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ELECTRO/88 PREVIEW:
SESSIONS & PRODUCTS

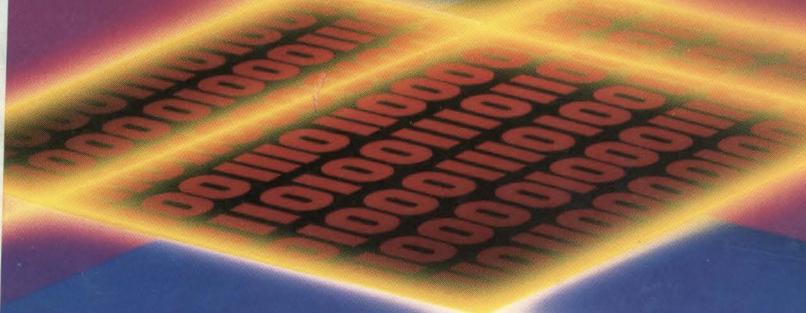
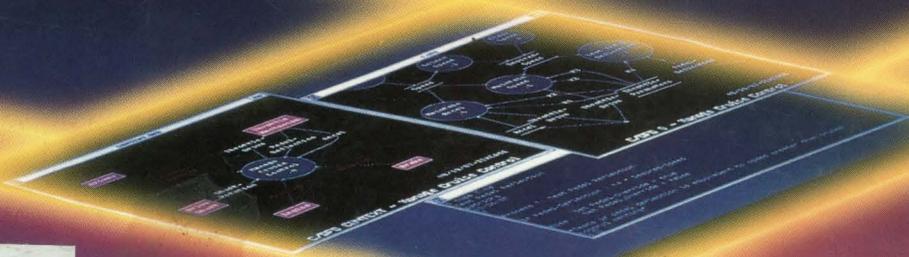
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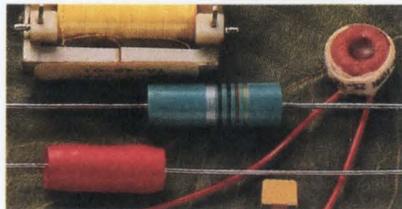
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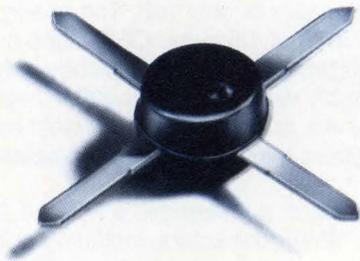
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from



dc to 2000 MHz amplifier series

SPECIFICATIONS

MODEL	FREQ. MHz	GAIN, dB			Min. MHz (note)	● MAX. PWR. dBm	NF dB	PRICE \$ Ea.	Qty.
		100 MHz	1000 MHz	2000 MHz					
MAR-1	DC-1000	18.5	15.5	—	13.0	0	5.0	0.99	(100)
MAR-2	DC-2000	13	12.5	11	8.5	+3	6.5	1.50	(25)
MAR-3	DC-2000	13	12.5	10.5	8.0	+8□	6.0	1.70	(25)
MAR-4	DC-1000	8.2	8.0	—	7.0	+11	7.0	1.90	(25)
MAR-6	DC-2000	20	16	-11	9	0	2.8	1.29	(25)
MAR-7	DC-2000	13.5	12.5	10.5	8.5	+3	5.0	1.90	(25)
MAR-8	DC-1000	33	23	—	19	+10	3.5	2.20	(25)

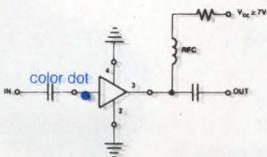
NOTE: Minimum gain at highest frequency point and over full temperature range.

- 1dB Gain Compression
- +4dBm 1 to 2 GHz

designers amplifier kit, DAK-2

5 of each model, total 35 amplifiers

only \$59.95



Unbelievable, until now... tiny monolithic wide-band amplifiers for as low as 99 cents. These rugged 0.085 in. diam., plastic-packaged units are 50ohm* input/output impedance, unconditionally stable regardless of load*, and easily cascable. Models in the MAR-series offer up to 33 dB gain, 0 to +11 dBm output, noise figure as low as 2.8dB, and up to DC-2000MHz bandwidth.

*MAR-8, Input/Output Impedance is not 50ohms, see data sheet.
Stable for source/load impedance VSWR less than 3:1

Also, for your design convenience, Mini-Circuits offers chip coupling capacitors at 12 cents each.†

Size (mils)	Tolerance	Temperature Characteristic	Value
80 × 50	5%	NPO	10, 22, 47, 68, 100, 470, 680, 100 pf
80 × 50	10%	X7R	2200, 4700, 6800, 10,000 pf
120 × 60	10%	X7R	.022, .047, .068, .1μf

† Minimum Order 50 per Value

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setting higher standards

Mini-Circuits

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CIRCLE NO 77

C113-Rev. D

tiny SPDT switches

absorptive... reflective

dc to 4.6 GHz from \$32.95⁽¹⁻²⁴⁾

Tough enough to pass stringent MIL-STD-883 tests, useable from dc to 6GHz and smaller than most RF switches, Mini-Circuits' hermetically-sealed (reflective) KSW-2-46 and (absorptive) KSWA-2-46 offer a new, unexplored horizon of applications. Unlike pin diode switches that become ineffective below 1MHz, these GaAs switches can operate down to dc with control voltage as low as -5V, at a blinding 2ns switching speed.

Despite its extremely tiny size, only 0.185 by 0.185 by 0.06 in., these switches provide 50dB isolation (considerably higher than many larger units) and insertion loss of only 1dB. The absorptive model KSWA-2-46 exhibits a typical VSWR of 1.5 in its "OFF" state over the entire frequency range. These surface-mount units can be soldered to pc boards using conventional assembly techniques. The KSW-2-46, priced at only \$32.95, and the KSWA-2-46, at \$48.95, are the latest examples of components from Mini-Circuits with unbeatable price/performance.

Connector versions, packaged in a 1.25 x 1.25 x 0.75 in. metal case, contain five SMA connectors, including one at each control port to maintain 3ns switching speed.

Switch fast... to Mini-Circuits' GaAs switches.

SPECIFICATIONS

Pin Model	KSW-2-46	KSWA-2-46
Connector Version	ZFSW-2-46	ZFSWA-2-46
FREQ. RANGE	dc-4.6 GHz	dc-4.6 GHz
INSERT. LOSS (dB)	typ max	typ max
dc-200MHz	0.9 1.1	0.8 1.1
200-1000MHz	1.0 1.3	0.9 1.3
1-4.6GHz	1.3 1.7	1.5 2.6
ISOLATION (dB)	typ min	typ min
dc-200MHz	60 50	60 50
200-1000MHz	45 40	50 40
1-4.6GHz	30 23	30 25
VSWR (typ)	ON 1.3:1 OFF —	1.3 1.4
SW. SPEED (nsec)		
rise or fall time	2(typ)	3(typ)
MAX. RF INPUT (bBm)		
up to 500MHz	+17	+17
above 500MHz	+27	+27
CONTROL VOLT.	-5V on, OV off	-5V on, OV off
OPER./STOR TEMP.	-55° to +125°C	-55° to +125°C
PRICE (1-24)	\$32.95 \$72.95	\$48.95 \$88.95

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C 117 REV.D



On the cover: CASE tools link all phases of the software design process—from concept to maintenance. See pg 110. (Photo courtesy Tektronix Inc, Computer-Aided Software Engineering Div)

DESIGN FEATURES

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Computer-aided software engineering is becoming vital to the success of large projects, and vendors are starting to make progress in filling two of the technology's most serious gaps.—*Chris Terry, Associate Editor*

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Electro's technical program expands to 54 sessions, 35 of which focus on software.—*Dan Strassberg, Associate Editor*

Electro/88 Products 139

Decade 90: The future of system design—Part 5 180

Fault-tolerant design techniques developed originally for aerospace systems will pervade the electronics industry as customers demand the utmost in reliability from every electronic product, even those intended for use on Earth.—*Steven H Leibson, Regional Editor*

Silicon compilers tame 10,000-gate-plus ASICs, gate arrays 195

Silicon compilation offers a new paradigm for the management of large complex designs.—*William J Stenzel, Tandem Computers Inc*

Take care when choosing controllers for flat-panel displays 209

Emissive flat-panel displays are well suited for applications requiring minimum size and weight. To optimize overall system performance, you must select a controller that's right for the job, keeping in mind that a flat-panel display's control requirements are more stringent than are a CRT's.—*Colin McManus, Digital Electronics Corp*

Mini dc/dc supplies simplify redundancy in parallel systems 225

Miniature, on-card dc/dc converters make it possible to design parallel-redundant systems that offer higher efficiency than that attainable from conventional UPS designs.—*Lars Thorsell, Rifa Power Products*

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EDN® (ISSN 0012-7515) is published 38 times a year (biweekly with 1 additional issue a month) by Cahners Publishing Company, A Division of Reed Publishing USA, 275 Washington Street, Newton, MA 02158-1630. Terrence M McDermott, President; Frank Sibley, Electronics/Computer Group Vice President; 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 80206-5191. Telephone: (303) 388-4511. Second-class postage paid at Denver, CO 80206-5191 and additional mailing offices. POSTMASTER: Send address corrections to EDN® at the Denver address. EDN® copyright 1988 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, \$100/year; Canada/Mexico, \$115/year; Europe air mail, \$135/year; all other nations, \$135/year for surface mail and \$210/year for air mail. Except for special issues where price changes are indicated, single copies of regular issues are available for \$6, \$8, and \$10 (USA, Canada/Mexico, and foreign). Please address all subscription mail to Eric Schmierer, 44 Cook Street, Denver, CO 80206-5191.

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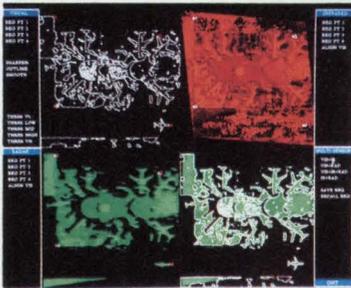
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asking

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CG08709



Your choice of machine-vision equipment depends on your application and the amount of money you want to spend (pg 55).

EDN magazine now offers Express Request, a convenient way to retrieve product information by phone. See the Reader Service Card in the front for details on how to use this free service.



TECHNOLOGY UPDATE

Sophisticated hardware and software beget efficient machine-vision systems 55

Because of recent developments in machine-vision technology, you no longer need a lot of specialized knowledge to develop vision systems that let machines search for and differentiate among patterns.—*J D Mosley, Regional Editor*

Advances in speed and voltage ratings enhance applications for optocouplers 75

The widespread use of optocouplers is testimony not only to their long history, but to the great variety of types for sale.—*Dave Pryce, Associate Editor*

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Program aids resistive-divider calculations 240

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IEEE database service encourages entrepreneurial urges.—*Deborah Asbrand, Associate Editor*

LOOKING AHEAD

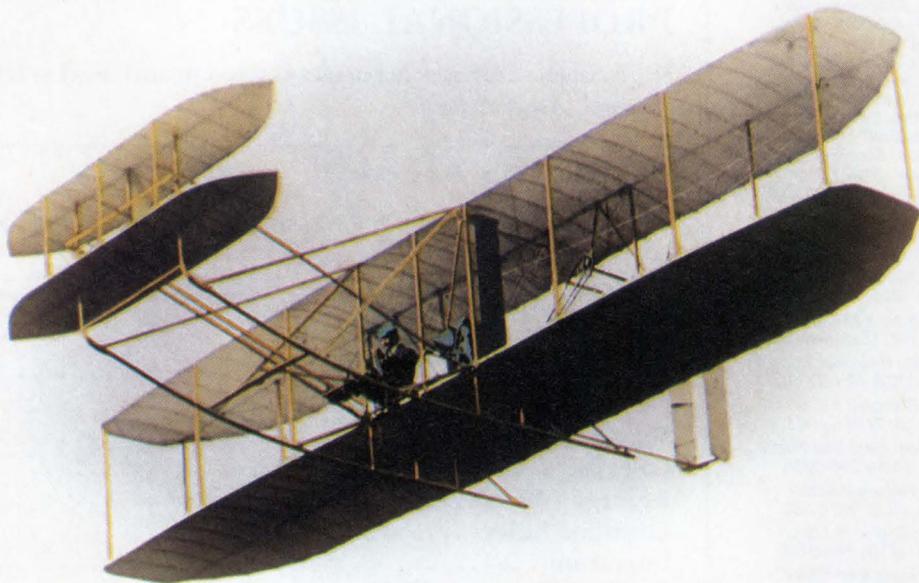
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US capacitor sales are on the way up... LAN market to grow at 20% rate through '91.

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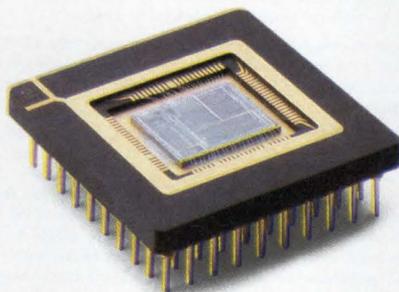
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**"WITH THE EXCEPTION
OF OBSERVATION, I SEE NO
MILITARY USE FOR IT."
AMERICAN GENERAL, 1908**



"IT'S GOT POSSIBILITIES, BUT IT'S JUST TOO POWERFUL FOR MY APPLICATION NEEDS!"

DESIGN ENGINEER, 1988



Over the centuries, people have looked at the latest in technology with a bit of skepticism. The Transputer from INMOS is no exception.

When we first introduced the Transputer, designers were indeed intrigued. They were impressed with our T800—a 32-bit floating point microprocessor with an average speed of 10 MIPS and the ability to sustain 1.5 MFLOPS or 4.0 million single precision whetstones. "Incredible," designers said. "But it's more than we can use."

Not true. The fact is as a stand-alone processor, the T800 gives you benefits you can use every day. It runs programs even faster than Intel's combined 80386 and 80387 or Motorola's combined 68020 and 68881. Plus, it requires significantly less memory to hold compiled code.

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with no limit to the number of Transputers that can operate concurrently. Like linking seven T800's together to give you the processing power of a mighty Cray T3E supercomputer.

Or you could use ten IBM add-in cards from INMOS carrying ten T800's each, to enable your desktop PC to deliver 150 MFLOPS. That's like having the power of 150 11/780 VAX machines right at your fingertips.

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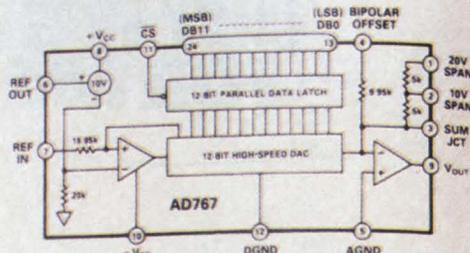


Fast Interface 12-Bit D/A Converter

AD767

FEATURES

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



AD767 Functional Block Diagram

PRODUCT DESCRIPTION

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

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

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

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

PRODUCT HIGHLIGHTS

- Complete 12-bit DACPORT™. The AD767 is a complete voltage output DAC with voltage reference and digital latches on a single IC chip.
- The input latch responds to write pulse widths as short as 40ns assuring direct interface with the industry's fastest microprocessors.
- The internal buried zener reference is laser trimmed to 10 00 volts with a $\pm 1\%$ maximum error. The reference voltage is also available for external application.
- The gain setting and bipolar offset resistors are matched to the internal ladder network to guarantee a low gain temperature coefficient and are laser trimmed for minimum full-scale and bipolar offset errors.
- The precision high-speed current steering switches and on-board high-speed output amplifier settle within 1/2LSB for a 10V full-scale transition in 3.0 μ s when properly compensated.

DACPORT is a trademark of Analog Devices, Inc.

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

Both the AD767 and AD7245 feature an on-chip stable buried Zener reference, output amplifier and microprocessor interface logic. And these complete

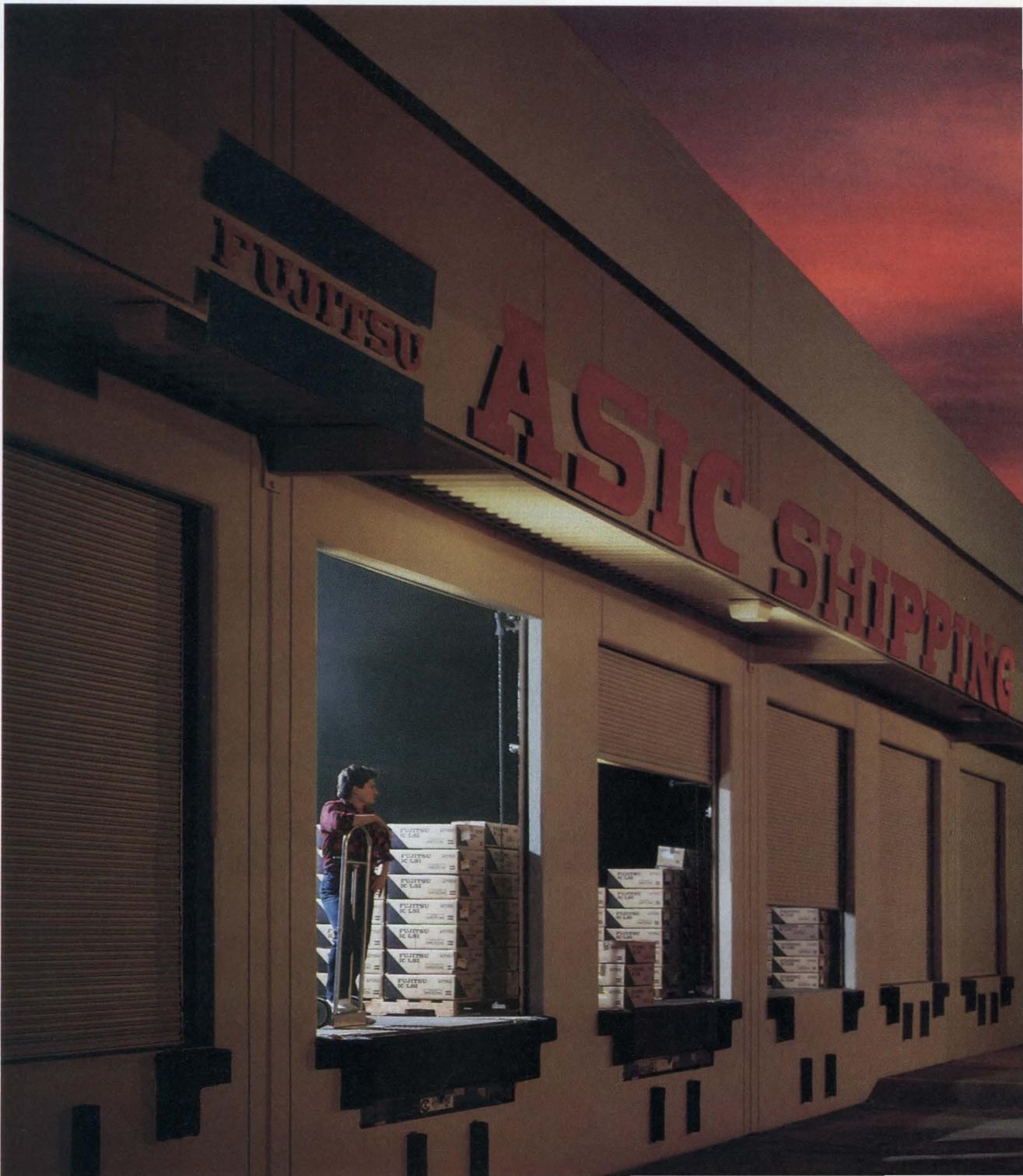
functions come packed into skinny 0.3" DIPs. All this means you no longer have to deal with error budgets, product characterizations, or space constraints related to external components.

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

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and final test, including 100% AC testing at frequency. So nothing is left to chance.

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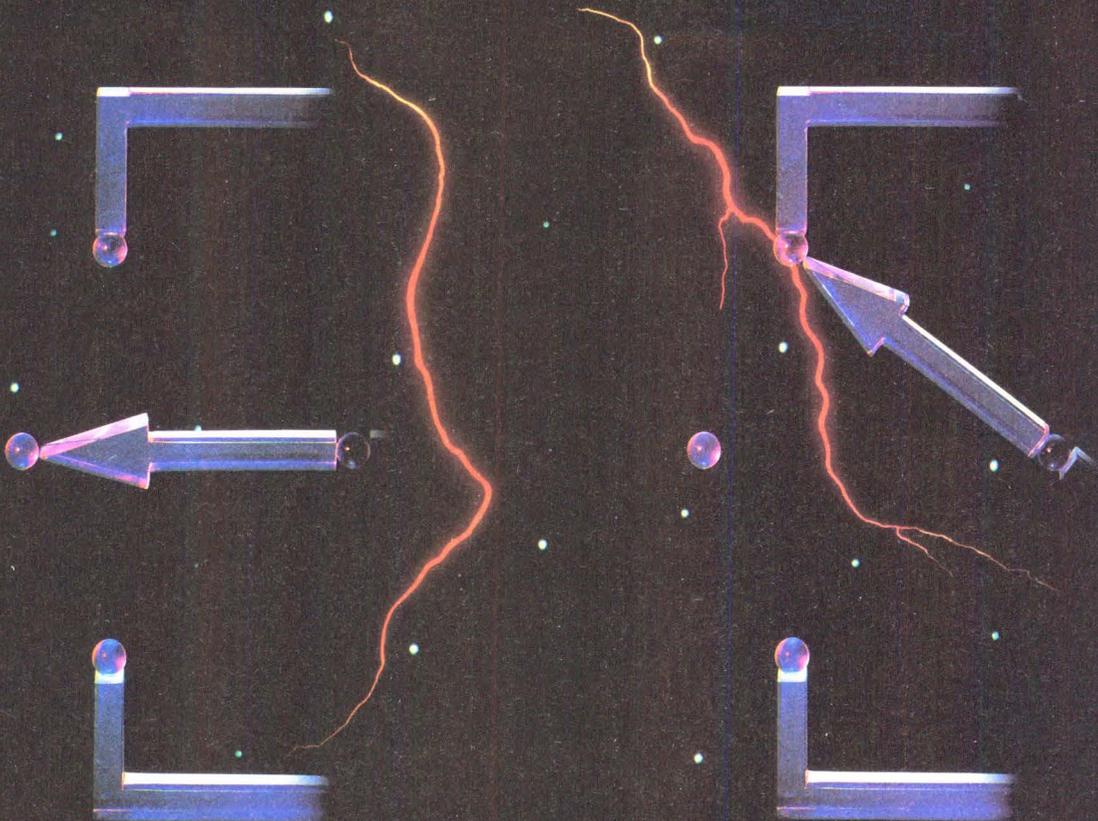
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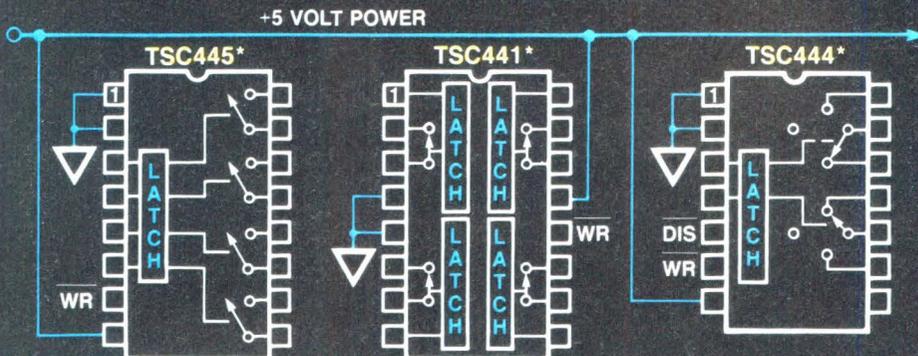


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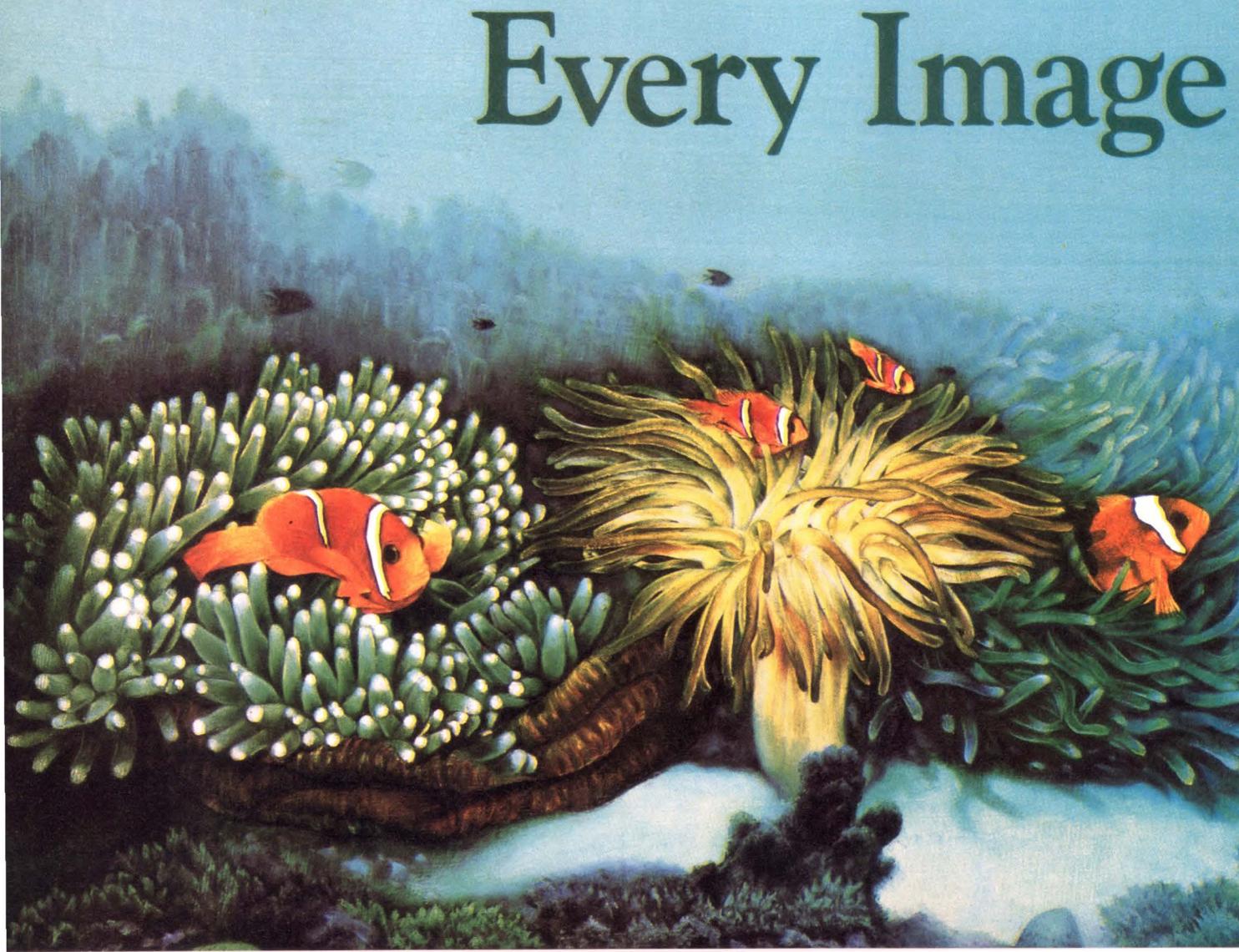
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NEWS BREAKS

EDITED BY JOANNE CLAY

OPTICAL WORM DRIVE STORES 1.2G BYTES ON A CARTRIDGE

The ISi 525GB write-once, read-many (WORM) optical-disk subsystem from Information Storage Inc (Colorado Springs, CO, (303) 579-0460) stores 1.2G bytes of information on its double-sided cartridge. At any one time, an application has access to one side (600M bytes) of the cartridge. In addition, the optical drive features a 6.5M-bps data-transfer rate, which the company claims can provide better throughput than some magnetic hard-disk drives. A subsystem designed to be mounted in an IBM PC or compatible computer costs \$5988 and includes the WORM drive, controller board, cables, and software. An enclosed subsystem that adds a power supply and cabinet costs \$6188. The company will offer a similar drive with a SCSI interface in August. Meanwhile, the company has lowered the price of its 230M-byte ISi 525WC subsystem from \$3995 to \$2088.—Steven H Leibson

DSP BOARD AND SUBSYSTEM BOOST HP 9000 WORKSTATION PERFORMANCE

The DSP300 add-in board for Hewlett-Packard's 9000 Series 200/300 workstations employs an AT&T WE-DSP 32 processor to increase the speed at which the workstations perform floating-point operations. Infotek Systems (Anaheim, CA, (714) 956-9300) offers the board as a stand-alone product or as part of the GA300 graphics-accelerator subsystem. The GA300 also includes the BC305 Basic 5.0 compiler and graphics-accelerator software, and it can execute applications such as real-time modeling and animation as much as 40 times faster than the Series 200/300 processor can. Available now, the DSP300 costs \$2000 (including the assembler and C compiler) and the GA300 sells for \$2395. The company plans to introduce FFT and array-processing subsystems based on the DSP300 in the third quarter of 1988.—Maury Wright

MENU-DRIVEN DMM INCLUDES BAR GRAPH AND FREQUENCY COUNTER

The Model 560 menu-driven digital multimeter from Simpson Electric Co (Elgin, IL, (312) 697-2260) is a 2.5-lb, Z80-based instrument that stores 2150 readings in non-volatile, battery-backed RAM. The basic unit costs \$2195. The 560's menu interface simplifies the task of selecting storage parameters for the meter's readings. The readings have 5-digit resolution (allowing for 99,999 counts) and a minus sign. A 52-segment bar graph provides real-time voltage and autorange representations that are independent of the decibels or hertz you're measuring, so you can simultaneously take a reading and observe events at the test point in real time.

The DMM features a built-in frequency counter, true-rms ac measurements, fusing on both current inputs, low-forcing-current and high-forcing-current resistance ranges, a diode-test function, high-speed autoranging, a zero function that eliminates lead resistance in readings, digital filtering, a temperature-compensated reference, and digital calibration. The unit also provides a peak-hold function. You can order the 560 with either an RS-232C serial port or a Centronics-compatible parallel port for \$2395.—J D Mosley

MONOLITHIC OP AMP OPERATES FROM $\pm 45V$ SUPPLIES

Burr Brown's (Tucson, AZ, (602) 746-1111) OPA445 monolithic op amp operates from $\pm 45V$ power supplies and provides an output swing of $\pm 35V$ into 5-k Ω loads or generates as much as 15 mA with a maximum output swing of $\pm 28V$. The laser-trimmed part features a maximum 1-mV offset voltage, a 10- μV offset drift, and a 10V/ μ sec slew rate. The company offers the device for \$3.80 (100) in either a TO-99 package or an 8-pin DIP with industry-standard op-amp pinouts.—Steven H Leibson

NEWS BREAKS

SOFTWARE PACKAGE INOCULATES DISKS AGAINST COMPUTER VIRUSES

After one of its computers became infected with a destructive virus program (sometimes called a Trojan horse program), Sophco Inc (Boulder, CO, (303) 444-1542) added an inoculation module to its \$195 Protec software-protection package for computers running MS-DOS version 3.0 and higher. An engineer at the company had downloaded a seemingly innocuous program (an X-rated animated graphics program) from an electronic bulletin board to a computer's hard disk. That program contained an infectious module that installed delayed-action routines into executable software on the hard disk. Later, the routines destroyed the files on the disk.

Protec version 3.2 can safeguard your programs with a protective virus program called Vaccinate, which you install in your executable files with another program called Syringe. The Protec system also includes a decoy program called Canary that you can use to test suspect software. You include Canary on a floppy disk along with the dubious software and run the suspect program. If the Canary program "dies" after the suspect program finishes, you know there's a virus program on your disk. Sophco has also initiated the Center for Computer Disease Control, which will act as a clearing house for information about such antisocial software.—Steven H Leibson

NONVOLATILE RAMs REQUIRE NO BACKUP BATTERIES

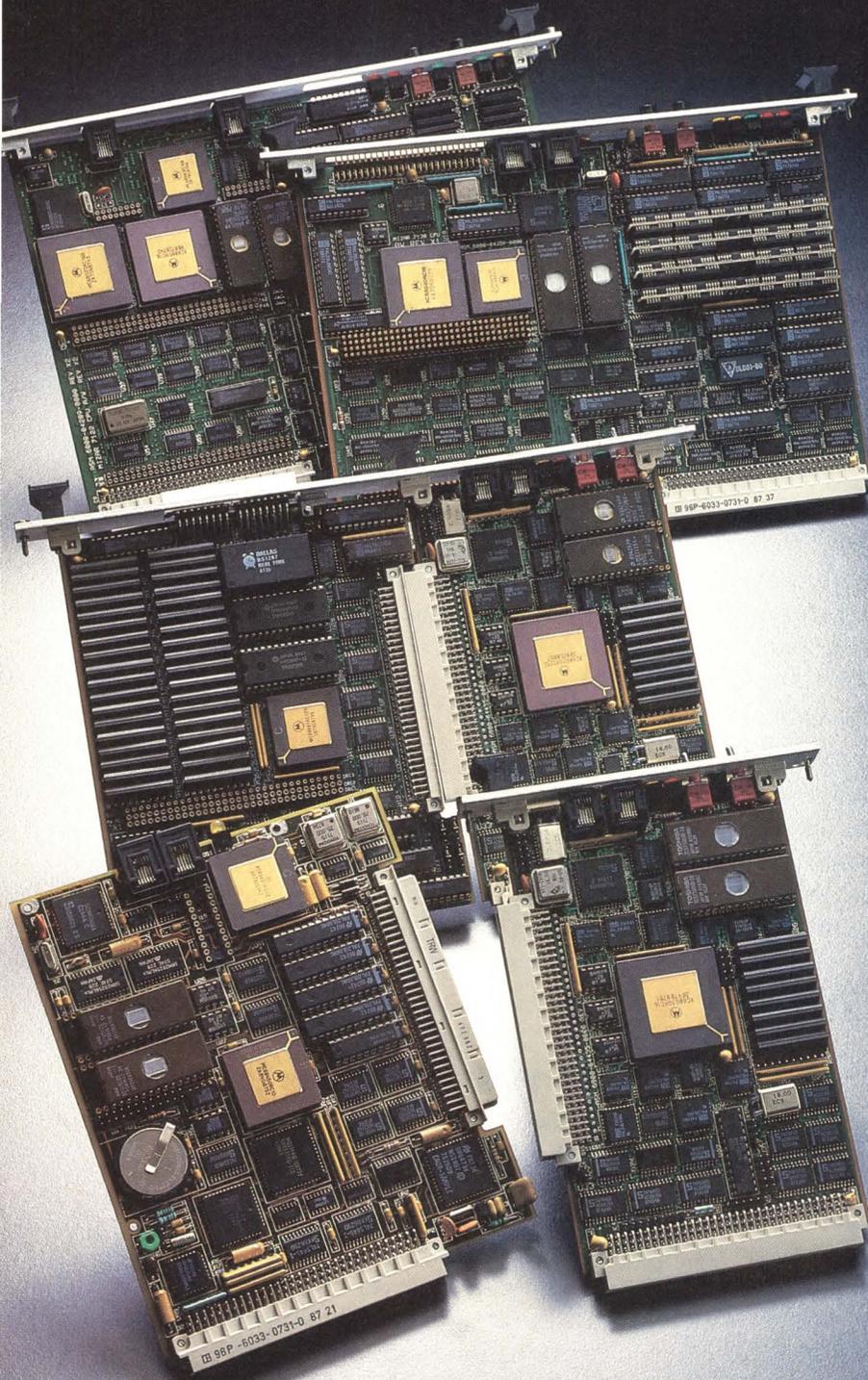
Selected customers are currently evaluating a promising new development in semiconductor memories—nonvolatile RAMs. Dubbed ferroelectric RAMs (FRAMs) or "shadow" RAMs, the prototype static-RAM devices from Ramtron Corp (Colorado Springs, CO) have a 256×1-bit organization and require no backup batteries. Instead, a pair of special storage capacitors provides backup for each bit cell. These capacitors have a thin-film-ceramic dielectric called "lead zirconate titanate" (PZT), whose bistable polarization allows the indefinite storage of data; you set the polarization state by applying a 2.5V coercive voltage. The initial product (FMx 801) operates on 5V and features 100-nsec read and write operations. Products having higher speed and higher bit density will follow. At present, the company offers the FMx only to qualified customers as a technology-demonstration vehicle, but it expects to have the product available for sale during the third quarter of 1988. The company is also developing nonvolatile dynamic RAMs (based on a 1-transistor memory cell) that have capacities of 256k bits and greater.—Tarlton Fleming

FLASH MEMORIES ALLOW IN-SYSTEM REPROGRAMMING

The 27F64 and 27F256 64k- and 256k-bit flash-memory devices from Intel (Santa Clara, CA, (800) 548-4725) feature in-circuit electrical erasure and reprogramming. You program or erase the devices by writing the appropriate command to a control register and supplying 12V to the programming pin. You program the devices one byte at a time; an erase command erases the entire memory. Erasing the devices takes less than 1 sec; reprogramming them takes less than 4 sec. If you hold the programming pin at 5V, the control register is disabled, allowing normal EPROM read operations. The 27F64 costs \$8; the 27F256 is \$19.90 (10,000).—Richard A Quinnell

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Mizar's engineers have reduced critical wait-states to zero at 16.7, 20 and 25 MHz in many cases. To enhance multiprocessor system performance, Mizar's new on-card memory arbitration logic frees the CPU during time-consuming memory operations across the VMEbus, allowing concurrent local processing. And for more demanding applications, Mizar's 68030 based MZ 7130 even includes cache options.

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NEWS BREAKS: INTERNATIONAL

CAD PACKAGE ALLOWS YOU TO DESIGN AND ORDER RESISTOR NETWORKS

Supplied free of charge on a floppy disk, the Resicalc CAD package from Ericsson Business Area Components (Granna, Sweden, phone (46) 39011020) allows you to design your own resistor networks on an IBM PC. The CAD package, which incorporates the design rules for the company's semicustom Erisistor resistor networks, allows you to design through-hole or surface-mounting SIP (single in-line package) resistor networks, or networks packaged in leadless chip carriers. For each internal resistor, you can specify the absolute value, absolute and relative tolerances, absolute and relative temperature coefficients, and power rating. You then define the leadout connections for each resistor, and the program automatically tells you whether the network is manufacturable as an Erisistor product. If your design isn't feasible, the program suggests parameters you can change to make it manufacturable. In addition to providing an instant guide price for the network, Resicalc allows you to dial up the company's computer on a toll-free line to obtain accurate pricing and delivery information and to place your order.—Peter Harold

CPU CARD PERFORMS 32-BIT DMA TRANSFERS TO VME OR VSB BUS

The FIC8230 intelligent VME Bus board from Creative Electronic Systems SA (Petit-Lancy, Switzerland, TLX 421320) is based on a 16- or 24-MHz 68020 μ P and a 68881 or 68882 math coprocessor. The board offers an optional DMA controller that can perform 16- or 32-bit block data transfers across the VME Bus's entire 4G-byte addressing range at data rates as high as 8M bytes/sec. The DMA controller can also transfer 32-bit data over the VSB Bus at data rates in excess of 10M bytes/sec. Another DMA channel allows you to transfer data to or from an 8-bit I/O port, which you can configure for a variety of uses (for instance, you can use it as a SCSI port).

The board has 512k bytes or 1M byte of zero-wait-state CMOS static RAM that's ported to the 68020 and to the VME Bus, and is ported to the VSB Bus via a DMA channel. The board also has 128k bytes of local RAM, and it includes space for as much as 128k bytes of EPROM. Four independent 255 \times 32-bit LIFO/FIFO buffers provide the board with message-passing capabilities. The board's additional facilities include two RS-232C serial I/O ports, a 16-bit timer/counter, and a real-time clock. The board configuration is software programmable. The FIC8230 costs between \$4500 and \$6000, depending on configuration.—Peter Harold

JAPAN KEY TECHNOLOGY CENTER EARMARKS ¥222M FOR RESEARCH

The Japan Key Technology Center, which is responsible for funding technological developments in the private sector and supporting local information-oriented businesses, has set aside ¥222 million to fund research in various electronic and materials technologies. The organization falls under the jurisdiction of both the Ministry of Posts and Telecommunications (MPT) and the Ministry of International Trade and Industry (MITI). It has designated ¥77 million for research on amorphous magnetic materials and electronic devices and ¥145 million for funding experimental research into high-precision light-detection devices containing superconductive materials, low-voltage EL displays, infrared-image fiber sensors, color filters for use in flat LCDs, and equipment that can measure the effects of electrostatic fields on radio waves.—Joanne Clay

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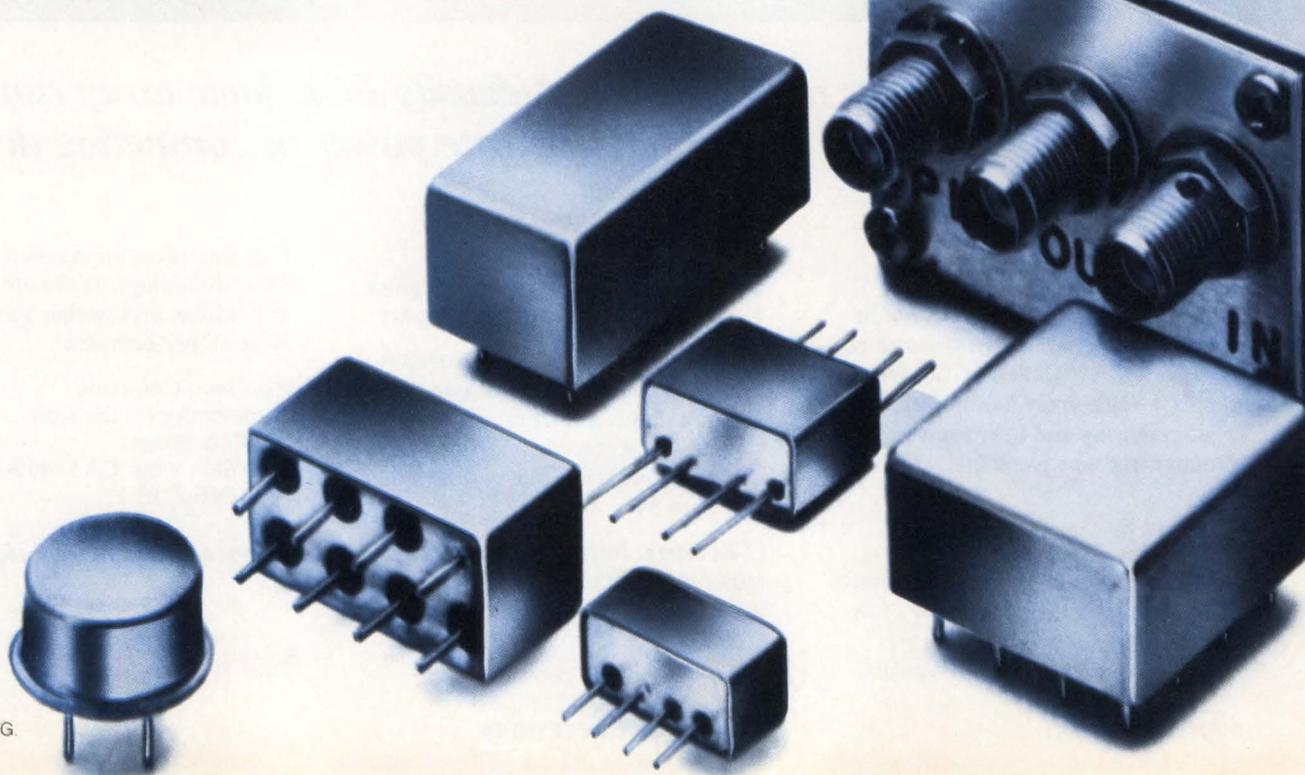
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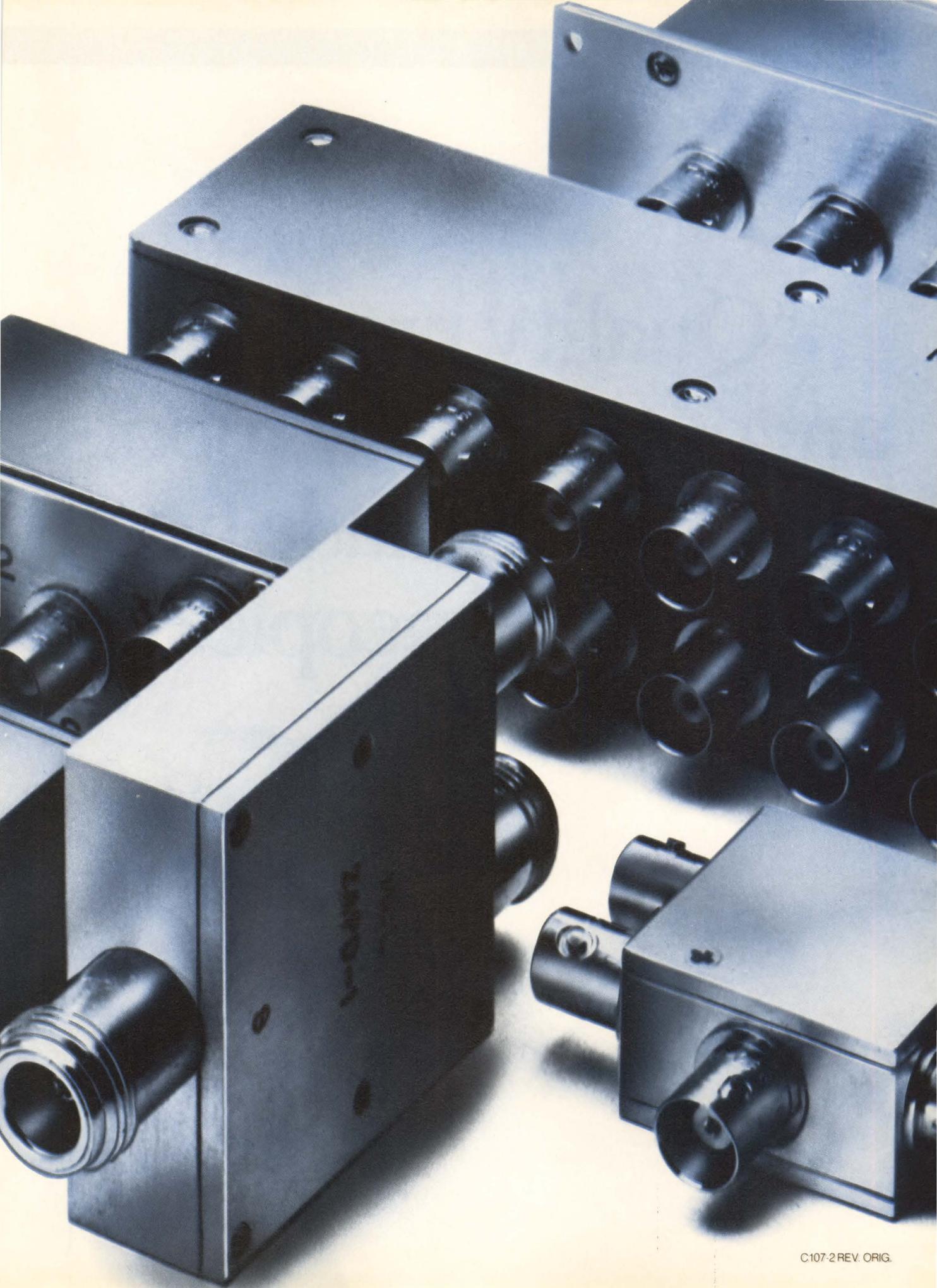
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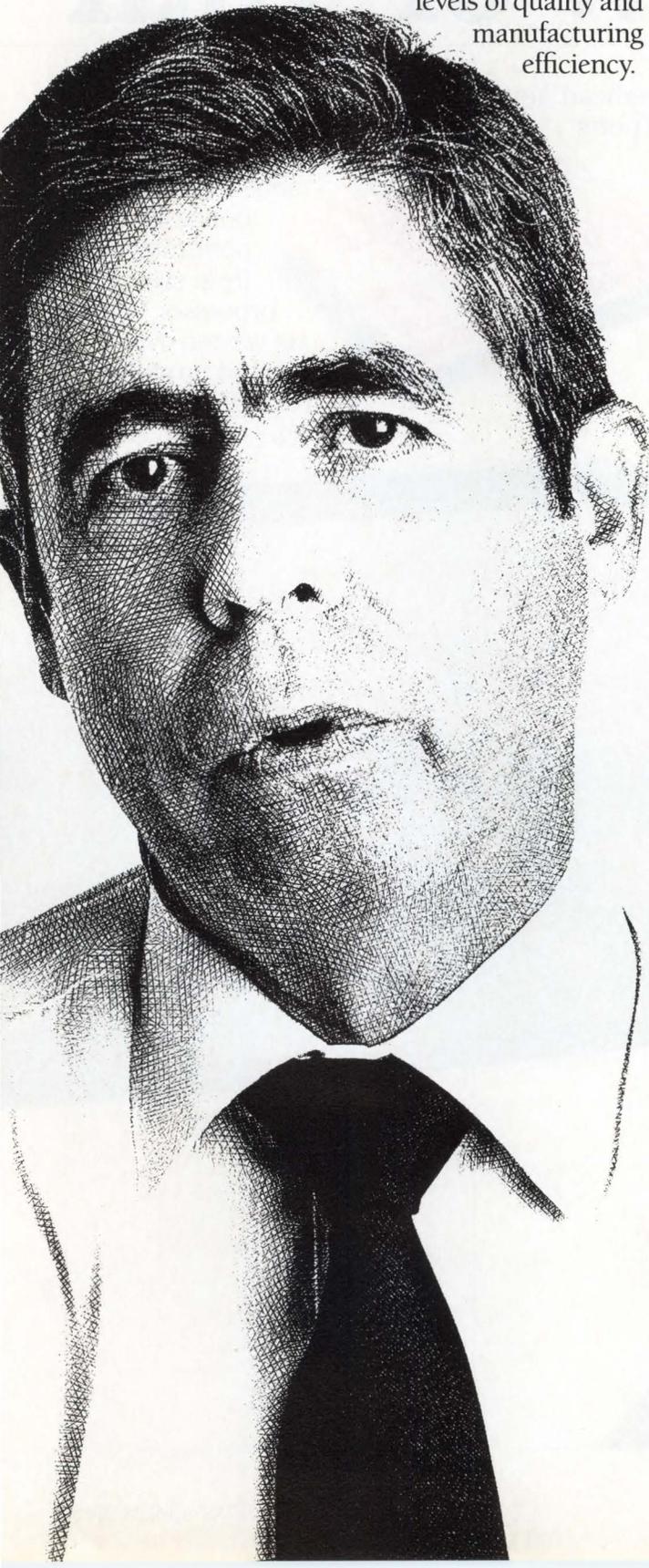


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American electronics companies today face some serious challenges in manufacturing—the main one being how to compete successfully with our offshore rivals. That's why at Motorola we've taken several radical steps aimed at reaching new levels of quality and manufacturing efficiency.



A commitment to 6-Sigma quality levels.

Last year, Motorola began working toward a quality goal of 6 Sigma for all manufacturing, as part of our Statistical Process Control program. That translates into a defect rate of 3.4 parts per million, or an effective yield of 99.99966%. In short, zero defects. And remember, we're talking about *board-level* here, not components.

The move to Just-in-Time manufacturing.

To reach those quality levels, we've undergone a revolutionary change in our manufacturing culture at Motorola, using Just-in-Time techniques. JIT gives us a discipline for looking at *every* step of our manufacturing process, and eliminating waste. It has already helped us shorten our build cycle over 80%. Ultimately, we want to be able to build only those products our customers want. And ship them the same day they're ordered.

The right tools for total quality control.

At Motorola, we make what amounts to custom products, using mass manufacturing techniques. To track the 78 different products we build, we've recently installed an on-line Quality Information System that uses bar code readers to gather process and quality data. We're evolving toward a "paperless" factory that experts tell us is a showcase in the industry.

The necessity of strong manufacturing for survival.

Quality and manufacturing excellence are more than just words. They're essential in today's global competitive environment. Which is why we feel—quite frankly—that only those corporate cultures focused on quality goals like 6 Sigma will survive. In fact, any VME board or system vendor who *doesn't* have strong manufacturing isn't really in this business to stay. That's why we're always ready to *demonstrate* our capabilities. Because we don't know of anyone who has a stronger commitment to quality and manufacturing excellence than Motorola. That's what being the leader means.



MOTOROLA Microcomputer Division

Approaching our technology from your point of view.

For reprints of this series, call 1-800-556-1234, Ext. 230; in California, 1-800-441-2345, Ext. 230. Or write: Motorola Microcomputer Division, 2900 South Diablo Way, Tempe, AZ 85282.

VME/PLUS™ gives view of your

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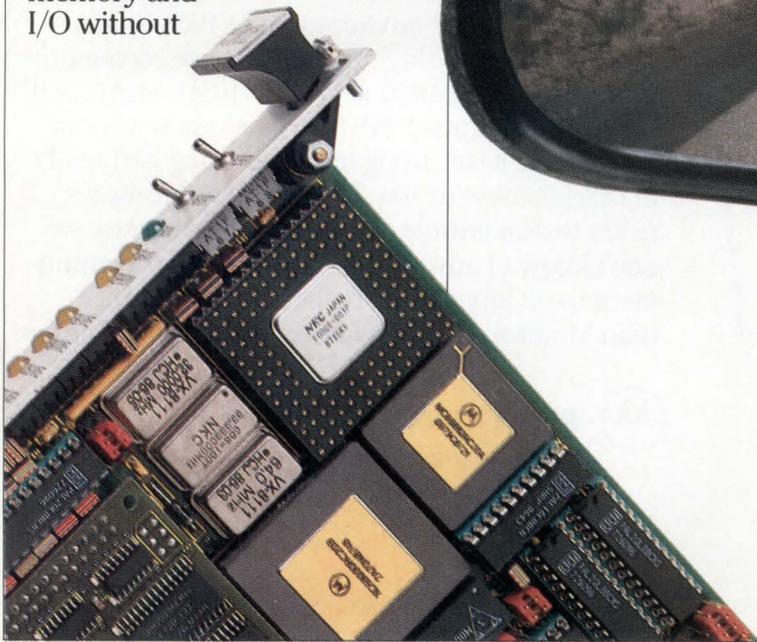
VME/PLUS gives you a choice of microprocessors, including a 68030 running at 25MHz without wait states. Complemented by 1MB of local memory. There's also a new VSB interface on P2. Which lets you add lots of local memory and I/O without

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

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

AVAILABLE WITH 68030

Think about the possibilities for real-time applications. For the first time, you can squeeze every ounce of performance from every processor. With no wasted overhead. And no stalls. But that's only the beginning. The newest



you a different competition.

member of the VME/PLUS family, CPU-32, comes with



a powerful new real-time, multitasking monitor called VMEPROM. It's resident in

EPROM, so there's no license required and no extra charge.

CPU-32 also includes full support for real-time operating systems and UNIX 5.3.

What this new technology means for you is unprecedented levels of speed and system throughput, exceptional reliability and - here's

CPU-32 CHARACTERISTICS

PROCESSOR	68030/16.7 TO 25 MHz
CO-PROCESSOR	68882/16.7 TO 25 MHz
ZERO-WAIT-STATE	
SRAM	1MB
VMEPROM	REAL-TIME, MULTITASKING MONITOR
EPROM	UP TO 4MB @ 1 WAIT-STATE
SERIAL I/O	2 RS-232 CHANNELS
SECONDARY BUS SUPPORT	VSB

the best part - lower total system cost.

And if that's not enough, we also offer a full set of off-the-shelf peripheral boards

and software. All VMEbus compatible. And guaranteed to cut the wait states out of your design cycle.

So if you're looking for the best way to stay ahead of your competition and your deadline, take a close look at VME/PLUS.

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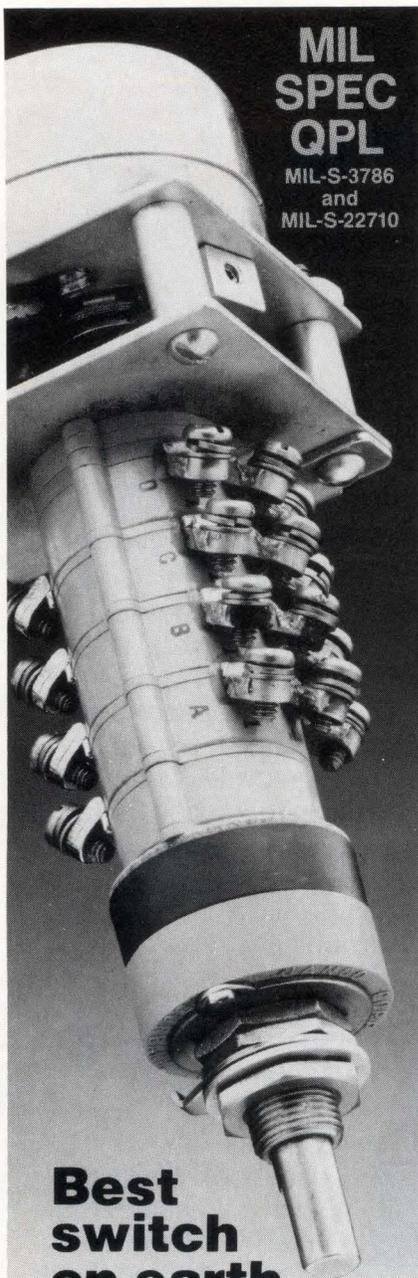


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CIRCLE NO 2

SIGNALS & NOISE

IEEE will survive its current troubles

In his February 4 editorial (pg 53), Jon Titus predicted that the IEEE was facing extinction. Although I concur with Jon's observations relating to the IEEE Board of Directors' decision on approval voting, I don't feel that it spells the end for the IEEE. The IEEE has survived for 104 years and will continue to do so. Whether it has the impact it has had in the past remains to be seen. Issues such as portable pensions, reinstatement of the IRA deduction, and engineer utilization are still being worked on by committees of the IEEE. Unfortunately, all these efforts by numerous volunteers have been lost in the miasma of the Board's actions. Although I can't defend or explain away the Board's recent action, I can still recommend membership in the IEEE.

*Paul J Kostek
Boeing Aerospace Co
Seattle, WA*

Feerst takes prize for endurance

Bravo to Jon Titus for his editorial "The IEEE faces extinction" in the February 4 issue (pg 53). Verily he speaks the truth, but who is listening?

I've been in this business a long time, but I quit the IEEE in disgust back in 1967 for the same general reasons that Jon Titus and Irwin Feerst state. I've helped the Committee of Concerned EEs at least once, but the indifference of my fellow engineers made it seem hopeless. Irwin Feerst surely deserves the prize for patience, endurance, and faithfulness to his ideals.

Jon Titus is in a position to be a great help to the working engineer. I hope that he continues to do so.

*Gene D Barber
(A working engineer)
San Diego, CA*



"I HAVE AN IDEA WHY WE'VE
HAD SO MUCH DOWN TIME ON
OUR COMPUTERS."

Single-chip μ C comes Forth

Isn't it funny how computer languages expose intolerance in people (see Robert Johnson's letter in EDN, February 18, 1988, pg 34). Personally, I believe that anyone not using Fortran on single-chip micros should be stood up against the wall Seriously, though, Steve Leibson might like to know that Micromint (Vernon, CT, (203) 871-6170) sells a Forth chip based on the Z8.

*Peter Hand
PDA Designs Ltd
Portsmouth, England*

YOUR TURN

EDN's Signals and Noise column provides a forum for readers to express their opinions on issues raised in the magazine's articles or on any topic that affects the engineering industry. Send your letters to the Signals and Noise Editor, 275 Washington St, Newton, MA 02158. We welcome all comments, pro or con. All letters must be signed, but we will withhold your name upon request. We reserve the right to edit letters for space and clarity.

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A_{VOL}	200	10	V/mV min
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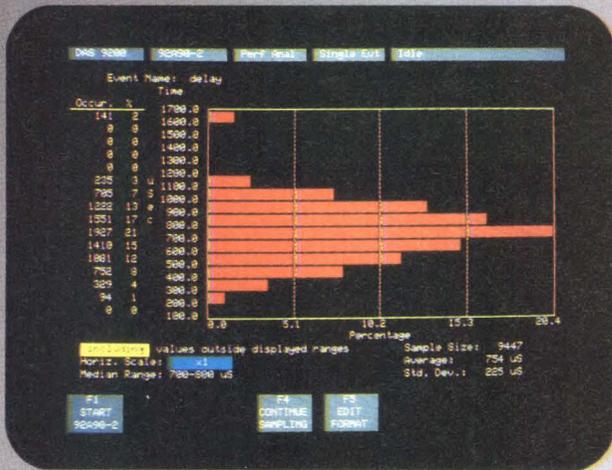
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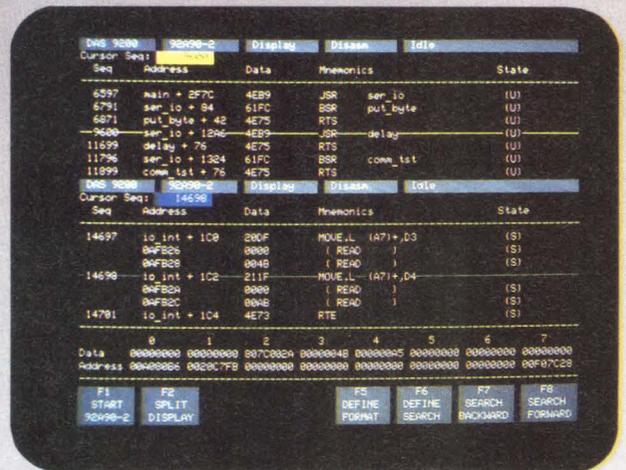
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DAS9200 DIGITAL ANALYSIS: NOW TEK MAKES THE IMPOSSIBLE LOOK EASY.



Software Performance Analysis, like this distribution of a subroutine's execution times, helps you easily understand the activity of your code.



Step backwards through acquired data, including subroutines, stack and register models, using time-correlated split-screen displays to pinpoint problems.

In every dimension— speed, channel width, memory depth, trigger capability, modularity and ease of use—the DAS9200 dwarfs what's been possible before.

The DAS9200 features a tightly coupled, high-speed architecture in which multiple card modules can act as a single unit. Large color-coded displays, pop-up menus, performance analysis graphs,



multi-tasking and more combine to take logic analysis to levels like these:

1 State-driven triggering at 200 MHz.

You can use up to 384 channels of sync and async data acquisition. You can assure-test high-speed logic at full speed, using 4-level state tracking and high-speed counter/timers. You can monitor and verify all timing measurements in a circuit.

2 Symbolic, real-time software debugging.

Register deduction and stack simulation let you pinpoint problems like stack overflow or incorrectly restored pointers—without breakpoints or manual notation.

3 Simultaneous integration of up to six microprocessors.

Use the dual timebases and real-time handshaking between system modules to set up split-screens displays that scroll in precise time alignment.

4 160 channels of acquisition at 2 GHz.

Use up to 500 ps sample interval and

1.5 ns glitch detection to identify race conditions, spurious clocks and setup/hold violations in any logic family. System probes feature input capacitance of <1 pf.

5 Easy ASIC verification at up to 50 MHz.

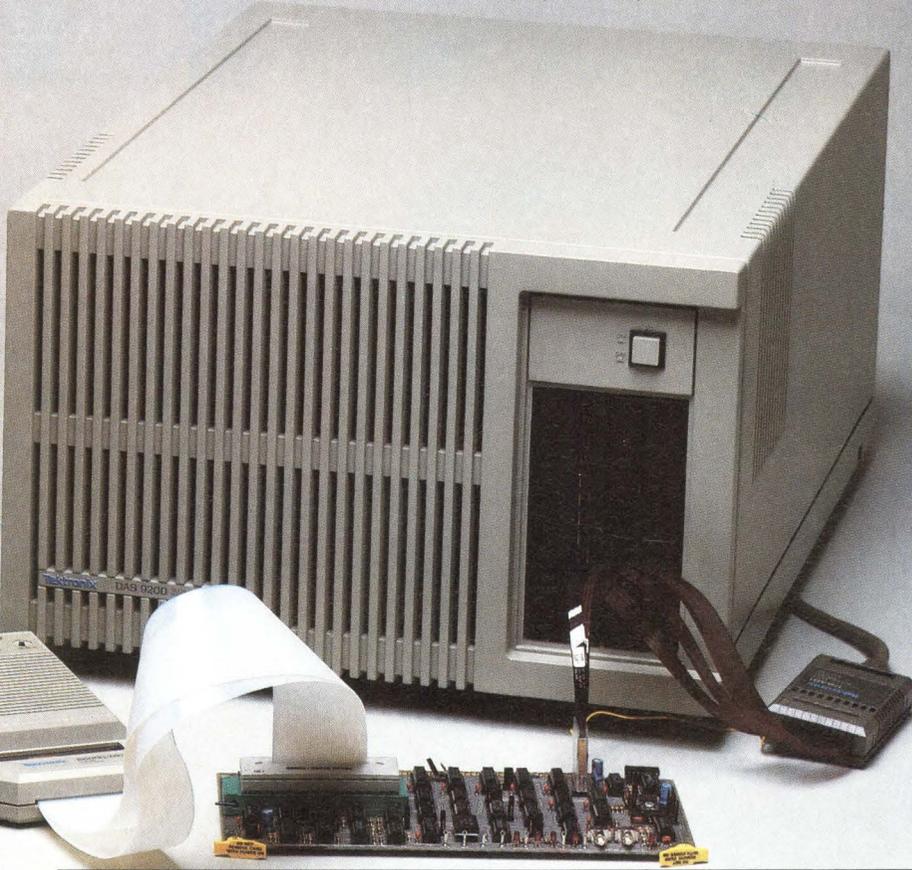
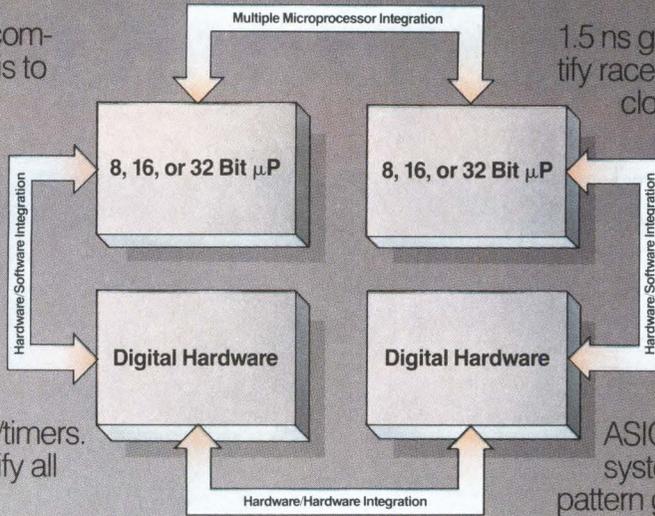
The DAS9200 is available as a low-cost turnkey ASIC device verification system. Featuring 50 MHz pattern generation, 8K bit vector depth, and 1 ns edge placement, it offers the power, precision and simplicity to be an attractive alternative to centralized systems.

6 Stop wishing for the impossible in digital analysis:

Compare your wish list against the complete list of DAS9200 capabilities. Contact your Tek sales engineer, or call toll-free for more information.

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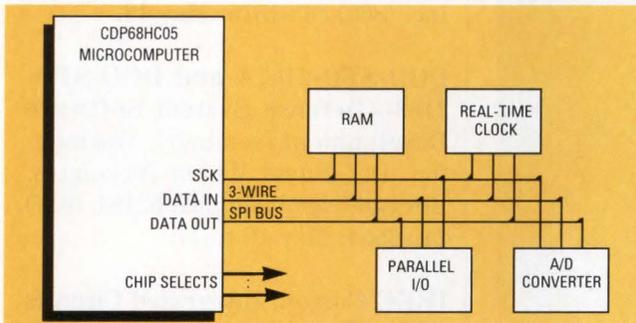
Not an easy job. But certainly easier when you use our 6805 and 68HC05 micros and serial peripheral interface devices.

Extend your micro's power.

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

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

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



True design versatility.

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

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

And since you don't need complex software to

operate the bus, you save ROM space.

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

Powerful family of micros.

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

68HC05 Microcomputers

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

*prescaler fixed as ÷4

Easy to prototype, too.

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

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

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

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

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



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The Polaroid Ultrasonic Ranging System is an accurate, highly sensitive way to detect and measure the presence and distance of objects from 10.8 inches to 35 feet. What's more, accuracy, sensitivity and range can all be improved with circuit modifications.

Three of a kind. Polaroid offers three ultrasonic transducers for a wide variety of applications. You can choose the original instrument-grade transducer, proven in millions of SX-70 Sonar Autofocus cameras. Or our Environmental Transducer, available in a sturdy housing to withstand exposure to rain, heat, cold, salt spray, chemicals, shock and vibration. And now you can select our newest, smallest transducer, developed for Polaroid Spectra, the camera of the future. All use reliable, accurate and sensitive electrostatic transducer technology. All are backed by Polaroid.



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CIRCLE NO 3

CALENDAR

Pittsburgh Conference on Modeling and Simulation, Pittsburgh, PA. William Vogt or Marlin Mickle, 348 Benedum Engineering Hall, University of Pittsburgh, Pittsburgh, PA 15261. May 5 to 6.

Worst-Case Circuit Analysis (seminar), Washington, DC. Design and Evaluation, 1000 White Horse Rd, Suite 304, Voorhees, NJ 08043. (609) 770-0800. May 9 to 11.

Electro/88, Boston, MA. Electronic Conventions Management, 8110 Airport Blvd, Los Angeles, CA 90045. (800) 421-6816; in CA, (213) 772-2965. May 10 to 12.

EMC Expo, Washington, DC. Karen Smith, EMC Expo, Box D, Gainesville, VA 22065. (703) 347-0030. May 10 to 12.

Analog Applications (seminar), Chicago, IL. Precision Monolithics Inc. (800) 843-1515. May 13.

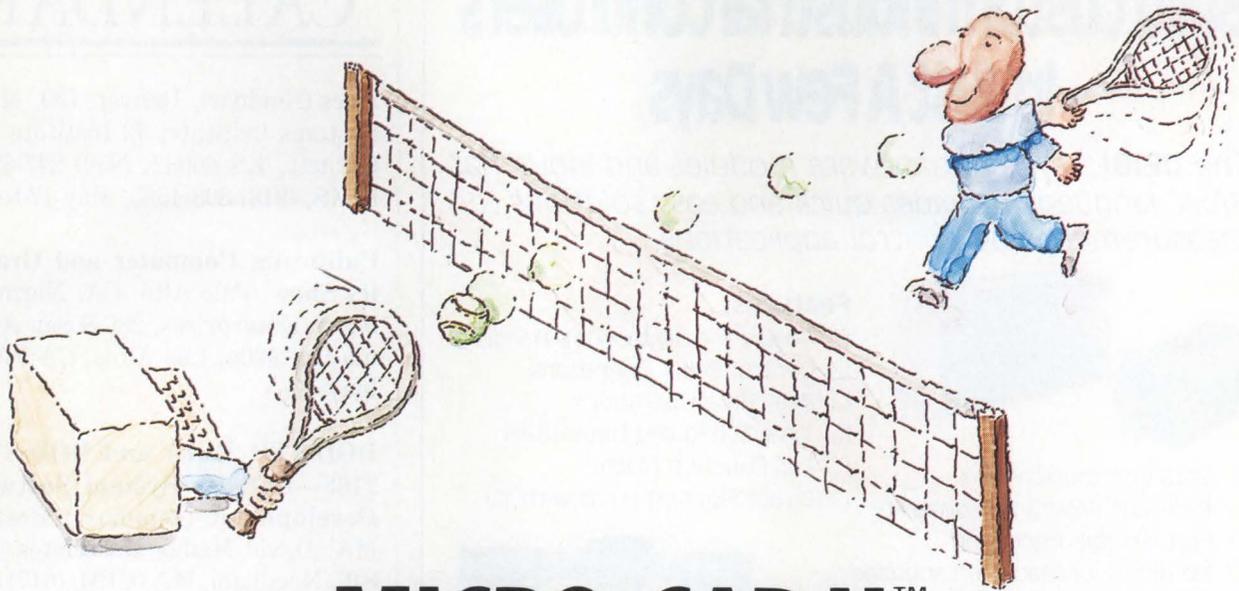
DOD-STD-2167A and DOD-STD-2168—Defense System Software Development (seminar), Washington, DC. David Maibor Associates, Box 846, Needham, MA 02194. (617) 449-6554. May 16 to 17.

IEEE Custom Integrated Circuits Conference, Rochester, NY. Roberta Kaspar, 20 Ledgewood Dr, Rochester, NY 14615. (716) 865-7164. May 16 to 19.

Modern Electronic Packaging (seminar), Minneapolis, MN. Technology Seminars, Box 487, Lutherville, MD 21093. (301) 269-4102. May 17 to 19.

C Programming: Hands-on Workshop (short course) Palo Alto, CA. Integrated Computer Systems, Box 3614, Culver City, CA 90231. (800) 421-8166; in CA, (213) 417-8888. May 17 to 20.

Troubleshooting Microprocessor-Based Equipment and Digital De-

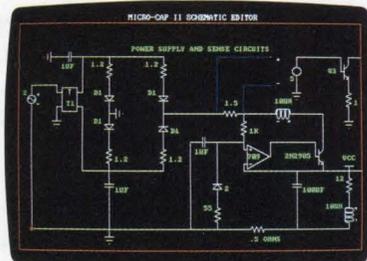


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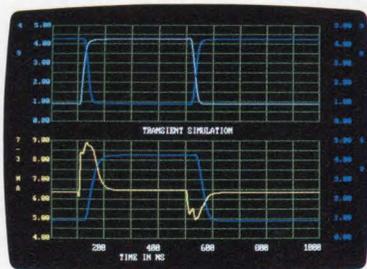
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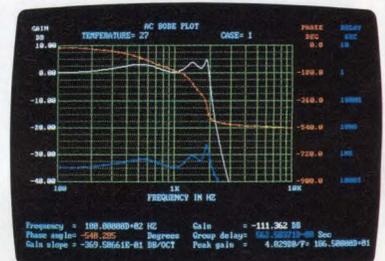
component values, and run worst-case scenarios—all interactively. And a 500-type* library of standard parts is at your fingertips for added flexibility.

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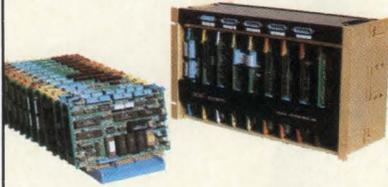
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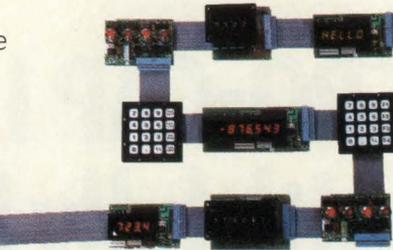
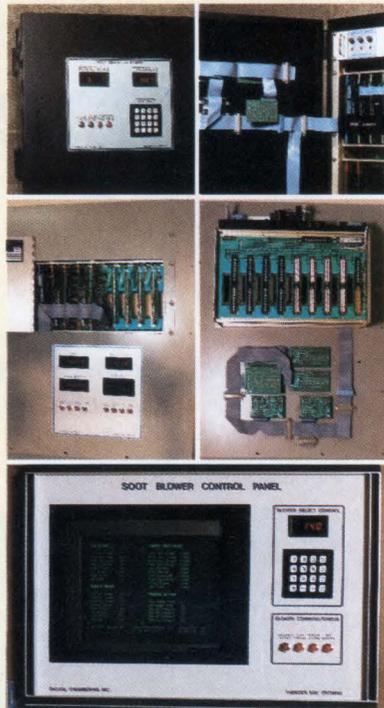
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CIRCLE NO 4

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CALENDAR

vices (seminar), Denver, CO. Micro Systems Institute, 73 Institute Rd, Garnett, KS 66032. (800) 247-5239; in KS, (913) 898-4695. May 17 to 20.

California Computer and Graphics Show, Palo Alto, CA. Norm De Nardi Enterprises, 289 S San Antonio Rd, #204, Los Altos, CA 94022. May 19.

DOD-STD-2167A and DOD-STD-2168—Defense System Software Development (seminar), Boston, MA. David Maibor Associates, Box 846, Needham, MA 02194. (617) 449-6554. May 19 to 20.

DOD-STD-2167A and DOD-STD-2168—Defense System Software Development (seminar), Orlando, FL. David Maibor Associates, Box 846, Needham, MA 02194. (617) 449-6554. May 23 to 24.

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

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

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

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



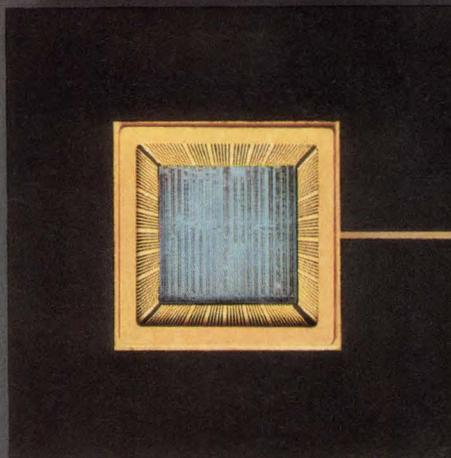
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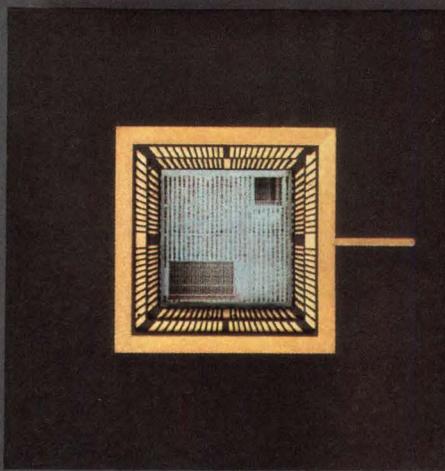
families, using compatible macrocell libraries and CAD software.

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GATES	880 to 6,000	540 to 10,000	3,200 to 10,000	2,100 to 50,000
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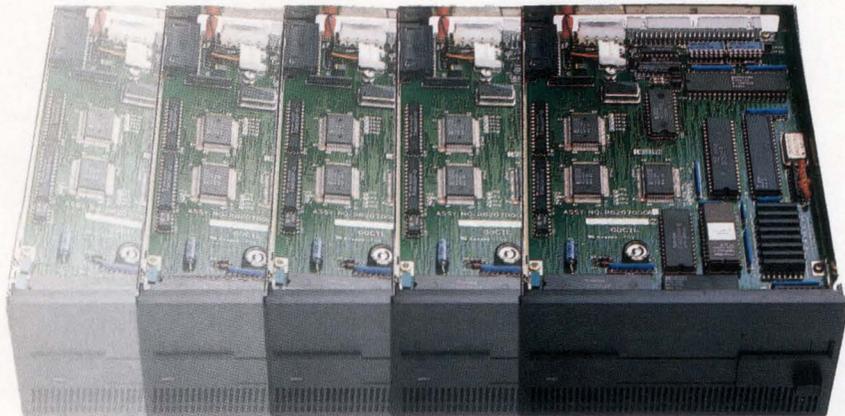
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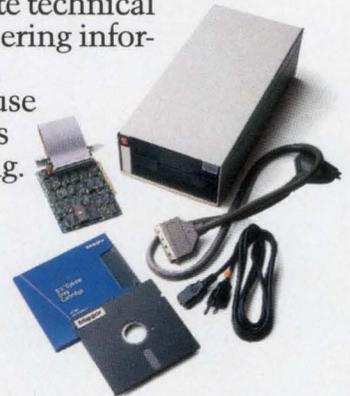
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EDITORIAL

Trouble in the Pacific



There's a formula somewhere that measures a country's strength by examining its economy, social structure, and political system. Unfortunately, recent newspaper and magazine reports from Pacific-rim countries emphasize economic strengths while ignoring political and social problems. If we are going to make decisions about the electronic industry's future, however, it's worth looking beneath the veneer of economics.

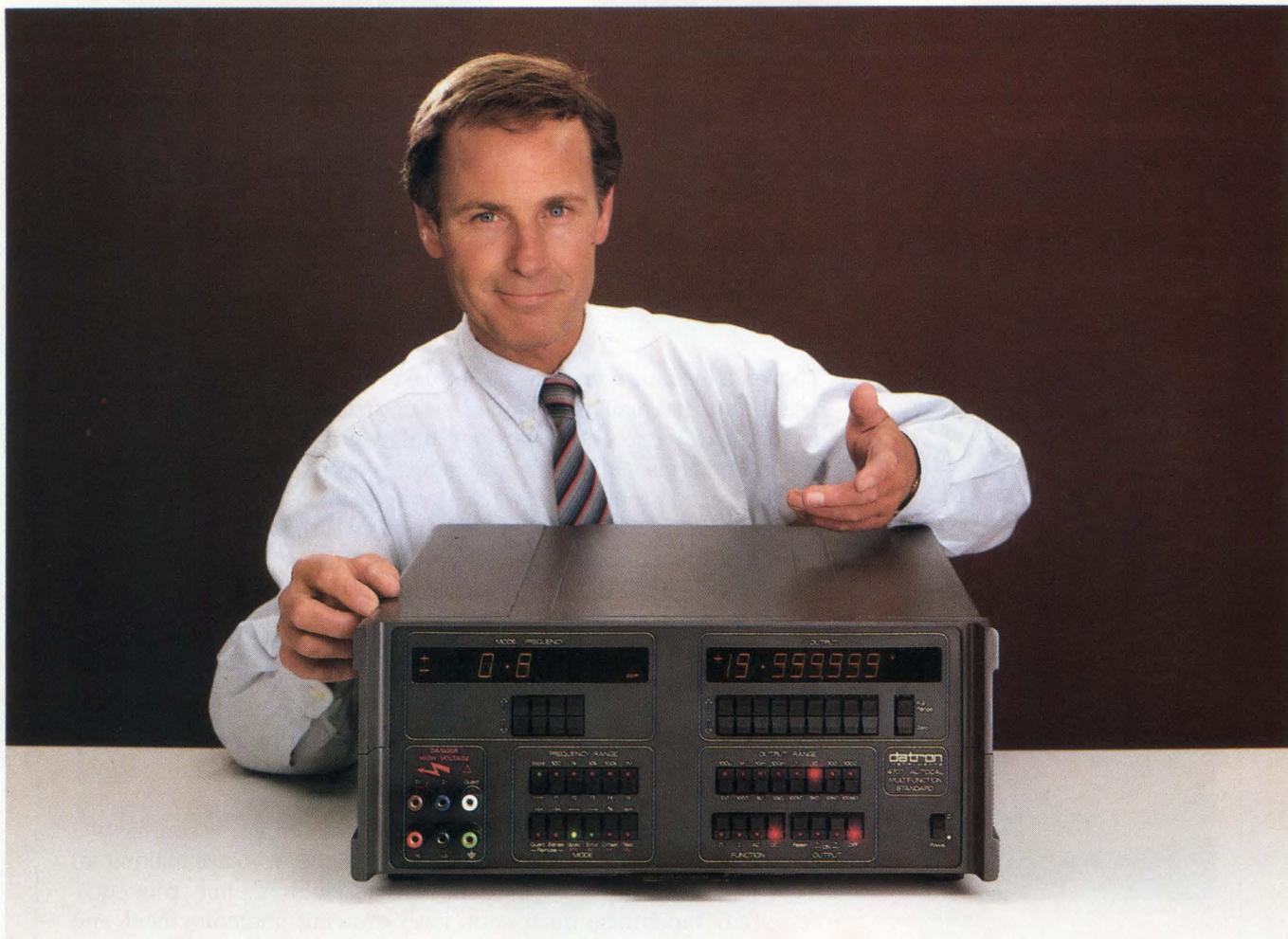
Among the Pacific-rim countries, Japan stands out as an economic power for others to emulate. Yet for all its economic strength, Japan has little global political stature and feels reluctant to undertake defense tasks in the northern Pacific. It's quite likely that in a confrontation between the USA and the USSR, Japan would retreat into isolationism and refuse to involve itself. Military and political strength cuts both ways. Memories of World War II haunt nearby countries that see little good in a strong Japan.

Japan faces other problems as well. For example, it confronts a lack of long-term-care facilities for older people, who are making up more and more of the population. And although it's not frequently reported, Japan also must cope with growing unemployment and the loss of heavy-industry jobs.

Korea, too, has problems. The Koreans spend heavily on defense, primarily to guard against attack from North Korea. Keep in mind that a state of war still exists between the two countries. South Korea's defense has worked for over 35 years, but much of it depends on a continuing US military presence. Future US Congresses may be reluctant to continue aiding a nation that adopts rigid protectionist trade policies. Korea must also deal with internal unrest brought about by radicals and moderates who want to overthrow or change the government.

And consider Taiwan, the Republic of China (ROC), which still lays claim to mainland China. The republic has no chance of retaking the mainland, but authorities consider any realistic talk about a separate and independent Taiwan to be seditious. The archaic Koumintang government still contains members—elected in 1947—who “represent” mainland provinces. Although both mainland China and the republic desire reunification, each has its own irreconcilable terms. The ROC also has internal problems. Only about 15% of Taiwan's population is from mainland China, yet those people dominate the country's government. The native Taiwanese want a greater say in their own affairs, but don't expect to see great upheavals in Taiwan unless mainland China presses for reunification at all costs.

The future of Hong Kong, which will revert to mainland China—the People's Republic of China (PRC)—in 1997, remains in doubt. Companies must wonder about their local investments in Hong Kong and how those investments will fare under PRC masters. The



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EDITORIAL

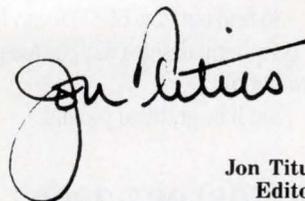
Evaluating the strength of Pacific-rim countries involves more than economics. Social and political structures require a close look, too.

British refuse to discuss adopting direct representative elections—a measure that might forestall the complete PRC domination of Hong Kong's laissez-faire economy. It's unlikely that the new Chinese leaders will destroy Hong Kong's economy, but they offer only vague promises of future economic and political flexibility. So, money and people from Hong Kong are already departing for Canada and the US. Labor is still plentiful and somewhat cheap in Hong Kong, but even more laborers are available at lower rates in mainland China. Once China and Hong Kong are unified, the latter may offer few new business advantages.

The fate of the Philippines also remains unknown. Corazon Aquino's "revolution" has just about run its course. Political assassinations, kidnappings, and rebel activities once again overshadow attempts at government reform. Peace talks between the government and communist and Muslim rebels have broken down, and a renewed commitment to US military facilities is in doubt.

Malaysia and Singapore—important manufacturing locations—form the southern end of the Pacific's economic rim. In Malaysia, the prime minister detains people and suspends the publication of newspapers for "disturbing the racial peace." Ethnic Chinese and Indians—among the most important economic segments of the population—remain restive. In Singapore, prime minister Lee Kuan Yew has prevented the distribution of several publications that refuse to bow to his censorship. Companies with significant investments in microcode should note that Lee recently suspended copyright protection for several publications. It could happen for bit patterns, too.

All nations and governments have their share of problems, and the events and situations noted above don't portend the demise of the Pacific-rim nations. But companies that rely upon Pacific-rim countries either as suppliers or for markets must consider the long-term stability of the region. After all, Iran was once a tower of strength and our foremost ally in the Persian Gulf. How quickly events sweep away preconceived notions of stability.



Jon Titus
Editor

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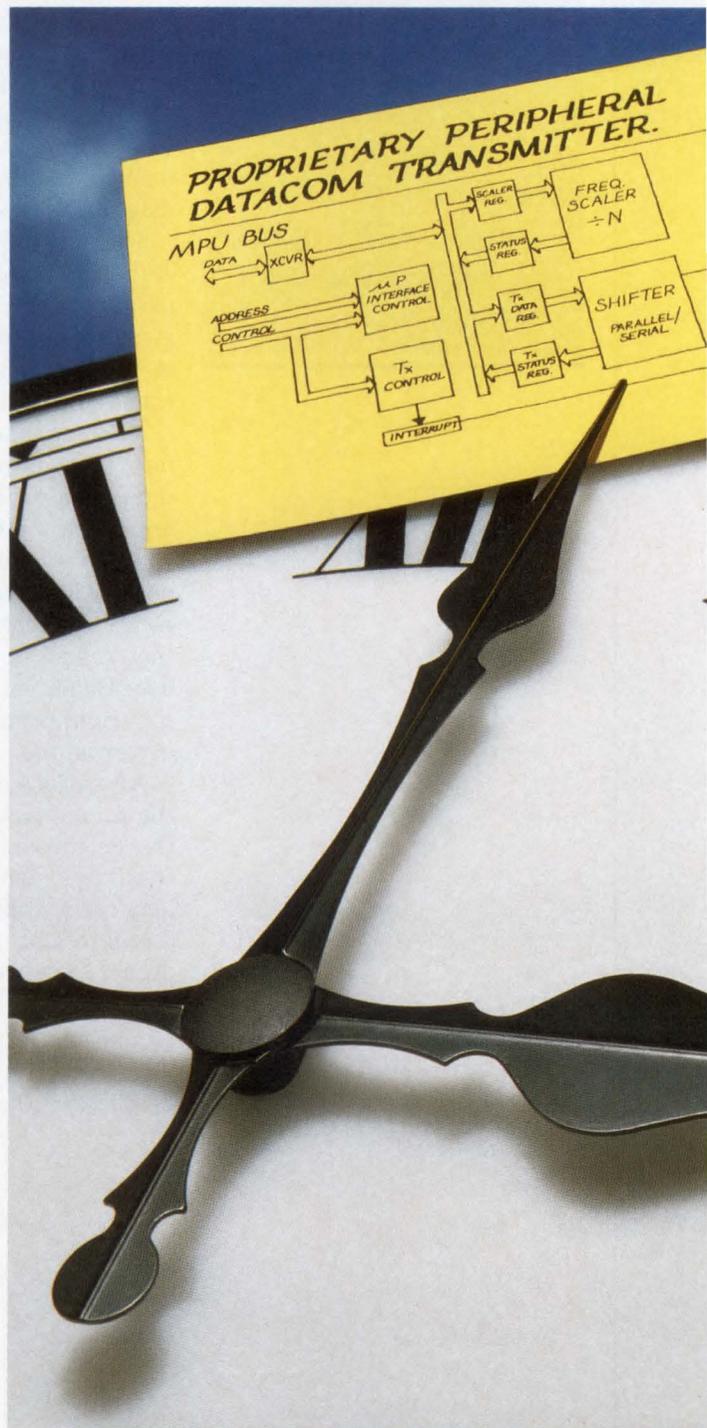
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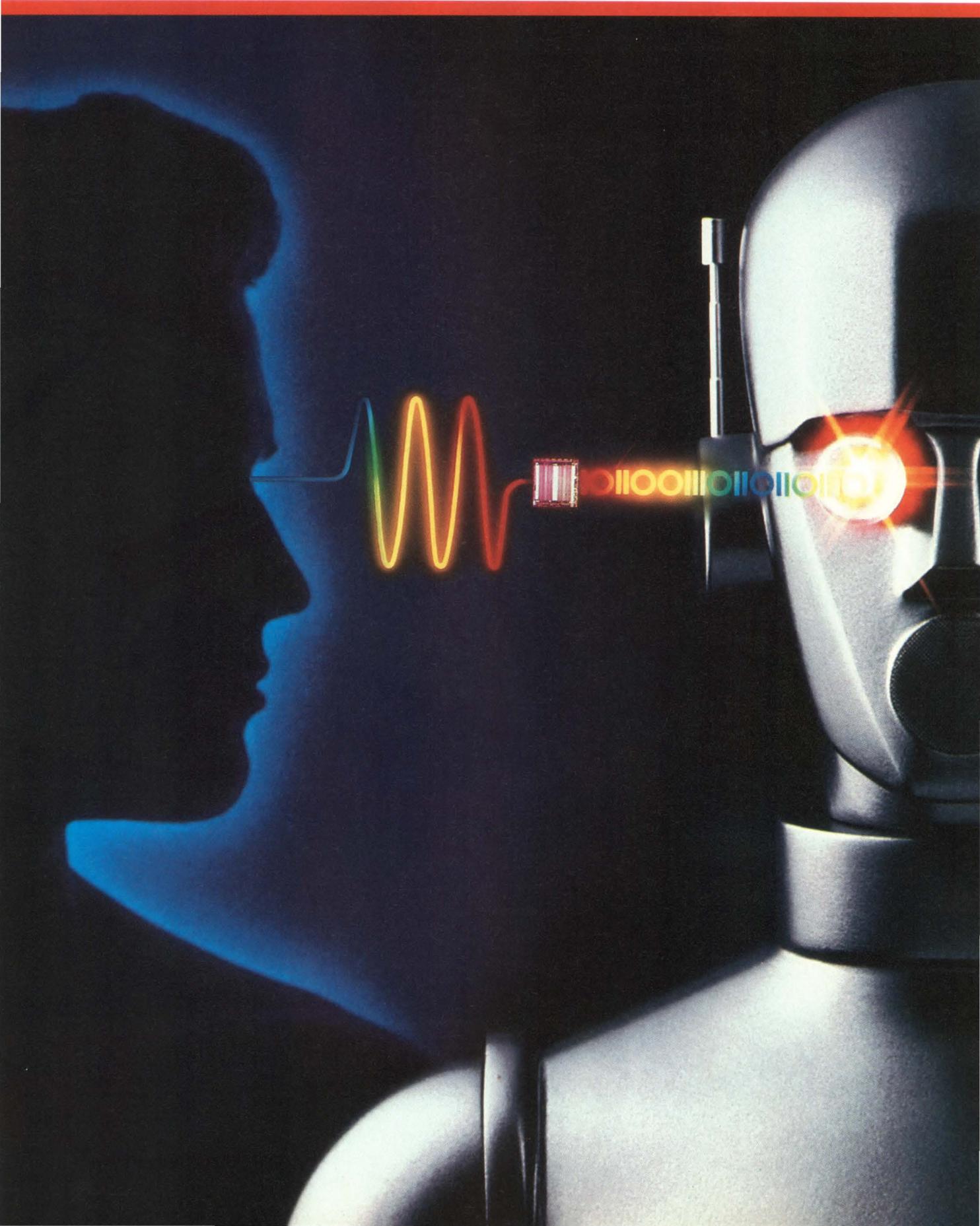


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CA3318E/3318CE	8	15M	150	24	38.50/24.00
CA3310E/3310AE	10	150K	15	24	6.00/8.00
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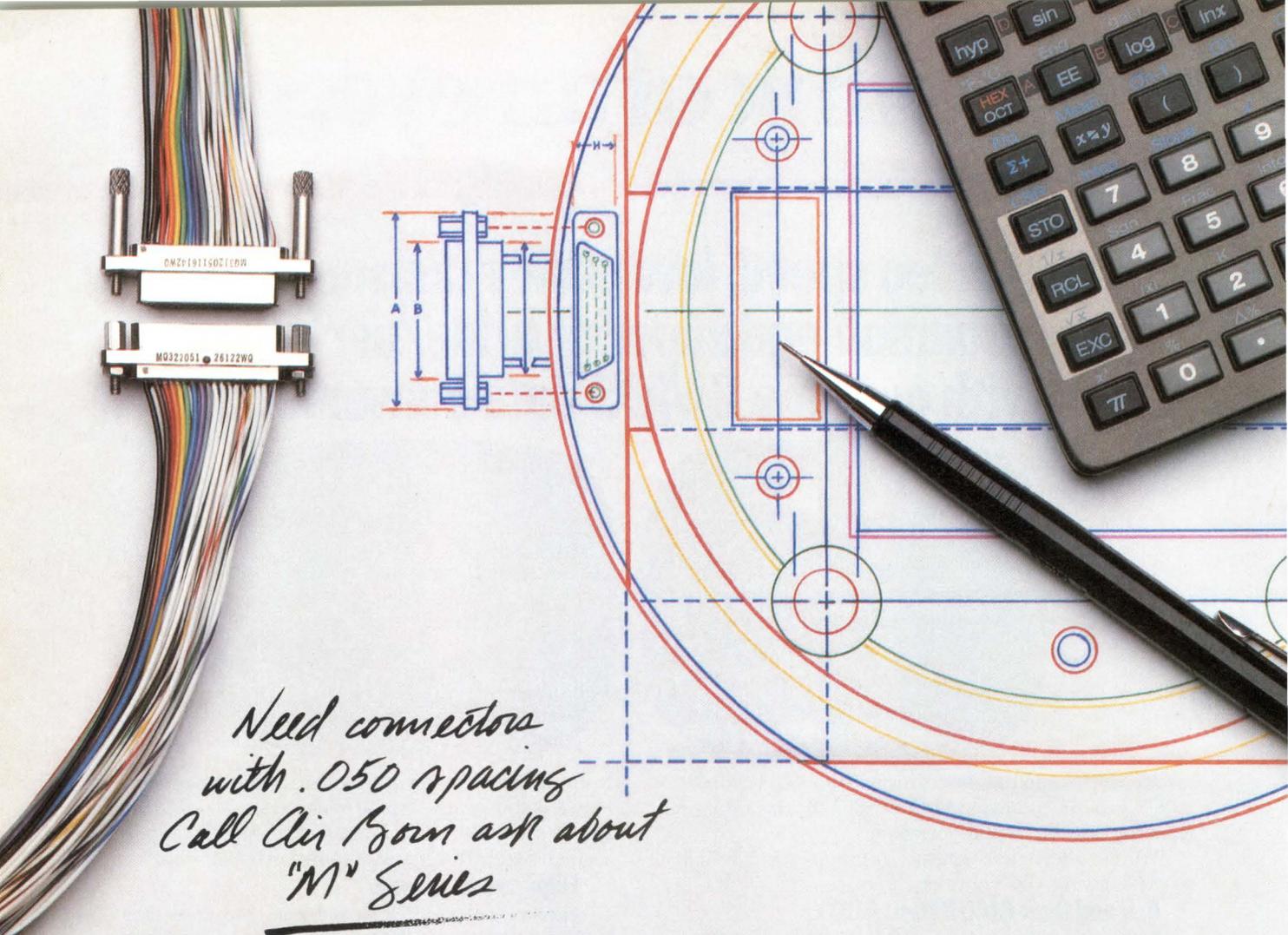


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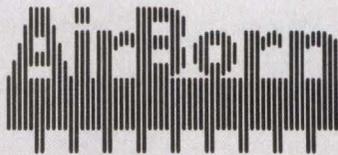
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TECHNOLOGY UPDATE

Sophisticated hardware and software beget efficient machine-vision systems

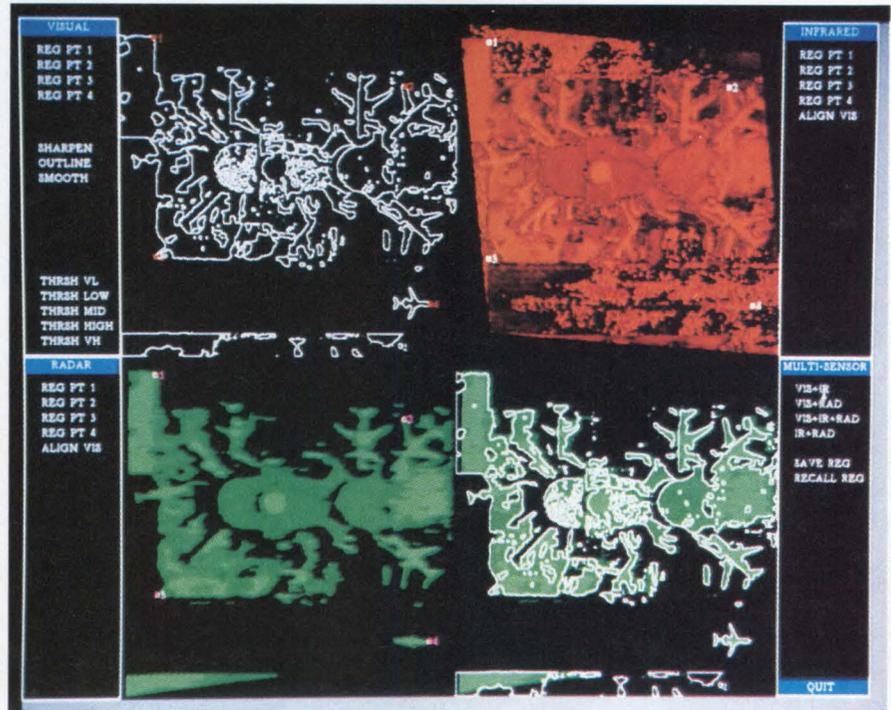
J D Mosley, *Regional Editor*

Because of recent developments in machine-vision technology, you no longer need a lot of specialized knowledge to develop vision systems that let machines search for and differentiate among patterns. You can now choose from an assortment of systems, subsystems, boards, and software packages that let machines efficiently perform such real-world tasks as examining ICs for defects or scanning products on conveyor belts.

Your choice of machine-vision equipment depends on your application and the amount of money you have to spend: The available products range from expensive, stand-alone vision systems that you can integrate in production equipment, to moderately priced boards for workstations or personal computers, to sophisticated software algorithms that let you create customized vision systems with standard hardware.

Using radar, infrared, and image-enhancement techniques, state-of-the-art machine-vision systems can literally see in the dark or identify microscopic imperfections in a surface. By using sophisticated pattern-recognition algorithms based on artificial-intelligence (AI) paradigms, the systems can identify and analyze images in such applications as government surveillance, semiconductor inspection, film colorization, and robot guidance.

Recognition Technology, a Westborough, MA, image-processing company, describes machine vision as a cycle that begins with image acquisition, proceeds to image storage, then continues with image enhancement, feature extraction, data



In darkness or over long distances, machines can "see" better than humans by combining a variety of sensor data obtained from a single scene. Visual Information Technologies' Model 120 uses four Parallel Image Processors (Pips) to perform parallel operations on multispectral data. The operations shown are visual with edge enhancement (top left), infrared (top right), radar (bottom left), and all three operations fused by the windowing and overlay operations (bottom right). (Visual data courtesy Hughes Aircraft)

reduction, recognition and decision making, and further data reduction. The cycle then repeats. Current machine-vision systems can perform the steps of this cycle fairly well, but they can't always perform them in real time. For example, in 1984, a robot called Neptune used a vision system to negotiate an obstacle-strewn 35-ft room at Carnegie Mellon University—but it took more than an hour to do so.

Consider the challenge of processing and analyzing the visual information contained in a 2-dimensional television picture, in which more than one million pixels change thirty times a second. Adding the third dimension further complicates the analysis. In computer terms—

according to Cognex Corp, a manufacturer of machine-vision systems—the human brain performs approximately 100 billion logical floating-point operations per second (flops) just to see objects and determine what they are. That performance is 400 times that of a Cray-1 supercomputer.

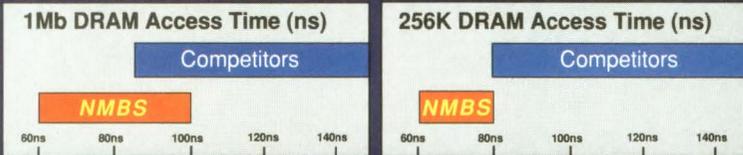
AI simplifies the task

Although you can't yet provide a machine with vision equivalent to human sight, you can focus the present technology to perform useful operations by limiting the scope of each specific vision task. For example, Cognex Corp uses artificial-intelligence (AI) techniques to modify a vision procedure that the company

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TECHNOLOGY UPDATE

refers to as "searching." Instead of resorting to intensive calculations to compare a stored image with a sample image—a process called "template matching"—Cognex scans the sample image at low resolution and uses AI-based algorithms to make intelligent guesses about where objects should be within the image. This searching technique can give a single pc board an equivalent throughput rate that's 30 times faster than that of a Cray-1 performing traditional template-matching calculations at its maximum speed, 1000 MIPS.

The company's latest product, the Cognex 1500, is a \$10,000 subsystem that can analyze the input from as many as four video cameras to locate objects and determine their positions. The 1500 was specifically designed to address the needs of OEMs and system integrators that design automated equipment for pc-board production, machine guidance, and alignment. The Cognex 1500 includes a rack-mountable chassis, a solid-state video camera, a monochrome video monitor, a trackball, cables, software, and documentation. You must supply an IBM PC to control the system via an RS-232C connection. The software's pull-down menus let you access the 1500's set of 25 instructions. You use the trackball to manipulate the cursor and to select commands, objects, and search regions.

The 1500 uses gray-scale pattern matching to locate objects and features in a scene. This method is more flexible and consistent than binary pattern-matching techniques, and it provides accuracy of better than ± 0.001 in. It helps the 1500 achieve processing times ranging from 0.050 to 0.500 sec, depending on the desired accuracy, object size, and scene complexity. In addition, the embedded image-analysis algorithms let the 1500 identify the correct pattern even when the image is degraded, or when changes in color, reflectance, orientation, or contrast occur. Even a poorly fo-



Able to overcome such real-world problems as a defocused lens or reduced contrast caused by poor lighting, a \$10,000 (OEM) Cognex 1500 starter kit includes an electronics module, a video camera, a lens kit, a monitor, a trackball, cables, and documentation. You supply the PC host, which communicates with the 1500's electronics module via an RS-232C link.

cused lens will not prevent the system from correctly identifying a pattern; however, the company does note a reduction in image quality on a 1000-part scale.

The correlation values produced by the gray-level pattern-recognition technique are statistically normalized for image gain and offset. Thus, the technique is insensitive to variations in light intensity and contrast even within a single image. Placing a colored filter over a portion of the object won't prevent the Cognex device from identifying the object.

The 1500 identifies the x and y coordinates of the pattern, and it comes with calibration software that translates the visual data on the screen into the corresponding real-world units of measure. It can thus permit a robot to reposition misaligned objects. The 1500's vision-processor board includes a 12-MHz MC68000 μ P, an image digitizer with a resolution of 576×448 pixels and with 64 gray levels, as much as 2M bytes of dynamic RAM, a 512k-byte ROM, 128k bytes of battery-backed CMOS RAM, and a proprietary vision coprocessor that

implements pattern matching in hardware. This proprietary vision IC is a custom circuit that interprets images through gray-scale normalized correlation; it interfaces to any 68000-family CPU. The 1.5- μ m CMOS chip can perform normalized correlation three times faster than a board-level circuit, yet costs one-tenth as much.

For designers who want more extensive vision capabilities, the company also offers the Cognex 2000/DS vision-development system, which lets you write custom application programs in C on your IBM PC or compatible computer. As soon as you have debugged an application program, you can download it to a floppy disk or burn it into EPROMs to transfer full control to the 2000/DS. You need the PC only for editing, program development, and downloading.

The 2000/DS performs the same functions as the 1500, but adds image processing to manipulate its output, as well as development access to C function calls and programming utilities. The 19-in., fan-cooled, rack-mountable chassis contains a single-board vision processor (the chassis has slots for as many as four vision-processor boards), a card-cage/backplane assembly, a power supply, an 800k-byte floppy-disk drive, three RS-232C ports, six TTL digital-input ports, four TTL digital-output ports, and a 64-byte I/O expansion port. The 2000/DS also comes with a 12-in. monitor, a trackball, cables, a solid-state camera, system software and utilities, searching software, character-recognition software, inspection software, a communications program, and a text editor.

Adaptive automation meets Mac

Another challenge that developers of machine-vision systems face is that of allowing systems to adapt to changes in their environment. To enable machines to react to changes in industrial surroundings and to adjust to variations in parts, manu-

TECHNOLOGY UPDATE

facturing processes, object location, and equipment speed, Automatix Inc combines standard sensors and controllers with application-specific software to create a variety of "adaptive automation" systems.

Automatix, which has already installed more than 1000 of these systems, offers a broad line of machine-vision products. Microspec, for example, is a \$100,000 SMD-inspection system that examines pc boards for missing, misplaced, or incorrectly oriented components. Partracker is a software package that locates parts and solves fixturing and fit-up

problems prior to robot manipulation; Seam Tracker is a vision-guided welding system. The firm also offers AI 90, an \$8500 ruggedized Macintosh II-compatible computer for industrial applications, and Autovision 3, a \$17,500 menu-driven vision and robot-guidance system. Every customer that purchases an Automatix product receives membership in Acuity, an international user group for industrial vision systems.

Central to the Automatix concept of adaptive automation is the Rail programming language. This pro-

prietary interpretive language is written in C and is designed for vision processing, high-speed calculations, and robotic control. It includes algorithms for edge detection, gray-scale gradient detection, convolution filtering, structured light analysis, and connectivity analysis. With this language, your system can control as many as 16 cameras. The interpreter includes diagnostic software. Rail comes with all Autovision systems; you can order the source code under a special licensing agreement.

For \$23,000, you can also order

Neural networks help a system learn to see

Machine-vision systems represent an attempt to give machines an analog to human vision that robots and other types of computer systems can use. To improve the way machines understand and use this sensory data, engineers are using an artificial-intelligence technology called neural networks.

Neural networks are intended to emulate human learning patterns; they contain loosely coupled processing elements, or nodes, that compute activity locally and share those computations with other nodes according to a weighted transfer function. Their goal is to mimic the way human brain cells exchange information and to mimic the way the brain weights the information transfer among brain cells.

Nestor Inc, which was founded in 1975, is reportedly the oldest of the neural-network companies. The company has adapted this parallel-processing-oriented technology for use with serial-processing von Neumann hardware—specifically with IBM PC/ATs, Sun workstations, and Apollo workstations. The \$25,000 Nestor Development System (NDS) uses neural-network technology to solve a wide variety of pattern-recognition problems. To use the system, you need a PC/AT or Sun or Apollo workstation with at least a 1.2M-byte floppy-disk drive, 640k bytes of RAM, and a 20M-byte hard-disk drive. If you use a PC/AT, you must have an EGA- or VGA-compatible interface and monitor, MS-DOS 3.0 or higher, a Microsoft C compiler (version 4.0 or higher), and a Microsoft mouse. You must use C for software development—all of the NDS code is written in C, although portions of the training program and the code described in the tutorial are supplied by the manufac-

turer as source code.

The resulting system generates a Restricted Coulomb Energy (RCE) neural network. The network develops weighted pattern maps, solving categorization problems by assigning probability estimates of complex relationships to the relevant variables. The RCE network is a patented model that uses three processing layers. The input layer has nodes that register the value of a feature of the input. The output layer has nodes that correspond to a pattern category; the fewer the output nodes triggered by a certain input, the less ambiguous the input and the greater the certainty about a pattern's identity. The internal layer of nodes constructs the mapping that will trigger the correct output node in response to a given input pattern. The network "learns" by adjusting internal-node thresholds with training signals that move from the output layer back into the internal layer.

In an RCE network, memory is stored in weight vectors between the input layer and the internal layer. Training affects only areas of the memory associated with local vectors, therefore. Accordingly, Nestor's RCE network lets you add new information without retraining the entire system; you address only the nodes associated with a particular vector threshold.

To use the Nestor Development System, you must write a feature-extractor program. The company provides examples of feature extractors in C source code. You then train the system by presenting it with a series of classified patterns; the system batch processes the patterns and uses them to define the system architecture and to store the training/testing protocol.

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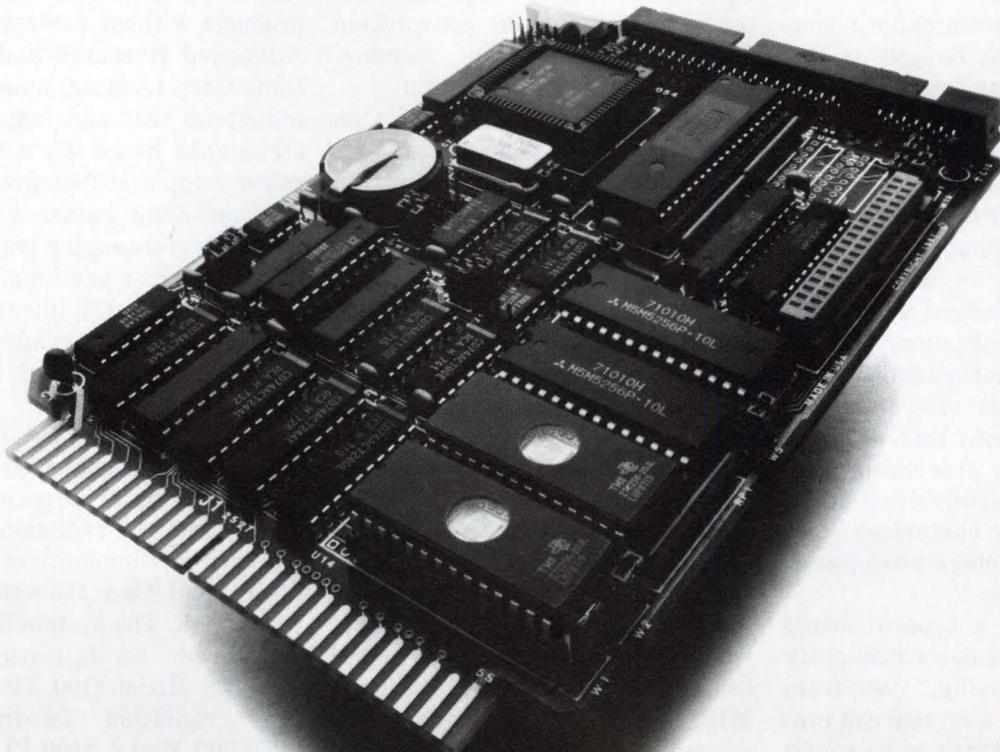
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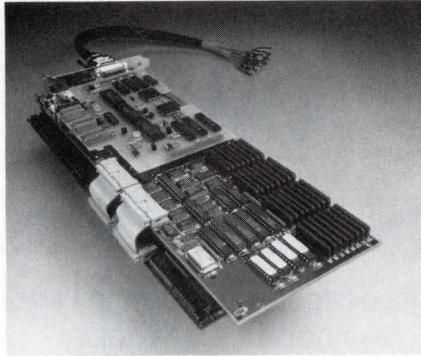
TECHNOLOGY UPDATE

the Automatrix Lab Development Package, which is based on the Autovision 3 and includes a CCD camera, cables, lenses, Rail, two floppy-disk drives, a 12-in. CRT, a keyboard, and manuals. The package comes with an assortment of software, including a menu-driven visual gauging system, a program that increases the speed of selected connectivity calculations, a program that identifies parts by their silhouettes, a program that uses convolution operations to locate and analyze edges and lines, a program that calculates and compares gray-scale averages and histograms, and a program that performs arithmetic and logical operations on the contents of pixel buffers.

Image processing gets smart

If you don't want to spend the money for a programmable vision system, you might be able to get away with using an image-processing system instead. Image processing is only a subset of the complex task of machine vision, but vendors have recently introduced some more-advanced image-processing systems that may be able to take the place of full-fledged vision systems in certain applications. For example, Visual Information Technologies Inc (Vitec) offers "image computers," systems that do more than mere image processing. According to the company's definition, image computing comprises computer graphics, image processing, and image analysis.

An example of a type of image computing is multisensor fusion. By combining, or "fusing," data from different sensors, a system can provide information that's more useful to you than the separate output from individual sensors. For example, Vitec's image computers can perform multisensor fusion by using Parallel Image Processor (Pip) chips to perform parallel operations on multispectral data gathered from the same scene by different sensors. The Pips are custom VLSI array



Plug-in boards for PC-based image processing such as Data Translation's DT2871 color frame-grabber board) let you perform gray-scale processing, hue and saturation processing, and frequency-domain analysis at capture and display rates reaching 30 frames/sec. The DT2871 plugs into the DT7020 floating-point array processor to boost system performance during computation-intensive operations such as color edge detection, compression, and FFT analysis.

processors that are specifically equipped to handle computation-intensive tasks such as convolution filtering, scaling, rotating, zooming, blending, and pixel replication.

To perform multisensor fusion on data gathered from an aircraft, for instance, you could have one Pip perform image-enhancement and edge-detection operations on visual data from a video camera while another Pip processes infrared data. At the same time, a third Pip could process radar data, and a fourth could perform windowing and overlay operations on the three types of data. By combining the visual, infrared, and radar data and fusing the result, you can greatly enhance your ability to interpret the data.

Vitec offers two image-computing systems, Model 100 and Model 120, which start at \$30,000. Model 100 has four Pips that can execute 122 MIPS; four 27-MHz video processors; 6M bytes of image memory; and a 13-in., 640×480-pixel RGB monitor. The Model 120 comes with four Pips that can execute 160 MIPS; four 107-MHz video processors; 10M bytes of image memory; and a 19-in., 1280×1024-pixel RGB monitor. Each model also comes with a 16.67-MHz 68020 CPU; a 68881 floating-point coprocessor; a

32-bit VME Bus; a 140M-byte, hard-disk drive; a 60M-byte, ¼-in. tape drive; a 94-key keyboard; and a 3-button optical mouse.

