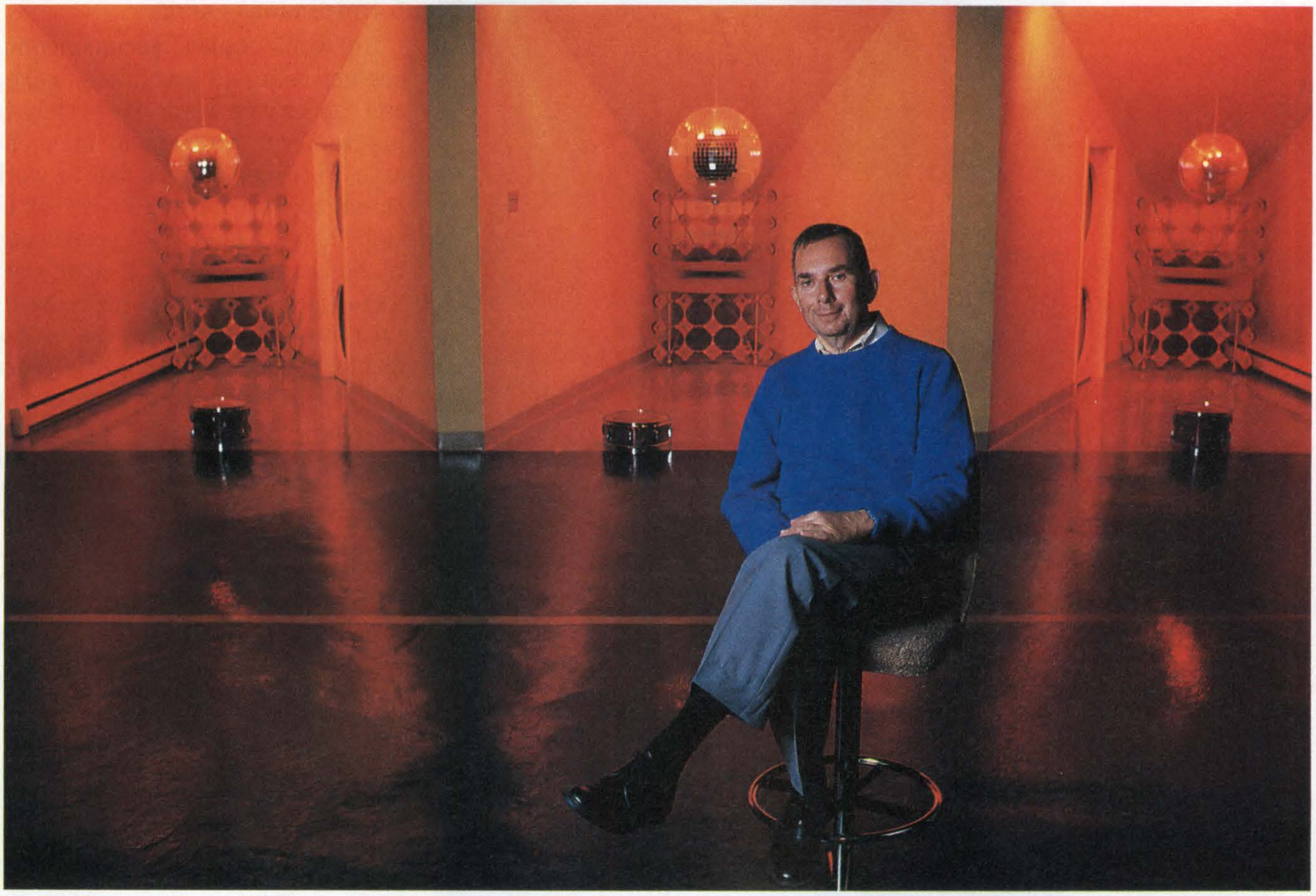
Mixing a love of engineering with a passion for hi-fi

Deborah Asbrand, *Associate Editor*

Most independent consultants work out of their homes, and Dick Burwen is no exception. The analog-circuit designer's home contains office space, an extensive technical library, and a basement laboratory equipped with signal sources, measuring instruments, a temperature chamber, and thousands of electronic parts.

Burwen differs from some consultants, however, in that he likes to listen to music while he works and so has punctured one laboratory wall with five shoebox-size holes through which he can hear his stereo. His audio system, moreover, is not your average assemblage of components. For one thing, he designed and built all of the signal-processing equipment. For another, the stereo employs 159 speakers, five giant speaker horns, and 17 stereo amplifiers. It also produces 20,000W of power. "I can really rattle the dishes in the kitchen," he says.

For the past 38 years, Burwen has successfully mixed his love of engineering with his passion for high-fidelity equipment. Having built a profitable consulting practice and



Webb Chapell

Burwen's quiet, inconspicuous manner belies a tremendous energy and capacity for work.

constructed an internationally acclaimed home listening/recording studio, he could easily rest on his laurels. Yet he keeps pushing the limits of analog-circuit design. His latest efforts include designing ultrahigh-efficiency switching-power amplifiers.

Shades of the career to come

Burwen's first move after college graduation foreshadowed the direction his career would eventually take. "When I got out of school, I retired for eight months," he says with a smile. "I went down to the basement to build a high-quality hi-fi set. It had an amp built into the base of the record player and it put out about 30W of power, which was remarkable in those days. But by the time I finished it, I realized that the people who could afford it didn't care, and that the people who did care couldn't afford it. It was what today you'd call 'high-end' gear."

