A CAHNERS PUBLICATION JULY 7, 1988

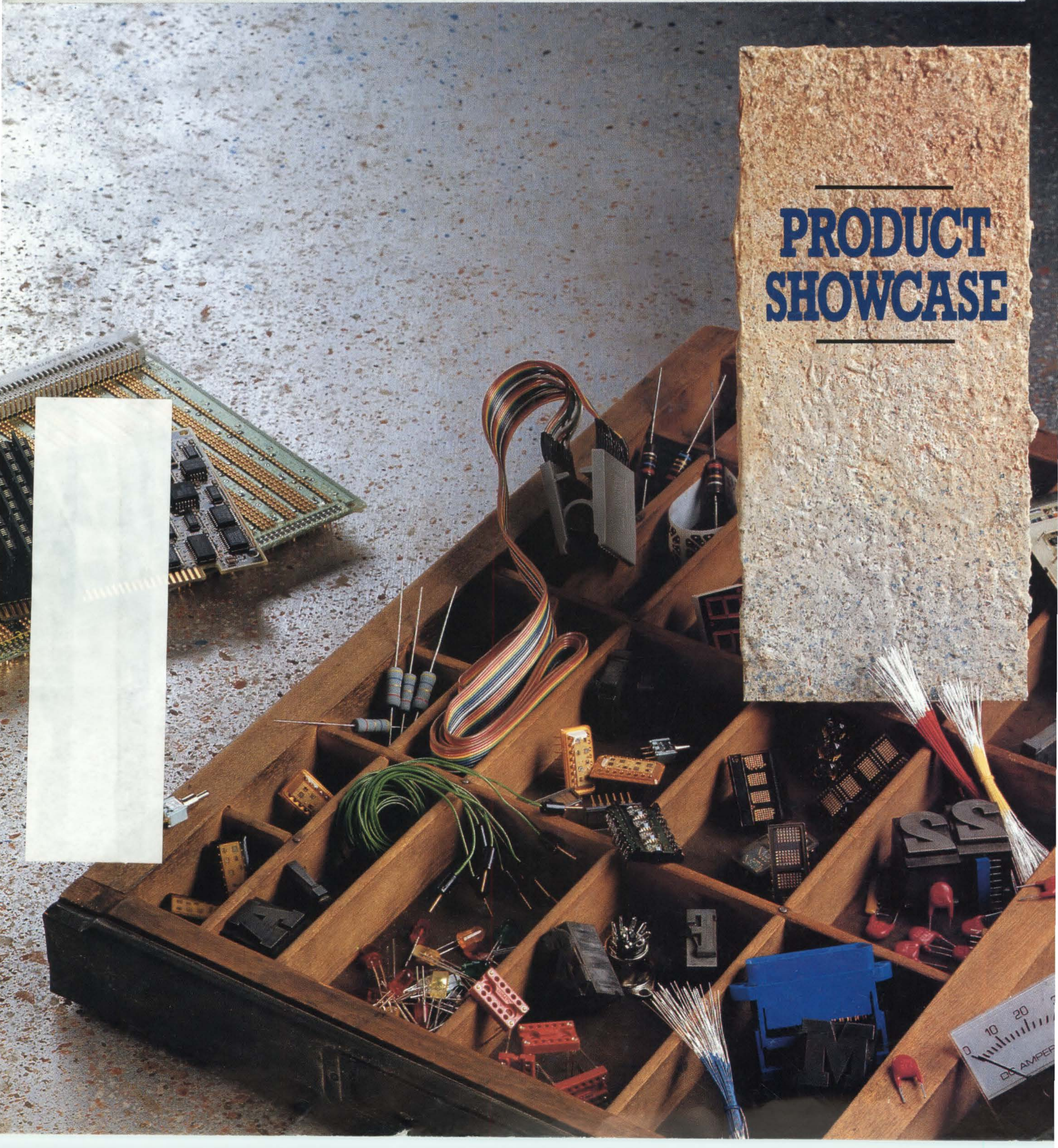
EDN®

SPECIAL ISSUE—Part 1
Product Showcase No 27

Highlighting key trends in power sources, software, integrated circuits, and hardware and interconnects

Expanded literature section

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



When World Class Precision and Performance Are Required

Highest precision available with 10 μV input offset voltage from Raytheon.

Raytheon's RC4077 Series high-precision op amp family offers the highest performance in the industry. Looking for the lowest input offset voltage—Raytheon has it. The lowest power dissipation—Raytheon has it. The 4077 Series can upgrade your system to new heights of precision and performance. You can depend on Raytheon's reliability and advanced design techniques to enhance your system.

☐ **Ultimate precision:** ± 10 μV maximum guaranteed input offset voltage, delivered in a variety of package types including low-cost commercial plastic DIPs, sets the RC4077 series apart from other precision op amps. No monolithic op amp—except noisy chopper-stabilized types—has better V_{OS} performance. Additionally Raytheon offers an 8-lead SOIC specified at ±25 μV.

☐ **Well balanced specs:**
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Gain: 5 million minimum
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☐ **Companion product:** Raytheon's LT1001 high-precision, high-performance op amp follows RC4077's lead with a very low 15 μV offset voltage. The LT1001 offers 2 nA offset current and gain of .45 million minimum.

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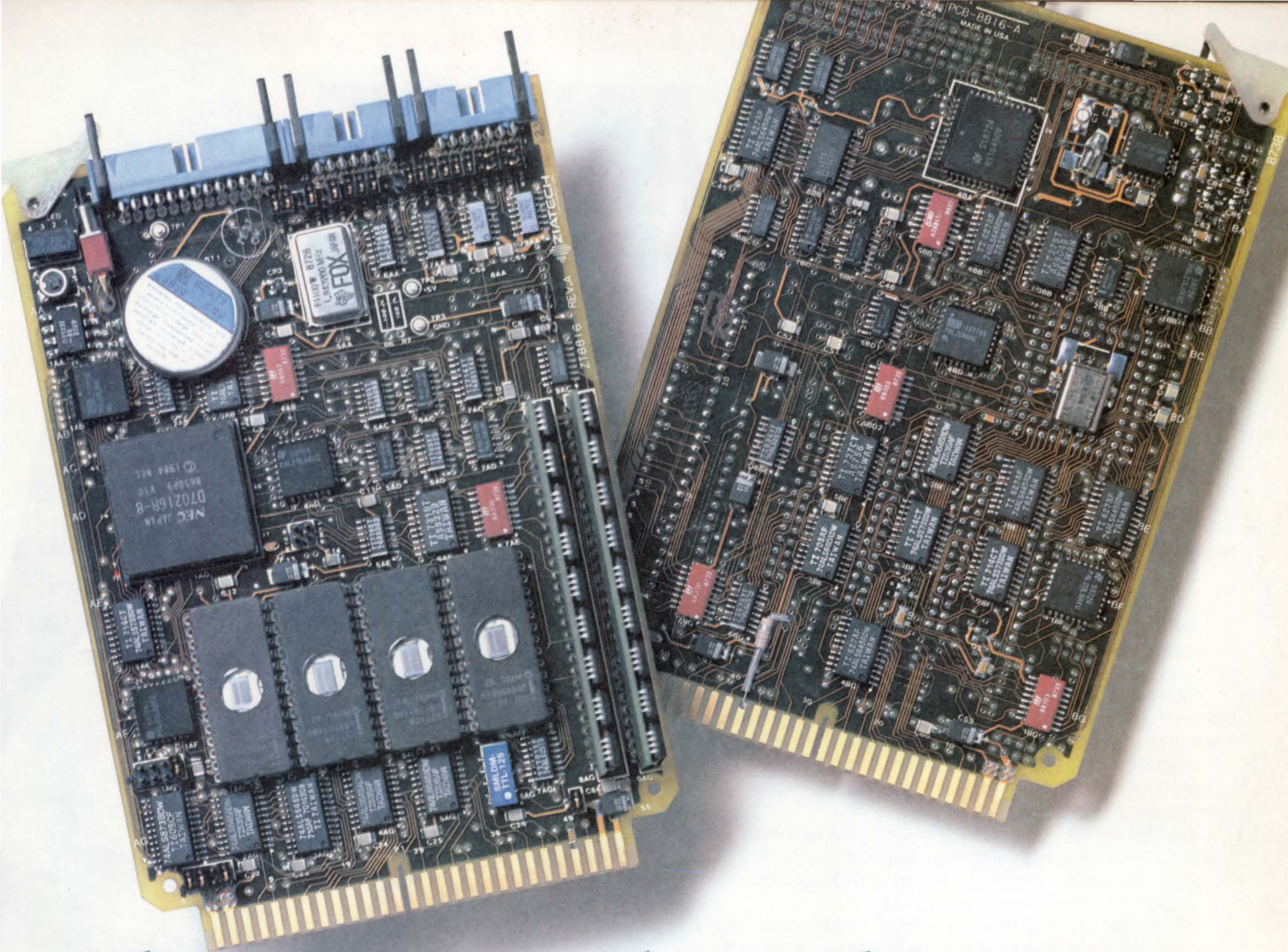
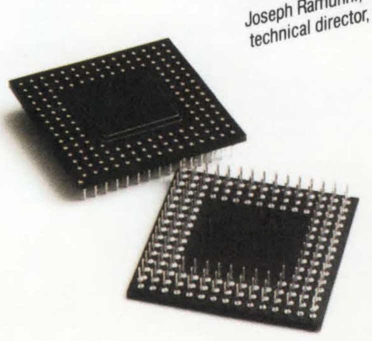
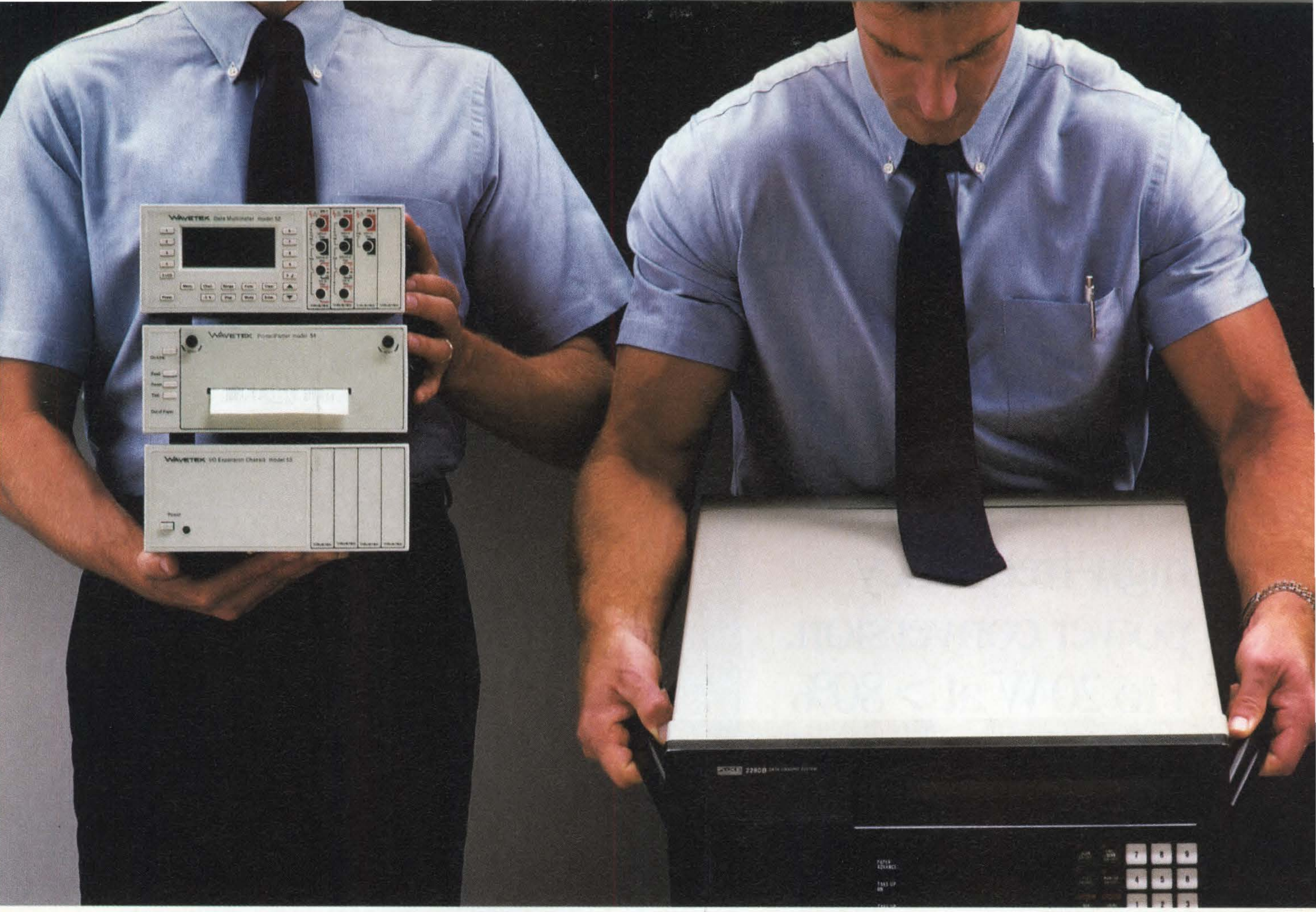


Joseph Ramunni, chairman (left), and Jack Regula, technical director, VME Technology Consortium.





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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.

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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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CIRCLE 197 FOR LITERATURE CIRCLE 198 FOR DEMONSTRATION

Volume 33, Number 14

EDN

July 7, 1988

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

On the cover: *Part 1 of EDN's Product Showcase No 27 puts products in their places. Staff-written articles lead off each product section and cover various topics: the advantages of using current-feedback op amps (pg 84); high-power supplies and the question of efficiency (pg 162); design considerations in the use of multilayer backplanes (pg 208); and the need for cross-development software tools (pg 252). (Photography by Dana Sigall; art direction by Kathleen Ruhl)*

DESIGN FEATURES

Continued on page 7

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VBPA ABP

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The Fluke 37. A bold new shape emerges with more features for the money than any other bench DMM. Period.

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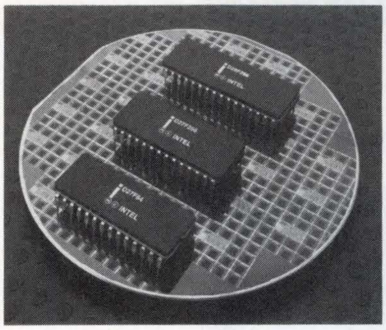

***Product coverage** in this issue begins with a review of ICs and semiconductors (pg 100). Coverage continues with reviews of power sources (pg 174), hardware and interconnect devices (pg 219), and software (pg 260).*

PRODUCT UPDATE

PRODUCT REVIEWS

DESIGN IDEAS

LITERATURE

Continued on page 9

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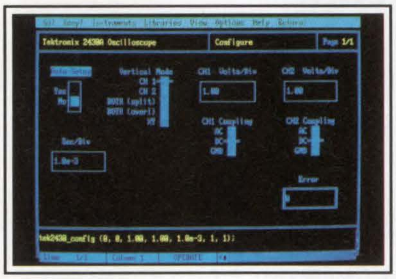
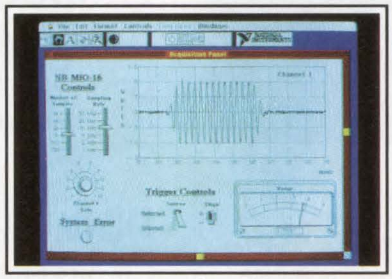
Acquisition

Integrated libraries for GPIB, RS-232, A/D-D/A-DIO plug-in cards, and modular instruments.



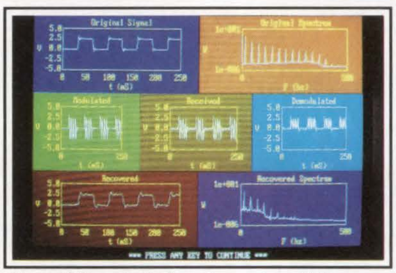
Intuitive character-based function panels that automatically generate source code.



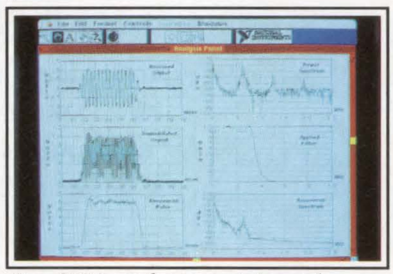
Front panel user interface with virtual instrument block diagram programming.

Analysis

Extensive libraries for data reduction, digital signal processing, and statistical analysis.



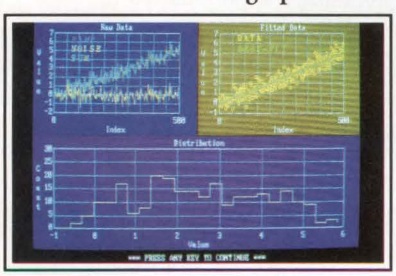
Over 100 analysis functions plus all the built-in functions of your language.



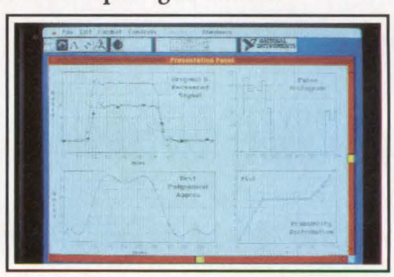
Over 250 icons for computation and analysis.

Presentation

Flexible high-performance graphics and report generation.



Extensive graphics support for CGA, EGA, MCGA, VGA, and Hercules.



Macintosh Desktop Publishing compatibility.

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Continued from page 7

EDITORIAL 59

Another computer myth—that of the paperless office—finally comes to an end.

PROFESSIONAL ISSUES 301

How two engineers built—and nearly lost—their business.—*Deborah Asbrand, Associate Editor*

LOOKING AHEAD 315

Electronic still imaging to gross $540M in 1992. . . Demand for T3 test devices is expected to boom.

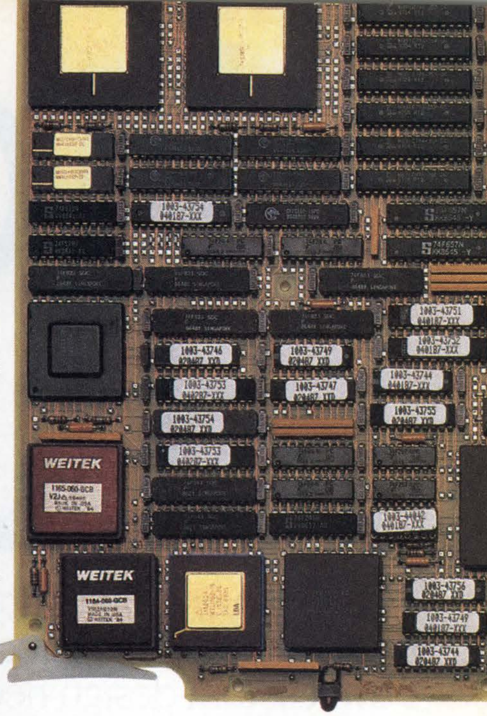
DEPARTMENTS

A product-oriented design aid

To save you time in your efforts to keep current, EDN's editors have surveyed the new-product offerings from thousands of companies, screening and selecting only the most significant of those offerings introduced in the last six months. We present our findings—the best of the best—in a format devised to make your product selection as easy as possible. You can keep this Product Showcase as a reference until the next one that covers these four key product areas appears in December.

This year, you'll hear a lot of claims that "systems" design automation has arrived.

At Mentor Graphics, we know better. And so do our customers.



This 32-bit processor board was designed and simulated on Mentor Graphics workstations by Sequent Computer Systems for its multi-processor Symmetry computer system. It contains over 175 IC components including 80386 processors, a 14,000-gate standard cell and two 10,000-gate arrays. By simulating at the board level, Sequent was able to bypass breadboarding and proceed directly to fabrication prototype.

Skeptical about "systems" electronic design automation?

You should be. Because in many cases, it's a triumph of form over content. Look behind the facade of so-called "systems" design automation tools, and you'll find little substance, if any.

Buy into this kind of systems design methodology, and you're participating in a very costly experiment. With highly uncertain results.

They preach. We practice.

There's only one practical yardstick for evaluating a systems design solution. And that's how many successful products it has produced. Apply this measure and the field narrows dramatically. Essentially, down to a single vendor.

Mentor Graphics.

For over five years, our customers have been turning out sophisticated board products with our EDA tool set. Repeatedly.

Test their claims.

Some interesting (and essential) questions you should ask potential EDA vendors:

Does your tool set have a common database and user interface? Does it extend from design definition through completed PCB layout?

Does your workstation lead the industry in ASIC library support? Can you include ASICs in board simulations?

Can your tools manage 1000-page product documentation projects? Have you integrated mechanical packaging and analysis into the electronic design and layout process?

Anything less than a perfect score is a total loss. Perfect means each item must be backed with the production-proven performance only Mentor Graphics can provide.

Experience makes the difference.

When we speak about systems design automation, we speak from experience. We have the largest customer base in the industry, and with good reason. Over 70 % are repeat customers who've realized genuine value added from our products and seek to expand their competitive advantage.

To be continued.

So much for the present. We're already developing new EDA tools for systems design that will extend to every dimension of electronic product development. From high-level systems descriptions to CASE. It's what our customers expect. It's what we'll deliver.

It's all part of a vision unique to Mentor Graphics, the leader in electronic design automation. Let us show you where this vision can take you.

Call us toll-free for an overview brochure and the number of your nearest sales office.

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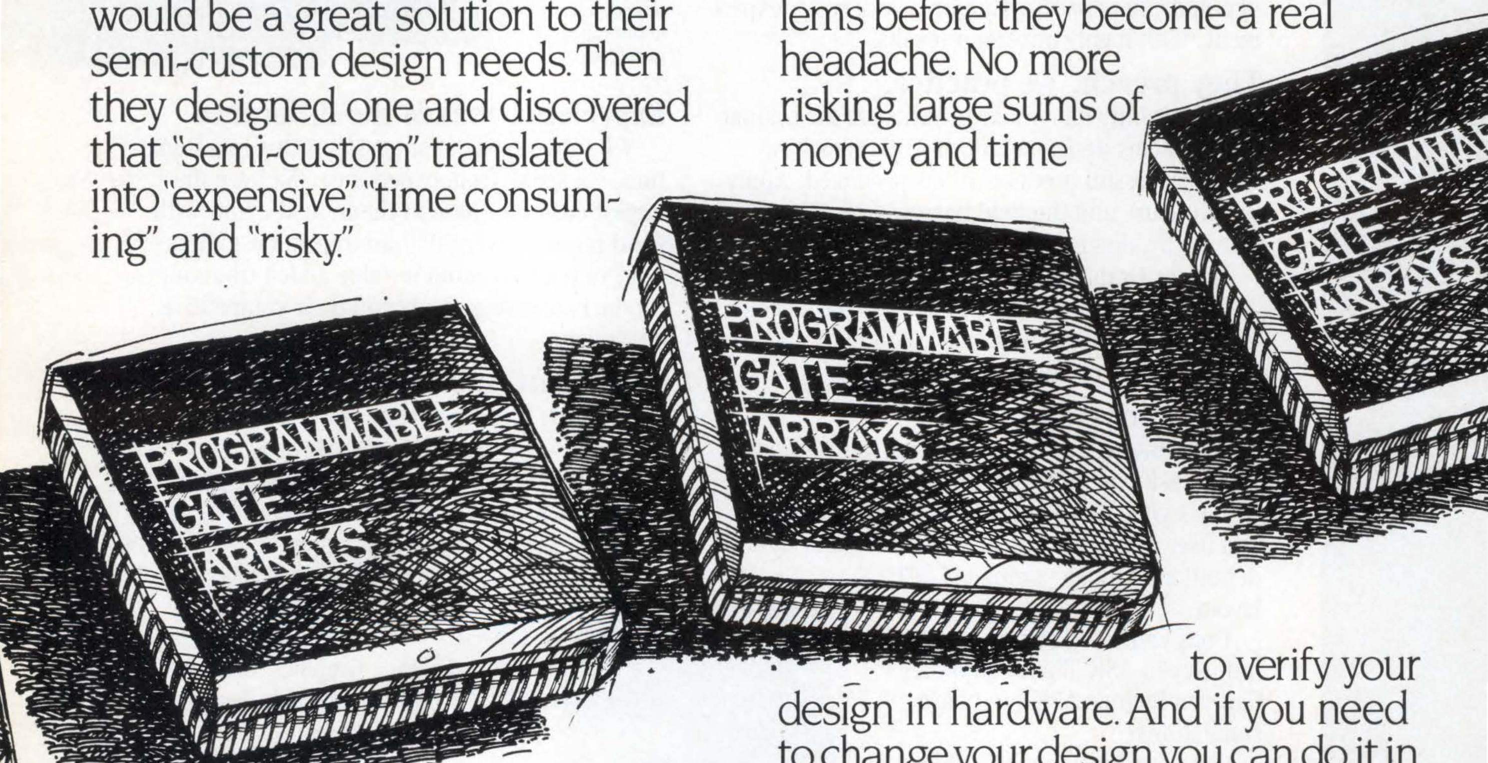
PGAs let you spot system problems before they become a real headache. No more risking large sums of money and time



to verify your design in hardware. And if you need to change your design you can do it in a matter of minutes. Not months. And you won't have to spend any more money.

The solution to the solution.

Meet the Logic Cell™ Array— the first Programmable Gate Array. It's a high density CMOS chip of unmatched technology that's user programmable where it's easiest for you to program—in software.

Your development cycle is cut to a week or two instead of six months. So you can get your product to market that much sooner.

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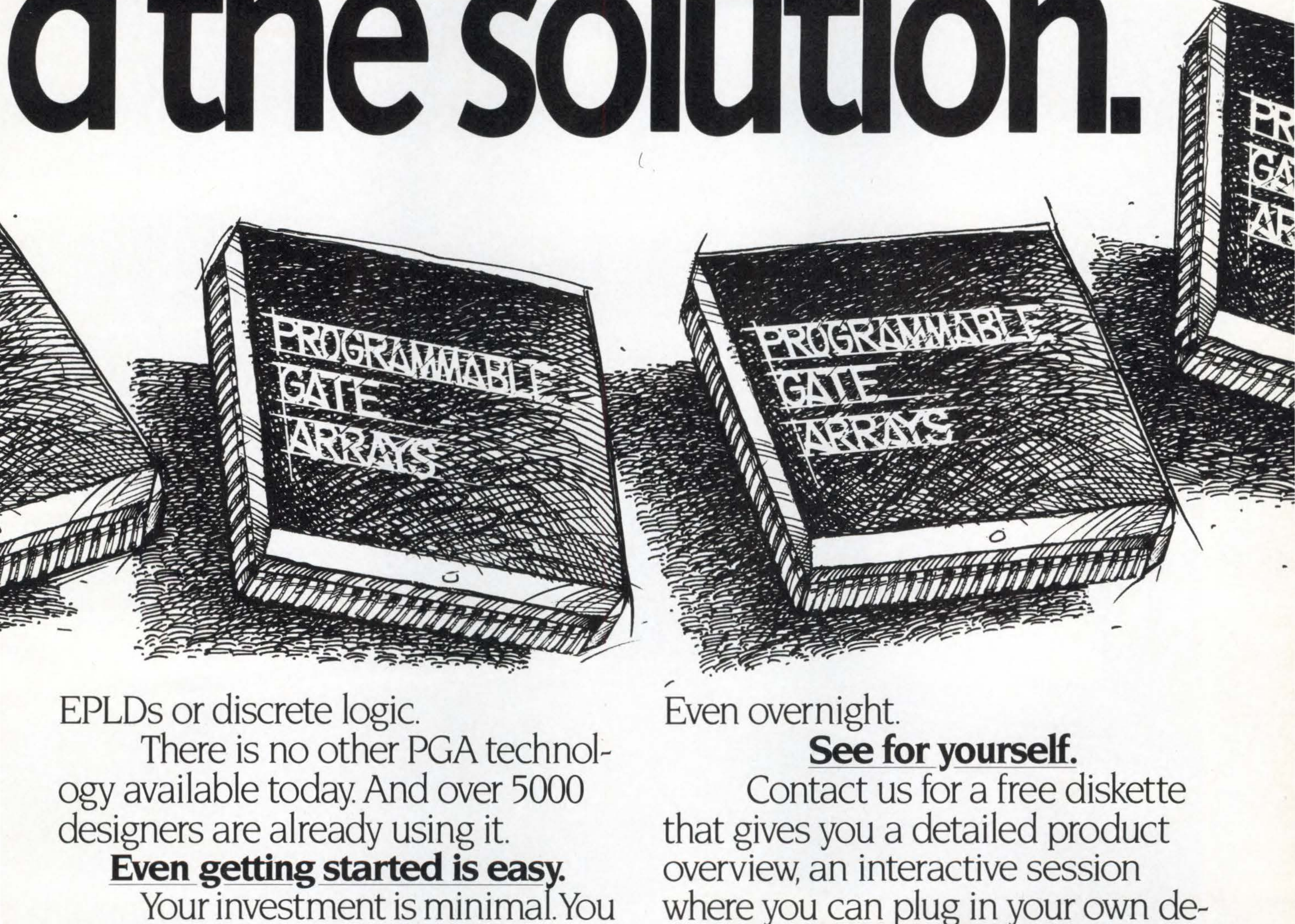
The Am2000 series has densities from 1000 to 2000 usable gates and the Am3000 series has densities from 2000 to 9000 usable gates. With those densities (we'll have even higher densities later), you need fewer parts to get the same functions as

ve the problem, d the solution.



EPLDs or discrete logic.

There is no other PGA technology available today. And over 5000 designers are already using it.

Even getting started is easy.

Your investment is minimal. You don't have to finance months of NRE. You can get started for the price of a PC (which you probably already have) and some software.

PGAs are the epitome of the just-in-time product. They are the only gate arrays stocked in production quantities at your distributor. And they're programmable instantly. Which means you can go from design to production as fast as you need to. Even overnight.

See for yourself.

Contact us for a free diskette that gives you a detailed product overview, an interactive session where you can plug in your own design criteria and find out how PGAs can help your design. Part of the PGA development software is included so you can get started saving time and money right away.

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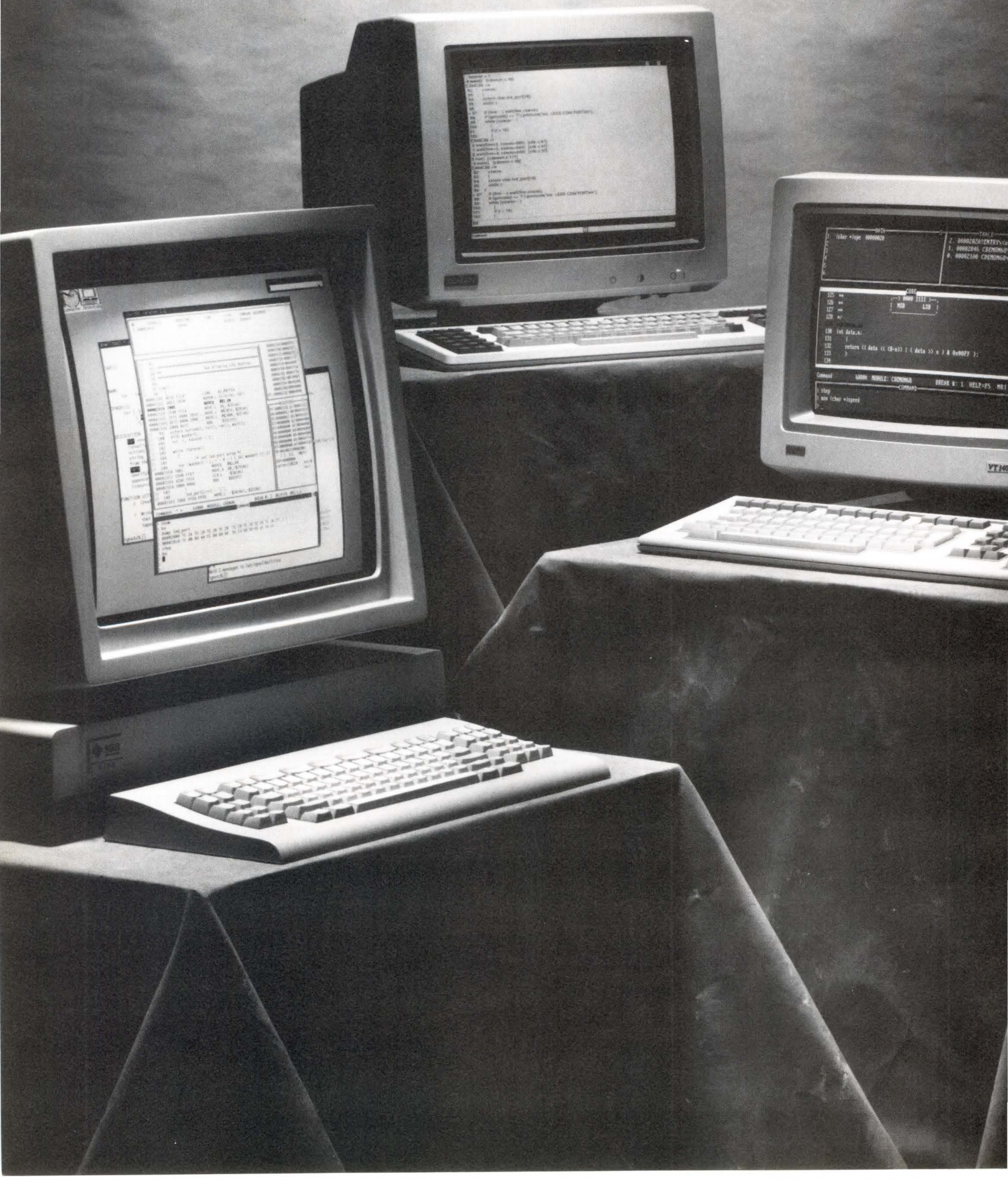
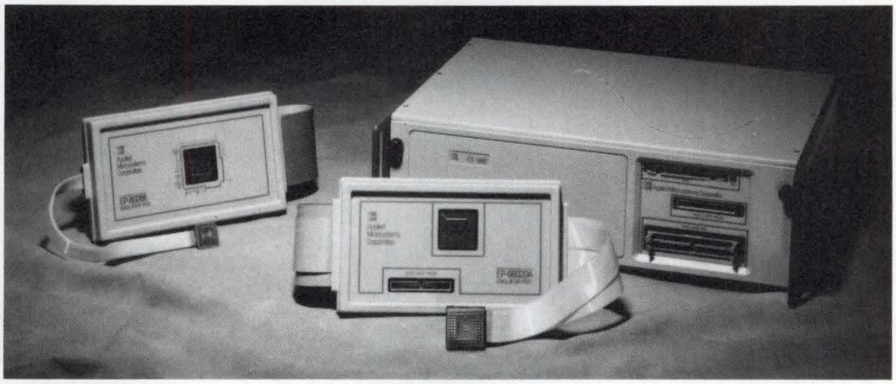


The highest performance development tools.



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VAX MicroVAX Apollo Sun PC PC XT PC AT PC Compatibles	VMS ULTRIX UNIX® MS-DOS	**Intel:** 8048 family, 8051 family 8080, 8085, 8086/8, 80186/188 and 80286 **Motorola:** 68HC11, 6800/2/8, 6809/9E, 68000/08/10 and 68020 **Zilog:** Z80, Z80H, MK 3880/4 and Z8001/2 **NSC:** NSC 800 **Hitachi:** 64180	**C** **Pascal** **FORTRAN** **PL/M** **Assembler** **Jovial** **ADA (VERDIX)**	Compilers Assemblers Linkers Locators	**ES 1800** (16 & 32-bit) **EC 7000** (8-bit microcontrollers) **EM Series and** **EL 800** (8-bit microprocessors)	**VALIDATE** and other software products for source and symbolic debugging

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The intelligent answer for small system control problems

The raccoon has a remarkable ability to thrive in any type of environment. His sheer intelligence and ingenuity let him adapt to whatever circumstances he may find, and prosper with only minimal resources at hand.

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*This **new generation** of 4-bit micros is a far cry from the old 4- or 8-bit designs you're used to.* They execute efficient 10-bit instructions in as little as 0.89μs, and include powerful on-chip peripherals such as large EPROMs, LCD and vacuum fluorescent drives, and multiple serial interfaces.

For example, our new HD4074408 has an 8K one-time-programmable EPROM, a 512 x 4 bit RAM, 58 I/O lines, comparator inputs, PWM timer outputs and serial interfaces—all in a plastic package. Future devices will include A/D converters, phase locked-loop circuitry, DTMF generators, and much more.

Most importantly, Hitachi's ZTAT™ technology gives you Zero Turn-Around Time. The on-board one-time user-programmable EPROM eliminates the need to wait three or four months for mask ROM devices. The very *day* you finish development, ZTAT gets you into production. And, you can implement software changes *immediately*, to stay one step ahead of everyone else.

Put all of Hitachi's HMCS400 series resources to work for you: Ceramic windowed devices for deve-

lopment, ZTAT devices for pilot and small-scale production, and mask ROM devices for large-scale production. And, a full complement of development support tools is available for use with IBM-PC*, DEC VAX*, and Hitachi systems.

Plus, when you consider all the on-chip integration, you also get the lowest-cost solution for your design. The packaging is one of the reasons why ZTAT only costs slightly more than mask ROM microcontrollers, and is a lot cheaper than ceramic reprogrammable devices.

Clearly, Hitachi's HMCS400 series is right for a broad range of today's small systems applications in automotive, consumer, handheld instrumentation, telecom, and industrial products.

There's no need to wait. Hitachi is delivering the 4-bit all-CMOS HMCS400 series *right now*—including EPROM-on-chip ZTAT devices. For more information, call your local Hitachi Sales Representative or Distributor Sales Office today.

Literature Fast Action: For product literature only, CALL TOLL FREE, 1-800-842-9000, Ext. 6809. Ask for literature number #SB-106.

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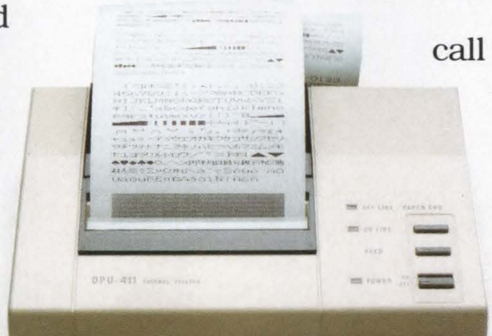
And thanks to its small size and rechargeable battery back-up, it's completely portable. In fact, at a featherweight 2.2 pounds, you can take it wherever you need a small, ultra-quiet printer.

With both RS232C and Centronics 8-bit parallel interfaces standard, the DPU-411 will fit easily into your system. And you can print either a standard 40 column or condensed 80 column line.



Of course, like all Seiko printers, it's manufactured for a long life.

What's more, the only maintenance you'll ever need to perform is putting in new paper. Which means it won't create any noise from people yelling about messy ribbons or upkeep.

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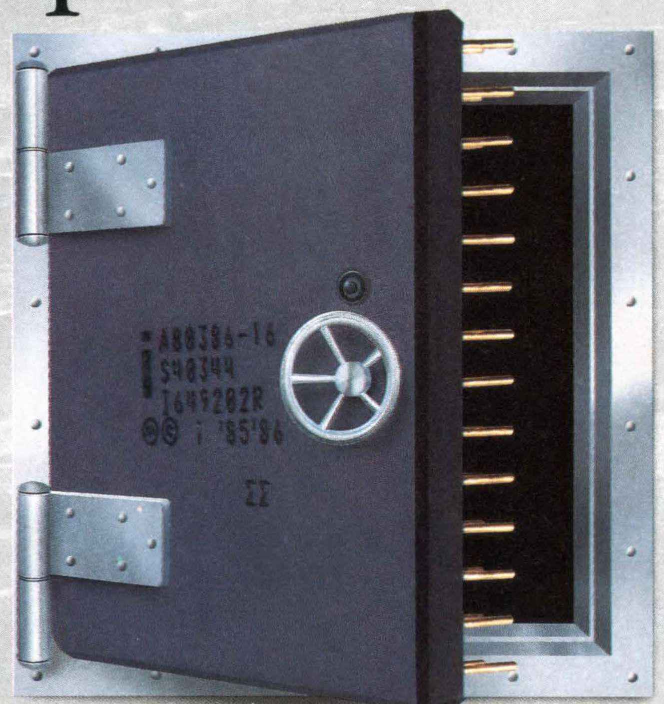

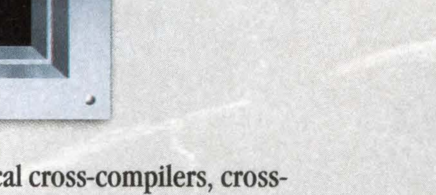

EDITED BY JOANNE CLAY

ISDN TRANSCEIVER ICs EXCEED ANSI SPECS

The MC145474 and MC145475 CMOS single-chip ISDN transceiver ICs have passed CCITT and ANSI conformance testing, and are available in sample quantities from Motorola Inc (Austin, TX, (512) 928-7944). These transceivers offer multiframing S- and Q-channel operation and maintenance-signaling channels. An adaptive receiver circuit automatically selects the optimum sampling phase and detection threshold of incoming signals, thereby permitting both devices to double the point-to-point range required by ISDN's I.430 specification. The 28-pin MC145475 is suitable for use in an NT1 Star bus configuration. The 22-pin MC145474 costs $17 (1000), and the MC145475 sells for $18 (1000).

Both chips come with selectable NT and TE modes for both line-card and terminal applications. An Interchip Digital Link (IDL) interface lets these devices exchange B- and D-channel information among a variety of ISDN components and systems. Other features include loop-back support, activation and deactivation functions, extended-range operation, and a line driver that can tolerate a 1:1 transformer ratio without the need for complex protection circuitry.—J D Mosley

12-BIT A/D CONVERTER MOVES ONTO ASIC

Sierra Semiconductor (San Jose, CA, (408) 263-9300) now offers a standard cell for an A/D converter (ADC) that can resolve 12 bits. The ADC12B is a 12-bit-plus-sign, dual-slope integrating ADC standard cell for the company's CMOS-based analog/digital ASICs. The ADC12B is similar to the standard 7109 ADC; it can resolve a minimum of 50 μV and has a typical conversion rate of 10 conversions/sec. The device requires 1.5 mA in active mode and 1 μA in power-down mode. The ADC12B is the newest member of a cell library that contains 50 analog cells, 300 digital cells, and 20 EEPROM cells.
—David Shear

THREE VENDORS OFFER TRANSLATORS FOR GENRAD 179X PROGRAMS

The news that ATE vendor GenRad Inc (Concord, MA, (617) 369-4400) will no longer be producing the 179X series of board-test systems has prompted announcements by two of the firm's competitors as well as by GenRad itself. Both Teradyne Inc (Boston, MA, (617) 482-2700) and Schlumberger Technologies (San Jose, CA, (408) 998-0123) now offer facilities that permit users of the GenRad systems to migrate to other testers without compromising their investment in board-test programs and fixtures. That ability is particularly important to defense-electronics manufacturers and armed-forces repair depots, because they deal with assemblies whose life cycles are longer than those of most commercial products.

Teradyne's 179X/L200 Program Translator, which starts at $25,000, creates programs that run on the company's L200 test systems. These programs support go/no-go testing and guided-probe fault diagnosis; an option converts the programs to the format of Teradyne's Lasar Version 6 simulator. Schlumberger's CAPS/ITG, which adapts programs to run on the firm's 700 Series testers, includes similar capabilites. In addition, Schlumberger offers an adapter that lets you use 179X test fixtures on the 700 Series. Including the hardware adapter, CAPS/ITG for the 179X costs under $50,000. Meanwhile, GenRad continues to support the 179X Series in several ways. The company supplies spare parts and maintenance service for the testers. It has also refurbished used systems and furnished them to customers who wanted to expand capacity without migrating to different equipment, and it may continue to offer that service depending on the availability of used machines. Finally, the company offers software (priced from $5000) and fixture adapters to let you run 179X Series programs on the newer 2750 Series.—Dan Strassberg

MONOLITHIC BUFFER AMPLIFIER ACHIEVES 730-MHz BANDWIDTH

The CLC110 unity-gain buffer amplifier from Comlinear Corp (Fort Collins, CO, (303) 226-0500) features a −3-dB bandwidth of 730 MHz with a guaranteed gain flatness of better than 1 dB from dc to 200 MHz. It thus allows you to buffer very-high-frequency signals in circuits such as phase-locked loops and flash A/D converters. At dc, the device exhibits a maximum output offset voltage of 13 mV. Packaged in an 8-pin plastic DIP, the commercial version of the device (the CLC110AJP) costs $15.50 (100).

—Steven H Leibson

SHORT-DISTANCE OPTICAL LINK CARRIES THREE 40-MHz ANALOG SIGNALS

A 3-channel, fiber-optic transmission system from Molex Inc (Lisle, IL, (312) 969-4550) accommodates analog signals with frequencies of 40 Hz to 40 MHz over as much as 5m of cable. Inputs require full-scale drive currents of 30 mA p-p, which produce an output signal of 108 mV p-p riding on a 3.3V dc offset. A 3-channel system, including transmitters, receivers, and a terminated 2m cable assembly, costs $98.

—Steven H Leibson

1-μm CHIP FAMILY IS FASTEST ECL TECHNOLOGY AVAILABLE

A new family of ICs that implement standard logic functions represents the fastest ECL technology available, according to Sony Corp of America's Component Products Div (Cypress, CA). Introduced at the Electro show in Boston (May 10 through May 12, 1988), the ECL chips feature 1-μm geometry, 60-psec gate delays, and 4-GHz operation, which rivals the speed of GaAs devices. The 24 initial offerings cost from $40 to $70 (1000). They come in metal flat packs; more economical versions in plastic leaded chip carriers will be available soon. All the functions are derived from a 200-gate chip that will become available in August as a product for custom digital applications. For linear-ASIC applications, the company will introduce an ECL-technology analog array in October 1988. The array includes 3-GHz npn transistors and 350-MHz vertical pnp transistors.—Tarlton Fleming

SCSI-CONTROLLER CHIP INTERFACES DIRECTLY TO PC BUS

The 53C400 SCSI controller from NCR Microelectronics Div (Colorado Springs, CO, (800) 334-5454) comprises bus-interface circuitry, two 128-byte RAM buffers, address-decode and interrupt logic, and a 53C80 core cell with high-current SCSI-bus drivers. The controller interfaces directly to IBM's PC, PC/AT, and PS/2 buses. The $13.51 (1000) chip performs SCSI-bus transfers at greater than 2M bytes/sec and accomplishes PC-bus burst transfers at 1M byte/sec.—Steven H Leibson

CLAMPING AMPLIFIER GUARDS A/D CONVERTERS FROM OVERLOAD

You can protect circuits from off-scale voltage excursions with the $17.10 (100) CLC501 clamping op amp. The high-speed device features a −3-dB bandwidth of 80 MHz (at a gain of 32), but unlike conventional op amps, it includes two extra clamping-voltage inputs, V_H and V_L, that you can use to confine its output between two voltage levels. One possible way to apply the part would be to use it as a residue amplifier in a 2-stage, subranging A/D-conversion system. The op amp's clamping action protects the second-stage A/D converter from overload damage. In addition, the CLC501 speeds up the subranging A/D-conversion system's recovery rate from overloads, because the op amp recovers more quickly than an A/D converter (the op amp typically recovers in 1 nsec).—Steven H Leibson

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CIRCLE NO 27

NEWS BREAKS: INTERNATIONAL

DELTA CODEC MEETS MILITARY COMMUNICATIONS REQUIREMENTS

Meeting the requirements of the Eurocom D1-IA8 specification, the FX619 single-chip CVSD (continuously variable slope delta) codec is suitable for use in a variety of military communications equipment. The device is manufactured by Consumer Microcircuits Ltd (Witham, UK, TLX 99382; in the US: Mx-Com Inc, Winston-Salem, NC, (919) 744-5050). It operates in full-duplex mode, and it includes input and output audio filters. An on-chip oscillator clocks the device's on-chip switched-capacitor filters and its CVSD modulator and demodulator. The oscillator accepts a crystal or an external clock input.

You can program the device's sampling rate to 16k, 32k, or 64k bps. The chip provides clock outputs so that you can synchronize external circuitry to the codec. Other programmable features include an encoder-enable/disable facility, encoder/decoder idle modes, 3- or 4-bit companding algorithms, and a low-power standby mode. The FX619 is a CMOS device that operates from a single 5V supply and is available in a 22-pin DIP or a 28-lead surface-mount package. The company expects to sell the chip for less than £20 (1000).—Peter Harold

X.25 COMMUNICATIONS CARD IMPLEMENTS OSI LAYERS 1 TO 3

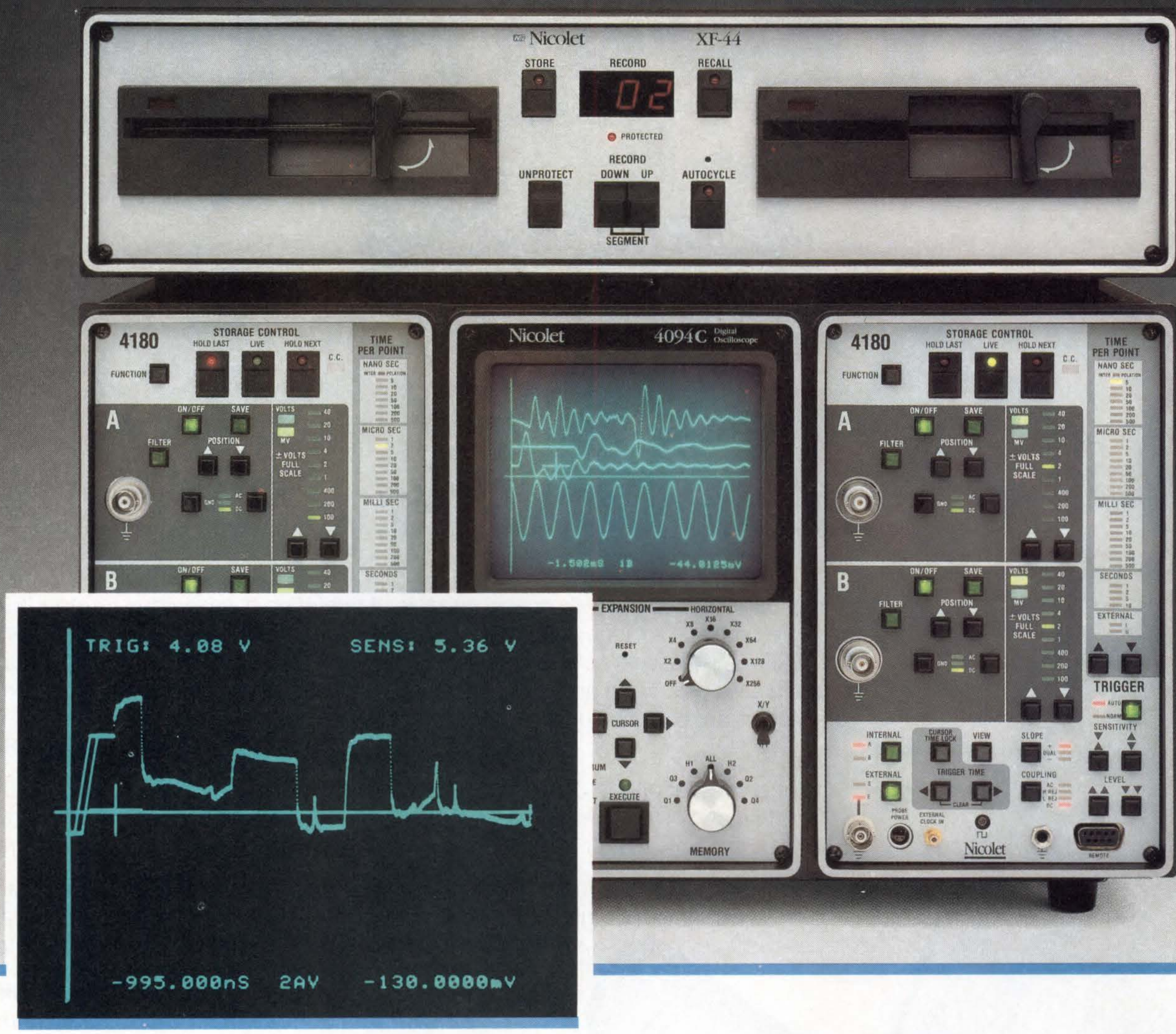
Simplifying the software that you have to write during systems integration, the $3675 CC-125 VME Bus X.25 communications card conforms to the X.213 specification for communication to layer-4 functions of the OSI model. The card, which is available from Compcontrol (Eindhoven, The Netherlands, TLX 51603; in the US: Los Gatos, CA (408) 356-3817), implements layers 1 to 3 of the OSI model.

Layer 1 operates in accordance with the X.21 bis (V.24/V.28) standard, and layer 2 conforms to the LAPB (link access procedures balanced) protocol standard. The board's layer-3 software handles the X.25 packet-level protocol and imposes flow control to prevent the communications link from overloading. Messages are passed between the CC-125 and the VME Bus system's layer-4 functions via dual-port RAM on the CC-125. The messages, coded according to X.409 recommendations, are transferred to the dual-port RAM in the form of network-service data units that can be as long as 4k bytes. The 68000-based board is suitable for transmitting packet-switched data over public or private data networks at bit rates as high as 64k bps.—Peter Harold

MODULE PUTS IBM PC/AT-COMPATIBLE COMPUTER IN VME BUS SYSTEMS

The $2500 PX4000 VME Bus module from Philips' Industrial and Electroacoustic Systems Div (Eindhoven, The Netherlands, TLX 35000; in the US: (201) 529-3800) allows you to implement an IBM PC/AT-compatible computer in VME Bus systems. The 2-board sandwich runs an 80286 μP and an optional 80287 math coprocessor at 8 MHz. It includes all the ports you'd expect to find on a standard PC/AT (for example, keyboard, monitor, printer, and floppy-disk interfaces), and it runs the MS-DOS operating system. However, the module's video output provides CGA-compatible color graphics as a standard feature. In addition to accessing the board's 512k bytes of on-board dynamic RAM, processor and DMA channels can transparently access additional memory via the VME Bus. If you use the μP's protected-addressing mode, the μP can access as much as 16M bytes of memory. The onboard RAM is also accessible to other VME Bus masters. A hard-disk-controller board that operates in conjunction with the PX4000 is also available.—Peter Harold

Flexible Triggering An Issue?



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Flexibility — With Nicolet's 4180 plug-in and 4094C Digital Storage Oscilloscope, you can take the guesswork out of triggering. The Trigger View feature gives you a graphic representation of trigger slope, level and sensitivity superimposed on the actual trigger input signal. What this means for you is easy and accurate trigger setting. Using the 4094C with two 4180's allows four input channels with each two-channel plug-in having its own independent time base and trigger settings. That's flexibility!

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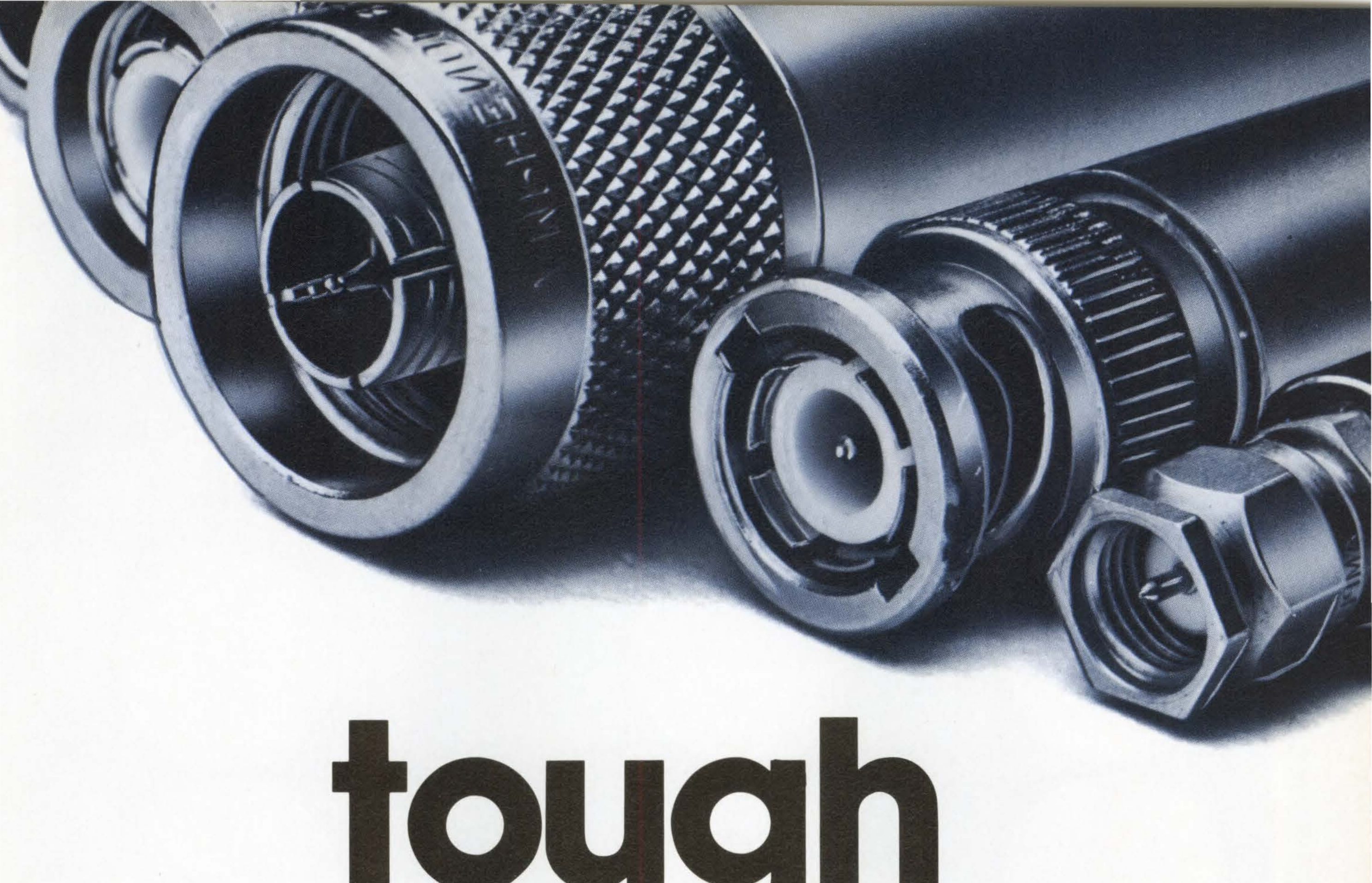

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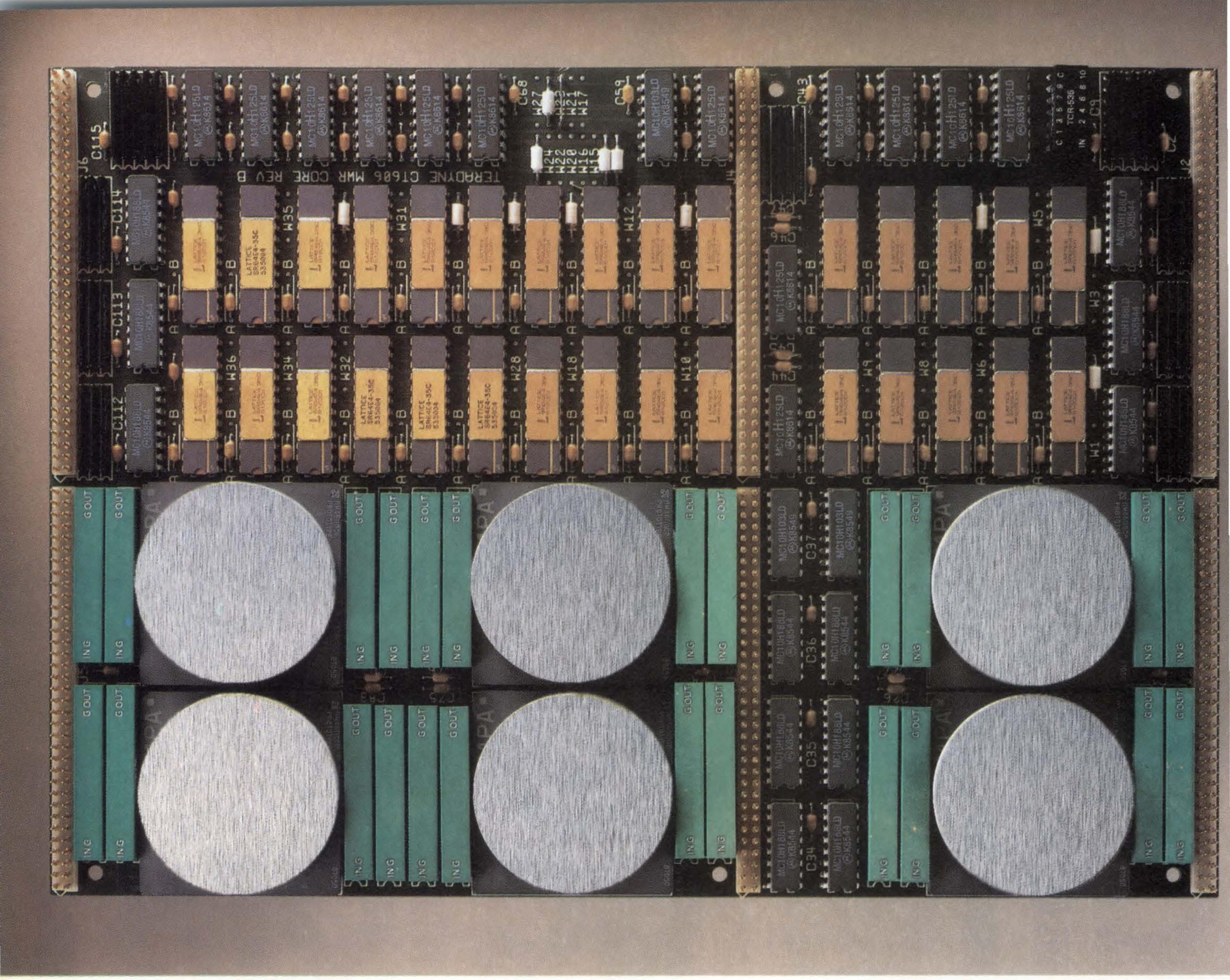


If you're testing complex boards

You're facing one of test engineering's toughest challenges. VLSI boards like this one. But with a Teradyne L200 board tester on your side, complex test problems can be conquered quickly.

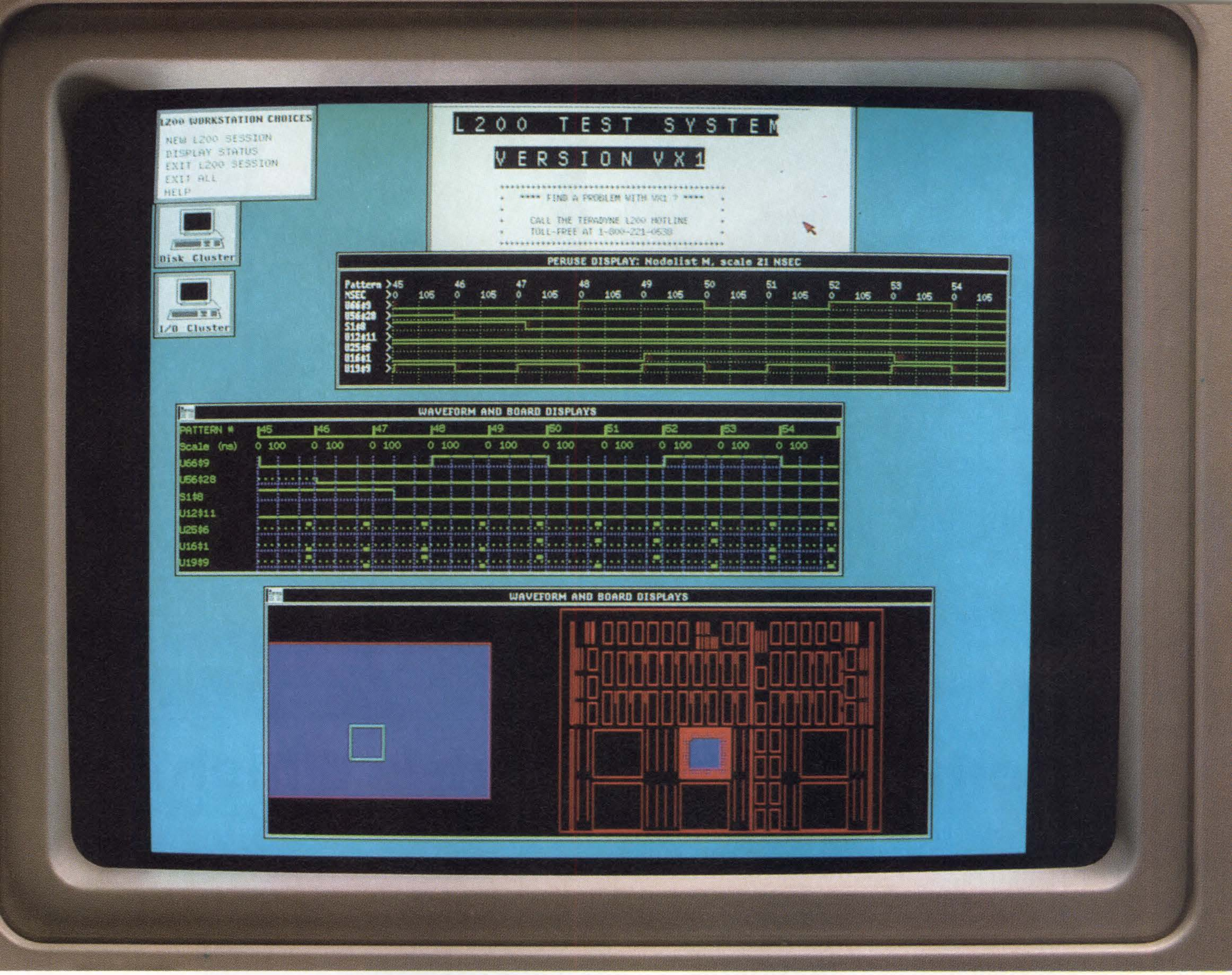
The L293 VLSI Module Test System.

Stay in front of VLSI/VHSIC advances.
Start with the most advanced hardware for analog and digital testing. An L200 fires functional test patterns at 40 MHz rates. At up to 1152 test channels. Top speed is 80 MHz. That's 4 to 8 times faster than any competitor can deliver.

And the L200 hits test signal timing precisely. With up to 32 timing sets for drive phases and test windows. Its 250 ps programming resolution with zero dead time puts signal edges right where you want them.

Divide and conquer.
VLSI/VHSIC boards demand large, complex test programs. But the L200's distributed computer architecture simplifies matters.

Testing is controlled by a VAX computer. It sends tasks to specialized processors for rapid deployment of analog, digital, and memory tests.



here's a simple plan of attack.

Programmers will appreciate clustered VAX workstations. Graphics, like waveforms and shmoo plots, make heavy debug and analysis light work.

Simulation and other tactics.

High-powered software tools tailor L200 test development to modern design techniques and test strategies. Precisely the caliber of tools you need to get tests up and running fast.

	Test Channels	Maximum Pattern Rate	Channel Skew
L297	1152	80 MHz	±1.5 ns
L293	576	80 MHz	±1.5 ns
L280vx	1152	10 MHz	±10 ns
L210vx	576	10 MHz	±10 ns

L200 VLSI board test systems are the performance leaders.

Take our LASAR simulator. It works closely with the L200 for both cluster and board-level testing. LASAR accurately predicts VLSI circuit responses and reports test program fault coverage.

Significantly, LASAR simulates L200 characteristics. So test programs automatically include when to test board responses. And what response is expected. The result is uncompromising go/no go tests as well as precise guided probe or fault dictionary diagnosis.

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L200's have proven themselves under fire at hundreds of advanced manufacturing sites worldwide. So if you're about to take on a new VLSI/VHSIC project, find out how to launch a winning test strategy. Call Daryl Layzer at (617) 482-2700, Ext. 2808 without delay.

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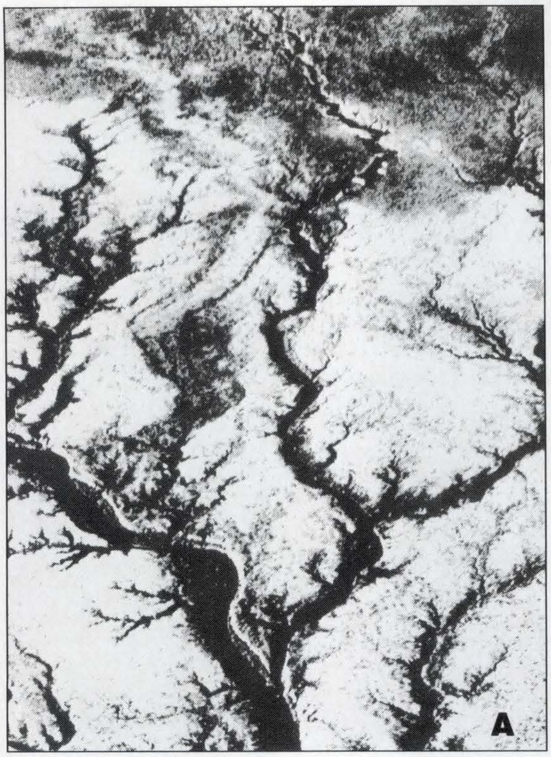

Delta or Aorta? Which is Which?

No problem here because both of these images were processed on Raytheon's new TDU-850 Thermal Display Unit.

The TDU-850 is the only thermal recorder to display true grey levels (not mere halftone representations) at such high speeds and resolutions. Utilizing 203 dots per inch, the unit offers 64 grey levels and can provide 256 grey levels through the use of super pixels. The TDU-850 is your assurance of high quality images. Standard units about $5,000. (Slightly higher overseas). RS-170 video and IEEE-488 computer interfaces are available.

When you must know what you're looking at, look for equipment that knows what to look for. For details call or write **Marketing Manager, Recorder Products, Raytheon Company, Submarine Signal Division, 1847 West Main Road, Portsmouth, RI 02871-1087. Phone: (401) 847-8000.**

Raytheon

A. Satellite view of river delta. **B.** Arterial angiogram.

Note: These began as continuous tone images which were processed in black and grey by a TDU-850. The TDU-850 images, however, had to be converted to conventional halftones in order to be shown in this magazine. Thus the high quality of the original TDU-850 images have been obscured. For true results ask to see a demonstration.

SIGNALS & NOISE

IEEE is alive and well

IEEE membership will pass the 300,000 mark this year, so the organization is far from heading toward extinction. With 267 sections, over 900 chapters, and over 550 student branches all over the world, and a steady annual growth in spite of editorials such as EDN's ("The IEEE faces extinction," EDN, February 4, 1988, pg 53), it is not hard to see that the IEEE is indeed meeting the needs and desires of many engineers. It is the noisy whiners on the sidelines who make news sometimes—and apparently catch the attention of EDN's editor. The literally thousands of volunteers who man committees, serve as officers in student branches, chapters, subsections, sections, societies, and the national and international boards are dedicated people who work for no pay . . . just the desire to make the IEEE better and stronger—and more responsive.

It really hurts to see an editorial like EDN's, because it is obviously giving recognition to the few very vocal dissidents (who give no volunteer effort to the IEEE and who have never served in any office), while ignoring the thousands of volunteers who are moving the IEEE forward through their quiet, dedicated efforts. I hope Jon Titus will take a little time to look at the other side of the coin. The IEEE is doing a lot for the profession! We could do even more if the complainers would join with the many other volunteer workers and help pull the load in improving our Institute.

Robert S Duggan, Jr
Candidate for IEEE Executive Vice President (1989)
IEEE
Atlanta, GA

Criticism of IEEE was undeserved

In his editorial of February 4 (pg 53), Jon Titus has indulged a desire to create controversy at the expense of any reasonable approximation of good journalism and attention to facts. "Yellow journalism" was the term used to describe the type of unfounded allegations that abound in the editorial. He certainly has a right to a biased opinion on the vitality of the IEEE and on the merit or lack of it of actions taken by the IEEE's board of directors. But there is a minimum standard of integrity and factual information that should be observed.

Let me be very specific and to the point:

1. Approval voting. Jon says that "the board of directors modified the election procedure by changing the organization's bylaws, not by asking

members to amend the organization's constitution," implying some sort of violation of proper procedure in our action. The facts are that the voting method for member election of officers and directors of the IEEE has *not* previously been specified in *either the constitution or the bylaws*; the board of directors felt it would be desirable to specify in the governing documents of the Institute the procedure to be followed, particularly with the introduction of approval voting; and the principle stated in the IEEE's constitution is that " . . . methods of nomination and election shall be specified in the Bylaws."

The board acted properly in placing this information in the bylaws. It would *not*, in fact, have been in keeping with the guidelines in our constitution to have proposed a constitutional change. Of the three governing documents for the IEEE, the constitution is a very general, 4-page document, while the bylaws provide more-detailed guidance and are about 50 pages long. Our *Policies and Procedures Manual* is still longer and provides further procedural information.

In his criticism of the board's action, Jon Titus has also conveniently chosen to ignore the fact that the new approval-voting procedure offers the best opportunity for a non-establishment candidate to win, if he or she truly represents the interests of a preponderance of the voting members. It should be obvious that this method gives voting members greater flexibility to express their views, and helps ensure that the winning candidate most closely reflects the will of the majority. If Jon's point is that he is opposed to majority governance, perhaps he should come right out and say it, rather than leave EDN's readers with a false impression.

2. Professional concerns. Jon Titus says that "engineers will observe no action on tax or pension reforms, no action on age discrimination, and no action on other professional concerns. In short, no action at all." Perhaps if he took the time to look into these areas, he might find out what's going on, and the extent of the IEEE's role. Pension-reform legislation has been an active target of the IEEE for over a decade. The IRA bill owed much of its momentum to IEEE work. The reduction in tax breaks in the course of the overwhelming pressure for tax reform in 1986 was fought by the IEEE, and we are actively supporting the passage of the newest pension-reform bill dealing with portability and nonintegration. Can Jon point to anyone or any organization that is even close to this record?

Let me go on about other professional concerns. Who stimulated the government guidelines against wage busting and other unfair prac-

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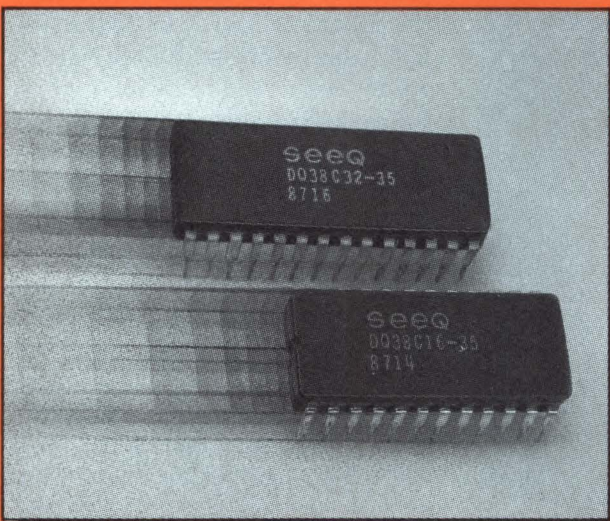

Org.	Part No.	Pin Out	I_{cc}	T_{aa}	T_{ce}	Packages
2K x 8	36C16	Same as bipolar PROM	100 mA	45 ns	30 ns	DIP, LCC
4K x 8	36C32	Same as bipolar PROM	100 mA	45 ns	30 ns	DIP, LCC
2K x 8	38C16	JEDEC STD E²	100 mA	45 ns	30 ns	DIP, LCC PLCC
4K x 8	38C32	JEDEC STD E²	100 mA	45 ns	30 ns	DIP, LCC PLCC

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E² Is Our Middle Name

CIRCLE NO 33

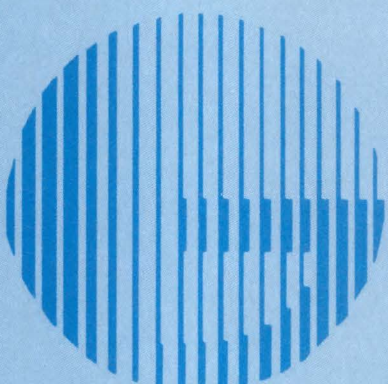
tices in service contracts? The IEEE. Who called nationwide attention to age-discrimination problems, cosponsoring a national conference on the aging workforce? The IEEE. Who has provided the Department of Labor guidelines for determining the admissibility of alien engineers and provided engineers with guidelines to evaluate fair hiring practices? The IEEE. Who is generating the salary information to give guidance on proper rates to be paid for experience and other skill factors? The IEEE. Who is in the lead in dealing with these and many other professional concerns among all the engineering fields? The IEEE.

3. Publications. The editorial dismisses journals and publications as not being at "the heart of a vital *professional* organization." I'm aghast! Jon seems unable to grasp what constitutes a professional in our field. First and foremost is technical competence. We maintain that competence in a variety of ways, not the least of which is via access to technical journals and publications. The only aspect of our professional life that he seems to recognize—that is, the part dealing with the working environment—is covered primarily by the IEEE's US Activities Board (USAB). Its activities, just a few of which I cited earlier, are too numerous and wide-ranging to cover adequately in a letter.

I believe the IEEE has demonstrated and continues to demonstrate its value to the profession in a great number of areas. We're not solely technical and not solely "professional" either. We serve both these aspects and many others besides. We do not believe that we do everything to perfection, and we encourage communication from those who have *constructive* suggestions on how we can improve. Unfortunately, editorials such as the one I have cited are not constructive and only mislead the casual reader. The engineering community deserves better coverage, and I hope EDN will accept the challenge to provide it.

Perhaps you recall the old adage that it's better to light a single candle than to curse the darkness. The IEEE is lighting the candles.

Russell C Drew
1988 President
IEEE
Sterling, VA



WRITE IN

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

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CHIPS

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The semiconductor industry has always approached these needs from a traditional, discrete-based point of view. As systems have become more powerful and sophisticated, this perspective has proven increasingly inadequate.

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The systems approach.

Our design process begins with a broader perspective—a thorough examination of the market trends and advanced technologies that affect the future of microcomputing.

We focus on industry-standard hardware architectures and software environments. To ensure 100% compatibility. And to avoid the kind of short-sighted silicon implementations that might require expensive OEM redesigns.

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This "tops-down" design process results in highly integrated CHIPSets.™ Providing higher system performance, increased functionality and 100% compatibility.

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"Since its inception, Chips and Technologies has pioneered an unusual concept in the semiconductor industry, involving the sale not just of silicon circuits, but of entire CHIPSets and design services, which incorporate a substantial amount of personal computer systems expertise."

Edward White
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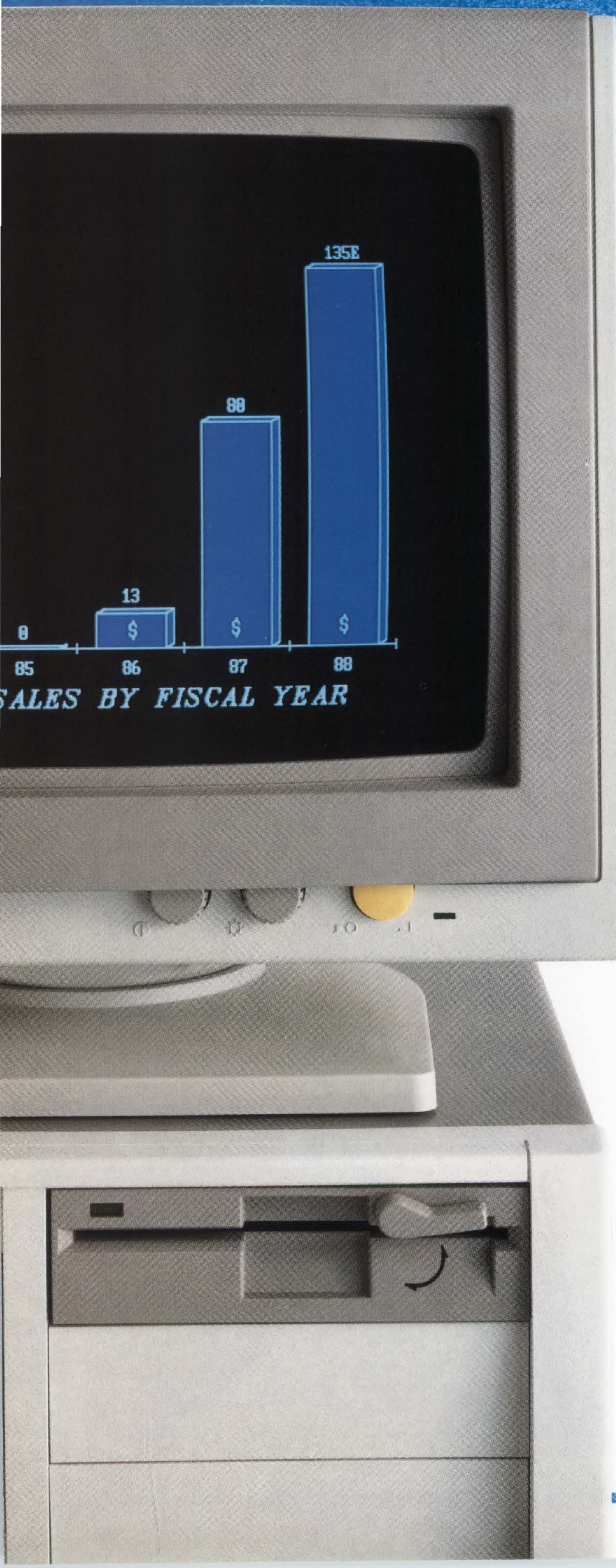

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Drew Peck
Donaldson, Lufkin & Jenrette

that merely "clones" all the flaws, imperfections comings of the original.

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In 1985, Chips and Technologies introduced its very first products—the EGA™ CHIPSet and the 286/AT CHIPSet for AT-compatible microcomputers.

Both products outperformed standard industry implementations. And dramatically reduced OEM manufacturing costs and system development time as well.

The second generation: architectural innovation.

As microprocessors got much faster, system performance was being constrained by the comparatively slow-moving AT bus. Using our systems expertise, we arrived at an ideal solution: a mainframe-like asynchronous architecture that decouples the bus from the processor and memory. Enabling each to run comfortably at maximum speed, with no loss in compatibility.

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These high-performance CHIPSets incorporate advanced microcomputer features, like 4-way page interleaved memory and shadow RAM. They offer OEMs the ultimate in cost-effective solutions: the ability to accommodate high-speed 286 and 386™ processors, with a seamless upgrade path from 12 to 25 MHz and beyond.

That means customers can build 16 MHz AT-compatibles based on lower cost 286 microprocessors. And still run MS-DOS™ software *faster* than most 16 MHz 386-based systems.

NEAT CHIPSets also offer an extra measure of flexibility: automatic mode switching between MS-DOS and OS/2.™ A real advantage for OEMs and end-users alike.

Unprecedented performance.

NEAT CHIPSets improve the speed and performance of OEM products through architectural innovations that allow faster data communications between the tightly coupled subsystems. And by extending systems logic interface techniques throughout the entire microcomputer.

By implementing mainframe-level techniques in our CHIPSets, we continue to work with OEMs to push AT performance and economy to new levels. For both desktop and laptop systems.

In doing this, we've developed the expertise to do precisely the same for the PS/2™ market.

With a micro-mainframe proprietary architecture fundamentally changed

Systems-level thinking and mainframe expertise are no longer optional. They're requirements.

The features that distinguish PS/2 – mainframe-like architecture, a higher degree of functional integration, and close coupling of hardware and software – are a long way from where traditional semiconductor companies presently find themselves.

Meeting the new standard.

While compatibility is only the starting point, it's now much more difficult to achieve.

Chips and Technologies has approached the PS/2 market with four years and five million CHIPSets of directly applicable experience. Systems expertise that has enabled us to achieve *gate-level* compatibility with PS/2 and the Micro Channel™ architecture.

Our PS/2-compatible offerings, CHIPS/250™ and CHIPS/280™ CHIPSets, incorporate all the innovations we've developed to date.

Beyond compatibility.

The CHIPS/250 and CHIPS/280 CHIPSets operate up to twice as fast as the industry standard. Both are available for high-performance, cost-effective, desktop configurations, which provide Model 80 functionality in a Model 50 chassis.

We even offer a special CHIPS/280 version which supports both cache and page interleaved memory systems. Giving OEMs the option to use low-cost, slower DRAMs with no reduction in system performance. What's more, the matched memory technique used in the IBM PS/2 Model 80 is incorporated into our CHIPS/250 CHIPSet—doubling the rate of data transfer over the Micro Channel bus for Model 50-compatible designs.

Our CHIPS/450™ family provides VGA™ compatibility down to the *gate level* as well. Including implementation of hidden modes—the only *real* assurance of compatibility. And close coupling with our systems logic CHIPSets enables our VGA chips to run twice as fast as the industry standard. Without the need for special drivers.

Along with other enhancements in our VGA chips, we've also implemented a bus architecture that's configurable for either AT or PS/2 environments. So one chip can serve two applications, with no compromise in performance.

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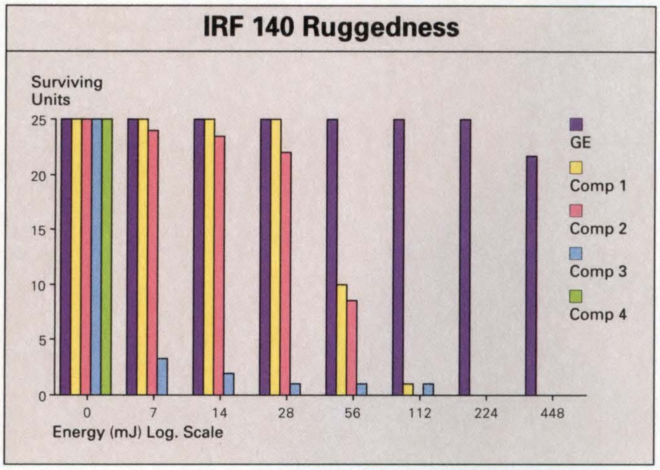

In this test conducted by Associated Testing Laboratories, Inc., the ruggedness of 25 GE IRF-series MOSFETs was compared with 25 devices from each of four competitors. As you can see, the GE parts significantly outperformed the others.

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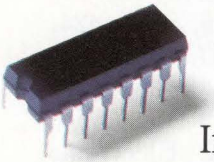

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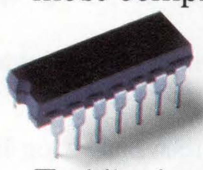

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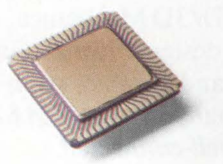

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Toshiba has ample design capability at its design centers, so with our experience, LDS™ software applications staff, you can develop your own advanced 50,000 gate, 0.7ns gate arrays and standard cells. Plus new 1.5μ hard megacell custom chips, which we have been producing for four years now.

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CIRCLE NO 34

CALENDAR

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

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

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

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

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

Modern Electronic Packaging (seminar), Santa Clara, CA. Technology Seminars, Box 487, Lutherville, MD 21093. (301) 269-4102. September 7 to 9.

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

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

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

CALENDAR

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

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

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

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

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

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

Frontiers '88: The 2nd Symposium on the Frontiers of Massively Parallel Computers, Fairfax, VA. Frontiers Symposium, Box 334, Greenbelt, MD 20770. October 10 to 12.

International Electronic Manufacturing Technology (IEMT) Symposium, Lake Buena Vista, FL. Bill Moody, 2529 Eaton Rd, Wilmington, DE 19810. (302) 478-4143. October 10 to 12.

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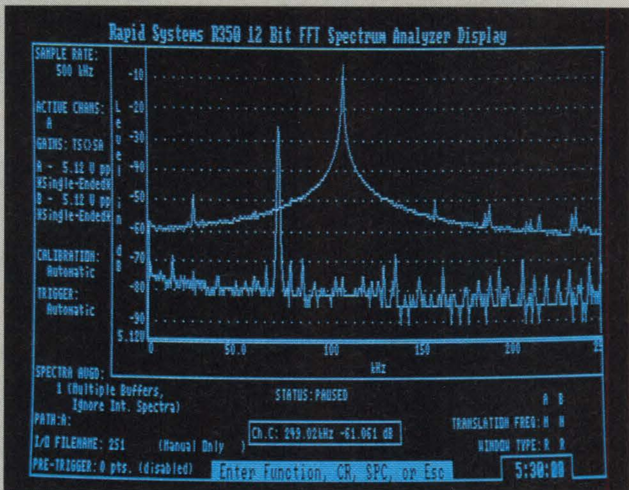
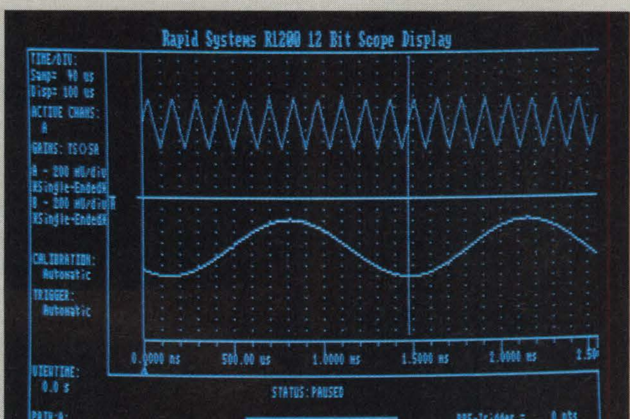


The R350 is a PC-based 12-bit, 2-channel, 500 KHz, real-time, FFT spectrum analyzer. Sample 2 channels simultaneously. 32K data buffers. Autosave spectrums to hard or floppy disk. Two modes of spectrum averaging. Fully differential inputs. Linear or log amplitude scaling. Amplitude and frequency cursor. Display spectrums 5 to 10 times a second. Print, store, retrieve and overlay spectrums. 500 KHz anti-aliasing filters on each channel, 80db of dynamic range.



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CIRCLE NO 45

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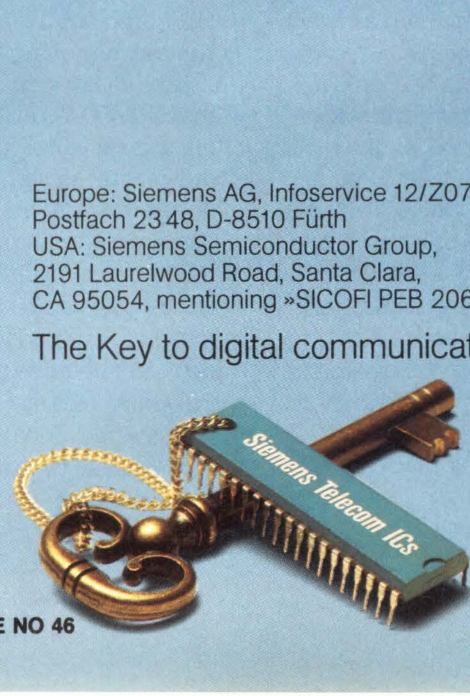


CIRCLE NO 46

If you built your own logic analyzer . . .
. . . it would be

Why make just an analyzer when you could build a complete, flexible logic analysis system? A modular system with a 400 megasample/s digitizing oscilloscope, an interactive 50 Mbit/s pattern generator, up to 400 state/timing channels available, and a variety of features that make it versatile and easy to use. Plus a configurable price that you could easily justify to the boss.

Fortunately, you don't have to build it yourself to get all this. Just choose the modular HP 16500A Logic Analysis System. HP has already done it for you.

HP Logic Analyzers: the extra measure.

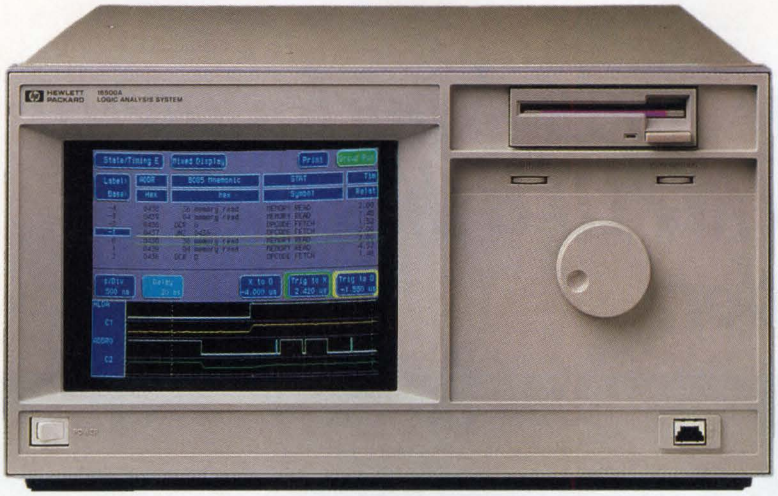
Like all HP logic analysis tools, the HP 16500A delivers an extra measure of value. There are four different measurement modules to choose from. To maximize your investment, configure the HP 16500A, using its five mainframe slots, with the module combination that best matches your budget and application. Just imagine the possibilities for mixing and matching:

- 80-channel, 25MHz state/100MHz transitional timing module (400 channels maximum)
- 2-channel, 400 megasample/s digitizing scope module (8 channels maximum)
- 50 Mbit/s pattern generator module (204 channels maximum)
- 16-channel, 1 GHz timing analyzer module (80 channels maximum)

If your applications are in hardware, powerful inter-module cross-domain triggering allows high speed waveforms from both the scope and analyzer modules to be time correlated, giving you unmatched analysis capability. And you can use measure-

we never stop asking

"What if..."



more than a logic analyzer.

ment results for simulation by using HP's bi-directional CAE link.

If you're a software developer, the HP 16500A offers complete support for popular 8-, 16- and 32-bit microprocessors. You can also develop your own support package for use with your custom processors or ASICs.

But we didn't stop there. We designed a full set of features into the HP 16500A that make it easy to use. A touch screen or mouse controls functions through pop-up menus. Use your choice of a front panel knob or screen keyboard to change values. Plus, there are two built-in disc drives for data set-up and storage, HP Auto-Scale, and color hardcopy output at the push of a button. And the proverbial much more.

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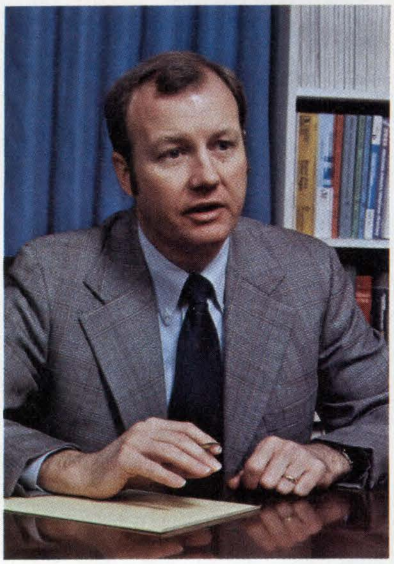
1-800-752-0900, Ext. H215.

See for yourself how the modular HP 16500A Logic Analysis System is the logic analysis tool you'd design yourself. Like every logic analyzer in the HP family, it delivers *the extra measure* of value you're looking for!

HEWLETT PACKARD

EDITORIAL

The paperless-office myth



Back at the birth of business computers, various industry prophets predicted paperless offices. In those days, when timesharing was a computing technique and not a vacation style, people envisioned sharing great quantities of information that was stored in a large central computer. Thus, they thought, offices would no longer need vast quantities of paper or the facilities to store reports and memos.

Such talk spread panic among paper and office-equipment manufacturers. After all, they couldn't survive if offices no longer needed paper and file cabinets. It turns out that the words "paperless office" have become an oxymoron, much like "plastic silverware" and "solid tubing." In fact, developments in the last few years have increased rather than decreased the amount of printed material that offices create.

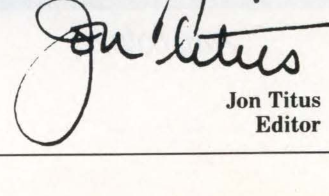
Hardly a day goes by, for example, that I don't receive a computer-products catalog in the mail. Over a week or two, those catalogs add considerable bulk to the household paper trash. Not only that, but many flyers and advertisements entice me to buy special paper, labels, envelopes, and forms—more paper. And the advent of the personal computer also spawned many, many computer publications, magazine supplements, and newspaper sections—even more paper.

These days, people talk about diskless workstations, but it's hard to imagine a computer without a printer. In fact, many computer stores sell a desktop computer and an inexpensive printer as a package deal. On most computers, printer-output ports are standard, and after all, a word-processing program without a printer has little value.

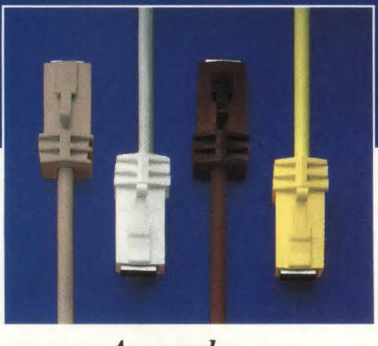
The laser printer has exacerbated the situation. I receive countless newsletters that bear the mark of a laser printer. With a laser printer and a desktop-publishing program, anyone can become a publisher, editor, and promoter. The equipment can exalt even the most modest communications. Instead of just telling people about a meeting, for example, you can handcraft a beautiful, printed meeting notice.

Other computer software also beckons me to use more paper. I see ads for form-designing software that lets you create a form for every possible use. Once hooked on such software, you'll find that you need many more forms than you use today—and it becomes easy to create them. Now there's no excuse to use a small stick-on note when you can design and use a 1-page form instead. We editors are guilty, too: It's easy to make profligate use of printouts for revision upon revision of an article.

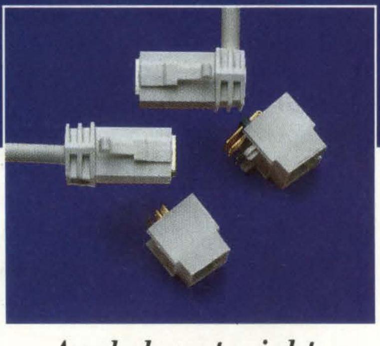
Now that I have all this wisdom about the paper-full office, I'm sorry I didn't invest in paper futures a few years ago. But I'm playing it smart by looking for investment bargains among trash-hauling and paper-recycling companies. It pays to be ready.



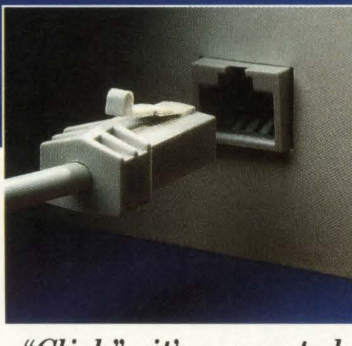
Jon Titus
Editor



Any color.



Angled or straight.



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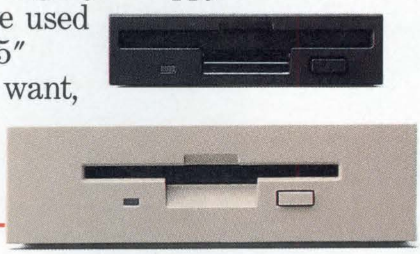

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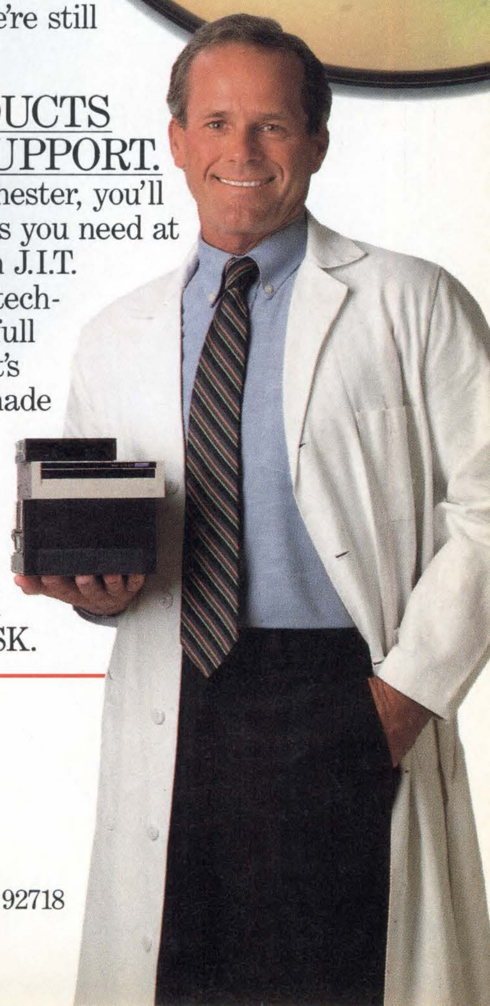

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CIRCLE NO 48

V33: The world's fastest 16-bi

The V33 runs fast. 16MHz fast. And it offers a 16M-byte address space in the extended mode.

High-speed processing makes the V33 ideal for your instrumentation or control equipment design. And the ample address space gives you an edge in advanced PC applications.

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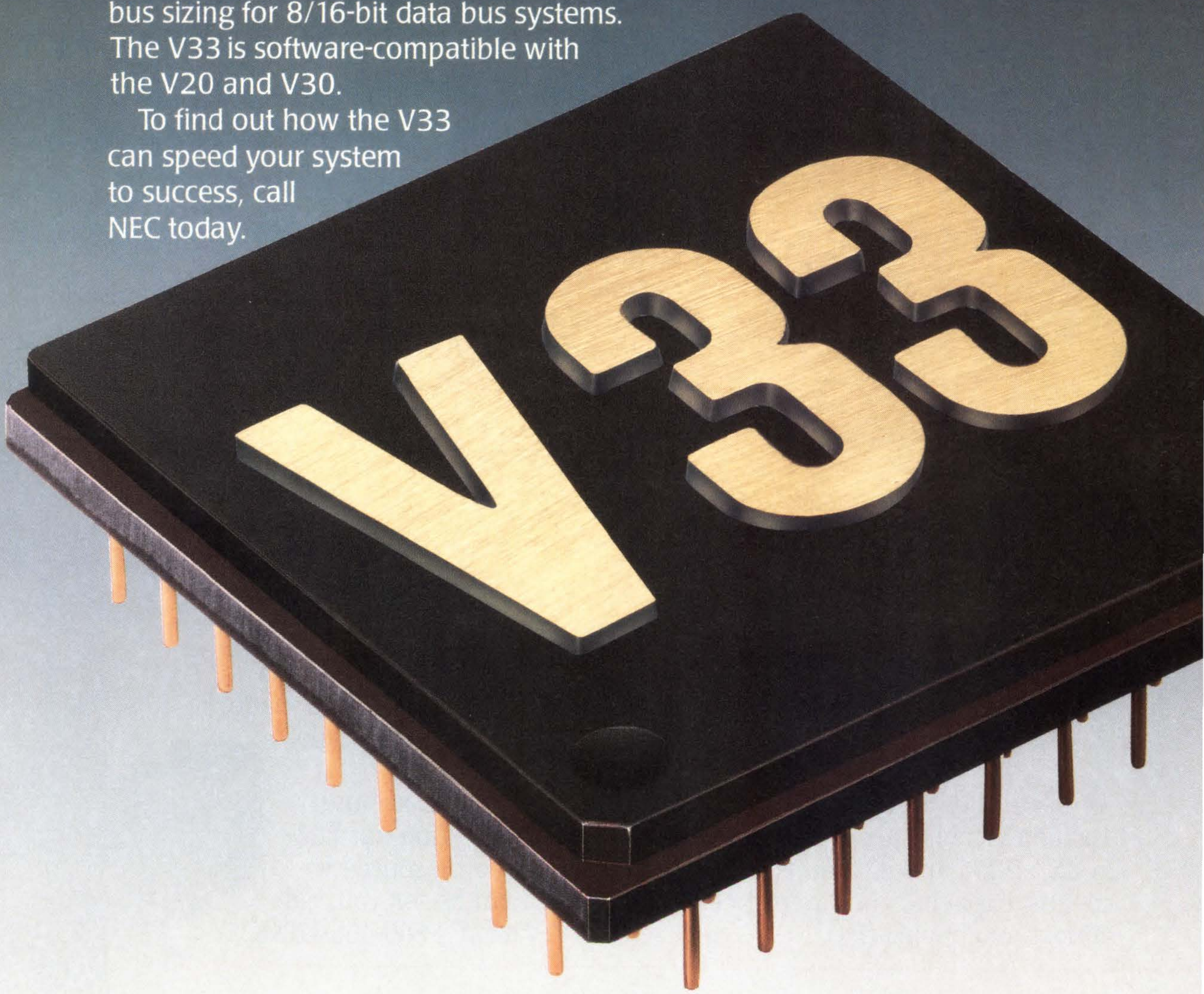
To find out how the V33 can speed your system to success, call NEC today.



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CIRCLE NO 49

NEC

VME + FCC
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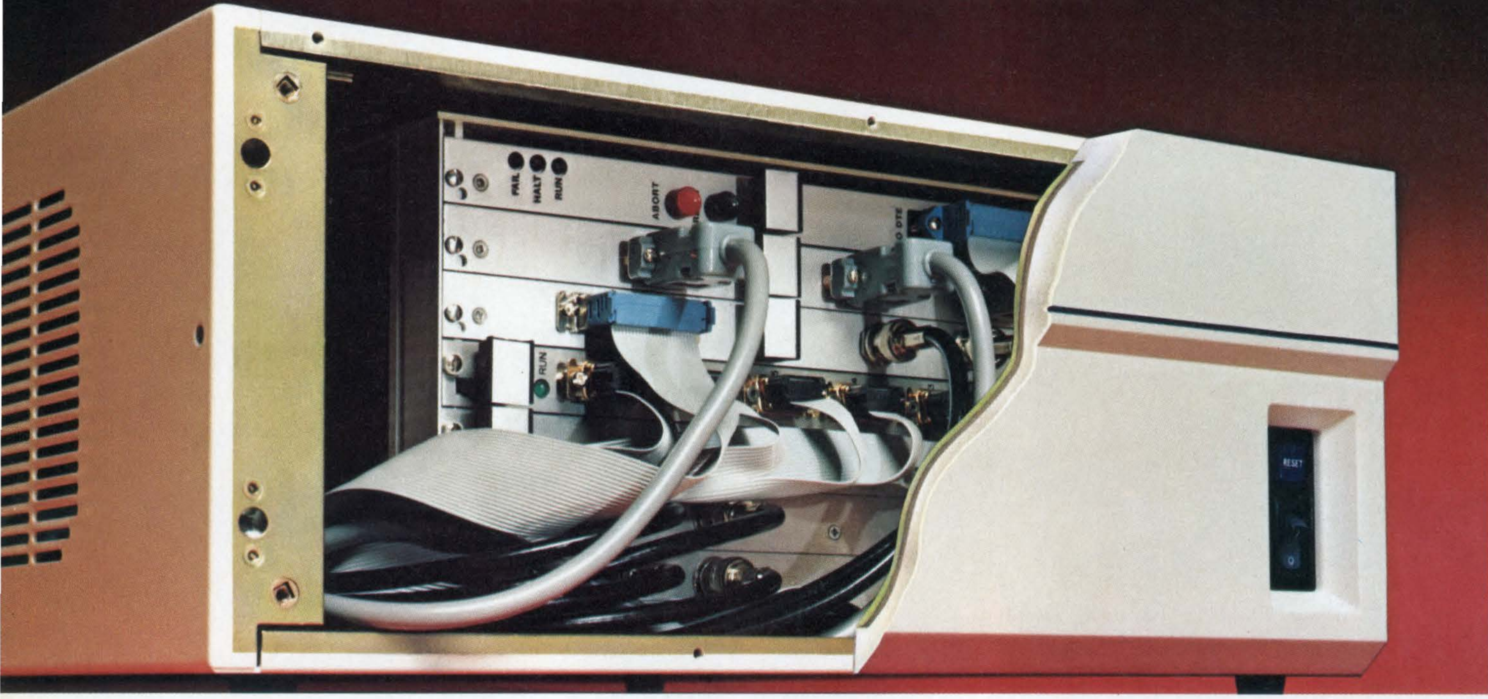

The only VME System Enclosures with EMI/RFI Compliance

With Electronic Solutions VME enclosures you don't have to take any static about FCC compliance. Because your VME system can meet or exceed FCC Class A Part 15 EMI/RFI standards. No other enclosure manufacturer can make that statement.

Here's why: Only Electronic Solutions puts a new face on VME, an outer front panel that—with other design features—keeps your EMI/RFI signals from straying. What's more, it hides those I/O connectors and dangling cables so your system looks a lot cleaner and more attractive.

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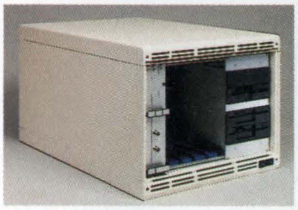

GEMINI enclosures to 40 slots.

SERIES enclosures to 12 slots.

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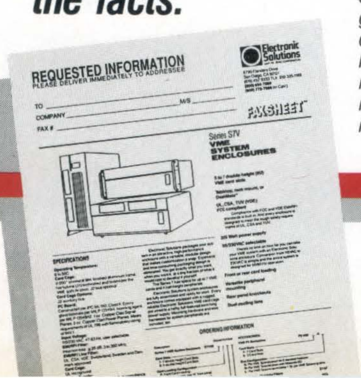

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CIRCLE NO 50

Microcontroller chip features analog and digital I/O lines

Aimed specifically at low-cost applications in consumer-electronic equipment and handheld devices, the Z86C08 microcontroller chip provides 11 digital I/O lines and 2k bytes of internal ROM. Three additional signal inputs accept either digital or analog signals, depending on how your software configures the chip. The μC chip furnishes 124 general-purpose 8-bit registers in addition to 15 control and status registers that control the I/O ports, timers, register pointer, and interrupts. The chip also provides a stack that saves addresses and data in the general-purpose registers.

The CMOS chip operates with either a 12-MHz-max crystal or an external oscillator. By turning off the clock signals, you'll save power, a requirement for low-power applications that depend on batteries. The software instructions let you select one of two power-saving standby modes: stop or halt. The halt mode stops the chip's internal clock, but not the crystal-oscillator circuit. The stop mode, however, stops both the chip's internal clock and its oscillator circuit. You can release the μC from either the stop or halt mode by generating an external interrupt signal.

The chip furnishes three inputs that you can use to measure analog voltages. One input connects an external reference voltage to two comparators that monitor two unknown voltages—one at each of the two remaining pins. When an unknown voltage exceeds the reference level, the corresponding comparator interrupts the CPU. The CPU provides as many as six interrupts; four from I/O lines, which include the comparators, and two from internal counter/timer registers.

If you already program the manufacturer's Z8 μP-family chip, you'll be able to transfer software to the Z86C08 directly, because the new chip maintains instruction compatibility. The instruction set includes a watchdog timer code that refreshes a 15-msec timer within the chip. If the timer is not refreshed within the 15-msec period, it resets the CPU. The watchdog timer is a maskable option, so you must specify whether or not you want it when you order the chip and specify your masked ROM pattern. The μC chip is available now and costs $1.62 in 25,000 quantities.—***Jon Titus***

Zilog Inc, 210 Hacienda Ave, Campbell, CA 95006. Phone (408) 370-8000. TWX 910-338-7621.

Circle No 745

Sequential-sampling digital scope has 2-GHz bandwidth and 1-mV/div sensitivity

The PM 3340 2-channel digital oscilloscope uses sequential equivalent-time sampling to achieve a 2-GHz repetitive-signal bandwidth. Many engineers think that this technique combines extraordinary bandwidth with high resolution, but that it takes longer to reconstruct waveforms than other data-capture techniques such as random sampling. "Not so," says Hans Toorens, product marketing manager at John Fluke Manufacturing Co, exclusive US distributor of Philips' test and measurement products. "For certain simple waveforms, a random-sampling scope might give you an idea of what the picture will look like a little sooner but, in general, the sequential-sampling instrument will present a complete display more rapidly." He further points out that the economies inherent in sequential sampling permit his company to offer products with a superior price/performance ratio.

In the PM 3340, the sampling gates are right at the input. After the gates, the scope's circuits process medium-frequency information. Most of the instrument does not need—or use—costly, high-frequency design techniques. According to Toorens, competitive instruments contain a substantial amount of wideband electronics. Whereas the PM 3340 delivers a combination of 2-GHz signal bandwidth, 2-GHz trigger bandwidth, 20-psec/div sweep speed, and 1-mV/div sensitivity, several instruments in the same class only offer half the bandwidth and 1/10th the sensitivity. Furthermore, the PM 3340 digitizes with 10-bit resolution—four times what some of the competitive units provide.

The front panel *of the PM 3340 resembles that of an analog scope, but the row of softkeys to the right of the screen and the keypad reveal its digital heritage.*

The engineers who designed the scope did not overlook the user interface in their effort to provide maximum performance. Insofar as possible, the scope's controls behave like their counterparts on analog scopes, which all potential users are familiar with. But there are also many convenience features that users of state-of-the-art digital scopes have come to expect. For example, menus appear on screen to the right of the waveforms; you make your selections using a row of softkeys to the right of the screen. Pressing an "autoset" button enables you to quickly obtain a trace. Nonvolatile memory can store 250 control settings. For automated-test applications, the unit includes both RS-232C and IEEE-488 interfaces.

The scope also offers many signal-processing capabilities. Signal averaging allows enhancement of S/N ratios; four memory registers permit waveform comparisons (each register stores 4k words—eight times the number of samples that appear on a full screen); an "eye" display mode facilitates jitter measurements; and firmware-based calculation functions let you measure amplitude, time, frequency, and phase. The instrument can determine FFTs and amplitude histograms. Moreover, it can add, subtract, multiply, divide, integrate, and differentiate.

Prices for the PM 3340 start at $16,000. Delivery is six weeks ARO.

—Dan Strassberg

John Fluke Mfg Co Inc, Box C9090, Everett, WA 98206. Phone (800) 443-5853.

Circle No 785

Philips Test and Measurement, Bldg HKF, 5600 MD Eindoven, The Netherlands. Phone local office.

Circle No 786

Z I L O G

KILLER I/O

The Z84C90: Two serial, three parallel ports and a counter/timer on one chip. Just think what you can do with it.

Zilog's Z80 SPCT, Killer I/O,™ gives you a true "System on Silicon.™" With all the advantages of CMOS technology, Superintegration,™ and proven Z80 performance. Think of it as the door to a whole lot of new opportunities.

The Z80 Family: Still growing strong.

The Z80 remains the most commonly used 8-bit microprocessor in the industry. No wonder. As the family has continued to develop, so have the advantages: the familiarity of working with devices you know and trust, the tremendous value of being able to use software you've already developed, and, of course, there's the impressive Z80 performance.

As the Z80 Family has evolved through NMOS, CMOS, high-performance and high-integration, our commitment to Z80 has never wavered. New products have continued to be developed. Besides the 16-bit Z280 and the new Z84C90—the Killer I/O—there are a few more you really ought to look at:

- *Z84C80/81* — *Z80-based systems GLU logic that can be used in every Z80 application*
- *Z80180* — *the Z180 8-bit MPU combines a Z80 CPU, MMU, 2 UARTs, DMA, a C/T and more, with no extra logic needed for Z80 peripherals*
- *Z84C01* — *combines a Z80 CPU with an on-board oscillator*

Lots of I/O.

You're simply not going to get more serial/parallel I/O anywhere. We've put together the most popular combination of discrete devices . . . two independent synch/asynch serial channels, two independent parallel ports, an 8-bit programmable port and four counter/timers. And, since they're all fully compatible with PIO, SIO and CTC devices, you have the advantage of "commonality."

Lots of performance.

Superintegration and CMOS technology mean the Z84C90 provides plenty of performance and flexibility. 8 MHz speed for instance. Plus you've got four independent counter/timers and on-chip oscillator to work with. And the peripherals can be used in any combination you need.

Lots of benefits.

You're designing with a highly integrated chip. And you're working with the familiar software and proven performance of the Z80 Family. That's enough to make the Killer I/O the best choice. But think about the lower cost you get from less real estate, lower manufacturing cost and reduced inventory. Think about improved time to market. Or the higher performance and reliability that come with super integration. And it's all off the shelf and backed by Zilog's proven quality.

So whether you're upgrading existing designs or looking for solutions in new applications like cellular phones, personal computers, industrial control, or data communications, you owe it to yourself to contact your local Zilog sales office or your authorized distributor today. Zilog, Inc., 210 Hacienda Ave., Campbell, CA 95008, (408) 370-8000.

Right product. Right price. Right away. **Zilog**

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CIRCLE NO 52

Making mistakes is not the problem.

It's where you make them that matters. The most inexpensive and efficient place is on a computer, where you can change a design in minutes. Building a prototype, on the other hand, can take days.

You can streamline the process even more by integrating the design steps with the rest of the manufacturing operation. So everyone, from engineers and draftsmen, to machinists and floor managers, works together more efficiently.

Stop manufacturing your mistakes.


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READERS' CHOICE

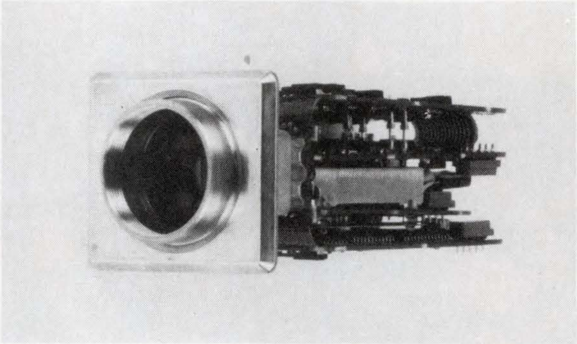
Of all the new products covered in EDN's **April 14, 1988,** issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, refer to the indicated pages in our **April 14, 1988,** issue, or use EDN's Express Request service.

▲ DSP IN-CIRCUIT EMULATOR

The 320C25 ICE Pak is a low-cost in-circuit emulator for Texas Instruments' TMS320C25 DSP chip (pg 98). You can use it with any host computer or terminal by plugging it into the host's RS-232C port.
Memocom
Circle No 605

VOLTAGE TRIPLER

The SL6670 provides voltage tripling without the use of external inductors or transformers by employing charge-pump techniques (pg 255). It is programmable via an external resistor.
Plessey Semiconductors Ltd
Circle No 601
Plessey Semiconductors
Circle No 602

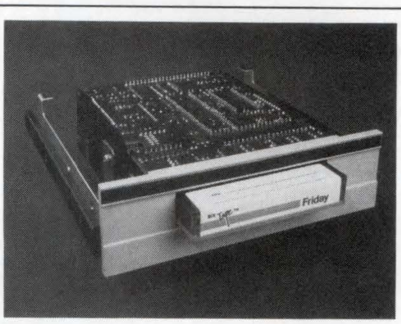


▲ CAMERA ASSEMBLY

You only need to add a chassis and lens to this solid-state image sensor assembly to produce a black-and-white video camera suitable for surveillance or machine-vision systems (pg 270).
Philips
Circle No 603
Amperex Sales Corp
Circle No 604

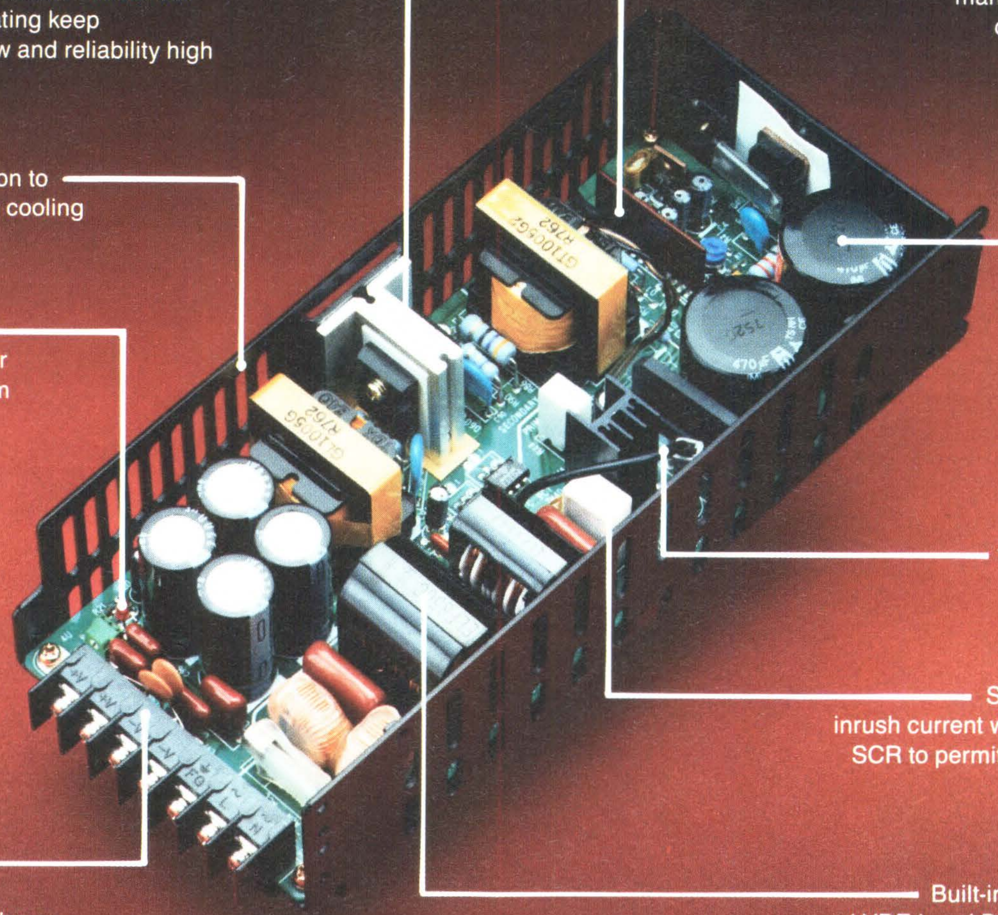
SCIENCE TOOLS

The Science and Engineering Tools package consists of a set of C functions for general statistics, multiple regression, curve fitting, integration, FFTs, differential and simultaneous equations, matrix math, complex math, and special functions (pg 305).
Quinn-Curtis
Circle No 607



▲ TAPE SYSTEM

The Jumbo 40M-byte tape backup system for IBM PC, PC/XT, PC/AT, PS/2, and compatible computers can store 10M bytes of data for an IBM PC/AT within five to six minutes, according to the vendor (pg 280).
Colorado Memory Systems Inc
Circle No 606



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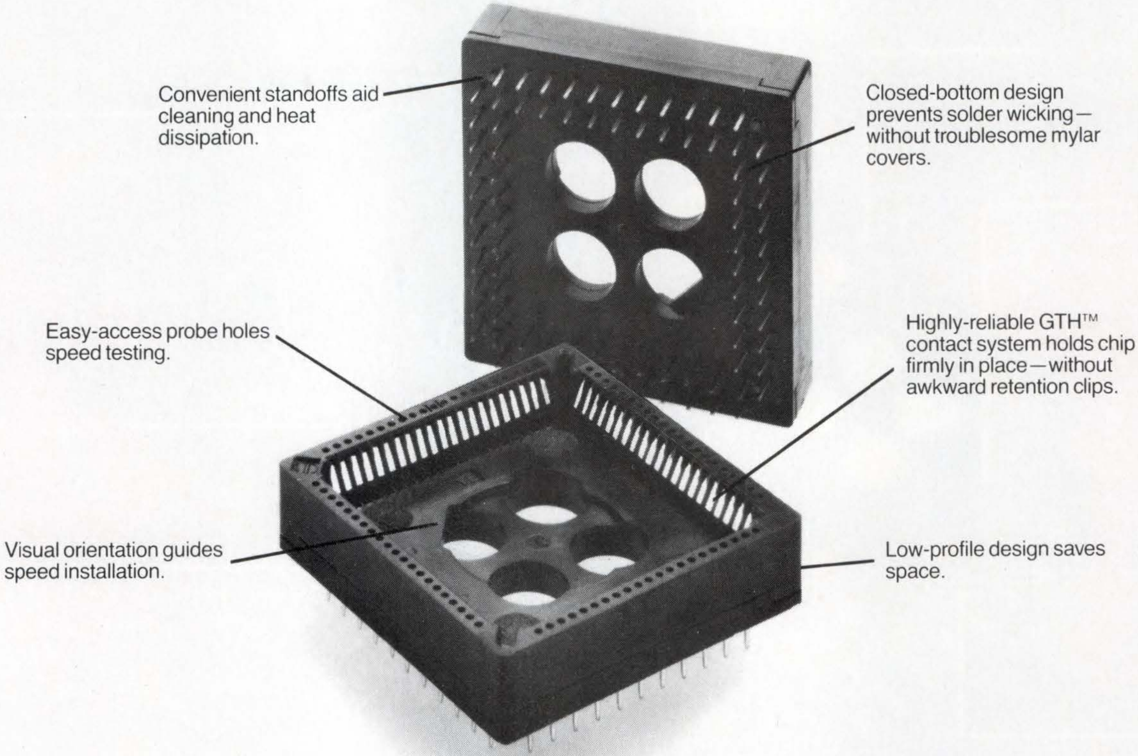
CIRCLE NO 53

WITH ALL THIS GOING FOR YOU,



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CIRCLE NO 192

58158

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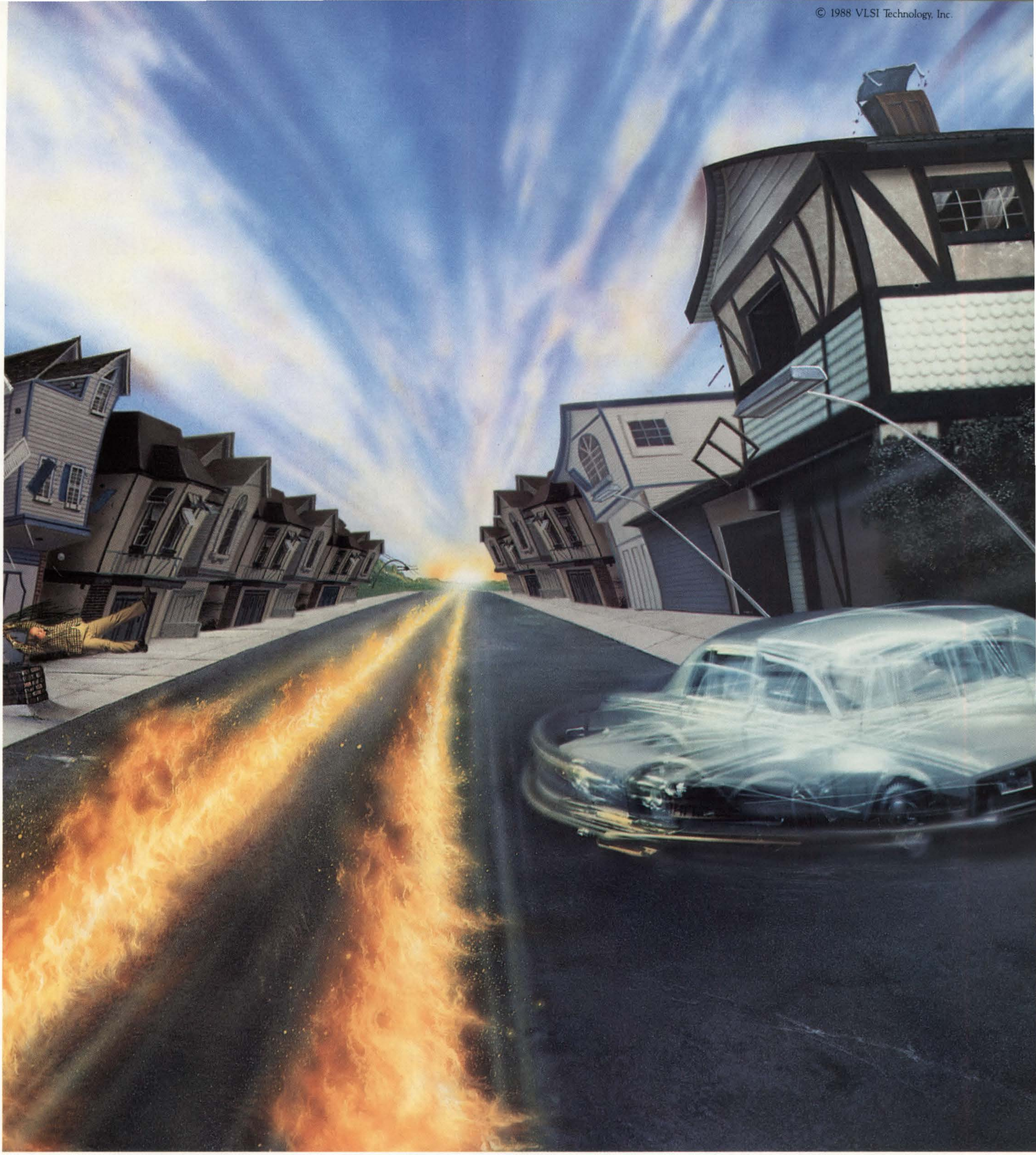

BLOW RIGHT BY THE COMPETITION.

tion, and packaging possibilities. In short, it tells you the best silicon solution to your problem.

Simply enter your design in block diagrams and global interconnect forms. Design Assistant shows you ways to implement it. Gate array, standard cell or cell-based.

You can run dozens of "what if" configurations in a few hours. In no time, you'll have the crucial information you used to wait forever for vendors to supply.

STREAMLINED DESIGN, COMPLIMENTS OF OUR COMPILERS.

Our logic and memory compilers create multipliers, PLAs, or super fast SRAM memory blocks as fast as 8ns.

And we've got a couple of "expert" compilers for cell-based or gate array designs that think exactly the way you do.

When you design a datapath, you think of it as a linear schematic, right?

Well, our Datapath Compiler just happens to use schematics as input. Complex multi-bit datapaths practically pop right out of it.

When you design state machine and other logic blocks, you think in terms of equations. Our State Machine Compiler does, too.

And it even optimizes your equations.

GET IT TOGETHER. FAST.

Ready to place and route your cell-based design? Just call up our Chip Compiler.

It provides floor-planning and auto-routing. It works with our compilers and standard cell libraries to produce an optimized layout.

It even pours standard cells into the gaps between blocks to make sure you use the minimum chip area required.

How fast does it work? Glad you asked.

A company came to us with a layout that took them three months. We did it in two days.

TO BE FAST, YOU HAVE TO BE FLEXIBLE.

Only our Portable Library lets you choose gate array or cell-based, 1.5μ or 2μ, *after* you've completed your logic design.

It can allow you to do that because your library always remains stable. No matter what process you use.

Process obsolescence is now obsolete.

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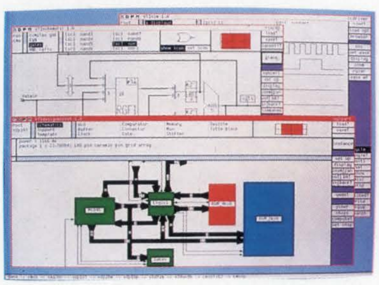
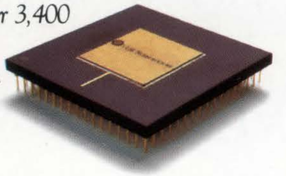
Because when you're driving to market this fast, it's good to have insurance.

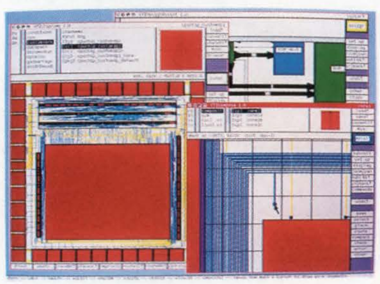
CONCEPT EXPRESS™:



The Concept Express Design System's highly productive logic tools and silicon compilers were used to develop this very-large-scale ASIC. It incorporates a 2901 datapath, RAM, ROM, and over 3,400 gates of random logic.

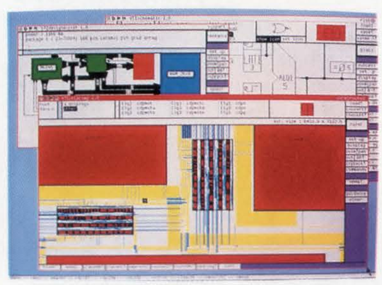


DESIGN EXPRESS™:



This highly-integrated design combines control logic, a register file, a refresh counter, and five peripheral chips onto a die size of 275x315 mils. The logic design, layout, and verification were completed in only 12 weeks.

SILICON EXPRESS™:



This design integrates all the peripheral chips for an AT computer with six megacells and control logic. Using the Silicon Express Design System, logic and physical designs like these can be implemented in under two man months.

VLSI TECHNOLOGY, INC.

Introducing 100MHz performance for $3465 in a general purpose digitizing oscilloscope.

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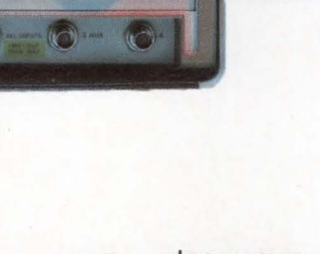

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CIRCLE NO 56

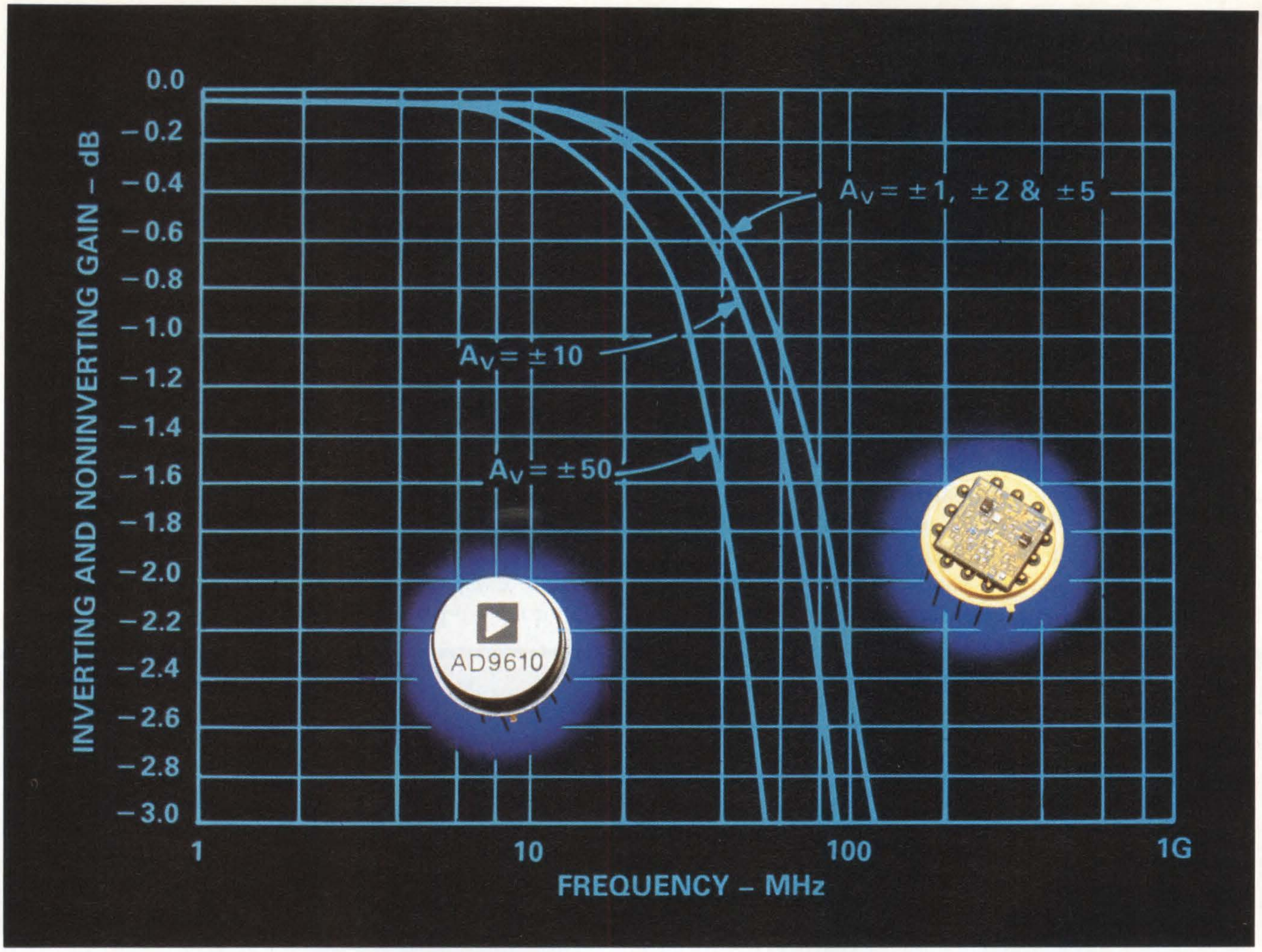
Current-feedback op amps ease high-speed circuit design

Because they're free from gain-bandwidth limitations, current-feedback op amps excel in high-frequency and fast-settling circuitry. The latest models also achieve a fair amount of dc accuracy without sacrificing speed—an important consideration when you're designing high-frequency circuits such as flash A/D converters.

Peter Harold, *European Editor*

For high-frequency applications—for instance, high-speed A/D and D/A converters, video drivers, pulse amplifiers, and radar and IF processors—current-feedback op amps offer particular advantages, such as a very wide bandwidth that's independent of closed-loop gain. They also provide a fair degree of precision, sparing you the painful choice between speed and precision that conventional voltage-feedback op amps usually require you to make. Current-feedback op amps (or transimpedance amps) settle quickly, provide a linear phase response, and are generally free from stability problems. And although they might at first glance seem more expensive, they could in fact save you money: Unlike a conventional op amp, a current-feedback type doesn't require any individual tweaking to meet performance requirements in high-speed or high-frequency applications.

Unlike a conventional op amp, a current-feedback op amp can achieve high speed without a huge sacrifice in dc performance. Models with bandwidths of over 100 MHz are available with input offset voltages as low as 0.3 mV typ and input-offset-voltage temperature coefficients of 5 μV/°C. In addition, because current-feedback op amps aren't subject to the gain-bandwidth-product restrictions of conventional op amps, you can alter the closed-loop gain of the current-feedback de-



100-MHz, low-offset-voltage op amp *(Analog Devices Inc)*

vices without affecting their frequency response.

Although many analog-signal-processing applications, such as video- and IF-signal amplifiers, require high-bandwidth op amps, it's today's trend towards processing analog signals in the digital domain that places the greatest demands on op-amp performance. Almost by definition, digital-signal-processing (DSP) systems start off by capturing a real-world analog input, and more often than not, they end up with an analog output in the form of drive waveforms for a CRT display. Therefore, you'll almost certainly find an A/D converter at the front end of a DSP system, and a D/A converter at the back end. To accurately model the system's analog input in the digital domain, this A/D converter must satisfy the requirement of Nyquist's sampling theorem. This theorem requires that the A/D converter sample the input signal at twice the frequency of the signal's highest frequency component that has an amplitude greater than the ADC's least significant bit.

To digitize the output of a high-resolution video camera, for example, you'll need to digitize the camera's analog output signal at around 15M to 20M samples/sec. To buffer and scale this signal to suit the input of an 8-bit A/D converter, you'll need an op amp that can settle to within 0.5 LSB (0.2%) in well under 50 nsec. This settling time is not outside the capabilities of a conventional high-speed op amp (especially if you can operate it at a gain close to 1, where it has optimum settling performance), but it would require some fairly clever compensation circuitry. That settling time is, however, well within the capabilities of a low-cost, general-purpose current-feedback op amp. By using a suitable current-feedback op amp, you can also be sure that you won't need to tweak the individual A/D converters during production to ensure their consistent performance.

Current-feedback op amps outperform conventional types in applications that require further increases in speed or resolution. A 12-bit flash A/D converter, for example, often uses a 2-pass subranging technique to achieve its 12-bit resolution. On the first pass it typically digitizes the input signal to only 7-bit resolution. During the second pass, it feeds back this 7-bit result to the input via a 7-bit D/A converter whose output is accurate to 12 bits. At the input, the D/A converter's output voltage is subtracted from the input signal so that the A/D converter can digitize the residue to obtain five more bits of resolution. In such an A/D converter, the residue must be scaled to the full input range of the A/D converter: In this case, it must operate at a gain of 32. To aggravate matters, the op

Settling to 0.2% accuracy in under 50 nsec is within the capabilities of even a low-cost, general-purpose current-feedback op amp.

amp must be able to drive the highly capacitive input of the flash converter's comparator chain.

Because conventional op amps are subject to a gain-bandwidth limitation, operating a conventional op amp at a gain of 32 will reduce its closed-loop bandwidth by a factor of 32 (as compared to its closed-loop bandwidth at unity gain), seriously impairing its settling time. Not so for a current-feedback op amp: They're not restricted by the gain-bandwidth product (see **box**, "Current-feedback defies gain-bandwidth limitations"), and their closed-loop bandwidth and settling times, therefore, remain relatively unchanged over the gain range of 1 to 20. Even at higher gains, the bandwidth falls by only about one third when you increase the gain to around 40. As a result, a current-feedback op amp is the ideal choice for the residue amplifier in subranging flash A/D converters.

Comlinear Corp had this application in mind when it designed the CLC501, its latest current-feedback op amp. The relevant specifications for this device pertain to a gain of 32, where it has a typical bandwidth of 80 MHz for a 5V p-p output signal, and typically settles to

Current feedback defies gain-bandwidth limitations

A current-feedback op amp owes its ability to maintain its bandwidth over a wide range of closed-loop gain settings to its internal architecture. Unlike a conventional op amp, which relies on feedback to drive its inverting and noninverting inputs to the same potential, the current-feedback op amp's noninverting and inverting inputs are linked by a unity-gain buffer. As a result, the op amp's inverting input automatically assumes the same potential as the noninverting input and has a very low input impedance, to or from which current can flow.

The output stage of the current-feedback op amp is a transimpedance amplifier with high gain ($A_{(s)}$) that senses the current flowing in the op amp's inverting input and generates a corresponding output voltage. As you can see from the accompanying **figure**, the current that flows at the op amp's inverting input (I_{INV}) is given by the equation

$$I_{INV} = I_1 - I_2 = \frac{V_2}{R_1} - \frac{V_O - V_2}{R_2}. \quad \text{(A)}$$

However, $V_O = I_{INV} \times A_{(s)}$ and $V_2 = V_1$.

When you substitute these equations into **Eq A**, you obtain the equation

$$\frac{V_O}{A_{(s)}} = \frac{V_1}{R_1} - \frac{V_O - V_1}{R_2},$$

which rearranges to

$$\frac{V_O}{V_1} = \frac{1 + \frac{R_2}{R_1}}{1 + \frac{R_2}{A_{(s)}}}.$$

Letting

$$1 + \frac{R_2}{R_1} = G,$$

as you would for a conventional op amp with the same feedback configuration, gives you

$$\frac{V_O}{V_1} = \frac{G}{1 + \frac{R_2}{A_{(s)}}}. \quad \text{(B)}$$

When you compare **Eq B** with the closed-loop gain equation for a conventional op amp, you obtain

$$\frac{V_O}{V_1} = \frac{G}{1 + \frac{G}{A_{(s)}}}, \quad \text{(C)}$$

which shows that the ideal closed-loop voltage gain for the two types of op amp (that is, when the op amp has an infinite $A_{(s)}$) is the same and is equal to G.

However, in reality $A_{(s)}$ is a polynomial function of frequency with zeros and poles. In other words,

$$A_{(s)} = \frac{N_{(s)}}{D_{(s)}}.$$

Substituting $N_{(s)}/D_{(s)}$ for $A_{(s)}$ in **Eqs B** and **C** yields a closed-loop gain for the current-feedback op amp:

$$\frac{V_O}{V_1} = G\frac{N_{(s)}}{N_{(s)} + R_2D_{(s)}}.$$

For a conventional op-amp, the substitution yields a gain of

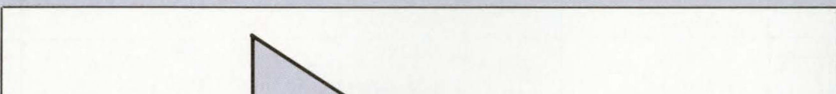
$$\frac{V_O}{V_1} = G\frac{N_{(s)}}{N_{(s)} + GD_{(s)}}.$$

By comparing these two equations, you can see that in the

0.05% in 12 nsec. The op amp also incorporates another important feature that makes it suitable for use as a residue amplifier—it has programmable output-voltage clamping, and it recovers from the condition in which the output is clamped in 1 nsec typ (<3 nsec max). The output clamping protects the A/D converter's input during the transients that can occur when the residue amplifier is switched in and out of the signal path, or when it's subjected to the full input signal before the feedback has been applied.

The device's clamping function should suit it to other applications that require fast overload recovery—for example, radar equipment and optical transducers. You can set separate positive and negative clamping levels by applying dc voltages to two of the device's pins. A simple resistive divider is all that's necessary to establish these voltage levels. Alternatively, because the clamping-voltage inputs have their own 3-dB bandwidth of 50 MHz, you can drive them dynamically at high frequencies to achieve functions such as pulse-height modulation.

Text continued on pg 90



current-feedback op amp—unlike the conventional op amp—the position of the poles (contained within $D_{(s)}$), and hence the bandwidth of the current-feedback op amp, is not dependent on the closed-loop gain. Provided that you keep R_2 constant, you can change the closed-loop gain of a current-feedback op amp—without affecting the op amp's pole positions or the circuit bandwidth—by changing R_1.

In practice, second-order effects do result in some degree of bandwidth limitation as you increase the closed-loop gain of a current-feedback op amp, but these are slight compared to the gain-bandwidth limitations of conventional op amps. For example, the bandwidth of a typical current-feedback op amp that has a 3-dB bandwidth of 220 MHz only falls to around 180 MHz when you increase the closed-loop gain from 4 to 40. For the same gain change, a conventional op amp's bandwidth would fall to around 20 MHz.

The approximate, dc closed-loop gain equations for a current-feedback op amp are the same as those for a conventional voltage-feedback op amp. For most current-feedback op amps, the feedback resistor, which usually has a value of between 1 and 2 kΩ, is integrated in the device. The device's ac specifications all assume this internal feedback resistor is being used. Therefore, unless you wish to deliberately restrict (or try to improve) the device's bandwidth, you should use the internal feedback resistor whenever possible. If you use an *external* feedback resistor, you must take particular care in laying out the circuit in order to to minimize the capacitance to ground at the op amp's inverting input.

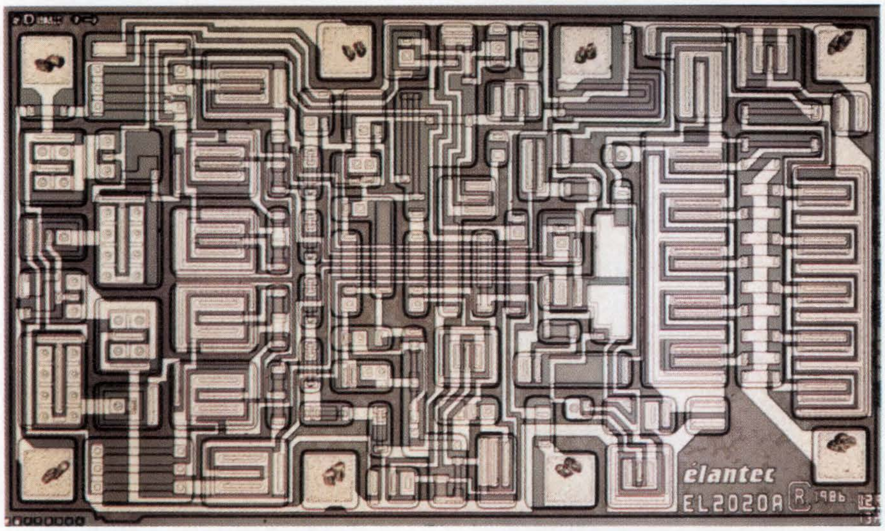
REPRESENTATIVE CURRENT-FEEDBACK OP AMPS

MANUFACTURER	DEVICE	FREQUENCY-DOMAIN PERFORMANCE: 3-dB BANDWIDTH (MHz)	FULL-POWER BANDWIDTH (MHz)	DISTORTION: LEVEL (dB), HARMONIC	DISTORTION: FREQUENCY (MHz*)	TIME-DOMAIN PERFORMANCE: SLEW RATE (V/μSEC)	SETTLING TIME (NSEC)	STEP SIZE	RISE/FALL TIME (NSEC)	STEP SIZE	INPUT OFFSET VOLTAGE (mV*)
ANALOG DEVICES	AD846	46 AT A_V=−1 31 AT A_V=−10 15 AT A_V=−30	6.8 AT 20V p-p	0.0002% THD	100 kHz	450	80 TO 0.1% 110 TO 0.01%	10V	10	10V	25 μV
	AD9610	100 AT A_V=−1 95 AT A_V=−10 75 AT A_V=−20	—	−55, THD	20	>3500	18 TO 0.1% 30 TO 0.02%	5V	<3.5	5V	±0.3
	AD9611	>280 AT A_V=−5	210 AT 3V p-p	−54, 2ND −58, 3RD	60	1900	13 TO 0.1% 16 TO 0.05% INTO 50Ω LOAD	3V	1.3/1.5 1.4/1.6	1V 3V	±0.5
APEX MICROTECHNOLOGY	WA-01 WA-01A	150 AT V_{OUT}= 4V p-p AND I_{OUT}=50 mA	40 AT 20V p-p	—	—	4000	20 TO 0.1%	10V	3/2.5	20V	(−01) ±4 (−01A) ±2
COMLINEAR	CLC103A	170 AT A_V=±4 150 AT A_V=±20 130 AT A_V=±40	80 AT 20V p-p	−48, 2ND −48, 3RD	20	6000	10 TO 0.4%	10V	2.3 4	5V 20V	10
	CLC200A	100 AT A_V=±4 95 AT A_V=±20 90 AT A_V=±40	25 AT 20V p-p	−52, 2ND −58, 3RD	20	4000	18 TO 0.1% 25 TO 0.02%	10V	3.6 4	2V 20V	10
	CLC201A	100 AT A_V=±4 95 AT A_V=±20 90 AT A_V=±40	50 AT 20V p-p	−52, 2ND −58, 3RD	20	4000	18 TO 0.1% 30 TO 0.02%	10V	3.6 4	2V 20V	0.5
	CLC203A	180 AT A_V=±4 160 AT A_V=±20 130 AT A_V=±40	60 AT 20V p-p	−55, 2ND −55, 3RD	20	6000	15 TO 0.2%	10V	2.5 4	5V 20V	0.5
	CLC205A	190 AT A_V=±4 170 AT A_V=±20 120 AT A_V=±40	100 AT 10V p-p	−57, 2ND −68, 3RD	20	2400	22 TO 0.1% 24 TO 0.05%	10V	2.2 4.8	2V 10V	3.5
	CLC206A	200 AT A_V=±4 180 AT A_V=±20 90 AT A_V=±40	70 AT 20V p-p	−59, 2ND −67, 3RD	20	3400	19 TO 0.1% 22 TO 0.05%	10V	2.0 7	2V 20V	3.5
	CLC220A	200 AT A_V=±4 190 AT A_V=±20 160 AT A_V=±40	100 AT 10V p-p	−58, 2ND −62, 3RD	20	7000	8 TO 0.1% 15 TO 0.02%	5V	1.9 2	2V 5V	10
	CLC221A	200 AT A_V=±4 170 AT A_V=±20 120 AT A_V=±40	130 AT 10V p-p	−58, 2ND −62, 3RD	20	6500	15 (TO 0.1%) 18 (TO 0.02%)	5V	2.1	2V	0.5
	CLC231A	165 AT A_V=±1 165 AT A_V=±2 120 AT A_V=±5	95 AT 10V p-p	−55, 2ND −59, 3RD	20	3000	12 (TO 0.1%) 15 (TO 0.05%)	5V 2.5V	2 5	2V 10V	1
	CLC300-A, -B	105 AT A_V=±4 85 AT A_V=±20 70 AT A_V=±40	45 AT 20V p-p	−48, 2ND −48, 3RD	20	3000	20 (TO 0.8%)	10V	4 7	5V 20V	10
	CLC400	220 AT A_V=±1 200 AT A_V=±2 60 AT A_V=±8	50 AT 5V p-p	−60, 2ND −60, 3RD	20	1200 700 (AT A_V = 0 TO 2)	10 (TO 0.1%) 12 (TO 0.05%)	2V	1.6 6.5	0.5V 5V	2
	CLC401	180 AT A_V=±7 150 AT A_V=±20 75 AT A_V=±50	100 AT 5V p-p	−45, 2ND −60, 3RD	20	1200	10 (TO 0.01%)	2V	2.5 5	2V 5V	3
	CLC501	120 AT A_V=20 80 AT A_V=32	80 AT 5V p-p	−45, 2ND −60, 2ND	20	1200	12 (TO 0.05%)	2V	4.3 5	2V 5V	1.5
ELANTEC	EL2020	50 AT A_V=1 30 AT A_V=10	7.95	—	—	500 (INTO 400Ω)	50 (TO 1%) 90 (TO 0.1%) INTO 400Ω	10V	25 (FOR A_V=10)	1V	3
	EL2022	165 AT A_V=2	—	—	—	1900	22 (TO 0.1%)	2.5V	2.1 4.3	2V 10V	1
PRECISION MONOLITHICS	OP260-A, -E, -F, -G	8 MIN AT A_V= 1 TO 50 5 MIN AT A_V=100	—	—	—	300	—	—	—	—	(-A, —E) 8 MAX (-F) 9 MAX (-G) 10 MAX

NOTES:
* EXCEPT WHERE SPECIFIED OTHERWISE
1. ALL VALUES QUOTED ARE TYPICAL VALUES AT 25°C UNLESS OTHERWISE STATED, AND SHOULD THEREFORE ONLY BE CONSIDERED AS A GUIDE IN COMPARING OP AMPS
2. WHERE APPLICABLE, ALL SPECIFICATIONS ASSUME THE OP AMP'S INTERNAL FEEDBACK RESISTOR IS BEING USED
3. PRICE QUOTED IS FOR THE LEAST EXPENSIVE VERSION
4. ABS MAX=ABSOLUTE MAXIMUM VALUE
5. THD=TOTAL HARMONIC DISTORTION

DC PERFORMANCE			QUIESCENT SUPPLY CURRENT (mA, NO LOAD)	TEST CONDITIONS			PACKAGE	PRICE (100)	COMMENTS
OFFSET VOLTAGE DRIFT (μV/°C°)	OUTPUT DRIVE CURRENT (mA)	OUTPUT DRIVE VOLTAGE		CLOSED-LOOP GAIN	SUPPLY VOLTAGE	LOAD (Ω)			
(-J, -S) 2 (-K) 1	±50 MIN	±10V MIN	5	−1	±15V	500	8-PIN TO-99, 8-PIN DIP	$4.50 TO $18.75	HIGH PRECISION
±5	±50 MIN	±10V	21	−10	±15V	200	12-PIN TO-8	$49.88 TO $79	LOW OFFSET AND DRIFT
±5	±50	±3V	70 AT 5V 74 AT −5V	−5	±5V	100	12-PIN TO-8	$84 TO $125	LOW OFFSET AND DRIFT
(−01) 15 (−01A) 10	±400 ABS MAX	±11V AT 0.4A ±12V AT 0.1A	25	—	±15V	FULL LOAD	8-PIN TO-3	(WA01) $107.20 (WA01A) $139.40	HIGH POWER
50	±200 ABS MAX	±11V MIN NO LOAD	30	20	±15V	100	24-PIN DIP	$128	HIGH OUTPUT CURRENT
35	±100 ABS MAX	±12V NO LOAD	29	20	±15V	200	12-PIN TO-8	$92	GENERAL PURPOSE
5	±100 ABS MAX	±12V NO LOAD	29	20	±15V	200	12-PIN TO-8	$99	LOW OFFSET AND DRIFT
5	±200 ABS MAX	±11V MIN NO LOAD	30	20	±15V	100	24-PIN DIP	$135	HIGH OUTPUT CURRENT
11	±50	±12V NO LOAD	19, 5.6 AT 5V	20	±15V	200	12-PIN TO-8	$56	LOW POWER, OVERDRIVE PROTECTED
11	±100	±12V NO LOAD	29, 8.7 AT 5V	20	±15V	200	12-PIN TO-8	$56	OVERDRIVE PROTECTED
35	±50 ABS MAX	±10V MIN NO LOAD	30	20	±15V	200	12-PIN TO-8	$105	GENERAL PURPOSE
5	±50 ABS MAX	±10V MIN NO LOAD	30	20	±15V	200	12-PIN TO-8	$112	LOW OFFSET AND DRIFT
10	±100 ABS MAX	±12V NO LOAD	18	2	±15V	100	12-PIN TO-8	$56	LOW-POWER BUFFER FOR LOW-GAIN APPLICATIONS
25	±100 ABS MAX	±10V	24	20	±15V	100	24-PIN DIP	(-A) $39 (-B) $29.50	
20	±70	±3.5V AT A_V=5	15	2	±5V	100	8-PIN DIP, NAKED DIE	$15.50	LOW-POWER OP AMP FOR USE AT GAINS BETWEEN ±1 AND ±8
20	±70	±3.5V	15	20	±5V	100	8-PIN DIP, NAKED DIE	$15.50	LOW-POWER OP AMP FOR USE AT GAINS BETWEEN ±7 AND ±50
10	±70	±3.5V	18	32	±5V	100	8-PIN DIP	$17.10	PROGRAMMABLE OUTPUT CLAMPING; RECOVERS FROM OUTPUT CLAMPING IN 1 NSEC TYP
−15 TO +15 mV OVER TEMPERATURE	±32.5 INTO 400Ω	±13V INTO 400Ω	9	10	±15V	100	8-PIN DIP, 20-LEAD PLCC, 20-PAD LCC	$4.95	LOW POWER, ENABLE INPUT
10	±100 ABS MAX	±12V NO LOAD	18	2	±15V	100	12-PIN TO-8	$65 TO $97	LOW POWER
(-A, -E) 25 MAX (-F) 30 MIN	±20 MIN	±12V MIN 1-kΩ LOAD	11 MAX FOR BOTH OP AMPS	—	±15V	—	8-PIN DIP, TO-99	$7.95	DUAL OP-AMP; OFFSET VOLTAGE MATCHING TO 1 mV; LOW POWER

Even when operated at high gain levels, current-feedback op amps don't suffer from restricted bandwidth.