The systems also come with several software packages: Vitec's Image Display List System (IDLS) for application development; an interactive IDLS script interpreter; an IDLS script-to-C translator (pre-processor); a version of the X-Windows program (developed at MIT) that has enhanced imaging features; the company's Imaging Window and Menu Tools (IDLX); a primitive module for image and graphics algorithms; and Unix, which is integrated with the Network File System (NFS).

Machines that have x-ray scanning abilities can outperform human inspectors on assembly lines, because the machines can evaluate products without destroying them. Advanced Research and Applications Corp (Aracor) manufactures industrial test and inspection instruments based on a technique called computed tomography (CT). This technique passes a collimated x-ray beam through a test object to render a cross-sectional image of that object. A CT image displays more than 1000 times more information than conventional x-ray film processes do.

Aracor has transferred this technology to the Model 4100 automatic semiconductor-irradiation system, which tests the radiation tolerance and latch-up immunity of electronic devices and ICs at the wafer stage of production. The system is available in three configurations: The \$163,000 Model 4100 XP measures only radiation hardness; the \$259,000 Model 4100 PL provides independent testing for latch-up and radiation hardness; and the \$310,000 Model 4100 XPL integrates and automates the radiation and latch-up tests.

Another way to build a machine-vision system is to buy image-processing software for use on one of the major workstations and hook up

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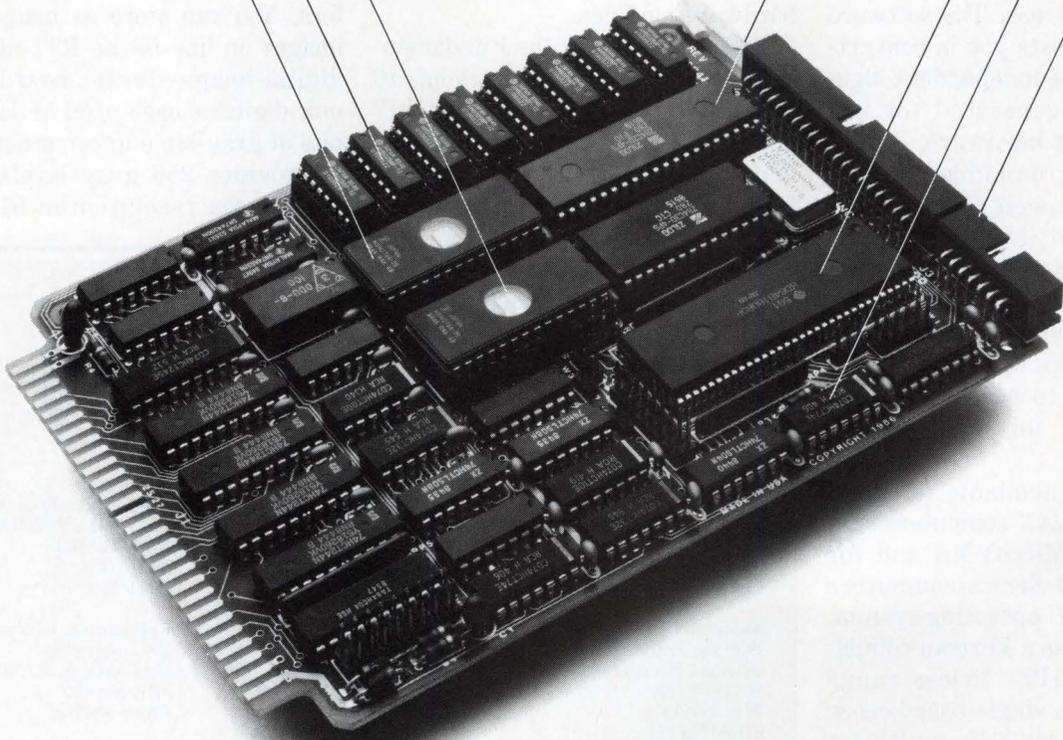
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your own video camera for gathering data. Logica Inc's Vista-IPS tool kit, for example, is a hardware-independent software-development environment for image-processing algorithms. It has a multiuser environment and two separate user interfaces—one is a high-level interface that offers commands that resemble Basic; the other is a low-level programming environment that lets you use Vista-IPS utilities to develop image-processing primitives in your host computer's high-order program-development language.

Vista-IPS provides access to more than 200 primitives supplied in Fortran source code. You can nest as many as nine levels of test procedures for flexibility at the experimentation and design phases of the development process. The software package also assists you in converting the hardware-independent algorithms you've generated for use with the target hardware. Vista-IPS uses foreground/background processing to speed the development cycle, and it supports both interactive and batch processing. Its Autoload command provides automatic loading of procedures and primitives, and its windowing facility enables you to process smaller portions of an image or "subimages."

Vista-IPS is available for DEC VAX and MicroVAX computers running VMS or MicroVMS and for Masscomp 5000 Series computers running the RTU operating system. You must also use a Fortran compiler with Vista-IPS. Prices range from \$6000 for a single-user license to \$20,000 per copy for multiuser systems.

Menu-driven library

Recognition Technology offers a menu-driven library of routines written in (and callable from) the C language. The library lets your IBM PC, Multibus, or VME Bus host control the company's line of image-processing boards and subsystems. The \$1795 library, RTILib/500, con-

tains more than 300 routines that are specifically developed for machine-vision and image-processing applications. For dedicated applications, you can bypass the menu-driven executive.

The library is structured in three layers. You use the interactive, menu-driven executive layer to execute most of the RTILib/500 subroutines. The layer of high-level, C-callable subroutines performs such functions as image transforms and utilities, spatial and temporal filtering, region growing, arithmetic and statistical operation, and graphics processing. The third layer is a layer of low-level primitives and macros that provides access to the control and status registers and data tables of the various image-processing hardware modules.

RTIExec includes the Fundamental Vision Tools Menu, which has 16 screens, each offering seven to 17 additional selections. A help menu and a menu of utilities are accessible from all the other menus in

RXIEExec. Because most of the menu-driven commands have a one-to-one correspondence with RTILib's C-callable routines, you can quickly translate a string of menu calls into a dedicated program.

The company's latest subsystem that uses the RTILib/500 software package is the RTI-Station, a stand-alone box that connects to your IBM PC, Sun or Masscomp workstation, Multibus host, or VME Bus computer. For real-time performance, the unit includes a 10-MHz pipeline pixel processor that passes 18 bits of data bidirectionally on each clock cycle. To avoid overloading the host computer's bus, the RTI-Station contains multiple synchronous video buses for high-speed image transfers. You can store as many as 20 images on line in the RTI-Station's digital-image-storage boards. The unit digitizes each pixel of data as 8 bits of gray-scale information; thus, it provides 256 gray levels at an active-area resolution of 512x512

For more information . . .

For more information on the vision systems 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 Research and Applications Corp (Aracor)
425 Lakeside Dr
Sunnyvale, CA 94086
(408) 733-7780
Circle No 710

Automatix Inc
1000 Tech Park Dr
Billerica, MA 01821
(617) 667-7900
TLX 951518
Circle No 711

Cognex Corp
150 Gould St
Needham, MA 02194
(617) 449-6480
TLX 948022
Circle No 712

Data Translation Inc
100 Locke Dr
Marlboro, MA 01752
(617) 481-3700
Circle No 713

Datacube Inc
4 Dearborn Rd
Peabody, MA 01960
(617) 535-6644
TWX 710-347-0125
Circle No 714

Digital Vision Inc
66 Eastern Ave
Dedham, MA 02026
(617) 329-5400
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Woburn, MA 01801
(617) 938-8444
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Logica Inc
3 Embarcadero Center
Suite 1720
San Francisco, CA 94111
(415) 397-0496
Circle No 717

Nestor Inc
One Richmond Square
Providence, RI 02906
(401) 331-9640
TLX 272848
Circle No 718

Recognition Technology
160 E Main St
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(617) 366-4800
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Visual Information Technologies Inc (Vitec)
3460 Lotus Dr
Plano, TX 75075
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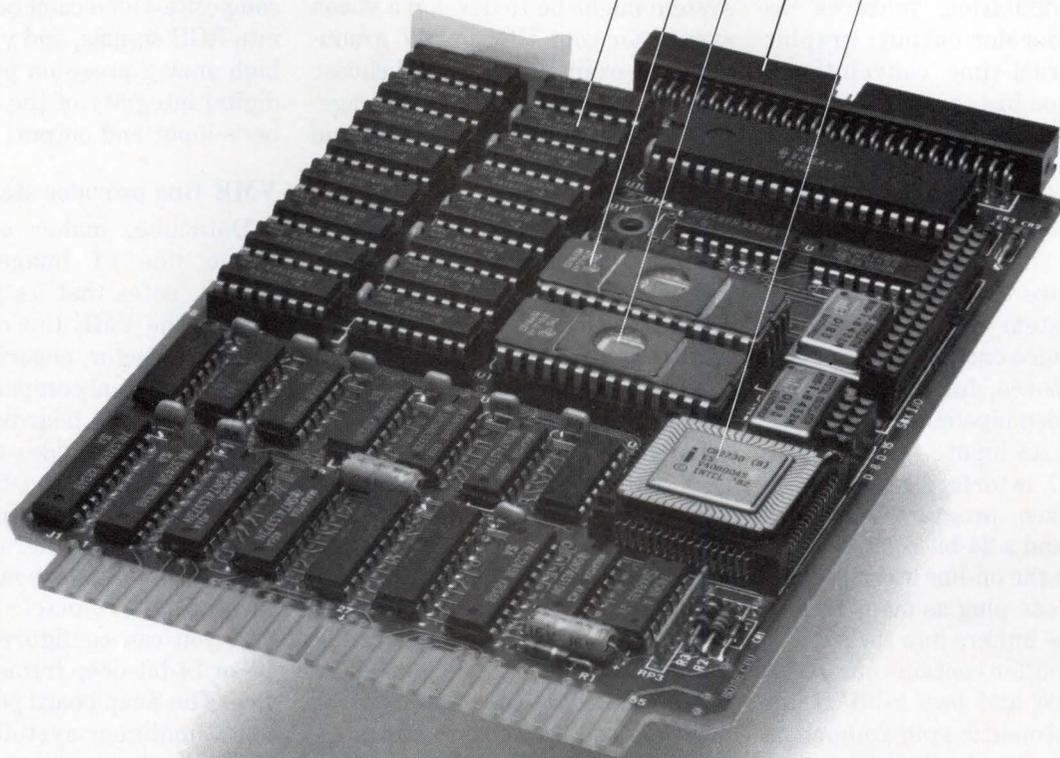
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pixels. Prices for the RTI-Station start around \$10,000.

Faster-than-real-time imaging

Offering an 8-bit image-processing speed faster than $\frac{1}{30}$ sec on a PC/AT-type computer, the Series 151 subsystem from Imaging Technology connects to your IBM PC/AT or VME Bus computer via a proprietary interface that lets the PC/AT control the subsystem's operation. This \$11,495 package gives you RS-170, RS-330, and CCIR 8-bit video acquisition. Its onboard, dual-ported frame memory can store multiple images. The 151's pipeline processing and expandable architecture enhance the subsystem's performance. Its I/O look-up tables and read/write registers facilitate such image-manipulation features as RGB pseudocolor output, graphic overlays, real-time convolutions, and real-time histograms.

The subsystem uses separate boards for its A/D interface (ADI-151), frame buffer (FB-151), pipeline processor (ALU-151), real-time convolver (RTC-151), and histogram/feature extractor (HF-151). The subsystem also uses separate buses for video data from the A- and B-frame stores, for graphic overlays, for video pipeline data, and for the video data input.

The A/D interface includes an 8-bit digitizer, programmable gain and level, and a 24-bit color display. To increase the on-line storage capability, you can plug as many as four of the frame buffers into the subsystem; each buffer contains one 16-bit frame store and two 8-bit frame stores. Automatic spin compensation adjusts for pipeline-processing delays. The pipeline processor performs three types of real-time image processing: arithmetic, logical, and bit-plane oriented. The histogram/feature extractor offers 10-bit histograms and performs feature extraction of as many as 16 features simultaneously.

The Series 151 subsystem comes with a driver-level software pack-

age called Toolbox that helps you integrate the subsystem with your host computer. You can order IteX, an optional subroutine library of image-processing functions, which includes programs for look-up-table operations, image save and restore, graphics functions, area and image geometry, image analysis and point processing, and linear/nonlinear operation. The company's line of image-processing products ranges from the \$1995 PCVision+ frame grabber (for IBM PCs and compatibles) to the \$28,995 Series 200 image-processing subsystem for (MicroVAX II hosts).

PC/AT-based vision systems

Another alternative to buying a costly, dedicated machine-vision system might be to develop a vision system for your IBM PC/AT gradually. For example, you could choose from the plethora of plug-in image-processing, array-processing, and data-acquisition boards that Data Translation offers, and mix and match the boards to design a custom system. The company's latest image-processing board is the \$2995 DT2871, a color frame grabber with a Hue-Saturation-Intensity (HSI) chip set, which converts the red-green-blue (RGB) images from a color video camera to hue, saturation, and intensity values in $\frac{1}{30}$ sec. The DT2871 captures images in 512x512-pixel resolution; each pixel represents one of 16,777,216 colors.

The benefit of converting RGB images to HSI values is that each H, S, and I value can be processed independently of the other two values. You can therefore perform operations on the visual data that you can't perform on mere RGB images. For example, to learn about the frequency and distribution of the image's colors, you can generate a histogram from just the hue values. To enhance edges or remove white noise from a color image, you can perform a convolution on just the intensity values.

Because manipulating the hue,

saturation, or intensity of an image is simpler and faster than manipulating RGB information, the DT2871 color frame grabber lets a PC/AT perform color conversion in real time. The DT2871 can also convert HSI data back to an RGB image after processing.

The company offers the Aurora Subroutine Library for the DT2871; the library costs \$995 and provides Pascal, C, and Fortran subroutines that permit color-image capture, processing, and display. It also lets you perform graphics operations, and it supports the functions of the \$995 DT2869 video decoder/encoder, which the vendor offers as an accessory for the DT2871. The decoder/encoder reformats standard NTSC or PAL video signals from composite-video cameras and VCRs into RGB signals, and vice versa; its high analog precision preserves the digital integrity of the frame grabber's input and output.

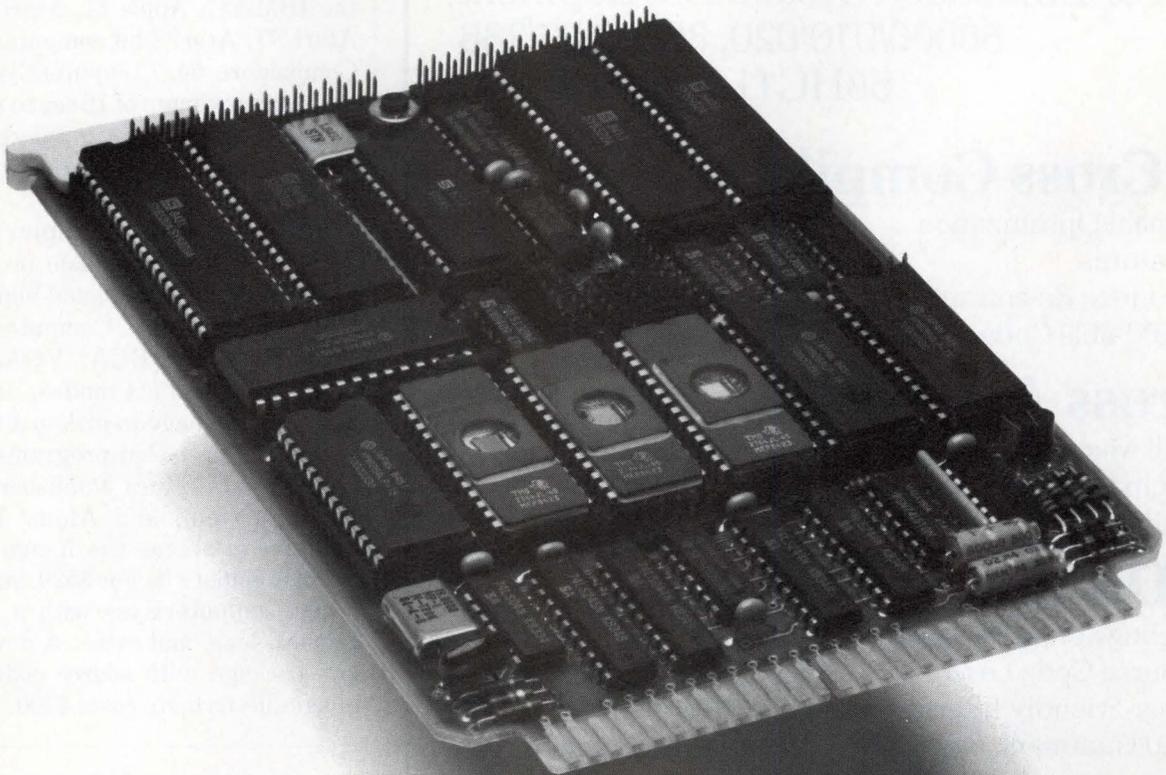
VME Bus provides standard

Datacube, maker of the Max-Video line of image-processing boards, notes that its products adhere to the VME Bus double Euro-card form factor, ensuring electrical and mechanical compatibility with other vendors' boards. The Max-Video family includes the DigiMax video-signal A/D and D/A converter, which accepts input from as many as eight cameras. The vendor's FrameStore board provides three 512x512-pixelx8-bit stores that you can configure as a single 16- or 24-bit-deep frame-storage device. The Snap board performs real-time, nonlinear systolic-neighborhood processing at 180 million 8-bit comparisons/sec. The Max-SP signal processor lets you merge multiple images, perform barrel shifting, and multiply. The VFIR linear pixel processor can perform 100 million 20-bit precision multiply-accumulation operations/sec.

For \$1000, you can buy MaxWare version 2.0, a software support package that provides primitive and

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diagnostic support for the aforementioned boards, as well as a number of other boards, including the ROIStore region-of-interest frame store, the MaxScan asynchronous digitizer module, the MaxMux digital crosspoint switch, and the MaxGraph graphics-overlay board.

Low-cost imaging available

As high-end products gain more sophistication and features, the technology trickles down to low-end systems, improving the capabilities of the inexpensive imaging packages available for such computers as the Atari ST and the Commodore 64. For example, Digital Vision Inc offers a \$250 slow-scan image-capture program called ComputerEyes for the IBM PC, Apple II, Atari IIgs, Atari ST, Atari 8-bit computer, and Commodore 64. ComputerEyes requires a maximum of 12 sec to scan a single monochromatic image at a resolution of 640×200 pixels with 64 gray levels.

Besides offering simple digitizing, ComputerEyes also provides gray-scale, false color, and high contrast for the image. ComputerEyes supports CGA, EGA, VGA, and Hercules graphics modes. It lets you save an image to disk in a variety of formats so that programs such as Xerox's Ventura Publisher, Microsoft's Gem, and Aldus' PageMaker can access the image data and manipulate it. For \$520, you can order ComputerEyes with a video camera, lens, and cable. A developer's package with source code and image-file formats costs \$100. **EDN**

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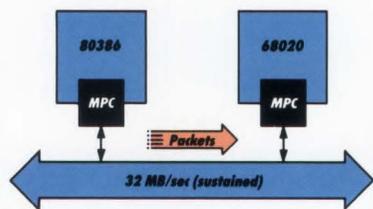
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	PIN USAGE (MPX) Multiplexed (NON) Non-Multiplexed	NON
	ARBITRATION (CENT)ralized (DIST)ributed	CENT.
	INTERRUPTS (DED)icated (VIR)tual	DED.
	GLOBAL MEMORY Communications	YES
ADVANCED FEATURES	PARITY	NO
	AUTO-CONFIGURATION (Geographic Addresses)	NO
	MESSAGE PASSING (Hardware)	NO
OTHER FEATURES	BUS I/F SILICON	NO
	ADDRESS WIDTH (Bits)	20,24
	DATA WIDTH	8,16
	BOARD AREA (sq. in.)	84
	CONNECTOR TYPE	EDGE
	MAX. 5V POWER (Per slot)	24A

*Implemented outside IEEE 1014 using several proprietary schemes.

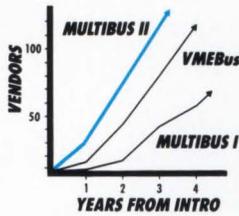
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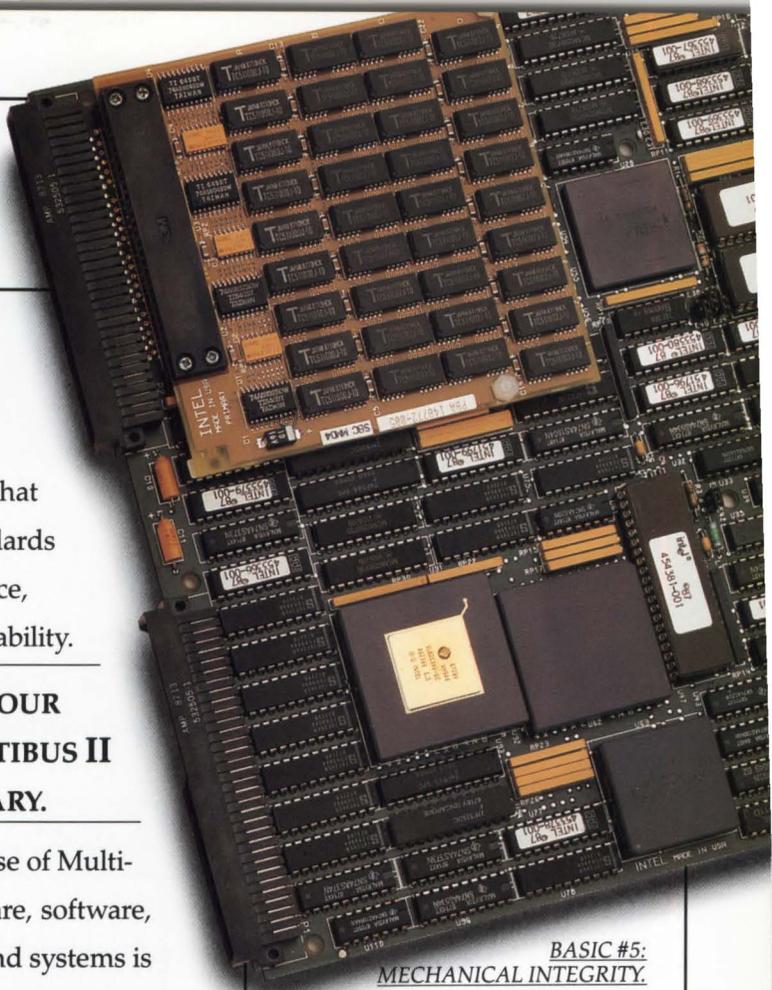
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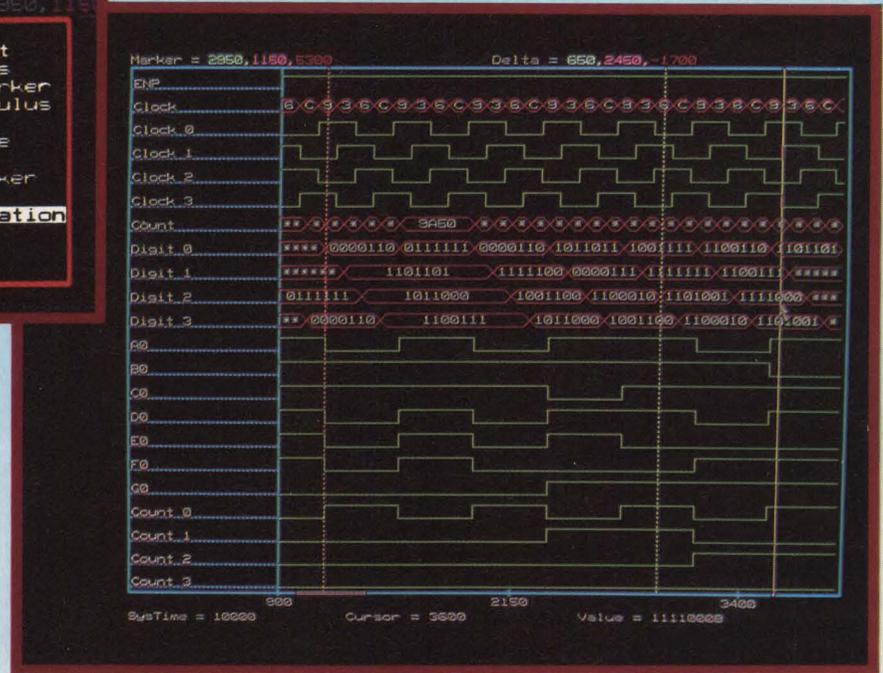


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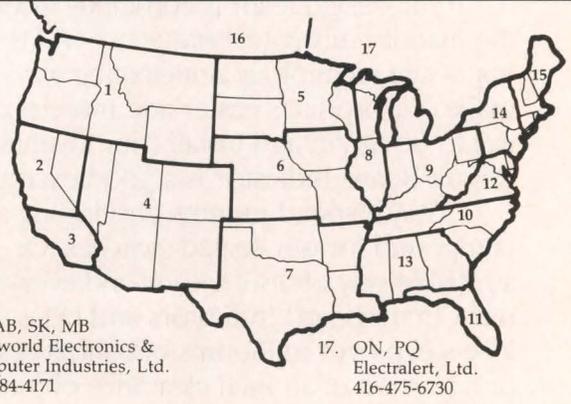
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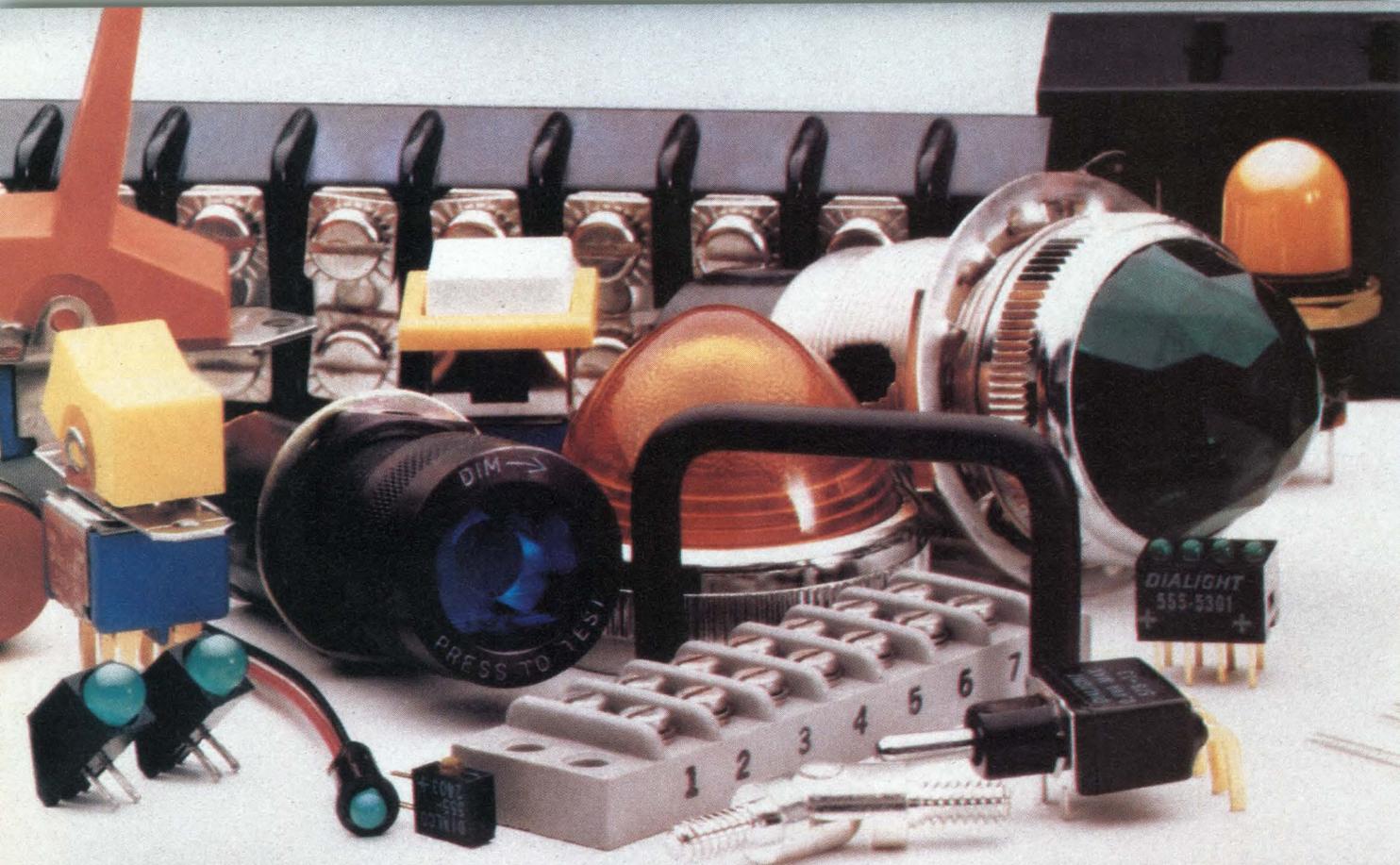


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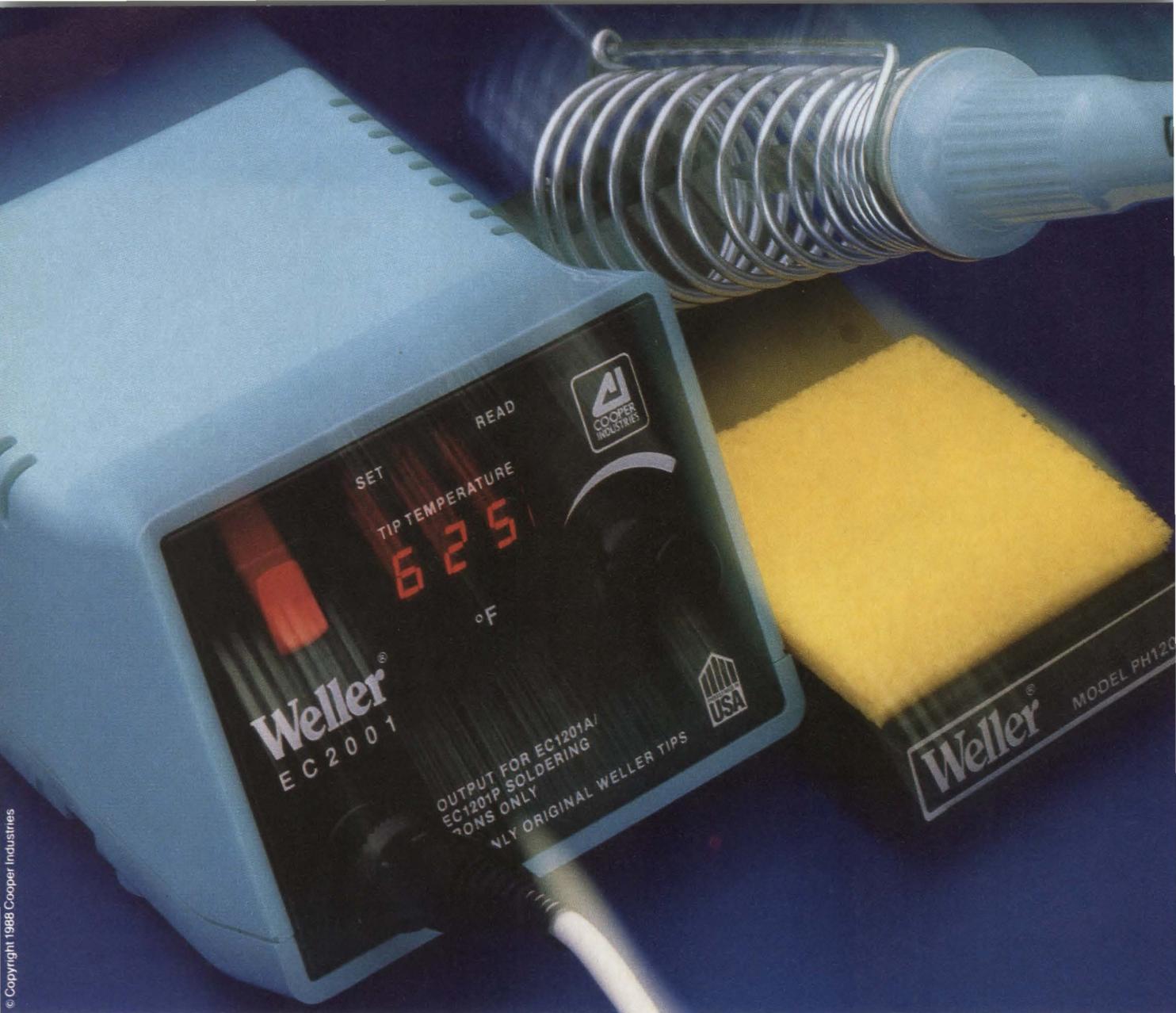
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Advances in speed and voltage ratings enhance applications for optocouplers

Dave Pryce, Associate Editor

The widespread use of optocouplers is testimony not only to their long history, but to the great variety of types for sale. Optocouplers are available in several possible output configurations, including LDRs (light-dependent resistors), various transistor types, logic elements, and SCRs and triacs (bidirectional triode thyristors) (Fig 1).

From factory-floor networks to missiles and satellites, the use of optocouplers to provide isolation between different environments continues to increase. You'll find the devices suitable for such diverse applications as motor controls, process controls, power supplies, data transmission, CD players, VCRs, and telecommunications equipment.

It all starts with the emitter

Key to the operation of an optocoupler is the emitter (normally an LED), which generates the light energy, and the silicon detector, which is the photosensitive output device. In the case of optocouplers, the light energy from the emitter is usually in the infrared or near-infrared portion of the spectrum. Emitters are fabricated in either GaAs, GaAsP, or GaAlAs, depending on the intended application of the optocoupler and certain cost/performance tradeoffs determined by the manufacturer.

Motorola, for example, uses three different emitters in its optoelectronic products (Fig 2):

- 660-nm (visible light) GaAlAs
- 850-nm (near infrared) GaAlAs
- 940-nm (infrared) GaAs.

Although the 940-nm GaAs emitter's spectral emission is not per-

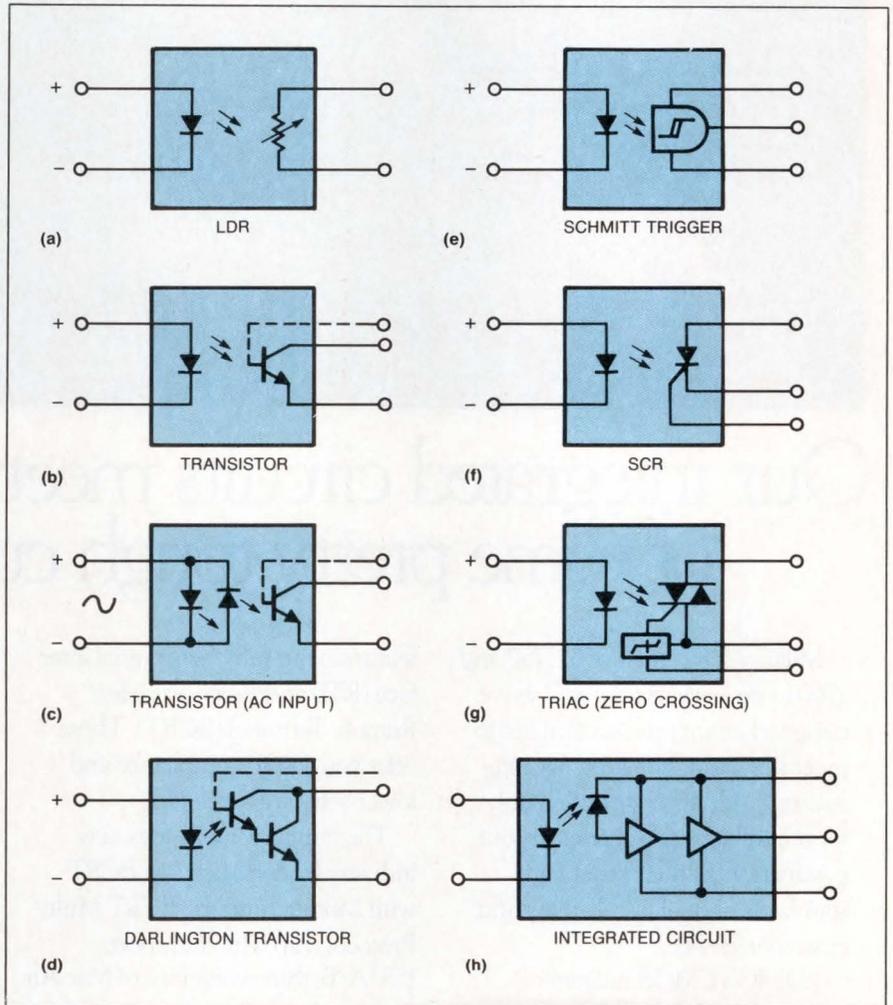


Fig 1—Optocouplers come in a wide variety of types. The primary differences show up in the output stages, which include, but are not limited to, the types depicted here.

fectly matched to the response of a silicon detector, Motorola uses this emitter in most of its optocouplers for reasons of cost effectiveness. Most general-purpose applications can tolerate a certain amount of spectral mismatch, and the resulting lower cost of the optocoupler justifies the use of such an emitter.

The 850-nm GaAlAs emitter's peak emission does closely match the response of a silicon detector, and Motorola uses this emitter in optocouplers designed for applica-

tions where high efficiency and fast speed are important.

The 660-nm GaAlAs emitter is poorly matched to the response of a silicon detector, and for this reason Motorola doesn't use it in any of its optocouplers. (This type of emitter is ideal for use in other optoelectronic products, however—in plastic fiber-optic communications systems, for example. At 660 nm, the attenuation curve of plastic fiber is near its minimum value.)

Other manufacturers take similar



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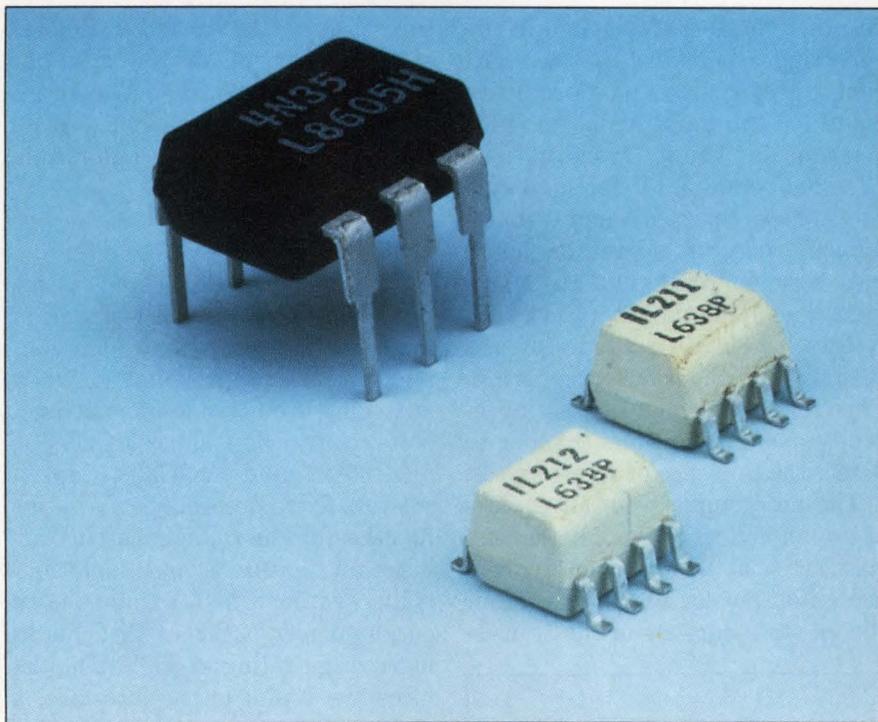
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Optocouplers often come in 6- and 8-pin DIPs, but some types are now available in SOIC (small-outline integrated-circuit) or other surface-mount packages. These types from Siemens are representative.

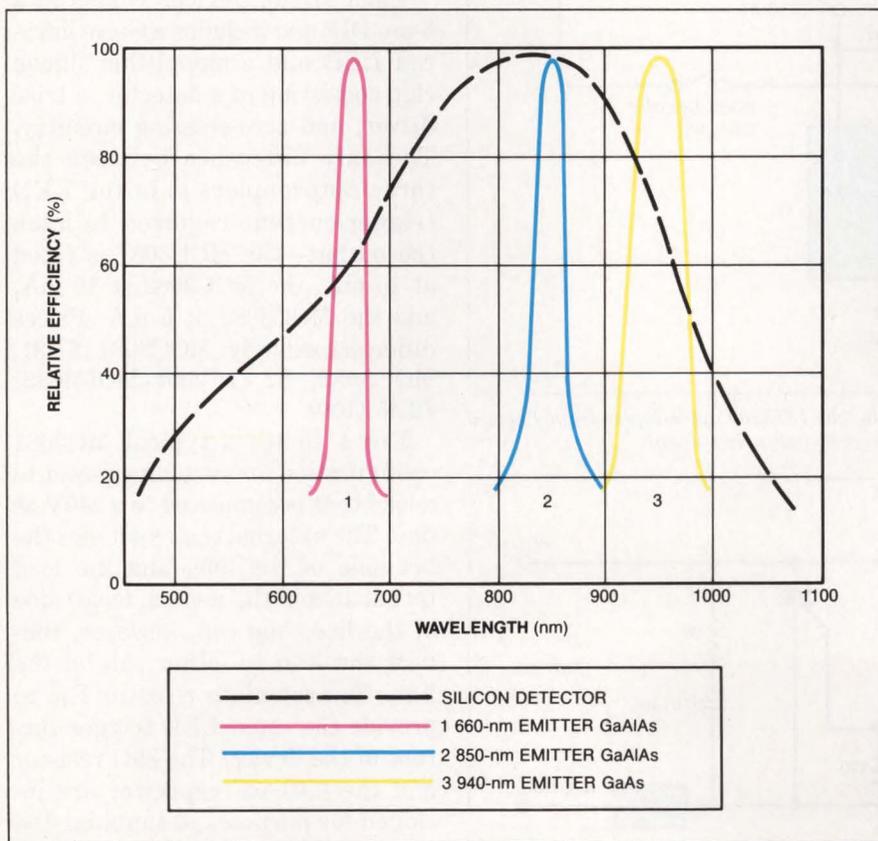


Fig 2—Optocoupler emitters are usually made from materials such as GaAs, GaAsP, and GaAlAs. Application-dependent factors such as efficiency and the wavelength of the emitter's spectral emission determine which type a manufacturer selects. Fortunately, a silicon detector can accept a wide range of emitted wavelengths.

approaches in their selection of LEDs for use as emitters in optocouplers. Philips in The Netherlands, for example, (along with its subsidiary in the US, Amperex Electronic Corp), uses GaAlAs emitters with wavelengths of 830 nm and 740 nm. Philips uses the 830-nm emitter with photodiodes and phototransistors whose peak sensitivity is between 800 and 850 nm; it uses the 740-nm emitter with integrated photoreceivers whose peak sensitivity is between 700 and 750 nm.

Curiouser and curiouser

Hewlett-Packard chooses to use an 820-nm GaAlAs emitter for many of its high-speed optocouplers. Curiously, HP reverses the order of the first two chemical symbols and lists the emitter material as AlGaAs.

Although many companies use GaAs and GaAsP emitters, the trend is to GaAlAs. The reason for this increase in use is because manufacturers can alter the bandgap of GaAlAs emitters to produce radiation at any desired wavelength between 650 and 900 nm. It is the gallium/aluminum ratio that determines the bandgap. Another advantage of GaAlAs emitters are their generally lower drive-current requirements, which makes them a better choice for use in optocouplers that interface with CMOS ICs.

Most manufacturers of GaAlAs emitters use a homojunction technology having a single bandgap. Philips and Amperex, however, use a single-heterojunction technology that has two epitaxial layers with different bandgaps. Philips claims that using this structure significantly lessens the degradation (over time) of the emitters' current-transfer ratio (CTR).

Compared with emitters, photo-detectors don't present as many choices—or as many problems. Silicon detectors have a wide spectral response that extends from 700 to 950 nm, with a broad, flat peak between 750 and 900 nm. And, be-

TECHNOLOGY UPDATE

cause of this wide response, they accommodate a wide range of emitter wavelengths.

Because of the choice of materials, structures, and output configurations available, optocouplers satisfy the isolation requirements of a variety of applications. One such application example uses the LDA200 dual-channel, current-monitoring switch from Theta-J Corp. The \$2.75 (100) LDA200 is useful in industrial applications for input-to-output isolation and control-system monitoring, but its principal use is in telecommunication circuits (Fig 3). In this application, the optocoupler provides ring-current sensing and loop-current detection.

The LDA200 allows the circuit

designer to select the actual in-circuit trigger point for the loop current by choosing an appropriate value for the input shunt resistor. Without a shunt resistor, the LDA200 remains off for loop currents of less than 5 μA and turns on for loop currents of greater than 6 mA. A shunt resistor of 120 Ω provides loop detection at 16 mA, but rejects loop noise currents of less than 6 mA without false triggering. The other channel of the optocoupler acts in a similar manner to detect the presence of a ring signal.

The optocoupler's output devices are open-collector bipolar transistors rated at 20V. Normally, you use an output-load resistor to limit the on-state current in the transis-

tor so as not to exceed a steady-state dissipation of 150 mW per transistor, or 400 mW for the entire package. You have a choice of an 8-pin DIP or a surface-mountable version.

Traditional uses still remain

One of the traditional applications for optocouplers is the isolation of low-voltage circuits from high-voltage circuits, particularly when switching the hot side of an ac line. Not only do the MOC3081, MOC3082, and MOC3083 optoisolators from Motorola perform this function for line voltages to 240V ac, but they feature a high isolation-voltage rating of 7500V (min) and an output driver (triac) with a blocking-voltage rating of 800V. The devices are useful in the interface of logic systems to motors, solenoids, industrial controls, and consumer appliances.

Each of the devices comes in a 6-pin DIP and includes a GaAs infrared LED and a monolithic silicon chip consisting of a detector, a triac driver, and zero-crossing circuitry. The only difference between the three optocouplers is in the LED trigger-current required to latch the output—the MOC3081 is rated at 15 mA, the MOC3082 at 10 mA, and the MOC3083 at 5 mA. Prices differ accordingly: MOC3081, \$1.81; MOC3082, \$2.11; and MOC3083, \$2.45 (100).

Fig 4 shows a typical MOC3081 configuration for switching power to a load that is connected to a 240V ac line. The external triac switches the hot side of the line, and the load terminates in the neutral (cold) side of the line. You can, however, connect the load to either side of the line. You calculate resistor R_{IN} to provide the rated LED trigger current of the device. The 39 Ω resistor and the 0.01- μF capacitor are included for purposes of snubbing the triac, and they may not be necessary for certain triac-load combinations.

Siemens Components also offers a

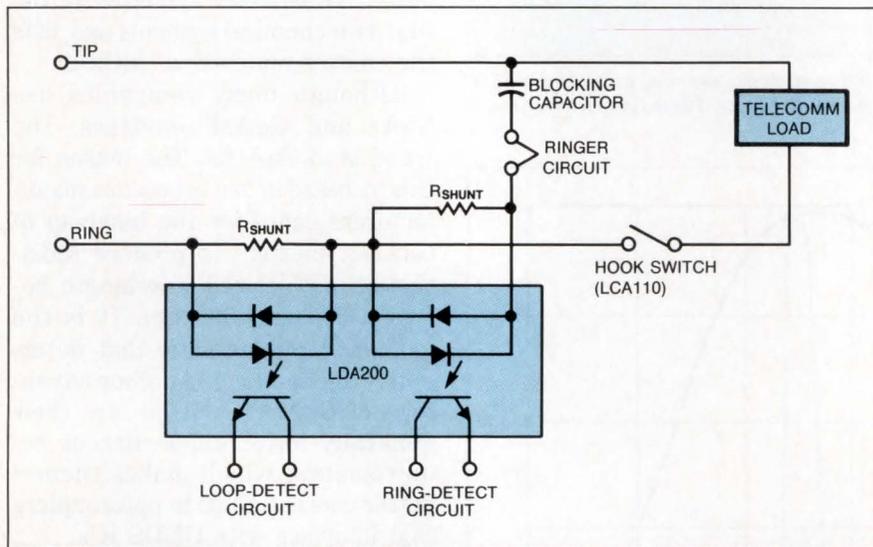


Fig 3—In this telecommunications application, the LDA200 optocoupler from Theta-J monitors the line to detect the presence of loop current and a ring signal.

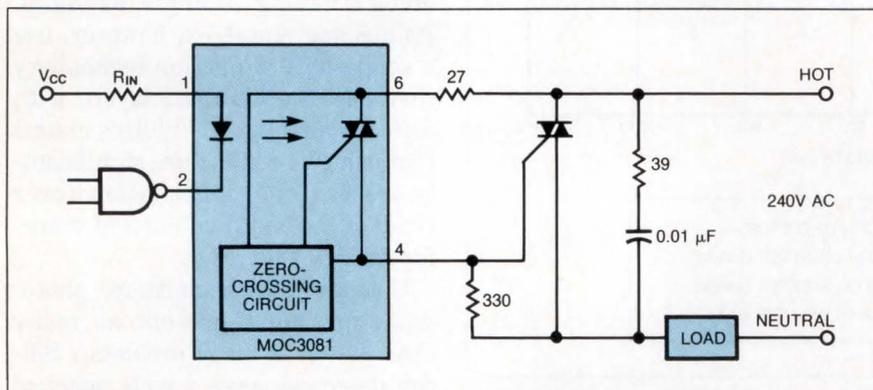
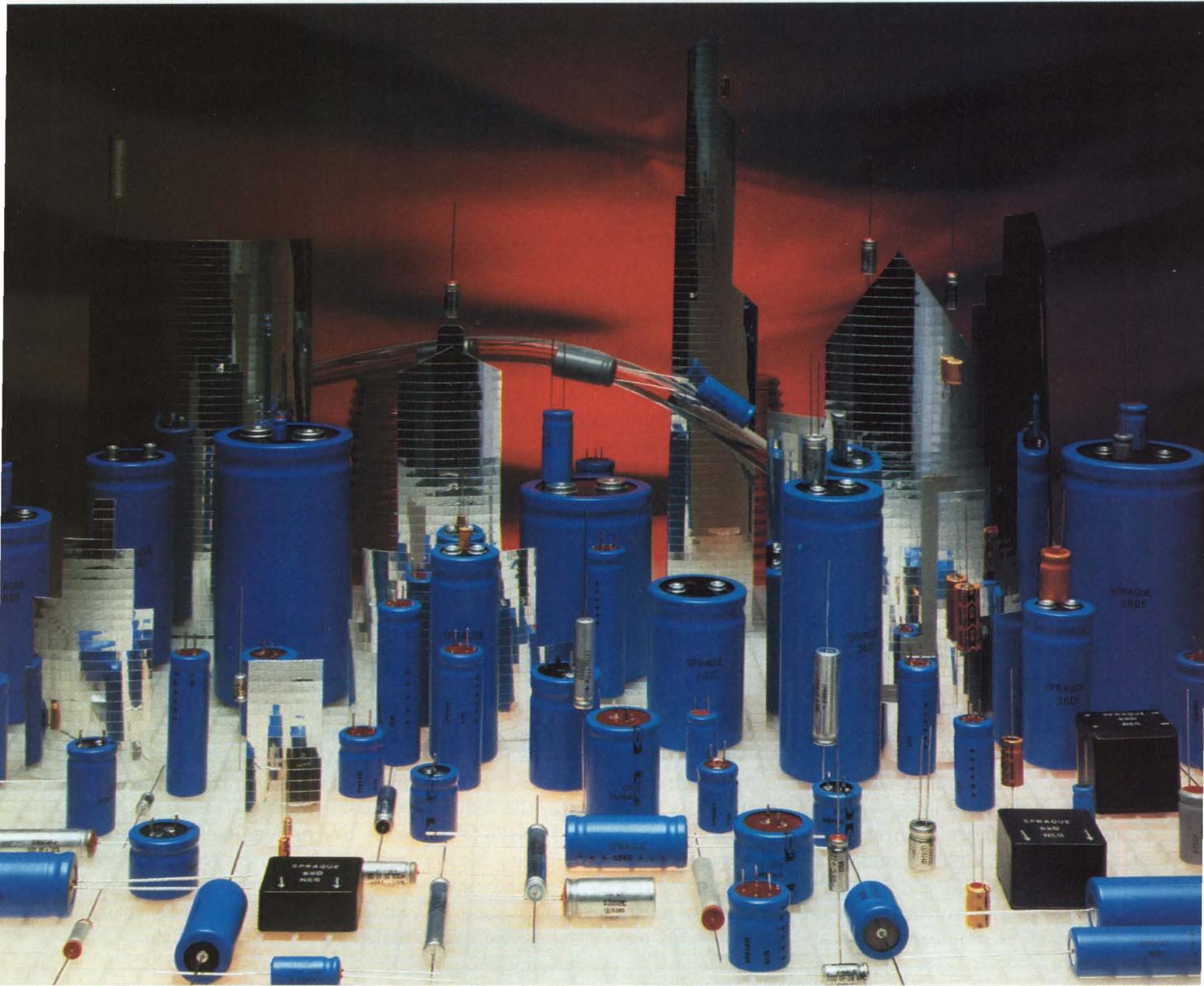


Fig 4—Optocouplers are commonly used to isolate high voltages from sensitive input circuits. This triac-output type from Motorola switches power to a load connected to a 240V ac line. The MOC3081's blocking-voltage rating is 800V.

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device similar to members of the MOC3081 Series. The IL410 is a triac optocoupler with a zero-crossing detector circuit, but its internal circuitry is somewhat different. The output chip integrates a photosensitive npn transistor and a MOSFET with a triac driver. The addition of the MOSFET interface reduces the light output required from the emitter to drive the triac, thus providing an input sensitivity of 2 mA. The optocoupler has an isolation-voltage rating of 7500V, and the triac output stage has a blocking-voltage rating of 600V. Like the MOC3081 Series, the IL410 comes in a 6-pin DIP. It costs \$1.95 (1000).

High-speed types are available

In addition to the optocouplers' improvements in voltage ratings, the development of high-speed devices is also advancing. Until comparatively recently, optocouplers were not known for their blinding speed. Over the past few years, however, companies like Hewlett Packard have been instrumental in changing this situation.

The HCPL-2400 logic-gate optocoupler is a good example. Designed for use in high-speed logic systems, computer-peripheral interfaces, switching power supplies, and digital isolation of ADCs and DACs, it provides a typical data-transfer rate of 20M baud. Depending on operat-

ing conditions, the device is capable of achieving speeds as high as 40M baud.

It also has high common-mode transient immunity and provides a logic-compatible output and, in contrast to a transformer, it offers dc as well as ac performance. The HCPL-2400 comes in an 8-pin DIP and costs \$4.65 (100).

In a typical application circuit (Fig 5), the HCPL-2400 uses the fast current-switching capabilities of Schottky TTL logic (74STTL) to attain the 20M-baud data-transfer rate. The 74S04 totem-pole driver sources current to drive the input of the HCPL-2400 optocoupler in series. The 348 Ω resistor limits current to the emitter, and the 30-pF capacitor assists in speeding up the emitter's turn-on and turn-off times.

At the output side, the optocoupler, which does not require a pullup resistor, directly drives the logic element. If desired, you can substitute a noninverting buffer at either the input or the output to change the circuit's function.

Of course, fast is relative

Although not nearly as fast as the Hewlett Packard device, the industry-standard 6N135 and 6N136 (Fig 6) nevertheless qualify as high-speed types. They have a bandwidth of 2 MHz and a typical switching speed of 1M bps. Each device con-

tains a GaAsP emitter and an integrated photon detector comprising a photodiode and an open-collector output transistor. Separate connections for the photodiode bias current and the collector output of the transistor reduces the base-to-collector capacitance of the output transistor. This arrangement results in speeds as much as 100 times that of a conventional phototransistor.

The UL-registered optocouplers are designed for analog- and digital-interface applications in appliances, vending machines, facsimile machines, character readers, and telephones. In particular, the 6N135 is designed for TTL/CMOS, TTL/LSTTL, and wideband analog applications; the 6N136 suits high-speed TTL.

The devices (along with other family members 6N137, 6N138, and 6N139) are available from a number of suppliers, including Texas Instruments, General Electric, General Instrument, and Hewlett Packard. They are enclosed in 8-pin plastic DIPs and vary in price from \$2.50 to \$3 (100).

One of the earliest types of optocouplers used an LDR as the detector element. These types are still in wide use as feedback elements in automatic gain control (AGC) circuits, and in other applications where isolated control of a variable resistance is necessary. The CLM51

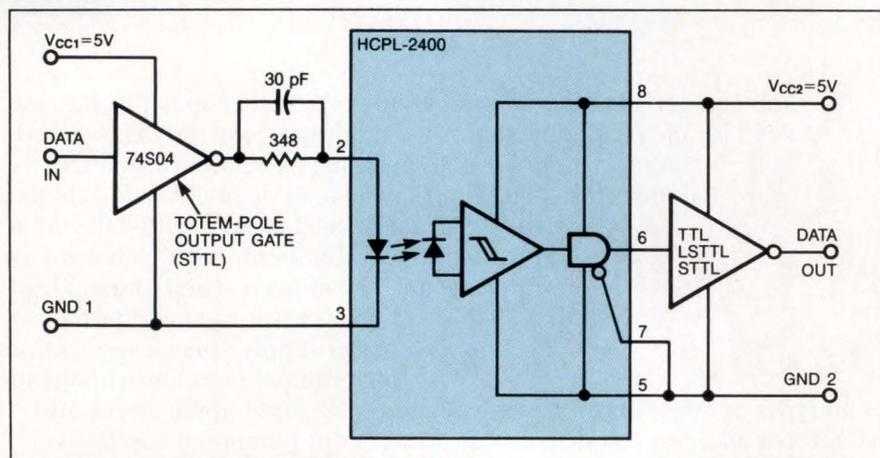


Fig 5—Designed for use in high-speed logic systems and computer-peripheral interfaces, the HCPL-2400 from Hewlett Packard has a typical data-transfer capability of 20M baud. Depending on operating conditions, the device can achieve speeds as high as 40M baud.

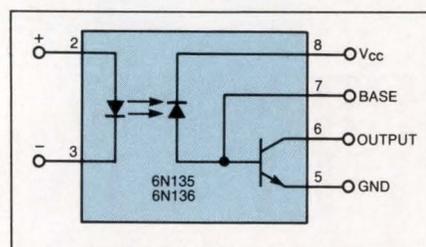


Fig 6—The 6N135 and 6N136 optocouplers are JEDEC registered and UL approved. The 6N135 is useful for TTL/CMOS and TTL/LSTTL applications; the 6N136, for TTL applications. The separate biasing pin for the photodiode reduces the transistor's collector-base capacitance, which speeds operation by a factor of 20 to 100 compared with conventional phototransistors. Both types are available from a number of suppliers, including Texas Instruments, General Electric, General Instrument, and Hewlett Packard.

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TECHNOLOGY UPDATE

(single channel) and CLM51-2 (dual channel) LDR optocouplers from Clairex are contemporary examples.

The CLM51-2 has a center-tapped LDR as the output detector (Fig 7). You can connect the typical 2-k Ω

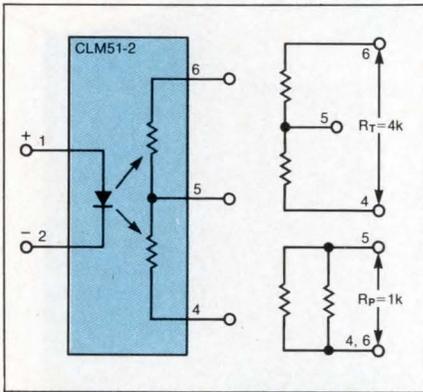


Fig 7—This optocoupler has an LDR as the detector. You can set the reference resistance of the Clairex CLM51-2 at 1, 2, or 4 k Ω . By varying the LED current from 0.1 to 10 mA, you can vary the reference-resistance value over a 10:1 range.

resistor elements in series or parallel to alter the total reference resistance over a 4:1 range. By varying the LED current from 0.1 to 10 mA, you can vary the reference-resistance value over a 10:1 range. The maximum current rating of the LED is 40 mA.

The optocoupler's frequency response, which is essentially flat from dc to 100 kHz, is more than adequate for audio applications, and its 3 dB roll-off point of 3 MHz makes it useful for higher-frequency applications. Both the single- and dual-channel versions come in 6-pin DIPs. In 100-piece quantities, the CLM-51 costs \$1.74, and the CLM51-2 sells for \$2.05.

EG&G Vactec also makes LDR-type optocouplers. These devices have a wide range of axial-lead types that use neon lamps, incandescent lamps, or LEDs as the light source. Available resistance values

range from 100 Ω to 10 k Ω .

Vactec's VTL-5 types, for example, use an LED emitter and come in plastic molded packages with either four leads (single element) or five leads (dual element). Characteristics of the VTL-5 Series, which includes seven single- and two dual-element types, are low distortion, low capacitance, and wide frequency response spanning dc to 5 MHz. In large quantities (10,000), their prices range from about \$0.80 to \$1.50.

Logic-oriented types of optocouplers, which make digital interfacing easier, are also available. About two years ago, General Instrument—a supplier of optoelectronic products for nearly twenty years—introduced its Optologic line of logic-to-logic couplers. These devices provide buffer and inverter interfaces for LSTTL/TTL and LSTTL/CMOS logic. The 74OL6000 Series, part of the Optologic family, includes devices with totem-pole outputs and open-collector outputs. These products have found acceptance in such applications as transmission-line receiver/driver interfaces, bus interfaces, and high-speed ac/dc voltage sensing.

General Instrument's most recent product introduction, however, is not a logic coupler. The \$1.17 (5000) MCT9001 is a dual phototransistor optocoupler that features two isolated channels in a standard 8-pin DIP. The end-stackable package (two packages fit into a 16-pin DIP socket) offers a high packing density and reduced insertion costs.

The device has a CTR of 50% (min) and 600% (max) at LED currents of 5 mA. Each output transistor is rated at 50 mA (max) and has a dissipation rating of 150 mW. The MCT9001 is also fairly fast; 3 μ sec turn-on and turn-off times are typical.

EDN

For more information . . .

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

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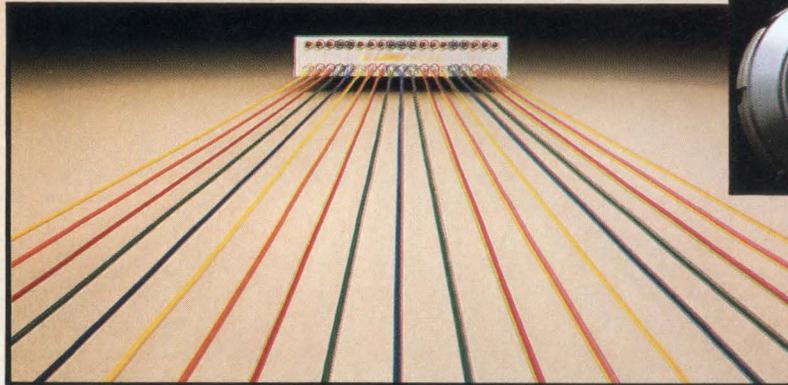
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Software package relieves designer of physical details of ASIC design

You can avoid dealing with the physical design details of ASIC design if you use IC Works software to create the devices. Once you've completed the schematic capture and design verification, the computer handles the rest of the design process automatically, from cell placement through routing, clock generation, and rule checking. The complete package (including the schematic capture, cell libraries, and validation tools) sells for \$10,000.

The software requires an IBM PC/AT or compatible running MS-DOS, a color monitor with an EGA card, a hard disk, and a mouse. IC Works is tailored to run on a standard computer, so it doesn't need any hardware accelerators.

During schematic capture, you can connect as many as 14 pages of schematics in one file. You can also define macros to represent frequently used circuits, or to simplify the top-level schematic. If you don't choose to name them yourself, the computer automatically labels circuit elements and nets. Command menus or sub-menus are available on screen at all times; you can, for example, bring up a window when selecting elements for placement. Whenever you are working with a net, all nodes of the collection flash for easy identification.

The cell library for IC Works is based on a 2- μ m, double-metal CMOS process and offers over 100 entries, including Boolean gates, counters, shift registers, and adders. You can add RAM, ROM, and PLA structures to your design simply by specifying their configuration and any necessary programming. You can also define custom cells by using the building blocks in the library. Thus you can make a



When you use this automated ASIC-design package, you don't have to deal with the physical details of the design. IC Works can generate 50 placement alternatives from 50 different initially randomized cell placements in order to provide the best solution.

3-bit adder or a 5-bit counter if that is what your circuit needs. The library is not proprietary, so you can take your final design to any foundry you wish.

IC Works offers a variety of time-saving test and verification tools. While designing, you can perform logic simulation and timing verification on various parts of the design. You can then save the test vectors generated by this method for use in verifying the final design.

Initially, the automatic cell placement is randomized; then the software swaps pairs of cells until it reaches a workable routing pattern. Because the results of this technique strongly depend on the initial random placement of cells, you have the option of running an optimization routine that examines 50 different placements for the best results.

The computer can automatically place the cells and route the connections, or you can maintain complete

control of the placement. In either case, the software provides complete electrical- and design-rule checking of the final layout at the transistor level.

In order to take advantage of the automatic features in IC Works, you will have to live with some restrictions. For example, you must use synchronous design techniques, because all of the storage devices in the cell library include a connection to a master clock. Some of the routines, such as the one that optimizes the device layout, take hours to run. Finally, the package handles designs limited to about 5000 gates. The company does offer a \$5000 prototype fabrication service and guarantees the resulting devices will perform as simulated.

—Richard A Quinnell

IC Designs, 12020 113th Ave NE, Kirkland, WA 98034. Phone (206) 821-9202. TLX 4949856.

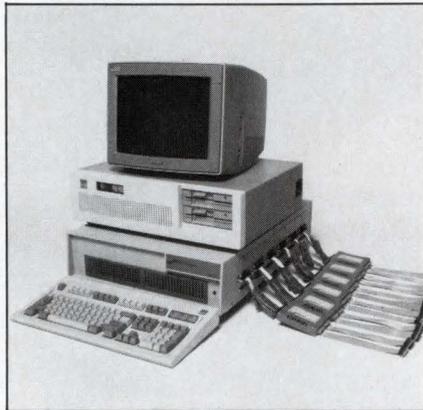
Circle No 697

Mid-range development tools streamline μ programmable chip-based system design

By combining a comprehensive set of software tools with economical hardware—including a logic-state analyzer—the Step-50 development system improves the odds that mere mortals can develop and debug high-performance products based on microprogrammed processors. Although products using microprogrammed computing elements are faster and harder to duplicate than those based on fixed-instruction-set processors, until recently they have been quite difficult to develop because designers had to become experts in devising not only hardware but also machine-language software. Furthermore, available development systems either performed unneeded functions and cost too much, or they lacked features required to debug complex products with high confidence.

An IBM PC/AT or compatible computer hosts the Step-50. The software, based on MS/PC-DOS (version 3.x), runs under Microsoft Windows (version 2.03). An enclosure slightly larger than the PC/AT system's unit houses the hardware. It connects to the system under test via 16-channel pods; you can attach as many as ten of these pods at once. The unit's 4k-word writeable control store (WCS) supports a target-system word width of 160 bits. The 80-bit-wide, 25-MHz real-time trace memory is also 4k-words deep and is organized as a circular buffer. You can effectively increase the buffer's depth by specifying qualifications of data before storing it.

The logic-state analyzer includes clock and breakpoint controls. Using a Windows dialogue box, you can qualify trigger conditions—or data



The probes used with the mid-range Step-50 are identical to those used by the entry-level and top-of-the line members of the vendor's product line. You also use the same software with all members of the family.

to be captured in the trace memory—with as many as five 80-bit match words and with a sequence of four independent state-machine levels. In addition, you can select sequencing from one or more of the 80-bit match words and/or from the address and data-range comparators. You control the logic-state analyzer with either the keyboard or a mouse.

The software furnished allows you to load the WCS, edit and save its contents, compare those contents against disk files, search the WCS for data patterns, and duplicate lines or blocks of code. You can also fully define the op-code symbols and trace-display format. The system accepts bit patterns entered as binary, octal, or hexadecimal codes or as user-defined symbols. An event counter determines the number of occurrences of a selected pattern. Another software feature lets you save trace data and compare it with other traces.

The Step-50 is part of a product

family that includes the Micro-Step at the low end and the Step-40 at the high end. All of the family members are PC-based. They have the same user interface and work with the same probes and compatible software. At approximately \$6500 for a typical configuration, the Micro-Step is an entry-level product targeted at teaching prospective microcode developers what the process is all about. Its maximum word width is 128 bits, and it lacks a logic-state analyzer. The Step-40, which starts at about \$25,000, is aimed at integration of multiple microcoded processors within systems.

The vendor believes that Step-50 is ideal for developing subsystems and systems that have a single microcoded processor. In more complex systems, where the integration of multiple processors is necessary, the Step-40 is the tool of choice.

Aside from its probes, the Step-50 configuration is fixed. It costs \$15,000 without probes; \$16,800 with probes for 96 channels; and \$18,000 when configured for the maximum of 160 channels.

—Dan Strassberg

Step Engineering, Box 3166, Sunnyvale, CA 94088. Phone (408) 733-7837. TWX 910-339-9506.

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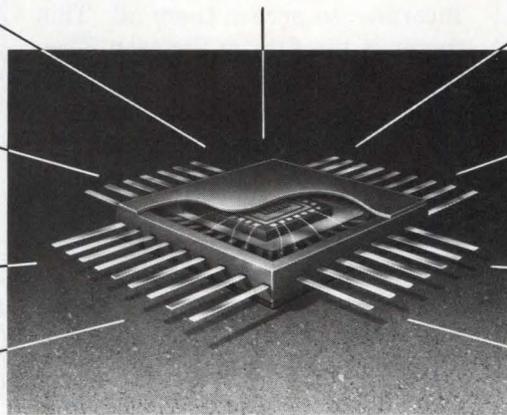
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CXB1103Q	Quint Line Receiver	410 ps	1.5 GHz	650 mW	24 FLAT
CXB1104Q	Dual D Flip Flop	620 ps	3.2 GHz	520 mW	24 FLAT
CXB1105Q	Triple Fan-out Buffer	590 ps	1.5 GHz	720 mW	24 FLAT
CXB1106Q	4-Stage Ripple Counter		3.4 GHz	720 mW	24 FLAT
CXB1107Q	Decision Circuit		3.2 GHz	430 mW	24 FLAT
CXB1108Q	Laser Driver		2.0 GHz	740 mW	16 FLAT
CXB1109Q	Quad D-FF with Master Reset	620 ps	3.4 GHz	790 mW	24 FLAT
CXB1110Q	16 to 1 Multiplexer	610 ps	1.5 GHz	680 mW	24 FLAT
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CXB1130Q	9, 8, 4-bit Multiplexer		1.6 GHz	730 mW	32 FLAT
CXB1131Q	9, 8, 4-bit Demultiplexer		1.6 GHz	1000 mW	32 FLAT
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CXB1134Q	22, 15, 7-Stage Descrambler		1.6 GHz	610 mW	24 FLAT
CXB1135Q	8-16 bit Comparator		1.3 GHz	630 mW	32 FLAT
CXB1136Q	8-bit Universal Counter		1.2 GHz	730 mW	32 FLAT
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The set is packaged in two 28-pin and one 40-pin DIP; or, for surface mount applications, one 44-pin and two 28-pin PLCC packages. Utilizing low power CMOS technology, the 2404DS draws only 600 mW from $\pm 5V$ supplies.

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CIRCLE NO 6

PRODUCT UPDATE

Menu-driven DMM features bar graph

The Model 560 DMM is a sophisticated DMM with an abundance of features and includes a menu-driven interface to access them all. This meter is the fifth in Simpson Electric's Professional Series of instruments—and it demonstrates an impressive and innovative change of pace. The basic unit costs \$2195 and consists of a 2.5-lb Z80-based DMM that stores 2150 readings in nonvolatile, battery-backed RAM.

The 560 gives you readings with 5-digit resolution (99,999 counts); it also indicates negative polarity. Its 52-segment bar graph provides real-time voltage and autorange representations that are independent of the dB or Hz you're measuring, so you can take a reading and monitor the test point in real time simultaneously.

In addition to the standard ohms range, the meter has a high-power ohms range that is useful in testing semiconductor junctions. Other features include frequency counting, true RMS, fusing on both current inputs, diode testing, high-speed autoranging, digital filtering, a TC reference, and digital calibration. A zero function eliminates lead resistance in your readings. The unit also provides a peak-hold that is completely independent of A/D converters, so it can catch small line transients that would otherwise be lost.

The menu interface simplifies the task of selecting storage parameters for the meter's readings. Using it, you can specify the range for stored readings; you can also set the storage rate and the dB reference. A REL SET option lets you key in a reading so that subsequent input is displayed relative to that reading. The nonvolatile RAM also stores the



Providing a menu-driven user interface, the Model 560 digital multimeter includes a frequency counter and a dual display with bar graph.

meter's final settings so that the unit maintains the same range limits when you turn it off and on again.

Two interface options are available: a Centronics-compatible parallel port or an RS-232C serial port. Each is fully isolated, has its own power supply, and costs \$200. Unfortunately, there are no field upgrades, so you have to send the unit back to Simpson for an interface installation. Or you can simply order a 560 with either port already installed for \$2395. If you plan to take a lot of range-limited readings, you'll want to use a printer with the meter because the 560's display doesn't provide as much information as you get on a printout.

—J D Mosley

Simpson Electric Co, 853 Dundee Ave, Elgin, IL 60120. Phone (312) 697-2260. TLX 722416.

Circle No 696

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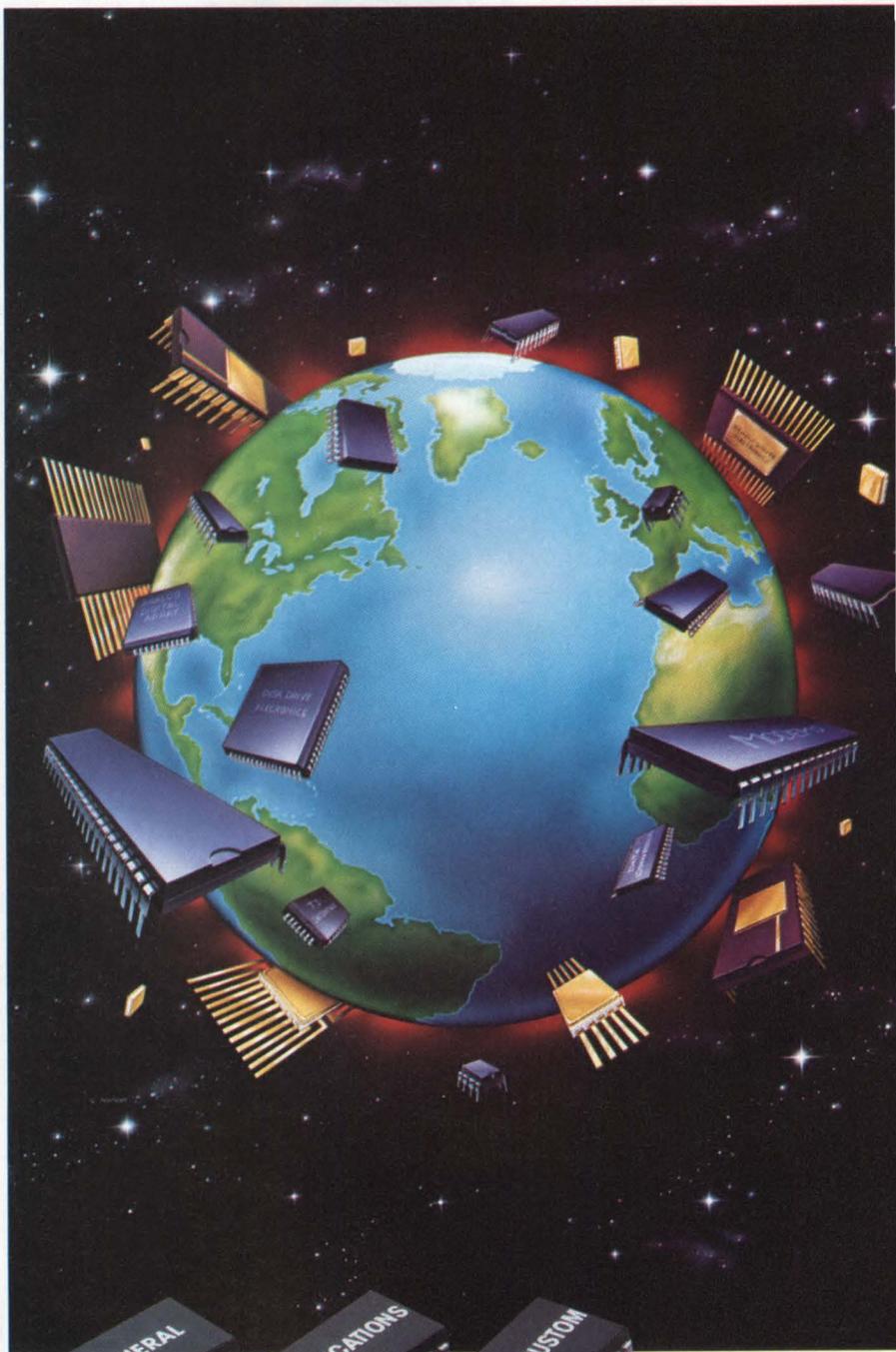
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The big news is SGS-THOMSON's MK48Z08. The MK48Z08 has an 8K × 8 architecture—plus a battery cell life of over 11 years at 70°C. Four configurations are offered for maximum design flexibility. Each conforms to JEDEC 28-pin DIP packaging to allow direct replacement of conventional 8K × 8 SRAMs, 2764 EPROMs or 8K × 8 EEPROMs.

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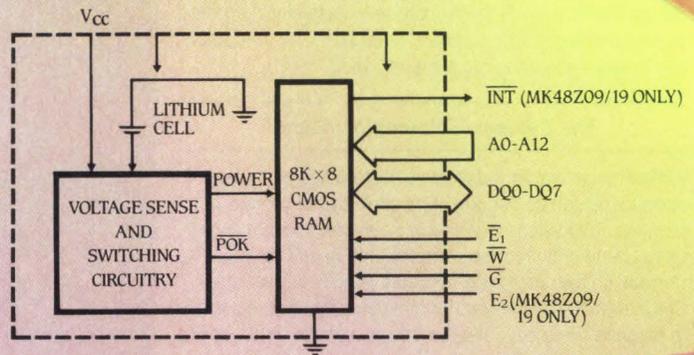
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densities are just over the horizon) are based on the industry's most sophisticated assembly technology and over 5 years of proven battery experience.

For convincing reliability documentation and a complete set of application notes, contact the winning team—SGS-THOMSON Microelectronics, 1000 E. Bell Road, Phoenix, AZ 85022. 602/867-6259.

DEVICE	TEMP RANGE	WRITE PROTECT VOLT.	BATTERY LIFE OVER TEMP	U.L. RECOG	SPEED	KEY FEATURES
MK48Z02	0-70 C	4.75V	11 yrs.	Yes	120-250ns	2K × 8 SRAM unlt. write cycles
MK48Z12	0-70 C	4.5V	11 yrs.	Yes	120-250ns	2K × 8 SRAM unlt. write cycles
MK148Z02	-40-85 C	4.75V	6 yrs.	Yes	120-250ns	2K × 8 SRAM indust. temp. range
MK148Z12	-40-85 C	4.5V	6 yrs.	Yes	120-250ns	2K × 8 SRAM indust. temp. range
MK48T02	0-70 C	4.75V	11 yrs.*	Yes	120-250ns	2K × 8 SRAM w/realtime clock
MK48T12	0-70 C	4.5V	11 yrs.*	Yes	120-250ns	2K × 8 SRAM w/additional CE
MK48Z08/09	0-70 C	4.75V	11 yrs.	Yes	150-250ns	8K × 8 SRAM w/additional CE and power fault flag (-09)
MK48Z18/19	0-70 C	4.5V	11 yrs.	Yes	150-250ns	8K × 8 SRAM w/additional CE and power fault flag (-19)

*3.3 yrs. minimum clock operating in battery backed mode.



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CIRCLE NO 159



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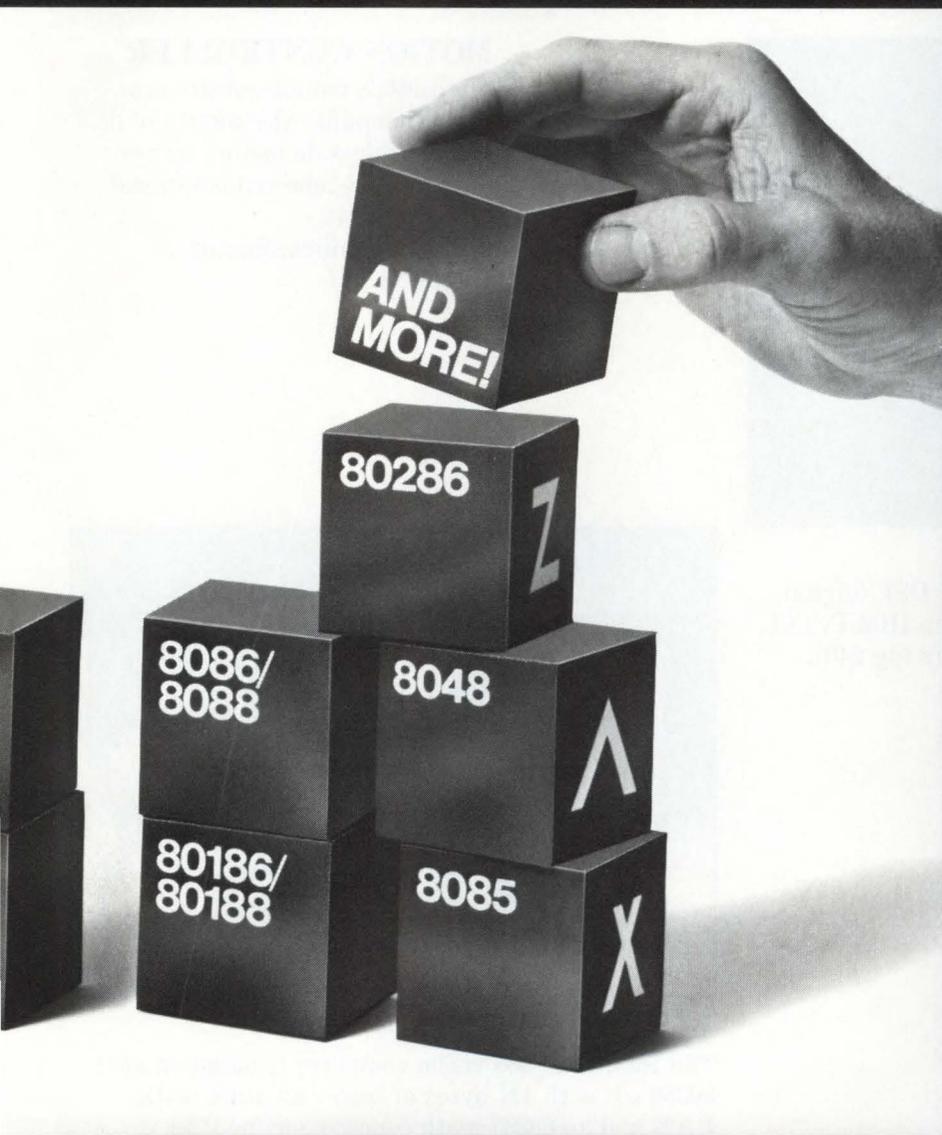
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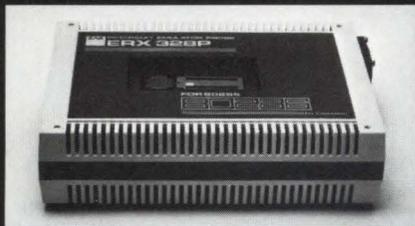
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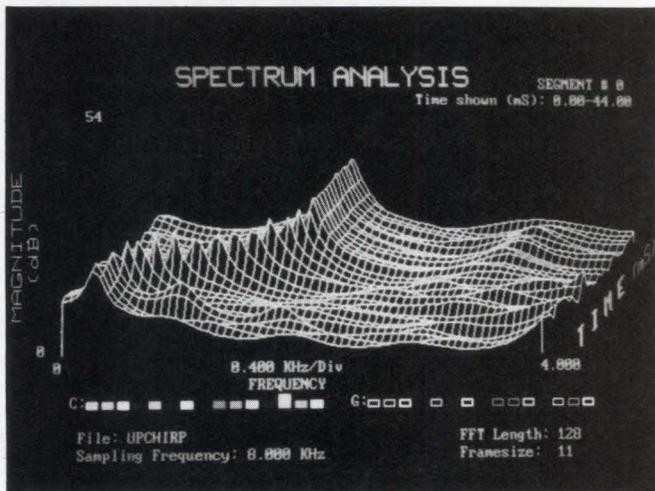
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CIRCLE NO 157

READERS' CHOICE

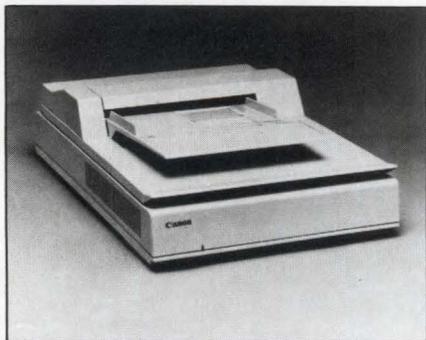
Of all the new products covered in EDN's **February 4, 1988**, issue, the ones reprinted here generated the most reader requests for additional information. If you missed them the first time, find out what makes them special: Just circle the appropriate numbers on the Information Retrieval Service card, or refer to the indicated pages in our **February 4, 1988**, issue, or use EDN's Express Request service.



▲ DSP SOFTWARE

Hypersignal and Hypersignal Plus are DSP (digital signal processing) programs that run on IBM PC/XT, PC/AT, PS/2, and compatible computers (pg 240).

Hyperception
Circle No 605



▲ IMAGE SCANNER

The desktop IX-12F image scanner provides 300-dot/in. image scanning for text, graphs, drawings, maps, and pictures and can enter them into a computer (pg 212).

Canon USA Inc
Circle No 603



MOTION CONTROLLER

The LM628 motion-control processor simplifies the control of dc and brushless dc motors by performing real-time computational tasks (pg 104).

National Semiconductor
Circle No 601



▲ VISION SYSTEM

The Intellevue 386 vision computer is based on an 80386 μ P with 1M bytes of zero-wait-state static RAM and an 80287 math coprocessor (pg 229).

Intellex
Circle No 604

◀ CLOCK BATTERIES

The Model 843 and 844 batteries utilize a 4.5V, 1-Ahr alkaline system and replace the lithium battery that comes with all IBM PC/AT computers (pg 203).

Rayovac Corp
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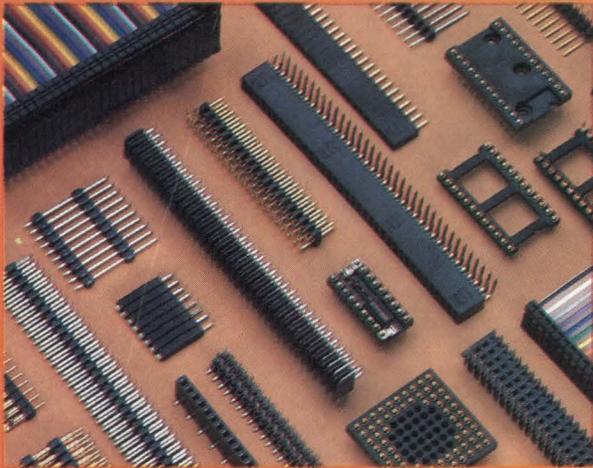
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Company "C"	Test Instrumentation	100%
Company "D"	Cellular Radios (Telecom)	100%
Company "E"	Medical Instrumentation	100%
Company "F"	Computers	Zero Defects
Company "G"	Telecommunications	100%
Company "H"	Industrial Motors	100%
Company "I"	Telecommunications	100%
Company "J"	Medical Instrumentation	100%
Company "K"	Heart Pacemakers	Excellent

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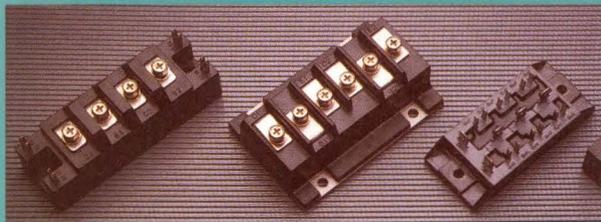


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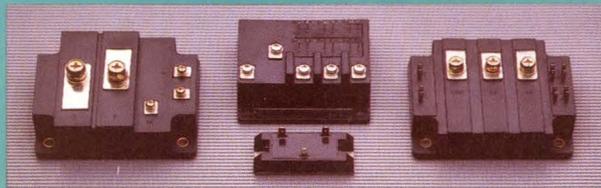
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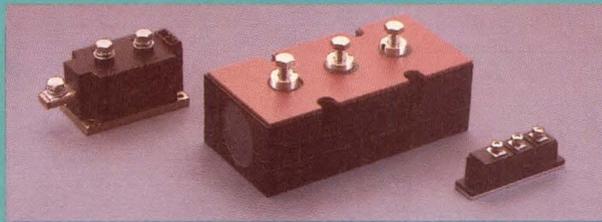
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CIRCLE NO 137

LEADTIME INDEX

Percentage of respondents

ITEM	Percentage of respondents							Average (weeks)	Last month's average (weeks)
	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Over 30 weeks		
TRANSFORMERS									
Toroidal	6	23	47	18	6	0	7.2	7.3	
Pot-Core	0	8	67	17	8	0	10.3	7.8	
Laminate (power)	5	45	27	14	9	0	7.6	8.3	
CONNECTORS									
Military panel	0	0	73	27	0	0	10.2	10.8	
Flat/Cable	22	39	30	9	0	0	4.6	5.6	
Multi-pin circular	9	25	25	25	8	8	8.6	9.4	
PC (2-piece)	7	29	50	14	0	0	6.8	7.4	
RF/Coaxial	10	50	35	5	0	0	4.6	5.3	
Socket	23	54	14	9	0	0	3.6	4.7	
Terminal blocks	32	59	4	5	0	0	2.3	5.4	
Edge card	24	33	38	5	0	0	4.5	5.7	
D-Subminiature	20	40	35	5	0	0	4.4	5.1	
Rack & panel	22	36	21	21	0	0	5.8	6.4	
Power	20	27	40	13	0	0	5.8	5.5	
PRINTED CIRCUIT BOARDS									
Single-sided	0	47	48	5	0	0	5.6	5.4	
Double-sided	0	48	48	4	0	0	5.4	5.8	
Multi-layer	0	25	63	12	0	0	7.5	7.5	
Prototype	0	79	13	8	0	0	3.9	4.3	
RESISTORS									
Carbon film	49	27	14	10	0	0	3.3	4.2	
Carbon composition	29	38	14	19	0	0	4.9	4.0	
Metal film	31	35	26	8	0	0	4.1	4.4	
Metal oxide	23	38	31	8	0	0	4.5	4.6	
Wirewound	10	32	32	26	0	0	7.4	8.8	
Potentiometers	24	40	60	16	0	0	5.0	6.1	
Networks	27	32	27	14	0	0	5.0	6.3	
FUSES									
	38	38	19	5	0	0	3.1	4.4	
SWITCHES									
Pushbutton	24	43	28	5	0	0	3.9	5.8	
Rotary	21	32	37	5	5	0	5.7	6.1	
Rocker	11	47	32	10	0	0	5.1	5.4	
Thumbwheel	6	22	55	6	11	0	8.7	7.7	
Snap action	8	38	46	8	0	0	5.7	6.5	
Momentary	17	33	39	11	0	0	5.5	6.3	
Dual in-line	13	50	31	6	0	0	4.4	6.6	
WIRE AND CABLE									
Coaxial	27	41	27	5	0	0	3.8	4.2	
Flat ribbon	35	42	19	4	0	0	3.0	5.5	
Multiconductor	22	50	17	11	0	0	4.1	4.6	
Hookup	56	33	7	4	0	0	1.9	3.2	
Wire wrap	31	50	12	6	0	0	2.9	4.2	
Power cords	35	38	23	0	4	0	3.6	5.9	
POWER SUPPLIES									
Switcher	11	17	50	11	11	0	9.0	7.4	
Linear	11	33	45	11	0	0	6.0	7.7	
CIRCUIT BREAKERS									
	6	26	42	26	0	0	8.0	8.0	
HEAT SINKS									
	25	32	43	0	0	0	4.1	5.1	
RELAYS									
General purpose	24	19	38	14	5	0	7.0	6.1	
PC board	19	33	26	22	0	0	6.3	7.2	

ITEM	Percentage of respondents							Average (weeks)	Last month's average (weeks)
	Off the shelf	1-5 weeks	6-10 weeks	11-20 weeks	21-30 weeks	Over 30 weeks	Over 30 weeks		
RELAYS									
Dry reed	27	20	27	26	0	0	6.7	8.6	
Mercury	20	20	30	30	0	0	7.6	9.1	
Solid state	12	35	35	18	0	0	6.4	8.9	
DISCRETE SEMICONDUCTORS									
Diode	37	27	18	12	3	3	5.6	7.0	
Zener	37	19	18	18	4	4	7.0	7.3	
Thyristor	11	21	47	11	5	5	8.8	8.8	
Small signal transistor	30	10	20	30	5	5	9.5	7.4	
MOSFET	10	35	20	30	0	5	8.7	10.2	
Power, bipolar	19	25	19	31	0	6	8.8	9.3	
INTEGRATED CIRCUITS, DIGITAL									
Advanced CMOS	12	19	44	25	0	0	7.9	9.6	
CMOS	19	23	27	27	4	0	8.0	7.1	
TTL	39	22	17	17	5	0	5.8	6.5	
LS	33	29	14	19	5	0	6.0	5.9	
INTEGRATED CIRCUITS, LINEAR									
Communication/Circuit	23	15	46	16	0	0	6.5	8.7	
OP amplifier	23	14	36	18	5	4	8.6	6.3	
Voltage regulator	27	11	35	19	4	4	8.3	7.2	
MEMORY CIRCUITS									
RAM 16k	13	20	33	27	0	7	9.5	9.7	
RAM 64k	11	37	16	31	0	5	8.5	8.8	
RAM 256k	0	25	38	25	6	6	11.0	10.0	
RAM 1M-bit	0	17	33	33	0	17	14.4	12.5	
ROM/PROM	0	17	25	50	8	0	12.4	11.0	
EPROM 64k	17	28	17	33	5	0	8.5	9.5	
EPROM 256k	7	20	20	53	0	0	10.5	9.3	
EPROM 1M-bit	0	18	27	46	9	0	12.2	11.6	
EEPROM 16k	0	22	14	64	0	0	11.8	10.6	
EEPROM 64k	0	19	25	56	0	0	11.3	10.9	
DISPLAYS									
Panel meters	7	21	43	29	0	0	8.5	6.7	
Fluorescent	0	18	27	55	0	0	11.3	8.5	
Incandescent	20	40	10	30	0	0	6.4	6.5	
LED	32	20	36	12	0	0	5.2	8.1	
Liquid crystal	0	12	44	44	0	0	10.8	10.5	
MICROPROCESSOR ICs									
8-bit	24	18	29	29	0	0	7.3	7.6	
16-bit	6	25	19	50	0	0	10.0	9.3	
32-bit	0	15	15	62	8	0	13.5	7.6	
FUNCTION PACKAGES									
Amplifier	20	20	30	30	0	0	7.6	6.4	
Converter, analog to digital	7	29	28	36	0	0	8.6	8.6	
Converter, digital to analog	0	46	27	27	0	0	7.4	9.2	
LINE FILTERS									
	13	20	40	27	0	0	7.9	9.4	
CAPACITORS									
Ceramic monolithic	17	25	46	12	0	0	6.1	5.8	
Ceramic disc	30	30	22	18	0	0	5.2	5.1	
Film	14	38	19	24	5	0	7.4	4.8	
Aluminum electrolytic	19	23	35	23	0	0	6.9	4.8	
Tantalum	24	32	32	8	4	0	5.5	6.2	
INDUCTORS									
	5	37	42	16	0	0	6.7	9.3	

Source: Electronics Purchasing magazine's survey of buyers

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Input protection	MIL-STD-1399 sec 103
Operating temperature range	-20°C to 71°C
Storage temperature range	-55°C to 85°C
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Standard	176,000 hours
ER Option	759,000 hours
MTBF* (naval sheltered)	
Standard	33,000 hours
ER Option	125,000 hours

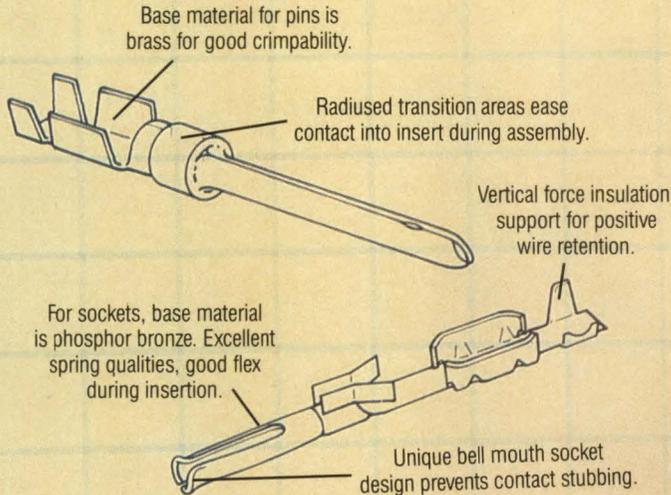
*MIL-STD-217D (50°C baseplate)

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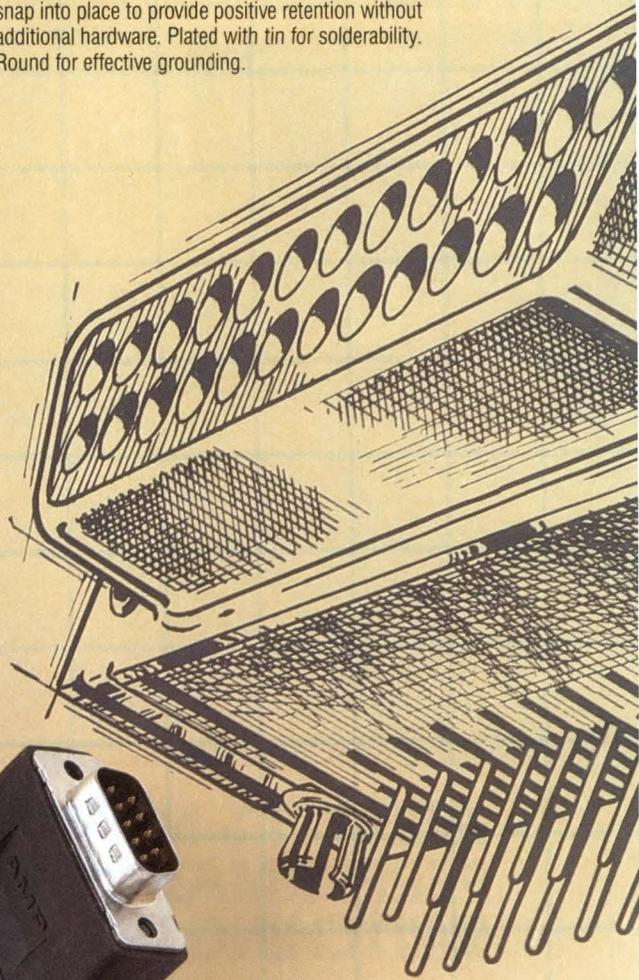
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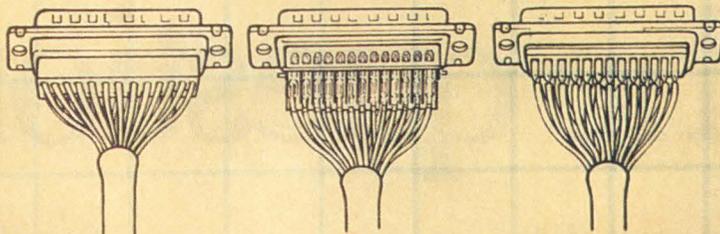
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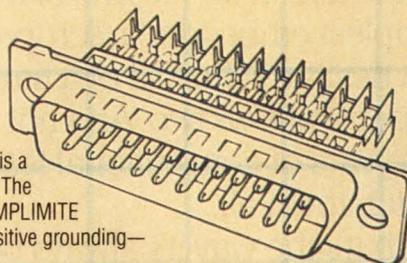
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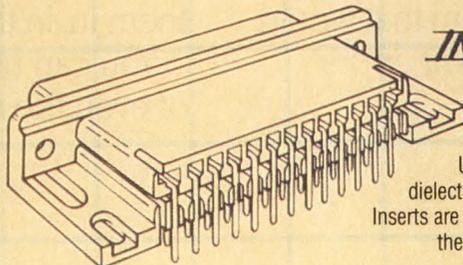
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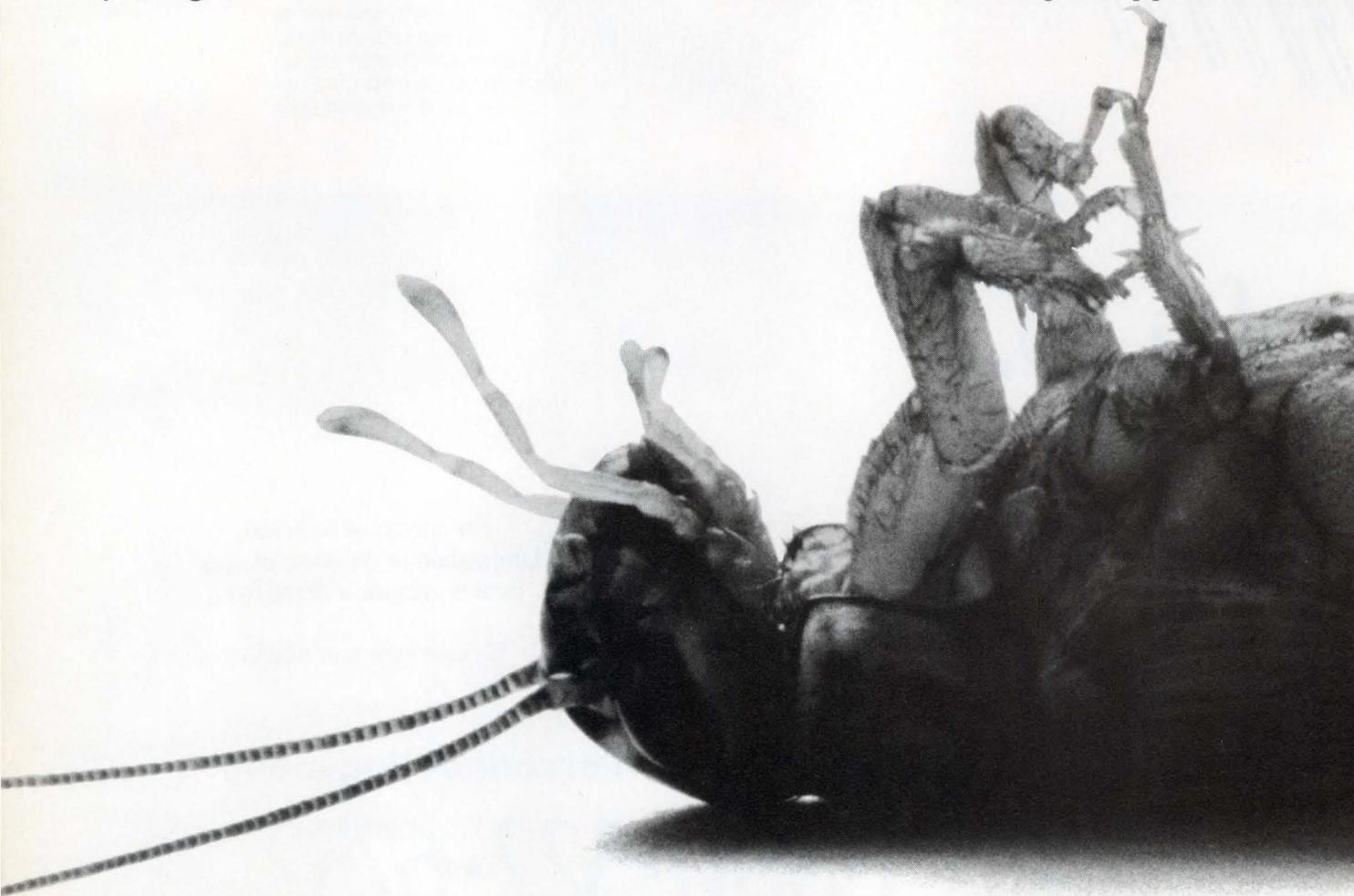
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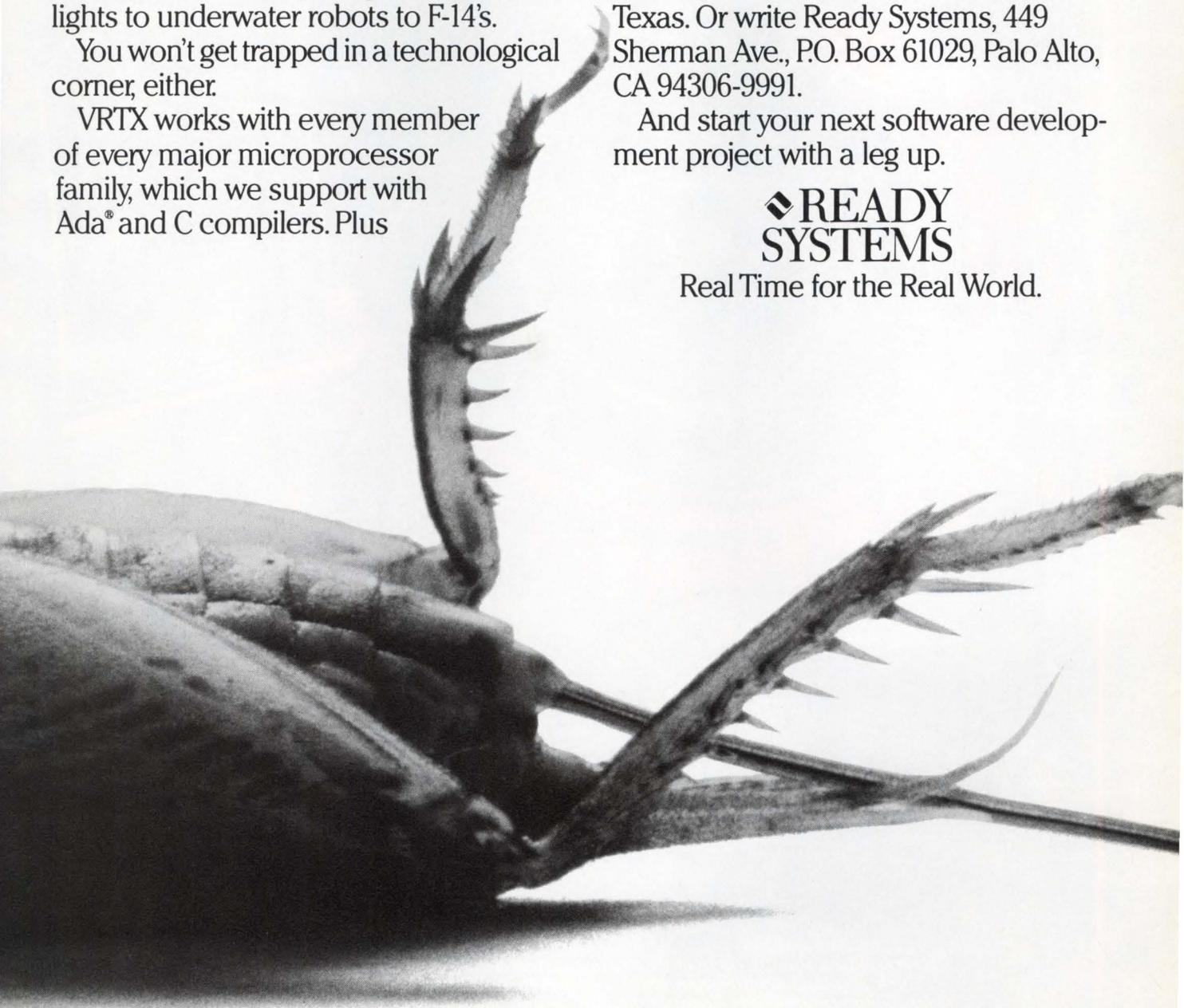
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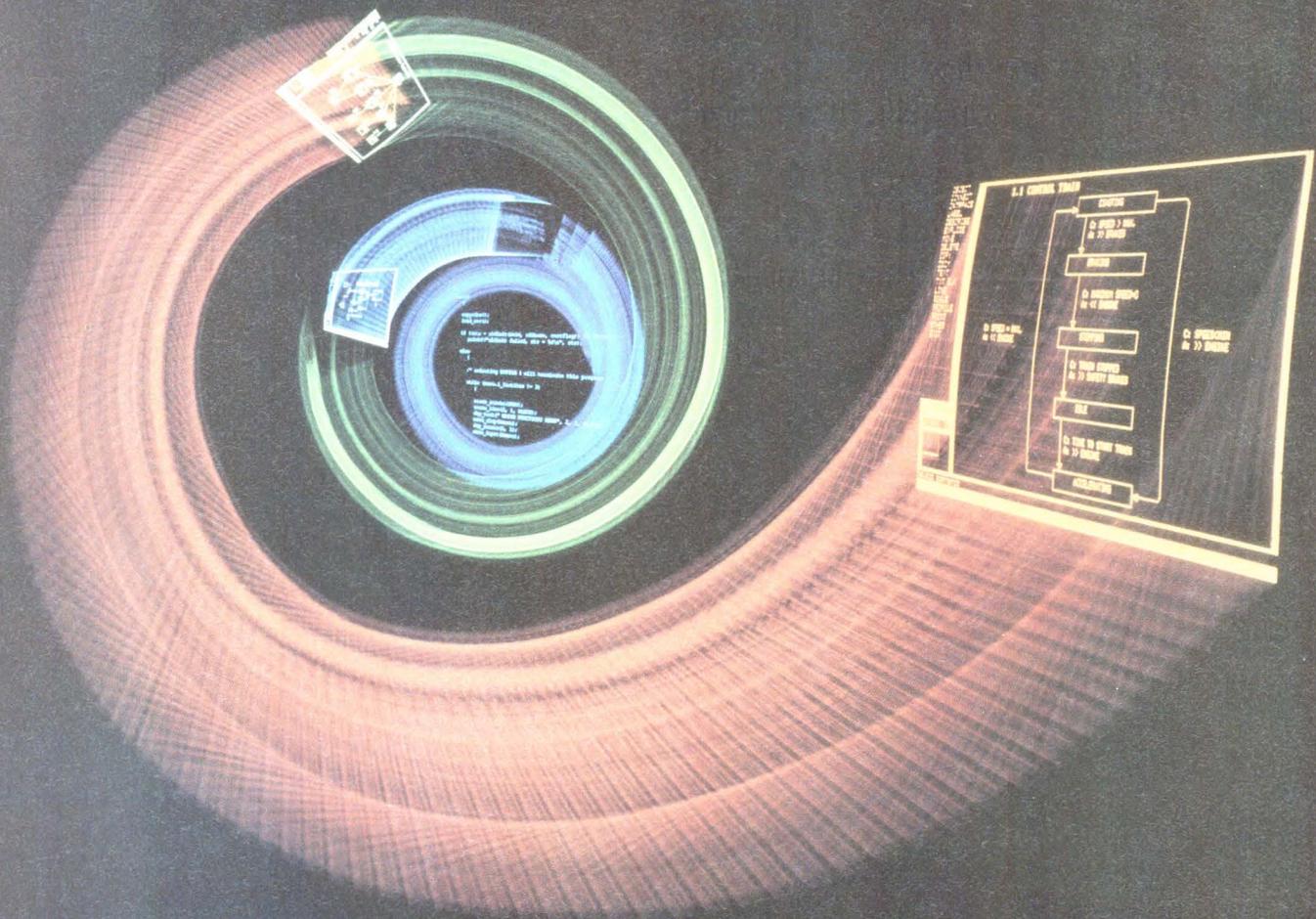
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Representing the life cycle of a software system as a spiral can be illuminating. Each proposed modification of the system starts a new pass through the loop comprising requirements analysis, module design, coding, and testing, and yields a result that is different (displaced) from the previous one.
 (Photo courtesy Index Technology)

CASE tools

More and more, CASE (computer-aided software engineering) is becoming vital to the success of large projects, and vendors are starting to make progress in filling two of the technology's most serious gaps—code generation and intertool communication.

Chris Terry, Associate Editor

An ideal set of CASE tools would not only help you analyze your system requirements and design the program modules to fulfill those requirements, but would also automatically generate the code, perform version-control and maintenance functions, and allow you to extract any drawing or specification or code block from the database for inclusion in the documentation. For maximum versatility, the ideal toolset would allow you to import data from or export data to other vendors' CASE tools and, by means of reverse-engineering techniques, it would help in updating existing programs and systems that weren't originally designed with CASE.

Unfortunately, the ideal CASE toolset does not yet exist. Considerable gaps in the sequence of CASE design remain, and the necessary technology, or industry-wide agreement, to fill these gaps is lacking. CASE tool vendors (of which there are currently more than 50) are well aware of these gaps, however, and are working to develop more sophisticated tools and to integrate

these more closely. (*Ed Note: Because the price of a CASE toolset varies so much—from \$1000 to \$97,000—and because the price is so dependent on the target system and configuration you have in mind, this report does not include prices.*)

At present, the toolsets are strongest in the requirements-analysis and module-design phases—so-called front-end tools. Recently, too, reverse-engineering tools for the maintenance phase have started to become a reality. The biggest gaps still show up in the code-generation phase and in intertool-communication capabilities, but here, too, improvements are in progress.

All CASE toolsets provide a means of fully and accurately specifying *what* a software system must do: The system-requirements phase is the key to success or failure. At this stage, it's feasible and relatively inexpensive to change the design to satisfy new customer requirements, and to ensure that the logic of the design is correct and makes allowance for future changes. The ease or difficulty with which you can make such changes depends on the complexity of the project.

In a large project, it's not easy for any one designer to grasp the whole picture of what the system must do. CASE tools allow as many people as necessary to work on different parts of the design; built-in functions check the completeness and consistency of each part of the system requirements. Because CASE tools give you instant access to all sections of a design, you can look up the interfacing information that you'll need to ensure that your own section joins accurately and smoothly to the other sections.

Many of today's CASE tools offer you a choice among

At present, the toolsets are strongest in the requirements-analysis and module-design phases—so-called front-end tools.

several design methodologies for two main reasons. First, such flexibility means that you won't necessarily have to learn a new methodology to be able to use a particular tool. Second, if you're already familiar with several methodologies and their notations, you can apply the methodology that best suits your problem.

The notation and the kind of diagram available for requirements analysis vary widely according to the toolset. The most common convention is the data-flow diagram (DFD) of Yourdon and DeMarco's structured-analysis methodology, in which curved lines (representing data elements) connect circles (representing processes) and short pairs of parallel lines (representing storage areas) (Fig 1). Cadre's Teamwork and Index Technology's Exceleator use this type of convention. Some tools may also use Warnier/Orr diagrams, in which each process is named at the root of a large curly brace, and where subtasks appear at the tips of the brace; they in turn are further decomposed into subtasks. Appropriately, Ken Orr & Associates' Brackets toolset uses this type. Or your tool may use Nassi-Shneiderman "structograms," which are a form of decision table; an example is Softlab's Maestro. If your toolset is intended for database design, it is more likely that it uses Chen-Merise diagrams, which emphasize the nature and interrelationships of data structures, rather than of processes (Chen & Associates' ER-Designer utilizes these types of diagrams).

Front-end tools check internal consistency

A key feature of all system-specification CASE tools is the ability to store descriptions of data elements and processes in a database (called the data dictionary). The tools use the information in the data dictionary to crosscheck every entry, not just against the design rules of your chosen methodology, but also against your previous entries. The tools detect and report errors such as data elements that are never used, inconsistent naming of data elements, and many others.

Most tools provide many levels of detail so that you can break down a large task into a number of subtasks, and each of those, in turn, into "subsubtasks." The built-in completeness and consistency checks can help at this stage, for example, by warning you if your description of a process requires an input data element that you haven't yet defined. The decomposition of tasks is often called structured analysis (a term that Edward Yourdon and Tom DeMarco originated), and it continues until you reach a level of detail that will let you start to specify how to perform the subtasks.