His first employer was Spencer-Kennedy Laboratories, a pioneer in cable television. He developed the company's wide-band television distribution system, which brought television to rural communities. In Barre, VT, Burwen supervised the installation of huge horns on poles that would receive signals from Boston, MA, 90 miles away.

Eleven years and several jobs later, Burwen concluded that the corporate environment was not for him. He had no interest in pursuing managerial positions and preferred to work on his own. "I was doing consulting on the side when I decided I would see if I could get into the business full time," he says. "I took a vacation, made some phone calls, and six weeks later, I had three clients, so I quit my job."

In the 27 years since, Burwen has done much engineering. Stacked in the back of his basement are more than 100 3-in. binders filled with his project notes. He has worked on a fascinating array of assignments, from the development of a correlation receiving system for satellites to automotive ignition systems. For Lafayette, an early electronics-parts dealer, Burwen designed a 200W ultralow distortion amplifier. He also consulted on military and space-related projects and helped design instrumentation to measure the moon's magnetic field.


Webb Chappell

An estimated 2500 op amps power the system, and Burwen once counted 1100 knobs on the many components.

A tremendous energy

Burwen's quiet, inconspicuous manner belies a tremendous energy and capacity for work. He prefers to juggle three projects at once, he says, "because I don't like to work on one project for more than six or eight hours a day." Not surprisingly, he has no truck with small talk. Asked how he happens to come by such interesting and diverse assignments, he answers simply, "When you charge as much money as consultants do, people only bring you the interesting projects." And in response to a question about his instant success as a consultant—he's made a total of two "cold" calls to prospective clients—he shrugs, "Word travels."

In 1965, with Matt Lorber and Ray Stata, Burwen founded Analog Devices, the Norwood, MA, manufacturer of integrated circuits. "I used to run around with a couple of op amps in my pocket to see if anyone wanted to buy them," he explains, with typical understatement. "I ran into Matt Lorber and Ray Stata who got into making them." It was Burwen who designed the company's first line of op amps and, later, of regulators and

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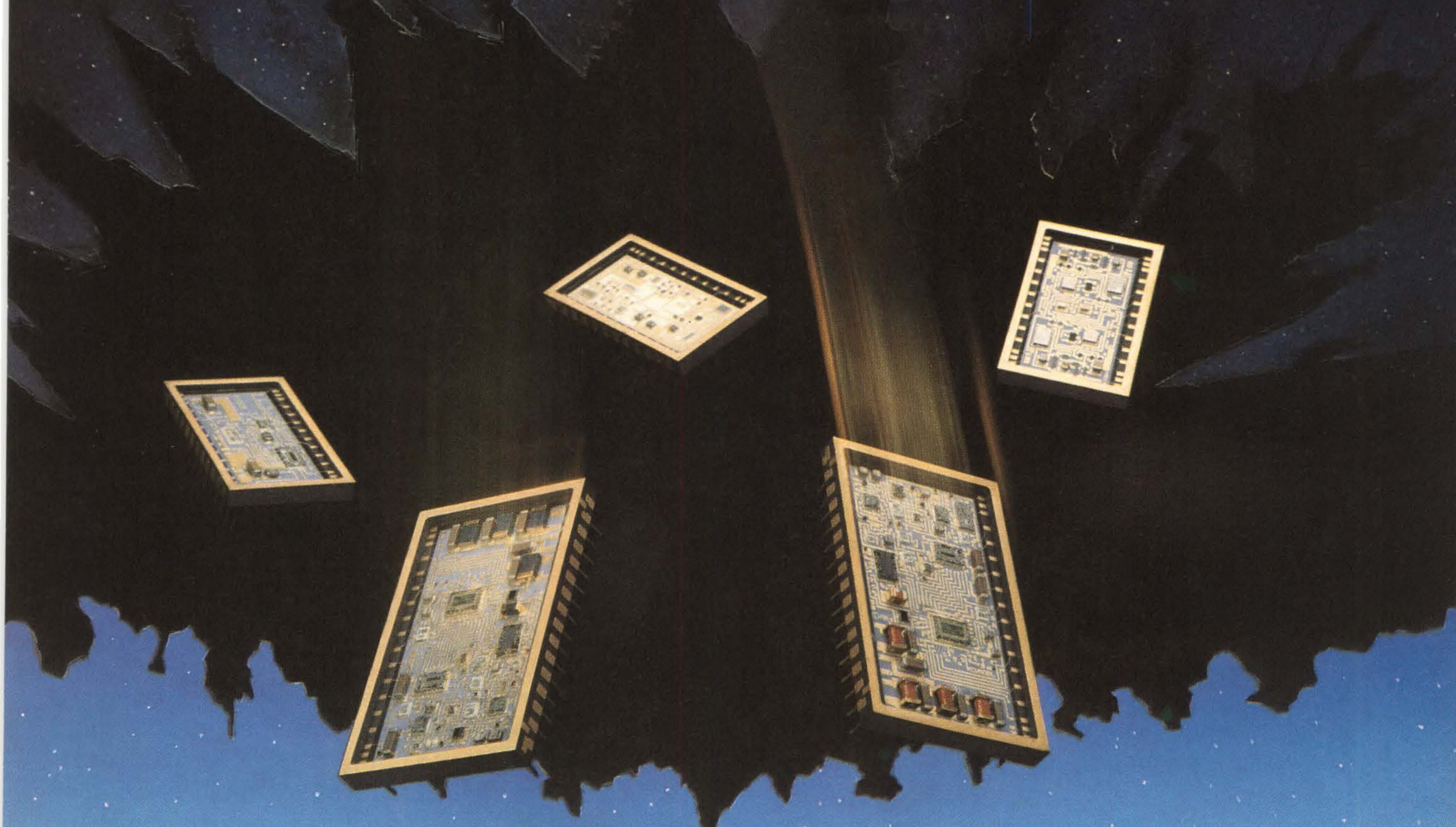