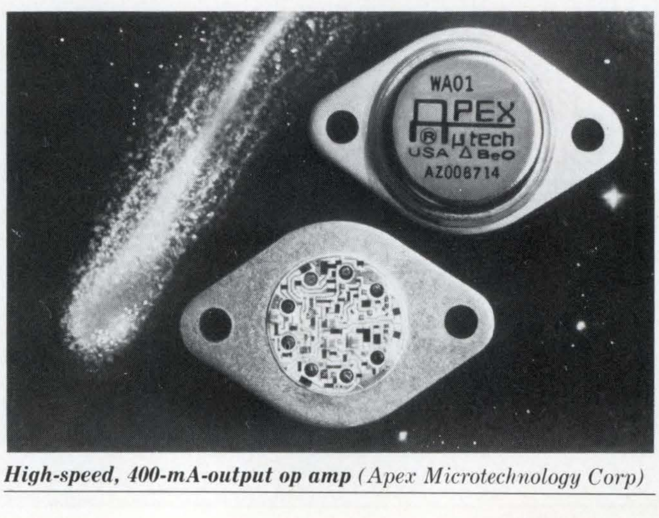
Micrograph of low-cost, 50-MHz op amp (Elantec Inc)

The settling-time performance of current-feedback op amps makes them equally attractive as an output stage for high-speed D/A converters. As a bonus, if you use the op amp in an inverting gain mode, the low input impedance of the op amp's inverting input effectively shorts out the output capacitance of the D/A converter, reducing the effect that this capacitance has on the overall settling time.

As you increase the resolution of high-speed A/D and D/A converters, you'll also need to improve the dc performance of the front and back-end amplifiers. In particular, an op amp's input-offset voltage and drift will become critical. For example, for a 12-bit A/D converter with a 10V input range, you'll require the op amp's output offset (input offset × gain) to be less than 1.25 mV (0.5 LSB). A number of recently introduced op amps are capable of such performance. Analog Devices' AD-9610 and -9611 and Comlinear Corp's CLC-201A, -203A, and -221A, for example, all spec an input offset voltage of 0.5 mV or less and an offset voltage drift of 5μV/°C. At the same time, they provide small-signal (2 to 4V p-p depending on the device) bandwidths of 100 MHz or more at low gain values, and they settle to 0.1% or better in under 20 nsec. (Note that these numbers are all typical values at 25°C, so unless you're prepared to test and select op amps for specific parameters, make sure you check the devices' absolute maximum specifications over the required temperature range before committing to a design.)

Commensurate with these op amps' low input offset voltages are their input bias currents and input-bias-current drifts, which are both relatively low compared to those of other current-feedback types. The inverting input of the AD9610 specs ±5 μA and ±70 nA/°C; the noninverting input specs ±15 μA and ±30 nA/°C. For the AD9611, those figures are ±1 μA and ±140 nA/°C and ±1 μA and ±75 nA/°C, respectively. For both inputs of the Comlinear devices, the numbers are 5 μA and 50 nA/°C. (The numbers given are all typical values at 25°C.) You'll note from these figures that in a current-feedback op amp, the bias currents and bias-current drifts are not always as well matched at the inverting and noninverting inputs as they are in a conventional op amp.

What's more, for some devices you can't always guarantee that the temperature drift at both inputs will be in the same direction. As a result, you can't always mimimize bias-current errors by driving both inputs from the same source impedance as you would with a conventional op amp. Because the value of the



***High-speed, 400-mA-output op amp** (Apex Microtechnology Corp)*

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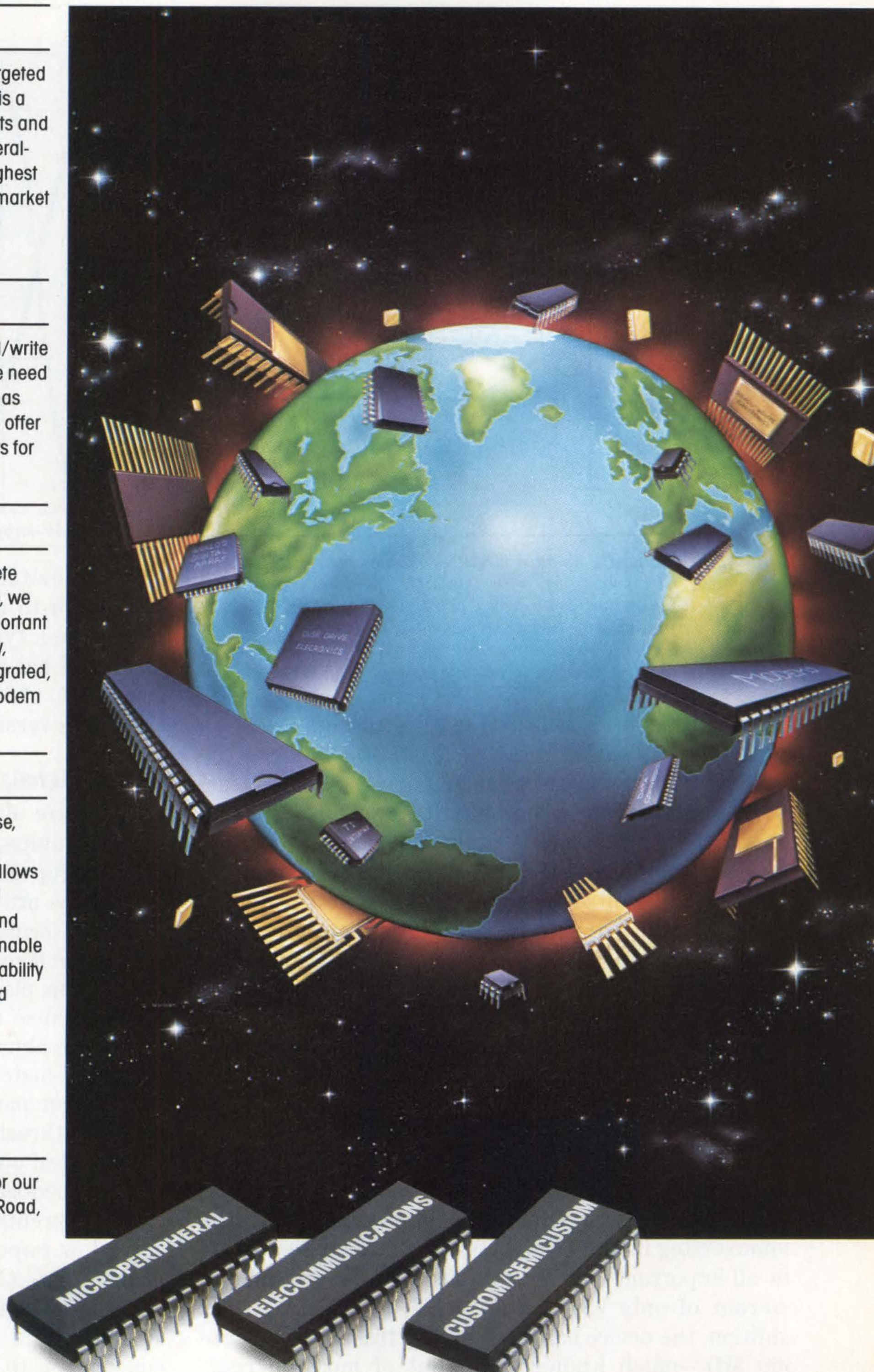

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Although they can't match conventional precision op amps, current-feedback op amps are available with low offset and drift characteristics.

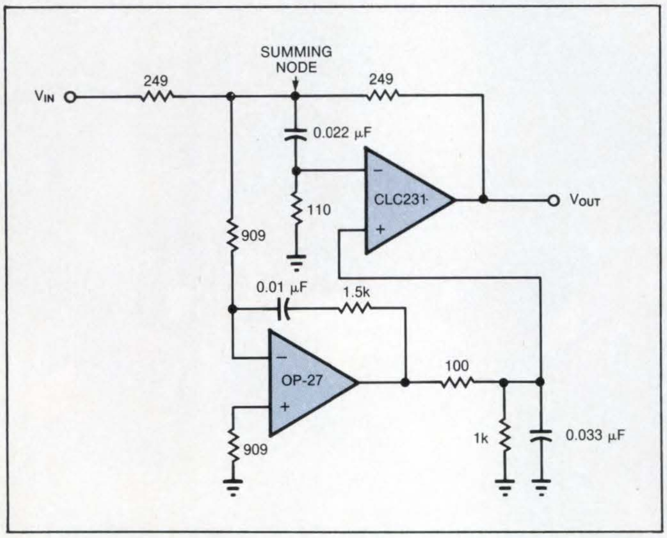
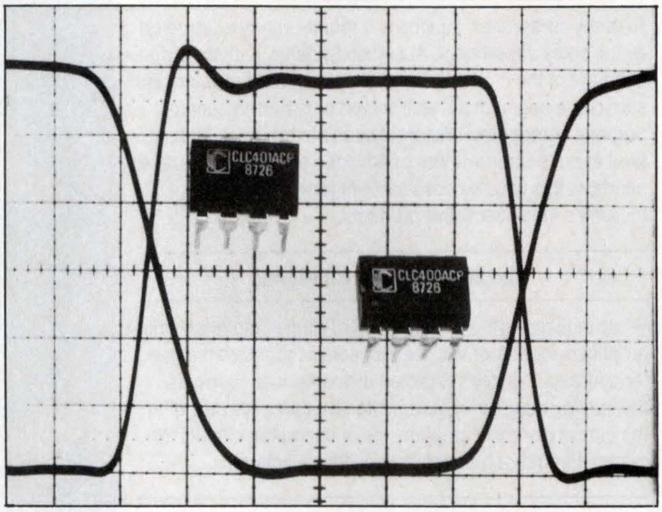


Fig 1—This composite op-amp circuit *combines the low offset and drift of the OP-27 op amp with the high speed of the CLC231 current-feedback op amp to produce a circuit that settles to 0.1% in 17 nsec, yet maintains high dc accuracy. The OP-27 maintains the summing node at an accurate virtual earth potential; the CLC231 takes over at high frequencies to provide good ac performance.*



200-MHz, ±5V-supply op amps *(Comlinear Corp)*

input and feedback resistors used with high-speed op amps is low (usually 2 kΩ or less), and because the devices are usually operated at fairly low gain, bias-current errors tend to be reduced. However, in applications that require high accuracy, you'll almost certainly have to add offset- and bias-current compensation circuitry to these op amps. One way to achieve very low input offset and drift over a wide temperature range while maintaining a high ac bandwidth is to combine a current-feedback op amp with a high-precision conventional op amp, as shown in **Fig 1**.

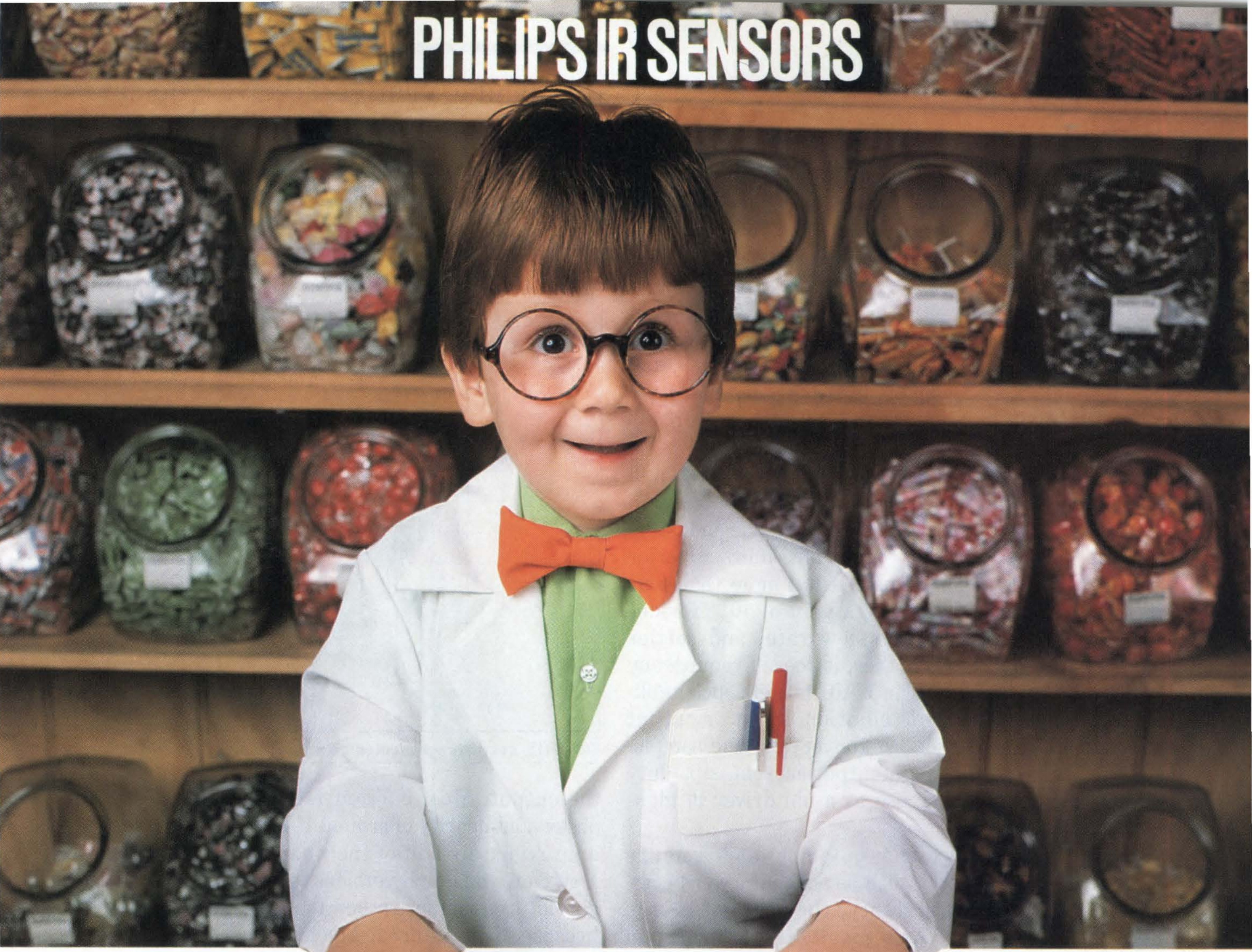
You might also consider using Analog Devices' AD846, which specs a typical 25°C input offset voltage of only 25 µV and is available in two versions having input offset voltage drifts of 2 or 1 µV/°C. The absolute maximum values for input offset over 0 to 70°C are 400 µV for the 2-µV/°C version and 250 µV for the 1-µV/°C version. Although the input bias current at the noninverting input of the AD846 is a modest 10 µA typ, its all-important inverting input specs a typical bias current of only 75 nA that drifts at 6.5 nA/°C. In addition, the device has an open-loop transimpedance of 500 MΩ—much higher than that of most current-feedback op amps—which reduces the closed-loop gain error due to open-loop gain to a mere 0.0005%.

The AD846's common-mode rejection ratio (CMRR), specified at 125 dB, is also considerably better than the 50 to 60 dB typical of most other current-feedback op amps. Inevitably, you must make some tradeoff in bandwidth to achieve this high dc accuracy, but the part specs a typical small-signal 3-dB bandwidth of 46 MHz, and has typical 10V-step settling times, to 0.1% and 0.01%, of 80 and 110 nsec, respectively. A commercial-grade version in a plastic DIP costs $4.50 (100).

Digital signals need analog performance

There are also good reasons for using current-feedback op amps to process digital signals. As these signals propagate along transmission lines, their pulse waveforms are degraded by imperfections in the line and by external interference. To recover the signal and retransmit it to the next section of cable, therefore, you must often place repeaters at strategic points in the line. Because a current-feedback op amp's internal stages are almost entirely symmetrical, the device has very well-matched output rise and fall times. When used as comparators to detect when the input signal crosses a threshold, these op amps can generate highly symmetrical pulse waveforms. In addition, many of the current-feedback op amps on the market can deliver output currents of 100 mA or more, so they can directly drive low-impedance coaxial cables. Although Comlinear Corp's CLC501 has a recommended output current that's limited to ±50 mA, the device has particular advantages in pulse-recovery applications, because it enables you to clamp the output at the required logic levels, even though the input signal may saturate the amplifier.

Apex Microtechnology Corp's WA01 current-feedback op amp is especially suited for applications that require a high-speed, high-current drive capability.



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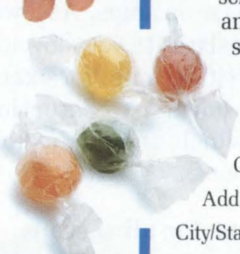

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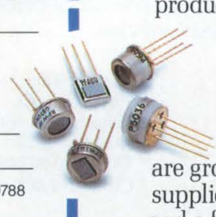

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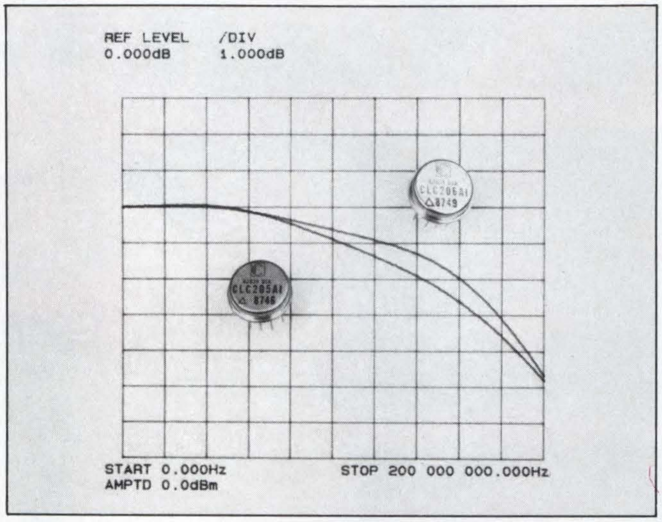
Combining a current-feedback op amp with a conventional op amp can give you the best of both worlds—both high speed and precision.

Even when delivering 400 mA at 20V p-p, the op amp achieves a typical power bandwidth of 40 MHz; with a 4V p-p, 50-mA output, its typical bandwidth is 150 MHz. The op amp is available in two grades that have input offset voltages of ±4 and ±2 mV and offset-voltage drifts of 15 and 10 μV/°C, respectively.

The WA01 provides balance pins so that you can null the amplifier's input offset with an external potentiometer. The WA01 is pin compatible with the industry-standard 3554 wideband op amp, but offers superior performance at low gain values: It has more than four times the 3554's bandwidth at a gain of 10, provides over three times the 3554's slew rate, and settles around six times faster. Further, it doesn't require any compensation capacitors. The WA01 targets such applications as video-signal distribution, input or output drivers for flash A/D and D/A converters, and sample/hold-circuit drivers. Its high output-current capability also makes it suitable for use as a pin driver in high-speed ATE equipment.

Because current-feedback op amps don't require phase-degrading circuitry such as ac feedforward compensation to maintain stability, they exhibit a very linear phase response. As a result, the propagation delay through the amplifier is the same for both the fundamental and harmonic components of the input signal, leading to a high degree of waveform fidelity at the output. Most current-feedback op amps exhibit phase nonlinearity of around 1° typ (at 25 °C, from dc to approximately half of their small-signal bandwidth). However, you'll find versions for which that figure is an absolute maximum rather than a typical value. Also, because their internal bipolar transistors operate as current amplifiers rather than voltage amplifiers, they introduce very low levels of harmonic distortion: Their second and third harmonic-distortion levels are typically between −50 and −70 dB at 20 MHz for the Comlinear op amps. At lower frequencies, that parameter translates to very low levels of distortion indeed (for its AD846 op amp, for example, Analog Devices quotes a total-harmonic-distortion figure of 0.0002% at 100 kHz, which should make for some impressive hi-fi equipment).



200-MHz, overdrive-protected op amps *(Comlinear Corp)*

Op amps for all seasons

Finally, most of the current-feedback op amps on the market are available in versions that suit the industrial temperature range (−25 to +85°C) and the military temperature range (−55 to +125°C). You'll also find devices that are tailored for ±5V supplies, low power dissipation, or low cost, as well as devices that feature output-short-circuit or input-overdrive protection. However, because current-feedback op amps rely on bipolar transistors to achieve their high-frequency performance, you won't find a CMOS version. **EDN**

For more information . . .

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

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Box 9106
Norwood, MA 02062
(617) 329-4700
TWX 710-394-6577
Circle No 360

Apex Microtechnology Corp
5980 N Shannon Rd
Tucson, AZ 85741
(602) 742-8600
Fax (602) 888-3329
Circle No 361

Comlinear Corp
4800 Wheaton Dr
Fort Collins, CO 80525
(303) 226-0500
TLX 450881
Circle No 362

Elantec Inc
1996 Tarob Ct
Milpitas, CA 95035
(408) 945-1323
TWX 910-997-0649
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Precision Monolithics Inc
1500 Space Park Dr
Santa Clara, CA 95052
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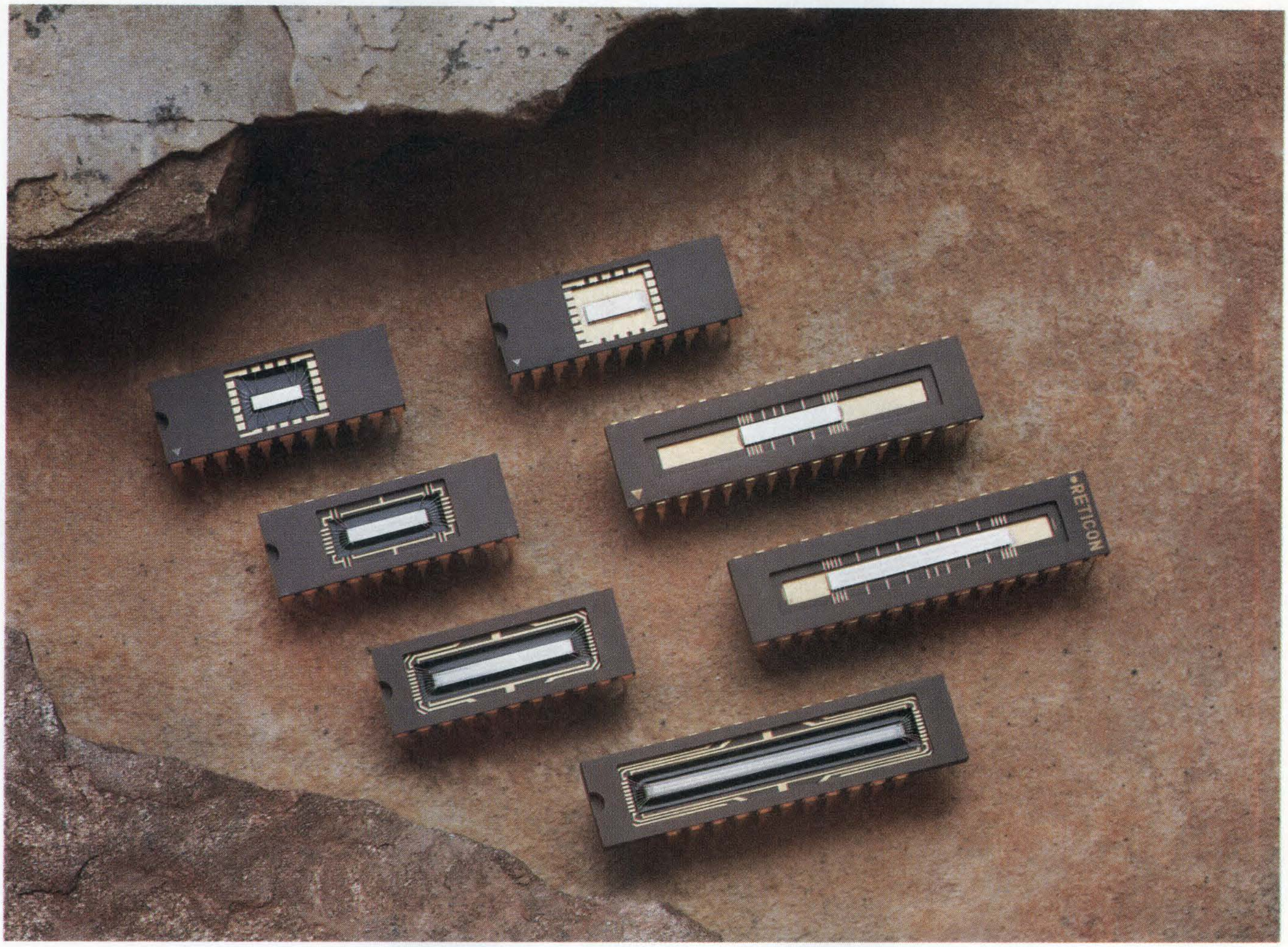

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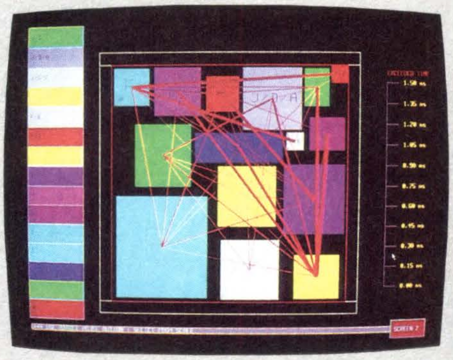

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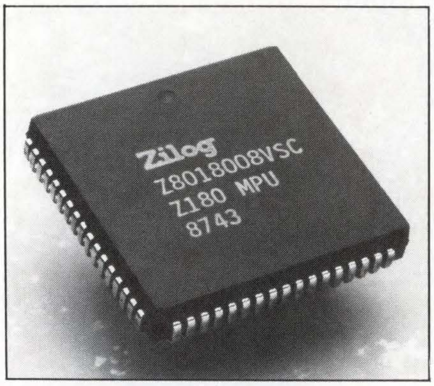
Enhanced Z80 microprocessor can address 1M byte of memory

The Z80180 is an enhanced version of the company's Z80 microprocessor. It incorporates an on-chip memory-management unit (MMU) that can address as much as 1M byte of memory and support 64k bytes of logical I/O space. The μP contains two direct-memory-access (DMA) channels for transferring data from memory to memory and memory to I/O.



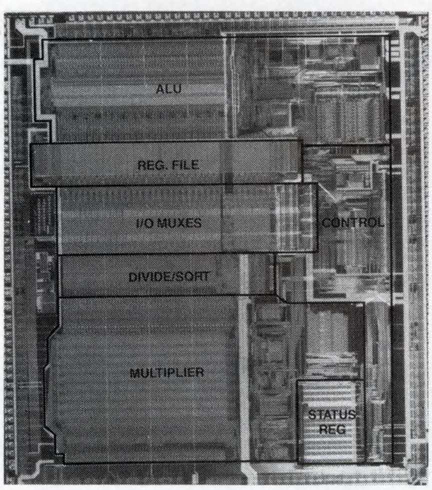
In addition to supporting the Z80 instruction set, the chip uses seven additional high-level instructions, including multiply. Other features include an on-chip wait-state generator, a programmable dynamic-RAM refresh controller, two full-duplex asynchronous serial-communications (UART) channels, a clocked serial-I/O port, two 16-bit programmable timers, an on-chip clock oscillator, and an interrupt controller. The CMOS chip comes in a 64-pin plastic DIP and a 68-pin plastic leaded chip carrier. When operating at 8 MHz from a 5V supply, the chip dissipates 200 mW; in system-standby mode, it dissipates less than 50 mW. It operates over 0 to 70°C. The 8-MHz part sells for $11.45 (100). A 6-MHz version costs $8.55 (100). Delivery is 10 to 12 weeks ARO.

Zilog Inc, 210 Hacienda Ave, Campbell, CA 95008. Phone (408) 370-8000. TWX 910-338-7621.

Circle No 410

1-chip, 64-bit floating-point processors achieve a peak rate of 20M flops

The WTL 3164 and WTL 3364 are 64-bit floating-point processors. The single-chip devices contain a 64-bit floating-point multiplier, a 64-bit floating-point ALU, a divide and square-root unit, and a register file that contains thirty-two 64-bit words. The register file is accessible through six independent, internal ports.



The processors' functions include single- and double-precision floating-point, integer, shift, logical, and min/max instructions that operate at a peak rate of 20M flops for the 100-nsec grade. You can use the 3364 in applications, such as vector and array processors, that require high throughput rates. The 3164 suits applications that are computationally intensive, but the I/O bandwidth requirement is of secondary importance. The 168-pin 3364 has three 32-bit ports; a bidirectional, an input, and an output port. You can use the ports in that configuration, or you can combine the input and output ports to connect to a 64-bit bidirectional bus. The 144-pin 3164 is functionally identical to the 3364 except that it has a single 32-bit bidirectional bus. Both chips have a single-cycle throughput for all multiplier and ALU operations. Register-to-register operations take two cycles. Double-precision divide and square-root operations take 17 and 30 cycles, respectively. The 100-nsec 3164 costs $829 (10).

Weitek Corp, 1060 E Arques Ave, Sunnyvale, CA 94086. Phone (408) 738-8400.

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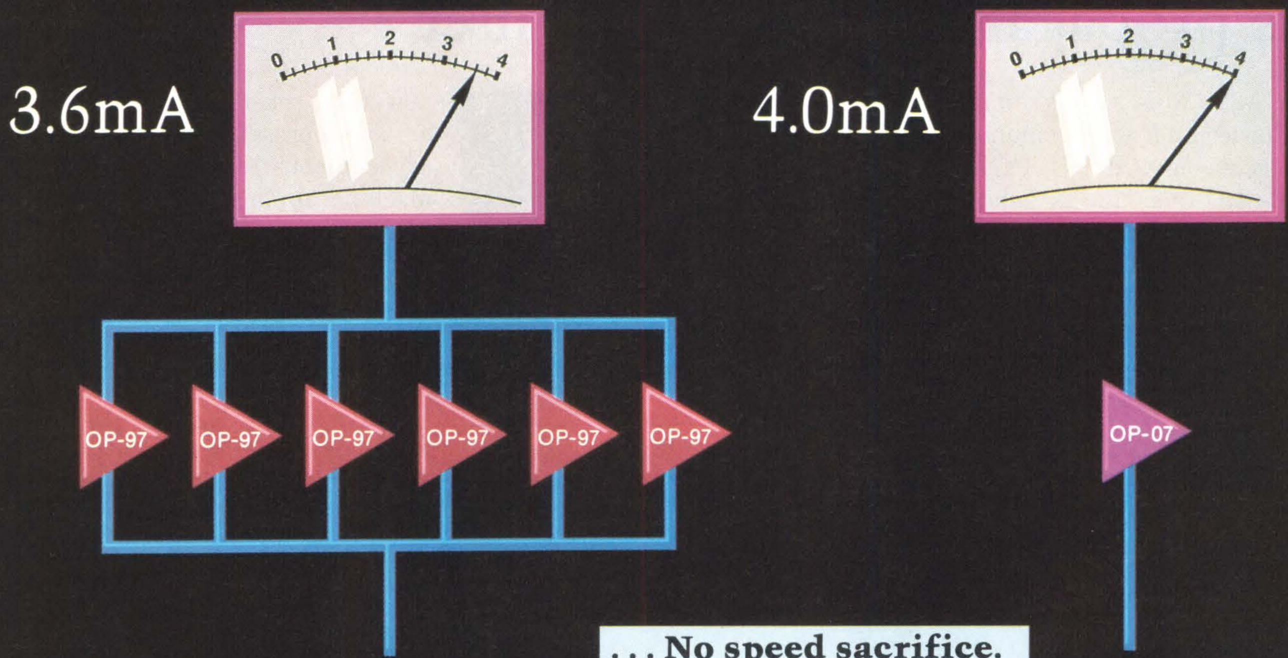

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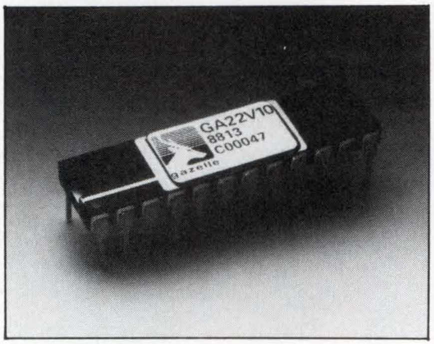
CIRCLE NO 62

GaAs programmable logic device has propagation delay of 10 nsec

The GA22V10 is a programmable logic device built with gallium arsenide technology. It has TTL-compatible I/O lines and is functional and pin compatible with the silicon version of the 22V10. The propagation delay between an input signal and a nonregistered output is 10 nsec max for the commercial version, 12 nsec max for the military version.



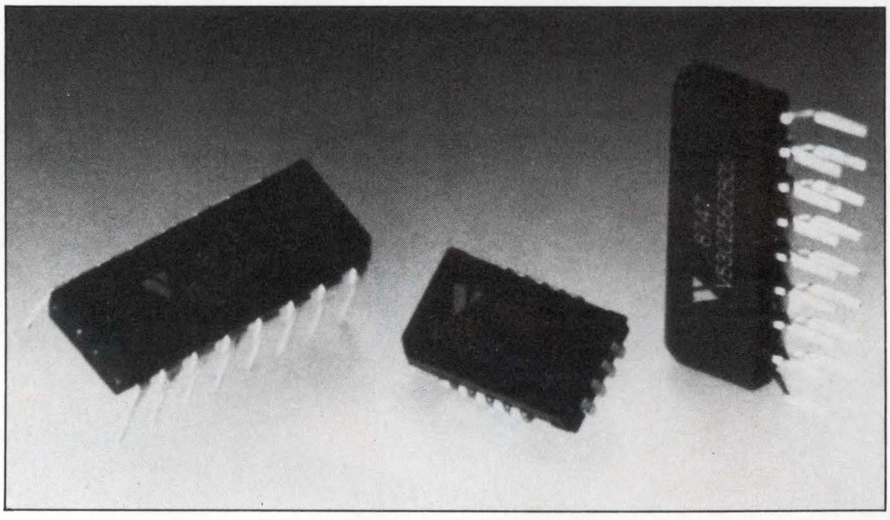
The commercial version of the device can run at 90 MHz max; its military counterpart can be clocked at 71 MHz. The chip provides 22 inputs and ten 3-state outputs that you can program for registered or combinatorial data with active-high or active-low polarities. It also has a power-up reset command, a synchronous preset command, and an asynchronous reset mode for state-machine applications. To prevent unauthorized access to the internal configuration, a security link disables the pattern-verification function and the preloading of the registered outputs. The PLD costs $55 (100).

Gazelle Microcircuits Inc, 2300 Owen St, Santa Clara, CA 95054. Phone (408) 982-0900. Fax 408-982-0222.

Circle No 416

256k×1-bit dynamic RAMs offer access times as low as 70 nsec

The V53C256 and the V53C258 are families of 256k×1-bit dynamic RAMs. Each family contains four models offering row-access times (RAS) of 70, 80, 100, and 120 nsec, respectively. All the inputs of these CMOS devices are TTL compatible. When operating in fast-page mode, the 70-nsec-RAS version of the -256 RAM lets you randomly access as many as 512 bits within a row at a cycle time of 50 nsec. If you keep the RAS line active while applying successive column-access strobes (CAS), the device retains the row address internally, so you don't need to reapply it on each cycle. During fast page-mode operation, the RAM lets you perform Read, Write, Read-Modify-Write, or Read-Write-Read operations. The part also provides a sustained data rate of 19 MHz.



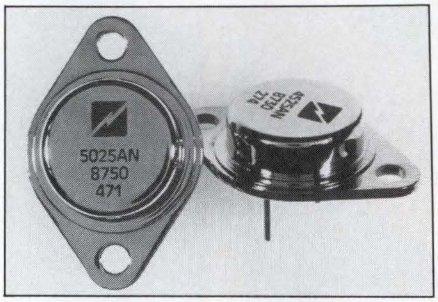
The -258 family offers a similar mode called the static column mode; for the 70-nsec-RAS version of the -258, that mode lets you randomly access 512 bits within a row at a cycle time of 45 nsec. In this mode, the device acts as a static RAM for multiple-column accesses within a row so that you can mix read and write cycles. The chip provides a sustained data rate of 22 MHz. The RAMs ara available in 16-pin DIPs, 16-pin ZIPs (zigzag in-line packages), and 18-pin PLCCs. The 70-nsec versions of both devices cost $7.87 (100).

Vitelic Corp, 3910 N First St, San Jose, CA 95134. Phone (408) 433-6000. TLX 3719461. Fax 408-433-0331.

Circle No 414

Power MOSFETs can carry drain currents as high as 22A

The 23 new members of the Power MOS IV line of power MOSFETs offer a range of current-handling capabilities and come either in TO-3 packages or in die form. An example of the TO-3 devices is the APT4020AN, which has a drain-to-source voltage (V_{DS}) rating of 400V, a drain-to-source on-resistance—R_{DS} (on)—of 0.20Ω, drain-to-source current (I_D) rating of 22.0A, and 2400-pF input capacitance (C_{ISS}). Another example, the APT6035AN, has a V_{DS} rating of 600V, an R_{DS} (on) of 0.35Ω, an I_D rating of 17.0A, and a C_{ISS} of 2400 pF. You can also obtain units with 800-pF C_{ISS}, 180-pF output capacitance (C_{OSS}), or 60-pF transfer capacitance (C_{RSS}). The dies for hybrid applications have similar specifications; however, their drain-current specifications depend on the package you use. The devices' large die sizes lower their thermal resistance and increase their thermal capacity. The APT6035AN costs $28.86 (100); the APT4020AN is $22.65 (100).



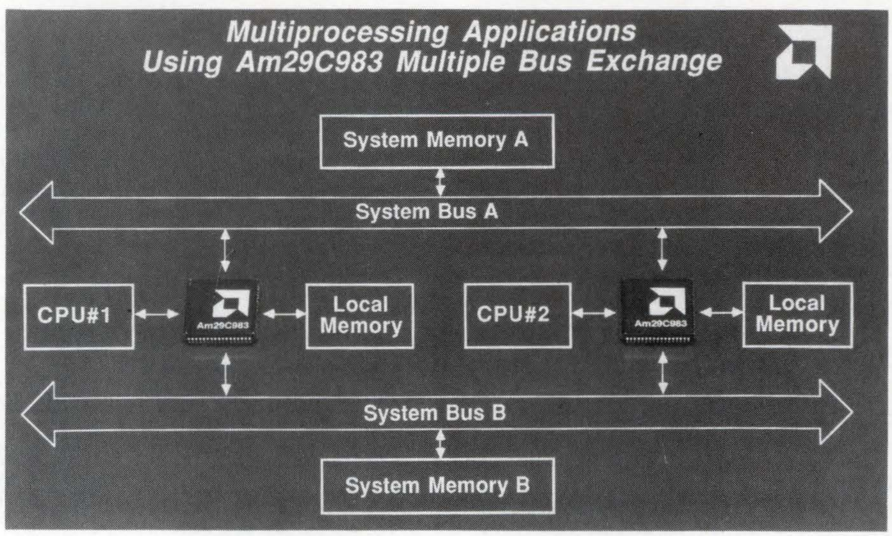
Advanced Power Technology, 405 SW Columbia St, Bend, OR 97702. Phone (503) 382-8028. Fax 503-388-0364.

Circle No 417

Multiple-bus exchangers act as digital crossbar switches

The Am29C982 and the Am29C983 are multiple-bus exchangers that act as digital crossbar switches. Both chips are fabricated with CMOS technology. You can select each of the four bidirectional, 4-bit ports on the Am29C982 independently to connect to any of the other ports. This organization permits data routing and multiple-bus communications. The device comes in a 28-pin DIP, leadless chip carrier (LCC), or plastic leaded chip carrier (PLCC), and it exhibits typical port-to-port delays of 7 nsec.

The Am29C983 is a similar device except that the four ports are each 9 bits wide. In addition, each I/O port has an input latch and an output latch to capture incoming and outgoing data, respectively. Each latch has an independent latch-enable input. The chip has independent output-enable lines that can place the output drivers in a high-impedance state. All the I/O lines go to a high-impedance state upon power-down. The device is available in a 68-pin PLCC or LCC, and it exhibits typical port-to-port delays of 9 nsec. The ports for each of these devices are TTL compatible and can sink 48 mA of output drive current. The 28-pin DIP version of the Am29C982 costs $8.50 (100); the 68-pin PLCC version of the Am29C983 costs $24.50 (100).



Advanced Micro Devices Inc, Box 3453, Sunnyvale, CA 94088. Phone (408) 732-2400. TLX 346306.

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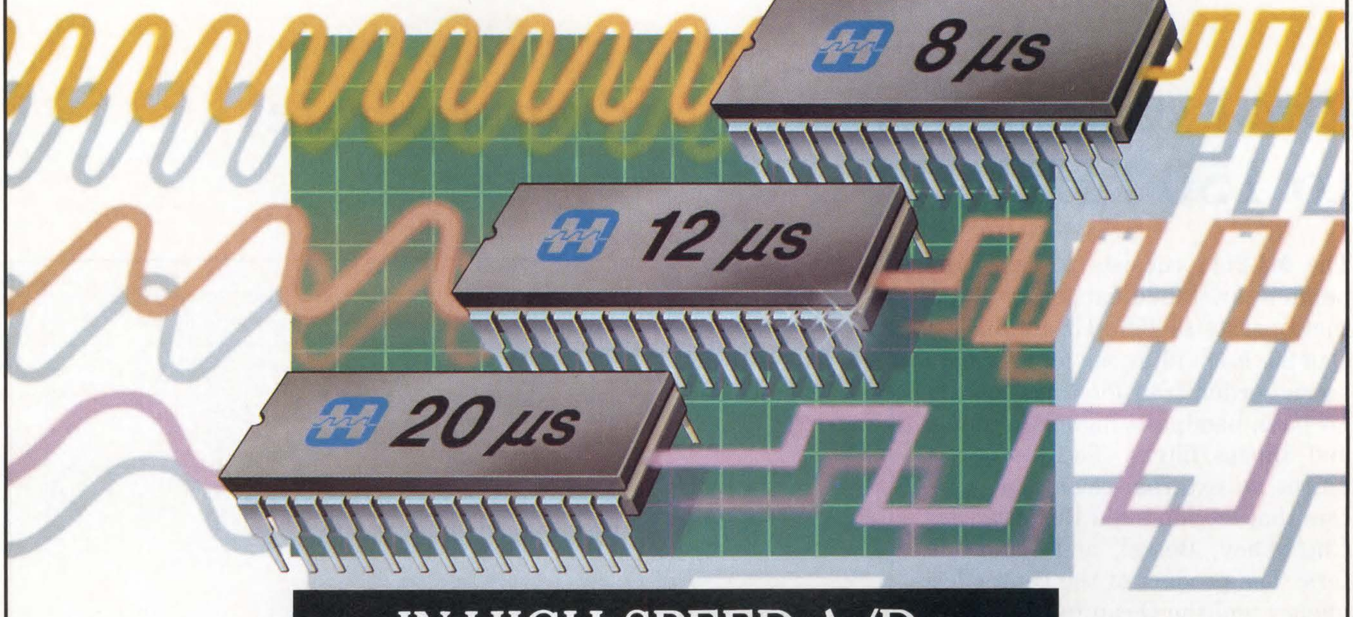
All three pinout-identical models are complete 12-bit ADCs with reference and clock, incorporating 8-, 12-, or 16-bit microprocessor bus interface with 150 ns bus access time. All guarantee break-before-make action, eliminating bus contention during read operations.

Conversion times: Model HI-574A, 20 μs...HI-674A, 12 μs...HI-774, 8 μs.

The HI-774 features a smart successive approximation register; its digital error correction circuitry improves dynamic accuracy and throughput rate. All three ADCs can operate under control of the processor, or in a stand-alone mode. Models come in commercial and military temperature ranges — including MIL-STD-883. Packages: 28-pin Cerdip and leadless chip carriers (LCCs).

For information call 1-800-4-HARRIS, Ext. 1405. In Canada, 1-800-344-2444, Ext. 1405. Or write: Harris Semiconductor Products Division, P.O. Box 883, MS 53-035, Melbourne, Florida 32902-0883.



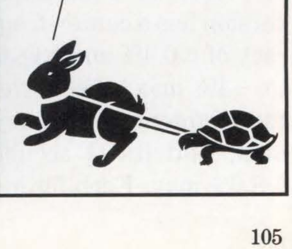
IN HIGH-SPEED A/Ds, THE NAME IS

HARRIS

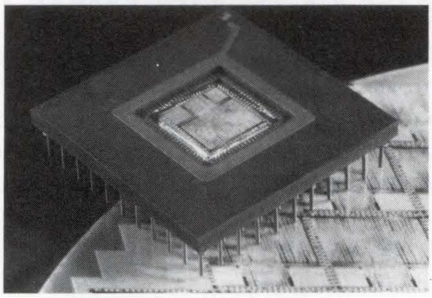
Harris Semiconductor: Analog - CMOS Digital
Gallium Arsenide - Semicustom - Custom

HARRIS

"Fast Harris ADCs compensate for slower components."



16-bit microcontroller executes within 400 nsec after an interrupt



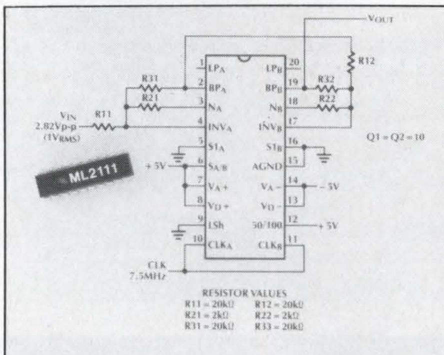
The RTX 2000 is a 16-bit microcontroller for embedded real-time applications. The chip, which is designed around the company's Forth-based RISC (reduced-instruction-set computer) core processor, can begin an instruction sequence within 400 nsec after an interrupt. While running at 10 MHz, the chip can execute a maximum of 40 million Forth operations/sec and can typically operate at a sustained rate of 10 million operations/sec. It also features a dual-stack architecture; each stack is 256 words long. The parameter stack stores data temporarily and passes data between subroutines. The return stack stores the return address when the microcontroller calls subroutines. The chip has an on-chip 16×16 multiplier that can execute in a single cycle; an on-chip interrupt controller; and three general-purpose, 16-bit timers. An ASIC bus lets you attach ASIC devices to the chip. The CMOS device comes in an 84-pin PGA (pin-grid array) package and costs $190 (1000).

Harris Corp, Semiconductor Sector, Box 883, Melbourne, FL 32901. Phone (305) 724-7418.

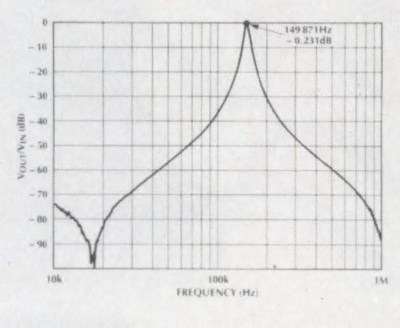
Circle No 418

Dual switched-capacitor filters operate to 150 kHz

The ML2111 consists of two independent switched-capacitor filters that operate to 150 kHz and have a Q of 20. Each filter can approximate second-order transfer functions for lowpass, bandpass, highpass, notch, and allpass filters. The device requires an external clock and resistors that let you build Butterworth, Chebyshev, Bessel, and Cauer filters. The product of the center frequency and the Q can range as high as 5 MHz. A control pin allows you to select a clock-to-frequency ratio of 50:1 or 100:1 or to hold the last output sample. The vendor offers two versions of the ML2111: The -B version has a center-frequency accuracy of ±0.4% and a Q accuracy of 0 to −4% max; the -C version's center-frequency accuracy is ±0.8% max, and its Q accuracy is 0 to −8.0% max. Each filter consists of a



Cascading 2 Sections in Mode 1, Each with $Q = 10$ Results in a Bandpass Filter with $Q = 15.5$ and $f_0 = 150kHz$.



The Frequency Response of the Circuit on the Left with $f_{CLK} = 7.5MHz$.

low-offset (15-mV max) voltage amplifier, a voltage summer, two integrators, and control logic. The filters maintain their specifications when operating from ±5V supplies with ±10.0% tolerances. The device can also operate from a single 5V±10% supply at a maximum operating frequency of 100 kHz. An ML2111 in a 20-pin DIP costs $6.95; in a 20-pin SOIC package, it's $7.15.

Micro Linear Corp, 2092 Concourse Dr, San Jose, CA 95131. Phone (408) 433-5200. TLX 275906.

Circle No 415

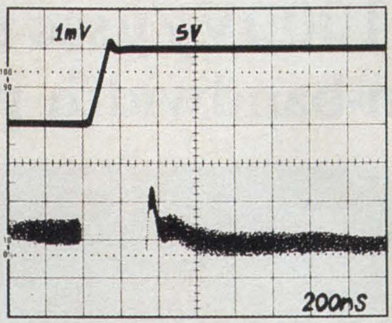
ANALOG DEVICES

500ns Settling BiFET Op Amp

AD744

FEATURES
Fast Settling:
500ns to 0.01% for 10V Step
1.5μs to 0.0025% for 10V Step
Slew Rate: 75V/μs
Total Harmonic Distortion (THD): 0.0003%
>1000pF Capacitive Load Drive Capability with 10V/μs Slew Rate

Input Offset Voltage: 0.25mV max
Input Offset Drift: 3μV/°C max
Open Loop Gain: 250V/mV min
Noise: 4μV p-p max, 0.1Hz to 10Hz



AD744 Settling Characteristics 0 to + 10V Step

PRODUCT DESCRIPTION

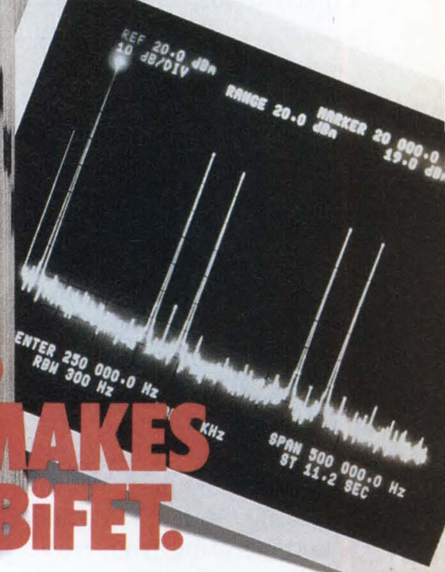
The AD744 makes a breakthrough in the high speed BiFET market by offering guaranteed maximum settling to 0.01% in 750ns. It also offers the excellent dc characteristics of the AD711 BiFET family with enhanced slew rate, bandwidth and load driving capability.

The single-pole response of the AD744 provides fast settling: 500ns to 0.01% typically, and 750ns maximum. This feature, combined with high dc precision, makes the AD744 suitable for use as a buffer amplifier for 12-, 14- and 16-bit DACs and ADCs. Furthermore, the AD744's low total harmonic distortion (THD) level of 0.0003%, low noise and gain bandwidth product of 13MHz make it an ideal amplifier for demanding audio applications. It is also an excellent choice for high speed instrumentation amplifiers and for use in active filters.

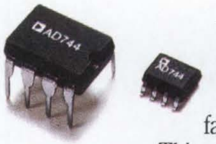
The AD744 offers optional custom compensation for additional design flexibility. This external compensation allows the AD744 to drive capacitive loads up to 2000pF and greater with full stability, making the AD744 outstanding for use as a coaxial cable driver. Alternatively, external decompensation may be used to increase the gain bandwidth of the AD744 to over 200MHz at high gains. This makes the AD744 ideal for use as an ac preamp in digital signal processing (DSP) front ends.

PRODUCT HIGHLIGHTS

1. The AD744 offers exceptional dynamic response. It settles to 0.01% in 500ns and has a 100% tested minimum slew rate of 50V/μs.
2. The combination of Analog Devices' advanced processing technology, laser wafer drift trimming and well-matched ion-implanted JFETs provide outstanding dc precision. Input offset voltage, input bias current and input offset current are specified in the warmed-up condition and are 100% tested.
3. The AD744 has a guaranteed and tested maximum voltage noise of 4μV p-p, 0.1 to 10Hz.
4. The AD744 is a high speed BiFET op amp that offers excellent performance at competitive prices. It outperforms the OP42/44, OPA602, LF356 and LF400.



THIS PAGE SETTLES THE QUESTION OF WHO MAKES THE FASTEST SETTLING BiFET.



A lot of companies say they have fast-settling, high-performance BiFET amps. But our AD744 settles to 0.01% in 500ns and to 0.0025% in 1.5μs – making it the world's fastest-settling, highest-performance BiFET.

This superior settling, combined with excellent dc performance, makes the AD744 unbeatable for active filters, and for buffering DACs and ADCs up to 16 bits.

The AD744, with a total harmonic distortion of just 0.0003%, low noise, a clean pulse response, and a gain bandwidth product of up to 200MHz, is also ideal for digital signal processing and audio applications.

If you work in communications, you'll appreciate the AD744's ability to drive loads greater than 2000pF with full stability. And you'll also appreciate the fact that the AD744 can drive a 1000pF cap load while maintaining a slew rate of 10V/μs.

The AD744 isn't our only outstanding BiFET, either. The AD711 single, AD712 dual, and soon the AD713 quad, settle in 1μs with the same high resolution as the AD744. If low power with precision is critical, try our AD548 single or AD648 dual.

Whichever BiFET your application requires, you'll find our products deliver excellent performance at an excellent price. For example, the AD744 starts at only $2.25; the AD711 at $.80; and the AD548 at $.75 (100s).

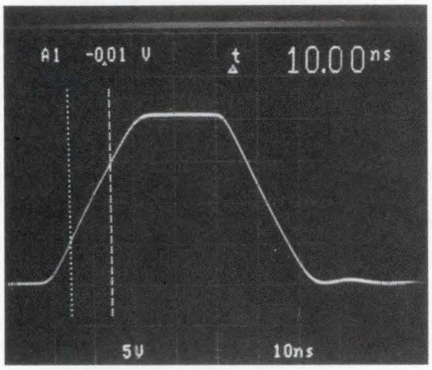
If you'd like to see more proof on why we can say we make the best BiFETs, call Applications Engineering at (617) 935-5565, ext. 2628 or 2629. Or write to Analog Devices, P.O. Box 9106, Norwood, MA 02062-9106.

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: (719) 590-9952; Maryland: (301) 992-1994; Ohio: (614) 764-8795; Pennsylvania: (215) 643-7790; Texas: (214) 231-5094; Washington: (206) 251-9550; Austria: (222) 885504; Belgium: (3) 237 1672; Denmark: (2) 845800; France: (1) 4687-34-11; Holland: (1620) 81500; Israel: (052) 911415; Italy: (2) 6883831, (2) 6883832, (2) 6883833; Japan: (3) 263-6826; Sweden: (8) 282740; Switzerland: (22) 31 57 60; United Kingdom: (932) 232222; West Germany: (89) 570050

Op amp offers a 1000V/μsec slew rate and a 1-GHz gain-bandwidth product

The EL2038 is a monolithic op amp with a gain-bandwidth product of 1 GHz and a 1000V/μsec slew rate. The device is stable for gains of 20V/V or greater and is pin-compatible with the HA2539 and NE5539 op amps. Operating at a gain of 20V/V, it provides a 50-MHz bandwidth when driving a 400Ω load. When operating from ±15V supplies, it can deliver a ±11V output signal and can source and sink 25 mA into a 400Ω load. This output-drive capability lets the device drive capacitive loads as high as 25 pF at



the 1000V/μsec slew rate. You can power the device from supplies ranging from ±5 to ±17V. Other specifications include a 2-mV max offset voltage, a 17-mA max power-supply current, an 80-dB open-loop gain, and a high-power bandwidth of 15.9 MHz typ. The military version complies with MIL-STD-883 revision C; the vendor performs a burn-in test at 125°C before delivery. The commercial-grade device costs $3.90 (100); the MIL-STD-883 device sells for $32.40 (100).

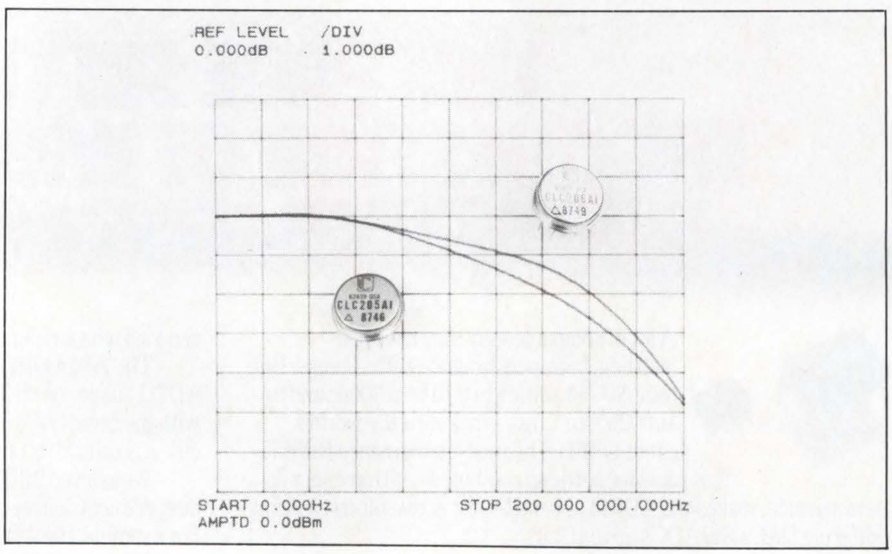
Élantec Inc, 1996 Tarob Ct, Milpitas, CA 95035. Phone (800) 821-7429; in CA, (408) 945-1323.

Circle No 419

High-speed op amps offer overdrive and short-circuit protection

The CL205 and CL206 are op amps that employ current-feedback technology. When you set its voltage gain to 20V/V, the CLC205 has a 3-dB bandwidth of 170 MHz. It settles to 0.05% of final value in 24 nsec. It consumes 570 mW when operating from ±15V, and 56 mW when operating from ±5V. The op amp's output swing can be ±12V with a 50-mA output current. For a voltage gain of 20V/V, the CL206 has a 3-dB bandwidth of 180 MHz. It settles to 0.1% of its final value in 19 nsec, and its output drive current is 100 mA. The part features a slew rate of 3400V/μsec, which provides a full-power 3-dB bandwidth of 70 MHz for a 20V p-p output swing when the op amp is operating at a voltage gain of 20V/V.

The op amps self-limit the input currents when the outputs are saturated. You can use diode-clamp circuits on the inputs when the input signal level exceeds the maximum



differential input voltage (±3V) or common-mode input voltage ($\pm V_{CC}-1V$). You can protect the outputs from the effects of short circuits by using output-current-limiting techniques. Industrial versions of the op amp cost $56 (100) and are available from stock. Military versions are $138 (100); they're available for delivery within six weeks ARO.

Comlinear Corp, 4800 Wheaton Dr, Fort Collins, CO 80525. Phone (303) 226-0500. TLX 450881. Fax 303-226-0564.

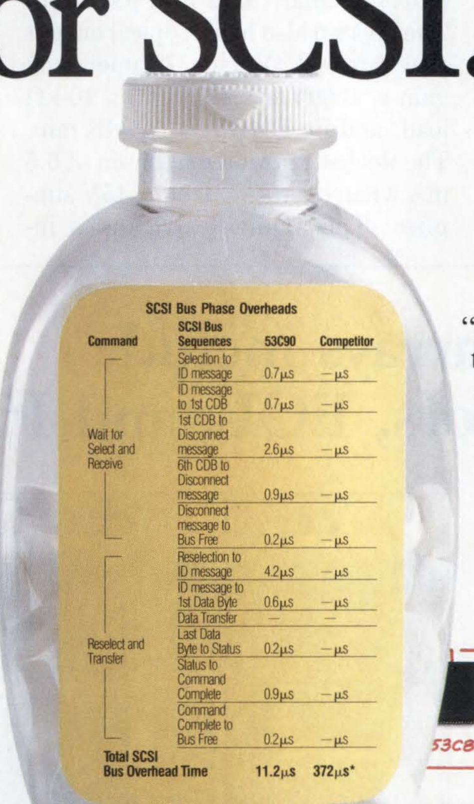
Circle No 412

NCR keeps raising the standards for SCSI.

Finally, a cure for SCSI overheadaches.

NCR's 53C90 is the only chip that can give you fast, fast, fast relief from overheadaches. Using combination commands, dedicated sequential logic and dual-ranked registers for command pipelining, the 53C90 is quickest on and off the bus. Plus NCR implements complex bus sequencing in hardware, not time-wasting software.

Transfer rates? NCR's 53C90 delivers the SCSI bus maximum of 5.0 MBytes/sec synchronous and 3MBytes asynchronous at 25MHz for the full length of the bus.

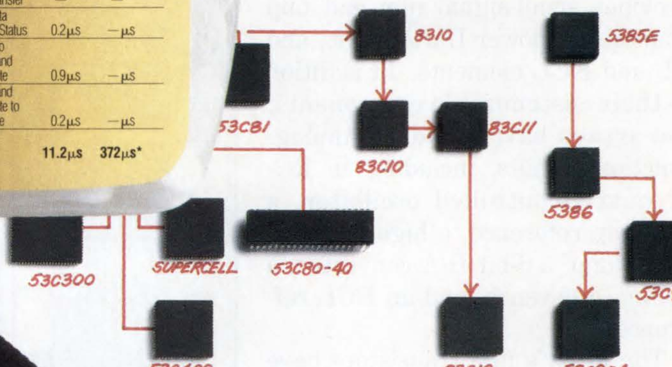


SCSI Bus Phase Overheads

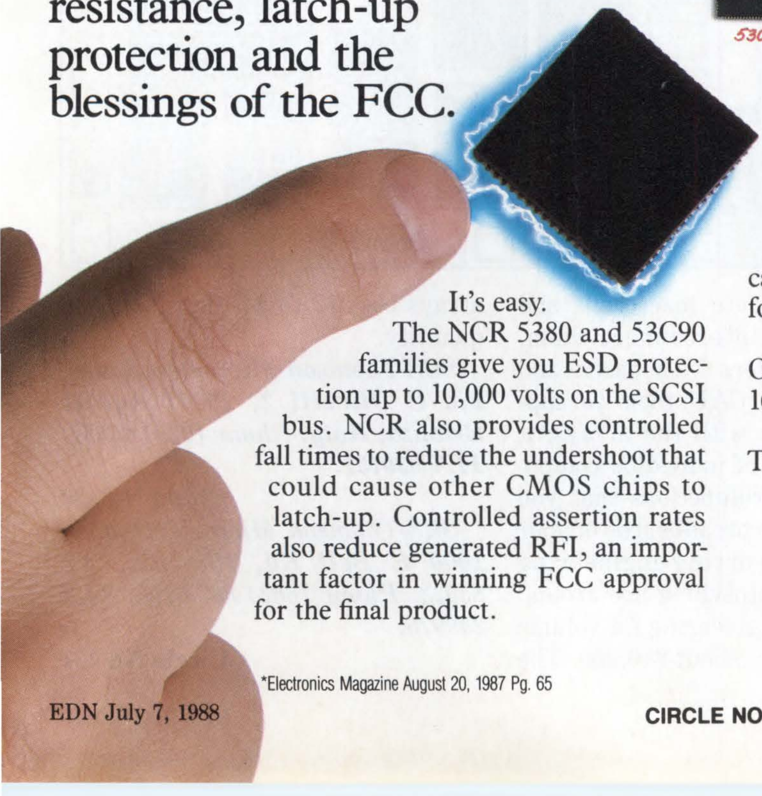
Command	SCSI Bus Sequences	53C90	Competitor
Wait for Select and Receive	Selection to ID message	0.7μs	—μs
	ID message to 1st CDB	0.7μs	—μs
	1st CDB to Disconnect message	2.6μs	—μs
	6th CDB to Disconnect message	0.9μs	—μs
	Disconnect message to Bus Free	0.2μs	—μs
Reselect and Transfer	Reselection to ID message	4.2μs	—μs
	ID message to 1st Data Byte	0.6μs	—μs
	Data Transfer	—	—
	Last Data Byte to Status	0.2μs	—μs
	Status to Command Complete	0.9μs	—μs
	Command Complete to Bus Free	0.2μs	—μs
Total SCSI Bus Overhead Time		11.2μs	372μs*

A big, well-connected family.

NCR's family goes back to the "Mayflower" of SCSI controllers with the 5385 in 1982. The most recent offshoot–the high-performance 53C90A. Other family members include a single chip host bus adapter (53C400), an integrated buffer controller (53C300) and even an ASIC supercell for circuit designers. Plus we'll be there with SCSI II.



How to get zap-resistance, latch-up protection and the blessings of the FCC.



It's easy.

The NCR 5380 and 53C90 families give you ESD protection up to 10,000 volts on the SCSI bus. NCR also provides controlled fall times to reduce the undershoot that could cause other CMOS chips to latch-up. Controlled assertion rates also reduce generated RFI, an important factor in winning FCC approval for the final product.

Raise your standards.

Because our chips have an edge in technology, they can help give you an edge in the market. So don't settle for the standard, call NCR today.

For documentation call our hot line 1-800-334-5454. Or write to, NCR Microelectronics, SCSI Products, 1635 Aeroplaza Drive, Colorado Springs, CO 80916.

For technical assistance, call 1-800-525-2252, Telex 452457.

NCR

NCR Microelectronics Division

*Electronics Magazine August 20, 1987 Pg. 65

CIRCLE NO 66

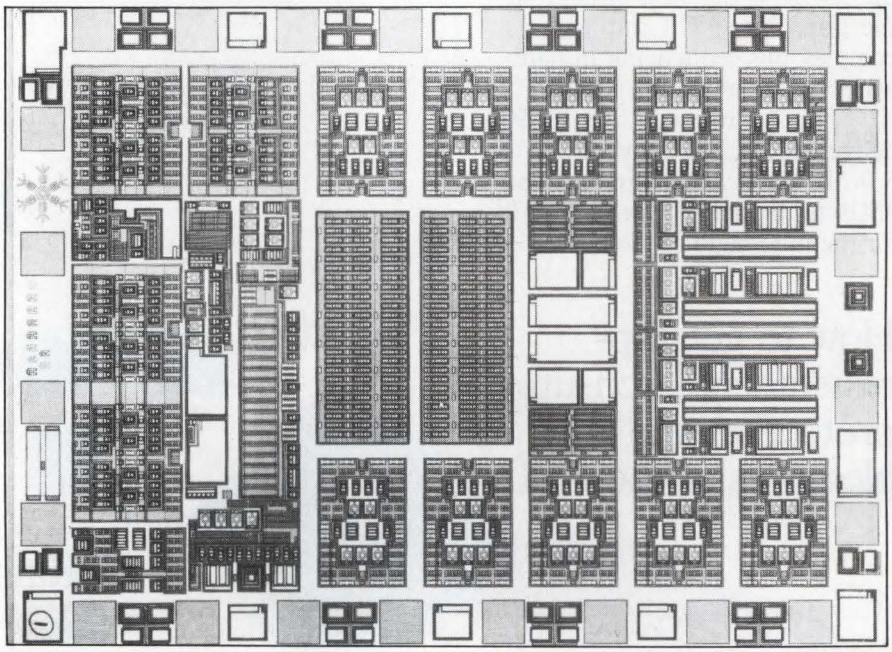
Dual op amp offers low noise and low input offset voltage

The OP-270 is a dual op amp that boasts a voltage-noise specification of 5 $nV/\sqrt{Hz}$ max at 1 kHz. Its input offset voltage is 74 μV max; its offset-drift spec is <1 $\mu V/°C$ over the military and industrial temperature ranges. The device is stable at unity gain; its gain-bandwidth product is 5 MHz typ. When operating at unity voltage gain, it settles to 0.01% of final value in 5 μsec typ. The op amp also has a typical output slew rate of 2.4V/μsec. Its open-loop gain is 1500V/mV min into a 10-kΩ load, and its CMRR is 106 dB min. The device draws a maximum of 6.5 mA when operating from ±15V supplies. The available packages include an 8-pin DIP and a 20-pin LCC package. Industrial-grade devices start at $4.50 (100); military-grade parts cost $10.50.

Precision Monolithics Inc, Box 58020, Santa Clara, CA 95052. Phone (408) 562-7384. TLX 713719541. Fax 408-727-1550.

Circle No 420

Analog-digital arrays include high-f_T transistors, ECL, and I^2L



The five members of the Polyuse-J family of analog-digital semicustom arrays range in complexity from 400 to 2300 components. Each array provides small-signal npn and pnp transistors, power Darlingtons, and I^2L and ECL elements. In addition to their customizable components, the arrays have standard analog-function circuits, including an RC- or quartz-controlled oscillator, a bandgap reference, a high-frequency op amp, a 6-bit D/A converter, a voltage reference, and an ECL reference.

The array's npn transistors have an f_T (transition frequency) of 3 GHz, so they let you implement high-performance, small-signal circuitry. You can design power stages by using the array's 200-mA npn Darlingtons and 30-mA pnp transistors. The ECL elements have multiple emitters, which let you implement stacked logic. You can operate the ECL circuitry at speeds as high as 200 MHz, and you can configure its inputs and outputs to be either ECL- or TTL-compatible. The I^2L gates operate at frequencies as high as 2 MHz.

You can customize the arrays with two metal layers, using the first level to route macrocells and the second to interconnect them. The vendor offers VAX-based and IBM PC-based CAD tools to support IC design with the arrays; it also offers kits of individual components and macrofunctions that you can use to make breadboards of your design. Nonrecurring engineering charges for prototyping are around $10,000, and engineering for volume production costs about $10,000. The arrays cost $2 to $4, depending on quantity.

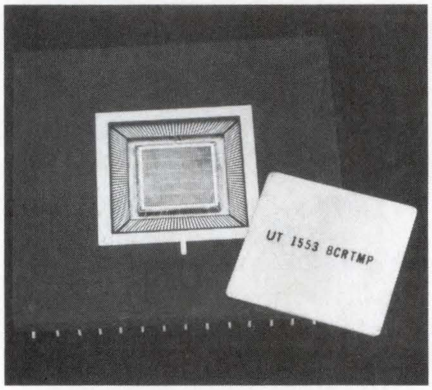
SGS-Thomson Microelectronics, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (039) 65551. TLX 330131.

Circle No 430

SGS-Thomson Microelectronics, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 431

MIL-STD-1553 bus controller supports multiple protocols

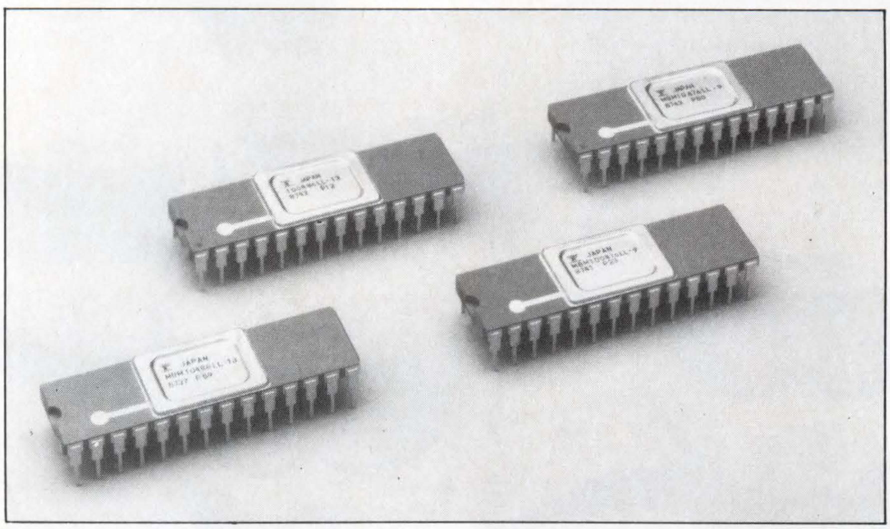


The UT1553 BCRTMP is a bus controller that supports the protocols for MIL-STD-1553A and -1553B. In addition, it supports the protocols for the McDonnell-Douglas A3818B, A5232, and A5690 and the Grumman Aerospace SP-G-151A specifications for the 1553 bus. The monolithic chip stores and retrieves 1553 messages through a host interface. The interface is either a DMA channel that must arbitrate for the host's bus or a pseudo-dual-port handshake that uses buffer registers to separate the message RAM from the host bus. The host interface has an address range of 64k words. When operating in the remote-terminal mode, the chip can store as many as 128 messages and can relocate data blocks to any subaddress. When operating in the bus-controller mode, it uses a memory scheme that allows the host to chain messages. The device comes in either a 144-pin PGA or a 132-lead flatpack, and it complies with MIL-STD-883 revision C. It costs $1047.

United Technologies Microelectronics Center, Military Standard Products Dept, 1575 Garden of the Gods Rd, Colorado Springs, CO 80907. Phone (800) 645-8862 or (303) 594-8259.

Circle No 421

On-chip write-pulse generator improves ECL RAMs' cycle time



The members of this family of ECL Self-Timed Rams (STRAMs) feature latched or registered I/O lines along with an on-chip write-pulse generator. A clock signal triggers the write-pulse generator. The timing of the internal write pulse to the memory cells minimizes the setup and hold times. As a result, the RAM automatically controls the critical relationship between the clock-pulse width and the write-enable timing. One member of the family, the MBM10486LL-13, is a 4k×4-bit RAM having a cycle time of 13 nsec min and an address-access time of 10 nsec max. It is compatible with 10K ECL devices. Another member, the MBM100476LL-9, is organized as a 1024×4-bit RAM; it has a 9-nsec min cycle time and a 1-nsec max address-cycle time, and it's compatible with 100K ECL products. The devices come in 28-pin ceramic DIPs. The 1k×4-bit units cost $55 (1000); the 4k×4-bit devices sell for $75 (1000).

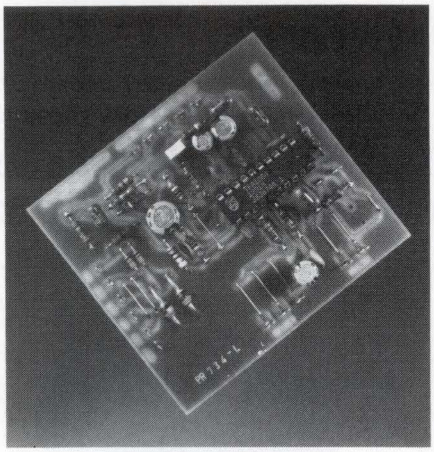
Fujitsu Microelectronics Inc, Marketing Communications, 3545 N First St, San Jose, CA 95134. Phone (408) 922-9000.

Circle No 422

Phone IC automatically compensates for loudness of phone user's voice

The TEA1064 speech/line-interface IC, for use in telephone sets, features dynamic gain limiting, which reduces distortion in the transmitted speech signal and reduces the transmitted side tone to a comfortable level. The device meets the performance requirements of all the major PTTs (post, telephone, and telecommunications authorities) in Europe, the USA, and the Far East. Because it can operate from a line voltage of 1.7V, it allows several phones to operate in parallel on the same subscriber line.

The speech circuit amplifies the voice signal received over the telephone line and provides a single-ended or differential drive for a variety of earpiece types. The earpiece amplifier generates only −85 dB of noise, even when operated at a gain of 31 dB. The microphone circuit is suitable for use with dynamic, magnetic, piezoelectric and electret microphones.



The IC has an interface for a dialer, and it produces an earpiece-confidence tone during DTMF dialing. A Mute input allows you to disable speech transmission during DTMF or pulse dialing. The DTMF amplifier has a typical gain stability of ±0.2 dB over the device's −25 to +75°C operating-temperature range. It also has automatic gain control, which allows you to operate the device with various values of exchange supply resistor and various voltages. The IC also generates a 3-mA supply from the line voltage for peripheral circuitry.

During normal operation, the TEA1064 works with line currents of between 11 and 140 mA. At a reduced-performance level, it operates at line currents as low as 2 mA and at a line voltage of 1.7V. Its maximum continuous line voltage is 12V. The device comes in a 20-pin DIP or a small-outline surface-mount package. It costs around gld 3 in high volume and is available for delivery within eight weeks ARO.

Philips, Components Div, Box 523, 5600 AM Eindhoven, The Netherlands. Phone (040) 757189. TLX 51573.

Circle No 428

Signetics Corp, 811 E Arques Ave, Sunnyvale, CA 94088. Phone (408) 991-4571.

Circle No 429

Error-detection and -correction units come in four speed grades

The P74PCT632CC is a family of CMOS error-detection and correction units (EDACs). The EDACs can detect and correct single-bit errors in a 39-bit word that consists of 32 data bits and 7 modified-Hamming-code check bits. In a typical application, when the system writes to memory, the EDAC reads the 32 data bits on the data bus and generates 7 check bits to produce a 39-bit-wide word to be stored in the system memory.

During a read operation, the chip reads all 39 bits from memory in order to detect any errors. If the chip detects a single-bit error, it corrects the data and sends the corrected data to the host and memory. If the chip detects a double-bit error, it notifies the host processor of the existence of the error. It can also detect and flag gross error conditions, such as all-zeros or all-ones conditions. The family comprises four models, which have error-detection time delays of 30 nsec, 25 nsec, 20 nsec, and 16 nsec max, respectively. Each chip operates from a −5V supply and comes in a 52-pin DIP. The 16-nsec version costs $138 (100).

Performance Semiconductor Corp, 610 E Weddell Dr, Sunnyvale, CA 94089. Phone (408) 734-8200. TWX 650-271-5784. Fax 408-734-0258.

Circle No 423

L/S Band Power GaAs FETs: A New Era In Power Amplifiers.

Power amplifier technology has come a long way. Just consider NEC's new L/S band power GaAs FETs.

There's the NE345L-10B L/S-band GaAs FET with 10W of linear power or the NE345L-20B L-band GaAs FET with 20W of linear power.

Part	*P1db (TYP)*	*GL (TYP)*	*Eff. (TYP)*
NE345L-10B	**40 dbm**	**9 db**	**40% @ 2.3 GHz**
NE345L-20B	**43 dbm**	**10 db**	**40% @ 1.5 GHz**

With MTBF's that are orders of magnitude better than TWT's, no warm-up time, and no heavy power supplies, these parts are ideal replacements for TWT's in existing systems.

The NE345L series' excellent linear gain, high performance, and hermetically sealed ceramic packaging also make them the perfect choice for many applications: such as phased array radars, airborne navigation systems, studio/transmitter links, educational TV, and mobile satellites.

Contact CEL for more information, data sheets, or application support. Then see how your power amplifiers can truly come of age.

NEC®

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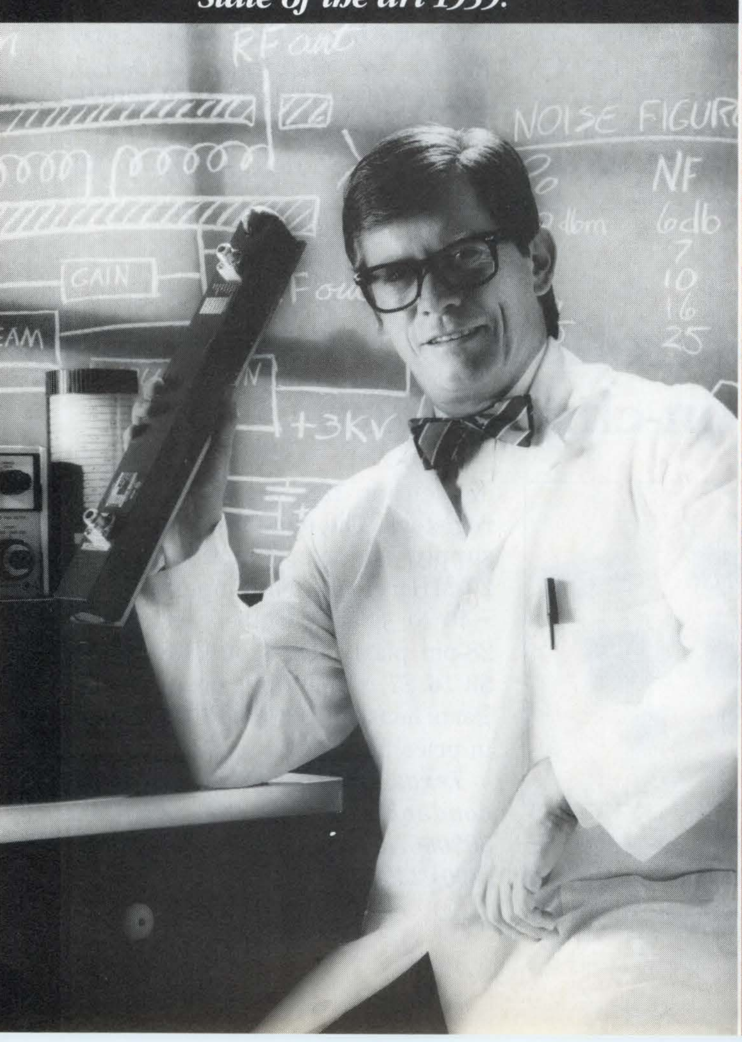
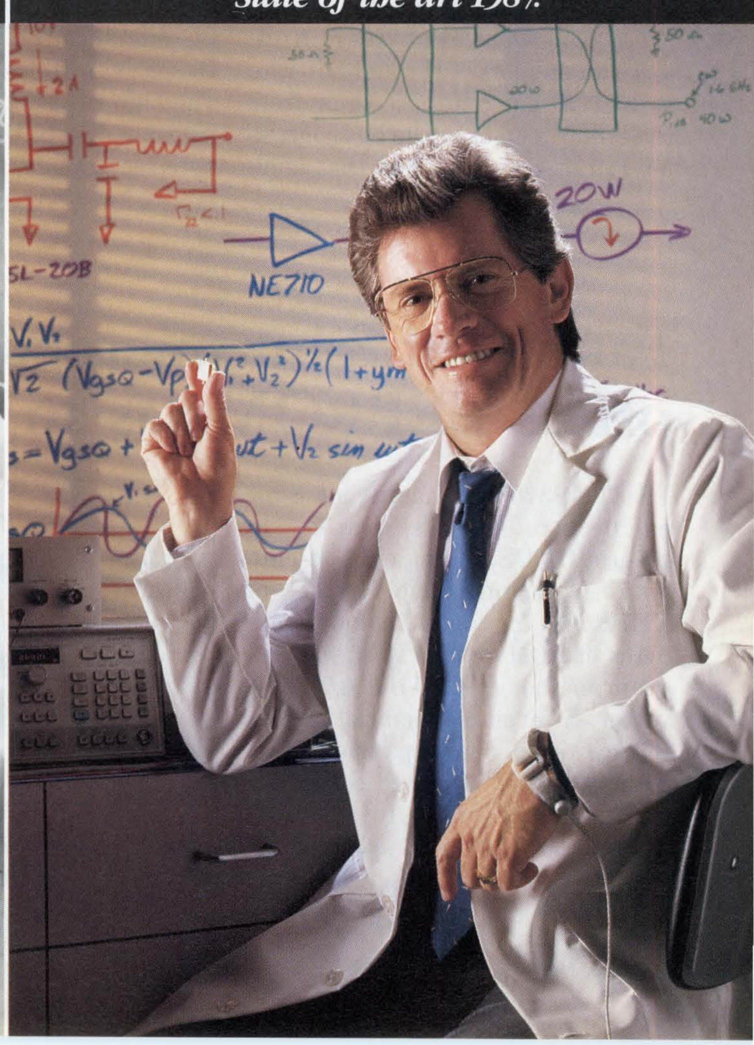
Europe NEC Electronics GmbH 0211/650301

CIRCLE NO 71

State of the art 1959.

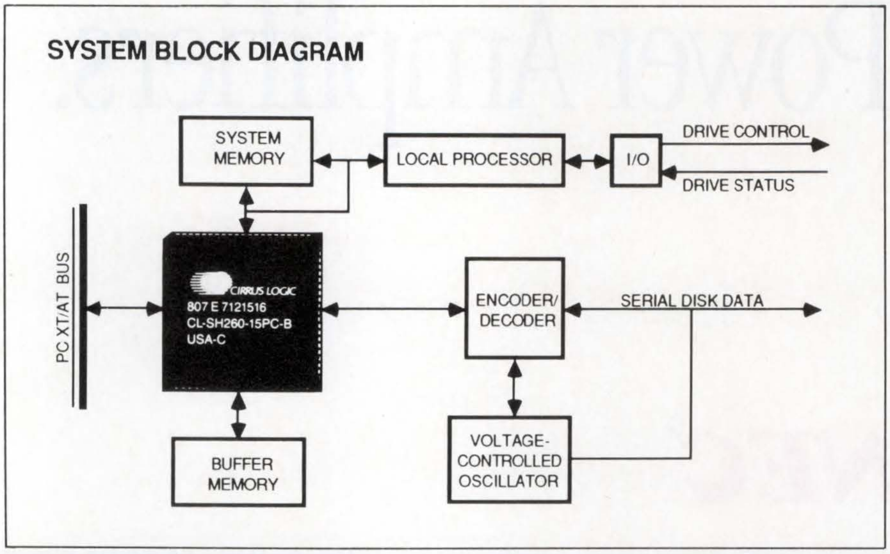


State of the art 1987.



Hard-disk-controller chip integrates formatter, buffer manager, and bus controller

The CL-SH260 is a hard-disk-controller chip for the IBM PC, PC/XT, and PC/AT and compatible computers. The single CMOS chip integrates formatter, buffer-manager, and bus-controller functions. The formatter can handle NRZ disk data rates as high as 20M bps. It consists of a serializer/deserializer, a RAM-based track sequencer, and selectable 16-bit CCITT CRC (cyclic redundancy check) or 32-bit AT ECC (error-correction code) circuitry. The hardware also generates a 56-bit ECC polynomial. The formatter supports 1:1 interleaves and can be used with interfaces to ST506/412, ST412HP, ESDI, and SMD disks. The buffer manager can address as much as 64k bytes of RAM and can support a throughput rate as high as 6M bytes/sec to or from the buffer memory. The bus controller has on-chip registers that emulate the IBM Task File for the PC/AT and the IBM Command Descriptor Block for the PC/XT. The chip can sustain a 2M-byte/sec transfer rate to the disk and a 4M-byte/sec transfer rate on the host bus. It sells for $30 (OEM qty).

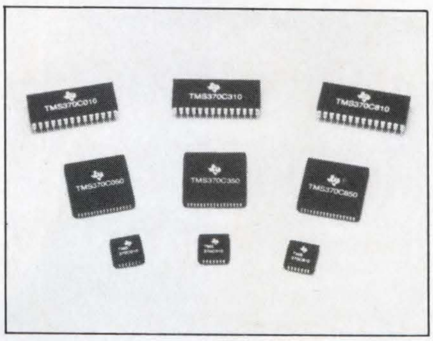


Cirrus Logic Inc, 1463 Centre Pointe Dr, Milpitas, CA 95035. Phone (408) 945-8300. TLX 171918. Fax 408-263-5682.

Circle No 425

Family of 8-bit microcontrollers offers EEPROMs as an on-chip option

The TMS370 is a family of 8-bit microcontrollers fabricated in 1.6-μm CMOS. The parts' on-chip options include 256 bytes of EEPROM for data memory, 4k bytes of ROM or EEPROM for program memory, an 8-bit A/D converter, a serial communications interface, and an expansion bus. Besides the six standard configurations that are currently available, the company offers 16 special-function modules for custom designs. Each of the standard μCs contains a serial peripheral interface, a watchdog timer, a 16-bit timer (on three of the units, two timers are standard), and either 128- or 256-byte data registers. The units use a single 5V supply and can function with a 20-MHz clock. They operate over −40 to +85°C. Chips packaged in 28-pin plastic DIPs or PLCCs cost $3 to $7, depending on quantity. Parts housed in 68-pin PLCCs range in price from $4.50 to $10.



Texas Instruments Inc, Semiconductor Group, SC-828, Box 809066, Dallas, TX 75380. Phone (800) 232-3200 ext 700.

Circle No 426

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At 14,400 bits-per-second, Rockwell's high-speed modems are a full generation ahead of the competition.

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CO Denver (303) 451-8383*
CT Connecticut (203) 265-3822*
FL Ft. Lauderdale (305) 977-4880*
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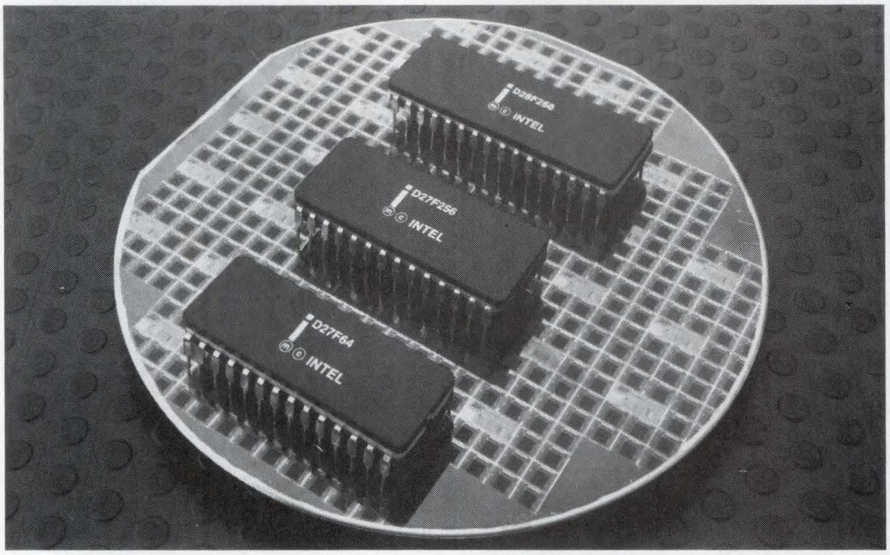
Nonvolatile flash memories offer 1-sec chip-erase times



The 27F256 and 28F256 are 256k-bit, nonvolatile, read/write flash memories. The chips, which are based on a proprietary ETOX (EPROM tunnel oxide) process, essentially add electrical chip-erasure and reprogramming capabilities to EPROM technology. The vendor's Quick-Erase algorithm typically erases all the memory cells simultaneously in 1 sec. The Quick-Pulse Programming algorithm reprograms the flash memories in less than 4 sec. The 28-pin 27F256 multiplexes the write-enable line and the A14 address line to maintain pin compatibility with standard EPROMs. The 32-pin 28F256 has a nonmultiplexed pinout, which eases the interface to the CPU and accommodates as many as 2M bytes of memory. The CMOS devices offer 170-nsec max access time and 100-μA max standby current. The devices also exhibit a failure rate of less than 0.01% for 100 erase/program cycles. They sell for $19.90 (10,000).

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

Circle No 424

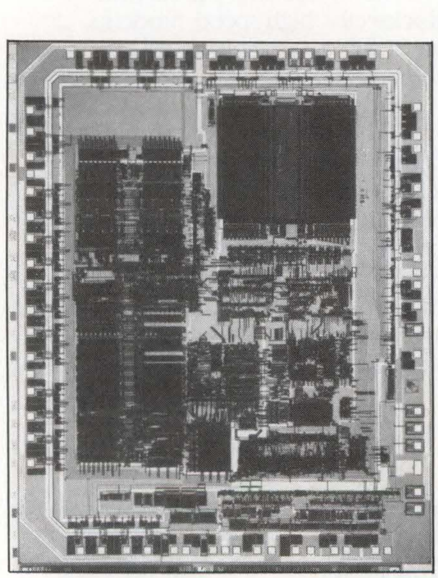
Printer/display processor features 32000 μP instruction set

The NS32CG16 is a member of the Series 32000 processor family. This 32-bit CMOS chip, which is designed for advanced printer and display applications, runs the 32000 instruction set plus 11 specific graphics instructions. The processor can perform bit-block transfers (BitBlts) with 6 on-chip logical operators. When supported by a DP8510 BitBlt-processing unit, the chip can transfer data at 18M bps and can transfer a matrix of 32×54 characters at 4700 characters/sec.

A 15-MHz version of the processor can draw a horizontal line at 9M bps, a long horizontal line at 60M bps, and a vertical line at 400k bps. It can clear memory at 60M bps. The processor also features a 16M-byte linear-address range; support for high-level languages, such as C, Pascal, Fortran, and Ada; floating-point support for outline fonts; and built-in binary compression or expansion instructions for font storage in RLL format. The chip comes in a 68-pin PLCC. A 10-MHz version costs $20 (10,000).

National Semiconductor Corp, Box 58090, Santa Clara, CA 95052. Phone (408) 721-3219. TLX 346353.

Circle No 427



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*** Coming soon:**

6301V, 6301X, 6301Y, 6303R, 6303X, 6303Y, 63701V, 63701X, 63701Y, 68HC11, 80C186-16, V25, V35, 80286, 80386-16/20

*** Planning**

Z8, Super 8, 68HC05, Z280, 80286-16, 68030, V60

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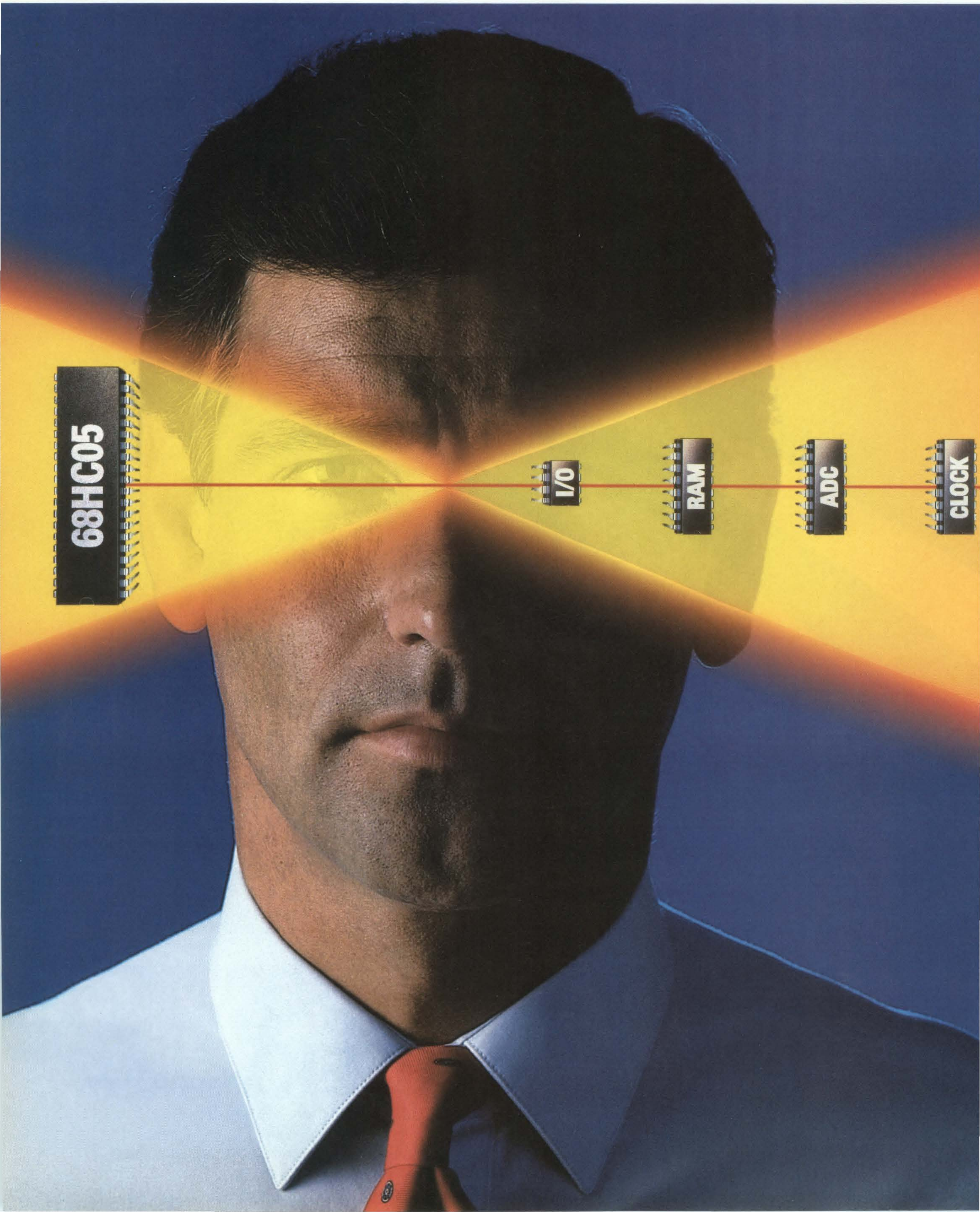
Telephone : (714) 541-2931 FAX : (714) 541-2933

CIRCLE NO 76

Expand your



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.

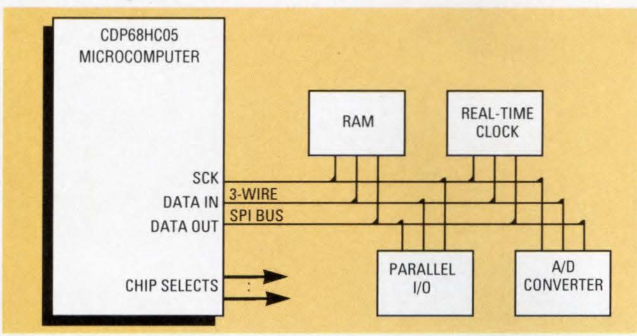
Not an easy job. But certainly easier when you use our 6805 and 68HC05 micros and serial peripheral interface devices.

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.

Two final points: we'll give you fast turnaround, and a wide variety of packages.

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

In Europe, call: Brussels, (02) 246-21-11; Paris, (1) 39-46-57-99; London, (276) 68-59-11; Milano, (2) 82-291; Munich, (089) 63813-0; Stockholm, (08) 793-9500.

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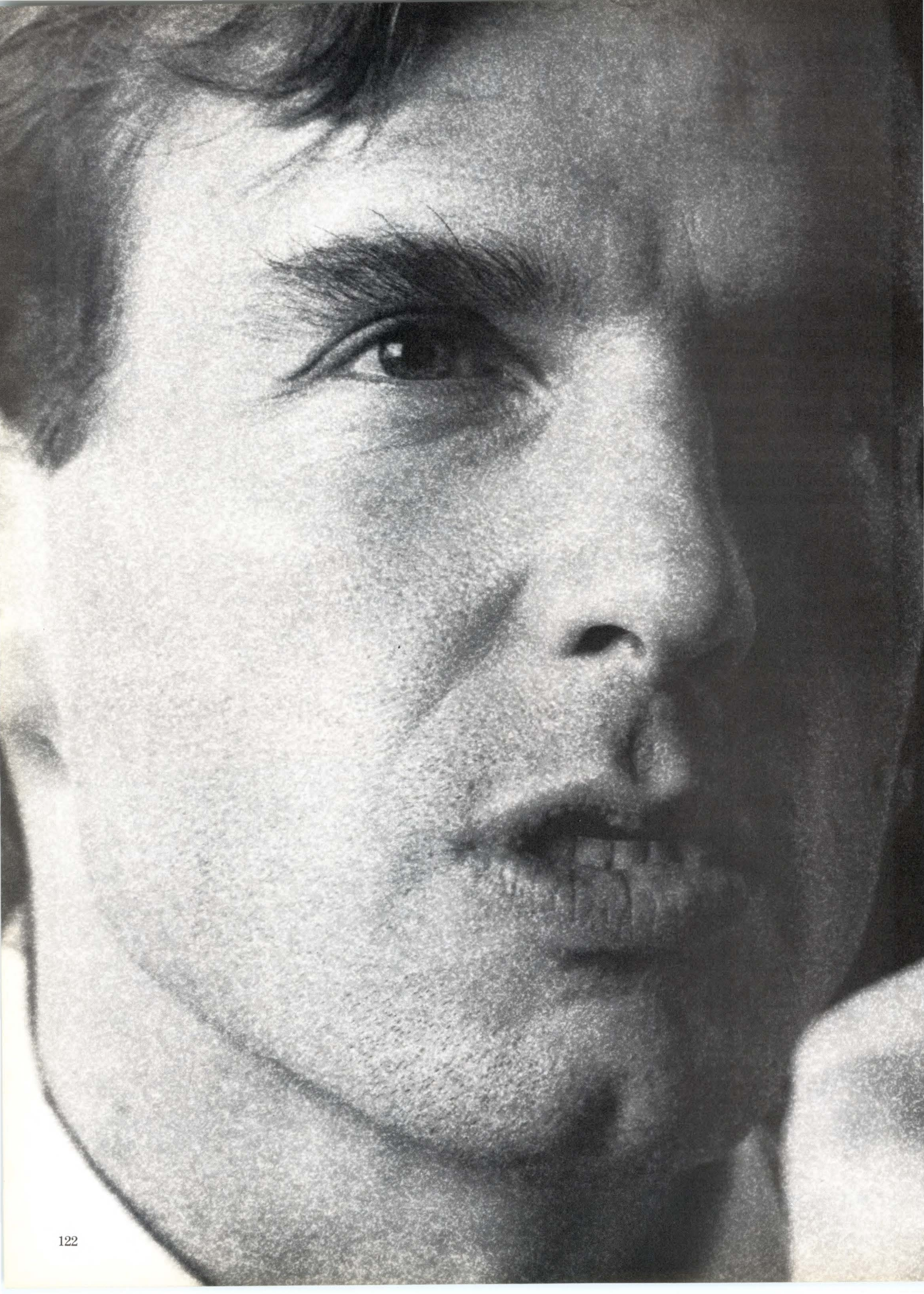

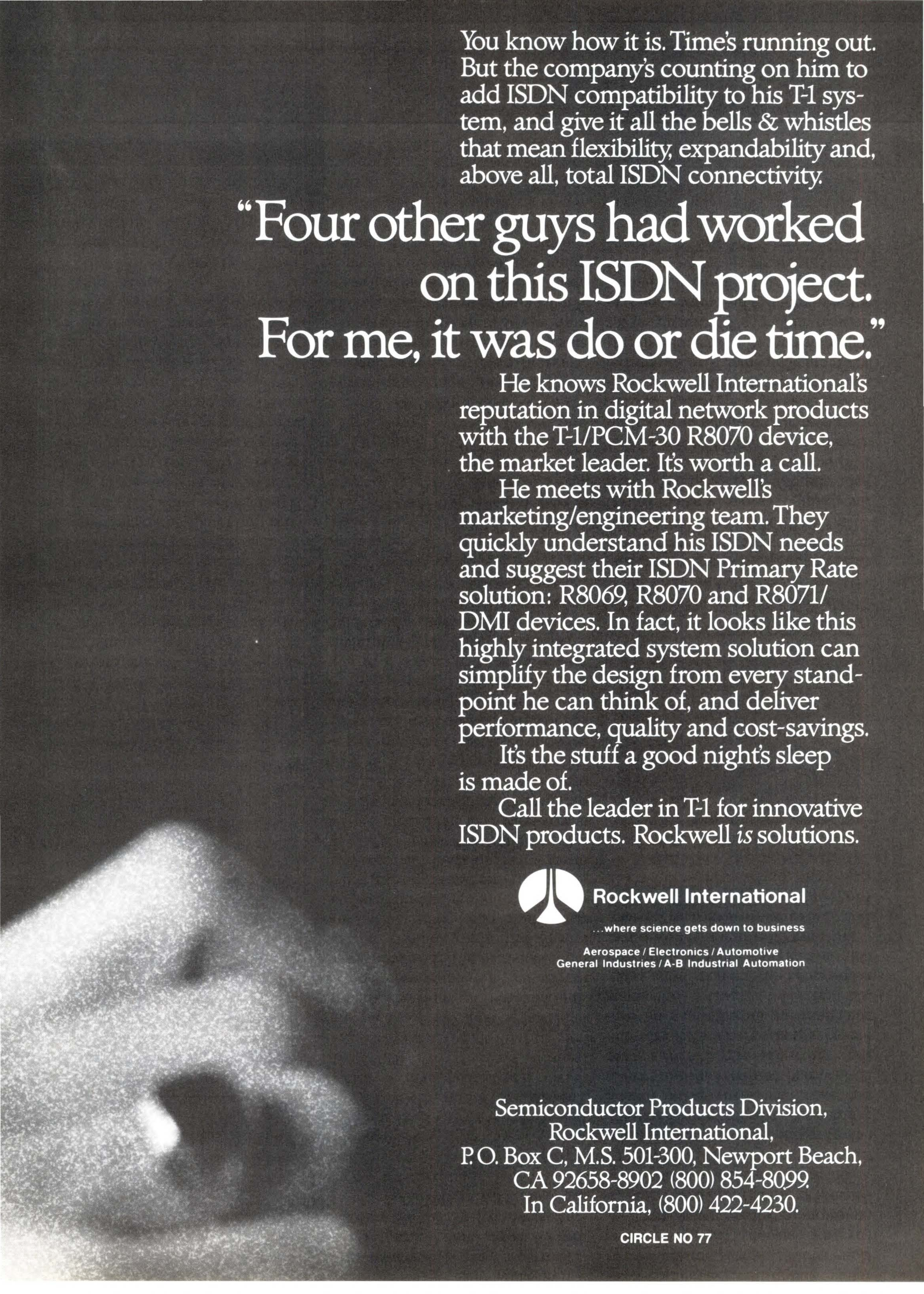
You know how it is. Time's running out. But the company's counting on him to add ISDN compatibility to his T-1 system, and give it all the bells & whistles that mean flexibility, expandability and, above all, total ISDN connectivity.
"Four other guys had worked on this ISDN project. For me, it was do or die time."
He knows Rockwell International's reputation in digital network products with the T-1/PCM-30 R8070 device, the market leader. It's worth a call.
He meets with Rockwell's marketing/engineering team. They quickly understand his ISDN needs and suggest their ISDN Primary Rate solution: R8069, R8070 and R8071/DMI devices. In fact, it looks like this highly integrated system solution can simplify the design from every standpoint he can think of, and deliver performance, quality and cost-savings.
It's the stuff a good night's sleep is made of.
Call the leader in T-1 for innovative ISDN products. Rockwell *is* solutions.
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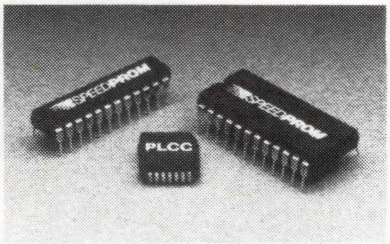
Semiconductor Products Division, Rockwell International, P.O. Box C, M.S. 501-300, Newport Beach, CA 92658-8902 (800) 854-8099. In California, (800) 422-4230.
CIRCLE NO 77

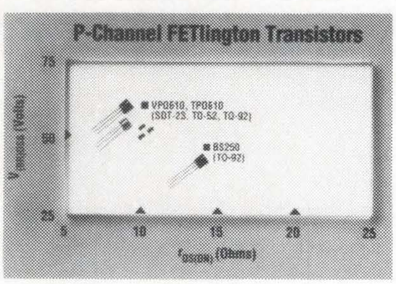


8k×8-BIT EEPROM

The XL46HC64 SpeedPROM, an 8k×8-bit EEPROM with a read access time of 35 nsec, is pin compatible with many bipolar PROMs and EPROMs. When operating at 10 MHz, the chip typically draws 40 mA. You can erase the entire chip in 10 msec and reprogram each byte in 1 msec; reprogramming the entire 64k-bit memory takes 8 sec. Users can read and verify each memory location, as well as program a data subset and then test the entire memory. You can also have a signature row of bits coded before shipment with identification data such as product codes or manufacturing lot number. This row does not take up any usable data space. The IOL (low-level output current) specification is 16 mA for TTL compatibility. $33 (100).

Exel Microelectronics Inc, Box 49007, San Jose, CA 95161. Phone (408) 432-0500. FAX 408-434-6444. TWX 910-338-2116.

Circle No 610

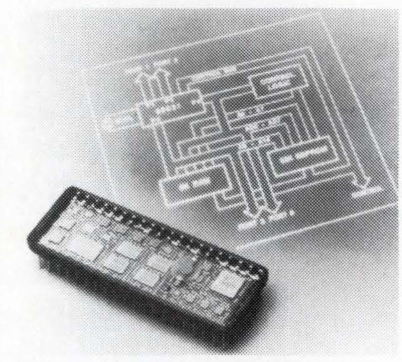


P-CHANNEL FETS

The VP0610 and TP0610 p-channel models complement the company's 2N700 and 2N7002 enhancement-mode MOS FETlington transistors. They allow you to connect complementary pairs of n- and p-channel FETlington transistors to drive CMOS logic devices. The transistors have a maximum drain-to-source voltage of 60V dc and a channel on-resistance of 10Ω. The VP0610 and TP0610 have thresholds of 3.5 and 2.4V, respectively, and operate directly from low voltage supplies. Both devices are available in surface-mount SOT-23, and hermetically sealed TO-52 and TO-92 packages. From $0.44 to $1.61 (100). Delivery, four to eight weeks ARO.

Siliconix Inc, 2201 Laurelwood Rd, Santa Clara, CA 95054. Phone (800) 554-5565; in CA, (408) 988-8000.

Circle No 611



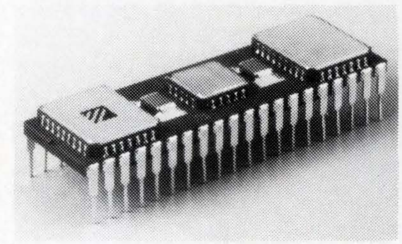
80C31 HYBRID μC

The Model C8-P31 hybrid μC combines an 80C31 μC, 32k bytes of EEPROM, 8k bytes of static RAM, a logical control unit, and a 7.3728-MHz crystal clock oscillator. The totally CMOS hybrid comes in a 40-pin DIP with standard 300-mil centers. It operates over the temperature range of −55 to +150°C and is designed for hostile environments.

The 32k-byte EEPROM is divided into an 8k-byte section for code only and a user-defined 24k-byte section for either code or data. The 8k bytes of static RAM is for data only. The hybrid μC can address 64k bytes of external memory for both data and program for a total of 128k bytes of external memory. It draws 35 mA from a 5V supply and has a sleep mode, which consumes 2 mA. $1000 (100). Delivery, 8 to 10 weeks ARO.

White Technology Inc, 4246 E Wood St, Phoenix, AZ 85040. Phone (602) 437-1520. TWX 910-951-4203.

Circle No 612



64k×16-BIT RAM

The EDI8M1664C high-speed CMOS static RAM module contains four 32k×8-bit RAMs organized as two banks. Each bank is a 32k×16-bit unit that produces a 64k×16-bit RAM in a single IC. The lower-byte control line selects the lower bytes (DQ0-DQ7), and the upper-byte control line selects the upper bytes (DQ8-DQ15). The unit operates from a 5V supply, and all inputs and outputs are TTL compatible.

The access times of the commercial and military versions measure 60 and 70 nsec, respectively. A 100-nsec access time is also available for both versions. The military version complies with MIL-STD-883C, test method 5004, Class B. The EDI8M1664C comes in a 600-mil-wide, 40-pin DIP. Commercial versions: 100 nsec, $249; 60 nsec, $445. Military versions: 100 nsec, $496; 70 nsec, $860 (100). Delivery, six weeks ARO.

Electronic Designs Inc, 42 South St, Hopkinton, MA 01748. Phone (617) 435-2341. TLX 948004.

Circle No 613

MOTION CONTROLLER

The LM628/LM629 NMOS motion controller for servo systems lets a host processor communicate with the chip through a parallel 8-bit asynchronous I/O port. The host generates a trapezoidal velocity profile and programs an on-chip digital-

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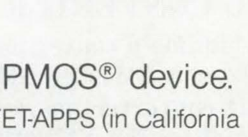

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CG/2000-441A WLM 772

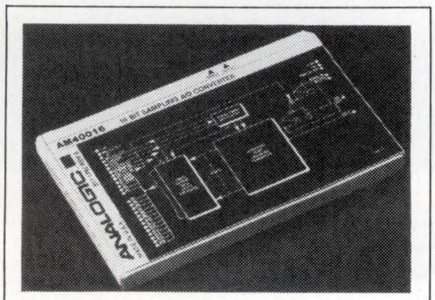
CIRCLE NO 79

compensation filter. An on-chip velocity-profile generator then calculates a 32-bit word for the required trajectory in either a position or a velocity mode of operation.

The quadrature incremental-position feedback signal interfaces to the chip through two quadrature inputs and an index pulse input. A feedback processor calculates a 32-bit position word and subtracts it from the profile word. The resultant error signal passes through the compensation filter to an 8-bit output port. The output of the LM628 is designed to drive an 8-bit DAC; the LM629 has eight PWM outputs for driving H-switches. The state of the feedback encoder can be captured at a 750-kHz rate. The device requires a 6-MHz clock and is available in a 28-pin DIP. $30 (100).

National Semiconductor Corp, Box 58090, Santa Clara, CA 95052. Phone (408) 749-7421. TLX 346353.

Circle No 616



A/D CONVERTER

Exhibiting a conversion rate of 500 kHz, the AM40016/AM40116 16-bit A/D converter has a built-in S/H amplifier. The AM40016 is available with 0 to 10V unipolar inputs, and the AM40116 comes with ±10V bipolar inputs. The unit features a $10^8\Omega$ input impedance, a differential linearity of ±¾ LSB, an integral linearity of ±0.003%, a dc offset error of ±5 mV max, and shielding against electromagnetic and electrostatic interference. The selectable coding formats for the digital outputs are binary, offset binary, or 2's complement. The converter requires ±15, 5, and −6V supplies, and operates in the 0 to 60°C temperature range. It comes in a 3×5×0.44-in. module that is pin compatible with the ADAM826-1 converter. $849 (100). Delivery, 12 weeks ARO.

Analogic Data Conversion Products Group, 360 Audubon Rd, Wakefield, MA 01880. Phone (617) 246-0300. TLX 949307.

Circle No 615

LASER DRIVER

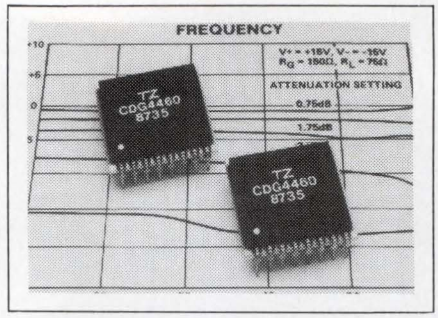
The ALD30010 laser-diode current driver has a frequency response from 10 kHz to 3 GHz. It features an on-chip 180° phase splitter that permits single input drives. The chip can deliver 60 mA min of peak bias current. The voltage-controlled input can modulate the current over a 0- to 30-mA-min range. An input signal level of 0 dBm achieves the maximum modulation current. An input amplifier has an 8-dBM third-order intercept point and a 1-dB compression point of 1 dBm. The large-signal rise and fall time is 100 psec typ with a typical propagation delay of 100 psec. The input return loss is 20 dB typ, and the reverse isolation is 30 dB typ. The device requires a −7V supply and a 60-mA supply current. 8-pin metal-ceramic flatpack, $65; die, $43.50 (1000). Delivery, stock to 90 days.

Anadigics Inc, 35 Technology Dr, Warren, NJ 07060. Phone (201) 668-5000. TWX 510-600-5741. FAX 201-668-5068.

Circle No 622

6-BIT ATTENUATOR

The CDG4460J 6-bit digitally controlled attenuator can attenuate analog signals with frequencies as high as 40 MHz. It consists of 3 CMOS/D-MOS integrated circuits and 11 laser-trimmed resistors mounted on a thick-film ceramic substrate. The attenuation range is 0 to 15.75 dB in 0.25-db increments. When operating in a 75Ω system, the unit displays constant input and



output resistance over the entire resistance range. An onboard data latch lets you set predetermined attenuation settings. It operates with power supplies ranging from ±6 to ±15V and dissipates 0.5 μW typ. The 16-pin hybrid package occupies 1 sq in. of board space. $39.50.

Topaz Semiconductor, 1971 N Capitol Ave, San Jose, CA 95132. Phone (408) 942-9100. TWX 910-338-0025.

Circle No 614

CMOS GATE ARRAYS

RVG CMOS gate arrays incorporate rad hardening and have 5670 to 20,440 2-input gates. Representative arrays include the 5670-gate RVG5, the 10,360-gate RVG10, the 14,640-gate RVG15, and the 20,440-gate RVG20. The 2-input NAND gate has a delay of 0.95 nsec with a fan-out of 2; its typical power dissipation is only 8 μW/MHz. The gate arrays feature symmetrical switching and edge delays, operate at 250-MHz flip-flop frequencies, and are TTL/CMOS compatible. Each I/O interface includes protection circuitry for a 2000V electrostatic discharge and is user programmable as an input, output, or bidirectional signal connection. You can select from an extensive macrocell library of SSI, MSI, and LSI functions. Military and commercial NRE (nonrecurring engineering) costs, from $35,000; military devices, from $150 (1000/year); commercial devices, from $65 (10,000/year).

Raytheon Co, Semiconductor Div, 350 Ellis St, Mountain View, CA 94043. Phone (415) 968-9211.

Circle No 636

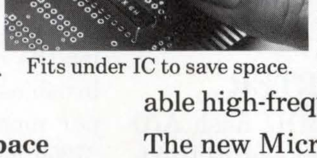
NOTHING TAKES EVERYTHING YOU CAN DISH OUT LIKE MICRO/Q® 2000 CAPACITORS.

For applications in severe conditions, nothing can take whatever the environment dishes out like Rogers new Micro/Q 2000 Flat Ceramic Decoupling Capacitor.

Nothing takes the heat or cold or humidity like Micro/Q 2000 with its unique molded construction and X7R dielectric.

Nothing takes up less space because only the Micro/Q 2000 fits *under* DIPs to save valuable board space. Retrofitable to simplify design. Supplied in antistatic tubes.

Nothing is as effective at reducing voltage noise spikes. Only Micro/Q 2000 provides the low-inductance and impedance levels necessary to reliable high-frequency decoupling.



Fits under IC to save space.

The new Micro/Q 2000 from Rogers. Nothing you can design with works or fits like it—even in the harshest environments.

Test results for MIL-C-39014D and MIL-STD-202F are available. Call or write a Rogers Micro/Q application engineer today for test results, free samples and technical information.

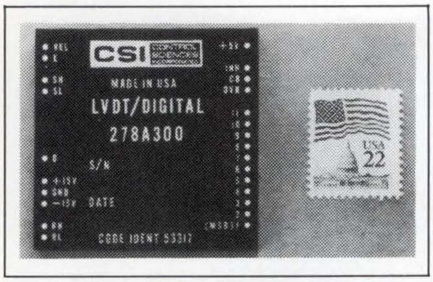
Another MEKTRON® interconnection component.

ROGERS

Rogers Corporation
Circuit Components Division
2400 South Roosevelt St.
Tempe, AZ 85282
Tel: (602) 967-0624
Fax: (602) 967-9385

OUTSIDE THE U.S. CONTACT: Europe: Mektron NV, Ghent, Belgium **Japan:** Rogers Inoue Corp., Nagoya **Brazil:** Rogers Coselbra, Sao Paulo **Singapore, Hong Kong, Taiwan:** Dynamar

CIRCLE NO 81



DIGITAL CONVERTERS

The 278A300 series digital converters translate the outputs of LVDT (linear variable differential transformer) and RVDT (rotary variable differential transformer) transducers into an 11-bit, offset-binary digital code. They employ a type II servo loop to generate an error signal between the reference input and transducer inputs. The reference frequency ranges from 400 Hz to 10 kHz.

A change equivalent to 1 LSB in the input signal initiates a conversion; the converters then issue a 1-μsec output busy command when the output code changes. An inhibit line provides a simple method of transferring the data to a computer. The inhibit command locks an internal up-down counter for reading. During a busy interval, the converters ignore the inhibit command. An overrange signal indicates whether the input signal exceeds the normal range. The units come in 2×2×0.395-in. modules and require ±15 and 5V. $230. Delivery, stock to 10 weeks ARO.

Control Sciences Inc, 9509 Vassar Ave, Chatsworth, CA 91311. Phone (818) 709-5510.

Circle No 617

MOS IGBT MODULES

Based on the company's high-voltage MOS IGBTs (MOS Insulated Gate Bipolar Transistors), the MOS-Block IGBT-module family consists of dual IGBTs in a phase-leg configuration with internal fast-recovery diodes across each IGBT. The continuous current ratings for the modules range from 25 to 100A in 600 and 1000V versions. The peak pulsed (1 msec) current ratings range as high as 200A. They are capable of switching rates as high as 30 kHz. The modules come in standard Japanese-style bipolar Darlington packages in two outlines: 94×34 and 95×62 mm. They exhibit a typical $V_{CE(SAT)}$ of 3.2 volts at a current of 50A. The current fall time is 800 nsec max for all devices. 25A, 600V device, $45.04; 100A, 1000V device, $129.41 (100).

IXYS Corp, 2355 Zanker Rd, San Jose, CA 95131. Phone (408) 435-1900.

Circle No 623

RF AMPLIFIER

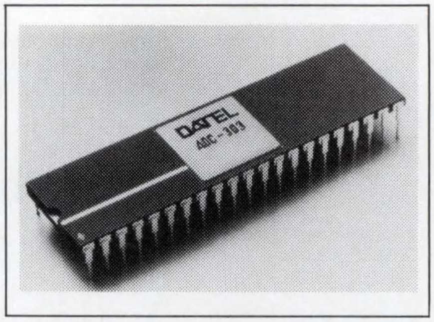
The LH4200 RF amplifier can operate over the 500-kHz to 1-GHz frequency range. It utilizes a GaAs input stage for high-frequency performance followed by two bipolar transistor stages. You can use series feedback for gain stabilization and control the gain via a control input. The amplifier features a 38-dB gain at 100 MHz, an AGC range of 60 dB at 100 MHz, an input impedance of 1 MΩ, and a noise figure of 3 dB for a 50Ω source impedance. The gain falls to 0 dB at 1 GHz. It has a typical 1-dB gain compression point of 14 dBm when operating at 100 MHz. The amplifier has internal bypass capacitors; however, it is recommended that an external capacitor of 10 μF be used to prevent low-frequency instabilities. The device comes in a 24-pin ceramic DIP. $54 (100).

National Semiconductor Corp, Box 58090, Santa Clara, CA 95052. Phone (408) 749-7421. TLX 346353.

Circle No 627

FLASH CONVERTER

The ADC-303 100-MHz flash A/D converter has an input-signal bandwidth of 40 MHz and operates on analog input signals in the 0 to −2V range when the reference voltage is set at −2V. The digital inputs and outputs are ECL compatible. The 8-bit parallel outputs are buffered and have open-emitter arrangements. The chip dissipates 1.2W and has an integral and differential linearity of ±½ LSB over its operating range. You can select one of the following output codes: binary, complementary binary, 2's complement, and complementary 2's complement. The chip operates with an external clock and reference source, and comes in a 42-pin DIP. Its operating temperature ranges from −20 to +100°C. $550.



Datel Inc, 11 Cabot Blvd, Mansfield, MA 02048. Phone (617) 339-3000. TLX 951340.

Circle No 618

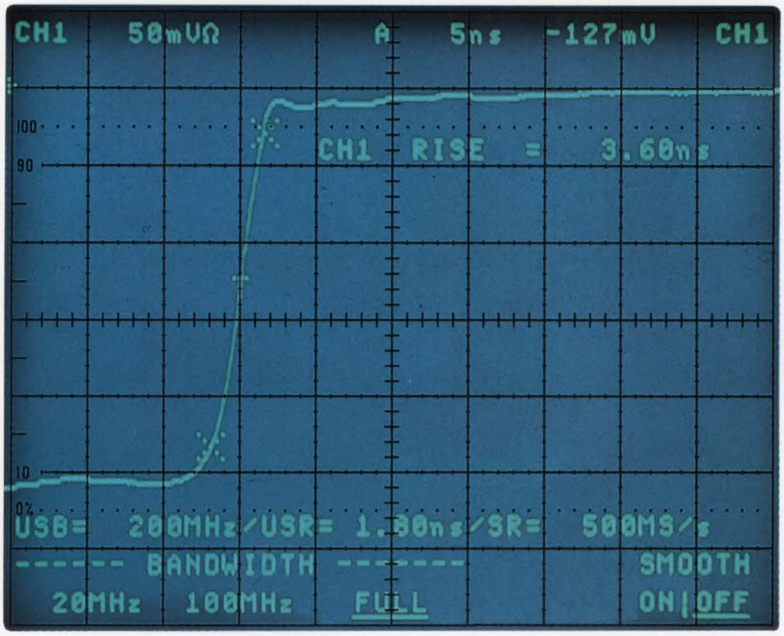
MOTOR-CONTROL ICs

Three custom ICs are available for designing proprietary motion-control systems. The MC3A is a 16-bit internal, 8-bit external, data-bus μP. It has 8k bytes of mask-programmed ROM that holds the servo algorithms and an abbreviated command set for minimum-performance systems. Working with the MC3A is the Motion-LSI chip, which has four channels of A/B quadrature encoder decoding. Internal registers permit software selection of various encoder operating modes.

Six digital outputs from the Motion-LSI chip provide PWM signals for the control of 2-, 3-, or 4-phase brushless dc, ac-induction, or stepper motors. The SMCC chip is a 27256 EPROM with a 12k-byte program that extends the command set beyond that contained in the MC3A μP. The 27256 chip comes with the first trial chip set. Thereafter, you must make your own duplications.

Text continued on pg 135

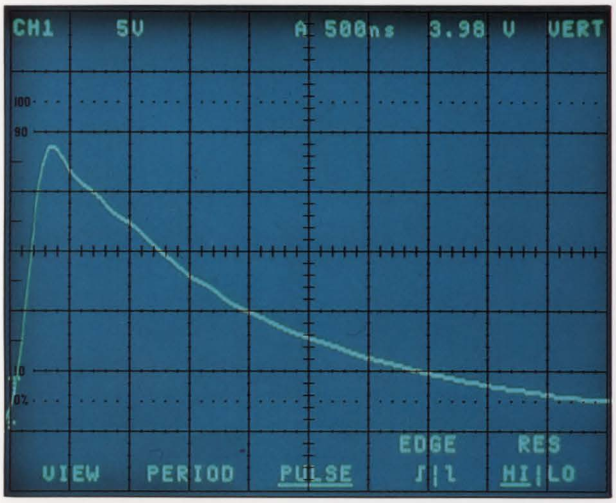
NEW 500 MEGASAMPLES/SEC 300 MHz DIGITAL PORTABLE



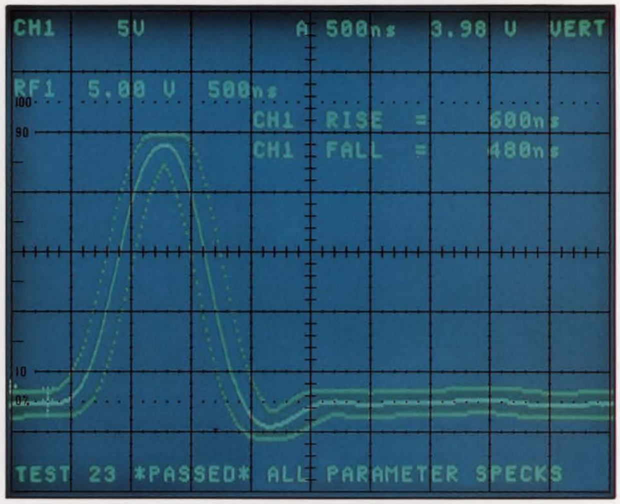
TEK PUSHES THE LIMIT...

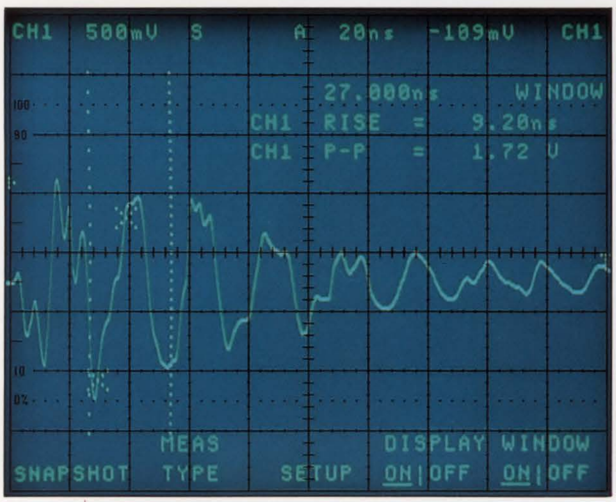
AT THE PUSH OF A BUTTON.

AUTO SETUP

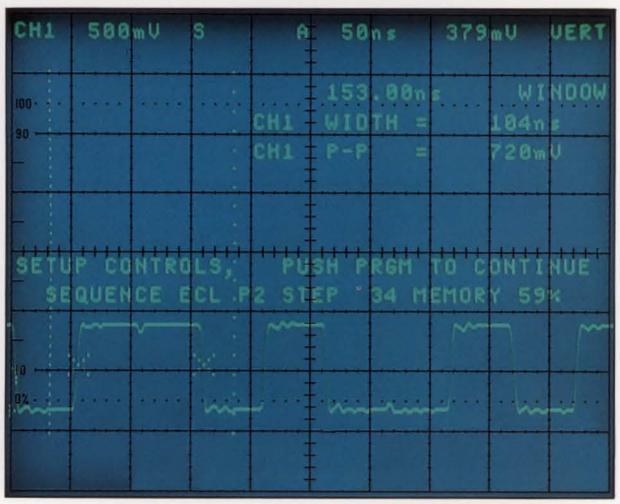


AUTO PASS/FAIL





AUTO MEASURE



AUTO SEQUENCE

ONLY FROM TEK.

The new Tek 2440 Digital Oscilloscope is the only portable offering a 500 MS/s sampling rate—on *two* channels simultaneously.

Capture signals competitors can't.

You can digitize, store and process single-shot phenomena to 200 MHz and repetitive signals to 300 MHz. At the touch of a button.

This is a scope built for solving tough problems fast.

Complete confidence in results.

Exclusive Tek digital features let you capture glitches as short as 2 ns with continuous sampling; automatically catch intermittent failures in babysitting applications; and see waveform changes virtually as they occur thanks to the high update rate.

With the 2440's 500 MS/s sample rate, 8-bit vertical resolution, and 0.0015% crystal-controlled timebase accuracy, you'll have complete confidence in the accuracy of your waveform data. You'll know what you're seeing is what's actually happening in your circuit.

A digital family you already know how to use.

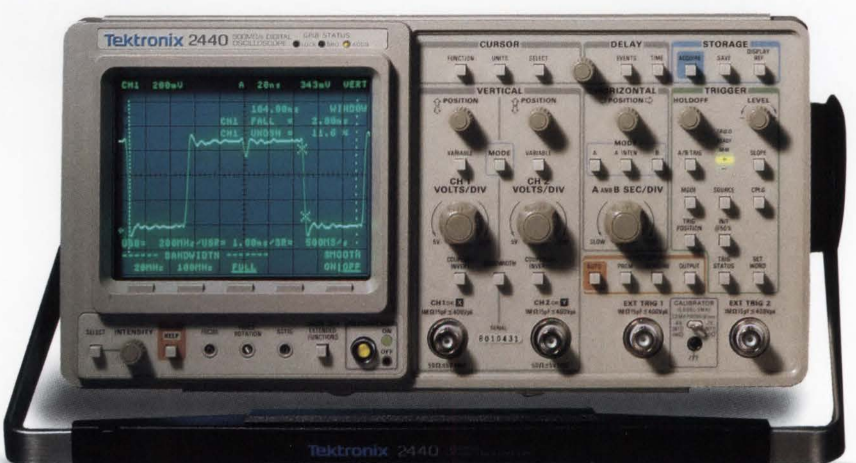
The 300 MHz 2440 and 2432, along with the 150 MHz 2430A, drive like the scopes you're used to. They feature a familiar front panel and simple, one-level menus.

Built-in automation simplifies operation even more. The scopes set up at the touch of a button. And you can characterize waveforms instantly: press another button and read out your choices from 21 different measurements.

Powerful system components.

On the design bench, the 2400 DSOs are effective standalone test systems. Full GPIB programmability, pass/fail testing and time-saving measurement sequencer make them equally powerful system components. With off-the-shelf software you can fully automate measurements and extend waveform analysis.

Don't settle for less. Get the total performance package only Tek delivers, feature for feature, spec for spec.



WHEN THE MEASUREMENT COUNTS, COUNT ON TEK.

No matter what you measure, Tek measures best.

The standard of excellence in portable scopes.

Analog or digital, standalone or automated, no other portables match Tek 2400 Series Oscilloscopes for sheer breadth of line, range of performance and wide choice of options.

Their proven reliability and built-in versatility are a result of Tek's dedication to superior waveform acquisition tailored to individual needs.

Answers at the touch of a button.

Six four-channel analog oscilloscopes combine pushbutton simplicity and leading-edge performance. They bring unprecedented efficiency to your design lab, production line or field service site.

The top-of-the-line 2467 with Tek's patented microchannel plate CRT even makes single-shot pulses to 350 MHz visible—at the touch of a button.

A complete range of options further extend each scope's capabilities.

Scope for scope, feature for feature, Tek has the best solution for your measurement needs.

Call Tek for details.

Ask your Tek representative for a demonstration. With the 2440 joining the family, there's an even better selection—in sample rate, performance and price. For more information, please return the reply card or call Tek direct: **1-800-426-2200.**

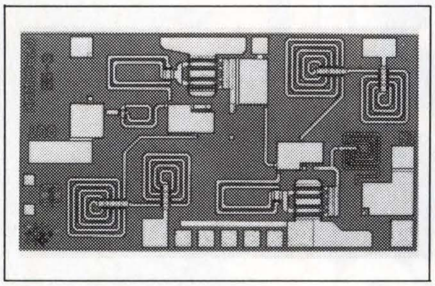
Tektronix®
COMMITTED TO EXCELLENCE

PXA-894

MC3A µP and Motion-LSI chip, $210 (100).

Delta Tau Data Systems, 21119 Osborne St, Canoga Park, CA 91304. Phone (818) 998-2095.

Circle No 648



AMPLIFIER

Operating over the 2- to 6-GHz frequency range, the HMM-10620 GaAs monolithic microwave IC amplifier runs from an 8.5V supply and draws a maximum of 100 mA (65 mA typ). Two FET gain stages with negative feedback provide 11.5 db of gain and a gain flatness specification of ±0.5 dB over the frequency range. The 1-dB gain compression point is +13 dB typ, and it has a typical noise figure of 5.5 dB. Input and output VSWRs are specified at 1.75:1 max. The device's internal dc blocking lets you cascade it with other units. The chip measures 37×70 mils and thermal-compression wedge bonding is recommended. $45 (1000).

Harris Microwave Semiconductor Inc, 1530 McCarthy Blvd, Milpitas, CA 95035. Phone (408) 433-2222. TWX 910-338-2247. FAX 408-432-3268.

Circle No 619

450V OP AMP

The PA85 op amp operates with power supplies ranging from ±15 to ±225V. It can also operate from a single supply ranging as high as 450V. The output can swing 430 V_{p-p} with a slew rate of 1000 V/µsec. It can deliver as much as ±200 mA of continuous current. A built-in thermal shut-off circuit prevents overheating and the safe operating area has no secondary breakdown limitations. A dual J-FET input stage provides a differential offset voltage of ±2 mV max and a differential offset current of ±100 pA max. The device achieves a full power bandwidth of 500 kHz with a 3.3-pF compensation capacitor. It comes in an 8-pin TO-3 package and dissipates 35W at the current rating. PA-85, $99.50; PA85A improved offset version, $129.35 (100). Delivery, 10 weeks ARO.

Apex Microtechnology Corp, 5980 N Shannnon Rd, Tucson, AZ 85741. Phone (800) 421-1865.

Circle No 629

VOLTAGE REFERENCE

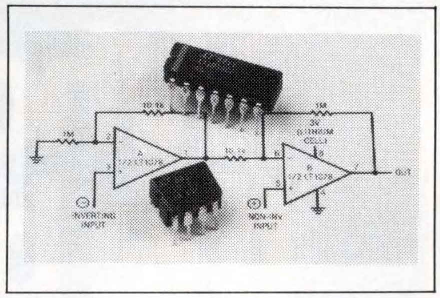
The Ref-43 precision voltage reference provides a 2.5V output with a maximum tolerance of ±0.05%. It operates from a supply voltage of 4.5 to 40V, and the output voltage changes less than 178 µV over the supply range. It can provide 10 mA of output current with more than a 10 ppm/mA load regulation. It requires 450-µA-max quiescent current, thus minimizing drift due to self-heating. The temperature coefficient is specified as 10 ppm/°C max. The unit also has a temperature output that provides an analog output sensitivity of 1.9 mV/°C. It comes in an extended industrial temperature range of −40 to +85°C, as well as military versions. MIL-STD-883 versions will be available in the 3rd quarter of 1988. Ref-43GP, from $3.75 (100).

Precision Monolithics Inc, Box 58020, Santa Clara, CA 95052. Phone (408) 562-7346. TLX 713719541.

Circle No 630

OP AMPS

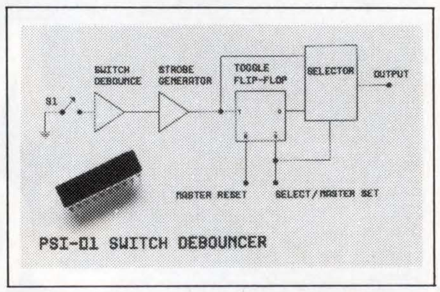
The LT1078 dual and LT1079 quad op amps can run from a 5V supply or from dual supplies ranging as high as ±15V. They feature a 50-µA-max supply current for each amplifier, an offset voltage of 70 µV max, a



250-pA-max offset current, 0.4 µV/°C offset voltage drift, a 200-kHz gain-bandwidth product, and a 0.07V/µsec slew rate. The 1/f corner of the voltage noise spectrum is 0.7 Hz. This low frequency corner permits a voltage noise specification of 0.6 μV_{p-p} and a current noise specification of 3 pA_{p-p} over the 0.1-Hz to 10-Hz frequency range. The outputs can source and sink 5 mA of load current. LT1078, $2.80; LT1079, $3.50 (100).

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

Circle No 620



SWITCH DEBOUNCER

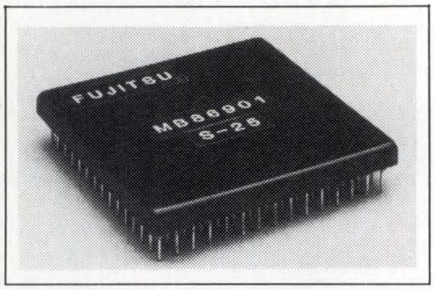
The PSI-01 IC interfaces electromechanical switches with digital circuits. It provides switch debouncing without any external components for as many as eight independent spdt switches. The reading is 32 msec both for the typical output delay after activating a switch, and for the maximum output delay after releasing a switch. The chip provides either a strobe output pulse or a toggled output that are user selectable. The outputs are TTL compatible and can source and sink 4 mA. The chip operates on voltage supplies ranging from 3 to 25V with a supply current drain of 5 mA. The

Text continued on pg 138

chip comes in a 20-pin DIP. $2 (1000).

Precision MicroDevices Inc, 711 Charcot Ave, San Jose, CA 95131. Phone (408) 432-3077.

Circle No 621



RISC μP

The S-25, a member of the Sparc 32-bit RISC μP family, achieves an average sustained processing rate of 15 MIPS at a clock rate of 25 MHz. A register file, consisting of 120 32-bit registers, stores frequently used variables to reduce program execution overhead. This triple-port register file can fetch two operands and write to a destination simultaneously in a single cycle. The chip has separate 32-bit address and data buses; it can directly address 4G bytes and can indirectly address 256 pages of 4G bytes.

The instruction set has five operator categories: load and store, arithmetic/logical/shift, control transfer, read/write control registers, and floating-point and coprocessor functions. It uses a single-length format and fixed field positions. Optimizing C, Fortran, and Pascal compilers are available for software development. The chip comes in a 179-pin pin-grid-array package. $325 (5000).

Fujitsu Microelectronics Inc, Advanced Products Div, 50 Rio Robles, San Jose, CA 95134. Phone (408) 922-9649.

Circle No 624

SMPS ICs

Operating on a master-slave principle, the TEA 2170 and TEA 2164 ICs provide all the regulation and protection functions required in isolated switchmode power supplies with output powers as high as 200W. They are optimized for use in low-cost power supplies for consumer equipment such as TV receivers, video recorders, and audio equipment. The devices allow you to isolate the secondary side of the supply from the line input with a low-cost transformer.

The TEA 2164's ±1.5A output can directly drive power transistors at switching frequencies as high as 60 kHz. In critical applications, you can synchronize the switching to an external frequency. The TEA 2164 contains oscillators, a start/stop pulse shaper, a switching transistor driver, and a safety processor, as well as current-limit V_{CC} supervision and repeated overcurrent detection circuitry. The TEA 2170 contains an error amplifier, a voltage reference, a master oscillator with synchronization input, a pulse-width modulator, and a pulse driver for the isolation transformer. Soft-start circuitry is also included. Approximately $1.46 (1000).

SGS-Thomson Microelectronics, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (039) 65551. TLX 330131.

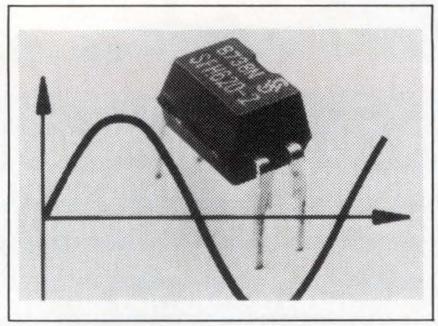
Circle No 650

SGS-Thomson Microelectronics, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 651

OPTOCOUPLER

The SFH620 optocoupler contains two back-to-back GaAs infrared emitters so that it can remain in the On state during both the positive and negative half-cycles of an ac-input waveform. The device is tested to an isolation voltage of 5.3 kV and incorporates a special ion screen that provides added protection against electrostatic field effects. The optocoupler's emitter and detector have an internal separation of 0.8 mm, allowing the company to



seek approval for the device to VDE-0884 safe electrical-operation specifications. The SFH620 is subjected to in-process testing and burn-in before being shipped. DM 0.79 (10,000).

Siemens AG, Zentralstelle für Information, Postfach 103, 8000 Munich 1, West Germany. Phone (089) 2340. TLX 5210025.

Circle No 652

Siemens Components Inc, 2191 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 980-4500.

Circle No 653

ANALOG MULTIPLEXERS

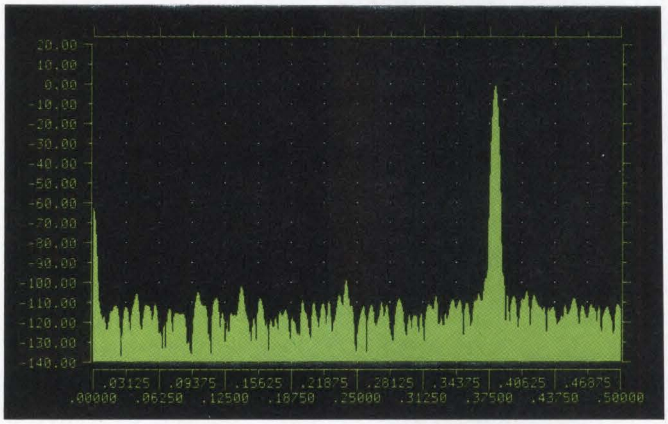
Fabricated in CMOS, the HI-506A, HI-507A, HI-508A, and HI-509A are analog muliplexers that have transfer accuracies of more than 0.1% at sampling rates to 200 kHz. The analog inputs of the devices can withstand an overvoltage to 70 V_{p-p}, and feature break-before-make switching. The four multiplexer models each provide the following number of channels: HI-506A, 16 single-ended; HI-507A, 8 differential; HI-508A, 8 single-ended; and HI-509A, 4 differential channels.

The input signal range for 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).

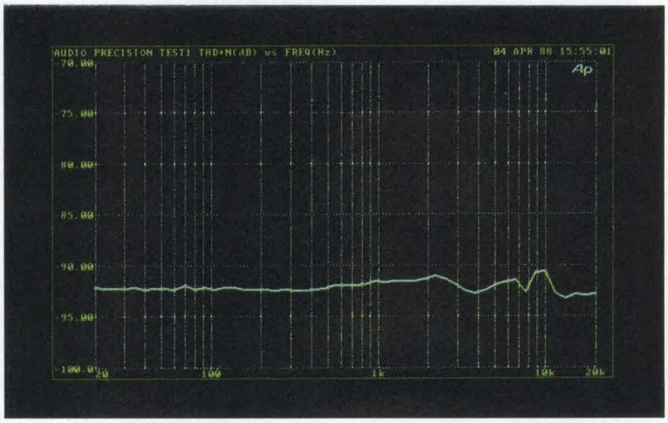
Burr-Brown, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TWX 910-952-1111.

Circle No 649

Stop, look, listen.



FFT: Detailed distribution of noise and harmonic distortion vs. input signal. Measurement of sample and hold and ZAD2716 A/D converter only. Computer analysis receives digital information from A/D converter (to avoid DAC reconstruction distortion).



Using an Audio Precision system, a sine wave is digitized by the ZAD-2716, then reconstructed by the ZDA-1801, and filtered by Apogee's 944S linear phase filter. Graph shows combined total harmonic distortion and noise vs. frequency.

Introducing the world's finest professional 16-bit stereo digitizing subsystem and 18-bit deglitched reconstruction DAC.

Want to position yourself at the leading edge of digital audio? Then hear this.

Analog Solutions gives you a new family of professional audio products with confirmed "Golden Ear" performance using the industry's two most powerful test criteria. The eye. And the ear.

If seeing is believing, you'll be impressed by the harmonic distortion and noise plots of our ZAD2716/ZSH202 digitizing subsystem (left) and ZDA1801 deglitched reconstruction DAC (right). Nobody's ever seen plots like those before.

But there's more to the story than a good plot.

The ZAD2716-2 coupled with the ZSH202 Dual Sample-Hold can provide stereo digitizing at a 50 kHz sampling rate per channel. The ZSH202 allows simultaneous sampling of both channels within ± 2 nsec with guaranteed –96 db/channel separation. And there's no sacrifice of phase linearity or sin x/x. In fact, we guarantee sin x/x performance of 0.01dB and phase linearity of 0.1 (degree) over 0 to 20 kHz. (Performance that brings a smile to any Golden Ear.) Cost savings are significant on a per channel basis, because you only need one converter for two channels.

Our ADC is also available in a ZAD2716-1 model with integral sample and hold amplifier and 100 kHz sampling speed for 2X oversampling applications.

Your needs extend over the entire audio spectrum. And that's how our products are tested. We test the way they're used. So we can guarantee signal-to-noise plus harmonic distortion of 92 dB over the entire 0-20 kHz audio range.

We maintain the same outstanding performance at the back end of your system with the ZDA1801. This 18-bit DAC, with a built-in deglitcher operating up to 200 kHz for up to 4X oversampling, offers guaranteed signal-to-noise plus harmonic distortion of 94 dB over the full audio range.

In short, we've raised digital audio to new levels.

Which should be music to your ears.

And to every Golden Ear in the business.

Find out more about our growing line of professional audio products. And learn how we can help plot your success in a growing industry.

Please address Analog Solutions, 85 West Tasman Drive, San Jose, CA 95134.
Phone (408) 433-1900. FAX (408) 433-9308.

ANALOG SOLUTIONS
A subsidiary of Silicon General, Inc.

CIRCLE NO 84

AUDIO PREAMP

Suitable for consumer audio equipment, the TEA 6300 audio preamplifier incorporates a signal source selector; volume, bass, treble, and stereo balance controls; and a quad fader to control the front and rear speaker amplifiers in surround-sound systems. A break in the signal path between the signal selector and the preamplifier's control circuits allows you to insert additional signal conditioning circuitry—that is, a compander, a booster amplifier, an equalizer, or a noise-reduction circuit.

The preamplifier's built-in IIC Bus interface allows you to digitally control the preamplifier from a microcontroller. You can adjust the volume and fader in 2-dB steps, and the bass and treble controls in 3-dB steps. The device doesn't generate any audible noise when you adjust its controls. The preamplifier also incorporates a mute function.

The preamplifier has a frequency response from dc to more than 20 kHz, an overall gain of 20 dB, and an input sensitivity for full output of 50 mV typ. It has a signal-to-noise ratio of 80 dB, a typical channel separation of 70 dB, and typically introduces 0.05% total harmonic distortion at full output power. The TEA 6300 operates from a 7 to 13.2V supply and is housed in a 28-pin DIP or a surface-mount minipack. Approximately gld 8.50 (10,000). The TEA 6310, a similar device without the source selector, but with a fader disable input, is also available.

Philips, Components Division, Box 523, 5600 AM Eindhoven, The Netherlands. Phone (040) 757189. TLX 51573.