When you've completed the system-requirements phase, you know what the system must do, in sufficient detail, to start identifying the program modules that will accomplish the tasks and subtasks you've specified. You're now embarking on the implementation phase—what Yourdon and DeMarco identified as structured design. Here you'll be using a different CASE tool, one that will allow you to specify not only what a program module will do, but how it will do it, its relationship to other modules, and how it will communicate with them.

The structured-design tool draws on the data dictionary that the structured-analysis tool has created, and adds new specifications to the dictionary. Here, too, built-in consistency and completeness checks prevent many of the conflicts that can arise when different programmers work on different parts of a system.

Many structured-design CASE tools, like their structured-analysis counterparts, provide a choice of methodology and allow you to apply the design methods best suited to your problem. For example, tools that implement the Boeing-Hatley extensions to DeMarco's original structured-design methodology, such as Cadre's Teamwork/RT and Index Technology's Exceleator, are particularly well-suited to the design of embedded real-time systems. The notation allows you to show the relationships between both synchronous and asynchronous events in the system.

When you've completed the implementation phase, you have a specification of each program module from which you can start coding. Some CASE tools allow the module specification in the database to contain skeleton

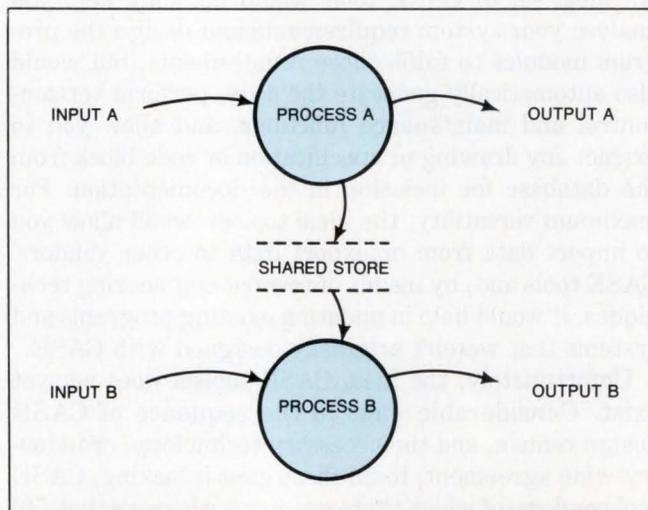


Fig 1—This simple data-flow diagram shows the symbology of the Yourdon-DeMarco structured-analysis methodology.

TABLE 1—REPRESENTATIVE CASE TOOLS WITH CODE GENERATORS AND REVERSE ENGINEERING

VENDOR	PRODUCT	FEATURES
ADVANCED TECHNOLOGY INTERNATIONAL	SUPERCASE	CODE FRAMES, CROSS DEVELOPMENT, REVERSE ENGINEERING
APTOOLS	APTOOLS	FULL CODE(ADA)
CADRE TECHNOLOGIES	TEAMWORK/ADA	CODE FRAMES (ADA)
COMPUTER COMMAND & CONTROL CO	MODEL	FULL CODE (ADA, C, PL/1)
HEARTLAND SYSTEMS	SOURCEVIEW	CODE FRAMES (C, COBOL, PASCAL), REVERSE ENGINEERING
ICONIX SOFTWARE ENGINEERING	POWERTOOLS	CODE FRAMES (ADA, C, FORTRAN, LISP, MODULA-2, PROLOG), REVERSE ENGINEERING
I-LOGIX	ADA PROTOTYPER	CODE FRAMES (ADA)
INTEGRATED SYSTEMS	AUTOCODE	FULL CODE (ADA, C, FORTRAN), CROSS-DEVELOPMENT
INTERACTIVE DEVELOPMENT ENVIRONMENTS	SOFTWARE THROUGH PICTURES	CODE FRAMES (ADA, C, PASCAL)
PROMOD INC	PRO/SOURCE, PROMOD/MD, RE-SOURCE	CODE FRAMES (ADA, C, PASCAL), REVERSE ENGINEERING
RATIONAL	R1000	FULL CODE (ADA) CROSS DEVELOPMENT
SCANDURA INTELLIGENT SYSTEMS	PRODOC	CODE FRAMES (ADA, C, PASCAL), REVERSE ENGINEERING
SOFTLAB	MAESTRO	CODE FRAMES (COBOL, PL/1, C)
SOFTWARE PRODUCTS & SERVICES (SPS)	EPOS	FULL CODE (ADA, C/ATLAS, FORTRAN, PASCAL, PEARL), CROSS DEVELOPMENT, REVERSE ENGINEERING
SYSCON	SKETCHER	CODE FRAMES (ADA), REVERSE ENGINEERING
TASC	ADAGRAPH	CODE FRAMES, FULL CODE (ADA), CROSS DEVELOPMENT
TELEDYNE BROWN	TAGS	FULL CODE (ADA) CROSS DEVELOPMENT

code or code fragments in the high-level language (HLL) of your choice.

It's at this point in the design sequence that you'll find one of the big gaps in CASE technology. An ideal toolset would be able to access all of the design data you've created and, from it, automatically generate a complete set of production code that would implement your design. Granted, satisfactory code generators for specialized tasks such as screen painting and report formatting have been around for several years, but designing a reliable *generalized* code generator has proven far more difficult.

Vendors are achieving some progress in this area, though, and of the more than 50 vendors of CASE tools, six now offer "full-code" generators that automatically generate 75% or more of the HLL code for implementing the program modules (Table 1). Eleven other vendors offer code generators that produce either code frames or skeleton HLL code. Both of these types use the data contained in the front-end tools' central database and generate output, usually consisting of Ada, Pascal, or C statements. Code generators for Modula-2,

Lisp, Prolog, PL/1, and Fortran do exist, but they are not widely available.

The full-code generators usually require that you define hardware-specific features of the target system by means of a program-definition language (PDL), and that you supply a library of previously coded low-level routines. The generators that produce code frames or skeleton code require even more manual intervention in order to ensure that new or modified hand-coded routines are reflected in the design data.

Some code generators also suffer from another problem, namely that they can't generate code for target machines with a different architecture than that of the host on which you're doing your development work. This restriction can pose a serious problem if you're cross-developing software for embedded systems. However, two vendors do offer Ada code-frame generators, and four others offer Ada full-code generators for embedded systems (Table 1).

When you've completed the coding of the modules—automatically or by hand—the straightforward part of the job is over. Now the complex tasks of correlation,

A key feature of all system-specification CASE tools is the ability to store descriptions of data elements and processes in a database.

testing, and configuration control begin. Most of the tools for these tasks are currently outside the realm of a CASE toolset's capabilities, but some do exist, and others are available from other vendors.

Correlation is the process of verifying that every function in the system requirements is implemented by some program module, and of identifying that module. Testing includes performance-analysis procedures to ensure that the code executes and also that every part of the code is executed at least once. CASE tools for automatic correlation and testing are rare; however, the Tektronix Tekcase toolset's Auditor tool provides a complete audit trail from system requirements to software deliverables. Also, Hewlett-Packard's HP/Teamwork toolset provides links to its AX-BA performance-analyzer tool.

Configuration control is the process of ensuring that the complete system always contains the latest version of each module. Typical tools for this are DEC's Test

Management System (TMS) and Configuration Management System (CMS) and the Unix Make utility. The configuration-control process begins during the implementation phase, and continues into the maintenance phase.

Tying up the loose ends

When you've reached the maintenance phase, reverse-engineering tools can provide valuable aid in two distinct ways. First, you can use them to ensure that the final code does indeed perform all the required functions and that changes in the production code are reflected in the design database. Second, you can apply them to the source code of existing programs that require updating, maintenance, or enhancement, but were not designed with the aid of CASE tools.

For example, reverse-engineering tools, such as Resource in the Promod toolset and Designer in the Tekcase toolset, accept HLL source code as input,

Manufacturers of CASE tools

For more information on CASE toolsets such as the ones 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.

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(212) 947-4755
Circle No 650

APTtools
945 Concord St
Framingham, MA 01701
(617) 875-5142
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Asyst Technologies
1080 Beaver Hall, Suite 1400
Montreal, Quebec, Canada H2Z 1S8
(514) 871-0108
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Santa Clara, CA 94089
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Circle No 653

Cadre Technologies Inc
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Providence, RI 02903
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CAP Gemini Software Products
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(617) 628-8500
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(617) 576-5732
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analyze it, and generate corresponding module-design and data-flow diagrams that the front-end tools can use as input. This capability allows you to utilize the full potential of CASE in a task that traditionally has been notoriously difficult and time-consuming.

All of the fundamental data necessary for proper documentation of a project is contained in the central design database originally created by the front-end tools. This data is in the form of drawings and data-element specifications, process specifications, interface specifications, and program-module specifications. The database may also contain skeleton code or substantial amounts of production code, depending on the nature of the toolset. Documentation tools can present integration problems, partly because they are, in themselves, complex systems that may be too large to be included in a CASE toolset, and partly because the best ones come from non-CASE vendors and may use an internal format incompatible with the one the CASE toolset uses.

Ways exist to overcome this incompatibility, however. One way is to arrange for the CASE tool to export text and drawings in print-image form, which the documentation tool can then treat as if it were keyboard input. Some toolsets, such as Cadre's Teamwork (which is also the basis of both the Hewlett-Packard and the Tektronix toolsets), Index Technology's Excelerator, and Teledyne Brown's Tags, now provide means by which Context's highly sophisticated documentation tool can request any data from the CASE database in print-image format. The Context tool does not directly access the design database, but can request both text and drawings in a print-image format that it can then store and incorporate into the system documentation.

The integration of different tools within a particular vendor's toolset is receiving the urgent attention of all CASE vendors except those few (Tektronix, Teledyne Brown, and SPS) that already offer toolsets that cover all phases of development from system requirements,

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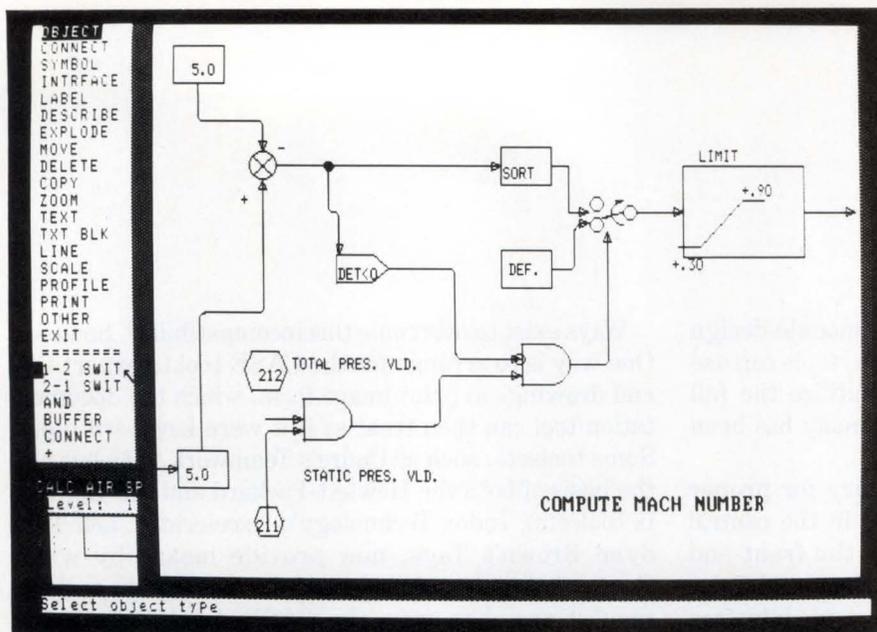
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Newton, MA 02165
(617) 969-4405
Circle No 688

Visual Software Inc

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Santa Clara, CA 95054
(408) 988-7575
Circle No 689

Yourdon Software Engineering

1501 Broadway
New York, NY 10036
(212) 391-2828
Circle No 690



CASE toolsets such as the Excelerator from Index Technology are well-suited to embedded, real-time system design. The toolset's notation enables the portrayal of synchronous vs asynchronous events.

through coding, to maintenance. The vendors' goal is to approach, as closely as possible, the ideal of a complete toolset whose components all generate and modify a single database throughout the life cycle of the software system. The continual use of a shared design database eliminates the synchronization problems that can arise when different team members each have a separate copy of the database.

Large projects may use a mixture of tools

Within any given toolset, integration problems arise mainly because some of the individual tools that ought to be part of a complete toolset do not exist in a form that is compatible with the other tools. Again, code generators serve as a good example of this problem. The code generator in the Maestro toolset from Softlab, for instance, requires PDL input in addition to the Nassi-Shneiderman structograms. The Teledyne Brown Tags toolset also incorporates a code generator, which receives its input from a proprietary specialized Input/Output Requirements Language (IORL) and currently generates only Ada source code (though the company intends to add VHDL ((VHSC Hardware Description Language)) as an output option during 1988). Of the six vendors who offer full-code generators, only three currently offer more than one HLL as output. Of the 10 who offer code-frame generators as part of their toolsets, five offer Ada, Pascal, and C as the output languages.

All of the other CASE toolsets available require either that you code by hand from the module-design specifications, or that you use a stand-alone code generator from some other vendor (such as DEC). The majority of such stand-alone generators are intended for management-information-system applications and generate Cobol code or code frames. However, Index Technology's Excelerator toolset does now generate diagrams that Pansophic Systems' Telon series of code generators can use directly.

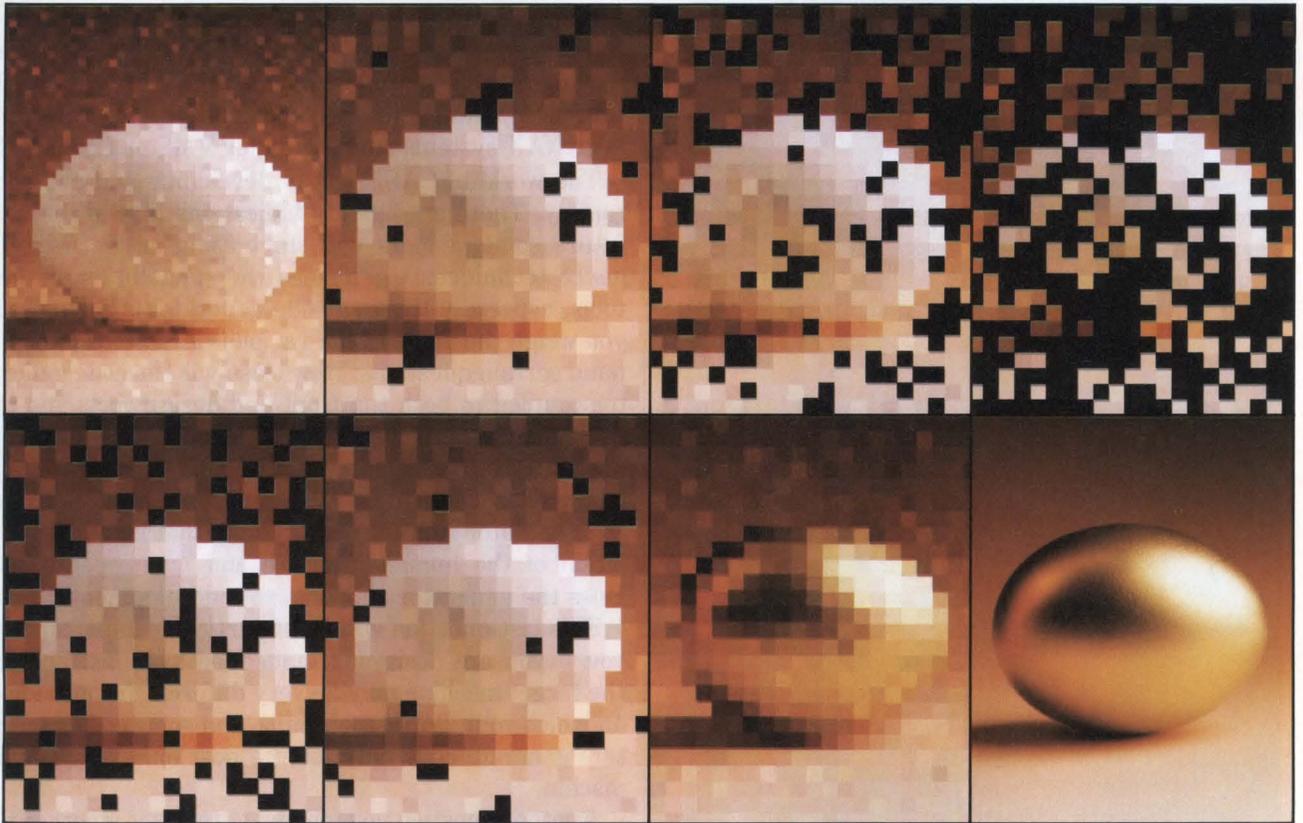
A very large project may require that different vendors at widely separated geographic locations develop different portions of the project. It is possible (and even probable) that the different vendors may use different CASE toolsets, and that the coordinating agency uses yet another toolset. There is at present no easy way to export data from one CASE tool to another, but vendors are at work on this intertool-communication problem.

Cadre has proposed extensions to the EDIF (Electronic Data Interchange Format) that would permit the interchange of data between CASE tools from different vendors, and also between CASE and CAE tools. A committee is currently working on translating Cadre's proposals into generally acceptable form, and it's possible that the use of EDIF may prove the best means of interchanging data between incompatible CASE tools at widely separated locations. However, EDIF is not easy to use and, as yet, no wild acclamation for it has been heard.

Atherton Technology has taken a different approach to intertool communication with its 4-layered Software Backplane. This tool is designed to provide you with uniform and independent access to many different software tools, while maintaining features that are native to the hardware of the host machine.

A monitor layer, based on MIT's X-Windows, provides a common display environment that gives all CASE tools a similar look and feel. The vendor claims that this characteristic will reduce the effort needed to learn the characteristics of an entire toolset. A management-control layer provides a variety of services, including source-version control and configuration management. An object-management layer provides a repository for all project-related data and imposes a single, consistent view of the data so that a variety of incompatible tools can share the information. And finally, a portability layer contains a generalized operating system that maps Software Backplane standard serv-

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ices to the native functions of the host operating system.

The vendor claims that once you've ported a CASE tool to the Software Backplane, the tool will run without any change on any hardware system that is equipped with the Software Backplane. The Software Backplane is compatible with the Sun-3 family of workstations operating under Unix and with all VAX and MicroVAX systems running under VMS or MicroVMS.

The world of CASE is still developing and changing rapidly. There are already indications that in the near future some vendors will start using artificial-intelligence techniques to enhance the capabilities of their tools, especially those of code generators. For now, as you weigh the value of the various CASE tools, keep in mind certain questions: How closely is the code generator coupled to both the front-end design tools and the back-end testing and maintenance tools? How complete are the design techniques and tools? What percentage of the finished code can the generator produce? Does the generator support prototyping (that is, quick simulation of the human interface and main operations)? Does the generator support cross development?

This last question will be of particular importance to you if you are designing embedded systems, because the target machine may be very different from the host on which your CASE tools run—and some code generators generate code only for the host or a very similar machine.

Another question you may want to ask is whether the tool produces documentation that is compatible with federal or military standards. Some CASE toolsets provide documentation that fully conforms to these standards, others do not.

Happily, you can easily gain access to a wealth of information to help you in your investigation. Some sources include CASE conferences and the papers presented there; vendor-run training seminars, which help you to focus on your specific needs and on finding the tool that best suits those needs; and at least one independent monthly journal, *Case Outlook* (Ref 1), which is devoted to surveys of CASE technology. **EDN**

References

1. *Case Outlook*, Case Consulting Group, Portland, OR (\$395/year).
2. Terry, Chris, "Customer training and reverse engineering promise to escalate the acceptance of CASE," *EDN*, March 17, 1988, pg 73.

Article Interest Quotient (Circle One)
High 470 Medium 471 Low 472

DRAMs,
SRAMs,
EEPROMs,
CMOS Logic,
Flash Converters,
SOT-23s,
Linear,
MOSFETs:

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Samsung is a leader in the manufacture of products utilizing state-of-the-art CMOS processes. Our 6-inch wafer fabrication lines in Korea are some of the most advanced in existence, as is our Class I wafer fab facility in San Jose, the heart

of Silicon Valley. Not only are we able to produce such leading edge products as DRAMs, SRAMs, CMOS Programmable Logic and Advanced CMOS Logic, but we produce them in high volume at low cost.

Samsung maintains advanced R&D facilities in Kiheung and Bucheon, Korea and in San Jose, California. At each of these facilities we have not only created our own advanced designs for current products, but we are at work now on our 4-megabit DRAM and our 1-megabit SRAM designs.

As you read on, one thing will be clear: Samsung is committed to designing, developing and delivering sophisticated products.

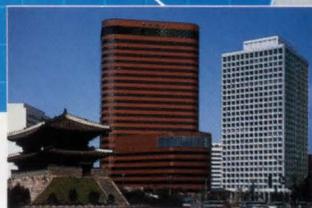
Products that set the pace.



Samsung's sophisticated manufacturing facility at Bucheon employs internally-developed Advanced CMOS and Bipolar processes.



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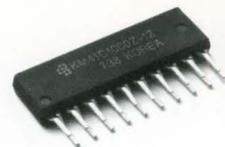


Samsung's World Headquarters in Seoul is the center of a global organization comprised of 26 companies which operate worldwide.



Samsung's U.S. Headquarters in San Jose includes Engineering, Marketing, Sales and Administration and also boasts state-of-the-art R&D and Class 1 manufacturing wafer fabrication.

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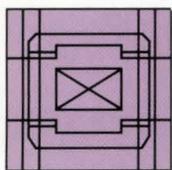
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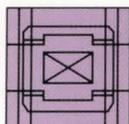
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Part Type	Organ.	Features	Speeds	Packages	Avail.
KM41C1000	1M x 1	Fast Page mode	100,120	DIP, ZIP, SOJ	Now
KM41C1001	1M x 1	Nibble mode	100,120	DIP, ZIP, SOJ	2Q 88*
KM41C1002	1M x 1	Static Column mode	100,120	DIP, ZIP, SOJ	2Q 88*
KM44C256	256K x 4	Fast Page mode	100,120	DIP, ZIP, SOJ	2Q 88
KM44C258	256K x 4	Static Column mode	100,120	DIP, ZIP, SOJ	2Q 88
KM41256	256K x 1	Page mode	120,150	DIP, ZIP, PLCC	Now
KM41257	256 x 1	Nibble mode	120,150	DIP, ZIP, PLCC	Now
KM41464	64K x 4	Page mode	120,150	DIP, ZIP, PLCC	Now
KM4164	64K x 1	Page mode	120,150	DIP	Now
KMM48/9256	256K x 8/9	Page or Nibble modes	120,150	SIP module	Now
KMM58/9256	256K x 8/9	Page or Nibble modes	120,150	SIMM module	Now
KMM48/91000	1M x 8/9	Fast Page mode	100,120	SIP module	2Q 88
KMM58/91000	1M x 8/9	Fast Page mode	100,120	SIMM module	2Q 88

*Samples available now.

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Part Type	Organization	Speed	Features	Technology	Pinout	Availability
KM2816AP	2K x 8	250,300,350	10ms (max) write time	NMOS	24 pin	Now
KM2817AP	2K x 8	250,300,350	Ready/Busy, 10ms (max) write time	NMOS	28 pin	Now
KM2864AP	8K x 8	250,300,350	Data Polling, 10ms (max) write time	NMOS	28 pin	Now
KM2865AP	8K x 8	250,300,350	Data Polling, Ready/Busy, 10ms (max) write time	NMOS	28 pin	Now
KM2864AHP	8K x 8	250,300,350	Data Polling, 2ms (max) write time	NMOS	28 pin	Now
KM2865AHP	8K x 8	250,300,350	Data Polling, Ready/Busy, 2ms (max) write time	NMOS	28 pin	Now
KM28C64P	8K x 8	150,200,250	Data Polling, 32-byte Page Mode, Low Power, 5ms (max) write time	CMOS	28 pin	May '88*
KM28C65P	8K x 8	150,200,250	Data Polling, 32-byte Page Mode, Low Power, 5ms (max) write time	CMOS	28 pin	May '88*

*Samples available now.

write time by a factor of 5.

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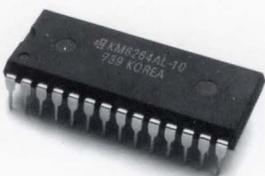
Samsung is ramping up production of both the 256K and 64K

Part Type	KM62256L	KM6264AL
Organization	32K x 8	8K x 8
Speeds	100, 120, 150ns	80, 100, 120ns
Package	28 DIP	28 DIP
Max Current (standby)	100 μ A	100 μ A
Availability	Now	Now

CMOS SRAMs. Our complete line is available now in industry standard packages and pinouts.

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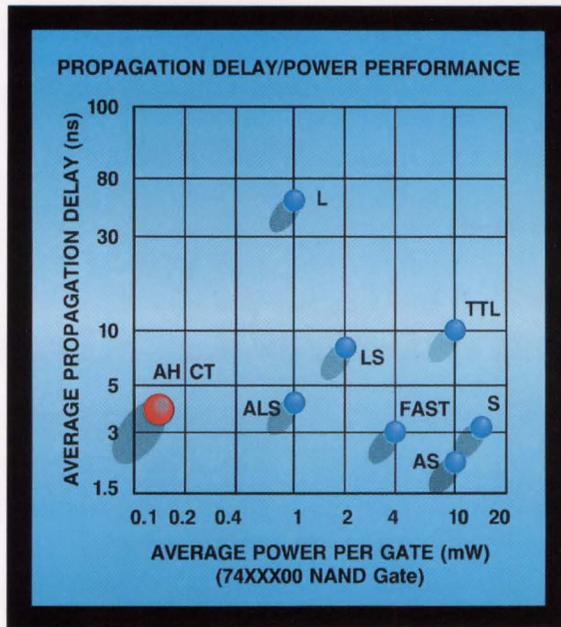
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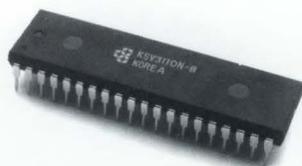
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Gates and Inverters		Flip-Flops		Transceivers/Registered Transceivers			Multiplexers	
00	20	73	399	242*	643	652*	151	253
01	21	74	534	243*	645	658*	153	257
02	22	76	564	245	646	659*	157	258
03	27	78	574	245	646	659*	158	352
04	30	107	670	640	648	664*	251	353
05	32	109	794*		651*			
08	51	112	821*	Counters			Shift Registers	
09	58	173	822*	160	190	590*	164	299
10	86	174	823*	161	191	591*	165	595
11	132	175	824*	162	192	592*	166	596
12	133	273	825*	163	193	593*	194	597
14	266	374	826*	168	390*		195	
		377		169	393		Arithmetic Circuits	
Buffers & Line Drivers		Latches		Decoders/Encoders			181*	522*
125	367	75*	793*	42	148*	238	182*	679
126	368	77*	841*	138	154	239	183	680
210	465*	259	842*	139	155		280	682
240	466*	373	843*	Multivibrators			518*	684*
241	467*	533	844*	121*	123*	423*	519	686*
244	468*	563	845*	Logic Level Converters			520*	688
365	540	573	846*	4049	4050*		521	689*
366	541							

*Part types available in 2Q '88. All other part types available now.

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The pacesetting technology of our single-chip KSV3110 A/D-D/A data converter provides independent 8-bit A/D converter functions and 10-bit R-2R D/A converter functions over an operating range of DC to 20MHz.

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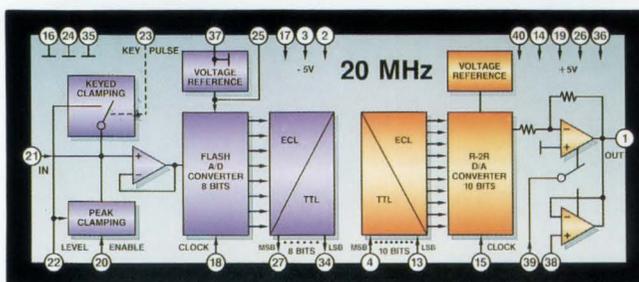
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Part Type	Resolution		Linearity		Conversion Speed	Industry Part
	A/D	D/A	A/D	D/A		
KSV3110N-10	8 bits	10 bits	$\pm \frac{1}{2}$ LSB	$\pm \frac{1}{2}$ LSB	20 MSPS	
KSV3110N-9	8 bits	10 bits	$\pm \frac{1}{2}$ LSB	± 1 LSB	20 MSPS	
KSV3110N-8	8 bits	10 bits	$\pm \frac{1}{2}$ LSB	± 2 LSB	20 MSPS	
KSV3110N-7	8 bits	10 bits	$\pm \frac{1}{2}$ LSB	± 4 LSB	20 MSPS	
KSV3100AN-8	8 bits	10 bits	$\pm \frac{1}{2}$ LSB	± 2 LSB	20 MSPS	UVC3101
KSV3100AN-7	8 bits	10 bits	$\pm \frac{1}{2}$ LSB	± 4 LSB	20 MSPS	UVC3101
KSV3208N	8 bits		$\pm \frac{1}{2}$ LSB		20 MSPS	
KAD0820ACN	8 bits		$\pm \frac{1}{2}$ LSB		1.5 μ sec	ADC0820BCN
KAD0820BCN	8 bits		± 1 LSB		1.5 μ sec	ADC0820CCN
KAD0808IN	8 bits		$\pm \frac{1}{2}$ LSB		100 μ sec	ADC0808CCN
KAD0809IN	8 bits		± 1 LSB		100 μ sec	ADC0809CCN
KDA0800CN		8 bits		$\pm \frac{1}{2}$ LSB	*100 nsec	DAC0800LCN
KDA0801CN		8 bits		± 1 LSB	*100 nsec	DAC0801LCN
KDA0802CN		8 bits		$\pm \frac{1}{4}$ LSB	*100 nsec	DAC0802LCN
KDA0806CN		8 bits		± 2 LSB	*150 nsec	DAC0806LCN
KDA0807CN		8 bits		± 1 LSB	*150 nsec	DAC0807LCN
KDA0808CN		8 bits		$\pm \frac{1}{2}$ LSB	*150 nsec	DAC0808LCN
KS7126CN	3 $\frac{1}{2}$ digit		$\pm \frac{1}{2}$ LSB		333 msec	TSC7126
KS25C02	CMOS 8-bit successive approx. register					DM2502
KS25C03	CMOS 8-bit successive approx. register					DM2503
KS25C04	CMOS 12-bit successive approx. register					DM2504

*Settling Time

Samsung's SOT-23s set the pace for surface mount technology.



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SOT-23 PART TYPES

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MMBT2222A	MMBT5088	MMBTA56
MMBT2484	MMBT5401	MMBTA63
MMBT2907A	MMBT5550	MMBTA64
MMBT3904	MMBT6428	MMBTA70
MMBT3906	MMBTA05	MMBTA92
MMBT4123	MMBTA06	MMBTA93
MMBT4124	MMBTA13	MMBTH10
MMBT4125	MMBTA14	MMBTH17
MMBT4126	MMBTA20	MMBTH24
MMBT4401	MMBTA42	BCX70G
MMBT4403	MMBTA43	BCX71G

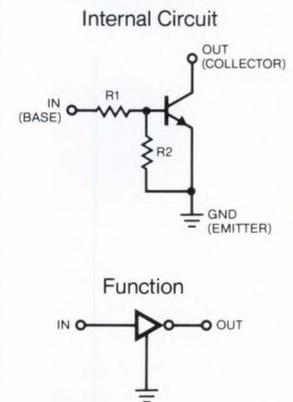
66 other types also available

Samsung now has available a new family of digital transistors, the KSR1000 Series (NPN) and KSR2000 Series (PNP), with 40 part types in each family. They're especially useful for applications where logic circuits are being interfaced with electromechanical systems.

We also offer an extensive line of industry standard TO-92, TO-126, and TO-220 transistors, plus TIP-Series power transistors, small signal transistors, high speed high voltage switching power transistors, Darlington power transistors and 1500V TO-3P transistors.

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Samsung sets a fast pace in delivering linear ICs.

The quality of Samsung linear ICs has gained them solid market acceptance. We now have over 250 industry-standard ICs available for immediate delivery. And Samsung has invested substantially to ensure that you get the latest technology, with high reliability in high volume at very low cost.

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KA336Z-5 (LM336-5)
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MC79MXXCT
MC79XXCT
 μ A78S40CN
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OP AMPS

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MC1458CN*
MC4558CN*
LM358N*
LM358AN*
LM348N*
LM324N*
LM324AN*
MC3403N*
KS271 (TLC271)
KS272 (TLC272)
KS273 (TLC273)

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KA2410N—Tone ringer
KA2411N—Tone ringer
KA2418N—Tone ringer with bridge diode
KA2412FN—Speech network
KA2413N—DTMF
KS5808N—DTMF
KS5805AN/BN—Pulse dialer
KS5819N—Pulse/DTMF (22 DIP)
KS5820N—Pulse/DTMF (18 DIP)
KT3040—CODEC filter
KT5116—CODEC
LM567N*—Tone decoder
LM567LN—Tone decoder Micropower

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KS555N* (CMOS)
KS555HN* (CMOS)
KS556N* (CMOS)
NE555CN*
NE556CN*
NE558CN

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KA710CN
LM311N*
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*Also available in surface-mount package (SOIC).

Samsung's MOSFETs have had fast-paced market acceptance.

Samsung's industry-standard power MOSFETs have rapidly gained market acceptance. Independent testing has demonstrated their excellent quality and superior ruggedness (2J at 500V). Each is screened to MIL-STD-750 specifications.

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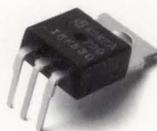
And Samsung is an established supplier with over 400 part types, in both N and P channel, one of the broadest lines on the market. Our MOSFETs range from 60V to 700V. Plus, we're especially deep in the 500V to 700V range. All with competitive pricing.

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Circle No. 174

TO-247 Full Pack N-Channel Types IRFS130 IRFS443 IRFS133 IRFS450 IRFS140 IRFS453 IRFS143 SSS4N70 IRFS150 SSS6N70 IRFS153 SSS10N70 IRFS230 SSS4N60 IRFS233 SSS6N60 IRFS240 SSS8N60 IRFS243 SSS15N60 IRFS250 SSS6N55 IRFS253 SSS8N55 IRFS330 SSS15N55 IRFS333 SSS20N50 IRFS350 SSS20N45 IRFS353 SSS25N40 IRFS430 SSS25N35 IRFS433 SSS40N20 IRFS440 SSS40N15	TO-3P Package N-Channel Types IRFP120 IRFP423 IRFP121 IRFP430 IRFP122 IRFP431 IRFP123 IRFP432 IRFP130 IRFP433 IRFP131 IRFP440 IRFP132 IRFP441 IRFP133 IRFP442 IRFP140 IRFP443 IRFP141 IRFP450 IRFP142 IRFP451 IRFP143 IRFP452 IRFP150 IRFP453 IRFP151 SSM3N70 IRFP152 SSM4N70 IRFP153 SSM6N70 IRFP220 SSM10N70 IRFP221 SSM15N55 IRFP222 SSM6N60 IRFP223 SSM8N60 IRFP230 SSM15N60 IRFP231 SSM4N55 IRFP232 SSM6N55 IRFP233 SSM8N55 IRFP240 SSM15N55 IRFP241 SSM4N50 IRFP242 SSM20N50 IRFP243 SSM4N45 IRFP250 SSM20N45 IRFP251 SSM6N40 IRFP252 SSM42N40 IRFP253 SSM5N35 IRFP320 SSM25N35 IRFP321 SSM7N20 IRFP322 SSM8N20 IRFP323 SSM40N20 IRFP330 SSM7N18 IRFP331 SSM8N18 IRFP332 SSM7N15 IRFP333 SSM8N15 IRFP340 SSM40N15 IRFP341 SSM7N12 IRFP342 SSM8N12 IRFP350 SSM10N10 IRFP351 SSM12N08 IRFP352 SSM10N08 IRFP353 SSM12N06 IRFP420 SSM10N06 IRFP421 SSM12N05 IRFP422 SSM10N05	IRF9220 IRF9232 IRF9221 IRF9233 IRF9222 IRF9240 IRF9223 IRF9241 IRF9230 IRF9242 IRF9231 IRF9243 TO-220 Package N-Channel Types IRF510 IRF741 IRF511 IRF742 IRF512 IRF743 IRF513 IRF820 IRF520 IRF821 IRF521 IRF822 IRF522 IRF823 IRF523 IRF830 IRF530 IRF831 IRF531 IRF832 IRF532 IRF833 IRF533 IRF840 IRF540 IRF841 IRF541 IRF842 IRF542 IRF843 IRF543 SSP3N70 IRF610 SSP4N70 IRF611 SSP4N60 IRF612 SSP6N70 IRF613 SSP6N60 IRF620 SSP6N55 IRF621 SSP4N60 IRF622 SSP4N55 IRF623 SSP4N50 IRF630 SSP4N45 IRF631 SSP5N40 IRF632 SSP5N35 IRF633 SSP7N20 IRF640 SSP6N20 IRF641 SSP7N18 IRF642 SSP8N18 IRF643 SSP7N15 IRF644 SSP8N15 IRF710 SSP8N15 IRF711 SSP7N12 IRF712 SSP8N12 IRF713 SSP12N10 IRF720 SSP10N10 IRF721 SSP12N08 IRF722 SSP10N08 IRF723 SSP12N06 IRF730 SSP40N06 IRF731 SSP10N06 IRF732 SSP12N05 IRF733 SSP10N05 IRF740
TO-3P Package N-Channel Types IRF120 IRF423 IRF121 IRF430 IRF122 IRF431 IRF123 IRF432 IRF130 IRF433 IRF131 IRF440 IRF132 IRF441 IRF133 IRF442 IRF140 IRF443 IRF141 IRF450 IRF142 IRF451 IRF143 IRF452 IRF150 IRF453 IRF151 SSM3N70 IRF152 SSM4N70 IRF153 SSM6N70 IRF220 SSM10N70 IRF221 SSM15N55 IRF222 SSM6N60 IRF223 SSM8N60 IRF230 SSM15N60 IRF231 SSM4N55 IRF232 SSM6N55 IRF233 SSM8N55 IRF240 SSM15N55 IRF241 SSM4N50 IRF242 SSM20N50 IRF243 SSM4N45 IRF250 SSM20N45 IRF251 SSM6N40 IRF252 SSM42N40 IRF253 SSM5N35 IRF320 SSM25N35 IRF321 SSM7N20 IRF322 SSM8N20 IRF323 SSM40N20 IRF330 SSM7N18 IRF331 SSM8N18 IRF332 SSM7N15 IRF333 SSM8N15 IRF340 SSM40N15 IRF341 SSM7N12 IRF342 SSM8N12 IRF350 SSM10N10 IRF351 SSM12N08 IRF352 SSM10N08 IRF353 SSM12N06 IRF420 SSM10N06 IRF421 SSM12N05 IRF422 SSM10N05	TO-3 Package P-Channel Types IRFP9120 IRFP9232 IRFP9121 IRFP9221 IRFP9122 IRFP9222 IRFP9123 IRFP9223 IRFP9130 IRFP9230 IRFP9131 IRFP9231 IRFP9132 IRFP9232 IRFP9133 IRFP9233 IRFP9140 IRFP9240 IRFP9141 IRFP9241 IRFP9142 IRFP9242 IRFP9143 IRFP9243	TO-220 Package P-Channel Types IRF540 IRF840 IRF541 IRF841 IRF542 IRF842 IRF543 IRF843 IRF544 IRF844 IRF545 IRF845 IRF546 IRF846 IRF547 IRF847 IRF548 IRF848 IRF549 IRF849 IRF550 IRF850 IRF551 IRF851 IRF552 IRF852 IRF553 IRF853 IRF554 IRF854 IRF555 IRF855 IRF556 IRF856 IRF557 IRF857 IRF558 IRF858 IRF559 IRF859 IRF560 IRF860 IRF561 IRF861 IRF562 IRF862 IRF563 IRF863 IRF564 IRF864 IRF565 IRF865 IRF566 IRF866 IRF567 IRF867 IRF568 IRF868 IRF569 IRF869 IRF570 IRF870 IRF571 IRF871 IRF572 IRF872 IRF573 IRF873 IRF574 IRF874 IRF575 IRF875 IRF576 IRF876 IRF577 IRF877 IRF578 IRF878 IRF579 IRF879 IRF580 IRF880 IRF581 IRF881 IRF582 IRF882 IRF583 IRF883 IRF584 IRF884 IRF585 IRF885 IRF586 IRF886 IRF587 IRF887 IRF588 IRF888 IRF589 IRF889 IRF590 IRF890 IRF591 IRF891 IRF592 IRF892 IRF593 IRF893 IRF594 IRF894 IRF595 IRF895 IRF596 IRF896 IRF597 IRF897 IRF598 IRF898 IRF599 IRF899 IRF600 IRF900 IRF601 IRF901 IRF602 IRF902 IRF603 IRF903 IRF604 IRF904 IRF605 IRF905 IRF606 IRF906 IRF607 IRF907 IRF608 IRF908 IRF609 IRF909 IRF610 IRF910 IRF611 IRF911 IRF612 IRF912 IRF613 IRF913 IRF614 IRF914 IRF615 IRF915 IRF616 IRF916 IRF617 IRF917 IRF618 IRF918 IRF619 IRF919 IRF620 IRF920 IRF621 IRF921 IRF622 IRF922 IRF623 IRF923 IRF624 IRF924 IRF625 IRF925 IRF626 IRF926 IRF627 IRF927 IRF628 IRF928 IRF629 IRF929 IRF630 IRF930 IRF631 IRF931 IRF632 IRF932 IRF633 IRF933 IRF634 IRF934 IRF635 IRF935 IRF636 IRF936 IRF637 IRF937 IRF638 IRF938 IRF639 IRF939 IRF640 IRF940 IRF641 IRF941 IRF642 IRF942 IRF643 IRF943 IRF644 IRF944 IRF645 IRF945 IRF646 IRF946 IRF647 IRF947 IRF648 IRF948 IRF649 IRF949 IRF650 IRF950 IRF651 IRF951 IRF652 IRF952 IRF653 IRF953 IRF654 IRF954 IRF655 IRF955 IRF656 IRF956 IRF657 IRF957 IRF658 IRF958 IRF659 IRF959 IRF660 IRF960 IRF661 IRF961 IRF662 IRF962 IRF663 IRF963 IRF664 IRF964 IRF665 IRF965 IRF666 IRF966 IRF667 IRF967 IRF668 IRF968 IRF669 IRF969 IRF670 IRF970 IRF671 IRF971 IRF672 IRF972 IRF673 IRF973 IRF674 IRF974 IRF675 IRF975 IRF676 IRF976 IRF677 IRF977 IRF678 IRF978 IRF679 IRF979 IRF680 IRF980 IRF681 IRF981 IRF682 IRF982 IRF683 IRF983 IRF684 IRF984 IRF685 IRF985 IRF686 IRF986 IRF687 IRF987 IRF688 IRF988 IRF689 IRF989 IRF690 IRF990 IRF691 IRF991 IRF692 IRF992 IRF693 IRF993 IRF694 IRF994 IRF695 IRF995 IRF696 IRF996 IRF697 IRF997 IRF698 IRF998 IRF699 IRF999 IRF700 IRF1000

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EEPROMs	<input type="checkbox"/> Samples	Part Type _____
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Setting the Pace.



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On April 5th, Intel made a major announcement about advanced 32-bit embedded control technology.

On April 12th, we'll explain it.

Intel unveiled three advanced embedded control technologies, two 32-bit embedded processors, and a radically new memory product line on April 5th.

On April 12th, seminars begin worldwide to show how to design significantly more powerful 32-bit systems that provide unparalleled price performance. The fully supported 80376 and 80960 families of embedded processors, and the breakthrough flash memory technology will be discussed in detail.

These free seminars will include lectures, comprehensive demonstrations, printed materials and a good lunch.

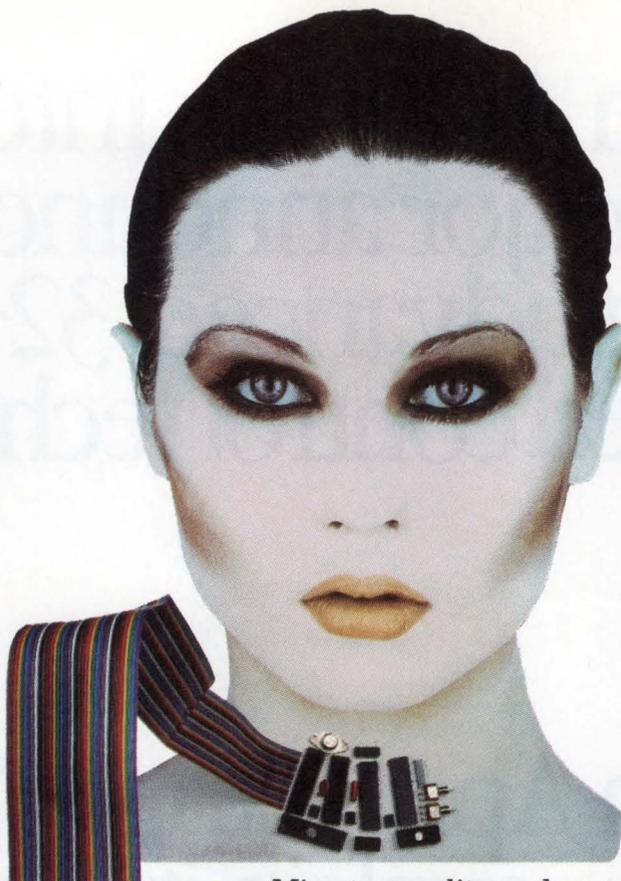
You're invited.

Call (800) 548-4725 for details, or to secure a spot.

And call now, as seating is limited, and we have a lot of explaining to do.



Alabama	Huntsville	4/29/88	Maryland	Baltimore	4/26/88	Pennsylvania	Philadelphia	4/12/88
Arizona	Tempe	4/18/88	Massachusetts	Boston	4/15/88		Pittsburgh	5/18/88
California	Anaheim	4/22/88	Michigan	Detroit	4/25/88	Texas	Austin	4/21/88
	Los Angeles	4/20/88	Minnesota	Minneapolis	4/14/88		Dallas	4/19/88
	San Diego	4/21/88	Missouri	St. Louis	5/19/88		Fort Worth	4/18/88
	Santa Clara	5/4/88	New Jersey	Kenilworth	5/13/88		Houston	4/20/88
	Van Nuys	4/19/88	New York	Binghamton	5/11/88	Virginia	Charlottesville	4/28/88
Colorado	Denver	5/3/88		Long Island	4/13/88		Tysons Corner	4/27/88
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	Orlando	4/26/88	North Carolina	Charlotte	5/4/88	Canada	Montreal	5/24/88
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Electro / 88

For 1988, Electro's technical and tutorial program expands to 54 sessions, 35 of which focus on software. Even for those whose work doesn't involve computers, Electro offers much food for thought.

Dan Strassberg, Associate Editor

*No beans in Boston; plenty of fish
Chinese food if that's your dish!*

Though the estimated 45,000 EEs who descend on Boston in mid-May are certain to partake of the city's copious gustatory enticements, it's not food for the body that will attract them. Rather, it's a bountiful platter of food for thought, in the form of Electro/88—the Eastern US's largest electronics-industry show and convention. Electro alternates between Beantown and the Big Apple. This year, it's Boston's turn. Electro/88 will be served up at the World Trade Center (WTC) on Commonwealth Pier and the Bayside Exposition Center from Tuesday May 10 through Thursday May 12.

The convention's theme for 1988 is "The Technology Bridge." In a marked departure from previous Electros, the expanded, 54-session technical/tutorial pro-

gram boasts 35 sessions related to software. The program emphasizes the application of software to the hardware-design process. In prior years, a computer-oriented program called Mini-Micro Northeast ran concurrently with Electro. But because computer technology is now so inextricably intertwined with every branch of electronics, Electro has subsumed Mini-Micro, which no longer exists as a distinct event.

Exhibitors include 900 companies

Most engineers who visit Electro attend not only for the professional program but also to see the wares on display and to get answers to specific technical questions from the show's exhibitors. This year, nearly 900 companies will exhibit their products in 1300 booths that will be divided approximately equally between Bayside Expo Center and the WTC. Among the exhibitors will also be some noncommercial organizations that aren't selling anything. For example, representatives of the IEEE Region I Committee on Women and Minorities and the Boston section of the Society for Women Engineers will be in Booth 2160 at the WTC to distribute information on the achievements of women and minorities in engineering.

Lester Thurow will deliver keynote address

It's an Electro custom to get up early to hear the keynote address. This year's program adheres to that tradition: The keynote breakfast will be held at 8:00 AM on Tuesday May 10 at Anthony's Pier 4 Restaurant (on



PROFESSIONAL-PROGRAM SESSIONS

WORLD TRADE CENTER

			TUESDAY, MAY 10
COMMERCIAL COMPLEX 1	COMMERCIAL COMPLEX 2	COMMERCIAL COMPLEX 3	TEACHERS UNION E
9:00 AM TO 11:30 AM TUTORIAL 1 MARKETING, THE KEY TO PRODUCT SUCCESS	9:00 AM TO 11:30 AM TUTORIAL 2 ELECTRICAL CAD	9:00 AM TO 11:30 AM TUTORIAL 3 TECHNICAL DOCUMENTATION FOR ELECTRONIC PRODUCTS	9:00 AM TO 11:00 AM SESSION 4 MODERN METEOR-BURST COMMUNICATIONS
12:30 PM TO 2:30 PM SESSION 7 SALES AND MARKETING: CLOSING THE SOFTWARE GAP	12:30 PM TO 2:30 PM SESSION 8 MODELING STRATEGIES FOR ASIC DESIGN	12:30 PM TO 2:30 PM TUTORIAL 9 COMPUTER-AIDED ACQUISITION AND LOGISTIC SUPPORT (CALS)	12:30 PM TO 2:30 PM SESSION 10 HIGH-TEMPERATURE SUPERCONDUCTORS
3:30 PM TO 5:30 PM SESSION 13 EXPORTING SOFTWARE TO JAPAN—FACT OR FANTASIES	3:30 PM TO 5:30 PM SESSION 14 DESIGN TOOLS FOR NEW PROGRAMMABLE SILICON DEVICES: DOES ONE SIZE FIT ALL?	3:30 PM TO 5:30 PM SESSION 15 CORPORATE ELECTRONIC PUBLISHING	3:30 PM TO 5:30 PM SESSION 16 ROBOTS IN THE REAL WORLD
			WEDNESDAY, MAY 11
9:00 AM TO 11:30 AM TUTORIAL 19 ENGINEERING TO MEET CUSTOMER NEEDS	9:00 AM TO 11:30 AM TUTORIAL 20 SOFTWARE DEVELOPMENT FOR REAL-TIME EMBEDDED SYSTEMS	9:00 AM TO 11:30 AM TUTORIAL 21 DESIGN FOR TESTABILITY	9:00 AM TO 11:30 AM TUTORIAL 22 COMPUTER INTEGRATED MANUFACTURING AND BUSINESS DECISIONS
12:30 PM TO 2:30 PM SESSION 25 SYSTEM SOLUTIONS FOR INCREASING SALES AND MARKETING PRODUCTIVITY	12:30 PM TO 2:30 PM SESSION 26 CASE TOOLS IMPROVE MANAGEMENT OF THE SOFTWARE CYCLE: INTRODUCTION, USAGE, HISTORIES, FUTURE TRENDS	12:30 PM TO 2:30 PM SESSION 27 SUCCESSFUL SYSTEM-DESIGN TECHNIQUES USING ASICs	12:30 PM TO 2:30 PM SESSION 28 CLEAN-ROOM AUTOMATION FROM CIM TO ROBOTS
3:30 PM TO 5:30 PM SESSION 31 SOFTWARE DESIGN TECHNIQUES FOR INNOVATIVE PLD ARCHITECTURE	3:30 PM TO 5:30 PM SESSION 32 COMPUTER-AIDED SOFTWARE ENGINEERING (CASE)	3:30 PM TO 5:30 PM SESSION 33 CHARACTERIZATION AND TESTING OF ANALOG-TO-DIGITAL CONVERTERS FOR DIGITAL SIGNAL PROCESSING APPLICATIONS	3:30 PM TO 5:30 PM SESSION 34 MACHINE-VISION APPLICATIONS IN ELECTRONICS MANUFACTURING
			THURSDAY, MAY 12
9:00 AM TO 11:30 AM TUTORIAL 37 MARKETING YOUR PRODUCT, YOUR DEAL, AND YOUR COMPANY	9:00 AM TO 11:00 AM SESSION 38 ENGINEERING EDUCATION—RESPONDING TO REAL WORLD DEMANDS	9:00 AM TO 11:00 AM SESSION 39 STRATEGIC DEFENSE INITIATIVE: ASSESSMENT OF PROGRESS AND PROSPECTS	9:00 AM TO 11:30 AM TUTORIAL 40 MECHANICAL CAD/CAM
12:30 PM TO 2:30 PM SESSION 43 SIMULATION OF ANALOG AND MIXED-MODE CIRCUITS	12:30 PM TO 2:30 PM SESSION 44 THE ROLE OF CONFIGURATION-MANAGEMENT TOOLS IN SOFTWARE DEVELOPMENT ENVIRONMENTS	12:30 PM TO 2:30 PM SESSION 45 SOFTWARE TOOLS FOR TEST AND MEASUREMENT APPLICATION PROGRAM DEVELOPMENT	12:30 PM TO 2:30 PM SESSION 46 HIGH-INTEGRATION SOLUTIONS FOR PERSONAL COMPUTER/PERSONAL SYSTEM DESIGN
3:30 PM TO 5:30 PM SESSION 49 LEAP INTO THE 90s WITH AN ACCELERATED NEW-PRODUCT DEVELOPMENT CYCLE	3:30 PM TO 5:30 PM SESSION 50 UNIQUE SOFTWARE CONSIDERATIONS FOR MICROCONTROLLERS WHEN LISTING HIGH-LEVEL LANGUAGES	3:30 PM TO 5:30 PM SESSION 51 TEST PROGRAM GENERATION: EXTRACTING TESTER PROGRAMS FROM SIMULATION	3:30 PM TO 5:30 PM SESSION 52 INDUSTRIAL REQUIREMENTS FOR REAL-TIME DIGITAL SIGNAL PROCESSING (DSP) APPLICATIONS

BAYSIDE EXPOSITION CENTER

TEACHERS UNION F

9:00 AM TO 11:30 AM
TUTORIAL 5
 IMPLEMENTING COMPUTER INTEGRATED MANUFACTURING (CIM)

12:30 PM TO 2:30 PM
SESSION 11
 INTRODUCING NEW PRODUCTS TO MANUFACTURING THROUGH CIM

3:30 PM TO 5:30 PM
SESSION 17
 PROCESS PLANNING AND SIMULATION OF MANUFACTURING OPERATIONS

9:00 AM TO 11:00 AM
SESSION 23
 RECENT ADVANCES IN "APPLICATION SPECIFIC" PLDs

12:30 PM TO 2:30 PM
SESSION 29
 ARTIFICIAL INTELLIGENCE IN MANUFACTURING

3:30 PM TO 5:30 PM
SESSION 35
 PUBLISHING OPPORTUNITIES IN THE IEEE

9:00 AM TO 11:00 AM
SESSION 41
 COMPUTER BACKPLANE INTERFACE USING HIGH-SPEED LOW-POWER CMOS INTERFACE ICs

12:30 PM TO 2:30 PM
SESSION 47
 MECHANICAL CAE IMPACTS ON PRODUCT DEVELOPMENT

3:30 PM TO 5:30 PM
SESSION 53
 SUPPORTING THE ETHICAL ENGINEER

TEACHERS UNION G

9:00 AM TO 11:30 AM
TUTORIAL 6
 INTRODUCTION TO GaAs DEVICES, TESTING AND EVALUATION METHODS

12:30 PM TO 2:30 PM
SESSION 12
 ADVENTURES IN TECHNOLOGICAL INNOVATION: HOW THE MASSACHUSETTS MIRACLE WORKS

3:30 PM TO 5:30 PM
SESSION 18
 DEVELOPMENT TOOLS FOR DIGITAL SIGNAL PROCESSORS (DSPs)

9:00 AM TO 11:00 AM
SESSION 24
 ENHANCING GLOBAL SECURITY THROUGH INFORMATION SHARING

12:30 PM TO 2:30 PM
SESSION 30
 RISK ASSESSMENT AND RESPONSE

3:30 PM TO 5:30 PM
SESSION 36
 SOCIAL IMPLICATIONS OF ARTIFICIAL INTELLIGENCE

9:00 AM TO 11:00 AM
SESSION 42
 RISC TECHNOLOGY ENTERS THE MAINSTREAM

12:30 PM TO 2:30 PM
SESSION 48
 FLOATING-POINT COPROCESSORS FOR ADVANCED PERSONAL MICROPROCESSORS

3:30 PM TO 5:30 PM
SESSION 54
 AN ARCHITECTURAL OVERVIEW OF CACHE CONTROLLERS FOR 32-BIT MICROPROCESSORS

Northern Ave near the WTC). Tickets to the breakfast cost \$20; you can buy them at the door. Those who attend will be treated to a talk by internationally acclaimed economist Lester C Thurow, who is Gordon Y Billard professor of management and economics and dean of the Sloan School of Management at Massachusetts Institute of Technology (MIT). Thurow served on the Council of Economic Advisors during the administration of President Lyndon Johnson. He has written or edited 12 books, including *Poverty and Discrimination*, *Investment in Human Capital*, *The Impact of Taxes on the American Society*, *Generating Inequality*, *The Zero-Sum Society*, and *Dangerous Currents: The State of Economics*. He is also a frequent guest on television talk shows.

The 54-session professional program will start at 9:00 AM on each of the three show days. Half of the sessions will take place at the WTC's Commercial Complex; the other half will run in Teachers' Union Rooms E, F, and G at Bayside.

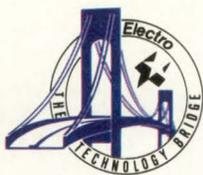
Technical program includes 11 tutorial sessions

Of the 54 sessions in the technical program, 11 are billed as tutorials. All the tutorials will take place from 9:00 to 11:30 AM—some at the WTC, others at Bayside. Five tutorials are scheduled for Tuesday, four for Wednesday, and two for Thursday. Because some sessions overlap, you may find it desirable to team up with a colleague, making each person responsible for attending certain sessions. For example, if you're interested in "Electrical CAD (Computer-Aided Design)" and "Implementing CIM (Computer-Integrated Manufacturing)," which will run concurrently, you can't be at both tutorials yourself.

However, in this particular instance and some others, you get a sort of second chance. If you attend the CAD tutorial on Tuesday, you can attend a tutorial on CIM and business decisions the following morning at Bayside. Readers of EDN's recent Technology Update on automatic test-pattern generation may want to make a point of obtaining further information on the subject by attending the "Design for testability" tutorial slated for Wednesday morning at the WTC.

Other tutorials of particular interest to EDN readers include Wednesday's "Software development for real-time embedded systems" and "Recent advances in application-specific PLDs," and Tuesday's "Introduction to GaAs devices: testing and evaluation methods."

Many of the sessions not billed as tutorials also cover subjects in which EDN readers have indicated great



interest. One such is "Design tools for new programmable silicon devices: does one size fit all?" This session will be held on Tuesday from 3:30 to 5:30 at the WTC. Another especially significant session takes place at the same time at Bayside. It's entitled "Development tools

for digital signal processors (DSPs)."

Wednesday features a cluster of sessions sure to attract many EDN readers: for example, "CASE tools improve management of the software cycle: introduction, usage, histories, future trends;" "Successful sys-

Please come to Boston (but don't bring your car)

Very few people haven't heard what a nightmare it is to drive in Boston. Though Boston drivers' reputation for daring and erratic behavior may be undeserved, even the most well-adjusted motorist is bound to be daunted by the scarcity of parking spaces and the inscrutable, albeit quaint, web of narrow one-way streets, which were literally laid out by eighteenth-century cows seeking the common grazing ground.

Furthermore, the zeal of the Boston Police Department's meter attendants is deservedly legendary, and, to top it all, despite some recent improvement, Massachusetts retains the title of car-theft capital of the world.

It's a good idea, therefore, not to drive to Boston if you can avoid it. With that caveat in mind, here's how to get to Electro/88 while preserving a least a portion of your sanity: Take Boston's MBTA or "T," which is a (pretty decent) public transportation system.

The Red Line gets you there

Both the World Trade Center (WTC), which is located at Commonwealth Pier on Northern Ave (in the South Boston section of the city) and the Bayside Exposition Center (in the Dorchester section) are within walking distance of the Red Line, one of the T's four major rapid-

transit lines. The WTC is near the South Station stop; the Bayside Exposition Center is near the JFK Library/U Mass stop on the Ashmont branch of the Red Line.

If you don't feel like walking the approximately 1½ miles from South Station to the WTC, you can take the City Point (No 7) bus, which stops close to the WTC. Similarly, if you don't feel like walking to Bayside from the JFK/U Mass Red Line station, you can take the No 8 bus or a shuttle run by Brush Hill Transit Co. Be sure to have a supply of quarters handy whenever you plan to ride a T bus. The T doesn't allow its drivers to accept bills or to make change.

Shuttle links WTC and Bayside

To travel between the Bayside Exposition Center and the World Trade Center, you can take one of the shuttle buses; they'll run continuously during the hours when Electro is open and will also stop at major Boston hotels.

If, despite all warnings, you insist on driving all the way to Electro, you can pay to park in a large lot at Bayside Exposition Center or another at the WTC. There will be additional parking for show attendees (for a fee) near Anthony's Pier 4 Restaurant on Northern Ave not far from the WTC. Remember,

though, that the total capacity of these lots is approximately 3900 cars, and Electro's attendance will exceed 45,000 people.

To reach the Bayside Expo Center from north of Boston, take Interstate 93 south to exit 15 and follow the signs. From the south, take I-93 north to either exit 14 or 15 and follow the signs. From the west, take the Mass Pike to its terminus at I-93, and follow I-93 south to exit 15, then follow the signs.

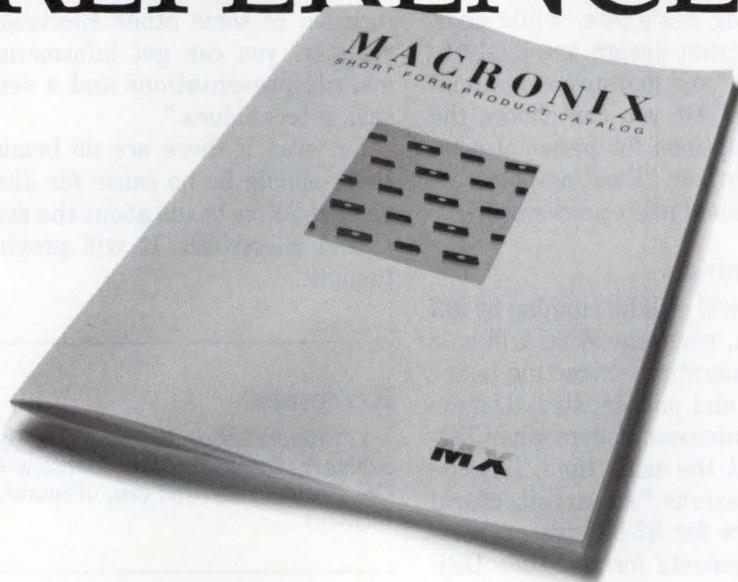
If you're driving and are unfamiliar with Boston, it's probably better to park at Bayside and take the shuttle to the WTC than to attempt to park at or near the WTC.

If you pay at the door and are not a member of the IEEE or ERA (Electronic Representatives Association), admission to Electro will cost \$20 for both the exhibits and the technical sessions. Admission for members is \$10. For those who preregistered by mail prior to April 21, the cost was \$5.

Exhibit hours are 9:30 AM to 5:00 PM on all three days. The professional program's hours are 9:00 AM to 5:30 PM on all three days.

When using the Electro Products section of EDN to plan your visits to exhibitor booths, remember that booths 1 to 1899 are at Bayside, and 1900 and above are at the WTC.

IF YOU NEED QUICK-TURN ROM, CHECK OUR REFERENCES.



If you've been looking for a reliable, and fast, supplier of mask ROMs look into the Macronix Quick-Turn ROM Catalog. You'll find a broad selection of ROMs in densities from 16 kbits to 1 Mbit. And delivery schedules that put finished product in your hands fast.

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For more information, ask for your copy of the Macronix Quick-Turn ROM Catalog. You'll find it's one of your most useful reference books. Macronix Inc. 2680 N. First Street. San Jose, CA 95134. (408) 434-1133. FAX (408) 434-1136.

MACRONIX PRODUCT LIST - ROMs						
Device	Size	Organi- zation	Speed	Tech- nology	Pins	Availa- bility
MX2316B	16K	2K x 8	150 ns	HMOS	24	NOW
MX2332/33	32K	4K x 8	150 ns	HMOS	24	NOW
MX2364	64K	8K x 8	150 ns	HMOS	24	NOW
MX2365/66	64K	8K x 8	150 ns	HMOS	28	Q2 88
MX23128/29	128K	16K x 8	150 ns	HMOS	28	Q2 88
MX23256	256K	32K x 8	175 ns	HMOS	28	NOW
MX23512	512K	64K x 8	200 ns	HMOS	28	NOW
MX231024	1M	128K x 8	200 ns	HMOS	28	NOW
MX23C1024	1M	128K x 8	200 ns	HCMOS	32	Q3 88
MX23C2048	2M	256K x 8	200 ns	HCMOS	32	Q3 88
MX23C4096	4M	512K x 8	200 ns	HCMOS	32	Q3 88
MACRONIX PRODUCT LIST - EPROMs						
MX27C64	64K	8K x 8	150 ns	HCMOS	28	Q2 88
MX27C128	128K	16K x 8	150 ns	HCMOS	28	Q2 88
MX27C256	256K	32K x 8	150 ns	HCMOS	28	Q2 88
MX27C512	512K	64K x 8	200 ns	HCMOS	28	Q3 88
MX27C1024	1M	128K x 8	200 ns	HCMOS	40	Q3 88
		64K x 16				





tem design techniques using ASICs;" "Software design techniques for innovative PLD architectures;" "Computer-aided software engineering (CASE);" and "Characterization and testing of analog-to-digital converters for digital-signal-processing applications." The last is one of the very few Electro/88 sessions targeted primarily at analog designers.

Thursday's sessions include a number of especially timely topics, such as "RISC technology enters the mainstream," and "Computer backplane interface using high-speed low-power CMOS interface ICs." The session entitled "Simulation of analog and mixed-mode circuits" should attract analog designers, while engineers interested in test-program design are likely to choose "Software tools for test and measurement application-program development." Or you can choose the session "High-integration solutions for personal computer/personal system design" or "Floating-point coprocessors for advanced personal microprocessors."

Good sessions just keep coming

The professional program will still be running at full speed on Thursday afternoon, when the WTC will host the session "Test program generation: extracting tester programs from simulation," and one entitled "Unique software considerations for microcontrollers when listing high-level languages." At the same time, Bayside will be the scene of the sessions "An architectural overview of cache controllers for 32-bit microprocessors" and "Industrial requirements for real-time DSP applications."

To make it easier to choose sessions to attend, Electro's organizers have divided the technical pro-

gram into "threads," each of which encompasses a group of related sessions. The threads and the numbers of the associated sessions are as follows (tutorials are indicated in italics).

- Electrical, mechanical, and software design process: *2, 8, 14, 20, 26, 32, 40, 43, 47, 49.*
- Documentation: *3, 9, 15, 44.*
- Testability: *21, 33, 45, 51.*
- Release Process: *5, 11, 17, 29.*
- Fabrication: *22, 28, 34, 52.*
- Marketing: *1, 7, 13, 19, 25, 37.*

This listing of tutorials and technical sessions omits mention of some other Electro/88 events. When you register, you can get information on such events as awards presentations and a seminar on "real-world selling techniques."

So, even if there are no beans in Boston, for EEs there should be no cause for dismay this May. If you want to *know* beans about the state of the art, you can attend Electro/88. It will provide plenty of food for thought.

EDN

Reference

1. From the song *Boston Beans* by Lee, Raskin, and Schluger. Copyright 1962, Denslow Music Co, Los Angeles, CA. (Incidentally, you can, of course, obtain baked beans in Boston.)

Article Interest Quotient (Circle One)
High 494 Medium 495 Low 496

Museum shows EE memorabilia

No EE should visit Boston without stopping at the Computer Museum. The museum, located at 300 Congress St on Museum Wharf, is only a stone's throw from the World Trade Center (WTC). Go down Northern Ave (where the WTC is located) toward Boston, and turn left on Sleeper St, just before the bridge. The museum will be on your left at the corner of Sleeper St and Congress St. A landmark

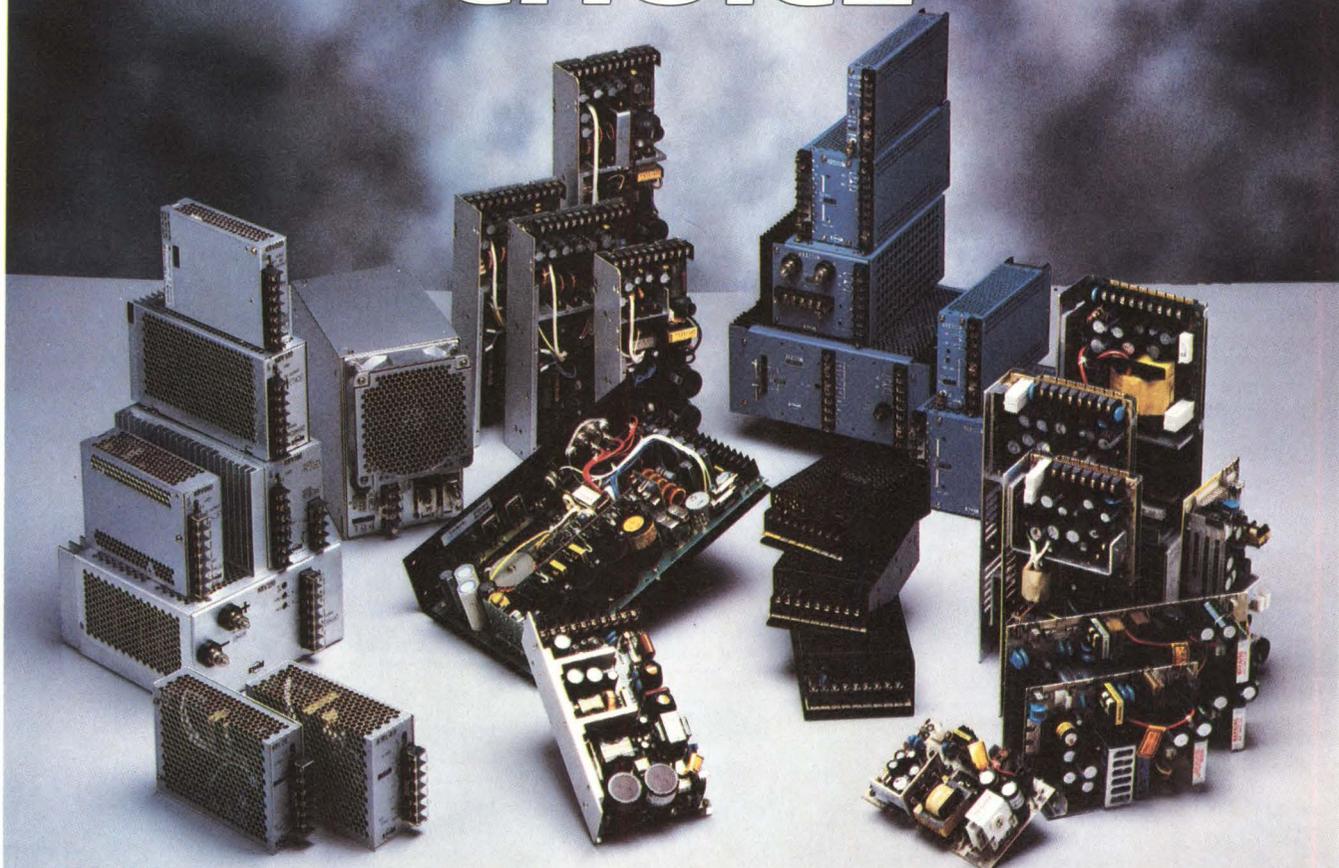
you can use to spot Museum Wharf is a building shaped like a milk bottle. It's probably best to walk to the museum from the WTC; as one (native Bostonian) EDN staffer puts it, "there's no place to park yah cah."

The computer museum chronicles the history of digital technology from a time before the advent of electronics to the present. Exhibits describe such historic computers as ENIAC at

the University of Pennsylvania, Mark I at Harvard, Whirlwind I at MIT, TX-0 at Lincoln Lab, and AN/FSSQ-7 on the DEW line. More modern machines—including PCs—are covered, too.

The museum is open from 10:00 AM to 5:00 PM Tuesday through Sunday. It stays open later on Fridays. Admission for adults is \$4.50; full-time students and children can obtain reduced rates.

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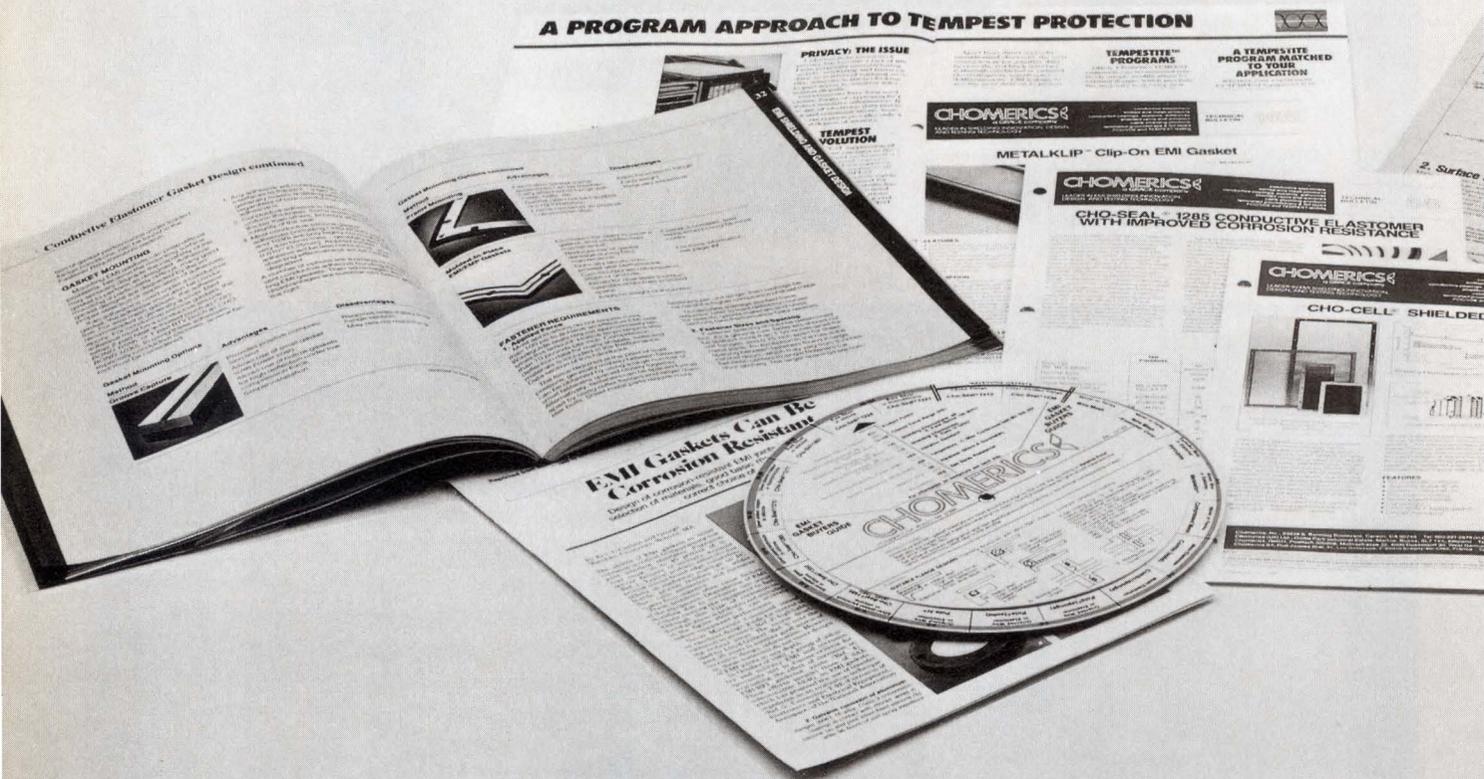


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- **Incorporating EMI shielding in your design**

CIRCLE NO. 39

- **Applications and material selection**

CIRCLE NO. 40

- **FCC/VDE compliance for commercial equipment**

CIRCLE NO. 41

- **MIL-SPEC compliance for military systems**

CIRCLE NO. 42

- **TEMPEST applications**

CIRCLE NO. 43

- **EMI testing**

CIRCLE NO. 44



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Solid-state
Memory
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Reliable storage for sweltering plants, vibrating factories, critical test labs, dusty quarries, bumpy roads, tossing ships, remote outposts...



Conventional disk drives work fine in most offices. But they can't take the kinds of abuse found in other environments.

Magnesys solid-state memory subsystems can.

These bubble memories stand up to shock, vibration, dust and high and low temperatures because they're non-mechanical and non-volatile. And they don't need batteries.

For design flexibility, the memory subsystems work with a variety of bus structures. Plug-and-play host adapters are available for the PC bus, STD-bus, Multibus* and VMEbus*.

Each subsystem has a 360K or 720K byte data cartridge. And a 3½" or 5¼" half-height electronic drive with embedded SCSI.

Until Magnesys, there were only two ways to get reliable bubble memory subsystems: Build one yourself from a kit and a 290-page instruction manual. Or pay the high price to have a middleman do it for you.

We fabricate our own bubble memories and subsystems right here in America. For a price roughly half what you'd pay for any comparable system.

For reliable data storage at an affordable price, there's nothing like Magnesys solid-state memory subsystems.

Find out for yourself by giving us a call.
(408) 988-1881.

Or write us at Magnesys, 1605 Wyatt Drive,
Santa Clara, CA 95054.

Multibus is a registered trademark of Intel Corp. VMEbus is a trademark of Motorola, Inc.

Magnesys

Reliable storage for an unreliable world.

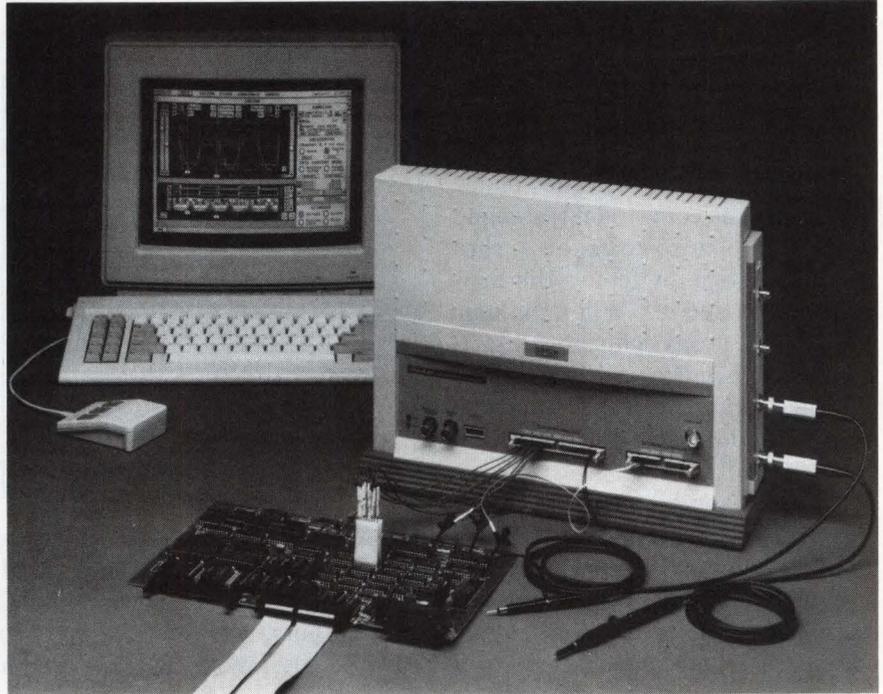
Electro/88 Products

Instrument combines 48-channel LA, 100-MHz DSO, and stimulus generator

The Omnilab 9240 is a combination digital-storage oscilloscope (DSO), logic analyzer (LA), and digital stimulus generator that comes in an attaché-case-sized enclosure. The unit is hosted by an IBM PC, PC/AT, or compatible computer. The scope offers a 100-MHz bandwidth; the 48-channel LA samples at 200M samples/sec.

Unlike separate instruments, the DSO and LA are designed to work in tandem. In combination with a feature named Multiview, the Select trigger system allows you to observe time-correlated analog and digital displays. Select combines the features of scope and logic-analyzer triggering. You can qualify the trigger conditions by use of truth tables stored in RAM, as well as by programming minimum and maximum time delays. Besides letting you see time-correlated displays, Multiview lets you watch digital data alone, analog data alone, or analog and digital displays representing separate time intervals.

Continuous sampling in conjunc-



tion with flexible triggering permits the unit to capture and display every occurrence of infrequent events such as missing pulses, metastable states, noise glitches, and bus contentions. From \$8900.

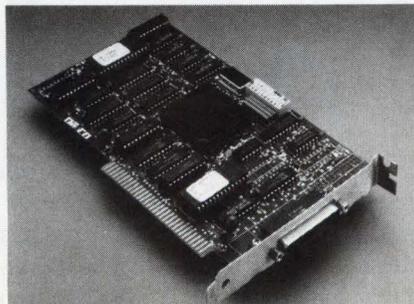
Orion Instruments, 702 Marshall St, Redwood City, CA 94063. Phone (800) 245-8500; in CA, (415) 361-8883. TLX 530942. Booth Nos 2741, 2743, and 2745.

Circle No 530

PC Bus card supports industry-standard graphic formats on flat-panel displays

The PC6424 half-sized card for the IBM PC Bus works in the IBM PC, PC/XT, PC/AT, and compatibles, letting you use electroluminescent panels, ac-plasma panels, and some LCD panels as display devices. The board supports the following standards: the CGA, double-scan CGA, MDA, Hercules graphics card, and 400-line-resolution mode. It can co-exist on the PC Bus with other monochrome and color display-adaptor cards.

The board contains a BIOS (basic input/output system) ROM that



initializes the controller without necessitating the loading of software drivers. The unit is compatible with display matrices of 640x200, 640x400, and 720x350 pixels.

The card includes an interface for the vendor's infrared touch-panel input device. \$350 (100).

Digital Electronics Corp, 31047 Genstar Rd, Hayward, CA 94544. Phone (415) 471-4700. TLX 172073. Booth No 475.

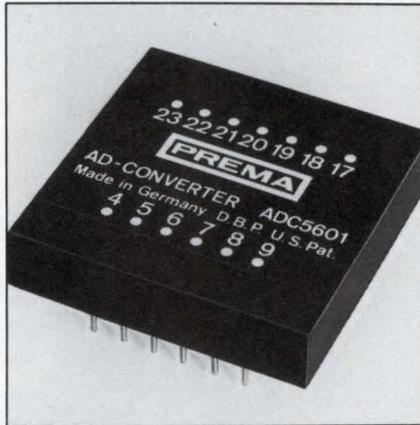
Circle No 534

Electro/88 Products

Modular analog-to-digital converter offers 25-bit resolution

The 2×2×0.4-in. ADC 5601 uses a proprietary conversion technique to produce a 25-bit result in 20 sec or a 14-bit result in 10 msec. The vendor claims that the conversion technique eliminates charge-transfer errors associated with switching the analog input on and off. When the unit signals that it has completed a conversion, you apply a pulse train to its shift-command input, and the module serially shifts out the conversion result.

You must connect a crystal to provide the module's timing reference and can use crystals that operate from 3.0 to 3.7 MHz to do so. You must also provide a voltage reference in the range of 6 to 8V to a



100-M Ω -impedance input; high-quality, temperature-compensated zener diodes, which have nominal 6.8V outputs, are well-suited to this purpose. By pin strapping, you can

configure the unit to accept an input of either 0 to -5V or ± 2.5 V; the input impedance equals 10 k Ω . After the module has undergone a 5-minute warmup, its temperature coefficient of gain, which is additive to the reference drift, equals <0.8 ppm/ $^{\circ}$ C. The offset drift is <0.6 μ V/ $^{\circ}$ C. The nonlinearity is < ± 1 ppm of full scale. The power required is <600 mW from ± 15 and +5V supplies. The power supply rejection typically equals 1 ppm/%V_s. \$360.

Prema Precision Electronics Inc, 6290 Sunset Blvd, Suite 1126, Los Angeles, CA 90028. Phone (213) 463-2294. Booth No 2811.

Circle No 532

Portable unit includes scope, counter, function generator, and power supplies

Testation 4444, housed in a 21-lb, 13×11×18-in. package, provides instruments commonly used for the development and testing of low-frequency analog circuits. The unit includes a dual-trace oscilloscope with a 20-MHz bandwidth; a 1-Hz-to-100-kHz function generator that produces sine, square, and triangular waves; a 3-output, regulated power supply that produces 5V at 1A, 12V at 200 mA, and -12V at 200 mA; and a 20-MHz frequency counter with 10-mV-rms maximum-sensitivity inputs that you can connect to the scope or to an external source. The counter's timebase accuracy, which varies no more than ± 30 ppm from 0 to 50 $^{\circ}$ C, is ± 20 ppm at 25 $^{\circ}$ C.



A 2-channel curve tracer lets you display and compare V/I characteristics of components. The scope has single-ended inputs with a maximum sensitivity of 2 mV/div. You

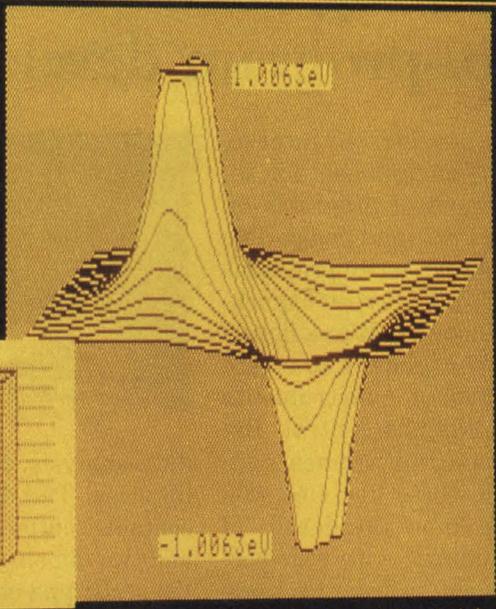
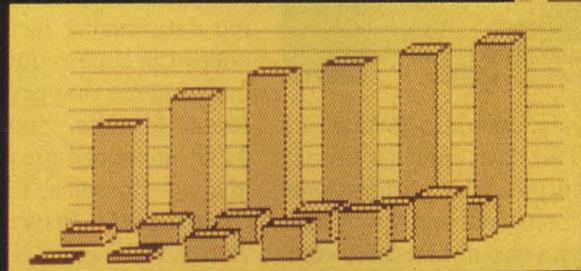
can subtract one channel from the other to provide a differential input. A 5 \times magnifier provides a maximum sweep speed of 100 nsec/div. A calibrator provides a 200-mV square wave whose amplitude accuracy is $\pm 2\%$. The function generator produces square and triangular waves whose maximum amplitude is 10V p-p into 600 Ω . The maximum sine wave output equals 1.5V rms. A step attenuator reduces the generator's output by 20, 40, or 60 dB. \$750.

ET&T Corp, 3001 Redhill Ave, Bldg 1-219, Costa Mesa, CA 92626. Phone (714) 557-2703. TLX 678352. Booth No 2624.

Circle No 531

FINLUX EL

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High reliability through Atomic Layer Epitaxy (ALE) process developed by Lohja

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Take a closer look at Finlux EL flat-panel displays, and you'll see right away why they're just right for your customers.

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See for yourself. Call or write Finlux Inc. today. You'll learn how remarkably capable something so remarkably compact can be.

	Input Voltages	Matrix Configuration	Display Area	Size	Weight
MD640.200-20	+5V/ +12V	640x200 pixels	4.8 x 7.68 in. (122 x 195mm)	6.24 in. (158.5mm)H 9 in. (228.5mm)W 1.38 in. (35.0mm)D	16.8 oz. (470g)
MD512.256-39S**	+5V/ +12V 37S +5V/ +15V 38S +5V/ +24V	512 x 256 pixels	3.85 x 7.69 in. (97.5 x 195mm)	5.67 in. (140mm)H 10.2 in. (260mm)W 1.38 in. (35.0mm)D	23 oz. (650g)
MD640.400-52	+5V/ +12V	640 x 400 pixels	4.8 x 7.68 in. (122 x 195mm)	6.24 in. (158mm)H 9 in. (228.5mm)W 1.38 in. (35.0mm)D	20 oz. (560g)
MD640.350-60	+5V/ +12V	640 x 350 pixels	4.8 x 7.05 in. (122 x 179mm)	6.24 in. (158mm)H 9 in. (228.5mm)W 1.38 in. (35.0mm)D	20 oz. (560g)
MD320.256-71	+5V/ +15V	320 x 256 pixels	3.0 x 3.78 in. (76.7 x 96 mm)	4.33 in. (110mm)H 5.12 in. (130mm)W 1.38 in. (35.0mm)D	15 oz. (420g)

*Process developed by Lohja Corporation, Finland

**Extended temp. range version available

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Electro/88 Products

Windowing environment for PCs supports control-program development in Basic and C

LabWindows provides an interactive windowing environment for development of control programs on the IBM PC, PS/2, and compatible computers. You can write programs in Microsoft C or in Microsoft Quick-Basic. LabWindows features libraries that enable beginners to create control programs for instruments under IEEE-488 bus control. Because many popular instruments are represented in these libraries, you don't need to know the details of how to communicate with your particular instrument in order to create the control programs.

To generate code sequences with LabWindows, you access pull-down menus and select functions by using a mouse or keyboard commands.

LabWindows includes graphics,



data-analysis, and data-formatting libraries. The data-analysis library contains routines that perform one- and two-dimensional array arithmetic, scalar and one-dimensional complex arithmetic, and statistical functions. An optional library includes digital signal processing, matrix and vector arithmetic, advanced statistics, and curve-fitting functions. A graphics library includes

routines for two-dimensional data plotting, multiple curve plots, and bar charts. An advanced graphics library provides axonometric and contour plots and interactive cursors. The data-formatting library contains routines for converting data among formats, which reduces the time required to program instruments that process data in different formats. Standard package, \$495; advanced-graphics and data-analysis libraries, \$895.

National Instruments Corp,
12019 Technology Blvd, Austin, TX
78727. Phone (800) 531-4742; in
TX, (800) 433-3488. TLX 756737.
Booth Nos 2803 and 2805.

Circle No 535

Schematic-capture and autorouting software works with popular CAD tool

The Pathfinder pc-board design system consists of a schematic-capture and layout program and an autorouter. Pathfinder works in conjunction with Autodesk Inc's Autocad program to provide mechanical as well as electrical-design capability on IBM PCs, PC/XTs, and PC/ATs. Included in the price of the autorouter is a 32-bit, parallel-processor card with 1M byte of RAM. You install the card in the system unit of the host computer.

The vendor claims that the schematic-capture and layout program places no limitations on board, grid, or schematic size; the number of schematic pages; or the number of parts, part types, pins/part, nets, pad sizes, hole sizes, or board layers. The schematic-capture function

can extract net lists from ASCII files, and lets you highlight individual nets.



The autorouter handles 16-layer boards and offers user-redefinable strategies and 45° routes. It is re-entrant, operates in single or multiple passes, and supports three algorithms: fast probe, exhaustive search, and rip up and reroute. For each 256k bytes of RAM on the coprocessor board, the autorouter can handle a board area of approximately 56 in.² and as many as 89,600 pins. Schematic capture and layout, \$1995; autorouter, \$2995.

Bishop Graphics CAD Systems Corp,
Box 5007, Westlake Village,
CA 91359. Phone (818) 991-2600.
TLX 662400. Booth Nos 2356 and
2358.

Circle No 533

POWER

Briefs

COMPACT 250 & 400 WATT SWITCHERS FEATURE FOUR-OUTPUT PARALLELING

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

The series can provide as many as seven outputs.

incorporated in three plug-in modules. Control circuitry is fabricated on a single circuit board using surface-mount technology. Standard features include switch selectable 115/230 VAC input, input line filter, remote on/off, power good signal, remote sensing, thermal protection with warning signal, overload protection, overvoltage protection, soft start and inrush current limiting. Optional features include current sharing, OVP crowbar and DC OK signal on main output, current monitor signal and others.



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

These switchers employ a bridge-driven forward converter using 100kHz MOSFET switching. The auxiliary outputs have either linear or magnetic amplifier regulation and are

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

Key Specifications:

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

From Computer Products/Power Products

Circle No. 1

NEW 4.5 WATT DC/DCs NEED ONLY HALF THE SPACE

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

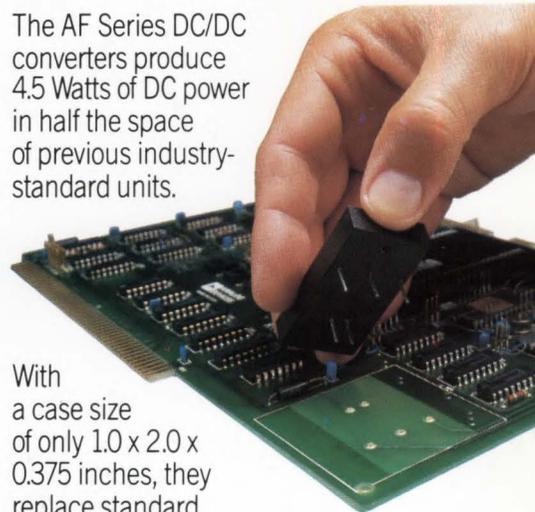
With a case size of only 1.0 x 2.0 x 0.375 inches, they replace standard 2 x 2 inch converters, yet have the same pinouts.

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

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

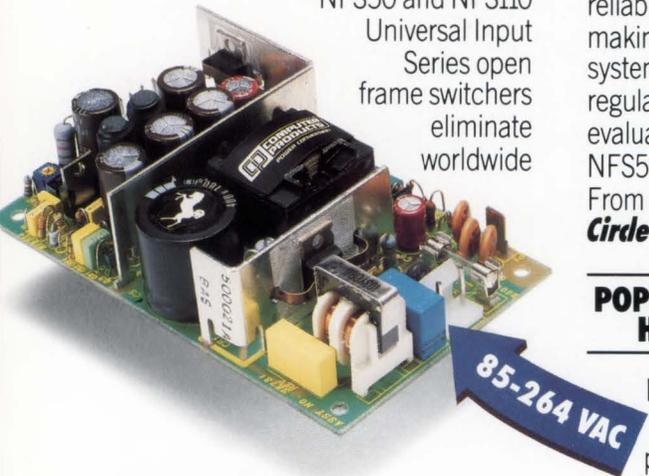
From Computer Products/Stevens-Arnold

Circle No. 2



UNIVERSAL INPUT SWITCHERS OPERATE FROM 85 TO 264 VAC

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



line voltage selection problems and offer system design flexibility.

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

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



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

All of these switchers will operate reliably with no load on the output, making them ideal for expansion systems. Also, each output is fully regulated. NFS40 and NFS110 evaluation units are now available. NFS50 is in distribution. From Computer Products/Boschert **Circle No. 3**

POPULAR DC/DC CONVERTERS HAVE NEW LOW PRICES

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

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

From Computer Products/Stevens-Arnold **Circle No. 4**

TAKING THE RISK OUT OF CUSTOM OPEN FRAME SWITCHERS

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

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

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

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

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

Manufacturability. Every supply we make is designed with manufacturability in mind. We use a common parts base, with well characterized components that meet our conservative stress derating guidelines. Check for further information on custom switchers. From Computer Products/Boschert **Circle No. 5**



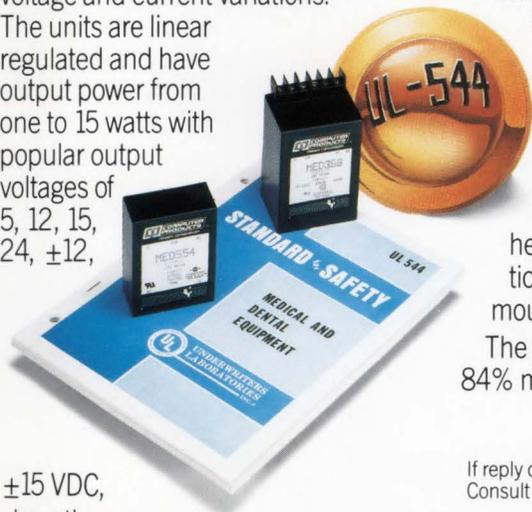
LINEAR POWER MODULES MEET UL544 MEDICAL REQUIREMENTS

For UL544 approval you can rely on Computer Products/Power Products new MED 300/500 Series of AC/DC encapsulated power modules. They meet or exceed the stringent UL544 requirements for medical equipment. These supplies are recommended for use in non-patient contact medical, dental and laboratory applications where high isolation and low leakage are critical. The MED 300/500 series is provided in single, dual and triple output models offering 63 different output voltage and current variations.

The units are linear regulated and have output power from one to 15 watts with popular output voltages of 5, 12, 15, 24, ± 12 ,

± 15 VDC, plus others available. Standard protection features such as overtemperature, overload and short circuit protection are included. The power modules incorporate a split-bobbin wound transformer which provides high isolation between primary and secondary with low coupling capacitance. This results in 2500 VAC isolation voltage and less than 10uA leakage current. The units are available in either printed circuit mountable or chassis mountable packages. In addition to UL544 approval the series is CSA certified.

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

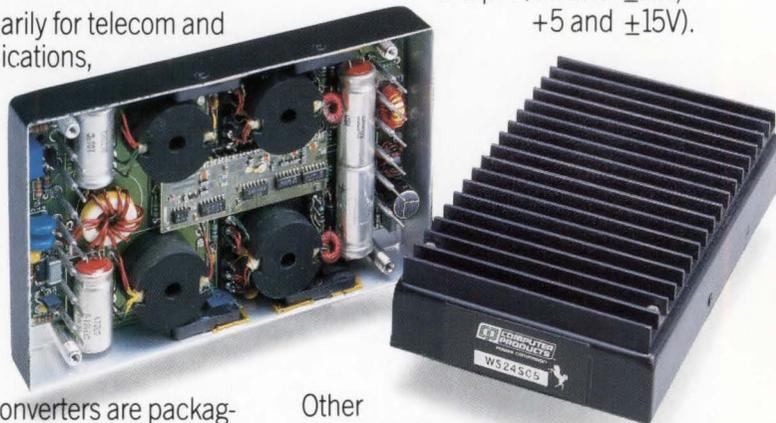


100 WATT DC/DC CONVERTERS HAVE LOW PROFILES, HIGH EFFICIENCIES

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

The WS Series has an efficiency of 84% minimum and a 2:1 input range

of either 18 to 36 VDC or 36 to 72 VDC. Output ranges supplied are single (+5, +12 or +15V), dual (+5 and +12V), or triple (+5 and ± 12 V, +5 and ± 15 V).



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

Key Specifications:

Line Regulation $\pm 0.5\%$ max.

Load Regulation 2.0% (to no load)

Ripple and Noise 100mV p-p max.

This series is available through distribution.

From Computer Products/Stevens-Arnold **Circle No. 7**

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



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UP TO 591,000 HOURS MTBF WITH OPEN FRAME LINEARS

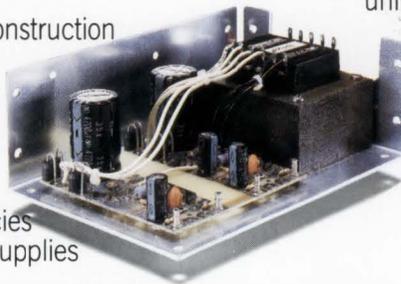
Step up to higher standards of reliability with the World-Standard Series of open frame linears. The aluminum frames and power

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

¹ Consult factory for additional models.
² Calculations per MIL-HDBK-217E @ 100% load; 115 VAC line; 25° C ambient temperature; ground, benign

ratings of the World-Standard Series are form, fit, and function replacements for all other open frame linear power supply manufacturers. With four different AC input line voltage ranges, these supplies can be connected for use in any country of the world.

These units have a VDE construction power transformer with enclosed split-bobbin windings and 3750 VAC minimum isolation. The designs are conservative with efficiencies up to 60% and all power supplies



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

receive a four-hour burn-in before shipment.

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

recognized, CSA certified, and TUV approved.

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

From Computer Products/Power Products **Circle No. 8**



MIL-SPEC POWER SUPPLIES FOR RUGGED ENVIRONMENTS

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

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

From state-of-the-art topologies to advanced package design, every attention is paid to cost-

effective custom designs for demanding environmental requirements. Let us modify an existing standard product or develop a totally new design to meet your system specifications. We are certified to manufacture to Mil-Q-9858A and conform to the guidelines of NAVMAT P4855-1.

Send for your free copy of our Mil-Spec Power Supply catalog. From Computer Products/Tecnetics **Circle No. 9**

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



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| 2. AF Series | 6. MED Series | 10. Engineering Handbook |
| 3. NFS 40/50/110 Series | 7. WS Series | 11. Have an Applications Engineer Call |
| 4. ES/EA/H Series | 8. World-Standard Series | 12. Have a Sales Person Call |

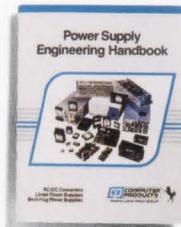
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Send for your free copy of our Power Supply Engineering Handbook providing specifications for our complete line of power supplies with power ranges from 1/2 Watt to 1500 Watts.

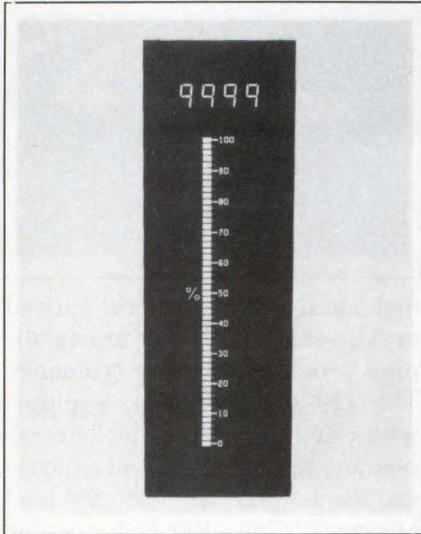
From Computer Products/Tecnetics **Circle No. 10**



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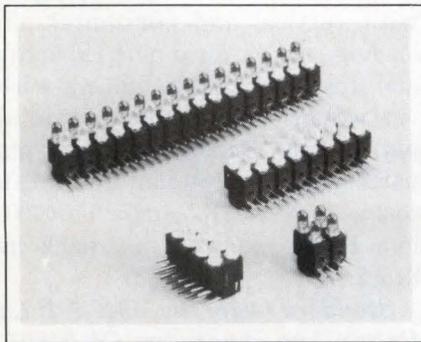


BAR GRAPH

The Model K051 51-segment LED-array bar graph features an analog bar that follows the level of an analog input signal with a response time of 55 msec. Simultaneously, a 4-digit readout displays the signal-input level with 0.1% accuracy. The unit measures 11.5×3.5 in. You mount it through a front panel cut-out and secure it with two adjustable retaining clips. The unit comes with a 110/220V ac power supply mounted on it. The standard unit features red LEDs; you can obtain amber, green, and multicolored LEDs as options. \$400. Delivery, eight to 10 weeks ARO.

Dixon Inc, Box 1449, Grand Junction, CO 81502. Phone (303) 242-8863. TWX 910-929-6991. Booth Nos 2203 and 2205.

Circle No 536



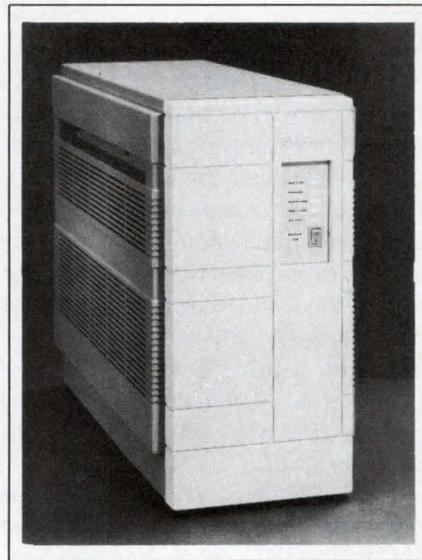
LED ARRAYS

T-1 LED arrays are arranged in single- or double-row packages for

right-angle mounting on a pc board. The preassembled LEDs come in blocks of 1, 2, 4, 8, and 16 to save assembly time. The blocks are arranged on a 2.54-mm pitch according to DIN 41494 requirements. The LEDs have a maximum installed height of .41 in., feature tinned terminals, require no mounting hardware, and operate over -40 to +85°C. They come in red, green, and yellow. The double-row packages provide such combinations as red/red, green/green, yellow/yellow, red/yellow, red/green, and yellow/green. From \$0.50.

Elma Electronic Inc, 41440 Christy St, Fremont CA 94538. Phone (415) 656-3400. FAX 415-656-3783. Booth Nos 2650 and 2652.

Circle No 537



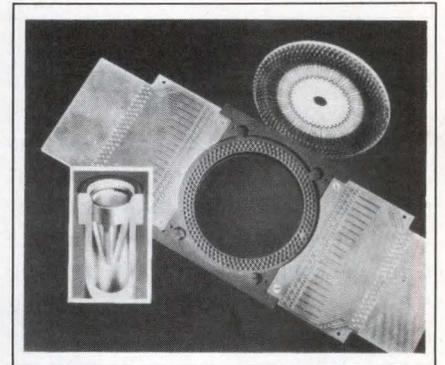
POWER SOURCE

The SPS/R standby power source features a 1-msec transfer time. When operating from ac power, a regulator, whose efficiency is 95%, passes the input sine wave through with less than 1% distortion. The regulator maintains the output voltage within +5 to -8% in the event of ac-input-voltage variations from +15 to -25%. If the input voltage falls below -25%, the unit shifts to inverter/battery power and supplies an output voltage within ±2% of nominal, with less than 5% harmon-

ic distortion. When the ac power returns to within -25% of its normal level, the unit shifts power back to the ac input with no breaks at the zero-voltage crossing. You can order 60-Hz units, with 120V ac input/output voltages, rated for 500, 1000, or 1500 VA. \$1445.

Sola, 1717 Busse Rd, Elk Grove Village, IL 60007. Phone (312) 439-2800. TLX 280538. Booth No 2703.

Circle No 539



RECEPTACLE

You can insert the 0300 6-finger receptacle with relatively little force. For example, when used in a circular probe card, the receptacle requires only 34 lb of insertion force. Its funnel-shaped design reduces the possibility of misalignment. This suits the device to applications that entail repeated plugging and unplugging. The device features a shell constructed of brass alloy 360 and contacts made of beryllium copper alloy 172. You can obtain a 0.320- or 0.397-in.-long receptacle. The device is suited for use with the vendor's 3137 pin. \$0.08 (10,000).

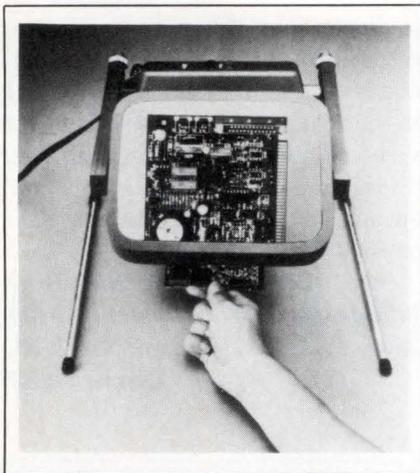
Mill-Max Mfg Corp, Box 300, 190 Pine Hollow Rd, Oyster Bay, NY 11771. Phone (516) 922-6000. TWX 510-221-1820. Booth Nos 1069 and 1071.

Circle No 538

MAGNIFIER

The MasterLens Illuminated Stereo Magnifier features a 6×8-in. rectangular glass lens that provides an

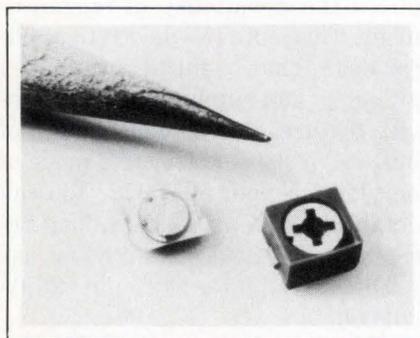
Electro/88 Products



extralarge viewing field. The unit causes less than 2% distortion and can provide magnification of more than 3 diopters, depending on the focal length. There is sufficient depth of field under the lens to allow free hand movement. You can rotate the lens and a fluorescent lighting system to obtain the best viewing angle. Model STV-1, with portable stand, \$299; model STV-2, with retractable arm, \$389.

Contact East Inc, Box 786, North Andover, MA 01845. Phone (617) 682-2000. TLX 383088. Booth No 206.

Circle No 540



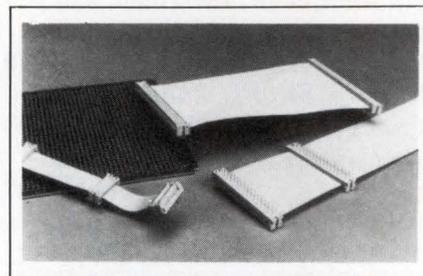
TRIMMER CAPACITORS

Surftrim surface-mounted trimmer capacitors are suited to vapor-phase reflow soldering. The vendor offers them unsealed or in sealed membranes that protect them against contaminants. You can obtain the unsealed devices in 3.2×4.5×2.8-mm carrier-and-reel packages and the sealed devices in 4.0×4.5×2.8-mm carrier-and-reel packages. The

vendor offers the devices with eight capacitance ranges from 1.7 to 60 pF. The capacitors operate over -25 to +85°C. They are rated at 100V dc, feature 220V dc dielectric withstanding voltage, and provide insulation resistance of 10⁴ MΩ min at 100V dc. \$0.36 (10,000).

Sprague-Goodman Electronics Inc, 134 Fulton Ave, Garden City Park, NY 11040. Phone (516) 746-1385. TLX 144533. Booth No 218.

Circle No 541



CONNECTORS

You can permanently attach LAT-CON 2-row transition, .050-in. flat-cable connectors to pc boards, eliminating the need for headers. They come with preassembled sockets and covers, but open on one end for lateral cable insertion. The vendor offers the connectors for 10 to 64 circuits with .100-in. row spacing. You can obtain them with either 0.118-in. or 0.157-in. solder pins, plated with 315 μin. of tin. From \$0.53 to \$3.67.

Panduit Corp, 17301 Ridgeland Ave, Tinley Park, IL 60477. Phone (312) 532-1800. Booth Nos 342, 343, 348, and 349.

Circle No 542

KEYBOARD

The G80-2000 multi-option keyboard is IBM compatible. Its layout is identical to that of the IBM 3270 keyboard, with 10 function keys on its left end and another 24 arranged in two rows along its top. The keyboard comes with an enhanced version of SmartKey that provides an extra 96 functions by permitting each function key to function alone,



and when shifted, control-shifted, or ALT-shifted. A liquid crystal display provides operator guidance. The 123-key keyboard, equipped with electronic options for bar-code reading, the installation of a mouse, and the use of a magnetic-card reader, costs \$765. Bar-code reader, \$170; light pen, \$45; and mouse, \$45.

Cherry Corp, 3600 Sunset Ave, Waukegan, IL 60087. Phone (312) 360-3585. Booth Nos 1431, 1433, 1435, 1437, and 1439.

Circle No 543

LOGIC BOARDS

Metric Series wire-wrap logic boards come in Eurocard sizes ranging from 3U×160 to 9U×400 mm. They are available with power and ground for the VME Bus, Multibus II, and IEEE 896 Futurebus, or in uncommitted versions for special development. The low-noise boards feature SMT decoupling capacitors throughout the board. You can obtain the boards in a variety of pin patterns, including a low-density universal DIP mounting, a high-density universal DIP mounting with vertical pin loading, a high-density universal DIP mounting with vertical and horizontal pin loading, and a hybrid pin grid array and universal DIP mounting with vertical or vertical and horizontal pin loading. Depending on its pin pattern, a 3U×160-mm board can cost as little as \$155 and a 9U×400-mm board can cost as much as \$1592.

Standard Logic Inc, 4940-A E La Palma Ave, Anaheim, CA 92807. Phone (714) 779-2897. Booth No 2137.

Circle No 544



PHILIPS



Counter-fit

If you think all low-cost frequency counters are inferior imitations of precision lab instruments, guess again. Fluke has a new 120 MHz counter that's a perfect fit for test systems, bench tops and budgets.

Honest performance at only \$995.

The Philips PM 6666 counter delivers seven full digits of resolution at gate times of one second. More than 20 measurement functions. Automatic trigger-level setting. And first-rate input protection to

350V. All packaged in a rugged, shielded metal case.

Add full programmability with the GPIB/IEEE-488 option. A 1.1 GHz input. Or Philips' unique mathematically-controlled crystal oscillator timebase for precise measurements with no warm-up time.

All this performance is backed up by one of the most trusted names in instrumentation: Fluke, with service and support that's never more than a phone call away.

So don't take chances. For genuine

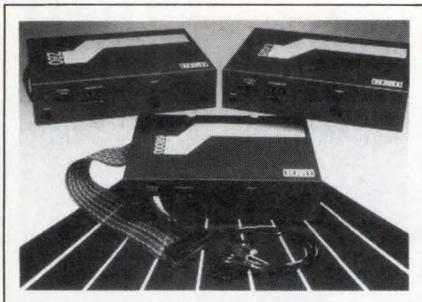
solutions to fit your test and measurement needs, come to Fluke. For more information and complete specifications, phone **1-800-44-FLUKE ext. 77.**

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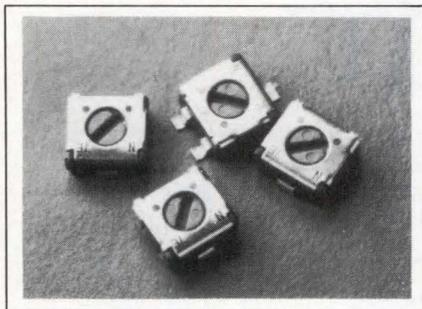


EMULATORS

The HMI-200 Series of in-circuit emulators now includes units that support the 8051/8031 family (including the Oki 80C59 Series), the 68HC11, the 6809, and the 8085. All units include two 72-bit \times 4k-frame trace buffers, logic-analyzer features, a general-purpose interval timer, and advanced break- and trigger-point parameters. The 6809 and 8085 emulators allow bank selection within emulation memory. They can also track the target system's bank selection mechanism. The 8051 emulator can trace all four of the microcontroller's ports in addition to address, data, and status values. This emulator can also use bit patterns on the 8051's 16 TTL inputs to qualify break and trigger conditions. The 68HC11 unit supports all of the μ C's modes. \$4750.

Huntsville Microsystems Inc,
Box 12415, Huntsville, AL 35082.
Phone (205) 881-6005. Booth No 2596 and 2598.

Circle No 564



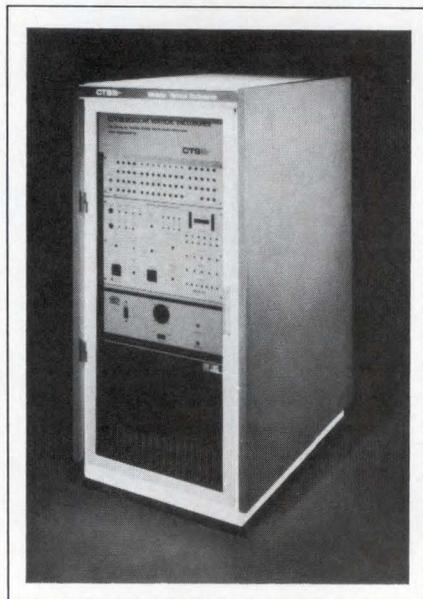
ROTARY SWITCH

The surface-mount CS-4 spdt selector switch has a 4.5 \times 5-mm outline. For a dc resistive load, the contact rating equals 0.5 VA; the maximum voltage and current ratings equal

16V and 100 mA from -25 to $+70^\circ\text{C}$. A high-temperature housing material allows the switch to survive IR and vapor-phase soldering processes for five minutes. The switch can also withstand immersion-type cleaning processes, even with the use of low-viscosity liquids. The rotational life and total rotational angle spec at 20 cycles and 90° , respectively. The units are available in J-hook and gull-wing styles in bulk or in tape-and-reel packaging. \$0.50 (5000).

Mecopal Co, 11468 Sorrento Valley Rd, San Diego, CA 92121.
Phone (619) 453-0332. Booth No 1349.

