A CAHNERS PUBLICATION

APRIL 27, 1989

EDN®

SPECIAL ISSUE:
Communications Technology

Attenuators solve transmission problems

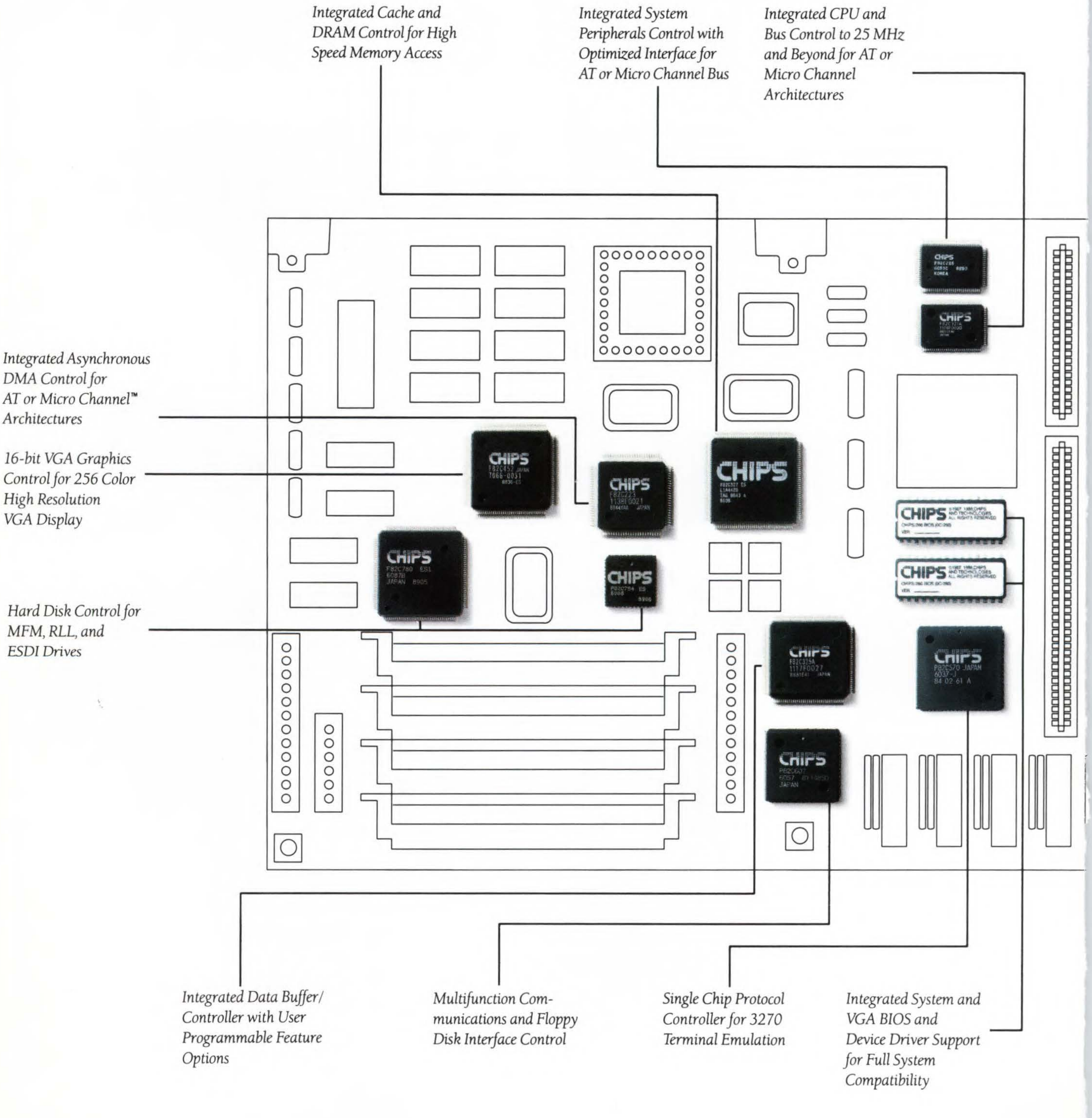
ISDN ICs

10M-bps twisted-pair Ethernet standard

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS

User-programmable gate arrays put logic functions at your fingertips

Put mor


Integrated Cache and DRAM Control for High Speed Memory Access
Integrated System Peripherals Control with Optimized Interface for AT or Micro Channel Bus
Integrated CPU and Bus Control to 25 MHz and Beyond for AT or Micro Channel Architectures
Integrated Asynchronous DMA Control for AT or Micro Channel™ Architectures
16-bit VGA Graphics Control for 256 Color High Resolution VGA Display
Hard Disk Control for MFM, RLL, and ESDI Drives
Integrated Data Buffer/ Controller with User Programmable Feature Options
Multifunction Communications and Floppy Disk Interface Control
Single Chip Protocol Controller for 3270 Terminal Emulation
Integrated System and VGA BIOS and Device Driver Support for Full System Compatibility
CHIPS

There is only one way to get more out of your AT, PS/2 or laptop design.

SIEMENS

Perfectly Balanced CMOS A/D Converters

In the eternal balancing act between speed, accuracy and cost-effectiveness, nothing comes closer to perfection than the Siemens family of A/D converters.

With speeds as fast as 13μs, and a total unadjusted error of only ±0.5 LSB over the entire temperature range, they're at the top of their class in performance. And when it comes to balancing costs, their flexibility and upgradability put them in a class by themselves.

Take our 12-bit SDA 0812. It's self-calibrating, so you can eliminate those time-consuming, labor-hungry trimming parts. It's fast (17μs). It also has a four-channel input multiplexer and 12-bit data output in a 2-byte format. Put it

TYPE	BITS	SPEED	ACCURACY*	TEMP RANGE	FEATURES
SDA 0812	12	17μs	±0.5 LSB	-40°C/+85°C	Self-calibrating
SDA 0810	10	15μs	±0.5 LSB	-40°C/+125°C	Software-upgrade of 8-bit to 10-bit systems
SDA 0808	8	13μs	±0.5 LSB	-40°C/+125°C	Faster and more accurate than the industry standard

*Total Unadjusted Error (TUE) over entire temperature range

all together and it's a perfectly balanced choice for your high-performance applications.

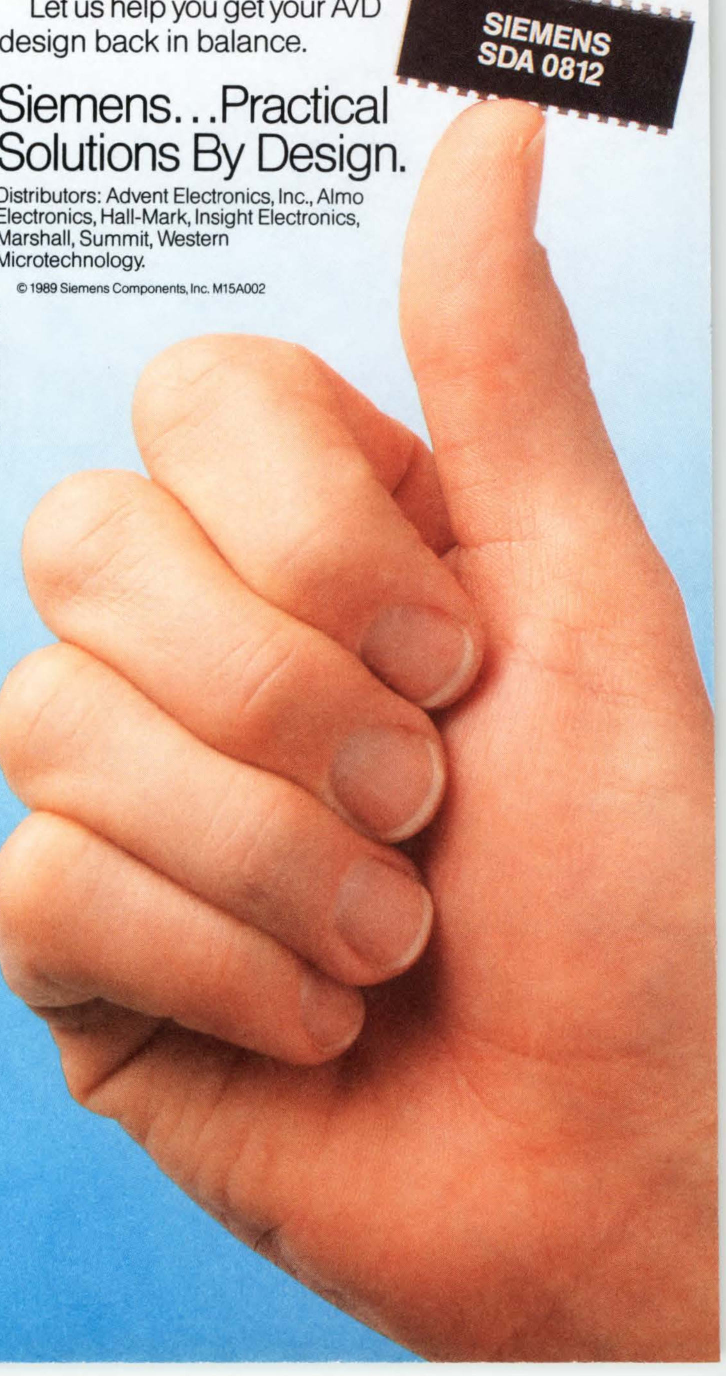
For an ideal balance between low and medium resolution requirements, our SDA 0808 and SDA 0810 both feature an 8-channel input multiplexer and are 100% pin-compatible with the ADC 0808 converters. In fact, you can even upgrade from 8- to 10-bit resolution by simply changing parts and adding a few lines of source code.

Find out more by calling 408-980-4500, ext. 4577. Or write Siemens Components, Inc., Consumer ICs, 2191 Laurelwood Road, Santa Clara, CA 95054-1514.

Let us help you get your A/D design back in balance.

Siemens...Practical Solutions By Design.

Distributors: Advent Electronics, Inc., Almo Electronics, Hall-Mark, Insight Electronics, Marshall, Summit, Western Microtechnology.



CIRCLE NO. 2

Super Amplifier

2.5KHz to 500MHz 250mW *only* $199

POWERFUL up to +23dBm undistorted output

FLAT within 1dB over the entire band. 2.5KHz to 500MHz

UNCONDITIONALLY STABLE regardless of load

DAMAGE-RESISTANT built-in voltage regulator; supply voltage 24V, 0.35A

RUGGED operates from −55 to +85° C, withstands shock and vibration, ground equipment

COMPACT only 3.75 by 1.8 by 2.6 in.

Packed with these super performance features, 22dB flat gain and a typical VSWR of 1.3 to 1, the ZHL-6A amplifier is ideally suited for your latest broadband systems designs. And where space is critical, its height can be cut in half, to only 0.9 in., by removing the heat sink and attaching the unit to your chassis.

Running tests in your lab or on the production line covering all or segments of the 2.5KHz to 500MHz range and need more output from sweep or signal generators? It's not necessary to purchase and connect/disconnect an assortment of amplifiers when the ZHL-6A does it all...at an attractive price of only $199.

For a super price/performance amplifier, order a ZHL-6A, available for immediate delivery with a one-year guarantee.

finding new ways...
setting higher standards

Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

AMERICAN EXPRESS

F127 REV. ORIG.

CIRCLE NO 9

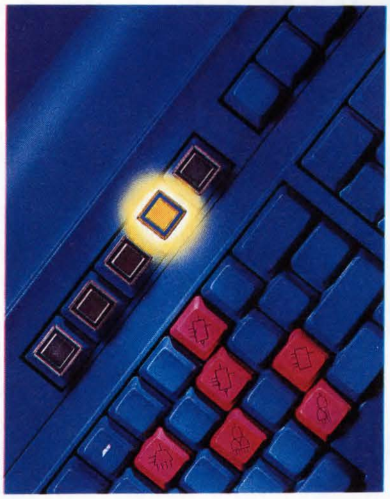
MCL
KSW2-
46

Volume 34, Number 9

EDN Magazine Edition

April 27, 1989

ELECTRONIC TECHNOLOGY FOR ENGINEERS AND ENGINEERING MANAGERS



On the cover: *Using the latest generation of user-programmable logic devices could be the key to your next successful design. See the Special Report, which begins on pg 146. (Photo courtesy Actel; concept and photography by Imagination; keyboard provided by KeyTronic)*

SPECIAL ISSUE: COMMUNICATIONS TECHNOLOGY

SPECIAL REPORT

User-programmable gate arrays — 146

The first generation of programmable logic devices (PLDs) allowed you to vacuum up five or 10 TTL devices into one package. The latest programmable devices, FPGAs, can replace many more TTL devices.—*Charles H Small, Associate Editor*

DESIGN FEATURES

Design linear circuits that serve digital system needs — 165

Digital circuits require a slew of analog support circuits to provide life support in the real world. Many of these functions are related to memory support and range from power-sense circuits to voltage supplies for programming onboard, nonvolatile memories.—*Jim Williams, Linear Technology Corp*

Designer's guide to dynamic RAMs—Part 3 — 183

To implement a DRAM system, you need a DRAM controller, which acts as a liaison between the CPU and the DRAM. This article, part 3 of a 4-part series, presents the basics of DRAM-controller design. Parts 1 and 2 of this series introduced the fundamentals of DRAMs and the architectural options available to the DRAM-system designer. Part 4 will consider DRAM-board layout.—*Robert Adams and Gregory Scavone, Texas Instruments*

Hybrid-IC techniques increase power in motor-drive circuits — 195

Thick-film, hybrid-circuit motor drivers not only let you save board space, but also preserve the motor-drive ICs' overtemperature protection and provide a high drive output.—*Ed Goodell, Omnirel Corp*

Continued on page 7

EDN®(ISSN 0012-7515) is published 49 times a year (biweekly with 2 additional issues a month, except for February, which has 3 additional issues and July and December which have 1 additional issue) by Cahners Publishing Company, A Division of Reed Publishing USA, 275 Washington Street, Newton, MA 02158-1630. Terrence M McDermott, President; Frank Sibley, Senior Vice President/General Manager, Boston Division; Jerry D Neth, Vice President/Publishing Operations; J J Walsh, Financial Vice President/Magazine Division; Thomas J Dellamaria, Vice President/Production and Manufacturing. Circulation records are maintained at Cahners Publishing Company, 44 Cook Street, Denver, CO 80206-5800. Telephone: (303) 388-4511. Second-class postage paid at Denver, CO 80206-5800 and additional mailing offices. POSTMASTER: Send address corrections to EDN® at the Denver address. EDN® copyright 1989 by Reed Publishing USA; Saul Goldweitz, Chairman; Ronald G Segel, President and Chief Executive Officer; Robert L Krakoff, Executive Vice President; William M Platt, Senior Vice President. Annual subscription rates for nonqualified people: USA, $105/year; Canada/Mexico, $125/year; Europe air mail, $150/year; all other nations, $150/year for surface mail and $230/year for air mail. Single copies are available for $10. Please address all subscription mail to Eric Schmierer, 44 Cook Street, Denver, CO 80206-5800.

Introducing surface-mount optocouplers ready for action.

HP's new family of high-reliability military optocouplers in 20-terminal LCC packages are the perfect choice for all your high-performance surface-mount applications.

Measuring just .350 inch square, our new 20-terminal LCC gives each channel of the dual-channel configuration full circuit independence. All in the industry's smallest standard leadless chip carrier.

Which makes it ideal for lightweight, compact systems with high component density.

While it's small in size, it's big in performance. You get high-output gain from low-input current or high-speed logic gates with data rates up to 20 Mbaud. Wide Vcc from 4.5 to 20 volts. And a unique AC/DC logic interface.

Our new family of surface-mount hermetic optocouplers are built to deliver the same high quality and reliability you've come to expect from our 16-pin and 8-pin hermetic optocouplers.

HP is a qualified manufacturer of these custom hybrid microcircuits. And all of our optocouplers meet tough DESC requirements.

If you'd like to know more about HP's new family of hermetic optocouplers in 20-terminal LCCs, just circle the reader service number. We'll show you how easy it is to take action.

HEWLETT PACKARD

CG08803

CIRCLE NO 11

Continued from page 5

***You can now find U-interface ICs** from a variety of manufacturers (pg 53).*

TECHNOLOGY UPDATE

ISDN ICs: The U interface comes of age 53

Most of the issues involving the U interface have been resolved by the standards committees. However, resolving the issues doesn't mean that there is a unifying standard.—*Michael C Markowitz, Associate Editor*

10M-bps twisted-pair Ethernet: An Ethernet LAN standard emerges 73

Before long, board and system designers may have to contend with designing local-area-network (LAN) interfaces based on the emerging IEEE-802.3 10BaseT standard, which will allow data transmission over standard phone lines at 10M bps.—*David Shear, Regional Editor*

Attenuators solve transmission problems 93

Digitally programmable attenuators are useful for almost any application in which you need to control signal-amplitude levels. —*Tom Ormond, Senior Editor*

Micropower op amps hit new lows 117

You no longer need to sacrifice dc performance for low power consumption when you design with micropower op amps. These devices are now available with input offset voltages as low as 5 μV and input offset drifts of 0.05 μV/°C.—*Peter Harold, European Editor*

PRODUCT UPDATE

60-MHz operational amplifier 135
DSP debugger 136
SCSI-2 disk-drive-array controller board 138
5¼-in. Winchester drives 140

DESIGN IDEAS

Self-biasing reference consumes low power 219
Single cell lights LED 220
Amplifier handles duplex line 221
Single-chip μP acquires Basic 221
Reactive limiter protects transformer 224

Continued on page 9

Cahners Publishing Company, A Division of Reed Publishing USA □ Specialized Business Magazines for Building & Construction □ Manufacturing □ Foodservice & Lodging □ Electronics & Computers □ Interior Design □ Printing □ Publishing □ Industrial Research & Technology □ Health Care □ and Entertainment. Specialized Consumer Magazines: □ American Baby □ and Modern Bride.

Continued from page 7

EDITORIAL 45

Patents on mathematical formulas and algorithms may block innovation rather than foster it.

NEW PRODUCTS

Computers & Peripherals 237
Integrated Circuits 244
Components & Power Supplies 256
CAE & Software Development Tools 264
Test & Measurement Instruments 270

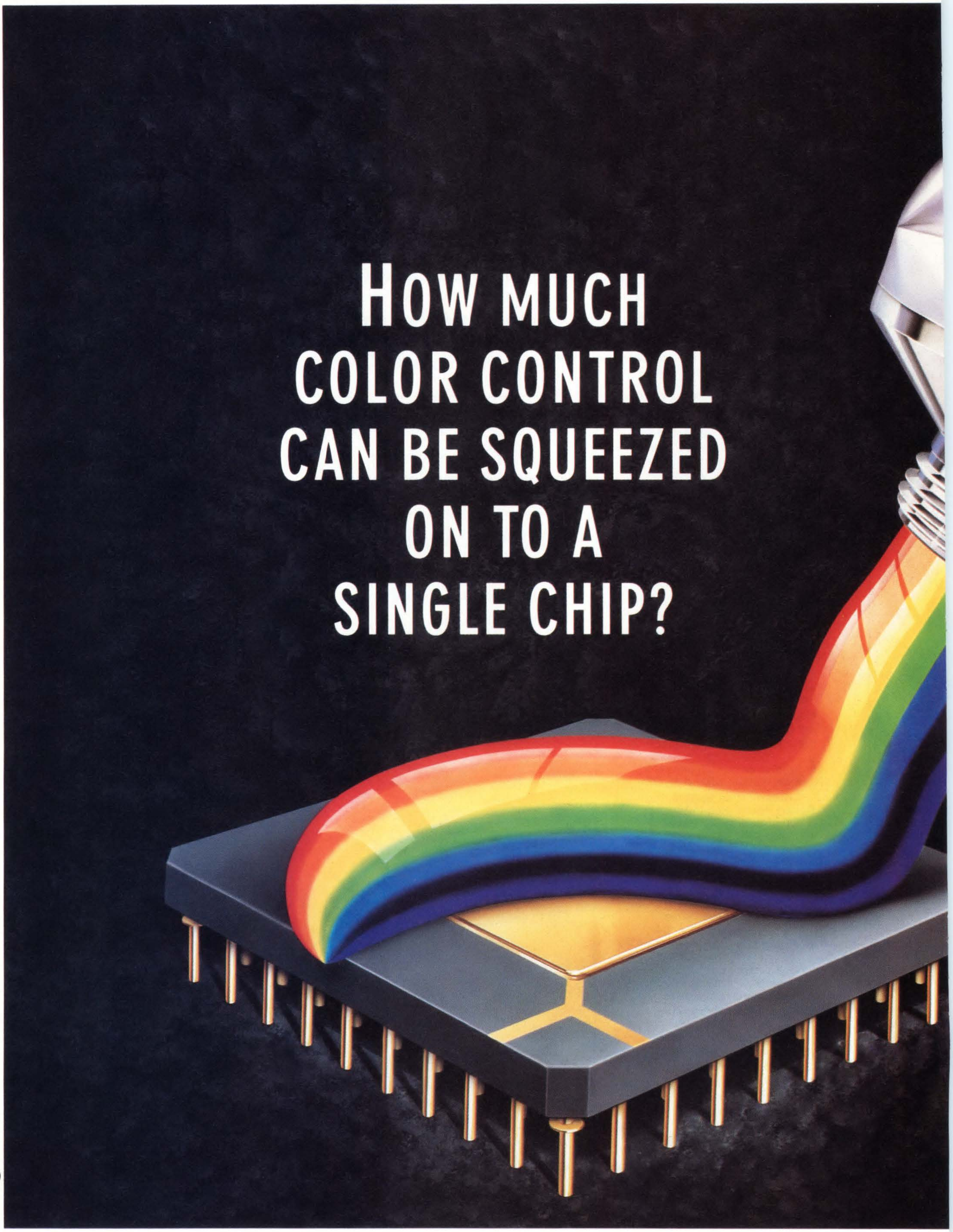
LOOKING AHEAD 303

RISC μPs to skyrocket to sales of $600M in 1993 . . . World CD market to grow to $10 billion in 1989.

DEPARTMENTS

News Breaks 21
News Breaks International 24
Signals & Noise 35
Leadtime Index 132
Literature 296
Career Opportunities 290
Business/Corporate Staff 298
Advertisers Index 300

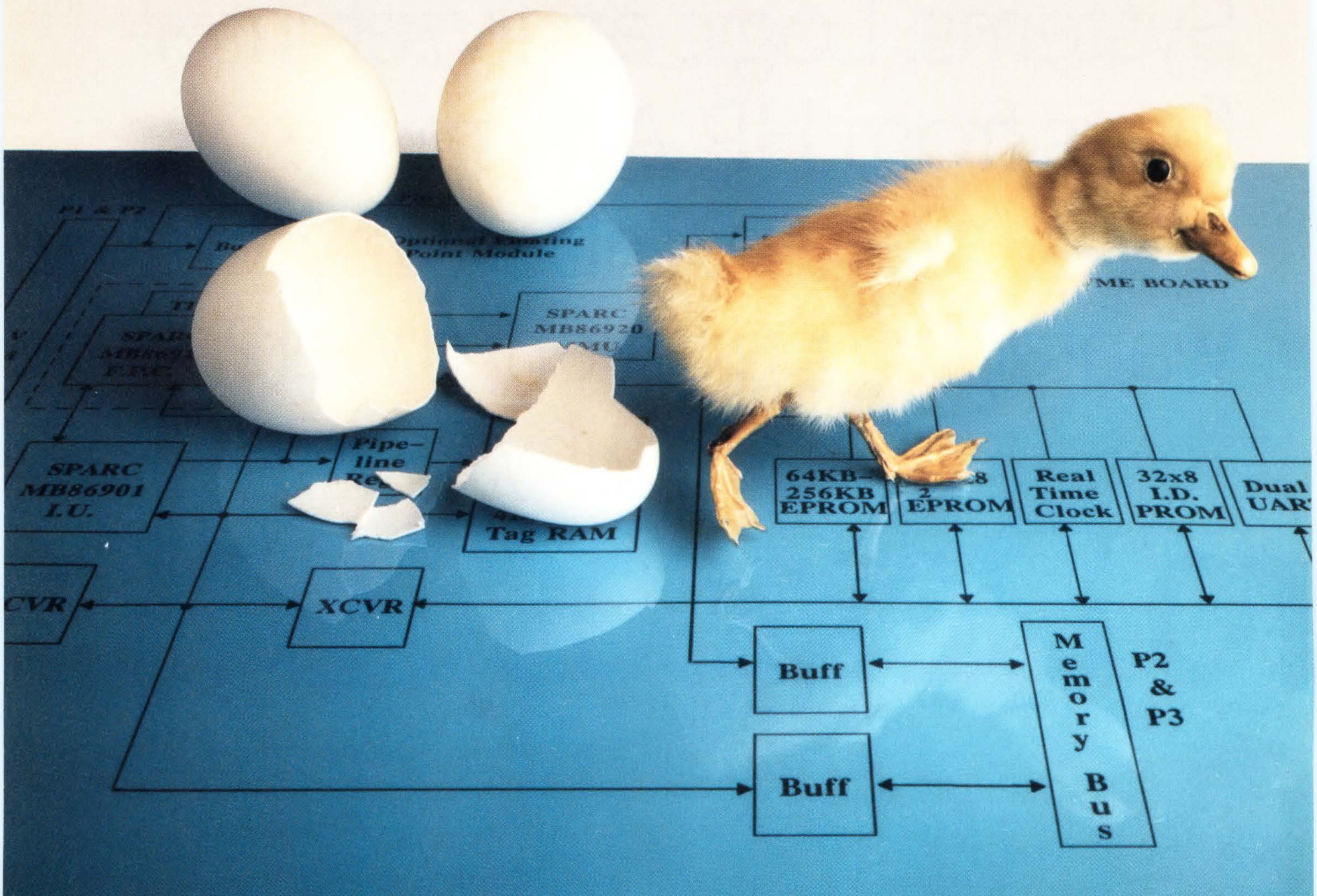
G300 CVC • PROGRAMMABLE VIDEO TIMING GENERATOR • COLOR LOOK-UP TABLE •



Baltimore (301) 995 6952 New York (914) 897 2422 Denver (303) 368 0561 Santa Clara (408) 727 7771 Atlanta (404)

CIRCLE NO 14

Fujitsu's new RISC chip-computer development.



set speeds up your

Break out!

Get your computer to market before your competitors.
When you need to be first, nothing helps more than getting a head start. And nothing will get you started faster than these new SPARC™ devices from Fujitsu.

Not just a speedy microprocessor—but a complete high performance RISC chip-set. One that accelerates the development cycle of powerful minis, PCs and workstations. And eliminates many components plus the time it takes to integrate them. Yet, offers a high degree of design flexibility.

A complete chip-set to speed up your product development.
Fujitsu's new S-25™ chip-set includes a 25 MHz, 32-bit Integer Unit (IU) for high-speed processing. A Memory Management Unit (MMU) ideal for the UNIX® environment and tailored for SPARC processors. And a Floating Point Controller (FPC) that allows interface to the IU and supports IEEE single and double precision arithmetic.

In addition, these devices are fully supported by a wide range of hardware and software development tools.

MB86901 (IU)	MB86911 (FPC)	MB86920 (MMU)
■ 25 MHz ■ 40 ns / cycle ■ 15 MIPS	■ Single & double precision floating point arith. ■ ANSI / IEEE 754-1985 std. ■ 64-bit int. data paths	■ 64-entry TLB ■ Fully associative ■ 64-Gbyte physical address

A proven architecture from a proven supplier.
SPARC is multi-sourced and proven over time. We first implemented it for the Sun 4/200 workstation over two years ago and have been producing it in volume ever since. Using the same Fujitsu manufacturing know-how that has made us a world leader in gate array and memory production.

The S-25 chip-set is a third-generation product designed at our Advanced Products Division in Silicon Valley. Where our engineering teams continue to advance the state-of-the-RISC-art—supported by the resources of a multi-billion dollar worldwide organization.

Break outs—without breakdowns!
Enjoy the competitive advantage of getting to market first! Rely on an architecture and supplier who can get you there. On time. On spec. On budget.

When you want to be first, we're the first ones to call.
(800) 523-0034

FUJITSU

FUJITSU MICROELECTRONICS, INC.

Advanced Products Division

50 Rio Robles, Bldg. 3, San Jose, CA 95134-1804

CIRCLE NO 15

With high-performance design system helps you

Now There's No Compromise Between Functionality And Integration With Our Complete IC Logic, Layout, And Analysis Toolset.

It's an uncompromised, netlist-driven toolset putting you in the driver's seat to faster IC design times. We've combined the industry's most powerful circuit design and analysis tools, with the most widely used layout tools.

That means complete integration between tools, as well as between your design and engineering teams. And it all runs in your networked EDA environment — whether you work on a Sun, Digital, or any other popular platform. So you can combine Valid's high-performance tools with any of your existing tools to extend and protect your investment.

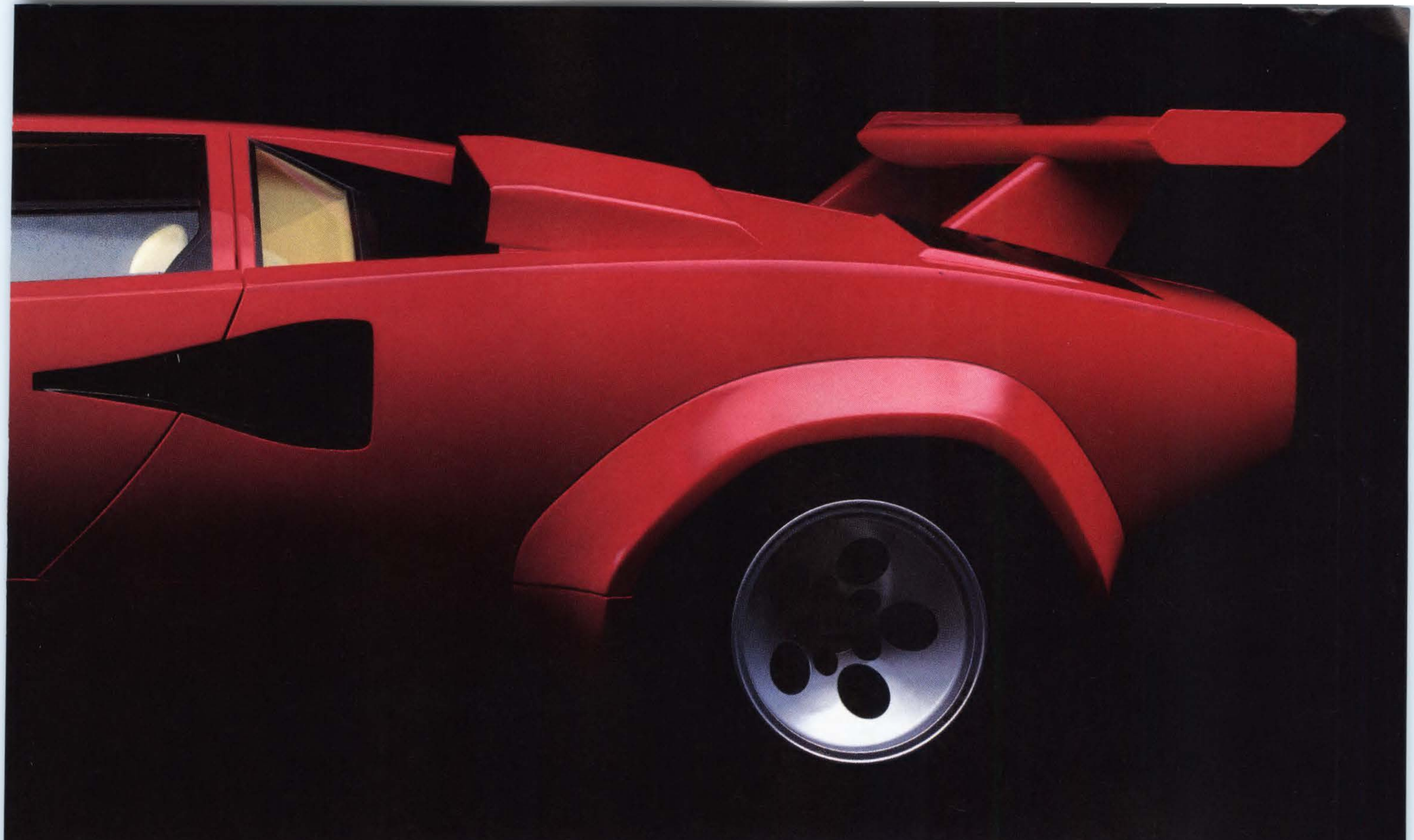
The result is increased productivity, and the certainty of winning the race to market.

The High-Performance Valid Toolset.

Logic design begins with Valid GED,™ an easy-to-use schematic capture system that accelerates design entry. It lets you graphically express designs at any level of hierarchy including block diagrams and flat schematics. Captured designs can be graphically verified with Advantage™ using the same procedures, terminology, and symbols as traditional workbench methods to address your analog design requirements.

For functional and timing analysis, use our ValidSIM™ tool. You can also link our RapidTEST fault simulator to get smooth, efficient fault analysis prior to test.

For layout of block and cell-level design, there's our ValidLED™ editor that gives you complete transistor-level editing. And there's also our powerful, user-configurable EDS III editor, with direct compatibility to GDS II databases.



front-to-back, Valid's IC win the race to market.

EPL, our versatile and interactive user-programming language lets you automatically create difficult and complex geometries. For chip assembly, there's our Compose™ environment. It's netlist-driven and accepts pre-defined cells or blocks from any library. All of which means you can automatically place, route, and compact any design, and guarantee correct-by-design layouts.

For analysis there's ValidDRC/EXTRACT™ which provides hierarchical verification tools, and Valid-COMPARE™ gives you an interactive logic-to-layout verifier.

Integrated into our toolset is TIMEMILL™ for transistor level simulation directly from your layout. It gives you event-driven timing simulation and critical path analysis so you can tackle large, high-speed IC designs quickly and accurately. And for CAM outputs, just link your designs to our Fast Mask Software (FMS). It provides both optical and electron beam pattern generation, as well as high-speed electrostatic plotting.

Together, the Valid IC design system gives you the performance needed to finish far ahead of the competition.

For more control, greater productivity, and no compromises, call Valid today and bridge the gap between functionality and integration: 1-800-821-9400 (In California, 408-432-9400 ext. 2311). Let us put you in the driver's seat of high-performance IC design.

VALID

Even though our products have been to Jupiter and beyond, you can still find them out in your garage.

Whether it's one of the switches in your automobile, or connectors used in space exploration, you'll find the products of ITT ElectroMechanical Components Worldwide everywhere.

With seventy-five years of leadership in the electronics industry, ITT EMC Worldwide is one of the world's leading suppliers of electronic components. With manufacturing facilities, engineering centers and customer service representatives in virtually every part of the world.

Our history is one of innovation, and ever-increasing capabilities. That's precisely why many of our products go on to become industry standards.

At ITT EMC Worldwide, we build reliability into every product we sell. That's why you'll find us in everything from appliances to satellites.

Our philosophy of "building in" quality control and testing means that you get the best possible product, every time. What's more, ITT EMC Worldwide manufactures and sells quality test accessories, to assist you in building a quality product as well.

No matter where in the world you are, chances are we have an office nearby. So drop us a line today. Even though we're an international company, we may be closer than you think.

1851 East Deere Avenue
Post Office Box 35000
Santa Ana, CA 92705-6500
Or call (714) 261-5300

ITT ElectroMechanical Components Worldwide
Discover our strengths.

CIRCLE NO 16

FLUKE AND PHILIPS – THE GLOBAL ALLIANCE IN TEST & MEASUREMENT

FLUKE®

PHILIPS

Finally! The one thing you've always wanted in a low-cost logic analyzer: No restraint.

The Philips PM 3655. It's the first *true* 100 MHz logic analyzer for under $10,000! That means it comes with a feature no other low-cost analyzer in the world can offer you: Freedom to use 100% of its capability 100% of the time.

UNRESTRAINED PERFORMANCE

- *High-speed timing and state analysis:* Get full 100 MHz synchronous and asynchronous sampling on up to 96 channels. And never again sacrifice width for speed.
- *Deep memory:* 2K memory depth per channel lets you measure complex data flows—with no loss of width, speed or glitch capturing potential.
- *GLITCH mode:* 5 ns glitch capture at 100 MHz on all channels. Again, without forfeiting speed, width or depth.
- *Flexible triggering plus Trace:* Powerful, multi-level triggerword sequence, range recognition and four clock qualifiers help you find and display exactly the data you're looking for.
- *Expandability:* Add 24-channel modules any time for 24, 48, 72 or 96 channel configurations.
- *Broad support:* Choose from a wide range of disassemblers and dedicated personality modules.

SIMPLE OPERATION PLUS PC

- *Immediate familiarity:* All this capability and so easy to use—menu-driven operation; extensive user-defined labeling; and standard PC-style keyboard interface.
- *Plus full MS-DOS-based PC:* Adds versatility and value without compromising logic analysis. On-line disk storage for measurement data and instrument set-ups. Expansion slots for extra memory, modem or other PC options.

UNRESTRAINED SUPPORT

Count on a one-year warranty and all the application and service assistance you'll ever need. From Fluke—the people who believe that extraordinary technology deserves extraordinary support.

TEST THE DIFFERENCE

Call Fluke today at **800-44-FLUKE ext. 77**. And look into a logic analyzer that unleashes your potential instead of tying your hands.

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

PM 3655 • 100 MHz • LOGIC ANALYZER

FLUKE®

CIRCLE NO 17

NEWS BREAKS

EDITED BY JOANNE DE OLIVEIRA

INTEL INTRODUCES THE 80486 CPU

Soon after the release of its 80860 RISC processor, Intel Corp (Santa Clara, CA, (408) 987-8080) announced the availability of its long-awaited 80486 32-bit CISC processor. The 486 is 100% binary compatible with the existing 386 CPU. Implemented in 1-μm technology, the 486 contains over one million transistors and integrates the functions of a 387 numeric coprocessor and an 82385 cache controller as well as paging and memory management. Intel claims the chips offer a twofold to fourfold performance increase over the popular 386/387 combination. The 486 has a 32-bit internal architecture and 32-bit data and address buses. At 25 MHz, the 486 operates at 15 to 20 VAX MIPS and executes 37,000 Dhrystones/sec. Samples of the 486 will be available in the third quarter of 1989; production quantities will be available in the fourth quarter. Beta-site testing of first-run samples is now taking place. The 486, which will initially be available in a 25-MHz version, costs $950 (1000) and comes in a 168-pin PGA package. Samples of a 33-MHz version will be available in the fourth quarter.

Along with the 486, the company has introduced the 82596 LAN coprocessor and the 85C508 programmable logic device (PLD). The 32-bit 82596 LAN coprocessor is optimized for file servers and single-user and multiuser workstations and minicomputers. The 82596CA (for the 486) costs $88; the 82596DX (for the 386) costs $65 (1000). Samples are available now; production quantities will be available in the fourth quarter. The 85C508 PLD provides high-speed, function-specific performance to reduce the interface-chip count in 486 and 33-MHz 386 systems. Packaged in a 28-pin PLCC, the 85C508 costs $14 (1000); production quantities are available now.

—Dave Pryce

32-BIT CONTROLLER FEATURES INTELLIGENT 16-BIT TIMER

The 68332 32-bit microcontroller from Motorola's Microprocessor Products Group (Austin, TX, (512) 891-3260) is the first member of the 68300 family, a group of controllers specifically designed for embedded applications. The 68332's features were defined by a joint effort between Motorola and Delco Electronics, and General Motors has announced plans to utilize the 332 to manage a variety of automotive-control functions in its next generation of automobiles. The 332 consists of five modules: a processing core based on the 68020 microprocessor with additional instructions optimized for embedded-control applications, a second processing unit that services timing events, a module that provides full synchronous and asynchronous communication capability, a system-integration module that reduces external logic components and provides on-chip system-debugging capability, and 2k bytes of static RAM. The two processing units, the CPU and the TPU (time processing unit), are completely independent; the TPU's RISC-like instruction set can simultaneously service as many as 16 timing events without the CPU's intervention. The modular architecture of the 68332 enables Motorola to interchange a host of features and options for different applications. Future 68300 products that are currently under development include EEPROM, DMA, A/D, and ROM products. The 68332 is fabricated in 1-μm CMOS and operates from a 5V supply. The controller requires an input clock of 32.75 kHz; on-chip frequency-multiplication circuitry creates an internal clock of 16.77 MHz. The 68332 comes in a 132-pin plastic quad flat pack. Samples are available for $125; volume production will begin in the fourth quarter of 1989. A hardware evaluation board is available for $332.—Anne Watson Swager

NEWS BREAKS

GRAPHICAL SOFTWARE LINKS ASIC DESIGN TO TEST

Tektronix (Beaverton, OR, (800) 245-2036) has announced a graphics-based software link between ASIC design and test. It allows you to display stimulus files as state or timing diagrams and to edit them extensively. In its initial release, the $5000 Tekwaves package runs on Apollo workstations and supports Tektronix's LV500 ASIC verifier. The software can import files created by simulators from Mentor, Daisy, Valid, Teradyne, and GenRad. It uses tester-hardware description files in a not-yet-final version of EDIF (the Electronic Data-Interchange Format). Currently, only the LV500 is described in this format, but Tektronix expects that other ATE vendors will make EDIF tester-description files available as soon as the format becomes final. Furthermore, Tektronix plans to offer the software in versions that run on additional vendors' workstations. These enhancements should make Tekwaves suitable for use in almost any company that designs or tests ASICs.

—Dan Strassberg

INTEL WINS EPROM EXCLUSION ORDER

The International Trade Commission (ITC) has ruled that Intel's patents on EPROM technology have been infringed. ITC issued an exclusion order preventing seven companies from importing and selling certain EPROM devices in the US. The seven companies are All-American Inc, Atmel Corp, Cypress Electronics Inc, General Instrument Corp, Hyundai Electronics Industries Co Ltd, Microchip Technology Inc, and Pacesetter Electronics Inc. The ruling prohibits importing, assembling, testing, marketing, distributing, and selling of the affected EPROMs. The products in question are the 64k-, 256k-, 512k-, and 1M-byte EPROMs. The ruling further prohibits the importation of Hyundai electronic equipment containing such EPROMs.

—Richard A Quinnell

SUPPORT FOR SCANNABLE DESIGNS GROWS IN BOARD AND ASIC TEST

As final adoption of the IEEE P1149 testability-bus standard nears, two companies whose products are in the mainstream of board test and ASIC verification have announced products that support the testing of scannable designs. (The term "scannable" refers to several specific design-for-test methodologies.) Teradyne Inc (Boston, MA, (617) 482-2700) has announced a $20,000 software package called BSD (boundary-scan diagnostics) that can be used with its L200 combinational (functional/in-circuit) board-test systems. The BSD package specifically addresses the problem of fault isolation. Asix Systems Corp (Fremont, CA, (415) 656-8664) has announced a scan-test module, a $50,000 combination of hardware and software that can be used with its Asix-1 ASIC-development system and Asix-2 production test system. Teradyne and Asix join Gillytron Inc (San Jose, CA, (408) 435-3043), in supporting the testing of scannable parts. Several months ago, Gillytron, a relatively new company, announced complete, low-cost systems dedicated to the testing of scannable devices.

—Dan Strassberg

100-MHz LOGIC ANALYZER BREAKS THE £1000 PRICE BARRIER

Including two TTL-level data pods, the LA3200 32-channel, 100-MHz logic analyzer from Thurlby Electronics Ltd (St Ives, UK, TLX 32475) costs £996. A 48-channel version of the analyzer, designated the LA4800, costs £1195. In synchronous (state-analysis) mode, the instruments provide three external clock inputs, each with a separate clock qualifier and a maximum input frequency of 25 MHz. In asynchronous (timing-analysis) mode, they can capture data on all input channels at an internal clock rate as high as 25 MHz, or data on eight of the input channels at a clock rate of 100 MHz. With suitable data pods, they can also capture glitches.

Each input channel is configurable to a memory depth of 1k or 8k bits, and you can transfer captured data into two nonvolatile reference memories. The logic analyzer's trigger facilities include four full-width trigger words that you can logically combine to produce trigger terms for the instrument's 4-step trigger sequencer. The trigger sequencer allows you to introduce conditional statements—for example, IF-THEN-ELSE commands—and includes event counting at each of its four steps. You can also AND glitch words with the trigger words. Trigger arming can be conditional on the result of a comparison between the trace and reference memories. The analyzers have a 640×200-pixel, back-lit LCD on which you can display state information in a variety of formats, or display as many as 16 annotated timing traces. An RS-423 interface is standard. Options include an IEEE-488 interface and a range of disassemblers for 8- and 16-bit μPs.—Peter Harold

LCD-DRIVER CHIP SET OPERATES AT VERY LOW POWER

Capable of operating at a number of multiplex rates, and drawing only 20 μA of supply current, the PCF8578 row/column driver can drive 8-row×32-column or 32-row×8-column dot-matrix LCDs. The chip set is equally suited to driving 7-segment LCDs, starburst LCDs, and LCDs of other formats. By adding PCF8579 column drivers, each of which typically adds only another 20 μA to the total amount of current drawn, you can drive an LCD as large as 32×1280 pixels at a multiplex rate of 1:32. Each PCF8579 controls 40 LCD columns.

The devices, manufactured by Philips' Components Div (Eindhoven, The Netherlands, TLX 35000; in the US: Signetics Corp, Sunnyvale, CA, (408) 991-2000, incorporate a pixel-mapped display RAM, which can, if required, double as scratch-pad memory. Display refreshing is automatic, and the on-chip display RAM features autoincrement addressing and display bank switching. The drivers have an I^2C bus interface for overall control of display-system parameters. They operate from a 2.5 to 6V supply over the −40 to +85°C temperature range. The drivers are available in 56-lead surface-mounting very-small-outline packages, or in a form suitable for tape-automated bonding or chip-on-glass assembly methods. Both devices are priced at around $3.30 (50,000).—Peter Harold

21st Century CMOS Technology, NOW

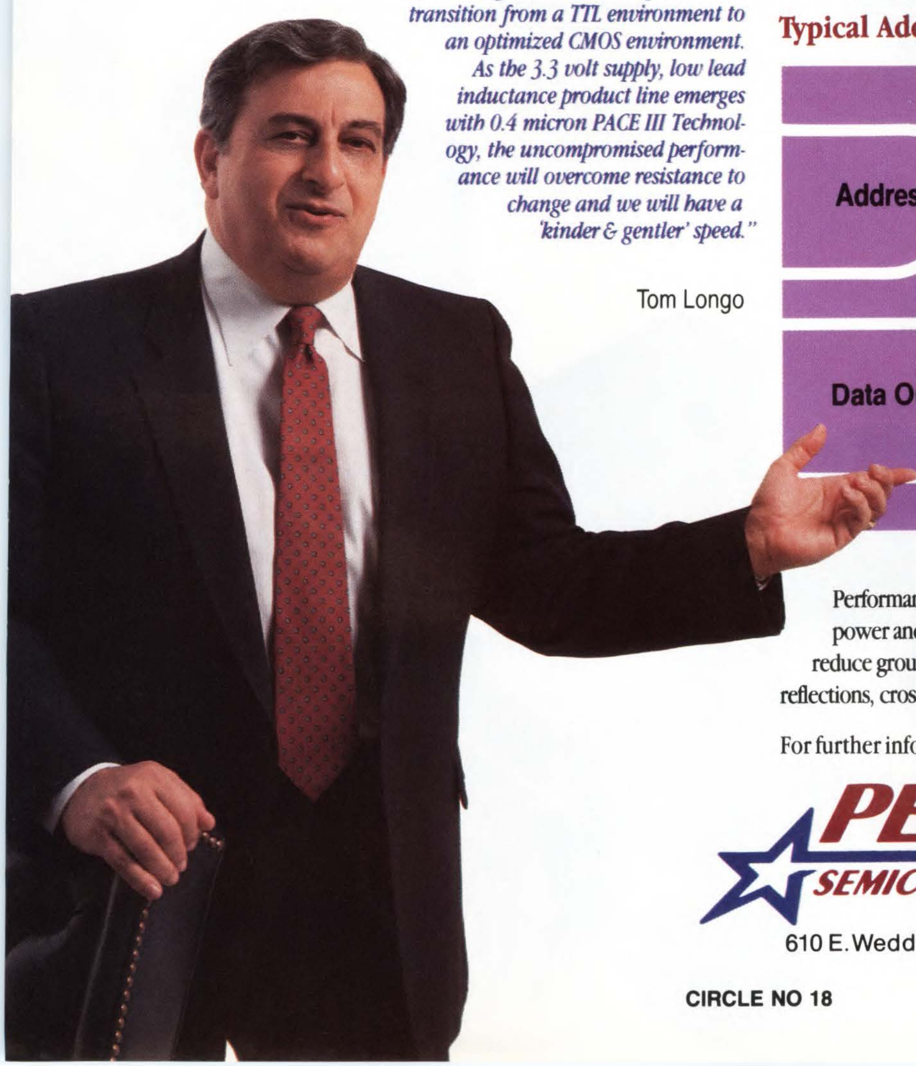
0.4 micron/6ns SCRAMs

First of a New Generation of 3.3V Center-Pin Power and Ground Products.

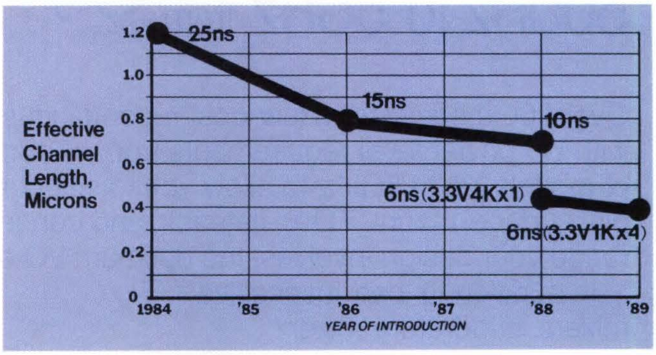
Performance now offers two 6ns SCRAMs: P3C3148 1Kx4 and P3C3147 4Kx1. These SCRAMs are superfast Static CMOS Random Access Memories. Future superfast products, using center-pin power and ground with a 3.3 volt power supply, will include SCRAMs with 4Kbit to 256Kbit densities and popular logic parts such as buffers, transceivers, latches, flip-flops, comparators, registers and gate arrays.

"It has been clear for some time that the primary consideration which could limit the use of future generations of CMOS technology in the highest speed applications were issues associated with constraints that have been hangovers from bipolar TTL circuit implementations. If those constraints are not removed, then either performance will be compromised or serious application problems will result. It is easy to see the value of the changes that are needed to take maximum advantage of the attributes of the fine line CMOS technology in the sub half-micron regime (PACE III). Therefore, we have decided to invest a significant part of our Company's technical and marketing resources to help make the transition from a TTL environment to an optimized CMOS environment. As the 3.3 volt supply, low lead inductance product line emerges with 0.4 micron PACE III Technology, the uncompromised performance will overcome resistance to change and we will have a 'kinder & gentler' speed."

Tom Longo

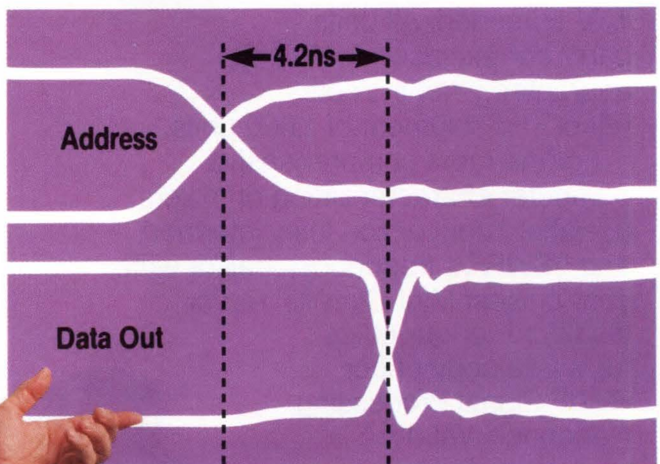


4K Bit Density Static RAM Speeds



Performance's PACE III Technology, which features 0.4 micron effective gate length, 0.75 micron line widths and 250ps gate delay, offers a 40 percent speed improvement even with a 35 percent voltage reduction. Superfast 6ns SCRAM performance is available now with significantly lower power dissipation.

Typical Address to Dataout Delay: 4Kx1 SCRAM



Performance's superfast 3.3 volt products incorporate multiple center power and ground pins as well as reduced signal swings to dramatically reduce ground bounce and simplify signal interconnection issues such as reflections, cross talk and ringing.

For further information or to order SCRAMs call or write:

PERFORMANCE SEMICONDUCTOR CORPORATION

610 E. Weddell Drive, Sunnyvale, CA 94089 (408)734-9000

mixers

the world's largest selection
500Hz to 5GHz from $2.49

Over 200 models, from low-cost rugged industrial to Hi-Rel military/space approved types, with LO power level requirements from +7dBm to +27dBm. We offer this wide variety of models, up to 5GHz, to allow you to select exactly what you need... pin, surface-mount, TO-8, flatpack, and connector package types, the specific frequency range your design involves, the optimum LO drive level, and a host of special types.

In addition to load-insensitive mixers, quadrature mixer/modulators, and our new ULTRA-REL™ mixers with a five-year guarantee, we offer a large number of MIL-mixer types tested to MIL-M-28837/A, TX and TXV screened. All units carry our exclusive 0.1% AQL guarantee...not a single reject in a shipment of 1,000 units.

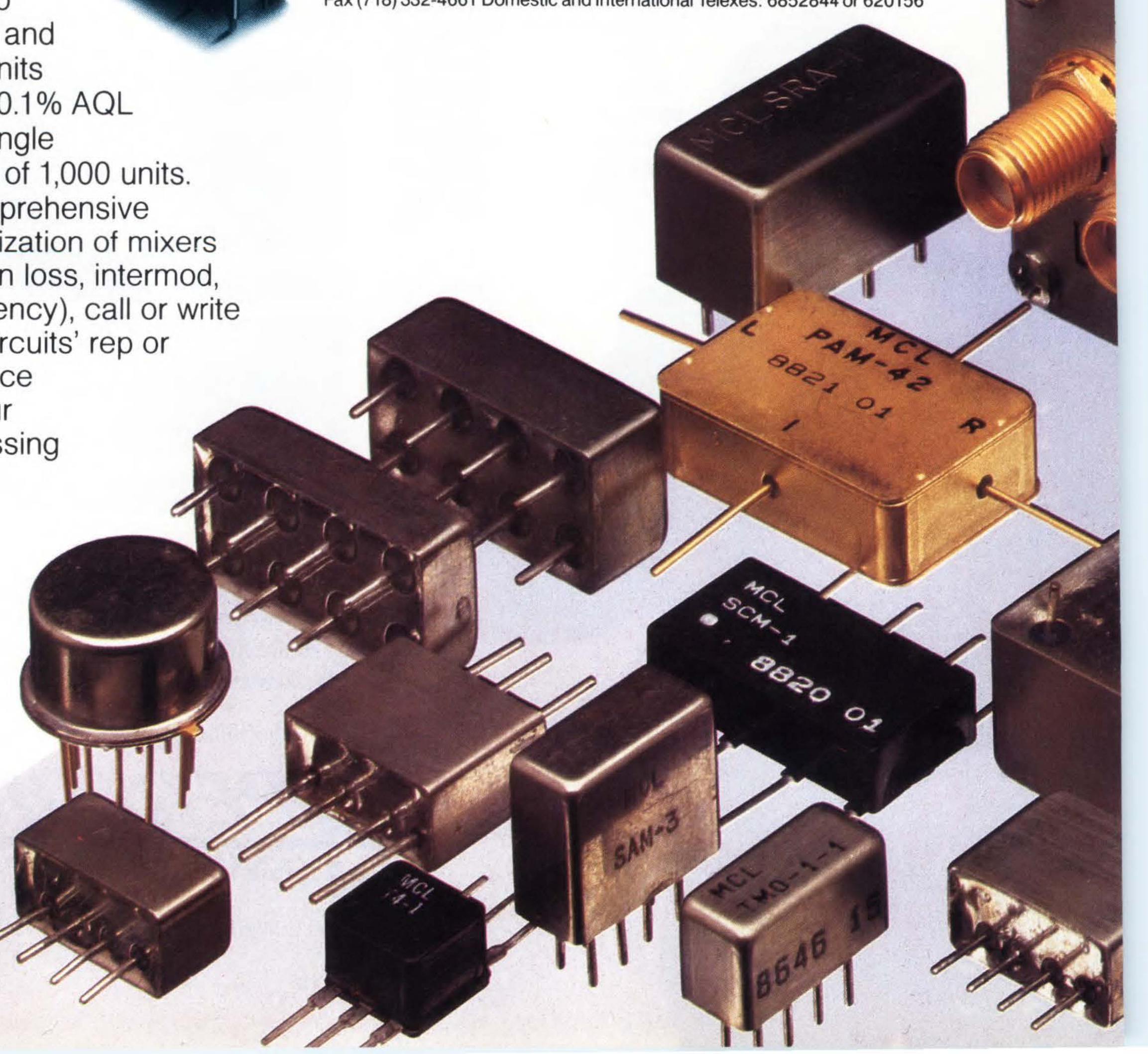
For the most comprehensive computer characterization of mixers (isolation, conversion loss, intermod, and VSWR vs frequency), call or write your closest Mini-Circuits' rep or distributor or our office for a free copy of our RF/IF Signal Processing Handbook, Vol. 1.

CIRCLE NO 19

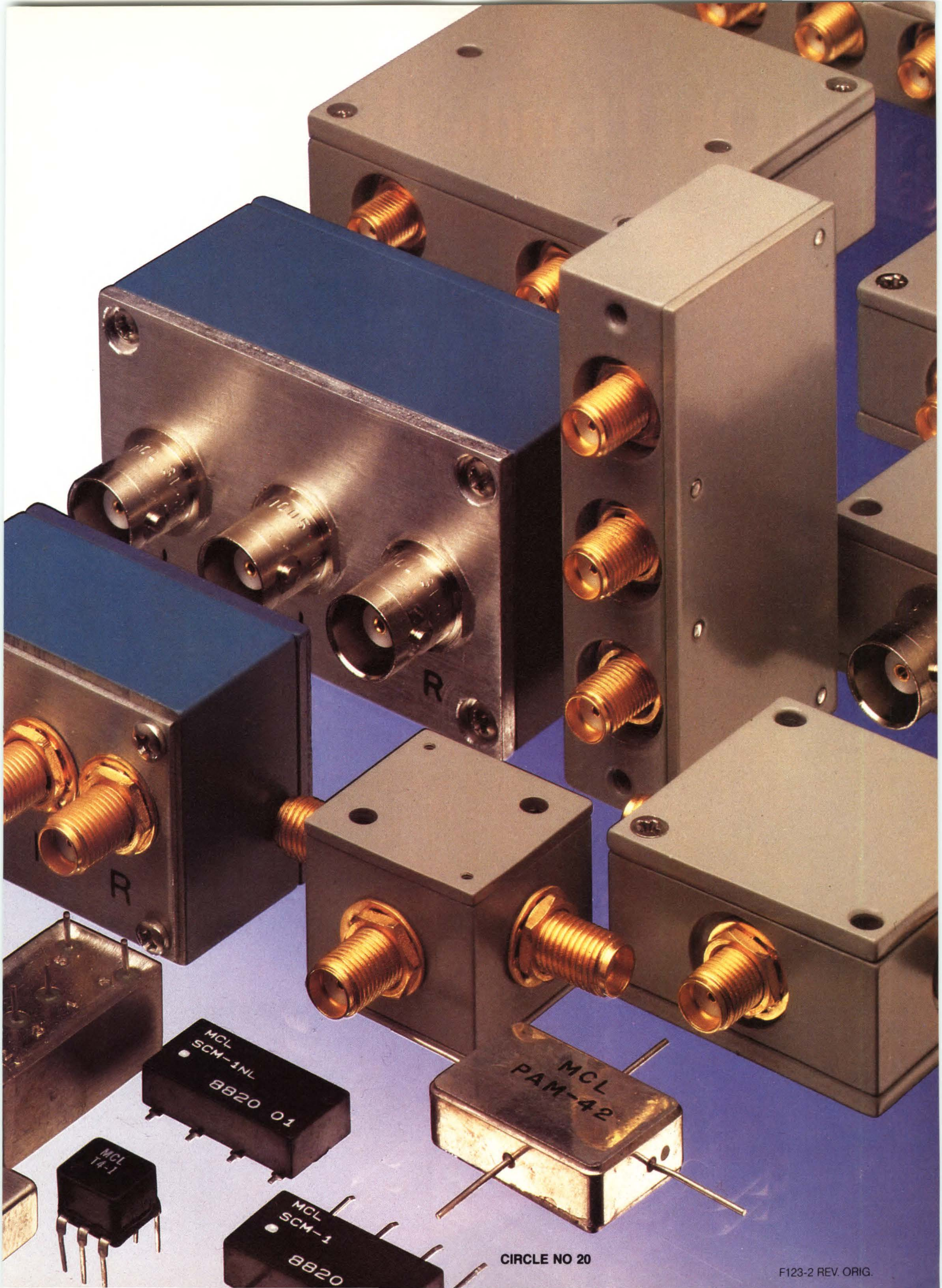
finding new ways...
setting higher standards

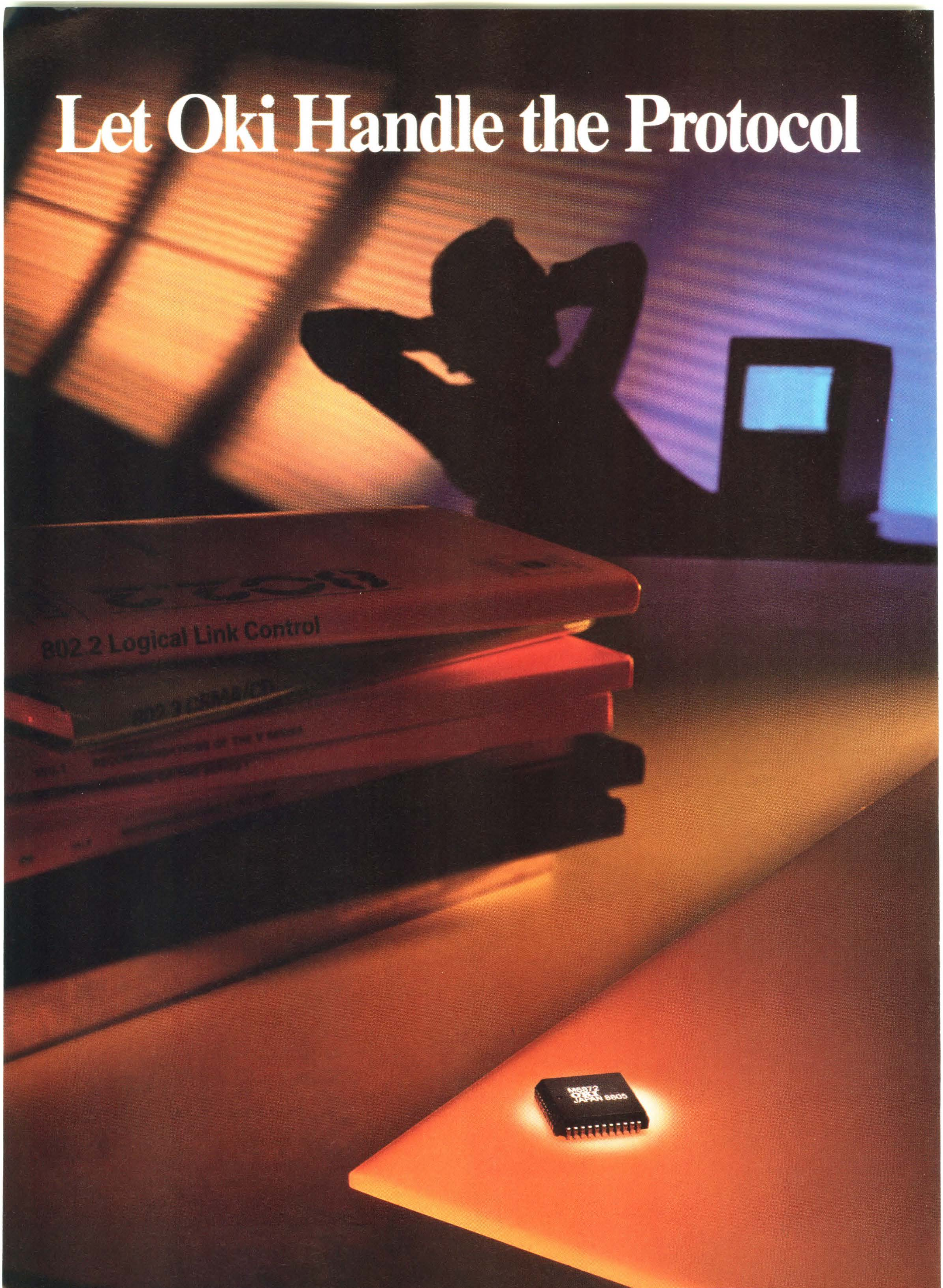
Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156



F123-1 REV. ORIG.


R
R
MCL
SCM-1NL
8820 01
MCL
PAM-42
MCL
T4-1
MCL
SCM-1
8820


Let Oki Handle the Protocol
802.2 Logical Link Control
M6872
JAPAN 8605

Oki's new PSCC provides automatic support for protocols—together with great networking flexibility

The new Protocol Serial Communications Controller (PSCC) from Oki Semiconductor is a highly innovative VLSI device which automatically supports LAPB and LAPD HDLC protocols and saves you from having to program and manage them. With a speed of 10 Mb/s, the PSCC also gives you great networking flexibility.

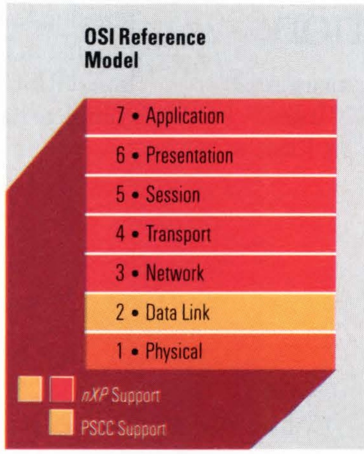
Integrated functions

The PSCC combines a full-duplex HDLC channel, on-board DMA controller, and 520 bytes of internal RAM. It allows you to send and receive messages directly from memory and frees system intelligence for higher level functions. It automatically supports the update and comparison of state variables for multiframe transmission. In addition, the PSCC supports collision and priority detection.

For even greater integration, the PSCC will be imbedded in Oki's high-performance 16-bit *nXP* microcontroller which will support all seven OSI levels of the ISDN.

Great flexibility

Easy interface is provided to standard 16-bit CPUs and to multiplexed buses. The PSCC can be easily customized to support different serial communications protocols. The high speed of the PSCC allows you to create a small inexpensive network, then to expand to a LAN, and later move into ISDN—all supported by Oki.



You can count on Oki

The PSCC is only one of the ways Oki can save you time and help you realize competitive advantages. You can also count on Oki for extensive experience, creative solutions, and proven reliability in every aspect of semiconductor device design and manufacturing. We invite you to put the full resources of Oki Semiconductor to work for you.

Automatic protocol support from Oki.

☐ Please send the complete technical data package on the MSM6872, the first member of Oki's Protocol Serial Communications Controller (PSCC) family.

☐ Please call. We have immediate requirements.

(   )
Phone

Name

Title

Company   EDN042789

Attach coupon to business card or letterhead and return to: PSCC Customer Service, Oki Semiconductor, 785 North Mary Avenue, Sunnyvale, CA 94086. Phone: (408) 720-1900.

OKI
SEMICONDUCTOR

CIRCLE NO 21

Power to spare.

DECstation 3100 workstation.

Here's a whole new measure of desktop power for UNIX™ users. Employing state-of-the-art RISC technology, the DECstation™ 3100 workstation gives you 14 MIPS of power at less than $1000/MIP. It's the first in Digital's family of UNIX-based RISC workstations, giving you complete hardware and software integration with installed VAX™ systems and industry-standard UNIX environments.

digital™

Power to share.

DECsystem 3100 multi-user computer.

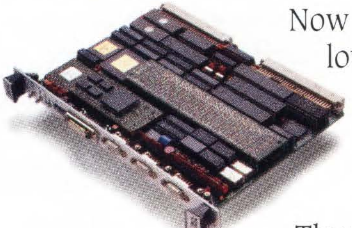
The new general purpose DECsystem™ 3100 computer delivers up to 14 MIPS of power to up to 64 people, working concurrently. The newest member of Digital's RISC family of computers brings RISC technology to multi-user UNIX environments. With up to 24 MB of main memory and up to 1.6 GB of disk storage, the DECsystem 3100 computer is the most cost-effective access to high performance computing for an entire department.

For more complete information, call your local Digital sales office, or call 1-800-369-8000

Digital has it now.

Introducing two ways VME single bo

CPU-37. The workhorse of VME.



Now you can harness all the power of VME and the 68030 with our new, low-cost single board computer.

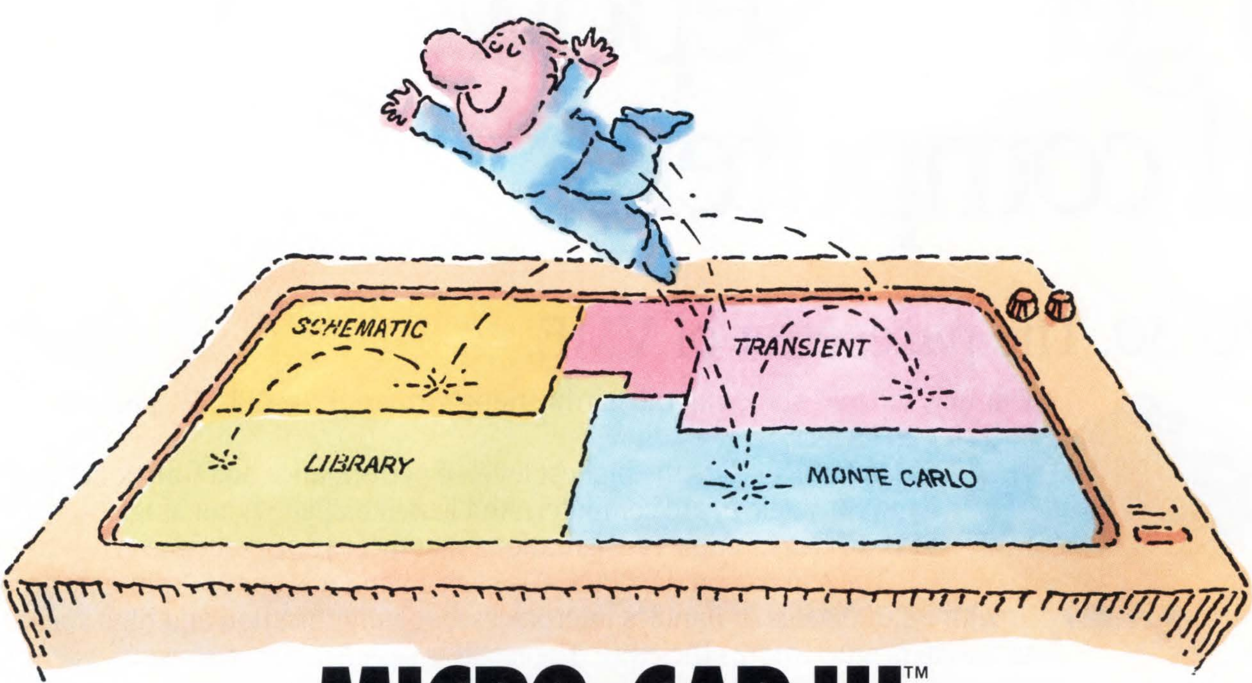
The new VME/PLUS™ CPU-37 comes with either a 16.7 or 25 MHz 68030, SCSI and floppy disk controllers, VMEPROM and 1 MB of memory. Options include an Ethernet controller and up to 4 MB of memory.

With the CPU-37, you now have the power of four boards in one. Thus reducing your system cost, weight and space requirements.

In addition, software products such as UNIX, PDOS, VxWorks, OS-9, pSOS, VRTX32 and C EXECUTIVE will be available. Plus our Running Start™ development package will let you start writing your applications quickly—under UNIX, PDOS or MS-DOS.

So if you need lots of horsepower without the thoroughbred price, hitch up with CPU-37.

Microwave Systems Corporation. pSOS is a trademark of Software Components Group, Inc. VRTX32 is a trademark of Ready Systems, Inc. C EXECUTIVE is a trademark of JMI Software Consultants, Inc. MS-DOS is a registered trademark of Microsoft Corporation.

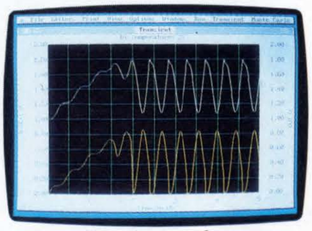


MICRO-CAP III.™
THIRD-GENERATION INTERACTIVE CIRCUIT ANALYSIS. MORE POWER. MORE SPEED. LESS WORK.

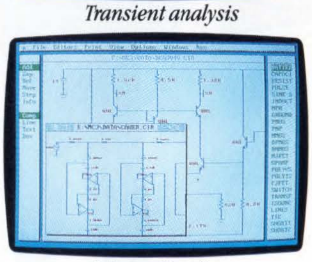
MICRO-CAP III,™ the third generation of the top selling IBM® PC-based interactive CAE tool, adds even more accuracy, speed, and simplicity to circuit design and simulation.

The program's window-based operation and schematic editor make circuit creation a breeze. And super-fast SPICE-like routines mean quick AC, DC, Fourier and transient analysis — right from schematics. You can combine simulations of digital and analog circuits via integrated switch models and macros. And, using stepped component values, rapidly generate multiple plots to fine-tune your circuits.

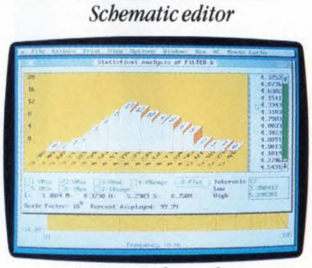
We've added routines for noise, impedance and conductance — even Monte Carlo routines for statistical analysis of production yield. Plus algebraic formula parsers for plotting almost any desired function.



Transient analysis



Schematic editor



Monte Carlo analysis

Modeling power leaps upward as well, to Gummel-Poon BJT and Level 3 MOS — supported, of course, by a built-in Parameter Estimation Program and extended standard parts library.

There's support for Hercules,® CGA, MCGA, EGA and VGA displays. Output for laser plotters and printers. And a lot more.

The cost? Just $1495. Evaluation versions are only $150.

Naturally, you'll want to call or write for a free brochure and demo disk.

spectrum

1021 S. Wolfe Road,
Sunnyvale, CA 94086
(408) 738-4387

SIGNALS & NOISE

Alien grads should be free to stay in the US

I read Jon Titus's editorial "Send alien graduates home" (EDN, October 27, 1988, pg 57), and I was surprised. As a former "alien graduate," I am very resentful of the fact that Jon's editorial advocated that foreign students should be forced to go home after graduation. If you walk into any high-tech business today, you will find a substantial number of engineers who were born abroad, many of them enjoying the wealth of this country. The opportunity to attend high-quality universities and to work in environments that offer professional development, challenges, and opportunities allows them to return some of the debt they owe this country for letting them reside here. Many of us have contributed heavily to the success of the industry in this country. Many innovations and inventions were developed by foreign-born scientists and engineers who selected this country as their new *home.*

Jon mentioned in his editorial that foreign-born engineers are taking jobs away from US citizens, but he did not mention that many of them opened businesses that employed many US citizens. Some examples are Dr Wang, Bose, and many other entrepreneurs. So please at least consider the positive aspect of having "foreigners" stay in the US.

I understand Jon's concern about the underdeveloped countries and the need for skilled people to help in their development; however, I do not feel that the US government should force professionals to become a foreign-policy tool. Let the people decide whether they want to help in the development of their countries of origin (by the way, some of those countries were hell on Earth for those people). In addition, I resent the idea that a country's need should dictate my professional interests: If I would like to be an EE, CE, ChE, etc, I'll make the decision.

As an engineering manager, I have recruited engineers in the past, and it was next to impossible to find engineers with the skills and talent I needed. In spite of extensive advertising and the willingness to pay a fair wage, I could not find engineers to fill the jobs (many trade magazines were stating that there was a severe shortage of engineers).

I am just wondering about the quality of information available to Jon. He stated in the editorial that foreign engineers "often work for less." In 18 years of working in the US, I never experienced salary deprivation because I was a foreigner. Yes, there might be some businesses that practice discrimination toward foreigners, but any reputable one would not do it, and I can testify from my own experiences.

Jon also mentioned his summer visit to a developing country and his observations regarding the energy being used, and how wasteful it was compared to solar or wind energy. Without knowing the details of his trip or the depth of his investigation, I would venture to assume that the issue is more political than technical. Solar and wind power are well-established technologies, and the issue is how to introduce them, not how to engineer or invent them. You will find similar issues in many Third-World countries. We, the foreign-born engineers, can do very little to influence political issues. Our skills are in the technical field, and in the right environment, we can do miracles.

On behalf of all the foreign-born, American-educated engineers, I would like to state that we would like to have free choice in selecting our home. This country is a conglomeration of nationalities, religions, races, creeds, and professions,

and let it stay that way; that is what made this country great.
Amos Friedner
Engineering Manager
Digital Equipment Corp
Marlboro, MA

Letting alien grads stay in the US benefits everyone

The advice to "send alien graduates home" (October 27, 1988, pg 57) ignores the larger perspective on immigration and naturalization. The current policy answers the basic US need for an optimal population base, while spreading benefits globally.

The US Department of Justice took a well-considered decision in 1966 to admit 200,000 foreign nationals yearly to the USA as immigrants. This decision was the result of a study on US demographics that projected the population growth to be insufficient to sustain the economy at a viable level beyond the year 2000 or so. Immigrants thus provide that vital extra fodder needed for the insatiable economic and industrial giant that the USA will continue to be throughout the 21st century. To suggest that foreign graduates should be returning while the less-educated immigrants remain is unfair.

Returning home is not the only way an immigrant can help his or her native land. The US and the "donor" countries reap mutual long-term benefits from the immigrant population. Poland, Israel, and Japan are just a few of the countries deriving advantages through their native sons and daughters living in the USA. And the favor is by no means one-sided.
M K Sadagopan
AT&T Bell Laboratories
Naperville, IL

The Fastest Way To Catch A Bus.

VME, VSB, Multibus or Micro Channel.

Have your new boards and systems up and running in record time. Off-the-shelf bus interface chips from PLX Technology get you to market faster and save a bundle in the process.

Pour on the power with bus control chips driving up to 64mA. Choose from a variety of master controllers, slave controllers, and other devices for immediate, space saving solutions. All of our chips incorporate on-board Schmitt trigger inputs and metastable hardened circuitry.

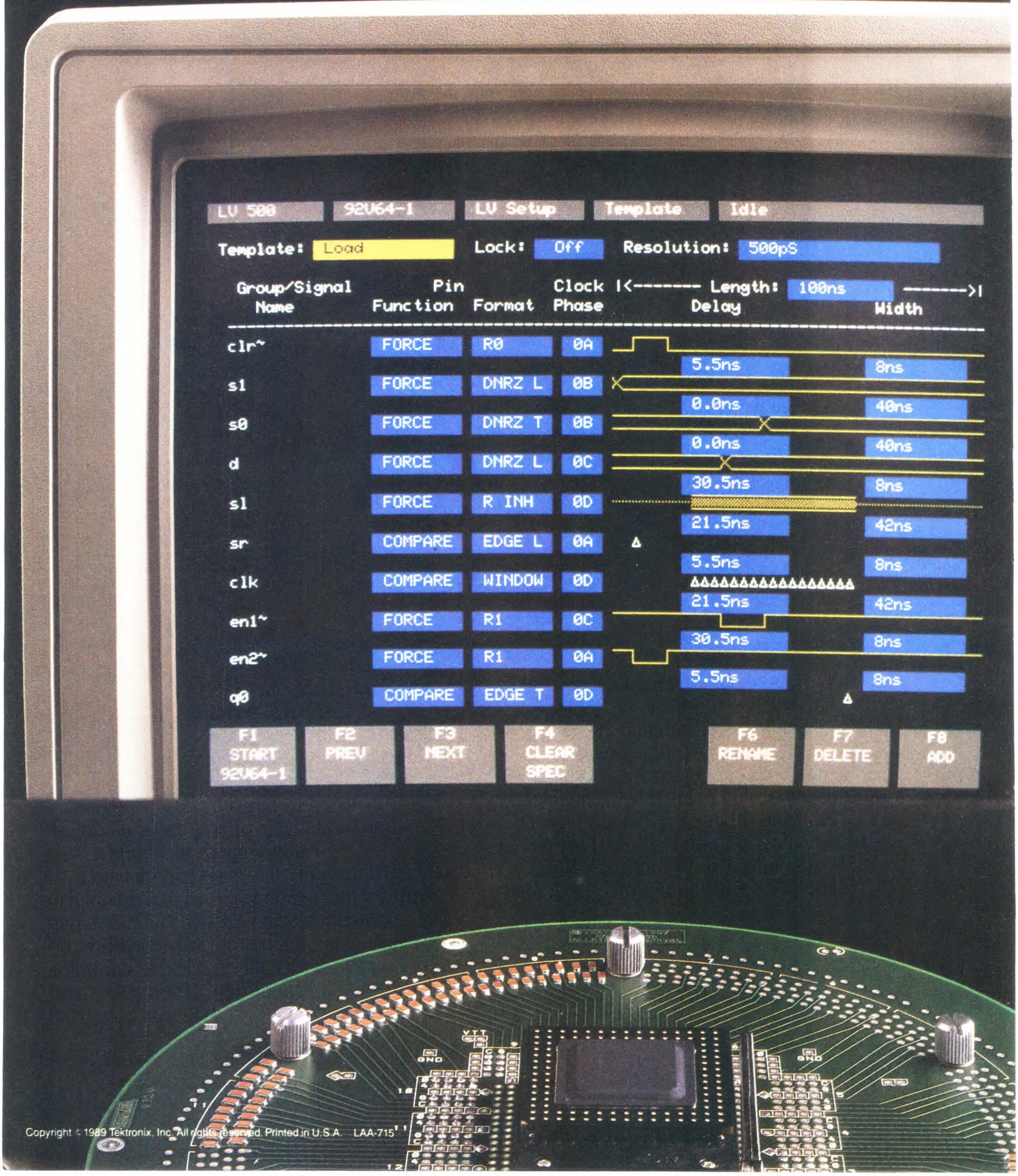
PLX packs everything into slim, 300-mil by 24-pin DIPs, or 28-pin LCC packages.

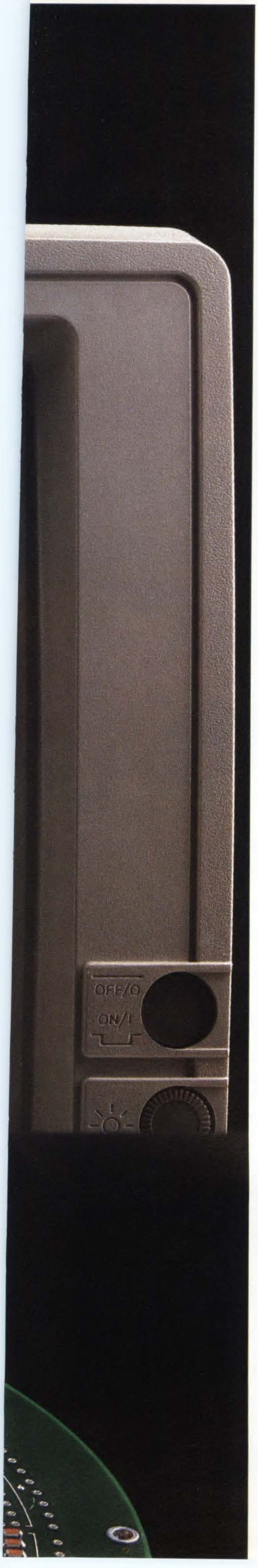
Suddenly, valuable board space is opened up, leaving you loads of extra room to implement that breakthrough design. Best of all, you'll finish way ahead of your competition.

Get on the fast track with bus interface chips from PLX Technology. Call us at 415-960-0448. Or write PLX Technology, 625 Clyde Ave., Mountain View, CA 94043.

PLX TECHNOLOGY

Tek's New ASIC Verification System.





Big Tester Performance At A Benchtop Price.

For a fraction of the price of large production testers, designers can now easily perform timing verification and margin analysis on their own ASICs, using a turnkey system with the critical timing of the million-dollar machines.

Tek's new LV 500 ASIC Verification System is a true *designer's* solution, integrated into a 50 MHz, 256-channel, 64K deep benchtop system with a test head just 17 inches square.

Using a simple menu structure and concepts familiar to the designer, the LV 500 combines elementary operation with astonishing performance, made possible by integrating all 256 bidirectional channels onto a single PCB. Results include:

- **More accurate simulation,** even for complex synchronous devices. The LV 500 lets you vary cycle length and timing for each of 16 clock generators on a cycle-by-cycle basis.
- **Familiar operation** for example, template-based test cycles replicate the everyday timing diagrams of your IC book.
- **Graphic displays.** See clearly when devices are operating too close to parametric boundaries.

Thanks to its high degree of integration, the LV 500 rarely needs calibration. DUT fixturing is simplified. And capacitance loading is reduced to about 25 pF, further contributing to the system's accurate results. And it is compatible with virtually all logic simulators.

Don't wait for chips to fail in production —or worse, for products to fail in the field. Start putting ASIC verification where it does the most good: in the hands of the designers themselves. For more information or a demonstration, contact your Tek sales representative. Or call 1-800-245-2036.

Tektronix®
COMMITTED TO EXCELLENCE

Circle 3 for literature **Circle 4 for Sales Contact**

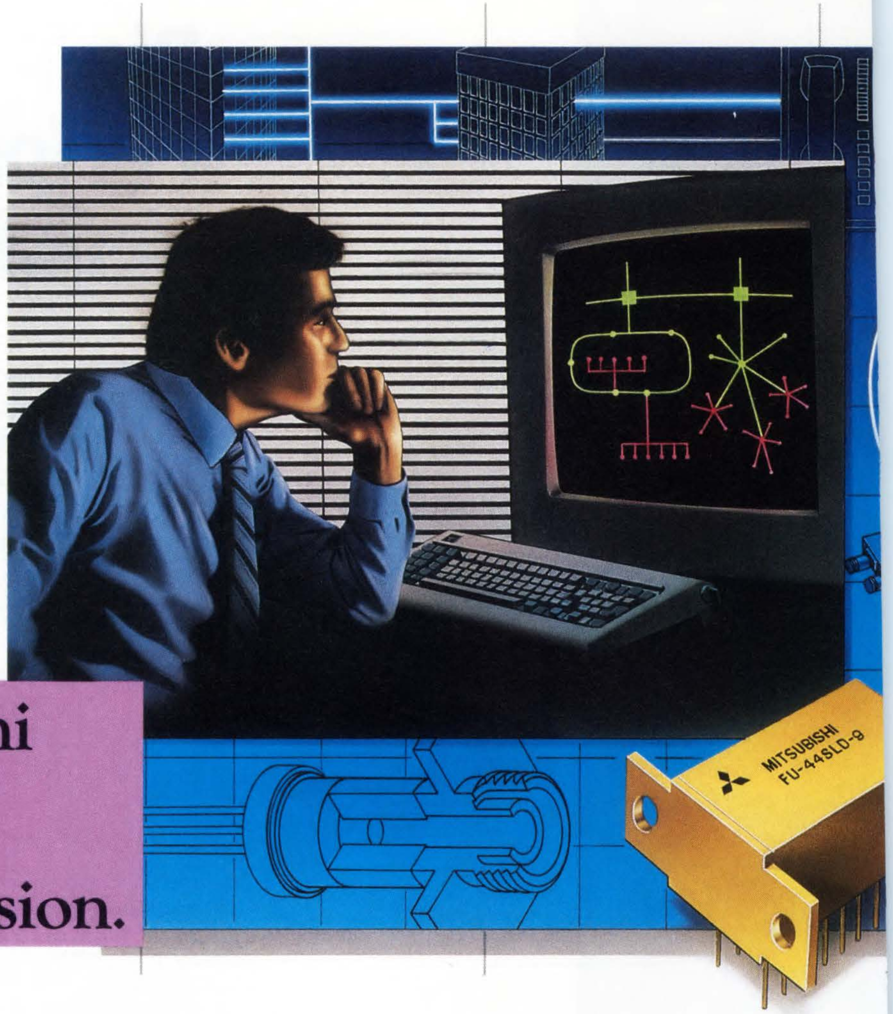
You Know Mitsubishi.

Fiber Optic Transmission...there are many possibilities. The marketplace will determine which designs and components succeed. But today, fiber optic system designers face many questions.

— How can fiber-to-the-home system costs be significantly reduced for commercial viability?

— Is it possible that FDDI-compatible LANs can become cost-effective for PCs and workstations?

— Are there components that meet CATV supplier requirements for AM transmission on fiber?



Mitsubishi Knows Optical Transmission.

Addressing these issues requires a partnership with the right optoelectronic supplier. One with a broad, integrated product base and sensible solutions. That's what Mitsubishi Electronics offers. We view market needs from our customer's perspective. We understand the critical issues. And we're addressing them now.

We've pioneered many new ideas for the industry. In fact, Mitsubishi was the first company to connectorize (singlemode) 1300nm laser diodes, providing smaller, lower cost options to DIP packages. Then we replaced the 1300nm laser with a CD laser to reduce costs even more. These innovations are proving critical for the commercial realization of fiber-to-the-home and expansion of fiber LAN markets.

As a result, Mitsubishi's connectorized lasers are being successfully evaluated in fiber-to-the-home and computer LAN applications right now. And, it appears that this package may become an industry standard since many users are beginning to specify connectorized laser packages.

Mitsubishi Electronics offers a broad range of laser transmitters and receivers in all three fiber windows, from 780nm to 1550nm. Our product line includes DFB lasers, PIN and APD detectors, SLEDs, ELEDs and data links...all available in a wide selection of packages.

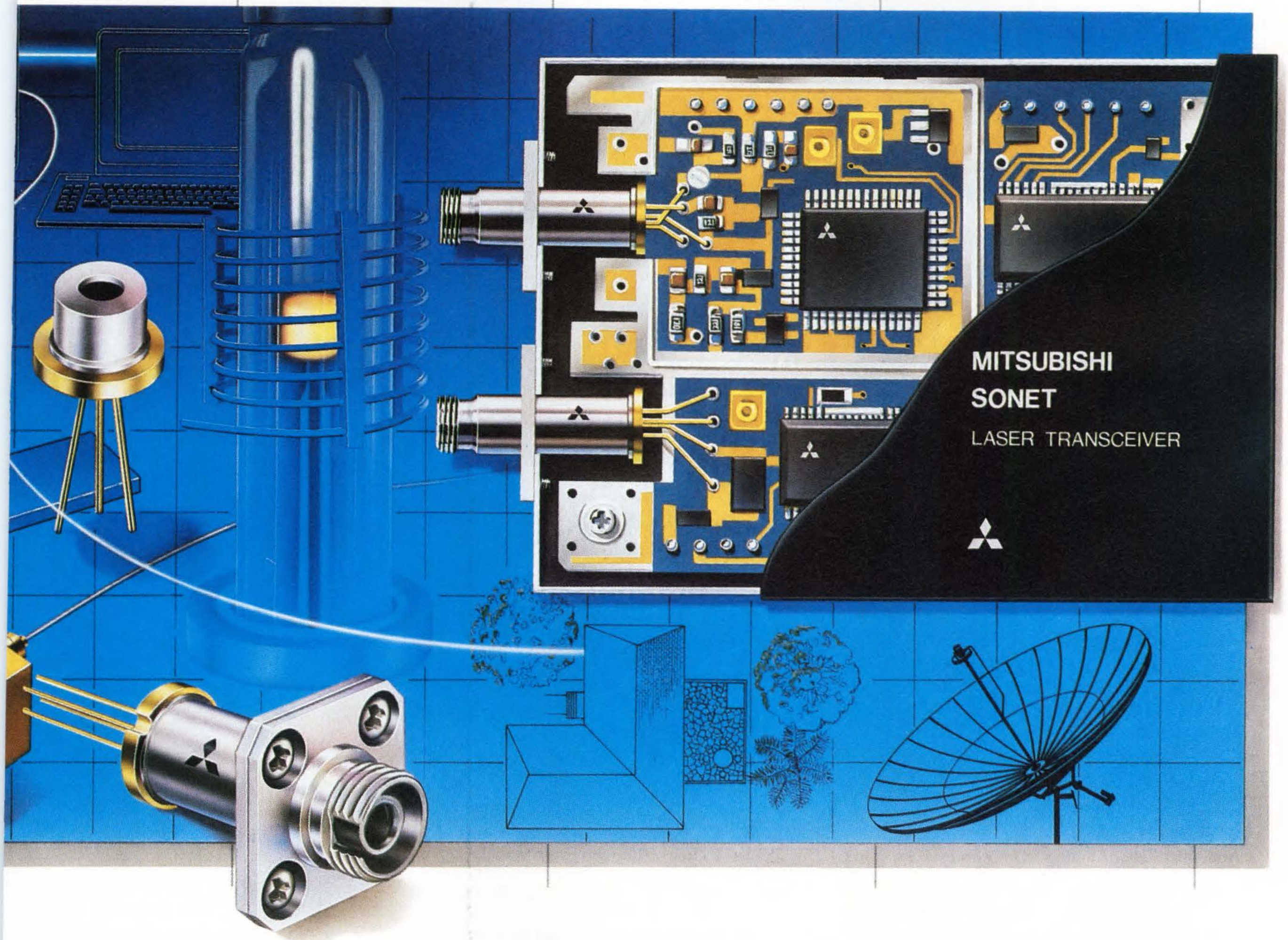
As your design goals come into focus, working closely with Mitsubishi can result in sensible solutions. And, you'll have the assurance of commitment from a solid, integrated optoelectronic supplier who will be here for the long-term.

FIBER-TO-HOME. MAKING HIGH VOLUME VIABLE

Lowering fiber-to-the-home system costs requires lasers that can be produced in high volume production quantities. Traditional DIP packages with fiber pigtail cannot be mass produced cost-effectively. So, Mitsubishi developed a singlemode, connectorized laser package specifically for automated high volume production.

With several fiber-to-home pilot programs in progress, Mitsubishi lasers offer extremely high reliability (> 100 million hours MTTF) over a wide temperature range and rugged packaging.

Regional Sales Offices:
NORTHWEST, Sunnyvale, CA (408) 730-5900
SOUTHWEST, Torrance, CA (213) 515-3993
SOUTH CENTRAL, Carrollton, TX (214) 484-1919
NORTHERN, Minnetonka, MN (612) 938-7779
NORTH CENTRAL, Mt. Prospect, IL (312) 298-9223
NEW ENGLAND, Woburn, MA (617) 938-1220
MID-ATLANTIC, Piscataway, NJ (201) 981-1001
SOUTH ATLANTIC, Norcross, GA (404) 368-4850
SOUTHEAST, Boca Rotan, FL (407) 487-7747
CANADA, St. Laurent, Quebec, (514) 337-6046



DATA COMMUNICATIONS. FDDI AND ALTERNATIVES

FDDI-compatible LANs can work for PC and workstation applications. Mitsubishi is developing a new FDDI-compatible data link that will provide a cost-effective alternative to LEDs at both ends (transmitter and receiver) of a fiber link.

By using mass produced, CD lasers and Si PIN detectors, Mitsubishi has reduced fiber optic LAN system costs for more applications.

TELECOMMUNICATIONS

Mitsubishi developed Si ICs for laser transmitters and receivers, offering size reduction and improved performance. We're supplying InGaAs APDs and DFB lasers for high-performance transmission systems. We also offer 780nm, 870nm, 1200nm, 1300nm and 1550nm lasers for WDM designs and bi-directional transmission. And, we are developing a SONET transceiver to meet the emerging standards.

CATV: AM FIBER TRANSMISSION POSSIBLE

With experience in AM, FM and digital video applications, Mitsubishi offers some of the highest power devices available (>10mW from a singlemode fiber) for better S:N ratio in CATV transmission.

We have also developed a 1300nm DFB laser module with isolator that features low RIN and high linearity for AM transmission.

Application	Mitsubishi Part Number	Description
Fiber-to-the-home	FU-01SLD-N(4406)/FU-04PD-N	780nm laser and detector in singlemode connectorized modules.
Fiber-to-the-home and Telecommunications	FU-11SLD-N/FU-13PD-N	1300nm laser and detector in singlemode connectorized modules.
AM CATV Transmission	FU-45SDF	1300nm DFB laser with opto-isolator and TE cooler.
Data Communications (FDDI)	MF-13125DF-T/R	1300nm LED/PIN 125MB/S transmitter/receiver
Data Communications	FU-01LD-N(4406)/FU-03PD-N	780nm laser and detector in multimode connectorized modules.
Telecommunications	FU-33AP	Long wavelength InGaAs APD module.

Quality through commitment. MITSUBISHI ELECTRONICS

CIRCLE NO 28

129,000 gates and 400 picosecond to none.

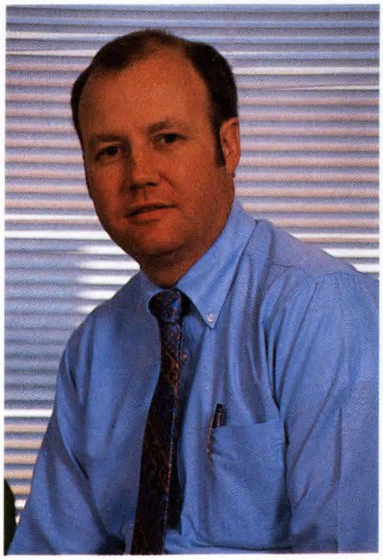
AREA SALES OFFICES: CENTRAL AREA, Toshiba America Electronic Components, Inc., (312) 945-1500; **EASTERN AREA,** Toshiba America Electronic Components, Inc., (617) 272-4352; **NORTHWESTERN AREA,** Toshiba America Electronic Components, Inc., (408) 737-9844; **SOUTHWESTERN REGION,** Toshiba America Electronic Components, Inc. (714) 259-0368; **SOUTH CENTRAL REGION,** Toshiba America Electronic Components, Inc., (214) 480-0470; **SOUTHEASTERN REGION,** Toshiba America Electronic Components, Inc., (404) 368-0203; **MAJOR ACCOUNT OFFICE, FISHKILL, NEW YORK,** Toshiba America Electronic Components, Inc., (914) 896-6500; **MAJOR ACCOUNT OFFICE, BOCA RATON, FLORIDA,** Toshiba America Electronic Components, Inc., (305) 394-3004. **REPRESENTATIVE OFFICES: ALABAMA,** Montgomery Marketing, Inc., (205) 830-0498; **ARIZONA,** Summit Sales, (602) 998-4850; **ARKANSAS,** MIL-Reps, (512) 346-6331; **CALIFORNIA** (Northern) Elrepco, Inc., (415) 962-0660; **CALIFORNIA** (L.A. & Orange County) Bager Electronics, Inc., (818) 712-0011, (714) 957-3367, (San Diego County) Bager Electronics, Inc., (619) 944-4188; **COLORADO,** Straube Associates Mountain States, Inc., (303) 426-0890; **CONNECTICUT,** Datcom, Inc., (203) 288-7005; **DISTRICT OF COLUMBIA**, D.G.R., Inc., (301) 581-1360; **FLORIDA,** Sales Engineering Concepts, (813) 823-6221, (305) 426-4601, (305) 682-4800; **GEORGIA,** Montgomery Marketing, Inc., (404) 447-6124; **IDAHO,** Components West, (509) 922-2412; **ILLINOIS,** Carlson Electronic Sales, (312) 956-8240, R.W. Kunz, (314) 966-4977; **IOWA,** Carlson Electronics, (319) 377-6341; **KANSAS,** D.L.E. Electronics, (316) 744-1229; **LOUSIANA,** MIL-Reps, (713) 444-2557; **MAINE,** Datcom, Inc., (617) 891-4600; **MARYLAND,** D.G.R., Inc., (310) 583-1360; **MASSACHUSETTS,** Datcom, Inc., (617) 891-4600;

CIRCLE NO 29

EDITORIAL

$$S(f) = \int_{-\infty}^{\infty} s(t)e^{-j2\pi ft}dt$$

PATENT PENDING?



Thankfully, the Fourier integral above was never patented. It's probably safe to say that in the early 1800s, when J B J Fourier analyzed heat conduction, he never thought of applying for a patent on his formulas. Today though, many mathematicians are applying for and receiving patents for their work. Those patents may stifle many further developments.

Certainly new inventions, processes, and techniques should be able to take advantage of our patent system—a system that offers inventors the right to exclude others from using their invention for 17 years. (Keep in mind that the patent system itself offers no protection. Inventors must protect their patented inventions on their own either through licenses or infringement lawsuits.) However, until recently, the US Patent and Trademark Office has turned down patent applications that cover mathematical formulas or algorithms. It used to be that inventors couldn't patent processes that could be performed mentally or with paper and pencil. In short, you couldn't patent mental exercises.

But, you could patent an algorithm if it was tightly coupled to a piece of hardware. For example, if you implemented a new fast Fourier transform algorithm in a patentable circuit, the patent could cover both the hardware and the algorithm it implemented. So, as long as the algorithm was claimed as part of the circuit, you could patent it. Now however, the US Supreme Court is taking a more liberal view of what types of formulas and algorithms you can patent.

The New York Times reports that in 1981 the Supreme Court expanded patent coverage to include the application of a mathematical formula to a known process. In 1982, a lower court ruled that an algorithm could be protected as long as it applied to physical elements or process steps.

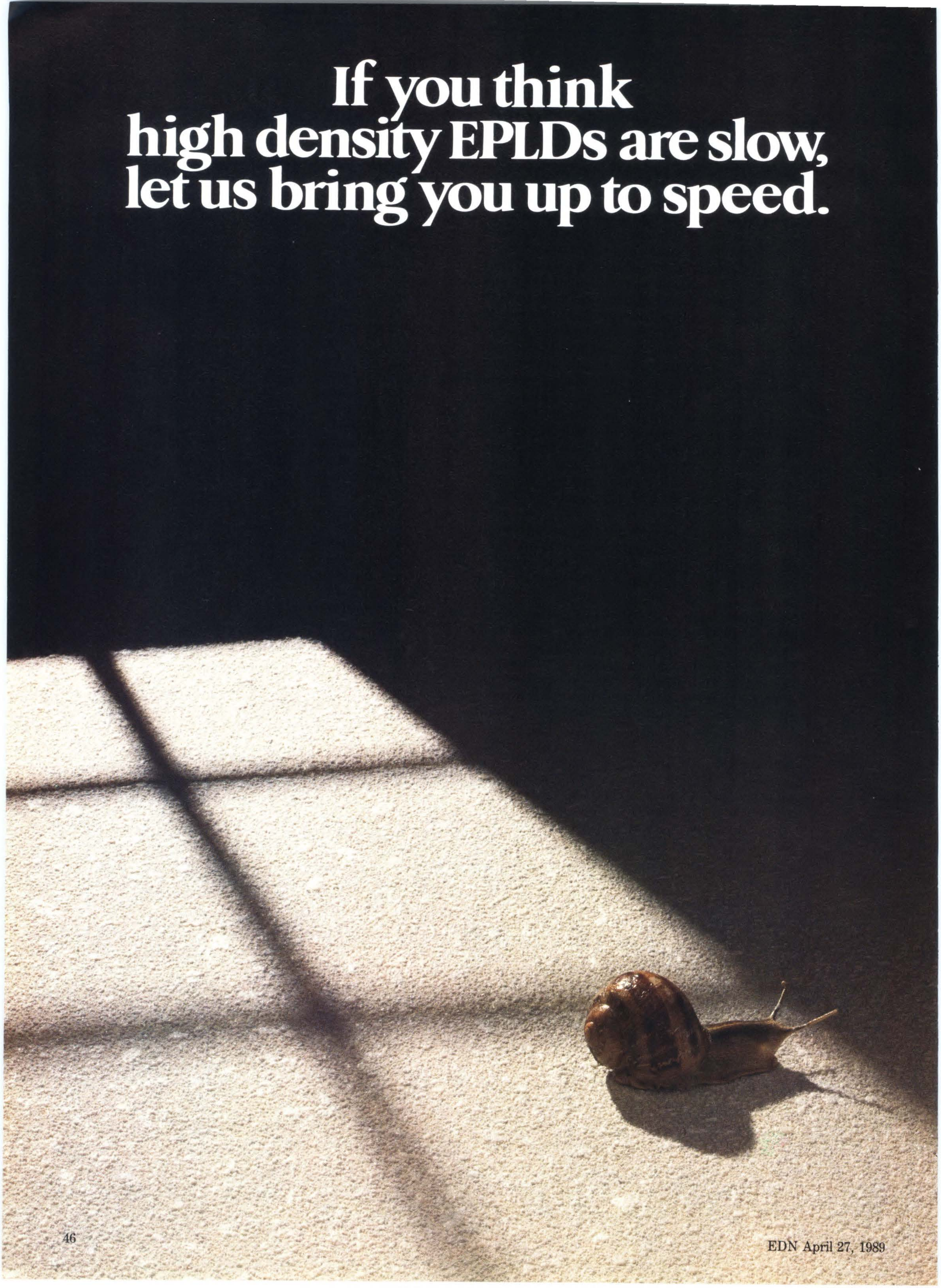
We take exception to the courts' rulings. Mathematical formulas and algorithms should remain unpatentable. Certainly, it is proper if someone wants to protect the *implementation* of an algorithm by placing it deep within an integrated circuit, by copyrighting program listings, or by licensing it as a trade secret. However, protecting the basic idea may bring many areas of mathematical research to a halt. Investigators who might benefit from patentable work will be reluctant to share their research results with fellow researchers. It's hard to imagine the state of the software industry if shell-sort, bubble-sort, and floating-point-math algorithms had received patents.

On the other hand, some might argue that there is little incentive to spend years of research and months of programming to develop an algorithm into useful form unless the algorithm can be patented. That's a valid point, but again, it should be the implementation that receives a patent, and not the underlying mathematical principle or process. To stay competitive, and to foster an exchange of mathematical thoughts and ideas, we need an atmosphere that's free of restrictive patent protection for underlying and abstract principles.

Jon Titus
Editor

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

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


If you think
high density EPLDs are slow,
let us bring you up to speed.

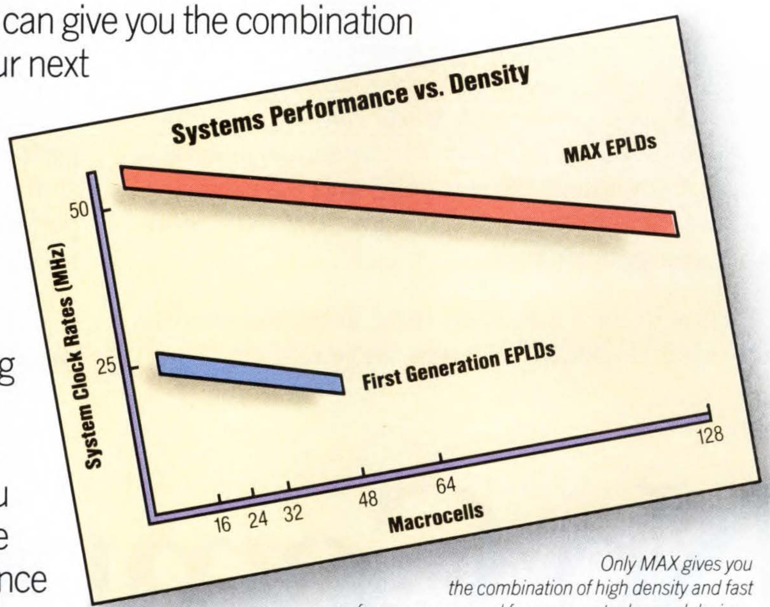
Introducing the MAX family. At up to 50 MHz, it's twice the speed of any other high density EPLD.

MAX is the only family of EPLDs that can give you the combination of speed and density you need in your next system design.

And not just raw speed, but predictable speed as well.

Because MAX's unique architecture gives you predictable delays between all corners of the chip.

And that means no more hair-pulling over lost speed. No gate array timing skews. No more multiple design iterations to get the speed you thought you were going to get in the first place. The result is more usable system performance at system clock rates up to 50 MHz.

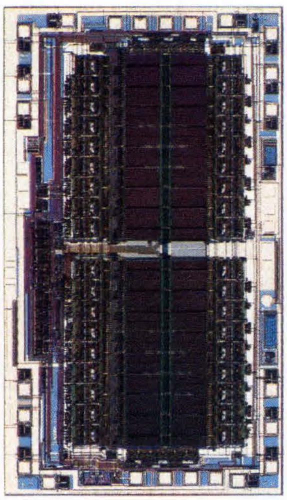


Only MAX gives you the combination of high density and fast performance you need for your most advanced designs.

Which makes MAX the fastest family of high density CMOS EPLDs in the world.

For example, with our EPM5032, you can design a bus controller that runs at 32MHz while utilizing 32 registers and up to 32 product terms feeding a single register.

For really big jobs like state-of-the-art DMA controllers, our EPM5128 has an array of 256 logic expanders, 128 macrocells and 52 I/O pins that can easily soak up all the logic you need.



Fast, high density controller designs can be implemented with the EPM5032, 32-macrocell MAX EPLD.

All of these logic functions can be designed fast, too. In just a matter of hours, in fact. Because MAX is supported by software that's easy to design with. Speeding you to market with a product that uses fewer parts, for unbeatable cost savings.

That's why the MAX family is destined to become the new standard for logic design.

For more information, call Altera today: 1-800-545-3377.

And we'll bring you up to speed on high density EPLDs.

ALTERA

3525 Monroe Street, Santa Clara, CA 95051
(408) 984-2800

Hitachi's Hi-BiCMOS™ Process Makes High-speed, Energy-efficient Performance a Reality

Hummingbirds are light, agile, and incredibly fast. They consume energy efficiently as they dart from flower to flower, beating their wings faster than the human eye can follow. This kind of high-speed, power-efficient performance has not been available in a semiconductor—until now. Finally, no compromises.

Hitachi brings you second generation Bi-CMOS—Hi-BiCMOS—the advanced process technology that delivers ECL-like speed with power consumption comparable to CMOS. Hi-BiCMOS transcends generic Bi-CMOS by intermixing bipolar and CMOS structures at the basic cell level, for power-efficient, high-speed performance.

Hitachi has more than three years' experience fabricating Hi-BiCMOS parts. We've refined Hi-BiCMOS into a reliable, high-yield process. You're assured of a dependable supply of devices, in production quantities—all with Hitachi's legendary quality.

A broad variety of mainstream devices, with leading edge performance, is now available as a result of Hitachi's Hi-BiCMOS process. Hitachi's newest 1M DRAMs use Hi-BiCMOS to achieve a fantastic 35ns access time. These fast memories feature high-performance with non-multiplexed addressing. They come in cool-running plastic packaging, and perform at half the access time of standard high-speed DRAMs.

Hitachi's Hi-BiCMOS SRAMs deliver 256K densities, with TTL I/O and 20ns access speeds.

No Compromises

That's enough density to build large cache memory arrays with unusually high hit rates. Plus, you have the product to support super system performance. And, we have 256K, 15ns ECL I/O devices now, with 10ns available in the near future.

Hitachi's Hi-BiCMOS gate arrays use advanced 1.3-micron structures with 1.0-micron effective lengths. On a system level, Hi-BiCMOS densities reduce chip count delays for performance comparable to ECL, but without ECL's power and heat penalties. The HG29M100 gives you: fast 400 ps gate delays with CMOS power consumption levels, advanced capabilities with 10,000 gates, 4.6K bits of on-board RAM and up to 220 I/Os. The HG21T30 offers you 3,000 gates and 90 I/Os with both ECL and TTL interfaces.

Hitachi's Hi-BiCMOS technology helps you eliminate frustrating design compromises. You can count on Hitachi's Hi-BiCMOS process to deliver the speed, density, and low-power performance in reliable, quality parts. For more information, call your local Hitachi Sales Representative or Distributor Sales Office today.

Hitachi America, Ltd.
Semiconductor & I.C. Division
Hitachi Plaza
2000 Sierra Point Parkway, Brisbane, CA 94005
Telephone 415/589-8300

HITACHI®

We make things possible

Now you have a choice for y

Standard devices for maximum performance.

Introducing three new off-the-shelf single-chip Switch Mode Power Supply controllers that save space, money and time.

The new 16-pin ML4825 has all the features and performance of a UC1825, plus a powerful package of enhancements.

For single-ended designs, the ML4823 is pin compatible with the UC1823 and adds all the enhancements of the ML4825.

A third new controller, the ML4809, is packed with extra features and functions for better compensation, easier starting and synchronization.

The ML4809 starts with all the features of the ML4825, then adds even more.

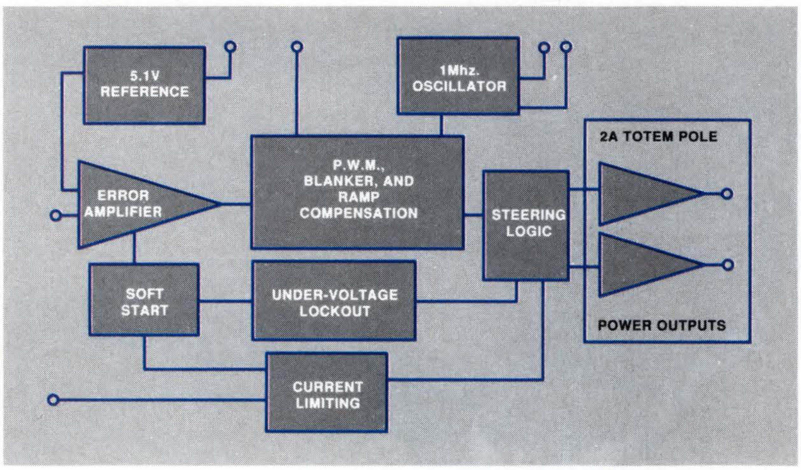
Synchronization:
- separate clock I/O pins
- wide dynamic range VCO
- toggle flip-flop output and preset inputs

Stability:
- on-chip programmable ramp compensation
- blanker to reject turn-on spike
- completely independent error ramp

Start-up/Fault conditions:
- 7 V hysteresis on under-voltage lockout
- full reset with programmable delay

PART TYPE	SOFT START RESET	UNDER-VOLTAGE OUTPUT STATE	COMPARATOR TO OUTPUT DELAY
ML4825	COMPLETE	LOW	40 nS
UC1825	PARTIAL	FLOAT	50 nS
ML4823	COMPLETE	LOW	40 nS
UC1823	PARTIAL	FLOAT	50 nS

Micro Linear/Unitrode Comparison



Micro Linear Standard PWM Controllers Provide Maximum Performance

These three new standard single-chip controllers are so good, they'll easily satisfy the demands of most high-frequency SMPS designs.

For those power supplies with special needs that can't be met by an "off-the-shelf" IC, you'll need a semi-custom controller designed and built to exacting standards.

And we know just where you can find one.

our power supply controller.

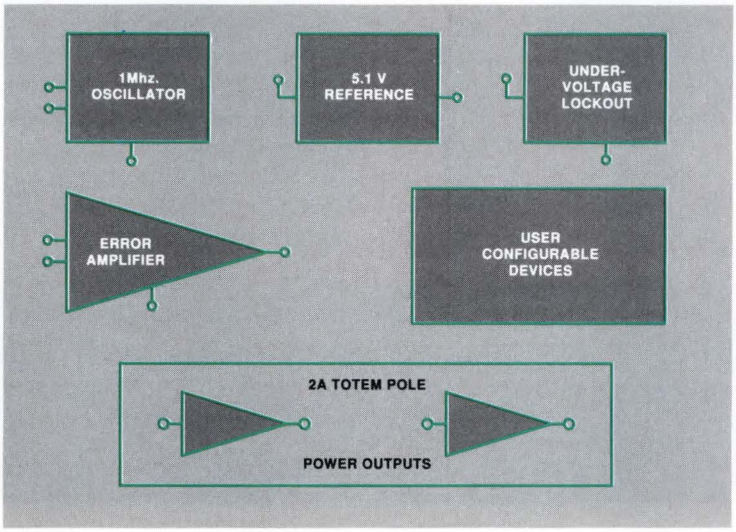
ASIC devices for maximum flexibility.

Introducing the new FB3480, a semi-custom array specifically designed to meet more challenging demands of high frequency Switch Mode Power Supply applications.

The FB3480 is a new concept in semi-custom IC technology. Most other analog semi-custom IC's are a collection of general purpose transistors, resistors and other components which can be connected in different ways to perform different IC functions. Not the FB3480. It's specifically designed for SMPS control. This unique array contains high-performance internal core cells optimized to perform the functions found in all PWM controllers. In addition, the array contains a large area of uncommitted transistors and resistors which can be configured to your specifications using Micro Linear's library of "soft macros." These macros implement a full complement of logic, comparator and other functions to make your customized controller unique. This "core cell" and "soft macro" design approach provides a customized solution with a minimum of cost and effort.