Circle No 654

Signetics Corp, 811 E Arques Ave, Sunnyvale, CA 94088. Phone (408) 991-4571.

Circle No 655

A/D ASICs

A library of 66 analog cells, 66 digital macrocells, and 28 I/O cells supports the TSGSM Series mixed A/D standard-cell ASICs. High-level analog cells in the library include 8- and 12-bit A/D converters, 8- and 12-bit D/A converters, twelfth-order switched-capacitor filters, 120-nsec comparators, and LCD driver circuitry. Where necessary, you can bias circuits from current or voltage bias generators, and include programmable current mirrors. You can also introduce grounded shielding around analog circuitry to improve its power-supply rejection ratio.

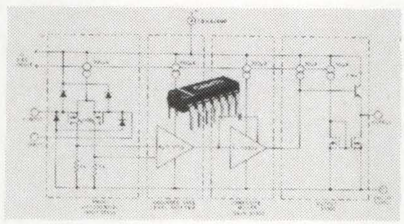
The digital cell library contains hard macros, but you can use them to generate your own soft macros for compiling more complex digital devices such as counters, shift registers, or dividers. All the library cells are fully characterized for operation from 3 to 10V supplies. CAD support for the series comprises the company's TCAD2A software. This CAD package includes H3Spice for analog simulation and allows you to perform mixed A/D simulation by modeling the analog functions. To design switched-capacitor filters, you can use the company's FilCAD software, and then import these filter designs into TCAD2A. The typical NRE (nonrecurring engineering) charges are $55,000. Depending on die size, from $1 to $8 (OEM qty).

SGS-Thomson Microelectronics, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (039) 65551. TLX 330131.

Circle No 659

SGS-Thomson Microelectronics, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 660



QUAD OP AMP

The CA5470 BiMOS-E general-purpose quad op amp combines high-speed CMOS and bipolar transistors on a single chip. It is specified for 5V single-supply and ±7.5V dual-supply operation over the military temperature range of −55 to +125°C. You can operate the unit from supplies ranging from 3 to 16V unipolar or from ±1.5 to ±8V bipolar. It has a unity-gain-bandwidth product of 12 MHz and a slew rate of 5 V/μsec. The amplifier has protection against ESD voltages as high as 2000V. The unit comes in a 14-lead plastic surface-mount package or plastic DIP. Plastic DIP, $1.21 (1000).

GE Solid State, Rte 202, Somerville, NJ 08876. Phone (201) 685-6652.

INQUIRE DIRECT

DSP CHIP

The PDSP16116 complex multiplier can multiply together two 16-bit complex words to produce a 32-bit complex-word result every 100 nsec.

Text continued on pg 145

SIGNALLING A NEW ERA

IN DSP.

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THE IMS A100 CASCADEABLE SIGNAL PROCESSOR

Using pulse compression to improve range resolution, a modern radar system compares signals transmitted to and reflected from a target.

A typical system may use a pattern 512 samples long, collected at a data rate of 2.5 MHz.

This requires more than a billion multiplications a second!

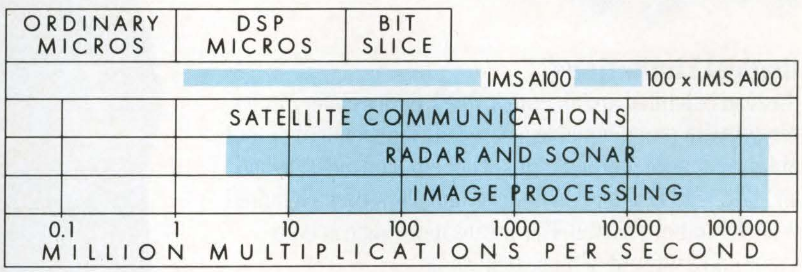
Yet the INMOS A100 Cascadeable Signal Processor enables a pulse compressor with this capability to fit a circuit board half the size of a typical PC card and dissipates less than 30 Watts.

A combination of performance, low power dissipation and reduced board area that means significant reductions in systems costs. Equally impressive results are found in applications such as beamforming, filtering and image processing.

Whatever DSP area you are in the INMOS IMS A100 processor is the only serious contender.

The following features show why the IMS A100 signals a whole new era in DSP. If you would like more information, clip the coupon today.

- Full 16 bit, 32 stage, transversal filter
- 36 bit internal precision
- Block floating point support
- Complex number support
- Easy to control from most ordinary and DSP microprocessors
- Data throughput to 10 MHz
- Power dissipation 1.5 Watts
- Fully static CMOS implementation
- 84 pin Ceramic PGA and Cerquad Packages
- MIL-STD-883C processing available



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Please send me information on the INMOS DSP family. My main area of interest is

Sonar ☐ Comms ☐ Radar ☐ Imaging ☐ Other (please specify) ☐

EDN070788

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Company ________ Address ________

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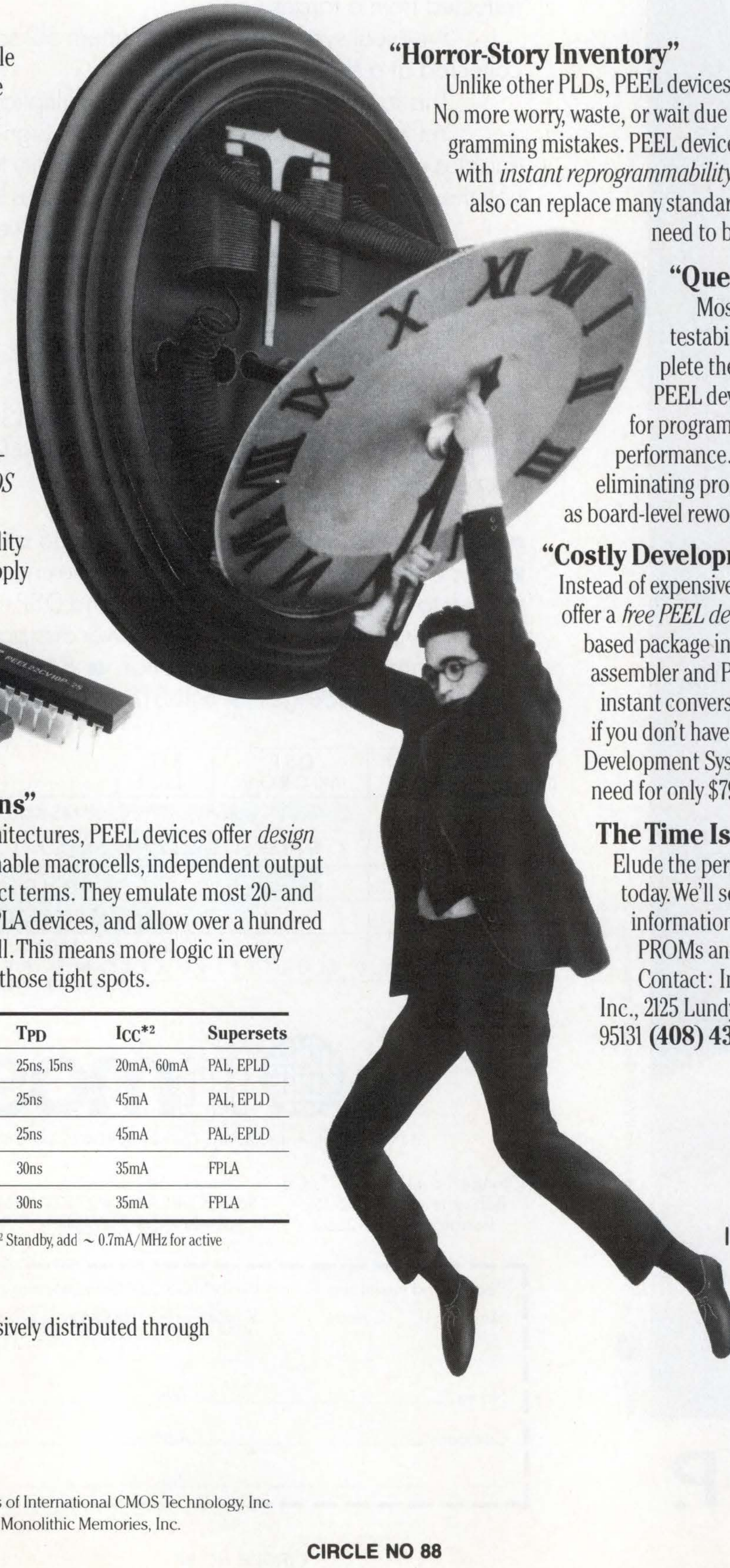
CIRCLE NO 86

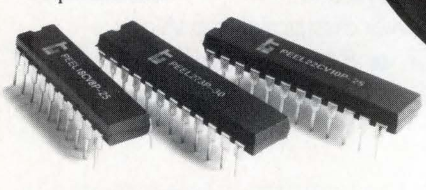
Elude the Perils of PLD



Ordinary programmable logic devices (PLDs) solve problems, but they create some as well. That's why ICT combined CMOS and E² technologies to make PEEL™ (Programmable Electrically Erasable Logic) devices. PEEL devices elude the perils of PLD.

"Sizzling Silicon"

Bipolar PLDs are power-hungry and run red-hot. Our *low-power CMOS* PEEL devices play it cool resulting in higher reliability and minimized power supply requirements.



"Illogical Limitations"

Instead of limited architectures, PEEL devices offer *design flexibility,* with programmable macrocells, independent output enables, and more product terms. They emulate most 20- and 24-pin PAL,® EPLD and FPLA devices, and allow over a hundred new configurations as well. This means more logic in every package and a way out of those tight spots.

PEEL Device	Pins	T_{PD}	I_{CC}*2	Supersets
PEEL18CV8*1	20	25ns, 15ns	20mA, 60mA	PAL, EPLD
PEEL20CG10	24	25ns	45mA	PAL, EPLD
PEEL22CV10*1	24	25ns	45mA	PAL, EPLD
PEEL153/253	20	30ns	35mA	FPLA
PEEL173/273	24	30ns	35mA	FPLA

*1 Zero Power versions also   *2 Standby, add ~ 0.7mA/MHz for active

"Horror-Story Inventory"

Unlike other PLDs, PEEL devices offer a risk-free inventory. No more worry, waste, or wait due to design changes and programming mistakes. PEEL devices are quick-to-the-rescue with *instant reprogrammability.* Since PEEL architectures also can replace many standard PLDs, fewer part types need to be inventoried.

"Questionable Quality"

Most PLDs have limited factory testability, leaving it up to you to complete the test. Electrically-Erasable PEEL devices are *100% factory tested* for programmability, function and AC/DC performance. This means higher quality, eliminating program and test fallout, as well as board-level rework.

"Costly Development Tools"

Instead of expensive development software, we offer a *free PEEL development kit.* This PC/XT/AT-based package includes the APEEL™ logic assembler and PLD-to-PEEL file translator for instant conversion of existing designs. And, if you don't have a PLD programmer, our PEEL Development System provides everything you need for only $795.00.

The Time Is Now

Elude the perils of PLD and call us today. We'll send you a PEEL packet and information on our High-Speed Erasable PROMs and Serial EEPROMs, too.

Contact: International CMOS Technology, Inc., 2125 Lundy Avenue, San Jose, California 95131 **(408) 434-0678.**

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CIRCLE NO 88

You can use the device in conjunction with two of the company's PDSP1601 ALUs, and two of its PDSP16316 complex accumulators to produce a block floating-point butterfly processor for evaluating FFTs. In combination with a single PDSP16316, you can create a 10-MHz 16×16-bit complex multiplier-accumulator.

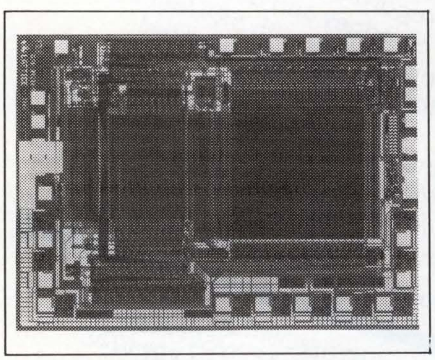
Internally, the PDSP16116 contains four 16×16 array multipliers, two 32-bit adder/subtractors, and control logic that provides fully automatic block floating-point operation. The device also includes trap logic to prevent −1×−1 products from leading to erroneous results. In addition, you can cause the device to complex conjugate either input to ease the implementation of complex correlators. A single pipeline delay through the device makes it suitable for use with recursive algorithms. The PDSP16116 is available in both military and industrial temperature ranges. Industrial version, £331.43 (100).

Plessey Semiconductors Ltd, Cheney Manor, Swindon, Wiltshire SN2 2QW, UK. Phone (0793) 36251. TLX 449637.

Circle No 656

Plessey Semiconductors, 9 Parker, Irvine, CA 92718. Phone (714) 472-0303.

Circle No 657

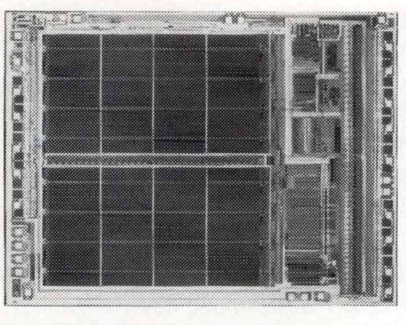


LOGIC ARRAY

The GAL39V18 programmable-logic array is designed with electrically erasable CMOS technology. It provides 10 output-logic macro cells along with 8 internal state-logic macro cells. In addition, it has 10 input logic cells and 10 I/O logic macro cells. The true or complement macro-cell outputs feed an AND array consisting of 75 product terms. Sixty-four of these terms serve as inputs to an OR array with 36 sum-term outputs. You can program all of the input and I/O signals into the array as registered, latched, or direct inputs. The registers are D-type flip-flops with separate clock enables and common or separate clocks. Total delay through the device is 30 nsec max and the clock-to-output delay is 15 nsec max. 24-pin plastic DIP, $21.10 (100).

Lattice Semiconductor Corp, 5555 NE Moore Ct, Hillsboro, OR 97124. Phone (505) 681-0118.

Circle No 631



DATA MANAGER

The Am95C85 Content Addressable Data Manager (CADM) is a CMOS peripheral chip for sorting and manipulating data, and stores data in an internal 1k-byte memory. The stored data is collated into records consisting of a key field and a pointer field. The chip uses the values in the key field to sort and search records. The content-addressable feature lets the host retrieve data without calculating physical addresses. The chip generates the addresses for memory access, and it can search an 8-byte field in less than 10 µsec. A stack-mode operation lets the user delete records by popping the records out of memory, and lets the user insert records by pushing the records into memory. You can cascade as many as 256 chips for applications that require a large storage area. The CMOS device comes in a 44-pin plastic leaded chip carrier. 12-MHz verion, $49.20; 16-MHz version, $66.50 (100).

Advanced Micro Devices Inc, Box 3453 Sunnyvale, CA 94088. Phone (408) 732-2400.

Circle No 634

COPROCESSOR

The VL82C389 message-passing coprocessor for Multibus II systems offloads the task of managing the iPSB (Parallel System Bus) arbitration from the local CPU. It also handles the bus transfers and exception-cycle protocols, and supports

dual-memory systems that coexist with message-passing architectures. The chip can handle all functions of the central service module (CSM).

The CSM features slot identification, arbitration identification, bus-clock generation, and bus time-out (watchdog) control. The CSM must reside in slot 0 of the Multibus II backplane, and its local microcontroller assigns slot and arbitration IDs to each module. No DIP switches are required. Once the module sets the system configuration, the CSM monitors the iPSB for

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Our four-member UTD 1.5μ gate-array family is built using UTMC's patented continuous-column architecture. The UTD handles design complexities up to 11,000 equivalent gates with auto placement and routing. The rad-hard version of this family, the UTD-R, easily meets total-dose tolerance of 1 x 10^6 rads (Si).

UTMC's five-member UTB 3μ gate arrays are DESC-certified and listed on the MIL-M-38510 JAN QPL. Like the 1.5μ family, it's designed to be more efficient than other gate array architectures by reducing the number of wasted transistors common on conventional structures.

Our VAX®-based HIGHLAND® Design System is certified as part of our JAN qualification and is available to assist you with design tasks ranging from design concept through layout and test generation. Additionally, our HIGHLAND system supports ASIC design on popular workstations such as Daisy®, Mentor®, and Valid®. The HIGHLAND workstation tool kits give you the ability to capture and simulate your design in a familiar environment. Or, if you prefer, a UTMC applications engineer can take your concept and create a complete design for you.

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CIRCLE NO 91

error conditions such as non-responding nodes in order to prevent blocked transfers between functional modules. $175 (100).

VLSI Technology Inc, 8375 S River Parkway, Tempe, AZ 85284. Phone (602) 752-6200. FAX 602-752-6000.

Circle No 625

ANALOG DELAY LINE

Suitable for television, video, radar, or sonar equipment, the WA1101 programmable CCD analog delay line allows you to select signal delays of 4, 5, 10, or 14 clock periods by using a 2-bit control code. By selecting a suitable clock frequency, you can arrange for the device to delay an analog signal between 100 nsec and 10 msec.

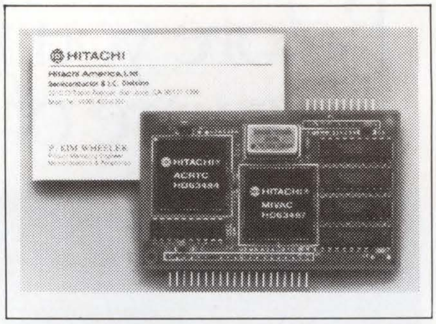
The device has both a signal and reference input that normally result in an output which is inverted with respect to the signal input. If you're willing to accept a slight degradation in linearity, you can interchange the signal and reference inputs to avoid this output inversion. An on-chip S/H circuit reconstitutes the analog waveform at the output. The WA1101 has a typical dynamic range of 68 dB and a TTL-compatible clock input. It draws approximately 15 mA from a 15V power supply. Commercial-grade device, approximately $28; high-reliability version, approximately $65 (1000).

Walmsley Microsystems Ltd, Aston Science Park, Love Lane, Birmingham B7 4BJ, UK. Phone 021-359 0981. TLX 334535.

Circle No 658

GRAPHICS CHIP

The HD63487, known as the MIVAC (Memory Interface and Video Attribute Controller), can control graphics memory, move images to a CRT screen at a rate of 33M pixels/sec, and perform horizontal scrolling and zooming. You can use the chip with the company's ACRTC controller and 1M bit of dynamic



RAM, arranged as 256k×4 bits, to build a graphics system in a space about the size of a business card. Such a system can draw images into its memory at 2M pixels/sec. Adjustable parameters include resolution, number of colors, pixel shift rate, and frame buffer size. The BiCMOS chip supports the hardware window feature of the ACRTC controller. It runs from a 5V supply and draws 120 mA max of supply current. It comes in a 68-pin surface-mount plastic leaded chip carrier or a 64-pin plastic DIP. $25 (5000).

Hitachi America Ltd, Semiconductor & IC Div, 2210 O'Toole Ave, San Jose, CA 95131. Phone (408) 435-8300. TLX 171581.

Circle No 626

16-BIT MULTIPLIER

The μIC16MP high-speed parallel multiplier produces a 32-bit product from two 16-bit operands in less than 20 nsec. The operands may be either 2's complement, unsigned magnitude, or mixed mode. The device, which operates from a single clock that has separate enables for x and y registers, can generate products at a rate of 50 MHz. A proprietary pipehold mode disables the clock enables for both registers and also reduces the current to less than 30 mA at 50 MHz. 50-MHz version in plastic leaded chip carrier, $112; in a pin-grid-array package, $136 (100).

Micro Integration Corp, 2833 Junction Ave, Suite 209, San Jose, CA 95134. Phone (800) 541-3425; in CA (408) 943-0344.

Circle No 639

Text continued on pg 152

MILITARY 256K RACE

EDI—First from the Start

Since 1983, when EDI introduced the first Military 64K SRAM, the company has been first in the race to market with the latest generation, highest density, CMOS MIL-STD 883 devices.

With a new family of fast 256K Monolithics, DESC quaiified devices, and a new JEDEC standard Megabit Module, EDI is maintaining its' leadership position with the widest array of Military CMOS Static RAMs available today.

EDI's 256K Gold Medalists

256Kx1 35, 45, 55ns
64Kx4 35, 45, 55ns
32Kx8 45, 55, 60ns

And, all are available in a variety of ceramic, JEDEC standard DIP and LCC Packages.

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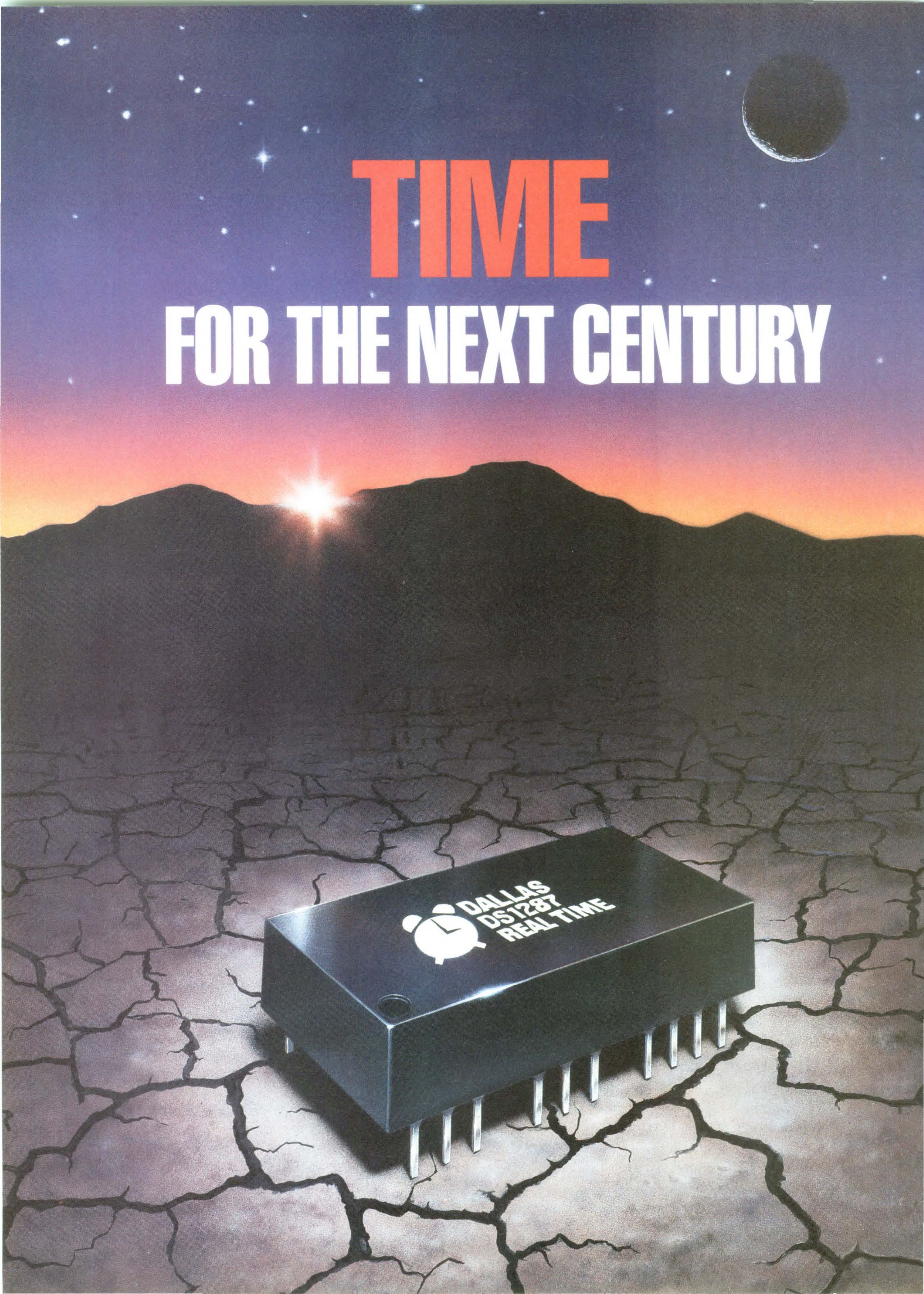
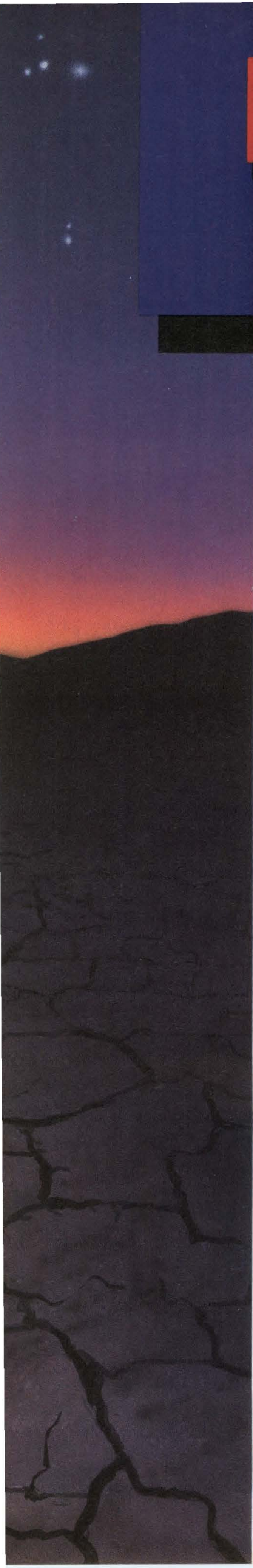
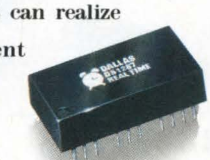
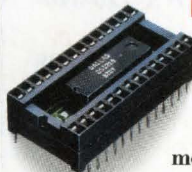
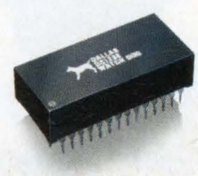
CIRCLE NO 93

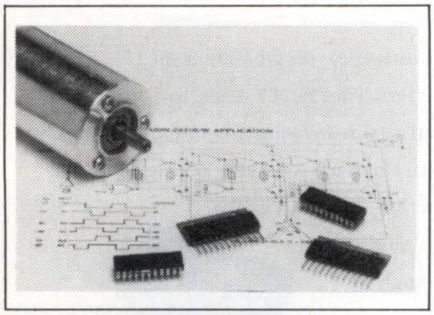

TIME
FOR THE NEXT CENTURY
DALLAS
DS1287
REAL TIME











MOTOR DRIVERS

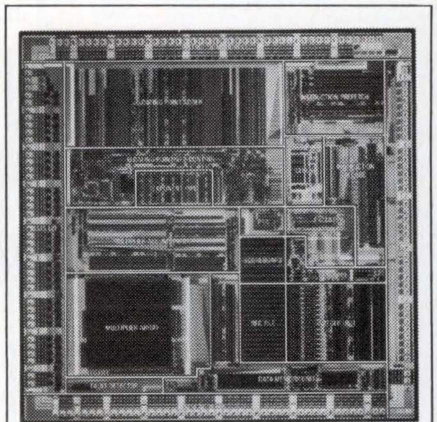
In the output stages, the UDN2931/2906 series 3-phase brushless dc motor drivers can provide 15V and ±2A of continuous current. At these ratings, the maximum output saturation voltage ($V_{CE(SAT)}$) is 1.3V. The peak start-up currents can be as high as ±3.5A. The series operates from a 15V supply to drive 12V brushless dc motors. The chips contain high-current clamp and flyback diodes to suppress inductive transients.

They also have a thermal shutdown feature with hysteresis that triggers at a chip temperature of 165°C. The UDN2931 contains logic circuitry, which is optimized for PWM current control. The chips also have one input that disables all the source drivers and another input that turns all source drivers on and all sink drivers off. The UDN2906 has the same output structure, but lacks the predrive logic features. Both devices come in a 12-pin DIP. UDN2906W, $2.95; UDN2931W, $3.10 (1000). Delivery, 8 to 12 weeks ARO.

Sprague Electric Co, Semiconductor Group, Box 2036, Worcester, MA 01613. Phone (800) 247-2077; in MA, (800) 247-2076. TWX 710-340-6304.

Circle No 628

RISC FAMILY



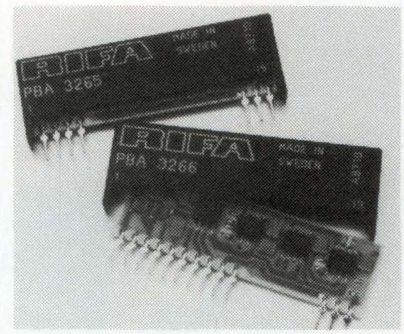
The 88000 family features 20-MHz reduced-instruction-set computer (RISC) chips that deliver a 14 to 17 VAX MIPS performance. It has an 88100 RISC μP and an 88200 Cache/Memory Management Unit (CMMU). The μP employs fine-grain parallelism, using four pipelines that execute concurrently. Most of the 51 instructions operate in one machine cycle. It integrates an integer and two floating-point units to deliver 7M to 12M flops. It has a 32-bit combinatorial multiplier and separate 32-bit data and data-

address buses. In addition, it contains a separate 30-bit instruction address bus and a separate 32-bit instruction bus.

The CMMU provides two logical-address spaces of 4G bytes each. It also provides a 4-way 16k-byte cache memory for instruction or data storage. General sampling of the HCMOS products will begin in the 3rd quarter of 1988; OEM quantities will be available in the 4th quarter of 1988. The 88100 will sell for \$495 (100), and the 88200 will cost \$795.

Motorola Inc, Microprocessor Products Group, 6501 William Cannon Dr W, Austin, TX 78735. Phone (800) 441-2447.

Circle No 633



DIGITAL FILTER

The PBA-3265 lowpass filter operates as a band-limiting, antialiasing filter in digital audio systems with 48- to 50-kHz sampling rates. The device exhibits a frequency response that is flat within 0.1 dB from dc to 20 kHz. Its stopband attenuation is 80 dB min from 24 to 100 kHz. The PBA-3266 matching delay equalizer corrects the filter's phase response. The resulting group-delay variation is constant within ±30 μsec for frequencies to 19 kHz. You can employ its built-in sin x/x compensation network in combination with the filter/equalizer to act as a reconstruction filter following a D/A converter. The sin x/x section is designed for a 48-kHz sampling-rate system. Each circuit comes in a single in-line package. PBA-3265, \$11; PBA-3266, \$15.50 (100).

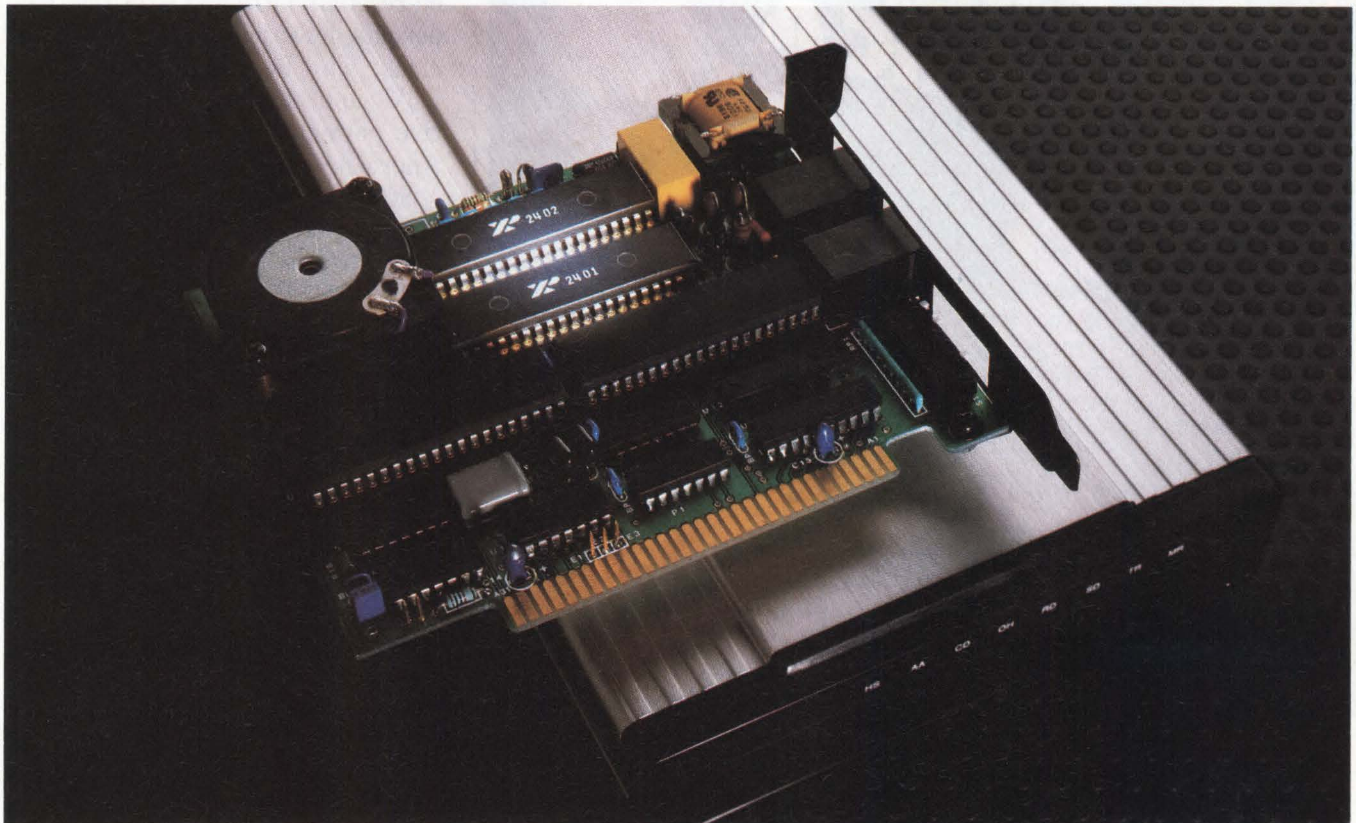
Rifa Inc, Box 853904, Richardson, TX 75085. Phone (214) 480-8300. FAX 214-680-1059.

Circle No 635

CODEC/FILTER

The M5913 CMOS codec/filter IC provides the A/D and D/A conversion and the transmit and receive filtering required to interface a full-duplex voice circuit to a time-division-mutiplexed PCM digital telephone system. The device is compatible with AT&T's D3/D4 standard and with applicable CCITT standards. It has a power-supply rejection ratio of −40 dB from dc to 150 kHz. You can operate the codec at either a fixed data-rate

MOVE UP TO 2400 BPS WITH EXAR'S MODEM ICs



EXAR's full featured V.22 bis chip set is 100% CCITT & Bell compatible

The XR-2401 digital signal processor and the XR-2402 analog front end form the perfect engine to your modem. The chip set was designed to interface directly to such popular microcontrollers as the 8051 and Z8. The XR-2400 chip set features:

- Low power CMOS – 450 mW max
- Two separate TX carrier wave shaping
- On-chip ASYN/SYN buffer with over speed buffer option
- Parallel TXD option for MNP implementation
- Analog loopback
- Local and remote digital loopback
- V.22 bis, V.22,212A compatible

Flexible architecture allows enhancements

Our modular architecture allows you to differentiate your product from your competitors. Since the XR-2401 & XR-2402 provide the complete modem function, and the command set is implemented separately in the microcontroller, you can easily incorporate your own customized "AT" command set to enhance your modem.

System design support

When you use EXAR's 2400 BPS solution, you are not only getting a versatile solution, but also a decade of modem design expertise. Since introducing the market's first monolithic modem solution EXAR has supported customers with system design. Today, to facilitate your design EXAR has a low cost XR-2400ES evaluation system consisting of:

- A fully tested stand-alone modem
- A system design manual
- A complete "AT" command set with documentation and source code.

And should you require further assistance, our experienced application staff is but a phone call away.

Call EXAR today and find out why we have achieved a reputation for service the world over.

The XR-2401 & XR-2402 are in full production now!

With the XR-2400 chip set in production since last year, you can be confident that you will go to production with the same ICs you designed with. You won't have to worry about the ICs going through any redesigns, or being unable to meet your production commitments.

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THE EXAR 2400 EVALUATION SYSTEM

☐ Rush me the XR 2400 Datasheet — EDN070788

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Tel. (408) 434-6400 FAX (408) 943-8245

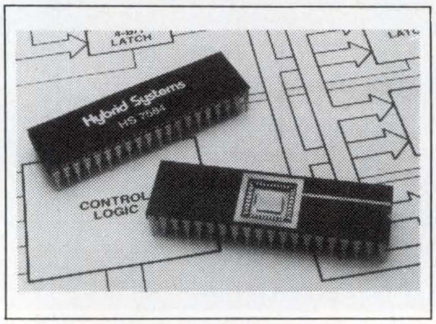
or in a variable data-rate mode. To ensure the integrity of the PCM highway, the unit contains power-on-reset circuitry and circuitry that permits detection of an interrupted clock. The device operates from ±5V supplies and has a typical active power dissipation of 60 mW. Approximately $6 (1000).

SGS Microelectronica SpA, Via C Olivetti 2, 20041 Agrate Brianza, Italy. Phone (039) 65551. TLX 330131.

Circle No 637

SGS Semiconductor Corp, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 638



12-BIT QUAD MDAC

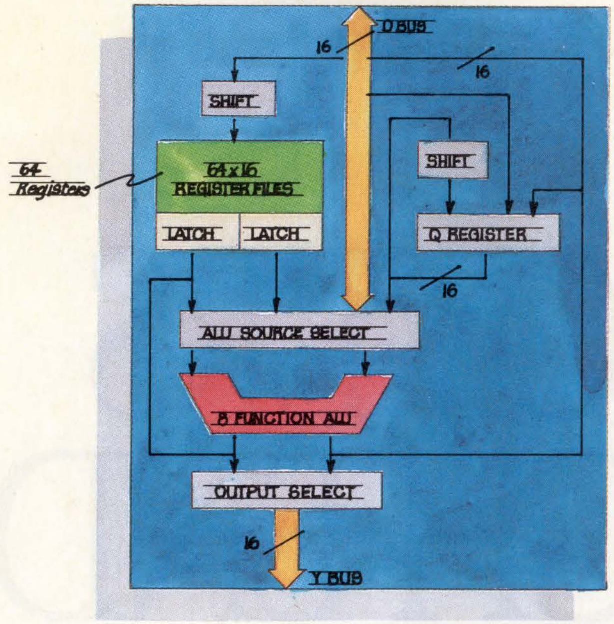
The CMOS HS-7584 contains four multiplying DACs, each having two current outputs and a separate reference input and feedback resistor. The double-buffered input structure accepts 12-bit parallel data or 8-bit/4-bit data, and interfaces with a μP. The use of thin-film resistors ensures 12-bit accuracy, and each DAC is laser trimmed for linearity and gain matching. The device's current-output settling time is 3 μsec max. The converter operates from a single 5V supply and draws 1 to 10 mA of current, depending on the input logic levels. The device comes in a hermetic 40-pin ceramic DIP or 40-pin ceramic LCC. HS7584C, $62; HS7584B, $120 (100). Delivery, six to eight weeks ARO.

Hybrid Systems, 22 Linnell Circle, Suburban Industrial Park, Billerica, MA 01821. Phone (617) 667-8700. TWX 710-347-1575.

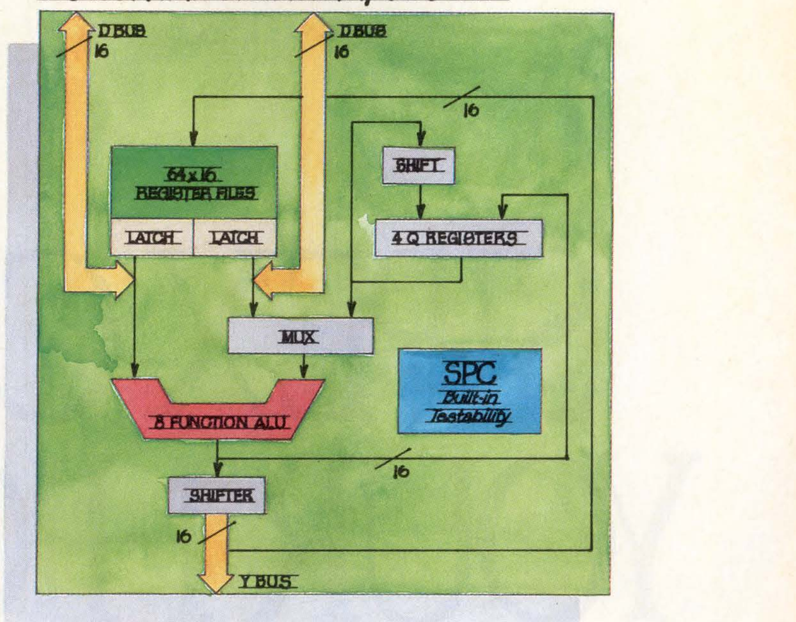
Circle No 641

The Ultimate 16-bit slice...

49C402: FAST, TWO BUSES



49C403: HIGH BANDWIDTH, 3 BUSES



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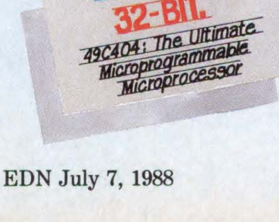

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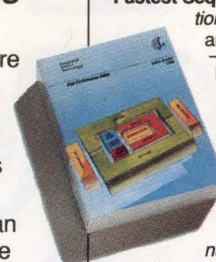

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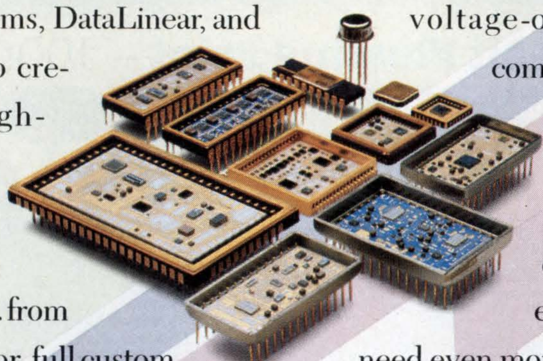

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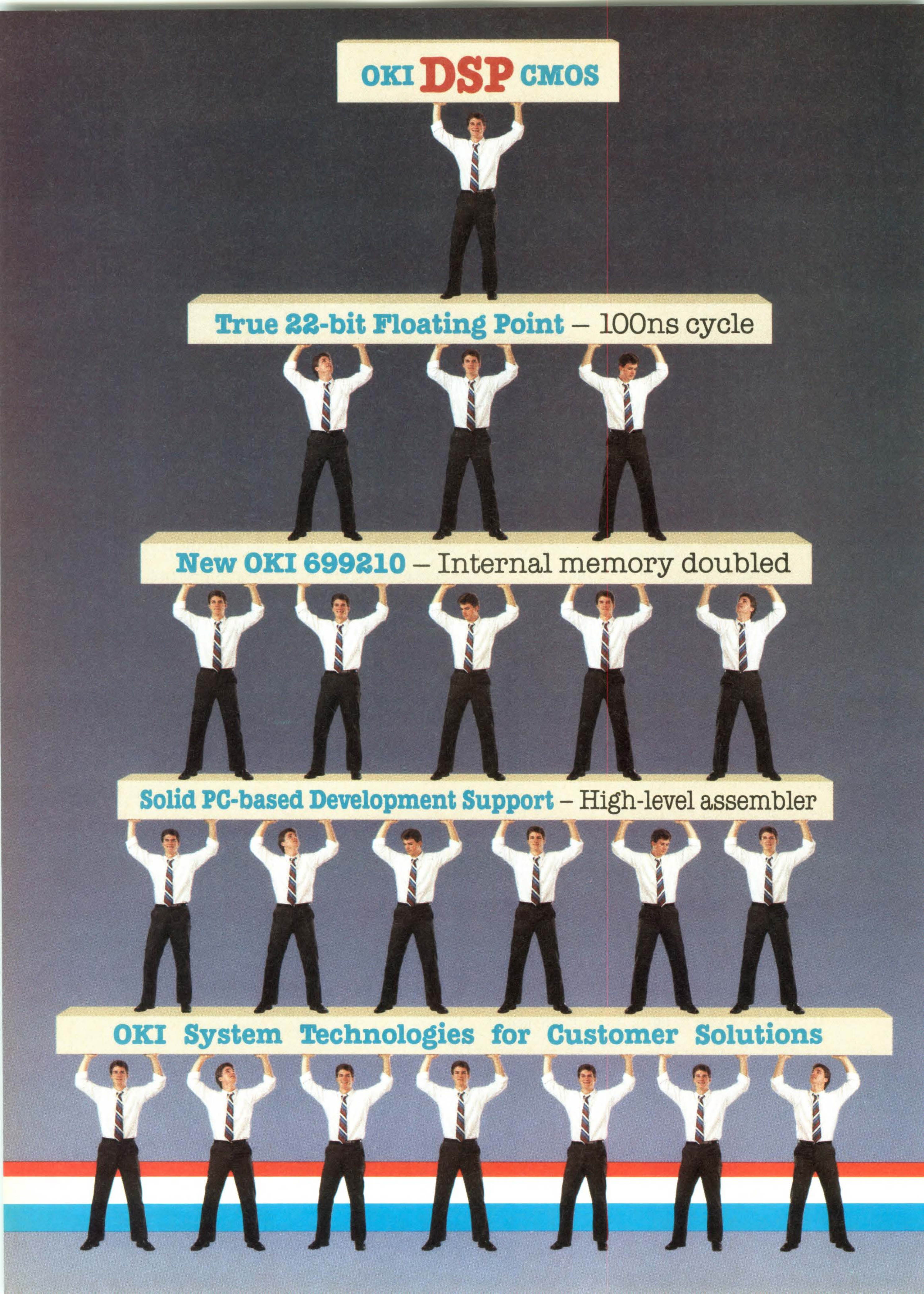
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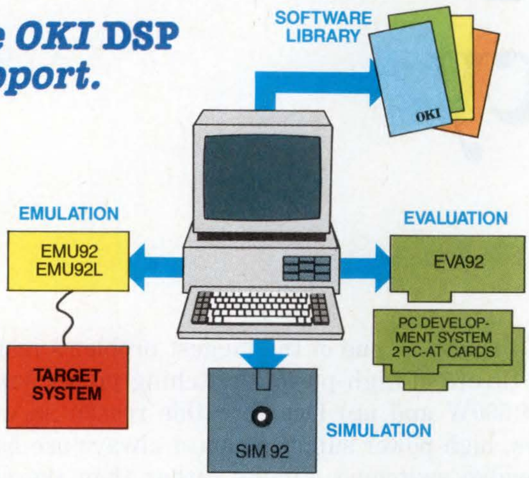

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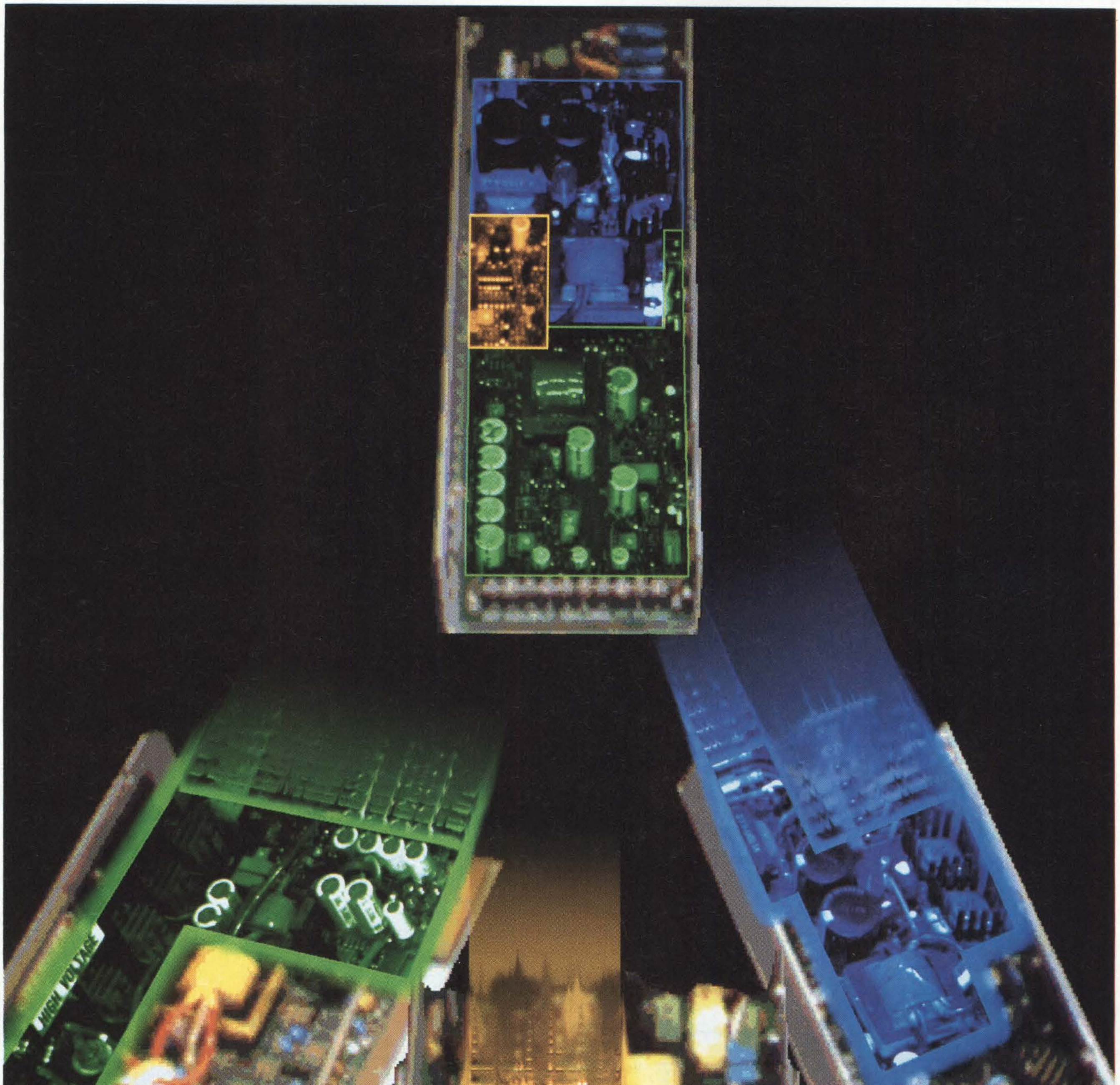
High-power switching supplies stress efficiency

Manufacturers of high-power supplies tend to emphasize efficiency over other performance considerations. Most of these supplies operate at frequencies well below 100 kHz and use half- or full-bridge circuits. Yet some manufacturers are shifting to higher frequencies and to the use of power MOSFETs instead of bipolar transistors.

Dave Pryce, *Associate Editor*

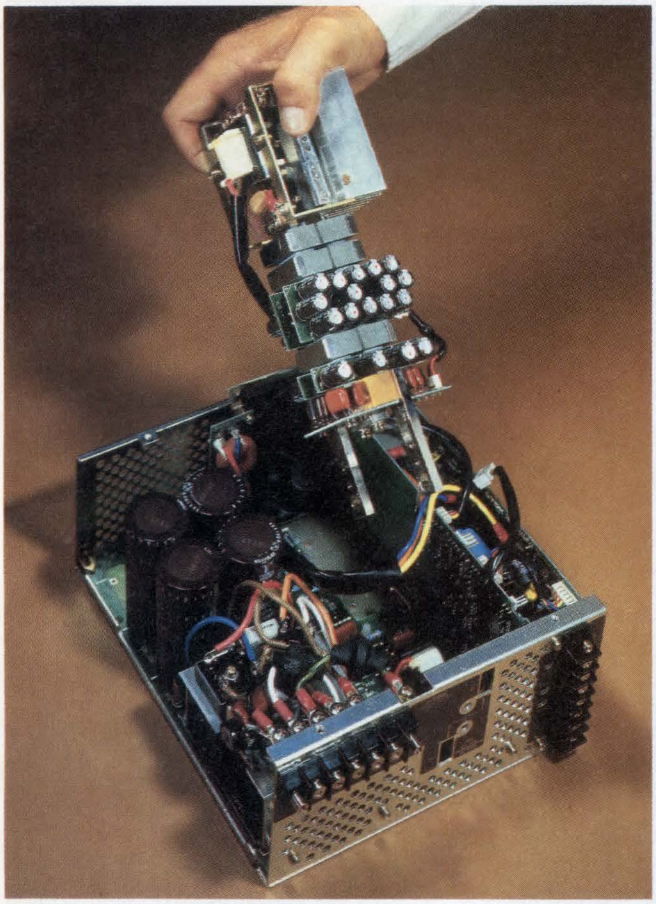
Efficiency is one of the biggest problems manufacturers of high-power switching power supplies (500W and up) face. For this reason as well as others, high-power supplies almost always use half- or full-bridge switching circuits rather than the single-transistor flyback converter or forward converters normally found on low-power supplies. And most of them operate at frequencies between 20 and 80 kHz and use the traditional bipolar transistors. Furthermore, although power MOSFETs are used in some high-power switchers because of their simpler drive requirements and their ability to operate in parallel, their fast switching times offer no advantage at low frequencies. The typical 20- to 30-nsec fall time of a power MOSFET is better utilized at switching frequencies in the range of 300 to 500 kHz.

Basically manufacturers of high-power supplies, which are used for products like superminicomputers, telecommunications devices, and laboratory and automated industrial equipment, don't gain much by reducing the size and weight of their products because portability is far less important in such applications than it is in low-power PC applications.



Semicustom high-power switching power supplies that use CAE *(Power Components)*

Power supplies in the 500W-and-up category generally use half-bridge or full-bridge switching circuits.



A 600W supply that uses a separate assembly for a 150-kHz converter *(Kepco Inc)*

One benefit of using bridge configurations in high-power switchers is that the corresponding transistors need only about half the blocking rating (V_{CEV}) that's required for the transistor in a flyback or forward converter. This characteristic is particularly important for supplies operating from 220V ac lines because a flyback converter needs a transistor with a V_{CEV} rating greater than 850V. Bridge circuits, on the other hand, turn on and off from the dc bus and never see more than the peak line voltage. In these latter circuits, V_{CEO} is the important transistor parameter—a 450V rating is sufficient.

Bridge circuits also offer other advantages: The primary winding of the transformer is driven in both directions, which results in better transformer-core utilization and makes the use of a full-wave output filter feasible. And, because the input-filter capacitors are located in series across the rectified 220V line, you can use them to double the voltage on a 120V line. In either case, the transformer continues to work from a nominal 320V bus. Finally, a bridge circuit allows the use of diode clamps across each transistor to minimize switching transients.

Qualidyne Systems has found that bridge circuits bolster the efficiency of its 400 to 1500W modular power supplies considerably. The bridge circuits not only enhance core utilization, they also facilitate the flow of huge amounts of current through the transformer while minimizing losses in the switching devices. The company has found it much easier to reduce these losses by

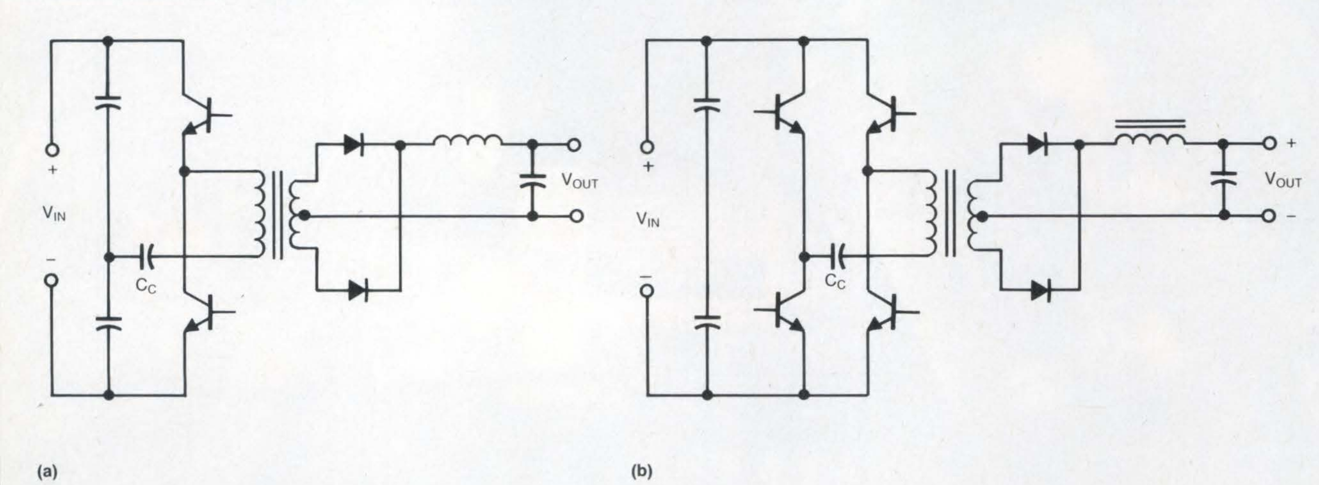
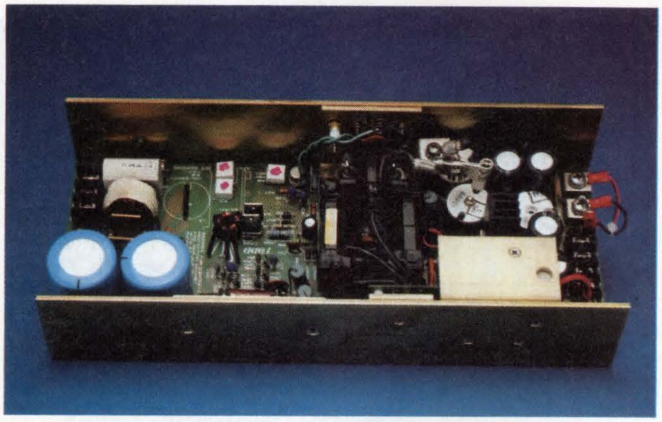


Fig 1—Most high-power switching supplies use either a half- or a full-bridge configuration. *The half-bridge circuit **(a)** is the most popular for transistor currents to about 20A. At higher currents, designers usually switch to the full-bridge circuit **(b)**, which nearly doubles the power output. Bridge circuits can use transistors that have about half the breakdown-voltage rating required for flyback or push-pull circuits.*



500W open-frame switcher *(Todd Products Corp)*

operating at lower frequencies; thus, although these units contain FETs, they don't use them to reach a higher frequency. In fact, they operate at only 30 kHz. Qualidyne has also found that using a single turn of copper foil rather than several turns of copper wire for the 5V high-current main output also reduces losses. Lower frequency combined with the single turn of foil actually decreases both resistance and heat losses.

The Qualidyne designs emphasize efficiency over and above such parameters as dynamic response, regulation, inrush current, and noise and ripple, and they do so for a very good reason. A 2000W supply that is 70% efficient, for example, loses 600W in heat. An improvement of only 5% in the efficiency rating decreases the loss by 100W—and 100W, which must be otherwise dissipated in the form of heat, can make a big difference to a circuit designer faced with overheating problems.

Qualidyne offers several series of high-power switching supplies ranging in power from 500 to 2000W and packaged in various case sizes. The Case-23 series provides power from as many as 7 fully regulated outputs. They come in low-profile 3×5×14.25-in. cases and typically cost less than $0.70/W (OEM qty). The maximum total power is 600W. The efficiency rating is typically 75%. The main channel on these supplies is 5V/100A; other channels, which are limited to a combined total of 240W, have 12, 15, or 24V outputs with current ratings in the 5 to 10A range. One model in this series provides a single 48V/13A output for use in telephone systems. Like most power supplies, all units operate from a selectable 90 to 132V or 180 to 264V ac input range. The line and load regulation is 1%; a typical holdup time is 16 msec. Other features include overload protection, thermal protection, and remote sensing.

Power Components, a subsidiary of Vanguard Electronics, makes custom and semicustom supplies, including a number of semicustom multi-output switchers with power ratings to 600W for open-frame types and 1000W for encased supplies. The mechanical design of these supplies permits a standard board to accept TO-3 or TO-220 devices, discrete postregulators, and prewound power transformers. The manufacturer establishes the output ratings during the final assembly stages when it adds the appropriate transformer, postregulators, and a few passive components. If you have an unusual mechanical configuration, the company will generate a new pc board to accommodate it. Power Components uses bipolar transistors that operate at 25 to 40 kHz in either a half-bridge (below 700W) or full-bridge configuration.

Common core moderates magnetic flux

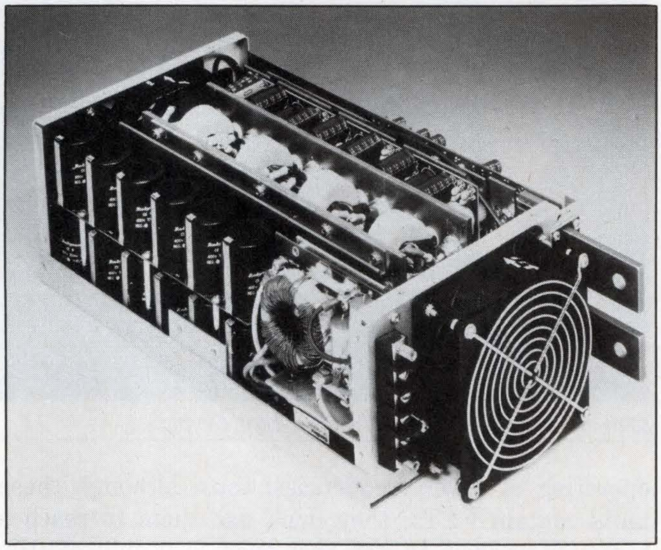
One unconventional feature of the Vanguard switchers is the use of a single, common core for all the output filter chokes. Because of this construction, the magnetic flux within the core is proportional to the combined power demand from all of the outputs, not just the main output. As a result, the switching-control circuit functions equally well with either a lightly or heavily loaded main output. Transient response also improves because sudden changes in auxiliary loading immediately are reflected to the control circuit. All Power Components switchers meet CSA, UL, and VDE isolation requirements. Instead of using the more common optocouplers, which place the control loop across the input-output isolation boundary, the manufacturer incorporates isolation transformers. A typical 4-output, 550W open-frame switcher sells for $385 (1000).

Computer Products' Power Conversion Group includes two organizations that participate in the high-power market: Boschert Inc and the group's Power Products Division. Both offer switching supplies in the 500 to 1500W range that are suitable for applications like minicomputers, CAD/CAE workstations, mainframe hard-disk systems, test equipment, industrial systems, and automated office equipment.

Although the Power Products Division uses 100-kHz switching frequencies and power MOSFETs for their low-power supplies, their high-power models use bipolar transistors switching at 20 kHz in either a half-bridge or full-bridge circuit. Both single-output and quad-output models are available. Typical of the single-output models is the 15S, a 1500W unit in a standard 5×8×11-in. case; it sells for $1250. Available output

Bridge circuits reduce the voltage stress on the switching transistors and also provide better transformer-core utilization.

Low-profile 600W switcher *(Qualidyne Systems Inc)*



Fan-cooled 3-kW supply in a 5×8×15-in. package *(Powertec Inc)*

ratings include 5V/300A, 12V/125A, 15V/100A, 24V/62A, 28V/53A, and 48V/31A. Standard features include protection against no load, overload, overvoltage, and thermal overload. The supply also incorporates remote sensing, current sharing, and a soft-start function.

Small package can pack power, too

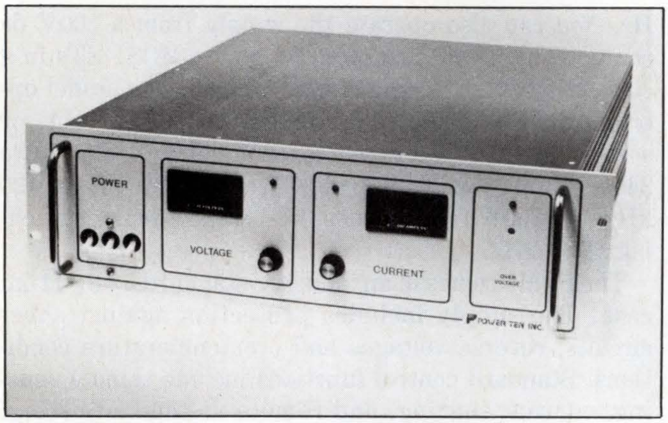
Lambda Electronics, a long-time supplier of both linear and switching power supplies to industrial users and OEMs, has a new series of high-power switchers that pack a lot of power into a relatively small package. The LFS-49, for example, comes in a 4.875×7.375×11.5-in. case and can provide 1500W. If you can accommodate a slightly longer (12.875-in.) case, the LFS-50 model can deliver 2000W. These single-output switchers are available with the standard output voltages of 2, 5, 12, 15, 20, 24, 28, and 48V. The LFS-49 and LSF-50 cost $900 and $1100 (100), respectively.

Innovative circuit boasts high efficiency

Instead of using bridge circuits for switching, the LFS series uses two alternately conducting forward converters. Each converter operates at 50 kHz and contains a MOSFET driver and two bipolar transistors, which are connected in parallel and which drive the primary of the switching transformer. The secondaries of the two transformers connect to a common full-wave rectifier that doubles the frequency to produce the 100-kHz switching rate. This dual-circuit configuration requires just a low-voltage MOSFET driver; it also reduces the operating frequency of the high-voltage bipolar transistors. The efficiency of these supplies attests to the effectiveness of this unusual circuit arrangement: Both the LFS-49 and LFS-50 have a minimum efficiency of 75% for their 5 through 15V models, and 80% for their 20 through 48V models. Line and load regulation is 0.1%, and the minimum holdup time falls between 16.7 and 20 msec (depending on model). These supplies also feature in-rush current limiting and overvoltage protection.

In what may be the most power yet stuffed into a 5×8×15-in. case, the 9R5-600-381 from Powertec provides a 5V/600A output at 50°C. The 3-kW supply uses a combination of hybrid and monolithic ICs, low-noise miniature capacitors, and 100-kHz power MOSFET switches. Other standard models in the 9R series provide outputs of 2, 12, 15, 24, 36 and 48V. The supplies operate from a nominal 220V (165 to 265V) ac input, either single-phase or three-phase. They can also be dc-to-dc converters from a 200 to 375V dc input. Standard features include current sharing, soft start, remote sensing, and thermal shutdown. Each switcher contains a ball-bearing dc fan. Four power inverters, which operate at different intervals in time, reduce the ripple current and minimize the stress on the input and output capacitors. Approvals are pending for UL, CSA, IEC, and VDE specifications. The 9R5-600-381 sells for $1890.

Another vendor who is adopting MOSFETs is Power Ten Inc. Its rack-mounted 4600 series, for example, uses MOSFETs in a full-bridge configuration that



***Rack-mounted 5-kW supply** (Power Ten Inc)*

switches at 60 kHz. Operating from a 3-phase ac supply, the 5-kW 10500 model delivers 10V at 500A and sells for $2700. Other voltages from 7.5 to 80V are available within the 4600 series as are power levels of 2.5 kW and 3.75 kW. Modular in construction, the 5-kW models use 4 field-replaceable units that deliver 1.25 kW each. The outputs from the modules are displaced slightly in time; this regulation of the outputs lightens the burden of filtering the rectified dc.

Power Ten has chosen to use the MOSFETs because of their relatively low prices. The drive circuitry is also quite simple in comparison to bipolar devices. Because MOSFETs are simpler and because they can function efficiently at frequencies of 500 kHz (and higher), the company projects power densities of 15 to 20W/in^3 within the next several years. Right now, 3 to 5W/in^3 densities are available.

Higher frequencies create losses

Operating at a frequency of 150 kHz, the RBX (600W) series from Kepco Inc uses MOSFET power switches in a half-bridge configuration. Because of the high-frequency operation, Kepco manages to pack the 600W of power into a package measuring 3.74×7.87×8.66 in. Switching frequencies in the range of 150 kHz and higher, however, produce three kinds of major losses. The first two involve power losses in the choke and the transformer cores, which increase with frequency, and copper losses in the transformer windings from the skin effect. The company solved the first problem with a low-loss ferrite core; it corrected the second by using separately insulated strands of wire called litz wire to increase the surface area of the windings.

The third problem arising at higher frequencies is the loss of filtering efficiency caused by the equivalent series resistance (ESR) and the equivalent series inductance (ESL) of the output filter capacitors. To overcome this problem, Kepco stacks 39 capacitors (all in parallel) on either side of the converter's output chokes. For a 5V output, each of these capacitors has a value of about 220 μF. Capacitors of this value have much lower ESR than do 5000-μF devices, for example. The short parallel connections also reduce the ESL. As a result of these compensations, the efficiency of the RBX 600W supplies approaches the state of the art: 80% for the 5 and 12V models and 85% for the 24 and 48V units.

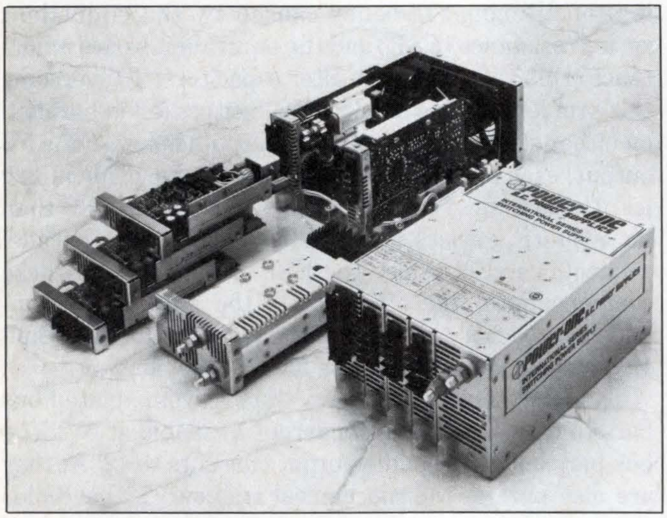
The RBX series uses heavy-duty, chrome-plated bus bars to carry the 120A of current available at 5V. The bus bars not only handle output currents to 120A; they are also part of the mechanical framework that holds the main power section together. Other features of these supplies, which sell for $675, include remote voltage control, current limiting, remote on/off control, remote error sensing, and a selectable 115/230V ac input.

Todd Products Corp offers a variety of power supplies targeted for specific market segments; it sells different supplies for the computer market, for example, and for the telecommunications segment. The computer series B MAX-503-0512 provides a maximum of 500W from outputs of 5V/80A, 12V/10A, and −12V/10A. The MAX-500 series comes in a 2.5×5×11.5-in. package, which is substantially smaller than the 5×8×11-in. package usually used for 500W supplies. The extensive use of surface-mount components contributes to the small size.

Todd also improved its current-fed inverter design, which now allows the supply to handle 500W of power with the same amount of cooling as a 400W switcher. The open-frame design of the MAX-500 uses system air for cooling, eliminating the need for a power supply fan. Priced at $431 (100), the MAX-500 series meets international safety standards for SELV applications, and the Class A RFI requirements of the FCC and VDE-0871.

Battery-backup saves data

If your computer system needs both a significant holdup time to save data and an orderly shutdown in the event of an ac power-line failure, consider the 750W H754 from Jeta Power Systems. The output rating for the main channel is 2 to 28V at 120A (600W max). Auxiliary channels 1, 2, and 3 are respectively rated at 2 to 28V at 20A (240W max), 2 to 28V at 5A (75W max), Many high-power supplies still use bipolar transistors in converter circuits that switch at only 20 to 30 kHz.



A 1500W modular supply (Power-One)

and 2 to 48V at 1A (48W max).

A 48V backup battery provides full power during a line failure, making it an uninterruptible power system. The holdup time depends upon the battery rating—a 5-Ahr battery provides 4 minutes of full-power operation. If the line power fails, the switch to battery power is automatic. A built-in, constant-current battery charger maintains battery power. During battery operation, a 100-kHz converter provides 300V dc for the main power stage. The dc/dc converter uses power MOSFETs and current-mode control for protection against transformer saturation. The main power supply is a half-bridge circuit operating at 20 kHz and using bipolar transistors. The outputs and the backup battery are fully isolated from the input. The entire power supply (including the battery) is contained in a 5×8×13-in. package. The H754 design meets UL, CSA, and VDE regulations. It costs $981 (100).

One modular power system that you can configure for your specific needs comes from Power-One. The SPM5 series has 5 slots that can hold 5 plug-in modules. The 12 available single-output modules range in power from 70 to 780W; voltages extend from 2 to 48V (with the usual steps at 5, 12, 15, and 24V). You can plug in 2 modules with power ratings of 300W and higher. Dual-output modules rated at 240W are available with voltage ratings of ±12V, ±15V, and ±24V. A 1000W uninterruptible power supply battery-backup model operates from a 48V battery.

Designed for international use, the SPM5 can supply 1500W of dc power from a selectable ac input of 90 to 132V or 180 to 264V at line frequencies from 47 to 440 Hz. You can also operate the supply from a 300V dc source. The SPM5 modules use power MOSFETs in a current-mode switching circuit that allows parallel operation of the modules for higher output current, or series operation for higher output voltage. The 70 to 240W modules use half-bridge circuits switching at 120 kHz; the 750W modules use full-bridge circuits switching at 60 kHz.

The SPM5 comes in an industry-standard 5×8×11-in. case. The supply includes protection against short circuits, reverse voltages and overtemperature conditions. Standard control functions include remote sensing, current sharing, and remote voltage adjusting. The supply signals when the input power fails. The SPM5 meets VDE, IEC, CSA, and UL safety specifications, as well as FCC and VDE EMI specifications. Pricing varies according to the modules selected. A system configured with one 750W and two 240W modules costs $922; a system with two 750W modules costs $857 (100).

Multi-output units extend to 2000W

HC Power Inc offers switching power supplies in the 500 to 2000W range with from 1 to 5 outputs. The units use a modified forward-converter construction that eliminates saturation of the inverter transformer core and also permits the use of lower-voltage MOSFETs. The converter switches at 147 kHz and uses current-mode control to achieve a transient response to load changes of under 50 μsec. Models are available in ratings of 500, 750, 1000, 1500 and 2000W. Output voltages for multi-output models range from 2 to 24V; for single-output models, the range is 2 to 48V. The supplies meet all specifications for UL, CSA, IEC and VDE. They are available with 1- or 3-phase ac inputs or with a 48V dc input. The base price for single-output switchers is $890 (1000W), $1277 (1500W), and $1550 (2000W). Quad-output supplies cost $1205 (1000W) and $1661 (1500W).

A line of high-power switches from Deltron Inc provides power outputs from 500 to 1750W. The VF series is available with from 1 to 5 outputs at voltages of 5, 12, 15, 18, 24, or 48V. The VF series of switchers operate from 90 to 132 or from 180 to 264V with a 47- to 63-Hz ac line. A factory option for 400-Hz line operation is available. These units convert at 80 kHz and have a typical efficiency of 80%. The triple-output VF3C 1000W model provides outputs of 200, 300, and 500W and comes in a 5×6×13-in. case and costs $608 (1000).

Introduced at Electro/88, Deltron's DVF series is

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In a Navy test, a Tomahawk cruise missile exploded into a concrete building. When the dust settled, little remained but gravel and fragments of casing.

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CIRCLE NO 104

Transformer design becomes critical at high currents. High operating frequencies only add to this problem.

similar to the VF series except that the newer supplies operate from a 40 to 60V dc source and have slightly different ratings. The available output voltages for the DVF series are 2, 3.3, 5, 12, 15, 18, 24, 28 and 48V. Efficiency is 75% typ. The triple-output DVF3C 1000W units with output of 200, 300, and 500W costs $672.

500W open-frame units have 3 outputs

Valor Electronics Inc makes 500W open-frame switchers with output voltages of 5, 12, 15, and 24V. The 5K series is convection cooled. It's designed for use in workstations, superminicomputers, and test systems. All units use a half-bridge configuration with bipolar transistors. The supplies have a minimum efficiency of 75%. Other specifications include load and line regulation of 0.15%, a transient response of 500 μsec, and maximum ripple and noise of 75 mV (p-p at full load). Standard features include overvoltage protection, foldback current limiting, and remote sensing. All 5K models meet UL, CSA, and VDE safety requirements; they also comply with FCC and VDE Class-A specifications for conducted noise. They cost $510 in small quantities and $300 in quantities of 1000.

Numerous other manufacturers offer lines of power supplies with a variety of options. Among the most significant are ACDC Electronics, Hewlett-Packard, LH Research, and Pioneer Magnetics. Each offers a variety of products in the 500W and up range.

ACDC Electronics, for example, has four different series in the high-power range: The RSF series has 500W models with 1 to 4 outputs and costs $598. The REV line has 800 and 1000W models with 2 to 4 outputs; the 800W models start at $1014. The JF series includes 750, 1000, and 1500W single-output versions; a 1000W model costs $751. The JFM line has 1600W models with 3 to 5 outputs and starts at $1595.

Hewlett-Packard's HP6030 series is a group of five power supplies in the 840 to 1200W range; they are designed for laboratory applications. These autoranging power supplies have DVMs and offer 12-bit programming and readback of both output voltage and output current, self-documenting programming codes,

For more information . . .

For more information on the high-power switching supplies 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.

ACDC Electronics
401 Jones Rd
Oceanside, CA 92054
(619) 757-1880
Circle No 391

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Boschert Inc
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2981 Gateway Drive
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(305) 974-2442
Circle No 393

Deltron Inc
Box 1369, Wissahickon Ave
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Circle No 394

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Circle No 395

Hewlett-Packard Co
Inquiries Manager
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Cupertino, CA 95014
Call local office

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2675 Junipero Ave
Signal Hill, CA 90806
(213) 427-0095
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Flushing, NY 11352
(718) 461-7000
Circle No 397

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(516) 694-4200
Circle No 398

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Tustin, CA 92680
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Circle No 399

Pioneer Magnetics
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Circle No 400

Power Components
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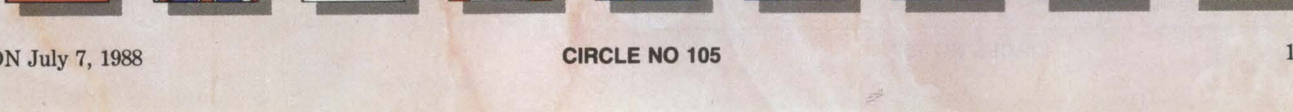


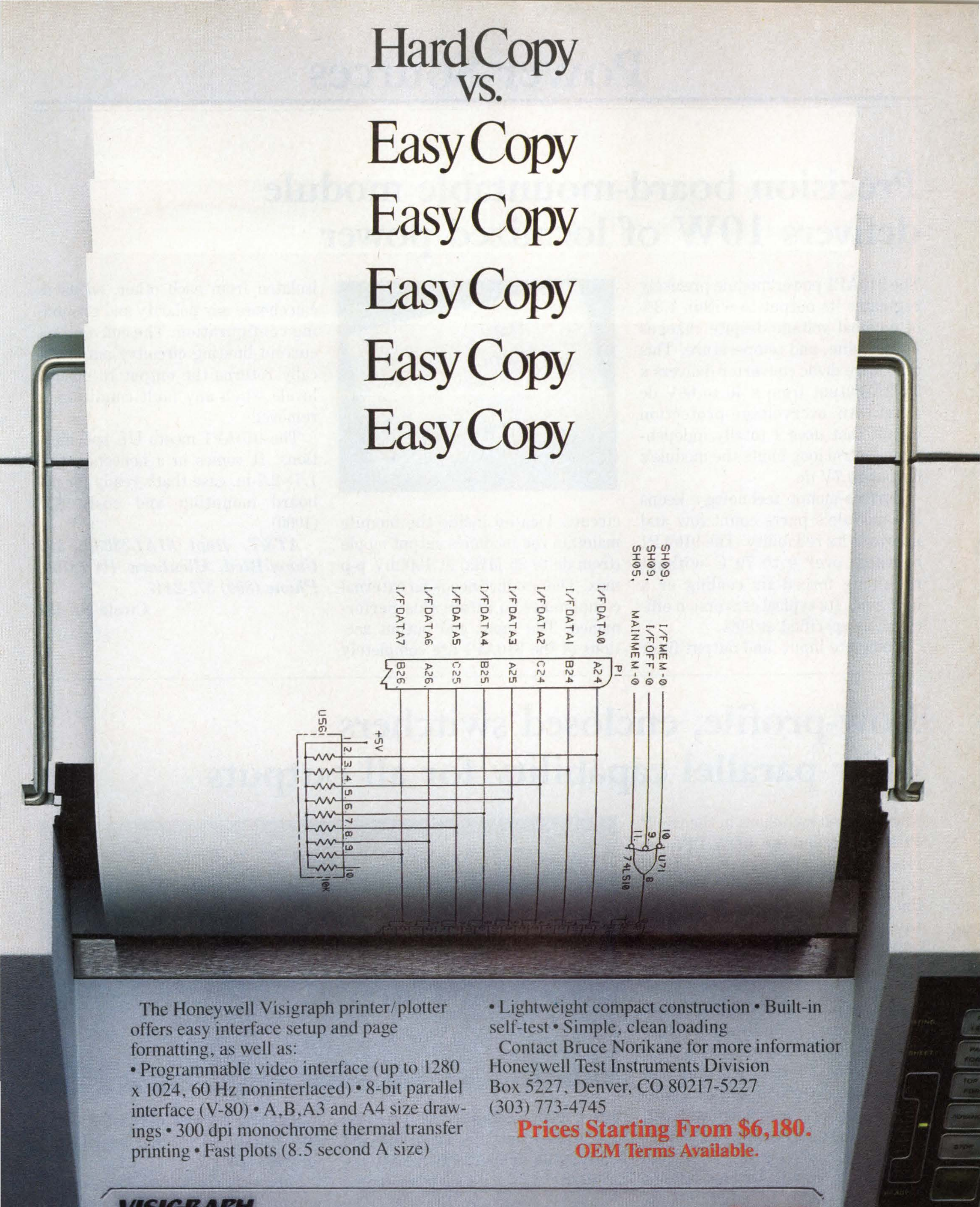
programming error detection, and readback of all programmable functions. The series offers a complete solution to automated-system power requirements. Base prices range from $2575 to $3400.

Four different lines of high-power switchers from LH Research give you several options: The MMA series provides 500 to 1500W with 1 to 9 outputs and sells for $630 to $1295. The SM line has 750 to 1500W supplies with 1 to 4 outputs and costs $680 to $1295. The SMA supplies provide a single output from 600 to 2000W; prices range from $1325 to $1600. The MGA switchers include 500 and 1000W models with single or multiple outputs; they are part of a high-reliability series and are guaranteed for five years; prices begin at $945 and run to $1613.

Pioneer Magnetics has more than a dozen kinds of high-power switchers at various levels in the 500 to 2000W range. Both single- and multi-output models are available. You can choose from models that operate from a 48V dc source. A battery-charging option is available for one of the 1400W models. Single-output versions cost from $500 to $1250. Multi-output models run from $695 to $1450 (OEM qty).

Power-hungry applications such as those in superminicomputers, large-scale computerized test systems, and telecommunications equipment have created a large and various market for high-power switching supplies that are required to perfrom as efficiently as possible. Beyond efficiency, these supplies reveal a trend, albeit a gradual one, toward switchers with higher frequencies and the consequently reduced size and higher component density. This trend promises to soon produce high-power switchers that will offer a three- to fourfold improvement in power density—at higher efficiency ratings and lower costs. **EDN**

Article Interest Quotient (Circle One)
High 497 Medium 498 Low 499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Precision board-mountable module delivers 10W of localized power

The 910AP1 power module precisely regulates its output to within 1.3% of nominal voltage despite changes in load, line, and temperature. This miniature dc/dc converter delivers a 5V/2A output from a 40 to 60V dc input. An overvoltage-protection circuit that uses a totally independent control loop limits the module's output to 7V dc.

Surface-mount technology keeps the module's parts count low and improves its reliability. The 910AP1 operates over 0 to 70°C without requiring forced-air cooling or a heat sink. Its typical conversion efficiency is specified at 80%.

Complete input- and output-filter circuits located inside the module maintain the module's output ripple (from dc to 20 MHz) at 100 mV p-p max. The product needs no external components to attain this performance. The input and output sections of the 910AP1 are completely isolated from each other, so users can choose any polarity and grounding configuration. The converter's current-limiting circuitry automatically returns the output to normal levels when any fault condition is removed.

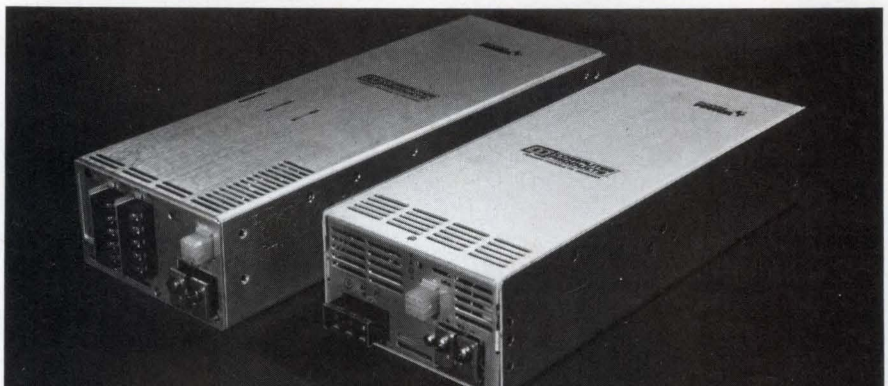
The 910AP1 meets UL specifications. It comes in a nonconductive 1.7×2.7-in. case that's ready for pc-board mounting and costs $37 (1000).

AT&T, Dept 51AL23030, 555 Union Blvd, Allentown, PA 18103. Phone (800) 372-2447.

Circle No 452

Low-profile, enclosed switchers offer parallel capability for all outputs

The enclosed switchers in the 250W PPM Series and the 400W PFS Series offer parallel capability (current sharing) for both main and auxiliary outputs. The vendor claims this feature meets stringent requirements for single-point failures in redundant-power-system applications.



The supplies offer a host of standard features, including a remote on/off control, margining, a power-good signal, thermal warning and protection, overload and overvoltage protection, an input line filter, inrush-current limiting, soft-start capability, and a switch-selectable 115/230V ac input. Various options are also available to satisfy almost any power-supply requirement.

All units in both series are UL recognized, CSA certified, and TUV approved. The supplies feature a modular design that provides one to seven outputs. Their line- and load-regulation performance is 0.2% or 10 mV max, and their switching frequency measures 100 kHz. The units' efficiency figures range from 70 to 85%. The maximum ripple and noise specs (for a 20-MHz bandwidth) are 1% or 50 mV for the main output and 1.5% or 75 mV for auxiliary outputs. A 5V/80A model sells for $432 (100).

Computer Products, Power Conversion Group, 2900 Gateway Dr, Pompano Beach, FL 33069. Phone (305) 974-5500. TWX 510-956-3098.

Circle No 453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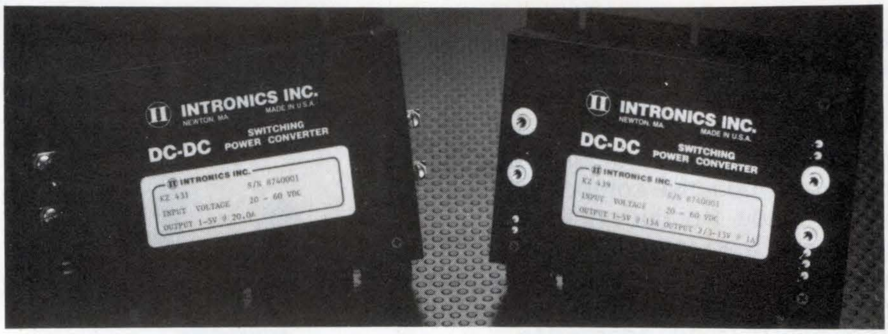
CIRCLE NO 109

Fully isolated, 100W dc/dc converters feature wide operating range

The KZ 400 Series 100W dc/dc converters offer as many as three outputs. The converters are protected against a variety of fault conditions, and they operate over −40 to +85°C.



The converters are available in models that accommodate input ranges of 20 to 60V dc or 36 to 72V dc. Models KZ 431, 432, and 433 provide 5V/20A, 12V/8.3A, and 15V/6.7A outputs, respectively. The triple-output converters in the series supply 5V and ±12 or ±15V, and they provide 15A on the main output and 1A on the auxiliary outputs. On the auxiliary outputs, 1.5A capability is optional.

The converters' accuracy is specified at ±1% for the main output and ±2% for auxiliary outputs. You can adjust the main output over a ±5% range. The ripple and noise specs (over a 20-MHz bandwidth) are 1% and 2%, respectively. The switching frequency is 200 kHz, and the converters' typical efficiency is 80%. The line- and load-regulation specs are ±1% for the main output and ±5% for the auxiliary outputs.

Overvoltage protection for the main output is standard, as is reverse-polarity and short-circuit protection, which features automatic recovery. Thermal protection and input-overvoltage protection are optional.

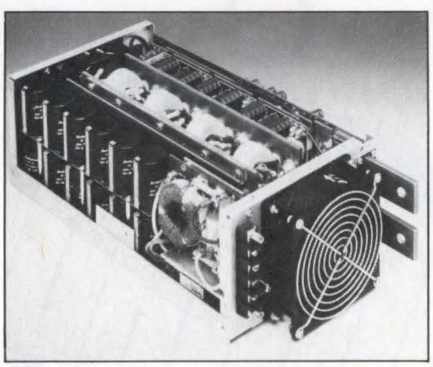
The KZ 400 Series converters sell for $140 to $175 (100) and are housed in a package that features 6-sided shielding. A side-mount model is available to satisfy low-profile applications.

Intronics Inc, 57 Chapel St, Newton, MA 02158. Phone (617) 964-4000. TLX 200095.

Circle No 454

Single-output, current-mode power supply packs 3000W into a 5×8×15-in. package

Series 9R power supplies include 2, 3, 5, 12, 15, 24, 28, 36, and 48V units. Each of the current-mode supplies generates 3000W and fits into a 5×8×15-in. package, which is only 4 in. longer than the industry-standard package for a 1500W supply.



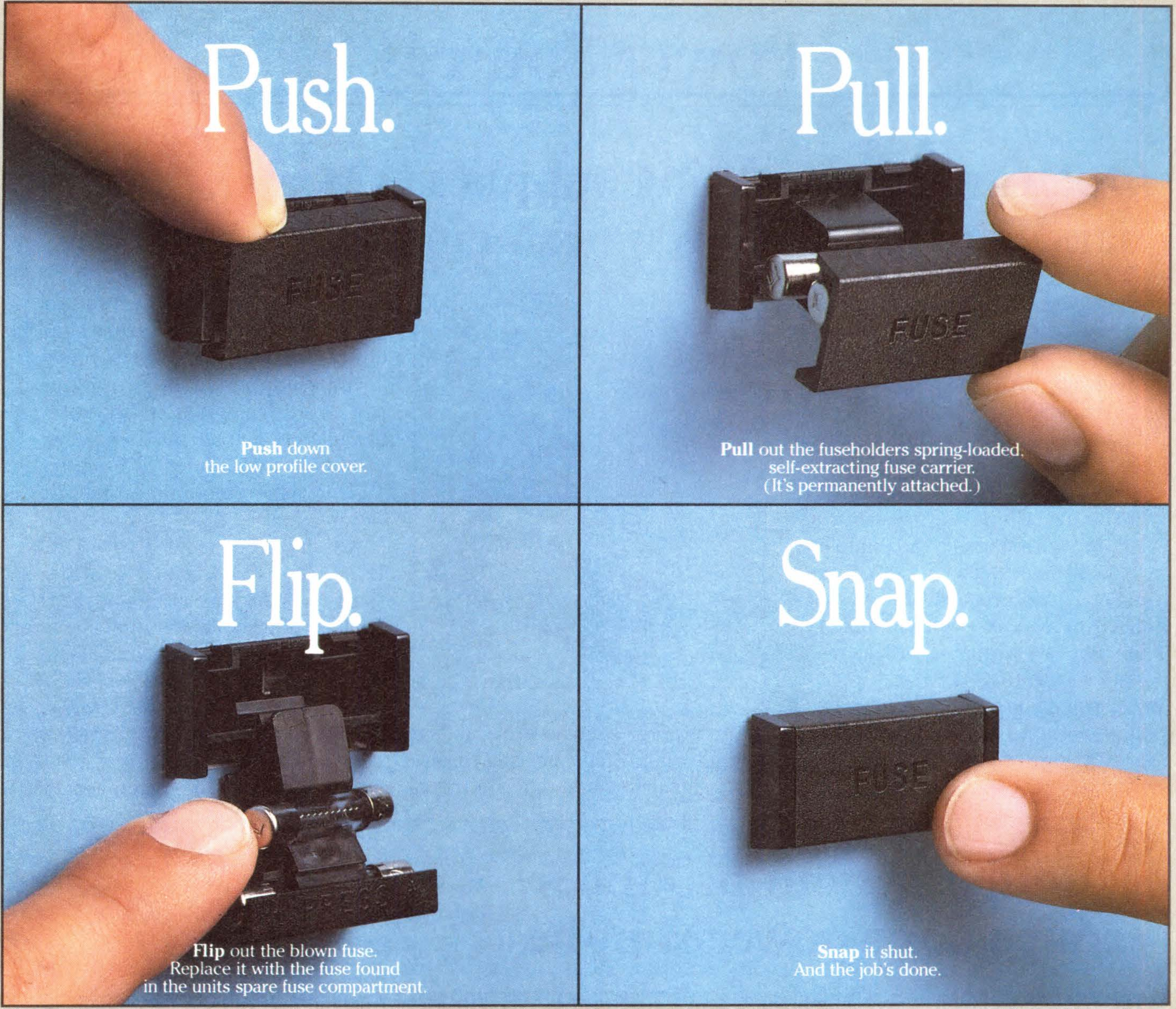
The supplies typically operate at 75% efficiency when running from a 230V ac source. When operating in the 0 to 50°C range, they supply 100% of their rated load, although the 2V unit can supply only 1400W because of output-bus-bar and rectifier-diode current-carrying limitations.

Other key specs include 5 mV or 0.1% (whichever is greater) line regulation, and 10 mV or 0.2% (whichever is greater) load regulation; dynamic response of 4% max for a 25%-step load change; 200-µsec output recovery to within 1% of nominal; and thermal regulation of ±0.02%/°C.

Current limiting and overvoltage protection are standard features of the supplies. You can also specify an SCR-crowbar feature for additional overvoltage protection. The units have terminals for remote sensing, and you can remotely control their outputs to within ±10% of nominal. The supplies also include indicators for valid outputs and for input-power failure. They cost $1800.

Bonar Powertec, 20550 Nordhoff St, Chatsworth, CA 91311. Phone (818) 882-0004. TLX 277483.

Circle No 450



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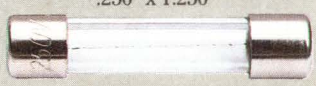
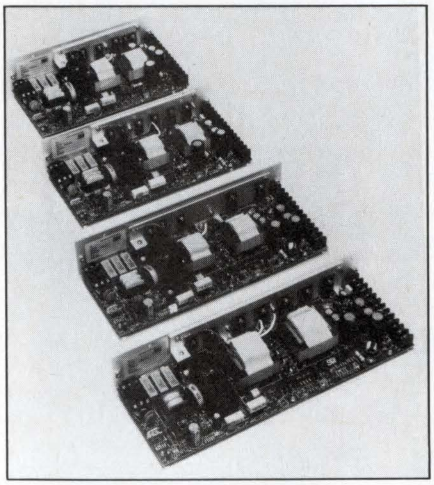


CIRCLE NO 110

Open-frame switching supplies handle drive-surge requirements

Among the SQM International Series switchers are models that offer a 150 to 350W continuous-output capability. All the units feature peak-power capabilities to accommodate the initial turn-up/spin-up loads required by peripherals such as disk or tape drives and printers.

The switchers feature main 5V outputs with current capabilities of 20 to 50A. Auxiliary 5, 12, 15, and 24V outputs are available with as much as 16A of peak current. All the units are available with as many as four outputs.



The supplies accept a variety of input voltages and offer overvoltage protection for their transformers' primary windings. Other standard features of the switchers are built-in line filtering, 3750V ac safety isolation, shielded power transformers, built-in overload and overvoltage protection, overtemperature shutdown, remote-sensing capability, vacuum-impregnated magnetics, and fixed-frequency pulse-width modulation. You can opt for a power-valid indicator and for TTL-high or TTL-low power-fail-detection circuitry.

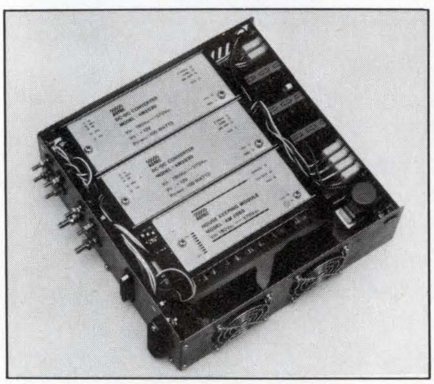
All the units meet VDE, IEC, UL, CSA, FCC, and VDE specifications for safety isolation and EMI/RFI emissions. The supplies cost $266 to $358 and are available for delivery from stock to 10 weeks.

Switching Systems International, Box 1599, Placentia, CA 92670. Phone (714) 996-0909.

Circle No 455

Modular system produces semicustom power supplies

The AMPSS modular power-supply system provides a semicustom approach to power-supply design. Each supply consists of an 8×5×11-in. mainframe that contains line-input rectification and smoothing circuitry and accepts dc/dc-converter modules. The mainframe operates from 90 to 135V or 180 to 270V line-input supplies and accepts power-supply modules having outputs as high as 1600W. It comes in versions that accommodate as many as eight 100W dc/dc-converter modules, four 100W modules and one 800W module, or two 800W modules. Smaller mainframes are available to house 600W max supplies.



The dc/dc-converter modules currently available include 100W units with output voltages of 5, 12, 15, or 24V; an 800W unit that generates a 5V output; and a 50W unit with −5 and −12V outputs. Except for the 2-output version, whose line- and load-regulation spec is 1%, the modules feature 0.3% typ line and load regulation. The units' output ripple is 1% of output (max) over a 20-MHz bandwidth. The single-output modules can share current when operating in parallel.

All the outputs feature short-circuit and overvoltage protection. An optional housekeeping module provides remote on-off facilities, overtemperature and input-undervoltage protection, ac-input-failure indicators, a 5V standby supply, a 12V fan supply, and semiregulated supplies for external circuitry. The supplies are designed to meet the relevant UL, CSA, and VDE requirements. A typical 400W version with a housekeeping module costs around £430 (100).

Astec Europe Ltd, 8B Portman Rd, Reading, Berkshire RG3 1EA, UK. Phone (0734) 509411. TLX 848047.

Circle No 456

Astec USA (HK) Ltd, 2880 San Tomas Expressway, Suite 200, Santa Clara, CA 95051. Phone (408) 748-1200. TLX 6839191.

Circle No 457

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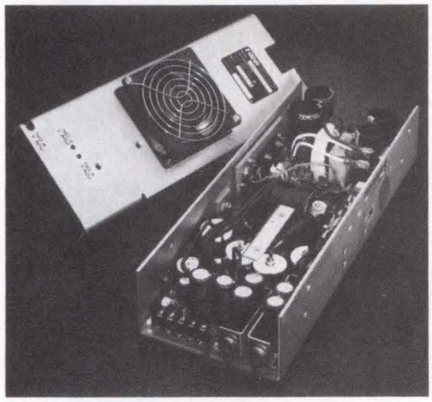
CIRCLE NO 111

High-current, low-profile switcher offers significant size advantage

The quad-output MAX-750 provides 750W of power in a package measuring 2.6×5×13.5 in., which is significantly smaller than the typical 5×8×11-in. shoebox switcher. The supply comes with a cover/fan assembly for self-cooling and features a thermal-cutoff system that protects the supply should the cooling system fail.



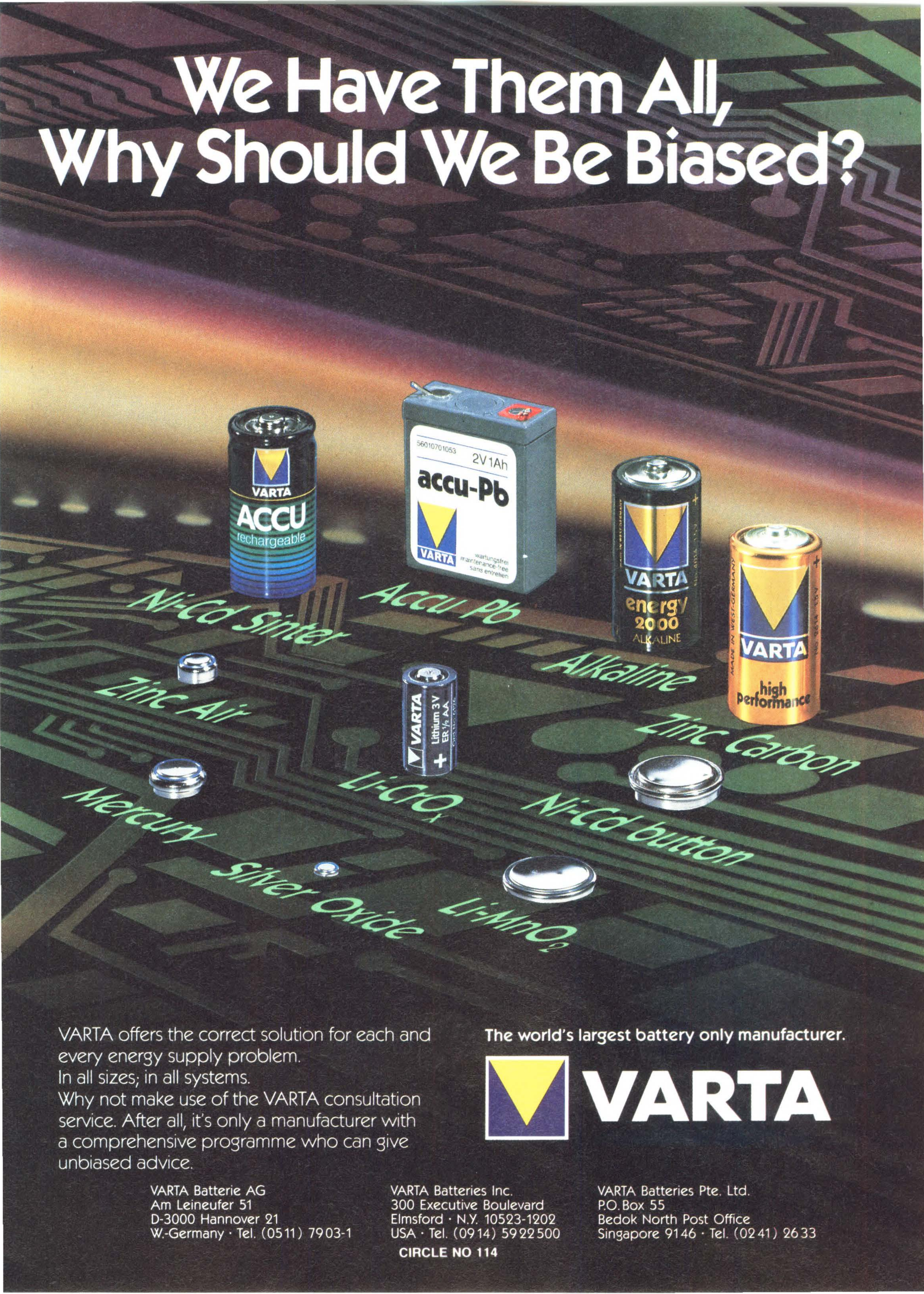
The supply's main output provides 5V at 120A. The three auxiliary outputs provide 12, −12, −5.2, and 24V in various combinations. A magnetic, switching postregulator holds the line and load regulation to 1% on the auxiliary outputs. A current-fed inverter that operates at 50 kHz achieves an efficiency rating of 80% min, the vendor claims. The unit specs 0.2% rms max ripple and noise.

The switcher's standard features include user-adjustable outputs (±5%), remote sensing on the 5V output, overload protection on all outputs, overvoltage protection on the main output, and the capability to inhibit the output remotely. An ac-power-failure indicator is optional.

According to the vendor, the MAX-750 meets international safety standards, including UL 478, CSA 22.2, IEC 380, IEC 435, and the Class A RFI requirements of FCC and VDE 0871. It also meets SELV requirements for creepage and clearance. It costs $589 (100).

Todd Products Corp, 50 Emjay Blvd, Brentwood, NY 11717. Phone (516) 231-3366. TWX 510-227-4905.

Circle No 451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CIRCLE NO 114

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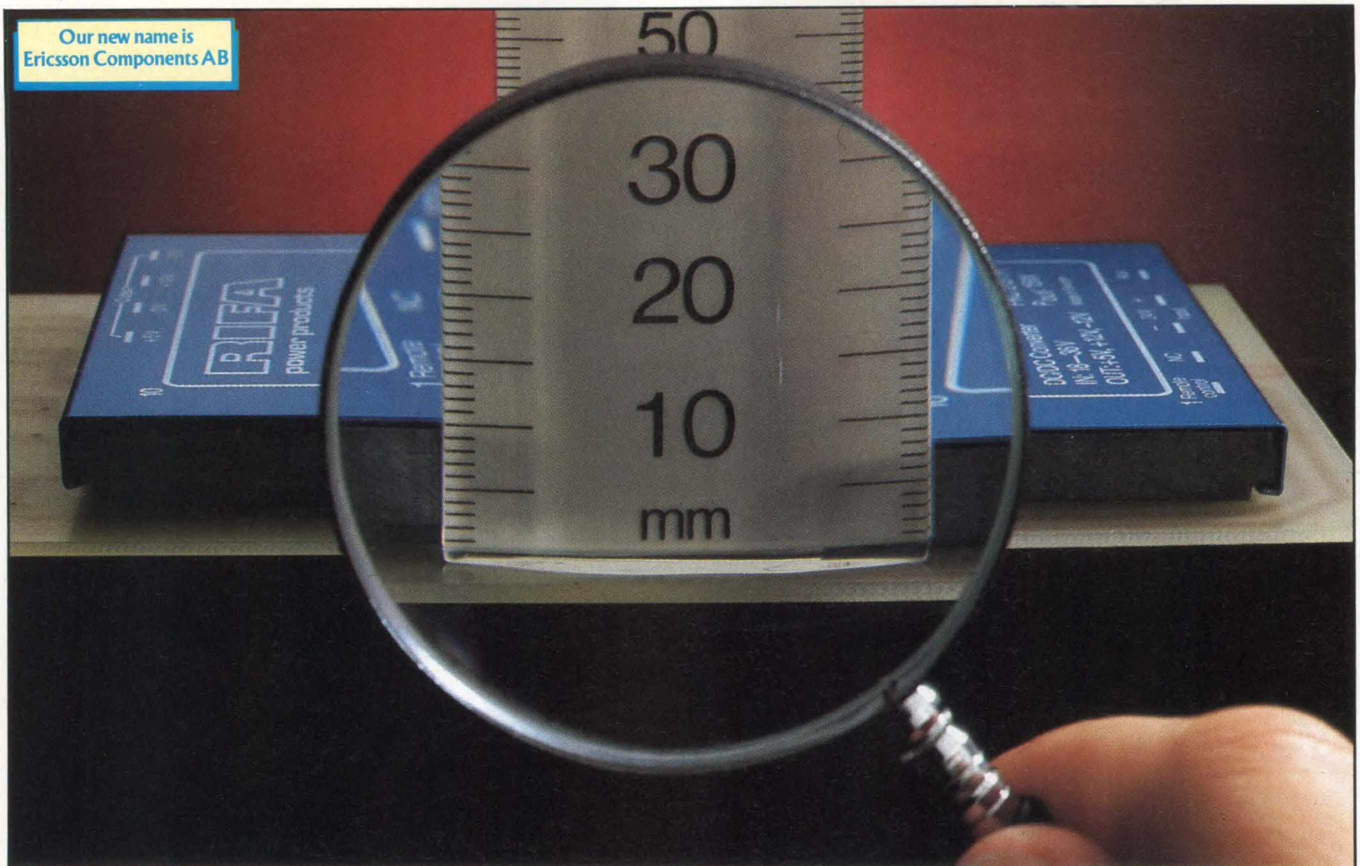

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Ericsson's new triple output, 15 Watt DC/DC converter is only 8·5mm high with In-Card™ mounting!

When you need high performance and a low profile in a DC/DC converter, Ericsson's new 15W PKC series has the answer.

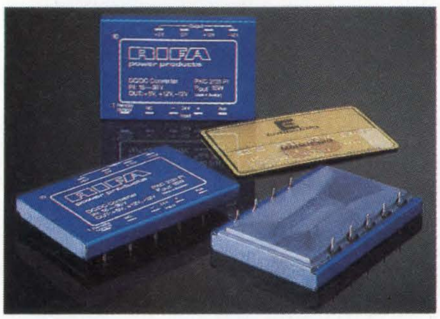
The PKC's advanced mechanical design offers two mounting options, Using conventional "On-Card" pcb mounting results in a height of 0·42" (10·7mm).

Where profile is critical our In-Card™ mounting provides the unique capability of recessing the supply into the pcb providing a height of 0·33" (8·5mm)!

Allowing inputs of 24V (18-36V) and 48V (36-72V) the PKC series provides 5, 12 and 15V dc outputs in single, dual and triple output configurations. A high reliability magnetic feed back loop ensures that all outputs are regulated to within 2·5%. Each model is fully isolated to 500V dc and all outputs are overvoltage protected.

Advanced technology, including the use of highly automated surface mount manufacturing and 300kHz switching frequency results in the PKC's exceptional MTBF of over 200 years.

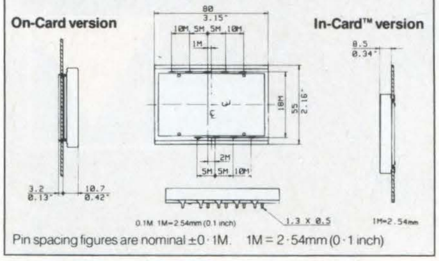
SMD components are assembled onto a thick film ceramic substrate to give excellent thermal characteristics. As a result, efficiency is 85% and the unit operates without derating over the temperature range of −45°C to +85°C!



The PKC takes up no more pcb space than a credit card.

Choose from On-Card or In-Card™ mounting.

Dimensions (Given as maximum values in mm unless otherwise stated)



Pin spacing figures are nominal ±0·1M. 1M = 2·54mm (0·1 inch)

No extra components, filters or heatsinks are required to meet VDE, FCC or CISPR regulations with respect to RFI specifications or high temperature environments.

Paralleling units for higher output requirements or redundancy configurations is easily accomplished by a simple connection.

To find out more about the world's most advanced 15W DC/DC converter, contact Ericsson today.

ERICSSON

RIFA Inc.
PO Box 853904, RICHARDSON,
TEXAS 75085-3904 USA
Tel: 214 480-8300 Fax: 214 680-1059
Telex: 735389 ERICS RCHN

Ericsson Components AB
Power Products, S-16481 KISTA-STOCKHOLM,
SWEDEN
Tel: +46 8 757 5000 Fax: +46 8 757 48 84
Telex: 109 48 POWERI S

CIRCLE NO 115

COMPUTER PRODUCTS
POWER CONVERSION

POWER Briefs

COMPACT 250 & 400 WATT SWITCHERS FEATURE FOUR-OUTPUT PARALLELING

The PPM and PFS Series 250 and 400 Watt cased switchers incorporate a unique closed-loop current sharing control circuit which permits simultaneous paralleling of up to four outputs, each with remote sensing. In addition, a single-point failure protection circuit assures that a single failure in a redundant power system will not cause the power bus to fail.

The series can provide as many as seven outputs.

Low profile cases only 5" wide by 2.75" high permit convenient stacking of the supplies. Power density is up to 2.4 Watts per cubic inch, and all models are efficiently cooled by a miniature internal ball bearing DC fan.

These switchers employ a bridge-driven forward converter using 100kHz MOSFET switching. The auxiliary outputs have either linear or magnetic amplifier regulation and are incorporated in three plug-in modules. Control circuitry is fabricated on a single circuit board using surface-mount technology. Standard features include switch selectable 115/230 VAC input, input line filter, remote on/off, power good signal, remote sensing, thermal protection with warning signal, overload protection, overvoltage protection, soft start and inrush current limiting. Optional features include current sharing, OVP crowbar and DC OK signal on main output, current monitor signal and others.

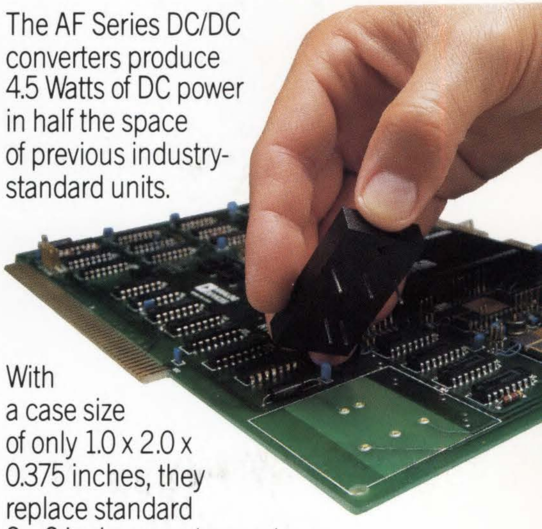
There are 25 stocked standard models in the 250W and 400W series. The models are UL recognized, CSA certified, and TUV approved.

Key Specifications:

Line Regulation	0.2%
Load Regulation	0.2%
Holdup Time	30 msec. min.
Efficiency	70 to 85%
Oper. Temp. Range	0° to 65°C

From Computer Products/Power Products **Circle No. 1**

NEW 4.5 WATT DC/DCs NEED ONLY HALF THE SPACE



The AF Series DC/DC converters produce 4.5 Watts of DC power in half the space of previous industry-standard units.

With a case size of only 1.0 x 2.0 x 0.375 inches, they replace standard 2 x 2 inch converters, yet have the same pinouts.

This series is fabricated with surface-mounted components on a miniature thick-film substrate to achieve 6 watts per cubic inch power density and efficiencies up to 66%. Available in single (+5, +12 or +15V) and dual (±12V or ±15V) outputs, the input voltage can be either +5 or +12VDC

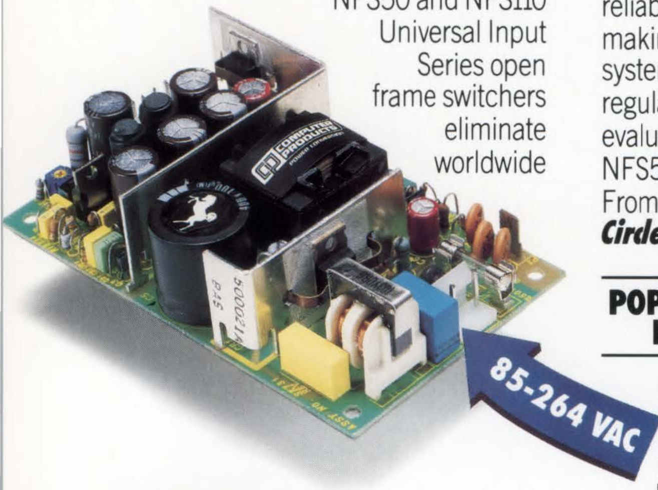
Other key specifications include ±1.0% line regulation, 0.5% load regulation, and 40mV p-p ripple and noise. These converters are ideal for board-mounted applications in computers, I/O boards, telecommunications, process control and scientific instruments. The AF Series is on distributor shelves now.

From Computer Products/ Stevens-Arnold
Circle No. 2

Your Partner in Power

UNIVERSAL INPUT SWITCHERS OPERATE FROM 85 TO 264 VAC

Operate from any line voltage from 85 to 264 VAC without changing jumper wires or switches. Computer Products/Boschert's new NFS40, NFS50 and NFS110 Universal Input Series open frame switchers eliminate worldwide line voltage selection problems and offer system design flexibility.



On the low end, the NFS40 series of single and multiple output 40 watt switchers measures a tiny 5" x 3" x 1.2". These switchers provide more than 2.2 watts/cubic inch, and will fit into very small spaces.

The NFS50-7608 50 watt switcher directly replaces the industry standard 6.3" x 3.9" 40 watt unit. No need to mechanically redesign. Just drop it in and enjoy the benefits of universal input, plus 10 additional watts for any system extras.

For small to medium systems, check out the NFS110 series 110 watt switchers. The +12V output will deliver up to 9 amps to start disk drives. The small 7.0" x 4.25" x 1.8" size delivers more than 2.0 watts per cubic inch.

All of these switchers will operate reliably with no load on the output, making them ideal for expansion systems. Also, each output is fully regulated. NFS40 and NFS110 evaluation units are now available. NFS50 is in distribution.

From Computer Products/Boschert
Circle No. 3

POPULAR DC/DC CONVERTERS HAVE NEW LOW PRICES

Design in high performance and reliable operation at new low prices. The ES, EA and H series have filled a lot of PC boards to date but never so economically. Prices have been reduced by 10% for the ES series and 15% for the H and EA series. Also, the H and EA series are available in new 1.0 x 2.0 x 0.38 inch non-conductive packages. Check the table below and send for the latest data on our top performers. Or better yet, call your distributor for these low cost solutions.

Series	Output Power	Output Type	Input Voltage	Output
H	1 Watt	Single	5, 24, 48V	±5V @ 200mA
EA	1.8 Watts	Dual	5V	±12 or ±15V @ 60mA
ES	15 Watts	Triple	12, 24, 48V	+5V & ±12V +5V & ±15V or ±5V & +12V

From Computer Products/Stevens-Arnold
Circle No. 4

TAKING THE RISK OUT OF CUSTOM OPEN FRAME SWITCHERS

Computer Products/Boschert can take the risk out of custom switcher development. You get a predictable, highly reliable switcher, based on our well-known standard circuits.

Here's why:

Field-Proven Building Blocks. The quickest, least expensive way to build a custom switcher is using existing circuits. Computer Products/Boschert has hundreds of building blocks, field proven over our 15 year history. We understand their use and limitations. Your custom design is predictable, economical and virtually risk-free.

Appropriate Topology. Using the wrong topology is either costly or unreliable. Since we understand and build virtually every type of switcher, there is no need to squeeze your custom needs into our favorite topology. You get the correct topology for your power requirement.

Experience. Your supply is built by a company exclusively dedicated to switchers for 15 years. Our ability to integrate electrical, mechanical and thermal designs is exceptional. Our new medium power designs deliver more than 2 watts/cubic inch. The result is a highly compact switcher that meets or exceeds your system requirements.

Safety Approval. UL and CSA usually take no more than eight weeks. Full VDE certification usually takes only 12 to 16 weeks after your final prototype approval. TUV approval is also available.

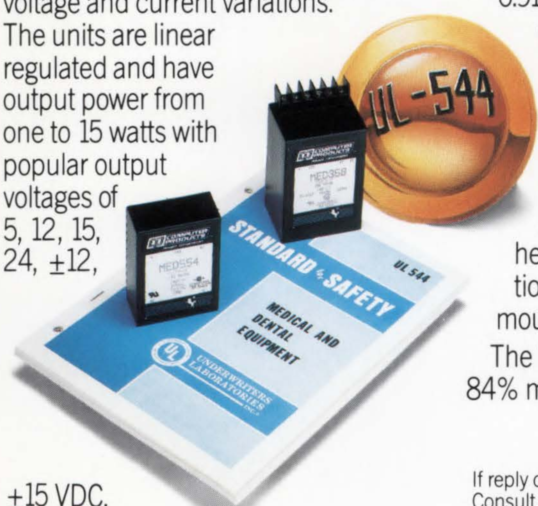
Manufacturability. Every supply we make is designed with manufacturability in mind. We use a common parts base, with well characterized components that meet our conservative stress derating guidelines. Check for further information on custom switchers.

From Computer Products/Boschert
Circle No. 5

LINEAR POWER MODULES MEET UL544 MEDICAL REQUIREMENTS

For UL544 approval you can rely on Computer Products/Power Products new MED 300/500 Series of AC/DC encapsulated power modules. They meet or exceed the stringent UL544 requirements for medical equipment. These supplies are recommended for use in non-patient contact medical, dental and laboratory applications where high isolation and low leakage are critical.

The MED 300/500 series is provided in single, dual and triple output models offering 63 different output voltage and current variations. The units are linear regulated and have output power from one to 15 watts with popular output voltages of 5, 12, 15, 24, ±12,



±15 VDC, plus others available. Standard protection features such as overtemperature, overload and short circuit protection are included.

The power modules incorporate a split-bobbin wound transformer which provides high isolation between primary and secondary with low coupling capacitance. This results in 2500 VAC isolation voltage and less than 10uA leakage current.

The units are available in either printed circuit mountable or chassis mountable packages. In addition to UL544 approval the series is CSA certified.

From Computer Products/ Power Products ***Circle No. 6***

100 WATT DC/DC CONVERTERS HAVE LOW PROFILES, HIGH EFFICIENCIES

Designed primarily for telecom and computer applications, the new WS Series from Computer Products/ Stevens-Arnold offers 100 watts with single, dual, and triple outputs. The converters are packaged in a low profile case (3.5 x 5.5 x 0.91 inches) producing a power density of 5.7 watts per cubic inch. Available in chassis mount with screw terminations or printed circuit board mounting. The PCB mount version is supplied with a heat sink (adds 0.35 inches to height) which allow for conventional cooling with *no* special mounting required.

The WS Series has an efficiency of 84% minimum and a 2:1 input range of either 18 to 36 VDC or 36 to 72 VDC Output ranges supplied are single (+5, +12 or +15V), dual (+5 and +12V), or triple (+5 and ±12V, +5 and ±15V).

Other important features include 500 VDC isolation, input surge protection, reverse voltage protection and remote on/off control with idle currents down to 10mA.

Key Specifications:

Line Regulation ...... ±0.5% max.
Load Regulation .. 2.0% (to no load)
Ripple and Noise .. 100mV p-p max.

This series is available through distribution.

From Computer Products/Stevens-Arnold
Circle No. 7

If reply card is missing, please circle reader service number.
Consult 1987/88 EEM, page 643 for local sales office or call (305) 974-5500, Ext. 7514.

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POSTAGE WILL BE PAID BY ADDRESSEE

COMPUTER PRODUCTS®
POWER CONVERSION

2900 GATEWAY DRIVE
POMPANO BEACH, FL 33069-9944

POWER Briefs No.1

UP TO 591,000 HOURS MTBF WITH OPEN FRAME LINEARS

Step up to higher standards of reliabilty with the World-Standard Series of open frame linears.

The aluminum frames and power ratings of the World-Standard Series are form, fit, and function replacements for all other open frame linear power supply manufacturers.

TYPICAL CALCULATED MTBFs

Output Voltage[1]	Output Current	MTBF[2]
5V	3.0A	**591,533** hrs
12V	6.8A	**417,240** hrs
15V	6.0A	**420,943** hrs
24V	4.8A	**328,798** hrs
5V/±12V	3A/±1.0A	**261,201** hrs

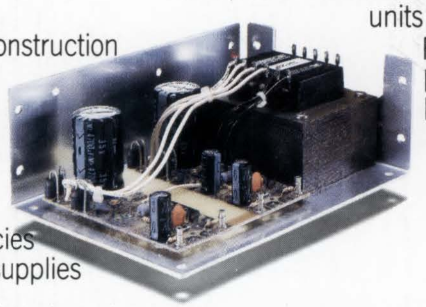
[1] Consult factory for additional models.

[2] Calculations per MIL-HDBK-217E @ 100% load; 115 VAC line; 25° C ambient temperature; ground, benign

With four different AC input line voltage ranges, these supplies can be connected for use in any country of the world.

These units have a VDE construction power transformer with enclosed split- bobbin windings and 3750 VAC minimum isolation.

The designs are conservative with efficiencies up to 60% and all power supplies receive a four-hour burn-in before shipment.



Other features include current-limiting short circuit protection on all outputs, overvoltage crowbar on 5V outputs, remote sensing on single outputs and the 5V output of triples, reverse voltage protection on all outputs, and operation from 0°C to 50°C with no derating. The World-Standard Series (PL Series) are UL recognized, CSA certified, and TUV approved.

Custom versions of this series are also available with outputs from 2 to 32VDC and output power levels of 15 to 150 watts. Your local Computer Products distributor has units available now.

From Computer Products/Power Products

Circle No. 8

MIL-SPEC POWER SUPPLIES FOR RUGGED ENVIRONMENTS

From missiles to submarines Computer Products/ Tecnetics has been solving Mil-Spec problems for over thirty years.

Specialists in Mil-Spec AC/DC power supplies and DC/DC converters, Computer Products/ Tecnetics has participated in many major military programs including F-16, Tomahawk, EA-6B, MSE and E2-C.

From state-of-the-art topologies to advanced package design, every attention is paid to cost-effective custom designs for demanding environmental requirements. Let us modify an existing standard product or develop a totally new design to meet your system specifications. We are certified to manufacture to Mil-Q-9858A and conform to the guidelines of NAVMAT P4855-1.

Send for you free copy of our Mil-Spec Power Supply catalog.

From Computer Products/ Tecnetics ***Circle No. 9***

If reply card is missing, please circle reader service number.
Consult 1987/88 EEM, page 643 for local sales office or call (305) 974-5500, Ext. 7514.

FREE!

Send for your free copy of our Power Supply Engineering Handbook providing specificaions for our complete line of power supplies with power ranges from 1/2 Watt to 1500 Watts.

Circle No. 10

QUICK ACTION REPLY CARD

PLEASE SEND:

1. PPM/PFS Series
2. AF Series
3. NFS 40/50/110 Series
4. ES/EA/H Series
5. Custom Switchers
6. MED Series
7. WS Series
8. World-Standard Series
9. Mil-Spec Catalog
10. Engineering Handbook
11. Have an Applications Engineer Call
12. Have a Sales Person Call

Name ______________________ Title __________

Company ______________________ Dept/MS __________

Street ______________________

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COMPUTER PRODUCTS®
POWER CONVERSION

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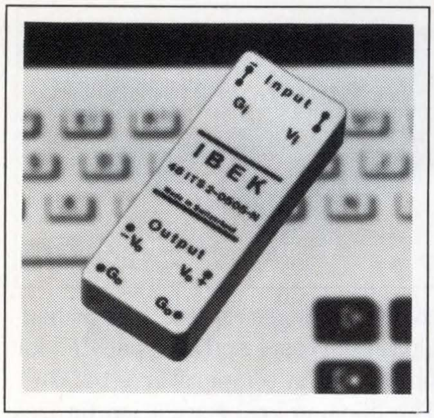
Your Partner in Power



DC/DC CONVERTERS

Housed in a 1×2×0.4-in. package, ITS Series isolated 2W dc/dc converters accommodate input voltages of 18 to 70V dc to cover 24, 36, 48, and 60V batteries or to compensate for long input-line drops in telecommunications applications. The converters are available with single or dual outputs of 5, 12, or 15V.

Each converter features a 500V isolation spec, protection against continuous short circuits and output overvoltage, and a typical efficiency of 80%. An integral input π filter suppresses all noise from the source —RFI input current measures a low 30 mA p-p.

Full power is available over a −25 to +71°C ambient range (−25 to +91°C case). Each unit features a shutdown pin for remote control of the output. $68.50 (100). Delivery, stock to eight weeks ARO.

Melcher Inc, 10 Cochituate St, Natick, MA 01760. Phone (617) 653-9979. TWX 510-100-3830.

Circle No 712

DC/DC CONVERTERS

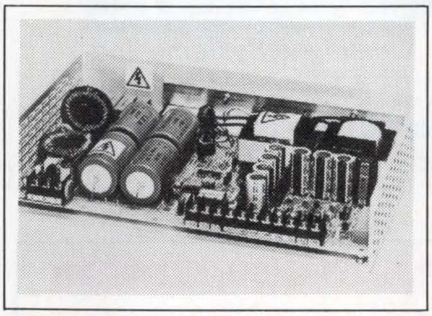
The vendor offers WS Series 100W dc/dc converters in chassis-mount and pc-board versions. Housed in a 3.5×5.5×0.91-in. case, they feature a 5.7 W/in.^{3} power density.

The converters accommodate input voltages of 18 to 36V and 36 to 72V dc. They come with a 5, 12, or 15V output; 5 and 12V dual output; and 5 and ±12 or ±15V triple output. All models spec 82% efficiency min.

The key features include ±0.5% max line regulation and 1% load regulation on the primary outputs for a full to 0.25% load change and 2% load change from full to no load. The ripple and noise measures, for a 20-MHz bandwidth, are 75 mV p-p. The devices also provide input surge, output short-circuit, and overvoltage protection. They also offer remote sensing on the primary outputs and remote on/off control. $260 to $295.

Computer Products Inc, Power Conversion Group, 2900 Gateway Dr, Pompano Beach, FL 33069. Phone (305) 974-5500. TWX 510-956-3098.

Circle No 714



SWITCHING SUPPLY

The F350 single-output switching power supply provides 350W of continuous power at 82% typ efficiency. In order to satisfy the needs of drives, printers, and other peripherals that have high peak-power demands, the supply features as much as 450W.

The supply provides 5V at 70A, 12/15V at 30A, 24/30V at 15A, or 48/60V at 7.5A output. The selectable inputs are 95 to 132, 180 to 264, or 250 to 370V ac.

Some of its features include ±0.02% line regulation for 5V models and ±0.05% for other versions. Load regulation, for a 10 to 100% load change, ranges from ±1 to ±4%. Overcurrent, overvoltage, thermal protection, and a power-fail indication are standard. The supply's conducted RFI is specified with VDE0871 Curve A. You can also obtain a version of the device that provides Curve B. $343 (500).

Powerline Inc, 10 Cochituate St, Natick, MA 01760. Phone (617) 655-7987. TWX 510-100-3630.

Circle No 715

LITHIUM BATTERIES

Units in the CSC line of lithium power cells feature no voltage delay and are suited for applications requiring immediate power on demand. With an open-circuit voltage of 3.395V, the cells provide an operating range of −32 to +93°C. Their capacity ranges from 0.75A/hour for the ½ AA size to 30A/hour for the DD size.

The cells have a 304L stainless-steel case and a header assembly that features a glass-to-metal hermetic seal for high reliability and safety. You can order the batteries in custom versions that configure the cells in series or in series-parallel to provide the energy density necessary to satisfy a range of applications. Some of the options are internal fusing, protection circuitry, and insulation. $14.95 to $42.50 (100).

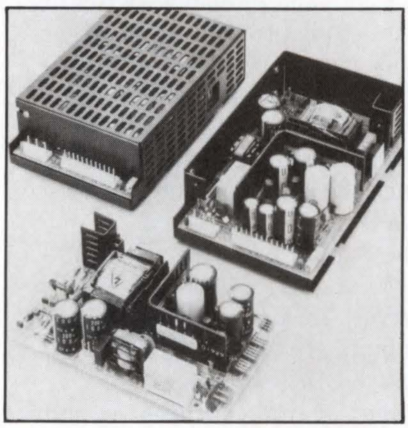
Electrochem Industries, 10000 Wehrle Dr, Clarence, NY 14031. Phone (716) 759-2828. TLX 91386.

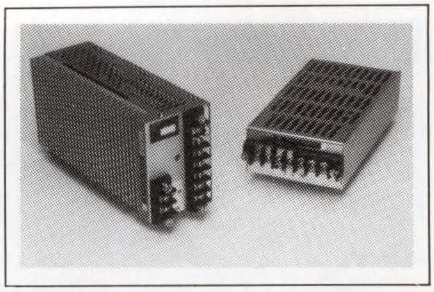
Circle No 713

DC/DC CONVERTERS

Available in chassis-mount packages, DCE and DCF Series dc/dc converters output 100 and 150W, respectively. Their efficiency ranges to 90%.

You can order units that provide outputs of 5, 12, 15, 24, and 48V dc from nominal inputs of 12, 24, 48, and 110V dc. These convection-





cooled units are housed in brushed-aluminum cases and are specified for full output at temperatures to 50°C. The line and load regulation figures spec at 0.8 and 0.9%, respectively.

All models feature adjustable outputs —±10%, input filter, overvoltage protection, and short-circuit protection. Also, remote-sense and disable features are standard. DCE Series, $219; DCF Series, $319. Delivery, stock to eight weeks ARO.

International Power Sources Inc, 10 Cochituate St, Natick, MA 01760. Phone (617) 651-1818. TWX 510-100-3630.

Circle No 716

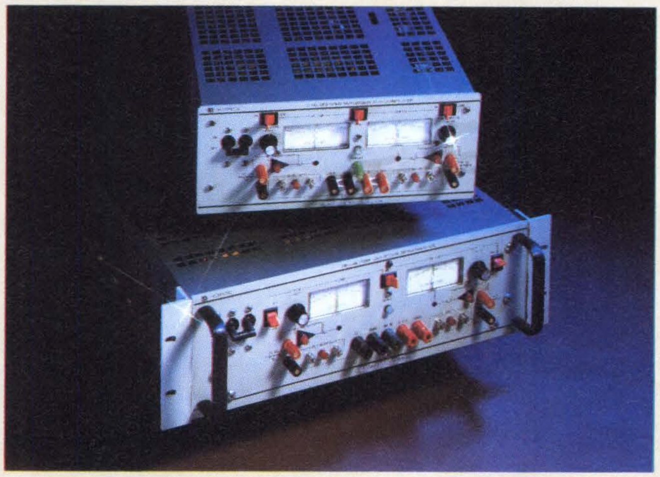
SUPPLIES

The MK line of 75W high-voltage dc modules features two models with outputs that range from 0 to 3 kV at 0 to 25 mA, to 0 to 60 kV at 0 to 1.2 mA. These air-insulated units are housed in a package that measures 5³⁄₁₆×4¾×11 in.

Using a circuit, you can monitor true current accurately, 1% of reading plus 0.05% of rated current, with respect to ground without breaking the common-ground connection. The laboratory-grade fea-

The only power supplies that: source and sink power in both directions; produce stabilized voltage or current, positive or negative, a-c or d-c; and get on the bus without fuss...

Kepco BOP Power Managers™ now have dazzling new speed!

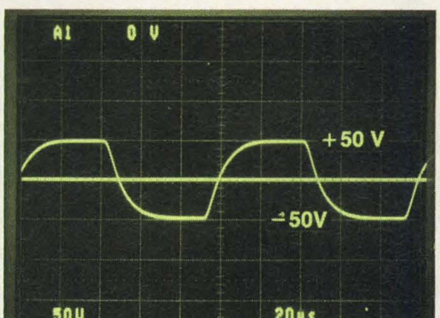


Two groups of BOP Power Managers are available: ¾-rack 100- and 200-Watt models (top), and full-rack 400-Watt models.

For years, now, people who have wanted a voltage that was equally agile above zero, below zero, and above *and* below zero, have counted on Kepco BOP (bipolar) Power Managers.

There's just nothing else like a BOP. Nothing else that can jump from, say, *plus* 100V to *minus* 100V, or from *minus* 20 Amps to *plus* 20 Amps in microseconds, passing through zero without a glitch. There's also nothing else that can produce rock-steady positive *or* negative voltages in the face of wildly fluctuating current—or vice versa. There's certainly nothing else that can operate not only as a source, but also as a sink, i.e., absorb 100% of its rated voltage or current when its voltage polarity and current direction are out of phase, or when its *load* suddenly turns around and becomes a *source*.

On top of all that, the BOPs have *also* been pretty fast performers. Their bandwidths have ranged from 1.8 to 4.5KHz, their slewing rates from 1 to 2V/μsec. Our model BOP 100-2M, for example, had a bandwidth of 3KHz in both the voltage and the current mode, and could jump from −100V to +100V in 100μsec.



Reproduction of a 10KHz square wave by a Kepco bipolar Power Manager Model BOP 50-2M, which actually has a 20KHz bandwidth in the voltage mode.

Well, now Kepco has improved the BOP. That same model can now make that same leap in 20μsec—a fivefold gain, and its bandwidth is 22KHz in the voltage mode, 15KHz in the current mode.

Furthermore Kepco has been able to speed up the BOPs without sacrificing stability—or anything else. They still do all the wonderful things they've always done. They just do it faster.

Incidentally, acquiring dazzling new speed isn't the only thing that's been happening to the BOP series. It's also acquired a new model, the ±200V, ±1 Amp BOP 200-1M. Also, models BOP 500M (±500V/80mA) and BOP 1000M (±1000V/40mA) have had their noise levels significantly improved. Maximum p-p noise on the BOP 500M *was* 500mV, *is now* 100mV. The total range of the BOP 500M is 1000 Volts—from *minus* 500V to *plus* 500V and 100mV noise in a 1000V p-p signal is 100 ppm. That's an 80dB signal-to-noise ratio!

BOP can interface with the IEEE-488 bus using a selection of external controllers, or an optional built-in interface card.

To find out more, call or write Dept. JYF-12.

KEPCO®
THE POWER SUPPLIER™

KEPCO, INC. • 131-38 SANFORD AVENUE • FLUSHING, NY 11352 USA • (718) 461-7000 • TWX #710-582-2631 • FAX: (718) 767-1102

CIRCLE NO 119

Plug-in power for VME!

Here's a fully featured 400-watt, triple-output power system that's configured for *direct connection* to the motherboard in your VME bus system. It's a standard MOSFET switcher that includes all the features you've come to expect from NCR Power Systems.

Switching frequency is 80 kHz, and the unit has protection against overvoltage, overcurrent, and input surges. It meets the stringent safety and EMI requirements established by UL, CSA and TUV (VDE). Packaging complies with the Eurocard standards defined in DIN-41494 and IEC-297 for plug-in attachment to the motherboard. Precise (±0.4%) line and load regulation and 75% efficiency make the unit ideal for data communications and processing applications.

Standard units can be modified by NCR for precise conformance to customer requirements.

For detailed specifications and price quotation, contact NCR Power Systems, 3200 Lake Emma Road, Lake Mary, FL 32746-3393; Telephone 800/327-7612 or in Florida, call 407/323-9250.

NCR

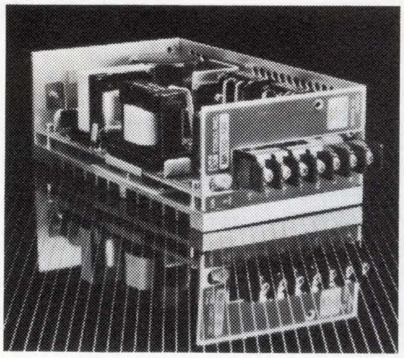
CIRCLE NO 120

tures include a voltage regulation of better than 0.005% for line and load, 0.05% max current regulation from short circuit to rated voltage, and a ripple of less than 0.03% rms at rated voltage for a full load.

You also get TTL enable/disable capability, interlock capacity, a 10V reference source, constant-current/constant-voltage operation, voltage and current monitoring and programming, and a shielded output cable. From $850.

Glassman High Voltage Inc, Box 551, Whitehouse Station, NJ 08889. Phone (201) 534-9007. TWX 710-480-2839.

Circle No 717



150W SUPPLY

MK-150 Series 150W switching power supplies provide a 2.45W/in.^{3} power density and efficiencies ranging from 77 to 84%, depending on output voltage.

The supplies have outputs of 5, 12, 15, and 24V. The input voltage is either 85 to 132V ac or 110 to 175V dc. The total regulation equals ±3%. The switching frequency is 250 kHz.

These convection-cooled units operate over a 0 to 60°C range. They use 105°C electrolytic capacitors to ensure reliability. Other components are derated by 20% to provide an added safety margin.

All supplies feature overcurrent and overvoltage protection and are available in open- or closed-frame designs. A 5V open-frame model, $188.

Toko America Inc, 1250 Feehan-

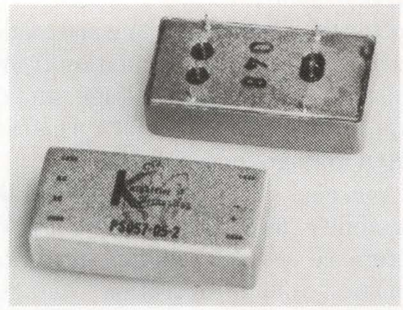
ville Dr, Mount Prospect, IL 60056. Phone (312) 297-0070. TLX 724372.

Circle No 718

AC/DC SUPPLIES

Although they measure 1.5×0.75×0.375 in., these miniature PS Series ac/dc supplies are suited for pc-board mounting. Input voltage capabilities of 90 to 264V ac lift the units to worldwide requirements.

The single-output power modules are available in 5, 12, and 15V models. The current capabilities are 150, 65, and 50 mA, respectively. The line regulation equals 0.05% for all versions; the load regulation is 0.8% for the 5V versions and 0.5% for 12 and 15V models.



The supplies' metal cases provide 6-sided shielding. The operating range, with no derating, spans −25 to +70°C. $39.50 to $43.50 (100).

Knightfire Technology, Box 8761, Coral Gables, FL 33075. Phone (305) 344-3682.

Circle No 719

HV SUPPLIES

The PS310, PS325, and PS350 provide 1.25, 2.5, and 5 kV, respectively, with 25W of output power. Their voltage regulation equals 0.001% for a ±10% line-voltage change, and their ripple is less than 0.002% of FS.

The units have two 4-digit displays that give continuous readout of current and voltage. A third readout displays the parameter being entered. You can set hard and soft current limits, and output voltages to 1V resolution.

Arc and short-circuit protection are standard. The devices feature connectors for remote voltage setting/ramping, and for current and voltage monitoring. The supplies will store and recall as many as 10 instrument settings. An optional GPIB port allows you to program input settings, and read output and

instrument settings. $995.

Stanford Research Systems Inc, 1290D Reamwood Ave, Sunnyvale, CA 94089. Phone (408) 744-9040. TLX 706891.

Circle No 720

DC/DC CONVERTERS

NWD Series 15W dual-output dc/dc converters have no min load requirements. The converters use current mode-control topology to accommodate inputs with 2:1 voltage ratios—9 to 18, 18 to 36, and 36 to 72V.

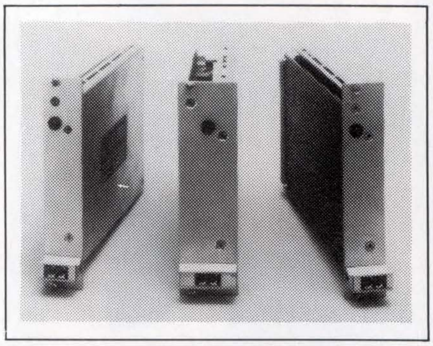
The modules operate at 100 kHz and provide efficiencies of 80 to 83%. Each features remote on/off capability and an LC input filter. Outputs of 5/12V, 12/12V, and 12/15V are available. Their line and load regulations are 1%. All units will withstand long-term output short-circuit conditions.

They offer voltage accuracy of better than 2%. For a 20-MHz bandwidth, the ripple and noise equal 100 mV p-p. And for a 50% load change, the transient response is less than 500 μsec. The temperature coefficient measures ±0.02%/°C.

The converters are encapsulated in 6-sided metal cases to eliminate noise radiation. $111. Delivery, stock to six weeks ARO.

International Power Devices Inc, 155 North Beacon St, Brighton, MA 02135. Phone (617) 782-3331. TLX 989752.

Circle No 721



DC/DC CONVERTERS

VMEC Series dc/dc converters are designed for VME Bus applications. They come in 40 and 80W versions. Both are housed in 3U-high packages that are 1 and 1.4-in. wide, respectively.

Models are available with single and dual outputs ranging from 2 to 48V dc. The temperature coefficient measures 0.02%/°C, the switching frequency equals 125 kHz, and the ripple and noise spec at 1% or 50 mV, whichever is greater.

Their standard features include

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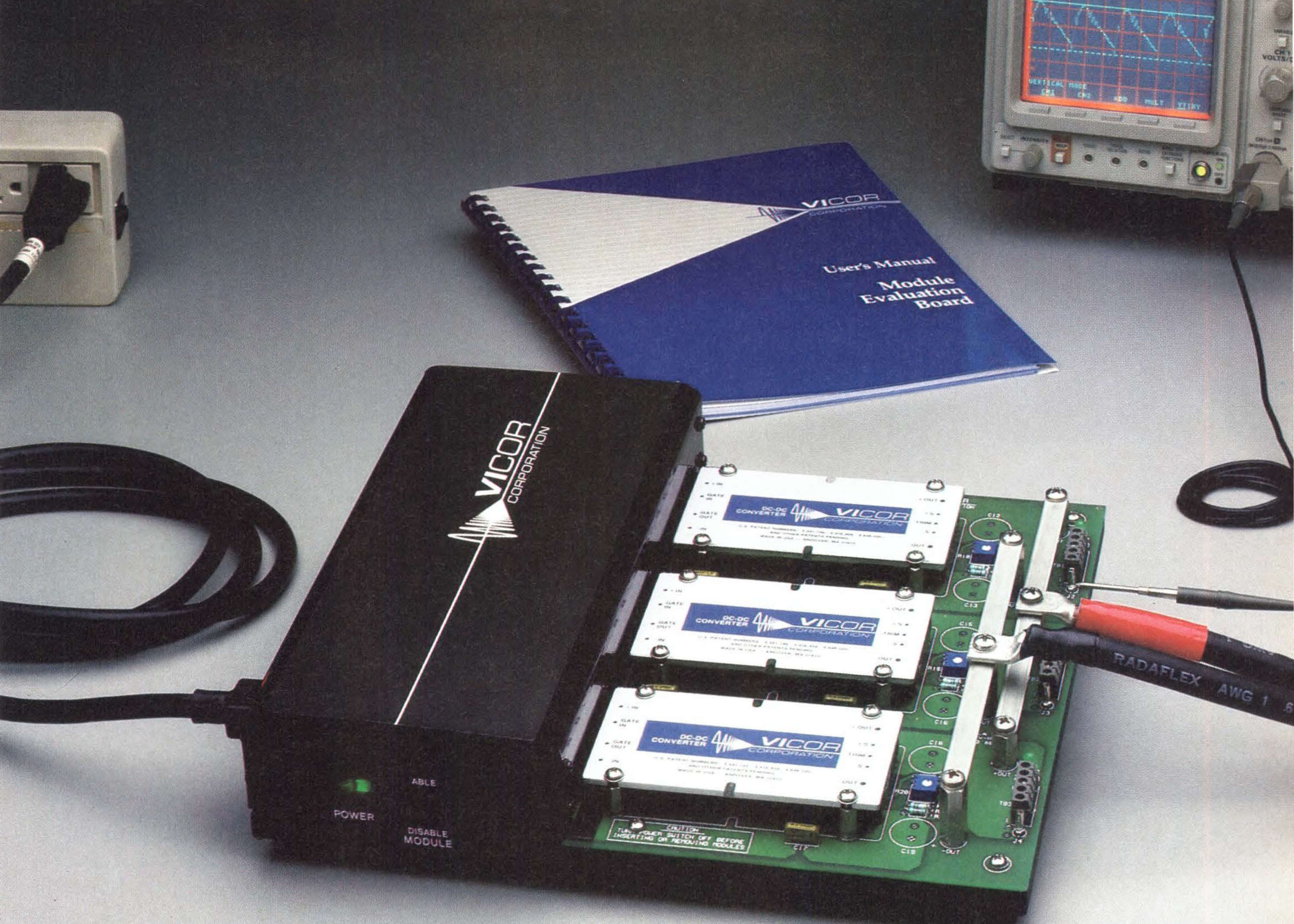

NEW AC INPUT / MODULE EVALUATION BOARD

Incorporating an on-board 750 watt AC front end, the VI-MEB-AC Module Evaluation Board is designed specifically for evaluation of Vicor converters in off-line applications. The front end features input surge protection, removable line cord, a visible power indicator, and provides easily accessible ON/OFF and 110/220 VAC range select switches.

Up to three 300 volt-input Vicor converters can be plugged into the assembly for evaluation of single, dual or triple output applications. Independent access to all converter interface pins allows for easy configuration of virtually any multiple-output or array application with a total power output of up to 600 watts. The 10.5" x 12" assembly comes complete with module sockets, strappable heavy-duty output lugs, output measurement jacks, and provisions for accessing the Gate, trim and sense connections on each converter. Module inputs are individually fused and on-board sockets are provided for adding Vicor Phased Array controllers. A detailed user's manual is provided which covers measurement techniques and useful applications information.

Vicor's "component level" megahertz converters allow power systems designers to focus on system solutions instead of circuit details. The benefits: fast, predictable design cycles; predictable field performance; and smaller, simpler, high reliability power assemblies with significantly reduced component count.

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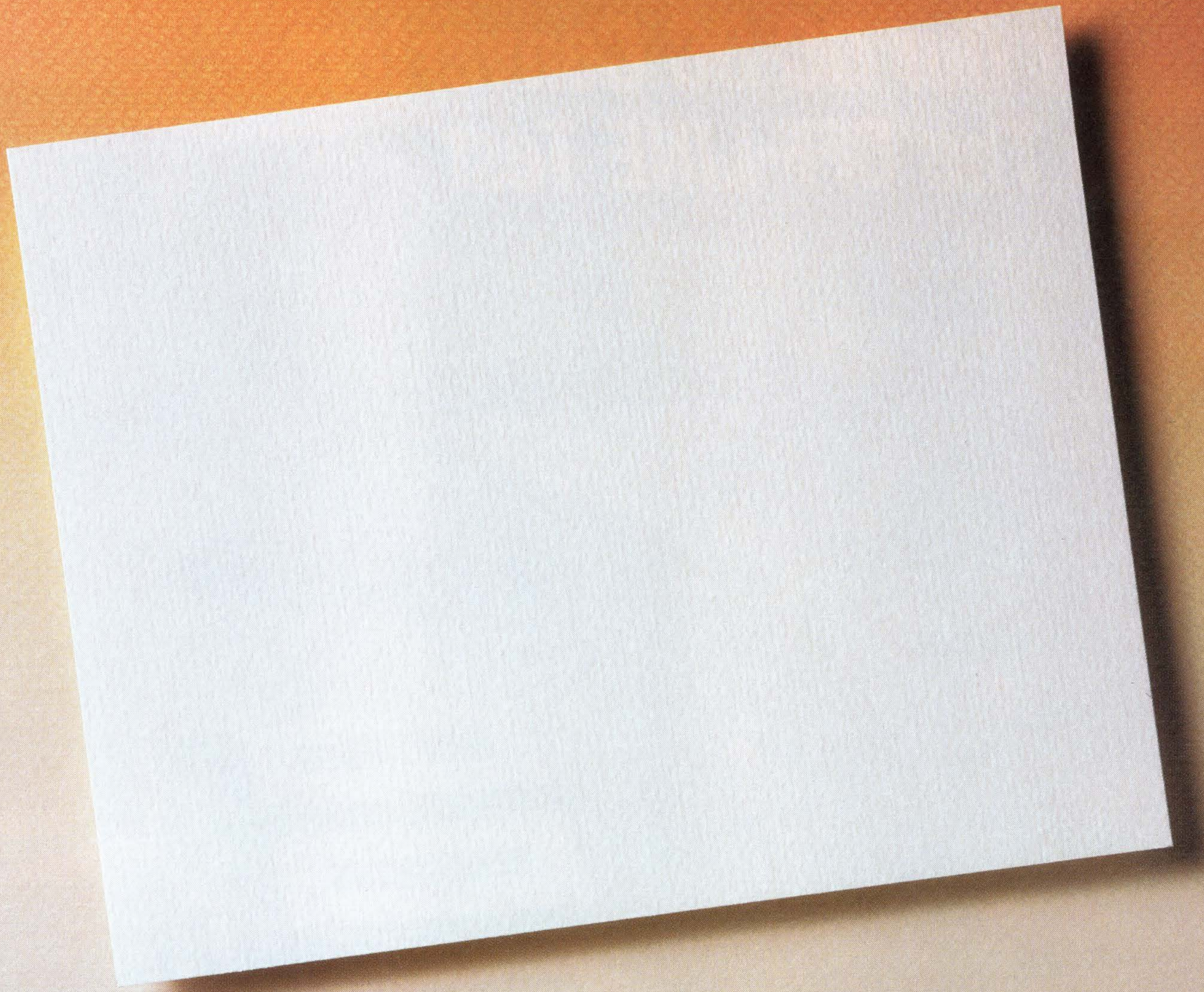


isolated outputs, EMI filtering, remote sensing, and overvoltage and overload protection. The line regulation equals ±0.1%, and the load regulation equals ±0.2%. 40W version, $127; 80W version, $169.

Power Pac Inc, Box 777, Norwalk, CT 06856. Phone (203) 866-4484.

Circle No 722

DC/DC CONVERTER

The PWS726 dc/dc converter features an oscillator, a driver circuit, dc switches, a transformer, internal filter capacitors, and a rectifier housed in a 32-pin DIP. It supplies ±7 to ±18V dc outputs at ±40 mA.

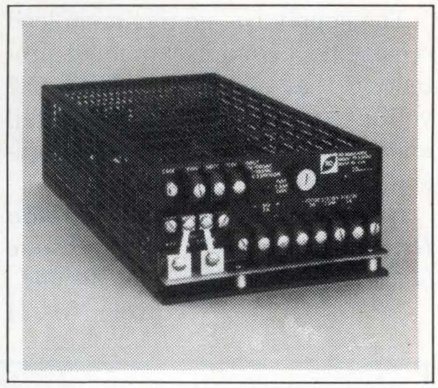
The galvanic input/output isolation is 100% tested at 800V dc and guaranteed to 2500V rms continuous, 3500V rms momentary. Other features include a 1.2 μA leakage current and a 9-pF leakage capacitance. A separate synchronous connection lets you frequency-synchronize as many as eight converters, while an enable input provides flexible control over outputs for power conversion and sequencing.