Circle No 553



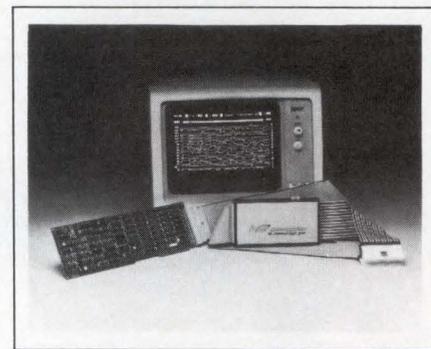
ENCLOSURES

The MVE line of knock-down vertical enclosures offers the strength and rigidity of welded enclosures. These easy-to-assemble units are made of 13-gauge, cold-rolled steel and feature an EPA-approved, textured acrylic-enamel finish. The enclosures' strength and rigidity come from the design of their corners. A heavy-gauge mounting plate is welded into the top of each corner post. This plate is recessed into the columns. When the assembler tightens the corner bolt, the plate and the contact area of the cabinet

frame deflect, forming a broad contact surface. The corner joints' tab-and-slot construction also guarantees correct assembly. The corner posts are always in the proper position for side-panel and door mounting. The MVE line includes models that are 42, 61, and 70 in. high, 25 or 30 in. deep, and 19 in. wide. From \$520 to \$670.

Precision Fabrication Technologies Inc, Highway 16 W, Monon, IN 47959. Phone (800) 558-7297; in IN, (219) 253-6666. Booth No 2769.

Circle No 547



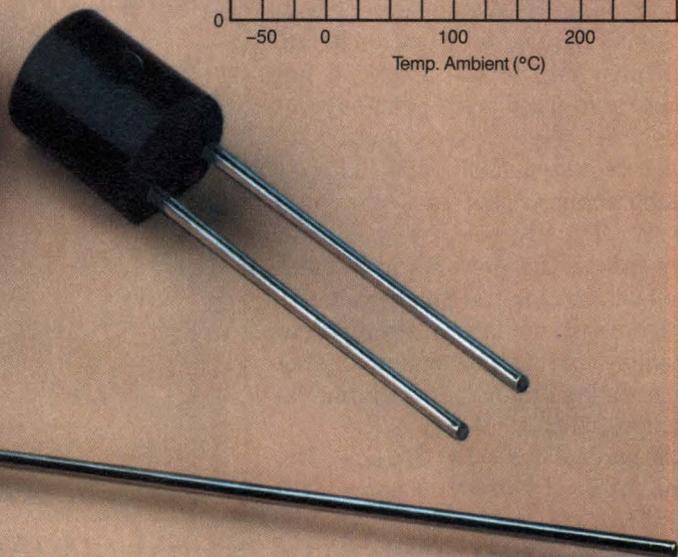
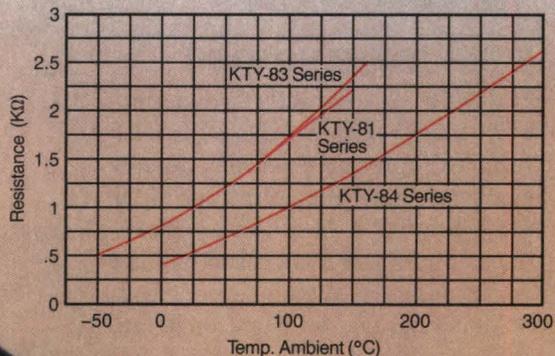
LOGIC ANALYZER

The PA480 logic analyzer is built on an IBM PC bus card. Disassembler pods are available for the 68000 and Z80 μ Ps. General-purpose pods support 48 channels at 25 MHz and 12 channels at 100 MHz. Using an internal clock, the 100-MHz pod can sample at 100-, 50-, 10-, 5-, 1-, 0.5- and 0.1 MHz. It will also sample at twice the frequency of a 50% duty-cycle external clock. The pod has one fixed TTL threshold plus two variable thresholds—one for even-numbered channels, the other for odd-numbered channels. You can set the variable thresholds from -5V to $+5\text{V}$. Four of the channels have glitch detection; they can detect glitches whose width at the threshold is 5 nsec or more. PA480, \$1595; general-purpose pods, \$350; 16-bit disassembly pods, \$695; 8-bit disassembly pods, \$495.

NCI, Box 11025, Huntsville, AL 35814. Phone (205) 837-6667. Booth No 2936.

Circle No 563

Philips KTY sensors. For sensing a wider range of temperatures, for pennies.



Philips KTY silicon temperature sensors are not only attractively priced, they also monitor a wider range of temperatures than any other sensor.

Three models monitor temperature ranges from -55°C to $+150^{\circ}\text{C}$; -55°C to $+175^{\circ}\text{C}$; and 0°C to 300°C .

Wide operating range and excellent reproducibility are direct results of proven silicon planar technology.

By utilizing the nearly linear temperature-dependent resistivity of silicon, Philips KTY sensors can detect and respond to temperature changes in the broad ranges mentioned, with response times as fast as one second.

Exceptional accuracy of Philips KTY sensors results from a positive temperature coefficient (PTC) of 0.7

percent per degree Centigrade. They are available off the shelf in tolerances of $\pm 1\%$, $\pm 2\%$, and $\pm 5\%$.

Because KTY sensors are small, are not polarity dependent, and need no special interfacing, they are ideal for applications involving solid-state circuitry. Configurations: plastic-encapsulated, axial lead glass bead, and surface-mounted device.

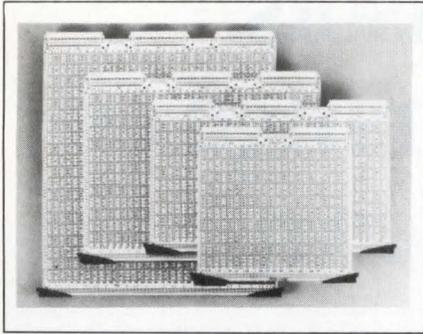
And remember, whatever the model, whatever the package, we're talking pennies.

To find out how Philips KTY sensors can fit into your measurement and control designs, call or write Ampere Electronic Corporation, A North American Philips Company, George Washington Highway, Smithfield, RI 02917. Phone (401) 232-0500; TWX 710-381-8808. In Canada contact Philips Electronics Ltd, ELCOMA Division.

Visit us at ELECTRO, Booths 1356 & 1358

Ampere[®]
A NORTH AMERICAN PHILIPS COMPANY

Electro/88 Products



WIRE-WRAP BOARDS

The Series 207 Schottky-compatible wire-wrap boards are available with standard connector power commitments for VME Bus, Multibus II, or the company's Metric configurations. The board's construction and layout minimize system noise, crosstalk ringing, and propagation delay, and provide the fast rise and fall times associated with Schottky devices. All four boards feature 4-layer construction with copper interpinning around each pin on all layers. You can selectively commit any pin to the power and ground planes, and plated-through holes are spaced on 0.2-in. centers to equalize current flow and accommodate surface-mount decoupling capacitors. \$625 to \$1630.

Mupac Corp, 10 Mupac Dr, Brockton, MA 02401. Phone (617) 588-6110. Booth No 737.

Circle No 556



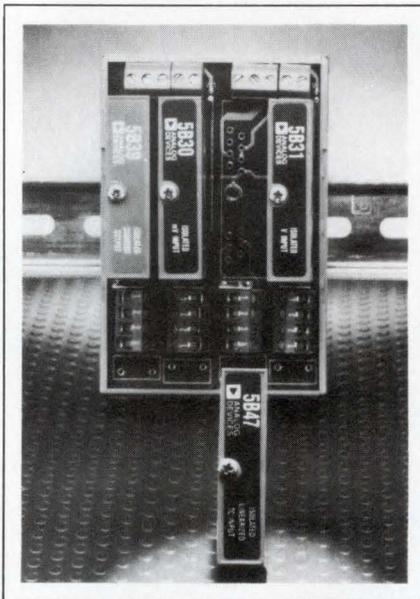
DISPLAY

The Model 3601-34-080 4-line x 20-character vacuum-fluorescent display module has 11.3-mm-high characters that are formed from a 5 x 7 dot matrix and are readable from a distance of 10 ft. It operates from a 5V supply, and an onboard μ P controls all display functions. A standard serial interface accepts either

RS-232C or RS-422 data at 1200 or 9600 bps. The module displays the full 96-character ASCII font as well as additional European characters and scientific symbols. The blue-green display has a brightness level that specs at 160 fL and is dimmable to 80 fL via software control. \$274 (100). Delivery, four to six weeks ARO.

IEE Inc, 7740 Lemona Ave, Van Nuys, CA 91409. Phone (818) 787-0311. TLX 4720556. Booth No 1453.

Circle No 551



SIGNAL CONDITIONER

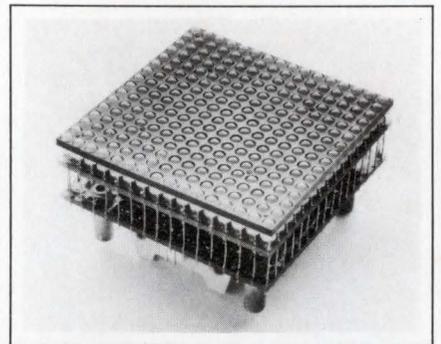
The 5B47 module accepts input signals from J-, K-, T-, E-, R-, S-, and B-type thermocouples and provides a linearized and isolated 0 to 5V output. It has a selectable signal-span range of ± 5 mV to ± 0.5 V and processes J- and T-type thermocouple signals with $\pm 0.5^\circ\text{C}$ accuracy (combined nonlinearity, hysteresis, and repeatability). The zero and span accuracy equals $\pm 0.05\%$ of span. The normal mode rejection specs at 60 dB.

The module has a 240V-rms input-protection rating, 160-dB CMR, and a 1500V rms input-to-output common-mode voltage rating. The device includes cold-junction compensation circuitry that corrects errors caused by parasitic thermocou-

ples formed by wire connections and screw terminals. Other features include open-thermocouple detection and a -25 to $+85^\circ\text{C}$ operating temperature range. \$130 (250).

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02121. Phone (800) 245-3900; in MA, (617) 461-3643. Booth No 1035.

Circle No 554



LED MODULE

Composed of 256 T1-type LED lamps arranged in a 16 x 16 matrix, the TLMM502A1 display module is available in red, green, and amber. It can replace CRTs in large-scale information-board applications—for example, airport and advertisement signs. The display module uses digital RGB driving circuits to provide compatibility with CRTs. As a result, it provides simple interface requirements in either graphic or alphanumeric display applications. It also has a Bright terminal that lets you adjust display brightness over a $\frac{1}{16}$ to $1\frac{1}{16}$ range—a total of 16 gradient levels. \$150 (100). Delivery, 10 to 12 weeks ARO.

Toshiba America Inc, Semiconductor Products Div, 2692 Dow Ave, Tustin, CA 92680. Phone (714) 832-6300. Booth No 2034.

Circle No 555

DC/DC CONVERTERS

The QWS Series 30W single-output dc/dc converters employ current-mode control technology and have no minimum output loading requirements. Internal control loops provide tight regulation for all outputs.

Text continued on pg 156

EDN April 28, 1988

High Powered Response



The ICE pacesetter that drives 15X faster than existing systems.

Rev-up your emulation performance. Do it faster and better than ever before. The SA98 from Sophia combines the flexibility to go from 8- to 32-bit microprocessors, and is fully compatible with IBM's PC/AT or XT. The SA98 is setting the pace as the price/performance leader.

Parallel Interface

Get a real speed boost over traditional RS-232 type interface with Sophia's unique parallel interface. You'll gain an 8X improvement in down load time. Optimize portability between IBM PC/AT, XT, or compatibles with Sophia's MS-DOS software drivers.

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Sophia's proprietary Direct Access Controller doesn't sidetrack ICE performance. It cuts through the curves others have to follow. The SA98, at high-speed, down loads to the target memory. Makes memory and data I/O modifications during program execution. Has full symbolic debugging. And you can view and augment trigger and trace conditions on-the-fly.

Dual Processor Emulation

Used in tandem, two SA98's emulate two separate 8- or 16-bit microprocessors simultaneously on a single host. Set your independent debug triggers, and

emulation. The split screen feature displays code execution for each . . . independently.

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Call Toll-Free Today

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1-800-824-6706 (CA)

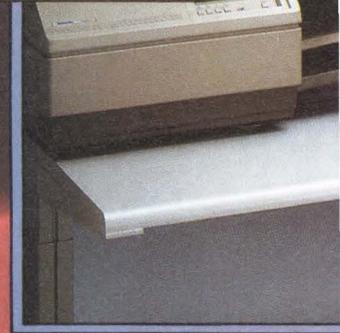
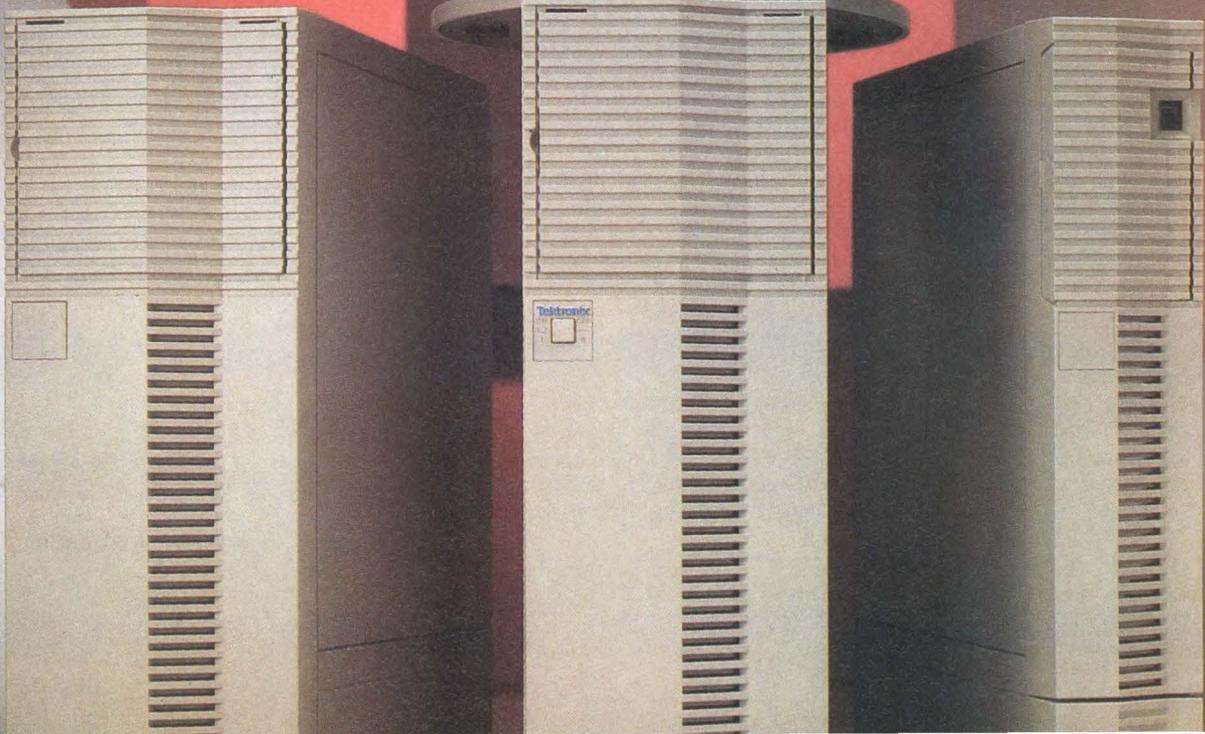
Sophia systems.

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U.S. & European Headquarters: Sophia Systems, 3337 Kifer Road, Santa Clara, CA 95051 (408) 733-1571
Corporate Headquarters: Sophia Systems Co., Ltd., NS Bldg. 8F, 2-4-1 Nishishinjuku, Shinjuku-ku, Tokyo 160 03-348-7000
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TEK UNIX-BASED WORKSTATIONS

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DESIGNED AS IF THERE
IS A TOMORROW.**





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engineering has lasting value.

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With 14 different configurations, a common user interface, Tek's de facto graphics standard, and unsurpassed quality, the 4300 Series allows not just leading performance until the next breakthrough comes along—but growth for tomorrow.

For more information on the 4300 Series, contact your local Tek representative today.

Or call 1-800-225-5434.

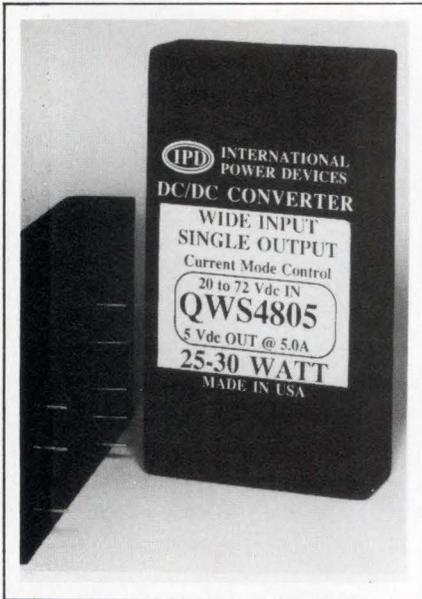
In Oregon, 1-235-7202.

CIRCLE NO 184

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Tektronix
COMMITTED TO EXCELLENCE

Electro/88 Products



All modules operate at 100 kHz. Models are available that operate on nominal input levels of 24 and 48V dc, having 9 to 36V and 20 to 72V limits, respectively. All units output either 5, 12, or 15V. The full-load efficiency specs at 82 to 86% and is virtually unaffected by line and load changes. The output accuracy specs at $\pm 1\%$.

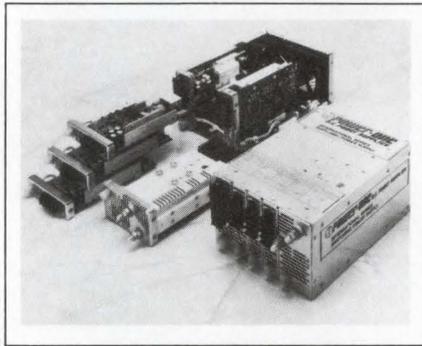
The converter noise and ripple measures 75 mV p-p over a 20-MHz bandwidth. The transient response is less than 200 μ sec with a 50% load change, and the temperature coefficient equals $\pm 0.02\%/^{\circ}\text{C}$. Load and line regulations spec at 0.5%. The converters are housed in encapsulated, all-metal cases to minimize radiation problems. \$139. Delivery, stock to six weeks ARO.

International Power Devices Inc., 155 N Beacon St, Brighton, MA 02135. Phone (617) 782-3331. TLX 989752. Booth No 2724.

Circle No 546

POWER SUPPLY

The Model SPM5 switch-mode power supply provides as much as 1500W of output power from as many as 15 outputs. It's based on a modular-design concept that allows you to specify a tailored multiple-output power system from a wide variety of off-the-shelf single-,

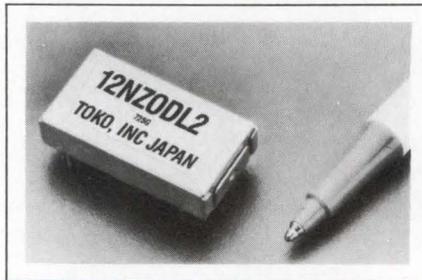


dual-, and triple-output plug-in power modules. All outputs are independent and floating, and can be configured for either positive or negative output levels. The outputs use fully isolated MOSFET switching regulators to achieve high conversion efficiency in a small package—the power density measures $3.4\text{W}/\text{in}^3$.

Current-mode control techniques help achieve precise current sharing when you operate outputs in parallel. The supply features field-selectable ac inputs that are compatible with worldwide requirements—90 to 132/180 to 264V, 47 to 440 Hz. The units meet VDE, IEC, CSA, and UL safety standards, and FCC and VDE EMI limits. \$924 (250).

Power-One DC Power Supplies, 740 Calle Plano, Camarillo, CA 93010. Phone (800) 235-5943; in CA, (800) 421-3439. Booth Nos 464 and 466.

Circle No 548



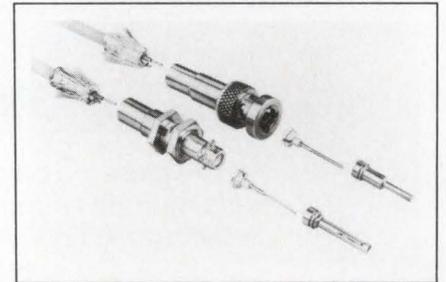
DC/DC CONVERTERS

The DL Series dc/dc converters use a thick-film circuit design to pack a 2W output capability into a $7.3 \times 3.0 \times 16$ -mm package. In addition, they feature a ceramic substrate that dissipates heat very rapidly. Three models are available in

the series; all operate on 12V inputs and output either -5, -12, or -15V. The switching frequency ranges from 100 kHz to 140 kHz, depending on the model. The -12 and -15V models operate at 65% efficiency and the -5V unit has a 55% efficiency. Built-in choke coils and a well-shielded case virtually eliminate EMI/RFI problems. The case features grounding tabs and pc-type terminations that simplify installation. From \$36.50.

Toko America Inc, 1250 Feehanville Dr, Mt Prospect, IL 60056. Phone (312) 297-0070. TLX 724372. Booth No 1526.

Circle No 557

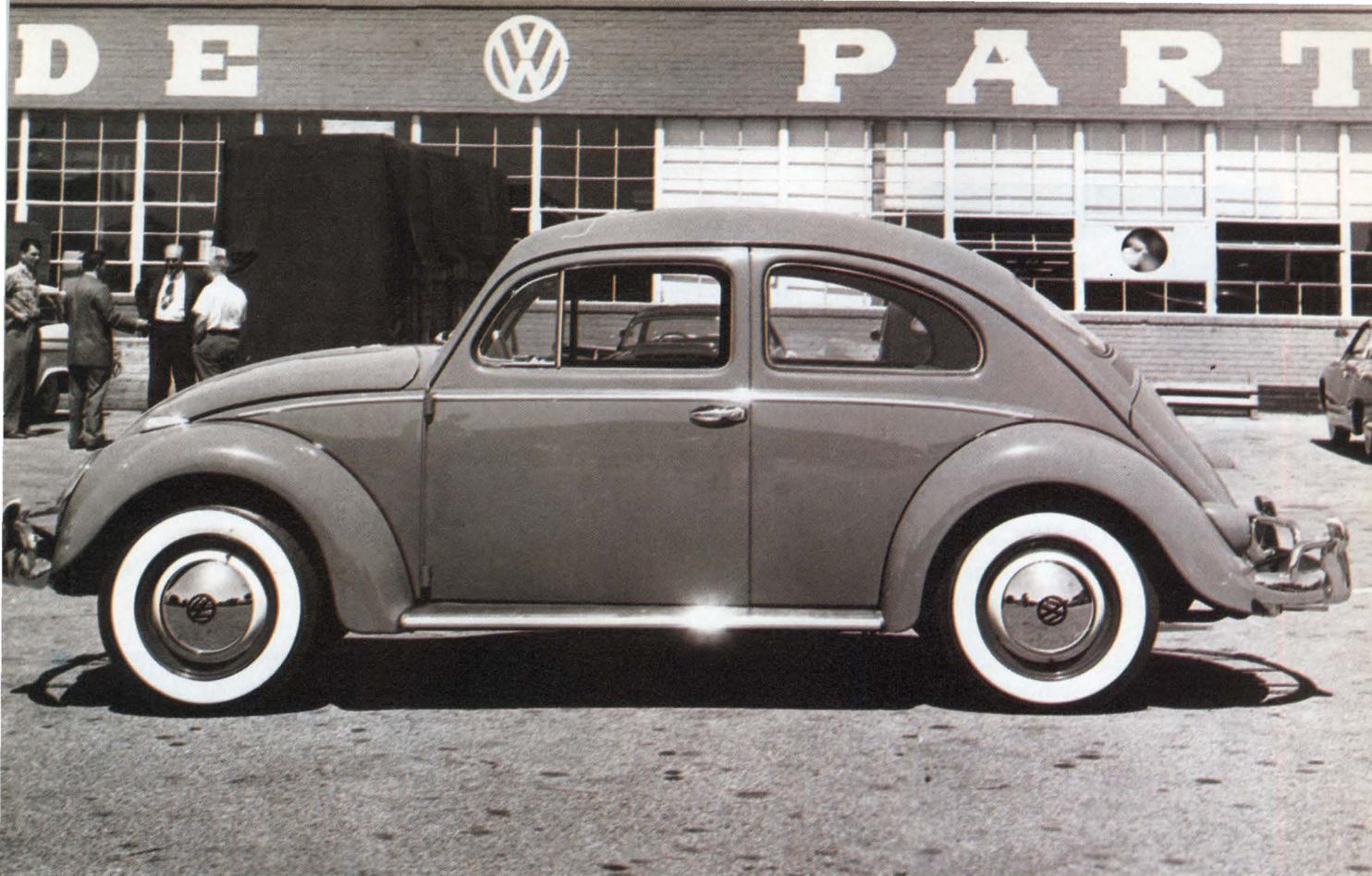


CONNECTORS

The field-installable, solderless, concentric twinax connectors in the 450 Series are designed for MIL-STD-1553B and MIL-STD-1760 digital data-bus applications. The series includes cable plugs and jacks, bulkhead cable jacks, and right-angle plugs. The connectors' plating satisfies the 500-hour salt-spray requirements of MIL-STD-1344A. Sealing gaskets and heat-shrink tubing provide weatherproofing. Center and intermediate contacts are interchangeable between pin or socket configurations; this interchangeability improves polarization capabilities and minimizes inventory requirements. The keying options include threaded types as well as 3- and 4-lug bayonet versions in multiple-lug positions. \$15 to \$20 (1000).

Trompeter Electronics Inc, Box 5069, Westlake Village, CA 91359. Phone (818) 707-2020. TWX 910-494-1210. Booth No 374.

Circle No 552



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Making something very small can be truly revolutionary.

At first people scoffed. Some laughed out loud. But the people's car set a new size standard for an entire industry.

Sizes are still shrinking in the micro-miniature world of cable and connector technology at

Precision Interconnect. We're designing the critical link between man and machine. These complete interconnect systems, usually using 38 AWG conductors, can be terminated to standard connectors with flex-strain reliefs or contain active devices within custom-molded housings.

To make these cable systems increasingly smaller, lighter, more rugged, and more comfortable to use without compromising signal fidelity, flex-life, or reliability is a continuing challenge presented to us by manufacturers of leading-edge medical equipment around the world.

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solve, ensures that reliability is designed in, built in, and tested. So we can solve big problems. With small, but revolutionary, innovations.



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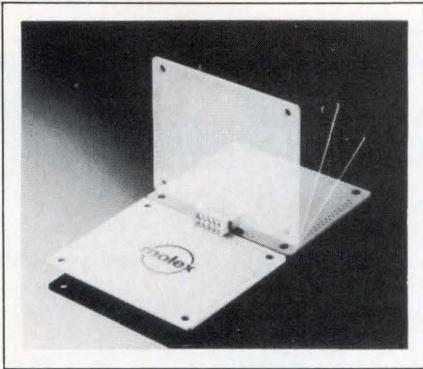
Offices in San Francisco, Boston,
Wilmington and Düsseldorf



Neonatal sensor for SensorMedics
oximeter measures pulse and
blood gases.

CIRCLE NO 194

Electro/88 Products



PC-BOARD CONNECTORS

These 2-piece hinged connectors feature a 1.25-mm contact center-line spacing. Measuring only 10.3×6.7 mm, the connectors are available in even-numbered sizes ranging from 4 to 20 positions. The connector design makes it easy to access the pc-board surface. The connectors mate on the co-planar axis or board-edge to board-edge, and allow you to rotate the boards by as much as 90°. They also mate in the reverse position when the pc boards are lined up in parallel position.

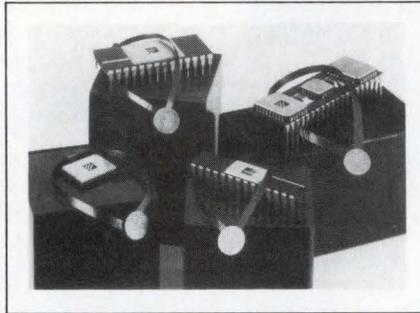
The connectors utilize a high-pressure, tuning-fork-type contact system. The terminals are tinned phosphor bronze. To facilitate soldering operations and board-mounting stability, solder tails are arranged in a staggered pattern. The mating and rotation lifetime spec at 30 and 50 cycles, respectively. The connector housings are molded of UL 94-V0-rated polyester. The connectors have per-circuit contact ratings of 125V at 1A. \$0.054/circuit. Delivery, seven to eight weeks ARO.

Molex Inc, 2222 Wellington Ct, Lisle, IL 60532. Phone (312) 969-4550. TLX 254069. Booth No 1708.

Circle No 549

STATIC RAMs

The 256k×1-bit EDI81256C and the 64k×4-bit EDI8464C static RAMs offer access times of 34, 45, and 55 nsec. The EDI8832C, organized as 32k×8-bits, provides access times of 45 and 55 nsec. The ×1 and ×4

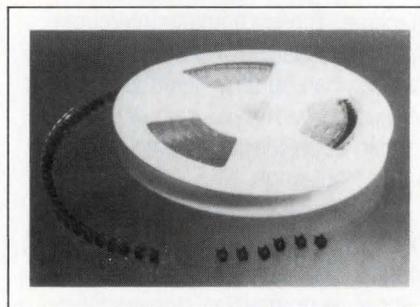


devices are available in a 24-pin, 300-mil DIP or a 28-pin LCC; the ×8 device is available in a 28-pin, 600-mil DIP or a 32-pin LCC. All of the devices conform to JEDEC standard pinouts and meet the requirements of MIL-STD-883C.

The EDI8M1664C is a high-speed 64k×16-bit module, containing four 32k×P8-bit devices in leadless chip carriers surface-mounted on a ceramic substrate on a 40-pin, 600-mil DIP. EDI81256C and EDI8464C, \$302 to \$453; EDI8832C, \$223; EDI8M1664A, commercial version, \$249 to \$445; military version, \$496 to \$860 (100).

Electronic Designs Inc, 42 South St, Hopkinton, MA 01748. Phone (617) 435-2341. TLX 948004. Booth Nos 2827 and 2829.

Circle No 561



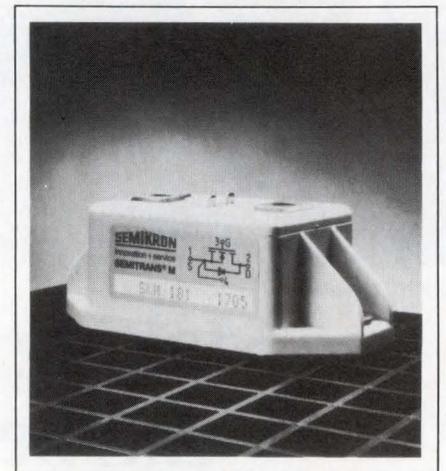
SURFACE-MOUNT LED

The configuration of the 6200 Series right-angle, surface-mount LED provides easy visibility, making the device particularly suitable for high-density applications where boards are mounted in parallel. The device is available in red, green, and yellow. The 12 models include standard and low-current versions as well as standard and low-current versions that include a resistor and operate

from 5V. The series' design and packaging meet the requirements of automated surface-mount production-line equipment. The device can withstand the processing temperatures of either IR or vapor-phase reflow soldering operations. It's available on 16-mm tapes that hold 1000 LEDs/reel. \$0.89 (1000).

Industrial Devices Inc, 260 Railroad Ave, Hackensack, NJ 07601. Phone (201) 489-8989. Booth No 2143.

Circle No 550



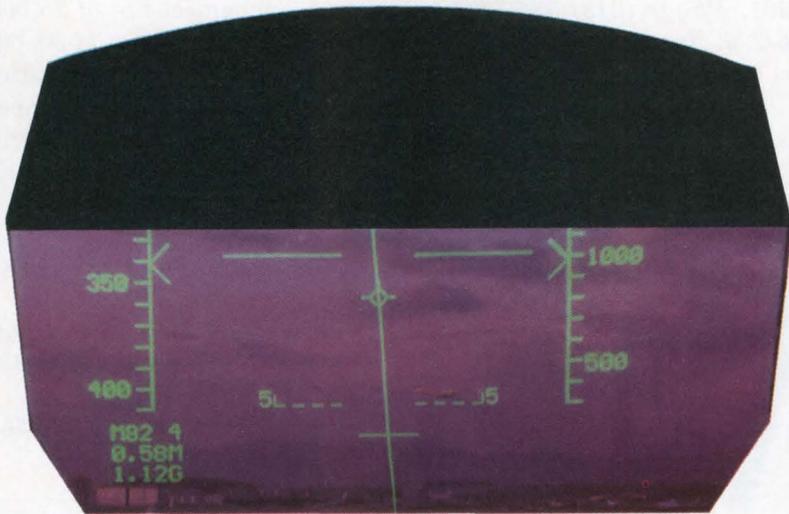
POWER MODULES

The SKM-181 rated at 30A, 800V and the SKM-151F rated at 50A, 500V each contain several power MOSFETs connected in series and in parallel in an isolated package. The SKM-151F also includes an integrated fast-recovery diode. The package has an isolation voltage rating of 2500V. The short internal connections minimize lead inductance and the possibility of parasitic oscillations. The modules also eliminate the labor-intensive job of paralleling TO-3 or TO-220 devices. A single module can replace as many as six individual TO-3 power MOSFETs. Because of the top-mounted connections, it is easy to connect the modules to bus bars. SKM-151F \$70 (50).

Semikron Inc, Box 66, Hudson, NH 03051. Phone (800) 258-1308; in NH, (603) 883-8102. Booth No 818.

Circle No 558

**IF YOU'RE NOT
CONSIDERING OUR
OP AMPS, YOU'RE
NOT GETTING
THE WHOLE PICTURE.**



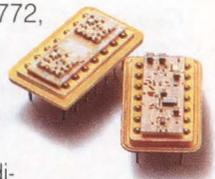
Teledyne Philbrick op amps. The front-runners for speed and accuracy.

Fast settling over a wide bandwidth is the essence of high-performance op amps in sophisticated, high-speed data acquisition, microwave transmission and video/CRT applications. So it pays to specify the best: the 1467 and 1493 operational amplifiers from Teledyne Philbrick.

These Teledyne Philbrick designs are specially engineered to maximize DC characteristics and high-speed performance. The 1467, 1GHz gain-bandwidth op amp ensures 70ns settling times to $\pm 0.01\%FS$ while providing ultra-low input offset voltage of $\pm 30\mu V$ and input offset voltage drift of $\pm 1\mu V/^{\circ}C$.

The 1493, a dual 350MHz gain-bandwidth op amp, features individual compensation and offset adjustments, FET inputs, 180ns settling times to $\pm 0.01\%FS$ and 80dB isolation at 100KHz.

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

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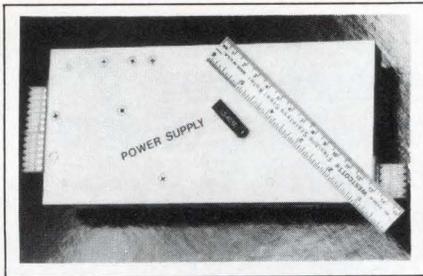
40 Allied Drive, Dedham, MA 02026-9103, Tel: 617-329-1600 Fax: 617-326-6313

WEST:
30423 Canwood St.,
Suite 212
Agoura Hills
CA 91301
Tel: (818) 889-3827
Fax: 818-889-8215

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Tel: 571-9596
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Fax: 571-9442

JAPAN:
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Taiko No. 3 Bldg.
2-10-7 Shibuya-Ku
Tokyo 542, Japan
Tel: 797-5251
Telex: 781-24335
Fax: 797 5255

Electro/88 Products

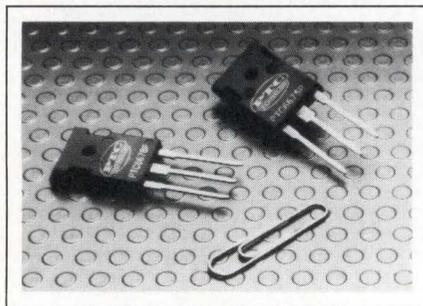


SMPS CONTROLLER

Designed for resonant-mode switching power supplies, the LD405 uses frequency modulation to control the regulation. The pulse width is held constant while the frequency is varied in response to load changes. Operating at high frequencies in the resonant mode, the device provides several advantages over conventional modes of operation. These advantages include reduced power-supply size and weight, reduced switching losses, and reduced component stress caused by zero-current switching. Other features include overload shutdown, soft start, and the ability to drive power MOSFETs directly. 16-pin plastic DIP, \$3.50 (1000).

Gennum Corp, Box 489, Station A, Burlington, Ontario, Canada L7R 3Y3. Phone (416) 632-2996. TLX 0612996. Booth Nos 389 and 391.

Circle No 560



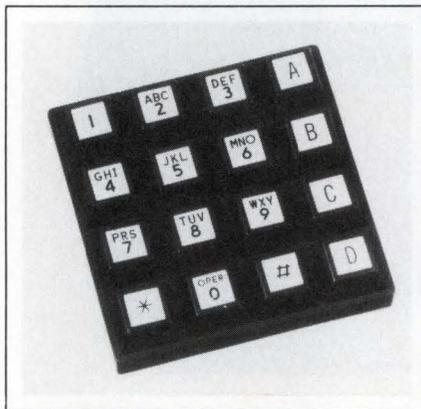
POWER TRANSISTORS

The PTC6675P and PTC6678P npn power transistors, available in TO-247 plastic packages, are electrically equivalent to the 2N6675 and 2N6678 devices in TO-3 metal cans. The TO-247 devices can replace TO-3 types in nonhermetic environments. The PTC6675P is rated at

10A, and the PTC6678P is rated at 15A. Both devices have sustaining-voltage ratings of 400V. The switching characteristics include a storage time of 2.5 μ sec and a fall time of 0.5 μ sec. PTC6675P \$3.45, PTC6678P \$4.75 (100).

Power Technology Components, 23201 S Normandie Ave, Torrance, CA 90501. Phone (213) 534-3737. TLX 664276. Booth No 2934.

Circle No 559



16-BUTTON KEYPAD

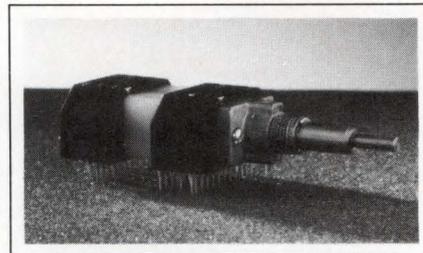
Encapsulated in a military grade, silicone rubber boot, the Series 84 4x4-button keypad is sealed from its environment when mounted on a panel. A snap-dome contact system provides tactile feedback, and the contact side of the dome is gold plated to ensure low contact resistance for 3M operations/button. Each button switch is rated at 24V dc/10 mA. The device also features EMI shielding and custom button legends. \$25.85 (100). Delivery, six to eight weeks ARO.

Grayhill Inc, 561 Hillsgrove Ave, Box 10373, LaGrange, IL 60525. Phone (312) 354-1040. Booth No 1301.

Circle No 566

ROTARY SWITCH

You can use the S-400 rotary switch, which comes in 8- and 12-pin versions, in applications that require multifunction switching in a minimum amount of space. The switch construction provides for the seal-



ing in of the lifetime lubricant and allows a mechanical life of 25,000 operations. Detent angles of 30, 60, and 90° are available, as are a variety of shaft and bushing sizes. Special options include molded Delrin spacers between decks and shaft extensions. The switch can carry 6A and has a make/break rating of 0.1A at 125V ac and 0.25A at 28V dc. \$8 (OEM qty).

Electroswitch, 2510 North Blvd, Raleigh, NC 27604. Phone (919) 833-0707. Booth No 2858.

Circle No 565



CLOCK OSCILLATOR

This clock oscillator provides dual outputs, using independently operating crystals. It uses high-speed CMOS technology and is TTL compatible. Frequencies from 4 MHz to 60 MHz are available. The module not only saves board space, but costs less than two individual clocks. For frequencies in the 4-MHz to 18-MHz range, the module costs \$2.90 (25,000). Evaluation samples are available.

Pletronics Inc, 9026 Roosevelt Way NE, Seattle WA 98115. Phone (206) 523-9395. TLX 4740170. Booth No 2119.

Circle No 562

POWER PLUS SAFETY.

The Maxell Super Lithium Battery.* Good for a decade, these lithium thionyl chloride batteries are hermetically sealed for super safety plus long shelf and service life. And at 3.6 volts, they supply the high energy



density you're looking for. Specify Maxell Super Lithium Batteries for critical applications where a safe battery is imperative.

Specify Maxell Super Lithium Batteries for quality and a name you can trust. When you need power and you need it safe, look for Maxell.

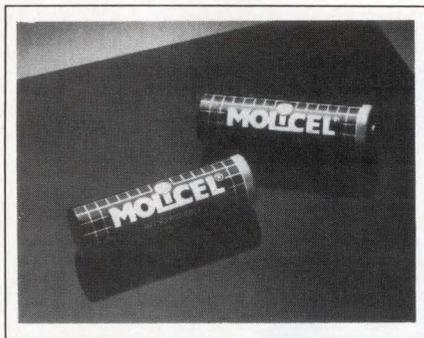
maxell.

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22-08 Route 208
Fair Lawn, NJ 07410

*Recognized under the
Component Program
of Underwriters
Laboratories.

See us at ELECTRO, Booth 3013

Electro/88 Products



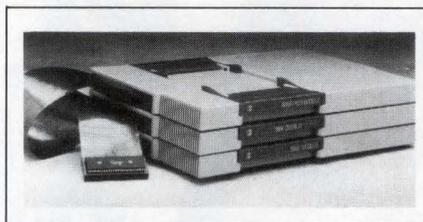
LITHIUM CELLS

The MoliceL rechargeable lithium cell comes in an AA-sized package and can operate from 1.3 to 2.4V. You can choose various voltage limits, depending on the discharge rate, operating temperature, and capacity and life-cycle requirements. The cell features an 0.6 Ahr capacity and, after one year at room temperature, provides 90% charge retention. The unit operates from -30 to +55°C and, when subjected to a discharge current of 120 mA, reaches a 1.3V cut-off voltage in 300

minutes. The unit weighs 22g. \$3 (10,000).

Moli Energy LTD, 3958 Myrtle St, Burnaby, British Columbia, Canada V5C 4G2. Phone (604) 437-6927. TLX 04356708. Booth No 2228.

Circle No 545



EMULATOR

The EL 800 in-circuit emulator performs zero-wait state emulation of the Z-80H μ P at 8 MHz and of the HD64180 at 6 MHz and does so without preempting any interrupts. To minimize propagation delays, the emulator uses a hybrid circuit that plugs into the target μ P socket and

drives the 16-in. cable back to the emulator. The vendor provides the emulator in the form of 8.5x11x0.85-in. modules that stack on top of each other and snap together to make electrical as well as mechanical connections. You need only purchase one module; you add additional features by adding modules. A single power supply drives all the units. Your personal computer must run MS-DOS version 3x and have 640k bytes of RAM. \$4850.

Applied Microsystems Corp, Box 97002, Redmond, WA 98073. Phone (206) 882-2000. TLX 185196. Booth Nos 804, 806, and 808.

Circle No 567

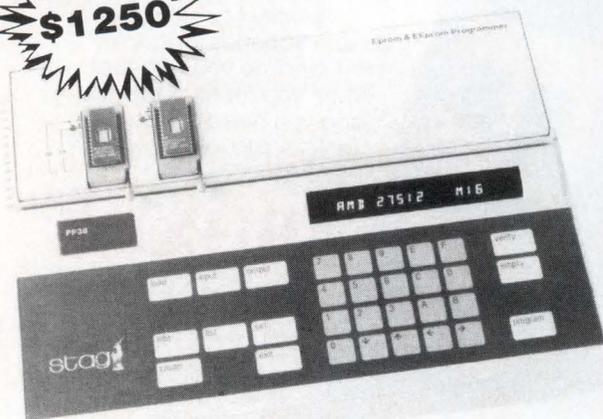
SIMULATOR

The handheld NSG 432 electrostatic discharge simulator tests electronic equipment for susceptibility to electrostatic discharges as defined in 16 current and proposed national and

Text continued on pg 167

With a Stag PP38 You Don't Have to Blow Your Budget to Burn Your PROMs

\$1250



Contact your nearest regional office for more details and a **FREE TRIAL** of the best programmer at \$1250.

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3 Northern Boulevard,
Amherst, NH 03031,
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Compare the **NEW Stag PP38** to any EPROM/EEPROM programmer in its class and it will out perform them all.

Features such as a comprehensive device library, manufacturers' approved programming algorithms, Stag's high quality of manufacture and low price, backed by Worldwide support make the PP38 the ideal choice.

It can program two identical devices simultaneously and handle 8, 16 and 32-bit sets. In fact the PP38 can program a 16-bit set in just one operation.

We've even included an RS232C interface so you can remotely control the PP38 from your PC and 11 formats are provided for interfacing to development systems.

Comprehensive editing features such as Insert, Delete, Block Move and String Search are included for total data control.

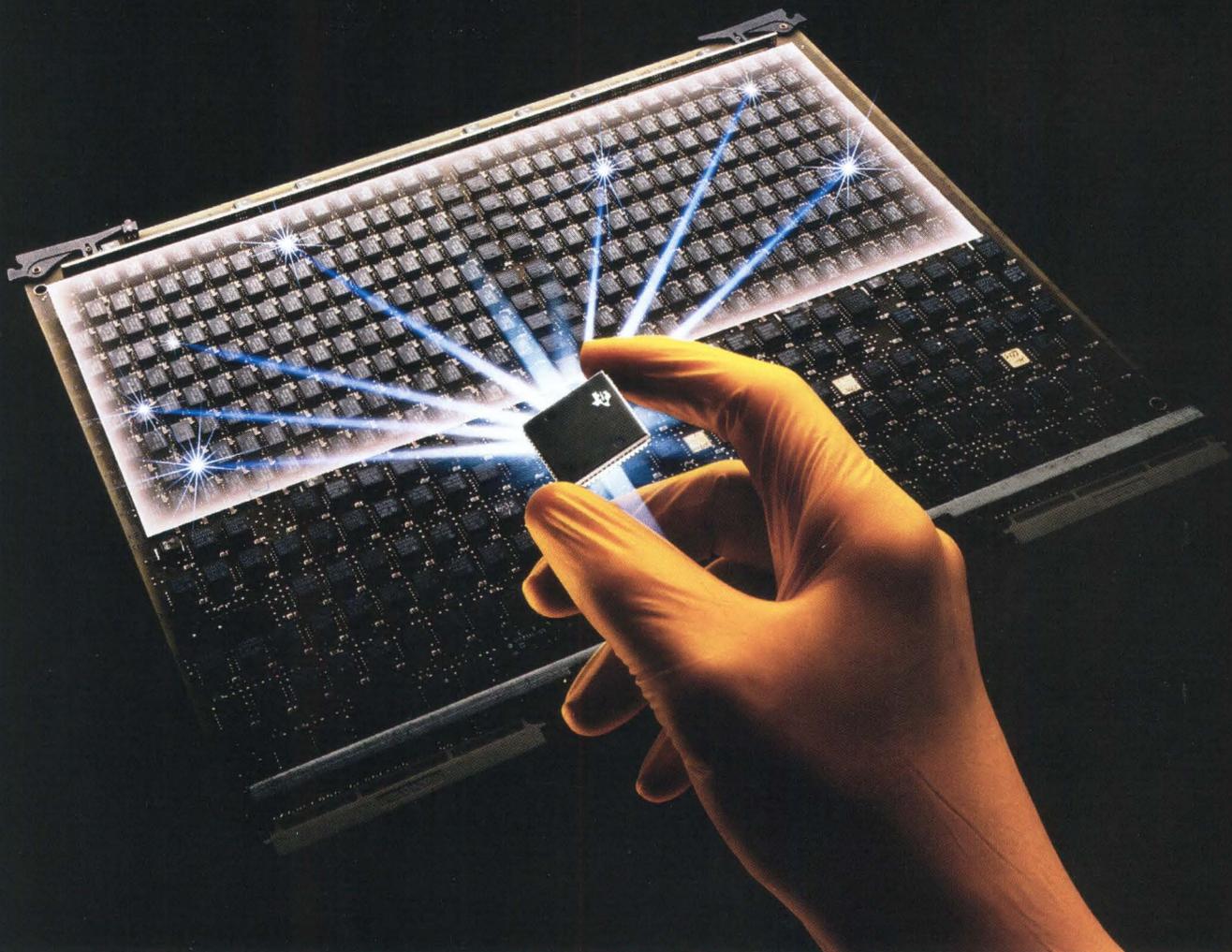
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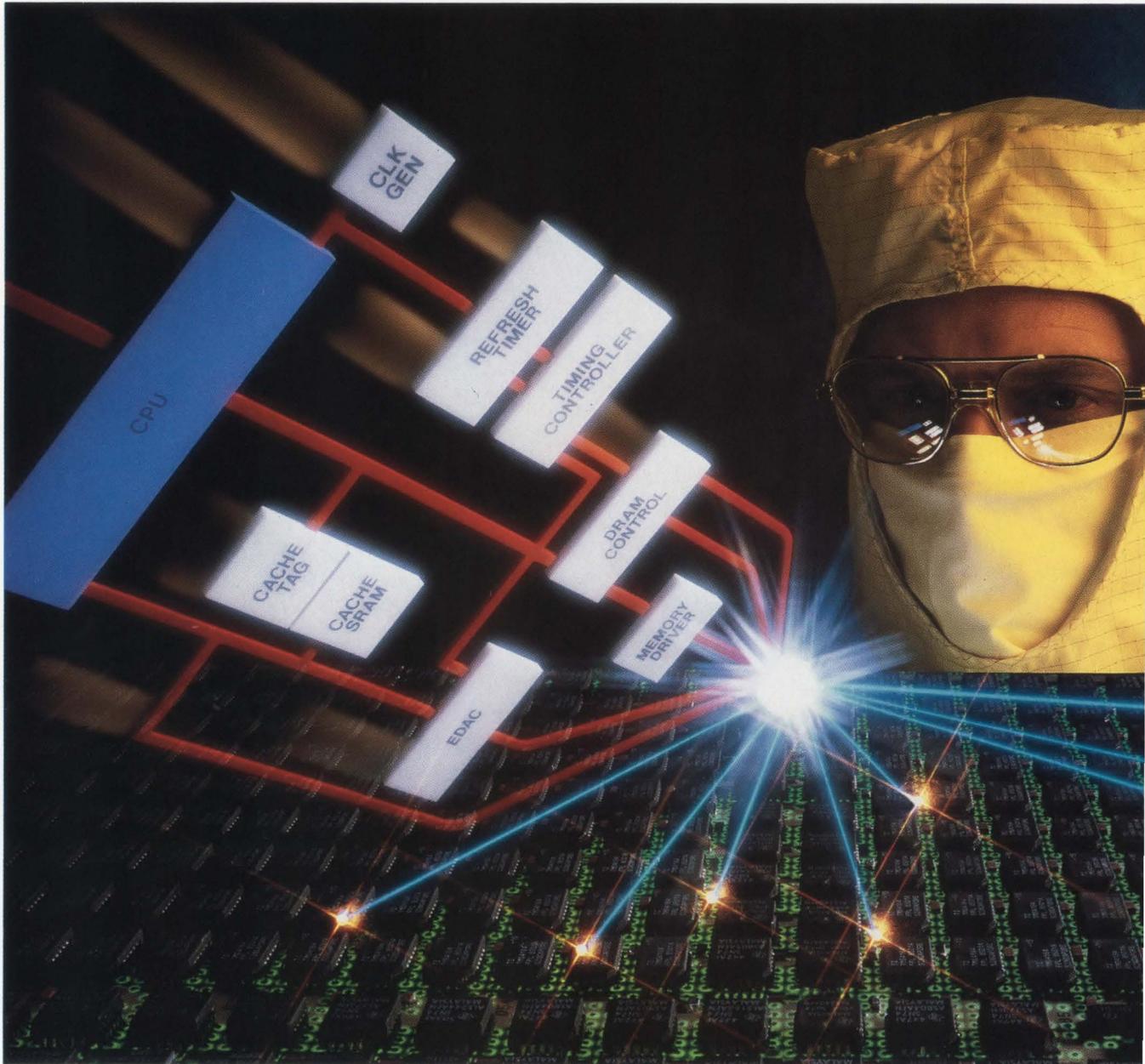
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Memory management in the Era of MegaChip Technologies:

Memory-management ICs from you bring memory arrays up to



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

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

Texas Instruments can help processor speeds.

TI's comprehensive Memory Management Design Kit (see page 4).

TI addresses your major memory-design concerns

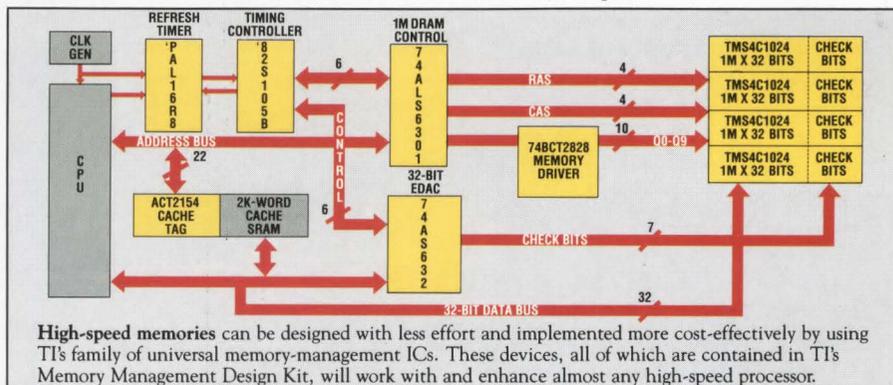
To immediately improve memory-access time, use both main and cache memories, as shown in the block diagram. This approach can produce up to a 3X increase in system performance.

Frequently accessed data and instructions are stored in a few high-speed static random-access memories and "tagged" by a TI industry-standard cache controller (SN74ACT2151/4). These 2Kx8 CMOS controllers are the fastest available and can support deep cache architectures of 16K or even 32K.

TI's MegaChip Technologies

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

tions on chip to improve flexibility and speed and to allow for custom timing routines. This controller supports nibble- and page-mode access and scrubbing-mode refresh to increase memory output.



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

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

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

Interfacing between processor and main memory gets tougher as speeds increase. But TI has the SN74ALS6301 DRAM timing controller. It can handle any DRAM up to 1 Mbit and incorporates only the essential func-

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

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

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

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

In addition, your component count is cut because these are single-chip VLSI circuits. Your design time and effort are shorter and easier because of

► Turn page for more information.

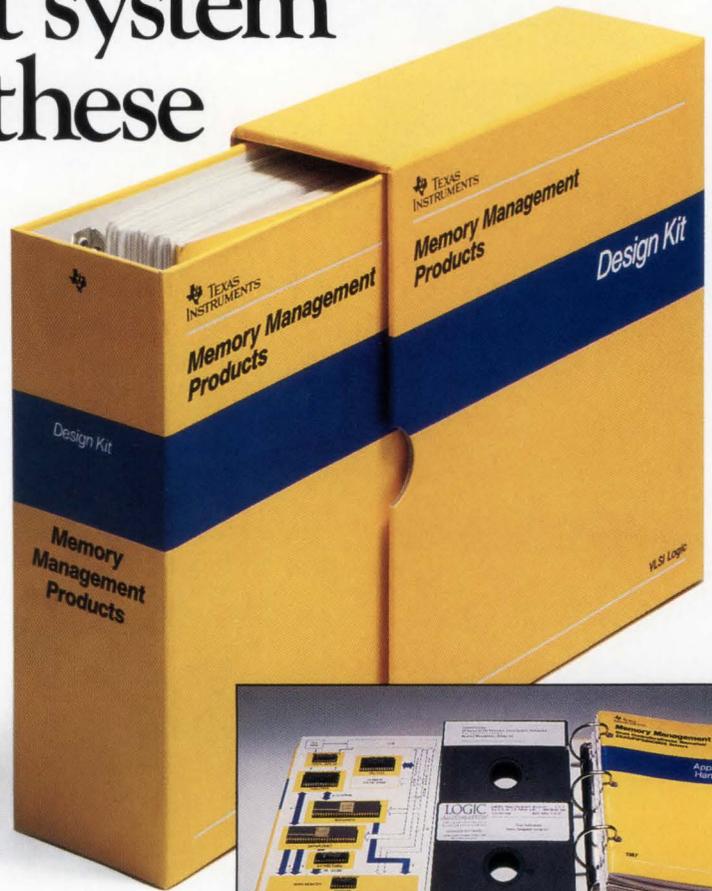


The tools you need to design a high-performance memory-management system are between these covers:

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

- All necessary high-performance ICs, including
 - SN74ACT2154 2K × 8 Cache Address Comparator
 - SN74AS632 32-bit EDAC
 - SN74ALS6301 16K to 1 Mbit DRAM Controller
 - SN74BCT2828 10-bit Buffer/Driver with series-damping resistor
 - TIBPAL16R8-10 and TIB82SI05B High-speed Programmable-logic Devices for user-defined timing control
 - TMS4464 256K DRAM
- *Memory Management Applications Handbook* containing applications reports and briefs that supply valuable insights into memory-management system design.
- Data sheets on TI circuits designed for efficient memory management.
- Memory-management-product software graphic-symbol libraries and supporting documentation for use with Futurenet™ or Mentor Graphics™ CAE systems.

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



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

SDV063ED800C

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

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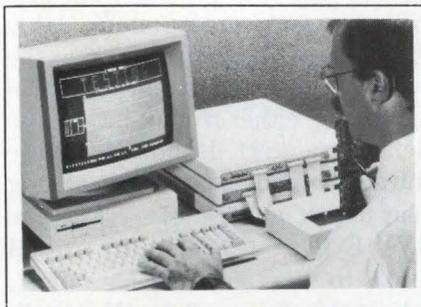
Electro/88 Products



international standards. The standard unit produces a positive-polarity output that you can set from 2 to 25 kV; you can obtain negative-polarity output by replacing a plug-in module. To use the gun-shaped unit, you select the voltage you want it to dispense, then touch the unit's tip to the part of the device under test where you want to simulate the effect of a static discharge. Pulling the standard unit's trigger prompts the discharge of a 150-pF capacitor through a 150Ω resistor to generate a narrow pulse. You can special order units that have different R and C values. The gun runs off a separate, high-voltage supply; you can obtain an optional power supply that lets you initiate discharges once per second. \$4900 in PR.

Schaffner EMC Inc, 825 Lehigh Ave, Union, NJ 07083. Phone (201) 851-0644. TLX 6853444. Booth Nos 2717 and 2719.

Circle No 568



TEST SYSTEMS

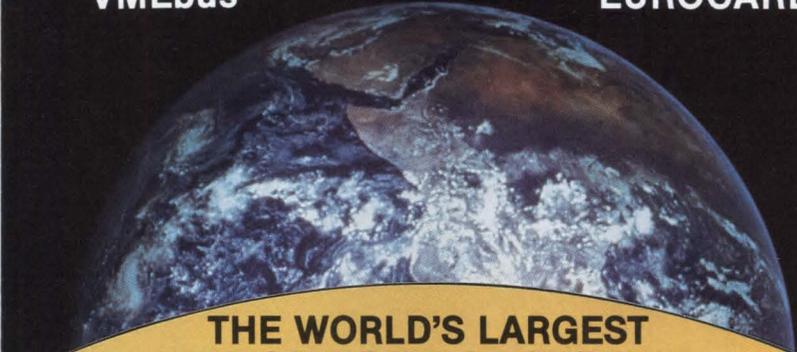
MCP-2 software adds analog test-generation and analysis capabilities to systems containing as many as 15 of the vendor's MFI-1000 mainframes, including GFT-family com-

ponent and populated-board testers. According to the vendor, the software eliminates most of the programming usually required to produce test programs and thus greatly reduces the time you must devote to their creation. The software's "learn" mode builds a tolerance database from a statistical sample of known-good units; the software

uses this database to create analog- and digital-waveform guard bands. You can create test vectors with a waveform editor or you can transfer them from simulators. A macro control language, which links tests with conditional branching, eases component-level fault isolation. MCP-2, \$695; test systems, from \$5000.

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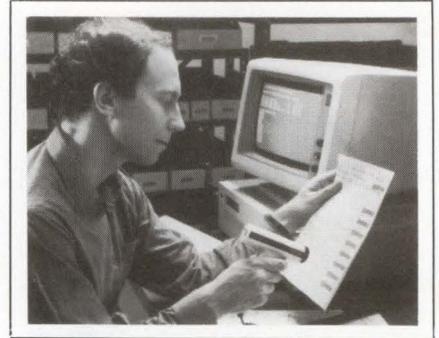
Array Analysis, 200 Langmuir Lab, Brown Rd, Ithaca, NY 14850. Phone (800) 451-8514; in NY, (607) 257-6800. Booth No 2833.

Circle No 569

BAR-CODE SCANNER

S25 Series handheld, noncontact, bar-code scanners include units that

feature internal decoding and a DB-25 connector that connects directly to a computer's RS-232C port. The scanners read 0.007-, 0.010-, and 0.020-in. bars. The units, enclosed in polycarbonate housings, employ visible-red light sources composed of four or six LEDs, depending on the bar size. You use a thumb-activated trigger

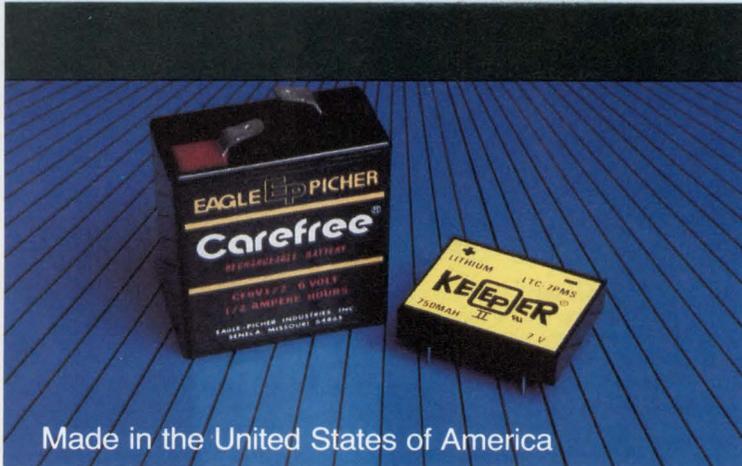


to switch on the LEDs during scans; at other times, the LEDs remain in an off-state in order to conserve battery life. \$310 to \$575.

Skana-matic Corp, Box S, Elbridge, NY 13060. Phone (315) 689-3961. TWX 710-545-0220. Booth No 2125.

Circle No 570

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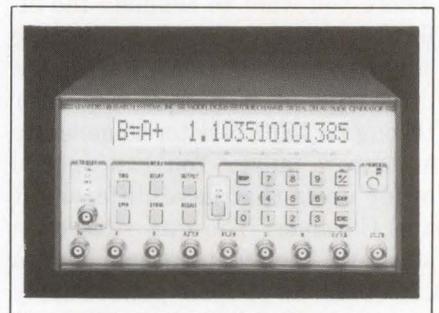
Eagle-Picher Industries, Inc.

Box 130 • Bethel Road • Seneca, MO 64865

Phone: (417) 776-2256 • TWX-62864271

Circle 187 for Keeper Battery

Circle 188 for Carefree Battery



PULSE GENERATOR

The DG535 pulse-and-delay generator outputs complementary pulses on two pairs of lines after effecting programmable, crystal-controlled delays. These delays can span 0 to nearly 1000 sec, and you can set them in 5-psec increments. The unit includes four independent delay generators. You can determine the width of an output pulse by programming either a start and a stop delay or a start delay and a pulse duration. You can choose among four output pulse levels—TTL (0 to 4V), ECL (-1.8 to -0.8V), NIM (-0.8 to 0V), and variable (offset, adjustable from -3 to 4V; amplitude, adjustable from 0 to 4V). The generator drives high-impedance or 50Ω loads with a 2-nsec transition time on the ECL output and with a 3-nsec transition time on the TTL output. The overshoot equals <100

Electro/88 Products

mV+10% of the pulse amplitude. The unit, which is fully programmable via an IEEE-488 interface, will output pulses continuously from 0.001 Hz to 1 MHz. It can also output bursts of two to 32766 pulses. \$2995.

Stanford Research Systems Inc,
1290D Reamwood Ave, Sunnyvale,
CA 94089. Phone (408) 744-9040.
TLX 706891. Booth No 2154.

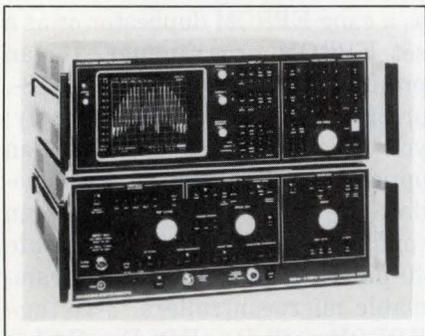
Circle No 572

DIGITIZERS

Century Series waveform digitizers consist of four models: an 8-bit-resolution unit that takes 1.3G samples/sec; an 8-bit unit that takes 200M samples/sec and can store 2M samples; an 8-bit unit that takes 100M samples/sec and can store 2M samples; and a 12-bit unit that takes 5M samples/sec and that, if fully expanded, can store 8M samples. These digitizers, suited to bench mounting or rack mounting, feature modular construction, which lets you add channels. You can operate additional digitizers independently or you can synchronize them to capture multichannel data. \$8950 to \$16,950. Delivery, four to six weeks ARO.

LeCroy Corp, 700 Chestnut Ridge Rd, Chestnut Ridge, NY 10977. Phone (914) 425-2000. TWX 710-577-2832. Booth Nos 2211 and 2213.

Circle No 571



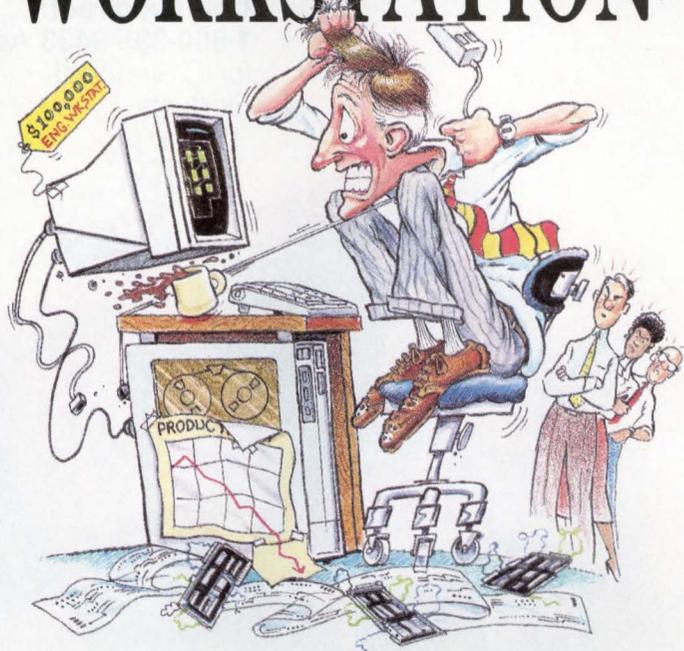
SPECTRUM ANALYZER

The 2383 spectrum analyzer covers 100 Hz to 4.2 GHz. It offers a 3-Hz

min resolution bandwidth and a ± 1.5 -dB accuracy at 4.2 GHz. A tracking generator prevents frequency drift from impairing synchronous swept measurements. An FM demodulator allows display of demodulated audio signals. An active probe permits the instrument to make high-impedance measurements at frequencies as high as 1.25

GHz. On a single screen, the analyzer can display a full-band sweep covering 100 Hz to 4.2 GHz. The residual responses are -110 dBm, and the intermodulation equals < -90 dBc. The analyzer's IEEE-488 port lets you dump displayed spectra to plotters and storage devices. \$41,950. Delivery, 60 days ARO.

GOODBYE WORKSTATION



It's time to say goodbye

to expensive engineering workstation based CAD systems. Why should management tie up \$100,000.00 or more in a workstation when the same (and often better) performance is obtained with **PADS-PCB**, a PC based CAD system?

PADS-PCB is a high performance printed circuit board design software that offers a degree of functionality a designer could expect only from an expensive engineering workstation.

CIRCLE NO 11

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Marconi Instruments, 3 Pearl Ct, Allendale, NJ 07401. Phone (201) 934-9050. Booth Nos 2509 and 2511.

Circle No 573

DATA RECORDER

The RTP-650A instrumentation tape recorder records 14 channels of

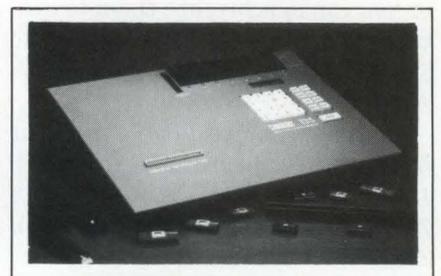
dc-to-40-kHz information and a voice channel on standard Beta-format cassettes. You can trade off recording time for bandwidth: When operating in the standard FM mode at the maximum tape speed, the unit records 40-kHz data for 3.3 minutes with a 47-dB S/N ratio; when running in this mode at the lowest tape speed, it records 625-Hz



data for 3 hours and 28 minutes with a 39-dB S/N ratio. If the unit is operating in the optional direct-record mode at the maximum tape speed, the bandwidth extends from 200 Hz to 150 kHz with a 30-dB S/N ratio; if the unit is running at the slowest tape speed in the same mode, the bandwidth extends from 100 Hz to 2.35 kHz with a 26-dB S/N ratio. The vendor offers the unit with an option that enables it to perform PCM recording that conforms to IRIG 106-80. \$35,750.

Kyowa Dengyo Corp, 81 Ruckman Rd, Closter, NJ 07624. Phone (201) 784-0500. TLX 135067. Booth No 2925.

Circle No 574



PROGRAMMER

The 135 Multiprogrammer functions as a gang EPROM duplicator or as a set EPROM programmer. It can program as many as eight 24-, 28-, or 32-pin devices simultaneously; you can obtain the unit with an option that enables it to accommodate 16 devices. The vendor can configure the unit to accommodate 40-pin EPROMs, 40-pin programmable microcontrollers, 3-voltage EPROMs, PLDs, EPLDs, GALs, and bipolar PROMs. When you use the unit as a set programmer, it can program 16- or 32-bit words dis-

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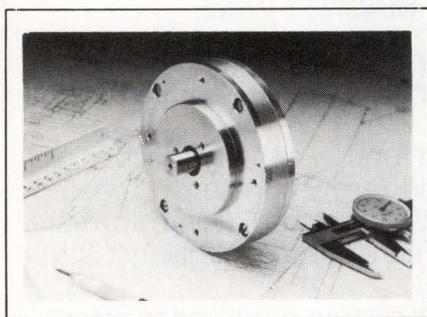
Tektronix
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posed in two or four devices. The unit includes a 256k-byte memory, which you can expand to 2M bytes; a 25-key keypad; a 16-character \times 2-line alphanumeric liquid crystal display; a parallel printer port; and an RS-232C interface operable at speeds as high as 19,200 bps. \$1195.

Bytek Corp, 1021 S Rogers Circle, Boca Raton, FL 33487. Phone (305) 994-3615. TLX 4998369. Booth No 2954.

Circle No 575



SERVOMOTOR

The 4.38-in.-wide, 0.92-in.-thick N Series servomotors produce 69 oz-in. of torque over 0 to 4000 rpm. They provide a peak torque of 755 oz-in. The motors rotate without cogging even at low speed. Their rated terminal voltage equals 30V, and their rated current is 7.9A. They feature 0.85 Ω terminal resistance and <100- μ H armature inductance. Their moment of inertia ranges from 0.396 to 0.586 kg-cm². One motor in the series has a tachometer output that produces 3.5 V/krpm. \$550. Delivery, eight to 10 weeks ARO.

PMI Motion Technologies, 49 Mall Dr, Commack, NY 11725. Phone (516) 864-1000. TWX 510-223-0007. Booth No 432.

Circle No 576

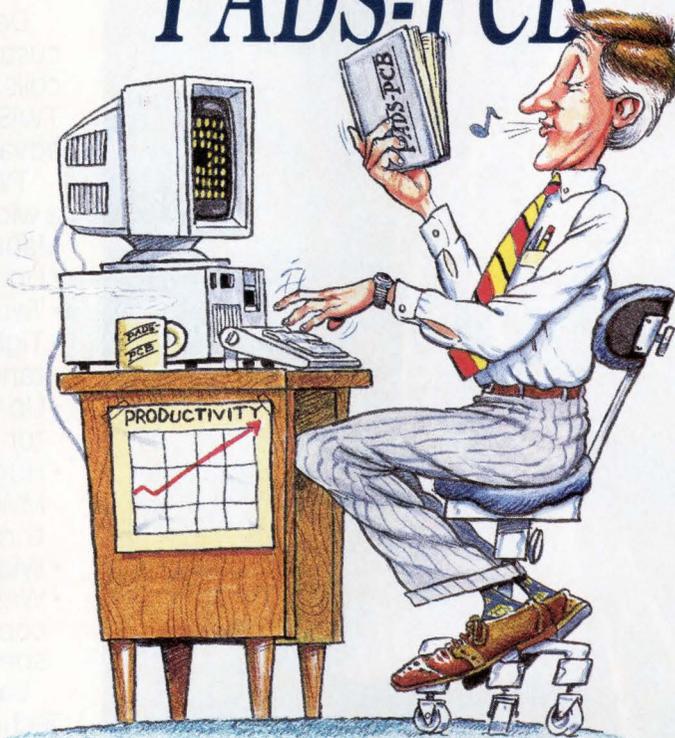
CAE SYSTEM

EE Designer III is a complete CAE software package that runs on the IBM PC/AT, PC/XT, and compatibles. The software supports 2M bytes max of expanded memory and lets you design pc boards as large as

32 \times 32 in. and with as many as 36 layers. You can include as many as 64,000 connection segments and 64,000 text strings. The schematic design module provides for forward and back annotation of multipage schematics to the layout, and for automatic parts packaging of gates with pin numbers and part identification. The on-line net-list-genera-

tion feature automatically adds parts to the net list as you incorporate them into your design. The system lets you edit, copy, and mirror symbols. The simulation module handles both analog and digital circuits, and can simulate as many as 50 nodes simultaneously. The layout module allows you to edit and view as many as 16 layers simultaneous-

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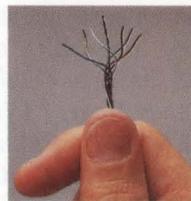
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ly, with a grid resolution of 1 to 800 mils. The package includes an auto-router that minimizes the number of layers in your design. \$3995.

Visionics Corp, 343 Gibraltar Dr, Sunnyvale, CA 94089. Phone (408) 745-1551. TLX 346352. Booth Nos 2838 and 2840.

Circle No 577

DEBUGGER

The Xray68K high-level debugger/simulator package runs on a variety of host computers and generates code for the Motorola 68000 family of μ Ps. The package includes the MCC68K C cross-compiler, a relocating macro crossassembler, a linking loader, and a library utility. You can write your application in C, using your standard editor, and then assemble and link it to generate native code for the target machine. The debugger/simulator emulates the target machine in software

and allows you to control and examine the execution of your code either at the assembly-language level or in terms of C source-code lines. You can set both simple and complex breakpoints and display both interrupts and user I/O operations. Alternatively, you can direct simulated target output to a disk file for later examination and analysis. From \$3500 to \$14,000.

Microtec Research Inc, 3930 Freedom Circle, #101, Santa Clara, CA 95054. Phone (408) 733-2919. TLX 4990808. Booth Nos 2619 and 2621.

Circle No 578

SCHEMATIC CAPTURE

The HiWire-Plus schematic-capture software package runs on the IBM PC and compatibles and has been enhanced by the addition of an ECL component library and a ladder-diagram library. Other new features



include 0.001-in. resolution, the ability to create pc-board layouts with as many as 250 layers and the ability to handle boards as large as 60x60 in. You can direct output to pen plotters, dot-matrix printers, and laser printers. The package includes utilities for the creation of net lists and a bill-of-materials, and for comparing these with your final board layout. The vendor offers a 3½-in. diskette version of the package for use on the IBM PS/2 family and some laptop machines. \$895.

Sports Card

Shift into high gear with the high-performance, quick-handling HK68/V2E card.

This 32-bit single-board microcomputer is well-equipped to handle even the most challenging dedicated control tasks. Now you can have speed and versatility without sacrificing the functionality you need for sophisticated real-time applications. Standard equipment:

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CIRCLE NO 14

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The system features eight I/O expansion slots, and is designed to run standard PC operating systems and applications packages. It's perfect for computer aided design, computer aided engineering and advanced financial analysis applications.

Intel's open system architecture can give your system the flexibility to accommodate future changes in technology and customer requirements. That's because Intel supports the most popular computer bus architectures — PC-bus, Multibus* I and Multibus II. Together, these three bus architectures account for almost 70% of the OEM bus market.

Finally, with the System 301 you'll get the assurance and quality you've come to expect from Intel, the world's largest supplier of 386-based OEM platforms, plus the timely delivery of quality services you've come to expect from Hamilton/Avnet's Systems Engineering Group.

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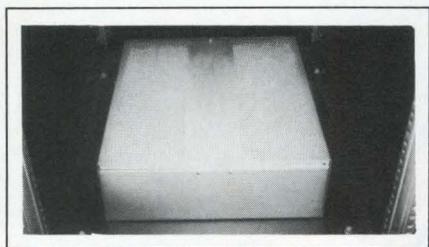
CIRCLE NO 191



Electro/88 Products

Wintek Corp, 1801 South St, Lafayette, IN 47904. Phone (800) 742-6809; in IN, (317) 742-8428. TLX 709079. Booth No 519.

Circle No 579



IMPELLER BLOWER

The 803N-2 motorized impeller blower comes in a smaller, more efficient package than do centrifugal blowers. The blower is balanced in two planes to ensure minimum vibration, and you can mount it in any position. The motor and bearings are sealed to provide maintenance-free operation. If you mount the blower on the floor of the equip-

ment frame, you must maintain a $1\frac{1}{16}$ -in. clearance between the frame base and the floor for air intake. The blower operates on 115V ac at 50/60 Hz and draws 1.18 amps. Its speed is variable between 2200 and 2570 rpm, and it delivers 445 to 540 cfm at a noise level of -55 dB. The blower case, which also contains a filter, measures 5×14.5×13.5 in. \$265.

Amco Engineering Co, 3801 N Rose St, Schiller Park, IL 60176. Phone (312) 671-6670. TWX 910-227-3152. Booth Nos 1308, 1310, and 1312.

Circle No 580

CMOS BACKUP

μ PowerCell 2.8V lithium-iodine batteries feature a shelf life of over 20 years at temperatures below 37°C. The vendor offers them in two configurations, round or rectangular. The round, axial-lead B-35 features

35-mAh capacity and comes on sequenced tape reels for automatic insertion. The rectangular B-400, B-600, and B-1000 have capacities of 400, 600, and 1000 mAh, respectively. The batteries operate over -55 to +125°C. The vendor also offers the DRM and DRM2 data-retention modules, which provide battery-switchover capability, and the NVRM (nonvolatile RAM module), which features 2k bytes of Toshiba static RAM in addition to the switchover capability. B-35, from \$3 (100).

Catalyst Research, 1421 Clarkview Rd, Baltimore, MD 21209. Phone (301) 296-7000. TLX 898095. Booth No 1269.

Circle No 582

Dream Card

The HK68/V30 is the card you've been dreaming of.

This fully-loaded single-board VME microcomputer combines the highly sought-after qualities of high speed and advanced on-card functionality. Now you can have high-end performance for UNIX and real-time applications. Standard equipment:

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- Up to 1 MB of EPROM
- 2 serial I/O ports
- Single 8-bit parallel port
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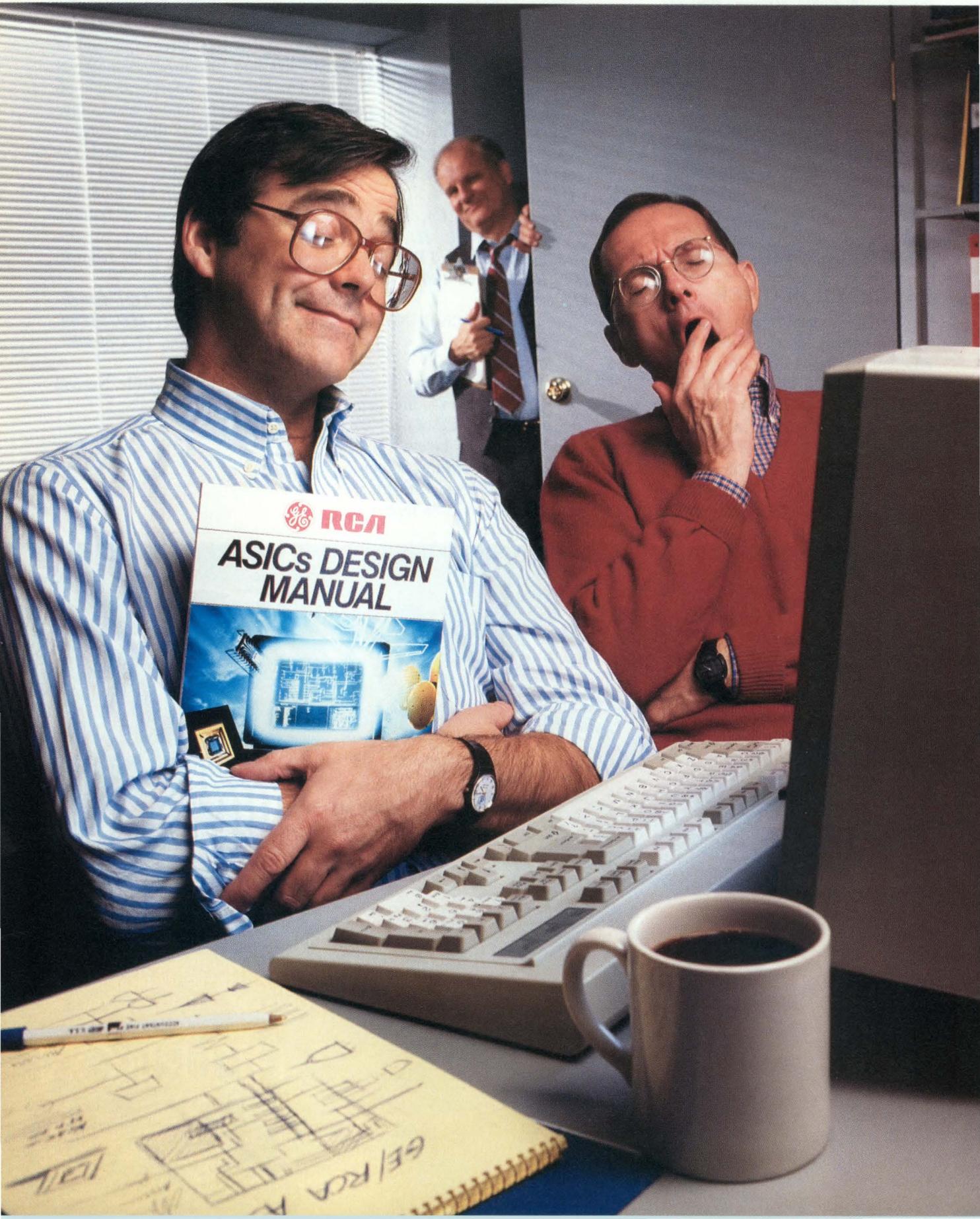
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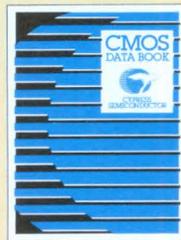
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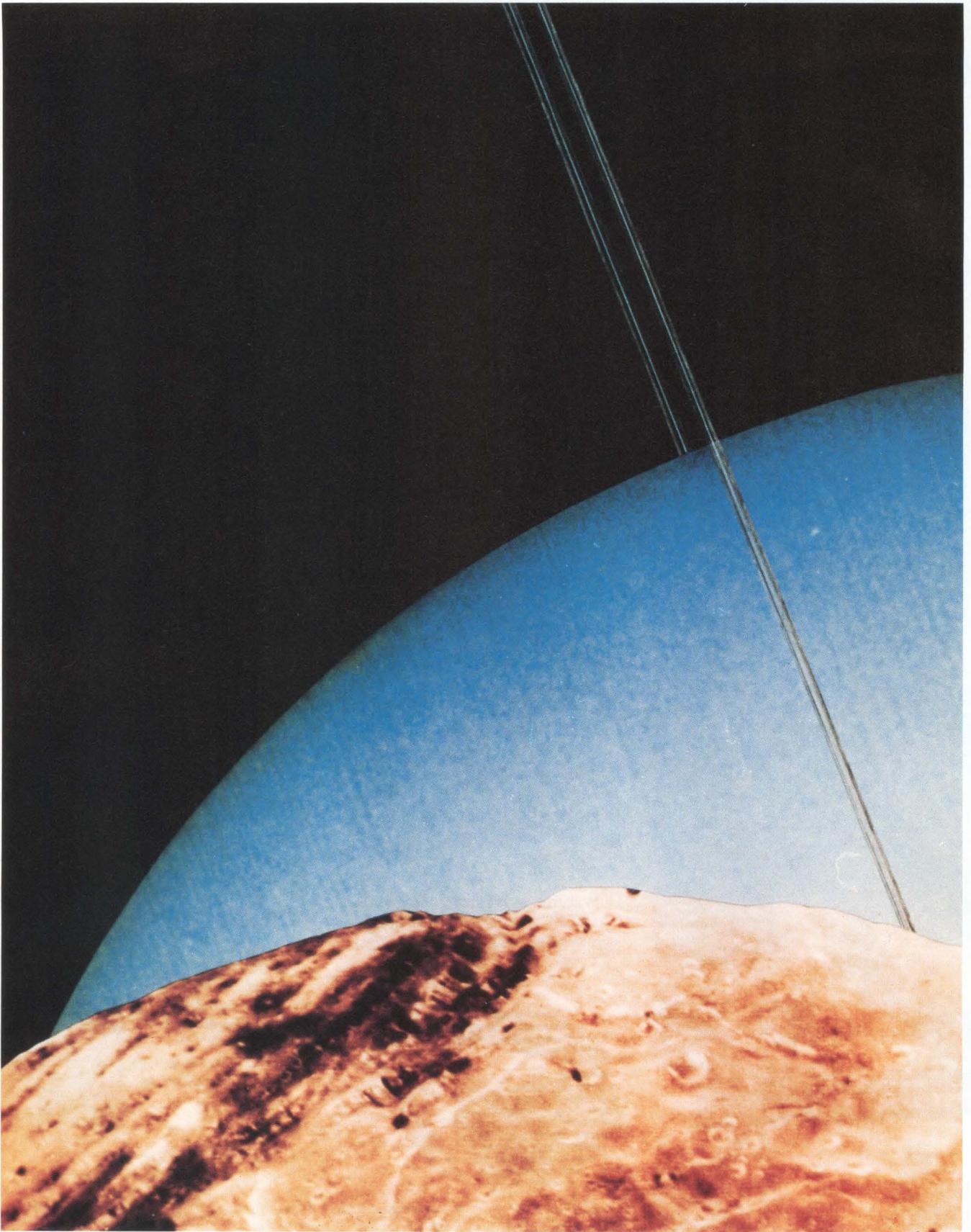
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Nine years and approximately 1,750,000,000 miles from the nearest service depot on Earth, Voyager 2 photographed Uranus, its rings, and its moons, including the moon Miranda (shown in the foreground of this composite photo). Missions such as those of the Voyager spacecraft underscore the need for ultrareliable space systems. Voyager 2 will fly by Neptune in August 1989. (Photo courtesy Jet Propulsion Lab/NASA)

Fault-tolerant design spans terrestrial and space applications

The growing commercialization of space will boost many more electronic systems into orbit in the 1990s. Fault-tolerant design techniques developed originally for aerospace systems will pervade the electronics industry as customers demand the utmost in reliability from every electronic product, even those intended for use on Earth.

Steven H Leibson, *Regional Editor*

Space has been a commercial frontier for more than 20 years, thanks to communications satellites. In the 1990s, a lot more hardware is headed off Earth both to enhance existing communications facilities and to expand the commercial use of space into other areas. President Reagan recently revealed a new space initiative that calls for increased commercialization of space, and several companies are now deeply involved in plans to make that vision real. As a result, during the next decade, engineers will design many more electronic systems for spaceborne applications than they have in past years.

Systems for use in space must meet stringent reliability requirements. They must also withstand the unusual environmental hazards present in space, such

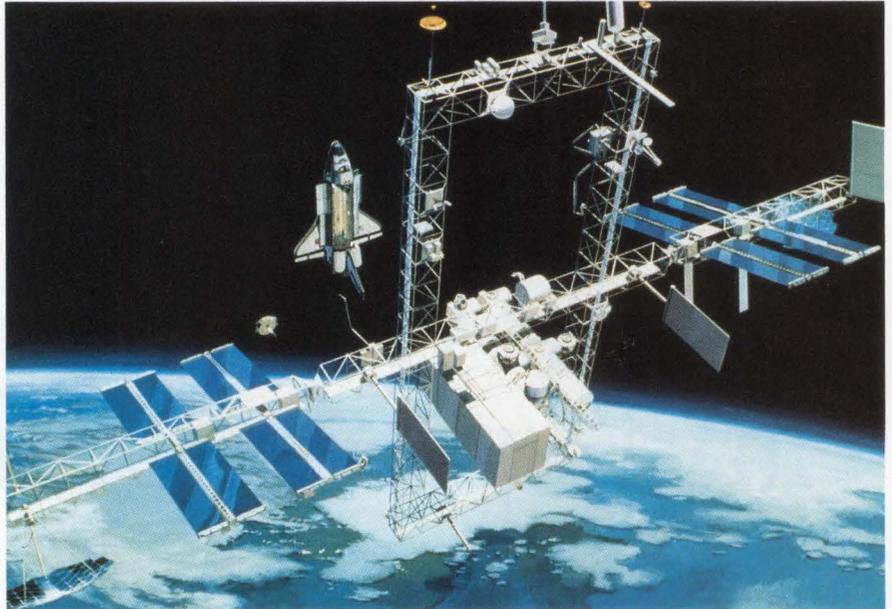
as temperature extremes and radiation. What's more, as electronics spreads throughout earthbound applications, any system that plays a vital role in the health and welfare of human beings will have to meet requirements similar to those for spaceborne systems. Whether they're designing systems for use in space or on Earth, therefore, more engineers will have to become better acquainted with fault-tolerant design.

Space presents immediate challenges

The US's permanently manned space station, which NASA plans to make operational by 1997, represents a major opportunity for progress in space electronics. Just for its construction, the station requires extensive development of automated systems that manage data, environmental-control, life-support, thermal, and power systems. NASA divided the space-station project into four work packages and, last December, awarded contracts for these packages to Boeing Aerospace Co (Huntsville, AL), McDonnell Douglas Astronautics Co (Huntington Beach, CA), the Astro-Space Div of General Electric Co (Valley Forge, PA), and the Rocketdyne Div of Rockwell International (Canoga Park, CA).

In February 1988, President Reagan revealed a new space policy that plays up the role of private companies in US space efforts. In fact, firms in the US such as Space Services Inc (Houston, TX), with its Conestoga Series small boosters, are already attacking the first major hurdle—cost-effective access to orbit—by developing independent launch systems to supplement US

The US's permanently manned space station, which is scheduled to become operational in 1997, presents several opportunities for designing fault-tolerant systems that manage data, environmental-control, life-support, thermal, and power systems. In addition, the space station will provide a platform for conducting manufacturing-related investigations, which will also require fault-tolerant systems to oversee the experiments. (Photo courtesy NASA)



government vehicles. One forward-looking company, Orbital Transport Services Inc (Phoenix, AZ), is developing an electromagnetic catapult that employs superconducting storage rings to provide the electrical energy for launching a payload into orbit.

A space station smaller than NASA's planned one, the industrial space facility (ISF) designed by Space Industries Inc (Houston, TX), is scheduled to become operational in 1991, much earlier than the manned space station. The unmanned ISF will provide a platform for materials research and automated manufacturing. Unlike the manned space station, it will not incorporate life-support systems, but will be visited occasionally by the space shuttle for repairs, supplies, and retrieval of manufactured products.

Many other countries, attracted by the potential profits in satellite delivery, have entered the space-transportation business. The European Space Agency (ESA) has already launched several payloads with its Ariane booster series, and has recently decided to build an improved model—the Ariane 5—as well as the Hermes space shuttle and the Columbus manned space laboratory. China and the USSR have also entered the competition by selling rides on their respective Long March and Proton heavy-lift boosters. Japan, though not yet in the fray, is currently developing a commercial launch vehicle of its own. Consequently, a lot of electronic hardware will be heading for space during the 1990s.

Though more electronic systems will end up in space during the 1990s, many engineers today lack the expertise to design systems for extraterrestrial environments. Electronic systems in space applications must tolerate radiation, and few engineers are familiar with the components and techniques necessary to build radiation-resistant circuitry (see **box**, "Proofing electronic systems against radiation").

Space hardware must also be very reliable, because on-site service is either very costly or unavailable. Furthermore, most space equipment must be robust enough to handle unplanned problems without human intervention. Today, engineers developing equipment for aerospace applications are some of the world's leading experts on fault-tolerant, redundant design.

Aircraft need fault tolerance

According to Gary Kravetz, vice president of engineering at Fail-Safe Technology Corp (a consulting firm specializing in reliable-system design), engineers first started using fault-tolerant and fail-safe designs for aircraft flight-control systems in the 1960s. At that time, aeronautical engineers were starting to design inherently unstable airframes, such as that of the F-16 fighter, that required a computer to dynamically position the control surfaces for stable flight. The control computers had to be absolutely reliable, because computer failure in such applications results in catastrophic consequences—the plane will fall out of the sky.

Proofing electronic systems against radiation

Besides requiring reliability, redundancy, and robustness, spaceborne systems encounter an environmental hazard not common to most terrestrial applications: radiation. All ICs tolerate radiation to some extent, but because manufacturers are always trying to optimize other characteristics such as yield or speed in their commercial parts, chips that are not specifically hardened against radiation may not have repeatable radiation tolerance from lot to lot. Engineers confer hardness on a design by using special device geometries and spacings and by fabricating the chips with carefully controlled processes.

Spurred by the US government's requirements for radiation-hardened devices in military and space applications, several companies now offer ICs specifically built for high-radiation environments. For example, Harris Semiconductor (Melbourne, FL), offers several lines of rad-hardened analog and digital ICs. The company even offers a hardened version of the Intel 8086 μ P, which Ball Aerospace Systems Div (Boulder, CO) has incorporated in its subsystem processor, a computer subsystem that Ball plans to use as a controller in future spacecraft designs.

The United Technologies Microelectronics Center Inc (UTMC, Colorado Springs, CO) also offers rad-hardened ICs. The company makes both standard parts and ASICs for systems that must tolerate radia-



Voyager's mission posed some tough challenges for designers trying to harden the spacecraft's electronic systems against radiation. One such challenge presented itself in the form of reports from Pioneer 10 and 11—a year after the Voyager design was finished—that the radiation intensity in the vicinity of Jupiter was 1000 times greater than experts had estimated. The discovery required Voyager's designers to provide the craft with additional radiation hardening. (Photo courtesy JPL/NASA)

tion. Recently, UTMC introduced the UTD-R family of gate arrays, which meets all of its data-sheet specifications after absorbing a 1M-rad (Si) dose of radiation. That's about the radiation dosage an unshielded system must endure while orbiting the Earth for 10 years.

Different types of radiation (neutrons, ionizing radiation, and heavy ions) affect semiconductors differently. In addition, different dose rates create varying effects. Because device physicists don't yet fully understand all of the changes that different types of radiation produce in semiconductors, few standards for testing an IC's radiation hardness exist. Most of the existing standards were created by the US Department of Defense.

Rad-hardened-system design

has remained a rather esoteric field that's limited mostly to military and space applications. However, because of the growing number of electronic systems in space, more engineers will need to develop expertise in rad-hard design. The IEEE's Nuclear and Plasma Sciences Society serves as an excellent source of information concerning radiation effects on electronic devices. The society sponsors an annual Nuclear and Space Radiation Effects Conference (NSREC) that includes a short course on rad-hard design methods for the uninitiated. This year's conference will take place in Portland, OR, from July 11 to 15. For more information about the 1988 NSREC, contact Bobby Buchanan at Spire Corp (Bedford, MA, (617) 275-6000).

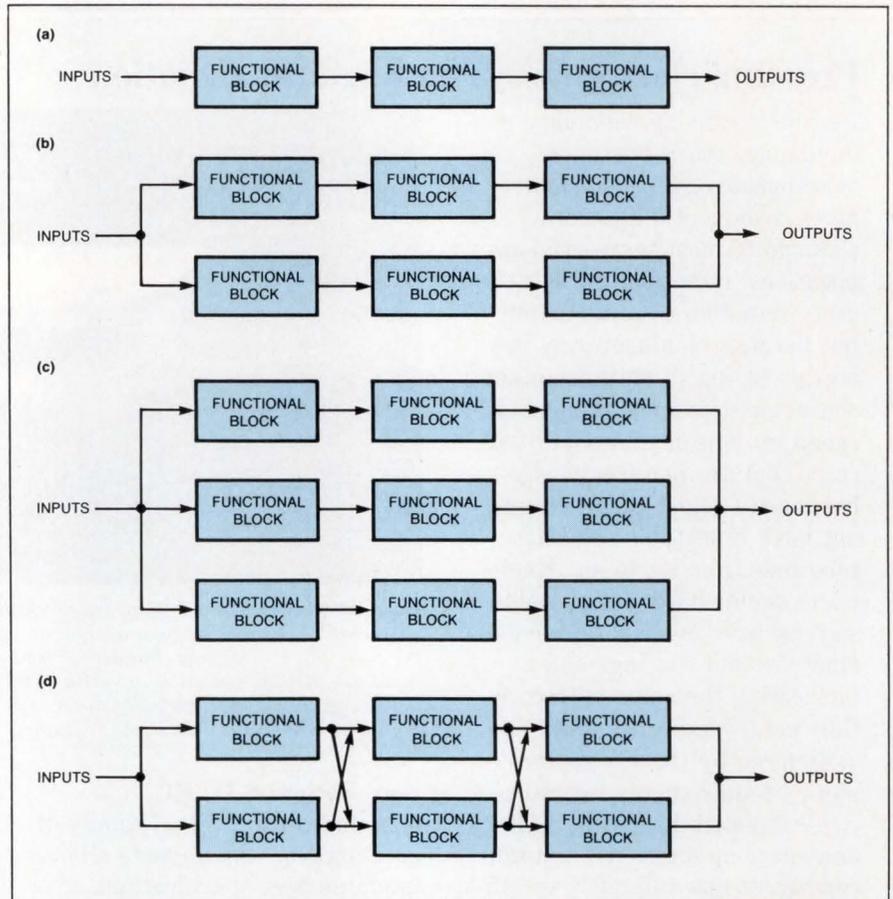


Fig 1—You can represent a complex system as a string of functional blocks, assign the string a reliability figure, and then compute the expected failure rate for the entire string (a). Should that figure not meet your system specs, you can add a parallel, redundant system (b), or even two of them (c), to boost the overall system reliability. To achieve even greater reliability, usually at lower cost, spacecraft designers often use cross-strapping, which allows one system to use functional components from another system in case of a failure (d).

Kravetz says that spacecraft requirements for electronic control systems vary according to the mission. The first orbiting satellites had fairly simple electronic systems, because they could rely on human ground controllers to rectify problems by radio control. Attitude controls, however, were made fail-safe so that a control-system failure would not plunge the satellite into the atmosphere before the ground crew could correct the fault.

Ball Aerospace Systems Div (Boulder, CO) specializes in building unmanned orbital spacecraft. William H Follett, deputy director of spacecraft systems at Ball, says that the aerospace industry has developed several approaches to improving system reliability. For example, you can represent a complex system as a series of functional blocks, assign a reliability figure for the string, and then compute the expected failure rate for the entire string (Fig 1a). Should that figure not meet your system specifications, you can add a parallel, redundant system (Fig 1b).

If that step does not achieve the desired system reliability, you could add another redundant system to the design (Fig 1c), but spacecraft designers often use a different approach, cross-strapping, which allows one system to use functional components from another system in case of a failure (Fig 1d). Cross-strapping achieves better reliability than simple replication, and it does so at a lower hardware cost than you'd incur by building systems with triple redundancy.

For orbital spacecraft, ground controllers can manually switch components into operation by using cross-strapping. Planetary probes such as the Voyager and Galileo spacecraft developed by the Jet Propulsion Laboratory at the California Institute of Technology (Los Angeles, CA), however, can't depend on ground control, because planets and other celestial objects occasionally block radio transmissions. Such spacecraft require electronic control systems that are not only fail-safe, but redundant, self-repairing, and autonomous as well.



Commercial space development in the 1990s will strengthen the communications systems already in orbit and will initiate the era of manufacturing in space. Such enterprises require robust, reliable, redundant electronic systems that can manage operations, providing a less-expensive alternative to constant human attention. (Photo courtesy Motorola Inc, Phoenix, AZ)

Robust, redundant, highly reliable systems certainly are critical for space applications. But they're important for applications on Earth, too. For example, by the early 1990s, at least one auto manufacturer will offer vehicles with drive-by-wire steering, in which there's no mechanical linkage between the steering wheel and the front wheels. Such a system requires less energy to operate than a hydraulic power-steering system does. The electronic steering subsystem in a drive-by-wire car had better be as robust, reliable, and redundant as any of the circuitry in a planetary space probe. In addition, as electronics become more pervasive in medical equipment, redundant and reliable design will be needed to safeguard a patient's health and well being.

Other applications in which lives hang in the balance include automated transportation, such as San Francisco's BART (Bay Area Rapid Transit) system, and industrial process control. Such applications demand fault-tolerant electronic systems. Moreover, after the USSR's Chernobyl disaster and the Three Mile Island scare in the US, many utility companies are retrofitting manual control systems in nuclear power plants with fault-tolerant, computer-based controls.

Computers in the loop

In the past, most designers resisted using computer-based control systems in critical control loops because the computers simply weren't reliable enough. Now, however, the highly reliable design techniques devel-

oped for aerospace applications greatly reduce that problem. Further, industrial disasters, such as explosions or fires in refineries or chemical plants, underscore the utility of fault-tolerant backup computers in emergencies that a human operator can't cope with.

In fact, even lower-risk applications benefit from fault-tolerant and fail-safe design. Tandem Computers (Cupertino, CA) has offered its highly reliable NonStop minicomputers for many years. The machines find use in such applications as transaction-processing systems (computers that process the information from automatic tellers, for instance), in which the financial institutions often determine that it's less expensive to pay for a very reliable system than it is to re-enter data lost because of a computer failure.

Reliability is cheap enough for μ Cs

Fail-Safe Technology Corp believes that microcomputer-based applications can also benefit from highly reliable design techniques. The company will start shipping its FS-66 series of 80286- and 80386-based, fault-tolerant, PC-compatible computers later this year. Each FS-66 incorporates two μ Ps and an ASIC that monitors the operation of both processors. If one processing subsystem should fail, the ASIC switches operations over to the second μ P.

Fail-Safe claims that the FS-66 computers will provide 99.99% uptime and an MTBF of three years, yet will cost about the same as equivalent PCs from IBM.

Fail-Safe says that its machines will find use in critical data-processing equipment such as file servers, where the loss of one machine could stall or lose data from several tasks. In fact, NASA has expressed interest in using FS-66 computers to control experiments aboard the space shuttle, where a computer failure could destroy a multimillion-dollar experiment. Fail-Safe Technology also plans to incorporate the FS-66 technology in a single-board computer for embedded applications.

Many of the systems designed over the next decade will borrow freely from the fault-tolerant design techniques developed for space. Because of the greater number of electronic systems on Earth, because so many Earth systems need fault tolerance, and because technology of the 90s will make fault tolerance much less expensive to build into systems, you can expect designers of earthbound systems to take over the lead from aerospace designers in creating such rugged systems during the 1990s, further driving system engineers to adopt fault-tolerant design universally.

You can employ fault tolerance today

The tools and technologies needed to create highly reliable electronic systems are appearing rapidly. Soaring IC integration levels, for instance, are helping to make redundant design easier than ever for engineers who can wield the proper design techniques. And system-level CAD tools can simulate the performance of alternative designs; thus, you can iteratively improve a design to create the optimal solution. By rapidly creating software simulations of a prototypical system and testing them in simulated environments, you can find and eradicate many flaws before they creep into your hardware. Simulation also allows you to pit your designs against situations that could be very difficult or impossible to create in a physical test, but that could occur in the systems' target environment.

Testability is another key to reliable design: It lets you quickly verify prototype systems and thoroughly test freshly manufactured systems, ensuring that they contain no hidden flaws. Gigascale levels of integration make vast quantities of transistors available to designers so they can dedicate enough circuitry to test and maintenance functions. Built-in-test circuits will help functioning systems diagnose and perhaps even repair themselves before critical failures occur.

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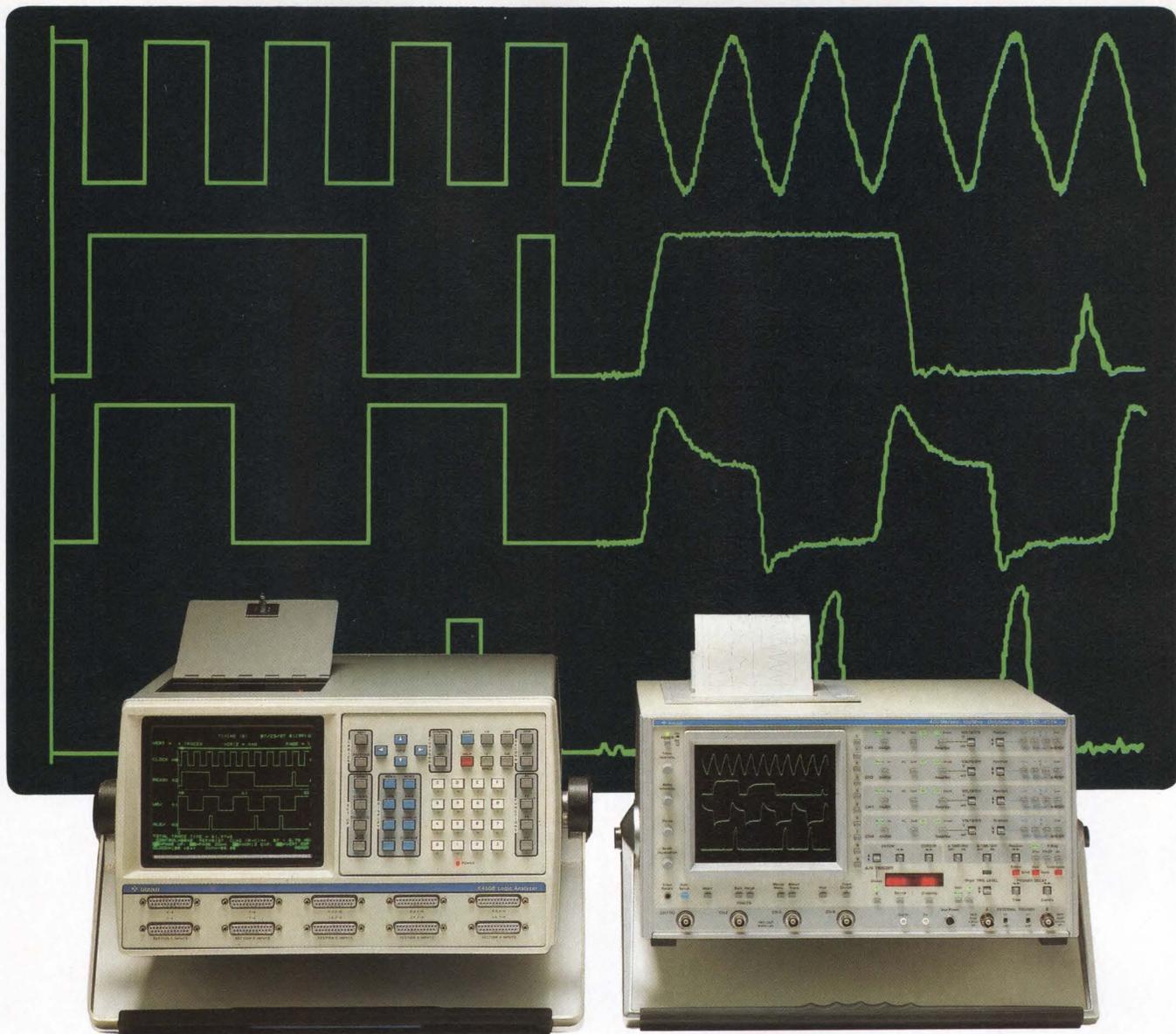
Whether they're destined for space or for terrestrial applications, electronic systems of the 1990s will be more reliable than today's designs. Many of your customers already perceive reliability as a key differentiating factor when making purchase decisions, and that attitude will become more prevalent in the future. In fact, applications involving life-or-death situations—and applications where errors are extremely costly—absolutely require highly reliable, fault-tolerant designs. In any case, reliability will be a big selling point for almost any type of system in the next decade. The companies that recognize and act promptly to satisfy these needs will become the leading system designers of the 1990s.

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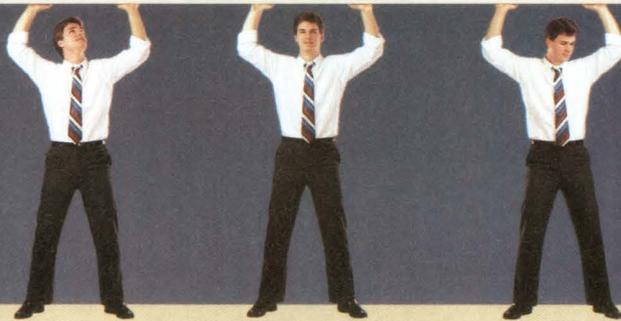
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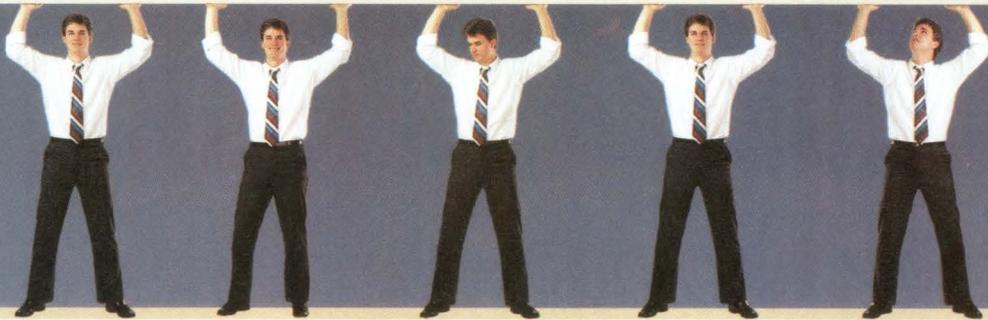
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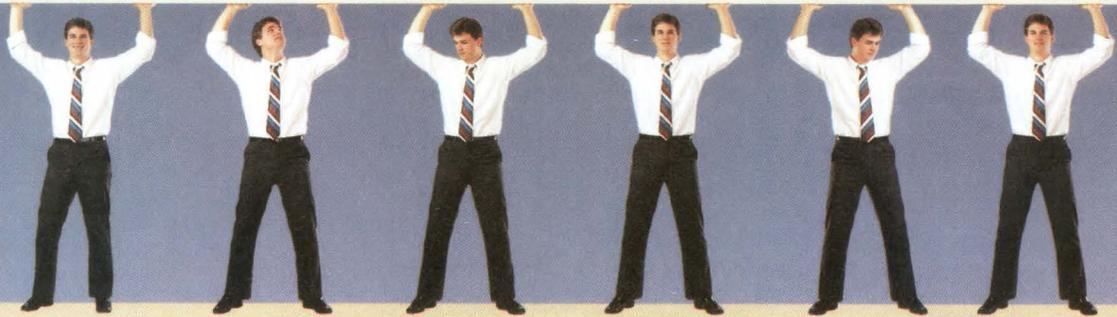
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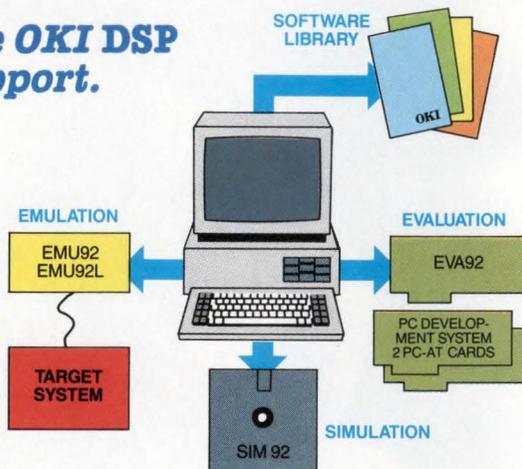
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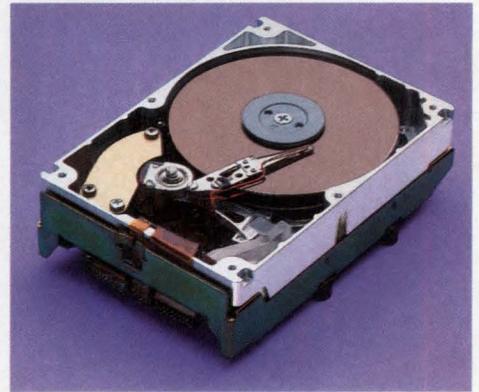
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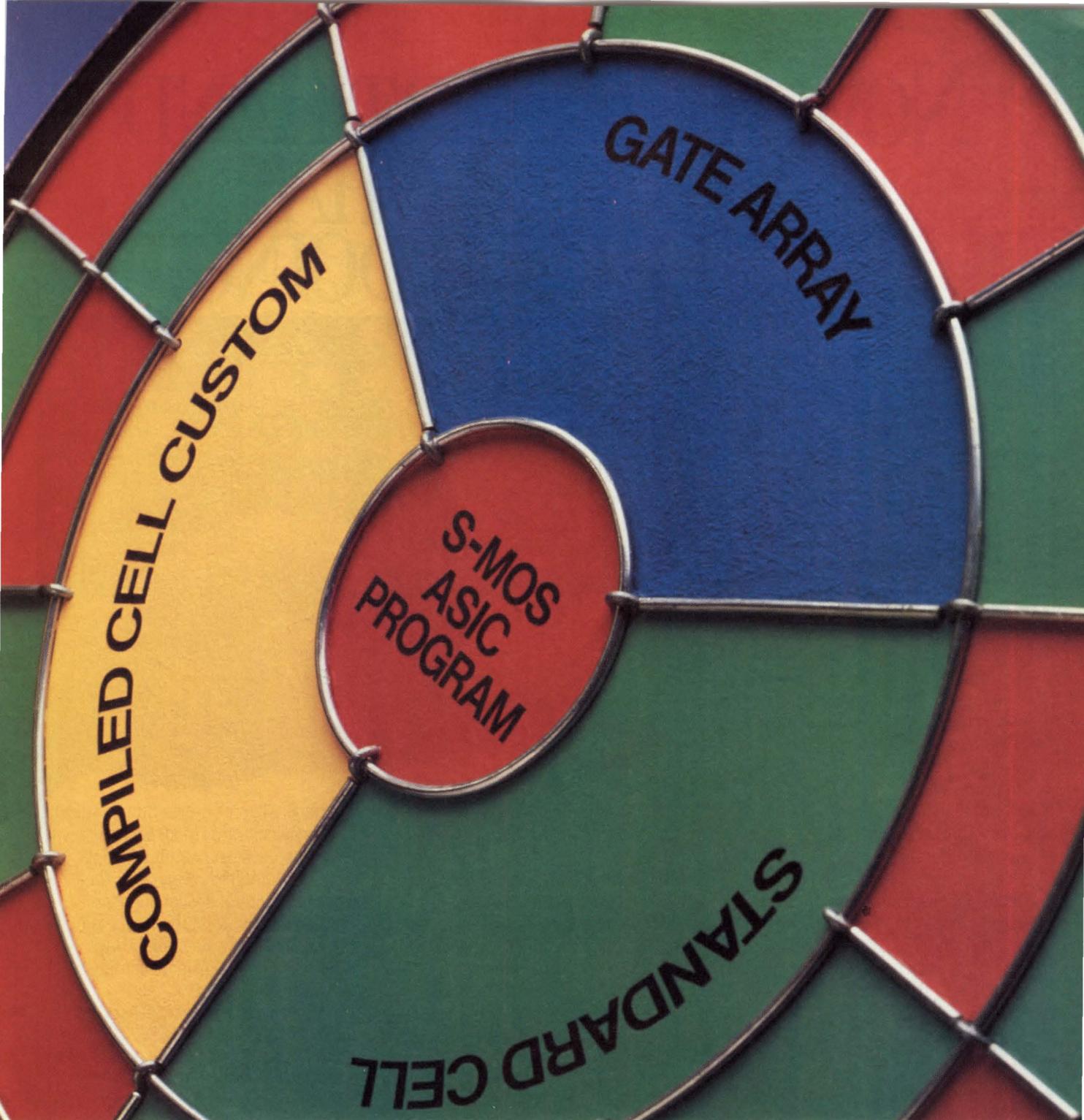
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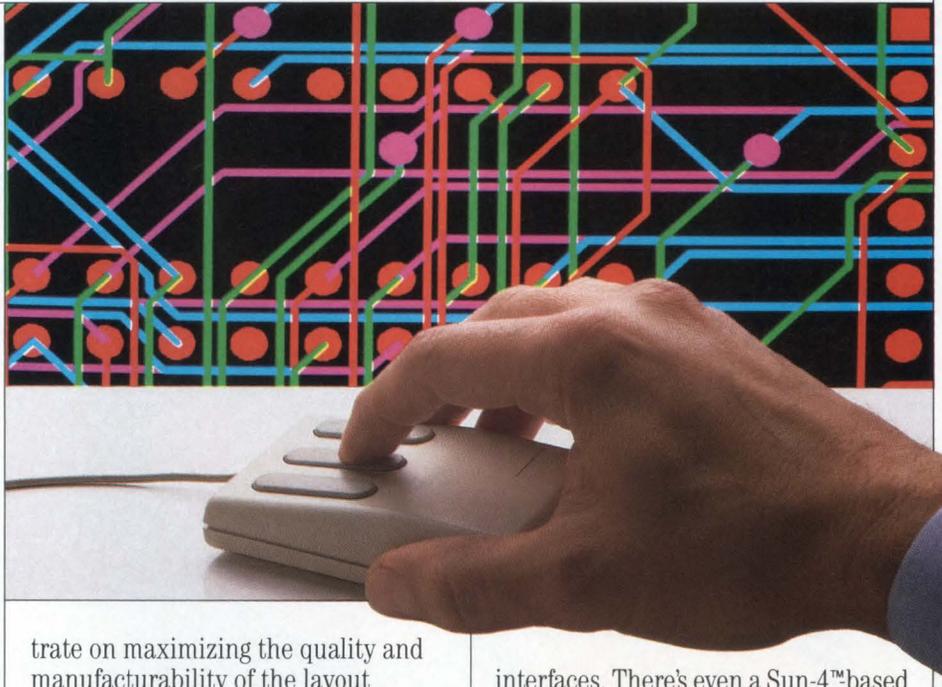
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Silicon compilers tame 10,000-gate-plus ASICs, gate arrays

Traditional design methods that manipulate gates or simple macrocells become unwieldy at densities of tens of thousands of gates per chip. However, silicon compilation offers a new paradigm for the management of these large, complex designs.