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ADC-5101	8	900 nSec	
ADC-815		700 nSec	
ADC-303		10 nSec	
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Datel, Inc., 11 Cabot Boulevard, Mansfield, MA 02048 (617) 339-3000 references. He also developed multipliers, chopper-stabilized amps, and some of the company's early ICs.

In 1972, Burwen started his own company, Ohmtec Corp, which manufactured consumer and professional audio equipment. He calls the move "the biggest mistake of my life" and dismisses the business, which folded in 1976, as "a bad marriage." KLH, however, bought an Ohmtec subsidiary, Burwen Labs, and continued to manufacture some of its noise-reduction equipment under the name KLH Burwen Research.

Whatever the consequences, Burwen has worked on his own terms ever since becoming a consultant. He has also carefully preserved his independence, retaining his consultant status even while he was actively involved in Analog Devices. Resolutely confident of his engineering skills, he has attached his name to that of almost every company he's started: Burwen Labs, Burwen Research, Burwen Studios, and Burwen Technology.

Burwen's engineering expertise has fueled his passion for hi-fi—though he has no ready answer as to where the roots of his hi-fi addiction lie. The most he can do is trace its history to his teenage interest in ham radios, which he was forced to abandon in favor of hi-fi equipment when amateur radio operation was banned during World War II.

World's best home stereo

In his youth, Burwen had assembled a 25-speaker stereo system powered by a 3W amp; however, in the early 1960s, when he and his young family moved into a small home of their own, the close quarters cramped his audio style. For 10 years, he'd been working on plans for a system that would generate not just better sound, but the world's best home-stereo audio. With that goal in mind, Burwen hired an architect to help him build a home that could accommodate such a project. Not surprisingly, Burwen's meeting with the architect led to a new endeavor. "It turned out that the house would have cost more than I could afford, so I listened and watched the architect very carefully. I drew up my own plans and hired an engineer to do the framing of the structure. It worked out, fortunately."

Thoroughness is Burwen's hallmark. "Dick likes to do things in a big way," says Matt Lorber, who once again is Burwen's business partner, this time in Copley Controls, a Newton, MA, maker of dc servo amps. "He's a critical thinker, and he pursues things to an extent I've never seen before." The stereo system that Burwen built illustrates this point. (So does the security system that protects his two-story brick home. It, too, is a Burwen design.)

The listening/recording studio measures 48×28 ft. There are no windows in the concrete foundation, and the basement ceiling is constructed of extra-heavy plaster. The system's 159 speakers terminate in five giant horns that dominate the room. Each speaker horn is 8×8×13 ft. The walls of each horn are made of 4-in. filled cinderblock. The speakers have a dynamic range of more than 105 dB.

In addition to the speakers, the system employs 17 stereo amplifiers. Burwen designed the array and crossover system. The 8500W of amplifiers, together with the electronic crossover, give the system power equivalent to that of one 20,000W amplifier. An estimated 2500 op amps power the system, and Burwen says he once counted a total of 1100 knobs on the many components. The control panel is 7 ft tall, and the 5-ft, 9-in. Burwen has to stand on his toes to adjust the uppermost knobs.

The basement is also equipped for recording, and Burwen has acted as recording engineer for the dozen albums that have been made in his studio. "Dick is patient and intense," says Steven Schoenberg, a local pianist who several years ago recorded an album of improvisational compositions at Burwen's studio. Indeed, Burwen's natural affability dissolves as soon as he begins to ready his system for a demonstration: Once the music starts to play, he stands looking downward, hands on his hips, listening to every note's acoustical travels.

The welcome invasion of digital

Aside from his home recording, Burwen produces master recordings for the Boston Philharmonic Orchestra, the Civic Symphony Orchestra of Boston, and the Banchetta Musicale, a chamber orchestra. Six years ago, he began recording with digital equipment, which he finds infinitely easier to use than the cumbersome analog apparatus he had previously used. "To record an 8 PM concert, I'd have to get to the hall at 2 PM to set up," he says. "I had my own noise-reduction equipment and analog tape recorders, about eight suitcases full of stuff. Now with three small suitcases that contain the main sound system and a complete spare, I make better recordings in 2-channel stereo digitally."

Although Boston boasts several fine recital halls, Burwen's favorite is the New England Conservatory of Music's 1100-seat Jordan Hall. While other local auditoriums are acoustically "dead" or "dry," he says, Jordan Hall is "nearly perfect." Burwen's attentive ears, however, detect subtle differences even within such near perfection. "There are only four perfect seats," he adds. "They're right under the edge of the balcony on either side of the aisle."