In order to protect the switches and prevent high-inrush current during the turn-on stage, a soft start/driver design ensures that the oscillator is fully operational before either MOSFET driver turns on. Input current sensing protects both the converter and the load from thermal damage by limiting the output fault currents. $27.70 (100).

Burr-Brown Corp, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TWX 910-952-1111.

Circle No 723

POWER SUPPLY



The quad-output Model 524EU power supply employs a 50-kHz MOSFET design with independent magnetic amplifiers in the secondary windings. The supply outputs are 5V at 20A, 12V at 3A, −12V at 2A, and 24V at 2A (for disk-drive applications).

The secondary windings are adjustable to 15V at 2.5A and −15V at 1.5A. You can select input ranges of 105 to 130 or 198 to 265V ac. All outputs are current limited and have continuous overload, short-circuit, and overtemperature protection. Self-recovering overvoltage protection is provided on all outputs.

The supply has no minimum load requirements and has an input protection that meets the IEEE-587 voltage-transient test. Power-fail and logic-inhibit signals are available as options. From $395.

RO Associates Inc, 246 Caspian Dr, Sunnyvale, CA 94088. Phone (408) 744-1450. TWX 910-339-9304.

Circle No 724

DC/DC CONVERTERS

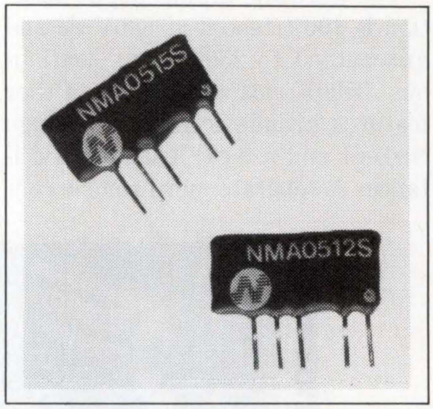
XC Series dc/dc converters accept input voltage between 24 and 72V dc and provide one of three outputs: 5V at 3A, 12V at 1.25A, or 15V at 1A. All three converters have an 80% min efficiency, even for 20% load levels.

Their key specifications include 0.2% line and load regulations, 30-mV output noise p-p, 500V dc isolation, and −25 to +80°C operating range. The internal circuitry supplies 8 hours min short-circuit protection, and an internal thermal-limit circuit shuts the converters when the case temperature exceeds the specified limit. They restart automatically when the temperature returns to normal.

Filter circuits provide conducted noise protection for input and output. A 6-sided shielded case minimizes RFI problems. $120.

Calex Mfg Co Inc, 3355 Vincent Rd, Pleasant Hill, CA 94523. Phone (415) 932-3911. TLX 338506.

Circle No 725



DC/DC CONVERTERS

Models in the NMA line of dc/dc converters accept inputs of 5, 12, 24, or 48V dc. The units provide an output of ±5, ±12, or ±15V with 750 mW of power.

The converters come in single in-line packages and in DIPs—both will deliver the full rated output. Their efficiency ranges to 80%. Over the operating range of −25 to +80°C, the converters require no heatsinking. With a 0.18-in.^{2} real estate requirement, the converters are adaptive to applications where space constraint is a factor.

The converters' isolation figure is 500V dc. Both the single in-line and DIP versions are encapusulated in epoxy and thereby meet UL 94V-0 requirements. $19.50. Delivery, stock to eight weeks ARO.

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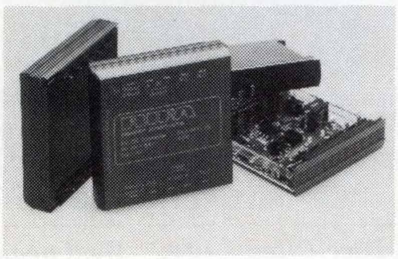


DC/DC CONVERTER

The PKA 4411 PIL isolated dc/dc converter provides a 5V/8A output from a pc-board-mount package that measures 3×3×0.78 in. Because the package extends only 0.78-in. above the pc board, you can mount the units on boards that have 6TE (1.2-in.) spacing.

The converter accepts dc input voltages ranging from 39 to 64V and has an input-to-output isolation to 500V dc. Its predicted MTBF, at an ambient temperature of 45°C, is more than 200 years. The converter operates from −45 to +65°C.

However, you can obtain the PKA-4411-PI model, which has an integral heat sink that extends the operating range to 85°C. This other version also has a 3×3-in. footprint, but it is 1.39 in. high. A chassis-mount version with fast-on terminals is also available. Approximately 811 Swedish Krona (100).

Rifa AB, Power Products Div, 16381 Stockholm, Sweden. Phone (8) 757-5000 TLX 10948.

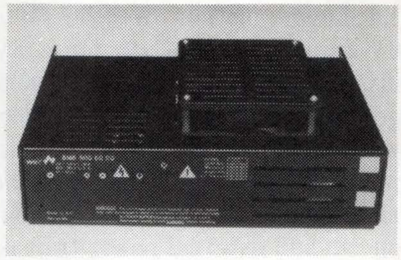
Circle No 727

Rifa Inc, Greenwich Office Park 3, Greenwich, CT 06836. Phone (203) 625-7300.

Circle No 728

POWER SUPPLIES

SMS600 Series single-output, fan-cooled, switch-mode power supplies provide a 600W output. They are available with nominal output voltages of 12, 15, 24, or 50V. The 12



and 15V outputs are provided by a single model, which employs a potentiometer for output selection. The 24 and 50V versions have a potentiometer, which gives you approximately ±10% control over the output voltage.

The line regulation is less than 0.25%, for a ±15% change in the input voltage, and the load regulation is better than 0.5%, for a 10 to 100% load change. At normal operating loads, the supplies have an 80% efficiency.

Some of the key features include remote output sensing, and signals that either indicate that the devices are fully operational or notify you that a power failure occurred in the output fan. The output is protected against overcurrent and overvoltage conditions. The supplies meet major safety and RFI standards. £275 (100).

Weir Electronics Ltd, Durban Rd, Bognor Regis, Sussex PO22 9RW, UK. Phone (0243) 865991. TLX 86543.

Circle No 729

Weir Inc, 418 3rd St, Annapolis, MD 21403. Phone (301) 268-0122.

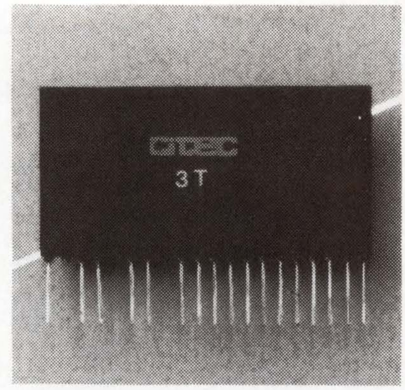
Circle No 730

DC/DC CONVERTER

By employing surface-mount technology on a ceramic substrate, the type 3T switch-mode dc/dc converter produces an output power of 50W from a pc-board mount single in-line package that measures 2.0×1.1×0.16 in. It can provide full output power over a 0 to 70 °C temperature range without additional heatsinking. You can program the converter with shorting links so that it produces an output voltage of

5, 12, 15, 18, or 24V. At 12V, it achieves an operating efficiency of around 94%.

The converter accepts a dc input voltage of between 11 and 40V; you can also configure the device so that it operates as an ac/dc converter. Zero to full-load output regulation is 0.5% for an output voltage of 5V and 1.0% for all other output voltages. The line regulation over the 11 to 40V input range is 1% for a 5V output and 2% for other output voltages. For ±10% input changes, however, the line regulation for all output voltages is only 0.2%. The maximum output current is 3A, but you can add external power transistors to provide greater output currents. £10 (100).



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

Circle No 738

CONVERTER

Ibek-48-ITS-2 Series 2W dc/dc converters feature 18 to 70V dc input. They are available with one or two outputs that provide 5, 12, or 15V and that feature an active-low inhibit input that turns all the outputs off. With the outputs inhibited, the converters draw a maximum input current of 2 mA. All the outputs are protected against continuous short circuits.

The converters achieve a typical operating efficiency of 80% and require no derating over their entire −25 to +71°C operating temperature range. They are housed in 10.5-mm-high DIL packages that are suitable for pc-board mounting. SFr 83 (100).

Melcher AG, Ackerstrasse 56, 8610 Uster, Switzerland. Phone (01) 9413737. TLX 828554.

Circle No 739

Melcher Inc, 10 Cochituate St, Natick, MA 01760. Phone (617) 653-9979. TLX 510-100-3630.

Circle No 740

SWITCH-MODE SUPPLY

RL150 Series power supplies deliver 150W of output power from a package that measures 8.4×2.4×4.6 in. All versions of the supply have a 5V main output that can deliver a maximum continuous current of 15A.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The secondary outputs are either ±12V and 12V, ±12V and 24V, ±12V and −5V, or ±15V and −5V. You can trim the output voltages by ±5%. The supplies will operate with a main output load of as little as 1.2A with all other outputs unloaded, and they can cope with the high peak current requirements of, for example, disk drives. Other features include 75-kHz FET switching, warm- and cold-start inrush current control, and line input failure signaling.

The load regulation for a 40% change on a 60% load is ±0.5% for the main output, ±2% for the split positive and negative supplies, and ±0.5% for the single supply secondary. The supplies operate from ac line input voltages of 99 to 132V or 187 to 265V and have a line regulation of ±0.1% for a ±15% line input change. They meet the relevant IEC, CSA, VDE, UL, and BS reliability standards as well as the requirement of NATO standard AQAP4.

Coutant Electronics Ltd, Kingsley Ave, Ilfracombe, EX34 8ES, UK. Phone (0271) 65656. TLX 46310.

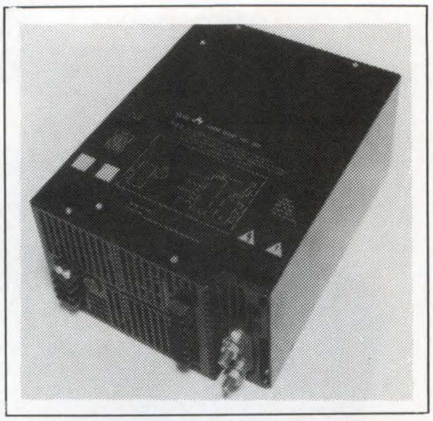
Circle No 741

Qualidyne Systems Inc, 3055 Del Sol Blvd, San Diego, CA 92154. Phone (619) 575-1100. TLX 709029.

Circle No 742

SWITCH-MODE SUPPLY

The SMM1500-0000 is the part of a series of single- and multiple-output power supplies, which are capable of delivering 1500W of dc power from an industry-standard 11×8×5-in. package. This initial version has five outputs. Its fully floating main output can deliver 5V at 200A and has remote sensing that can compensate for a voltage drop of 0.25V in the power connecting leads. You can parallel the main outputs of two or



more power supplies to increase the 5V output's current capability. The four auxiliary outputs share a common 0V terminal and provide outputs of ±12V, −5.2V, and +24V. The combined load rating of the auxiliary outputs is 500W.

All outputs are protected against overcurrent and overvoltage conditions, and the fan-cooled supply is protected against overtemperature conditions. The supply has a remote shutdown input. The unit's power

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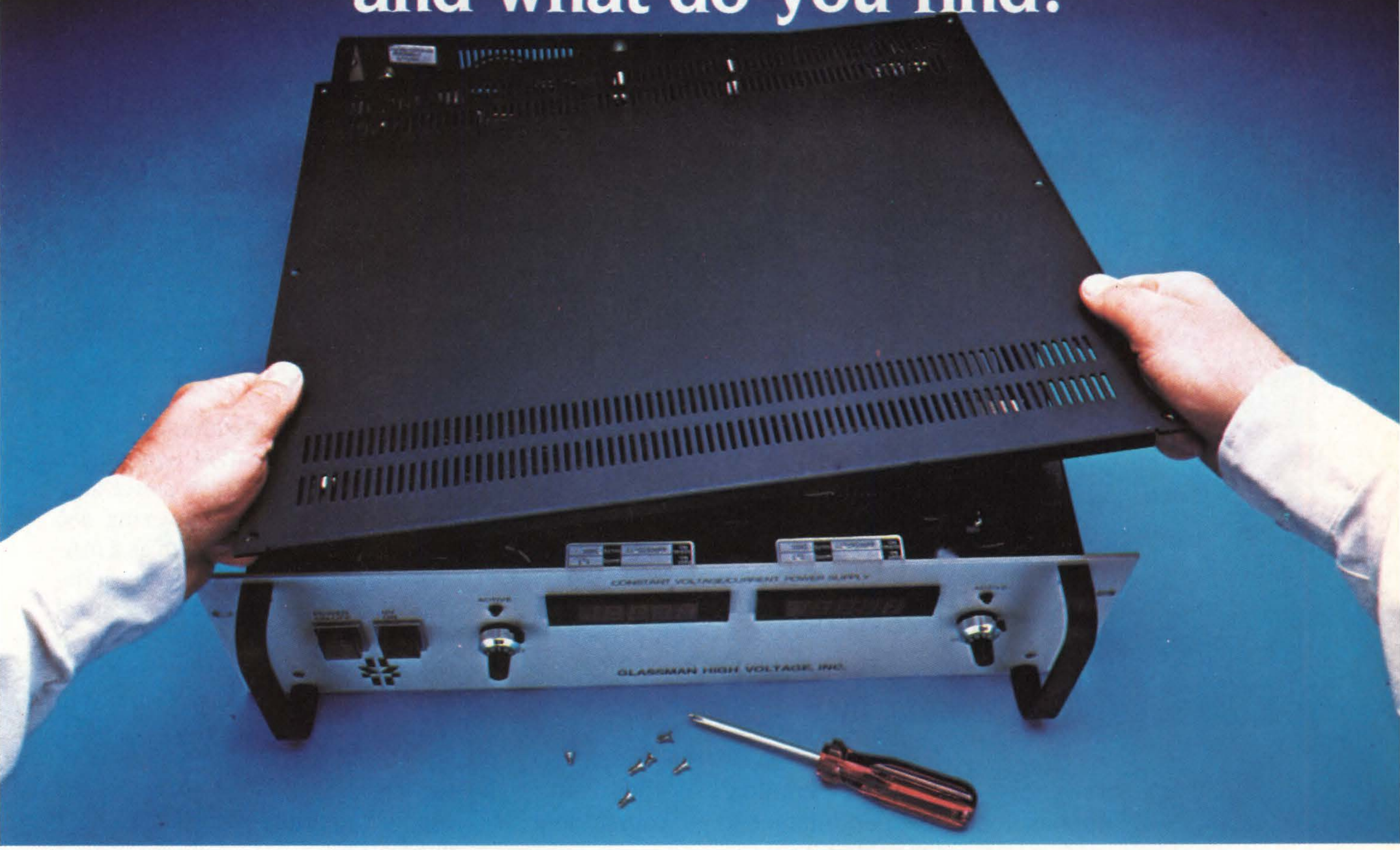

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factor is internally corrected to a value of 0.95 ±0.05 so that it draws a sinusoidal current from the line supply.

The supply meets relevant IEC, VDE, CAS, UL, and BS safety requirements. It also meets international EMC (electromagnetic compatibility) requirements, including those of VDE-0871 curve B. Around £1000.

Weir Electronics Ltd, Durban Rd, Bognor Regis, Sussex PO22 9RW, UK. Phone (0243) 865991. TLX 86543.

Circle No 743

Weir Inc, 418 3rd St, Annapolis, MD 21403. Phone (301) 268-0122. TWX 510-600-7370.

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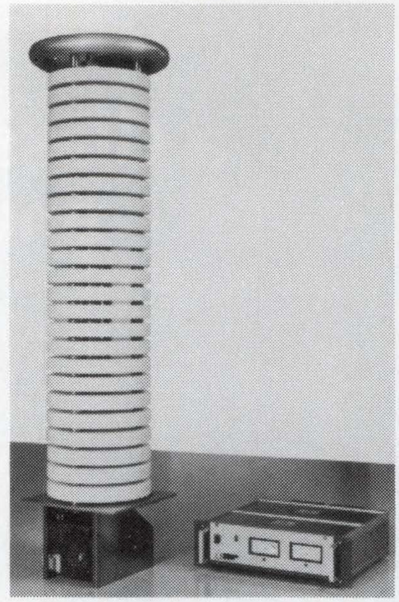

HV SUPPLY

To meet the requirements of the latest ion implantation equipment, Series 1200 high-voltage power supplies are capable of delivering 485 kV max at currents as high as 2 mA.

The power supply features independent voltage and current control with automatic crossover between the two modes. The overcurrent protection is built into the supply; in the event of output arcing, the damage to components is minimized by the low level of stored energy in the supply's multiplier stack. The supply features a 0- to full-load output regulation of 0.01%; its output ripple equals 0.1% of the rated output voltage p-p to 200 kV. Above 200 kV, its output ripple is less than 0.5%.

The power supply offers a rack-mounted converter that operates from 108 to 132V or 216 to 264V, 48- to 62-Hz ac line supplies. It also provides a voltage multiplier stack whose sections are rigidly joined so that you can mount the stack in any orientation. Around £19,000 for a 485 kV model. Delivery, 20 weeks ARO.

Bonar Wallis Hivolt Ltd, Dominion Way, Worthing, Sussex BN14 8NW, UK. Phone (0903) 211241. TLX 877112.

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Multilayer backplanes require careful design specs

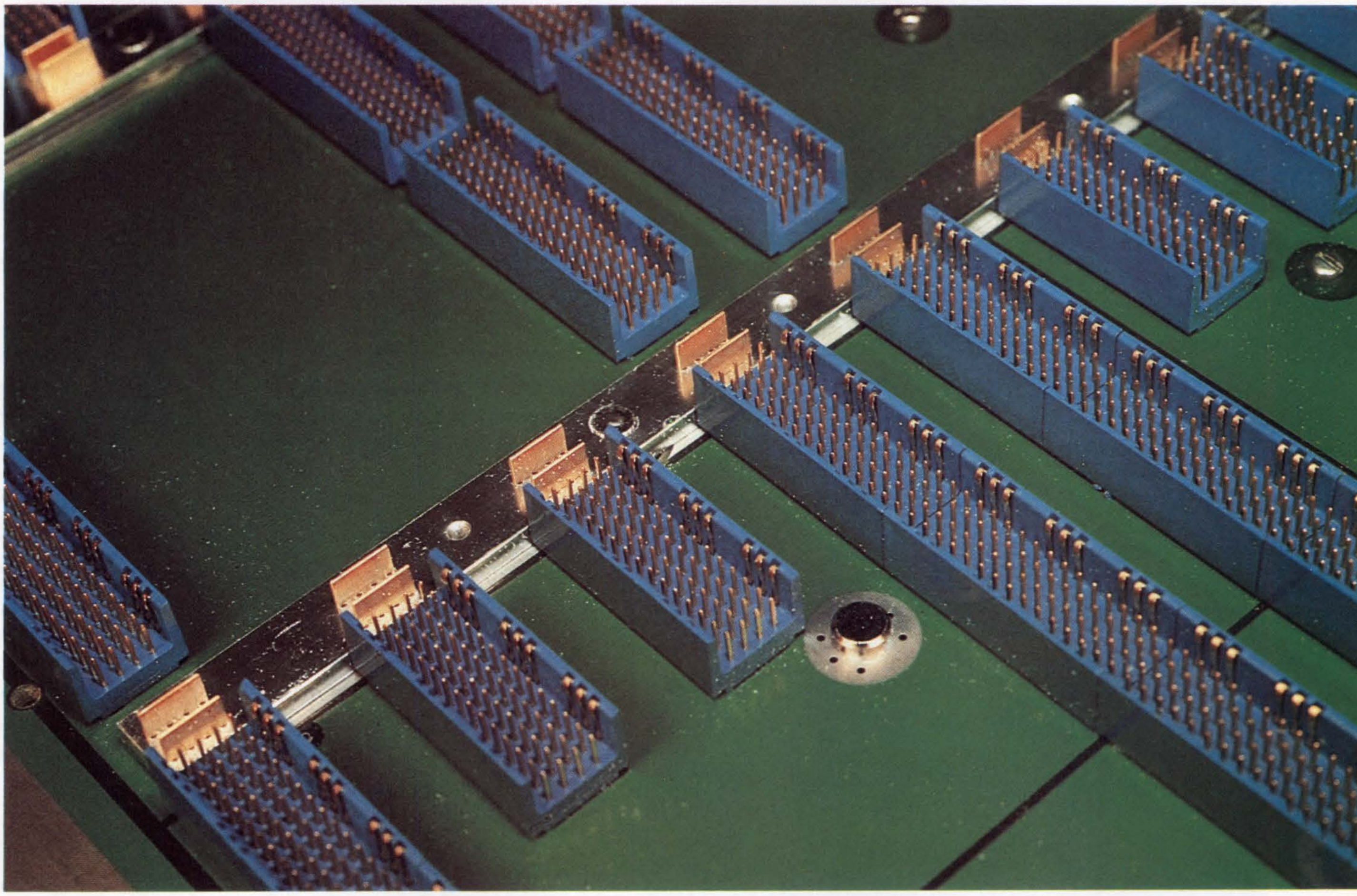
Dense, multilayer backplanes are necessary for connecting today's heavily populated daughter boards. But to get the highest performance out of your system, you have to keep in mind design considerations that reduce noise and prevent transmission degradation.

J D Mosley, *Regional Editor*

As electronic components continue to surpass the speed specs of previous-generation components, the need for transmission networks that can rush signals to their destination has forced the continuing evolution of backplanes. Along with these increasingly sophisticated backplanes has come denser and more-complex board-to-board connectors. If you don't understand subtle electrical-design considerations when it comes time to specify your backplane, you may not be able to adequately control the noise that can result.

The first basic design step, of course, is to define the physical characteristics of the backplane, or mother board. Count the number of daughter boards you need to mate and the type and number of interconnections that are required. Determine the connector pitch and I/O locations. Estimate the physical size of the backplane and the card cage.

Once you've specified these physical characteristics, the remaining design steps have to do with electrical-design considerations. Preventing excessive noise will



Backplane with modular connectors *(Teradyne Connector Systems)*

pose the primary electrical-design obstacle. Several parameters are critical: reference impedance, signal and power leads, system rise time, and your circuit's plated through holes, if any. Luckily, you can adjust these parameters and thereby decrease the amount of noise in your system. Bear in mind that easing the impact of one factor may aggravate the problems generated by another.

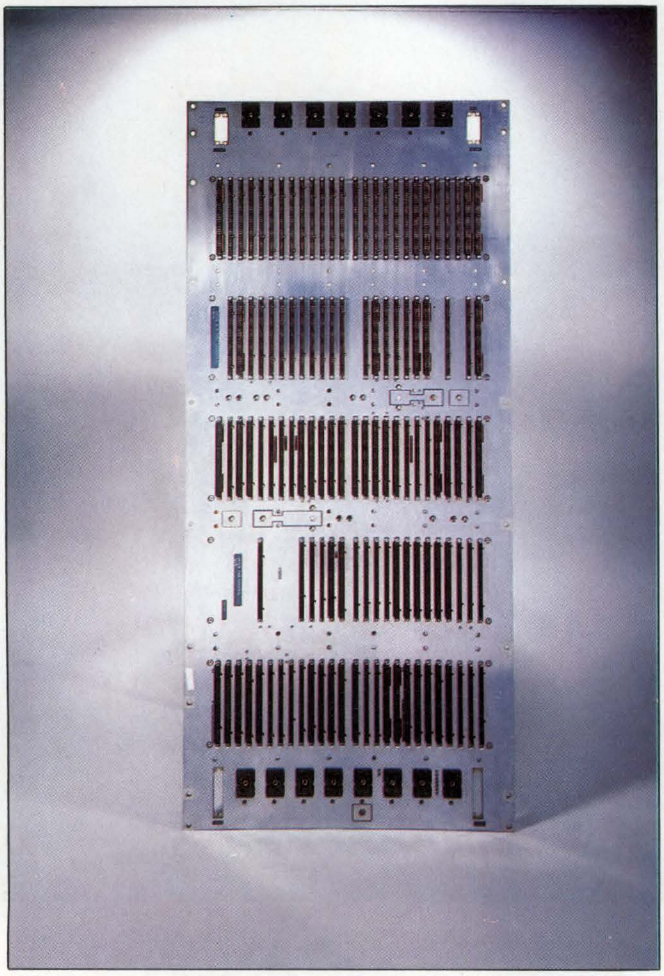
According to Michael Hayward, president of Hybricon Corp, a supplier of VME Bus backplanes, the characteristic reference impedance of a typical backplane varies between 50 and 100Ω. To ensure the fastest possible rise and fall times and the lowest possible crosstalk, he suggests lowering the signal density as much as possible and maintaining a low-impedance ground plane to reduce capacitive crosstalk.

He also sees power distribution, or the location of the power leads, as an important contributor to noise. You should carefully assign power-entry points on your backplane to produce the most uniform current density possible. And, if the number of voltage drops across the board seems excessive, increase the number of entry points. You may also want to consider increasing the copper thickness if the problem persists.

A common cause of reflections (and noise) is when a signal encounters an impedance level that differs from that of the originating transmission line's. Engineers at Teradyne Connector Systems know of several techniques that can help you control a mother board's impedance level. These techniques include varying factors such as the grounding of the board stiffener, the direction of the signal being transmitted, the connector tail lengths, and the density or location of the through holes to help alleviate impedance-level imbalances. You can use a time-domain reflectometer to measure and evaluate the reflection amplitudes as you tweak these parameters to attain optimal performance.

In addition, you can reduce reflection peaks by providing additional dielectric between the rows of your daughter boards. The tradeoff is that you slow the

Variations in the density of the conductors on your backplane can contribute to an unevenly distributed plating thickness across the panel's surface.



MIL-spec backplane measuring 42×22 in. (Methode Electronics)

signal speed and increase the reflection length and propagation delay. This approach may also increase the capacitive crosstalk between signal paths, so you may prefer to provide a local ground shield instead.

Remember that multilayer backplanes require sufficient resin to fill the core regions between the signal traces and the features in the power and ground planes. You can determine the minimum dielectric thickness needed for your design by multiplying the total thickness of opposing copper layers by a factor of 1½.

Because a backplane is thicker than a daughter board, its plated through holes offer greater capacitance on the transmission line. For this reason, signals travelling from the backplane to the daughter board tend to suffer degradation more often than signals travelling in the opposite direction. Feed-through connector tails appear to the signal as shunt transmission lines and produce successive reflections. You can control the severity of such reflections in the daughter board by grounding the contacts to improve impedance matching in the circuit.

The changing rise time of a signal through a circuit, when combined with mismatched connector impedances along the transmission line, also contributes to connector reflection. Because the circuit acts as a filter, you can tweak the L and C values anywhere in the circuit to help alleviate reflectance.

In addition, mismatched transmission-line connectors can slow the rising edge of digital signals, because these connectors act like lowpass filters in the line. As a result, you may also encounter signal absorption or delay in the extremely high frequency components of the transmitted signals.

Consider even the board's peripherals

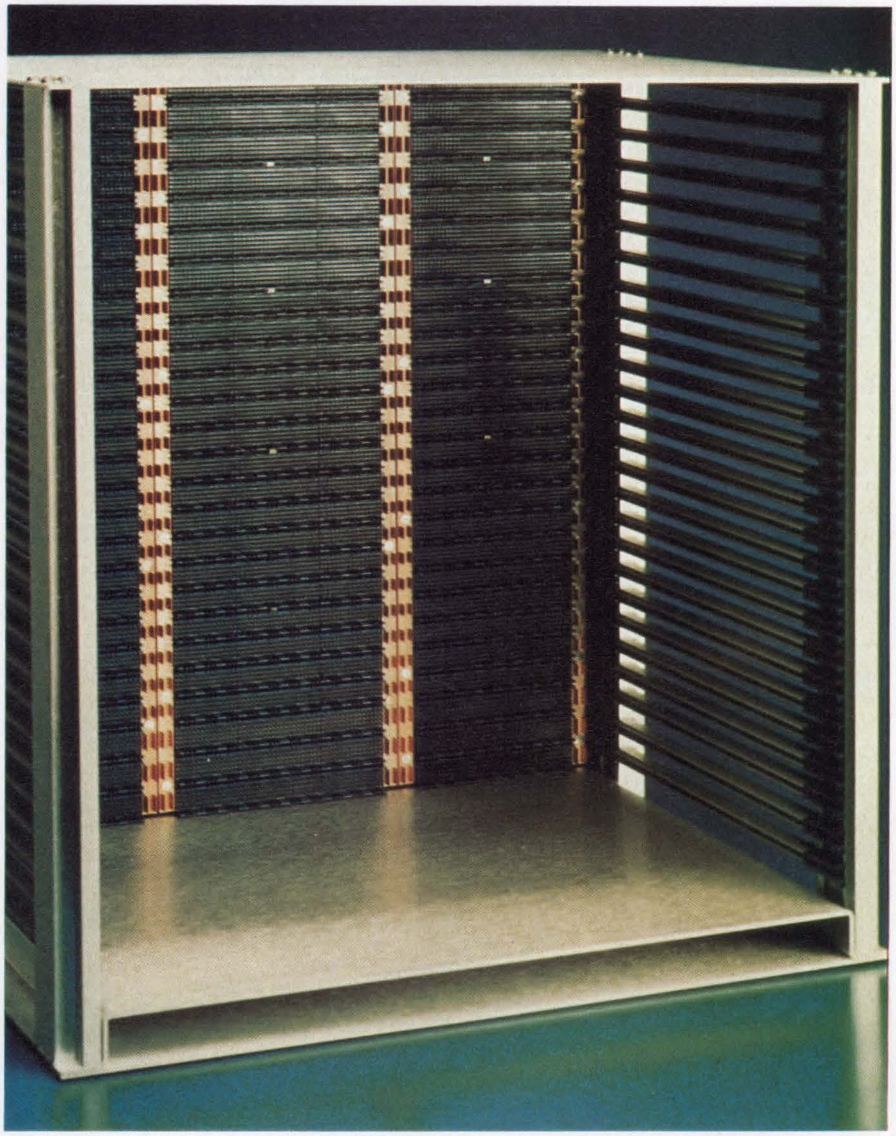
Aluminum stiffeners, which you'll find on the leading edge of many daughter boards and header assemblies, can affect a backplane's electrical performance by increasing static discharge to components on adjacent boards during insertion or removal. Grounding the stiffeners will protect your backplane from transmission-degradation problems. The use of mounting screws offers a convenient means of providing grounding between a stiffener and the board.

Depending on your system's I/O requirements, the tail lengths of the backplane will differ. Remember, though, that the longer the tails, the more capacitance you add to your system. By carefully considering what the impact of this capacitance has on your system's impedance levels, you may want to redesign your board and I/O specifications to optimize this factor in a high-speed system.

Don't overlook the effects of the capacitive nature of the plated through holes in your circuit. You can tune the effective impedance associated with the through holes by varying the dimensions of the through-hole pads and the clearance between the signal and ground layers. You may also consider changing the dimensions of the traces leading from the through holes.

Take advantage of experts' advice

Backplane experts at Teradyne Connector Systems have written numerous technical bulletins and tutorials that contain suggestions for enhancing the manufacturability of your backplane and ensuring that your design is cost effective. According to Teradyne, for example, you should specify your mother-board design so that the finished product makes maximum use of the avail-



***Backplane mounted in a card cage** (Teradyne Connector Systems)*

able real estate. For a final panel size of 12×12-in., for instance, the optimal working area you can expect is 10×10 in.; for an 18×24-in. panel, the final working area is 15×21 in.

The backplane design team at AMP Packaging Systems recommends that you specify gas-tight press-fit connectors to prevent damage to plated through holes. The company claims that its Action Pin connectors make the board manufacturing process less costly by allowing a greater tolerance (0.034 to 0.043 in.) in hole size. These contacts require less than 40 lbs of insertion force. Furthermore, you can remove and replace damaged press-fit connectors because the connectors never cut through the walls of the plated area, and the spring properties of the contacts help prevent damage to the hole upon removal.

AMP also offers the advice that variations in the density of the copper-wire conductors on your backplane can contribute to uneven plating thicknesses across the surface of the panel. To rectify this problem and achieve a uniform current density of evenly electrodeposited copper and tin lead, you can add nonfunctional connectors to your design in sparsely populated sections of the panel—a technique called thieving.

You also have to keep in mind the commercial safety standards for spacing the copper-wire conductors in a printed circuit. Agencies such as Underwriters Laboratories and the International Electrotechnical Commis-

Aluminum stiffeners on the daughter boards' leading edges may increase the danger of static discharge to components on adjacent boards.

TRADEOFFS TO CONSIDER WHEN DESIGNING A BACKPLANE

Increasing the number of conductors per routing channel will . . .	*decrease the number of signal layers, but increase crosstalk and decrease controlled-impedance-design flexibility.*
Decreasing the conductor spacing between connectors will . . .	*increase crosstalk.*
Reducing the conductor widths and increasing the number of conductors will . . .	*reduce design flexibility in controlled-impedance designs.*
Increasing the thickness and width of the copper printed-circuit connectors and increasing the acceptable high-temperature limit will . . .	*increase the current-carrying capacity of the connectors.*
Specifying a large printed-circuit panel size will . . .	*decrease labor cost per unit-area-processed, but will increase problems regarding dimensional stability and registration.*
Specifying nonplated through holes smaller than 0.187 in. will . . .	*prevent increased manufacturing costs resulting from the need to plug larger nonplated holes prior to electrodeposition, or the need to drill them a second time, which results in reduced registration accuracy.*
Using heavy-weight copper foils in your power and ground planes will . . .	*minimize current variations in high-power and high-current applications.*
Specifying heat-relief pads in copper layers of 2 oz or less will . . .	*ensure the complete fusion of the through-hole solders.*
Distributing multiple voltages (either by using multiple voltage planes, by dividing the voltage-distribution plane into voltage zones, or by utilizing externally applied bus bars) will . . .	*decrease noise.*

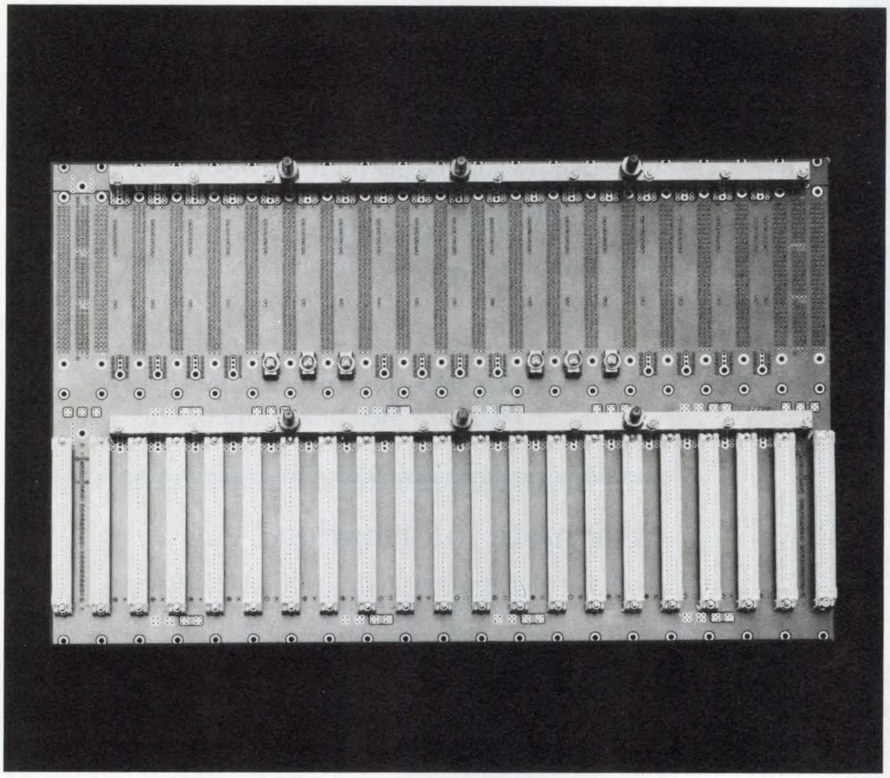
sion make recommendations to which your system may need to adhere.

Backplanes with modular connectors

Teradyne offers modular backplane and daughter-board connectors to provide you with maximum flexibility for your system design. The High Density Plus modules contain three to six rows of contacts and offer electrical compatibility with high-speed VLSI circuits. The field-repairable backplane connectors have low-insertion-force sockets and compliant, press-fit contacts. They include low-inductance grounding, multi-voltage power distribution, and controlled-impedance printed-circuit panels. An integral daughter-board stiffener is standard. You can select from several modular formats of power buses. The price for a complete backplane ranges from $0.20 to $0.26 per mated-signal contact pair; delivery is 8 to 12 weeks ARO.

For even more design convenience, you can order a mother board already mounted in an industrial card cage. RLC Enterprises offers its STD Bus BP-300 with this option. A 4-slot mother board, it carries signals from 8-MHz μPs. It also contains onboard passive terminations on all signal lines and has a ground plane for noise reduction. The connectors have gold contacts and are located on 0.6-in. centers.

The card cage is made of gold-irridited aluminum with antivibratory, shock-dampening, spring-loaded card guides. You can order it in either a side- or rear-mounting style or in a 19-in. rack-mount version.



Monolithic backplane with press-fit construction *(Bicc-Vero Electronics)*

Alone, the BP-300 costs $94. If you order it mounted in a card cage, it will cost $144. If you order it with a 5V at 6A, 12V at 2A, −12V at 200-mA optional power supply, it will cost $279. The company also offers 6-slot, 8-slot, and 12-slot versions of the BP-300.

Monolithic backplane reduces noise

Exhibiting an 11 to 56% improvement in crosstalk specs compared with earlier models, Bicc-Vero Electronics' new monolithic backplane for VME Bus systems features an 8-layer, press-fit construction. According to the manufacturer, this type of construction guarantees controlled impedance even when the board is fully populated with connectors and components. The board has two V_{CC} planes and three ground planes; the outer planes contain extra copper to reduce ground shift and protect the integrity of signals travelling through the inner layers.

In one 5.5-mm-thick board, the 21-slot backplane accommodates both J1 and J2 standards for the VME Bus system. The board contains press-fit connectors, multiple power taps, and through-board pins that let you make bus and jumper connections from either side of the mother board. Terminations are located at the back of the unit, so you can access terminations and jumpers from the front of the board. Among the board's five available power options is an external power-bus system. Prices range from $1000 to $1100, depending on the power option you choose.

If your design has to meet military standards, you may want to consider the MIL-C-28754 aluminum backplanes and components that Methode Electronics offers. These mother boards have drilled 6061-T6 aluminum per QQ-A-250/11, individually replaceable fork contacts of heat-treated beryllium copper per QQ-C-

STD Bus backplane and card cage *(RLC Enterprises)*

533, individually replaceable nylon insulators per MIL-M-20693, and a standardized military polarization system. Another configuration, which may better counteract excessive noise, consists of an aluminum backplane with separate ground and voltage planes, provided by laminating multiple electrically isolated aluminum plates. Other Methode MIL-spec boards are also available, including a 42×22-in. model coated with polyurethane or acrylic and processed to MIL-I-46058. **EDN**

Article Interest Quotient (Circle One)
High 473 Medium 474 Low 475

For more information . . .

For more information on the backplanes 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.

AMP Packaging Systems Inc
700-E Jeffrey Way
Round Rock, TX 78664
(512) 244-5100
FAX (512) 244-5112
Circle No 351

BICC-Vero Electronics Inc
100 Sherman Ave
Hamden, CT 06514
(203) 288-8001
TWX 510-227-8890
Circle No 352

BICC-Vero Electronics Ltd
Flanders Rd, Hedge End
Southampton SO3 3LG, UK
(0703) 266300
TLX 477984
Circle No 353

Hybricon Corp
Box 149
Ayer, MA 01432
(617) 772-5422
TWX 710-347-0654
Circle No 354

Methode Electronics Inc
7444 Wilson Ave
Chicago, IL 60656
(312) 867-9600
Circle No 355

RLC Enterprises
4800 Templeton Rd
Atascadero, CA 93422
(805) 466-9717
Circle No 356

Teradyne Connection Systems Inc
44 Simon St
Nashua, NH 03060
(603) 889-5156
Circle No 357

Tandem's powerful NonStop VLX™ computer systems are packed with proprietary technology. Including bi-polar and CMOS gate array logic designed with Tandem's own CAD system. When it came to connecting it all, however, Tandem chose to rely on interconnection specialists: Teradyne Connection Systems.

WE NEEDED CONNECTION TECHNOLOGY AS SOPHISTICATED AS OUR DEVICE TECHNOLOGY.

"We needed connection technology every bit as sophisticated as our VLSI technology," says Larry Laurich, V.P. of the Transaction Systems Division at Tandem. "And Teradyne's High Density Plus™ backplane system solves many of the

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

problems associated with interconnecting VLSI. Everything from controlled impedance and low inductance to preserve signal integrity, to high contact density and solid power and ground returns."

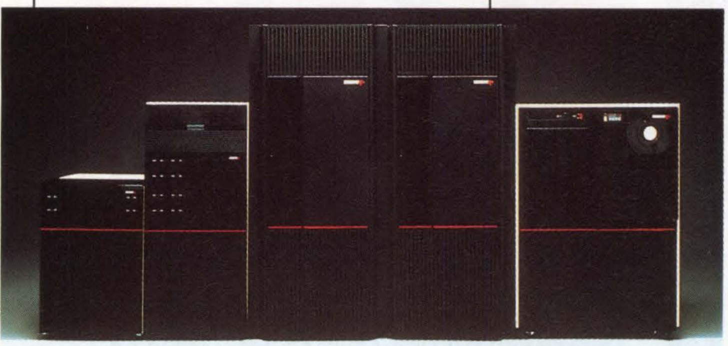
"On top of all that, Teradyne's modular design provides the

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

TANDEM CONNECTS

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

Now, nearly 1,000 backplane systems



The Tandem NonStop VLX™ system.

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

If you want uncompromising interconnection performance and reliability, your choice should be Teradyne, too. To find out how we can help interconnect your VLSI designs, call us today at (603) 889-5156, ext. 374. Or just write: Teradyne Connection Systems, 44 Simon St., Nashua, NH 03060.

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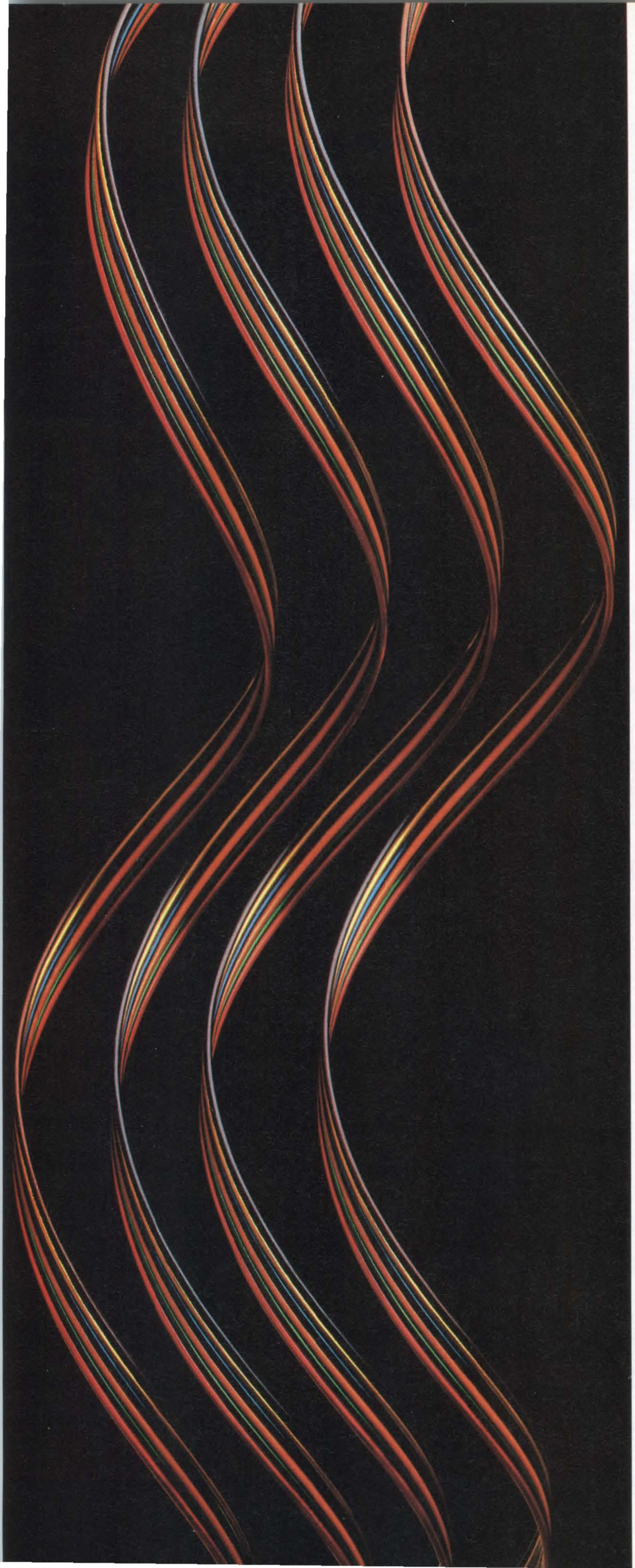
High Density Plus One backplane. High density modular connectors. A controlled impedance printed circuit panel. High current power busing.

TERADYNE

Interconnecting problem... and solution.

WITH TERADYNE

CIRCLE NO 141



MULTIFILAR®

MAGNET WIRE

Parallel bonded for windings and leads.

When two or more magnet wires travel together, MULTIFILAR magnet wire is an excellent alternative.

This parallel bonded, color-coded magnet wire offers more consistent capacitance and impedance characteristics when compared to windings using two or more separate magnet wires.

And, it allows for increased layer winding speeds, as well as reduced labor and handling. Color-coding assists in conductor identification and helps eliminate termination errors.

MULTIFILAR magnet wire is custom produced to guarantee flat, parallel construction in an array of sizes, 16–52 AWG, with up to 20 conductors in some sizes.

Available constructions include round, flat or square conductors. Individual conductors meet NEMA MW 1000, JW 1177, temperature classes 105–220°C; single through quadruple film builds. Color-coded conductors are available in most insulations with up to 10 different colors in some sizes.

Call or write for your free copy of our Technical Data Booklet and Capabilities Brochure. Both contain valuable information on all wire produced and inventoried by MWS Wire Industries. Samples of MULTIFILAR are available upon request.

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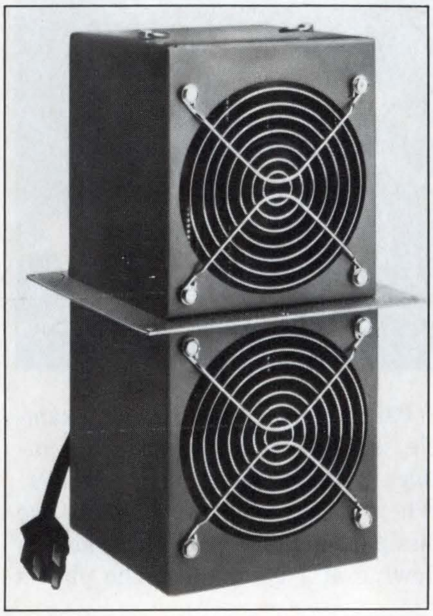
CIRCLE NO 142

Closed-loop air-to-air heat exchangers offer corrosion protection



The HE-11 and HE-15 air-to-air heat exchangers cool equipment in enclosures sealed against entry of outside air. Each unit has two blowers. One of them circulates air within the equipment enclosure and sends heat to a heat-core pipe that conducts it outside the enclosure. There, the second blower forces outside air past the heat core, dispersing heat into outside air by convection.

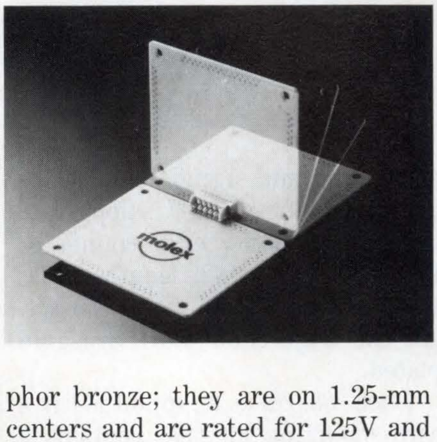
Two sizes are available: The HE-11 measures 5¼×5⅛×11⁵⁄₁₆ in. (5⅝ in. outside the cabinet). Its mounting flange is 6¾ in. square. When this unit is operating, the temperature of the air inside an enclosure rises an average of 1°F above the ambient temperature for each 7W of power dissipated by the equipment contained in the enclosure. The HE-15 measures 7⅛×7⅞×15 in. (7½ in. outside the cabinet). It has approximately four times as much cooling capacity.

Both heat exchangers can operate at ambient temperatures as high as 155°F. Quarter-turn fasteners facilitate disassembly and cleaning of the external portion of heat exchangers. You can order heat cores made of special materials to withstand specific corrosive atmospheres. Each unit has a gasket that keeps your enclosure sealed. Standard units operate from 50- or 60-Hz power sources. You can order models for 115 or 230V. The vendor can also supply dc-powered units. From $273.

McLean Midwest, 4000 83rd Ave N, Brooklyn Park, MN 55443. Phone (612) 561-9400. TLX 290883. FAX 612-569-0533.

Circle No 435

Small connector lets linked boards pivot for adjustment and service



This hinged connector places mated pairs of 0.06-in.-thick pc boards on 0.36-in. centers, and lets you pivot one of the boards 90° to gain access to otherwise inaccessible components. You can also mount the connectors in a way that lets you rotate your boards into a coplanar position; when you use the connectors in this way, you can move the boards to within 90° of each other. The vendor has demonstrated that the connectors withstand 50 rotational cycles and 30 mating/unmating cycles.

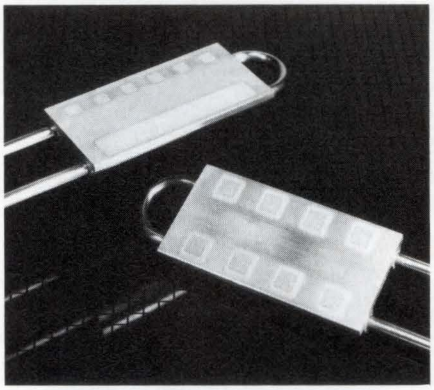
The contacts are tin-plated phosphor bronze; they are on 1.25-mm centers and are rated for 125V and 1A max/circuit. The tails are kinked to retain the connectors during soldering; they are arranged in a staggered pattern to reduce the likelihood of solder bridging. The glass-filled polyester dielectric has a 94V-0 UL rating. The line includes units with even numbers of contacts from 4 to 20. $0.054/circuit. Samples of 14- and 18-contact units are in stock; production quantities, seven to eight weeks ARO.

Molex Inc, 2222 Wellington Ct, Lisle, IL 60532. Phone (312) 969-4550. TLX 254069.

Circle No 438

Electrically insulated cold plates remove 1.5 kW from components

These liquid- and air-cooled plates have a ceramic coating with high thermal conductivity as well as good electrical insulation. The manufacturer uses a proprietary process for applying ceramic coatings to a metal base—an approach that provides lower thermal resistance than other insulation techniques do. The process also permits the application of a solderable copper coating over the ceramic layers. The solderable copper coating lets you mount several power semiconductor devices on a common heat sink. You can make connections to those devices and electrically isolate them from each other without using special hardware.



Part number 180-10-6, for example, is a 3×6-in. plate, with 0.01-in.-thick ceramic pads cooled by water. When the attached components are dissipating 400W, and the water is flowing at 1 gal/minute, the plate's temperature increases 40°C. If you increase the water-flow rate, you can lessen the temperature rise (or raise the dissipation while maintaining the temperature rise). This type of water-cooled plate is suitable for cooling devices that dissipate 200W to 1.5 kW.

You can get some configurations from stock, but the manufacturer expects that most orders will be custom ones. From $35.

EG&G Wakefield Engineering, 60 Audubon Rd, Wakefield, MA 01880. Phone (617) 245-5900. TWX 710-348-6713.

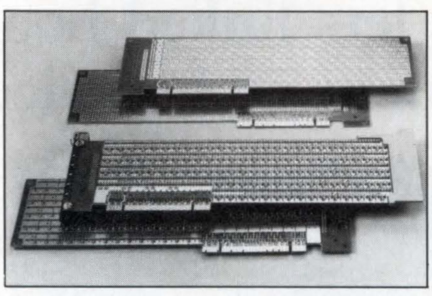
Circle No 436

PS/2 cards speed fast prototyping of computer add-ins

These prototyping boards are suitable for use in IBM PS/2 Model 50 and 60 computers. They are available as fully drilled pc boards etched with the company's Microboard interconnect pattern, or as boards fully populated with Speedwire terminals.

Adjacent to the Micro Channel connector, the boards have an additional edge connector that's compatible with the IBM PS/2's video expansion interface. In addition, you can mount a miniature D-connector, with as many as 37 pins, on the rear edge of the board.

The 4-layer boards contain internal power planes for +5V, −5V, +12V, and −12V supplies, and a full copper ground plane. To ensure that



all ground and signal connections are made before power is applied to the board, the 5V edge-connector fingers are reduced in length so that they are the last to make contact. All the edge connectors are gold plated.

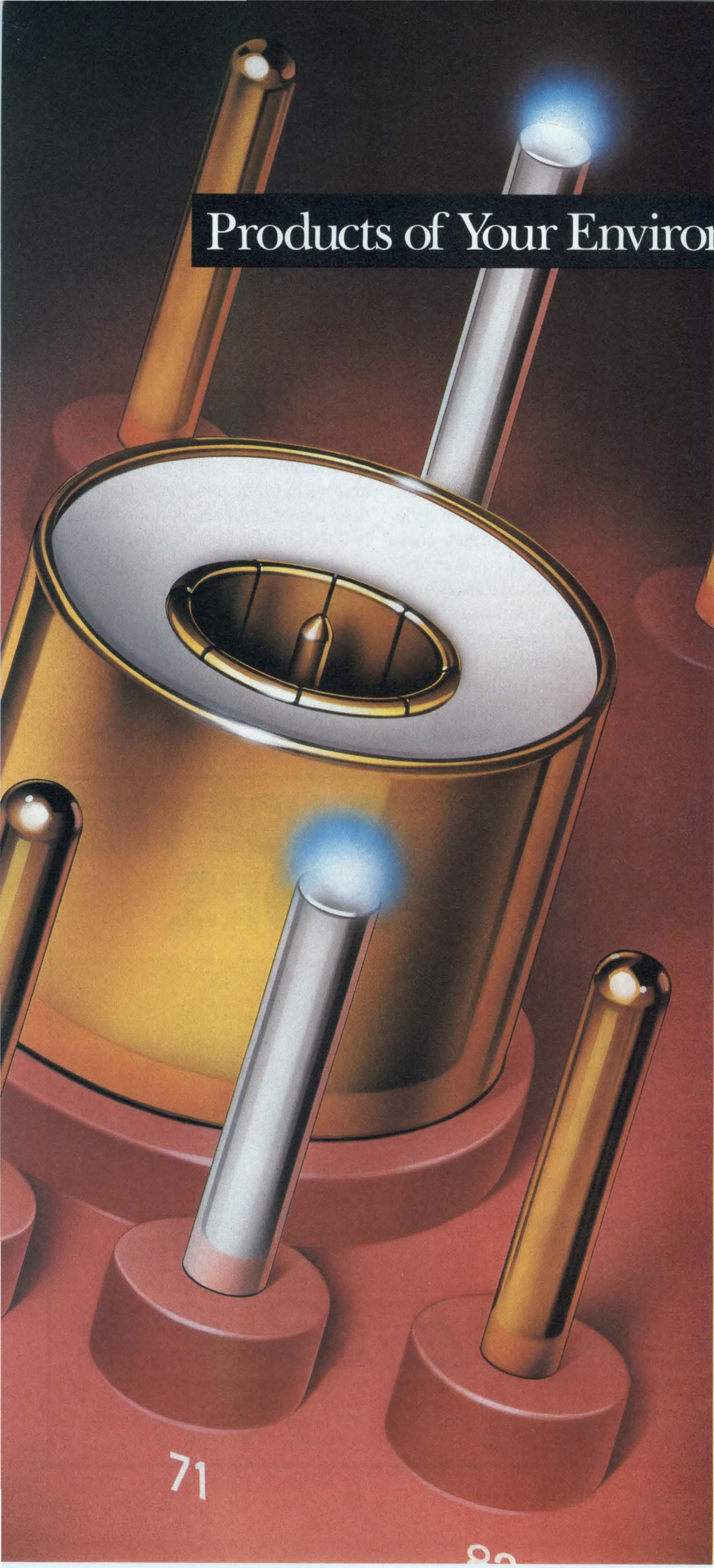
Each board is supplied with a card mounting kit that contains a plastic card pusher, a handle and card guide, and a stainless-steel bracket with a cutout for a 37-pin D-connector. An extender board, which allows you to work on the cards above the computer's chassis, is also available. Microboard protoyping card, around £40; Speedwire prototyping card, around £100.

Bicc-Vero Electronics Ltd, Flanders Rd, Hedge End, Southampton SO3 3LG, UK. Phone (0703) 266300. TLX 477984.

Circle No 439

Bicc-Vero Electronics Inc, 1000 Sherman Ave, Hamden, CT 06514. Phone (203) 288-8001. TWX 510-227-8890.

Circle No 440



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Then there's Cannon's near-zero defect rate. It got that way, and stays that way, because we test each product in a carefully simulated environment.

As for delivery, we built a dependable system by studying the needs and scheduling realities of our customers' business environments worldwide.

And Cannon stays price competitive by always asking the question, "How will this connector be used?" Considering the connector's ultimate environment has taught us that keeping quality high ends up costing our customer less.

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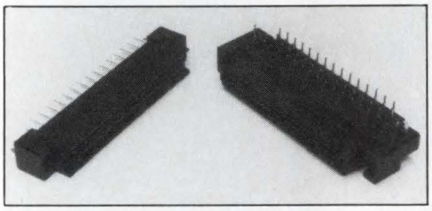
Fountain Valley, CA 92708
Or call (714) 964-7400

CIRCLE NO 143

ITT CANNON
We're making progress. Not excuses.

Connectors have redundant contacts on 0.050-in. centers

The RN Pak 50 series is a family of 2-piece connectors for mating pc boards to one another, to input/output connections, and to flat cables. The cables can have a conductor pitch of 0.025 in., and you mass terminate them through IDC (insulation-displacement crimping). The connector's halves have identical contacts. Pairs of contacts positioned on a 0.05-in. pitch permit high-density interconnections. You can mix them with older connectors by terminating a pair of 0.05-in.-center flat cables to a single IDC connector.



Both straight-through and right-angle styles are available to mount on pc boards. You can order 30-, 40-, 50-, or 60-pin versions of either style with as many as 200 contact positions. On pc-mounted connectors, alternate pairs of tails are staggered by 0.075 in. The insulators have clips to keep the connectors on the boards before soldering.

The devices use flat-beam, copper-alloy contacts. To improve reliability, each mated pair touches at two points. Selective gold-over-nickel plating covers the actual area of contact; tails are solder plated. The contacts can carry 0.5A; mated pairs have a maximum resistance of 25 mΩ. The rated, glass-filled-nylon insulation has a 94V-0 UL rating and withstands 650V rms for 1 minute. Insertion force is approximately 3.4 oz/contact position; withdrawal force is about one-fifth of insertion force. $0.10/mated pair (OEM qty).

Robinson Nugent Inc, 800 E Eighth St, New Albany, IN 47150. Phone (812) 948-0564. TWX 810-540-4082.

Circle No 437

Think SAE

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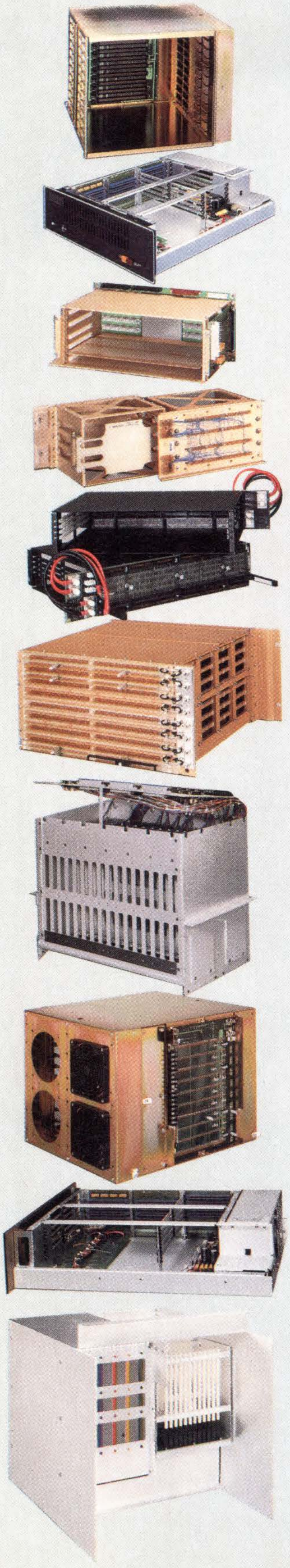

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- **Magnetic Components** transformers, modules and filters.
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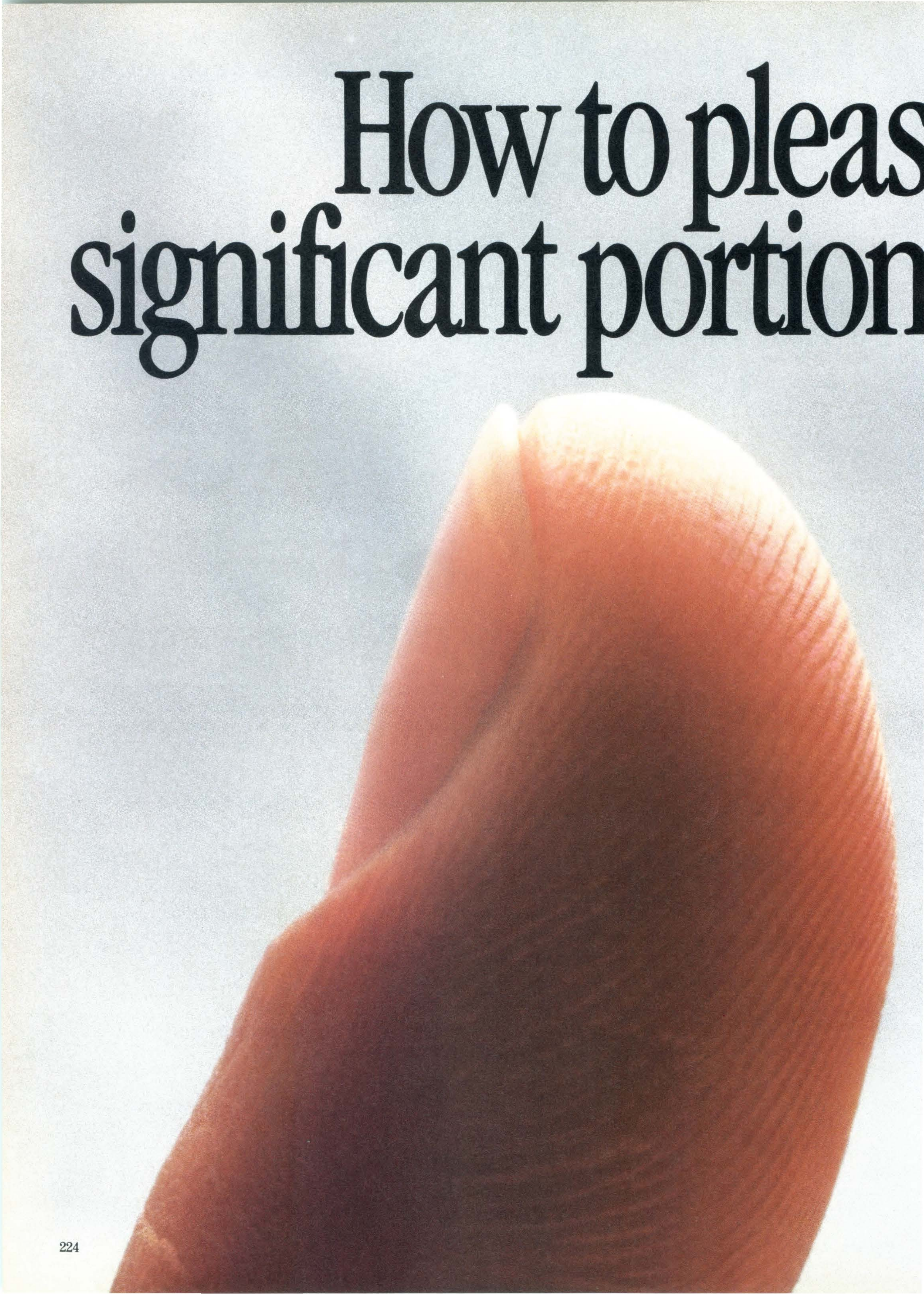

How to pleas
significant portion

e a small but
of your customers.

Pushbutton-operated devices are much more marketable when the buttons respond in satisfying ways to the user's touch.

So we made our new SLP control panels a touch more responsive.

We increased button travel to a more comfortable .050".

And we incorporated an enhanced conductive rubber pad, tested to ten million operations, that rewards the finger with a satisfying snap back when a button is actuated.

Actuator travel of 0.050" is more than twice that of conventional low-profile keypads.

The result is a control panel that adds to a user's comfort and confidence, for about the same price as those that generate feelings of vagueness and uncertainty.

But that's not the only bright feature of these new controls.

You can also get them in full-face, LED lighted versions that show up unmistakably, even in broad daylight.

And each button can be made to light independently of its on/off status, enabling the panel to guide a user through a sequence of operating steps.

Selective button lighting helps guide a user through a sequence of operating steps.

These new panels are available off-the-shelf in several standard arrays, or in custom packages with microprocessors, visual displays, special enclosures, or attachment cable included.

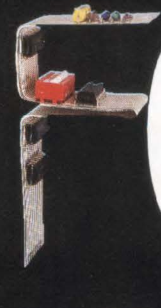
Making controls more responsive is just one of the many ways we can help you build competitive advantages into your products.

To make your designs easier to sell, more satisfying to use, or more cost-efficient to produce, call us at 815-235-6600.

Together, we can find the answers.

MICRO SWITCH
a Honeywell Division

CIRCLE NO 146

NOTHING O WERVES OR TO YOUR SPE BEND/FLEX.®

More flexible than rigid glass epoxy boards. More rigid than polyimide film. BEND/flex bendable circuit board material* from Rogers. The best of two technologies with a remarkable new twist: reduced production costs of up to 30%.

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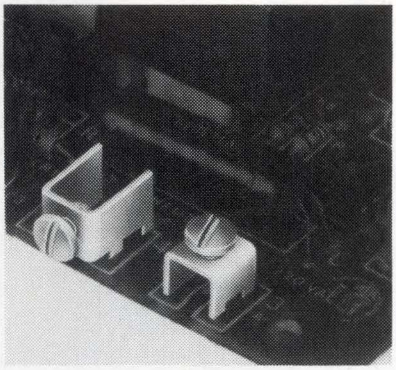


TERMINAL POSTS

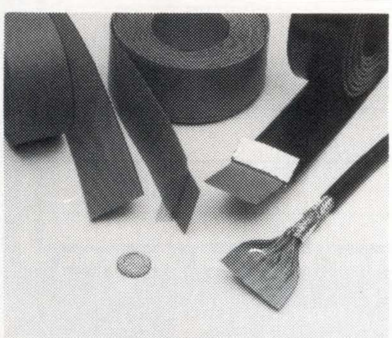
These tin-plated brass, screw-terminal posts solder to pc boards at four points to resist rocking and rotation.

You can specify a model that accepts wires inserted perpendicular to the board (you secure them using a screwdriver held parallel to the board plane) or a model whose wire entry is parallel to the board (in which case, you secure the wires with a screwdriver held perpendicular to the board).

The terminals' steel 6-32 binding screws accept solid or stranded wire from 14 through 22 AWG; they also accept crimped-on terminals and lugs. From $0.075.

Keystone Electronics Corp, 49 Bleeker St, New York, NY 10012. Phone (212) 475-4600. TLX 353700.

Circle No 665



0.025-IN PITCH CABLE

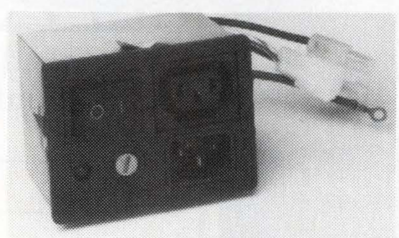
This "ribbon" cable contains wires spaced 0.025 in. center to center—which amounts to twice the density commonly found in ribbon cables.

You can use it with female-socket, transition, and D-subminiature insulation-displacement-terminated connectors that have 0.05×0.05-in. grids. Such connectors provide four times the density of more common interconnection devices.

Standard versions of the cable feature from 26 to 100 single-strand, 30-AWG, bare copper wires; the vendor can also supply the cable with stranded 32-AWG copper wire. The gray PVC insulation is marked for polarity along one edge, UL listed, and rated for operation from −20 to 105°C. One version of the cable includes a copper-mesh shield and drain wire; another is jacketed as well as shielded; and a third is round and features a jacket and shield. This last version includes flat sections for termination. From $82.66/100 ft for 50 conductors (in 1000-ft rolls).

Amphenol/Spectra-Strip, 720 Sherman Ave, Hamden, CT 06514. Phone (800) 572-2253; in CT, (203) 281-3200.

Circle No 666



POWER INLET

The F15352 EMI filter attenuates transients generated by switching-regulated power supplies; it includes an IEC ac inlet connector, an on/off switch, a fuse, an indicator lamp, and an IEC ac outlet. The unit snaps into a 3.10×2.32-in. panel cutout without the use of screws, extra holes, or mounting brackets.

It is rated to carry 10A in the US (6A in Europe) at 115V to 250V ac 50 or 60 Hz. The line-to-ground leakage is 0.25 mA max at 115V 60 Hz and 0.05 mA max at 250V 50 Hz. The test voltages are 2250V dc from line to ground and 1450V dc from line to line. According to the vendor, the filter complies with UL, CSA, and TUV interference requirements. $24.00 (1000). Delivery, two weeks ARO for samples and eight weeks ARO for production quantities.

Stanford Applied Engineering, 3520 De La Cruz Blvd, Santa Clara, CA 95050. Phone (408) 988-0700. TWX 910-338-0132.

Circle No 667

EMI SHIELD

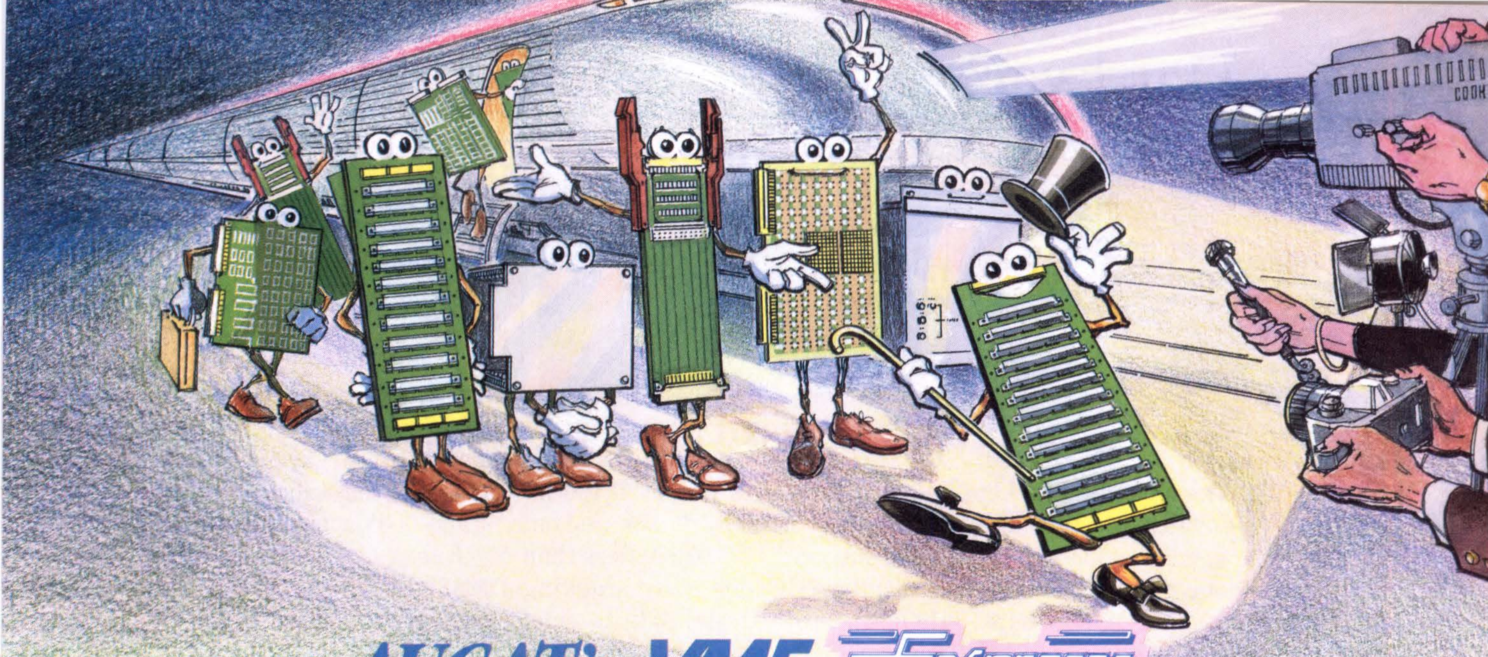
According to the vendor, this Copper Cloth material provides exceptional shielding. One version features 80×80 wires/in. and is 0.011 in. thick; the other offers 100×100 wires/in. and is 0.0046 in. thick. The vendor combines the shielding material with 12 types of zippered insulating jackets that you can apply to round and flat cables. A continuous copper strap facilitates termination and grounding of the shield. $2 to $3/ft.

The Zippertubing Co, Box 61129, Los Angeles, CA 90061. Phone (312) 321-3901.

Circle No 668

BURN-IN SOCKETS

These test/burn-in sockets accept ICs in plastic-quad flatpacks with or without bumpers. One socket, which features a hinged cover, accepts "naked" devices; the other serves as a socket/carrier combination. The carrier-style socket ac-



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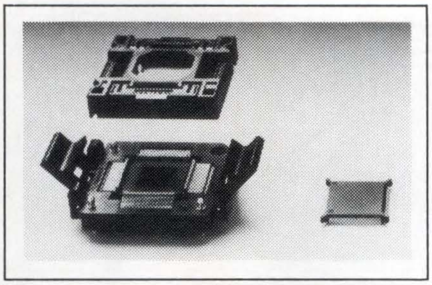
INTERNATIONAL OFFICES: Northern Europe Augat Ltd. (0908) 676655/**Central Europe** Augat Gmbh 089 576 085
Southern Europe Augat SA 1 46 68 30 90/**Japan** Augat KK 45 473-7301

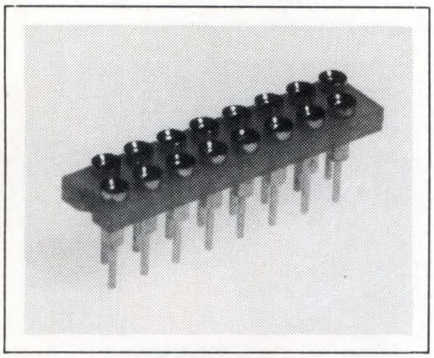
CIRCLE NO 148



cepts devices with 52, 68, 84, 100, and 132 leads. The hinged-lid socket accepts devices with 84, 100, and 132 leads. The insulation material is polyethersulphone/polyetherimide. The contacts are made of beryllium-copper and feature gold-over-nickel plating. 132-pin socket and carrier, $92.11 (100).

Nepenthe, 2471 E Bayshore Rd, Palo Alto, CA 94303. Phone (800) 637-3684; in CA, (415) 856-9332.

Circle No 669

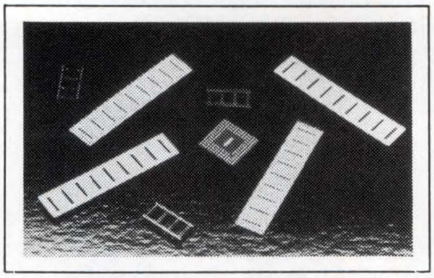


ZIP SOCKET

This socket accommodates devices in zigzag in-line packages. Its two rows of contacts are on a staggered, 0.1×0.1-in. grid. They accommodate recently introduced RAM devices from manufacturers such as Fujitsu and Mitsubishi. The contacts incorporate a screw-machined outer sleeve with a closed bottom that the vendor claims provides complete protection against solder wicking. You can specify 16-, 20-, 24-, or 28-position versions with solder tails or 2- or 3-level wire-wrappable terminations. 16-pin socket, $0.83.

Electronic Molding Corp, 96 Mill St, Woonsocket, RI 02895. Phone (401) 769-3800.

Circle No 670



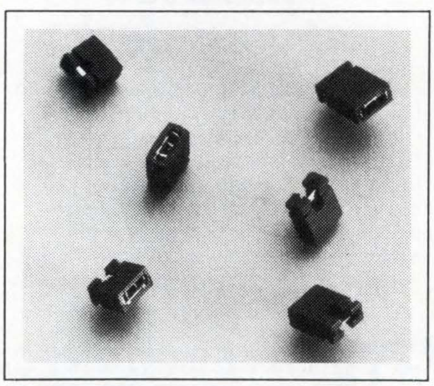
LOW-PROFILE SOCKETS

M600 DIP sockets project 0.100 in. above the board they're mounted on, which amounts to 0.070 in. less than a standard IC does. By stacking them end to end and side to side, you can create very dense packages. Their black, 94V-0-rated thermoplastic, polyester insulators are open to facilitate visual inspection after soldering. Their beryllium-copper contacts have three tines to achieve high reliability through redundancy, and the contacts' seamless, drawn outer sleeves have hollow bases to accept longer-than-normal device leads.

You can obtain the sockets with 24 to 40 positions in three configurations, and can mount them on 0.063- to 0.093-in. thick boards. You can specify contacts with gold-over-nickel or tin-over-copper plating. $0.80 to $1.20.

Mark Eyelet Co, 63 Wakelee Rd, Wolcott, CT 06716. Phone (203) 756-8847. TWX 510-600-7291.

Circle No 671

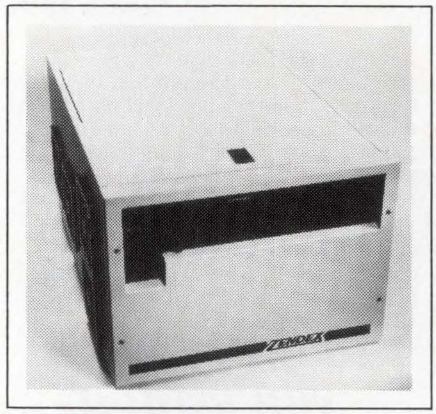


MINIATURE SHUNT

You can use these B-type shunts as jumpers to set equipment configurations. Their 2.44-mm width allows you to position them on 0.1-in. centers. The shunts are 4.5 mm high, which is nearly the same height as a standard DIP IC. Their gold-plated, phosphor-bronze, double-tuning-fork contacts have a maximum resistance of 20 mΩ; they carry 3A and fit 0.64-mm square posts. Their black, 94V-0-rated thermoplastic PBT insulators are self-extinguishing and 30%-glass filled, exhibit a 100 MΩ resistance min, and withstand 650V rms at sea level. $0.06.

Kycon Cable and Connector Inc, 1887 O'Toole Ave C103, San Jose, CA 95131. Phone (408) 435-1110. FAX 408-435-1149.

Circle No 672



ENCLOSURE

The ZX-981 enclosure can house a Multibus, Multibus II, or a VME Bus Hbackplane. Rear-loading versions accept 15-slot Multibus or 12-slot VME or Multibus II backplanes. Top-loading versions accept 15- or 20-slot Multibus, 12- or 20-slot Multibus II, or 12-, 16-, or 20-slot VME Bus backplanes.

The enclosures feature a removable front panel; lift-up top cover; front-panel-mounted power, interrupt, and reset switches; and four dc-powered fans. The vendor can supply mounting brackets that accommodate two full-height or four half-height storage peripherals. A shielded power-supply bay accommodates off-the-shelf switching supplies with outputs to 1000W. Troughs and numerous prepunched holes facilitate the neat routng of cables. You can attach rack slides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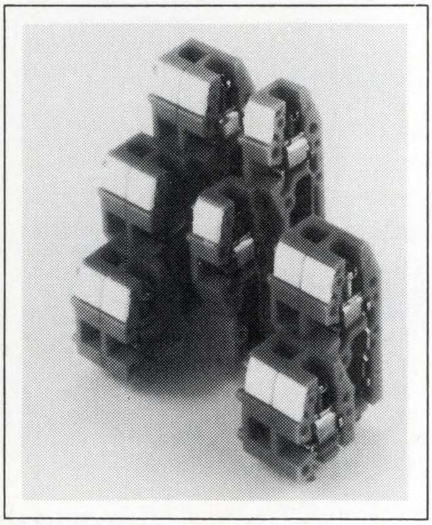
using holes provided for the purpose. $4500.

Zendex Corp, 6700 Sierra Lane, Dublin, CA 94568. Phone (415) 828-3000.

Circle No 673



TERMINAL BLOCKS

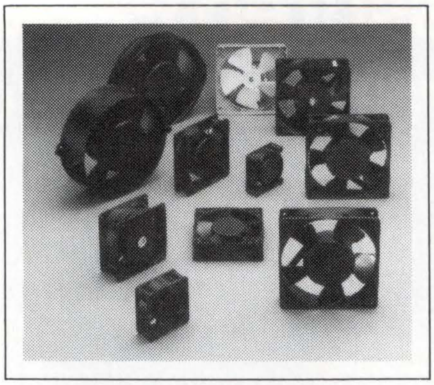
LP and LPK Series terminal blocks mount on pc boards and permit the attachment of discrete wires from 14 to 26 AWG. You secure the wires by tightening self-locking and, according to the vendor, vibration-proof screw clamps. The vendor provides the Dekafix marking system for standard- or custom-circuit identification. The blocks are UL and CSA approved for carrying currents to 10A at voltages to 300V. The blocks have closed bottoms. The contacts are spaced 0.2 in. apart, on one, two, or three levels. $0.55/point.

Weidmuller Inc, 821 Southlake Blvd, Richmond, VA 23236. Phone (804) 794-2877. TLX 828376.

Circle No 674

SPEED-SENSING FANS

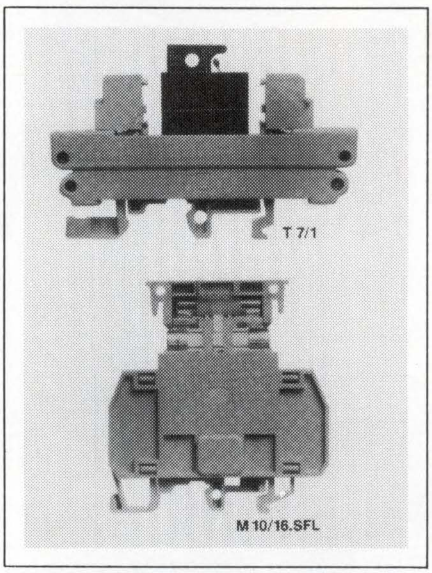
These "intelligent" fans sense their rotation speed and automatically restart after a service interruption. You can obtain models that draw power from 115V ac and from 12 and 24V dc sources. Though most models feature ball bearings, some have



sleeve bearings. Their diameters range from 60 to 164 mm, and their free-air delivery ranges from 9.5 to 180 cfm. $15 to $20 (OEM qty).

NMB Corp, 9730 Independence Ave, Chatsworth, CA 91311. Phone (818) 341-0820. TLX 651340.

Circle No 675



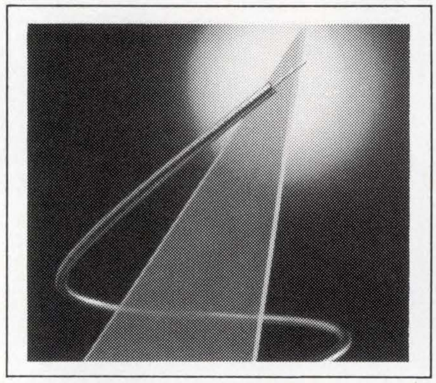
FUSE BLOCKS

These fuse terminal blocks snap into DIN mounting rails. The M 10/16.SF accepts wire sizes from 18 to 8 AWG and accommodates standard $\frac{1}{4}\times1\frac{1}{4}$-in. cartridge fuses rated from 0.25 to 16A. It is 16 mm thick and is UL recognized for operation at 600V. You can specify a unit containing a blown-fuse indicator—a neon lamp rated for operation from 57 to 480V ac or an LED that operates at 24V dc.

Other of the vendor's fuse terminal blocks accept type GMT fuses rated from 0.18 to 10A. One model, the 13-mm-wide T 7/1, accepts a single fuse and incorporates an auxiliary contact; the 89-mm-wide T 7/8 accepts eight fuses and features eight auxiliary contacts. M 10/16.SF, $8.30; T 7/8, $98.50.

Entrelec, 2 Tam Ridge Rd, Spring Valley, NY 10977. Phone (800) 431-2308; in NY, (914) 425-7460. TLX 996619.

Circle No 679

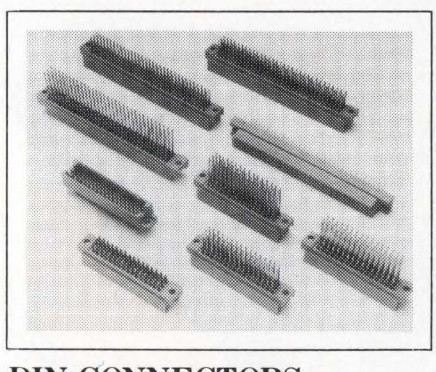


FLEXIBLE CABLE

You can bend Conformable Coaxial Cable sharply without using special tools. According to the vendor, its copper-tin composite shield provides 100% shielding. The cable is rated for use at 200°C. It is compatible with most noncrimp connectors usually used for cable. The standard lengths range from 100 to 1000 ft. From $295 (500 ft).

Belden Wire and Cable, Box 1980, Richmond, IN 47375. Phone (800) 235-3364; in IN, (317) 983-5200.

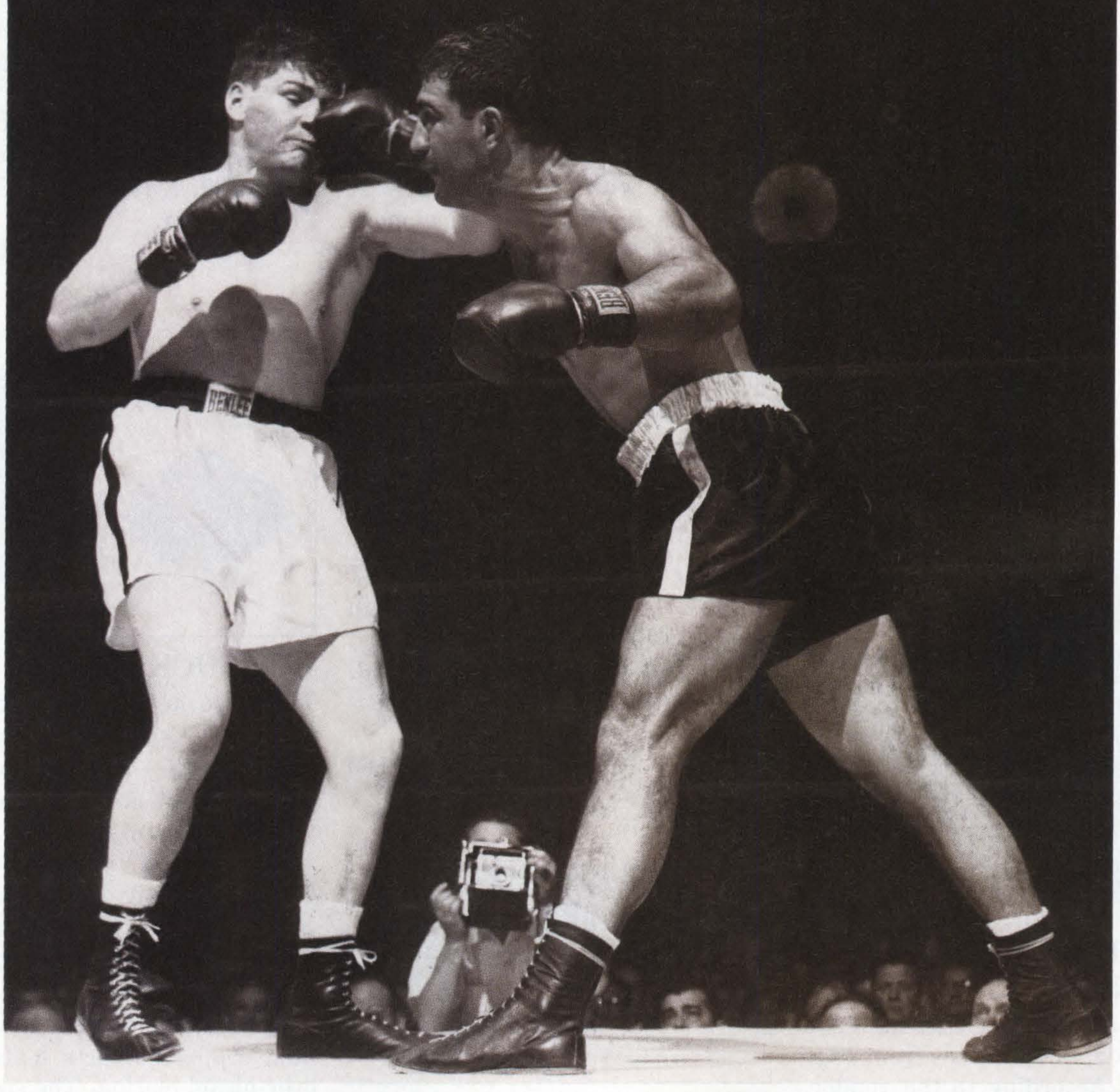
Circle No 676



DIN CONNECTORS

These connectors comply with DIN

It Takes An Unbeatable Combination To Score A Technical Knockout.



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- **FLEXIBLE.** All outputs are independently isolated, mag amp regulated, and adjustable. Outputs 2 and 3 can be widely adjusted between 10 and 15V. to meet different equipment demands–at no extra cost!
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Output & Voltage Current Ratings

Model	Max Output Power (Watts)	Main Output		2nd Output		3rd Output		4th Output		Size (inches)
		Volts DC (Min/Max)	Amps (Min/Max)	Volts DC (Min/Max)	Amps (Min/Max)	Volts DC (Min/Max)	Amps (Min/Max)	Volts DC (Min/Max)	Amps (Min/Max)	
ZPS-250-N	250	4.75/5.25	3.5/35.0	10.0/15.5	0.4/4.0 PK6	10.0/15.5	0.4/4.0 PK6	4.75/5.25	0.3/3.0	5.0 x 2.5 x 13
ZPS-300-N	300	4.75/5.25	4.5/45.0	10.0/15.5	0.8/8.0 PK12	10.0/15.5	0.8/8.0 PK12	4.75/5.25	0.4/4.0	5.0 x 2.5 x 13
ZPS-400-N	400	4.75/5.25	5.5/55.0	10.0/15.5	1.0/10.0 PK15	10.0/15.5	1.0/10.0 PK15	4.75/5.25	0.6/6.0	6.0 x 2.5 x 13

For optional steel cover substitute -C for -N in model number.

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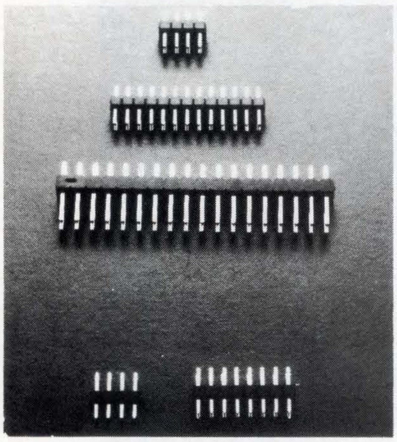
41612, IEC 603-2, VG 95324, MIL-C-55302/131-134, and MILC55302/157-158. Types BK, CK, and C can have as many as 96 contacts; types D, E, and F have 32 or 48 contacts; and types Q and R have an inverse configuration. You can obtain the devices equipped for wire wrappable, wave solderable, or press fit termination. Type BK with 48 pins, $2; type BK with 96 pins, $3 (1000).

Stanford Applied Engineering, 3520 De La Cruz Blvd, Santa Clara, CA 95050. Phone (408) 988-0700. TWX 910-338-0132.

Circle No 677



¼-IN.-HIGH SOCKETS

The FCN723 2-mm-pitch discrete-wire connector is 0.256 in. high and accommodates wire sizes from 26 to 34 AWG. According to the vendor, board-to-board and wire-to-board interconnections made with discrete-wire sockets and board-mounted headers take up less space and permit better airflow than do ribbon-cable connections. The vendor also claims that a single connector can join three pc boards. The series includes straight- and right-angle styles with 2 to 18 pins in a single row and 4 to 36 pins in 2 rows. 30-pin header and socket, $0.80.

Fujitsu Component of America Inc, 3320 Scott Blvd, Santa Clara, CA 95054. Phone (408) 562-1000. TWX 910-338-0190.

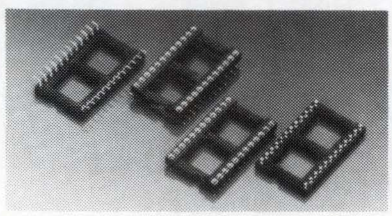
Circle No 678

SOCKETS

Designed for burn-in service, these sockets accommodate 44- and 84-pin PLCC (plastic leaded chip carrier) devices. They have a locking mechanism that facilitates manual or automated loading and unloading, prevents damage to delicate leads, and ensures positive lead contact. A simple push seats the PLCC firmly in the socket with an audible click. A second push ejects the device above the socket edge for easy removal. Guided entry and alignment ribs ease the PLCC into proper orientation within the socket. An improved socket design provides more contact area at the top and sides of the leads to improve reliability. The sockets feature quick visual polarization, and its side and bottom vents allow increased airflow for heat dissipation, as well as access for test probes. 44-pin unit, $9.98; 84-pin version, $15.12 (1000).

3M, Dept EP87-109, Box 2963, Austin, TX 78769. Phone (512) 834-1803.

Circle No 680



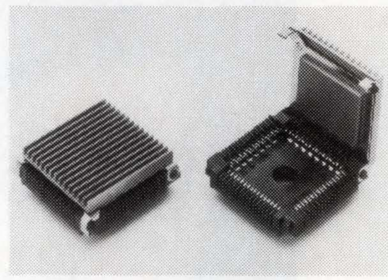
IC SOCKETS

Type 105 and 117 IC sockets are designed for surface-mount applications. Type 105 units have angled pins (gull type) that provide easy access for in-circuit testing and troubleshooting. Type 117 units feature a floating-contact design that compensates for the effects of unevenly dispensed solder paste. Both types can accommodate most soldering processes that are used for surface-mount fabrication.

The insulator body is glass-filled thermoplastic polyester with a UL 94V-0 flammability rating. The contacts use a 4-finger clip made of stamped beryllium copper, gold, or tin plate over copper and nickel. The pins are screw-machined brass with tin plating over copper and nickel. Types 105 and 117, with 28 pins and tin plating, cost $1.75 and $1.65, (100) respectively. Delivery, four to six weeks ARO.

IEE Inc, Component Products Div, 7740 Lemona Ave, Van Nuys, CA 91409. Phone (818) 787-0311. TLX 4720556.

Circle No 681



LCC SOCKETS

These sockets can accommodate 68-pin LCC devices in actual-use applications—not just in burn-in service. They are available with or without aluminum heat sinks, in versions that mount to either JEDEC Type A or Type B ceramic leadless chip carriers. Their body material consists of polyphenylene sulfide, and their cover material is made of stainless steel. Their beryllium copper contacts feature gold-over-nickel plating. The sockets can withstand 150°C operating temperatures. $4.01 (1000). Delivery, stock to six weeks ARO.

Nepenthe, 2471 E Bayshore Rd, Palo Alto, CA 94303. Phone (415) 856-9332.

Circle No 682

DATA LINKS

Series 5660 analog fiber-optic data links consist of a transmitter, a receiver, and a 50m cable. The transmitter and receiver are housed in 24-pin DIPs. The devices feature a 10-kHz bandwidth, ±0.025% FS linearity, an 80-dB signal-to-noise

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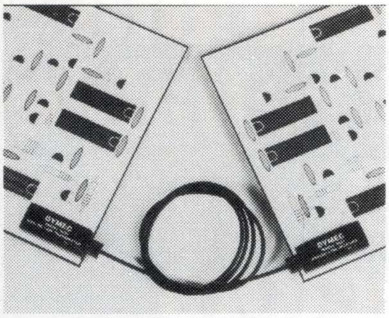


ratio, and a 100-ppm/°C temperature coefficient. The transmitter and receiver FS input and output voltages are pin-selectable for 0 to 1, 0 to 2, ±5, and ±1V. The transmitter and receiver modules operate from a single supply of 11.5 to 20V. The receiver includes a 3-pole, active lowpass filter, which you can bypass to suit your application. $200. Delivery, six to eight weeks ARO.

Dymec Inc, 8 Lowell Ave, Winchester, MA 01890. Phone (800) 225-1151; in MA, (617) 729-7870. TWX 710-348-6596.

Circle No 683

INDUSTRIAL NETWORK

The Efiway industrial control network lets you control as many as 8064 distributed I/O lines from an IBM PC/AT or a Multibus I. The token-ring network, which employs an optical fiber cable that operates at 3.5M bits/sec, can accommodate as many as 63 computers or I/O stations.

Communication between a computer and the network occurs via a dual-port RAM on the computer's network interface card. Automatic packet transmission over the network transfers the contents of this RAM into remote I/O locations or into the dual-port RAM of other network computers. In addition, the input states of remote input channels are transferred back into the computer's dual-port RAM. These transfers occur automatically, without software support from the control computer; consequently, the computer perceives the system as a memory-mapped system rather than as a network. The vendor estimates the cost of a 5-station network with one intelligent station at around FFr 150,000.

Efisysteme, 21-43 rue de la Grande-Charriere, La Boisse, 01120 Montluel, France. Phone 78062155. TLX 340821.

Circle No 708

INDUSTRIAL NETWORK

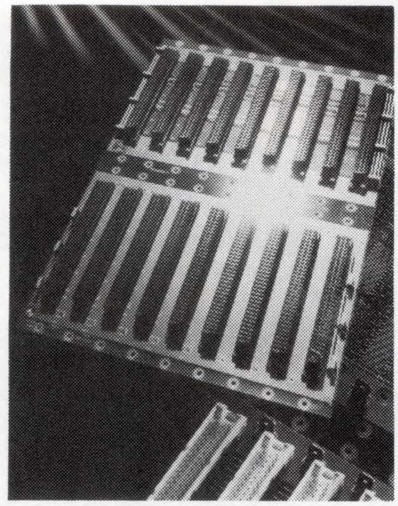
The Signatrans-ZM50 modular industrial networking system, which operates over 2-wire cabling, lets you transmit data and commands between as many as 256 network stations. It is suitable for use in data-acquisition and process-control applications that employ a range of sensors and actuators.

When the networking system is running in its simplest operating mode, you don't need an intelligent network controller. Rather, you can cause the network to automatically transfer data from the input to the output channel simply by setting DIP switches to allocate the same address to an input channel and an output channel. You can set up as many as 128 of these I/O pairs and can join input and output channels anywhere in the network.

You can use a handheld programming unit to program the system to perform point-to-multipoint transfers, so that the information on one input channel automatically appears at several output channels. Alternatively, you can add to the network a communications processor station, which provides terminal control of the network as well as a gateway to other networks. The network can have open-ended or ring topology and can be as long as 20 km. A typical I/O station, with modules to provide analog and digital I/O capability, costs around DM 2000.

Funke & Huster GmbH, Langemarckstrasse 28, 4300 Essen 1, West Germany. Phone (0201) 22091. TLX 857637.

Circle No 709



BACKPLANE

Suitable for use in 32-bit VME Bus systems, V316 Series double-height VME Bus backplanes incorporate both J1 and J2 connectors. The units currently come in 9-, 12-, and 20-slot versions, and a 5-slot version is in development. The boards feature DIN-41612 connectors and passive termination networks. They employ a tracking arrangement that provides a ground screen around every signal track to reduce crosstalk and ringing.

The units incorporate the bus-busy signal routing as recommended in the latest revision of the VME Bus specification. The boards have full copper grounding and +5V power planes that extend across the J1 and J2 sections of their backplanes. You make power connections to the board via spade connectors. £145 (100).

Dage (GB) Ltd, Rabans Lane, Aylesbury, Bucks HP19 3RG, UK. Phone (0296) 393200. TLX 83518.

Circle No 710

Dage Precision Industries Inc, 46701 Fremont Blvd, Fremont, CA 94538. Phone (415) 683-3930.

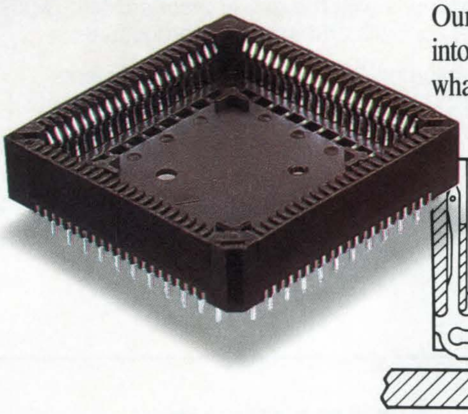
Circle No 711

BREADBOARDS

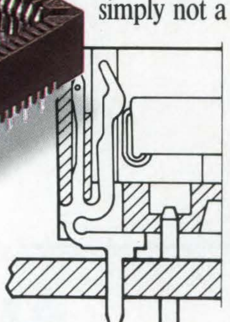
X-tra Edge-style solderless breadboards feature an extra multiuse edge panel for organizing and mounting components that don't fit

Text continued on pg 241

A chip carrier socket that won't play "pop goes the circuit."



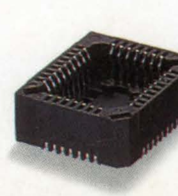
Our sockets are designed to get solidly into contact and stay in contact. No matter what the outside influences. Pop-out is simply not a problem.



Controlled contact interface angle in AMP HPT sockets ensures positive chip carrier retention. Our exclusive removable housing allows direct inspection of solder joints, and fast repair/replacement of contacts.

The contacts are High Pressure Tin, an AMP proprietary design which creates very high normal forces—a minimum of 200 grams per contact—for maximum retention and reliable interconnection. Short-signal-path contacts float in the housing to accommodate thermal expansion.

Two basic styles of sockets are available: square or 32-position rectangular EPROM and SO-J. Both come in solder



Seven socket sizes are available, with carrier extraction tools provided for each size.

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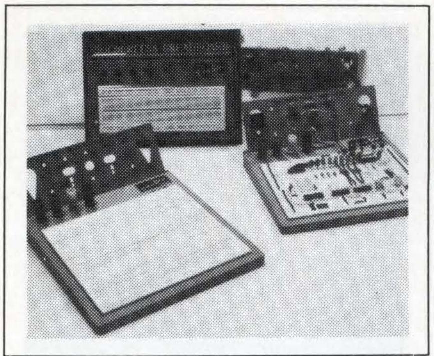
Schroff Eurorack and Minirack cabinets are manufactured in the United States. They meet EIA, IEC, VDE and DIN standards. And they're made to deliver maximum rigidity and strength. As a result, you, and your customers, can be sure these cabinets will last as long on the job as they will in the market.

If your present cabinets can't pass the test of time the way Eurorack and Minirack can, it's time you looked at Schroff.

CIRCLE NO 154

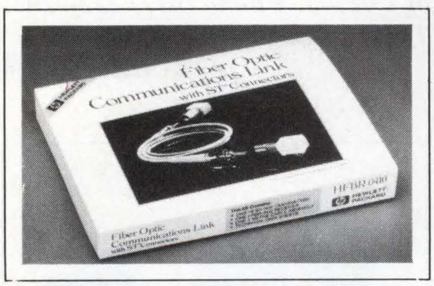
Hardware



into DIP-spaced breadboard socket connections. The boards come in four models that offer from 810 to 2940 tie-points. Each model includes an area containing both distribution and terminal strips that accommodate all DIP sizes, lead components, and wire gauges of 20 to 29 AWG. The phosphor bronze, nickel-plated contacts provide a 3-mΩ initial contact resistance and a 10,000 in-out-cycle min lifetime rating. Each breadboard features four multipurpose binding posts. $16.95 to $59.95.

Chenesko Products Inc, 21 Maple St, Centereach, NY 11720. Phone (516) 736-7977.

Circle No 684



OPTICAL MODULES

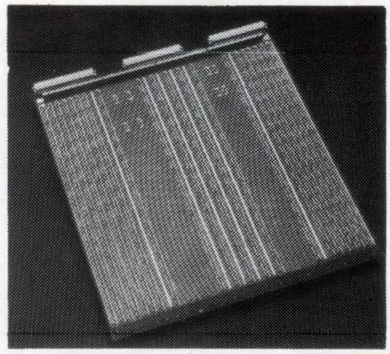
HFBR-X400 fiber-optic transmitter and receiver modules mate directly with both AT&T's ST connector and with bayonet-style connectors from various manufacturers. You can use them in computer-communication channels, industrial systems, and data-communication links of 3 km or less. The modules interface with 62.5/125-, 50/125-, and 100/140-μm multimode fibers.

The module line includes the HFBR-1412, a standard transmitter; the HFBR-1414, a high-power transmitter; the HFBR-2412, a 5Mbaud receiver; and the HFBR-2414, a 25-MHz analog receiver.

The transmitters and receivers come in autoinsertable and wave-solderable DIPs. When operating at 40°C, the units feature an MTBF in excess of 5 million hours. To ease the evaluation process, you can order a kit containing a transmitter, receiver, and 3m of connectorized cable. Modules, $12.50 to $23 (1000); kit (HFBR-0410), $49.95.

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 685

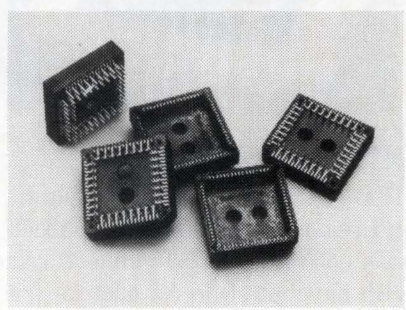


PROTOTYPE PANEL

The 8136-VME940-03D is a 9U×400-mm wire-wrappable panel for use in VME Bus applications. It features 4-layer construction—two ground planes and two V_{CC} planes—that maximize power distribution. Integral surface-mounted decoupling capacitors increase distributed capacitance and decrease overall impedance, making the panel compatible with high-speed logic devices. The panel accommodates as many as 595 16-pin DIPs when you also use the PGA (pin grid array) areas for the ICs. The PGA areas withstand the high power dissipation that is typical of devices in PGA packages. $1583.

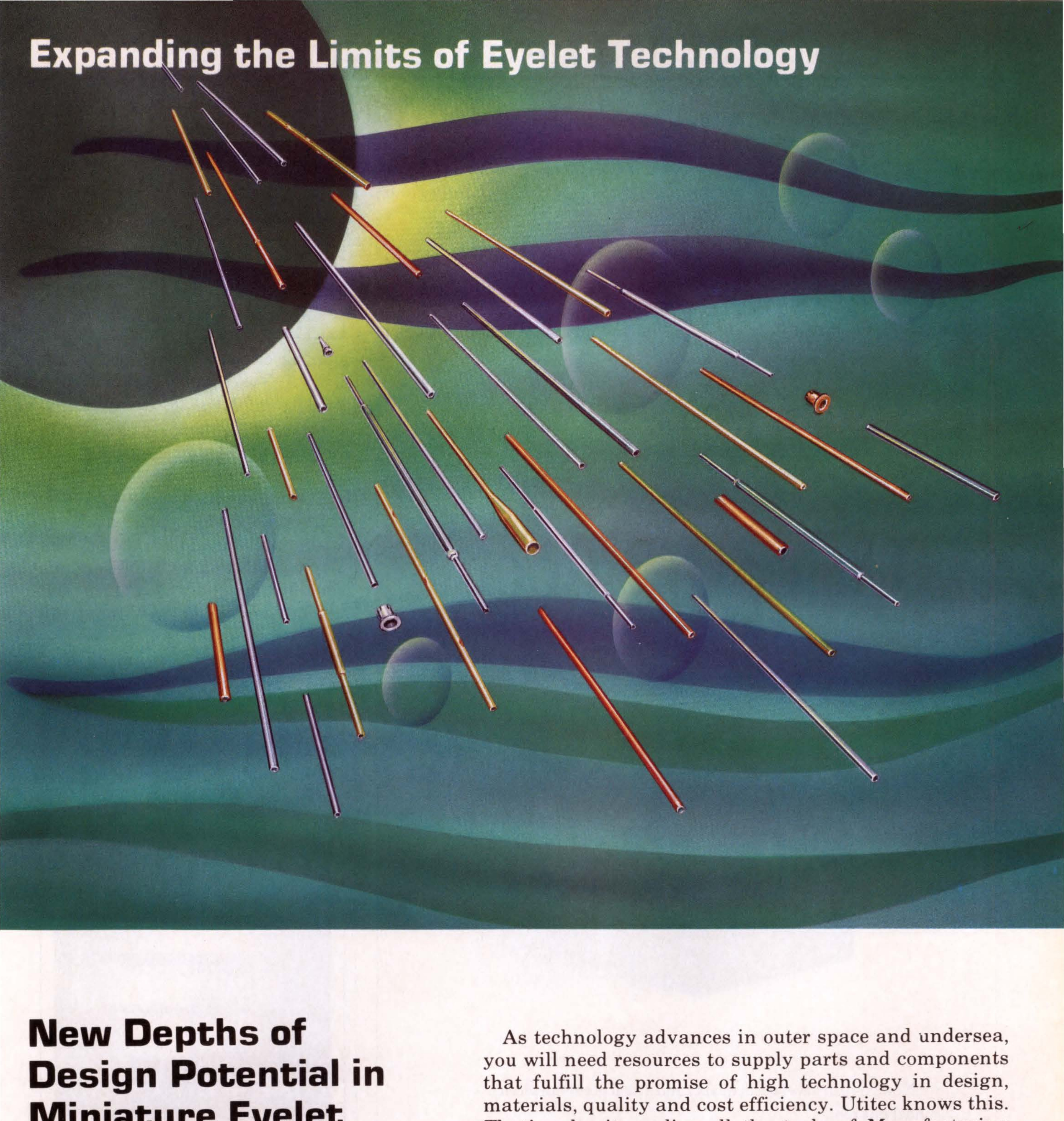
Augat Inc, Box 1037, Attleboro, MA 02703. Phone (617) 222-2202. TWX 710-391-0644.

Circle No 686



SOCKET

The PLCC-068 socket accepts 68-pin PLCC (plastic leaded chip carrier) devices. The socket is JEDEC-qualified for type-A carriers and features an 8×8-position contact array that places contacts on 0.050-in. centers. Its glass-filled polyphenylene sulfide insulator carries a 94V-0 UL rating, and its



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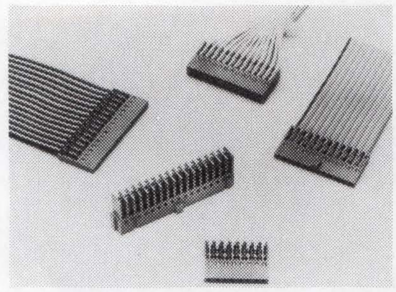
CIRCLE NO 158

preloaded, stamped-and-formed, copper-alloy contacts have a tin-lead plating. The socket features a compact low-profile design and perforated construction to ease board cleaning. The socket's design lets you probe the chip-carrier pins in the circuit. The socket operates over −65 to +125°C. $3 (100). Delivery, stock to eight weeks ARO.

Precicontact Inc, Box 798, Langhorne, PA 19047. Phone (215) 757-1202.

Circle No 687

SOCKET SYSTEM

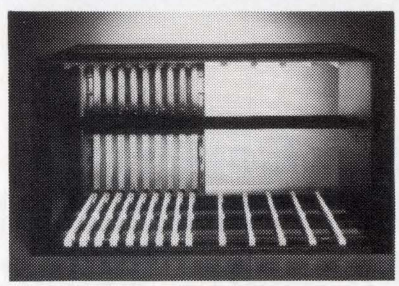


The CHG wire-mount socket system is designed for signal-transmission and logic-power applications requiring current ratings between 1 and 3A. Two contact options accommodate 22/24 or 26/28 AWG discrete-wire or prenotched ribbon cable on a 0.1-in. grid spacing.

You can select 1- and 2-row sockets containing from 2 to 40 or 4 to 80 contacts without polarization or with center-bump polarization. The 2-row military and DIN versions contain from 10 to 80 contacts and are available with or without the center bump. The contact plating includes a choice of 0.1-μin. tin-lead (entire contact) or 10 or 30 μin. of gold over 50 μin. of nickel. $0.96 (1000) for a 1-row, 10-position socket with 30 μin. of gold plating and no center bump.

3M, Dept EP7-99, Box 2963, Austin, TX 78769. Phone (512) 834-1800.

Circle No 688

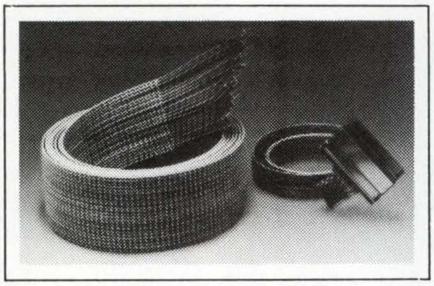


CARD FRAMES

HD167 card frames meet MIL-STD-167 and the IEEE mechanical specification draft P1101. The units are constructed of ⅛-in. aluminum plate and extrusions, which are conductively finished. Their features include positive locking bars for card guides, which prevent rollover; conductive and nonconductive spacers for use in mounting backplanes; and beryllium-copper ground clips to selectively control EMI/RFI emissions on daughter boards. The card frames are available in five standard sizes to suit buses such as the VME Bus, Multibus II, G-64, and Futurebus. The card guides can accept either $\frac{1}{16}$- or $\frac{3}{32}$-in.-thick pc boards with 15¼-in. depths. From $75.

Bicc-Vero Electronics, 1000 Sherman Ave, Hamden, CT 06514. Phone (203) 288-8001.

Circle No 689



COAXIAL CABLE

This subminiature ribbon coaxial cable is highly flexible. You can fold the cable upon itself, bundle it in rectangular or round sections, or group it with other cable for routing.

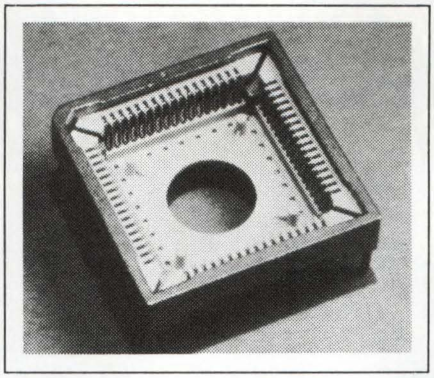
To terminate each signal set, you secure the signal conductor and companion drain wire to the appropriate connector terminals. The vendor can provide custom-designed multilayer paddle cards or pc boards to eliminate impedance mismatch. You can order the cable in varying lengths, with six to 64 signal conductors, single or dual drain wires, and impedances of 50 to 130Ω. $1.25/ft (100 ft).

Woven Electronics, Box 667850, Charlotte, NC 28266. Phone (803) 963-5131.

Circle No 690

BURN-IN SOCKETS

These low-insertion-force, burn-in sockets come in 20- to 68-position versions. They accept square, plastic chip carriers with J leads on 0.05-in. centers.

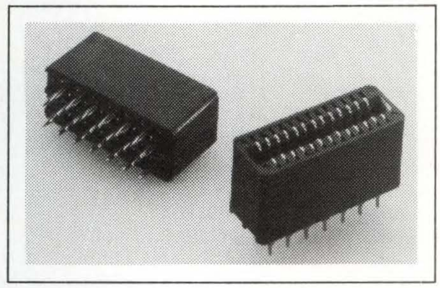


The units feature liquid crystal polymer housings rated for continuous operation at 200°C. You can obtain them with three types of contacts: beryllium copper rated to 200°C, beryllium copper rated to 150°C, and phosphor bronze rated to 125°C.

The contacts feature nickel-boron platings. The sockets have metal-locking frames that reduce insertion forces, and positive ejection systems that facilitate manual or automatic loading and unloading and that also improve heat exchange. Their insertion life specs at 5000 cycles min. From $8, depending on model and quantity.

Mark Eyelet Inc, 63 Wakelee Rd, Wolcott, CT 06716. Phone (203) 756-8847. TWX 510-600-7291.

Circle No 691



CONNECTORS

Mini-Edge pc-board connectors have 0.35-in. profiles and 0.050-in. center-to-center pin spacings. Each of the connectors features 26-contacts arranged in two 13-position rows and gold-over-nickel plating on

Text continued on pg 249


We believed so strongly in Plessey Microsystems' commercial and military computer products,
we bought the company.

Introducing Radstone Technology, a new name with more computer experience than any company in the business.

If you've been following the commercial or military microcomputer industries in recent years, you know that the hot company has been Plessey Microsystems. In VME, for example, we soared from entry level to Number 3 worldwide in just a few short years.

As the management team of Plessey Microsystems, we saw an opportunity to go even higher. Our product development and technical support programs were clearly the class of the industry. But still we weren't satisfied. So, we decided to position the company even better to meet the needs of the commercial and military markets we serve. To do this, we bought the company from our corporate parent, Plessey.

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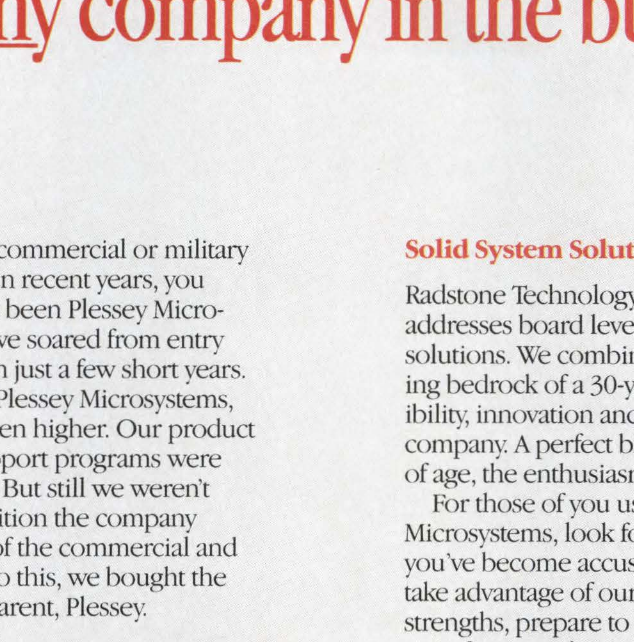
Meet Radstone Technology. A new name, yes. But a solid, well established and fully resourced company with more board level and computer system expertise than any company in the OEM microcomputer market.

Our firsts in the computer industry span a 30-year history of breakthroughs–from developments in core, bubble and semiconductor memory technologies to the world's first 68030-based VMEbus processor board and the world's first and still only true mil spec VME product line.

Today, Radstone Technology means business as usual, only better. We've intensified our product development efforts to further accelerate our growing lead in the introduction of advanced products that match market needs precisely.



Solid System Solutions

Radstone Technology is built on a philosophy that addresses board level hardware, software and systems solutions. We combine the solid technical and marketing bedrock of a 30-year industry veteran with the flexibility, innovation and responsiveness of a brand new company. A perfect blend: the wisdom and experience of age, the enthusiasm and agility of youth.

For those of you used to dealing with us as Plessey Microsystems, look for an increase in the excellence you've become accustomed to. For those of you yet to take advantage of our proven problem solving strengths, prepare to be impressed.

As for our relationship with our former parent, Radstone Technology will continue to be a valued supplier of board and system level products to Plessey's vast telecommunications and defense efforts. We'll also participate in a continuing technology transfer with Plessey through a cross-licensing arrangement. We couldn't ask for a better partner or customer...nor they for a better supplier.

The best is getting even better

Radstone Technology. System solutions through a constantly expanding range of VMEbus processor, controller, I/O and memory boards, software and development systems; full mil spec or ruggedized VMEbus and Multibus boards, software and packaged systems; and bubble memory systems.

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CIRCLE NO 162

the card-edge contact areas; the individually replaceable beryllium-copper contacts apply continuous normal force to 0.022-in. plated-through holes and are arranged in pairs to accommodate double-sided pc boards.

The connectors' 94V-0-rated polyester housings resists the high temperatures of flow soldering. Their molded-in standoffs facilitate cleaning processes. \$5.83 (1000). Delivery, four to six weeks ARO.

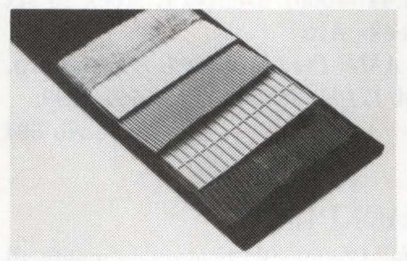
Amp Inc, Box 3608, Harrisburg, PA 17105. Phone (717) 564-0100.

Circle No 693

FLAT CABLE

In addition to providing high impedance and low capacitance, the 3751 PVC flat cable offers full shielding. It's designed for applications involving certain DEC Q Bus- and Unibus-compatible peripherals.

The cable helps you comply with

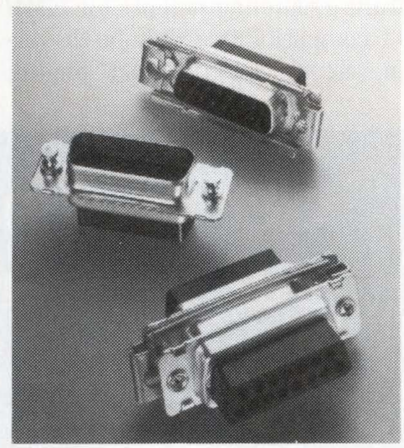


FCC regulations for EMI/ESD protection; it features a full 360° wrap of extended copper shield. Dielectric PVC material, located above and below the cable inside the shield, maintains precise shield-cable spacing, thus providing the high-impedance and low-capacitance values.

The cable is available with 26, 40, and 50 28 AWG conductors on a 0.05-in. center pitch. The impedance measures 90Ω with connectors in ground-signal-ground configuration and 115Ω in the signal-to-ground shield configuration. The capacitance specs at 17.4 pF/ft. \$3.20/ft (1000 ft) for 40-conductor cable.

3M, Box 2963, Austin, TX 78769. Phone (512) 834-1800.

Circle No 692



CONNECTORS

These Amplimite 15-position subminiature D connectors feature preassembled slide latches and locking

CIRCLE NO 163

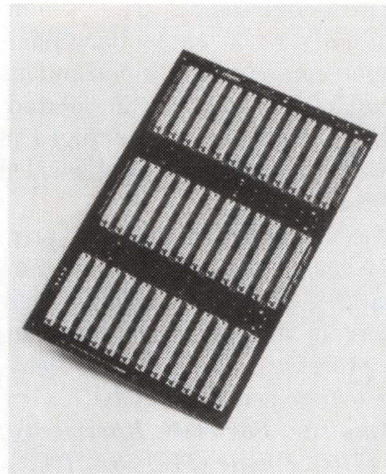
posts that save valuable installation time and effort. Compatible with the IEEE-802 standard for LAN interfaces, these tin-plated, metal-shell plug and receptacle connectors offer a lifetime spec of 500 mating/unmating cycles. The plug shells feature grounding indents for EMI/RFI compatibility. Slide-latch version, $2.30; locking-post model, $1.44 (1000). Delivery, stock to six weeks ARO.

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

Circle No 694

BACKPLANE

This 12-slot, 9U backplane meets all specifications for any Sunbus mod-



els that require such a configuration. Based on transmission-line technology, the backplane is mechanically compatible with both VME and Sun card cages. It duplicates the Sun backplane and includes the signal busing necessary to implement the Sun proprietary P2 bus. The 5-layer combination microstrip/stripline design provides high-performance operation to 40 MHz. Bus bars facilitate the power hookup and disconnection. $1275.

Dawn VME Products, 47073 Warm Springs Blvd, Fremont, CA 94539. Phone (415) 657-4444.

Circle No 697

PROTOTYPING BOARD

The MD12BRD 4-layer universal prototyping board provides an easy way to evaluate high-speed GaAs logic devices. The board, which has nine sites for 16-pin flatpack ICs and three sites for 20-pin flatpack ICs, offers easy access to power-supply and RF interconnections. It is suitable for applications reaching impedance levels as high as 50Ω and clock speeds as high as 5 GHz. The unit comes with application and assembly information, as well as a list of recommended capacitors, termination resistors, heat sinks, and RF interconnections. $100.

California Eastern Laboratories Inc, 3260 Jay St, Santa Clara, CA 95054. Phone (408) 988-3500.

Circle No 696

Integrated tool sets simplify software cross-development

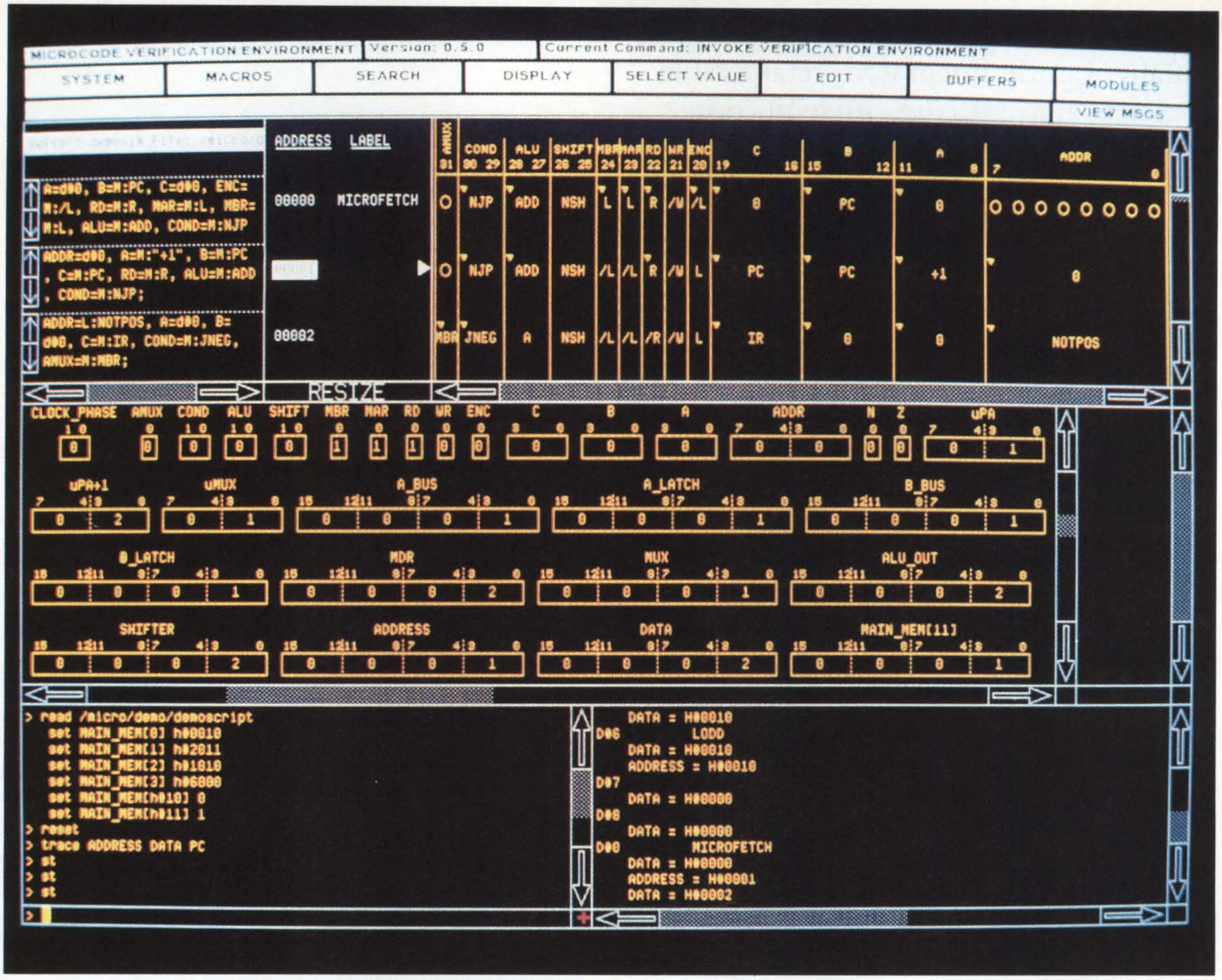
The prevalence of various types of workstations has not only automated some software-development tasks—it's also created a need for sophisticated cross-development tools. Using these packages, you can now write software more easily and efficiently for embedded systems or for structurally dissimilar μPs.

Chris Terry, *Associate Editor*

Three trends in the computer industry have made good cross-development software tools a necessity rather than a luxury: First, software developers are now using powerful yet relatively inexpensive workstations, with graphics and computational capabilities undreamed of only a short time ago, in large numbers. Second, disparate architectures for workstations and other processors are increasing. Third, the use of embedded microprocessor systems is growing rapidly within application areas such as laboratory instruments, domestic appliances, and process-control systems of all kinds. From these concurrent trends has arisen a strong demand for tightly integrated tool sets that provide all of the facilities necessary for generating, testing, debugging, and integrating software that will run on some specific target system, which is quite different from your development machine.

Early tools were makeshift

The idea of using the resources and speed of a large computer to develop software that can run on a machine that lacks development tools is by no means new—some cross-development tools appeared as early as 1970. But at that time, cross-assemblers were scarce, and symbol-



A graphics editor for simplifying microcode development *(Trimeter Technologies Corp)*

ic debuggers were nonexistent. As for cross-compilers, programmers often defined them as "compilers that are guaranteed to make their users cross."

In those early days, the need for cross-development tools was felt only at a relatively few large installations. Dun & Bradstreet, for example, had IBM mainframes at their central database installation and Quotron 16-bit minicomputers at their 75 field offices. Because these minicomputers had only a rather primitive assembler and lacked any high-level-language (HLL) tools, Dun & Bradstreet was forced to commission a Fortran cross-assembler, and later a Fortran cross-compiler, so that it could use mainframe resources to develop new application programs for its minicomputers within a reasonable time. Those tools did work, but they were slow and awkward to use.

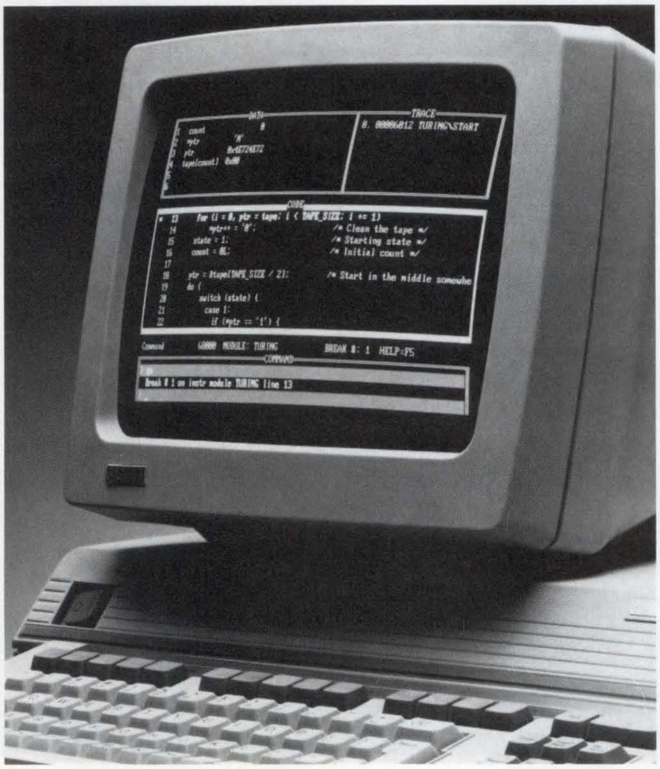
Modern cross-development tools differ from their precursors in several ways. Intensive, long-term studies of translator principles have yielded algorithms for very sophisticated parsing and efficient code generation. In addition, you can now choose to optimize the code either for speed or for the most effective use of limited memory (there's usually a tradeoff between those two goals). Furthermore, if you're designing software for embedded systems, you can find compilers that can generate ROMable code for embedded systems. Finally, tightly integrated, retargetable tool sets are replacing single-purpose compilers for cross-development.

Single-purpose compilers and cross-compilers are limited to one language and one target machine. They generate either native machine code for the target or assembly-language source code. If you obtain the latter, you use a cross-assembler to assemble it into relocatable object code. You can then link that object code with routines from the library that the vendor generally supplies with a compiler. In either case, the compiler produces code for only one kind of target processor. Moreover, each compiler vendor tends to use a proprietary set of directives and switches for optimizing code, handling errors, and listing features. So if you change compilers, you have to learn a new set of rules for using them.

Cross-compilers translate HLLs

Any of the new tool sets can provide all the software-development facilities you need for a number of different target processors. The compiler for a given lan-

Finally, tightly integrated, retargetable tool sets are replacing single-purpose compilers for cross-development.



A typical cross-debugger with multiple windows *(Applied Microsystems Corp)*

guage usually consists of a front end that translates HLL source code into a processor-independent intermediate language, optimizes the code, and generates a symbol table. A symbolic debugger can then use this table to display HLL source code while executing the corresponding machine code.

Modular structure makes compilers retargetable

The addition of a common intermediate language has several important advantages. For any given HLL front end, the vendor can provide a number of hardware-specific, back-end modules that translate the intermediate language into the native machine languages of different target machines. Conversely, for any given target, the vendor can match the back-end module to compatible front-end compiler modules for different high-level languages. Thus, a tool set can support multiple languages and multiple target types, merely by matching the appropriate front-end and back-end modules. The process is simple, economical, and expandable.

What's more, you can easily call routines written in assembly language from any point in the HLL code. Although modern compilers generate faster code than their predecessors, you may still need to write the most time-sensitive routines in assembly language to obtain maximum execution speed—especially for real-time embedded systems.

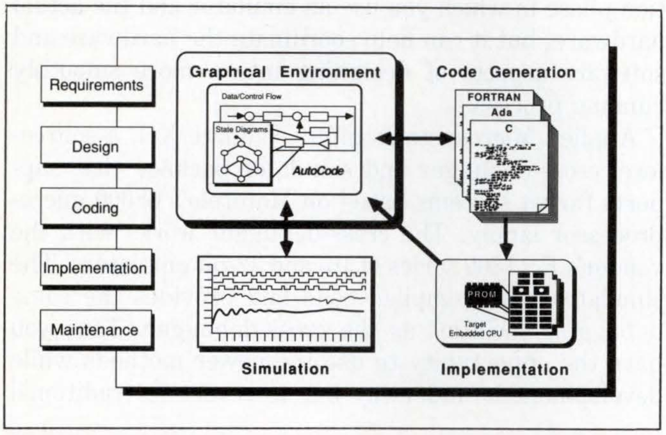
From the user's point of view, the biggest advantage is that the human interface, including all directives and switches, is constant no matter how many different HLLs and target machines you work with. In this way, integrated tool sets can streamline the schedule for any large software project significantly and thus cut costs.

C and Ada prevail

You can find cross-development tools for a variety of programming languages, including C, Pascal, Ada, Forth, Modula-2, PL/M, and others, but the predominant languages are C, for commercial products, and Ada, which is mandatory for all projects related to the US government. C has become popular because it provides good low-level access to the hardware. Unlike Basic and Pascal, it hasn't fragmented into numerous dialects. Also many programmers learn to work in C on a Unix machine in college. Whether C is the ideal language for embedded systems is questionable (you could start a riot by even suggesting such a heresy to Forth, Pascal, or Modula-2 proponents), but it is widely accepted, relatively standard, and conditionally portable. Consequently, commercial tool-set vendors who don't wish to support multiple HLLs generally choose C.

The Intertools series from Intermetrics exemplifies highly integrated cross-development tool sets. It contains a retargetable cross-compiler for C, or Pascal; a run-time library and a librarian for managing program libraries; a linker; a locater that closely controls how and where data and code are placed in the target machine's memory; a ROM processor that automates the downloading of initial data values from ROM to the target's RAM when the program starts executing in the target system; and a source-level debugger that can operate in conjunction with a variety of in-circuit emulators. Ancillary tools include a cross-assembler for the target machine, and a formatter for downloading code to the emulator or target. The formats provided include Intel hex, Motorola S-records, and other industry standards.

Intertools is available for VAX/VMS and VAX/Ultrixc computers; Hewlett-Packard, Sun, and Apollo workstations; and IBM PCs and compatibles. Its target machines include the Intel 8086/186/286 family; Motoro-



***The major steps in the cross-development process** (Integrated Systems Inc)*

la's 6800, 6809, and 68000 families; Zilog's Z80; NEC's V60 and V70; and a variety of 8-bit microcontrollers. The company recently added AMD's 29000 RISC processor to its target list. Compiler prices range from $1000 for a PC host to $7000 for a VAX 8800 host; the corresponding debuggers range from $1500 to $8500.

Intermetrics also sells Ada tools that include a real-time compiler; it runs on IBM mainframes under MVS or VM/CMS. An Ada cross-compiler is also available and runs on VAX machines and generates code for MIL-STD-1750A processors.

Some tool sets generate microcode

If you want to develop systems based on bit-slice or other processors for which you have to write the microcode, you have a choice of integrated tool sets too. Step Engineering sells the Metastep Microprogram Language System for $3000. This tool set lets you define the microcode you'll use, and develop microprograms on an IBM PC/AT or compatible. To test the software, you also need MicroStep ($3695), which includes a plug-in interface card, one or more ROM/PROM/RAM pods, and a debug and control package. The system supports 25-nsec Writable Control Store memories as large as 4k words deep and 128 bits wide.

Another set, the Microcode Assistant from Trimeter Technologies Corp, runs on Apollo workstations and lets you create microword formats graphically, construct complete microprograms using these formats, and then interactively validate their operation. The package has four parts: Using the format editor, you can customize the whole tool set for a specific hardware architecture. With its microprogram editor, you can create and manipulate microcode at the word, block, or macro level. Its mapping format editor maps, with bit-mapped graphics, whatever is the most convenient logical format into the physical format required by the hardware. You can use its multiwindowed simulator to interactively test, debug, and simulate your microprograms. The complete package costs $16,100.

Debugging approaches vary

For embedded systems, you face the compounded problem of trying to write software for still unfinished hardware, whose characteristics are not fully tested. Therefore regardless of what precautions you take to prevent errors in those situations, eventually you must marry the software to the hardware and then thoroughly test and debug it. An in-circuit emulator is essential for running the software and monitoring its performance. Usually a high-speed RS-232C serial line (sometimes a parallel data line) links the emulator to the host development system. This link allows the debugger, running on the host, to pass commands to the emulator and to receive from it reports on all aspects of the performance.

There are two schools of thought on how best to accomplish the integration of the hardware and software. The traditional approach is to supply the design requirements both to the hardware designers and the software designers and to allow them to work more or less independently until the integration phase of the project. At that stage the cross-debugger and in-circuit emulator provide the first indications of how successfully the two groups have met the design requirements.

Given two good teams, whose members communicate with each other throughout the development stages, this approach can work well. If communication in the early stages is inadequate, however, the integration phase may reveal bugs and incompatibilities that can be difficult and expensive to correct. The increasing use of CAE and CASE tools is helping both to bring hardware and software groups together at an earlier stage, and to reduce the time needed to correct any operational problems that arise, but these tools are only just beginning to generate trustworthy code automatically.

Simulation helps software design, too.

As hardware costs drop and the computing power and speed of workstations increase, simulators are becoming more and more valuable. Hardware designers, particularly IC designers, have been using simulators for several years. These products can simulate very precisely on a computer the operation of a proposed

Any of the new tool sets provides all software-development facilities you need for a number of different target processors.

logic design and so detect timing errors and unforeseen interactions between logic elements, long before the designer is committed to hardware (or silicon).

Recently, several vendors of software development tools have introduced simulators that can execute the instruction set for a target machine entirely in software on the host computer. Thus you can exercise and debug your software at speeds close to real time, and discover potential problems long before the target hardware is operational. In addition, because you can test a software module as soon as it's complete, you can alert the hardware designers to any problems you find. The simulator won't eliminate the need for the final integration phase in which you use an emulator and the actual hardware, but it can help coordinate the hardware and software aspects of designing into a more smoothly running process.

Applied Microsystems offers Validate/Xel, a source-level cross-debugger and simulator package that supports target systems based on Motorola's 68000 microprocessor family. The cross-debugger works with the vendor's ES 1800 series of 16- and 32-bit emulators. The simulator runs compiled code and provides the same debugging facilities as the cross-debugger. Thus you have the opportunity to use the newer methods while development is underway but to revert to traditional

For more information . . .

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

Applied Microsystems Corp
Box 97002
Redmond, WA 98073
(206) 882-2000
Circle No 365

Integrated Systems Inc
2500 Mission College Blvd
Santa Clara, CA 95054
(408) 980-1500
TLX 559631
Circle No 366

Intermetrics Inc
733 Concord Ave
Cambridge, MA 02138
(617) 576-3266
Circle No 367

Step Engineering
Box 3166
Sunnyvale, CA 94088
(408) 733-7837
Circle No 368

Trimeter Technologies Corp
200 Hightower Blvd, Suite 100
Pittsburgh, PA 15205
(412) 787-8630
Circle No 369

In addition, EDN has identified the following companies as suppliers of cross-development tools:

Archimedes Software
2159 Union St
San Francisco, CA 94123
(415) 567-4010
Circle No 370

Avocet Systems Inc
Box 490
Rockport, ME 04856
(207) 236-9055
Circle No 371

First Systems Corp
865 Manhattan Beach Blvd
Manhattan Beach, CA 90266
(213) 546-5581
Circle No 372

Harris Corp
Semiconductor Sector
Box 883
Melbourne, FL 32901
(305) 724-7800
Circle No 373

Hewlett-Packard
1501 Page Mill Rd
Palo Alto, CA 94304
Call local office
Circle No 374

Hunter Systems
444 Castro St
Mountain View, CA 94041
(415) 965-2400
Circle No 375

Insignia Solutions Inc
1255 Post St, Suite 625
San Francisco, CA 94109
(415) 771-7001
Circle No 376

Intel Scientific Computers
15201 Greenbriar Pkwy
Beaverton, OR 97006
(503) 629-7631
Circle No 377

Micro Focus
2465 E Bayshore Rd
Palo Alto, CA 94303
(415) 856-4161
Circle No 378

Microtec Research
Box 60337
Sunnyvale, CA 94086
(408) 733-2919
Circle No 379

National Semiconductor Corp
Box 58090
Santa Clara, CA 95052
(408) 749-7432
Circle No 380

Oasys
230 Second Ave
Waltham, MA 02154
(617) 890-7889
Circle No 381

Oregon Software
6915 SW Macadam Ave
Portland, OR 97219
(503) 245-2202
Circle No 382

Quantitative Technology Corp
8700 SW Creekside Pl
Beaverton, OR 97005
(503) 626-3081
Circle No 383

Ready Systems
Box 61029
Palo Alto, CA 94306
(415) 326-2950
Circle No 384

Sierra Systems
6728 Evergreen Ave
Oakland, CA 94611
(415) 339-8200
Circle No 385

SofTech Inc
460 Totten Pond Rd
Waltham, MA 02254
(617) 890-6900
Circle No 386

Symbolics Inc
11 Cambridge Center
Cambridge, MA 02142
(617) 621-7500
Circle No 387

Telesoft
10639 Roselle St
San Diego, CA 92121
(619) 457-2700
Circle No 388

Unisoft Corp
739 Allston Way
Berkeley, CA 94710
(415) 644-1230
Circle No 389

Whitesmiths Ltd
59 Power Rd
Westford, MA 01886
(617) 692-7800
Circle No 390

methods for the final check. The package is intended for use with Microtec Research's MCC68K C cross-compiler. Prices range from $5000 for an IBM PC or compatible host, to $18,000 for a VAX/VMS host.

Simulator acts as real-time embedded system

Integrated Systems Inc offers a simulation tool that is available separately but is a part of a complete CASE system called Autocode. The system is a complete set of design tools for real-time embedded systems, one of which is a module called the Graphical Programming Environment, and the others are a simulator and an automatic code generator. The simulator imitates not only the proposed hardware/software target system, but also the peripheral signals the system responds to and controls. The automatic code generator accepts input from the database of the graphical programming environment, and generates optimized, real-time source code in C, Ada, or Fortran. The source code is ready for compilation or cross-compilation with standard tools. Prices start at $10,000 for each code generator, $19,000 for the graphical programming and simulation tools, and $29,000 for the complete package.

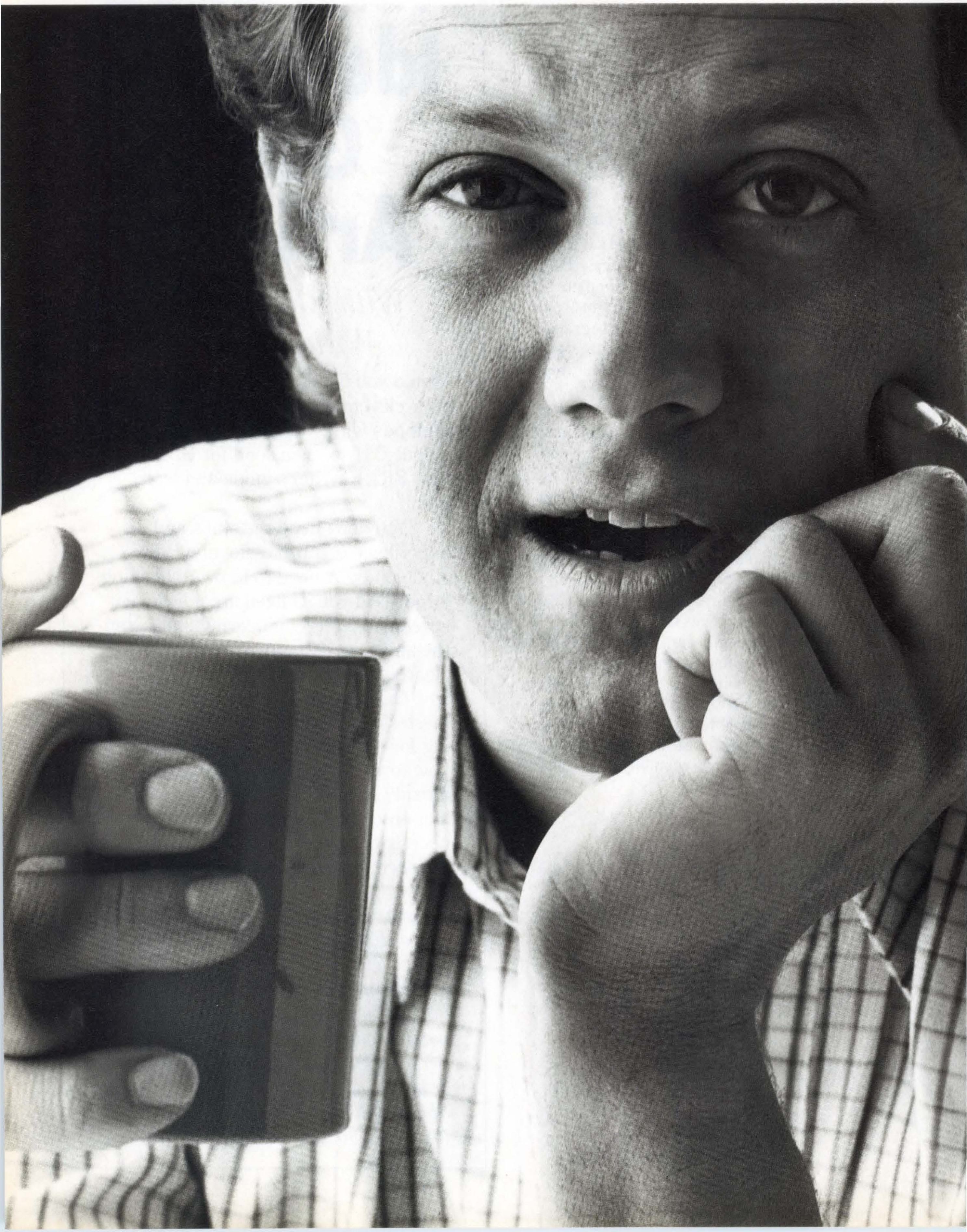
Richard C. Jensen, vice president of Product Development at Applied Microsystems Corp, notes that CAE tools have given design engineers, manufacturing and test engineers, and personnel in auxiliary services, a common language that improves communication between departments considerably. He looks forward to a time when CAE and CASE tools will similarly lead to closer collaboration between the hardware and software designers. Simulators can certainly play a significant role in achieving that goal. **EDN**

References

1. Leibson, Steven H, "HLL cross-compilers speed 1-chip-μC software development," *EDN*, Dec 24, 1987, pg 126.
2. Terry, Chris, "Cross-development tools for PCs and minis let you devlop software for 8-bit μPs," *EDN*, April 15, 1987, pg 89.

Article Interest Quotient (Circle One)
High 470 Medium 471 Low 472

"I shop the specs



because it's my job. But I buy the product because it's my career."

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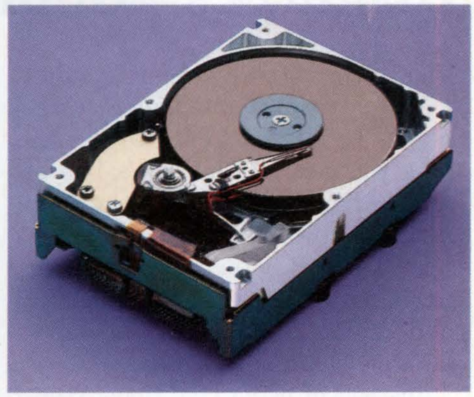

The numbers are the easy part. Either a product has them or it doesn't.

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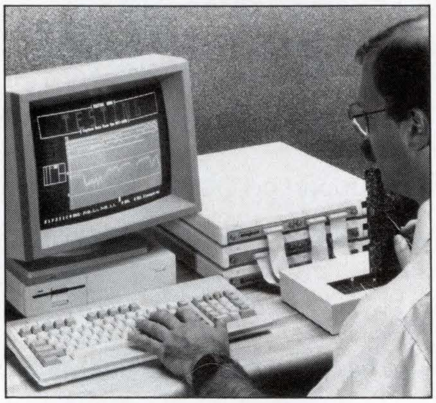
- *42, 84 MB SCSI units in mass production now*
- *42, 84 MB AT-Bus units available early summer '88*

Quantum

Quantum Corporation
1804 McCarthy Blvd.
Milpitas, CA 95035

CIRCLE NO 165

Test-program generator with AI diagnoses populated circuit boards



The DES (diagnostic expert system) employs artificial-intelligence techniques to quickly generate debugging routines for the firm's line of analog/digital test systems costing under $10,000. Test programs developed with DES prompt the operator to check nodes, tweak adjustments, and replace components in populated pc boards under test.

Instead of using traditional step-by-step programming, the test-program generator learns to recognize fault conditions in your boards. You create a fault dictionary by either simulating failures in software or adding fault conditions to the dictionary as they occur during normal testing. You expand the software's database of error patterns and their associated causes by simply typing in the cause of new errors as you encounter them.

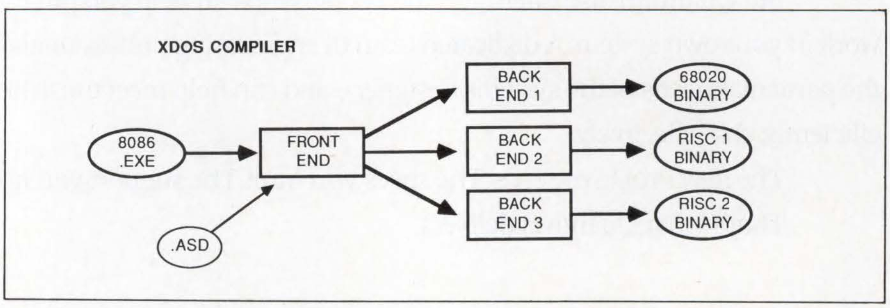
Using a graphics editor, you can manually enter analog and digital test vectors, reference data, and tolerance guardbands. Alternatively, the software can learn these parameters from the system under test by analyzing a statistically valid sample of known-good boards. With proper format-conversion routines, the software can also accept test vectors from software circuit simulators.

The software can also capture a sequence of manually executed test steps, store the sequence as a macro, and then later execute the macro automatically. DES costs $1985, and test systems start at $6669. A DES demo disk is free.

Array Analysis Inc, 200 Langmuir Lab, Brown Rd, Ithaca, NY 14850. Phone (607) 257-6800; in NY, (800) 451-8514.

Circle No 444

Unix utility converts 8086 code into executable 68020 code



XDOS converts binary-code programs written for the IBM PC to binary images for Unix computers. This Unix utility program for 68020-based computers includes a binary compiler that performs the code conversion and an emulator for MS-DOS. It permits the end user to simultaneously execute multiple, converted, IBM PC programs in Unix windows.