The core cells feature a 1 Mhz oscillator, a 5 Mhz bandwidth 6V/μSec slew-rate error amplifier, a voltage reference with a $\pm$2% tolerance over the full temperature range, and a programmable threshold under-voltage lockout circuit.

The chip also contains two totem-pole 2A output driver cells to quickly charge and discharge the high gate capacitance of power MOSFETs.



FB3480 Array Enables Easy Custom Design

For more information on the new single-chip standard and semi-custom SMPS controllers from Micro Linear, call (408) 433-5200, extension 900.

Or write:
Micro Linear, Dept. SP,
2092 Concourse Drive,
San Jose, CA 95131

CIRCLE NO 33

Micro Linear

ISDN ICs

The U interface comes of age

Most of the issues involving the U interface have been resolved by the standards committees, and IC vendors are gearing up to supply the chips. However, resolving the issues doesn't mean that there is a unifying standard.

Michael C Markowitz,
Associate Editor

The Integrated Services Digital Network's (ISDN) U interface is, in the words of one IC vendor, "defined, but vulnerable." Some of the vulnerabilites revolve around the test and maintenance features and call set-up and tear-down. But most of these problems are addressable in software, and the committee charged with defining the U interface is committed to reverse compatibility. As a result, many IC vendors have begun to introduce their versions of U-interface ICs.

But all is not rosy and waiting for you to begin the design of your network termination (NT1) equipment or central office (CO) and private automatic branch exchange (PABX) line cards (LT) for the U interface. The T1E1.4 (Telecommunications Interface) subcommittee of the Exchange Carrier Standards Association has issued and the American National Standards Institute (ANSI) has published T1.601-1988, which defines the U interface for North America. The specification, which is also being adopted in Japan, specifies a line code of 2B1Q (2 binary, 1 quaternary). According to Tom Starr, chairman of the T1E1.4 subcommittee, this line code offers maturity, the best technology, and the largest base of support. The situation in Europe, however, is not as clear.

Unlike in the US, each European PTT (Post, Telegraph, and Telephone Administration) owns all of the NT1s tied to its network. As a result, the PTTs control both sides of the U interface. The monopoly exercised by each of the PTTs has manifested itself in conflicting line-code standards; there are currently six options offered in Appendix 6 of the CCITT Blue Book. The French and German PTTs have chosen 4B3T (four binary, three ternary); British Telecom is leaning toward 2B1Q (two binary, one quaternary).

Two other issues further confuse the European picture. First, the potential exists that all of the PTTs may become

Hardware- and software-development tools, *like this PC-based ISDN evaluation system from Siemens, help you with code generation, chip emulation, and test-measurement requirements.*

Seagate's 3.5″ drives Now with AT interface

Seagate's field proven ST157 product line now features embedded controllers with an AT® interface. These reliable to-the-bus solutions offer improved cost/performance over non-integrated solutions.

The ST125A, ST138A and ST157A provide 21, 32 and 43 megabytes of formatted capacity respectively, and feature 28 or 40 msec typical access times, with an impressive 50,000 hour MTBF. All models support the standard 16-bit AT task file interface, 1:1 interleave capability, an internal data rate of 7.5 megabits/second, and up to 4 megabytes/second at the interface.

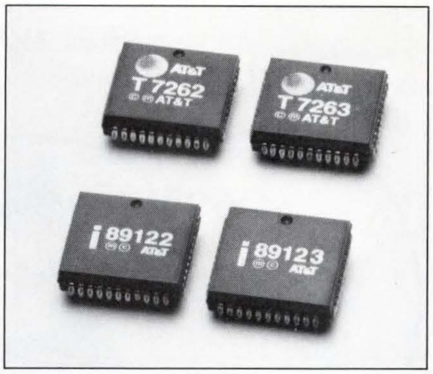
For more information on the drives that offer a lower cost of connection and higher system performance for OEMs and systems integrators, call your nearest Seagate sales office, or call Seagate directly at 800 468-DISC or (408) 438-6550.

Seagate
The first name in disc drives

part of the private sector or be deregulated, a la Ma Bell and British Telecom. Secondly, 1992, the year the European Community is scheduled to become a true common market, is looming large on the horizon and could hasten the privitization and deregulation efforts already underway.

Finally, Tom Starr indicated that the T1E1.4 subcommittee issued the T1.601.1988 specification with some areas of the U interface left for further study. For example, the T1M1.2 (Telecommunications Maintenance) subcommittee is looking at some potential changes to the physical layer of ISDN, which defines the R, S, T, and U interfaces. Any changes to the spec will appear in the form of an addendum to the ANSI standard. Although Starr expects some changes to impact the design of currently available U-interface ICs, he promises that the committee is making every effort to provide downward compatibility.

The ISDN Basic Rate Network consists of a collection of ISDN-compatible and -incompatible equipment connected across interfaces.



***A second-source agreement** between AT&T and Intel for the 2-chip U-interface IC set, which is shown here in both vendors' packages, ensures the availability of the set.*

For the uninitiated, ISDN is a virtual alphabet soup of abbreviations; therefore, a brief description should help clarify the network. **Fig 1** might help you visualize what can be an incredibly confusing mess. Also see the **box,** "An ISDN glossary" for a more complete description of these ISDN terms.

Terminal equipment type 1 (TE1) is an ISDN terminal, like a digital telephone. You can connect TE1s directly to the ISDN at an S interface. Terminal equipment type 2 (TE2) is a nonISDN terminal, like an RS-232C or X.21 terminal, that you connect through an R interface to a terminal adapter (TA). You can only connect nonISDN terminals to the S interface of the network through a terminal adapter (TA). The S interface connects to the T interface through a network termination type 2 (NT2) box. This box is an ISDN PABX that functions as a multiplexer concentrating two or more TE1s or TAs.

A network termination type 1 (NT1) box provides physical and electrical termination between the 4-wire S or T interface and the 2-wire U interface. The S and T interfaces are electrically identical, although the protocols that operate over them are slightly different. The T interface exists only to link NT2 boxes to an NT1 box. Finally, the U interface connects the local exchange termination (LT) at the central office (CO) to the NT1 box at the customer's location.

As specified by the T1E1.4 committee, the U-interface requires a single twisted-pair transmission medium. The interface standard provides for data transmission over

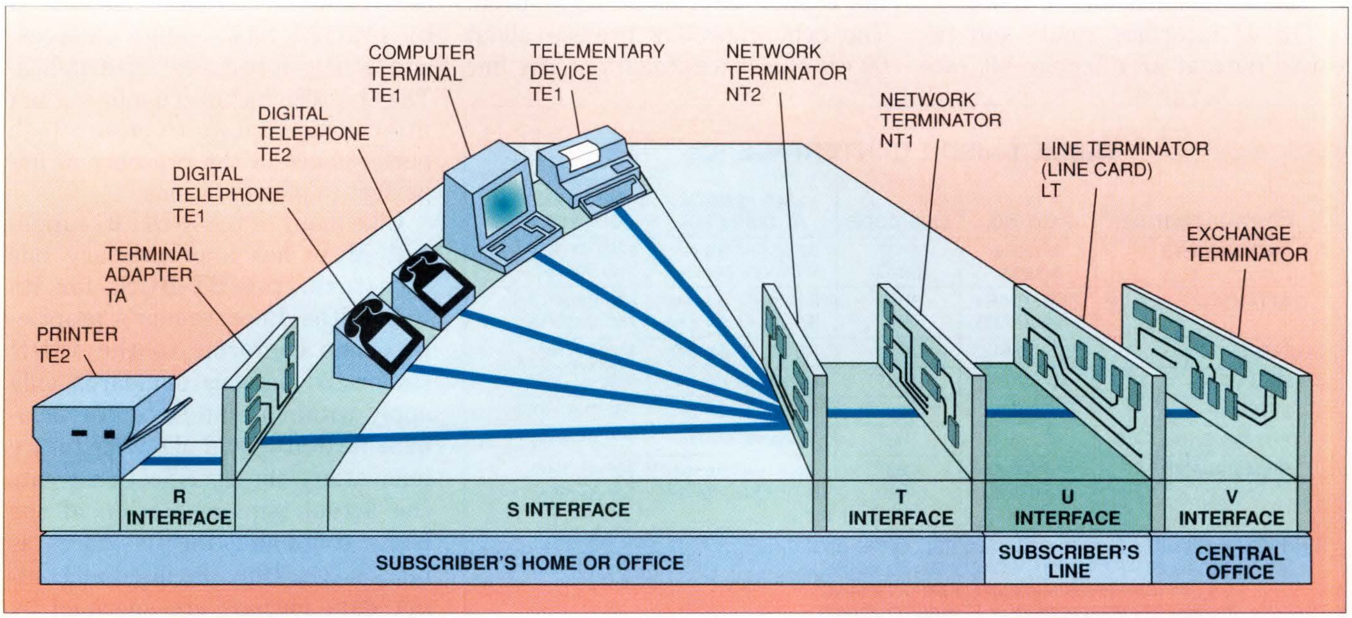


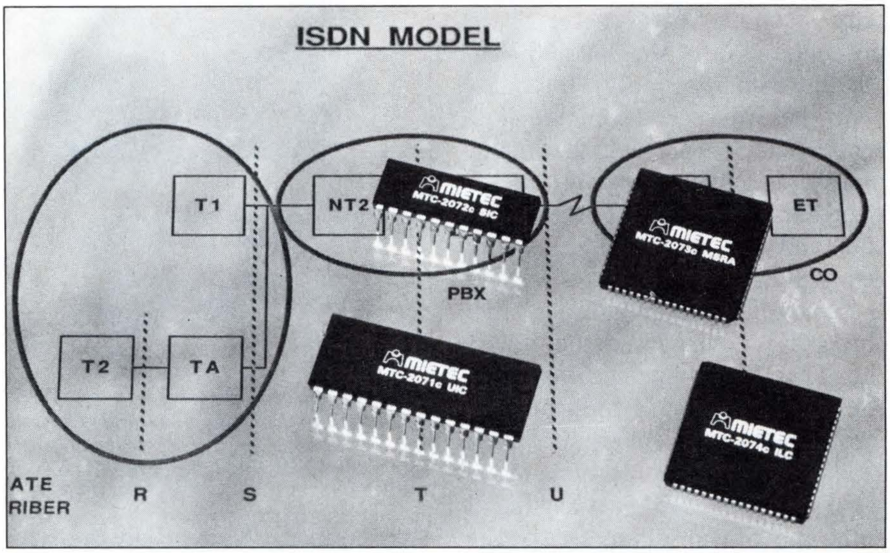
***Fig 1—The ISDN consists of many different segments,** which are called interfaces. To obtain maximum effectiveness at a particular interface, the ISDN terminators read a signal in one format and convert it to the proper format for the next step in the path.*

ISDN ICs

5.5 km (18,000 ft) of 0.5-mm (24 AWG) cable. However, you can use ICs like Precision Monolithics' LIU-01 Serial Data Receiver ($12 in 100-piece quantities) to recover data over the U interface and act as repeaters for longer-distance transmission. The LIU-01 automatically adjusts for the signal attenuation and frequency distortion caused by long transmission lines. Another, more expensive, approach to long-distance transmission is to use U-interface ICs in a back-to-back configuration as repeaters.

The digital subscriber line consists of the transceivers in the LT at the switch end of the U interface and those in the NT1 box at the subscriber's end of the interface. Full-duplex signals can be sent over the same pair of wires. The transceiver's job is to separate the signals traveling in both directions across the wires and to subtract the digital bit streams that it sends from the total bit stream, regardless of the corruption that might have occurred during the transmission of the signal. Corruption may result from bandwidth limitation, crosstalk, line echoing, or noise.

The U interface sends and receives data at an effective bit rate of 160k bps: 144k bps for the 2B + D data, 4k bps for embedded-operation-channel (eoc) messages, and 12k bps for framing and maintenance functions. To correct for signal echoing at the terminations, the U interface uses echo cancellation.



The U-interface chip is only one piece of the ISDN puzzle. *Each vendor supplies a number of other pieces, like this family of parts from Mietec.*

The transceivers in the U interface use adaptive echo cancelers, equalizers, and line-code encoders and decoders to transport data over the copper arteries at high speed. The echo cancelers provide about 60 dB of echo cancellation. The line codes allow for the reduction of the transmitted data from two bits to one bit in 2B1Q and from four bits to three bits in 4B3T—but at the expense of some signal-to-noise bandwidth.

The MT8910 Quaternary Network Interface Circuit (QNIC) from Mitel uses the 2B1Q line code. An onboard Decision Feedback Equalizer (DFE) compensates for intersymbol interference (ISI) caused by bridged taps, gauge changes, and other impedance mismatches. The chip also includes nonlinear and jitter compensators to ensure high performance in the presence of imperfect implementations.

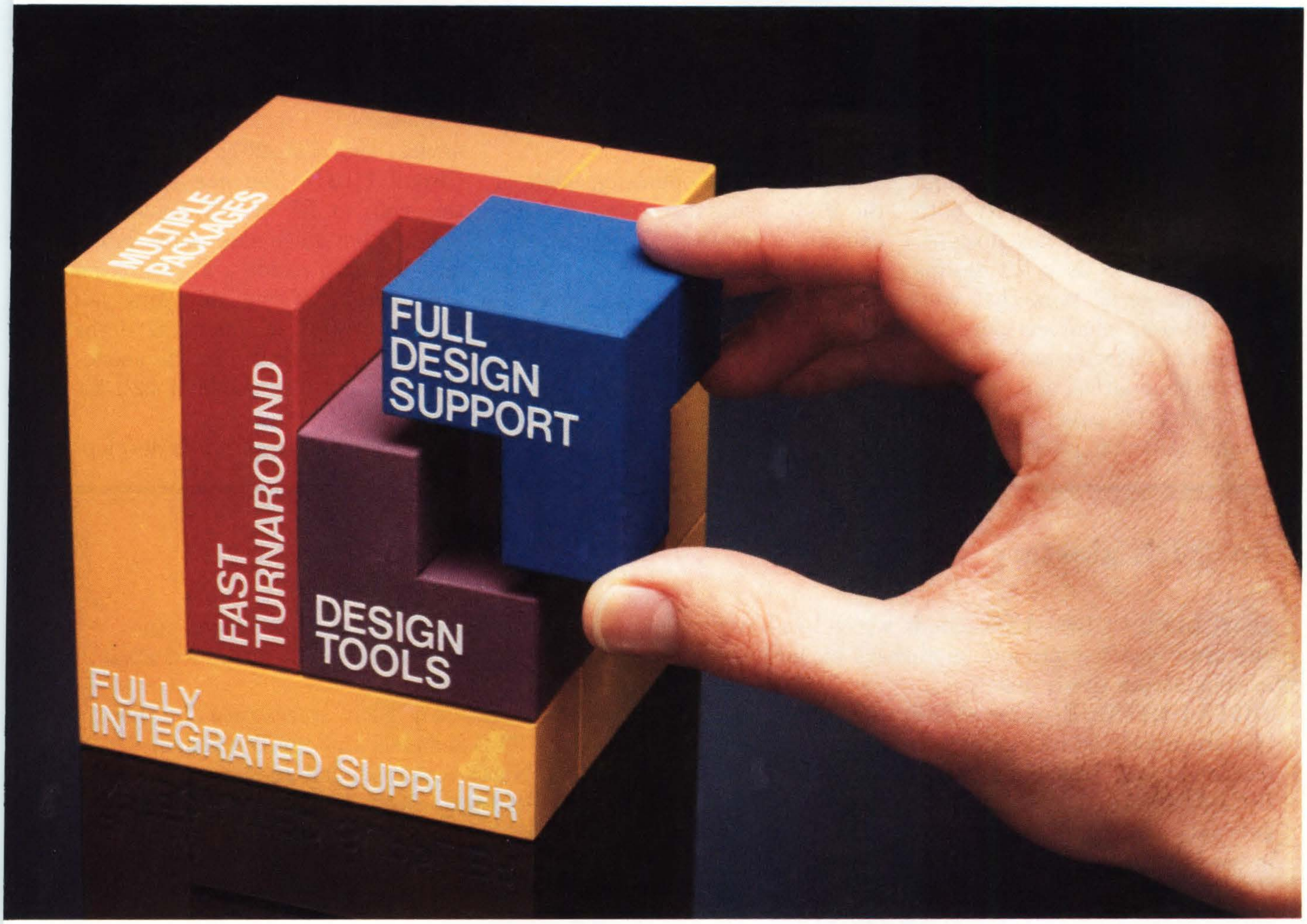
Like many of the ISDN IC suppliers, Mitel has a proprietary bus structure, the ST-BUS, for its ISDN ICs. Each vendor's proprietary bus conforms to the ISDN standards, but the standards only apply within an interface. To maximize flexibility and allow for future innovation, the specification treats the actual implementation of the boxes containing the interfaces as black boxes. Only the input and output data formats are specified by the CCITT and T1E1.4 committees. For example, any vendor's S inter-

TABLE 1—ISDN U-INTERFACE ICs

COMPANY/PARTNER	PART NO.	LINE CODE	LINE LENGTH AT DIAMETER	PRICE AND QUANTITY
AMD/SIEMENS	Am2090 Am2091	4B3T 2B1Q	9.5 km AT 0.6 mm IN DEVELOPMENT	$289 AT 100 $121 AT 100
ATT/INTEL	T7262/T7263 T7260/T7261	2B1Q AMI	5.5 km AT 0.4 mm 5.5 km AT 0.4 mm	$95 SAMPLES $50 SAMPLES
INTEL/ATT	i89122/i89123	2B1Q	5.5 km AT 0.4 mm	$130 AT 100
MIETEC	MTC2071	4B3T	8.2 km AT 0.8 mm	$120 AT 1000
MITEL	MT8910	2B1Q	5.5 km AT 0.5 mm	$61.10 AT 1000
PHILIPS/SIGNETICS	PCB2390	4B3T	8 km AT 0.6 mm	$50 AT 1000
SIEMENS/AMD	PEB2090 PEB2091	4B3T 2B1Q	9.5 km AT 0.6 mm IN DEVELOPMENT	$90 AT 1000 $70 AT 1000

NOTES: ALL 2B1Q DEVICES PASS ALL BELLCORE LOOPS.
0.4 mm IS APPROXIMATELY EQUAL TO 26AWG.
0.5 mm IS APPROXIMATELY EQUAL TO 24AWG.
0.6 mm IS APPROXIMATELY EQUAL TO 22AWG.
0.8 mm IS APPROXIMATELY EQUAL TO 20AWG.

The Analog ASIC Solution



All the pieces—from Raytheon, your development partner:

Raytheon's RLA Linear Array Family of user-configurable macrocell arrays—and full design support. (RLA 40, 80, 120, and 160)

☐ **Configurable macrocells:** 4, 8, 12 or 15 gain blocks that can be configured into a variety of analog functions to achieve your system's needs.

☐ **Design support:** Raytheon offers a comprehensive design kit containing applications and design documentation, 200X plots, a printed circuit board, and 23 macrocell kit parts.

Software includes SPICE[1] model data files that can run on PCs and various workstations.

Application engineers provide personalized service and full support from design conception through product delivery. Take advantage of Raytheon's extensive experience in custom and semicustom products.

☐ **And more:** Choose from a wide variety of packages including plastic and ceramic DIPs, SOICs, PLCCs, and LCCs in commercial, industrial and military temperature ranges.

Analog ASICs need not be a puzzle. Not with Raytheon's RLA Family. And the support we provide with more than 15 years' experience as a supplier of high-volume commercial custom and semicustom devices.

Call us for complete RLA program information and details on the RLA Macrocell Array Design Kit.

Raytheon Company
Semiconductor Division
350 Ellis Street
Mountain View, CA 94039-7016
(415) 966-7716

Raytheon

Where quality starts with fundamentals.

[1] SPICE developed by University of California

CIRCLE NO 35

face chip can talk to any other vendor's S interface chip. But if you're designing an NT1, you would want to use a single vendor's S- and U-interface chip set structured around that vendor's bus to simplify both the hardware and software designs.

Mitel's ST-BUS is a 2048k-bps bidirectional serial port that consists of 32 8-bit channels per 125-μsec frame. The frame pulse defines the frame boundaries, and the pulse repeats every 125 μsec. Each of the 32 channels is 3.9 μsec in length with bit periods of 488 nsec. All data that the QNIC transmits across the U interface arrives via this bus.

You select the operating mode of the QNIC using three pins. You use one pin to put the chip into master or slave mode, another pin selects between single- and dual-port operation, and the third pin routes data through the Control/Data ST-BUS output in dual-port mode. Additionally, the QNIC has a provision for daisy chaining multiple devices together, so you can utilize the 32-bit ST-BUS more efficiently.

Mietec's U-interface IC is a 4B3T device, the MTC-2071 U Interface Circuit (UIC). You can configure this chip in LT or NT mode, depending on which side of the interface the chip resides. Further, the architecture of the chip lets you time-multiplex as many as eight UICs in burst mode. In this mode, the chip multiplexes data in 32 1-bit wide time slots.

Perhaps due to the high develop-

An ISDN glossary

2B1Q LINE CODE—Line code in which two binary bits are converted into one quaternary bit for transmission across the U interface.
4B3T LINE CODE—Line code in which four binary bits are converted into three ternary bits for transmission across the U interface.
B CHANNEL—A switchable, optionally transparent, 64k-bps channel. Two B channels are included in the basic-rate service.
BASIC RATE—An ISDN access rate of 192k bps allocated as two B channels of 64k bps, one D channel of 16k bps, and 48k bps of overhead for framing and error detection.
CO—Central office. The telephone switching location nearest to the customer's premises.
D CHANNEL—A channel whose primary purpose is to convey signaling information between a terminal and the network switch but whose surplus capacity can be used for user-packet data and other data, such as telemetry. It operates at 16k bps for basic-rate access and 64k bps for primary-rate access.
ISDN—Integrated Services Digital Network. ISDN supports both digitized-voice and data transmission.
LT—Line Termination. A line card that provides termination of the subscriber loop at the PBX or central office.
NT1—Network Termination 1. A box that provides physical and electromagnetic termination of the 2-wire U-interface transmission line and conversion into the 4-wire S or T interface.
NT2—Network Termination 2. A box that provides switching and concentration of a subscriber's lines at the S interface.
PABX—Private automatic branch exchange. An automatic, private switchboard linked to the central office via a trunk line.
PRIMARY RATE—An ISDN access rate of either 1.544M bps—23 B channels and one D channel, which is the North American and Japanese standard—or 2.048M bps—30 B channels and one D channel, which is the European standard.
R INTERFACE—Connects a terminal adapter (TA) to nonISDN (TE2) equipment, often through an RS-232C port.
S INTERFACE—A reference point on the customer side of the NT2 to which you can connect either an ISDN terminal (TE1) or a TA; for example, the interface through which a digital telephone could connect to a PABX. This interface accommodates point-to-point and point-to-multipoint operation.
TA—Terminal Adapter. Connects nonISDN terminals (TE2) to the digital network via the S interface. The interface between the TA and the TE2 is the R interface.
TE1—Terminal equipment type 1. Standard ISDN terminal equipment that you can connect to the S or T interface.
TE2—Terminal equipment type 2. An analog or non-ISDN digital terminal.
T INTERFACE—Electrically identical to the S interface, the T interface has a different protocol than the S interface to link NT2 boxes to the NT1 box.
U INTERFACE—A twisted-pair subscriber loop that provides basic-rate access to the NT1 reference point from the ISDN network. This interface only supports point-to-point operation.

PMI®

THE ANALOG IC SEARCH STARTS...

AND STOPS HERE

PMI's free **Precision Decisions selector guide disk** eliminates the search of your entire library for the analog or data conversion IC essential to your design.

All you need is the disk, an IBM©-compatible PC, and DOS. With PMI's unique program, input your IC design specs or current part number and the disk does the searching. **Once the optimum device has been identified for you,** (operational amplifier, data converter, matched transistor, voltage reference, voltage comparator, sample-and-hold amplifier, analog switch, or multiplexer) refer directly to the appropriate data sheet in PMI's 1300 page full line catalog for complete design curves and specifications on the part.

Precision Decisions also features pricing, Mil/Aero and SSM Audio product listings, new product guide, sales office listing, and part numbering system. **Free quarterly updates** ensure you have current information available.

PMI offers the latest design tools to make your job easier. Call us and find out the other ways we can help you.

To receive your free copy of Precision Decisions, call **800-843-1515** or complete and mail the coupon below. **Your next search for an analog IC will start and stop with PMI.**

PMI®

Precision Monolithics, Inc.
A Bourns Company

1500 Space Park Drive
P.O. Box 58020
Santa Clara, California 95052-8020

Please send me a free copy of Precision Decisions

Name: ____________________

Title: ____________________

Company: ____________________

Address: ____________________

____

Phone Number: ____________________

Check boxes that apply:

☐ I would like to recieve free quarterly updates of Precision Decisions

☐ Also send me PMI's full line catalog

EDN042789

ALTAMONTE SPRINGS: (407) 260-9780, **ATLANTA**: (404) 263-7995, **BOSTON**: (508) 794-0026, **CHICAGO**: (312) 250-0808, **DALLAS**: (214) 690-3495, **DENVER**: (303) 792-9595, **DETROIT**: (313) 227-2190, **LOS ANGELES**: (818) 886-6881, **MILPITAS**: (408) 942-8060, **ORANGE COUNTY**: (714) 637-9602, **PHILADELPHIA**: (215) 953-1070

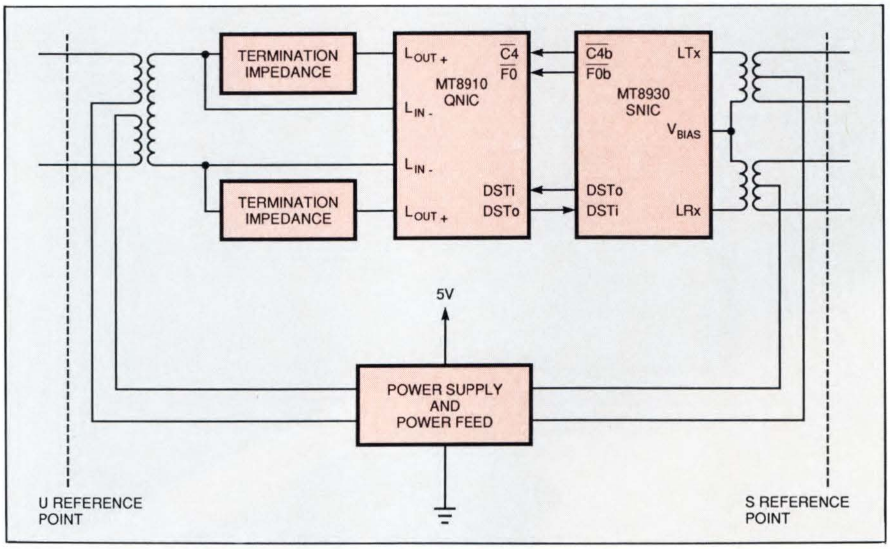
CIRCLE NO 36

ISDN ICs

ment costs associated with designing ISDN chips, many vendors have agreed to partnerships whereby they either split the engineering costs and agree to second-source each other's ICs or license chips in return for other considerations. Among the partnerships announced to date are those between Siemens and Advanced Micro Devices, Intel and AT&T, National Semiconductor and SGS-Thomson, and Philips and Signetics.

Siemens was one of the driving forces behind the Deutsche Bundespost's acceptance of the 4B3T line code. Needless to say, the company has a 4B3T U-interface chip, the PEB2090 ISDN Echo Cancellation Circuit (IEC). Siemens has organized the IEC to fit onto its ISDN-Oriented Modular (IOM) bus, which is similar to and compatible with the General Component Interface (GCI) bus. According to Dataquest, a market research firm in San Jose, CA, the GCI bus has been adopted and is supported by such vendors as Siemens, AMD, National Semiconductor, SGS-Thomson, Plessey, Philips, and Signetics. Siemens is modifying its 2090 chip to transmit and receive 2B1Q line code; it's planning to name the new part the PEB2091.

A number of other 4B3T alterna-



Due to proprietary bus structures, *many ISDN chip families interface easily. Here, a Mitel 8910 acting in a slave mode terminates the subscriber line from the CO and extracts the clock from the data. The QNIC outputs a 4096k-bps bit clock and feeds an 8-kHz frame clock to the SNIC.*

For more information . . .

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

AT&T
Dept 51AL330240
555 Union Blvd
Allentown, PA 18103
(800) 372-2447
in Canada,
(800) 553-2448
Circle No 720

Intel Corp
3065 Bowers Ave
Santa Clara, CA 95051
(408) 765-8080
Circle No 721

Mietec
Raketstraat 62
1130 Brussels
Belgium
(32) 2-728-1811
TWX 65299
FAX 322-242-7552
Circle No 722

Mitel Corp
350 Legget Dr
Kanata, Ontario
Canada K2K 1X3
(613) 592-2122
in North America,
(800) 267-6244
FAX 613-592-6909
TLX 053-3221
Circle No 723

National Semiconductor
2900 Semiconductor Dr
MS16-171
Santa Clara, CA 95052
(408) 721-2358
Circle No 724

Philips Components Div
Box 218
5600 MD
Eindhoven, The Netherlands
(040) 783749
TLX 35000
Circle No 725

SGS-Thomson Microelectronics
1000 East Bell Rd
Phoenix, AZ 85022
(602) 867-6100
Circle No 726

Siemens Components Inc
2191 Laurelwood Rd
Santa Clara, CA 95054
(408) 980-4500
Circle No 727

Signetics Corp
811 E Arques Ave
Sunnyvale, CA 94088
(408) 991-2000
Circle No 728

16-Bit CMOS Microcontrollers. More Functions and More Memory On-Chip. Now. From Mitsubishi.

32K bytes EPROM or ROM. 2K bytes RAM. Two UARTs, with on-board baud rate generator. 8-bit, 8-channel A-D converter. Eight multi-function 16-bit timers that operate in five modes (timer, event-counter, one-shot, pulse-period and pulse-width), and pulse-width modulation. 12-bit watchdog timer. Interrupt controller. 68 independently programmable 1/0 ports. All on-chip.

Plus, linear access for 16 megabytes external memory. Powerful instruction set optimized for high-performance operation. High efficiency hardware multiply and divide instructions. And, configurable for 8- or 16-bit external operation. All in low power, 1.3 μm silicon-gate CMOS technology. All part of a broad 16-bit MCU product line.

IBM®-PC based development and software support tools. Plus, masked ROM, ROM-less and OTP ROM versions and prototyping adapters.

All available now from Mitsubishi. Driven by your applications, we put more on-chip and give you more choices, so you can reduce system component count, save board space, lower overall design costs and get products to market fast. For more information call now. (408) 730-5900 Ext. 2106. 1050 E. Arques Avenue, Sunnyvale, CA 94086.

IBM is a registered trademark of International Business Machines Corporation.

MITSUBISHI ELECTRONICS

Applications-Driven Microcontrollers

CIRCLE NO 40

tives are currently available, and the 2B1Q ICs will soon join the party. But be aware that the line-code disparity requires that you know where your design will operate and that you design flexibility into your product, so you can adjust the circuitry if the need arises. Additionally, although the U interface has been standardized, that standard is not yet etched in stone. You obviously don't want to have to redesign your NT1 or line card because you failed to properly analyze the market. EDN

References

1. Drazin, Jonathan, "ISDN—The ICs and their Applications," Dataquest, January 1989.
2. Leibson, Steven H, "Integrated Services Digital Network," *EDN*, November 12, 1987, pg 118.
3. Scott, Howard A, "ISDN Basic Access Transport," *ISDN User*, September/October 1987, pg 11.

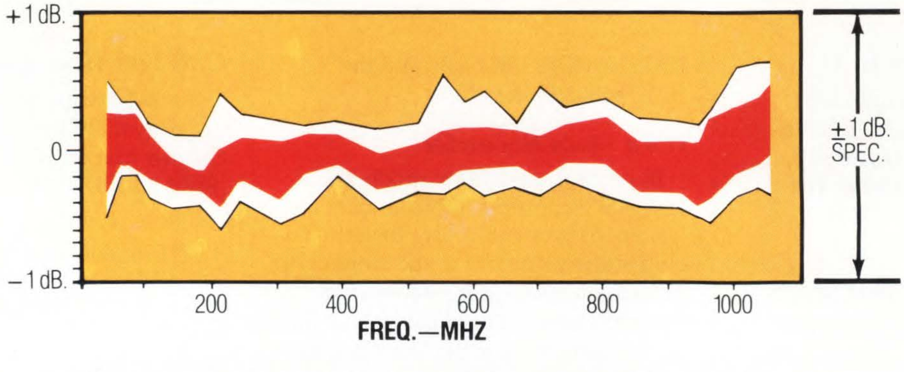
Acknowledgment

The author would like to thank Information Gatekeepers (Boston, MA) and the Information Network (San Francisco, CA) for their assistance.

Article Interest Quotient
(Circle One)
High 512 Medium 513 Low 514

FLUKE

Truth.



6060B typical level accuracy vs. frequency at -127 dBm.

Sample: 38 units. Solid line: worst case. Shaded: Typical (75%).

Getting the performance you expect from your instruments can sometimes be a pain. But not when it comes to the Fluke 6060B RF signal generator. It delivers more performance than you thought you paid for, even at the extremes.

On paper, most general purpose RF signal generators look pretty much the same.

But how they perform in your real-world test environment is another matter.

Take the Fluke 6060B. Its specified amplitude level accuracy in a typical working environment is ±1 dB. Nothing surprising there. Except that this performance is available over the entire dynamic range of -127 dBm to +13 dBm. What's more, as the chart above shows, typical performance is much better: 2:1 or more. Even at -127 dBm. And in the over range areas to +16 dBm and -140 dBm, the 6060B typically stays within its ±1 dB specification.

That means the devices you test can be specified and measured more precisely with increased confidence. Your test yields go up. And you can process more workload with a single signal generator.

What is the key to this extra margin of performance? Attention to the details. Software compensation techniques. And outstanding linearity and repeatability over the 6060B's amplitude and frequency range.

Which means you can be sure of your measurements. From instrument to instrument. Test to test.

A L L I A N C E   I N   T E S T   &   M E A S U R E M E N T

PHILIPS

Hertz.

The 1.05 GHz Fluke 6060B.

The 6060B also offers a number of amenities that make it easy to use. Uncluttered front panel layout. Bright digit editing. Stored front panel set-ups. Increment stepping. And relative amplitude and frequency. To name a few.

The 6060B is just one member of a family of general purpose RF signal generators from Fluke, each designed to deliver more performance than you thought you paid for.

Test the true performance of the 6060B for yourself. Because what you don't know might hurt you. Call Fluke toll-free at **1-800-44-FLUKE** and arrange for a demonstration.

Fluke 6060B
10 kHz — 1.05 GHz
+13 dBm maximum output level
±1 dB level accuracy
-60 dBc spurious

John Fluke Mfg. Co., Inc., P.O. Box C9090, M/S 250C, Everett, WA 98206. U.S. (206) 356-5400. Canada (416) 890-7600. Other countries: (206) 356-5500. Specifications subject to change without notice. Ad no. 0881-F6060.

FLUKE

SAMSUNG NOW

NEW SAMSUNG MICRO
BECAUSE YOU'RE EITHER

PROCESSOR PERIPHERALS. QUICK OR YOU'RE DEAD.

Samsung's hot new microprocessor peripherals are the fastest industry-standard family made by anyone.

We offer these CMOS parts with top speeds of 10 Mhz, 12 Mhz, and even 16 Mhz.

And in a world where the drive for speed takes no prisoners, that kind of performance can just about save your life.

8086/286/386 microprocessors have steadily gotten faster. But today, they're slowed down by microprocessor peripherals that haven't.

Our new parts change that. They will let your fast CPU run the way it was meant to—fast.

Besides being fast, Samsung's peripherals are in CMOS, which means they're low in power dissipation and will keep your designs cool. And unlike most peripherals, they're available through the entire line in PLCC surface mount packaging, in addition to DIP.

Best of all, these speedy peripherals are for real: you can get as many of them as you want, because we're a high-volume supplier and we have parts ready for immediate delivery in quantity.

Of particular note: our 82C37 DMA Controller, which at 10 Mhz is the fastest made. Also: our 53C80 SCSI Interface, and our blow-the-doors-off, performance-boosting 1- and 4-Mb DRAM Controller, affectionately known as the System Accelerator.

Microprocessor peripherals from Samsung. The fastest family made, they're designed to let your CPU run at the speeds it was meant to.

In a world where you're either quick or you're dead, we think you'll find them extremely helpful.

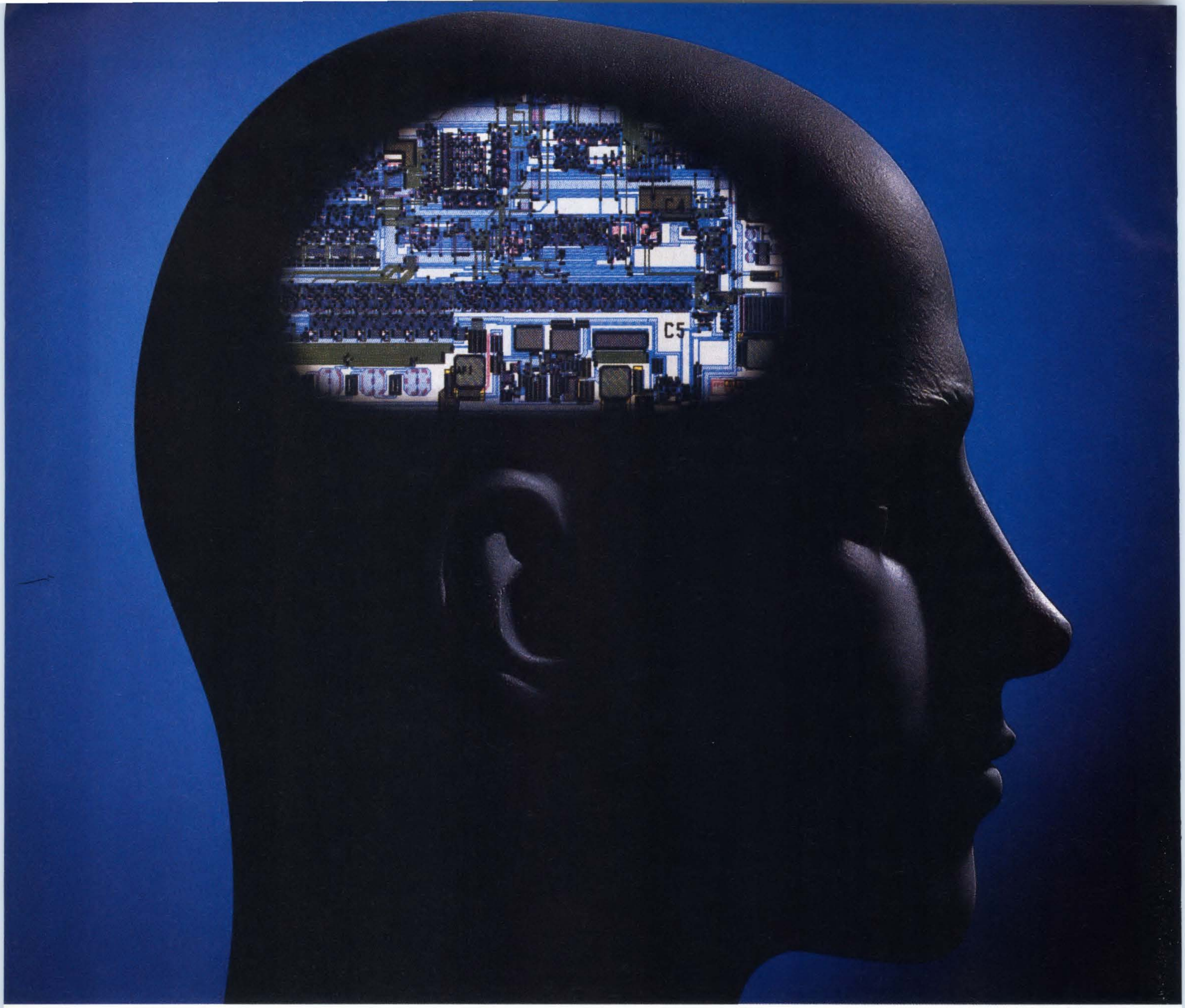
Call Microprocessor Peripheral Marketing now for samples, databooks, or application notes, at 1-800-669-5400 or 408-922-7754. Or write to Microprocessor Peripheral Marketing, Samsung Semiconductor Inc., 3725 No. First Street, San Jose, CA 95134-1708.

SAMSUNG'S CMOS MICROPROCESSOR PERIPHERALS

PART	SPEED	AVAILABLE
KS53C80 SCSI Interface	1, 3 Mbyte/sec.	Now
KS82C37A DMA Controller	5, 8, 10 Mhz	Now
KS82C50A UART	8, 10 Mhz	Now
KS82C52 Serial Controller Interface	8, 10 Mhz	Now
KS82C54A Interval Timer	8, 10 Mhz	Now
KS82C55A Programmable Peripheral Interface	8, 10 Mhz	Now
KS82C59A Interrupt Controller	8, 10 Mhz	Now
K82C84A Clock Generator	8, 10 Mhz	Now
KS82C88 Bus Controller	8, 10 Mhz	Now
KS82C284 80286 Clock Generator	10, 12, 16 Mhz	Now
KS82C288 80286 Bus Controller	10, 12, 16 Mhz	Now
KS82C289 80286 Bus Arbiter	10, 12, 16 Mhz	Now
KS68C45S CRT Controller	4, 6 Mhz	Now
KS84C21/22 DRAM Controller	25, 40 Mhz	Now
KS85C30 SCC	6, 8, 10 Mhz	June

SAMSUNG
Semiconductor

CIRCLE NO 42



Anything this system can think of,

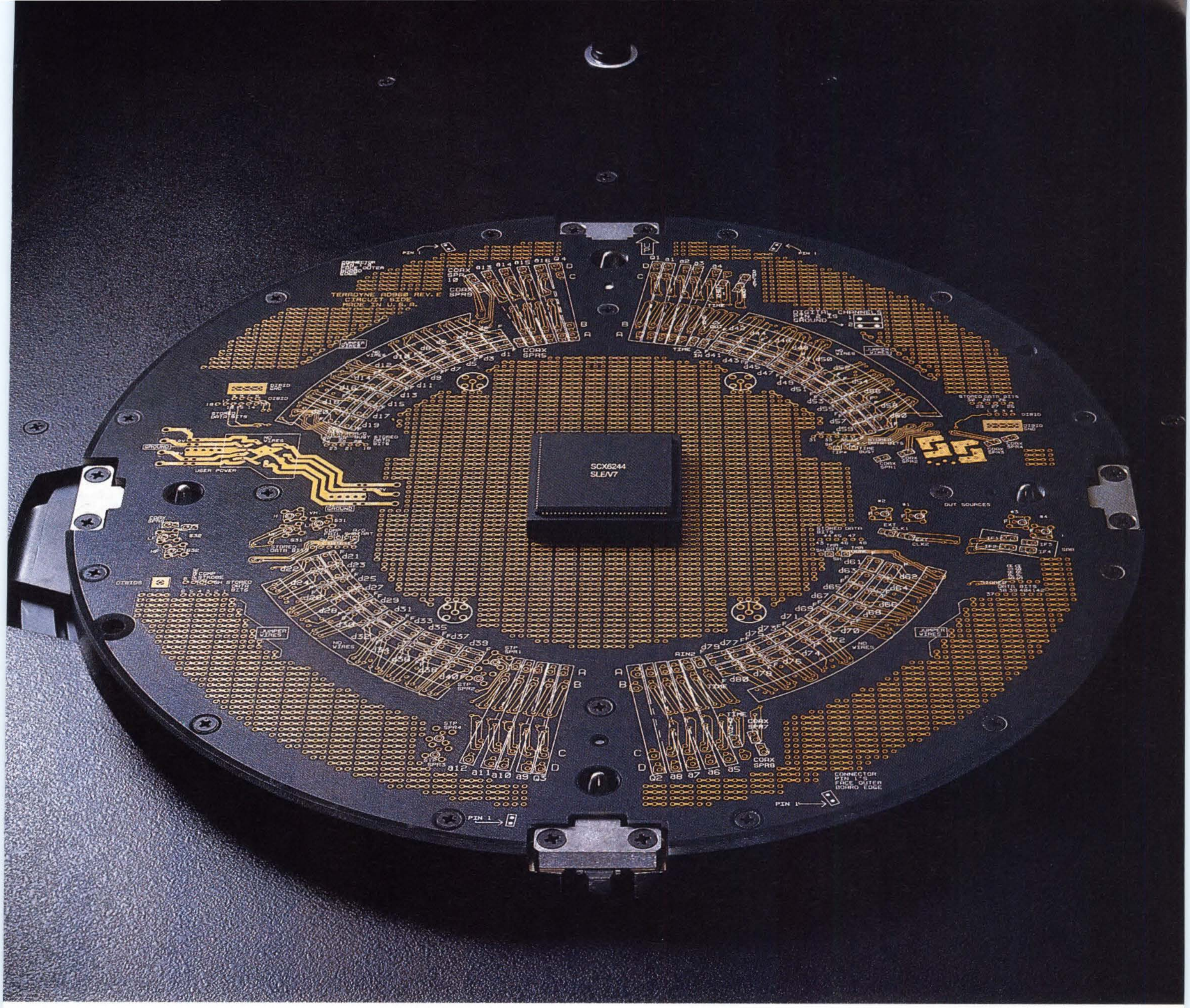
Now there's a family of test systems that will change the way you think about Analog VLSI testing.

The system on the left thinks up new device designs so fast that most test systems can't keep up with it. Except the one on the right.

Teradyne's revolutionary A500. The only system that's ready to test the most complex "system silicon" devices as fast as you can dream them up. In fact, the A500 is already helping many leading companies cut critical product development time and bring their advanced products to market faster, and with a lower overall cost to test.

Now, you can test anything from standard linear to mixed-signal AVLSI.

Teradyne has taken its revolutionary A500 architecture and created two new, compatible systems. The A510, a workstation-based standard linear tester, with the lowest cost



this system can test.

to test per test head, and the A520, which packs all the performance of an A500 into a smaller footprint at a lower capital cost.

Teradyne's new A500 family not only gives you the capability to test the range of today's devices, it's ready to help you test tomorrow's devices, as well.

The A500 family shares an architecture based on today's "open systems" standards–dual Sun computers, a UNIX operating system, powerful C-based IMAGE™ software and Ethernet TCP/IP networking. In addition, each system provides full tester simulation on stand-alone workstations, with graphic debug and analyzer tools as powerful as any CAD/CAE tools.

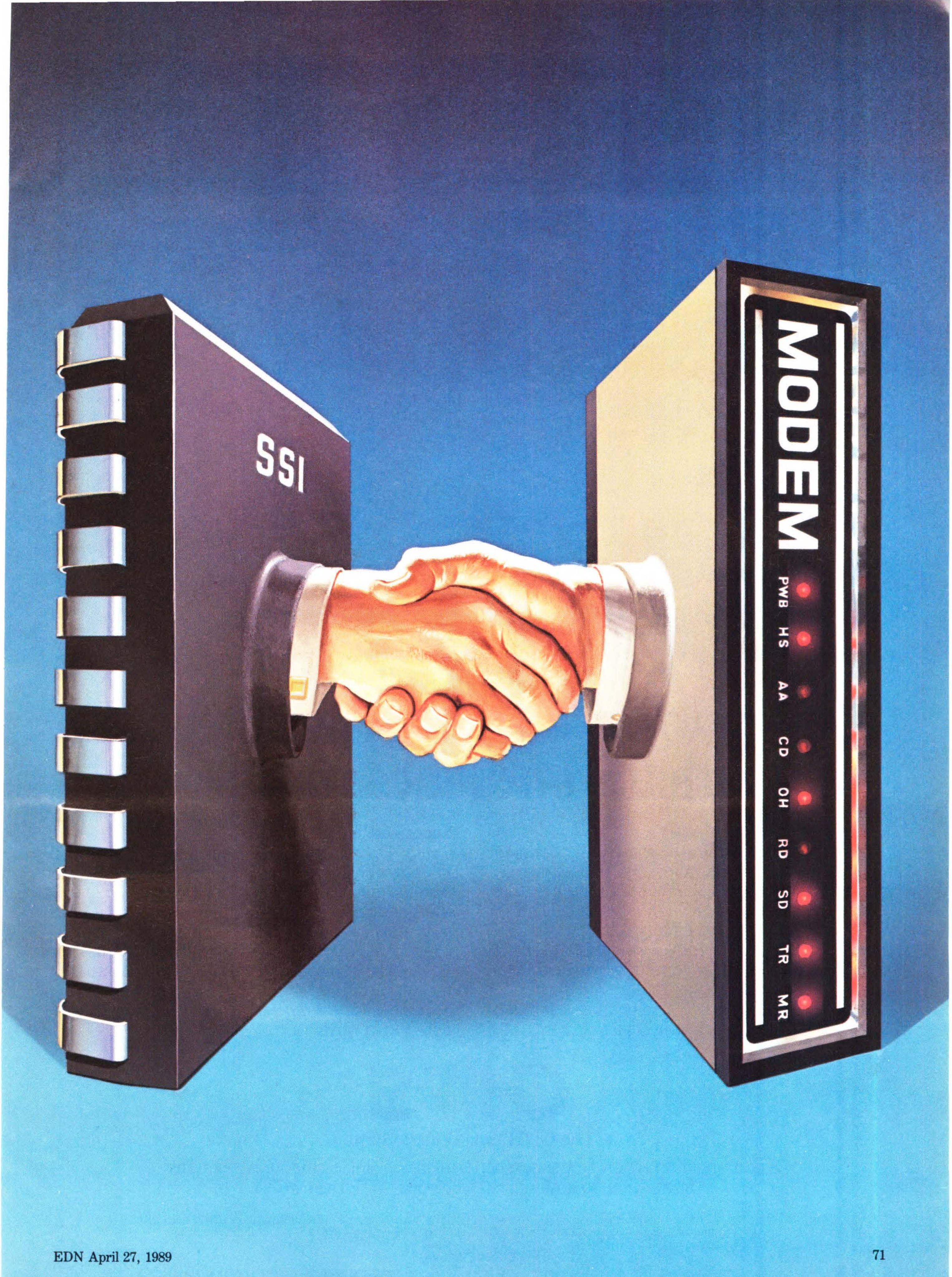
Spend your time testing designs instead of designing tests.

If you want to help your company bring next-generation products to market faster, prevent premature product rollouts and cut test engineering costs drastically, use the system on the left. Which can only lead you to the system on the right.

For more thoughtful details, call Beth Sulak at (617) 482-2700, ext. 2746. Or call your nearest Teradyne sales office or write: Teradyne, Inc., 321 Harrison Avenue, Boston, Massachusetts 02118.

TERADYNE

We measure quality.


SSI
MODEM
PWB
HS
AA
CD
OH
RD
SD
TR
MR

Laptop to desktop. VGA™ performance that won't fence you in.

Single-chip VGA for Laptops.

Compact, powerful laptop systems demand a single-chip VGA solution for high-quality graphic display. The CHIPS 82C455 VGA controller is the choice of major laptop OEMs because it delivers this quality in production quantities. Today. VGA color applications are intelligently converted to 16 shades of crisp, flicker-free, high-contrast grayscale for all laptop screen technologies. Battery life is extended with power-down features. And backward compatibility protects your user's software investment. Today.

Super VGA for Desktops.

For desktop applications, equip your AT and PS/2™ systems with VGA performance 5 times faster than the industry standard. The CHIPS 82C452 Super VGA controller's optimized memory architecture uses inexpensive DRAMs to deliver performance comparable to more expensive VRAM-based VGAs. You also get extended high-resolution modes, including 640 x 480 in 256 colors. ***The 452 Super VGA is guaranteed to outperform all DRAM-based VGA cards.***

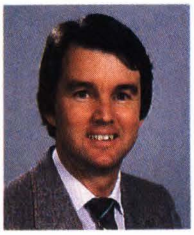
CHIPS

The CHIPSet™ *is* the system.

For more information on the best performance in single-chip VGA solutions from laptop to desktop, call **1-800-323-4477, Dept. MC-8.**

10M-BPS TWISTED-PAIR ETHERNET

An Ethernet LAN standard emerges



The proposed IEEE-802.3 10BaseT standard will allow Ethernet LANs to transmit data over 99% of the installed telephone lines.

David Shear,
Regional Editor

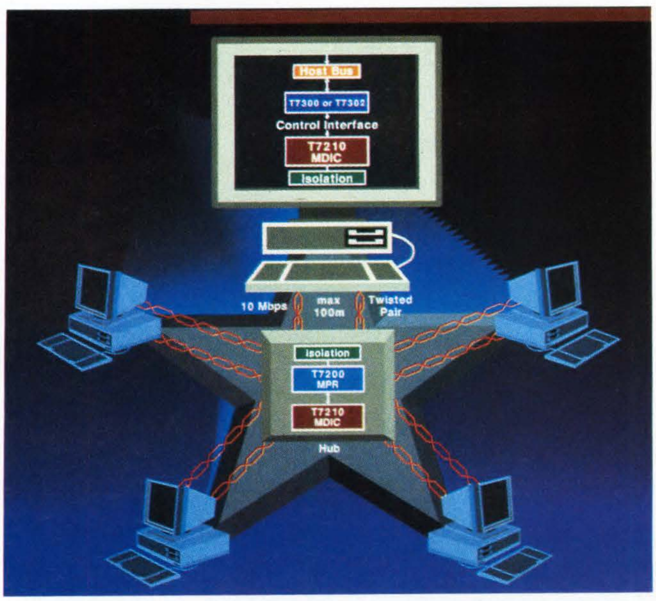
Before long, board and system designers may have to contend with designing local-area-network (LAN) interfaces based on the emerging IEEE-802.3 10BaseT standard, which will allow the transmission of data over standard phone lines at the full 10M-bps data rate. The standard is nearing ratification, and you may soon have to design a compatible LAN interface into almost any type of system you develop. Help is on the way. Many vendors are preparing 10BaseT-compatible transceiver chips, and some of the parts are already available.

The maximum length of twisted-pair cable that the 10BaseT standard allows is 100m. Statistically, this length will allow you to use 10BaseT-compatible equipment with 99% of the currently installed phone lines. This ability to use the phone lines instead of the expensive and cumbersome coaxial cables that the current 10M-bps Ethernet standard uses will increase the proliferation of Ethernet LANs. In some cases, a LAN interface will prove to be a better choice than either the RS-232C or the IEEE-488 type as a system's standard interface.

Ethernet is currently the most popular local-area network. Industry observers expect that Ethernet will remain the most popular LAN for the foreseeable future.

The IEEE-802.3 standard defines both the CSMA/CD and the physical layer. CSMA (carrier-sense multiple access) is the part of the standard that defines medium-access control. The CSMA standard uses a contention method that is probabilistic; in other words, it doesn't guarantee that any particular station will have access to the transmission medium. A station wishing to transmit must first listen to the channel. If the line is clear, it can send its message. Otherwise, it must wait for another opportunity to transmit.

Keep in mind that Ethernet in its present form may not meet your real-time needs, because it doesn't let you determine the worst-case data-transmission



The proposed 10BaseT standard *will allow Ethernet systems to send data over 99% of the installed phone lines.*

CADSTAR™ CHALLENGES WORKSTATION ROUTERS...

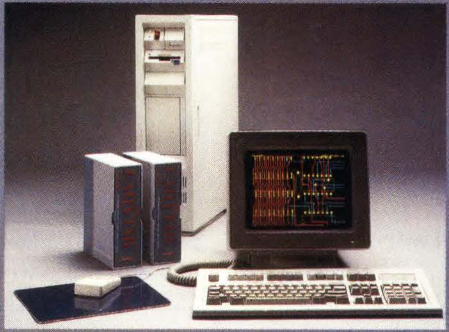
...ON SPEED!

The CADSTAR 386 Advanced Router is the fastest, most economically priced PC-based 32-bit gridless router in the business. And we challenge the competition to match its results.

In a recent benchmark, CADSTAR's 386 router proved superior in speed and performance. It routed in one-fifth of the time that it took the competition. And the results were completely manufacturable. Features like rip up, retry, shove aside, and re-entrant routing make board layout fast. And ECO's have never been easier.

...ON PERFORMANCE!

CADSTAR's PC-based Design and Layout Software is the best mid-range CAD system in the industry. It enables you to perform 95 percent of all the interactive and automatic capabilities of high-end workstations. As a result, you'll be able to handle today's most sophisticated boards—high-density dual in-line boards and multilayer, surface-mount designs. CADSTAR is easy to learn and fully supported with our hot-line service.



...ON PRICE!

CADSTAR meets the challenge. It combines the best in PCB CAD software with our CADSTAR Advanced 32-bit Gridless Router. Buy this package for a fraction of the cost of workstation systems. Or ask for CADSTAR PCB separately.

And CADSTAR is the only mid-range system that offers you a true migration path, from our low-end PC-based MAXI/PC system up to CADSTAR and from there to our high-end Visula™ engineering workstation.

Call for the dealer nearest you for complete details. Order today.

CADSTAR™

RACAL-REDAC

238 Littleton Road
Post Office Box 365
Westford, MA 01886-9984
Telephone: 1-508-692-4900

RACAL

time. This situation can certainly be a problem for real-time applications. If you must be able to determine the worst-case response time in such an application, you may have to use other LANs.

The "CD" in CSMA/CD stands for collision detection. When two or more stations begin to transmit at the same time, they detect the message collision by seeing corrupted data on the bus. After detecting the collision, each station that is trying to transmit waits a random length of time and tries again.

Physical-layer options

IEEE-802.3 also defines the physical layer, or the medium over which the LAN transmits data (**Fig 1**). The original physical layer specified for Ethernet is 10Base5, which stands for 10M-bps baseband with a maximum segment distance of 500m. In this bus topology, each station connects to a transceiver module called a medium-attachment unit (MAU). The cable specified for 10Base5 is expensive and cumbersome.

To make Ethernet easier for end users to employ, the 10Base2 (Cheapernet) option was created. Cheapernet is also a bus topology, but it uses thinner, less-expensive coaxial cable. Its interconnections are inexpensive T connectors, and the MAU can be integrated into the station. 10Base2 provides for a maximum segment distance of 200m.

The 1Base5 (StarLAN) option was created to allow Ethernet systems to use existing phone lines. This option is a star topology that matches the way that telephones are wired into a building. The topology looks like that of any other bus-based Ethernet LAN. 1Base5 LANs operate at only 1M bps, but their maximum distance between nodes is 500m.

Recognizing the need for a 10M-bps twisted-pair Ethernet LAN that could operate at the same speed as the other physical-layer options, Synoptics, 3Com and other firms created a limited-distance version that could do just that. From these ideas came the standards effort for 10BaseT, or 10M-bps baseband on unshielded twisted-pair lines (common telephone lines).

10BaseT LANs will be able to use existing phone lines to a maximum distance of 100m. Statistically, 99% of the installed phone lines fall within that limit. The limited distance will permit 10M-bps data rates, which will allow the entire

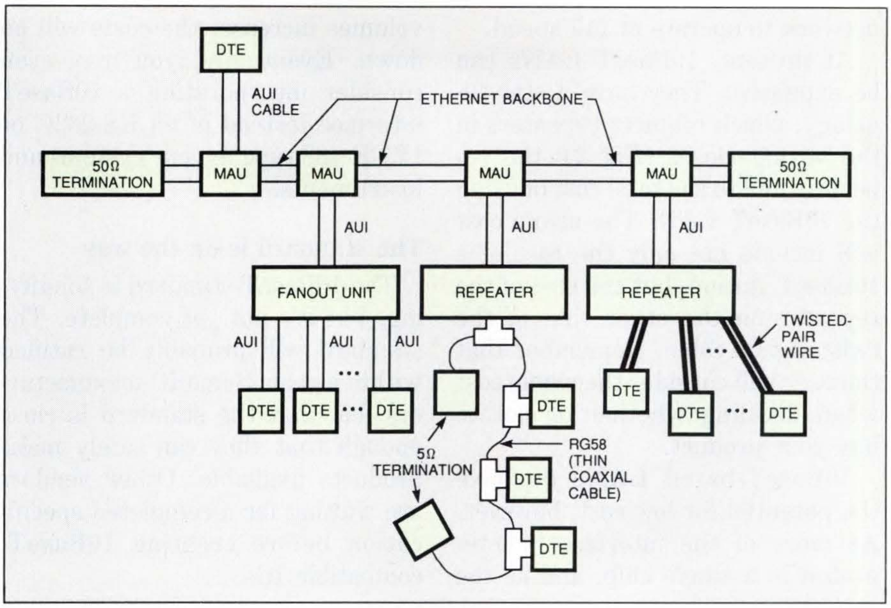


*Fig 1—**The IEEE-802.3 standard** has many physical-layer options that you can mix and match to meet varying requirements.*

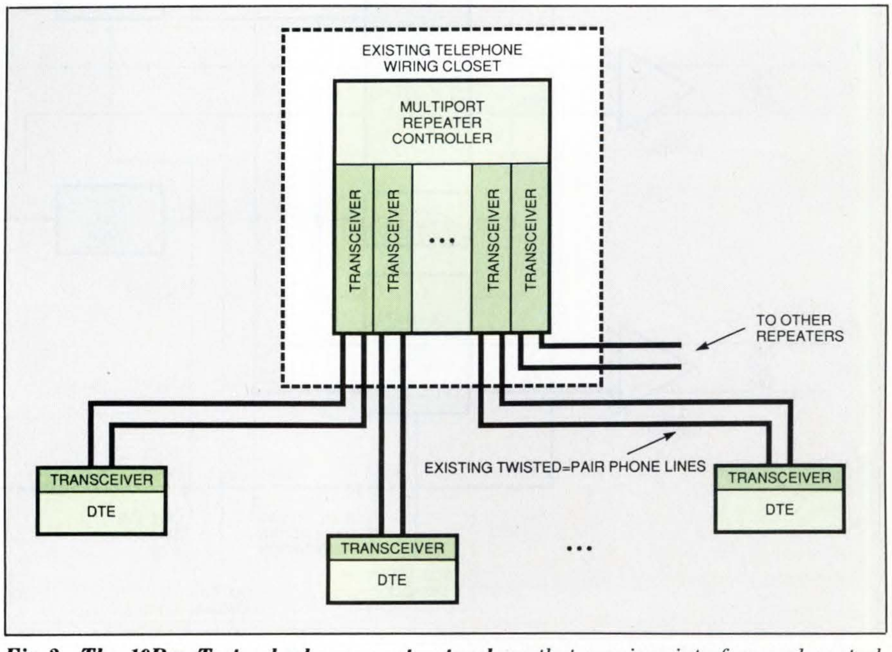


*Fig 2—**The 10BaseT standard uses a star topology** that requires interface and control electronics at both ends of the twisted-pair cable.*

network to operate at full speed.

At present, 10BaseT LANs can be expensive. They have a star topology, which requires repeaters in the wiring closet (**Fig 2**); the repeaters add to the total cost of using the 10BaseT LAN. The user's cost will include not only the cost of a 10BaseT station, but the cost of the repeater on the other side of the twisted-pair cable. Remember that the user will consider the whole cost when deciding whether or not to buy your product.

10BaseT-based LANs do have the potential for low cost, however. As more of the interface is integrated in a single chip, and as the volumes increase, the costs will go down. Eventually, you may even consider incorporating a 10BaseT interface instead of an RS-232C or IEEE-488 type in your systems and instruments.

The standard is on the way

The 10BaseT standard is solidifying, but it's not yet complete. The standard will probably be ratified within a year. Some IC manufacturers feel that the standard is close enough that they can safely make products available. Other vendors are waiting for a completed specification before creating 10BaseT-compatible ICs.

One of the intrepid vendors to come out with a 10BaseT-compatible chip is NCR. The company offers the 92C02, a digital transceiver that uses external analog line drivers and receivers (**Fig 3**). The chip is intended for use with a LAN controller and a Manchester encoder/decoder. It includes digital pre-equalization, collision detection, SQE (signal-quality error) test, a jabber timer, and link-beat generation and detection for testing link integrity. The 92C02 costs $15 (5000).

The 10BaseT standard specifies that transceiver chips use Manchester encoding, which makes it

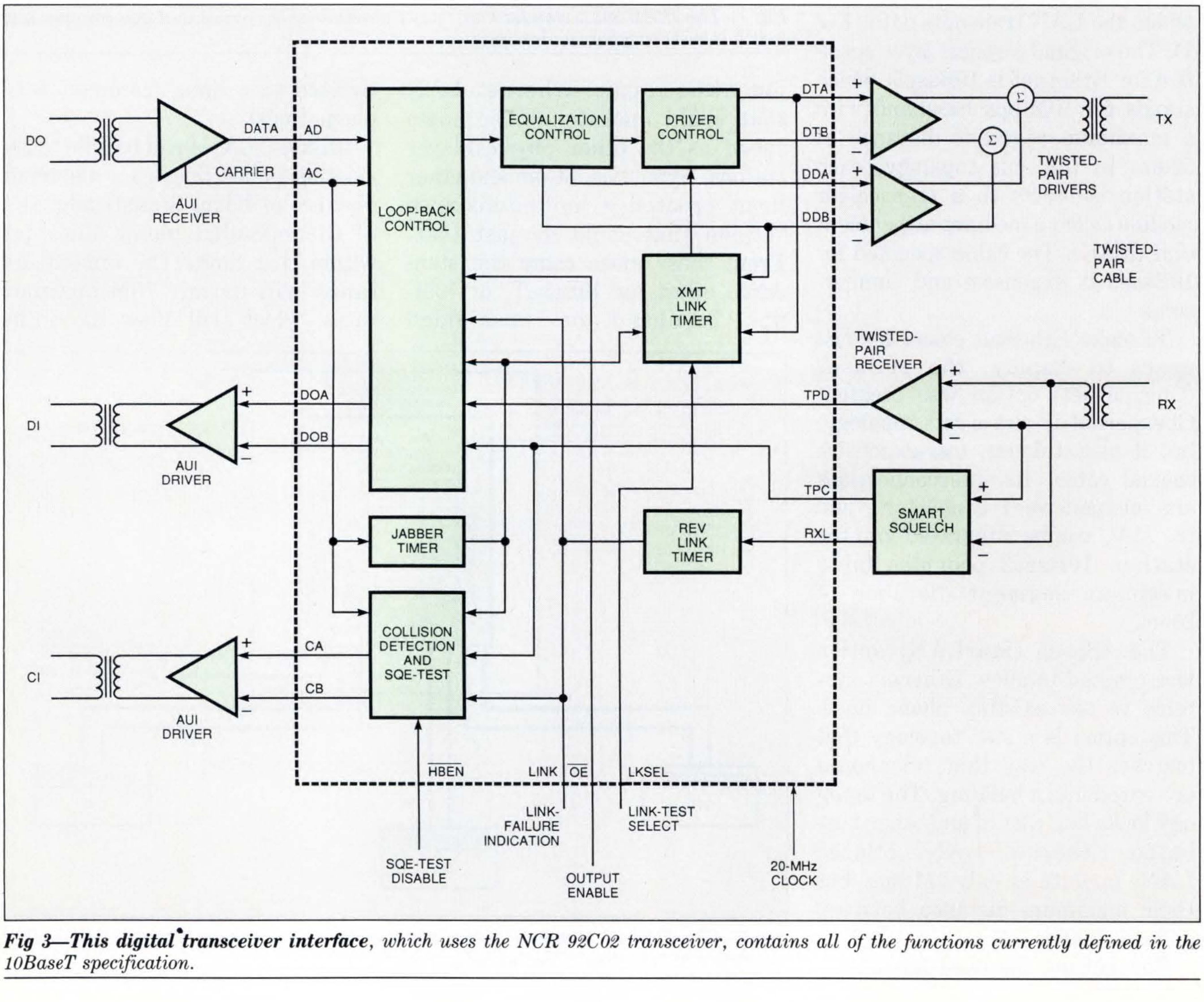


***Fig 3—This digital transceiver interface**, which uses the NCR 92C02 transceiver, contains all of the functions currently defined in the 10BaseT specification.*

88000 WAYS TO GET TO UNIX V.4 FASTER.

The future of computer operating systems is UNIX,® and the fastest way of getting to its next release, V.4, is Motorola's 88000 microprocessor.

While other companies seem to promise the same thing, only Motorola's 88000 has the solution. *Today.*

Because the 88000 has the only published Binary Compatibility Standard (BCS) on UNIX System V 3.2.

The 88000 BCS assures manufacturers of having application software on hand immediately by enabling release 3.2 application software to execute under release 4.

That's one reason AT&T chose the 88000 BCS as the early development platform for their V.4 Application Binary Interface.

Designers moving software for other hardware platforms will spend months recompiling.

We think software vendors have better things to do with their time.

And systems manufacturers more important things to do than wait for them.

Don't waste another second.

Call us today. 1-800-441-2447.

Winner 1988 Malcolm Baldrige National Quality Award

MOTOROLA

possible to have a 5-MHz component in the signal. At other times the signal can be 10 MHz, depending on the data being sent. The signal's clock rate is 10 MHz. Manchester encoding allows you to send the data and the clock signal over the same wire.

Because the twisted-pair wire is similar to a lowpass filter, it has greater attenuation at 10 MHz than at 5 MHz. Therefore, the 5-MHz components of the signal must be attenuated prior to transmission so that they'll be at the same power level as the 10-MHz components when they reach the receiver.

To condition the signals prior to transmission, 10BaseT transceiver chips use pre-equalization or predistortion methods. This conditioning makes it easier to reconstruct signals correctly at the receiving end.

The 10BaseT transceiver chip implements the SQE test function after every transmission. This function tests the collision-detection circuitry. It must be disabled in applications in which the transceiver is used in a repeater.

Stop that runaway transmitter

A jabber timer monitors each transmitter and disables it if it continuously transmits for more than a preset amount of time. The link-integrity function uses a link-beat method. This method continually checks the integrity of the link between the station and the repeater. If no data is sent within a preset amount of time, a link pulse is sent along the twisted-pair wire. The interface at the other end of the twisted pair then responds. If the originator receives this response, the integrity of the line is intact.

10BaseT transceiver chips also include a loop-back function, which makes 10BaseT equipment compatible with software written for other Ethernet physical layers. Some software expects to see the transmitted data come back through the receiver. When using a bus topology, you can easily see the data being transmitted, because your system is connected to the bus. A twisted-pair system isn't directly connected to a bus, however, so the interface must provide this loop-back feature.

The 92C02 is designed to use the Adapter Unit Interface (AUI), so you can incorporate the chip in an external Medium Attachment Unit (MAU). You can use this MAU to replace other 10M-bps MAUs when converting existing stations for use

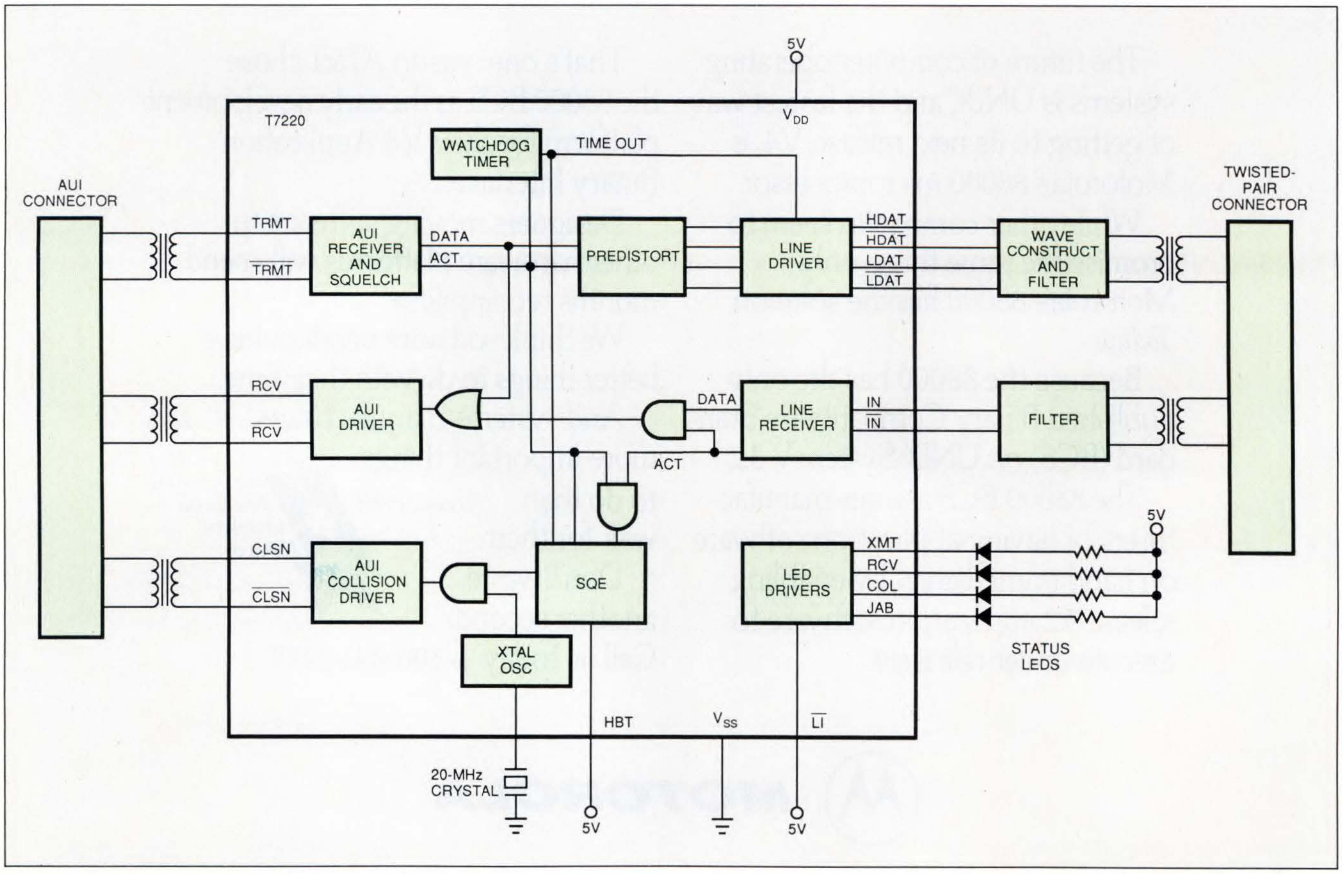
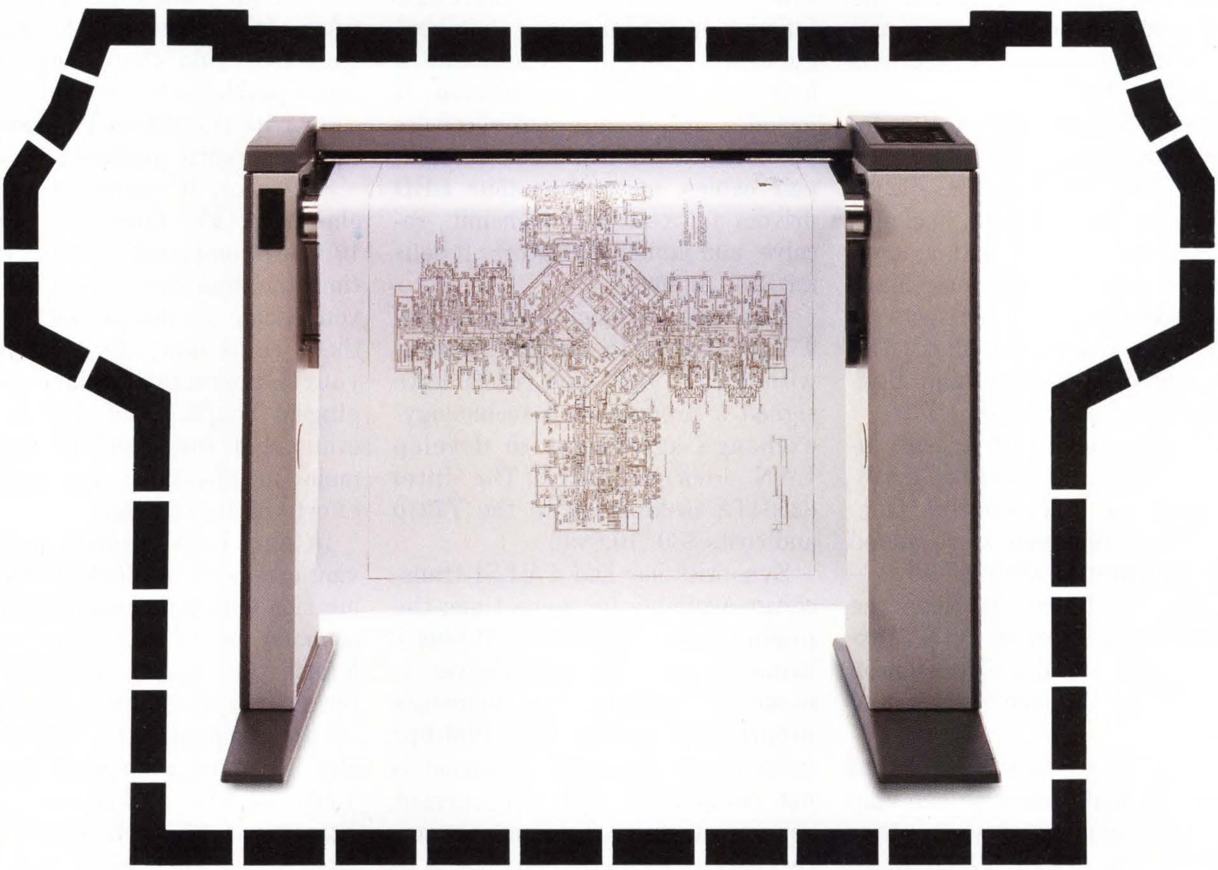


*Fig 4—**Because it has the AUI and twisted-pair** line drivers and receivers on chip, the AT&T T7220 twisted-pair medium-attachment unit (MAU) provides a single-chip solution for replacing MAUs that are compatible with other versions of the Ethernet physical layer.*

Versatec announces drastic reductions on electrostatic plotters.



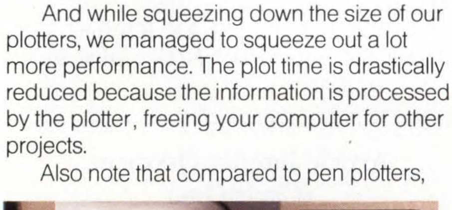
Introducing a plotter that's half the usual size and weight.

And half the price you'd expect to pay for electrostatic performance.

Yet our 8500 Series gives you all the quality you've come to expect from Versatec. The leader in electrostatic technology for over two decades.

And while squeezing down the size of our plotters, we managed to squeeze out a lot more performance. The plot time is drastically reduced because the information is processed by the plotter, freeing your computer for other projects.

Also note that compared to pen plotters,



the 8500 has 6 to 20 times more throughput.

Now that's fast. But the 8500 Series is easy to handle as well. Media loading is up front. You simply plug in the system and it's ready to plot.

A unique user-friendly keypad takes anyone through the plotting process quickly, easily and in plain English. A built-in micro-floppy drive stores plotter setups and configurations on-disk. Which means no more time-consuming setups.

The 8500 Series is also the first plotter that's literally ready-to-roll. Its built-in casters let you move quickly to any location for sharing. You can also share the 8500 through networking with a plot server.

With optional features the 8500 also automatically cuts and winds plots. Up to 999 copies, overnight, completely unattended if you want. And it's available in both 400 and 200 ppi resolution, in either 24" or 36" formats.

You also get full support for 906/907 and HP-GL pen plotter data formats. So designers have the freedom to use virtually any major CAD package they choose.

Incidentally, the same technology that reduces the size of the 8500 also makes it three to four times more reliable than the industry standard. Which means you'll have little need for the most comprehensive service and support organization in the world.

For more information on our 8500 Series, call our toll-free number now: (800) 538-6477;

in California, (800) 341-6060.

But do it now. Because choosing any other electrostatic plotter could have drastic consequences for your budget.

VERSATEC
A XEROX COMPANY
Engineering Systems Division

We deliver performance.

Versatec Inc.
2710 Walsh Avenue, Santa Clara, CA 95051

CIRCLE NO 46

with twisted-pair cable, or you can connect the 92C02 directly to the Manchester encoder/decoder and LAN controller when the system is not using an MAU.

The AT&T T7210 Manchester decoder and interface chip is based on a linear CMOS process. The T7210, which costs $15 (10,000), includes predistortion control and a loop-back function. It also has Manchester decoding, so it connects directly to a LAN controller. The LAN controller provides the Manchester-encoding function.

Currently, the T7210 doesn't include an SQE-test function, a jabber timer, or link-integrity functions. These functions were added to the specification after AT&T created the T7210. By the time the standard is completed, AT&T expects to offer a single-chip solution that includes the line drivers and receivers.

You can't easily use the T7210 to replace an MAU, because the chip lacks AUI signals and some other functions. The AT&T T7220 is designed to be a twisted-pair MAU **(Fig 4)**. Like the NCR 92C02, the T7220 includes pre-equalization, collision detection, an SQE-test function, a jabber timer, link-beat generation and detection, and a loop-back function. In addition, it includes line drivers and receivers for both the AUI and the twisted-pair cables, as well as four LED drivers for collision, transmit, receive, and jabber indicators. It sells for $15 (10,000).

Intel has its own version of the T7210, thanks to an arrangement with AT&T. Intel and AT&T have signed a product- and technology-exchange agreement to develop LAN devices jointly. The Intel 82504TA is identical to the T7210 and costs $30 (10,000).

Synoptics has had a VLSI transceiver available for some time; the product costs $5.50 (10,000) plus a licensing fee. The transceiver is based on Lattisnet, the company's proprietary version of a 10M-bps twisted-pair Ethernet. Lattisnet is not compatible with the current version of 10BaseT. Furthermore, the part is available only via a licensing agreement.

Designing a 10BaseT interface into your design is risky at present, because the standard is as yet unratified. It's quite possible that the standard could change enough to cause problems for anyone who designs with the 10BaseT information that's currently available.

Still, most IC manufacturers are claiming that they will have a 10BaseT-compatible product by the time the standard is completed. If you decide to design with one of these chips now, it's wise to put your Ethernet interface onto a plug-in board. That way, in the event that the standard requires major modifications, your redesign effort will be minimal.

In sum, LANs provide many advantages, such as increased communication within an organization, the common use of databases to make information widely available, and the sharing of resources throughout an organization. And they're rapidly becoming even more popular. You'd be wise to keep an eye on Ethernet LAN technology, therefore: Before long, you'll very likely be asked to design a LAN interface into your system. LANs are here to stay. **EDN**

For more information . . .

For more information on the 10BaseT interface chips 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.

AT&T Microelectronics
555 Union Blvd
Dept 50AL330240
Allentown, PA 18103
(800) 372-2447
In Canada, (800) 553-2448
FAX (215) 266-2935
Circle No 713

Intel
Literature Dept
3065 Bowers Ave
Santa Clara, CA 95052
(800) 548-4725
(916) 351-5237
Circle No 714

NCR
Microelectronics Div
2001 Danfield Ct
Fort Collins, CO 80525
(800) 334-5454
(303) 226-9500
FAX (303) 226-9556
Circle No 715

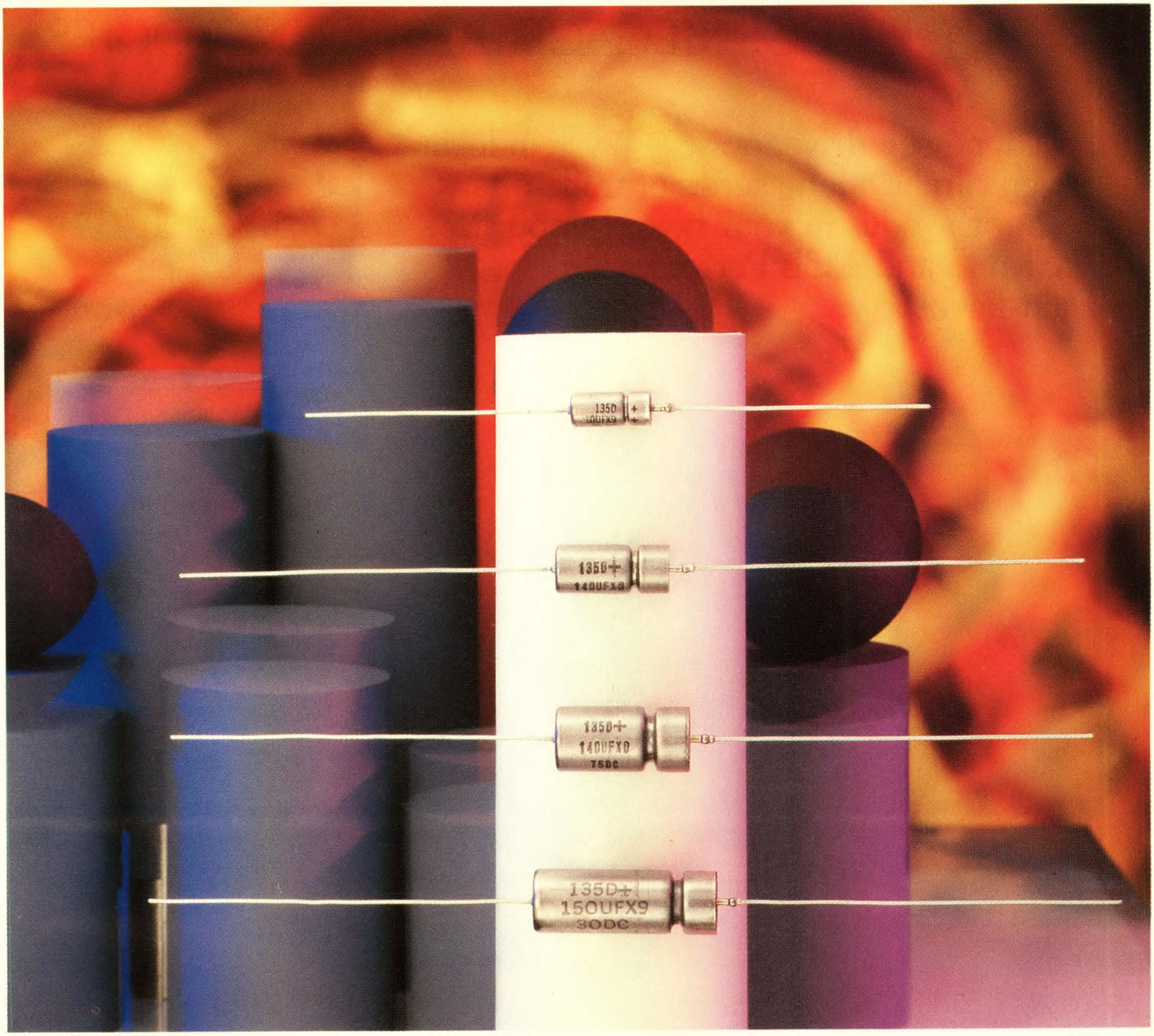
Synoptics Communications Inc
501 E Middlefield Rd
Mountain View, CA 94043
(800) 872-8023
FAX (415) 967-8710
Circle No 716

References

1. Intel, "Local Area Networking (LAN) Tutorial," *Intel*, 1989.
2. Wiegand, Jim, "LAN ICs for IEEE-802 networks," *EDN*, April 30, 1987, pg 130.

Article Interest Quotient
(Circle One)
High 509 Medium 510 Low 511

SURVIVABILITY.



4SX-3159R3

SPRAGUE TANTALUMS CAN TAKE THE SHAKES.

As you might expect, Sprague was first to offer Option H 'High Random Vibration and High Shock' Mil Style CLR79 Tantalum-cased Tantalum Capacitors. Now MIL Style CLR79 *and* CLR81 to MIL-C-39006/22 and /25 are available in *all* four case sizes (T1 thru T4) and in *all* voltages (6 thru 125 VDC). The 51g random vibration capability is provided by unique cathode construction at *no extra cost to users*.

Performance characteristics are backed with over 50 million hours of documented testing.

For technical information, write to Technical Literature Service, Sprague Electric Company, P.O. Box 9102, Mansfield, MA 02048-9102.

SPRAGUE®

CIRCLE NO 47

FASTEST OF THE FAST

INTRODUCING THE FASTEST 8" DISK DRIVE IN THE WORLD.

A new standard for speed

The Sabre™ 2HP, a two-head parallel disk drive with unparalleled performance. The Sabre 2HP design permits reading and writing from two heads simultaneously. As a result the drive attains an incredible 6MB per second (48MHz) transfer rate.

Splitting of data on "writes" and combining data on "reads" is transparent to the disk controller adaptor so changes to your system are minimized.

For super performance

The Sabre 2HP features a capacity of 1,154 megabytes, a 15 millisecond average seek and industry standard IPI-2 interface. Plus, a synchronized spindle capability permits powerful multi-drive configurations.

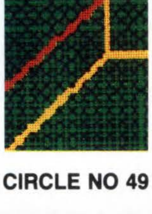
A Sabre for the task

In applications where rapid reading and writing of data is paramount, the Sabre 2HP has no equal. It's the storage device for applications where enormous quantities of data must be handled very quickly. It's ideally suited for medical imaging, high-speed graphics, animation or other technical or scientific processing applications.

Get the high-performance edge . . .
Sabre Disk Drives from Imprimis.

For the authorized distributor nearest you call:

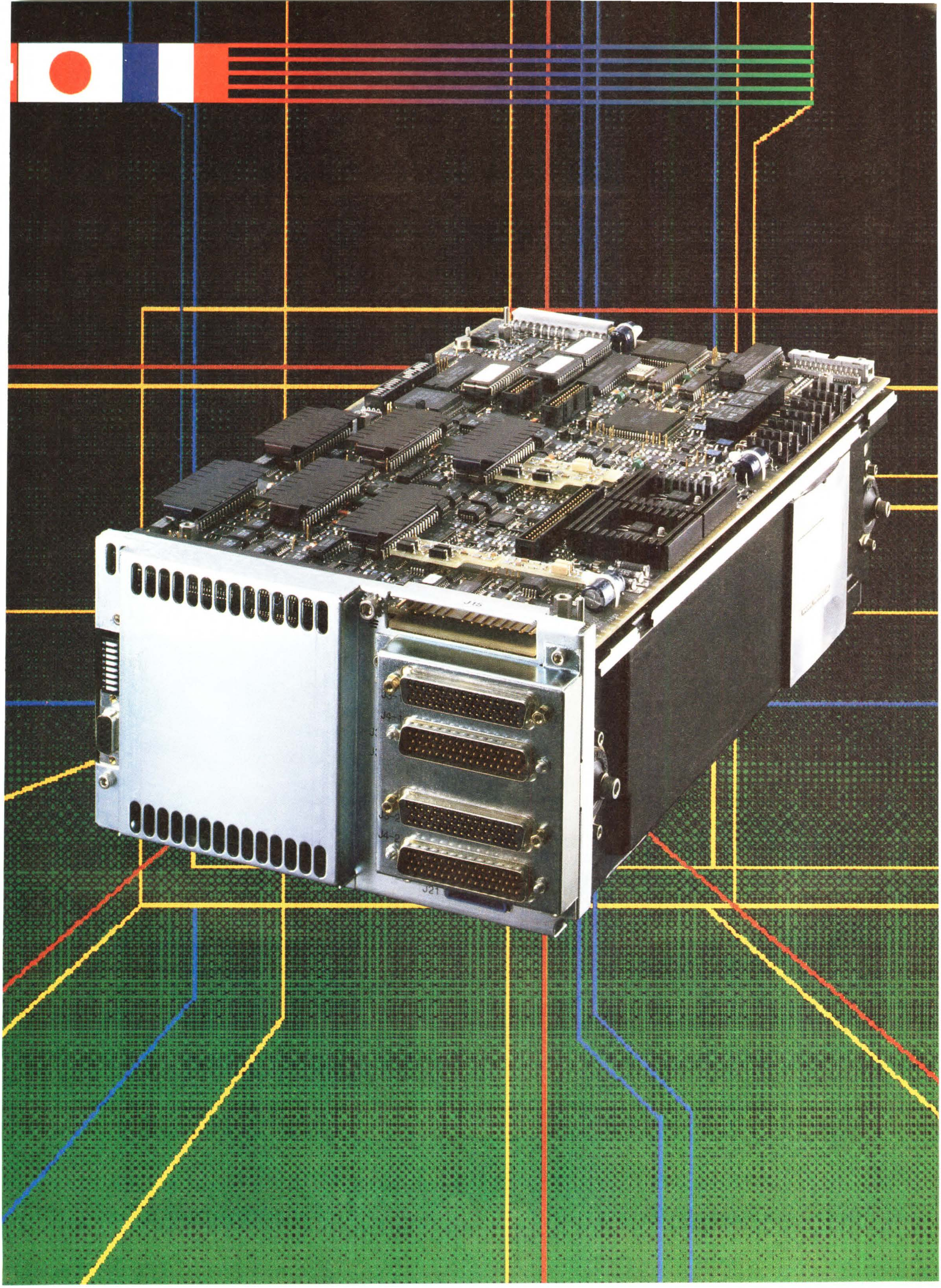
Arrow Electronics:	**1-800-777-ARROW**
Anthem Electronics:	
Northwest Region	**1-800-395-3502**
Central Region	**1-800-395-3517**
Eastern Region	**1-800-395-3511**
Southwest Region	**1-800-395-3501**

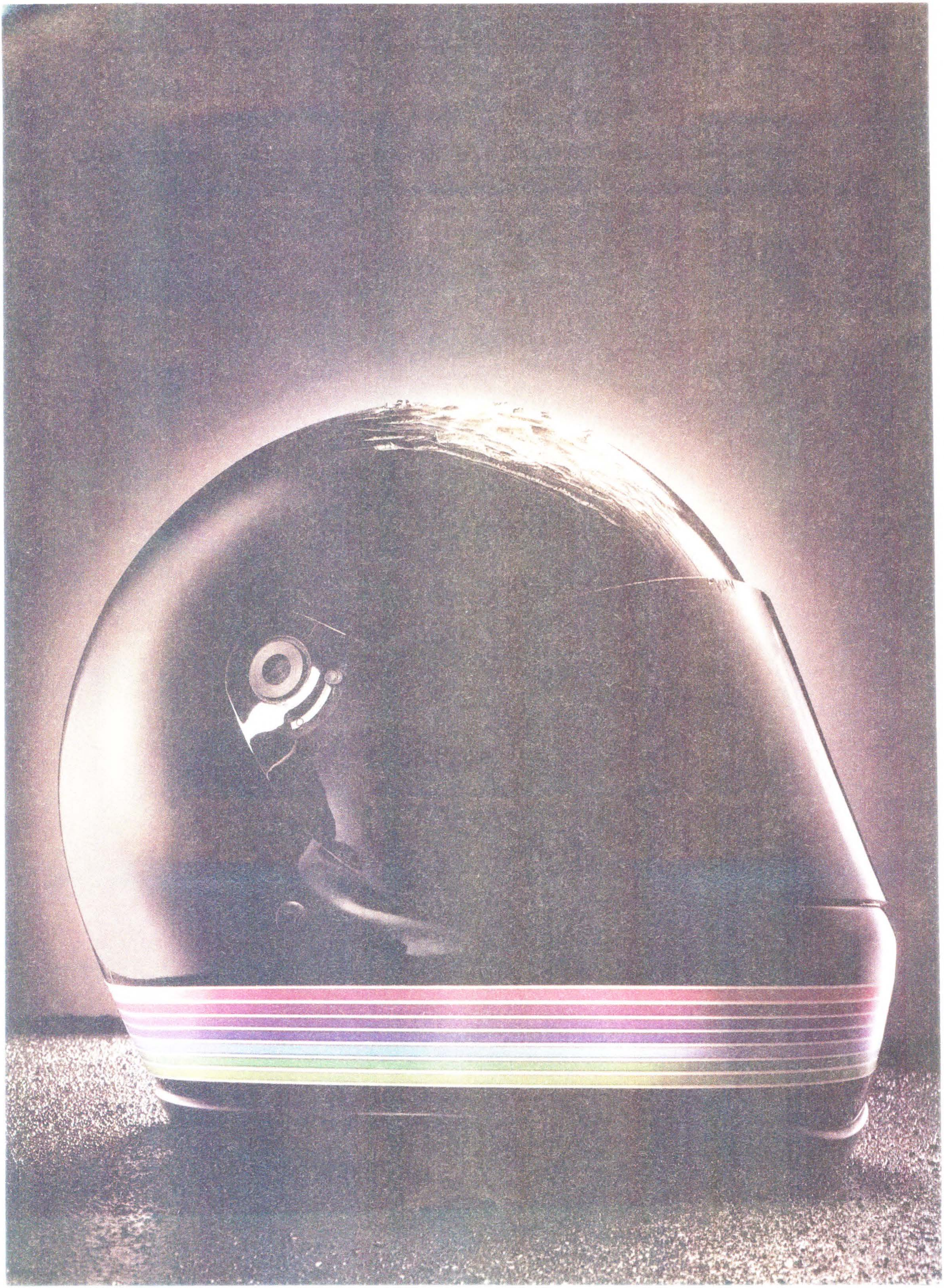


CIRCLE NO 49

IMPRIMIS

A Subsidiary of Control Data





Perfect protection doesn't have to be ugly.

Your design will need protection from the tough reality of the workplace. Take a look at enclosure systems from RITTAL. They are not only tough and functional, but aesthetically beautiful, too.

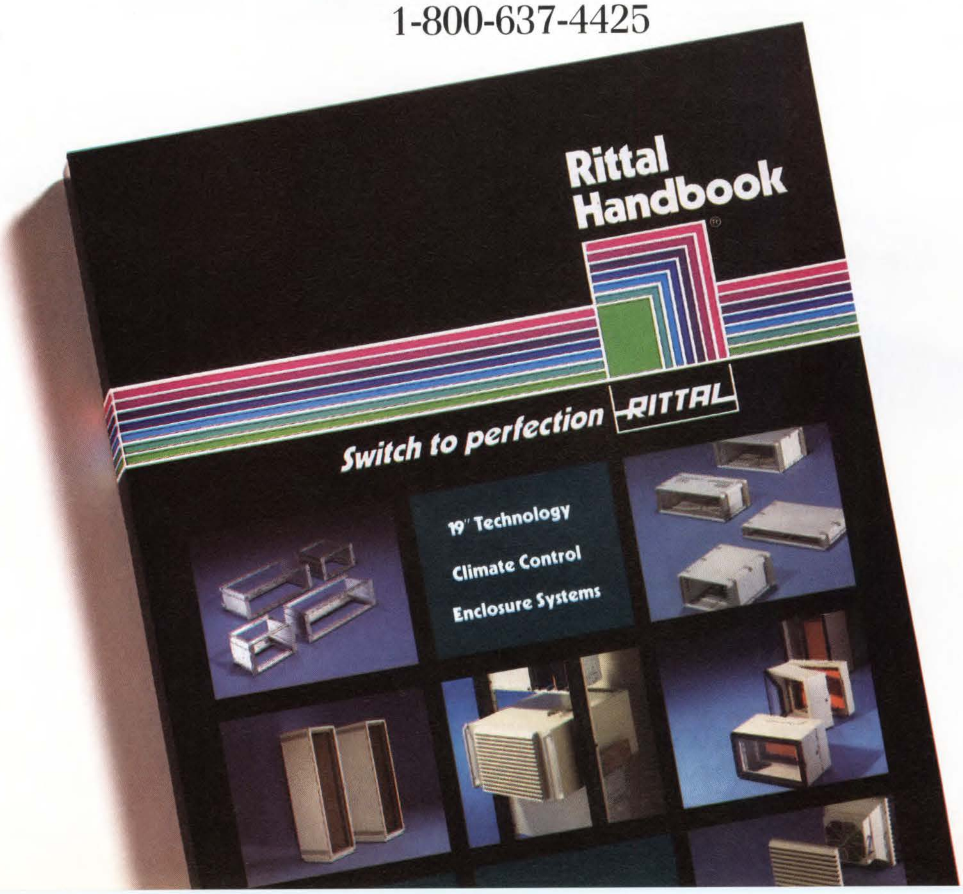
See for yourself with our comprehensive handbook. It's filled with the most advanced packaging solutions...a "how-to book" on protection!

Plus our warehouses throughout the country maintain an inventory of over 200,000 units for off-the-shelf just in time delivery, anywhere. Fast.

So, why put your ideas in an ugly, inadequate box that makes your sophisticated system look like everyone elses? Just give us a call at 1-800-637-4425 and we'll send you our full-line handbook. It's free, and the information may keep you from losing your head.

Take your design all the way to perfection... switch to RITTAL.

1-800-637-4425



RITTAL Corporation
P.O. Box 1284
3100 Upper Valley Pike
Springfield, OH 45504
Phone: (513) 399-0500
Fax: (513) 390-5599

CIRCLE NO 50

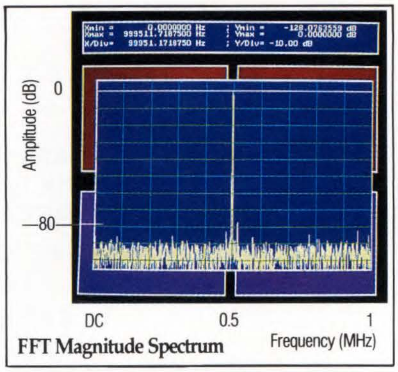
One company offers 1,2,5,&10MHz 12-bit sampling A/D converters. DATEL.

Superior dynamic performance brings both harmonic distortion and signal-to-noise ratios to new lows.

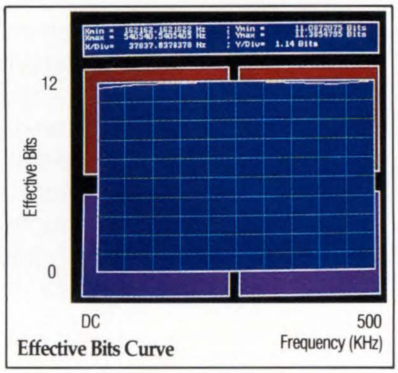
We're working hard at DATEL to bring you new lows - to create new highs in performance. The *lowest* harmonic distortion. The *lowest* non-linearity. The *lowest* absolute accuracy errors. The *lowest* power consumption. The *lowest* physical size. And the *lowest* price. All to produce the highest dynamic and static performance in sampling A/D converters available anywhere.

Features unavailable anywhere else in all models include an internal sample hold with full power input bandwidth higher than Nyquist frequency, together with a functionally complete architecture. DATEL has truly produced the First complete Family of 12-bit ADCs.

With DATEL, you now have four new reasons guaranteed to shorten your ADC selection cycle. Bottom-line, compare these converters with our competition and you'll see that there is no reason to look anywhere else. Call us at (508) 339-3000.



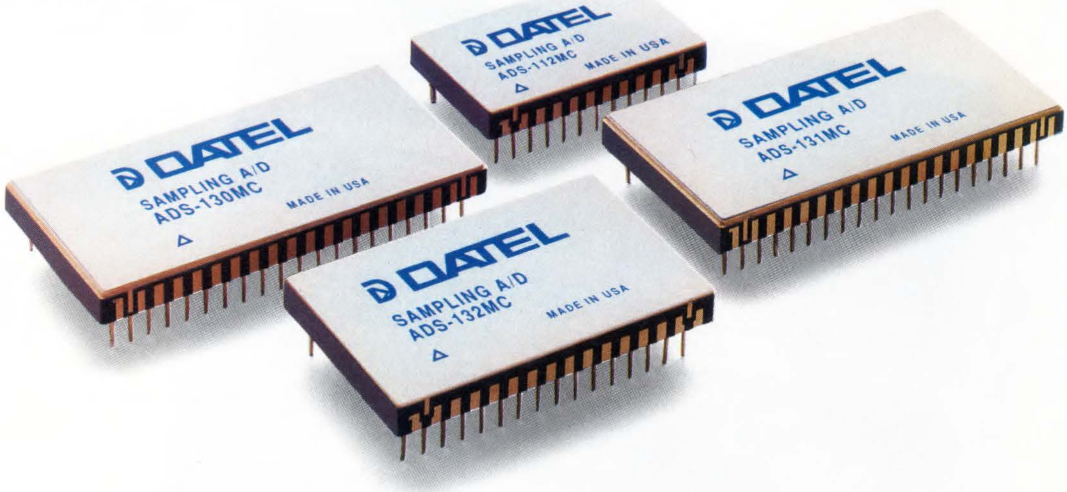
FFT Magnitude Spectrum



Effective Bits Curve

Model	Sampling Rate	Effective Bits at Nyquist Frequency	THD* at Nyquist Frequency	Power Dissipation	Package	Price (1-9)
ADS-112	1MHz	11.0	-73 dB	1.3 watts	24-pin DDIP	$259
ADS-132	2MHz	11.0	-73 dB	2.9 watts	32-pin TDIP	$346
ADS-131	5MHz	10.6	-69 dB	4.2 watts	40-pin TDIP	$549
ADS-130	10MHz	10.6	-69 dB	4.5 watts	40-pin TDIP	$775

* THD (Total Harmonic Distortion)



DATEL

INNOVATION AND EXCELLENCE IN PRECISION DATA ACQUISITION.
Datel, Inc., 11 Cabot Boulevard, Mansfield, MA 02048 (508) 339-3000

MIL-STD-1772 DATEL CERTIFIED

CIRCLE NO 51

Attenuators solve transmission problems

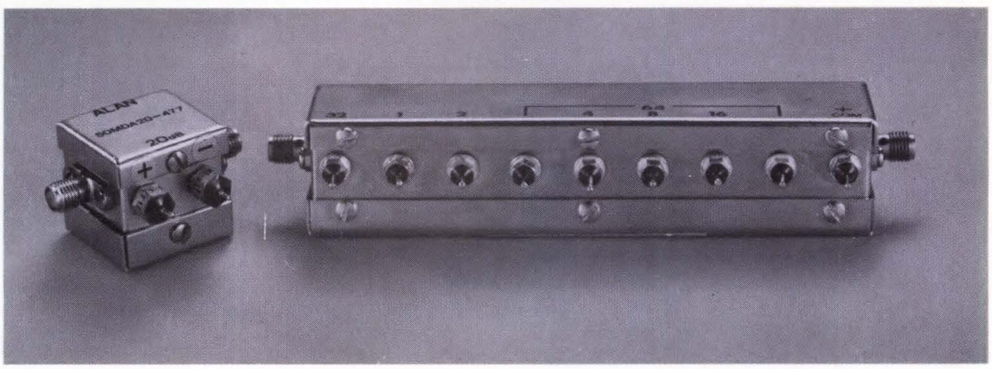
Digitally programmable attenuators let you automatically control signal amplitudes without introducing any impedance or phase distortion.

Tom Ormond,
Senior Editor

Digitally programmable attenuators are useful for almost any application in which you need to control signal-amplitude levels. You can, for example, use them in application that involve radar signals, telecommunications networks, automatic test equipment, video attenuation, amplifier gain control, variable burst generation, logarithmic D/A conversion, and frequency synthesis. You can also use attenuators to extend the range of power meters, prevent burnout or overloading problems in sensitive equipment, and set standards for loss measurements. Today's programmable attenuators suit not only a variety of applications, but a wide range of frequencies as well; the selection of available programmable attenuators lets you accommodate frequencies from the kilohertz to the gigahertz range.

To understand how programmable attenuators can help you solve transmission problems and control signal amplitudes easily, consider the role that they play in a telecommunication system. In a typical telephone network, each link between a subscriber's home and the central office constitutes a local loop. The receiving equipment at the central office must interface with thousands of transmitter signals. These signals are sent over links that have widely varying lengths and loss characteristics. If the receiving equipment is calibrated to interface with the most remote transmitter in the system, the transmitters from closer sources overload the receivers.

To prevent this overload condition, you could use unique transmitters, which are designed to meet the minimum receiver requirements when they operate in a particular local loop. Although this scheme will work, it isn't a very viable solution from an economic standpoint. Using a digitally programmable attenuator at the receiving end of each local loop, however, is a less expensive and more effective solution. As each loop comes on line, the installers at the central office can adjust the attenuator to ensure that the incoming transmissions are well within the established limits of the receiving equipment.



Operating over dc to 1 GHz, *the MDA Series attenuators from Alan Industries feature total attenuation specs ranging from 15 to 127 dB, a switching time of 6 msec, and a switch life of 10^7 operations per bit.*

Now, what about the other 95% of your design?

We've got the guts!

Make us prove it. Call (800) 227-1817, ext. 982 and ask for our new capabilities brochure.

One standard. 0 defects.

Signetics

a division of North American Philips Corporation

PHILIPS

CIRCLE NO 54

Programmable attenuators

This system not only prevents signal-saturation problems, but also eliminates the need for custom receivers and transmitters.

Are you there, Watson?

Sierra's SC11310 programmable gain/loss circuit is just one of the attenuators that you can use to increase the efficiency of a telecommunication system. This device is designed to provide precise interface levels in telecommunication equipment and voice-line circuits. It is also well suited to diagnostic applications involving loopback control circuits. In this case, the SC11310 is usually located in front of the codec on the line card, which is in the central office.

The SC11310 features a 0.05-dB gain/loss error, −60-dB total harmonic distortion, 40-mW power dissipation, and a 10-dBrnCo idle-channel noise level ("dBrnCo" refers to decibels above reference noise, C-message weighted). The device works from supply levels of ±5V and has large- and small-signal bandwidths of 200 kHz and 1.5 MHz, respectively. The SC11310, which sells for $4.92 (100), is housed in a 20-pin DIP.

Processed in low-power CMOS technology, the SC11310 consists of latch circuitry, control logic, and a gain/loss network that includes a string of four op amps that are connected in series. You control the circuit's operation by using 10 inputs: the G_0 through G_7 inputs, the Si/GL input, and the mode pin. The G_0 through G_7 inputs generate an 8-bit word that controls the magnitude of the gain/loss setting in 0.1-dB steps. The Si/GL input selects either the amplification or the attenuation, and the mode pin establishes one of two control modes.

When the mode pin is high, the circuit has 511 distinct setting steps, and the gain varies from −25.5 to +25.5 dB. The Si/GL pin selects the gain/loss function to provide a total dynamic range of 51 dB. When the mode pin is low, the SC11310 has 481 distinct setting steps, and the gain varies from −24 to +24 dB, resulting in a total dynamic range of 48 dB.

The PST (parallel/serial/through) pin lets you operate the SC11310 in one of three ways. If you apply 5V to the PST pin, you can control the chip over the parallel bus. The circuit will have gain when the Si/GL pin is at 5V, and it will have loss when the Si/GL pin is at −5V. The $\overline{WR}$ writes the data into the chip. Data latches into the SC11310 on the rising edge of $\overline{WR}$, and the new gain/loss value is effective immediately.

If the PST pin receives 0V, you can interface the SC11310 through the serial port—the Si/GL pin in this case. The SC pin serves as the shift clock, and $\overline{WR}$ acts as the enable clock. After nine SC pulses, data latches into the chip on the rising edge of $\overline{WR}$, and the gain/loss status becomes effective. At the same time, the internal register holds the previous gain/loss value during the serial shift to prevent the output from making any unpredictable changes.

To accommodate high frequency and power needs, *Daico Industries offers a line of 7-bit attenuators that operate over the 30- to 500-MHz range and accept input power levels of 13 dBm. They operate from a 5V supply.*

If the PST pin receives −5V, the SC11310 interface operates in the "through" mode. In this mode, the attenuator's internal circuitry ignores $\overline{WR}$ and SC, and the data that you place on the parallel bus (using switches) is effective at all times. The through mode is essentially designed for applications that don't require a microcontroller.

Step up the frequency

Keep in mind that all IC-type attenuators aren't restricted to voice-frequency applications. Many of these devices, such as Topaz Semiconductor's CDG4460 and CDG4469, accept frequencies from 5 to 40 MHz.

The CDG4460 is a 6-bit, 40-MHz attenuator that is designed for video applications. It will attenuate signals over a 0 to 15.75-dB range in 0.25-dB increments. When operating in a 75Ω system, the unit maintains constant input and output impedance over the entire attenuation range. The onboard data latch lets you use predetermined attenuation settings or recall attenuation settings from memory. Housed in a 16-pin hybrid package, which occupies 1 in.^{2} of board space, the CDG4460 operates from ±6 to

Programmable attenuators

±15V supplies and dissipates 0.5 μW typ.

The CDG4469, on the other hand, is an 8-bit attenuator that is designed for applications that require a wide range of attenuator settings. Featuring a usuable frequency range of 5 MHz, the unit attenuates signals over the 0 to 127.5-dB range in 0.5-dB steps. The attenuator can accommodate analog input voltages as high as 6V rms, and it has a constant input impedance of 650Ω. The CSG4469 is housed in a 16-pin hybrid package. It operates from ±6 to ±15V supplies and dissipates 0.5 μW max.

Both of these digitally controlled attenuators are designed and fabricated with a combination of CMOS/DMOS ("DMOS" is double-diffused MOS) integrated-circuit and hybrid technologies. The CMOS/DMOS portions consist of the CMOS input logic and the level translators that drive the DMOS FET switches. The attenuator ladder is made of thick-film resistors that are deposited on a ceramic substrate.

The attenuators' control logic accepts CMOS logic levels and provides internal level translation for the DMOS FET gates, which are tied to either the positive or the negative supply rail. The complementary logic controls the FET switches in pairs. The resistor attenuator ladder is designed to ensure that the series FETs and the thick-film resistors provide the majority of the attenuator level settings. The shunt FETs and the remaining thick-film resistors combine to maintain a constant attenuator input impedance. In addition, both devices contain diodes to protect the inputs against damage from high static voltages or electrical fields. The CDG4460 and the CDG4469 cost $28.21 and $23.50 (100), respectively.

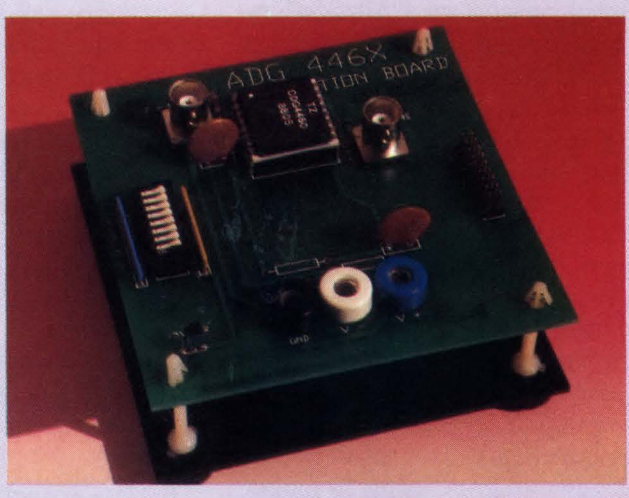
Attenuators that are based on IC technology work well in applications that involve frequencies ranging to tens of megahertz. However, you can also use attenuators for applications that demand even higher frequencies. Although the devices in this high-frequency category employ different fabrication tech-

Evaluation boards ease testing procedures

Evaluation boards are a vital factor in the acceptance of new ICs, because they provide designers with a complete, ready-to-use test system. Most semiconductor vendors acknowledge this fact, but few have the resources and/or the commitment to offer evaluation boards. EDI Corp tries to fill this void; the vendor's ADG446X-1 board lets you assess the attenuation performance of CDG4460 and CDG4469 programmable attenuators from Topaz Semiconductor before you incorporate the devices into your system.

When you test the 6-bit CDG4460, the board uses pin 5 for the latch-enable signal and pin 13 for the latch-reset signal. The board uses these two pins for attenuation control when you test the 8-bit CDG4469. You can use either onboard DIP switches or external logic to control all the attenuator pins, as well as the latch enable and the latch reset. The external logic accesses the board via a cable that's connected in parallel with the DIP switches through a double-row header connector. The header has only ground pins on the outer row to facilitate the cable-termination process.