Although a frequent concert goer, Burwen is an engineer first and a music lover second. "At the symphony, I listen to the instruments, but especially to the sound of the hall. I spend half of my time there visualizing how I would record the music."

Burwen expends much of his professional energy on Copley Con-

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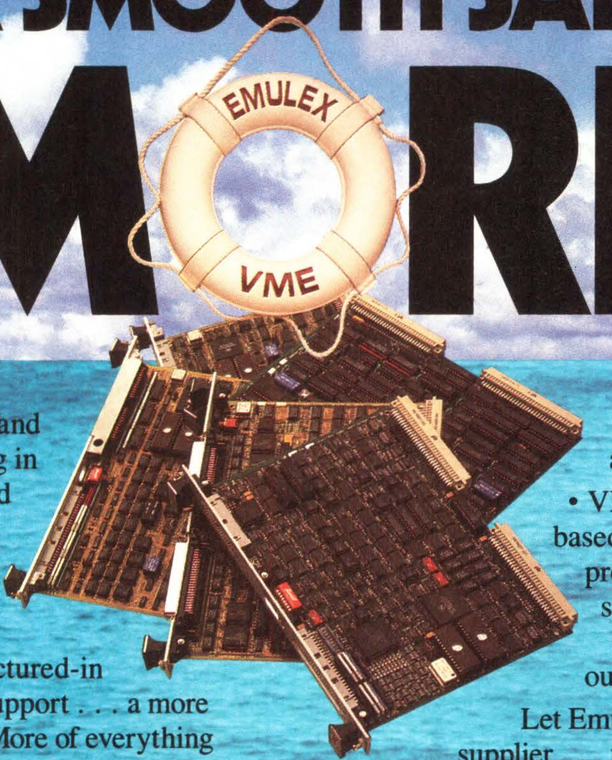

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International Offices: Bracknell 344-484234 Munich 89-3608020 North Sydney 2-957-1669 Paris 134-65-9191 Tokyo 3-234-8951 Toronto (416) 673-1211 trols, the 5-year-old company he started with Lorber. As director of research, he designs all of the company's ultrahigh-efficiency switching power amps, which are used for, among other things, driving servo motors in motion-control systems and magnet coils in magnetic-resonance imaging systems. The switching technology allows Burwen to create amplifiers that produce from tens of watts to kilowatts in a volume of under 100 in^3. The products' efficiency, which exceeds 95%, allows them to dissipate less than 10% of the power dissipated by conventional linear amps. The lower dissipation permits the systems that use the amps to have smaller power supplies and to run at lower temperatures, hence to exhibit higher reliability.

Designing such amps is a delicate, painstaking process. To be successful at it, designers must be keenly aware of the subtleties of circuit components and pc-board layouts. The inductance of a 1-in.-long etch run has been known to wreak havoc on switching-amplifier designs.

Burwen owns 25% of the company, but, true to form, retains a consultant's status vis a vis the firm. He also continues to operate his independent consulting firm, Burwen Technology, although he admits that his work for Copley Controls takes up most of his time. Unlike his earlier joint venture, he describes Copley Controls as "a good marriage." He still works out of his home laboratory, driving to Copley Controls' headquarters three times a week. The arrangement suits both Burwen and Lorber. "In the company environment, there are day-to-day matters that would be disturbing to Dick," says Lorber. "He wouldn't be able to devote his time to technical tasks."

Last year, tired of being "the only design engineer in the world without a computer," Burwen invested in a personal computer and bought software for stock-market trading, word processing, and schematic drafting. He's an avid stock-market watcher and one of the first things he does on starting work each day at 6:30 AM is to log on to a subscription stock service.

But, betraying his analog background, he finds the long hours needed to set up the computer immensely frustrating. "Right now I'm trying to learn schematic drafting," he says, shaking his head. "I wasted so much time trying to get the machine started and configured. I spent six or eight hours a day getting my software installed and reading the books—but not doing anything useful."

At 61, Burwen shows few signs of slowing down. For the past three months, he's been involved in projects that have frequently required his attention from early morning to past midnight. He says—unconvincingly—that he'd like to reduce the number of hours he works. Indeed, he ticks off a list of projects he has yet to complete. "See this pile of wires?" he says, pointing to a breadboard on a bench next to the electric organ. "It's a signal processor and an electronic replacement for the rotating speaker in the organ. It's been working like this for about 12 years. I don't know if I'm going to get to finish it or not."

When he does, he'll undoubtedly work to the accompaniment of a selection from his collection of "about six or eight hundred" recordings. "It's hard to work without music." **EDN**