In a two-stage conversion process, XDOS converts MS-DOS programs without modifying them. First, the binary compiler analyzes instruction flow and generates a proprietary, intermediate data format. Then, the optimizing compiler generates executable code for the target system.

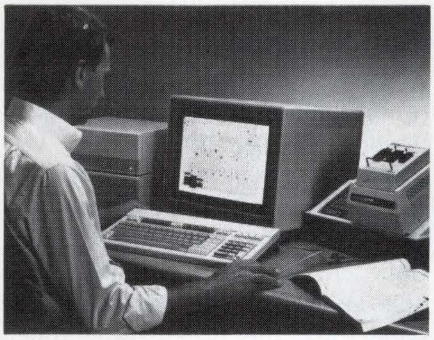
After the compiler has performed the conversion, the end user can directly execute the program on the Unix system, because the XDOS utility maps MS-DOS, MS-DOS BIOS, and hardware system calls to Unix calls, and also manages calls that invoke MS-DOS data structures.

Programs converted with XDOS are not affected by the MS-DOS limit of 32M-byte disk volumes and can therefore use the full Unix disk capacity. The programs can read and write Unix files because the package maps the MS-DOS files onto Unix files. XDOS also provides a Unix utility that reads MS-DOS files. End-user pricing ranges from $425 to $2000, depending on the number of users the Unix system supports.

Hunter Systems, 444 Castro St, Mountain View, CA 94041. Phone (415) 965-2400.

Circle No 445

PLD design software accepts designs as schematics, waveforms, or tables



The 74150A PLD Design System software accepts PLD design specifications as Boolean equations, schematics, waveforms, and state-transition or truth tables. The software runs on the company's Model 9000 Series 300 workstations. It takes your design, minimizes its equations, simulates its operation, checks for glitches, selects target PLDs, partitions the design to fit in one or more PLDs, and generates a PLD fuse map and test vectors.

The software's waveform editor allows you to define a PLD using timing diagrams. For synchronous circuit design, you can create state-transition diagrams (STDs) with a special STD editor that shows individual states as boxes linked with state-transition arrows and pop-up state-transition tables.

The software accepts designs without regard to a target PLD. You can also ask the PLD Design System to select the most appropriate device automatically from its PLD library, and you can specify vendor-type, inventory, or power-consumption parameters. The PLD library contains devices from Altera, AMD, Intel, Lattice, Monolithic Memories, NEC, Ricoh/Panatech, Signetics, and VTI.

The PLD Design System can exchange circuit and simulation data with the other software tools in the company's Electronic Design System for complete board-level design entry and simulation. The PLD Design System costs $8000 to $14,500. Delivery is 12 weeks ARO.

Hewlett-Packard Co, 1820 Embarcadero Rd, Palo Alto, CA 94303. Phone local office.

Circle No 446

Real-time operating system runs at twice the speed of other systems

According to its maker, the BSO/Realtime Craft real-time operating system (RTOS) runs at least twice as fast as any other 16- or 32-bit RTOS. The system is written in assembly language for Intel 8086/286 (286 real mode only), Motorola 68000/20, and National Semiconductor 32000 μPs. Compiler interfaces are available for Intel C and Pascal, Microsoft C, Alsys Ada, and all of the manufacturer's compilers.

Running on an 8-MHz 8086 or 68000 μP, the system performs a complete context switch in 110 μsec; each of the system executive's 28 primitives requires between 25 and 60 μsec for execution. The application program makes all operating-system calls via software interrupts.

The system comprises four modules: the real-time executive, an input-output supervisor, a file-management system, and a debugger. BSO/Realtime Craft comes burnt into a PROM. The executive, for example, occupies less than 3k bytes of PROM space.

The input-output supervisor provides hooks for user-written device drivers and allows for dynamic allocation of RTOS objects such as tasks, programs, semaphores, and mailboxes. It also manages the dynamic allocation of memory. Drivers for some common peripherals are available. Each real-time task can dynamically specify the size of its memory buffers.

The file-management system works with the I/O supervisor to provide cached disk I/O, and it can read Unix files. The maker claims that you can always read your files even in the event of a system crash or after a power failure. BSO/Realtime Craft costs $6300 to $16,000, depending on the number of modules licensed.

Boston Systems Office Inc, 128 Technology Ctr, Waltham, MA 02254. Phone (617) 894-7800. TWX 710-324-0760. FAX (617) 642-5762.

Circle No 447

Software package merges Unix and real-time executives

Based around the Unix System V operating system and Ready Systems' VRTX32 real-time executive, VXCEL provides an integrated environment for the development and supervision of real-time multiprocessor VME Bus applications. The package is compatible with the company's range of VME Bus boards, and allows both a processor running Unix and processors running real-time applications to coexist on the same VME Bus backplane without compromising system performance. VXCHIP, a ROM-resident multiprocessor executive with built-in communications channels to the Unix host processor, accompanies each real-time processor.

The Unix host environment allows you to use a wide range of commercially available software tools for program generation. VXCEL's command interpreter, VXSHELL, then allows you to interact with multiple target boards to download, debug, and execute your real-time program code. The debugger displays the VXCHIP status, as well as data structures such as queues, event flags, semaphores, and mailboxes that exist on each of the system's real-time processors.

In addition to providing a multitasking executive, VXCHIP includes facilities for I/O management, file management, distributed processing, Unix host communications, and integrated debugging. Local disk facilites include an MS-DOS-compatible file system.

A message-passing scheme, which uses a shared VME Bus memory architecture, supports distributed processing. This architecture allows task-to-task or task-to-group communications between processors. If system facilities are not directly available on one processor, you can access them by executing a remote procedure call to another processor. In addition, a name server allows you to make local or global objects visible to other processors in the system. License charges for VXCEL range from $6000 to $12,000, depending on the system configuration and the software modules.

Plessey Microsystems Ltd, Water Lane, Towcester, Northants NN12 7JN, UK. Phone (0327) 50312. TLX 31628.

Circle No 448

Plessey Microsystems, 1 Blue Hill Plaza, Pearl River, NY 10955. Phone (914) 735-4661. TWX 710-541-1512.

Circle No 449

CIRCLE NO 166

SIMULATOR

The Libra harmonic-balance simulation program combines linear analysis in the frequency domain with time-domain analysis of nonlinear elements. The package includes the vendor's Touchstone frequency-domain simulator for linear simulation. By extending the file to include appropriate models, you can add nonlinear-analysis capabilities. The simulator will show you time-dependent voltage waveforms at any node; time-dependent current into any nonlinear device; power density and total power; frequency-selective power; and frequency-selective voltage and current, including phase response.

You can transfer all of the data from a simulation to a disk file. If you need steady-state response to sinusoidal waveforms, the package lets you obtain solutions based on the vendor's library of microwave components. A new large-signal and small-signal model for GaAs FET transistors improves the precision of nonlinear simulations of microwave active networks. The program currently runs on VAX/VMS workstations, Apollo Domain-IX workstations, and HP 9000, Series 300 computers under the HP-UX operating system. From $20,000.

EEsof Inc, 5795 Lindero Canyon Rd, Westlake Village, CA 91362. Phone (818) 991-7530. TLX 384809.

Circle No 525

NEURAL-NET TUTORIAL

Netwurkz introduces you to associative-memory concepts and their implementation by means of a neural model. This model consists of processing elements, analogous to neurons, that use rules such as the sum of products to produce an output from multiple inputs. The output of one neuron can form part of the input to other neurons to produce an aggregate (a neural net), which can learn complex patterns and recall patterns correctly, even when the input is not an exact match.

The associative-memory demo comes with a PL/D compiler that lets you add new Data statements in the demo or modify existing statements. The example uses approximately 50 neurons, and you can expand the net to a maximum of 1000 neurons. To run the program, you'll need an IBM PC, PC/XT, or PC/AT that's equipped with at least 192k bytes of RAM and MS-DOS version 2.0 or later. Netwurkz, $79.95; PL/D compiler, $124.95; both programs, $154.95.

DAIR Computer Systems, 3440 Kenneth Dr, Palo Alto, CA 94303. Phone (415) 494-7081.

Circle No 526

SOFTWARE TOOL

This version of the chipForth software-development system allows you to write and debug software for Intel's 8051/8031 family of microcontrollers without using an in-circuit emulator. Instead, chipForth provides you interactive program development, using only the on-chip RAM of the μC and a ROM emulator. You can write programs that use only the on-chip RAM and ROM of the μC or programs that use the 8051's 64k bytes of external data and program space. You can also implement systems with overlapping data and program space.

The development system uses the Forth programming language, which combines an editor, an assembler, and a compiler. This development software runs on an IBM PC, PC/XT, or PC/AT linked to the target system via a serial port. The Forth multitasking kernel that's supplied uses as few as 40 bytes/task. It imposes no overhead on the μC's interrupt handling and does not affect its bit-handling capabilities. £1800.

Computer Solutions Ltd, Canada Rd, Byfleet, Surrey KT14 7HQ, UK. Phone (09323) 52744. TLX 946240 (Request ref 19012265).

Circle No 529

IEEE-488 DEVICE DRIVER

The NI-488 MS-DOS device-driver software package helps you develop instrument-control software on IBM PC and PS/2 computers. The enhancements to the package support Version 4 of Microsoft's QuickBasic. They also include an applications monitor that gives you program-tracing facilities and a special interrupt service request, using the Basic On Pen statement. This feature eliminates the need for continuous polling to capture instrument service requests.

The package includes a QuickBasic language-interface library and a BasicA library. You can instruct the monitor to install breakpoints that show the details of the most recently executed IEEE-488 call on a pop-up screen. The display can also show you a listing of as many as 255 of the preceding IEEE-488 calls. This feature obviates inserting debugging statements in the instrument-control source code. The package is included with the vendor's GPIB-PCII, $395; GPIB-PCIIA-2, $495; and MC-GPIB,$495 interface boards. Current users of these products may upgrade to the new package at nominal cost.

National Instruments, 12109 Technology Blvd, Austin, TX 78727. Phone (800) 531-4742; in TX, (800) 433-3488. TLX 756737.

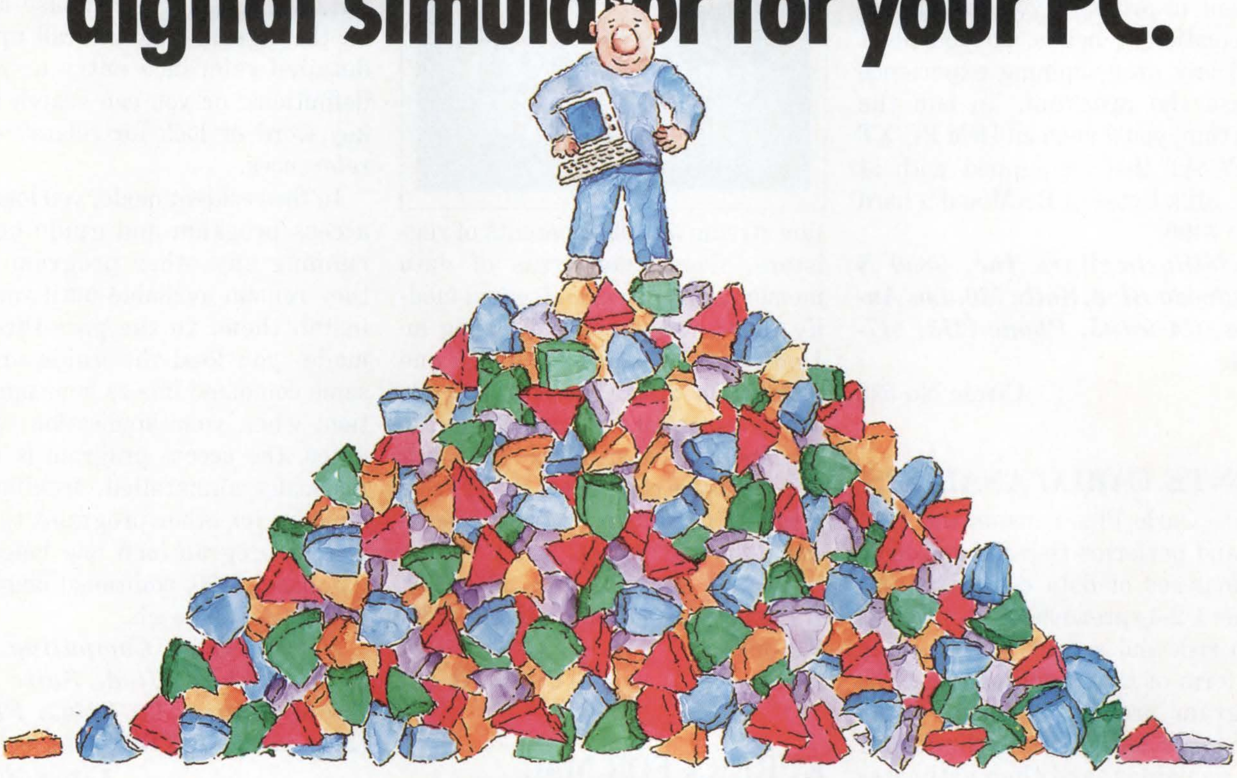
Circle No 527

DATABASE ANALYZER

IXL: The Machine Learning System combines statistical methods, symbolic data analysis, induction, and deduction to explore and reveal previously unknown data interdependencies and relationships in very large databases. You can specify the level of error you are willing to accept, the kind of rules that the program should use, and the concepts (both exact and inexact) that the program should use in constructing the rules.

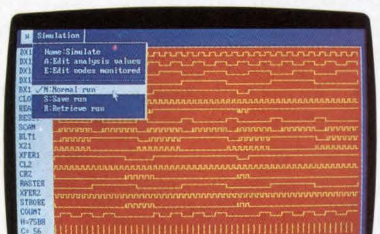
The program presents its results in the form of the percentages of

MICRO-LOGIC II.™
The CAE tool with a 10,000-gate digital simulator for your PC.



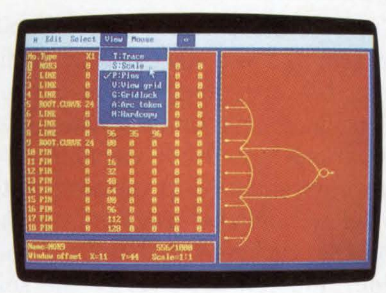
Spectrum Software's MICRO-LOGIC II® puts you on top of the most complex logic design problems. With a powerful total capacity of 10,000 gates, MICRO-LOGIC II helps engineers tackle tough design and simulation problems right at their PCs.

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.

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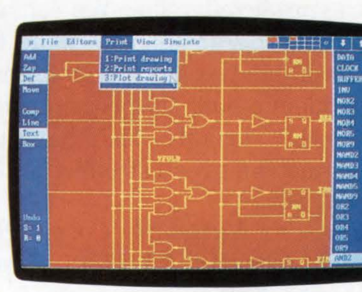


Schematic Editor

spectrum

1021 S. Wolfe Road, Dept. E
Sunnyvale, CA 94087
(408) 738-4387

CIRCLE NO 175

data elements that conform to each rule, with a confidence factor based on the variations in the database contents. The user interface is menu driven; it prompts you for all the information it needs, so you don't need any programming experience to use the program. To run the program, you'll need an IBM PC/XT or PC/AT that's equipped with at least 512k bytes of RAM and a hard disk. $490.

IntelligenceWare Inc, 9800 S Sepulveda Blvd, Suite 730, Los Angeles, CA 90045. Phone (213) 417-8896.

Circle No 528

MONTE CARLO ANALYSIS

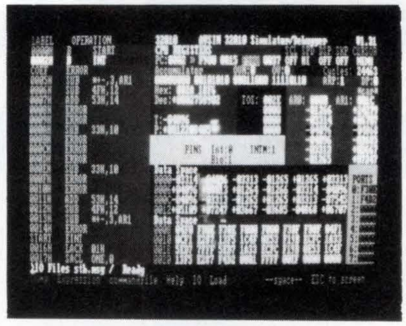
Monte Carlo Plus runs on the IBM PC and performs risk and sensitivity analyses of data contained in a Lotus 1-2-3 spreadsheet; it provides both risk and sensitivity results in the form of tables and graphs. The program prompts you to supply high- and low-accuracy limits for key variables, and then estimates the statistical probability that a particular result computed by the spreadsheet will exceed or fall short of the predicted value. You can also use the program to determine the effect of independent variables on a dependent result; the program identifies the variables that have the least and the greatest effect on the result. $89.

Suntex National Corp, Box 772868, Houston, TX 77215. Phone (713) 783-9059.

Circle No 530

DSP SIMULATORS

The AVSIM321 and AVSIM322 are software simulators/debuggers for the Texas Instruments 32010 and 32020 families of digital signal-processing chips. They run on an IBM PC or a compatible computer, and interactively execute object code under the control of a full-screen symbolic debugger. The screen display shows you the current instruc-



tion stream and the contents of registers, flags, and areas of data memory. You can examine and modify these at any time; by using an Undo key, you can back up, one instruction at a time, through recently executed instructions to determine where an error occurred. You can issue commands either from a menu structure or from a command line. $379 each.

Avocet Systems Inc, Box 490, Rockport, ME 04856. Phone (207) 236-9055.

Circle No 531

EUREKA FOR MAC

Eureka: The Solver is a mathematical tool that lets you use your Macintosh to solve mathematical problems, including simultaneous linear equations in multiple variables. You enter an equation in the text-editor window, and the program searches for the variables and finds a solution. You can then verify the solution, plot it, or send a report to the printer or to a disk file. The program can use the Macintosh II's 60881 math coprocessor and color capabilities. $195.

Borland International Inc, 4585 Scotts Valley Drive, Scotts Valley, CA 95066. Phone (408) 438-8400. TLX 172373.

Circle No 532

ON-LINE MANUALS

The Norton On-Line Programmer's Guides provide reference material for 8088 assembly language as well as for the Basic, Pascal, and C languages. You load a RAM-resident access program, which occupies 65k bytes, and a language database; while you're running an application program, pressing Shift and F1 puts the language-database menu on the screen. You can call up the detailed reference entry or short definitions; or you can search for a key word or look for related cross references.

In the resident mode, you load the access program and guide before running any other program, and they remain available until you uninstall them. In the pass-through mode, you load the guide on the same command line as your application; when your application terminates, the access program is automatically uninstalled, freeing the memory for other programs to use. Access program and one language database, $100; additional language databases, $50 each.

Peter Norton Computing Inc, 2210 Wilshire Blvd, Suite 186, Santa Monica, CA 90403. Phone (213) 453-2361. TWX 650-226-1869.

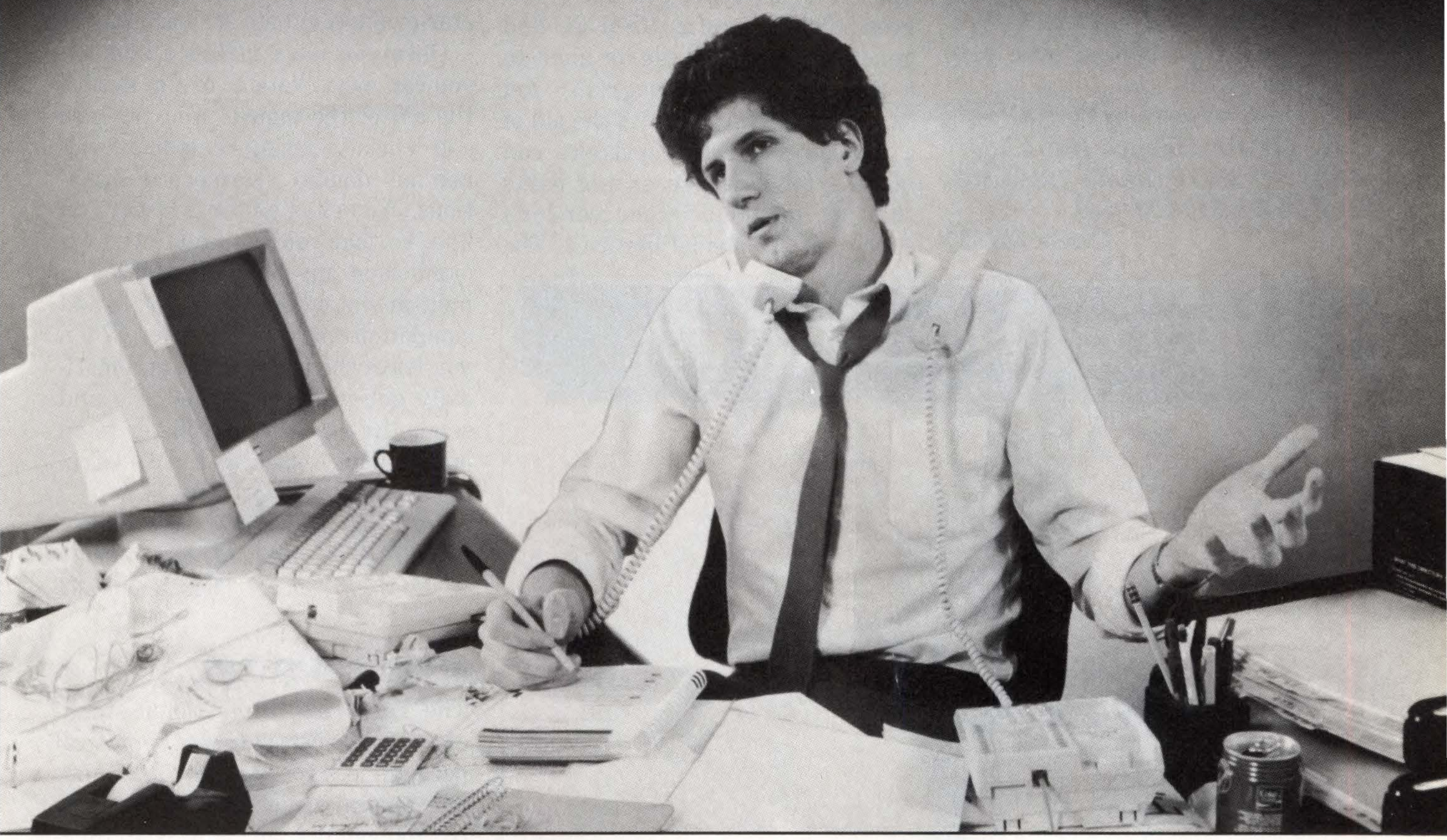
Circle No 533

REAL-TIME OS

You can use the UniFlex/RT multiuser, multitasking operating system for VME Bus systems based on the 68020 processor with the Macintosh II. The real-time features include fast message exchanges, a named enqueue/dequeue mechanism, and shared data pages and text segments. The OS runs on a minimal Macintosh II computer that has at least 1M byte of main memory, 20M bytes of disk storage space free, and the 68851 memory-management chip. If you have a larger hard disk, you can partition the disk so that you can use the Mac OS as well as UniFlex/RT.

The system comes with the utilities for real-time, assembly-language software development, including a relocating macroassembler, a linking loader, a library generator, and a symbolic debugger, as well as file- and system-

WHO DO YOU CALL WHEN YOUR DEBUGGER WON'T DEBUG?



The problem with most real-time operating systems is simple, they're not an integrated solution. You end up dealing with a multitude of suppliers for languages, compilers, debuggers and other important development tools. And when something does go wrong, it can be a frustrating experience trying to straighten out the mess.

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- uMACS Text Editor
- Electronic Mail
- Communications
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- Math Coprocessor Support

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- Fortran
- Ada**
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Microware Japan Ltd.
41-19 Honcho 4-Chome
Funabashi City
Chiba 273, Japan
Phone: 0474 (22) 1747

CIRCLE NO 176

maintenance programs. You can obtain such options as a System V-compatible C compiler, X-Windows, a screen editor, or a text processor. $750.

Technical Systems Consultants Inc, 111 Providence Rd, Chapel Hill, NC 27514. Phone (919) 493-1451. TWX 510-920-0540.

Circle No 537

SCHEMATIC CAPTURE

Spice_Net is a schematic-entry program that runs on an IBM PC and generates an ASCII file for input to a Spice simulator program. You draw your schematic with the aid of a mouse; a single keystroke can place symbols representing parts that are included in the vendor's subcircuit and model libraries. The symbol library contains drawing information, connectivity, and parameter-evaluation data for each part.

Once you have placed a symbol, you can move, rotate, or flip it with the aid of the mouse. You can also add labels to assign component values and display reference designations. A symbol editor is always on line, so that you can create custom symbols at any time. In addition, a built-in text editor allows you to add simulation-control directives. When you leave the program, it automatically generates a net-list file and sends the drawing to a file or to an output device such as a dot-matrix printer or a plotter. $295.

Intusoft, Box 6607, San Pedro, CA 90734. Phone (213) 833-0710.

Circle No 534

MATH SOFTWARE

The MathView Professional standalone, interactive mathematical package lets you evaluate and tabulate several variables simultaneously. You can plot as many as 10 functions simultaneously in Cartesian or polar coordinates; plot parametric relationships and raw data sets; and plot surfaces in 3-D, with the option of removing hidden lines.

The package can solve linear systems of equations or eigenvalues for symmetric matrices, compute direct and inverse FFTs, and perform extensive matrix operations. It can also solve nonlinear systems of equations, using either Newton's method or the Broyden algorithm; solve ordinary and partial differential equations; and compute integrals by various methods.

In addition to providing a comprehensive set of descriptive statistical functions, the package lets you determine series coefficients and Chebyshev, Legendre, and Bessel elliptic functions. To run the package, you need a Macintosh equipped with at least 512k bytes of RAM, 128k-byte (or larger) ROMs, and two 800k-byte floppy-disk drives or a hard disk. $249.95.

Brainpower Inc, 24009 Ventura Blvd, Suite 250, Calabasas, CA 91302. Phone (818) 884-6911.

Circle No 536

RF SIMULATION

You can use the enhanced simulation program Touchstone version 1.6 for the design, analysis, and optimization of microwave/RF circuits. A new sparse-admittance matrix-reduction feature permits this version of the simulation program to use computer memory more efficiently than did earlier versions and speeds up the analysis of large, complex circuits. You can include as many as 250 variables and equations in a circuit file. Other added features and capabilities include a sweep progress indicator, print- and plot-interrupt facilities, and the ability to make VSWR measurements and to simulate stripline-cross and stripline-curve elements.

The network-analyzer interface works with the Wiltron 360 vector network analyzer, as well as with HP network analyzers. The program runs on IBM PCs, VAXs, HP 9000 Series 300 machines, and Apollo and Sun workstations. From $9900.

EEsof Inc, 5795 Lindero Canyon Rd, Westlake Village, CA 91362. Phone (818) 881-7530.

Circle No 535

CROSS-DEVELOPER

The ST Universal Cross-Development Kit runs on Atari 520, 1040, and Mega-ST computers. The package includes a text editor with which you can write assembly-language programs for a wide variety of 4-, 8-, and 16-bit μPs and microcontrollers. The table-driven cross-assembler translates the source code into the target machine's native code. The cross-assembler contains tables for 20 μPs, including the HD64180, Z80, 6502, 68000, 8048, 8051, 8085, 8086/88, and 8096.

When you've assembled your program, you can download the object code to the EPROM emulator, which plugs into the target machine's EPROM socket. The emulator is compatible with EPROMs in the 2716 through 27256 families. The access time for the emulator is 150-nsec. For downloading purposes, both the cross-assembler and the EPROM emulator can handle Intel Hex, Motorola S-record, and simple binary formats. Most serial EPROM programmers can operate with at least one of these formats. $575.

Memocom, 1920 Arbor Creek Dr, Carrollton, TX 95010. Phone (214) 446-9906.

Circle No 538

CAE FOR MAC

The EDS-I electronic-design software system runs on the Apple Macintosh II. The schematic-capture module lets you generate schematics, using both standard and user-defined component libraries, and automatically produces a net list and a parts list. The layout module can handle pc-boards as large as 32×32 in. and provides zoom and pan features, auto-tooling extraction, multilayer editing, and Gerber photoplotting files. The autorouting module accepts the net list and parts list as input, lets you define routing parameters and options as well as keep-out areas, and lists unfinished nets.

The Gerber translator module lets you convert Gerber files created by other systems into the electronic design software's internal format, or Gerber files produced by the software into PostScript files for use by high-resolution graphics printers in the Linotronics 300/500 series so you can check the photoplot drawings before committing them to film. You can order modules separately. Full system, $1500.

Vamp, 6753 Selma Ave, Los Angeles, CA 90028. Phone (213) 466-5533. TWX 650-262-3069.

Circle No 539

CASE TOOLS

The C Documenter and C Scan utilities for the IBM PC aid in documenting and examining programs written in the C programming language. Where such programs are subdivided into separate subsystems, C Documenter generates a set of four reports containing cross-reference information, such as which modules or functions are called by other modules or functions. You can use the reports to define the interface between two program subsystems—even those written by different programmmers.

When you examine your programs, C Scan lets you use symbolic names to locate and display portions of code, regardless of the source-code file in which they're contained. By keeping a record of your program's files, C Scan lists the type of items in the program, such as functions, global variables, structures, and union members; upon your selection of an item, C Scan displays all items of that type in your program and lets you locate them. You can obtain the utilities separately or as part of the C Dev cross-development tool set, which includes a C cross compiler, a mimic simulator, and a cross-assembler. C Scan, £195; C Documenter, £195; C Dev, approximately £2000.

Real Time Systems Ltd, Viking House, Nelson St, Douglas, Isle of Man, UK. Phone (0624) 26021. TLX 94011289.

Circle No 540

FAX PACKAGE

The PC FAX package allows you to use an IBM PC/XT, PC/AT, or compatible computer to send or receive FAX messages to or from any International Group III FAX machine. You can also use it to send telex or electronic mail. The package can transmit or receive any word-processed document, desktop publishing image, or paint-box system image.

You can generate input from the PC's memory or keyboard, from an optional digitizer tablet, or from a hard-copy scanner or an existing FAX machine. In addition, the FAX software can capture and transmit drawings generated by CAD packages. In normal mode, the package provides 202×98-pixel FAX, but you can select a fine mode that increases resolution to 204×196 pixels.

Although the standard software operates to International Group III CCITT FAX standards, you can upgrade it to Group IV. The transmission software includes a directory of FAX numbers, and automatic dialing and redialing facilities. You can also program the software to transmit messages during cheap-rate periods, and to poll other FAX or communications systems to check for any FAX messages programmed for transmission to your PC's number.

The PC can receive FAX messages while you're using it for other tasks. When incoming FAX messages are automatically saved to disk, you are alerted by audible and on-screen prompts. You can then recall messages to the PC's screen, zoom in on them to examine fine detail, or output them to a printer or plotter. An optical character recognition (OCR) package that can learn new character fonts is optionally available. The PC-FAX package, including the telephone-line interface hardware, costs £895. The OCR package costs £395.

Softech Professional Systems Ltd, 9 Tonbridge Chambers, Pembury Rd, Tonbridge, Kent TN9 2HZ, UK. Phone (0732) 362688. FAX (0732) 770263.

Circle No 553

IEEE-488 SOFTWARE

This IEEE-488 management software package allows a VME Bus computer system to control an IEEE-488 instrumentation bus via the company's CC-91 IEEE-488 interface card. It allows you to implement IEEE-488 talker, listener, and system controller functions. The software comprises an IEEE-488 manager and an IEEE-488 device driver, running under the OS-9/68k operating system, and allowing you to write application programs in C or Pascal.

Running as a background task, the manager configures and initializes the IEEE-488 bus, and arbitrates all communication between the IEEE-488 device-driver software and the application program. To execute an IEEE-488 bus operation, the application program passes a command-parameter block, specifying the device name and address, the action required, and the source

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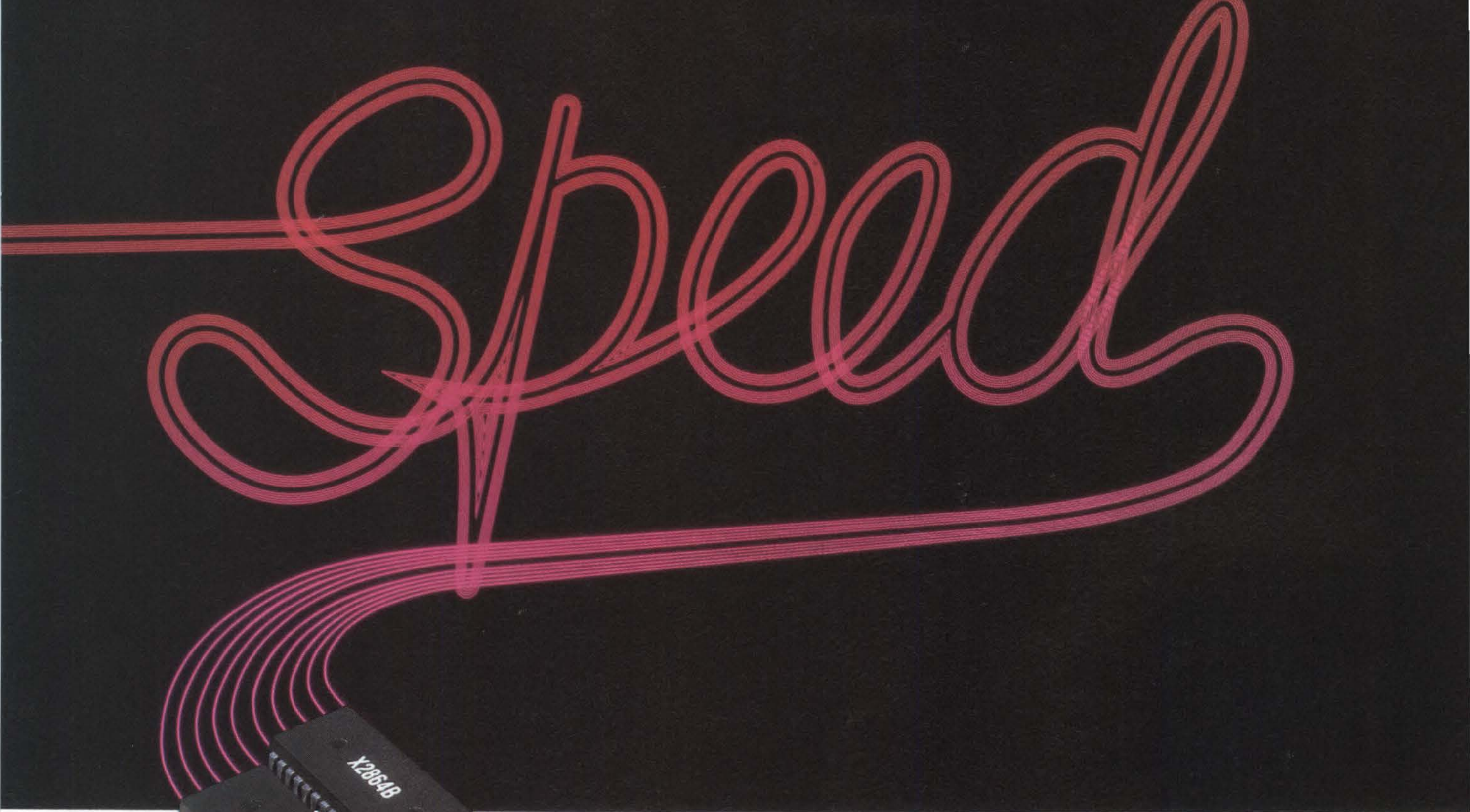

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and destination of transferred data via the manager to the device driver. A device descriptor provides the driver with information about the addressed device's IEEE-488 capabilities. The manager also includes a time-out monitor to detect excessive delay in an instrument's response. Sample device descriptors, a menu-driven system test program, and sample application programs are included in the software package. Approximately $750.

Compcontrol bv, Stratumsedijk 31, 5600 AD Eindhoven, The Netherlands. Phone (040) 124955. TLX 51603.

Circle No 551

Compcontrol Inc, 15466 Los Gatos Blvd, Suite 109-365, Los Gatos, CA 95032. Phone (408) 356-3817. TWX 510-601-2895.

Circle No 552

DIAGNOSIS TOOL

The TestBench software package uses artificial intelligence techniques to build expert systems for the diagnosis and repair of malfunctions in complex machines and processes. It consists of three modules: TestBuilder, TestBridge, and TestView. The TestBuilder expert-system development system, which runs on a TI Explorer, helps you acquire an expert technician's knowledge of the diagnostic and repair procedures for a complex machine or process, and builds a knowledge base that combines this information with documentation and rules of thumb. When you have completed the knowledge base, a less expert technician can run the expert system and receive guidance in troubleshooting and repairing the target equipment.

TestBridge translates the information captured by the development system into a form that Test View can use, a similar expert system that runs on an IBM PC/AT or compatible. Thus, you can develop a diagnostic expert system on the Explorer and distribute it to several repair stations that can run it on the much less expensive PC/AT. Complete TestBench package, including one week of training and one year of software maintenance, $42,000.

Texas Instruments Data Systems Group, Box 2909, Austin, TX 78769. Phone (512) 250-6314.

Circle No 548

Carnegie Group Inc, 5 PPG Place, Pittsburgh, PA 15222. Phone (412) 642-6900. TLX 4970240.

Circle No 549

VME BUS FORTH

The PolyForth V4000 software-development system suits VME Inc's V4000 VME Bus CPU board. The V4000 board uses NCR's NC4016 μP, which executes high-level Forth code as its native instruction set. The NC4016 chip runs at 8 MHz; at this speed, according to the vendor, Forth programs execute 19 times faster than do compiled C programs running on a 10-MHz 80286.

The software package includes complete source code, an optimizing compiler, clock/calendar management facilities, and utilities. You can create ROM-resident Forth programs as large as 64k bytes for embedded applications. At additional cost, you can obtain libraries of mathematical and database-management routines. Software only, $2950; software and CPU board, $5745.

Forth Inc, 111 N Sepulveda Blvd, Manhattan Beach, CA 90266. Phone (213) 372-8493. TLX 275182.

Circle No 545

LANGUAGE

PC-Simula is a version of the Simula object-oriented programming language that you can run on IBM PCs. The language can run under MS-DOS, Xenix, or OS/2 operating systems. An 80386-based version is under development.

The company recommends that the MS-DOS version for standard IBM PC/XT and PC/AT computers have at least 640k bytes of RAM. It has tested the Xenix version under Santa Cruz Operation's Xenix System-V and under Microsoft Xenix. It has also tested the OS/2 version on an IBM PC/AT running Microsoft OS/2. When you run the language under Xenix or OS/2, the company recommends that your computer have at least 1.5M bytes of RAM, a math coprocessor, and a hard disk.

Cross-compilers to transfer programs between MS-DOS and Xenix, and between MS-DOS and OS/2 are available. Single-user license for the MS-DOS version, 10,000 Norwegian Kroner; for the Xenix and OS/2 versions, 15,000 Norwegian Kroner; and for the cross-compilers, 20,000 Norwegian Kroner.

Simula as, Box 4403, Torshov, 0402 Oslo 4, Norway. Phone (2) 156710. FAX (2) 156051.

Circle No 550

NEURAL NET

The Awareness software package runs on IBM PCs and consists of programs that demonstrate four neural-network paradigms. The generalization paradigm uses a generalized learning rule and demonstrates that a layered neural network can solve the exclusive-OR function. The associative paradigm exhibits many of the computational capabilities of neural networks, such as preferential learning, fault tolerance, differentiation, and association.

The optimization paradigm is an example of a neural network that can produce solutions to combinatorial optimization problems. The self-organization paradigm is an example of a nearest-neighbor classifier that behaves as an optimal signal processor in the presence of noise. The documentation contains introductory material on neural networks, together with the equations

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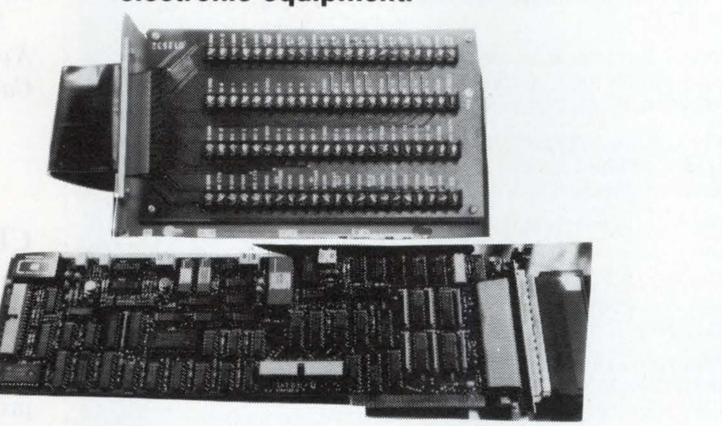

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• TECHNICAL DATA

ANALOG INPUT: The analog input functions of the adapter operate in eigher programed or interrupting mode. The analog input functions provide 12-bit relative accuracy.

RESOLUTION - 12 bits

INPUT CHANNELS- four differential

INPUT MODES-	unipolar or bipolr, user-selectable
INPUT RANGES:	
unipolar	0 TO ±10 volts, user-selectable
bipolar	±5 and ±10 volts user-selectable
OUTPUT MODE:	
unipolar	straight binary
bipolar	offset binary
INPUT IMPEDANCE	>100 megohms with 100 picofarads
INPUT CURRENT	limited to less than ±4 mA
INPUT VOLTAGE:	
Normal mode	±30 volts maximum, without damage, power on or power off
Common mode	±11 volts maximum
COMMON MODE	
Rejection ratio	72 db
Integral linearity error	±1 LSB maximum
DIFFERENTIAL Linearity	
Error	± ½ LSB maximum
Stability	±5 ppm/degrees C of FSR (max)
GAIN:	
Error	±0.1% between ranges (max) any range adjustable to 0
Stability	±32 ppm/degrees C of FSR (max)
OFFSET:	
Error	adjustable to 0
Unipolar stability	±24 ppm/degrees C of FSR (max)
Bipolar stability	±24 ppm/degrees C of FSR (max)
MONOTONICIITY	0 to 50 degrees C
THROUGHPUT to memory	15,000 conversions/second min.

The analog output functions of the adapter operate in programed I/O mode. The analog output functions provide 12-bit relative accuracy.

RESOLUTION	12-bits
Number of output channels	2
OUTPUT modes	unipolar or bipolar, user-selectable
OUTPUT ranges:	
Unipolar	0 to ±10 volts, user-selectable
Bipolar	±5 and ± +10 volts, user-selectable
INPUT CODE:	
Unipolar	straight binary
Bipolar	offset binary
OUTPUT Current	+5 milliamps, min. with normal loading and protection from damage with the output shorted to common.
OUTPUT Impedance	2 ohm, max.
CAPACITIVE loading	0.5 microfarads, max.
GAIN:	
Error	0.1 betweem ranges (max.), any range adjustable to 0
Stability	± ppm/degrees C of FSR(max)
OFFSET:	
Error unipolar	±3.25 millivolt max.
Error bipolar	adjustable to 0
Unipolar stability	±8 ppm/degrees C of FSR (max)
Bipolar stability	±24 ppm/degrees C or FSR (max)
MONOTONICITY	0 to 50 degrees C
SETTLING TIME	10 microseconds max. to within 0.1% FSR for a 10 volt step with 1000 of load
PROTECTION	Protected for short to common
OVERSHOOT	±1% of FSR max
THROUGHPUT from memory	25,000 conversion/second

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and references from the original papers that describe each paradigm. To run this software, you'll need an IBM PC that has a graphics card and at least 256k bytes of RAM. A math coprocessor is recommended but not essential. $250.

Neural Systems Inc, 2827 W 43rd Ave, Vancouver, BC V6N 3H9, Canada. Phone (604) 263-3667.

Circle No 546

CROSS-COMPILER

The LMI Forth metacompiler runs on an IBM PC or PS/2 and generates ROMable native code for Texas Instruments' TMS34010 graphics processor. The Forth metacompiler provides multipass, table-driven compilation; allows local labels and conditional compilation directives; and permits optional generation of "headerless code" to conserve memory in the target system. The package is compatible with the Forth-83 standard and lets you build applications in layers, using incremental compilations. You can create either ROMable or disk-based applications.

To make programming easier, both the compiler and the cross-assembler accept byte addresses, automatically translating these into the bit addresses required by the TMS34010. The package includes a loader program that not only uploads a compiled image into the RAM on a TMS34010 development board, but also provides communication between the development board and the host PC. You'll need a host that has at least 320k bytes of RAM and runs under DOS 2.0 or later; because the source files for the TMS34010 target system require 400k bytes of disk space, the vendor recommends a hard disk. $1000.

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EDITED BY CHARLES H SMALL

Latched bus provides foolproof I/O

Samuel C Creason
Beckman Industrial Corp, La Habra, CA

You can reduce the time necessary to interface a μP-controlled system to parallel I/O devices (ADCs, DACs, etc) if you adopt a standard I/O bus comprising latched-I/O lines (**Fig 1**). Such a bus provides several benefits: It eliminates I/O-device timing problems; it partitions your design task into smaller, independent tasks; and it produces an easily modifiable design.

The only disadvantage of this latched-I/O bus is that accesses are slower than they would be if you tied the devices directly to the μP's system bus. For example, instead of requiring just a single instruction, writing to a device requires four instructions: one each to write bytes to the address and data ports, and two to toggle the data-transfer strobe on and off. Reading from an external device also requires four instructions. Fortunately, this extra overhead is not significant for any but the most I/O-intensive systems.

In **Fig 1,** the circuit elements to the left of the dashed line are conventional I/O ports. In fact, you could replace them, during development, with any personal computer that has parallel I/O ports. IC_1 is an octal, 3-state, positive-edge-triggered D-type flip-flop, and IC_2 is an octal, 3-state buffer/line-driver/receiver; together, they form an 8-bit, bidirectional I/O data bus. IC_3 and IC_4 are both octal, D-type flip-flops. IC_3 drives the I/O address bus; IC_4 simply acts as a data-transfer strobe. Note that IC_5, a dual 2- to 4-line decoder/demultiplexer, gates IC_1, IC_2, IC_3, and IC_4 during read and write operations.

This scheme has an unusual aspect: I/O address lines A_3 through A_7 from IC_3 drive IC_6 and IC_7 (3- to 8-line decoder/demultiplexers). IC_6 and IC_7 provide eight input and eight output strobes, respectively. (I/O address lines A_0, A_1, and A_2 are available for other uses.) Note that address line A_7 also controls IC_1's 3-state output. Because this circuit requires a high signal to disable IC_1's 3-state output, input devices must have an I/O address of 80_{HEX} or higher.

Using IC_3 and IC_4 to generate the input and output strobes directly might seem to be a simple way to reduce chip count and μP overhead. However, if you employ such a scheme, a glitch in your software could easily enable more than one I/O device at a time. The scheme in **Fig 1** trades μP overhead for foolproof I/O.

EDN

To Vote For This Design, Circle No 747

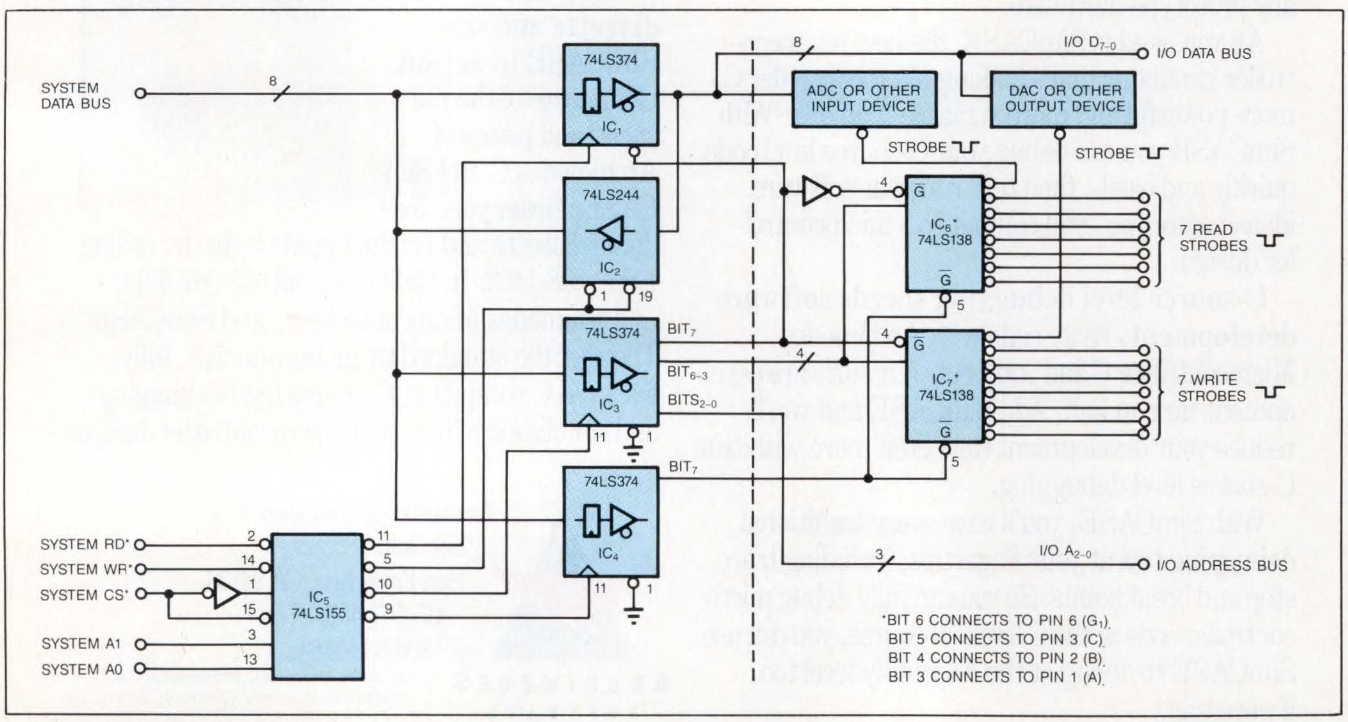

Fig 1—By adopting this foolproof, latched-I/O scheme *as a standard for μP-based systems that must handle parallel I/O, you can quickly adapt it to different tasks.*

State machine controls PLD programming

V Lakshminarayanan
Sneha Corp, Bangalore, India

The 5P8 PAL and the 74273 octal flip-flop in **Fig 1** form a finite-state machine that functions as a programming-waveform timer for numerous Monolithic Memories' PALs (5P8, 5P8A, 8P4, 8P8, 9P4, 9P8, 10P4, 10P8, 11P4, 11P8, 12P4, 12P8, 9R8, 10R8, 11RA8, and 11RS8) and generates the timing diagram of **Fig 2.** The Boolean statements in **Fig 3** reduce to the Boolean equations in **Listing 1.** A Boolean-equation compiler such as Palasm can produce a fuse-map program for **Fig 1**'s 5P8 PAL.

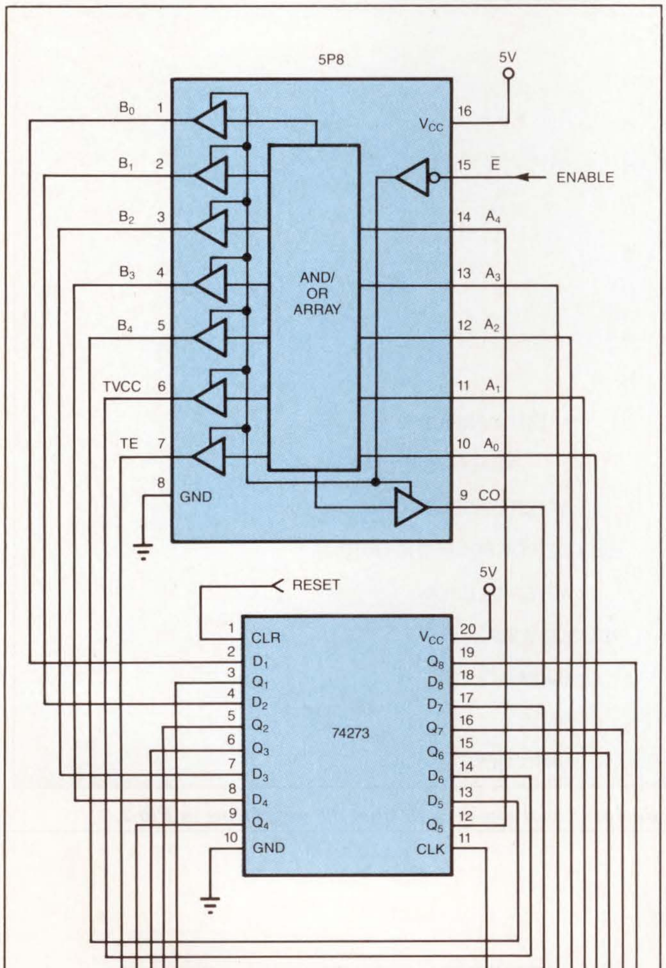

***Fig 1—A state machine consisting of a 5P8 PAL** and an octal flip-flop generates programming-timing control signals for programming common PALs.*

The 5P8 develops the three control signals necessary to program PLDs: TVCC controls the application of supervoltages to the target PLD's supply pin; TE is the timing signal for enabling the target PLD; and CO

LISTING 1—MINIMIZED BOOLEAN EQUATIONS

```
ADD A0 A1 A2 A3 A4
DAT B0 B1 B2 B3 B4 TVCC TE CO

;NEXT STATE GENERATOR

B0 = /A4 * /A0 + A4 * /A3 * /A2 * /A0          ;INCREMENT LSB

B1 = /A4 * /A1 *A0 + /A4* A1*/A0 + /A3 * /A2 * /A1 * A0
     + /A3* /A2* A1 * /A0                      ;INCREMENT BIT1

B2 = /A4 *A2*/A1 + /A4 *A2* /A0 + /A4* /A3 */A2* A1 *0
     + /A4 * A3 * /A2 *A1*A0                   ;INCREMENT BIT2

B3 = /A4 * A3 */A2 + /A4 * A3 * /A1 + /A4 * A3 * /A0
     + /A4 * A3 * /A0 + /A4 * /A3 * A2* A1* A0   ;INCREMENT BIT3

B4 = /A4 * A3 * A2 * A1 * A0 + A4 * /A3 * /A2* /A1
     + A4 * /A3 * /A2 * /A0                      ;INCREMENT BIT4

;TIMING WAVEFORMS

TVCC = /A4 */A1 *A0 + /A4 * A1 */A0 + /A4 * /A3 * A1
       + /A4 *A2 */A1 + /A4 * A3 * /A2      ;TIMING FOR VCC

TE = /A4 */A3 */A2* /A1 + /A4 * A3 * A2 * A0
     + /A4 * A3 * A2 * A1 + /A4 * /A3 * /A2 * /A0 ;TIMING
                                                ;FOR E

CO = /A4 * /A3 * A1 + /A4 *A2 */A1
     + /A4* A3 */A2                         ;TIMING FOR OUTPUTS
```

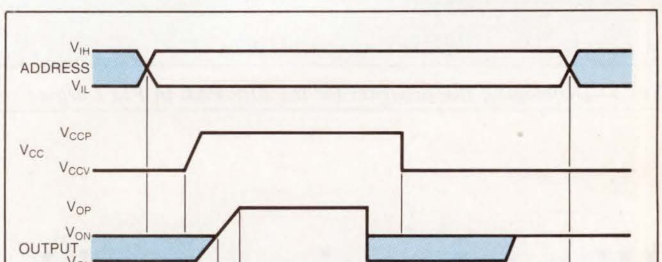

***Fig 2—The state machine in Fig 1** generated these waveforms.*

controls the application of supervoltages to the target PLD's outputs.

If you apply a 1-MHz clock signal to the circuit, it will generate a t_D (delay time between programming steps) of 1 μsec; a t_{PW} (programming pulse width) of 10 μsec; and a t_{VCC} (V_{CC} supervoltage-application time during programming) of 14 μsec. **EDN**

To Vote For This Design, Circle No 749

;STATE ;AAAAA	NEXT STATE BBBBB	TIMING WAVEFORMS TVCC	TE	CO	
LLLLL	LLLLH	L	H	L	;DISABLE CHIP
LLLLH	LLLHL	H	H	L	;AFTER TD DELAY ;TAKE VCC TO VCCP
LLLHL	LLLHH	H	H	H	;AFTER TD DELAY ;APPLY VOP TO THE OUTPUT
LLLHH	LLHLL	H	L	H	;AFTER TD DELAY TAKE ;E TO VIL FOR A PERIOD TPW
LLHLL	LLHLH	H	L	H	
LLHLH	LLHHL	H	L	H	
LLHHL	LLHHH	H	L	H	
LLHHH	LHLLL	H	L	H	
LHLLL	LHLLH	H	L	H	
LHLLH	LHLHL	H	L	H	
LHLHL	LHLHH	H	L	H	
LHLHH	LHHLL	H	L	H	
LHHLL	LHHLH	H	L	H	
LHHLH	LHHHL	H	H	H	;AFTER A PERIOD TPW ;DISABLE THE CHIP
LHHHL	LHHHH	H	H	L	;AFTER TD DELAY ;REMOVE VOP FROM THE OUTPUT
LHHHH	HLLLL	L	H	L	;AFTER TD DELAY ;REMOVE VCCP
HLLLL	HLLLH	L	L	L	;LOOP
HLLLH	HLLHL	L	L	L	;HERE
HLLHL	HLLHH	L	L	L	;UNTIL RESET

***Fig 3—Developing the program for the 5P8 PAL in Fig 1** begins with Boolean equations derived from the waveforms in **Fig 2**.*

Watchdog timer avoids μP overhead

Shen-Feng Hwang
Norfin International Inc, Seattle, WA

A simple pair of retriggerable one-shots can function as a watchdog timer while eliminating the programming overhead and dedicated output line associated with conventional watchdog timers. In a typical system, the μP periodically pulses an internal watchdog timer. If the μP's software malfunctions, the μP will fail to reset the timer. When the timer times out, it triggers the μP's nonmaskable interrupt (NMI), thereby restarting the μP.

The circuit in **Fig 1** accomplishes the same task but doesn't require that the μP reset the watchdog timer. IC_1 gates all of the μP-generated input-enable signals to IC_2, a retriggerable one-shot. In this circuit, the enable signals are active low. Any active-low signal to IC_1 will retrigger the one-shot. The one-shot's time-out period equals $1.1R_2C_2$. You should set the time-out period longer than the longest expected time between two consecutive input-enable signals from the μP. Thus, if the μP fails to enable the inputs at the proper rate (indicating that the μP will not respond to inputs and is, in effect, going deaf), the one-shot will trigger the μP's NMI. **EDN**

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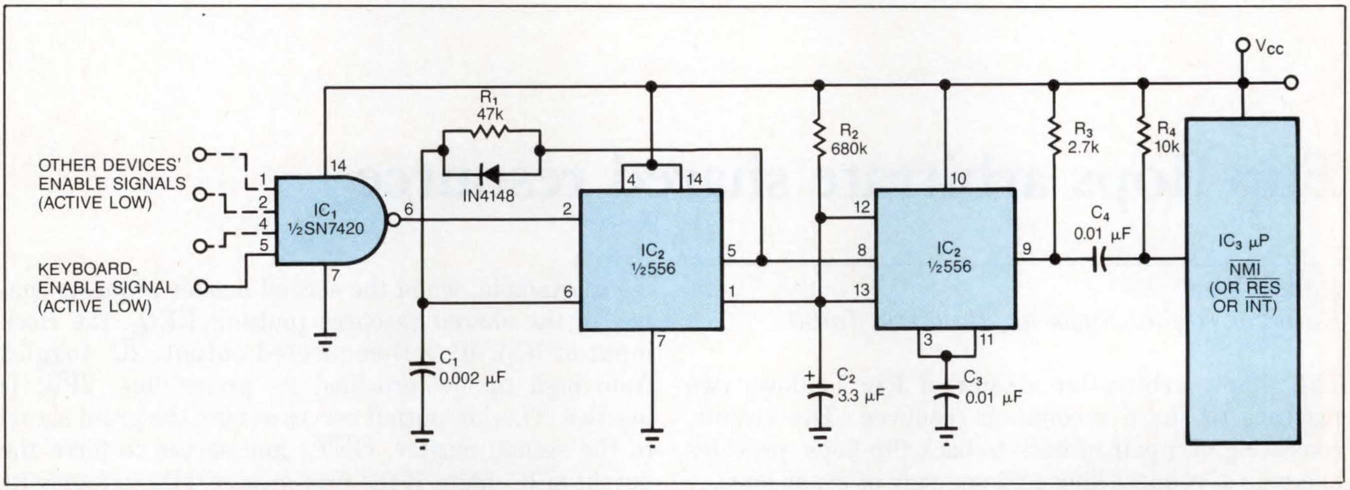

*Fig 1—**This watchdog timer saves μP overhead** and eliminates a dedicated output line. It uses the μP's input-enable signals to retrigger its one-shot rather than employing a specific watchdog-timer command.*

Flip-flop multiplies input frequency

Paul D Gracie
The Microdoctors Inc, Palo Alto, CA

The output frequency of the classical flip-flop circuit of **Fig 1a** is twice the clock input frequency. Although the circuit generates a narrow, positive pulse at each edge of its Clock input, you cannot cascade the circuit to further multiply the input frequency without some modifications.

Assume that the clock's signal and the flip-flop's Q output are low to begin with. The rising edge of the Clock input passes through the XOR gate unchanged and triggers the flip-flop, causing its Q output to go high. The flip-flop's Q output feeds back to the XOR gate, transforming it into an inverter. The XOR gate then truncates the Clock signal, resulting in a narrow positive pulse at the flip-flop's clock (CK) input. When the Clock signal goes low, the XOR gate inverts it, triggering the flip-flop again. This retriggering generates a second pulse at the flip-flop's CK input, causing

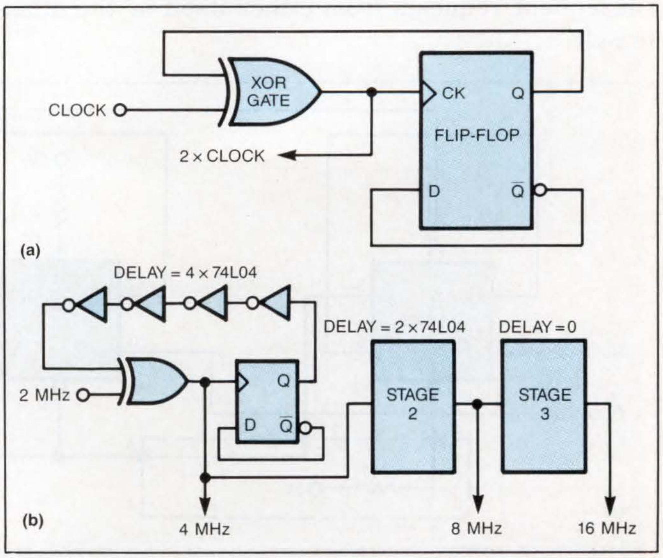

*Fig 1—**A simple circuit** can double the clock input frequency **(a)**. However, you cannot cascade such doublers unless you insert appropriate delays in the feedback paths as in **b**.*

its Q output to go low.

The width of the pulses at the flip-flop's CK input depends on the propagation delay of the XOR gate and the flip-flop. For 74LS devices, this combined delay is about 30 nsec. Because the input Clock signal must stay high until the pulse to the flip-flop's CK input is completed, you can not cascade this basic circuit unless you lengthen the pulse. **Fig 1b** shows inverters placed in the feedback path of the first and second stages of a 3-stage clock-frequency multiplier. This circuit achieves a 16-MHz output from a 2-MHz input signal. **EDN**

To Vote For This Design, Circle No 748

Flip-flops arbitrate shared resource

Aditya Dua
Kanazia Digital Systems, Bombay, India

The simple arbitration circuit of **Fig 1** allows two masters to share a common resource. The circuit, consisting of a pair of back-to-back flip-flops, provides one pair of request lines and one pair of grant lines.

In operation, either master can request access to the shared resource by first pulsing the appropriate request line (either REQ_1 or REQ_2). If the resource is available, the requester will receive an active-low authorization signal on its respective grant line ($\overline{GNT_1}$ or $\overline{GNT_2}$). If the resource isn't available, the requester must repeatedly pulse its request line and poll its grant line until the grant line goes low. When a master relinquishes control of the shared resource, it must pulse its request line one last time to clear the way for subsequent requests from either itself or the other master.

For example, when the second master requests control of the shared resource (pulsing REQ_2, the clock input of IC_2), IC_2's D-connected output, $\overline{2Q}$, toggles from high to low provided its preset line, $\overline{2PR}$, is inactive. This low output serves as both the grant signal to the second master, $\overline{GNT_2}$, and serves to force the output of IC_1 high. If the first master tries to toggle its flip-flop, IC_1, it will fail until the second master toggles its own flip-flop one more time.

Note that if both masters try to gain control of the shared resource simultaneously, only one of them will succeed. Also note that, upon power up, the circuit is in an indeterminate state. You must either initialize the circuit with a power-up initialization routine or add an AND gate **(Fig 1b)**. **EDN**

To Vote For This Design, Circle No 746

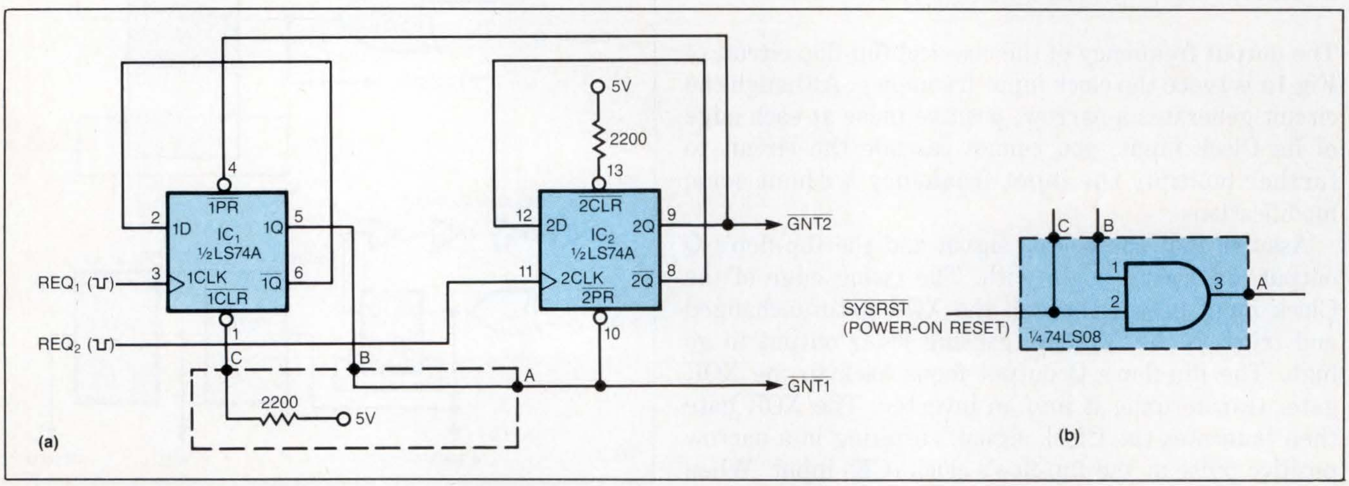

Fig 1—A pair of back-to-back flip-flops *can arbitrate access to a shared resource. A master requesting access will be blocked until the second master relinquishes control because each resource-grant flip-flop, when active, engages the other flip-flop's preset input. The AND gate in* ***b*** *forces the circuit to a predetermined state upon power up.*

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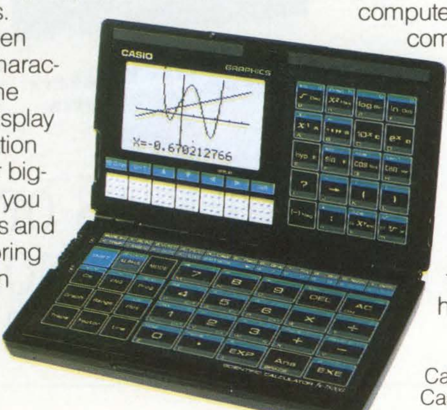

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CIRCLE NO 183

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DESIGN NOTES

Number 12 in a series from Linear Technology Corporation *July, 1988*

An LT1013 and LT1014 Op Amp SPICE Macromodel

Walter G. Jung

With the advent of low cost and powerful desktop computers, present day op amp circuit designs can mature more quickly with good simulation tools. One such tool since its inception has been SPICE, the standard analog circuit simulator. However, while PCs and workstations may now be present on more and more desks, a potential bottleneck towards effective simulation has been SPICE models for the more popular parts.

The macromodel approach to simulation of an op amp is viable for many designs, with the great asset of simulation speeds far faster than that of a full device-level circuit. With this design note, Linear Technology Corporation introduces op amp macromodels to its applications library. It is hoped that eventually most op amps in the product line will be developed as macromodels and made available to customers.

The LT1013 and LT1014 devices are popular single supply LTC op amps, and are thus logical candidates for macromodels. While existing macromodels for the generic 358 and 324 types might suffice for some applications, circuit designs which take advantage of the unique precision and functional features of the LT1013 warrant a model which reflects those features. The schematic diagram of the LT1013 and LT1014 macromodel is shown in Figure 1, and is applicable to one channel of either device.

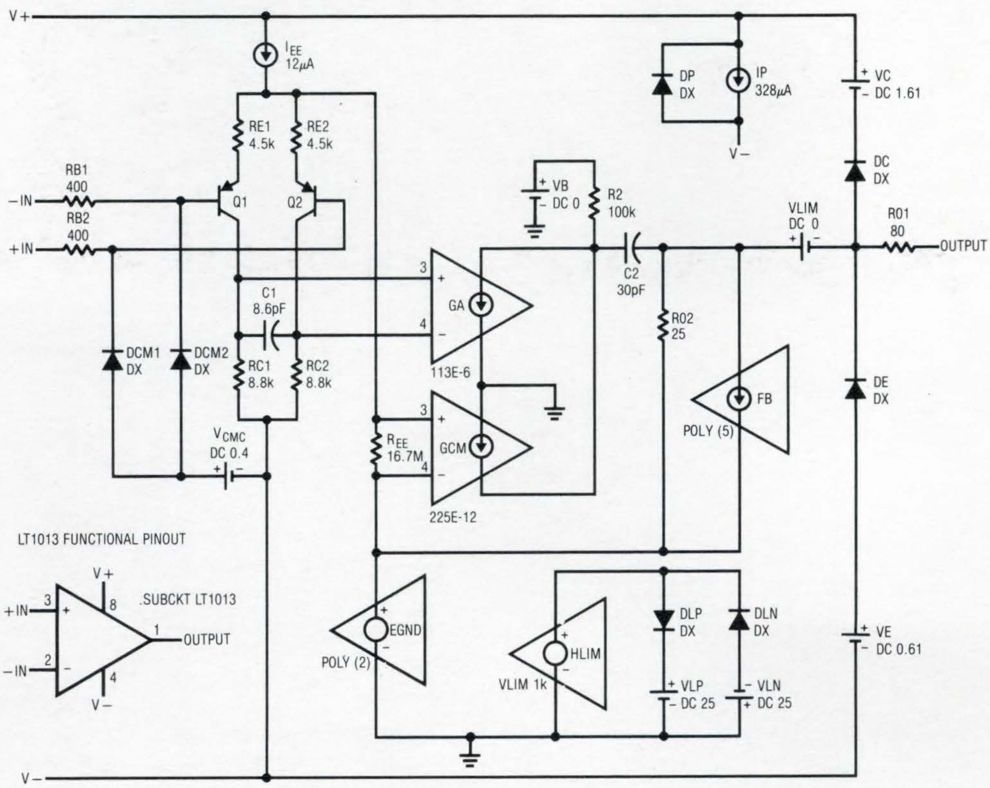

Figure 1. LT1013 Op Amp Macromodel

Key op-amp specifications for the commercial device are:
offset voltage = 50μV (offset is not simulated)
bias current = 8nA
gain = 1000000
slew rate = 0.4V/μs
bandwidth = 0.8MHz
Also, the model simulates the input common mode range (which includes ground) and the output characteristics of swinging to ground while sinking current.

This macromodel acts very much like the real LT1013 or LT1014 device which incorporates input common mode clamping, to prevent the sign-reversal errors common to the 358/324 types. For example, comparison responses for the LT1013 and the 358 are shown in Figure 2. The common conditions of this test are for an overdriven, +5V single-supply follower. In both instances, the input signal is V_{IN}, a −20V to 20V sweep fed through 10k, while the output is V(5).

Note that with the 358, the output reverses sign when the input is overdriven below ground. In contrast, the LT1013 model is well behaved, simply clamping the overdrive at ground level...just like the real LT1013 device does!

The model itself is listed on this page, and can be entered by typing it in (carefully!). Registered users of MicroSim's PSPICE simulator will automatically receive this macromodel as part of the model library update with version 3.07. Interested readers may contact MicroSim at the address or phone number listed at the end of this note for further information.

This LT1013/LT1014 op amp macromodel is being supplied to users as an aid to circuit designs. While it reflects reasonably close similarity to the actual device in terms of performance, it is not suggested as a replacement for breadboarding. Simulation should be used as a forerunner or a supplement to traditional lab testing.

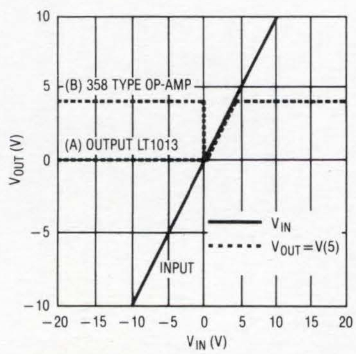

Figure 2. LT1013 Test Circuit: Single-Supply (+5V), Overdriven Follower

This more complete macromodel has been adapted from the Parts program generated LT1013/LT1014 model. This version features closer fidelity to the real part, with input common mode clamping and compensated output clamping. It can be used for large signal and/or single supply applications, where the inputs can potentially be overdriven.

SPICE List for LT1013 Macromodel

```
connections:      non-inverting input
*                 |  inverting input
*                 |  |  positive power supply
*                 |  |  |  negative power supply
*                 |  |  |  |  output
*                 |  |  |  |  |
.subckt LT1013    1  2  3  4  5
*
*
c1     11  12           8.661E-12
c2      6   7           30.00E-12
dc      8  53   dx
de     54   8   dx
dlp    90  91   dx
dln    92  90   dx
dp      4   3   dx
egnd   99   0           poly(2) (3,0) (4,0) 0 .5 .5
fb      7  99           poly(5) vb vc ve vlp vln 0
                        2.475E9 -2E9 2E9 2E9 -2E9
ga      6   0   11  12  113.1E-6
gcm     0   6   10  99  225.7E-12
iee     3  10   dc      12.03E-6
hlim   90   0           vlim 1k
q1     11  102  13  qx
q2     12  101  14  qx
rb1     2  102  400
rb2     1  101  400
dcm1  105  102  dx
dcm2  105  101  dx
vcmc  105   4   dc      0.4
r2      6   9           100.0E3
rc1     4  11           8.841E3
rc2     4  12           8.841E3
re1    13  10           4.519E3
re2    14  10           4.519E3
ree    10  99           16.63E6
ro1     8   5   80
ro2     7  99   25
ip      3   4           328E-6; supply current
vb      9   0   dc  0
vc      3  53   dc      1.610
ve     54   4   dc      .61
vlim    7   8   dc  0
vlp    91   0   dc  25
vln     0  92   dc  25
.model dx D(Is=800.0E-18)
.model qx PNP(Is=800.0E-18 Bf=400)
.ends
```

PSPICE simulator is available from:
MicroSim
23175 La Cadena Drive
Laguna Hills, CA 92653
(714) 770-3022; (800) 826-8603

For LT1013/14 literature call **800-637-5545**. For help with an application call (408) 432-1900, Ext. 361.

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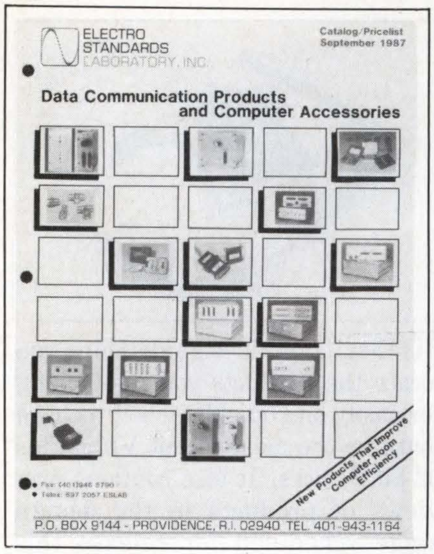


Computer and datacomm products categorized

This product catalog can help you plan a new network installation, or maintain or expand existing networks. It contains the vendor's line of RS-232C breakout boxes; cable adapters; line drivers; modem eliminators; surge protectors; computer and printer switches; data, bulk-data, and personal-computer cables; and twin-axial interface products.

Electro Standards Laboratory Inc, Box 9144, Providence, RI 02940.

Circle No 770

How to connect plotters to personal computers

The 4-color brochure, *Versatec puts power in personal-computer plotting,* tells you how to receive hard-copy information on your IBM PC or compatible or about your Macintosh personal computer. Its diagrams show the configurations, including software, interface or rasterizer, and plotter. Besides discussing the advantages of using electrostatic and thermal-transfer plotters, the folder contains a product table to help you select the right plotter for speed, size, and high-quality output.

Versatec, 2710 Walsh Ave, Santa Clara, CA 95051.

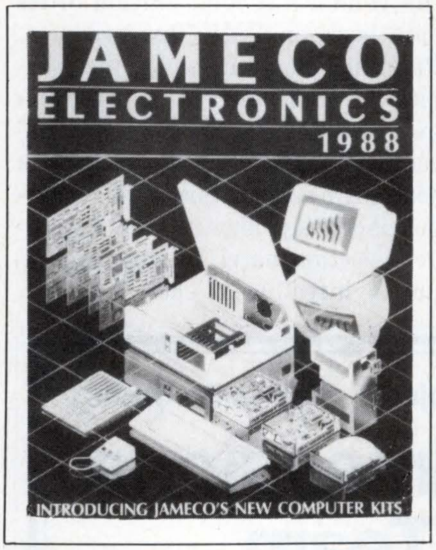
Circle No 772

Monograph series reports on computer memory

Memory Pointers, the vendor's newsletter, analyzes current technical developments in the add-in computer-memory market and analyzes the various computer memory offerings of Apollo, Sun, Hewlett-Packard, and other computer manufacturers. It provides regular features such as a question-and-answer column and a new-product section.

Clearpoint Inc, 99 South St, Hopkinton, MA 01748.

Circle No 771



Listing of computer/electronic products

The vendor's 1988 illustrated catalog lists more than 5000 items. The product lines feature a variety of items from computer kits and peripherals to integrated circuits. An 8-pg insert highlights IBM, Apple, Commodore, and Tandy computer peripherals. Also included is a 6-pg insert of pin-out data.

Jameco Electronics, 1355 Shoreway Rd, Belmont, CA 94002.

Circle No 774

Multibus I and II boards cataloged

This 35-pg catalog covers a complete line of Multibus I boards and accessories, and four new Multibus II products. It contains photographs, descriptions, and specifications for more than 30 Multibus I, Multibus II, and VME Bus board-level products. Among the devices it describes are a Multibus II communications controller, a SCSI controller, a floppy-disk controller, an SBX single-board computer, and an intelligent prototype board.

Central Data Corp, 1602 Newton Dr, Champaign, IL 61821.

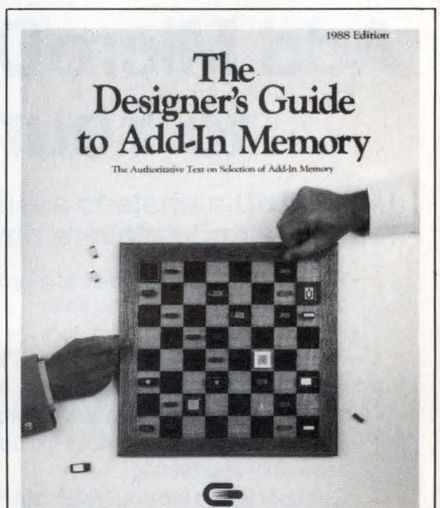
Circle No 773

Computer printers displayed

This fold-out brochure illustrates the vendor's full line of computer printers suitable for business, scientific, or personal applications. Besides listing the printing speeds, performance capabilities, and special features of each printer type, it presents the options, accessories, and supplies that are available.

Seikosha America Inc, 1111 MacArthur Blvd, Mahwah, NJ 07430.

Circle No 775



Guide to memory requirements

The 1988 Designer's Guide to Add-In Memory describes a broad range of memory products from the very technical to the management-oriented. The 80-pg catalog contains information about buses currently in use; DEC's latest offerings;

where to find the best price and performance for memory products; and a survey of performance and memory options available from IBM. Also included are the features for the HP-9000 and the MIPS and number of megabytes that are available for the Sun 4/2XX and Apollo DN 4000.

Clearpoint Inc, 99 South St, Hopkinton, MA 01748.

Circle No 777

STD μCs and IEEE-488 interfaces categorized

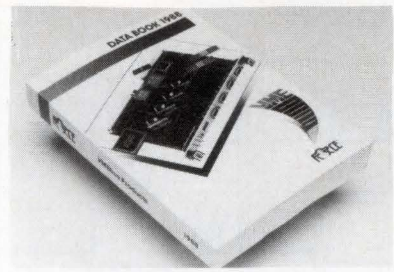
The 200-pg Technical Data Book details the vendor's complete line of STD-8088 industrial computer systems and IEEE-488 interfaces of microcomputers. The new-products section focuses on industrial-networking products, IBM-compatible STD DOS systems, interfaces for the IBM PS/2, single-board computers, STD and IEEE-488 drive packages, and bubble-memory systems. The catalog provides application examples, a system designer's guide to 8088-based STD Bus systems, and the complete STD-8088 Bus specification. It also includes specifications, configuration guidelines, and ordering information.

Ziatech Corp, 3433 Roberto Ct, San Luis Obispo, CA 93401.

Circle No 778

Publications feature VME Bus and VME/Plus

The 560-pg *VME Data Book 1988* is the vendor's second edition of its data book on VME Bus products. Published simultaneously, the technical brochure on VME/Plus examines several growth-oriented architectural features. The data book contains nine chapters with numerous photos and illustrations. A product-selection matrix arranged in columns introduces each chapter.



Further, a product guide helps you locate the products you are looking for easily and quickly. The brochure features the most recent VME/Plus 32-bit devices. It also contains previews of products in the design stage scheduled for release this year.

Force Computers Inc, 3165 Winchester Blvd, Campbell, CA 95008.

Circle No 779

System components and reference data categorized

This 80-pg, pocket-sized catalog lists versions of the PC Bus, Multibus, VME Bus, and Q Bus, as well as computers that are 100% compatible with IBM PCs. It provides descriptions and specifications for each product. Further, the application-information and reference-data sections contain useful features, such as application maps.

Diversified Technology, Box 748, Ridgeland, MS 39158.

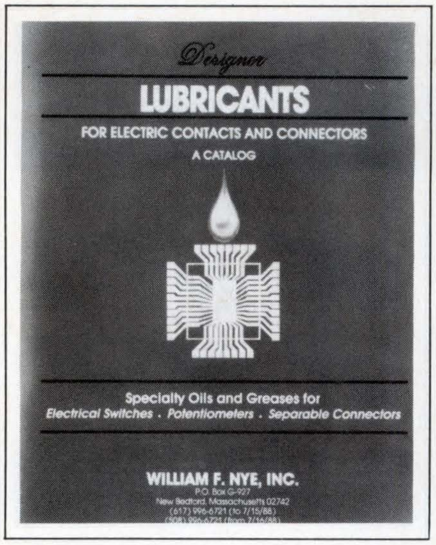
Circle No 776

Brochure sums up PC-to-mainframe transfers

The 6-pg publication *Mag Tape Power for Your PC* presents three different approaches to processing bulk data transfers between PCs and mainframe computers. It includes software solutions for DOS and Xenix, based on PC systems. It also describes Filetran for selective file-based backup, as well as hardware solutions, using three different tape systems.

Telebyte Technology Inc, 270 E Pulaski Rd, Greenlawn, NY 11740.

Circle No 781



Booklet discusses specialty lubricants

Lubricants for Electric Contacts and Connectors is the vendor's catalog of specialty oils and greases. It covers four application areas: greases for sliding electric contacts, as in electric switches; oils for sliding contacts and potentiometers; potentiometer greases; and lubricants for stationary separable electric connectors. The catalog describes lubricant properties and operating-temperature ranges, and discusses lubricants you can use to help suppress arcing conditions.

William F Nye Inc, Box G-927, New Bedford, MA 02742.

Circle No 560

Optoelectronics guide and data book

The two publications, *Optoelectronics Selector Guide (SG87/D)* and *Optoelectronics Data Book (DL118/D)*, are divided into products sections: emitters/detectors, isolators, slotted switches, and fiber-optic components. The data book contains 65 new products and their applications, as well as a new section on optoelectronic chips or die. Both books contain an industry cross-reference and a reliability section.

Motorola Inc, Technical Information Center, Box 52073, Phoenix, AZ 85072.

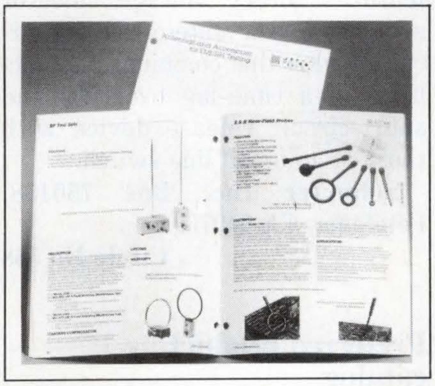
Circle No 561

Application note defines common voltage terms

The DPM-10 application note helps clarify your questions about several common terms and problem areas, such as isolated and nonisolated signal-source inputs, common-mode voltages, and safety precautions for wiring primary line power to any device. The note provides wiring diagrams and standard formulas for component selection in voltage dividers, attenuators, and shunt circuits. The publication also helps you measure high- and low-level voltages and signals from resistance bridges, solid-state temperature sensors, and similar devices.

Acculex, 440 Myles Standish Blvd, Taunton, MA 02780.

Circle No 563



Antennas and accessories

The vendor's 1988 catalog features antennas and accessories for EMI/RFI testing, and a product- and antenna-selection guide in the form of a 20×30-in. calendar. In addition to product information, the catalog features FCC and VDE regulations, tables that help you make a selection, and a list of formulas.

EMCO, Box 1546, Austin, TX 78767.

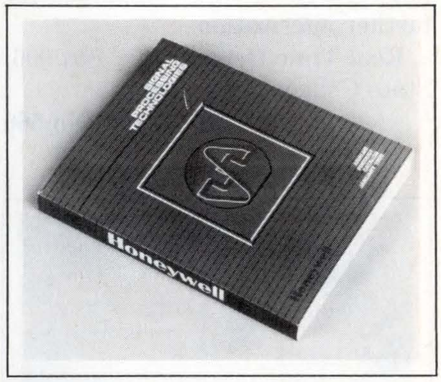
Circle No 564

Folder introduces absorption material

This introductory packet includes a folder and a sample of Poron products, the vendor's high-density cellular urethanes. It describes five simple tests that you can conduct at your desk. The tests indicate energy absorption, resistance to impression, self-healing after puncture, resiliency, and resistance to long-term compression set.

Rogers Corp, 1 Technology Dr, Rogers, CT 06263.

Circle No 565



Comprehensive catalog heralds upcoming products

This 520-pg catalog summarizes products from the vendor's Signal Processing Technologies division. It also features preliminary reports about devices in production, as well as application notes for switched capacitor filters, flash converters, and video D/A converters. The catalog's component data sheets and technical descriptions help you select the signal-processing products you need for designs.

Honeywell Inc, Signal Processing Technologies, 1150 E Cheyenne Mountain Blvd, Colorado Springs, CO 80906.

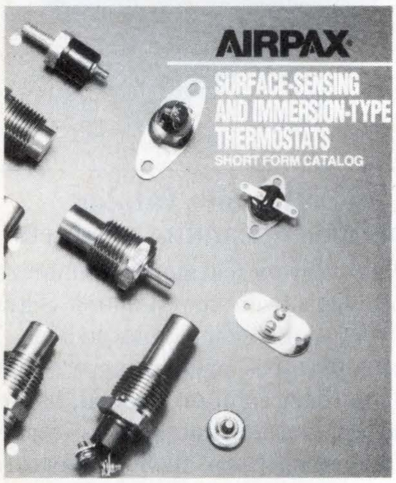
Circle No 567

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. The publication 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 566



Brochure deals with thermostats

This 4-pg folder provides you with information about the vendor's line of surface and immersion-sensing snap-action thermostats. It includes low-profile, grounded, isolated-contact, and sealed and hermetically sealed units.

Airpax Corp, Husky Park, Frederick, MD 21701.

Circle No 569

Buyer's guide to French components

The *French Electronic Passive Component Industry Catalog 1988/89* lists over 10,000 products from 84 French component manufacturers in both English and French. Product categories include, capacitors, resistors, printed circuits, connectors, keyboards, switches, ferrites, coils and transformers, quartz filters, antennas, fans, hybrid circuits, cable accessories, enclosures, fiber-optic components, protection devices, and microwave components.

Syndicat des Industries de Composants Electroniques Passifs, 11 rue Hamelin, 75783 Paris Cedex 16, France.

Circle No 574

Publication presents range of components

The technical data and drawings that fill the vendor's 80-pg catalog help you select fuse and fuse-holder variations, as well as power-entry-module combinations over a range from ac connector and line switch to ac connector. The publication also features rotary voltage selector switches and a state-of-the-art circuit breaker that combines the functions of a time-lag overload and short-circuit release device with those of an on/off line switch.

Schurter Inc, Box 750158, Petaluma, CA 94975.

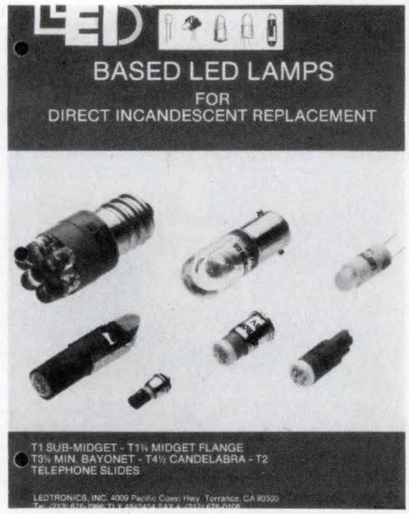
Circle No 568

Preferred product catalog

This 700-pg *Preferred Type Range Catalog 1988* spotlights the components that appeal to the majority of the vendor's customers. The catalog provides type numbers, catalog numbers, selection guides, and brief technical information about this preferred product range. Components that meet CECC (Cenelec Electronic Components Committee) requirements are listed at the end of those product sections in which they are described. The catalog has six major sections that cover integrated circuits, semiconductors, electron tubes, capacitors, resistors, materials, and other products.

Philips, Components Div, Box 523, 5600 AM Eindhoven, Netherlands.

Circle No 575



Publication details based LED lamps

This 46-pg catalog describes the company's submidget flange, screw, groove, wedge, and bipin LEDs. It also details miniature bayonet LEDs, and candelabra cluster and telephone slide lamps that come in a selection of sizes. The catalog also features application notes and a cross reference to incandescent bulbs.

Ledtronics Inc, 4009 Pacific Coast Hwy, Torrance, CA 90505.

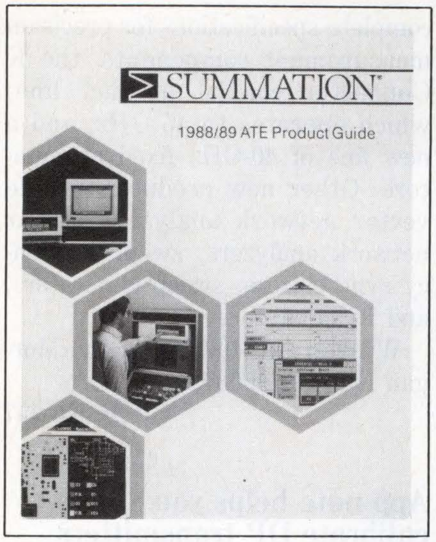
Circle No 572

Chart your way through "magnetic phantoms"

This wall chart of inductor applications helps design engineers rid their circuits of the "phantoms of magnetics," and it helps specifiers understand how to use inductive components to solve circuit-design problems. The chart covers component descriptions, diagrams of typical circuits, and brief design application notes for 11 inductor styles: molded inductors, variable inductors, and tunable coils; chip and surface-mount magnetics; wideband chokes; noise filters; toroids; pot cores; air coils; delay lines; high-current chokes; and balun chokes.

Inductor Supply, 15204 Transistor Lane, Huntington Beach, CA 92649.

Circle No 573



ATE described

The vendor's 136-pg 1988/1989 catalog presents its line of automatic test equipment. The volume covers the vendor's inventory and services in these areas: configured ATE systems, test frames, accessories, test fixtures, computers, software, ATE networks and services, and digital-, analog-, and custom-function modules. The publication features a subject index, model-number index, and an ATE configuration guide.

Summation, 11335 NE 122nd Way, Kirkland, WA 98034.

Circle No 755

Pamphlet describes simulator/analyzer

This 6-pg, 4-color document details the features and options of the TE820A DS1/T1 frame simulator/analyzer. It describes applications including testing and evaluating, troubleshooting, simulation, analyzing, and field testing. A listing of additional options is included.

Tekelec, 26540 Agoura Rd, Calabasas, CA 91302.

Circle No 758

Applications for dual-channel analyzers

The 32-pg booklet *A World of Applications* deals with 12 applications where you can use a dual-channel analyzer to identify and help you solve engineering problems. In the area of acoustics, it focuses on sound-intensity measurements and architectural acoustics. The section on electroacoustics reviews transducer measurements and sound-reinforcement systems. It also provides an analysis of servo systems and materials. Finally, it outlines how dual-channel analyzers can assist you in college courses.

Bruel & Kjaer Instruments Inc, 185 Forest St, Marlborough, MA 01752.

Circle No 756

How to use a scope to find video digital signals

The application note *See Digital Controlled Video Signals and Make Precision Timing Measurements Using the 2467 Portable Scope (38W-6797)* explores a wide range of measurement techniques from basic video to digital/frame-rate timing. It reports on the measurement of pulses as narrow as 50 nsec and explains how you can see them in full detail on an MCP (microchannel plate) CRT scope. The note provides several illustrations of this waveform-viewing feature.

Tektronix Inc, Box 1700, Beaverton, OR 97077.

Circle No 765

Reference for microwave and RF engineers

The 61-pg brochure *Microwave Datamate* deals with topics such as microwave applications by frequency, waveguide parameters, connections, transmission lines, power measurement, and scalar network analyzers. Following the first section on general information is an explanation of satellite and terrestrial telecommunications systems. Another section examines waveguide parameters and has a waveguide data chart. Among the subjects examined in the final section are IEEE-488 programming, a status and message-exchange overview, S-parameters and transformations, and scattering parameter relationships.

Marconi Instruments, 3 Pearl Ct, Allendale, NJ 07401.

Circle No 761

Comprehensive guide categorizes test equipment

The Test Equipment Reference Guide 1987/1988 is a 375-pg catalog that contains technical specifications and prices for more than 4000 reconditioned test instruments, as well as new instruments, power supplies, coaxial components, waveguides and waveguide components, and a line of technical books. Many items are available for short-term rental or lease. The equipment categories include amplifiers, analyzers, avionics and telecommunications test equipment, frequency measuring instruments, generators, bridges, calibration and standards, meters, oscilloscopes, power supplies, RFI/EMI, and microwave components.

Tucker Electronics Co, Box 461966, Garland, TX 75046.

Circle No 759

Guide to instrumentation

The vendor's 1988/1989 product guide covers more than 5000 different models from major manufacturers of electronic test and measurement instruments, data-processing equipment, and telecommunications test devices that you can rent, lease, or buy. The 400-pg reference book contains specifications, descriptions, photos, and other technical data. Included in its listings are analyzers, CAE/CAD equipment, generators, meters, recorders, oscilloscopes, signal modifiers, microcomputers, and general telecommunications test equipment.

US Instrument Rentals, 2988 Campus Dr, San Mateo, CA 94403.

Circle No 764

A catalog of microwave products

The vendor's 1988 92-pg, 4-color catalog highlights microwave measurement components, instruments, and systems in the dc to 60-GHz range. General information before each major product group helps you to make the best choice for your particular needs. The book also features complete specifications for precision measurement components; the K Connector coaxial product line, which operates to 46 GHz; and a new line of 40-GHz fixed attenuators. Other new products include vector network analyzers, scalar network analyzers, swept-frequency synthesizers, sweep generators, and RF analyzers.

Wiltron Co, 490 Jarvis Dr, Morgan Hill, CA 95037.

Circle No 757

App note helps you calibrate DP transmitters

Application Bulletin P-80 tells you how to calibrate differential-pressure (DP) transmitters on site, thus eliminating the task of having to remove the DP cells and take them back to the shop for calibration. It also describes three calibration devices and provides illustrations.

Rochester Instrument Systems Inc, Test & Calibration Products, 255 N Union St, Rochester, NY 14605.

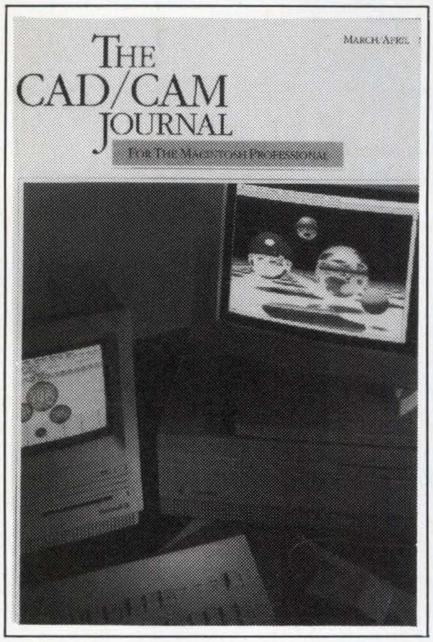
Circle No 768

Scope details

The vendor's 10-pg brochure describes its SAS-812A digitizing oscilloscope with which you can observe and analyze ultrahigh-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 and the 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 767



Journal for Macintosh users

The CAD/CAM Journal for the Macintosh Professional surveys Macintosh advancements in computer-aided design and computer-aided manufacturing. The publication covers the expanding field of CAD/CAM/CAE applications and features stories about evaluations of 2-D and 3-D drafting and design software, communications and CAD, hardware evaluations, and the most recent CAD/CAM/CAE products. $20 (six issues).

The CAD/CAM Journal, 16 Beaver St, New York, NY 1004.

INQUIRE DIRECT

Publication spreads CAD news

The *CAD Educator* publicizes educational opportunities, new products, activities, and applications in the world of AutoCAD. For example, in the March 1988 issue, Joe Oakey's column notes the transformation of the former Manuals and Tutorials List (renamed In Print) into an updated list of text and support materials for the vendor's products; the lead story reports on advanced AutoLisp training offered by a joint venture of Gold Hill and AutoCAD training centers; and a feature story focuses on the application of AutoCAD for numerical control. The quarterly also lists upcoming trade shows.

AutoDesk Inc, 2320 Marinship Way, Sausalito, CA 94965.

Circle No 753

Computer-integrated manufacturing ideas

The 12-pg publication *The Role of Automated Information in Computer-Integrated Manufacturing* presents the company's philosophy toward computer-integrated manufacturing—that is, to unify all production, administrative, and engineering functions in one computer system. The vendor's goals include improved productivity and higher quality. The brochure also presents major concepts involved in integrating management information and plant-floor information.

Allen-Bradley Response Ctr, Dept 5234, Box 92846, Rochester, NY 14692.

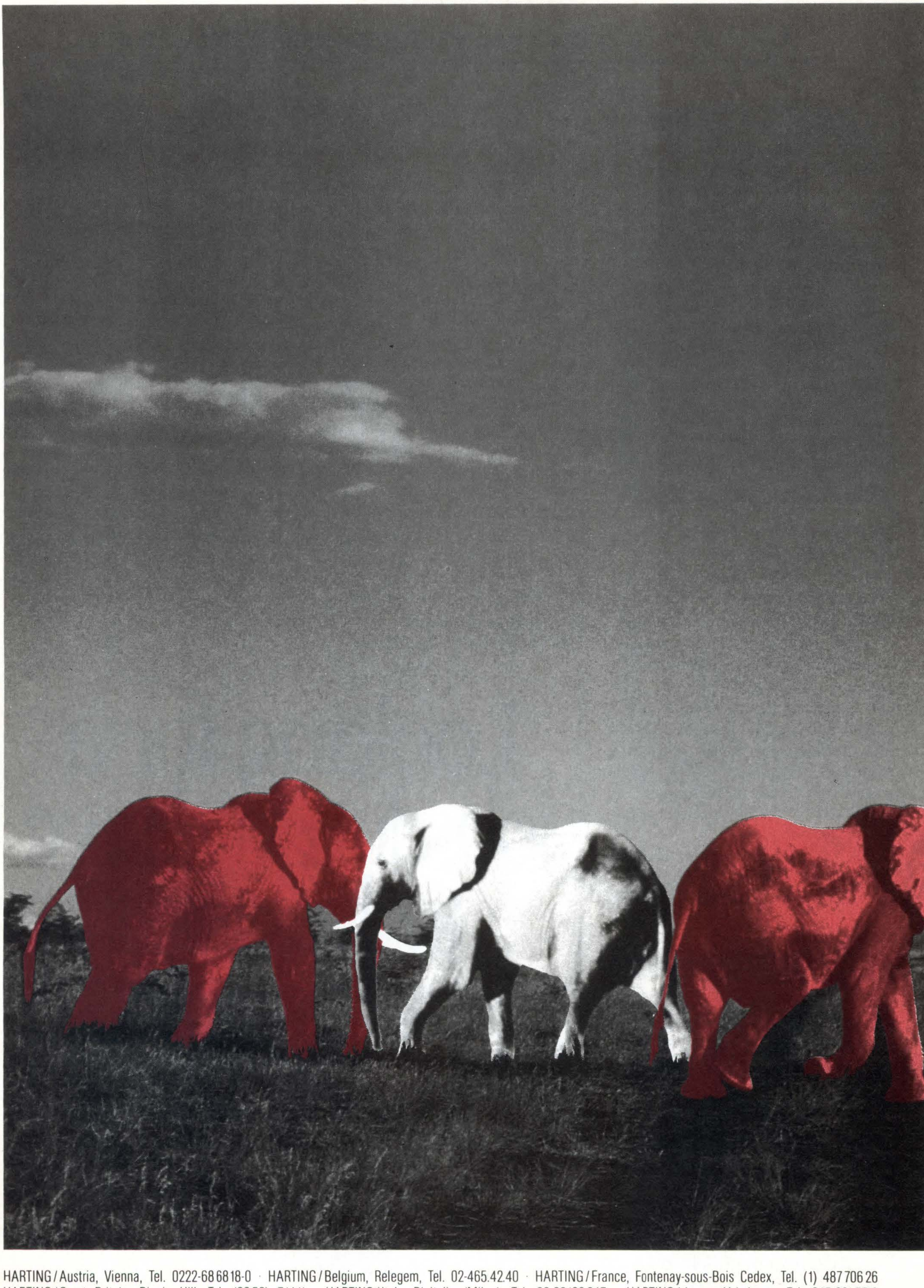
Circle No 752

Scientific- and engineering-software aids discussed

Lifeboat, a scientific- and engineering-software guide, describes 100 packages designed for use in solving equations, analyzing data, breaking down numbers, and designing 3-D CAD/CAM. The products are listed side by side to make it easier for you to compare them and make a selection. The product categories include circuit design, embedded systems, data acquisition/signal analysis, languages/utilities, Basic, C, cross-assemblers, and Fortran.

Lifeboat Associates Inc, 55 S Broadway, Tarrytown, NY 10591.

Circle No 751



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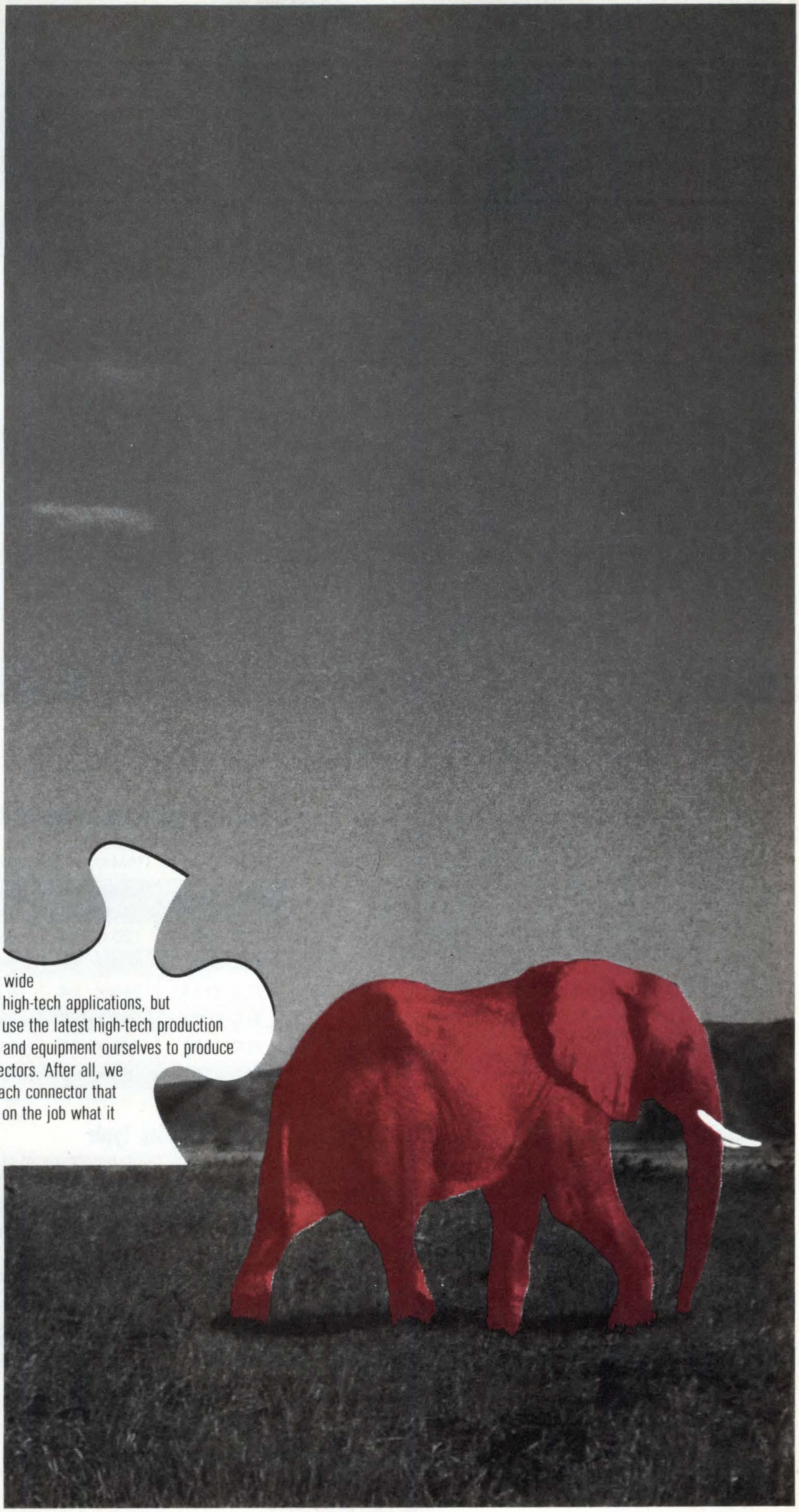

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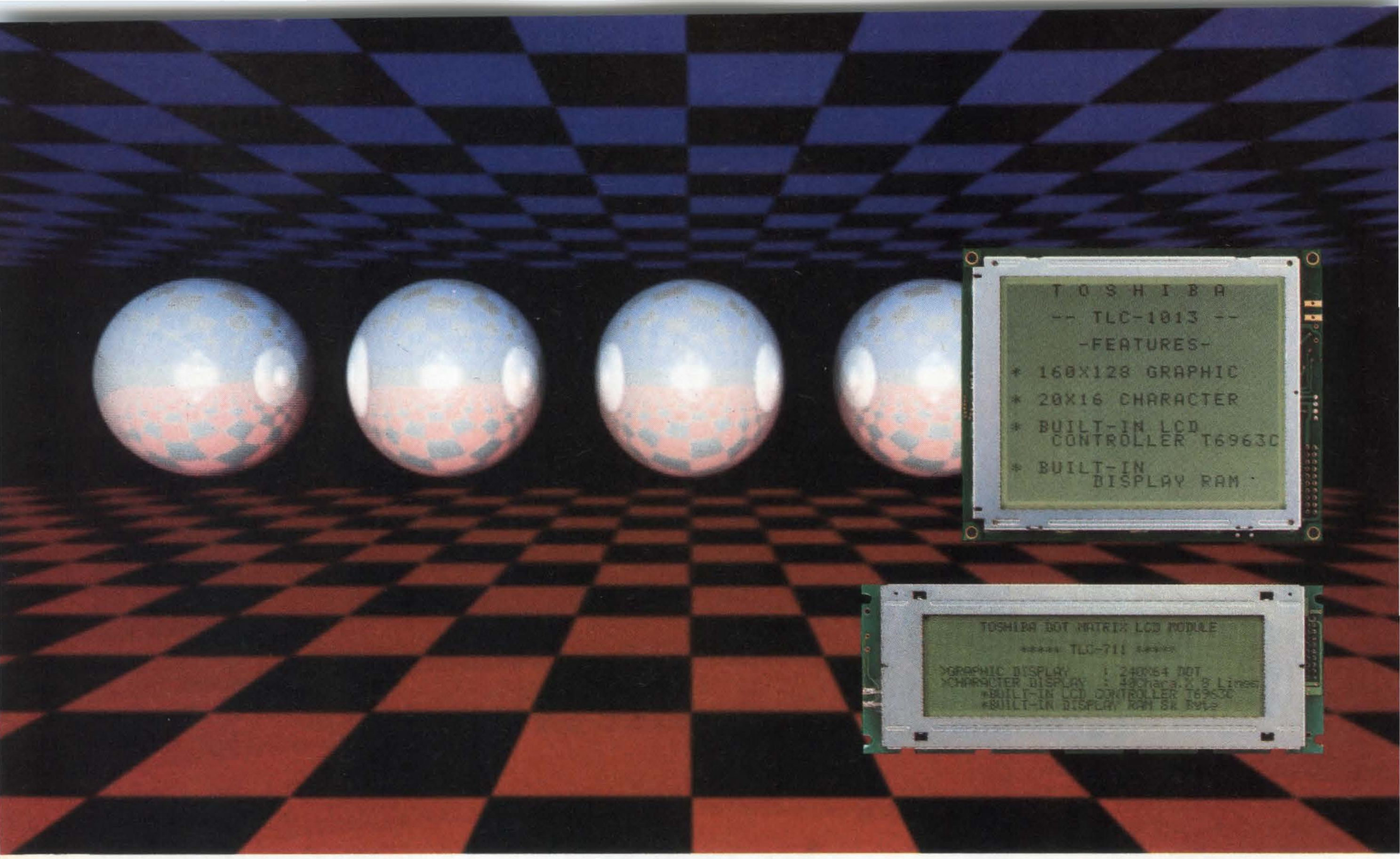

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Character Display Type with Built-in Controller

High character height and easy-to-read display.
Easy-to-use design thanks to high contrast TN.

Model name	Number of characters	Outline dimensions (mm)
TLC-671	16 × 1	80.0 × 36.0 × 12.0
TLC-241	16 × 1	80.0 × 36.0 × 12.0
TLC-491	16 × 2	80.0 × 36.0 × 12.0
TLC-731	16 × 4	87.0 × 60.0 × 12.0
TLC-501	20 × 2	116.0 × 37.0 × 12.5
TLC-721	20 × 4	98.0 × 60.0 × 12.0
TLC-691	24 × 1	126.0 × 36.0 × 12.0
TLC-771	24 × 2	118.0 × 36.0 × 12.0
TLC-601	40 × 1	182.0 × 33.5 × 13.0
TLC-591	40 × 2	182.0 × 33.5 × 13.0
TLC-1001	40 × 4	221.0 × 76.0 × 12.5

Graphic Display Type with Built-in Controller

Clear display thanks to high contrast TN.
Easy-to-use C/G, RAM and ROM built-in types.

Model name	Number of dots	Outline dimensions (mm)	Controller
TLC-1021	120 × 64	85.0 × 70.0 × 20.0	T6963C
TLC-682	160 × 64	125.0 × 50.0 × 18.0	T6963C
TLC-711A	240 × 64	180.0 × 65.0 × 12.0	T6963C
TLC-1013	160 × 128	129.0 × 104.5 × 14.0	T6963C
TLC-1091	240 × 128	241.0 × 125.3 × 12.0	T6963C
TLC-1101	160 × 32	140.0 × 40.0 × 12.0	T6963C

*We provide many options.
*We can meet the need for customized products.

Graphic Display Type

Clear display through employment of high contrast TN.
Capable of displaying large-size letters and special letters.

Model name	Number of dots	Outline dimensions (mm)	Controller
TLC-612	640 × 32	320.0 × 48.0 × 14.0	(T6963C)
TLC-761	640 × 64	320.0 × 47.0 × 14.0	(T6963C)
TLC-341AK	128 × 128	93.2 × 86.6 × 12.0	(T6963C)
TLC-531A	128 × 128	132.2 × 111.0 × 13.0	(T7755)
TLC-972	480 × 128	274.0 × 114.4 × 20.0	(T7755)

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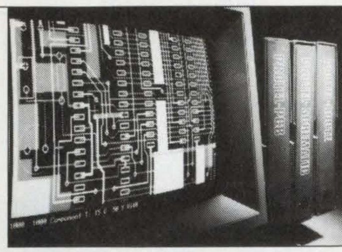

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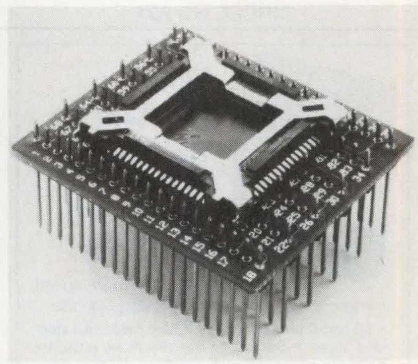

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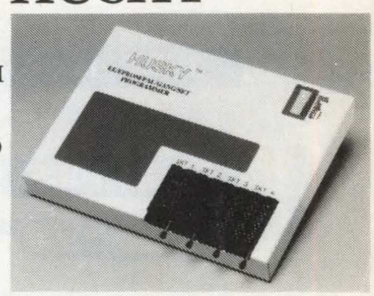

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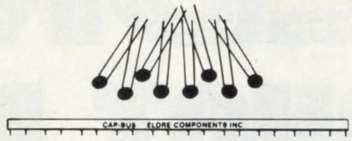

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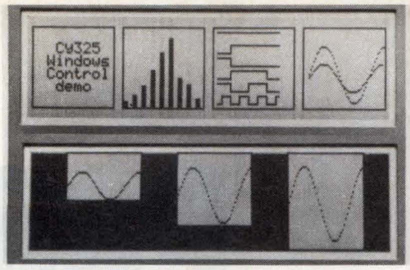

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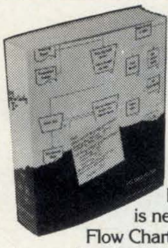

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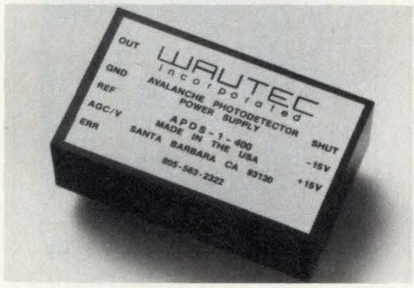

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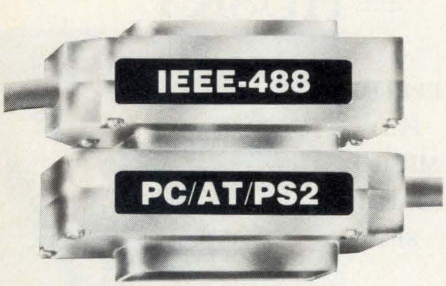

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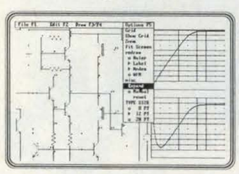

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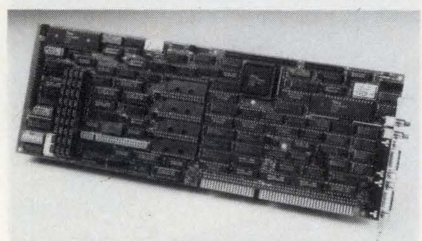

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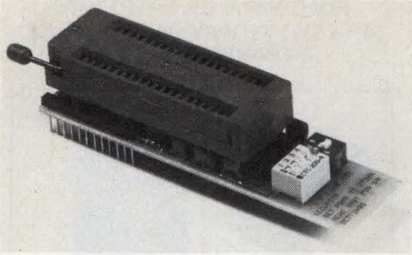

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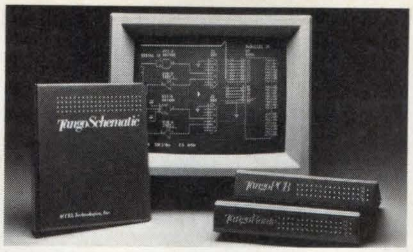

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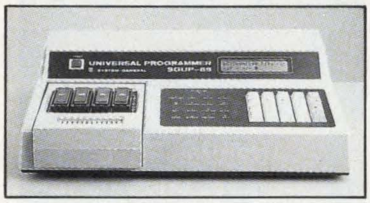

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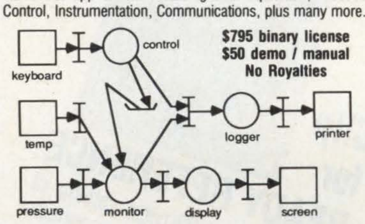

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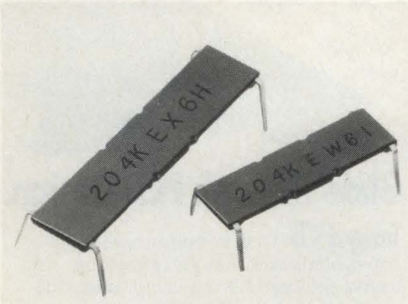

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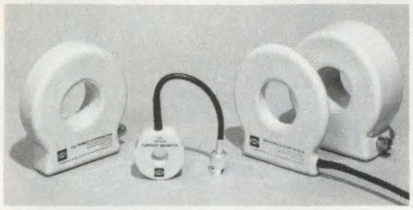

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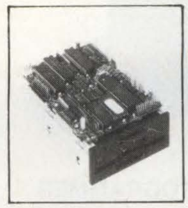

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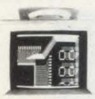

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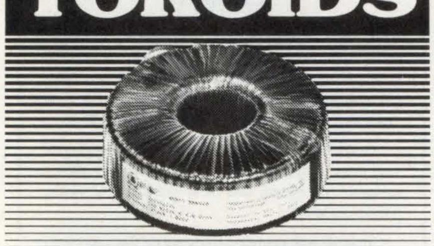

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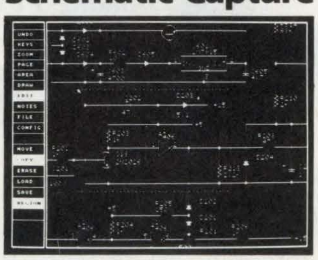

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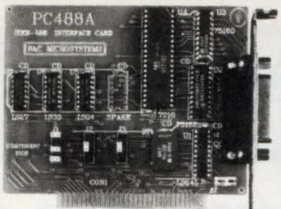

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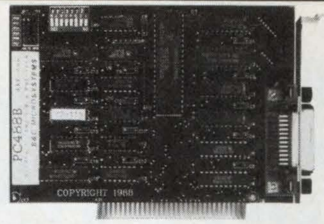

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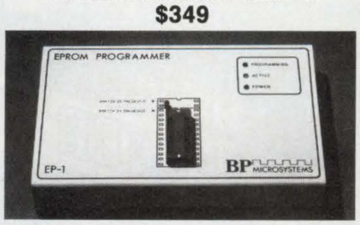

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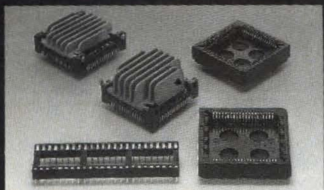

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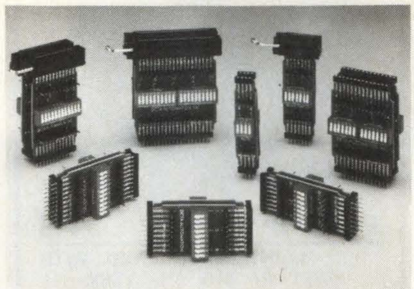

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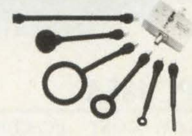

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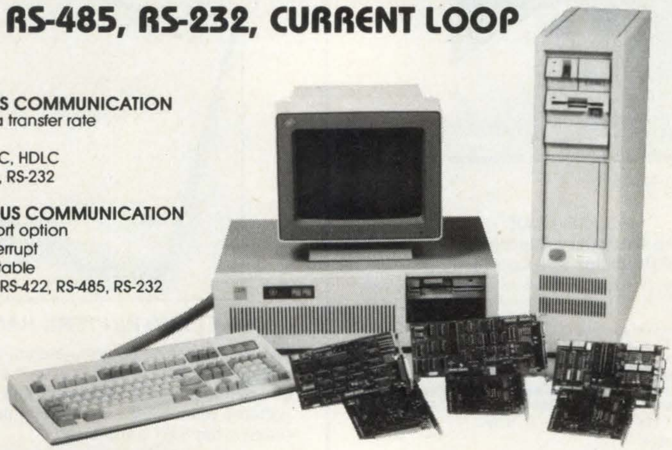

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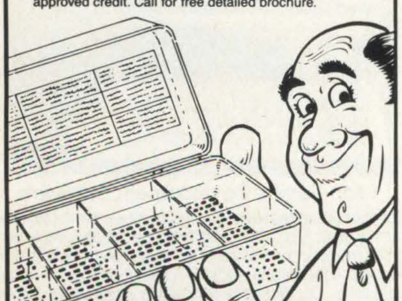

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How two engineers built —and nearly lost— their business

Mike Wells and Jack Hancock started their company with plenty of technical know-how but no business experience. Together, they made every mistake in the book. After a series of near-disasters, which gave them an intensive on-the-job business education, they expect $8 million in sales this year.

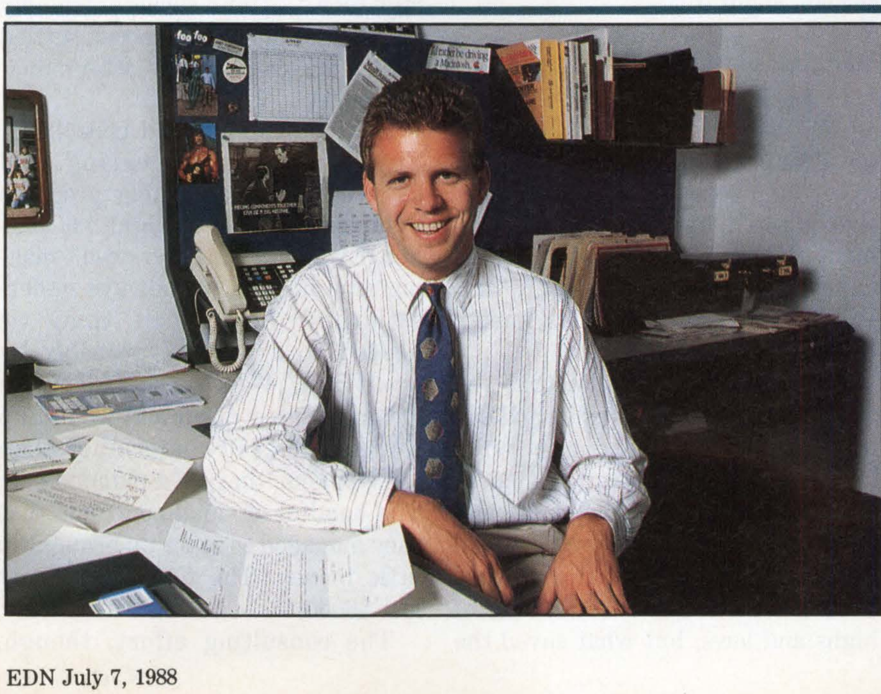
Deborah Asbrand, *Associate Editor*

They make the oddest of couples. Mike Wells is 32 years old. After college, he spent only two years in the engineering work place before he became disillusioned with corporate attitudes and fled. Jack Hancock is a 67-year-old mechanical engineer who worked for the same employer for 31 years. Somehow, the two men strike a perfect balance as business partners.

In 1985, however, two years after they founded Arnet Systems, the company's equilibrium was anything but balanced. The prospects for success looked grim. The Internal Revenue Service was demanding payment of $30,000 in witholding taxes. Local banks refused them credit, and representatives of one bank recommended liquidation. A year later, the situation was even worse. The loss of a major contract forced them to lay off nearly half of their employees, and the corporate infrastructure—what there was of it—was about to cave in.

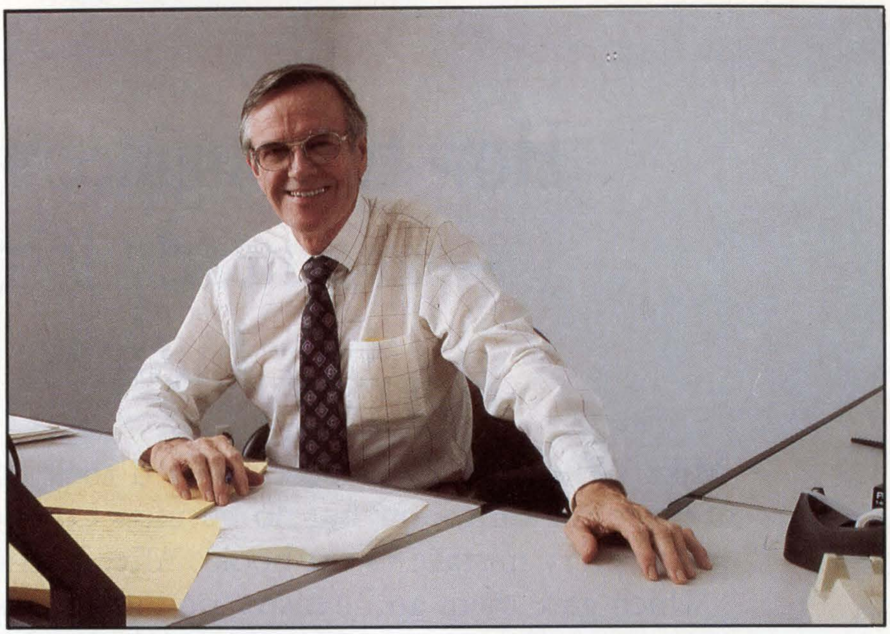
Luckily, Arnet Systems was able to regain its equilibrium. Part of the ballast is no doubt a function of the differences between Mike Wells and Jack Hancock. "The brashness and risk-taking innate to Mike are foreign to Jack," observes one of their colleagues, Bob McKeown. "And Jack's solidness and conservatism are foreign to Mike." Wells serves as Arnet's president and supervises its long-range growth and market plans. Hancock is the company's chairman and oversees investments, stock transactions, and export activities.

The two men first met in 1972. When Wells was 16 years old, Han-



Photographs by Clark Thomas

Mike Wells: "The PC market was easy to enter and attracted lots of young people with no credibility —like me."



Jack Hancock: "I'd always toyed with the idea [of starting a business], but I never got serious about it until Mike came along."

cock, a 51-year-old divorced father of two, married Wells' mother, Betsy. The men's early relationship was tenuous at best. "We just kind of avoided each other for a while," Hancock recalls. Eventually, they became friends, and when Wells went off to Vanderbilt University, he chose to study electrical engineering, a decision both men now attribute to Hancock's influence.

In 1980, Wells graduated from Vanderbilt with a master's degree in electrical engineering. He went to work for Merrick Corp, a Nashville company specializing in robotic arc welding. Shortly afterwards, the owners sold the business to a large, Houston-based company. Immediately it became apparent that the new managers had little understanding of engineering and little interest in preserving Merrick's small-company atmosphere.

Morale in the engineering department, where Wells and about a dozen others worked, quickly deteriorated. "We were behind, and the managers came in and told us that the products had to ship on the scheduled day," Wells remembers. "We told them that the products weren't ready, that they weren't debugged. They said 'ship them anyway.' Twenty units were shipped, and every one of them came back. It was the beginning of their demise. It ruined their reputation."

Feeling disenfranchised by the business's bottom-line philosophy, Wells left after two years. He returned to Vanderbilt to earn a doctoral degree in electrical engineering. After one year back on campus, however, he grew restless.

Around the same time, Hancock was considering an early retirement from E I du Pont de Nemours, where he worked as a senior research engineer in the company's textile-fiber division. Hancock saw his early leavetaking as an opportunity not to sit in a rocking chair but to try something new. "I didn't really want to retire," he recalls. "I'd always toyed with the idea [of starting a business], but I never got serious about it."

Hanging out a shingle

In April 1983, Wells and Hancock agreed to give entrepreneurship a try. The plan, albeit a bit fuzzy, was to set up a consulting business specializing in industrial-control equipment. Hancock would draw on his expertise in machine design, and Wells would contribute his knowledge of microprocessors.

The chances were slim that the two business novices would make it in the rough-and-tumble electronics industry. For Wells and Hancock, the past few years have been anything but easy. Like many small businesses, Arnet's growth has been a wild roller-coaster ride of highs and lows, but what saved the company from going out of control was its founders' quickly learned lessons and a rare candor in admitting their mistakes.

The two men capitalized the business themselves, retaining full ownership, and, as they would later come to realize, full responsibility. Hancock took out a second, $15,000 mortgage on his home, and Wells kicked in his $2000 in savings. They rented a small office in downtown Nashville. They named the business Arnet Systems because "the theory was to have a business that started with the letter 'A' so we'd be first in the consultants directory. We also wanted something that sounded high tech." After a series of friendly disputes, Wells and Hancock settled on Arnet, which is the latter's middle name.

Neither man enjoyed consulting. They both disliked making cold sales calls and designing products that clients might or might not market. Even worse, they weren't making any money. "We always underestimated how much time we needed on a project—probably by about 50%," Wells says. "Usually we got negotiated down and wound up working for $10/hour rather than the $45/hour that we'd planned on." The handful of small contracts that they managed to scare up brought in little money. The first year Arnet lost $6000.

The consulting effort, though,

was part of a larger plan that Wells and Hancock had hatched. They envisioned consulting as a stepping stone to the business they wanted to build. Wells was one of the legions of people attracted to the potential gains of the burgeoning personal-computer industry. "For a while I thought we would make a standard product in the industrial-control area," he says. "But the area didn't seem to be growing. And, because it was stable, it was hard to enter. The PC market was easy to enter and attracted lots of young people with no credibility—like me."

Choosing a standard product

To transform their struggling consulting practice into a full-fledged business, Wells and Hancock needed a standard product. In December 1983, they got their opportunity. A local company was planning to enter the personal-computer market with a software program that monitored telephone switchboards. The company was dissatisfied with the design of the 4-port RS-232C card that a Minneapolis vendor had developed for it, and agreed to let Arnet Systems redesign the card and implement new features on it.

"Because we were so small and unknown, they had absolutely no faith in us," Wells says. For this reason, the deal they struck required Arnet to absorb the design costs and committed the client to purchase a maximum of only 50 boards. In return, Arnet retained full ownership of the product.

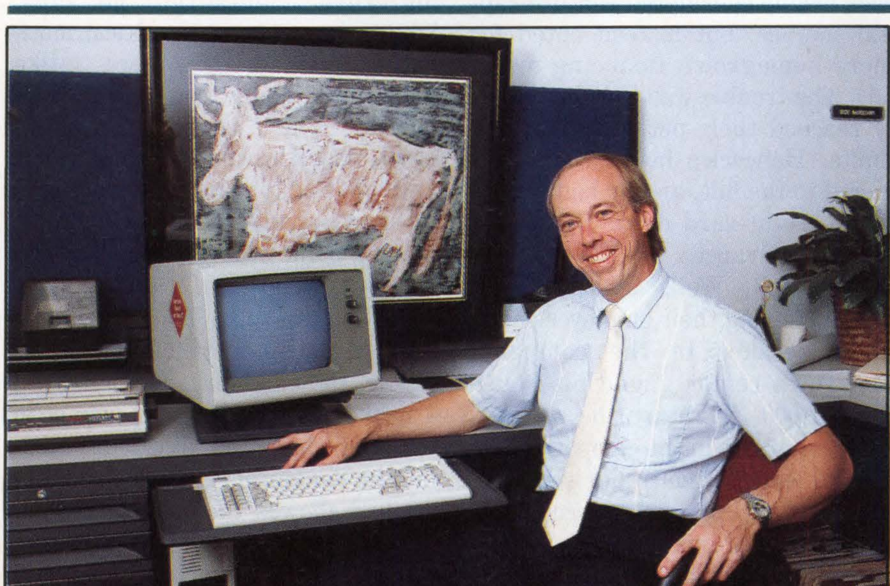
Within four months, Wells and Hancock demonstrated a printed-circuit-board prototype for their client. Not only did the company purchase the required 50 boards, but it continued to buy them at a rate of 50 each month. With that contract earning Arnet $25,000 a month in revenue, Wells and Hancock could begin plowing some of their earnings into the development of their own products. Fortuitously, they got the idea of enhancing the pc board and making it the long-awaited product they had been looking to build a company upon from another vendor's product brochure.

The two men also decided they could now afford to hire another full-time engineer. Wells turned to Bob McKeown, a colleague from his days at Merrick. McKeown, like Wells, had chafed under Merrick's new owners' attempts to impose strict rules on the engineering department. The new manager "felt we lacked commitment because we lacked discipline," McKeown remembers. "His way of making us disciplined was to institute a dress code and to rigidly enforce working hours."

One experience, in particular, cemented McKeown's belief that the new management's policies were largely misguided. The day after a memo instructed all male employees to wear ties at work, McKeown arrived wearing blue jeans—and no tie. His action, he says, carried no message of defiance. To McKeown, it was simply keeping in line with Nashville's southern casualness. "I wore my best dressy jeans and didn't think of it as rebellious."

An enlightening ride

His new manager did. He asked McKeown to accompany him for a drive to his ranch 20 miles outside of Nashville. There, the manager pointed to the livestock and explained that there were two kinds of



Bob McKeown: "I still live vicariously through the engineering department."

Just days before the IRS planned to padlock Arnet's doors, the company found a bank willing to lend them money.

cattle—those that accepted nurturing and were allowed to go on producing, and those that wound up on dinner tables. What kind of cattle, the supervisor wanted to know, was McKeown?

McKeown's memory of the incident is vivid. "I thought he was a lunatic," he says. "I started looking for a job and took the first one I got." A year later, when Wells contacted him about joining Arnet, he jumped at the chance.

McKeown began working on some of the company's existing contracts, and Wells began looking around for other product niches. The issue of copy-protection schemes for personal computers was attracting a lot of attention at that time, and Wells got the idea to design protective devices. "I'd read in a databook about using PAL chips to protect software. We started thinking maybe this could be a standard product for us." It was a market different from the add-in one that the company was hoping to penetrate with its expansion board, but it seemed to hold promise. Wells and Hancock had no idea that venturing into two disparate markets would nearly cause the company's downfall.

Mounting a marketing effort

In the spring of 1985, Arnet Systems was ready to release both the copy-protection device, which it called Gardware, and the upgradable IBM PC expansion board, which it called Multiport. There was no extra capital to fund the salary of a sales and marketing professional, so Wells, already working hard as head of new-product development, assumed the responsibility for assembling a marketing campaign. He checked a dozen books out of the library, pored over all of them, and became a self-taught product promoter. He wrote press releases, arranged for photo shoots, concocted direct-mail packages, and worked on company and product brochures.

Times were improving

By August, the company's efforts began to show results. Multiport and Gardware were selling well. Gardware, in particular, was generating a great deal of revenue for the young company, thanks to a lucrative contract with Computervision, a Bedford, MA, CAE company that was buying thousands of units each month. Arnet had eight employees and was growing rapidly, and the 7-day workweeks were beginning to pay off.

Any sense of accomplishment, however, was fleeting. Despite steady product sales, the business needed a cash infusion to provide working capital and, more important, to pay the IRS $30,000 for back payroll taxes. Wells and Hancock briefly considered venture-capital sources, but instead opted for more homegrown financing methods. The trouble was they had nearly reached their personal-financing limits. Hancock's home was mortgaged to the hilt, and he had run up large credit-card debts by taking out cash advances.

That fall, Wells and Hancock began offering their employees ownership stakes in the company. McKeown remortgaged his house for $11,000. In return, he received 10% ownership in the company. Lisa Ernst, Arnet's controller, contributed her savings and became a 6% owner. The company pitch was also heard by miscellaneous aunts, uncles, and other relatives with untapped bank accounts.

At the same time, Hancock, Wells, Ernst, and Elaine Floyd, an Arnet sales representative, were also giving the team pitch to area banks in the hopes of securing a loan or a line of credit. Complicating matters was pressure from a local bank through which Arnet had a Small Business Administration loan. Nervous about Arnet's precarious financial condition, the bank sent two representatives to assess the company's condition. The men (both electronics-industry veterans) toured Arnet's facilities and then spent several hours with Wells. Their verdict was liquidation. "They didn't even suggest Chapter 11," Wells says, referring to the bankruptcy-law provision that offers a company protection from its creditors while it reorganizes its finances. "They advised us not to compete in the add-in market and to go back to consulting."

Wells refused to comply. "They had the 'you can't compete with the big guys' mentality," he says. Wells's tenacity was a critical motivating force for the others. "Mike just wasn't going to give up," says Ernst. The group continued meeting with other bank officers, and just days before the IRS planned to padlock Arnet's doors, it found a bank willing to advance the necessary funds.

Although Wells, Hancock, et al thought they had orchestrated a reprieve, they had already committed a near-fatal mistake that was soon to become apparent. Without realizing the danger of it, Arnet's managers had allowed the company to become dependent on the revenue from the Computervision contract.

Arnet nicknamed its 6-week effort "Rambo marketing" and assigned every available staff member to follow up on sales leads.

"We had built up the company based on revenues from one customer, and we failed to realize how vulnerable we were," recalls Ernst.

A bird in the hand . . .

In early 1986, a Gardware EEPROM began failing in the field. Arnet lacked the resources to trace the problem and rectify it, and Computervision, which had purchased more than $600,000 worth of the EEPROM, grew concerned about quality control. "What was really going on was that between Multiport and Gardware, we were going crazy with customer support," explains Wells. Arnet decided to forgo further development of Gardware. It did plan to continue providing support for its existing customers, however.

Abandoning further development irked Arnet's biggest customer. Computervision cancelled its contract and gave its business to Rainbow Technologies, Arnet's closest competitor. "Our income dropped 50% overnight," Wells says. To make up the badly needed revenue, the company mounted an all-out campaign to increase sales of Multiport. Arnet nicknamed the effort "Rambo marketing" and assigned every available staff member to follow up on sales leads that had come in over the past few months.

The intensive 6-week effort brought in some extra revenue, but not enough. Without drastic measures, the company would be forced to close its doors. "It got scary," remembers Ernst. "There was a lot of pressure, and we knew our survival depended on laying people off." An emergency meeting in June determined that 9 of the company's 22 employees had to be let go. Most of these had been hired within the previous six months, and they came from a variety of departments within the company. Wells and Hancock met with the soon-to-be-laid-off employees, explained the company's status, and offered them an admittedly meager severance package—two weeks' pay and the preparation of their resumés.

A favorable outlook—again

While Arnet limped along, the company's sales efforts gradually began to show results. Sales of Multiport started to climb. The company was inching back from the precipice—or so it seemed. To operate efficiently and avoid repeating past mistakes, however, Arnet had to synchronize its inner workings. As president, director of R&D, and company marketing representative, Wells had assumed responsibility for many of the company's key functions. As Arnet grew, he was stretched ever thinner and was slowly grinding Arnet's progress to a halt. "The company was moving along but there was no way for people to sit down and plan together and get a feeling for what was going on," says Ernst. "Mike was so involved with the marketing that it was as if we had no leader."

Finally, Ernst took Wells aside and minced no words in describing the business's status. Looking around the company, Wells says, he knew she was right. The problems were genuine—and acute. Among other things, the company was constantly running out of inventory and was slow to fill orders. Members of the engineering department were unsure of their direction. "I was making lots of decisions in a vaccuum," Wells concedes. A short time later, he hired a sales and marketing manager and turned his attention to working full-time as the company president and new-product director.

Rounding the corner

For a while, the new organization worked. But even after passing on the sales and marketing responsibilities, Wells remained overextended. By early 1987, the pressure had become too much. At a staff meeting one January morning, he lost his cool. "Everything was behind schedule, and there seemed to be 25 problems to solve. I seemed to be the only one concerned. No one seemed to be taking any initiative or getting fired up.

"I screamed and called [the managers] wimps." Fuming, Wells stormed out of the meeting and left the office for the day. "I wanted to quit." His ego got the best of him, he admits. He almost wanted to leave for a month and see the company crash and burn. "On the other hand," Wells says, "I was begging for help." Several days of introspection ensued. "My ego had definitely become a problem," he continues. "I didn't understand how I could be president and not be in charge of everything."

Among the first remedial steps Wells took was to distribute some of his responsibilities. To relieve himself of day-to-day management duties, he created the position of chief executive officer. "I needed to find someone who liked managing," Wells says. "I hated it all—the meetings, the performance reviews, all the details."

Ernst became chief executive officer, and Wells promoted McKeown to executive vice president.

McKeown realized that it was a position of prestige, but it also meant leaving behind his engineering tasks. "I had to do a lot of soul searching to decide if it was the right thing for me," McKeown says. "My specialty was never microprocessor technology, so the company had really evolved out from under me. But the excitement of being part of this organization had always been enough compensation for me."

He takes pride in the fact that one of his board designs recently received a top rating from *Infoworld* magazine, and he adds, "I still live vicariously through the engineering department." Now ensconced in administrative work, McKeown commemorates his days at Merrick with a painting of a cow, which hangs on his office wall.

As another measure to further diffuse the decision-making process, Wells and Hancock created an executive committee to make decisions by consensus. Besides the company's founders, Ernst and McKeown became board members.

Arnet now has 35 employees, 15 of whom own stock in the company. In 1988, Wells and Hancock expect to double their fiscal 1987 profits. They've continued to expand their product line and now produce four communications boards. In April, the *Nashville Business Journal* bestowed its Small Business of the Year award on Arnet. Buzz Heidtke, a member of the judging panel, visited the company and came away impressed both by Arnet's comeback and by the atmosphere it has created. As Heidtke says, "They got some good contracts and were a bit too successful too early. Now, they seem to really work on quality." **EDN**

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1988 Editorial Calendar and Planning Guide

EDN

Issue Date	Recruitment Deadline	Editorial Emphasis	EDN News
Aug. 4	July 14	Sensors & Transducers, Analog ICs, Graphics	Closing: July 21
Aug. 18	July 28	Military Electronics Special Issue, Displays, Military ICs	Mailing: Aug. 11
Sept. 1	Aug. 11	Instruments, Op Amps, Computers & Peripherals	
Sept. 15	Aug. 25	Data Acquisition, Data Communications, Digital ICs	Closing: Sept. 1
Sept. 29	Sept. 8	DSP, Graphics, Optoelectronics	Mailing: Sept. 22
Oct. 13	Sept622	Test & Measurement Special Issue, Instruments, Computers & Peripherals	Closing: Sept. 29
Oct. 27	Oct. 6	CAE, Computers & Peripherals, Integrated Circuits, Wescon '88 Show Preview	Mailing: Oct. 20
Nov. 10	Oct. 20	Programmable Logic Devices, Integrated Circuits, Test & Measurements, Wescon '88 Show Issue	Closing: Oct. 27
Nov. 24	Nov. 3	Microprocessor Technology Directory Graphics, CAE	Mailing: Nov. 17
Dec. 8	Nov. 16	Product Showcase—Vol. I, Power Sources, Software	Closing: Nov. 21
Dec. 22	Dec. 1	Product Showcase—Vol. II, Computers & Peripherals, Test & Measurement	Mailing: Dec. 15

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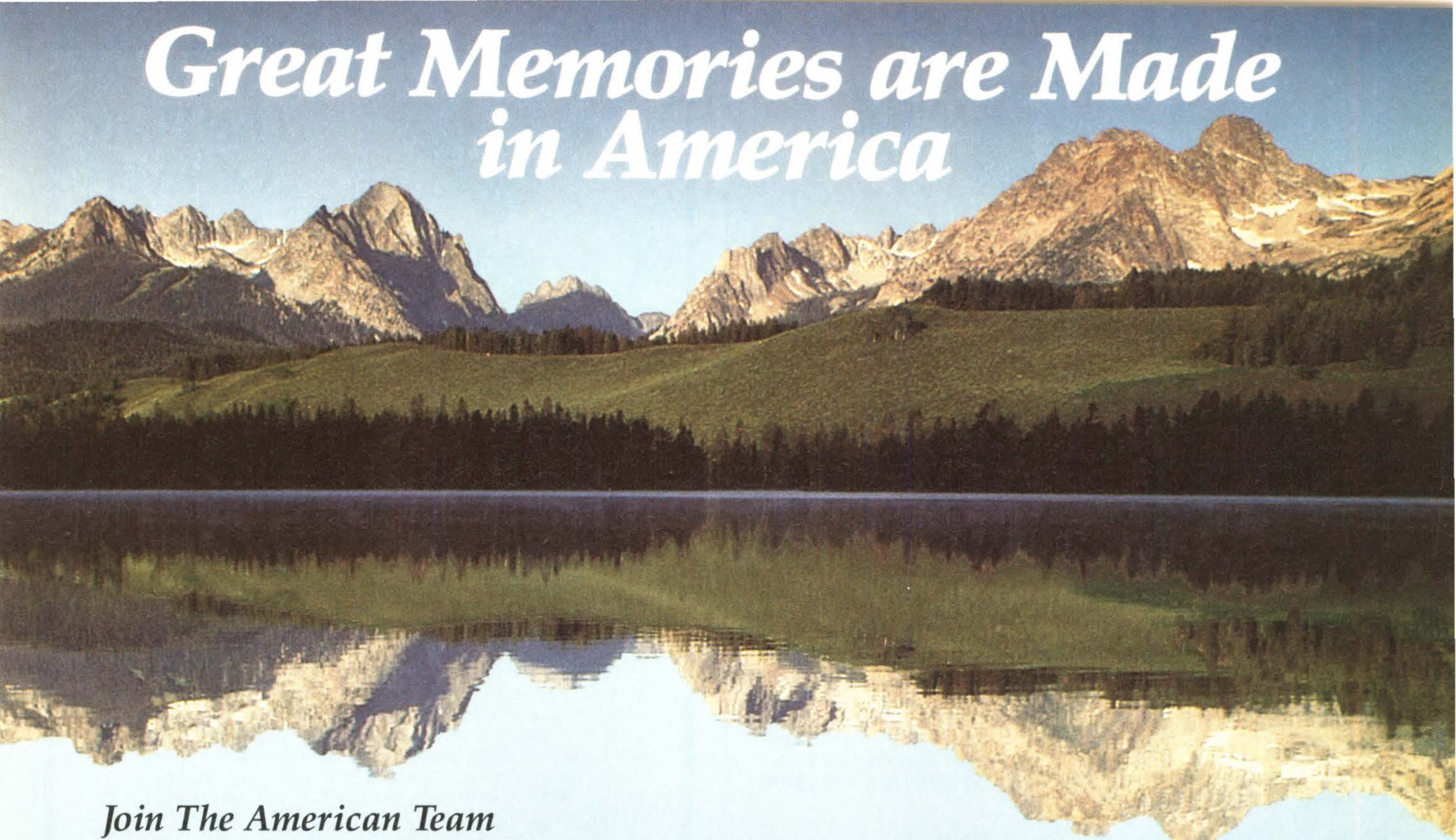

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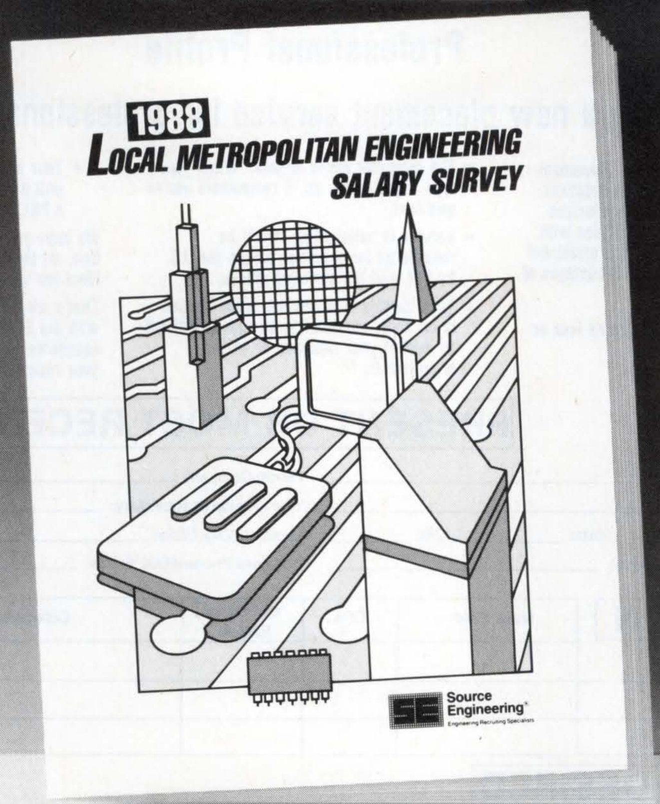

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EDITED BY CYNTHIA B RETTIG

Electronic still imaging to gross $540M in 1992

The market for equipment that produces and processes electronic still images, a relatively new commercial technology, should flourish during the next few years. Estimated at $68.5M for this year, the international market for electronic still-image equipment will reach $542.6M by 1992, according to Electro-Imaging Advisors Inc (La Jolla, CA). Improvements in picture quality, together with the usual reductions in price that accompany a rise in sales volumes, will cause the market to grow dramatically by 1990.

A somewhat new approach to photography, electronic still imaging solves the problems involved in accumulating photos and sending them economically to a distant location in a short period of time. The technology includes the capture of images by a sensor—typically of heat or light—and the subsequent processing, transmission, storage, and display of such images in individual frames. A charged-couple-device sensor, a video camera, or an electronic still-image camera captures the images for processing.

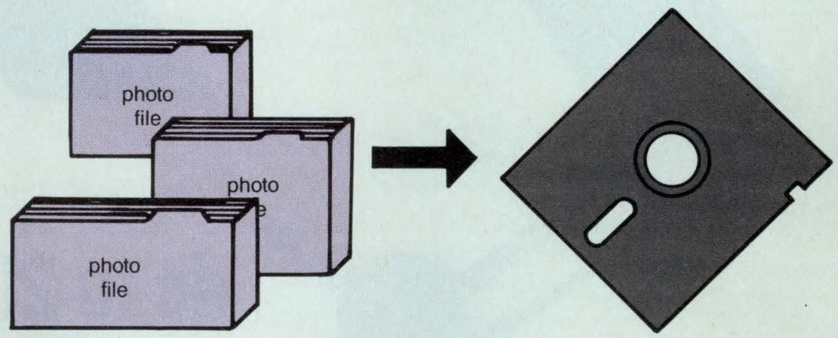
In spite of its youth, the industry has some established standards. All recording devices use a 2-in. floppy disk, and the format for recording allows the recording of 25 frames or 50 fields on each disk. The images can be transmitted via a still-frame communication unit, or via telephones or satellite. The person who receives the images can view them on a monitor or on hard copy and then store them on a hard disk for later reference.

EIA has identified seven key commercial markets. Very large companies, for example, will use the technology for presentations, archives, artwork and advertising files, communication systems, and security. Within five years, corporations will have electronic still-imaging systems in 20 to 25% of their facilities.

TABLE 1—ELECTRONIC STILL-IMAGING MARKET
(MILLIONS OF DOLLARS)

	1988	1989	1990	1991	1992
REAL ESTATE	$3.6	$5.0	$10.7	$18.6	$24.1
RETAIL	3.2	4.5	5.5	6.0	8.1
PUBLISHING	9.4	14.3	24.2	36.2	36.8
CORPORATE	14.8	26.8	44.3	60.9	70.3
LAW ENFORCEMENT	8.6	12.3	17.1	20.2	24.0
CONSUMER	0.0	0.0	45.6	95.3	192.0
GOVERNMENT & OTHER	28.9	55.5	112.5	160.6	187.3
WORLDWIDE TOTAL	$68.5	$118.4	$259.9	$397.8	$542.6

(SOURCE: ELECTRO-IMAGING ADVISORS)



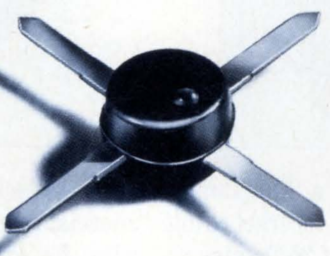
Demand for T3 test devices is expected to boom

The digitization of America, fueled by the Bell operating companies and other, independent telecommunications companies, should quadruple the market for T3 transmission test equipment over the next five years, according to Able Telecommunnications Inc, a consulting and market research company based in Milpitas, CA. Currently worth $24 million, that market should attain a $100 million value by 1992.