The board's pullup resistors connect to a 5V supply that's generated by an onboard 3-terminal regulator; they guarantee that the DIP switches' Off position designates logic high. All the board's switches connect to ground through high-value pull-

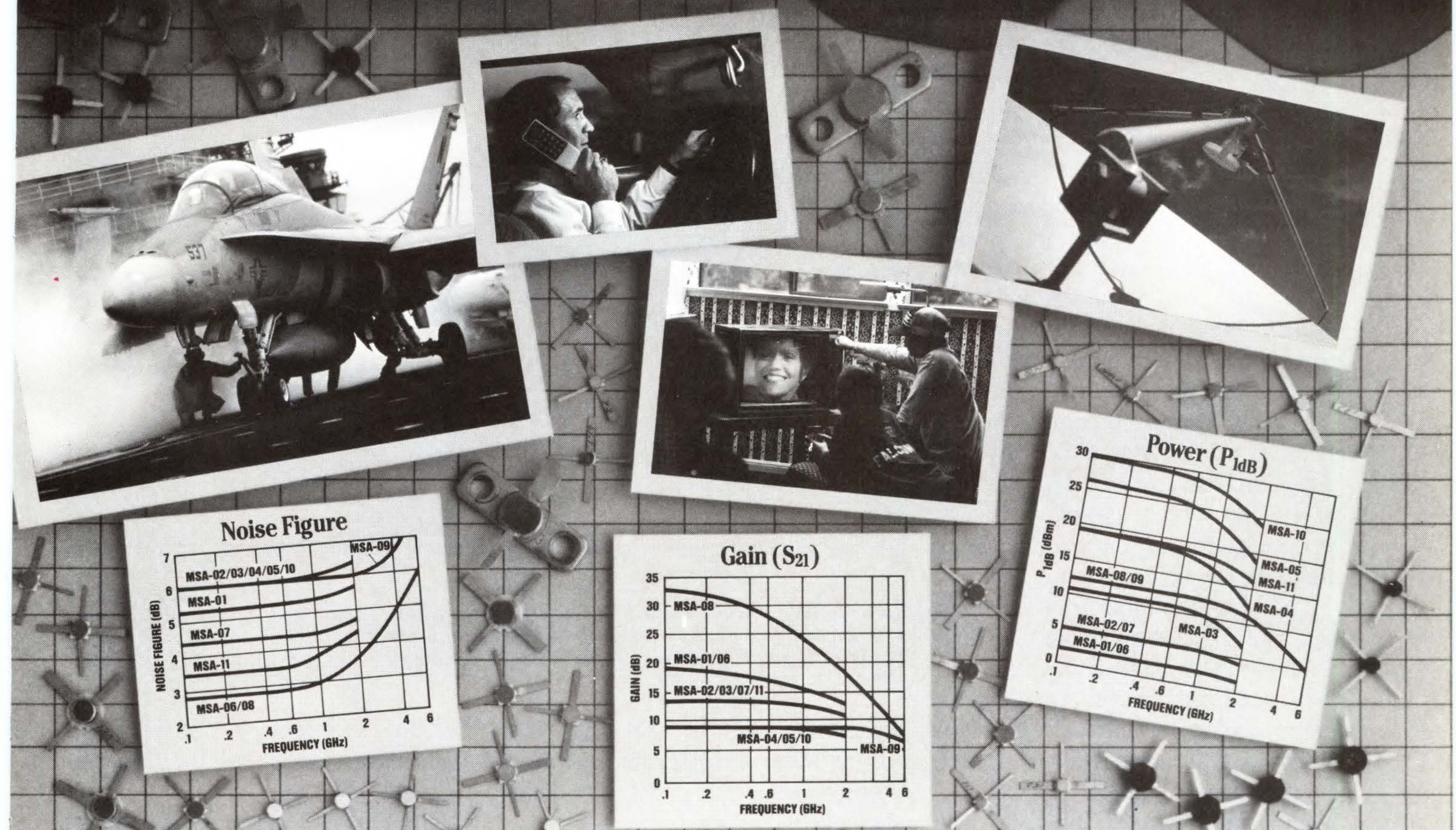


To facilitate the testing process, *the ADG446X-1 evaluation board from EDI Corp lets you excercise the 6- and 8-bit attenuators from Topaz Semiconductor. The board can serve as a test fixture or a ready-made development vehicle for a variety of applications.*

down resistors. This arrangement lets you safely transfer test-signal control to external circuits that automatically override the DIP-switch settings.

The board's power-input sockets are labeled V^+ and V^-. You can use the attenuators by applying ±6 to ±15V to these pins. The ADG446X-1 is priced at $105 and comes with one attenuator, data sheets for the board, and application literature.

Silicon MMICs Any Way You Want!



Avantek Offers the Widest Selection of Wideband Silicon MMIC Amplifiers

Now the trade off between performance, package and price is easier. Avantek has a package/die combination that offers the ideal solution to your overall system performance and cost goals. Our MODAMP™ series, DC to 6 GHz silicon MMIC wideband amplifiers, includes eleven different amplifier die types and nine package options. A total of more than 70 different models. These MMIC amplifiers are available with a wide spectrum of performance options to satisfy nearly every design need.... Minimum noise figures as low as 2.8 dB, gains as high as 33 dB, and P_{1dB} as high as 29 dBm.

Packages — Low Cost to High Rel

The MMIC performance you need is available in a range of packages to fit your overall system design and cost needs. Avantek's new Package "86" (85 mil surface mount plastic package) combines premium performance with low cost. Both Package "86" and the industry standard SOT-143, are available on tape and reel, making them ideal for low cost, high volume applications. For high reliability applications, such as space or military environments, we offer MODAMP MMICs in a range of hermetic metal/ceramic packages. MODAMP packages include:

- SOT-143 Plastic
- 4-Pac Plastic
- 85-Mil Plastic
- 85-Mil Plastic Surface Mount
- micro-X Stripline
- 70 Mil Hermetic
- 100 Mil Hermetic
- 200 Mil BeO
- 230 Mil Flange

Available in Quantity for Volume Applications

Avantek presently produces more than 1,000,000 MMICs per month. So you can be assured the MMICs you need will be available to support your volume production programs. And, all MODAMP MMICs are in stock at your local Avantek distributor. For additional information, or the name and address of your local distributor, contact the regional sales office nearest you.

Regional Sales Offices

North America

Eastern:	(301) 381-2600
Central:	(214) 437-5694
Western:	(805) 373-3870
European:	(44) 276-685753

AVANTEK

3175 Bowers Avenue
Santa Clara, California 95054-3292

CIRCLE NO 121

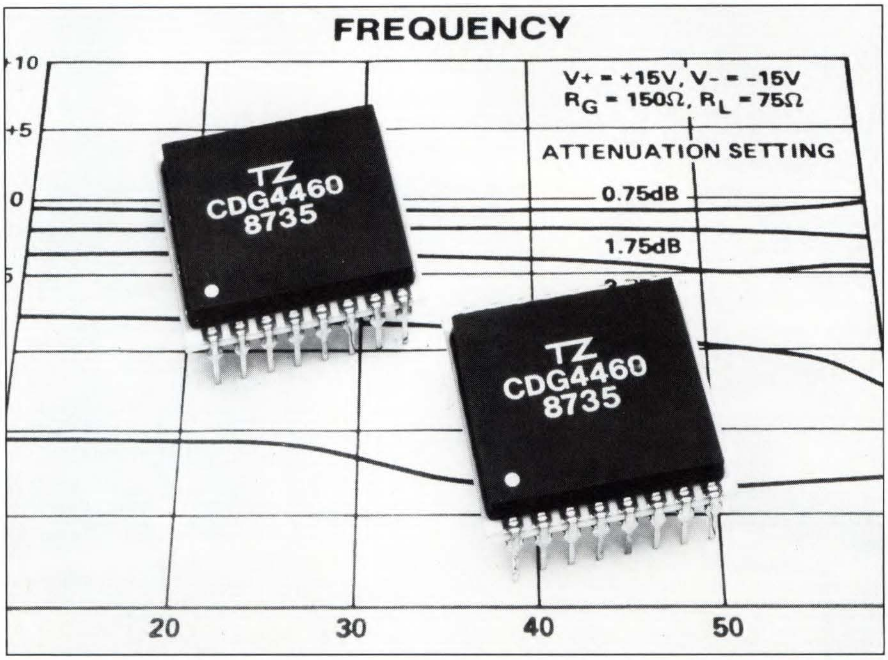
Programmable attenuators

niques, their performance levels are just as impressive as the IC-type attenuators' performance.

Daico Industries, for example, provides three attenuators that operate in the RF range; the 7-bit step attenuators operate over the 30- to 500-MHz range. The attenuators are available in 38-pin DIPs and in packages that include integral SMA-type connectors. They accept 13-dBm input power levels and operate over the full military temperature range (−55 to +125°C).

Each of the seven control inputs includes a CMOS or a TTL driver. These drivers control the parallel PIN-diode switches, which activate or deactivate the resistor pads that make up the attenuation chain.

The CMOS-compatible DAO285 and the TTL-compatible DAO295 are low-power attenuators that feature a 63.5-dB total attenuation range, which you can select in 0.5-dB steps. Operating from 5V dc, the devices draw 30 and 50 mA, respectively. Their typical insertion loss is less than 6 dB, and their maximum VSWR is 1.35:1. Both models have a maximum switching speed of 5 μsec and an RF transient time of 3 μsec. Their attenuation accuracy varies with different settings; at a 0.5-dB attenuation setting, the attenuators' accuracy is 0.125 dB. At all other attenuation settings, their accuracy is 0.15 dB ± 2% of the attenuation setting.



Suitable for portable applications, *the 6-bit attenuator from Topaz Semiconductor consumes 0.5 μA of current from supplies that can provide from ±6 to ±15V. The CDG4460 features a total attenuation of 16 dB in 0.5-dB increments and operates over dc to 40 MHz.*

The third model in the series, the DAO617, is designed for high-speed applications. Over the frequency range of 45 to 250 MHz, the unit provides 0 to 63.5-dB attenuation in 0.5-dB increments. The high-speed TTL drivers enable the DAO617 to achieve a 7-nsec transition time and a 25-nsec total switching time.

The DAO617 has a second intercept point of 82 dBm and a third intercept point of 34 dBm. It also has a 50-mV transient voltage level and an 8-dB maximum insertion loss. Its VSWR measures 1.35:1 max. One drawback of this device, however, is that you trade power consumption for high speed; operating from a 5V supply, the 617 draws 640 mA. The DAO617 costs $555; the DAO285 and the DAO295 are priced at $511 (100).

Like Daico's high-frequency attenuators, the MDA Series of programmable attenuators from Alan Industries employ PIN-diode switches to activate or deactivate the π-type resistor pads in the attenuation network. This line of attenuators, however, is designed for ATE (automatic test equipment) applications and operates over dc to 1 GHz. The attenuators include one EMI/RFI filter for each control bit and a common filter for the

For more information . . .

For more information on the programmable attenuators 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.

Alan Industries Inc
Box 1203
Columbus, IN 47202
(812) 372-8869
FAX 812-372-5909
Circle No 708

Daico Industries Inc
2351 E Del Amo Blvd
Compton, CA 90220
(213) 631-1143
TWX 910-346-6741
Circle No 709

EDI Corp
Box 366
Patterson, CA 95363
(209) 892-3270
Circle No 710

Sierra Semiconductor Corp
2075 N Capitol Ave
San Jose, CA 95132
(408) 263-9300
FAX 408-263-3337
TLX 384467
Circle No 711

Topaz Semiconductor
1971 N Capitol Ave
San Jose, CA 95132
(408) 942-9100
TWX 910-338-0025
Circle No 712

UPDATE

Programmable attenuators

ground or negative rail.

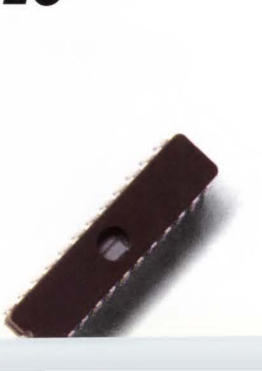
The Series consists of four models that feature attenuation specs of 15 (Model 50MDA15), 31.5 (Model 50MDA31.5), 63 (Model 50MDA63), and 127 dB (Model 50MDA127). The 4-bit 50MDA15, the 6-bit 50MDA63, and the 8-bit 50MDA127 all feature 1-dB attenuation increments; the 6-bit 50MDA31.5 attenuates signals in 0.5-dB increments. At 500 MHz, the parts' attenuation accuracy is ±0.5 dB (±1 dB for the 50MDA127 when the attenuation level is above 32 dB). At 1 GHz, the accuracy is ±0.75 dB for the 50MDA15 and 50MDA31.5, ±1 dB for the 50MDA63, and ±0.7 dB for the 50MDA127 (±1.5 dB for the 50MDA127 when the attenuation level is above 32 dB).

The units' maximum insertion loss ranges from 2 to 3 dB, and their switching speed is 6 msec max. The maximum VSWR for all four attenuators is 1.3:1 at 500 MHz and 1.4:1 at 1 GHz. The PIN-diode switches are rated for 10^7 operations per bit. Their on- and off-level control signals are 17 to 26.5V dc and 0 to 5V dc, respectively. The RF connectors are available in SMA, SMB, and SMC styles. The prices for MDA Series attenuators range from \$220 to \$410. EDN

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

Quick.

Name the three requirements for highest performance system design.



One. Innovation.

At Tektronix, technology innovation means excitement in broadcasting and video.

When you watched the Seoul Olympics, you saw the results of Tektronix television innovation in action.

Consider hundreds of video sources, covering hundreds of Olympic events. A non-stop torrent of video images routed live over miles of links through a central switching system that synchronizes all those asynchronous signals, to let the producer switch at will from any live, tape, or computer source.

Then add magic.

Complex digital manipulations, dissolves, cuts, overlays, and graphics, delivered in real time, to broadcast standards without a second's pause.

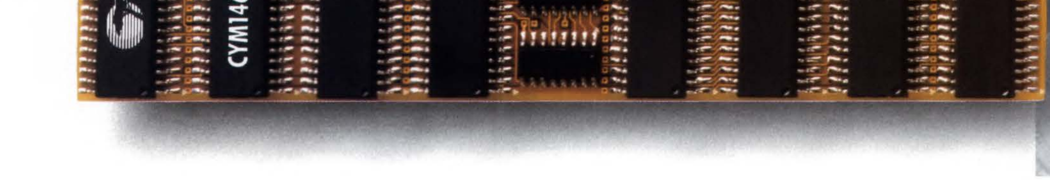
Tektronix Grass Valley Group provides the innovation for the switching and graphics.

Tektronix Television Group provides the test equipment, ensuring a feed quality high enough to satisfy the most finicky producer.

Cypress Semiconductor supported that innovation with high performance, erasable PLDs that let Tektronix pack faster, more reliable logic into less board space.

Tektronix also specifies our high speed, low power PROMs and SRAMs, to speed digital information through the system at broadcast video rates.

Equally important, we helped Tektronix assure the highest system reliability, by delivering parts with rock-solid dependability demanded by the world's largest broadcasters—Tektronix customers.




25ns
64Kx4 SRAM
NEW
CY7C194
CY7C261
30ns
8Kx8 PROM
NEW
45ns
32Kx8 PROM
NEW
CY7C271
15ns
2Kx8 PROM
NEW
CY7C245A
68
CY100E474
3ns
4K ECL RAM
NEW

Two. Innovation.

At Siemens, technology innovation means a new and better way to look at medical images.

Medical information from a variety of diagnostic sources—Computed Tomography, Magnetic Resonance Imaging, Digital Radiography, Ultrasound, Nuclear Medicine, or Positron Emission Tomography—is now captured digitally.

In fact, hospitals capture 10–15 Gigabytes *daily*.

Siemens Picture Archiving and Communications System (PACS) is arguably the most advanced, innovative system for retrieval and display of this vital diagnostic information.

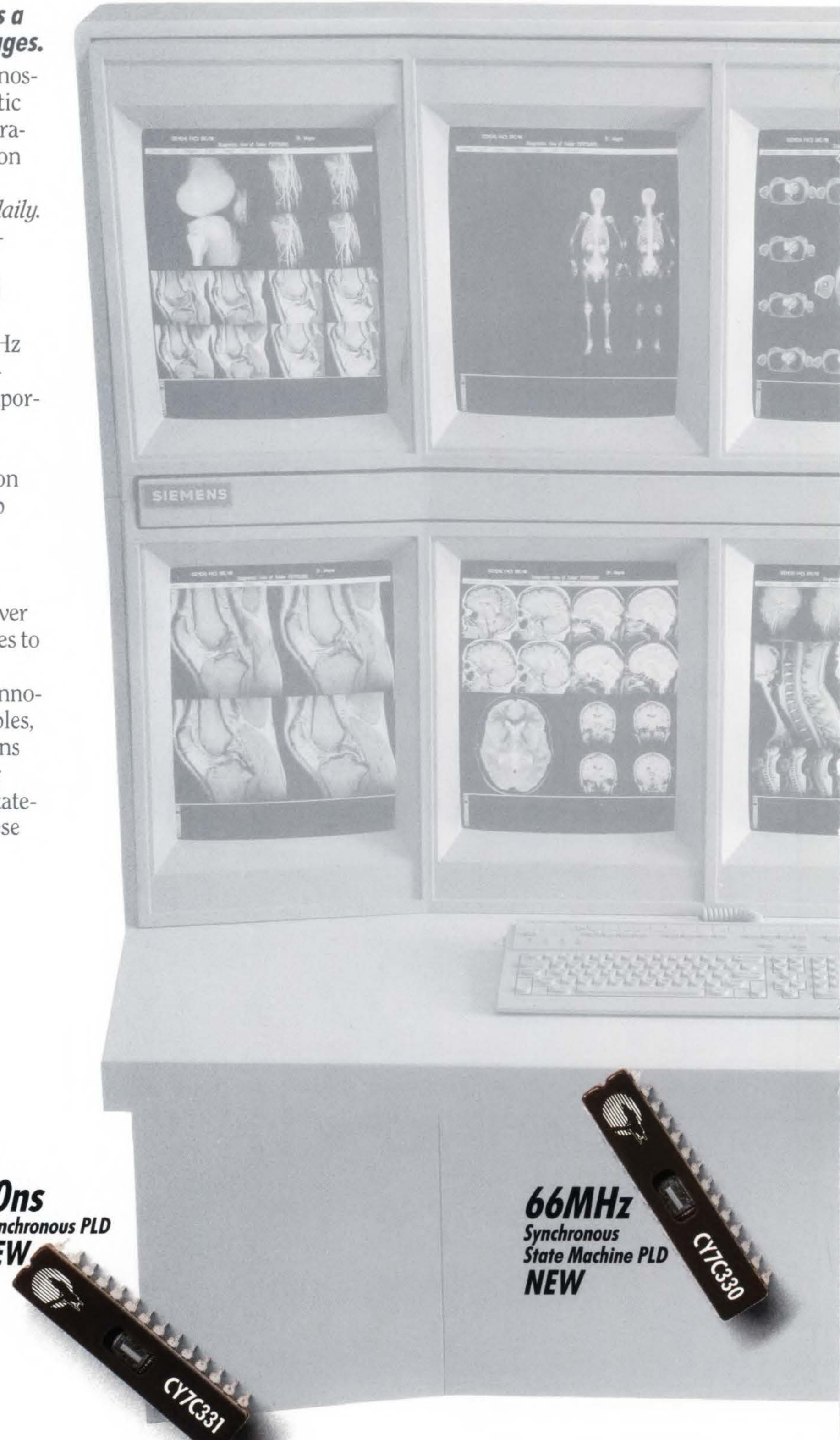
Banks of high resolution 1280 x 1024, 120 Hz displays give professionals the familiar multiviewer format and clarity of film, but with important new innovations.

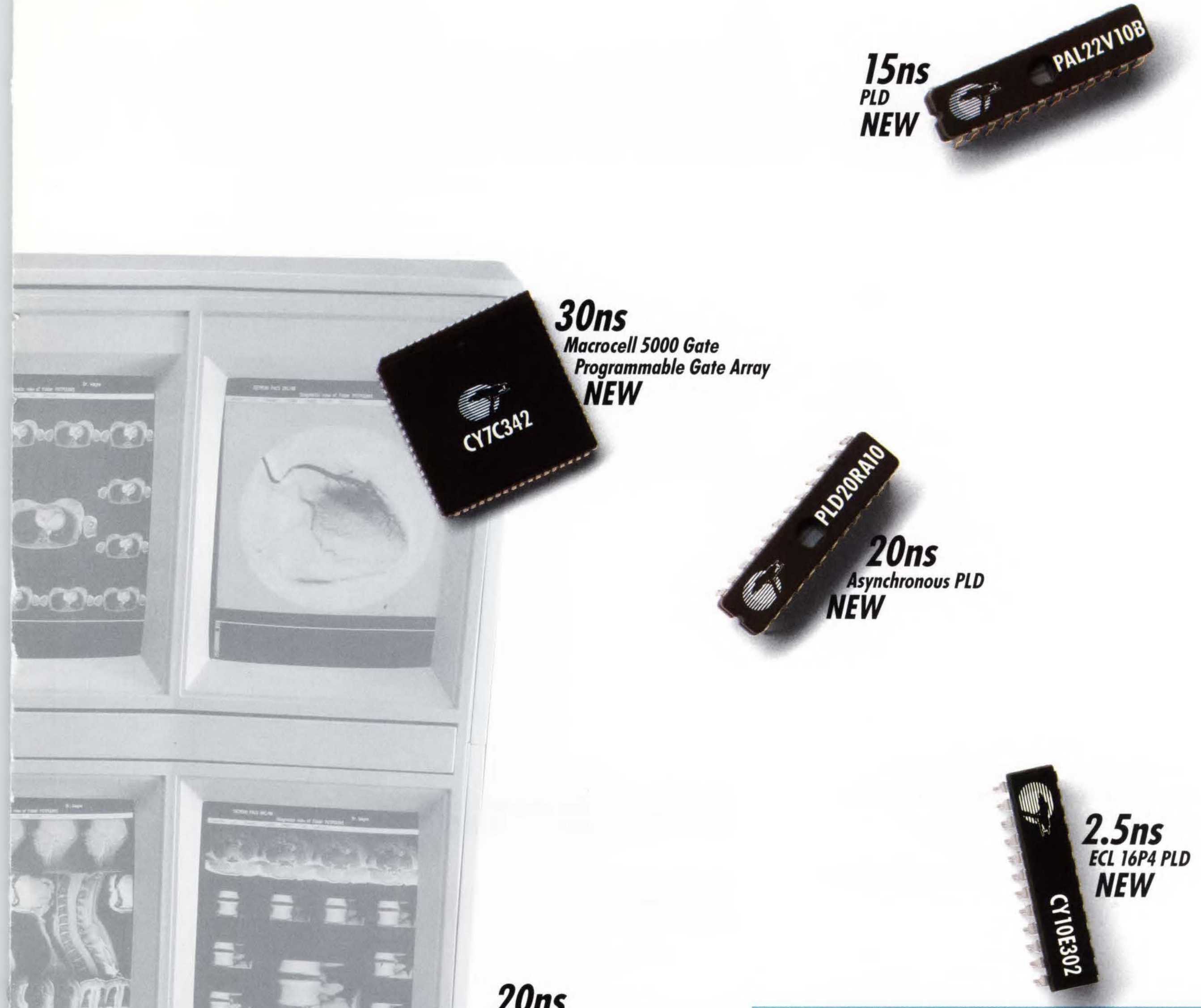
Viewers can adjust gray-scale, invert grayscale, swap images, overlay images, magnify on the fly, pan, or run "cine" image sequences up to 30 frames-per-second, all in real time.

Whatever they need to perform diagnosis rapidly and accurately.

At 120 Hz, the system is pumping data at over 100 M/bytes per second through look-up tables to display memory.

Cypress Semiconductor streamlines that innovation, with high speed SRAM for look-up tables, and high speed programmable logic—Siemens uses up to 105 PLDs per board, and up to four boards per system—to perform the blazing state-machine and multiplexing functions that these image calculations require.





What's new in high performance programmable logic? A lot.

Programmable logic is one of the industry's fastest growing segments. New performance levels and new circuit densities, together with innovative architectures and optional reprogrammability, mean dramatic new opportunities for high performance systems designers.

Cypress Semiconductor innovations in EPLDs include the CY7C330 state machine, now capable of 66MHz.

Our popular 22V10 now delivers 15ns performance.

For new ECL-based designs, our ECL 16P4 PLD, in our 0.8 micron BiPolar STAR™ process, offers a record-breaking 2.5ns access time.

And we're introducing exciting new Programmable Gate Arrays—including our CY7C342, with up to 5K gates, and just 30ns propagation delay!

CYPRESS
SEMICONDUCTOR

Three. Innovation.

High performance CMOS microprocessors are changing the way computers are designed—from desktop to workstation to minicomputer.

RISC.

Ours is based on SPARC,™ the Scalable Processor ARChitecture originally developed by Sun Microsystems, and now an emerging industry standard.

Scalability means the same architecture can be applied to a variety of systems—from next-generation embedded controllers, to PCs that challenge workstations, to workstations that challenge supercomputers, to next-generation minicomputers, and beyond.

Cypress RISC performance means those new systems will set systems performance records. A few examples:

ARIX. Innovators there are rewriting the rules for minicomputer systems. Using our RISC family in *multiprocessor* configurations, designers are creating systems that will set new performance standards for commercial UNIX® multi-user systems.

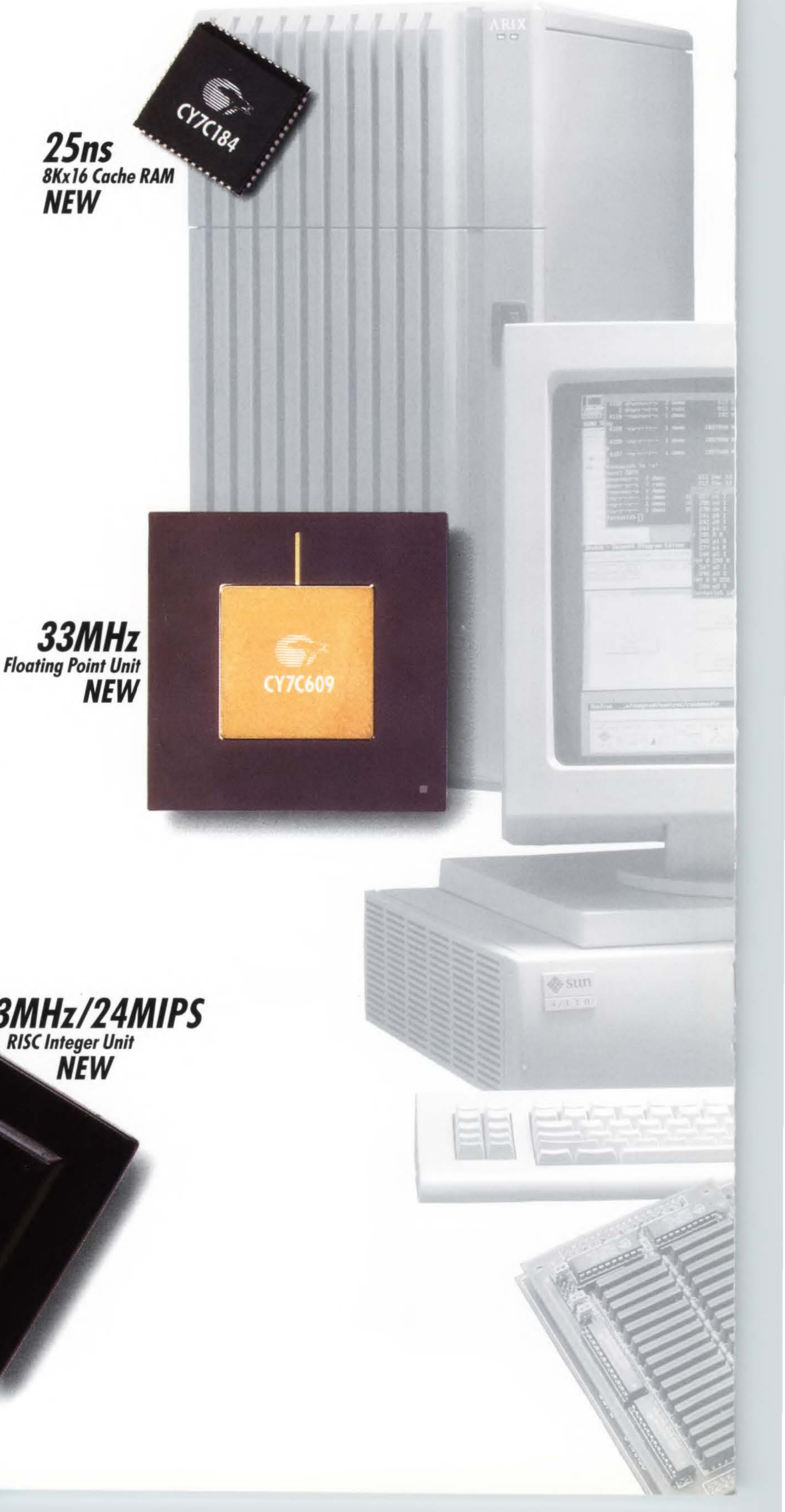
We make that innovation easier, with logic that sets standards for performance, while easing design-in.

Sun Microsystems. Today, innovators are developing the next generation of workstations, based on the Cypress Semiconductor RISC family.

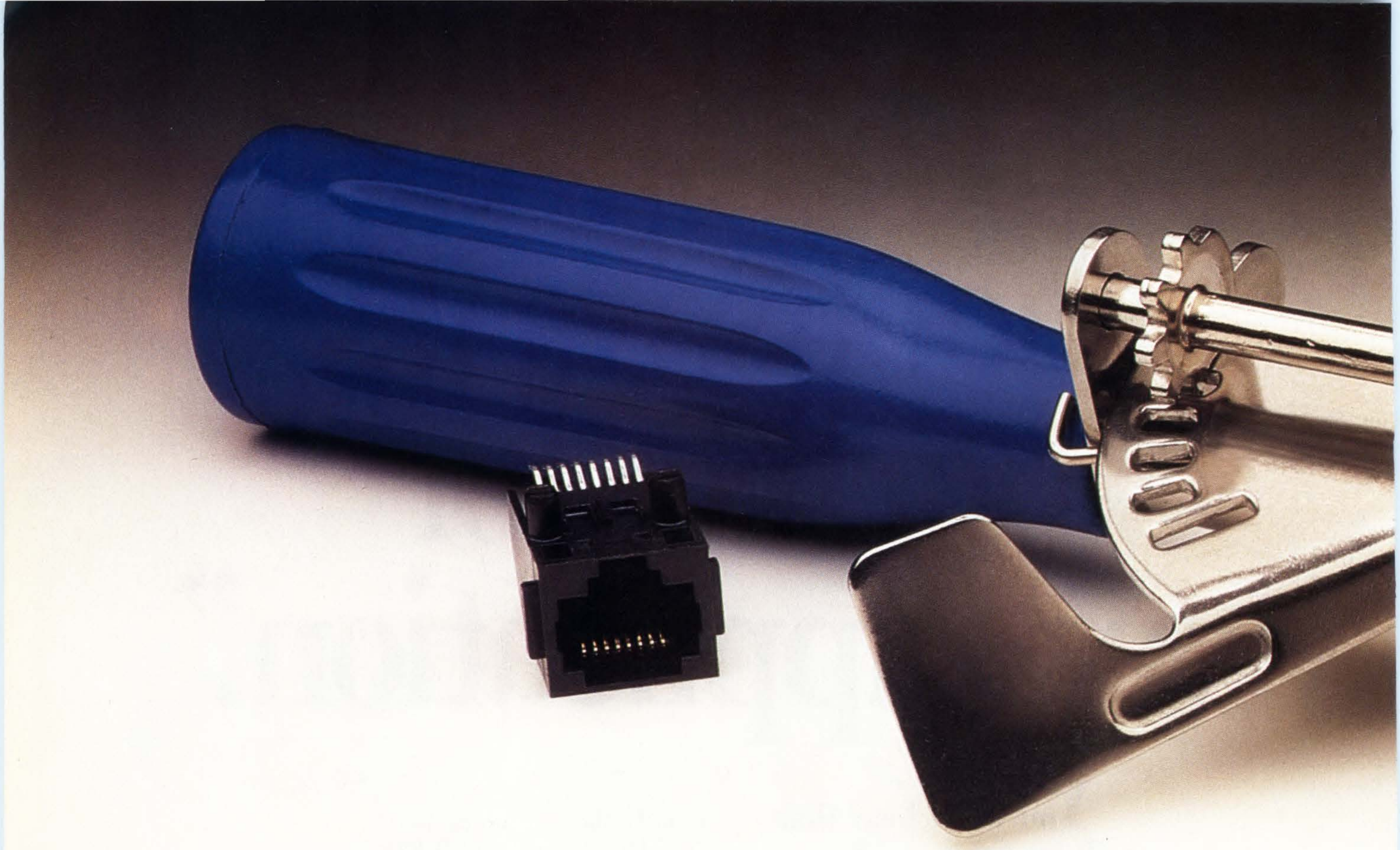
Expect new workstations that will aggressively attack the old rules for workstation price-performance. Last year's rules.

Definicon. Now you can open up a PC-AT and install Definicon's innovative, SPARC-based, 12 MIPS board—a board with all the power of a workstation.

You create a system capable of running the same software that runs on the popular Sun-4 workstation. An excellent, low-cost development platform for RISC development, including embedded control applications.



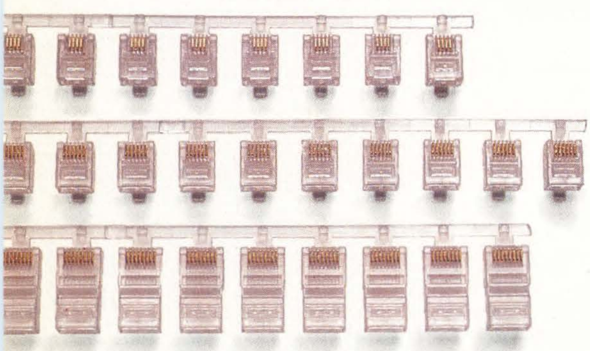

CY7C9116
35ns
16-Bit Microcontroller
NEW
25MHz
1Kx9 FIFO
NEW
CY7C425
CY7C9101
30ns
16 Bit Slice
NEW
25MHz
512x9 FIFO
NEW
CY7C420
25MHz
2Kx9 FIFO
NEW
CY7C429
What's new in high performance microprocessing? A lot.
Our SPARC-based RISC Integer Unit—the CY7C601—now runs at 33MHz, delivering 24 VAX MIPS without breathing hard.
It's the cornerstone of our RISC family, which includes a Cache Controller/Memory Management Unit, Cache RAM, and Floating Point Unit.
Your RISC development efforts are supported by the broad array of SPARC-based workstations available now. Workstations that, in turn, support a broad array of development software and third-party development tools.
For 80386-based systems, our new CY7C184 and CY7C183 128K Cache RAMs give you the performance you need for clock rates to 33MHz.
And all our parts—LOGIC, PROM, SRAM, PLD—give you the speed you need to turn high performance processors into market-leading systems.
CYPRESS SEMICONDUCTOR
35MHz
64Kx8 FIFO
NEW
CY7C408
CY7C604
33MHz
Memory Management Unit
NEW



Modular plugs and jacks. In surface-mount. Shielded.

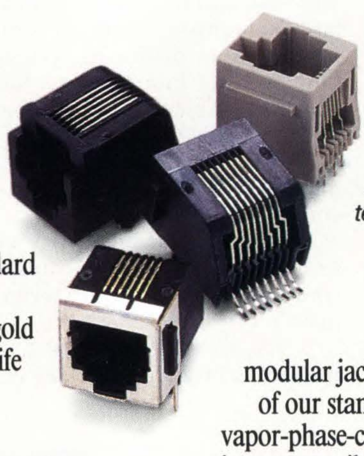
Our modular plug and jack designs have always been a great concept, especially for I/O.

And we have the whole, big scoop on breadth of line.



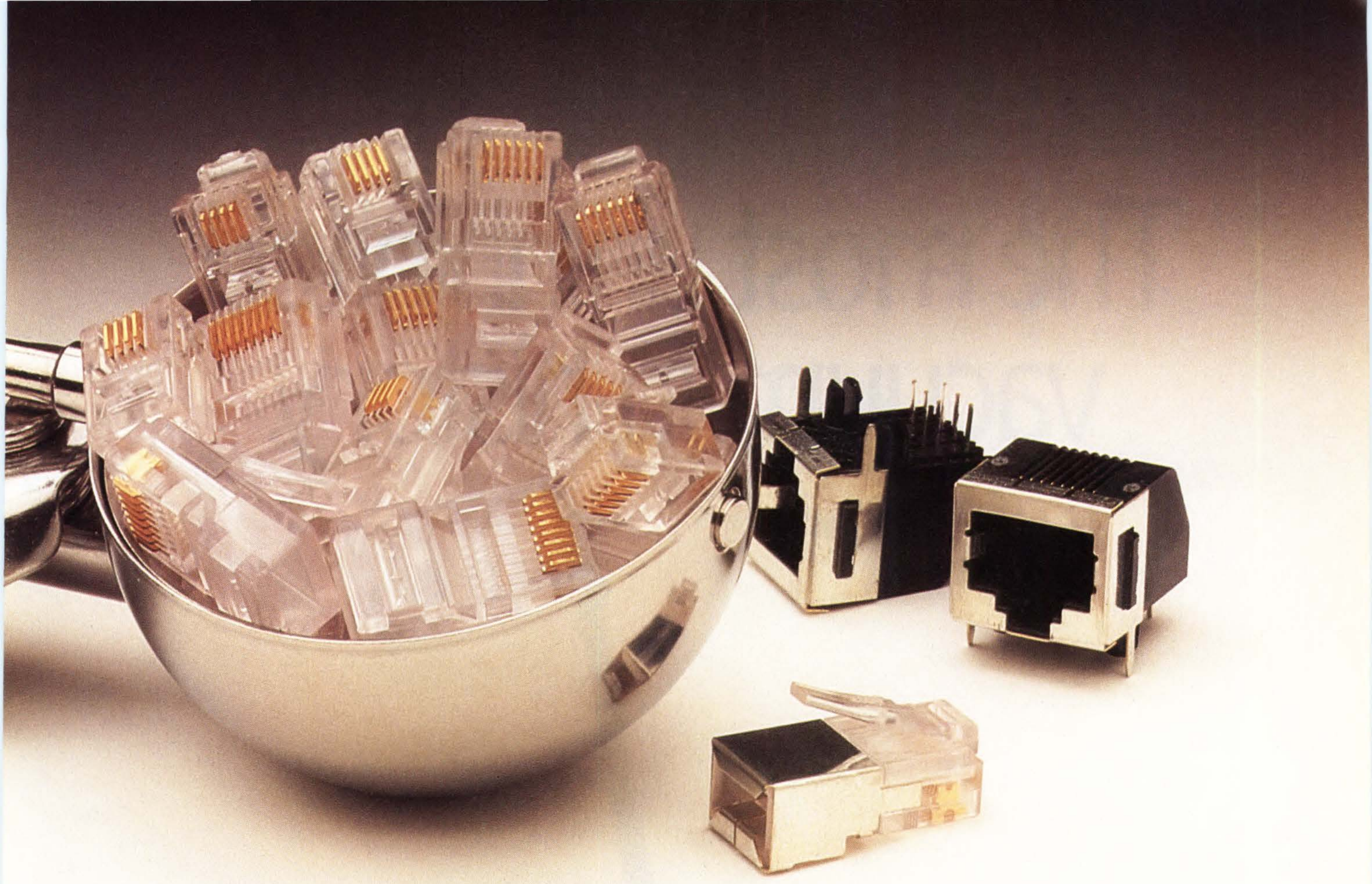
Strip-form mod plugs allow termination with high-speed application tooling.

We offer you the standards. Preloaded plugs that mass terminate round or flat-oval wire. And our standard top- and side-entry jacks with selective gold contacts for longer life at lower cost.



Shielded mod plugs in fully-loaded 6- and 8-position versions have insulation-piercing terminals. Shielded jacks in board-ground or panel-ground designs.

Or the surface-mount modular jacks. With all the features of our standard line in low-profile, vapor-phase-compatible modules that integrate easily with accepted processing, even robotic insertion.



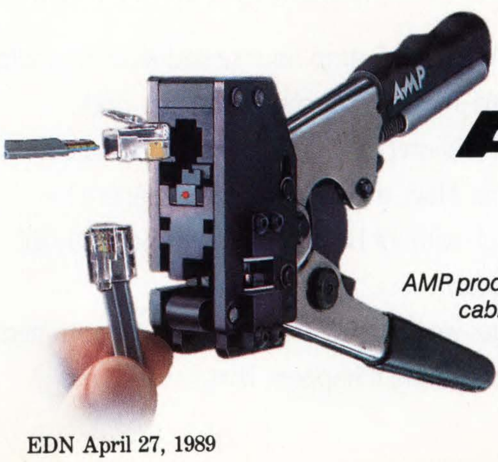
And plain ol' vanilla.

Or shielded. The industry's only low-cost modular shielded plugs and jacks. With a minimum of 20dB shielding effectiveness from 30MHz to 500 MHz. Redundant shielding tabs. Fully intermateable with standard product and conforms to FCC regulations.

And nowhere else can you find the tooling capability AMP offers you. A production hand tool that's acknowledged to be the best in the industry. Our low-cost field/prototype tool. And benchtop and high-speed application machinery.

Details on all our "flavors" are ready for you. Just give us a call.

Call 1-800-522-6752 for literature on AMP Modular Connectors. AMP Incorporated, Harrisburg, PA 17105-3608.



AMP Interconnecting ideas

AMP production hand tool cuts cable, strips cable jacket, and mass terminates loose-piece plugs.

VF Technology... The Bright Decision

Futaba, a world leading manufacturer of vacuum fluorescent displays, offers a wide assortment of *display tubes* in many sizes and formats. Also, Futaba offers *display modules* with all the electronics required to refresh the display and easily interface with host system.

GRAPHIC DISPLAY

Both front glass phosphor, which provides maximum viewing angle and uniform surface appearance, and conventional back glass phosphor, with optimum brightness and software dimming capabilities, are available. All Futaba graphics modules offer complete drive electronics, bit mapped control with a DC/DC converter. All active components are surface mounted onto a single board.

DOT MATRIX MODULES

Utilizing Futaba's dot matrix displays, a completely intelligent line of "dot modules" is available. Each includes all drive, power supply and microprocessor components surface mounted onto a single board. Surface mounted technology results in higher reliability and allows for a smaller overall package and lower cost. All dot modules require only a 5V DC power source and can accept parallel or 8 possible serial baud rates.

GRAPHIC DISPLAYS/MODULES

Futaba Display	Futaba Module	Pixels (Row X Char.)	Brightness (FT-L)	Module Dimensions (in.)
GP1013A	GP1013A02	64X34	200	3.35X2.95X0.7
GP1005B	GP1005B03	128X64	400	7.28X3.35X1.77
GP1010B	GP1010B01	176X16	200	7.32X2.16X1.70
GP1009B	GP1009B03	240X64	200	6.2X2.76X1.57
GP1006B	GP1006B04	256X64	200	9.84X3.35X1.77
GP1002C	GP1002C02	320X240	100*	7.10X6.30X1.60
GP1018A	GP1018A01	400X240	40	7.10X6.30X1.61
GP1004C	GP1004C03	640X400	30	9.65X7.3X1.85
GP1019A	GP1019A03	640X400	35	7.10X6.70X2.56

*Different Versions Available

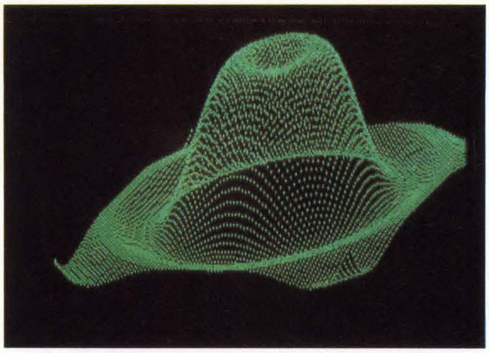
DOT MATRIX/CHARACTER DISPLAY MODULES

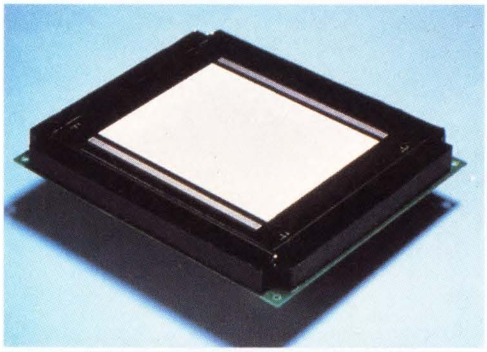
Futaba Display	Futaba Module	Char. X Row	Dot Format	Char. Ht. (in.)	Module Dimensions (in.)
16LD03G	M16LD03B	16X1	5X7	0.433	8.90X1.95X.98
16SY03Z	M16SY03B	16X1	14 SEGMENT ALPHANUMERIC	0.200	4.92X1.32X.83
20SD01Z	M20SD01	20X1	5X7	0.200	6.3X1.97X.75
20SD42Z	M20SD42	20X1	5X12	0.344	7.1X2.16X.88
40SD02Z	M40SD02	40X1	5X7	0.200	9.45X2.16X.88
40SD42Z	M40SD42	40X1	5X12	0.344	9.45X2.16X.88
202SD03Z	M202SD03	20X2	5X7	0.200	6.7X2.56X.90
402SD04Z	M402SD04	40X2	5X7	0.200	10.43X2.56X.90
MANY OTHER DISPLAYS	NEW MODULES AVAILABLE SOON				

FUTABA
Corporation of America
Electronic Components Division

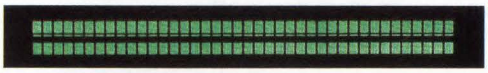
711 E. State Parkway
Schaumburg, IL 60173

Telephone: (312) 884-1444
FAX: (312) 884-1635

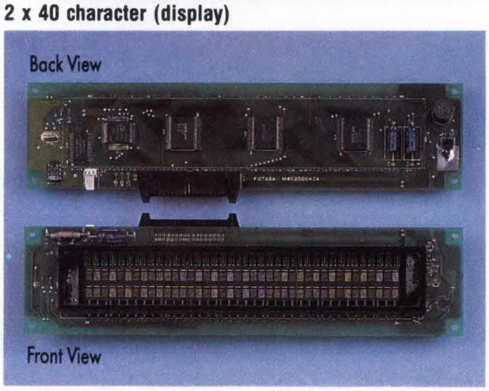




Compact, flat panel graphic displays and modules present clean, sharp images, whether for text or full graphics application.



2 x 40 character (display)

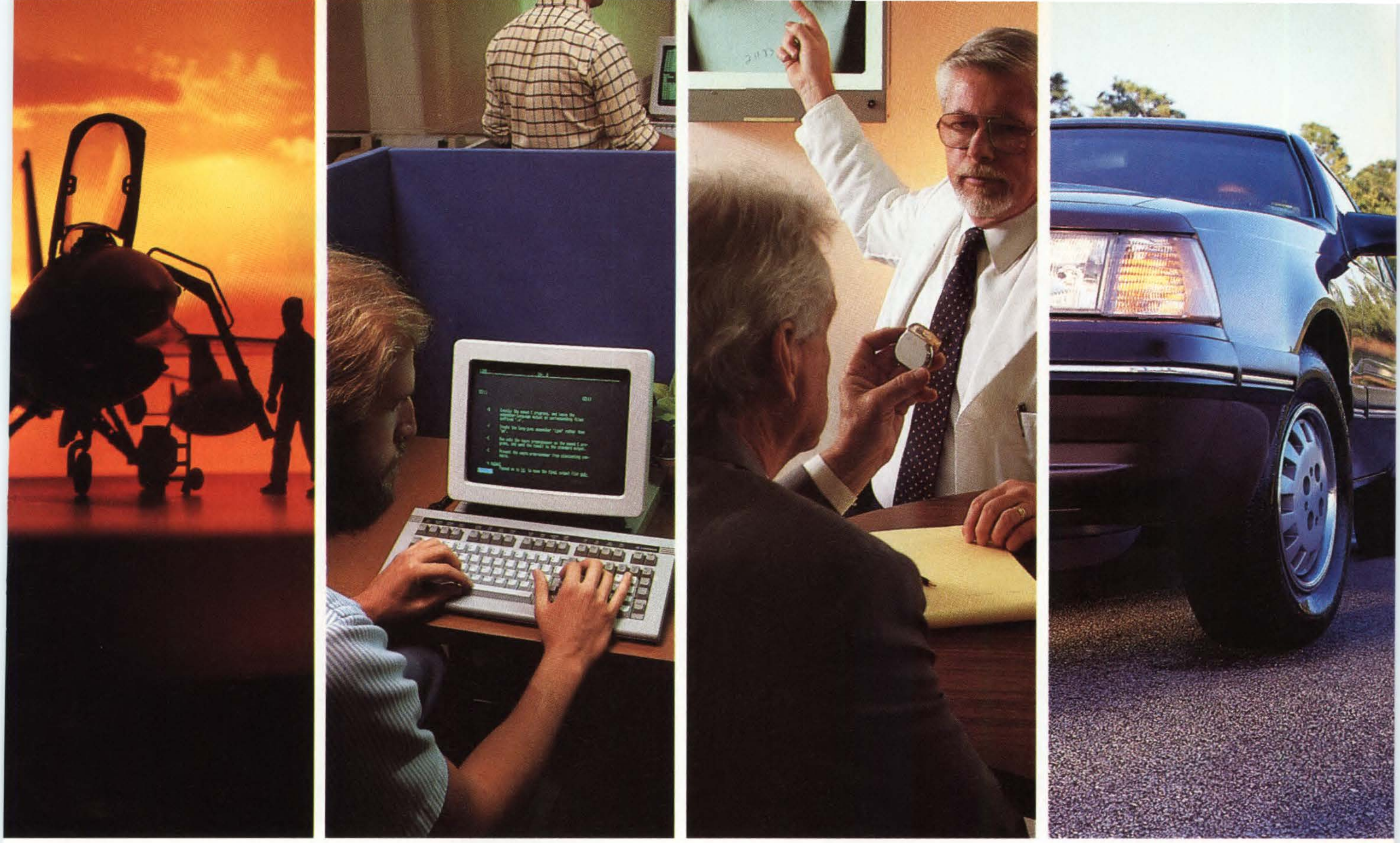


2 x 40 character (module)

Pattern flexibility and pleasing appearance are offered by Futaba in dot displays and modules.

Futaba also offers a complete catalog of alphanumeric, segmented displays.

Futaba supports its products with design engineering and system integration assistance. Call or write today.



#1 in Tantalum Chips...and We've Only Touched the Surface!

Mepco/Centralab SMD® tantalum chips reduce your system's size and increase its performance in every application — military, telecommunications, information systems, medical, automotive — and give you the broadest selection.

For peak reliability and volumetric efficiency, systems designers take our patented, conformally coated "Blue Chip®" to heart — in fact, it's used in 95% of the world's implanted pacemakers. And it's the **only** military hi-rel chip (CWR06 to MIL-C-55365) approved to reliability levels M, P, R, B, C and D!

Our "Star Chip®", the cost-effective alternative for your high-volume industrial applications, provides design flexibility not available with molded chips. Its patented features make it ideal for super computer (cryogenic) use, and for switching power supplies at 100 kHz and greater.

Our "Ultra Chip" is the ultimate in real estate efficiency, and our uniform-sized "Molded Chip" (approved to MIL-C-55365, Type CWR11) is available at very attractive prices.

A leader in leaded parts, too.

Our axial-leaded, hermetically sealed cylindrical and modular wets and solids meet the requirements of MIL-C-39006, -39003, and more. With capacitances from 0.0047 to 22,000 μF, for operation on 3 to 630 vdc. And large-capacity programs to meet your dock-to-stock and J-I-T requirements.

Write for our catalogs and get acquainted with America's broadest line of tantalum chip capacitors — from Mepco/Centralab, the active leader in passive components.

Mail to: Mepco/Centralab
Attn: Corp. Advertising
2001 W. Blue Heron Blvd.
P.O. Box 10330
Riviera Beach, FL 33404

Please send me the following:

- ☐ Surface Mount Device Catalog
- ☐ Leaded Resistor/Capacitor Data Book
- ☐ Please have a sales representative call

Name/Title ______________________

Firm/Dept./Div. ______________________

Address/MS ______________________

City/State/Zip ______________ Phone ( ) ______________

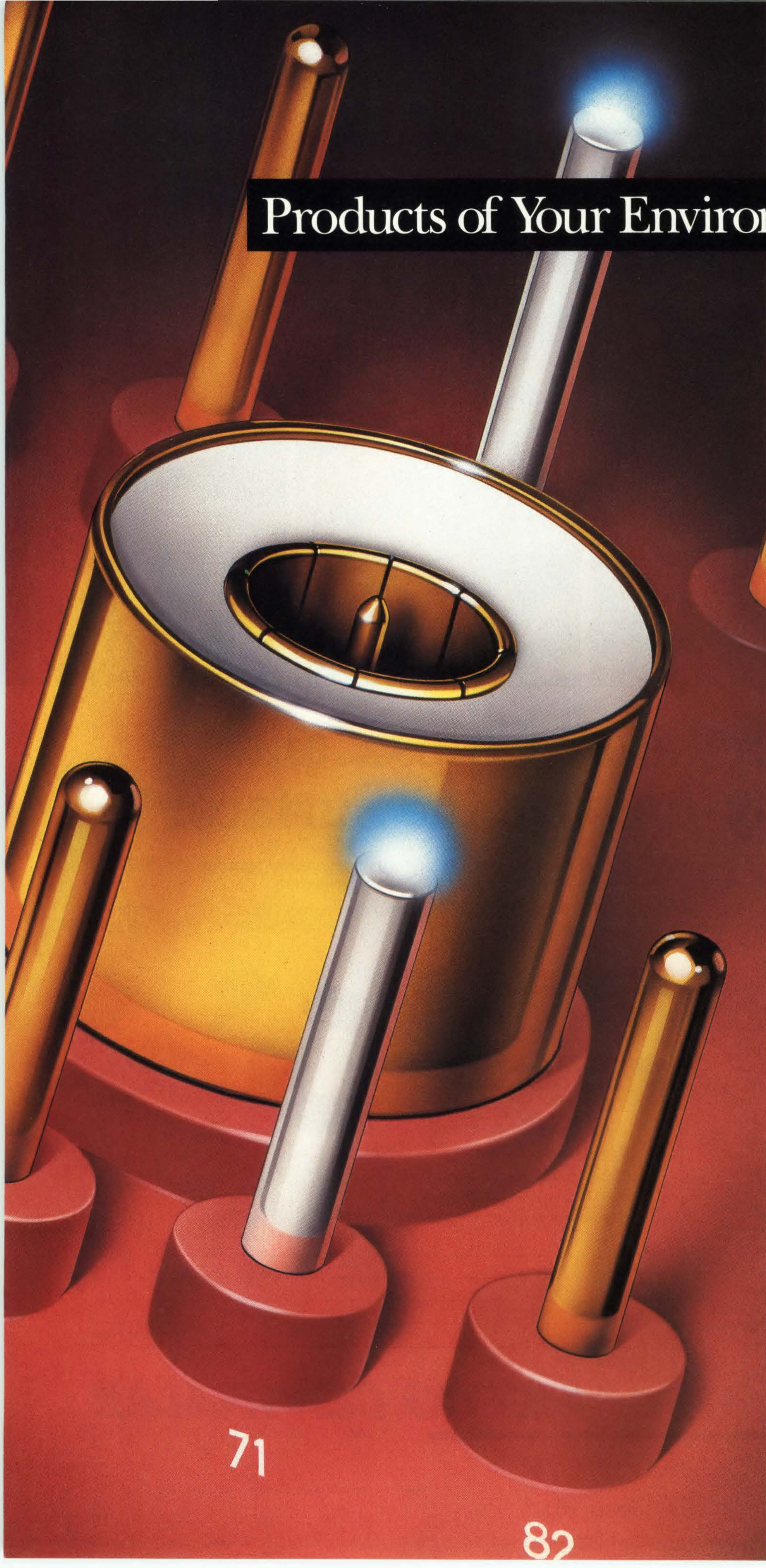
EDN 04/27/89

MEPCO/CENTRALAB
A DIVISION OF NORTH AMERICAN PHILIPS CORPORATION

PHILIPS

®SMD is a service mark of North American Philips Corporation.

CIRCLE NO 61



Products of Your Environment.

A field-use fiber optic connector so tough, you could roll a 5 ton truck over it. A Parallel Interconnect that allows a gas-tight interface in 60 seconds flat. A cabling assembly enabling a single connector to handle electronic signals, fiber optics *and* power supply.

These are but a few innovations in interconnections from ITT Cannon. But we couldn't have done it without you. Because success throughout our company relies on a thorough knowledge of your company's environment.

Take strategic partnering, for example. We don't create a custom solution by shaking your hand and jotting down a few notes. When we design-in, we get *inside* your environment.

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.

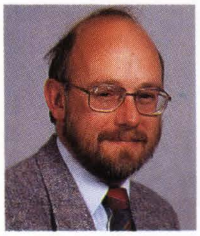
So if you'd like a partner who will take the time to learn about your environment, take a moment to contact ITT Cannon at (714) 261-5300.

Worldwide Headquarters
1851 East Deere Avenue
Post Office Box 35000
Santa Ana, CA 92705-6500

ITT Cannon
An ITT ElectroMechanical Components Worldwide Company
Discover our strengths.

CIRCLE NO 62

Micropower op amps hit new lows



The latest micropower op amps not only draw less current than their predecessors, they also operate from lower voltages.

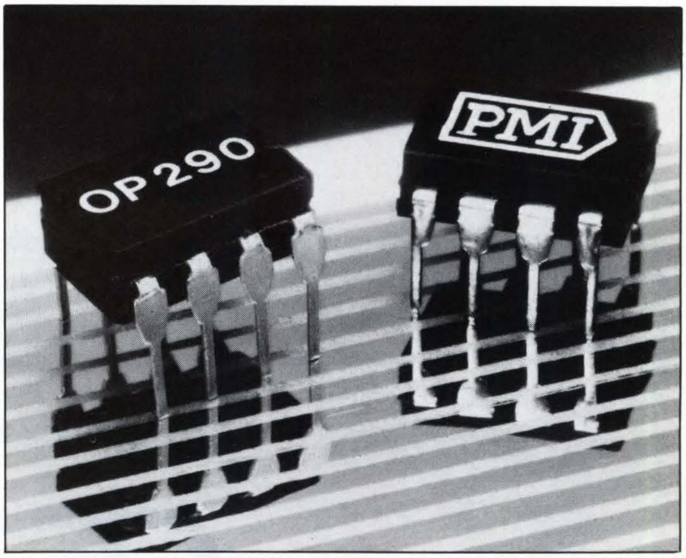
Peter Harold,
European Editor

You no longer need to sacrifice dc performance for low power consumption when you design with micropower op amps. These devices are now available with input offset voltages as low as 5 μV and input offset drifts of 0.05 μV/°C, and micropower op amps with 1-μV input offset voltages are already on the horizon. However, some performance tradeoffs, such as speed versus power, still remain. **Table 1** (see pg 124) details the basic specifications of a range of op amps that have a maximum quiescent supply-current rating of 500 μA or less at 25°C.

Op-amp manufacturers finally got the message that you don't always want to run micropower devices from ±15V supply rails. You can now get guaranteed performance at low supply voltages. Low-voltage supplies are not only desirable to save power consumption; but more often than not, they are all that's available in battery- or solar-powered equipment. In addition, low-voltage operation lets you power op amps from the same supply as logic circuitry. As a result, many manufacturers now provide full specifications for their devices at these low supply voltages—typically ±2.5V but sometimes as low as ±1.5V. Thus, you can design them in with confidence.

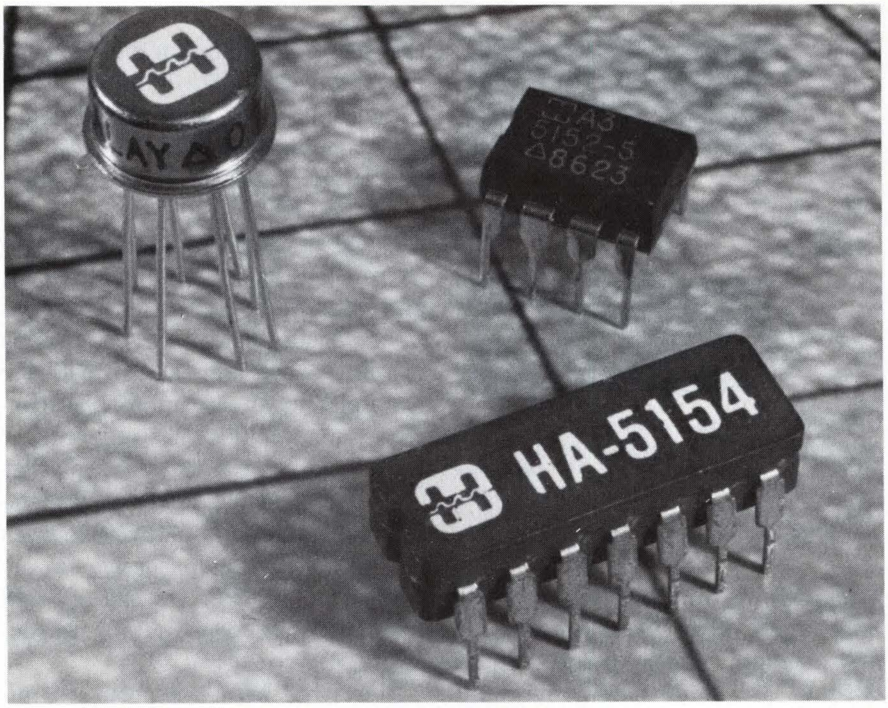
Micropower op amps are also increasingly specified for single-supply operation instead of or in addition to split-supply operation. When you operate a conventional split-supply op amp from a single supply, you may be faced with having to generate an artificial ground that's midway between the supply's ground and positive rails. This step is usually necessary to ensure that the op amp stays within its common-mode input-voltage limitations. However, op amps that are specified for single-supply operation have a common-mode input-voltage capability that includes ground. These op amps can handle input signals that swing right down to ground potential.

Check carefully to ascertain whether the op amp's output has a similar capability. If the device won't drive its open-circuit output to ground, you'll have to add a power-consuming pull-down resis-



The OP290 precision, dual, micropower op amp *from PMI is fully specified for supply voltages in the 1.5 to 15V and −1.5 to −15V ranges.*

Micropower op amps



The HA5154 is a quad micropower op amp *from Harris that achieves a 6V/µsec slew rate and a full-power bandwidth of 95 kHz.*

tor to achieve a 0V output.

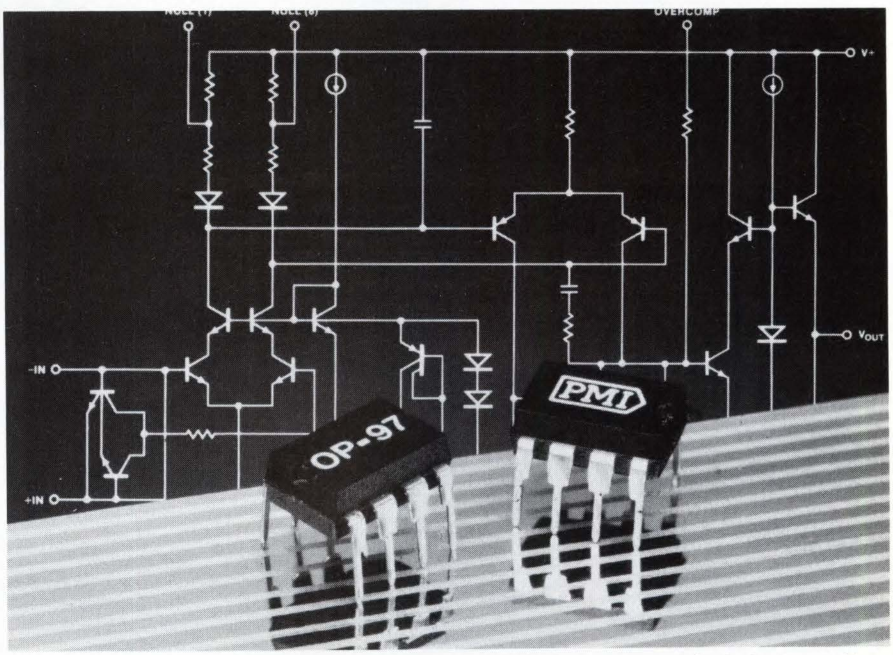
Ideally, the greater the common-mode input- and output-voltage ranges of the op amp, the greater the dynamic range you'll be able to use for your analog signals. When you're operating on supply voltages of 5V or less, maintaining dynamic range through several op-amp stages can be essential to ensure that your signal doesn't get lost in the noise. Advanced Linear Devices claims to be the first company to provide low-voltage, low-power op amps with common-mode input- and output-voltage ranges that include both supply-rail voltages. In the future, you'll see an increasing number of op amps with this rail-to-rail input and output capability.

Low V_{OS} maintains precision

In the past, low power consumption and precision dc performance didn't go hand in hand. That situation is rapidly changing. Micropower op amps with maximum input offsets of 1 mV are now commonplace, and several devices have maximum input offset-voltage specifications of 100 µV or less. But the best input offset-voltage specifications—5 µV maximum at 25°C—are currently achieved by chopper-stabilized devices. These devices include Maxim's MAX-422, MAX-423, and MAX-432, and Teledyne Semiconductor's TSC900 micropower op amps.

Maxim will add another low-power precision op amp to its offerings later this year. Designated the MAX425 Superamp, it will employ two active error-correction schemes to keep all sources of input offset-voltage error to less than 1 µV at 25°C. The device's input offset-voltage drift will be a mere 0.05 µV/°C over the full military temperature range. The input bias current will be 1 pA max at 25°C, rising to 100 pA max at 85°C. The power-supply current, however, will be as large as 1.2 mA for supply voltages in the 2.5 to 7.5V and −2.5 to −7.5V ranges. The lowest grade version of the MAX425 Superamp is expected to sell for around $5 (100).

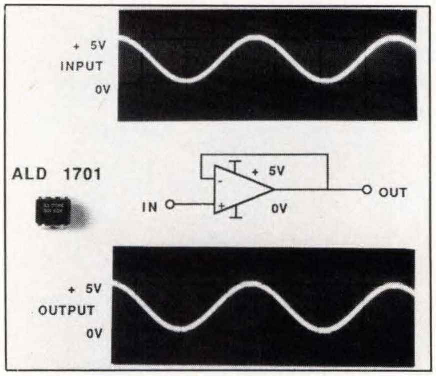
Although it's not included in the



The OP97 precision op amp *from PMI consumes 1/6th the power and 1/20th the input bias current of the company's OP07 device yet has the same dc performance.*

table because of its maximum supply-current specification of 600 μA, PMI's OP97 is a precision op amp that's close on the heels of currently available chopper-stabilized micropower devices. The device has a maximum input offset voltage of 25 μV at 25°C and an offset-voltage drift of 0.6 μV/°C. And because it doesn't employ chopper techniques to achieve these specifications, the OP97 won't introduce the clock-related ripple and noise that often appears on the input and output of chopper-stabilized op amps. This factor is of particular significance if your design requires wide-band frequency response. The OP97 costs $1.60 (100).

Another company attacking the market for precision micropower op amps is Raytheon. Later this year, the company's semiconductor division is set to introduce the RC4097, a micropower op amp with a maximum input offset voltage of 15 μV and an input offset-voltage drift of 0.3 μV/°C. The device's provisional data sheet also specifies a maximum input bias current of ±100 pA at 25°C. The input bias current increases to a maximum of ±250 pA over the commercial temperature range and ±600 pA over the military temperature range. Prices for the RC4097 are expected to start at around $2.75 (100).



Offering rail-to-rail *common-mode input- and output-voltage ranges, the ALD1701 CMOS micropower op amp from Advanced Linear Devices suits low-voltage, single-supply applications.*

Some micropower op amps have extremely good input bias-current and input offset-current specifications. Analog Devices' best grades of the AD-548 and the AD-648, for example, have maximum bias currents and input offset currents of 10 pA and 5 pA, respectively, at 25°C. As a result, you can drive the inputs from high-impedance sources without incurring excessive dc errors. The AD-548 and the AD-648 cost $0.75 and $1.25 (100), respectively.

However, before choosing a micropower op amp for its bias current and input offset-current specifications, carefully check how these pa-

For more information . . .

For more information on the micropower 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.

Advanced Linear Devices Inc
1180F Miraloma Way
Sunnyvale, CA 94086
(408) 720-8737
FAX 408-720-8297
Circle No 661

Analog Devices
One Technology Way
Norwood, MA 02062
(617) 329-4700
TWX 710-394-6577
Circle No 662

Burr-Brown Corp
International Airport Industrial Park
Tucson, AZ 85734
(602) 746-1111
FAX 602-889-1510
Circle No 663

Harris Semiconductor
Box 883
Melbourne, FL 32902
(407) 724-3800
Circle No 664

Linear Technology Corp
1630 McCarthy Blvd
Milpitas, CA 95035
(408) 432-1900
FAX 408-434-0507
Circle No 665

Maxim Integrated Products Inc
120 San Gabriel Dr
Sunnyvale, CA 94086
(408) 737-7600
FAX 408-737-7194
Circle No 666

National Semiconductor Corp
2900 Semiconductor Dr
Santa Clara, CA 95052
(408) 721-5000
TWX 910-339-9240
Circle No 667

Precision Monolithics Inc
1500 Space Park Dr
Santa Clara, CA 95052
(408) 727-9222
FAX 408-727-1550
Circle No 668

Raytheon Co
Semiconductor Div
350 Ellis St
Mountain View, CA 94039
(415) 968-9211
TWX 910-379-6484
Circle No 669

SGS-Thomson Microelectronics
Via C Olivetti 2
20041 Agrate Brianza
Italy
(039) 65551
TLX 330131
Circle No 670

SGS-Thomson Microelectronics
1000 E Bell Rd
Phoenix, AZ 85022
(602) 867-6100
TLX 249976
Circle No 671

Siemens AG
Zentralstelle fur Information
Postfach 103
8000 Munich 1
West Germany
(089) 2340
TLX 5210025
Circle No 672

Siemens Components Inc
2191 Laurelwood Rd
Santa Clara, CA 95054
(408) 980-4500
Circle No 673

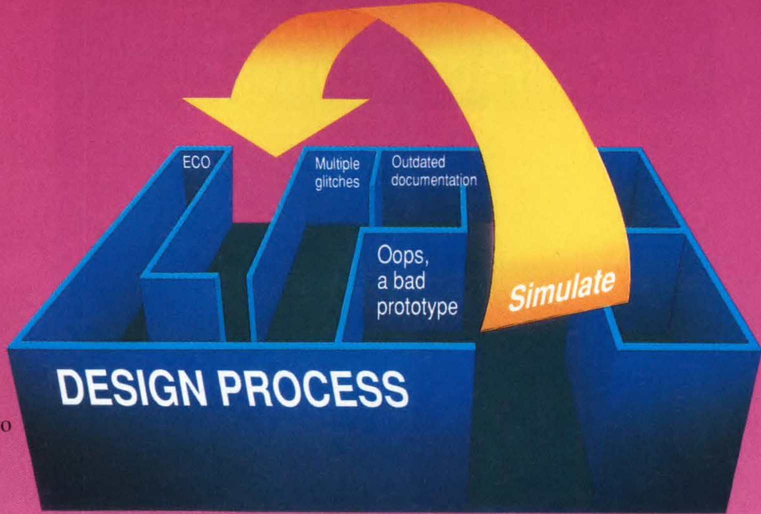
Siliconix Inc
2201 Laurelwood Rd
Santa Clara, CA 95054
(408) 988-8000
FAX 408-727-5414
Circle No 674

Teledyne Semiconductor
1300 Terra Bella Ave
Mountain View, CA 94039
(415) 968-9241
TWX 910-379-6494
Circle No 675

Texas Instruments
Semiconductor Group
Box 809066
Dallas, TX 75380
(800) 232-3200
Circle No 676

OrCAD Answers Your Questions About

Logic Simulation



Q: Why simulate?

A: To save time.

The ideal development cycle is schematic to prototype to production. Simulation dramatically decreases the dreaded loop of schematic to prototype to schematic to prototype to schematic to...

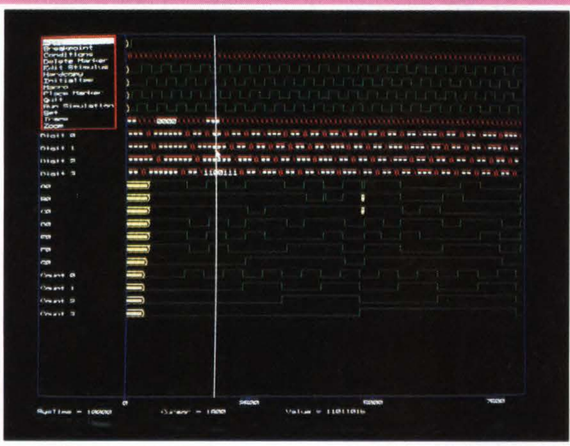
A: To save money.

If your design goes through several iterations, is the documentation still accurate? Suddenly your time and budget are being spent on laying in patches, not producing.

A: To make you look good.

Your schematic is supposed to be the best answer to someone else's design problem. Think of how great you'll look when you present a solution with no glitches, timing violations or other problems.

Verification of your design doesn't have to be handled at the prototype stage (or worse yet, the production stage).



You need a digital simulator that helps you find timing violations and design anomalies before you spend time and money on prototypes. The result: fewer iterations, a shorter design cycle, a more reliable product and getting the project right.

Why OrCAD/VST?

A: OrCAD/VST enables you to interactively verify your design as it develops. A netlist from OrCAD's powerful Schematic Design Tools is all that's required to get started.

A: OrCAD/VST features a user interface similar to OrCAD/SDT III, including easy-to-use menu driven commands and powerful keyboard macros. Your valuable time is spent designing and testing rather than trying to learn a new system.

A: OrCAD/MOD extends OrCAD/VST to PLDs. A set of PLD Simulation Modeling Tools, OrCAD/MOD produces models of PLDs for OrCAD/VST to use in simulation of the larger circuit in which the PLD will operate.

A: OrCAD/VST at only $995 offers unsurpassed performance on a PC. Independent benchmark tests have hailed OrCAD's logic simulator as superior to other simulators costing 20 times as much. Add OrCAD/MOD for only $495 simulate PLDs in a larger design.

- Event driven, 12-state functional simulator
- 16,000+ events/sec. on an 8 MHz AT
- 65,000+ events/sec. on a 20 MHz 386
- Over 14,000 gate capability without additional memory
- Logical analyzer display format (virtual screen displays 50 channels)
- User selectable min. and max. displays
- Includes component models of TTL, ECL, CMOS, Memory devices & utilities for creating custom models
- OrCAD's excellent support: technical staff, 24 hour BBS, 1 year free product updates, and a trained sales and support network.

Call or write today for your **FREE** Demo Disk and brochure.

OrCAD® Systems Corporation
1049 S.W. Baseline Street Suite 500
Hillsboro, Oregon 97123
(503) 640-9488

Contact your local OrCAD representative for further information

1. WA, OR, MT, ID, AK
Seltech, Inc.
(206) 746-7970

2. N. CA, Reno NV
Elcor Associates Inc.
(408) 980-8868

3. So. CA
Advanced Digital Group
(714) 897-0319

4. Las Vegas NV, UT, AZ, NM, CO
Tusar Corporation
(602) 998-3688

5. ND, SD, MN, W. WI
Comstrand, Inc.
(612)788-9234

6. NE, KS, IA, MO
Walker Engineering, Inc.
(913)888-0089

7. TX, OK, AR, LA
Abcor, Inc.
(713)486-9251

8. MI, E. WI, IL
Mackeller Associates
(313) 335-4440

9. IN, OH, KY, WV, W. PA
Frank J. Campisano, Inc.
(513) 574-7111

10. TN, VA, NC, SC
Tingen Technical Sales
(919) 878-4440

11. FL
High Tech Support
(813) 920-7564

12. MS, AL, GA
Electro-Cadd
(404) 446-7523

13. E. PA, NJ, NY, DE, MD, DC
Beta Lambda, Inc.
(201) 446-1100

14. CT, RI, MA, VT, NH, ME
DGA Associates, Inc.
(617) 935-3001

15. BC, AB, SK, MD
Interworld Electronics & Computer Industries, Ltd.
(604) 984-4171

16. ON, PQ & Maritimes
Electralert, LTD.
(416) 475-6730

)R8839

CIRCLE NO 64

Micropower op amps

rameters vary over the device's operating temperature range. The bias current of most FET-input op amps tends to double for every 10°C rise in temperature. Although bipolar-input op amps tend to have higher bias currents to begin with, their bias current varies with temperature at a much lower rate. For example, a bipolar-input op amp with a 25°C bias-current specification of 5 nA will exhibit a typical bias-current variation of only 1 or 2 nA over its entire operating temperature range.

Speed/power tradeoffs remain

Unfortunately, like all op amps, micropower op amps suffer from an inevitable speed-vs-power tradeoff. Even devices at the 500-μA limit for inclusion in the **table** don't have unity gain × bandwidths greater than 2 MHz. Although PMI's OP421 has a typical unity gain × bandwidth of 1.9 MHz, that figure only applies for supply voltages of ±15V. The device meets the 500-μA limit only if you operate it on ±2.5V supplies. At these supply voltages, its gain × bandwidth falls to around 1.6 MHz. The OP421 sells for $1.80 (100).

Micropower op amps with a maximum supply current of 250 μA typically achieve unity gain × bandwidths of around 1 MHz. If you require very low power consumption and have to use op amps that draw only a few tens of microamperes from low-voltage supplies, you'll have to put up with unity gain × bandwidths of 100 kHz or less. **EDN**

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

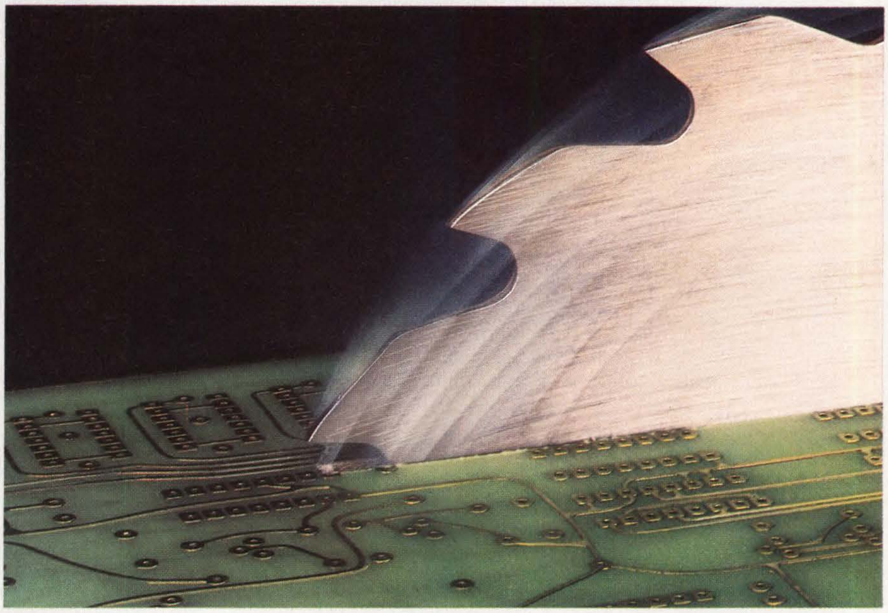
SIEMENS

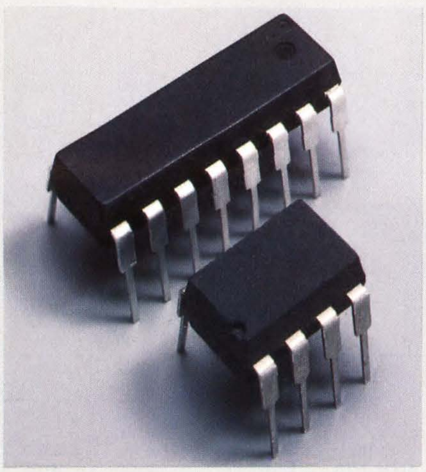
Multi-Channel optocouplers cut costs and save board space!

Attention single channel optocoupler user!

Our quad- and dual-channel devices, available in both phototransistor and photodarlington versions, offer these important benefits over single-channel couplers!

- **Greater than 40% savings in PC board real estate**
- **A 33% reduction in pin count—reducing assembly time and costs.**
- **Lower cost per channel**
- **Reduced component count—each Quad replaces 4 singles; each Dual replaces 2 singles—increasing system reliability.**
- **More closely matched current transfer ratios**





Siemens Multi-Channel Coupler Family

CTR (%)	Industry Standard Single Channel	Dual Channel	Quad Channel
Type: Phototransistor			
20 (Min)	4N25/4N26/IL1/HIIA2/AACT2	ILCT6/ILD1/AACT6	ILQ1
10	4N27/4N28	ILCT6/ILD1	ILQ1
50	IL5/HIIA1	ILD5	ILQ5
100	4N35/4N36/4N37	ILD2	ILQ2
40,63,100 & 160	CNY 17 Series	ILD610-1, -2, -3, & -4	—
50,20 & 100 (1)	HIIAA3/HIIAA1/HIIAA4	ILD250/ILD251/IDL252	—
Type: Darlington			
400 (TYP) (2)	IL30/HIIB3	ILD30	ILQ30
400 (2)	IL31/HIIB2	ILD31	ILQ31
400 (3)	IL55	ILD55	ILQ55
800	4N32	ILD32	ILQ32
800	4N33	ILD33	ILQ33

Footnotes: (1) bidirectional input; (2) $BV_{CEO} = 30V$; (3) $BV_{CEO} = 55V$

Siemens Components, Inc.,
Optoelectronics Division,
19000 Homestead Road,
Cupertino, CA 95014
(408) 257-7910.

Siemens National Distributors: Hall-Mark and Marshall
Siemens Regional Distributors: Advent Electronics, Inc., Almo Electronics, Insight Electronics, Quality Components, Summit and Western Microtechnology.

Siemens...
your partner for the future.

CIRCLE NO 153

CG/2600-032A WLM 769

TABLE 1—REPRESENTATIVE MICROPOWER OP AMPS

MANUFACTURER	TYPE NUMBER	OP AMPS PER PACKAGE	SUPPLY-VOLTAGE RANGE (V)	QUIESCENT SUPPLY CURRENT PER OP AMP[3] (μA)	MAXIMUM INPUT OFFSET VOLTAGE (mV)	MAXIMUM INPUT BIAS CURRENT (nA)	MAXIMUM INPUT OFFSET CURRENT (nA)
ADVANCED LINEAR DEVICES	ALD1701G	1	±1 TO ±6 (ABS MAX) 2 TO 12 (ABS MAX)	300 MAX, FOR V_S = ±2.5V	10	0.050	0.030
	ALD1701			250 MAX, 120 TYP FOR V_S = ±2.5V	4.5	0.030	0.025
	ALD1701B			250 MAX, 120 TYP FOR V_S = ±2.5V	2	0.030	0.025
	ALD1701A			250 MAX, 120 TYP FOR V_S = ±2.5V	0.9	0.030	0.025
	ALD1706G	1	±1 TO ±6 (ABS MAX) 2 TO 12 (ABS MAX)	50 MAX, 20 TYP FOR V_S = ±2.5V	10	0.050	0.030
	ALD1706			40 MAX, 20 TYP FOR V_S = ±2.5V	4.5	0.030	0.025
	ALD1706B			40 MAX, 20 TYP FOR V_S = ±2.5V	2	0.030	0.025
	ALD1706A			40 MAX, 20 TYP FOR V_S = ±2.5V	0.9	0.030	0.025
	ALD2701	2	±1 TO ±6 (ABS MAX) 2 TO 12 (ABS MAX)	250 MAX, 120 TYP FOR V_S = ±2.5V	10	0.050	0.030
	ALD2701B			250 MAX, 120 TYP FOR V_S = ±2.5V	5	0.030	0.025
	ALD2701A			250 MAX, 120 TYP FOR V_S = ±2.5V	2	0.030	0.025
	ALD4701	4	±1 TO ±6 (ABS MAX) 2 TO 12 (ABS MAX)	250 MAX, 120 TYP FOR V_S = ±2.5V	10	0.030	0.025
	ALD4701B			250 MAX, 120 TYP FOR V_S = ±2.5V	5	0.030	0.025
	ALD4701A			250 MAX, 120 TYP FOR V_S = ±2.5V	2	0.030	0.025
ANALOG DEVICES	AD548-J, -A, -S	1	±4.5 TO ±18 (ABS MAX)	200 MAX, 170 TYP	2	0.020	0.010
	AD548-K, -B, -T			200 MAX, 170 TYP	0.5	0.010	0.005
	AD548C			200 MAX, 170 TYP	0.25	0.010	0.005
	AD648-J, -A, -S	2	±4.5 TO ±18 (ABS MAX)	200 MAX, 170 TYP	2	0.020	0.010
	AD648-K, -B, -T			200 MAX, 170 TYP	1	0.010	0.005
	AD648C			200 MAX, 170 TYP	0.3	0.010	0.005
BURR-BROWN	OPA21G	1	±2.5 TO ±18 (ABS MAX)	325 MAX	0.5	50	4
	OPA21E			230 MAX, 200 TYP	0.1	25	1
	OPA201-AG, -RG	1	±2.5 TO ±18 (ABS MAX)	500 MAX, 425 TYP	0.5	50	4
	OPA201-BG, -SG	SEE		500 MAX, 425 TYP	0.2	40	2
	OPA201CG	COMMENT		500 MAX, 425 TYP	0.1	25	1
HARRIS	HA5141	1	±1.5 TO ±15 3 TO 30	150 MAX, 100 TYP 80 MAX, 45 TYP FOR V_S=5V	6	100	10
	HA5142	2		150 MAX, 100 TYP 80 MAX, 45 TYP FOR V_S=5V	6	100	10
	HA5144	4		150 MAX, 100 TYP 80 MAX, 45 TYP FOR V_S=5V	6	100	10
	HA5151	1	±1.5 TO ±15 3 TO 30	250 MAX, 200 TYP 250 MAX, 200 TYP FOR V_S=5V	3	250	50
	HA5152	2		250 MAX, 200 TYP 250 MAX, 200 TYP FOR V_S=5V	3	250	50
	HA5154	4		250 MAX, 200 TYP 250 MAX, 200 TYP FOR V_S=5V	3	250	50
LINEAR TECHNOLOGY	LT1078-M, -C	2	±0.9 TO ±15 1.8 TO 30	75 MAX, 47 TYP AT V_S = ±15V	0.35	10	0.35
				55 MAX, 39 TYP AT V_S=5V	0.12	10	0.35
	LT1078-AM, -AC	2		65 MAX, 46 TYP AT V_S = ±15V	0.25	8	0.25
				50 MAX, 38 TYP AT V_S=5V	0.07	8	0.25
	LT1079-M, -C	4		75 MAX, 47 TYP AT V_S = ±15V	0.35	10	0.35
				55 MAX, 39 TYP AT V_S=5V	0.15	10	0.35
	LT1079-AM, -AC	4		65 MAX, 46 TYP AT V_S = ±15V	0.25	8	0.25
				50 MAX, 38 TYP AT V_S=5V	0.10	8	0.25
	LT1178-M, -C	2	±0.85 TO ±15 1.7 TO 30	25 MAX, 17 TYP AT V_S = ±15V	0.48	6	0.35
				21 MAX, 14 TYP AT V_S=5V	0.12	6	0.35
	LT1178-AM, -AC	2		21 MAX, 16 TYP AT V_S = ±15V	0.35	5	0.25
				18 MAX, 13 TYP AT V_S=5V	0.07	5	0.25
	LT1179-M, -C	4		25 MAX, 17 TYP AT V_S = ±15V	0.48	6	0.35
				21 MAX, 14 TYP AT V_S=5V	0.15	6	0.35
	LT1179-AM, -AC	4		21 MAX, 16 TYP AT V_S = ±15V	0.35	5	0.25
				18 MAX, 13 TYP AT V_S=5V	0.10	5	0.25
MAXIM	ICL76-1×D, -2×D	1, 2	±1 TO ±8	250 MAX, 100 TYP AT I_{set} = 100 μA; 20 MAX, 10 TYP AT I_{set} = 10 μA FOR V_S = ±5V FOR ALL GRADES	15	0.050	0.030
	ICL76-1×B, -2×B	1, 2			5	0.050	0.030
	ICL76-1×A, -2×A	1, 2			2	0.050	0.030
	ICL76-3×E, -4×E	3, 4	±1 TO ±8	250 MAX, 100 TYP AT I_{set} = 100 μA; 22 MAX, 10 TYP AT I_{set} = 10 μA FOR V_S = ±5V FOR ALL GRADES	20	0.050	0.030
	ICL76-3×C, -4×C	3, 4			10	0.050	0.030
	ICL76-3×B, -4×B	3, 4			5	0.050	0.030
	MAX422C	1	±2.5 TO ±16.5	500 MAX, 300 TYP	0.010	0.100	0.200
	MAX423C			500 MAX, 300 TYP	0.010	0.100	0.200
	MAX422-E, -M			500 MAX, 300 TYP	0.005	0.030	0.060
	MAX423-E, -M			500 MAX, 300 TYP	0.005	0.030	0.060
	MAX432-E	1	±2.5 TO ±16.5	500 MAX, 300 TYP	0.010	0.100	0.200
	MAX432-C			500 MAX, 300 TYP	0.005	0.100	0.200
NATIONAL SEMICONDUCTOR	LF441	1	±5 TO ±18 (ABS MAX) ±5 TO ±22 (ABS MAX) FOR A-SUFFIX VERSIONS	250 MAX, 150 TYP	5	0.100	0.050
	LF441A	1		200 MAX, 150 TYP FOR V_S = ±20V	0.5	0.050	0.025
	LF442	2		250 MAX, 200 TYP	5	0.100	0.050
	LF442A	2		200 MAX, 150 TYP FOR V_S = ±20V	1	0.050	0.025
	LF444	4		250 MAX, 200 TYP	10	0.100	0.050
	LF444A	4		200 MAX, 150 TYP FOR V_S = ±20V	5	0.050	0.025

NOTES:

1) THE TABLE LISTS OP AMPS THAT HAVE A MAXIMUM SUPPLY CURRENT SPECIFICATION OF 500 μA OR LESS AT 25°C.
2) ALL LISTED SPECIFICATIONS ARE THOSE THAT APPLY FOR AN AMBIENT TEMPERATURE OF 25°C UNLESS OTHERWISE INDICATED.
3) LISTED SPECIFICATION APPLIES FOR V_S = ±15V UNLESS OTHERWISE STATED.
4) PRICE LISTED IS FOR THE LOWEST GRADE DEVICE.

MINIMUM COMMON-MODE INPUT-VOLTAGE RANGE[3] (V)	MINIMUM OUTPUT-VOLTAGE RANGE[3] (V)	TYPICAL GAIN × BANDWIDTH[3] (kHz)	TYPICAL SLEW RATE[3] (V/μSEC)	PACKAGE TYPES	PRICE[4] (100)	COMMENTS
$+V_S$ TO $-V_S$	$+V_S$ TO $-V_S$	700 FOR $V_S = \pm 2.5V$ 1000 FOR $V_S = \pm 5V$	0.7 FOR $V_S = \pm 2.5V$ 1 FOR $V_S = \pm 5V$	DIP-8, SO-8, DICE	$1.55	
$+V_S$ TO $-V_S$	$+V_S$ TO $-V_S$	400 FOR $V_S = \pm 2.5V$ 300 FOR $V_S = \pm 1V$	0.17 FOR $V_S = \pm 2.5V$ 0.17 FOR $V_S = \pm 1V$	DIP-8, SO-8, DICE	$1.89	
$+V_S$ TO $-V_S$	$+V_S$ TO $-V_S$	700 FOR $V_S = \pm 2.5V$ 1000 FOR $V_S = \pm 5V$	0.7 FOR $V_S = \pm 2.5V$ 1 FOR $V_S = \pm 5V$	DIP-8, SO-14, DICE	$1.90	
$+V_S$ TO $-V_S$	$+V_S$ TO $-V_S$	700 FOR $V_S = \pm 2.5V$ 1000 FOR $V_S = \pm 5V$	0.7 FOR $V_S = \pm 2.5V$ 1 FOR $V_S = \pm 5V$	DIP14, SO-24	$3.63	
±11	±12	1000	1.8	DIP-8, TO-99	$0.75	
±11	±12	1000	1.8	DIP-8, TO-99	$1.25	
−12.5 TO +14.3	−13.7 TO +14	300	0.2	DIP-8	$3.25	
±12.5	±13.5	500	0.18	DIP-14	$4.05	HAS TWO DIGITALLY SELECTABLE DIFFERENTIAL INPUT STAGES FEEDING ONE OUTPUT STAGE
±10 0 TO 3 FOR V_S=5V	±10 1.0 TO 3.8 FOR V_S=5V	400	1.5	SINGLE: DIP-8, TO-99 DUAL: DIP-8, TO-99 QUAD: DIP-14	HA5141: $4.05	
±10 0 TO 3 FOR V_S=5V	±10 1.0 TO 3.2 FOR V_S=5V	1300	6 4.5 FOR V_S=5V	SINGLE: DIP-8, TO-99 DUAL: DIP-8, TO-99 QUAD: DIP-14	HA5151: $4.05	
−15 TO +13.5 0 TO 3.5 FOR V_S=5V	±13 0 TO 4.2 FOR V_S=5V	200 FOR V_S=5V	0.1 FOR $V_S = \pm 15V$ 0.07 FOR V_S=5V	DUALS: DIP-8, TO-5 QUADS: DIP-14	LT1078: $2.80 LT1079: $3.50	
−15 TO +13.5 0 TO 3.5 FOR V_S=5V	±13 0 TO 4.2 FOR V_S=5V	85 FOR $V_S = \pm 15V$ 60 FOR V_S=5V	0.04 FOR $V_S = \pm 15V$ 0.025 FOR V_S=5V	DUALS: DIP-8, TO-5 QUADS: DIP-14	LT1178: $3.00 LT1179: $3.50	
ICL7612: −5.1 TO +5.3 ICL7616-A, -B: −5.1 TO +3 ICL7616D: −5.1 TO +2.7 OTHERS: −4.0 TO +4.2 AT I_{set}=100 μA FOR $V_S = \pm 5V$	±4.9 AT $V_S = \pm 5V$	480 AT I_{set}=100 μA FOR $V_S = \pm 5V$ 44 AT I_{set}=10 μA FOR $V_S = \pm 5V$	0.16 AT I_{set}=100 μA FOR $V_S = \pm 5V$ 0.016 AT I_{set}=10 μA FOR $V_S \pm 5V$	SINGLES: DIP-8, TO-99 DUALS: DIP-8, DIP-14, TO-99	ICL761x: $0.75 ICL762x: $1.20	SINGLES: AVAILABLE AS PROGRAMMABLE BIAS CURRENT AND FIXED 100-μA BIAS-CURRENT VERSIONS DUALS: HAVE FIXED 100-μA BIAS CURRENT
ICL7642: −4.0 TO +4.4 FOR $V_S = \pm 5V$ ICL7631, ICL7632: −4.0 TO +4.2 AT I_{set}=100 μA FOR $V_S = \pm 5V$	±4.9 AT $V_S = \pm 5V$	480 AT I_{set}=100 μA FOR $V_S = \pm 5V$ 44 AT I_{set}=10 μA FOR $V_S = \pm 5V$	0.16 AT I_{set}=100 μA FOR $V_S = \pm 5V$ 0.016 AT I_{set}=10 μA FOR $V_S = \pm 5V$	TRIPLES: DIP-16 QUADS: DIP-14	ICL763x: $1.89 ICL764x: $1.79	TRIPLES: HAVE PROGRAMMABLE BIAS CURRENT QUADS: AVAILABLE WITH FIXED 10-μA OR 1-mA BIAS CURRENT
−15 TO +12	±14	125	0.125	MAX422: DIP-8, TO-99 MAX423: DIP-14, SO-16, DICE	MAX422: $4.95 MAX423: $5.45	CHOPPER STABILIZED
−15 TO +12	±14	125	0.125	DIP-8	$6.22	CHOPPER STABILIZED; REQUIRES NO EXTERNAL CAPACITORS
±11 ±16 ±11 ±16 ±11 ±16	±12	1000	1	SINGLES: DIP-8, SO-8, TO-99 DUALS: DIP-8, TO-99 QUADS: DIP-14, SO-14, SMD-14	LF441: $0.50 LF442: $0.90 LF444: $1.45	

KEY:

*INDICATES A FIGURE THAT IS APPLICABLE OVER THE DEVICE'S FULL OPERATING TEMPERATURE RANGE

ABS MAX = ABSOLUTE MAXIMUM
COM = COMMERCIAL TEMPERATURE RANGE
DIP-xx = DUAL-IN-LINE PACKAGE (xx DENOTES NUMBER OF PINS)
FP-xx = FLAT PACK (xx DENOTES NUMBER OF LEADS)
IND = INDUSTRIAL TEMPERTURE RANGE
LCC-xx = LEADLESS CHIP CARRIER (xx DENOTES NUMBER OF LEADS)
MAX = MAXIMUM
MIL = MILITARY TEMPERATURE RANGE
SO-xx = SMALL OUTLINE SURFACE-MOUNT PACKAGE (xx DENOTES NUMBER OF LEADS)
SMD-xx = 0.3-in.-WIDE SURFACE-MOUNT PACKAGE (xx DENOTES NUMBER OF LEADS)
TYP = TYPICAL

TABLE 1—REPRESENTATIVE MICROPOWER OP AMPS (CONTINUED)

MANUFACTURER	TYPE NUMBER	OP AMPS PER PACKAGE	SUPPLY-VOLTAGE RANGE (V)	QUIESCENT SUPPLY CURRENT PER OP AMP[3] (µA)	MAXIMUM INPUT OFFSET VOLTAGE (mV)	MAXIMUM INPUT BIAS CURRENT (nA)	MAXIMUM INPUT OFFSET CURRENT (nA)
NATIONAL SEMICONDUCTOR (CONTINUED)	LM146	4	±1.5 TO ±22 (ABS MAX)	63 MAX, 35 TYP AT I_{set} = 1 µA	5	20	—
	LM246		±1.5 TO ±18 (ABS MAX)	75 MAX, 35 TYP AT I_{set} = 1 µA	7	100	—
	LM346		±1.5 TO ±18 (ABS MAX)	75 MAX, 35 TYP AT I_{set} = 1 µA	7	100	—
	LM4250	1	±1 TO ±18 (ABS MAX)	100 MAX AT I_{set} = 10 µA	5	50	10
				11 MAX AT I_{set} = 1 µA	3	7.5	3
	LM4250C			100 MAX AT I_{set} = 10 µA	6	75	20
				11 MAX AT I_{set} = 1 µA	5	10	6
	LP124	4	±1.5 TO ±16 (ABS MAX)	32 MAX, 21 TYP AT V_S = 5V	2	4	1
			3 TO 32 (ABS MAX)				
	LP324		±1.5 TO ±16 (ABS MAX)	38 MAX, 21 TYP AT V_S = 5V	4	10	2
			3 TO 32 (ABS MAX)				
	LP2902		±1.5 TO ±13 (ABS MAX)	38 MAX, 21 TYP AT V_S = 5v	4	20	4
			3 TO 26 (ABS MAX)				
PRECISION MONOLITHICS	OP20H	1	±2.5 TO ±15 5 TO 30	95 MAX, 60 TYP	1	40	4
				70 MAX, 45 TYP FOR V_S = ±2.5V			
	OP20-C, -G			85 MAX, 57 TYP	0.5	30	2.5
				55 MAX, 40 TYP FOR V_S = ±2.5V			
	OP20-B, -F			80 MAX, 55 TYP	0.25	25	1.5
				63 MAX, 44 TYP FOR V_S = ±2.5V			
	OP21G	1	±2.5 TO ±15	420 MAX, 250 TYP	0.5	150	6
				300 MAX, 190 TYP FOR V_S = ±2.5V			
	OP21-B, -F			360 MAX, 235 TYP	0.2	120	5
				230 MAX, 170 TYP FOR V_S = ±2.5V			
	OP21-A, -E			300 MAX, 230 TYP	0.1	100	4
				275 MAX, 180 TYP FOR V_S = ±2.5V			
	OP22-H	1	±1.5 TO ±15 3 TO 30	210 MAX, 180 TYP AT I_{set} = 10 µA	1	50	3
				21 MAX, 18 TYP AT I_{set} = 1 µA	1	10	3
	OP22-B, -F			190 MAX, 160 TYP AT I_{set} = 10 µA	0.5	35	2
				19 MAX, 16 TYP AT I_{set} = 1 µA	0.5	7.5	2
	OP22-A, -E			170 MAX, 150 TYP AT I_{set} = 10 µA	0.3	30	1
				17 MAX, 15 TYP AT I_{set} = 1 µA	0.3	5	1
	OP32G	1	±1.5 TO ±15 3 TO 30	200 MAX, 150 TYP AT I_{set} = 10 µA	1	50	3
				21 MAX, 15 TYP AT I_{set} = 1 µA	1	10	3
	OP32-B, -F			190 MAX, 150 TYP AT I_{set} = 10 µA	0.5	35	2
				19 MAX, 15 TYP AT I_{set} = 1 µA	0.5	7.5	2
	OP32-A, -E			170 MAX, 150 TYP AT I_{set} = 10 µA	0.3	35	2
				17 MAX, 15 TYP AT I_{set} = 1 µA	0.3	5	2
	OP220-C, -G	2	±2.5 TO ±15 5 TO 30	110 MAX, 103 TYP	0.75	30	3.5
				67.5 MAX, 62.5 TYP FOR V_S = ±2.5V	0.75	30	3.5
	OP220-B, -F			95 MAX, 75 TYP	0.3	25	2
				62.5 MAX, 57.5 TYP FOR V_S = ±2.5V	0.3	25	2
	OP220-A, -E			85 MAX, 70 TYP	0.15	20	1.5
				57.5 MAX, 50 TYP FOR V_S = ±2.5V	0.15	20	1.5
	OP221-C, -G	2	±2.5 TO ±15 5 TO 30	450 MAX, 425 TYP	0.5	120	7
				325 MAX, 275 TYP FOR V_S = ±2.5V	0.5	120	7
	OP221-B, -F			425 MAX, 400 TYP	0.3	100	5
				300 MAX, 250 TYP FOR V_S = ±2.5V	0.3	100	5
	OP221-A, -E			400 MAX, 300 TYP	0.15	80	3
				275 MAX, 225 TYP FOR V_S = ±2.5V	0.15	80	3
	OP420H	4	±2.5 TO ±15 5 TO 30	150 MAX, 98 TYP	6	40	6
				100 MAX, 50 TYP FOR V_S = ±2.5V	6	40	6
	OP420-C, -G			115 MAX, 90 TYP	4	30	2.5
				75 MAX, 42.5 TYP FOR V_S = ±2.5V	4	30	2.5
	OP420-B, -F			90 MAX, 83 TYP	2.5	20	1.5
				50 MAX, 35 TYP FOR V_S = ±2.5V	2.5	20	1.5
	OP421H	4	±2.5 TO ±15 5 TO 30	500 MAX, 225 TYP FOR V_S = ±2.5V	6	150	20
	OP421-C, -G			375 MAX, 175 TYP FOR V_S = ±2.5V	4	80	10
	OP421-B, -F			450 MAX, 300 TYP	2.5	50	5
				250 MAX, 150 TYP FOR V_S = ±2.5V	2.5	50	5
	OP90G	1	±0.8 TO ±18 (ABS MAX) 1.6 TO 36 (ABS MAX)	20 MAX, 14 TYP	0.45	25	5
	OP90F			15 MAX, 9 TYP FOR V_S = ±1.5V	0.25	20	5
	OP90-A, -E			FOR ALL GRADES	0.15	15	3
	OP290G	2	±0.8 TO ±18 (ABS MAX) 1.6 TO 36 (ABS MAX)	20 MAX, 12.5 TYP	0.5	25	5
	OP290F			15 MAX, 9.5 TYP FOR V_S = ±1.5V	0.3	20	5
	OP290-A, -E			FOR ALL GRADES	0.2	15	3
	OP490G	4	±0.8 TO ±18 (ABS MAX) 1.6 TO 36 (ABS MAX)	20 MAX, 15 TYP	1	25	5
	OP490F			15 MAX, 10 TYP FOR V_S = ±1.5V	0.75	20	5
	OP490-A, -E			FOR ALL GRADES	0.5	15	3
SGS-THOMSON MICROELECTRONICS	TS271	1	4 TO 10	200 MAX, 150 TYP AT I_{set} = 25 µA,	10	0.15 *	0.1 *
	TS271-I, -M			V_S = 10V	10	0.3 *	0.2 *
	TS271A			15 MAX, 10 TYP AT I_{set} = 1.5 µA,	5	0.15 *	0.1 *
	TS271B			V_S = 10V FOR ALL GRADES	2	0.15 *	0.1 *
SIEMENS	TAE1453	1 SEE COMMENT	±1 TO ±18 (ABS MAX)	400 MAX, 250 TYP FOR V_S = ±5V TO ±15V	5.5	150	15

NOTES:
1) THE TABLE LISTS OP AMPS THAT HAVE A MAXIMUM SUPPLY-CURRENT SPECIFICATION OF 500 µA OR LESS AT 25°C.
2) ALL LISTED SPECIFICATIONS ARE THOSE THAT APPLY FOR AN AMBIENT TEMPERATURE OF 25°C UNLESS OTHERWISE INDICATED.
3) LISTED SPECIFICATION APPLIES FOR V_S = ±15V UNLESS OTHERWISE STATED.
4) PRICE LISTED IS FOR THE LOWEST GRADE DEVICE.

MINIMUM COMMON-MODE INPUT-VOLTAGE RANGE[3] (V)	MINIMUM OUTPUT-VOLTAGE RANGE[3] (V)	TYPICAL GAIN × BANDWIDTH[3] (kHz)	TYPICAL SLEW RATE[3] (V/μSEC)	PACKAGE TYPES	PRICE[4] (100)	COMMENTS
±13.5	±12	100	0.04	DIP-16	LM146: $5.00 LF246: $3.00 LM346: $1.25	PROGRAMMABLE BIAS CURRENT
±13.5 ±0.6 FOR $V_S = \pm 1.5V$	±12 ±0.6 FOR $V_S = \pm 1.5V$	200 AT I_{set}=10 μA 70 AT I_{set}=1 μA	0.2 AT I_{set}=10 μA 0.03 AT I_{set}=1 μA	DIP-8, SO-8	$1.20	FULLY SPEC'D FOR $V_S = \pm 1.5V$
$-V_S$ TO $(+V_S-1.5)$	0.8 TO 3.4 FOR V_S=5V	100 FOR V_S=5V	0.05 FOR V_S=5V	LP124: DIP-14 LP324: DIP-14, SO-14 LP2902: DIP-14, SO-14	LP124: $2.75 LP324: $0.57 LP2902: $0.75	
−15 TO +13.5 0 TO 3.5 FOR V_S=5V	±14.1 0.7 TO 4.1 FOR V_S=5V	100	0.05	DIP-8, TO-99, DICE	$3.20	
−14.5 TO +13.5	−13.7 TO +13.9	600	0.25	DIP-8, TO-99, DICE	$2.50	
−15 TO +13.5 0 TO 3.5 FOR V_S=5V	±13.5, ±0.75 FOR $V_S = \pm 1.5$ ±14, ±0.8 FOR $V_S = \pm 1.5V$ ±14, ±0.8 FOR $V_S = \pm 1.5V$	250 AT I_{set}=10 μA 15 AT I_{set}=1 μA	0.08 AT I_{set}=10 μA 0.008 AT I_{set}=1 μA	DIP-8, TO-99, DICE	$2.50	PROGRAMMABLE BIAS CURRENT
−15 TO +13.5	±13.8, ±0.75 FOR $V_S = \pm 1.5V$ ±14, ±0.8 FOR $V_S = \pm 1.5V$ ±14, ±0.8 FOR $V_S = \pm 1.5V$	~1000 AT I_{set}=10 μA 100 AT I_{set}=1 μA	~0.6 AT I_{set}=10 μA ~0.06 AT I_{set}=1 μA	DIP-8, DICE	$2.25	PROGRAMMABLE BIAS CURRENT
−15 TO +13.5 0 TO 3.5 FOR V_S=5V	±14, 0.8 TO 4 FOR V_S=5 ±14, 0.7 TO 4 FOR V_S=5V ±14, 0.7 TO 4 FOR V_S=5V	200	0.05	DIP-8, TO-99, DICE	$3.50	
−15 TO +13.5 0 TO 3.5 FOR V_S=5V	±13.5, 0.8 TO 4 FOR V_S=5V ±13.8, 0.7 TO 4.1 FOR V_S=5V ±13.8, 0.7 TO 4.1 FOR V_S=5V	600	0.3	DIP-8, TO-99, DICE	$3.50	
−15 TO +13.5 0 TO 3.5 FOR V_S=5V	±13.8, 0.9 TO 3.8 FOR V_S=5V ±14, 0.8 TO 4 FOR V_S=5V ±14, 0.7 TO 4.1 FOR V_S=5V	150	0.05	DIP-14, LCC-20, DICE	$1.80	
−15 TO +13.5 0 TO 3.5 FOR V_S=5V	0.9 TO 3.8 FOR V_S=5V, 0.8 TO 3.9 FOR V_S=5V ±14, 0.7 TO 4 FOR V_S=5V	1900	0.5	DIP-14, DICE	$1.80	
−15 TO +13.5 0 TO 4 FOR V_S=5V	±14 0 TO 4 FOR V_S=5V	25	0.012	DIP-8, DICE	$1.65	
−15 TO +13.5 0 TO 4 FOR V_S=5V	±13.5 0 TO 4 FOR V_S=5V	20	0.012	DIP-8, SO-16, LCC-20, DICE	$2.50	
−15 TO +13.5 0 TO 4 FOR V_S=5V	±13.5 0 TO 4 FOR V_S=5V	20	0.012	DIP-14, SO-16, LCC-28, DICE	$3.30	
0 TO 9	8.7 AT I_{set}=25 μA 8.8 AT I_{set}=1.5μA	700 AT I_{set}=25 μA 100 AT I_{set}=1.5μA	0.6 AT I_{set}=25 μA 0.04 AT I_{set}=1.5μA	DIP-8, SO-8	$0.29 (1000)	PROGRAMMABLE OP AMP
$(-V_S-0.2)$ TO $(+V_S-1.8)$	−14.7 TO +14.9	—	1.0	DIP-6, SO-6	DM 1.40	AVAILABLE AS DUAL AND QUAD OP AMPS WITH A SUPPLY CURRENT OF 750 μA MAXIMUM PER OP AMP

KEY:
*INDICATES A FIGURE THAT IS APPLICABLE OVER THE DEVICE'S FULL OPERATING TEMPERATURE RANGE
ABS MAX =ABSOLUTE MAXIMUM
COM =COMMERCIAL TEMPERATURE RANGE
DIP-xx =DUAL-IN-LINE PACKAGE (xx DENOTES NUMBER OF PINS)
FP-xx =FLAT PACK (xx DENOTES NUMBER OF LEADS)
IND =INDUSTRIAL TEMPERATURE RANGE
LCC-xx =LEADLESS CHIP CARRIER (xx DENOTES NUMBER OF LEADS)
MAX =MAXIMUM
MIL =MILITARY TEMPERATURE RANGE
SO-xx =SMALL OUTLINE SURFACE-MOUNT PACKAGE (xx DENOTES NUMBER OF LEADS)
SMD-xx =0.3-in.-WIDE SURFACE-MOUNT PACKAGE (xx DENOTES NUMBER OF LEADS)
TYP =TYPICAL

TABLE 1—REPRESENTATIVE MICROPOWER OP AMPS (CONTINUED)

MANUFACTURER	TYPE NUMBER	OP AMPS PER PACKAGE	SUPPLY-VOLTAGE RANGE (V)	QUIESCENT SUPPLY CURRENT PER OP AMP[3] (μA)	MAXIMUM INPUT OFFSET VOLTAGE (mV)	MAXIMUM INPUT BIAS CURRENT (nA)	MAXIMUM INPUT OFFSET CURRENT (nA)
SIEMENS (CONTINUED)	TAF1453	1 SEE COMMENT	±1 TO ±18 (ABS MAX)	350 MAX, 250 TYP FOR V_S = ±5V TO ±15V	4	100	10
SILICONIX	L144C LF144-A, -B	3	±1.5 TO ±15	133 MAX 117 MAX	10 5	250 200	70 50
TELEDYNE SEMICONDUCTOR	TSC900B TSC900A	1	±2.25 TO ±8	400 MAX AT V_S = ±5V 200 MAX, 140 TYP AT V_S = ±5V	0.015 0.005	0.080 0.050	0.0005 TYP 0.0005 TYP
TEXAS INSTRUMENTS	TLC251C TLC251AC TLC251BC	1	1.4 TO 16	20 MAX, 10 TYP AT LOW BIAS; 300 MAX, 150 TYP AT MEDIUM BIAS FOR V_S = 10V FOR ALL GRADES	10 5 2	0.600* 0.600* 0.600*	0.300* 0.300* 0.300*
	TLC25L-2C, -4C TLC25L-2AC, -4AC TLC25L-2BC, -4BC	2, 4	1.4 TO 16	20 MAX, 10 TYP FOR V_S = 10V; 2 TYP FOR V_S = 1.4V FOR ALL GRADES	10 5 2	0.600* 0.600* 0.600*	0.300* 0.300* 0.300*
	TLC25M-2C, -4C TLC25M-2AC, -4AC TLC25M-2BC, -4BC	2, 4	1.4 TO 16	300 MAX, 150 TYP FOR V_S = 10V; 2 TYP FOR V_S = 1.4V FOR ALL GRADES	10 5 2	0.600* 0.600* 0.600*	0.300* 0.300* 0.300*
	TLC271C TLC271AC TLC271BC TLC271I TLC271AI TLC271BI TLC271M	1	3 TO 16 FOR C-SUFFIX GRADES 4 TO 16 FOR I- AND M-SUFFIX GRADES	300 MAX, 143 TYP AT MEDIUM BIAS; 23 MAX, 14 TYP AT LOW BIAS FOR V_S = 10V 280 MAX, 105 TYP AT MEDIUM BIAS; 17 MAX, 10 TYP AT LOW BIAS FOR V_S = 5V FOR ALL GRADES	10 5 2 10 5 2 10	0.600* 0.600* 0.600* 2* 2* 2* 35*	0.300* 0.300* 0.300* 1* 1* 1* 15*
	TLC27L-2C, -4C TLC27L-2AC, -4AC TLC27L-2BC, -4BC TLC27L-2I, -4I TLC27L-2AI, -4AI TLC27L-2BI, -4BI TLC27L-2M, -4M	2, 4	3 TO 16 FOR C-SUFFIX GRADES 4 TO 16 FOR I- AND M-SUFFIX GRADES	23 MAX, 14.5 TYP FOR V_S = 10V 17 MAX, 9.5 TYP FOR V_S = 5V FOR ALL GRADES	10 5 2 10 5 2 10	0.600* 0.600* 0.600* 2* 2* 2* 35*	0.300* 0.300* 0.300* 1* 1* 1* 15*
	TLC27L-7C, -9C TLC27L-7I, -9I TLC27L-7M, -9M	2, 4	3 TO 16 FOR C-SUFFIX GRADES 4 TO 16 FOR I- AND M-SUFFIX GRADES	23 MAX, 14.5 TYP FOR V_S = 10V 17 MAX, 9.5 TYP FOR V_S = 5V FOR ALL GRADES	0.8 FOR V_S = 10V 0.5 FOR V_S = 5V 0.8 FOR V_S = 10V 0.5 FOR V_S = 5V 0.8 FOR V_S = 10V 0.5 FOR V_S = 5V	0.600* 0.600* 2* 2* 35* 35*	0.300* 0.300* 1* 1* 15* 15*
	TLC27M-2C, -4C TLC27M-2AC, -4AC TLC27M-2BC, -4BC TLC27M-2I, -4I TLC27M-2AI, -4AI TLC27M-2BI, -4BI TLC27M-2M, -4M	2, 4	3 TO 16 FOR C-SUFFIX GRADES 4 TO 16 FOR I- AND M-SUFFIX GRADES	300 MAX, 143 TYP FOR V_S = 10V 280 MAX, 105 TYP FOR V_S = 5V FOR ALL GRADES	10 5 2 10 5 2 10	0.600* 0.600* 0.600* 2* 2* 2* 35*	0.300* 0.300* 0.300* 1* 1* 1* 15*
	TLC27M-7C, -9C TLC27M-7I, -9I TLC27M-7M, -9M	2, 4	3 TO 16 FOR C-SUFFIX GRADES 4 TO 16 FOR I- AND M-SUFFIX GRADES	300 MAX, 143 TYP FOR V_S = 10V 280 MAX, 105 TYP FOR V_S = 5V FOR ALL GRADES	0.8 FOR V_S = 10V 0.5 FOR V_S = 5V 0.8 FOR V_S = 10V 0.5 FOR V_S = 5V 0.8 FOR V_S = 10V 0.5 FOR V_S = 5V	0.600* 0.600* 2* 2* 35* 35*	0.300* 0.300* 1* 1* 15* 15*
	TL03-1C, -2C TL03-1AC, -2AC TL03-1I, -2I TL03-1AI, -2AI TL034-C, -I TL034-AC, -AI	1, 2 1, 2 1, 2 1, 2 4 4	±5 TO ±15	280 MAX, 217 TYP 250 MAX, 192 TYP FOR V_S = ±5V FOR ALL GRADES	1.5 FOR V_S = ±15V 3.5 FOR V_S = ±5V 0.8 FOR V_S = ±15V 2.8 FOR V_S = ±5V 1.5 FOR V_S = ±15V 3.5 FOR V_S = ±5V 0.8 FOR V_S = ±15V 2.8 FOR V_S = ±5V 4 FOR V_S = ±15V 6 FOR V_S = ±5V 1.5 FOR V_S = ±15V 3.5 FOR V_S = ±5V	0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2 0.2	0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1 0.1
	TLC1078C TLC1078I TLC1079C TLC1079I	2 2 4 4	1.4 TO 16 FOR C-SUFFIX GRADES 3 TO 16 FOR I-SUFFIX GRADES	23 MAX, 14.5 TYP FOR V_S = 10V 17 MAX, 9.5 TYP FOR V_S = 5V FOR ALL GRADES	0.6 FOR V_S = 10V 0.45 FOR V_S = 5V 0.6 FOR V_S = 10V 0.45 FOR V_S = 5V 1.15 FOR V_S = 10V 0.85 FOR V_S = 5V 1.15 FOR V_S = 10V 0.85 FOR V_S = 5V	0.600* 0.600* 2* 2* 0.600* 0.600* 2* 2*	0.300* 0.300* 1* 1* 0.300* 0.300* 1* 1*

NOTES:

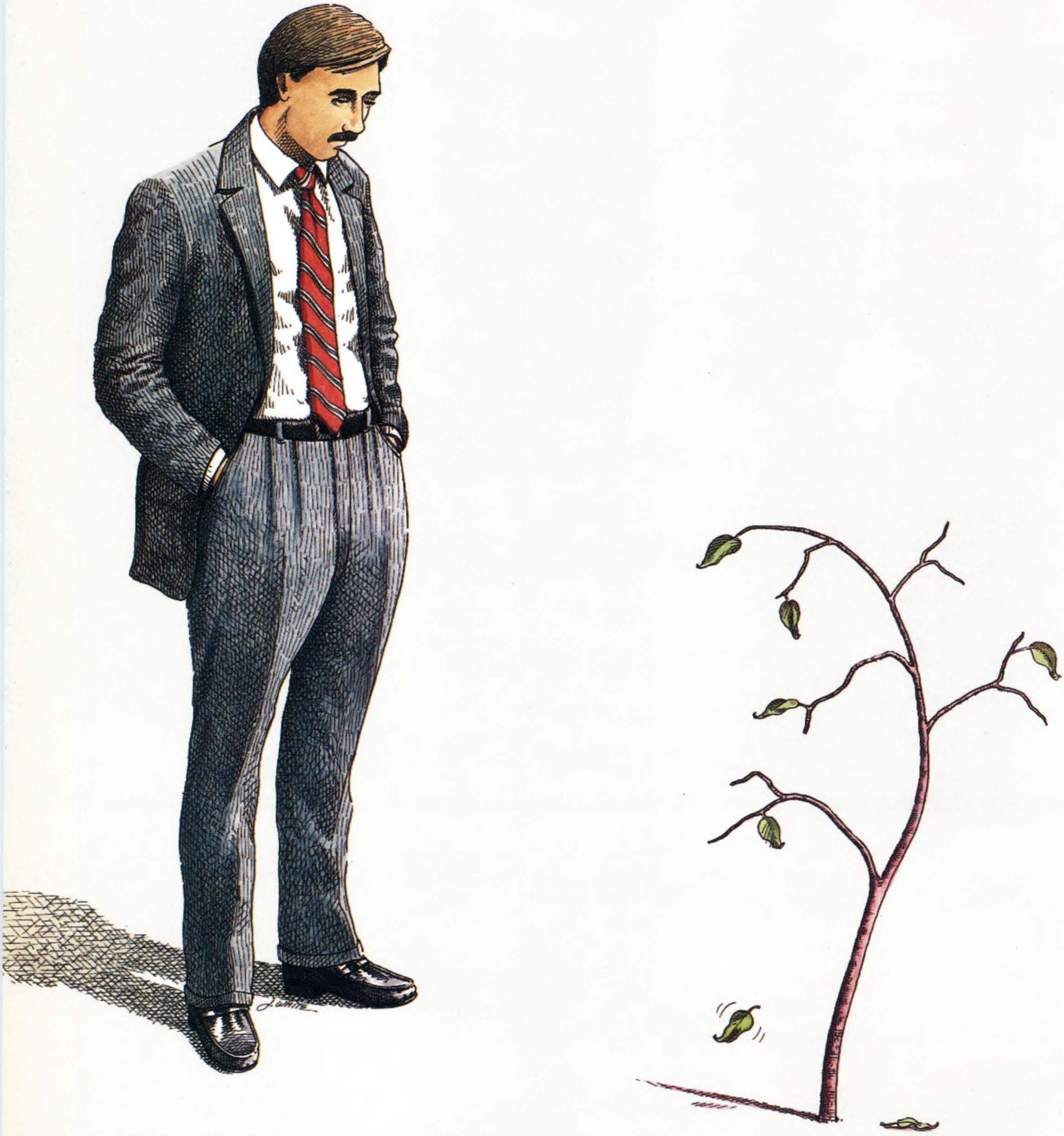
1) THE TABLE LISTS OP AMPS THAT HAVE A MAXIMUM SUPPLY-CURRENT SPECIFICATION OF 500 μA OR LESS AT 25°C.
2) ALL LISTED SPECIFICATIONS ARE THOSE THAT APPLY FOR AN AMBIENT TEMPERATURE OF 25°C UNLESS OTHERWISE INDICATED.
3) LISTED SPECIFICATION APPLIES FOR V_S = ±15V UNLESS OTHERWISE STATED.
4) PRICE LISTED IS FOR THE LOWEST GRADE DEVICE.