William J Stenzel, *Tandem Computers Inc*

Silicon compilation is an alternative to gate arrays and standard cells for implementing ICs. A silicon compiler creates layouts of part or all of a chip from a high-level description. Therefore, when using a silicon compiler, you can focus your efforts on high-level verification and system-timing issues rather than on low-level circuits and gates. Conceived for custom chips, silicon-compilation techniques also prove useful for gate arrays containing more than 30,000 gates.

Unlike gate-array or standard-cell designs, which require a gate-by-gate approach, silicon compilers allow you to manipulate high-level functions. You'll find silicon compilers' advantages most evident when you design data-path blocks and specify compiler functions in terms of latches, register files, multiplexers, arithmetic and logic units (ALUs), and shifters as well as in terms of their connections to data buses. In contrast, when using standard cells or gate arrays, you build up

high-level functions from a library of low-level elements, such as gates and flip-flops, and then route signals between them.

Compiled chips, like standard-cell chips, require full wafer processing, in contrast to gate arrays, which require only the personalization of an existing base wafer's metalization. Consequently, nonrecurring expense (NRE) and time required to fabricate prototypes of a compiled chip are similar to those of standard-cell chips and higher than for small gate arrays.

Silicon compilation excels at highly structured, regular functions, such as data paths and memories. Such functions appear, for example, in digital signal processors, which are primarily structured blocks with most of their interconnections going to the external pins. Further, more complex chips may have islands of regularity in a sea of interconnection.

Look at your application to decide if your design is large enough to benefit from compilation. To consolidate only a few thousand gates of random logic, you might find a gate array more cost-effective. Designs in excess of 10,000 gates are the best candidates for compilation.

Compiler vendors offer two types of tools

When evaluating silicon-compiler vendors, you will find that some offer generic tools while others offer tools specific to their own foundries. Two that offer generic tools are Compiler Systems Corp (San Jose, CA) and Seattle Silicon Corp (Bellevue, WA). You may compile your design for fabrication at one of several

Silicon compilers allow you to manipulate high-level functions; you needn't work at the gate level.

foundries these two companies' compilers support. In contrast, VLSI Technology Inc (San Jose, CA) offers compilation tools customized to VLSI Technology's fabrication process.

Other differences among compiler vendors lie in the features their compilers offer. Compilers from Silicon Compiler Systems and VLSI Technology are complete packages, including data entry, simulation, and timing analysis. Seattle Silicon's offering requires a third-party CAE workstation and software to provide many functions, such as schematic capture and logic simulation. Finally, Silicon Compiler Systems and Seattle Silicon offer tools that let sophisticated customers such as semiconductor houses create their own block compilers. This feature enables such customers to add proprietary functions or to tune functions to their own processes.

Changing your mindset

When first using a silicon compiler, you might need to make some changes to your design approach, particularly if your experience is with board-level TTL. Estimating whether or not a given design will fit onto a chip requires a set of guidelines that differ from those for pc-board layout. For example, when you size the pc-board area for a TTL design, half a dozen inverters and a 64k-byte RAM take about the same amount of space. Conversely, area within compiled chips depends more on the amount of logic in a function. Moreover, interconnections within a chip consume considerable space, occupying as much area as active logic in many cases.

Circuitry details, too, might dictate some changes in your design methods when you first use a silicon compiler. For example, although most systems use an edge-triggered register methodology that's familiar to TTL designers, Silicon Compiler Systems' Genesil differs in that it supports a latch-based scheme with 2-phase, nonoverlapped clocks and precharged buses, more typical of custom IC designs.

In contrast to edge-triggered schemes, which use registers as state elements that sample inputs at a clock edge (and which allow data an entire clock period to propagate through the subsequent logic before being sampled at the next clock edge), 2-phase latch-based schemes use transparent latches as state elements. The latches propagate data from their inputs to their outputs when the clock that enables them is asserted, and they hold their data when the clock is not asserted.

In the 2-phase scheme, a clock generator converts a master clock into two phases: phase A and phase B.

Phase A is asserted when the master clock is high; phase B, when the master clock is low. These two phases are interlocked so that they are never simultaneously asserted (hence the term "2-phase nonoverlapped").

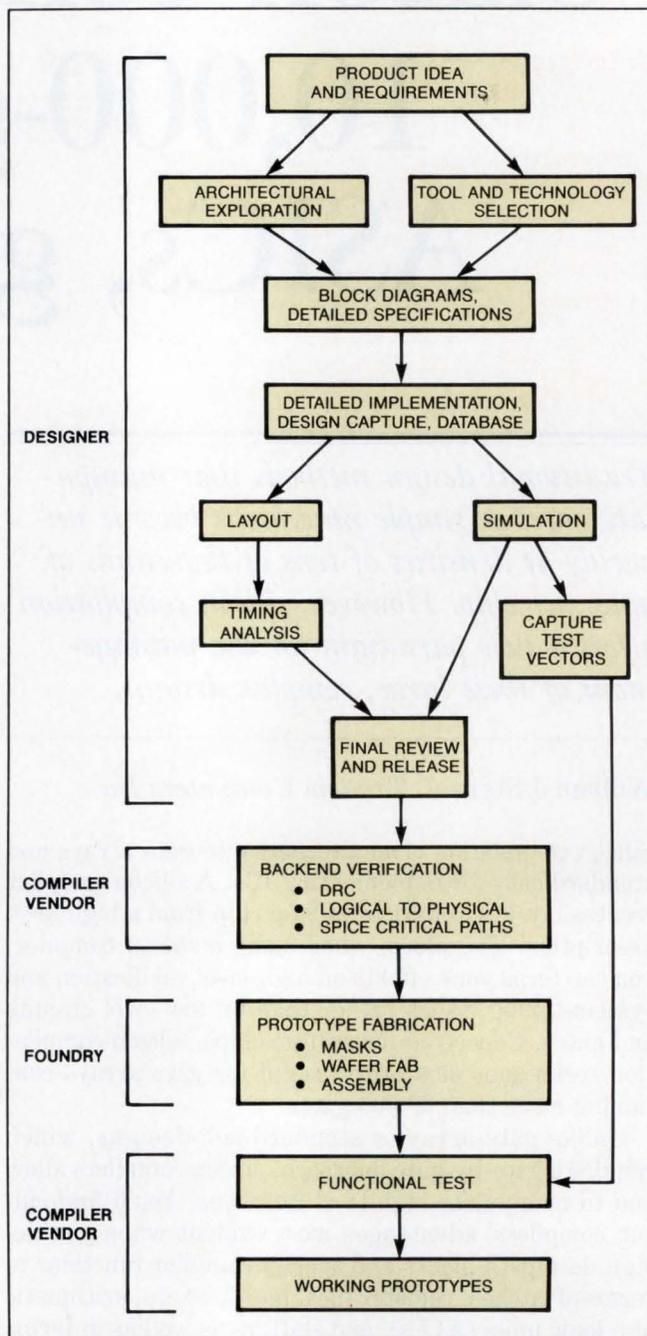


Fig 1—The designer, the compiler vendor, and the silicon foundry must all cooperate to bring an IC from an idea to a working chip.

You must alternate which phase controls the latches throughout your design: Signals originating in a latch controlled by phase A must terminate in a latch controlled by phase B. When a phase A latch is propagating, the subsequent phase B latch is holding, and vice versa, thus eliminating race conditions. Transparent latches require roughly half the space and internal logic as edge-triggered registers. Hence, they provide an advantage in chip size. After becoming familiar with the technique, you will find the latch-based scheme to be flexible and useful for pushing the performance of critical timing paths.

Design process

Fig 1 charts the steps—covering several design disciplines—that you must take to transform your product idea into a working chip. You must organize major projects with an awareness of these disciplines. During the specification and initial design phase, several engineers might each concentrate on a functional area of the design. As the project progresses, each engineer might focus on simulation, layout, or timing analysis.

In the architectural-definition phase, you must determine how to map your idea onto chips and evaluate design alternatives against system cost and performance requirements. Using the compiler, you can create trial designs of major blocks for evaluation. Because you describe blocks by their functional attributes, the compiler can capture the rough design and do the detail work necessary to determine size and speed estimates.

For example, within a data path, you could specify interconnections between ALUs, latches, register files, and multiplexers via major buses (as you would when drawing a conceptual block diagram). You can sketch the design alternatives and have the compiler expand the sketch into full detail to facilitate experimental designs for architectural evaluation. By the end of this phase, you will produce block diagrams and detailed specifications for the design.

Cost estimates

The major variables in a chip's cost are its size, package, and foundry. You can estimate size by experimenting with designs on the compiler and incorporating major logic blocks, signal buses, and an allowance for details not included in the rough design. High pin counts can create pad-limited chips in which I/O pads on the periphery determine the die size. As the die size increases, chip cost dramatically increases. Your foundry should help by estimating the cost based on die size.

Pin-count estimates should include power and ground pins. To reduce noise from simultaneously switched outputs, you need at least one power and ground pin for every eight to ten simultaneous outputs. The required ratio varies with the speed of the output drivers and the fabrication process. As pin counts increase, package costs also increase. Ceramic pin-grid-array (PGA) packages of 100 to 180 pins are available, but they can add \$10 to \$20 to parts cost.

Design capture

To implement your design, the compiler must capture several layers of information. Working from the inside of the chip to the outside, you should follow these steps in the design capture:

- Define the functional blocks and specify block interconnections.
- Specify chip I/O pads for function and location on the chip periphery.
- Connect the pads to the internal circuitry.
- Specify the package type and the bonding between chip I/O pads and package pins.

At the block-specification phase, you begin by selecting the desired type of functional block from a block-creation menu. The detailed specification varies with the type of block. For example, a random-logic block would comprise simple gates. Seattle Silicon and Silicon Compiler Systems support a schematic-capture mode using third-party CAE workstations. In this mode, you could specify the random-logic block by interactively drawing a schematic of the gates and identifying the external ports. Alternatively, Silicon Compiler Systems also supports a menu-driven, text-oriented means of specifying random-logic blocks.

A RAM or FIFO block, on the other hand, requires different information. The meaningful parameters for these blocks are size, organization, and timing. You may specify these parameters in a menu-driven fashion by filling in the appropriate blanks for the number of inputs, the number of words, the speed options, whether the block is to be single or multiple ported, and whether or not the output is latched.

Such blocks as read-only memory (ROM) or programmable-logic arrays (PLA) need this type of menu-driven structural information; in addition, they require programming information to specify their contents. For example, Genesil accepts truth tables, fuse maps, logic equations, or state-machine descriptions as formats for conveying PLA contents. Logic minimizers, such as Espresso from the University of California at Berkeley,

Silicon compilation excels at implementing highly structured, regular functions, such as data paths and memories.

are available for PLA minterm reduction on several compilers.

You also have options in the method of specifying ROM contents. Genesil includes a macro assembler that can create symbolic macros and generate ROM contents by macro assembly. Alternatively, you can use a file containing the object code as ASCII ones and zeros. (At Tandem, designers develop microcode on a system other than the compiler and then port the finished

object code to the compiler, formatting it appropriately along the way.)

Consider also complex blocks such as data paths. Genesil uses a menu-driven approach to specify data-path elements, bus connections, and orientation. Under Genesil, the entire data path is the same bit width (that is, number of bits in a word slice), although some elements allow masking of selected bits. (Although this scheme might sound restrictive, it's actually quite versatile.)

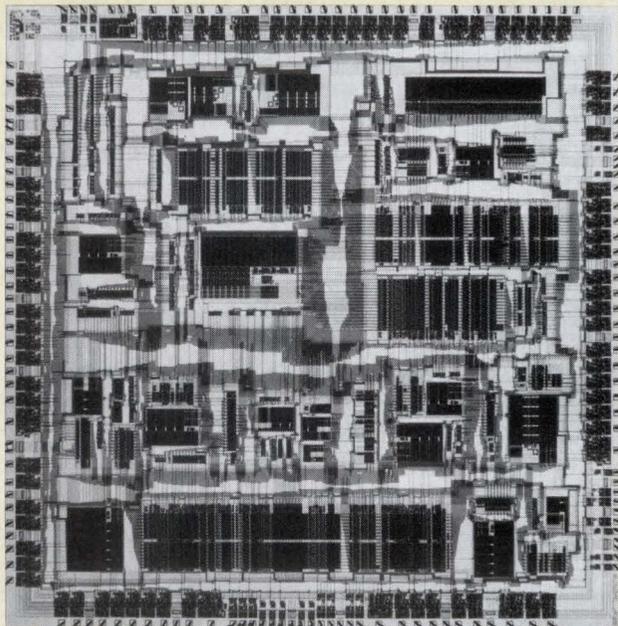
After you create the functional blocks, you must interconnect them. Genesil uses a textual net list to connect the external ports on each functional block to a named net. Seattle Silicon uses a third-party CAE-workstation schematic package to interconnect blocks.

Careful planning and good naming conventions are important to the interconnection phase. If several engineers work on different portions of a complex chip, prior agreement on net names and spellings will allow smooth and accurate net listing. Make the port names the same as the net names whenever possible.

Background

Silicon compilers began generating interest in 1983 and 1984 (Refs 1, 2, and 3), and they have since evolved into practical tools, yielding such products as graphics controller chips (Ref 4).

The information in this article is based on the experience of designers at Tandem Computers, who used silicon compilation to realize four CMOS chips employed in the company's NonStop CLX, a user-serviceable distributed on-line transaction-processing (OLTP) system. One of the chips—the CPU—measures approximately 500×500 mils and contains 60,000 transistors.



Tandem Computers Inc produced this CPU chip with a silicon compiler for its NonStop CLX fault-tolerant computer. Part of a four-chip set, the CPU measures 500×500 mils and contains over 60,000 transistors.

Chip layout

The first step in chip layout is compiling the functional blocks, transforming them from a text description into a custom layout. After compilation, you can manipulate them as blocks having signal ports on their edges, without dealing with their internal layout. The rest of the layout phase consists of placing the blocks and routing their interconnections.

Compilers rely on an automatic signal router for interconnection. Because a chip's size is flexible at this stage, the router can push blocks away from each other to make room for the interconnections, guaranteeing that all the interconnections can be made. However, the result can be a very large chip. Designers exert the most influence on the layout through their placement of the blocks. Other factors affecting layout include the relative priority of signals and, on some compilers, assignment of routing channels.

You should have a layout plan in mind for the overall interconnection of the blocks (such as where major buses tie to which blocks). Although compilers have placement aids or even auto-placement algorithms available, your insight is important in producing a tight layout of a complex chip. Experimenting with alternate layouts will be fruitful, both for trying significantly different placements and for fine tuning the most promising placement. Achieving a good layout is very much an iterative process.

The compiler should assure adequate power and clock distribution. For example, Genesil calculates the power of each block and uses a power/ground bus width based on the total power of all blocks downstream from a given point. This procedure results in power buses that begin with a width of the power bonding pad and taper progressively. Clock lines may benefit from high-priority routing and several-times wider-than-minimal metal lines. In some cases, the clock lines can be isolated from other signals by surrounding them with ground lines.

Because interconnection delays stemming from wiring capacitance can be significant in CMOS, you must monitor the chip's critical paths while optimizing the chip size.

Simulation—verifying your design

Verifying your design through simulation is essential to maintaining the project schedule and budget. The expense, effort, and time required for chip iterations make a first-pass success highly desirable. Good simulation tools and a careful strategy make first-pass success attainable. The compiler generates a simulation model for your design automatically, ensuring that what you simulate corresponds to what you implemented.

Table 1 describes several levels at which to simulate. As you enter your design, you may interactively simulate small portions. For example, you may perform a check on a piece of control logic by manually applying a few patterns and observing the response. This level

does not provide comprehensive verification, but it's a good indication that you're on the right track.

At the next level, you can apply hand-coded simulation vectors to the whole chip or to large parts of it. These vectors can become production-test vectors. This level is more rigorous and is reproducible as a regression test. However, it still relies on your ingenuity to specify the stimulus and response. Because simulation runs can require hundreds or thousands of vectors, the simulator must check for the expected response to a given stimulus and automatically flag any discrepancies. This rigorous simulation is far superior to the alternative of visually checking a printout of the simulator's output for erroneous responses.

Finally, you can embed the chip into a model of its intended application and perform system-level simulations. This level can expose subtle bugs and boundary conditions that you would not normally find in your lab.

Timing analysis

Accurate prediction of the performance of your chips is an important part of the design. You need to relate your system's goals and constraints and identify the areas of your chip that need fine tuning.

Two main components of CMOS circuit delays are the gate propagation delay and the additional delay arising from the capacitance and resistance of the interconnection. To obtain accurate timing numbers, you need to incorporate the interconnection loading derived from the actual layout of the chip. In a large chip, the interconnection delay of a signal crossing the chip can exceed a gate's nominal propagation delay. An excessive interconnection delay indicates a very long routing or a net with a large fan-out. You can shorten the delay by increasing the strength of the driver, altering the placement of the chip to shorten the interconnection length, or revising the logic to reduce the fan-out.

Two classes of timing-prediction tools exist. The more traditional tool is based on circuit simulation. Using a model of your circuit, you can stimulate it to trace specific circuit paths to obtain their delay. In general, the more accurate the calculations, the slower the simulator. Spice, a commercially available circuit simulator, is an example of a very accurate and computation-intensive tool. One of the main drawbacks of this type of tool is that it gives you information about only the paths you specify and already suspect—not unexpectedly slow paths.

The second class of timing tool, static analysis, can examine all paths and tell you which are the longest.

TABLE 1—LEVELS OF SIMULATION

TYPE	CHARACTERISTICS/USE
INTERACTIVE	<ul style="list-style-type: none"> • GOOD FOR INITIAL DESIGN CHECKOUT OR TROUBLE SHOOTING. • POOR FOR COMPREHENSIVE VERIFICATION. • POOR REPRODUCIBILITY.
HAND-CODED VECTOR	<ul style="list-style-type: none"> • ALLOWS SIMULATOR TO CHECK EXPECTED RESULTS. CAN BE RERUN AFTER CHANGES AS A REGRESSION TEST. • CAN BE USED AS PART OF PRODUCTION TEST. • RELIES ON DESIGNER INGENUITY TO COVER ALL TEST CASES. CAN OVERLOOK SYSTEM-LEVEL PROBLEMS.
SYSTEM-LEVEL	<ul style="list-style-type: none"> • EXERCISES CHIP IN SYSTEM ENVIRONMENT. • GIVES HIGHEST DEGREE ON CONFIDENCE. • CONVERGES MICROCODE/SOFTWARE AND HARDWARE VERIFICATION. • CAN EXTRACT RESPONSES FOR PRODUCTION TEST.

Two types of compiler vendors exist: those offering generic tools and those offering tools specific to their own foundries.

Static timing analyzers first characterize the delay from input transitions at each gate to the output transition at the gate's loads. They then trace the paths through the circuit, adding up the delays as they go. The most powerful form of analysis traces paths from their origin in a clocked element to their termination in a clocked element. In a synchronous system, this analysis identifies the critical paths limiting clock speed.

The static-analysis tool's obvious benefit is that it tells you about timing paths you may not have realized were slow. Other capabilities of a sophisticated static tool include incorporating external setup and hold requirements, checking margins on internal hold times, and the ability to specify timing paths to be ignored. Genesil also has the ability to automatically extract a Spice model of a specified path to allow more exact timing simulation where desired. The accuracy of a static timing analyzer depends on the sophistication of its models of transistor characteristics and resistive and capacitive loading. Static timing analyzers better suit synchronous circuits than asynchronous ones.

You can use both timing tools to observe the effects of temperature, variations in voltage, and variations in the fabrication process.

The next step is to assure that the physical mask that the compiler produced accurately represents your design. To accomplish this task, compiler vendors provide various types of post-design checks. The most basic is the traditional design-rule check (DRC). The DRC program processes the mask's data against the physical design rules for the foundry you have selected, checking that trace width and spacing meet a minimum specified size and that the transistors are properly formed, for instance. This checking assures that the chip can be fabricated.

Checking the mask

You can make an additional check by programmatically extracting the circuit's topology (that is, by deriving the circuit elements and the net list that they implement from the mask). This extraction can further verify the physical design, either by direct comparison to the logic design you previously simulated or by simulation against the same stimulus/response vectors you previously used.

You may wonder why compilers need this type of post-verification; after all, they should automatically generate correct silicon. However, one of the benefits of a silicon compiler is that it facilitates large, complex chip designs, such as microprocessors. Designers de-

TABLE 2—PROTOTYPE FABRICATION STEPS

TASK	TIME	COST
FINAL VERIFICATION	2 TO 4 WEEKS	SEE NOTE
DATABASE CONVERSION	1 WEEK	\$2k TO 10k
PLOT APPROVAL	2 DAYS	—
MASK GENERATION	1 TO 2 WEEKS	\$30k TO 40k
WAFER FABRICATION	6 TO 10 WEEKS	\$1k TO 20k
ASSEMBLY	1 TO 2 WEEKS	—
PACKAGE PART TEST	1 TO 2 WEEKS	SEE NOTE

NOTE: PART OF BROKERAGE PACKAGE FROM COMPILER VENDOR.

mand rich sets of design elements, and vendors enhance their products for higher density and performance. The result is that as designers push beyond what has been done before, a possibility of generating bugs exists. Even a single error in a chip can cause a malfunction; therefore, post-verification is essential to ensuring correct silicon.

After verification, build prototypes

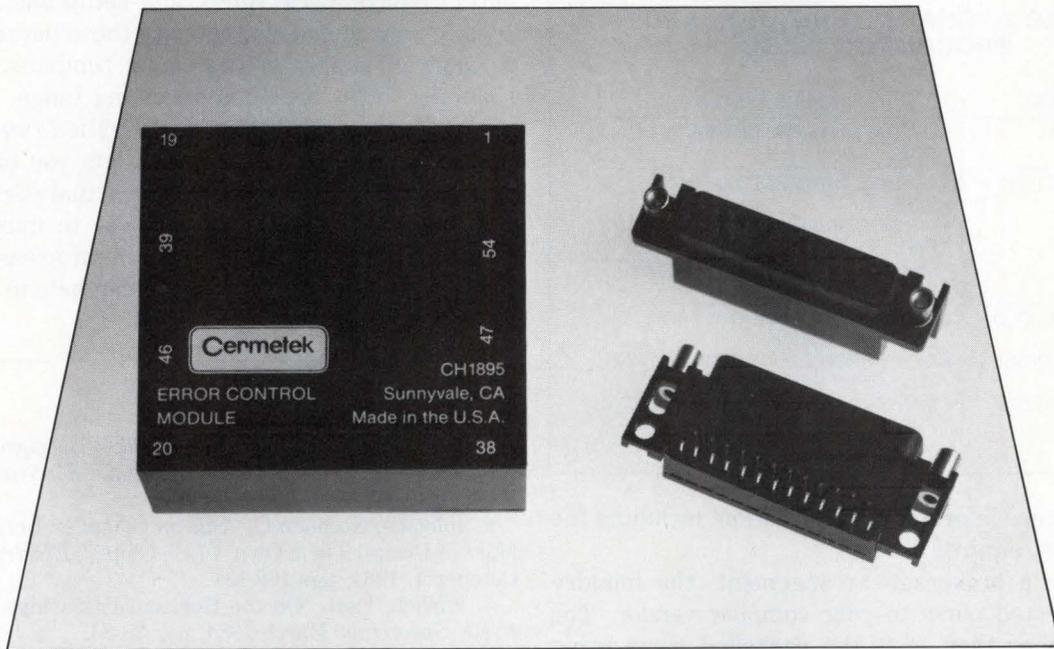
When your chip has completed final verification, you are ready to build prototypes. Several compiler vendors offer a brokerage service, for which they coordinate initial fabrication with the foundry and deliver the working parts to you. Seattle Silicon and Silicon Compiler Systems offer this service with guarantees of working parts.

To ensure a smooth path for your prototypes and to prepare for production, you need to begin a business relationship with your foundry well in advance of first silicon. This preparation can insure that the right resources and materials are in place when you need them. For example, if you specify a package type that the foundry does not stock, the lead time to procure it can be longer than the fabrication time.

Advance discussions can also clarify the time and charges for fabrication. The overall time and charges for getting tested parts are substantially more than for simply running a wafer lot. You need to make certain that you understand the steps in the process (**Table 2**). For example, starting from a database tape, the foundry converts database formats for the mask vendor and has the masks fabricated, inspected, and repaired before processing. After processing, the parts are assembled. You also need to allow time for testing, either at the foundry or at the compiler vendor. **Table 2** de-

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You may need to make some changes to your design approach, particularly if your experience is with board-level TTL.

TABLE 3—CHARACTERIZATION AND PRODUCTION TESTS

TYPE OF TEST	AREAS TESTED
FUNCTIONAL	<ul style="list-style-type: none"> • OVERALL LOGICAL INTEGRITY OF CHIP.
DC PARAMETRIC	<ul style="list-style-type: none"> • VOLTAGE THRESHOLD OF INPUT PINS. • VOLTAGE AND CURRENT OF OUTPUT PINS. • LEAKAGE CURRENT OF INPUT AND 3-STATE PINS.
AC—SETUP/HOLD	<ul style="list-style-type: none"> • CHIP INPUT SETUP/HOLD FROM EXTERNAL CLOCK
—OUTPUT DELAY	<ul style="list-style-type: none"> • DELAY FROM CLOCK OR INPUT PINS TO OUTPUT PINS.
—CYCLE TYPE	<ul style="list-style-type: none"> • MAXIMUM OPERATING FREQUENCY FOR CLOCK.

scribes the steps in prototype fabrication, including the time and cost required.

If you use a brokerage arrangement, the foundry delivers untested parts to your compiler vendor. The compiler vendor then tests the packaged parts using test vectors from your simulation runs. This test assures functional parts and provides some speed testing. The compiler vendor's involvement usually ends here.

You must still do substantial test development to put your parts into production. Production tests have three broad components: functional tests, dc tests, and ac tests (Table 3).

Functional tests find fabrication faults quickly. The vectors used for simulation during design verification may not be appropriate for production. Verification typically assumes that the logic elements are perfect and checks to determine if your design functions as intended. These tests can have poor fault coverage or can be excessive in length. One current weakness of silicon compilers is poor support for fault-grading tools with which you improve production tests.

Compilers support transporting simulation vectors to selected IC testers. (With Genesil, Tandem designers needed to develop a format converter for Sentry Schlumberger Inc and Ando Corp for production. Once this tool was in place, they captured vectors from system-level simulations and incorporated them into production tests. This tool proved to be very effective: The chips could be tested with the same stimuli that they would ultimately encounter in the system.)

Dc and ac tests check the chip against its data-sheet specifications. The dc tests include input-voltage thresholds, output voltage levels at specified currents,

and input and 3-state leakage currents. Ac tests include output delays, cycle times, and setup and hold times. Ideally, you should characterize these parameters over a range of supply voltages and temperatures corresponding to the specified operating range. Use a sampling of parts over different fabrication runs to include process variations. This testing lets you balance your system requirements against the actual performance of the chips and establish test limits to maximize your yield. It can also indicate problem areas requiring further attention. Your foundry can help in performing this characterization.

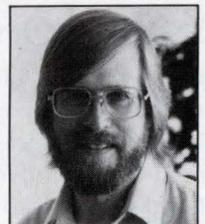
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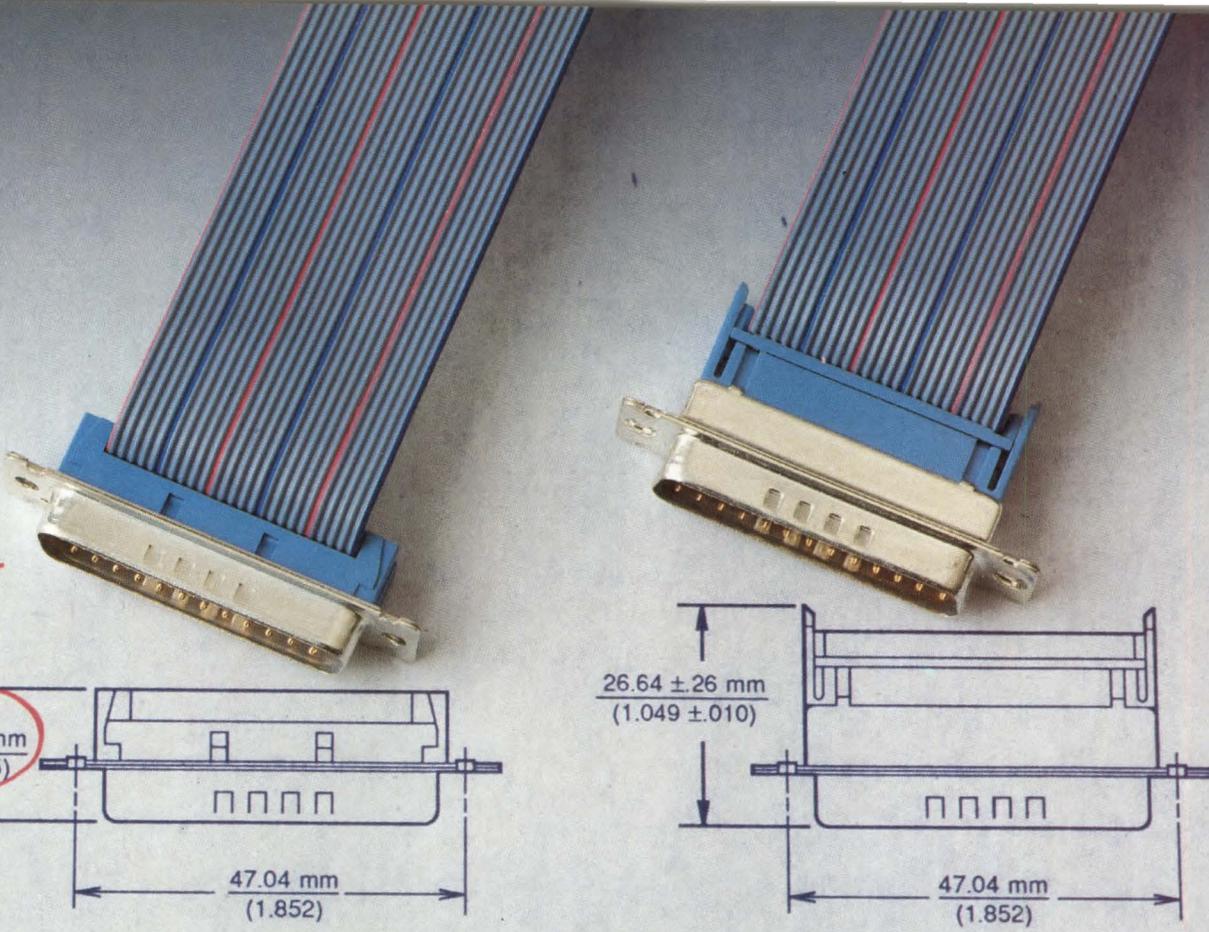
Author's biography

William Stenzel is a development engineering manager for Tandem Computers Inc (Cupertino, CA) and has been with the company for seven years. He is currently responsible for processor and memory development for distributed systems. Prior to Tandem, he spent five years with Hewlett-Packard, where his responsibilities included management of a custom CMOS processor project. He received his BS in Computer Engineering and MS in Computer Science from the University of Illinois.



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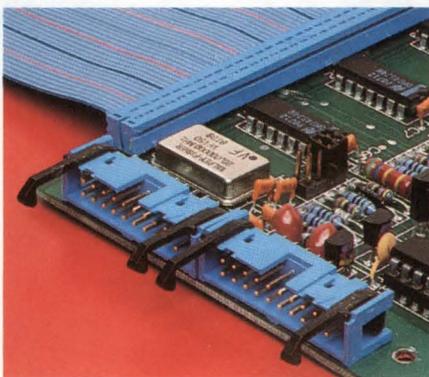
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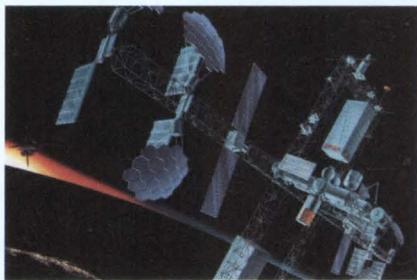
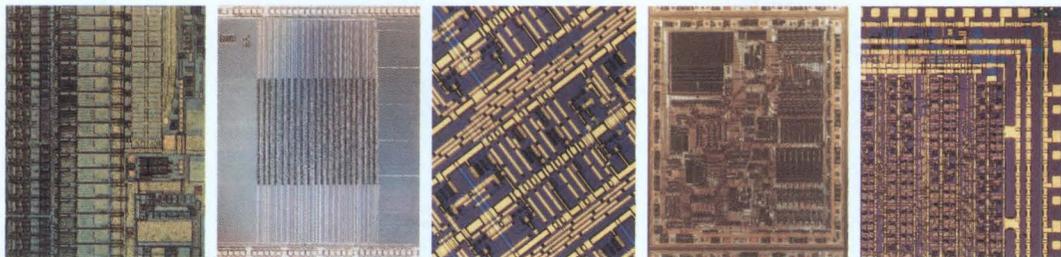
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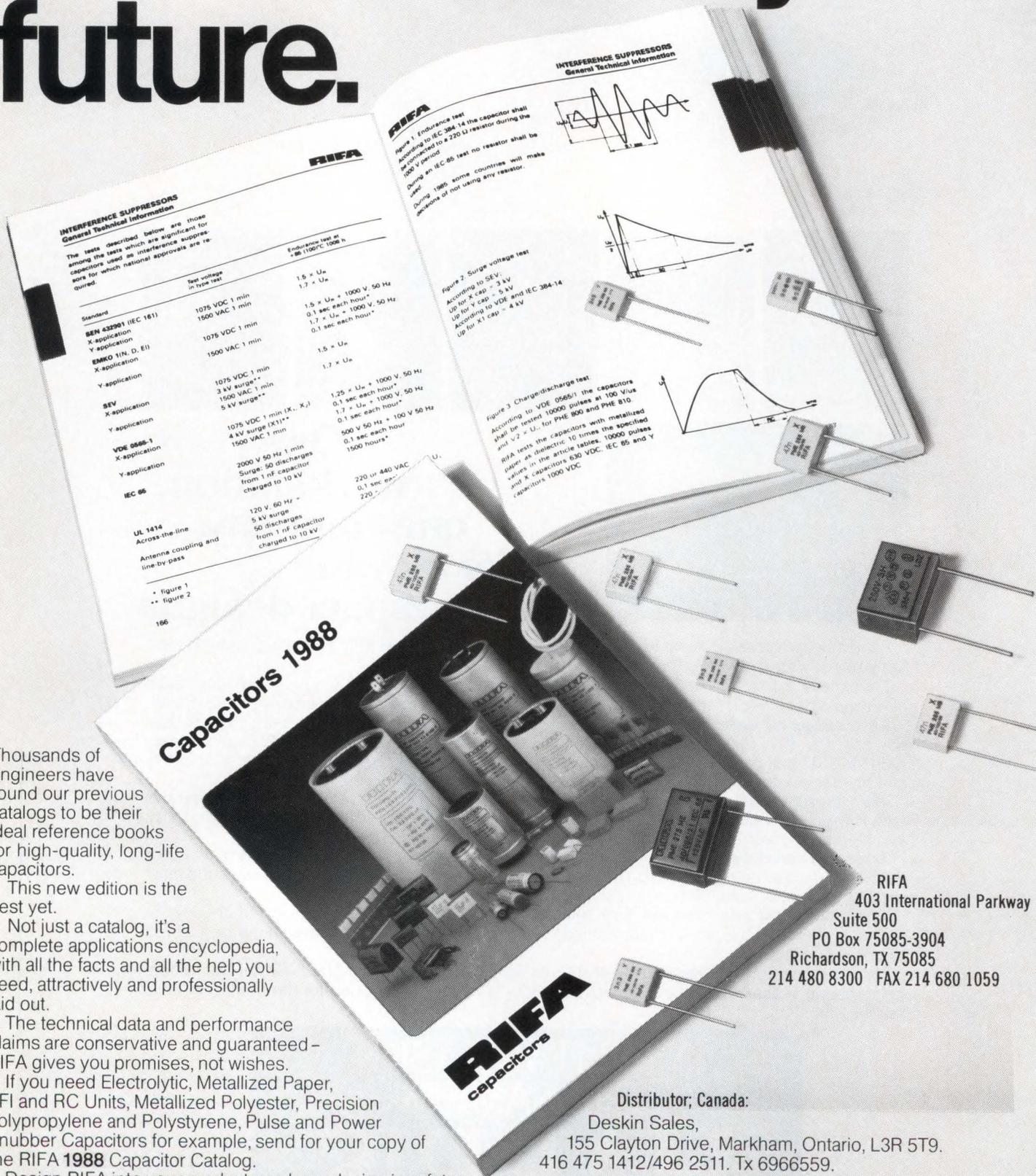
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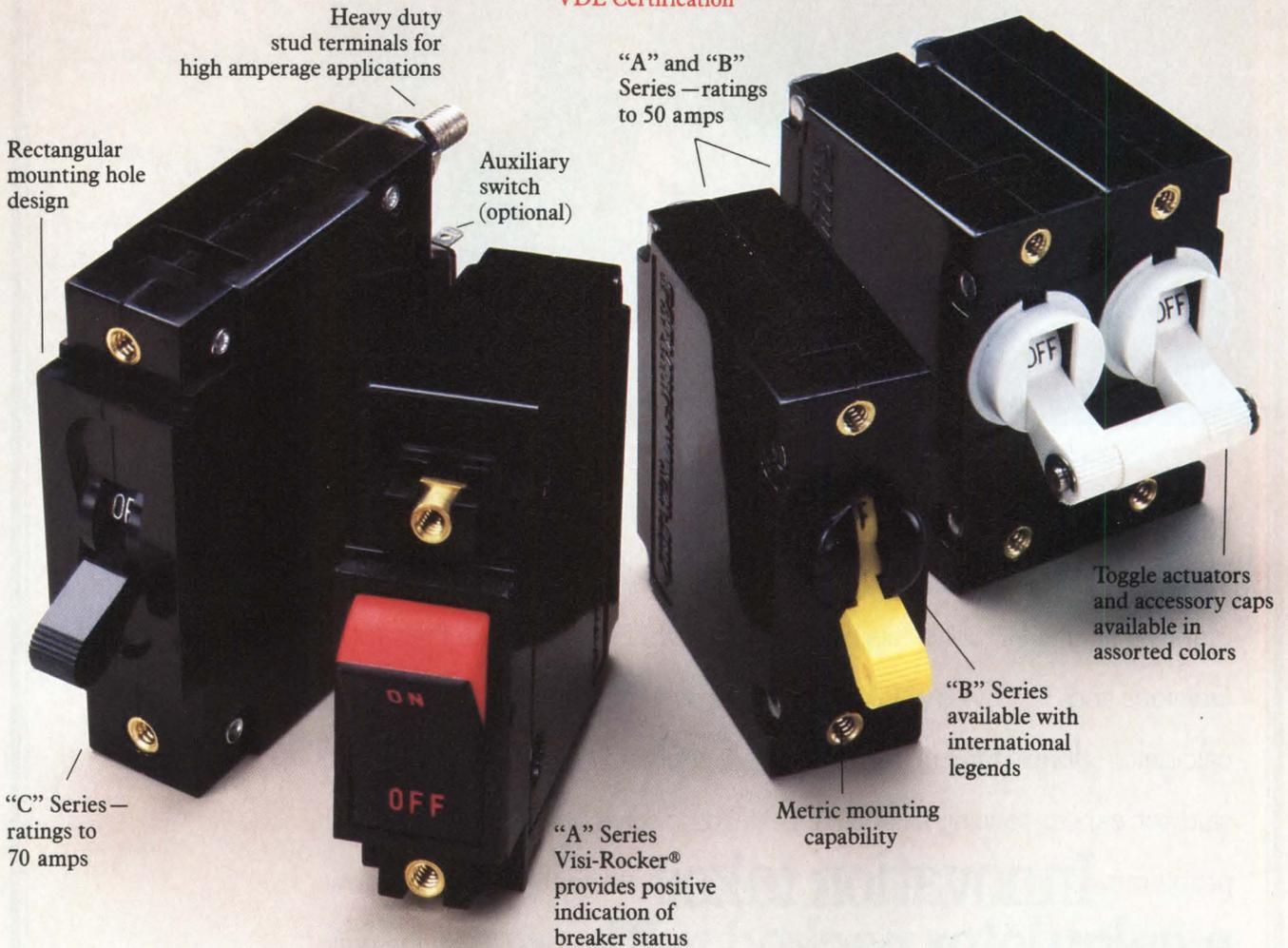
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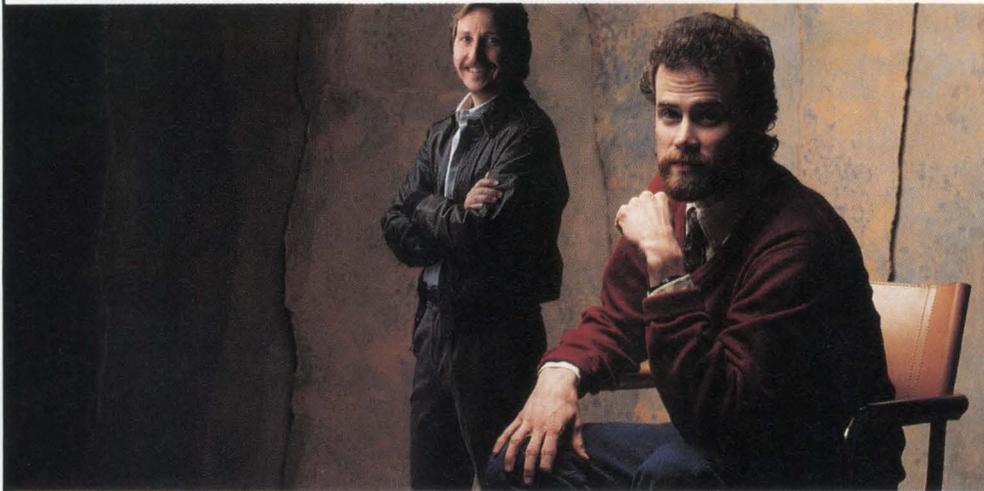
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Take care when choosing controllers for flat-panel displays

Emissive flat-panel displays are well suited for applications requiring ruggedness and minimum size and weight. To optimize overall system performance, you must select a controller that's right for the job, keeping in mind that a flat-panel display's control requirements are more stringent than are a CRT's.

Colin McManus, *Digital Electronics Corp*

Flat-panel displays can outperform traditional CRTs in many applications. However, integrating a flat-panel display into a system involves far more than simply choosing the display. Selecting the proper display controller is even more important when it comes to overall system performance.

Among the factors you must consider are the flat-panel displays' physical interface requirements. A flat-panel display has a discrete pixel matrix that imposes much more stringent timing requirements than do CRTs. You must also understand how to evaluate manufacturer's performance specs, what hardware configurations are available, and what levels of software support the display manufacturer provides. With all these factors in mind, you must carefully weigh trade-

offs between cost, integration time, and design-cycle time before committing to a specific controller.

The following discussion concentrates on emissive-type flat panel displays: electroluminescent (EL), plasma, or vacuum fluorescent. Although light-emitting properties vary among these display technologies, the technologies all have similar control principles. To help you understand the terms used to describe display interfaces, consider first the components of a typical display/controller subsystem.

The display itself is the piece of glass containing the basic light-emitting elements—electroluminescent film or neon-gas cells, for example. The drive electronics, which connects directly to the display, consists of basic signal-timing circuits and high-voltage interfaces. Functionally, the drivers take a fairly conventional set of video signals and transform them into the high-voltage pulses required to operate an emissive-type flat-panel display. Normally, display manufacturers sell the display and the drive electronics bundled together.

A display controller—such as the familiar CRT controller—is a circuit that takes data (such as ASCII characters) from a host computer and transforms them into video signals. Although similar in function, flat-panel-display controllers differ from CRT controllers with respect to the video-interface and timing signals that the respective devices generate.

Even among flat-panel displays, drive-signal requirements vary widely. However, some operating principles remain consistent for most drive circuits. For

Although input-signal requirements vary for different display technologies, some operating principles are consistent for most drive circuits.

example, two orthogonal sets of electrodes—the row and column electrodes—typically form the display matrix. The display medium separates these electrode sets: The column electrodes are typically on the front of the display, and the row electrodes are on the back. Each picture element (pixel) forms at the junction of a row and column electrode. The pixel emits light only if both these electrodes are activated.

A picture builds up row by row just as in a CRT. The row electrodes sequentially activate one at a time. During each row period, the column electrodes corresponding to the pixel in that row turn on. Therefore, while a CRT activates one pixel at a time, the flat panel display shows a row at a time.

The drive electronics consists of three elements—the row drivers, the column drivers, and the timing and control circuits (Fig 1). The row and column drivers act as the high-voltage interface circuits. The row and column drivers each contain a shift register; the column drivers also include a buffer latch. Connected together, the row drivers form a long shift register with one output set high and all others set low. Each horizontal-sync input pulse shifts the active output by one.

The column drivers also form a long shift register. In this case, however, the registers contain pixel data for the next row. When a row is complete, the horizontal-sync pulse transfers the shift-register data to the buffer latches, which are connected directly to the high-voltage outputs. During this transfer, the row drivers activate a new row.

The timing and control circuit produces the actual signals for the drivers. In addition, it acts as a safety check by blanking the display if the input video-sync signals do not fall within their proper frequency range, and it also controls power-saving functions.

Establishing contact with the timing circuit

The user interface to this timing circuit is of most concern here. Generally, the interface consists of four signals—video data, video clock, horizontal sync, and vertical sync.

Horizontal-sync frequencies typically vary from 15.6 kHz for a 512×256-pixel array to 25.6 kHz for a 640×400-pixel matrix. Usually, video-clock rates are higher than the value necessary to support horizontal sync—as high as 15 MHz for the smaller displays and 20

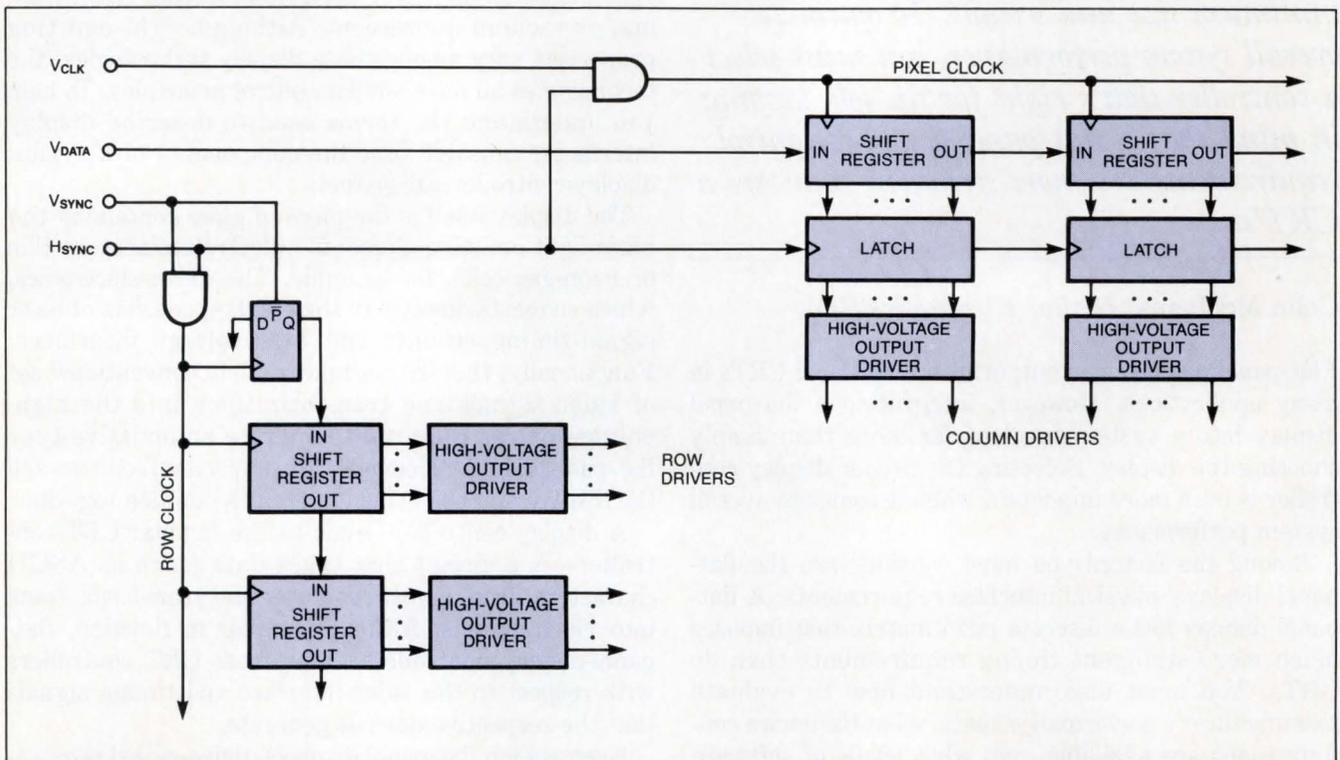


Fig 1—A flat-panel display's drive electronics typically includes three elements: row drivers, column drivers, and timing and control circuits.

MHz or more for larger displays. This parameter is critical because some display controllers cannot write new data into the display memory during the image-refresh period. These controllers can only write new data during a period that corresponds to a CRT's retrace time.

At first glance, you might assume that you can use a CRT controller to drive a flat-panel display. However, input-signal requirements are much tighter for flat-panel displays, and the flat-panel display's input signals must contain more information. Two basic display-surface phenomena come into play here: The flat panel has a discrete pixel matrix while the CRT has a continuous display surface, and the flat-panel display has no border around the edge, as does a CRT.

The flat panel's discrete pixel matrix requires the controller to sample the incoming video data instead of transferring it continuously to the screen. To recognize a valid sample, the input circuit needs a video-clock signal that has a specific relationship to the data.

Because the flat panel has no edge border, controller circuitry must know precisely when blanking ends and starts—when video data is good, in other words. To satisfy this requirement, flat-panel controllers often use a blanking-control signal rather than the HSYNC signal typically found in CRT controllers.

Consequently, it's difficult to drive a flat-panel display with a controller designed for a CRT, and the results are usually disappointing. Nevertheless, two control schemes are often attempted. One technique brings out the video-clock signal and modifies the HSYNC and VSYNC signals as necessary. However, you would find this approach a difficult one to implement unless you have a thorough working knowledge of the controller circuit and access to schematics and timing diagrams. At best, this approach might yield a working prototype but not a product that's suitable for production.

In the second approach, designers employ circuitry that accepts the output signals of the CRT controller and converts them to drive the flat panel. On the surface, this task seems simple enough, but the scheme has basic problems that stem from the fact that there is not enough information implicit in the CRT signals.

Specifically, there are three issues—matrix size, video-clock generation, and regeneration of the front- and back-porch timing signals. The controller's inherent image matrix size must match that of the flat-panel display exactly. This matching is easy enough for PC-based controllers because most of the common

matrix sizes for flat-panel displays are geared to PC-display standards.

When it comes to the video clock, it's a simple matter to use a PLL to produce a signal that has the right frequency. However, it is not so easy to define and maintain the right phase relationship with the video data. Because this clock latches the data into the driver shift registers, its active edge must occur while the data signal is stable. CRT controllers provide a horizontal-sync pulse for synchronization purposes. Unfortunately, its exact phase relationship to the data stream isn't controlled because CRTs have no need for phase-relationship data.

You can compensate for this shortcoming by designing a manual phase adjustment into the clock circuit. The clock signal itself must be very stable, however, because any frequency variations cause the image pixels to flutter. Such stability is difficult to attain because the synchronizing signal for the PLL (the horizontal-sync signal) is $\frac{1}{640}$ times the output clock signal.

Finally, there's the question of front- and back-porch timing-signal regeneration. For CRTs, small changes are not noticeable because of the border of unused display area around the image. For a CRT, changes in porch timing simply move the image by small amounts left or right. A flat-panel display has no such border, however, so data shifted past the edge disappears. Consequently, for a flat-panel display, a shift of only one pixel to the left may make the leading characters on each line unreadable.

With a PC-based controller, the application program running at the time sets the exact porch size. Although most applications-program writers follow the standard IBM guidelines for the porch settings, there is no way to guarantee what the exact value will be. Porch-size values also change depending on the operating mode—text or graphics. Consequently, you might have to make a manual adjustment every time the video controller switches from text to graphics mode.

The alternative, and by far the most satisfactory approach, is to design or buy a controller specifically tailored for flat-panel displays. Enigmatically, this controller circuit can employ a CRT-controller chip because the CRT chips do in fact generate all the required timing signals. The video-clock-phase and porch-timing problems just detailed arise because the required signals are not available at the output of a complete CRT-controller circuit board.

The **box**, "Examples illustrate interfacing details,"

Because a flat-panel display has a discrete pixel matrix, the controller must sample the incoming video data rather than transfer it directly to the screen.

discusses how the necessary signals for a particular flat-panel display can be derived from a CRT controller chip. Over the years, various flat-panel displays' interface-signal requirements have differed in many aspects. However, you can now find more similarities. For

example, panel manufacturers are starting to loosen the timing and parameter specifications. Planar (Beaverton, OR), for instance, is providing programmable back-porch delay times on its recently introduced 640×400-pixel display.

Examples illustrate interfacing details

Signal requirements vary among flat-panel displays. For example, the Planar 512×256 EL display's interface includes four active signals: video data (VID), video clock (VCLK), horizontal or row synch (HS), and vertical or frame sync (VS). These signals are supported by three mode inputs: video-signal polarity (VIDPOL), video-clock polarity (VCLKPOL), and video input-mode select (DATASEL).

The polarity inputs, when high, ensure that a logic 1 indicates a lit pixel on video data and that the clock's falling edge latches data.

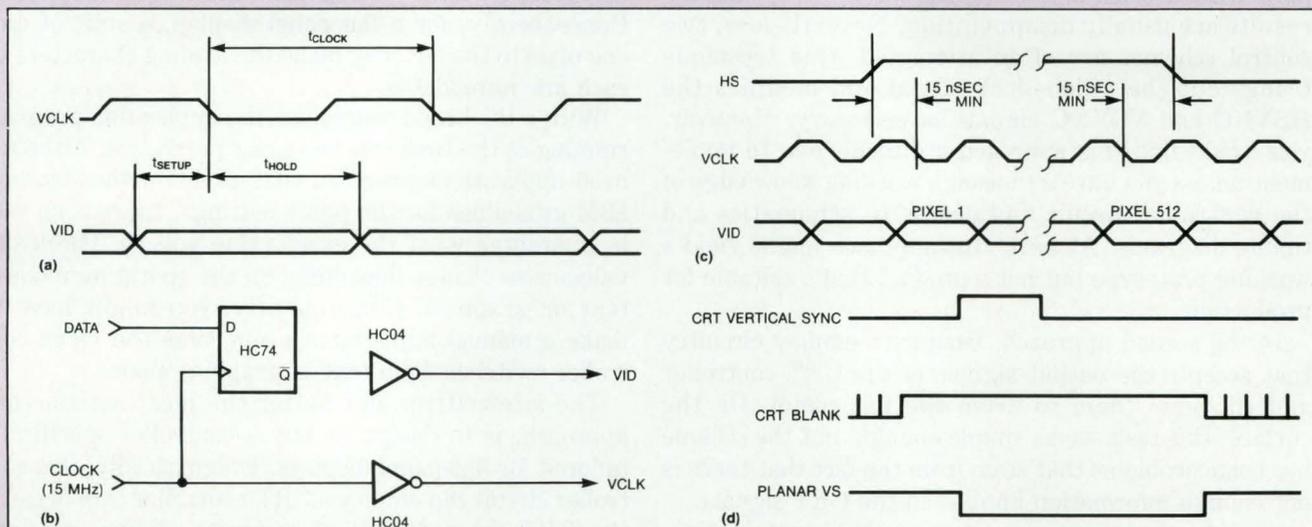
The input mode-select signal

determines whether the video data will be sent on one line or two. For the 2-line mode, two adjacent pixels are sent as a pair each clock cycle. This mode effectively halves the frequency and thus can reduce EMI problems. The following discussion, however, assumes the single data-line mode.

First, the video clock signal latches data into a shift register, so the data must satisfy minimum setup and hold times: 20 nsec each with respect to the falling clock edge for the display's default modes. At a 15-MHz clock frequency, the cycle time, t_{CLK} , is only 66 nsec.

Unlike a CRT's corresponding horizontal-sync signal, the flat-panel display's HS signal must also indicate when data is valid. Each display line consists of 512 bits of valid picture data, and HS must go high at the beginning of the first valid data bit and go low at the end of the last valid data bit. Thus, this signal is more like a CRT's blanking signal than a horizontal-sync signal, and in fact the blanking signal can be used for HS, although it must pass through a synchronization stage at the controller's output, as the video data does.

VS is similar to a CRT's vertical-sync signal, but VS must in-



Timing for flat-panel displays differs from that for CRTs. A Planar display, for example, requires that data satisfy setup and hold times (a), which can be ensured by device propagation delays in a synchronizing circuit (b). The HS signal also must meet stringent timing requirements (c). VS can be derived from CRT-controller signals (d) and must meet HS/VS edge-timing requirements (e); a simple circuit suffices for VS generation (f). For an NEC display, timing requirements differ somewhat (g).

Fig 2 illustrates a typical flat-panel-controller output stage. This output stage can drive all popular sizes of EL displays as well as many plasma models. The circuit can readily control displays from Planar, Sharp (Paramus, NJ), GTE (Greenland, NH), Sigmatron-Nova

(Thousand Oaks, CA), Finlux (Cupertino, CA) and World Products (distributor for NEC, Sonoma, CA).

In general, display controllers fit into one of two categories—dumb controllers and smart controllers. Performance and architecture, overhead requirements,

indicate when the first line of valid data occurs.

Control of the Planar display also requires care in setting line-count parameters. The display must receive 260 HS pulses, requiring that—if a blanking signal is used for HS—the controller chip's active-line parameter be set to 260 instead of 256.

(Only the first 256 lines will be displayed, so it's not important what data reside on the last four lines. Note too that lines beyond 260 are not only not necessary—they may cause the display to flicker.) In addition, the duration of VS should be kept short—to no more than three or four

HS periods.

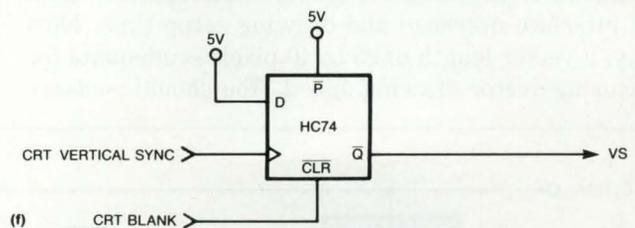
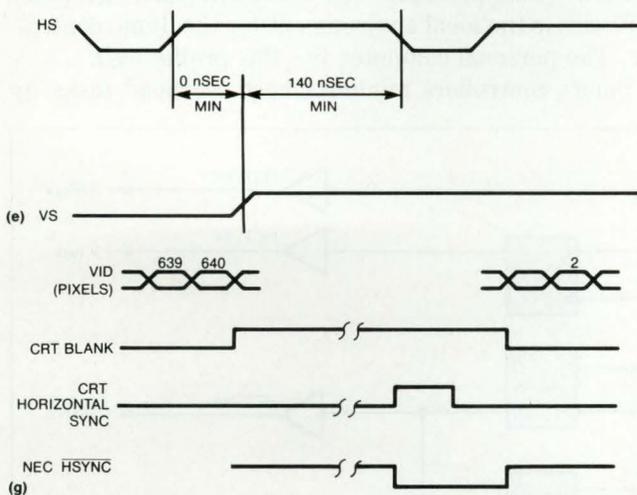
Timing requirements differ somewhat for the NEC 640×400 Model PD640G400CA-100A display. It lacks the Planar display's mode lines but adds a brightness-control line.

The NEC unit's $\overline{\text{HSYNC}}$ signal indicates an end of a row, as does the Planar unit's HS signal, but $\overline{\text{HSYNC}}$ also affects brightness: When low the display is blanked, so for maximum brightness $\overline{\text{HSYNC}}$'s low state should be kept as short as possible.

In addition, although the leading and trailing edges of Planar's HS define the end and beginning of valid data, only the trailing

edge of $\overline{\text{HSYNC}}$ is critical (it defines the start of valid data), so the leading edge can be delayed after the end of valid data. For best results with the NEC display, a CRT controller chip's parameters should be set so that horizontal retrace or blanking time consists of a long front porch followed by a short sync pulse and back porch.

The NEC display's brightness input is driven by an on-time duty-cycle controller; the input is a variable-length pulse signal that's synchronized with $\overline{\text{HSYNC}}$. Feeding $\overline{\text{HSYNC}}$ into a one-shot can generate the brightness input.



In general, display controllers fit into one of two categories—dumb controllers and smart controllers.

and ease of application are the main factors that define these categories.

Many designers rely on drawing-performance specs to evaluate display controllers. It's very difficult to compare these speed parameters on an apples-to-apples basis because vendors usually measure and report performance differently. For example, there are three popular measures of performance—pixels per second, vectors per second, and text characters per second.

Although the pixel/sec parameter is commonly used to specify performance, it is probably the most misleading because pixels are not written continuously but in bursts. Unless a system can continuously write pixels at the specified pixel/sec rate, the average number of pixels per second will be much lower than the burst rate. Manufacturers often publish the burst rate rather than the more important average rate.

The drawing operation itself also greatly influences pixel rate. For example, a simple block-fill operation can run at a much higher pixel rate than a vector-drawing routine. You can write as many as 16 or 32 pixels in a single cycle for a block-fill operation while you have to individually write each pixel for a vector-draw operation. Obviously, it's important to know the relationship between the published pixel/sec rate and the drawing operation.

A system's vector/sec drawing capability is a much better measure of overall performance. This parameter is much more meaningful because it incorporates both host-interface overhead and drawing setup time. Normally, a vector length of 25 to 40 pixels is adequate for measuring vector drawing speed. You should measure

performance by continually sending instructions for at least several seconds and then calculating the average time it takes to draw one vector. It's important to use random vectors here to maximize the setup overhead—using the time it takes to draw a single vector is not a valid measure of performance.

The text-character/sec spec is also a useful parameter for evaluating and comparing text-display speeds. As with vectors, it's important to consider the average speed over a time period rather than the time it takes to display a single character.

Architectures aren't all the same

With a dumb controller, the host has to do all of the display processing. A typical unit consists of a 2-port video memory, an automatic refresh controller that continuously cycles through the video memory and sends data to the display, and logic circuitry that generates the four display-control signals. The refresh controller can only read the video memory; the host has to draw all the figures and graphics in the video memory. Most popular graphics boards available for personal computers are examples of dumb controllers.

Because the host must generate the display image, a dumb controller places a considerable burden on the host. You can use a character-generator ROM to generate text easily, but it is much more difficult to generate graphics. An application involving a powerful, lightly burdened host processor and readily available graphics software is the ideal environment for the dumb controller. The personal computer fits this profile well.

Smart controllers minimize host overhead tasks by

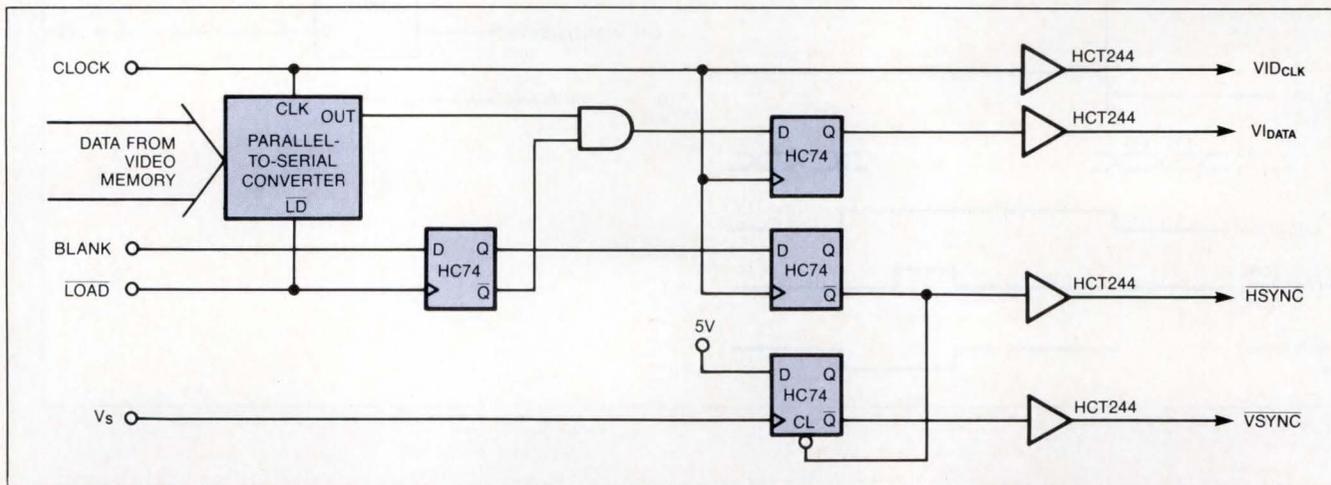


Fig 2—Flexibility is a key feature of today's flat-panel controllers. This output stage, for example, can drive all popular sizes of EL displays as well as many plasma-type devices.

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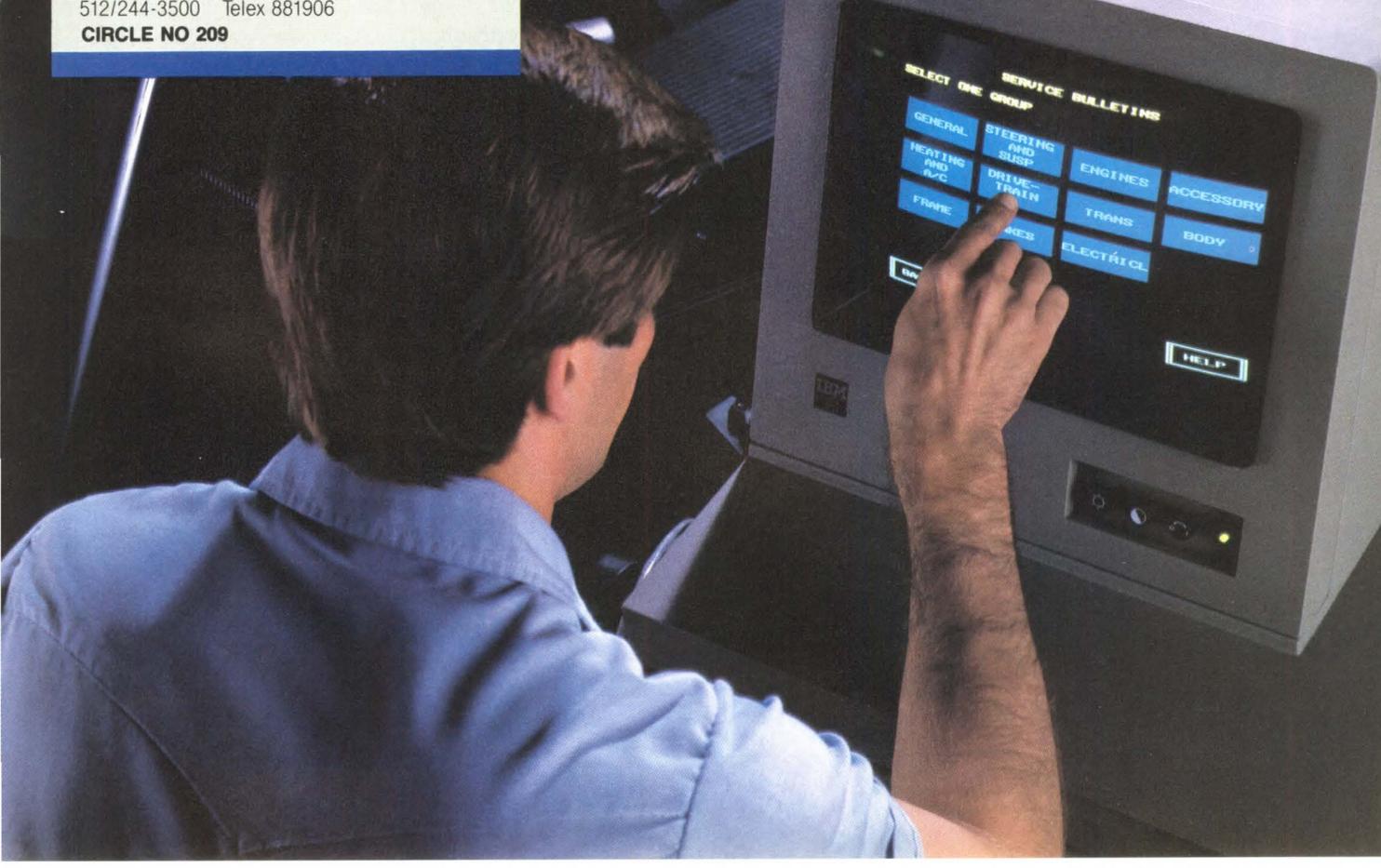
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Smart controllers minimize host overhead tasks by providing local intelligence at the display-control level.

providing local intelligence at the display-control level. There are two popular architectures.

There's smart and then there's smart

Low-end smart controllers consist of a general-purpose microcontroller coupled with a dumb refresh unit and video memory. You can program this typical low-end controller with a limited set of drawing algorithms that reside in its program memory. Such a controller might include simple algorithms for drawing lines, circles, rectangles, and so on. Although this low-end smart controller does ease the host's overhead burden, it must still implement all the drawing algorithms in software and also handle all communications with the host. As a result, the microcontroller's speed limits display performance. The block diagram in Fig 3 illustrates a typical low-end smart controller.

The high-end smart controller couples a general-purpose processor and a specialized drawing processor into a pipelined architecture to achieve high-speed performance. Using this approach, the controller can execute the three main program sections of the DDA (digital differential analyzer), a commonly used vector-drawing algorithm, simultaneously. The drawing processor computes the coordinates of the next pixel while the previous pixel is being written into memory. In parallel, the general-purpose processor handles the setup for the next figure. Tasks are done in parallel; while the DDA processor is calculating the next bit location to modify, the memory-control interface is performing a read-modify-write operation for the cur-

rent one. In contrast, a low-end smart controller system only modifies the video memory once each time the microprocessor goes through the algorithm's loop.

The block diagram in Fig 4 exemplifies a high-end smart controller. Note that one of the two processors is dedicated to I/O control and display-list processing. It communicates with the host via a serial or parallel interface. The host communicates to the controller via a high-level ASCII-based command set. The graphics processor provides parallel display processing and control functions.

Don't overlook software-support considerations

Design-cycle time is an important consideration when choosing a flat-panel-display system for any application. Design cycle time for product introductions is often short given today's market demands and competitive pressures. Because the development effort for custom software can easily exceed one man-year, it's important for designers to seriously consider the trade-offs between custom display systems and off-the-shelf systems.

Although a dumb controller usually minimizes system hardware costs, it can also extend design cycle time because it lacks a high-level command set and other features. In addition, it burdens the host with display-control tasks. Smart controllers can significantly reduce design-cycle time while simultaneously maximizing the level of overall system performance.

When evaluating either low- or high-end smart controllers, it's important to look for built-in terminal-

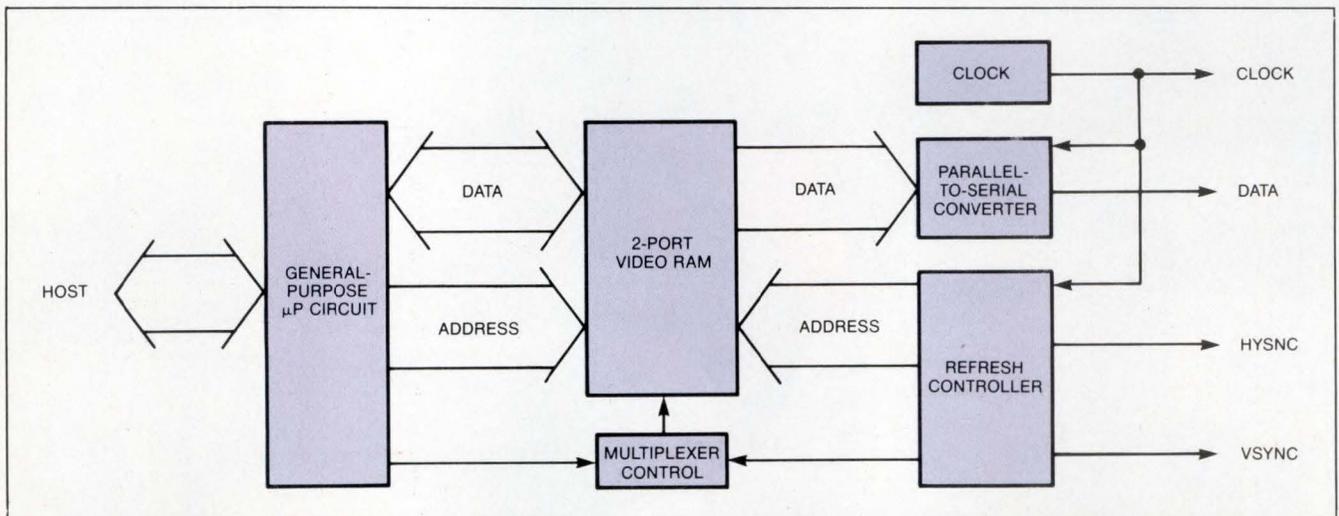


Fig 3—Although this low-end smart controller eases host-overhead tasks, it must still implement all the drawing algorithms in software and handle all communications with the host.



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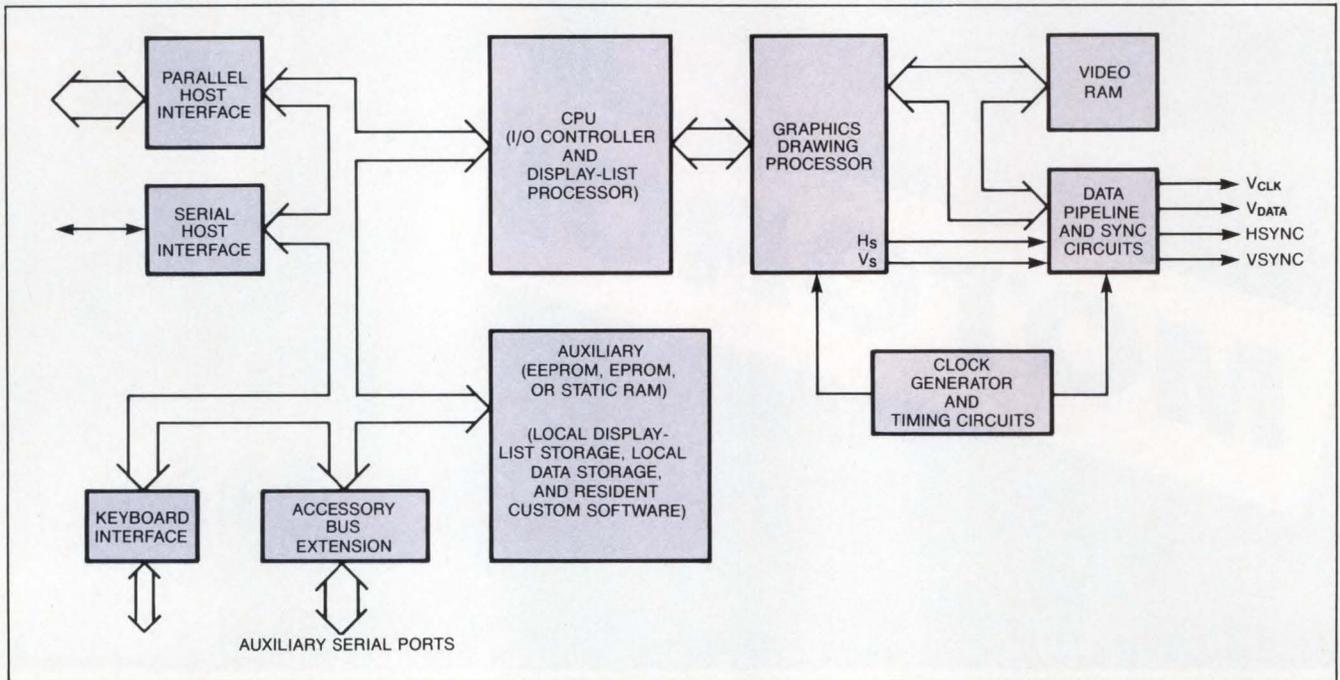


Fig 4—High-end smart controllers typically employ a dual-processor design. One processor controls all I/O tasks while the second provides parallel display processing and control functions.

emulation capabilities, a high-level graphics and display-control command set, and other special features. Standard terminal-emulation capability allows you to easily interface the display and controller to existing applications routines.

A high-level graphics and display-control command set is essential for developing and revising applications quickly and cost effectively. In addition to graphics primitives (such as vector, arc, and circle) and operations (such as fill), the controller should provide window and clipping operations and DMA operations to video memory.

The ability to locally store frequently used, host-accessible frames (display lists) is another important feature to look for in a smart controller. Storing display frames locally removes a significant burden from the host because it negates the need to transfer the display list for the frame—the host merely sends to the controller a single command that indicates which frame to display. The controller then locates the display list in its local memory and uses it to generate the display.

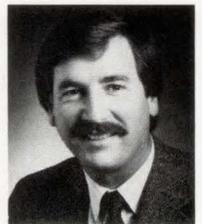
There are a few other issues to consider when evaluating smart controllers. There's the interface question, for example. Does the controller offer standard serial and parallel ports for fast and easy connection to the host system? Can you use all of the ports simultaneous-

ly? If operator input comes in whole or in part from a keyboard, you must consider whether the controller offers a straightforward keyboard interface. Flat-panel display applications often call for a touchscreen interface, so you should consider whether the controller supports touchscreen input.

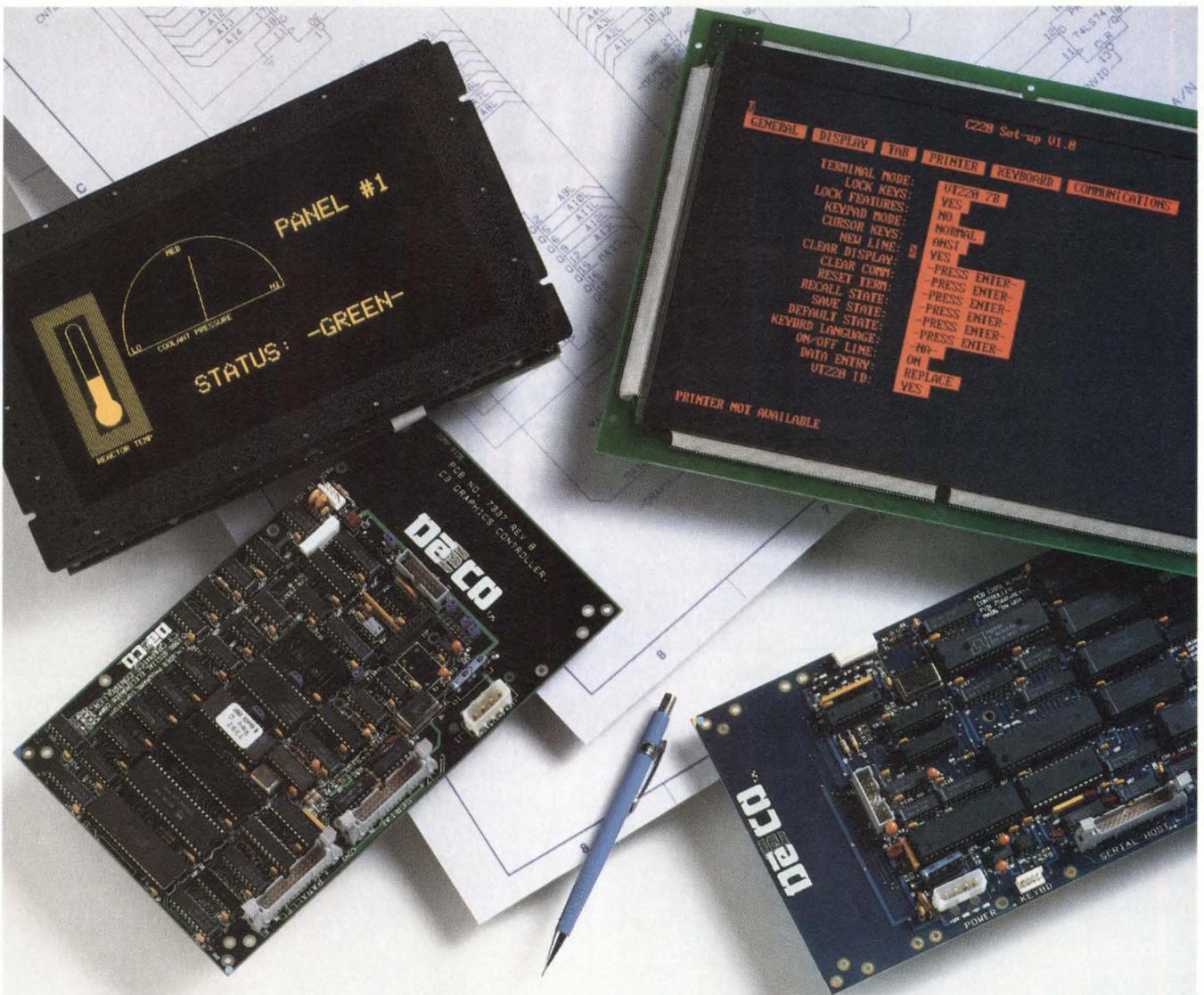
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Author's biography

Colin McManus is vice president of engineering at Digital Electronics Corp (Hayward, CA). With the company five years, he was previously employed at Humphery Instruments. Colin holds BSEE and MSEE degrees from Queens University in Belfast, Ireland. While four children take up a good deal of his spare time, Colin busies himself with carpentry projects and reading history when time is available.



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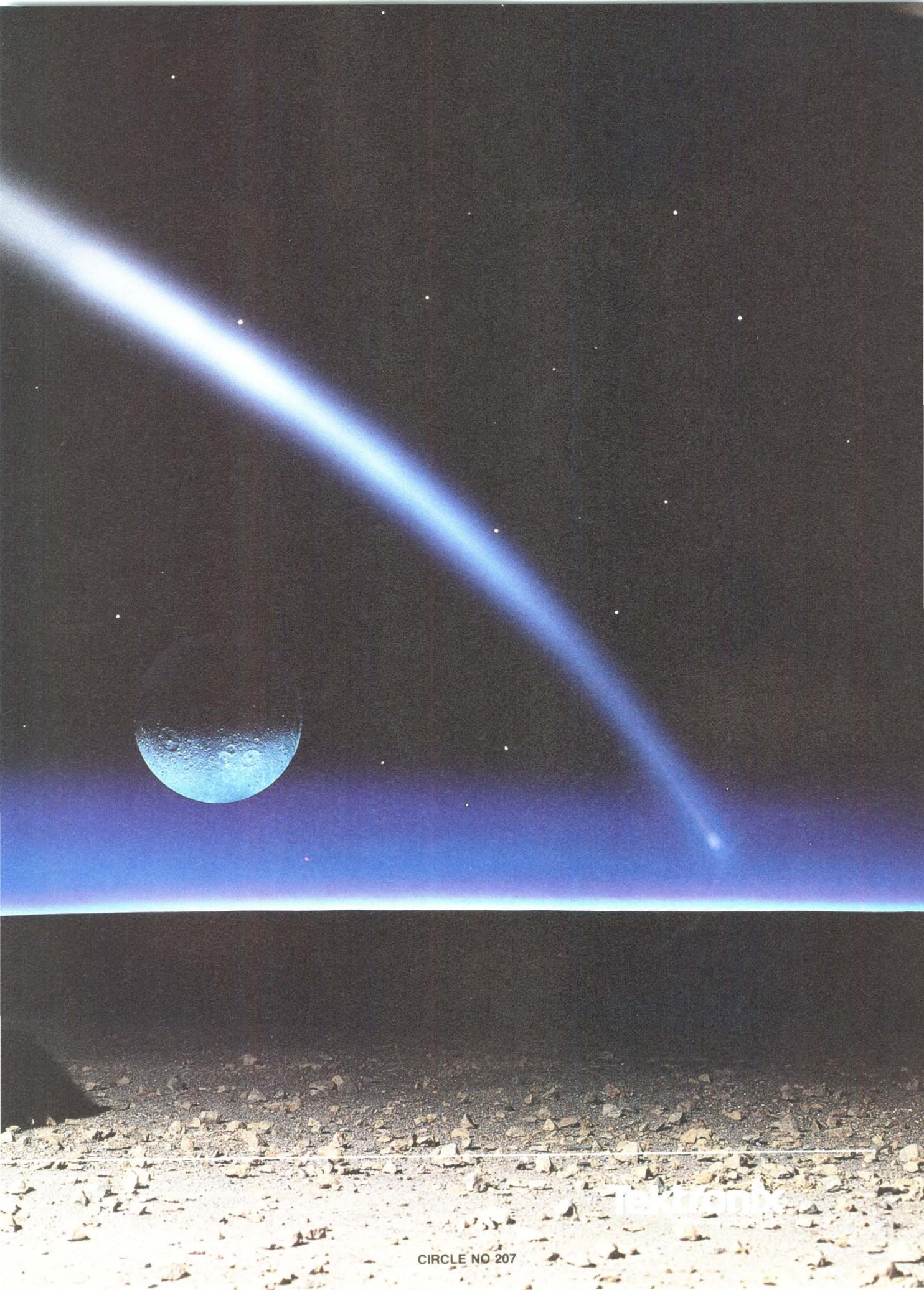
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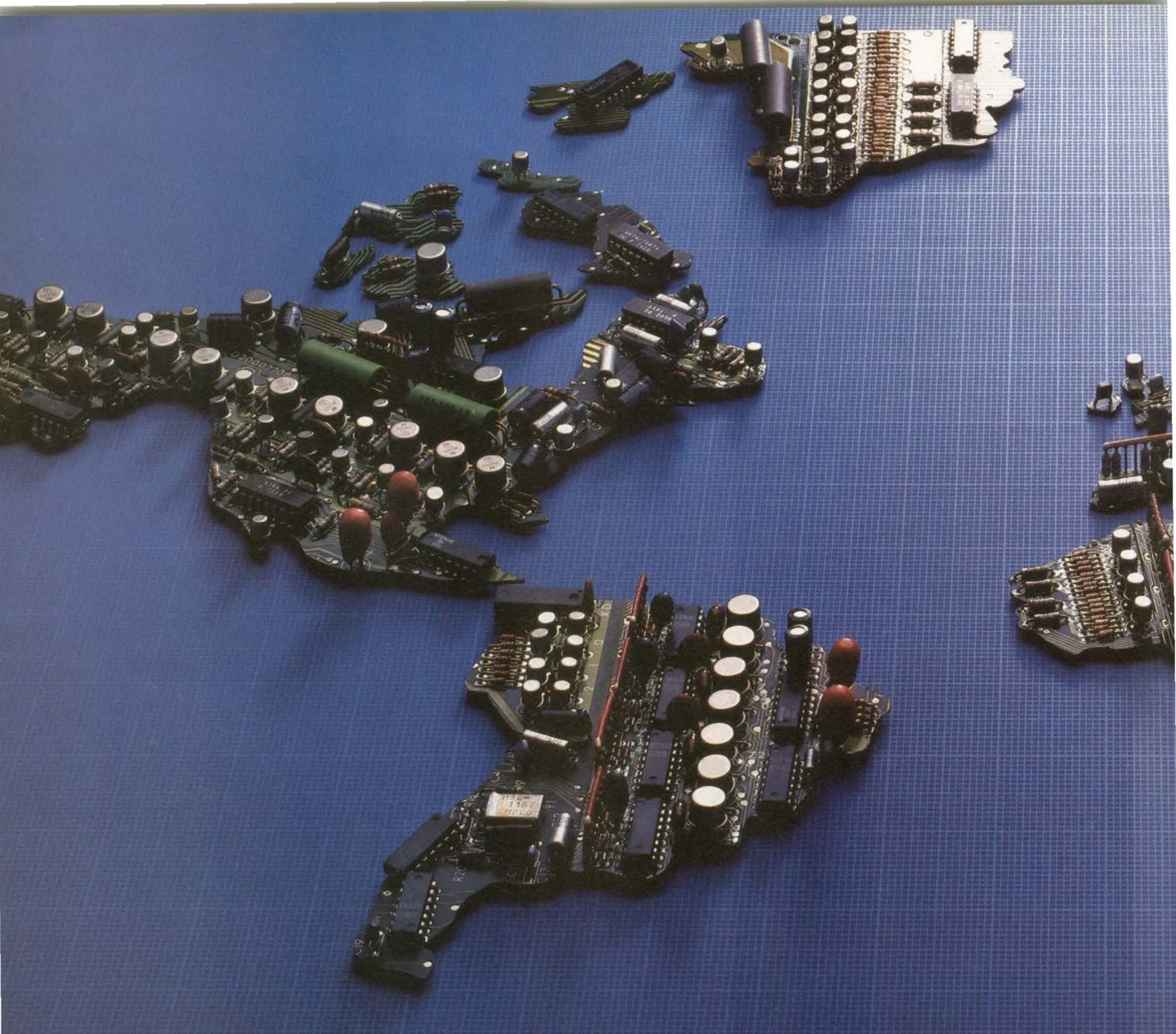
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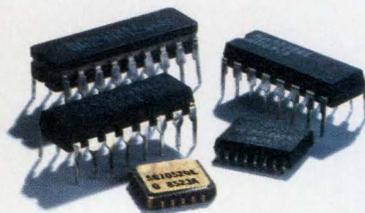
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Mini dc/dc supplies simplify redundancy in parallel systems

You can significantly increase the reliability of an uninterruptible power supply (UPS) by connecting dc/dc converters in parallel to implement redundancy. Miniature, on-card dc/dc converters make it possible to design parallel-redundant systems that offer higher efficiency than that attainable from conventional UPS designs.

Lars Thorsell, Rifa Power Products

A source of uninterrupted power is increasingly becoming a requirement for computing systems. A total or even partial power failure, and the subsequent loss of data, can be catastrophic for many applications. In such applications, you must address the problem of fault tolerance in your equipment design. Many of these critical applications rely on uninterruptible power supplies (UPS) to satisfy the requirement of continuous operation. Miniature, on-card dc/dc converters, connected in parallel, provide a highly reliable, redundant power-distribution system.

Conventional UPS systems, on which many of these critical applications rely, suffer from the reliability limitations of their internal electronic circuitry. You can increase the reliability of a power-distribution system

by introducing parallel redundancy. In many situations, however, this solution introduces new difficulties of thermal management, size, efficiency, and cost. Miniature dc/dc converters make it possible to design UPS systems that exhibit efficiencies as high as 65%, as compared with the 40% that's typical of conventional UPS systems that use parallel redundancy. Before exploring these efficient UPS designs, it might be useful to gain some insight into the design of a conventional UPS system.

Conventional UPS has shortcomings

A conventional UPS (**Fig 1**) consists of an ac/dc rectifier that also serves as a battery charger; a battery, and a dc/ac inverter. An on-line UPS (**a**) operates continuously and provides a power-line conditioning filter as well as battery back-up. A standby UPS (**b**) has a bypass switch that switches in the UPS only when a line failure occurs. The start-up time of a standby UPS is usually shorter than the hold-up time of the principal supply in the equipment, so no power interruption occurs during the switchover.

Although a conventional UPS solves problems related to interruptions or bad conditions in the main ac power line, it cannot deal with faults that occur in the power-conversion circuits. The overall power system requires a dc/ac converter after the battery in the UPS, followed by an ac/dc supply in the equipment (**Fig 2**). This dual conversion process is the weakest link in the overall power system because of the electrolytic filter

Although a conventional UPS solves problems related to the main ac line, it cannot deal with faults in the power-conversion circuits.

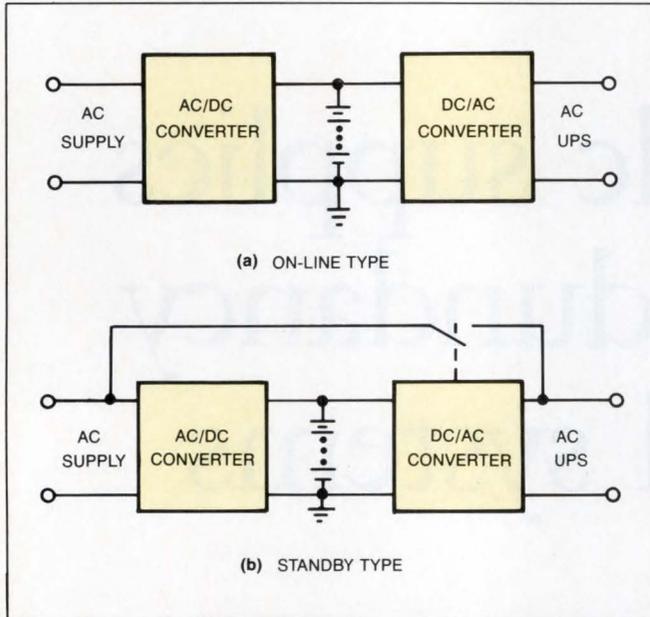


Fig 1—A conventional UPS comes in two configurations. An on-line type (a) operates continuously, and provides line filtering and battery back-up. A standby type (b) has a bypass switch that switches in the UPS only in the event of a line failure.

capacitors—often operated at levels near the capacitors' specified operating limits—used to reduce line-frequency ripple. Electrolytics are also required for long hold-up times in the ac/dc supply.

Further, the dual power conversion lowers the overall efficiency of the power system, and this reduced efficiency also contributes to lower reliability figures. Inverter circuits used in the UPS typically have an MTBF (mean time between failure) of 50,000 hours, and switch-mode supplies typically have MTBFs from 50,000 to 100,000 hours. In fact, the down time attributable to power-conversion faults can be four times the

down time caused by interruptions in the main ac supply (see **box**, "Weak links limit UPS reliability").

To overcome the down-time problem, UPS designers build parallel-redundant functions into the weak links of the power system (**Fig 3**). Successful parallel redundancy depends on the use of redundant parts that are easily repairable or replaceable. In calculating the MTBF of the system, it's safe to assume that faults occur one at a time and that supervisory circuits with alarms detect the fault occurrences. The MTTR (mean time to repair) must be many times lower than the MTBF.

Because doubling up all the weak-link circuits leads to bulkiness as well as high costs, designers often duplicate only the principal power-supply unit (**Fig 4**). Note, however, that the nonduplicated inverter substantially reduces the overall reliability figures.

The outputs of the redundant power supplies connect to the load through ORing diodes. The diodes are required because of the existence of relatively low-reliability components, such as electrolytic capacitors, on the output side of the power supplies. The voltage drops and power dissipation attributable to the diodes can contribute appreciable losses in a high-power system.

Raising redundancy reliability

A more reliable UPS is illustrated in **Fig 5**. The ac/dc supply in the equipment receives back-up from a battery and battery charger. This back-up scheme eliminates the need for large electrolytic units acting as hold-up capacitors. The dc voltage from the supply feeds directly to dc/dc converters, thereby eliminating the dual power-conversion reliability figures from the overall reliability calculations.

Achieving redundancy is a matter of connecting dc/dc converters in parallel. The dc/dc converters are

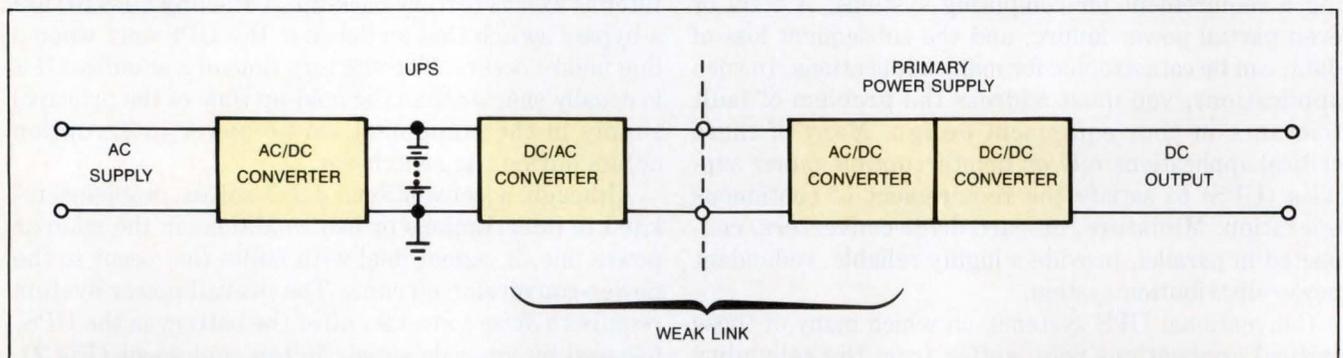


Fig 2—The weak link in a conventional UPS system is the dual power-conversion circuitry. The electrolytic filter capacitors used to reduce line-frequency ripple and to provide long hold-up times are the main contributors to reliability compromises in these systems.

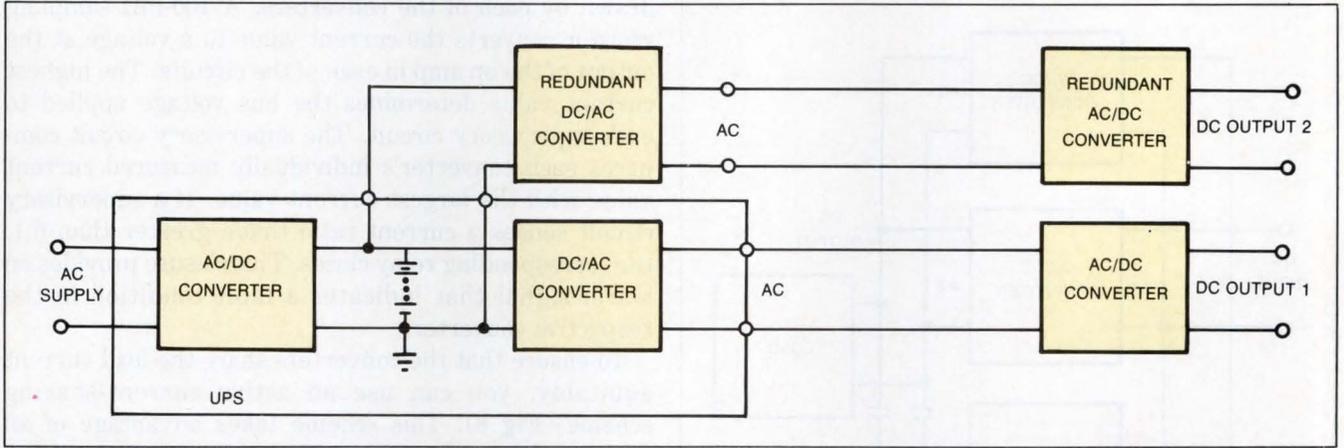


Fig 3—Building redundancy into a conventional UPS system can be bulky and expensive. In this configuration, both the dc/ac inverters and the ac/dc output rectifier supplies have redundancy.

mounted on system cards to conserve space. They use high switching frequencies, and can therefore use smaller and more reliable (vs electrolytics) ceramic capacitors to eliminate ripple-frequency components. For example, the PKA Series of dc/dc converters uses a 300-kHz switching frequency in a full-wave bridge arrangement. This series quotes an MTBF of 200 years (approximately 1.75 million hours). (See box, "Converter switching frequencies creep upward".)

The battery directly feeds the dc/dc converters, which are connected in parallel to the load without the use of ORing diodes (Fig 6). This connection method is possible thanks to the use of reliable ceramic capacitors on the converters' outputs. The system achieves redun-

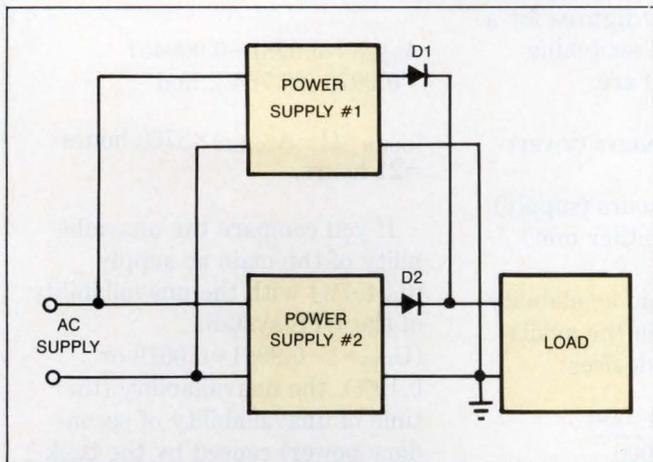


Fig 4—Doubling up on the power supplies yields redundancy in this configuration. The ORing diodes are required because the supplies' output circuits contain weak-link components (electrolytic capacitors).

dancy by adding only one extra unit instead of duplicating the entire power supply. To build a 100W system, five 25W dc/dc converters, connected in parallel, are enough to ensure redundancy. Only 125W power capability is needed, compared with the 200W needed to double up on the power supplies.

Distributing the individual dc/dc converters around the various system boards enhances the system reliability. The heat dissipation is spread evenly throughout the system. This uniform distribution eliminates hot spots that would arise from the concentration of bulky power units.

Fig 7 illustrates a redundant system that uses on-card dc/dc converters connected in parallel. This connection works well when the distributed resistances (R_{DISTR}) range between 20 and 40 mΩ. The converters will typically share the load current in a 3:2 ratio, with a worst-case ratio of 2:1.

The supervisory circuits measure the input currents

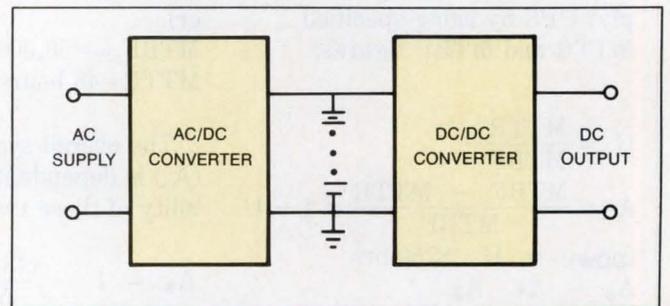


Fig 5—A more reliable UPS structure eliminates the dual power-conversion circuitry seen in Fig 4. This architecture eliminates the need for large electrolytic capacitors that would otherwise be required for hold-up purposes.

The down time attributable to power-conversion faults can be four times the down time arising from interruptions in the main ac supply.

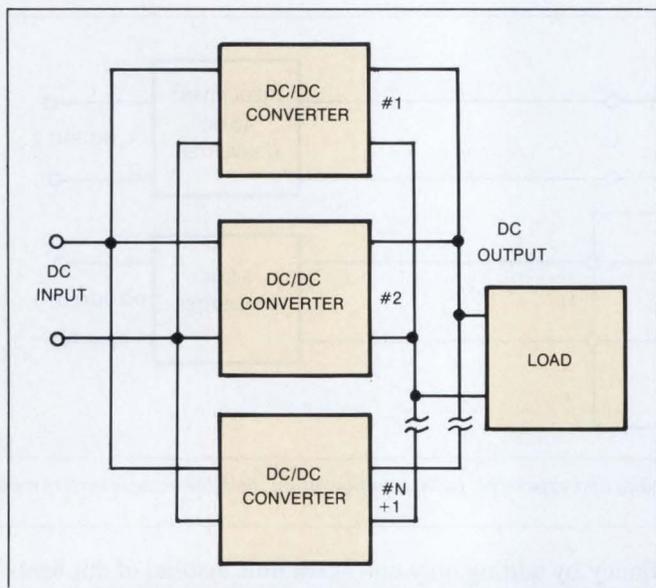


Fig 6—A redundant system built with parallel dc/dc converters connects directly to the load without the need for ORing diodes. This is a reliable configuration, thanks to the use of small ceramic filter capacitors in the converters' outputs.

drawn by each of the converters. A 100-mΩ sampling resistor converts the current value to a voltage at the output of the op amp in each of the circuits. The highest current value determines the bus voltage applied to each supervisory circuit. The supervisory circuit compares each converter's individually measured current value with the largest current value. If a supervisory circuit senses a current ratio that's greater than 6:1, the corresponding relay closes. This closure provides an alarm signal that indicates a fault condition in the respective converter.

To ensure that the converters share the load current equitably, you can use an active current-sharing scheme (Fig 8). This scheme takes advantage of an output-voltage adjustment pin available on the PKA Series of dc/dc converters. Each converter has two regulation loops. One of these loops senses the output current of the respective converter through a 20-mΩ sampling resistor. The highest current value sets the reference voltage on the output bus. This voltage is distributed as a reference value to the individual regulation loops. Each of the regulation loops compares the

Weak links limit UPS reliability

The overall reliability of a power supply is determined by the weakest parts in the system. In a UPS, these parts are the inverter and the succeeding ac/dc power supply, because both these blocks use electrolytic capacitors for filtering. You can obtain representative reliability figures for a 2-subpart (for example, inverter and power supply) UPS by using specified MTTR and MTBF figures:

$$U = \frac{MTTR}{MTBF}$$

$$A = \frac{MTBF - MTTR}{MTBF} = 1 - U$$

$$t_{DOWN} = U \cdot 8760 \text{ hrs}$$

$$A_s = A_1 \cdot A_2$$

$$= (1 - U_1)(1 - U_2)$$

$$A_s = 1 - (U_1 + U_2)$$

(neglecting $U_1 \cdot U_2$),

where A is the operational availability of a subpart of the system, U is the unavailability, t_{DOWN} is the accumulated down time (for example, 1 year), and A_s is the system availability.

Typical reliability figures for a UPS's inverter and switching power supply (SPS) are:

$$MTBF_{UPS} = 50,000 \text{ hours (inverter)}$$

$$MTBF_{SPS} = 50,000 \text{ hours (supply)}$$

$$MTTR = 48 \text{ hours (either unit)}$$

The overall system availability (A_s) is dependent on the availability of these two devices:

$$A_s = 1 - \frac{(48 + 48)}{50,000}$$

$$= 0.9981 = 99.81\%$$

This figure does not include

the unavailability of the main ac supply. A practical figure for the unavailability of the main supply is $U_M = 4.57 \times 10^{-4}$. Taking this value into account, the overall availability is

$$A_{TOTAL} = 0.9981 - 0.000457$$

$$= 0.9976 \text{ (99.76\%)}, \text{ and}$$

$$t_{DOWN} = (1 - A_{TOTAL}) \times 8760 \text{ hours}$$

$$= 21 \text{ hours.}$$

If you compare the unavailability of the main ac supply (0.0457%) with the unavailability of the UPS system ($U_{SYS} = 1 - 0.9981 = 0.0019$ or 0.19%), the unavailability (the time of unavailability of secondary power) caused by the backup system is more than four times greater than that attributable to the main ac supply.

reference value with individually sensed output-current values.

The second loop senses the distributed voltage and compares it with that of a stable reference diode. The outputs of the two regulation loops are connected in parallel and sent to the voltage-adjust pin on each dc/dc

converter. If either the sensed value of the output current or the sensed distributed voltage differs from its respective reference value, the control loop adjusts the voltage of the appropriate dc/dc converter to balance the load distribution.

Each converter has a supervisory circuit for its input

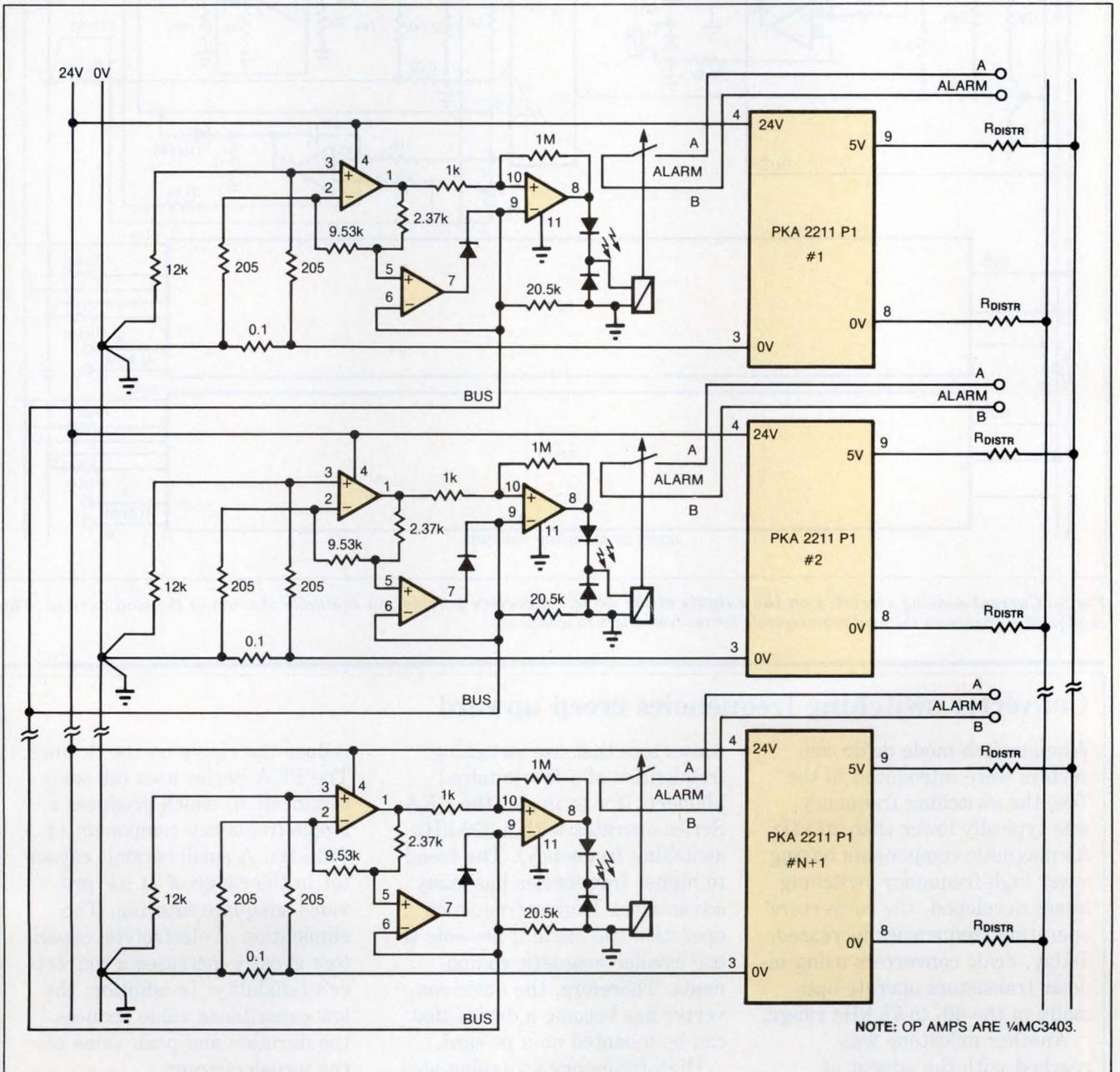


Fig 7—Supervisory circuits sense the input currents to the dc/dc converters and trigger an alarm when a fault is detected. The converters in this configuration typically share the load current in a 3:2 ratio. If a ratio exceeds 6:1, an alarm indicates a fault condition in the appropriate converter.

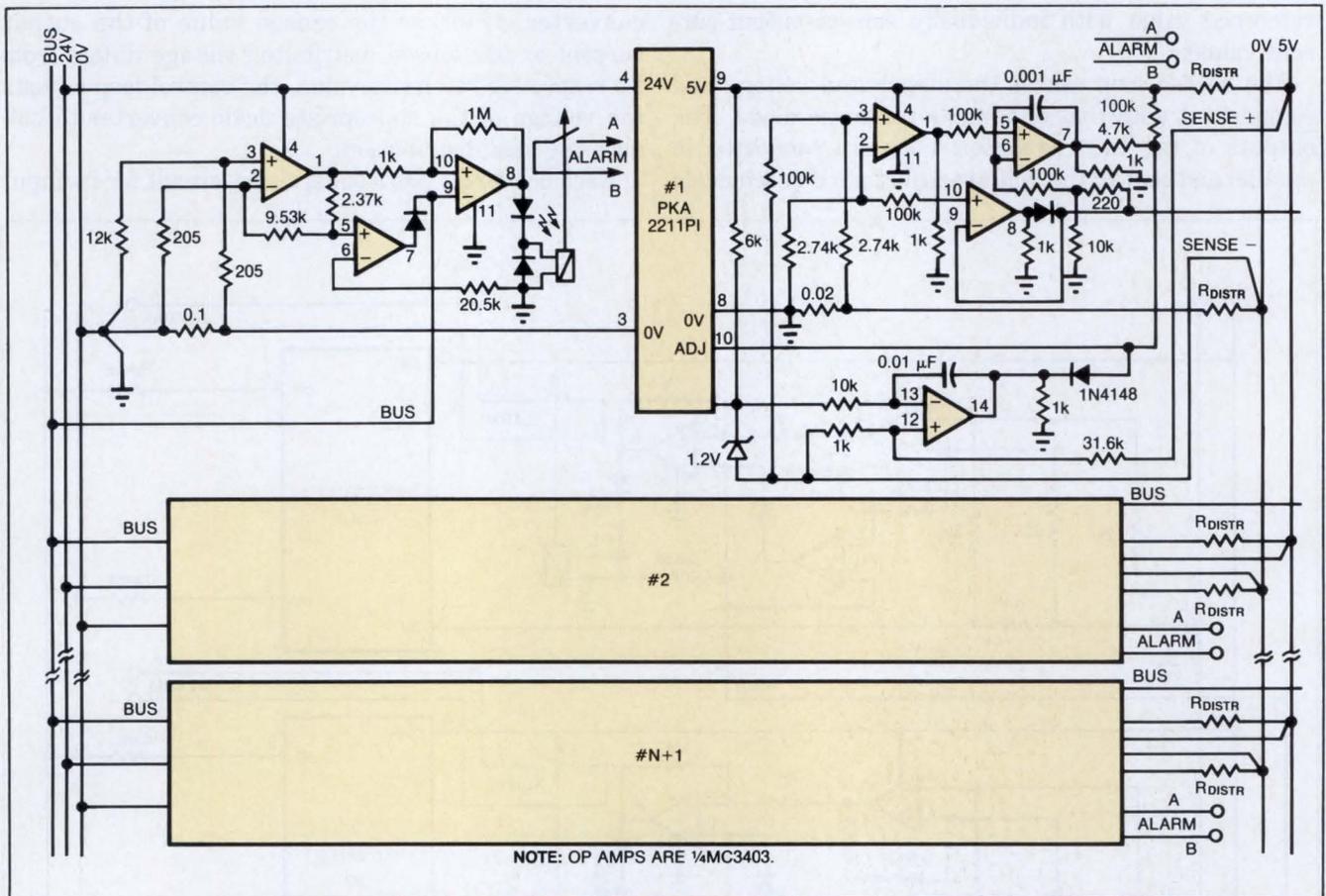


Fig 8—Current-sensing circuitry on the outputs of the dc/dc converters provides an equitable sharing of the load current. This configuration balances the load requirements for the converters to within 5%.