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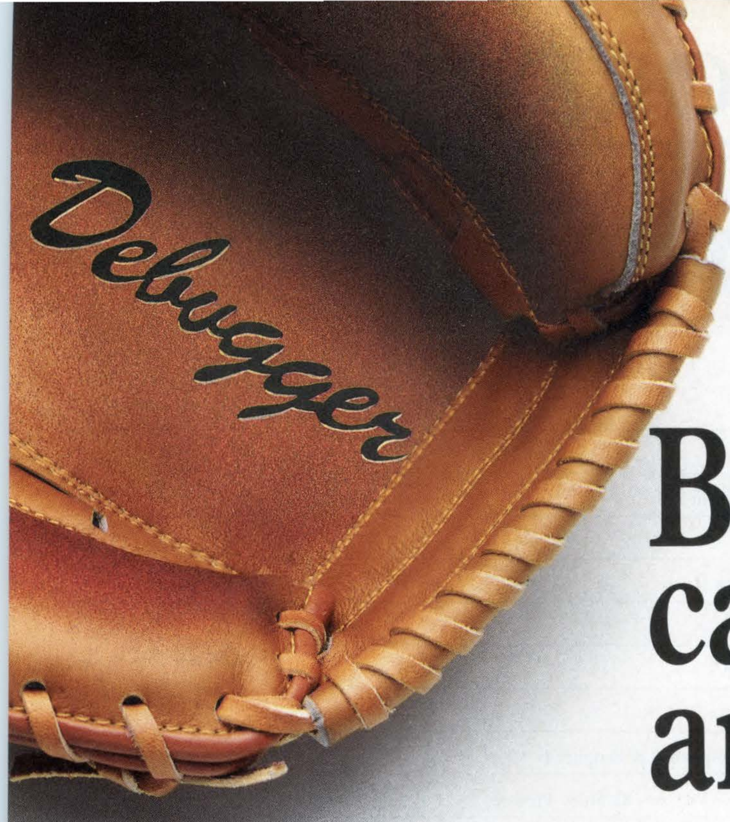

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Issue Date	Recruitment Deadline	Editorial Emphasis	EDN News
June 9	May 19	CAE, Analog ICs, Test & Measurement	Closing: May 29 Mailing: June 16
June 23	June 2	Data Communications, DSP, Components	
July 7	June 14	Product Showcase—Vol. I, Power Sources, Software	Closing: June 23 Mailing: July 14
July 21	June 30	Product Showcase—Vol. II, CAE, Test & Measurement	
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	

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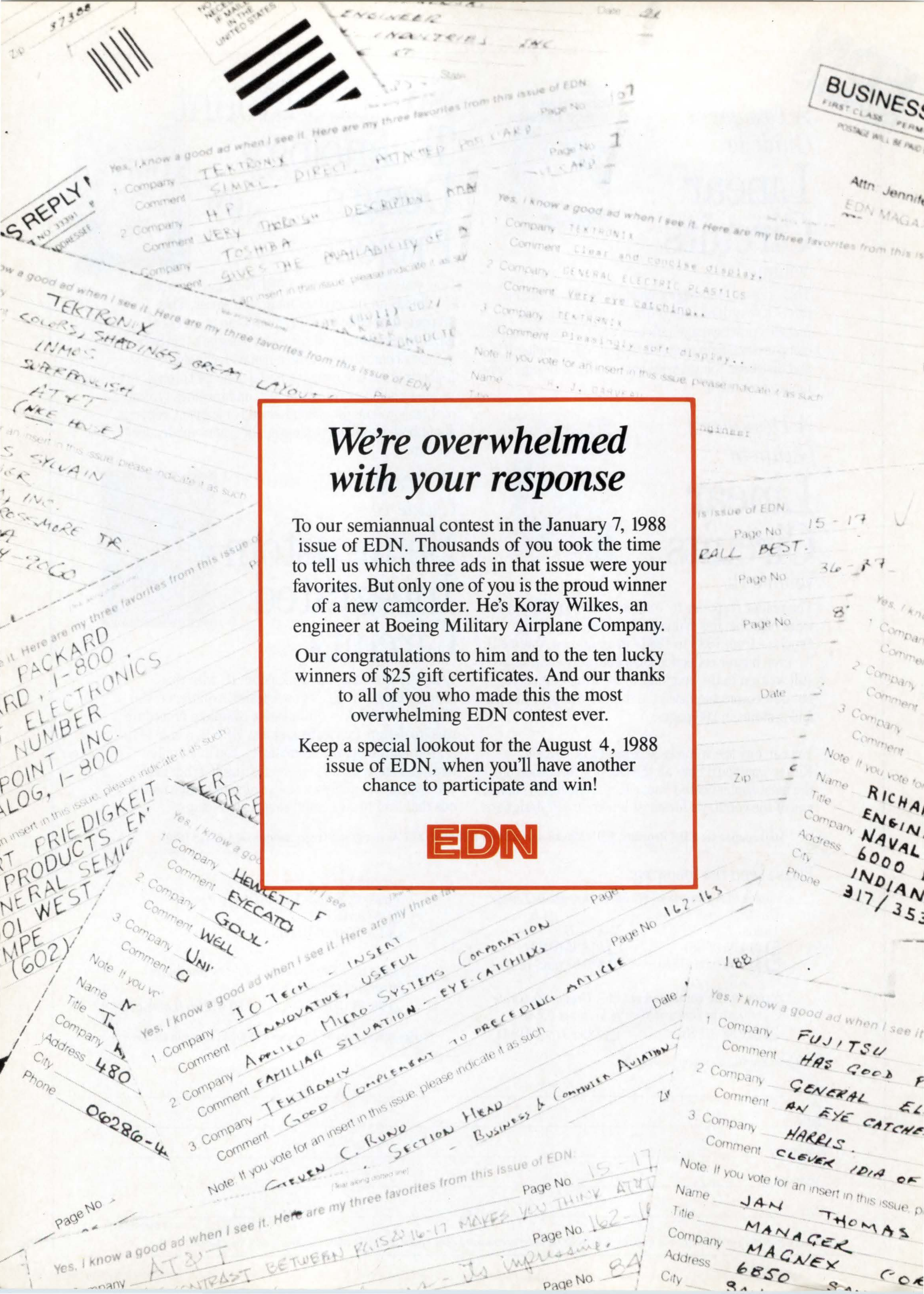