MINIMUM COMMON-MODE INPUT-VOLTAGE RANGE[3] (V)	MINIMUM OUTPUT-VOLTAGE RANGE[3] (V)	TYPICAL GAIN × BANDWIDTH[3] (kHz)	TYPICAL SLEW RATE[3] (V/μSEC)	PACKAGE TYPES	PRICE[4] (100)	COMMENTS
$(-V_S-0.3)$ TO $(+V_S-1.5)$	−14.7 TO +14.9	—	1.0	DIP-6, SO-6	DM 2.00	AVAILABLE AS DUAL AND QUAD OP AMPS WITH A SUPPLY CURRENT OF 750 μA MAXIMUM PER OP AMP
±12	±10	600	0.4	DIP-14, FP-14	$15.90	PROGRAMMABLE BIAS CURRENT (FIGURES QUOTED ARE FOR AN R_{set}=3Ω)
−5 TO +1.5 FOR V_S=±5V	−4.9 TO +3.9 FOR V_S=±5V	700 FOR V_S=±5V	0.2	DIP-8, DIP-14	$2.17	CHOPPER STABILIZED
−0.2 TO +9 FOR V_S=10V 0 TO 0.2 FOR V_S=1.4V	0 TO 8 FOR V_S=10V 0 TO 0.45 FOR V_S=1.4V	100 AT LOW BIAS SETTING 700 AT MEDIUM BIAS SETTING FOR V_S=10V	0.04 AT LOW BIAS SETTING 0.6 AT MEDIUM BIAS SETTING	DIP-8, SO-8	$1.88	THREE PROGRAMMABLE BIAS CURRENT SETTINGS
−0.2 TO +9 FOR V_S=10V 0 to 0.2 FOR V_S=1.4V	0 TO 8 FOR V_S=10V 0 TO 0.45 FOR V_S=1.4V	100 FOR V_S=10V 12 FOR V_S=1.4V	0.04 FOR V_S=10V 0.001 FOR V_S=1.4V	DUALS: DIP-8, SO-8 QUADS: DIP-14, SO-14	TLC25L2: $3.13 TLC25L4: $5.21	
−0.2 TO +9 FOR V_S=10V 0 TO 0.2 FOR V_S=1.4V	0 TO 8 FOR V_S=10V 0 TO 0.45 FOR V_S=1.4V	700 FOR V_S=10V 12 FOR V_S=1.4V	0.6 FOR V_S=10V 0.001 FOR V_S=1.4V	DUALS: DIP-8, SO-8 QUADS: DIP-14, SO-14	TLC25M2: $3.13 TLC25M4: $5.21	
−0.2 TO +9 FOR V_S=10V −0.2 TO +4 FOR V_S= 5V FOR COM (-C) AND IND (-I) GRADES 0 TO 9 FOR V_S=10V 0 TO 4 FOR V_S=5V FOR MIL (-M) GRADES	0.05 TO 8 FOR V_S=10V 0.05 TO 3.2 FOR V_S=5V	635 AT MEDIUM BIAS FOR V_S=10V 110 AT LOW BIAS FOR V_S=10V 525 AT MEDIUM BIAS FOR V_S=5V 85 AT LOW BIAS FOR V_S=5V	0.62 AT MEDIUM BIAS FOR V_S=10V 0.05 AT LOW BIAS FOR V_S=10V 0.43 AT MEDIUM BIAS FOR V_S=5V 0.03 AT LOW BIAS FOR V_S=5V	DIP-8, SO-8, LCC-20	$0.47	THREE PROGRAMMABLE BIAS SETTINGS
−0.2 TO +9 FOR V_S=10V −0.2 TO +4 FOR V_S=5V FOR COM (-C) AND IND (-I) GRADES 0 TO 9 FOR V_S=10V 0 TO 4 FOR V_S=5V FOR MIL (-M) GRADES	0.05 TO 8 FOR V_S=10V 0.05 TO 3.2 FOR V_S=5V	110 FOR V_S=10V 85 FOR V_S=5V	0.05 FOR V_S=10V 0.03 FOR V_S=5V	DUALS: DIP-8, SO-8, LCC-20 QUADS: DIP-14, SO-14, LCC-20	TLC27L2: $0.77 TLC27L4: $1.25	
−0.2 TO +9 FOR V_S=10V −0.2 TO +4 FOR V_S=5V FOR COM (-C) AND IND (-I) GRADES 0 TO 9 FOR V_S=10V 0 TO 4 FOR V_S=5V FOR MIL (-M) GRADES	0.05 TO 8 FOR V_S=10V 0.05 TO 3.2 FOR V_S=5V	110 FOR V_S=10V 85 FOR V_S=5V	0.05 FOR V_S=10V 0.03 FOR V_S=5V	DUALS: DIP-8, SO-8, LCC-20 QUADS: DIP-14, SO-14, LCC-20	TLC27L7: $1.59 TLC27L9: $2.61	
−0.2 TO +9 FOR V_S=10V −0.2 TO +4 FOR V_S=5V FOR COM (-C) AND IND (-I) GRADES 0 TO 9 FOR V_S=10V 0 TO 4 FOR V_S=5V FOR MIL (-M) GRADES	0.05 TO 8 FOR V_S=10V 0.05 TO 3.2 FOR V_S=5V	635 FOR V_S=10V 525 FOR V_S=5V	0.62 FOR V_S=10V 0.43 FOR V_S=5V	DUALS: DIP-8, SO-8, LCC-20 QUADS: DIP-14, SO-14, LCC-20	TLC27M2: $0.77 TLC27M4: $1.25	
−0.2 TO +9 FOR V_S=10V −0.2 TO +4 FOR V_S=5V FOR COM (-C) AND IND (-I) GRADES 0 TO 9 FOR V_S=10V 0 TO 4 FOR V_S=5V FOR MIL (-M) GRADES	0.05 TO 8 FOR V_S=10V 0.05 TO 3.2 FOR V_S=5V	635 FOR V_S=10V 525 FOR V_S=5V	0.62 FOR V_S=10V 0.43 FOR V_S=5V	DUALS: DIP-8, SO-8, LCC-20 QUADS: DIP-14, SO-14, LCC-20	TLC27M7: $1.59 TLC27M9: $2.61	
−11.5 TO +14 −1.5 TO +4 FOR V_S=±5V	12.5 TO +13 ±3 FOR V_S=5V	1100 FOR V_S=±15V 1000 FOR V_S=±5V	2.9 FOR V_S=±15V 2 FOR V_S=±5V	SINGLES: DIP-8, SO-8, LCC-20 DUALS: DIP-8, SO-8, LCC-20 QUADS: DIP-14, SO-14, LCC-20	TL031: $0.57 TL032: $0.77 TL034: $1.42	
−0.2 TO +9 FOR V_S=10V −0.2 TO +4 FOR V_S=5V	0.025 TO 8.2 FOR V_S=10V 0.025 TO 3.2 FOR V_S=5V	110 FOR V_S=10V 85 FOR V_S=5V	0.047 FOR V_S=10V 0.032 FOR V_S=5V	DUALS: DIP-8, SO-8, LCC-20 QUADS: DIP-14, SO-14, LCC-20	TLC1078: $2.76 TLC1079: $4.01	

KEY:

*INDICATES A FIGURE THAT IS APPLICABLE OVER THE DEVICE'S FULL OPERATING TEMPERATURE RANGE

ABS MAX =ABSOLUTE MAXIMUM
COM =COMMERCIAL TEMPERATURE RANGE
DIP-xx =DUAL-IN-LINE PACKAGE (xx DENOTES NUMBER OF PINS)
FP-xx =FLAT PACK (xx DENOTES NUMBER OF LEADS)
IND =INDUSTRIAL TEMPERATURE RANGE
LCC-xx =LEADLESS CHIP CARRIER (xx DENOTES NUMBER OF LEADS)
MAX =MAXIMUM
MIL =MILITARY TEMPERATURE RANGE
SO-xx =SMALL OUTLINE SURFACE-MOUNT PACKAGE (xx DENOTES NUMBER OF LEADS)
SMD-xx =0.3-in.-WIDE SURFACE-MOUNT PACKAGE (xx DENOTES NUMBER OF LEADS)
TYP =TYPICAL



LEADTIME INDEX

Percentage of respondents

ITEM	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Average (weeks)	Last month's average (weeks)
TRANSFORMERS								
Toroidal	0	17	66	17	0	0	8.4	11.0
Pot-Core	8	8	53	23	8	0	10.0	11.0
Laminate (power)	0	15	62	23	0	0	8.9	7.9
CONNECTORS								
Military panel	33	0	33	17	17	0	9.6	9.6
Flat/Cable	18	35	35	12	0	0	5.7	6.3
Multi-pin circular	22	0	56	22	0	0	7.8	6.9
PC (2-piece)	8	33	33	26	0	0	7.6	5.3
RF/Coaxial	11	33	33	23	0	0	7.1	5.7
Socket	12	41	35	12	0	0	5.8	4.3
Terminal blocks	7	20	53	20	0	0	7.9	5.4
Edge card	7	40	40	13	0	0	6.4	5.2
D-Subminiature	6	50	31	13	0	0	5.9	4.6
Rack & panel	10	30	40	20	0	0	7.1	5.5
Power	9	27	45	19	0	0	7.3	5.6
PRINTED CIRCUIT BOARDS								
Single sided	5	42	42	11	0	0	6.3	5.1
Double sided	0	38	54	8	0	0	6.6	6.2
Multi-layer	0	17	66	17	0	0	8.4	8.8
Prototype	8	75	17	0	0	0	3.6	3.9
RESISTORS								
Carbon film	30	35	35	0	0	0	3.8	3.4
Carbon composition	30	26	35	9	0	0	4.9	4.5
Metal film	26	30	39	5	0	0	4.7	3.5
Metal oxide	0	38	54	8	0	0	6.6	3.1
Wirewound	20	20	55	5	0	0	5.7	4.0
Potentiometers	5	41	36	18	0	0	6.8	5.9
Networks	20	40	35	5	0	0	4.7	4.7
FUSES	14	36	50	0	0	0	5.0	3.0
SWITCHES								
Pushbutton	17	28	44	11	0	0	6.0	4.6
Rotary	6	41	41	12	0	0	6.3	5.9
Rocker	6	47	41	6	0	0	5.6	5.8
Thumbwheel	10	20	50	20	0	0	7.6	5.4
Snap action	7	27	46	13	7	0	8.2	6.3
Momentary	6	44	44	6	0	0	5.7	5.8
Dual-in-line	9	45	36	10	0	0	5.7	5.2
WIRE AND CABLE								
Coaxial	25	25	37	13	0	0	5.7	4.7
Flat ribbon	35	40	20	5	0	0	3.5	3.5
Multiconductor	26	32	37	5	0	0	4.6	5.6
Hookup	29	41	30	0	0	0	3.6	2.8
Wirewrap	38	23	31	8	0	0	4.4	2.7
Power cords	16	41	32	11	0	0	5.4	5.1
POWER SUPPLIES								
Switcher	8	17	58	17	0	0	7.7	6.7
Linear	17	33	33	17	0	0	6.2	5.3
CIRCUIT BREAKERS	11	11	56	22	0	0	8.2	7.7
HEAT SINKS	8	33	33	26	0	0	7.6	4.6
BATTERIES								
Lithium coin cells	30	20	30	20	0	0	6.1	3.8
9V alkaline	60	10	30	0	0	0	2.7	1.3
Real-time clock back-up	43	14	43	0	0	0	3.8	4.7
RELAYS								
General purpose	27	13	26	27	7	0	8.4	8.0
PC board	0	38	23	31	8	0	9.8	8.5
Dry reed	0	37	25	38	0	0	8.9	9.9
Mercury	0	0	25	75	0	0	13.6	8.4
Solid state	0	50	0	50	0	0	9.2	9.7
DISCRETE SEMICONDUCTORS								
Diode	28	20	32	20	0	0	6.2	5.7
Zener	22	26	17	35	0	0	7.5	5.8
Thyristor	13	25	25	37	0	0	8.4	5.4
Small signal transistor	21	21	16	42	0	0	8.4	6.2
MOSFET	20	13	40	27	0	0	7.7	7.2
Power, bipolar	8	25	42	25	0	0	7.9	6.3
INTEGRATED CIRCUITS, DIGITAL								
Advanced CMOS	15	15	40	30	0	0	8.2	5.5
CMOS	23	14	45	18	0	0	6.8	6.2
TTL	35	13	35	17	0	0	5.8	4.5
LS	36	23	27	14	0	0	5.0	4.9
INTEGRATED CIRCUITS, LINEAR								
Communication/Circuit	20	0	40	30	10	0	10.3	6.7
OP amplifier	14	8	57	21	0	0	8.0	6.6
Voltage regulator	19	25	37	19	0	0	6.6	5.9
MEMORY CIRCUITS								
DRAM 16K	18	18	10	45	9	0	10.6	12.3
DRAM 64K	9	18	18	45	10	0	11.5	14.3
DRAM 256K	8	17	25	42	8	0	11.0	14.8
DRAM 1M-bit	9	10	27	45	9	0	11.7	14.8
SRAM 4K × 4	10	10	30	40	10	0	11.4	12.4
SRAM 8K × 8	8	0	31	38	15	8	14.6	15.4
SRAM 2K × 8	11	0	11	78	0	0	12.9	14.5
ROM/PROM	8	9	50	33	0	0	9.3	11.4
EPROM 64K	6	19	37	38	0	0	9.4	10.7
EPROM 256K	14	7	43	29	7	0	9.9	10.8
EPROM 1M-bit	0	0	29	57	14	0	14.7	12.0
EEPROM 16K	10	0	50	30	10	0	11.1	11.4
EEPROM 64K	0	8	31	53	8	0	12.9	12.9
DISPLAYS								
Panel meters	0	13	49	38	0	0	10.1	4.5
Fluorescent	0	17	17	49	17	0	13.7	6.6
CRT 12-inch monochrome	11	23	22	44	0	0	9.2	7.0
LED	23	31	31	15	0	0	5.7	6.7
Liquid crystal	0	23	46	31	0	0	9.1	10.4
MICROPROCESSOR ICs								
8-bit	9	19	45	27	0	0	8.3	8.8
16-bit	10	20	30	40	0	0	9.1	9.3
32-bit	0	27	18	45	10	0	11.7	11.0
FUNCTION PACKAGES								
Amplifier	22	12	44	22	0	0	7.2	7.2
Converter, analog to digital	9	19	45	27	0	0	8.3	8.3
Converter, digital to analog	10	20	40	30	0	0	8.4	8.8
LINE FILTERS	10	30	10	50	0	0	9.4	6.9
CAPACITORS								
Ceramic monolithic	20	35	20	25	0	0	6.5	5.4
Ceramic disc	13	25	37	25	0	0	7.5	4.5
Film	17	28	22	33	0	0	7.7	5.8
Aluminum electrolytic	11	17	39	33	0	0	8.7	5.5
Tantalum	18	12	41	29	0	0	8.1	5.9
INDUCTORS	0	29	35	36	0	0	9.2	7.8

Source: Electronics Purchasing Magazine's survey of buyers.

GENERAL DYNAMICS LAND SYSTEMS

Generations from now, when today's state-of-the-art fighting systems have taken their place in armament history books, today's Abbott power supplies will still be operating reliably.

Outfitted for Enhanced Reliability, for example, our new 60 Watt triple-output switching DC-DC converter achieves an MTBF rating up to 600,000 hours; more than 68 years. A single-output model is rated even longer.*

Yet this compact package is fully self contained. It meets the tough EMI limits of MIL-STD-461C. And the punishing environmental specs of MIL-STD-810C and MIL-S-901C.

While the BC60 is brand new, this is no "developmental" power supply. Its topology is identical to our field proven BC100 and BC200 models. Its design integrity is verified through rigorous ESS testing.

We're delivering power supplies for projects critical to America's defense, including MILSTAR, the EH101 helicopter, the TOW missile, INEWS and the F/A-18 Hornet.

For a copy of our 1988 Military Power Supply Product Guide, write us at 2721 S. La Cienega Boulevard, Los Angeles, CA 90034. (800) 556-1234 XT9; CA (800) 441-2345 XT9.

*MTBF FIGURES CALCULATED PER MIL-HDBK-217E GROUND.

Our power supply is built to outlast the tank.

Versatile new 60 Watt switcher measures 5 x 4 x 1.5 inches. Provides outputs of 5, 12, 15, 24 or 28 V dc, from inputs of 18 to 36 V dc. Operating temperature from −55°C to +100°C. Overvoltage protection & short circuit protection standard.

abbott

WHEN RELIABILITY IS IMPERATIVE.™

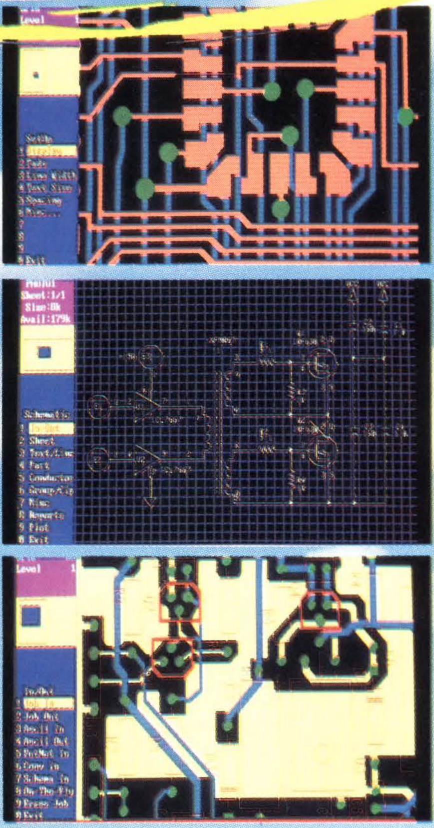
CIRCLE NO 68

NEED SUPER-FAST DESIGN THRUPUT?

Giving you the ability to complete an electronic design ahead of time, and with a level of performance you might expect from an expensive Engineering Workstation, the PADS-PCB design system does it all.

From product concept and design, through implementation, PADS-PCB shortens long design cycles by allowing the engineer to complete a job at one station with features such as:

- LOGIC CAPTURE
- PRINTED CIRCUIT BOARD DESIGN
- AUTOPLACEMENT
- 100% RIP-UP & RE-ROUTE AUTOROUTING
- AUTO CHECKING
- AUTOCAD INTERFACE



Utilizing a design-oriented database, ***PADS-CAE*** accesses all the sheets of a schematic simultaneously. Auto REF DES, Auto Gate Assignment and Data Checking across all sheets are also provided.

PADS-PCB is the most popular Printed Circuit Board Design System on the market and offers:

*Inputs from PADS-CAE, Futurenet, Orcad, Schema, and others
*1 mil database-32″ x 32″ board size, 30 layers
*400 IC Circuit Size capability
*Automatic and Interactive Component Placement Aids, Track Routing, Design Rule Checking
*Complete SMD Capability
*1,2,3 Tracks between IC Pins
*Superb Analog Design Capability

PADS-SUPERROUTER is the only PC-based Ripup and Retry to 100% Completion Autorouter on the market today, and makes the tedious and time-consuming task of Board Design simple.

PADS-DXF integrates Autocad, PADS-PCB, and the PADS-SUPERROUTER into the most powerful Electro-Mechanical PC-based CAD system available for Mechanical Design/Drafting, Logic Capture and Board Design.

The best news is that PADS-PCB design system is ***PRICED LOW!*** The system is affordable enough to allow every designer to have his/her own personal PADS station.

EVALUATION PACKAGE! Call for a NO-COST evaluation package, so that you can see for yourself how PADS-PCB gives you SUPER-FAST DESIGN THRUPUT!
INSIDE MA: **(508) 486-8929** or **(800) 255-7814.**

CAD Software, Inc.
119 Russell Street
Suite #6
Littleton, MA 01460

CIRCLE NO 69

60-MHz operational amplifier provides 2000V/μsec slew rate

Though it boasts a rapid slew rate, wide bandwidth, and low offset voltage, the AD844 monolithic op amp's best feature may be its price/performance ratio. Commercial versions in an 8-pin plastic miniature DIP cost only $4.50 in 100-piece quantities. Higher-cost industrial and military versions are also available. While other op amps can meet or exceed an individual AD844 spec, none provide the overall performance at this price level.

The AD844 slews at the dazzling speed of 2000V/μsec. It also features a number of other impressive specifications. For example, the amplifier's unity-gain bandwidth is 60 MHz and its full-power (20V p-p, $R_L = 500\Omega$) bandwidth is 20 MHz. At 2V p-p, the bandwidth is 40 MHz.

Strictly speaking, the AD844 does not slew-rate limit; instead, it has a constant 10-nsec rise time whether the signal is a 1 or a 20V step. Moreover, because it is a current-feedback op amp, the AD844 does not degrade in bandwidth at higher gains. Although optimized for use in current-to-voltage conversion and as an inverting-mode amplifier, it is also suitable for non-inverting applications.

Settling time is only 100 nsec to 0.1% for a 10V step and is independent of gain. Differential gain error is only 0.1%, and differential phase error is only 0.1° at 3.58 MHz. Powered by a ±4.5 to ±18V supply, the AD844 can drive as much as ±50 mA into loads as low as 50Ω in parallel with 100 pF, or capacitive loads to 10,000 pF with an external network.

Many of the chip's impressive dc specifications result from laser trimming during manufacture. For example, input offset voltage (V_{os}) is typically 150 μV, offset-voltage drift is only 2 μV/°C, and bias-current drift is a low 8 nA/°C. Quiescent current is 6.5 mA max, and the output is short-circuit protected to 80 mA.

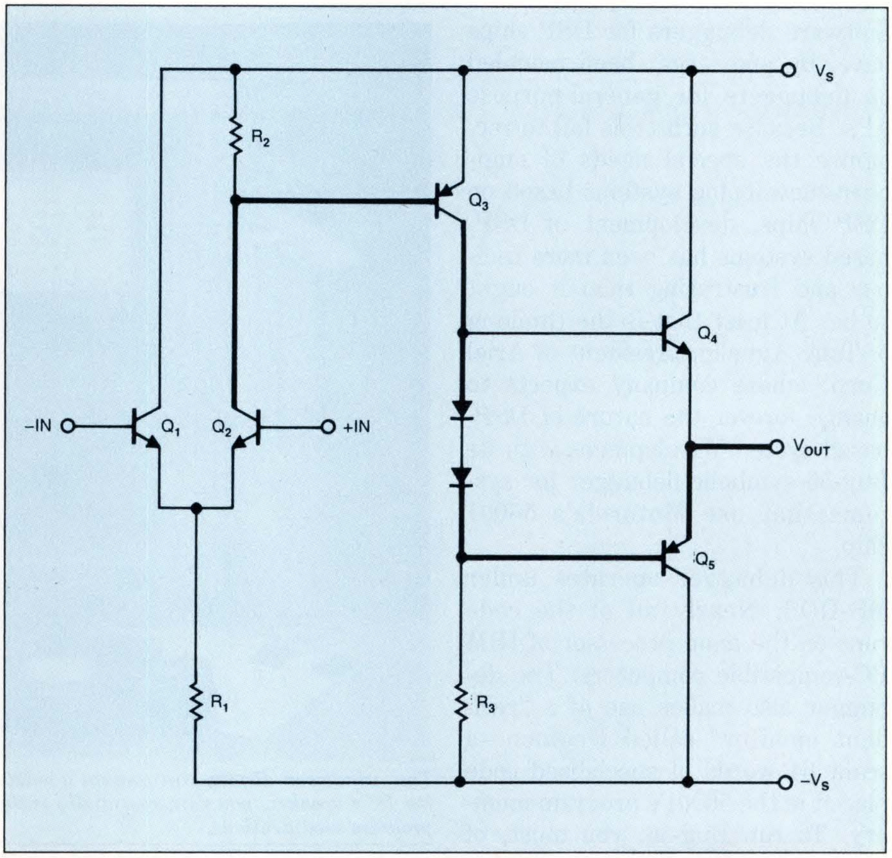


Fig 1—The pnp transistors in this basic op amp are needed for level shifting and output drive. *The AD844 op amp features true complementary performance—both the pnp and npn transistors have identical gain-bandwidth products.*

The key contributor to the AD844's ac performance is its CB (complementary bipolar) processing. This process uses p-type epitaxy and a p-well structure with up-down isolation to produce npn and pnp bipolar transistors having complementary characteristics. Both the npn and pnp transistors have nearly identical gain-bandwidth products (f_T) of about 550 MHz.

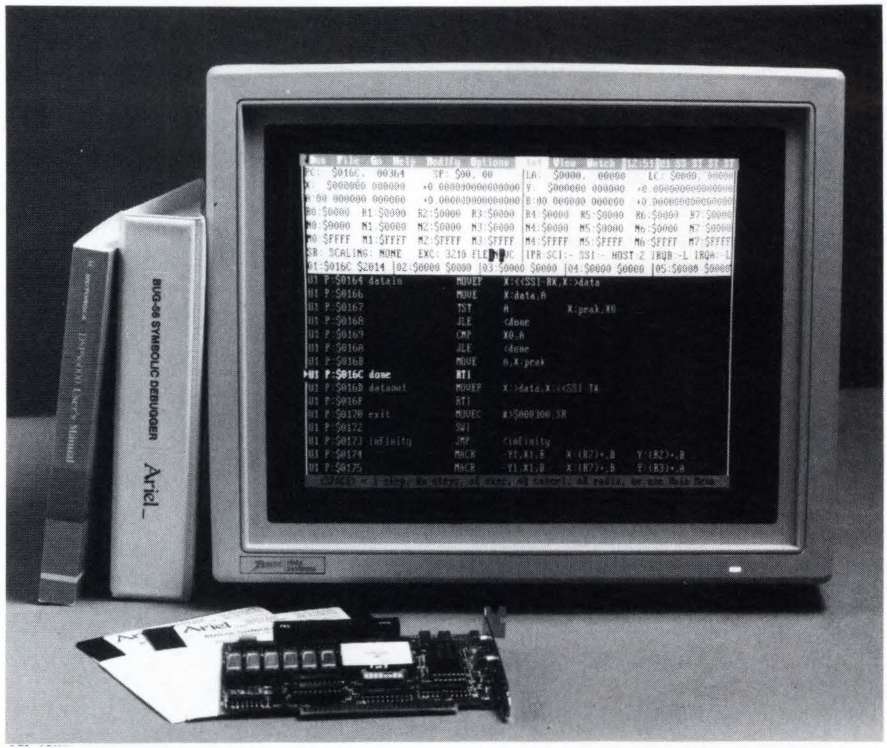
The basic op amp (**Fig 1**) requires pnp transistors for both level shifting and efficient load drive. If, as is typically the case with many op amps, the pnp transistors are much slower (lower f_T) than the npn transistors, the resulting op amp is also slow and exhibits a narrow gain-bandwidth product. An op amp having complementary and identically performing npn/pnp transistors is inherently a better amplifier.

—Dave Pryce

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 935-5565.

Circle No 734

DSP debugger lets you instantly see and hear effects of code changes



This windowed display *can contain a mixture of text and graphics. Moreover, by use of the PC's speaker, you can, essentially instantaneously, hear as well as see the effects of program modifications.*

Software debuggers for DSP chips have, by and large, been modeled on debuggers for general-purpose μPs. Because such tools fail to recognize the special needs of engineers developing systems based on DSP chips, development of DSP-based systems has been more tedious and frustrating than it ought to be. At least that is the thinking of Tony Agnello, president of Ariel Corp, whose company expects to change forever the nature of DSP-based system development with its Bug-56 symbolic debugger for systems that use Motorola's 56001 chip.

This debugger operates under MS-DOS. Nearly all of the code runs on the main processor of IBM PC-compatible computers. The debugger also makes use of a "resident monitor" called Degmon—a scant 64 words of specialized code placed in the 56001's program memory. To run Bug-56, you must, of course, install a board containing the DSP chip in one of the PC's I/O slots. One such board comes from the debugger's manufacturer. The $595 PC-56 contains, beside the 56001, a 14-bit ADC and DAC capable of handling analog data at 20k samples/sec. The company plans additional DSP boards with faster, higher-resolution converters.

The software provides a windowed display with pull-down menus that enable you to access many facilities—for example, the full-screen symbolic debugger with program tracing capability, symbolic breakpoints, and symbolic patch assembly. The debugger lets you directly modify control-register bits, and it can update the register display and make changes to register and memory contents while programs run at full speed. In addition, there is on-line help, a file browser, and a capability called DSPeek, which provides a graphic display of the data in any 56001 memory space with programmable scaling and "zooming." The software can perform an FFT to let you view the data in the frequency domain and can send data to the PC's speaker, enabling you to hear as well as see the effects of program changes.

To avoid having to simultaneously debug programs running on the DSP chip and the PC's μP, Bug-56 lets programs running on the 56001 perform a wide range of MS-DOS functions. Programs running on the DSP chip can access the PC's real-time clock, poll the keyboard, verify the existence of DOS files, open, read, write, and append those files, and determine the free space on a disk. Such programs can also access custom windows you create to provide users with menu options and information.

Bug-56 for IBM PCs and compatible computers sells for $395. The manufacturer intends to make it available in the future to run on additional computing systems.

—Dan Strassberg

Ariel Corp, 433 River Rd, Highland Park, NJ 08904. Phone (201) 249-2900. FAX 201-249-2123.

Circle No 732

Not Bad For A Five Year Old.

Today

We're showing you our rapid rise into high-speed, high-density SRAMS to dramatize one singular point: *Sony's serious commitment to your SRAM needs.*

Major SRAM investment. Answering your demands for higher speeds, we've beefed-up our SRAM engineering, design and production capabilities. Dramatically.

Already, we're producing 16K x 4-bit models at 25, 30 and 35 ns. 32K x 8-bit models at 25, 30 and 35 ns. 64K x 4-bit models at 35, 45 and 55 ns. And 256K x 1-bit models at 35, 45 and 55 ns.

In a range of DIP, SOP and SOJ packages.

0.8-micron CMOS technology: The best is yet to come. Soon we'll debut all new SRAMs based on our 0.8-micron CMOS technology. With even higher speeds and densities. *In combinations never before available.*

Sony SRAMs are shipping now. And they're available at very competitive prices. Backed by the reliability and responsive service you expect from any Sony product.

Be a part of our success story. When you're considering high-speed, high-density SRAMs, first consider this: Sony's SRAM success story has only just begun.

For full details, call (714) 229-4197 today. Or write Sony Corporation of America, Component Products Division, 10833 Valley View St., Cypress, California 90630, Attn: Semiconductor sales. FAX (714) 229-4271.

SONY®

Sony is a registered trademark of Sony Corporation.

SONY HIGH-SPEED, HIGH-DENSITY SRAMS.

MODEL	CONFIGURATION	SPEED (ns)	PACKAGE
CXX5863P	8K x 8	25/30/35	DIP 300 mil
CXX5863M	8K x 8	25/30/35	SOP 450 mil
CXX5863J	8K x 8	25/30/35	SOJ 300 mil
CXX5464AP	16K x 4	25/30/35	DIP 300 mil
CXX5464AJ	16K x 4	25/30/35	SOJ 300 mil
CXX5465P*	16K x 4	25/30/35	DIP 300 mil
CXX5465J*	16K x 4	25/30/35	SOJ 300 mil
CXX5164P	64K x 1	25/30/35	DIP 300 mil
CXX5164J	64K x 1	25/30/35	SOJ 300 mil
CXX5971P	8K x 9	25/30/35	DIP 300 mil
CXX5971J	8K x 9	25/30/35	SOJ 300 mil
CXX58255AP	32K x 8	25/30	DIP 300 mil
CXX58255AJ	32K x 8	25/30	SOJ 300 mil
CXX58258P	32K x 8	35/45	DIP 600 mil
CXX58258SP	32K x 8	35/45	DIP 300 mil
CXX54256P	64K x 4	35/45/55	DIP 300 mil
CXX51256P	256K x 1	35/45/55	DIP 300 mil

*O/E

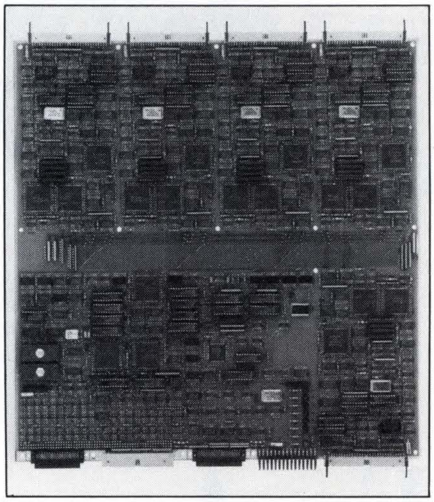
SCSI-2 disk-drive-array controller board stores data across five ESDI drives

Disk-drive arrays offer you a way to improve system data-transfer rates, and now you can buy a disk-drive-array controller board off the shelf. The Rimfire 6600 disk-drive-array controller stores data on four drives and uses a fifth drive to store parity information. The board also offers SCSI-2 (Small Computer System Interface) as an interface to the system and ESDI (Enhanced Small Device Interface) as an interface to the drives. The use of industry-standard interfaces simplifies the system design and integration task.

The Rimfire 6600 and five ESDI drives appear to the system, via the SCSI bus, as a single SCSI drive with a quadruple capacity provided by the individual drives in the array. During write operations, the controller breaks up each byte, word, or long word of data and spreads or "stripes" the data among the four data drives. The controller reconstructs the data during read operations for transmission to the system.

The controller also reads and writes parity data to the fifth drive. The parity drive allows the array to continue to function when any single drive fails. Furthermore, after a single drive failure and replacement with a new drive, the controller can regenerate the data on the replacement drive from data on the four operational drives.

Potentially, the controller provides four times the raw-data-transfer rate offered by a single drive. Typical ESDI drives feature read-channel data rates of 15M bits/sec (almost 2M bytes/sec). The array can generate a raw-data rate four times that number and system transfers at rates as high as 20M bytes/sec. But ultimately, the SCSI implementation on the host may control the true transfer rate.



Five ESDI drives and the disk-drive-array *controller emulate a large single drive, but they offer raw data rates four times the rate of a single drive and SCSI-2 transfer rates as high as 20M bytes/sec.*

The interface on the Rimfire 6600 supports the new SCSI-2 specification, including 16- and 32-bit-wide data-transfer options. In the synchronous mode, the controller can transfer data at 20M bytes/sec, using a 32-bit-wide path. The controller retains compatibility with the original 5M byte/sec synchronous, 8-bit SCSI spec, however. Most currently available host adapters support only the original SCSI spec.

The controller includes a 512k-byte cache on board. The cache performs read-ahead operations and allows the interface to operate at maximum speeds of 20M bytes/sec when the data requested by the host is in the cache. Furthermore, read requests from the host have no seek-time delay on cache hits. On reads or writes to the disk, however, the array subsystem suffers a seek-time latency equal to the seek time associated with a single drive.

Other SCSI-2 controller features include tagged commands. These commands allow the system to perform command queuing; that is, to issue multiple commands to the SCSI controller before the command first issued has been completed. The controller uses tagged commands to optimize operations by combining and sorting commands.

The Rimfire 6600 is offered as a 16 × 16.5-in. board suitable for rack mounting. The board costs $5995 and will be available in August. You can use the controller board with any ESDI drives that offer spindle synchronization.—***Maury Wright***

Ciprico Inc, 2955 Xenium Lane, Plymouth, MN 55441. Phone (612) 559-2034. FAX 612-559-8799. TWX 910-240-0585.

Circle No 731

A lot of designs were raised on it.

Some designs might starve without a steady diet of basic, off-the-shelf Static RAMs. That's why SGS-THOMSON has made a major commitment to produce them. In fact, you can count on SGS-THOMSON to deliver 6116s on time, every time—at prices you'll eat up.

FAST SHIPMENT ON FAST CMOS SRAMs

MK41H66N	16K x 1	20, 25, 35ns A
MK41H67N	16K x 1	20, 25, 35ns A
MK41H68N	4K x 4	20, 25, 35ns A
MK41H69N	4K x 4	20, 25, 35ns A
MK41H78N	4K x 4	25, 35ns A
MK41H79N	4K x 4	25, 35ns A
MK41H87N/X	64K x 1	35, 45, 55ns A, B
MK48H64N/S	8K x 8	70, 120ns C, D
MK48H65N	8K x 8	35, 45, 55, 70, 120ns A
MK6116N	2K x 8	150, 200, 250ns C

Available in Low Power and Industrial Grade.
A-300 MIL PDIP, B-DIP 300 MIL SOJ
C-600 MIL PDIP, D-330 MIL SOIC

Plain or fancy bytewide chips.

Any way you slice it, SGS-THOMSON is working hard to be a leading SRAM source. Our variety is an outstanding example. Take your pick of standard, low power, industrial temperature grade—even surface mount—SRAMs.

Hungry for speed?

SGS-THOMSON delivers devices as fast as 20ns—in 4K x 4 as well as 16K x 1 configurations. For those with a bigger appetite, we're cooking up even higher density SRAMs like the 8K x 8 and beyond. So why go anywhere else? We serve up a smorgasbord of high quality Static RAMs in a variety of appetizing packages. And we serve them fast.

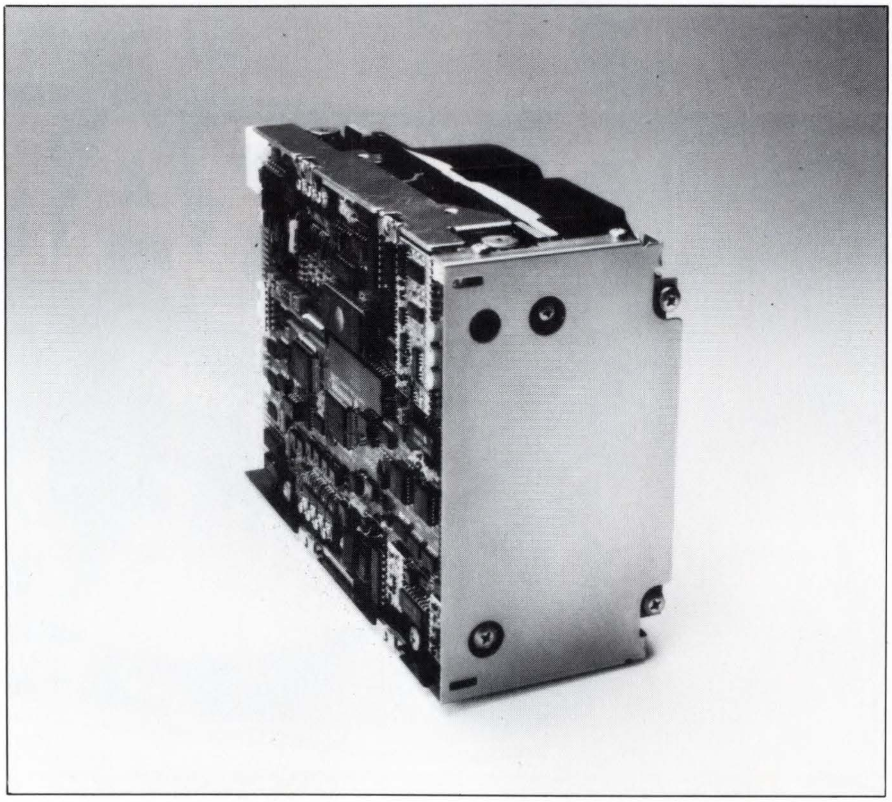
Free recipe book.

Send for our free Memory Databook and data sheets. You'll have all the SRAM facts you need to keep your company cooking. Contact SGS-THOMSON Microelectronics, 1000 E. Bell Road, Phoenix, AZ 85022 602/867-6264.

SGS-THOMSON
MICROELECTRONICS

CIRCLE NO 71

Full-height 5¼-in. Winchester drives store 760M bytes and seek in 16 msec



Based on a dedicated and embedded servo-scheme combination, *the MK-358 family of disk drives includes ESDI and SCSI models that store 760M bytes.*

The MK-350 family of 5¼-in. Winchester disk drives offer an unformatted storage capacity of 760M bytes. The drives can perform a seek command to data in an average of 16 msec. You can choose a drive with ESDIs (Enhanced Small Device Interface) or SCSIs (Small Computer System Interface). The SCSI drive employs a soft-loaded command set that the company calls "Virtual SCSI."

The MK-358FA ESDI and MK-358FB SCSI drives share the same HDA (head and disk assembly). The HDA includes eight platters; that is, 16 data surfaces. One of the surfaces stores dedicated servo information and the other 15 store data. When designing the drive, the designers also chose to store servo information embedded between each data sector on the drive.

The company believes that the servo scheme, called a hybrid servo, offers performance and reliability. The dedicated servo surface allows the HDA to accurately perform fast seeks. And the embedded servo information allows the drive to make fine tracking adjustments, thus eliminating off-track conditions caused by thermal expansion.

Other key drive features include a track-to-track seek time of 4 msec, a worst-case seek time of 36 msec, and a MTBF of 30,000 hours. The drives have 1632 cylinders, a track density of 1330 tpi, and a recording density of 31,400 bpi. The HDA features a read-channel data rate of 15M bits/sec, and employs sputtered thin-film media and mini-monolithic heads.

The MK-358FB drive includes an embedded controller compatible with the SCSI-2 specification. The Virtual SCSI controller includes no command set in EPROM. Instead, on power-up the controller loads a command set stored on the disk into RAM.

The soft command set offers several advantages compared with more traditional EPROM-resident command sets. For example, you can download firmware updates from a floppy disk in the field. Furthermore, the company has implemented a robust command set for the drive. Because few customers have use for the entire command set, the customer can pick and choose from available commands and create a custom implementation.

The SCSI controller can decode any command in less than 1 msec. The controller also includes a 64k-byte, 3-track read-ahead cache. Firmware implements zero-latency reads and writes, and the controller transfers data at 1.5M bytes/sec in asynchronous mode and 5M bytes/sec in synchronous mode.

The MK-358FA ESDI costs $2495; the MK-358FB SCSI sells for $2645 (1000). You can expect samples of the drives around mid-year.—***Maury Wright***

Toshiba America Inc, 9740 Irvine Blvd, Irvine, CA 92718. Phone (714) 380-3000. FAX 714-583-3133. TLX 183812.

Circle No 730

Sorry, no checks for Intel ICE.

	AMC	Intel
▶ Supports the new 16 MHz 80C186 and 80C188 as well as other Intel CPUs at full speeds with no wait states	✓	
▶ VALIDATE/Soft-Scope is a complete in-circuit source level debugger that shows variables, data structures and assembly instructions	✓	
▶ VALIDATE/Soft-Scope has in-circuit source level debug capability in 286 protect mode	✓	
▶ Tool chain supports Microsoft C (Also other versions of C and Pascal, FORTRAN, PL/M, Assembler, Jovial)	✓	
▶ Add processor support by merely adding emulator board and probe module	✓	
▶ Has unlimited breakpoint capability	✓	
▶ Over a megabyte of overlay memory is available	✓	

Just because you've bought one of those great Intel chips is no reason to buy Intel development tools.

Why? Because Applied Microsystems is better. That's a fact. Our checklist proves it.

Intel chips are state-of-the-art, but their development tools aren't. Compared to ours, Intel's ICE is limited, slow and awkward.

If you want to design, debug and integrate your target system faster, easier and more completely, you need to turn to Applied Microsystems. It's the only comprehensive solution in the business. Which includes not only the most complete and most reliable tool chain, but also all the help you need from our field applications engineers and sales engineers.

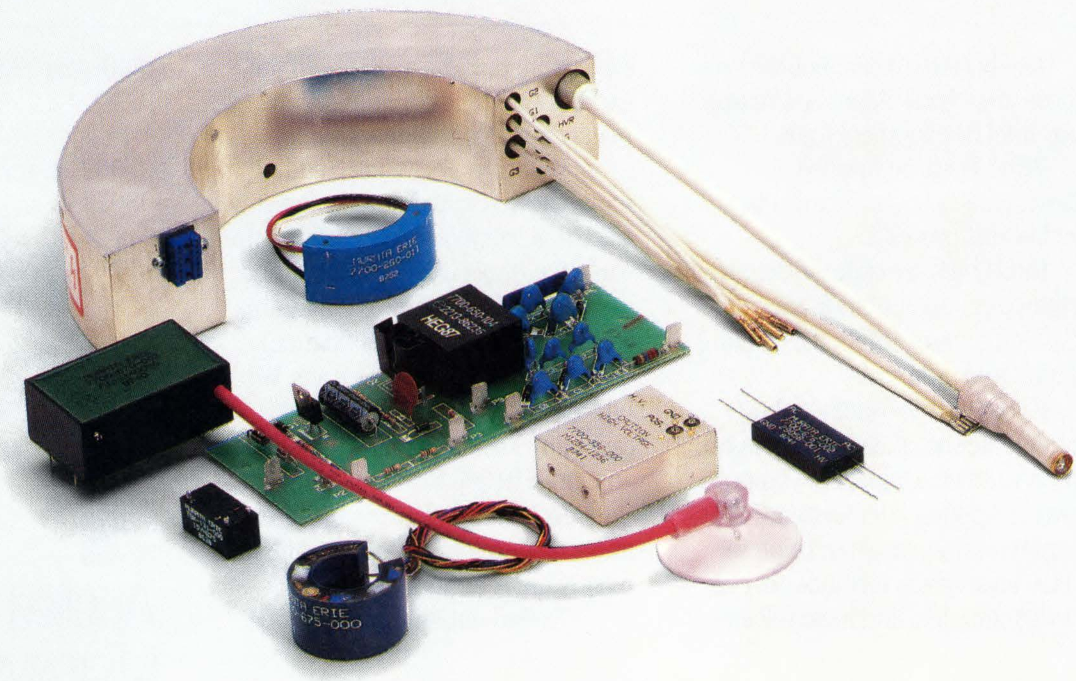
What's more, we keep adding more checks to our list. Like dynamic trace that lets you review performance while the target is still running. And we use an SCSI interface that downloads code at disk speeds 20 times faster than RS232 connections. We offer performance measurement capability without making you spend an extra $10,000.

As you can plainly see, there's only one development environment really worth checking out.

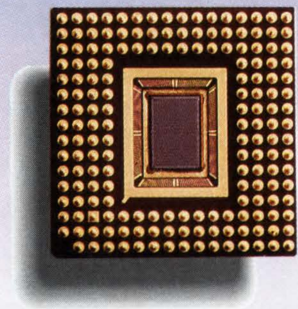
To find out more, call toll free (800) 426-3925. (In Washington (206) 882-2000.) Or write Applied Microsystems Corporation, P.O. Box 97002, Redmond, Washington, USA 98073-9702.

Applied Microsystems Corporation

In Europe contact Applied Microsystems Corporation Ltd., Chiltern Court, High Street, Wendover, Aylesbury, Bucks, HP22 6EP, United Kingdom. Call 44-(0)-296-625462.
In Japan contact Applied Microsystems Japan, Ltd., Nihon Seimei Nishi-Gotanda Building, 7-24-5 Nishi-Gotanda Shinagawa-KU, Tokyo T 141 Japan. Call 03-493-0770.



User-programmable GATE ARRAYS

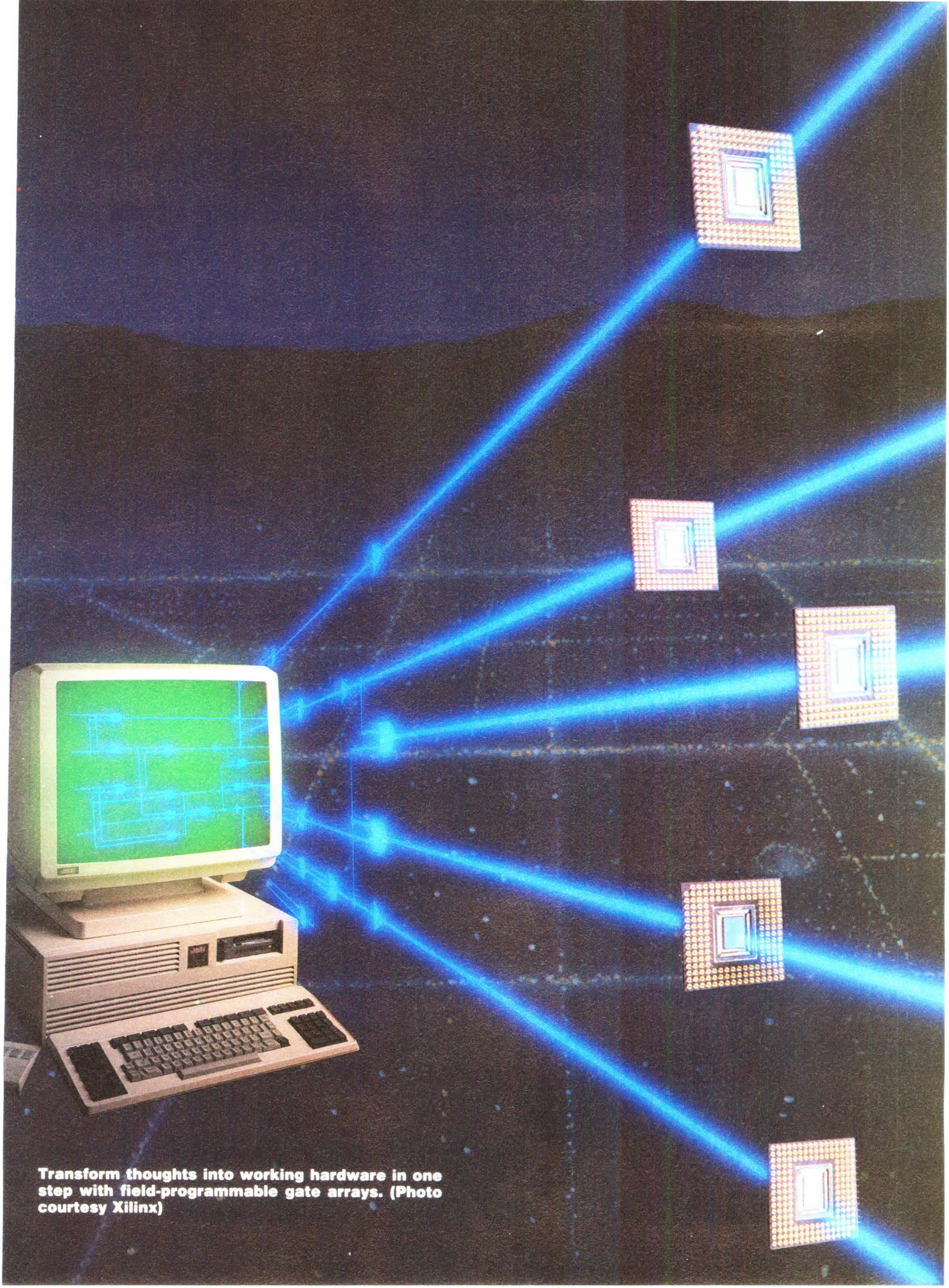


The first generation of programmable logic devices (PLDs) allowed you to vacuum up five or 10 TTL devices into one package. The latest programmable devices, FPGAs, can replace many more TTL devices.

Charles H Small, *Associate Editor*

Some of the latest programmable logic devices (PLDs) are so large that they can replace small mask-programmed gate arrays. Consequently, engineers are calling these new devices "field-programmable gate arrays" (FPGAs), despite the fact that the name ignores a few problems. First, the abbreviation "FPGA" is too similar to the established one for pin-grid arrays (PGA). Second, although the FPGAs share a common application area with factory-programmed gate arrays, on the whole, the FPGAs from different manufacturers bear little resemblance to each other. And, among other things, FPGAs bear no resemblance whatsoever to mask-programmed gate arrays. **Fig 1** shows a portion of a conventional mask-programmed gate array; keep its structure in mind as you examine the architecture of FPGAs in the course of this article.

No matter what you call them, you should have no problem deciding to consider these FPGAs for your next design. A glance at the sparsely populated pc boards in **Figs 2a** and **2b** should provide all the motivation you need. Consider not only that you can pack a lot of logic into these devices but also that you can program these devices right on your lab bench. Programming FPGAs in your lab means that you don't have to pay the large, up-front, nonrecurring engineering (NRE) costs—or suffer the long turn-around times—as-



Transform thoughts into working hardware in one step with field-programmable gate arrays. (Photo courtesy Xilinx)

Although the FPGAs share a common application area with factory-programmed gate arrays, they bear little resemblance to each other.

sociated with custom ASICs such as mask-programmed gate arrays.

You'll actually confront only two barriers to adopting these devices: their high cost per gate compared with mask-programmed gate arrays, and the effort you must make to understand these new devices and master their new design techniques.

If you recall the wide variety of divergent design approaches taken by early automobile and airplane designers, you won't be surprised to find that the new, large FPGAs employ wildly different architectures, processing technologies, and programming methods. This field is in its infancy, and chip designers will surely continue to explore innovative approaches for some time before FPGAs settle down and mature into a few industry-standard types.

Right now, you can get FPGAs from Xilinx, Altera, Actel, and Signetics. (Despite unsubstantiated stories in the rumor-mongering segment of the electronics trade press, Plessey insists it will have no FPGAs until next year.) Each company's products exemplify a fascinating, unique approach to providing you with a blank slate upon which you can inscribe your logic.

Programmable devices intrude

Xilinx was the first company to make a device large enough to start nipping at the heels of mask-programmed gate arrays. Advanced Micro Devices is an alternate source for Xilinx devices; the company has also added AMD-designed versions of Xilinx parts that have "toggle rates" of 100 MHz instead of the 70-MHz toggle rates of Xilinx's original parts.

Beware: Toggle rate is one of those specs, like MIPS or calculated MTBF specs for power supplies, that everyone touts but that mean little or nothing. The toggle rate of an FPGA's logic elements would be a useful spec only if your design simply spins its wheels, clocking the logic at full speed, but not actually processing any inputs or generating any outputs. In systems doing useful work, FPGAs actually run at some fraction of their toggle rate—typically around 60%.

Similarly, you should be aware that the term "gate count" is a holdover from conventional, mask-programmed gate arrays. The gate count refers to the total number of 2-input NAND gates that would be required to realize a logic function. Because a mask-programmed gate array is, in fact, a sea of uncommitted gates, the gate count provides an exact measure of the device's capacity.

FPGAs, on the other hand, are generally not a sea of uncommitted gates. FPGA manufacturers base their gate counts upon how large a design will fit into both a given FPGA chip and a mask-programmed gate array. In other words, if the FPGA can hold a design that also fits into a 2000-gate mask-programmed gate array, the manufacturer claims that the product is a "2000-gate-equivalent" device. The accuracy of the gate-equivalency measure depends heavily on the nature of the circuits used for comparison and the percentage of utilization of the FPGA.

Xilinx calls its FPGAs "logic-cell arrays" (LCAs). The name is apt because a rectangular, 2-dimensional array of programmable logic blocks—called, for no good reason, *configurable* logic blocks—occupies the bulk of the interior of Xilinx devices (**Fig 3**). A protective phalanx (hollow square) of I/O cells comes between the programmable logic blocks and the outside world.

Connecting the I/O blocks to the logic blocks and the logic blocks to each other is an elaborate network of programmable interconnection lines. These intercon-

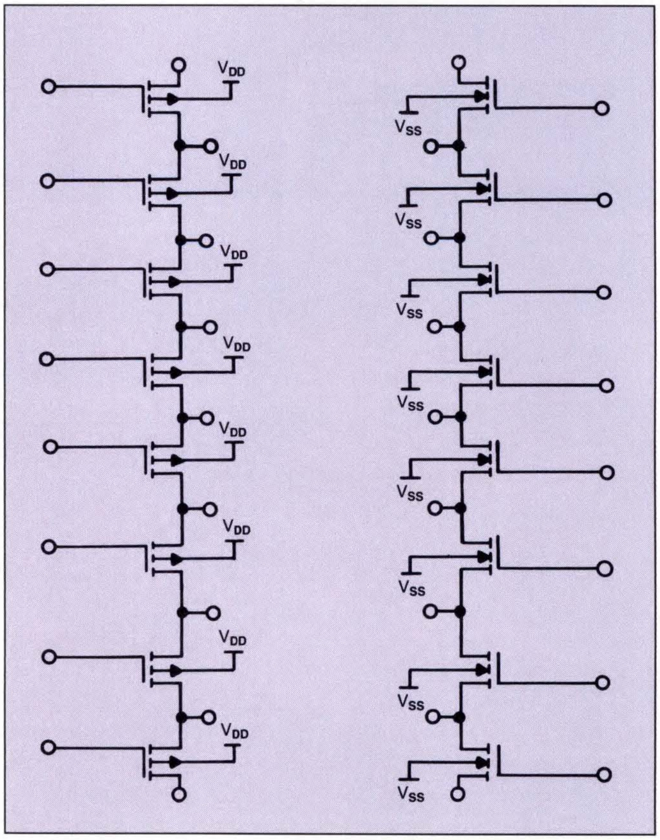


Fig 1—The architecture of a typical mask-programmed gate array *bears little resemblance to any field-programmable gate array (FPGA).*

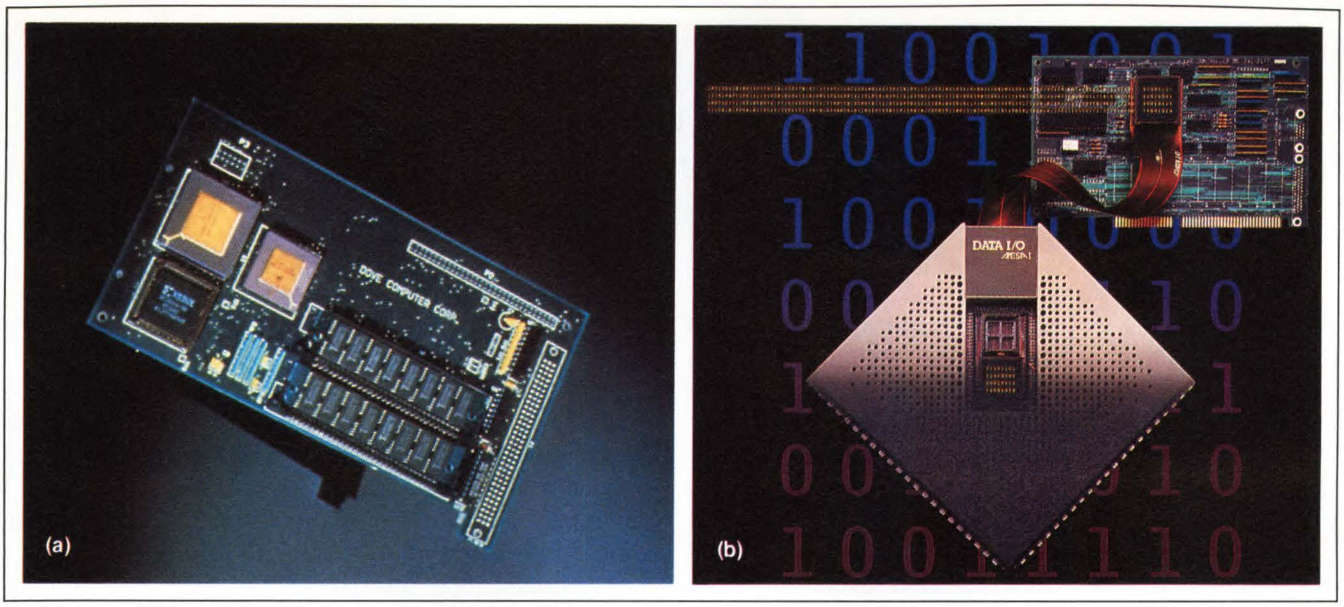


Fig 2—This accelerator board for the Macintosh (a) *(from the Dove Computer Co, Wilmington, NC) has a 68030 μP and companion floating-point processor, some bus drivers, and only a single Xilinx FPGA, which contains all the board's logic. The Data I/O Mesa I in* ***(b)*** *is an in-circuit emulator for Xilinx devices that uses 12 such devices for all its logic functions.*

nection lines form a waffle-like pattern in whose interstices the logic blocks reside. At the intersections of the interconnection lines lies a sort of crossbar switch. Although some global long lines bypass these programmable crossbar switches, the bulk of the interconnection lines must go through the crossbar switch. Note that these crossbar switches get programmed only once, when the device is initialized; you don't switch them dynamically as you would a real crossbar switch in a telephone exchange.

Tie lines from the logic blocks and I/O blocks tap into these interconnection lines. You route signals around the device by threading them from one interconnection line to another via the switches.

Xilinx's parts have two types of logic blocks. The original XC2018 and XC2064 have 100 and 64 logic blocks, respectively. These devices' logic blocks have a single flip-flop and enough associated logic elements so that you can program them to execute *any* Boolean function of four variables. The XC3090 has 320 logic blocks, each of which contains two flip-flops and can execute two 4-input Boolean functions or one 5-input function. For all Xylinx devices, you need not use the flip-flops in the logic blocks; you can bypass the flip-flops to achieve combinational functions as well as registered ones. The parts' gate-equivalency figures range from 1200 gate equivalents for the XC2064 to 9000 gate equivalents for the XC3090. For the same range of devices in the lowest cost packages, the prices are \$11.25 to \$135 (1000). AMD offers the 1200-gate-equivalent Am2064 for \$21.44 (100), the 1800-gate-equivalent Am2018 for \$32.50 (100), and the 2000-gate-equivalent Am3020 for \$42 (100).

Timing specs for FPGAs vary widely—some are easy to calculate, some are difficult. Because of the nature of the programmable interconnection lines, the timing specs for Xilinx's devices depend heavily on the layout.

The Max family is Altera's (Intel and Cypress Semiconductor are alternate sources) answer to some of the problems that chip designers encountered when they tried to enlarge the scale of the now-familiar PAL-device architecture. The basic PAL-device architecture suffers from a lack of flexibility and a tendency to underutilize its internal logic elements. The UV-erasable Max family currently consists only of the 500- to 1250-gate-equivalent EPM5032 (which costs \$30 in

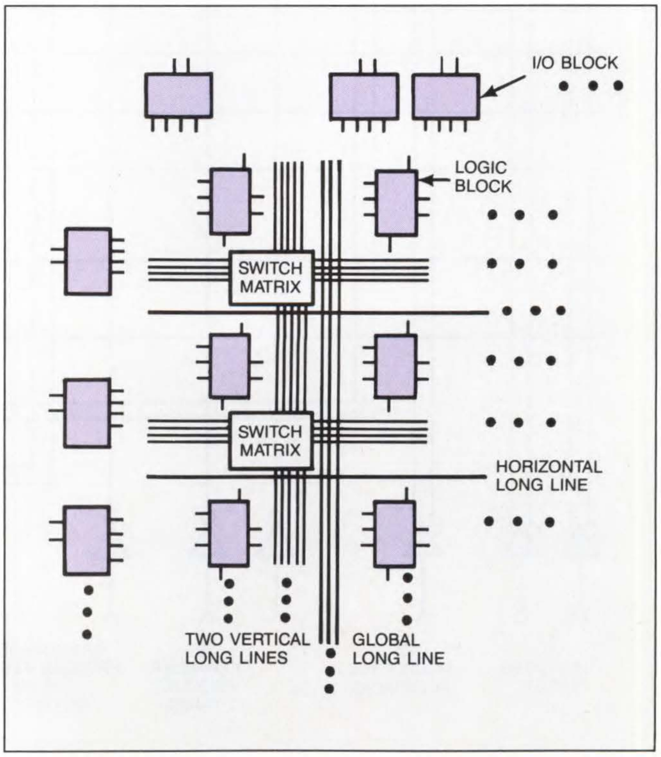


Fig 3—These FPGAs feature programmable logic blocks *embedded in a matrix of programmable and fixed interconnection lines. A ring of programmable I/O blocks lines the periphery of the device, which hails from Xilinx.*

Only two barriers really exist to adopting FPGAs: their high cost and the effort needed to understand both these new devices and their new design techniques.

sample quantities and $24 in quantities of 1000) and the 2000- to 5000-gate-equivalent EPM5128 (which sells for $111 in sample quantities and $90 in quantities of 1000), but other members are currently gestating. The Max family retains the programmable-AND/fixed-OR structure of conventional PAL devices—with a couple of twists (**Fig 4**).

First, a Max device's external inputs link to a programmable matrix of interconnection lines that Altera calls the PIA (programmable interconnect array). This interconnection array is, in effect, a crosspoint switch for linking any input on the chip, whether external or internal, to any output.

Internal inputs to the interconnection array include feedback lines from the chip's macrocells and feedback from programmable I/O lines. The feedback from the chip's macrocells allows you to use a macrocell's I/O pin as an input and simultaneously use its flip-flop as a buried register.

Outputs from the interconnection array go, naturally enough for a PAL-like device, to the AND/OR and XOR minterms that feed the registers in the chip's

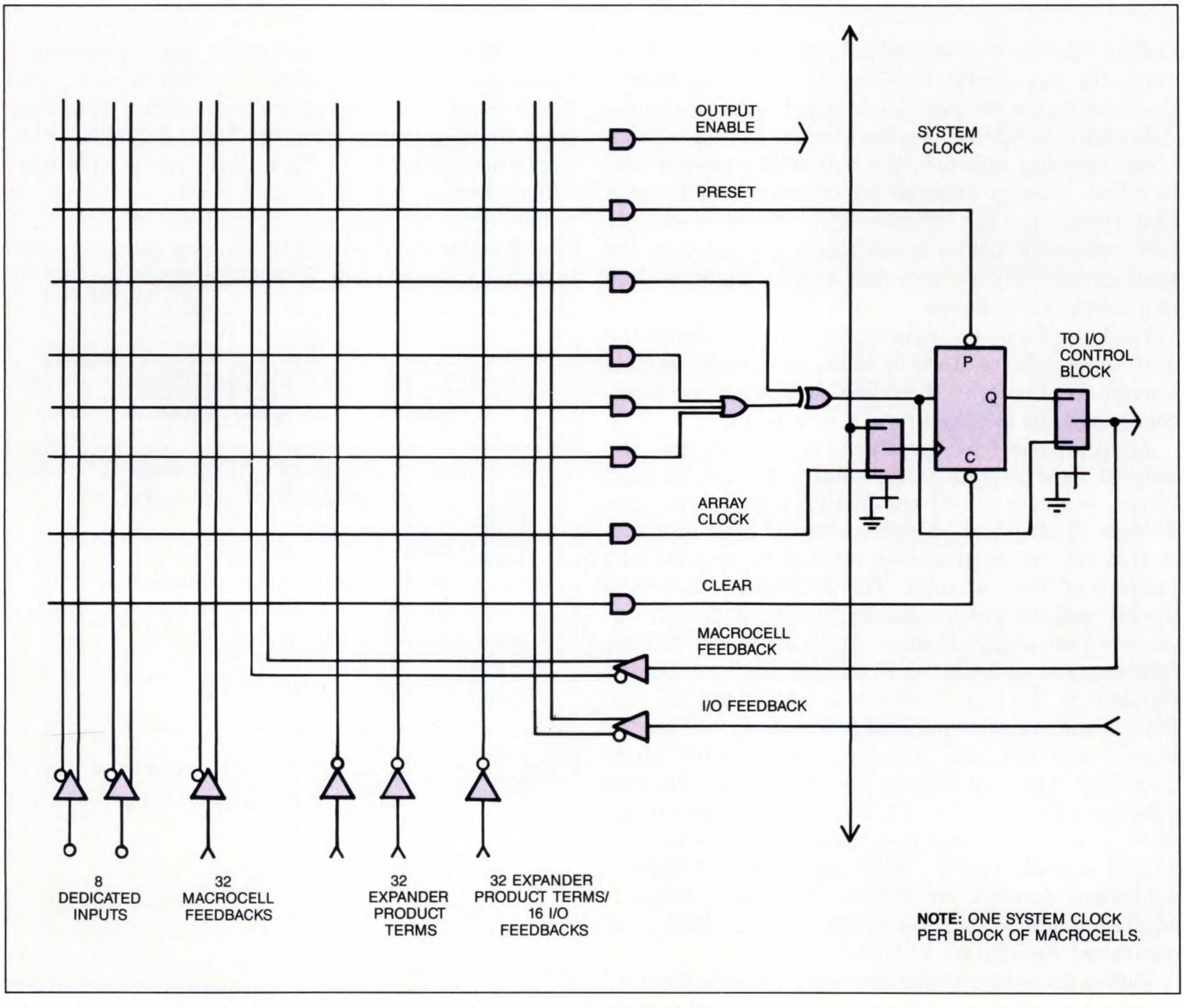


***Fig 4—The Max family devices** from Altera contain blocks of macrocells linked by an interconnection array. Note that each macrocell has only three dedicated AND gates; for minterms with more than three AND gates, you link in uncommitted AND gates from the expander-product array.*

macrocells. Other outputs from the interconnection array handle housekeeping functions for the macrocells, functions such as output enable, preset and clear, and clock.

The chip's macrocells, as is common with advanced CMOS PLDs, have flip-flops that you can program to be one of five types: D, T, J-K, S-R, and D with enable. Note that some advanced PLDs have 8 or 12 programmable register types.

So far, the Max family appears to differ little, in principle, from advanced PLDs such as the 22V10 or the 39V18. However, a close inspection of the diagram of the devices' architecture discloses a surprising fact: Each macrocell's AND/OR minterm has only three AND gates; PAL devices traditionally have eight AND gates or more per minterm.

Altera explains this surprising paucity of AND gates by claiming that the company's research shows that the vast majority of PAL-device designs use three or fewer AND gates per minterm—leaving five or more AND gates unused in PAL devices. However, you will not be left in the lurch if your Max-family design calls for more than three AND gates per minterm. Lurking in the heart of a Max device is a sea of uncommitted AND gates (the EPM5032 has 64 such gates), which gives the Max device a hint of the flavor of a programmable gate array. Altera calls these gates the "expander array" or "expander terms."

These expander-array gates' inputs and outputs communicate with the same interconnection array that links all the other elements of the device. Thus, at the cost of some extra delay, you can selectively add AND gates to any macrocell's AND/OR array. If you don't need some or all of the uncommitted AND gates, you can cross-connect pairs of them to form extra registers.

The underutilization bugaboo departs

Altera hopes that the expander array of uncommitted AND gates will solve the biggest bugaboo of PAL-type devices: underutilization of gates. Designs that require considerable conditioning or qualifying logic to precede registers tend to use a significant portion of a PAL device's AND/OR array. On the other hand, register-intensive logic elements, such as counters, tend to use up PAL devices' registers long before they make a dent in the available AND/OR resources.

When designing the Max devices, Altera strove to make all the paths through the chips the same length. Thus, you can easily calculate a Max chip's timing. The delay through the chip is fixed at one of two values; which value it is depends on whether you use the expander array or not.

Actel makes no bones about the nature of its devices; the company calls them desktop-configurable gate arrays. (Presumably, the company means you can configure its FPGAs *on* your desktop, not configure them *as* a desktop.)

The architecture of Actel's ACT family (Texas Instruments is an alternate source) resembles that of a medieval castle (**Fig 5**). The company offers the 1200-gate-equivalent ACT1010 for $62 (in sample quantities) and $45 (1000), and the 2000-gate-equivalent ACT1020 for $109 (in sample quantities) and $80 (1000). A ring of I/O cells lines each chip's outer perimeter. Inside lie rows of logic-block cells separated by horizontal rows of interconnection lines. Each logic block has eight inputs and one output. You can program a logic block to function as multiplexers and D flip-flops as well as a subset of common 2-, 3-, and 4-input logic gates. Other common logic elements require two or more logic blocks.

The logic blocks' input and output lines run vertically, at right angles to the interconnection lines. At each intersection of a logic block's input or output line and an interconnection line is a unique, one-time-programmable "antifuse."

Like PROMs, conventional fuse-programmed PLDs come with all the possible connections made. You program these devices by blowing fuse links and opening up connections you *don't* want. In contrast, Actel's parts come with all connections open and you blow the

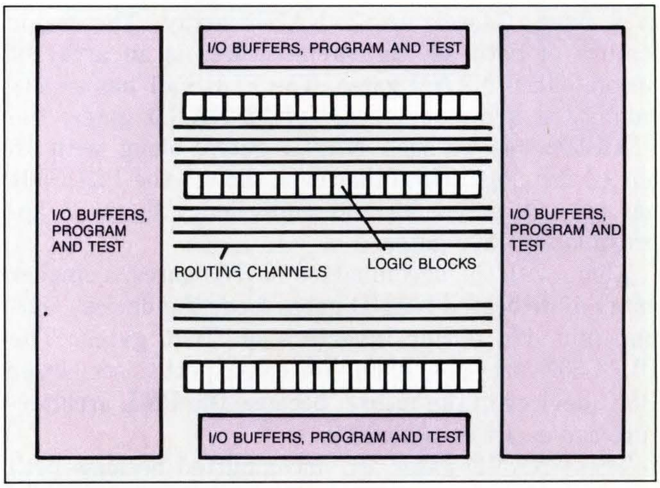


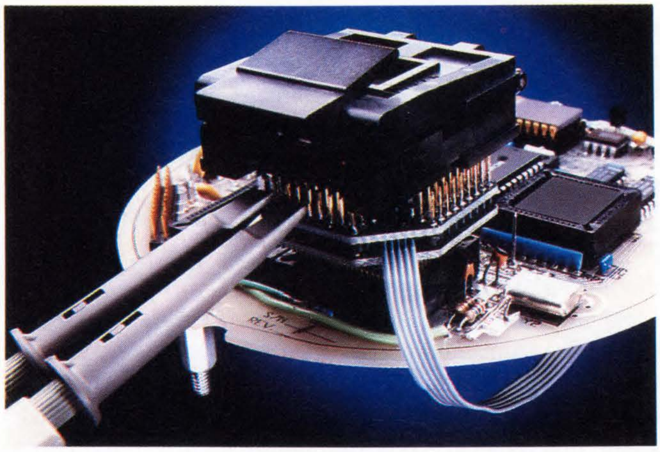
***Fig 5—Rows of programmable logic blocks** are separated by horizontal routing channels in these FPGAs from Actel. I/O buffers encircle the logic-block array.*

FPGA chip designers are sure to continue to explore innovative approaches for some time before FPGAs settle down and mature into a few industry-standard types.

insulation between any two lines you *do* want to connect.

The distinction between fuses and antifuses is pretty much academic for all users except device-programmer designers. The key spec for antifuses that matters to most users is their small size. An antifuse is 50 times smaller than a RAM cell and 10 times smaller than an EPROM cell—both of which are programming elements in other FPGAs. The small size of Actel's programming element allows the company to put more programming elements on a chip—by an order of magnitude—than their competition does.

The timing specs of a design realized in an Actel device are obviously layout dependent. However, the firm has enough confidence in its layout software's ability to pack the logic together, and in the speed of its interconnection lines, that it has factored in interconnection delays in the specs for its gate delays.



This utility meter takes advantage *of the built-in diagnostic feature of Actel's ACT1020 to simplify testing.*

Sea of gates

The Signetics PML devices (programmable macro logic) come in two versions, the PLHS501 and the PLHS502. These fuse-programmed, bipolar devices are based on a variation of the same basic principle of Boolean logic that animates PAL-device PLDs. Conventional PAL devices have a 2-level AND/OR architecture, because once you cast your logic equations in canonical, sum-of-products form, you can realize any logic function with a combination of AND and OR gates. The PML devices embody a variation of that basic axiom and use NAND gates instead (**Fig 6**).

Further, the PML devices' NAND gates do not come in a fixed, 2-level NAND/NAND array. The major feature of both devices' architectures is an array of uncommitted NAND gates. The PLHS501 has an uncommitted array, or "sea," of 72 NAND gates; the PLHS502 has 64 such NAND gates, along with 16 buried flip-flops. Note that even though the PLHS501 has only 72 gates, its gate-equivalency figure is approximately 1800 gates.

Along with the uncommitted NAND gates, a smaller array of dedicated NAND gates feeds the devices' output pins via either inverters or XOR gates. The PLHS502 costs $14 (1000). You can expect to see larger PML devices in the future, because the PML architecture can easily be scaled up.

These NAND gates are uncommitted because both their inputs and outputs connect—along with the external inputs—to the same interconnection array. Thus, you can loop any gate's output back into the interconnection array and use it as an input to another gate or gates. With this flexibility, you can create many-layered logic functions. Logic designs for PML devices often resemble the equivalent circuits printed in TTL manuals.

PML timing specs are straightforward to compute. You simply calculate a fixed delay for input and output gates plus another fixed delay for every layer of NAND gates that your logic uses.

Will your design fit?

The preceding quick tour of the architectures of the new FPGAs only hints at their complexity. Without doing a complete, detailed design and simulation, you can't be absolutly sure that your design will fit into and run fast enough in a given FPGA.

You can, however, get a rough idea by first counting up the total number of inputs and outputs your design requires and then consulting each company's library of preprogrammed logic functions (macros). Matching your design's logic functions to the functions in the manufacturer's macro library will give you a rough count of the number of logic elements your design will consume, because the manufacturers list the number of such elements that each of their macros uses.

Although the areas of application for all these devices overlap, each device suits some application areas better than others. For example, the Signetics PML has only 72 uncommitted gates—far less logic than the many, more-powerful logic blocks in the Xilinx and Actel devices. Yet each PML gate can accept as many as 32 external and 72 internal inputs; the logic blocks accept only a few inputs each. Thus, the PML can easily handle decoding jobs in 32-bit systems that would exhaust the other devices' resources.

Or take the Altera Max devices. Like their PAL-device forebears, they have dedicated registers for only their outputs. By contrast, the Xilinx and Actel devices have a plentiful supply of registers. But the Max devices have a dense, populous AND/OR array feeding their registers. Therefore, Max devices suit designs, such as state machines, that require considerable conditioning of inputs prior to registering. Register-intensive applications such as counters breeze into Actel and Xilinx parts.

Onboard programming opens up options

The programming technology these devices employ can affect your product-development and production-testing practices in fairly obvious ways. What's not so obvious is how the programming methods can affect your design itself.

Actel's and Signetics' devices are fuse-programmed, which means, obviously, you have to use the "blow-and-go" method to verify a prototype of your design. Also, fuse-programmed parts present an obvious and well-known challenge to your testing department, which won't be able to check out the parts until they're programmed.

Note that Actel devices have special pins that you can program to sample the state of any node in the chip. Actel devices need these test probes because the chip is so large that many possible failures could occur at internal nodes not visible at the chip's outputs.

Experienced µP users will be able to roll their in-circuit-emulator prototyping skills over only to the Xilinx devices. Both Xilinx and Data I/O offer in-circuit emulators for Xilinx devices. (Data I/O's $9390 Mesa I is a testimonial to Xilinx devices; the unit uses 12 Xilinx devices internally.)

In practice, the Mesa I provides a "shadow" device that responds to inputs just as your target-system device does. The shadow device, however, does not need

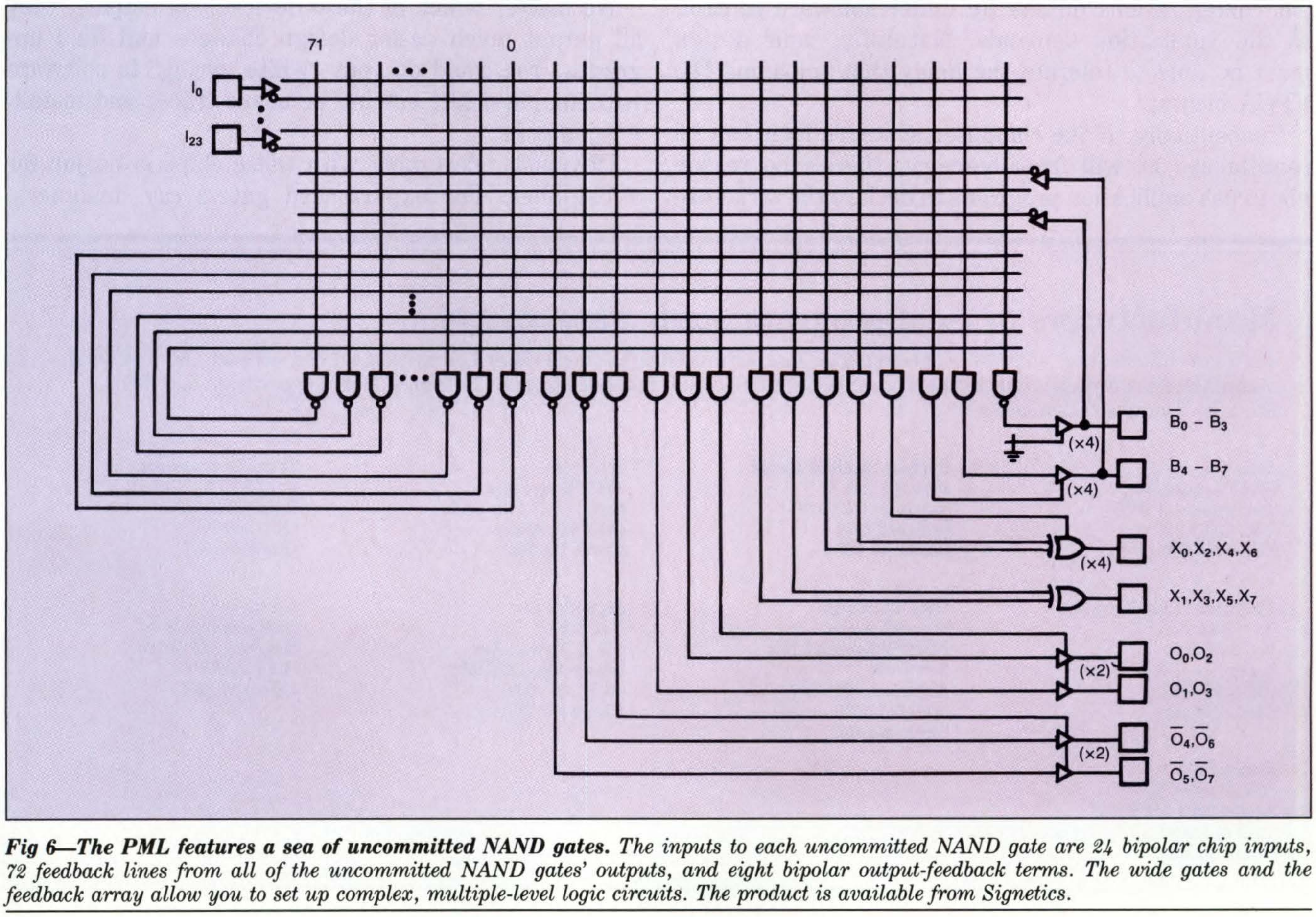


Fig 6—The PML features a sea of uncommitted NAND gates. *The inputs to each uncommitted NAND gate are 24 bipolar chip inputs, 72 feedback lines from all of the uncommitted NAND gates' outputs, and eight bipolar output-feedback terms. The wide gates and the feedback array allow you to set up complex, multiple-level logic circuits. The product is available from Signetics.*

The accuracy of the gate-equivalency measure depends heavily on the nature of the circuits used for comparison and the percentage of utilization of the FPGA.

to have the same output structure as the target-system device does, because it has no function in the target system. Therefore, you can program the shadow device's outputs to connect to any node in the device. The Mesa I does not record any of the shadow device's inputs or outputs. To perform that task, you must add your logic analyzer.

Altera's UV-erasable parts, on the other hand, allow you to reuse devices during the development phase of your design. Similarly, Xilinx's RAM-based programming links have to be initialized at least at each power-up. Because these devices are reusable, the factories can program a variety of test patterns into the devices and test them before shipping.

Less obviously, you could employ Xilinx devices' RAM-based programming in a number of novel ways. For example, you could store several configurations in memory and load whichever version suits your customers' applications. Thus, one pc board could suit several applications. Or your design could load different configurations on the fly under software control, as the application demands. Naturally, your design must be able to tolerate the delay that reloading the FPGA incurs.

Conceptually, if the computer system's logic can be reinitialized at will from memory, there's no reason not to use application programs to declare the structure of a computer system's hardware constructs along with its software constructs. If high-level-language compilers were intelligent enough to set up some common software constructs in programmable hardware, real-time and computationally intensive software could run much faster than it does now.

For example, real-time systems rely on intertask communication, coordination, and synchronization mechanisms such as semaphores, mailboxes, queues, schedulers, and timers. Although you could design custom hardware to accomplish these tasks at high speed, most real-time systems build these constructs entirely in software and thereby sacrifice a considerable amount of operating speed on the altar of flexibility.

When programmable logic is available, a suitable compiler could translate an individual program's definitions of counts, timeouts, pattern matches, semaphores, queues, priority levels, and myriad other constructs into custom, hardwired logic specific to that program.

No matter which of these devices you employ, they all permit much easier design changes and field upgrades. You could do your "white wiring" in software without physically cutting pc-board traces and installing jumpers.

Obviously, designing with these chips is no job for a beginner. For experienced gate-array designers,

Manufacturers of field-programmable gate arrays

For more information on field-programmable gate arrays such as those 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.

Actel Co
955 E Arques Ave
Sunnyvale, CA 94086
(408) 739-1010
Circle No 650

Advanced Micro Devices
901 Thompson Pl
Box 3453
Sunnyvale, CA
(408) 235-7487
Circle No 651

Altera Co
3525 Monroe St
Santa Clara, CA 95051
(408) 984-2800
Circle No 652

Cypress Semiconductor
3901 N First St
San Jose, CA 95134
(408) 943-2614
Circle No 653

Data I/O Corp
FutureNet Div
10525 Willows Rd NE
Box 97046
Redmond, WA 98073
(800) 247-5700 ext 461
Circle No 654

Intel Co
3065 Bowers Ave
Santa Clara, CA 95051
(408) 967-8080
Circle No 655

Signetics Co
Box 3409
811 E Arques Ave
Sunnyvale, CA 94088
(408) 739-7000
Circle No 656

Texas Instruments
Box 225012
Dallas, TX 75265
(214) 995-2011
Circle No 657

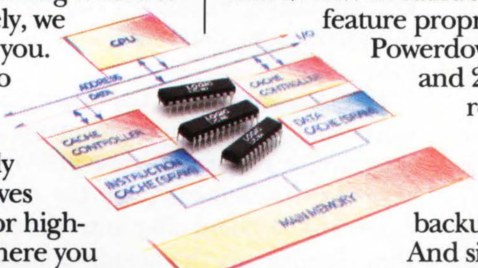
Xilinx Inc
2069 Hamilton Ave
San Jose, CA 95125
(408) 559-7778
Circle No 658

SRAMs

Our New SRAMs Haul Access.

At 15 nsec, Our SRAMs Really Tear Up The Track.

If you've been wondering where to find fast SRAMs lately, we have good news for you. Now you can look to Logic Devices–the logical choice.



Our new family of CMOS SRAMs gives you more options for high-end applications, where you have to match fast CPU speeds. They're available in speed categories from 15 to 45 nsec. So even your high-performance RISC and 32-bit micro designs can forget about wait states.

Because these parts just plain haul access. But without making you pay a power penalty. Their advanced CMOS technology runs as low as 340 mW in active mode, and 25 mW in standby. Plus they feature proprietary Auto Powerdown™ circuitry and 2 volt data retention, making them ideal for battery backup operation.

And since these parts are plug-compatible with industry-standard SRAMs, you have a clear upgrade path to higher performance. We've revved up production for delivery today, on all popular organizations, including 64K x 1, 16K x 4 and 8K x 8 –in a variety of package types.

For full details, call us today toll free at (800) 851-0767; in California, (800) 233-2518.

ORGAN.	SPECIAL FEATURES	MAX t_{AA}ns
16K x 1*	SEP I/O	12
4K x 4*	COM I/O	15
4K x 4*	COM I/O W/OE	15
4K x 4*	SEP I/O TRANSP/WRITE	15
4K x 4*	SEP I/O HI IMP/WRITE	15
2K x 8*	COM I/O W/OE	20
64K x 1	SEP I/O	15
16K x 4	COM I/O 1 CHIP ENABLE	20
16K x 4	COM I/O 2 CHIP ENABLES + OE	20
16K x 4	COM I/O 1 CHIP ENABLE + OE	20
16K x 4	SEP I/O TRANSP/WRITE	20
16K x 4	SEP I/O HI IMP/WRITE	20
8K x 8	COM I/O 2 CHIP ENABLES + OE	25

* PRELIMINARY

Or write: Logic Devices, Inc., 628 East Evelyn Avenue, Sunnyvale, CA 94086; Telex 172387.

LOGIC
DEVICES INCORPORATED

CIRCLE NO 74

Successful designers will learn all the ins and outs of FPGAs and design circuits that take into account all the parts' strengths and weaknesses.

switching to these FPGAs should prove to be no problem. For designers experienced with TTL, PLDs, or μPs, the transition could be painful.

Some industry observers, however, claim that the transition to FPGAs need not be painful if designers employ a variation of the Carver-Mead method called the DWBH approach (don't worry—be happy, pronounced "dweeb," also used as a verb, as in "to DWBH something"). Using this approach, you simply lay out your design in any fashion that suits your fancy, without regard for the target device's peculiarities.

Many vendors offer schematic-capture packages that allow you to draw up a design that looks just like the TTL designs you are familiar with. When your design looks good, you submit it to a schematic compiler or so-called "logic synthesizer" (actually, such programs don't synthesize any logic at all; they merely extract Boolean equations from the logic inherent in your circuit diagram).

If your design won't fit the target device when you compile the design, you simply select a larger device and recompile. Similarly, if simulation shows your design to be too slow, you just get a faster version of the target device.

Clearly, the more successful designers will probably learn all the ins and outs of FPGAs and design circuits for them that take into account all the devices' strengths and weaknesses.

Painful transitions

Curiously, an experienced TTL designer would probably have less trouble mastering the Xilinx and Actel devices than the Altera or Signetics devices. Designing with the devices that present an array of programmable logic blocks is like designing with a somewhat retarded set of TTL devices.

Actel and Xilinx publish detailed sets of recommendations concerning which logic functions fit their devices' logic blocks best. For example, a single Actel logic block can implement many—but not all—3-input gates directly and only a handful of 4-input gates directly. Xilinx logic blocks, on the other hand, can easily implement any 4-input function, including a majority gate. If experienced TTL designers restrict their design approaches to these recommended ones wherever possible, they will produce optimal designs that will fit their target devices better than a haphazard design will. Instead of just packing the maximum number of functions into a single chip, designers will strive to use the smallest number of logic elements for a given function, because the fewer logic elements a design uses, the faster the target device will run.

Experienced PLD designers will feel more at home with the Altera and Signetics devices. In fact, the greater flexibility of these devices in comparison with PAL devices should liberate designers from constraints rather than saddle them with new ones.

CAE—like it or not

Unfortunately, all these chips are so large that they virtually require computer-aided design techniques. Designers who prefer manual methods will finally have to give in and start working on an IBM PC or engineering workstation.

The software for FPGAs ranges in price from nothing to tens of thousands of dollars. The cost of the software will come as no shock to gate-array designers who have been using expensive, powerful software on mainframes for years. PLD designers who are used to free software from PLD vendors will be in for some sticker shock when they price software. Signetics' Snap for its PML devices, for example, costs $500 to $1000. Xilinx's XACT costs $3600 to $12,000, and Actel's ACT1 costs $20,000 to $25,000.

The high price of the software stems from two factors. The first is that the FPGA software is much more complex than PAL-device software. PAL devices contain a relatively small amount of logic and have logically simple internal structures. Thus, PAL-device software can consist of no more than a simple Boolean-equation to fuse-map translator. (More advanced PAL-device software packages are available, but they're not absolutely necessary—especially for experienced designers who don't use a wide variety of PAL devices.)

FPGA software, on the other hand, includes a multitude of different input formats: truth-table, circuit-diagram, waveform, logic-equation, and state-machine formats. Additionally, for the chips having arrays of logic cells, vendors offer autorouters and timing simulators. To give you the benefit of other designers' experience, FPGA packages include macros—or predefined, optimized logic functions that you can plug into your design as building blocks.

An unbeatable price/performance ratio

The FPGA software having the best price/performance ratio is Signetics' Amaze for its PML devices. In fact, Amaze's price/performance ratio is unbeatable: Amaze is free, and it works. If, however, you wish to

12mA MAKES THE DIFFERENCE

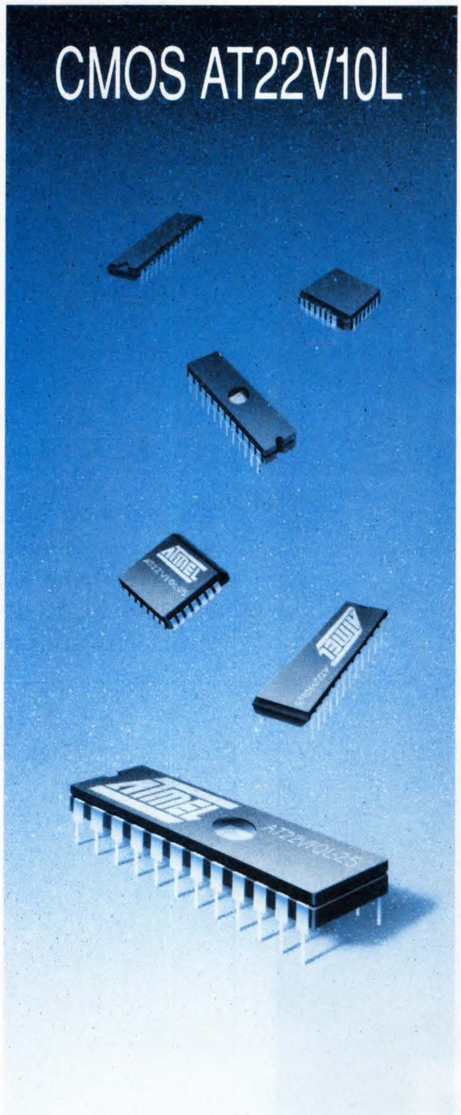
When your 22V10s are in standby, they just sit around and waste power. Those milliamps can add up to megabucks fast!

THAT'S CHANGED.

When you replace your standard 22V10 programmable logic devices with Atmel's new, proprietary low-power versions, you'll be cutting your standby power bill. Atmel's 22V10L needs only 12 milliamps (15 milliamps for the military version). That's about one-tenth of what you're used to. With Atmel, you lower costs, have less heat to worry about and improve your system reliability.

SPEED DOESN'T COST POWER.

And don't think you're going to compromise your processing speed just to pay for this power savings. The AT22V10L delivers a blazing 25 nanoseconds. This device can keep up with your microprocessor – not drag it down.



PUT THEM IN UNIFORM.

You can enlist these CMOS wonders for your military system as well. The Defense Electronic Supply Center (DESC) has approved Atmel's 22V10 and 22V10L low-power version on three different drawings. No one else scores that high!

DESC SMD Numbers

AT22V10	5962-87539	DIP/LCC (Windowed)
AT22V10	5962-88670	DIP/LCC (Non-windowed)
AT22V10L	5962-88724	DIP/LCC (Low Power)

For more information on the Atmel difference, call (408) 434-9201, or write:
Atmel Corporation
2095 Ringwood Avenue
San Jose, CA 95131

ATMEL®

The People Who Make The Difference.

CIRCLE NO 75

compile designs generated on third-party, schematic-entry software packages such as OrCAD/STD or FutureNet, you will have to purchase Signetics' Snap. Snap also provides state-machine entry and macros for common logic functions.

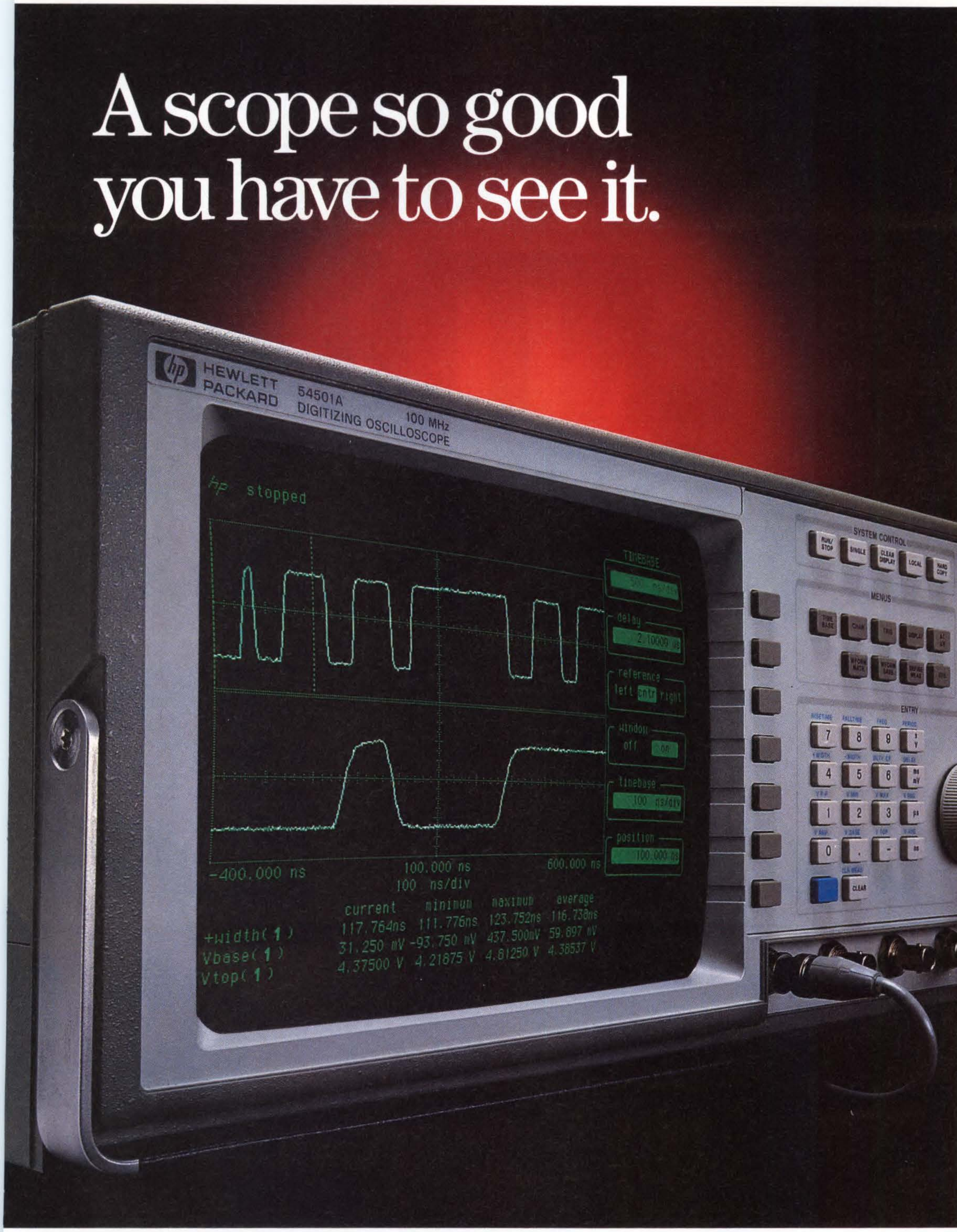
Signetics is not alone in seeing the marketing appeal of using common schematic-capture programs as a front end to logic compilers that suit their particular chips. Xilinx packages Data I/O's FutureNet as a front end to its logic-synthesis, autorouting, and simulation software. Xilinx's back-end software also interfaces with common CAE packages such as Daisy's ACE or DED II, Mentor's Idea, Schema II, OrCAD's SDT, Valid, CASE, PCAD, and ViewLogic.

Similarly, Altera offers Max + Plus software for its Max devices, and Actel has the Action Logic System (ALS) for its programmable gate arrays. The Actel offering also includes an autorouter, which the company claims can route 100% of all paths while using up 95% of a device and a test-software generator.

To understand why this software costs so much, consider that in addition to the much higher software-development costs that FPGA vendors must assume to write such advanced software, recent startups in this field aren't really in the semiconductor business just yet. Right now, these companies are selling more software than hardware and are, rightly speaking, in the software business. If engineers begin to design with these companies' parts and the companies then begin shipping lots of chips, the firms may forsake the software business for the chip business and, as a result, their software prices may come down. EDN

Article Interest Quotient (Circle One)
High 494 Medium 495 Low 496

A scope so good you have to see it.



A 100 MHz Digitizing Oscilloscope for $3,465. The HP 54501A.

- **100 MHz bandwidth**
- **Four channels**
- **8-bit vertical resolution**
- **Instant hardcopy output**
- **Full HP-IB programmability**
- **Automatic measurements**

It's no typo! $3,465. Call for the FREE video and see the best price/performance, portable, digitizing oscilloscope on the market. See the power of glitch, dropout and TV triggering, measurement limit test and dual timebase windowing. The HP 54501A outperforms analog oscilloscopes and delivers extra capabilities found only in expensive digitizing oscilloscopes. See the ease and versatility of the HP 54501A on videotape.

Call HP now:

1-800-752-0900.

Ask for extension 216D for your free video, or to order.

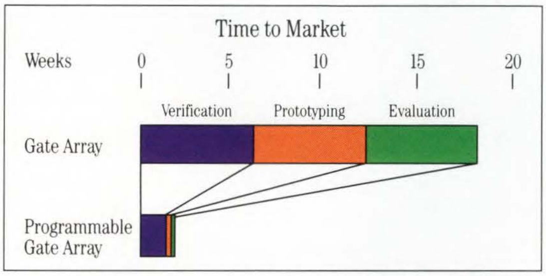
HEWLETT PACKARD

Convention says that gate arrays often take months to develop.

Convention says that TTL and PLD-based designs sacrifice production cost effectiveness.

Maybe it's time you flaunted convention.

With Xilinx Programmable Gate Arrays. They give you all the benefits of gate arrays, but you can program them right at your desktop.



Cut up to 15 weeks from your design schedule. Because Xilinx Programmable Gate Arrays mean no waiting, and no risk.

Xilinx Programmable Gate Arrays cut months off your development cycle and replace boards full of TTL and PLDs.

You don't worry about NRE, because there isn't any.

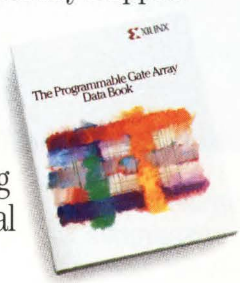
You work with a proven standard part that has already been 100% tested down to the last transistor. And our standard parts are priced the way most standard parts are priced. Low and getting lower.

If all this sounds too good to be true, consider the evidence:

Design engineers are using more than 2,500 of our development systems. And this year they'll create more than 10,000 designs, guided by Xilinx's comprehensive design tools and complete technical support.

Production benefits are well proven: We've already shipped more than a million fully tested parts.

So if you're tired of working the conventional way, take a look at Xilinx's Programmable Gate Array. Our new data book shows you how to get more density with less risk and get your ideas to market faster.



Just call (800) 255-7778. In California call (408) 559-7778. Or contact your local Xilinx distributor, rep, or sales office and ask for a copy.

It defies conventional logic. But it makes perfect sense.

Programmable design cuts your expenses, not your options. Xilinx offers you a broad range of Logic Cell™ Arrays for every application.

XILINX

The Programmable Gate Array Company℠

CIRCLE NO 77

Any way you look at it—speed, density or price—Xilinx's Programmable Gate Arrays make conventional logic design seem prehistoric by comparison.

End the connector compromise...

1. LIF RACK & PANEL CONNECTORS

2. MULTIPIN WITH 8-200 AMP CONTACTS

3. MIL-C-28748A RELIABILITY

...in electronic power supplies

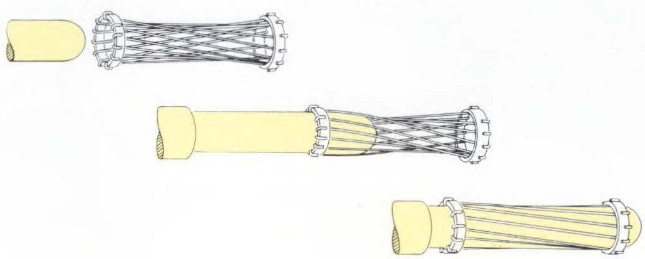
Only Hypertronics ends the compromise in power supply connectors for backplane subassemblies—in military, computer and other electronic systems—by combining Low Insertion Force (LIF) power, signal and MIL spec reliability in a single rack & panel connector.

Our modular design gangs power contacts, rated from 15 to 200 amps, with low-insertion-force signal contacts. Combine these design alternatives with high current/small size performance of the Hypertac® contact—for unique cost and space efficiency.

And now our L Series connectors have been proven to MIL-C-28748A performance standards.

Now you can have it all...in rack & panel connectors for power and signal applications ranging from power supply to portable disc drives. End the connector compromise by calling 1-800-225-9228, toll free.

HYPERTAC®:
Inserting pin into hyperboloid sleeve.



HYPERTRONICS CORPORATION

"New Horizons in Connectors"

16 Brent Drive, Hudson, MA 01749 **(508) 568-0451** Telex 951152 FAX **(508) 568-0680**

Design linear circuits that serve digital system needs

Digital circuits require a slew of analog support circuits to provide life support in the real world. Many of these functions are related to memory support and range from power-sense circuits to voltage supplies for programming onboard, nonvolatile memories.

Jim Williams, *Linear Technology Corp*

The pristine, regimented symmetry of digital circuit boards is occasionally interrupted by irregular huddles of linear components. Designers tolerate these aberrants because they perform a variety of ancillary tasks necessary to keep the digital system running. Most analog designers wouldn't relish lifetime employment working on digital circuit boards, but the need for certain kinds of analog circuits exists. Memory- and power-control circuits are two examples of linear circuits needed in digital systems.

The recently introduced flash memories offer a good example of linear circuits supporting a predominantly digital function. Flash memory, unlike conventional EPROM, lets you erase and reprogram a memory chip electrically. A full-chip erasure takes one second with 100-μsec byte-program times and two seconds for full-chip programming. (See **box,** "A primer on flash memory," for a more complete description of flash memory.)

Flash-memory devices require carefully controlled, high-voltage programming power. A typical unit, the Intel 28F010 1M-bit flash memory, specifies V_{PP} pulses of 12 or 12.75±0.2V, depending on the part type. (PP stands for program power.) V_{PP} excursions beyond 14V for 20 nsec or longer will destroy the device. To reliably generate such pulses in a 5V-powered digital system, you must deal with several analog issues. You must derive or supply a high-voltage source and then control its output and the pulses generated from it within the tight tolerances required by the memory device. In addition, you may want to control the high-voltage pulses with a 5V logic command.

Memories require precise programming pulses

A simple way to provide the necessary programming power would be to use an existing high-voltage power-supply line or a switching-regulator output voltage set at the desired V_{PP} level. You could then use a simple, low-resistance FET or bipolar switch to generate the V_{PP} pulses. In theory, this approach will work. In practice, however, transmission-line effects in printed-circuit trace runs may cause memory-destroying overshoots. The **box,** "Preventing memory destruction," details this phenomenon.

In general, you need more sophisticated design techniques to stay within the V_{PP}-pulse tolerance limits. The circuit shown in **Fig 1a** meets almost all flash-

Whichever design world you find yourself in—analog or digital—you should be aware of the linear-circuit needs of different types of digital circuitry.

memory V_{PP} requirements. When the V_{PP} command pulse goes low (**Fig 1b,** trace a), the LT1072 switching regulator drives L_1, thus producing high voltage at the output. Resistors R_1 and R_2 provide the necessary dc feedback; the ac rise and fall times are controlled by the 2-pole compensation of the LT1072. This compensation is set by the values chosen for C_1, C_2, and R_3; these values have been selected for optimal compensation with respect to this application. The circuit's response should have no overshoot under any conditions including short-circuit recovery (see **Ref 1** for more information on LT1070/LT1072 compensation).

The final output of the circuit is a smoothly rising V_{PP} pulse (**Fig 1b,** trace b) that settles to either 12 or 12.75V, depending on the values you choose for R_1 and R_2. The 5.6V Zener diode permits the output to return to zero volts when the V_{PP} command pulse goes high; you may delete the diode in cases where a 4.5V minimum output is acceptable or desirable. You can eliminate circuit-trimming requirements by using precision resistors for R_1 and R_2. Alternatively, you can use 1% resistors and a trimmer for R_1 and R_2.

You can easily modify the circuit of **Fig 1a** to eliminate the 1N5919 Zener diode and its attendant power dissipation by inserting a pnp transistor in its place as shown in **Fig 2a**. To further modify the circuit for

A primer on flash memory

Saul Zales, *Intel Corp*

Flash memories reduce firmware-update costs for EPROM-based products. Such products often need software revisions, and EPROMs are costly to update. You often have to dismantle your equipment, either to UV erase and then reprogram the EPROMs or to replace them with new ones. This operation takes a technician at least 15 minutes. Double that time if you wait for UV erasure. In contrast, flash memories allow in-system reprogramming in seconds and are not discarded as EPROMs often are. In the factory, flash EPROMs let you execute multiple tests during a single board-testing step.

To distinguish between EEPROMs and flash EPROMs consider that EEPROMs suit parameter storage, as opposed to code storage. Parameters need to be rewritten individually in real time—that is, while the system is on-line and in normal operation. Parameters also require less memory storage space than code does.

In contrast, flash EPROMs better match embedded-code needs. Even if you only change one line of code, an entirely new microcomputer program results. You must update the software as a complete copy to ensure error-free updating. Flash memories accomplish this process with full-chip erase characteristics in a few seconds of off-line system time.

One flash-EPROM reprogramming method is In-System-Write (ISW). ISW eliminates external programming equipment altogether; it uses an existing data-communication channel, such as a modem. ISW utilizes the embedded, local CPU for the flash-memory device's reprogramming "intelligence," thus taking advantage of the off-line nature of updates. The only new requirement for ISW is a local programming power supply (V_{PP}) of either 12 or 12.75V, depending on device specifications.

The author is an applications engineer at Intel Corp (Santa Clara, CA).

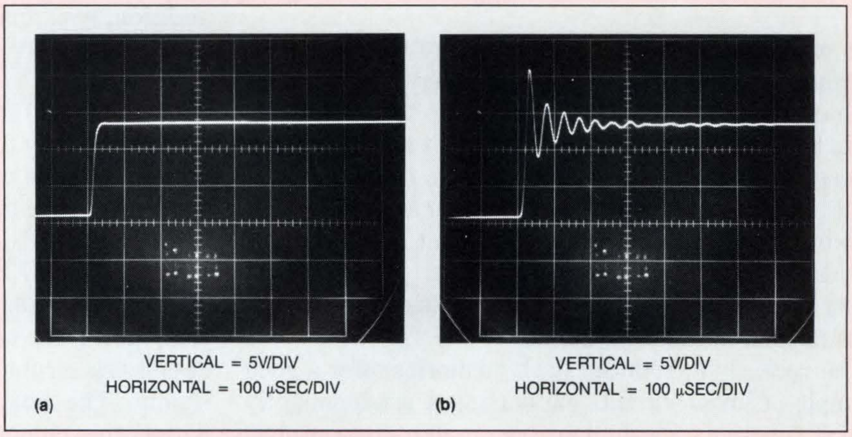
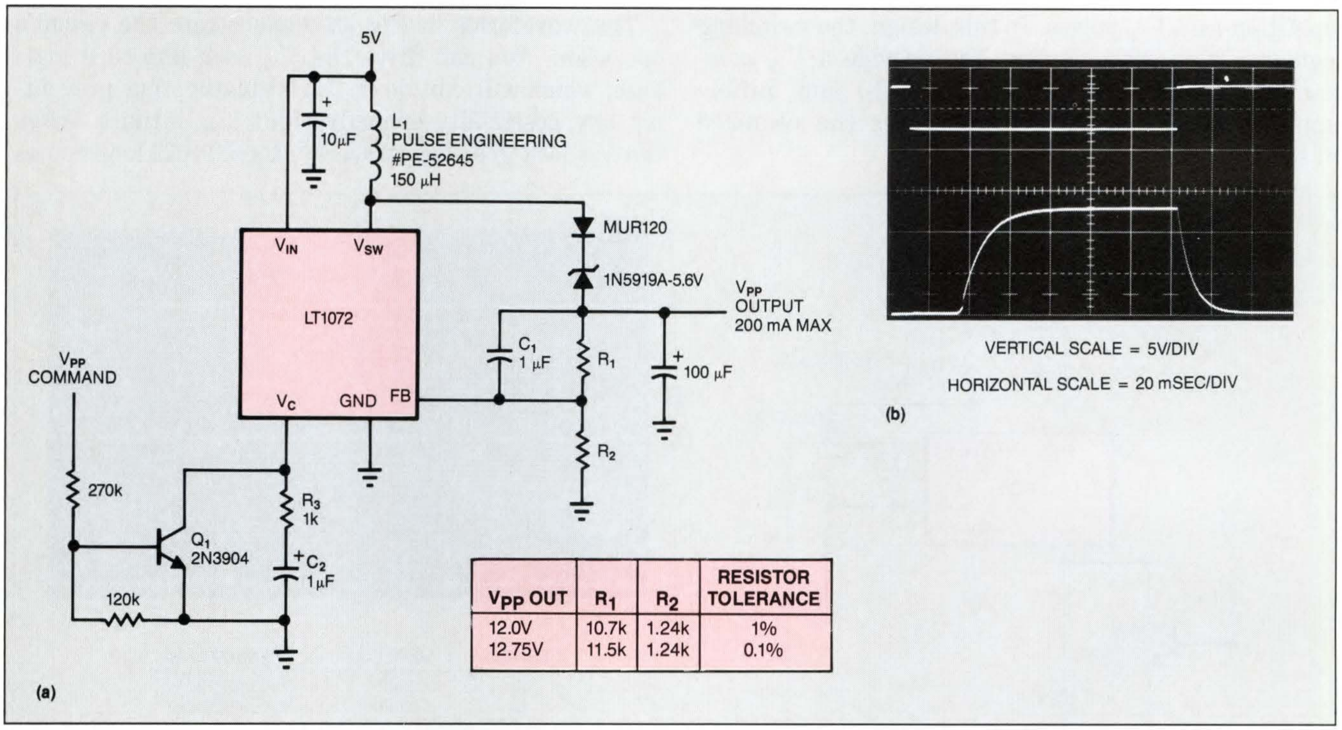


Fig A—An ideal flash EEPROM V_{PP} pulse *has a smooth rise time with no overshoot (**a**). If your pulse-generator design doesn't include circuitry for rise-time control, the pulse can ring at destructive voltages (**b**) simply due to transmission along a pc trace.*



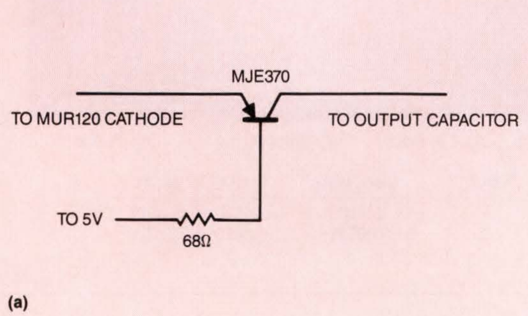
V_{PP} OUT	R_1	R_2	RESISTOR TOLERANCE
12.0V	10.7k	1.24k	1%
12.75V	11.5k	1.24k	0.1%

Fig 1—High-voltage pulses with smooth rise characteristics *are the basic flash-memory programming requirements that this circuit* ***(a)*** *fulfills. Due to the compensation of the LT1072 switching regulator, the command pulse (****b****, trace A) produces a pulse with a clean rise-time characteristic (****b****, trace B).*

high power outputs, see the table in **Fig 2b.**

A key feature of the circuit in **Fig 1a** and many circuits similar to it is that they will not spuriously overshoot during power-up or power-down, thereby preventing memory destruction. This feature is due to the compensation of the LT1070, which causes a highly overdamped pulse response, and to the fact that the control components of these circuits function even at low supply voltages. In other words, the control circuits will be active long before the memory circuits settle and will prevent uncontrolled V_{PP} outputs.