Converter switching frequencies creep upward

When switch-mode dc/dc converters were introduced in the '60s, the switching frequency was typically lower than 20 kHz. As magnetic components having lower high-frequency switching losses developed, the converters' operating frequencies increased. Today, dc/dc converters using bipolar transistors operate optimally in the 40- to 75-kHz range.

Another milestone was reached with the advent of power MOSFETs. It became possible to build efficient dc/dc

converters that use switching frequencies of a few hundred kilohertz (for example, the PKA Series operates with a 300-kHz switching frequency). The trend to higher frequencies has many advantages. Higher-frequency operation has made it possible to use smaller magnetic components. Therefore, the dc/dc converter has become a device that can be mounted on a pc card.

High-frequency switching also makes it possible to use smaller and more reliable capacitors to

reduce the ripple on the dc lines. The PKA Series uses full-wave rectification, which produces a ripple-frequency component of 600 kHz. A small ceramic capacitor in the range of 1 μF provides adequate filtering. The elimination of electrolytic capacitors greatly increases a converter's reliability. In addition, the low capacitance value reduces the duration and peak value of the inrush current.

current. This supervisory circuit triggers an alarm circuit similar to the one in Fig 7. The current-sharing scheme can balance the load requirements for the dc/dc converters to within 5%. Consequently, the units are never overstressed, and never operate at their maximum rated output power. This low-stress environment naturally enhances the converters' reliability.

When dc/dc converters are connected in parallel, the only factor that affects the overall operation is a failure in the output circuitry of a converter. Therefore, the reliability of the output circuitry of the converters is the sole contributor to the overall reliability figure. The MTBF of the output circuitry in the PKA Series of dc/dc converters is 4500 years. Therefore, the overall reliability figure is

$$\text{MTBF} = 4500 \text{ years} \div (\text{number of converters in parallel})$$

If the overall MTBF figure determined by this expression is not adequate, then you can connect the outputs of the dc/dc converters through ORing diodes. However, the remote-sensing circuits must then compensate for the voltage drops across the diodes.

Efficiencies of about 65% are achievable from parallel-connected dc/dc converters that don't use the ORing diodes. This number compares favorably with the typical 40% efficiency of a conventional UPS. **EDN**

Author's biography

Lars Thorsell is product marketing manager for Rifa Power Products in Stockholm, Sweden. After receiving a BSEE from the Stockholm Tekniska Institute in 1969, he designed power supplies and power systems in the power-supply department at Ericsson for nine years. He then gained four years of experience in the semiconductor industry while working as an applications engineer and product marketing manager at SGS Scandinavia AB. Before joining Rifa, Thorsell served as product manager and marketing manager for Ulceco Power Products.



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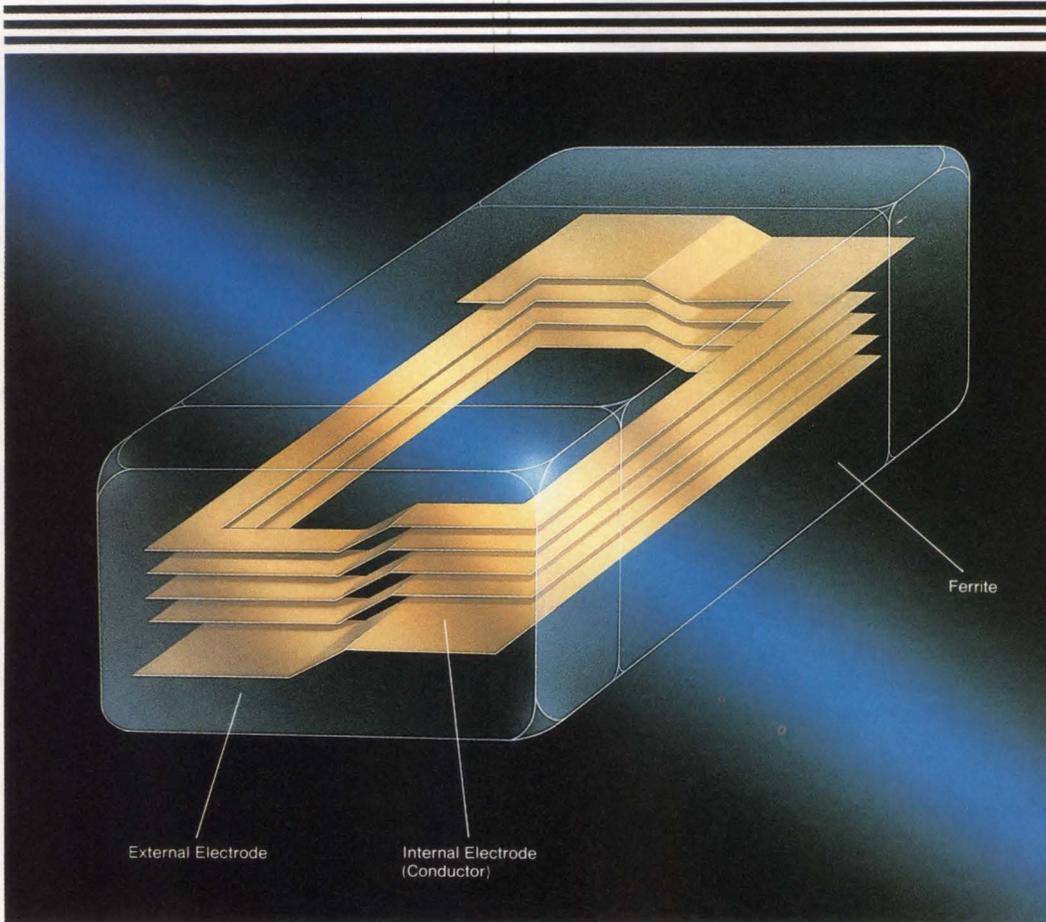
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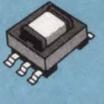


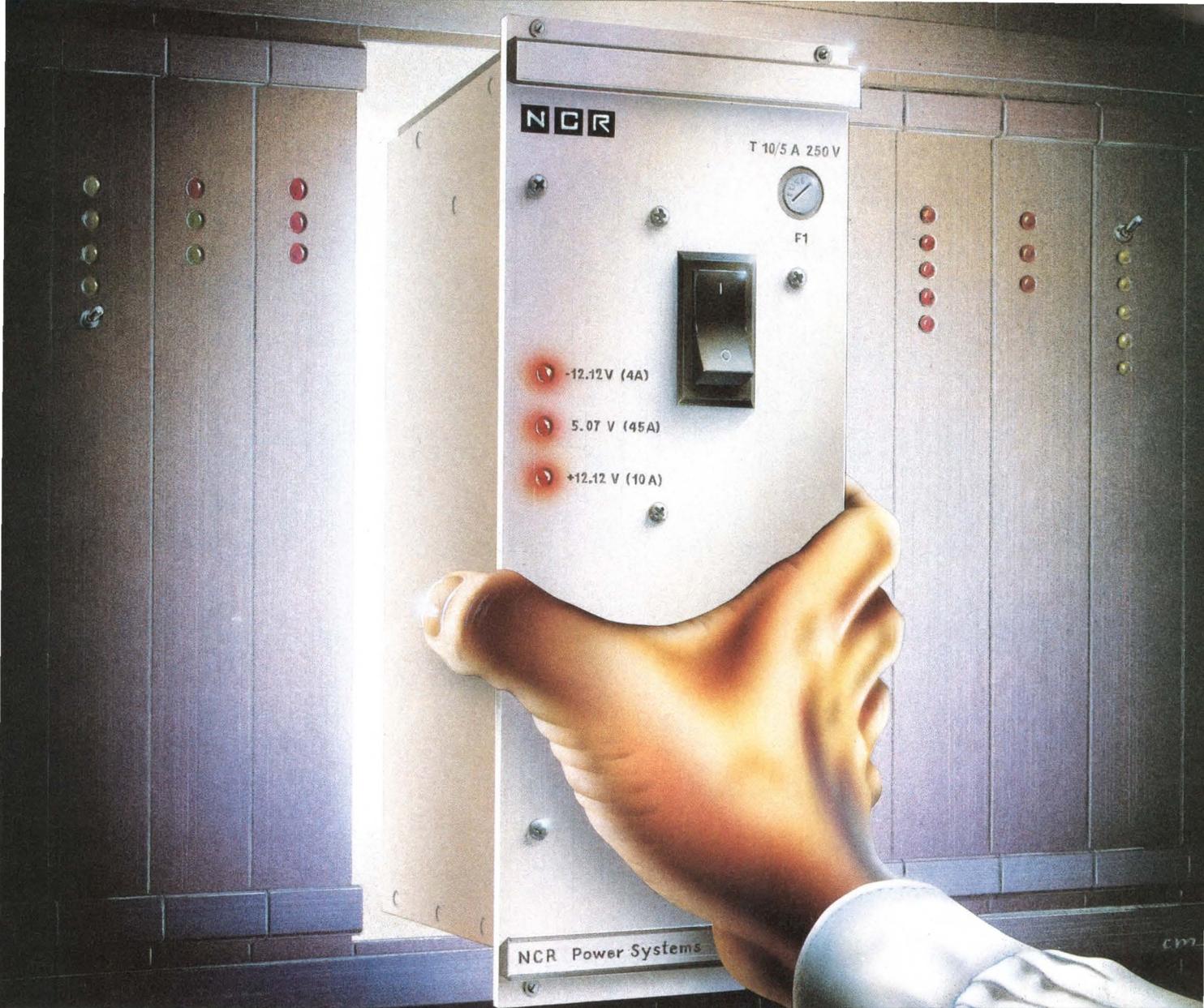
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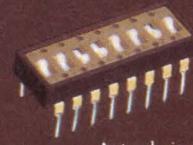
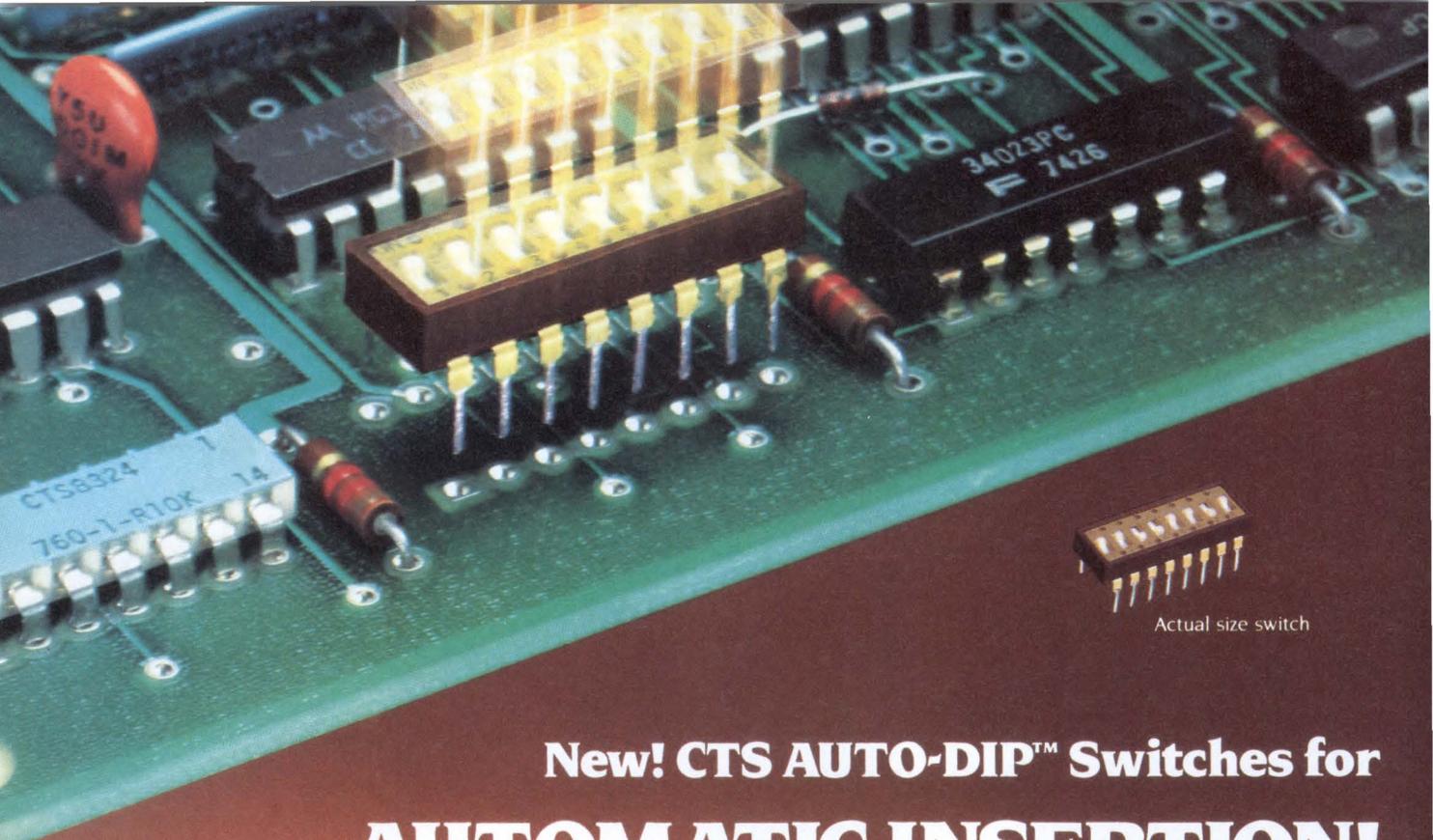
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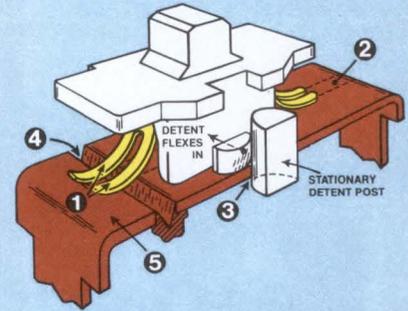
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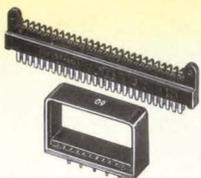
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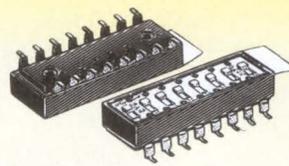
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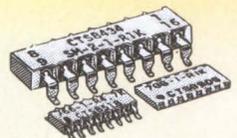
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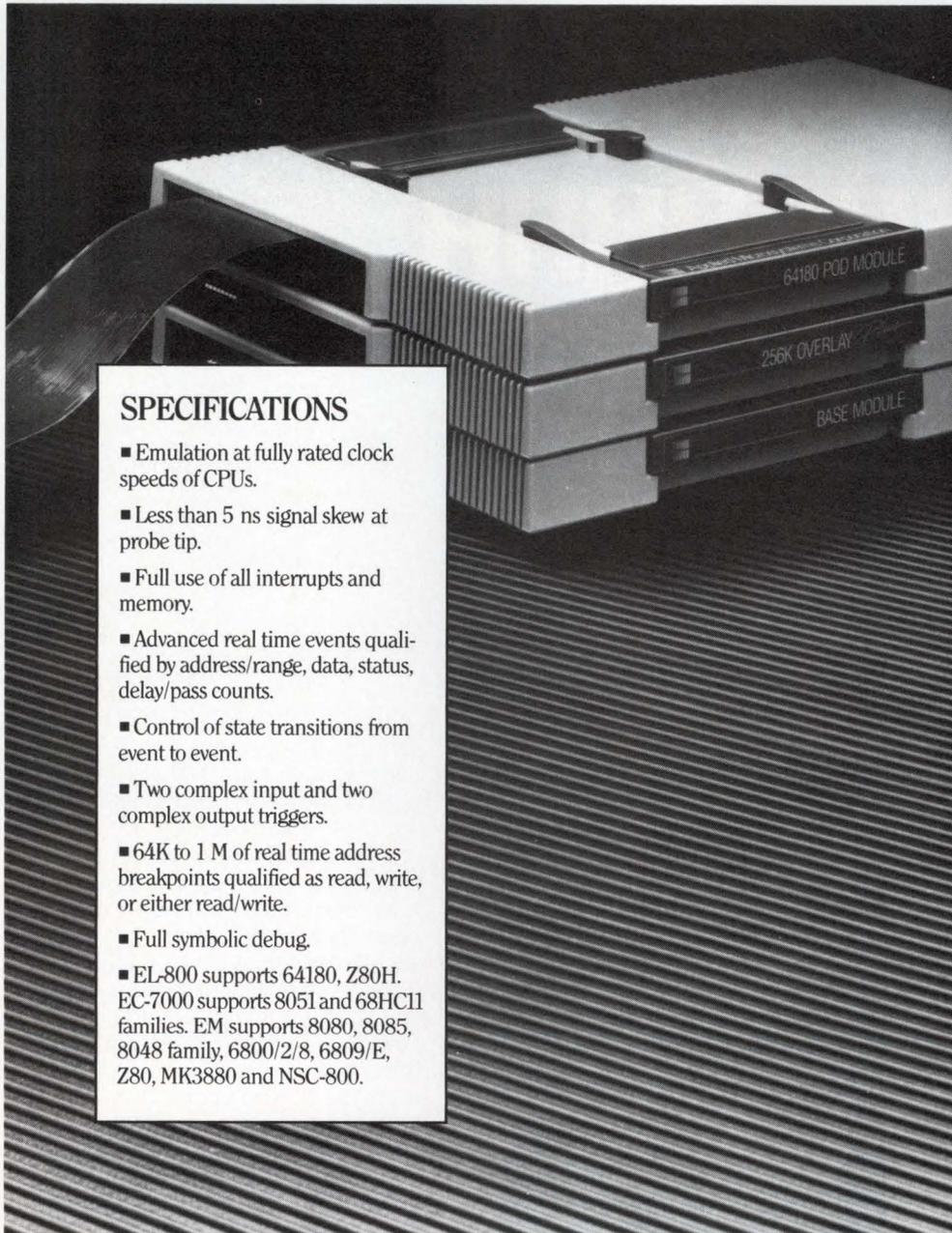


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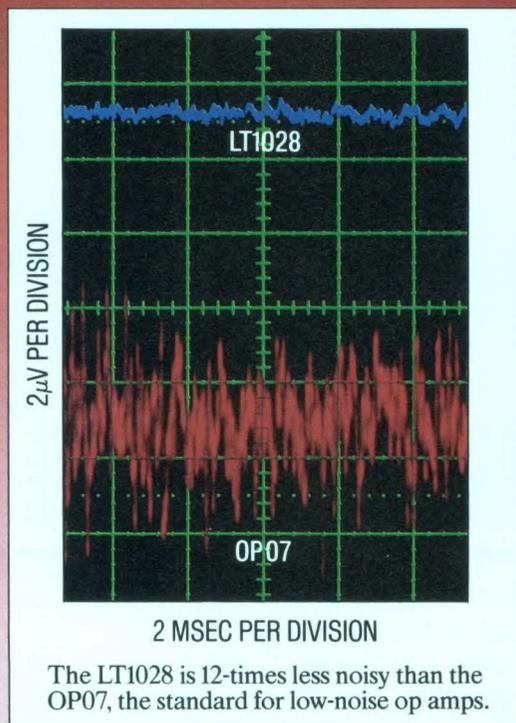
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CIRCLE NO 197

DESIGN IDEAS

EDITED BY TARLTON FLEMING

Electronic thermometer has 10-mV/°F output

Bill Donofrio and Dennis R Bernard
Moore Research Ctr, Grand Island, NY

Using type-K thermocouple wire, you can build an inexpensive electronic thermometer that generates 10 mV/°F (Fig 1). Because type-K thermocouples are reasonably linear for the range of 0 to 660°C, you can obtain a moderately accurate temperature measurement for this range by adding a scaling voltage to the cold-junction reference voltage.

The 9V battery powers a bridge circuit in which the temperature sensor, IC₂, and the 2.5V reference, IC₃, provide a signal and reference voltage, respectively. You should place the cold-junction thermocouple close to the temperature sensor. Note that the chromel wires form secondary junctions where they attach to the circuit (nodes A and B). To avoid introducing dc errors, you should maintain these junctions at the same temperature by placing them close together. Bypass capaci-

tors C₆ and C₇ guard against errors due to RF pickup.

Potentiometer R₅ produces a temperature-dependent scaling voltage, and the chopper-stabilized op amp, IC₁, amplifies (with a gain of 1001) the sum of the scaling and thermocouple voltages. As a result, the output V_T equals the sum of the thermocouple cold-junction voltage plus the scaling voltage (0.744 mV), divided by 0.0226. Potentiometer R₆ determines the 0.0226 figure.

To calibrate the circuit, first adjust R₄ for 2.554V across IC₃. Then adjust R₃ so the voltage across IC₂ equals 10 mV times the ambient temperature (in °K). Place the hot-junction thermocouple in a well-stirred mixture of crushed ice and water, and adjust R₅ so that the op-amp output (across R₆) equals 0.744V. To complete the calibration, adjust V_T to 0.32V using R₆. EDN

To Vote For This Design, Circle No 748

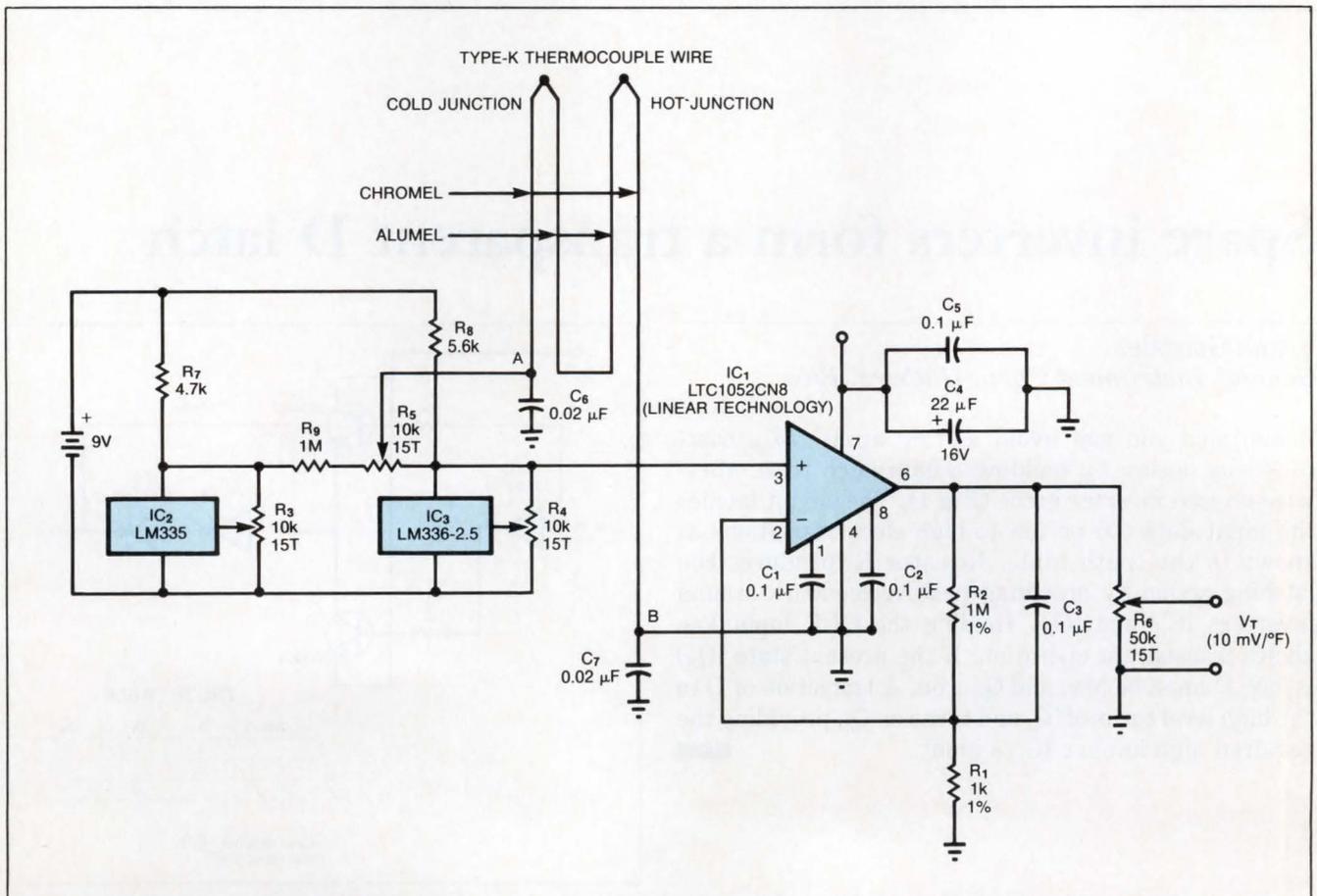


Fig 1—This circuit adds a linearizing voltage to the thermocouple voltage and produces an output V_T of 10 mV/°F.

Add two 16-bit pointers to the 8031 μ P

Noor Singh Khalsa
EG&G Inc, Los Alamos, NM

Although Intel's 8031 μ P has only one 16-bit pointer (DPTR), the device's page-mode addressing feature allows you to add two more. The 8031 restores any value on the P2 output port (the upper address byte) following each instruction fetch, so you can use the R0 and R1 registers for indirectly addressing memory in the current "page" selected by P2:

```
MOVX    A,@R0
MOVX    A,@R1
```

By dedicating two other registers (such as R6 and R7) for the upper address byte, you can form two 16-bit pointers, R6,R0 and R7,R1, for use in accessing the external memory (Table 1). This technique does not affect the DPTR, so you can avoid the code space otherwise needed to save the 2-byte DPTR (two push

TABLE 1—BLOCK-MOVE ROUTINE

BLKMOVE: MOV	P2,R6	: SELECT PAGE OF MEMORY
		: TO ACCESS
MOVX	A,@R0	: READ BYTE AT R6,R0
MOV	P2,R7	: CHANGE PAGE
MOVX	@	: STORE BYTE AT R7,R1
INC	R0	: INCREMENT SOURCE
		POINTER
INC	R1	: INCREMENT DESTINATION
		PTR
DJNZ	R3,BLKMOVE	: BYTE COUNT STORED IN R3

instructions and two pop instructions). Because a sub-routine call or an MOVX A, @DPTR instruction will modify the P2 value following an instruction fetch, you mustn't execute these instructions without restoring the P2 pointer value. **EDN**

To Vote For This Design, Circle No 749

Spare inverters form a transparent D latch

Frank Gonzalez
General Instrument Corp, Hatboro, PA

Sometimes you can avoid adding an IC to a cost-conscious design by building a data latch with otherwise-unused inverter gates (Fig 1). The circuit latches the input data (D) on low-to-high clock transitions as shown in the truth table. Resistor R₃ produces the latching action by providing positive feedback around inverters IC_{1B} and IC_{1C}. Holding the CLK input low allows transparent operation: If the present state (Q_N) is low, D must be low, and Q₁ is on. A transition of D to the high level turns off Q₁ and turns on Q₂, providing the required high level at IC_{1B}'s input. **EDN**

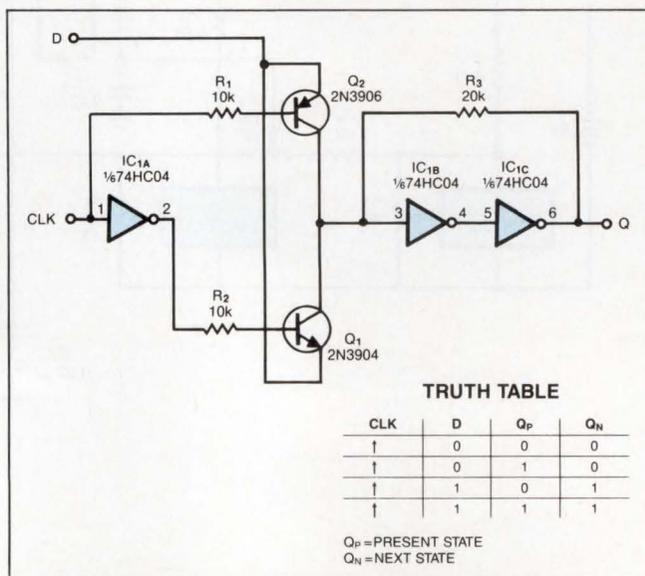


Fig 1—This transparent D latch operates on the clock signal's rising edge. Operation is transparent when the CLK input is low.

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Max, 20dB Stop Frequency (MHz)			19	32	47	70	90	147	210	290	410	580	750	840	1000	1100	1340

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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

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*Prefix P for pins, B for BNC, N for Type N, S for SMA [example: PLP-10.7](#)

Adders enable detection of multiple inputs

S Murugesan
ISRO Satellite Centre, Bangalore, India

The Fig 1 circuit determines whether more than one input in a group of digital inputs is active. It is simpler and more versatile than an earlier idea ("Tree structure detects multiple inputs," EDN, February 19, 1987, pg 195): It provides a digital measure of the number of active inputs, and it allows you to establish a threshold for majority-decision applications (that is, whether the number of active inputs is more than, less than, or equal to a value between 1 and 15). You can monitor more inputs by cascading the adders.

Each binary adder, IC₁ and IC₂, forms two full adders (FAs). Each FA monitors three input lines and generates a 2-bit output representing the number of inputs active. IC₃ and IC₄, by summing the outputs of two FAs plus an input line, individually measure how many in a group of seven inputs is active. Similarly, by monitoring the 3-bit outputs of IC₃ and IC₄ plus one input, IC₅ measures how many in the group of 15 are active. The OR gate (IC₆) simply indicates whether more than one input is active.

EDN

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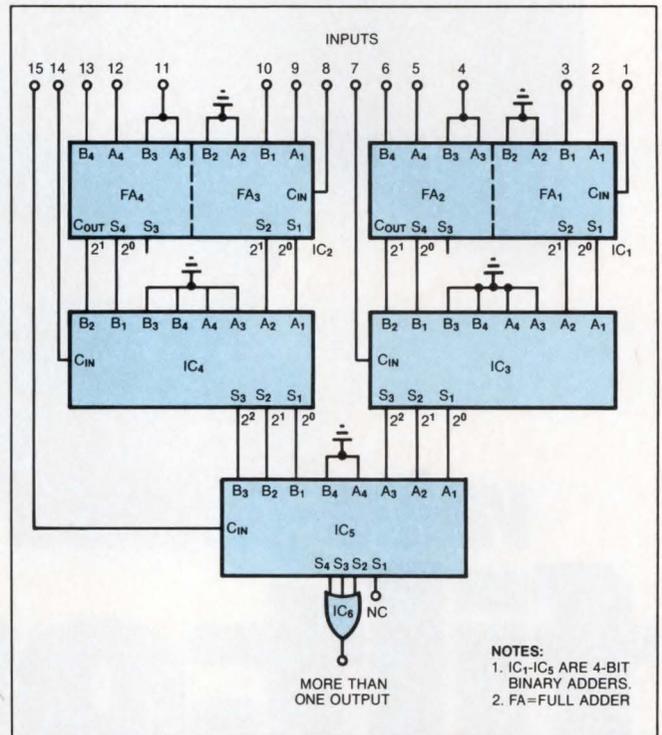


Fig 1—By counting in parallel, these binary adders determine the number of active inputs among a group of 15. The OR gate indicates whether more than one is active.

Program aids resistive-divider calculations

Hugh M Adams
Rtronics Inc, Pensacola, FL

Listing 1 helps you solve the general problem shown in Fig 1: how to determine the maximum possible value for V₂ and the minimum possible value for V₁, given the expected minimum and maximum values for V₁ and the values and percent tolerances for R₁, R₂, and R₃. Fig 2 shows a typical application for this network. The goal in this case is to choose optimum resistor values that will set the voltage regulator's output within the specified limits of 4.5 to 5.5V.

The regulator, IC₁, includes a voltage reference

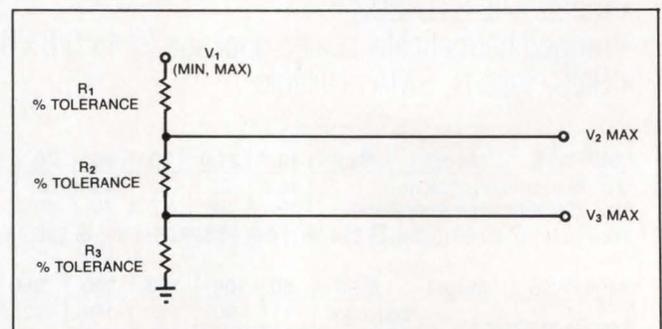


Fig 1—This circuit illustrates the general problem that Listing 1 solves. You provide the V₁ minimum and maximum inputs, plus a value and tolerance for each of the resistors.

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DESIGN IDEAS

whose output (pin 6) can have any value from 6.95 to 7.35V. You must choose reasonable values and tolerances for resistors R_1 - R_3 . After receiving these eight data items, the program takes less than five seconds to calculate the resulting values for V_2 max and V_1 min. You continue to alter the inputs and rerun the program until it produces satisfactory outputs, a procedure that typically takes 5 to 10 minutes. (Note that an LM723 regulator's reference should not deliver more than 1 mA. For that device, you should double the resistor values to 1.36 k Ω , 2 k Ω (the potentiometer), and 4.3 or 4.4 k Ω .) Listing 1 is written in HP Basic, but the program is also available in True Basic for the IBM PC.

EDN

To Vote For This Design, Circle No 747

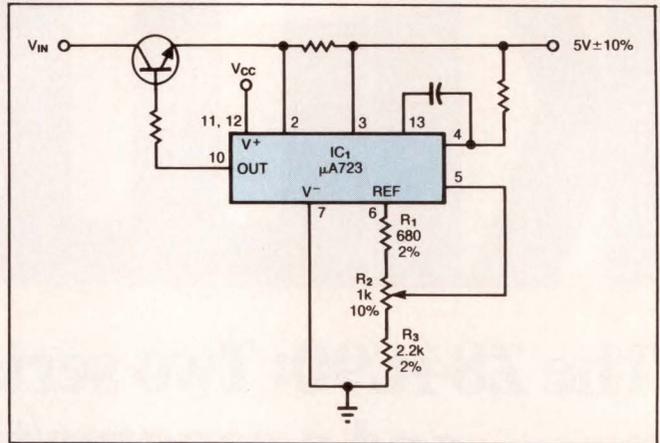


Fig 2—Using the Listing 1 program, you can choose a combination of standard values and tolerances for resistors R_1 - R_3 that will be nearly optimum for production.

LISTING 1—RESISTIVE-DIVIDER PROGRAM

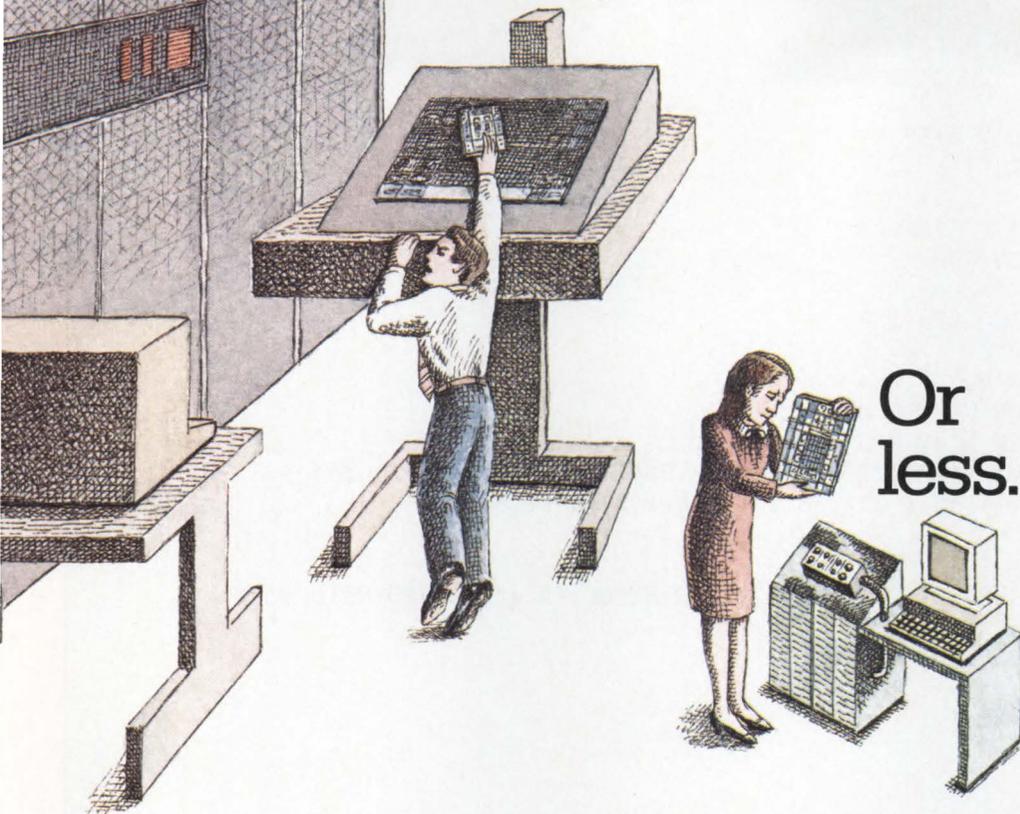
```
10 CLEAR
20 REM THREE RESISTOR DIVIDER PROGRAM
30 OPTION BASE 1
40 DISP "THIS PROGRAM AIDS IN SOLVING THE VOLTAGE DIVIDER PROBLEM"
50 DISP "FOR A DIVIDER HAVING THREE RESISTORS AND TWO INPUT VOLTAGE."
60 DISP
70 DISP
80 DISP "ENTER INPUT VOLTAGES VIMIN AND VIMAX";
90 INPUT VIMIN,VIMAX
100 DISP "ENTER R1,R1TOL(%)";
110 INPUT R1,R1TOL
120 DISP "ENTER R2,R2TOL(%)";
130 INPUT R2,R2TOL
140 DISP "ENTER R3,R3TOL(%)";
150 INPUT R3,R3TOL
160 DISP
170 DISP
180 R1L=R1*(1-R1TOL/100)
190 R1H=R1*(1+R1TOL/100)
200 R2L=R2*(1-R2TOL/100)
210 R2H=R2*(1+R2TOL/100)
220 R3L=R3*(1-R3TOL/100)
230 R3H=R3*(1+R3TOL/100)
240 DIM RM(8,3)
250 MAT RM=ZER
260 FOR W=1 TO 4
270 RM(W,1)=R1L
280 NEXT W
290 FOR W=5 TO 8
300 RM(W,1)=R1H
310 NEXT W
320 FOR W=1 TO 5 STEP 4
330 RM(W,2)=R2L
340 RM(W+1,2)=R2L
350 NEXT W
```

Listing continued on pg 244

You shouldn't buy
more board tester
than you need.

*we never stop
asking*

"What if...



Or
less.

Now, you don't have to settle for too little or too much in a board tester. You can get one that's just right for you. From HP.

The HP 3065 family of board testers offers you flexibility. So you can get a system that fits your board mix, process, volume, and budget. Right now. And you can add capability or upgrade at any time to keep pace with your needs.

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For a free videotape on the HP board test family, or more information, call 1-800-634-TEST (in Colorado, call collect: 303-669-9325.)

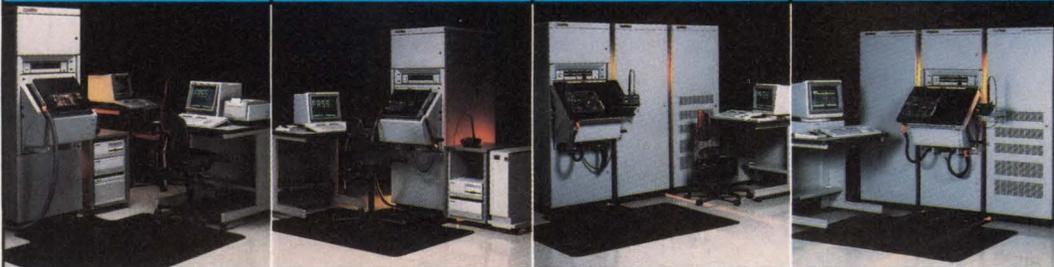
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HP 3065ST - Low cost test

HP 3065L - In-circuit test

HP 3065AT - Combinational

HP 3065AT - HP Telecomtest



*Some restrictions apply.

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DESIGN IDEAS

LISTING 1—RESISTIVE-DIVIDER PROGRAM (Continued)

```
360 FOR W=3 TO 7 STEP 4
370 RM(W,2)=R2H
380 RM(W+1,2)=R2H
390 NEXT W
400 FOR W=1 TO 7 STEP 2
410 RM(W,3)=R3L
420 NEXT W
430 FOR W=2 TO 8 STEP 2
440 LET RM(W,3)=R3H
450 NEXT W
460 DIM V2A(8,2),V3A(8,2)
470 FOR J=1 TO 2
480 FOR I=1 TO 8
490 IF J=1 THEN V1=V1MIN
500 IF J=2 THEN V1=V1MAX
510 V2A(I,J)=V1*((RM(I,2)+RM(I,3))/(RM(I,1)+RM(I,2)+RM(I,3)))
520 V3A(I,J)=V1*(RM(I,3)/(RM(I,1)+RM(I,2)+RM(I,3)))
530 NEXT I
540 NEXT J
550 DISP "R1=";R1;R1TOL;"%";"R2=";R2;R2TOL;"%";"R3=";R3;R3TOL;"%"
560 DISP
570 DIM V2B(16),V3B(16)
580 W=0
590 FOR J=1 TO 2
600 FOR I=1 TO 8
610 W=1+W
620 V2B(W)=V2A(I,J)
630 V3B(W)=V3A(I,J)
640 NEXT I
650 NEXT J
660 FOR X=1 TO 15
670 LET SW=0
680 FOR K=16 TO X+1 STEP -1
690 IF V2B(K-1)<=V2B(K) THEN 740
700 SW=1
710 TM=V2B(K-1)
720 V2B(K-1)=V2B(K)
730 V2B(K)=TM
740 NEXT K
750 IF SW=0 THEN 770
760 NEXT X
770 DISP "V2MIN=";V2B(1)
780 FOR X=1 TO 15
790 SW=0
800 FOR K=16 TO X+1 STEP -1
810 IF V3B(K-1)<=V3B(K) THEN 860
820 SW=1
830 TM=V3B(K-1)
840 V3B(K-1)=V3B(K)
850 V3B(K)=TM
860 NEXT K
870 IF SW=0 THEN 890
880 NEXT X
890 DISP "V3MAX=";V3B(16)
900 END
```

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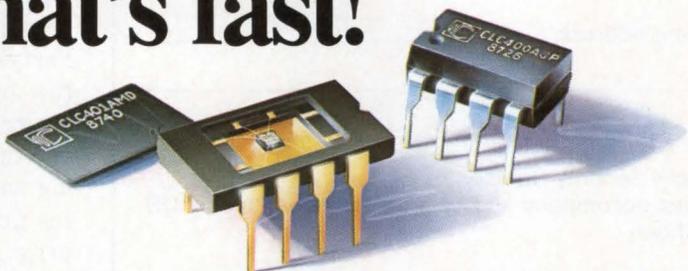
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Design Entry Blank

\$75 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.

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Your vote determines this issue's winner. All designs published win \$75 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.

ISSUE WINNER

The winning Design Idea for the February 4, 1988, issue is entitled "Zero-current sensor protects relay contacts," submitted by B Erik Valeur of Electronic Instrument & Specialty Corp (Stoneham, MA).



Winning Idea improves upon earlier design

Andrzej Partyka's Design Idea, "Frequency divider generates 50% duty cycle," is the 1987 Design Idea of the year, and Mr Partyka is the recipient of the \$1500 cash award that goes along with it. The Design Idea originally appeared in the September 3, 1987, issue of EDN, but Mr Partyka got the inspiration for his winning idea from an earlier issue of EDN.

As he read Irwin Cohen's entry, "Divider produces symmetrical output" in EDN's January 23, 1986, issue, he realized, "it could be done better." According to Mr Partyka, his approach to obtaining a 50% duty cycle has the advantage of being more elegant and easier to comprehend. In addition, his solution is more general, and therefore more applicable. (Of course, there's nothing wrong with Mr Cohen's Design Idea—it didn't win the grand prize, but it did garner the \$75 issue-winner prize.)

Mr Partyka currently lives in New Jersey, but he grew up and went to school in Poland. He attended Silesian Polytechnic Institute in the city of Gliwice in southern Poland. In 1981 he received a BS in electronics, and in 1982 he earned an MS in the same discipline. Shortly thereafter he moved to New Jersey and began working for Blonder Tongue Labs, where he was involved in voice and television signal coding. He now works in Syosset, NY, for Ademco, a company that specializes in security hardware and servicing. Mr Partyka was hired to work on long-range radio communications, but he's also interested in bandwidth-efficient and spread-spectrum data communications.

Outside of the sphere of electronics, Mr Partyka's interests lie in the area of music. He enjoys listening to classical music in particular. Despite his claims that, because he doesn't play an instrument, he isn't an artist, it's obvious that he is creative. All of the editors at EDN congratulate you, Mr Partyka, for winning the 1987 Design Idea grand prize.—*Clare Mansfield*

Control Point

Test and Control Systems Product News from Ziatech

Spring 1988

Ziatech Corporation

Inside Control Point

Page Two New Packaged STD Bus Computer

The new ZT 300 from Ziatech is a packaged STD Bus computer with an NEC V20 Single Board Computer and STD DOS. This industrial computer is available in several versions, with networking and GPIB capabilities.

Page Three New STD Mass Storage Subsystems

Ziatech has introduced microfloppy, Winchester, and Bubble Memory units that integrate controller and drive while fitting into an STD Bus card cage.

Page Four New GPIB SBC and Software

A new single board GPIB computer and a new easy-to-use software driver are Ziatech's latest GPIB products.



New Industrial Computer Serves Test and Control Applications



The ZT 300 Industrial Computer is the first of a series of packaged IBM-compatible STD Bus systems from Ziatech. Ziatech's family of packaged systems will be on display at Control Expo, June 7-9, at the O'Hare Exposition Center, Rosemont, IL. (For more information on the ZT 300, see page 2 and/or check box A on the return card.)

ZT 300 Model 6 Computer Features

- NEC V20 Processor
- STD DOS
- Microfloppy and Winchester disk support
- STD-8088 and IBM XT compatibility
- Monitor and keyboard
- 19" rack-mounted card cage with power supply
- Network model
- IEEE 488 option
- Processor, I/O and enclosure options



New Packaged STD Bus Computer Family Integrates Many Ziatech Products

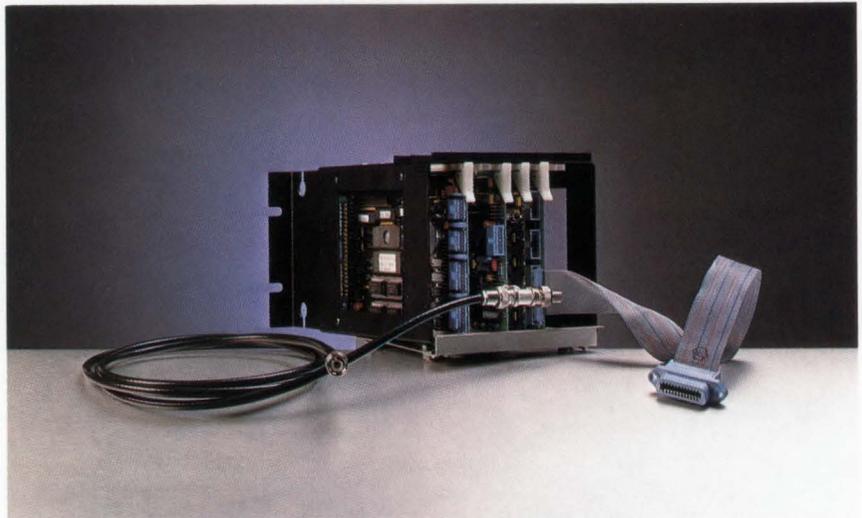
The New ZT 300 Industrial Computer from Ziatech is a packaged IBM-compatible STD Bus system for industrial control and testing applications.

NEC V20 SBC

The new computer is available in three models. The Model 5 features an NEC V20-based single board computer with STD DOS in firmware, leaving 15 user slots in the system's rack-mounted card cage/power supply. The Model 6 (see photo, page one) includes the same features plus a monitor, keyboard, integrated microfloppy and hard disk drives, with eight user slots.

STD Network Capability

The third model is called the ZT 300 Remote Computer. It is packaged in a smaller card cage for use as a remote network node in Z-NET, a local industrial network for Ziatech STD DOS-based systems. Based on the ARCNET protocol and ViaNet software, the ZT 300 RC is designed for embedded industrial networks where its ability to be remotely controlled from a supervised node is important.



The ZT 300-IB Remote Computer is both a remote node on Ziatech's Z-NET industrial network and a NEC V20-based GPIB controller. This model lets other nodes on a network remotely control IEEE 488 instruments attached to the ZT 300-IB RC.

IEEE 488 Capability

For instrumentation applications, all the ZT 300 models are available in an IEEE 488 (GPIB) configuration. This option includes an IEEE 488 interface and a software of choice (four available).

The combination of the ZT 300 RC and the IEEE 488 interface results in a powerful instrument controller that expands the geographic limitations of GPIB control. In this configuration, other nodes on a network can control the instruments attached to the ZT 300-IB RC. This is accomplished through GPIB calls directly to a GPIB device driver on the ZT 300-IB RC node. While the limit of GPIB control is normally 20 meters, Ziatech's Z-NET LAN provides access to instruments up to four miles away.

System Development

STD DOS system development for the ZT 300 is available in two versions. The ZT 300 Model 6 provides stand alone development capability with an IBM-compatible monitor and keyboard connected directly to the STD DOS system.

The PC-Assisted (PCA) version (Model 5) is the most cost-effective configuration because it utilizes a user's PC for its console and mass storage requirements.

Ziatech's unique Virtual System Console (VSC) simplifies PC-assisted development by enabling the PC console to switch from control of the PC to the serially-connected STD system at the touch of a key. With VSC, the PC disks and other resources are transparently accessible to the STD system.

Expanded Memory and Multiprocessing Option

Among the many options to the ZT 300 computer is the ZT 8825 Extended Memory System, an STD Bus memory unit that provides the ZT 300 with large solid state disks or expanded main memory.

Multiprocessing, via the ZT 8830 Intelligent Control Processor is another powerful option available on the ZT 300 to increase its I/O performance in demanding situations.

For more information on the ZT 300, check box A on the return card.

The ZT 300 At A Glance

- NEC V20 SBC
- STD DOS
- Network Model
- IEEE 488 Option
- IBM XT and STD-8088 Compatibility
- Processor, I/O options

New Floppy, Winchester and Bubble Mass Storage for STD Bus

The first fully integrated disk drive subsystems for STD DOS industrial computers are now available from Ziatech Corporation. The ZT 8856 Integrated Microfloppy Disk Drive, the ZT 8857 Integrated Hard Disk Drive, and the ZT 8858 Integrated Bubble Memory Drive provide mass storage support to Ziatech's STD DOS systems in the form of compact, modular units that are plugged directly into the STD Bus backplane.

Modular Units Plug into STD Bus Backplane

The new peripheral units require no cabling or assembly by the user, and are well suited to industrial OEM applications that require easy user interfacing, debugging, and maintenance.

The integration of the disk controller and disk drive into a single unit also significantly improves system MTTR (Mean-Time-To-Repair).

720 Kbyte Microfloppy

The ZT 8856 Integrated Microfloppy Disk Drive is a completely self-contained controller and 3 1/2" microfloppy disk drive, with 720 Kbyte storage capacity. It features push-button ejection and reliable, double-sided recording.

20 Mbyte MicroWinchester

The ZT 8857 Integrated Hard Disk Drive is a self-contained controller and a microWinchester hard disk with 20 Mbyte capacity. The ZT 8857 includes an SCSI controller, 2 Kbyte dual-ported FIFO data buffer, and self-diagnostic capabilities.

720 Kbyte Bubble Memory

The ZT 8858 Integrated Bubble Memory Drive combines a Ziatech disk controller with a Magnesys bubble memory drive and a removable data cartridge in a single modular unit. Offered in a 720 Kbyte industrial strength con-

figuration, the ZT 8858 is a good substitute for microfloppy disk drives in environments too harsh for conventional disk media.

Bubble memory is most effective for applications involving high temperature, humidity, and vibration. A real-time data collection system for earth-moving vehicles is one example of an application where the ZT 8858 was the only workable solution.

Ziatech also offers separate microfloppy, microWinchester and bubble memory disk drives that are designed to be used with Ziatech's ZT 8850 STD Bus Disk Controller, and are plugged into the STD Bus backplane separately.

For more information on Ziatech's integrated disks, check box B on the return card.

About Control Point

Control Point is a bi-monthly newsletter published by Ziatech Corporation for OEMs and system integrators designing industrial automation and instrumentation applications.

Control Point examines the new products, applications, and issues in today's test and control industries.

Ziatech Corporation, established in 1976, manufactures STD Bus-based computers, development and operating systems for the STD Bus, and IEEE 488 interfaces for MULTIBUS, STD Bus and personal computer systems.

For more information on Ziatech STD Bus and IEEE 488 products, return the Control Point Postcard, or call Ziatech at 805-541-0488.



The ZT 8856 Integrated Microfloppy Disk Drive and ZT 8857 Integrated Winchester Disk Drive are self-contained modular units providing mass storage to STD DOS systems.

ZIATECH
CORPORATION

New Software Driver for GPIB Interfaces

EZ.488, a new software driver from Ziatech, supports Ziatech's IEEE 488 interfaces for the IBM Personal System/2 (ZT/2), IBM and compatible PCs (ZT 1444/1488A), and STD Bus Systems (ZT 8847/8848).

Easy-to-use driver

This new driver is Ziatech's most general purpose approach and easiest to use. Initially installed into PC DOS/MS DOS and automatically loaded at system start-up time, EZ.488 allows the user to access IEEE 488 interfaces at a high level through any language. The EZ.488 syntax is comparable to the HP 85 instrument controller when using BASIC.

Ziatech offers two other types of software driver support to simplify the implementation of microcomputer-based test and measurement systems.

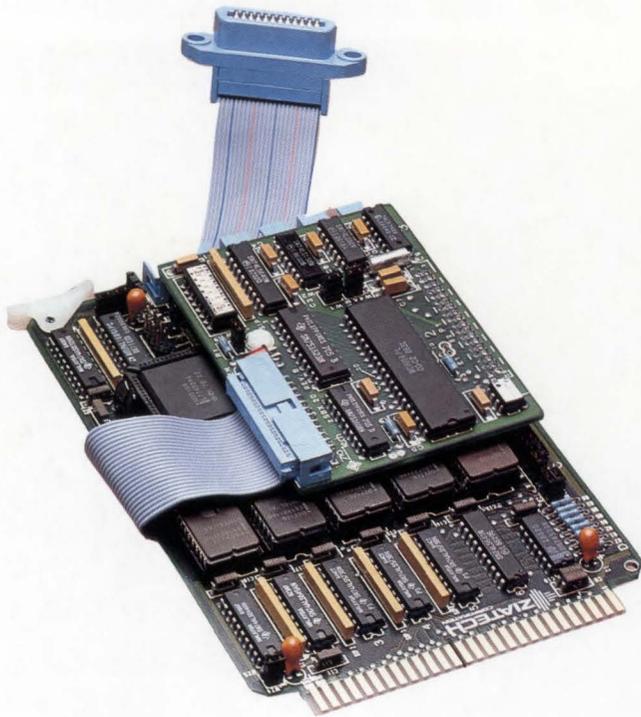
INSTALL.488

INSTALL.488 is an installable driver like EZ.488, but offers more efficient language interfaces for C, Pascal, FORTRAN, and Assembly. It also allows existing application software written for IBM and National Instruments GPIB interfaces to work with Ziatech hardware.

LINK.488

LINK.488 drivers are linked directly to the user's application code, without the overhead of an operating system. This makes for even more efficient IEEE 488 operation and the highest performance. LINK.488 drivers support several versions of C, Pascal, and Assembly languages. Both controller and talker/listener versions are available.

For more information on EZ.488 and Ziatech's IEEE 488 product line, check box C on the return card.



Ziatech's SBC-IB Single Board GPIB Computer

New Single Board GPIB Computer

Ziatech's new SBC-IB combines the 16-bit processing power of an 80188-based STD Bus single board computer (SBC) with complete IEEE 488 (GPIB) hardware and software capability.

For Test Systems and Instruments

Designed for OEMs and end users building GPIB test systems and embedded instrument controllers, the SBC-IB is available in three models. The Model 14 uses the ZT 8814 SBC with the 80188 at 5 MHz. The Model 15 uses the ZT 8815 SBC with the 80188 at 8 MHz, while the Model 30 gives GPIB capabilities to Ziatech's ZT 8830 Intelligent Control Processor.

Low Cost, Small Package

All the SBC-IB models are ideally suited for applications requiring real-time performance and high-speed programmable GPIB I/O. The SBC-IB provides these features at a low cost and in a very small package.

Software Support

Application software can be developed for the SBC-IB using Ziatech's Level 1 Development System. Two software driver packages are also available to simplify the implementation of GPIB instrument control: a talker/listener driver set for use in embedded device applications, and a controller set for controlling other instruments and devices.

For more information on the SBC-IB, check box D on the return card.

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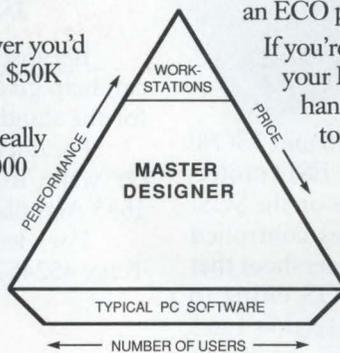
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NCR keeps raising the standards for SCSI.

Finally, a cure for SCSI headaches.

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

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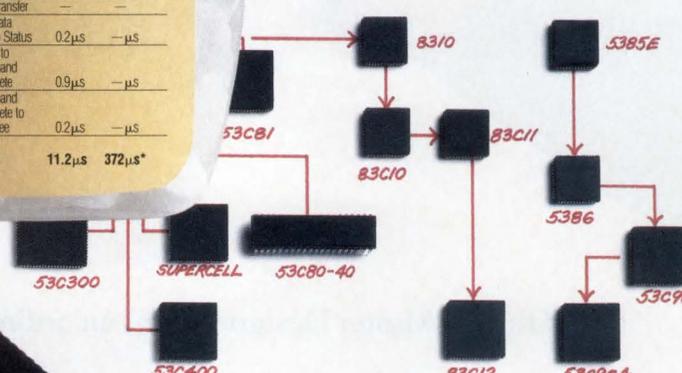
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The NCR 5380 and 53C90 families give you ESD protection up to 10,000 volts on the SCSI bus. NCR also provides controlled fall times to reduce the undershoot that could cause other CMOS chips to latch-up. Controlled assertion rates also reduce generated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

A big, well-connected family.

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

SCSI Bus Phase Overheads			
Command	SCSI Bus Sequences	53C90	Competitor
Wait for Select and Receive	Selection to ID message	0.7 μ s	— μ s
	ID message to 1st CDB	0.7 μ s	— μ s
	1st CDB to Disconnect message	2.6 μ s	— μ s
	8th CDB to Disconnect message	0.9 μ s	— μ s
	Disconnect message to Bus Free	0.2 μ s	— μ s
Reselect and Transfer	Reselection to ID message	4.2 μ s	— μ s
	ID message to 1st Data Byte	0.6 μ s	— μ s
	Data Transfer	—	—
	Last Data Byte to Status	0.2 μ s	— μ s
	Status to Command Complete	0.9 μ s	— μ s
	Command Complete to Bus Free	0.2 μ s	— μ s
Total SCSI Bus Overhead Time		11.2 μs	372 μs*



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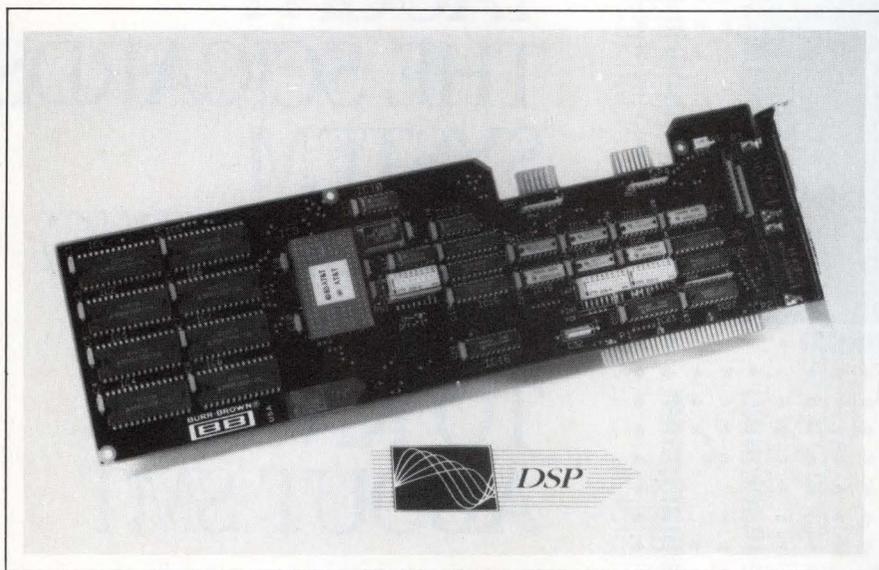


NCR Microelectronics Division

*Electronics Magazine August 20, 1987 Pg. 65

NEW PRODUCTS

COMPUTERS & PERIPHERALS



DSP BOARD

- Based on AT&T's DSP32 digital signal processor
- Software includes a C compiler operating under MS-DOS

The DSPeet digital signal-processing board for the IBM PC contains an AT&T WE DSP32 floating-point processor, 64k bytes of RAM, and buffered serial I/O ports. It can implement FIR (finite impulse response) filters at a rate of 250 nsec/tap and perform a 1024-point complex FFT in 20 msec. The board transfers data across the parallel IBM PC bus or over a high-speed

serial bus. By using the multiple-arithmetic-unit architecture and pipeline data processing available in the WE DSP32 chip, the board can do floating-point calculations at a rate of 8 million/sec. AT&T support tools include an assembler/linker, a simulator, and a C compiler operating under MS-DOS. The simulator is a debugging facility that allows access to all registers and memory. \$995.

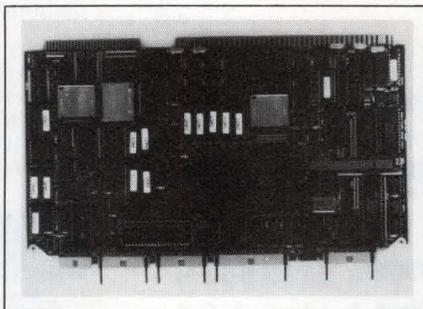
Burr-Brown Corp., Applications Engineering, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TLX 666491.

Circle No 370

1-BOARD COMPUTER

- Uses an 8-MHz 80286 with memory management for Multibus
- 100% software compatible with Intel's SBC 286/12

The CD21/8286 single-board computer with 2M or 4M bytes of zero-wait-state, dual-port RAM is designed for an 8-MHz 80286 μ P. The Multibus board provides memory management and is 100% software compatible with Intel's SBC 296/12. It includes interfaces for an 80287 coprocessor, an 82258 DMA control-



ler supporting three direct and eight multiplexed channels, four serial I/O channels, a synchronous or asynchronous LBX interface, and an SBX connector. It also includes

two 28-pin EPROM sockets, a parallel I/O port, programmable timers, and Multibus interface and priority interrupt logic. One of the four I/O ports can be configured as either an RS-232C or an RS-422/449 port. RMX86 and RMX286 operating systems are available. 2M-byte version, \$2035; 4M-byte version, \$2980 (100).

Central Data Corp., 16023 Newton Dr, Champaign, IL 61821. Phone (800) 482-0315; in IL, (217) 359-8010. TWX 910-245-0787.

Circle No 371



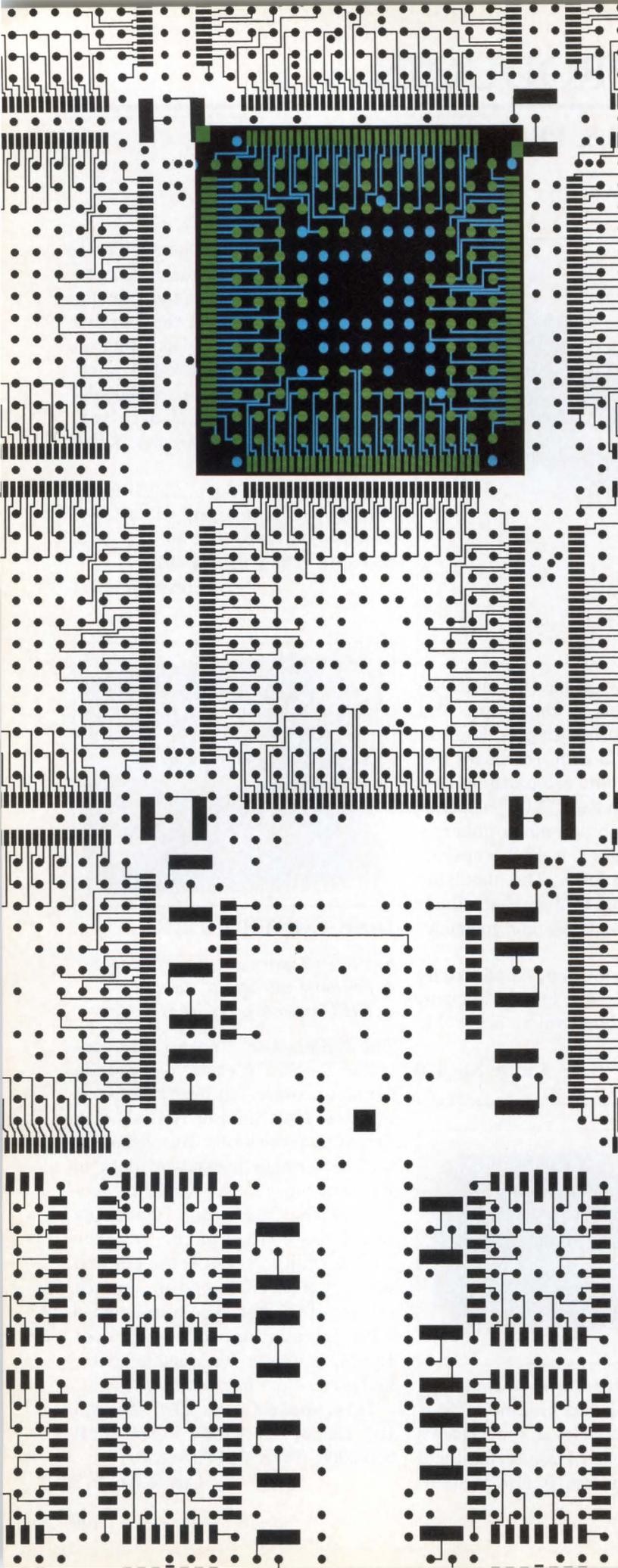
DISK CONTROLLER

- For Sun workstation interfaces
- Formats packets of data in FIFO memory before transfer

The V/SMD 4400 Phoenix disk controller for Sun workstations and file servers provides an interface for as many as four SMD or SMD-E disk drives. A proprietary Buspacket interface formats packets of data in FIFO memory before acquiring control of the VME Bus. Once the board has control of the bus, the FIFOs empty as fast as the bus and memory allow, followed by a quick release of the bus. The board comes with installation software, boot ROMs, a driver for queuing data, and a run-time formatter. \$3350.

Interphase Corp., 2925 Merrell Rd, Dallas, TX 75229. Phone (214) 350-9000. TWX 910-997-6245.

Circle No 372



WE'VE TAUGHT THE SCICARDS[®] SYSTEM EVERYTHING YOU NEED TO KNOW ABOUT SMT

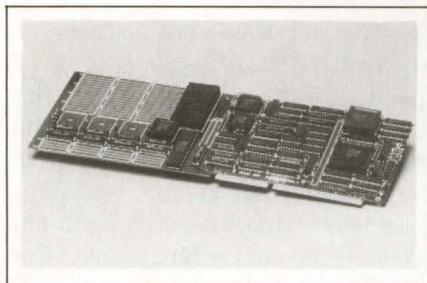
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CIRCLE NO 220



GRAPHICS BOARD

- Based on National's Advanced Graphics Chip Set
- Reaches 1600x1280-pixel resolution, using IBM PC/AT

Based on National's Advanced Graphics Chip Set, the Ultra 2000BW graphics board for the IBM PC/AT achieves a standard viewable resolution of 1600x1280 pixels, expandable to 2048x1536 pixels. It also handles addressable resolutions of 2048x2048 pixels/plane. The board can support as many as three additional memory planes that are stored off screen. According to the

vendor, it has a 160M pixel/sec fill rate, an 80M pixel/sec bit/blt (bit-block transfer) rate, and a 10M-pixel/sec draw rate in any direction with solid or patterned lines, as well as 128k bytes of EPROM and 2M bytes of program memory. Standard unit with 1600x1280-pixel resolution, \$1595.

Informations Now Inc, 6915 Hightech Dr, Midvale, Utah 84047. Phone (801) 561-1100. TLX 4992230.

Circle No 373

MODEM

- Complies with CCITT V.33 and V.29 standards
- Uses trellis-coded modulation and features error correction

The 2362 leased-line modem complies with the CCITT V.33 and V.29 standards. It operates at speeds from 4800 to 14.4k bps. When the modem is in V.33 operating mode,

the data rates are 14.4k bps and 12k bps. At these speeds, the modem uses error-correction coding and an 8-state trellis-coded modulation to provide 99.99% error-free transmission. When the modem operates in V.29 mode, the data rates are 9600, 7200, and 4800 bps. The unit employs quadrature amplitude modulation and V.29 speeds. You can obtain an optional 4- or 6-channel time division multiplexer (TDM), all of whose channels feature asynchronous to synchronous conversion. You can obtain the modem as a stand-alone unit or in a card version, and you can also order an enclosure that accommodates as many as 16 modem cards. Stand-alone unit, \$3195; card version, \$2915; 4-channel TDM unit, \$3795; 6-channel TDM unit, \$3995.

Codex Corp, Maresfield Farm, 7 Blue Hill River Rd, Canton, MA 02021. Phone (617) 364-2000.

Circle No 374

WINS/Streams.™ The natural solution to UNIX connectivity.

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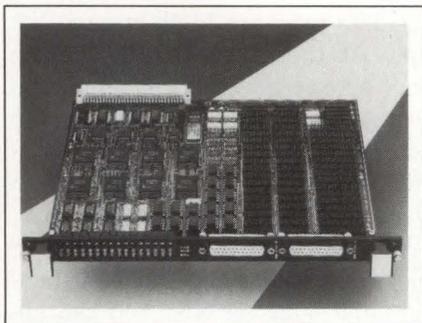
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your business card. The Wollongong Group, Inc., 1129 San Antonio Road, Palo Alto, Ca. 94303.

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SERIAL I/O BOARD

- Provides 16 serial I/O ports for VME Bus systems
- Has drivers for the OS-9/68000 operating system

The VME-68500-SI double-Euro-card VME Bus board provides 16 independent serial I/O ports that conform to either the RS-232C,

RS-423, and V.24 specifications or to the RS-422, RS-485, and V.11 specifications. Employing the RS-485 capability, you can use the board to configure low-cost LANs over more than 1000m of cable. Each port connects to a 25- or 15-pin D connector via a ribbon cable. The leadout via these ribbon-cable connections matches the DTE (data-terminal equipment) or DCE (data-communication equipment) pinouts of the relevant EIA and ISO standards. You can mount 25-pin D connectors via the board's front panel. Front-panel LEDs indicate TX-data and RX-data activity, as well as the "busy" status of each serial port. Software drivers for use under the OS-9/68000 operating system are available. DM 2480.

EKF Elektronik GmbH, Weidekampstrasse 1A, 4700 Hamm 1, West Germany. Phone (02381) 12630. TLX 828621.

Circle No 375

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AMCOs' BMI Motorized Impeller Blower

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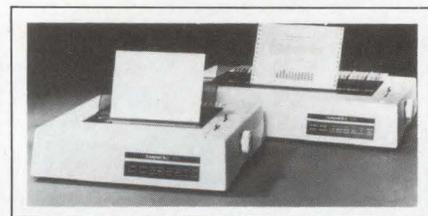
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FAX: 312-671-9469



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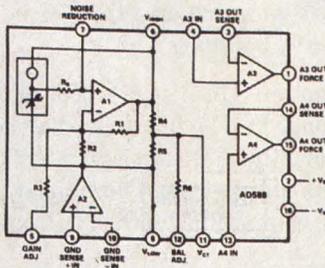
PRINTERS

- Print 200 cps in draft-quality dot-matrix mode
- Perform line, block, and dot-character graphics

The Models 4/20 and 4/21 dot-matrix printers provide draft-quality printing at 200 cps. The Model 4/20 is an 80-column printer, and the Model 4/21 is a 136-column printer. They accomplish letter-quality printing at 40 cps and perform line, block, and dot-character graphics. Variable character sizes and double-width horizontal spacing are standard features, along with variable line spacing under DIP-switch control. The dot-graphics resolution is 240 dots/in. horizontally and 72 dots/in. vertically. Twenty fonts are resident on

FEATURES

Low Drift - 1.5ppm/°C
 Low Initial Error - 1mV
 Pin-Programmable Output
 +10V, +5V, ±5V Tracking, -5V, -10V
 Flexible Output Force and Sense Terminals
 High Impedance Ground Sense
 Machine-Insertable DIP Packaging
 Guaranteed Long-Term Stability - 25ppm/1000
 Hours



AD588 Functional Block Diagram

PRODUCT DESCRIPTION

The AD588 represents a major advance in the state-of-the-art in monolithic voltage references. Low initial error and low temperature drift give the AD588 absolute accuracy performance previously not available in monolithic form. The AD588 uses a proprietary ion-implanted buried zener diode, and laser-wafer-drift-trimming of high stability thin-film resistors to provide outstanding performance at low cost.

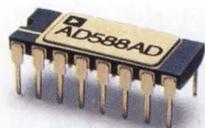
The AD588 includes the basic reference cell and three additional amplifiers which provide pin-programmable output ranges. The amplifiers are laser trimmed for low offset and low drift and maintain the accuracy of the reference. The amplifiers are configured to allow Kelvin connections to the load and/or boosters for driving long lines or high-current loads, delivering the full accuracy of the AD588 where it is required in the application circuit.

The low initial error allows the AD588 to be used as a system reference in precision measurement applications requiring 12-bit absolute accuracy. In such systems, the AD588 can provide a known voltage for system calibration in software and the low drift allows compensation for the drift of other components in a system. Manual system calibration and the cost of periodic recalibration can therefore be eliminated. Furthermore, the mechanical instability of a trimming potentiometer and the potential for improper calibration can be eliminated by using the AD588 and autocalibration software.

PRODUCT HIGHLIGHTS

1. The AD588 offers 12-bit absolute accuracy without any user adjustments. Optional fine-trim connections are provided for applications requiring higher precision. The fine-trimming does not alter the operating conditions of the zener or the buffer amplifiers and thus does not increase the temperature drift.
2. Long-term stability is excellent and the CD and TD versions are 100% tested and guaranteed for 25 parts-per-million stability in a 1000-hour period.
3. Output noise of the AD588 is very low - typically 6µV p-p. A pin is provided for additional noise filtering using an external capacitor.
4. A precision ±5V tracking mode with Kelvin output connections is available with no external components. Tracking error is less than one millivolt and a fine-trim is available for applications requiring exact symmetry between the +5V and -5V outputs.
5. Pin strapping capability allows configuration of a wide variety of outputs: ±5V, +5V & +10V, -5V & -10V dual outputs or +5V, -5V, +10V, -10V single outputs.

FOR THE WORLD'S MOST ACCURATE MONOLITHIC REFERENCE, REFER TO THIS PAGE.



If the voltage references you've been using have forced you to choose between low initial error and low drift, we'd like to refer you to our new AD588. With only 1mV of initial offset and 1.5ppm/°C of drift over temperature, it offers the best absolute accuracy possible in a monolithic reference.

This exclusive combination provides a range of user-programmable voltage outputs. You can choose from single +10V, +5V, -10V, and -5V ranges, simultaneous outputs of +10V and +5V, or -10V and -5V, or even a ±5V tracking range.

All of this is available with typical long-term stability of 15ppm, with selected versions tested for 1,000 hours and certified to be less than 25ppm. And you can get the AD588 for about half the cost of similar hybrid or in-house designs. Prices start at \$12.75 in 100s, to be exact.

For the most accurate reference on the AD588, call Applications Engineering at (617) 935-5565, Ext. 2628 or 2629. Or write to Analog Devices, P.O. Box 9106, Norwood, MA 02062-9106.



Analog Devices, Inc., One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106; Headquarters: (617) 329-4700; California: (714) 641-9391, (619) 268-4621, (408) 559-2037; Colorado: (303) 590-9952; Maryland: (301) 992-1994; Ohio: (614) 764-8795; Pennsylvania: (215) 643-7790; Texas: (214) 231-5094; Washington: (206) 251-9550; Austria: (222) 885504; Belgium: (3) 237 1672; Denmark: (2) 845800; France: (1) 4687-34-11; Holland: (1620) 81500; Israel: (052) 28995; Italy: (2) 6883831, (2) 6883832, (2) 6883833; Japan: (3) 263-6826; Sweden: (8) 282740; Switzerland: (22) 31 57 60; United Kingdom: (932) 232222; West Germany: (89) 570050

plug-in cartridges or disk and are downloaded into the printer. The printers are compatible with IBM graphics printers and the Epson FX-80. Model 4/20, \$645; Model 4/21, \$899.

Honeywell Bull Inc, 300 Concord Rd, Billerica, MA 01821. Phone (617) 671-2517.

Circle No 376

Q-BUS COMPUTERS

- *Runs PDP-11 operating system*
- *Has as much as 4M bytes of on-board memory*

Based on DEC's J11 μ P and an optional FPJ11 floating-point accelerator, the SBCM80 and SBCM90 Q-bus single-board computers are fully compatible with PDP operat-

ing systems and software—for example, RSX, RSTS, RT-11, Unix, DSM, BOS, and TSX. They plug directly into standard 22-bit Q-bus backplanes and are downward compatible with the 16- and 18-bit LSI-11 bus. The M80 runs at a clock frequency of 15 MHz, and the M90 runs at a clock frequency of 18.5 MHz. Both boards are available with 1M to 4M bytes of zero-wait-state, parity-checked dynamic RAM. You can expand the memory of the 1M-byte versions to 4M bytes with off-board memory. The boards support normal- and block-mode DMA transfers between the on-board dynamic RAM and other Q-bus modules. Additional onboard facilities include four DLV11-J compatible serial I/O lines, space for 32k bytes of bootstrap EPROM, and a real-time clock. Most of the board's functions are software configurable via EEPROM, and the bootstrap firmware allows you to sequence through as many as six boot devices during system initialization. M80 with 1M-byte dynamic RAM, £2500; M90 with 4M-byte dynamic RAM £5150 (50).

Mentec Computer Systems Ltd, Sandyford Industrial Estate, Leopardstown Rd, Foxrock, Dublin 18, Ireland. Phone 952316. TLX 93309.

Circle No 377

Model CPU20 with Dual-Ported, One kbyte, SRAM Mail Box for Multiprocessor Applications

Standard Features

- 32 Bit-Wide Address & Data Range.
- Clock Rates = 12.5 & 16.
- One Mbyte (4 Mbyte) DRAM with Parity Option.
- One Mbyte EPROM Space.
- SCSI Interface.
- Two Serial Ports
 - RS 232C
- One Parallel Port
 - 24-Bit Counter/Timer
- NOVRAM
 - An SRAM that saves special or user-definable variables, even at Power Fail or Power Down.

Special Features

- Four LEDs.
- Four-Digit Programmable Alphanumeric Display.
- Four Soft Touch Control Buttons with LEDs.
- EPROM Space = One 32-Pin Socket.

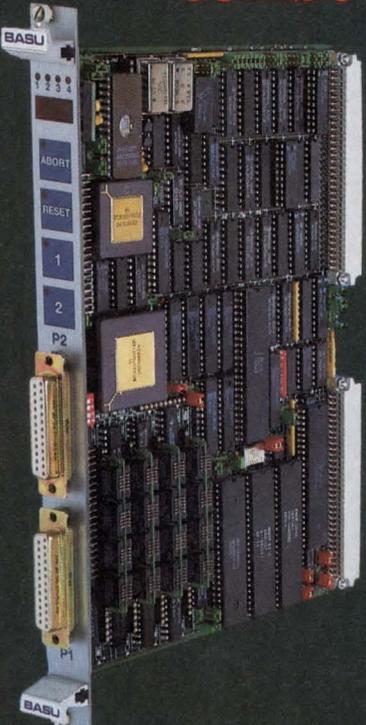
Marketed in the US by
Dage Precision Industries Inc.
PO Box 120A, Santa Clara, Ca 95052
Ph. (408) 727-1932

European Headquarters
MicroSys GmbH, Anzinger Str. 1
D-8000 Munich 80, Ph. (89)63801-0
TLX 5213288 mibad

Ask about our soon-to-be announced CPU21 & 22 (68020 w/Dual Ported SRAM or DRAM)

BASU

NEW 68020/SCSI Combo



Options

FPU (MC68881) & PMMU Piggy Back

Operating Systems

OS-9	(*Microware)
PDOS	(*Eyring)
UNIPLUS+	(*Unisoft)

VMEbus

PARALLEL SYSTEM

- *Processes data at 4 to 20 MIPs*
- *Bus has a data-transfer rate of 100M bytes/sec*

The Multimax 310 modular parallel-processing system delivers 4 to 20 MIPS. You can configure the system, using 16M to 64M bytes of shared memory, a streaming cartridge-tape drive, and from 300M bytes to 4.8G bytes of disk capacity. According to the manufacturer, its Unix-based UMax 4.2 and UMax V operating systems allow the 310 to take full advantage of the power of parallel processing. An entry-level

Grayhill shrinks the I/O module

to save you space, money, and problems

This new series of space-saving I/O modules for control applications measures 0.40" deep and 1.00" high, compared to 0.60" and 1.25" for "standard" models, and reduces the length of a 16-module rack by 4 inches! (The wide side is the same 1.70" as standard modules, for plug compatibility.)

Grayhill mini-modules consume 30% less power than their big brothers, and offer immunity from false triggering caused by electrical transients (per IEEE-472). Using SMT construction, Grayhill shrinks the package, yet upgrades performance even compared to its own standard modules, much less anyone else's. AC output units have lower leakage current, DC output units offer faster switching, and AC input modules have a higher input impedance.

The new mini-modules come in all standard configurations, at pricing comparable to standard-size I/O modules.



They plug into 16 module racks without screws; a hold-down strip keeps them in place. Surface-mount LEDs with writing space provide status and function indication.

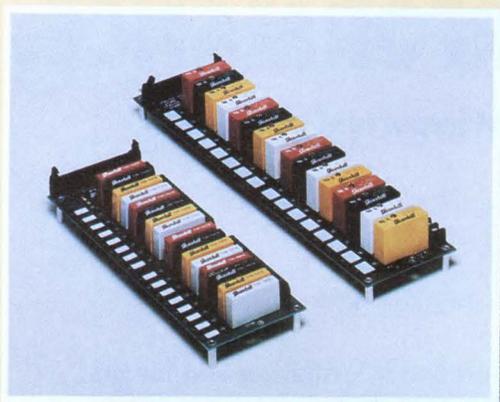
Using the new modules saves you cost at least four ways—you use a smaller rack, a smaller power supply, a smaller

enclosure, and you save the labor of screwing modules into place. And you get better performance besides.

What else could you ask for? How about local availability from Grayhill distributors worldwide! You get that too. So now your next step is send or call for free literature. Do it today.

COMPARISON CHART

PHYSICAL CHARACTERISTICS	STANDARD I/O MODULES	MINI I/O MODULES
Module dimensions	0.60" x 1.70" x 1.25	0.40" x 1.70" x 1.00
16-position rack length	14"	10"
Installation	Individual screw-down	Hold-down strip
ELECTRICAL CHARACTERISTICS		
Power consumption/ module-AC output	18 milliamps	12 milliamps
Pass IEEE-472	No	Yes
Switching speed—DC output	75 μ s turn on 500 μ s turn off	20 μ s turn on 40 μ s turn off
Input impedance—AC input	14K Ohm (120 VAC) 45K Ohm (240 VAC)	22K Ohm (120 VAC) 60K Ohm (240 VAC)



Grayhill
INC.

561 Hillgrove Avenue, P.O. Box 10373
LaGrange, Illinois 60525-0373 USA
Phone: (312) 354-1040 FAX: (312) 354-2820
TLX or TWX: 190254 GRAYHILL LAGE

configuration, which operates at 4 MIPS, includes 16M bytes of memory, 300M bytes of disk capacity, a tape cartridge, and an Ethernet interface. An 11-slot Nanobus backplane transfers data at 100M bytes/sec. The modular parallel-processing boards are based on National's NS32032 and NS32332 μ Ps, which can support as many as 200 users. From \$89,000 to \$500,000. Delivery, 60 days ARO.

Encore Computer Corp, 257 Cedar Hill St, Marlborough, MA 01752. Phone (617) 460-0500.

Circle No 378

BREAKOUT BOX

- Monitors 15 RS-232C lines with red and green LEDs
- Data lines illuminate the LEDs

The Easy Bob Model 725 breakout box for monitoring RS-232C lines has two 3-in. ribbon cables with



dual-gender DB25 connectors for easy insertion into an RS-232C line. The box monitors 15 lines with red and green LEDs. Positive voltages illuminate the red LEDs, and negative voltages illuminate the green LEDs. One spare LED set (red and green) is positioned at the top center of the unit to monitor lines other than those with dedicated LEDs. You can enable the 25 monitor points, using 25 DIP switches—one for each line of the connector. Each point has a socket which accepts a jumper wire to configure different

interconnections. The unit requires no power or batteries; the voltage on the data lines illuminates the LEDs. It comes complete with jumper wires and an operator's manual. \$99.

Beckman Industrial Corp, 3883 Ruffin Rd, San Diego, CA 92123. Phone (619) 495-3224.

Circle No 379

CONTROLLER BOARD

- For IBM PS/2, Models 50, 60, 80, and compatibles
- Provides 10M-byte/sec DMA transfer rate

You can use the ACB-2610 controller board for the ST412/506 MFM hard-disk-controller board with the IBM PS/2 Models 50, 60, 80, or a compatible computer. It features 1:1 sector interleaving and a host DMA transfer rate of 10M bytes/sec. The board runs with MS-DOS, OS/2, Xenix,

PSR/NSR: THE LITTLE SWITCHING REGULATORS WITH THE GREAT PERFORMANCE.



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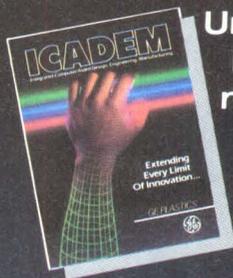
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GE Plastics

and Unix operating systems. At the heart of the controller is the company's AIC-011 programmable media sequencer and the AIC-6225 bipolar monolithic data separator. The board has a data-to-disk transfer rate of 5M bps with full-track buffering and a read-ahead cache. An optional 8k-, 32k- or 64k-byte buffer is available. \$160 (1000).

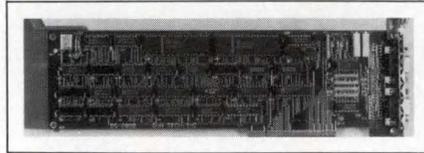
Adaptec Inc, 580 Cottonwood Dr, Milpitas, CA 95035. Phone (408) 432-8600.

Circle No 380

RS-422A BOARD

- Fit in IBM's PS/2 Models 50, 60, and 80 computers
- Two serial ports have data rates from 50 to 256k baud

The DS-2000 communications board for the IBM PS/2 Models 50, 60, and 80 has two independent RS-422A interfaces. Balanced-line serial driv-



ers and receivers provide communications to a limit of 4000 ft. D-9 connectors provide noise rejection when communications occur through shielded cables. A 16550 asynchronous communications element, containing a UART and a programmable baud-rate generator, controls each port. The transmission rate of each interface is individually programmable from 50 to 256k baud. The address and the interrupt used by each port are selectable. The possible addresses include COM1 through COM8, and the possible interrupts include IRQ3, IRQ4, IRQ7, and IRQ9. \$395.

Qua Tech Inc, 478 E Exchange St, Akron, OH 44304. Phone (216) 434-3154. TWX 510-101-2726.

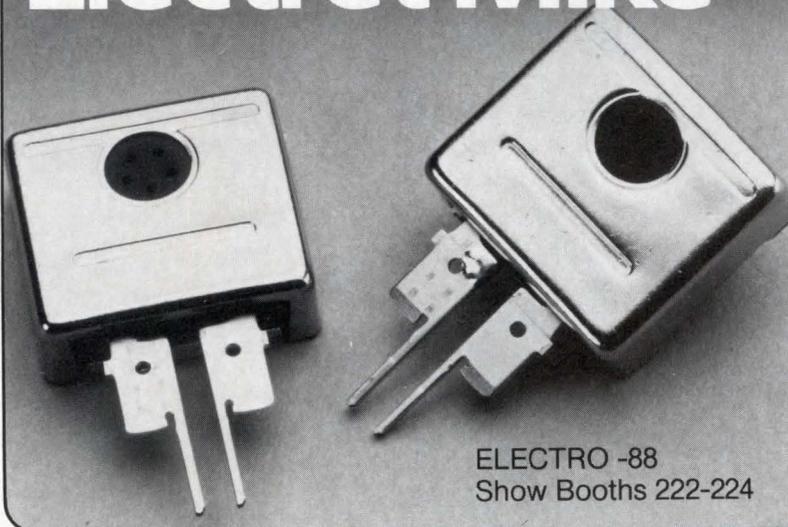
Circle No 381

68020 COMPUTERS

- 192 users at a time can use Unix System V-type system
- Mountable in 19-in. industry-standard racks

As many as 192 users can log onto the System 22 and System 22E 25-MHz 68020 computers at the same time. The systems run the C-XIX 3.0 operating system, the company's enhanced multiprocessor version of AT&T's Unix System V, Rel 3.0. The System 22 has 4M bytes of parity-checked RAM and is expandable to 96M bytes; the System 22E has 4M bytes of RAM with error-correction code and is expandable to 128M bytes. Using from one to 10 modules, you can expand the systems to achieve computing power as high as 32 MIPS. The systems also include a file I/O processor, a 180M-byte Winchester disk, a 60M-byte cartridge tape, a Centronics parallel port, a SCSI port, and an

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Sensitive
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The microphone can be used both for handsets and loud-speaking telephones. With only two terminal contacts it is designed for fast, automatic or manual assembly without soldering. Terminals can be supplied bent at 90° to adapt to your specific design.

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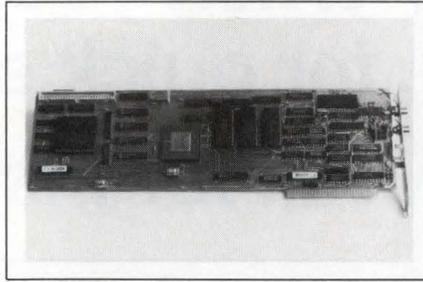
See us at the Electro Show, Booth #1456-1458.

COMPUTERS & PERIPHERALS

Ethernet port. The systems support bit-mapped graphics displays, using 68020 display processors. A 17-user System 22, \$19,000; a 70-user System 22E, \$56,000.

Counterpoint Computers, 2127 Ringwood Ave, San Jose, CA 95131. Phone (408) 434-0190. TLX 856884.

Circle No 382



board, debug monitor, documentation and Cross-Software and Simulator, \$2995; without Cross-Software and Simulator, \$2595.

Spectrum Signal Processing Inc, 460 Totten Pond Rd, Waltham, MA 02154. Phone (800) 323-1842; in MA, (617) 890-3400.

Circle No 383

DEVELOPMENT BOARD

- For Analog Devices' ADSP-2100 digital signal processor
- System comes with a debug monitor and simulator

The ADSP-2100 development system for the IBM PC, PC/XT, PC/AT, and compatible computers can develop software for the Analog Devices' ADSP-2100 Digital Signal Processor. It comes with a debug monitor and Analog Devices' Cross-Software and Simulator. The board comes with 8k×24 bits of program

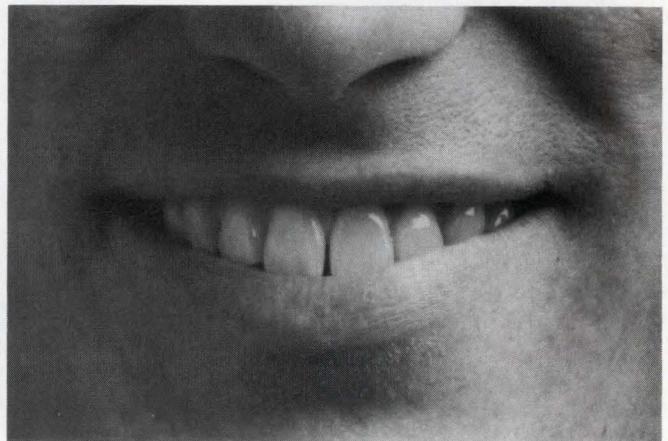
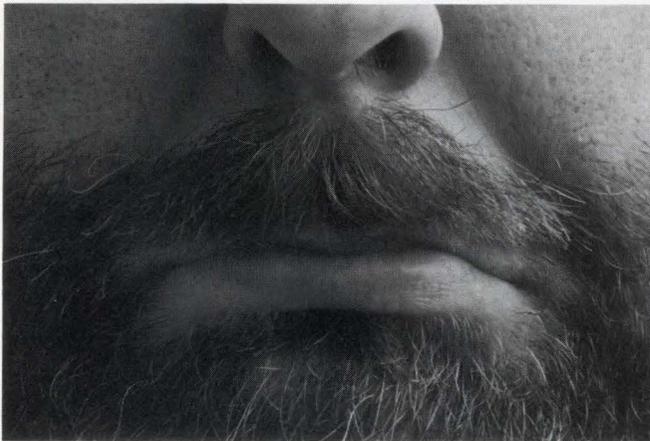
memory that has a 45-nsec access time. The program memory is expandable on board to 32k×24 bits, and the data memory is 8k×16 bits expandable off board to 16k×16 bits. Both memories are dual-ported to the PC. The system includes a 200-kHz, 12-bit A/D converter and a D/A converter. The converters can be clocked externally or from an onboard 16-bit timer running at 4 MHz. The debug monitor controls all of the board's functions, providing memory-access commands, register examination, breakpoints, and a Help facility. ADSP-2100, including PC plug-in

TRANSPUTER BOARDS

- Provide parallel processing for DEC MicroVax computers
- Compatible with Inmos' Micro-VMS tool-set software

Using the QT0 and QT4 Q-bus-compatible Transputer boards, you can add the parallel-processing power of Transputer arrays to MicroVax computers. The QT0 contains a single IMST212 Transputer that provides a bridge between the Q-bus and four Transputer links. Each link appears to the VAX as a separate

THEIR PROBLEM. OUR PROBLEM.



For years, metallurgists have known that pure-tin-plated board surfaces can grow nasty circuit-killing "tin whiskers" over time.*

Makes you wonder why some board suppliers would use pure tin and risk such failure in the first place.

Standard Logic wouldn't. Our boards have always used a lead-tin alloy for plating material. So tin whiskers wouldn't ever grow. And there'd never be a problem.

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So we're letting you know that Standard Logic is now delivering the highest-quality, whisker-free logic

cards in the packaging business.

45 different DIN-standard designs are available. They're compatible with the major bus interfaces and are the only ones with built-in decoupling capacitors.

Take advantage of this now and by next year maybe we'll be famous, too.

Write: Standard Logic Inc., 4940-A E. La Palma Ave., Anaheim, CA 92807. Or call 714/779-2897 today.

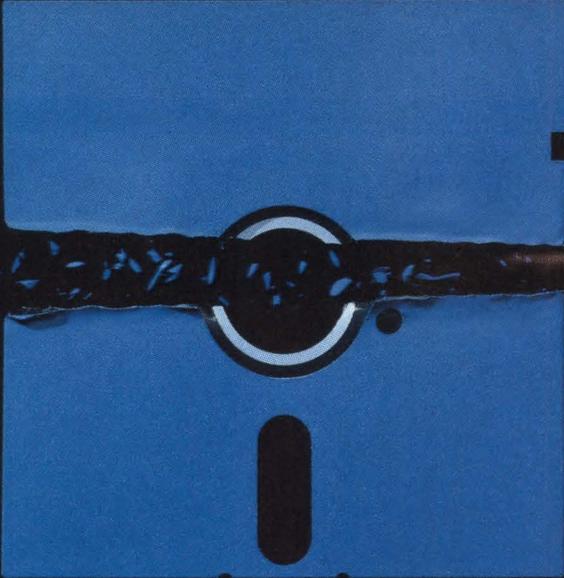


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*Learn more about the "tin whisker" problem. Write for free IEEE Spectrum article reprint.

CIRCLE NO 22



NEW AVOCET C™ FOR MICROCONTROLLERS— A BREAKTHROUGH IN SPEED AND QUALITY.

Introducing Avocet C™ Fast, *optimizing* cross-compilers that can cut microcontroller development time in half—without sacrificing code quality.

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That's why we spent two years field-testing and perfecting Avocet C for both speed and quality. We built in three separate phases of optimization—for object code tight enough for real applications. And we integrated Avocet C with an assembler package that's mature in its own right—not an afterthought. So you can still work magic at the bits-and-bytes level.

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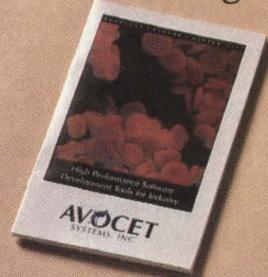
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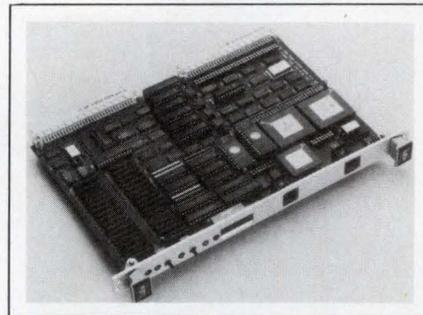
Avocet Systems, Inc., 120 Union Street
P.O. Box 490BP, Rockport, Maine 04856
*In Maine, or outside U.S., call (207) 236-9055
TLX: 467210 Avocet CI, FAX: (207) 236-6713
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DEC-standard device; DMA accesses over the Q-bus are accomplished via dual-port buffers. The Transputer links operate at data rates of 5M, 10M, or 20M bytes/sec. The IMST212 Transputer provides local intelligence for each link with independent subsystem control. The board comes with device-driver software and benchmark applications. Linked to the VAX via the QT0's Transputer links, one or more QT4 boards allow you to configure a Transputer array with the required topology. Each board houses as many as four IMST414 or four IMST800 32-bit Transputers, each provided with 1M byte of dynamic RAM. You can select the cycle time of the Transputers, and the board will accept the Inmos IMST800-30 Transputer without modification. To create a multiuser program-development environment, you can use the boards with the Inmos stand-alone Occam Micro-VMS tool

set. QT0 £1795; QT4 with IMST414 Transputer £3995.

Caplin Cybernetics Corp Ltd, 47 Cannon Drive, London E14 9SU, UK. Phone 01538 1716. Fax 01-538 4151.

Circle No 384



32-BIT CPU BOARD

- 25-MHz 68020 CPU and 1M byte of RAM for VME Bus
- Real-time processor with memory protection

The MZ 7122 32-bit CPU board for the VME Bus features a 25-MHz 68020 CPU, 1M byte of dual-ported RAM with parity, as much as 128k bytes of EPROM, two RS-232C ports, and a time-of-day clock with battery backup. It has a 32-bit master/slave interface to the VME Bus along with an interrupt handler, an interrupt generator, a mailbox interrupt, and controller functions

with 4-level arbitration. Its options include a VSB memory expansion interface, a 68851 paged-memory-management unit, and a 68881 or 68882 floating-point coprocessor. Software support for the board includes VRTX/32 Real-Time Executive from Ready Systems, OS-9 from Microware Systems, and PDOS from Eyring Research. \$2695.

Mizar Inc, 1419 Dunn Dr, Carrollton, TX 75006. Phone (800) 635-0200; in TX, (214) 446-2664. TWX 510-600-4272.

Circle No 385

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DN 4/28

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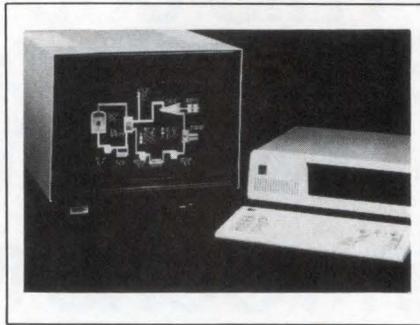


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EGA MONITOR

- Provides automatic sync from 20 to 33 kHz
- Preconverged CRT has trio dot pitch of 0.31 mm

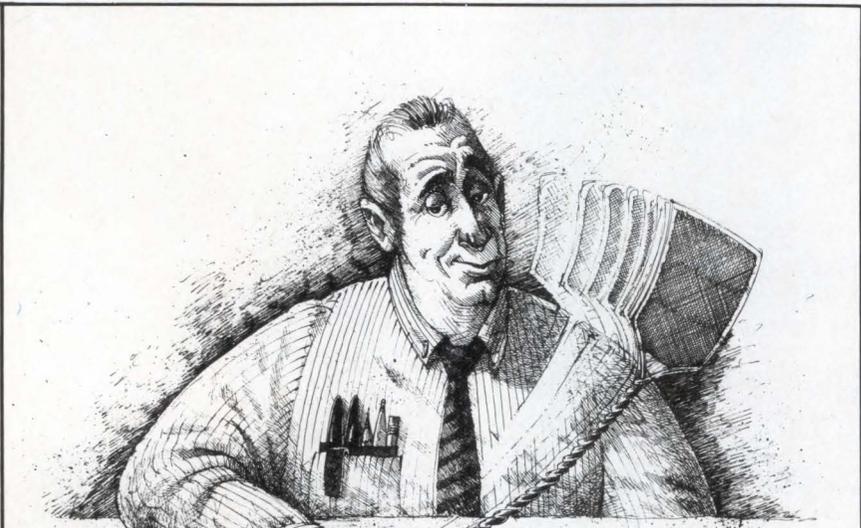
The EG2040 Model 1 19-in. monitor for the IBM PC/AT and compatible computers runs with an IBM EGA card or compatibles; it adjusts to



resolutions from 640x350 to 640x480 pixels as well as other resolutions in the 20- to 33-kHz range. The preconverged CRT has a trio dot pitch of 0.31 mm. The vertical scan frequency ranges from 40 to 100 Hz. The video bandwidth is 65 MHz and the user controls include power, brightness, and degaussing. The TTL inputs provide a color palette of 16 out of 64 colors. The monitor is available in a 19-in. metal enclosure or a RETMA standard 19-in. rack mount. From \$1587.

Colorgraphic Communications Corp., Box 80448, Atlanta, GA 30366. Phone (404) 455-3921.

Circle No 386



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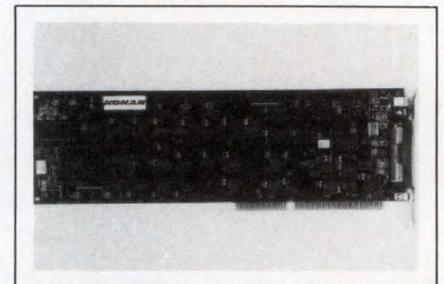
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CIRCLE NO 24



DISK CONTROLLER

- Achieves average access time of 3 msec
- Host-to-controller transfer rate is 4M bytes/sec

The Ten Time caching disk controller for the IBM PC, PC/AT, and compatible computers contains a cache RAM with battery backup that controls as many as two ST506/412 disk drives, achieving an average disk access time of 3 msec. The board also controls two floppy-disk drives. The caching algorithm produces 90 to 95% hits in most applications. Consequently, the effective transfer rate of all data requests is 4M bytes/sec. A zero-latency read allows the drive to start reading and transferring data immediately, regardless of which data sector the head lands on. \$595.

Konan Corp., 4720 S Ash Ave, Tempe, AZ 85282. Phone (602) 345-1300.

Circle No 387

Now it's safe to switch HI-506A-HI-509A MUXs.



MODEL	HI3-0506A-5	HI1-0506A-5	HI1-0506A-2	HI3-0507A-5	HI1-0507A-5	HI1-0507A-2	HI3-0508A-5	HI1-0508A-5	HI1-0508A-2	HI3-0509A-5	HI1-0509A-5	HI1-0509A-2
Channels												
Single Ended	16	16	16				8	8	8			
Differential				8	8	8				4	4	4
Temp Range (°C)	0/+75	0/+75	-55/+125	0/+75	0/+75	-55/+125	0/+75	0/+75	-55/+125	0/+75	0/+75	-55/+125
Package	28-Pin Plastic DIP	28-Pin CERDIP	28-Pin CERDIP	28-Pin Plastic DIP	28-Pin CERDIP	28-Pin CERDIP	16-Pin Plastic DIP	16-Pin CERDIP	16-Pin CERDIP	16-Pin Plastic DIP	16-Pin CERDIP	16-Pin CERDIP
Price	\$13.50	\$14.75	\$28.69	\$13.50	\$14.75	\$28.69	\$7.35	\$8.25	\$17.35	\$7.35	\$8.25	\$17.35

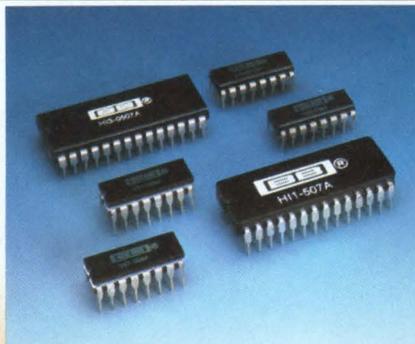
Drop-in replacements

Our new CMOS analog multiplexers are identical, drop-in replacements for the "other" HI-506A series parts. Same performance. Same pin-outs. Same dielectric isolation. Same circuit behavior. Same model numbers and data sheets.

Proven quality, fast delivery

We make these MUXs completely, from silicon to stock. We control production and quality throughout to make sure you get the parts you need when you need them.

*U.S. unit prices, in 100s.



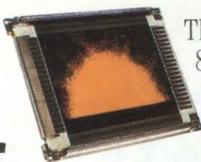
Key HI-506A/509A Features

- input overvoltage protection to 70Vp-p
- $\pm 15V$ signal range
- break-before-make switching
- $3.5\mu s$ max settling time (0.01%)

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DIM VIEW OF
ANYTHING ELSE.**



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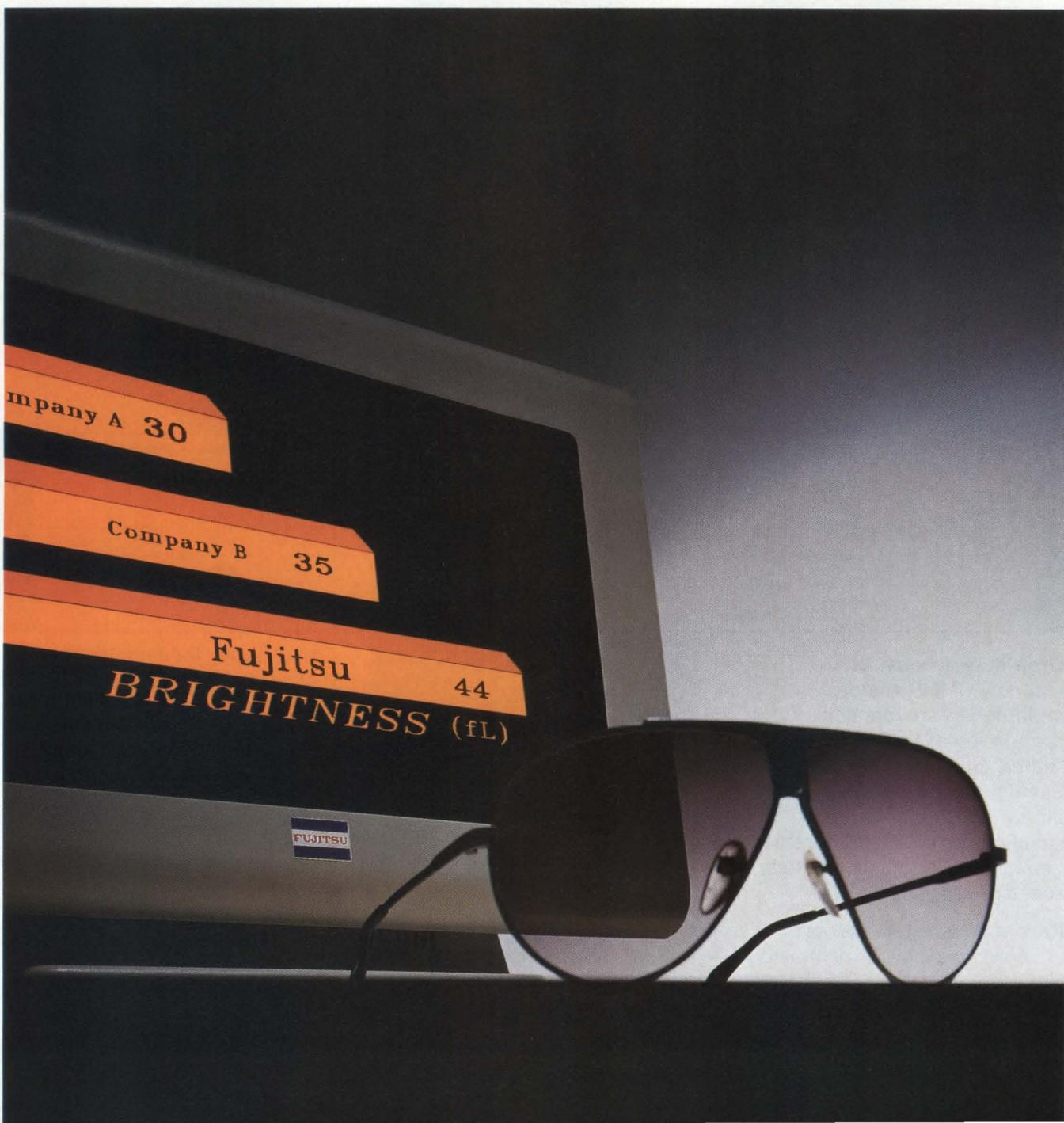
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CIRCLE NO 225



FUJITSU
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NEW PRODUCTS

COMPONENTS & POWER SUPPLIES

PROCESS INDICATOR

- Combines alarm and indicator in one unit
- Accepts a wide range of process-level input signals

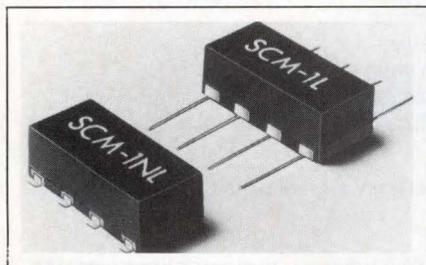
The Model 40235 is designed for applications where both an alarm and an indicator light are needed in the same panel space. Standard features include a metal 1/8-DIN case, a 0.56-in. LED display, 12 or 24V dc outputs for driving external transducers or 2-wire current transmitters, a relay output rated for 8A at 115V ac, and screw-terminal wiring connections. You can select common process-level signal inputs, such as 4- to 20-mA, 1 to 5V, or 0 to 10V. You can also choose the display offset (within ± 2000 counts) and the full-scale spans (10 to 2000). An extra right-hand digit (dummy zero) is available when needed to display in a count-by-10 mode. Front-panel



controls include pushbutton set-point display and setting, deadband range (0.1 to 10% of span), and zero and span adjustments. \$249.

Extech Instruments Corp, 150 Bear Hill Rd, Waltham, MA 02154. Phone (617) 890-7440.

Circle No 390



RF MIXERS

- Operate from 1 to 500 MHz
- -55 to +100°C temperature range

Offering a 1- to 500-MHz operating range, SCM-1 RF mixers work with a 7-dBm local-oscillator (LO) output and have a 6-dB conversion loss. LO to RF and LO to IF isolation measure 45 and 40 dB, respectively. The 1-dB compression point is 1 dBm. Two versions are available; the SCM-1L with leads, and the SCM-1NL without leads. Both have solder connections on the edge to im-

prove soldering reliability. Each unit is housed in a nonhermetic plastic-ceramic package that measures 0.8x0.4x0.3 in. Operating range is -55 to +100°C. \$2.49 (1000).

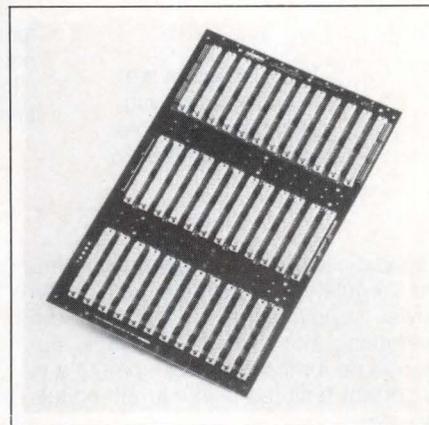
Mini-Circuits Lab, 2625 E 14th St, Brooklyn, NY 11235. Phone (718) 934-4500.

Circle No 391

BACKPLANE

- Compatible with both VME and Sun card cages
- Features a combined microstrip and stripline design

This 12-slot, 9U backplane meets all specifications for any Sunbus models requiring such a configuration. Based on transmission-line technology, the backplane is mechanically compatible with both VME and Sun card cages. It duplicates the Sun backplane and includes the signal



busing necessary to implement the Sun proprietary P2 bus. The 5-layer combination microstrip/stripline design provides high-performance operation as high as 40 MHz. Bus bars facilitate the power hook-up and disconnection. \$1275.

Dawn VME Products, 47073 Warm Springs Blvd, Fremont, CA 94539. Phone (415) 657-4444.

Circle No 392

How to turn the d-c you have into the d-c you want.

Pass it through a KEPCO/TDK 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).

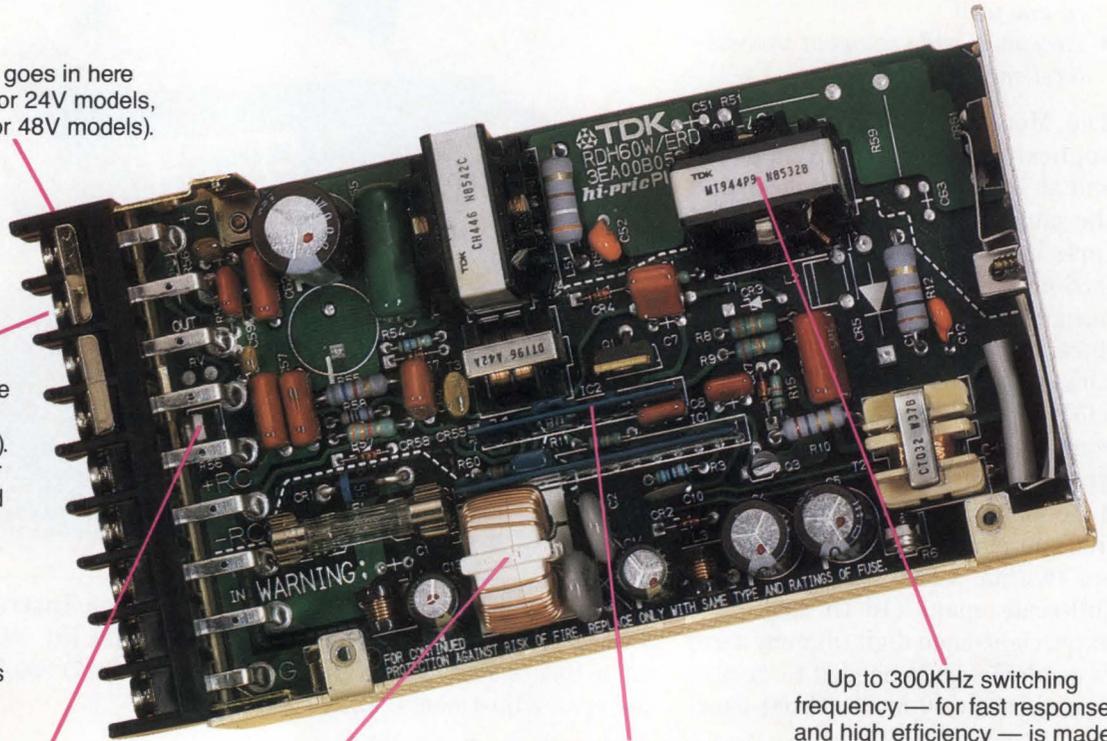
The input can be of either polarity, because the output is transformer-isolated from the input, and is fully floating off ground.