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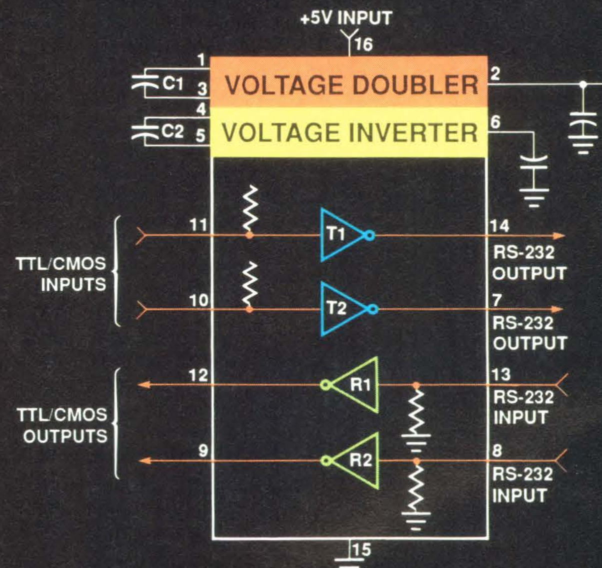

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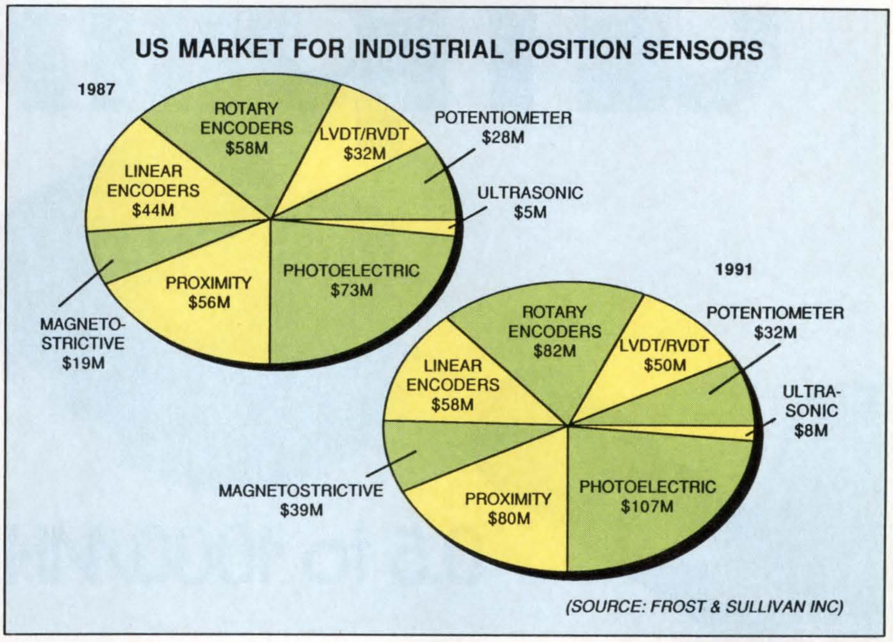
CIRCLE NO 155

EDITED BY CYNTHIA B RETTIG

US position-sensor market to grow steadily through '91

While different segments of the US market for industrial position sensors are expected to grow at strikingly varying rates over the next few years, the overall market prediction points to a healthy, steady growth through 1991, according to Frost & Sullivan (New York, NY). Last year, the US market grossed $315 million; by 1991, the total figure should reach $456 million. For onboard automotive sensors, the research data indicates that, in spite of declining sales for autos made in the US, this market segment will nevertheless grow because of expected increases in the sale of light trucks.



Magnetostrictive sensors are expected to boast an 18% average annual growth through 1991: Sales in that year are expected to reach $39 million, up close to 100% from the 1987 figure. This type of sensor takes advantage of the characteristic of some ferromagnetic materials (for example, iron, nickel, cobalt, and manganese) by changing size in response to a magnetic field. To date, the largest application for magnetostrictive sensors has been in electrohydraulic actuators, where the sensors can be embedded within the actuator piston for absolute-value positioning.

With primary uses in automated material handling and packaging machinery, photoelectric sensors should reach a total of $107 million in sales by 1991. Manufacturers are finding these devices useful not just in measuring proximity or displacement but also in counting and identifying. Photoelectric sensors can also transmit information to other systems by sending logic-level data via a modulating LED light beam.

Among the newer devices, ultrasonic sensors will rise rapidly in industrial applications, from $5 million in 1987 to $8 million at the end of the forecast period. Although their price tag—about $250 each in small quantities—remains a real deterrent for more general use, ultrasonic devices have some big advantages. Most important, devices based on that technology remain unaffected by harsh environments, where even photoelectric devices can falter.

Consider associated costs of nonimpact printers

The costs involved in owning a nonimpact printer include not only the price of the printer itself but also charges for service, consumables, paper, and electricity, advises CAP International Inc (Marshfield, MA). In fact, purchasers should consider specific applications as well as average monthly print volumes when trying to decide which kind of nonimpact printer suits their needs.