The repetition rate of the circuit in **Fig 1** is limited because the regulator must fully rise and settle for each V_{PP} command. Depending on how often your memory devices require updating, this limited repetition rate may or may not present a problem. Most requirements are for low repetition rates (from one hertz to the kilohertz range), but there are cases where the pulser is required to serve many memories. The circuit in **Fig 3** serves those cases that require higher-



(b)

POWER OPTIONS FOR BASIC V_{PP} PULSE GENERATOR

OUTPUT CURRENT	C_{OUT}	REGULATOR	INDUCTOR	ZENER
400 mA	200 μF	LT1071	PE-52645	1N5339A OR SYNCHRONOUS SWITCH OPTION
800 mA	400 μF	LT1070	PE-51516	1N5339 OR SYNCHRONOUS SWITCH OPTION

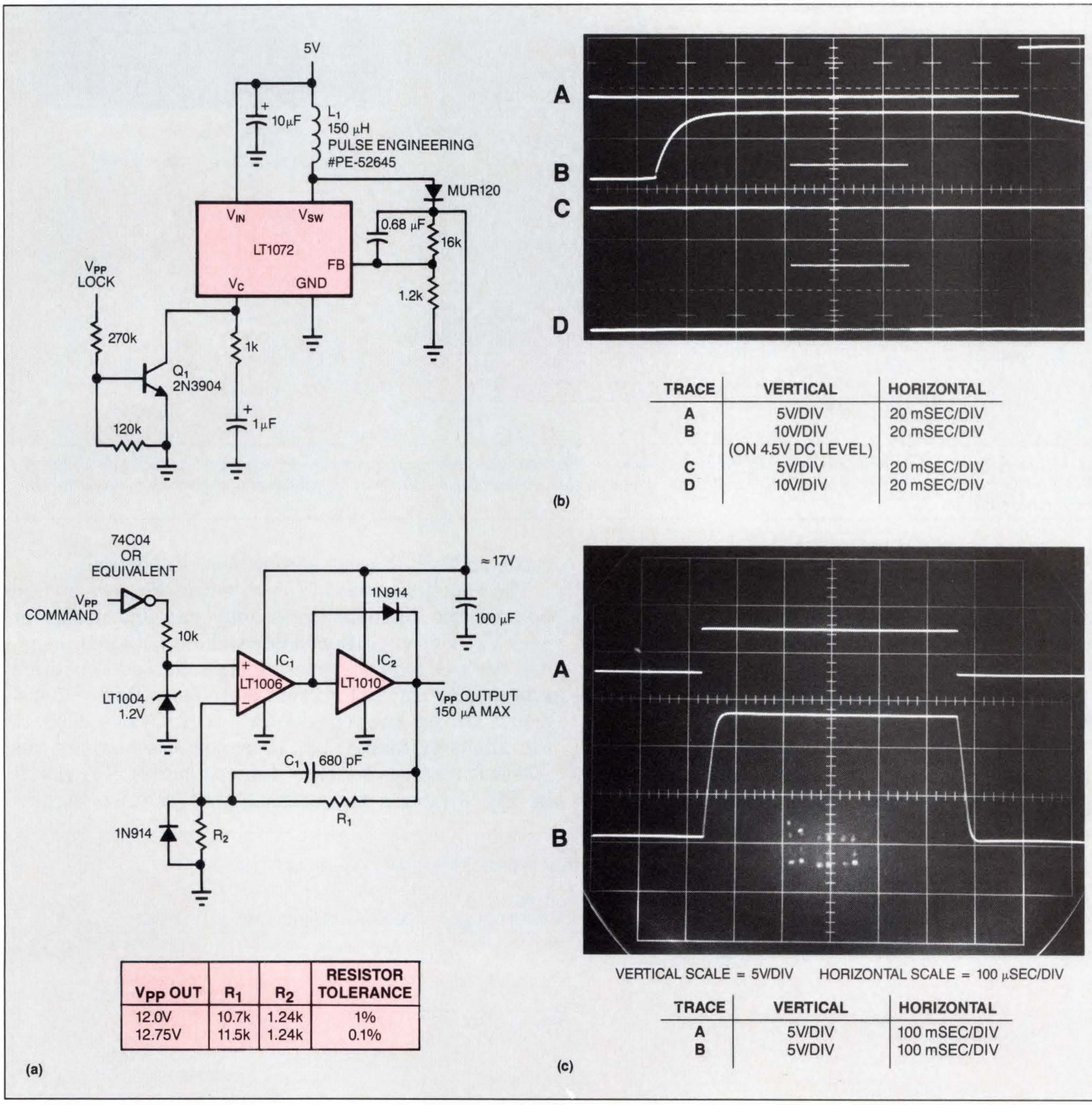
NOTE: ASSUME EACH 28F010 DEVICE REQUIRES 30 mA of VWF CURRENT

Fig 2—You can replace the Zener diode of Fig 1 *with a pnp transistor* ***(a)****. You can also modify* ***Fig 1*** *for higher power outputs* ***(b)****.*

Power control and memory management are just two areas where some analog design tricks will come in handy on a digital circuit board.

repetition-rate V_{PP} pulses. In this design, the switching regulator runs continuously. You provide a V_{PP} command pulse to drive an op-amp (IC_1) and buffer-amplifier (IC_2) loop, which generates the required pulses.

The waveforms in **Fig 3b** demonstrate the circuit's operation. You can drive the V_{PP} lock line to a logic high, which will shut down the regulator, thus preventing any possiblility of inadvertent V_{PP} outputs. After the V_{PP} lock goes low (trace A), the LT1072 loop comes

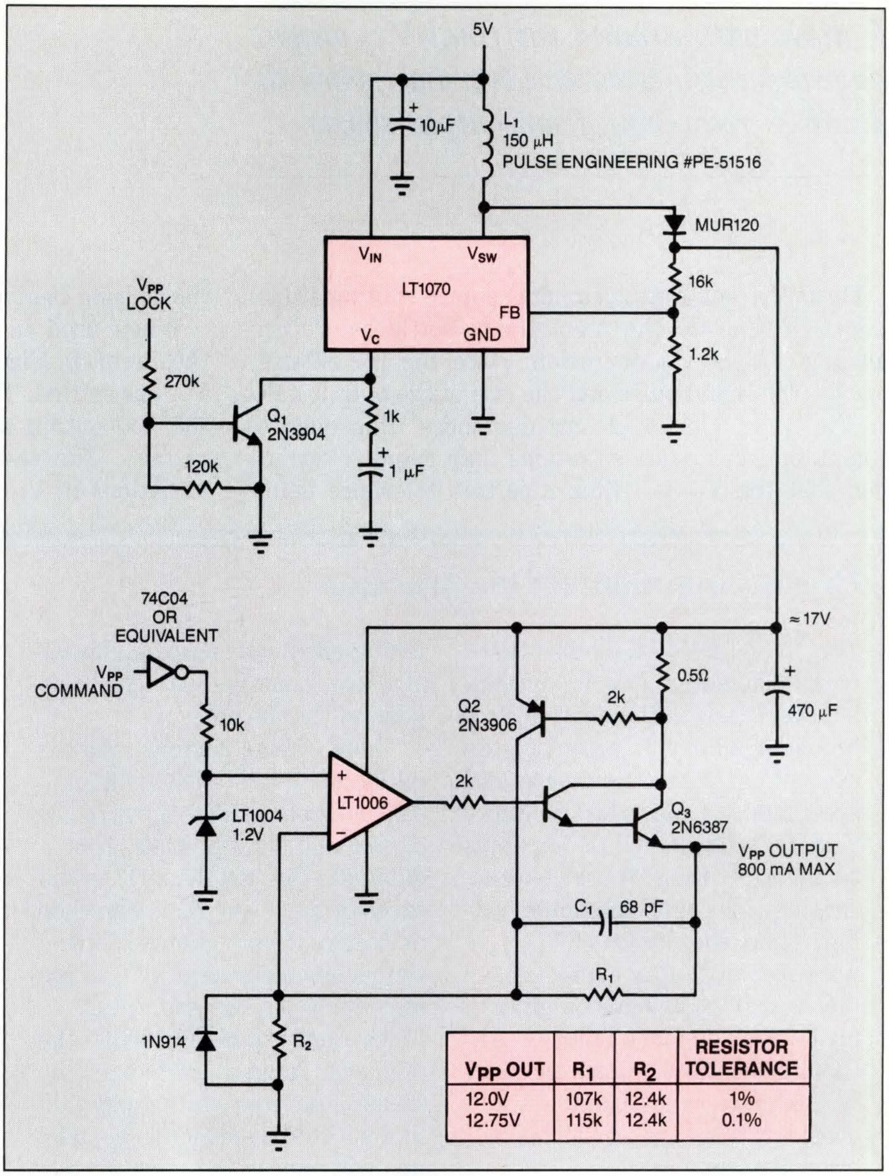


Vpp OUT	R1	R2	RESISTOR TOLERANCE
12.0V	10.7k	1.24k	1%
12.75V	11.5k	1.24k	0.1%

TRACE	VERTICAL	HORIZONTAL
A	5V/DIV	20 mSEC/DIV
B	10V/DIV (ON 4.5V DC LEVEL)	20 mSEC/DIV
C	5V/DIV	20 mSEC/DIV
D	10V/DIV	20 mSEC/DIV

TRACE	VERTICAL	HORIZONTAL
A	5V/DIV	100 mSEC/DIV
B	5V/DIV	100 mSEC/DIV

Fig 3—To fulfill higher-repetition-rate voltage-programming requirements, *you can run a switching regulator continuously and generate the V_{PP} pulses by using an op amp and a buffer amplifier* ***(a)****. High-voltage pulses, whose level is dependent on the value you choose for R_1 and R_2, result from the application of the V_{PP} command pulse (****b****, trace D); these pulses exhibit clean rise times (****c****, trace B).*



Vpp OUT	R1	R2	RESISTOR TOLERANCE
12.0V	107k	12.4k	1%
12.75V	115k	12.4k	0.1%

***Fig 4—By replacing the buffer-amplifier stage of Fig 3** with a discrete-output stage, you can supply up to 800 mA of output current.*

on (trace B), stabilizing at about 17V. Pulsing the V_{PP} command line then causes the 74C04's output (trace C) to bias the LT1004 reference. The LT1004 clamps at 1.23V, and the gain loop containing IC_1 and IC_2 produces a pulsed output voltage dependent on the values you choose for R_1 and R_2 (trace D). The 680-pF feedback capacitor, C_1, controls loop slewing, thereby eliminating overshoots. **Fig 3c** details the V_{PP} output. Trace A is the 74C04 output; trace B displays the clean V_{PP}-pulse characteristics.

As in **Fig 1**, the 2-pole compensation of the LT1072 in **Fig 3a** ensures a clean rise time, and spurious V_{PP} outputs are suppressed during power-up and power-down. The LT1010 buffer amplifier provides short-circuit protection and 150 mA of drive current, which is enough for five 28F010s. The diode path around the LT1010 prevents destructive overshoot when the circuit is recovering from output shorts. The diode at IC_1's input clips excessive negative voltages arising from C_1's differentiated response.

To drive more memory devices—supply more output current—you can modify the circuit in **Fig 3a** by replacing the LT1010 buffer amplifier with a discrete power stage, as shown in **Fig 4**. Q_3 furnishes up to 800 mA of output current, enough to drive 26 28F010 memories; Q_2 functions to limit the current to a maximum of approximately 1.2A. The values of the feedback components used in **Fig 3a** have been scaled by a factor of 10; R_1 and R_2 were increased and C_1 was decreased to maintain the same level of compensation. These changes prevent Q_2's collector current from causing excessive heating in the grounded resistor, R_2. This heating could occur during prolonged short-circuit conditions. The ac dynamics of the circuit in **Fig 4**, including a glitchless short-circuit recovery, are identical to those of the circuit in **Fig 3a**.

You should note that for both **Fig 3a** and **Fig 4** the LT1070 or LT1072 is running continuously to provide a fixed high voltage. If a suitable high voltage is already available in your system, you can power IC_1 and IC_2 directly from that high-voltage line and delete the regulators from the circuit.

A diode path around the final V_{PP} output stage prevents destructive overshoot when the circuit is recovering from output shorts.

These V_{PP}-generating circuits require waiting a small length of time for the regulator to settle before proceeding with a V_{PP} operation. Note the lag between the V_{PP} command pulse and the rise of the output pulse in **Fig 1**. In almost all circumstances, this delay is acceptable, but some situations may require verification that the V_{PP} is within a certain tolerance before the pulsing begins.

When used in conjunction with either V_{PP} pulser, the circuit in **Fig 5** gives a handshake output when the V_{PP} has settled. This simple circuit works by comparing the V_{PP} output against the known LT1004 reference voltage. The resistor values given allow for possible variations in V_{PP} voltage due to component tolerance

Preventing memory destruction

The 12 or 12.75V V_{PP} pulses used with flash memories seem uncomfortably close to the devices' 14V breakdown limit. In actuality, the overvoltage precautions required are similar to those for 5V rails. Excursions beyond 14V for durations longer than 20 nsec exceed the chip's absolute maximum rating. Thus, the design of V_{PP}-pulse-generating circuitry requires care to avoid seemingly mysterious memory failures. Although the 28F010 flash memory is used here as an example, the considerations are applicable to other devices.

In theory, a simple low-loss transistor switching a low-impedance power supply will generate the required pulses. In practice, this is a hazardous approach. **Fig Aa** shows an ideal V_{PP} pulse produced by simple transistor switching. The pulse settles to the desired V_{PP} level quickly with no overshoots or aberrations. **Fig Ab** shows the same pulse measured at the memory pins after a printed-circuit trace run. The pc trace looks like an unterminated transmission line with ill-defined characteristics. Reflections occur, which cause ringing exceeding 20V. This ringing is well beyond specified destructive levels and almost guarantees chip failures. Similar overshooting on the falling edge can cause equally destructive negative voltages to appear at the memory pins.

These effects demonstrate the necessity for rise-time control. The controlled edge times of the closed-loop circuits in the text eliminate this problem. Other features of these circuits make them attractive. Short-circuit protection is obviously desirable to protect the V_{PP}-pulse generator. More subtly, it also protects the memory. In an unprotected V_{PP} pulser, the pass switch may fail in a shorted condition. This failure will expose the memory to destructive overvoltage. You should design short-circuit-protection circuitry so that it does not cause overshoots when operating or recovering from overload.

For example, removing IC_2's shunt diode from the circuit shown in **Fig 3** in the text causes dangerous overshoots on short-circuit recovery. **Fig Ba** shows V_{PP} output recovery with the diode removed. With the diode in place (**Fig Bb**), the recovery is free from overshoot. Similar considerations apply on power-up and power-down. The V_{PP} generator must not produce spurious outputs during power application or removal. You can avoid these unwanted outputs by employing circuit techniques and ICs that operate down to low voltage. Circuits that provide control even when the power supply is not yet at its specified operating level yield predictable and controllable outputs during transient supply conditions.

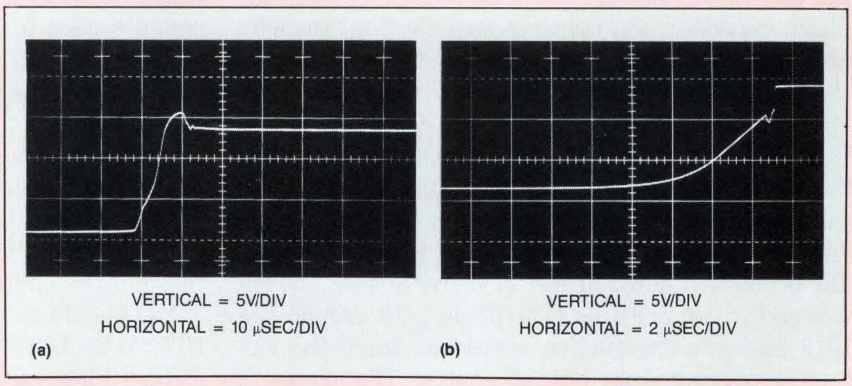


***Fig B—Without a shunt diode at the output** of a V_{PP}-pulse generator, dangerous memory-destroying overshoots can occur (**a**). With the diode in place, the recovery is smooth and controlled (**b**).*

stack-up. When you use this circuit, you should set the output of the V_{PP} generator circuit to within 0.4% of nominal value. You can set the output to a precise value by trimming or by using 0.05% resistors in place of the 0.1% values specified.

Although EEPROMs fulfill a different purpose than flash memories, their V_{PP}-pulse requirements have similarities. The Intel 2816 specifies a V_{PP} amplitude of 21 ± 1V with a maximum allowable voltage of 22.5V. A special EEPROM stipulation is that the V_{PP}-pulse rise time must have an RC time constant very close to 600 μsec. The circuit in **Fig 6** meets these requirements. As in the circuit in **Fig 3,** an LT1072 switching regulator generates the high supply voltage; an op amp (IC_1) and a buffer amplifier (IC_2) generate the actual V_{PP} pulse. While the Erase/Write lock line is low (**Fig 6b**, trace A), the LT1072 is in standby; no high voltage is produced, and there is no circuit activity. Under these conditions, the V_{PP} output line is pulled toward 5V via the 1N914 diode. (Note the 4.5V dc

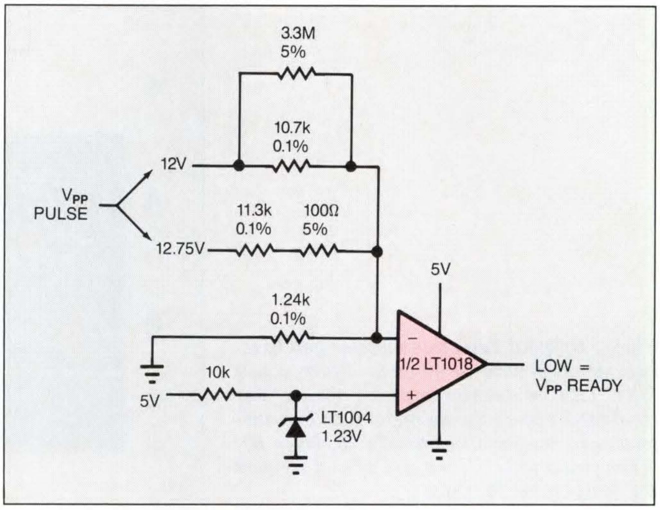
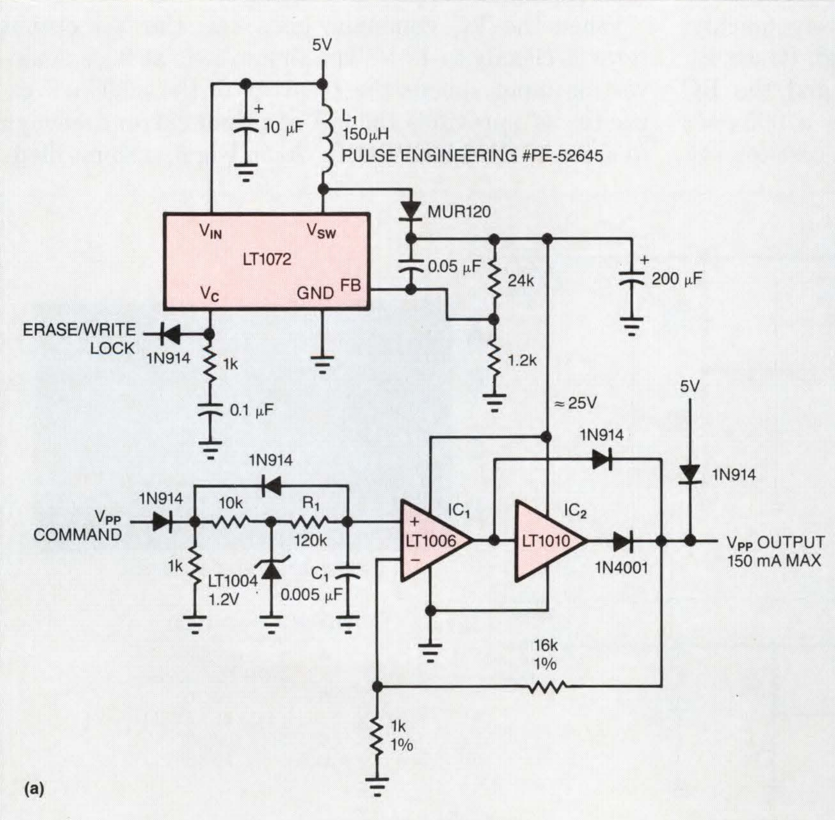
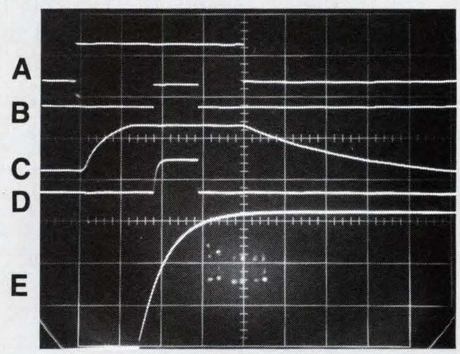


*Fig 5—**Switching-regulator-based circuits require** that you wait a certain length of time for the regulator output to settle before you begin a V_{PP} operation. This simple comparator circuit provides a handshake output when either of these two V_{PP} levels has reached its final value.*





TRACE	VERTICAL	HORIZONTAL
A	5V/DIV	10 mSEC/DIV
B	10V/DIV	10 mSEC/DIV
C	20V/DIV	10 mSEC/DIV
D	20V/DIV (ON 4.5V DC LEVEL)	10 mSEC/DIV
E	5V/DIV (ON 4.5V DC LEVEL)	1 mSEC/DIV

(b)

*Fig 6—**EEPROM high-voltage programming requirements** are similar to those of flash memory. EEPROMs require 21V amplitude pulses with RC time constants of 600 μsec. A simple modification of **Fig 3**'s input **(a)** provides rise-time control via R_1 and C_1. By choosing R_1 and C_1 so that their product equals 600 μsec, the output-pulse conditions are met (**b**, trace E).*

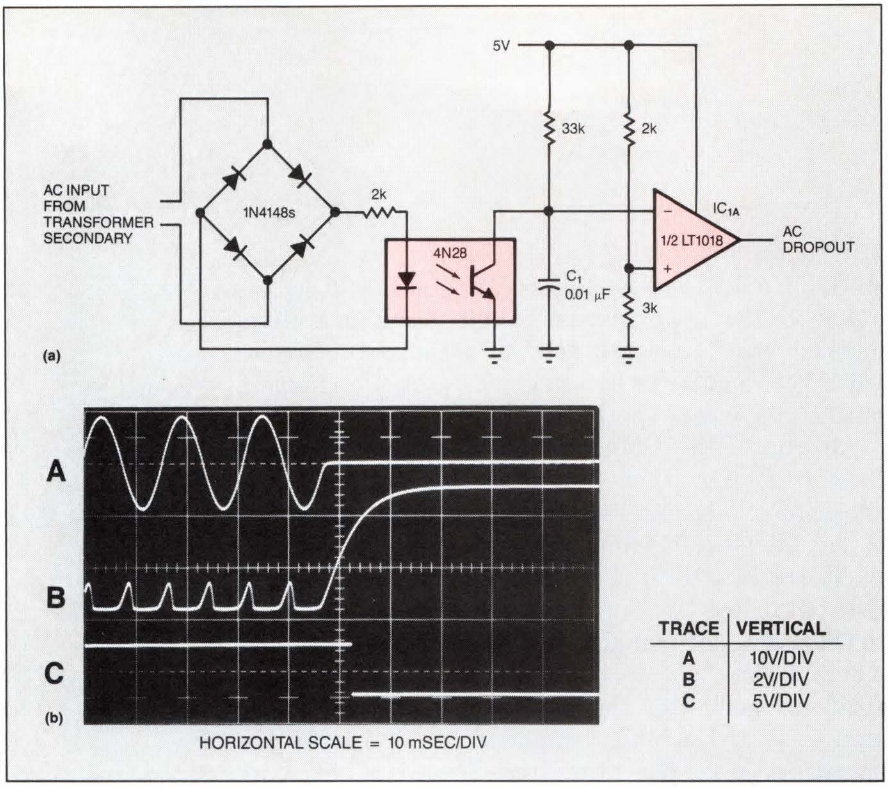


***Fig 7—Dropout detection enables you to issue** memory-store commands before power fails. This ac detector uses an optoisolator connected across the secondary of a transformer to continually reset C_1 (**b**, trace B). When power fails, C_1 charges up and triggers the comparator (**b**, trace C).*

level on traces D and E of **Fig 6b.**)

When the Erase/Write lock line goes high (trace A), the regulator output (trace C) builds smoothly and regulates at 25V. The 2-pole LT1072 compensation allows the regulator output to rise relatively quickly. When the V_{PP} command line is pulsed high (trace B), the LT1004 reference clamps at 1.23V, and the RC network made up of R_3 and C_1 delivers a 600-µsec edge to IC_1's positive input. The feedback-resistor values chosen produce 21V at the V_{PP} output (trace D). The 21V amplitude is ensured by the LT1004 reference and closed-loop operation. Trace E is a time- and amplitude-expanded version of this pulse.

When the V_{PP} command goes low, the V_{PP} output returns cleanly to 4.5V. The shunt diode at IC_1's noninverting input speeds the recovery of the 0.005-µF capacitor. IC_2 provides 150 mA of output current, enough to drive 10 2816 EEPROMs. As in **Fig 3**, a shunt diode

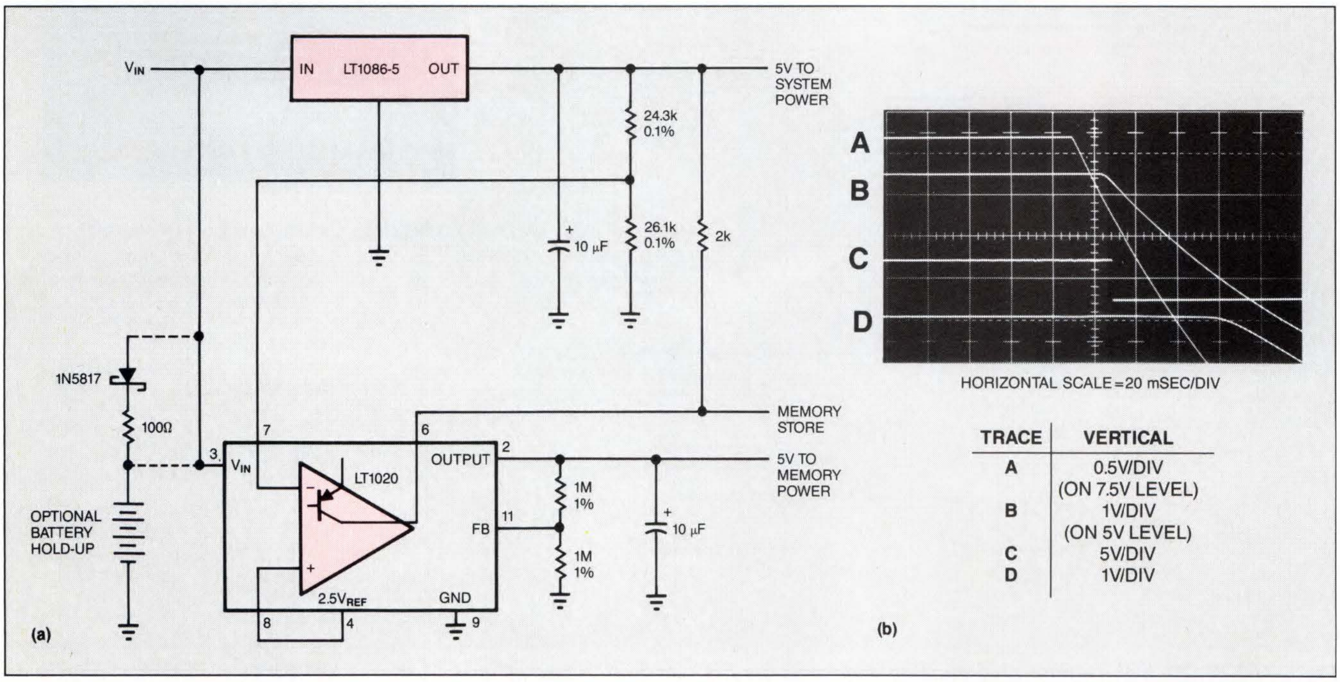
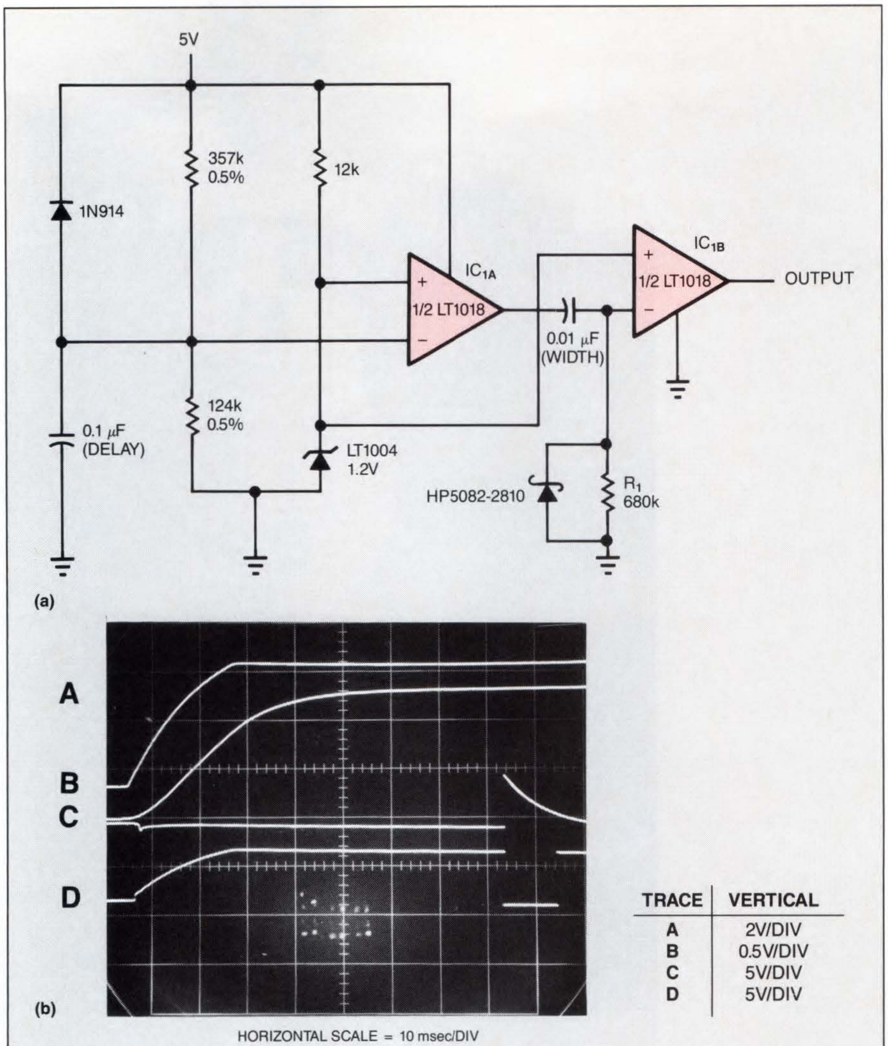


***Fig 8—By making use of two 5V dc regulators (a),** you can alert the memory section to store data (**b**, trace C) before the memory power fails (trace D).*



TRACE	VERTICAL
A	2V/DIV
B	0.5V/DIV
C	5V/DIV
D	5V/DIV

Fig 9—The flexible power-on-reset circuit *shown in* ***a*** *lets you modify the delay between the power onset and the pulse-onset trigger (**b**, trace C). The circuit also lets you modify the reset pulse-width by changing R_1 and C_1 (**b**, trace D).*

around the LT1010 prevents overshoot when the circuit is recovering from output shorts. When the Erase/Write lock line returns low, the regulator's output decays toward zero. As with the other V_{PP} circuits, this design does not produce undesired outputs during power-up or power-down.

Digital systems driven from the ac power line often require dropout detection. You'll want to implement fast ac line dropout detection in order to issue a memory-store command before the dc power falls. The circuit in **Fig 7** detects ac dropout by connecting an optoisolator across the power transformer's rectified secondary. Under normal power conditions, the ac line (**Fig 7b,** trace A) turns on the LED every 8 msec, or ½ cycle of the line. This repetitive action causes the output transistor to continually discharge the 0.01-μF capacitor (trace B). However, when the ac line drops out, the capacitor charges via the 33-kΩ resistor. IC_{1A} compares the resultant ramp voltage to a 5V supply-derived reference. In this case, the 2-kΩ and 3-kΩ resistors bias IC_{1A} to go low (trace C) within one cycle of ac line dropout.

In many cases, you won't have access to the ac power line. Such cases include PC add-on memory applications and battery-powered systems in which there simply isn't any ac power available. When ac line dropout detection isn't feasible, you'll have to implemement a dc-sensing circuit, such as the one shown in **Fig 8a.** This circuit uses the different dropout voltages of two regulators. Under normal operating conditions, the LT1086 supplies 5V power to the main system, and the LT1020 drives the memory section.

When the input power falls (**Fig 8b**, trace A), the LT1086 drops out first (trace B). This voltage change is detected by the LT1020's onboard auxiliary comparator, which then goes low (trace C). This action alerts the memory section to store data. The LT1020 regulator output (trace D) maintains memory power for an additional amount of time due to its low-dropout characteristics. The LT1020's output begins to fall approximately 50 msec after the memory-store command. You can include the optional battery and diode as shown in **Fig 8a** to extend the holdup time.

In addition to these power-fail circuits, digital systems often require power-up circuitry, such as power-on-reset. When supply power is applied to the circuit in **Fig 9a,** the 5V rail comes up (**Fig 9b**, trace A). The LT1004 clamps at 1.2V, and IC_{1A}'s positive input (trace

APPLICATION SPECIFIC PLASTICS FROM PHILLIPS 66

CONNECTING VALUE WITH PERFORMANCE

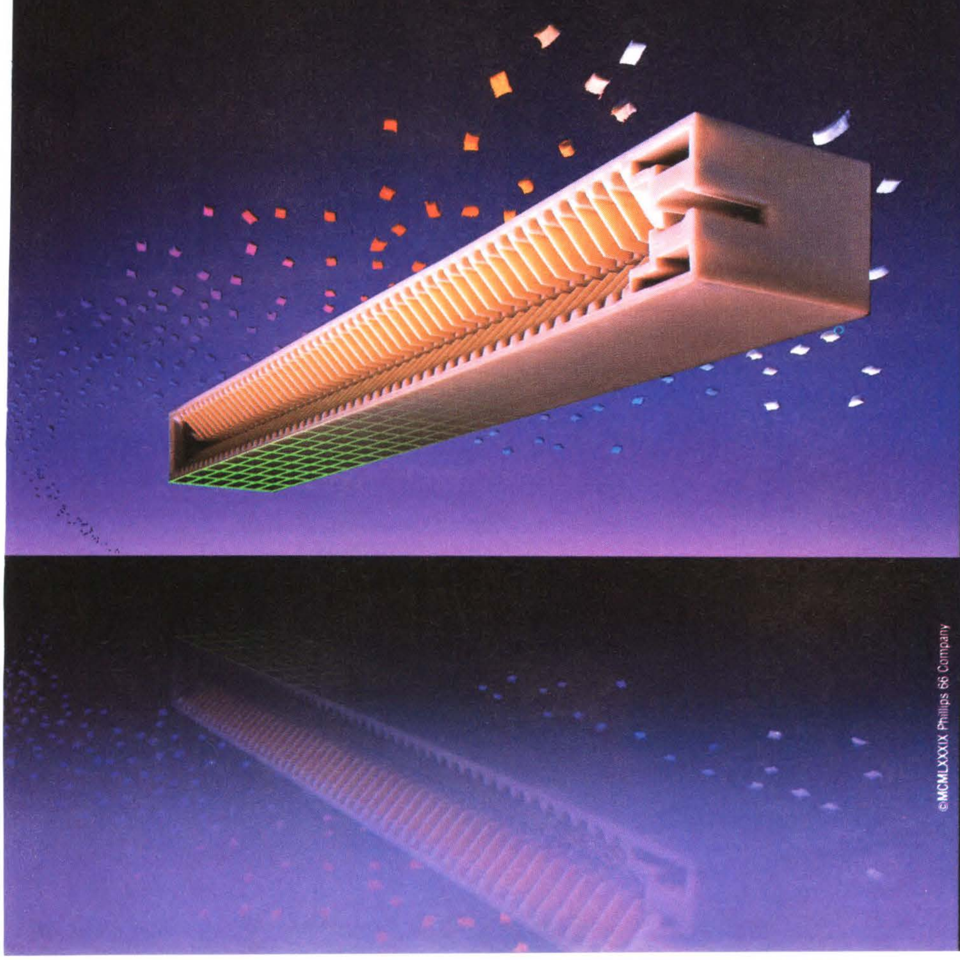
Performance and value. You can get both with Aspect™ TPPE from Phillips 66. This engineering thermoplastic polyester gives you:

- Improved flow and processability to help you mold complex, intricate parts—easily and precisely, at low injection pressures.
- Long-term thermal performance—retaining over 50% tensile strength after 17 weeks at 220° C.
- Excellent electrical properties—offering high arc resistance and low dielectric constant.

Aspect™ TPPE is ideal for applications such as high density interconnectors; thin, intricate and hard-to-mold bobbins; terminal blocks; and fuse holders.

With Application Specific Plastics such as Aspect™ TPPE from Phillips 66 you can take advantage of the expertise of the Phillips 66 Plastics Technical Center . . . its research and development and advanced molding facilities, the computer-aided design capabilities, the experienced staff, and more.

Phillips 66 offers other Application Specific Plastics for your electrical/electronic needs: Ryton® PPS, Ryton® S PPSS, and Crystalor™ PMP. For more information call toll free ***1-800-53-RESIN***. Or Telex #492455.



ASPECT™ TPPE

PLASTICS WITH POWER TO WIN™

PHILLIPS 66

CIRCLE NO 80

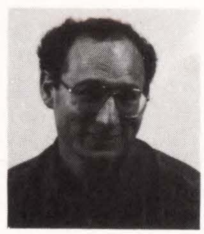
B) ramps at a time constant determined by the 0.5% resistors and the 0.1-μF capacitor. When IC_{1A}'s positive input ramps beyond the LT1004 potential, its output goes high, which delivers a differentiated pulse to IC_{1B}'s negative input (trace C). IC_{1B}'s output (trace D) then goes low for a period determined by the differentiator made up of R_1 and C_1. This pulse is used for system reset.

The 1N914 quickly resets the 0.1-μF delay capacitor, and the Schottky diode clips differentiator-caused negative voltages at IC_{1B}'s input. The ratio of the 0.5% resistors determines the turn-on threshold, in this case 4.8V. The output-pulse delay time—the time at the onset of the pulse in relation to the 5V rail—is controlled by the 0.1-μF capacitor; you can vary the delay time by changing the value of the capacitor. Similarly, the RC combination at IC_{1B} sets the output pulse width and may be similarly varied. As previously discussed, the LT1018's 1.2V minimum supply voltage prevents spurious output during supply power-up. EDN

References

1. Williams, Jim, "Regulator IC speeds design of switching power supplies," *EDN*, November 12, 1987, pg 193.

Author's biography



Jim Williams, staff scientist at Linear Technology Corp (Milpitas, CA), specializes in analog-circuit and instrumentation design. He has served in similar capacities at National Semiconductor, Arthur D Little, and the Instrumentation Development Lab at the Massachusetts Institute of Technology. A former student of psychology at Wayne State University, Jim enjoys tennis, art, and collecting antique scientific instruments.

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

If indicator lights look like this to you, look away.

Perhaps it's the brilliant colors. Or the sparkle of chrome. Somewhere along the way, the people who buy, and even the people who build indicator lights have come to think of them as little more than ornamentation.

Dialight disagrees. The way we see it, an indicator light might be the only way of knowing a critical system is on, off, up, down, hot, cold, dead or alive. An attitude you can see in every model of our incredibly wide selection.

Take our sub-sub-miniature incandescents, for example. Each fitted with a high reliability filament lamp enclosed in a high-impact, plastic cap. The lens is molded directly to the mounting bushing for added strength. The entire assembly is available in a wide variety of colors and meets the requirements of MIL-L-3661B.

With caps constructed of lexan to survive high-heat lamps, we've engineered indicators for continuous usage at levels to 250V.

And to provide operation at a specific voltage level while preventing instantaneous burnout, our neon indicators are ballasted with integral current limiting resistors.

We've even designed a line of ultra-miniature incandescent and neon indicators with plug-in replacement cartridges that make changing lamps a snap.

Incandescents, neon and LED indicators available in a virtually limitless range of colors, sizes, configurations and mounting styles. In fact no one makes more indicator lights for more applications than Dialight. Even designs that meet MIL-L-85762A night vision requirements and other military specifications.

If you're starting to look at indicator lights the way we do, we suggest you continue to do so in our catalog. It's available free by dialing 201-223-9400. Or by writing; Dialight Corporation, 1913 Atlantic Avenue, Manasquan, NJ 08736.

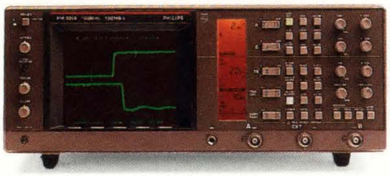
DIALIGHT CORPORATION
A Cambridge Electronic Industries Company

Engineering is the only commodity we sell.

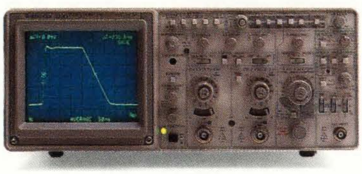
CIRCLE NO 83

FLUKE

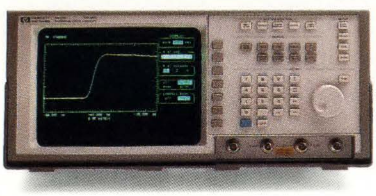
Compare our DSOs and you'll find a



PM 3365
Fluke



2230
Tek®



54501A
HP®

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

*10 points per period.

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

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

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

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

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

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

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

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

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

PHILIPS

to TEK® and HP® handy difference.

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

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

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

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

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

*Offer good only in North America.

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

CIRCLE NO 84

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

Name________

Title________

Company________

Address________

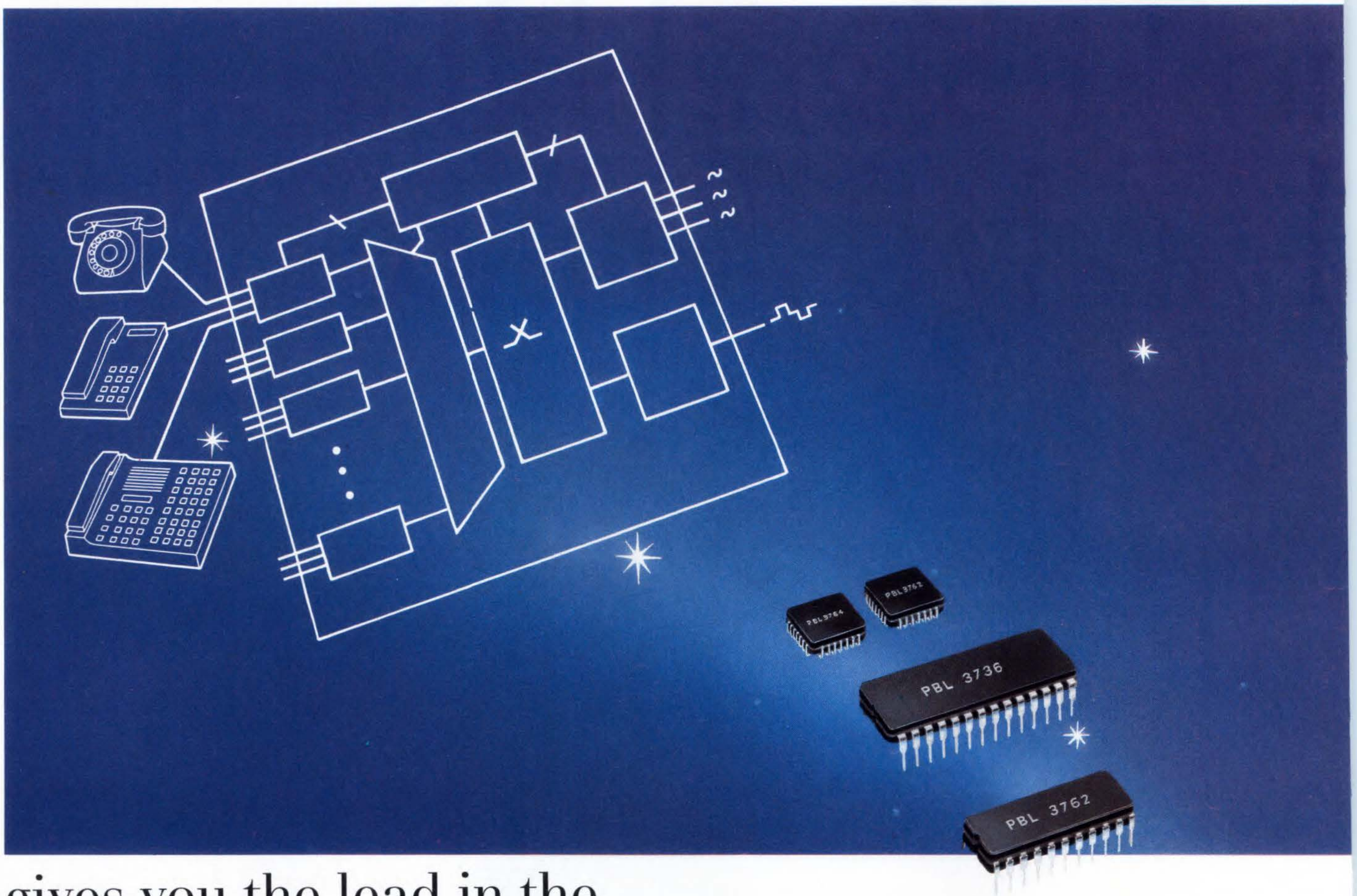
City______ State______ Zip______

Phone________

FLUKE

John Fluke Mfg., Inc., P.O. Box C9090, M/S 250C, Everett, WA 98206. U. S. (206) 356-5400. Canada (416) 890-7600. Other countries: (206) 356-5500. Ad no. 0291-P3350. Tek® & HP® are registered trademarks of Tektronix, Inc., and Hewlett-Packard, Inc.

Ericsson Leadership in SLIC IC design,



gives you the lead in the Line Card competition.

Goodbye, bulky transformers.
Hello, slim-line telecom line cards, designed around Ericsson's single-chip Subscriber Line Interface Circuits.
As a major supplier to the world's telecom industry, we believe we have built up more know-how, and put more resources into SLIC development, than any other semiconductor manufacturer.
To all designers of PBX, Central Office and Subscriber Loop Carrier Equipment, Ericsson offers wide selection, unmatched quality and genuine applications assistance in reaching the most cost-effective line interface solutions.
Contact us for more information.

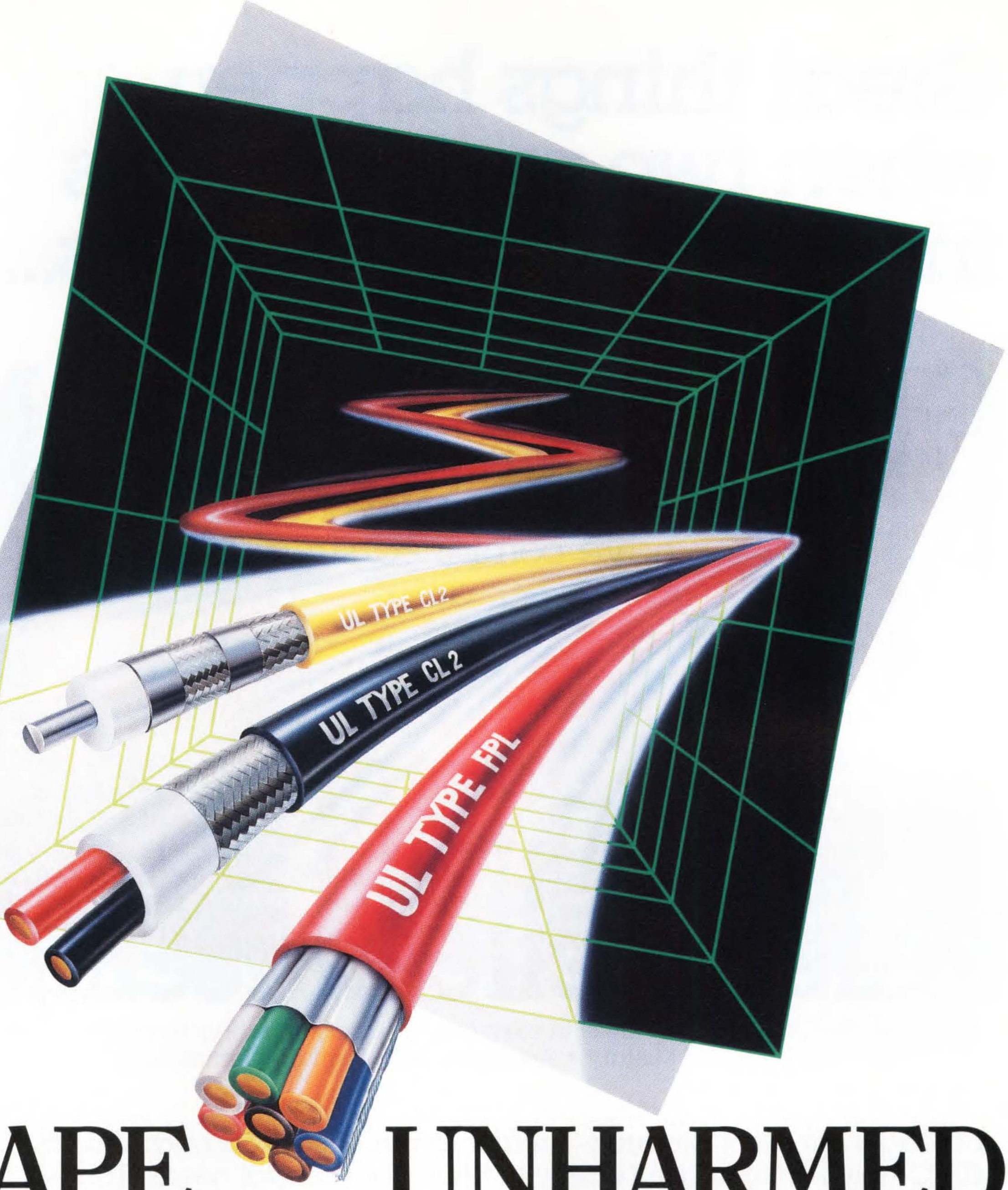
Ericsson SLIC family.

★ PBL 3762/64/65. High-performance SLICs with 70dB typical longitudinal balance.
★ PBL 3796/98/99. Central Office SLICs with 70dB longitudinal balance, plus on-chip switch-mode voltage regulator.
★ PBL 3736/39. Standard second-sourced SLICs, with switch-mode voltage regulator, for power-efficient line card design.
★ −40°C to +85°C versions available.

ERICSSON

We're in the lead

Ericsson Components Inc.
403 International Pkwy
Richardson, TX 75085-3904
Telephone (214) 480-8300
Telefax (214) 680-1059
CIRCLE NO 85



ESCAPE UNHARMED

With NEC Code approved cable from Manhattan.*

The heat is on! The NEC ruled that by July 1, 1988, all electronic cable installed through walls, floors or ceilings must be UL listed and meet the new fire safety requirements.

We're cable ready to meet your NEC Code needs from the industry's largest inventory. Our twelve regional sales centers are ready to ship cables that meet the requirements of installers, electrical contractors and OEM's, within 24 hours.

Call today for technical literature and ordering information on the 1987 NEC Code Cable. Escape Unharmed!

Manhattan
ELECTRIC CABLE CORPORATION

Station Plaza, Rye, New York 10580
Toll Free **1-800-228-MECC**

CIRCLE NO 86

NEC is a registered trademark of the National Fire Protection Association, Inc., Quincy, MA.

Great things happen when two major names in electronics join forces...

CTI

Circuit Technology, Inc.
and
Marconi Electronic Devices Incorporated
have combined strengths
as...

MEDI

Marconi Circuit Technology

Now your first choice for the finest in electronic products and services for every critical application.
Military ▪ Aerospace ▪ Industrial ▪ Commercial

A broader range of products, greater depth of support and expertise. You'll find it at MCTC—plus an increased ability to serve your special needs. There is greater strength in unity...further improvement in design capability, larger and improved manufacturing facilities ready to provide you with everything you require, on time, on spec and within budget.

Products cover frequency ranges from DC to gigahertz, power ranges from micro to megawatts and functions from discrete diodes to complete microprocessor based control systems and microwave radar subsystems for use in industrial to radiation hardened space applications.

Marconi Circuit Technology Corporation

45 Davids Drive, Hauppauge, New York 11788
(516) 231-7710/FAX: (516) 231-7923

Marconi
Electronic Devices

Marconi Electronic Devices Ltd.
Dodington Road
Lincoln LN6 3LF England, U.K.
Tel: 011-44-522-500-500
Fax: 011-44-522-500-550
Telex: 56380

Marconi Circuit Technology Corporation
45 Davids Drive, Hauppauge
New York 11788 U.S.A.
Tel: (516) 231-7710
Telex: 275801
Fax: (516) 231-7923

Marconi Electronic Devices
2 Rue Henri-Bergson
92600 Asnieres, France
Tel: (1) 47 33 51 45
Telex: 612850
Fax: (1) 47 33 11 31

Marconi Electronic Devices
Landeberger Strasse 65, D8034
Germering, West Germany
Tel: 49 898 49360
Telex: 5212642
Fax: 49 898 419142

CIRCLE NO 87

DESIGNER'S GUIDE

dyanmic RAMs
Part 3

Design a DRAM controller from the top down

To implement a DRAM system, you need a DRAM controller, which acts as a liaison between the CPU and the DRAM. This article, part 3 of a 4-part series, presents the basics of DRAM-controller design. Parts 1 and 2 of this series introduced the fundamentals of DRAMs and the architectural options available to the DRAM-system designer. Part 4 will consider DRAM-board layout.

Robert Adams and Gregory Scavone,
Texas Instruments

The heart of any memory system that uses dynamic RAMs (DRAMs) as building blocks is the DRAM controller. The simplest way to design a DRAM controller for your memory system is to perform "top-down" design. To design from the top down, you first consider what tasks the DRAM controller must perform, or, more specifically, what functions the controller must have. You then divide the functions into functional blocks and design or implement each one separately. Finally, you connect the functional blocks and design some circuitry to supervise their interaction.

Essentially, what a DRAM controller does is to coordinate the handshake between the system's CPU (or CPUs) and its DRAMs to facilitate efficient data transfer. The controller is responsible for establishing all of the DRAM's row and column addresses, timing parameters, refresh requirements, and access-mode sequences. A typical DRAM controller consists of a number of functional blocks that are interconnected with a sequential machine, which performs the supervisory tasks. It is instructive to look at each functional block separately before considering how to interconnect the blocks.

One of the DRAM controller's functions is to accept an N-bit address from a CPU and split it in half to produce a row and a column address for the DRAM. Because DRAMs are configured to accept the row and column addresses on the same pins, the controller requires a block that multiplexes the upper and lower halves of the N-bit input address onto an output address bus. A row- and column-address multiplexer block is shown in **Fig 1a.**

Some CPUs, such as the Intel 8086 µP, have a multiplexed address/data bus. In order to use these CPUs, you need some external circuitry to latch the address before the CPU can place the data on the bus. On the other hand, many CPUs, such as Motorola's 68000 µP, have separate address and data buses that don't require external latches. One way to handle both these types of CPU is to use transparent external latches.

A transparent latch, such as the one shown in **Fig 1b**, is a functional controller block whose outputs follow the address inputs when the latch-control signal is low. When the latch-control signal goes high, the latch holds the last address on the input address bus. This configuration can support CPUs with separate address and data buses by simply keeping the latch in its transparent condition. For a CPU with a multiplexed address and data bus, the latch-control signal causes the address to be held while the CPU places the data on the input bus.

Of course, the controller must guarantee that all of

The DRAM controller consists of a number of functional blocks that are interconnected with a sequential machine.

the DRAMs in the memory system are refreshed within the maximum allotted refresh period. The methods of refresh are numerous—RAS-only refresh, burst refresh, RAS-before-CAS refresh, or scrub refresh, to name a few (see part 1 of this series, "Unraveling the intricacies of dynamic RAMs," EDN, March 30, 1989, pg 155). Some refresh methods require more circuitry than others.

The RAS-only and the scrub refresh methods require the largest amount of internal DRAM-controller circuitry. In the RAS-only method, the controller provides a new row address every refresh interval, which is every few microseconds. An N/2-bit counter can easily generate the necessary row-refresh addresses. The outputs from the counter feed the row-and-column multiplexer, which drives the row-refresh address onto the output bus at the refresh interval.

In the scrub refresh method, the controller must generate a row and a column address every refresh interval. You can meet this requirement by extending the counter to N bits. **Fig 1c** shows the functional blocks that can perform both RAS-only and scrub refresh. When using the scrub refresh method, you shoud use the lower bits of the counter as the row address to ensure that each row is accessed once for each column. Using the lower bits as the row address maintains the refresh interval.

Other refresh methods, such as the RAS-before-CAS method, use an address counter that is internal to the DRAM. Therefore, the controller doesn't require an internal counter, a fact that significantly simplifies the controller's design. In either case, the controller must contain a timer that establishes the start of a refresh cycle.

Address generation and refresh are only part of the controller's functions. The controller must also contain a functional block that interfaces the control signals with the system CPU. To keep the host-interface block modular, you should make sure that the block produces the same output signals, regardless of the variations in the control-signal formats. That way, to accommodate different system CPUs, you only have to alter the interface block.

Systems with multiple CPUs require multiple control-signal interfaces, a fact that further complicates the controller design. With multiple interfaces and one refresh timer, the controller must contain an arbiter, which schedules access request from the CPUs. **Fig 2** shows a block diagram of a DRAM controller, including the CPU-interface and arbiter functions.

You'll note that the refresh counter doesn't enter into the arbitration process with the system CPUs. Even though refresh is a valid memory request, the DRAM controller performs the refresh as a top-priority item. Because the controller is responsible for refreshing all of the DRAM cells within the specified refresh period, it treats a refresh as a "super" request that supercedes all other memory requests.

To coordinate the activities within the DRAM controller, the design requires a block that can interconnect the functions. A state machine performs this task efficiently (**Fig 3**). After executing an initialization sequence, the state machine accepts a request from the arbiter for DRAM access. The state machine controls the multiplexer, via the S_0 and S_1 signals, to place the row address and the column address on the controller's output bus. The state machine also issues a combination of $\overline{RAS}$, $\overline{CAS}$, and $\overline{WRITE}$ signals; the particular

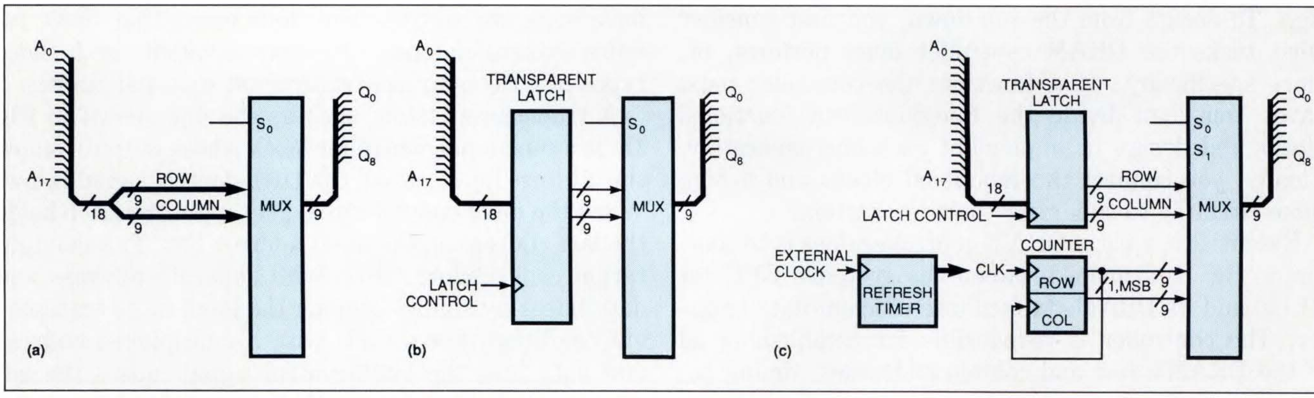


Fig 1—You build a DRAM controller from a number of functional blocks. *A multiplexer **(a)** splits the CPU address into a row and a column address. A transparent latch **(b)** permits the controller to handle separate and multiplexed address and data lines. A counter/timer **(c)** generates the refresh addresses at the specified refresh interval.*

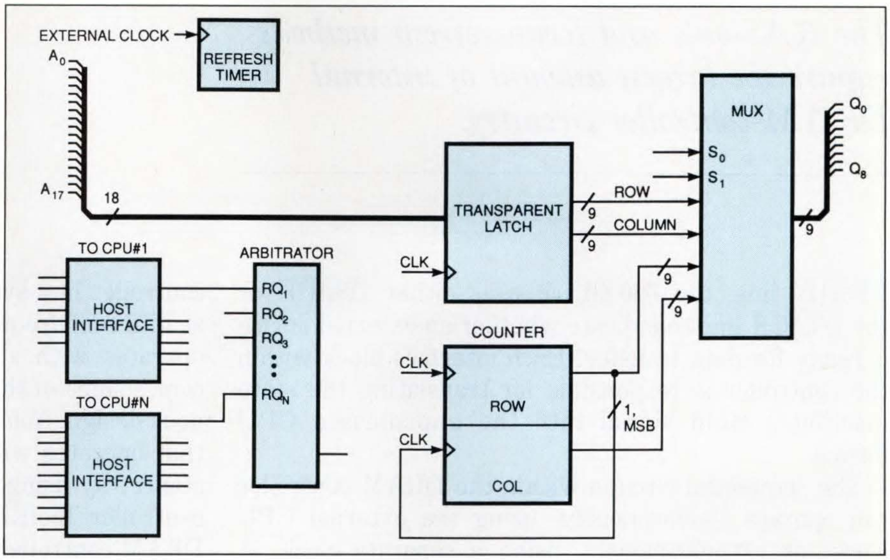


Fig 2—For systems that contain multiple CPUs, *the controller requires a host interface for each CPU. The host interface generates and acknowledges the handshake signals. Each interface must connect to an arbitration block, which grants memory access on a priority basis.*

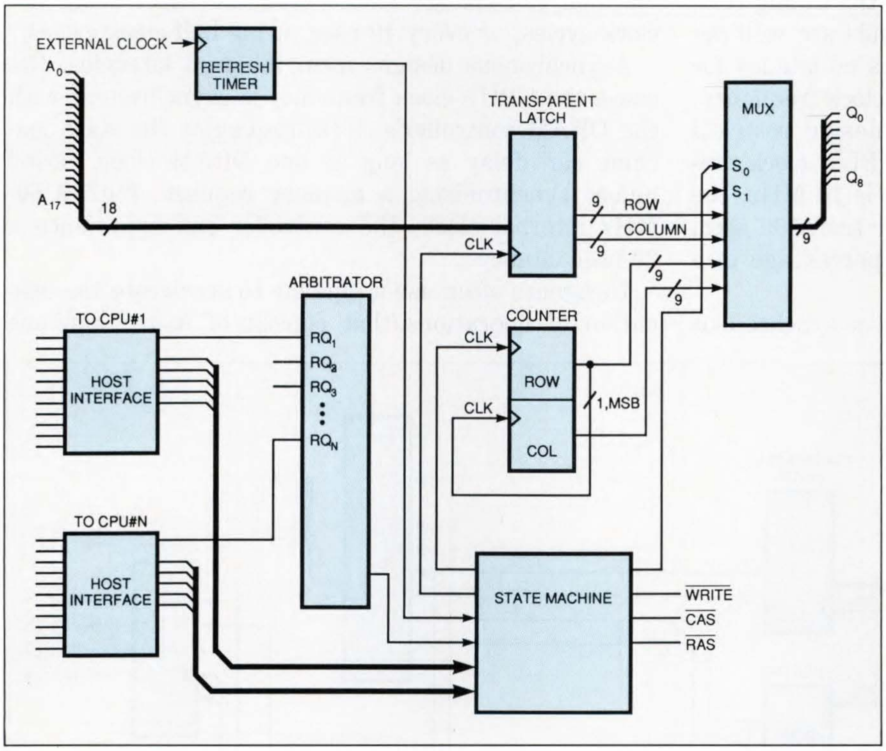


Fig 3—A state machine interconnects *all of the DRAM controller's functional blocks, and implements the memory-access modes as well.*

combination depends on whether the memory request is for a read, write, or refresh operation.

Finally, the controller should have independent control of several banks of memory. The controller needs separate $\overline{RAS}$, $\overline{CAS}$, and $\overline{WRITE}$ lines for each bank in order to achieve this independent control. **Fig 4** shows three demultiplexers, which generate four independent DRAM control signals by using the DRAM control signals from the state machine. Two bank-select lines select the individual control signals. The design includes a chip-select line and output-enable signals for the demultiplexers; both these features allow you to use the controller for larger memory systems.

Although the access times of today's DRAMs continue to decrease, DRAMs are often not able to keep up with current high-speed μPs. In such a case, the μP must execute wait states while waiting for the DRAM to complete an access cycle or a refresh operation. Wait states are CPU clock cycles during which the μP does nothing. Obviously, a CPU that has fewer wait states will execute a program faster than one that has more. Because the μP does not automatically execute wait states, the DRAM controller must provide an external control signal that indicates when the DRAM is ready.

Within the DRAM controller, the interface block sends a signal to the state machine, through the arbiter, when a CPU desires access to the memory. If the memory is busy, the state machine places the interface block "on hold." Subsequently, the interface block sends a control signal that indicates that the CPU should execute wait states. The 8086 μP uses the

The RAS-only and scrub-refresh methods require the largest amount of internal DRAM-controller circuitry.

$\overline{\text{READY}}$ line; the 680X0 µP uses either $\overline{\text{DSACK}}$ or the $\overline{\text{DTACK}}$ line to indicate whether an external device is ready for data transfer. Each interface block within the controller is responsible for translating the state machine's Hold signal into the appropriate CPU format.

The sequential circuits within the DRAM controller can operate synchronously, using the external CPU clock, or asynchronously, using a separate clock. A synchronous design is simpler because the timing relationships between the various commands are well defined. In addition, the controller incurs no latency for synchronizing the commands with the clock frequency. Practically, however, a synchronous design restricts the controller to operating at the CPU's clock frequency. If the CPU's clock frequency is 10 MHz, the state machine can't respond any faster than 100 nsec, which can amount to an appreciable percentage of a typical memory-access cycle.

In addition, you virtually can't use a synchronous controller in a system that has multiple CPUs running at different frequencies. An asynchronous design that operates with a high internal clock frequency overcomes some of the limitations imposed by the synchronous design. You can design an ASIC DRAM controller that operates with a 50-MHz clock frequency, for instance, by using a product such as TI's ASIC DRAM controller ToolKit (see **box**, "ASIC core yields flexible DRAM controller"). In such an ASIC design, the state machine can change states every 20 nsec, using full clock cycles, or every 10 nsec, using half clock cycles.

Asynchronous designs incur inherent latencies. Because the CPU's clock frequency is asynchronous with the DRAM controller's clock frequency, the state machine can delay as long as one DRAM clock period before synchronizing a memory request. With a 50-MHz internal clock, the controller can experience a 20-nsec latency.

Designers often use a pipeline to accelerate the execution of operations that consist of more than one

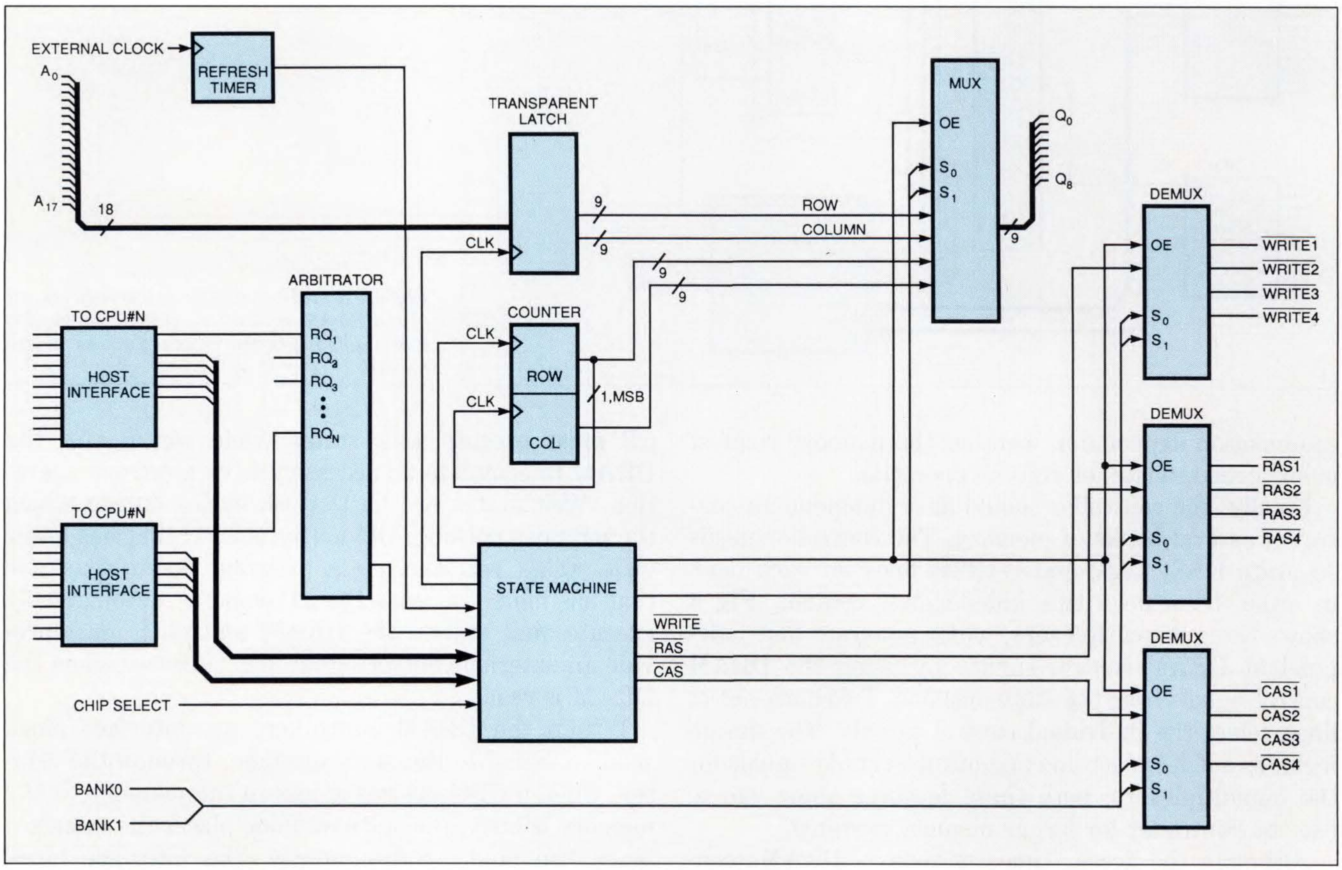


Fig 4—Systems with multiple memory banks *require separate $\overline{\text{WRITE}}$, $\overline{\text{RAS}}$, and $\overline{\text{CAS}}$ lines for each bank. A series of demultiplexers uses bank-select lines to generate these commands.*

ASIC core yields flexible DRAM controller

To build a DRAM controller around an application-specific IC (ASIC) core that can be tailored exactly to a system's needs, you can use TI's ASIC DRAM Controller ToolKit (**Fig A**). The product consists primarily of predefined functional blocks called SuperMacros. Each SuperMacro comprises 1-μm standard-cell elements, such as gates and buffers, and standard-cell soft macros, such as counters and shift registers. The vendor assembles and compiles these standard cells to form the SuperMacro, a hard macro that the ToolKit user can't alter.

Three types of SuperMacros are included in the kit: host interfaces, an arbiter, and a programmable sequence generator. The ToolKit contains several interface blocks for the major μPs, including Intel's 80186, 80286, and 80386 μPs, as well as Motorola's 68020 and 68030 μPs. The ToolKit also lets you design custom interfaces by using the company's standard-cell libraries.

The host-interface block generates and acknowledges the handshake signals between the host processor and the DRAM controller. In addition, it generates the enable and direction-control signals for any external bidirectional buffers, if necessary. A single arbitration SuperMacro can accept memory requests from as many as four host interfaces and grant memory access by using a fixed priority scheme. If there is a single host interface, the arbiter is not required. The programmable sequence generator produces the row and column addresses as well as the $\overline{WRITE}$, $\overline{CAS}$, and $\overline{RAS}$ control signals.

Because the sequence generator is programmable, you can design a DRAM controller that can handle a variety of operating modes. By adding a special port to the ASIC, you can design flexibility into the controller. Essentially, you can alter the timing parameters, access modes, and refresh modes during the power-up sequence. An internal delay-locked loop provides a timing resolution as small as 10 nsec when using an external 50-MHz clock. Further, the sequence generator can be programmed externally to handle many of the access modes and refresh methods described in this series. **Table A** lists some of the modes supported by the tool kit.

In order to design an ASIC DRAM controller, you need an engineering workstation for wiring the SuperMacros together. After this step, you can add whatever customization is necessary to complete the design. Finally, you should simulate the controller design at the workstation before submitting it to the vendor for final approval and fabrication.

TABLE A—DRAM CONTROLLER TOOLKIT MODES

MODE	ARCHITECTURE	RAS-ONLY	CAS-BEFORE-RAS	EDC-SCRUBBING
READ/WRITE	BANK-ORIENTED CAS	YES	YES	YES
	BYTE-ORIENTED CAS	YES	NO	NO
AUTO PAGE	BANK-ORIENTED CAS	YES	YES	YES
	BYTE-ORIENTED CAS	NO	NO	NO
STATIC-COLUMN	BANK-ORIENTED CAS	YES	YES	YES*
	BYTE-ORIENTED CAS	NO	NO	NO

*EDC-SCRUBBING REFRESH MODE CAN BE USED WITH ONLY ONE BANK OF STATIC-COLUMN MEMORY.

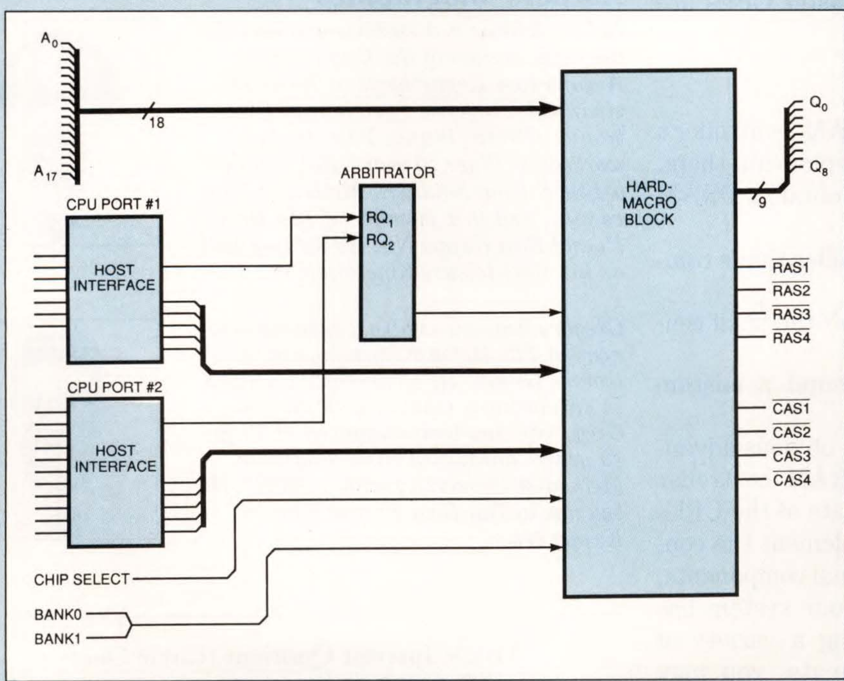


*Fig A—**A number of interconnected SuperMacros** compose the ASIC DRAM Controller ToolKit. The hard-macro block contains the input latch, the refresh timer and counter, the row- and column-address multiplexer, and the state machine, none of which can be physically altered by the user.*

The DRAM controller can take advantage of pipelining by latching the address and data early in the access cycle.

stage. The stages pass sequentially through the pipeline, a process that makes the execution of certain tasks overlap. The DRAM controller can take advantage of pipelining by latching the address and data early in the access cycle. Thus, the CPU or the memory is available for other operations before the cycle is complete. Using a pipeline in a DRAM-controller design is sometimes called the "latch-and-go" technique.

During a latch-and-go write cycle, the DRAM controller latches the address and data from the CPU as soon as they are available. The controller then sends a command that fools the CPU into believing that the write cycle is over. Subsequently, the CPU can release its I/O bus (or buses) and initiate the next operation while the DRAM controller completes the write cycle. The latch-and-go technique can significantly reduce the number of CPU wait states incurred during write operations to slow memory devices.

During a latch-and-go read cycle, the controller latches the CPU address and the data from the memory as soon as the DRAM's output data is valid. This arrangement is particularly useful in systems with multiple CPUs. Essentially, the technique permits slower CPUs to read the latched data while faster CPUs are accessing the memory.

Three ways to obtain controllers

Now that you're aware of the DRAM controller's functions, you must decide how to implement them. You can choose one of three methods to obtain a DRAM controller:

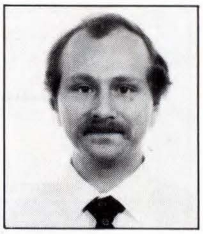
- Buy an off-the-shelf DRAM controller that's compatible with a specific CPU
- Design a DRAM controller from off-the-shelf controller subassemblies
- Design a DRAM controller around a custom ASIC.

An off-the-shelf component has some obvious advantages. Most CPU vendors offer a DRAM controller that is compatible with the signal formats of the CPUs they manufacture. You can usually implement the controller design by using only a few external components, such as 3-state buffers. However, if your system has special requirements, such as servicing a variety of CPUs that have different signal formats, you may spend more time trying to get a standard component to meet all the system requirements than you would if you designed the controller from scratch.

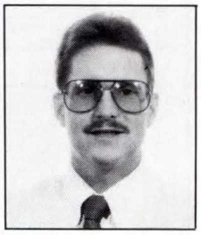
Using off-the-shelf controller subassemblies gives you a wider choice of controller design. IC vendors sell a variety of LSI devices that perform specific DRAM-controller functions. Some of these subassemblies include refresh timers, address and refresh multiplexers, programmable state machines, and page-mode address comparators. Of course, the disadvantage of this approach to controller design is that you need more components than the off-the-shelf method requires.

The custom ASIC design combines the advantages of a single VLSI component with the advantages of using predesigned controller subassemblies. For example, TI's ASIC DRAM Controller ToolKit lets you build a controller that incorporates a "hard macro" containing the state machine, the refresh counters, input latches, and the output multiplexer. The hard macro is a functional block designed and laid out by the vendor; you can't modify it. Therefore, you can be sure that the critical timing relationships for these modules are correct and will remain unchanged. It's up to you to design in the rest of the controller enhancements for your particular application. EDN

Authors' biographies



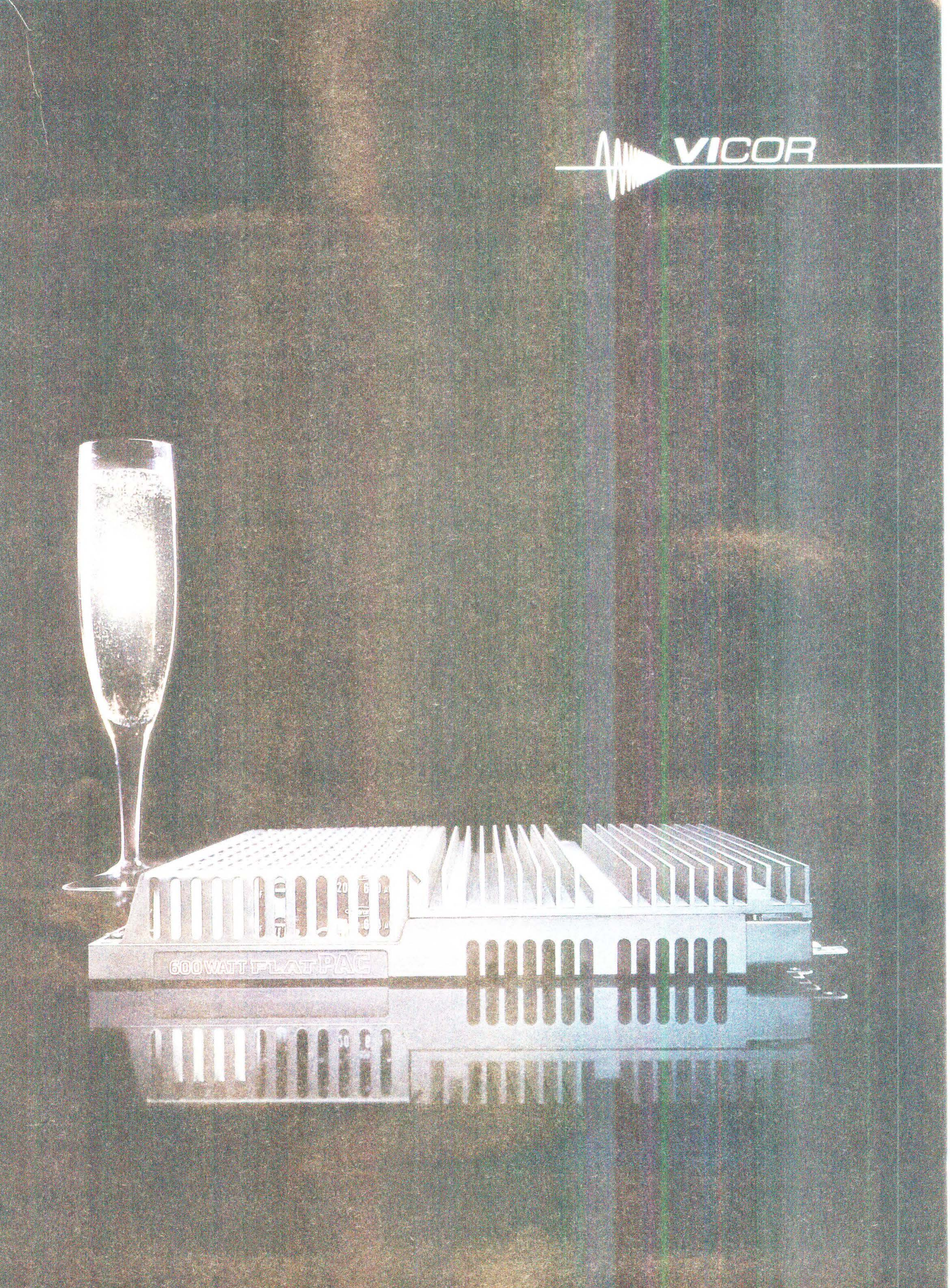
Robert Adams is a systems engineer for the CAE branch of the Engineering Automation Department of Texas Instruments' Defense System and Electronics Group (Plano, TX). He has worked for TI for 10 years. Bob obtained a BSEE from Southern Methodist University, and is a member of Tau Beta Pi and Etta Kappa Nu. He lists softball as his chief leisure-time interest.

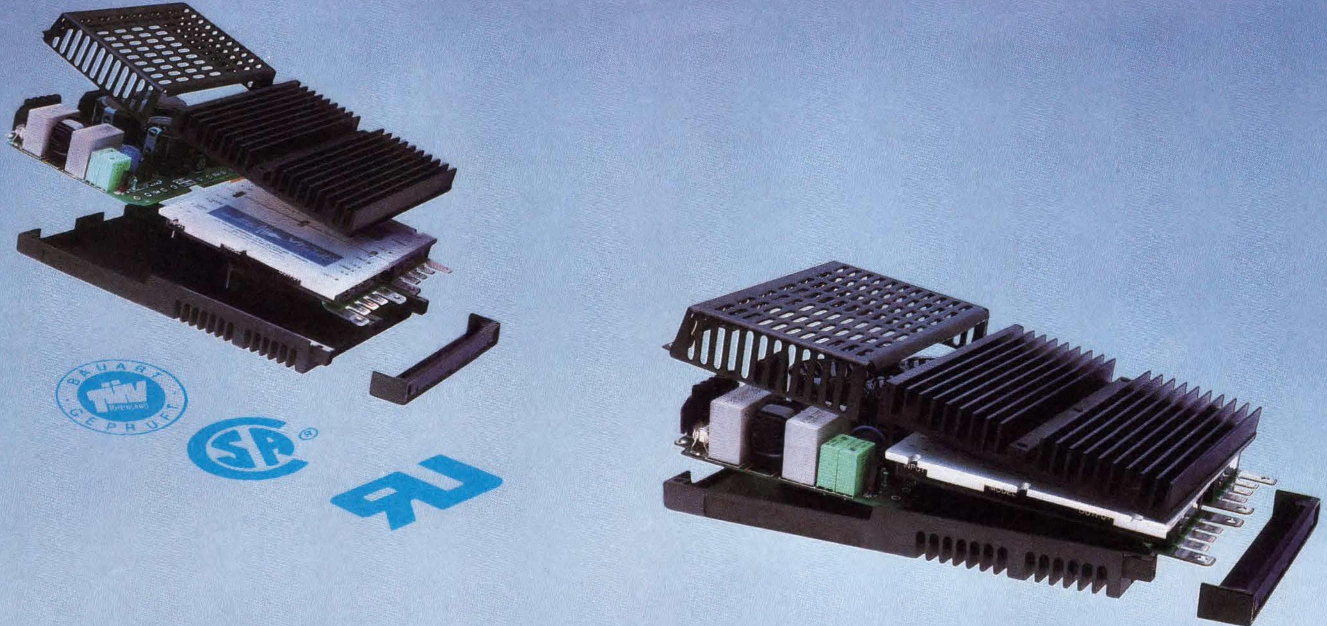


Gregory Scavone is also a systems engineer in TI's Defense Systems and Electronics Group. He's currently occupied in validating a CAE system for EEs. Greg, who has been employed at TI for 10 years, graduated from Southern Methodist University with a BSEE. He belongs to Tau Beta Pi and Etta Kappa Nu.

Article Interest Quotient (Circle One)
High 488 Medium 489 Low 490

VICOR





Celebrating The New Profile

Introducing the FlatPAC™ . . . Vicor's Family of User Definable, Multiple Output, Switching Power Supplies

Until now, your power system decision meant choosing between costly and unpredictable custom development, or bulky and inflexible catalog supplies . . . or you had to design and manufacture it yourself. Taking the next step in the power-component revolution, Vicor introduces FlatPAC, the user-definable, "off-the-shelf" alternative to customs that's economical from single units to OEM quantities . . . and which fits in a fraction of the space required by conventional off-line supplies!

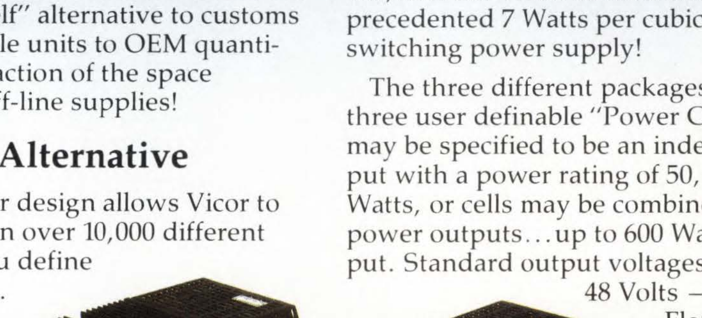
The Off-The-Shelf Alternative

FlatPAC's unique modular design allows Vicor to provide next day delivery on over 10,000 different FlatPAC configurations. You define your power requirements . . . Vicor does the rest – while eliminating the non-recurring costs, unpredictable lead times, risk, inflexibility, and reliability uncertainties associated with conventional solutions. No other power product offers FlatPAC's combination of power density, economy, and "off-the-shelf" flexibility!

Power Cells

Sharing a distinctive, space saving flat package profile (1.37" high x 8.6" long), FlatPACs come in widths of 2.5", 4.9", and 7.4", and supply up to 200, 400, and 600 Watts of total output power . . . an unprecedented 7 Watts per cubic inch in an off-line switching power supply!

The three different packages provide one, two, or three user definable "Power Cells". Each Power Cell may be specified to be an independent, isolated output with a power rating of 50, 75, 100, 150, or 200 Watts, or cells may be combined to form higher power outputs . . . up to 600 Watts from a single output. Standard output voltages are 5, 12, 15, 24, and 48 Volts – and because all FlatPAC outputs are field trimmable down to zero and up to 110% of nominal, a standard output can likely

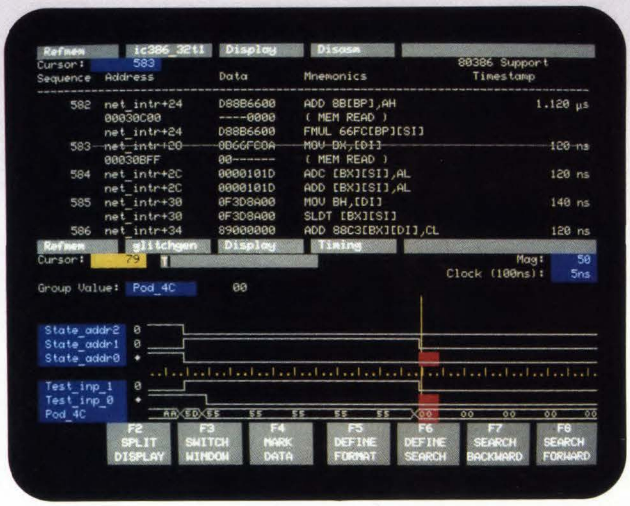


DAS 9200

Why one hour here saves a week anywhere else.

6 μP's AT ONCE

You may not need this kind of integration capacity today. But you can evolve into it, looking at the interactions of all hardware and software components at



Split screen display of data acquired simultaneously from two microprocessors. The cursors can be locked to scroll in parallel, highlighting data nearest to the same point in time.

NOW WITH FASTER μP SUPPORT.

The DAS 9200 Digital Analysis System: Why poke around for the problem when you can attack it on all sides at once, with the world's most powerful accumulation of digital troubleshooting tools? Now we've boosted DAS 9200 capabilities even further with Release 2 hardware and software... including a new high-speed microprocessor interface that pushes the edge of both RISC and CISC micro support.

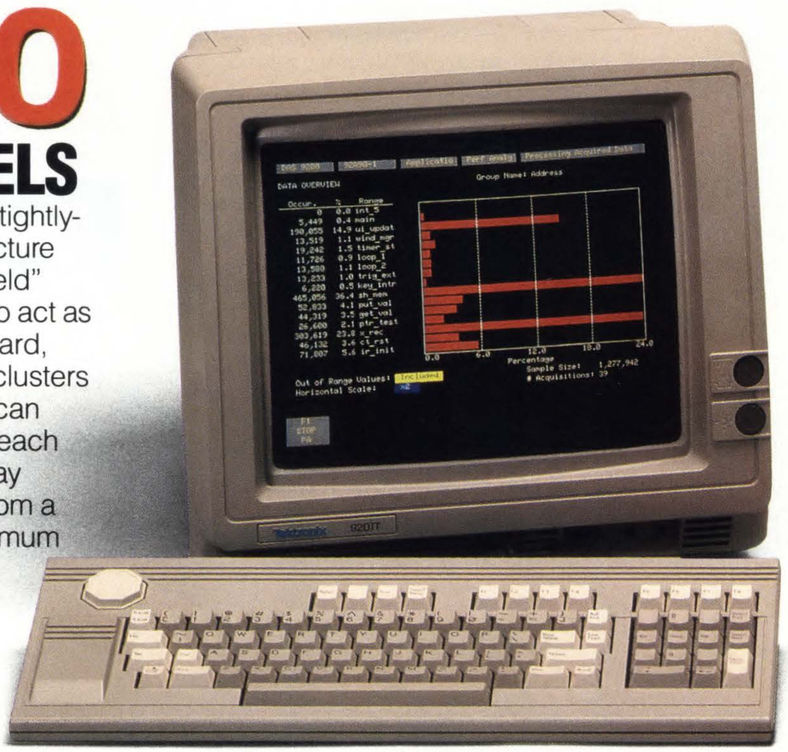
We now offer 33 MHz support for the 68030; 33 MHz for the 68020; 25 MHz for the 88100; and 25 MHz for the 80386—with the capacity for even greater speeds built-in.

128K PER CHANNEL

With the 92A90D acquisition module, you get about 128 times the memory depth of most analyzers. All DAS acquisition cards feature comprehensive triggering, plus selective data suppression, conditional branching, performance analysis, and much more.

540 CHANNELS

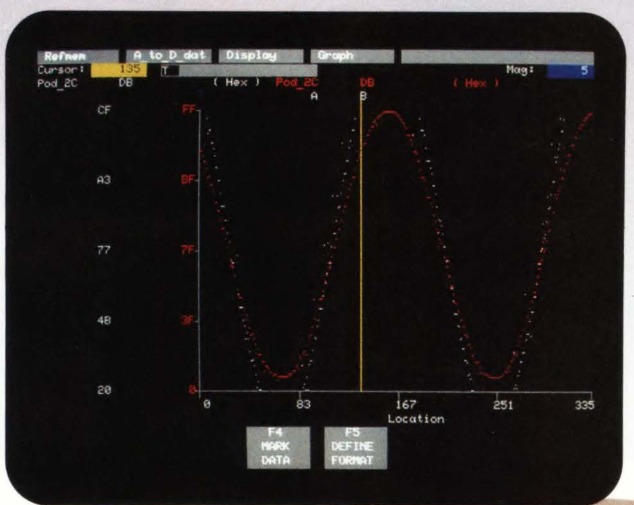
The DAS 9200's tightly-coupled architecture allows you to "weld" cards together to act as a single, wider card, or as individual clusters of modules that can trigger and arm each other, then display information as from a single unit. Maximum configuration: 540 acquisition channels or 1008 stimulus channels.

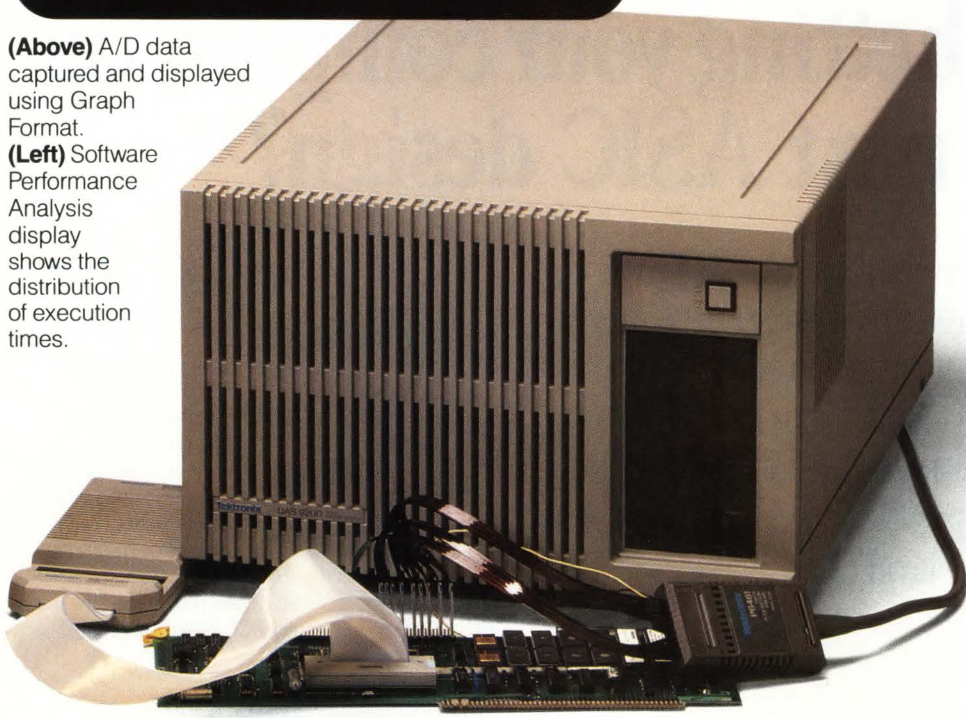


Version 2

once, with true time-correlation of all data.

Monitor the integration of dedicated I/O processors relative to the Main CPU. Test communications links between processors. Display disassembly activity together with high-resolution timing information to relate logic problems relative to specific events.



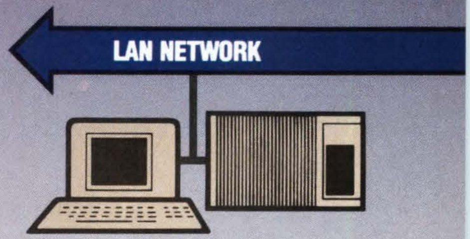


(Above) A/D data captured and displayed using Graph Format.

(Left) Software Performance Analysis display shows the distribution of execution times.

2 GHz

For applications requiring nanosecond edge resolution, the 92HS8 High-Speed Timing Module gives you 2 GHz bandwidth and a 500 ps sample interval, supported by a <1 pf input capacitance probe that eliminates common-mode noise and circuit loading. The 92HS8 also welds together to serve wide, parallel applications with no width/speed tradeoffs.



One new asked-for option is the 92LAN card, allowing the DAS to act a network node for efficient file transfer.

Add in its new 8 MB memory for fast response, new 40 MB hard disk, standard, and an assortment of software enhancements, and you see that the DAS not only started in a league by itself. It's staying there.

To find out more about the DAS 9200, contact your Tek representative, or call 1-800-245-2036. In Oregon, 231-1220.

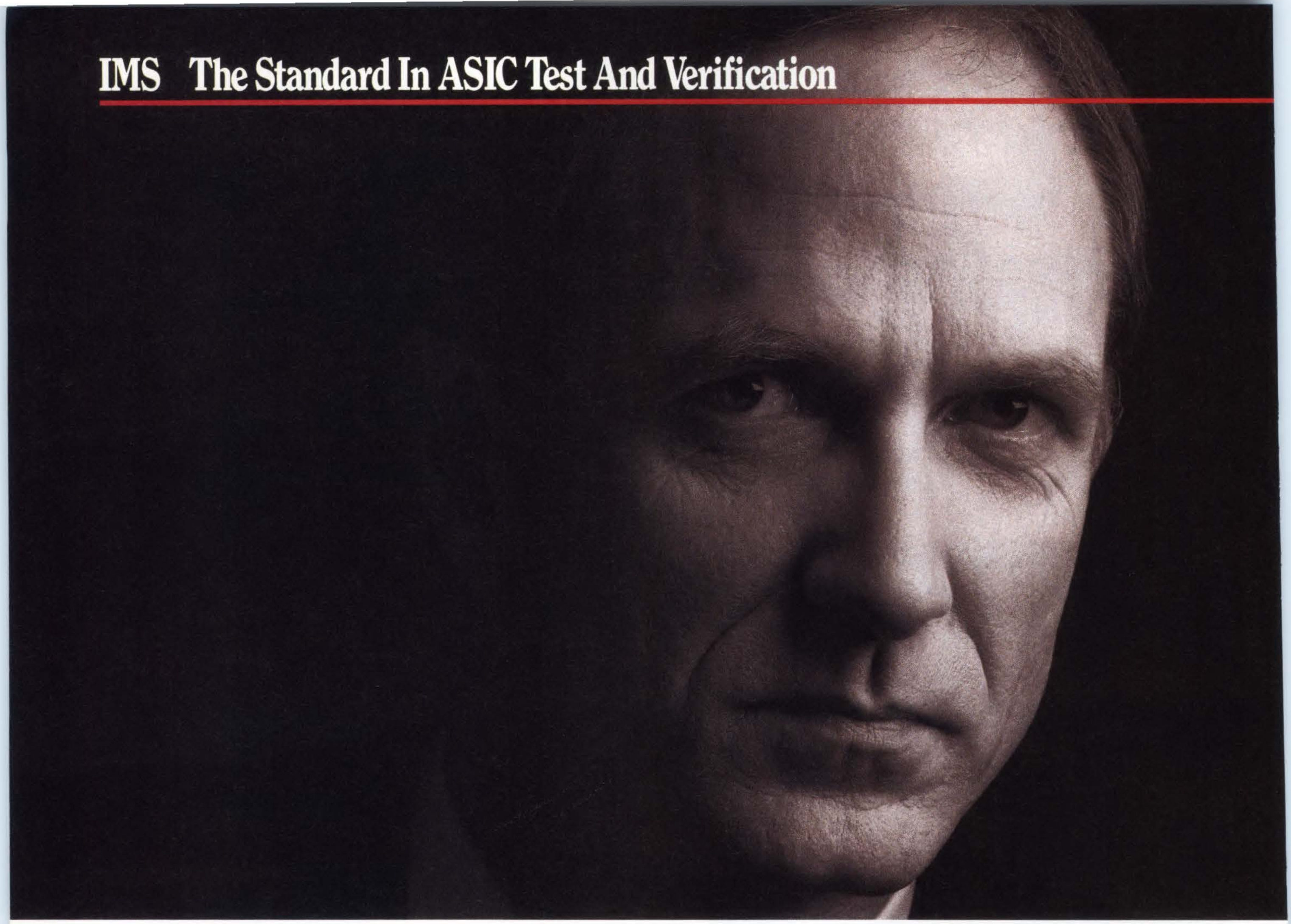
MORE TO COME

Tektronix
COMMITTED TO EXCELLENCE

Circle 6 for literature

Circle 7 for Sales Contact

IMS The Standard In ASIC Test And Verification



"Are you betting your company on your next ASIC design?"

"The wrong decision on when to release a prototype ASIC to manufacturing can mean expensive re-masking, boards that have to be rebuilt and missed commitments to customers. Those costs can kill you. Get the information you need to make the right decision. The Logic Master can be a critical factor in reducing your level of risk. Ask IMS to show you how."

Logic Master Verification Systems from IMS provide test and verification solutions for designers of custom circuits. This complete

family of systems meets all types of hardware verification needs, from benchtop to extremely high performance. Customers at more than 500 installations have proven the performance capabilities of Logic Master Systems in the development of high-speed RISC processors, VHSIC II components and the industry's most complex ECL, GaAs and CMOS devices.

IMS

Integrated Measurement Systems™, Inc.
A subsidiary of Valid Logic Systems
9525 S.W. Gemini Drive, Beaverton, Oregon 97005
(503) 626-7117 • FAX (503) 644-6969

Hybrid-IC techniques increase power in motor-drive circuits

Thick-film, hybrid-circuit motor drivers not only let you save board space, but also preserve the motor-drive ICs' overtemperature protection and provide a high drive output.

Ed Goodell, *Omnirel Corp*

Thanks to the availability of "smart-power" motor-drive ICs, you can control motors in a variety of applications. Problems arise, though, when an application requires more drive current than these ICs can provide. By simply adding output-drive transistors and other discrete components to a motor-drive IC's outputs, you can triple the drive current, but you also increase the board size and sacrifice the benefits of overtemperature protection. However, if you use hybrid circuits that combine a motor-drive IC with high current-output devices, you can minimize the space requirement of motor-control circuitry, preserve the IC's inherent thermal-protection capabilities, and obtain the power that your application requires.

A variety of motor-drive ICs that you might employ for servo applications use pulse-width-modulation techniques. Consider, for example, the industry-standard 2935 family of bipolar half-bridge drivers, which are available from Sprague Semiconductor, National Semiconductor, SGS-Thomson, Texas Instruments, and Silicon General. This type of driver **(Fig 1)** combines a source and sink output stage with diode transient protection, level shifting, logic stages, and a zener-diode voltage regulator that lets the IC operate from 8 to 35V power supplies. The device accepts TTL-level inputs from a variety of PWM controller ICs.

In addition, the 2935 incorporates an overtemperature shutdown capability and a logic-lockout feature that prevents the source and sink output drivers from turning on simultaneously. If lockout occurs, the output assumes a 3-state (high-impedance) characteristic. In its TO-220-style power package, which has an integral heat-sink tab, the 2935 can provide ±2A continuous current and ±3.5A peak current to a motor winding. To drive motors that require more current, you must add an external output stage that uses either bipolar power transistors or power MOSFETs.

Avoid simultaneous conduction

To obtain additional current, you may be tempted to add a pair of complementary power MOSFETs to the output of a 2935 motor driver. **Fig 2** shows a simple way to drive the p-channel Source driver and the n-channel Sink driver. The circuit is simple, but it presents several problems. First, the configuration gives rise to large crossover currents; that is, there is an interval during the transition from sinking to sourcing or vice versa when both Q_1 and Q_2 are on. During this transition interval, the power MOSFETs form a crowbar across the power-supply terminals, and enormous currents flow through the short circuit.

Another problem arises when the 2935's output assumes its high-impedance state. This condition occurs when both the Source and Sink logic inputs to the IC

You can use a 2950 motor-drive IC in one side of the bridge and a 2935 in the other side to provide a 180° phase differential.

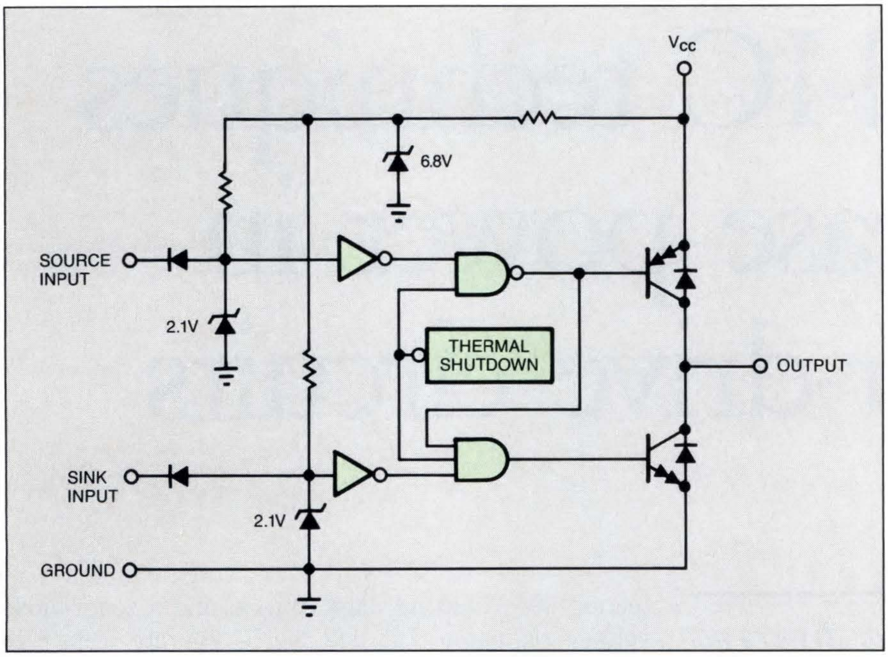


Fig 1—The multisourced 2935 motor-drive IC *supplies ±2.5A continuous current from 8 to 35V supplies. It has overtemperature shutdown and a logic-lockout feature that prevents the two output drivers from conducting simultaneously.*

are high (a forbidden, but nonetheless possible fault state). During this state, both Q_1 and Q_2 turn on, and, again, constitute a crowbar across the supply terminals. Invariably, at least one power MOSFET burns out.

Your goal, therefore, is to minimize crossover currents during the output transitions and to prevent output conduction when the 2935's output assumes its

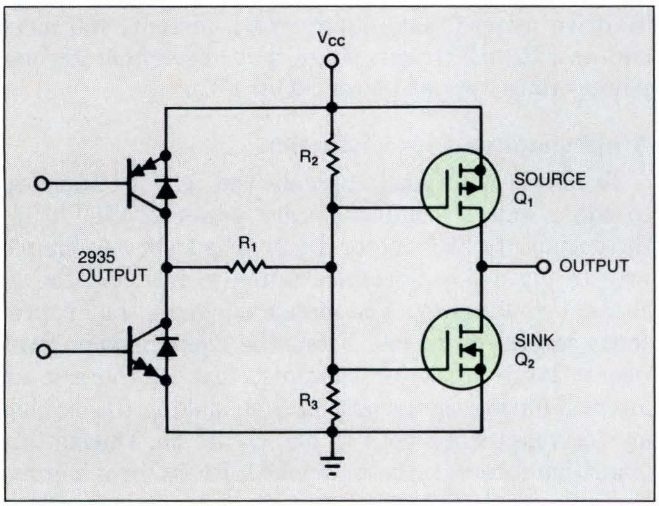


Fig 2—Simplicity is elegant, but it can be dangerous, *as this MOSFET-drive configuration shows. If the 2935's output assumes a high-impedance state (as the result, for example, of a forbidden logic state at the Source and Sink inputs), both MOSFETs conduct simultaneously and impose a crowbar across the supply terminals.*

high-impedance state. The configuration in **Fig 3** satisfies both conditions. In this circuit, the disparate on and off impedances of Q_1 and Q_2's collector circuits collaborate with the gate-source capacitances of the power MOSFETs Q_3 and Q_4 to eliminate simultaneous conduction.

Consider, for example, the case in which the output stage is sinking current; that is, Q_4 is on and Q_3 is off. In this condition, Q_2 is turned off, and the R_5-D_2 combination supplies an 18V gate-source turn-on voltage to Q_4. Q_1 is saturated and therefore holds Q_3's gate-source voltage well below the MOSFET's turn-on threshold. When the circuit switches from a sinking to a sourcing mode, Q_1 turns off and Q_3 turns on at the same time. When Q_1 turns off, its collector impedance is 2 kΩ in series with Q_3's gate-source capacitance (approximately 1000 pF). The time constant at the gate of Q_3 is therefore about 2 μsec; Q_3 turns on after a delay of less than 2 μsec.

Switching delays prevent crossover

The situation is different, however, for Q_4. When Q_2 turns on, it presents a low impedance to Q_4's gate circuit, and the gate capacitance discharges rapidly to turn off Q_4. Because of the disparate turn-on and turn-off impedances, the turn-on/turn-off time ratio is greater than 100:1. Both MOSFETs, therefore, are turned off for a significant interval during transitions, and no crossover current can flow.

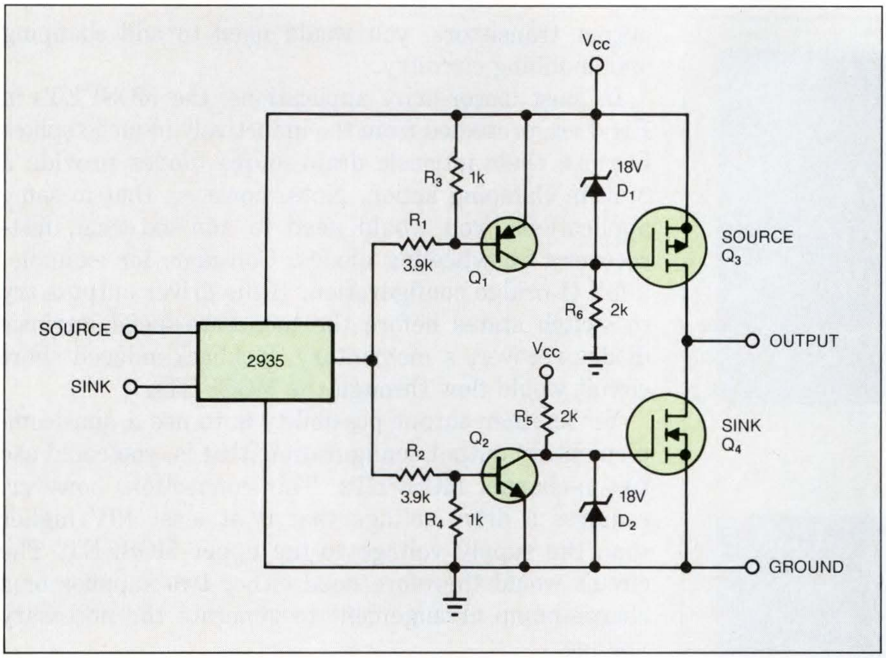


Fig 3—Simultaneous conduction of the two MOSFETs can't occur *in this circuit configuration. If the 2935's output assumes its high-impedance state, the voltage divider at the bases of Q_1 and Q_2 turns off both bipolar transistors and, consequently, turns off both MOSFETs.*

The oscilloscope photos in **Fig 4** show how the gate-circuit time constants ensure break-before-make operation of the output stage. In **Fig 4a,** the fast rising edge of the p-channel gate waveform in trace A makes the MOSFET turn off quickly. In trace B, the rising waveform's time constant ensures that the n-channel MOSFET doesn't turn on until after the p-channel device is turned off. The same situation applies to the negative-going gate signals; in this case, the p-channel MOSFET doesn't turn on until the n-channel device is firmly turned off. **Figs 4b** and **4c** show the output-current waveforms in relation to the gate signals of the n-channel MOSFETs **(b)** and the p-channel MOSFETs **(c)**.

The circuit in **Fig 3** also solves the problem of faulty logic at the inputs to the 2935 IC. When both the IC's Source and Sink inputs are asserted, the output stage in the 2935 turns off and assumes a high-impedance state. The voltage divider at the bases of Q_1 and Q_2 causes both transistors to turn on, and the saturated transistors hold both power MOSFETs off.

A similar fault condition can arise if the 2935 derives its power from a separate power supply. In **Fig 2,** if the MOSFETs' power supply turns on before the 2935's supply, both MOSFETs turn on simultaneously and, again, place a crowbar across the supply terminals. In the configuration shown in **Fig 3,** however, the MOSFETs stay off in this supply-sequencing scenario.

You might assume that **Fig 3**'s circuit configuration would be equally suitable for connecting bipolar output drivers, rather than MOSFETs, to the motor-drive IC. To do so, however, you must consider the bipolar transistors' high drive requirements. To produce a forced gain of 10, for example, to saturate the transistors, the drive circuitry would have to provide 600 mA of base drive to the output transistors. You can produce such drive current by scaling down the circuit impedances, but you waste a considerable amount of power.

Bipolar Darlington pairs, of course, reduce the base-drive requirement, but it's still appreciable. At a 6A continuous current and a 3V collector-emitter saturation voltage, the minimum current gain for a typical Darlington pair is 100. The required base-drive current, therefore, is 60 mA.

Another problem that attends the use of bipolar power transistors, whether you use a single or a Darlington configuration, is the disparity in current rise and fall times. Because the transistors have long storage times, they turn on faster than they turn off. You're therefore faced with large crossover currents that arise from the simultaneous conduction of the upper and lower power devices.