Able defines T3 transmission test equipment as systems that perform separate testing, monitoring, and error-testing functions on T3 lines, which feature digital bit streams to 44M bps. Interchange carriers, large corporations, and other organizations that use fiber-based networks are expected to follow the telecommunications companies' lead over the next few years.

In terms of unit sales, the market will grow from 3000 this year to 16,700 in 1992. At the same time, the price of a single test system should drop. Right now, T3 test systems average $8000 per unit; by 1992, they should cost about $6000 each.

from 99¢



dc to 2000 MHz amplifier series

Unbelievable, until now...tiny monolithic wide-band amplifiers for as low as 99 cents. These rugged 0.085 in.diam.,plastic-packaged units are 50ohm* input/output impedance, unconditionally stable regardless of load*, and easily cascadable. Models in the MAR-series offer up to 33 dB gain, 0 to +11dBm output, noise figure as low as 2.8dB, and up to DC-2000MHz bandwidth.

*MAR-8, Input/Output Impedance is not 50ohms, see data sheet. Stable for source/load impedance VSWR less than 3:1

SPECIFICATIONS

MODEL	FREQ. MHz	GAIN, dB 100 MHz	1000 MHz	2000 MHz	Min. (note)	• MAX. PWR. dBm	NF dB	PRICE $ Ea.	Qty.
MAR-1	DC-1000	18.5	15.5	—	13.0	0	5.0	0.99	(100)
MAR-2	DC-2000	13	12.5	11	8.5	+3	6.5	1.50	(25)
MAR-3	DC-2000	13	12.5	10.5	8.0	+8 □	6.0	1.70	(25)
MAR-4	DC-1000	8.2	8.0	—	7.0	+11	7.0	1.90	(25)
MAR-6	DC-2000	20	16	11	9	0	2.8	1.29	(25)
MAR-7	DC-2000	13.5	12.5	10.5	8.5	+3	5.0	1.90	(25)
MAR-8	DC-1000	33	23	—	19	+10	3.5	2.20	(25)

NOTE: Minimum gain at highest frequency point and over full temperature range.

• 1dB Gain Compression

□ +4dBm 1 to 2 GHz

designers amplifier kit, DAK-2

5 of each model, total 35 amplifiers

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† Minimum Order 50 per Value

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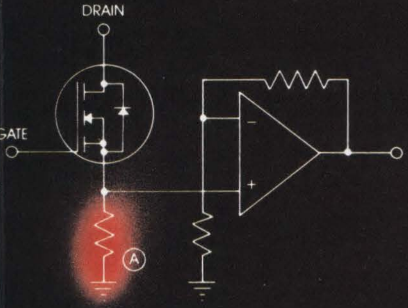
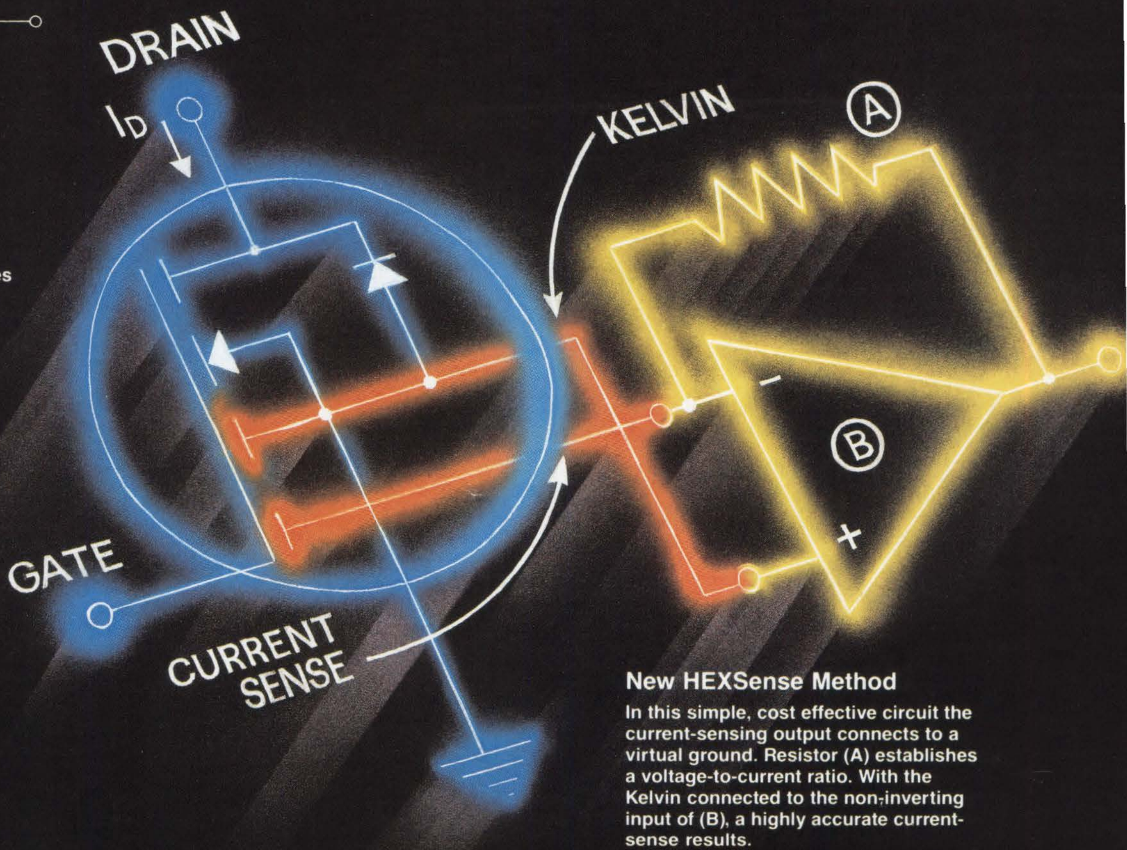


Old Method

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.

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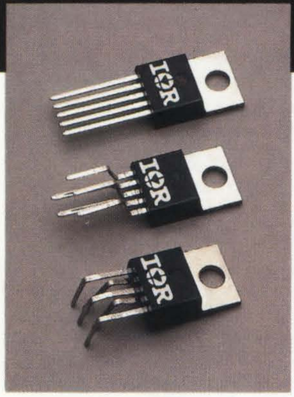

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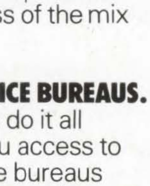

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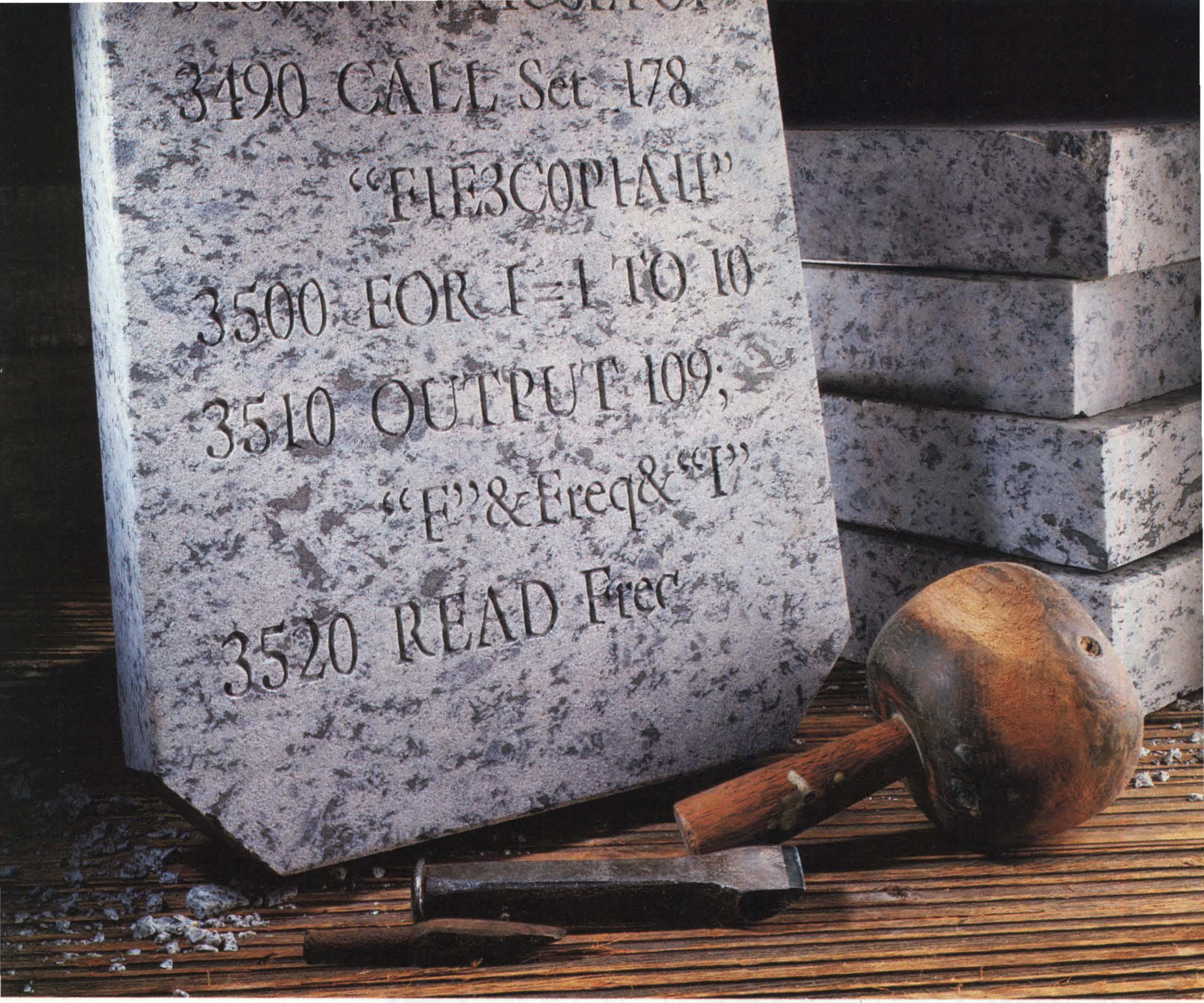
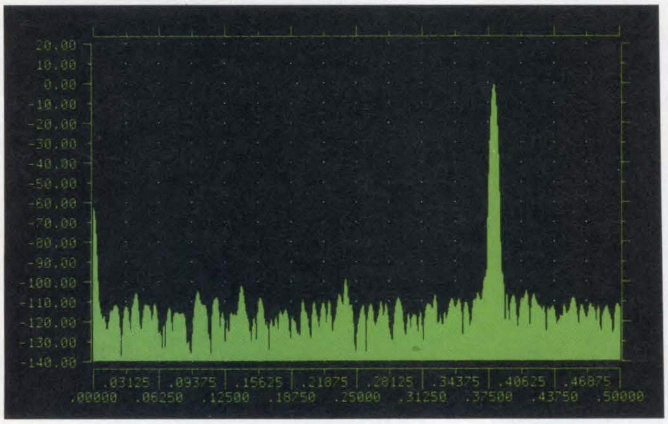
Design Ideas Special Issue VOLUME I

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

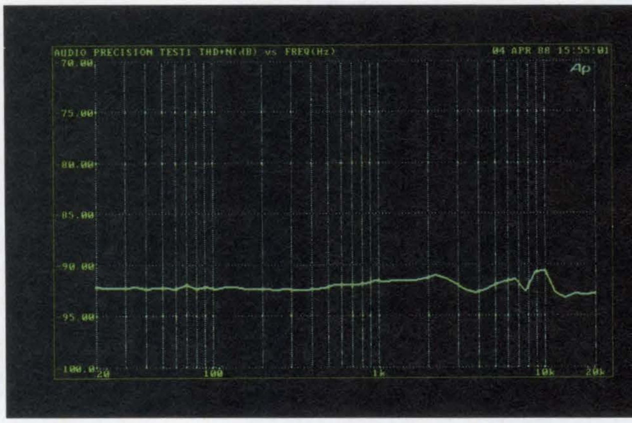


3490 CALL Set 178
3500 FOR I=1 TO 10
3510 OUTPUT 109;
“F”&Freq&“T”
3520 READ Frec

Stop, look, listen.



FFT: Detailed distribution of noise and harmonic distortion vs. input signal. Measurement of sample and hold and ZAD2716 A/D converter only. Computer analysis receives digital information from A/D converter (to avoid DAC reconstruction distortion).



Using an Audio Precision system, a sine wave is digitized by the ZAD-2716, then reconstructed by the ZDA-1801, and filtered by Apogee's 944S linear phase filter. Graph shows combined total harmonic distortion and noise vs. frequency.

Introducing the world's finest professional 16-bit stereo digitizing subsystem and 18-bit deglitched reconstruction DAC.

Want to position yourself at the leading edge of digital audio? Then hear this.

Analog Solutions gives you a new family of professional audio products with confirmed "Golden Ear" performance using the industry's two most powerful test criteria. The eye. And the ear.

If seeing is believing, you'll be impressed by the harmonic distortion and noise plots of our ZAD2716/ZSH202 digitizing subsystem (left) and ZDA1801 deglitched reconstruction DAC (right). Nobody's ever seen plots like those before.

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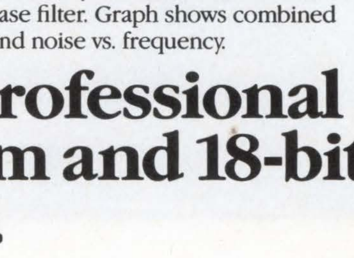

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CIRCLE NO 3

Volume 33, Number 14A

EDN

July 7, 1988

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

(Photography by Mike Blake)

Continued on page 5

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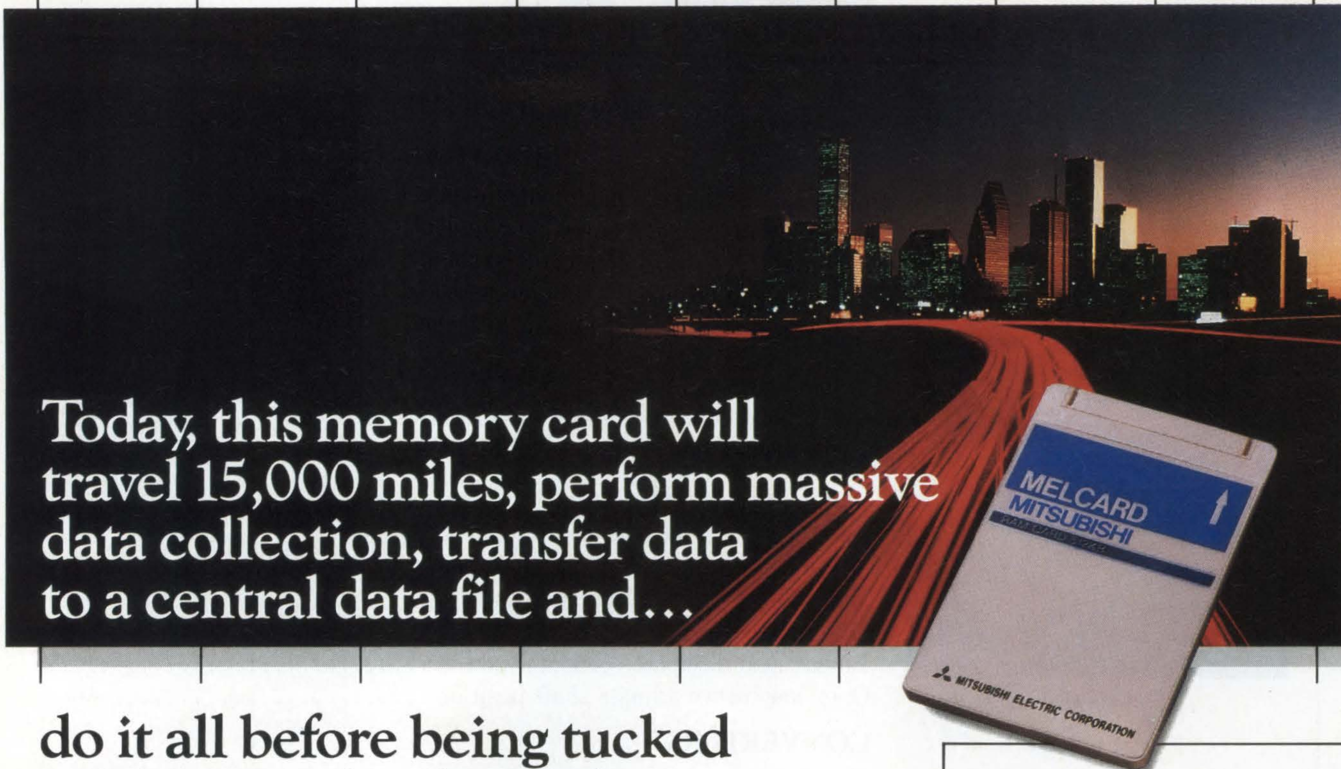

Today, this memory card will travel 15,000 miles, perform massive data collection, transfer data to a central data file and...

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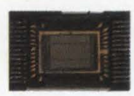
VSOP

13.8 mm x 8.0 mm x 1.0 mm = 110.4 mm^3



Chip-On-Board

15.4 mm x 9.8 mm x 1.0 mm = 150.9 mm^3

SOP

17.5 mm x 12.2 mm x 2.2 mm = 469.7 mm^3

"Transportable" Means "Rugged."

Mitsubishi designed its memory cards specifically for transportable applications. And, that means cards that are rugged and reliable. Even if a card is dropped, loss of valuable data is virtually eliminated, due to Mitsubishi's flexible, four-layer PCB and enhanced soldering techniques.

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CIRCLE NO 4

Continued from page 3

INTERFACES

LIMITERS

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SENSORS

SOFTWARE

TEST CIRCUITS

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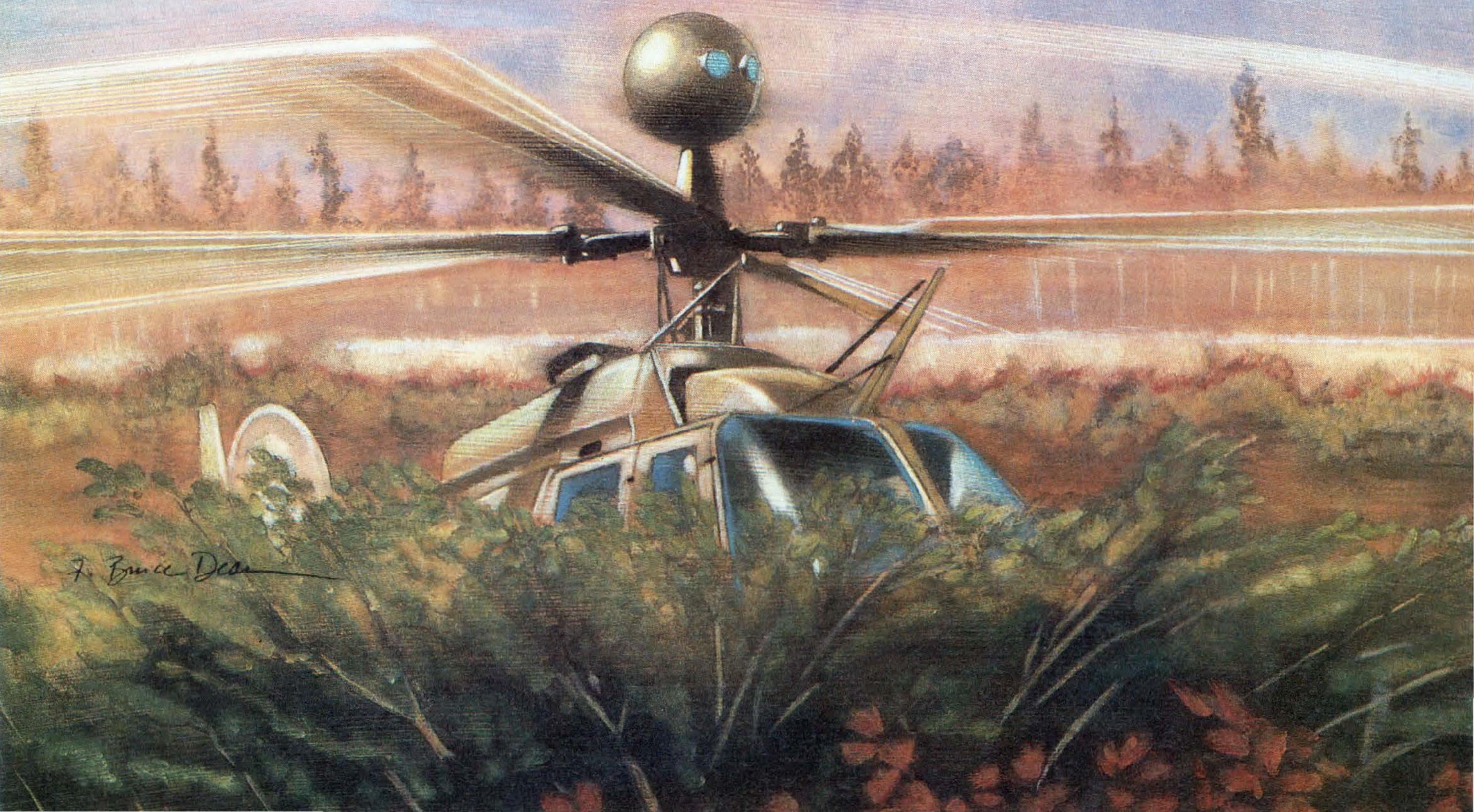

INTRODUCTION

Every batch of Reader Service cards we receive contains many comments about our Design Ideas section. Most often, readers tell us they've found a particularly useful circuit that helped them solve a tricky design problem. But readers also want to know how they can get a complete set of past circuits and software. Alas, such a compendium doesn't exist. But this Design Ideas Special Issue represents the next best thing—a collection of 50 of the best Design Ideas published in EDN from 1985 through June 1988.

This collection of designs reflects your needs and not the preferences of our technical editors. In fact, you and your colleagues voted for these winning ideas by circling the "bingo card" numbers that appear at the end of each Design Idea we publish. Of the circuit-design tips in this Design Issue, 29 garnered Best-of-Issue honors based on reader preference. The remaining Design Ideas received the second-highest number of reader votes over the 1985 to 1987 time frame.

In planning these Design Ideas Special Issues, EDN hoped to be able to present a good mixture from the standpoint of design disciplines. Happily, our readers' choices made it easy to achieve this goal. This issue contains 21 analog circuit designs and 24 digital designs, and the remaining five ideas highlight programming tips. To achieve some semblance of order, we've divided the ideas into some generic categories and provided an index that lists design and circuit categories. Although the index is a handy place to look for a special circuit, we'll bet that most readers will want to read the ideas one by one, just to see what circuits are available.

As you read these Design Ideas, remember that each one came from a reader who thought someone else might benefit from his or her work. So, if you find this issue helpful, thank your fellow engineers who submitted the ideas we've published over the years. And the next time you have an interesting and useful circuit, consider sharing it with other engineers by submitting it for publication in EDN's regular Design Ideas section.

Besides seeing your name in print and gaining an extra $100, you might find your idea has been selected as the issue winner. Each issue winner collects an extra $100 also. Keep in mind, too, that EDN's editors also choose a grand-prize winner each year. The grand prize includes a check for $1500. Your idea may also be selected to appear in a future Design Ideas Special Issue. You'll find an entry form in the Design Ideas section in most issues of EDN.

Our commitment to short, comprehensive design solutions includes two more Design Ideas Special Issues in 1988. You'll receive another with your next July showcase issue, and we'll publish a third later in 1988. If you enjoy this Design Ideas Special Issue and find it useful, we'd like to hear from you. If you have suggestions for improvements and changes, we'd like to hear those, too. Just send us a note or give us a call. We'd also like to thank all the readers who have submitted Design Idea entries over the years.

Enough introduction. Here are the ideas you've been clamoring for. Good reading.

Tom Ormond

Tom Ormond
Senior Editor

Big Performance. Little Package.

Rib-Cage connectors deliver 100-gram normal force in miniature/microminiature interconnectors.

Du Pont's RIB-CAGE™ design lets you pack 0.100-in. centerline performance into 0.050-in. c/l packages.

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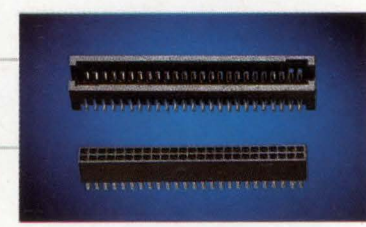
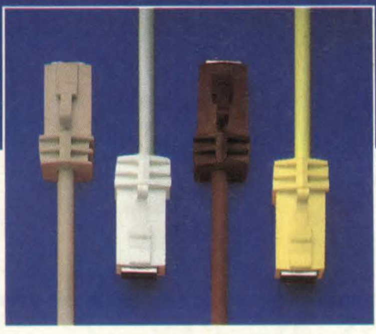
You get inductance, capacitance and impedance values that are compatible with faster signal speeds (thanks to the 0.050 in. design), along with high current capacity and low circuit resistance.



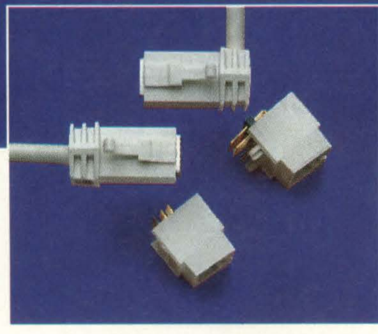
Actual size of 50-position 0.050-in. (1.27-mm) vertical surface-mount RIB-CAGE card connector and mating male header.

In addition, RIB-CAGE connectors let

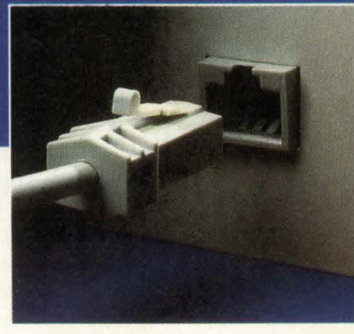
CIRCLE NO 6



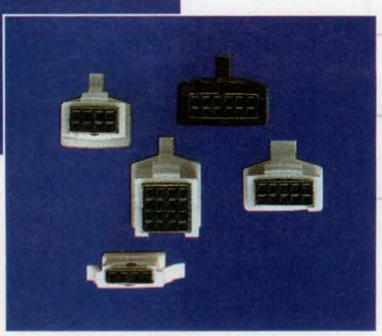
Any color.



Angled or straight.



"Click"—it's connected.



The smallest package.

Dual op amp forms RS-232C driver/receiver

Jean-Paul Lambrechts
National Semiconductor, Santa Clara, CA

To provide a single interface between an RS-232C line and a MOS LSI chip while saving board space and power, you can use a dual op amp (**Fig 1**) in place of the traditional 1488-type line driver and 1489-type line receiver. Further, the LF353N op amp handles transmission rates as high as 19,000 baud without exceeding the EIA's specification for maximum slew rate.

When node B is high, clamping action of the zener diode D_2 keeps op amp IC_{1A} in its linear region of operation. The 3.3V zener voltage is impressed across resistor R_3, which injects a constant current (84 μA) into node A. The resulting voltage at node A, by a Thevenin-equivalent analysis, is 1.82V; thus, node B is 1.82+3.3=5.12V (7V is the maximum allowed by IC_2). This 5.12V output at IC_{1A} is stable for all bipolar-low levels normally encountered at the RS-232C line input, ie, −2V and below for most terminals.

As the line input rises to the high level, the node A voltage decreases, causing the current through D_2 to reverse direction for some input level below 1.82V. The resulting forward bias across D_2 (0.7V) causes node A to drop to 0.85V, yielding 0.85−0.7=0.15V at node B. The circuit is actually a Schmitt trigger that behaves as a voltage regulator in both stable states. That is, node B assumes 0.15V for inputs above 0.91V and assumes 5.12V for inputs below approximately 0V.

In the line-driver section, op amp IC_{1B} acts as a comparator, with the node A voltage (0.85 or 1.83V) on its noninverting input. The corresponding serial output (SO) of IC_2 is 2.4 or 0.4V, so IC_{1B} inverts the SO signal as desired. Diodes D_1, D_3, and D_4 provide overvoltage protection, and R_6 limits the current exchanged with the line. **EDN**

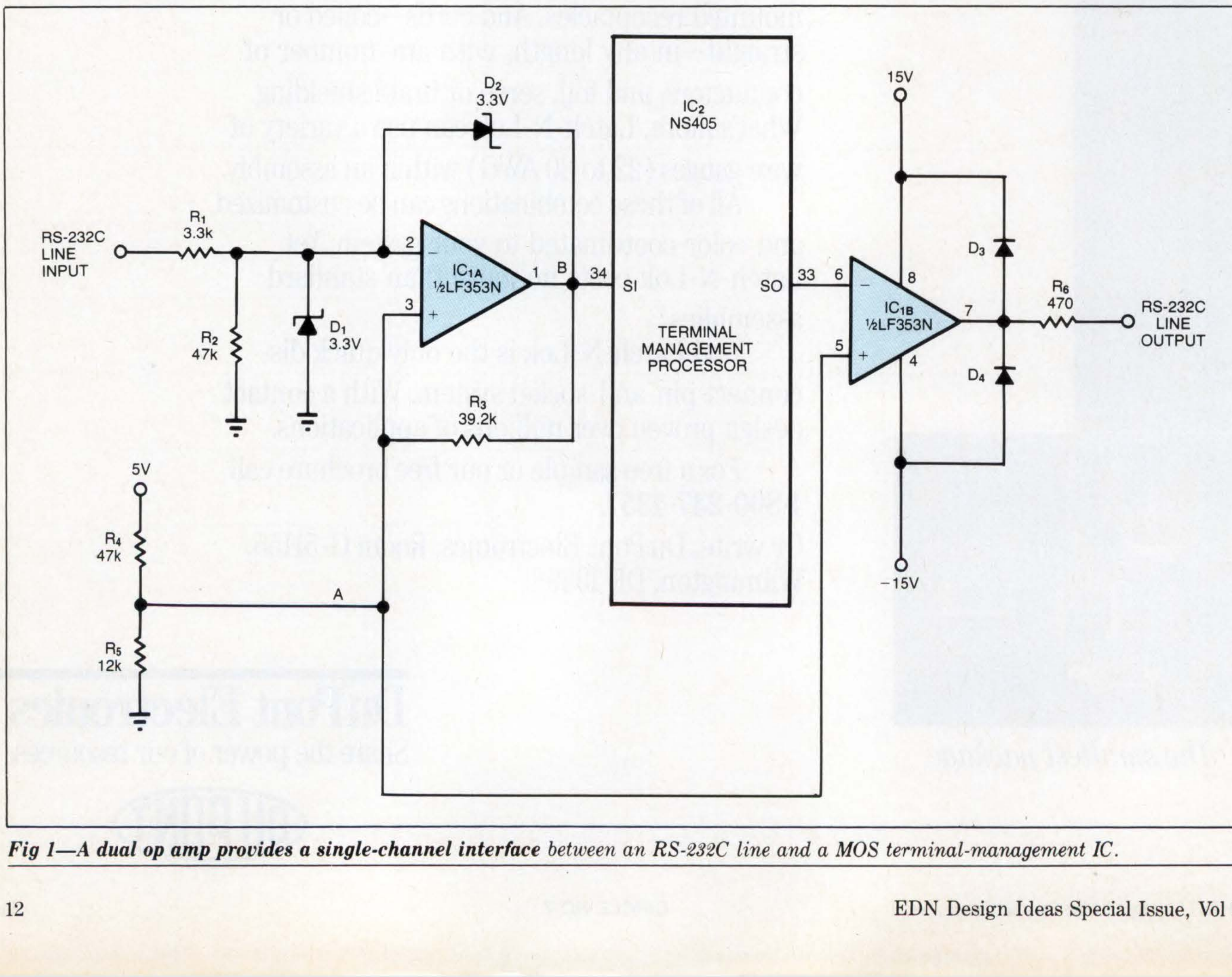


Fig 1—A dual op amp provides a single-channel interface *between an RS-232C line and a MOS terminal-management IC.*

EDITED BY TARLTON FLEMING

Circuit provides controllable resistance

H H Eck
Pulse Electronics Inc, Rockville, MD

The bipolar transistor Q_1 in **Fig 1** presents a linear, dependent resistance between nodes A and B. By extending the connections from IC_1, IC_2, and Q_1's base, you can remotely control a resistance value.

Nodes A and B may assume any voltage value within the output range of op amps IC_1 through IC_5, provided the voltage of node A is more positive than B. You set R_{AB} (the resistance between A and B) to its maximum value by adjusting R_B to its maximum. R_{AB} can't go to zero, but the divider action of R_K provides a lower (and adjustable) limit for the minimum value for R_{AB}. If R_B alone gives enough range, you may eliminate R_K and IC_4.

R_{AB} remains linear over a range exceeding 20:1. In the test configuration in **Fig 2**, $R_{AB}=0.061R_B\pm2\%$ as R_B varies from 34 to 825 kΩ.

For simplicity's sake, you can assign any convenient value to resistors R and R_K (eg, 5 kΩ) **(Fig 1)**. To derive an expression for R_{AB}, note that $V_1=(V_A-V_B)$, $V_3=(V_A-0.6V-V_2)$, and $V_2=V_1/K$, where K is the ratio of R_K's wiper voltage to V_1. Then,

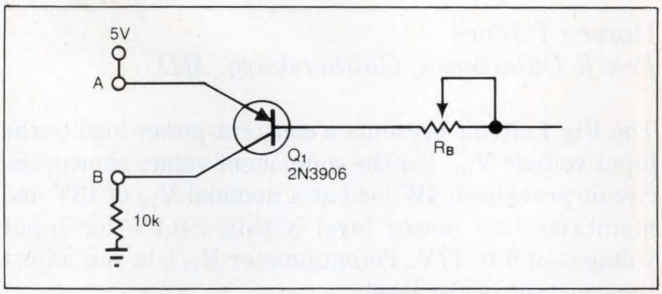


Fig 2—In this test configuration, *$R_{AB}=0.061R_B\pm2\%$ as R_B varies from 34 to 825 kΩ.*

$$I_C = \beta I_B = \beta\left(\frac{V_A - 0.6V - V_3}{R_B}\right) = \beta\left(\frac{V_A - V_B}{KR_B}\right),$$

where β is the transistor's short-circuit current gain. Assuming the transistor's emitter and collector currents are equal,

$$R_{AB} = \frac{V_A - V_B}{I_C} = \frac{KR_B}{\beta}.$$

EDN

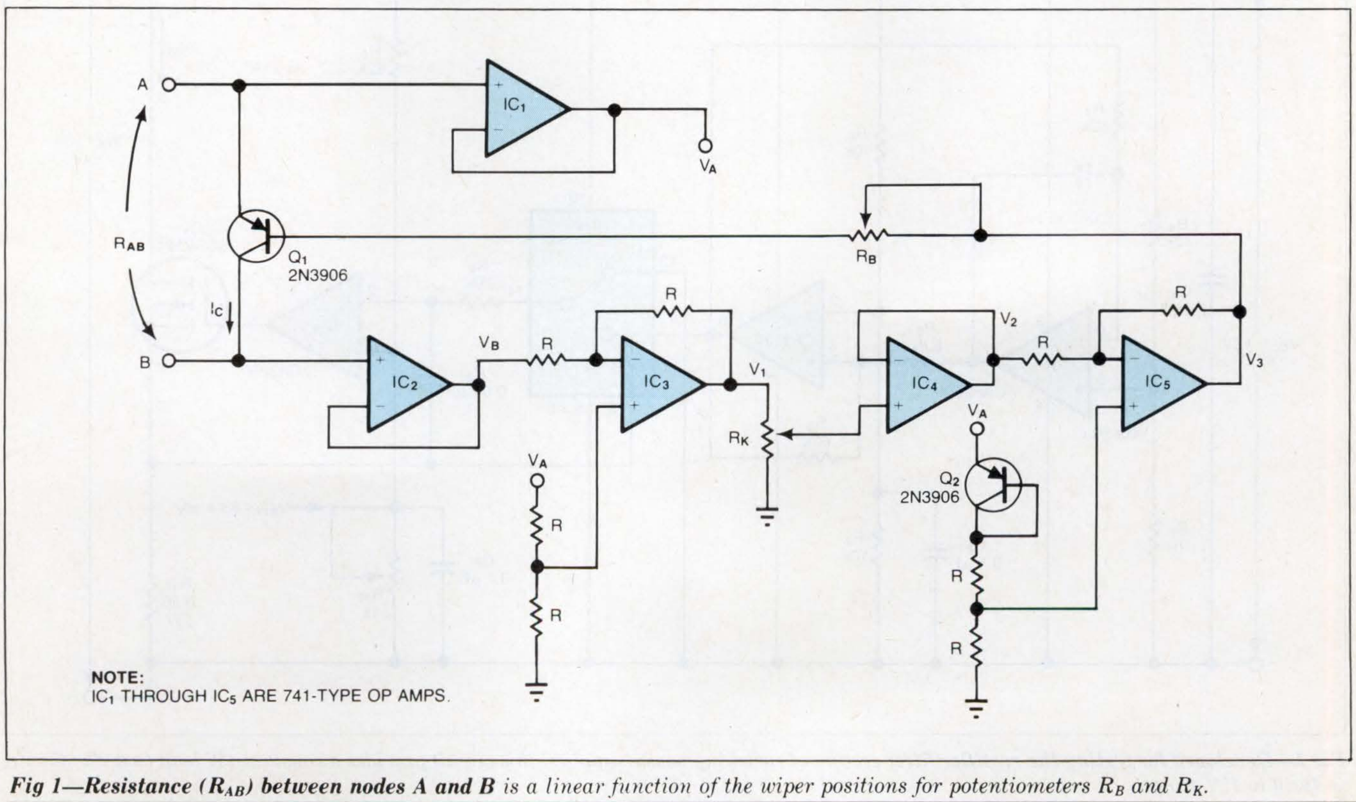


Fig 1—Resistance (R_{AB}) between nodes A and B *is a linear function of the wiper positions for potentiometers R_B and R_K.*

Linear load dissipates constant power

Horace T Jones
Penril Datacomm, Gaithersburg, MD

The **Fig 1** circuit presents a constant-power load to the input voltage V_{IN}. For the component values shown, the circuit provides a 4W load at a nominal V_{IN} of 13V and maintains this power level within ±0.2% for input voltages of 9 to 17V. Potentiometer R_{10} lets you adjust the constant-power level.

Select R_4 and R_5 to produce a voltage $V_{CONTROL}$ of approximately 6V at the inverting input of IC_{1A}. Op amps IC_{1A} and IC_2 form a pulse-width modulator whose output duty cycle (X) is a linear function of V_{IN} (X equals $V_{CONTROL}/V_{CC}$). The modulator's nominal 33-kHz operating frequency (f) decreases as V_{IN} varies above or below its nominal value:

$$f=\frac{X \cdot R_3(1-X)}{R_2R_1C_1}.$$

The modulator's output signal (pin 6 of IC_2) drives the analog switch IC_3, which in turn drives the linear current source formed by op amp IC_{1B} and MOSFET Q_1. Consequently, I_{IN} is inversely proportional to V_{IN}, so the load power P_{IN} is constant:

$$P_{IN}=V_{IN}I_{IN}=\frac{V_{CC}V_{REF}}{R_{11}}\left[1+\frac{R_4}{R_5}\right].$$

Filter components R_8 and C_3 suppress voltage ripple introduced by the switching action of IC_3. This switching action also limits the control loop's 3-dB bandwidth to about 480 Hz. **EDN**

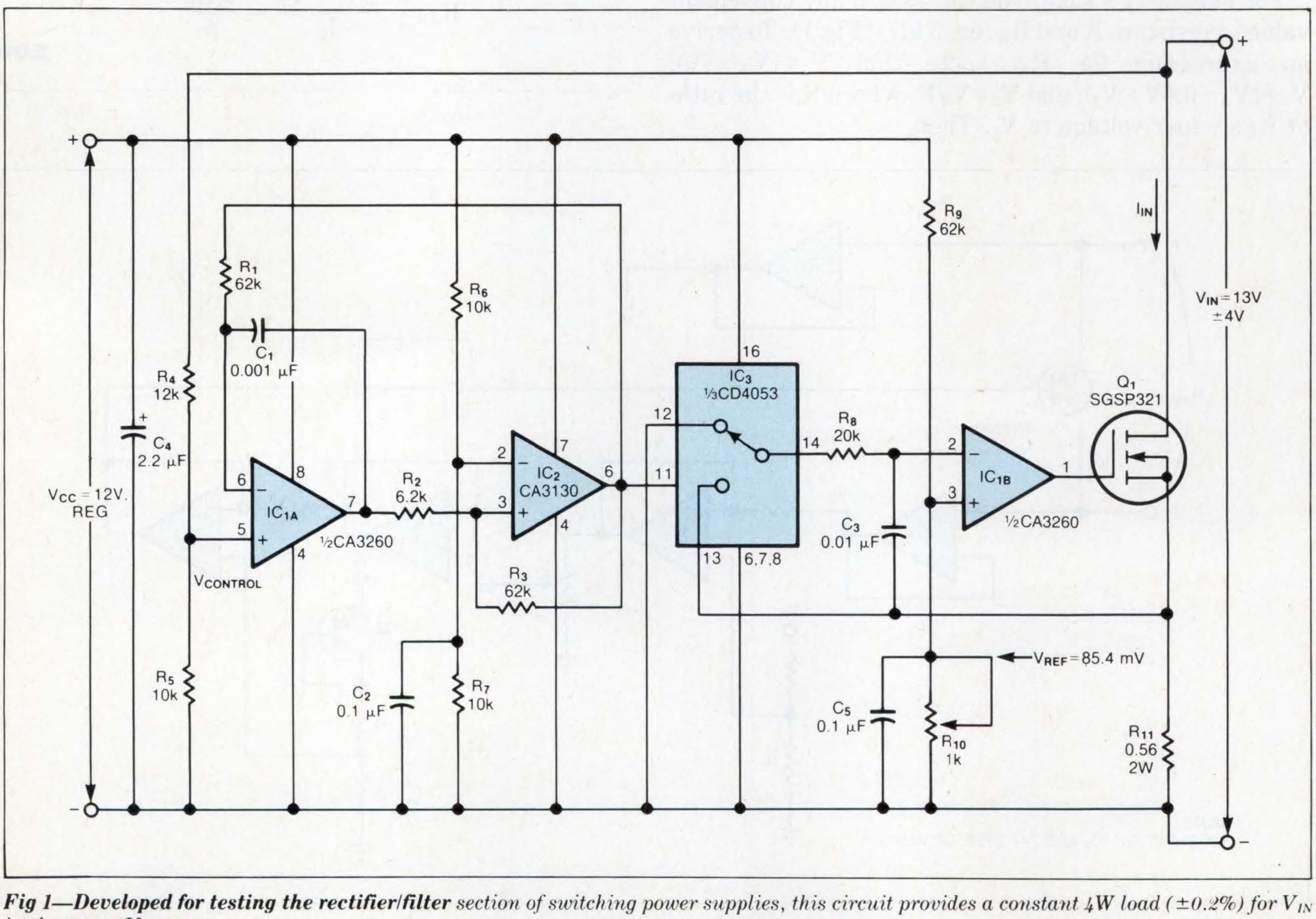
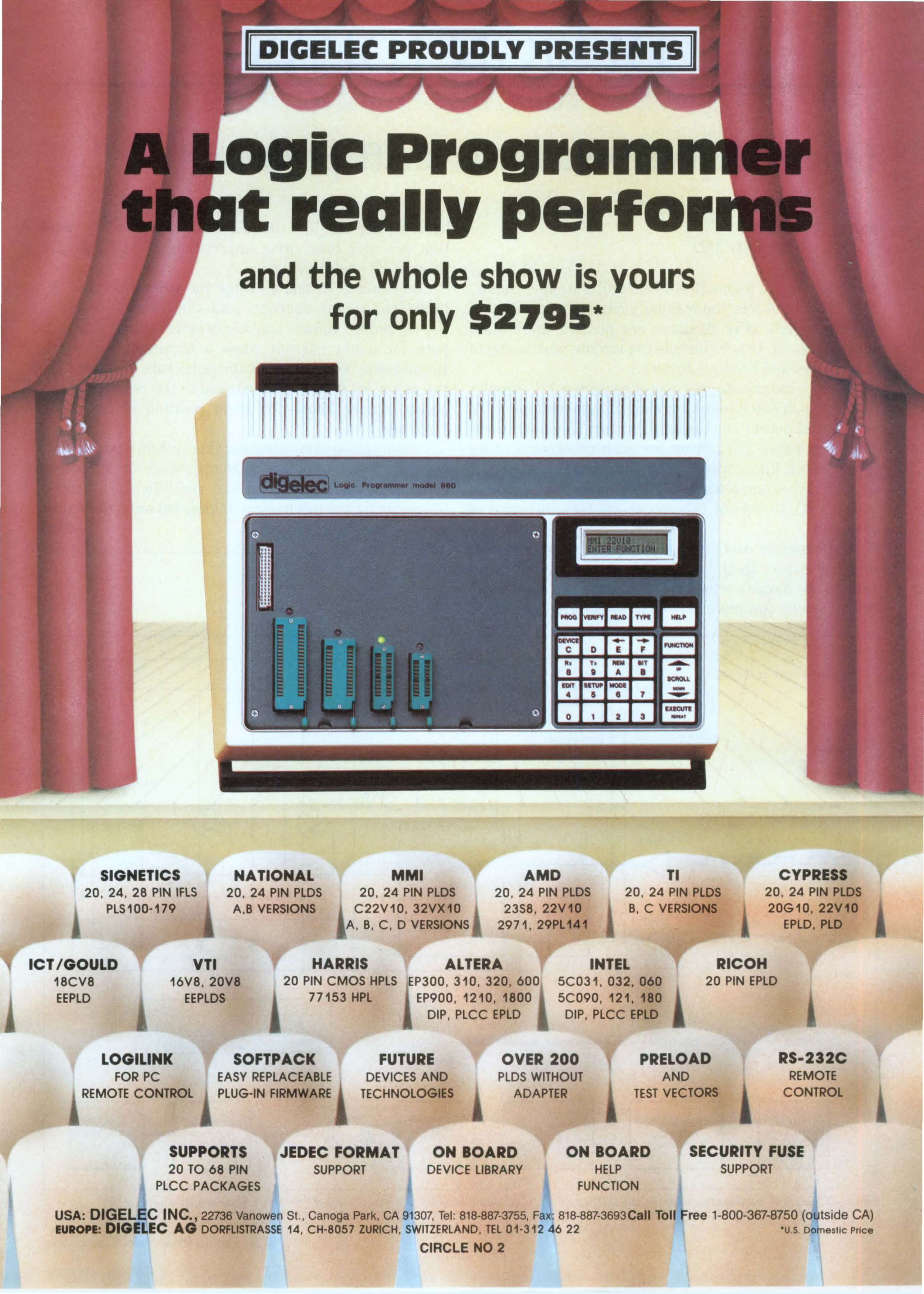


Fig 1—Developed for testing the rectifier/filter *section of switching power supplies, this circuit provides a constant 4W load (±0.2%) for V_{IN} in the 9 to 17V range.*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CIRCLE NO 2

DESIGN IDEAS

EDITED BY TARLTON FLEMING

Open-loop servo adjusts shaft position

James C Smith
NASA, Greenbelt, MD

By using digital techniques to control a stepper motor, **Fig 1a's** circuit lets you manually adjust the position of a remote shaft. (**Fig 1b** shows one possible application for the system. Others include the remote positioning of flow valves and leveling devices.)

The ICs and the stepper motor require a 12V supply, which also drives a regulator chip (IC_2) that supplies 5V to a digital potentiometer (not shown). This potentiometer generates 256 pulses for each revolution of its adjustment knob, producing the channel A and B quadrature square waves. These two signals enable flip-flop IC_3 to decode the potentiometer's direction of rotation.

IC_4 generates control signals for the stepper motor, and transistors Q_1-Q_4 supply the necessary drive current to the motor's windings. (IC_4 alone can supply 350 mA/phase to the motor. If your motor requires more current, use the IC's data sheet to select an R_3 value that provides base drive appropriate to the external transistors you're using.)

Components R_4 and C_1 filter the supply voltage, R_5 limits the motor current, and the 5V zener diodes (D_1-D_4) reduce voltage transients by providing a flyback path for motor current when a transistor turns off. Because the motor steps at the pulse rate of channel B, the motor rotation is proportional to the rotation of the potentiometer knob—for knob rotation below about 1 rev/sec.

Unlike analog servo circuits, this system's positioning capability isn't affected by temperature or long-term component drift. Precision and resolution are limited primarily by the mechanical linkage between the motor and its load. **EDN**

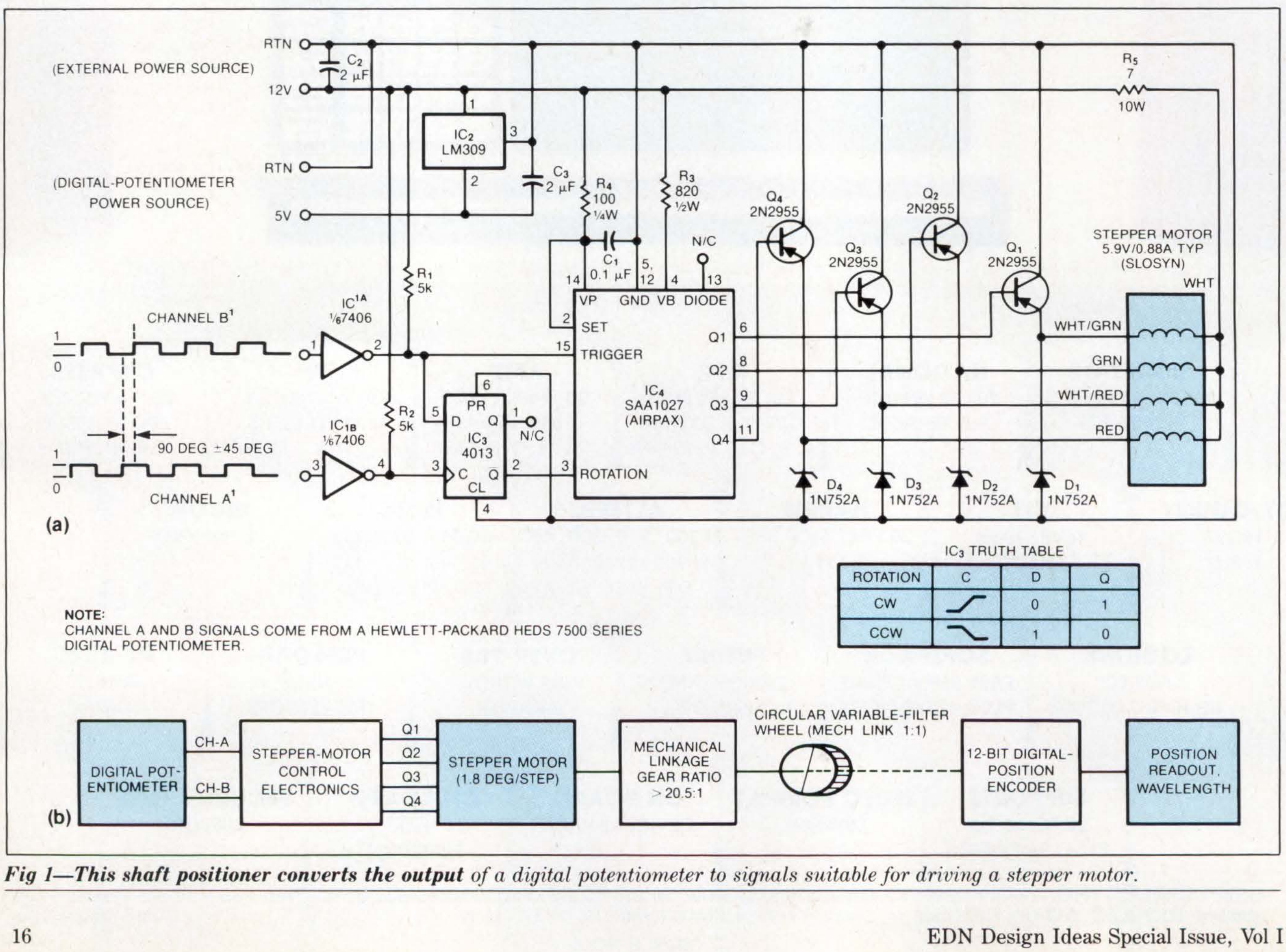
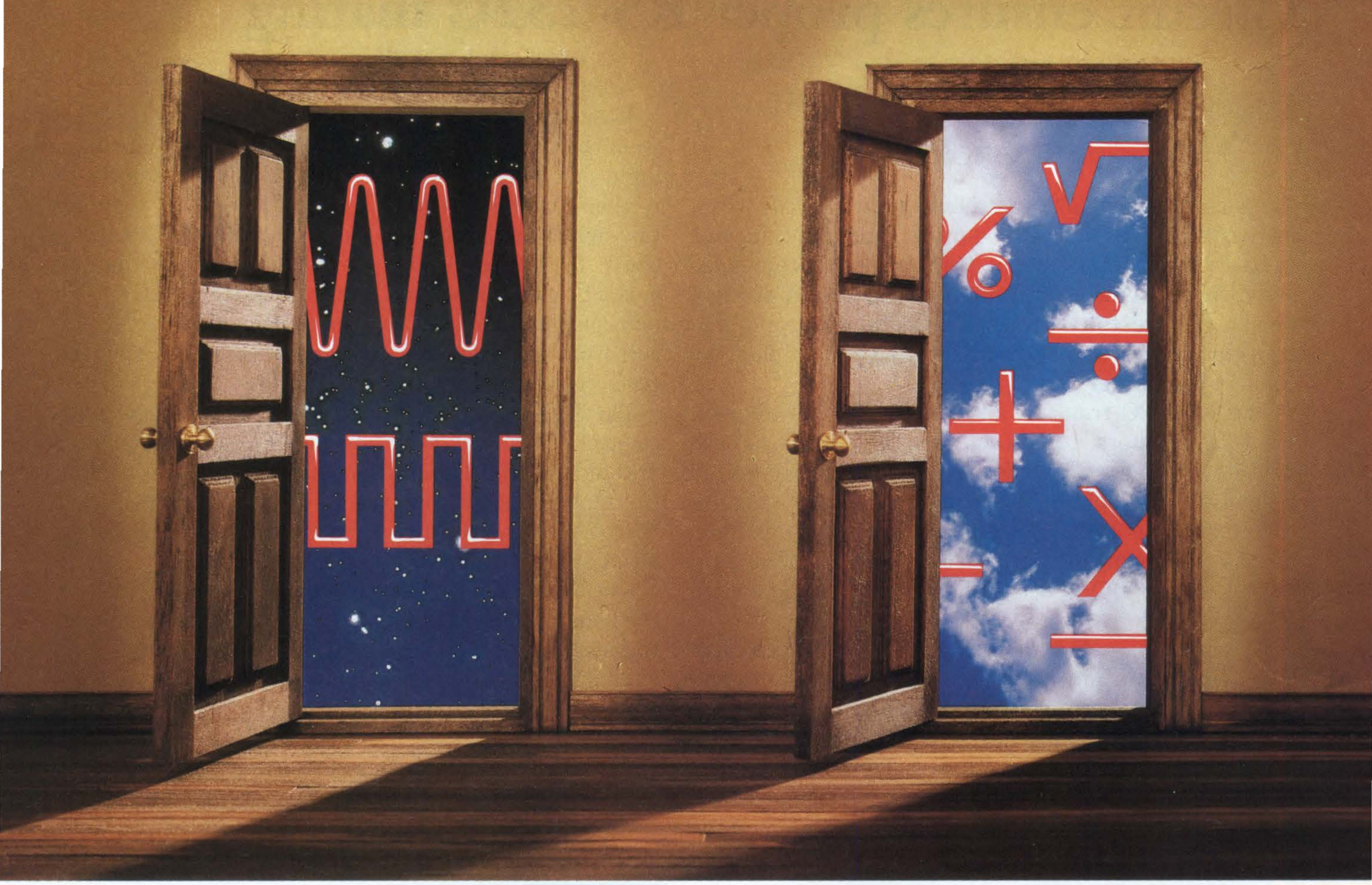


Fig 1—This shaft positioner converts the output *of a digital potentiometer to signals suitable for driving a stepper motor.*

Bringing the Worlds of Data Acquisition and DSP Together



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CIRCLE NO 9

Circuit ensures proper RS-232C mating

Ralph L Adcock
SKP Electronics, Santa Ana, CA

Connectors for RS-232C data links aren't keyed, which increases the chance that you might plug the connector in backwards, reversing the transmit and receive pins and disabling a piece of equipment. The circuit of **Fig 1** masks this mistake by automatically swapping the transmit and receive signals, allowing you to plug the connector in either way.

The RS-232C transmit and receive signals connect, via 1-kΩ resistors, to optocouplers IC_2 and IC_3. These devices produce a logic zero at their outputs (pin 6) in response to an input of either polarity having a magnitude exceeding 3.8V. (RS-232C signals are a minimum of ±5V.) In turn, the outputs cause the J-K flip-flop's output (IC_4, pin 5) to set the position of analog switch IC_1 correctly.

At power-on, active drivers at each end of the RS-232C link maintain a voltage on the transmit and receive lines—regardless of data transmission. If the plug is mated correctly, the voltages cause the optocouplers' outputs to each assert a logic zero. Consequently, the flip-flop's output remains unchanged.

If you insert the plug backwards, you remove voltage from the input of one of the optocouplers, producing a logic one output. The flip-flop will then toggle in response to the first negative clock transition, toggling the switch and restoring the proper RS-232C connections. (The clock input can be either a pushbutton contact closure or a signal of approximately 1 kHz.) The optocouplers' 250-μsec response time prevents the circuit from directing a change of connections during the zero-crossings of a data transmission.

The LED (D_1) indicates the direction of the plug connection—that is, whether the TXD signal is on pin 2 or 3 of the RS-232C interface. Also, when you apply a continuous clock signal, the LED indicates either that there isn't any RS-232C connection or that the power is off at the other end; the system will hunt under these conditions. A given clock frequency sets a lower limit on the baud rate, though. With a 1-kHz clock, for example, the system can handle 300 to 19.2k baud, but it may exhibit false switching at 50 baud. **EDN**

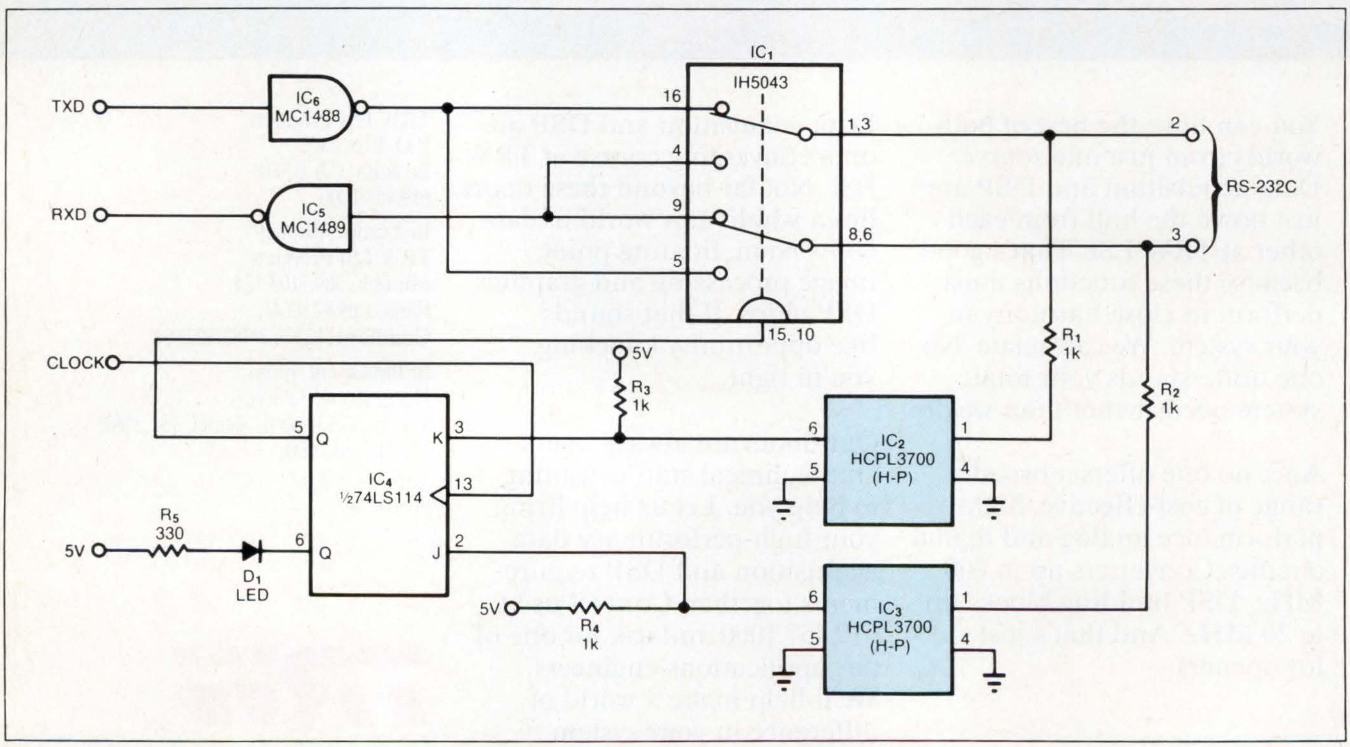
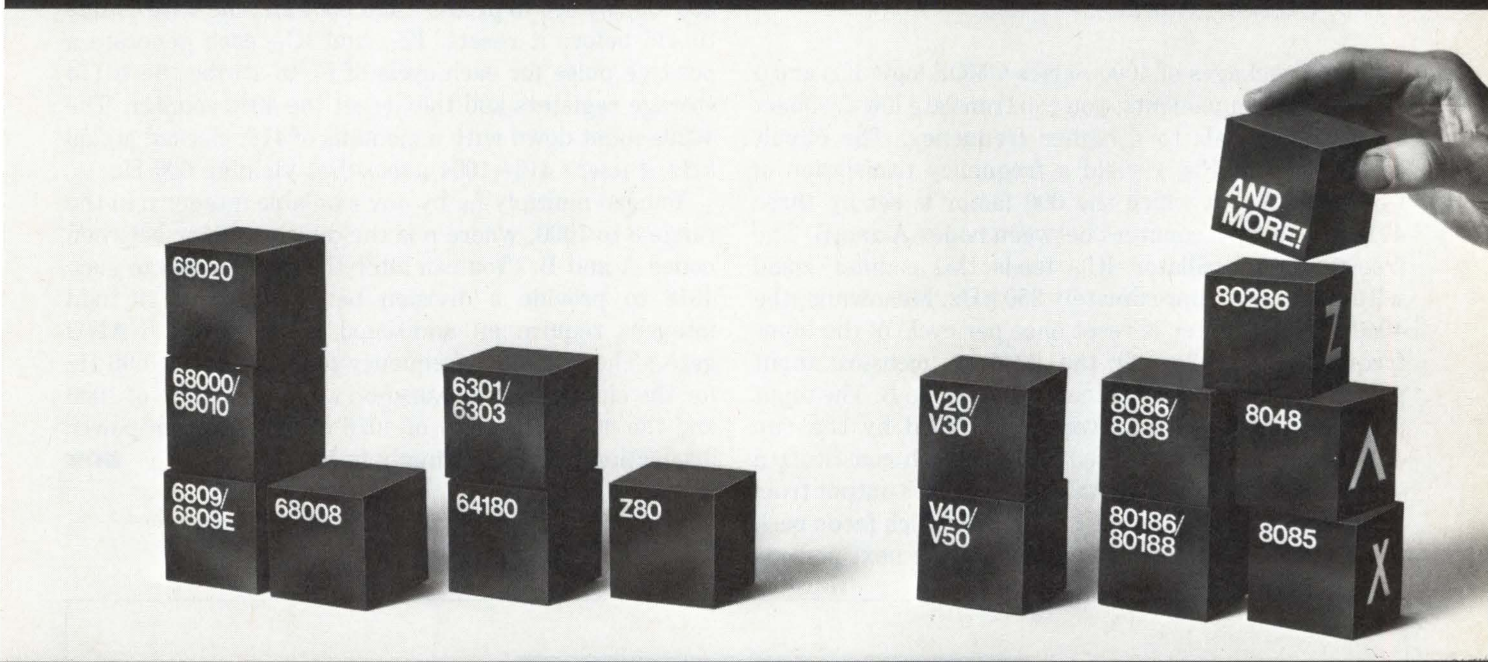


Fig 1—If you inadvertently plug in an RS-232C connector backwards *(crossing the transmit and receive signals), this circuit will detect the fault and automatically swap the signals back to the proper lines.*

Microprocessor Support Made Simple



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CIRCLE NO 10

EDITED BY TARLTON FLEMING

Circuit increases frequency to ×1000

Frank Michele
Brno, Czechoslovakia

Using 10 packages of 4000 Series CMOS logic ICs and a few passive components, you can translate low-frequency digital signals to a higher frequency. The circuit connections in **Fig 1** yield a frequency translation of $f_{OUT}=600\times f_{IN}$, in which the 600 factor is set by three 4018 divide-by-n counters between nodes A and B. The free-running oscillator IC_{1C} feeds this counter chain with a signal of approximately 250 kHz. Meanwhile, the 4040 binary counter is reset once per cycle of the input frequency f_{IN}, allowing the 4040 to measure input period in terms of output counts from node B. The input period (a 12-bit binary word) is latched by the two 40174s and fed to the three 4029s, which constitute a synchronous modulo-n down counter. Each output from this counter generates one f_{OUT} pulse, which feeds back to reset the 4029s for a countdown of the next period.

Consider $f_{IN}=1.0$ Hz, for example. The 4018s divide 250 kHz by 600 to produce 416.6667 Hz; the 4040 counts to 416 before it resets. IC_{1A} and IC_{1B} each generate a positive pulse for each cycle of f_{IN} to strobe the 40174 storage registers and then reset the 4040 counter. The 4029s count down with a modulus of 416, clocked at 250 kHz: 4 μsec×416=1664 μsec, thus yielding 600 Hz.

You can multiply f_{IN} by any available integer n in the range 8 to 1000, where n is the division factor between nodes A and B. (You can alter the connections to each 4018 to provide a division between 2 and 10; odd integers require an additional inverter and NAND gate.) The minimum frequency for f_{IN} is about 0.06 Hz for the circuit shown, based on a multiplication of 1000 and the 4040's capacity of 4096 counts. System power dissipation with a 9V supply is 100 mW. **EDN**

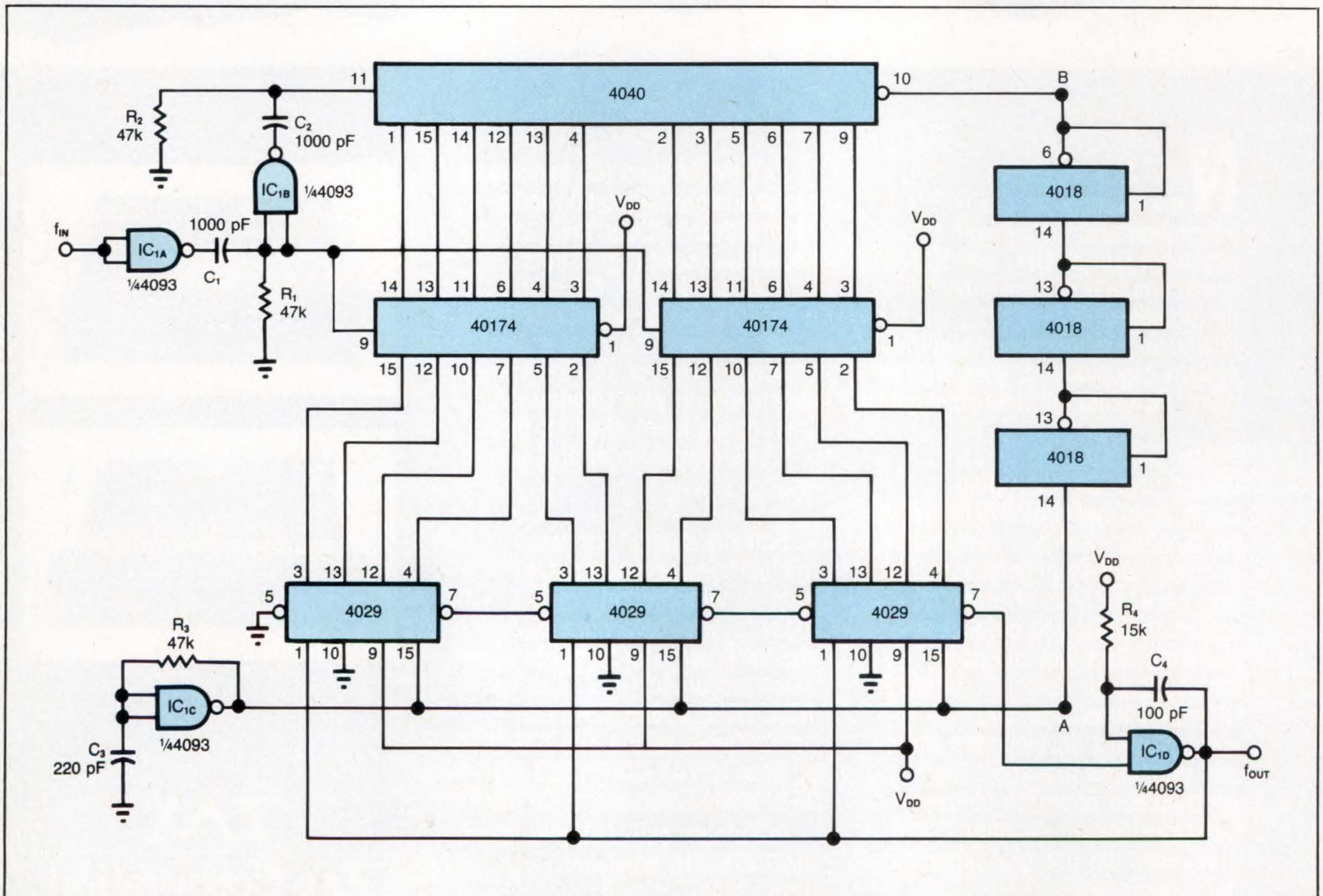

Fig 1—You can multiply frequency f_{IN} from eight to 1000 times by using 10 CMOS ICs and several passive components.

Divider produces symmetrical output

Irwin Cohen
Hewlett-Packard Co, Rockaway, NJ

In synchronous systems, you must often divide a symmetrical clock waveform by an odd integer and obtain a symmetrical output (ie, a 50% duty cycle). Unfortunately, J-K flip-flop dividers usually produce a waveform (labeled A in **Fig 1b**) in which the high and low intervals differ by one period of the input clock. The **Fig 1a** circuit corrects this situation by splitting the difference—it lengthens the short interval and shortens the long one by half a clock period. The circuit works for any odd-integer division producing an asymmetry of one clock period; division by 3 is used as an illustration.

Flip-flop IC_3's Q output is set high when waveform A is low; Q goes low with the first positive transition of f_{IN} after A returns high **(Fig 1b).** If $T_1 > T_2$, connect IC_{1B}'s Q output instead of the $\overline{Q}$ output to IC_3's preset input. **EDN**

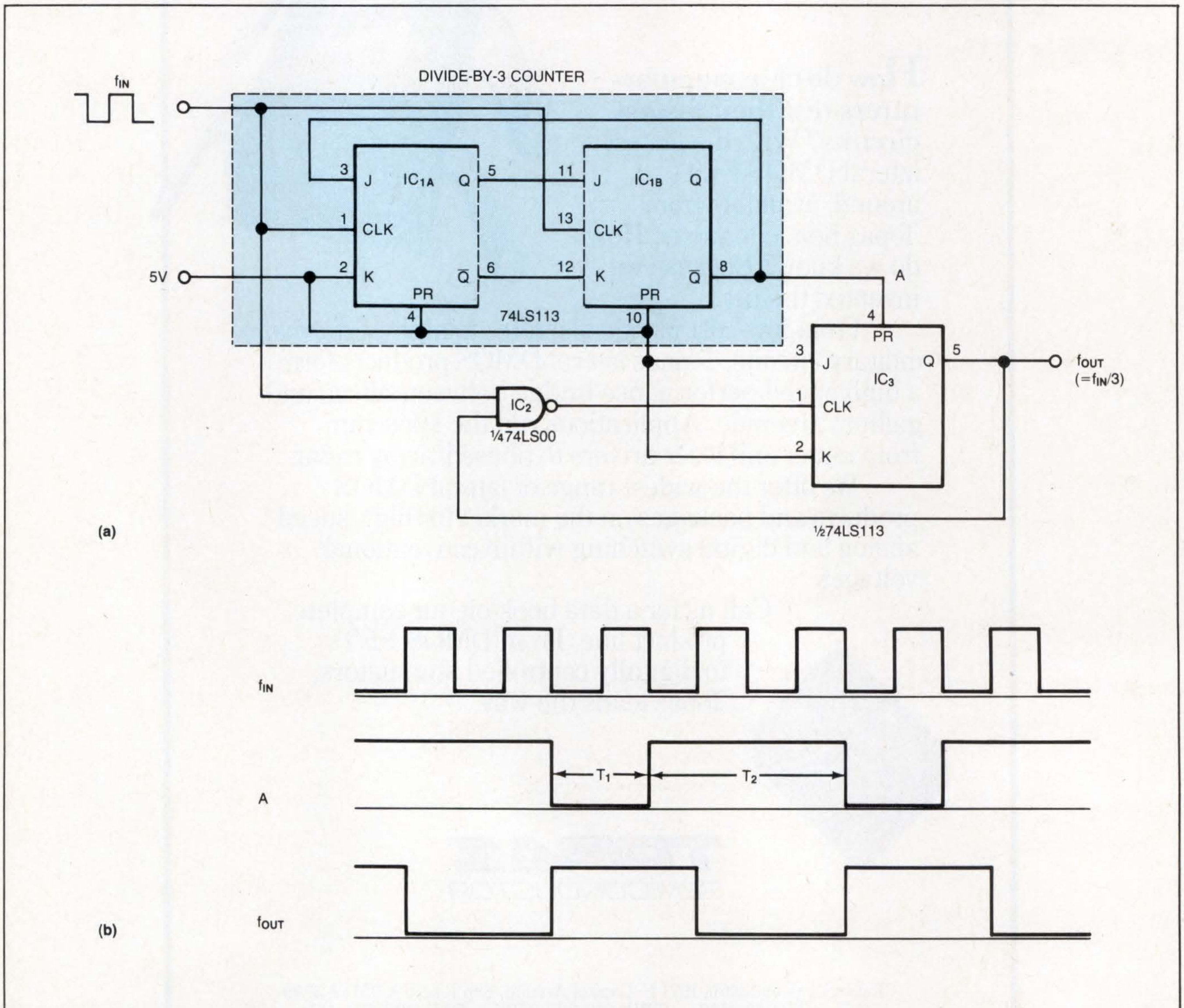

*Fig 1—**Odd-integer division** performed using a divide-by-3 counter **(a)** produces the asymmetrical waveform (such as the one labeled A in part **b**), but you can add additional circuitry to generate a symmetrical f_{OUT} signal.*

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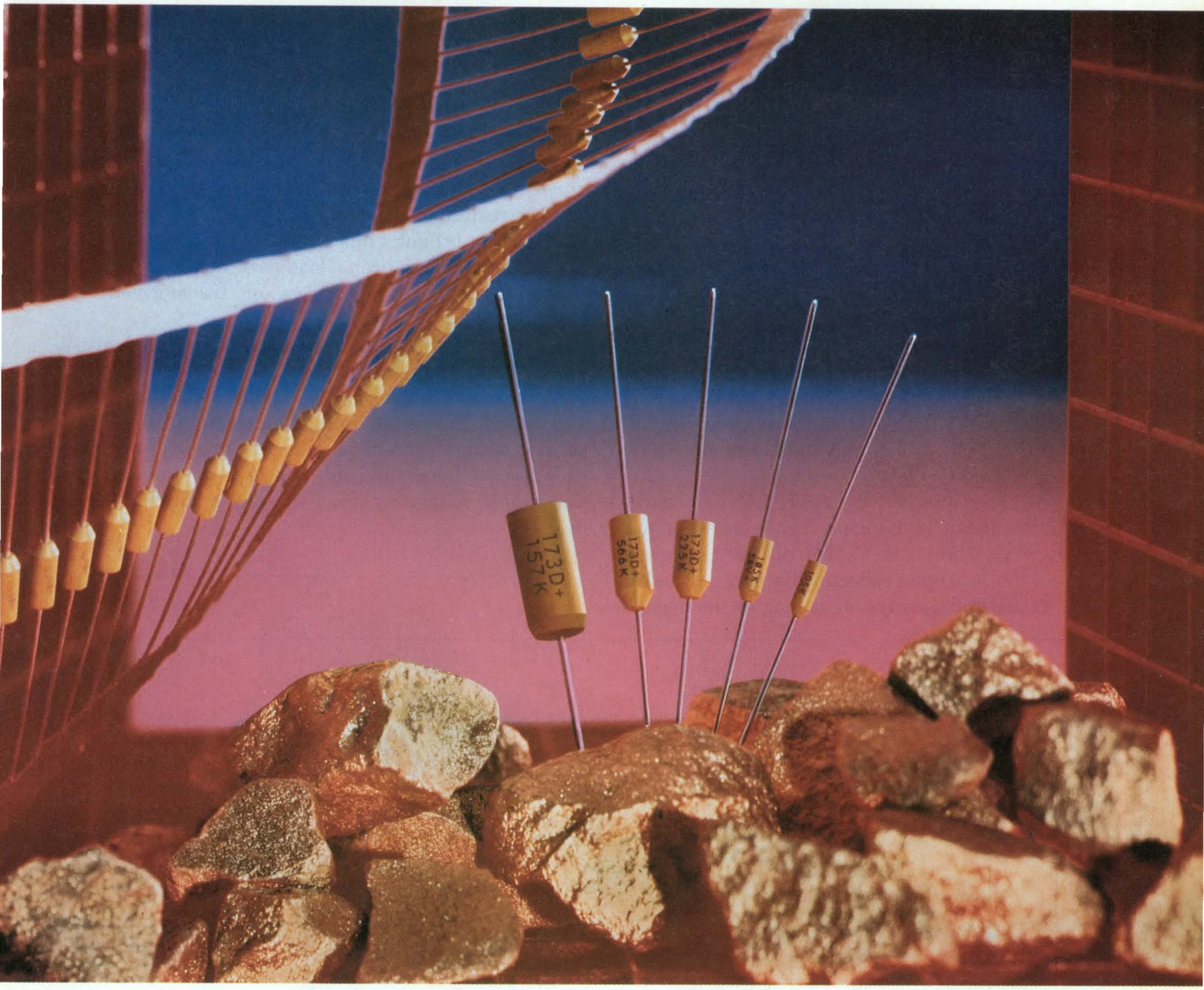

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CIRCLE NO 12

Low-cost regulator converts V^+ to $-5V$

Ron Lashley
ITT Courier, Phoenix, AZ

The power-supply circuit in **Fig 1a** converts a 12 to 15V positive supply voltage to −5.2V and delivers 0 to 50 mA. The parts only cost about $1.25. You should add a preregulator circuit **(Fig 1b)** when using an unregulated 15V supply.

During operation, the 555 timer's frequency varies with load current. The resulting positive output pulses (pin 3) have a varying repetition rate but a relatively constant duration. Each pulse turns on Q_1 and rapidly charges capacitor C_4. When pin 3 pulls the plus side of C_4 low, the charge on C_4 transfers to C_3.

Load and line regulation are about 1.5%. C_1 charges through R_1 while pin 3 is high; pin 3 goes low when pin 6 reaches its $\frac{2}{3}V_{CC}$ threshold. C_1 then discharges through R_3, Q_2, and the IC's open-collector discharge transistor at pin 7. Transistor Q_2 stays off as long as the negative output voltage is large enough to turn on the 6.0V zener diode D_5. When load current discharges C_3 enough to turn off D_5, Q_2 turns on and begins another discharge of C_1. The resulting output ripple is about 100 mV. Unless load current is light, ripple frequency is above the audio range; nonetheless, even if load current varies, ripple is inaudible because no chokes or transformers are present.

The output voltage increases slightly with temperature. You can generate a more negative output voltage by choosing a higher-voltage zener diode, but diode losses limit the output voltage maximum to about −8V at low output current. IC_1 should not operate above 15V, especially at full load. If necessary, you can limit the supply voltage by using the preregulator shown in **Fig 1b**. **EDN**

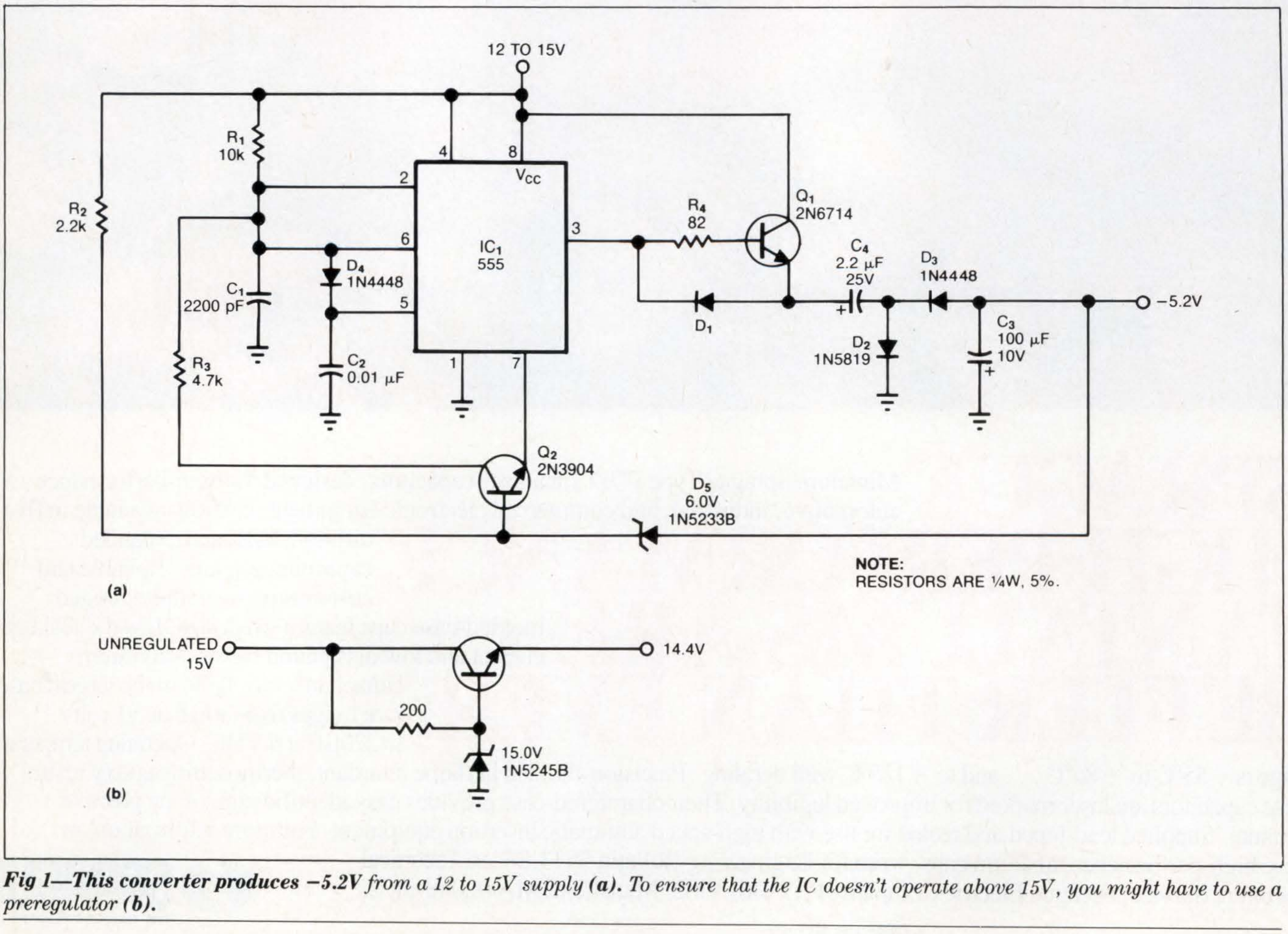

Fig 1—This converter produces −5.2V from a 12 to 15V supply (a). To ensure that the IC doesn't operate above 15V, you might have to use a preregulator (b).

KEITHLEY ON SEMICONDUCTOR MEASUREMENTS:

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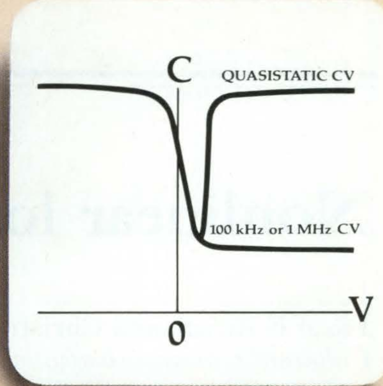

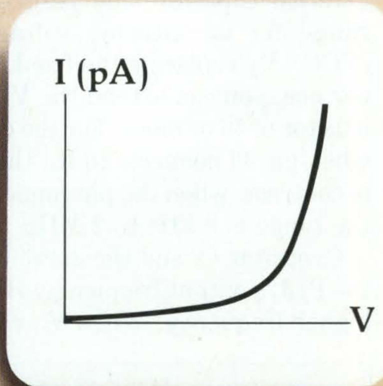

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CIRCLE NO 13

Nonlinear load extends PLL frequency range

Basel F Azzam and Christopher R Paul
Coherent Communications, Hauppauge, NY

A PLL chip such as the 74HC4046 in **Fig 1** uses an external capacitor and resistor to set the frequency range for an internal voltage-controlled oscillator (VCO). By replacing the fixed resistor R_4 with a nonlinear one, you can extend the VCO's frequency range by a factor of 50 or more. For the component values shown, when pin 11 connects to R_4, the range is 17 to 300 kHz; in contrast, when the pin connects to the nonlinear load, the range is 2 kHz to 2 MHz.

Capacitor C_1 and the current through pin 11 control the PLL's output frequency. Higher current produces a higher frequency. When V_{11} equals 0.5V, for example, the high-β transistor Q_1 is off and the resistance from pin 11 to ground is R_2+R_3. As V_{11} increases, Q_1 turns on and draws more current from pin 11. Thus, the effective impedance, Z, is

$$Z=\frac{\dfrac{R_2R_3}{\beta(R_2+R_3)}+R_e}{\dfrac{R_3}{R_2+R_3}-\dfrac{V_{BE}}{V_{11}}},$$

where β is the transistor's beta and V_{BE} equals 0.75V. **EDN**

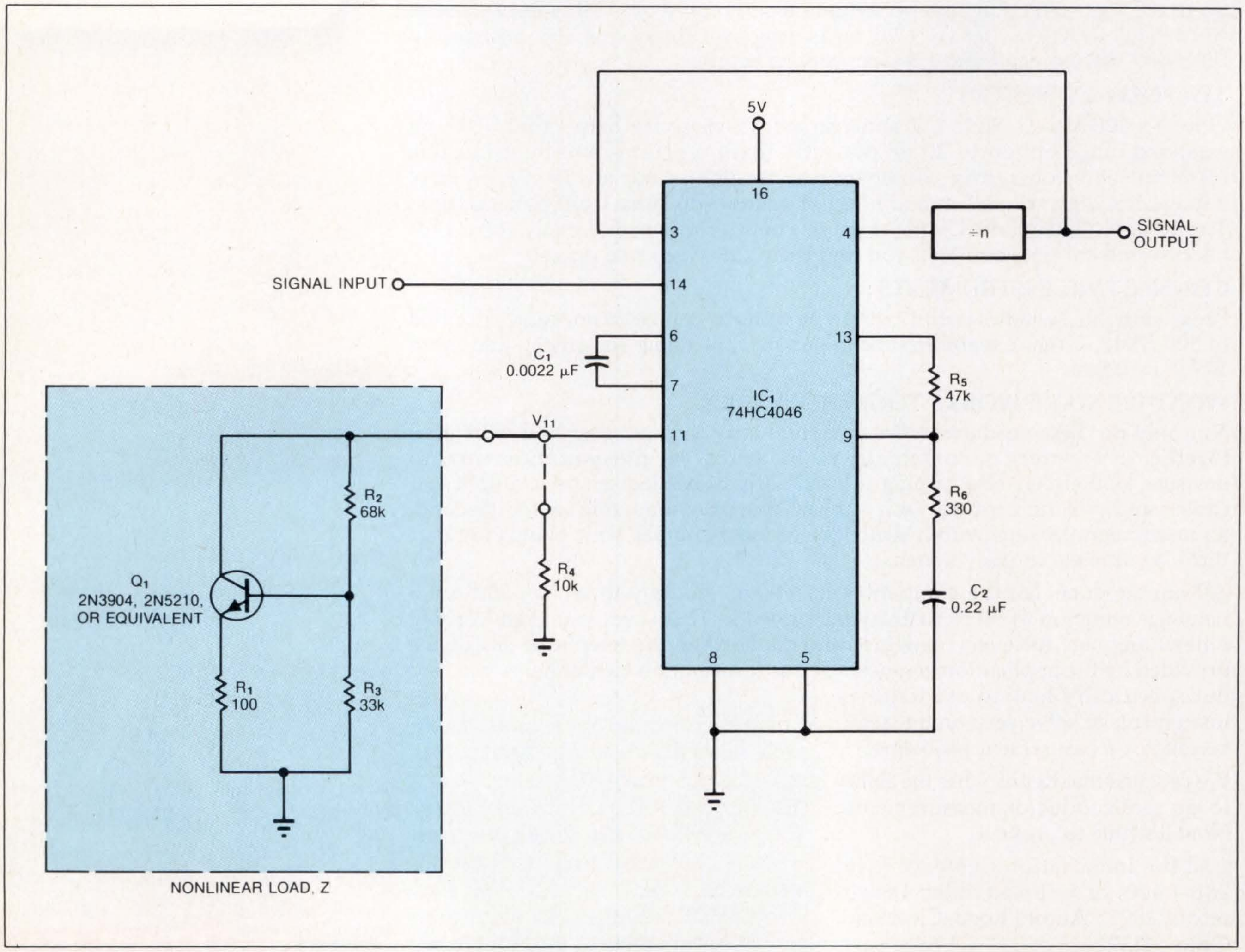


Fig 1—By connecting the nonlinear load Z *to pin 11 of the PLL chip IC_1, you can extend the PLL's frequency range by a factor of 50, as compared with that possible by using a fixed resistor (R_4).*

CIRCLE NO 14

EDITED BY TARLTON FLEMING

IF chip forms audio decibel-level detector

Robert J Zavrel
Signetics Inc, Sunnyvale, CA

The NE604 is a low-power IF chip that includes a logarithmic signal-strength output. **Fig 1**'s circuit draws less than 5 mA from a 6V supply and offers a signal sensitivity of 10.5 μV. Although the chip is intended for cellular-radio and other RF applications, the log output provides an 80-dB range of response and ±1.5-dB accuracy in the 100-Hz to 10-kHz audio range **(Fig 2)**.

You capacitively couple the audio signal to pin 16. The log circuit generates approximately 10 μA per 20 dB of input signal at pin 5; you convert this current to voltage by connecting 100 kΩ (R_2) from pin 5 to ground. You can then measure this voltage directly with a voltmeter, or buffer and filter the voltage as shown using op amps IC_{2A} and IC_{2B}. A standard 0 to 5V meter with a linear decibel scale serves to display 80 dB of signal level. To measure higher audio levels, add a resistive attenuator at the chip's audio input.

R_1 and C_1 form a lowpass filter. Specifying 2 kΩ for R_1 provides maximum linearity; you should adjust C_1 to change the filter's cutoff frequency. A higher value for C_1 lowers the circuit's output to about 0.6V when no audio signal is present **(Fig 2)**. Lowering C_1 increases the frequency response, but raises the circuit's output when no audio signal is present. The filter R_3/C_3 provides a tradeoff between meter damping and ripple attenuation. If both a quick response and low ripple are required, you must substitute a more complex, active lowpass filter. EDN

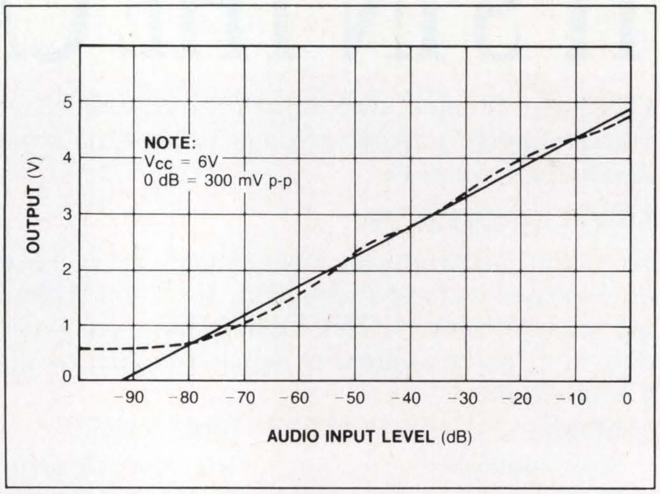


Fig 2—The dotted line indicates the response of Fig 1's circuit *for the 100-Hz to 10-kHz audio range; the solid line indicates an ideal response. Full scale (0 dB) equals 300 mV p-p.*

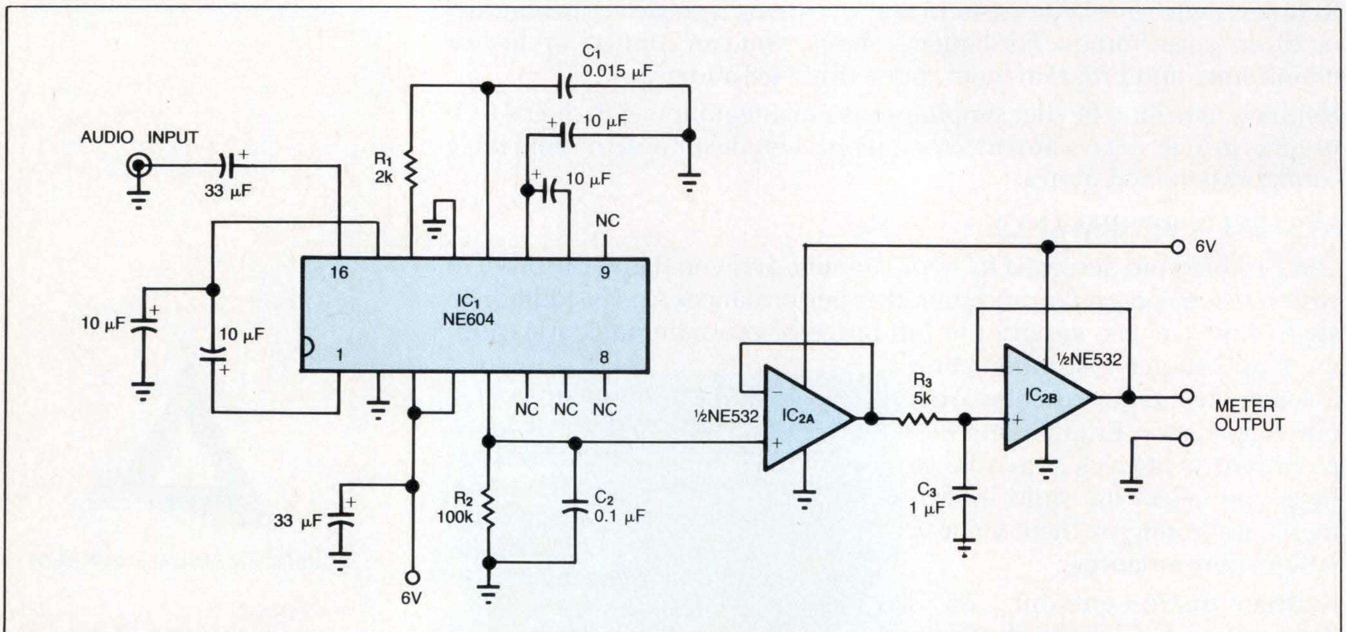
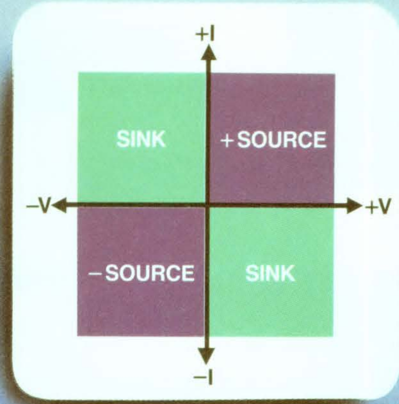


Fig 1—You can measure audio signal levels to ±1.5-dB accuracy *using a dual op amp and an FM IF chip (normally used for cellular-radio and other RF applications). Sensitivity is 10.5 μV; power consumption is 30 mW.*

KEITHLEY ON SOURCES:

QUALIFIED SOURCE



If you think there isn't much difference between a source and a power supply, then it's time you tried a Keithley source. The advantages are many.

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One of the chief benefits is the ability to set the exact range of output values you need. The key word here is "exact."

Keithley current sources have outputs programmable from ±0.5pA to 10A with output impedances up to $10^{14}\Omega$. That's precision no power supply can touch. In fact, **only** precision sources like these meet test requirements in applications such as DC parametric testing on devices and materials for semiconductors, resistivity studies such as microcrack analysis on new materials, and calibration of low current sensing instrumentation.

As further evidence, consider the ±50μV resolution of Keithley's Model 230 voltage source, necessary to achieve fine levels of control when extracting families of curves on semiconductors. Higher voltages to 100V are available for biasing devices and supplying power to circuits.

For calibration applications that need accurate low current, the Model 263 sources as low as ±50aA. Lastly, for calibration of charge ranges on electrometers and nuclear instruments, the Model 263 will source to 20μC. Voltages to 20V are also available.

THE RANGE OF KEITHLEY SOURCES

Source Type	Output Range	Model
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Current	±0.5pA to 100mA	220
Current	±0.5nA to 100mA	224
Voltage/ Current	±1mV to 100V ±100μA to 10A	228
Calibrator	±50aA to 20mA ±0.5fC to 20μC ±5μV to 20V 1kΩ to 100GΩ	263

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Unlike most power supplies, Keithley sources can both source and sink when connected to the DUT. This four-quadrant operation can either supply power to the device or act as a programmable load up to the full rated power of the output. Sink capability can also help reduce transients and dissipate energy stored in circuit reactances.

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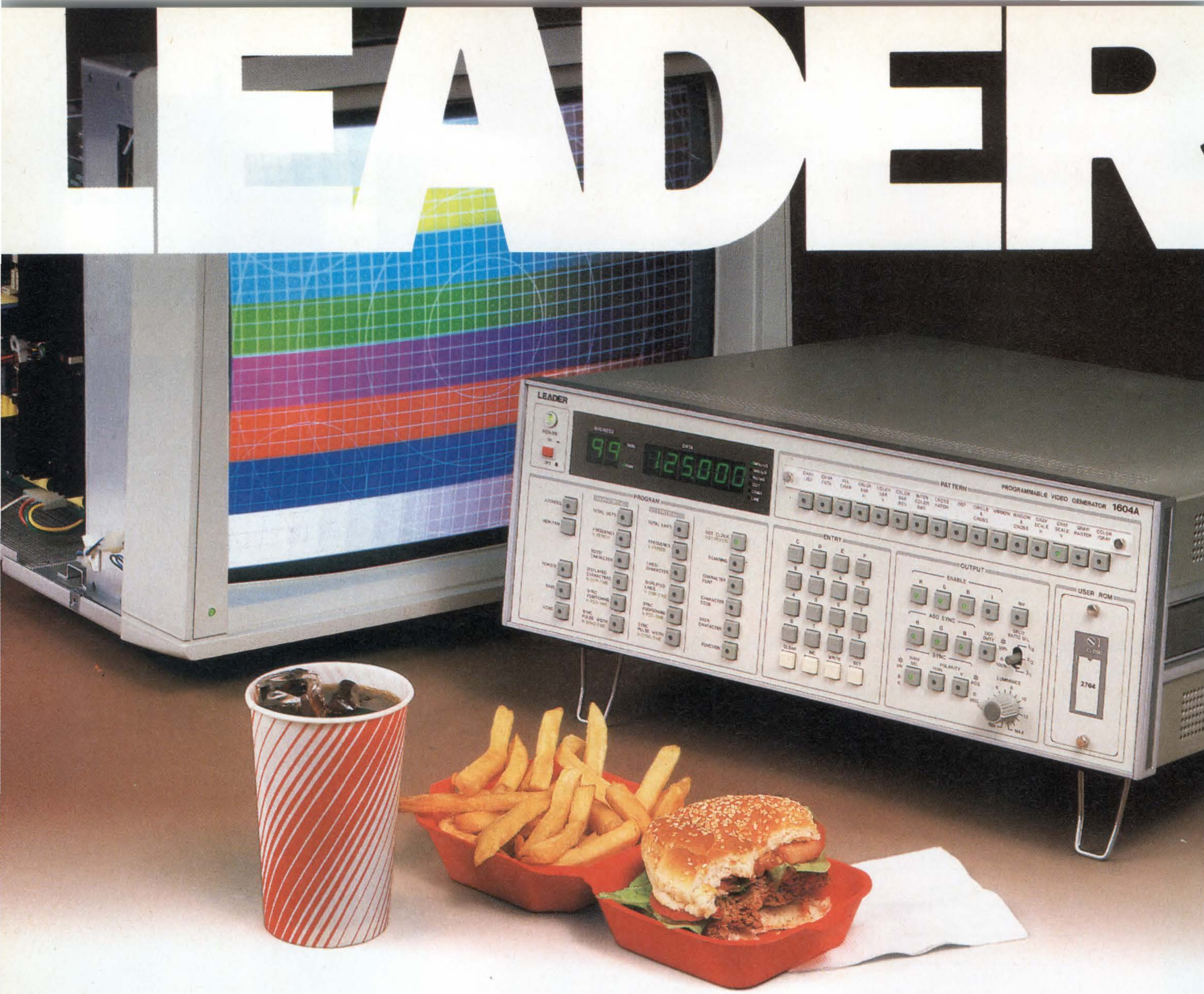
CIRCLE NO 15



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CIRCLE NO 16

EDITED BY ROBERT M CLARKE

Dual optoisolator detects zero crossings

Paul Galluzzi
Dynamics Research Corp, Wilmington, MA

By using the dual optoisolator shown in **Fig 1a**, you can build a zero-crossing detector that gives you TTL-level output pulses. You can then use those pulses to drive a counter or as an input to a control system. **Fig 1b** compares the circuit's input waveform and its output pulses.

This circuit accepts the ±15V output swing of an Inductosyn-driven PLL demodulator. Current through R_1 into IC_1's LED_1 (an HP HCPL-2630 dual optoisolator) holds V_2 at nearly 0V when V_1 is at its maximum positive value. Then, when V_1 crosses through zero as it heads for its −15V negative maximum, LED_1 ceases emitting; this shuts off Q_1. Pullup resistor R_2 causes V_2 to reach 5V. When V_1 goes negative, diode D_1 conducts to protect LED_1.

The zero-crossing detector's input circuit is symmetrical. Resistor R_3 provides a wired-OR output connection. The Schmitt triggers (IC_{2A} and IC_{2B}), C_1, and C_2 ensure that a clean pulse results from each zero crossing, resulting in an effective circuit for medium-speed inputs. EDN

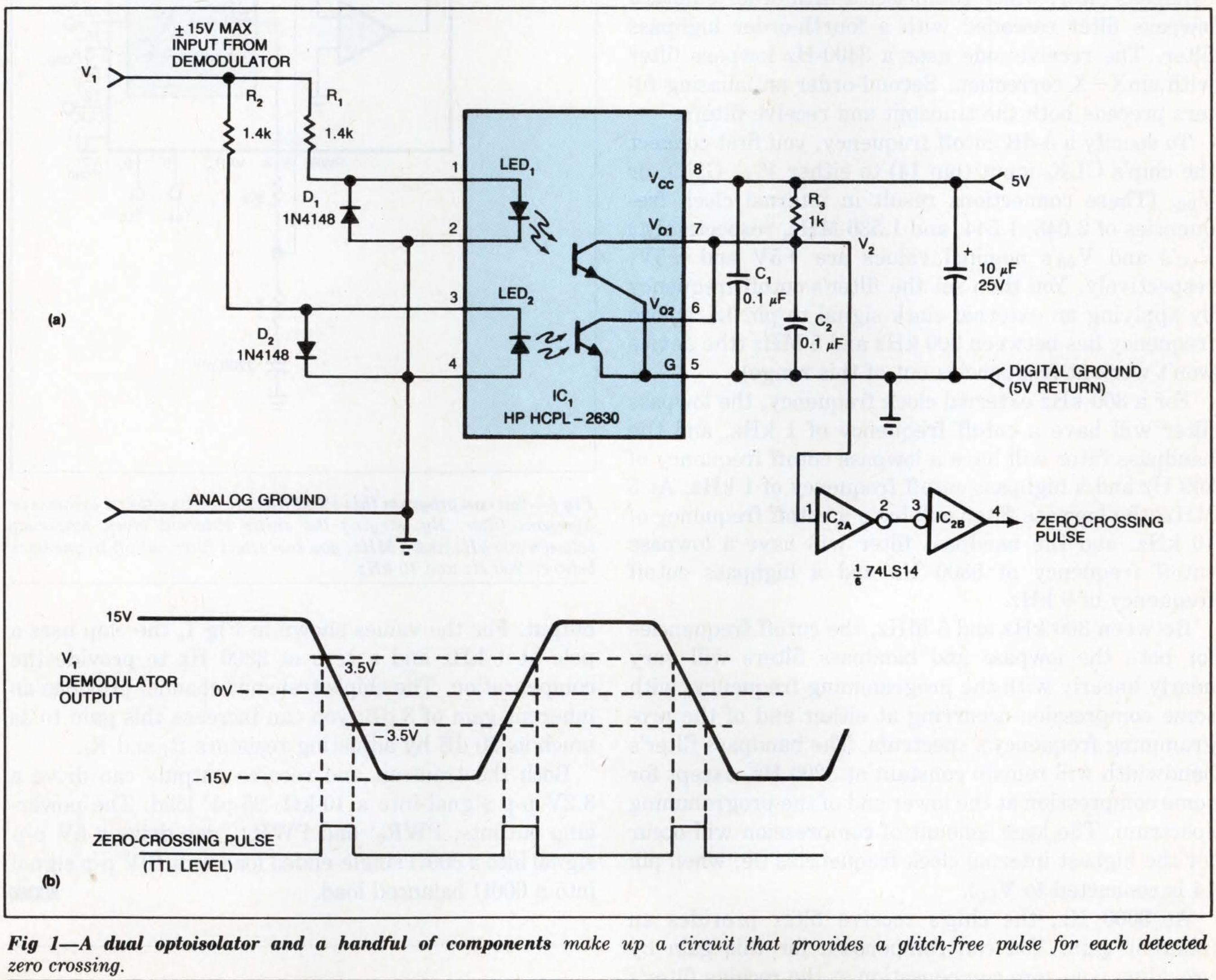


***Fig 1—A dual optoisolator and a handful of components** make up a circuit that provides a glitch-free pulse for each detected zero crossing.*

PCM filter offers lowpass, bandpass options

David J Donovan
Harris Corp, Melbourne, FL

The Harris HC-5512, 5512A, and 5512C pulse-code-modulated (PCM) filters are switched-capacitor monolithic circuits that were originally designed for PCM codec filtering in systems that sample at 8 kHz. However, by taking advantage of the devices' receive lowpass filter and transmit highpass filter, you can build a wide range of lowpass and highpass filter circuits with cutoff frequencies ranging from 200 Hz to 10 kHz **(Fig 1).** To program the filter's cutoff frequency, you simply vary the device's input clock frequency.

The chip's transmit side uses a 200- to 3400-Hz bandpass filter, which comprises a fifth-order elliptical lowpass filter cascaded with a fourth-order highpass filter. The receive side uses a 3400-Hz lowpass filter with sinX÷X correction. Second-order antialiasing filters precede both the transmit and receive filters.

To specify a 3-dB cutoff frequency, you first connect the chip's CLK_0 input (pin 14) to either V_{CC}, GND, or V_{BB}. (These connections result in internal clock frequencies of 2.048, 1.544, and 1.536 MHz, respectively.) V_{CC}'s and V_{BB}'s nominal values are +5V and −5V, respectively. You then set the filter's cutoff frequency by applying an external clock signal to pin 12, whose frequency lies between 300 kHz and 5 MHz (the device won't work at frequencies out of this range).

For a 300-kHz external clock frequency, the lowpass filter will have a cutoff frequency of 1 kHz, and the bandpass filter will have a lowpass cutoff frequency of 200 Hz and a highpass cutoff frequency of 1 kHz. At 5 MHz, the lowpass filter will have a cutoff frequency of 10 kHz, and the bandpass filter will have a lowpass cutoff frequency of 5800 Hz and a highpass cutoff frequency of 9 kHz.

Between 300 kHz and 5 MHz, the cutoff frequencies for both the lowpass and bandpass filters will vary nearly linearly with the programming frequency, with some compression occurring at either end of the programming frequency's spectrum. The bandpass filter's bandwidth will remain constant at 3200 Hz, except for some compression at the lower end of the programming spectrum. The least amount of compression will occur for the highest internal clock frequencies (ie, when pin 14 is connected to V_{CC}).

At 3300 Hz, the chip's receive filter provides an inherent gain. You can compensate for this gain by providing pole-zero compensation at the receive filter's output. For the values shown in **Fig 1,** the chip uses a pole at 1 kHz and a zero at 3300 Hz to provide the compensation. The chip's transmit channel provides an inherent gain of 3 dB; you can increase this gain to as much as 20 dB by adjusting resistors R_1 and R_2.

Both the transmit and receive outputs can drive a 3.2V p-p signal into a 10-kΩ, 25-pF load. The power-amp outputs, PWR_0^+ and PWR_0^-, can drive a 5V p-p signal into a 300Ω single-ended load or a 10V p-p signal into a 600Ω balanced load. **EDN**

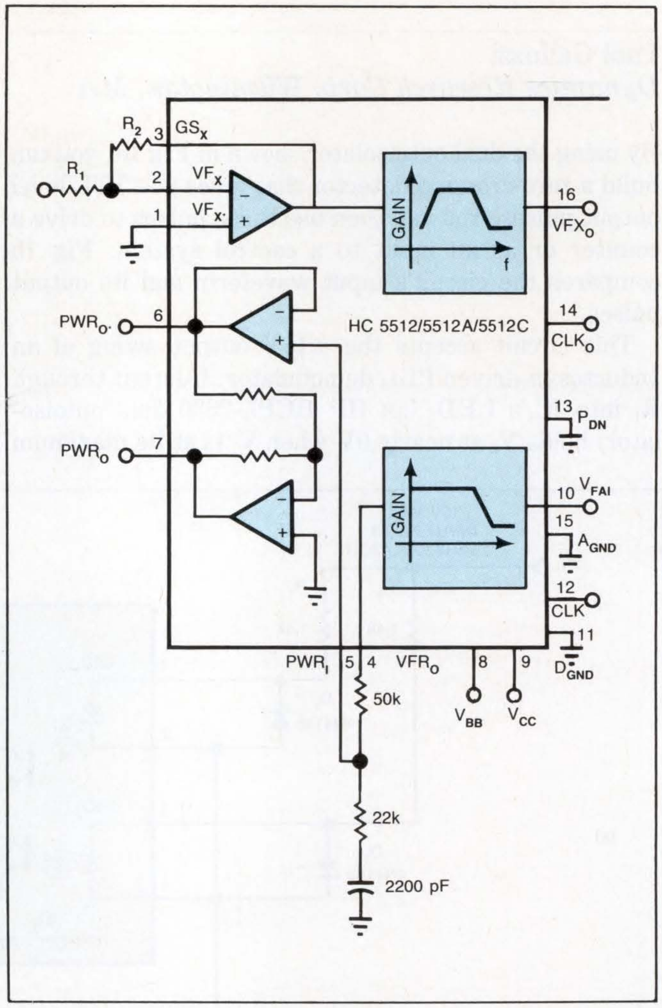


***Fig 1—You can program this PCM filter** to act as either a lowpass or highpass filter. By varying the chip's external clock frequency between 300 kHz and 5 MHz, you can select filter cut-off frequencies between 200 Hz and 10 kHz.*

EDITED BY TARLTON FLEMING

Current-folding circuit breaker resets itself

Shalom Bukimer
Tadiran, Syosset, NY

The circuit breaker shown in **Fig 1** limits load current to 0.5A; if the load is heavy enough (below 1.6Ω), it further limits load current to about 50 mA. You don't have to reset the breaker; it resets itself shortly after the overload is removed. A delay introduced by capacitor C_1 lets the circuit breaker ignore overloads of brief duration.

An increasing load current creates a voltage across R_1, which lowers the voltage at comparator IC_{1A}'s noninverting input. When the R_1 drop equals approximately 0.2V, the comparator output goes low, reducing the load current via Q_3 and Q_1. Comparator IC_{1B} monitors the falling load voltage V_L as Q_1 throttles the load current, and it turns off Q_1 when V_L reaches approximately 0.8V.

Equally important, R_2 provides 50 mA through the load to enable comparator IC_{1B} to sense a rise in the load impedance. When R_L rises a few ohms above its threshold, IC_{1B}'s output goes low, which turns on Q_1 and reconnects the source and load.

The circuit has the following characteristics:

- The trip point is well defined and only slightly affected by changes in temperature.
- The circuit breaker makes a fast transition from off to on, and it consumes little power in either state.
- Q_2 and the LED may be omitted unless you require a visual overload indicator.
- You can manually open the circuit breaker by shorting IC_{1A}'s noninverting input to ground.

EDN

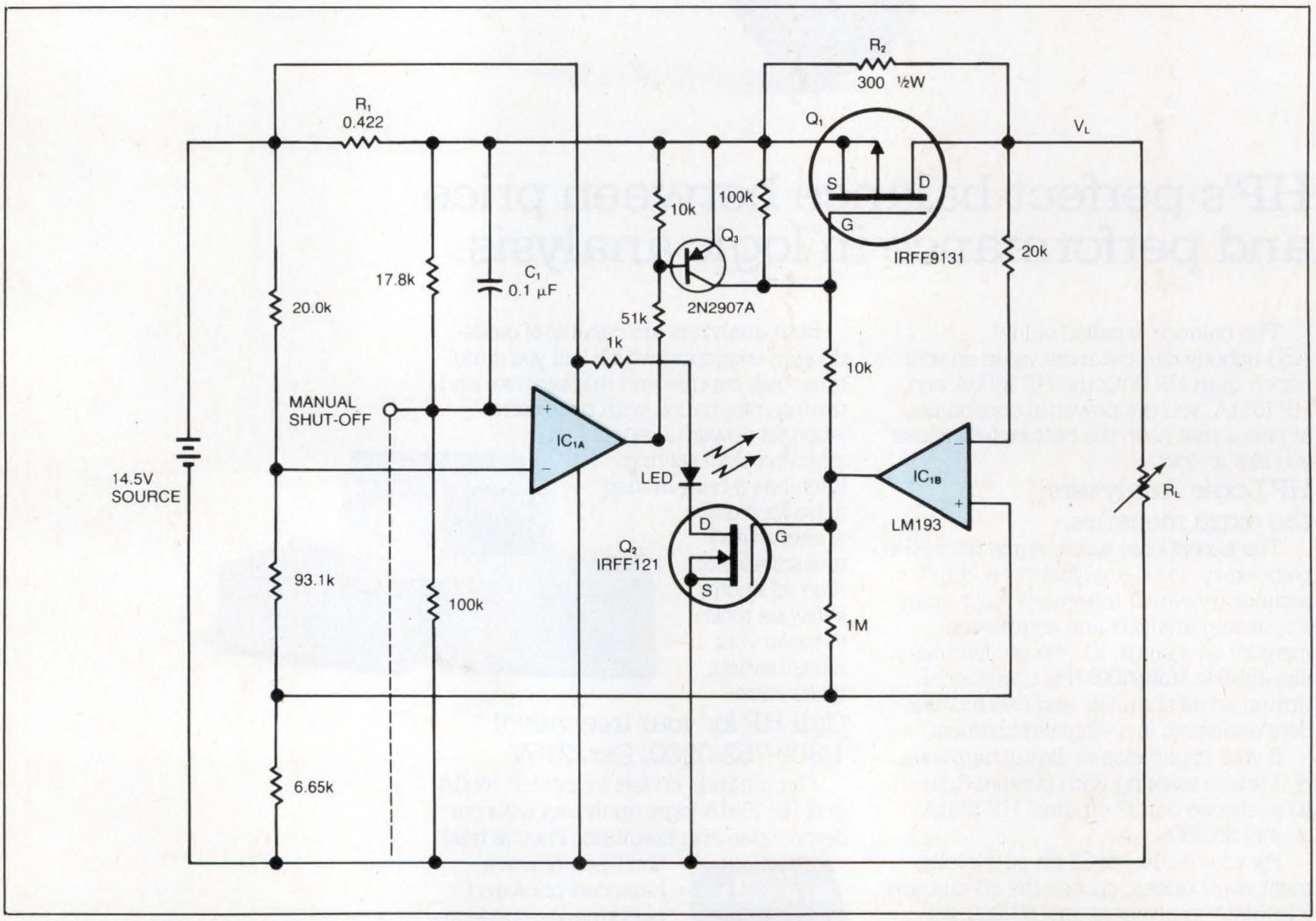
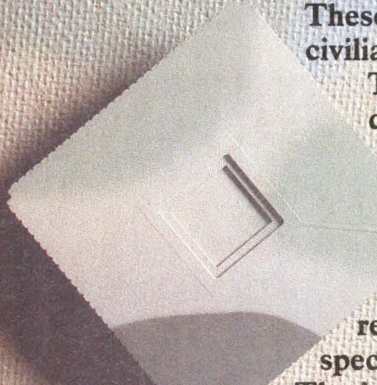


*Fig 1—**Load currents higher than 0.5A** trip this electronic circuit breaker. The circuit resets automatically when the overload is removed.*

BATTLECHIPS.



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CIRCLE NO 17

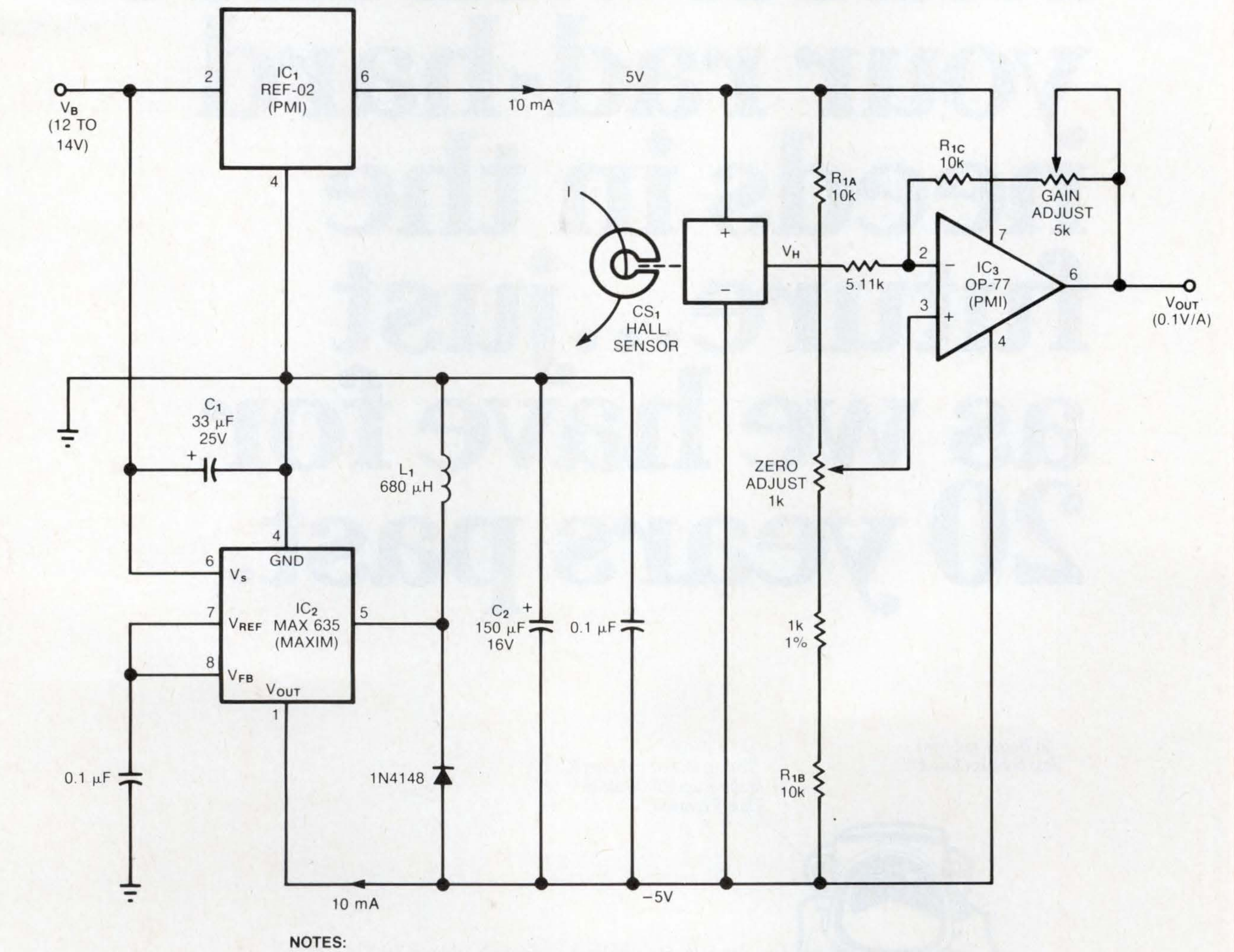
EDITED BY TARLTON FLEMING

Current monitor uses Hall sensor

Paul Galluzzi
Dynamics Research Corp, Wilmington, MA

The **Fig 1** circuit uses a Hall-effect sensor, consisting of an IC that resides in a small gap in a flux-collector toroid, to measure dc current in the range of 0 to 40A. You wrap the current-carrying wire through the toroid; the Hall voltage V_H is then linearly proportional to the current (I). The current drain from V_B is less than 30 mA.

To monitor an automobile alternator's output current, for example, connect the car's battery between the circuit's V_B terminal and ground, and wrap one turn of wire through the toroid. (Or, you could wrap 10 turns—if they'd fit—to measure 1A full scale.) When I=0V, the current sensor's (CS_1's) V_H output equals one-half of its 10V bias voltage. Because regulators IC_1 and IC_2 provide a bipolar bias voltage, V_H and V_{OUT} are zero when I is zero; you can then adjust the output gain and offset to scale V_{OUT} at 1V per 10A. **EDN**



NOTES:
1. C_1 and C_2 ARE 199D TANTALEX CAPACITORS FROM SPRAGUE.
2. L_1 IS A 6860-23 INDUCTOR FROM CADDELL-BURNS.
3. R_{1A}, R_{1B}, AND R_{1C} ARE PART OF A THIN-FILM RESISTOR NETWORK SUCH AS THE CADDOCK T914-10K.
4. CS_1 IS A HALL-EFFECT CURRENT SENSOR (CSLA1CD) FROM MICROSWITCH.

Fig 1—This circuit's Hall-effect current sensor CS_1 *enables V_{OUT} to register dc current at 1V per 10A.*

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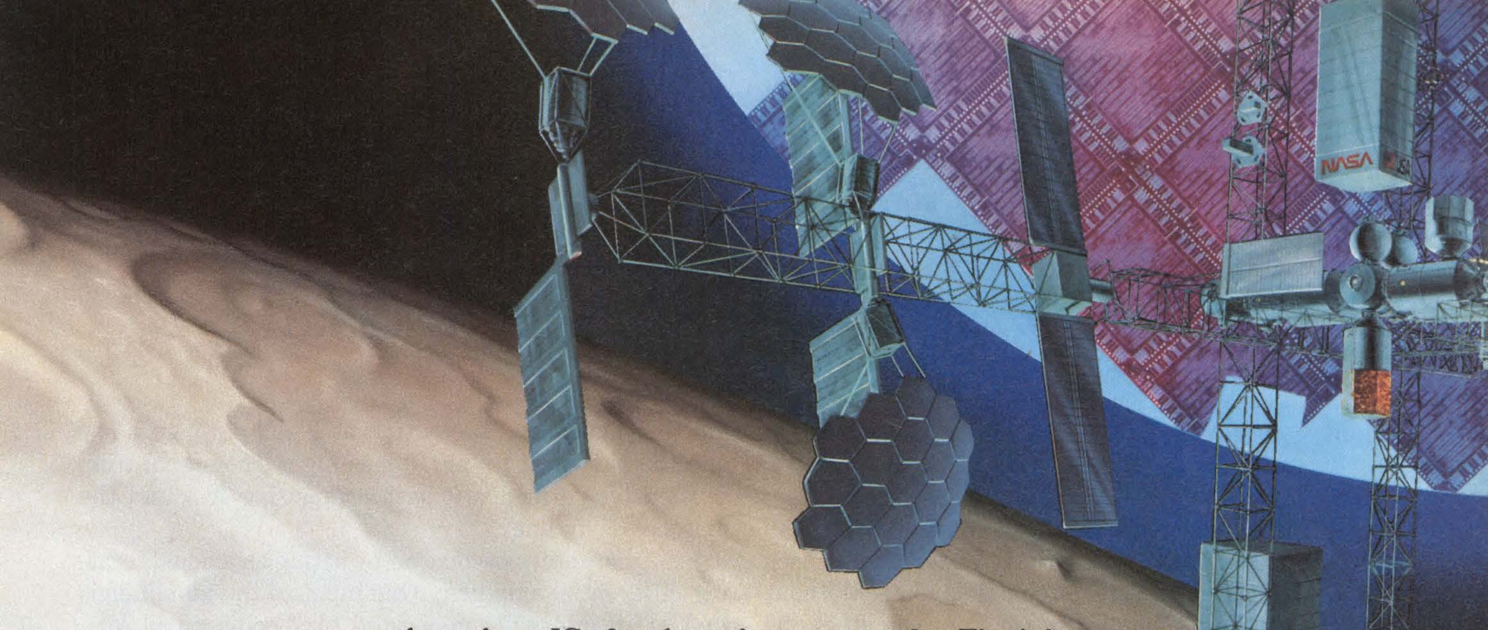

EDITED BY ROBERT M CLARKE

Build a 1-chip, 300-MHz gateable oscillator

Donald Trimble
Harris GASD, Melbourne, FL

Using a Plessey SP16F60DC, you can build the 300-MHz ring oscillator shown in **Fig 1.** The oscillator uses two ECL OR gates and an optional delay line. Without a delay line, the oscillator runs at approximately 300 MHz. Using a delay line reduces the oscillator's operating frequency. For example, a 9-ft RG-316/U delay line produces 30-MHz oscillations.

In **Fig 1**, the two ECL OR gates and a delay line are connected as a ring oscillator. **Fig 2**'s timing diagram shows the relationship between the inputs and outputs of the OR gates. When the oscillator's enable input (pin 7 of IC_{1A}) goes low, the output at IC_{1A}'s pin 2 goes low and the output at its pin 3 goes high. The signal from pin 3 drives a feedback path comprising IC_{1B} and the optional delay line.

IC_{1B} guarantees oscillation by acting as a nonsaturating differential amplifier. One input of the amplifier is tied to an internally generated bias point called V_{BB}. The amplifier's other input comes from external pin 13. The amplifier compares this input to V_{BB} (**Ref 1**).

For IC_{1B}'s noninverting (pin 15) output to change state, pin 13's input must go sufficiently above or below V_{BB} (**Ref 2**). This noninverting output drives either the optional delay line or IC_{1A}, completing the ring. IC_{1B}'s 550-psec typical propagation time allows IC_{1A} to settle to an ECL logical low level.

You can use any of IC_{1A}'s unused inputs (pin 7 is used in **Fig 1**) to gate the oscillator. Note that although the oscillator always starts in the same state, it can stop in either a high or low state, unless you use a counting or control scheme to prevent it. Letting all unused inputs float low gives you a free-running oscillator. **Fig 3** shows the oscillator's performance. You can obtain similar results using 100K Series ECL parts. **EDN**

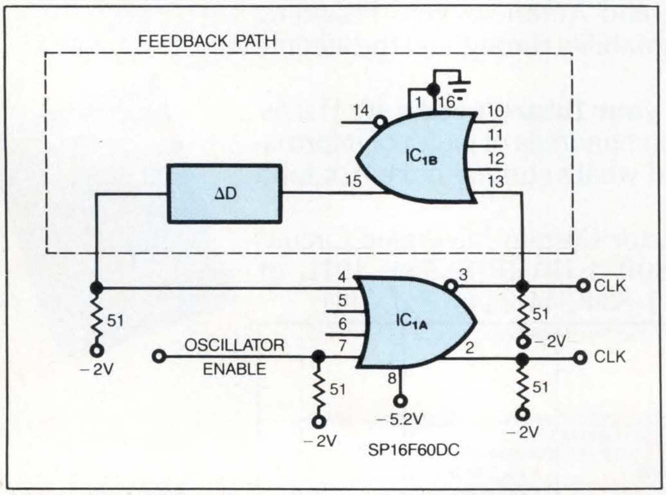

Fig 1—Two ECL gates and an optional delay line provide a 300-MHz gateable oscillator.

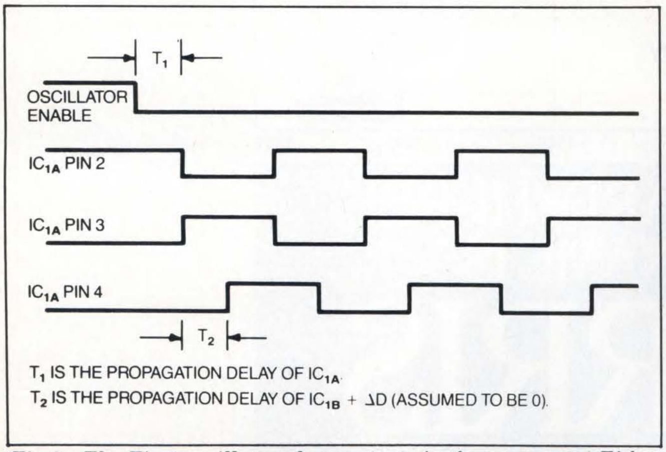

Fig 2—The Fig 1 oscillator always starts in the same state. Either IC_{1B}'s internal propagation delay by itself or the delay and an optional feedback loop determine the frequency of oscillation.

References

1. *Digital IC Handbook*, Plessey Semiconductor, pg 115.
2. *F 100K ECL User's Handbook*, Fairchild Advanced Bipolar Div, pgs 2-5.

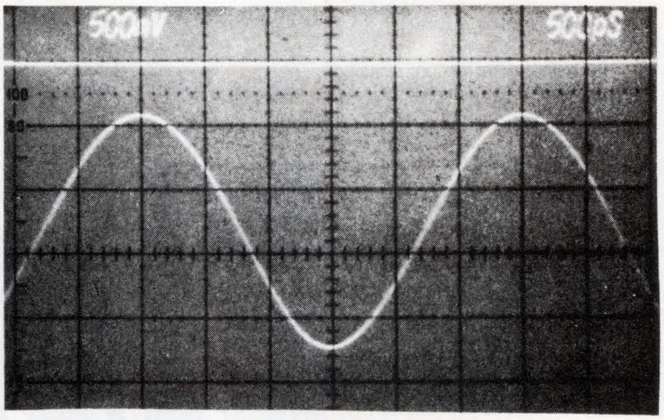

Fig 3—The Fig 1 free-running oscillator furnishes a clean output that varies between −0.5 and −2.25V. Here, the vertical scale is 500 mV/div; the horizontal scale, 500 psec/div. The horizontal line at the top of the display represents the zero level.

Crystal oscillator sets pulse width

T G Barnett
London Hospital Medical College,
London, England

You can use the circuit in **Fig 1a** to set precise pulse widths that are independent of component aging, power-supply variations, and temperature. The monostable multivibrator (IC_1) is configured in the nonretriggerable mode, and the RC time constant is set wider than the desired pulse width. In **Fig 1b**, the time constant is set at 15 msec; this value produces an output pulse that's 10 msec wide. The pulse width equals RC. The Q output of IC_1 is connected to the reset pin of the programmable oscillator (IC_2), and the output of the oscillator is inverted and connected to the reset pin of IC_1.

The programming pins of IC_2 are set to give a 50-Hz output frequency in the form of a square-wave output with equal high and low periods of 10 msec. IC_1 is triggered by the rising edge of an input pulse (A in **Fig 1b**). The Q output goes high, resetting the oscillator. The oscillator's output remains low for 10 msec; when the oscillator's output goes high, the inverted output ($\overline{Q}$) resets IC_1, and the oscillator's reset pin goes low until the next trigger signal on IC_1. The PXO 600 (IC_2) can be programmed for 57 different frequencies over 0.005 Hz to 1 MHz, so you can choose a wide range of pulse widths. **EDN**

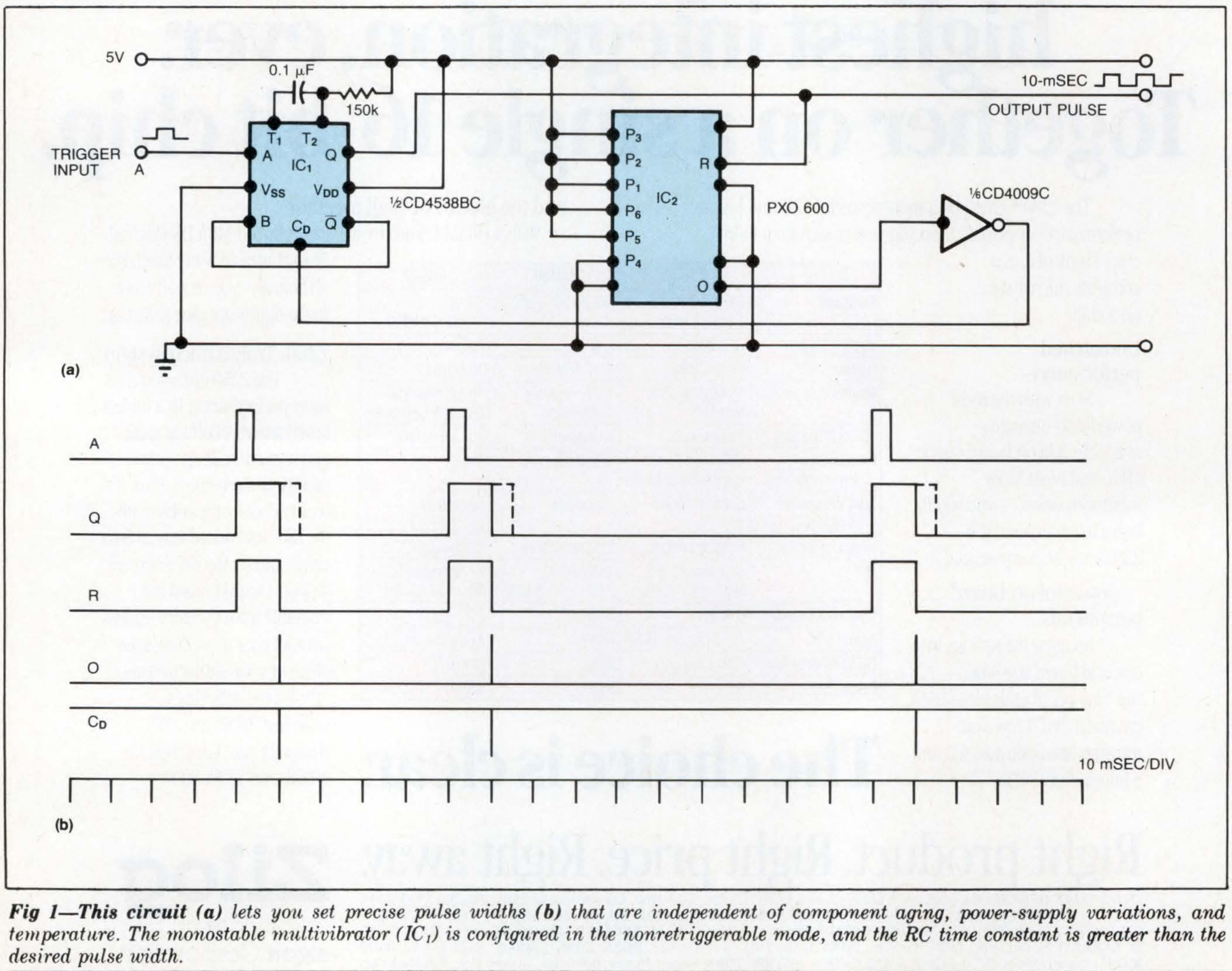

***Fig 1—This circuit (a)** lets you set precise pulse widths **(b)** that are independent of component aging, power-supply variations, and temperature. The monostable multivibrator (IC_1) is configured in the nonretriggerable mode, and the RC time constant is greater than the desired pulse width.*

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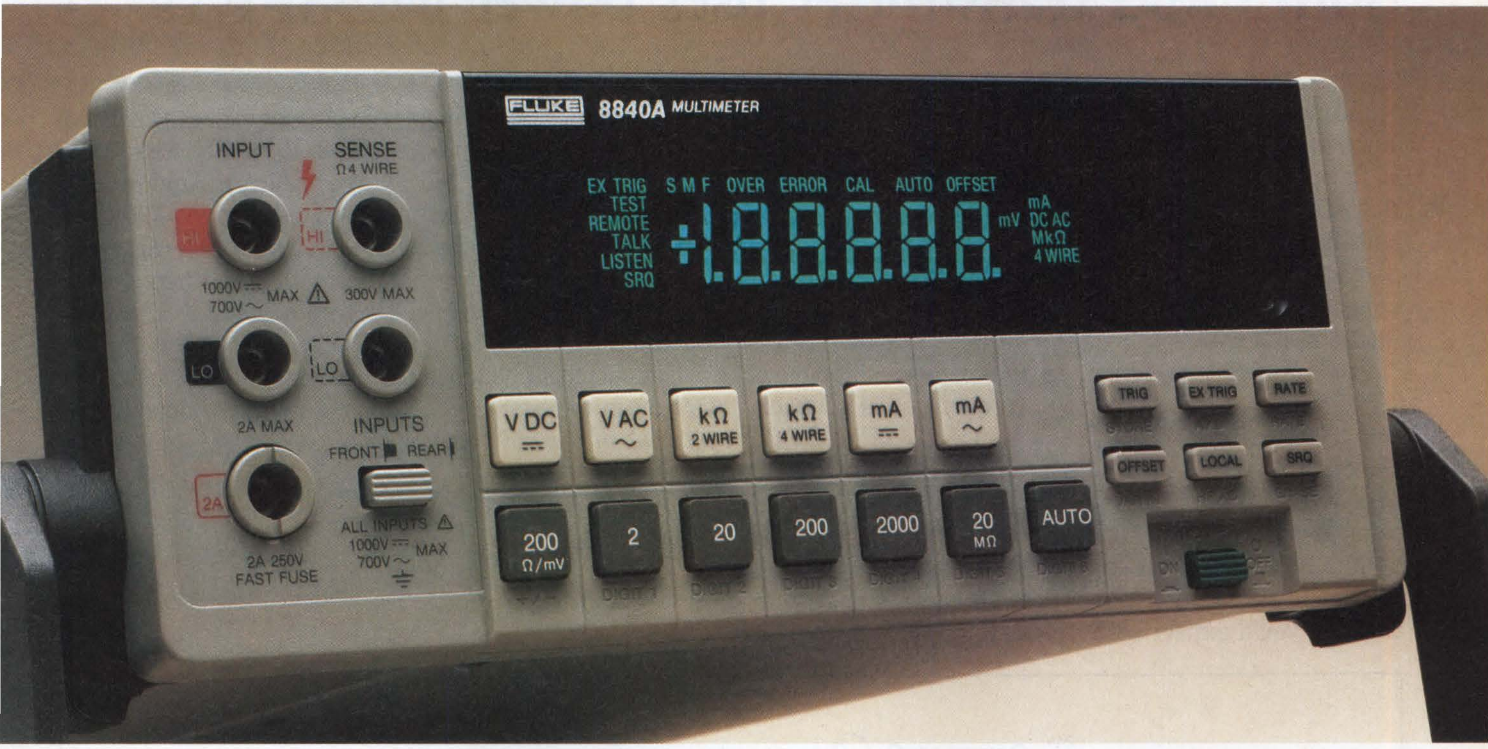

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CIRCLE NO 21

80m radio transmitter uses power MOSFETs

Robert G Culter
Tektronix Inc, Beaverton, OR

By using power MOSFETs as active elements, you can build the 80m amateur-radio transmitter of **Fig 1** with parts that cost less than $20. The circuit consists of a keyed crystal oscillator/driver and a high-efficiency final amplifier.

In the oscillator section, an inexpensive color-burst TV crystal determines output frequency. In addition, the 700- to 1200-pF input capacitance C_{iss} of MOSFET Q_2 constitutes an essential part of the oscillator's feedback—the oscillator won't operate without Q_2. Q_1 retains enough gain for oscillation while driving amplifier Q_2 in a 50%-duty-cycle (approximate) switching mode.

The output stage achieves 84% efficiency rather than the 50% you'd expect with a class-C amplifier. When Q_2 turns off, current through inductor L_3 causes the drain voltage to rise well above the 24V supply (the 100V zener diode D_1 limits this voltage excursion) and remain high for part of the conduction cycle as well. The high drain voltage allows the FET to deliver a given amount of power with less internal dissipation and hence with greater efficiency than if the drain voltage remained constant.

The output impedance-matching network is based on Q_2's drain impedance R_O, which is twice the dc value as a result of the 50% duty cycle:

$$R_O = V_{CC}^2/2P_O = 24^2/(2\times45) = 6.4\Omega.$$

EDN

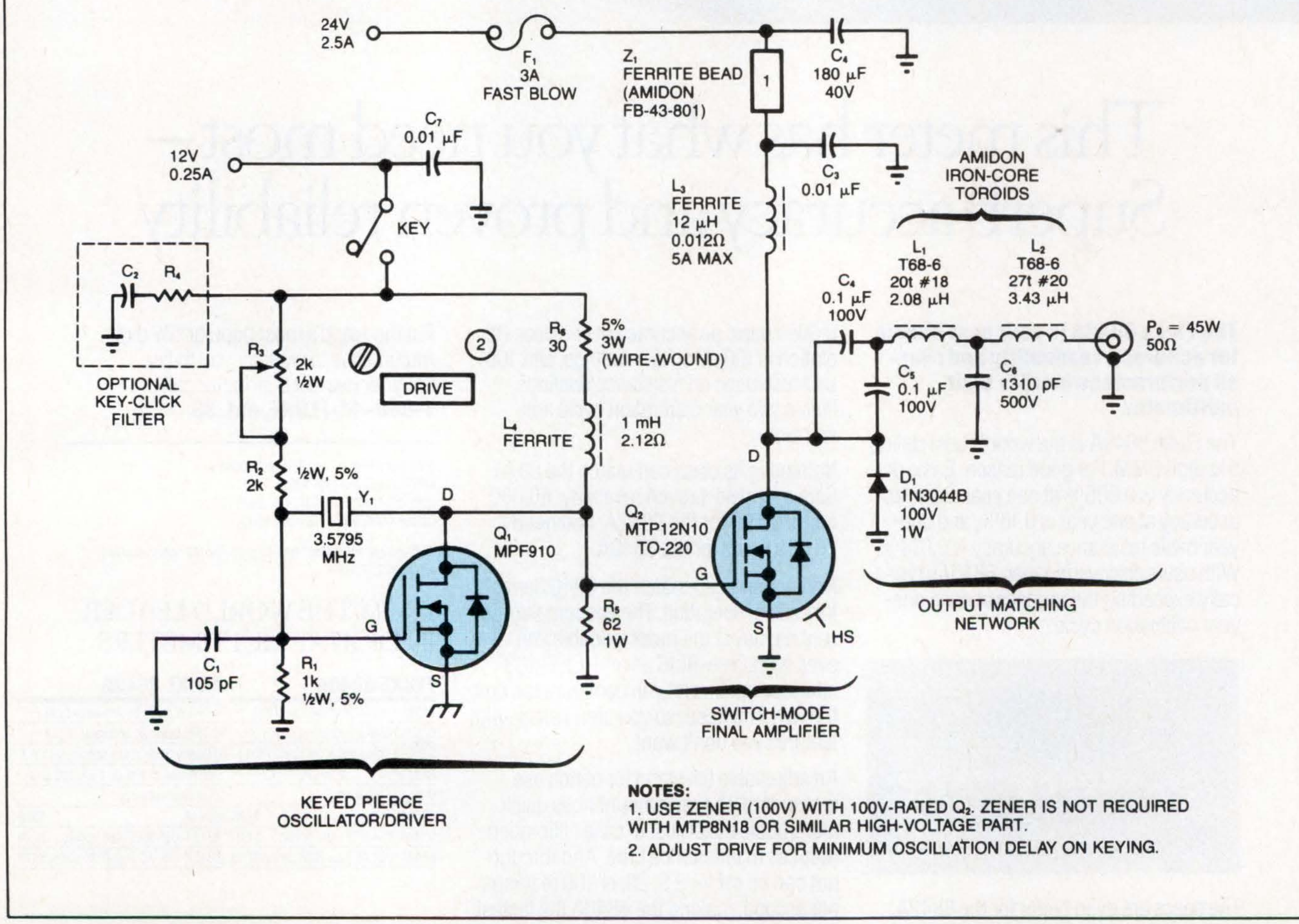

***Fig 1—This 80m amateur-radio transmitter** includes one MOSFET for the oscillator and a second MOSFET for the final amplifier.*

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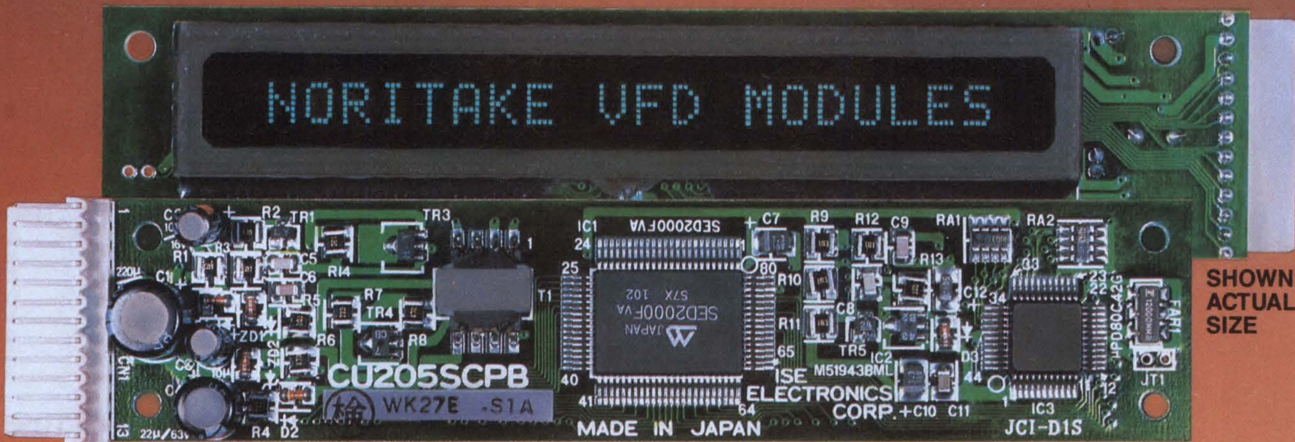

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SCPB	14-SEGMENT + COMMA +D.P.	FU169SCPB-S1A	1 X 16	9.4	S/P	X	X		
		FU209SCPB-S1A	1 X 20	9.0	S/P	X	X		
	5 x 7 DOT MATRIX	CU205SCPB-S1A	1 X 20	5.0	S/P		X		1
	5 x 7 DOT MATRIX + CURSOR	CU20026SCPB -S20A	2 X 20	5.0	P	X	X		5
		CU40026SCPB -S20A	2 X 40	5.0	P	X	X		2
MCPB	5 x 7 DOT MATRIX + CURSOR	CU406MCPB -S1A; -S31A	1 X 40	5.0	S/P	X	X	X (-S31A)	8
		CU20026MCPB -S1A; -S31A	2 X 20	5.0	S/P	X	X	X (-S31A)	8
		CU40026MCPB -S1A; -S31A	2 X 40	5.0	S/P	X	X	X (-S31A)	4

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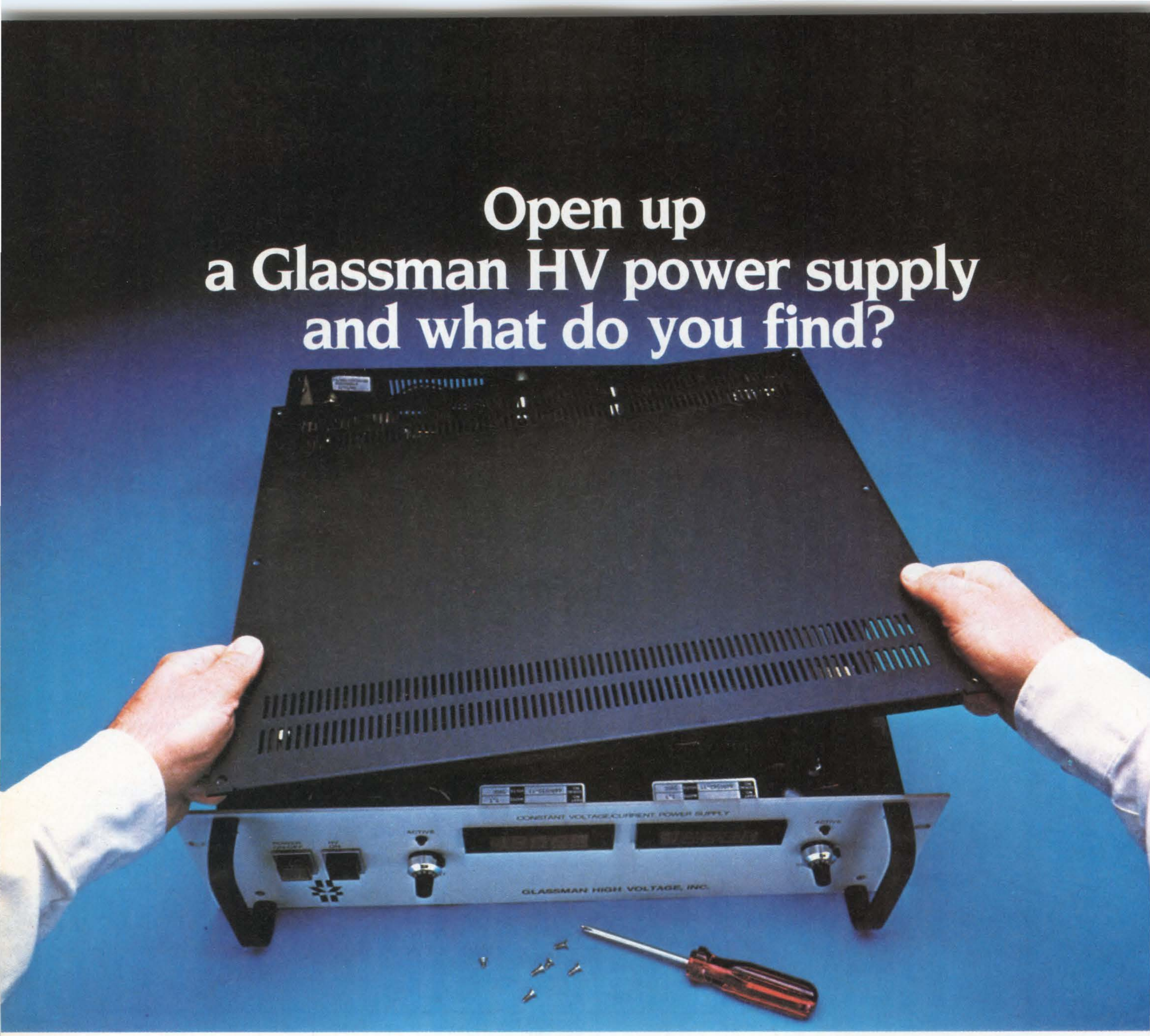

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CIRCLE NO 23

DESIGN IDEAS

EDITED BY TARLTON FLEMING

Use simple circuit to program EPROMs

Richard Poindexter
Telex Computer Products, Tulsa, OK

You can program 21V, 28-pin EPROMs (eg, models 2764 or 27128) using a circuit that occupies little space on a pc board (**Fig 1**). The signal interface consists of an 8-bit control word and an 8-bit data bus.

The switching regulator (IC_3) provides the EPROM's programming voltage by stepping the 5V supply to 21V. The 12-bit binary counter (IC_1) simplifies the generation of EPROM addresses. After resetting the counter to 0 by applying a pulse to pin 11, you can step the EPROM through its addresses by applying pulses to the counter's clock input, pin 10. Refer to the EPROM data sheet for details on controlling the other inputs (O_1, O_2, and O_5 to O_7).