An analysis of the leading nonimpact printer types reveals four primary operating environments.

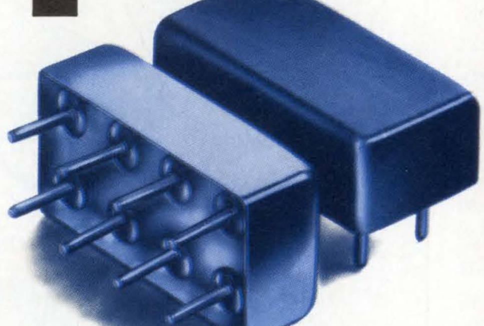
The first, the centralized data-processing facility, typically requires the production of more than 1M copies per month. Printers employed in such a facility run as fast or faster than 80 pages per minute and cost over $300,000.

The second primary operating environment, a distributed data-processing site, is linked to or controlled by a central facility. Generally, printers operating in such an environment produce 100,000 to 500,000 copies per month and operate at speeds between 35 and 80 pages per minute. They range in price from $15,000 to $140,000.

The third type of environment is an office cluster serving either a single department or a group that produces similar work. Nonimpact printers used in this environment produce between 5000 and 50,000 copies per month and run at speeds between 10 and 35 pages per minute. They cost between $3000 and $35,000.

The personal workstation that has five or fewer users is the final category of primary operating environment. A printer used as part of such a workstation produces between 5000 and 3000 copies per month and produces fewer than 10 pages per minute. Prices range from $1400 to $8000.

rugged plug-in amplifiers



0.5 to 1000MHz from $13.95 (5 to 24 qty)

Tough enough to meet full MIL-specs, capable of operating over a wide -55° to +100°C temperature range, in a rugged package...that's Mini-Circuits' new MAN-amplifier series. The MAN-amplifier's tiny package (only 0.4 by 0.8 by 0.25 in.) requires about the same pc board area as a TO-8 and can take tougher punishment with leads that won't break off. Models are unconditionally stable and available covering frequency ranges 0.5 to 500MHz and 0.5 to 1000MHz, and NF as low as 2.8dB.

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MAN-1	0.5-500	28	1.0	8	4.5	60	13.95
MAN-2	0.5-1000	19	1.5	7	6.0	85	15.95
MAN-1LN	0.5-500	28	1.0	8	2.8	60	15.95
◊MAN-1HLN	10-500	10	0.8	15	3.7	70	15.95

††Midband $10f_L$ to $f_{u/2}$, ± 0.5dB †1dB Gain Compression ◊Case Height 0.3 In.
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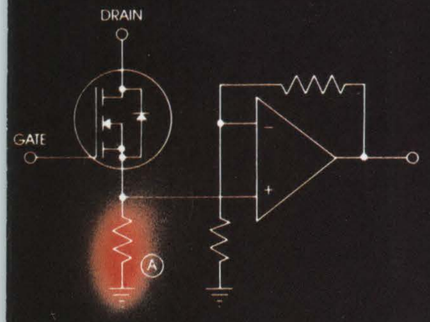
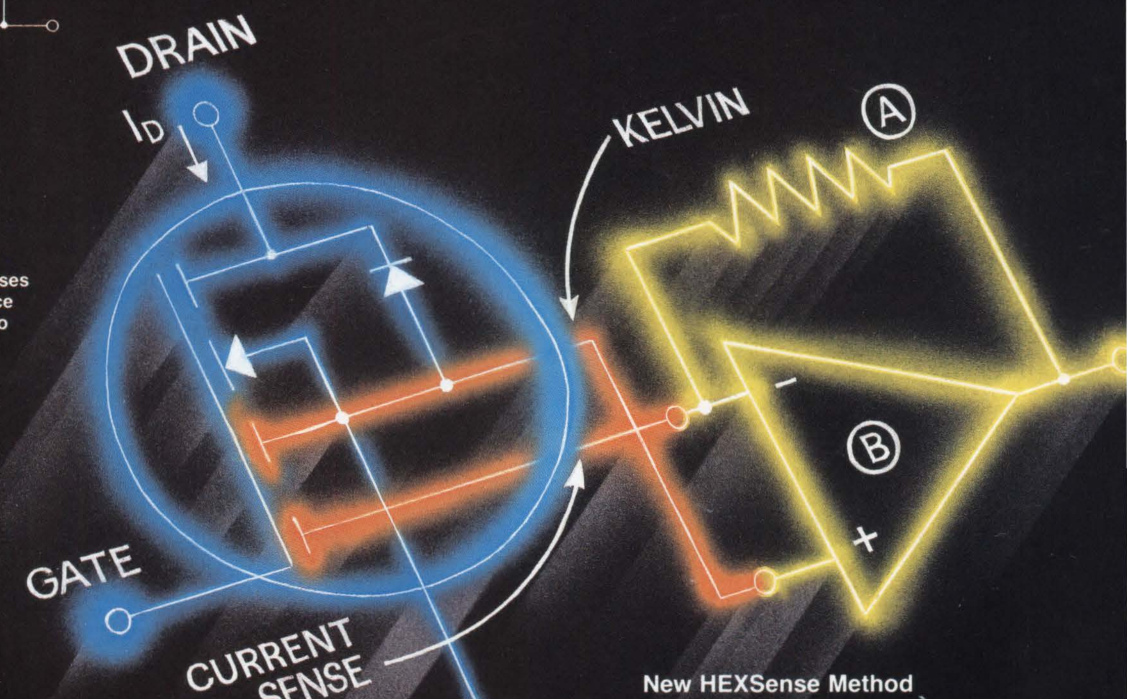