Bipolar transistors (both single and Darlington) are also susceptible to secondary breakdown. This problem is especially acute for motor-drive circuits because the winding inductance of a motor can induce large voltage spikes (the inductive-kickback effect). To protect the

Adding a pair of complementary power MOSFETs to the ICs' outputs is a poor high-drive solution.

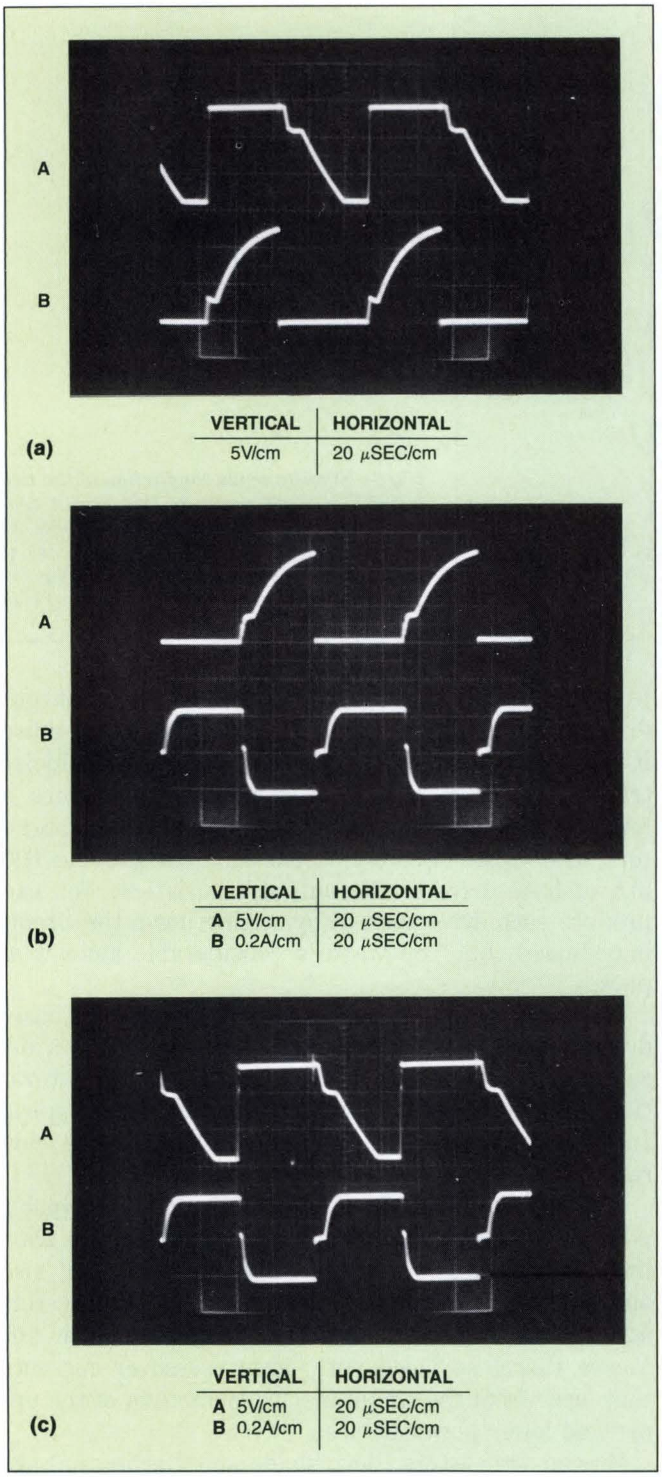


Fig 4—Disparate turn-on and turn-off times eliminate crossover currents. *The bipolar drivers' rapid turn-on times ensure that each power MOSFET turns off well before its complementary partner turns on.*

output transistors, you would need to add clamping and snubbing circuitry.

In most motor-drive applications, the MOSFETs in **Fig 3** are protected from the inductively induced spikes because their intrinsic drain-source diodes provide a built-in clamping action. Note, however, that in some applications, you would need to add external, fast-recovery freewheeling diodes. Consider, for example, a full H-bridge configuration. If the driver outputs try to switch states before the moderate-speed intrinsic diodes recover, a momentary, kickback-induced short circuit would flow through the MOSFETs.

Yet another output possibility is to use a quasicomplementary output configuration; that is, you could use two n-channel MOSFETs. This connection, however, requires a drive voltage that is at least 10V higher than the supply voltage to the upper MOSFET. The circuit would therefore need either two supplies or a charge-pump arrangement to generate the necessary voltage.

Layout considerations

If you choose to use the fail-safe, crossover-free circuit of **Fig 3,** you must select the proper components for the application and lay out the circuit. Assume your single-ended motor requires 6A continuous, 10A peak current—three times the current you can obtain from an unassisted 2935 motor-drive IC. To satisfy these requirements, you can use an inexpensive power MOSFET such as the n-channel MTP3055E and its MTP12P05 complement from Motorola (and other manufacturers). The TO-220-housed devices provide 50V and 6A continuous output current.

For commercial or industrial applications, these low-cost MOSFETs fill the bill. A quick thermal analysis reveals that the MTP3055E and MTP12P05 can easily provide the 6A continuous current. The n-channel MTP3055E, for example, has 0.15Ω on-resistance ($r_{DS(on)}$) at 25°C and 3.12°C/W junction-to-case thermal resistance ($R_{\theta JC}$).

Based on your knowledge of the maximum permissible junction-temperature rise and the power dissipated in $r_{DS(on)}$, you can calculate the maximum allowable current. Keep in mind, however, that a power MOSFET's on-resistance isn't a constant—it increases with temperature. In fact, at 150°C (the maximum permissible junction temperature), a typical MOSFET's on-resistance is about 2.2 times the value at 25°C. The MOSFET's on-resistance thus becomes 0.33Ω at 150°C.

Assuming you provide sufficient heat removal to keep the TO-220 case at 70°C, the allowable junction-to-case temperature differential is 80°C. If you divide this temperature rise by the 3.12°C/W thermal resistance, you find that the allowable power dissipation is 25.64W.

Because the $I^2r_{DS(on)}$, or $0.33I^2$, equals the 25.64W, I is about 8.8A. Although the p-channel MTP12P05 has an $r_{DS(on)}$ that is about twice that of the MTP3055E, its junction-to-case thermal resistance is about half that of the n-channel device (because of the larger die employed). The thermal calculation for the MTP12P05 yields a permissible continuous current of about 8.5A.

Hybrid circuits combine benefits

Fig 5a shows a possible pc-board layout of the MOSFET-augmented, half-H-bridge motor driver. The IC and the power MOSFETs in this layout come in TO-220-style plastic packages; the small-signal transistors are housed in plastic TO-92 packages. Using the same layout, you can make a hermetically sealed, military version of the driver. As a result of the cooperative efforts of Omnirel and Sprague Semiconductor, the 2935 IC is also available in a hermetically sealed package, whose outline is similar to that of a TO-220 package.

The power MOSFETs, too, are available in hermetically sealed, TO-220-outline packages: the TO-258 and TO-220H packages. Note, however, that these devices aren't cheap; MOSFETs in the hermetic TO-258 packages cost more than \$40. For about \$4, you can get the same device in the TO-3 package. However, the inexpensive, TO-3-packaged power MOSFETs shown in **Fig 5b** consume about 65% more pc-board space than the versions in **Fig 5a**. The hermetically sealed hybrid circuit shown in **Fig 5c** combines the features

Text continued on pg 202

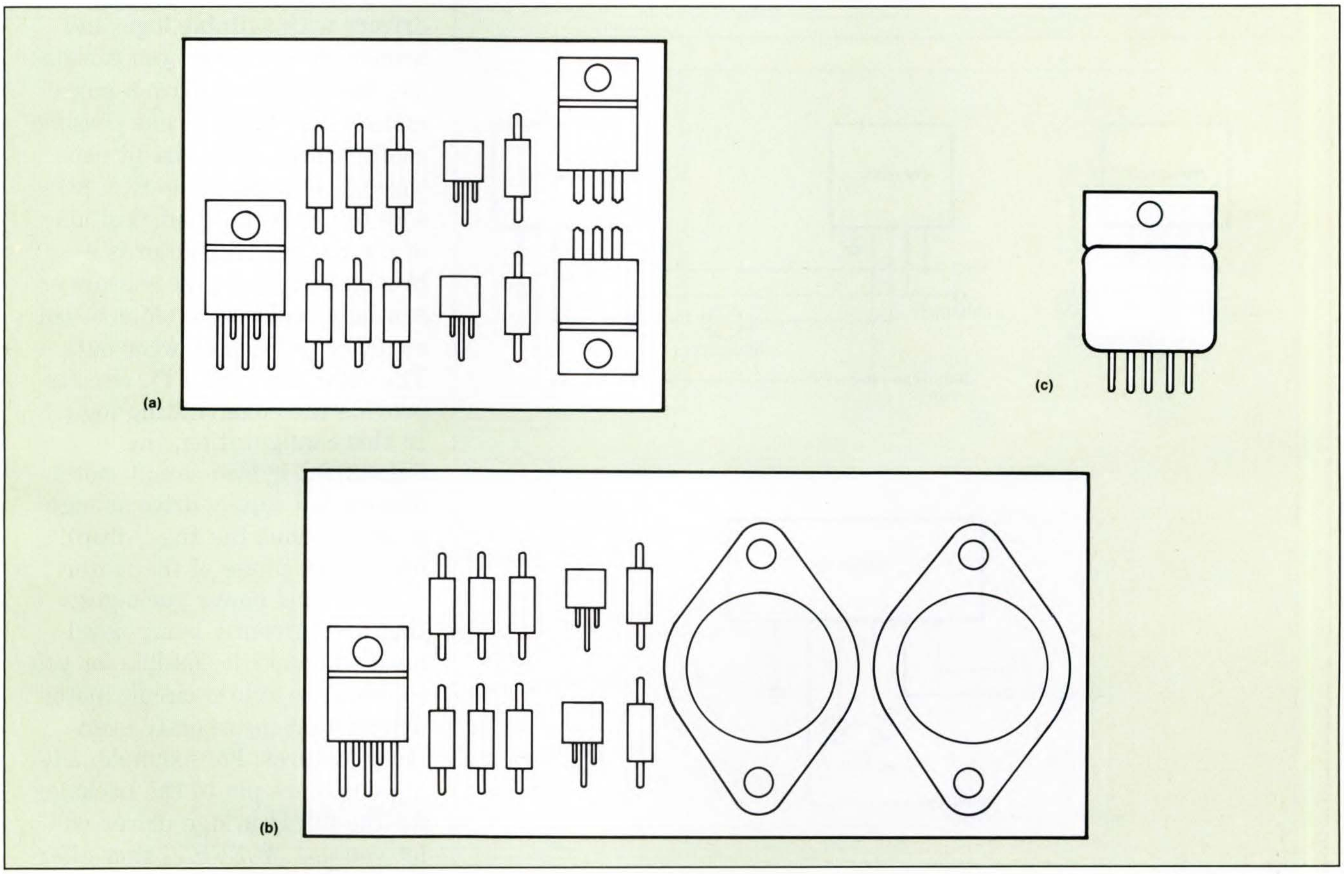


Fig 5—The pc-board version (a) *uses plastic or hermetically sealed TO-220-style power devices in the layout of* ***Fig 3's*** *circuit. Another hermetic version* ***(b)*** *uses less-expensive power MOSFETs in the classic TO-3 package. The hermetically sealed hybrid-circuit version* ***(c)*** *offers the same power capabilities as the pc-board versions, and it provides thermal coupling from the power MOSFETs to the overtemperature-protected 2935 motor-drive IC.*

Use hybrids to power your motors

Three hybrid-circuit versions of the H-bridge motor drivers are currently available: the OM9320SS, OM9319SC, and OM9321SC. Model OM9320SS is a full-H-bridge motor driver; the OM9319SC and the OM9321SC are half-H-bridge drivers. The OM9319SC corresponds to (and uses) the 2935 motor-drive IC; the OM9321SC uses the inverted-phase 2950 IC. **Table A** is the truth table for the three models. You can see that the forbidden 1,1 input combination (0,1 for the drivers that incorporate the 2950) produces an open condition at the outputs.

Table B gives some of the salient performance characteristics of the hybrid-circuit motor drivers. For all the specifications shown, the input high and low levels are the standard TTL levels of 0.8V max, 2.4V min, respectively. You can see that the on-to-off propagation delay is much shorter than the off-to-on delay, thereby ensuring a break-before-make characteristic in the output stage. The output on voltages are given with the 10A maximum peak current; for the 6A maximum specified continuous current, the figures are 33V and 2V, respectively.

TABLE A—MOTOR-DRIVER TRUTH TABLE

SOURCE INPUT	SINK INPUT	OM9319SC OUTPUT	OM9321SC OUTPUT	OM9320SC OUTPUT 1	OM9320SC OUTPUT 2
0	0	HIGH	LOW	HIGH	LOW
0	1	HIGH	HIGH Z	HIGH	HIGH Z
1	0	LOW	HIGH	LOW	HIGH
1	1	HIGH Z	HIGH	HIGH Z	HIGH

Fig A shows three ways to use the motor drivers with single-phase dc motors. In **Fig Aa**, the OM9321SC drives a motor in a half-H-bridge connection. Note that the motor's return lead must connect to a voltage equal to half the supply voltage. As a result, the drive to the motor is $0.5V_{CC}$ p-p.

Figs Ab and **Ac** show two ways to implement full-H-bridge drivers. These drivers let you control both the direction and the speed of the motor. In these full-H-bridge drivers, the motor receives peak-to-peak drive equal to the full power-supply voltage minus $Ir_{DS(on)}$ of the power MOSFETs.

If you couple the hybrid motor drivers with suitable logic and proper phase timing, you can also use the drivers to drive 3-phase motors. **Fig B** shows one possible configuration. This circuit uses three UGN-3130 Hall-effect sensors to sense the shaft position of the motor. The motor is a brushless dc type; the sensors essentially replace the older brush switches, which can wear out. The 7400 and 7402 TTL circuits provide the commutating logic. In this configuration, the OM9321SC hybrid-circuit motor drivers can supply drive as high as 35V (minus the $Ir_{S(on)}$ drop), 6A to each phase of the motor.

Additional power packages that are currently being developed will make it possible for you to fabricate hybrid-circuit motor drivers that incorporate even more features. For example, adding one more pin to the package for the full-H-bridge driver will let you use MOSFETs that offer a current-sensing terminal. With the addition of some simple feedback circuitry, this sensing termi-

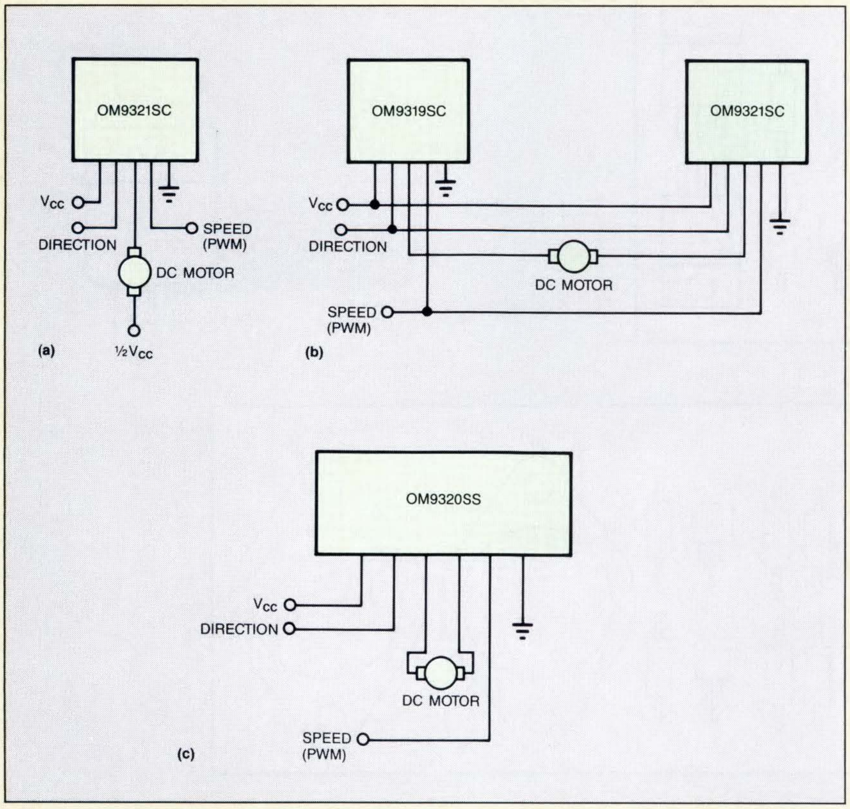


*Fig A—The OM9321SC half-H-bridge driver in **a** provides a voltage swing equal to half the supply voltage. In the full-H-bridge configurations in **b** and **c**, the single-phase dc motor receives a voltage swing equal to the full power-supply voltage minus $Ir_{DS(on)}$.*

nal allows you to control the current limiting in the driver.

Packages with higher pin counts would also let you power the 2935 and 2950 motor-drive ICs from a separate power supply. With the addition of some level-shifting circuitry, you could run the MOSFETs from high-voltage (100V and higher) power supplies. In additon, by using larger power-device dies, you could produce hybrid-circuit drivers that handle tens of amperes and several hundred volts.

TABLE B—MOTOR-DRIVER SALIENT CHARACTERISTICS

PARAMETER	MINIMUM	MAXIMUM	UNITS
OUTPUT OFF—STATE LEAKAGE CURRENT		50	μA
OUTPUT ON VOLTAGE AT OUTPUT=10A			
HIGH STATE	30		VOLTS
LOW STATE		3.3	VOLTS
INPUT CURRENT			
LOW STATE		1.5	mA
HIGH STATE		50	μA
PROPAGATION DELAY			
OUTPUT ON-TO-OFF		750	nSEC
OUTPUT OFF-TO-ON		2	μSEC
INTRINSIC DIODE FORWARD VOLTAGE AT OUTPUT=6A		2.2	VOLTS
SUPPLY CURRENT			
HALF H-BRIDGE		80	mA
FULL H-BRIDGE		160	mA

NOTES:
T_A=25°C, T_{TAB}=70°C, AND V_{CC}=35V

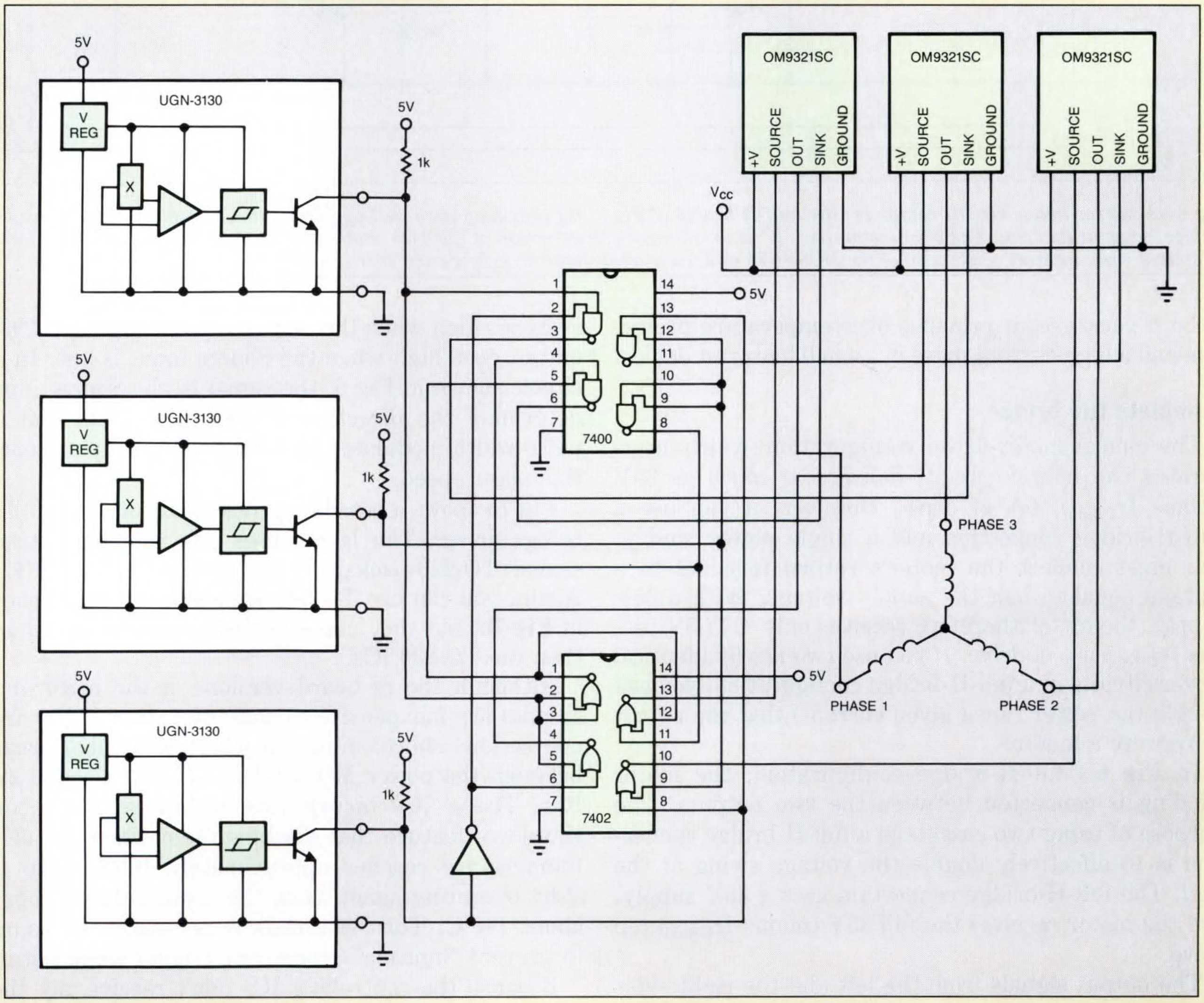


Fig B—Hall-effect sensors and a dash of logic provide the 3-phase drive in this configuration. The UGN-3130 sensors provide shaft-position information; the 7400-series TTL circuits provide the commutating logic. The OM9321SC hybrid-circuit motor drivers provide drive as high as 35V, 6A to each of the three phases of the motor.

If the Source and Sink inputs are asserted, the output stage of the 2935 turns off and assumes a high-impedance state.

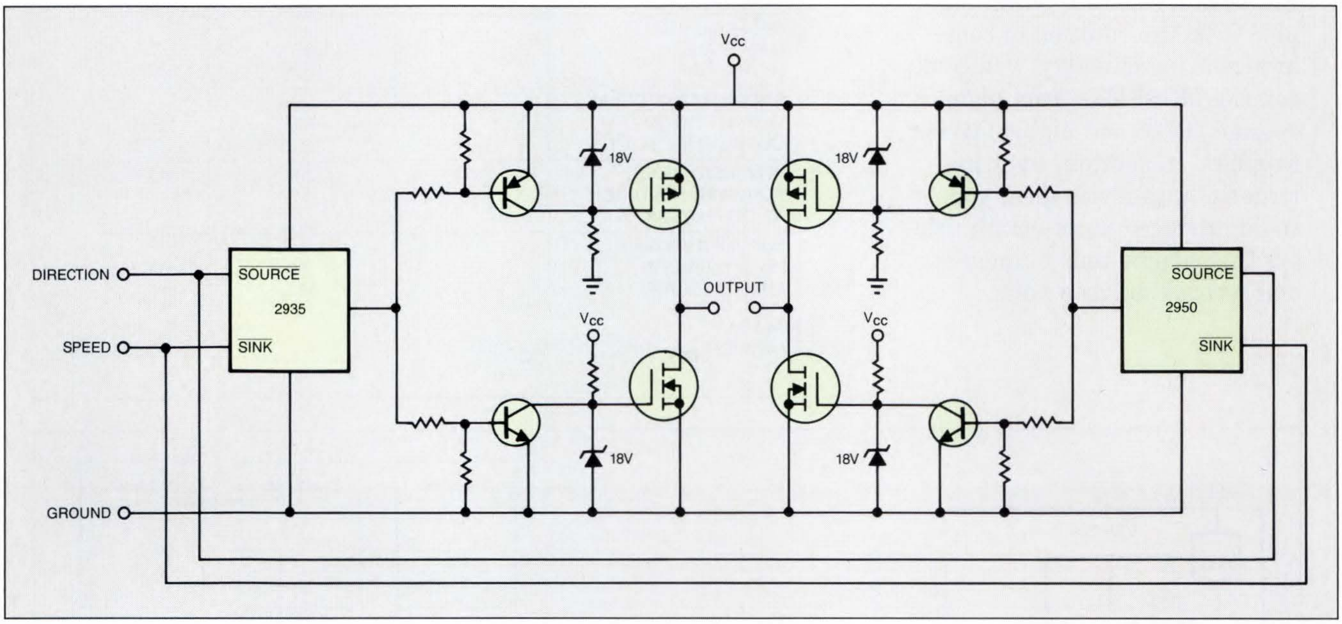


***Fig 6—A mirror-image circuit completes the half-H bridge** of Fig 3. By providing push-pull operation, this circuit doubles the available voltage swing at the load. The 2950 motor-drive IC is an inverted-phase version of the 2935. Both sides of the bridge feature logic lockout to prevent simultaneous conduction of the MOSFETs and, as a result, offer crossover-current-free switching.*

of both packages; it provides overtemperature protection and a high current drive in a small footprint device.

Complete the bridge

The bipolar motor-driver configuration, which incorporates the hybrid circuit, delivers as much as 35V (minus $Ir_{DS(on)}$), 6A of drive. However, if you use a half-H-bridge connection and a single power supply, you must connect the motor's return terminal to a voltage equal to half the supply voltage. With a 35V supply, the motor therefore receives only ±17.5V (minus $Ir_{DS(on)}$) p-p of drive. If you use two nearly identical driver circuits in a full-H-bridge configuration, you can double the power (for a given current) that the circuit delivers to a motor.

In **Fig 6's** full-H-bridge configuration, the motor winding is connected between the two outputs. The purpose of using two circuits in a full-H-bridge connection is to effectively double the voltage swing at the load. The full-H-bridge connection uses a 35V supply, and the motor receives the full 35V (minus $Ir_{DS(on)}$) p-p drive.

The output signals from the left and the right sides of the bridge must be 180° out of phase. The circuit in **Fig 6** accomplishes this phase inversion by using a 2950 motor-drive IC in the right side of the bridge. This IC is identical to the 2935, except that its output switches high when the Source input is high; the 2935's output goes high when the Source input is low. In the circuit shown in **Fig 6,** the signal to the Source inputs determine the direction of motor rotation, and the pulse-width-modulated signal to the Sink inputs control the motor speed.

Fig 7a shows a possible pc-board layout of the full-H-bridge driver. This layout uses plastic or hermetically sealed TO-220-packaged ICs and power MOSFETs. Again, you can use TO-3-housed MOSFETs, as shown in **Fig 7b,** but they use about 85% more pc-board area than the TO-220 ICs.

Although the pc-board versions of the motor-drive circuits are inexpensive to construct, they suffer from one serious shortcoming. No thermal feedback exists between the power MOSFETs and the 2935 and 2950 ICs. These ICs incorporate an overtemperature-shutdown feature that disables them when the chips' temperature reaches approximately 165°C. The ICs start operating again when the temperature drops to about 140°C. This hysteresis is necessary, of course, to prevent "hunting" around the trigger temperature.

Because the controlling ICs don't receive any thermal feedback, they can't protect the power MOSFETs against fault conditions in the load. For example, if a motor becomes overloaded, the excessive current flow could burn out one or both of the MOSFETs. There-

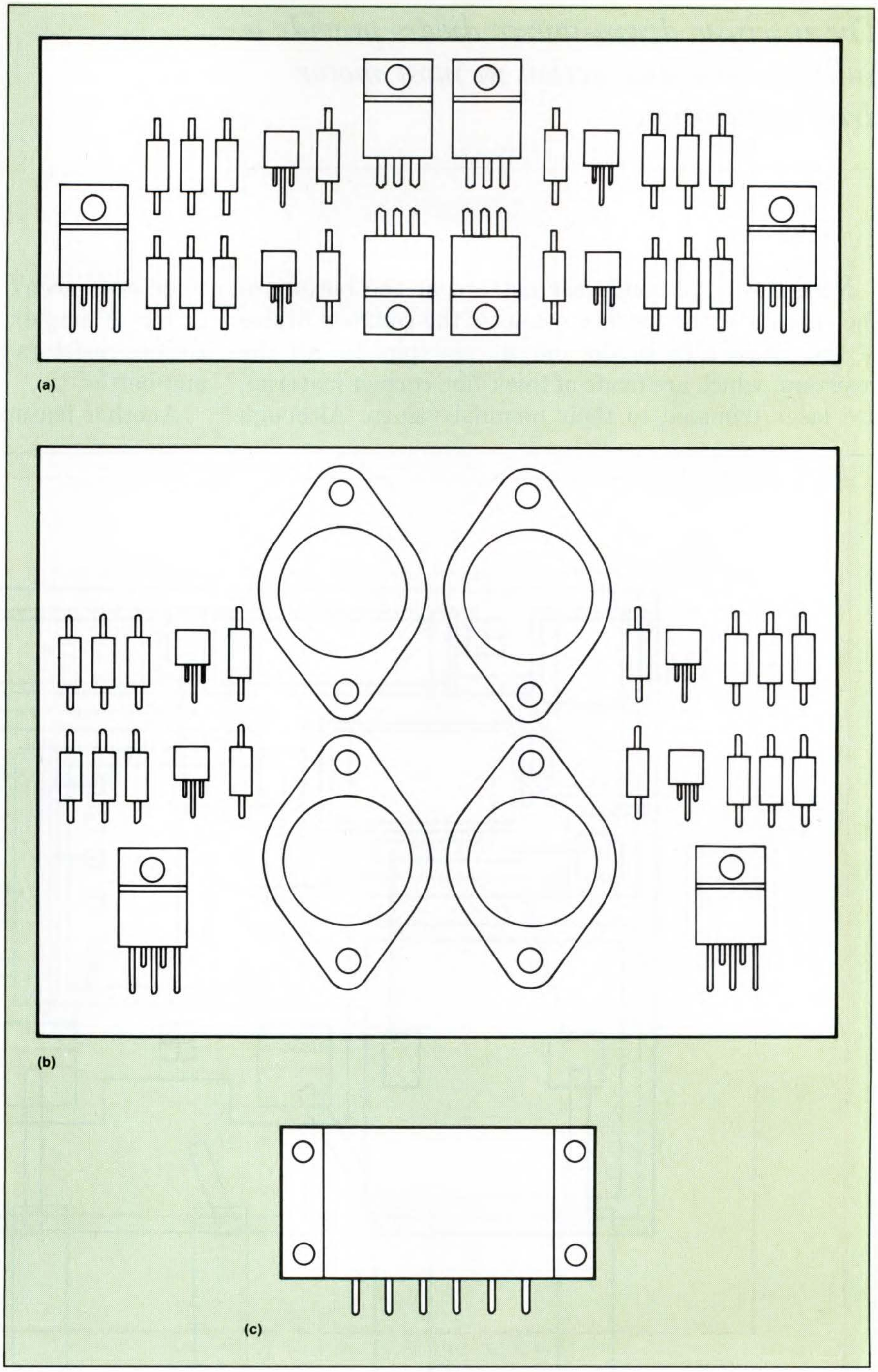


Fig 7—Layouts for the full-H-bridge circuit of ***Fig 6*** *use either plastic or hermetically sealed TO-220-style power devices shown in* ***a*** *or TO-3-housed power MOSFETs shown in* ***b.*** *The hermetically sealed, hybrid-circuit version in* ***c*** *uses about 20 and 10% less space than the pc-board versions in* ***a*** *and* ***b,*** *respectively.*

fore, in addition to space-saving considerations, the intrinsic thermal coupling of devices is another benefit of developing a hybrid-circuit motor driver. **Fig 7c** shows this hybrid-circuit implementation of the full-H-bridge driver.

Making the hybrid

To make the hybrid, you must optimize the ICs' thermal intimacy, and, at the same time, provide efficient heat transfer from the circuit elements to the pc board and/or the external heat sink. A beryllia (BeO) substrate, soldered to the metal-package header, fulfills these objectives. This substrate has thermal conductivity properties that are approximately equal to those of aluminum metal. This substrate serves three purposes: In addition to providing efficient heat transfer among the circuit elements and to the external environment, it provides electrical isolation to the circuit devices, and it offers a platform for printing conductors and thick-film resistors.

The hybrid-circuit layout for the half-H-bridge driver (**Fig 8**) is quite simple; its component designations are the same as the those in **Fig 3.** The semiconductors are bonded to the BeO substrate by a high-temperature solder-reflow process. The leads that connect the circuit to the package tabs are 10-mil aluminum wires that are stitch-bonded to the MOSFETs and the conductor pads on the substrate.

The intrinsic drain-source diodes provide a built-in clamping action in most motor-drive applications.

Note the large conductor pattern at the bottom of the substrate; the pattern connects the common drains of the MOSFETs to the output pin (pin 3). All the resistors, which are made of thick-film cermet material, are laser trimmed to their nominal values. Although tolerances aren't critical in these motor-drive circuits (±5% is ample), the laser-trimming process and the cermet resistors can easily produce tolerances of ±1% and better.

Another feature that you should note in this hybrid-

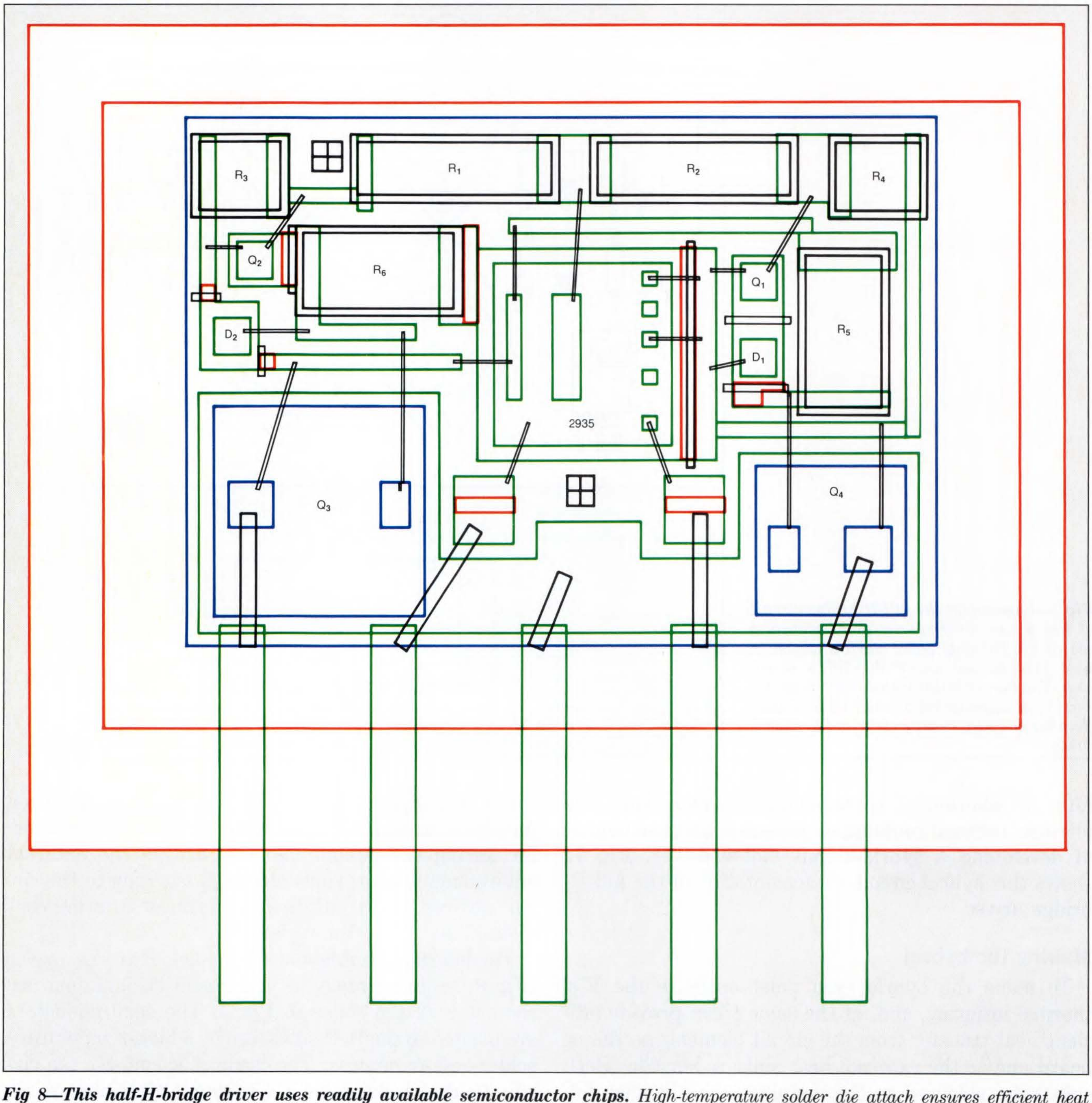


Fig 8—This half-H-bridge driver uses readily available semiconductor chips. *High-temperature solder die attach ensures efficient heat transfer from the junctions to the BeO substrate. The 10-mil aluminum wires eliminate high-temperature intermetallic problems that can accompany a gold-to-aluminum interface.*

New

Wideband SWOP AMPs For High Speed Signal Switching And Conditioning

OPA675 is compatible with ECL inputs, OPA676 with TTL.

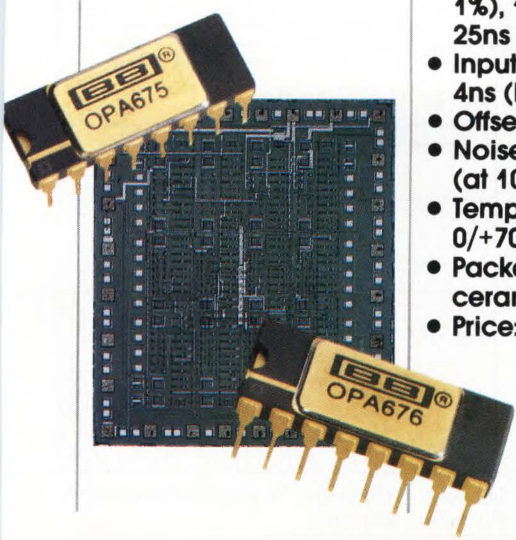
What's a SWOP AMP®?

OPA675 and OPA676 are new, monolithic, wideband operational amplifiers with two independent differential inputs selectable by an external logic signal. We call these switchable op amps "SWOP AMPS", and we made a new symbol for them.

These devices employ a classic op amp circuit topology, eliminating the asymmetrical inputs and noisy, long settling tails associated with many current-feedback designs. They may be used in any application requiring speed and precision.

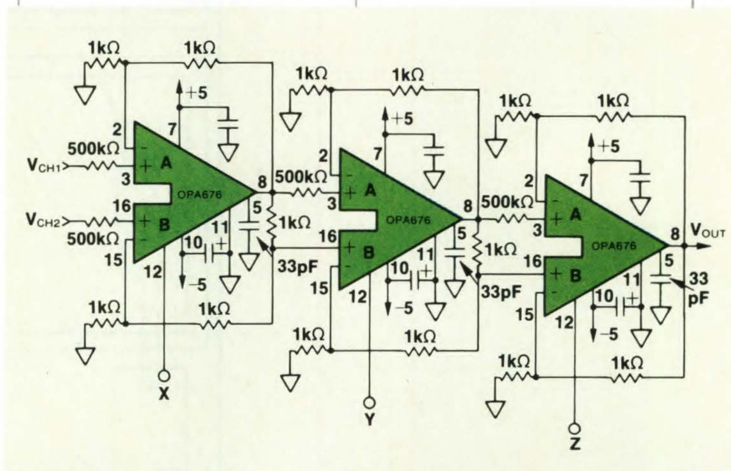
What are the specs?

- **Gain-bandwidth product: 3GHz (A = +50V/V)**
- **Settling time: 9ns (to 1%), 15ns (to 0.1%), 25ns (to 0.01%)**
- **Input switching time: 4ns (ECL), 6ns (TTL)**
- **Offset voltage: 250μV**
- **Noise: 2.4nV$\sqrt{Hz}$ (at 100kHz)**
- **Temp ranges: 0/+70°C, -55/+125°C**
- **Package: 16-pin ceramic DIP**
- **Price: from $19.35***



What can you do with it?

OPA675/676 amps settle fast to high accuracy and make excellent "front ends" for a broad range of high speed analog signal processing applications. Use it for programmable-gain amps, multiplexers, and pulse, video and RF amplifier circuits.



30MHz Programmable-Gain Amp with two multiplexed inputs.

CALL 1-800-548-6132 Toll-Free for immediate assistance.

Burr-Brown Corp., P.O. Box 11400, Tucson, AZ 85734.

SWOP AMP® - Burr-Brown Corp.
*U.S. unit prices, in 1000s (JG)

CIRCLE NO 90

BURR-BROWN®

By thermally coupling devices, you enable the controlling ICs to protect the power MOSFETs against fault conditions in the load.

circuit layout is the proximity of the 2935 motor-drive IC to the two power MOSFETs. Because the IC is situated between the two power devices, it quickly senses any overtemperature condition in either or both of the MOSFETs and shuts down accordingly. The high thermal conductivity of the BeO substrate plays a major role in this isothermal design.

By making some thermal calculations, you can determine the maximum continuous operating current for the half-H-bridge driver. Again, $R_{\theta JC}$ for the package

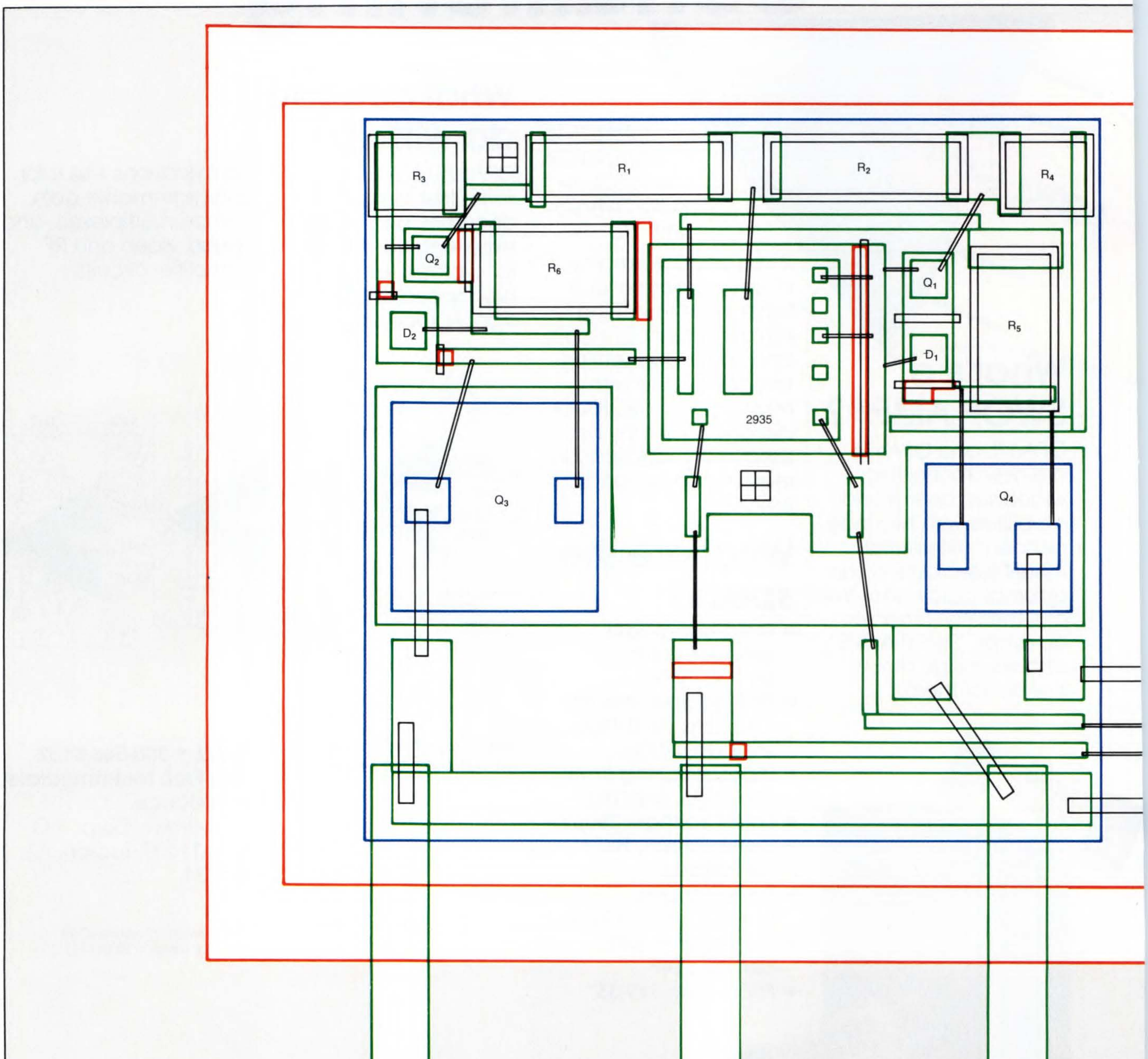
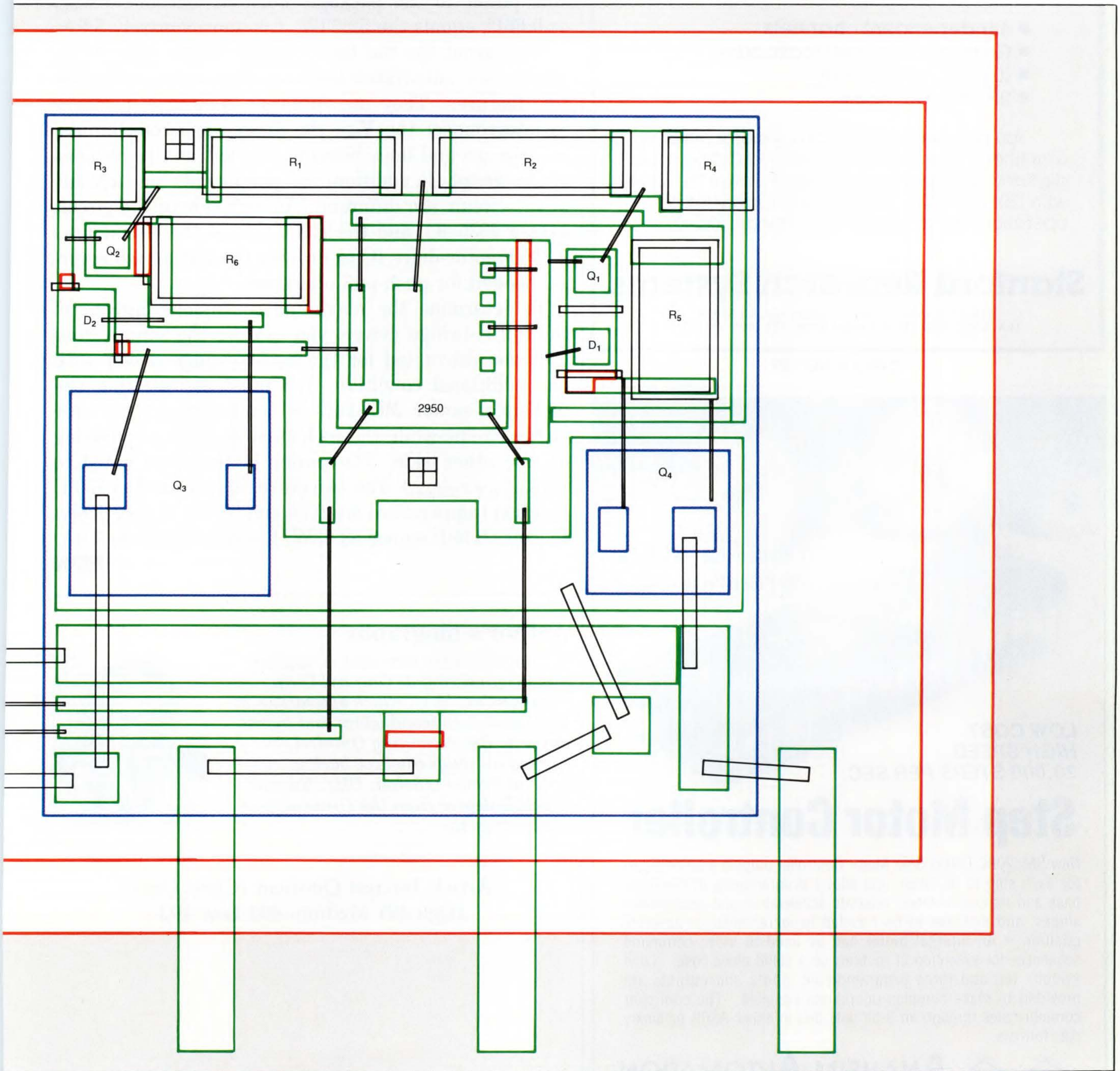


Fig 9—This full-H-bridge layout provides bonding pads *for interconnecting the left and the right sides of the bridge. To provide the necessary phase inversion for push-pull operation, the right side of the bridge uses a 2950 motor-drive IC instead of a 2935.*

and $r_{DS(on)}$ for the power MOSFETs are the determining factors in your thermal analysis. You need to calculate the values for only one of the MOSFETs because when one is on, the other is off. Because the p-channel MOSFET's $r_{DS(on)}$ is higher than that of the n-channel device, the p-channel 12P05 produces the worst-case current-limiting situation.

For the 12P05, $r_{DS(on)}$ is 0.3Ω at 25°C. At the maximum allowable junction temperature of 150°C, $r_{DS(on)}$ is approximately 0.66Ω. $R_{\theta JC}$ for both packages is 1.5°C/

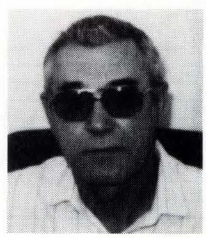


W. Assuming the package temperature is held at 70°C, the permissible junction-temperature rise is 80°C. Dividing 80°C by the 1.5°C/W yields the maximum allowable power in the package: 53.33W. Because $I^2R_{\theta JC}$, or $0.66I^2$, equals the 52.33W, I is approximately 8.9A.

The layout for the full-H-bridge driver **(Fig 9)** includes two substrates that are the same except for two features. They use different conductor patterns to interconnect the V_{CC}, the Source and Sink inputs, and the ground lines between the left and right sides of the circuit. In addition, the components on each side of the circuit are different. The left side of the circuit uses a 2935 IC, and the right side of the circuit uses a 2950 motor-drive IC to provide the 180° phase reversal needed for push-pull operation.

To determine the maximum continuous current of the full-H-bridge driver, you can use the same values that you calculated for the half-H-bridge driver with one additional condition. You must assume that the p-channel power MOSFET is conducting on one side of the circuit while the n-channel device is conducting on the other side. The power is therefore equal to $I^2(r_{PDS(on)}+r_{NDS(on)})$. The two on-resistances at the 150°C junction temperature are 0.66 and 0.33Ω, respectively. Because $0.99I^2$ equals 53.33W, I is approximately 7.3A. EDN

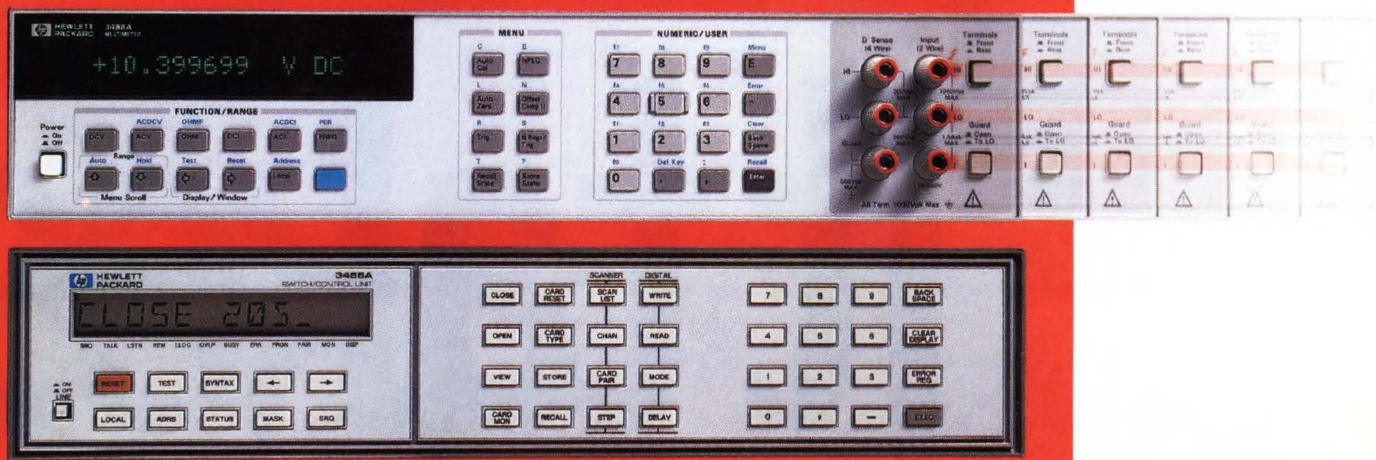
Author's biography



Ed Goodell is the manager of applications engineering at Omnirel Corp (Leominster, MA), which specializes in high-power semiconductors and hybrid circuits. Before joining Omnirel, he worked on magnetic-tape backup systems at Tecmar (Solon, OH). Ed holds a BSEE degree from the University of Massachusetts.

Article Interest Quotient (Circle One)
High 491 Medium 492 Low 493

Fast one.



Free one.

A $2000* switch FREE with each HP 3458A Multimeter.

Get a big jump on the cost of your next functional test system. When you buy the world's fastest system multimeter, you get an HP 3488A mainframe and 10-channel switch absolutely free. No catches. No gimmicks. You simply get a great package deal. All for under $6,000.*

You get a big jump in performance too. Up to 200 function and range changes/sec. and 100,000 measurements/sec. at 4½ digits. Which makes the HP 3458A the fastest multimeter around... at any accuracy level.

But a deal this good can't last forever. You have to order before July 31, 1989. So call

1-800-752-0900, Ext. 176C

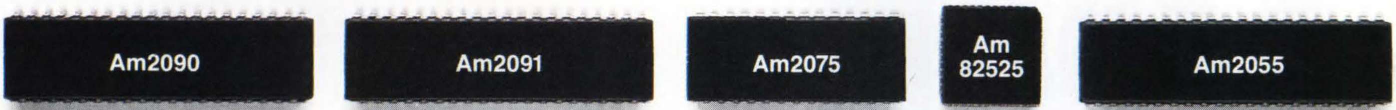
today if you need more details. And if you're already convinced, call your local HP sales office to order now.

*U.S. list prices

HEWLETT PACKARD

ISDN S-transceiver | ISDN S-transceiver + data link controller | ISDN S-transceiver/ extended performance | ISDN Integrated Data protocol controller | ISDN high level serial controller | ISDN Ping pong transceiver

It takes to make a



ISDN U-transceiver (4B/3T + 2B/1Q)

ISDN U-transceiver (4B/3T + 2B/1Q)

ISDN Quad data link controller

ISDN high level serial controller/ extended performance

ISDN Line card controller

guts switch.

We have all the guts you need. In one complete ISDN chip set.

It's flexible and integrated. You can meet the future without tearing up the past. Start with any transceiver, then come back later and replace it to meet new requirements.

Not only will you avoid major redesigns, you'll avoid the wrath of your programmers because there'll be just minimal changes in software.

These parts were designed to meet the IOM™-2 standard so they're guaranteed to work with any other IOM-2 based devices. No acrobatics, no patching things together.

We've even got your analog loop needs covered with a new IOM-2 DSLAC.™

Plus, all these ISDN devices are part of a common chip set available from both Siemens and AMD. So you'll never feel like you're on hold.

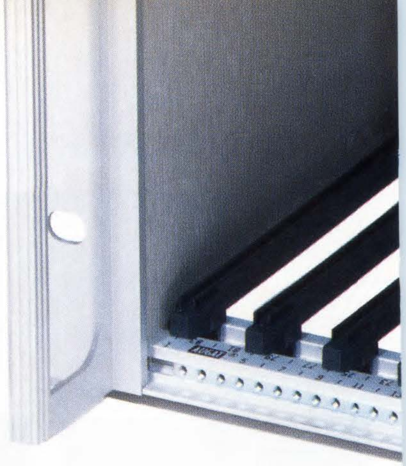
Call (800) 222-9323 and find everything you need to make a switch.

Advanced Micro Devices

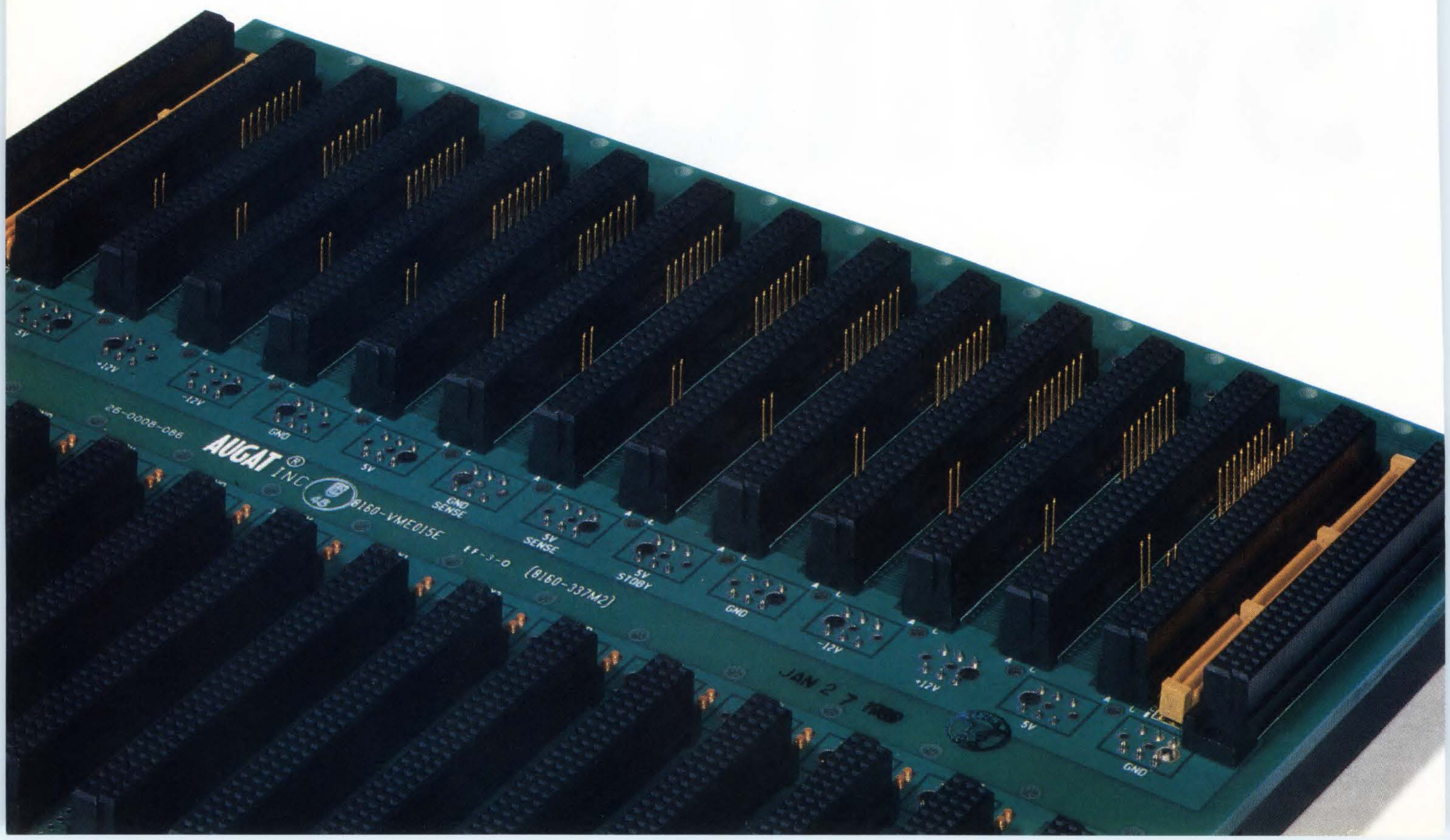
901 Thompson Place, P.O. Box 3453, Sunnyvale, CA 94088.

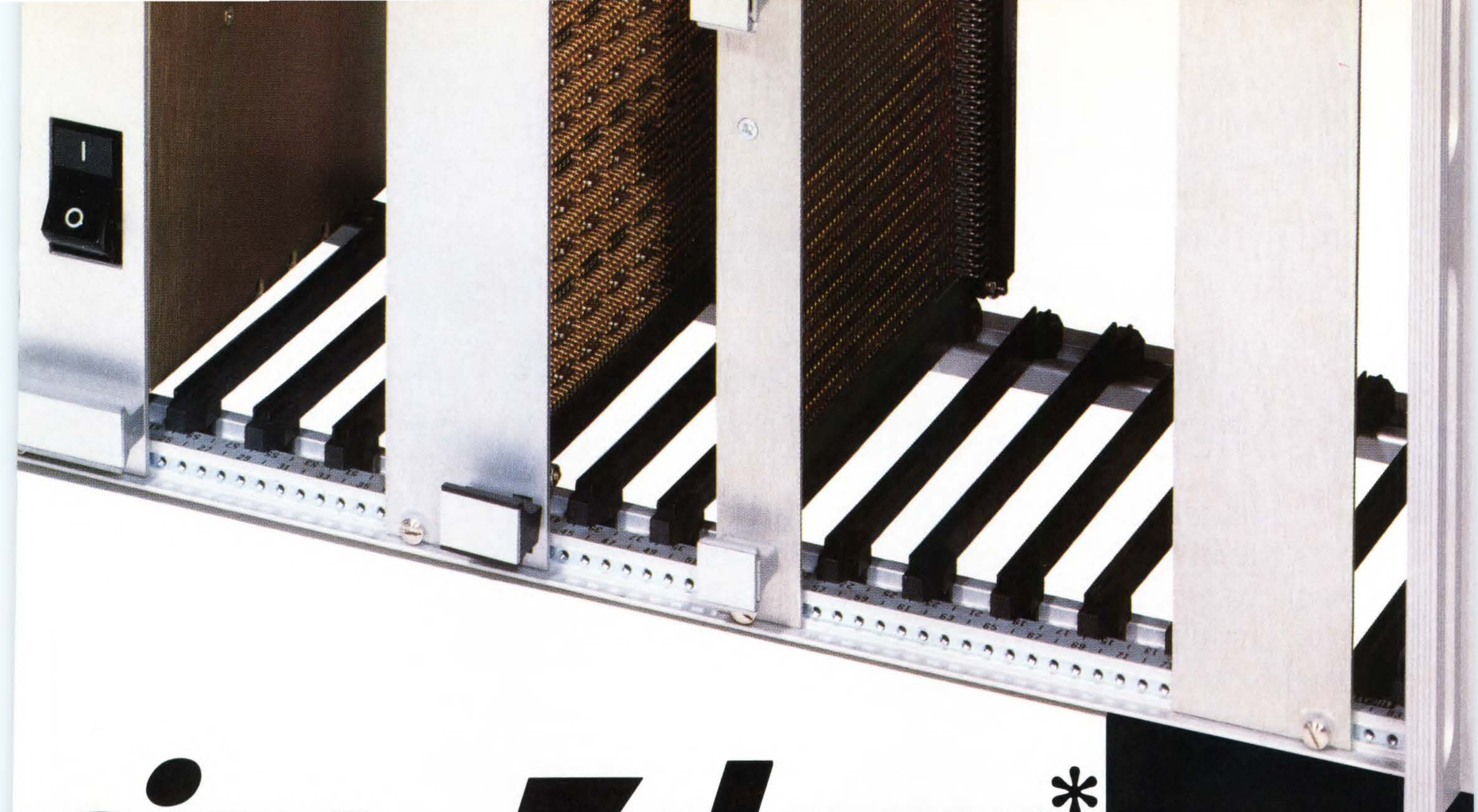
CIRCLE NO 92

AUGAT VME...



Any slot...Any





size…7 days*

Now, within just 7 working days, AUGAT will ship you a backplane or card cage in any size you need, from 3 through 21 slots. This isn't simply a promise — it's AUGAT's GUARANTEE*…

Or you pay 20% less!

Our no-nonsense 7-Day VME Program includes both J1 and J2 backplanes. It even includes our new high-performance monolithic backplanes, too. Only AUGAT has the production capability to guarantee 7-day shipment on such a broad selection of backplanes. Now you can plan on the arrival of your VME packaging hardware with no fear of delaying your critical development schedule.

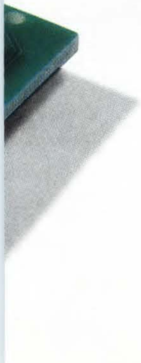
In addition, AUGAT has greatly expanded its entire VME line to include more standard products … including new VME power chassis complete with backplane, fully harnessed power supply, cooling, card cage and optional enclosure. AUGAT also has the engineering talent and experience to handle your customized VME packaging needs.

Send for a copy of our new VME catalog today … because when time is of the essence in locating quality VME products with full engineering support, your surest source is AUGAT!

* AUGAT GUARANTEES to ship backplanes and/or card cage kits in any size (from 3 through 21 slots) in 7 working days from date of approved credit — or you pay 20% less! (limit: 3 pieces per part number)

For answers or orders

1-800-999-9VME



AUGAT®

AUGAT INC., INTERCONNECTION PRODUCTS GROUP

CIRCLE NO 93

†Wire-Wrap is a registered trademark of Gardner-Denver

PLUS
An Expanded VME Product Line

NEW Power Chassis

More Power Supplies

More Extender Boards

More Wire-Wrap† Panels

More Cage Dividers

More Support Data

The new modem family promises to be really hot. Without a doubt the next-generation leader.

But the designers need more time and money to go for it. And his market window is disappearing fast.

"It was either find the right modem or lose a big chunk of the market."

His team calls the company that sets the industry standards in modems: Rockwell International. He knows that'll save design time and costs, plus provide worldwide compatibility from 300bps to 14.4kbps.

And with one basic design, engineering can spin off a dozen different products by using Rockwell's OEM modem series with its compatible hardware features. It's a complete solution to all their modem needs. The clincher: Rockwell's 5-year standard warranty assures his customers of quality and reliability.

He'll beat the competition to market with the right products. And that's what it's all about.

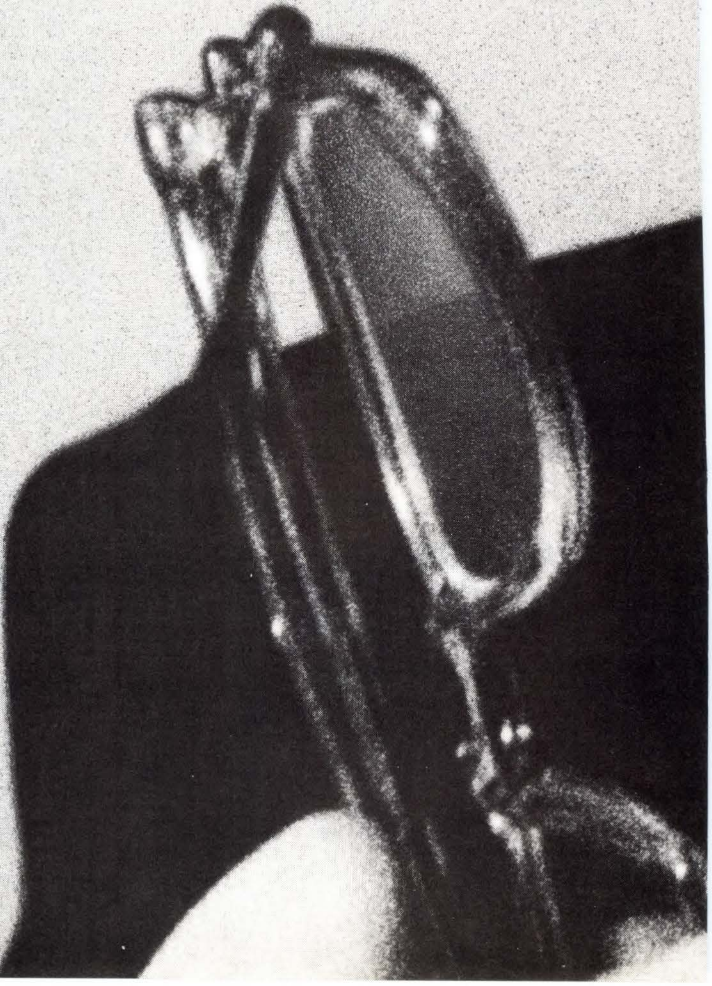
Call the leader in modem technology. Rockwell *is* solutions.

Rockwell International

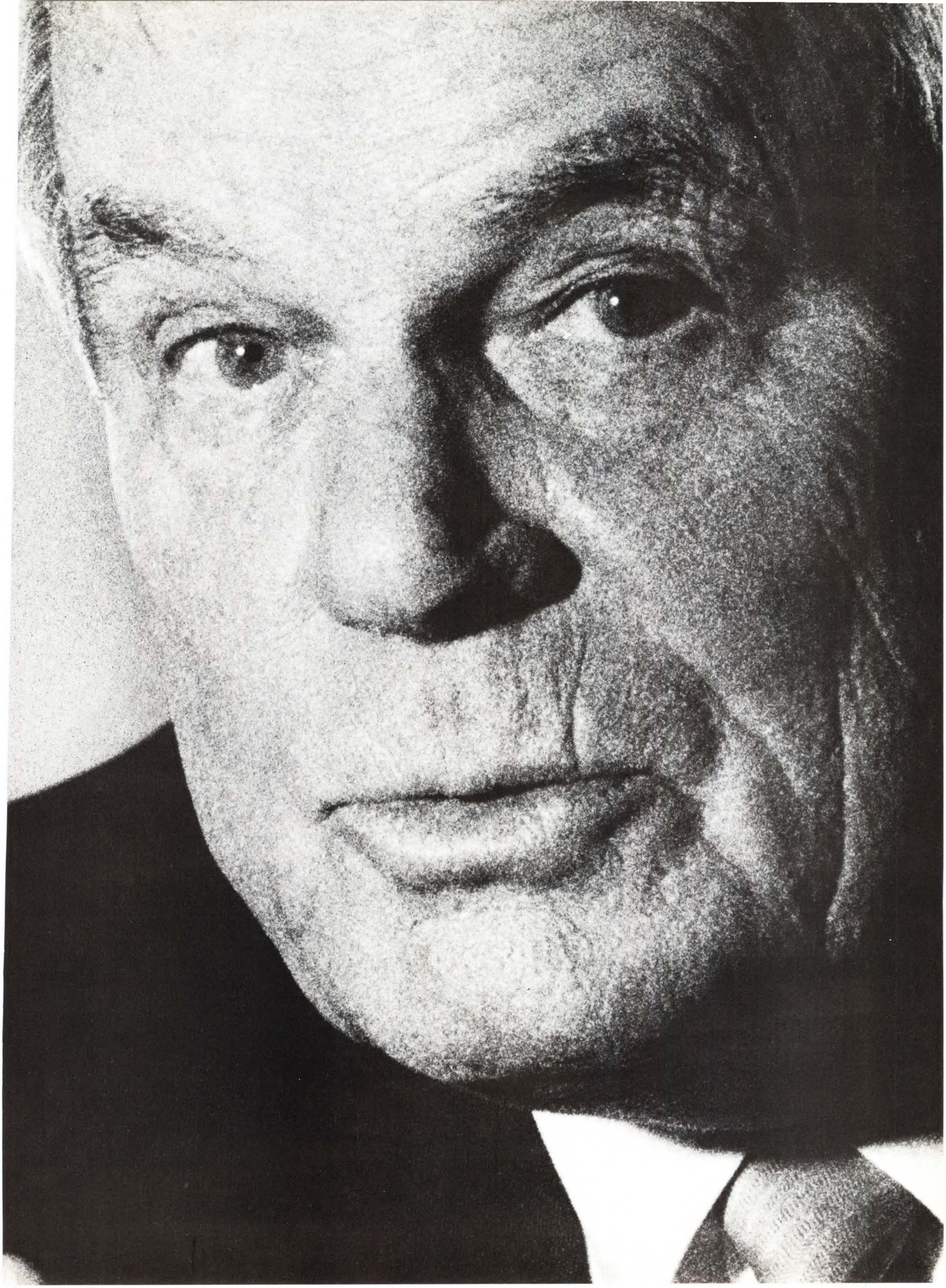
...where science gets down to business

Aerospace / Electronics / Automotive
General Industries / A-B Industrial Automation

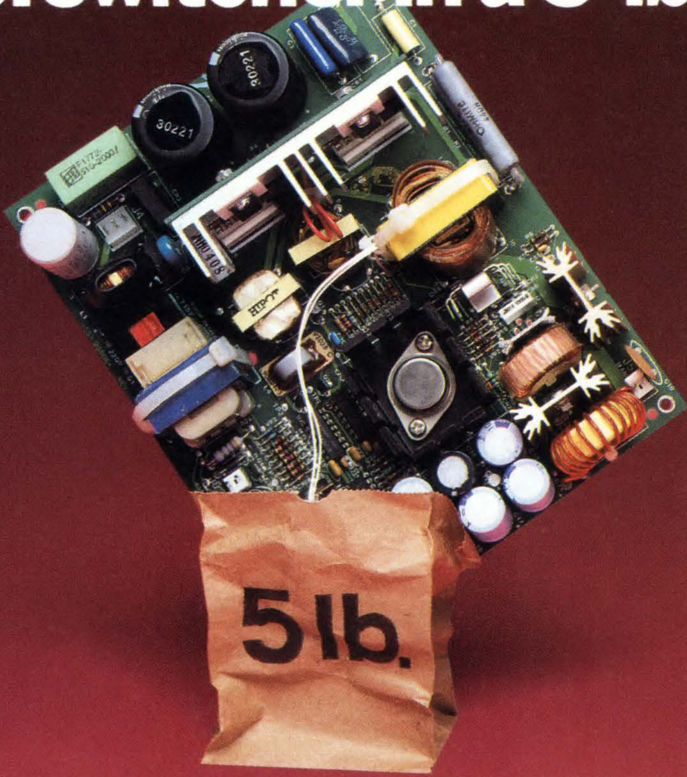
CIRCLE NO 94



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.



Tired of trying to put a 10-lb. switcher in a 5-lb. bag?



Say goodbye to trying to cram your bulky switcher with all kinds of external parts into a tiny board space.

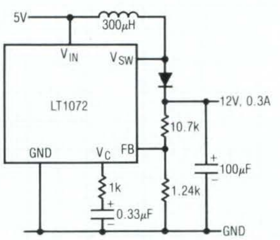
And say hello to our powerful LT1072 high efficiency switching regulator. It's a lot of switcher in a mini-DIP package.

Our LT1072 simplifies design and dramatically reduces board space needed for most applications because it contains all switching, protection and control circuitry on a single chip.

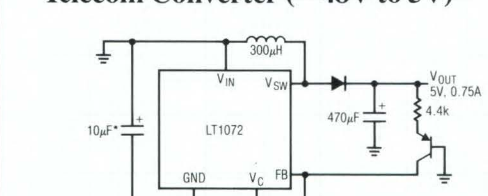
The LT1072 features an internal, low saturation 1.25A switch and offers a wide range of unique operating advantages. Now you can work with supply voltages from 3V to 60V, and draw only 6mA quiescent current. Our switcher packs a wallop by delivering load power up to 15 watts, while remaining extremely efficient at low power levels.

With the LT1072, you can utilize current-mode switching techniques for excellent transient and DC load and line regulation, and operate in nearly all switching topologies. As a bonus, the chip draws only 50μA supply current in the shutdown mode.

Boost Converter (5V to 12V)



Telecom Converter (−48V to 5V)



LINEAR TECHNOLOGY

TOUGH PRODUCTS
FOR TOUGH APPLICATIONS.

Enjoy many features not offered by other difficult-to-use low power control chips on the market today. All our LT1072 family of devices use an adaptive, anti-saturation circuit for high switching efficiency and fast switching times. An optional "flyback regulation mode" permits you to generate totally isolated and regulated outputs, without opto-couplers or extra transformer windings.

The LT1072 operates efficiently over a broad range of input voltages, load currents and switching configurations. The LT1072 comes in both mini-DIP or TO-220 versions. Pricing for the LT1072CN8 is $2.95 each, in quantities of 100 (and a lot less in 10,000 piece lots.) Higher current switching regulators (2.5A and 5A) are also available.

Cut your switcher problems down to size with our LT1072, and bid farewell to shoehorning forever. For a complete data package on our high-efficiency switching regulators, contact Linear Technology Corporation, 1630 McCarthy Blvd., Milpitas, CA 95035. Or call **800-637-5545.**

EDITED BY CHARLES H SMALL

Self-biasing reference consumes low power

Walter Jung and George Erdi
Linear Technology Corp, Milpitas, CA

The circuit in **Fig 1** is a micropower, buffered reference that works best with loads that source current. It will operate from any supply that is 3V higher than the reference voltage, including 4 to 9V batteries. Typical line regulation is 10 ppm/V. The overall temperature coefficient of the circuit is essentially that of D_1: 20 ppm/°C (max for the B device grade).

Overall, this reference's quiescent current is 30 μA—essentially the quiescent current of the dual op amp plus the currents in R_2 and R_3. The reference can source several milliamperes of load current to external loads. For example, the IC_{1A}, 1.227V stage has a typical output impedance of 30 μV/mA for currents of 10 mA or less.

Normally, you would bias D_1—a 20-μA, 2-terminal reference diode—with a simple series resistor connected to V^+. This simple biasing scheme, however, can be sensitive to line-voltage changes and could depart from micropower operation when heavily loaded.

Instead, op amp IC_{1A}'s 30-μA quiescent current provides a "free" bias source for D_1. Both the input and the output of the op amp used for IC_{1A} must be able to swing down to the op amp's V^- voltage level. In this case, the op amp's V^- pin will be at 1.225V ±15 mV.

The simple RC filter comprising R_1 and C_1 feeds the noninverting input of IC_{1A}, which functions as a low source-impedance buffer. The other half of IC_1 functions as a precision 2× amplifier/buffer. Note that both op-amp sections draw their input currents through R_1. These currents serve to raise the op amps' inputs a few millivolts above the level of the reference diode. This slight raise and the tiny current drawn by R_2 serve to bias IC_{1A} and IC_{1B}'s inputs up into a slightly more linear operating region than they would experience at the negative rail.

Note that you should use caution when employing this circuit with current-sinking loads, because the sunk current must necessarily flow through the reference diode. While the diode can safely sink up to 20 mA, the saturation characteristics of the op amp will add an error proportional to the sunk current. EDN

To Vote For This Design, Circle No 749

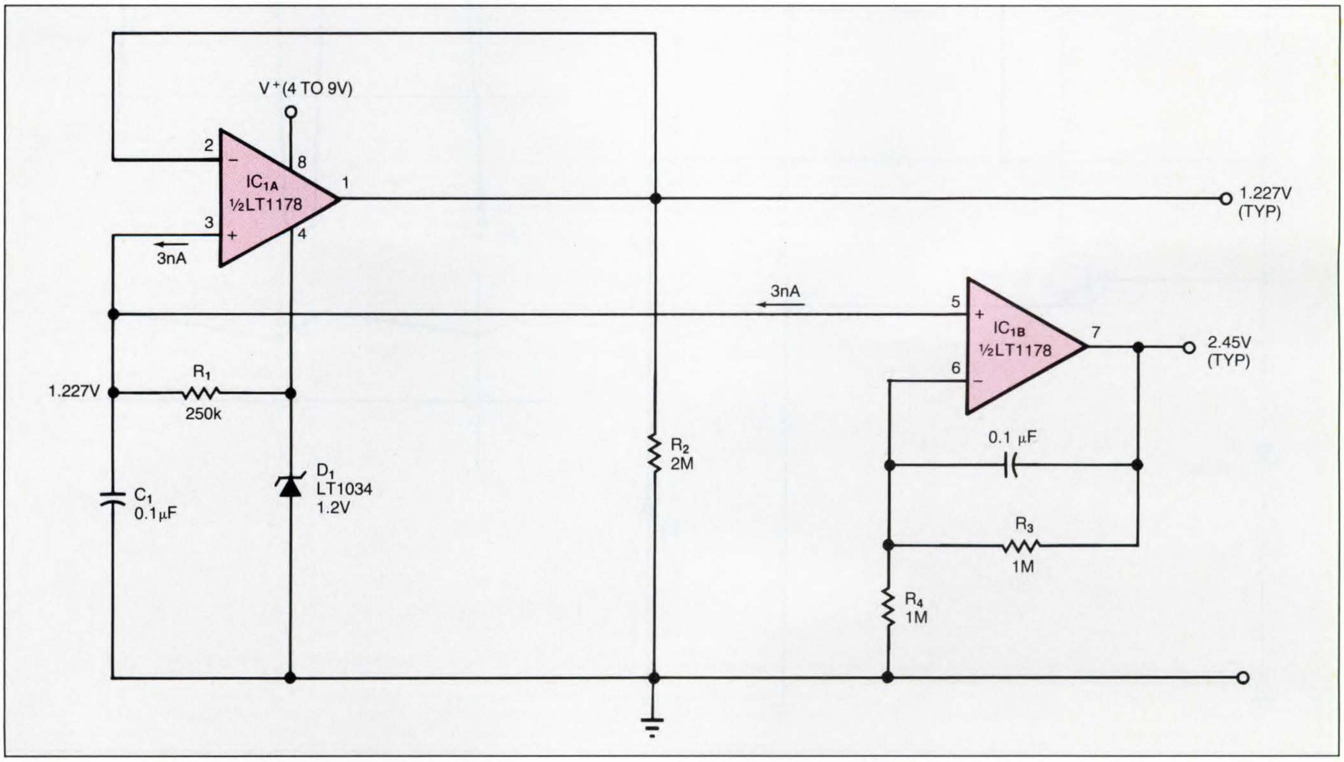


Fig 1—A micropower op amp provides both the bias current and buffering for a 2-terminal reference diode.

Single cell lights LED

Lacz Gyula and Bunsits József
Hiradástechnika Szövetkezet, Budapest, Hungary

You can light LEDs from a low-voltage source with the 150-kHz shunt switch-mode driver in **Fig 1.** Without this circuit, for example, a 1.2V battery has insufficient voltage to bias an LED on via a series resistor.

In the circuit, comparator Q_1 turns electronic switch Q_2 on and off. When Q_2 turns on, current flow ramps up in L_1, and LED D_2 is back-biased. Eventually, the voltage this current flow develops across R_6 turns off Q_1. Q_1's turning off, in turn, turns off Q_2. When Q_2 turns off, LED D_2 acts as a freewheel diode for L_1 and lights up.

Diode D_1 compensates for the temperature dependence of Q_1's base-emitter voltage and reduces the sensitivity of the R_1/R_2 divider to changes in supply voltage. R_4 limits the base current of Q_2, and R_5 adds hysteresis to the Q_1 comparator. EDN

To Vote For This Design, Circle No 750

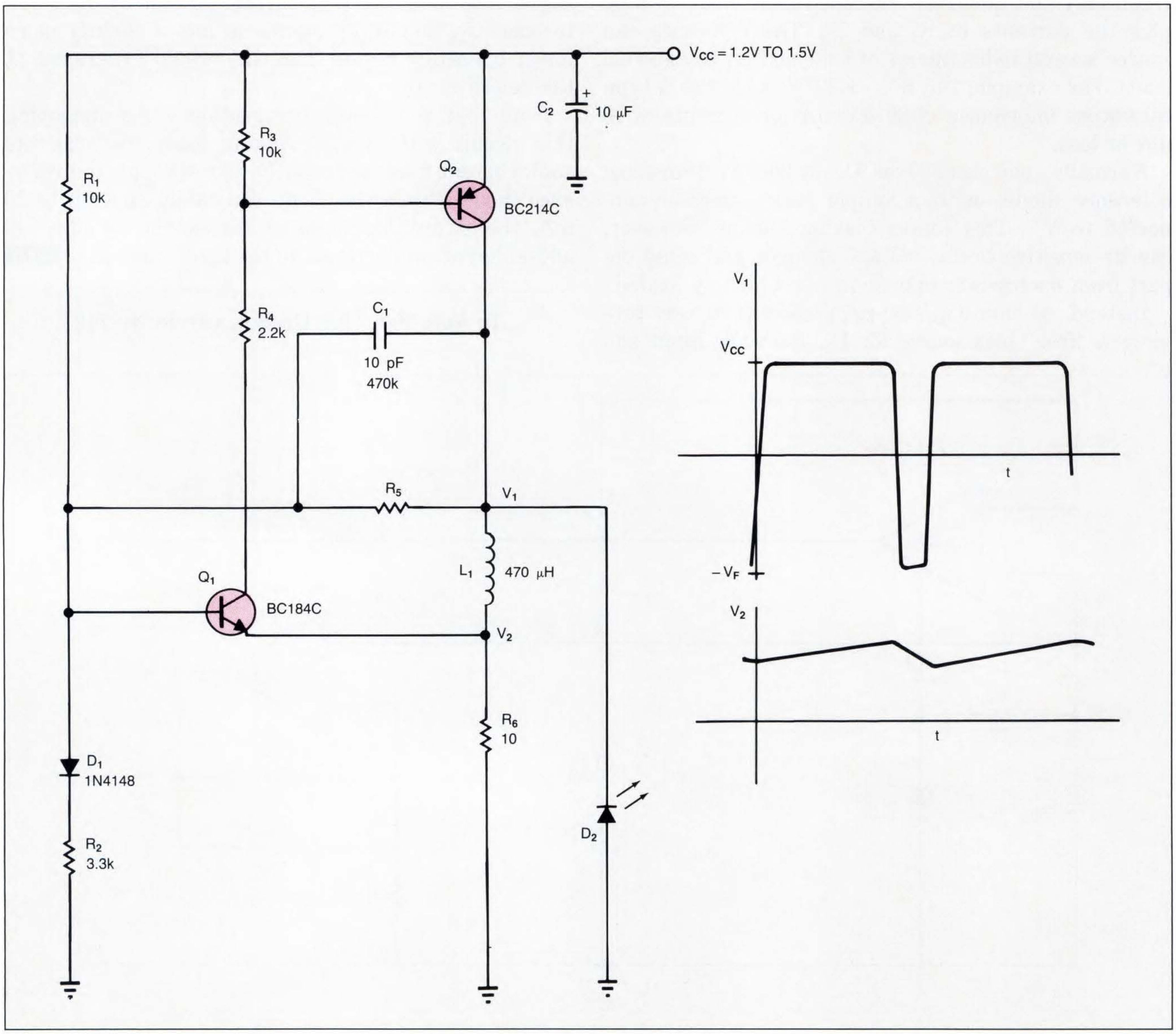


***Fig 1—This free-running switch-mode driver** can light an LED from a low-voltage source.*

Amplifier handles duplex line

Mansour Ahmadian
Technical and Engineering University,
Tehran, Iran

The circuit in **Fig 1** is a bidirectional amplifier that can amplify both signals of a duplex telephone conversation. It uses the principle of negative resistance. Obviously, such an amplifier could easily be unstable; however, you can adjust R_1 in **Fig 1** for maximum amplification and the circuit will remain stable. You might also consider replacing the LM324 op amps with op amps that would distort less, such as the LM1558, LF412, LF353, or LF442. EDN

To Vote For This Design, Circle No 746

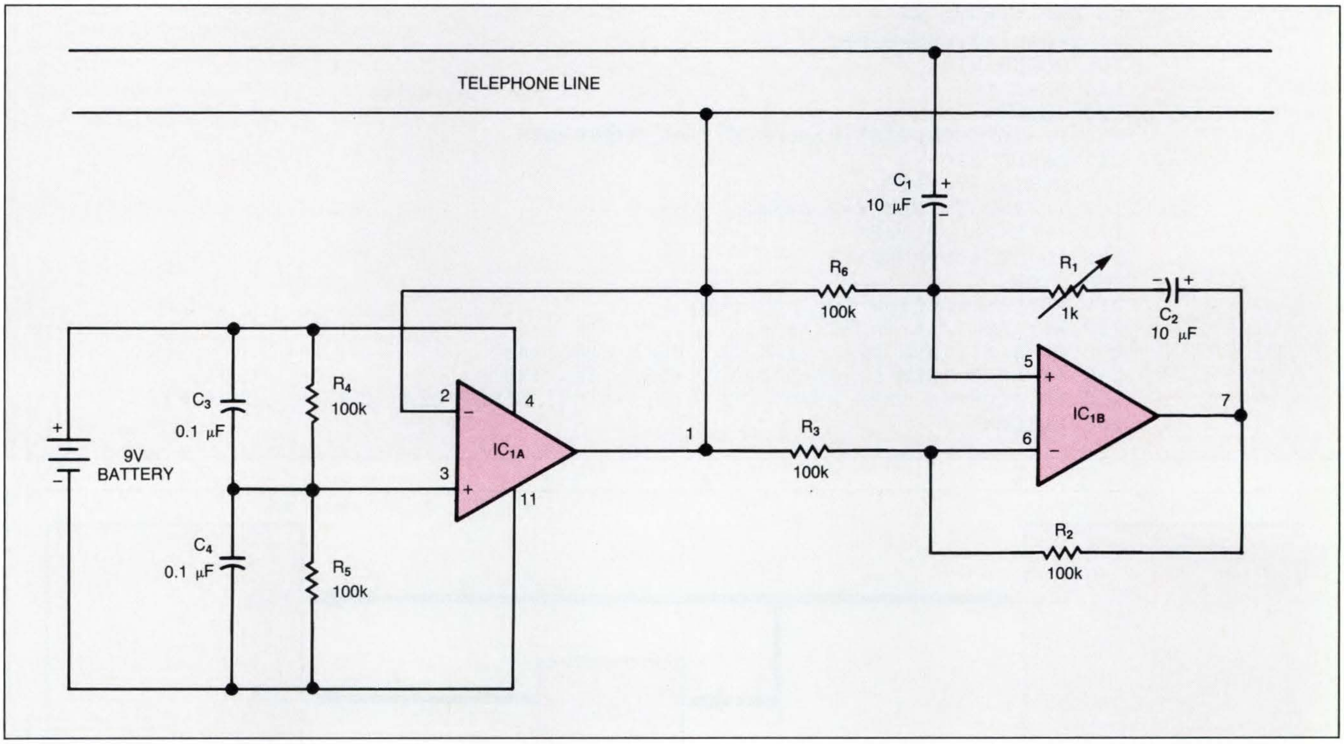


Fig 1—This amplifier uses the negative-resistance principle to amplify full-duplex telephone signals.

Single-chip µP acquires Basic

G Nagendra Rao
ISRO Satellite Centre, Bangalore, India

Unfortunately, no CMOS equivalent exists for the very handy 8052-AH single-chip µP with built-in Basic interpreter. This NMOS chip draws 100 mA typ. A low-power CMOS version of the 8052, the 80C32, lacks the on-chip Basic interpreter. You can remedy this situation by simply dumping the contents of an 8052-AH's onboard ROM into a 27C64 CMOS EPROM for subsequent use by the 80C32.

The combination of the CMOS single-chip µP and EPROM consumes 1/10 the power of the NMOS chip and cost 2/3 less. Running the Basic program in **Listing 1** on the single-chip µP board in **Ref 1** results in a dump, in Intel hex format, of the Basic interpreter through the board's console port. You can store this file on a disk using the Capture command of any communication program such as Crosstalk or Mirror. Subsequently, you can download this file to any EPROM programmer that accepts Intel hex format.

Of course, your target system must have chip-select circuitry that places the EPROM in the single-chip µP's External Code space from 0000_{HEX} to $1FFF_{HEX}$ (**Fig 1**). **EDN**

To Vote For This Design, Circle No 748

LISTING 1—BASIC INTERPRETER DUMP ROUTINE

```
10 REM To transmit data in Intel HEX format
20 M=0:X=0:Y=0:
30 COUNT=0:SUM=16+X+Y+0
40 PRINT ":10",
50 T=X:GOSUB 210
60 T=Y:GOSUB 210
70 T=0:GOSUB 210
80 FOR I=M TO M+15
90 T=CBY(I):SUM=SUM+T
100 GOSUB 210
110 NEXT I
120 COUNT=1
130 B1=INT(SUM/256):B2=SUM-B1*256:T=256-B2
140 GOSUB 210
150 M=M+16:Y=Y+16
155 IF Y>255 THEN Y=0:X=X+1
170 IF M<2000H THEN 30
180 PRINT":00000001FF"
190 STOP
210 REM subroutine for hex conv
220 A1=INT(T/16):A2=T-16*A1
230 IF A1>9 THEN C1=65+(A1-10) ELSE C1=A1+48
240 IF A2>9 THEN C2=65+(A2-10) ELSE C2=A2+48
250 IF COUNT=1 THEN PRINT CHR(C1),CHR(C2) ELSE PRINT CHR(C1),CHR(C2),
260 RETURN
```

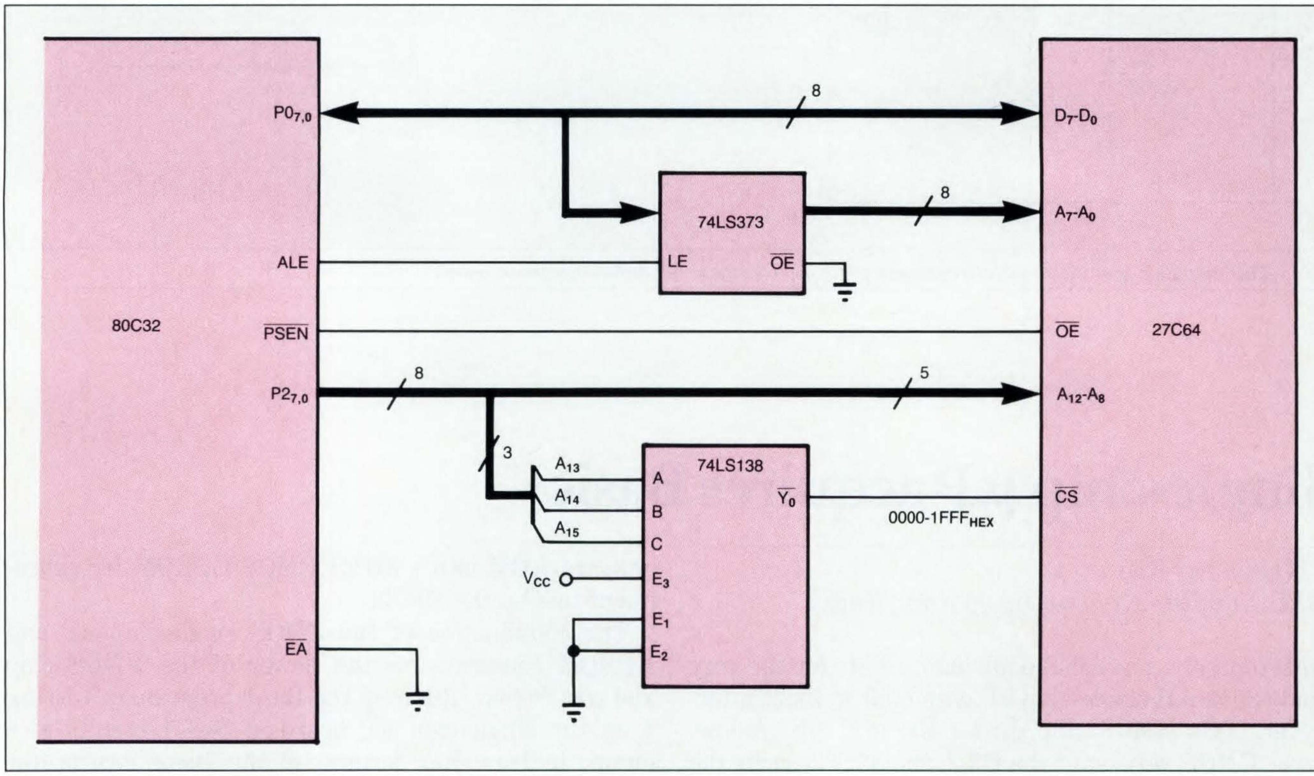


Fig 1—With a simple modification to an 80C32 system's *chip-select circuitry, the CMOS single-chip µP can access a Basic interpreter residing in an EPROM and function like a low-power version of the NMOS 8052-AH.*

value-packed filters from $11.45

dc to 3GHz

- less than 1dB insertion loss over entire passband
- greater than 40dB stopband rejection
- 5 section, 30dB per octave roll-off
- VSWR less than 1.7 (typ)
- over 100 models, immediate delivery
- meets MIL-STD-202
- rugged hermetically sealed package (0.4 x 0.8 x 0.4 in.)
- BNC, Type N, SMA available

finding new ways ...
setting higher standards

Mini-Circuits

A Division of Scientific Components Corporation
P.O. Box 350166, Brooklyn, New York 11235-0003 (718) 934-4500
Fax (718) 332-4661 Domestic and International Telexes: 6852844 or 620156

LOW PASS Model *LP-	10.7	21.4	30	50	70	100	150	200	300	450	550	600	750	850	1000
Min. Pass Band (MHz) DC to	10.7	22	32	48	60	98	140	190	270	400	520	580	700	780	900
Max, 20dB Stop Frequency (MHz)	19	32	47	70	90	147	210	290	410	580	750	840	1000	1100	1340

Prices (ea.): Qty. (1-9) P $11.45, B $32.95, N $35.95, S $34.95

HIGH PASS Model *HP-		50	100	150	200	250	300	400	500	600	700	800	900	1000
Pass Band (MHz)	start, max.	41	90	133	185	225	290	395	500	600	700	780	910	1000
	end, min.	200	400	600	800	1200	1200	1600	1600	1600	1800	2000	2100	2200
Min. 20dB Stop Frequency (MHz)		26	55	95	116	150	190	290	365	460	520	570	660	720

Prices (ea.): Qty. (1-9) P $14.95, B $36.95, N $39.95, S $38.95

*Prefix P for pins, B for BNC, N for Type N, S for SMA   *example:* **PLP-10.7**

C105 REV. E

CIRCLE NO 96

Reactive limiter protects transformer

Jim Zannis
Renishaw Metrology Ltd, Gloucestershire, UK

The simple reactive voltage divider in **Fig 1** (a capacitor in series with the primary of a transformer) performs a dual function: It protects the transformer against excessive currents if its secondary gets shorted, and it prevents damage if anyone inadvertantly connects a 120V transformer to a 240V line.

The reactive current-limiting scheme works best if your load normally draws little current through its mains-connected transformer (**Fig 2**). You should therefore choose jX_C to be less than the effective input impedance of your transformer's normal load. Under fault conditions, jX_C drops a proportionally larger voltage than under normal, lightly loaded conditions, which reduces the voltage across the transformer's primary. This reduction of voltage prevents the transformer from saturating and thus overheating.

The capacitor in the limiter dissipates no significant power because its voltage is not in phase with its current. However, the circuit reaction can impress a voltage on the capacitor that is greater than the mains' input voltage. You must choose a capacitor, such as a high-quality film capacitor that can handle both the expected current and the voltage overstress. EDN

To Vote For This Design, Circle No 747

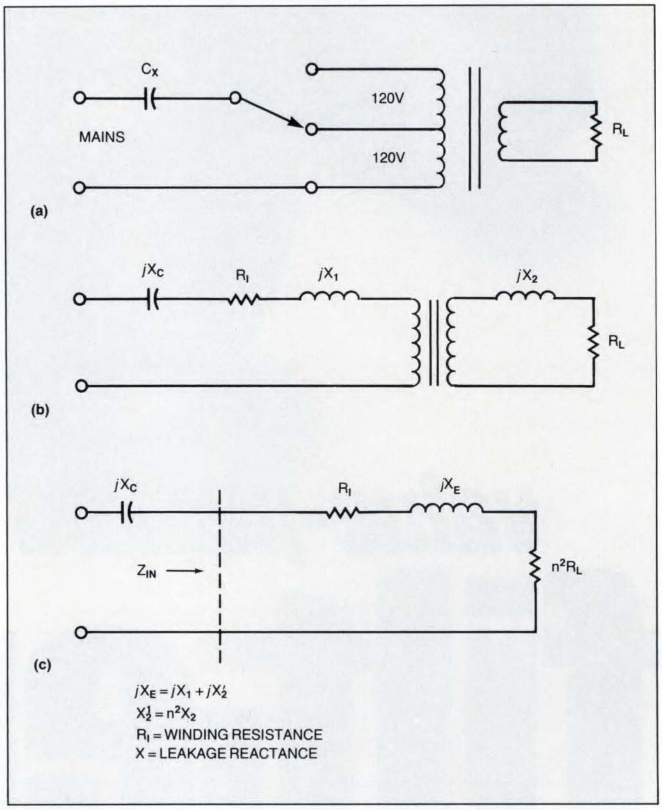


*Fig 1—**The 120/220V transformer** in **a** has a current-limiting capacitor in its primary circuit; **b** shows the transformer's equivalent circuit. Reflecting all the circuit elements over to the primary side of the circuit produces the equivalent circuit in **c**.*

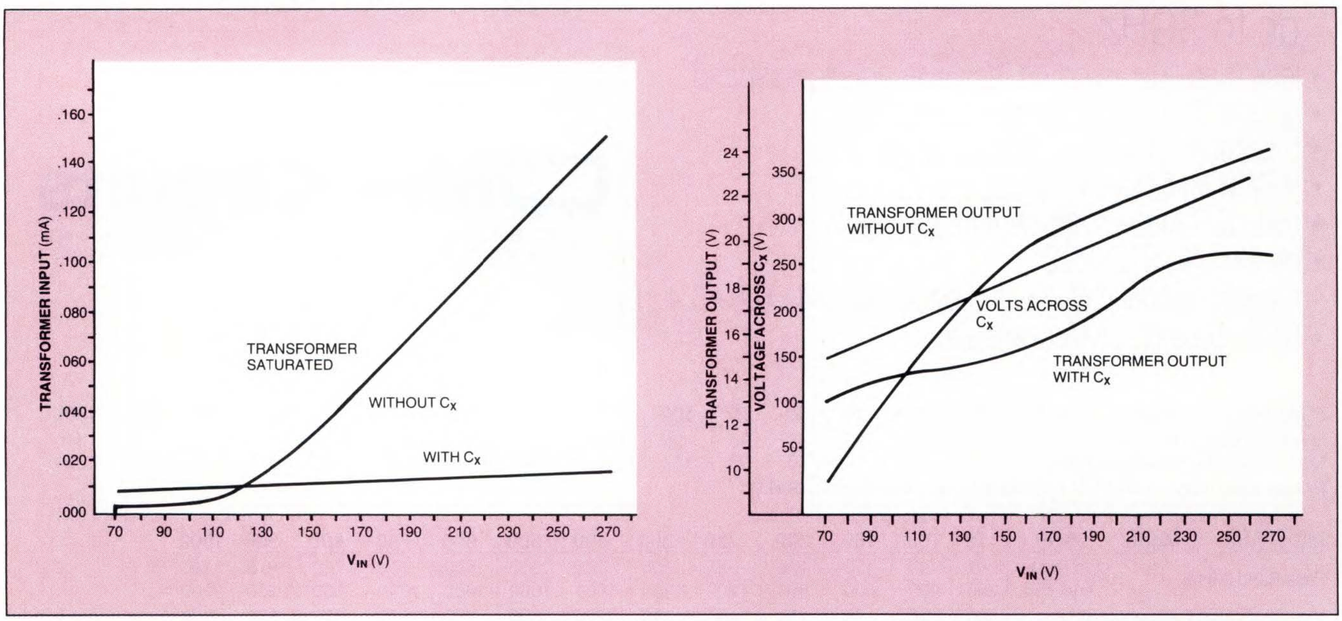
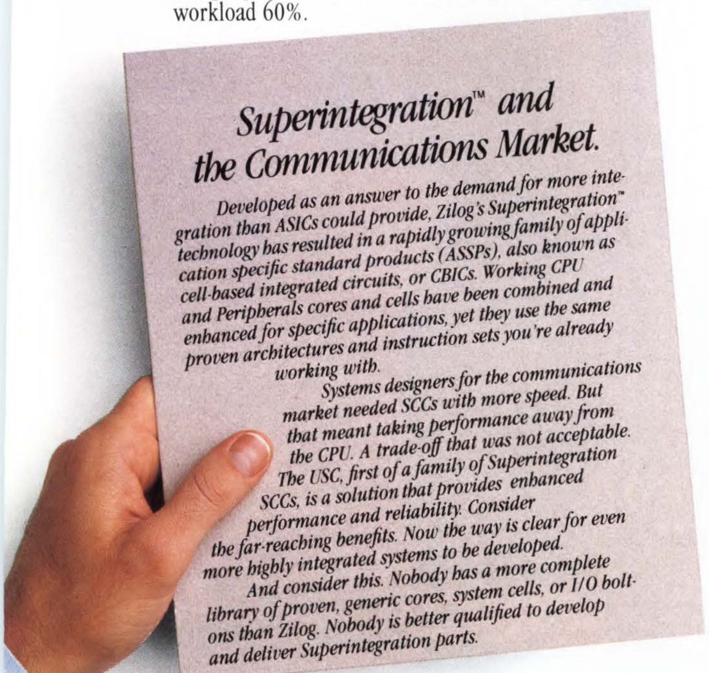


*Fig 2—**If you select** jX_C to be less than the effective impedance of the equivalent circuit in **1c**, then your power-supply transformer will not saturate during an overvoltage stress.*

Z I L O G

The next standard.
A new generation of high performance SCCs.

Zilog's universal serial communication controller, the USC (Z16C30™), provides higher throughput than any general purpose SCC. And it does it while reducing the CPU workload 60%.


Superintegration™ and the Communications Market.

Developed as an answer to the demand for more integration than ASICs could provide, Zilog's Superintegration™ technology has resulted in a rapidly growing family of application specific standard products (ASSPs), also known as cell-based integrated circuits, or CBICs. Working CPU and Peripherals cores and cells have been combined and enhanced for specific applications, yet they use the same proven architectures and instruction sets you're already working with.

Systems designers for the communications market needed SCCs with more speed. But that meant taking performance away from the CPU. A trade-off that was not acceptable. The USC, first of a family of Superintegration SCCs, is a solution that provides enhanced performance and reliability. Consider the far-reaching benefits. Now the way is clear for even more highly integrated systems to be developed.

And consider this. Nobody has a more complete library of proven, generic cores, system cells, or I/O bolt-ons than Zilog. Nobody is better qualified to develop and deliver Superintegration parts.

More speed.

The USC is four times faster than any general purpose SCC. You get guaranteed data rates of 10 Mbits/sec. But speed is not the only USC advantage.

More CPU power.

The USC requires less attention from the system CPU. That means more power for the system. The USC's lower overhead is due to easy initialization, auto-sequencing word transfers from deep FIFOs, fly-by DMA control, and reduced latency from an efficient, chained interrupt structure.

More flexibility.

You've got two completely independent channels, as well as multi-protocol capability. Because the USC has two BRGs per channel you can transmit and receive at two different bit rates. And the USC's universal bus interface means you can cut the cost of GLU logic and expensive board real estate.

More performance.

CMOS and Superintegration™ bring more CPU power and higher data throughput. The USC carries a 12.5 MByte/sec bus bandwidth punch. Straight DMA connect and 32-byte FIFOs make the USC's systems simple, elegant and fast. Very fast.

More reliability.

With the USC you get Zilog's proven quality and reliability. Unique built-in testability features allow access to nodes and registers for testing program functionality in real time. Find out more about the USC or any of Zilog's growing family of Superintegration products. 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

ZILOG SALES OFFICES: CA (408) 370-8120, (714) 838-7800, (818) 707-2160, **CO** (303) 494-2905, **FL** (813) 585-2533, **GA** (404)923-8500, **IL** (312) 517-8080, **MA** (617) 273-4222, **MN** (612) 831-7611, **NJ** (201) 288-3737, **OH** (216) 447-1480, **PA** (215) 653-0230, **TX** (214) 987-9987, **CANADA** Toronto (416) 673-0634, **ENGLAND** Maidenhead (44) (628) 39200, **W. GERMANY** Munich (49) (89) 612-6046, **JAPAN** Tokyo (81) (3) 587-0528, **HONG KONG** Kowloon (852) (3) 723-8979. **TAIWAN** (886) (2) 741-3125, **SINGAPORE** 65-235 7155, **DISTRIBUTORS: U.S.** Anthem Electric, Bell Indus., Hall-Mark Elec., JAN Devices, Inc., Lionex Corp., Schweber Elec., Western Microtech. **CANADA** Future Elec., SEMAD, **LATIN AMERICA** Argentina—Yel.-(1) 46-2211, Brazil—Digibyte (011) 241-3611, Mexico—Semiconductores Profesionales (5) 536-1312.

CIRCLE NO 97

Design Entry Blank

$100 Cash Award for all entries selected by editors. An additional $100 Cash Award for the winning design of each issue, determined by vote of readers. Additional $1500 Cash Award for annual Grand Prize Design, selected among biweekly winners by vote of editors.

To: Design Ideas Editor, EDN Magazine
Cahners Publishing Co
275 Washington St, Newton, MA 02158

I hereby submit my Design Ideas entry.

Name ______________________

Title ______________ Phone __________

Company ______________________

Division (if any) ______________________

Street ______________________

City ______________ State ______ Zip ________

Design Title ______________________

Home Address ______________________

____

____

Social Security Number ______________________
(Must accompany all Design Ideas submitted by US authors)

Entry blank must accompany all entries. Design entered must be submitted exclusively to EDN, must not be patented, and must have no patent pending. Design must be original with author(s), must not have been previously published (limited-distribution house organs excepted), and must have been constructed and tested.

Exclusive publishing rights remain with Cahners Publishing Co unless entry is returned to author or editor gives written permission for publication elsewhere.

In submitting my entry, I agree to abide by the rules of the Design Ideas Program.

Signed ______________________

Date ______________________

ISSUE WINNER

The winning Design Idea for the January 19, 1989, issue is entitled "Filter settles faster than a Butterworth," submitted by Einar Abell of ADA Instruments (Three Rivers, CA).

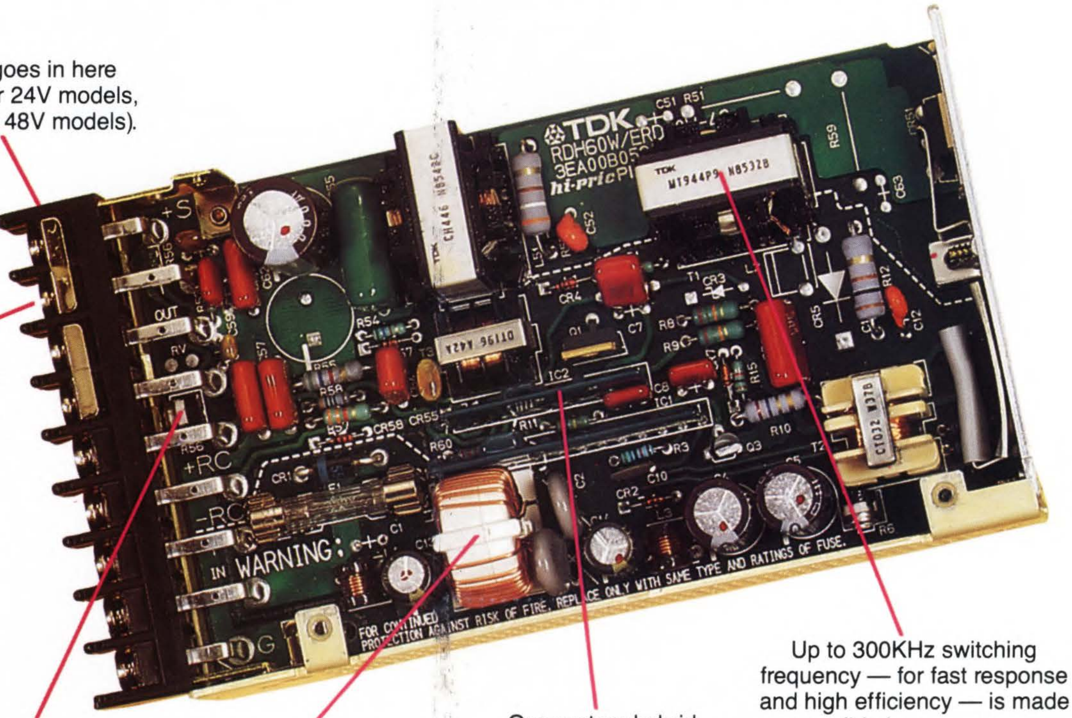
Your vote determines this issue's winner. All designs published win $100 cash. All issue winners receive an additional $100 and become eligible for the annual $1500 Grand Prize. **Vote now**, by circling the appropriate number on the reader inquiry card.

TEAR ON DOTTED LINE TO REMOVE AND SAVE.

How to turn the d-c you have into the d-c you want.

Pass it through a KEPCO ERD d-c to d-c converter

Your d-c goes in here (20~30V for 24V models, 40~56V for 48V models).



The d-c delivered here is stabilized to better than 0.2% (typ). As you increase your load to the rated load current, the voltage will remain constant within 0.3% (typ).

The input can be of either polarity, because the output is transformer-isolated from the input, and is fully floating off ground.

You can adjust the output voltage with a trimmer reachable through the enclosure.

Onboard EMI filter reduces the conducted noise fed back on your input bus within the limits of MIL-STD-461B.

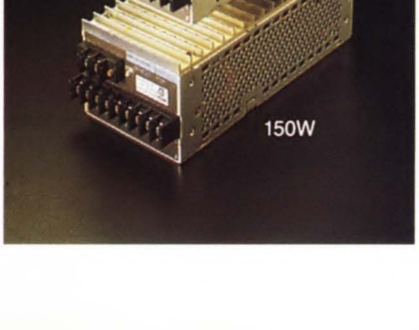
Our custom hybrid microcircuits (surface mount components on alumina substrates, sealed against moisture) reduce parts population, improve reliability.

Up to 300KHz switching frequency — for fast response and high efficiency — is made possible by a new, very low-loss TDK ferrite.

The model shown is our ERD 15-10-48. Output is 15V/10A; input is 48V.

Kepco d-c to d-c converters are not simple "regulators". They are full-fledged power supplies that do for your d-c everything that a-c to d-c voltage stabilizers do for the power company's a-c. Important features built into all models include:

- Self-contained heat sinks, convection cooled (no need to bolt an ERD to an external cold plate).
- Remote error sensing (allows for a voltage drop up to 0.4V in the wires to the load).
- Remote on/off (an optically isolated TTL logic control).
- Rectangular current limit (allows you to drive non-linear loads, parallel units, and use redundancy paralleling).
- LED power OK status indicator.

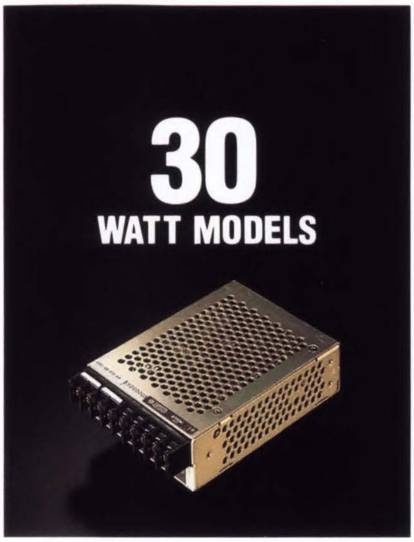


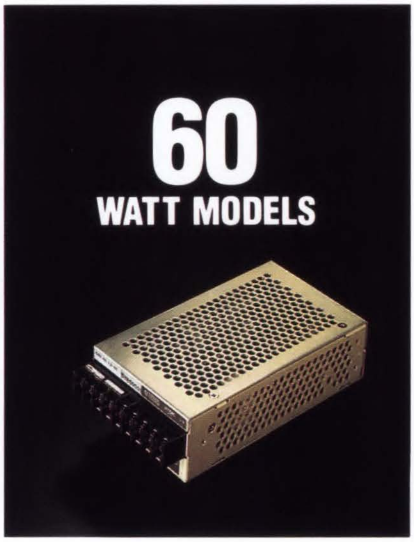
- Overvoltage protector (reduces the output to zero if the voltage tries to exceed the preset limit).
- Three sizes: 30 Watts, 60 Watts, and 150 Watts.
- Low cost, immediate availability.
- 5-Year warranty.

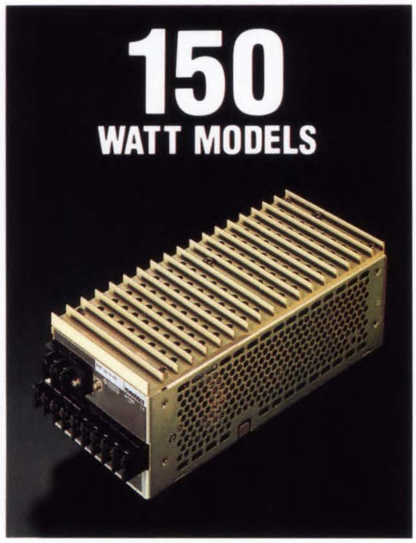
For more information or a demo for your lab, please write or call Dept JIM-12, KEPCO, INC., 131-38 Sanford Avenue, Flushing, NY 11352 USA
(718) 461-7000 • FAX: (718) 767-1102
Easylink (TWX): 710-582-2631.