You can verify the contents of the EPROM against your original object code by the same process of strobing the counter for each address and reading the data bus for that address. Again, refer to the data sheet for details on reading data from the EPROM. **EDN**

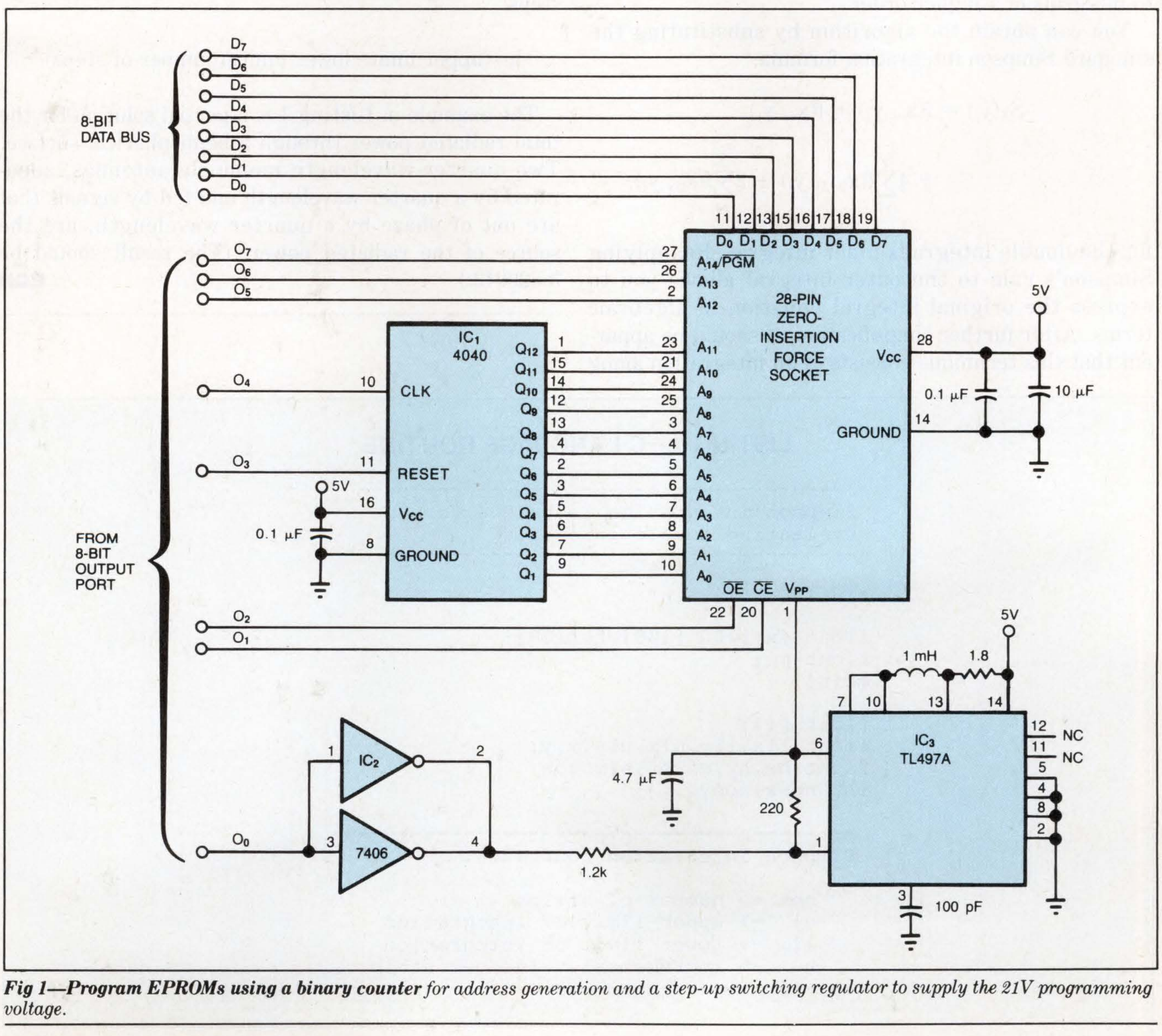

*Fig 1—**Program EPROMs using a binary counter** for address generation and a step-up switching regulator to supply the 21V programming voltage.*

Simpson's rule solves double integrals

A Cameron
Defence Research Centre, Adelaide, SA, Australia

Although one generally uses Simpson's rule to approximate single integrals, you can extend the technique for use in solving double integrals. The C language routine of **Listing 1** contains the required algorithm plus an example, demonstrating that you can apply Simpson's rule to certain complex double integrals that would normally require the application of numerical techniques. In addition, the technique applies equally well to integrals of a higher order.

You can obtain the algorithm by substituting the standard Simpson integration formula,

$$S_X(y_j) = f(x_0, y_j) + f(x_n, y_j) + 4\sum_{i=1}^{\frac{n-2}{2}} f(x_{2i-1}, y_j) + 2\sum_{i=1}^{\frac{n-2}{2}} f(x_{2i}, y_j),$$

for the double integral's inner integral. Reapplying Simpson's rule to the outer integral allows you to express the original integral equation in algebraic terms. After further simplification, it should be apparent that this technique consists of an integration along one axis for each interval on the orthogonal axis, followed by an application of Simpson's rule on the accumulated results along the orthogonal axis.

If $S_X(y_n)$ represents Simpson's rule applied along the x-axis as a function of the position y_n on the y-axis, then

$$\text{SIMPSON} = \frac{h_X * h_Y}{9}(S_X(y_0) + S_X(y_n) + 4*S_X(y_1) + 2*S_X(y_2) \ldots \text{etc}),$$

where h_X and h_Y represent the increments between steps:

$$h = (\text{upper limit} - \text{lower limit})/(\text{number of steps}).$$

The example in **Listing 1** is a partial solution for the total radiated power through a hemispherical surface. Two quarter-wavelength monopole antennas, separated by a quarter wavelength and fed by signals that are out of phase by a quarter wavelength, are the source of the radiated power. (The result should be 3.829042.) **EDN**

LISTING 1—C LANGUAGE ROUTINE

```
/*-----------------------------------------
 Simpson integration technique for
 evaluating double integrals.
-----------------------------------------*/

#include "math.h"

float fxy[100][100],fy[100];
float pi;
main() {

float f();
float llx,lly,ulx,uly,x,y;
float hx,hy,ef,of,simpson;
int nosx,nosy,i,j;

/*-----------------------------------------
 Simpson integration constants.

    nos -> number of strips
    ul  -> upper limit of integration
    ll  -> lower limit of integration
    h   -> incremental value per strip
-------------------------------------------*/
```

EDITED BY TARLTON FLEMING

Simple circuit tests twisted-pair cables

Mark D Braunstein
Contel Information Systems, Fairfax, Va

Using the system shown in **Fig 1,** you can quickly test a cable containing twisted-wire pairs and detect open or reversed pairs, shorted pairs, and shorts between unrelated pairs. The tester consists of an active test set that plugs into one end of the cable, and a passive terminator that plugs into the other end. (An RS-449 cable is used as an example.)

A battery or a dc supply delivers 15 to 24V to the test set. The voltage regulator (IC_1) is connected as a current regulator to supply a nominal 25 mA to the LED strings at each end of the cable. The cable in this example contains eight twisted pairs, and for a good cable, all eight LEDs in the test set (D_A through D_H, which are series-connected segments of a bar-graph display) and all eight LEDs in the terminator (D_1 through D_8) will light. If a twisted pair is open or reversed, the corresponding LED on the terminator will be extinguished; if a pair is shorted, corresponding LEDs at both ends will be extinguished; and if any two unrelated wires of different pairs are shorted, all intervening LEDs in the strings at both ends will be extinguished. For example, if pins 4 and 6 are shorted, LEDs D_A, D_B, D_1, and D_2 will not light.

You can add a heat sink to the IC_1 regulator as a safety precaution, but normal tester operation is well within the regulator's power-dissipation limits. Even with many shorted pairs, a dissipation of 700 mW would cause no more than a 60°C junction temperature, and the IC is guaranteed to turn itself off at 160°C. The complete tester costs less than $50 to build. **EDN**

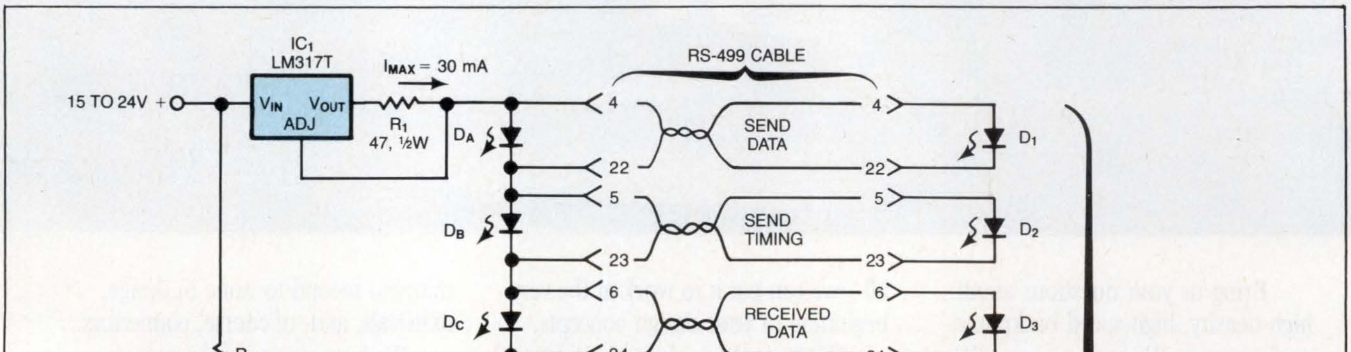

Fig 1—By driving two LED strings from a common current source, *you can quickly check a cable of twisted-pair wires for short circuits, open circuits, and pair-to-pair shorts.*

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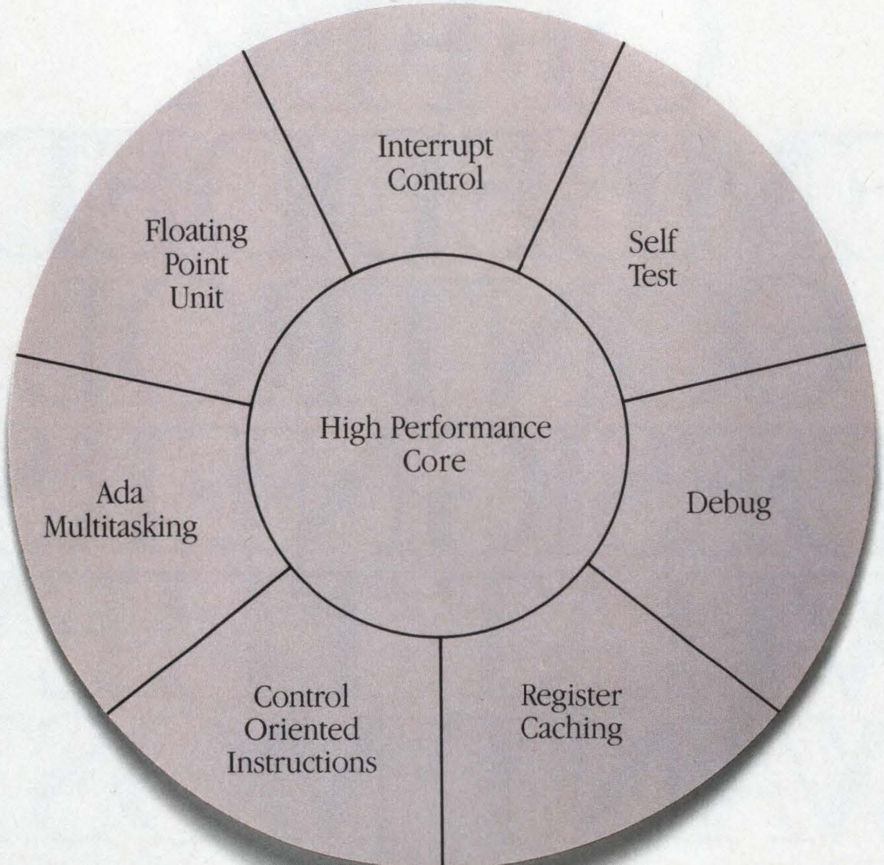

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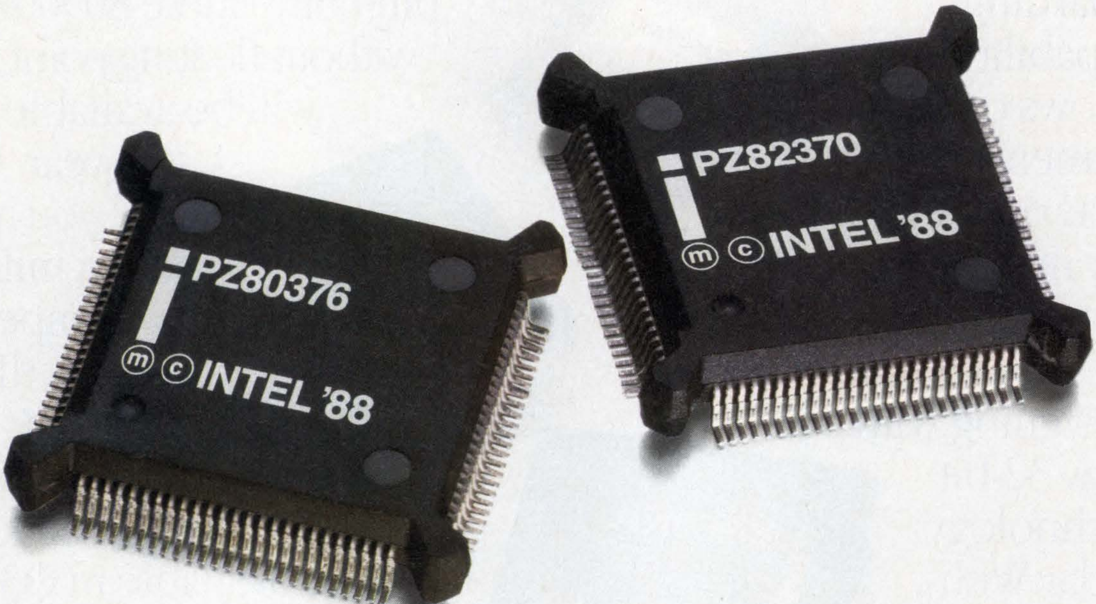

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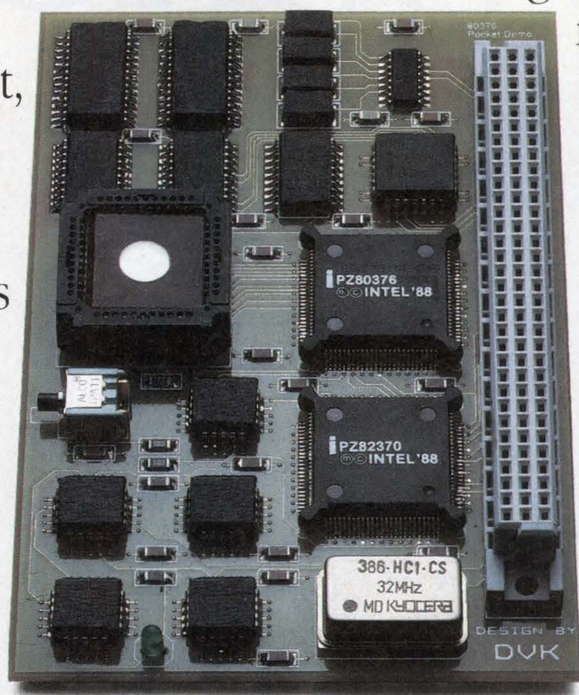

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CIRCLE NO 66

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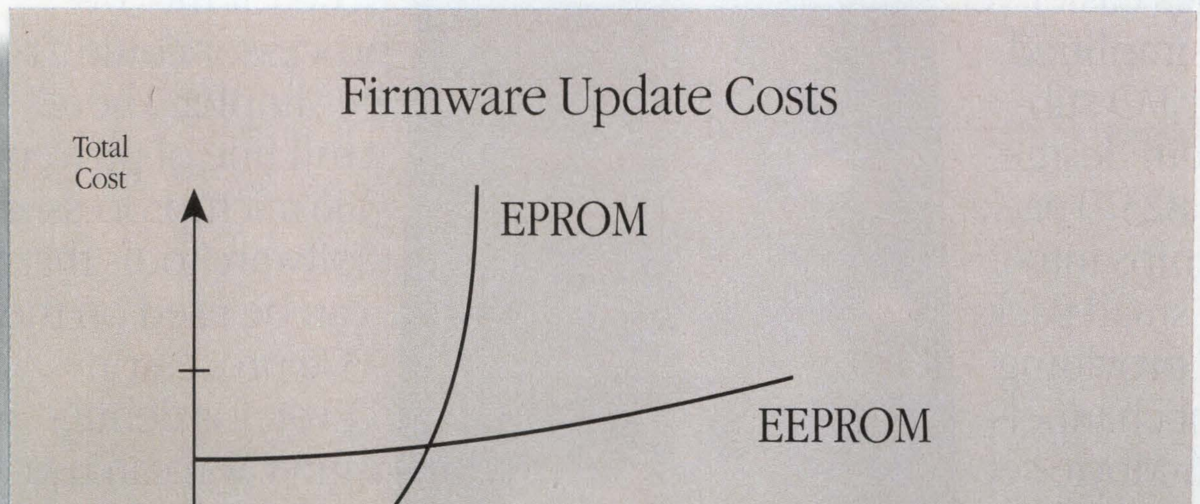

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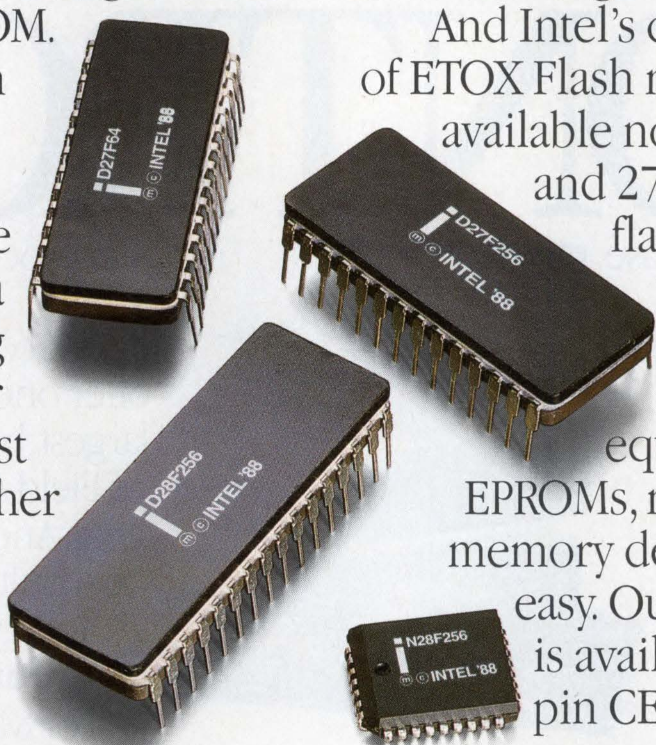

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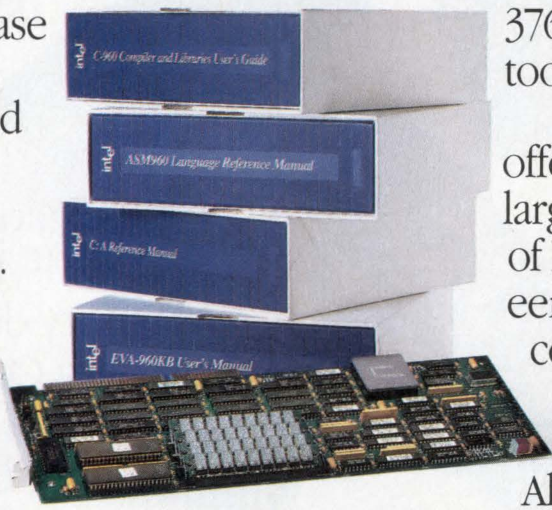

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Isolation amp uses balanced modulators

Moshe Gerstenhaber, Steve Miller,
and Chuck Kitchen
Analog Devices Semiconductor, Wilmington, MA

The isolation amplifier of **Fig 1** can faithfully transfer low-frequency information across a potential of 3 kV or more. Over the ±10V V_{IN} range, V_{OUT} deviates no more than 350 μV—that is, less than 0.0018%, which corresponds to a linearity of better than 14 bits. Offset-voltage drift and gain drift are less than 2 ppm and 50 ppm/°C, respectively. Typical bandwidth and output noise are 35 Hz and 1 mV rms. If necessary, you can improve these two specs by optimizing the output-filter characteristics.

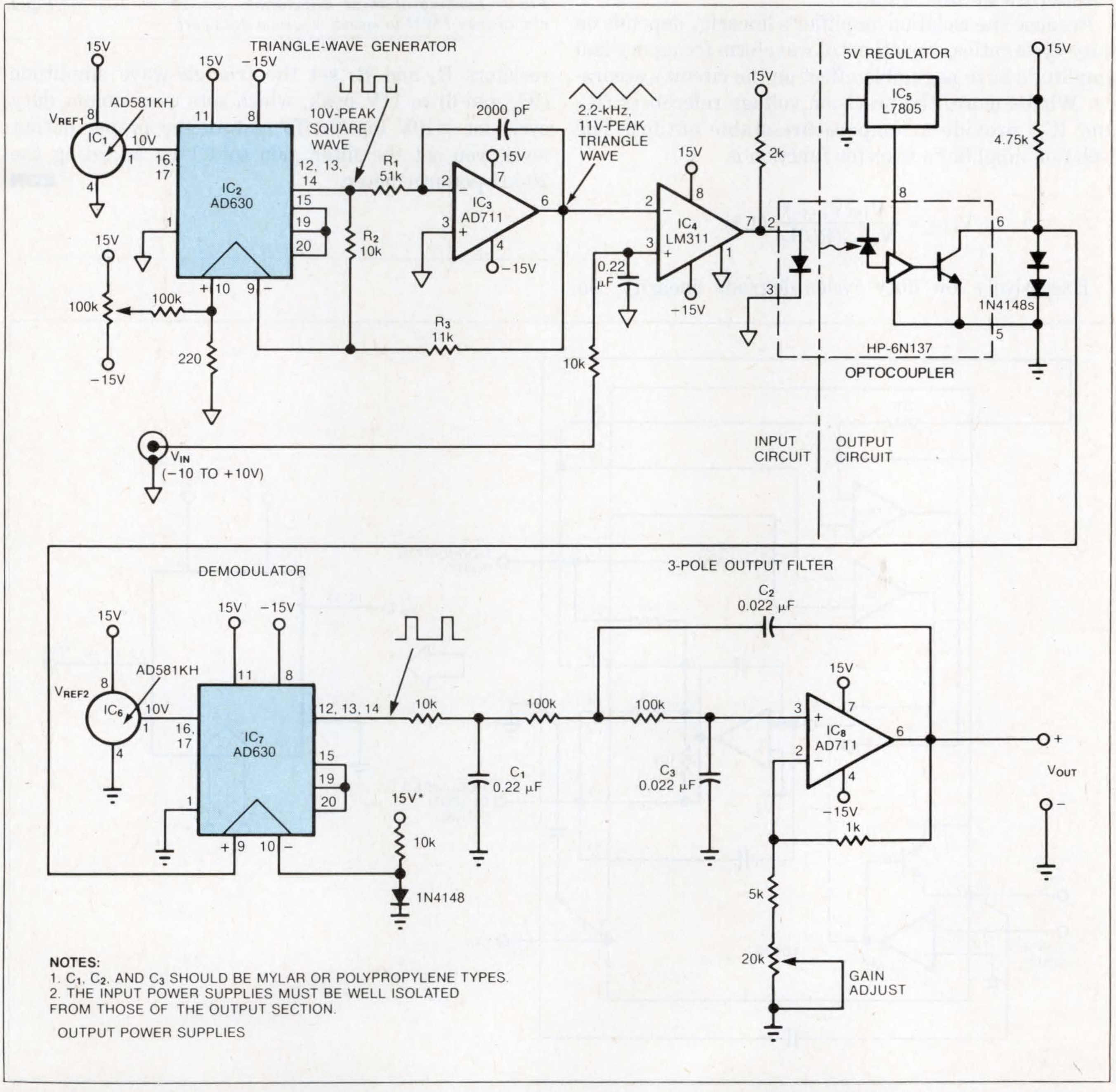

Fig 1—This isolation amplifier *employs PWM and optocoupling to transfer low-frequency signals across a barrier of 3 kV or more.*

Each balanced modulator (IC_2 and IC_7) is connected as a ±unity-gain block **(Fig 2)**. IC_2 and op amp IC_3 constitute a triangle-wave generator that produces a 2.2-kHz, 11V pk waveform at the inverting input of comparator IC_4. With V_{IN} applied to its other input, the comparator produces a PWM output in which V_{IN} is encoded as a duty cycle.

This modulated signal passes through the optocoupler and, together with 10V from reference IC_6, directly drives IC_7, the second modulator. IC_7's ±10V output **(Fig 3)** has a duty cycle that corresponds precisely to V_{IN}. Finally, the 3-pole, lowpass output filter reconstructs V_{IN} by extracting the duty-cycle waveform's average value.

Because the isolation amplifier's linearity depends on duty-cycle ratios, variations of waveform frequency and amplitude have negligible effect on the circuit's accuracy. What's more, the precision voltage references (IC_1 and IC_6) provide a temperature-stable output. The isolation amplifier's transfer function is

$$V_{OUT} = \frac{V_{IN}(V_{REF2})}{V_{REF1}(R_3/R_2)}\ (1.1).$$

Excessively low duty cycles degrade linearity. So, resistors R_2 and R_3 set the triangle-wave amplitude (IC_3, pin 6) to 11V peak, which sets a minimum duty cycle for ±10V inputs. To restore the proper output level, you set the filter gain to 1.1 by adjusting the 20-kΩ potentiometer. **EDN**

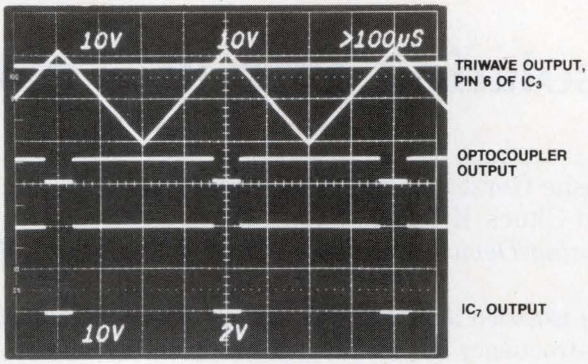

Fig 3—Looking at these waveforms, *you can see how the* ***Fig 1*** *circuit uses PWM to encode V_{IN} as a duty cycle.*

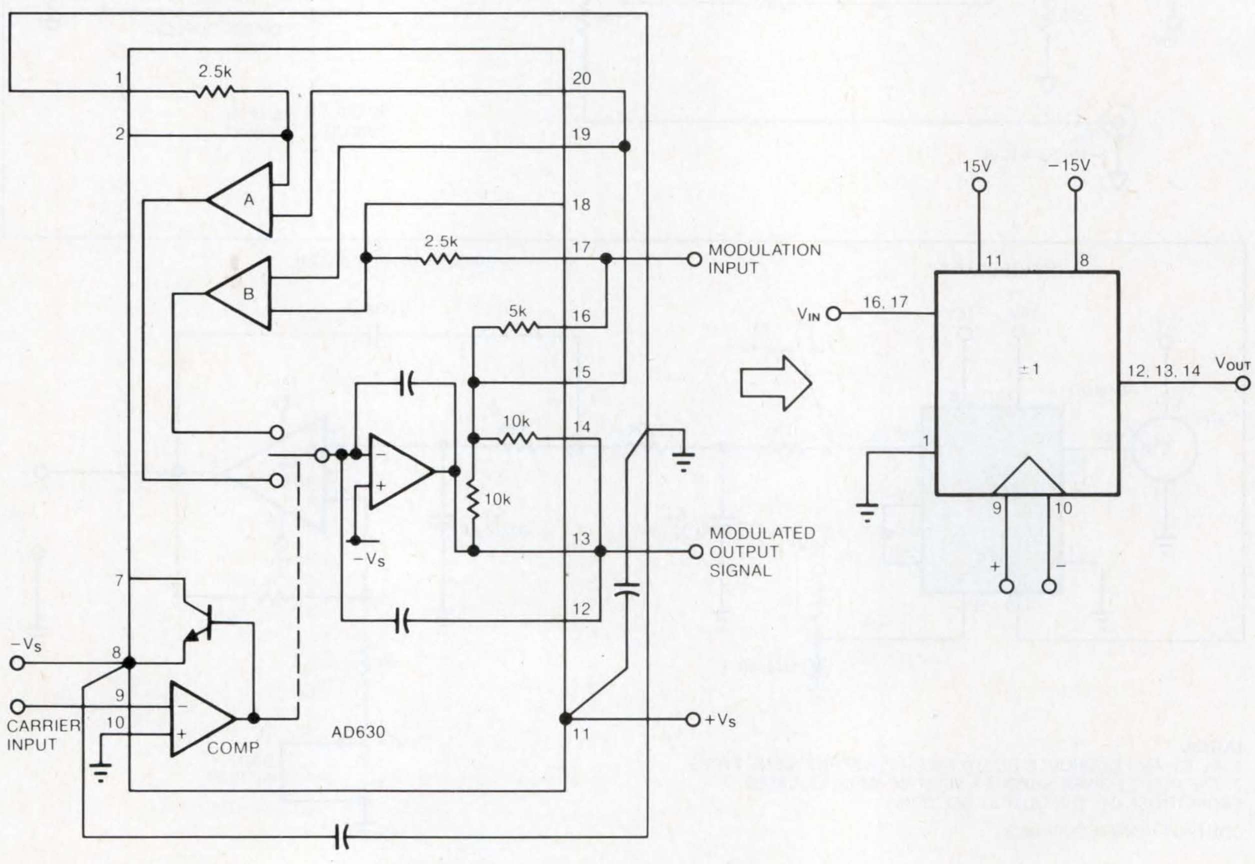

Fig 2—This balanced modulator/demodulator *is configured as a ±unity-gain device.*

Standard logic provides interrupts for Z80

Don Johnson
Network Sciences Corp, Newport Beach, CA

The circuit of **Fig 1a** implements vectored interrupts in a Z80-based system without requiring Z80-peripheral devices—a counter/timer circuit (CTC), for example, or a serial I/O (SIO) chip. First, configure the Z80 for mode 2 interrupt operation. In this mode, the μP responds to a low level on its $\overline{INT}$ input by using the contents of its 8-bit I register to access a memory-based table of interrupt-handler addresses. (You must store this table on a modulo-256 address boundary.) During the interval when $\overline{M1}$ and $\overline{IORQ}$ are low **(Fig 1b)**, the interrupting device supplies an 8-bit vector that enables the μP to select an address from the table.

As shown, **Fig 1a** supports eight interrupts. You can

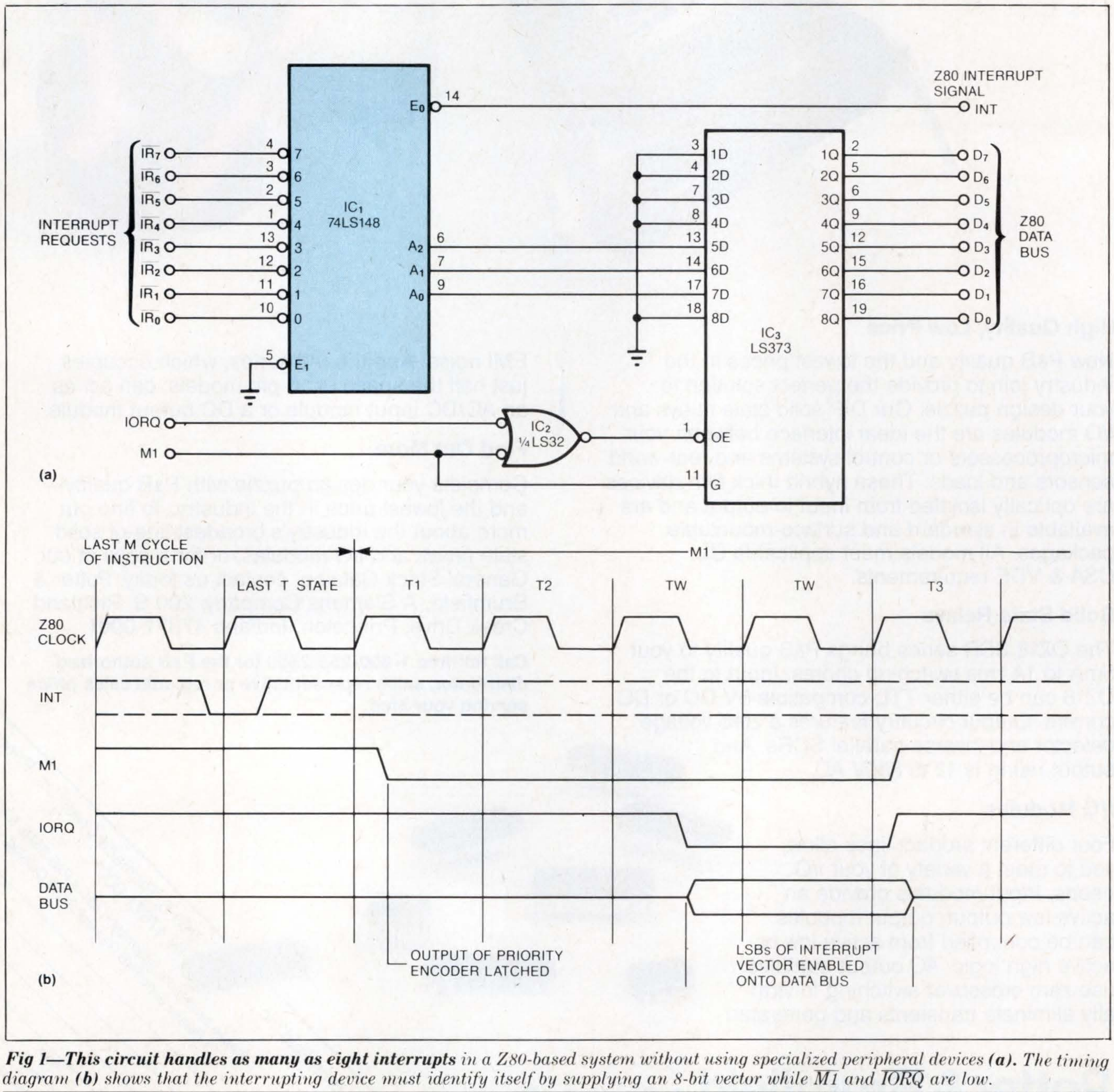

Fig 1—This circuit handles as many as eight interrupts *in a Z80-based system without using specialized peripheral devices* ***(a)****. The timing diagram* ***(b)*** *shows that the interrupting device must identify itself by supplying an 8-bit vector while $\overline{M1}$ and $\overline{IORQ}$ are low.*

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increase this number to 16 by adding an LS00 gate and another 74LS148; the second 74LS148 uses the first 74LS148's E_1 input (pin 5, connected to ground in **Fig 1a**) as a chip-enable input.

The interrupt signal from each interrupting device must go low and remain low until reset by the interrupt-handler subroutine. If the interrupting device generates a pulse instead of a level change, you must supply an edge-triggered flip-flop to capture and retain the interrupt signal. **Listing 1** contains assembly-code fragments for initializing the Z80's I register, for entering and exiting from the interrupt-handler subroutines, and for setting up the interrupt-handler address table.

EDN

LISTING 1—CODE FRAGMENTS FOR INTERRUPT SYSTEM

```
                            .Z80
                            TITLE Z80 INTERRUPT MODE 2 DEMO
0000'                       ASEG

                            ORG    0                  ; start at address 0

0000                STARTUP:

                    ;-----  I Register initialization

0000    3E 01               LD     A,HIGH VECTORS     ; get msb bits of vector table address
0002    ED 47               LD     I,A                ; load I register
0004    ED 5E               IM     2                  ; enable interrupt mode 2
0006    FB                  EI                        ; enable interrupts

                    ; the rest of the non-interrupt handler code follows


                    ;----- typical interrupt handler entry and exit code

0007                IHO:                              ; interrupt #0 handler entry
0007    08                  EX     AF,AF'             ; save registers (or push on stack)
0008    D9                  EXX

                    ; body of code goes here including the instructions to reset the interrupt

0009    D9                  EXX                       ; restore registers
000A    08                  EX     AF,AF'
000B    FB                  EI                        ; enable interrupts
000C    C9                  RET                       ; don't need RETI because interrupt
                                                      ; acknowledges are not needed

000D                IH1:                                 ; other interrupt handler entry points
000D                IH2:
000D                IH3:
000D                IH4:
000D                IH5:
000D                IH6:
000D                IH7:
000D    FB                  EI                        ; enable interrupts
000E    C9                  RET                       ; exit


                    ;----- interrupt handler address table

                            ORG    ($/256+1)*256      ; make table address mod 256

0100                VECTORS:
0100    0007                DEFW IH0                  ; interrupt handler #0 address
0102    000D                DEFW IH1
0104    000D                DEFW IH2
0106    000D                DEFW IH3
0108    000D                DEFW IH4
010A    000D                DEFW IH5
010C    000D                DEFW IH6
010E    000D                DEFW IH7

                            END
```

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Subroutine plots data from Basic programs

Brown Porter Jr
Unisys Corp, Bristol, TN

Listing 1, a graphics subroutine for the IBM PC, is capable of plotting a graph of the data generated by your Basic program, using any or all quadrants of the Cartesian plane. It gives you scale options of linear, semilog (X or Y axis), or log-log (one to five cycles); it provides automatic ranging and scaling; and it lets you set the Y scale, typically from ¼ to a full page (2½ to 10 in.). It also prints the title, subtitle, and scale labels in text mode, using upper- and lower-case characters.

LISTING 1—GRAPHICS SUBROUTINE

```
1000 '~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~
1010 '     **** PLOT1 S/R ****
1020 '
1030 HT%=15                                          'Set height of graph
1040 CLS: KEY OFF
1050 DIM A$(62), B$(62)
1060 GOSUB 2120                                      'Define plot char S/R
1070 IF (XSCALE$="G") OR (XSCALE$="g") THEN 1080 ELSE 1120
1080 GOSUB 1790                                      'Scale X S/R
1090 IF (YSCALE$="G") OR (YSCALE$="g") THEN 1100 ELSE 1120
1100 GOSUB 1860                                      'Scale Y S/R
1110 '  --- Find Min and Max ---
1120 FOR N=1 TO AP
1130   IF N<>1 THEN 1160
1140   XMAX=X(1): XMIN=X(1): YMAX=Y(1): YMIN=Y(1)          'Intl regs
1150   GOTO 1240
1160   IF XMAX>=X(N) THEN 1180                       'Find Xmax
1170   XMAX=X(N)
1180   IF XMIN<X(N) THEN 1200                        'Find Xmin
1190   XMIN=X(N)
1200   IF YMAX>=Y(N) THEN 1220                       'Find Ymax
1210   YMAX=Y(N)
1220   IF YMIN<Y(N) THEN 1240                        'Find Ymin
1230   YMIN=Y(N)
1240 NEXT N
1250   FOR I=1 TO N
1260     Y(I)=Y(I)-YMIN                              'Translate all X & Y values
1270     X(I)=X(I)-XMIN                              'to avoid negative numbers
1280   NEXT I
1290 XDIV=60/(XMAX-XMIN): YDIV=HT%/(YMAX-YMIN)   'Calculate scale factors
1300 XAXIS%=HT%-YMAX*YDIV: YAXIS%=INT(.5-XMIN*XDIV)       'Locate axes
1310 PRINT YUNIT$
1320 GOSUB 2050                                      'Print top border
1330 '  --- Build Image Line ---
1340 FOR I=1 TO 60
1350   IF I<>YAXIS% THEN 1380                        'Y axis ?
1360   A$(I)="+"                                     'Yes
1370   GOTO 1390
1380   LET A$(I)=" "                                 'no
1390 NEXT I
1400 IF HT%<>XAXIS% THEN 1420                        'X axis ?
1410 FOR I=1 TO 60: A$(I)="-": NEXT I                'Yes
1420   FOR I=1 TO N
1430     IF Y(I)<=(HT%-.5)/YDIV THEN 1470            'Value Y(I) = line value?
1440     K%=X(I)*XDIV                                'Yes; find X location
1450     A$(K%)=CURVE1$                              '"*"
1460     Y(I)=-Y(I)
1470   NEXT I                                        'No
1480 A$(61)=YBORDER$                                 'Right boundry
1490 V=YMIN+HT%/YDIV
1500 IF (YSCALE$="G") OR (YSCALE$="g") THEN 1510 ELSE 1520
1510 GOSUB 1930
1520 IF HT%/5<>INT(HT%/5) THEN 1560                  'Print every fifth line
1530 GOSUB 1970                                      'Label axis
1540 PRINT TAB(10); YBORDER$;"-";                    '"I-"
1550 GOTO 1570
1560 PRINT TAB(10); YBORDER$;" ";                    'Print non label lines
1570 FOR I=1 TO 61: PRINT A$(I);: NEXT I             'Print image line
1580 PRINT
1590 HT%=HT%-1                                       'Next line
1600 IF HT%>=0 THEN 1340                             'Finished plotting?
```

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CIRCLE NO 28

LISTING 1—GRAPHICS SUBROUTINE *(Continued)*

```
1610    FOR I=1 TO 7                                  'Yes
1620      PRINT TAB(I*10+2); YBORDER$;                'Print X axis divisions
1630    NEXT I
1640 GOSUB 2050                                       'Print bottom border
1650   FOR I=0 TO 6
1660      V=XMIN+I*10/XDIV
1670      IF (XSCALE$="G") OR (XSCALE$="g") THEN 1680 ELSE 1690
1680      GOSUB 1930
1690      PRINT TAB(I*10+9);                          'Print X labels
1700      GOSUB 1970
1710   NEXT I
1720 PRINT: PRINT: PRINT TAB(27) XUNIT$
1730 PRINT: PRINT: PRINT TAB(27) TITLE$: PRINT
1740 PRINT TAB(27) SUBTITLE$
1750 RETURN
1760 END
1770 '
1780     --- LOG SCALE X S/R ---
1790 FOR I=1 TO AP:X=X(I)
1800 ON SGN(X)+2 GOTO 2170,2190,1810
1810 X=LOG(10*X)/LOG(10): IF X<0 THEN 2210
1820 X(I)=X: NEXT I
1830 RETURN
1840 '
1850 '  --- Log Scale Y S/R ---
1860 FOR I=1 TO AP: Y=Y(I)
1870 ON SGN(Y)+2 GOTO 2170,2190,1880
1880 Y=LOG(10*Y)/LOG(10): IF Y<0 THEN 2210
1890 Y(I)=Y: NEXT I
1900 RETURN
1910 '
1920 '  --- Log Scale Label S/R ---
1930 V=10^V/10
1940 RETURN
1950 '
1960 '  --- Axes Labeling S/R ---
1970 IF V<>0 THEN 1980: PRINT V; GOTO 2020
1980 IF V>99 THEN 2010
1990 IF V<0!-99 THEN 2010
2000 PRINT USING "###.##";V;: GOTO 2020
2010 PRINT USING "##.##^^^^";V;
2020 RETURN
2030 '
2040 '  ---   Border S/R   ---
2050 FOR I=1 TO 61: B$(I)=XBORDER$ : NEXT I      'Fill top/bot border
2060 PRINT TAB(11);
2070 FOR I=1 TO 61: PRINT B$(I);: NEXT I         'Print top/bot border
2080 PRINT
2090 RETURN
2100 '
2110 '  --- Plot Char. Table ---                IBM     Star    Epson
2120 XBORDER$=CHR$(196)                         '196    241     133
2130 YBORDER$=CHR$(179)                         '179    245     134
2140 CURVE1$ =CHR$(254)                         '254    239     147
2150 RETURN
2160 '
2170 PRINT"Negative numbers are illegal on log scales."
2180 GOTO 995
2190 PRINT"Zero is illegal on log scales."
2200 GOTO 995
2210 PRINT"This program will plot log scales down to 0.1 with printing resolutio
n. Units  smaller then 10^-1 should be converted to milli, micro etc. to preser
ve plotting accuracy."
2220 GOTO 995
```

The subroutine has minimal impact on your main program, and it precludes the necessity of writing a special plotting routine, or of trying to visualize a curve by looking at a list of output data. **Listing 2** is an example of how the subroutine operates in a short program. The program includes a For/Next loop that generates discrete points on a continuous, 2-dimensional curve called a strophoid.

You establish an X-Y array (lines 30 and 900 to 915), select linear or log scales (lines 920 and 930), and then provide the title and scale labels (lines 940 to 970). To center the titles, add or subtract spaces between the quotation mark and the first character. The graph's vertical dimension depends on line 1030 (HT%=nn) in **Listing 1.** The variable "nn" lets you size charts for inclusion in technical reports; 15 is a good size for screen viewing, and 30 is a good starting value for printing.

As you can see, the subroutine displays the graph on a monitor. Using the echo print method, you can make a

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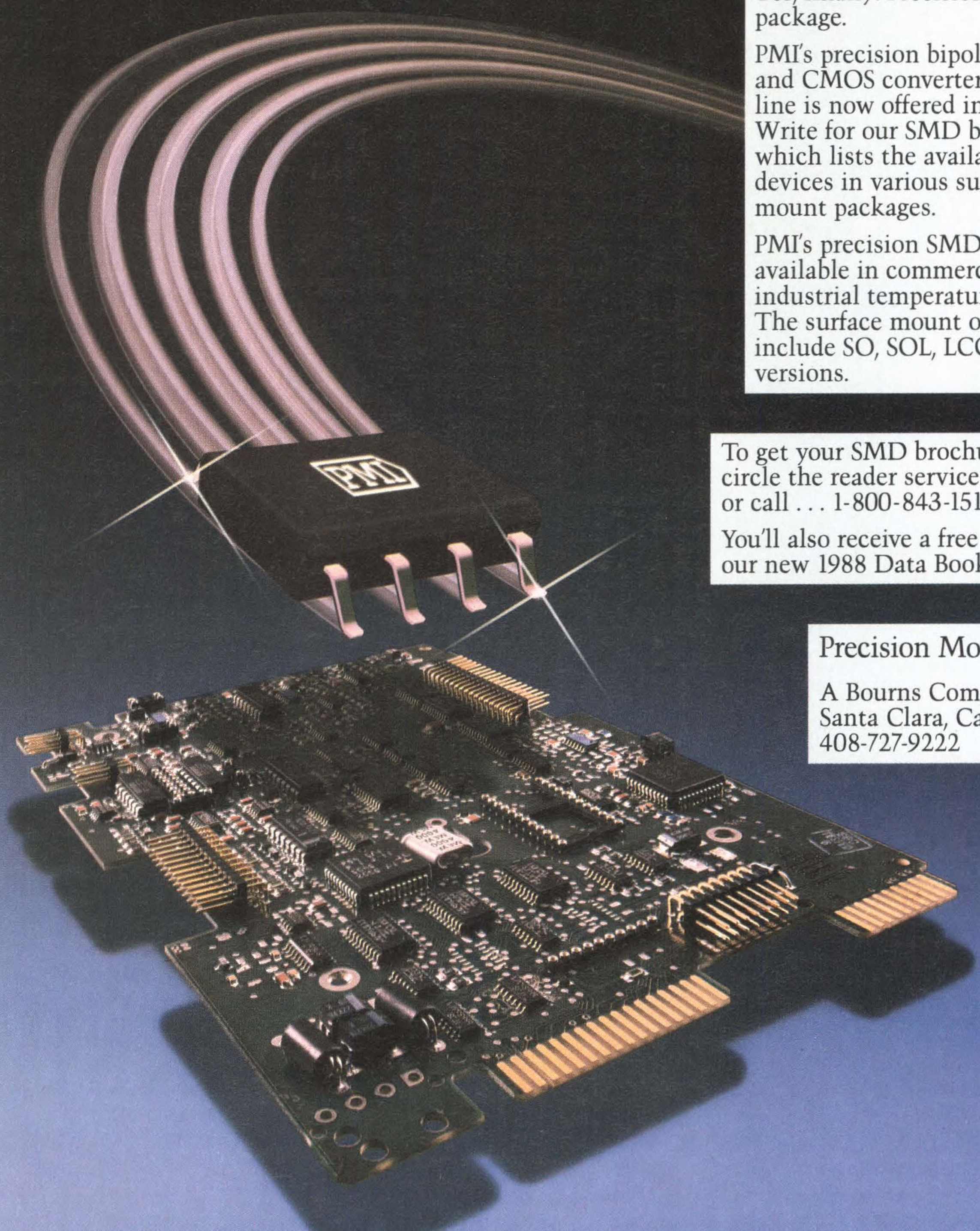

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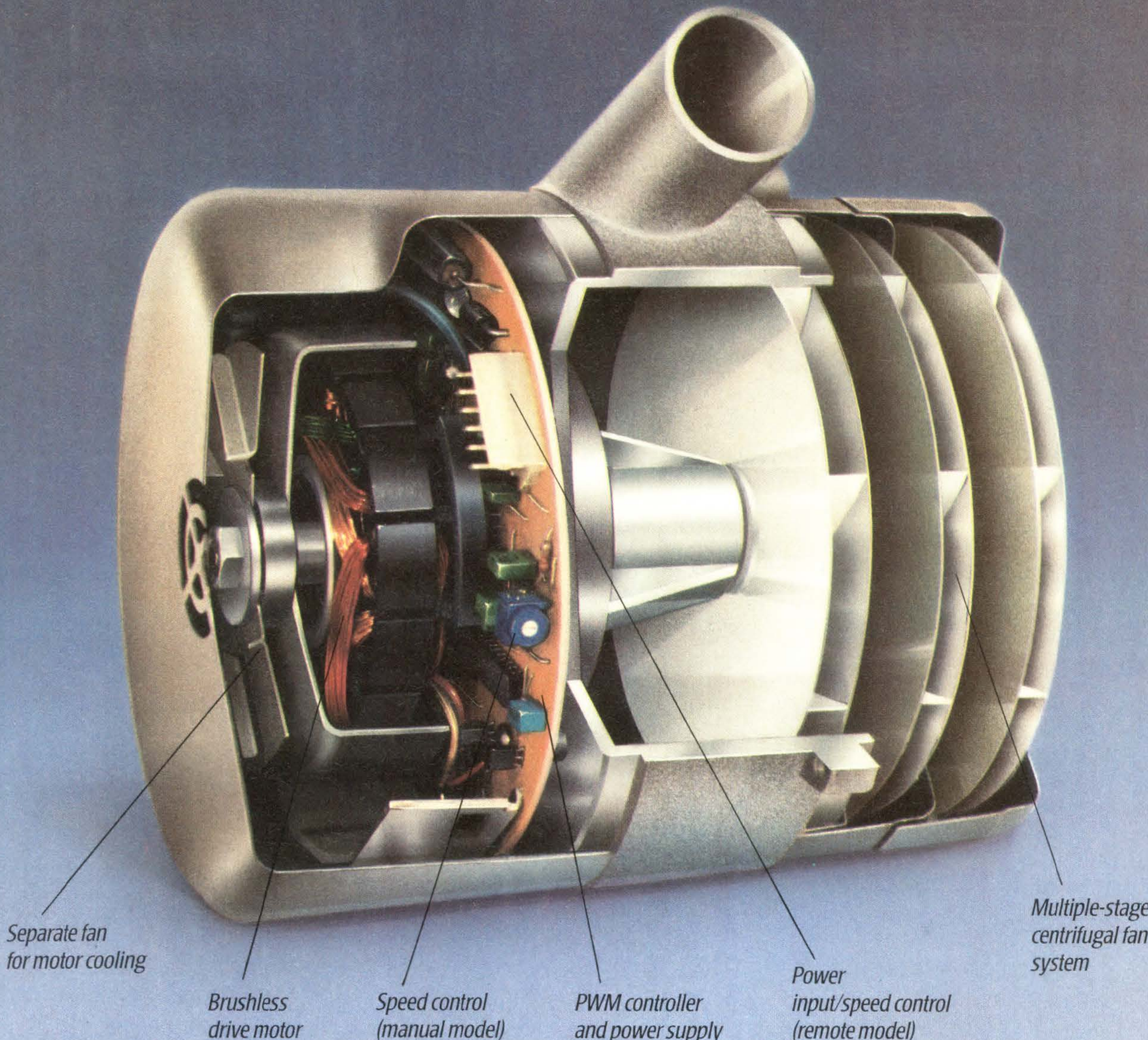

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Just 5.7″ in diameter, the blowers have 1-, 2-, or 3-stage fans for performance from 50″ H_2O vacuum at 0 CFM to 110 CFM at 0″ H_2O. With one version, a 0 to 10 VDC signal from a sensor or other device will control motor speed and adjust air performance from 0 to 100%. Or, a second model provides manual speed control by means of a potentiometer located in the blower housing.

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LAMB ELECTRIC DIVISION

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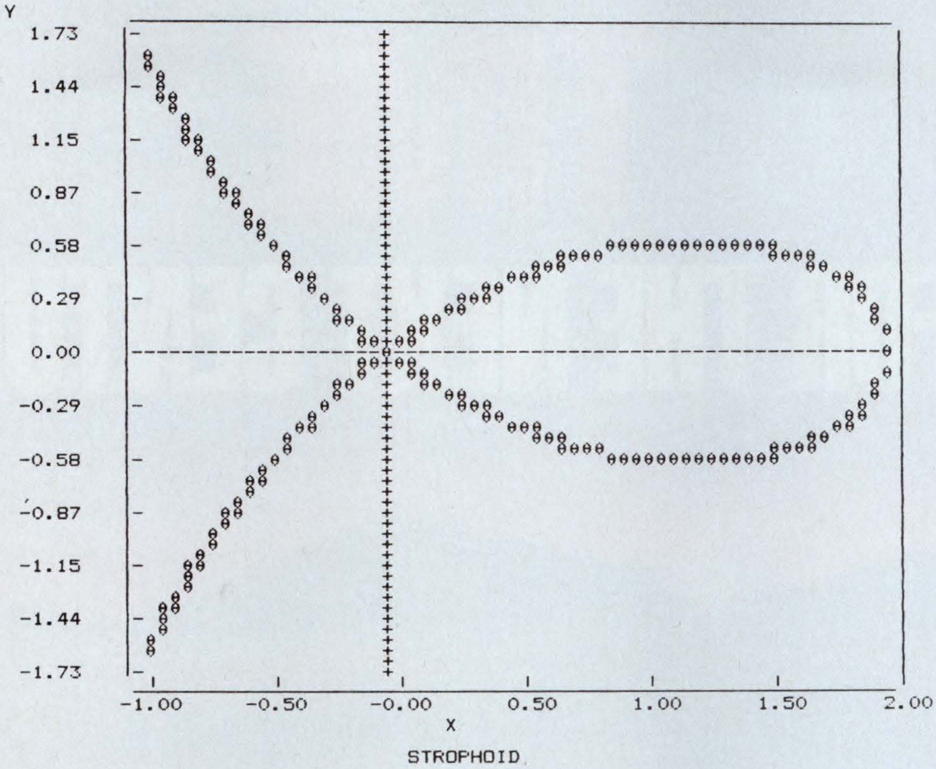
LISTING 2—SAMPLE PROGRAM



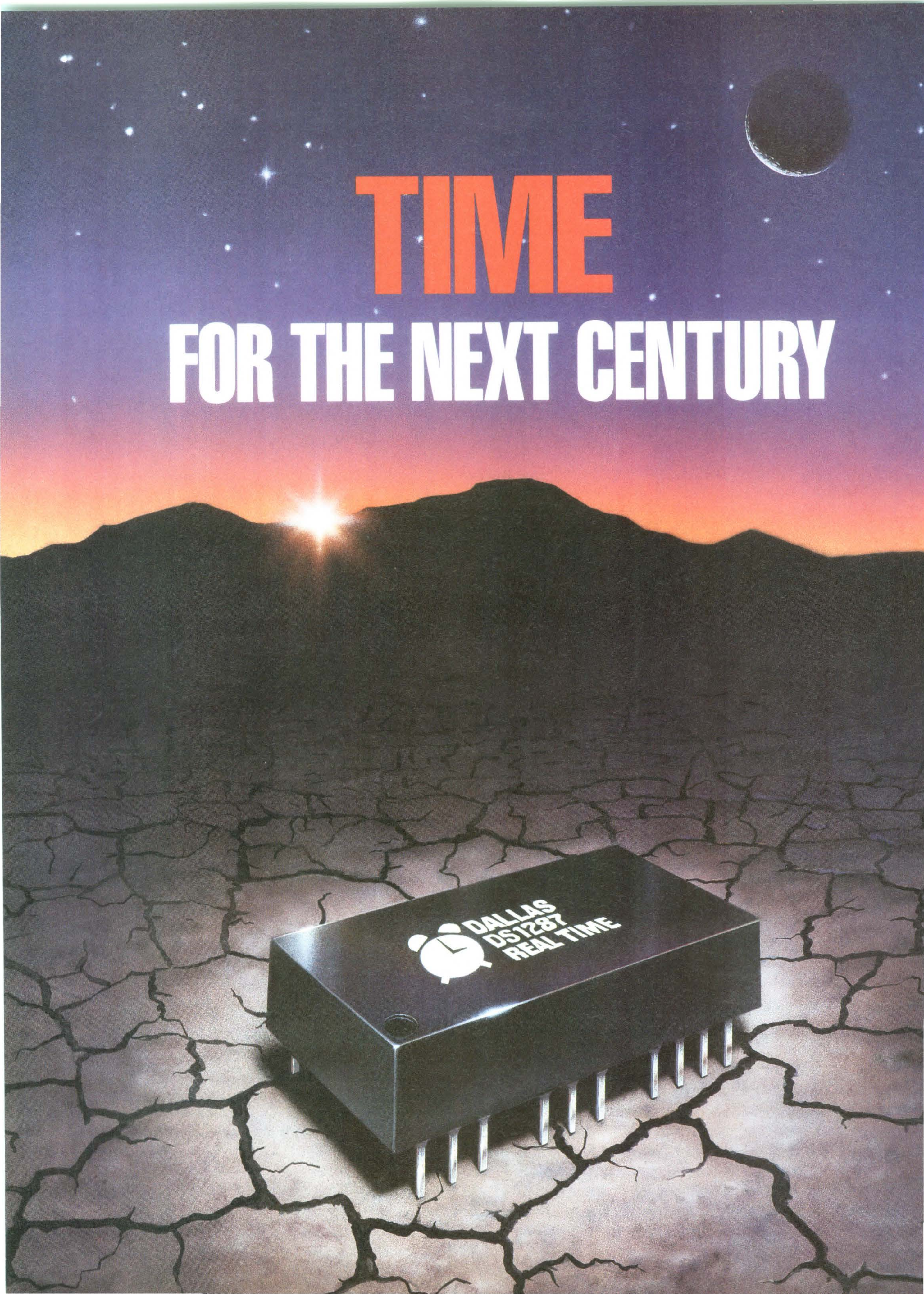

```
Ok
10 '   >>> STROPHOID <<<
20 '~~~~~~~~~~~~~~~~~~~~~~~~~
30 DIM X(500),Y(500) : AP=0
100     FOR X=-1 TO 4 STEP .02
110     A=(2-X)/(2+X)
120     IF A<0 THEN 915
130     Y=SQR(X^2*A)
900     AP=AP+1
902     X(AP)=X
904     Y(AP)=Y
906     AP=AP+1
908     X(AP)=X
910     Y(AP)=0-Y
915     NEXT X
920 XSCALE$= "L"                                'Linear(L) or Log(g)
930 YSCALE$= "L"                                'Linear(L) or Log(g)
940 TITLE$=    "       STROPHOID                 "
950 SUBTITLE$="                                  "
960 YUNIT$=    "Y          "
970 XUNIT$=    "          X                      "
980 '
990 GOSUB 1000
995 END
```

hard copy by pressing Ctrl and then pressing PrtSc (Fn, Echo on the IBM Jr) and then running the program. Don't forget to clear the echo mode by repeating this key sequence after the printing is finished. If you don't want or need to preview the graph on the screen, change all PRINT statements to LPRINT ones, which route the output directly to the printer.

To use different printers or change the appearance of your graph, look up the special characters for plotting the curve and borders, which you can find at line 2110 in **Listing 1.** If you're using a printer that doesn't have an IBM mode, and therefore inserts unwanted spaces in the vertical borders, try adding lines 1052, 1054, and 1745:

```
1052 PRINT CHR$(27);"@"                 'Clear printer presets
1054 PRINT CHR$(27);"A";CHR$(6)         'Print W/O spaces
1745 PRINT CHR$(27);"@"                 'Return printer to text mode
```

If this doesn't work, you'll have to consult your printer manual for a command that allows printing without spaces. **EDN**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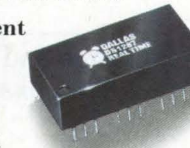
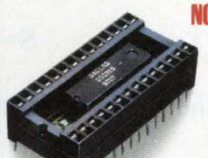
DS1287
REAL TIME




DALLAS
REAL TIME




DESIGN IDEAS

EDITED BY ROBERT M CLARKE

Pocket calculator eases filter design

Arthur Delagrange and Reynold Douyon
Naval Surface Weapons Center, Dahlgran, VA

By using this filter-design method and **Fig 1**'s circuit, you can pick the poles and zeros for a bandpass filter and then calculate the corresponding component values on a pocket calculator.

A previous article (**Ref 1**) described a circuit for a floating synthetic inductor that you can use to convert any prototype lowpass filter to a bandpass or bandstop filter. David C Bidwell (**Ref 2**) revised the bandpass-filter design using a more efficient circuit. His conversion, however, entailed "complex polynomial-manipulation procedures requiring extensive computer manipulation."

The method presented here achieves an efficient design. It involves tedious calculations, but you can perform them on a pocket calculator having square root and trigonometric functions.

The method consists of calculating new poles and zeros for the bandpass filter and determining component values directly from the poles and zeros. This example uses a 3-pole, 2-zero prototype filter that specs 1.25-dB ripple and 39-dB stopband (**Ref 3**). The prototype filter has zeros at

$$S=\pm j2.6003$$

and poles at

$$S=-0.48307$$

and

$$S=-0.20690\pm j0.96264.$$

The bandpass transformation makes the substitution

$$S \rightarrow \frac{S^2+\omega_0^2}{S}.$$

Substituting for the pole-zero pair at

$$S=-A+jB$$

and solving by means of the standard quadratic equation and Euler's formula gives the new poles or zeros:

$$S=\frac{-A\pm jB}{2}\pm(\cos\theta\mp j\sin\theta)\sqrt[4]{\left(\frac{A^2-B^2-4\omega_0^2}{4}\right)^2+\left(\frac{AB}{2}\right)^2},$$

where

$$\theta=\mathrm{ARCTAN}\frac{AB/2}{(A^2-B^2-4\omega_0^2)/4+\sqrt{\left(\frac{A^2-B^2-4\omega_0^2}{4}\right)^2+\left(\frac{AB}{2}\right)^2}}.$$

In this example, $\omega=1$.

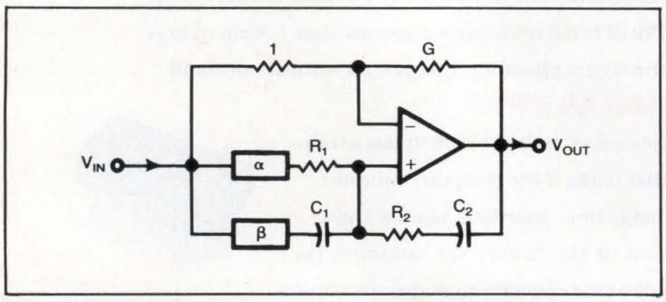


Fig 1—Use this building-block circuit *to generate the pole-zero pairs used in bandpass-filter design.*

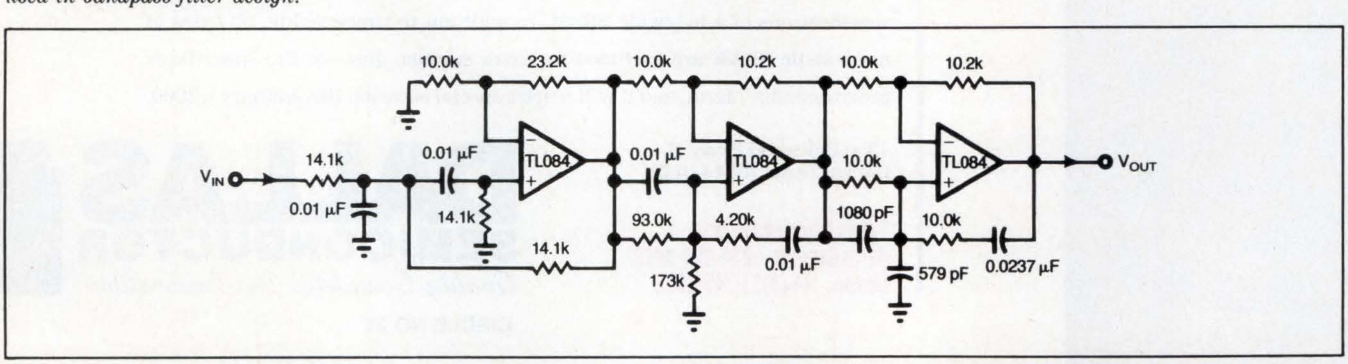
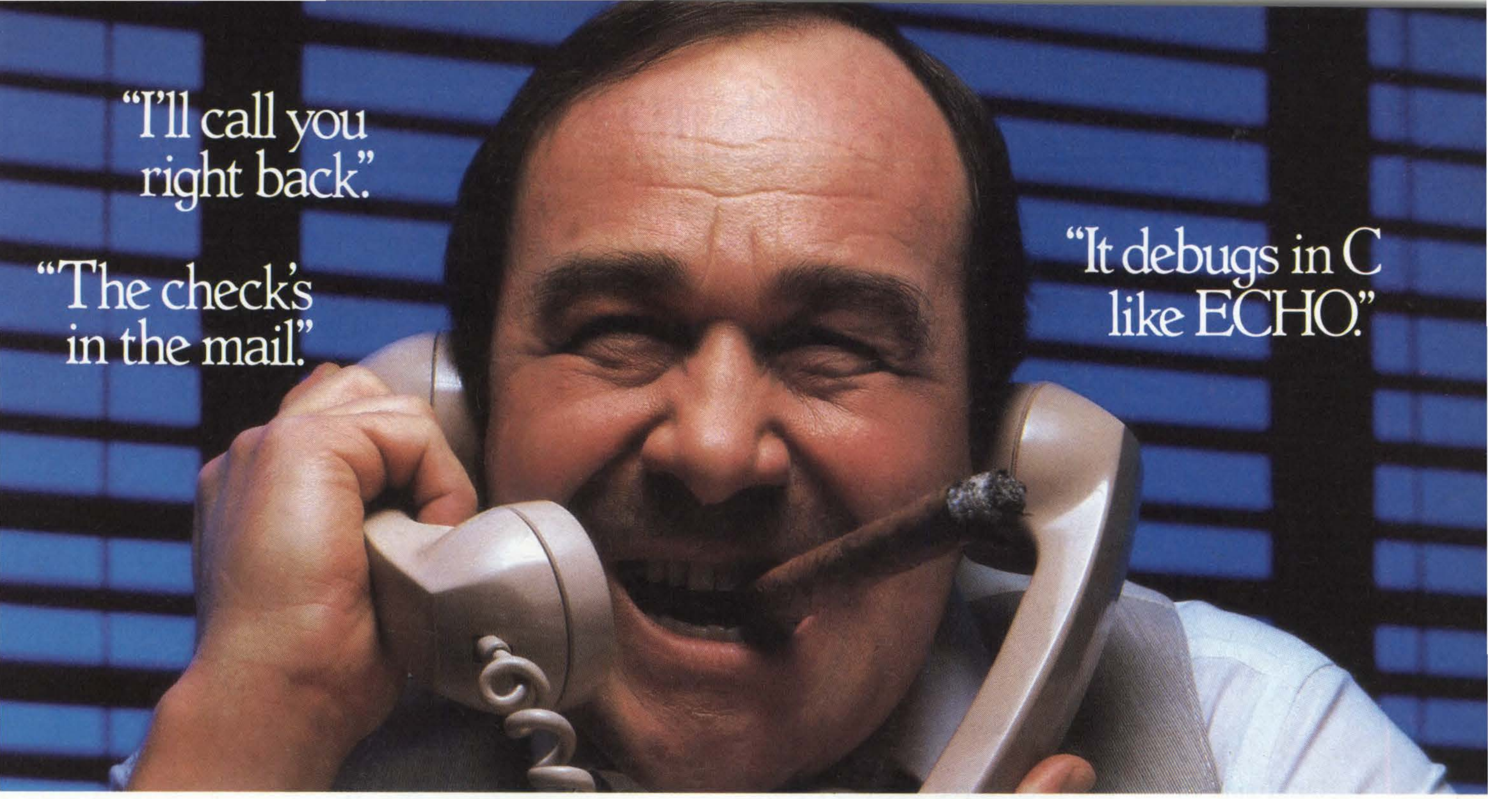


Fig 2—You can achieve a 39-dB stopband *and 1.25-dB ripple using this bandpass filter. Scale the capacitor values to change its center frequency.*



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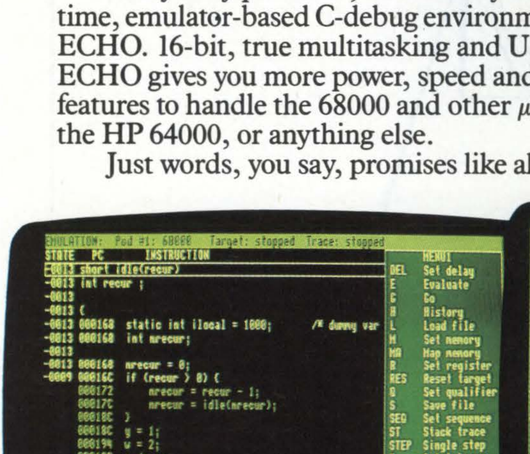
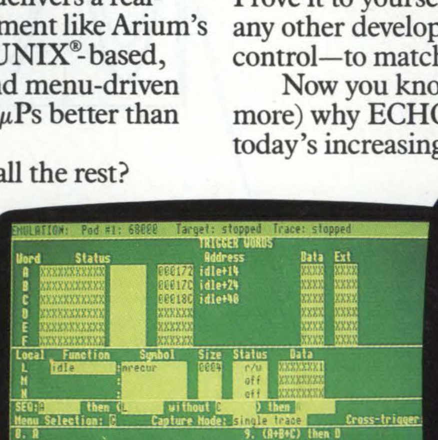
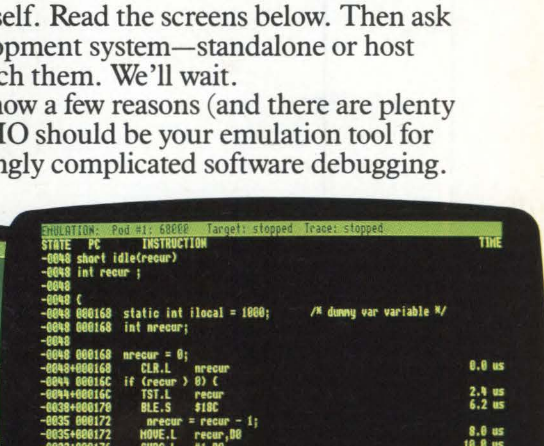


Code Preview™ lets you see where your code is going. You can follow calls and branches (to 99 levels) on the screen, to select the source line on which to trigger, then set and break in one keystroke! The highlighted trace display (in source) and stack trace window show the path your program took.



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



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CIRCLE NO 32

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This equation gives zeros at

$$S=\pm j0.3398$$

and

$$S=\pm j2.9406.$$

It has a real pole at

$$S=-0.2415\pm j0.9704.$$

Finally, the equation has complex poles at

$$S=-0.05843\pm j0.6246$$

and

$$S=-0.1485\pm j1.5872.$$

To build this filter, you need three sections: bandpass, highpass, and lowpass. The bandpass section can be an ordinary Sallen-Key resonator **(Ref 4),** but the highpass and lowpass sections require zeros. **Fig 1's** circuit can provide these zeros. Its transfer function (omitting the gain factor) is

$$\frac{S^2+\dfrac{[(G\beta+\beta-G)R_1C_1+(G\alpha+\alpha-G)R_2C_2-GR_1C_2]S}{(G\beta+\beta-G)R_1R_2C_1C_2}}{S^2+\dfrac{(R_1C_1+R_2C_2-GR_1C_2)S}{R_1R_2C_1C_2}+\dfrac{1}{R_1R_2C_1C_2}}$$

$$+\frac{+\dfrac{(G\alpha+\alpha-G)}{(G\beta+\beta-G)R_1R_2C_1C_2}.}{S^2+\dfrac{(R_1C_1+R_2C_2-GR_1C_2)S}{R_1R_2C_1C_2}+\dfrac{1}{R_1R_2C_1C_2}.}$$

The lowest frequency zero pair and the lowest frequency pole pair combine to give the highpass-filter section. Similarly, the highest frequency pole and zero pairs give the lowpass-filter section. For each section, you can divide the product of the poles by the product of the zeros and write the transfer function in the form

$$\frac{S^2+D}{S^2+AS+B}.$$

Identifying these transfer-function terms with the

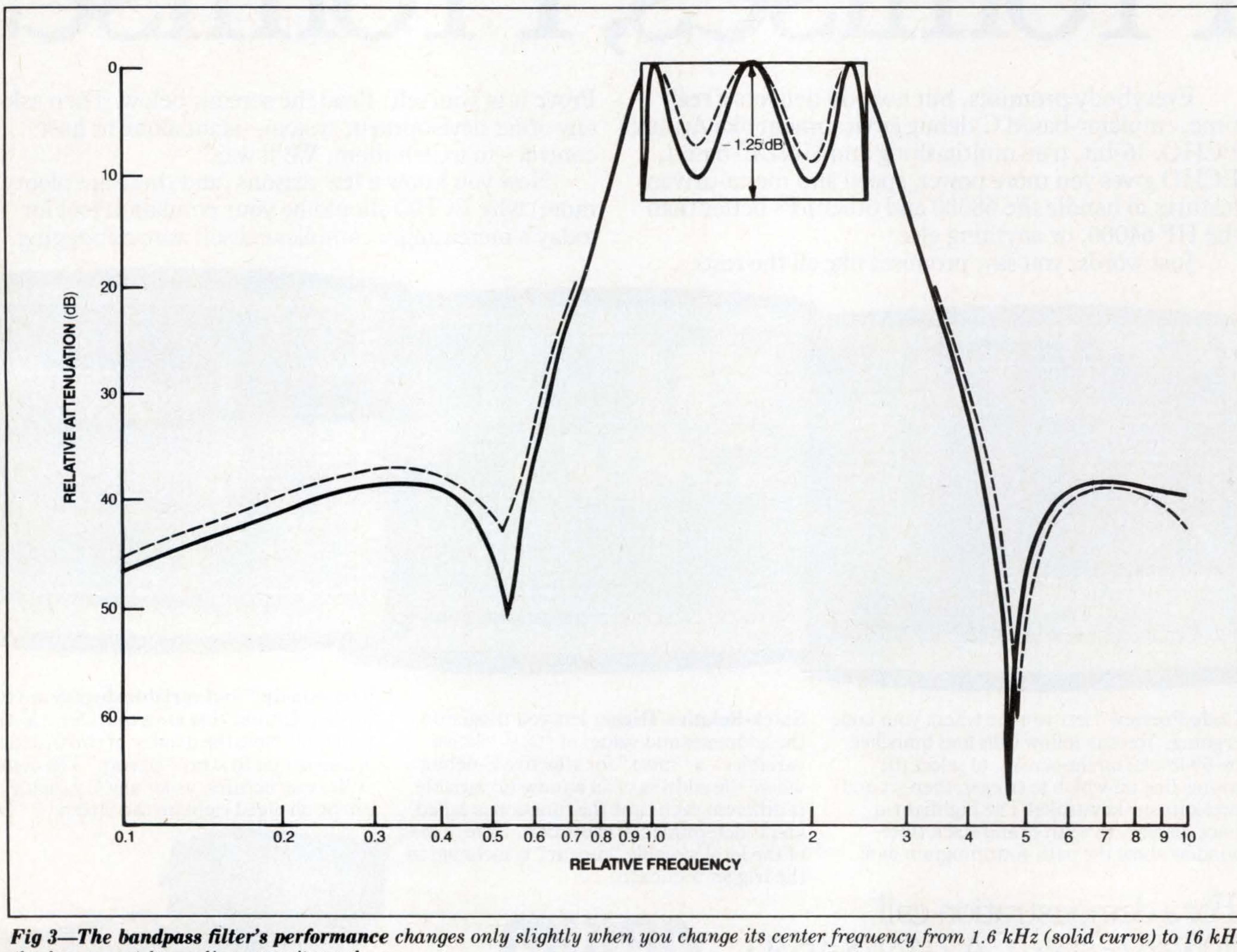

***Fig 3—The bandpass filter's performance** changes only slightly when you change its center frequency from 1.6 kHz (solid curve) to 16 kHz (broken curve) by scaling capacitor values.*

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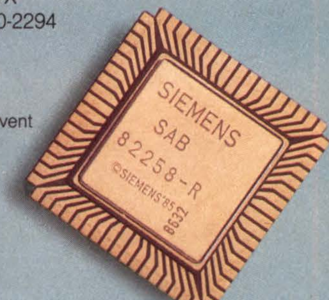

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COMPONENT VALUES FOR SECTIONS WITH ZEROS

HIGHPASS	LOWPASS
LET $\beta = 1; C_1 = C_2 = 1$	LET $\alpha = 1; R_1 = R_2 = 1$
$R_1 = \frac{(1 - \frac{D}{B})}{A}$	$C_2 = \frac{(1 - \frac{B}{D})}{A}$
$R_2 = \frac{1}{BR_1}$	$C_1 = \frac{1}{BC_2}$
$G = \frac{(R_1 + R_2 - \frac{A}{B})}{R_1}$	$G = \frac{(C_1 + C_2 - \frac{A}{B})}{C_2}$
$\alpha = \frac{G + \frac{D}{B}}{G+1}$	$\beta = \frac{G + \frac{B}{D}}{G + 1}$
$R_{SERIES} = \frac{R_1}{\alpha}$	$C_{SERIES} = \beta C_1$
$R_{SHUNT} = \frac{R_1}{(1-\alpha)}$	$C_{SHUNT} = (1 - \beta)C_1$

terms in the complete transfer function and solving the equation yields the parameters listed in the **table.** Included at the bottom are the values for splitting the input resistor or capacitor to give a Thevenin-equivalent voltage-divider ratio α or β.

Fig 2 shows the complete filter circuit. You need just seven precision resistors and three op amps. The filter's output comes from an op amp and doesn't need buffering. The values calculated for this prototype have been scaled up by a factor of 10^4 in frequency (1.6 kHz) and 10^4 in impedance (10 kΩ). Components were selected to 1% tolerance, and the first stage's gain and Q were then adjusted to equalize the amplitude in the peaks of the filter's response (**Fig 3**). Note that the vertical scale is expanded in the passband. The solid line shows the response of **Fig 2**'s circuit with a 1.6-kHz center frequency. The actual performance is quite close to that predicted by theory. The broken line gives the response for the same circuit with capacitor values reduced by a factor of 10 to give a new center frequency of 16 kHz.

EDN

References

1. Delagrange, Arthur, "Make passive filters active with a floating synthetic inductor," *EDN*, June 23, 1983, pg 277.
2. Bidwell, David C, "GICs yield efficient bandpass filter," *EDN*, January 12, 1984, pg 289.
3. Zverev, A I, *Handbook of Filter Synthesis*, John Wiley and Sons, New York, 1967.
4. Huelsman, L P, and Allen, P E, *Introduction to the Theory and Design of Active Filters*, McGraw-Hill, New York, 1980.

Components enhance amplifier's bandwidth

Eric Filseth
National Semiconductor Corp, Santa Clara, CA

Two modifications to the standard hookup for an LH0002 current amplifier will boost its 30-MHz frequency response from that shown in **Fig 1a** (standard performance using ± 5V power supplies) to that of **Fig 1b**.

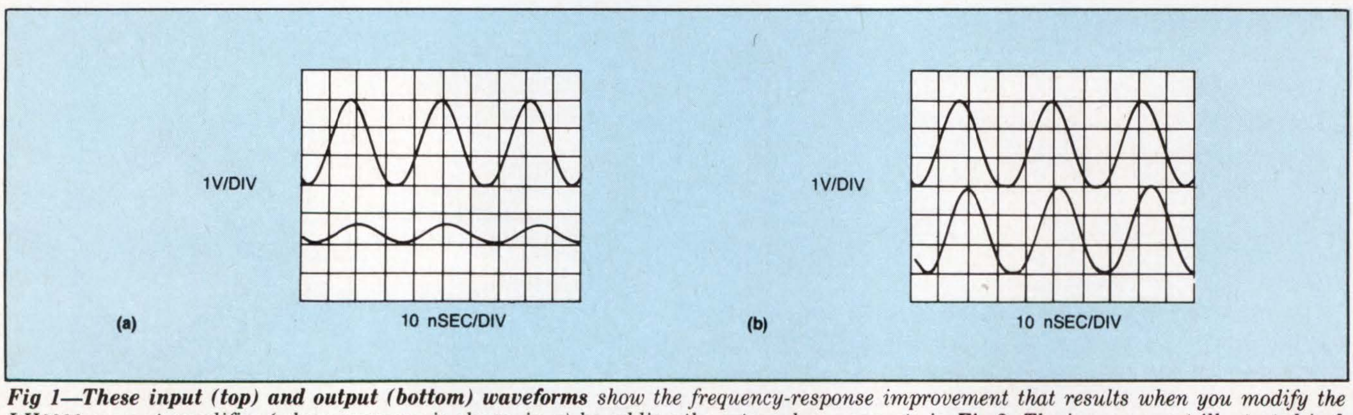

Fig 1—These input (top) and output (bottom) waveforms *show the frequency-response improvement that results when you modify the LH0002 current amplifier (whose response is shown in* ***a****) by adding the external components in* ***Fig 2****. The improvement illustrated in* ***b*** *results when R_S=1 kΩ, R_L=50Ω, and frequency equals 30 MHz.*

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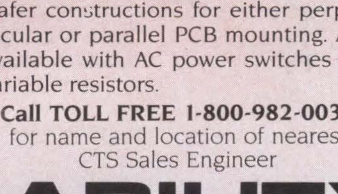

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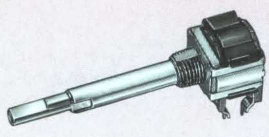

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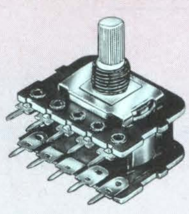

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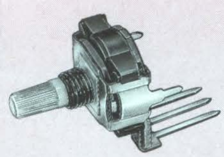

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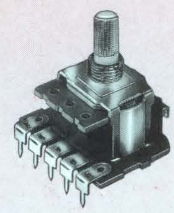

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Spring Return Switch
Phone: (219) 295-3575
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First, you increase the input-stage bias currents tenfold by adding 500Ω resistors R_A and R_B to pins 10 and 6 **(Fig 2).** The higher bias current increases the input transistors' f_t and provides more base drive for the output transistors. Note that the output devices' beta is probably less than 10 at 30 MHz, so each will need at least a 3-mA base current to provide the required 30-mA output current. Also, higher base current provides more drive to the input capacitance of these transistors; the increased drive increases the amplifier's slew rate.

Adding R_A and R_B increases the quiescent supply current, of course, and lowers the amplifier's input impedance to about 15 kΩ. The variation of input impedance over the operating bandwidth is less, however, than for an unmodified LH0002. At high frequencies, the modified circuit's input impedance (particularly the reactive part) is actually greater. The main advantage, though, is the speed and bandwidth obtained for ±5V applications. (Incidentally, you must use the 10-pin DIP version of the LH0002; pins 6 and 10 offer connections that are not present on the 8-lead TO-5 version.)

The second modification is useful in applications with high source resistance, where speed is limited by the product of source resistance and LH0002 input capacitance. The input capacitance is mostly collector-base capacitance from Q_3 and Q_4; you can bootstrap (minimize the effects of) this capacitance by adding resistors R_X and R_Y, and then adding capacitors C_1 and C_2 to bypass the output stage **(Fig 2).** The amplifier's output voltage now drives its input capacitance via the capacitors.

EDN

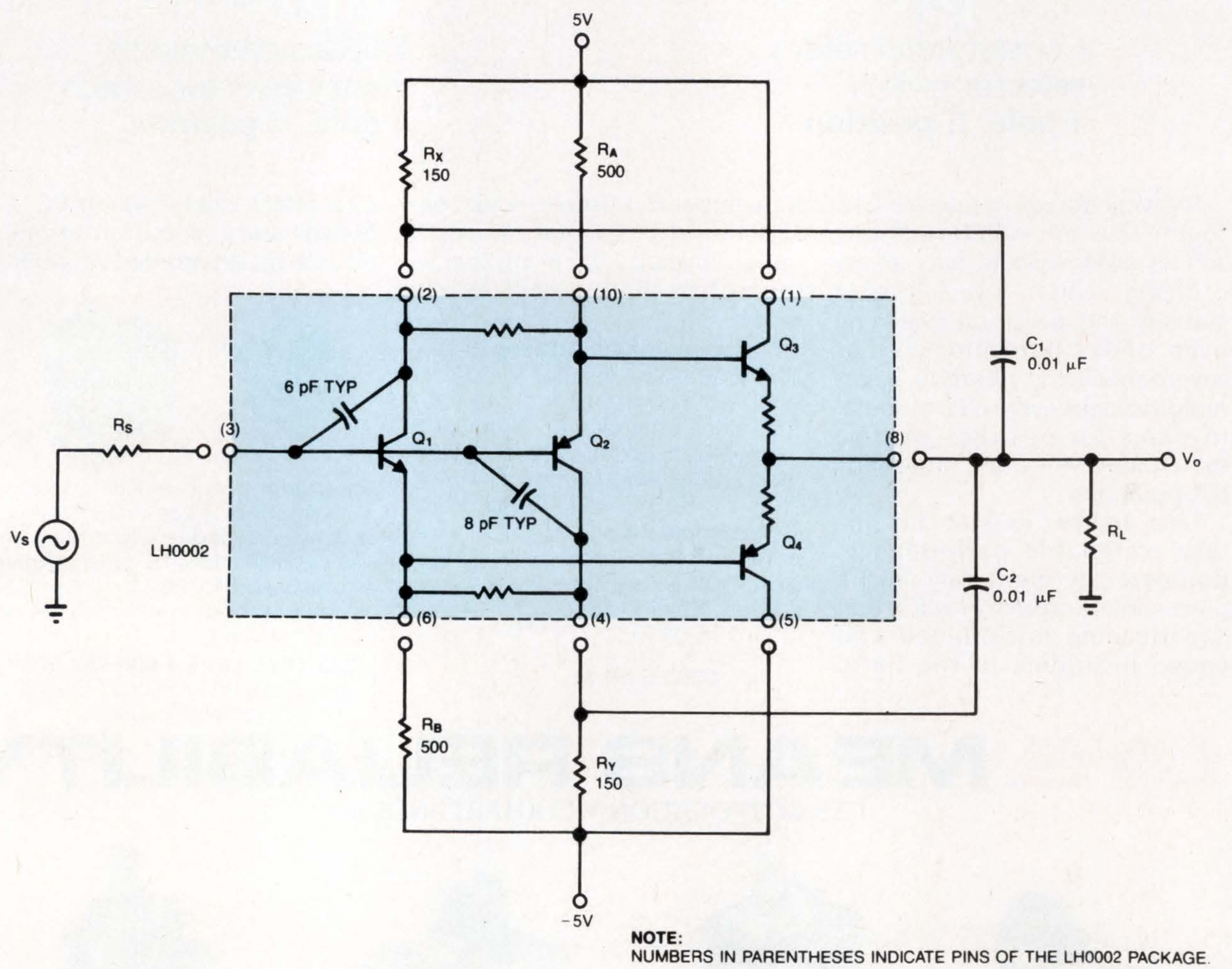

***Fig 2—You can add components to extend the bandwidth** of an LH0002 amplifier. This circuit increases the input-stage bias currents and bootstraps the amplifier's input capacitance.*

Audio AGC circuit has 40-dB dynamic range

Norman M Hill
Zetron Inc, Bellevue, WA

The automatic-gain-control (AGC) circuit of **Fig 1a** operates on ±5V supplies and provides good fidelity for audio signals over an input range of 40 dB. The circuit maintains an output of 0 dBm (±1.1V) by varying the input attenuation from 0.1 to 10 (−20 to 20 dBm).

JFET Q_1 operates as a variable resistor. Q_1 and resistor R_1 divide the input signal in response to the control voltage on the gate of Q_1. Op amp IC_{1A} (with R_4 and R_5) then provides enough gain to accommodate input signals of ±20 dBm **(Fig 1b).**

To ensure low distortion in a JFET, you should add approximately one-half the drain-source voltage to the gate voltage. The voltage divider (R_2/R_3) and the buffer amplifier (IC_{1B}) provide this gate bias by charging and discharging capacitor C_2. R_8 isolates the gate-source diode in Q_1.

The peak-detector amplifiers (IC_{1C} and IC_{1D}) have a gain of 20. Their outputs reside at negative-saturation levels when V_{OUT} is between 1.1 and −1.1V; the resulting Q_1 gate voltage (−4V) allows maximum circuit gain. When V_{OUT} makes an excursion outside this range, one of the peak-detector outputs rises in the positive direction, discharging C_2 and driving Q_1's gate in a more positive direction. Thus, Q_1 regulates the output by increasing the input-signal attenuation. C_2 discharges through the attack resistor, R_6, until the output level returns to 0 dBm. When the input level subsides, C_2 slowly recharges through the decay resistor, R_7. For a 20-dBm change, the attack time is 5 msec and the

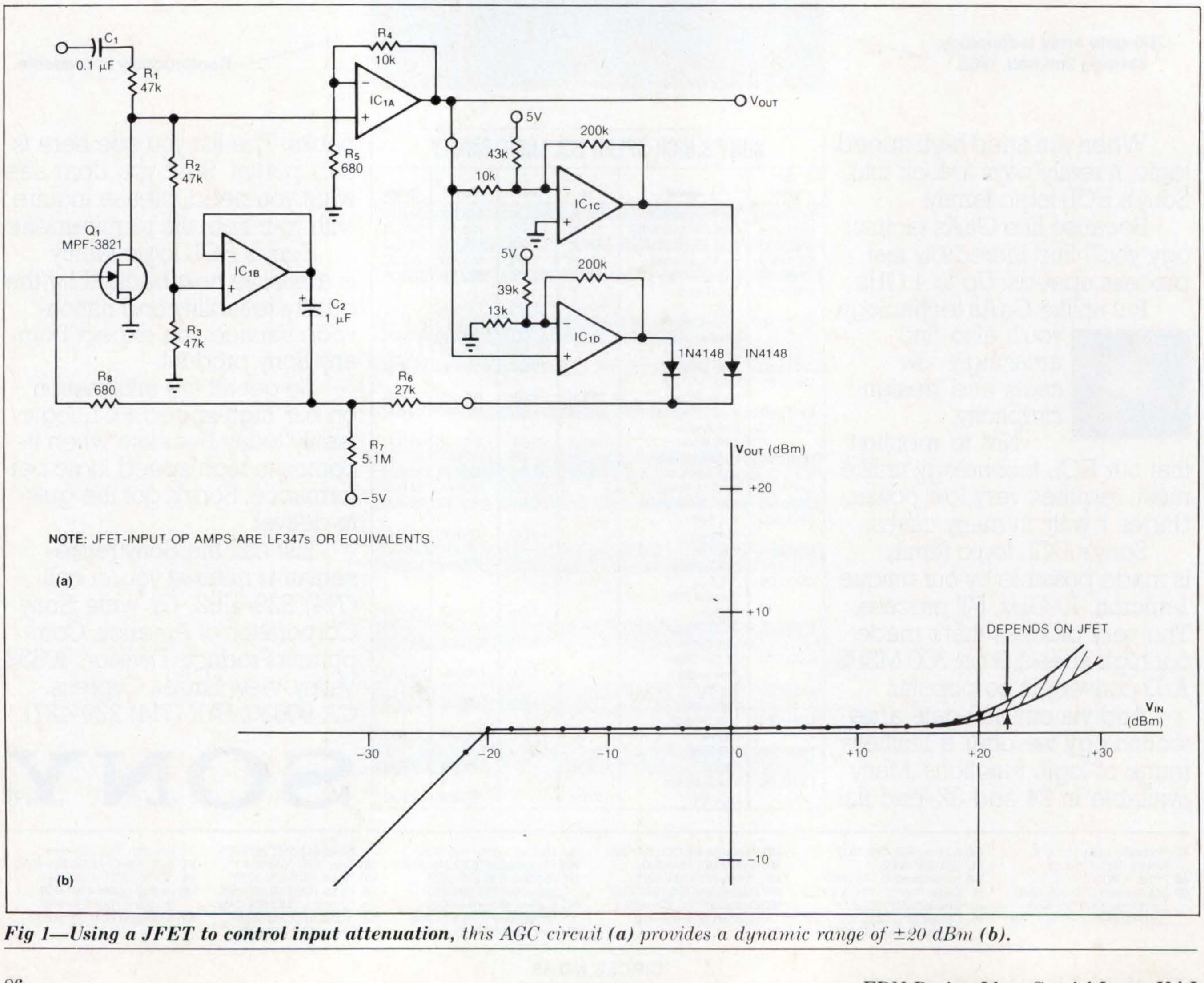

Fig 1—Using a JFET to control input attenuation, *this AGC circuit* ***(a)*** *provides a dynamic range of ±20 dBm* ***(b).***

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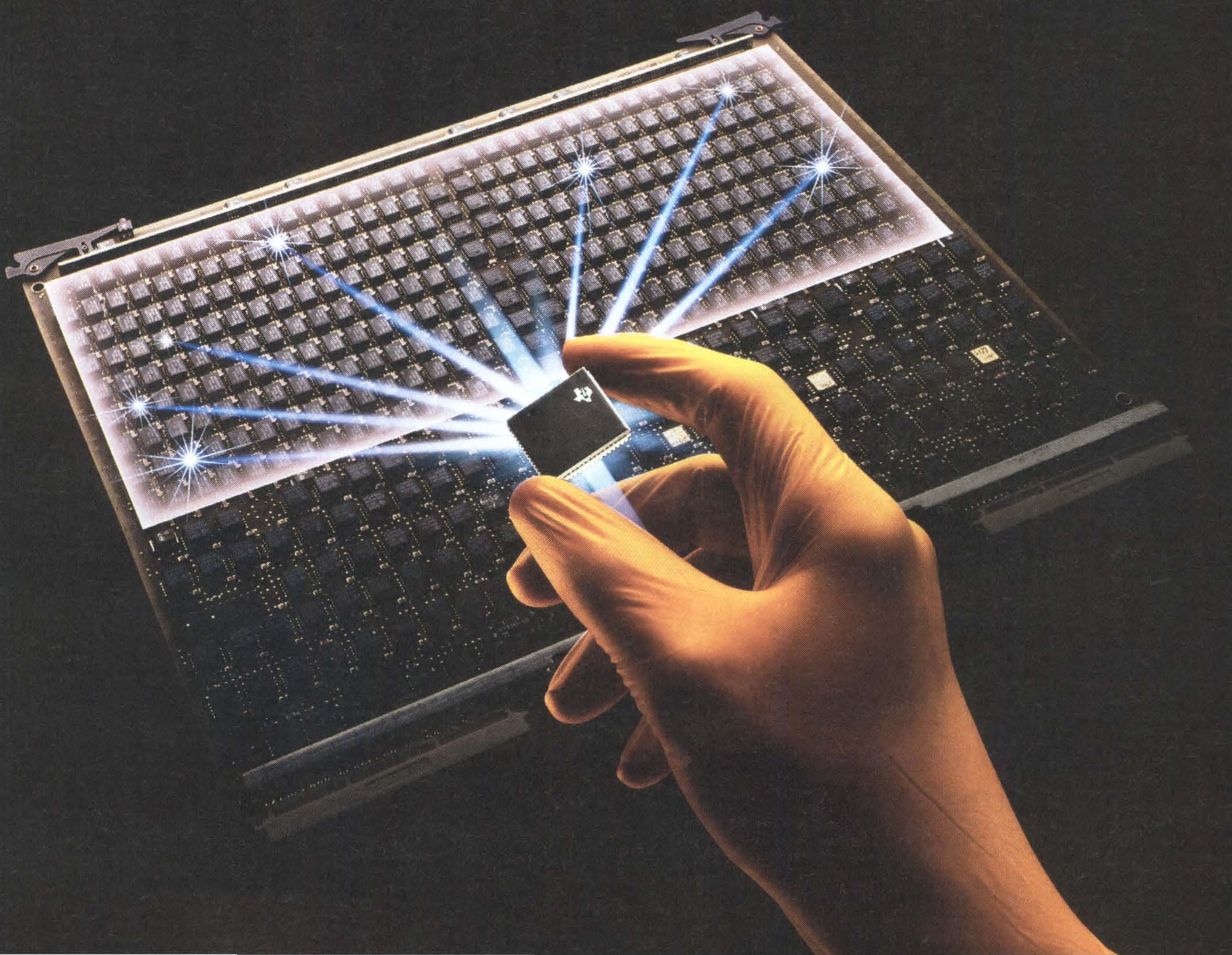

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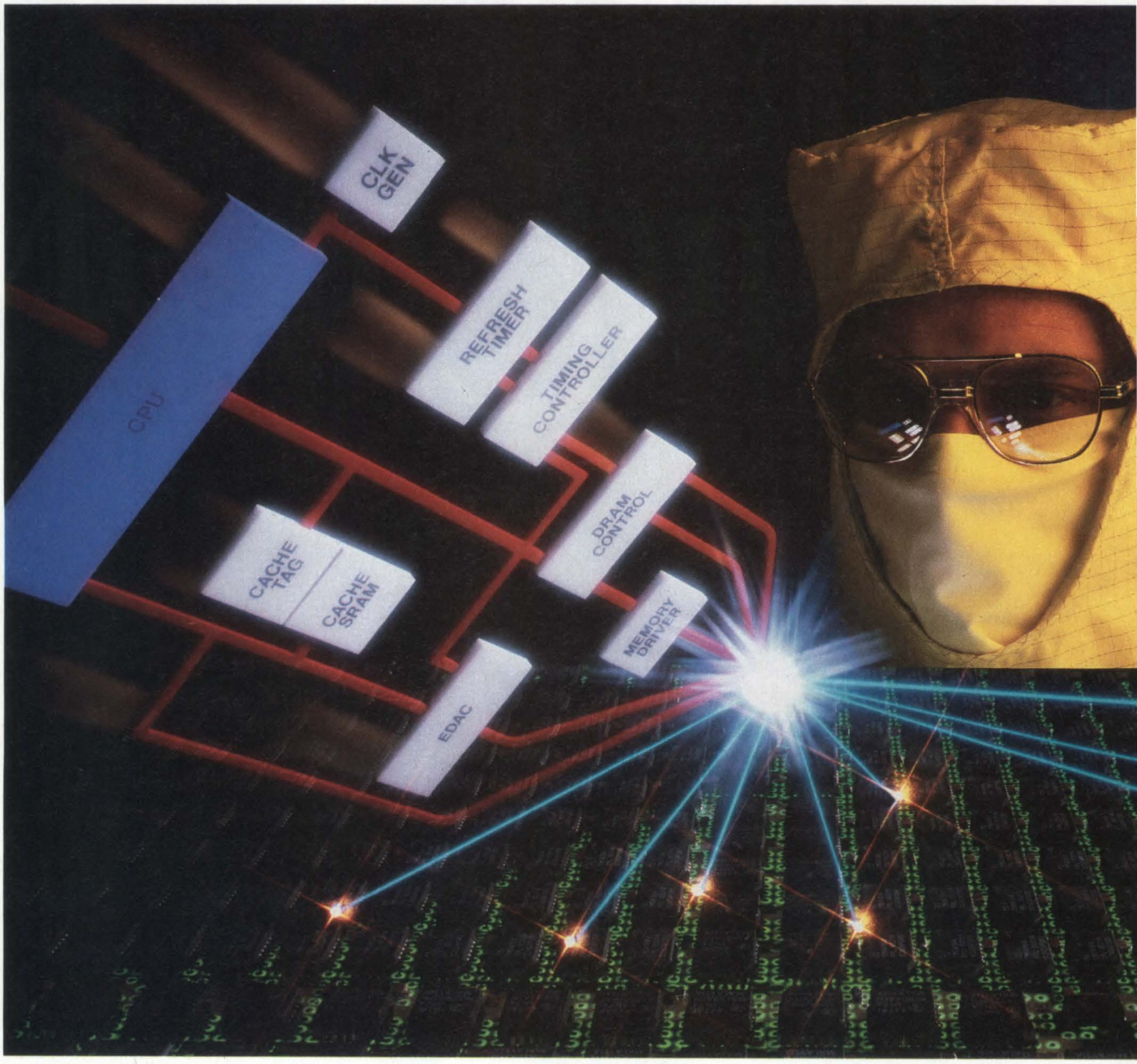

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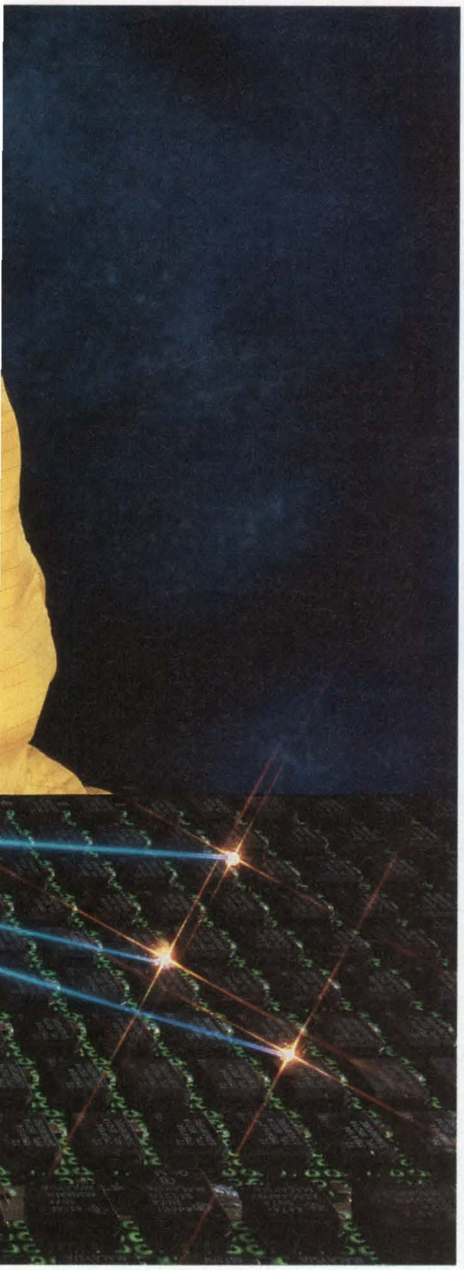

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When you must assure system integrity, use of an error-detection-and-correction (EDAC) circuit can improve system reliability 500-fold. Since this approach is necessary with memory arrays larger than half a million bits, TI offers its leadership 32-bit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

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.

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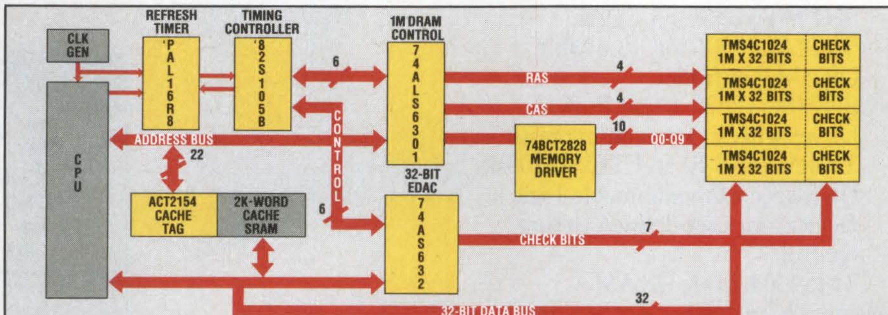

High-speed memories can be designed with less effort and implemented more cost-effectively by using TI's family of universal memory-management ICs. These devices, all of which are contained in TI's Memory Management Design Kit, will work with and enhance almost any high-speed processor.

▶ *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:

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  - —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.

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27-4510B

TEXAS INSTRUMENTS

CIRCLE NO 36

decay time is 1 sec.

For a small sacrifice in audio quality, you can reduce the parts count by substituting a simplified peak detector (**Fig 2**). The simpler circuit causes a faint buzzing, but this noise is audible only with some stereo equipment.

You can also shift the 40-dBm gain range. Changing R_4 to 30 kΩ, for example, sets the range from −30 to 10 dBm. (With the higher gain, you need a capacitor in series with R_5 to prevent excessive voltage offset.) Because the noninverting input of op amp IC_{1A} is noise-sensitive, it should be physically small and remote from the noisy peak-detector outputs. **EDN**

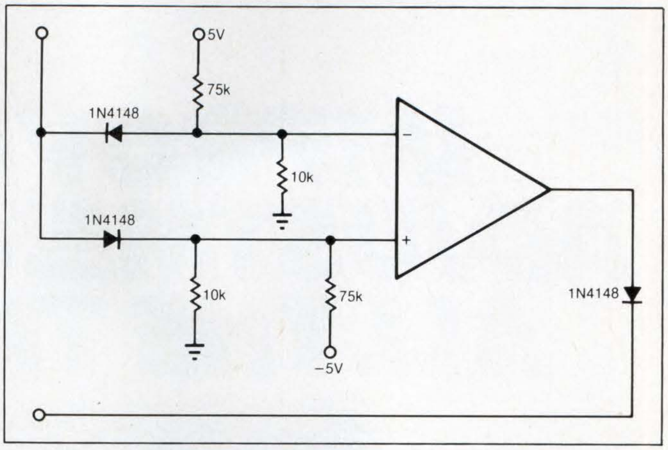

Fig 2—You can save parts *by using this peak detector in the* ***Fig 1*** *circuit.*

Three-rail power supply uses four diodes

Luis de Sa
Universidade de Coimbra, Coimbra, Portugal

The circuit shown in **Fig 1** generates three supply voltages using a minimum of components. Diodes D_2 and D_3 perform full-wave rectification, alternately charging capacitor C_2 on both halves of the ac cycle. On the other hand, diode D_1 with capacitor C_1 and diode D_4 with capacitor C_3 each perform half-wave rectification. The full- and half-wave rectification arrangement is satisfactory for modest supply currents drawn from the −5 and +12V regulators (IC_3 and IC_2).

You can use this circuit as an auxiliary supply in a µP-based instrument, for example, and avoid the less attractive alternatives of buying a custom-wound transformer, building a more complex supply, or using a secondary winding (say 18V ac) and wasting power in the 5V regulators. **EDN**

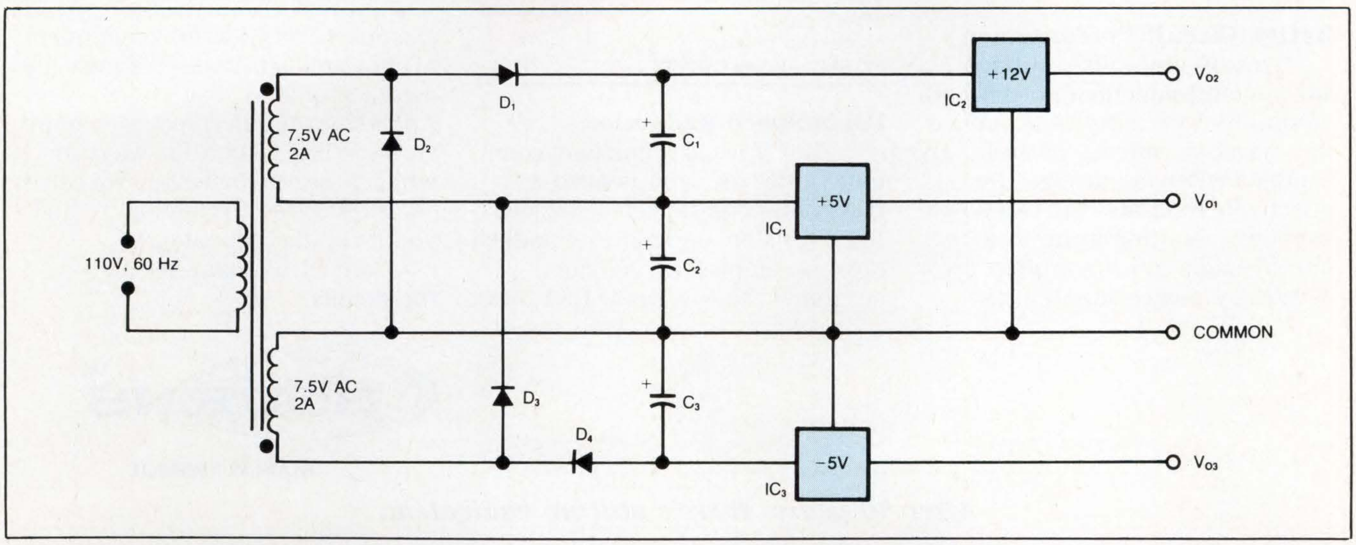

Fig 1—This simple power supply *generates three regulated voltages using a minimum of components.*

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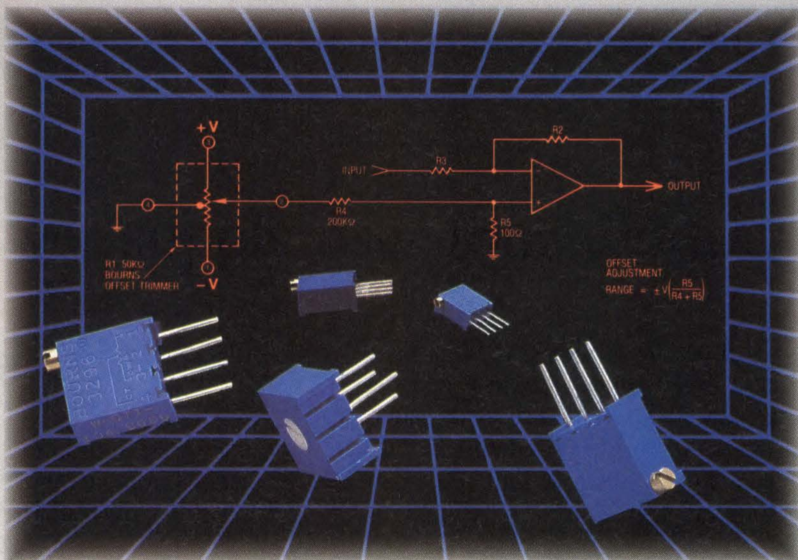

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CIRCLE NO 37

Circuit generates frequency difference

Steve Momii
University of Washington, Seattle, WA

Fig 1's output pulse rate equals the difference in pulse rates of the inputs F_0 and F_1, where $F_1<F_0$. (You must generate $2F_0$, but the duty cycle need not be 50%.)

The easiest way to understand the circuit's operation is in terms of sampling theory. Consider the exclusive-OR gate IC_2 as a modulator, in which F_1 modulates the carrier frequency F_0. The resulting waveform contains the sum and difference of F_0 and F_1. By using IC_{1B} to sample this waveform at $2F_0$, you generate an aliasing frequency that folds around the Nyquist frequency F_0; ie, the output difference frequency becomes

$$F_D=2F_0-(F_0+F_1)=F_0-F_1.$$

Of course, variations are posssible. If $F_1=F_0/n$ (using a divide-by-n counter), then $F_D=F_0(1-1/n)$. And, if $F_1=F_0 \cdot m/n$ (using a rate multiplier), then $F_D=F_0(1-m/n)$. **EDN**

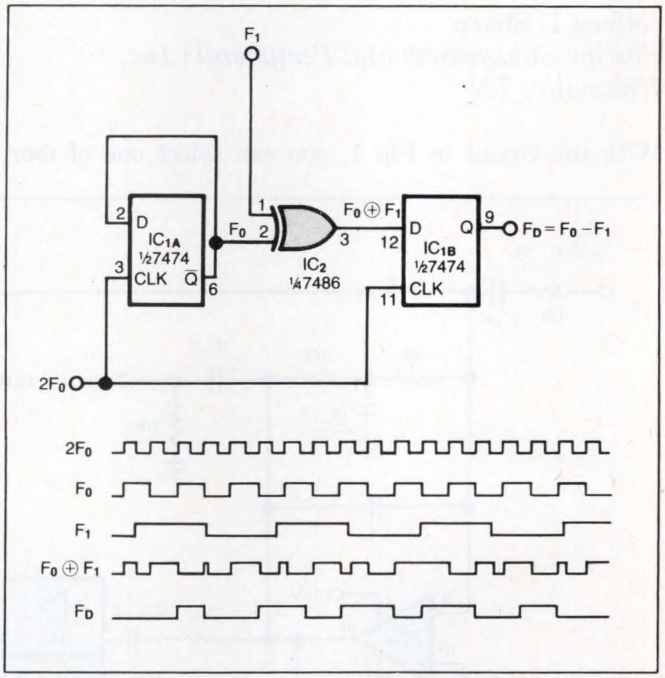

*Fig 1—**Two ICs generate** the frequency difference between F_0 and F_1.*

Multivibrator achieves near-50% duty cycle

Edward W Rummel
Robin Baker Associates Inc, Short Hills, NJ

The 3-component astable multivibrator of **Fig 1** provides an output with a near-50% duty cycle. Using this circuit, you don't need the additional flip-flop usually required to obtain such a duty cycle. What's more, the CMOS timer shown costs a penny less than often-used equivalent bipolars (100-piece price).

Three factors contribute to the output symmetry. The capacitor charges and discharges through the same external resistor. An internal resistive divider sets accurate switching thresholds within the chip (the bipolar types use dividers as well). And most important, IC_1's CMOS output stage switches fully between ground and V_{CC}, avoiding the errors due to asymmetry that are often found in a TTL timer's output. The IC's internal switching-threshold tolerances can cause a deviation of several percent from the desired 50% duty cycle. To meet a tighter specification, you might have to select from a group of ICs. **EDN**

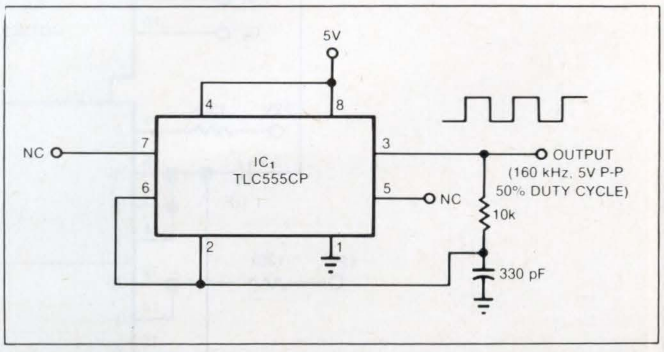

*Fig 1—**Based on a CMOS version of a 555 timer,** this astable multivibrator's output symmetry depends on the tolerance of the internal switching thresholds.*

Digital inputs program audio compressor

Jeffery L Sharp
Philips Subsystems and Peripherals Inc,
Knoxville, TN

With the circuit in **Fig 1**, you can select one of four different gain-compression slopes (1:1, 2:1, 3:1, or 4:1) without changing the circuit's unity-gain point. A compressor is characterized by two attributes of its amplitude transfer function—the slope and the 0-dB gain point **(Fig 2)**.

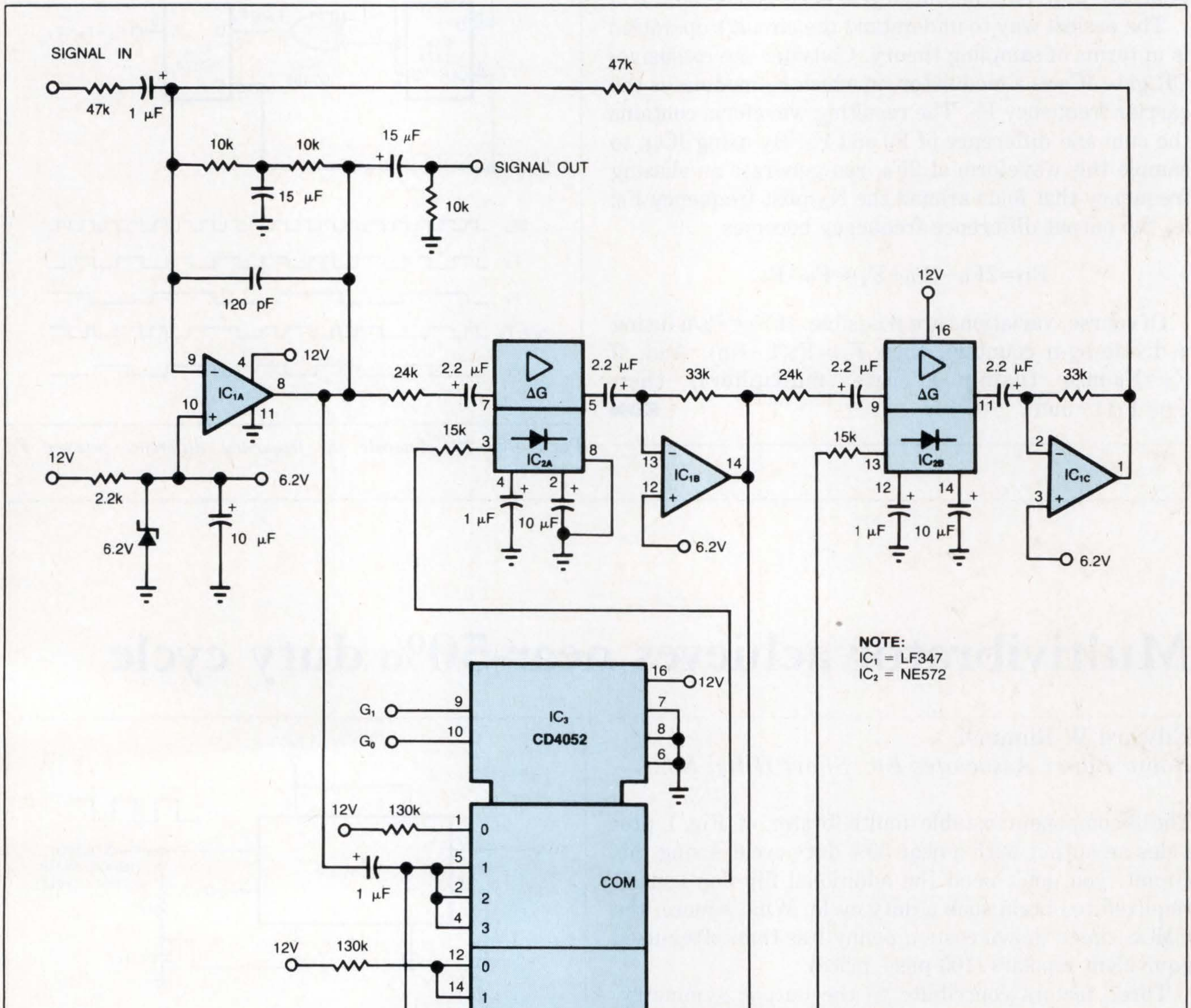

*Fig 1—**With this circuit, you can select** gain-compression ratios of 1:1, 2:1, 3:1, and 4:1 without changing the unity-gain point. By changing inputs G_0 and G_1 of the analog multiplexer, you control the detector current in each half of the NE572 (IC_2), and, therefore, the gain of each section.*

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Marconi
Instruments

CIRCLE NO 38

The gain of amplifier IC_{1A} is determined by the NE572 variable-gain cells (IC_{2A} and IC_{2B}). Each half of the NE572 multiplies the value of the current passing through the ΔG section by the value of the current flowing into the IC's detector section. When gate inputs G_0 and G_1 equal 0, the detector currents are constant. The gain of IC_{1A} is the same for all input amplitudes, resulting in a 1:1 transfer slope. For the other gate-input combinations (01, 10, and 11), the detector currents are selected by the 4052 analog multiplexer (IC_3); the currents provide gains that are inversely proportional to the second, third, and fourth powers of the input-signal amplitude. In all cases, 1V rms produces unity gain. EDN

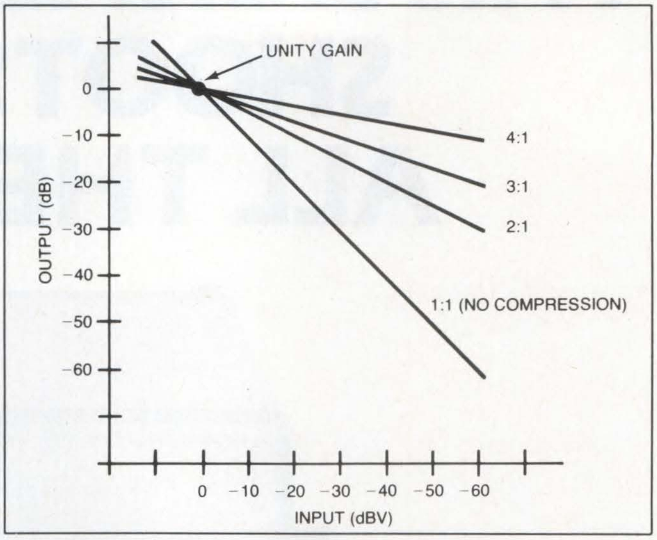


Fig 2—The input/output transfer-function curves *of the circuit in **Fig 1** show the four possible signal-compression slopes and the unity-gain point for each slope.*

Transducer improves ultrasonic ranging

Mitchell Lee
National Semiconductor, Santa Clara, CA

In an ultrasonic ranging system, a single transducer often does double duty: First, it behaves like a loudspeaker while generating the transmit pulse; then—ideally—it immediately stops ringing and behaves like a microphone while listening for the return echo. Piezo-

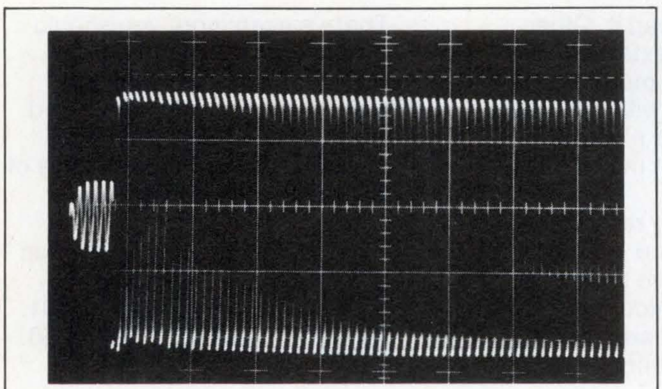


Fig 1—The ringing that follows excitation *of a piezoelectric transducer can last for 20 msec, masking the echoes from targets within 10 ft of the transmitter. In this photo, scale is 5V/div in the vertical axis and 200 μsec/div in the horizontal axis.*

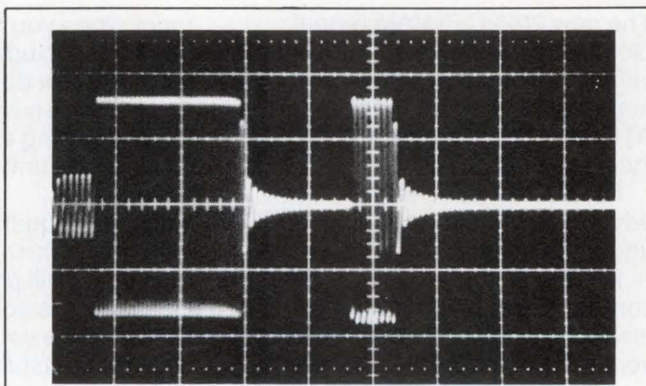
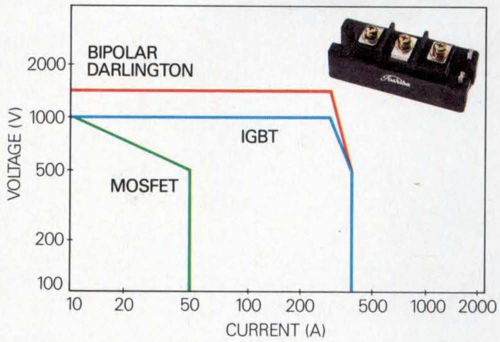


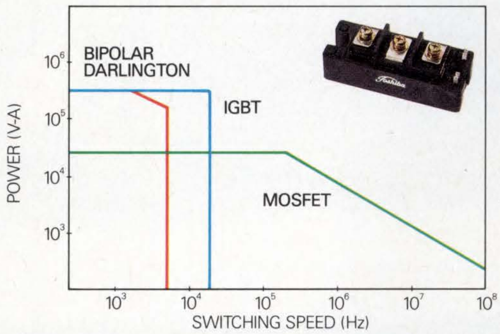
Fig 2—Ring duration for an electrostatic transducer *is less than 1/20th that of a piezoelectric type, allowing easy recognition of an echo that occurs 800 μsec after the transmit pulse begins. Here, scale is 5V/div in the vertical axis and 200 μsec/div in the horizontal axis.*

IGBTs. The *latest* comparisons.

Compare Power



Compare Speed



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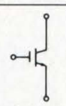
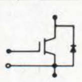
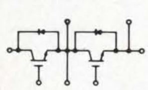
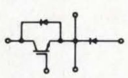
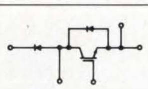
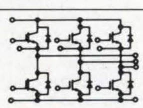
Compare Selection

IGBT (Insulated Gate Bipolar Transistor) Selection Guide

CIRCUIT	SYMBOL	V_{CES}(V)	MAXIMUM RATING COLLECTOR CURRENT Ic (A)									
			8	15	25	50	75	100	150	200	300	400
	BS	500		GT15H101† MG15H1BS1	GT25H101† MG25H1BS1	GT50G101† (400V) MG50H1BS1	MG75H1BS1*	MG100H1BS1				
	BS	1000	GT8N101†*	GT15N101† MG15N1BS1	MG25N1BS1	MG50N1BS1	MG75N1BS1*					
	US	500									MG300H1US1	MG400H1US1
	US	600									MG300J1US1*	MG400J1US1*
	US	1000								MG200N1US1*	MG300N1US1*	
	US	1200								MG200Q1US1*	MG300Q1US1*	MG400Q1US1*
	YS	500			MG25H2YS1	MG50H2YS1	MG75H2YS1	MG100H2YS1	MG150H2YS1	MG200H2YS1		
	YS	600					MG75J2YS1*	MG100J2YS1*	MG150J2YS1*	MG200J2YS1*		
	YS	1000		MG15N2YS1	MG25N2YS1	MG50N2YS1	MG75N2YS1	MG100N2YS1	MG150N2YS1*			
	YS	1200			MG25Q2YS1*	MG50Q2YS1*	MG75Q2YS1*	MG100Q2YS1*	MG150Q2YS1*	MG200Q2YS1*		
	YS	1400			MG25S2YS1*							
	JS	1000			MG25N1JS1							
	ZS	500				MG50H1ZS1						
	ZS	1000			MG25N1ZS1							
	ES	500		MG15H6ES1*								
	ES	1000	MG8N6ES1*	MG15N6ES1*								

†Non Isolated Type TO-3P *Under Development

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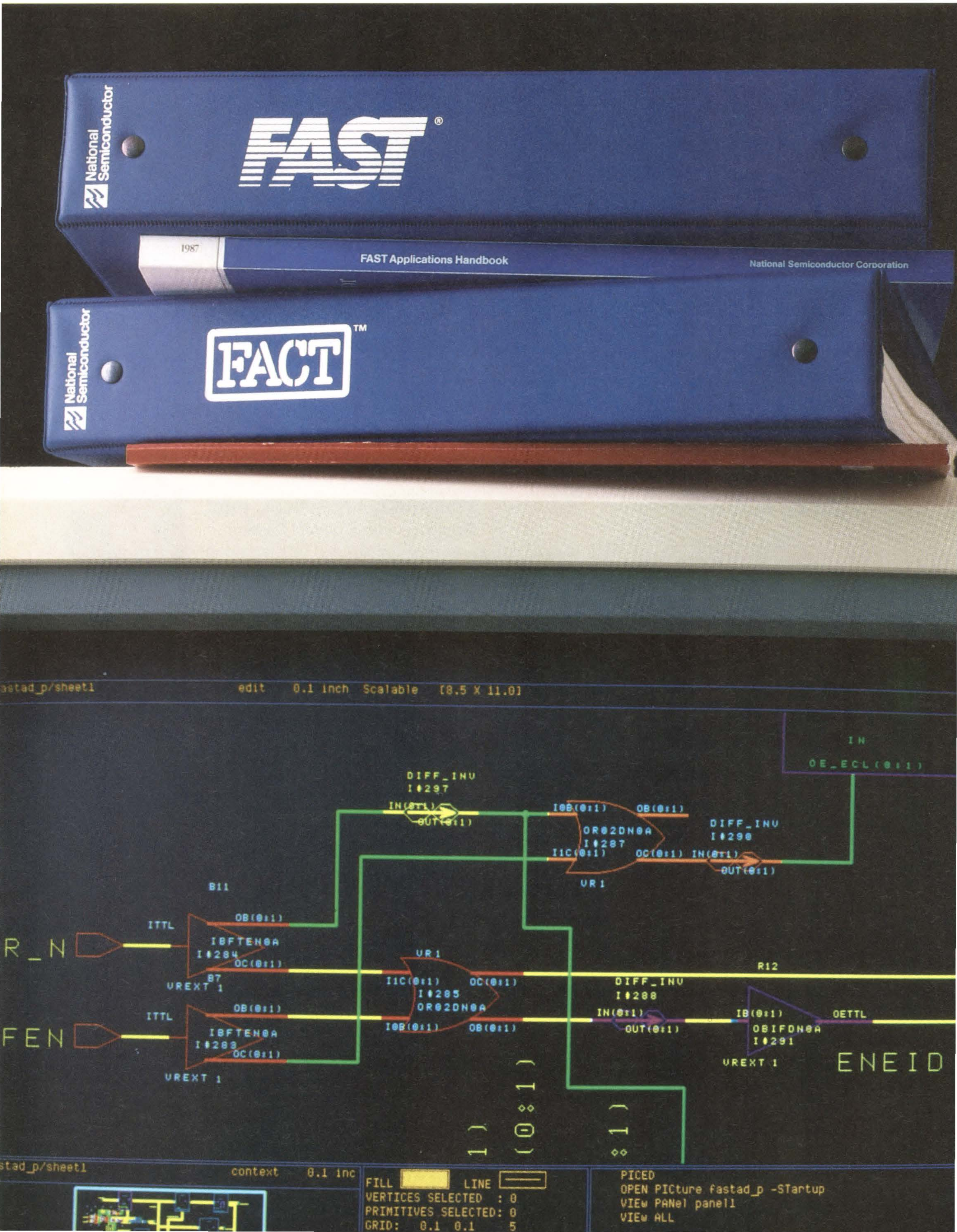
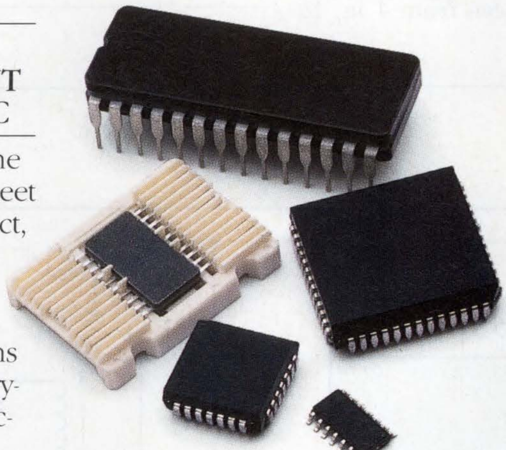
SPD-88-003

CIRCLE NO 39

National Semiconductor



The logic in choosing National.



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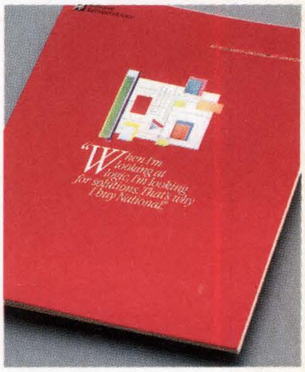

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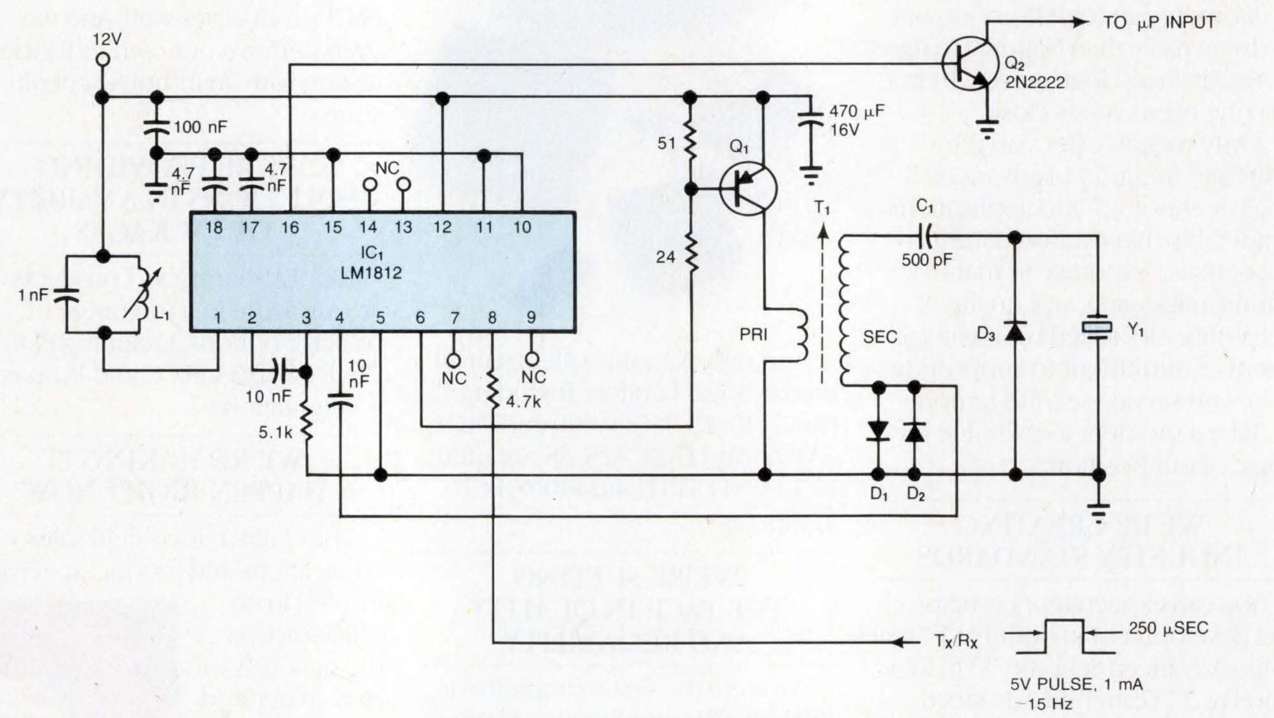
electric transducers, however, have a high Q and can continue to ring for 20 msec or more after excitation has ceased, thus masking return echoes representing more than 10 feet of range (**Fig 1**).

Broadband electrostatic transducers, however, lower the minimum range by reducing the ring time (**Fig 2**). You can combine an electrostatic transducer with an ultrasonic transceiver IC (**Fig 3**) to build a ranging system that senses objects at distances from 4 in. to more than 30 feet.

Transducer Y_1's broadband characteristic simplifies tuning. The secondary of T_1 resonates with the 500-pF capacitor C_1 at a frequency between 50 and 60 kHz. You tune L_1 to this frequency by using an oscilloscope to note the maximum echo sensitivity at pin 1. Step-up transformer T_1 provides 150V bias for the transducer. **EDN**



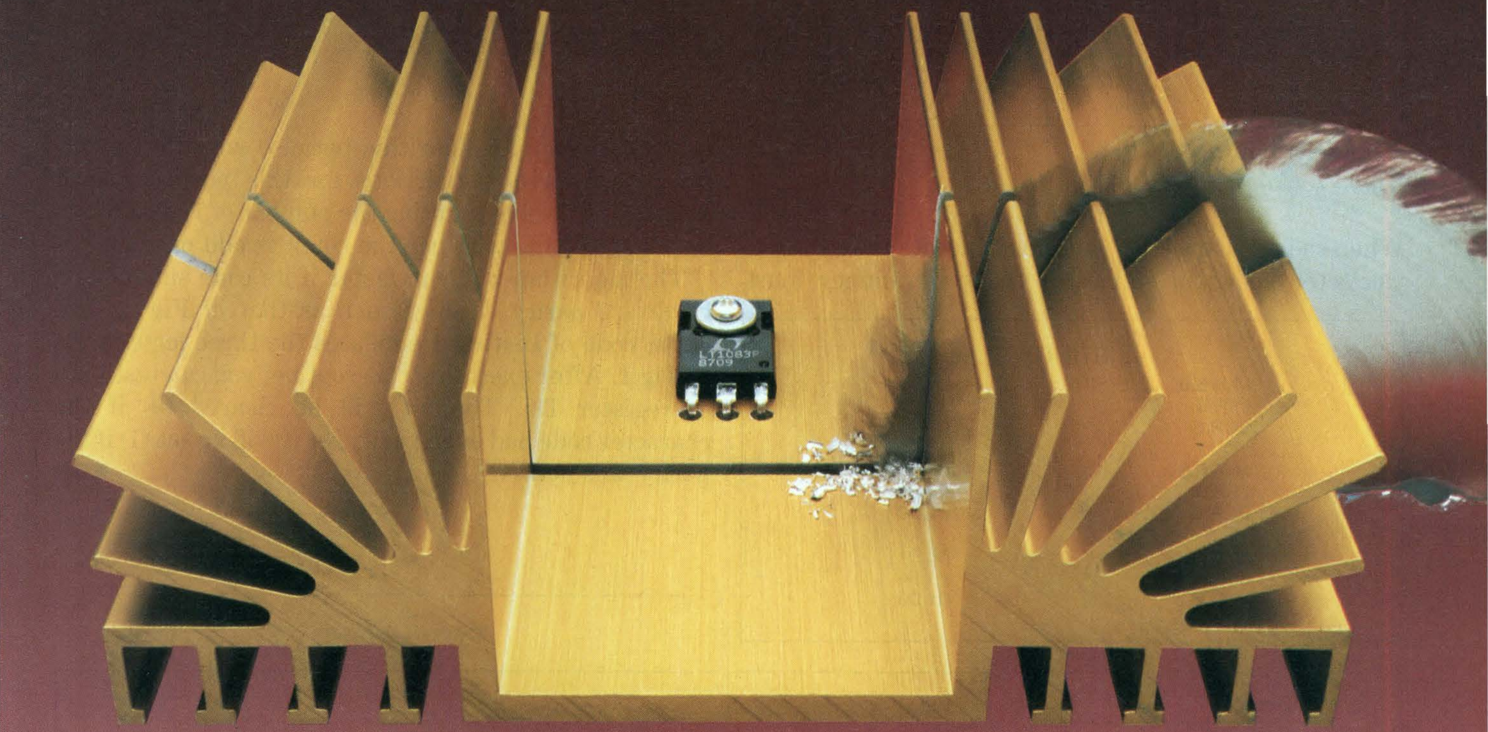
PARTS LIST

PART	DESCRIPTION	MANUFACTURER
L_1	15.8 mH ADJUSTABLE #CLN-2A900HM	TOKO AMERICA (SKOKIE, IL)
T_1	PRIMARY 8 TURNS #24* SECONDARY 110 TURNS #30* POTCORE RM8P-A630-3B7 BOBBIN RM8 PCB1-4 CLIPS 991-393-00	FERROXCUBE (SAUGERTIES, NY)
X_1	TRANSDUCER	POLAROID (CAMBRIDGE, MA)
Q_1	D45C6 I_C = 5A MIN; V_{CBO} = 40V MIN	NATIONAL SEMICONDUCTOR (SANTA CLARA, CA)

*IF MACHINE WOUND, SLIGHTLY LARGER WIRE SIZES MAY BE USED.

Fig 3—This ultrasonic ranging system *features an ultrasonic transceiver (IC_1) and an electrostatic transducer (Y_1). Its sensing range is 4 in. to more than 30 ft.*

Cut your losses



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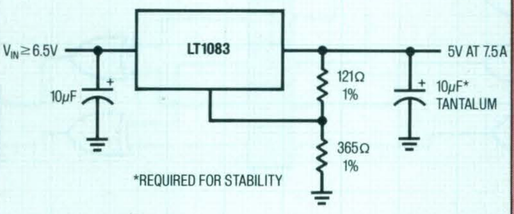

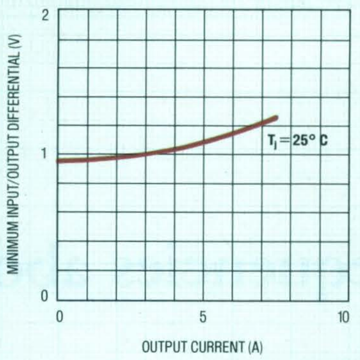

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CIRCLE NO 41

Software provides rapid parity check

Jerold R Thompson
Sperry Corp, Salt Lake City, UT

When the need arises to check or generate the parity of character codes in software, the programmer must usually develop an algorithm because very few microprocessors have instructions for this purpose. Such algorithms involve counting the number of 1-valued bits and then testing whether the count is odd or even.

LISTING 1

```
MOVE.B    D0,D1
LSR.B     #4,D1
EOR.B     D1,D0

MOVE.B    D0,D1
LSR.B     #2,D1
EOR.B     D1,D0

MOVE.B    D0,D1
LSR.B     #1,D1
EOR.B     D1,D0
```

The algorithm will run faster if its code simulates a hardware parity checker such as that of **Fig 1.** The 68008 code of **Listing 1** emulates the three logic levels of **Fig 1.** After executing this routine, you can test bit 0 of register D0. The bit will be cleared (0) if the character code had even parity, or it will be set (1) if the parity was odd. EDN

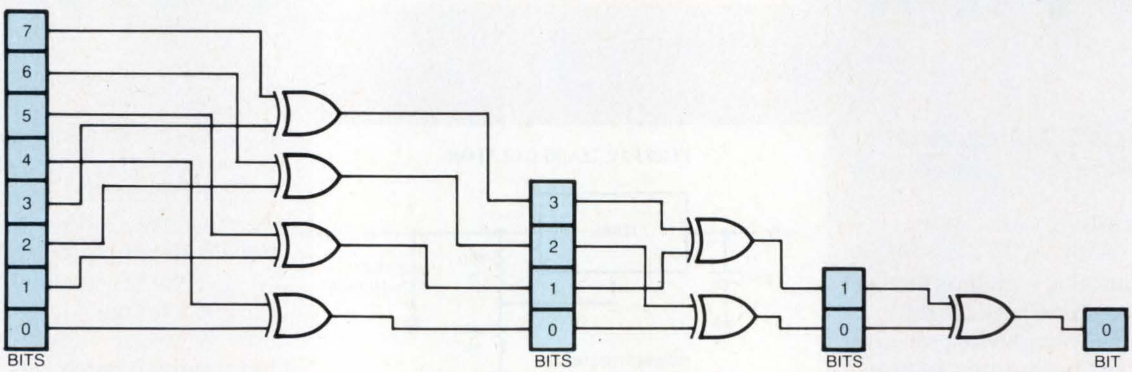

***Fig 1—You can quickly test 8-bit character codes for parity** by emulating this hardware in a software routine.*

VCO generates frequencies above 40 MHz

Doug Farrar
Apple Computer Inc, Cupertino, CA

The VCO of **Fig 1** is inexpensive, operates from 5V, and generates square, TTL-compatible complementary outputs. In addition, the circuit lends itself to integration because it uses only npn transistors and standard digital functions.

V_{IN} and R_T, along with transistor Q_{1E} and its emitter resistor, set the input current I_T. Current-mirror transistors Q_{1B} and Q_{1D} also each sink I_T. Then, the timing capacitor C_T works with current-source transistors Q_{1A} and Q_{1C} to set the output half-cycle interval. Flip-flop IC_{2B} buffers the heavily loaded Q and $\overline{Q}$ outputs of IC_{2A}.

A high level at IC_{2A}'s Q output, for example, forces Q_{1A}'s base voltage near V_{CC}, which clamps node A about

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Silicon Systems offers two new line interface transceivers that can provide an optimum solution to users for easing the transition to ISDN. The new SSI 78P233 conforms to the North American T1 standards, and the SSI 78P234 conforms to the world-wide CEPT standards.

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Historically, interface devices have had a spotty track record. Older designs require manual tuning for clock recovery. New designs trade off added features for increased cost. Some newer devices are only available in the form of two-chip sets. Other more hopeful entries into the marketplace have been either untested or lagging, and facsimile transmission is accelerating, both in North America and overseas.

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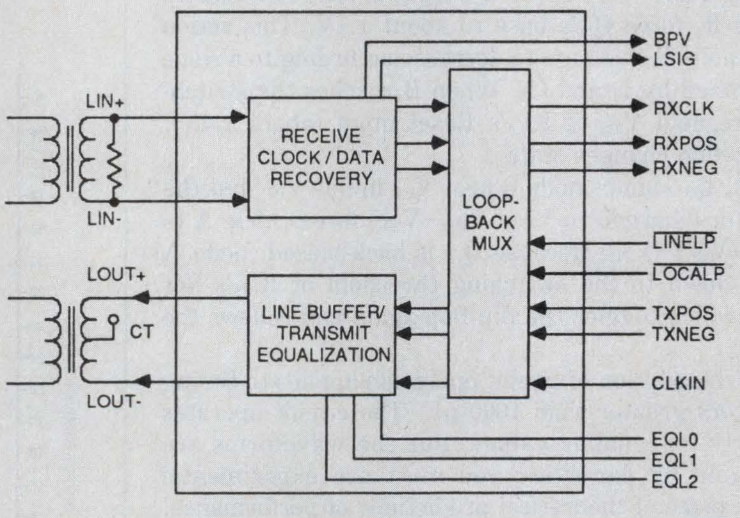
The SSI 78P233, conforming to the T1's 1.544 Mbps standard transmission rate and the SSI 78P234, conforming to CEPT's 2.048 Mbps transmission rate, are complete line interface chips. As single-chip analog front-end devices, they are actually transceiver devices consisting of receiver, transmitter, and loopback sections.

Both single chip devices are designed in Silicon Systems' low-noice, high performance bipolar technology—best suited to combine high speed functions and low cost for dependable equipment line interfacing. And both devices are available for plug compatibility in 24-pin DIP and SO packages and require only a single 5-volt power supply. The SSI 78P234 is additionally available in the smaller 20 pin DIP and SO versions.

For more information, send for the SSI 78P233 data sheet: Silicon Systems, 14351 Myford Road, Tustin, CA 92680. Phone: (714) 731-7110.

78P233 Block Diagram



The receiver performs clock and data recovery on the incoming signal, and then converts them to TTL-level. This is accomplished through the use of a trimmed analog phase locked loop and an external precision resistor. No other tunable or precision components are required. Easy interfacing to deframer circuitry is achieved through the use of standard TTL-level receive outputs.

The transmitter accepts TTL data and clock signals to be transmitted, combines and converts them to alternate mark inversion (AMI)-level and then equalizes and shapes outgoing pulses according to line length, as selected by the user. Featured are six different line equalization settings for pulse shaping at the DSX-1 level, which eliminates the need for off-chip adjustable networks.

The loopback section is used for test and diagnostic operations on the line side or local side of the chip.

CIRCLE NO 42

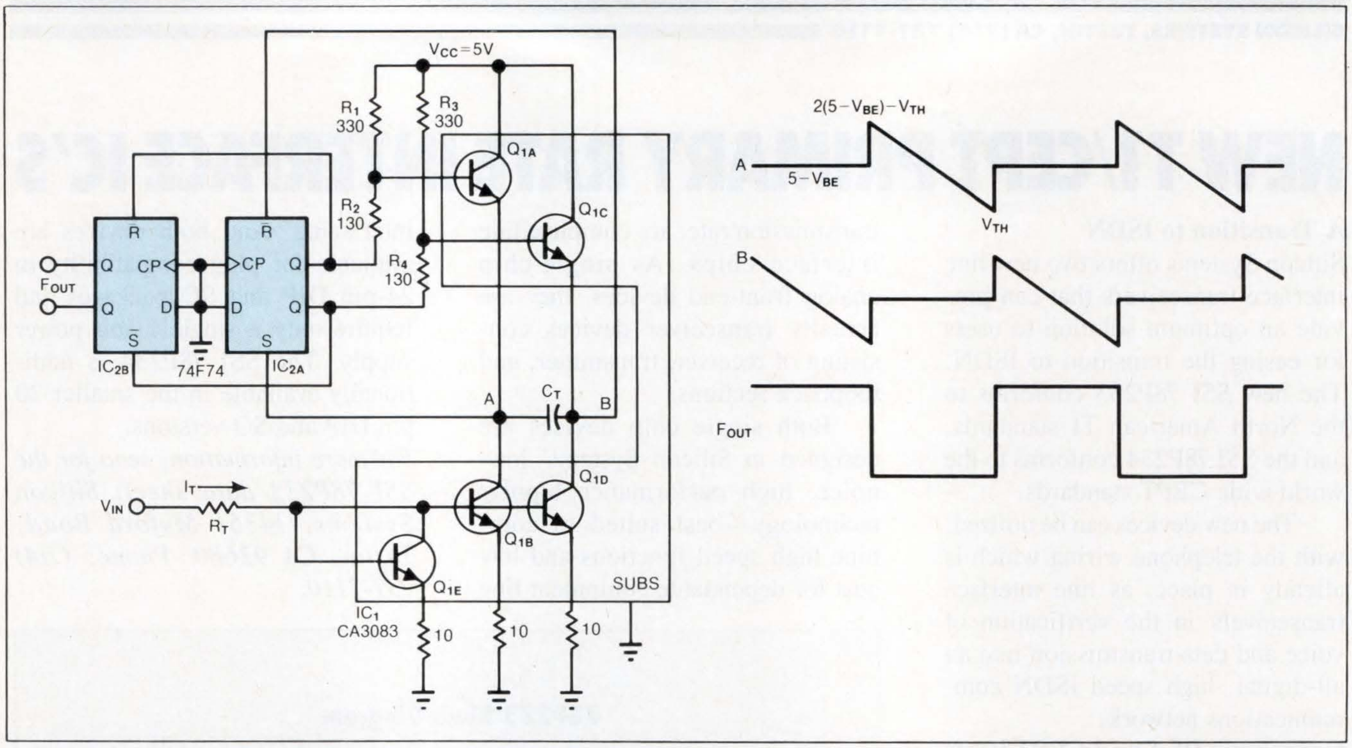


***Fig 1—Two ICs form a voltage-controlled oscillator** that generates TTL-compatible, complementary outputs with maximum frequency above 40 MHz.*

one V_{BE} below V_{CC}. IC_{2A}'s $\overline{Q}$ output is low, so resistors R_3 and R_4 force Q_{1C}'s base to about 1.7V. This action allows node B's voltage to decrease according to a slope determined by I_T and C_T. When B reaches the switching threshold V_{TH} of IC_{2A}'s Reset input (about 1.4V), the flip-flop changes state.

Next, Q_{1C} clamps node B near V_{CC} minus V_{BE}, but the capacitor (charged to $V_{CC}-V_{BE}-V_{TH}$) forces node A to $2(V_{CC}-V_{BE})-V_{TH}$. Because Q_{1A} is back-biased, node A ramps down to the switching threshold of IC_{2A}'s Set input, which toggles the flip-flop again and renews the cycle.

This description of circuit operation applies to timing capacitors greater than 1000 pF. The circuit operates properly for smaller values, but the waveforms are dominated by parasitics; you must use experimental data in place of theoretical predictions of performance. The output waveform remains square, however, for frequencies to 40 MHz and above. **Fig 2** shows measured values of input current I_T vs output frequency for different values of timing capacitance.