Old Method

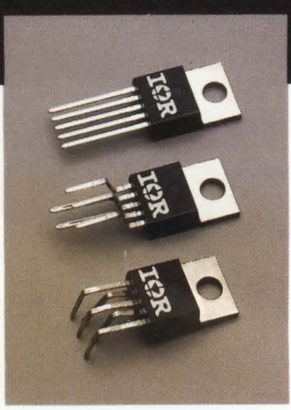
This circuit uses a fractional value resistor (A) to measure current, causing a voltage drop which increases power losses. Its parasitic inductance also slows down switching speed. To offset these losses, a lower $R_{DS(ON)}$ power MOSFET may be used, increasing circuit cost.



New HEXSense Method

In this simple, cost effective circuit the current-sensing output connects to a virtual ground. Resistor (A) establishes a voltage-to-current ratio. With the Kelvin connected to the non-inverting input of (B), a highly accurate current-sense results.

HEXSense offers 5-pin lead forms for vertical and horizontal pcb mounting.



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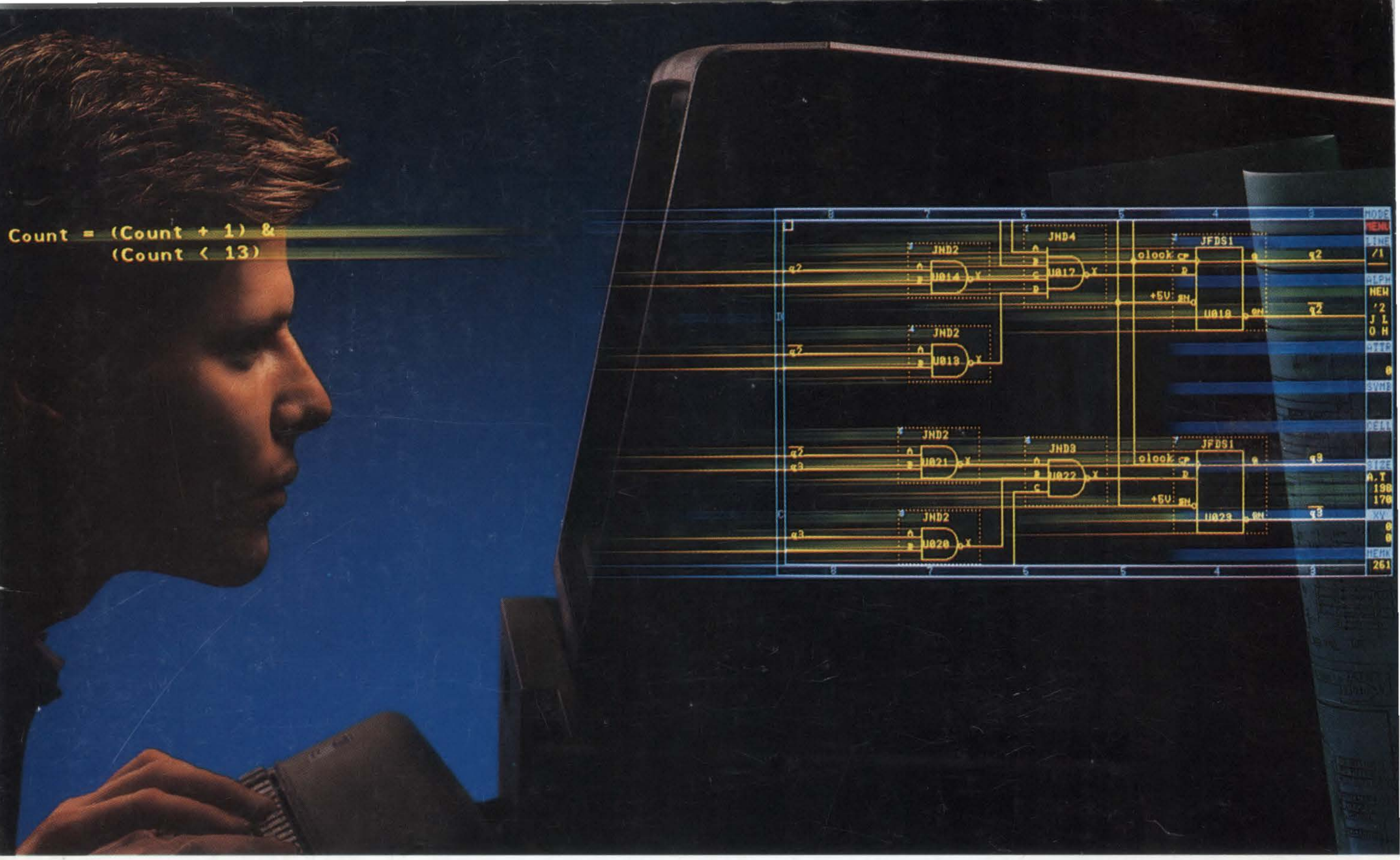

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