KEPCO®
THE POWER SUPPLIER™

KEPCO SERIES ERD™ SINGLE OUTPUT D-C TO D-C CONVERTERS







ERD MODEL TABLE (-24, 24V input range: 20-30V; -48, 48V input range: 40-56V)

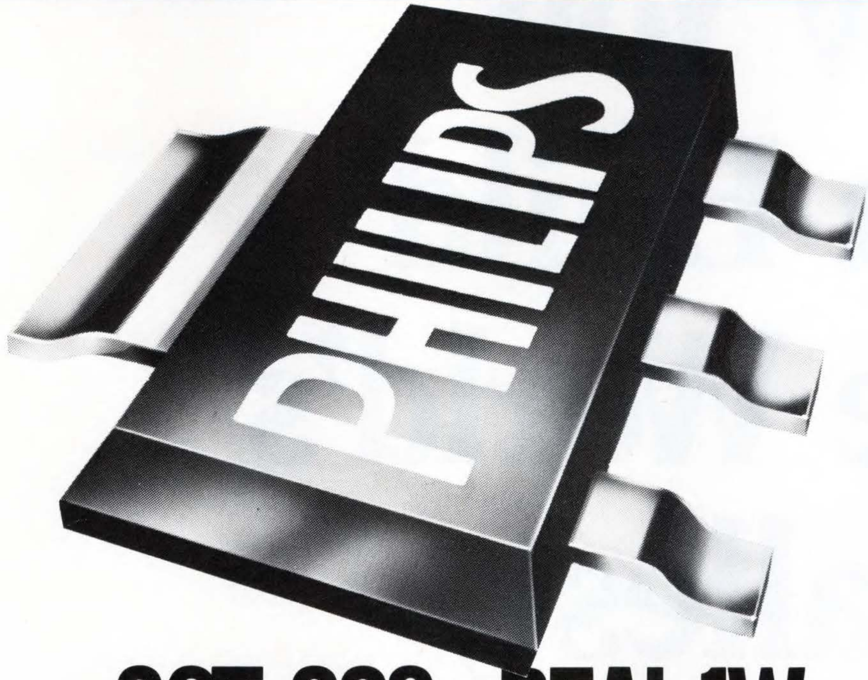
SPECIFICATION	OUTPUT VOLTAGE		OVP SETTING	OUTPUT CURRENT			CURRENT LIMIT	RIPPLE		NOISE (SPIKE)	EFFICIENCY
Unit	Volts		Volts	Amps			Amps	mV		mV	Percent
Condition	Factory set,(1)	Adjustment range	Nom. input, 25°C	50°C	60°C	71°C	25°C nom input, rectangular fixed	nom input max load p-p typ	max	d-c to 50MHz	nom input max load typ
30 WATT MODELS							Size: 1.38″ H x 3.74″ W x 5.12″ D			Net weight: 0.9 lb.	
ERD 5-6-24 ERD 5-6-48	5	4.0~ 5.5	6.0~ 6.9	6.0	4.2	2.4	6.6~ 7.1	30	50	100	
ERD 12-2.5-24 ERD 12-2.5-48	12	8.4~13.2	13.7~15.7	2.5	1.8	1.0	2.8~ 3.1	50	80	170	
ERD 15-2-24 ERD 15-2-48	15	12.0~16.5	17.0~19.5	2.0	1.4	0.8	2.3~ 2.6	50	80	200	77%
ERD 24-1.3-24 ERD 24-1.3-48	24	16.8~26.4	27.0~30.5	1.3	0.9	0.5	1.5~ 1.8	50	100	290	
ERD 48-0.6-24 ERD 48-0.6-48	48	32.6~52.8	55.0~63.0	0.6	0.4	0.2	0.7~ 1.0	60	150	530	
60 WATT MODELS							Size: 1.69″ H x 3.74″ W x 6.3″ D			Net weight: 1.2 lb.	
ERD 5-12-24 ERD 5-12-48	5	4.0~ 5.5	6.0~ 6.9	12.0	8.4	4.8	13.2~13.8	30	50	100	
ERD 12-5-24 ERD 12-5-48	12	8.4~13.2	13.7~15.7	5.0	3.5	2.0	5.6~ 6.0	50	80	170	
ERD 15-4-24 ERD 15-4-48	15	12.0~16.5	17.0~19.5	4.0	2.8	1.6	4.5~ 4.9	50	80	200	24V input: 79%
ERD 24-2.5-24 ERD 24-2.5-48	24	16.8~26.4	27.0~30.5	2.5	1.8	1.0	2.8~ 3.1	50	100	290	48V input: 82%
ERD 48-1.2-24 ERD 48-1.2-48	48	32.6~52.8	55.0~63.0	1.2	0.8	0.5	1.4~ 1.7	60	150	530	
150 WATT MODELS							Size: 3.15″ H x 3.74″ W x 8.66″ D			Net weight: 2.6 lb.	
ERD 5-30-24 ERD 5-30-48	5	4.0~ 5.5	6.0~ 6.9	30.0	21.0	12.0	33.0~35.0	30	50	100	
ERD 12-12-24 ERD 12-12-48	12	8.4~13.2	13.7~15.7	12.0	8.4	4.8	13.4~14.4	50	80	170	
ERD 15-10-24 ERD 15-10-48	15	12.0~16.5	17.0~19.5	10.0	7.0	4.0	11.2~12.0	50	80	200	24V input: 79%
ERD 24-6-24 ERD 24-6-48	24	16.8~26.4	27.0~30.5	6.0	4.2	2.4	6.8~ 7.3	50	100	290	48V input: 81%
ERD 48-2.8-24 ERD 48-2.8-48	48	32.6~52.8	55.0~63.0	2.8	2.0	1.1	3.3~ 3.6	60	150	530	

(1) Nominal input, maximum load, 25°C

For complete specifications send for Switcher Catalog 146-1605.

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

NEW SURFACE MOUNT OUTLINE.



SOT-223...REAL 1W SMD PERFORMANCE ON PRINTED CIRCUIT BOARDS!

Now you can benefit from SMD technology in a wider range of applications with the new Philips SOT-223 surface mounted package.

The SOT-223 gives performance of 1W on PCBs and 2W on ceramic substrates without extra cooling. It enhances the performance of small signal devices currently available in other surface mounted packages. Plus, it's equally compatible with reflow and wave soldering techniques.

Devices now available in SOT-223 include switching, high voltage, darlington and driver transistors, RF broadband transistors up to 7.5 GHz and P and N Channel DMOS-FETs.

But that's just the start. SOT-223 offers you power—plus an impressive list of board mounting benefits.

- Design ensures level mounting which eliminates hot spots and also allows visual inspection of solder joints.
- Supplied on standard 12mm tape for speed and simplicity of automated placement.
- Formed leads absorb thermal stress, preventing damage to die.
- Accepts extensive range of die up to 2.5mm square.
- Tab position leaves base free to be glued for wave soldering.
- Can be mounted on the same solder pad design as the DPAK outline.

Benefit from this breakthrough now!
For designers in consumer electronics, automotive, telecommunications, EDP industries, etc., SOT-223 is a major advance in SMD technology. Get the full facts fast. Call or write today.

Amperex®

DISCRETE SEMICONDUCTOR PRODUCTS GROUP

PHILIPS

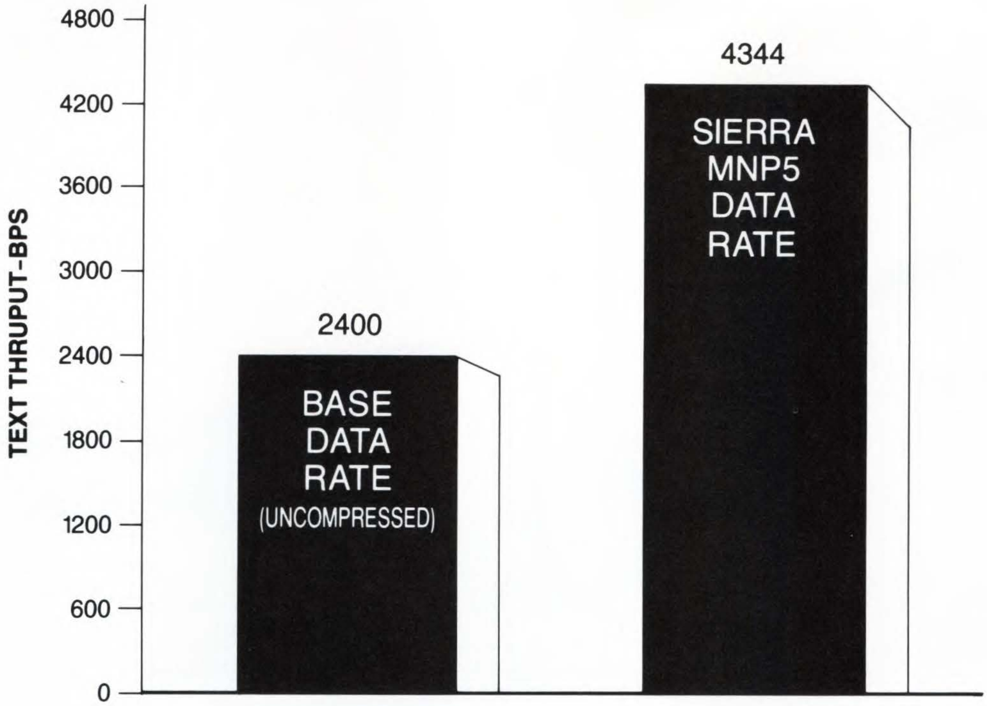
SMD TECHNOLOGY

Amperex Electronic Company, George Washington Highway, Smithfield, RI 02917 (401) 232-0500
In Canada: Philips Electronics Ltd., 601 Milner Ave., Scarborough, Ontario M1B 1MB (416) 292-5161

CIRCLE NO 99

Now You Can Build The World's Smallest, Lowest Power MNP5™ 2400 BPS Modem With The...

...Highest Thruput



Sierra's SC11024 2400 BPS Modem, SC11018 Controller and MNP5 peripheral provides the basis for error free data communications at a thruput rate of over 4300 BPS. This 5.0V chip set is fully Microcom compatible.

Using field proven MMA (Michael Mooradian Associates) architecture and offering the full complement of extended AT commands, this powerful Sierra chip set provides the lowest cost solution for data compressed, error-free communications. (No license fees are required.)

The SC11018 contains an on-board UART so parallel operation requires no extra chips.

This pair isn't all we have — Sierra's Data Communications Products span the data rate range of 300 BPS to 14,400 BPS and conform to CCITT and Bell Standards.

FAX, write or call today for complete information on our MNP5 solution. Data Communications Marketing, Sierra Semiconductor, 2075 N. Capitol Avenue, San Jose, CA 95132. (408) 263-9300 FAX (408) 263-3337

Triple Technology™ In CMOS

SIERRA SEMICONDUCTOR

Microcom Networking Protocol and MNP are both trademarks of Microcom Inc.

CIRCLE NO 102

This 12-bit, 10MSPS A/D is hard to beat... and easy to use.

Comlinear designed the CLC925 as a next generation A/D converter. At 10MSPS, with a 5MHz analog input, SNR is an impressive 68dB. And harmonics are down 70dBc. Perfect for radar processing, electronic imaging, FLIR systems, and high-speed instrumentation.

We also made it easy to use with internal track-and-hold, precision voltage reference, error correction, and digital timing circuits. Plus simple gain adjustment. And a 2Vpp input range you can set anywhere between +2V and −2V. All in a 2.1″ × 1.1″ package 40% smaller than the competition. Just connect supplies, an analog input, and a convert signal.

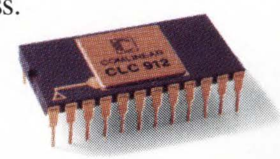
You're ready to go. And ask about availability of our 883 version.

12-bit D/A conversion at 25MHz... and no hiccups.

Here's a monolithic 12-bit D/A that's fast... and quiet. The CLC912 handles data conversion rates to 25MHz. And has a low 25pV-sec output glitch energy. Without deglitching circuits. What's more, it has 1LSB integral non-linearity. A 30ns settling time to reconstruct signals with better than 64dB signal purity. And it drives a 50-ohm load to 1V full scale. Directly.

Frequency-domain characterization helps you put it to work in digital frequency synthesis, arbitrary waveform generators, electron-beam positioning systems, professional video reconstruction, and high-resolution A/D converters.

And you can do it simply. Just supply power, a simple reference circuit, a TTL convert signal and data. That's it. You're in business.

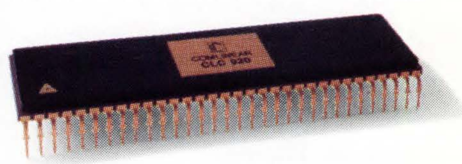


Big performance in a flash... 10-bits and 25MSPS.

This monolithic flash ADC–the CLC920–can make a big difference in your system's performance. It encodes video-bandwidth input signals at rates to 25MSPS. With 0.1%(max) integral non-linearity. All without an external track-and-hold.

Its 58dB SNR makes it perfect for radar receivers, professional video, waveform analyzers, high-speed instrumentation, and medical imaging.

To help in design, we've characterized the part in the frequency domain. And features like reference sense lines, intermediate ladder tap points, and user configurable data formats deliver high performance with flexibility.



Now, push us for immediate action. Call 303-226-0500 for the details you need... today.

CLC925

CIRCLE NO 104

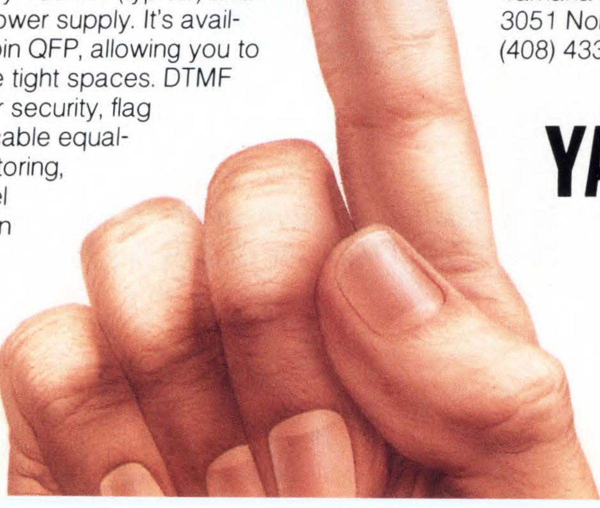
We've Got Everybody Talking

and FAXing with Just One Chip.

Now it's easy to put Group 3 FAX capability anywhere you want it. Just start with the YM7109, a true single-chip 9600bps FAX MODEM from Yamaha LSI. It's ideal for laptops. It's perfect for cellular telephones, facsimile machines, PC FAX boards, communications cards or external modems. Wherever space is scarce. Wherever low power consumption is critical. Wherever you need a more cost-effective way to add both FAX and modem capabilities to your product.

It's in There.

The YM7109 consumes only 180mW (typical) and needs only a single +5V power supply. It's available in 40-pin DIP and 64-pin QFP, allowing you to fit the YM7109 into all those tight spaces. DTMF detect for remote control or security, flag pattern detect, selectable cable equalization, receive signal monitoring, programmable receive level adjust and auto equalization are all in the chip.



Of course, the YM7109 meets CCITT V.29, V.27ter, V.21 channel 2, V.23 backward channel, V.21 and Bell 103 standards, is compatible with industry-standard chip sets and has been fully tested on both domestic and international telephone lines.

And, Yamaha will be there when you need technical support for hardware and software development or applications assistance.

Get the FAX.

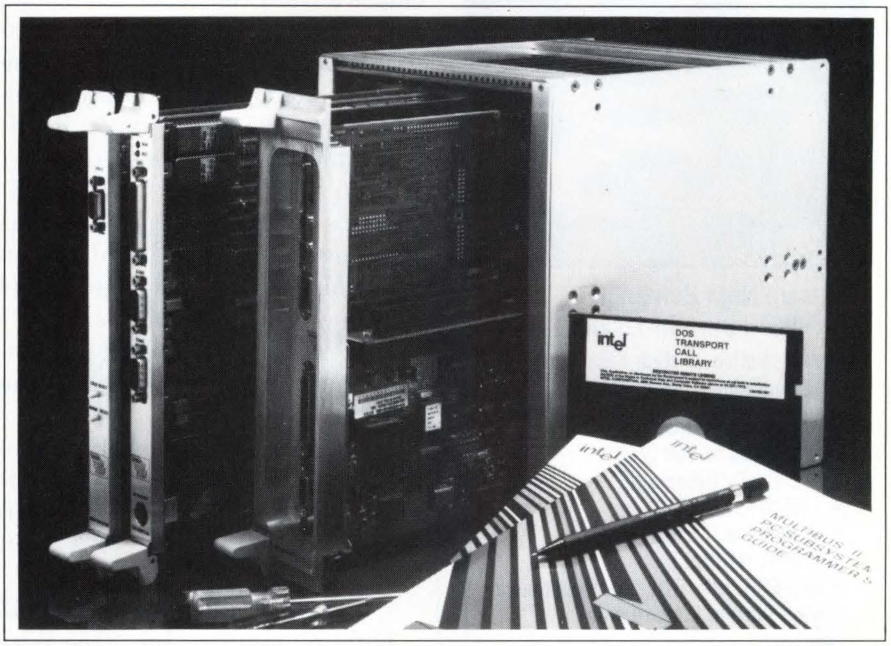
Just call 1-800-543-7457
Yamaha LSI, Systems Technology Division
3051 North First Street, San Jose, CA 95134
(408) 433-5260 FAX (408) 433-5230

YAMAHA® LSI

CIRCLE NO 105

MULTIBUS II SYSTEM

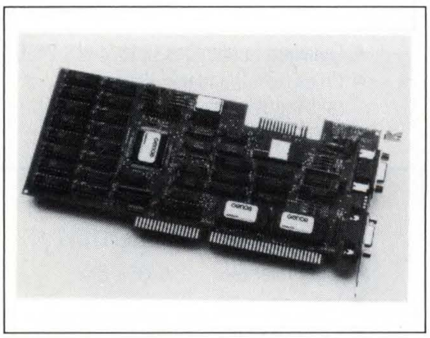
- *Contains a CPU board with a 16-MHz 80386 μP*
- *Companion board has a hard disk and VGA controller*



The Multibus II PC Subsystem consists of three Multibus II-compatible boards that operate with DOS-compatible software. The CPU board contains a 16-MHz 80386 μP, a socket for an 80387 coprocessor, a 64k-byte static RAM cache, two serial ports, a parallel port, and keyboard and floppy-disk-drive controllers. You can purchase memory-expansion modules to add as many as 16M bytes of dynamic RAM to the board. The message-passing coprocessor can communicate with other systems running on the bus. A companion board includes a VGA graphics controller, a central service module, and a hard-disk controller for ST-506/ST-412-compatible drives. An adapter board accommodates up to four half-size IBM PC, PC/XT and compatible boards. The system includes an Award BIOS and runs with PC-DOS or MS-DOS. CPU board, $4700; companion board, $1295; adapter board, $995; 2-slot backplane, $195; 4-slot backplane, $295.

Intel Corp, Literature Dept, #AP-13, Box 58065, Santa Clara, CA 95052. Phone (800) 548-4725.

Circle No 350



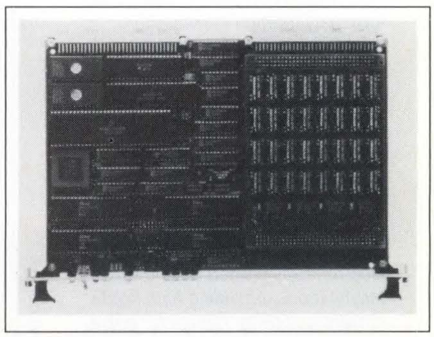
GRAPHICS ADAPTER

- *Provides 1024×768-pixel resolution with 16 colors*
- *Automatically switches between IBM PC/XT and PC/AT buses*

The SuperVGA 16-bit graphics adapter is a VGA card for the IBM PC, PC/XT, PC/AT and compatible computers. The adapter provides 1024×768-pixel resolution with 16 colors for interlaced and noninterlaced monitors and comes in two models: the 5300, which has 256k bytes of display RAM, and the 5400, which has 512k bytes of display RAM. (You can upgrade the 5300 to a 5400 by purchasing an extra 256k bytes of RAM.) Both models come with drivers for AutoCAD, Ventura Publisher, Lotus 1-2-3, and Windows. Each board has an autosensing capability to automatically switch between an 8-bit PC/XT bus and a 16-bit PC/AT bus. The 5400 offers the following resolution and color combinations: 1024×768 pixels with 16 colors, 800×600 pixels with 256 colors, and 640×480 pixels with 256 colors. Both products support digital and analog monitors. 5300, $499; 5400, $699.

Genoa Systems Corp, 75 E Trimble Rd, San Jose, CA 95131. Phone (408) 432-9090. FAX 408-434-0997. TLX 172319.

Circle No 351



PARALLEL I/O BOARD

- *Has 64 configurable parallel I/O lines with handshake facilities*
- *Includes an onboard 68000 μP and a DMA controller*

The SYS68K/IPIO-1 parallel I/O board includes an onboard 68000 μP and can offload parallel I/O control tasks from VME Bus CPUs. A piggyback board accommodates the board's 64 I/O lines. You can select from a range of piggyback boards that allow you to configure the I/O lines with relay, optocoupler, or TTL-level interfaces. The board includes a DMA controller that allows you to set up high-speed data transfers between the I/O port and the board's 128k bytes of onboard, zero-wait-state, dual-port static RAM. Communication between the host system's CPU and the SYS68K/IPIO-1's onboard µP is also via this dual-port RAM. The board has an EPROM-resident real-time kernel based on the company's VME-PROM real-time kernel for processing commands that are sent by the host CPU. DM 2995.

Force Computers GmbH, Daimlerstrasse 9, 8012 Ottobrunn/Munich, West Germany. Phone (089) 600910. TLX 524190. FAX 089-6097793.

Circle No 352

Force Computers Inc, 3165 Winchester Blvd, Campbell, CA 95008. Phone (408) 370-6300. FAX 408-374-1146.

Circle No 353

VME A/D BOARD

- *Samples at 300 kHz and has 12-bit resolution*
- *Contains a 68010 µP and 64k bytes of dual-port RAM*

The DVME-601E, an A/D board in a 6U VME form factor, contains a 12-bit A/D converter that can sample 16 single-ended or 8 double-ended inputs at 300 kHz. The board also contains a 68010 µP that can access one port of a dual-port RAM; the other port services the VME Bus. The board has 64k bytes of EPROM that is expandable to 128k bytes, and its µP can access 64k bytes of local RAM. Other peripherals include an interrupt controller, an RS-232C port, five TTL I/O ports, three timer outputs, and two timer-counter inputs. The board comes with executive and monitor firmware supplied in EPROM. Using the host, you can download user-written code through the dual-port RAM or from the RS-232C

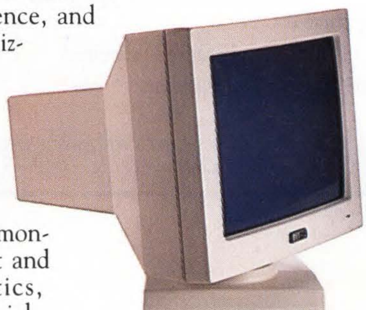
WE LOOK AT MONITORS FROM YOUR POINT OF VIEW.

Cost/Performance/Reliability...

That's how most engineers look at monitors. Whether you're buying high resolution, medium resolution or standard TV resolution, custom or off-the-shelf, with whatever pallet of colors, pixel triads, or scanning rates, you want the best... at the best possible price.

And that's what the Dotronix/VMI team can deliver. Our years of combined OEM experience, and worldwide manufacturing facilities each specializing in a specific monitor technology, mean you always get the best possible monitor at the best possible price.

Video Monitors inc ...for your high resolution needs. Our Video Monitors Inc. facility is well recognized for continually defining "state of the art" monitor technology in high performance broadcast and video displays for Medical Diagnostics, CAD/CAM, Desktop Publishing and other high resolution applications.



Dotronix--Mpls./St.Paul...specializing in monitor design and manufacture for Financial, Transportation, Medical Instrumentation and S-VHS applications.

Dotronix--Boulder...when it comes to monitors for Instrumentation and Process Control applications.

Dotronix--Taiwan...providing high volume production for cost advantages in VGA and OEM displays.

Talk to an Applications Specialist Today.
Phone 612/633-1742 FAX 612/633-7025

DOTRONIX

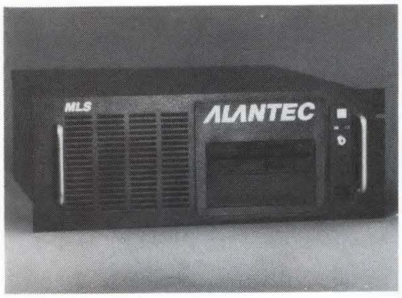
DOTRONIX INC.
160 First Street S.E. New Brighton, MN. 55112
Service Locations:
Los Angeles, CA ◊ San Jose, CA ◊ Boulder, CO
Mpls./St.Paul, MN ◊ Eau Claire, WI ◊ New Jersey

COMPUTERS & PERIPHERALS

port. Sample software drivers in both C and assembly language are supplied on the floppy disk. $2195.

Datel Inc, 11 Cabot Blvd, Mansfield, MA 02048. Phone (508) 339-3000. FAX 508-339-6356. TLX 174388.

Circle No 354



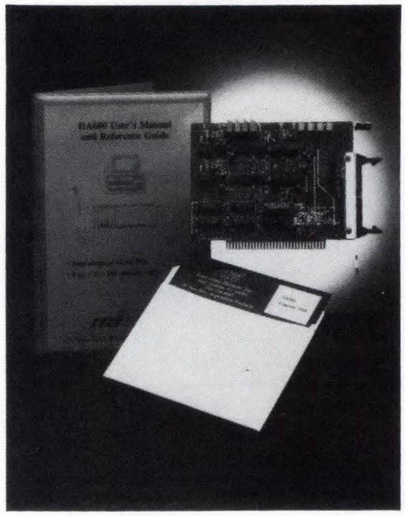
LAN SWITCH

- *Connects local-area networks using a 160M-bps data rate*
- *Connects LANs 10 km apart using fiber-optic links*

The Multi LAN Switch Ethernet bridge can connect several local-area networks (LANs) at a 160M bps data-transfer rate. A patent-pending architecture converts an IBM PC/AT bus into a packet-switching bus to provide the high-speed operation. The unit can connect as many as 16 LANs in one building or it can connect LANs as far apart as 10 km by using fiber-optic cable. A network manager can dynamically forward packets to each LAN segment based on protocol types, source or destination address, packet length, broadcast identifiers, or TCP/IP connection requests. The network administrator can isolate traffic or enforce security, such as in applications where network segments can send but not receive packets from other locations. A 4-port configuration with Ethernet connectors, $9800; expansion cards, $2000 each.

Alantec, 101 Hammond Ave, Fremont, CA 94539. Phone (415) 770-1050.

Circle No 355



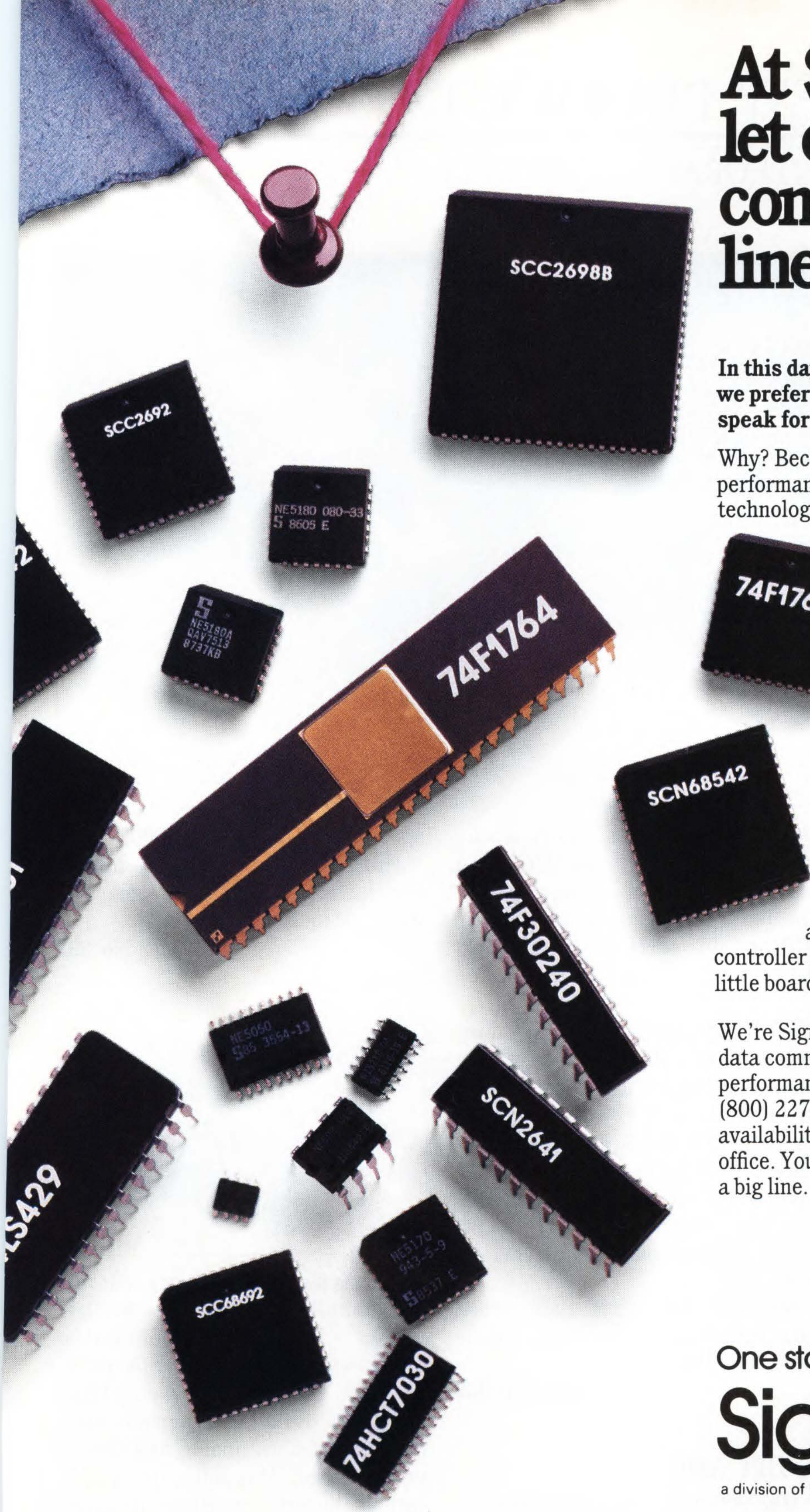
12-BIT D/A BOARD

- *Uses the AD7537 chip; fits IBM PCs, PC/XTs, and PC/ATs*
- *Provides two channels of analog output*

The DA600 12-bit D/A converter for the IBM PC, PC/XT, PC/AT and compatible computers is based on Analog Devices' AD7537 chip, which contains two D/A converters. Having two converters in one IC package ensures close matching between channels. The board provides two 12-bit analog-output channels that you can optionally upgrade to four channels, and it uses an AD712 precision op amp as an output buffer that provides 1.8-μsec settling time to .01% of full scale. The host can control both channels in software including a clear function for generating calibration routines or specialized waveforms. Each board has two jumper-selectable full-scale output ranges of 5 or 10V and includes a manual and a disk with programming examples in Basic, Turbo C, Pascal, and Forth. 2-channel version, $179; 4-channel version, $239.

Real Time Devices Inc, Box 906, State College, PA 16804. Phone (814) 234-8087. TLX 4948141. FAX 814-234-6864.

Circle No 356



At Signetics, we let our data communications line do the talking.

In this day and age of big talk and lofty promises, we prefer to let our data communications family speak for itself.

Why? Because it speaks exactly to your need for high performance. And high reliability. All in a range of technologies and packages to solve applications from peripherals and multiplexers to LANs, fiber optic networks and more.

One example is our new CMOS SCC2698B Octal UART from the serial communications family. It delivers eight full duplex channels and support circuits in a single, low-power chip.

Or, from our transmitter/receiver family, there's the new NE5211 transimpedance amplifier for applications that require high input sensitivity such as fiber optic receivers and extended communication links. And, for communication buffer management, our new N74LS429 FIFO RAM controller addresses up to 64K locations using very little board space for very large buffer implementation.

We're Signetics. We've got the guts—those essential data communications products to improve system performance. For your free information packet, call (800) 227-1817, ext. 995D. Or for military product availability, contact your local Signetics sales office. You'll learn why we speak softly—and carry a big line.

One standard. 0 defects.

Signetics

a division of North American Philips Corporation

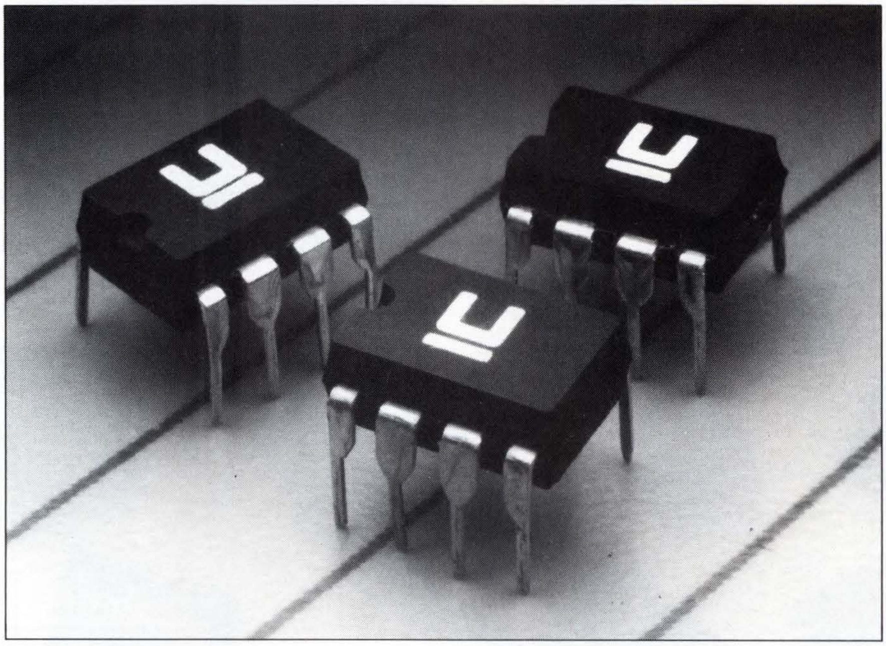
PHILIPS

PHILIPS

CIRCLE NO 116

CURRENT-MODE PWMs

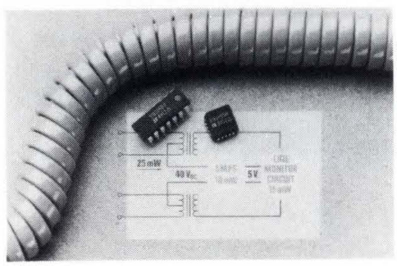
- *Improved industry-standard types*
- *High-current totem-pole outputs*



The UC3842A, UC3843A, UC3844A, and UC3845A are improved, pin-compatible versions of the industry-standard 3842/3/4/5 family of current-mode PWMs that are widely used in switched-mode power supplies. The "A" series features a start-up current of <0.5 mA, a precise oscillator-discharge current of 8.2 mA, and a 1A peak-output stage that can sink at least 10 mA at <1.2V during undervoltage lockout (UVLO) for V_{CC} over 5V. The family members differ in their UVLO thresholds and maximum duty-cycle ranges. The UC3842A has UVLO thresholds of 16V (on) and 10V (off). The corresponding UVLOs for the UC3843A and UC3845A are 8.5 and 7.9V. The UC3842A and UC3843A can operate to duty cycles approaching 100%; the UC3844A and UC3845A are clamped at a maximum of 50%. The units are available in an 8-pin DIP and 14- or 16-pin SOIC packages. 8-pin DIP, $1.32 (1000).

Unitrode Integrated Circuits, 7 Continental Blvd, Merrimack, NH 03054. Phone (603) 424-2410.

Circle No 361



ISDN SWITCHMODE IC

- *Meets CCITT requirements*
- *Features high conversion efficiency*

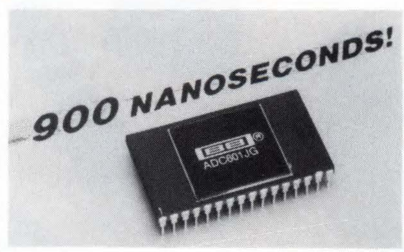
The Si9105 high-voltage switchmode regulator is designed for use in low-power, high-efficiency dc/dc converters. CCITT recommendations for ISDN power supplies call for conversion from 40V down to 5V with 40 to 60% efficiency for the light-load condition. The Si9105 provides typical efficiencies of 64% under light-load conditions, and 88% under full-load conditions. The CCITT recommends a total power consumption of <25 mW during emergency operation in the power-down state. An ISDN power supply using the Si9105 uses approximately 10 mW, leaving the 15 mW needed for line-activity detection circuitry. 14-pin plastic DIP, $5.97; 20-pin plastic leaded-chip carrier, $6.95 (100).

Siliconix Inc, 2201 Laurelwood Rd, Santa Clara, CA 95054. Phone (408) 988-8000.

Circle No 362

12-BIT ADC

- *Has 900-nsec conversion rate*
- *2-tone IMD is −77 dBc*



Specially characterized for dynamic performance, the ADC601 12-bit, successive-approximation A/D converter features a 900-nsec conversion rate. Other dynamic specifications, measured at the Nyquist frequency with the company's SHC804 S/H amplifier, include −68-dBc THD, −77-dBc intermodulation distortion, and a 67-dBc S/N ratio. The ADC601 employs a 2-chip bipolar/CMOS design that permits optimization of both analog and digital performance. Maximum dc specifications include ±0.012% integral-linearity error, ±0.1% offset error, and ±0.2% gain error. 32-pin ceramic DIP, $79 (1000).

Burr-Brown, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TLX 666491.

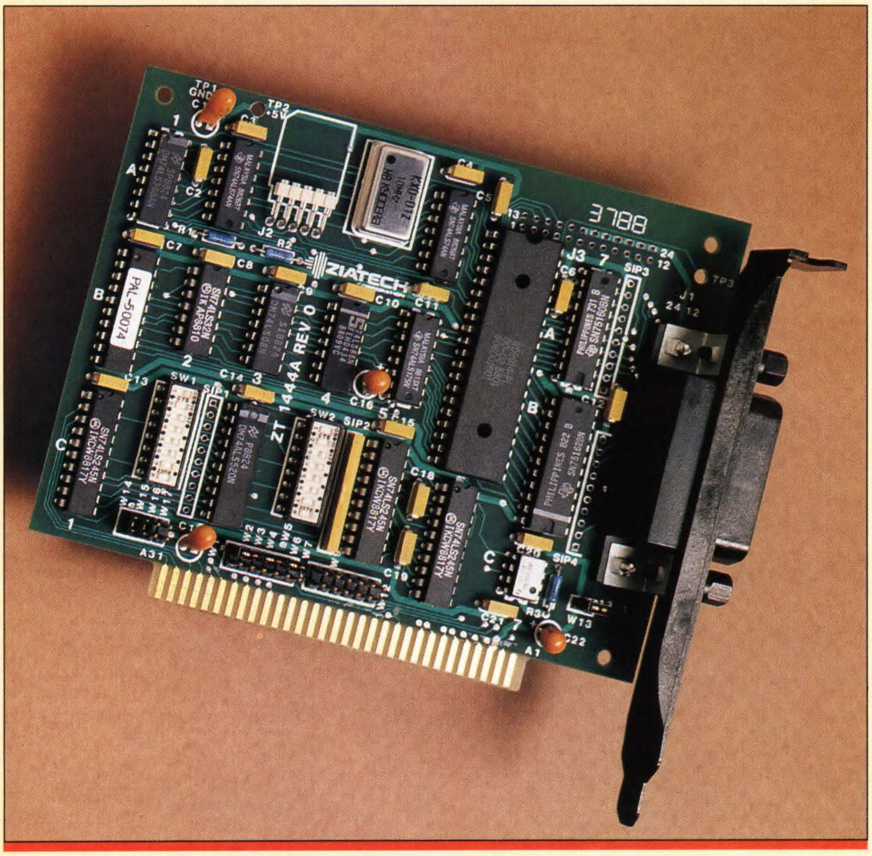
Circle No 363

ZIATECH CORPORATION

CONTROL POINT

Test and Control Product News from Ziatech Corporation Spring, 1989

ZIATECH OFFERS WORLD OF IEEE 488 CHOICES



A free, easy-to-use software driver comes with Ziatech's ZT 1444 GPIB interface to PCs.

GPIB hardware supports PCs, PS/2s, STD, MULTIBUS and MULTIMODULE standards

Ziatech's IEEE 488 interfaces are a popular choice of OEMs and end users utilizing GPIB products in their test and measurement designs. The Ziatech interfaces owe their popularity to their cost efficiency, their wide array of software choices and the extensive technical support capabilities of Ziatech.

GPIB SINCE 1976

Ziatech was the first to bring the IEEE 488 bus concept to microcomputers with its charter

(Continued on page 2)

Software simplifies IEEE 488 control

Ziatech offers a wide array of software drivers and programs to support its IEEE 488 hardware interfaces, including an installable driver called EZ.488 that is offered at no additional charge with Ziatech's interfaces for personal computers.

All of Ziatech's software drivers are available with no recurring license fees for multiple systems, making purchases of Ziatech GPIB interfaces cost-efficient for high volume users.

Ziatech offers two types of installable drivers, both of which allow IEEE 488 interfaces to be configured as controllers or talker/listeners.

(Continued on page 3)

INSIDE

GPIB:
Hard Choices .... Page 2

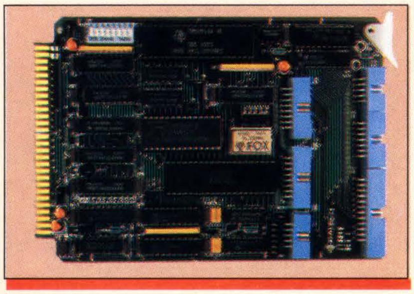
Ziatech's Large
Software Menu ..... Page 3

GPIB Control
Gets Smart .... Page 4

ZIATECH CORPORATION

Free software drivers with PC and PS/2 boards –

ZIATECH GPIB BOARDS PROVIDE COST-EFFECTIVE INSTRUMENT CONTROL



ZT 8847 interface for STD systems

(Continued from page 1)

product in 1976, a GPIB interface for MULTIBUS systems. The Ziatech product line now features a number of hardware interfaces for personal computers, the IBM PS/2, STD Bus and MULTIBUS systems, as well as software packages and drivers that simplify system integration.

GPIB FOR THE PC

The most popular GPIB interface in the Ziatech product line is the ZT 1444A. Each interface controls up to 15 GPIB instruments from within an IBM-compatible PC, XT, AT or PS/2 Models 25 and 30. The ZT 1444A offers an optional security device for protecting OEM software. This interface occupies a short slot in a PC, while the ZT 1488A interface requires a full slot because of two additional capabilities, a battery-backed clock/calendar and MULTIMODULE (SBX) expansion. Both GPIB boards come with a free software driver, Ziatech's EZ.488 (see software story, pages 1 and 3).

GPIB FOR PS/2

Ziatech also supports GPIB systems using the IBM PS/2 Models 50, 60, 70 and 80, with the ZT/2 interface. This interface features free software support, an Adaptor Description File for setting system parameters, a "watchdog timer" to help prevent system hang-ups and an optional security device for protecting OEM software.

GPIB FOR STD

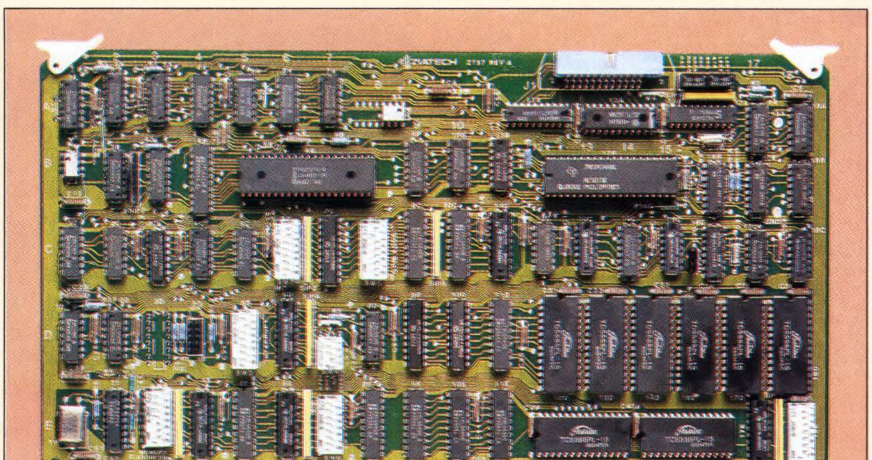
As a leading supplier of board-level and packaged STD Bus systems, Ziatech offers several options for adding GPIB capability to STD systems. Up to 15 IEEE 488 devices can be interfaced through one STD I/O slot with Ziatech's ZT 8847 or ZT 8848 GPIB interfaces. Ziatech also offers single board computers and integrated systems with GPIB capability. (See story, page 4.)

GPIB FOR MULTIBUS

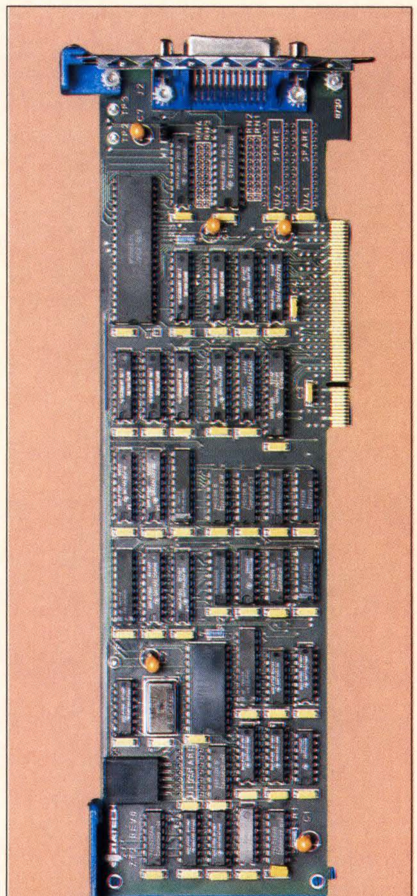
The ZT 87A IEEE 488 Interface for MULTIBUS systems features data rates of 300 Kbytes per second with on-board DMA utilizing 64 Kbytes of dual-ported RAM.

GPIB MULTIMODULE

Ziatech's zSBX 20 controller brings GPIB control to any system that uses the MULTIMODULE standard, without using an additional I/O slot. (See story, page 4).



ZT 87A interface for MULTIBUS systems



ZT/2 interface for IBM PS/2s

For information circle **120**

No recurring fee for mulitpe use of software drivers –
ZIATECH SOFTWARE INSTRUMENTAL TO GPIB APPLICATION SUCCESS

(Continued from page 1)

EZ.488 – EASY TO USE

EZ.488 is the simplest installable driver to use, with HP 85 compatible syntax and the ability to access IEEE 488 devices from most high-level languages. EZ.488 is the best choice for applications requiring a driver that is accessible from any language. Many OEMs choose EZ.488 for their products because of its flexibility and ease of use.

INSTALL.488 – PC DOS-COMPATIBLE

Like EZ.488, INSTALL.488 uses the resources of PC DOS, but with efficient language interfaces for BASIC, C, Pascal, FORTRAN and Assembly. This driver type is a good choice for system integrators who want to use National Instruments' IEEE 488 interfaces as second sources for Ziatech interfaces. It also allows existing application software written for IBM and National interfaces to work with Ziatech hardware.

The compatibility of Ziatech's installable drivers with PC DOS-based STD Bus systems (STD DOS) enables system designers to connect STD Bus and PC systems via IEEE 488 interfaces, using identical software in both. It also allows a system designed on a PC or PS/2 to be easily ported over to the more industrial STD Bus.

LINK.488 – FAST DRIVERS LINK TO LANGUAGES

Ziatech offers high-level language linkable software support for both controllers and talker/listeners. This high-performance software, called LINK.488, is designed to provide extremely efficient code for accessing the IEEE 488 bus while maintaining a user-friendly environment. LINK.488, available in versions that support C, BASIC, Pascal and Assembly, is best suited for Original Equipment Manufacturers (OEMs) whose products provide integral IEEE 488 support. In many cases, once the software is developed, it is placed in EPROM, never to be changed again.

MENU-DRIVEN INSTRUMENT CONTROL

In addition to its software driver support, Ziatech offers software packages from selected companies that enhance the functionality of Ziatech GPIB interfaces.

ASYST, for example, is a completely integrated package allowing full control of a wide assortment of I/O devices with data collection and graphic display capabilities. This package has an interactive, menu-driven user interface which speeds program development and is easy to use. With the ASYST package, highly sophisticated data acquisition programs can be developed, complete with graphical display or plotting capabilities.

ASYSTANT GPIB

ASYSTANT GPIB uses the same user interface as ASYST, but is limited to supporting IEEE 488 I/O. This package allows the user full control of IEEE 488 instruments, combined with full data analysis and graphics display capabilities.

Ziatech's STD DOS systems run GPIB control software like ASYSTANT GPIB.

(Continued from page 2)

GPIB LOGIC ANALYZER

Ziatech's ZT 488 is a low cost, handheld logic analyzer that can help eliminate hours of wasted troubleshooting time in building, debugging and servicing IEEE 488 systems.

For more information, circle the response number or return the Control Point postcard.

For information circle **120**

Unique GPIB network capability –

ZIATECH INDUSTRIAL COMPUTERS PROVIDE INSTRUMENT CONTROL

Ziatech offers a variety of STD Bus-based industrial computers with GPIB capability for users requiring "smart" GPIB control.

"SLOT-LESS" GPIB

GPIB capability can be added to Ziatech's 80188-based single board STD Bus computers (ZT 8814/15), and 8088-based intelligent control processor (ZT 8830) via the zSBX 20 MULTIMODULE controller. This expansion capability will also be available on Ziatech's soon-to-be-released ZT 8832 I/O control processor. These SBC-IB products allow system designers to expand their IEEE 488 capabilities without using an additional I/O slot.

Ziatech's integrated STD systems, the ZT 300 Industrial Computer and the ZT 1000 Industrial Workstation, can also be easily configured for GPIB-based instrumentation applications.

RACK-MOUNTED COMPUTER

The ZT 300 integrates an STD Bus computer and IBM PC DOS in an enclosure designed for rack-mounting. It is available in a diskless configuration for embedded applications, in a PC feature set with video display and keyboard, and as a remote node in an industrial ARCNET network. All of these configurations are available with GPIB capability via an IEEE 488 interface and driver software.

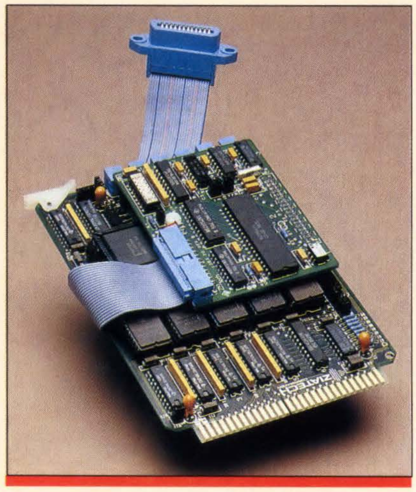
NETWORK EXTENDS GPIB CONTROL

The combination of network and GPIB capability in the ZT 300 results in a powerful instrument controller that extends the geographic limitation of GPIB control. This combination allows other nodes on the network to transparently control GPIB instruments connected to the ZT 300 or ZT 1000, extending the 20-meter GPIB limit to the ARCNET network limit of up to four miles away.

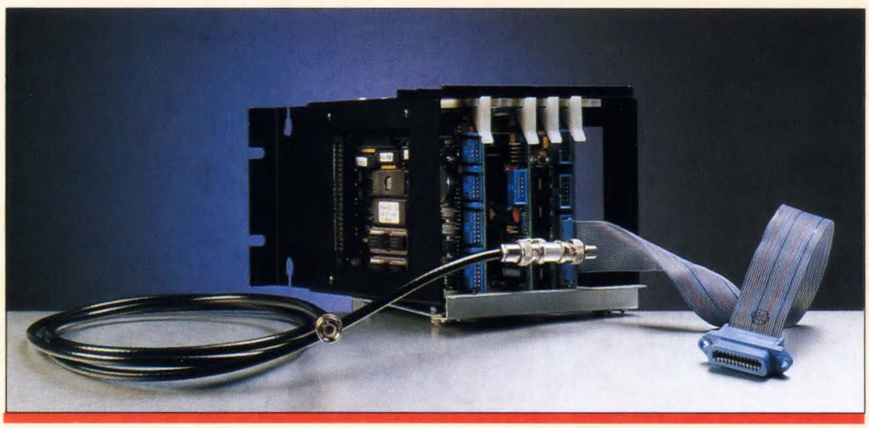
FACTORY FRIENDLY GPIB

The ZT 1000 Industrial Workstation combines a reliable, easy-to-operate industrial STD Bus computer with a rugged enclosure for machine and process control applications. With Ziatech's GPIB interfaces, it can be configured as a simple-to-use instrument controller rugged enough for the factory floor.

For more information, circle the response number or return the Control Point postcard.



The SBC-IB, a Ziatech 80188 single board computer with GPIB control via the zSBX 20 MULTIMODULE interface.



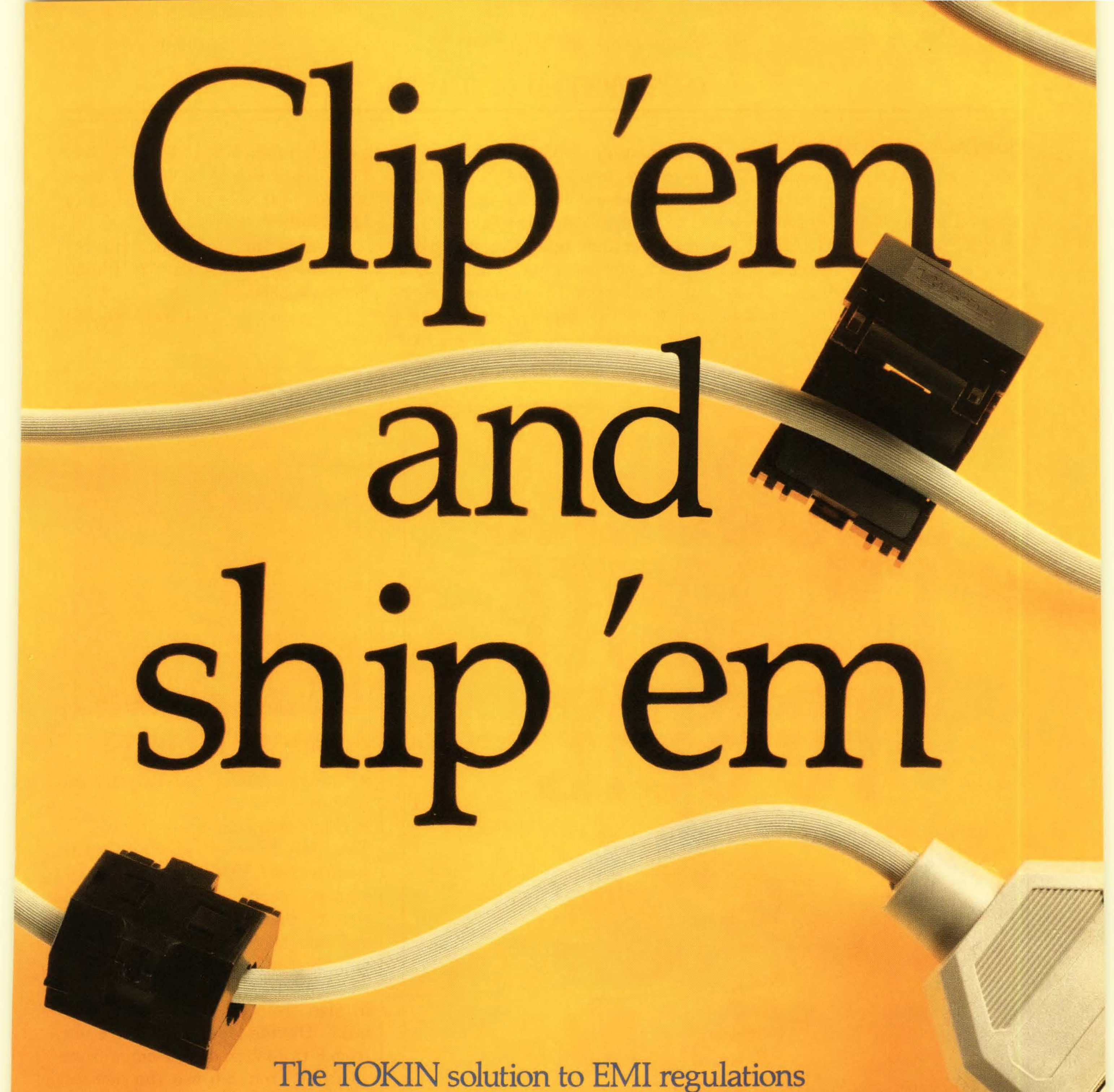
Ziatech's integrated STD Bus computers such as the ZT 300 combine ARCNET industrial network cabability with GPIB control.

CONTROL POINT

Published bimonthly by Ziatech Corporation. For information on any product or service mentioned in *Control Point*, please call (805) 541-0488.

ZIATECH CORPORATION

3433 Roberto Court
San Luis Obispo, California
93401 USA
ITT Telex 4992316
FAX (805) 541-5088
Telephone (805) 541-0488



The TOKIN solution to EMI regulations

This is it: the answer to your EMI problems and inventory buildups. And it's *as close as your telephone*. TOKIN's ESD-QR Series of clip-on Data Line Filters gives you a convenient, cost-effective method of meeting noise emission and susceptibility regulations, for a wide range of electronic products. So give us a call. Overnight gets you the finest TOKIN filters. Clip them on, and watch your shipments move out.

TOKIN

Tokin Corporation

Hazama Bldg., 5-8, Kita-Aoyama 2-chome, Minato-ku, Tokyo 107, Japan Phone: 03-402-6166 Fax: 03-497-9756 Telex: 02422695 TOKIN J

Tokin America Inc.

155 Nicholson Lane, San Jose, California 95134, U.S.A. Phone: 408-432-8020 Fax: 408-434-0375
Chicago Branch 9935 Capitol Drive, Wheeling, Illinois 60090, U.S.A. Phone: 312-215-8802 Fax: 312-215-8804

CIRCLE NO 117

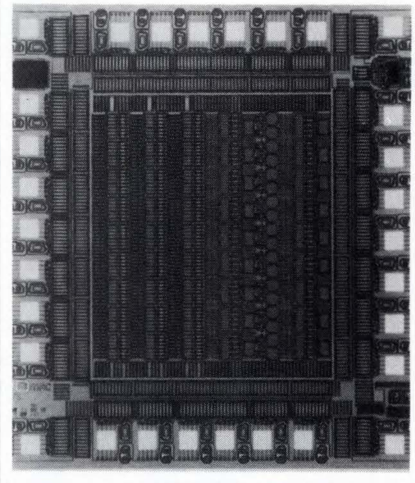
VOLTAGE REFERENCES

- *10, −10, and ±10V outputs*
- *±2.5- to ±5-mV accuracy*

Supplied in JEDEC-compatible 28-pin LCC packages, the HC2700 Series precision voltage references offer a choice of 10, −10 and ±10V models. The devices are available in both industrial (−25 to +85°C) and military (−55 to +125°C) temperature grades, and in accuracy ratings of either ±2.5 or ±5 mV. The temperature coefficient over the specified operating-temperature range is either ±3.0 ppm/°C or ±10.0 ppm/°C. All models operate from 15V supplies and maintain line regulation of 300 μV/mA over a supply range of ±13.5 to ±16.5V. Load regulation is 50 μV/mA over a range of 0 to ±10 mA. $61.75 to $127 (100).

Hycomp Inc, 165 Cedar Hill St, Marlborough, MA 01752. Phone (508) 485-6300.

Circle No 364



SEMICUSTOM ARRAYS

- *Combine analog and digital functions*
- *Eight chip sizes are available*

The MA Series analog/digital semicustom CMOS arrays let IC designers create application-specific circuits that range from 45 gates and 400 MOSFETs to 1150 gates and 2500 MOSFETs. The MA Series consists of eight arrays varying in size from 67×77 to 189×223 mils. Device operation extends from 3 to 14V, and I/Os range from 18 to 84. You can use the devices at internal flip-flop toggle frequencies to 50 MHz and at amplifier bandwidths to 5 MHz. A library of more than 50 digital and 20 analog macrocells is available. Nonrecurring engineering charges vary from $10,000 to $50,000, depending on complexity. Delivery, eight to 16 weeks ARO.

Plessey Semiconductors, 1500 Green Hills Rd, Scotts Valley, CA 95066. Phone (408) 438-2900. TLX 4940840.

Circle No 365

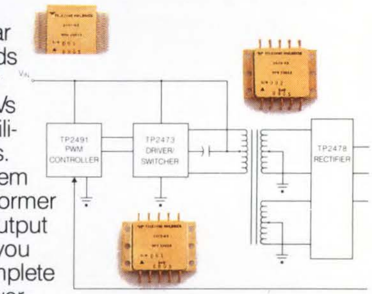
POWER SUPPLIES AT YOUR COMMAND.

Introducing a complete system of modular hybrid components for military SMPS designs.

What do you do when all the primary electronics are in place, but there's precious little time, budget or real estate left for the power supply?

Call Teledyne Philbrick. We offer a unique, new series of complete modular hybrid power components that are designed to be customized to your exact specifications.

Just choose the configuration you need. The 2491 Regulating Pulse Width Modulator provides all the control functions for the PSU. The 2473 is a dual MOFSET switch with high speed drivers and current sensing circuitry. And the 2478 Dual Schottky Bridge Rectifier provides up to three output voltages from a single power package.



New modular power hybrids are ideal for missiles, RPVs and other military systems. Combine them with a transformer and input/output filters, and you create a complete custom power supply—in a fraction of the time, and at a fraction of the cost, it would take to start from scratch.

Qualified to MIL-STD-1772, Teledyne Philbrick is a leading manufacturer of high performance, high reliability standard and custom microcircuits for industrial, medical, military and space applications worldwide. Send for complete specifications. Or call us toll-free at 1-800-325-1330 (outside MA).

MIL-STD-1772 Qualified

TELEDYNE PHILBRICK

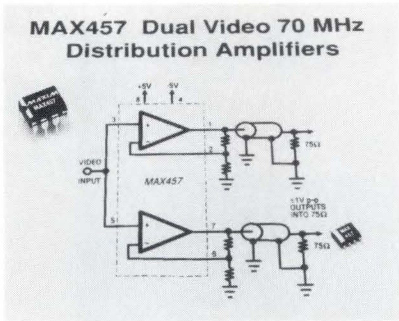
40 Allied Drive, Dedham, MA 02026-9103, Tel: 617-329-1600 Fax: 617-326-6313

WEST:
30423 Canwood St.,
Suite 212
Agoura Hills
CA 91301
Tel: 818-889-3827
Fax: 818-889-8215

U.K.:
The Harlequin Centre
Southall Lane
Southhall
Middlesex
UB2, 5NH, U.K.
Tel: 571-9596
Telex: 935008
Fax: 574-8177

JAPAN:
4th Floor
Taiko No. 3 Bldg.
2-10-7 Shibuya-Ku
Tokyo 542, Japan
Tel: 797-5251
Telex: 781-24335
Fax: 797-5255

CIRCLE NO 119



VIDEO AMPLIFIER

- *Has a 70-MHz bandwidth*
- *Has dual 75Ω drive capability*

Using a silicon-gate CMOS process to achieve high-speed performance, the MAX457 dual op amp has a unity-gain bandwidth of 70 MHz and can drive two 75Ω outputs. Because of the device's low-input bias current of 100 pA, its low-input capacitance of 4 pF and its high-input impedance of $10^{10}\Omega$, you can tie the two inputs together with minimum loading of the source. Both outputs can simultaneously drive ±1V into a 75Ω-terminated video coaxial cable. The differential phase error is 0.2° typ and differential gain error is 0.5% typ. These values make the device suitable for low-cost video broadcast applications. The MAX457 is available in commercial and industrial temperature grades in an 8-pin DIP, an 8-pin SOIC, or an 8-pin ceramic DIP. From $4.45 (1000).

Maxim Integrated Products, 120 San Gabriel Dr, Sunnyvale, CA 94086. Phone (408) 737-7600.

Circle No 366

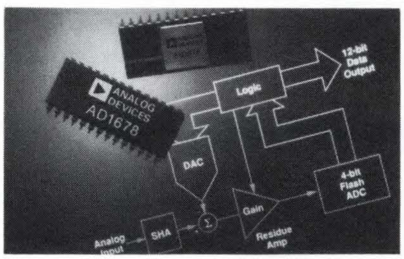
ENCODER/DECODERS

- *Low-power CMOS operation*
- *Operate from a 5V supply*

Fabricated in low-power, high-speed CMOS, the MC145439 and MC142103 encoder/decoder units translate clocked serial data into two streams of return-to-zero digital pulses. The pulses are externally mixed to form a selection of ternary signals for driving transmission lines. Reversing the process translates the two streams of clocked pulses into a single stream of clocked binary data. Encoder/Decoder functions are useful in converting T1 links to clear channels. The devices, which operate from a 5V supply, perform coding and decoding functions independently at clock rates from dc to 9M bits/sec. Both parts perform HDB3 coding/decoding functions within CCITT G.703 guidelines. The MC145439 comes in a 20-pin DIP, and the MC142103 is available in a 16-pin DIP. Each device, $7.13 (500).

Motorola Inc, Box 52073, Phoenix, AZ 85072. Phone (512) 928-7364.

Circle No 367



12-BIT ADC

- *Features recursive subranging*
- *Has a 5-μsec conversion time*

The AD1678 A/D converter uses recursive subranging to deliver a conversion time of 5 μsec for a throughput rate of 200k samples/sec. The AD1678 contains an S/H amplifier, a 12-bit ADC, a reference, a clock, and a processor interface on a single BiCMOS chip. The chip's ac performance includes a 1-MHz typ input bandwidth, a min S/N + D ratio of 72 dB, and a maximum THD and intermodulation distortion of −80 dB. The AD1678's S/H amplifier has a 10-MΩ input impedance, thus eliminating the need for external input-signal buffering. A complete digital interface permits a μP or a digital signal processor to read data in either a 12-bit or an 8 + 4-bit format for 16- or 8-bit buses, respectively. The AD1678, which operates in either a synchronous or an asynchronous mode, accommodates both unipolar or bipolar input signals. The device operates from 5 and ±12V supplies. From $38 (100).

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 935-5565.

Circle No 368

TELETEXT DECODER

- *Provides 2-chip teletext systems*
- *Includes character sets for thirteen languages*

With the addition of a dynamic RAM, the MV1815 single-chip CMOS teletext decoder produces a complete teletext system. By adding more memory, you can produce a teletext system that can store as many as 254 teletext pages. The decoder includes a complete set of level-one teletext functions and also has several level-2 capabilities. In addition, it has an on-chip data slicer, two separate page-acquisition circuits, and RGB color-display logic. Its selectable character sets support thirteen languages, including most European and Scandinavian languages. Around £5 (100,000).

Plessey Semiconductors Ltd, Cheney Manor, Swindon, Wiltshire SN2 2QW, UK. Phone (0793) 518000. TLX 449637. FAX 0793-518198.

Circle No 369

Plessey Semiconductors Corp, 1500 Green Hills Rd, Scotts Valley, CA 95066. Phone (408) 438-2900. TLX 4940840. FAX 408-438-5576.

Circle No 370

BIFET OP AMP

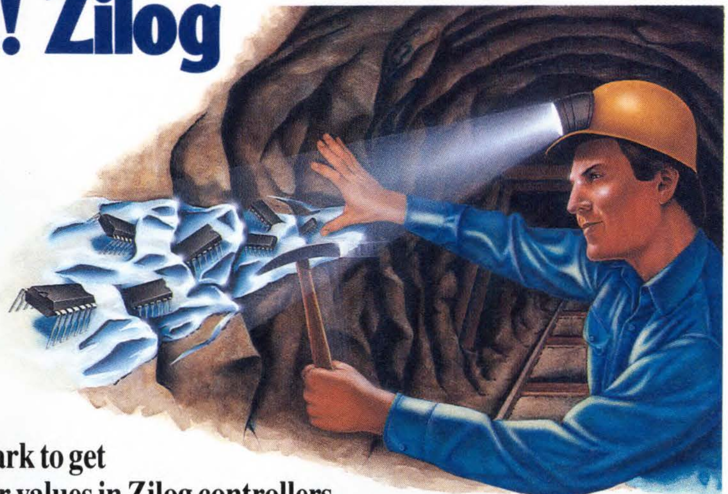
- *Has good dc characteristics*
- *Fast settling time is guaranteed*

Combining good dc and ac characteristics, the LF401A BiFET op amp is guaranteed to settle to 0.01% of a 10V step in <400 nsec. The standard LF401 carries a spec of 500 nsec. The typical settling time for both parts is 365 nsec. Other ac specs include a minimum gain-bandwidth product of 14 MHz, an input noise voltage of 2.3 μV, a slew rate of 70 V/μsec, and THD of only 0.002%. Maximum dc specs include an input-offset voltage of 200 μV for the LF401A and 500 μV for the LF401; an input bias current of 200 pA at 25°C; and a CMRR of 90 dB. 14-pin DIP, $9.60 (100).

National Semiconductor Corp, Box 58090, Santa Clara, CA 95052. Phone (408) 721-2274. TLX 346353.

Circle No 371

Searching for a source for Z80180s? Competitively priced... from an American company? You found it! Zilog from Hall-Mark.



64180Z™ users call Hall-Mark to get both Superintegration™ and super values in Zilog controllers.

Instead of reinventing the wheel, improve on it. Add the impact of CMOS and the flexibility of Superintegration of the Z80180 to the proven performance of Z80™/8080™ and you have a product that's ready to go to market. Fast.

Call a nearby Hall-Mark office to get the facts on Zilog Application Specific Standard Products (ASSPs). Using Superintegration you can add cells to the working core, incorporate the extra instructions, and draw upon the onboard peripherals and your product is ready to go to market. All without up-front engineering costs, the risk of development or inefficient use of real estate.

Your Hall-Mark representative can show you how to profit by switching or upgrading to the Z80180. It's 100% object code compatible with Z80/8080 and a direct replacement for the Hitachi version (HD64180Z). Zilog offers immediate delivery of the Z80180s in 6, 8 and 10 mhz and in DIP, PLCC and Quad Flat Pack (QFP).

If a super value on Superintegration sounds better than developing your own controller, call Hall-Mark to find out how the right Z80180 can increase your profit line. Fast.

HALL-MARK Not just parts, solutions.

Hall-Mark Electronics Corporation • Dallas, Texas

Alabama
Huntsville (205) 837-8700
Arizona
Phoenix (602) 437-1200
California
Bay Area (408) 432-0900
Orange County (714) 727-6000
Sacramento (916) 624-9781
San Diego (619) 268-1201
San Fernando Valley (818) 773-4500
Colorado
Denver (303) 790-1662
Connecticut
Connecticut (203) 271-2844
Florida
Ft. Lauderdale (305) 971-9280
Orlando (407) 830-5855
Tampa Bay (813) 541-7440
Georgia
Atlanta (404) 447-8000
Illinois
Chicago (312) 860-3800
Indiana
Indianapolis (317) 872-8875
Kansas
Kansas City (913) 888-4747
Maryland
Baltimore (301) 988-9800
Massachusetts
Boston (617) 935-9777
Michigan
Detroit (313) 462-1205
Minnesota
Minneapolis (612) 941-2600
Missouri
St. Louis (314) 291-5350
New Jersey
Fairfield (201) 575-4415
New York
Long Island (516) 737-0600
Rochester (716) 425-3300
North Carolina
Raleigh (919) 872-0712
Ohio
Cleveland (216) 349-4632
Southern Ohio (614) 888-3313
Oklahoma
Tulsa (918) 254-6110
Pennsylvania
Philadelphia (215) 355-7300
Texas
Austin (512) 258-8848
Dallas (214) 553-4300
Houston (713) 781-6100
Utah
Salt Lake City (801) 972-1008
Washington
Seattle (206) 547-0415
Wisconsin
Milwaukee (414) 797-7844

CIRCLE NO 125

WHEN THERE'S NO ROOM FOR ERROR:
Tektronix 11802 DIGITAL SAMPLING OSCILLOSCOPE

INTRODUCING TEK'S 20 GHZ, MULTICHANNEL COMPREHENSIVE MEASUREMENT SYSTEM.

Imagine characterizing GaAs, ECL, or high-speed TTL circuits with 1 picosecond repeatability and .01 picosecond sample interval.

Or acquiring not one or two, but up to 68 channels of waveform data simultaneously. All under manual or program control.

Imagine reducing propagation delay measurements to the push of a button. Or performing single-ended TDR and—for the first time—true differential TDR, *with unprecedented accuracy.*

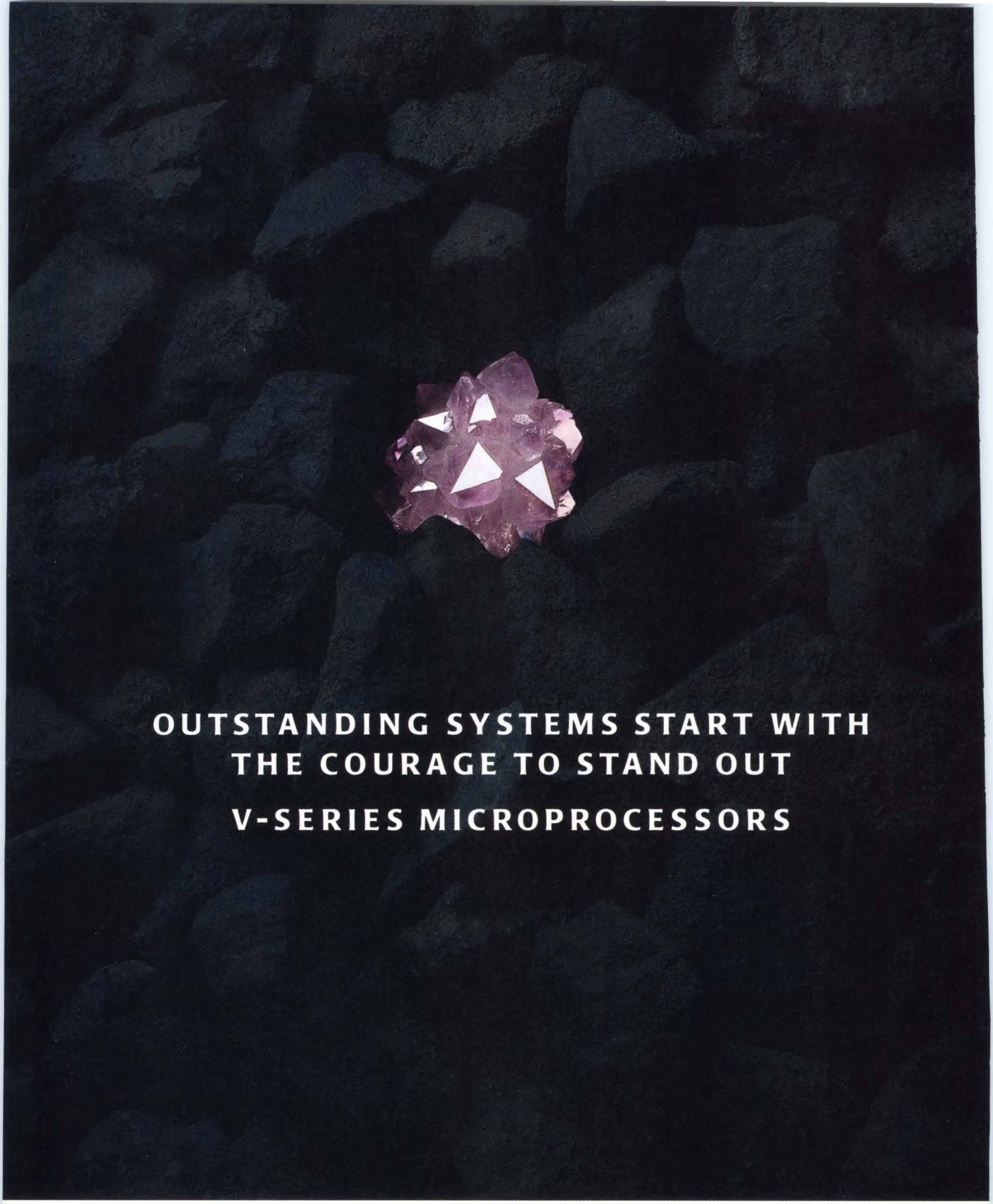
Nothing else lets you work at the leading edge with so much confidence. *The new Tektronix 11800 Series makes previously difficult measurements routine. Even if you use it infrequently, you'll find its operation straightforward and unforgettable.*

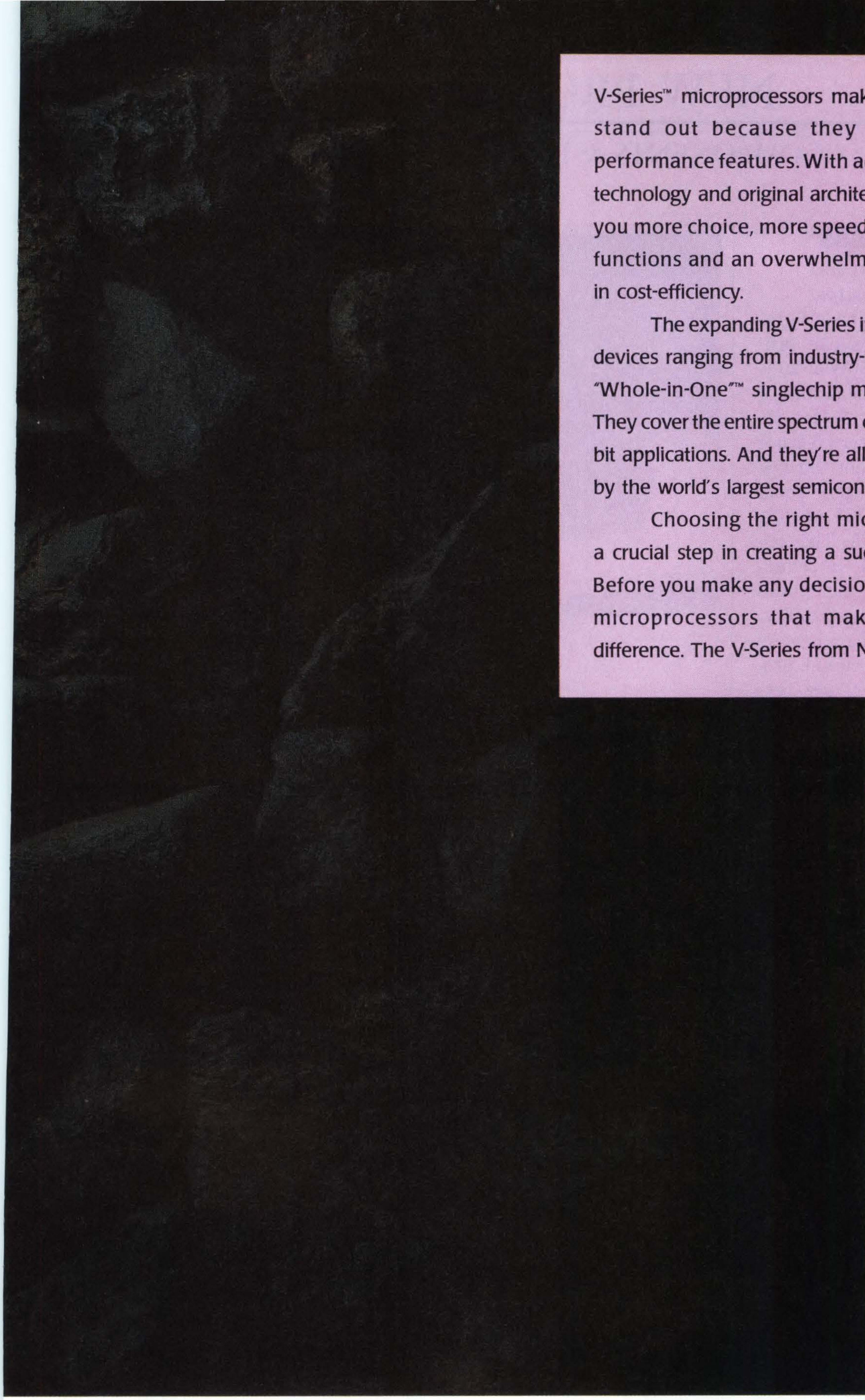
Measurement readouts on the 11800 Series are continuous—not just misleading "snapshots." Mean and standard deviation statistics on each measurement give you a true picture of measurement integrity.

With its maximum 136 acquisition channels, complete programmability, extensive on-board waveform processing and unparalleled accuracy, the 11800 Series is the clear choice for designers and engineers working at the leading edge of technology.

When there's no room for error, count on Tek. *For more information on these and other Tek scopes, contact your local Tek sales representative, or call 1-800-835-9433, X170.*

Tektronix®
COMMITTED TO EXCELLENCE


OUTSTANDING SYSTEMS START WITH
THE COURAGE TO STAND OUT
V-SERIES MICROPROCESSORS



V-Series™ microprocessors make your product stand out because they offer unique performance features. With advanced CMOS technology and original architecture, they give you more choice, more speed, more on-chip functions and an overwhelming advantage in cost-efficiency.

The expanding V-Series includes a dozen devices ranging from industry-standard μPs to "Whole-in-One"™ singlechip microprocessors. They cover the entire spectrum of 8-, 16- and 32-bit applications. And they're all fully supported by the world's largest semiconductor supplier.

Choosing the right microprocessor is a crucial step in creating a successful system. Before you make any decision, discover the microprocessors that make a world of difference. The V-Series from NEC.

For fast answers, call us at:

USA Tel: 1-800-632-3531. TWX: 910-379-6985.
W. Germany Tel: 0211-650302. Telex: 8589960.
The Netherlands Tel: 040-445-845. Telex: 51923.
Sweden Tel: 08-753-6020. Telex: 13839.
France Tel: 1-3946-9617. Telex: 699499.
Italy Tel: 02-6709108. Telex: 315355.
UK Tel: 0908-691133. Telex: 826791.
Hong Kong Tel: 3-755-9008. Telex: 54561.
Taiwan Tel: 02-522-4192. Telex: 22372.
Singapore Tel: 4819881. Telex: 39726.
Australia Tel: 03-267-6355. Telex: 38343.

NEC

CIRCLE NO 149

NEW PRODUCTS

COMPONENTS & POWER SUPPLIES

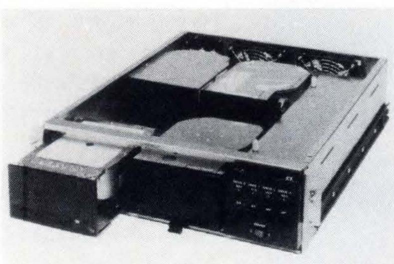
DC/DC CONVERTERS

- *Require no fan or heat sink*
- *Feature 125 to 150W output*

Units in the RO Series single-output dc/dc converters can produce outputs of 125 to 150W at 20°C without the need for a heat sink or a fan. Housed in a 0.98×3.4×4.85-in. package, the converters feature a 2.5°C/W case to ambient thermal resistance. Converter outputs equal 5V at 25A, 12V at 12A, 15V at 10A, 24V at 6A, and 28V at 5A. The converters feature true N+1 redundancy with current-sharing, paralleling, and hot plug-in capability. Nonshutdown overvoltage protection, logic on/off, short-circuit protection, and overtemperature protection are standard on all units. The converters comply with MIL STD 810D, UL, CSA, and VDE requirements. The converters operate with inputs of 36 to 66V in the RO 48 Series or 200 to 400V in the RO 300 Series. $249. Delivery, stock to 60 days ARO.

RO Associates Inc, 246 Caspian Dr, Sunnyvale, CA 94088. Phone (408) 744-1450. FAX 408-744-1521.

Circle No 376



CHASSIS

- *Holds four drives*
- *Contains five supplies*

The SA-H188 expansion chassis can support four 5¼-in. removable Winchester drives. The drives mount on a bracket that's compatible with DEC's drive-mounting shoe. The drive/bracket assembly slides easily in and out of the chassis to provide portability between systems. The chassis contains a front console with write protect and ready switches and LEDs for each drive. The chassis also includes a controller I/O panel to ease the cabling to an ESDI or SCSI disk controller. The modular power-supply unit contains five 52W modules. Each module powers one of the drives; the fifth module powers the fans and other chassis functions. You can replace any power module without affecting the operation of other drives in the chassis. $1270.

Sigma Information Systems, 3401 LaPalma Ave, Anaheim, CA 92806. Phone (714) 630-5417. TLX 298607.

Circle No 377

DC/DC CONVERTERS

- *Provide 5W from single- or split-voltage outputs*
- *Operate over a 2:1 input-voltage range*

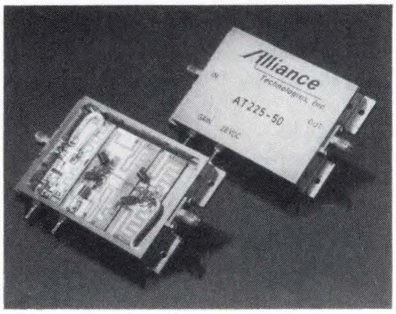
PT4900 Series 5W dc/dc converters operate over 2:1 input-voltage ranges of 9 to 18V, 18 to 36V, or 36 to 72V. They are available in single-output versions with an output voltage of 5, 12, or 15V, and as dual-output versions with output voltages of ±12 or ±15V. Line regulation is ±0.1% over the full operating input-voltage range, and zero-to full-load output regulation is 0.2% max for single-output versions and ±2% for dual-output versions. An internal Pi filter minimizes conducted RFI. The converters feature an input-to-output isolation voltage of 500V dc, and have output current limiting that allows you to operate them in series or parallel combinations. They have an operating temperature range of −25 to +71°C, and an MTBF at 25°C of 120,000 hours. PT4900 converters are housed in 51×51×9.6-mm screened cases. £63.

Powertrade GmbH, Lechwiesen Strasse 9, 8910 Landsberg, West Germany. (08191) 46068. FAX 08191-21770.

Circle No 378

Dowty Electronics Corp, Box 250, Brandon, VT 05733. Phone (802) 247-6811.

Circle No 379



POWER AMPLIFIER

- *Has a 50W output*
- *Operates from a single supply*

The AT225-50 miniature RF power MOSFET amplifier is designed for airborne and military/aerospace applications. Over a bandwidth of 225 to 400 MHz, it provides a 50W output. The amplifier is housed in a hermetically sealed, gold-metallized module, which measures 2.75 × 2 × 0.45 in., excluding mounting flanges. The amplifier requires a 28V power supply and operates over a −55 to +85°C range. The module features feedthrough capacitor gain control and dc input pins. The unit is available with SMA or 50Ω pin terminations. $595 (250). Delivery, stock to 14 weeks ARO.

Alliance Technologies Inc, 16150 NE 85th St, Suite 217, Redmond, WA 98052. Phone (206) 882-4535. FAX 206-882-7517.

Circle No 380

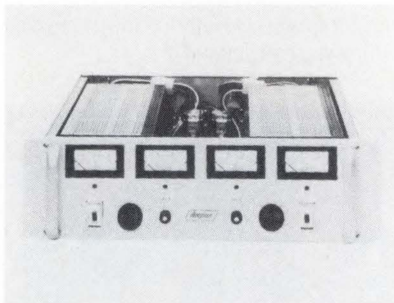
DISPLAY

- *Features sidelighting*
- *Has a 50° viewing cone*

Featuring cold cathode fluorescent sidelighting, the FLC640-480 WSUB black and white LCD uses double super-twisted nematic technology. The display's polarizing layers consist of indium tin-oxide coated glass substrates, which produce a high-refractive coefficient of light. The display has a 640 × 480 dot matrix and features a 50° viewing cone. The display has a 15:1 contrast ratio and features a 15.12-fL brightness. The unit also has a 180-msec response time and a viewing area that measures 8.3 × 6.2 in. The overall panel measurements are 11.7 × 8 in. $575 (1000).

Fujitsu Component of America, 3330 Scott Blvd, Santa Clara, CA 95054. Phone (408) 562-1000.

Circle No 381



POWER SUPPLIES

- *Offer redundant operation*
- *Current outputs to 61A*

This line of power systems includes 27 models, which provide outputs of 5 to 120V dc at current levels ranging to 61A. Each system consists of a 19-in. rack, containing two modular supplies. The supplies are configured to provide the required output to the load even if one supply should fail. You can remove a defective supply while the host system remains in operation. Each supply contains an overvoltage-protection circuit as well as a voltage-monitoring circuit that operates a relay. The relay contacts are available for use in controlling an external alarm or other circuitry. Built-in alarms are available as an option. $1095 to $2795.

Acopian, Box 638, Easton, PA 18044. Phone (800) 523-9478.

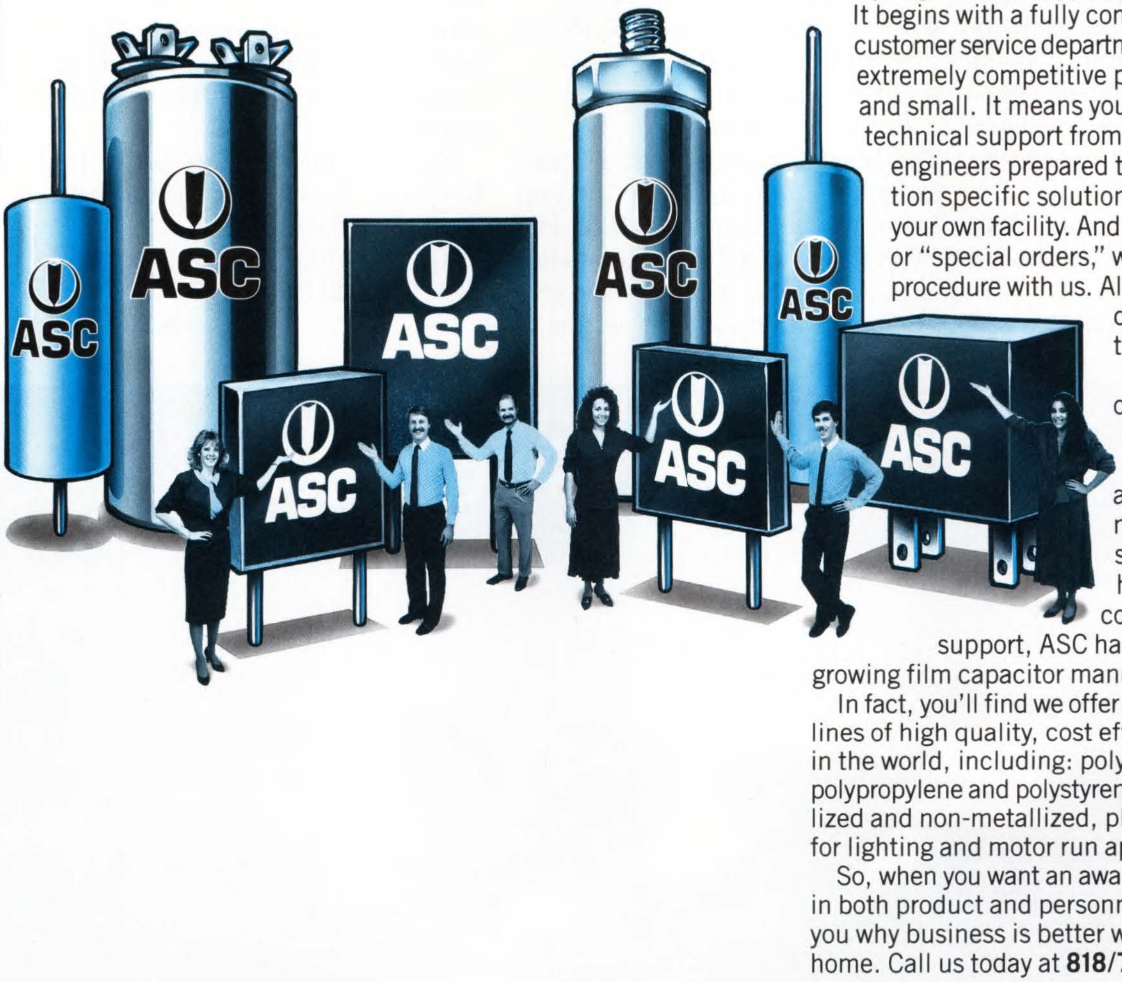
Circle No 382

MAP CABLES

- *Meet IEEE-802.4 requirements*
- *Feature EMI shielding*

These 75Ω coaxial cables for MAP (manufacturing automated protocol) networks meet IEEE-802.4 requirements and are CL2X rated.

BEST PERFORMANCE IN A SUPPORTING ROLE.



ASC Presents First Class Film Capacitors And Technical Support, Second To None.

When you buy high technology film capacitors from ASC, you get all the support you need, absolutely free.

It begins with a fully computerized sales and customer service department authorized to provide extremely competitive prices on volumes large and small. It means you get the highest level of technical support from a nationwide team of engineers prepared to help you with application specific solutions over-the-phone or at your own facility. And, when it comes to custom or "special orders," well, it's just standard procedure with us. All this, plus "just in time" deliveries that go out on time.

Since our acquisition of TRW's film capacitor division, ASC has acquired a reputation for service and support, second to none. By combining strong engineering know-how, and an even stronger commitment to technical support, ASC has emerged as the fastest growing film capacitor manufacturer in the U.S.

In fact, you'll find we offer one of the most complete lines of high quality, cost effective film capacitors in the world, including: polyester, polycarbonate, polypropylene and polystyrene dielectrics, both metallized and non-metallized, plus oil filled capacitors for lighting and motor run applications.

So, when you want an award winning performance in both product and personnel, call ASC. We'll show you why business is better when it's done right, at home. Call us today at **818/710-8555.**

ASC®

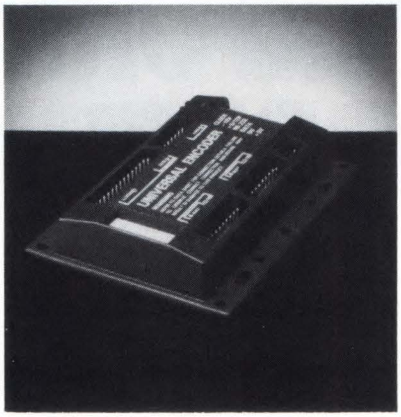
Sales & Marketing, Canoga Park, California
Engineering & Manufacturing, Ogallala, Nebraska
ASC, 21541 Blythe Street, Canoga Park, CA 91304

CIRCLE NO 129

The 1223A cable is designed for broadband and carrier-band applications. It features a #18 AWG solid copper-covered steel conductor and a black PVC jacket. The 1224A cable can accommodate either trunk cable or carrier-band transmissions. It has a #14 AWG solid conductor and a PVC jacket. Both cables feature a shield design that provides effective protection against EMI. The double-layer foil shield is bonded to the dielectric core, followed by an aluminum braid and an overall copolymer mylar foil. The outer foil has a shorting fold that provides metal-to-metal contact to maximize shield effectiveness. The cables are available in 1000-ft putups. 1223A, $220.65; 1224A, $377.25.

Belden Wire and Cable, Box 1980, Richmond, IN 47375. Phone (800) 235-3364.

Circle No 383



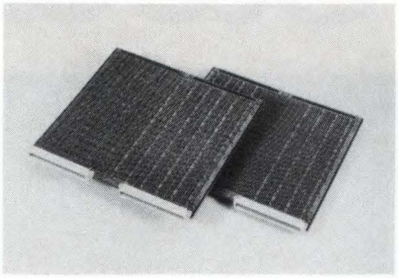
KEYBOARD ENCODER

- *Provides IBM PC-compatible or ASCII output codes*
- *Operates with a range of keyswitch technologies*

The Input universal encoder translates as many as 90 individual keyswitch positions into IBM PC, PC/XT, or PC/AT keyboard codes, or ASCII codes. It requires no programming other than the setting of DIP switches to its operating mode. In the PC modes the encoder produces PC-compatible upstroke and downstroke codes at TTL output levels. In the ASCII mode you can select TTL, RS-232C, or RS-423 output levels. Operating at TTL or RS-423 output levels, the encoder only requires one 5V supply. The unit is fully enclosed in an ABS plastic case that you can mount directly behind the company's Input range of sealed keyboards, or within standard Eurocard packaging systems. The encoder works with a variety of commonly used keyboard technologies, including touch-sensitive membrane switch panels. £70.

Keymat Technology Ltd, 14 Bentinck Court, Bentinck Road, West Drayton, Middlesex UB7 7RQ, UK. Phone (0895) 431421. FAX 0895-431132.

Circle No 384



SOCKET BOARDS

- *Designed for Multibus II applications*
- *Feature a high-density layout*

These 6U × 220-mm wire-wrap socket boards are designed for Multibus II applications. They feature a high-density layout that supports both FAST (Fairchild advanced Schottky TTL) and ECL in all sizes of DIPs at maximum packing density. The board layout imposes no predetermined device location restrictions. Two versions are available—the P/N 031-108-xx, which has no pin-grid-array (PGA) areas, and the P/N 031-109-xx, which includes PGA areas. The PGA area has a 26 × 77-pin pin-grid pattern on 0.100-in. centers. The 4-layer boards are constructed of copper-clad epoxy laminate FR-4 and are available with a choice of finishes and wrap-pin lengths. Boards with 3-level wrap pins: P/N 031-108, $595; P/N 031-109, $617.

Hybricon Corp, 12 Willow Rd, Ayer, MA 01432. Phone (508) 772-5422. TWX 710-347-0654.

Circle No 385

FILTERS

- *Housed in surface-mount packages*
- *Reject high-frequency noise*

EPA120G RF filters reject noise transfer between the cable and keyboard of personal computers. Each module contains a 4-line common-mode filter whose inputs and outputs are interchangeable. The filters exhibit an impedance of 425 to 637Ω at 50 MHz and 421 to 631Ω at 70 MHz. At 30 and 100 MHz, the filter's impedance measures 326 to 489Ω and 328 to 540Ω, respectively. Filter characteristics include a 1A/winding max dc current and a 45°C temperature rise at 25°C ambient. The devices undergo a 500V high-potential test. The units are housed in an 8-pin transfer-molded package, which measures 0.4 × 0.25 × 0.78 in. and is compatible with automatic insertion equipment. $1.04 (1000). Delivery, stock to six weeks ARO.

PCA Electronics Inc, 16799 Schoenborn St, Sepulveda, CA 91343. Phone (818) 892-0761. FAX 818-894-5791.

Circle No 386

Steel,

NCR

ASICs have become an integral part of today's automotive products.

Improving performance.

Increasing reliability.

Enhancing driver safety and convenience in ways unimaginable just a few years ago.

In this very demanding industry, on the most unforgiving proving grounds, NCR has earned an enviable reputation for first-pass success, responsive service and high quality.

Today, we have a solid track-record of successful ASIC programs with all the major U.S. automotive corporations spanning initial design to high volume production—including "Just In Time" delivery and dock-to-stock QA programs.

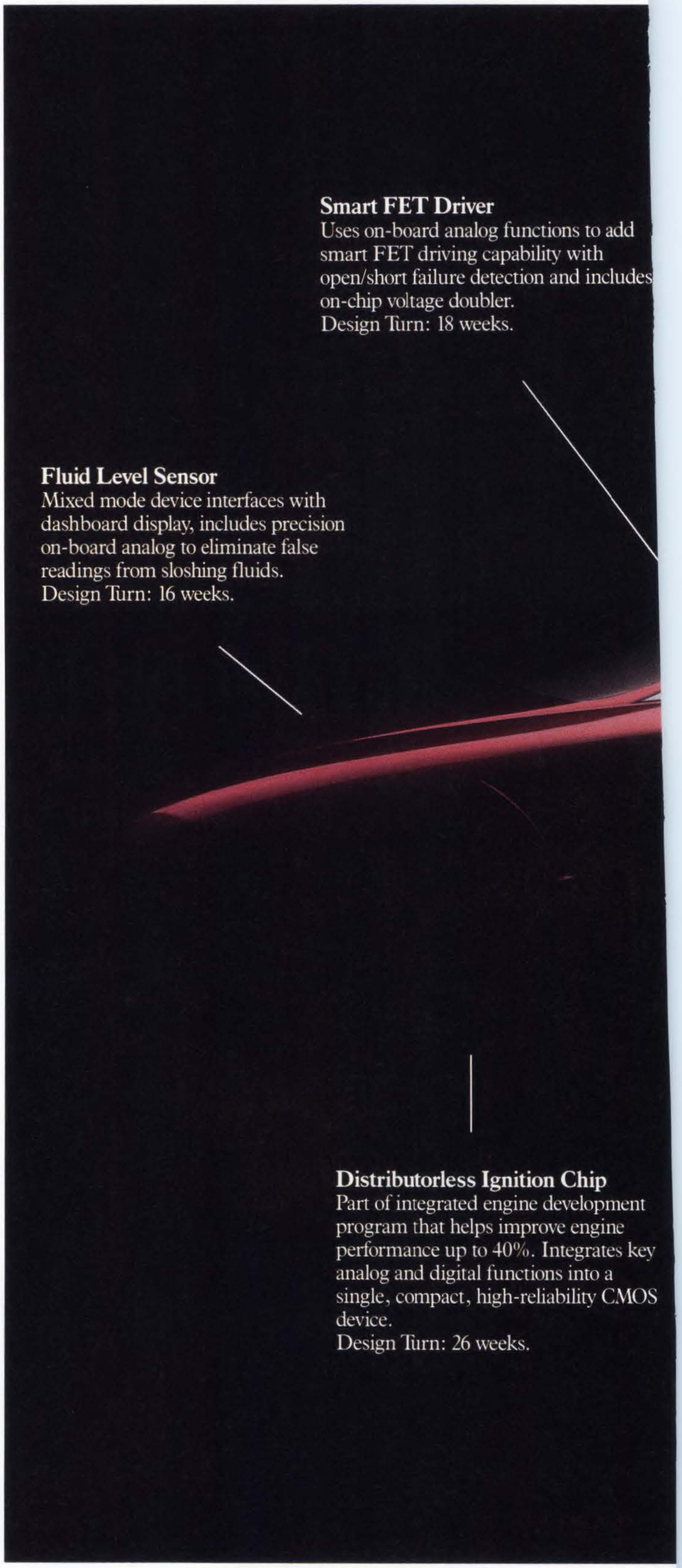
And NCR design tools are becoming the choice of fast-track ASIC designers. With NCR Design Synthesis™ and Design Advisor™ expert system, designers can spend more time creating, less time bogged-down in minute details.

To kick the tires on our automotive, commercial and military ASIC libraries, call today: 1-800-334-5454.

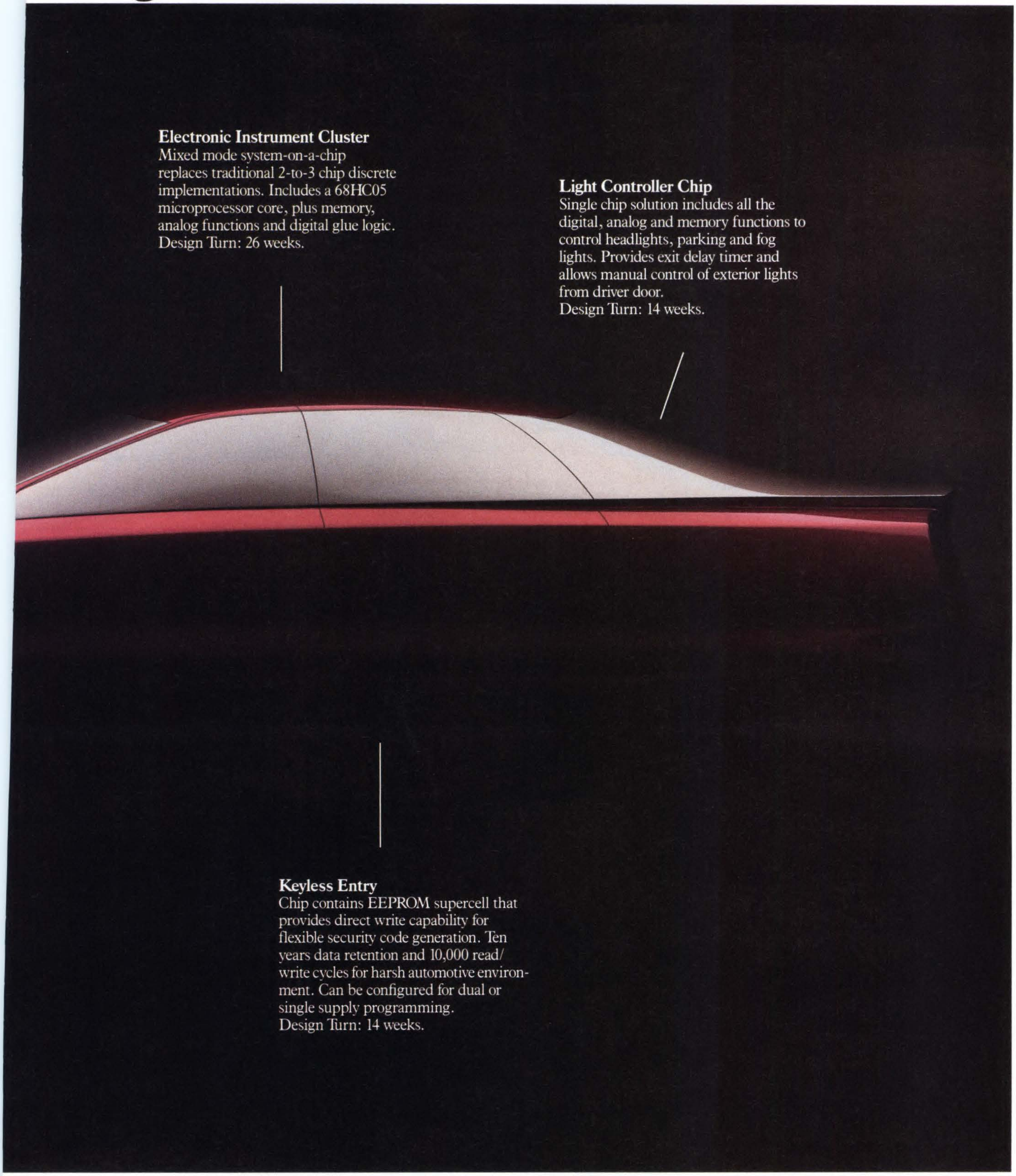
NCR Microelectronics, 1700 South Patterson Blvd., Dayton, Ohio 45479.

CIRCLE NO 131

Creating value



Style & Silicon.

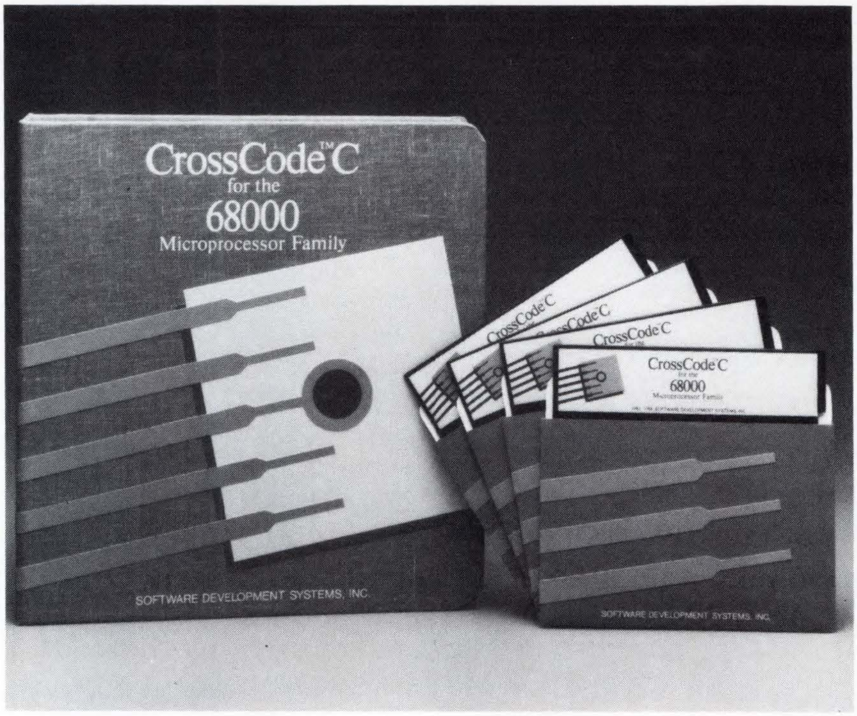


NEW PRODUCTS

CAE & SOFTWARE DEVELOPMENT TOOLS

C CROSS-COMPILER

- *Runs on VMS, Unix, or MS-DOS host computers*
- *Generates code for MC68000-family target systems*



CrossCode C, an optimizing C cross-compiler, lets you develop software for target systems based on one of the MC68000-family processors. The compiler runs on all members of the VAX family under VMS or Unix and on IBM PCs, PS/2s, and compatibles, generating identical object code regardless of the host architecture. It generates ROMable object code for all members of the MC68000 family, including the 68020 and 68030 processors, the 68881 and 68882 numeric coprocessors, and the 68851 memory-management unit. You can share source- and object-code files across systems; for example, the CrossCode linker running on a VAX can link object files that were generated by the CrossCode compiler running on a PC or PS/2 host. The package includes a Motorola-compatible assembler, a linker, a librarian, and a library of more than 47 C functions. You also get a universal downloader that converts your object code to Motorola S records, Intel Hex records, or a variety of other industry-standard file formats for downloading to a target system or to an EPROM programmer. VAX host for the MicroVAX 2000, from $1595.

Software Development Systems Inc, 4248 Belle Aire Lane, Downers Grove, IL 60515. Phone (312) 971-8170. FAX 312-971-8513.

Circle No 391

80960 TOOLS

- *Allow you to develop software for the 80960 controller*
- *Run on MS-DOS, Sun-3, and VAX hosts*

The ASM-960 cross-assembler and iC-960 C cross-compiler allow you to develop software for embedded systems based on the vendor's 80960 microcontroller. Different versions of the cross-assembler and cross-compiler run on IBM PCs and PS/2s under MS-DOS, on Sun-3 workstations under Unix, and on VAX and MicroVAX systems under Unix. Support services include training classes and workshops, on-site and telephone consulting, and hardware maintenance contracts. ASM-960 cross-assembler, $1950; iC-960 cross-compiler, $1550; packaged together, $3150.

Intel Corp, Box 58065, Santa Clara, CA 95052. Phone local office.

Circle No 392

ROM-RESIDENT OS

- *Equivalent to MS-DOS 2.x*
- *Boots up on a standard IBM PC and runs .EXE and .COM files*

ROM-DOS is a small, modifiable ROM-resident operating system that is equivalent to MS-DOS 2.0 and higher. It boots up on a standard IBM PC and operates directly from ROM. (It does not have to be downloaded to RAM.) ROM-DOS occupies only 29k bytes of ROM for all functions, and less if some functions are not needed; you can use it with the vendor's standard BIOS or with the vendor's miniBIOS, which occupies only 3k bytes of ROM. The miniBIOS provides support for a hardware timer and serial ports (one of which can serve a remote console). The development kit lets you customize the OS to include only the functions that are needed by the target system; you can link application programs and load them into ROM with the OS and miniBIOS. Development kit, $495; source-code license, $5000; firmware, $6/copy (5000).

Datalight, 17505 68th Ave NE, Suite 304, Bothell, WA 98011. Phone (206) 486-8086.

Circle No 393

Not only does Signetics offer 3 more I/O ports than the 80C51, we also do windows.

At first glance, it's easy to see why our new SC87C451 offers you a rare window of opportunity.

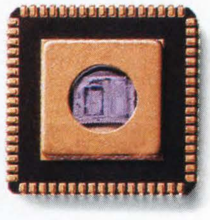
It's called EPROM flexibility.

And it comes in both UV and OTP EPROM versions that cut costs and save time in system development. Especially when you consider that it's fully supported by the Signetics development system.

The 87C451 gives you seven I/O ports for advanced applications. You'll find up to 60 I/O lines—28 more than on the standard 80C51.

Other 87C451 features include a "mailbox" interface for parallel communications, which gives you the ability to use port #6 for handshake data transfers. For added flexibility, the 87C451 also comes in ROM and ROMless versions, as well as in 12- and 16-MHz frequencies, and commercial and extended temperature ranges.

The 87C451 is just one part of our large and growing family of 80C51 derivatives. We also offer a 24-pin 80C51 microcontroller in ROM, UV or OTP EPROM. As well as parts with on-chip A/D that are available now. Each one is fully compatible with the 80C51 instruction set.



We're Signetics. We've got the guts—those essential microcontrollers to improve system performance. For a free '451 Microcontroller Information Packet, call us at (800) 227-1817, ext. 993D.

For surface mount requirements and military product availability, contact your local Signetics sales office. Learn the advantages of window-shopping at Signetics.

One standard. 0 defects.

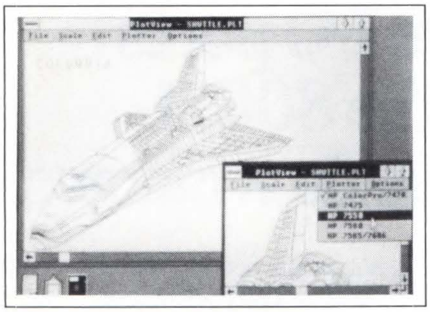
Signetics

a division of North American Philips Corporation

PHILIPS

PHILIPS

CIRCLE NO 132



PLOT-FILE EDITOR

- *Lets you view, edit, and print HPGL plot files*
- *Features include scaling, rotating, and scrolling*

PlotView 2.0 is a utility program for viewing, editing, and printing plot files in HPGL format. The program operates under Microsoft Windows so that you can view HPGL plot files while running other applications. You can display a plot, output it to a graphics printer, or paste an image into other documents. New features include cutting and pasting, selection of pen colors and widths, and unrestricted input-file size. The program also features scaling, rotating, and scrolling; zooming in and out; the emulation of five different plotters; and the ability to control laser, inkjet, and other graphics printers. $79.

Ajida Technologies Inc, 613 Fourth St, Santa Rosa, CA 95404. Phone (707) 545-7777. TWX: 650-363-9045.

Circle No 394

REAL-TIME ADA

- *Lets you develop software on Sun or Mizar workstations*
- *Real-time OS lets you run code on SPARC or 68000 systems*

The VADSWorks Ada software package combines the Verdix (Chantilly, VA) Ada Development System (VADS) and Wind River Systems' (Emeryville, CA) VxWorks real-time operating system. This combined package can run on Sun-3 and Sun-4 workstations or on the vendor's Hybrid Ada Development System. You can use VADS to develop and debug your code; the package includes a window- and mouse-based source-level debugger that lets you debug multiple tasks in separate windows. The VxWorks operating system for real-time, multitasking target systems provides task-state control, intertask communications and synchronization, and performance-analysis features. Networking features allow programs running on a real-time system to communicate with other target systems or with multiple host computers. The VADSWorks development subsystem is based on the Sun-3 Eurocard set, and includes a 20-MHz 68020 processor; 4M bytes of dynamic RAM;

an MC68881 numeric coprocessor; SCSI, Ethernet, and monochrome video controllers; a 141M-byte hard disk; a 65M-byte streaming tape drive; a 19-in. monochrome monitor; and a keyboard and mouse. VADSWorks, from $27,500; with complete workstation, from $58,095.

Mizar, 1419 Dunn Dr, Carrollton, TX 75006. Phone (214) 446-2664. FAX 214-522-5997.

Circle No 395

METRIC TOOL

- *Measures complexity of dBASE-III and -IV application programs*
- *Predicts probable number of errors and modification difficulty*

PC-Metric is a software-measurement package that accepts a dBASE III or dBASE IV application program as input and applies a variety of measurement techniques to the source code. PC-Metric generates reports that estimate the difficulty of understanding and modifying your program, the probable number of programming errors in the source code, and the amount of time required to write the program. The statistics include total and unique operators and operands, length vs predicted length, purity ratio, volume, effort, cyclomatic complexity, and estimated errors. A text report advises you whether each function conforms to recognized standards of excellence. To run PC-Metric, you need an IBM PC or compatible that runs PC-DOS 2.11 or higher. Other versions of PC-Metric are available for C, Cobol, Pascal, Modula-2, Fortran, and Basic. $199.

SET Laboratories Inc, Box 83627, Portland, OR 97283. Phone (503) 289-4758.