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.

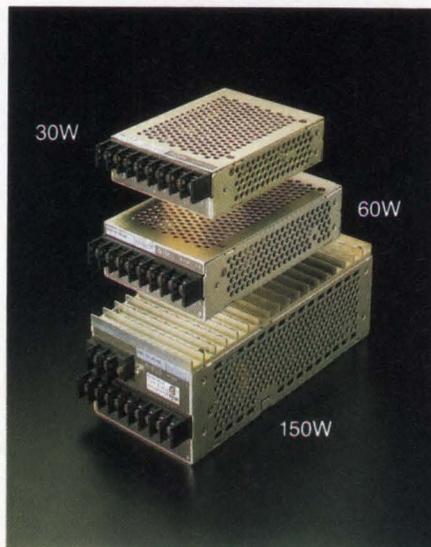
Up to 300KHz switching frequency — for fast response and high efficiency — is made possible by a new, very low-loss TDK ferrite.



The model shown is our ERD 15-10-48. Output is 15V/10A; input is 48V.

Kepeco 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. KRF-05, KEPCO, INC., 131-38 Sanford Avenue, Flushing, NY 11352 USA
(718) 461-7000 • TWX #710 582 2631
FAX (718) 767-1102.



COMPONENTS & POWER SUPPLIES



STEPPER MOTORS

- Provide 200 or 400 steps per revolution
- Holding torques range from 6.2 to 9.5 oz-in.

These high-resolution, 1.8°, size 11 stepper motors feature an excellent torque-to-size ratio. Holding torques range from 6.2 to 9.5 oz-in. Dynamic torques span 3.9 to 5.9 oz-in. and the standard accuracy ranges within $\pm 5\%$. These direct-drive motors feature ball-bearing construction and measure only 1.5 in. long by 1.067 in. wide. The motors deliver 200 or 400 steps per revolution in full- or half-step, bipolar or unipolar drive schemes. Special winding configurations and other custom modifications are available. From \$20. Delivery, 90 to 120 days ARO.

Clifton Precision, Litton Systems Inc, Box 160, Murphy, NC 28906. Phone (704) 837-5115. TWX 510-935-1068.

Circle No 393

PROTECTION DIODES

- Protect data buses against electrostatic discharges)
- Provide short-circuit protection for data lines

The TH6P04T6V5CL and TH6P05T25CL Transils, which feature eight bidirectional clamping diodes in a single 20-pin DIP, suit data-bus protection applications.

EDN April 28, 1988

SWITCH MODE POWER FIT FOR YOUR NEEDS

Case 21

750 Watts
5"x6.5"x10"
Single Outputs
Up to 5V 150A
15A Auxiliary Mag
Amp Outputs

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CIRCLE NO 25

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an inch...
and
**1200
WATTS**



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For compact high-current single and multiple output power supplies from 500 to 2200 watts, contact JETA.

See EEM pages D1706-1708

JETA

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CIRCLE NO 26

EASY

40-220 WATT POWER SUPPLIES ARE NOW EASY TO SELECT...

Simply find the output configuration you need. And call. It's that EASY.

WATTS	MAIN	CH 2	CH 3	CH 4	MODEL No.	TYPE
40	+5V/2.5A	+12V/2.0A	-12V/0.1A		RBT 41	PCB
60	+5V/5.0A	+12V/2.5A	-12V/0.5A		RBT 61	PCB
70	+5V/6.0A	+12V/2.5A	-12V/0.7A	-5V/0.7A	RBQ 71	PCB
135	+5V/15A	+12V/4.0A	-12V/0.7A	-5V/0.7A	RBQ 131	
135	+5V/15A	+15V/3.2A	-15V/0.7A	-5V/0.7A	RBQ 132	
135	+5V/15A	+12V/3.0A	-12V/0.7A	+24V/1.5A	RBQ 133	L BRACKET
135	+5V/15A	+15V/2.4A	-15V/0.7A	+24V/1.5A	RBQ 134	L BRACKET
175	+5V/20A	+12 or 15V/4A	-12 or 15V/3A	-5V/1.0A	RBQ 171	U CHANNEL
175	+5V/20A	+12 or 15V/4A	-12 or 15V/3A	+24V/1.5A	RBQ 173	U CHANNEL
220	+5V/25A	+12 or 15V/4A	-12 or 15V/3A	-5V/1.5A	RBQ 221	U CHANNEL
220	+5V/25A	+12 or 15V/4A	-12 or 15V/3A	+24V/3.0A	RBQ 223	U CHANNEL

EASY TO QUALIFY

- UL, CSA, IEC 380/VDE 0806
- Replaceable internal fuse
- Full output to 50°C
- FCC 20780 & VDE 0871 level A
- 115/230 VAC selectable input
- Full power convection cooled

IT'S EASY TO SEPARATE VENDORS.

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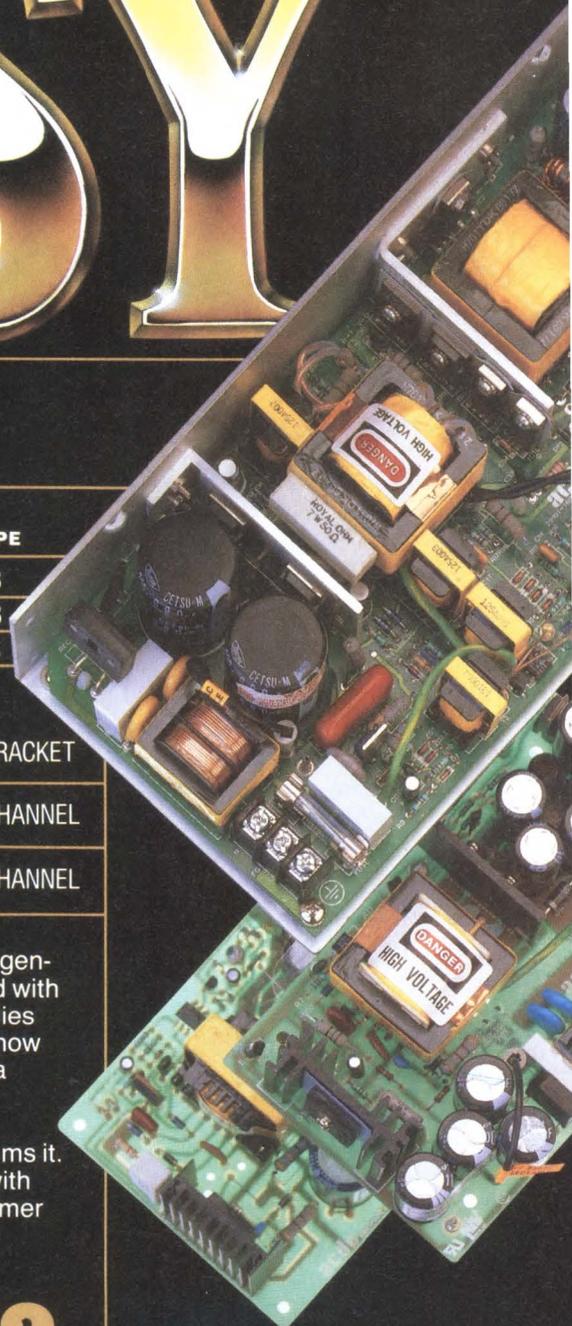
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acdc
electronics

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TEL: 619/757-1880. TLX: 350227. FAX: 619/439-4243



COMPONENTS & POWER SUPPLIES

The devices have breakdown voltages of 6.5 and 25V, respectively, and clamping voltages of 12 and 35V, respectively. At 5V, they have shunt capacitances of 500 and 300 pF, respectively. Their overload voltage rating is 25 kV. In addition to shunting the data bus with the protection diodes, the devices also provide protection against continuous short circuits on the lines. In the event of short circuits, the pin-to-die bonding wires within the package act as fusible links, which open circuit the line. TH6P04T6V5CL, \$5.50; TH6P05T25CL, \$5 (1000).

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

Circle No 394

DC/DC CONVERTERS

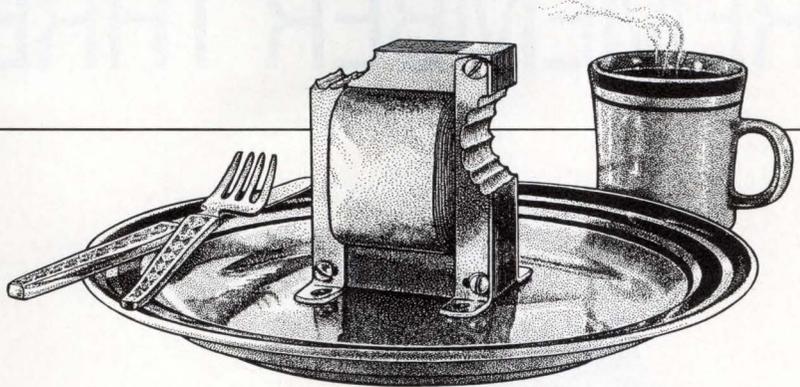
- Provide a minimum efficiency of 80%
- Line and load regulations are 0.2%

The XC Series dc/dc converters accept any input voltage between 24 and 72V dc and provide one of three outputs: 5V at 3A, 12V at 1.25A, or 15V at 1A. All three converters have an 80% (min) efficiency, even for 20% load levels. Key specifications include 0.2% for both line and load regulations, 30-mV output noise (p-p), 500V dc isolation, and -25 to +80°C operating range. Internal circuitry supplies 8 hours min short-circuit protection, and an internal thermal-limit circuit shuts a unit down when the case temperature exceeds the specified limit. The converters automatically restart when the temperature returns to normal. Filter circuits provide conducted-noise protection for both the input and the output. A 6-sided shielded case minimizes RFI problems. \$120.

Calex Mfg Co Inc, 3355 Vincent Rd, Pleasant Hill, CA 94523. Phone (415) 932-3911. TLX 338506.

Circle No 395

We eat conventional transformers for breakfast



With our advanced toroidal transformers, we offer a veritable menu of benefits for your state-of-the-art electrical designs and applications.

Our TOREMA toroids are lighter, quieter and smaller than traditional laminated transformers AND other toroids, too... food for thought when you're looking for exceptional technical and design advantages as well as significant savings in your finished product.

Contact us for more information on TOREMA toroidal transformers—we'll feed it to you in a hurry.

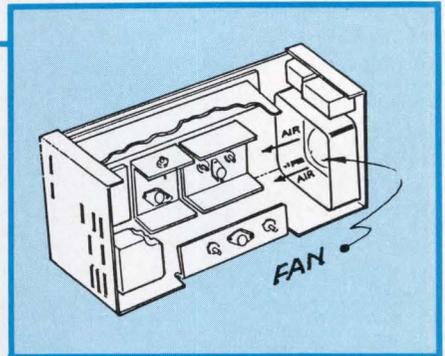
TOREMA
TRANSFORMERS

Torema U.S.A., Inc.
6699 Portwest Dr. / 130
Houston TX 77024
(713) 861-6643



CIRCLE NO 27

go the extra mile...
LOWER
component-to-ambient temperature gradient throughout entire product line.



JETA's hybrid thermal design ensures the lowest component-to-ambient temperature gradients to keep your products running cool, calm and collecting data.

This construction actually utilizes the power supply's chassis to function as a heat sink—the result of JETA's mechanical engineering emphasis. After all, with everyone using more or less identical electronic components, how else are you going to make a better box? By having more M.E.'s devoted to superior thermal management.

For cooler operating high-current single and multiple output power supplies from 500 to 2200 watts, contact JETA.

See EEM pages D1706-1708

JETA

POWER SYSTEMS, INC.

2675 Junipero Avenue ■ Signal Hill, CA 90806

Tel: 213/427-0095 ■ TWX: 510-101-1804 ■ FAX: 2134262417

CIRCLE NO 28

WHEN BUYING SWITCHES REMEMBER THREE THINGS.



C&K Components, The Primary Source Worldwide,[®] celebrates its 30th anniversary by expanding your sources for switches.

For toggle, rocker, slide, DIP and thumbwheel switches, your source is the original C&K Components, Inc.

For switchlocks, rotary and slide switches, your source is C&K Clayton Division.

For snap-acting and metal-cased control switches, your source is the new C&K/Unimax.

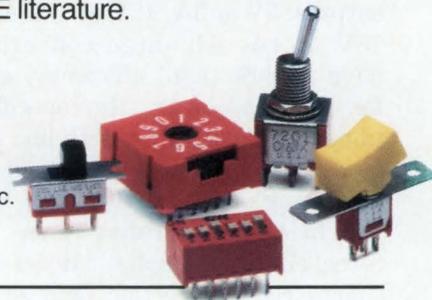
Whichever you choose, remember C&K gives you the broadest selection of switching configurations to meet a variety of changing needs plus quality, quantity, performance, delivery and low-cost.

Need proof? Just send us your specs and description of your application, we'll quickly send you a sample switch that fits your needs. Without charge or obligation.

Or, call for our FREE literature.

C&K[®]

C&K Components, Inc.
Newton, MA 02158
Tel. (617) 964-6400



C&K[®]

C&K Clayton Div.
Clayton, NC 27520
Tel. (919) 553-3131



C&K / Unimax[™]

C&K/Unimax
Wallingford, CT 06492
Tel. (203) 269-8701

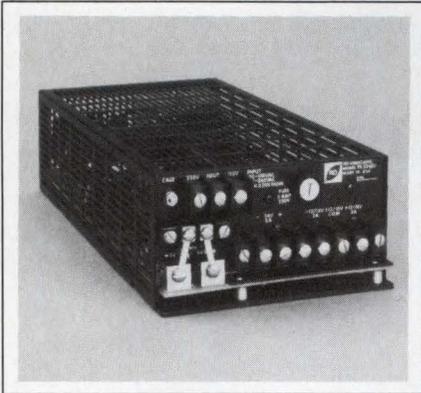


See us at ELECTRO, Booth #s 434-438

CIRCLE NO 212

EDN April 28, 1988

COMPONENTS & POWER SUPPLIES



POWER SUPPLY

- One output dedicated to disk-drive needs
- Includes self-recovering OVP on all outputs

The quad-output Model 524EU power supply employs a 50-kHz MOSFET design with independent magnetic amplifiers in the secondary windings. The supply outputs are 5V at 20A, 12V at 3A, -12V at 2A, and 24V at 2A (for disk drive applications). The secondary windings are adjustable to 15V at 2.5A and -15V at 1.5A. You can select input ranges of 105 to 130 or 198 to 265V ac. All outputs are current limited and have continuous overload, short-circuit, and overtemperature protection. Self-recovering overvoltage protection is provided on all outputs. The supply has no minimum load requirements and includes input protection that meets the IEEE-587 voltage transient test. Power-fail and logic-inhibit signals are available as options. From \$395.

RO Associates Inc, 246 Caspian Dr, Sunnyvale, CA 94088. Phone (408) 744-1450. TWX 910-339-9304.

Circle No 396

OSCILLATORS

- Suitable for use in military and avionics equipment
- Tolerance of ± 100 ppm over operating temperature range

The outputs of QC6111- and QC6112-Series surface-mount crys-



INTROL CORPORATION

647 W. Virginia St.
Milwaukee, WI 53204
Phone: 276-2937
Fax: 276-7026

LIBRARIES
UTILITIES
DEBUGGERS
MACRO ASSEMBLERS
MODULA-2 COMPILERS
C COMPILERS

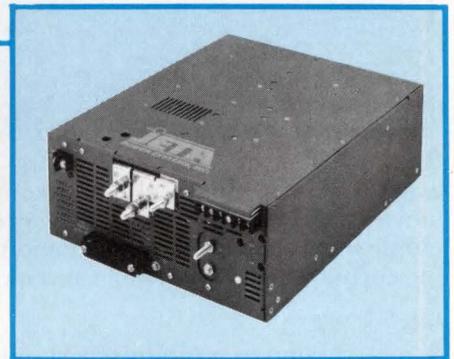
MAKE THE MOST EFFICIENT USE OF YOUR TARGET PROCESSORS' RESOURCES WITH INTROL CROSS DEVELOPMENT TOOLS.

■ TARGETS SUPPORTED:
6804 6805 6301/03 6801/03
6809 68HC11 68000/08/10/12
68020/30/881/851 32000/81/82

■ Available for the following hosts:
■ VAX ■ APOLLO ■ SUN
■ PC, XT, AT & COMPATIBLES
■ GOULD POWER NODE

CIRCLE NO 29

with 5 outputs...
to **2200 WATTS**



Main output to 300A. Our 2200 watt, UL/CSA/VDE/IEC compliant, power supply offers 1 to 5 outputs. Standard features include DC OK, FCC EMI filter, power fail, remote inhibit, remote margining, electronic soft start and more—many of which would be costly options elsewhere.

High reliability is derived from a reduced component count, high-voltage transistor V-I load reshaping for maximum SOA and careful thermal management to ensure the best operating environment for critical components.

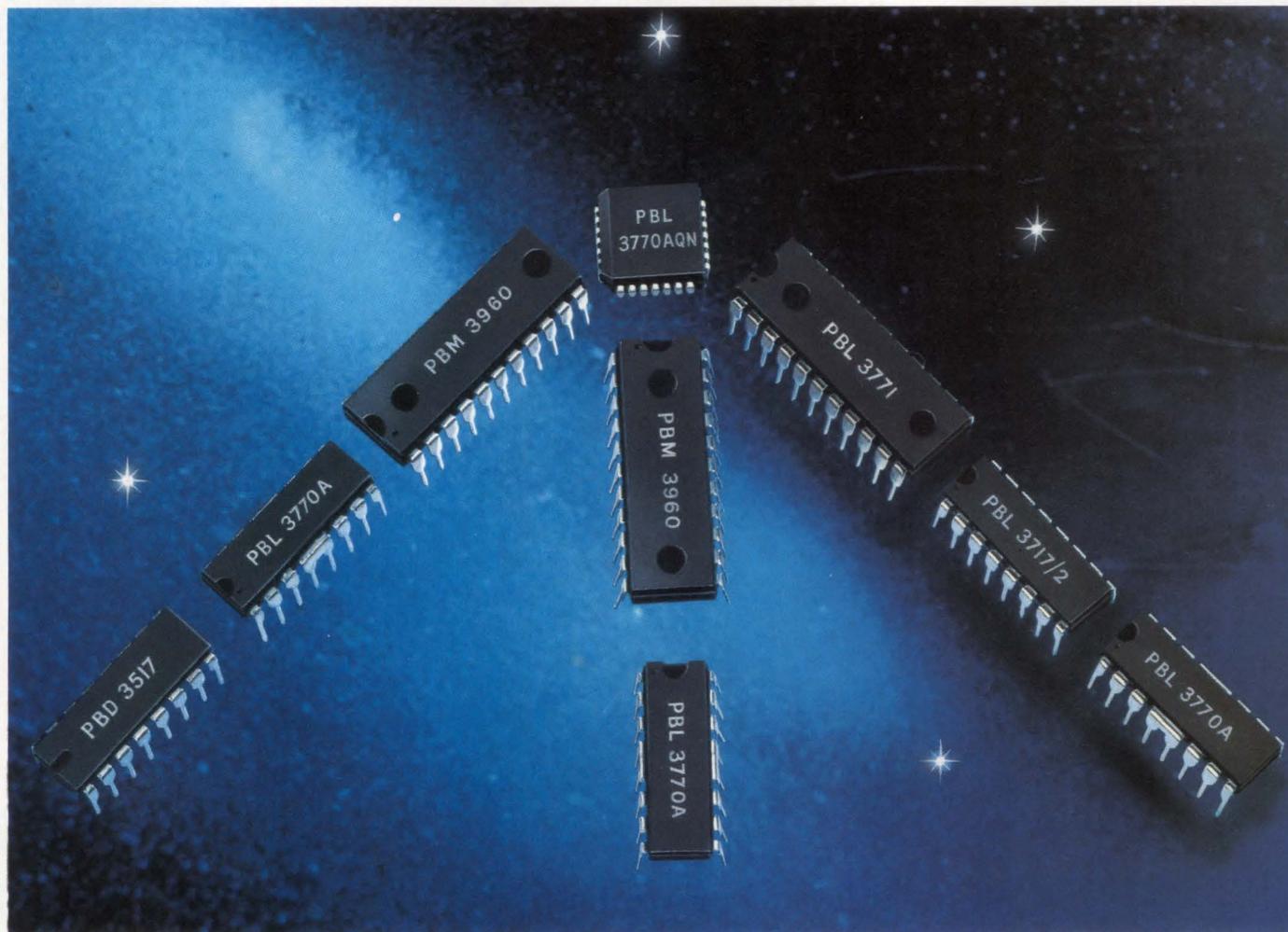
For reliable high-current single and multiple output power supplies from 500 to 2200 watts, contact JETA.

See EEM pages D1706-1708

JETA POWER SYSTEMS, INC.
2675 Junipero Avenue ■ Signal Hill, CA 90806
Tel: 213/427-0095 ■ TWX: 510-101-1804 ■ FAX: 2134262417

CIRCLE NO 30

Stepper Motor Drivers.



Choose RIFA and discover how the world's leading family of motor control devices gives you more choice, more applications, more innovation and much more performance for your space and money.

PBL 3717/2.

Latest version of our industry-standard PBL 3717. Constant current switchmode control updated to 1.0A continuous output current from previous 0.8A. High, medium, low (park) and true zero output; half- and micro-stepping capabilities; all with the utmost efficiency and performance. Widely copied – come to the source for the brightest and best.

PBL 3770A.

Our brilliant new star. 1.5A continuous, 1.8A peak current. Drives all kinds of motors. Low heat dissipation, high packing density. 16-pin DIP version is pin-compatible with 3717; also 28-pin PLCC version.

PBD 3517.

Low-cost driver for unipolar motors. Economical, reliable, complete – you only need one small driver per motor.

PBL 3771 + PBM 3960.

The new, sophisticated micro-stepping system. Dual precision chopper-driver with dual 7-bit-plus-sign D/A converter. Output 600mA per phase, automatic slow/fast current decay, plus very good low-current linearity – this is the universal leader in micro-stepping performance.

Note: All our stepper motor drivers (except PBD 3517) are available in DIP or PLCC packages. PBL 3717/2, 3770A, and 3771 all have a special lead-frame for heat-sinking through ground pins to the pc board copper.

We're in the lead

RIFA Inc.

403 International Pkwy
Richardson, TX 75085-3904
Telephone (214) 480-8300
Telefax (214) 680-1059

ERICSSON 

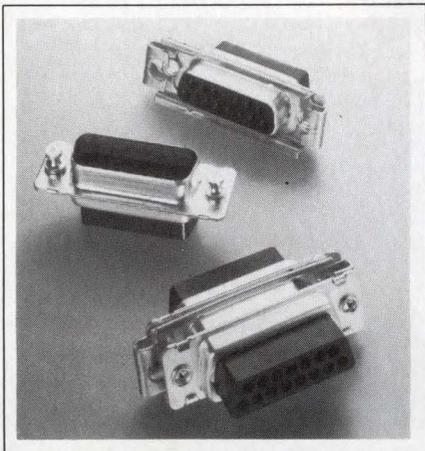
RIFA is a member of the Ericsson Group

COMPONENTS & POWER SUPPLIES

tal oscillators are TTL/CMOS compatible and TTL compatible, respectively. They are available with output frequencies in the 875-kHz to 28-MHz range. In addition, the oscillators have an operating-environment specification that meets or exceeds the requirements of MIL-0-55310/19—making them suitable for use in military and avionics equipment. All the oscillators are housed in a 40-pin ceramic-chip-carrier package, and they have an operating temperature range of -55 to $+125^{\circ}\text{C}$. Over this operating temperature range, their frequency tolerance (relative to their nominal frequency) is ± 100 ppm. For even more demanding applications, the oscillators will be available in a radiation-hard form, constructed from high-purity quartz crystal and SOS circuitry. Approximately £40 (100).

Salford Electrical Instruments Ltd, Times Mill, Heywood, Lancashire OL10 4NE, UK. Phone (0706) 67501. TLX 635106.

Circle No 397



CONNECTORS

- Compatible with the IEEE-802 standard
- Grounding indents for EMI/RFI compatibility

These Amplimate 15-position sub-miniature D connectors feature pre-assembled slide latches and locking posts that save valuable installation time and effort. Compatible with

DOING PART OF THE JOB IS NOT ENOUGH Integrated CADDy Does It All!

Schematic capture: Dynamic symbol call-up... automatic naming/numbering... rubberbanded connections... edge-of-sheet and bus symbols... expandable library.

Component data base: Defines/manages data flow between schematic and PC Board. Automatic features—file naming, multi-sheet management, BOM, netlist, back-annotation, layer management, project archiving.

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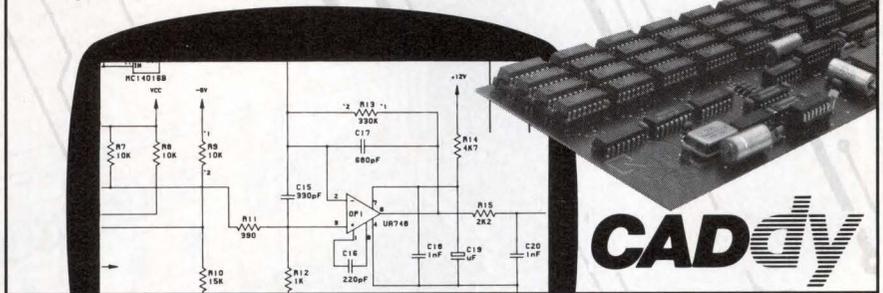
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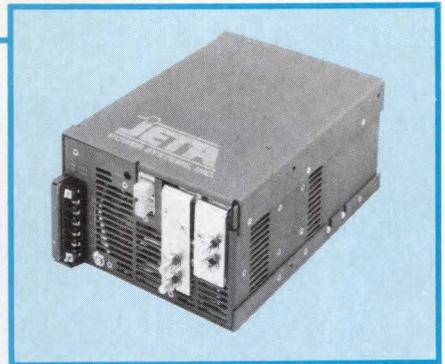
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CADDy CORPORATION, 3 Crossroads of
Commerce, Rolling Meadows, IL 60008
Toll-free: 1-800-CADDY11 (In Illinois:
1-312-394-7755)



See us at ELECTRO, Booth 2951.

CIRCLE NO 31

or...
1500 or
1800
WATTS
in the same box.



Whether you need 1500 or 1800 watts, JETA satisfies your power supply need with a single case size. So if your system requires higher power ratings in the future, you won't have to worry about fitting in a new power supply... saving you both time and money.

As with all JETA power supply designs, these units undergo our standard "beat-up" tests to assure continued performance under operating conditions that your system will probably never see—from powering-up into short circuit and no-load conditions to short circuiting the unit at full load—over and over again. Finally, they get a 24-hour burn-in.

For cost-effective, performance proven, high-current single and multiple output power supplies from 500 to 2200 watts, contact JETA.

See EEM pages D1706-1708

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Tel: 213/427-0095 ■ TWX: 510-101-1804 ■ FAX: 2134262417

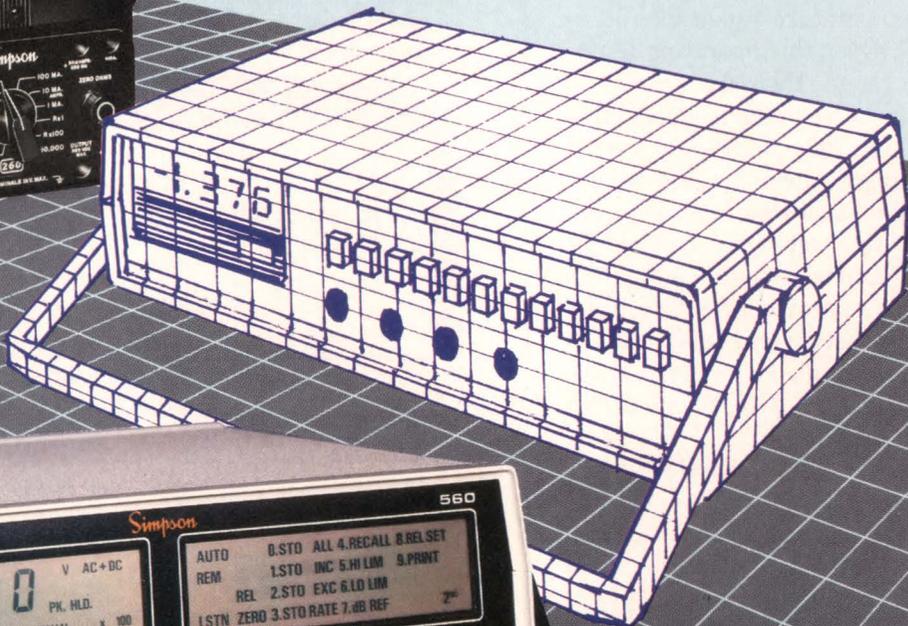
Simpson® Professional Series

★ Quality and Reliability ★

MENU-DRIVEN MULTIMETER — MODEL 560

The newest addition to the **PROFESSIONAL SERIES**, the MODEL 560, incorporates measurement capabilities usually provided through the use of separate instruments. The 560 is a microprocessor based, 52,000 count, menu-driven multimeter designed and built with the requirements of the serious engineer in mind. The 560 provides the accuracy and stability necessary for exacting testing applications.

COMPUTER-AGE SOPHISTICATION IN A BENCH TOP DMM



MENU-DRIVEN MULTIMETER

- Model 560 \$2,195.00
- Model 560 w/BUS Interface . . . \$2,395.00



SIMPSON ELECTRIC COMPANY

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A CHIPPEWA NATION TRIBAL ENTERPRISE

Features

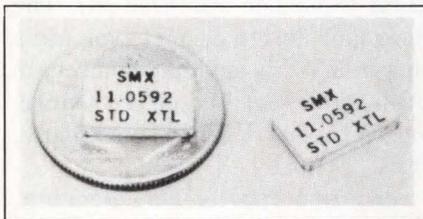
- Ultra Fast Autoranging
- Front Panel Programming
- Data Logging to 2150 Readings on any Selected Range
- 52 Segment Bar Graph
- 500kHz Frequency Counter
- Battery Backed Data Storage Buffer
- RS232C Capable
- Centronics Printer Capable
- REL and Continuity

COMPONENTS & POWER SUPPLIES

the IEEE-802 standard for LAN interfaces, these tin-plated, metal-shell plug and receptacle connectors have a lifetime spec of 500 mating/unmating cycles. The plug shells feature grounding indents for EMI/RFI compatibility. Slide-latch version, \$2.30; locking-post model, \$1.44 (1000). Delivery, stock to six weeks ARO.

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

Circle No 398



CRYSTALS

- Operate from -55 to $+150^{\circ}\text{C}$
- Compatible with automatic assembly equipment

Devices in the SMX Series of ceramic surface-mount AT quartz crystals measure $0.07 \times 0.4 \times 0.25$ in. They are available with frequencies between 5 and 160 MHz. The standard operating range is -55 to $+150^{\circ}\text{C}$; typical drive level is $150 \mu\text{W}$. Crystals with room-temperature tolerances of 0.001, 0.005, or 0.01% are available. The basic construction features soldering pads that make the units compatible with automatic assembly equipment. \$4.80 to \$9 (1000). Delivery, 10 to 12 weeks ARO.

Standard Crystal Corp, 9940 E Baldwin Pl, El Monte, CA 91731. Phone (818) 443-2121.

Circle No 399

DESKTOP UPS

- Protects desktop equipment from line failures
- Includes line-supply filtering and internal batteries

Measuring $15.75 \times 15.75 \times 2.95$ in. ($400 \times 400 \times 75$ mm), the DT300 unin-

Are you trying to put a PC where it doesn't belong?

Our **STD BUS** single board computer runs **MS-DOS 3.3** and thrives as the embedded micro-computer inside your machine. And it needs no special handling in the rugged conditions of the factory floor.

Choose your disks—semiconductor, hard or floppy. Add the STD BUS analog & digital I/O and networking you need. Now you have an industrial strength computer that will go where the PC shouldn't. A two-year warranty is standard.

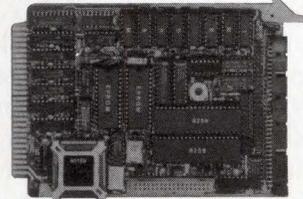
GONE DISKLESS LATELY?

Many applications don't need disk storage. So why bother with disks, and the overhead and royalties that come with them?

Ask us about our software tools for the diskless MS-DOS environment.

To learn more, call and ask for our **FREE "Application Guide for the CDI-DOS Spectrum."**

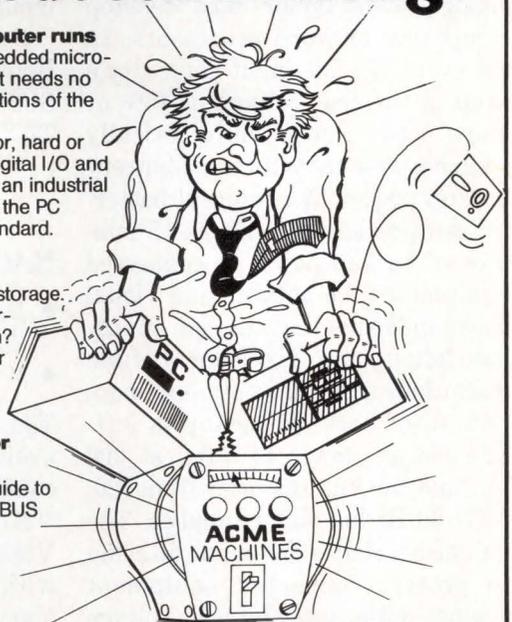
MORE new application notes—"A Guide to Interfacing the STD BUS with the BITBUS Communications Network."



CPU-188 Single Board Computer runs MS-DOS.

MS-DOS is a trademark of Microsoft Corp.

BITBUS is a trademark of Intel Corp.



Computer DYNAMICS
COMPUTER DYNAMICS SALES
107 S. MAIN ST., GREER, SC 29651 (803) 877-8700

CIRCLE NO 33

...and we'll back it up!
750 WATT
multiple output
battery backup
supply.



For safe and orderly system shutdown in the event of blackout or even brownout situations, choose our battery backup switching power system.

JETA's proven multiple output power supply technology combines with a dual-stage charger, boost converter and 48V battery to provide your system with unlimited holdup time (depending on battery capacity) in the event of AC line failure.

2-YEAR WARRANTY on all models

At JETA, we back up all our power supplies with a full two-year guarantee. After we beat them up and then burn them in, we're confident that you'll receive the finest high-current power supplies built.

For single and multiple output power supplies from 500 to 2200 watts, contact JETA. We back them up.

See EEM pages D1706-1708



POWER SYSTEMS, INC.

2675 Junipero Avenue ■ Signal Hill, CA 90806

Tel: 213/427-0095 ■ TWX: 510-101-1804 ■ FAX: 2134262417

CIRCLE NO 34

interruptible power supply is small enough to fit under most desktop computers or word processors. In the event of a line-input failure, or a drop in the line voltage of 15% or more, the unit automatically switches over to its integral-battery backup power. The integral batteries can provide as much as 15 minutes of backup power to connected equipment. An audible and visual alarm indicates that the line supply has failed, and a second audible alarm indicates that only one more minute of battery backup is left. The output power is rated at 300 VA, and the unit operates from 220/240V 50-Hz line-input supplies. The unit also includes line-input filtering to protect connected equipment against noise, interference, voltage spikes, or voltage surges that appear on the line supply. It has two 220/240V 50-Hz output connectors supplied from the uninterruptible supply, and one output socket that

is supplied from the filtered line input. £300.

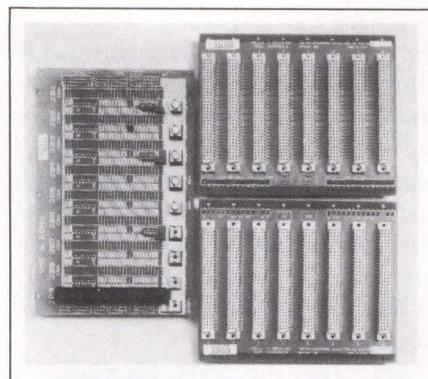
Dowty Power Conversion Ltd,
Brunel Rd, Salisbury, Wiltshire
SP2 7PT, UK. Phone (0722) 28801.
TLX 477064.

Circle No 400

BACKPLANES

- Designed for VME Bus applications
- 5- to 20-slot versions available

The VMEJ Series of backplanes is available in a variety of sizes and configurations to meet almost any VME Bus application. Both the VMEJ1 and VMEJ2 models come with anywhere from 5 to 20 slots. You can order the VMEJ1 with anywhere from 6 to 21 power terminals; the VMEJ2 line, from 4 to 10 power terminals. All versions have a multi-layer backplane design that conforms to the most recent VME Bus



specifications, jumper positions for daisy-chaining Bus Grant and IJack signals, 20A power terminals, and 32-bit expansion and user I/O. The backplane design also lets you use a plug-in VMX board that connects to I/O-bus rows A and C on the connector. A 5-slot VMEJ1 backplane, \$195.

Stanford Applied Engineering,
3520 De La Cruz Blvd, Santa Clara,
CA 95050. Phone (408) 988-0700.
TWX 910-338-0132.

Circle No 401
Continued on pg 288

FAST DC/DC TRANSIENT RESPONSE CONVERTERS

FAST DELIVERY

- Current Mode Controlled
- Excellent Line Regulation
- Wide Input Range
- High MTBF



INTERNATIONAL POWER DEVICES
DC/DC CONVERTER
WIDE INPUT
TRIPLE OUTPUT
Current Mode Control
9 to 18 Vdc IN
NWT120S-12
15 WATT
5V @ 1.5A 2512V @ 310mA
MADE IN USA

WATTS	SERIES
5	GW
15	NW
30	QW
40	LK
60	RW
120	UW

95

MODELS FROM



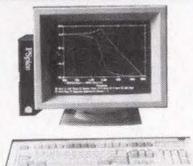
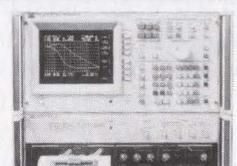
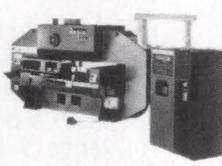
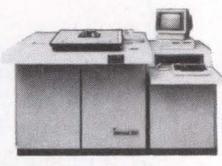
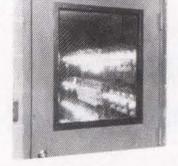
INTERNATIONAL POWER DEVICES, INC.
155 N. BEACON ST., BRIGHTON, MA 02135
Phone: (617)782-3331 * Fax: (617)782-7416 * Telex: 989-752

CIRCLE NO 35

See us at ELECTRO, Booth 2724

V SERIES SWITCHING POWER SUPPLIES

Engineered and Manufactured
by Perfectionists!

 <p>Simulations by SPICE</p>	 <p>Stability by HP/VENABLE</p>	  
 <p>Sheet Metal by AMADA</p>	 <p>Auto Insert by UNIVERSAL</p>	
 <p>Testing by ZEHNTEL</p>	 <p>Burn In by CENTIGRADE</p>	 <p>Service by PHILLIPS</p>
<p>Call Toll Free 1-800-523-2332</p>		
 <p style="font-size: 0.8em; margin: 0;">P.O. BOX 1369 ■ WISSAHICKON AVENUE, NORTH WALES, PA 19454 PHONE 215/699-9261 ■ TWX 510/661-8061 See us at ELECTRO/88, Booths 406-408</p>		

CIRCLE NO 36

EDN April 28, 1988

PRESENTING

THE WINNING

ADVERTISERS

*From the EDN
January 7, 1988
Issue*

Here are the winning advertisements from EDN's January 7, 1988 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. A special thank you to the readers who took the time to participate. Here then are the outstanding performers . . .



- COMPANY: Inmos
- AGENCY: Thomas & Perkins



- *"Football player draws interest. Text ties in well with picture."*
Chief Engineer, Beckman Instrument
- *"Eyecatching color graphics. Table gives lots of info quickly."*
Engineer, Litton Electron Devices
- *"Seasonal picture, good layout, concise details."*
Member Technical Staff, Advanced Micro Devices

- COMPANY: IOtech
- AGENCY: In-house



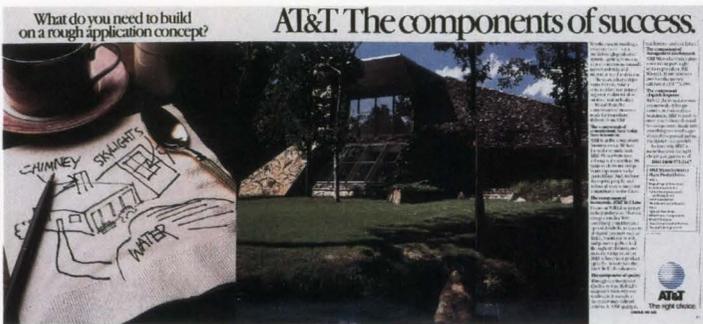
- *"Describes the products very well."*
Engineering Manager, International Rectifier
- *"Contains useful information, including prices."*
Senior Engineer, Johnson Controls Inc.
- *"Great use of color."*
Engineer, Wilding Electronics

- COMPANY: 3M Industrial Chemical Products Division
- AGENCY: Kerker & Associates, Inc.



- "A very colorful, sophisticated, yet simple ad."
Electronic Engineer, UPA Technology
- "Interesting design. Full of information."
Aerospace Engineer, NASA
- "Full page graphics draw attention to informative product specs."
Engineer, National Security Agency

- COMPANY: AT&T Microelectronics
- AGENCY: FCB / Leber Katz Partners



- "Allows imagination to prompt reading of entire ad."
Engineer, General Electric
- "Nice concept. The house is a dream."
Component Test Engineer, NCR
- "Dedicated to every engineer who has scribbled on a napkin!"
Project Manager, IRT Corp.

- COMPANY: Dupont Electronics
- AGENCY: Ketchum Advertising



- "Picture caught my eye."
Design Engineer, Hewlett-Packard
- "Impressive close-up."
Software Engineer, Unisys
- "Sharp photograph. Good packaging."
Chief Scientist, U.S. Army

- *"I was looking for power supplies. Fold-out ad did it."*
Software Manager, Teledyne Systems Co.
- *"I like the detachable ad. I can remove for future reference."*
Senior Field Test Engineer, Bendix Oceanics Division
- *"Very well laid out with a wealth of information."*
Engineer, Delco Systems Operations

- **COMPANY:** Kepco, Inc.
- **AGENCY:** Zam, Kirshner, and Geller



- *"Very clever ad."*
Design Engineer, Hewlett-Packard
- *"Excellent close-up photography and just enough text."*
Member Technical Staff, Rockwell International
- *"Good graphics, good text. I can relate to the problem the product addresses."*
Chief Engineer, EDI Inc.

- **COMPANY:** Teradyne Industrial Consumer Division
- **AGENCY:** Ingalls, Quinn & Johnson



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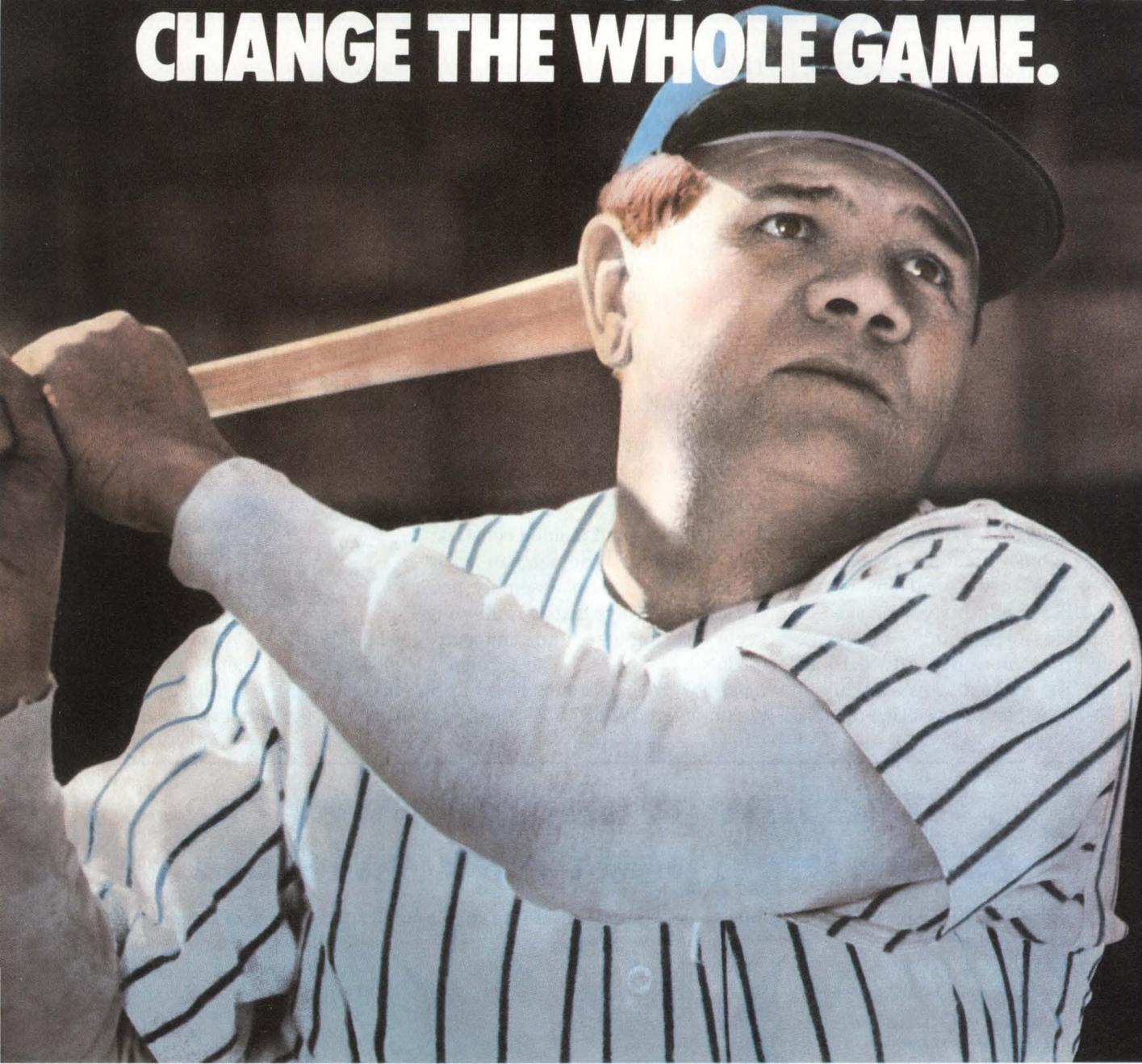
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SOMETIMES A MAJOR PLAYER CAN CHANGE THE WHOLE GAME.



INTRODUCING ZENITH'S NEW STANDARD SWITCHING POWER SUPPLIES.



Now that Zenith's stepped into the batter's box, standard power supplies will never be the same. Because we've taken our expertise from years in the "custom" business, and designed a full-featured product... at

a standard price. And that means significant cost savings for you!

Starting this January, Zenith will offer a complete family of medium power, off-the-shelf, switching power supplies. And our new power supplies have got all the bases covered...

- Safety. The new series meets international safety requirements of UL 478; CSA 22.2, No. 154; IEC 380; VDE 0806; VDE 0871/B; FCC PART J, CLASS B.
- Flexible. All outputs are independently isolated, mag amp regulated, and adjustable. Outputs 2 and 3 can be widely adjusted between 10 and 15.5V to meet different equipment demands—at no extra cost!

Visit us at ELECTRO '88, Booths 2433, 2435, 2437

- Tough. Exceeds 100,000 hours MTBF for durable performance.
- Reliable. Comes with 2-year warranty, fully backed by Zenith.

Output & Voltage Current Ratings

Model	Max Output Power (Watts)	Main Output		2nd Output		3rd Output		4th Output		Size (Inches)
		Volts DC (Min/Max)	Amps (Min/Max)	Volts DC (Min/Max)	Amps (Min/Max)	Volts DC (Min/Max)	Amps (Min/Max)	Volts DC (Min/Max)	Amps (Min/Max)	
ZPS-250-N	250	4.75/5.25	3.5/35.0	10.0/15.5	0.4/4.0 PK6	10.0/15.5	0.4/4.0 PK6	4.75/5.25	0.3/3.0	5.0 x 2.5 x 13
ZPS-300-N	300	4.75/5.25	4.5/45.0	10.0/15.5	0.8/8.0 PK12	10.0/15.5	0.8/8.0 PK12	4.75/5.25	0.4/4.0	5.0 x 2.5 x 13
ZPS-400-N	400	4.75/5.25	5.5/55.0	10.0/15.5	1.0/10.0 PK15	10.0/15.5	1.0/10.0 PK15	4.75/5.25	0.6/6.0	6.0 x 2.5 x 13

For optional steel cover substitute -C for -N in model number.

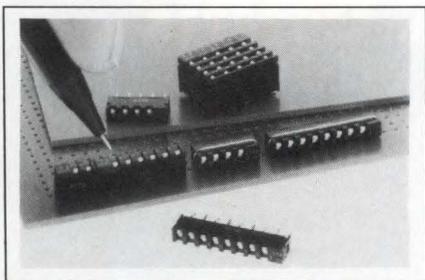
For more information, call
1-312-391-8700.

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SEE US IN ZENITH BOOTH 500-502
AT THE WESCON TRADE SHOW,
NOVEMBER 17TH-19TH.

THE QUALITY GOES IN BEFORE THE NAME GOES ON*

CIRCLE NO 74



SWITCHES

- SIP design saves board space
- Lifetime specs at 1000 cycles

Designed in a single in-line package with a common bus, switches in the S Series take up about 50% of the board space utilized by a conventional DIP switch. The units are compatible with existing SIP insertion equipment and are available in two height configurations—0.295 and 0.177 in. Both versions are also available in right-angle configurations that measure only 0.16 in. high. The switches are available in 2-, 4-, 6-, 8-, and 10-position models.

They feature high-pressure, gas-tight contacts and can accommodate wave soldering and aqueous or solvent cleaning processes. The switches have a rated lifetime of 1000 cycles. An 8-position model, \$1.12 (10,000).

Augat Alcoswitch, 1551 Osgood St, North Andover, MA 01845. Phone (617) 685-4371.

Circle No 402

REED RELAYS

- Contacts rated for 5W or 5 VA
- Designed to withstand SMA processes

The materials and molded construction for the JS1 Series can withstand surface-mount assembly processes. The relays feature gull-wing style terminals and measure 0.235×0.22×0.55 in. The 1 Form A (spst NO) reed switch is rated for a maximum of 5W or 5 VA. Maximum

switching voltage is 100V ac or dc, and maximum switching current specs at 0.5A. Initial dielectric strength equals 250V dc min between open contacts and 1000V dc between coil and contacts. The standard coil voltages are 5, 12, 15, and 24V dc. Nominal coil power dissipation ranges from 66 to 288 mW, depending on model. \$4.26 (500). Delivery, stock to 10 weeks ARO.

Potter & Brumfield Inc, 200 S Richland Creek Dr, Princeton, IN 47671. Phone (812) 386-2276.

Circle No 403

OSCILLATOR

- ±0.02% initial accuracy
- 2-ppm/°C drift (full MIL temperature range)

The SWR200's 7.07V rms output has an initial accuracy of ±0.02% max over the full military temperature range. Temperature drift over

the low profile answer to the high power question . . .

The next time you ask yourself how to get all that power into such a small space, think of Intronics.

Introducing our new 100 Watt triple output, low profile DC/DC converter.

The KZ 400 Series does the job of three single output converters in a much smaller area—saving you valuable board space. It costs significantly less than individual converters and saves time and money on installation and inspection.

Designed primarily for the telecommunications, computer and instrumentation markets, the KZ 400 is metal encased with six-sided shielding and comes with a number of standard features. With 20 standard single and triple output models to choose from, it boasts a wide input range of 20-60 VDC and 36-72 VDC.



The KZ 400 delivers an impressive 80% typical efficiency and has a fixed switching frequency of 200 KHz. Line/load regulation specifications are ±1% main channel and ±5% auxiliaries. The unit is available in PC board and side mount models.

Get all the power you need at a lower cost—while increasing valuable board space. And at Intronics, you also get dependable service and product support. Call Intronics today at (617) 964-4000 about the new 100 Watt KZ 400 triple output DC/DC converter—the answer to your high power needs.

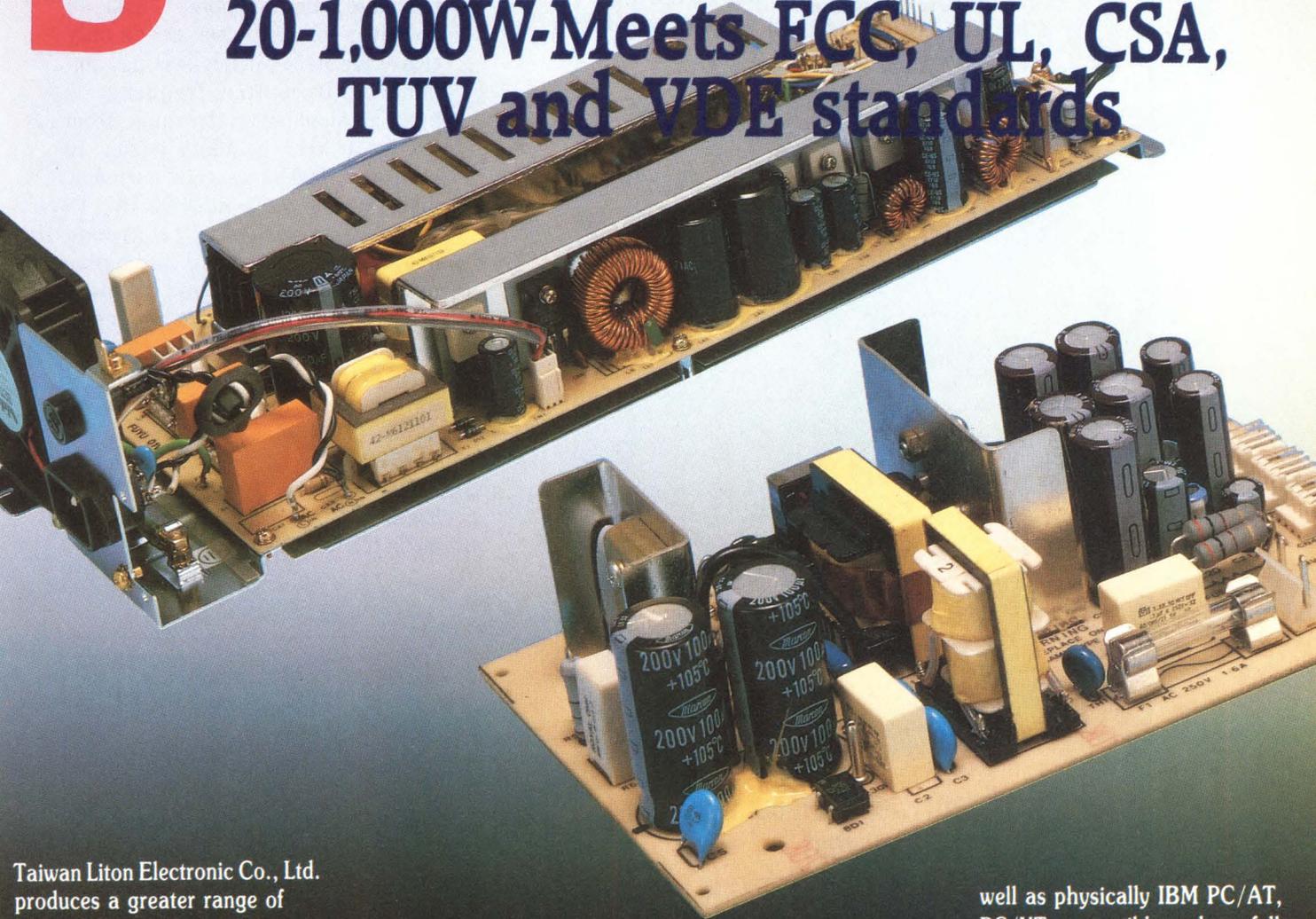
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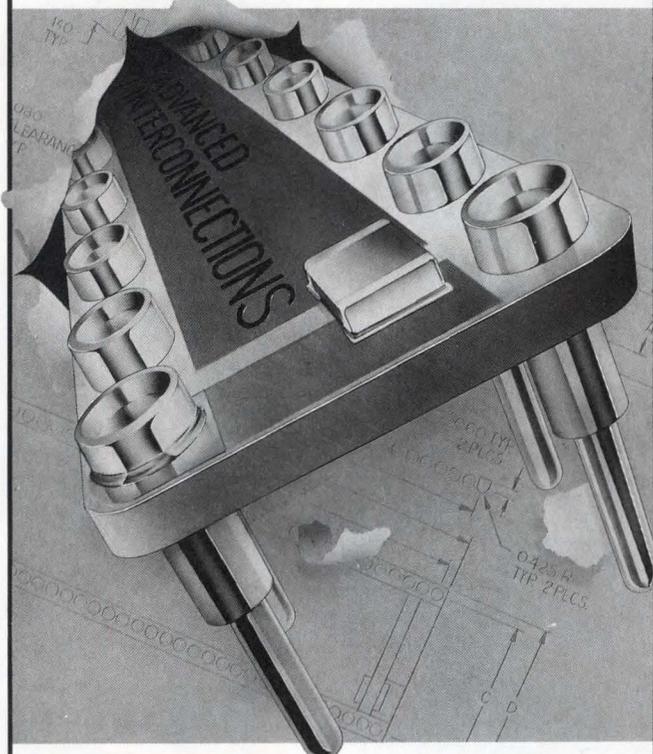
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12th Fl., 25 Tunhwa S. Rd., Taipei, Taiwan, ROC

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CIRCLE NO 73

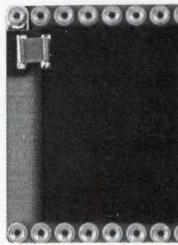
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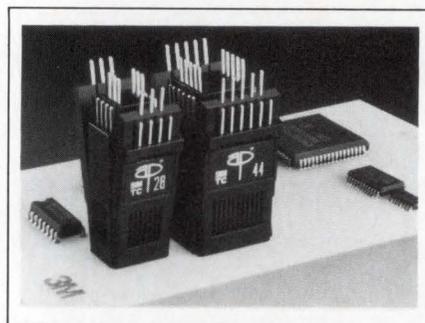
Wire-Wrap® is a registered trademark of Gardner-Denver Co.

COMPONENTS & POWER SUPPLIES

the same range is 2 ppm/°C max. To operate, the oscillator needs only two external frequency-setting components. Its output frequency is programmable over the range from 0.4 to 10 kHz. Stability equals 10 ppm over 1000 hours; total harmonic distortion is 0.5% at 3300 Hz. To eliminate errors due to ground drops, two separate ground pins provide accurate ground sensing. The oscillator is available in either a 14-pin DIP or a flat pack. It's screened to MIL-STD-883C requirements. DIP versions, \$86 to \$112.20 (100); flat-pack models, \$98 to \$126.09.

Thaler Corp, 10940 N Stallard Pl, Tucson, AZ 85737. Phone (602) 742-5572. TLX 825193.

Circle No 404



PLCC TEST CLIPS

- Feature heavy-duty springs for positive contact pressure
- Narrow body design accommodates high-density applications

The vendor's plastic leaded-chip-carrier (PLCC) test clips are now available in 28- and 44-pin sizes. They have an action-wedge design that allows all four sides to open simultaneously, thus providing a 1-step secure attachment to the PLCC under test. The clips also feature helical compression springs that ensure positive contact pressure, an insulating contact comb to prevent accidental short circuits, and a patented wiping action to ensure contact integrity in testing. The clips' narrow body design accommodates high-density pc-board

ELIMINATING FIRE RISK WITH PAPER!

Metallized plastic film capacitors

Rifa metallized paper capacitors

Without a capacitor, the power supplies or household appliances that you manufacture could cause radio frequency interference. With an unsafe capacitor, they could catch fire.

On average, such a cap has to take more than ten transient attacks a day. Consequently, the self-healing ability is decisive for a long life. But as the number of self-healings increases, so does the risk of breakdowns and short-circuits.

The ability to withstand high voltage transients is measured by a test called First self-healing. This is defined as a voltage drop of 5 V, and is executed periodically at the Rifa Laboratories in Kalmar, Sweden. For years, the outcome of this test has always been the same: 95% of metallized plastic film caps start self-healing at voltages lower than 3 kV; of

metallized paper caps made by Rifa, less than five percent.

This test is regarded as a realistic way to quantify the risk of short-circuits. To that, add another aspect. The type of damage that can occur in a plastic cap, resulting in the winding melting or glowing, is a far greater fire hazard than a similar occurrence would be in a paper type cap.

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In our book, QUALITY means meeting your customer's performance requirements, and he certainly doesn't expect your product to catch fire or cause interference with radio frequencies, does he?



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CIRCLE NO 72

applications. Staggered clip contacts are located on 0.1-in. centers. Standard 0.025-in.-square contact pins accept single-row female socket connectors or wire-wrap connectors that can interface with test equipment. From \$23.98 for a 28-pin clip; from \$30.95 for a 44-pin clip.

3M, Electronic Products Div, Box 540, Mentor, OH 44060. Phone (800) 321-9668; in OH, (216) 354-2101.

Circle No 405

TRANSFORMERS

- Phase shift equals 1° max
- Occupy <0.5-in³

The Series 1800 isolation transformers provide high isolation with phase shifts of as little as 1° max. The units are designed to precede the input stages of hybrid synchro or resolver-to-digital devices. Two of the units can also work with digital-to-synchro converters. The trans-

formers occupy less than 0.5 in³ and weigh only 0.75 oz. The family includes seven members with designations ranging from SIT/RIT1800 to SIT/RIT1840, and from RT1850 to RT1860. The SIT/RIT series and the RT1850 model are designed for frequencies from 360 to 440 Hz; the RT1860 accommodates frequencies of 47 to 440 Hz. \$65 to \$150. Delivery, six to eight weeks ARO.

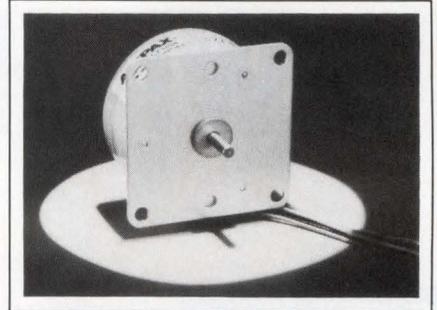
Natel Engineering Co Inc, 4550 Runway St, Simi Valley, CA 93063. Phone (805) 581-3950. TWX 910-494-1959.

Circle No 406

STEPPER MOTORS

- ±0.5° tolerance
- Available in unipolar or bipolar versions

The Series L82400 permanent-magnet (PM) 42-mm stepper motors are designed to satisfy worldwide safe-

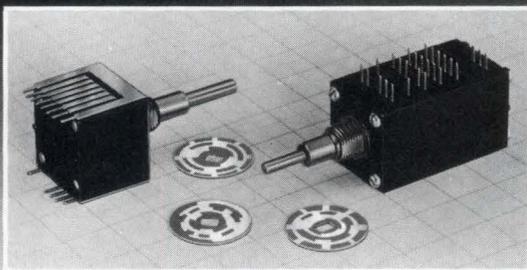


ty requirements. The holding torque specification for the PM motors ranges to 12.4 oz-in. and the step angle is 7.5°—48 steps per revolution. Noncumulative step-angle tolerance equals ±0.5°. The motors feature permanently lubricated bronze sleeve bearings. Versions are available for unipolar or bipolar operation from supply voltages of 5 or 12V dc. \$7.65 (500) for bipolar version. Delivery, 4 to 12 weeks ARO.

Airpax Co, W Johnson Ave, Cheshire, CT 06410. Phone (203) 272-0301.

Circle No 407

MMP/REL™ Encoded Rotary Switch



The leader in digital rotary switching now brings you:

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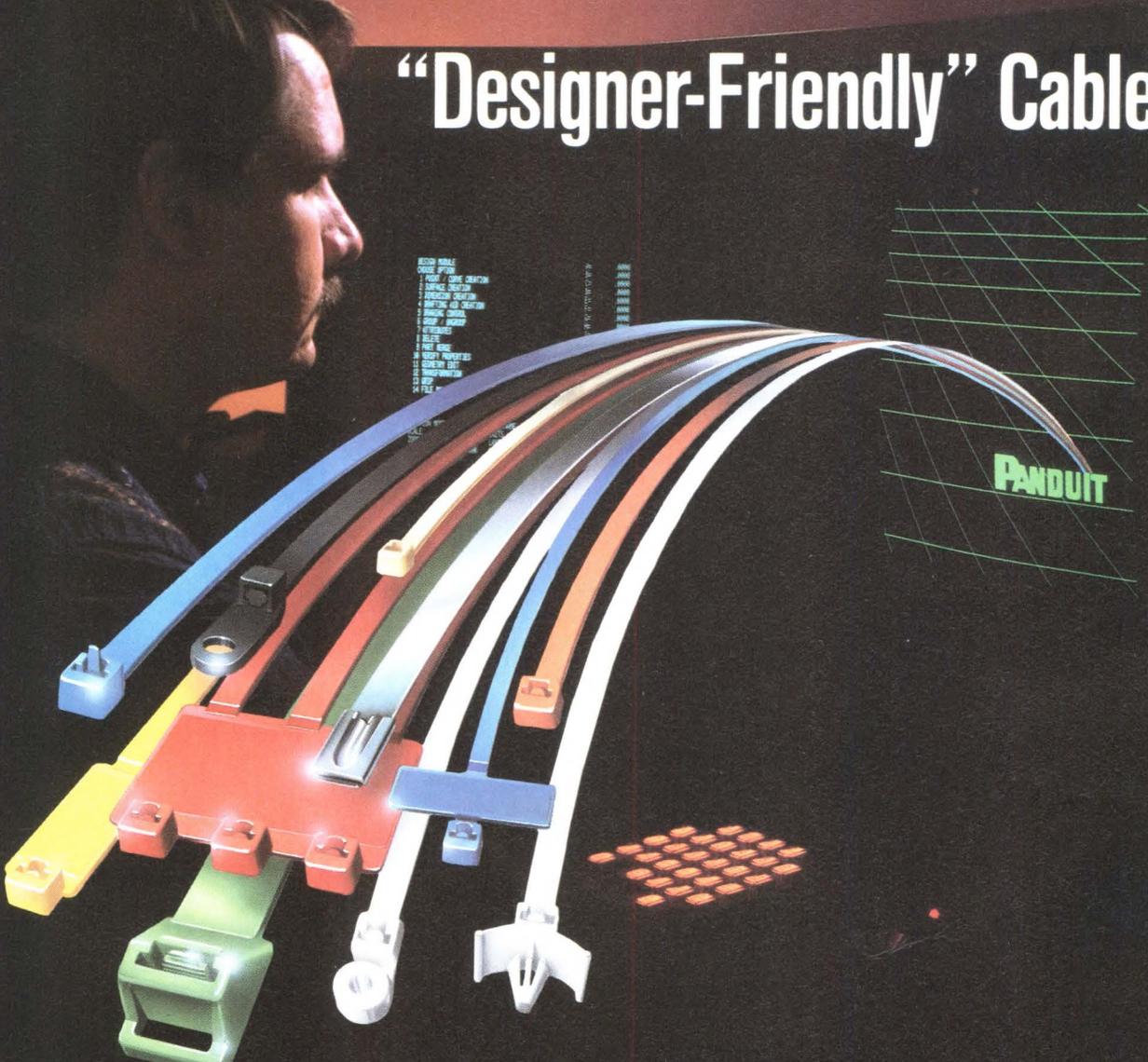
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CIRCLE NO 234



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Visit PANDUIT at ELECTRO '88 Booths 342-343

An Instrument is only as Good as its Output

Will the hardcopy output of your next instrument reflect the quality, precision and capability you build into it?

Instrument users get more than data from their printout . . . they also get a continuing impression of the overall quality and accuracy of the instrument that produces it.

Plots that can't keep pace with real-time events, that display rough, visible jaggies, that are limited in format and have noticeably lower resolution may adversely reflect on the quality of your instruments.

WHERE DO YOU GO FOR SMOOTH, HIGH-SPEED, HIGH-RESOLUTION RECORDING?

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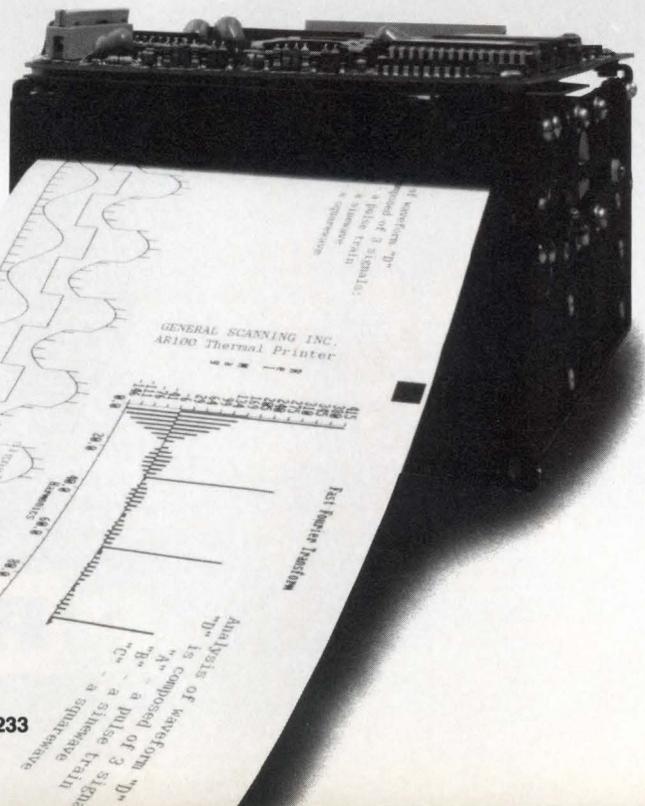
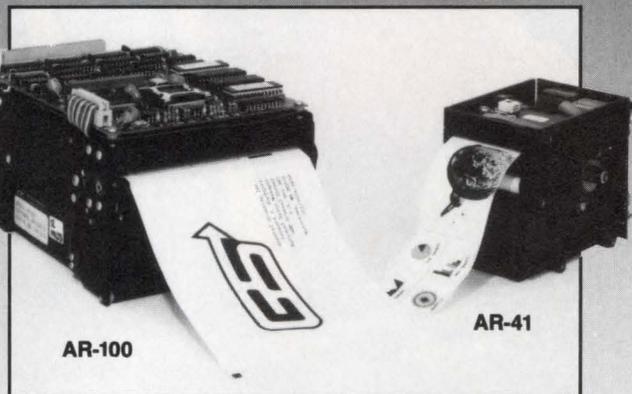
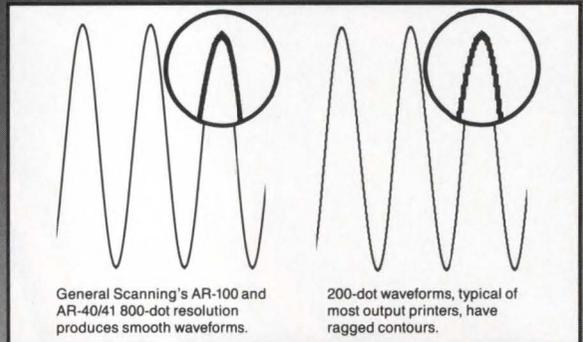
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CIRCLE NO 233

NO

THIS IS NO ORDINARY 220-400 WATT OPEN FRAME POWER SUPPLY SERIES.

NO COMPROMISE IN DESIGN.

This is not another flyback converter, it's the RMV/RMC/RMF series... with half-bridge rectification, mosfet switching & 70 KHz operation for superior performance and reliability.

NO LIMITATIONS...

...of standard features or component selection. Fully regulated auxiliaries ($\pm 0.5\%$); TTL compatible remote inhibit & remote sense are all standard.

Triac soft-start circuitry provides inrush current limiting.

NO MINIMUM LOAD REQUIRED.

Auto preload circuitry maintains regulation on the auxiliary outputs—regardless of main output load conditions.

NO NEED FOR EXTERNAL FILTERING.

ACDC's RMV/RMC/RMF series has an on-board EMI filter which meets FCC Docket, Class A & VDE 0871, Class A.

NO NUISANCE TRIPPING...

of overload circuitry. MAGAMPS provide peak current on demand—for unequalled performance in drive & stepper motor applications.

NO. You're not limited by thermal considerations. You can have convection, air or fan cooling.

NO. You're not stuck with a common ground—all outputs are floating & isolated.

YES

You just found the high performance power supply you need. Check the chart below then call ACDC Electronics at (619) 439-4200.

MODEL SELECTION CHART

WATTS	SINGLE RMC 301	MULTI RMV (Conv. cooled)	MULTI RMC (Air cooled)	MULTI RMF (Fan cooled)
220		■		
300	■	■	■	■
400			■	■

1600w 1500w 1000w 800w 750w 500w 400w 300w 220w 175w 135w 70w 40w 15w

ACDC's POWER OFFERING

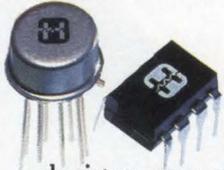
CIRCLE NO 246

UL, CSA,
IEC 380/VDE 0806
safety certification on all units

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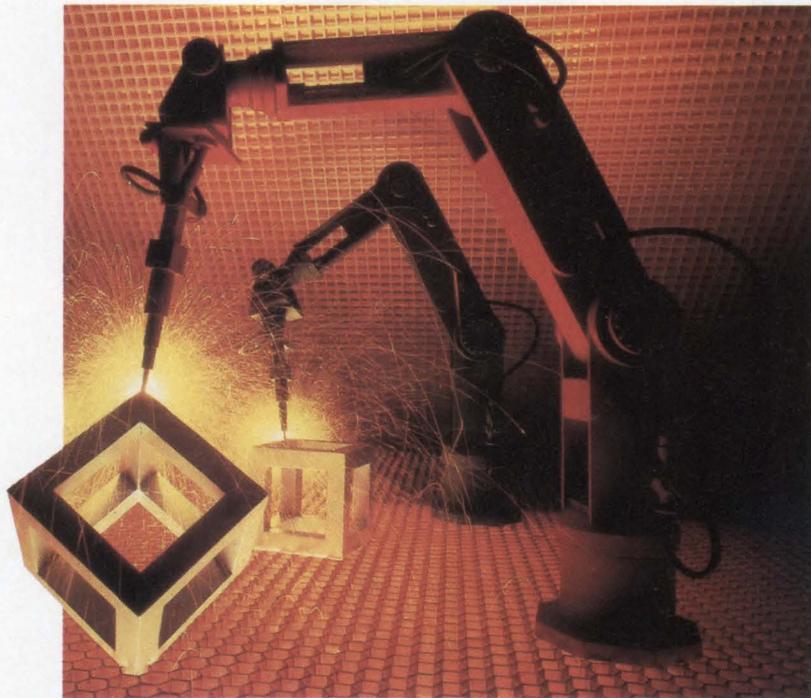
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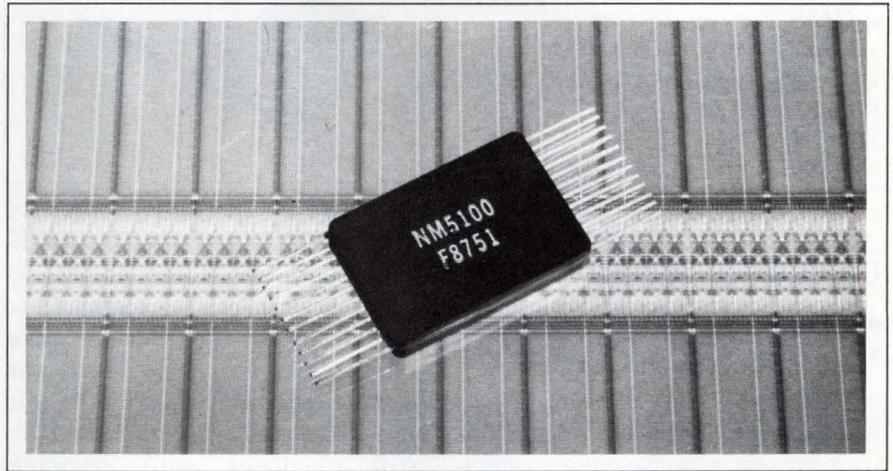
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INTEGRATED CIRCUITS

FAST STATIC RAM

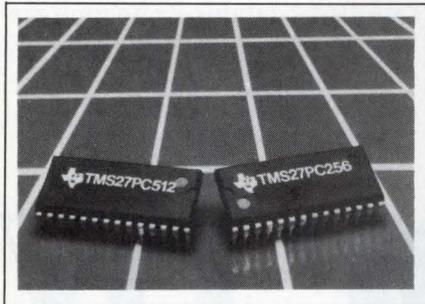
- Available in 15- and 18-nsec speed grades
- 10K and 100K ECL-compatible

Organized as 262,144 words \times 1-bit, the NM5100 high-performance static RAM is compatible with 10K and 100K ECL I/O interfaces. The device is available in 15- and 18-nsec versions and operates from a supply voltage of $-5V$. The power dissipation is less than 1W. To meet the requirements of MIL-STD-883C, the device has 2000V electrostatic discharge protection. The latch-up immunity exceeds 200 mA. The device comes in either a 24-pin, 400-mil ceramic DIP or in a low-induc-



tance 365 \times 535-mil ceramic flatpack with a 30-mil lead pitch. 15-nsec version, \$125; 18-nsec version, \$96 (100).

National Semiconductor Corp., Box 58090, Santa Clara, CA 95052. Phone (408) 749-7400. TLX 346353. **Circle No 351**



CMOS PROMs

- One-time programmable
- Available in four densities

Available in 64k-, 128k-, 256k-, and 512k-byte densities, the TMS27PC64, -27PC128, -27PC256, and -27PC512 CMOS PROMs feature high-speed performance comparable to NMOS devices and provide the added benefits of lower power dissipation and improved reliability. With device speeds ranging from 150 to 200 nsec, the PROMs are designed for systems that do not require the reprogrammability of EPROMs. Because the package used for these PROMs is windowless, the PROMs offer improved data integrity when compared with windowed EPROMs. The devices

feature an active power dissipation of less than 220 mW. Depending on type, from \$3.16 to \$6.16 (100).

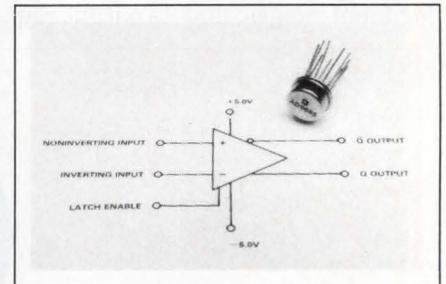
Texas Instruments, Semiconductor Group, SC-800, Box 809066, Dallas, TX 74380. Phone (800) 232-3200, ext 700.

Circle No 352

TTL COMPARATOR

- High-speed operation
- Complementary TTL outputs

Featuring a 7-nsec propagation delay, the AD9686 comparator provides a latch-enable control line with a 2-nsec setup time for high-speed voltage comparisons. It can detect high-speed voltage transitions in both analog and digital systems. The device has an input-offset voltage of 2 mV max that typically drifts less than 10 $\mu V/^{\circ}C$ over the -55 to $+125^{\circ}C$ temperature range. Other key specifications include a 4- μA input bias current and 85-dB common-mode rejection. The comparator comes in a TO-100 metal can, a 16-pin ceramic DIP, or a 20-terminal ceramic LCC. From \$3



to \$16 (100).

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 935-5565. TWX 710-394-6577.

Circle No 353

DISK CONTROLLER

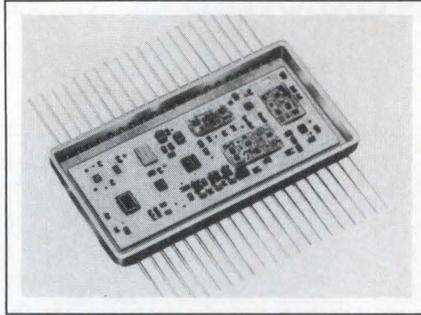
- Single-chip, floppy-disk controller
- Compatible with standard data formats

The $\mu PD72067$ single-chip, floppy-disk controller is compatible with industry-standard data formats, including IBM and Sony's European Computer Manufacturers Association format. The device incorporates write compensation and system clock-generation circuitry that sim-

plify its use. Its high bit-jitter rejection also enhances overall stability. In a plastic DIP, \$10; in a PLCC surface-mount package, \$11 (10,000).

NEC Microelectronics Inc., Box 7241, Mountain View, CA 94039. Phone (415) 960-6000. TWX 910-379-6985.

Circle No 354



HYBRID 12-BIT ADC

- *Includes a track/hold amplifier*
- *Comes in a hermetic, 40-pin flat pack*

Encased in a hermetic, 40-pin flat pack for use in surface-mount applications, the ADC-00302 hybrid includes a 12-bit A/D converter, a track/hold amplifier, data registers, 3-state output buffers, and timing circuits. The IC provides nine bipolar/unipolar jumper-selectable analog input ranges, and its output reg-

isters and 3-state buffers interface to most CPUs. Because of its self-contained timing, the device requires only an encode command to start its conversion cycle. Its other characteristics include 68-dB min harmonic reduction, a 65-dB min signal-to-noise ratio, and a 0.025%-FSR (feedback shift register) max linearity error. The vendor offers MIL temperature-range versions. From \$750.

ILC Data Device Corp., 105 Wilbur Pl, Bohemia, NY 11716. Phone (516) 567-5600. TWX 310-685-2203.

Circle No 355

SWITCH-MODE ICs

- *Enable switch-mode supplies with output to 200W*
- *Use low-cost transformers to provide input/output isolation*

Operating on a master-slave principle, the TEA2170 and TEA2164 provide regulation and protection functions for isolated switch-mode power supplies with outputs as high as 200W. They are suited for use in low-cost power supplies for consumer products—for example, TV receivers, video recorders, and audio equipment. The devices let you isolate a supply's secondary side from the line input with a low-cost transformer. The TEA2164's $\pm 1.5A$ output can directly drive power transistors at switching frequencies as high as 60 kHz. You can also synchronize the switching to an external frequency, such as the line-scan frequency of a TV set. The TEA2164 contains protection cir-

Color by

Sun Microsystems' Sun-4/260 workstation with the TAAC-1 Applications Accelerator lifts visualization capabilities to new heights. Brooktree provides the lift with four Bt458 RAMDACs small enough to fit on a single board. The result: Amazing detail in both pseudo and true color.

cuitry to limit the current in the power transistor and to protect the supply against repeated output overcurrent, overvoltage, and undervoltage conditions. Both devices also provide soft-start circuitry. Around \$1.46 (1000).

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

Circle No 356

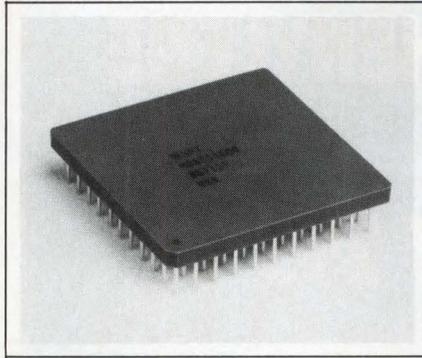
SGS-Thomson Microelectronics, 1000 E Bell Rd, Phoenix, AZ 85022. Phone (602) 867-6100. TLX 249976.

Circle No 357

MULTIPLEXED DAC

- 250-MHz, 8-bit performance
- Five TTL/CMOS-compatible input buses

The HDAC51600 250-MHz, 8-bit multiplexed D/A converter has five



TTL/CMOS-compatible input buses. It simplifies system designs that combine high-speed analog inputs with TTL or CMOS logic. Included on chip are a voltage reference, data latches, timing and control logic, a 5:1 multiplexer, and a video DAC. Synchronization, blank, bright, and force-high controls are available. The device also provides a clock output for system-memory control. When used with CMOS memory, the converter creates a high-speed system that provides cost- and power-savings, compared with designs

that use discrete video DACs and ECL memories. The device's linearity is guaranteed to $\pm\frac{1}{2}$ LSB, and the slew rate is 525 V/ μ sec min. The outputs of the device can drive either 50 or 75 Ω loads. In a 46-pin pin-grid array, \$98.75 (100).

Honeywell Inc., Signal Processing Technologies, 1150 E Cheyenne Mountain Blvd, Colorado Springs, CO 80906. Phone (719) 540-1000.

Circle No 358

REGISTER FILE IC

- Provides three ports
- Features 20-MHz read/write capability

The TMC3220 three-port register file is a specialized memory IC that features one write and two independent read ports. The IC features 20-MHz, asynchronous read/write capability. You may use it as a

Brooktree®



Brooktree Bt458. Triple 8-bit color RAMDAC. Available in speeds from 80 MHz to 125 MHz.

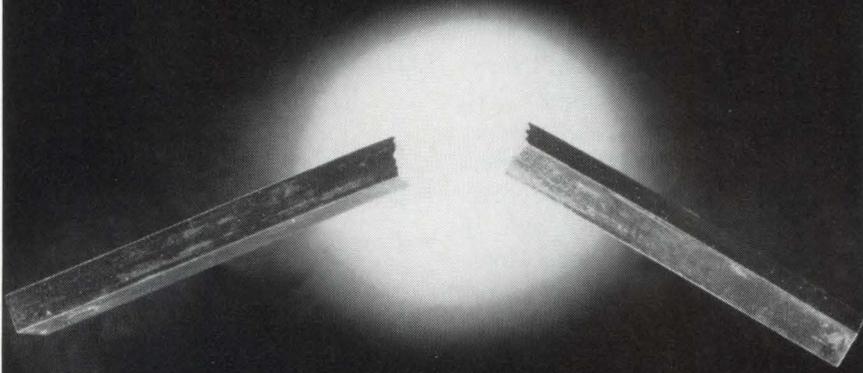
Sun Microsystems' Sun-4/260 Workstation with TAAC-1. Provides pseudo color (8 bit) and true color (24 bit), with a choice of 256 colors or 16.8 million colors.



Brooktree Corporation,
9950 Barnes Canyon Road,
San Diego, California 92121
1-800-VIDEO IC.

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THE MOMENT OF TRUTH FOR POLYPHENYLENE SULFIDE— 3 HOURS AT 255°C.



Today's tough product liability laws, along with tightened manufacturing standards, demand more accurate product performance information.

Plastics Engineering Company, Sheboygan, Wisconsin, manufacturers of Plenco thermoset molding compounds, is concerned that temperature/stress ratings for engineering thermoplastics may not reflect actual performance under load at high temperatures. Current test methods either measure strength after a heated part has cooled or measure the temperature at which a test sample deflects 0.010 in.

Plastics Engineering Company conducted a test of twelve materials' ability to perform under continued load at high temperature to determine a heat stress rating. The results of the heat and stress tests of nine engineering thermoplastics showed catastrophic failure at temperatures significantly lower than expected.

Polyphenylene sulfide (40% glass filled), under this test method, demonstrated a maximum temperature rating of 245°C compared to its published deflection temperature under load (ASTM D648) rating of 260°C. Polyphenylene sulfide fractured after 3 hours of exposure to 255°C. In fact, all the thermoplastic compounds tested resulted in maximum temperature ratings significantly below their published deflection temperature under load.

The results of these tests should be reviewed by engineers, designers, and manufacturers — anyone who specifies plastic parts. For a detailed report write or give us a call at (414) 458-2121. You'll be glad you did instead of wish you had.

PLENCO
THERMOSET PLASTICS

PLASTICS ENGINEERING COMPANY
Sheboygan, WI 53081

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for over 50 years.*

Through Plenco research... a wide range of ready-made or custom-formulated phenolic, melamine-phenolic, alkyd and polyester thermoset molding compounds, and industrial resins.

INTEGRATED CIRCUITS

scratchpad memory with 32-bit floating-point products such as the TMC3200 floating-point arithmetic unit, the TMC3201 floating-point multiplier, and the TMC3210 floating-point divider. Fully TTL compatible, the device operates from a 48-nsec clock and uses just 30 mA max of current when operating in the commercial temperature range. It comes in a 48-pin ceramic DIP. Commercial-grade version, \$29; military-grade version, \$61 (1000).

TRW, LSI Products Div, Box 2472, La Jolla, CA 92038. Phone (619) 457-1000.

Circle No 359



PREAMPLIFIER

- *Dual-channel preamplifier for Inductosyns*
- *Internally matched gain resistors*

The IPA-15805 preamplifier raises the low-level output of an Inductosyn to 2V rms, thus providing the needed drive for an Inductosyn-to-digital converter. The hybrid features high gain, together with matched gain and matched phase. You can use the device without trimming, or for maximum circuit accuracy, you can trim it externally for both gain and phase. Available in a small, 18-pin hermetically sealed package, the device has an operating temperature range of -55 to 125°C. \$148. Delivery, stock to 90 days.

ILC Data Device Corp, 105 Wilbur Pl, Bohemia, NY 11716. Phone (516) 567-5600. TWX 310-685-2203.

Circle No 360

CIRCLE NO 73

INTEGRATED CIRCUITS



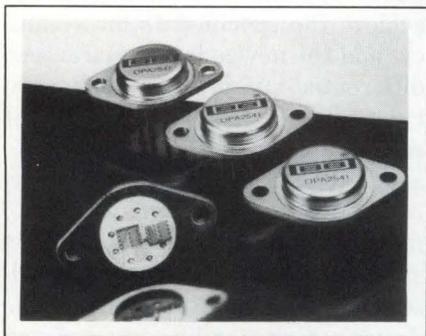
12-BIT ADC

- 2-MHz throughput
- Operates from $\pm 15V$ and 5V supplies

The completely shielded, integrated ZAD1202 module is a 12-bit sampling A/D converter that minimizes the number of converters needed in multichannel digitizing systems. It has a 2-MHz throughput, which includes the S/H operation and the A/D conversion. The harmonic distortion is -74 dB from dc to 500 kHz, and -68 dB from 500 kHz to 1 MHz. The device's S/N ratio is -70 dB min at 100 kHz, and its relative accuracy is $\pm 3/4$ LSB max. The gain and offset of the module is adjustable. \$449 (100).

Analog Solutions, 85 W Tasman Dr, San Jose, CA 95134. Phone (408) 433-1900.

Circle No 361



DUAL-POWER OP AMP

- Output currents to 5A
- Power supplies to $\pm 40V$

Containing two monolithic power-amplifier chips, the OPA2541 op amp can deliver 5A continuous from ± 10 to $\pm 40V$ supplies.

THE MOMENT OF TRUTH FOR PLENCO 06582— 500 HOURS AT 285°C.

Today's tough product liability laws, along with tightened manufacturing standards, demand more accurate product performance information.

Plastics Engineering Company, Sheboygan, Wisconsin, manufacturers of Plenco thermoset molding compounds, is concerned that temperature/stress ratings for engineering thermoplastics may not reflect actual performance under load at high temperatures. Current test methods either measure strength after a heated part has cooled or measure the temperature at which a test sample deflects 0.010 in.

Plastics Engineering Company conducted a test of twelve materials' ability to perform under continued load at high temperature to determine a heat stress rating. The results of the heat and stress tests of nine engineering thermoplastics showed catastrophic failure at temperatures significantly lower than expected. The engineering-grade phenolic was a different story.

Plenco 06582 was subjected to the highest heat possible in a standard laboratory test oven—285°C—for 500 hours. The test sample deflected 4° under continued stress. **Plenco 06582** withstood the stress and more heat, far longer. And it costs a fraction of the engineering thermoplastics.

The results of these tests should be reviewed by engineers, designers, and manufacturers—anyone who specifies plastic parts. For a detailed report write or give us a call at (414) 458-2121. You'll be glad you did instead of wish you had.

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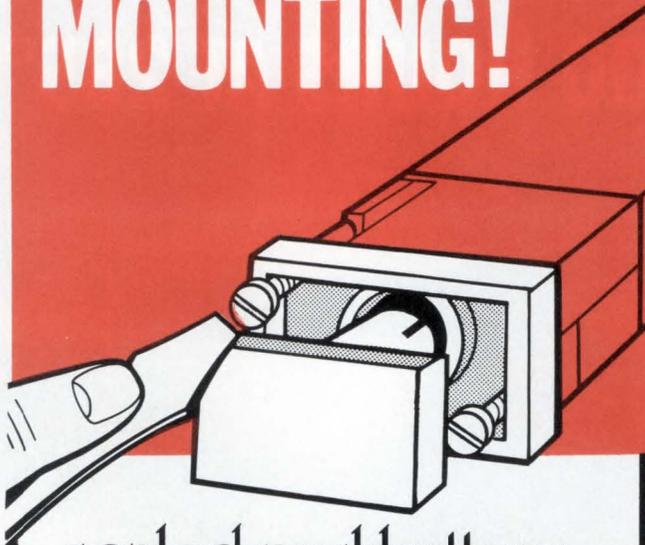
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power switches with

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MOUNTING!**

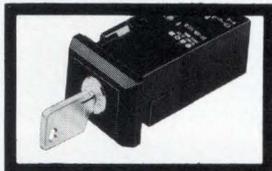


sealed pushbuttons,
keylocks & mushrooms

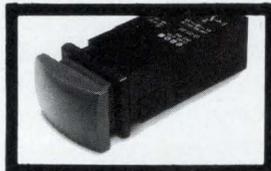
10 AMP; 380 VOLTS, AC

Series 22 industrial power pushbuttons and keylocks are easy to mount from the front of the panel by **one person**—just tighten two screws! Designed for use in harsh environments, they feature a front sealed to IP65 specifications; a ruggedized, shock proof case which resists chemicals and meets IP20 standards. Another plus...rear connections are completely insulated against inadvertent contact. Screw terminals may be converted to .250 Q.C. terminals and snap-on insulator sleeve is available for Q.C. protection. Also, they fit panels 1.5 to 6 mm thick and operate in a broad temperature range: -25° to $+85^{\circ}$ C.

For superbright illumination, select neon, T $1\frac{3}{4}$ midget grooved lamps or T $1\frac{3}{4}$ based multichip LED's in red, yellow, or green. Choose from three bezel shapes and eight lens colors for style. All Series 22 switches are UL, CSA, VDE and SEV listed.



Keylock



Mushroom pushbutton

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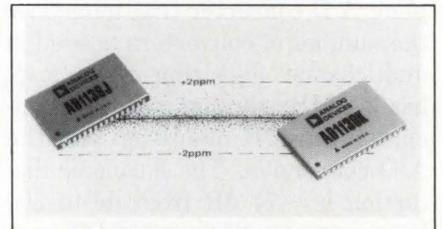
ELECTRO Booth #242
CIRCLE NO 51

INTEGRATED CIRCUITS

The offset voltage is ± 1 mV max, and the bias current is 50 pA max. The open-loop gain is 96 dB, and the slew rate is $6\text{V}/\mu\text{sec}$ min. The device has FET inputs, and its class A/B output stage minimizes crossover distortion. The TO-3 package is electrically isolated for direct mounting on a heat sink. The device is available in three performance grades and two temperature ranges. From \$28.95 (100).

Burr-Brown, Box 11400, Tucson, AZ 85734. Phone (602) 746-1111. TLX 666491.

Circle No 362



HYBRID DAC

- *Adjustment-free 18-bit accuracy*
- *$\pm 1/2$ -LSB differential and integral nonlinearity*

The AD1139 D/A converter has voltage- and current-output data latches, an internal reference, an output amplifier, and application resistors for output ranging. You don't have to make adjustments to achieve the specified 18-bit accuracy, and the device has a guaranteed differential and integral nonlinearity of $\pm 1/2$ LSB. Voltage output ranges are 0 to 5V, 0 to 10V, ± 5 , and ± 10 V. You can also select current outputs of -1 mA and ± 0.5 mA. The settling time is 6 μsec for a single LSB change, and the full-scale settling time is 40 μsec . The device's high-stability internal reference is available through a built-in buffer for use as an external reference. Data bits are presented to the DAC via a single 18-bit bank of parallel, 5V CMOS-compatible latches, which ease the interface to processor buses. The device requires 5V and ± 15 V supplies. It

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One Octal D-Type Flip-Flop 3-State*

One Octal Transparent Latch 3-State(Inverting)

One Octal Inverting Transparent Latch 3-State

*Standard Military Drawings available

† FAST is a trademark of Fairchild Semiconductor Corp.



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*Trademark of General Electric Company, U.S.A., not connected with the English Company of a similar name.

INTEGRATED CIRCUITS

comes in a hermetic 32-pin, triple-wide DIP. J grade with ± 1 -LSB performance, \$195; K grade with $\pm 1/2$ -LSB performance, \$295 (100).

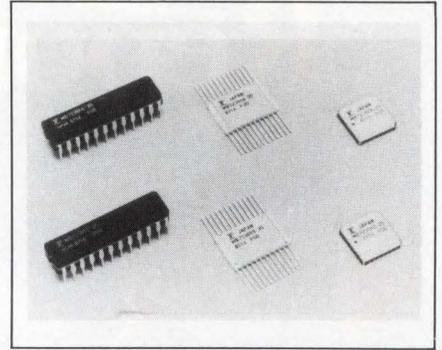
Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021. Phone (617) 935-5565. TWX 710-394-6577.

Circle No 363

out controls and input-ready and output-ready status indicators. The FIFOs are cascadable in depth and expandable in word width; they can operate at 30 MHz typ with flags. 74HC/HCT40105, \$2.85; 74HC/HCT7030, \$35 (100).

Signetics, Box 3409, Sunnyvale, CA 94088. Phone (408) 991-2000.

Circle No 364



FIFO REGISTERS

- Has 16-word \times 4-bit silicon gate CMOS device
- 40-MHz data-rate capability

Except for their capacities, the 74HC/HCT40105 16-word \times 4-bit and the 74HC/HCT7030 64-word \times 9-bit FIFO registers are functionally identical. The devices feature a 40-MHz typ burst-in/burst-out data rate without flags, and a very low power consumption (essentially zero in the idle mode). Other features include independent shift-in/shift-

FAST PROMs

- Registered outputs
- 20-nsec clock-access times

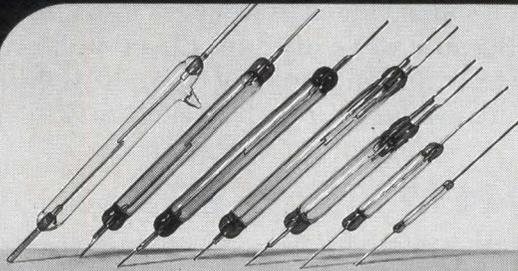
Organized as 8-bit-wide devices, the MB7226, MB7232, and MB7238 PROMs provide 4-, 8-, and 16-bit-wide storage capacities, respectively. The built-in register of these devices latches the output data, eliminating the need for an external register. Each of the three PROMs features a 20-nsec access time; 25-nsec versions are also available. You

can program the register's initial contents to any 8-bit value when programming the rest of the PROM's contents. The PROMs are TTL compatible and operate from a 5V supply. The package options include a 24-pin ceramic DIP, a 24-pin ceramic flatpack, and a 28-pin LCC. From \$5.25 to \$17.

Fujitsu Microelectronics Inc, 3320 Scott Blvd, Santa Clara, CA 95054. Phone (408) 562-1000.

Circle No 365

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spectron

glass and electronics inc.

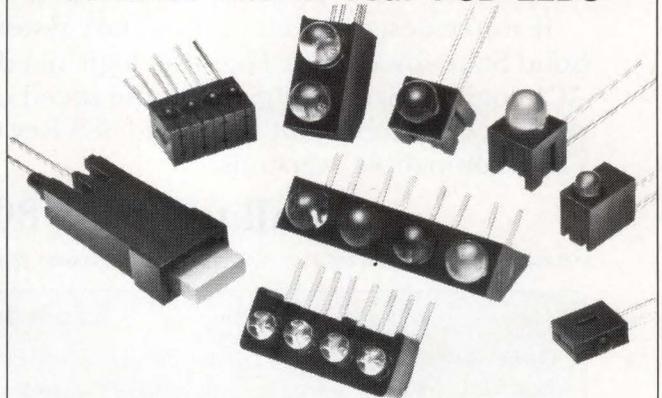
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CIRCLE NO 52

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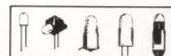
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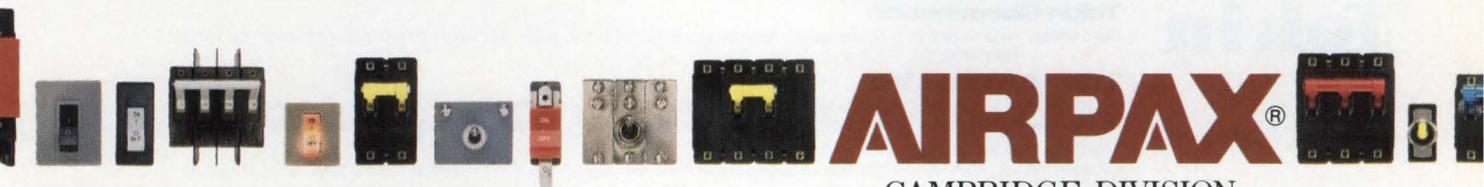
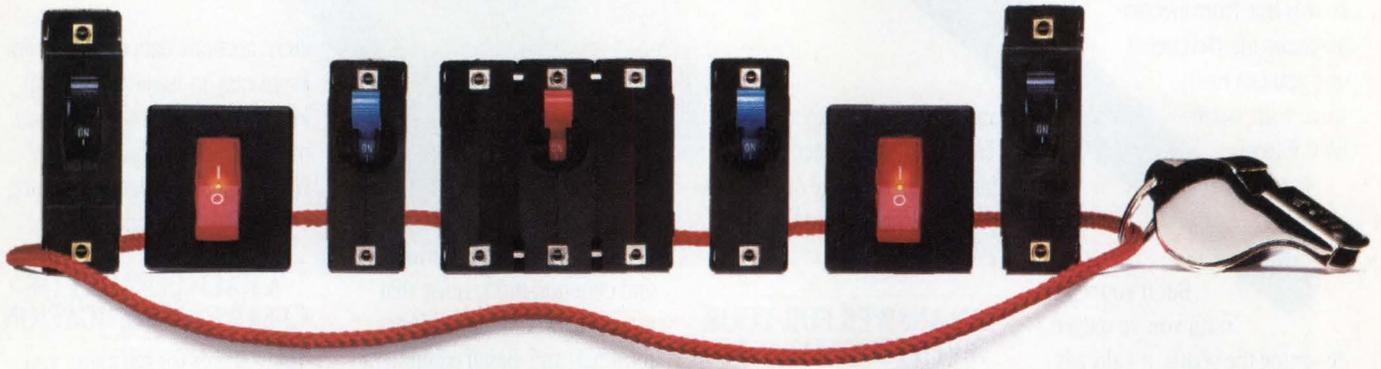
EDN April 28, 1988

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Specifications (EMC Chip Filters)

Model	Circuit	Frequency Range (MHz)	Impedance (Ω)	Rated Current (mA)
M608	1 circuit; Common-mode	5 - 200	≥ 300 (at 100MHz)	100
M614	1 circuit; Common-mode	5 - 100	≥ 700 (at 50MHz)	100
M620	1 circuit; Common-mode	5 - 50	≥ 1,000 (at 30MHz)	100
M720N	20 circuits; Normal-mode	50 - 300	≥ 50 (at 200MHz)	50

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Specifications (DIP Noise Filters)

Model	Circuit	Rated Current per Line (mA)
D-03C/ D-03C1	8 circuits; Common-mode	100
D-05N1	8 circuits; Normal-mode	100
D-07C1	8 circuits; Common-mode	300
D-08C2	4 circuits; Common-mode	2,300
D-08C2A	4 circuits; Common-mode	500
D-16C	4 circuits; Common-mode	100
D-20C	8 circuits; Common-mode	500
D-40C	3 circuits; Common-mode	300
D-42C	5 circuits; Common-mode	300
D-45C	8 circuits; Common-mode	300
D-47C	10 circuits; Common-mode	300
D-55C	5 circuits; Common-mode	300
D-58C	8 circuits; Common-mode	300

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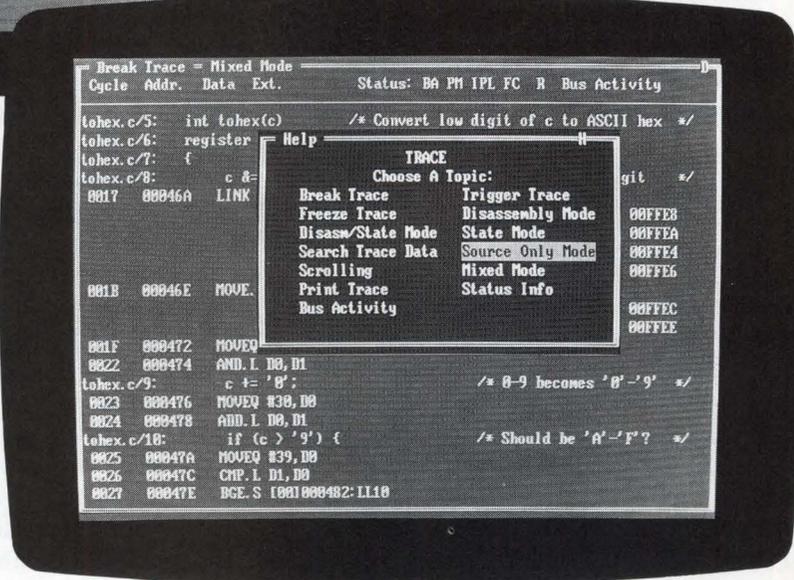
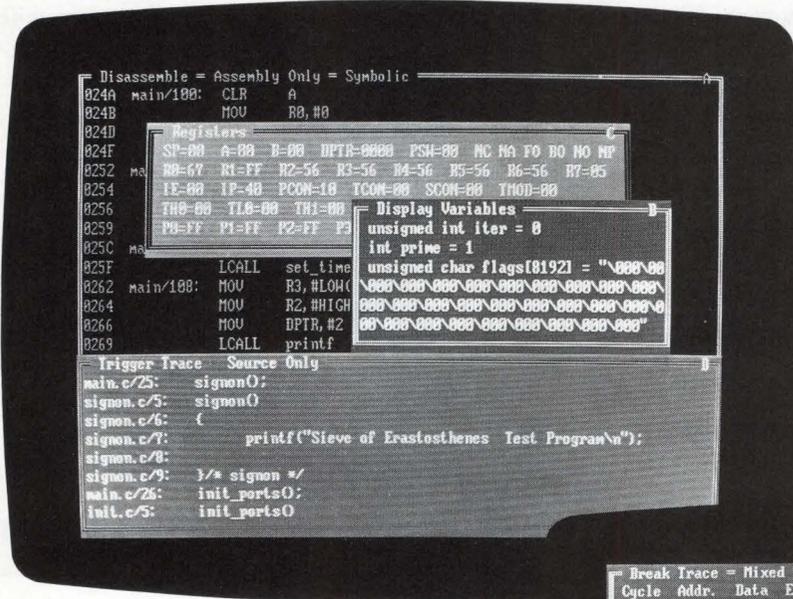
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Supported Processors:

8051 Family	
68HC11	64180/Z180
Z80	68000 Family
6809	8085

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- Works with both MFM and RLL controllers

Disk Technician+ runs on the IBM PC, PC/XT, PC/AT, and compatibles. The disk-maintenance software package provides automated daily, weekly, and monthly testing procedures that prevent failures and recover data from damaged sectors on both hard and floppy disks. The program works with both MFM and RLL controllers, and with PC/AT 1.2M-byte floppy-disk drives. You can use one or two hard drives. The program reads from and writes to every individual bit in the hard-disk partition under test, using proprietary algorithms that can detect marginal bits, predict potential failures, and correct these failures if they occur. The package provides two formatting procedures: a nondestructive formatter for PC/AT-type machines, with adjustable interleaving to maximize system speed;

and a destructive, low-level formatter with adjustable interleaving for PC/XTs, PC/ATs, and compatibles. You can retain or ignore the disk-manufacturer's bad-track table, and can add bad track or sectors at any time, nondestructively. The package also includes the SafePark memory-resident program, which automatically moves the heads to a safe zone if there is no hard-disk activity for a user-specified period within 1 to 15 sec. \$129.95

Prime Solutions, 1940 Garnet Ave, San Diego, CA 92109. Phone (619) 274-5000.

Circle No 410

SPECTROSCOPY TOOL

- Automates the acquisition and analysis of spectroscopy data
- Handles ultraviolet, visible, infrared, and other data

The Spectrochart-PC software package automates the acquisition and analysis of spectroscopic data. Using the vendor's Adalab-PC data-

acquisition board and an IBM PC or compatible, you can record and analyze voltage signals from the recorder output of any type of spectrometer, including those that operate with ultraviolet, visible, or infrared radiation as well as those that work with fluorescence, reflectance, atomic emission, or atomic absorption. You can analyze as many as 100 standard or unknown samples in any sequence. The program will record a single value for each sample, or, for kinetic studies, will provide each with multiple, timed values. The graphics routines can plot multiple samples, kinetic curves, or spectra in windows to 640x200 pixels max. You can select the position, size, background color, X and Y scale factors, and labels for each graph. You can display the value of a point by moving the cursor along the curve to that point. \$595.

Interactive Microware Inc, Box 139, State College, PA 16804. Phone (814) 238-8294.

Circle No 411

CAE FOR MAC

- Provides schematic entry, layout, and routing modules
- Can translate Gerber files to PostScript format

The EDS-I electronic-design software system runs on the Apple Macintosh II. The schematic-capture module lets you generate schematics, using both standard and user-defined component libraries, and automatically produces a net list and a parts list. The layout module can handle pc-boards as large as 32x32 in. and provides zoom and pan features, auto-tooling extraction, multilayer editing, and Gerber photoplotting files. The autorouting module accepts the net list and parts list as input, lets you define

routing parameters and options as well as keep-out areas, and lists unfinished nets. The Gerber translator module lets you convert Gerber files created by other systems into the electronic design software's internal format, or Gerber files produced by the software into PostScript files for use by high-resolution graphics printers in the Linotronics 300/500 series so that you can check the photoplot drawings before committing them to film. You do not have to order all the modules, but rather, can select just those that you need. Full system, around \$1500.

Vamp, 6753 Selma Ave, Los Angeles, CA 90028. Phone (213) 466-5533. TWX 650-262-3069.

Circle No 412

CASE TOOLS

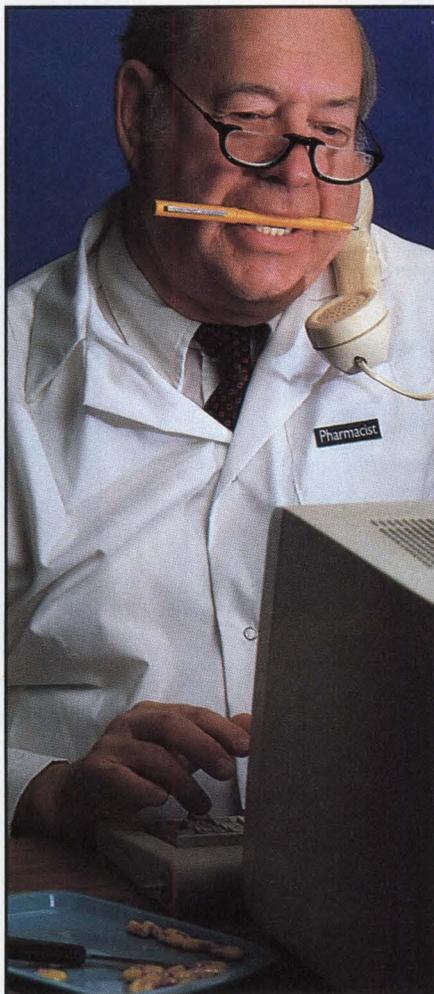
- Help you document and examine multiple-module C programs
- Run on IBM PCs under MS-DOS

The C Documenter and C Scan utilities for the IBM PC and compatibles ease the task of documenting and examining programs written in the C programming language. Where such programs are subdivided into separate subsystems, C Documenter generates a set of four reports containing cross-reference information, such as which modules or functions are called by other modules or functions. You can use the reports to define the interface between two program subsystems, which is advantageous when differ-

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ent programmers are writing the subsystems. When you examine your programs, C Scan lets you use symbolic names to locate and display portions of code, regardless of the source-code file in which they're contained. By keeping a record of your program's files, C Scan lists the type of items in the program, such as functions, global variables, structures, and union members; upon your selection of an item, C Scan displays all items of that type in your program and lets you locate them. You can obtain the utilities separately or as part of the C Dev cross-development tool set, which also includes a C cross compiler, a mimic simulator, and a crossassembler. C Scan, £195; C Documenter, £195; C Dev, about £2000.

Real Time Systems Ltd, Viking House, Nelson St, Douglas, Isle of Man, UK. Phone (0624) 26021. TLX 94011289.

Circle No 413

REAL-TIME OS

- Operates with minimal hardware configuration
- Provides many real-time tasks and features

The UniFlex/RT multiuser, multitasking operating system for VME Bus systems based on the 68020 processor is now available for Apple's Macintosh II computer. The real-time features include fast message exchanges, a named enqueue/dequeue mechanism, shared data pages and text segments, and other facilities needed by real-time systems. The OS runs on a minimal Macintosh II computer that has at least 1M byte of main memory, 20M bytes of disk storage space free, and the 68851 memory-management chip. If you have a larger hard disk, you can partition the disk so that you can use the Mac OS as well as UniFlex/RT. The system comes with the utilities that you'll need for

real-time, assembly-language software development, including a relocating macroassembler, a linking loader, a library generator, a symbolic debugger, and file- and system-maintenance programs. You can also obtain such options as a System V-compatible C compiler, X-Windows, a screen editor, and a text processor. \$750.

Technical Systems Consultants Inc, 111 Providence Rd, Chapel Hill, NC 27514. Phone (919) 493-1451. TWX 510-920-0540.

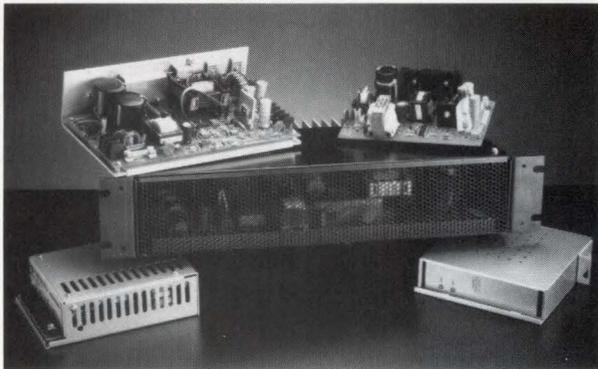
Circle No 414

CROSS COMPILER

- Generates efficient code for 8051 family of μ Cs
- Supports internal bit operations

AVPAS51 version 3.0 is an optimizing Pascal cross compiler for the 8051 family of μ Cs. The language is a dialect of Pascal that is closely matched to the architecture of the

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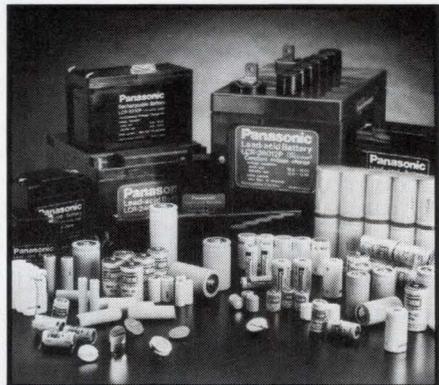


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8051 family and that can use all 8051 memory spaces. When you're writing programs for enhanced μ Cs such as the 8052, you can also use the upper 128 bytes of on-chip memory to store variables. The compiler lets you declare individual subroutines as static, which reduces code size and improves execution speed. According to the vendor, the code is efficient enough that you should not need to rewrite time-dependent routines in assembly language. The compiler does not support a few Pascal features, such as real-number arithmetic, but it does support the interrupt handling, special-function registers, and internal bit operations of the 8051. The compiler runs on the IBM PC and compatibles. Compiler, \$495; with AVMAC macroassembler, \$795.

Avocet Systems Inc., Box 490, Rockport, ME 04856. Phone (207) 236-9055.