Small timing capacitors also allow lower excursions for the waveforms at nodes A and B. Clamps on these nodes ensure that the excursions go low enough to set and reset flip-flop IC_{2A} without saturating the current sources Q_{1B} and Q_{1D}. Resistors R_1-R_4 bias the transistor bases Q_{1A} and Q_{1C} (at 1.7V low) to clamp nodes A and B at about 0.9V min. **EDN**

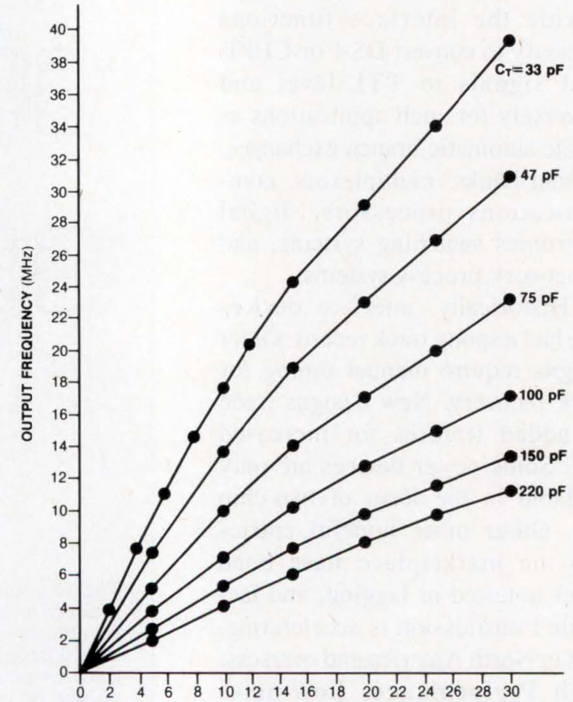
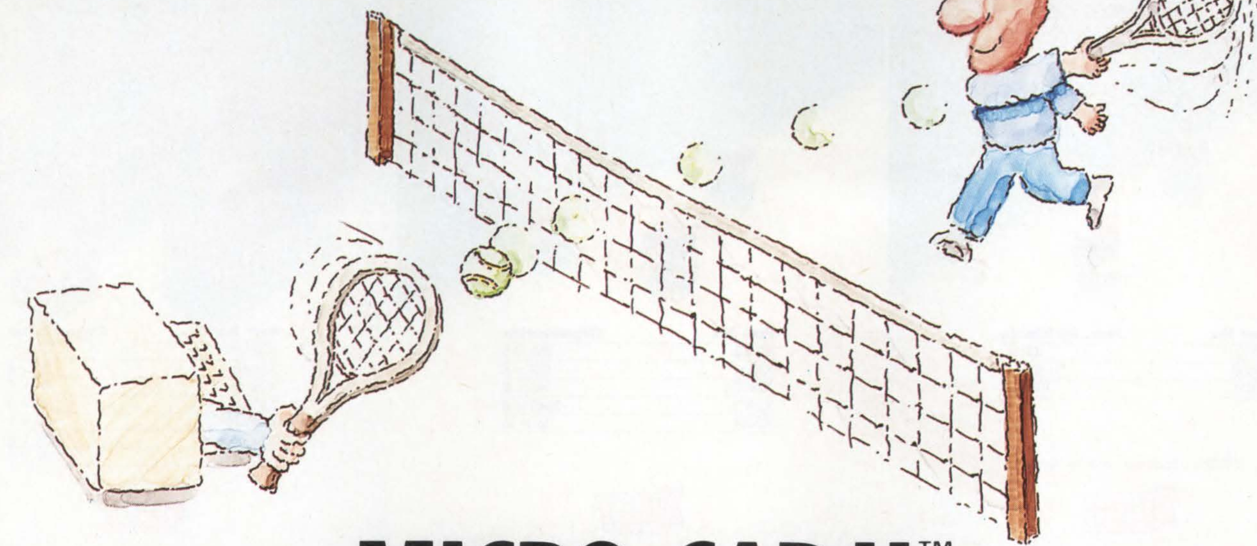


***Fig 2—This graph illustrates** how different values of Fig 1's timing capacitor C_T provide different output frequencies for a given value of input current.*



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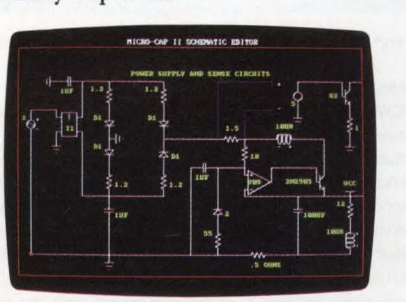

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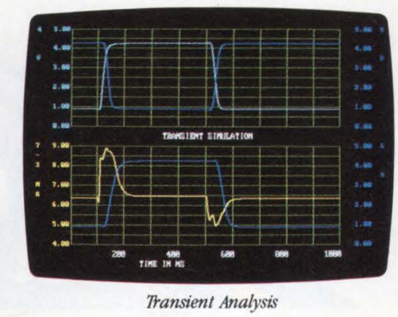

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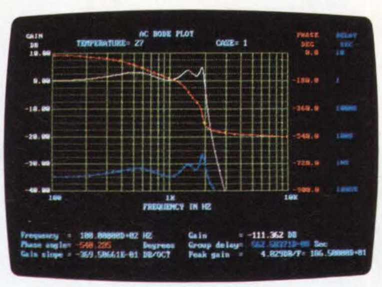

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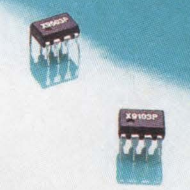

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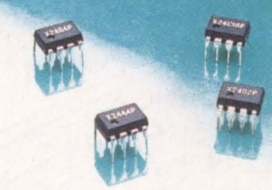

Part No.	Organization
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X24C04	512 x 8
X24C16	2048 x 8
X2444	16 x 16

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X2816B	2K x 8
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X2864B	8K x 8
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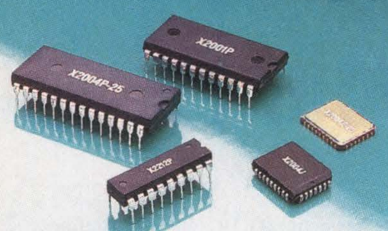

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Serial interface buffers parallel data

Steve Walker
ITT Federal Electric Corp, Vandenberg AFB, CA

The data interface of **Fig 1** accepts byte-parallel data and transmits it in a bit-serial format. The FIFO memory (IC_1) performs the parallel-to-serial conversion and also accumulates 16 data bytes before initiating the serial transmission. The circuit is useful in applications that require a slow accumulation of data for subsequent transmission in one high-speed burst, or in applications in which data transmission on a byte-by-byte basis requires too-frequent service from the data source.

The FIFO memory (32 8-bit bytes) can serialize output data or deserialize input data. Each rising edge of the Data Strobe signal (pin 18) clocks a byte of data into the memory (**Fig 2**). Following the sixteenth byte, the half-full signal (Flag output, pin 19) goes high, which sets the flip-flop (IC_2,) which in turn activates the VCO IC_3.

The VCO generates the system's serial clock signal. You can vary this signal from 200 to 1000 kHz by adjusting the 10-kΩ potentiometer, or you can generate lower frequencies by connecting a larger capacitor to the VCO. (For operation above 500 kHz, however, you would have to use the Am2812A FIFO memory instead of the Am2812.)

The FIFO generates an output-ready pulse (OR, pin 3) for each bit of serial data transmitted. Counter IC_5 counts these pulses and signals the transmission of 128 bits (16 bytes) by asserting a logic-high signal on its

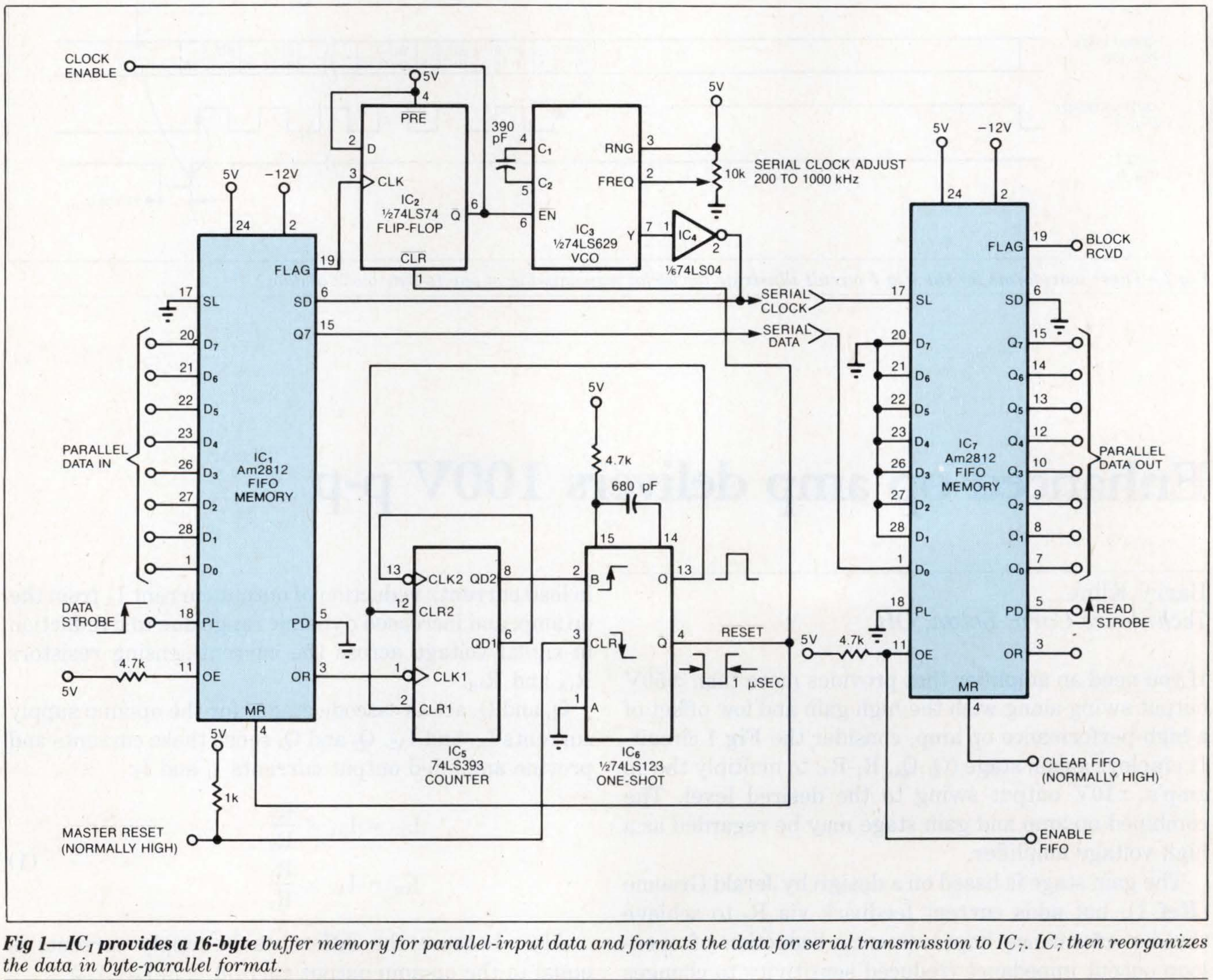

Fig 1—IC_1 provides a 16-byte *buffer memory for parallel-input data and formats the data for serial transmission to IC_7. IC_7 then reorganizes the data in byte-parallel format.*

QD2 output (pin 8). This signal triggers the one-shot IC_6, causing it to produce 1-μsec pulses at outputs Q and $\overline{Q}$. These pulses reset the flip-flop (which turns off the VCO), the counter, and the FIFO memory. When the data source sees the Clock Enable output go low, it can load another 16 bytes into the FIFO memory, provided the receiver signals that it is ready.

A second FIFO memory, IC_7, can receive and buffer the serial data. Its Flag output indicates reception of a complete block of data; you must then clear the device by asserting a $\overline{\text{CLEAR FIFO}}$ signal at pin 4. The IC has 3-state outputs controlled by the OE signal at pin 11, so you can connect the chip directly to a data bus.

If desired, you can use the one-shot's $\overline{\text{RESET}}$ output to interrupt the data source. You can add extra circuitry to increase the block size to 32 bytes, and you can cascade additional FIFO memories to increase the buffer memory (in 32-byte increments). **EDN**

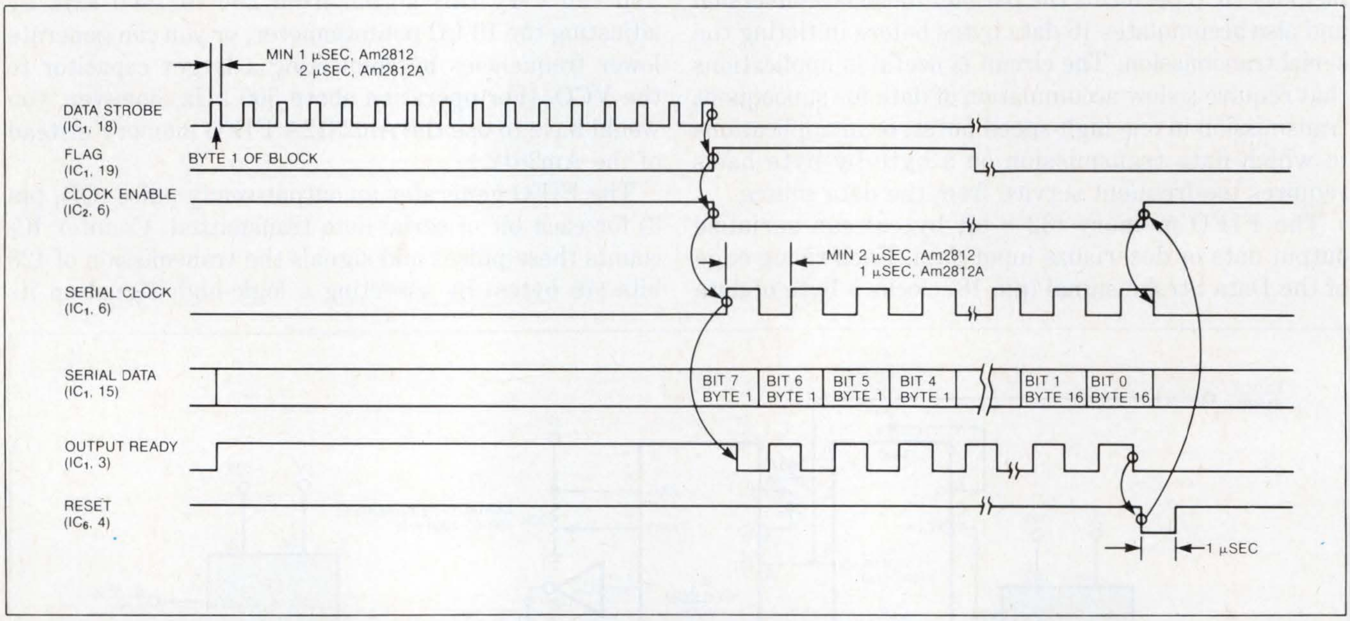

Fig 2—These waveforms for the Fig 1 circuit illustrate the serial transmission of one 16-byte block of data.

Enhanced op amp delivers 100V p-p

Barry Kline
Technicare Corp, Solon, OH

If you need an amplifier that provides more than ±50V output swing along with the high gain and low offset of a high-performance op amp, consider the **Fig 1** circuit. It employs a gain stage (Q_1-Q_4, R_1-R_4) to multiply the op amp's ±10V output swing to the desired level. The combined op amp and gain stage may be regarded as a high-voltage amplifier.

The gain stage is based on a design by Jerald Graeme **(Ref 1)**, but adds current feedback via R_4 to achieve three performance improvements: reduction of open-loop output impedance (reduced sensitivity to changes in load current); reduction of output current I_A from the op amp; and increased dynamic range due to a reduction in signal voltage across the current-sensing resistors R_{1A} and R_{1B}.

Q_1 and Q_3 act as cascode stages for the op-amp supply currents I_{A1} and I_{A2}. Q_2 and Q_4 sense these currents and provide amplified output currents I_1 and I_2:

$$I_{O1} = I_{A1} \times \frac{R_1}{R_2}$$
$$I_{O2} = I_{A2} \times \frac{R_1}{R_2} \qquad (1)$$

Also, because the difference in supply currents is equal to the op-amp output current ($I_A = I_{A1} - I_{A2}$),

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$$I_{O1} - I_{O2} = (I_{A1} - I_{A2}) \times \frac{R_1}{R_2} = I_A \times \frac{R_1}{R_2}. \quad (2)$$

Feeding this current imbalance back to the op-amp output terminal provides negative feedback for the booster stage. Recall that:

$$I_{O1} - I_{O2} = I_A \times \frac{R_1}{R_2}. \quad (3)$$

In addition,

$$I_4 = (I_{O1} - I_{O2}) - I_L = \left(I_A \times \frac{R_1}{R_2}\right) - I_L.$$

But, $I_A = I_3 - I_4$.

$$\text{So,} \quad I_4 = (I_3 - I_4) \times \left(\frac{R_1}{R_2}\right) - I_L. \quad (4)$$

$$\text{Or,} \quad I_4\left(1 + \frac{R_1}{R_2}\right) = \left(I_3 \times \frac{R_1}{R_2}\right) - I_L.$$

Substitute V_A for the op amp's output voltage:

$$I_4 = \frac{V_{OUT} - V_A}{R_4}$$
$$I_3 = \frac{V_A}{R_3} \quad (5)$$
$$I_L = \frac{V_{OUT}}{R_L}.$$

Therefore:

$$\frac{V_{OUT} - V_A}{R_4}\left(1 + \frac{R_1}{R_2}\right) = \frac{V_A R_1}{R_3 R_2} - \frac{V_{OUT}}{R_L}. \quad (6)$$

The equation can be solved for voltage gain of the booster stage:

$$\frac{V_{OUT}}{V_A} = \frac{1 + \frac{R_4}{R_3}\left(\frac{R_1}{R_1 + R_2}\right)}{1 + \frac{R_4}{R_L}\left(\frac{R_2}{R_1 + R_2}\right)} = \left[1 + \frac{R_4}{R_3}\left(\frac{R_1}{R_1 + R_2}\right)\right]\left(\frac{R_L}{R_O + R_L}\right). \quad (7)$$

Output impedance (R_O) is:

$$R_O = \frac{R_4 \times R_2}{R_1 + R_2}. \quad (8)$$

To calculate the op amp's output current (I_A):

$$I_A = I_3 - I_4 = \frac{V_A}{R_3} - \frac{V_{OUT} - V_A}{R_4} = V_A\left(\frac{1}{R_3} + \frac{1}{R_4} - \frac{V_{OUT}}{V_A R_4}\right). \quad (9)$$

The no-load booster gain is obtained by setting R_L to infinity in **Eq 7**:

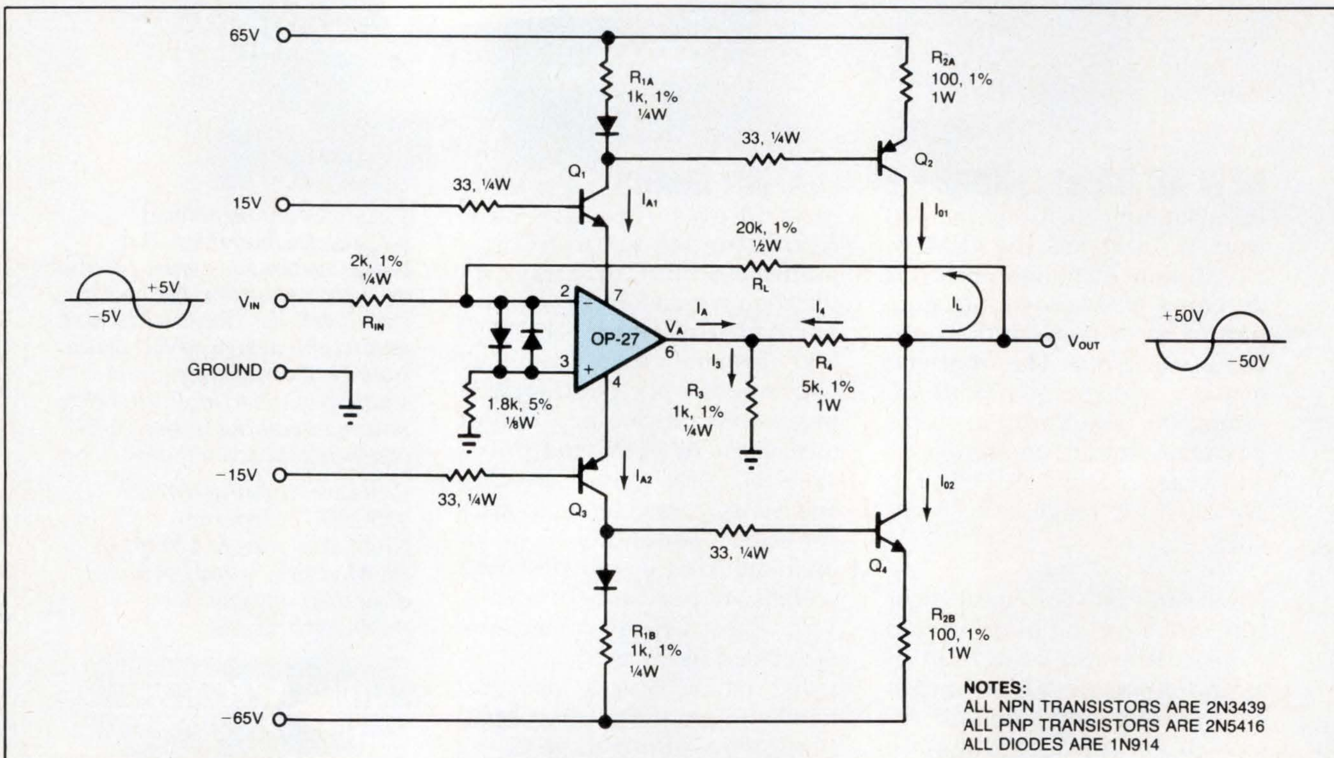

Fig 1—Gain stage with current feedback *boosts a conventional op amp's output to more than 100V p-p.*

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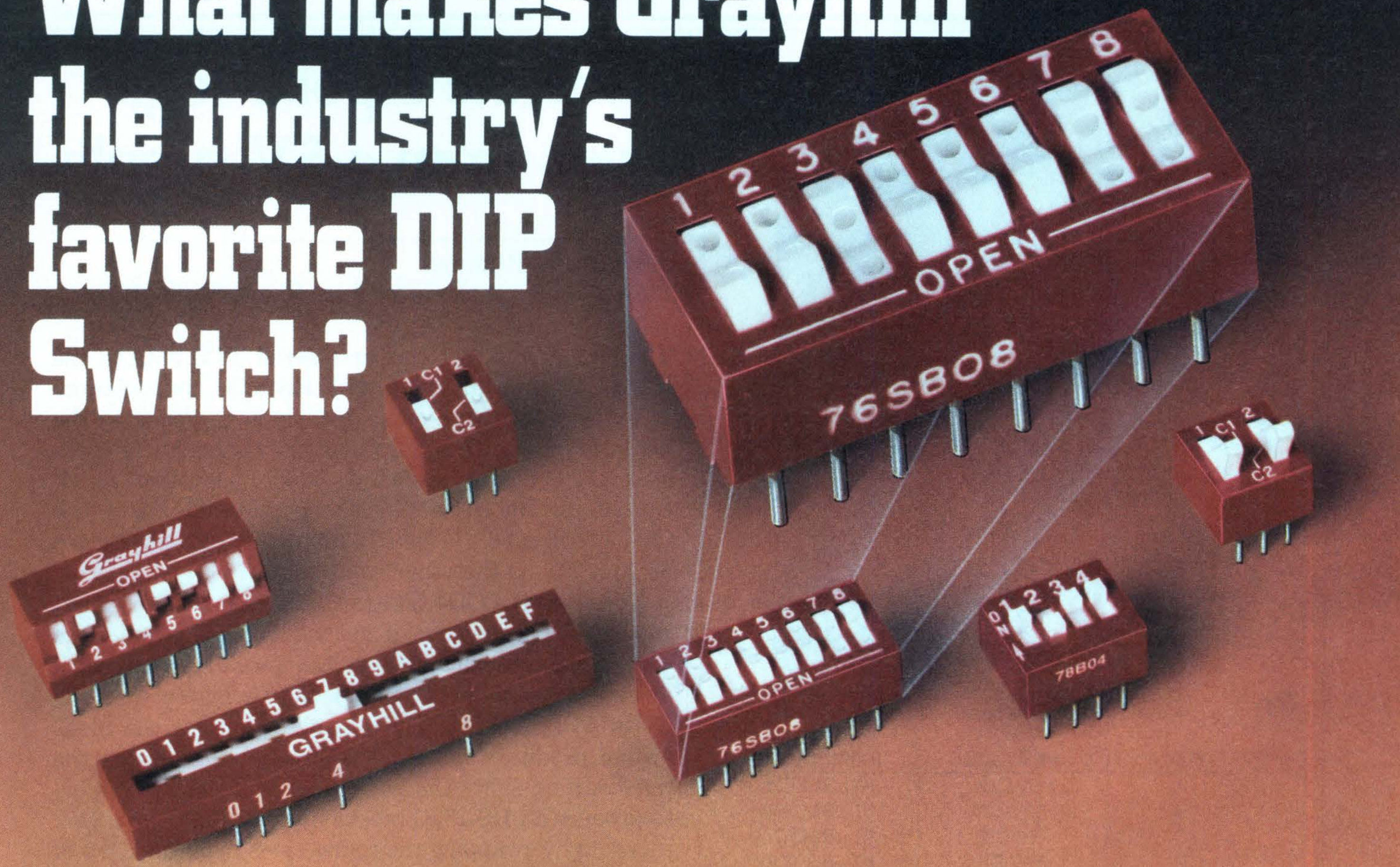

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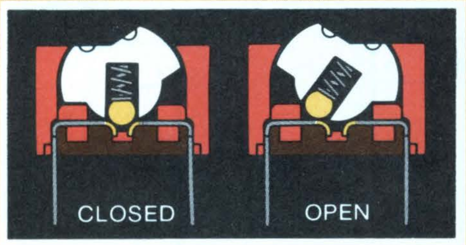

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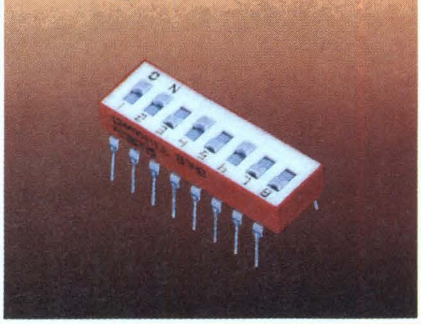

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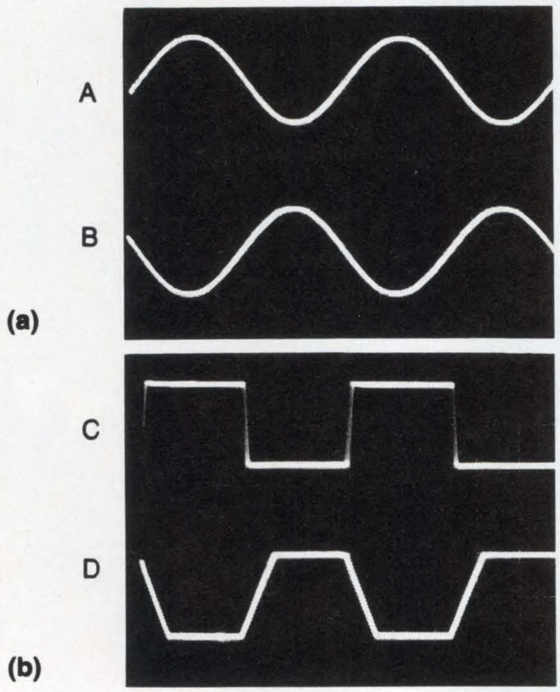
CIRCLE NO 46



TRACE	VERTICAL	HORIZONTAL
A	5V/DIV	10 µSEC/DIV
B	50V/DIV	10 µSEC/DIV
C	5V/DIV	10 µSEC/DIV
D	50V/DIV	10 µSEC/DIV

*Fig 2—**The Fig 1 circuit produces 100V p-p** sine- and square-wave outputs—**a** and **b**, respectively. Slew response to the square wave is a product of the OP-27 slew rate (2.8V/µsec typ) and gain of the booster stage (approximately 5.5).*

$$\frac{V_{OUT}}{V_A} = 1 + \frac{R_4}{R_3}\left(\frac{R_1}{R_1 + R_2}\right). \quad (10)$$

Substituting the **Eq 10** no-load booster gain into **Eq 9** yields:

$$I_A = \frac{V_A}{R_3}\left(\frac{R_2}{R_1 + R_2}\right) \quad (11)$$

The use of current feedback reduces the output impedance and the required op-amp output current by a factor of $R_2/(R_1+R_2)$. Also, reducing I_A reduces signal current variations in the supply lines.

Be careful not to exceed the power-dissipation capacity of components Q_2, Q_4, R_2, R_4, and R_L. In addition, quiescent current in Q_2 and Q_4 is proportional to the current gain R_1/R_2, so choose this ratio carefully. **EDN**

Reference

1. Graeme, Jerald G, *Designing with Operational Amplifiers—Applications Alternatives*, McGraw-Hill, 1977, pg 14.

Generate bipolar logic levels from a 5V supply

Edward W Rummel
Robin Baker Associates Inc, Short Hills, NJ

The circuit in **Fig 1** converts serial TTL data to the bipolar levels compatible with RS-232C transmission. It employs a charge-pump technique to generate the necessary negative supply voltage by using an inexpensive 3P2T analog switch (CD4053) and two 10-µF capacitors. The circuit saves money in some cases (the CD4053 costs \$0.87; the ICL7660 dc/dc converter costs \$2.40 (100), on the other hand).

Note that the CD4053 has a built-in level shifter but requires a square-wave drive (the ICL7660 includes the square-wave oscillator)—you can use a clock signal if available, or build a simple RC oscillator (eg, the CD40106 in **Fig 1**). Thus, two sections of the 3P2T switch produce the negative supply voltage, and the third section shifts the voltage level of the TTL signal to produce an RS-232C bipolar format. (You can invert this data by swapping the connections to pins 3 and 5 of the CD4053.) **EDN**

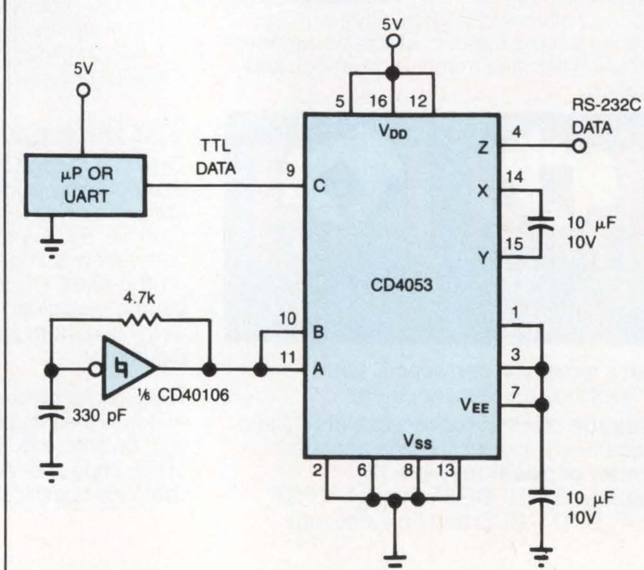


*Fig 1—**Two inexpensive ICs convert serial TTL data** to a bipolar format suitable for transmission on RS-232C lines.*

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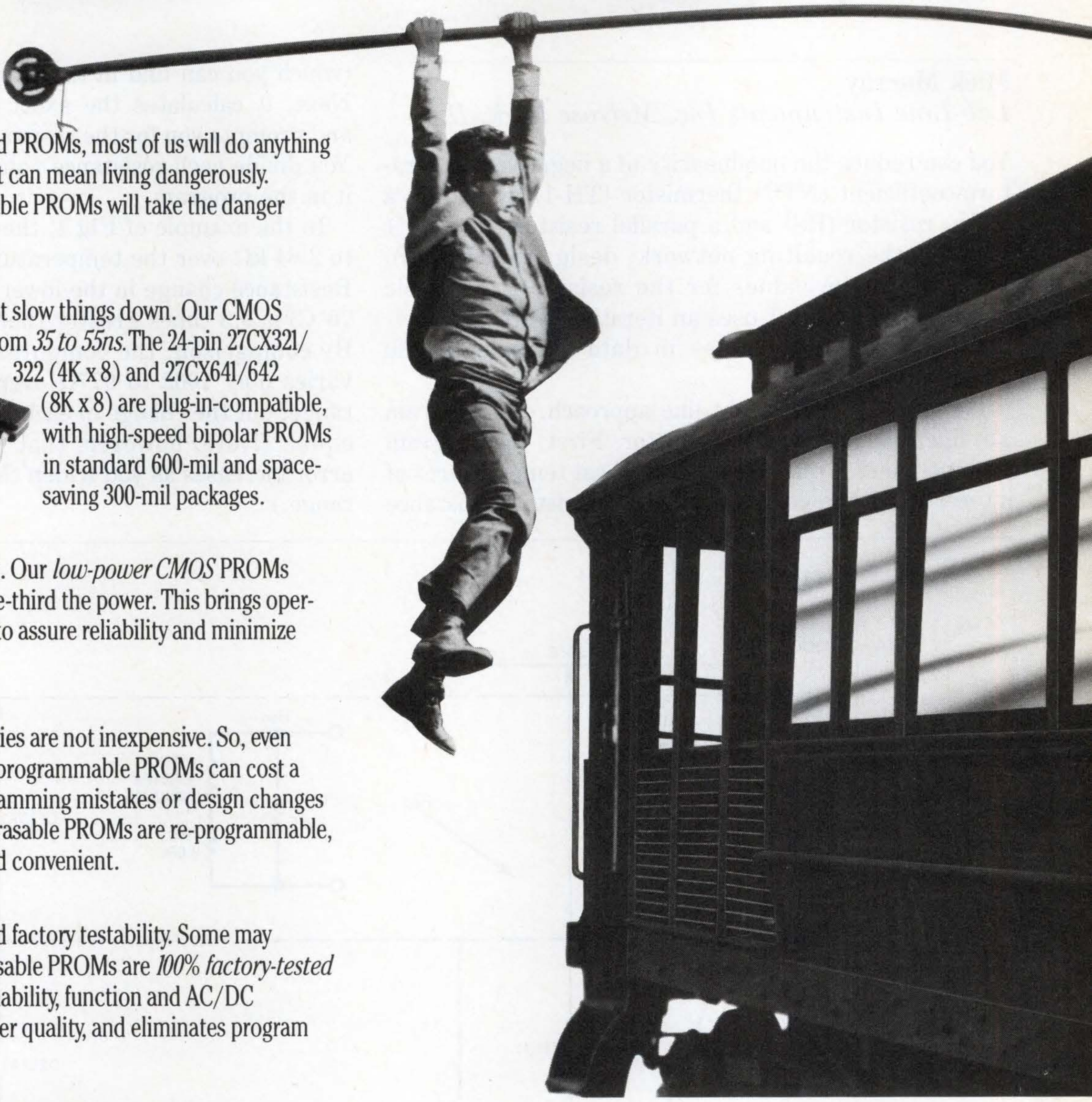

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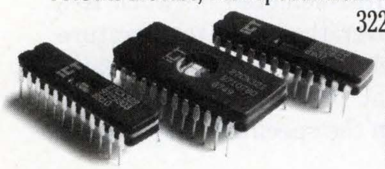

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Device	Pins	Package	Organization	Speed (T_{AC})	Power (I_{CC})
27CX321	24	600 mil	4K x 8	35, 40, 45ns	40mA*
27CX322	24	300 mil	4K x 8	35, 40, 45ns	40mA*
27CX641	24	600 mil	8K x 8	40, 45, 55ns	60mA
27CX642	24	300 mil	8K x 8	40, 45, 55ns	60mA

* User-programmable 500 μA low-power standby mode

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CIRCLE NO 47

Basic program linearizes thermistors

Mick Murray
Lab-Line Instruments Inc, Melrose Park, IL

You can reduce the nonlinearity of a negative-temperature-coefficient (NTC) thermistor (TH-1) by adding a series resistor (RS) and a parallel resistor (R). **Fig 1** contains the resulting network, designated R_{EQ}. To define optimum values for the resistors, the Basic program of **Listing 1** uses an iterative process, selecting from standard values in data statements 480 through 560.

Using a 3-point straight-line approach, the program can linearize any NTC thermistor. First, the program prompts you for the lowest and highest temperatures of interest and the corresponding thermistor resistance (which you can find in the manufacturer's data sheet). Next, it calculates the exact mid-range temperature and prompts you for the resistance at that point as well. You divide each resistance value by 1k before entering it in the program.

In the example of **Fig 1,** thermistor TH-1 varies 127 to 2.64 kΩ over the temperature range of 20 to 130°C. Resistance change in the lower half of this range (20 to 75°C) is 9.3 times greater than that in the upper half. By comparison, the computer-selected network R_{EQ} varies only 1062 to 977Ω over the same temperature range, but the change in each half of the range is nearly equal. (Note, however, that the network's linearity error increases as you widen the specified temperature range.)

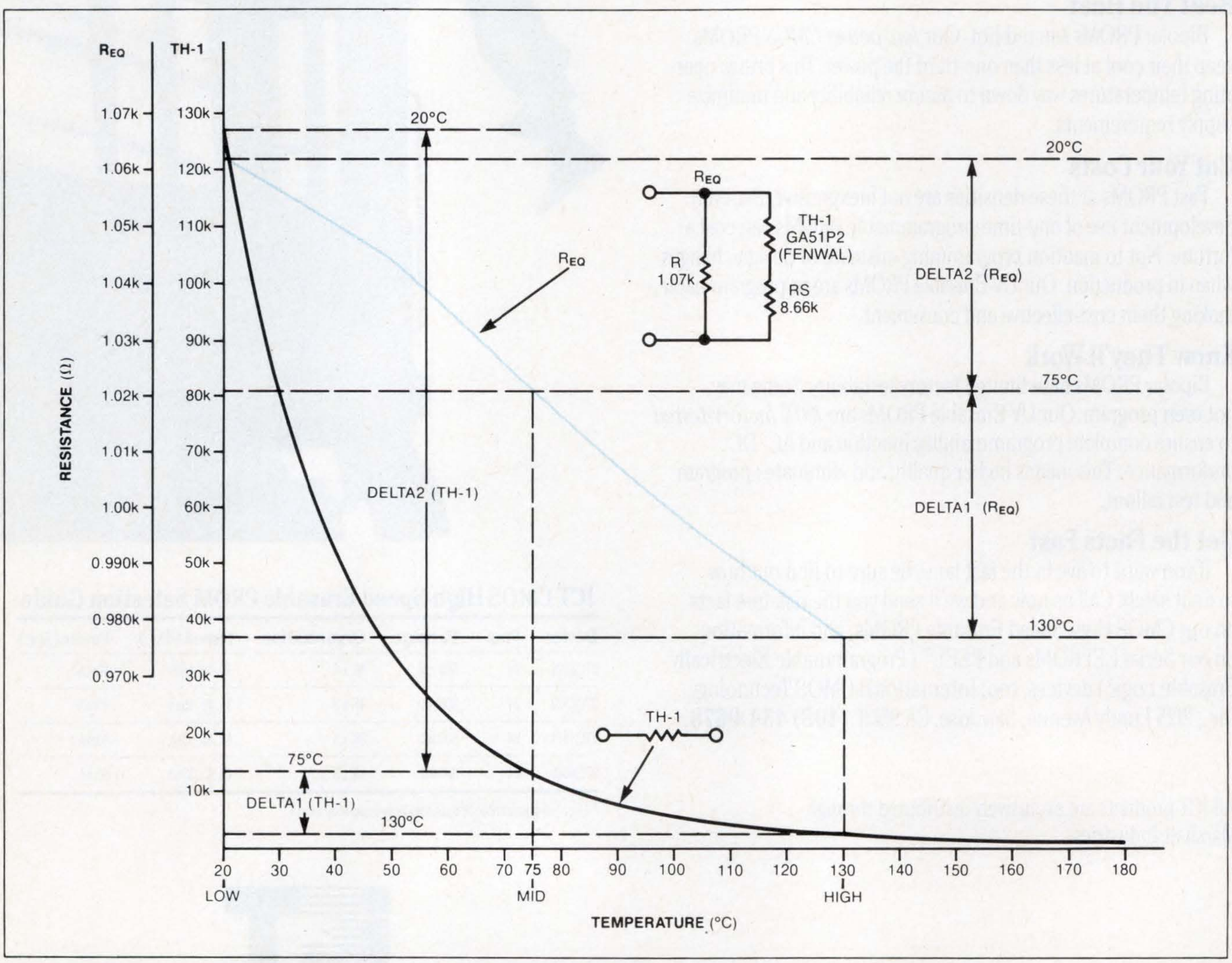

***Fig 1—The Basic program in Listing 1** selects the standard values for resistors R and RS that provide the most nearly linear relationship between R_{EQ} and temperature.*

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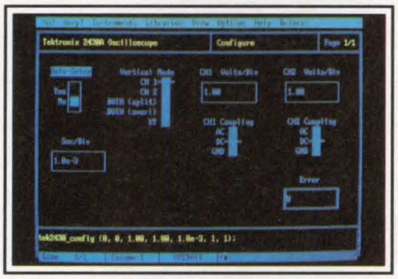

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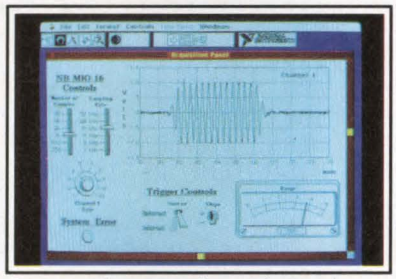

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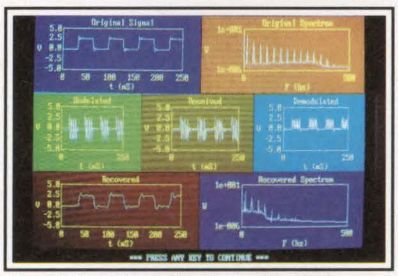

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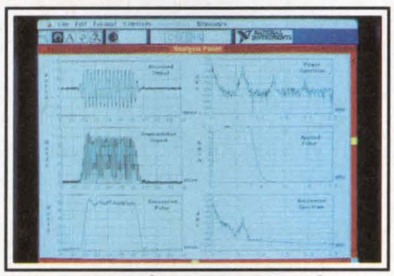

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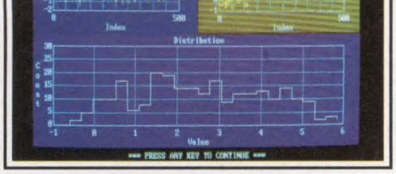

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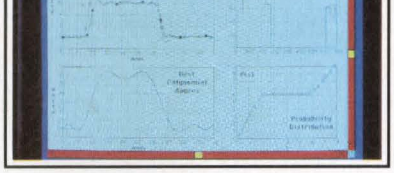

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CIRCLE NO 48

LISTING 1—LINEARIZATION PROGRAM

```
10 REM ********************************
20 REM
30 REM THERMISTOR LINEARIZATION PROGRAM
40 REM COPYRIGHT 1986 MICK MURRAY
50 REM LAB-LINE INSTRUMENTS, INC.
60 REM MELROSE PARK, IL. 60160
70 REM
80 REM ********************************
90 A$=STRING$(70,"*")
100 FOR T=1 TO 24:PRINT:NEXT
110 INPUT"INPUT LOW TEMPERATURE:";L
120 INPUT"INPUT LOW TEMP RESISTANCE:";RL
130 INPUT"INPUT HIGH TEMPERATURE:";H
140 INPUT"INPUT HIGH TEMP RESISTANCE:";RH
150 M=((H-L)/2)+L
160 PRINT"THE CALCULATED MID-POINT TEMPERATURE = ";M;"DEGREES."
170 PRINT"INPUT THERMISTOR RESISTANCE AT ";M;" DEGREES:";
180 INPUT RM:ST=1000
190 REM DE=DELTA, ST=STORE
200 PRINT A$:PRINT:PRINT
210 DIM A(96):DIM B(96)
220 FOR X=1 TO 96:READ A(X):B(X)=A(X):NEXT X
230 FOR I=1 TO 96
240   FOR J=1 TO 96
250     LO=((RL+A(I))*B(J))/(RL+A(I)+B(J))
260     MI=((RM+A(I))*B(J))/(RM+A(I)+B(J))
270     HI=((RH+A(I))*B(J))/(RH+A(I)+B(J))
280     X=ABS(HI-MI)
290     X1=ABS(MI-LO)
300     DE=ABS(X1-X)
310     IF DE<=ST THEN ST = DE:RS=A(I):R=B(J):GOSUB 380
320   NEXT J
330 NEXT I
340 IF SD=0 THEN GOTO 580
350 PRINT" END OF CALCULATIONS."
360 PRINT CHR$(7);:FORP=1TO1000:NEXT:GOTO360
370 END
380 PRINT"BEST SO FAR:"
390 PRINT"RS =";A(I);"OHMS, AND R =";B(J);"OHMS."
400 PRINT"    *** (AT";L;"DEGREES, Rth=";LO;"OHMS.)"
410 PRINT"    *** (AT";M;"DEGREES, Rth=";MI;"OHMS.)"
420 PRINT"    *** (AT";H;"DEGREES, Rth=";HI;"OHMS.)"
430 PRINT"DELTA1 =";X;"OHMS, AND DELTA2=";X1;"OHMS."
440 HL=ABS(HI-LO)
450 PRINT"THE TOTAL CHANGE IN RESISTANCE FROM";L;"TO";H;"DEGREES IS";HL;"OHMS."
460 PRINT:PRINT A$:PRINT"Working...":PRINT
470 RETURN
480 DATA 1.00,1.02,1.05,1.07,1.10,1.13,1.15,1.18,1.21,1.24
490 DATA 1.27,1.30,1.33,1.37,1.40,1.43,1.47,1.50,1.54,1.58
500 DATA 1.62,1.65,1.69,1.74,1.78,1.82,1.87,1.91,1.96,2.00
510 DATA 2.05,2.10,2.15,2.21,2.26,2.32,2.37,2.43,2.49,2.55
520 DATA 2.61,2.67,2.74,2.80,2.87,2.94,3.01,3.09,3.16,3.24,3.32
530 DATA 3.40,3.48,3.57,3.65,3.74,3.83,3.92,4.02,4.12,4.22,4.32,4.42
540 DATA 4.53,4.64,4.75,4.87,4.99,5.11,5.23,5.36,5.49,5.62,5.76,5.9
550 DATA 6.04,6.19,6.34,6.49,6.65,6.81,6.98,7.15,7.32,7.5,7.68,7.87
560 DATA 8.06,8.25,8.45,8.66,8.87,9.09,9.31,9.53,9.76
570 REM THE FOLLOWING IS FOR THE SECOND DECADE OF RS VALUES:
580 SD=1:RESTORE
590 FOR N=1 TO 96
600  READ A(N):B(N)=A(N):A(N)=10*A(N)
610 NEXT N:GOTO230
```

With each iteration, the program checks the network resistance R_{EQ} at the low, middle, and high temperatures. It seeks to achieve an equal resistance change in the upper and lower halves of the temperature range by trying all combinations of R and RS by substituting values from the data statements. It prints a result, searches for a better result, prints that, and continues (**Fig 2**). Remember to denormalize the final result by multiplying the resistance values by 1k. Typical execution time is about 10 minutes. **EDN**

```
INPUT LOW TEMPERATURE: 20
INPUT LOW TEMP RESISTANCE: 127
INPUT HIGH TEMPERATURE: 130
INPUT HIGH TEMPERATURE RESISTANCE: 2.64
THE CALCULATED MID-POINT TEMPERATURE = 75 DEGREES.
INPUT THERMISTOR RESISTANCE AT 75 DEGREES: 12.96
★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★
BEST SO FAR:
RS = 1 OHMS, AND R = 1 OHMS.
    ★★★ (AT 20 DEGREES, REQ = .9922482 OHMS.)
    ★★★ (AT 75 DEGREES, REQ = .9331552 OHMS.)
    ★★★ (AT 130 DEGREES, REQ = .7844828 OHMS.)
DELTA1 = .1486723 OHMS, AND DELTA2= .059093 OHMS.
THE TOTAL CHANGE IN RESISTANCE FROM 20 TO 130 DEGREES IS .2077653 OHMS.

★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★
                         •
                         •
                  (12 ITERATIONS)
                         •
                         •
★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★
Working. . .
BEST SO FAR:
RS = 8.66 OHMS, AND R = 1.07 OHMS.
    ★★★ (AT 20 DEGREES, REQ = 1.061627 OHMS.)
    ★★★ (AT 75 DEGREES, REQ = 1.019542 OHMS.)
    ★★★ (AT 130 DEGREES, REQ = .9774454 OHMS.)
DELTA1 = .0420962 OHMS, AND DELTA2= .04208481 OHMS.
THE TOTAL CHANGE IN RESISTANCE FROM 20 TO 130 DEGREES IS .08418102 OHMS.

★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★★
Working. . .
END OF CALCULATIONS.
```

Fig 2—This example of Listing 1's output *shows two of the 14 iterations that the program prints in determining the R_{EQ} network in* ***Fig 1.*** *$R=1.07\ k\Omega$ and $RS=8.66\ k\Omega$ are the final values.*

Test probe measures 4 to 220V

Christos S Koukourlis
Demokritos University of Thrace,
Xanthi, Greece

Using inexpensive components, you can fit a simple probe circuit (**Fig 1**) into a pencil-sized enclosure. When both LEDs are on, the probe indicates the presence of an ac voltage; either LED alone indicates the presence and polarity of a dc voltage.

The diode-bridge arrangement allows a 1-way current source (R_1, R_2, Q_1, and Q_2) to light either LED (or both) when the probe is activated by a test voltage.

Diodes in series with the LEDs provide the necessary peak-inverse voltage rating; the four diodes should each withstand 300V min. R_3 and C_1 provide a spike-suppression network to protect the current-source transistors when the probe is connected to a high voltage. *(Ed Note: The author recommends BF459 transistors. We substituted 2N3439 transistors (which are rated 350V min collector-emitter sustaining voltage) only for want of data on the BF459.)* EDN

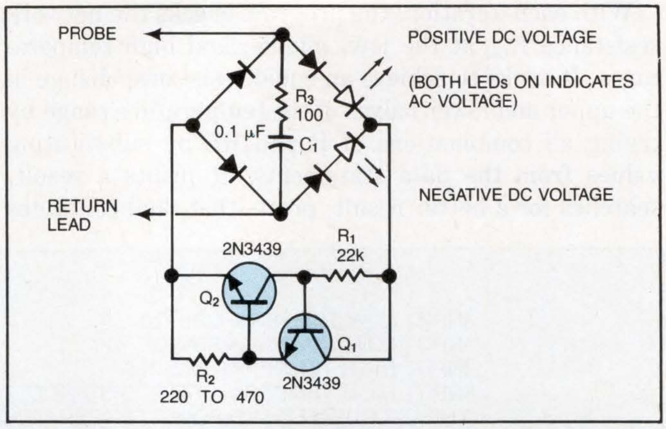


Fig 1—This simple test probe indicates ac or dc voltage *over a 4 to 220V range. The current source (R_1, R_2, Q_1, and Q_2) ensures a constant current in the LEDs for any acceptable test voltage.*

Wien-bridge filters enhance tone control

Frédéric Boes
Brugge, Belgium

Most audio tone controls affect midband gain, and they often create booming or hissing sounds when activated. You can avoid these problems by using a dual Wien-bridge filter to provide independent control of the treble and bass frequencies.

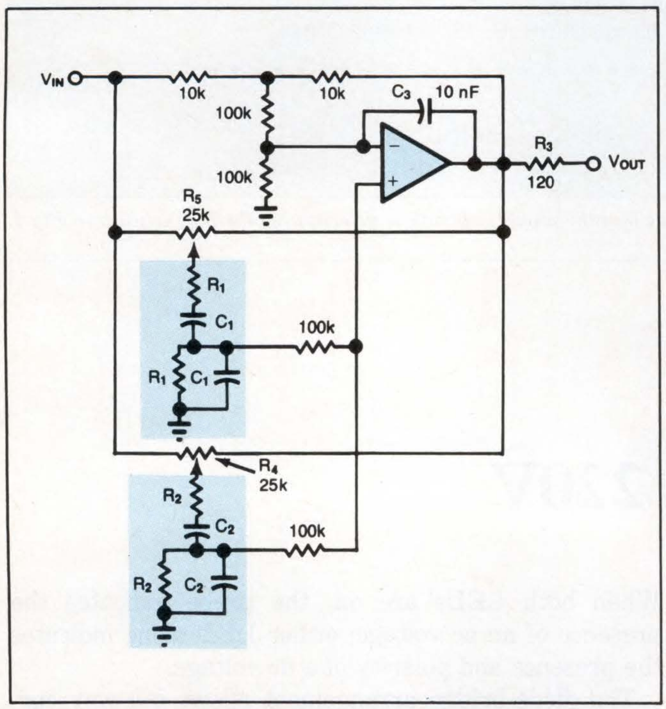


Fig 1—This audio filter's two Wien-bridge networks *provide ±9 dB of tone control for treble and bass frequencies.*

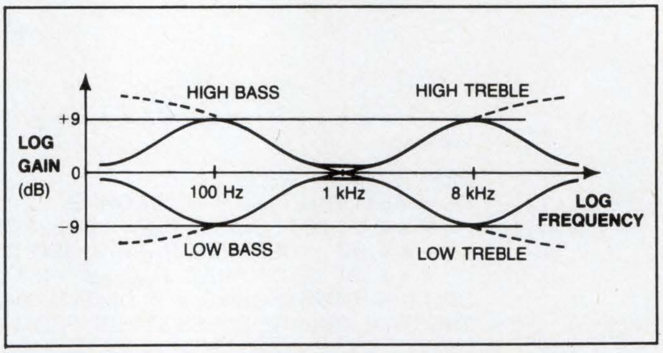


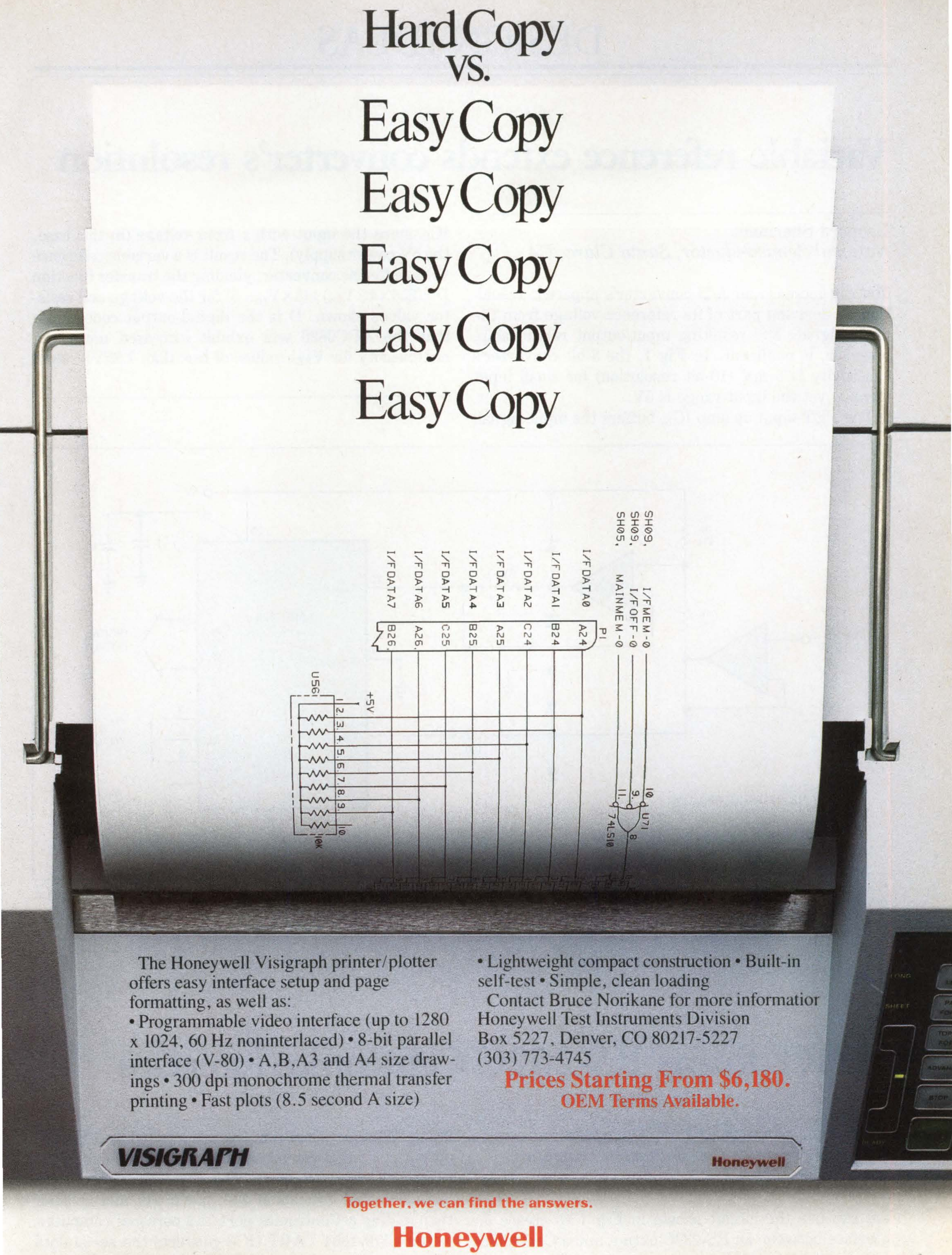
Fig 2—The frequency response *of the dual-filter tone control* ***(Fig 1)*** *shows little effect at 1 kHz but ±9-dB variation in the treble and bass regions. For comparison, the dashed lines show the response of a Boxandal tone control.*

Experiments with equalizers indicate that the optimum center frequencies are about 100 Hz and 8 kHz. Using the relation $f=(2\pi RC)^{-1}$, set the **Fig 1** values accordingly:

100 Hz: R_1=15 kΩ; C_1=0.1 μF
8 kHz: R_2=16 kΩ; C_2=1.3 nF.

R_3 and C_3 provide stability. You obtain a ±9-dB variation of treble and bass by adjusting the potentiometers R_4 and R_5, respectively. The filter's frequency response is shown in **Fig 2**.

(Ed Note: The LF356 BiFET op amp is a good choice for this application: It provides low I_B, low noise, and a good slew rate.) EDN



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CIRCLE NO 51

Variable reference extends converter's resolution

Leonard Sherman
National Semiconductor, Santa Clara, CA

You can increase an A/D converter's apparent resolution by deriving part of its reference voltage from the input signal. The resulting input/output relationship, however, is nonlinear. In **Fig 1**, the 8-bit converter's sensitivity is 5 mV (10-bit resolution) for small input signals, yet the input range is 5V.

The FET-input op amp IC_{1A} buffers the input signal; IC_{1B} sums the input with a fixed voltage (in this case, the 5V power supply). The result is a variable reference voltage for the converter, yielding the transfer function $D=(256\times4\times V_{IN})\div(3\times V_{IN}+5)$ for the voltage and resistor values shown. D is the digital-output code. Note that the ADC0820 will exhibit increased noise and nonlinearity for V_{REF} values of less than 1.25V. **EDN**

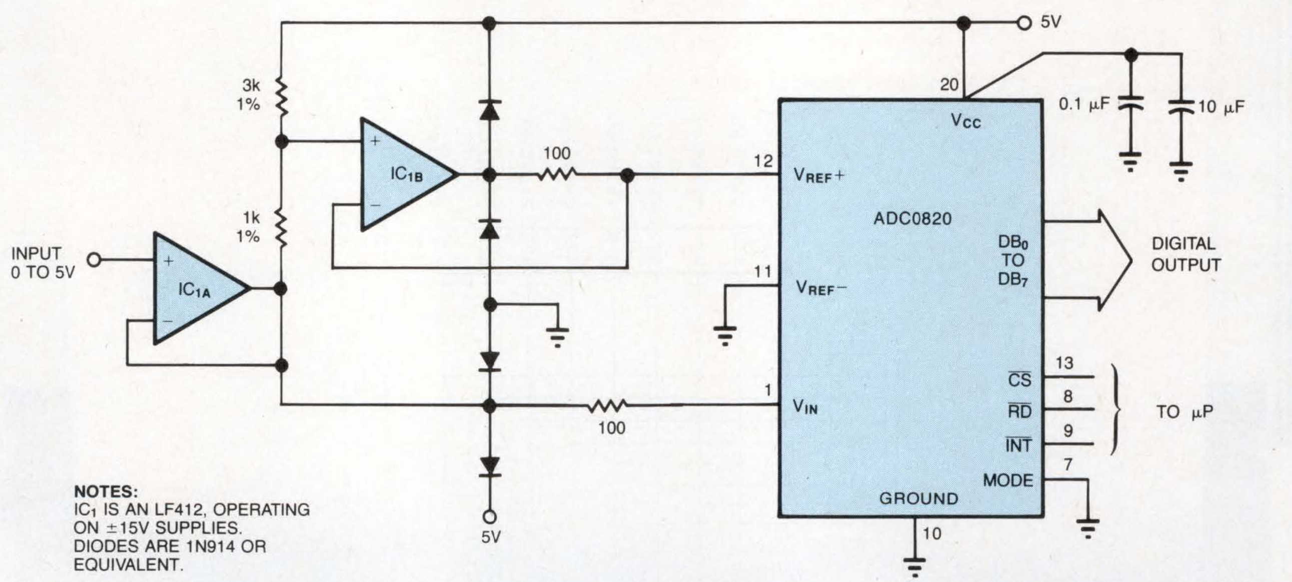

Fig 1—You can increase an A/D converter's apparent resolution by combining the input signal with a fixed reference voltage and feeding this sum to the converter's reference input.

UART forms RS-232C/Centronics interface

K S Perianayagam and U K Kalyanaramudu
Bharat Electronics Ltd, Jalahalli, Bangalore, India

You can use the circuit shown in **Fig 1** to create an interface between an RS-232C output and a Centronics input. Many personal computers contain only RS-232C output ports that cannot send information to line printers with Centronics ports. The **Fig 1** interface, which has parts that cost about $10, is simpler and cheaper than adding a Centronics port to a personal computer.

The CDP-1854 UART (IC_1) converts the serial-data

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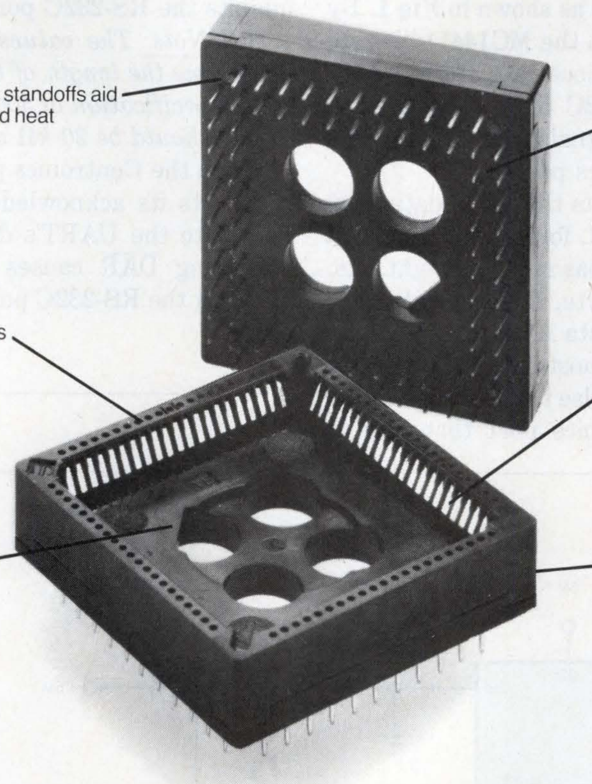

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CIRCLE NO 52

58158

stream from the RS-232C port into a byte-wide parallel transfer. You configure the UART by connecting its control pins to 5V and GROUND as shown in **Fig 1.** By selecting one of the outputs from the MC14411 bit-rate generator (IC_2), you match the clock rate of the UART to the baud rate of the RS-232C line. The 74LS244 3-state buffer (IC_3) drives the signals from the UART's parallel outputs to the Centronics port.

The 1489A receiver IC converts the serial data from the RS-232C connection into TTL format and applies it to the UART. When the UART has received eight bits, it assembles them into a data byte, drives the byte to the 74LS244, and asserts the Data Available (DA) pin. The assertion triggers the monostable multivibrator (IC_4), which delivers a voltage pulse to the strobe signal $\overline{STB}$, indicating to the Centronics port that data is ready at the outputs of IC_3. The assertion of DA also asserts the $\overline{CTS}$ through the 1488A line-driver IC. $\overline{CTS}$ inhibits the RS-232C port from transmitting.

(Ed Note: The values of the components R and C determine the length of the strobe $\overline{STB}$. Given a minimum specification of 500 nsec for a Centronics port, R and C should be 20 kΩ and 40 pF, respectively.)

When the Centronics port has latched the data byte, it asserts its acknowledge signal $\overline{ACK}$, which is connected to the UART's data-acknowledge input, $\overline{DAR}$. Asserting $\overline{DAR}$ causes the UART to deassert DA, allowing the RS-232C port to send another eight bits of data. **EDN**

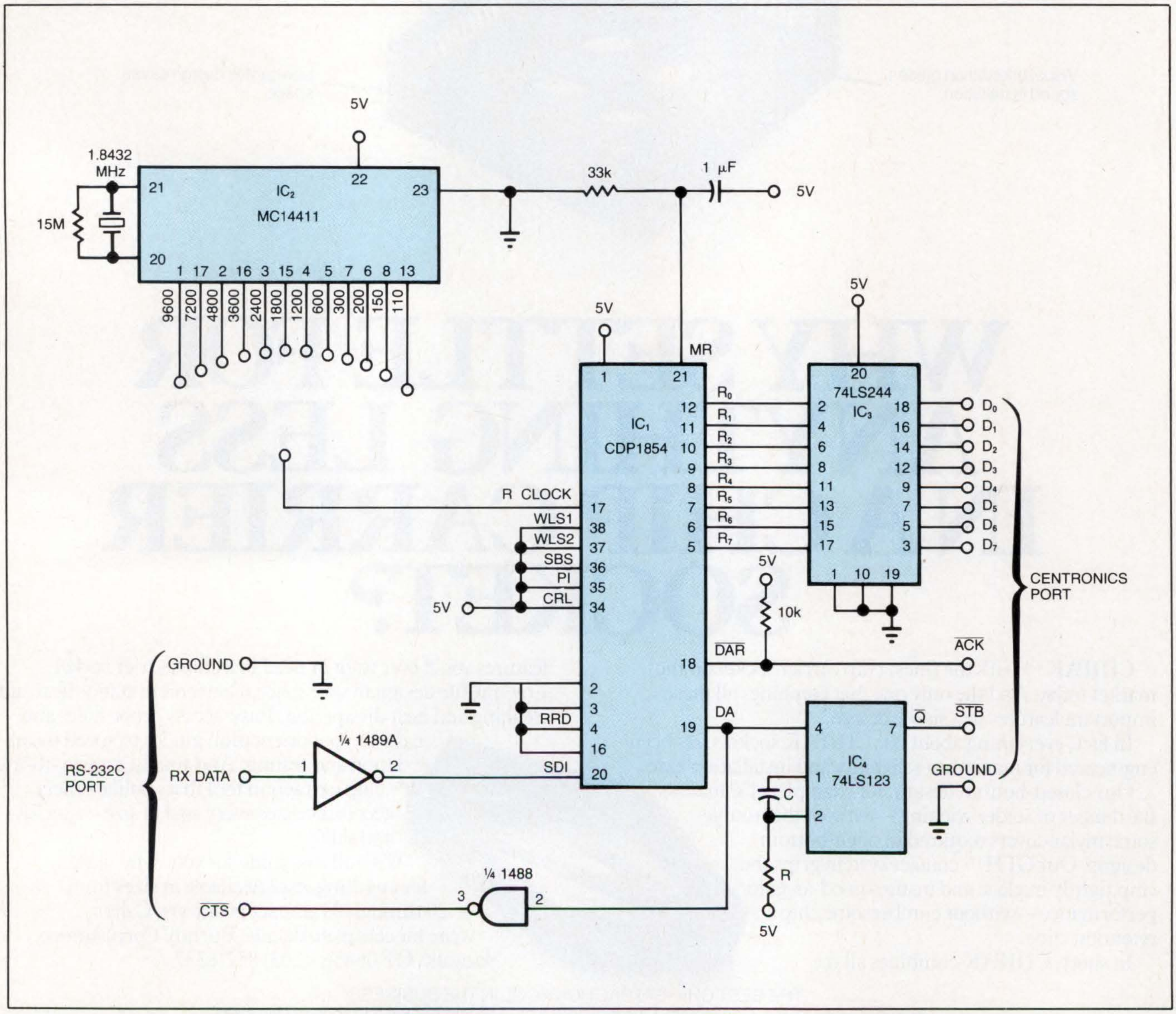

Fig 1—The CDP-1854 UART assembles serial RS-232C data into bytes for a Centronics port. IC_2 provides a baud rate that matches the RS-232C transmission rate, and IC_3 buffers the data byte to the Centronics port. Signals DA and $\overline{DAR}$ control the timing of the two ports.

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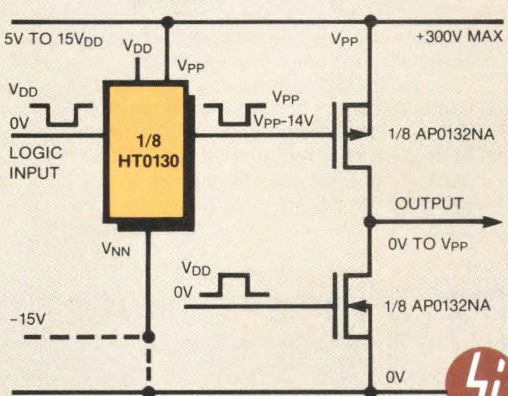

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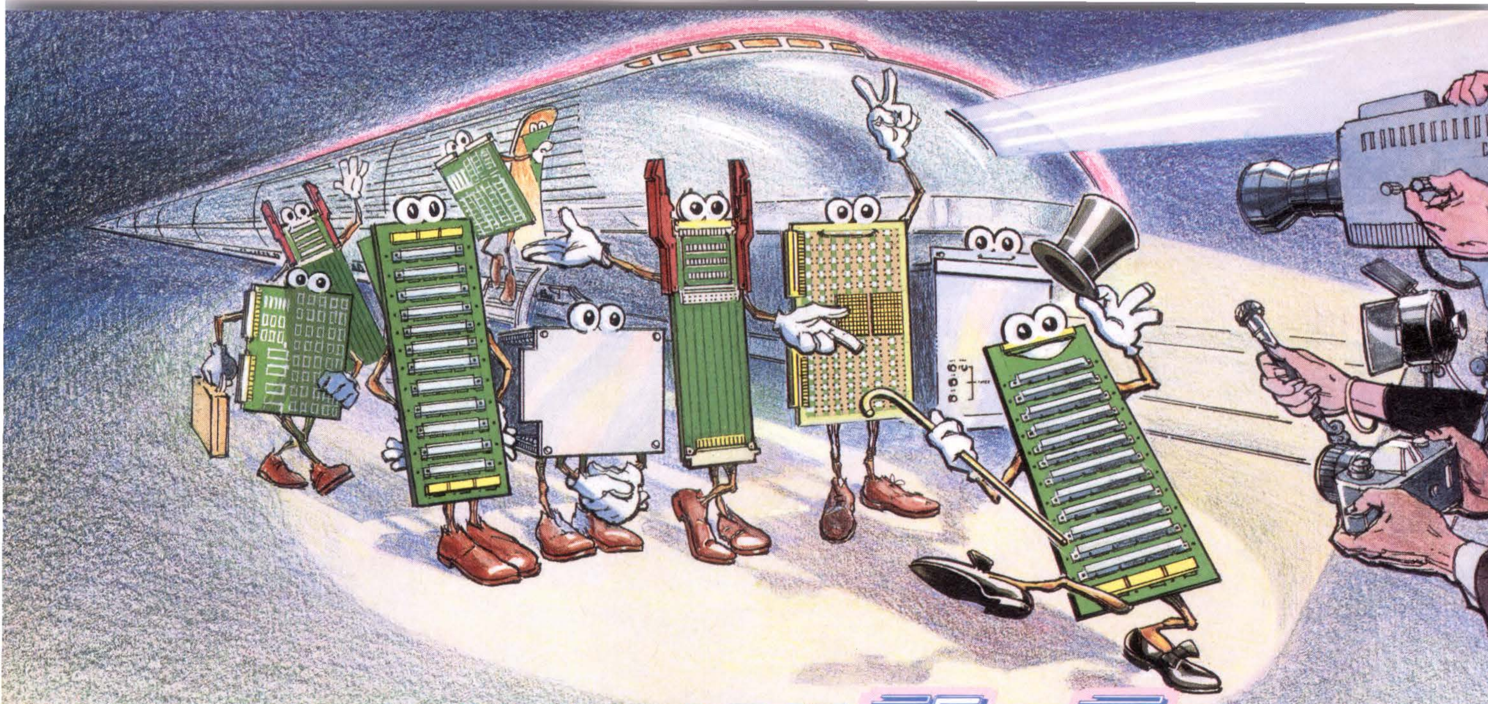

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CIRCLE NO 54

Build step-up/step-down regulator

Jade Alberkrack
Motorola Semiconductor Products, Phoenix, AZ

Using a single inductor, a switching-regulator IC, and a few external components, you can build the step-up/step-down battery-output regulator circuit in **Fig 1**. The circuit's novelty stems from its use of a single inductor to provide the voltage transformation. The circuit combines two basic switching-regulator configurations: a step-up circuit and a step-down circuit. **Table 1** lists the regulator's specifications.

Fig 2's collection of switching circuits shows the evolution of **Fig 1**'s circuit. The voltage step-down circuit in **Fig 2a** generates a voltage lower than that supplied by the battery. **Fig 2b**'s circuit steps up the voltage provided by a battery. By combining the circuits as shown in **Fig 2c** and using a switching-regulator IC to provide Q_1 and Q_2, you get the design in **Fig 1**.

In **Fig 2c**'s circuit, inductor L stores energy while Q_1 and Q_2 are on (during T_{ON}). When the transistors are

TABLE 1—SWITCHING-REGULATOR SPECIFICATIONS

TEST	CONDITIONS	RESULTS
LINE REGULATION	V_{IN} = 7.5 TO 14.5V, I_{OUT} = 120 mA	Δ = 22 mV; ±0.11%
LOAD REGULATION	V_{IN} = 12.6V, I_{OUT} = 10 TO 120 mA	Δ = 3.0 mV; ±0.015%
OUTPUT RIPPLE	V_{IN} = 12.6V, I_{OUT} = 120 mA	95 mVP-P
SHORT-CIRCUIT CURRENT	V_{IN} = 12.6V, R_L = 0.1Ω	1.54A
EFFICIENCY	V_{IN} = 7.5 TO 14.5V, I_{OUT} = 120 mA	74%

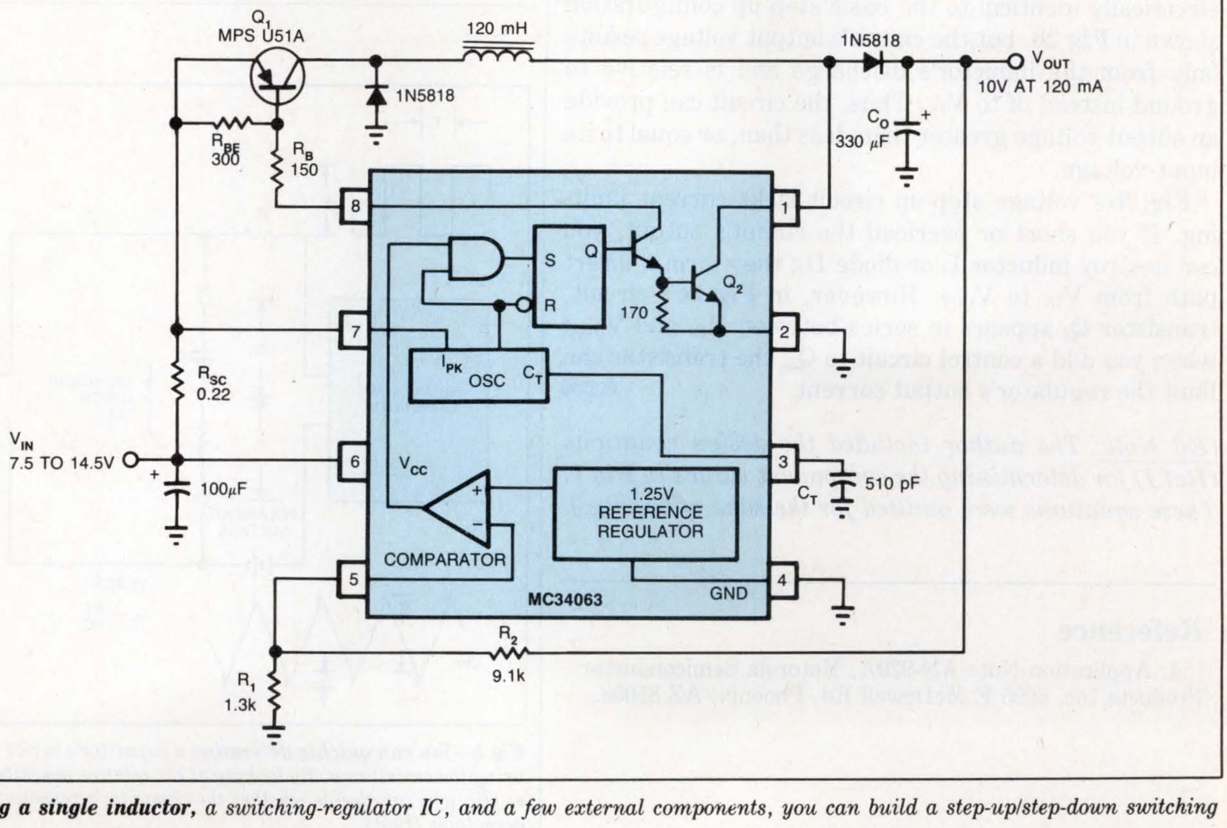


***Fig 1—Using a single inductor,** a switching-regulator IC, and a few external components, you can build a step-up/step-down switching regulator.*

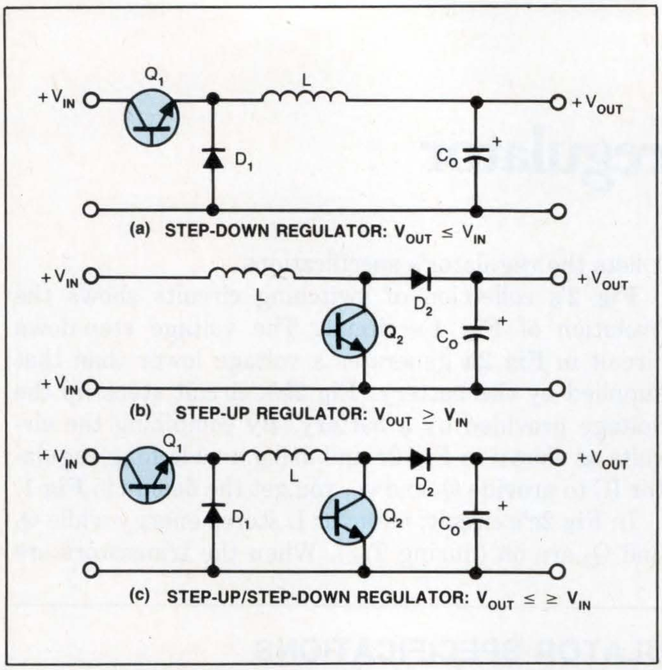


*Fig 2—**These three switching circuits** show the evolution of **Fig 1**'s circuit. The voltage step-down circuit in **a** generates a voltage lower than that supplied by the battery. The circuit in **b** steps up the voltage provided by a battery. By combining these circuits as shown in **c** and using a switching-regulator IC to provide the switching function and Q_2, you derive the design in **Fig 1**.*

switched off, the inductor discharges into output capacitor C_O and into the circuit's load, thus forward-biasing diodes D_1 and D_2. During T_{OFF}, **Fig 2c**'s circuit is electrically identical to the basic step-up configuration shown in **Fig 2b**, but the circuit's output voltage results only from the inductor's discharge and is relative to ground instead of to V_{IN}. Thus, the circuit can provide an output voltage greater than, less than, or equal to its input voltage.

Fig 2b's voltage step-up circuit lacks current limiting. If you short or overload the circuit's output, you can destroy inductor L or diode D_2; they form a direct path from V_{IN} to V_{OUT}. However, in **Fig 2c**'s circuit, transistor Q_2 appears in series between V_{IN} and V_{OUT}; when you add a control circuit to Q_2, the transistor can limit the regulator's output current. **EDN**

*(Ed Note: The author included the design equations **(Ref 1)** for determining the component values in **Fig 1**. These equations were omitted for the sake of brevity.)*

Reference

1. Application Note AN-920A, Motorola Semiconductor Products Inc, 5005 E McDowell Rd, Phoenix, AZ 85008.

Circuit measures capacitor's resistance

Fred Brown
Consulting Engineer, Lake San Marcos, CA

To test large numbers of capacitors in production runs, use the circuit in **Fig 1a**, which lets you use an oscilloscope to determine a capacitor's series resistance at a glance. You drive the circuit with a square wave. If the capacitor has no series resistance, the oscilloscope will display a perfect sawtooth wave. If the capacitor has series resistance, however, the oscilloscope will display a sawtooth wave with a square wave superimposed on it (**Fig 1b**). The larger the superimposed square wave, the greater the series resistance.

To obtain a quick approximation of the capacitor's series resistance, look at the ratio of e_r to e_C. For RC>>T, e_C=ET÷RC, where T is the square wave's period and e_C is the voltage across the capacitor. The ratio of e_r to e_C equals the ratio of the capacitor's series resistance to T÷C. For nonpolarized capacitors, you can omit the dc polarizing voltage. **EDN**

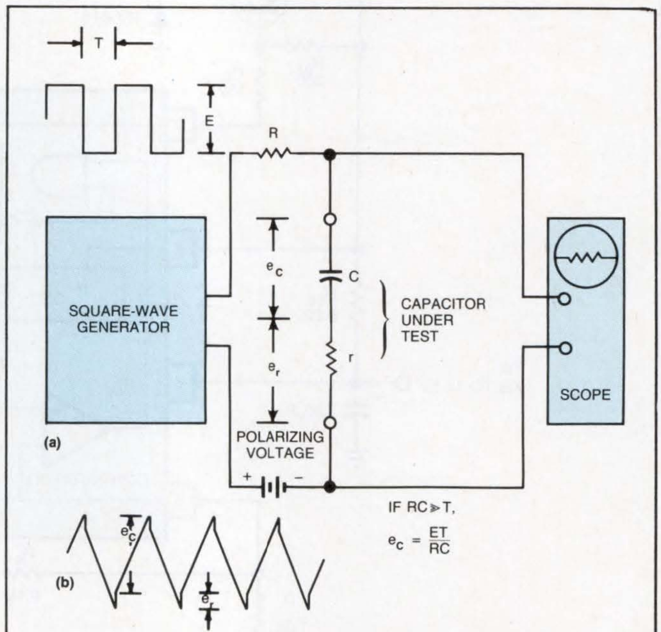


*Fig 1—**You can quickly determine** a capacitor's series resistance by using the circuit in **a**. By looking at the relative magnitudes of e_r and e_C (**b**), you can decide whether the capacitor's resistance lies within acceptable limits.*

Use 3-state buffer as PLL phase detector

Tom Lange
Rochester NY

Using a 3-state buffer as a PLL's phase detector, you can keep the PLL synchronized with a pulse train—even when pulses are missing. As Fig 1 shows, the circuit is simple: To implement it, just connect the pulse source to the buffer's output-enable ($\overline{OE}$) input, and connect the PLL's VCO output to the buffer's input.

As the timing diagram in **Fig 2** illustrates, when an input pulse occurs, the VCO's output is high, the 3-state buffer's output is high, and capacitor C is being charged. In the pulse's second portion, the VCO's output goes low, the buffer's output goes low, and the capacitor discharges. Once the pulse ends, it places the

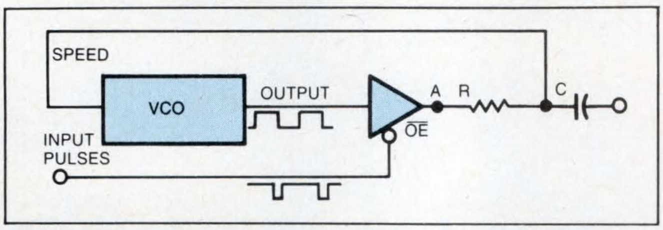


***Fig 1—Using a 3-state buffer** as a PLL's phase detector, you can keep the PLL synchronized with a pulse train—even when pulses are missing.*

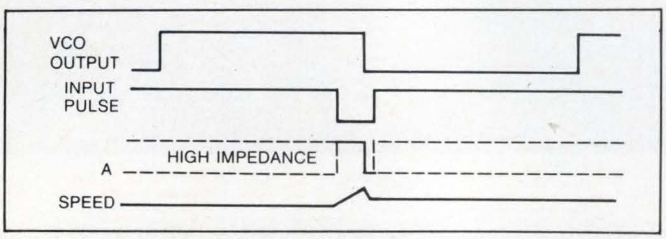


***Fig 2—The output of Fig 1's VCO** is high when an input pulse occurs; simultaneously, the 3-state buffer's output is high, and capacitor C charges. Then, the VCO's output goes low, the buffer's output goes low, and the capacitor discharges.*

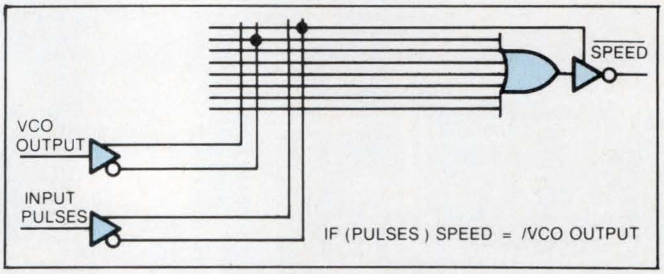


***Fig 3—Using a PLD with 3-state outputs,** you can implement **Fig 1**'s circuit. Just connect the pulse source to a gate's output enable and the VCO's output to the gate's input. Because these PLDs have inverted outputs, you'll have to invert some signals.*

3-state buffer in its high-impedance state, thus causing the capacitor's charge to remain at a constant level.

On the other hand, if the falling edge of the VCO's output occurs after the center of the pulse, as it does in **Fig 2,** the net charge on the capacitor increases. Thus, the VCO's speed input, and hence VCO operating frequency, increases. Conversely, if the falling edge of the VCO's output waveform occurs earlier than the center of the pulse, the VCO's operating frequency decreases.

If the 3-state buffer receives no input pulse at all, it remains in its high-impedance state; the capacitor charge remains constant; and the VCO frequency stays the same.

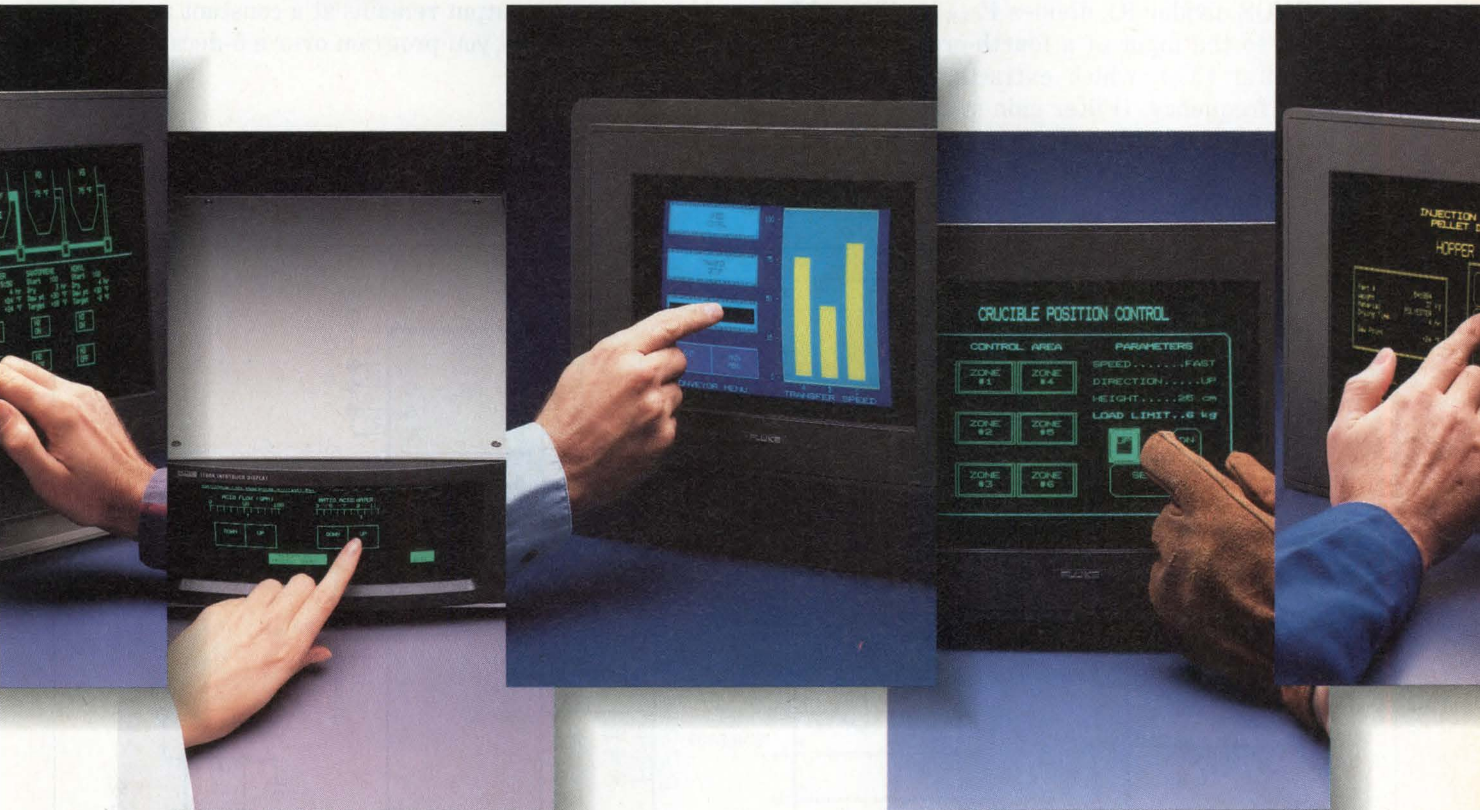
You can also implement this circuit using a programmable logic device (PLD) that has 3-state outputs (eg, a 16L8, 16R4, or 20L10 PAL). To use one, connect the pulse source to a gate's output-enable pin and the VCO's output to the gate's input. Because these devices have inverted outputs, you'll have to invert some signals. **Fig 3** shows one possible PAL implementation of this scheme, including the PALASM equations. **EDN**

Program a sine-wave oscillator's frequency

Shvalbe Gershon
Holon, Israel

Fig 1 depicts a sine-wave oscillator that produces a constant-amplitude, programmable-frequency audio signal. You derive the basic timing frequency from a μP and a programmable-interval timer chip.

The 8748 microcomputer divides its 6-MHz crystal-clock frequency by 3 and provides the resulting 2-MHz signal at pin 1 when the CPU executes an ENTO CLK instruction. Pin 1 feeds the signal through a noninverting buffer (IC_2) to the CLK_0 input of the 8253


CRUCIBLE POSITION CONTROL
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programmable-interval timer (PIT). The PIT includes three fully independent, 16-bit counters, but in this case it only uses one. By programming the 0 counter's initial state and count, you can obtain a desired frequency (F_{CLK}) at the Q_0 output (pin 10).

The CMOS divider IC_5 divides F_{CLK} by 100 and feeds the result to the input of a fourth-order Butterworth lowpass filter (IC_6), which extracts the fundamental sine-wave frequency. (Filter gain is about ⅓; you may need an output amplifier, as shown within the dotted lines.) The filter realizes a fourth-order response by cascading two second-order functions: The A side has a gain of 0.3 and a Q of 0.504, and the B side has a gain of 1 and a Q of 1.306.

Because the programmed frequency F_{CLK} also serves as the switched-capacitor filter's clock input, the filter's output and cutoff frequencies maintain a fixed relationship. Thus, the output remains at a constant amplitude for any frequency you program over a 5-decade range.

EDN

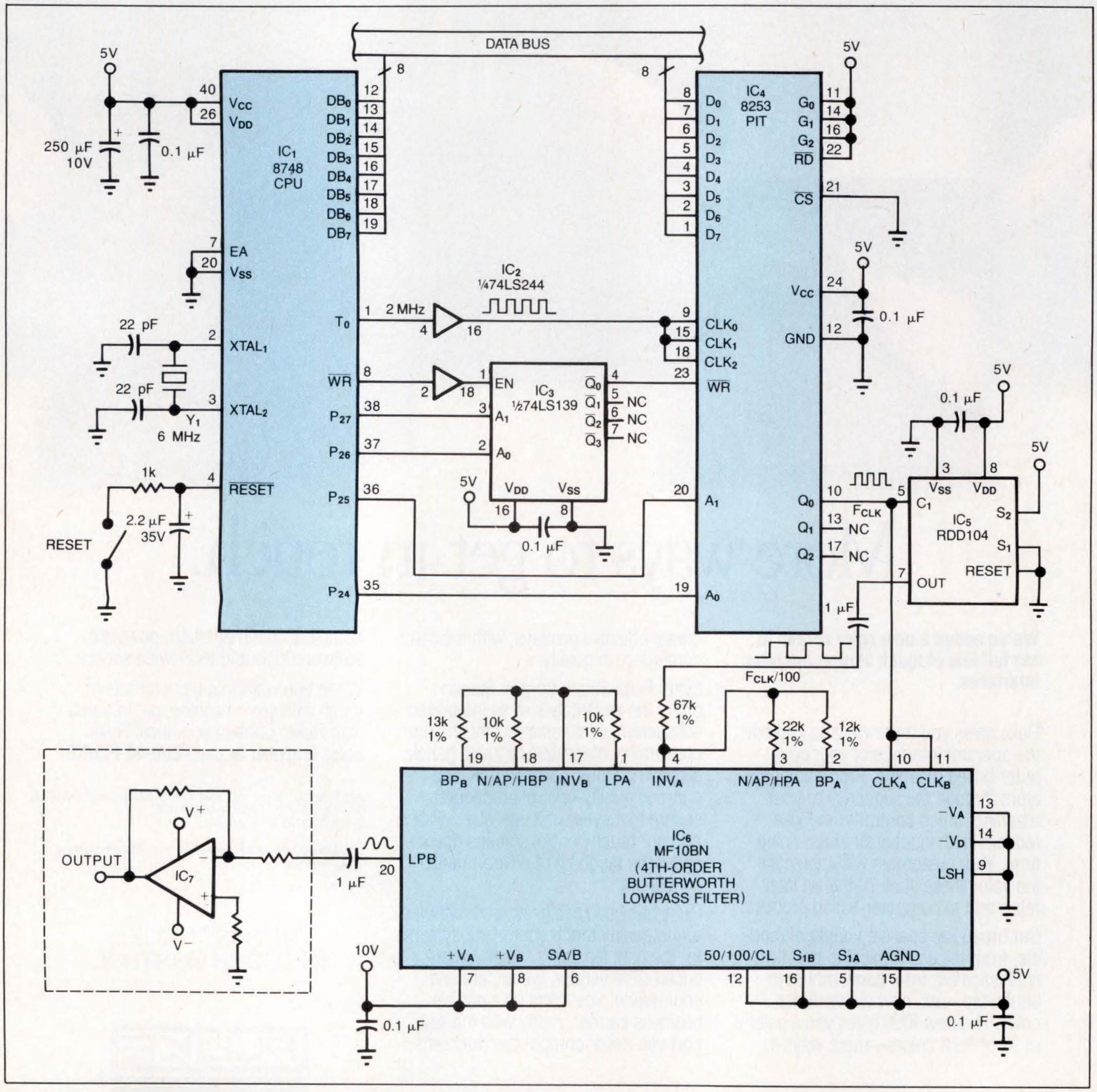
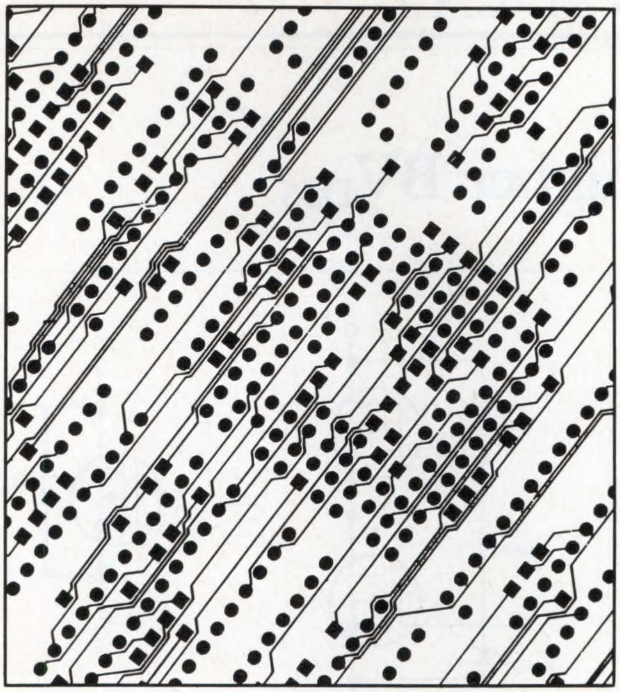


Fig 1—***This microcomputer-controlled system*** *produces a constant-amplitude, programmable-frequency audio output.* ***Frequency range*** *spans five decades to 20 kHz.*



MOSFET circuits yield higher BV_{DSS}

Tosh Mizuno
Dalmo Victor Co, Belmont, CA

You can create a composite MOSFET whose BV_{DSS} is double that of a single MOSFET by combining two devices with a diode and two resistors **(Fig 1)**. Even though you can buy an MTP1N100 MOSFET from Motorola that has a 1000V minimum BV_{DSS}, you may need a higher value for use in a gated image intensifier, for example, or a TWT grid modulator.

With a voltage V_{DD} between the composite drain and source, $V_{G2}=½V_{DD}$. Therefore, the voltage at P equals $½V_{DD}$ minus Q_2's gate-source threshold voltage $V_{GS(TH)}$, but $V_P \approx ½V_{DD}$ for large V_{DD}. The 12V zener diode D_1 ensures that the gate of Q_2 is sufficiently positive for Q_2 to remain in saturation under all conditions. Thus, Q_2's on-resistance remains low, and the composite MOSFET's electrical characteristics depend only on the characteristics of Q_1.

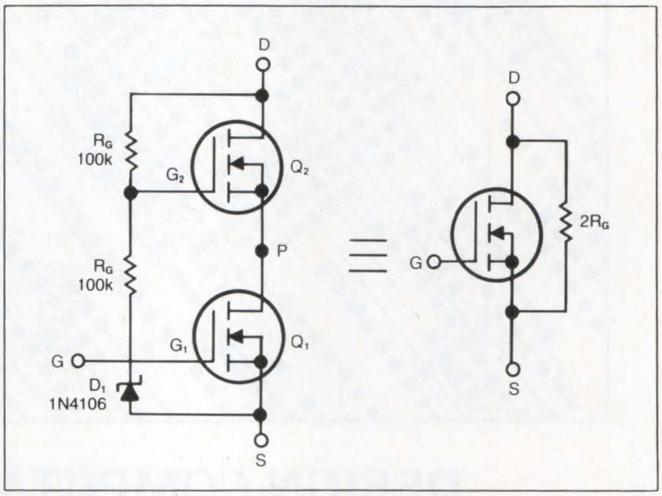


Fig 1—Double a MOSFET's BV_{DSS} by connecting two units in series. This composite device behaves as shown in the equivalent diagram.

Typical applications of this composite MOSFET include the common-source connection **(Fig 2a)** and the source-follower connection **(Fig 2b)**. For the source

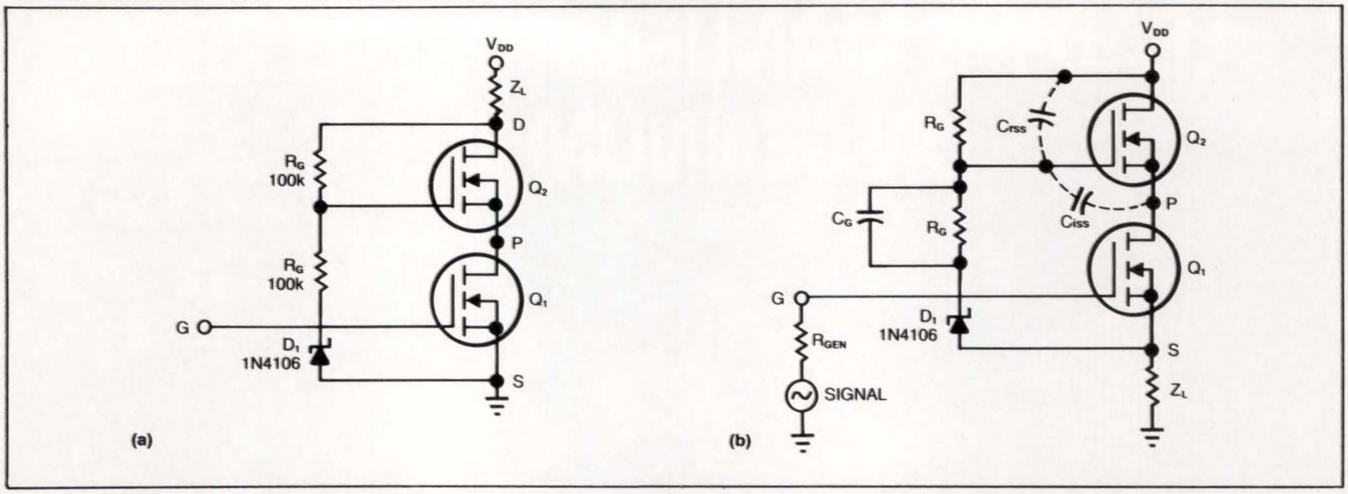


Fig 2—You can use the composite MOSFET *in conventional high-V_{DD} applications such as common-source* ***(a)*** *and source-follower* ***(b)*** *connections.*

follower, you must add capacitor C_G to compensate for the gate capacitance of Q_2. Because this gate capacitance doesn't generally equal the sum of C_{rss} and C_{iss}, you must experiment to determine the required compensation value. (For example, you might want to select a capacitor that achieves less than −90° of phase shift at the highest signal frequency of interest.) **EDN**

Transistor array squares control current

Burkhard Braach
Wandel & Goltermann, Eningen, West Germany

A simple 5-transistor array and a resistor **(Fig 1)** generate a square-law relationship between I_{IN} and I_{OUT}. The circuit is useful in PLL frequency synthesizers and other closed-loop systems requiring square-law amplification in the feedback path.

Assume that the transistor base currents are negligible and that Q_1-Q_2 and Q_4-Q_5 have negligible base-emitter offset voltages. These transistor pairs then form ideal current mirrors, and their collector currents equal the input current:

$$I_1 = I_2 = I_4 = I_5 = I_{IN}. \qquad (1)$$

The Q_1 and Q_3 collector currents are

$$I_1 = I_S e^{\frac{qV_{BE1}}{KT}} \text{ and } I_3 = I_S e^{\frac{qV_{BE3}}{KT}},$$

respectively, and their ratio is

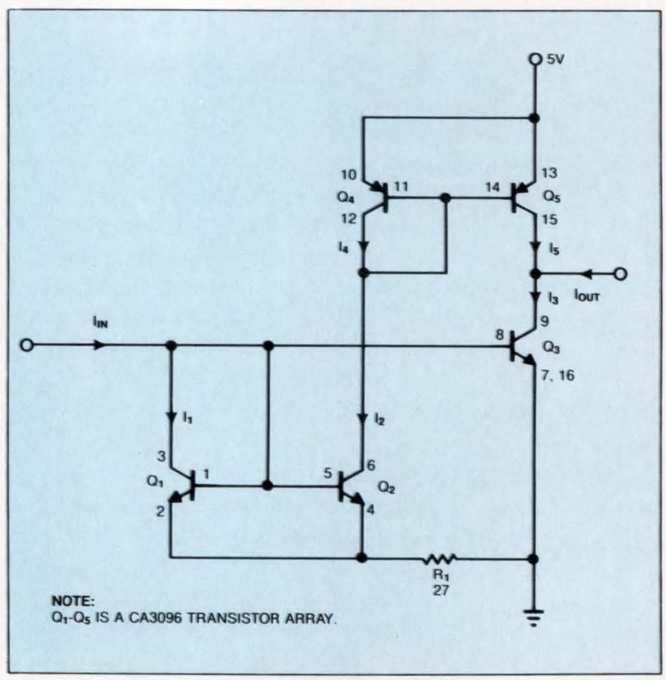
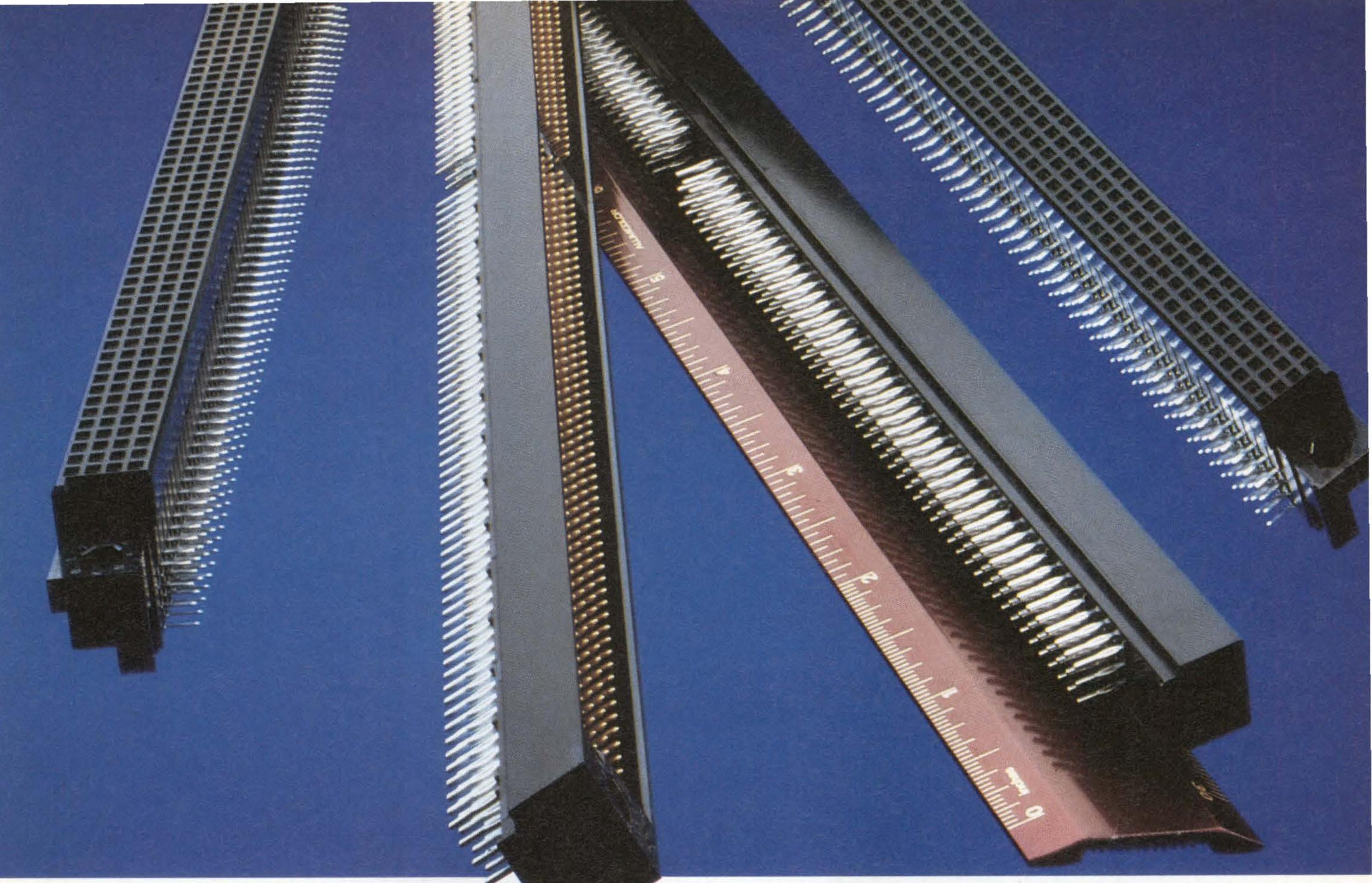


Fig 1—This transistor-array circuit *performs square-law amplification of I_{IN}.*



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$$\frac{I_3}{I_1} = e^{\frac{q(V_{BE3} - V_{BE1})}{KT}}, \qquad (2)$$

where I_S=saturation current, q=electron charge, K=Boltzmann's constant, T=absolute temperature, and V_{BE1} and V_{BE3} are the base-emitter voltages for transistors Q_1 and Q_3.

Because $V_{BE3}=V_{BE1}+R_1(I_1+I_2)$, you can write **Eq 2** as

$$I_3 = I_1 e^{\frac{q(I_1 + I_2)R_1}{KT}}.$$

Substituting I_{IN} from **Eq 1** yields

$$I_3 = I_{IN} e^{\frac{2qI_{IN}R_1}{KT}}.$$

Thus, transistor Q_3 provides an exponential function that you can expand as a power series in the form of $e^x=1+x/1!+x^2/2!+x^3/3!+\ldots$ to yield

$$I_3 = I_{IN}\left[1 + \frac{2qI_{IN}R_1}{KT} + \left(\frac{2qI_{IN}R_1}{KT}\right)^2/2 + \left(\frac{2qI_{IN}R_1}{KT}\right)^3/6 + \cdots\right]. \qquad (3)$$

The output current is $I_{OUT}=I_3-I_5=I_3-I_{IN}$. Substituting for I_3 **(Eq 3)** eliminates the linear term, so the series begins with the quadratic term:

$$I_{OUT} = \left(\frac{2qR_1}{KT}\right)I_{IN}^2 + \left(\frac{2qR_1}{KT}\right)^2 I_{IN}^3/2 + \left(\frac{2qR_1}{KT}\right)^3 I_{IN}^4/6 + \ldots.$$

In short, the circuit produces a useful squaring characteristic for low $2qR_1/KT$ ratios and low input currents. **Fig 2** shows the measured and calculated results for a CA3096 transistor array and a 27Ω resistor. You can extend the 20:1 output-current range by using transistor pairs with tighter V_{BE} matching and higher betas. If desired, you can reverse the output-current polarity by inserting a resistor with a value $2R_1$ in the emitter of Q_4 (remove the Q_1-Q_2 emitter resistor in this case).

EDN

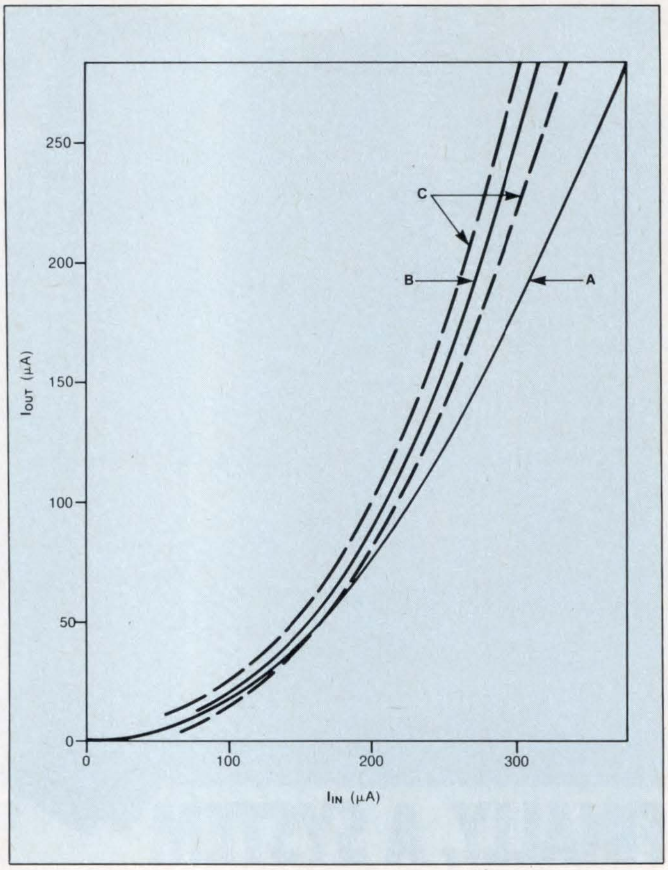

***Fig 2—These curves illustrate** the performance of **Fig 1**'s circuit. The curve labeled A represents the ideal squaring function, the curve labeled B shows the calculated function, and the two curves labeled C form an envelope for the results obtained using five different CA3096 arrays.*

Digital power controller handles 1 kW

John A Haase
Colorado State University, Fort Collins, CO

With this power controller (Fig 1) you can vary the power to a load according to a 2-decade BCD word, obtained either manually or from a computer. For an open-loop system you can deliver at least 1 kW to a resistive load, in 1% increments (0 to 99%). Or, you can combine the controller with a sensor and heater, for example, to regulate temperature. The controller delivers an integral number of line cycles every 1.67 sec; switching occurs near the zero-voltage crossing so the

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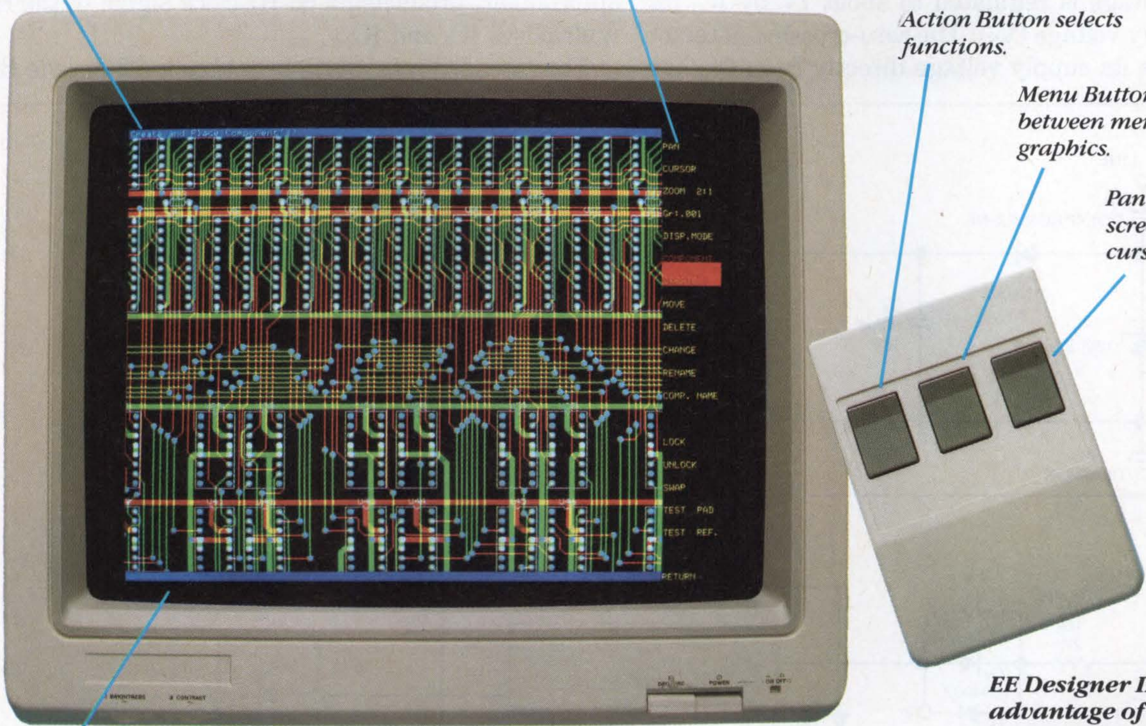

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CIRCLE NO 61

load current has no dc component.

AC line voltage is regulated to about 7V by IC_1 for use as a supply voltage (V_S). The zero-crossing detector IC_2 also takes its supply voltage directly from the line via R_4 and R_5. In addition, the line drives the 4N26 optocoupler, producing a 60-Hz clock signal to the rate multipliers IC_3 and IC_4.

The cascaded rate multipliers accept a 2-decade BCD

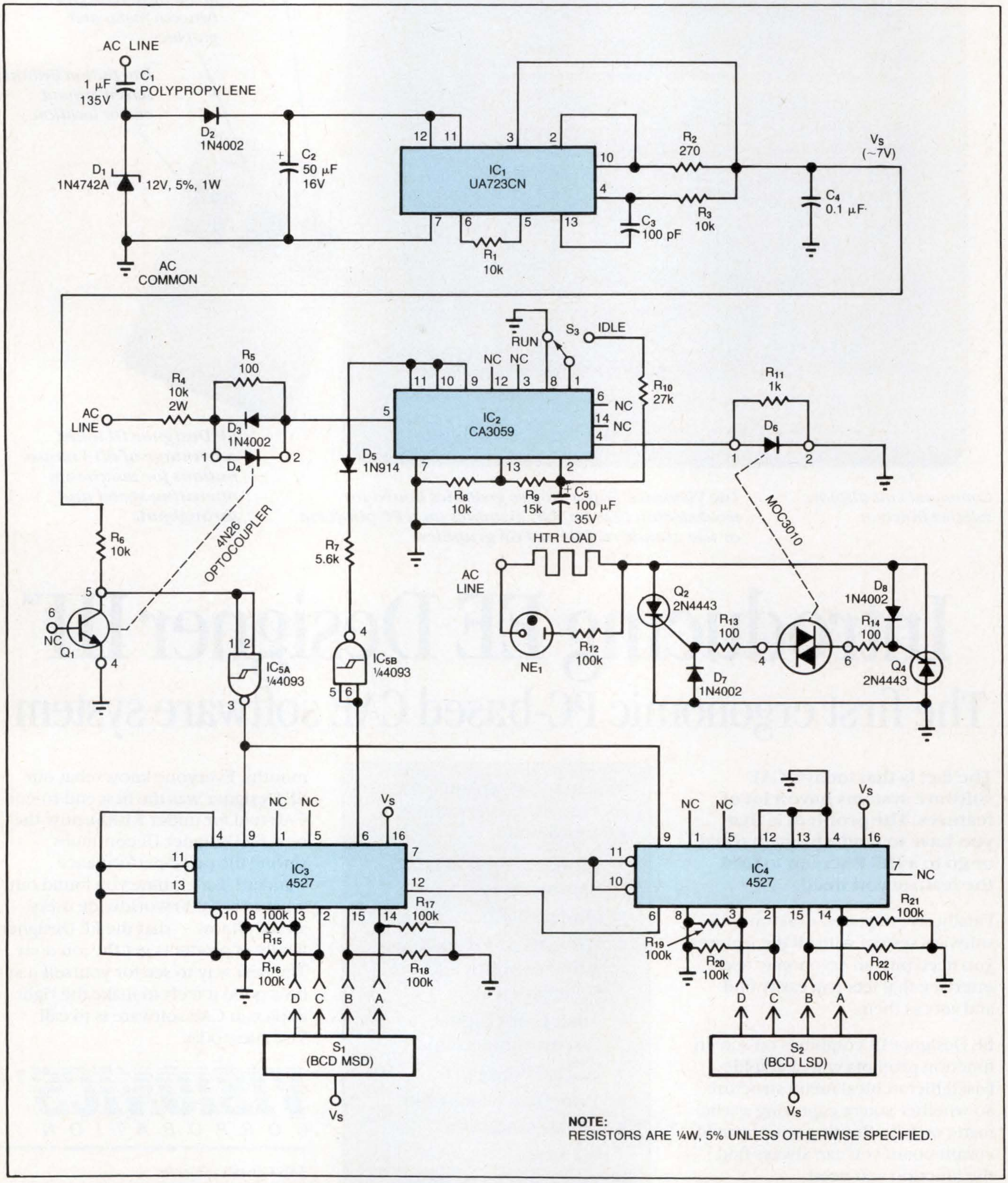

Fig 1—A low-power circuit provides digital control *of 1 kW, or more, in 1% steps. A zero-crossing detector ensures that only an integral* ***number of full line cycles reach the load during any 1.67-sec control period.***

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word and provide an output (pin 6, IC_3) of one-tenth the word value times 60 Hz. (In this system, you enter the control word manually using the quad switches S_1 and S_2.) The shunting effect of R_5 ensures that the LED D_4's on-period is well within a positive half-cycle of the line voltage **(Fig 2).** Consequently, the count-advance pulses from IC_{5A} to the rate multipliers occur once per line cycle and in advance of the zero crossing.

Then, for each output pulse via the Schmitt trigger IC_{5B}, the zero-crossing detector IC_2 emits two pulses at pin 4, which are optically coupled to the gates of SCRs Q_2 and Q_4. As a result, the appropriate SCR turns on during two consecutive half-cycles of the line voltage (highlighted areas in **Fig 2**).

This circuit can replace an autotransformer in many applications, offering less weight, less volume, and better control resolution. The circuit also has the following characteristics:

- S_3 is an on-off switch—no power to the load in the idle position.
- Brightness of the neon lamp NE_1 gives an approximate indication of load power.
- Power switching is optically isolated from the control circuits.
- No partial- or half-cycles of line voltage are delivered to the load.
- Power cycles are uniformly spaced for power-of-2 control words. Note, however, that other control words may cause a noticeable variation in power over the 1.67-sec control interval.

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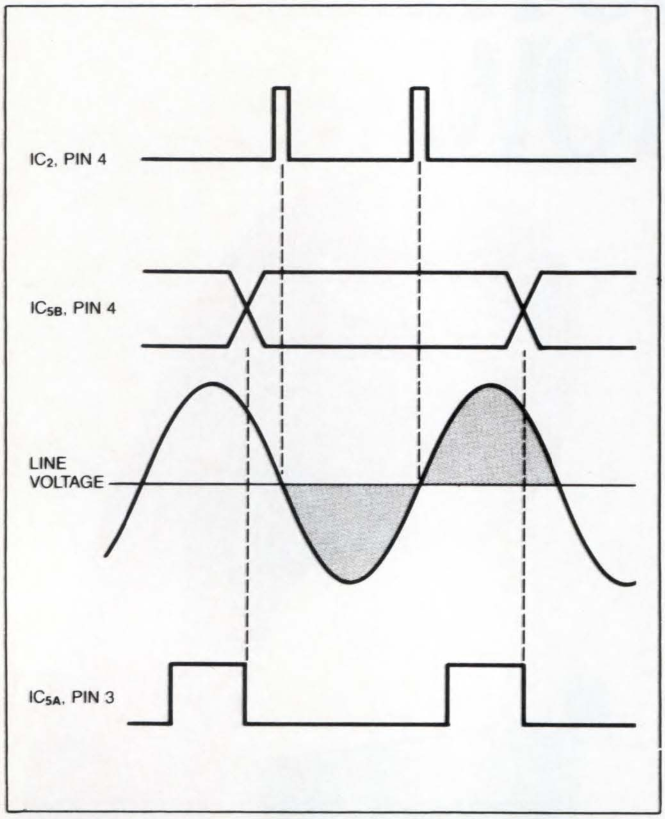

Fig 2—This circuit is timed to fire the SCRs Q_2 and Q_4 (Fig 1) so that only one full line cycle (highlighted area) is passed to the load for each pulse from IC_{5B}, pin 4.

Circuit checks remaining battery capacity

Rolf Zinniker
Swiss Federal Institute of Technology, Zurich, Switzerland

The test circuit in **Fig 1** gives an indication of the capacity remaining in a battery. By noting the time (in seconds) that the LED remains on after you depress the test switch S_1, you can read the remaining battery life (in hours) from the curve in **Fig 2a.** The circuit has proven reliable in testing NiCd-, carbon-, and alkaline-type batteries, all of which have a discharge-vs-time characteristic similar to the NiCd curve shown in **Fig 2b.**

Closing S_1 activates the circuit by applying voltage from the battery under test. Voltage V_1 jumps to a value $V_0=V_RR_3/(R_2+R_3)$ when the switch closes **(Fig 3)** and then increases with a time constant $T=C_1(R_2+R_3)$. The divider R_4/R_5 fixes V_2. The reference circuit IC_1 sets V_R to approximately 2.5V.

The op amp's output remains high (LED on) until V_1 rises to the level of V_2, when the LED turns off. You calculate the on-time t_{ON} as follows:

$$t_{ON} = T \cdot \ln\left(\frac{V_R-V_0}{V_R-V_2}\right).$$

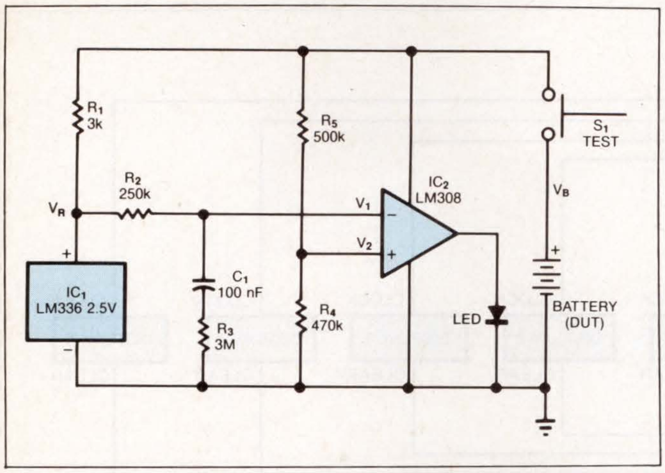

***Fig 1—This test circuit checks the remaining charge** in a battery; the charge is proportional to the time the LED remains on after you depress S_1.*

The on-time is zero when $V_2<V_0$ and infinite when $V_2>V_R$. By substituting t_{ON} for t and V_2 for V_1 in **Fig 3,** you obtain a curve for t_{ON} as a function of V_2.

You must choose voltages V_S and V_E **(Fig 2b)** that correspond to the desired range for t_{ON}. Then, set the resistor values as follows:

$$\frac{R_4}{R_5}=\frac{V_R}{V_S-V_R};\ \frac{R_3}{R_2}=\frac{V_E}{V_S-V_E}.$$

You can make R_5 a variable resistor for convenience in calibrating the circuit. Because the curves of **Fig 2b** and **Fig 3** have a similar rate of change over the range of interest, the resulting relation **(Fig 2a)** between t_{ON} and remaining battery lifetime is quite linear. To use the circuit, simply depress S_1 and hold it. If the LED remains on for several seconds, the battery contains more than 70% of its rated charge. If the LED remains on for only 0.5 sec, for example, the battery is good for approximately four hours while loaded as in **Fig 2b,** that is, with 100Ω. **EDN**

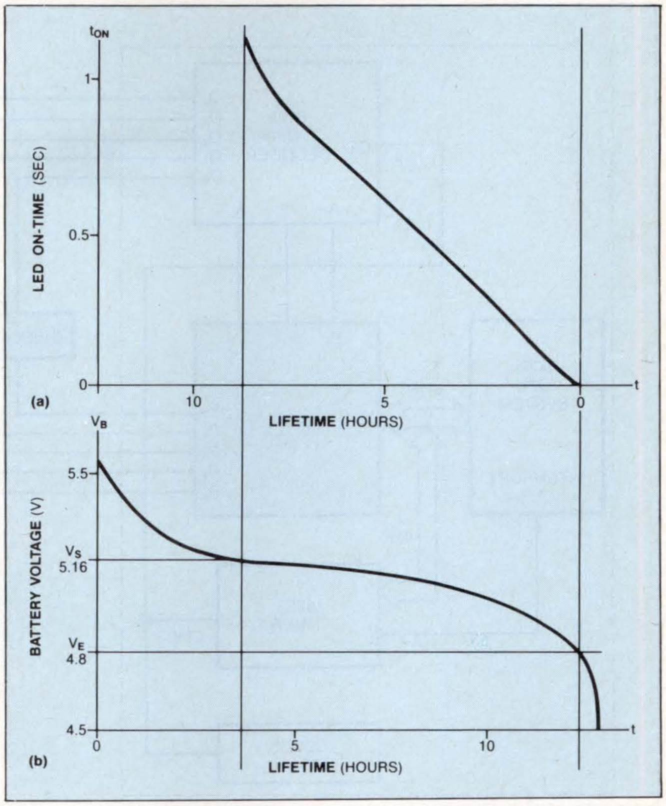

***Fig 2—The calculated on-time** in seconds for the LED in **Fig 1** corresponds to the battery's remaining life in hours, based on a 100Ω load **(a)**. The curve in **b** shows the measured rate of discharge for a NiCd battery (four Varta RS600 cells loaded with 100Ω).*

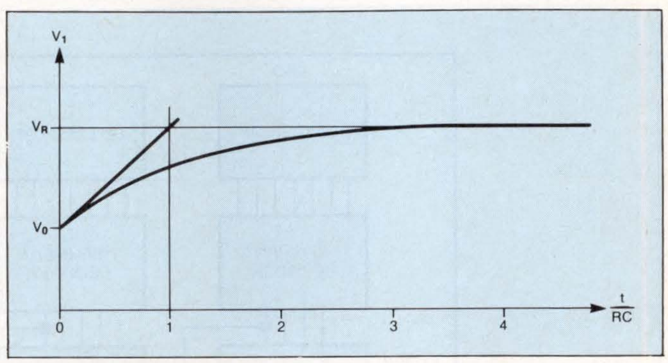

***Fig 3—This curve shows the variation of V_1** following closure of S_1 and caused by the charging of capacitor C_1.*

Simple hardware drives multiple displays

R Jayapal
Bharat Heavy Electricals Ltd,
Trichirappalli, India

In **Fig 1**, one 8-bit port drives five displays, each of which can include any reasonable number of digits. Regardless of the number of digits, each display **(Fig 2)** requires only two signals, Clock and Clear. This approach includes less hardware and fewer interconnections than are found in the more conventional multiplexing and serial-communications methods used in microprocessor-based systems.

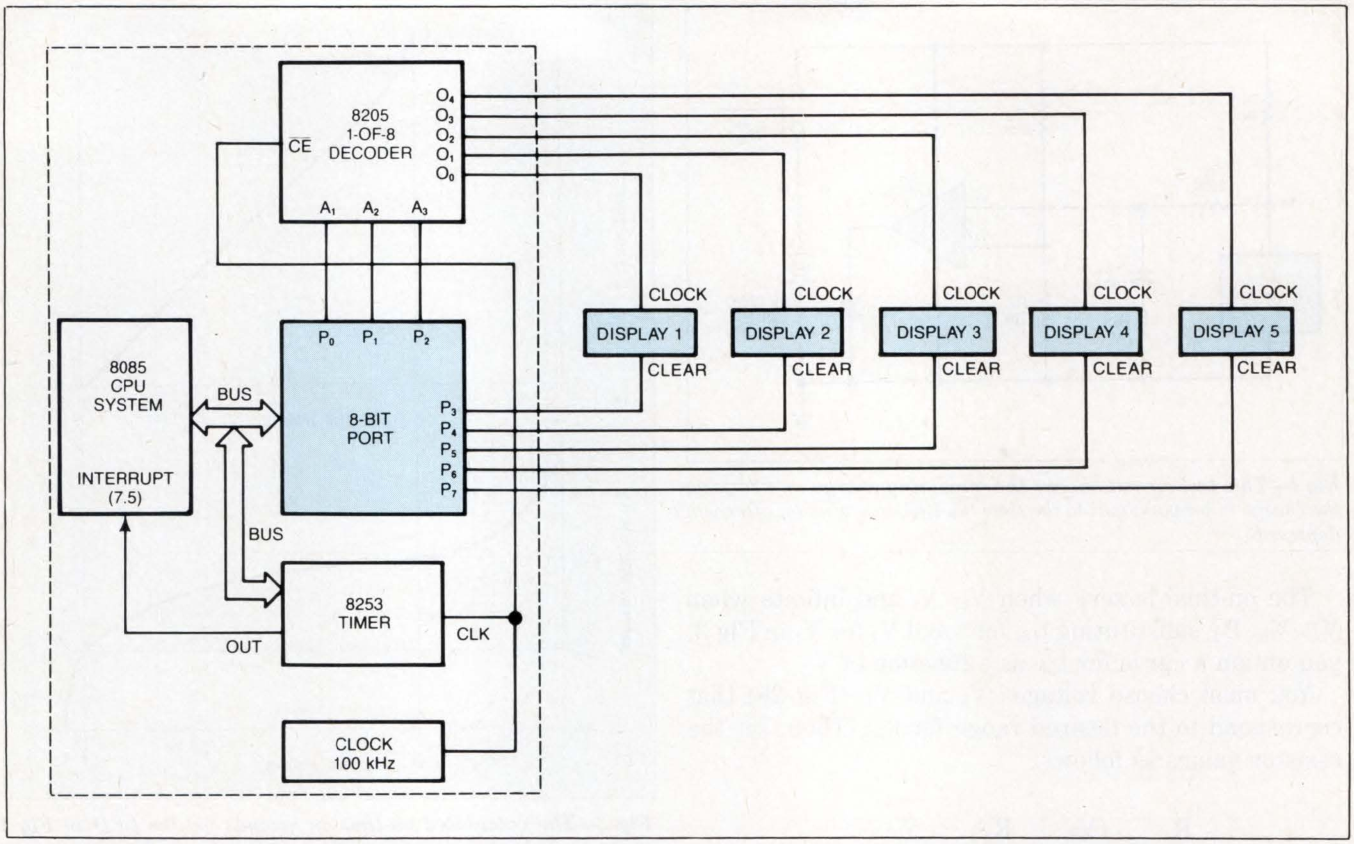

Fig 1—One 8-bit port drives five displays, *each with an arbitrary number of digits. Each display requires only two signals, Clock and Clear.*

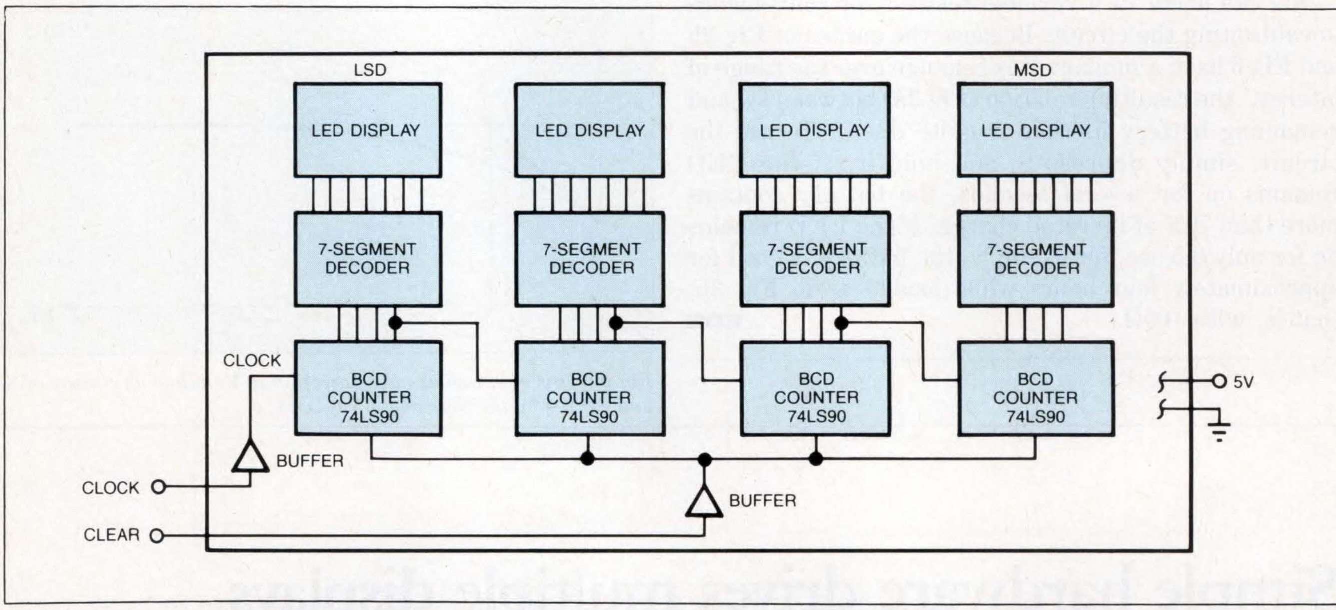

Fig 2—A typical display in Fig 1 *includes a digit display, 7-segment decoder, and BCD counter for each digit.*

Port bits P_0, P_1, and P_2 select the display to be updated: 000 for Display 1, 001 for Display 2, etc. These bits should be 111 when the displays aren't being updated.

To load Display 1, first clear it by issuing a software-generated pulse on P_3. Next, initialize the 8253 programmable-interval timer for BCD counting and load it with the decimal number to be displayed. After loading P_0-P_2 with 000 and starting the timer, the CPU can continue with other processing. When the 8253's count reaches the desired value, the 8253 issues an interrupt to the CPU.

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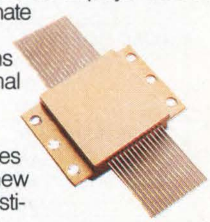

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The interrupt service routine simply loads P_0-P_2 with 000, P_3-P_7 with 00000, and returns. Thus, Display 1 reads the desired value, and you use a similar procedure to update the other displays. **Table 1** gives the bit patterns required at the 8-bit port for handling each of the five displays.

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TABLE 1—BIT PATTERNS

OPERATION	PORT BIT PATTERN								HEX	REMARKS
	P_7	P_6	P_5	P_4	P_3	P_2	P_1	P_0		
1. NO OPERATION/ INTERRUPT SERVICE	0	0	0	0	0	1	1	1	07	COUNTERS STOP COUNTING
2. LOAD DISPLAY 1										
(a)	0	0	0	0	1	1	1	1	OF	CLEAR DISPLAY COUNTER 1
(b)	0	0	0	0	0	0	0	0	00	DISPLAY COUNTER COUNTS
(c)	LOAD AND START TIMER									
3. LOAD DISPLAY 2										
(a)	0	0	0	1	0	1	1	1	17	CLEAR DISPLAY COUNTER 2
(b)	0	0	0	0	0	0	0	1	01	DISPLAY COUNTER 2 COUNTS
(c)	LOAD AND START TIMER									
4. LOAD DISPLAY 3										
(a)	0	0	1	0	0	1	1	1	27	CLEAR DISPLAY COUNTER 3
(b)	0	0	0	0	0	0	1	0	02	DISPLAY COUNTER 3 COUNTS
(c)	LOAD AND START TIMER									
5. LOAD DISPLAY 4										
(a)	0	1	0	0	0	1	1	1	47	CLEAR DISPLAY COUNTER 4
(b)	0	0	0	0	0	0	1	1	03	DISPLAY COUNTER 4 COUNTS
(c)	LOAD AND START TIMER									
6. LOAD DISPLAY 5										
(a)	1	0	0	0	0	1	1	1	87	CLEAR DISPLAY COUNTER 5
(b)	0	0	0	0	0	1	0	0	04	DISPLAY COUNTER 5 COUNTS
(c)	LOAD AND START TIMER									

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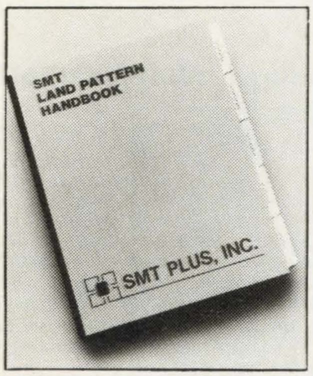

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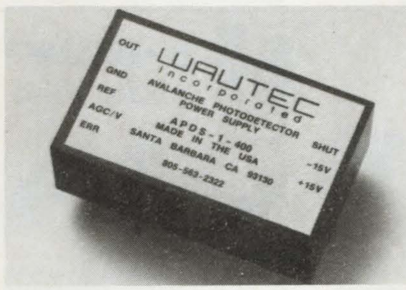

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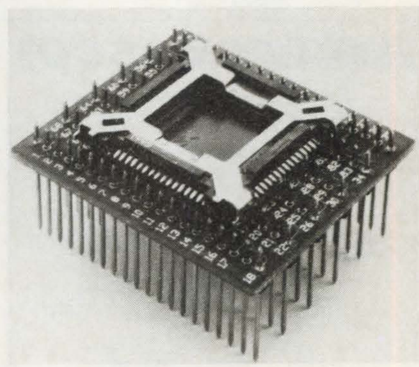

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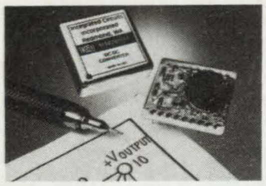

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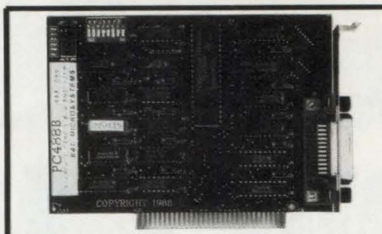

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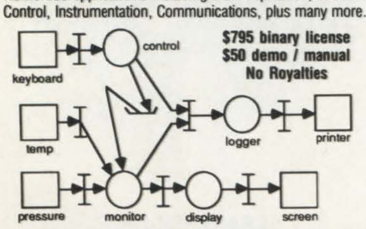

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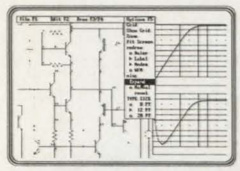

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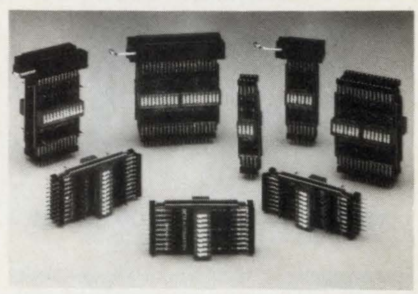

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BS/MS in Mechanical Engineering and previous experience in electronics equipment packaging in order to apply these skills to custom metalwork and custom plastic design. Background in Computer Aided Design is a must with experience in ComputerVision helpful.

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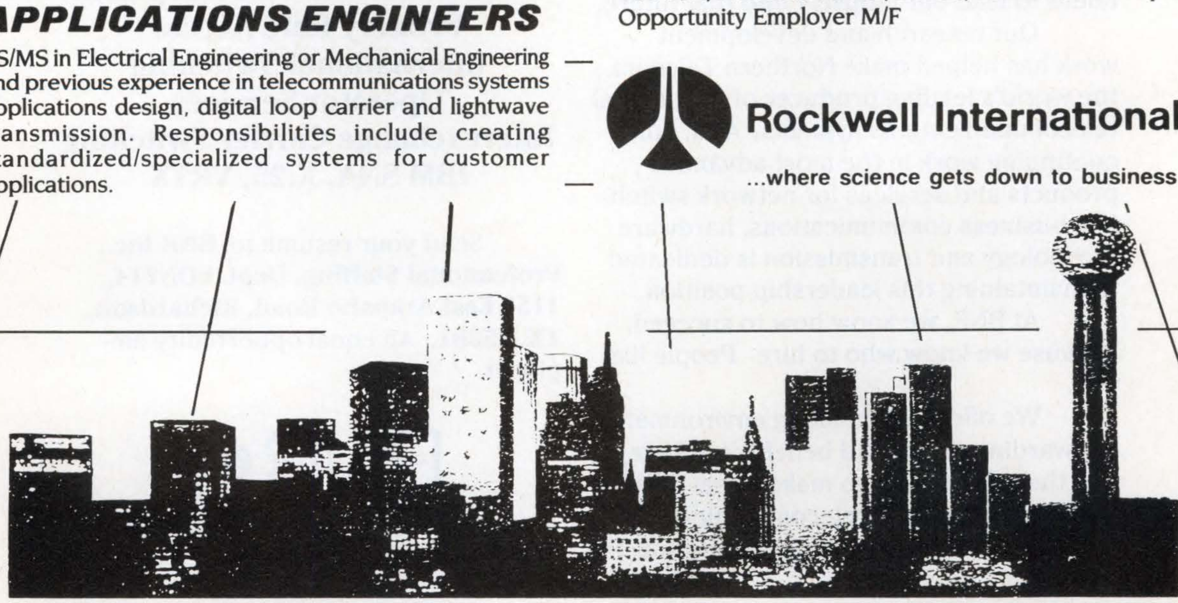

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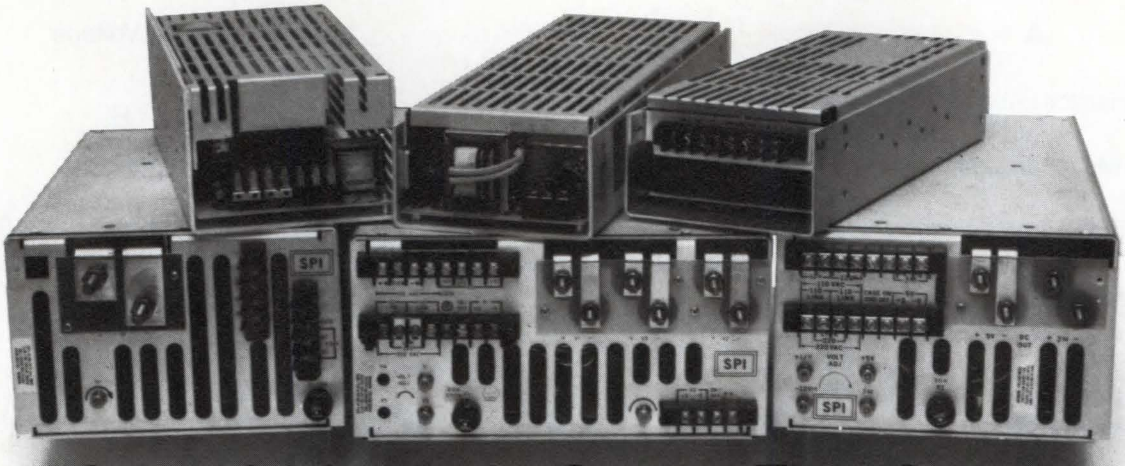

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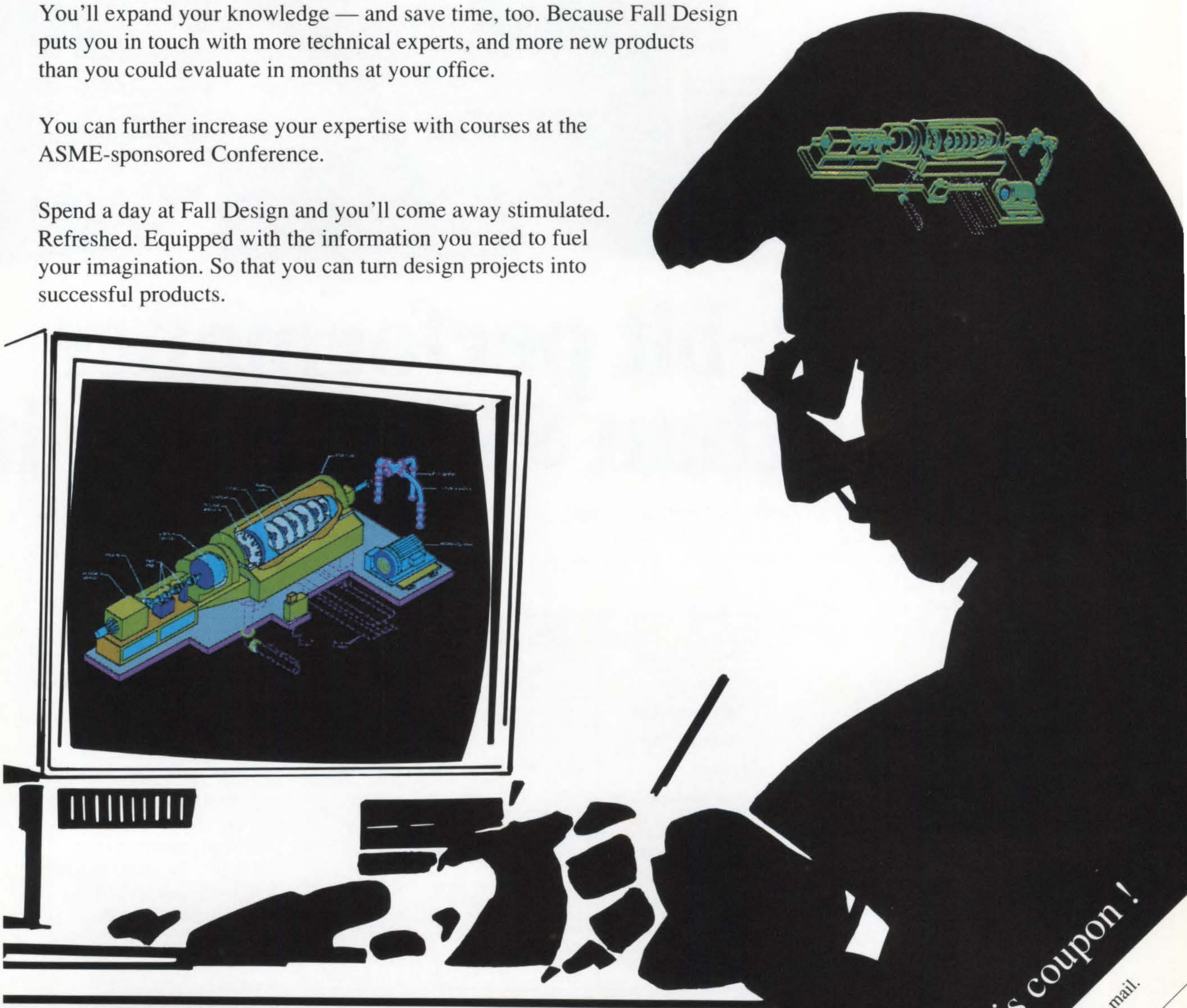

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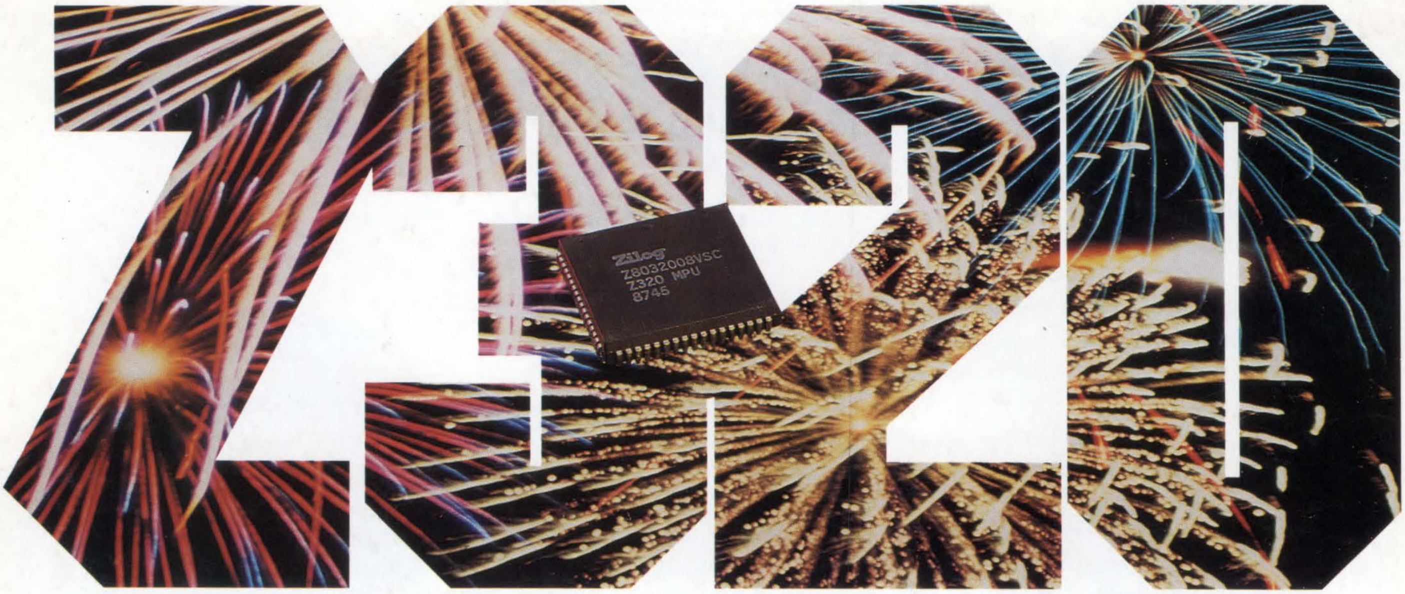

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What's the catch?

There isn't any. The Z320 gives you everything you expect from a 32-bit chip. In fact, the Z320 offers plenty you don't get with most of the high-priced 32-bit offerings: a dual-ported cache for instructions and data, a demand paged virtual memory management system, dual execution in the six-stage pipeline with two ALUs, dual-port access to a large general purpose register file, programmable wait states, and bus-width for two areas in memory, I/O and interrupts, bus scaling that allows cost memory, to mention just a few.

	Z320™	80386	68030
Die Size (K sq mil)	106	160	160
Transistors (K)	93	275	270
Clock Speed (MHz)	10	16	20
Max Power (Watts)	3.5-4	2.5	2-2.5
Package	68 PLCC	132 PGA	124 PGA
Multiplexed Add/Data	YES	NO	NO
Bus Scaling	YES	NO	NO
Max Memory Access (No Wait States)	200 NS	67 NS	45 NS
Prog. Wait States	YES	NO	NO
Performance Range (MIPS)	2-5	2-5	4-8
Price Range	$25-50	$150-600	$500-550

The choice is clear.

How can you do it so cheap?

First of all, the Z320's HMOS technology is less expensive. And the smaller PLCC package and lower transistor count give you savings without giving up crucial performance. In short, the Z320's technology offers full 32-bit performance for the price of the aging 286.

Why are you doing this?

The real question is, "Why isn't anybody else producing an affordable 32-bit microprocessor?" We designed the Z320 to open the door to 32-bit performance for any cost-sensitive applications that can use 32-bit engines as peripheral processors or as embedded, non-programmable processors. Laser printers, copiers, synthesizers, for instance.

There's a lot more to tell you about the unbelievable Z320. But affordable 32-bit performance, off the shelf, backed by Zilog's proven quality and reliability ought to give you something to think about. Contact your local Zilog sales office or your authorized distributor today. We'll make a believer out of you. Zilog, Inc., 210 Hacienda Ave., Campbell, CA 95008, (408) 370-8000.

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