Circle No 396

ANALYSIS PACKAGE

- *Includes menu-and command-file-building tools*
- *DOS shell lets you perform DOS operations from within the tool*

Asyst version 3.0 is a programmable data-acquisition and -analysis software package that runs on IBM PC and PS/2 computers and compatibles. Several new features make it easy to create customized turnkey systems with simple and effective user interfaces. The Easy Coder feature uses a series of menus to prompt you for parameters and to generate code for a number of common operations such as data acquisition, GPIB control, and data analysis. A new language interface lets you call up routines from within Asyst that you've previously developed in C or Fortran. Menu-building tools let you create menus that can call other menus, run custom macros, perform status checks, or display directories, and the new DOS shell allows you to run application software or perform DOS operations without leaving Asyst. From $1695.

Asyst Software Technologies Inc, 100 Corporate Woods, Rochester, NY 14623. Phone (716) 272-0070. FAX 716-272-0073.

Circle No 397

CAD SOFTWARE

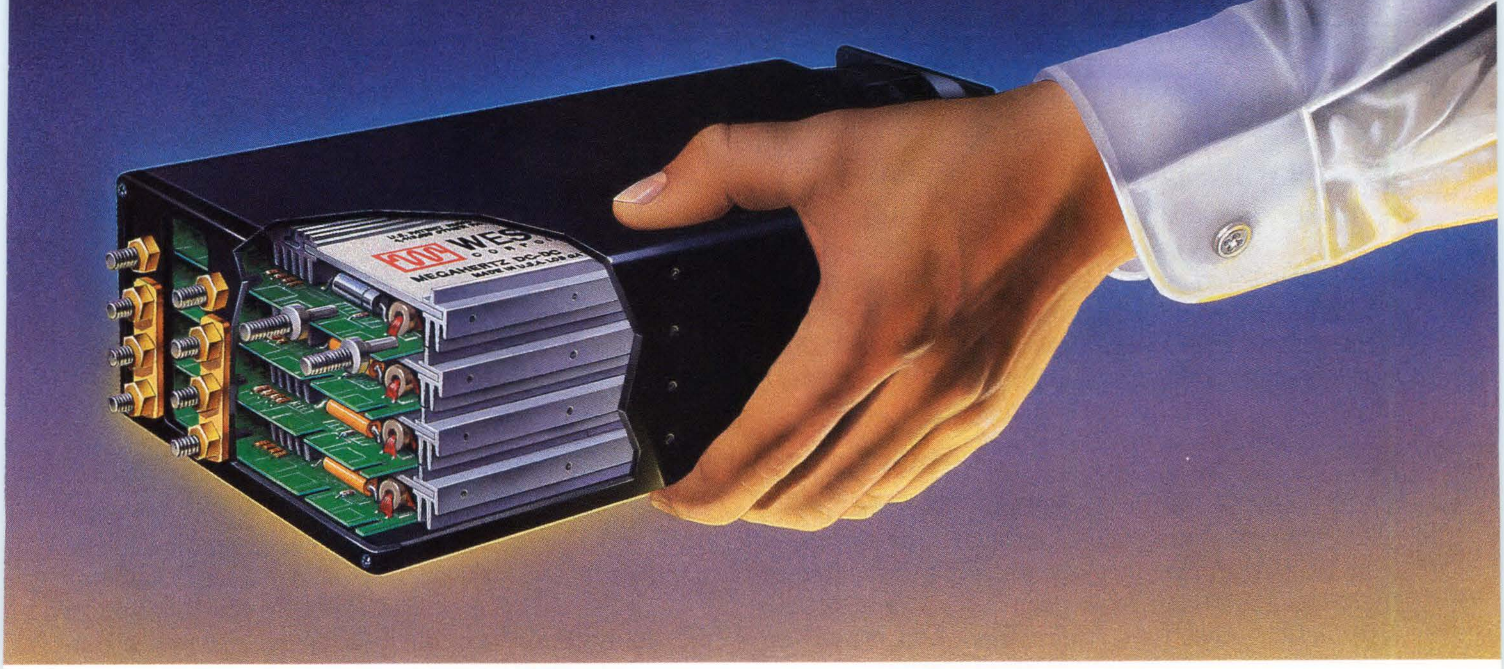
- *Integrates the Ella and Idea VLSI design tools*
- *Allows high-level circuit description and top-down VLSI design*

The Ellalink CAD package lets you transfer design information between the Ella VLSI design system and the Mentor Graphics Idea design-to-fabrication CAD system. By integrating Ella and Idea, the package allows you to perform top-down design of VLSI devices. In the early stages of the design, you can generate schematics using abstract Ella types, allowing you to assess various system architectures. Once you've partitioned the design, Ellalink lets you transfer well-defined circuit blocks to Idea so that you can do detailed design and simulation. Ellalink generates a hierarchical schematic in Mentor Graphics NETED format to translate Ella circuit descriptions into a form that can be used with Mentor Graphics design tools. The package works with the full Ella language. Behavioral primitives are represented by symbols, and abstract signal types are preserved during the translation. You can set up the translator to use Mentor Graphics library parts rather than Ellalink's normally generated symbols to represent components in the Ella design; this facility allows you to transfer the design to Mentor Graphics low-level simulation and layout tools without manual editing. Multiuser license, £8000.

Praxis Systems plc, 20 Manvers St, Bath BA1 1PX, UK. Phone (0225) 444700. TLX 445848. FAX 0225-65205.

Circle No 398

THE POWER SUPPLY



REDEFINED

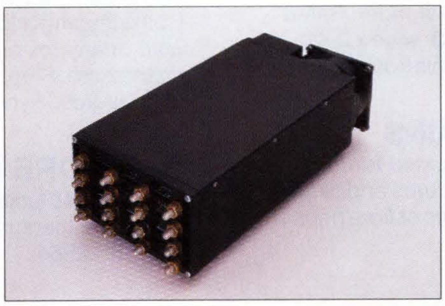
THE WESTCOR STAKPAK™. NEW GENERATION 250 TO 1200 WATT SINGLE OR MULTIPLE OUTPUT OFF-LINE SWITCHER. 3.2 X 5.5 X 11.4 INCH CASE. FAN-COOLED.

Stack the odds in your favor by designing-in Westcor's 6 watt/cubic inch high power megahertz switcher. Capitalizing on patented and proven megahertz module technology and innovative thermal management techniques, the StakPak provides up to 1200 watts of power at 50°C with 1 to 8 isolated and fully regulated outputs.

For existing designs the StakPak's small size and low profile allow system enhancement without mechanical redesign. Simply replace your open frame switcher with up to 1200 watts of StakPak power or replace your "box switcher" with 2 StakPaks and realize up to twice the power without losing additional space. StakPak power factor correction provides 850 watts of output power from a standard 115 VAC wall outlet. In new designs, more space can be devoted to functionality or the system can be downsized.

The StakPak's 8 module output section can be factory configured in virtually an infinite number of voltage, current and power combinations. Special models providing between 250 to 1200 watts and outputs from 2 to 95 VDC are available.

Other features include outstanding electrical performance; UL, CSA, VDE safety agency approval (in process); variable speed fan option for low ambient noise enviroments and 3 phase or DC input options. Indeed, with unprecedented power density, versatility and new features, the StakPak redefines power packaging. Please contact Westcor for a data sheet, pricing and additional information.



STANDARD 1200 WATT STAKPAK MODELS (110/220 VAC input)

Model	Output Voltage (VDC) and Maximum Current (amperes) per Channel #1	#2	#3	#4	#5
Single Output					
SP1-1801	2 @ 240				
SP1-1802	5 @ 240				
SP1-1803	12 @ 100				
SP1-1804	15 @ 80				
SP1-1805	24 @ 50				
SP1-1806	28 @ 42				
SP1-1807	48 @ 25				
Dual Output					
SP2-1801	2 @ 120	5 @ 120			
SP2-1802	5 @ 120	5 @ 120			
SP2-1803	5 @ 120	12 @ 66			
SP2-1804	12 @ 66	12 @ 66			
SP2-1805	15 @ 53	15 @ 53			
Triple Output					
SP3-1801	5 @ 180	12 @ 16	12 @ 16		
SP3-1802	5 @ 150	12 @ 33	12 @ 16		
SP3-1803	5 @ 180	15 @ 13	15 @ 13		
SP3-1804	5 @ 150	15 @ 26	15 @ 13		
Quad Output					
SP4-1801	5 @ 150	12 @ 16	12 @ 16	5 @ 30	
SP4-1802	5 @ 150	15 @ 13	15 @ 13	5 @ 30	
SP4-1803	5 @ 150	12 @ 16	12 @ 16	24 @ 8	
SP4-1804	5 @ 150	15 @ 13	15 @ 13	24 @ 8	
Five Output					
SP5-1801	5 @ 120	12 @ 16	12 @ 16	5 @ 30	24 @ 8
SP5-1802	5 @ 120	15 @ 13	15 @ 13	5 @ 30	24 @ 8

Total output power may not exceed 1200 watts for any model, single or multiple output. Lower power StakPak models are available. Please contact the factory.

™

WESTCOR CORPORATION • 485-100 Alberto Way • Los Gatos, CA 95032 • (408) 395-7050 • FAX (408) 395-1518

Westcor is a subsidiary of VICOR CORPORATION

CIRCLE NO 161

TEST TRANSLATOR

- *Adapts programs from Lasar Version 6 to Genrad 2225/35*
- *Handles go/no-go tests and guided-probe fault diagnosis*

Genrad Inc's 2225 and 2235 testers can now run go/no-go and, optionally, guided-probe diagnostic test patterns developed using the vendor's Lasar Version 6 simulator. The Lasar/2225 postprocessor software makes the conversion for you. The translator can incorporate a fault dictionary that allows noninvasive testing—that is, testing without probing any of a board's internal nodes. Many military applications require such an approach. The translator, which runs on DEC V VAX systems under the VMS operating system, includes algorithms for "compacting" test programs to fit the testers' memory. $22,000; guided-probe diagnostic capability, $4500; fault dictionary, $13,500.

Teradyne Inc, 5155 Old Ironsides Dr, Santa Clara, CA 95054. Phone (408) 980-5200.

Circle No 403

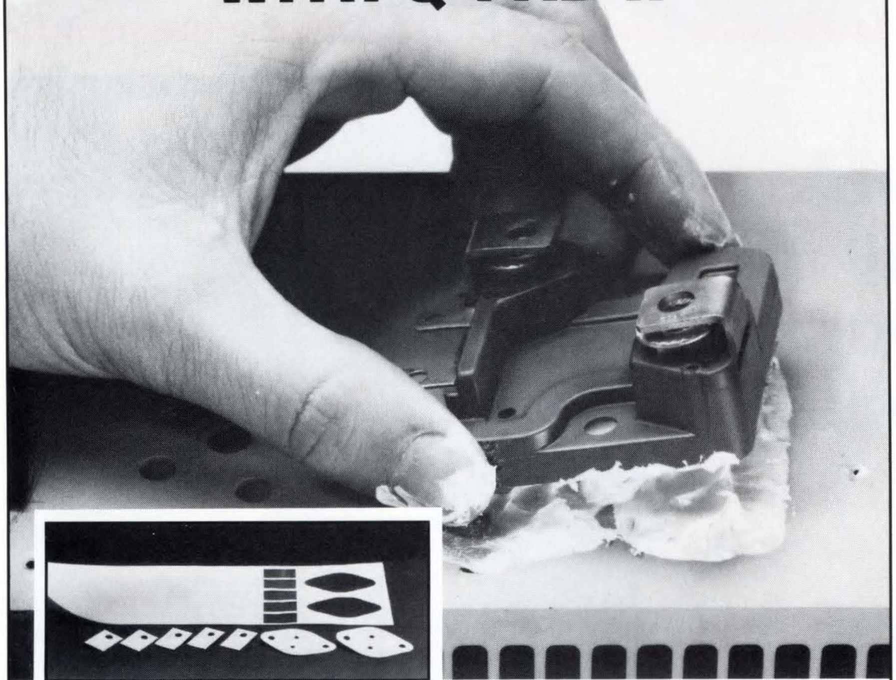
WAFER IDENTIFIER

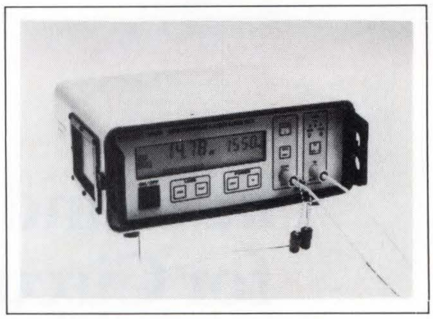
- *Reads identifying codes written on wafers with laser*
- *Provides accuracy greater than 99%*

You install the WIS 2000 system's solid-state cameras on units that perform semiconductor wafer-processing operations. With accuracy exceeding 99%, the system reads alphanumeric characters scribed by a laser onto the wafers being processed. The characters uniquely identify individual wafers for process control. The system includes a 68000-based single-board computer in a chassis, a video monitor, a trackball for operator input, menu-driven software, and as many as eight cameras. 8-station system, approximately $66,000.

Microvision Corp, 12849 Industrial Park Blvd, Minneapolis, MN 55441. Phone (612) 559-2608.

Circle No 404





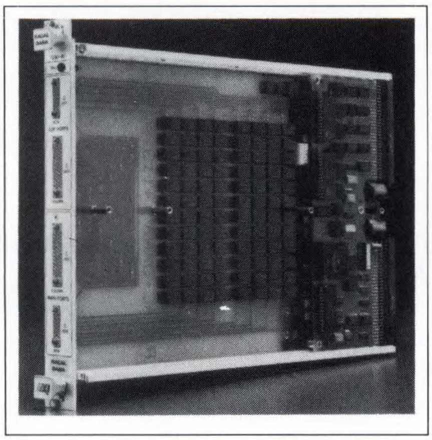
LASER LOSS SET

- *Combines power meter and dual-wavelength source*
- *Operates from ac or battery*

The 160B laser loss set includes an optical power meter and two stable light sources. It makes simultaneous power or loss measurements at wavelengths of 1300 and 1500 nm and includes preset −10-dB calibration. You can operate it from batteries or ac-line power. It includes a fiber-identifier input and a 2-kHz modulator that you can use for fiber identification. The unit is enclosed in a weatherproof case. $15,950. Delivery, four to six weeks ARO.

Intelco Corp, 8 Craig Rd, Acton, MA 01720. Phone (508) 264-4485. TLX 510-601-3687.

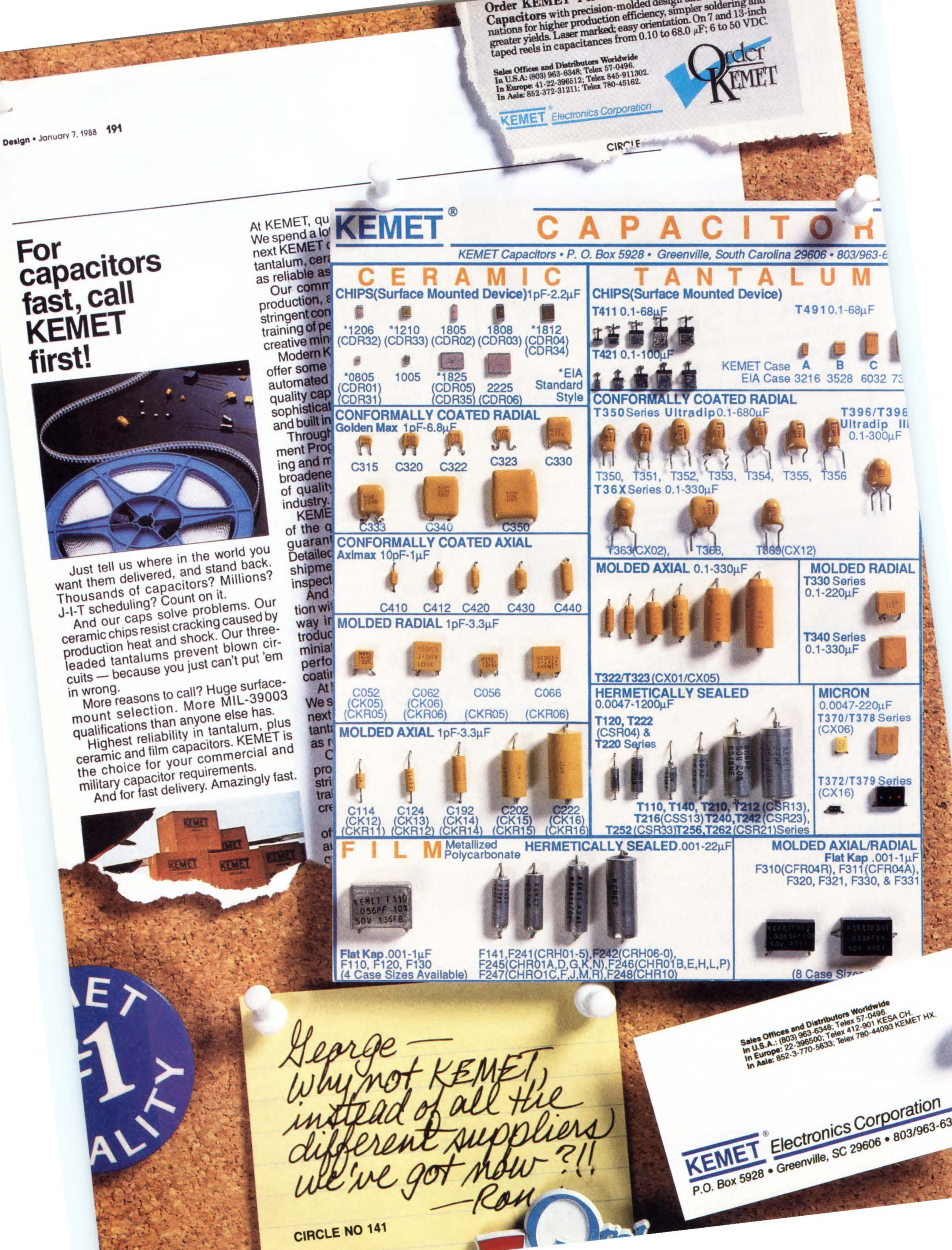
Circle No 405



VXI SIGNAL SWITCH

- *Switches signals from dc to 26.5 GHz*
- *Stores test setups in nonvolatile memory*

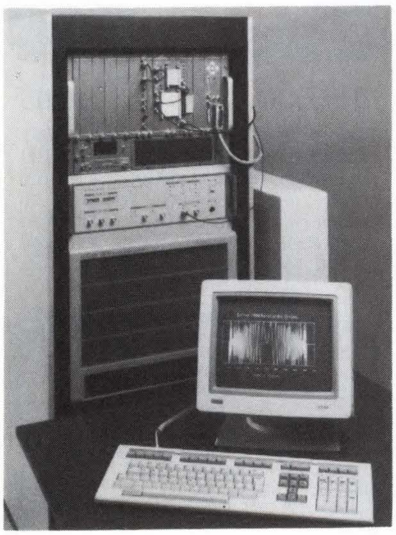
Units in the Series 1260 signal-switching and routing system conform to VXI (VME eXtensions for


Order KEMET
Capacitors with precision-molded design and ... simpler soldering and ... nations for higher production efficiency, simpler soldering and ... On 7 and 13-inch ... greater yields. Laser marked; easy orientation. On 7 and 13-inch taped reels in capacitances from 0.10 to 68.0 µF; 6 to 50 VDC.
Sales Offices and Distributors Worldwide
In U.S.A: (803) 963-6348; Telex 57-0496.
In Europe: 41-22-396512; Telex 845-911302.
In Asia: 852-372-31211; Telex 780-45162.
KEMET Electronics Corporation
Order KEMET
For capacitors fast, call KEMET first!
Just tell us where in the world you want them delivered, and stand back. Thousands of capacitors? Millions? J-I-T scheduling? Count on it.
And our caps solve problems. Our ceramic chips resist cracking caused by production heat and shock. Our three-leaded tantalums prevent blown circuits — because you just can't put 'em in wrong.
More reasons to call? Huge surface-mount selection. More MIL-39003 qualifications than anyone else has.
Highest reliability in tantalum, plus ceramic and film capacitors. KEMET is the choice for your commercial and military capacitor requirements.
And for fast delivery. Amazingly fast.
KEMET® CAPACITOR
KEMET Capacitors • P. O. Box 5928 • Greenville, South Carolina 29606 • 803/963-6
CERAMIC
CHIPS (Surface Mounted Device) 1pF-2.2µF
*1206 (CDR32) *1210 (CDR33) 1805 (CDR02) 1808 (CDR03) *1812 (CDR04) (CDR34)
*0805 (CDR01) (CDR31) 1005 *1825 (CDR05) (CDR35) 2225 (CDR06) *EIA Standard Style
CONFORMALLY COATED RADIAL
Golden Max 1pF-6.8µF
C315 C320 C322 C323 C330
C333 C340 C350
CONFORMALLY COATED AXIAL
Aximax 10pF-1µF
C410 C412 C420 C430 C440
MOLDED RADIAL 1pF-3.3µF
C052 (CK05) (CKR05) C062 (CK06) (CKR06) C056 (CKR05) C066 (CKR06)
MOLDED AXIAL 1pF-3.3µF
C114 (CK12) (CKR11) C124 (CK13) (CKR12) C192 (CK14) (CKR14) C202 (CK15) (CKR15) C222 (CK16) (CKR16)
TANTALUM
CHIPS (Surface Mounted Device)
T411 0.1-68µF
T491 0.1-68µF
T421 0.1-100µF
KEMET Case A B C
EIA Case 3216 3528 6032
CONFORMALLY COATED RADIAL
T350 Series Ultradip 0.1-680µF
T396/T398 Ultradip II 0.1-300µF
T350, T351, T352, T353, T354, T355, T356
T36X Series 0.1-330µF
T363(CX02), T368, T369(CX12)
MOLDED AXIAL 0.1-330µF
T322/T323 (CX01/CX05)
MOLDED RADIAL
T330 Series 0.1-220µF
T340 Series 0.1-330µF
HERMETICALLY SEALED 0.0047-1200µF
T120, T222 (CSR04) & T220 Series
T110, T140, T210, T212 (CSR13), T216 (CSS13) T240, T242 (CSR23), T252 (CSR33) T256, T262 (CSR21) Series
MICRON 0.0047-220µF
T370/T378 Series (CX06)
T372/T379 Series (CX16)
FILM Metallized Polycarbonate
HERMETICALLY SEALED .001-22µF
MOLDED AXIAL/RADIAL
Flat Kap .001-1µF
F310(CFR04R), F311(CFR04A), F320, F321, F330, & F331
Flat Kap .001-1µF
F110, F120, F130
(4 Case Sizes Available)
F141, F241(CRH01-5), F242(CRH06-0), F245(CHR01A,D,G,K,N), F246(CHR01B,E,H,L,P) F247(CHR01C,F,J,M,R), F248(CHR10)
(8 Case Sizes ...)
George — why not KEMET, instead of all the different suppliers we've got now?!! —Ron
Sales Offices and Distributors Worldwide
In U.S.A.: (803) 963-6348; Telex 57-0496.
In Europe: 22-396500; Telex 412-901 KESA CH.
In Asia: 852-3-770-5633; Telex 780-44093 KEMET HX.
KEMET® Electronics Corporation
P.O. Box 5928 • Greenville, SC 29606 • 803/963-63
CIRCLE NO 141

Instrumentation) standards and provide coaxial switching for rf signals at frequencies as high as 26.5 GHz. The units also handle power and low-level signals at dc and low frequencies. You can chain many modules together; the first unit in the chain must contain an option 01 control module that makes it a message-based device. The units contain a nonvolatile memory that stores test setups. You can designate one of these setups as a unit's power-up state. $1000 to $3000.

Racal-Dana Instruments Inc, 4 Goodyear St, Irvine, CA 92718. Phone (800) 722-3262; in CA, (714) 859-8999. FAX 714-859-2505.

Circle No 406



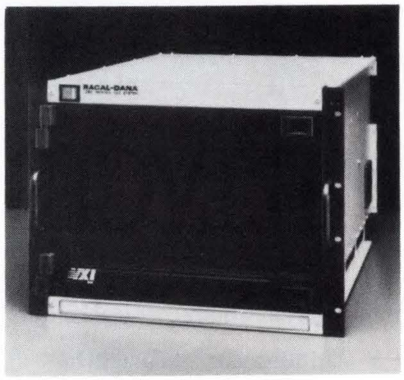
WAVEFORM RECORDER

- *Captures 640M samples on two channels at 200M samples/sec*
- *Resolves 8 bits or 12 bits at 5M samples/sec*

The 7900 WaveCorder digitizes analog waveforms to 8-bit precision at any rate to 200M samples/sec. It stores as many as 640M samples—more than 3 sec of data at the maximum sampling rate, and much more at lower rates. An option allows you to substitute a 12-bit digitizer that acquires data at a maximum rate of 5M samples/sec. The system can also replay captured waveforms at the same rate at which it acquired them. The system works with an IBM PC/AT or a compatible computer, VAX/MicroVAX, or a VME-based computer. 40M-sample system, expandable to 160M samples, $160,000.

LeCroy Corp, 700 Chestnut Ridge Rd, Chestnut Ridge, NY 10977. Phone (914) 425-2000. TWX 710-577-2832.

Circle No 407



VXI BUS CHASSIS

- *Accommodates C-size modules*
- *Incorporates 8-output power supply*

The 1261 is a C-size chassis for VXI (VME eXtensions for Instrumentation) bus modules. It includes a 12-layer backplane, cooling fans, and a power supply that produces 5V, ±12V, 26V, −24V, −5.2V, and −2V in addition to providing 5V standby power separately from the main 5V supply. The supplies have transient-peak current capabilities that exceed those required by revision 1.2 of the VXI spec. The backplane uses DIP switches rather than jumpers to route the daisy-chained signals past unused slots. Cooling air enters the sides of the unit and exits through the rear. A cable tray facilitates wiring to the VXI modules. $6350.

Racal-Dana Instruments Inc, 4 Goodyear St, Irvine, CA 92718. Phone (800) 722-3262; in CA, (714) 859-8999. FAX 714-859-2505.

Circle No 408

Presenting The Winning Advertisements

Here are the winning advertisements from EDN Magazine Edition's January 5, 1989 Reader Vote Contest. Our readers analyzed and evaluated the advertisements in the issue to select the ones they judged to be the most informative, helpful and attractive. Congratulations to the advertisers and agencies who combined well-written copy and superior design to create these winning advertisements. And, a special thank you to the readers who took the time to participate. Here then are the outstanding performers.

EDN Magazine Edition News Edition

FIRST

COMPANY: Tektronix
AGENCY: Young & Roehr

"They always have very good ads!"
- Staff Engineer, Harris Corporation

"Shows instruments well/gives prices!!! That's what I want to know!"
- Senior Development Engineer, Valmet Automation

"Extremely Creative!"
- Electrical Engineer, DuPont

SECOND

COMPANY: GE Plastics
AGENCY: Fahlgren & Swink

"Most attention getting ad in this issue!"
■ Senior Systems Engineer, AT&T Network Systems

"Bigger than life! Colorful and catchy."
■ Associate Engineer, McDonell Douglas

"Sometimes bigger is better—can't miss it."
■ Senior R&D Engineer, Ford Aerospace

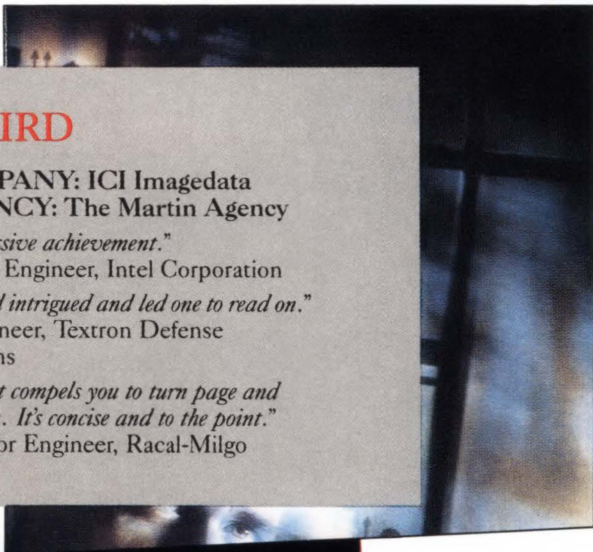
THIRD

COMPANY: ICI Imagedata
AGENCY: The Martin Agency

"Impressive achievement."
- Staff Engineer, Intel Corporation

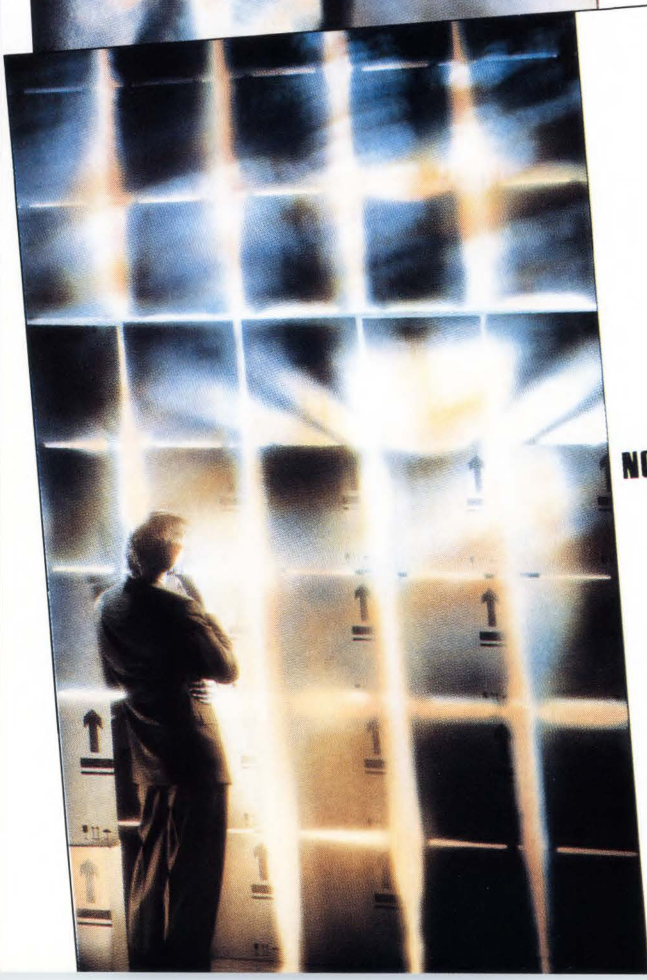
"The ad intrigued and led one to read on."
- Engineer, Textron Defense Systems

"Layout compels you to turn page and read on. It's concise and to the point."
- Senior Engineer, Racal-Milgo



WE TOOK 150,000 HOURS TO DEVELOP A PICTURE

WE SPENT 10 MILLION DOLLARS ON A PIECE OF PAPER



NOW WILL YOU TAKE A SERIOUS LOOK AT THE FUTURE OF ELECTRONICS?

We predict the big money will be in hardware.

But only if it's of a kind suited to the most advanced electronic media.

That's where ICI Imagedata is currently leading the way with two very important developments.

The first is *Digital* Paper, the data storage equivalent of traditional paper. It's low cost, indelible and permanent. Yet, unlike paper, Digital Paper offers the areal capacity and recording advantages of optical disks.

One 12" reel made from this unique material holds up to two Terabytes of data (that's 2,000,000,000 Kbytes), on-line if you like.

What's more, it's flexible. We can cut Digital Paper into disks of any size (one 5¼" disk provides 1.5 GB of data, fast). Chop it into tag form. Or use it as a tape for mass storage.

Our second development is no less impressive.

It involves a colored ribbon for use in a thermal printer plus a new receiver paper which won't tear, scratch, curl or run.

The process is called dye diffusion thermal transfer (D2T2 for short). It produces brilliant color images from an electronic source (video camera, computer, fax etc.). The final picture looks as good as a photographic print (with a choice of millions of colors for every dot), even though it's produced on a simple desk top printer.

So what will these materials mean to you, the hardware manufacturer, software developer or system integrator?

A great deal.

Potential markets for both are enormous ... everything from data networking and logging, on- and off-line storage and recording to publishing, computer graphics and business presentations.

ICI Imagedata is already inspiring new designs of disk drives, tape drives and thermal printers.

In fact, ICI spends $2.5 million per day on research and development.

But your contribution in electronics will further improve the performance standards we've set. That's why we'd like to discuss the future with progressive hardware and systems developers.

For a detailed brief on the technology and media of the future, call Rick Lamb (D2T2) or David Owen (Digital Paper) toll-free at 1-800-456-3669.

Or write to us at ICI Imagedata, Concord Pike, Wilmington, DE 19897 and we'll send in-depth information.

You'll learn in an hour what's taken us considerably longer to develop.

ICI Imagedata

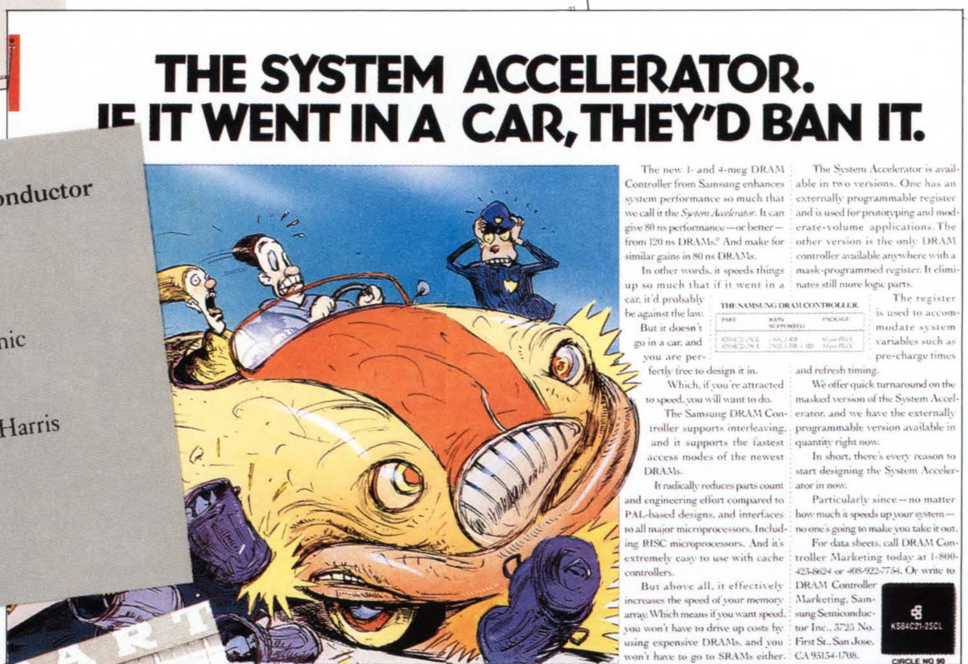
CIRCLE NO 149

COMPANY: National Semiconductor
AGENCY: FCB/Technology Group

"Good eye-catcher and well worded."
■ Senior Manufacturing Engineer, MCT, Inc.

"Very good relation between pictures and message."
■ Senior Product Engineer, Optek Technology Inc.

"Makes the point in an attractive way."
■ Senior Engineer, Nicolet Audiodiagnostics



COMPANY: Samsung Semiconductor
AGENCY: Curtin, Emerson, Ransick

"Curious caption. I read entire ad. It held my interest."
■ Senior Engineer, AVW Electronic Systems, Inc.

"Interesting, great layout!"
■ Associate Principal Engineer, Harris Corporation

"Humorous!"
■ Senior Engineer, Raytheon Company

COMPANY: Precision Interconnect
AGENCY: Thompson & Huffschmidt

"Nostalgic."
■ Field Engineer, CAE Industries–Link Division

"Brings back fond memory and supports theme precisely."
■ Advisory Engineer, IBM

"Clear, concise—photos are good attention grabbers."
■ Engineer, Micro-Radian Instruments

COMPANY: Teradyne
AGENCY: Ingalls, Quinn & Johnson

"Effective advertising."
■ Engineering Manager, GATX Terminals

"Good concept, imaginative."
■ Quality Engineer, Digital Equipment Corporation

"Inspires 'possibility' thinking."
■ Engineer, Hughes Aircraft

COMPANY: Altera
AGENCY: Austin Associates

"Tells me all I want to know."
■ Design Electrical Engineer, Dow Corning Corp.

"Funny and captive ad."
■ Electrical Engineer, NASA–Ames Research Center

"Very fishy!"
■ Group Engineer, Emerson Electric Co.

COMPANY: Force Computers
AGENCY: Austin Associates

"Good information on boards with pleasing ad."
▪ Engineering Manager, Applied Materials

"Ad quickly and creatively shows product concept. Gives useful information."
▪ Electrical Engineer, Instrument Development Inc.

"Attracts one's attention readily."
▪ Consulting Engineer, Lockheed Electronics Company

COMPANY: Hitachi America Ltd.
AGENCY: Sutter Martin Inc.

"Attractive and informative."
▪ Project Engineer, Ametek Microelectronics

"Nice graphic, good information."
▪ Staff Engineer, Data General

"Very colorful—grabs your attention."
▪ Senior Design Engineer, GE Fanuc Automation N.A.

EDN Magazine Edition / News Edition

A Partnership in Power and Prestige Worldwide

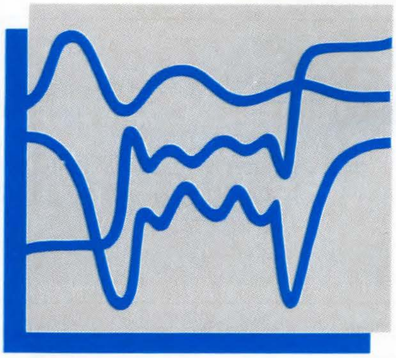
Cahners Publishing Company

A Division of Reed Publishing USA

Specialized Business Magazines for Building & Construction, Manufacturing Foodservice & Lodging, Electronics & Computers, Interior Design, Printing, Publishing, Industrial Research & Technology, Health Care, and Entertainment.

Specialized Consumer Magazines: American Baby and Modern Bride.

HSPICE



Convergence · Speed · Accuracy
Models · Large Circuits · Optimization

☑ Optimization

- Model parameter generation from measured data
- General circuit analysis using optimized models
- Full circuit optimization — DC, AC, transient, distortion, noise, pole-zero and S-parameter analysis

☑ New Features

- Input and output algebraic equations and functions
- Transmission Lines
- New MOS Models for analog and submicron technologies
- Auto stop option

☑ DDL 2000

- 2000+ discrete device library models for PCB designers.
- Includes diodes, zener diodes, JFETs, BJTs, bipolars, powerMOS, op amps, comparators, timers and SCRs.
- Runs on Mentor workstations as a superior alternative to Accusim/Acculib

☑ HSPICE 386 PC Version

- Full HSPICE capabilities
- Fast and accurate
- $4,000 stand-alone price
- Volume discounts available

HSPICE meets *all* your engineering needs!

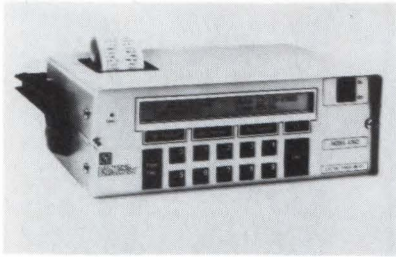
- Automation of model characteristics
- Circuit optimization
- Full chip analog simulation
- High frequency circuit design
- Mixed S-parameter and transient design
- Cell characterization
- Multi-vendor model support
- Mixed workstation vendor support
- PC to Cray computing
- Evaluation software available upon request

**Visit us at the
Custom Integrated Circuit Conference
(CICC) May 15-18 in San Diego, CA
Booth 19 & 20**

META-SOFTWARE

50 Curtner Avenue
Campbell, CA 95008
Phone (408) 371-5100 • FAX (408) 371-5638
Toll Free (800) 346-5953

POWER ANALYZER

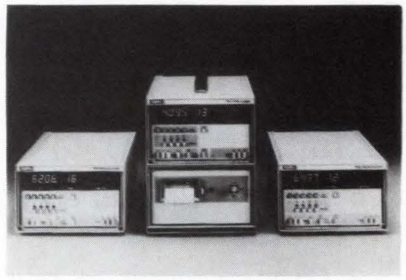


- *Analyzes V, I, P, PF, and reactive power*
- *Is portable and battery powered*

The Model 4760 power analyzer is a 16-lb, portable, battery-powered, μP-based instrument that measures voltage (V), current (I), power (P), power factor (PF), reactive "power" (VAR), active energy, reactive energy, and time. It can continuously monitor a power line for 15 minutes and retain in a nonvolatile memory the largest value it measured. An internal printer can create a permanent record of measurement results. $3300.

Electronic Development Corp, 11 Hamlin St, Boston, MA 02027. Phone (617) 268-9696. TLX 951596.

Circle No 409



DATA LOGGERS

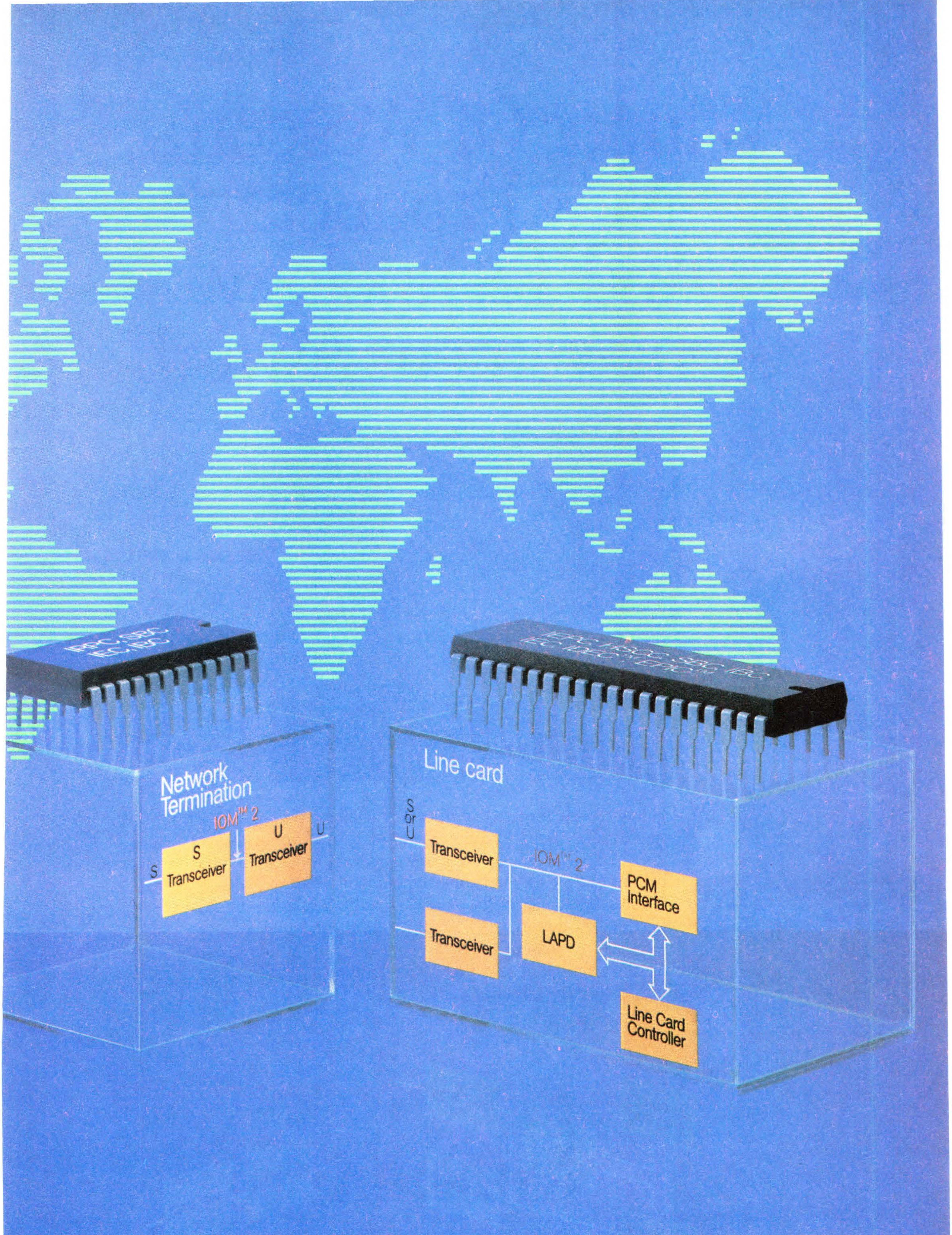
- *Scan at 40 channels/sec*
- *Accept thermocouple, RTD, and process-transmitter outputs*

The 1100 series of portable data loggers includes four members. All accept inputs from thermocouples, RTDs (resistance temperature detectors), process-variable transmitters, and transducers. They scan at 40 channels/sec and can have 20 or 40 channels. The 1101 includes a printer. The 1102 scans and monitors alarms and optionally provides an RS-232C or IEEE-488 output. The 1103 is remotely programmable and includes an RS-232C port. The 1104 includes a digital tape deck that stores 45,000 readings in ANSI/ECMA (American National Standards Association/Electronic Computer Manufacturers Association) format on standard cassettes. The 1101 and 1104 optionally operate from 9 to 35V dc power. 1101, $2600; 1102, $1875; 1103, $2250; 1104, $4150.

Digitec, 959 Cheney Ave, Marion, OH 43302. Phone (614) 387-3444.

Circle No 410


ACME'S LAW OF RAW POWER
TO FULFILL THE BASIC NEED FOR RAW POWER, YOU MUST PROVIDE THE SIMPLICITY & CONVENIENCE OF CHOICE.
The simple alternative of Acme's "Black-Line" Series
Brute Force. One of the most basic power supplies on the market today – and, one of the simplest. Acme provides this convenient alternative to "deluxe" power supplies in the broad range of its Standard Power "Black-Line" Series.
Excellent for satisfying DC power applications where unregulated power is acceptable, the "Black-Line" Series can be relied upon to fulfill the basic power demands of relays, DC to DC converters, DC motors, solenoids, lamps, L.E.D.'s, and signal systems. Installation is fast and easy.
Should point-of-use regulation be required, Acme offers a broad range of voltage/current outputs, with its VCR Series of Voltage Control Regulators.
When it's simple, convenient, reliable raw power you require, there is a "Black-Line" power supply available.
For more information on the "Black-Line" or "VCR" Series, contact your authorized electronic distributor or contact us direct.
Acme Electric. We're putting power supplies in a whole new light.
☐ Off-the-shelf availability
☐ Models 7-48 volts
☐ All models UL recognized
☐ Open-frame construction for maximum thermal dissipation
☐ Floating outputs
☐ Low component count, high MTBF
Acme Electric Power Products
Lumberton, North Carolina 28358
1-919-738-9202
Outside North Carolina
1-800-247-7507
CIRCLE NO 145


Network Termination
IOM™ 2
S
S Transceiver
U Transceiver
U
Line card
S or U
Transceiver
Transceiver
IOM™ 2
PCM Interface
LAPD
Line Card Controller

CIRCLE NO 150

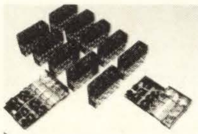
EDN PRODUCT MART

This advertising is for new and current products.

Please circle Reader Service number for additional information from manufacturers.

CUSTOM POWER SUPPLIES

1 KW DC-DC CONVERTER MODULES CAN BE PARALLELED TO 10 KW



Specializing in designing and building DC-DC Converters, Switchmode Power Supplies, Linear Supplies, Electronic Loads, Switchmode Magnetics to your specification.

- ☐ Commercial and Military
- ☐ High Power Density (20 W in³)
- ☐ Fast Personal Service

Call or write for free Consultation and Descriptive Brochure or send RFQ to:

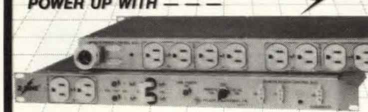
SIERRA WEST POWER SYSTEMS
2615 Missouri, Bldg. #5
Las Cruces, New Mexico 88001
505-522-8828

CIRCLE NO 325

Don't Get Zapped!

High inrush current can **destroy** your sensitive VAX CPUs and peripherals **in less time than it takes to flip a switch.**

THE SOLUTION?
Power up with ***Z-LINE* TPC 115-10 MTD™ the smallest** power distribution and control system available.
POWER UP WITH — — — **Z-LINE**



Our proprietary **Multiple Time Delay™ circuitry sequences** your power-up to **protect** your systems from the spikes and surges, EMI & RFI, that **destroy your hardware and erase your data.** And our remote on/off and emergency shutdown **gives the power control back to you.**

All Pulizzi Engineering MTD™ **controllers are compatible with DEC and UPS systems.**
PRICES FROM $436 TO $305

DON'T WAIT UNTIL IT HAPPENS, CALL TODAY!
PULIZZI ENGINEERING INC.
3260 S. Susan Street, Santa Ana, CA 92704-6865
(714) 540-4229 FAX (714) 641-9062

CIRCLE NO 326

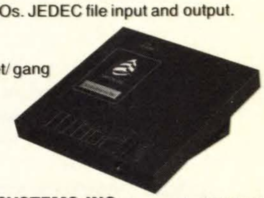
PLD/MICRO PROM/EPROM/EEPROM

SAILOR: The most dependable and affordable programming instrument

S/W driven by PC/XT/AT/PS2 or laptop computers, powerful and expandable.

Sailor-PAL: supports PALs, GALs, PLDs, EPLDs, PEELs, ECLs, PLAs, PLSs, PROMs, EPROMs, EEPROMs and MICROs. JEDEC file input and output. $1095–$1895.

Sailor-2, Sailor-8: set/gang high speed EPROM programmers. $545– $1995.



ADVIN SYSTEMS INC. Sunnyvale, CA 94086
(408) 984-8600 • FAX (408) 736-2503
(800) 627-2456 Please call for free demo disk

CIRCLE NO 327

HIGH FREQUENCY NOISE PROBLEMS?

DESIGN IN PGA/DECUP

PGA/DECUP Capacitors provide superior noise reduction to pin grid array (PGA) devices like 32-bit micro processors, and ASIC's that must operate in todays high frequency, low inductance applications. The inherent low inductance and rapid delivery of the charge allow PGA/DECUP capacitors to suppress high speed switching transients with superior results. PGA/DECUP Capacitors fit under PGA packages and LCC sockets, delivering high efficiency decoupling without using any valuable board space.

ELDRE CORPORATION
1500 Jefferson Rd., Rochester, N.Y. 14623
TEL: 716-427-7280 Fax: 716-272-0018

CIRCLE NO 328

EXTRUDED ALUMINUM PANEL MOUNT ENCLOSURES

- Depths 6" & 8"
- Any depths, 10 or more
- Satin, clear anodize finish
- Lock-in panel-mount
- Modifications and screen printing available

DIN STANDARDS

Bezel	Case
48 x 96 mm	44 x 91 mm
72 x 144 mm	67 x 136 mm
96 x 192 mm	91 x 184 mm
96 x 96 mm	91 x 91 mm
	184 x 184 mm

FREE CATALOG

Buckeye
555 Marion Road
Columbus, OH 43207
614/445-8433

CIRCLE NO 329

Telecom Design!

CALL PROGRESS

TONE DETECTORS

Tone detector ICs for all telecommunications products. 5V, 3.58 MHz time base, tristatable outputs.

- **M-980** band pass detector from 340 Hz to 620 Hz. Ideal for detecting non-precise call progress tones. 8 pin.
- **M-981** provides precise detection of 350,400,440 and 480 Hz. 22 pin.
- **M-982** provides precise detection of 350,440,480 and 620 Hz. 22 pin.

For more info call: **1-800-426-3926**
(In Washington State: 206-827-9626)

TELTONE®
10801-120th Avenue NE, Kirkland, WA 98033

CIRCLE NO 330

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

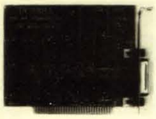
A Lot For A Little

Reach 137,000 specifiers of electronics components, equipment, and systems for only **$780**.

◆

EDN Product Mart

To advertise in Product Mart, call Joanne Dorian, 212/463-6415



LOW COST INTERFACE CARDS FOR PC/XT/AT/PS2

RS-485/422 Card [PC485] $95/125

- Serial Async. Communication up to 4,000ft; 2 or 4 wires; NS16450 UART;
- Can be configured as COM1-COM4; Maximum Baud Rate **56KB/115KB**.
- Dual drivers/receivers;Handles 64 devices;Compatible with most comm. sftwr.
- **DB9** or **phonejack**. Sample communication software available - **$50/150**

IEEE-488 Card [PC488A] $145

- Includes **INSTALLABLE DOS DEVICE DRIVERS** and support for **BASIC**.
- Additional Support for **ASSEMBLY, C, Pascal** and **FORTRAN - $ 50.**
- **IRQ (1-6). DMA** channel **1** or **2**. Up to **4 boards** per computer.
- Compatible with most **IEEE-488 Software packages** for IBM-PC (e.g. **ASYSTANT-GPIB, Lotus Measure**). Compatible with NI's **GPIB-PCIIA**.

IEEE- 488 Card [PC488B] With Built-In Bus Analyzer $345

- Software Support for BASICA, QuickBASIC and GWBASIC.
- Additional libraries for **C, Pascal, FORTRAN, Assembly** available - **$95 (all)**
- **Powerful menu-driven BUS ANALYZER** runs in the background while 488 programs or commands are executed; Features **Program Stepping, Break points,** real time **bus data capture** (4K buffer), **instant screen toggling.**
- **Complete Controller / Talker / Listener** capability. Based on TI's **TMS-9914.**
- **NEC-7210** based card (compatible with Nat. Instruments **PCII/PCIIA**) - **$445.**

PS2 Ser/Par Card [PS2IOA] $95/125

- I/O card for PS2 Models 50-80; Ser. port 1-2; Par. port 1-3; IBM registered ID.

A/D + D/A + DIO + Counter $295-995

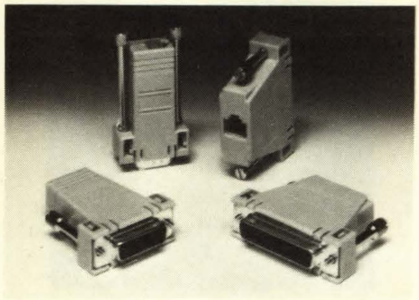
- 16/8 Channels; 12-14 bit Resolution; 25k-100ks/sec; 16 DIOt; 16 bit Counter;

MC / VISA / AMEX *Call today for datasheets!*

B&C MICROSYSTEMS INC.
355 West Olive Ave, Sunnyvale, CA 94086
TEL: (408)730-5511 FAX: (408)730-5521

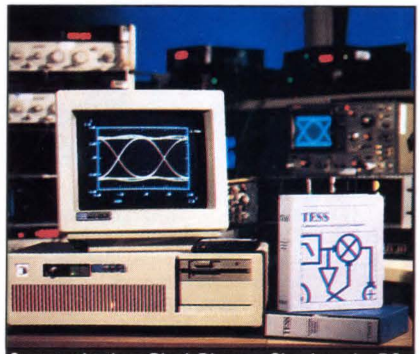
CIRCLE NO 340

.RS232 ADAPTORS



.RS232 – ADAPTOR RJ45. AVAILABLE IN 9, 15, & 25 POSITIONS IN KIT FORM AND WIRED TO SPECIFICATIONS. .RS232 – ADAPTOR RJ11. AVAILABLE IN 9, 15 & 25 POSITIONS IN KIT FORM AND WIRED TO SPECIFICATIONS. .RS232 – "DEC TYPE" ADAPTOR. AVAILABLE IN 9, 15, & 25 POSITIONS. THIS ADAPTOR WILL ACCEPT DIGITAL EQUIPMENT CONNECTOR PLUGS. 48 HOUR DELIVERY (215) 343-8990. **J.A.W. INDUSTRIES, INC.**, 1750 A. COSTNER DRIVE, WARRINGTON, PA 18976, FAX (215) 343-8942.

CIRCLE NO 341



Communications Block Diagram Simulator for PCs

- •**TESS**™ simulates modems, radios, & other systems
- •Built-in FFT spectrum analyzer, plus over 50 models: filters, mixer, VCO, logic & PAL's, BERT and test eqmt
- •Capture schematics graphically with OrCAD® & PCAD®
- •Add your own models to **TESS** easily using MODGEN
- •Call for 3-disk demo kit •**TESS** *is not copy protected*

TESS Simulator	$495	**TESOFT** PO BOX 305
MODGEN™ Model Generator	$245	Roswell GA 30077-0305
OrCAD/SDT III® Part Library	$145	☎404-751-9785 FAX 404-664-5817
P-CAD® Part Library	$225	VISA, MasterCard, PO's accepted

CIRCLE NO 342

Enhance Your IBM Token Ring LAN with S.I. Tech Fiber Optic Transceiver

Use Model 2875 Bit-Driver® between Multi-station Access Units (MAU). This stand-alone transceiver substitutes for cable connection between wiring concentrators in IBM Token Ring LANs. Provides optical isolation, greater signal transmission; also eliminates EMI and RFI interferences and lightning strike damage between buildings. Data rate: 4 MBps to 2 Km (or 5 Km option); 16 MBps soon to be available. Five LED diagnostic status indicators standard. Easy connect/disconnect. Call (312) 232-8540. Or write:

S.I. TECH
P.O Box 609, Geneva, IL 60134 U.S.A.

CIRCLE NO 343

C for the 8051 Compare:

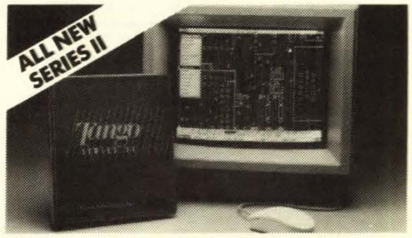
Benchmark Results —Sample program: Eratosthenese sieve Program from BYTE (1/83), expanded with I/O and interrupt handling.

	Archimedes ICC51 v2.20A	MCC51 v1.2	FRANKLIN C51 v2.00
Compilation time	*12 sec*	*18 sec*	*17 sec*
Linkage time	*29 sec*	*9 sec*	*6 sec*
Execution time	*11.46 sec*	*9.00 sec*	*1.08 sec*
Total code size	*5318 bytes*	*3798 bytes*	*1776 bytes*

Call for free DEMO disk.

FRANKLIN
SOFTWARE, INC.
888 Saratoga Ave. #2 • San Jose, CA 95129
(408) 296-8051 • FAX (408) 296-8061

CIRCLE NO 344



Tango. Now More Than Ever, The Best Value in PCB Design.

Take a look at the all new **Tango Series II**. Our pop-up menu interface sets a new standard for ease-of-use and productivity. Lay out simple prototypes or complex, multi-layer, SMT designs with over 100 new features including user-definable tracks, pads, and grids.

For IBM-PCs and compatibles, Tango-PCB Series II, **just $595**. Tango-Route Series II autorouter, **just $495**. Both include one year's updates, free tech support, 30-day money-back guarantee. Call today.

FREE EVALUATION PACKAGE
800-433-7801 619-695-2000

ACCEL Technologies, 7358 Trade Street, San Diego, CA 92121

CIRCLE NO 345

SIMPLIFY BOARD LAYOUT

MICRO/Q 1000 ceramic decoupling capacitors share board mounting holes with IC pins to simplify board design. Now add more active devices with increased density in the same space. or design the same package on a smaller board. Rogers Corp. 2400 S. Roosevelt St., Tempe, AZ 85282. 602/967-0624

CIRCLE NO 346

BUY THE WORLD'S MOST POPULAR PROGRAMMER FOR ONLY $159* A MONTH!

If you are budget limited, but need the reliability of an industry-standard 29B Programming System, call today for information on Data I/O's leasing alternative through U.S. Instrument Rentals.

Call Data I/O at **1-800-247-5700, Ext. 519**
or U.S.I.R. at **1-800-USIR-123**

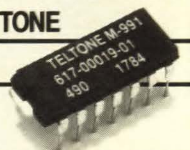
*Based on a $5,565 system price with a 4-year lease-to-own.

DATA I/O
Corporation

CIRCLE NO 347

Telecom Design!

CALL PROGRESS TONE GENERATOR



M-991 generates precise dial tone, busy tone, reorder tone, ringing, and other call routing tones for use in telephone systems, test equipment, callback security and other telecommunications systems.

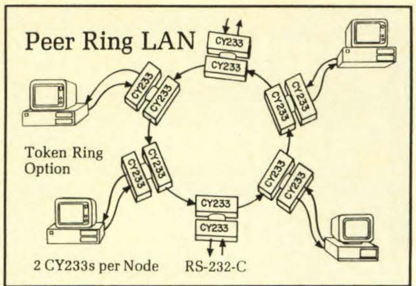
- 14-pin CMOS DIP
- Single 5V power supply
- 3.58 MHz time base
- Combinations of all standard frequencies

For more info call: **1-800-426-3926**
(In Washington State: 206-827-9626)

TELTONE®
10801-120th Avenue NE, Kirkland, WA 98033

CIRCLE NO 348

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

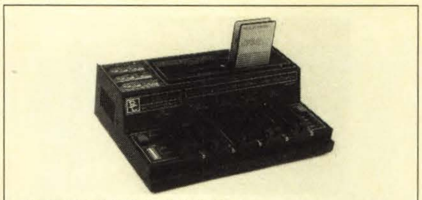


CY233-LINC Network Control

Connect computers, intelligent peripherals, or remote sites. 5v CMOS 40-pin IC. Up to 57.6K baud. Many configs such as Peer LAN shown and Host LAN with opt token; Simpler Networks allow host to control up to 255 parallel devices; UART mode with Ser/Par conversion can connect parallel devices over serial interface and save wire. $75 ea ($30/100). Box 3000, San Gregorio CA 94074. 415/726-3000.

Cybernetic Micro Systems

CIRCLE NO 776



E(E)PROM, MEMORY CARD & MICRO PROGRAMMER **$345 - $595**

- All 24/28/32 pin **EProms/EEProms** to 4 MBit (upgr. to **32MB**).
- **Flash Eproms; Micros: 8741,-2,-8,-8H,-9,-9H,-51,-C51,-52,-55 ...**
- **Memory Cards:** Seiko/Epson, Mitsubishi, GI. **Modular design.**
- **Stand-alone** E(E)Prom & Memory Card Duplication / Verify.
- User friendly **menu - driven** driver for **IBM-PC & Macintosh.**
- Built-in **Eraser/Timer** option ($50). **Gang-Module** ready.
- Full 1 year warranty. Direct technical support. Dedicated BBS.

INTELLIGENT PROM EMULATOR **$395**

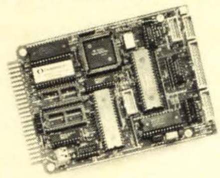
- **2716 thru 27512** (2k to 64k bytes). Binary/Hex/Intel/Motorola.
- Intelligent features include: **Reset Output, Address Compare,**
- **Address Snapshot, Trigger Input, Program Editing capabilities.**
- **FAST** data loading via parallel port (**64k bytes in less than10sec).**

MC/VISA/AMEX *Call today for datasheets!*

B&C MICROSYSTEMS INC.
355 WEST OLIVE AVE. SUNNYVALE, CA 94086
TEL: (408)730-5511 FAX: (408) 730-5521

CIRCLE NO 777

DATA ACQUISITION & CONTROL COMPUTER



The SBS-250 is an intelligent data acquisition and control system on a single card. Includes CAMBASIC™ language, a multitasking industrial compiler. Programs autorun on powerup. Supports bit manipulation, floating point, interrupts, strings, serial communications, realtime clock and more. Built-in EPROM and EEPROM programmers. CMOS-temperature range –20° to 65°C. 12-bit A/D converter, 32 digital I/O lines, two serial ports, keypad port, opto-module rack and relay drivers. Only 4.5" x 5". IBM PC can be used to develop programs. Try it **FREE** for 30 days. Call 303-430-1500 for demo information and complete catalog. Price **$395** single unit.

OCTAGON SYSTEMS CORPORATION 6510 W. 91st Ave. Westminster, CO 80030

CIRCLE NO 778

Join Forces

Combine your
larger ads with
EDN Product Mart ads
for a total
marketing program.

♦

EDN Product Mart

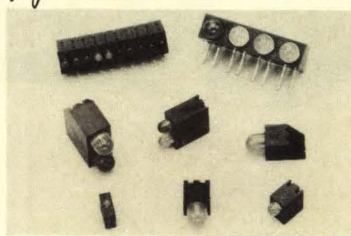
CIRCLE NO 779

MICRO/Q 2000

FOR A DECOUPLING CAPACITOR THAT SAVES SPACE, DEFEATS NOISE, IS SUITABLE FOR MILITARY APPLICATIONS AND BEATS HUMIDITY, HEAT AND COLD:
ROGERS MICRO/Q® 2000
Rogers Corp., 2400 S. Roosevelt,
Tempe, AZ 85282. 602/967-0624

CIRCLE NO 780

dress up your **PC BOARDS**



with our

PCB LED'S!

2mm,3mm 5mm, Single. Bilevel & Multi-LED Arrays. Diffused or Clear, 2mA Low Current, Sunlight Visible , 3V & 5V Blinking, 5V & 12V Integrated Resistor, BiColors, TriColors, Cross to Dialight 550, 551, 555, 547 Etc.

Put More LIFE in Your LIGHT

LEDTRONICS, INC. TEL: 213-676-7996
FAX: 213-676-0108 TLX: 494-5454
4009 Pacific Coast Hwy., Torrance, CA 90505

CIRCLE NO 781

smARTWORK® PCB Software. In a fraction of the time hand taping requires, you can create double-sided printed-circuit boards with smARTWORK and your IBM PC. The program's features include continual design-rule checking, automatic pad shaving, a silkscreen, and text for all three layers. **smARTWORK** with autorouting is $895 (without, $495) and comes with a 30-day money-back guarantee. Credit cards accepted. Write or call

Wintek Corporation
1801 South Street, Lafayette, IN 47904
(800) 742-6809 or (317) 742-8428

CIRCLE NO 782

RELIABILITY PREDICTION SOFTWARE

ARE YOUR PRODUCTS RELIABLE?

The RelCalc 2 Software Package predicts the reliability of your system using the part stress procedure of MIL-HDBK-217E, and runs on the IBM PC and full compatibles. Say goodbye to tedious, time consuming, and error prone manual methods! RelCalc 2 is very easy to use, and features menu windows, library functions, global editing for what-if? trials, and clear report formats. Try our Demo Package for $25.

T-CUBED SYSTEMS, 31220 La Baya Drive #110, Westlake Village, CA 91362. (818) 991-0057 • FAX: (818) 991-1281

CIRCLE NO 783

FREE

RF + MICROWAVE LINE CARD!!!!!!

250,000 PARTS IN STOCK/
OVER $3,000,000 IN INVENTORY/
ACTIVE + PASSIVE/DC-50 GHZ

(408) 730-0300 (CA)
(800) 255-6788

520 MERCURY DRIVE, SUNNYVALE
CALIFORNIA 94086-4018

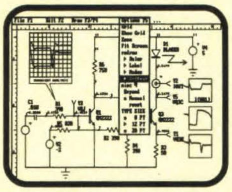
PENSTOCK

CIRCLE NO 784

To advertise in Product Mart, call Joanne Dorian, 212/463-6415

Analog Circuit Simulation

Completely Integrated CAE with ICAP/2



From Schematic Capture through SPICE Simulation to Post Processing

for Only $790†

†IsSPICE $95, the complete SPICE program that runs on all PC's. Performs AC, DC, and Transient analyses.

IsSPICE/386 $386, enhanced SPICE for 386 PC's.

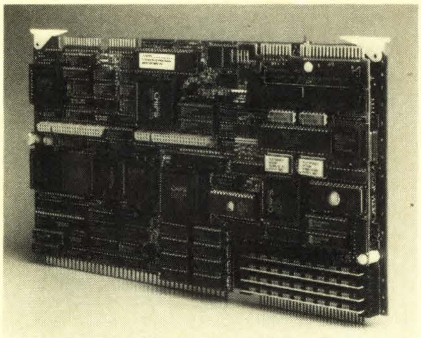
†SPICENET $295, a schematic editor for any SPICE simulator. Generates a complete SPICE netlist.

†INTUSCOPE $250, a graphics post processor that performs all the functions of a digital oscilloscope.

†PRESPICE $200, extensive model libraries, Monte Carlo analysis and parameters sweeping.

intusoft P.O. Box 6607 San Pedro, CA 90734-6607 (213) 833-0710 30 Day Money Back Guarantee

CIRCLE NO 767



MULTIBUS™ AT-COMPATIBLE SBC

Multibus I is now IBM PC/AT™ compatible with MAT286,™ our newest single board solution. MAT286 includes all of the functions of a 10 MHz AT motherboard, plus 2 serial ports, a parallel port, two SBX expansion-module interfaces, up to 512K EPROM/EEPROM/SRAM, and up to 4M of parity-checked, dual-ported DRAM. A piggy-back card, MATxSYSIO, adds EGA, floppy, and SCSI interfaces. Embed all the guts of an AT, two SBX modules, and more, into two Multibus slots!
Phone (408) 253-0250 or write for more information.

Single Board Solutions, Inc.
20045 Stevens Creek Blvd, Cupertino, CA 95014

Multibus is a registered trademark of Intel Corp.
MAT286 and MATxSYSIO are trademarks of Single Board Solutions, Inc.
IBM and PC/AT are trademarks of International Business Machines Corp.

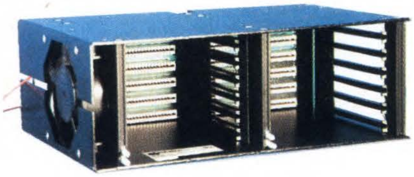
CIRCLE NO 768

Quartz Crystals
Oscillators
212-505-5340

- World's Smallest
- SMT & Thru-hole
- 10kHz–35 MHz
- Ceramic & Metal Pkgs
- Free Catalog

Micro Crystal Division/SMH

CIRCLE NO 769



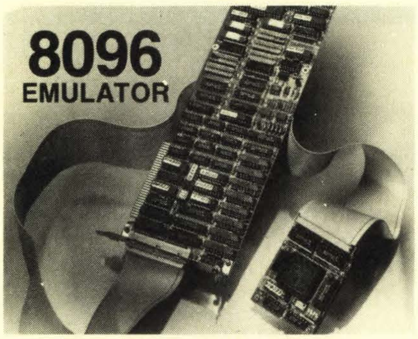
STDbus
12-SLOT CARD CAGE/BACKPLANE ASSEMBLY

OFFERS MORE FUNCTION CAPABILITY IN LESS SPACE
INEXPENSIVE ALTERNATIVE TO MULTIBUS I WITH SIMILAR FORM FACTOR
IDEAL FOR PC BUS EMULATION APPLICATIONS
CAN BE USED FOR 8 TO 16 BIT APPLICATIONS
BUILT-IN COOLING SYSTEM

Hybricon

12 Willow Road, Ayer, MA 01432
Factory 508-772-5422
Western Operations 602-921-1824

CIRCLE NO 770



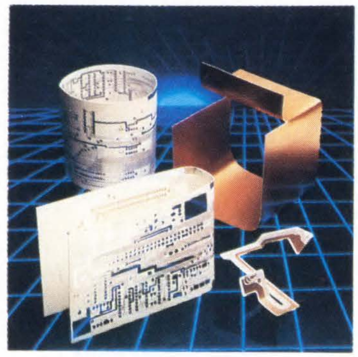
EASY TO LEARN – EASY TO USE

- Edit and compile while debugging in the IBM, PC/AT/XT
- Access, display and modify variables with zero speed impact on 8096/196 microcontrollers.
- Symbolic debugging with ASM96, PL/M96 & C96
- Multiple hardware breakpoints.

Annapolis Micro Systems, Inc.

612 Third St., Annapolis, Maryland 21403
(301) 269-8096

CIRCLE NO 771

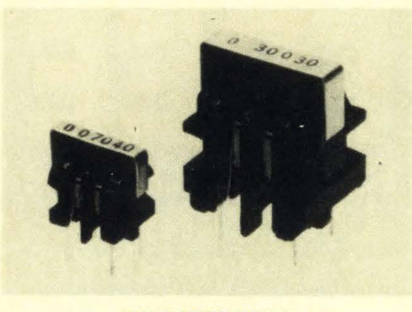


WE'RE BENDING THE RULES FOR CIRCUIT DESIGNERS

BEND/FLEX™, the bendable board material flexible enough to bend into any multi-plane shape. Eliminates stiffeners, flex-hardboard connectors. May reduce cost of two- and three-plane interconnect systems by as much as 30%!

Rogers Corporation. One Technology Dr., Rogers, CT 06263. (203) 774-9605.

CIRCLE NO 772



SU SERIES COILS
COMMON MODE NOISE FILTERS

Tokin America has recently expanded their offering in the popular SU Series of line filter. These miniature filters are rated at 250 VAC with current ratings from .1 to 3.4 amps. Inductance values range from .5 to 60 mH with a minimum IR of 100 Mohms. The units are available in both vertical and horizontal mount. Most effective in switching power supplies where there is concern for FCC, VDE, CISPR, & VCCI conformity.

Tokin America
155 Nicholson Lane, San Jose, CA 95134
408-432-8020

CIRCLE NO 773

Fast and easy Data Acquisition

UnkelScope

Menu-driven software package for your PC

JUNIOR - $125
Take, store, retrieve, print data - perfect for Design Engineers
LEVEL 2+ - $549
Data acquisition plus: experiment control, data analysis. The complete package.
FREE Demo Disk. Money-back guarantee

***Unkel Software** Inc.*

62 Bridge St. Lexington, MA 02173 (617) 861-0181

CIRCLE NO 774

DATA ACQUISITION
PC-BASED

MODULES:

- 12 BIT A/D and D/A
- 8 BIT A/D and D/A
- 72 Line Digital I/O
- Counter/Timer

1-800-553-1170

QUA TECH INCORPORATED

478 E. Exchange St., Akron, OH 44304
TEL: (216) 434-3154 FAX: (216) 434-1409
TLX: 5101012726

CIRCLE NO 775

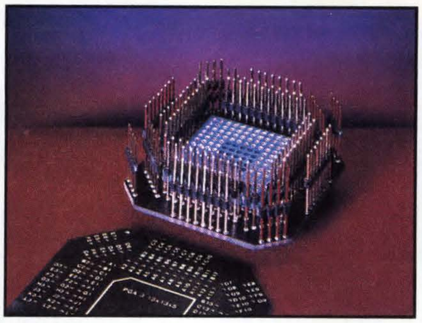
To advertise in Product Mart, call Joanne Dorian, 212/463-6415

Easy Emulator Pods & Adapters

- Plug your PLCC and LCC packages into your PC board in minutes, with these easy-to-use adapters.
- Emulator/logic analyzer users: Adapt-a-Pod™ converts one package type to another (LCC, PLCC, PGA, and DIPs).
- Emulator pods and adapters are available in all standard pin counts, with ribbon or ribbon cable headers.
- Custom engineering services and do-it-yourself emulator pod converters. Free catalog.

Emulation Technology, Inc.
2368-B Walsh Ave. Santa Clara, CA 95051
Phone: 408-982-0660 FAX: 408-982-0664

ET

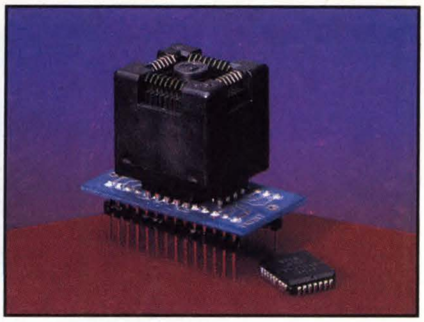


Complete Line of Debug Tools

- Famous Bug Katcher™ makes it easy to attach test leads to ICs in LCC, PLCC, PGA, PQFP, and DIP packages.
- Eliminates need for noisy cables; reduces capacitance and inductance in your test set-up.
- You can also quickly isolate and reconnect sections of your socketed IC with our Bug Isolator.™ (All packages.)
- Quick turnaround on custom engineering services, if needed. For a free catalog, contact:

Emulation Technology, Inc.
2368-B Walsh Ave. Santa Clara, CA 95051
Phone: 408-982-0660 FAX: 408-982-0664

ET



PAL/PROM Programmer Adapters

- Any EPROM programmer designed for DIPs can be converted to accept LCC, PLCC, and SOIC sockets in seconds!
- To program, just insert an Adapt-A-Socket™ between the programmer's DIP socket and the circuit to be programmed.
- Designed to fit all types of EPROM programmers, including Data I/O 120/121A, Stag, Logical Devices, etc.
- Quick turnaround on custom engineering services, if needed. For a free catalog, contact:

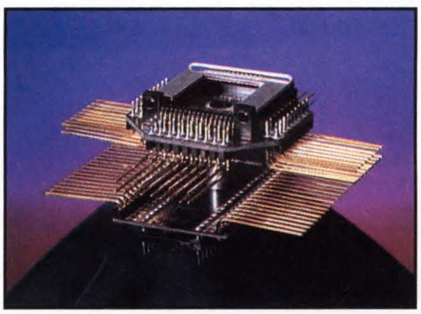
Emulation Technology, Inc.
2368-B Walsh Ave. Santa Clara, CA 95051
Phone: 408-982-0660 FAX: 408-982-0664

ET

Now you can connect any VLSI or surface mount circuit to any other type of circuit—or test equipment—thanks to our complete line of adapters, connectors, and test clips. Solve *your* "wrong prong" problem—contact us today for a *free catalog!*

Wrong Prong?

CIRCLE NO. **762**

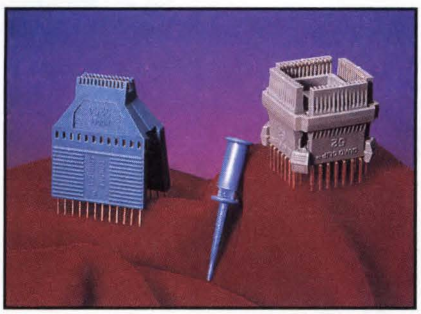


Quick, Fast Socket Conversion

- Convert-A-Socket™ makes it a snap to convert a production socket to a test socket and vice-versa.
- Complete line of male/female sockets for LCC, PLCC, PGA, PQFP, and DIP circuits.
- A must if you're inserting circuits repeatedly in low insertion force sockets.
- Quick turnaround on custom engineering services, if needed. For a free catalog, contact:

Emulation Technology, Inc.
2368-B Walsh Ave. Santa Clara, CA 95051
Phone: 408-982-0660 FAX: 408-982-0664

ET

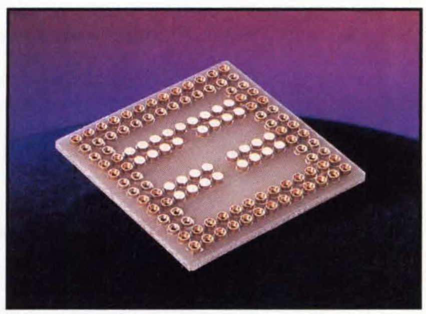


Quality Debugging Accessories

- Protect your ICs from damage. Insert and extract LCC, PLCC, PGA, and PQFP packages with the right tool.
- Use receptacle boards to build test fixtures, and mount your test equipment, in half the time.
- Get the right production sockets, burn-in sockets, test leads, and test clips for SMT, SOIC, or PLCC circuits.
- Quick turnaround on custom engineering services, if needed. For a free catalog, contact:

Emulation Technology, Inc.
2368-B Walsh Ave. Santa Clara, CA 95051
Phone: 408-982-0660 FAX: 408-982-0664

ET



Over 150 Prototyping Adapters

- Adapt-A-Boards™ make it easy to adapt standard or high-density prototyping boards to a variety of packages.
- For all package types: LCC, PLCC, PGA, PQFP, SDIP (shrink DIP devices), SOIC and more!
- Bottom configurations adapt to wire wraps or solder tail pins. Boards conform to Mil-C-45204.
- Quick turnaround on custom engineering services, if needed. For a free catalog, contact:

Emulation Technology, Inc.
2368-B Walsh Ave. Santa Clara, CA 95051
Phone: 408-982-0660 FAX: 408-982-0664

ET

WE INVITE YOU TO PERFORM IN THE COMPANY OF IDEAS

When you're creating advanced electronic systems, nothing is more powerful or valuable than a strong idea. Interstate Electronics Corporation is a recognized leader in a wide range of sophisticated technologies, such as the Global Positioning System (GPS) and Satellite Communication Systems.

Interstate Electronics has experience both as a developer and user of GPS-based tracking systems. We've produced total GPS solutions for a wide range of military needs, from the Navy's Trident Program to the Strategic Defense Initiative (SDI). We are also taking the lead in the U.S. Government Satellite Communications arena as part of the GE STGT (Second TDRSS Ground Terminal) team. We are developing a state-of-the-art demodulator for NASA's critical TDRSS Space/Ground communications system.

As a principal player in the industry, we can offer you the opportunity to become an integral part of a wealth of dynamic projects. Consider the following opportunities:

Communications Systems and Design Engineers

Positions are available at all levels, with particular emphasis on those with advanced degrees (MS/PhD). The ideal candidates will have a background in one or more of the following areas. **Dept. DH.**

- Digital demodulator design/modeling/performance estimation
- Coding theory and implementation
- QPSK/MSK/TCM waveforms
- LPI/AJ communications
- TDMA/FDMA/CDMA networks
- VSAT technology/implementation

Staff Engineers (Acoustic Signal Processing)

Will support the business of airborne ASW and acoustic signal processing systems. Provide system designs for large signal processing systems including algorithms, architectures, busses, and displays. Prepare proposals and make customer presentations. Experience with current sonobuoy processing and analysis systems including displays, and display formats. BS or MS in Engineering or equivalent and 5-10 years experience are required. **Dept. DH.**

The projects we work on are the kind you would expect to find at an industry giant. But unlike a large company, you'll be involved throughout the program, not just on one component.

If you possess the above qualifications and would like to work on the leading edge of technology, we would like to talk to you. We offer an excellent salary and benefits package. For immediate consideration, please send your resume (indicating appropriate Dept.) to: Personnel Department, Interstate Electronics Corporation, 708 E. Vermont Ave., Anaheim, CA 92803. Equal Opportunity Employer. U.S. Citizenship May Be Required.

INTERSTATE ELECTRONICS CORPORATION
A Figgie International Company

COMPUTER ENGINEERING SUPERVISOR

System Energy, newest operating company of the Middle South Electric System, has an immediate opportunity for a Computer Engineering Supervisor at the Grand Gulf Nuclear Station near Vicksburg, MS.

Responsibilities include providing the highest quality and reliable service of the process control computers, computer instrument systems, departmental computers and their software/databases; establishing and maintaining standards of software development; and establishing hardware and software standards for process computer implementation and operations. Qualifications include a BS in Engineering or Computer Science and 6-8 years experience in Project Management, and staff or engineering development of computer systems with 1 year in nuclear power or similar industry. A working knowledge of Realtime software development and UNIX operating systems is essential. At least 1 year of supervisory experience is also required.

System Energy offers a competitive salary, comprehensive benefits package, relocation assistance and advancement potential in a dynamic environment. For immediate consideration, please submit resume and salary history to: **Laura Lillard, System Energy, P.O. Box 23070, Jackson, MS 39225-3070.** EEO/AA/M/F/H/V.

System Energy

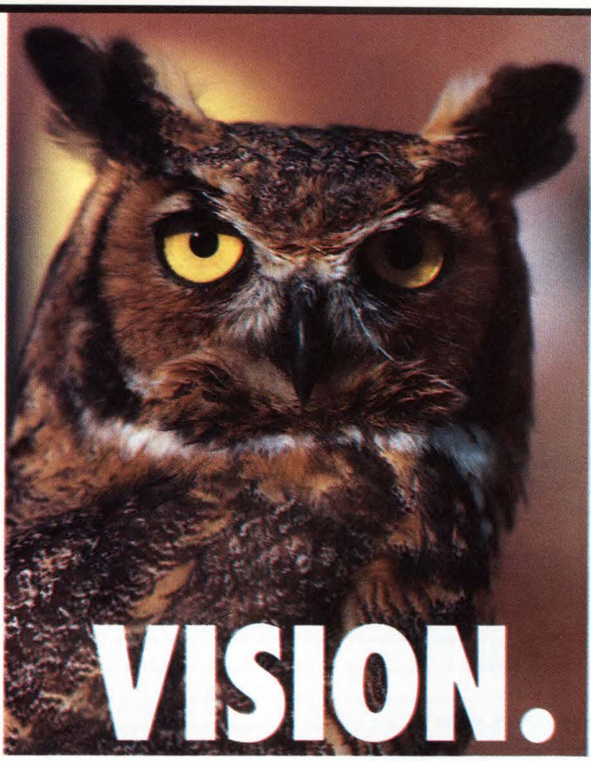
CAREER OPPORTUNITIES

1989 Editorial Calendar and Planning Guide

EDN

Issue Date	Recruitment Deadline	Editorial Emphasis	EDN News Edition
May 25	May 4	Digital ICs, Computer Peripherals	Closing: May 25 Mailing: June 15
June 8	May 18	Components, Digital ICs	
June 22	June 1	Semicustom ICs, Computer Boards	Closing: June 9 Mailing: June 29
July 6	June 15	Product Showcase — Volume I, Power Supplies	Closing: June 22 Mailing: July 13
July 20	June 29	Product Showcase — Volume II, Components	Closing: July 21 Mailing: Aug. 10
Aug. 3	July 13	Integrated Circuits, Computer Boards	

Call today for information:
East Coast: Janet O. Penn (201) 228-8610
West Coast: Mary Beth West (213) 826-5818
National: Roberta Renard (201) 228-8602



Unusual competence in discernment or perception; intelligent foresight.

It's not so much what we see, but the way in which we see it. At Motorola Semiconductor Products Sector, we believe every idea has potential. And every person has an important contribution to make. Which is why we encourage our people to test their limits. To speak their minds. And to aggressively pursue even the most far-sighted goals. As a result, we received the Malcolm Baldrige National Quality Award in 1988 and we'll introduce hundreds of industry-standard microelectronics products in the years to come.

The visionary leader in semiconductor technology. Naturally, it's Motorola SPS. Join us in one of the following facilities:

Motorola SPS — Arizona

CAD PROFESSIONALS

Simulation, Modeling & Test — Will create interfaces for ASIC-related digital test of completed designs. Knowledge of test equipment such as Sentry, Trillium, Ando and Genrad is desired, as well as an understanding of Verilog, Quicksim and Ikos logic simulators. Expertise in providing accurate simulation models, regardless of the simulator used, would be a plus.

Systems Integration Test Group — Qualified individuals will be professional testers with specific experience in ASIC software product testing. Will also consider candidates with heavy general software test experience.

Macro Design CAD Support — Requires experience with Spice or Lsim circuit simulators and transistor design. Strong general knowledge of full custom design systems and tools such as CALMA, CAECO or other silicon compiler systems would be beneficial.

System Design/Tool Development — Experience with system level CAD support is a key factor here. Will perform activities related to design synthesis using Synopsis, Silc, SCS or Trimeter tools. Familiarity with the Aida suite of tools is a must.

Open Architectural CAD System/Systems Engineering — Engineering expertise in databases, operating systems and CAD frameworks is essential, as well as an understanding of hierarchical netlist configurations and incremental data update. Familiarity with design management concepts within a framework database system would be a plus.

Motorola SPS — Texas

Microprocessor Architect/System Designers — Will contribute to processor and memory system design, plus interact with customers applying current/future MC88000 RISC Microprocessors in high performance systems from PCs to mainframes. Also model system in 'C'/Silicon Compiler Systems behavioral language. Requires MSCS or MSEE and 5 years experience in computer design.

VLSI CMOS Circuit Designers — Selected candidates will be responsible for high level modeling/simulation of architecture, CMOS logic and circuit design, layout design and verification using silicon compiler software on engineering workstations. BS/MSEE and at least 3 years design experience required.

Analog Circuit Designers — Will design oversampled analog-to-digital converters for implementation in CMOS and/or BICMOS technologies. Requires thorough knowledge of analog and digital IC design techniques, IC technology capabilities and CAD tools. BS/MSEE and minimum 5 years IC design experience are a must.

Process Development Engineers — Will develop new processes/devices and troubleshoot problems, as well as improve/characterize processes using statistical techniques. Must be experienced in all areas of wafer fabrication, have an advanced degree, and 5 years experience. SRAM/DRAM experience a plus.

Device Development Engineers — You will develop advanced silicon BICMOS/CMOS technologies and integrate new process techniques into manufacturing, development and characterization of device design. Must have an advanced degree plus 5 years experience.

A challenging career at either of our attractive locations includes a competitive compensation/benefits package. If you have the qualifications, call or send a resume to the facility of your choice:

Motorola SPS, Arizona
Attn: SPS-306
725 S. Madison
Tempe, AZ 85281
(602) 994-6394, COLLECT

Motorola SPS, Texas
Attn: ATX-123
1112 W. Ben White Blvd.
Suite 200
Austin, TX 78704
(800) 531-5183, TOLL FREE
(512) 462-0202, COLLECT

MOTOROLA

Semiconductor Products Sector

An Equal Opportunity/Affirmative Action Employer

IT'S IN OUR NATURE.

EDN Databank

Professional Profile

Announcing a new placement service for professional engineers!

To help you advance your career. Placement Services, Ltd. has formed the EDN Databank. What is the Databank? It is a computerized system of matching qualified candidates with positions that meet the applicant's professional needs and desires. What are the advantages of this new service?

- It's absolutely free. There are no fees or charges.
- The computer never forgets. When your type of job comes up, it remembers you're qualified.
- Service is nationwide. You'll be considered for openings across the U.S. by PSL and it's affiliated offices.
- Your identity is protected. Your resume is carefully screened to be sure it will not be sent to your company or parent organization.
- Your background and career objectives will periodically be reviewed with you by a PSL professional placement person.

We hope you're happy in your current position. At the same time, chances are there is an ideal job you'd prefer if you knew about it.

That's why it makes sense for you to register with the EDN Databank. To do so, just mail the completed form below, along with a copy of your resume, to: Placement Services, Ltd., Inc.

IDENTITY

Name ______
Home Address: ______
City ______ State: ______ Zip: ______
Home Phone (include area code): ______

PRESENT OR MOST RECENT EMPLOYER

Parent Company ______
Your division or subsidiary: ______
Location (City, State) ______
Business Phone if O.K. to use: ______

EDUCATION

Degrees (List)	Major Field	GPA	Year Degree Earned	College or University

POSITION DESIRED ______

EXPERIENCE

Present or Most Recent Position From: To: Title:

Duties and Accomplishments: Industry of Current Employer:

Reason for Change:

PREVIOUS POSITION:

Job Title: ______
Employer: ______ From: ______ To: ______ City: ______ State: ______
Division: ______ Type of Industry: ______ Salary: ______
Duties and Accomplishments: ______

COMPENSATION/PERSONAL INFORMATION

Years Experience	Base Salary	Commission	Bonus	Total Compensation	Asking Compensation	Min. Compensation

Date Available | I Will Travel ☐ Light ☐ Moderate ☐ Heavy | ☐ I own my home. How long? ______ I rent my home/apt. ☐

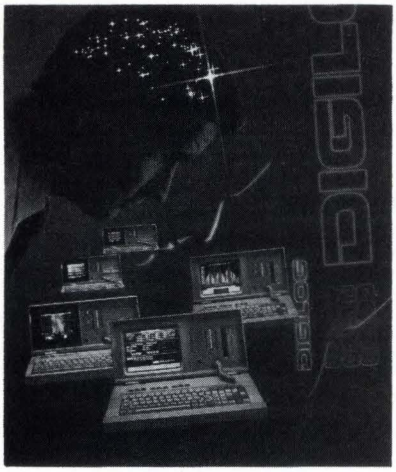
☐ Employed ☐ Self-Employed ☐ Unemployed | ☐ Married ☐ Single | Height______ Weight______

Level of Security Clearance | ☐ U.S. Citizen | ☐ Non-U.S. Citizen | My identity may be released to: ☐ Any employer ☐ All but present employer

☐ WILL RELOCATE ☐ WILL NOT RELOCATE ☐ OTHER ______

EDN Databank

A DIVISION OF PLACEMENT SERVICES LTD., INC.
265 S. Main Street, Akron, OH 44308 216/762-0279



Catalog describes protocol analyzers

The New Wave of Digilog Automatic Protocol Analyzers presents a wide range of protocol analyzers and applications for field service, data-communications operations, and protocol development, including the vendor's recent models for ISDN analysis/emulation. The 20-pg catalog has display-screen pictures of protocol decodes, response times, and statistical charts that show how you can use the equipment for a variety of needs. Also included are a variety of turnkey applications for automatic monitoring, testing, and analysis of dataline performance. A specifications list completes the catalog.

Digilog Inc, 1370 Welsh Rd, Montgomeryville, PA 18936.

Circle No 415

Leaflet discusses analyzer-emulation software

The vendor's 4-pg brochure explains its Maestro II multichannel analyzer-emulation software package. The 4-color publication describes the software, listing its functions, features, and hardware prerequisites. The vendor also offers a demonstration disk of the software.

EG&G Ortec, 100 Midland Rd, Oak Ridge, TN 37831.

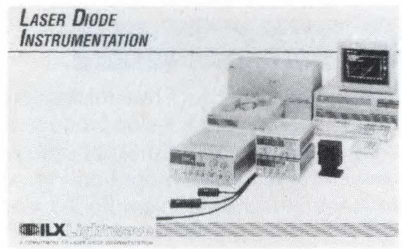
Circle No 416

Package helps you evaluate circuit-design series

This kit for qualified design engineers contains software and a 60-pg illustrated tutorial guide, which describes the Series II Tango-PCB and Tango-Route design-software programs. The guide details features such as pop-up menus, user-definable macros, on-screen prompts, context-sensitive help, and "Hot Spot" and "Speed Palette" aids.

Accel Technologies Inc, 7358 Trade St, San Diego, CA 92121.

Circle No 417



Fold-out focuses on laser-diode instruments

The vendor's 6-pg fold-out brochure features three recently released products for laser-diode instrumentation and highlights its expansion into custom-built laser-diode test systems. The pamphlet provides specifications, illustrations, and prices.

ILX Lightwave Corp, Box 6310, Bozeman, MT 59771.

Circle No 418

Product note tells you how to increase throughput

The company's 16-pg product note explains how to increase functional test throughput using its 3458A multimeter. Topics covered include an overview of parameters (as well as reading rates) that affect throughput; dc and ac measurements; choosing the best mode and specifications for each application; frequency and period-selecting gate time to achieve allocation, intelligence, and computer/multimeter interactions; and benchmarks with properly structured programs to obtain maximum throughput.

Hewlett-Packard Co, 19310 Pruneridge Ave, Cupertino, CA 95014.

Circle No 419

Directory of ESD-control products

Three 4-in.-post binders contain the vendor's "yellow pages" of the CPF (Control Products File) Consulting Service for ESD-control products. The reference work is updated quarterly and is organized for comparative analysis of products. It's arranged in seven major categories: chemicals & raw materials; ionizers; meters and instruments; packaging; personal protection; workstation products; and miscellaneous (tools, tapes, etc). More than 2000 pages of data sheets, indexes, directories, and selection tables are included in the document. In US, first-year subscription, $335; renewal, $195. In Canada, $375 and $225, respectively; elsewhere, $425 and $260, respectively.

SAR Associates, 1212 E Dominick St, Rome, NY 13440.

INQUIRE DIRECT

Listing of code numbers

The *1989 EIA Source Code and Date Code Booklet* provides an alphabetical and numerical listing of code numbers that are stamped or marked on electronic products to identify production sources or the vendor assuming product responsibility. The EIA code system also provides for adding numerals to the source-code symbol to identify both the year and week of production. $5.

Electronic Industries Association, EIA Engineering Dept, 2001 Eye St NW, Washington, DC 20006.

INQUIRE DIRECT

EDN's CHARTER

EDN is written for professionals in the worldwide electronics industry who design, or manage the design of, products ranging from circuits to systems.

EDN provides accurate, detailed, and useful information about new technologies, products, design techniques, and careers.

EDN covers new and developing technologies to inform its readers of practical design matters that will be of concern to them at once or in the near future.

EDN covers new products

- that are immediately or imminently available for purchase
- that have technical data specified in enough detail to permit practical application
- for which accurate price information is available.

EDN's Magazine Edition also provides specific "how to" design information that its readers can use immediately. From time to time, EDN's technical editors undertake special "hands on" engineering projects that demonstrate EDN's commitment to readers' needs for useful design information.

EDN's News Edition also provides comprehensive analysis and news of technology, products, careers, and distribution.

EDN

275 Washington St
Newton, MA 02158
(617) 964-3030

BUSINESS/CORPORATE STAFF

Peter D Coley
VP/Publisher
Newton, MA 02158
(617) 964-3030; Telex 940573
Ora Dunbar, Assistant/Sales Coordinator

Mark J Holdreith
Advertising Sales Director
Newton, MA 02158
(617) 964-3030
Heather McElkenny, Assistant

Deborah Virtue
Business Director
Newton, MA 02158
(617) 964-3030

NEW ENGLAND
Chris Platt, Regional Manager
199 Wells Ave
Newton, MA 02159
(617) 964-3730

STAMFORD 06904
George Isbell, Regional Manager
8 Stamford Forum, Box 10277
(203) 328-2580

NEW YORK, NY 10011
Daniel J Rowland, Regional Manager
249 West 17th St
New York, NY 10011
(212) 463-6419

PHILADELPHIA AREA
Steve Farkas, Regional Manager
487 Devon Park Dr, Suite 206
Wayne, PA 19087
(215) 293-1212

CHICAGO AREA
Clayton Ryder, Regional Manager
Greg Anastos, Regional Manager
Jack Johnson, Regional Manager
Cahners Plaza
1350 E Touhy Ave, Box 5080
Des Plaines, IL 60017
(312) 635-8800

DENVER 80206
John Huff, Regional Manager
44 Cook St
(303) 388-4511

DALLAS 75243
Don Ward, Regional Manager
9330 LBJ Freeway, Suite 1060
(214) 644-3683

SAN JOSE 95128
Walt Patstone, Regional Manager
Bill Klanke, Regional Manager
Philip J Branon, Regional Manager
James W Graham, Regional Manager
3031 Tisch Way, Suite 100
(408) 243-8838

LOS ANGELES 90064
Charles J Stillman, Jr
Regional Manager
12233 W Olympic Blvd
(213) 826-5818

ORANGE COUNTY/SAN DIEGO 92715
Jim McErlean, Regional Manager
18818 Teller Ave, Suite 170
Irvine, CA
(714) 851-9422

PORTLAND, OREGON 97221
Pat Dakin, Regional Manager
Walt Patstone, Regional Manager
1750 SW Skyline Blvd, Box 6
(503) 297-3382

UNITED KINGDOM/BENELUX
Jan Dawson, Regional Manager
27 Paul St
London EC2A 4JU UK
44 01-628 7030
Telex: 914911; FAX: 01-628 5984

SCANDINAVIA
Stuart Smith
27 Paul St
London EC2A 4JU UK
01-628 7030
Telex: 914911; FAX: 01-628 5984

FRANCE/ITALY/SPAIN
Alasdair Melville
27 Paul St
London EC2A 4JU UK
01-628 7030
Telex: 914911; FAX: 01-628 5984

WEST GERMANY/SWITZERLAND/AUSTRIA
Wolfgang Richter
Sudring 53
7240 Horb/Neckar
West Germany
49-7451-7828; Telex: 765450

EASTERN BLOC
Uwe Kretzschmar
27 Paul St
London EC2A 4JU UK
01-628 7030
Telex: 914911; FAX: 01-628 5984

FAR EAST
Ed Schrader, General Manager
18818 Teller Ave, Suite 170
Irvine, CA 92715
(714) 851-9422; Telex: 183653

HONG KONG
John Byrne & Associates Ltd
1613 Hutchison House
10 HGarcourt Road
Central Hong Kong
Tel: 5-265474
Tlx: 61708 WEDIN HX
Fax: 5-8106781

JAPAN
Kaoru Hara
Dynaco International Inc
Suite 1003, Sun-Palace Shinjuku
8-12-1 Nishishinjuku, Shinjuku-ku
Tokyo 160, Japan
Tel: (03) 366-8301
Telex: J2322609 DYNACO

KOREA
Kim Kyong-Hae, BK International
Won Chang Bldg, 3rd Floor 26-3
Yoido-dong, Youngdungpo-ku
Seoul 150, Korea
Tel: 785-6665; FAX: 784-1915
Telex: K32487 BIZKOR

SINGAPORE/MALAYSIA/INDONESIA/THAILAND/ THE PHILIPPINES/AUSTRALIA/NEW ZEALAND
Asia Pacific Media House PTE Ltd
Peter Cheong
100 Beach Rd
#24-03 Shaw Tower
Singapore 0718
Tel: 2915354; Telex: RS 50026 MESPLY

TAIWAN
Acteam International Marketing Corp
6F, No 43, Lane 13
Kwang Fu South Rd
Mailing Box 18-91
Taipei, Taiwan ROC
760-6209 or 760-6210
Telex: 29809; FAX: (02) 7604784

PRODUCT MART
Joanne Dorian, Manager
249 West 17th St
New York, NY 10011
(212) 463-6415

INFO CARDS
Donna Pono
Newton, MA 02158
(617) 558-4282

CAREER OPPORTUNITIES/CAREER NEWS
Roberta Renard, National Sales Manager
(201) 228-8602

Janet O Penn, Eastern Sales Manager
(201) 228-8610
103 Eisenhower Parkway
Roseland, NJ 07068

Mary Beth West, Western Sales Manager
12233 West Olympic Blvd
Los Angeles, CA 90064
(213) 826-5818

Staci Comstock, Sales Assistant
(201) 228-8608
FAX: 201-228-4622

Wendy A Casella, *Advertising/Contracts Coordinator*
Nan E Coulter, *Advertising/Contracts Coordinator*
Aileen B Turner, *Advertising/Contracts Coordinator*
(617) 964-3030

William Platt, Senior Vice President, Reed Publishing USA

Cahners Magazine Division
Terry McDermott, President, Cahners Publishing Co
Frank Sibley, Senior Vice President/General Manager, Boston Division
Tom Dellamaria, VP/Production & Manufacturing

Circulation
Denver, CO: (303) 388-4511
Eric Schmierer, Group Manager

Reprints of EDN articles are available on a custom printing basis at reasonable prices in quantities of 500 or more. For an exact quote, contact Joanne R Westphal, Cahners Reprint Service, Cahners Plaza, 1350 E Touhy Ave, Box 5080, Des Plaines, IL 60018. Phone (312) 635-8800.

ADVERTISERS INDEX

Abbott Transistor Laboratories Inc 133
Acme Electric Corp 279
Advanced Micro Devices 12-13, 212-213
Altera Corporation 46-47
AMCC 302
American Automation 36
AMP 110-111
Amperex Electronic Corp* 229
Anaheim Automation 296
Applied Microsystems Corp 141-143
Aries Electronics Inc 176
ASC 258-259
Atmel Inc 157
Augat-Interconnection Systems 214-215
Avantek 97
Bergquist Co 272
Bourns Resistive Components . . 91
Bradford Electronics 35
Braemar Computer Corp 241
Burr-Brown Corp 205
CAD Software Inc 134
Carroll Touch Inc 118
Cherry Semiconductor 226
Chips and Technologies C2, 72
Clarostat 246
Comdisco 266-267
Comlinear Corp 234-235
Commerce Tours Trade 301
Cybernetic Micro Systems 276
Cypress Semiconductor 23, 101-108
Dage Precision Industries Inc . . 268
Dale Electronics Inc 1
Data I/O Corp 8, 122
Datel* 90, 242
Delevan Div, API 238
Design Automation Conference 273
Dexter Magnetics 44
Dialight Corporation, A Cambridge Electronic Industries Co 177
Digelec Inc 241
Digital Equipment Corp* 30-31
Dotronix 239
Elantec 92
Electronic Trend 273
Emerson & Cuming Inc 109
Ericsson Components 180
Force Computers Inc 32-33
Foxboro Co 62
Frequency Devices 250
Fujitsu, APD 14-15
Futaba 114
Gates Energy Products Inc 112-113
Hall-Mark 251
Harris Semiconductor 130-131, 232-233
Hewlett-Packard Co . . . 6, 159-161, 209-211
Hitachi America Ltd* 48-49, 260-261
Holt Inc 176
Hurst Mfg 270
Hypertronics Corp 164
Illinois Capacitor 238
Imprimis Technology 86-87
Inmos Corp 10-11
Integrated Device Technology Inc 63
Integrated Measurement Systems Inc 194
Intel Corp 248
IOtech Inc 248
ITT Cannon 116
ITT ElectroMechanical Components Worldwide 18-19
John Fluke Manufacturing Co Inc* 20, 64-65, 178-179
Kemet Electronics 274
Kepco Inc 227-228
Linear Technology Corp 218
Logic Devices 155
Macrochip 249, 278
Manhattan Electric Cable Corp . . 181
Marconi/Circuit Tech 182
Marshall 52
Matsuo Electronics 122
Maxim Integrated Products . . Outsert
Mepco/Centralab 115
MetaLink Corp 240
Meta Software Inc 277
Micro Linear 50-51
MicroSim Corp 271
Mini-Circuits Laboratories . . . 3, 4, 26-27, 223
Mitsubishi Electronics America Inc 40-41, 61
Molex Inc 304
Motorola Semiconductor Products Inc 77
Murata Erie North America Inc* 144-145
National Design 62
NCR Corp 280-281
NEC Corp 254-255
OKI Semiconductor 28-29
OrCAD Systems Corp 121
Orion Instruments 297
Performance Semiconductor Corp 25
Philips T&M** 77, 139, 257
Phillips 66 Company 175
Phillips Components Inc** . . . 30-31
PLX Technology 37
Powertec 176A-F
Precision Interconnect 173
Precision Monolithics Inc 59
Racal-Redac 74
Raytheon 57
Reliability Inc 100
Rittal Corp 88-89
R.O. Associates, Inc 99
Rockwell International 216-217
Rogers Corp 275
Rohde & Schwarz** 2
Samsung Semiconductor* . . . 66-67
Samtec Inc 299
Schaevitz Engineering 158
Seagate Technology 54
SGS-Thomson Microelectronics* 139
Siemens Optoelectronics 123
Siemens Semi* 2
Sierra Semiconductor 230-231
Signal Transformer Co Inc C4
Signetics Corp 94, 243, 265
Silicon Systems Inc 70-71
Sonnenschein Batteries Inc . . . 240
Sony Corp of America 137
Spectrum Software 34
Sprague Electric Co 81
Standard Research Systems Inc 208
STD Mfg Group 276
Tektronix Inc 38-39, 192-193, 252-253
Teledyne Philbrick 247
Teradyne Inc 68-69
Texas Instruments Inc* 82-85
Tokin Corp 245
Toshiba Corp 282
Toshiba America Inc 42-43
Universal Data Systems C3
Valid Logic Systems 16-17
Versatec 79
Vicor 188-191
Volgen America 273
Westcor 269
Xilinx 162-163
Yamaha LSI 236
Ziatech Corp 244A-F
Zilog Inc 225

Recruitment Advertising 290-295
GE Aerospace, Astrospace
General DataComm Inc
Interstate Electronics
Motorola-SPS

*Advertiser in US edition
**Advertiser in International edition

1989 ELECTRONICS & COMPUTER TECHNOLOGY TOURS

SUMMER FAR EAST COMPUTER TOUR

June 1-10, 1989

Visit:
SEOUL and TAIPEI
Featuring:
- **KOREA ELECTRONICS PARTS & EQUIPMENT SHOW**
- **TAIWAN COMPUTER SHOW**

SOUTH AMERICA ELECTRONICS/COMPUTER TOUR

September 23 to October 3, 1989

Visit:
BRAZIL and ARGENTINA
Featuring:
- **BRAZIL COMPUTER SHOW**
- **BUSINESS MEETING IN ARGENTINA**

OCTOBER FAR EAST ELECTRONICS/COMPUTER TOUR

October 8-21, 1989

Visit:
SEOUL, TAIPEI, HONG KONG, OSAKA
Optional: Bangkok, Singapore, China
Featuring:
- **KOREA ELECTRONICS SHOW**
- **TAIPEI INTERNATIONAL ELECTRONICS SHOW**
- **HONG KONG ELECTRONICS FAIR**
- **JAPAN ELECTRONICS SHOW**

CALL, WRITE OR FAX FOR MORE INFORMATION I am interested in: __ Summer Computer Tour **EDN042789**

__ South America Electronics Tour __ October Far East Electronics Tour

COMMERCE TOURS INTERNATIONAL, INC.
870 Market Street, Suite 920
San Francisco, CA 94102
Tel: (415) 433-3072
Tlx: 278124 CTI UR
Fax: (415) 433-2820

Name ____________________

Company ____________________

Title ____________________

Address ____________________

City ____________________ State __________ Zip __________

TEL: __________ TLX: __________ FAX: __________

CIRCLE NO 154

OUR SEA OF CELLS™ PERFORMANCE RUNS DEEP.

Now high speed with low power is cost-effective.
We're making a big splash with our new family of BiCMOS logic arrays: The AMCC Q14000 Series.

Because now, for semicustom array applications such as high resolution graphics, telecom, work stations, computers and military designs, we're offering high performance, low power, and competitive price.

Sea of Cells™ Architecture.
At the core of this next-generation BiCMOS gate array family, is our unique Sea of Cells architecture, with triple-metal interconnections, offering up to 13,440 gates. It's a highly efficient channelless design that allows our arrays to achieve gate utilization over 95%.

Q14000 SERIES				
	Q2100B	Q6000B	Q9100B	Q14000B
Equivalent Gates	2160	5760	9072	13,440
Gate Delay* (ns)	.7	.7	.7	.7
Maximum I/O Frequency (MHz)	180	180	180	180
Utilization	95%	95%	95%	95%
Power Dissipation (W)	.5 - 2.0	1.0 - 2.8	2.0 - 4.0	1.4 - 4.4
I/O	80	132	160	226
Temperature Range	COM, MIL	COM, MIL	COM, MIL	COM, MIL

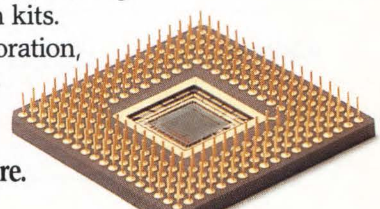
*(2 loads, 2 mm of metal)

Flexible I/O Structure.
AMCC's flexible I/O design allows a multitude of interface combinations such as 100K or 10KH ECL, TTL, CMOS with either single or dual supply. And, no translators are needed.

Design Made Easier, Too.
High performance gate array design is simplified because of embedded bipolar drivers in each macro. And, with only 25 ps per fanout load degradation, critical paths are less affected by metal routing and fanout. In addition, the bipolar drivers yield symmetrical loading degradation for rising and falling edges. Less pulse width shrinkage.

Useful Information and Evaluation Kits.
For more information on our new BiCMOS logic arrays with Sea of Cells architecture, in the U.S., call toll free (800) 262-8830. In Europe, call AMCC (U.K.) 44-256-468186. Or, contact us about obtaining one of our useful evaluation kits.

Applied MicroCircuits Corporation, 6195 Lusk Blvd., San Diego, CA 92121. (619) 450-9333.



A Better BiCMOS Array is Here.

AMCC

LOOKING AHEAD

EDITED BY JULIE ANNE SCHOFIELD

World CD market to grow to $10 billion in 1989

Shipments of compact disks to the United States, Japan, and Europe soared to 390-million units in 1988, up 56% from 250-million units in 1987, according to BIS Mackintosh (Luton, England). The company expects CD shipments to these three areas to grow 38% in 1989 to 540-million units and the overall world demand for CDs to increase to over 650-million units, worth almost $10 billion at retail.

Japan is now well into the CD age: Over 20% of all homes are equipped with CD players, and the markets are building for in-car and portable CD players. In contrast, less than 15% of homes in Europe and the US have CD players, but the CD-media market values there have exceeded those of vinyl records. In Europe, CD sales already match those of music cassettes, according to the market research company.

Manufacturers are continuing to price CDs to meet market expansion rates and the price tolerances of consumers. Overall, prices are down, mainly due to the introduction of budget-priced CDs, especially in the US. But popular CD releases will still cost 35 to 40% more than vinyl records and cassettes indefinitely as the older media fade into obsolescence in the 1990s.

RECORDED MUSIC FORECAST SUMMARIES (US, JAPAN, AND EUROPE TOTAL ALBUMS)

	1988		1992	
	VOLUME (MILLIONS)	VALUE ($M)	VOLUME (MILLIONS)	VALUE ($M)
COMPACT DISK	390	6,020	870	10,795
CASSETTES	787	6,740	720	6,360
VINYL	295	2,835	147	1,460
TOTAL ALBUMS	1,472	15,595	1,737	18,615

(SOURCE: BIS MACKINTOSH)

RISC µPs to skyrocket to sales of $600M in 1993

Total revenues for 32-bit reduced-instruction-set computer (RISC) chips will grow from $34 million in 1988 to $600 million in 1992, according to a report recently published by The Information Network, a San Francisco-based market research company. This increase corresponds to a compound average growth rate of 77.6%; the company expects the sales of 32-bit complex-instruction-set computer (CISC) chips to increase at a compound average growth rate of 14.1% during the same period.

The report also predicts that RISC consumption will grow from 3.1% of all 32-bit µPs in 1988 to 22.6% in 1993. IC manufacturers held the largest share of the market in 1988 with revenues of $30 million. These companies, such as AMD, Intel, Mips, Motorola, and Sun Microsystems, are expected to increase their market share from 88.2% in 1988 to 95% in 1993.

RISC chips will be used in both workstations and embedded systems, but the chips used in these two application areas will differ because of interrupt-response speed and memory-size constraints. According to the report, unit shipments of embedded RISC processors will grow from 41.2% of the market in 1988 to 76.2% of the market in 1993.

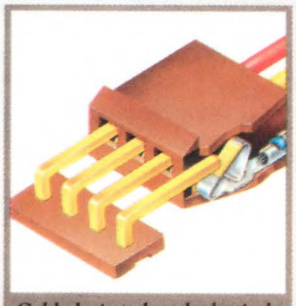
However, The Information Network also reports that many computer companies have been designing their own RISC processors in house. These companies include Apple Computer, Apollo Computer, Ardent, Compaq Computer, Hewlett-Packard, IBM, and Ridge Computer. Proprietary gate-array RISC implementations could undermine the efforts of RISC processor manufacturers.

Molex Is Making The Connection Between...

FLEXIBILITY & RELIABILITY

Eleven different components are your building blocks for thousands of interconnection solutions.

Molex's unique family of KK® connectors provide the flexibility you need to build interconnections precisely suited to your applications. Choose either tin or cost-effective selective gold plating, .100″ or .156″ center spacing. Crimp, solder, or insulation displacement termination...top, side, or bottom pin entry...break-to-size pin headers...they're all standard in thousands of demanding applications.



Gold plating placed selectively on terminal contact points means added economy.

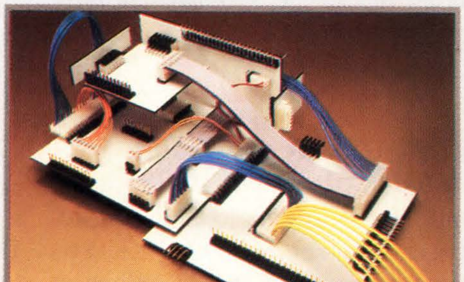
The KK® connector is just one example of how we take a total systems approach.

The KK® System includes a complete line of wire termination tooling from simple hand crimp tools to the latest automated insulation displacement technology. The System also features sophisticated pinsetting equipment. Molex goes beyond merely supplying connectors to help today's manufacturers achieve lower installed costs.

Dependable service worldwide.

Our multi-national organization offers you interconnection design, manufacturing, and technology from around the globe, with dependable supply and local service. Molex distributors stock the full line of flexible KK® connectors for your every need.

Intensive QC programs provide reliable connectors that stand up to tough environmental conditions in a wide range of electronic applications.



Unique break-away design allows you to order pin headers in bulk and break off the exact lengths you need to save on inventory and waste.

molex®

Service To The Customer...Worldwide

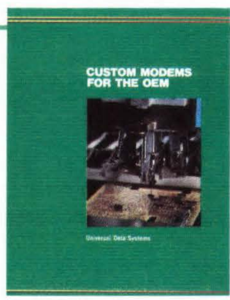
Corporate Headquarters: 2222 Wellington Ct., Lisle, IL 60532 USA, (312) 969-4550 • European Headquarters: Munich, West Germany, 49-89-4960937
Northern Asia Headquarters: Tokyo, Japan, 03-487-8333 • Southeast Asia Headquarters: Jurong Town, Singapore, 65-265-4755

CIRCLE NO 156

Exotic Customs at UDS

The special requirements of data communications OEMs have resulted in some pretty exotic custom modem cards from Universal Data Systems.

Funny form factors are routine fare for our custom designers. Nooks, crannies and odd card configurations are no problem, given sufficient square inches of real estate. UDS engineers have even designed a circular 212A modem that fits in the back of a residential electric meter.



For a generous sampling of UDS' custom design capabilities, ask for the new, free OEM modem brochure.

Non-standard modem functions are another specialty of the house. For example, UDS engineers have already designed and delivered a hand-held RF modem operating at 4800 bps!

UDS has successfully handled more than 3,000 custom OEM modem design assignments — and we can handle yours. To begin an exotic custom, contact Universal Data Systems, 5000 Bradford Drive, Huntsville, AL 35805. Telephone 205/721-8000; Telex 752602 UDS HTV.

Universal Data Systems

MOTOROLA INC.

Information Systems Group

CIRCLE NO 158

Created by Dayner/Hall, Inc., Winter Park, Florida