Circle No 415

IEEE-488 SOFTWARE

- Lets you write IEEE-488 control programs in C or Pascal
- Runs under the OS-9/68k operating system

This IEEE-488 management software package allows a VME Bus computer system to control an IEEE-488 instrumentation bus. It lets you implement IEEE-488 talker, listener, and system-controller functions. The software comprises an IEEE-488 manager and an IEEE-488 device driver that run under the OS-9/68k operating system and that permit you to write application programs in C or Pascal. Running as a background task, the manager configures and initializes the IEEE-488 bus and arbitrates all communication between the IEEE-488 device driver software and the application program. To execute an IEEE-488 bus operation, the application program passes a command

parameter block—specifying the device name and address, the action required, and the source and destination of transferred data—via the manager to the device driver. A device descriptor provides the driver with information about the addressed device's IEEE-488 capabilities. The manager also includes a time-out monitor to detect excessive delay in an instrument's response. The software package further includes sample device descriptors, a menu-driven system test program, and sample application programs. \$750.

Comcontrol bv, Stratumsedijk 31, 5600 AD Eindhoven, The Netherlands. Phone (040) 124955. TLX 51603.

Circle No 416

Comcontrol Inc., 15466 Los Gatos Blvd, Suite 109-365, Los Gatos, CA 95032. Phone (408) 356-3817. TWX 510-601-2895.

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- Detects Device type (signature)
- Detects misplaced device

SUPPORTS:

- 5 different programming algorithms, including Intel Intelligent and Quick-Pulse, AMD Flashrite

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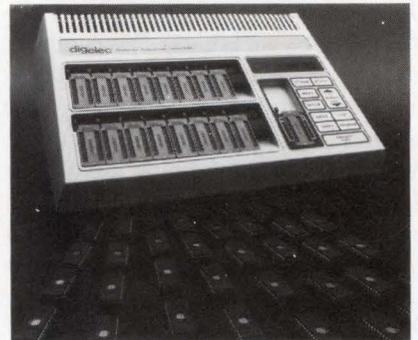
- SOFTLINK remote control software for IBM PC/XT/AT
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- Adapter for 1 M bit EPROMs and Motorola micros



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- Plug-in SOFTPACK cassette for do-it-yourself software updates

SUPPORTS:

- 5 different programming algorithms, including Intel Intelligent and Quick-Pulse, AMD Flashrite

DETECTS:

- Device type (signature)
- Reverse or misplaced device

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- RS-232C interface
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Programming Time
(in seconds for 16 devices)

DEVICE	*1INTEL	2	AMD	FUJITSU
2764	45	40	40	30
27256	185	50	151	135
27512	385	110	325	280

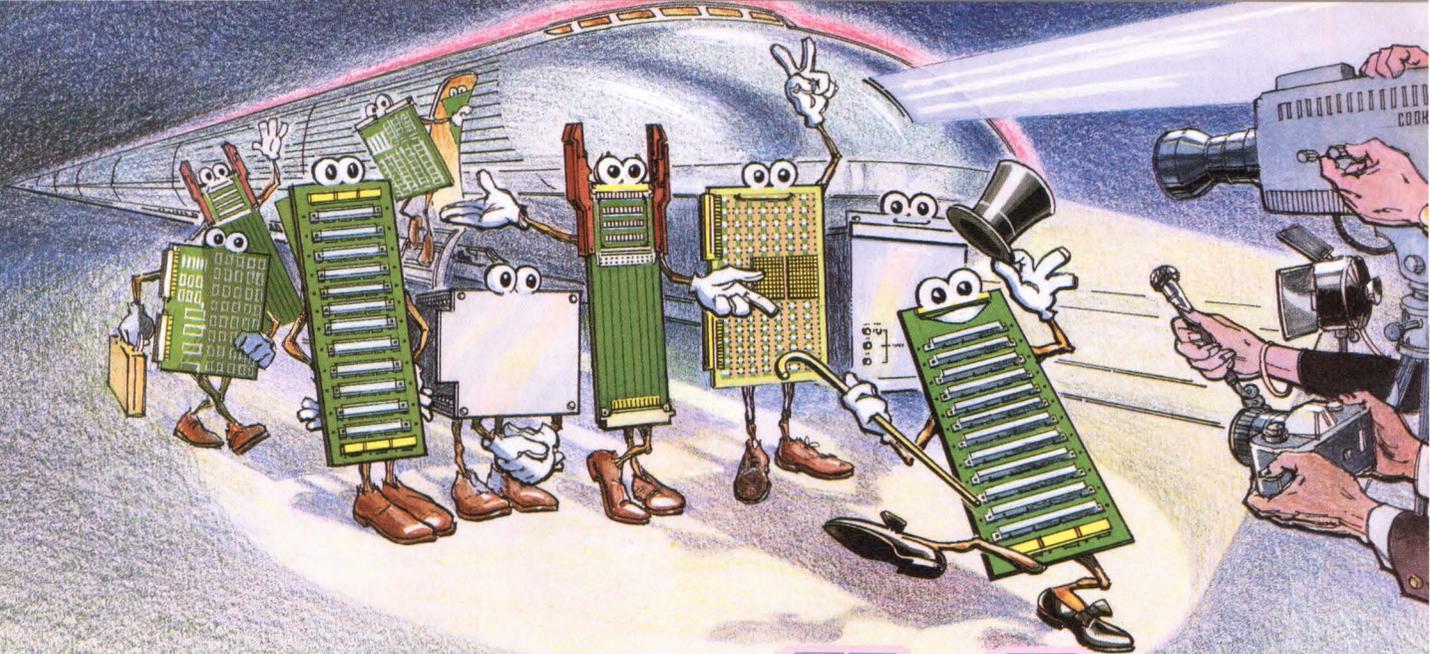
*1 = Intelligent

2 = Quick-Pulse



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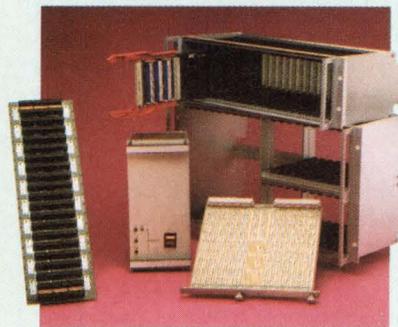
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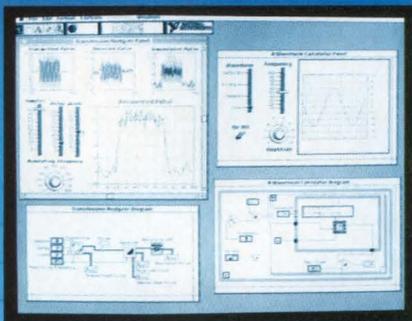
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Beckman Industrial Corp., 3883 Ruffin Rd, San Diego, CA 92123. Phone (619) 495-3240.

Circle No 421

LOGIC ANALYZER

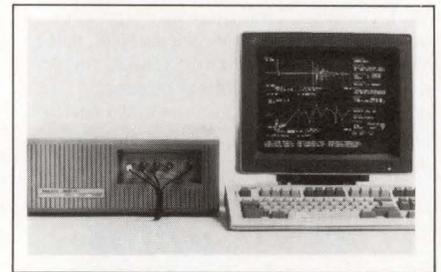
- Captures 10M bits×64 channels
- Acquires 16-channel data at 200 MHz

Without multiplexing, the K450M logic analyzer system can capture as many as 10 million, 64-bit-wide data frames at speeds as high as 50 MHz. From the front panel, you can reconfigure it to capture 40 million, 16-bit-wide data frames at speeds as high as 200 MHz. Another member

of the series, the K450B, can record 80-bit-wide data frames. Each system includes an analyzer, an IBM PC/AT-compatible computer, and a multimegaword memory with either 2.5M bits or 10M bits/channel. The vendor also offers the 80386 MAP (microprocessor analysis package), an 80386 μP disassembler that also supports the 80287 and 80387 coprocessors. Analyzer, \$165,000; disassembler, \$2495. Delivery, 90 days and eight weeks ARO, respectively.

Gould Inc., 3631 Perkins Ave, Cleveland, OH 44114. Phone (216) 361-3315.

Circle No 422



FOURIER ANALYZER

- Has two 20-kHz bandwidth channels
- Averages spectra in real time at 10 kHz

The standard 23-lb 2630 Fourier analyzer comes with two channels, but you can also obtain a four-channel version. The analyzer samples all channels simultaneously and provides 20-kHz bandwidth on each channel, with 75-dB dynamic range. The unit connects to the RS-232C port of an IBM PC or compatible computer equipped with an IBM EGA or compatible card. The analyzer's capabilities include computation of transfer functions, power spectra, coherence, impulse response, and cross spectra. It performs real-time spectral averaging of data gathered at a 10-kHz rate.

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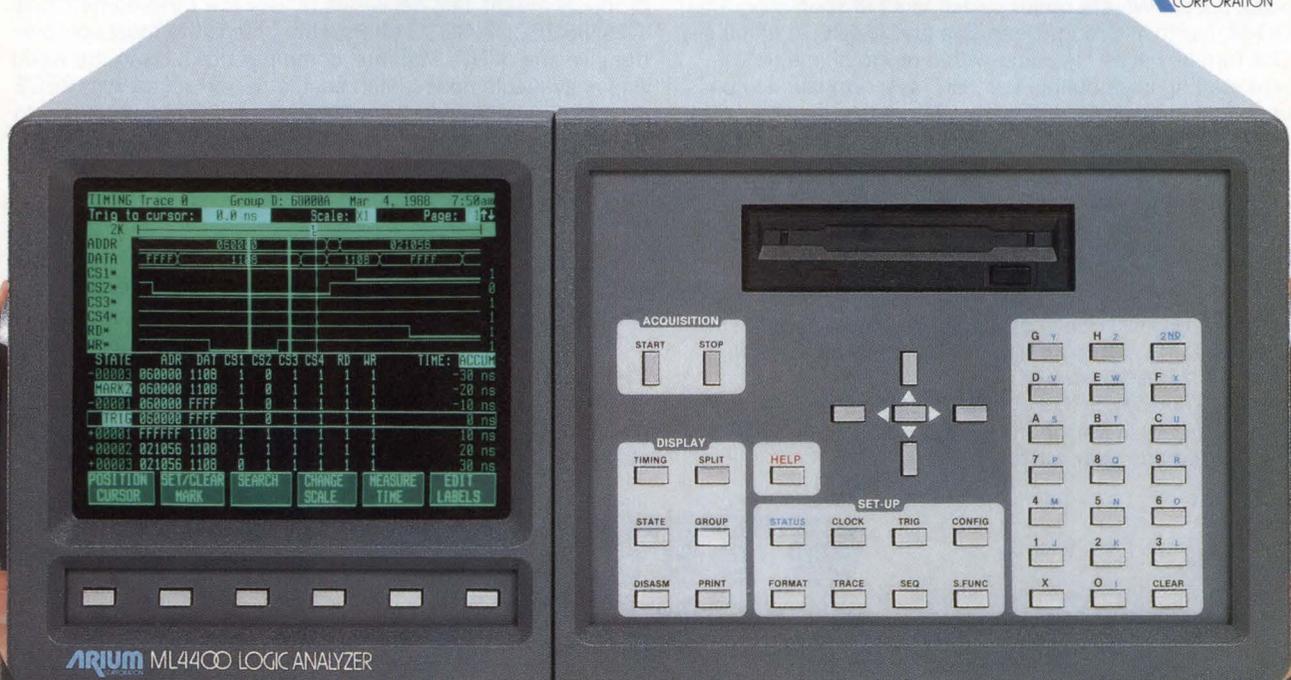
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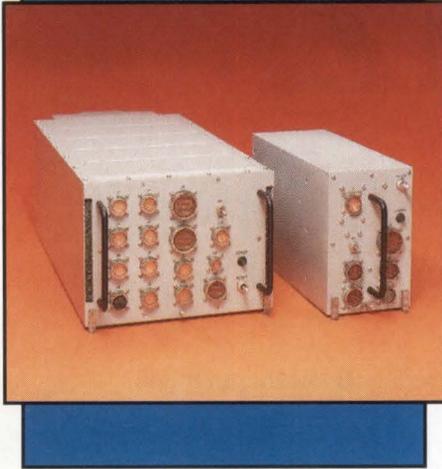


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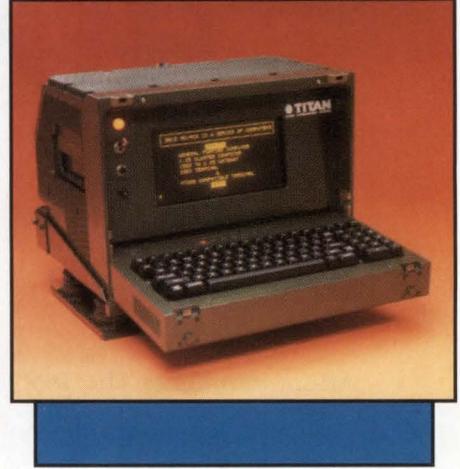
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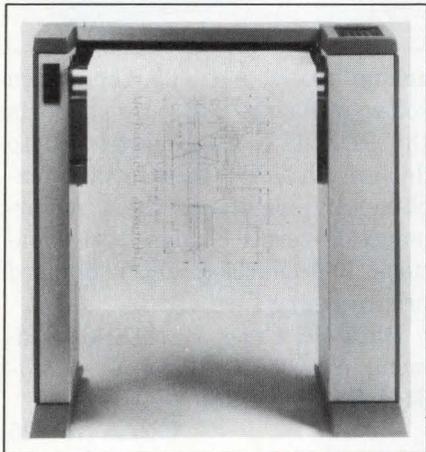
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800-423-5527

The control program, which runs on the PC, allows screen dumps to plotters and to dot-matrix or laser printers. \$9950.

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Circle No 420



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- Handle 24- and 36-in.-wide media
- Plot 200 points/in. at 1 in./sec

Series 8500 electrostatic, monochrome printers plot 200 points/in. at 1 in./sec. The 8524 plots on 24-in.-wide media; the 8536 uses 36-in.-wide media. The units accept data in HPGL (Hewlett-Packard Graphics Language) 906/907 formats. The vendor claims that the printers are three to four times more reliable than earlier units because their parts counts are 30% lower. The units' rasterizers, which convert vectors to raster-scan data, can accept an unlimited number of vectors. A full-page buffer stores the last page printed, enabling you to rapidly obtain multiple copies of a drawing. The units can produce D-size copies at 1.67 copies/min. Their RS-232C ports accept vector data at 38,400 bps. 8524, \$19,900; 8536, \$24,900.

Versatec, 2710 Walsh Ave, Santa Clara, CA 95051. Phone (800) 538-6477; in CA, (800) 341-6060. TWX 910-338-0243.

Circle No 451

LCR ANALYZER

- Measures C, leakage, ESR, and D/A of capacitors
- Measures L, ringing, and leakage of inductors

The portable LC77 auto-Z meter analyzes inductors, capacitors, and resistors. It makes the following capacitor measurements: capacitance

(C), leakage (shunt resistance), dielectric absorption (D/A), and equivalent series resistance (ESR). On inductors, it measures inductance (L), leakage resistance, and ringing. The meter counts the number of times that the voltage across a coil oscillates or rings following an interruption in current through the coil; the resulting total is related to the

BYTEK's 135 MULTIPROGRAMMER™ WITH 18/12 PROTECTION PLAN



Model 135-E: **\$995.00***

FREE 18 MONTH WARRANTY & ALSO FREE 12 MONTH DEVICE UPDATES. BYTEK's Model 135 leads the industry with a free 18-month warranty & also free 12-month Device Updates. The 135 can program 24, 28, 32 & 40-pin (E)EPROMs from 16K to megabit devices.

THREE PROGRAMMERS IN ONE: The 135 is a SET (E)EPROM Programmer, GANG (E)EPROM Duplicator, & UNIVERSAL Device Programmer. Sets of devices, 16- & 32-bit wide, can easily be downloaded into RAM & programmed. As a stand-alone Gang Duplicator, 8 (E)EPROMs can be copied at once. (16 (E)EPROMs optional). With 2 MegaBit RAM (256K x 8) expandable to 2 MByte, the 135 supports more devices than any other production programmer. Options are available to program 40-pin EPROMs, 40-pin Micros, Bipolar PROMs, & PLD/EPLD/GAL/FPLAs.

4 OPERATING MODES: (1) Stand-alone programming, including Data Editing (2) from a host computer (3) terminal mode, and (4) menu-driven operation using BYTEK's PROMSoft IBM PC-compatible software.

COMPATIBILITY: BYTEK's 135 is Data I/O* computer remote control & terminal mode compatible. The 135 also operates under PROMlink™**. See us at Electro 88, booth #2954 or call us toll free.

BYTEK

1-800-523-1565
In Florida: 1-407-994-3520

BYTEK Corporation
Instrument Systems Division, 1021 S. Rogers Cir., Boca Raton, FL 33487
Tel: (407) 994-3520 FAX: (407) 994-3615

BYTEK International
511 11th Avenue So., Minneapolis, MN 55415
Tel: (612) 375-9517 FAX: (612) 375-9460 Telex: 4998369 BYTEK

*U.S. price only **Data I/O & PROMlink are registered trademarks of Data I/O Corporation. (Some limitations may apply)

MODUTEC'S BIG-LITTLE GETS BOLDER & BRITER



THE WORLD'S ONLY LCD DPM WITH SUPER-BRITE LED BACKLIGHTING.

A cost-saving breakthrough! By using LED's...with 100K hours of life...for backlighting, Modutec's new LCD Big-Little DPM's now provide high visibility in daylight, nightlight, any light. You have a choice of red or green economical backlighting plus plug-in compatibility with Modutec standard LCD Big-Little DPM's. Backlighting power is 5, 12, 24 VDC or 115 VAC. Displays are -20°C to $+65^{\circ}\text{C}$ operating and storage with $3\frac{1}{2}$ digits, $\frac{1}{2}$ " high, full scale of 1999. Actual size: 2.36" L. x .95" H. x .51" D. Enjoy the benefits of low power consumption with Modutec's LCD DPM featuring an LED look.

Additional features:

- * ± 200 mV or $\pm 2\text{V}$ input
- * 3 power options: 9V battery, $\pm 5\text{VDC}$ or $+5\text{VDC}$
- * Window or bezel mount
- * Accuracy: $\pm(0.1\% + 1 \text{ count})$

For a day/night demonstration, contact your local Modutec sales representative, distributor or MOD Center, nationwide.

See us at Booth #1707 ELECTRO '88

MODUTEC

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MODUTEC, INCORPORATED
P.O. BOX 778, 18 MARSHALL ST.,
NORWALK, CT 06856-203/853-3636;
1-800/METERS-1 TWX 710-468-2039



CIRCLE NO 60

TEST & MEASUREMENT INSTRUMENTS

coil's Q (quality factor). The meter measures C from 1 pf to 19.99f, leakage current from 10 nA to 19.99 mA, ESR from 0.1 to 1990 Ω , D/A from 1 to 100% of impressed voltage, L from 0.1 μH to 19.99H, and resistance from 50 Ω to 999 M Ω . It can also test some active devices, such as SCRs and triacs. \$1895.

Sencore, 3200 Sencore Dr, Sioux Falls, SD 57107. Phone (800) 843-3338; in SD, (605) 339-0100.

Circle No 423

RTD SIMULATOR

- Simulates 2-, 3-, and 4-wire thermometers
- Covers -200 to $+850^{\circ}\text{C}$

The handheld, battery-powered RTD-700 can measure and simulate 2-, 3-, and 4-wire resistance temperature detectors (RTDs), or resistance thermometers. The unit operates in either Celsius or Fahrenheit mode, covers the temperature range from -200 to $+850^{\circ}\text{C}$, and offers four digits of resolution, with simulation accuracy of $\pm 0.1\%$ of setting and readout accuracy of $\pm(0.1\% + 0.1\Omega)$. The unit uses an industry-accepted test-current value of 1 mA to minimize the effects of self-heating of the detector. \$725.

General Resistance Co, Box 185, North Branford, CT 06471. Phone (203) 481-5721.

Circle No 424

CONTROLLER ADAPTER

- Supports programmable bus-controller IC
- Works with vendor's universal programming system

The 303A-PLX LogicPak adapter works with the vendor's 29B universal programming system to program and test PLX Technology Corp's PLX 448 high-drive-current programmable bus controller. The PLX 448 meets VME Bus, Multibus I, and Multibus II specifications,



among others. Abel 3.0, the design software for the 29B, also supports the PLX 448. Abel allows you to design PLX 448-based state machines by specifying their performance in terms of high-level equations. It produces JEDEC-standard programming files. \$495.

Data I/O Corp, Box 97046, Redmond, WA 98073. Phone (206) 881-6444. TLX 152167.

Circle No 425

ANALYZER

- Monitors, emulates, and analyzes high-speed data links
- Suits development and testing of ISDN terminal equipment

The DA-20 data-communications analyzer can capture and analyze data streams operating in full duplex mode at data rates as high as 72k bps. You can also use it to analyze the 192k-bps data on the S_0 interface of ISDN networks. Interchangeable EPROMs that plug into the instrument allow you to implement any data-communications protocol or procedure. The analyzer features two RX channels and one TX channel, allowing you to monitor, emulate, and statistically analyze data links. Data and programs are stored on 45M-byte tape streamer cartridges; you can thus build a library of instrument setups and results. You don't need a knowledge of high-level programming languages to program the instrument. You set it up via a simple menu-driven editor and soft-key controls. You can select transmission parameters manually or use the analyzer's autoconfigure

TEST & MEASUREMENT INSTRUMENTS

mode, and you can store setup information either in nonvolatile RAM or on tape. The analyzer has an integral printer. Around \$15,000.

Wandel & Goltermann, Postfach 1262, 7412 Eningen u A, West Germany. Phone (07121) 860. TLX 729833.

Circle No 426

Wandel & Goltermann Inc, 1030 Swabia Ct, Research Triangle Park, NC 27709. Phone (919) 941-5730. TLX 810-621-0002.

Circle No 427

LOGIC ANALYZER

- Analyzes software performance at 50-MHz in real time
- Excludes irrelevant data from analysis

The DT3750XA can study the performance of your software in real time at 50 MHz with no limits on the duration of the examination. The unit—which you can obtain with as many as 256 channels, configured in 16-channel increments—has logic-analysis capabilities that let you qualify the data it will consider and exclude irrelevant information. To avoid loss of data, a pair of 4k-word buffers store the acquired intelligence. While one buffer is filling, the other transmits its contents to a host computer via a high-speed interface. The state-machine triggering has 16 levels, with four test conditions per level. \$13,000 to \$90,000.

HiLevel Technology Inc, 31 Technology Dr, Irvine, CA 92718. Phone (714) 727-2100. TLX 655316.

Circle No 428

DMM

- Performs six measurement types and resolves 5½ digits
- Incorporates 8-channel scanner

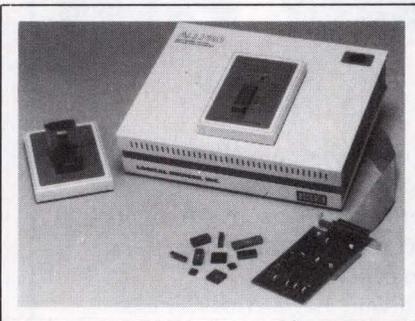
The half-rack-width Model 199 DMM incorporates an 8-channel scanner and measures dc and ac voltage, dc and ac current, resis-



tance, and dB, with 5½-digit precision. The instrument is also available optionally without the scanner; if you purchase a unit without the scanner and later decide to obtain the scanner, you can add it yourself. The unit offers sensitivity of 1 μ V, 1 m Ω , and 100 nA. It can take 150 readings/sec with 4½-digit resolution and, for one year after calibration, can measure dc voltages within an error rating of $\pm(0.007\%$ of reading + 2 counts). The scanner performs 40 measurements/sec, offers 2- or 4-pole switching, and introduces $<1 \mu$ V of thermal offset. \$995 to \$1395.

Keithley Instruments Inc, 28775 Aurora Rd, Cleveland, OH 44139. Phone (216) 248-0400. TLX 985469.

Circle No 429



DEVICE PROGRAMMER

- Programs PLDs, μ Ps, PROMs, and sequencers
- Software libraries support more than 1200 devices

The AllPro/28 programmer handles 28-pin PLDs, EPLDs, μ Ps, EPROMs, EEPROMs, and programmable sequencers. You can upgrade the unit to handle 40-pin devices by adding pin-driver cards. This retrofit converts the unit into the vendor's AllPro/40. You need an IBM PC, PC/AT, or compatible computer to host the programmer.

MODUTEC'S BIG-LITTLE™ GETS BOLDER & BRITER



THE WORLD'S ONLY LCD DPM WITH SUPER-BRITE LED BACKLIGHTING.

A cost-saving breakthrough! By using LED's...with 100K hours of life...for backlighting, Modutec's new LCD Big-Little DPM's now provide high visibility in daylight, nightlight, any light. You have a choice of red or green economical backlighting plus plug-in compatibility with Modutec standard LCD Big-Little DPM's. Backlighting power is 5, 12, 24 VDC or 115 VAC. Displays are -20°C to $+65^{\circ}\text{C}$ operating and storage with 3½ digits, ½" high, full scale of 1999. Actual size: 2.36" L. x .95" H. x .51" D. Enjoy the benefits of low power consumption with Modutec's LCD DPM featuring an LED look.

Additional features:

- * ± 200 mV or ± 2 V input * 3 power options: 9V battery, ± 5 VDC or $+5$ VDC
- * Window or bezel mount
- * Accuracy: $\pm(0.1\% + 1 \text{ count})$

For a day/night demonstration, contact your local Modutec sales representative, distributor or MOD Center, nationwide.

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See us at Booth #1707 ELECTRO '88

CIRCLE NO 61

319

The vendor will offer an interface card for IBM's PS/2 series in April 1988. The host computer runs the vendor's LogiPro support software, whose device library includes more than 1200 ICs. \$2795.

Logical Devices Inc, 1321 NW 65th Pl, Fort Lauderdale, FL 33309. Phone (305) 974-0975. TLX 383142.

Circle No 430

BUS ANALYZER

- On single I/O card for IBM PC/AT, PC/XT, or compatible
- Captures 8000 bus states in real time

The BusTrak microsystem-bus analyzer performs many functions usually associated with logic analyzers, code debuggers, and PC testers. It

is housed on a single I/O card that plugs into an IBM PC/AT, PC/XT, or compatible computer. The unit can capture 8000 80-bit-wide data frames in real time. You can set breakpoint conditions such as reads, writes, DMA requests, CPU bus cycles, DMA bus cycles, address or data ranges, or data-bus, I/O, or memory accesses. You attach the unit by plugging it in; there are no probes or clips. Its software can automatically scan acquired data and search for conditions that you define. \$1495; demonstration diskette, free.

Applied Physics Inc, 1291-E Cumberland Ave, W Lafayette, IN 47906. Phone (317) 497-1718.

Circle No 431

**Before you waste
\$40,000.00
on a test system,
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You've already paid for more than one half of a high-quality, low-cost test system and don't even know it. That's right, with your existing Logic Analyzer and the completely new Pulse Instruments PI-6500 Pattern Generator you can perform most of the functions of an expensive test system at a fraction of its cost.

In fact, the new Pulse PI-6500 and your Logic Analyzer can create almost any interactive Trigger/Flag/Clock/Pattern imaginable. What's more, the PI-6500 and your Logic Analyzer can both receive and input data from the DUT—making the system totally interactive.

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Pulse Instruments

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DMM

- Performs 18 types of measurements
- Permits 4½- or 5½-digit resolution

The PM2525 digital multimeter makes 18 kinds of measurements. It measures ac and dc voltage, ac and dc current, two- and four-wire resistance, capacitance, frequency, time, temperature, and decibel level; it also checks continuity. The meter allows you to select a readout resolution of 4½ or 5½ digits; it provides five voltage, seven current, and eight resistance ranges. Its maximum resolution is 1 µV, 100 pA, 10 mΩ, and 1 pF, and its ac measurement bandwidth extends to 100 kHz. \$795.

John Fluke Mfg Co, Box C9090, Everett, WA 98206. Phone (800) 426-0361; in WA, (206) 347-6100. TLX 185102.

Circle No 432

Superior Semiconductor Test Performance

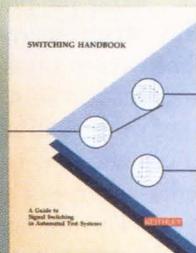
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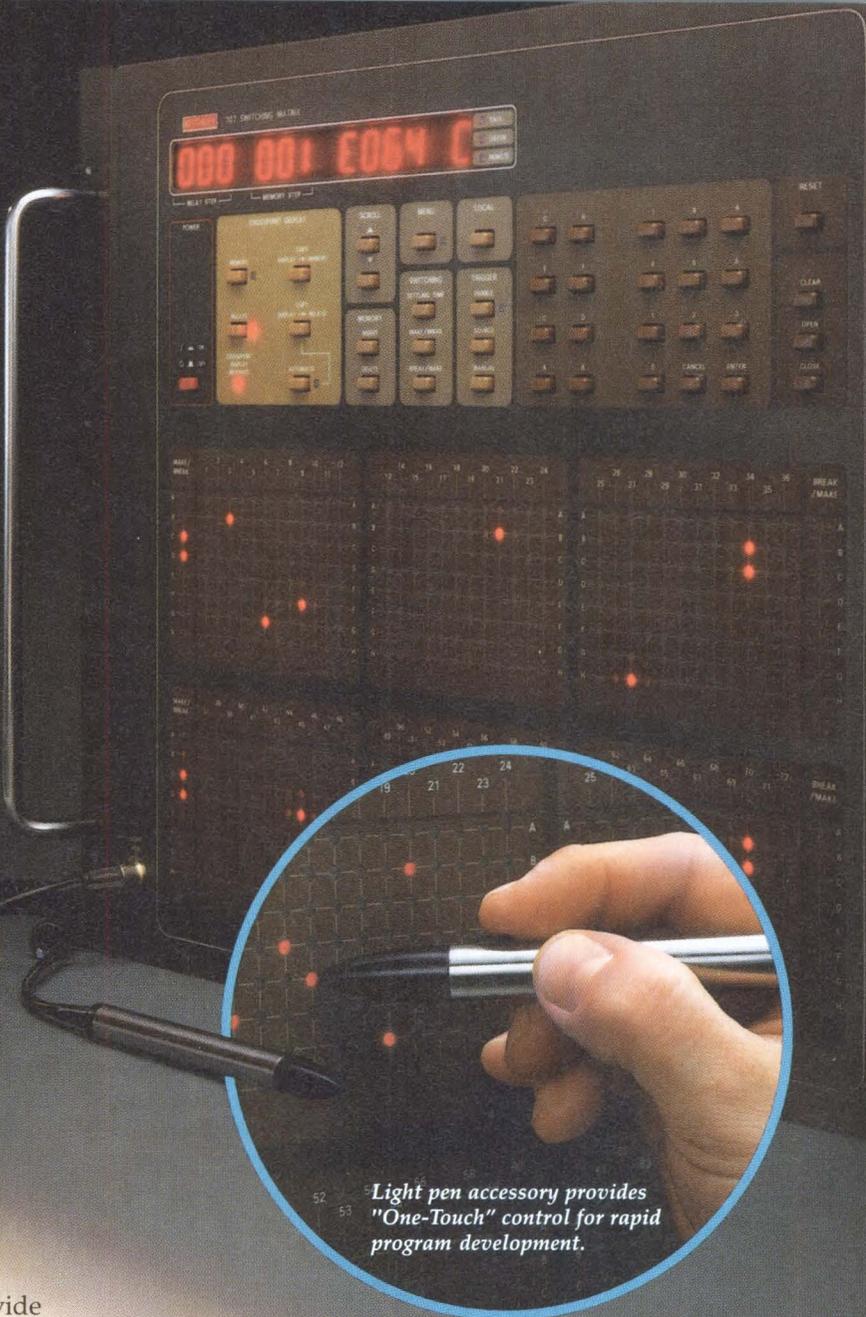
The new Model 707 Switching Matrix includes **two sub-picoamp** and **two high frequency CV** matrix switching paths. Four additional triaxial inputs provide signal paths with performance to 20pA. Mix general purpose and coaxial matrix cards to switch an entire spectrum of signals from 5 μ V to 200V, DC to 30MHz, in configurations up to 2880 relay crosspoints (8x360).

Integrate the Model 707 into your system quickly and easily, with preassembled cables and **standard connecting hardware**. General purpose, semiconductor, and coaxial switching cards are automatically interconnected through the analog backplanes, and are easily removed for maintenance.

Relay status is continually displayed on the 707's front panel. And the interactive Programming **Light Pen** accessory reduces program development time by eliminating keystrokes. Store up to 100 configurations in the 707's built-in, non-volatile **memory** for instant recall or fast triggered relay sequences.



Technical support literature and our Applications staff will help you select the appropriate system configuration.



Light pen accessory provides "One-Touch" control for rapid program development.

To get the complete story on Keithley switching, call **1-800-552-1115**.

The Model 707 Switching Matrix

KEITHLEY

Because you're thinking fast... count on us for the speed you need.

Now, 19ns settling op amps that survive saturations and shorts...

Comlinear's two new high-speed op amps bring you built-in protection against saturation. Plus simple short-circuit protection. That means easy solutions for fast input and output amplifiers in systems where signal level or load can't be controlled.

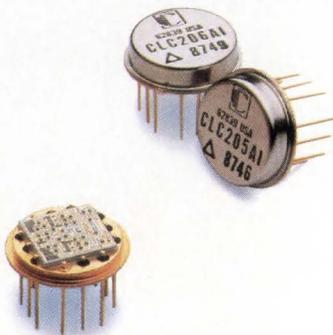
use as little as 57mW...

Our new 170MHz CLC205 offers fast dynamic performance and power consumption down to 57mW (with $\pm 5V$ supplies). A settling time of 24ns to 0.05% is complemented by the drive performance of a $\pm 12V$ output swing and $\pm 50mA$ output current.

or drive up to $\pm 100mA$.

For higher drive, call for our 180MHz CLC206 which will drive up to $\pm 100mA$ and settle in just 19ns (to 0.1%). It is coupled with a high slew rate of $3400V/\mu s$ and delivers a large-signal bandwidth of 70MHz at $20V_{pp}$.

Both of these new op amps give you saturation and short-circuit protection plus *tested and guaranteed performance at half the price of other high-speed amps*. Now you can be safe at high speed.



CIRCLE NO 63

Comlinear Corporation
Solutions with speed

4800 Wheaton Drive
Fort Collins, Colorado 80525
(303) 226-0500

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TEST & MEASUREMENT INSTRUMENTS



SYNTHESIZER

- Generates 0.1 Hz to 16 MHz with $5\frac{1}{2}$ -digit resolution
- Optional oscillator provides 1 ppm stability

The Model SI-102 frequency synthesizer provides $5\frac{1}{2}$ digits of resolution and covers 0.1 Hz to 16 MHz. When operating at 1 Hz and below, the unit provides a resolution of 10 μ Hz; when running at 1 kHz and above, it offers 100-Hz resolution. You can choose between two reference oscillators: The standard one is stable within ± 10 ppm, from 0 to $50^\circ C$; the optional reference is stable to ± 1 ppm. The half-rack-width instrument consumes 8W from a 50- or 60-Hz, 115 or 230V ac line. The vendor also offers BCD-programmability as an option. \$681.

Syntest Corp, 40 Locke Dr, Marlboro, MA 01752. Phone (617) 481-7827.

Circle No 433

ATE

- Combines functional and in-circuit testing
- Available with either 128 or 256 functional test channels

The System-730BT board-test system provides high-performance, 15-MHz functional testing, together with 10-MHz, in-circuit testing. You can dynamically switch between the two test techniques to optimize fault location strategies. Using the 15-MHz functional test channels around the edge of the board under test, you can detect device-interaction faults even on VLSI-based boards. Each functional test channel is backed by a $4k \times 4$ -bit RAM,

which you can reconfigure to a $16k \times 1$ -bit RAM to handle long bit streams. All the channels are de-skewed to eliminate propagation delay differences, and each channel offers 12 separate drive formats and measurement modes, including signature analysis. The system is available in either 128- or 256-channel forms and is suitable for high-speed cluster testing. It includes a timing generator in which the functional channels can apply algorithmic patterns, perform word recognition for triggering purposes, and provide both high- and low-frequency clock output functions. Around \$280,000.

Schlumberger Technologies, ATE Div, Ferndown Industrial Estate, Wimborne, Dorset BH21 7PP, UK. Phone (0202) 893535. TLX 41436.

Circle No 434

Schlumberger Technologies, ATE Div, 1801 Technology Drive, San Jose, CA 95110. Phone (408) 998-0123.

Circle No 435



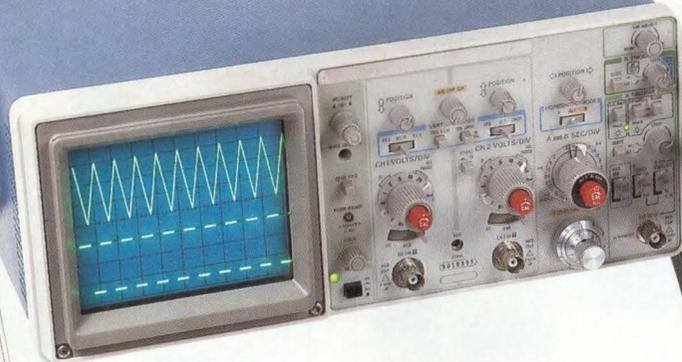
SIGNAL GENERATOR

- Provides phase noise of -130 dBc at 500 MHz
- Shows actual power-level at DUT despite cable losses

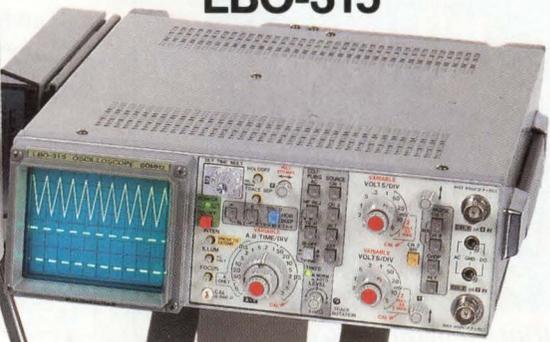
The HP 8657A synthesized signal generator covers the 100-kHz-to-1.04-GHz range. When running at 500 MHz, its phase noise is -130 dBc; when operating at 1 GHz, its phase noise equals -124 dBc. The residual FM is < 4 Hz. In combination, these characteristics allow you to use the unit to test selectivity of radios carrying -90 -dB selectivity specs. The unit incorporates an electronic attenuator that, according to the vendor, sets new standards for

LEADER

A TYPICAL "PORTABLE" SCOPE



THE TRULY PORTABLE
LBO-315



If both of these scopes are portable,
then this is a lapdog.

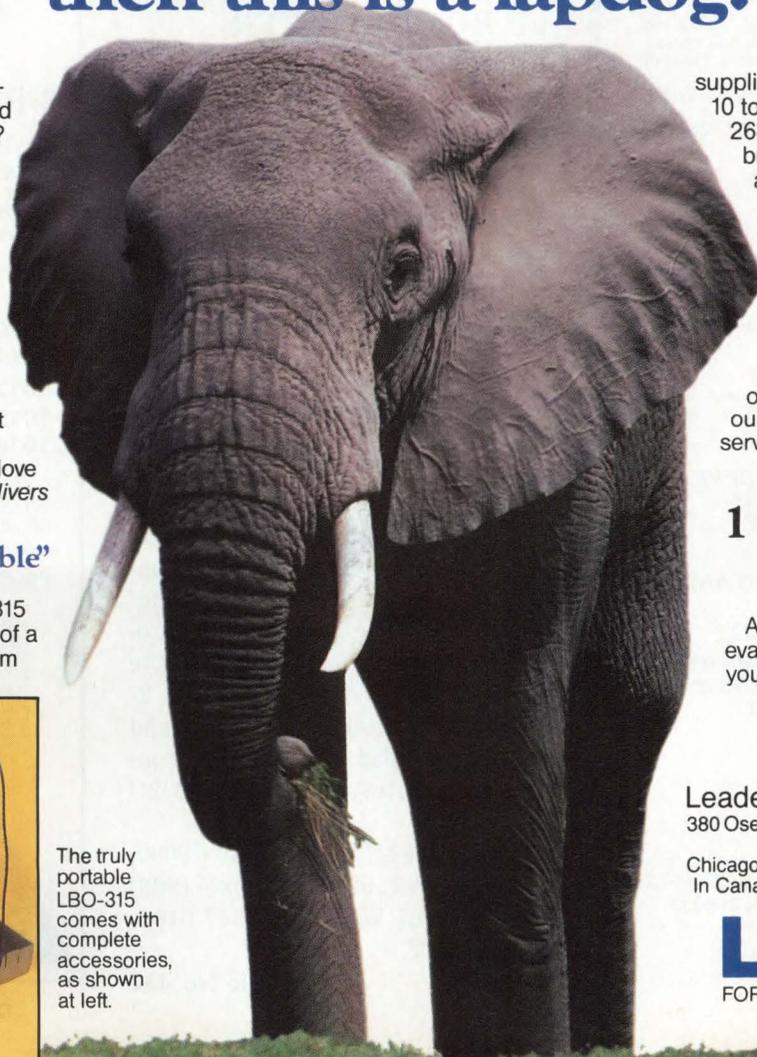
What's the difference between a portable scope and the *truly* portable LBO-315? A lot of weight, among other things. At just 10 lbs and 10.5 x 3 x 13" with battery, the full-function LBO-315 can easily go everywhere a technician goes.

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No so-called "portable" even comes close.

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supplied 12-Vdc battery, external 10 to 20 Vdc source or 85 to 264 Vac, without switching. Has bright 3.5", 12-kV, PDA CRT; alternate trigger, time base, and sweep; 2-channel and X-Y operation; variable holdoff, and more. *All this from a unit small enough to fit into an attache case!* Leader has "truly portable" 20 to 60-MHz oscilloscopes for ac/dc or ac operation. Each is backed by our 2-year warranty and factory service on both coasts.

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- Crystal: For .486" centers (HC6/U, MIL-S-12883/4), .273", .192" (HC25) centers and others.

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- Industrial, Military and Commercial grades.
- Molded and laminated constructions.

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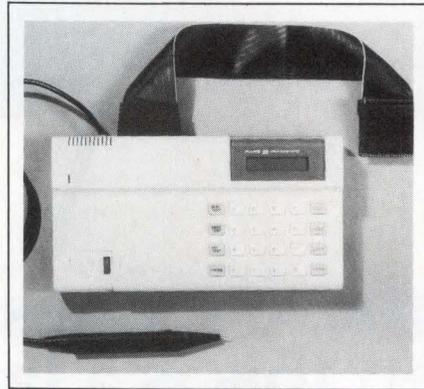
CIRCLE NO 64

INSTRUMENTS

reliability; its estimated MTBF is 500 years. The generator provides a dc-FM mode with <10 Hz/hour drift, and an amplitude-offset mode. It also has 100 storage registers for production-line use. \$7900. Delivery, eight weeks ARO.

Hewlett-Packard Co, 19310
Pruneridge Ave, Cupertino, CA
95014. Phone local office.

Circle No 436



μP BOARD TESTER

- Clips onto boards with soldered-in μ Ps
- Tests circuits by overdriving bus and control lines

You use the 90 Series stand-alone tester for troubleshooting pc boards that employ Z-80, 8085, and 6809 μ Ps. Because the tester clips onto boards under test, it can accommodate boards with soldered-in processor chips. Instead of emulating the processor, it "steals" processor cycles and overdrives the control and bus lines to test ancillary circuits, an arrangement that permits the unit under test to continue running while the tester executes diagnostic routines. Sixteen preprogrammed routines reside in the tester. The tester includes a 2-line \times 16-character LCD display and a 24-key keypad. You can also control it remotely via an RS-232C port. \$1395.

John Fluke Mfg Co, Box C9090,
Everett, WA 98206. Phone (800)
426-0361; in WA, (206) 347-6100.
TLX 185102.

Circle No 437

HIGH PROGRAMMING
YIELDS

EPROM PROM PLD

(LOGIC)

LOW
PROGRAMMING COSTS



PROGRAMMERS

A complete range of low priced separate products to meet your individual specific requirements (with device manufacturers' approvals).

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- E12C gang/set EPROM
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- 1012 Bipolar PROM / EPROM
- 1013 set EPROM (to 32/40 pin)
- 1014 EPLD & CMOS PLD

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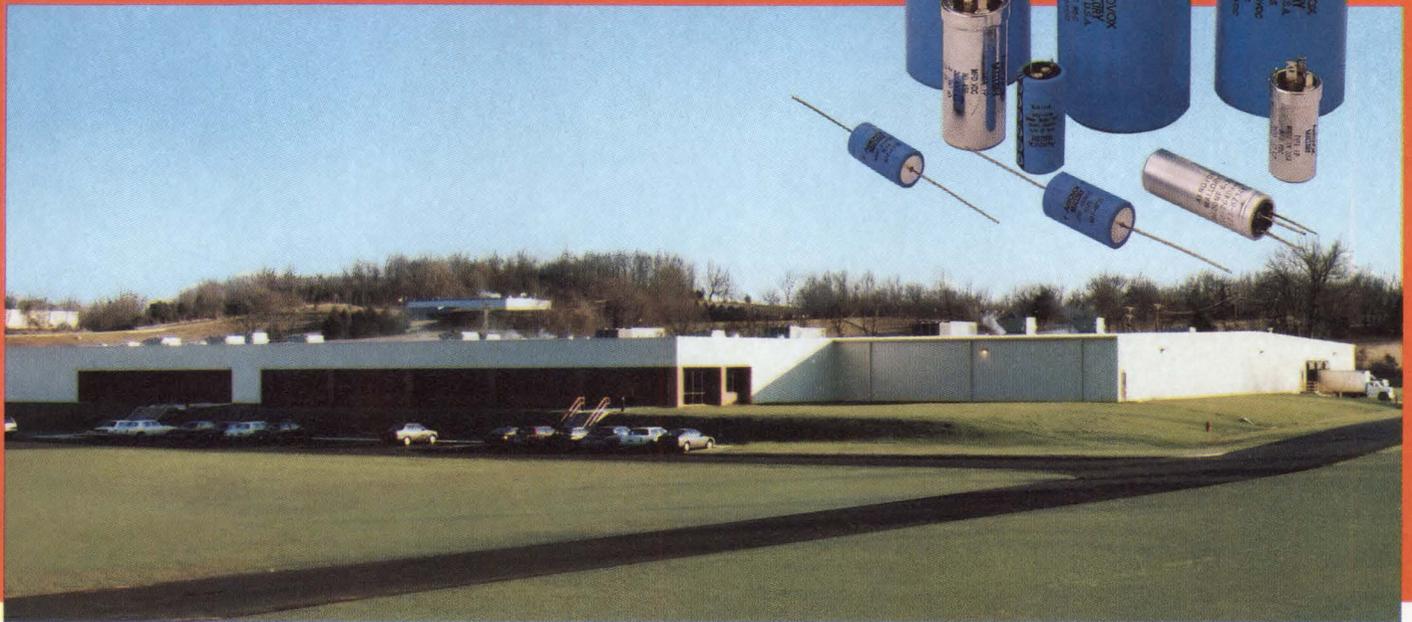


Elan Digital Systems
California
Tel: 800-541-ELAN
Telex: 9102400972

CIRCLE NO 65

EDN April 28, 1988

Since RTE bought Mallory's Aluminum Electrolytics, they've put their money where their mouth is.



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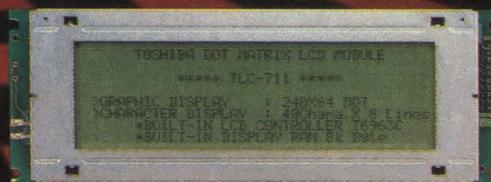
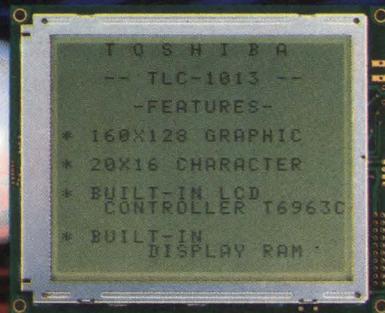
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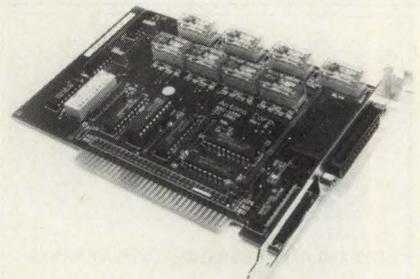
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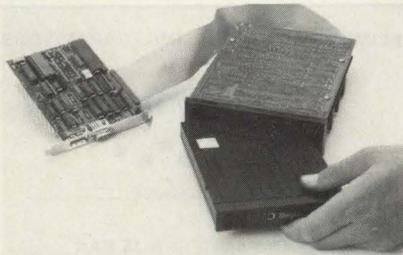
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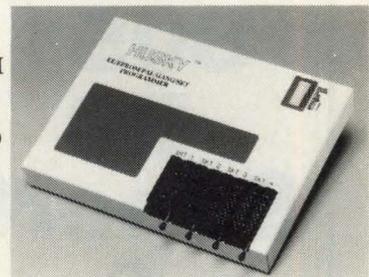
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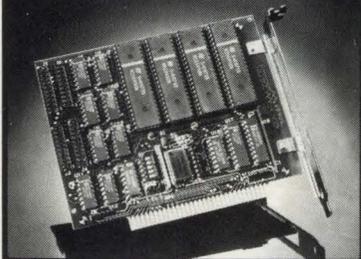
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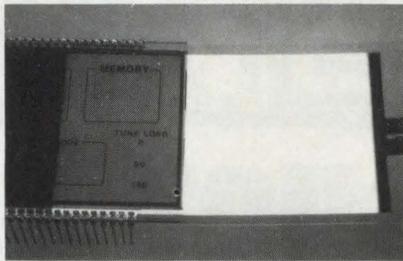
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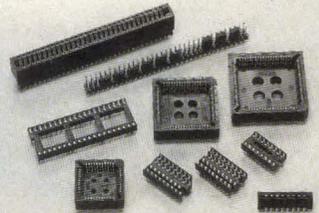
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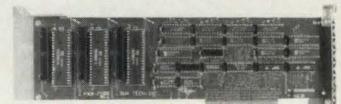
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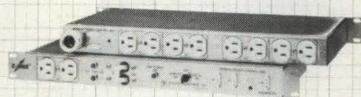
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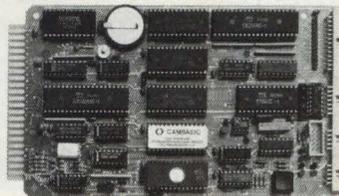
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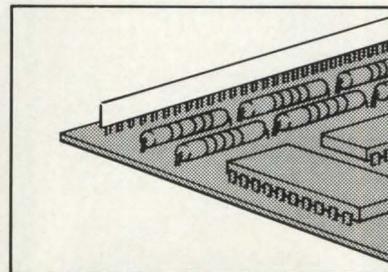
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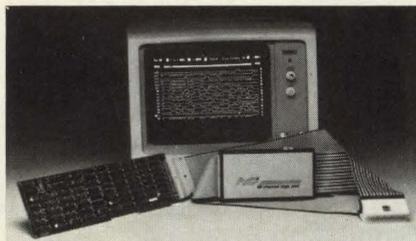
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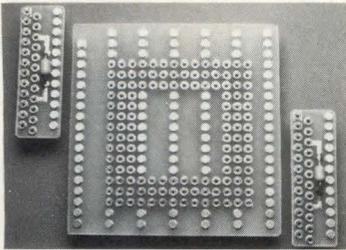
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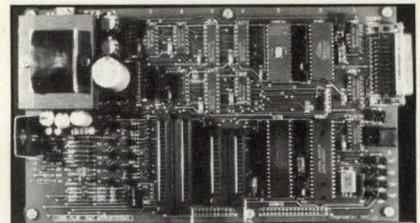
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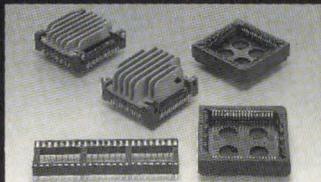
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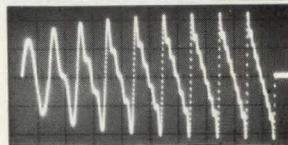
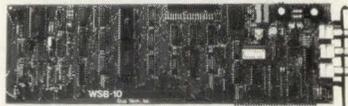


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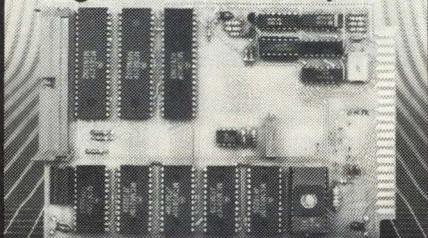
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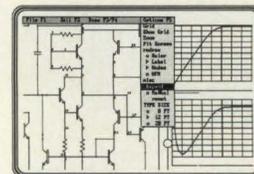
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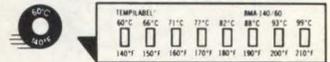
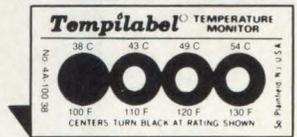
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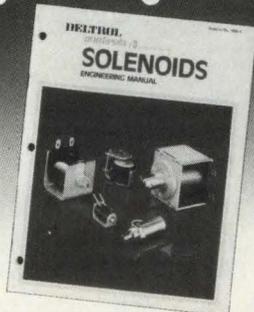
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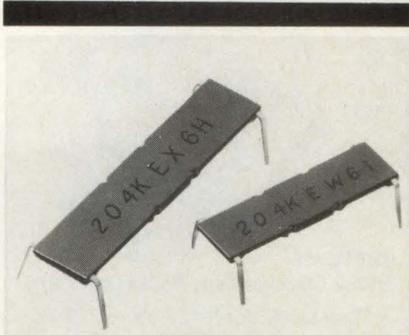


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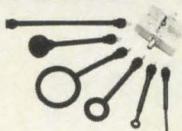
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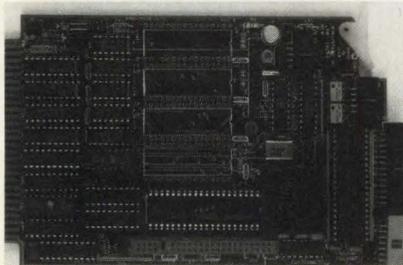
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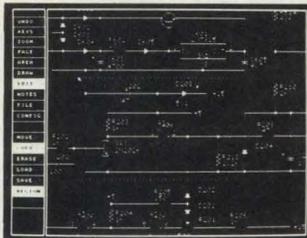
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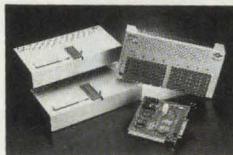
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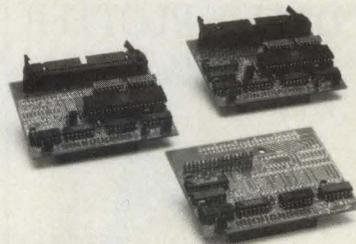
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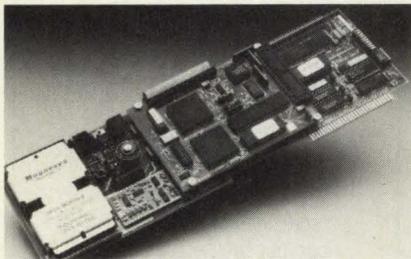
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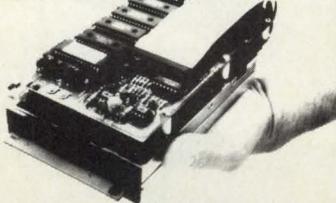
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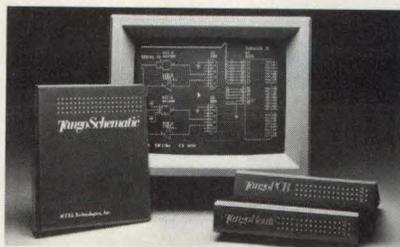
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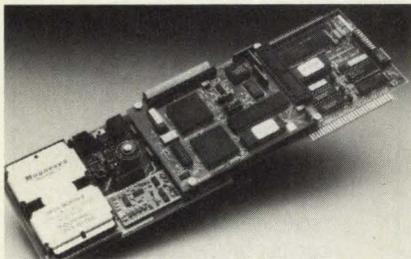
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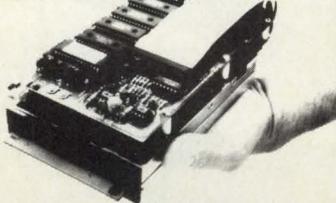
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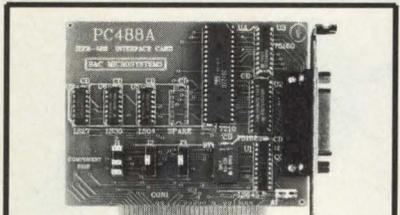
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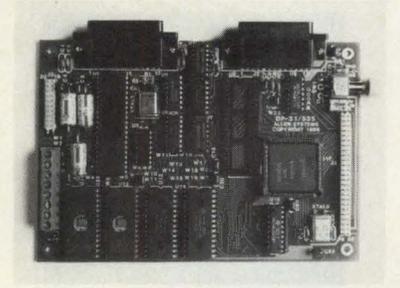
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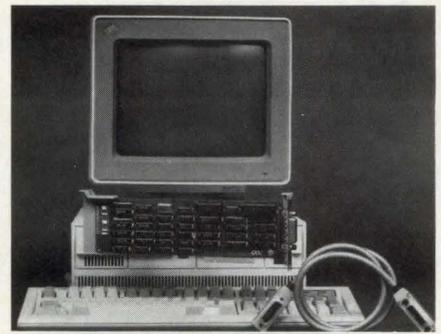
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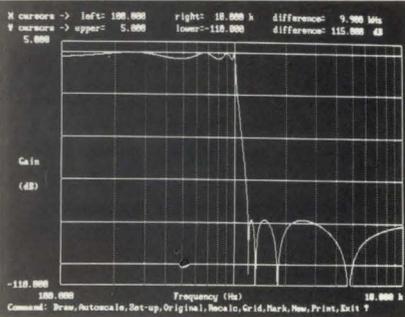
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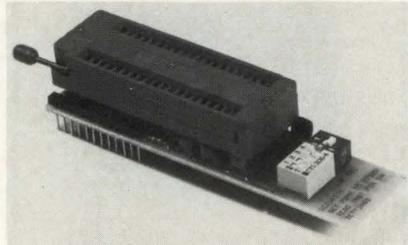
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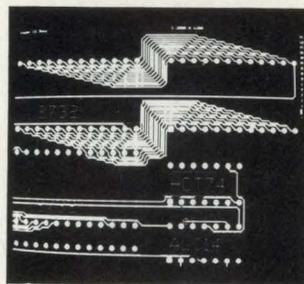
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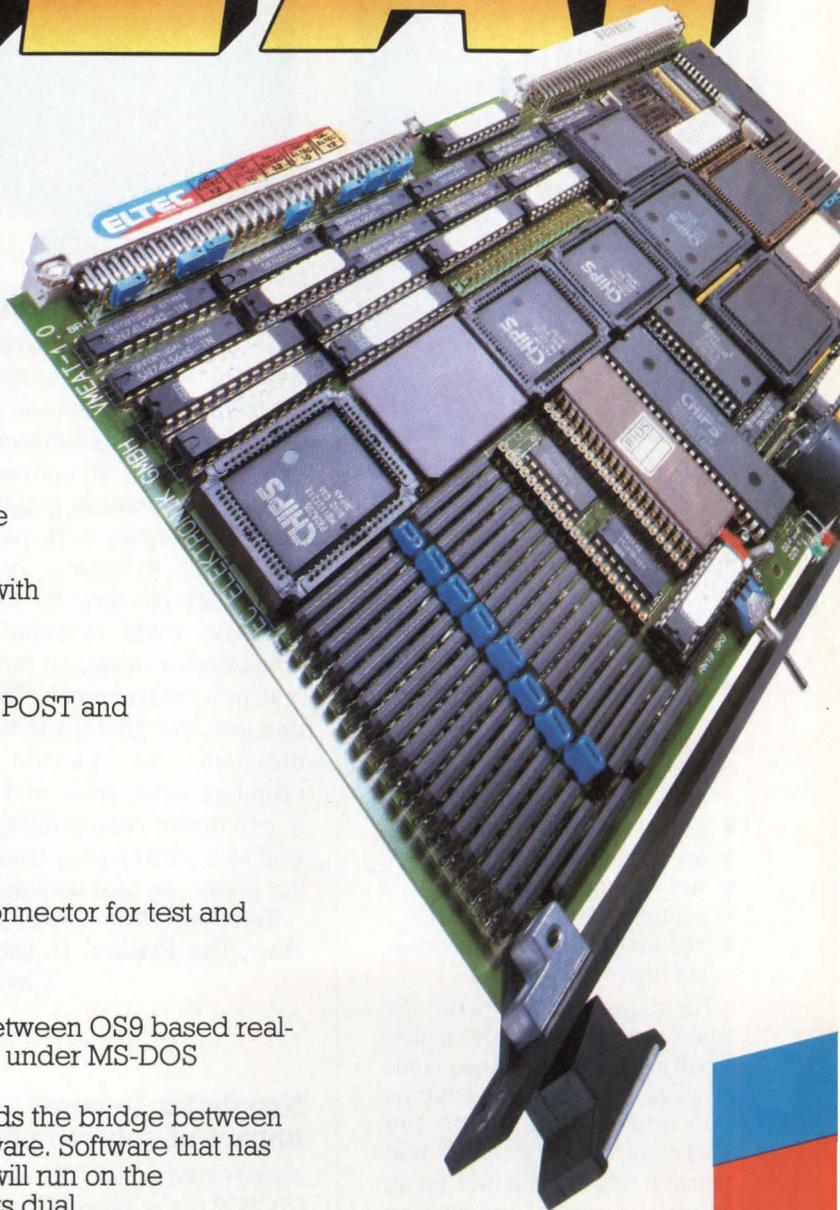
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CIRCLE NO 66

LITERATURE



Publication lists plotter media and supplies

This 52-pg, 4-color catalog deals with the vendor's selection of plotter media from bonds and vellums to polyester drafting films and custom-printed forms. It contains a new section of business graphics films designed for use with plotters and nonimpact printers. It also describes HP plotters: HP DraftPro of personal CAD systems and the DraftMaster designed for a shared-resource environment. The publication provides photographs and specifications for plotter supplies including pens, inks, and adapters. A pen/media compatibility chart as well as a plotter-pen, trouble-shooting guide are also included.

Teledyne Post, 700 E Northwest Hwy, Des Plaines, IL 60016.

Circle No 438

Newsletter to cover impact of superconductivity

SuperConductor World Report (SCWR) is a newsletter covering developments in superconductivity. It focuses on the interests of business executives, strategic planners, investment analysts, and product engineers all over the world. Therefore, rather than handle superconductivity as a scientific phenomenon, SCWR will concentrate on the

technology's economic and industrial uses, as well as its social and political implications. The second issue, for example, presents articles on investments, futures, government funding, and market strategy. Annual subscription, \$385.

Empire Communications Group, 23 Empire Dr, St Paul, MN 55103.

INQUIRE DIRECT



Folder introduces absorption material

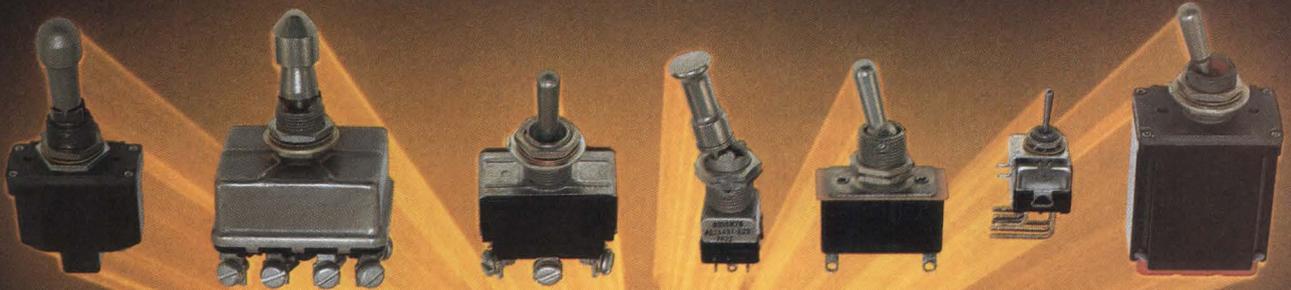
This introductory packet includes a folder and a sample of Poron products, the vendor's high-density cellular urethanes. It describes five simple tests that you can conduct right at your desk. The tests demonstrate energy absorption, resistance to impression, self-healing after puncture, resiliency, and resistance to long-term compression set.

Rogers Corp, 1 Technology Dr, Rogers, CT 06263.

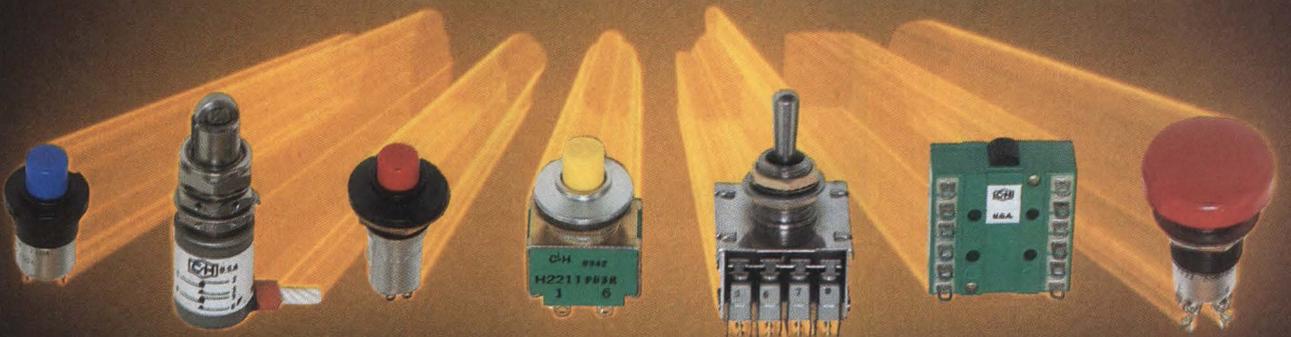
Circle No 440

Two ways to design antenna systems

The 6-pg technical bulletin *Celwave Opens the Door to 900 MHz Trunking* explains two practicable methods of designing and equipping 10-channel, 900-MHz antenna systems. These methods include the



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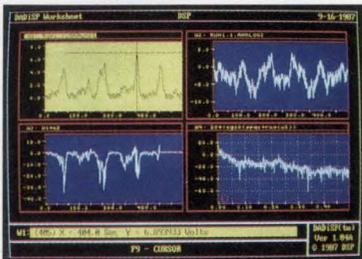
EATON

CIRCLE NO 238

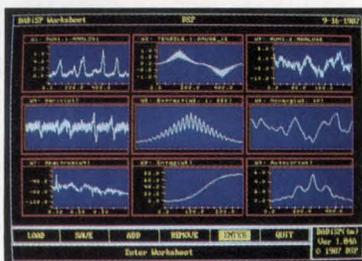
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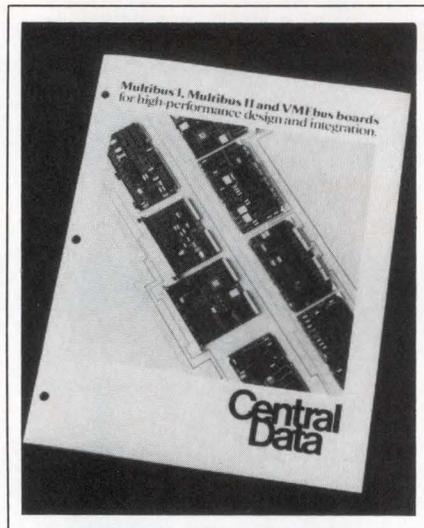


LITERATURE

use of combiners, receiver multi-
couplers, duplexers, antennas, and
cable.

Celwave RF, Div of Radio Fre-
quency Systems Inc, Route 79,
Marlboro, NJ 07746.

Circle No 441



Multibus I and II boards cataloged

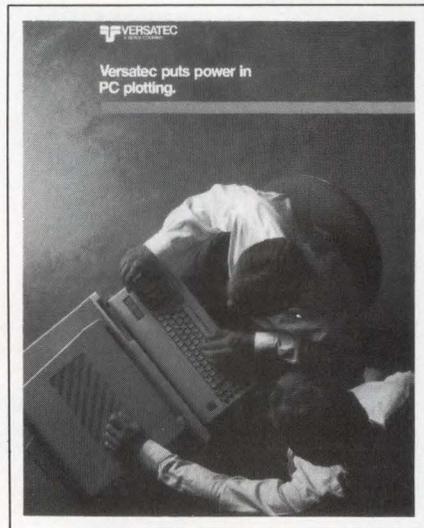
This 35-pg catalog covers a complete
line of Multibus I boards and acces-
sories, and four new Multibus II
products. It contains photographs,
descriptions, and specifications for
more than 30 Multibus I, Multibus
II, and VME Bus board-level prod-
ucts. It describes a Multibus II com-
munications controller, a SCSI and
floppy controller, an SBX single-
board computer, and an intelligent
prototype board.

Central Data Corp, 1602 Newton
Dr, Champaign, IL 61821.

Circle No 442

How to connect plotters to personal computers

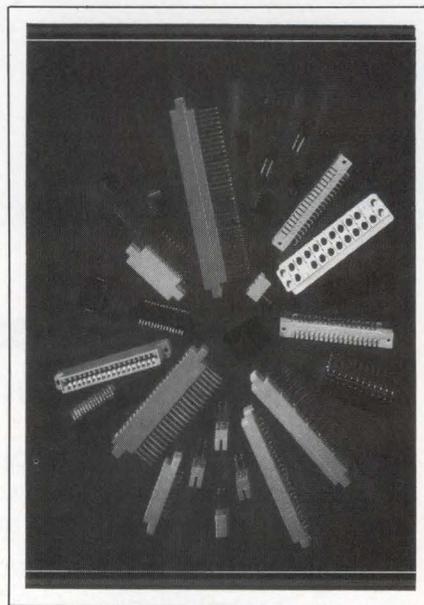
The 4-color brochure, *Versatec puts
power in personal-computer plot-
ting*, tells you how to receive hard
copy information on your IBM PC or
compatible, or your Macintosh per-
sonal computer. Its diagrams show
the configurations, including soft-
ware, interface or rasterizer, and
plotter. Besides discussing the ad-



vantages of using electrostatic and
thermal transfer plotters, the folder
also contains a product table to help
you select the right plotter for
speed, size, and high-quality out-
put.

Versatec, 2710 Walsh Ave, Santa
Clara, CA 95051.

Circle No 443



Booklet features card-edge connectors

The 36-pg catalog *Card Edge Con-
nectors* focuses on the vendor's card-
edge-connector series that come on
0.05- to 0.336-in. contact centers
with wire-wrap, dip-solder, solder-
eye, and right-angle terminations.
The descriptions of the 56 connector

Continued on pg 344
EDN April 28, 1988



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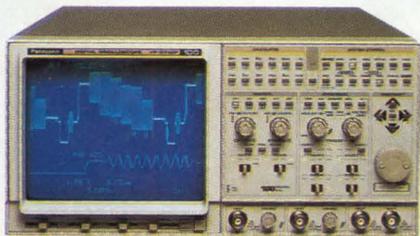


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lated and memory waveforms or related digital information. A GP-IB interface is built in. So are a host of calculating functions which include not only addition, subtraction, multiplication and division but advanced functions such as integration, differentiation, square and square root.

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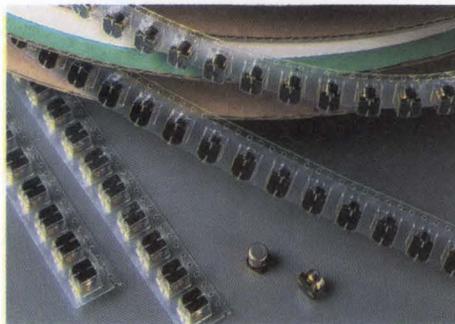
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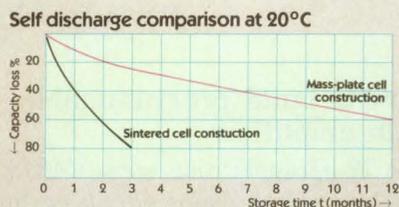


We invented the mass-plate cell construction which excels over competing sintered nickel-cadmium cells in key ways that improve your product performance.

In stand-by at ambient temperatures, our mass-plate button cells retain 60% capacity after 12 months versus about three months for sintered NiCd cells, because they have much lower internal losses. Similarly, they require much lower

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Varta mass-plate button cells and batteries usually take significantly less space — or let you put up to



40% more capacity in the same space. They can be stored in any state of charge for over five years without significant loss of performance. In addition, extra high temperature ratings and UL listings

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Yet, with all their advantages, Varta mass-plate button cells and batteries usually cost less than comparable sintered-type cells. Mass-plate button cell capacities range from 4 mAh to 1000 mAh and a wide variety of flat or stacked batteries can be assembled from them.



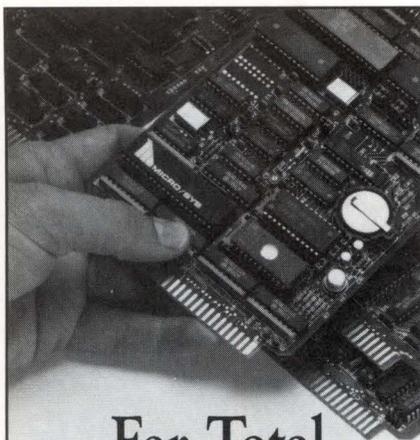
For rechargeable applications above 1000 mAh, Varta also offers a complete line of NiCd cells and batteries highly competitive in performance and cost.

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CIRCLE NO 235



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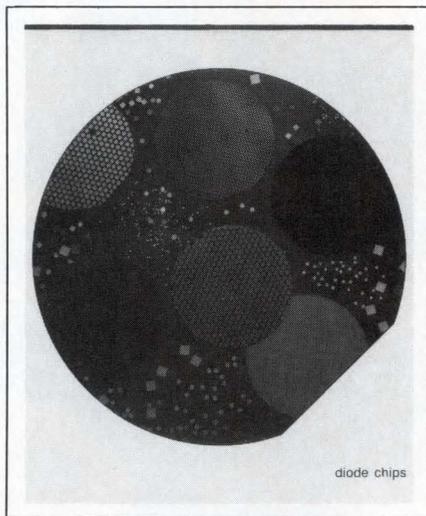


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series incorporate specifications, dimensional drawings, and photographs.

Methode Electronics Inc, Connector Div, 7447 W Wilson Ave, Chicago, IL 60656.

Circle No 444



diode chips

Brochure deals with diodes

The 12-pg brochure *Diode Chips* outlines unencapsulated die and surveys die geometries, types, and metallizations. Specific chips are available through the level equivalent of the Joint Army-Navy Specification. Devices offered in chip form include zener diodes, rectifiers, transient suppressors, and temperature-compensated chips.

Microsemi Corp, 2830 S Fairview St, Santa Ana, CA 92704.

Circle No 445

How to build programmable gain amplifiers

The 12-pg application note, *CMOS DACs and Op Amps Combine to Build Programmable Gain Amplifiers*, Part II examines the performance of dual-CMOS DACs as gain-determining elements in a programmable-gain-amplifier (PGA) system. It discusses how you can achieve greater accuracy over a wide dynamic range, using a dual-DAC circuit. Some of the subjects in the note include basic equations for

ANALOG DEVICES APPLICATION NOTE

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CMOS DACs and Op Amps Combine to Build Programmable Gain Amplifiers

Part II

by John Wynn

The Application Note investigates the performance of dual-CMOS DAC as gain-determining elements in a PGA system. It details how greater accuracy over a wider dynamic range can be achieved with a dual-DAC circuit as opposed to a single-DAC solution. A dual-DAC approach spreads the resistor system gain over two stages. This results in an isolated system gain which is the product of the individual gain stages. But the overall gain error is the sum of the gain errors of the individual gain stages.

Part I of the Application Note looked at the error sources which occur when a CMOS DAC is used in a programmable gain amplifier in the feedback loop of an op amp. A detailed comparison was made between the performance of a PGA circuit based on a 14-bit DAC, the AD7508 (AD7508) and a 12-bit DAC, the AD7505 (AD7505).

DUAL-DAC SOLUTION

With two DACs available in a single package—or, at times, two op amps also available in a single package—it becomes possible to use two, unique PGA circuits in series without taking up too much extra printed-circuit-board area. This is illustrated by a single-DAC stage. Figure 1 shows such a circuit. Each resistor contributes its own gain error and offset errors to the overall error. Gain errors are due to DAC input resistivity and to DAC gain error. Offset errors result from DAC input current and input offset currents and input offset voltages.

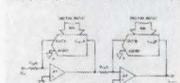


Figure 1. Dual-DAC PGA circuit

The dual-DAC circuit does, however, exaggerate the offset error terms. The offset errors of the first stage are multiplied by the gain setting of the second stage. This means that to keep within other tolerances for gain and setting, one must use a gain or more in the output of the second stage. For this reason, dual-DAC PGA systems are more costly than single-DAC systems.

Since DAC gain error can be trimmed to zero, voltage matching can be done to reduce the integral nonlinearity of a DAC. In addition, both the gain and the percentage gain error due to DAC nonlinearity are reduced by a factor of two for gain error. Following the comparison are made between the dual-DAC performance and the performance of both the single 14-bit and 12-bit DAC systems which were the subject of Part I of the Application Note.

THE BASIC EQUATIONS FOR A DUAL-DAC PGA

When only one op amp is used, the gain error of a single stage is:

$$\frac{\Delta G}{G} = \frac{\Delta R}{R} + \frac{\Delta I}{I} + \frac{\Delta V}{V} \quad (1)$$

Where ΔR is the gain error due to DAC

ΔI is the DAC input error in I_{in}

and ΔV is the DAC code in decimal

With two similar stages in series, the system gain is therefore:

$$\frac{\Delta G}{G} = 2 \left(\frac{\Delta R}{R} + \frac{\Delta I}{I} + \frac{\Delta V}{V} \right) \quad (2)$$

Where A and B suffixes refer to DAC A and B stages and DAC B and A stages respectively.

The percentage gain error of a single stage, again assuming zero-DAC gain error, can be expressed as:

$$1\% \approx \frac{\Delta R}{R} + \frac{\Delta I}{I} + \frac{\Delta V}{V} \quad (3)$$

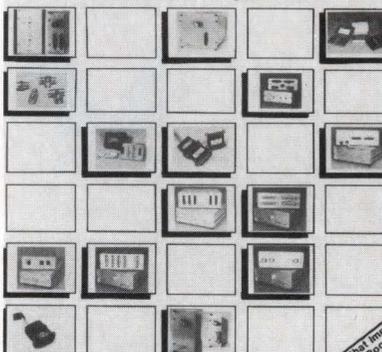
a dual-DAC PGA, comparing errors, small-signal bandwidth, and dynamic gain errors. Equations, circuit diagrams, and tables illustrate the text.

Analog Devices, Literature Center, 70 Shawmut Rd, Canton, MA 02021.

Circle No 446

ELECTRO STANDARDS LABORATORY, INC. Catalog/Price List September 1983

Data Communication Products and Computer Accessories



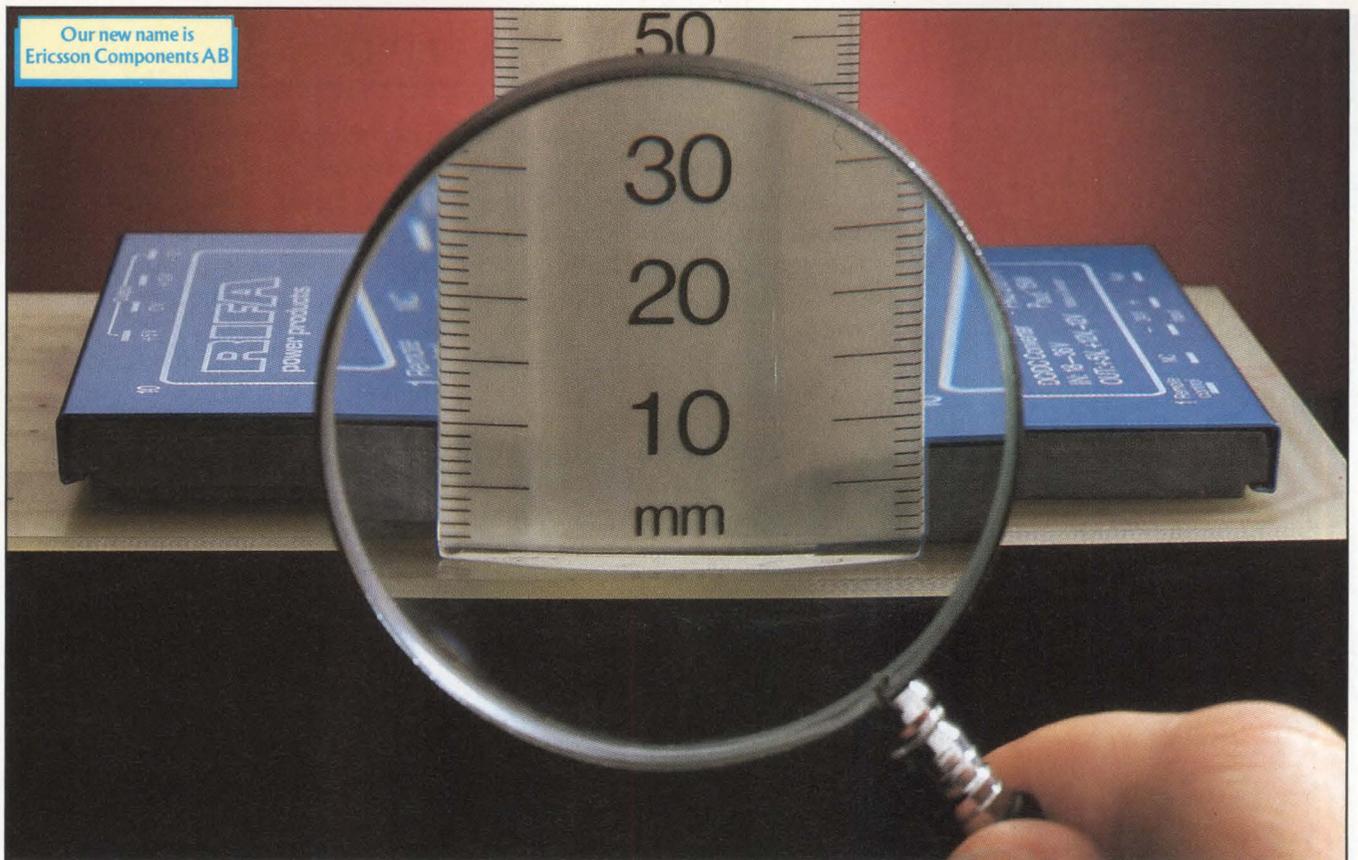
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New Products That Improve Computer System Efficiency

Computer and datacomm products categorized

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



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

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

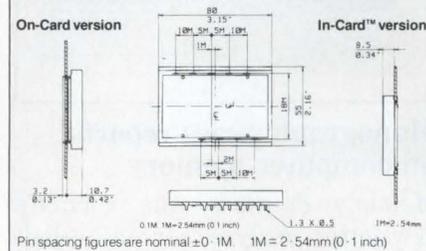
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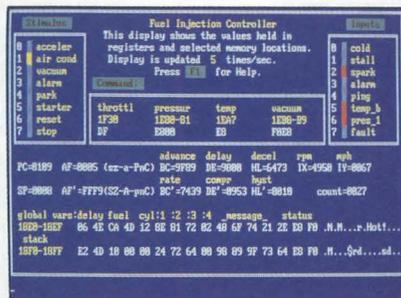
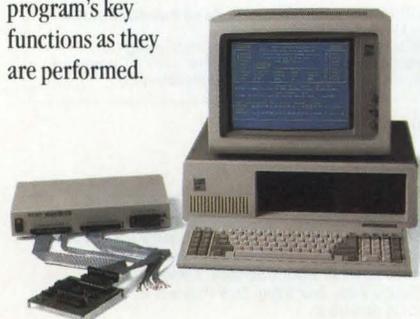
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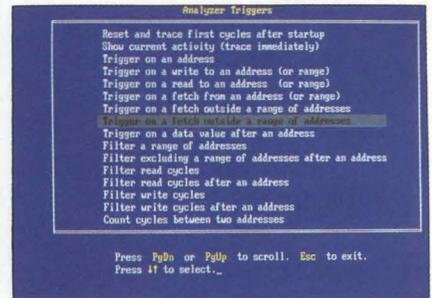
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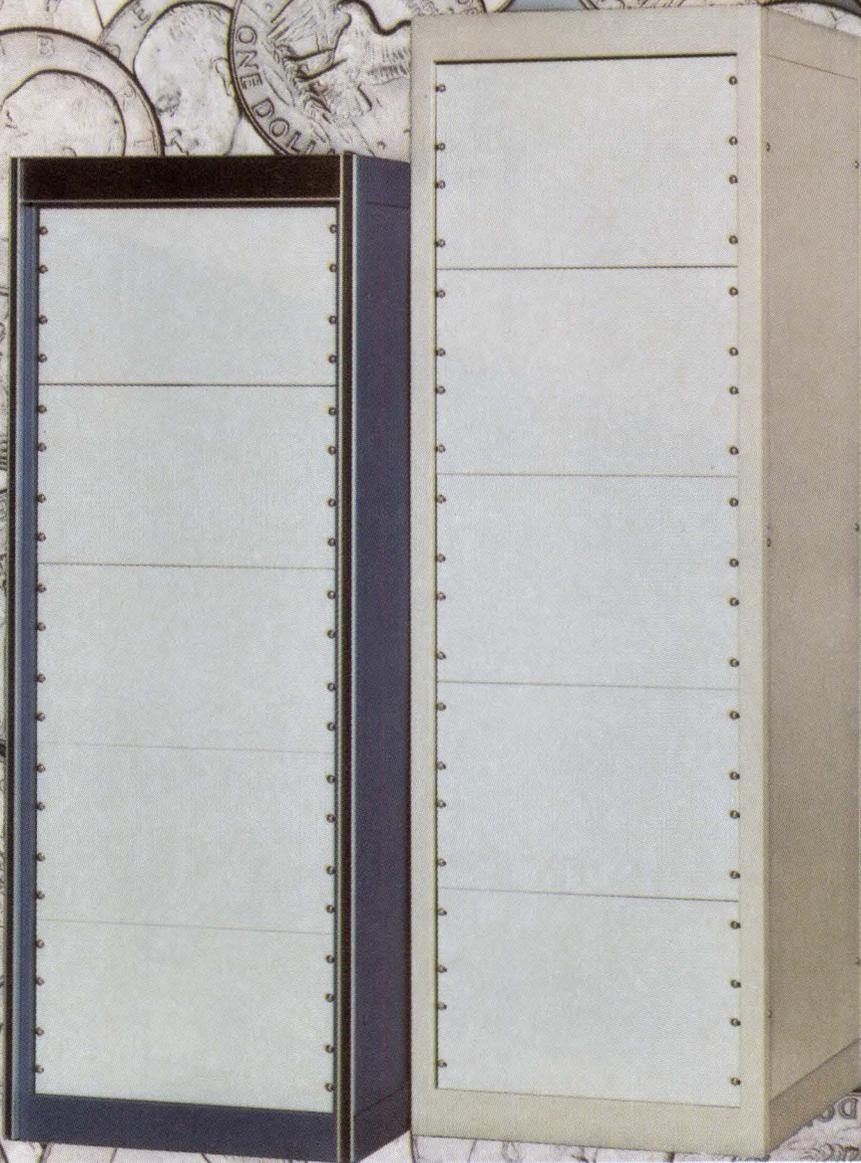
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IEEE

database service

encourages entrepreneurial urges

Deborah Asbrand, *Associate Editor*

The latest addition to the IEEE's résumé-database service matches independent consultants with potential corporate clients. The IEEE intends the database to serve both members who maintain their own consulting practices and those who are retired but desire part-time work. But it also has a third—much larger—group in mind: industry-employed members who would like to try consulting.

The database is part of the IEEE's effort in recent years to lend more support to its members' entrepreneurial urges. One reason the organization formed the new résumé service, called the Self-Employed Engineers Registry (SEER), was to give business-minded members an outlet for making contacts and undertaking independent assignments without having to give up full-time corporate employment first.

SEER is based on the success of the Professional Engineering Employment Registry, known as PEER. The PEER service contains the résumés of job-seeking engineers and scientists from 30 technical societies. The database has more than 300 clients, who access the system through terminals installed in their own facilities. PEER began operating in 1984. Since then, it has become one of the most successful of the computerized résumé services.

But there are important differences between SEER and PEER. In the PEER files, individuals' names don't appear on the résumés. A com-

pany identifies candidates who interest them by using code numbers, which are assigned to the résumés by Career Technologies Corp, the Andover, MA, business that maintains the service. Career Technologies then contacts the individuals that a company has expressed interest in.

SEER, on the other hand, is not confidential. Individuals' names appear on the résumés that employers review. SEER still acts as an intermediary in the notification process, however: Employers who access the database contact SEER about a consultant they're interested in, and SEER then contacts the individual. Because of SEER's nonconfidentiality, the IEEE encourages engineers who plan to moonlight as consultants to obtain their employer's approval first.

Another difference between SEER and PEER is the format in which the participating engineers and scientists present their professional qualifications. Companies typically hire consultants who have the necessary experience in very specific technical areas. As a result, consultants' résumés often contain long passages of technical information. SEER allows its participants to abandon the traditional résumé structure and instead describe their engineering experience in detail.

Companies access SEER for a variety of reasons, according to Joe Stacey, president of Career Technologies. In many instances, employers need additional design assist-

ance but can't afford to hire permanent, full-time technical professionals. Companies also hire independent consultants for short-term projects that don't warrant a full-time employee. Some corporate consulting needs are more unusual: Stacey says one company recently searched the database for an engineer to testify as an expert witness in a lawsuit.

Since SEER began operation (in September 1987), several hundred consultants have contributed résumés to the database. Stacey estimates that two dozen employers have used the service to date, and he says that although the level of interest in SEER will never equal that of PEER, he believes the market for SEER is sizable, particularly as the database grows. "More candidates result in more companies interested in using the service," he says.

Among the strongest supporters of SEER is Richard Backe, former chairman of the IEEE's Employment Assistance Committee and an active Region 2 member. Backe says that although the IEEE hasn't surveyed its members' opinions about starting businesses of their own, anecdotal evidence suggests that interest is strong. "There's been a hue and cry from people to gain some independence and try things from an entrepreneurial standpoint," he says.

The number of full-time consultants within the IEEE's ranks is small, only 5%. Yet Backe says that

independent consultants constitute 10 to 15% of other professional societies' memberships. He hopes that SEER will give more IEEE members the opportunity to explore the idea of running their own consulting practices. "I hope that it lights a light for people who are interested in doing this kind of work." To provide further encouragement, the IEEE now sponsors a committee on

entrepreneurship whose charter is to scout new sources of support and information for members who are considering starting small businesses.

The IEEE hopes that response to SEER will move along the same lines as it has to PEER, which, despite a slow start, now seems well established. The 1985 IEEE Member Opinion Survey, conducted one

year after PEER's inception, turned up few respondents who had used the PEER service, and those surveyed exhibited mixed feelings about continuing it. In the last four years, however, PEER has remained active in a field in which many similar services have failed. The IEEE hopes that the 1988 member survey, due to be released this summer, will show steady support for the résumé database.

The IEEE is optimistic about the future of such services and is now working on a third addition to its roster. The Graduate Engineer Employment Registry, designed for use by students, is scheduled for introduction next year. **EDN**

How to participate in SEER

IEEE members interested in participating in SEER need to include a registration form along with their résumés. To obtain a registration blank, write to Career Technologies Corp, SEER Service Center, 138 Old River Rd, Andover, MA 01810, or phone the company at (617) 683-0098. (Members interested in contributing to PEER should follow the same procedure.)

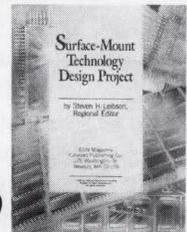
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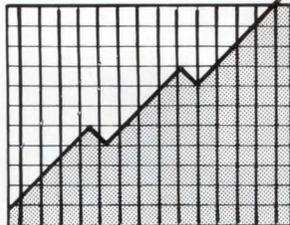
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June 9	May 19	CAE, Analog ICs, Test & Measurement	Closing: May 29 Mailing: June 16
June 23	June 2	Data Communications, DSP, Components	
July 7	June 14	Product Showcase—Vol. I, Power Sources, Software	Closing: June 23 Mailing: July 14
July 21	June 30	Product Showcase—Vol. II, CAE, Test & Measurement	
Aug. 4	July 14	Sensors & Transducers, Analog ICs, Graphics	Closing: July 21 Mailing: Aug. 11
Aug. 18	July 28	Military Electronics Special Issue, Displays, Military ICs	
Sept. 1	Aug. 11	Instruments, Op Amps, Computers & Peripherals	
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Oct. 13	Sept. 22	Test & Measurement Special Issue, Instruments, Computers & Peripherals	Closing: Sept. 29 Mailing: Oct. 20
Oct. 27	Oct. 6	CAE, Computers & Peripherals, Integrated Circuits, Wescon '88 Show Preview	
Nov. 10	Oct. 20	Programmable Logic Devices, Integrated Circuits, Test & Measurements, Wescon '88 Show Issue	Closing: Oct. 27 Mailing: Nov. 17
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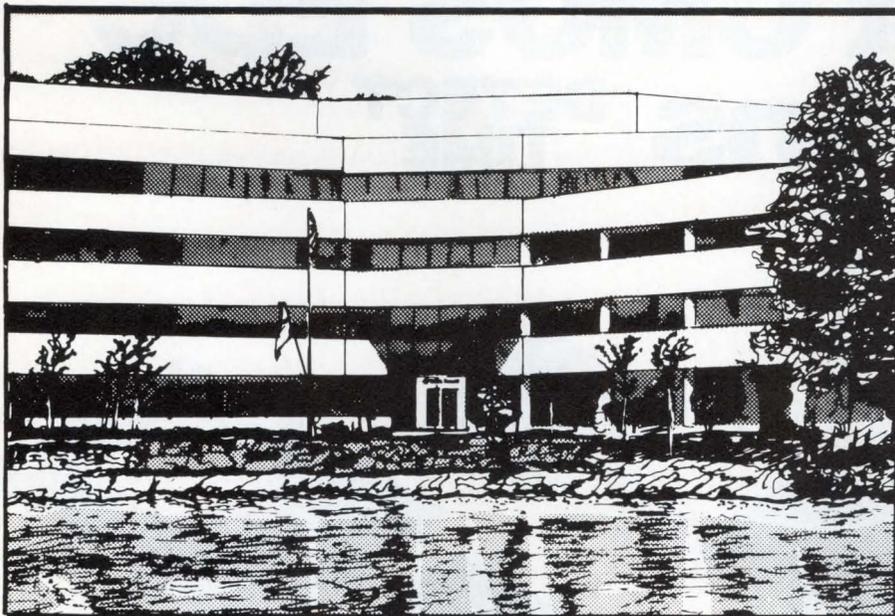
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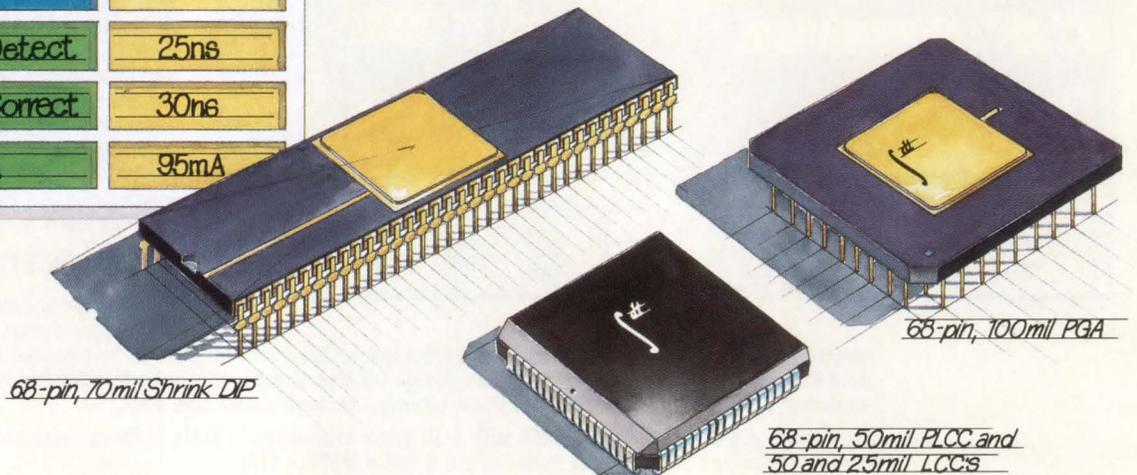
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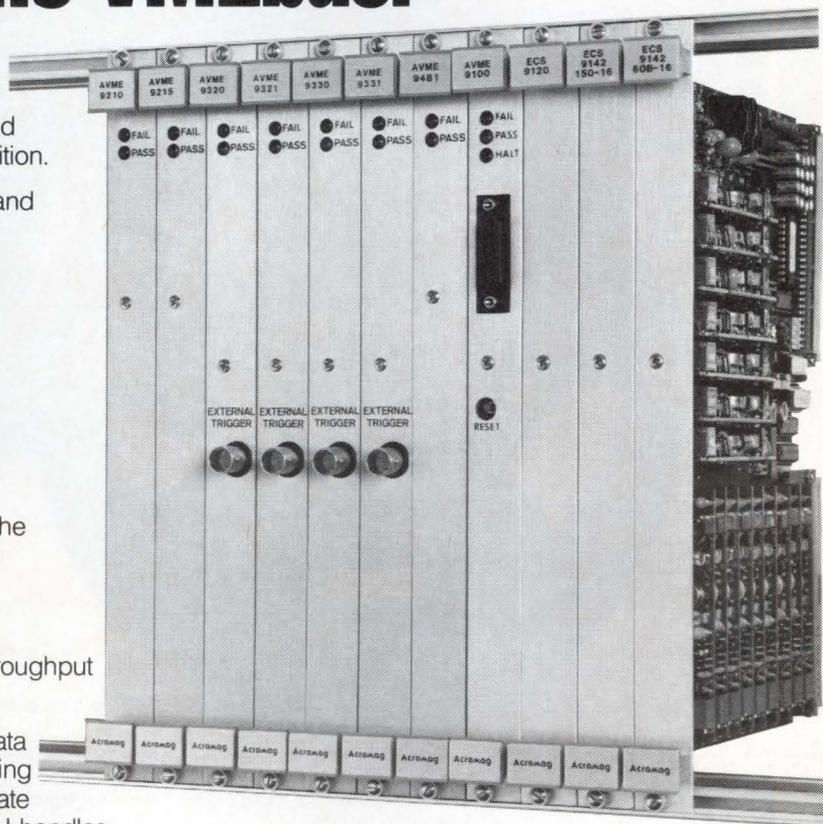
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Analog Out	8 out	±10V, Vout 4-20mA, Iout	12 Bit D/A, 6 μ sec Vout, 25 μ sec Iout, throughput	AVME9210 AVME 9215
Data Acq. Controller	16D/32SE in, opt.	±10V	14 Bit A/D, 256 in, scans, linearizes, limit checks	AVME9100 AVME9110
Subsystem Expanders	16D/32SE in	±10V	High level expander	ECS9120
	16D in	±10V	Filtered inputs	ECS9121
	8D/16D in	-6 to +60mV -15 to +150mV Thermocouple	250V isolation, interface for TC, RTD, and Pressure with termination panels	ECS9142-60 ECS9142-150 ECS9142-60B
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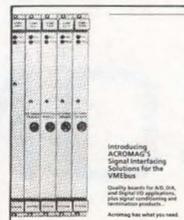
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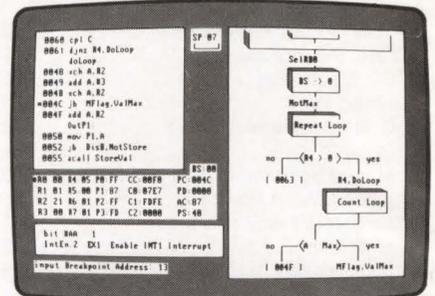
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CIRCLE NO 250

EDN April 28, 1988

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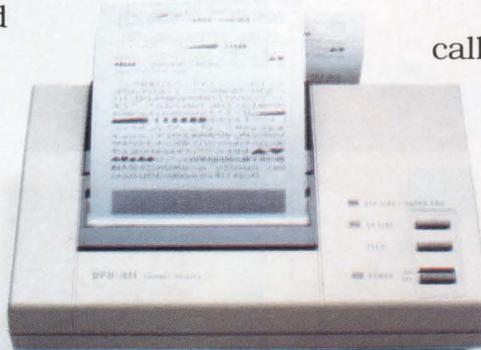


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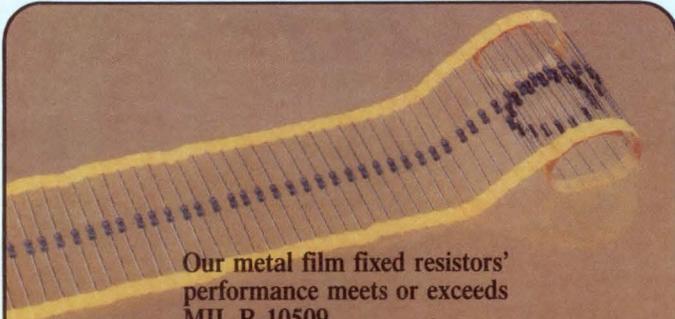
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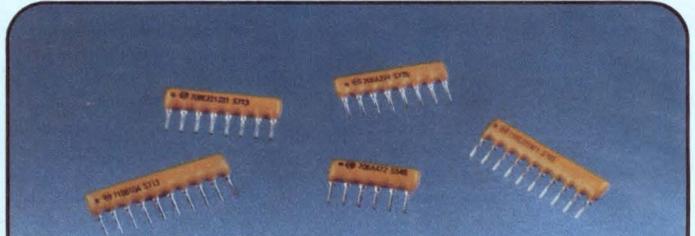


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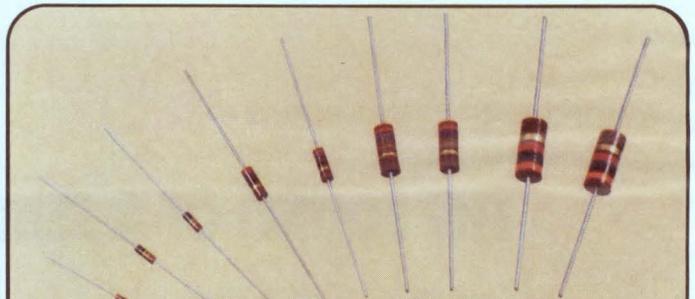
Surface mount SARAs and chip resistors

SARAs . . . resistor networks with solder bumped terminations for surface mount applications. Compatible with automatic placement equipment. Cost effective solution for space-saving custom circuitry. User trimmable.

Chip Resistors . . . 1206 and 0805 sizes. Laser trimmed thick film resistance element. Tight TCR. 5% and 1% tolerance in high volume. Utilizes Statistical Process Control in manufacturing for built-in quality. Call 800-592-4888 or 800-292-4888 in Texas.



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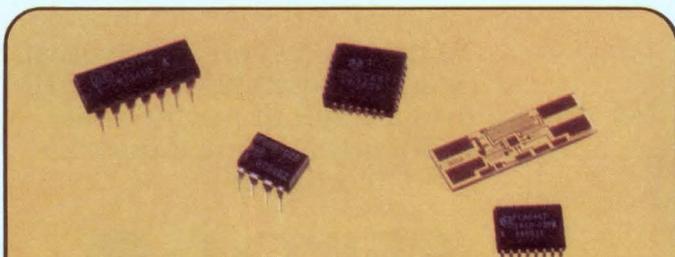


Billions of hours and no failures . . . A-B fixed carbon composition resistors

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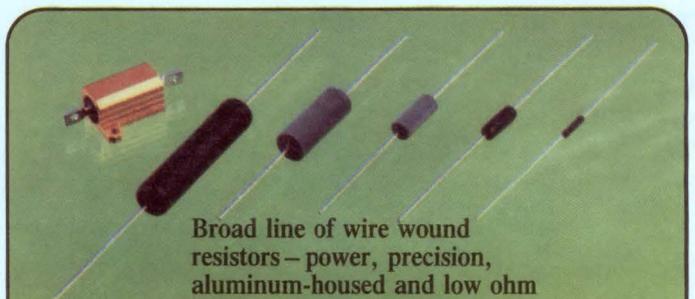


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Consist of integrated films of chromium cobalt vacuum deposited on specially selected glass or alumina substrates resulting in networks having precision tolerance and stability. Molded and ceramic DIP, ceramic SIP, surface mount, alumina and glass chip, and hybrid network substrates. Standard designs and custom circuits and packages. Meets MIL-R-83401 characteristic. Call 800-592-4888 or 800-292-4888 in Texas.



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LOOKING AHEAD

EDITED BY CYNTHIA B RETTIG

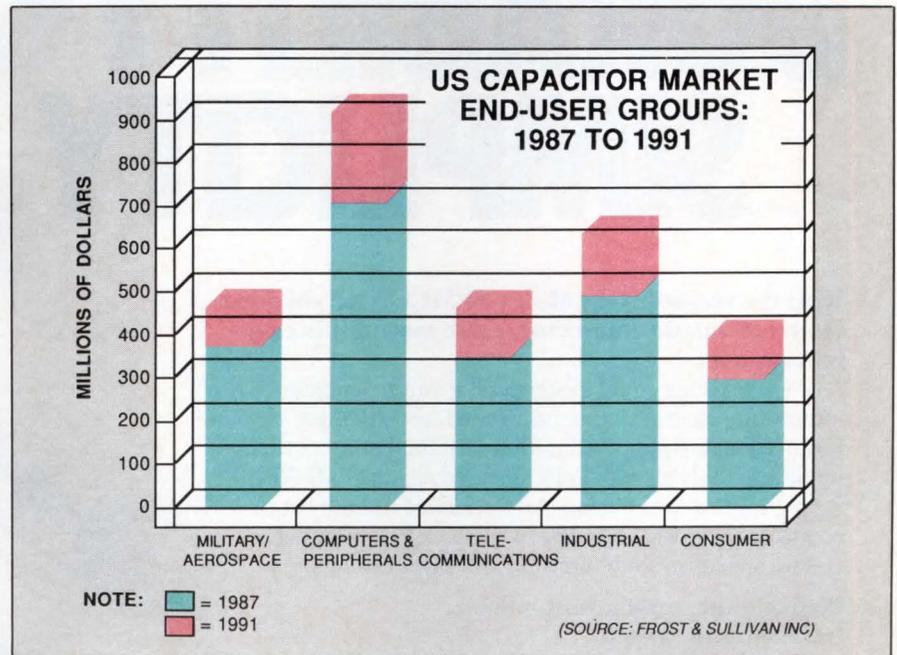
US capacitor sales are on the way up

Capacitor sales, which are closely linked to the health of the computer-and-peripherals markets, have suffered markedly as a result of the slump in the market for PCs. An OEM build-up caused a 27% rise in the dollar value of the capacitor market in 1984, only to be followed by a 30% decrease in capacitor demand in 1985. Now, however, the capacitor market is recovering, according to Frost & Sullivan. The New York market-research firm predicts 6.1% growth in sales dollar value and 9.4% growth in unit sales by 1991. The sale of 26.8 billion capacitors in 1991 will gross \$2.9 billion—partly as a result of decreased prices stemming from the large volume of OEM accounts.

Sales in 1987 are estimated to have been worth \$2.2 billion, which constitutes a 5.6% increase over the previous year's figure; 1987 unit sales are calculated to have been approximately 18.6 billion, 9% greater than 1986 unit sales.

The capacitor market is divisible into five principal OEM end-user categories: computers and peripherals, industrial, military/aerospace, telecommunications, and consumer. The computers-and-peripherals segment generated 31.1% of the dollar value of the 1986 market and is expected to account for nearly one-third of capacitor demand through 1991. Industrial sales, the next largest segment, will represent approximately 22% of the market through the forecast period. Demand for capacitors among military/aerospace OEMs is expected to grow quite slowly and to decline from 17.3% of the market in 1986 to 16.3% in 1991. The telecommunications sector will steadily consume just over 16% of the capacitor market, whereas consumer OEMs will increase their level of demand to 13.3% by 1991.

An examination of the capacitor market in terms of suppliers reveals



that the top five suppliers claim 46% of the total US market, and the top ten, 62%. This situation is expected to persist, leaving the rest of the market to some 200 smaller suppliers. However, smaller suppliers who specialize in custom design should see their opportunities grow over the next few years. Product quality and the ability to offer just-in-time delivery should also prove advanta-

geous for some suppliers, as will flexible operations.

Miniaturization and surface-mount technology will constitute significant factors across the entire market. Although surface-mount technology currently accounts for only about 12% of the US market, in Japan, it already claims 35%. By 1990, 50% of US products are expected to employ SMT.

LAN market to grow at 20% rate through '91

According to Arthur D Little Decision Resources (Cambridge, MA), the US market for local-area networks should grow from \$520 million in 1986 to \$1.3 billion in 1991, which translates into a 20% annual growth rate for the domestic market. Although all application areas will expand during this period, office applications will continue to constitute the largest segment, claiming about 41% of the LAN market by 1991. Factory and medical applications, however, should both grow more quickly—at annual rates of 58% and 35%, respectively, over the next few years. In general, prices are expected to decline about 3%.

Key issues for LAN suppliers vary from one application area to another, but, as is often the case today, interconnectivity emerges as a primary concern; the ability of LANs to cross the technical borders between various types of equipment is crucial to vendors, third-party vendors, and users alike. Joint ventures and consolidation to offer specialized products will serve as major avenues to growth for US LAN businesses; distribution techniques, relationships with value-added resellers, the availability of total systems, and software quality will also prove important factors.

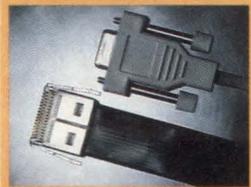
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With the versatile new Molex SEMCONN™ shielded electromagnetic connector, cable assembly is easy in, easy out.

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SEMCONN plugs insert faster and more securely than standard models, without the additional hardware.

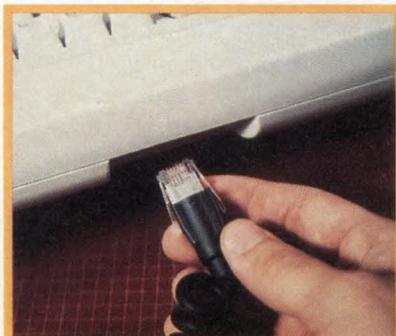
At 500 cycles, you can't find a more durable connector. All SEMCONN cable assemblies are 100% tested so you're assured of reliable, quality performance when you need it most. And Molex utilizes

Statistical Process Controls and Zero Defects manufacturing objectives, so reliability is built into every product.

When your cable assembly needs go beyond the standard, there's Molex.

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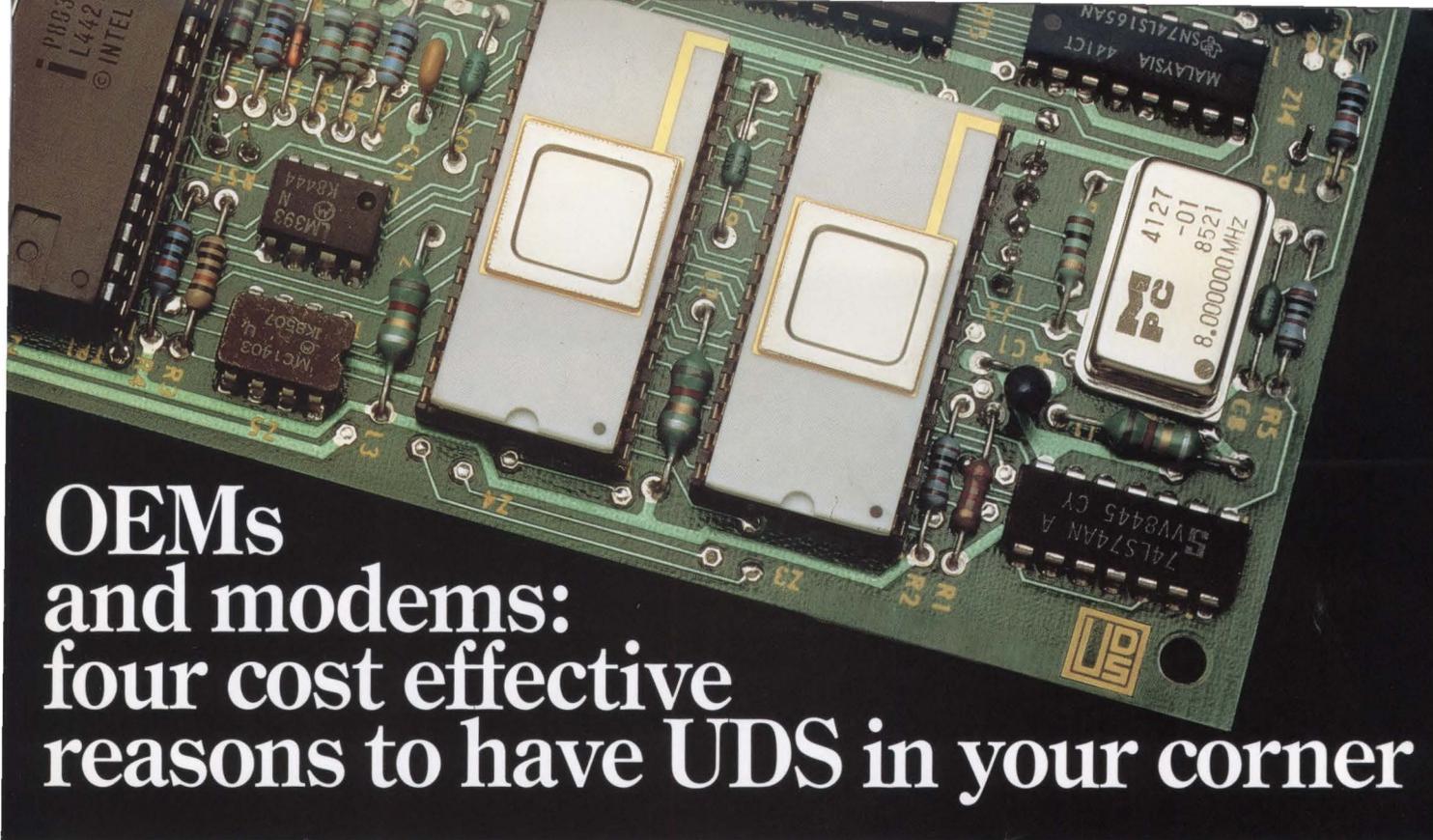
Molex's first shielded interconnection system, SEMCONN, provides protection from electrical noise.

Durable, SEMCONN shielded cables/plug assemblies reduce labor costs in a wide range of easy in/out applications.



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OEMs and modems: four cost effective reasons to have UDS in your corner

1. Concentration: spend your time and money on what you do best.

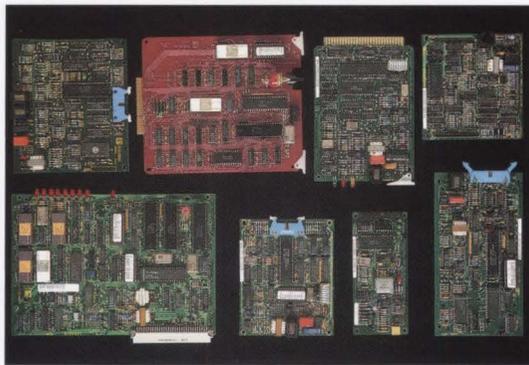
You excel at what you do; we excel at designing and producing modems. Devote yourself to developing and marketing your products more effectively, and get the modems you need from us. We have invested heavily in automated production equipment, test instrumentation and a large technical staff so you won't have to.

2. Reliability: because nothing costs like something that doesn't work.

Once you receive an OEM modem from UDS, install it, ship it and forget it. Our quality assurance procedure ranges from incoming chip burn-in to 100% testing of all modems prior to shipment. This attention to quality assurance has put our historical reliability rate near the 99th percentile.

3. Experience: we have already solved most of your problems.

Over the past 15 years, we have designed, produced and delivered more than 1,500,000 modems in over 3,000 different configurations. We have proved our capability to fulfill nearly any form, fit and function requirement from 0-300 to 14,400 bps.



4. Commitment: more than a promise, it's our reputation.

Supplying an edge in price/performance begins and ends with commitment. UDS is committed to the manufacture of modems – and only modems. We're also committed to the needs of OEMs, who buy over 50% of the modems we make. We have built a position as an industry leader by honoring commitments –

commitments to your quality demands, commitments to your deadlines, commitments to your demand for value.

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